

MID AMERICA POWER

ASR PHASE II
WELLFIELD MAINTENANCE FACILITY

PACKAGED ENGINE GENERATORS

OPERATION, INSTALLATION AND
MAINTENANCE DATA
WARRANTIES
SERVICE PARTS

AUTOMATIC TRANSFER SWITCHES –
MODELS KSS/KSP.....1

INDUSTRIAL GENERATOR INSTALLATION –
MODELS 20-3250 kW.....2

INDUSTRIAL GENERATOR OPERATION –
MODELS 20-300 kW.....3

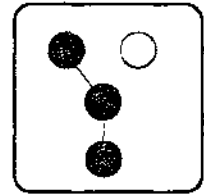
JOHN DEERE DIESEL ENGINE OPERATORS
MANUAL.....4

JOHN DEERE DIESEL ENGINE SERVICE
PARTS.....5

TAB 1

Operation and Installation

Automatic Transfer Switches



Models:

KSS/KSP

40 to 1000 Amperes

Controls:

MPAC™ 1500

KOHLER®

POWER SYSTEMS

9001
KOHLER
POWER SYSTEMS
NATIONALLY REGISTERED

TP-6447 1/09c

Product Identification Information

Product identification numbers determine service parts. Record the product identification numbers in the spaces below immediately after unpacking the products so that the numbers are readily available for future reference. Record field-installed kit numbers after installing the kits.

Transfer Switch Identification Numbers

Record the product identification numbers from the transfer switch nameplate.

Model Designation _____

Serial Number _____

Accessories

- ☐ Alarm Board
- ☐ Current Monitoring
- ☐ Battery Module
- ☐ Standard I/O Module (max. 4) qty: _____
- ☐ High Power I/O Module (max. 4) qty: _____
- ☐ Line-Neutral Monitoring
- ☐ Supervised Transfer Switch
- ☐ Digital Power Meter
- ☐ Battery Charger
- ☐ Logic Disconnect Switch
- ☐ Load Shed
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____

Controller Identification

Record the controller description from the generator set operation manual, spec sheet, or sales invoice.

Controller Description _____ MPAC™ 1500 _____

Software Version Number

Record the software version number.

Software Version Number _____

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Notes

Safety Precautions and Instructions

IMPORTANT SAFETY INSTRUCTIONS. Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. **SAVE THESE INSTRUCTIONS.**

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

DANGER

Danger indicates the presence of a hazard that **will cause severe personal injury, death, or substantial property damage.**

WARNING

Warning indicates the presence of a hazard that **can cause severe personal injury, death, or substantial property damage.**

CAUTION

Caution indicates the presence of a hazard that **will or can cause minor personal injury or property damage.**

NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

Accidental Starting

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

Hazardous Voltage/ Moving Parts

DANGER



Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

DANGER



Hazardous voltage.
Will cause severe injury or death.

Only authorized personnel should open the enclosure.

WARNING



Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Removing the transfer switch from bypass/isolation models. Hazardous voltage can cause severe injury or death. Bypass and isolate the transfer switch before removing it from the enclosure. The bypass/isolation switch is energized. Do not touch the isolation contact fingers or the control circuit terminals.

Installing the battery charger. Hazardous voltage can cause severe injury or death. An ungrounded battery charger may cause electrical shock. Connect the battery charger enclosure to the ground of a permanent wiring system. As an alternative, install an equipment grounding conductor with circuit conductors and connect it to the equipment grounding terminal or the

lead on the battery charger. Install the battery charger as prescribed in the equipment manual. Install the battery charger in compliance with local codes and ordinances.

Connecting the battery and the battery charger. Hazardous voltage can cause severe injury or death. Reconnect the battery correctly, positive to positive and negative to negative, to avoid electrical shock and damage to the battery charger and battery(ies). Have a qualified electrician install the battery(ies).

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Servicing the transfer switch. Hazardous voltage can cause severe injury or death. Deenergize all power sources before servicing. Turn off the main circuit breakers of all transfer switch power sources and disable all generator sets as follows: (1) Move all generator set master controller switches to the OFF position. (2) Disconnect power to all battery chargers. (3) Disconnect all battery cables, negative (-) leads first. Reconnect negative (-) leads last when reconnecting the battery cables after servicing. Follow these precautions to prevent the starting of generator sets by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer. Before servicing any components inside the enclosure: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Test circuits with a voltmeter to verify that they are deenergized.

Making line or auxiliary connections. Hazardous voltage can cause severe injury or death. To prevent electrical shock deenergize the normal power source before making any line or auxiliary connections.

Servicing the transfer switch controls and accessories within the enclosure. Hazardous voltage can cause severe injury or death. Disconnect the transfer switch controls at the inline connector to deenergize the circuit boards and logic circuitry but

allow the transfer switch to continue to supply power to the load. Disconnect all power sources to accessories that are mounted within the enclosure but are not wired through the controls and deenergized by inline connector separation. Test circuits with a voltmeter to verify that they are deenergized before servicing.

Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically. (600 volts and under)

⚠ WARNING



Airborne particles. Can cause severe injury or blindness.

Wear protective goggles and clothing when using power tools, hand tools, or compressed air.

Heavy Equipment

⚠ WARNING



Unbalanced weight. Improper lifting can cause severe injury or death and equipment damage.

Use adequate lifting capacity. Never leave the transfer switch standing upright unless it is securely bolted in place or stabilized.

Notice

NOTICE

Hardware damage. The transfer switch may use both American Standard and metric hardware. Use the correct size tools to prevent rounding of the bolt heads and nuts.

NOTICE

Improper operator handle usage. Use the manual operator handle on the transfer switch for maintenance purposes only. Return the transfer switch to the normal position. Remove the manual operator handle, if used, and store it in the place provided on the transfer switch when service is completed.

NOTICE

Foreign material contamination. Cover the transfer switch during installation to keep dirt, grit, metal drill chips, and other debris out of the components. Cover the solenoid mechanism during installation. After installation, use the manual operating handle to cycle the contactor to verify that it operates freely. Do not use a screwdriver to force the contactor mechanism.

NOTICE

Electrostatic discharge damage. Electrostatic discharge (ESD) damages electronic circuit boards. Prevent electrostatic discharge damage by wearing an approved grounding wrist strap when handling electronic circuit boards or integrated circuits. An approved grounding wrist strap provides a high resistance (about 1 megohm), *not a direct short*, to ground.

This manual provides operation and installation instructions for Kohler® Model KSS/KSP Automatic Transfer Switches with MPAC™ 1500 automatic transfer switch controls.

Information in this publication represents data available at the time of print. Kohler Co. reserves the right to change this literature and the products represented without notice and without any obligation or liability whatsoever.

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

The equipment service requirements are very important to safe and efficient operation. Inspect parts often and perform required service at the prescribed intervals. Obtain service from an authorized service distributor/dealer to keep equipment in top condition.

List of Related Materials

Separate manuals cover service and parts information for transfer switch power switching devices and electrical controls. The following table lists the available manual part numbers.

A personal computer and software can monitor and control transfer switches with microprocessor electrical controls and communication accessories. The following table lists the available manuals and part numbers for remote monitoring and control communication software and controller communication kits.

Literature Item	Part Number
ATS Specification Sheet	G11-108
ATS Parts Catalog	TP-6433
Monitor III Specification Sheet	G6-76
Monitor III Software Operation Manual	TP-6347
Monitor III Converters, Connections, and Controller Setup	TT-1405
Modbus® Communications Protocol Operation Manual	TP-6113

Service Assistance

For professional advice on generator power requirements and conscientious service, please contact your nearest Kohler distributor or dealer.

- Consult the Yellow Pages under the heading Generators—Electric.
- Visit the Kohler Power Systems website at KohlerPower.com.
- Look at the labels and stickers on your Kohler product or review the appropriate literature or documents included with the product.
- Call toll free in the US and Canada 1-800-544-2444.
- Outside the US and Canada, call the nearest regional office.

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East China Regional Office, Shanghai
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India, Bangladesh, Sri Lanka

India Regional Office
Bangalore, India
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(91) 80 3366231
Fax: (91) 80 3315972

Japan, Korea

North Asia Regional Office
Tokyo, Japan
Phone: (813) 3440-4515
Fax: (813) 3440-2727

Latin America

Latin America Regional Office
Lakeland, Florida, USA
Phone: (863) 619-7568
Fax: (863) 701-7131

Section 1 Product Description

1.1 Purpose

An automatic transfer switch (ATS) transfers electrical loads from a normal (preferred) source of electrical power to an emergency (standby) source when the normal source falls outside the acceptable electrical parameters.

When the normal (preferred) source fails, the ATS signals the emergency (standby) source generator set to start. When the emergency (standby) source reaches acceptable levels and stabilizes, the ATS transfers the load from the normal (preferred) source to the emergency (standby) source. The ATS continuously monitors the normal (preferred) source and transfers the load back when the normal (preferred) source returns and stabilizes. After transferring the load back to the normal (preferred) source, the ATS removes the generator start signal, allowing the generator set to shut down.

Figure 1-2 shows a typical installation block diagram.

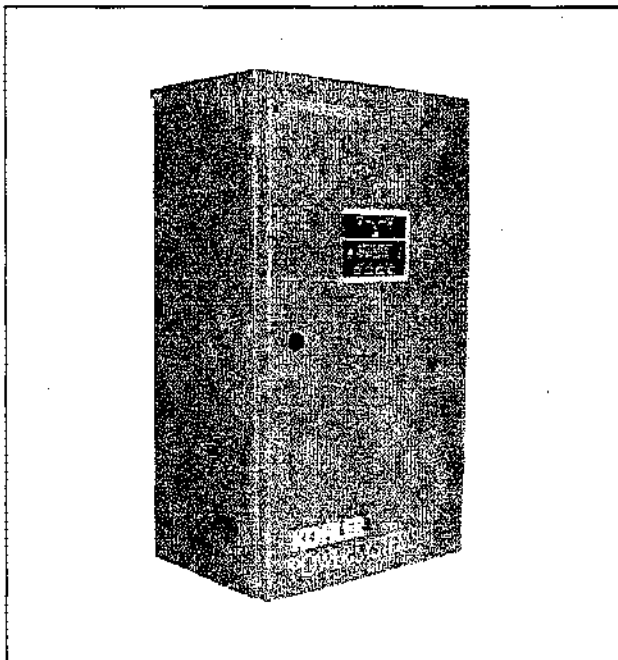


Figure 1-1 Automatic Transfer Switch

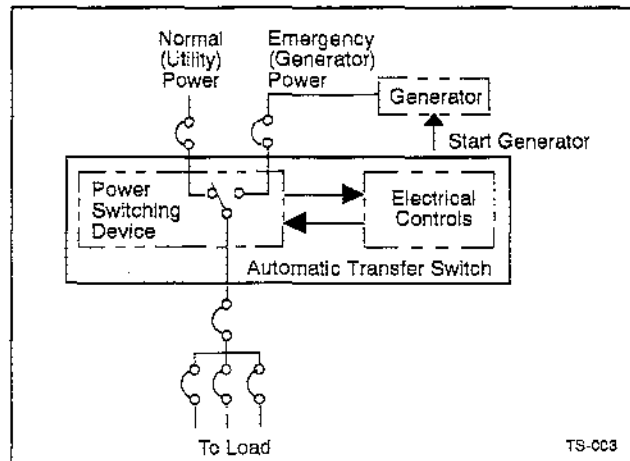


Figure 1-2 Typical ATS Block Diagram

1.2 Nameplate

A nameplate attached to the controller cover on the inside of the enclosure door includes a model designation, a serial number, ratings, and other information about the transfer switch. See Figure 1-3. The serial number is also shown on a label inside the transfer switch enclosure.

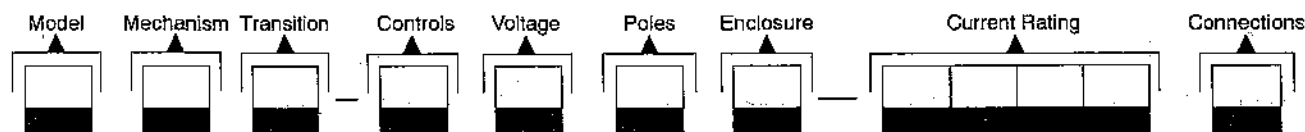
Copy the model designation, serial number, and accessory information from the nameplate to the spaces provided in the Product Identification Information section inside the front cover of this manual for use when requesting service or parts.

KOHLER KOHLER CO., KOHLER, WI. USA 1-800-544-2644		TRANSFER SWITCH FOR EMERGENCY SYSTEMS NEMA ENCLOSURE MFG. DATE	
MATERIAL		ACCESSORIES:	
MODEL			
SERIAL NO.			
AMPS	VOLTS		
WIRES	PHASE		
POLES	HERTZ		
BAR CODE			
		TRANSFER SWITCH FOR EMERGENCY SYSTEMS	

GM21291

Figure 1-3 Typical Transfer Switch Nameplate

1.3 Model Designation



Record the transfer switch model designation in the boxes. The transfer switch model designation defines characteristics and ratings as explained below.

Sample Model Designation: KSP-DCTA-0100S

Model

K: Kohler Transfer Switch

Mechanism

S: Specific-Breaker Rated

Transition

S: Specific-Breaker Rated

P: Programmed-Transition

Controls

D: MPAC™ 1500

Microprocessor Controls, Automatic

F: MPAC™ 1500

Microprocessor Controls, Non-Automatic

Voltage/Frequency

C: 208 Volts/60 Hz

D: 220 Volts/50 Hz

F: 240 Volts/60 Hz

G: 380 Volts/50 Hz

H: 400 Volts/50 Hz

J: 416 Volts/50 Hz

K: 440 Volts/60 Hz

M: 480 Volts/60 Hz

P: 380 Volts/60 Hz

R: 220 Volts/60 Hz

Enclosure

A: NEMA 1†

B: NEMA 12

C: NEMA 3R

D: NEMA 4

F: NEMA 4X

G: Open unit

† NEMA 1 enclosure standard. Other types available to order.

Current Rating: Numbers indicate the current rating of the switch in amperes:

0040 ‡	0200	0600
0080 ‡	0225 ‡	0800 ‡
0100	0260 ‡	1000 ‡
0150 ‡	0400	

‡ Standard-transition models only.

Power Connections

S: Standard

Number of Poles/Wires

N: 2-pole, 3-wire, solid neutral

T: 3-pole, 4-wire, solid neutral

V: 4-pole, 4-wire, switched neutral

2.1 Introduction

Kohler® transfer switches are shipped factory-wired, factory-tested, and ready for installation. Have the equipment installed only by trained and qualified personnel. Verify that the installation complies with applicable codes and standards. Installation includes the following steps:

- Unpack and inspect the transfer switch upon receipt.
- Verify that the transfer switch voltage and frequency ratings match the voltages and frequencies of the sources.
- Mount the transfer switch.
- Check the manual operation.
- Wire the normal power source (utility), emergency power source (generator set), and load circuits.
- Connect the generator set engine start leads.
- Connect accessories, if provided.
- Connect and initialize the electrical controls, as required.
- Check voltages and operation.

Protect the switch against damage before and during installation.

Note: A protective device such as a molded-case circuit breaker or fused disconnect switch **MUST** be installed on both sources of incoming power for circuit protection and use as a disconnect device.

The functional tests in Section 3 are a necessary part of the installation. Be sure to perform the functional tests, which include voltage checks and operation tests, before putting the transfer switch into service.

2.2 Receipt of Unit

2.2.1 Inspection

At the time of delivery, inspect the packaging and the transfer switch for signs of shipping damage. Unpack the transfer switch as soon as possible and inspect the exterior and interior for shipping damage. If damage and/or rough handling is evident, immediately file a damage claim with the transportation company.

2.2.2 Storage

Store the transfer switch in its protective packing until final installation. Protect the transfer switch at all times from moisture, construction grit, and metal chips. Avoid storage in low-temperature and high-humidity areas where moisture could condense on the unit. See Figure 2-1 for acceptable storage temperatures.

Item	Specification
Storage temperature	-40°C to 70°C (-40°F to 158°F)
Operating temperature	-20°C to 85°C (-4°F to 185°F)
Humidity	5% to 95% noncondensing

Figure 2-1 Environmental Specifications

2.2.3 Lifting

⚠ WARNING



**Unbalanced weight.
Improper lifting can cause severe
injury or death and equipment
damage.**

Use adequate lifting capacity.
Never leave the transfer switch
standing upright unless it is securely
bolted in place or stabilized.

See Figure 2-2 or Figure 2-3 or the dimensional drawing for the weight of the transfer switch. Use a spreader bar to lift the transfer switch. Attach the bar only to the enclosure's mounting holes or lifting brackets; do not lift the unit any other way. Close and latch the enclosure door before moving the unit.

Amps	Weight kg (lb.)		
	2-Pole	3-Pole	4-Pole
40-225	28 (62)	30 (65)	31 (68)
260-400	52 (115)	56 (123)	59 (131)
600	179 (395)	183 (403)	186 (410)
800	N/A	226 (498)	236 (520)
1000	N/A	231 (509)	241 (531)

Figure 2-2 Transfer Switch Weights, Standard-Transition Models, NEMA Type 1 and 3R Enclosures

Amps	Weight kg (lb.)		
	2-Pole	3-Pole	4-Pole
100-200	52 (115)	56 (123)	59 (131)
400	52 (115)	56 (123)	59 (131)
600	179 (395)	183 (403)	186 (410)

Figure 2-3 Transfer Switch Weights, Programmed-Transition Models, NEMA Type 1 and 3R Enclosures

2.2.4 Unpacking

Allow the equipment to warm to room temperature for at least 24 hours before unpacking to prevent condensation on the electrical apparatus. Use care when unpacking to avoid damaging transfer switch components. Remove dirt and packing material that may have accumulated in the transfer switch or any of its components.

Note: Do not use compressed air to clean the switch. Cleaning with compressed air can cause debris to lodge in the components and damage the switch.

2.3 Installation

NOTICE

Foreign material contamination. Cover the transfer switch during installation to keep dirt, grit, metal drill chips, and other debris out of the components. Cover the solenoid mechanism during installation. After installation, use the manual operating handle to cycle the contactor to verify that it operates freely. Do not use a screwdriver to force the contactor mechanism.

NOTICE

Hardware damage. The transfer switch may use both American Standard and metric hardware. Use the correct size tools to prevent rounding of the bolt heads and nuts.

Check the system voltage and frequency. Compare the voltage and frequency shown on the transfer switch nameplate to the source voltage and frequency. Do not install the transfer switch if the system voltage and frequency are different from the nominal normal (utility) source voltage and frequency or the nominal emergency source voltage and frequency shown on the generator set nameplate.

Plan the installation. Use the dimensions given on the enclosure dimension (ADV) drawings. Select a mounting site that complies with local electrical code restrictions for the enclosure type. Mount the transfer switch as close to the load and power sources as possible. Allow adequate space to fully open the enclosure and to service the switch. Provide cable bending space and clearance to live metal parts.

Prepare the foundation. Ensure that the supporting foundation for the enclosure is level and straight. For bottom cable entry, if used, install conduit stubs in the foundation. Refer to the enclosure dimension drawing for the conduit stub locations. When pouring a concrete floor, use interlocking conduit spacer caps or a wood or metal template to maintain proper conduit alignment.

Install the ATS. For easy access during installation and wiring, remove the front door of the enclosure. Open the door and disconnect the cable plug that connects the front door components to the internal components. Disconnect the grounding wire between the door and the enclosure. For NEMA type 1 and 3R enclosures, squeeze the release pins on each hinge together and remove the door. See Figure 2-4. Set the door out of the way to protect the controls. Cover the internal components of the transfer switch mechanism to keep debris out of the components.

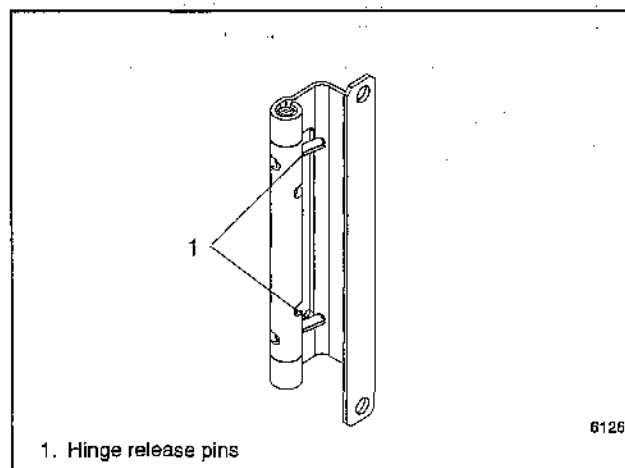


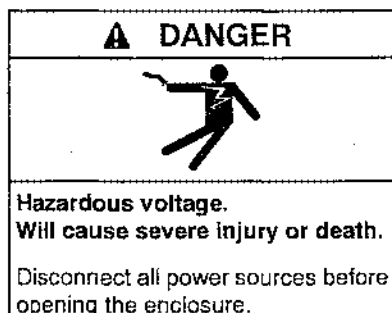
Figure 2-4 Hinge Release Pins

Vertically mount 40- through 400-amp transfer switches to a wall or other rigid vertical supporting structure. Use the template on the shipping carton to locate the mounting holes in the wall. Level the template before

marking and drilling the holes. Clearance holes through the back of each enclosure are provided for mounting. Use shims to plumb the enclosure. Verify that the door hinges are vertical to avoid distortion of the enclosure or door. Vacuum any debris out of the enclosure.

Bolt 600-amp automatic transfer switches directly to floor mounting pads. Shim the enclosure so that the enclosure is plumb.

2.4 Manual Operation Check



NOTICE

Improper operator handle usage. Use the manual operator handle on the transfer switch for maintenance purposes only. Return the transfer switch to the normal position. Remove the manual operator handle, if used, and store it in the place provided on the transfer switch when service is completed.

A manual operation handle is provided with the transfer switch *for maintenance purposes only*. Use the manual operation handle to check the manual operation before energizing the transfer switch. Use the following manual operation procedures to verify that the contactor operates smoothly without binding.

Note: A contactor in normal and serviceable condition operates smoothly without binding. Do not place the transfer switch into service if the contactor does not operate smoothly; contact an authorized distributor/dealer to service the contactor.

2.4.1 Manual Operation Procedure, Standard-Transition Switches

Note: Never use the maintenance handle to transfer the load with the power connected. Disconnect both power sources before manually operating the switch.

1. Remove the maintenance handle from its storage location inside the enclosure. See Figure 2-5 through Figure 2-7.
2. Attach the maintenance handle:
 - a. 40–600 Amp switches: Insert the maintenance handle into the hole in the shaft on the left side of the operator as shown in Figure 2-5 or Figure 2-6.
 - b. 800–1000 Amp switches: Slide the maintenance handle over the square shaft on the left side of the operator as shown in Figure 2-7.
3. Move the maintenance handle up or down as shown in the corresponding figure to manually operate the transfer switch. It should operate smoothly without any binding. If it does not, check for shipping damage or construction debris.
4. Return the transfer switch to the Normal position.
5. Remove the maintenance handle and return it to the storage location.

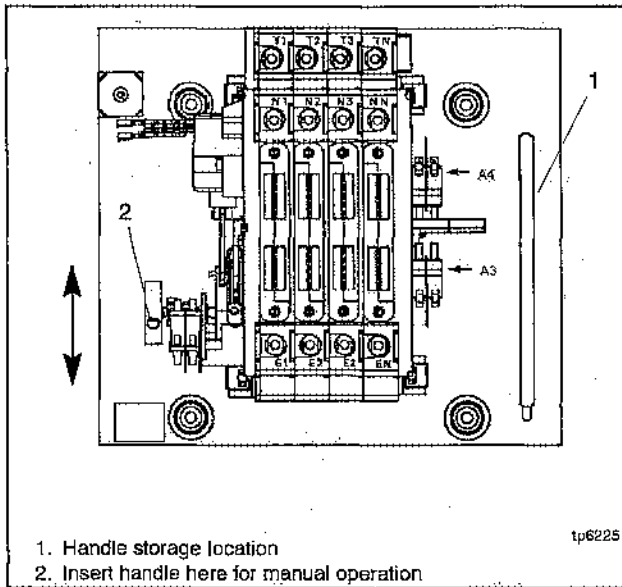


Figure 2-5 Manual Operation, 40-260 Amp Standard-Transition Switches

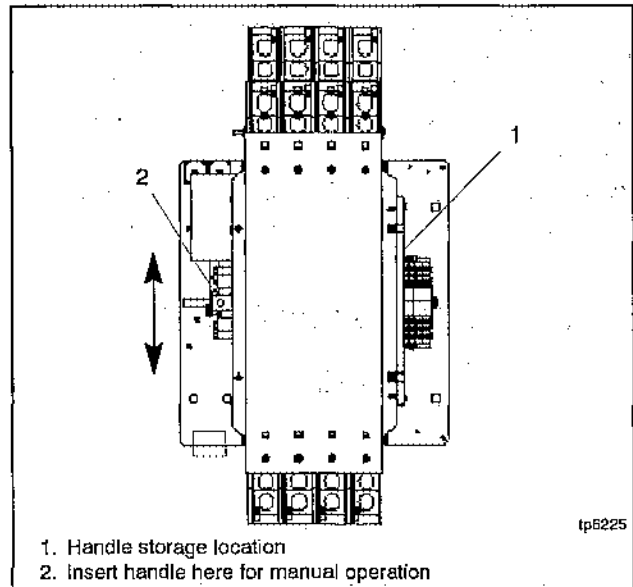


Figure 2-6 Manual Operation, 400-600 Amp Standard-Transition Switches

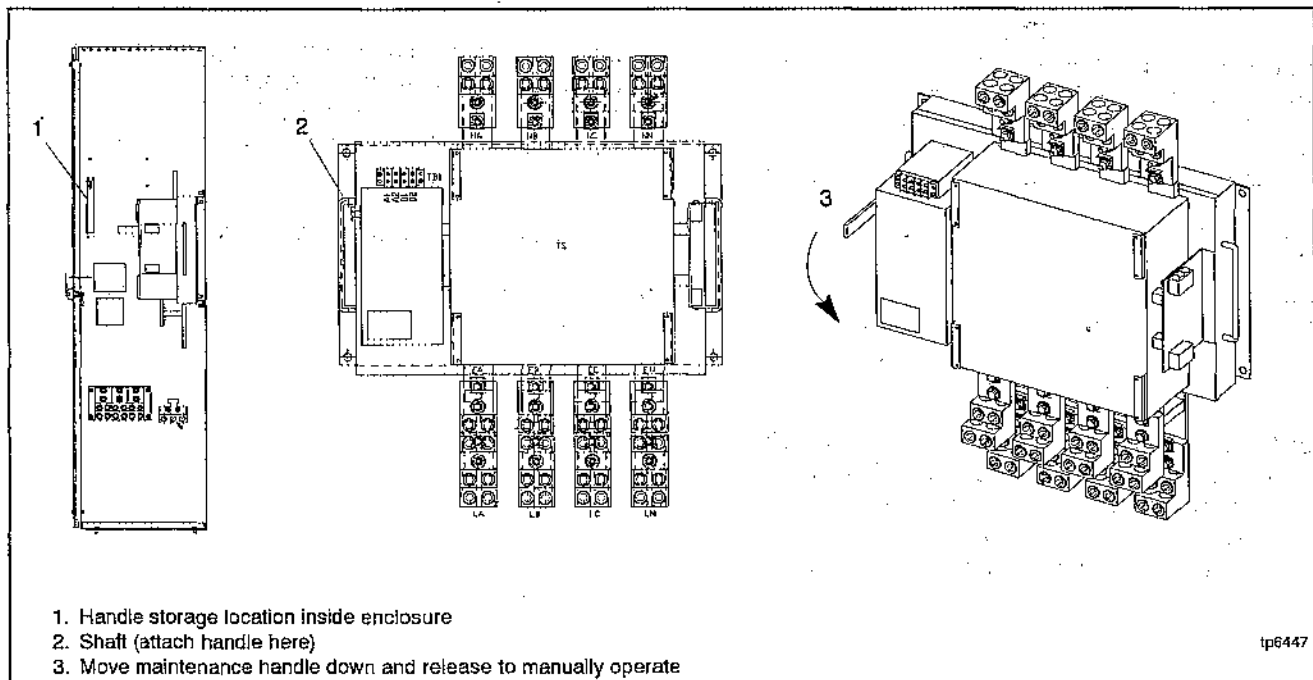


Figure 2-7 Manual Operation, 800-1000 Amp Standard-Transition Switches

2.4.2 Manual Operation Procedure, Programmed-Transition Switches

Note: Never use the manual operation handle to transfer the load with the power connected. Disconnect both power sources before manually operating the switch.

1. Check the contactor position, indicated by the A and B position indicators. See Figure 2-8. One position indicator will display ON to indicate the source position. If both indicators display OFF, the transfer switch is in the OFF position.

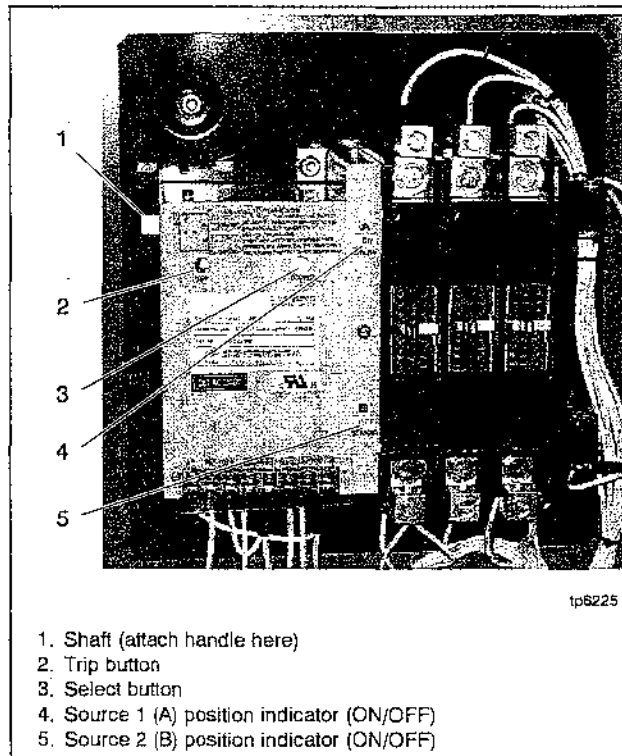


Figure 2-8 Manual Operation, Programmed-Transition Switches (handle not shown)

2. If the transfer switch is not in the OFF position, use a screwdriver or other tool to push the TRIP button.

See Figure 2-8. Check that both position indicators display OFF.

3. Slide the manual operating handle (provided with the switch) over the shaft on the left side of the switch. See Figure 2-8.
4. Move the switch to the A (Source 1) or B (Source 2) position as follows:
 - a. To move the switch to position A (Source 1), move the manual operation handle up and then release the handle. Verify that the A position indicator displays ON.
 - b. To move the switch to position B (Source 2), use a screwdriver or other tool to push the SELECT button. Hold the SELECT button in and move the manual operation handle up and then release the handle. Verify that the B position indicator displays ON.

Note: Always move the manual operation handle UP and then release it.

5. Remove the manual operation handle and store it in a convenient location.

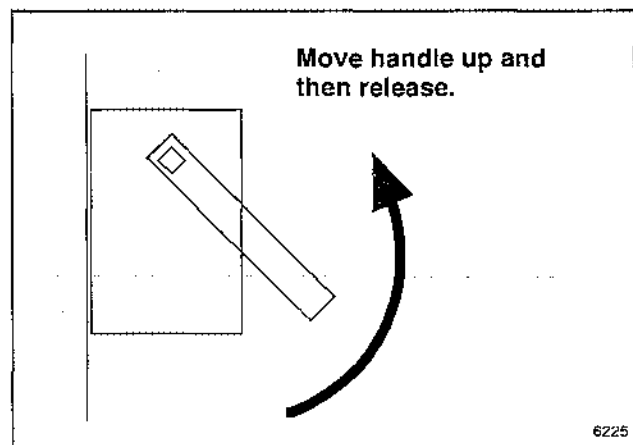
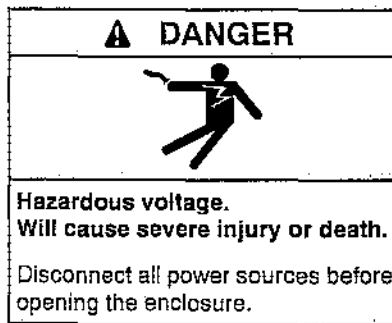


Figure 2-9 Manual Operating Handle, Programmed-Transition Switches

2.5 Controller



NOTICE

Electrostatic discharge damage. Electrostatic discharge (ESD) damages electronic circuit boards. Prevent electrostatic discharge damage by wearing an approved grounding wrist strap when handling electronic circuit boards or integrated circuits. An approved grounding wrist strap provides a high resistance (about 1 megohm), *not a direct short*, to ground.

The controller's logic board is mounted in a plastic housing on the inside of the transfer switch enclosure door.

Opening the cover. To gain access to the DIP switches and terminal strips on the main logic board, open the plastic housing by pushing up on the latch on the bottom of the cover and swinging the cover up and out. The cover is hinged at the top. Lift the cover off the hinges to remove it completely, if necessary.

Note: Always replace the cover before energizing the transfer switch controls.

Figure 2-10 shows the locations of the components on the logic board.

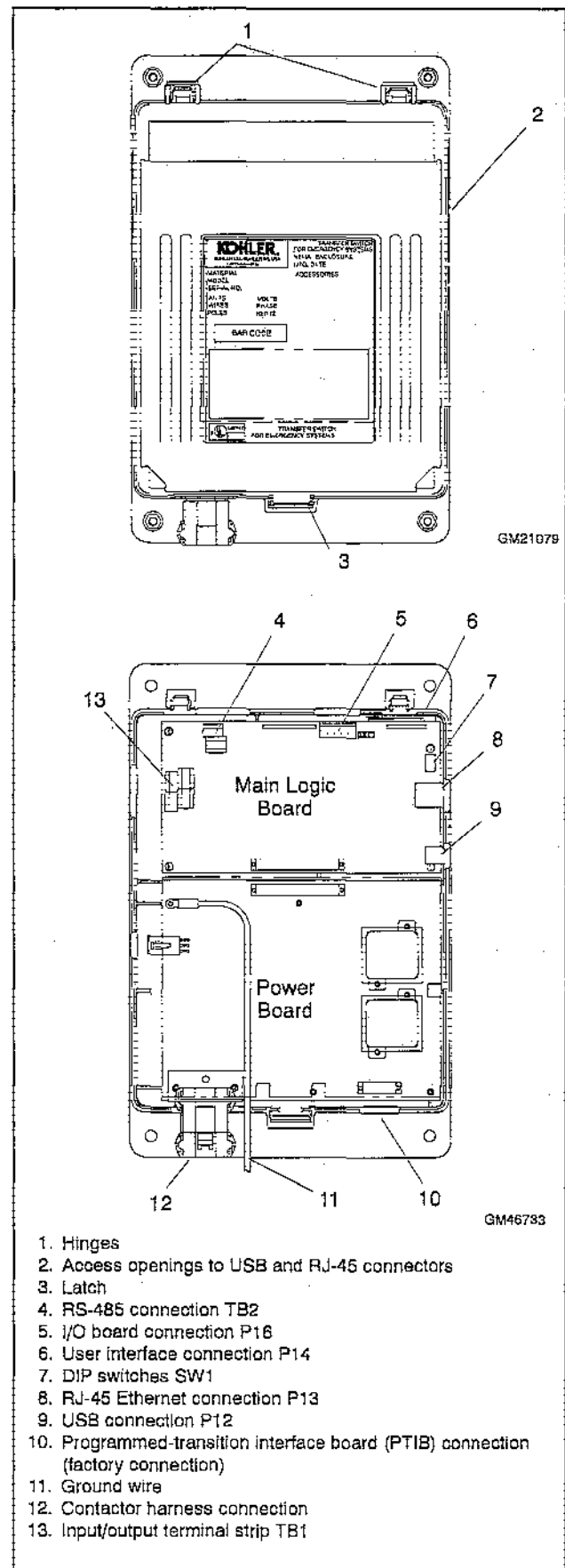


Figure 2-10 Controller Housing

2.5.1 Logic Board Input and Output Connections

Logic board terminal strip TB1 has two programmable inputs and two programmable outputs. See Figure 2-10 for the connector location.

Each input has a signal and a return connection. The outputs are C form contacts with ratings of 500 mA @ 120 VAC. See Figure 2-11 for the connections. Use #12-24 AWG wire and tighten the connections to 0.5 Nm (4.4 in. lb.).

See Section 10.4 for instructions to connect to optional input/output modules.

The controller logic board's programmable inputs and outputs can be assigned to the functions shown in Figure 2-12 and Figure 2-13. The I/O functions are shown here for planning and connections. You will need to assign functions to the programmable inputs and outputs through the controller interface using the Setup Menu—Set Inputs/Outputs later. See Section 6.12.

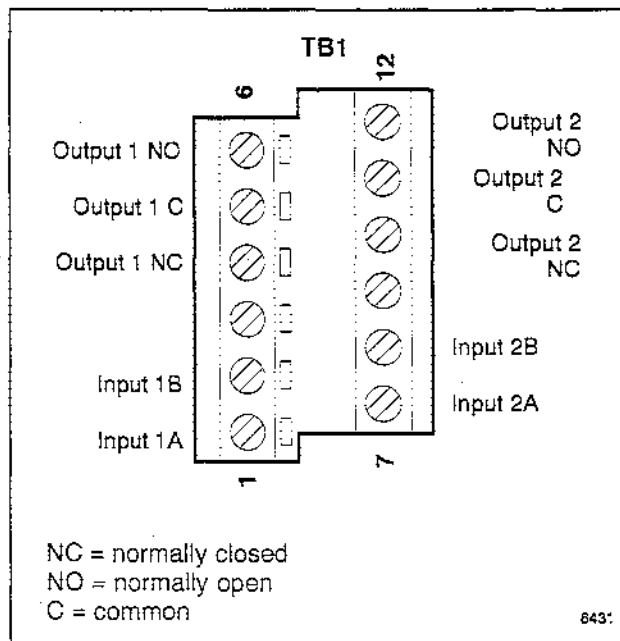


Figure 2-11 Logic Board Input and Output Connections to TB1

Programmable Output	Type
Audible Alarm	Control
IPM Synching	Control
Load Bank Control Active	Control
Load Control Out 0-8	Control
Soft Control RDO #1-4	Control
Source E Start Signal	Control
Source N Start Signal	Control
3 Src Sys Disabled	Control
Aux Switch Fault	Fault
Aux Switch Open	Fault
Common Alarm Active (2)	Fault
Fail to Acquire Preferred	Fault
Fail to Acquire Standby	Fault
Fail to Transfer	Fault
I/O Module Lost Comm.	Fault
New I/O Module Found	Fault
Source E Loss of Phase	Fault
Source E Over Frequency	Fault
Source E Over Voltage	Fault
Source E (Phase) Rotation Error	Fault
Source E Under Frequency	Fault
Source E Under Voltage	Fault
Source E Voltage Unbalance	Fault
Source N Loss of Phase	Fault
Source N Over Frequency	Fault
Source N Over Voltage	Fault
Source N (Phase) Rotation Error	Fault
Source N Under Frequency	Fault
Source N Under Voltage	Fault
Source N Voltage Unbalance	Fault
Battery Low (external battery)	Monitor
Contactors in OFF position	Monitor
Contactors in Preferred Position	Monitor
Contactors in Source E Position	Monitor
Contactors in Source N Position	Monitor
Contactors in Standby Position	Monitor
Exerciser Active	Monitor
Load Control Active	Monitor
Maintenance Mode	Monitor
Non-Emergency Transfer	Monitor
Not in Auto	Monitor
Peak Shave Active	Monitor
Preferred Source Available	Monitor
Standby Source Available	Monitor
Test Mode Active	Monitor

Figure 2-12 Available Programmable Outputs

Programmable Inputs
Bypass Contactor Disable
Forced Transfer to OFF (programmed-transition models only; requires load shed accessory)
Inhibit Transfer
Low Battery Voltage (external battery)
Peak Shave Mode
Remote End Time Delay
Remote Common Fault
Remote Test
Remote Monitor In #1-4
Three-Source System Disable

Figure 2-13 Programmable Inputs

2.5.2 Communications Connections

See Section 7 for instructions to connect to the controller's RS-485 serial port or Ethernet port for Modbus communication. See Section 7.4 for instructions to use the USB port for file transfer.

2.5.3 Controller Ground

Verify that the grounding wire is connected from the controller's lower left mounting stud to the enclosure. This connection provides proper grounding that does not rely upon the door hinges.

2.5.4 Controller Connection

Verify that the contactor harness is connected at the controller base (or at the logic disconnect switch, if equipped). See Figure 2-14.

Note: Verify that the power is disconnected before connecting or disconnecting the contactor harness.

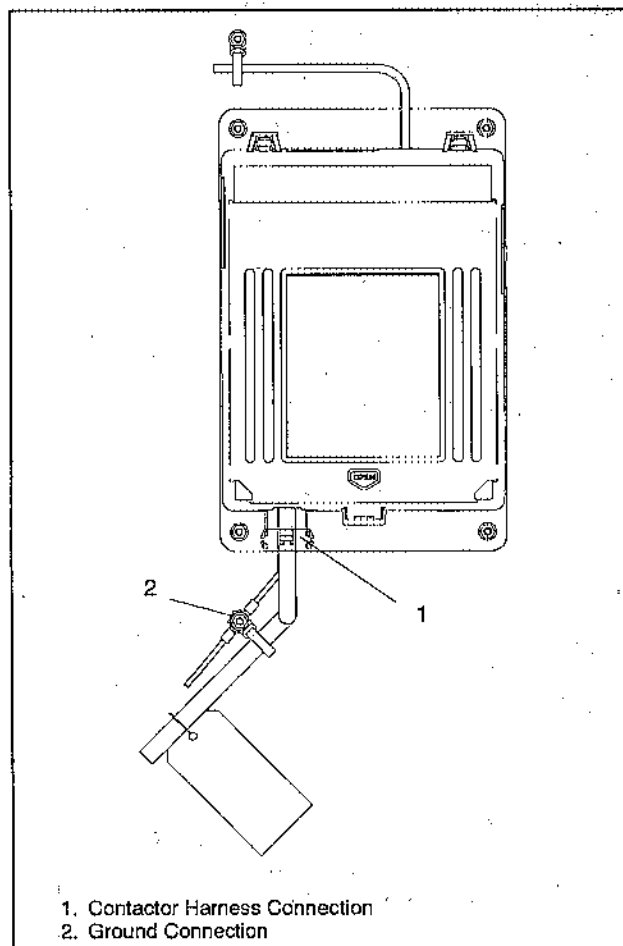


Figure 2-14 Contactor Harness and Controller Ground Connections

2.6 Electrical Wiring

The transfer switch is factory-wired and tested. Field installation includes connecting the sources, loads, generator start circuit(s), and auxiliary circuits, if used.

Note: An approved protective device such as a molded-case circuit breaker or fused disconnect switch **MUST** be installed on both sources of incoming power for circuit protection and use as a disconnect device.

Refer to the wiring diagrams provided with the transfer switch. Observe all applicable national, state, and local electrical codes during installation.

Install DC, control, and communication system wiring in separate conduit from AC power wiring.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ DANGER
Hazardous voltage. Will cause severe injury or death.
Disconnect all power sources before opening the enclosure.

Making line or auxiliary connections. Hazardous voltage can cause severe injury or death. To prevent electrical shock deenergize the normal power source before making any line or auxiliary connections:

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocutation is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

NOTICE

Foreign material contamination. Cover the transfer switch during installation to keep dirt, grit, metal drill chips, and other debris out of the components. Cover the solenoid mechanism during installation. After installation, use the manual operating handle to cycle the contactor to verify that it operates freely. Do not use a screwdriver to force the contactor mechanism.

2.6.1 Source and Load Connections

Determine the cable size. Refer to Figure 2-15 to determine the size and number of conductors that can be used. Make sure the lugs provided are suitable for use with the cables being installed. Watertight conduit hubs may be required for outdoor use.

UL-Listed Solderless Screw-Type Terminals for External Power Connections			
Normal, Emergency, and Load Terminals			
Model	Switch Rating, amps	Cables per Pole	Range of Wire Sizes, Copper or Aluminum*
KSS	40-150	1	#8 to 3/0 AWG
	200-225	1	#6 AWG to 250 MCM
	260	1	#6 AWG to 350 MCM
	400	1	#4 AWG to 600 MCM
		2	#1/0 AWG to 250 MCM
	600	2	#2 AWG to 600 MCM
	800	2	#1/0 AWG to 750 MCM
KSP	1000	4	#2 AWG to 600 MCM
	100	1	#14 to 1/0 AWG
	200	1	#6 AWG to 250 MCM
	400	2	1/0 AWG to 250 MCM
		1	#4 AWG to 600 MCM
	600	2	#2 AWG to 600 MCM
* Use 60°C minimum wire for #14 to #1 AWG. Use 75°C minimum wire for 1/0 AWG and larger.			

Figure 2-15 Cable Sizes

Drill the entry holes. Cover the internal components of the ATS to protect them from metal chips and construction grit. Then drill entry holes for the conductors at the locations shown on the enclosure drawings. Remove debris from the enclosure with a vacuum cleaner.

Note: Do not use compressed air to clean the switch. Cleaning with compressed air can cause debris to lodge in the components and damage the switch.

Install and test the power conductors. Leave sufficient slack in the conductors to reach all of the power connecting lugs on the power switching device. Test the power conductors after pulling them into position and before they are connected to verify that they are not defective and that they were not damaged during installation.

Connect the cables. Be careful when stripping insulation from the cables; avoid nicking or ringing the conductor. Clean cables with a wire brush to remove surface oxides before connecting them to the terminals. Apply joint compound to the connections of any aluminum conductors.

Refer to the wiring diagram provided with the switch. The connection points on the contactor are labeled Normal, Emergency, and Load. Be sure to follow the phase markings (A, B, C, and N). For single-phase systems, connect to A and C.

Note: Connect the source and load phases as indicated by the markings and drawings to prevent short circuits and to prevent phase-sensitive load devices from malfunctioning or operating in reverse.

Verify that all connections are consistent with drawings before tightening the lugs. Tighten all lug connections to the torque values shown in Figure 2-16. Carefully wipe off any excess joint compound after tightening the terminal lugs.

Socket Size Across Flats, in.	Bolt Torque	
	Nm	Ft. lb.
1/8	5	4
5/32	11	8
3/16	14	10
7/32	16	12
1/4	23	17
5/16	31	23
3/8	42	31
1/2	57	42
9/16	68	50

Figure 2-16 Tightening Torque for Lugs

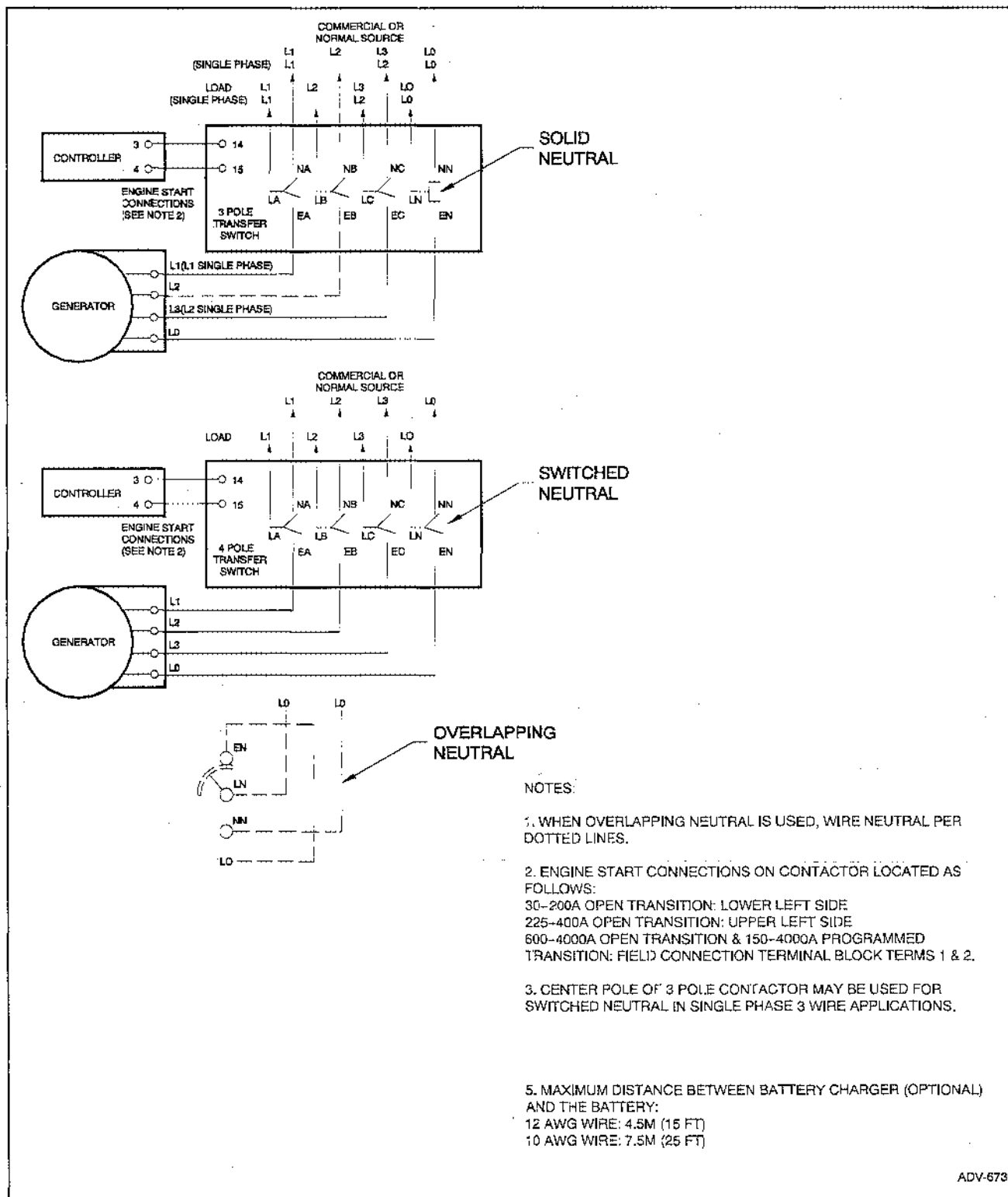


Figure 2-17 Interconnection Diagram

2.6.2 Engine Start Connection

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

Prevent the generator set from starting by moving the generator set master switch to the OFF position; disconnecting power to the generator engine start

battery charger, if installed; and disconnecting all generator engine start battery cables, negative (-) leads first.

Connect the generator set remote starting circuit to the engine start terminals located on the transfer switch contactor assembly. See Figure 2-19 through Figure 2-24 for the locations of the engine start terminals, which are labeled on the unit with a red decal. Refer to the generator set installation manual for wire size specifications.

The engine start contact ratings are shown in Figure 2-18.

2.6.3 Auxiliary Contacts

Connect the auxiliary contacts to customer-supplied alarms, remote indicators, or other devices. Auxiliary contacts provide contacts that close when the transfer switch is in the Normal position and contacts that close when the transfer switch is in the Emergency position.

Refer to the schematic diagram provided with the transfer switch to identify which auxiliary contacts are closed on Normal and which are closed on Emergency.

Figure 2-19 through Figure 2-24 show the locations of the auxiliary contacts for different models. The auxiliary contact ratings are shown in Figure 2-18.

Contacts	Resistive Load	Inductive Load	Motor Load	
			NC	NO
Engine Start Contacts	2 A @ 30 VDC	N/A	N/A	N/A
Auxiliary Contacts, KSS (40-600A)	15 A @ 250 VAC	N/A	N/A	N/A
Auxiliary Contacts, KSS (800-1000A)	15 A @ 480 VAC	15 A @ 250 VAC; 6 A @ 500 VAC	5 A @ 125 VAC; 3 A @ 250 VAC; 1.5 A @ 500 VAC	2.5 A @ 125 VAC; 1.5 A @ 250 VAC; 0.75 A @ 500 VAC
Auxiliary Contacts, KSP	15 A @ 480 VAC	15 A @ 250 VAC; 6 A @ 500 VAC	5 A @ 125 VAC; 3 A @ 250 VAC; 1.5 A @ 500 VAC	2.5 A @ 125 VAC; 1.5 A @ 250 VAC; 0.75 A @ 500 VAC

Figure 2-18 Contact Ratings

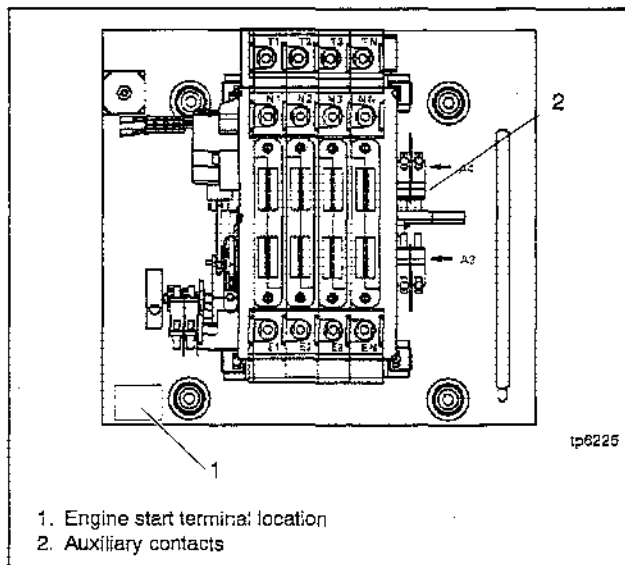


Figure 2-19 Engine Start and Auxiliary Contact Locations, 40-225 Amp Standard-Transition Switches

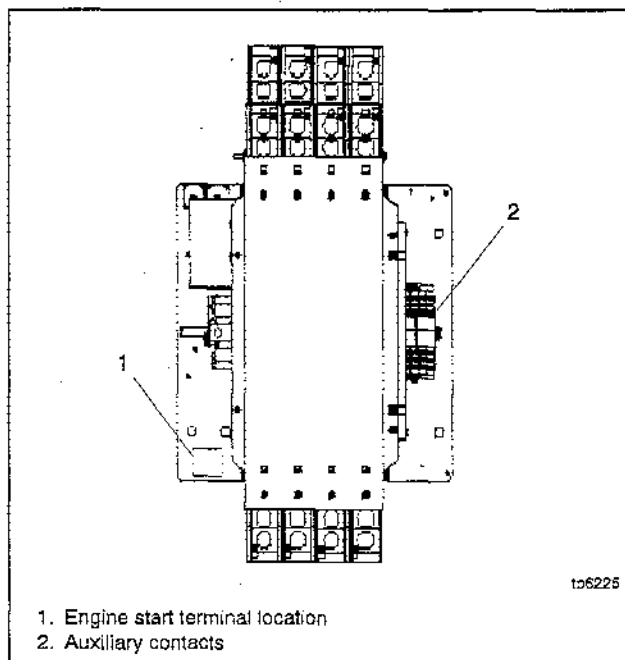


Figure 2-20 Engine Start and Auxiliary Contact Locations, 400-600 Amp Standard-Transition Switches

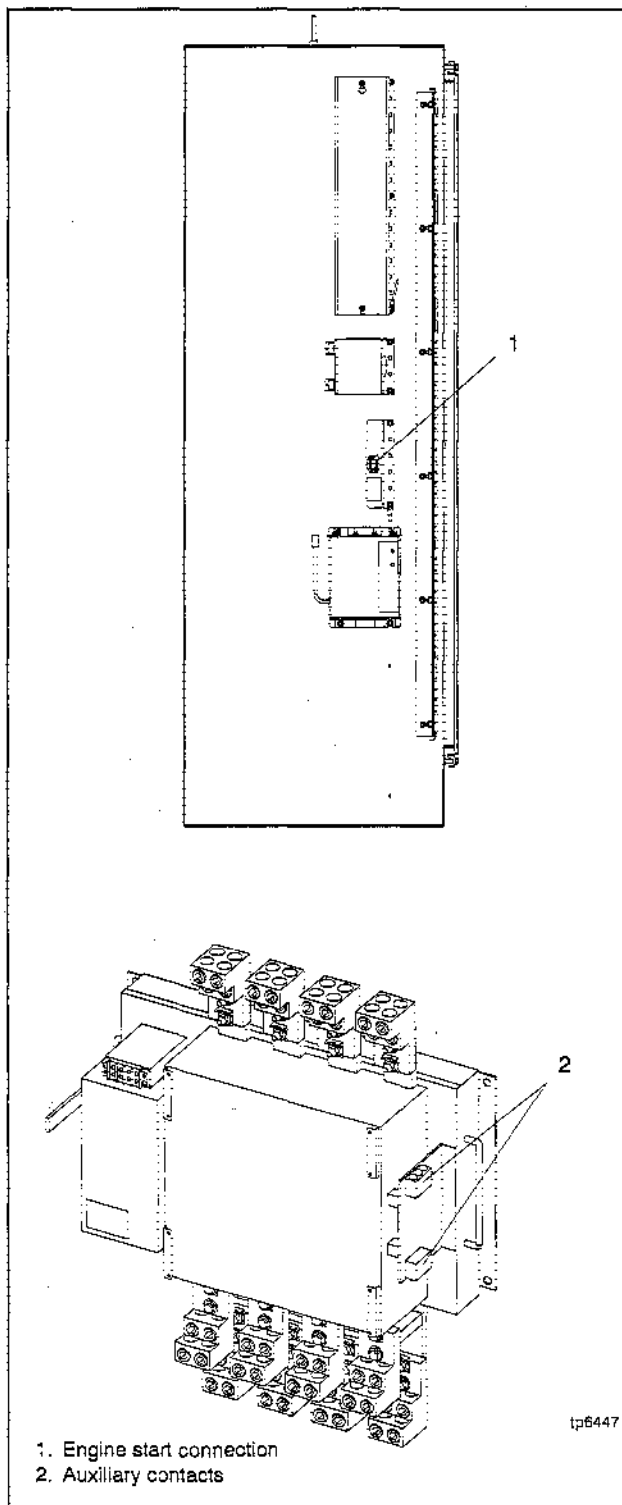


Figure 2-21 Engine Start and Auxiliary Contact Locations, 800-1000 Amp Standard-Transition Switches

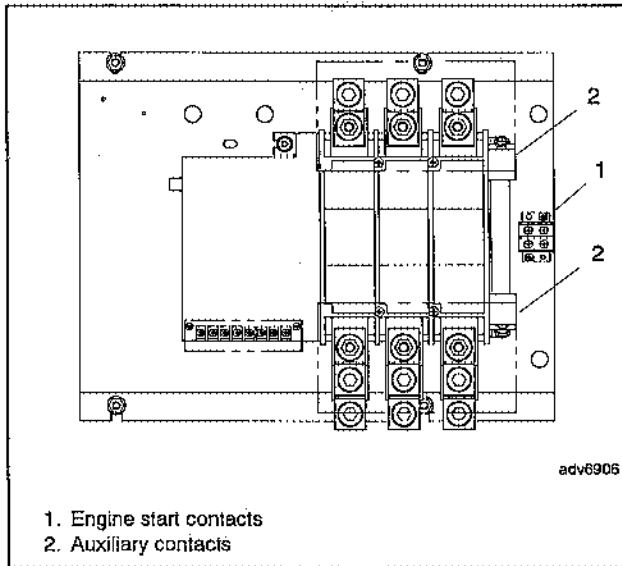


Figure 2-22 Engine Start and Auxiliary Contact Locations, 100-200 Amp Programmed-Transition Switches

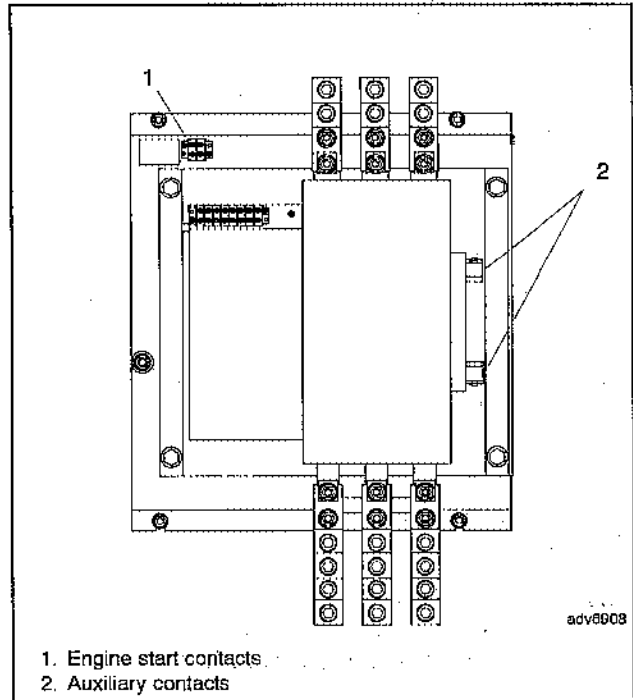


Figure 2-24 Engine Start and Auxiliary Contact Locations, 600 Amp Programmed-Transition Switches

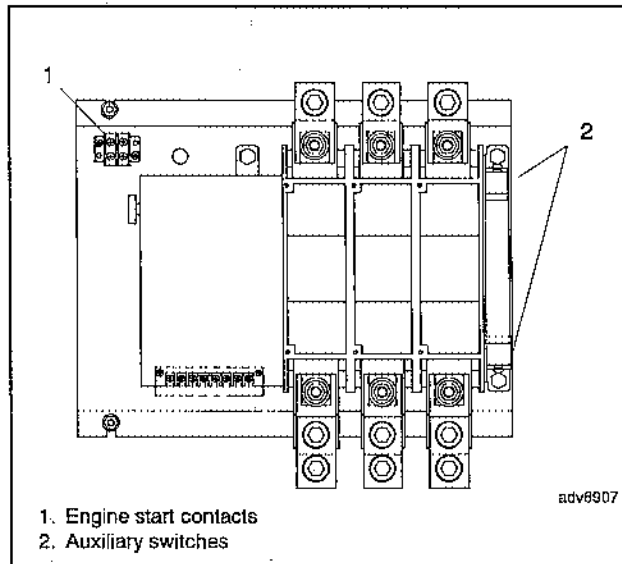


Figure 2-23 Engine Start and Auxiliary Contact Locations, 400 Amp Programmed-Transition Switches

2.7 Programmed-Transition Interface Board (PTIB)

Programmed-transition model transfer switches use a programmed-transition contactor and a programmed-transition interface board (PTIB). The PTIB is mounted on the inside of the enclosure door.

The PTIB is factory-wired and requires no additional wiring in the field. Verify that the PTIB wiring harness is connected to the main logic board. See Figure 2-25 for the PTIB connector location.

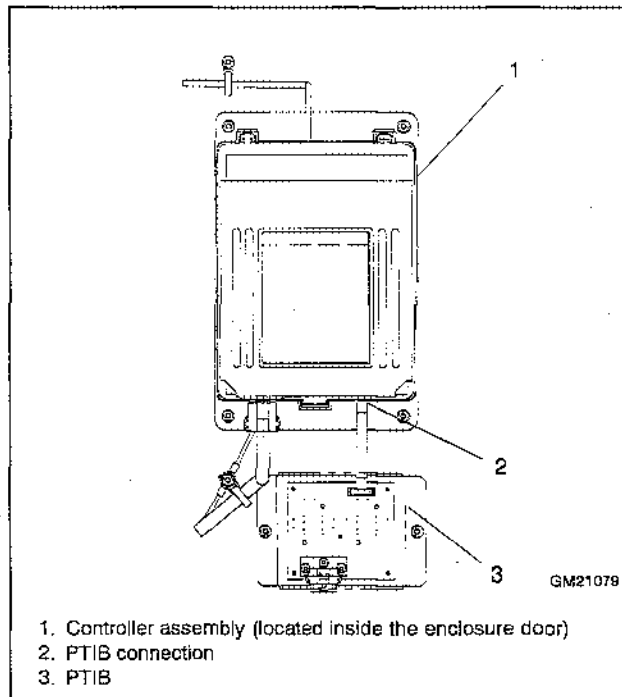


Figure 2-25 Programmed-Transition Interface Board (PTIB)

2.8 Final Equipment Inspection

Perform the following inspections before energizing the transfer switch:

1. Use a vacuum to remove any debris from the transfer switch.
2. Check the engine start connections.

3. Check the lug torque values at the power connections. Torque values are listed in Figure 2-16.

4. Check that all covers and barriers are installed and properly fastened.

2.9 Functional Tests

Perform the functional tests described in Section 3 before putting the transfer switch into operation.

2.10 System Setup

Set the controller's current time and date. See Section 6.6 for instructions.

The transfer switch is factory-set with default settings for time delays and other parameters. To view the settings, review the information about the controller's user interface in Section 4, and then refer to Section 5.6 for instructions to view settings.

If it is necessary to change settings, see Section 6 for instructions.

Note: Use caution when changing transfer switch settings. The source voltage and frequency settings must match the values shown on the transfer switch nameplate.

2.11 Exerciser Setup

Set the exerciser to start and run the generator set at least once a week. See Section 6.14 for instructions.

2.12 Warranty Registration

Complete a Startup Notification Form and submit it to the manufacturer within 60 days of the initial startup date. The Startup Notification Form covers all equipment in the power system. Power systems not registered within 60 days of startup are automatically registered using the manufacturer's ship date as the startup date.

Notes

Section 3 Functional Tests

3.1 Introduction

Be sure to perform all of the functional tests described in this section before putting the transfer switch into operation.

The functional tests include the following checks:

- Manual Operation Test
- Voltage Checks
- Lamp Test
- Automatic Operation Test

Note: Perform these checks in the order presented to avoid damaging the ATS.

Read all instructions on the labels affixed to the automatic transfer switch before proceeding.

3.2 Manual Operation Test

If you have not already done so, test the contactor manual operation before proceeding to the voltage check and electrical operation test.

Note: Disable the generator set and disconnect the power by opening the circuit breakers or switches for both sources before manually operating the transfer switch.

Follow the instructions in the Installation Section to check the transfer switch manual operation.

A contactor in normal and serviceable condition transfers smoothly without binding when operated manually. Do not place the transfer switch into service if the contactor does not operate smoothly without binding; contact an authorized distributor/dealer to service the contactor.

3.3 Voltage Check

The voltage, frequency, and phasing of the transfer switch and the power sources must be the same to avoid damage to loads and the transfer switch. Compare the voltage and frequency ratings of the utility source, transfer switch, and generator set, and verify that the ratings are all the same.

Use the voltage check procedure explained in this section to verify that the voltages and phasing of all power sources are compatible with the transfer switch before connecting the power switching device and controller wire harnesses together.

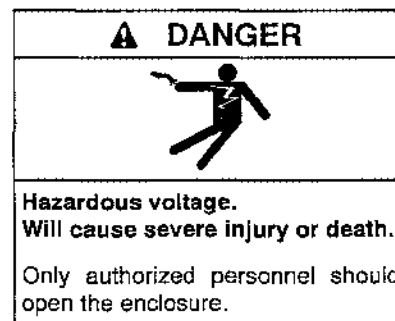
Follow the instructions provided with the generator set to prepare the generator set for operation.

Read and understand all instructions on installation drawings and labels on the switch. Note any optional accessories that have been furnished with the switch and review their operation.

Note: Source N is the source connected to the normal side of the contactor. Source E is the source connected to the emergency side of the contactor. Verify that the source leads are connected to the correct lugs before proceeding.

The voltage check procedure requires the following equipment:

- A digital voltmeter (DVM) with electrically insulated probes capable of measuring the rated voltage and frequency
- A phase rotation meter



Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically.
(600 volts and under)

Voltage Check Procedure

1. If Source N is a generator set, move the generator set master switch to the RUN position. The generator set should start.
2. Close the Source N circuit breaker or switch.

3. Use a voltmeter to check the Source N (normal) phase-to-phase and phase-to-neutral (if applicable) terminal voltages and frequency.
 - a. If Source N is the utility and the measured input does not match the voltage and frequency shown on the transfer switch nameplate, **STOP!** Do not proceed further in installation because the transfer switch is not designed for the application—call your distributor/dealer to order the correct transfer switch.
 - b. If Source N is a generator set and the generator set output voltage and frequency do not match the nominal system voltage and frequency shown on the transfer switch nameplate, follow the manufacturer's instructions to adjust the generator set. The automatic transfer switch will only function with the rated system voltage and frequency specified on the nameplate.

4. Use a phase rotation meter to check the phase rotation at the Source N (normal) terminals. Rewire the transfer switch Source N terminals to obtain the correct phase sequence if necessary.

Note: The default setting for the phase rotation on the controller is ABC. If the application uses a phase rotation of BAC, use the Source Setup screen to change the phase rotation setting on the controller.

5. If the source is a generator set, stop the generator set by moving the master switch to the OFF position.
6. Disconnect Source N by opening upstream circuit breakers or switches.
7. Repeat steps 1 through 5 for Source E. Then proceed to step 8.
8. Disconnect both sources to the transfer switch by opening the circuit breakers or switches.
9. Close and lock the transfer switch enclosure door.
10. Reconnect both power sources by closing the circuit breakers or switches.
11. Move the generator set master switch to the AUTO position.

Note: If the engine cooldown time delay setting is not set to zero (default setting), the generator set may start and run until the Time Delay Engine Cooldown (TDEC) ends.

12. Perform the lamp test and then proceed to the automatic operation test.

3.4 Lamp Test

To test the LEDs on the controller's user interface, go to the Main screen. Press the down arrow button once, then press the Lamp Test button and verify that all 6 LEDs on the user interface illuminate. See Figure 3-1.

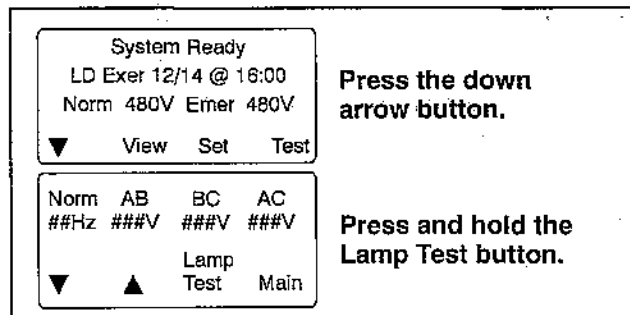


Figure 3-1 Lamp Test

3.5 Automatic Operation Test

Check the transfer switch's automatic control system immediately after the voltage check.

Note: Close and lock the enclosure door before starting the test procedure.

Preferred Source Selection. If the ATS is equipped with the alarm board accessory, check the preferred source selection before proceeding with the automatic operation test. The test procedure assumes that Source N is the preferred source.

Supervised Transfer Switch. If the transfer switch is equipped with a supervised transfer switch, verify that it is set to the Auto position.

Follow the procedure below to start a loaded test. Verify that the ATS starts the generator set and transfers the load to the emergency source, executing all time delays that are set up to operate during a loss of the normal source. End the test and verify that the transfer switch transfers the load back to the normal source and removes the engine start signal, executing all appropriate programmed time delays. Refer to Section 8.2.4 for a more detailed description of the test sequence of operation.

Note: If the standby source fails during a test, the ATS will immediately attempt to transfer to the preferred source.

Automatic Operation Test Procedure

1. Check the controller LED indicators to verify that the Position N and Source N Available indicators are lit.
2. Verify that the generator set master switch is in the AUTO position.
3. Refer to Figure 3-2. From the main screen, press the Test button. Enter the test password when prompted and press OK.
4. Press the down arrow button to display Type of Test Loaded.
5. Press the Start button.
6. Verify that the generator set starts and the Source E Available LED lights.
7. Verify that the switch transfers the load to Source E.
 - a. Standard-Transition Models: After the preferred-to-standby time delay, verify that the Position N LED goes out and the Position E LED lights, indicating that the switch has transferred the load to Source E.
 - b. Programmed-Transition Models: After the preferred-to-off time delay, verify that the Position N LED goes out. After the off-to-standby time delay, check that the Position E LED lights, indicating that the switch has transferred the load to Source E.

8. Press the End Test button.

9. Verify that the switch transfers the load back to Source N.

- a. Standard-Transition Models: After the standby-to-preferred time delay, verify that the Position E LED goes out and the Position N LED lights, indicating that the switch has transferred the load to Source N.
- b. Programmed-Transition Models: After the standby-to-off time delay, verify that the Position E LED goes out. After the off-to-preferred time delay, check that the Position N LED lights, indicating that the switch has transferred the load to Source N.

Note: The generator set may have an engine cooldown time delay that causes the generator set engine to run after the transfer switch engine start signal is removed.

This completes the functional tests.

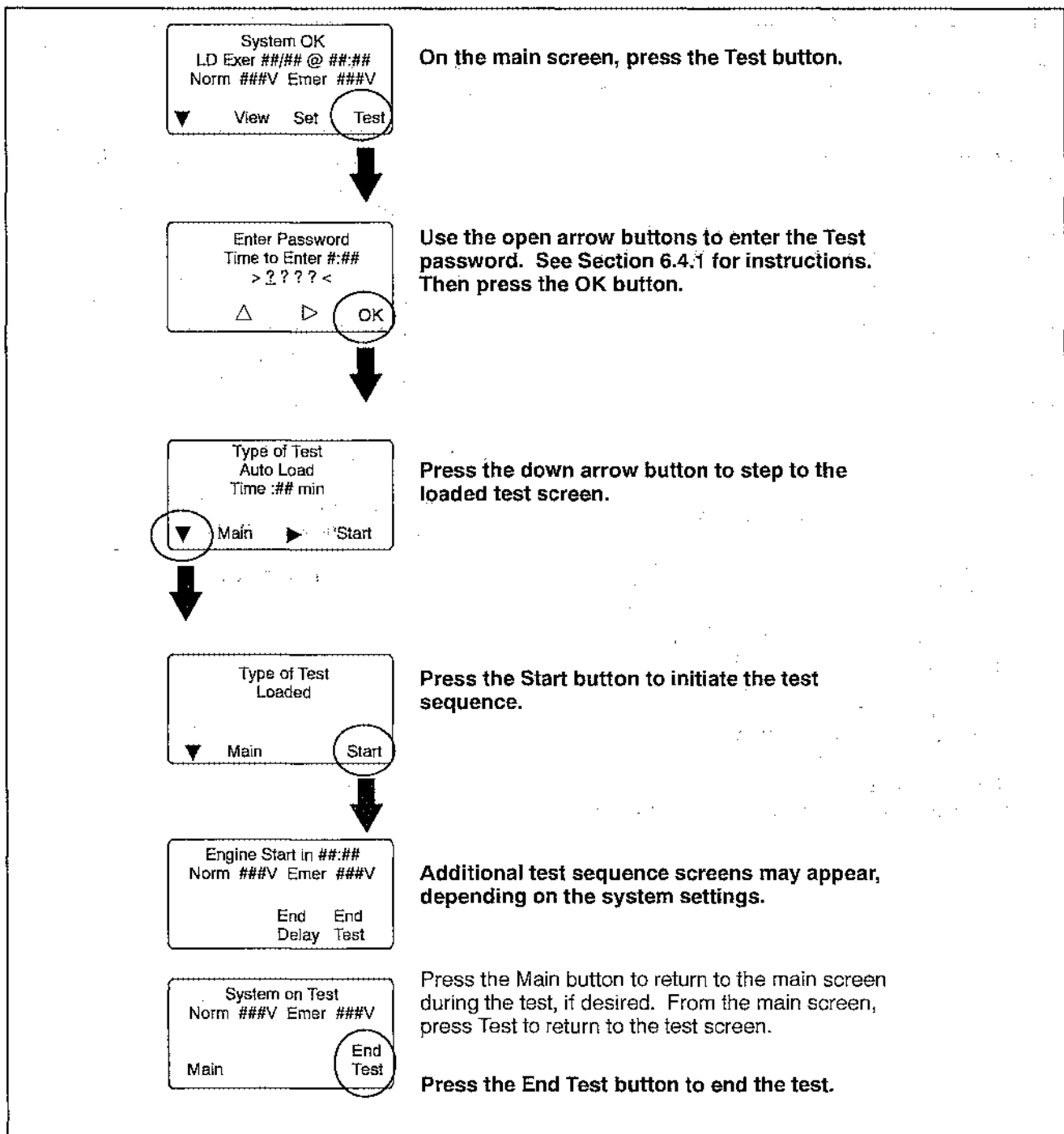


Figure 3-2 Starting and Stopping the Automatic Operation Test

Section 4 User Interface

4.1 Introduction

This section describes the controller's user interface panel.

4.2 User Interface Panel

The user interface panel is located on the transfer switch door. Figure 4-1 shows the user interface pushbuttons and LED indicators.

4.2.1 Display

The four-line display indicates transfer switch status and setup, including the following:

- System status
- Faults and warnings
- Active time delays
- Source voltages
- Source frequency (Hz)
- Current (amps)
- Source setup information
- Time and date
- Time and date of next scheduled exercise

The display also identifies the pushbutton functions, which can change from screen-to-screen.

The display and setup screens are illustrated in Sections 5.3 through 5.7.

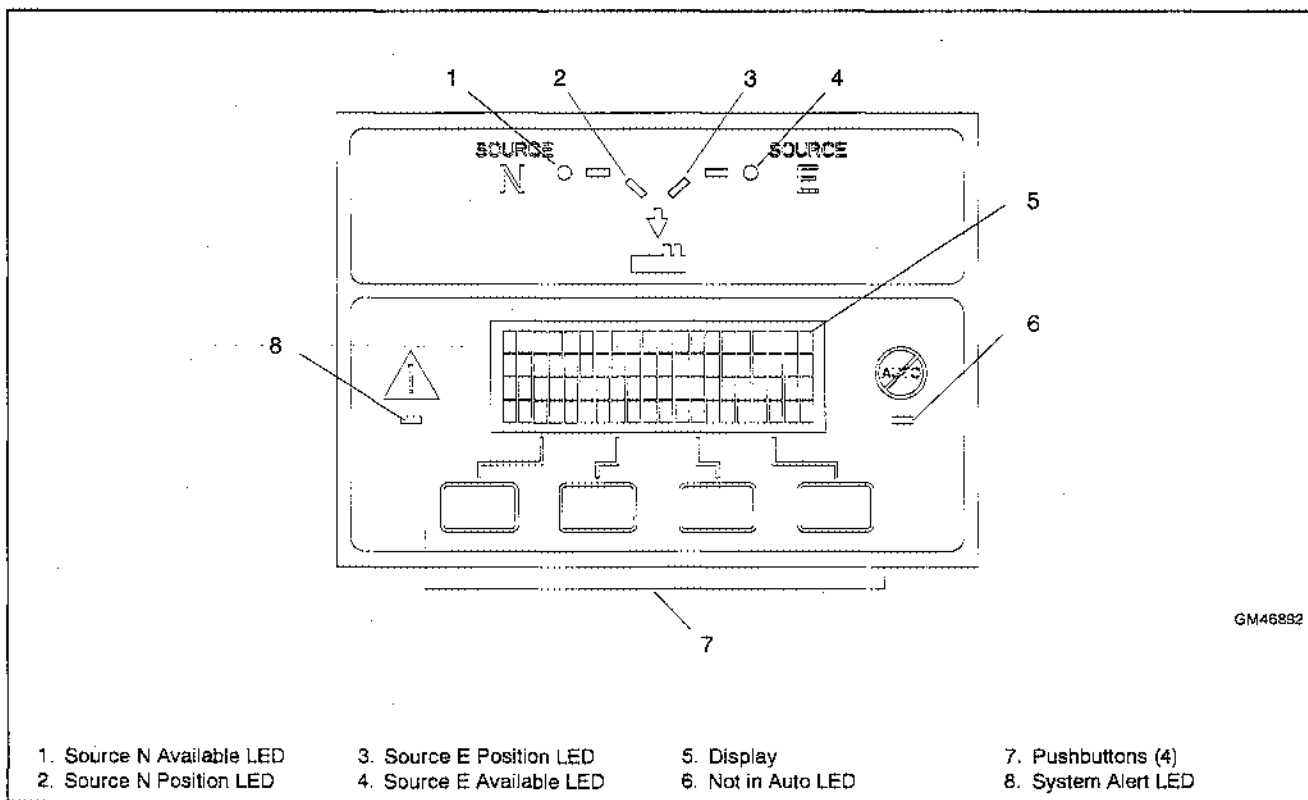


Figure 4-1 User Interface Panel

4.2.2 LED Indicators

LEDs on the user interface indicate contactor position, source availability, faults, and other conditions. The table in Figure 4-2 describes the functions of the LED indicators.

See Section 8.6 for more information about warnings and faults.

Some programmable inputs will trigger the LEDs to light or flash. See Section 6.12.

LED Indicator	Condition
Source N Available, Green	Source N is available.
Source E Available, Red	Source E is available.
Position A, Green	Contactor is in Normal position.
Position B, Red	Contactor is in Emergency position.
System Alert, Red	Fault. Identify and correct the cause of the fault condition, then reset faults at the controller. See Section 8.6.
	Input active: Low Battery Voltage or Remote Common Alarm. See Section 6.12.
Not in Auto, Red	ATS is not set for automatic operation or a load shed (forced transfer to OFF) sequence is active.
	Flashes for manual transfer waiting.
	Input active: Inhibit Transfer, Forced Transfer to OFF, or Bypass Contactor Disable. See Section 6.12.

Figure 4-2 User Interface LED Indicators

4.2.3 Pushbuttons

The user interface panel has four pushbuttons below the display. Pushbutton functions are shown above each button in the last line of the display and can change from screen-to-screen.

The pushbutton functions are defined in Figure 4-3.

4.2.4 Display Contrast

To adjust the display contrast, press and hold the second button until two rows of asterisks (*) appear. Then press the up arrow button to increase the contrast or the down arrow button to decrease the contrast. The display will return to the main screen after a few seconds if no buttons are pressed.

4.2.5 Pushbutton Example

Figure 4-4 illustrates how to use the pushbuttons to step through screens and change settings. This example shows setting the time.

- ▼ Down arrow (closed). Step down to the next screen or scroll through a list.
- ▲ Up arrow (closed). Step back to the previous screen.
- Right arrow (closed). Move to the next submenu.
- △ Up arrow (open). Increases the selected numerical value.
- ▽ Down arrow (open). Decreases the selected numerical value.
- ▷ Right arrow (open). Steps to the next digit in a selected numerical value.

- Back Steps back to the previous screen or submenu.
- End Delay Ends the current time delay.
- End Test Ends an active test sequence. See Section 8.2.4.
- OK Enters the displayed numerical value (password or setting).
- Main Returns to the main screen.
- Next Steps to the next parameter in an item with multiple settings (for example, in Exerciser Setup).
- Reset Reset the fault condition shown on the display, or reset an accessory module after connection.
- Save Saves settings shown on the display.
- Set From the main screen, moves to the first setup screen.
- Start From the Test screen, starts the test sequence.
- Test From the main screen, moves to the test sequence screens. See Section 5.5.
- View From the main screen, moves to the first view screen.

File transfer commands (USB device connected):

- Sel Select the displayed file.
- Del Delete the displayed file.
- Upload Load the displayed file to the USB device.
- Download Load the displayed file to the controller.

Figure 4-3 Pushbutton Functions

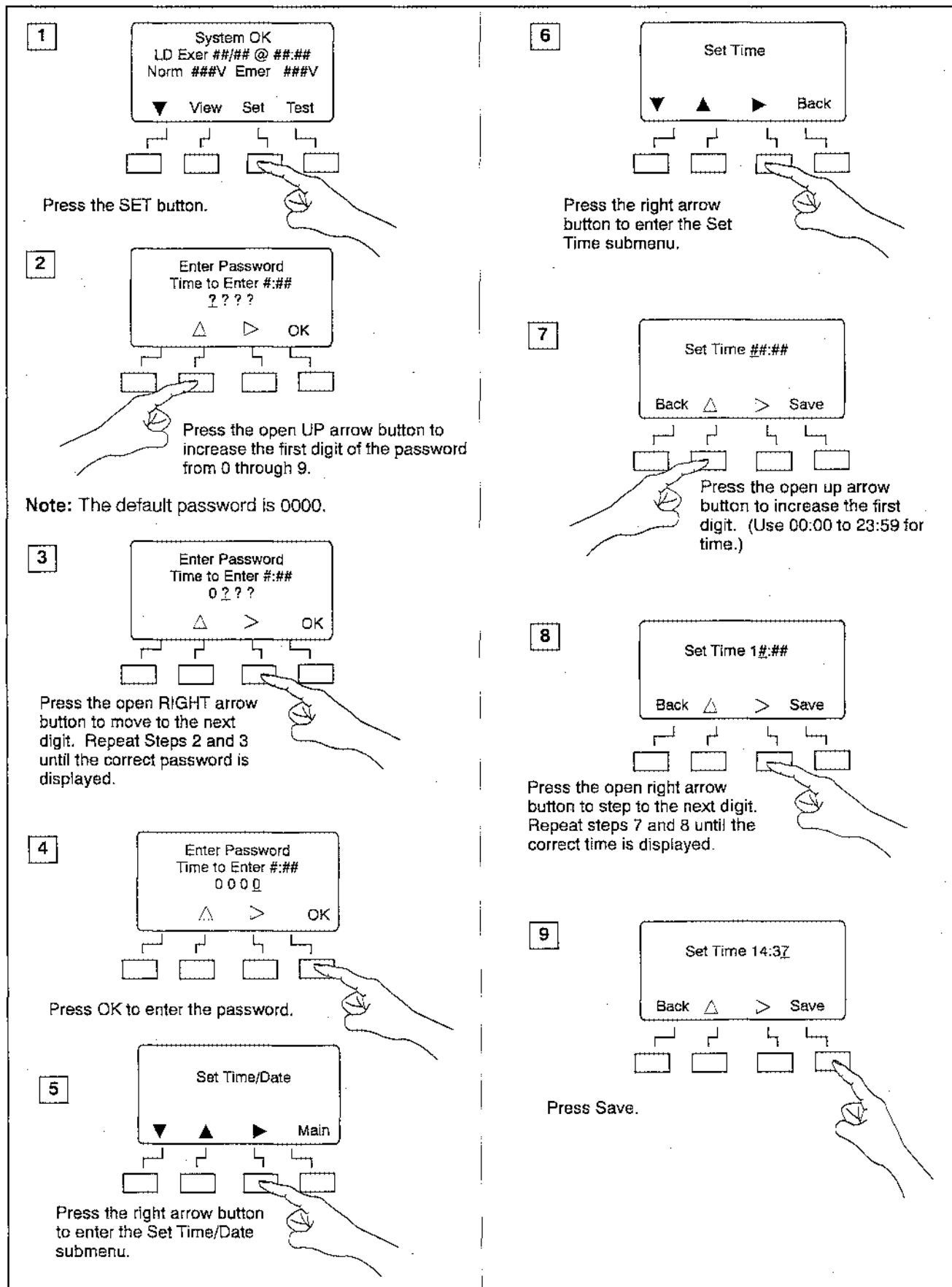


Figure 4-4 Example: Setting the Time

Notes

Section 5 Controller Screen Overviews

5.1 Introduction

This section illustrates the display and setup screens. For detailed operation instructions for using the setup screen, see Section 6.

Some parameters will appear only under certain conditions. For example:

- If no exercise runs are scheduled, the second line of the main screen is blank.
- The Daylight Saving Time settings are displayed only if DST is enabled.
- Phase rotation and in-phase monitoring are displayed only for three-phase systems.
- Some parameters and time delays appear only for programmed-transition models.
- The screens displayed during a test or exercise sequence will vary depending on the time delay settings.

5.2 Main Screen

The main screen appears at system startup and displays the following information (see Figure 5-1):

- System Status (see Figure 5-2)
- Date and time of the next scheduled exercise run (if programmed)
- Measured source voltages
- Pushbutton functions

Pressing the down arrow button steps to the normal operation screens shown in Section 5.3. Step through these screens to check the measured frequency, line voltages, current (if the current sensing accessory is installed), and other system information.

Pressing the View button steps to the view screens shown in Section 5.6.

Passwords are required to enter the setup and test modes. See Section 6.4 for more information about passwords.

Press the Set button to enter the setup mode. A password is required. See Section 6.5 for system setup screens.

Press the Test button to enter the Test mode. A password is required. See Section 8.3.

The display returns to the main screen after 30 minutes of no activity (no buttons pressed).

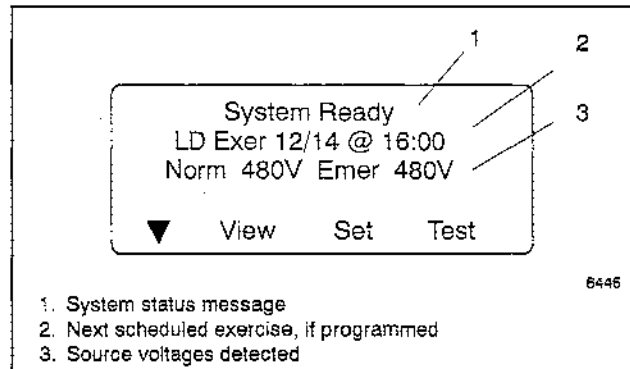


Figure 5-1 Main Screen

System Status Messages
Maint DIP Switch
Inhibit Transfer
Bypass Contactor Dis
Low Battery Voltage
Fail to Acquire Pref
Fail to Acquire Stby
Fail to Transfer
Module Lost Comm
New Module
Remote Common Alarm
External Battery Low
Phase Rotation Error
Aux Switch Fault
Aux Switch Open
Test Mode Active
Exerciser Active
Peak Shave Active
In Phase Waiting

Figure 5-2 System Status Messages

5.3 Normal Operation Screens

5.3.1 Single Phase

System Ready
LD Exer 12/14 @ 16:00
Norm 480V Emer 480V
▼ View Set Test

Norm ##Hz L1 ###V L2 ###V
▼ ▲ Lamp Test Main

Emer ##Hz L1 ###V L2 ###V
▼ ▲ Main

Amps L1 #### L2 ####
▼ ▲ Main

Time/Date
09:10 DST 01/13/06
▼ ▲ Main

Daylight Saving Time
Clock Ahead 1 Hour
Sun 03/12/06
▼ ▲ Main

Daylight Saving Time
Clock Back 1 Hour
Sun 11/05/06
▼ ▲ Main

Normal Preferred
Util-Gen Operation
No Commit Transfer
▼ ▲ Main

Standard Transition
▼ ▲ Main

Press the down arrow (▼) button to step to the next screen.

5.3.2 Three Phase

System Ready
LD Exer 12/14 @ 16:00
Norm 480V Emer 480V
▼ View Set Test

Norm ##Hz AB ###V BC ###V AC ###V
▼ ▲ Lamp Test Main

Norm ##Hz AN ###V BN ###V CN ###V
▼ ▲ Main

Emer ##Hz AB ###V BC ###V AC ###V
▼ ▲ Main

Emer ##Hz AN ###V BN ###V CN ###V
▼ ▲ Main

Amps LA #### LB #### LC ####
▼ ▲ Main

Time/Date
09:10 DST 01/13/06
▼ ▲ Main

Daylight Saving Time
Clock Ahead 1 Hour
Sun 03/12/06
▼ ▲ Main

Daylight Saving Time
Clock Back 1 Hour
Sun 11/05/06
▼ ▲ Main

Normal Preferred
Util-Gen Operation
No Commit Transfer
▼ ▲ Main

Standard Transition
Phase Rotation ABC
In Phase Enabled
▼ ▲ Main

Press the down arrow (▼) button to step to the next screen.

5.4 Exercise Sequence Screens

The following screens appear during an exercise run. See Section 6.14 for instructions to set up the exerciser.

Exerciser Active Fail to Acquire 00:59 Norm ###V Emer ###V Main End Exerciser Active Time Remaining 00:29 Norm ###V Emer ###V Main End	Display during generator set engine start or if engine does not start immediately. Display during exercise run.

5.5 Test Sequence Screens

Press the Test button to enter the Test mode. A password is required. See Section 8.3 for detailed instructions.

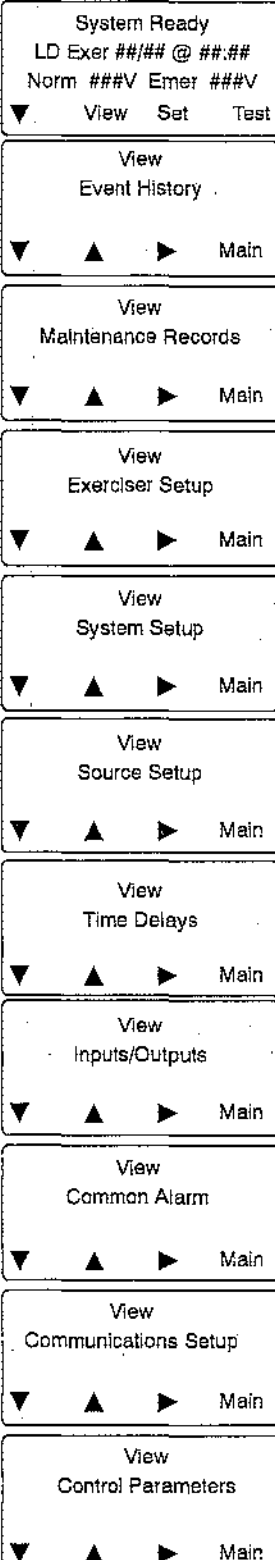
System Ready LD Exer #### @ #### Norm ###V Emer ###V ▼ View Set Test Enter Password Time to Enter #:## > 2 ??? < △ > OK Type of Test Auto Load Time :## min ▼ Main ► Start Type of Test Loaded ▼ Main Start Type of Test Unloaded ▼ Main Start	Auto Load Test Enter Time Time ?? min ▼ △ Back OK

The following screens may be displayed during the test sequence. Screens are dependent on the system settings and time delays.

Engine Start in #### Norm ###V Emer ###V Main End End Delay Test LD# Disc in #### Norm ###V Emer ###V Main End End Delay Test Xfr to Off in #### Norm ###V Emer ###V Main End End Delay Test Xfr to Emer in #### Norm ###V Emer ###V Main End End Delay Test Add LD# in #### Norm ###V Emer ###V Main End End Delay Test System on Test Norm ###V Emer ###V Main End End Delay Test LD# Disc in #### Norm ###V Emer ###V Main End End Delay Test Xfr to Off in #### Norm ###V Emer ###V Main End End Delay Test Xfr to Norm in #### Norm ###V Emer ###V Main End End Delay Test Add LD# in #### Norm ###V Emer ###V Main End End Delay Test Eng Cooledown #### Norm ###V Emer ###V Main End End Delay Test	Appears if load control time delays are set Programmed-transition models only Appears if load control time delays are set Appears if load control time delays are set Programmed-transition models only Appears if load control time delays are set

5.6 View Screens

From the main screen, press the View button to step to the first view screen, View Event History.



Main Screen. Press the View button to step to the first View screen.

Press the down arrow (▼) button to step to the next view screen.

Press the right arrow (▶) button to view details. See Sections 5.6.1 through 5.6.10.

System Ready
LD Exer #### @ ###
Norm ###V Emer ###V
▼ View Set Test

View Event History
▼ ▲ ▶ Main

View Maintenance Records
▼ ▲ ▶ Main

View Exerciser Setup
▼ ▲ ▶ Main

View System Setup
▼ ▲ ▶ Main

View Source Setup
▼ ▲ ▶ Main

View Time Delays
▼ ▲ ▶ Main

View Inputs/Outputs
▼ ▲ ▶ Main

View Common Alarm
▼ ▲ ▶ Main

View Communications Setup
▼ ▲ ▶ Main

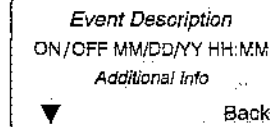
View Control Parameters
▼ ▲ ▶ Main

5.6.1 View Event History

The Event History screens show recent transfer switch events. The types of events recorded in the event history are shown in Figure 5-3. Events are time- and date-stamped. Check the event history for recent transfer switch operation, faults, or changes to settings. The event history is especially useful for transfer switch troubleshooting.



Press the right arrow (▶) button to view events in the event history log.



Press the down arrow (▼) button to step to the next event in the log.

Event Descriptions	
End Time Delay Btn	Remote Common Alarm
Test Btn	Bypass Contactor Dis
Exercise Btn	3 Src System Disable
Lamp Test	Over Frequency
Service Req'd Reset	Under Frequency
Maint DIP Switch	Phase Loss
Pwd DIP Switch	Phase Rotation Error
Manual Option Switch	Over Voltage L1-L2
New Module	Over Voltage L2-L3
Contactor in Off	Over Voltage L3-L1
Contactor in Src N	Under Voltage L1-L2
Contactor in Src E	Under Voltage L2-L3
Low Battery	Under Voltage L3-L1
Exerciser Active	Voltage Imbalance
Fail to Acquire Pref	Save History To File
Fail to Acquire Stby	Auto Loaded Test End
Fail to Transfer	Test Loaded Changed
I/O Module Lost Comm	Pref Source Changed
Aux Switch Fault	Reload Dflt Params
Aux Switch Open	MODBUS Peak Shave
Rem End Time Delay	MODBUS Forced to OFF
Forced Trans to Off	MODBUS System Test
Peak Shave Mode	Battery Control Out
Inhibit Transfer	USB Connected
Remote Test	USB Disconnected
Low Battery Voltage	

Figure 5-3 Event Descriptions

5.6.2 View Maintenance Records

View
Maintenance Records

▼ ▲ ► Main

View Maintenance
Maintenance Item
#####

▼ ▲ Back

Press the right arrow (►) button to view maintenance items.

Press the down arrow (▼) button to step to the next maintenance item.

Maintenance Items	
Reset Min Not Pref	Reset Fail Transfer
Total Min in Standby	Total Loss Pref Tran
Reset Min in Standby	Reset Loss Pref Tran
Total Min Operation	Transfer Time N>E
Reset Min Operation	Transfer Time E>N
Total Transfers	System Start Date
Reset Transfers	Last Maint Date
Total Fail Transfer	Last Loss Date/Time
Total Min not in Pref	Last Loss Duration

5.6.3 View Exerciser Setup

View
Exerciser Setup

▼ ▲ ► Main

Ex#?? Disabled HH:MM
Start MM/DD @ HH:MM
Weekly Unloaded

▼ ▲ Back

Exercise event number

Start date and time

Run time

Exercise interval and loaded or unloaded

Press the right arrow (►) button to view programmed exercise times.

Press the down arrow button (▼) to step to the next exercise event.

5.6.4 View System Setup

View
System Setup

▼ ▲ ► Main

System Setup
Standard Transition
Util-Gen Operation

▼ ▲ Back

System Setup
In Phase Disabled
Commit Transfer

▼ ▲ Back

System Setup
2 I/O Mods Installed

▼ ▲ Back

System Setup
Rated Current
225 Amps

▼ ▲ Back

System Setup
3 Src Eng Start Mode
Mode 1/Mode 2

▼ ▲ Back

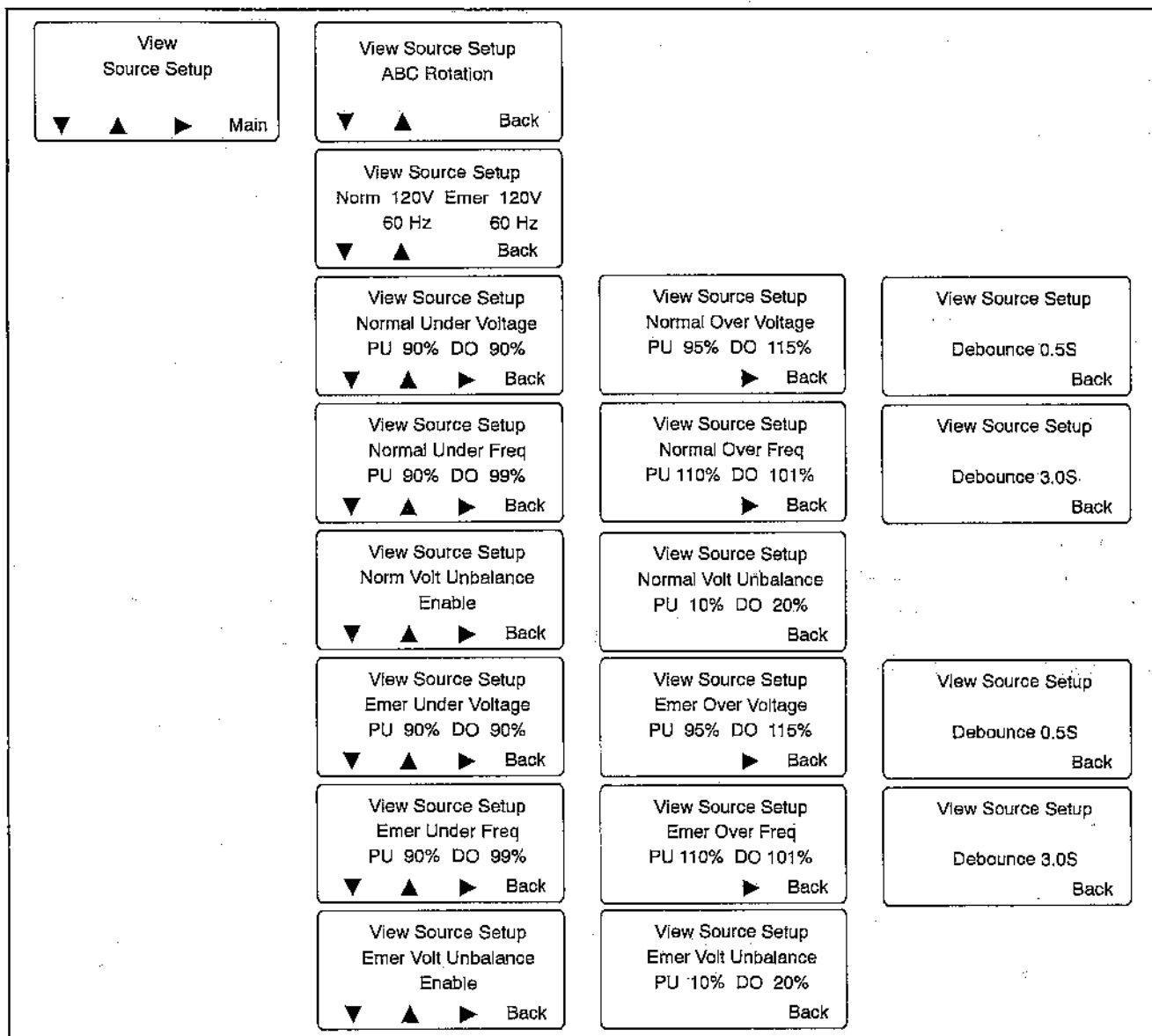
System Setup
Remote Test Loading
Loaded/Unloaded

▼ ▲ Back

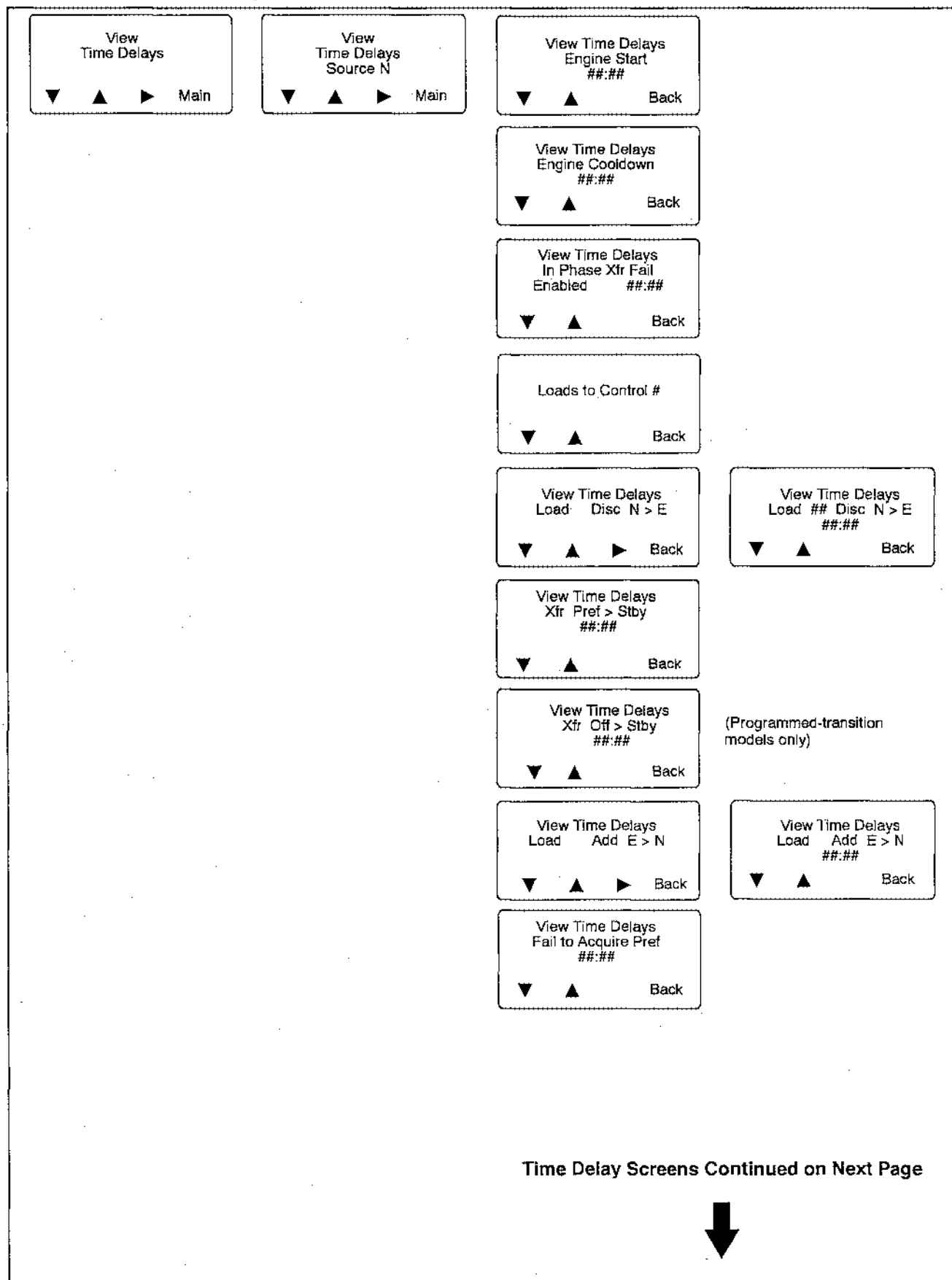
System Setup
Peak Shave TD Bypass
Enabled/Disabled

▼ ▲ Back

5.6.5 View Source Setup



5.6.6 View Time Delays



View Time Delays, continued

Time Delay Screens Continued from Previous Page

View
Time Delays
Source E

▼ ▲ ► Main

Loads to Control #

▼ ▲ Back

View Time Delays
Load Disc E > N

▼ ▲ ► Back

View Time Delays
Load ## Disc E > N
###

▼ ▲ Back

View Time Delays
Xfr Stby > Pref
Enabled ###

▼ ▲ Back

View Time Delays
Xfr Off > Pref
###

▼ ▲ Back

(Programmed-transition
models only)

View Time Delays
Load Add N > E

▼ ▲ ► Back

View Time Delays
Load ## Add N > E
###

▼ ▲ Back

View Time Delays
Fail to Acquire Stby
###

▼ ▲ Back

5.6.7 View Inputs/Outputs

View Inputs/Outputs ▼ ▲ ► Main	View Main Board I/O ▼ ▲ ► Back	Main Board I/O Input ## <i>Function Description</i> ▼ ▲ Back
		Main Board I/O Output ## <i>Function Description</i> ▼ ▲ Back
	View Auxiliary I/O ▼ ▲ ► Back	Module #1 Type ### Addr 1 Status: OK ▼ ▲ ► Back
		Module #1 Input ## <i>Function Description</i> ▼ ▲ Back
		Module #1 Output ## <i>Function Description</i> ▼ ▲ Back

See Section 6.12 for input and output function descriptions.

5.6.8 View Common Alarms

View Common Alarm ▼ ▲ ► Main	View Common Alarms Alarms Group # ▼ ▲ ► Main	View Common Alarms <i>Alarm Description</i> Audible:N Common:Y ▼ ▲ Back

5.6.9 View Communications Setup

View Communications Setup ▼ ▲ ► Main	View Comm Setup MODBUS Server TCP <i>Enabled/Disabled</i> ▼ ▲ Back
	View Comm Setup MODBUS Server Port # <i>Enabled/Disabled</i> ▼ ▲ Back
	View Comm Setup MODBUS Addr Port # ### ▼ ▲ Back
Baud Rates: 9600 19200 57600	View Comm Setup Baud Rate Port # ##### ▼ ▲ Back
	View Comm Setup MODBUS TCP Unit ID ##### ▼ ▲ Back
	View Comm Setup IP Address ###.###.###.### ▼ ▲ Back
	View Comm Setup Subnet Mask ###.###.###.### ▼ ▲ Back
	View Comm Setup MAC Address ##-##-##-##-##-## ▼ ▲ Back

5.6.10 View Control Parameters

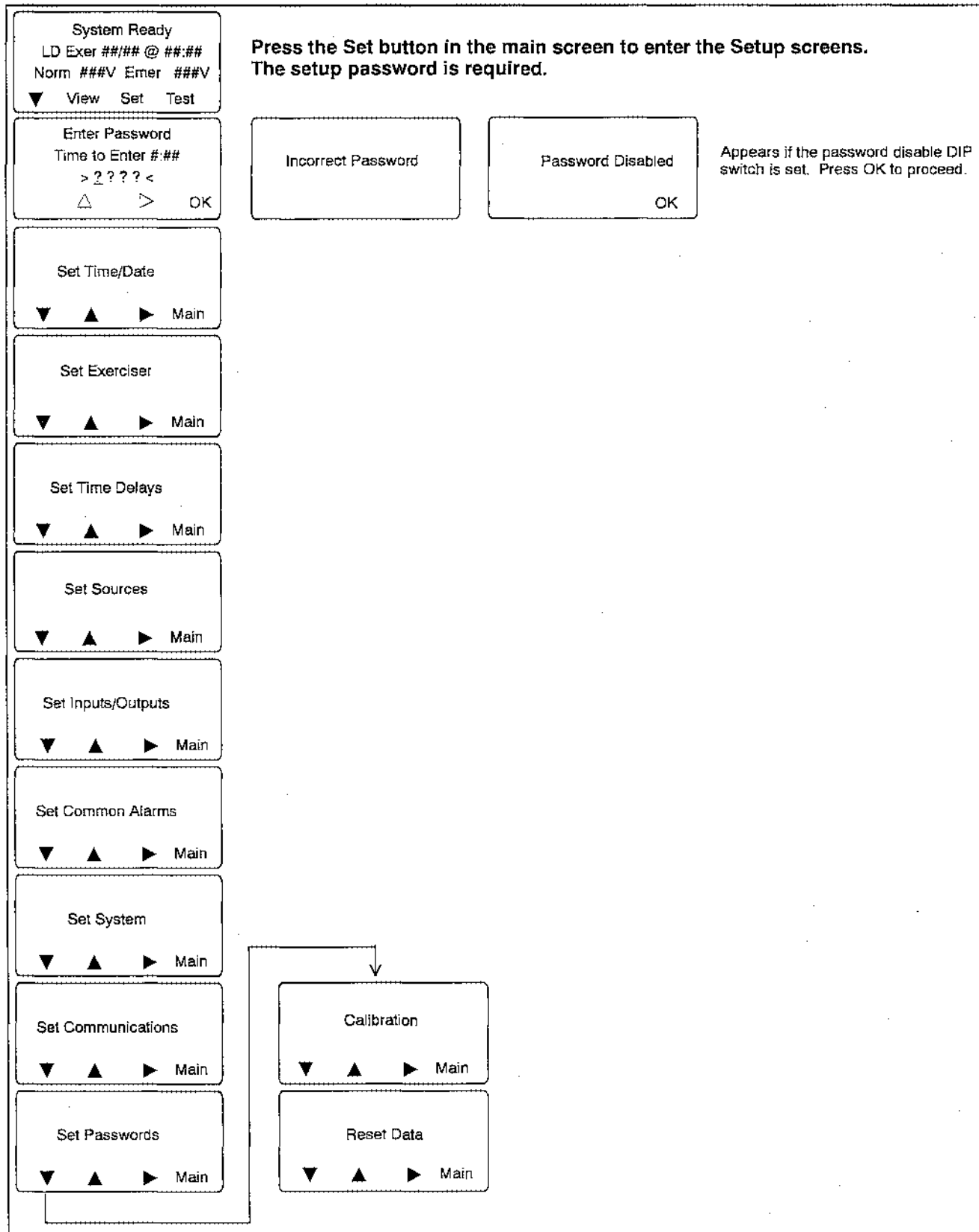
View Control Parameters ▼ ▲ ► Main	Control Parameters Code Version: ▼ ▲ Back
	Control Parameters ATS Serial Number: ##### ▼ ▲ Back
	Control Parameters Controller Ser. #: ##### ▼ ▲ Back
	Control Parameters Contactor Serial #: ##### ▼ ▲ Back
	Control Parameters Site Designation: NOT SET ▼ ▲ Back
	Control Parameters Load Description: NOT SET ▼ ▲ Back
	Control Parameters Branch Description: NOT SET ▼ ▲ Back
	Control Parameters Location: NOT SET ▼ ▲ Back

Note: Serial numbers are factory-set.
 Use optional Monitor III software
 to set other parameters.

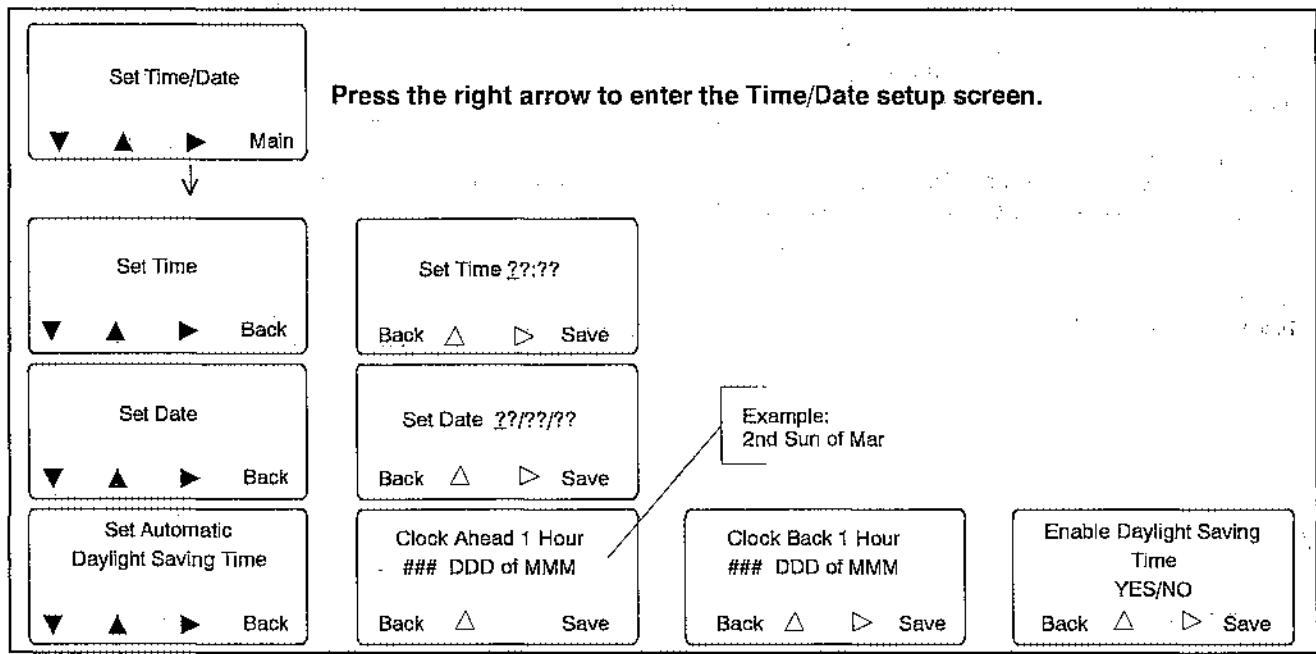
5.7 Setup Screens

From the main screen, press the **Set** button and then enter the setup password to enter setup mode.

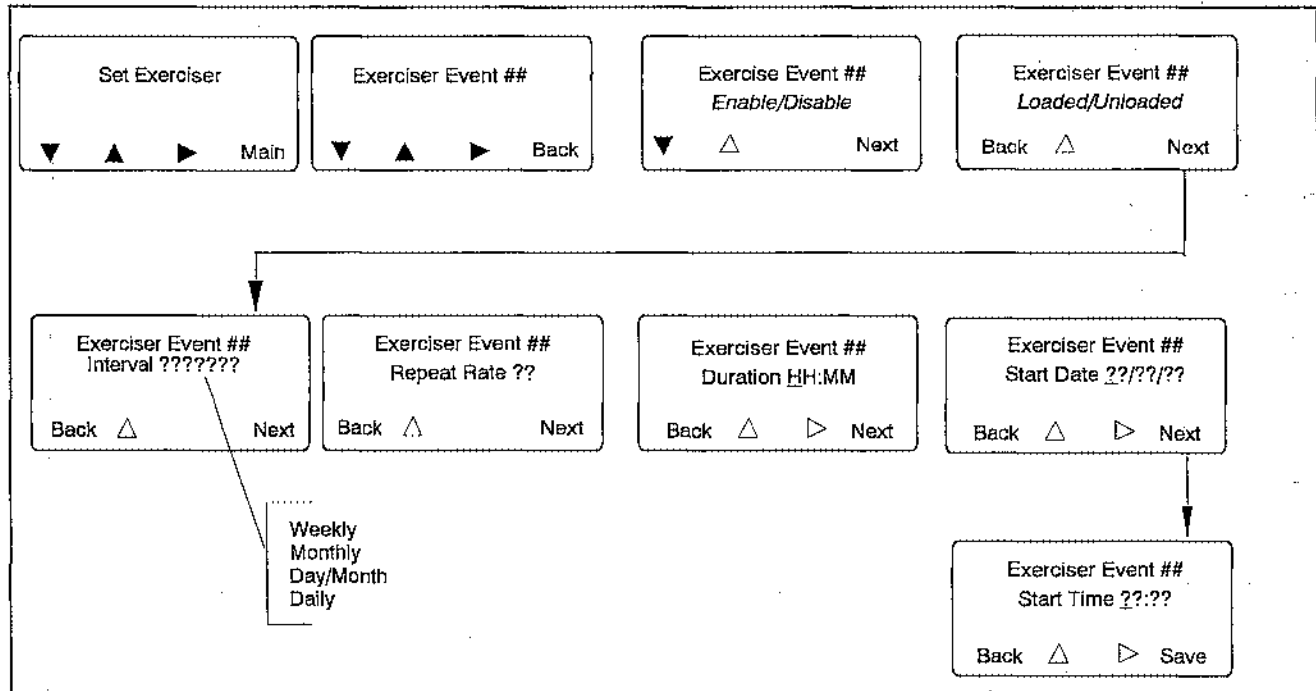
The setup screens are illustrated in this section. For detailed operation instructions for each setup screen, see Section 6.



5.7.1 Set Time/Date



5.7.2 Set Exerciser



Set Time Delays
▼ ▲ ► Main

↓

Set Time Delays Source N (E)
▼ ▲ ► Back

Set Time Delays Engine Start
▼ ▲ ► Back

External Battery Yes/No
Back ▲ ► Save

Engine Start ?? : ??
Back ▲ ► Save

Set Time Delays Eng Cooldown
▼ ▲ ► Back

Eng Cooldown ?? : ??
Back ▲ ► Save

Set Time Delays In Phase Xfr Fail
▼ ▲ ► Back

In Phase Xfr Fail Enable/Disable
Back ▲ ► Save

In Phase Xfr Fail ?? : ??
Back ▲ ► Save

Loads to Control: #
▼ ▲ ► Back

Loads to Control: ?
Back ▲ ► Save

Set Time Delays Load Disc N>E Source N
▼ ▲ ► Back

Load #? Disc N>E
▼ ▲ ► Back

Load #? Disc N>E ?? : ??
Back ▲ ► Save

Set Time Delays Xfr Pref>Stby
▼ ▲ ► Back

Xfr Pref>Stby ?? : ??
Back ▲ ► Save

Set Time Delays Xfr Off>Stby
▼ ▲ ► Back

Xfr Off>Stby ?? : ??
Back ▲ ► Save

Load #? Add E>N
▼ ▲ ► Back

Load #? Add E>N ?? : ??
Back ▲ ► Save

Set Time Delays Load Add E>N
▼ ▲ ► Back

Fail to Acquire Pref Enable/Disable
Back ▲ ► Save

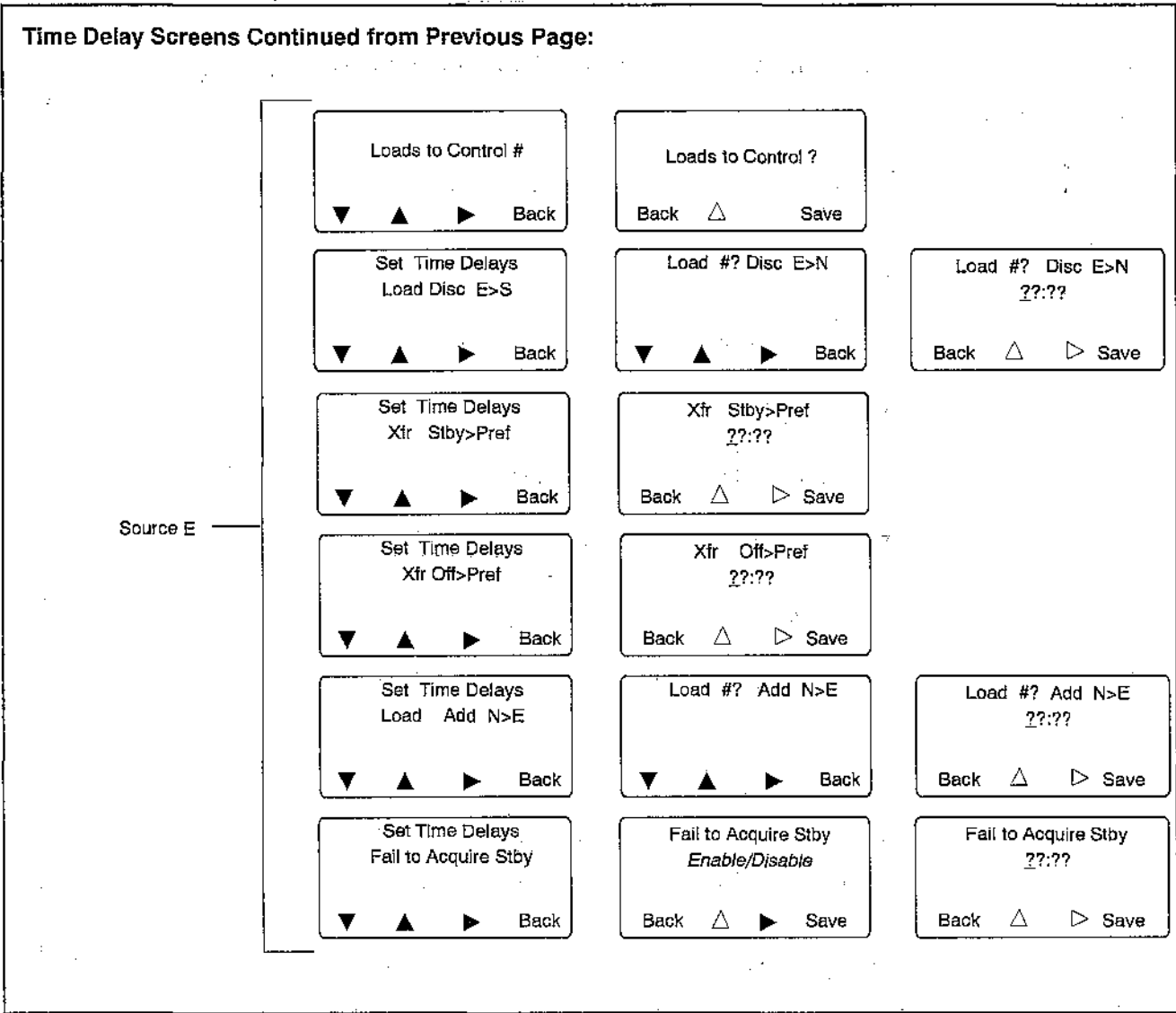
Fail to Acquire Pref ?? : ??
Back ▲ ► Save

Set Time Delays Fail to Acquire Pref
▼ ▲ ► Back

Time Delay Screens Continued on Next Page

↓

Set Time Delays, continued



5.7.4 Set Sources

Set Sources ▼ ▲ ► Main	Set Phase Rotation ▼ ▲ ► Back	??? Rotation ▲ Save Back
	Set Inphase Monitor Enable/Disable ▼ ▲ ► Back	Enable/Disable ▲ Save Back
	Set Inphase Monitor Angle ▼ ▲ ► Back	?? Degrees Back ▲ ► Save
	Set Preferred Source ▼ ▲ ► Back	Preferred Source Normal/Emergency ▲ Save Back
	Set Normal Source ▼ ▲ ► Back	Normal Source Set Number of Phases ▼ ▲ ► Back
		? Phase ▲ Save Back
	Normal Source Set Voltage ▼ ▲ ► Back	Set Voltage ??? VAC Back ▲ ► Save
	Normal Source Set Frequency ▼ ▲ ► Back	Set Frequency ?? Hz Back ▲ ► Save
	Normal Source Set Under Voltage Pickup ▼ ▲ ► Back	Pickup ??? % of Nominal 85-100% ▼ ▲ Save Back
	Normal Source Set Under Voltage Dropout ▼ ▲ ► Back	Dropout ??? % of Pickup 75-98% ▼ ▲ Save Back
	Normal Source Set Over Voltage Pickup ▼ ▲ ► Back	Pickup ??? % of Dropout 95-100% ▼ ▲ Save Back

Source Setup Screens Continued on Next Page

↓

Set Sources, continued

Source Setup Screens Continued from Previous Page:

Normal Source Set Over Voltage Dropout ▼ ▲ ► Back	Dropout ??? % of Nominal 106-135% ▽ ▲ Save Back
Normal Source Set Voltage Debounce ▼ ▲ ► Back	Debounce Time ?.? Seconds 0.1 - 9.9 Seconds ▽ ▲ Save Back
Normal Source Voltage Unbalance Enable/Disable ▼ ▲ ► Back	Voltage Unbalance Enable/Disable ▲ Save Back
Normal Source Voltage Unbalance Pickup ▼ ▲ ► Back	Pickup ???% 3-18% ▽ ▲ Save Back
Normal Source Voltage Unbalance Dropout ▼ ▲ ► Back	Dropout ???% 5-20% ▽ ▲ Save Back
Normal Source Set Under Frequency Pickup ▼ ▲ ► Back	Pickup ??? % of Nominal 80-95% ▽ ▲ Save Back
Normal Source Set Under Frequency Dropout ▼ ▲ ► Back	Dropout ??? % of Pickup 95-99% ▽ ▲ Save Back
Normal Source Set Over Frequency Pickup ▼ ▲ ► Back	Pickup ??? % of Nominal 105-120% ▽ ▲ Save Back
Normal Source Set Over Frequency Dropout ▼ ▲ ► Back	Dropout ??? % of Pickup 101-115% Nominal ▽ ▲ Save Back
Normal Source Set Freq Debounce ▼ ▲ ► Back	Debounce Time ?.? Seconds 0.1 - 15.0 Seconds ▽ ▲ Save Back

Source Setup Screens Continued on Next Page



Set Sources, continued

Source Setup Screens Continued from Previous Page:

Set Emergency Source ▼ ▲ ► Back	Emergency Source Set Number of Phases ▼ ▲ ► Back	? Phase ▲ Save Back
	Emergency Source Set Voltage ▼ ▲ ► Back	Set Voltage ??? VAC Back ▲ ► Save
	Emergency Source Set Frequency ▼ ▲ ► Back	Set Frequency ?? Hz Back ▲ ► Save
	Emergency Source Set Under Voltage Pickup ▼ ▲ ► Back	Pickup ??? % of Nominal 85-100% ▼ ▲ Save Back
	Emergency Source Set Under Voltage Dropout ▼ ▲ ► Back	Dropout ??? % of Pickup 75-98% ▼ ▲ Save Back
	Emergency Source Set Over Voltage Pickup ▼ ▲ ► Back	Pickup ??? % of Dropout 95-100% ▼ ▲ Save Back
	Emergency Source Set Over Voltage Dropout ▼ ▲ ► Back	Dropout ??? % of Nominal 106-135% ▼ ▲ Save Back
	Emergency Source Set Voltage Debounce ▼ ▲ ► Back	Debounce Time ?? Seconds 0.1 - 9.9 Seconds ▼ ▲ Save Back
	Emergency Source Voltage Unbalance Enable/Disable ▼ ▲ ► Back	Voltage Unbalance Enable/Disable ▲ Save Back

Source Setup Screens Continued on Next Page

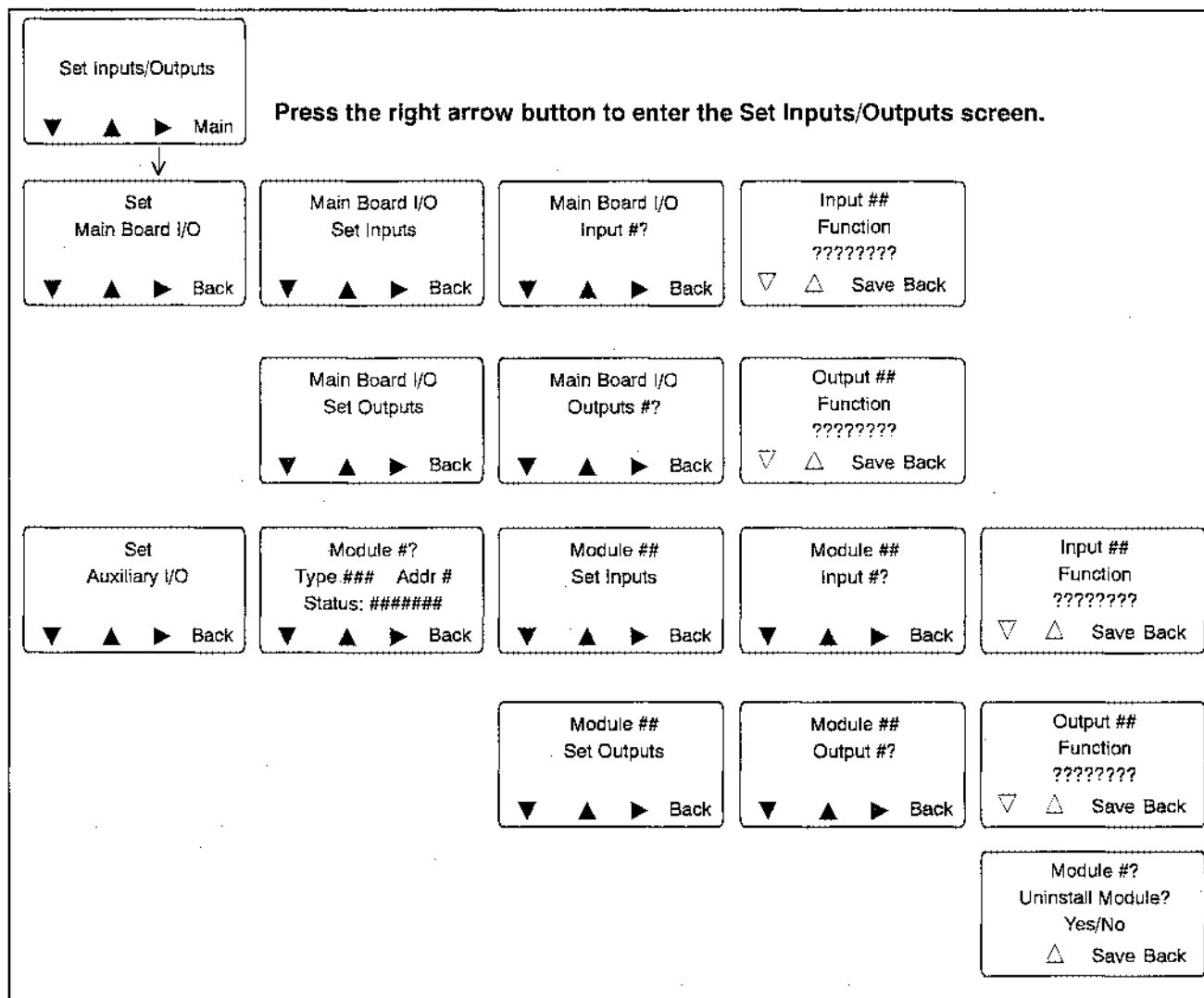


Set Sources, continued

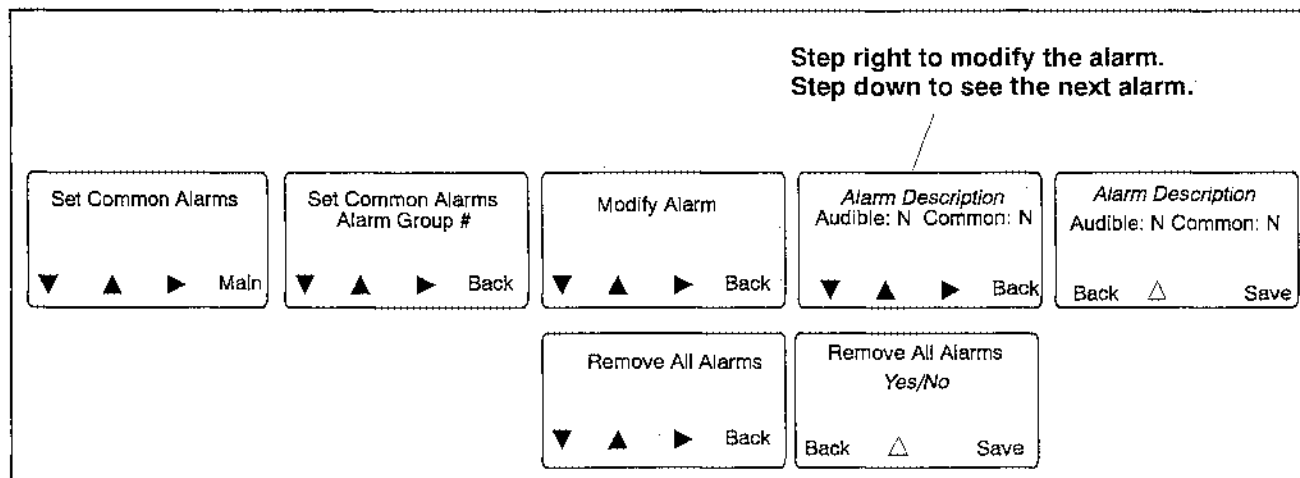
Source Setup Screens Continued from Previous Page:

Emergency Source Voltage Unbalance Pickup ▼ ▲ ► Back	Pickup ??% 3-18% ▽ ▲ Save Back
Emergency Source Voltage Unbalance Dropout ▼ ▲ ► Back	Dropout ??% 5-20% ▽ ▲ Save Back
Emergency Source Set Under Frequency Pickup ▼ ▲ ► Back	Pickup ??? % of Nominal 80-95% ▽ ▲ Save Back
Emergency Source Set Under Frequency Dropout ▼ ▲ ► Back	Dropout ??? % of Pickup 95-99% ▽ ▲ Save Back
Emergency Source Set Over Frequency Pickup ▼ ▲ ► Back	Pickup ??? % of Nominal 105-120% ▽ ▲ Save Back
Emergency Source Set Over Frequency Dropout ▼ ▲ ► Back	Dropout ??? % of Pickup 105-135% Nominal ▽ ▲ Save Back
Emergency Source Set Freq Debounce ▼ ▲ ► Back	Debounce Time ?.? Seconds 0.1 - 15.0 Seconds ▽ ▲ Save Back

5.7.5 Set Inputs/Outputs



5.7.6 Set Common Alarms



5.7.7 Set System

Set System ▼ ▲ ► Main	Source Type ▼ ▲ ► Back	Source Type ?????? - ?????? Back ▲ Save	Util-Gen Gen-Gen Util-Util Util-Gen-Gen
	Transition Type ▼ ▲ ► Back	Transition Type ???????? Back ▲ Save	Standard Transition Programmed Transition
	Rated Current ▼ ▲ ► Back	Rated Current ???? Amps Back ▲ ► Save	
	3 Src Eng Start Mode ▼ ▲ ► Back	3 Src Eng Start Mode Mode 1/Mode 2 Back ▲ ► Save	Pref Source Toggle Enable/Disable Back ▲ ► Save
	Transfer Commit ▼ ▲ ► Back	Transfer Commit Commit/No Commit Back ▲ Save	
	Remote Test Loading ▼ ▲ ► Back	Remote Test Loading Loaded/Unloaded Back ▲ Save	
	Peak Shave Delay ▼ ▲ ► Back	Peak Shave TD Bypass Enabled/Disabled Back ▲ Save	

5.7.8 Set Communications

Communications Setup ▼ ▲ ► Main	Communications Setup MODBUS Server TCP ▼ ▲ ► Back	MODBUS Server TCP <i>Enabled/Disabled</i> Back ▲ Save
	Communications Setup MODBUS Server Port # ▼ ▲ ► Back	MODBUS Server Port # <i>Enabled/Disabled</i> Back ▲ Save
	Communications Setup MODBUS Addr Port # ▼ ▲ ► Back	MODBUS Addr Port # ??? Back ▲ ► Save
	Communications Setup Baud Rate Port # ▼ ▲ ► Back	Baud Rate Port # ????? Back ▲ Save
	Communications Setup MODBUS TCP Unit ID ▼ ▲ ► Back	MODBUS TCP Unit ID ??? Back ▲ ► Save
	Communications Setup IP Address ▼ ▲ ► Back	IP Address ???.????.???. Back ▲ ► Save
	Communications Setup Subnet Mask ▼ ▲ ► Back	Subnet Mask ???.????.???. Back ▲ ► Save

9600
 19200
 57600

5.7.9 Set Passwords

Set Passwords ▼ ▲ ► Main	Setup Password ▼ ▲ ► Back Test Password ▼ ▲ ► Back	Old Password 2??? New Password 2??? Back ▲ ► Save	Incorrect Password
		Old Password 2??? New Password 2??? Back ▲ ► Save	Incorrect Password

5.7.10 Calibration

Calibration ▼ ▲ ► Main	Calibrate L - N Voltages Source N(E) ▼ ▲ ► Back	Calibrate L1 - L0 Voltage ▼ ▲ ► Back	L1 - L0 VAC ### Cal VAC 2?? Back ▲ ► Save
	Calibrate L - L Voltages Source N(E) ▼ ▲ ► Back	Calibrate L1 - L2 Voltage ▼ ▲ ► Back	L1 - L2 VAC ### Cal VAC 2?? Back ▲ ► Save
	Calibrate Load Current ▼ ▲ ► Back	Calibrate LA Current ▼ ▲ ► Back	LA Amps #### Cal Amps 2??? Back ▲ ► Save

5.7.11 Reset Data

Reset Data ▼ ▲ ► Main	Reset Maintenance Records Yes/No ▼ ▲ Save Back
	Reset Event History Yes/No ▼ ▲ Save Back
	Reset Default Parameters Yes/No ▼ ▲ Save Back
	Reset Exerciser Setup Yes/No ▼ Save Back
	Reset Test Password Yes/No ▼ ▲ Save Back
	Disable Test Password Yes/No ▼ ▲ Save Back
	File Maintenance ▼ ► Back
	Delete Files Filename ▼ ▲ Del Back
	Force History Save Save Back

5.8 USB Access Screen

(appears only when USB device is connected)

USB Connected

DownloadUpload

Download to Control
Filename
Free Space #### Kb
▼SelBack

Upload to USB
Filename
▼SelBack

6.1 Introduction

This section contains setup instructions, including:

- Controller DIP switch settings
- Default settings
- Setting the time and date
- Source setup
- System setup
- Three-source system setup
- Adjusting time delays
- Load control settings
- Programming inputs and outputs
- Common alarms
- Exerciser setup
- Communication setup
- Changing passwords
- Calibration

6.2 Controller DIP Switches

Two DIP switches on the main logic board are assigned functions. Switches 3 and 4 are not used. The DIP switches are located on the controller's main logic board on the inside of the enclosure door. Figure 6-1 shows the locations of the switches on the controller circuit board. It is not necessary to remove the logic assembly cover to see or adjust the DIP switches.

SW1-1, Password Disable. Turning ON the password disable DIP switch SW1-1 disables the setup password and resets it to the factory defaults. When the switch is ON, system setup and programming is allowed without the need to enter a password.

Note: Disable the setup password only during service unless the transfer switch is installed in a secure location.

Turning DIP switch SW1-1 ON and then OFF resets the password to the default value, 0000.

The test password is not affected by this DIP switch. Use the Reset Data screen to disable the test password.

SW1-2, Maintenance. The maintenance DIP switch inhibits transfer during ATS service. When this switch is in the ON position, sensing, timing, engine start and contactor functions are disabled. A preferred source failure will be ignored. The Not in Auto LED flashes red and the message Maintenance Mode is indicated on the LCD screen. In addition, a programmable digital output is turned on and an entry in the event log indicates that the maintenance mode has been activated. System monitoring and setup are allowed while in maintenance mode.

Switch SW1-2 should be ON only during maintenance or service. It must be OFF during normal operation.

Close and lock the enclosure door before energizing the transfer switch.

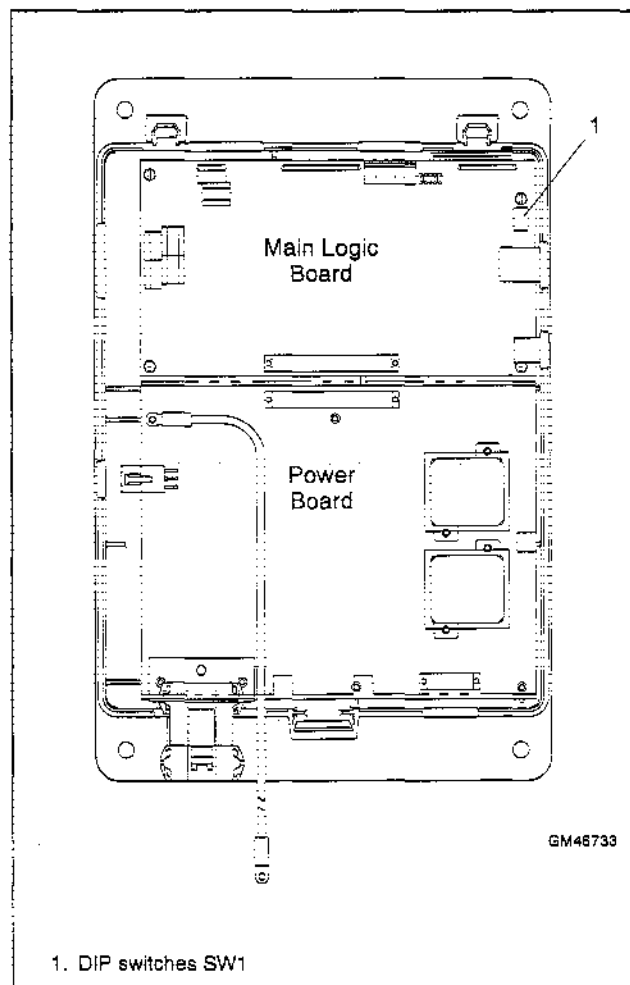


Figure 6-1 DIP Switch Location (cover removed)

6.3 Default Settings and Time Delays

The system can be operated using the factory settings listed in the following sections.

Use the Setup screens to change the controller time delays, pickup and dropout settings, inputs, outputs, and options if necessary.

6.3.1 System Parameters

The system parameter factory settings are shown in Figure 6-2. The controller voltage and frequency sensing are factory-set to the default values shown in Figure 6-3. The voltage and frequency debounce time delays prevent nuisance transfers caused by brief spikes and dips in the power supply.

System Parameter	Factory Setting
Standard or programmed transition	Set to order †
Single/three phase	Set to order †
Operating voltage	Set to order †
Operating frequency (50 or 60 Hz)	Set to order †
Phase rotation	ABC
Commit to transfer (yes or no)	No
Rated current	Set to order †
Operating mode: Generator-to-Generator, Utility-to-Generator, or Utility-to-Utility	Utility-to-Generator
In-phase monitor	Disabled
In-phase monitor transfer angle	5°
Transfer mode (automatic or non-automatic)*	Set to order
* The transfer mode (automatic or non-automatic) cannot be changed in the field.	
† See the nameplate and model designation. See Section 1.	

Figure 6-2 System Parameters

Voltage and Frequency Sensing	
Parameter	Default
Under voltage pickup	90% of nominal
Under voltage dropout	90% of pickup
Over voltage dropout	110% of nominal
Over voltage pickup	95% of dropout
Voltage debounce time	0.5 sec.
Under frequency pickup	90% of nominal
Under frequency dropout	99% of pickup
Over frequency dropout	101% of pickup
Over frequency pickup	110% of nominal
Frequency debounce time	3 sec.

Figure 6-3 Factory Settings, Voltage and Frequency

6.3.2 Time Delays

The factory settings for the time delays are shown in Figure 6-14.

The pre-transfer time delays operate only when both sources are available. These delays allow time to disconnect selected loads before transfer. The load control LED on the user interface lights when the pre-transfer signal is active. The pre-transfer and post-transfer time delays overlap the preferred-to-standby and standby-to-preferred transfer time delays.

Time Delay Description	Default Time
Emergency engine start (emergency source - Util/Gen and Gen/Gen modes)	3 sec
Normal engine start (normal source - Gen/Gen mode)	0 sec
Emergency engine cooldown (emergency source - Util/Gen and Gen/Gen modes)	
Normal engine cooldown (normal source - Gen/Gen mode)	0 sec
Fail to acquire standby source	1 min
Preferred to standby	1 sec
Pre-transfer to standby source	3 sec
Post-transfer to standby source	0 sec
Standby to preferred	15 min
Pre-transfer to preferred source	0 sec
Post-transfer to preferred source	0 sec
Fail to synchronize	1 min
Off (Preferred to Standby for programmed transition)	1 sec
Off (Standby to Preferred for programmed transition)	1 sec

Figure 6-4 Factory Settings, Time Delays

6.4 Passwords

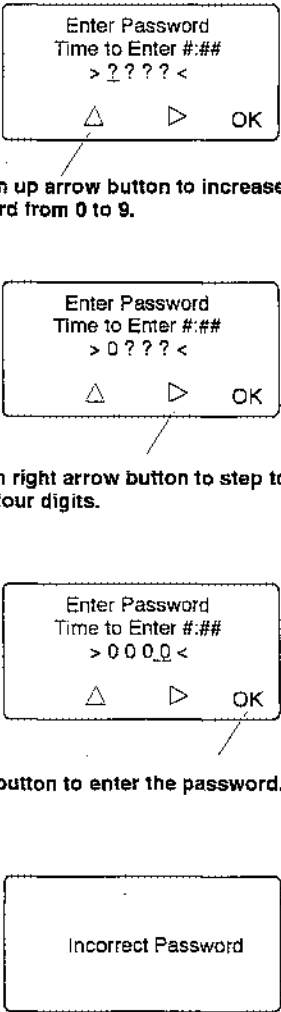
Passwords are required to enter the Test and Setup screens. Passwords are 4-digit numbers. See Figure 6-5 for instructions to enter the password using the pushbuttons on the controller's user interface.

If the correct password is not entered within 30 seconds, the display returns to the main screen.

The factory default password is 0000. Change the password to allow only authorized personnel to start and end tests or change settings.

6.4.1 Entering Password

Note: The factory default password is 0000.



Enter Password
Time to Enter #.##
> 2 ? ? ? <
△ ▷ OK

Press the open up arrow button to increase the first digit of the password from 0 to 9.

Enter Password
Time to Enter #.##
> 0 ? ? ? <
△ ▷ OK

Press the open right arrow button to step to the next digit. Repeat for all four digits.

Enter Password
Time to Enter #.##
> 0 0 0 0 <
△ ▷ OK

Press the OK button to enter the password.

Incorrect Password

If the wrong password is entered, the Incorrect Password screen appears. Check the password and try again.

Figure 6-5 Entering a Password

6.4.2 Changing Passwords

There are two passwords:

Setup Password. The setup password controls access to the system setup screens, which allow changes to system settings, time delays, etc.

Test Password. The test password controls access to the test sequence screens. The password is required to initiate a loaded, unloaded, or auto-loaded test.

Use the Passwords Setup Menu to change passwords. See Section 6.15.

6.4.3 Setup Password Reset and Disable

Turning ON the password disable DIP switch SW1-1 disables the setup password and resets it to the factory defaults. When the switch is ON, system setup and programming is allowed without the need to enter a password. See Figure 6-1 for the DIP switch location.

Turning DIP switch SW1-1 ON and then OFF resets the password to the default value, 0000.

The test password is not affected by this DIP switch. Use the Reset Data screen to disable the test password.

6.4.4 Test Password Reset and Disable

The test password can be reset to the default value or disabled. Use the Setup Menu-Reset Data screen. See Figure 8-11.

Disabling the test password allows any user to initiate a test sequence from the controller's user interface without entering a password. Initiating a test starts the generator set and, if a loaded test is selected, transfers the load.

6.5 Setup Screens

From the main operation window, press the Set button to enter the setup screens.

The setup password is required. The default password is 0000. (The password can be disabled; see Section 6.4.3.)

After entering the system password, use the black arrow keys to step through the setup screens as shown in Figure 6-6.

Timeout. After 10 minutes of no activity (no buttons pressed) the controller exits the setup mode and returns to the main screen.

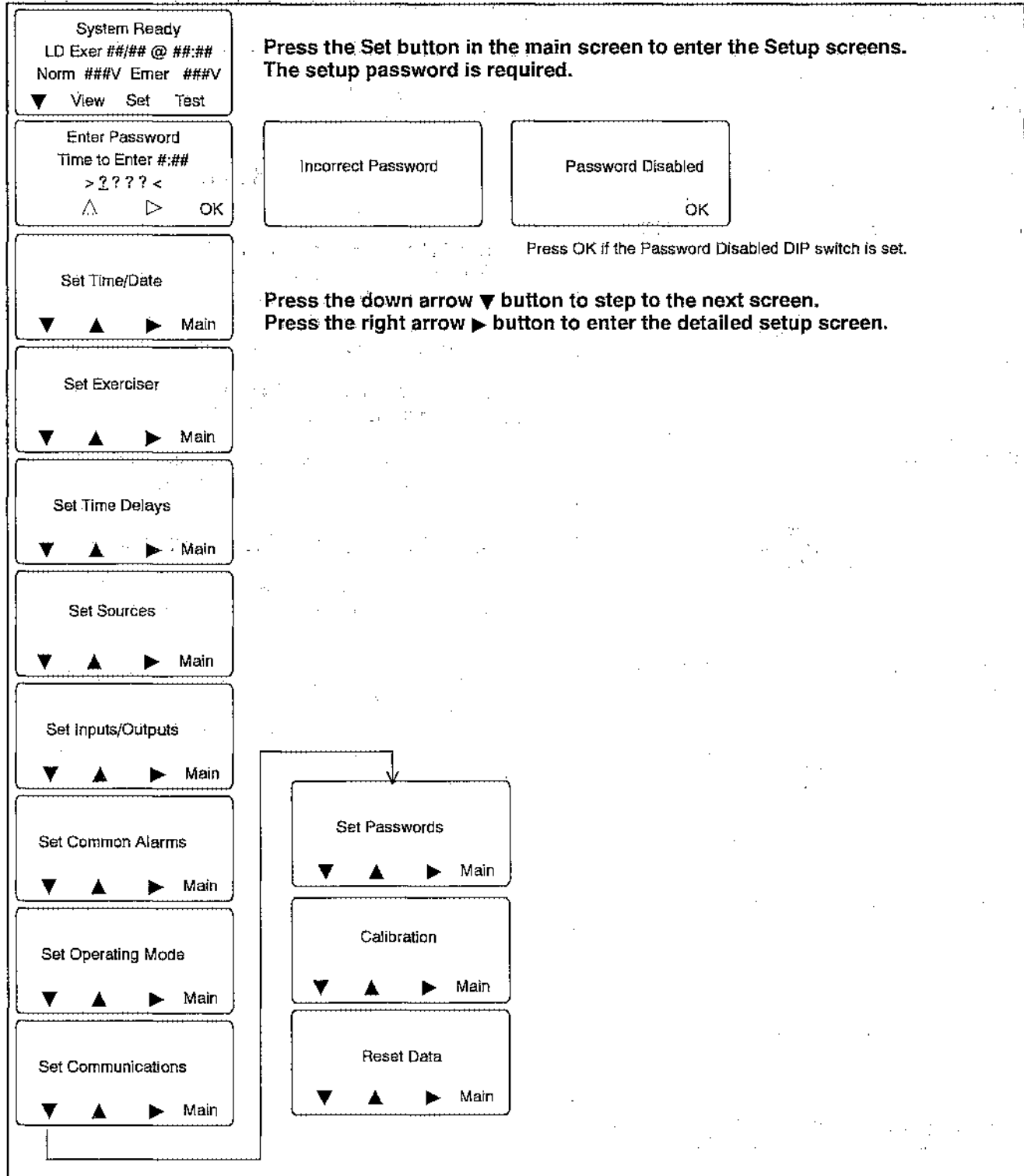


Figure 6-6 Main Setup Screen

6.6 Time/Date

Note: Set the current time and date after transfer switch installation or after an extended period of no power.

Set the current time and date. The time and date are used by the exercise function and event history functions.

The Time/Date setup screen includes the option to enable automatic Daylight Saving Time and set the start and stop date. See Figure 6-7.

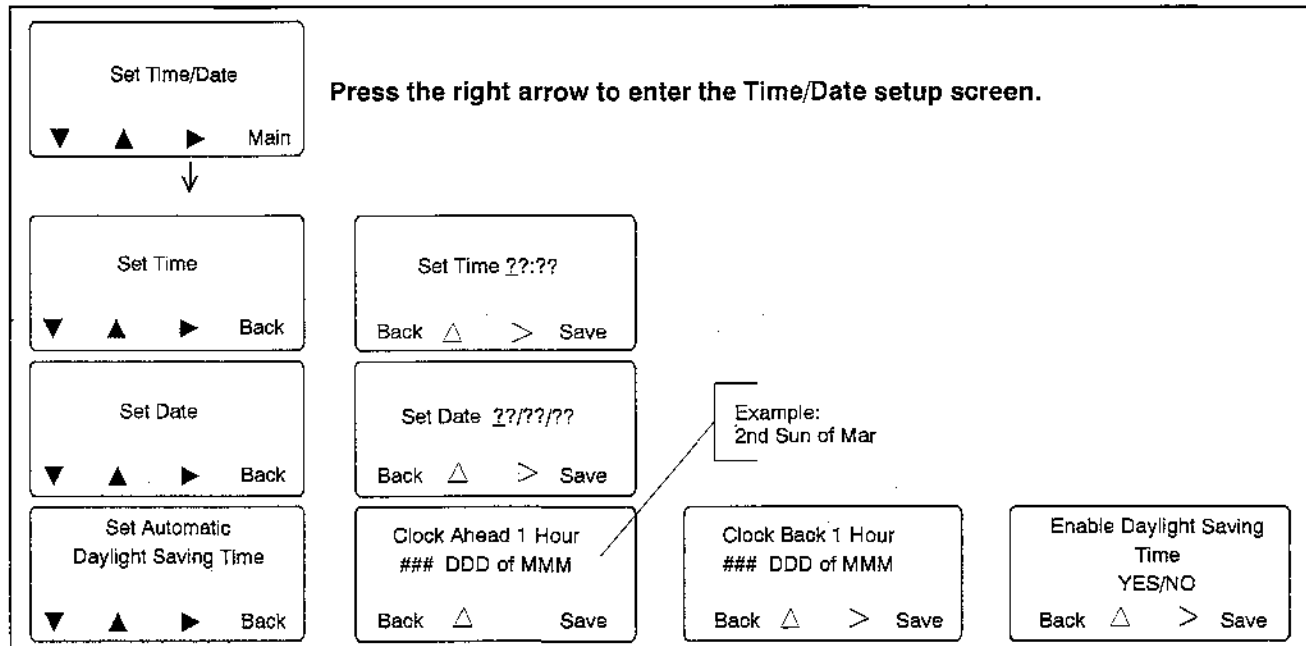


Figure 6-7 Setting the Time and Date

6.7 Source Setup

6.7.1 In-Phase Monitor

The in-phase monitor operates, prior to transfer, when both sources are available. Transfer is inhibited while both sources are greater than 2 cycles apart. If the connected source falls below 70% of its nominal voltage rating, the in-phase monitor terminates and allows transfer.

The synchronism window has a default value of 5° and is adjustable from 15° to 5° before synchronism only. The in-phase monitor feature can be enabled for Util-Gen and Gen-Gen modes of operation. In Util-Util mode, it is assumed that both sources are always in phase with each other, and immediate transfer occurs when in-phase monitoring is enabled.

6.7.2 Preferred Source Selection

The preferred source selection function allows selection of either Source N or Source E as the preferred source.

Note: The alarm module accessory must be installed for this function to operate. See Section 10.5.

The transfer switch seeks and transfers to the preferred source whenever it is available. Source N is always the source connected to the Normal side of the transfer switch, and Source E is always connected to the Emergency side. Generator engine start relays are assigned to the source (Source N or Source E). The engine start relays do not change when the preferred source selection changes. This prevents the need to change the wiring of the engine start relay(s) when the preferred source changes.

Operating Modes. The transfer switch is factory-set for the generator set-to-utility mode of operation. This mode uses one generator set, which is connected to the Emergency side of the contactor (Source E), and one engine start relay. The engine start contact is assigned to the connected generator set and does not change assignment when the preferred source selection is changed. In this mode, if the preferred source selection is set to Source E, the system operates the generator set indefinitely, transferring to utility power only if the generator set fails.

Use the Operating Mode setup screen to change the mode to generator set-generator set or utility-utility if necessary. The gen-gen mode uses two generator sets and requires the assignment of a second engine start output. Use the Input/Output Setup screen to assign one of the main logic board terminal strip or I/O module outputs to Start Source N Generator, and connect the engine start leads for the Source N generator set to the corresponding terminals on the terminal strip or I/O module terminals. See Section 6.12. The programmed engine start output remains tied to the Source N generator set regardless of the preferred source selection.

The utility-utility mode is designed to use utility power for both sources. This mode does not use the engine start outputs.

Time Delays and Source Parameters. Engine start relays and time delays, source voltage and frequency trip points, and load shed time delays are assigned to the source (N or E). They do not change assignment when the preferred source selection is changed.

Note: Source N is always connected to the Normal side of the transfer switch, and Source E is always connected to the Emergency side.

Other time delays are assigned to the source function (preferred or standby). System parameters that are assigned to the function automatically change source when the preferred source selection changes.

Figure 6-8 shows which parameters are assigned to the source and which are assigned to the function. The last two columns of the table show the effect of the preferred source selection on each parameter or time delay.

6.7.3 System Voltage and Frequency

For each source, set the number of phases, nominal voltage, and nominal frequency (50 or 60 Hz). Then proceed to set the pickup and dropout settings.

Item	Assignment	Preferred Source Selection	
		Normal	Emergency
Source N generator engine start relay	Source	N	N
Source E generator engine start relay	Source	E	E
Source N engine start time delay	Source	N	N
Source E engine start time delay	Source	E	E
Source N engine cooldown time delay	Source	N	N
Source E engine cooldown time delay	Source	E	E
Source N voltage and frequency trip points	Source	N	N
Source E voltage and frequency trip points	Source	E	E
In-phase monitor synch	Source	E	E
Pre-transfer to source N	Source	N	N
Pre-transfer to source E	Source	E	E
Post-transfer to source N	Source	N	N
Post-transfer to source E	Source	E	E
Preferred-to-standby time delay	Function	N to E	E to N
Standby-to-preferred time delay	Function	E to N	N to E
Failure to acquire standby source	Function	E	N
Off-to-standby time delay (programmed-transition only)	Function	Off to E	Off to N
Off-to-preferred time delay (programmed-transition only)	Function	Off to N	Off to E
Note: Source N is connected to the Normal side of the transfer switch, and Source E is connected to the Emergency side.			

Figure 6-8 Preferred Source Selection Effect on System Parameters and Time Delays

6.7.4 Voltage and Frequency Pickup and Dropout Settings

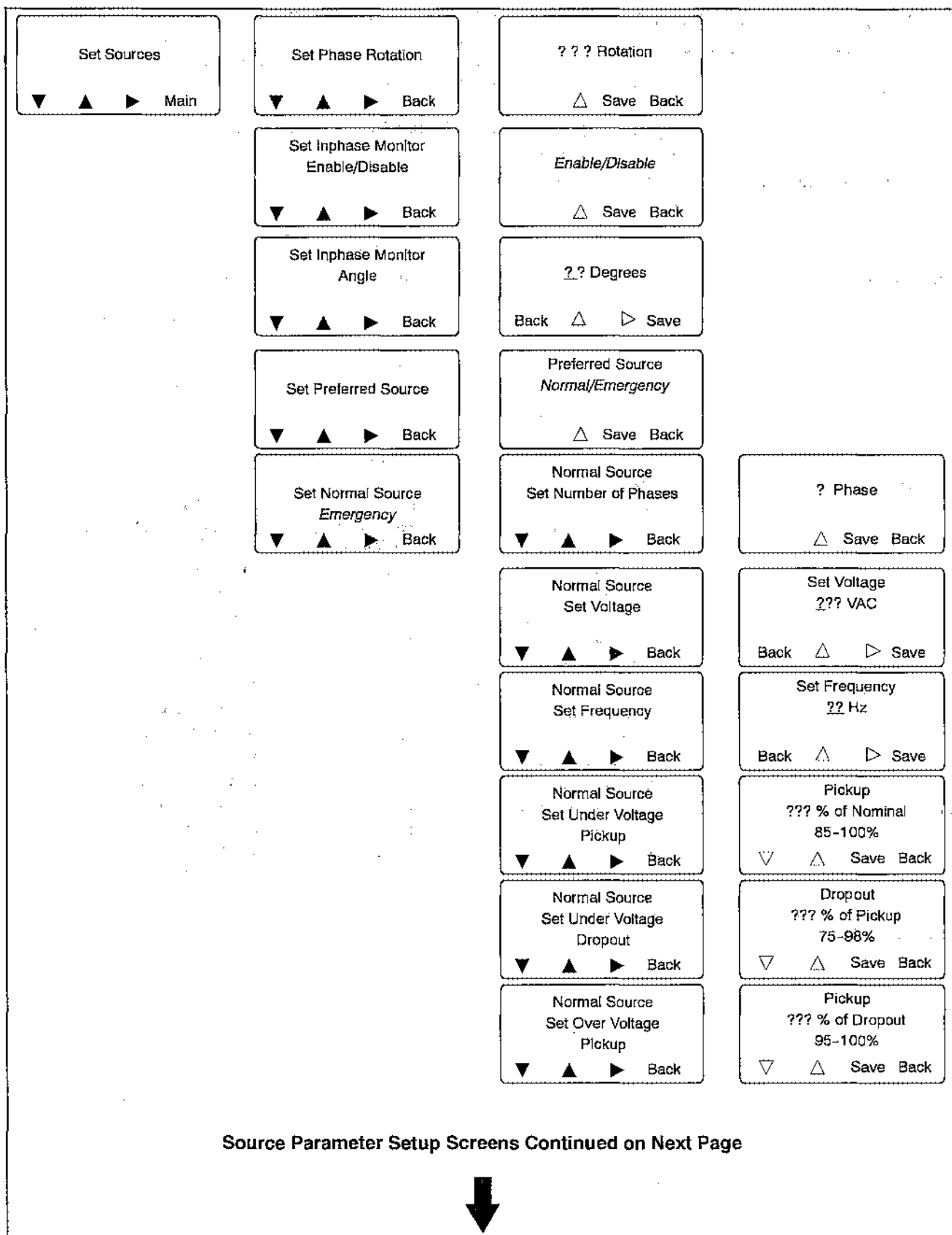
The controller senses the voltage on both sources with an accuracy of $\pm 0.5\%$. A source is considered available when its voltage and frequency are within the range of dropout settings. The debounce time prevents nuisance transfers caused by brief voltage spikes and

dips. If the voltage or frequency of the active source is outside the acceptable range for a length of time longer than the debounce time, the system attempts to transfer the load to the alternate source.

See Figure 6-9 for default settings and adjustment ranges.

Description	Settings	Default Setting	Adjustment Range
Normal source voltage	Under voltage dropout	90%	75% to 98% of Pickup
	Under voltage pickup	90%	85% to 100% of Nominal
	Over voltage dropout	115% (110% for 600 V systems)	106% to 135% of Nominal (maximum 690 Volts)
	Over voltage pickup	95%	95 to 100% of Dropout
	Unbalance enable	Enable	Enable or disabled
	Unbalance drop out	20%	5% to 20%
	Unbalance pick up	10%	3% to 18%
	Debounce time	0.5 seconds	0.1 to 9.9 seconds
Emergency source voltage	Under voltage dropout	90%	75% to 98% of Pickup
	Under voltage pickup	90%	85% to 100% of Nominal
	Over voltage dropout	115% (110% for 600 V systems)	106% to 135% of Nominal (Except 600 V Apps)
	Over voltage pickup	95%	95 to 100% of Dropout
	Unbalance enable	Enable	Enable or disabled
	Unbalance drop out	20%	5 to 20%
	Unbalance pick up	10%	3 to 18%
	Debounce time	0.5 seconds	0.1 to 9.9 seconds
Normal source frequency (Gen-Gen mode of operation only)	Under frequency dropout	99%	95% to 99% of Pickup
	Under frequency pickup	90%	80% to 95% of Nominal
	Over frequency dropout	101%	101% to 115% of Pickup
	Over frequency pickup	110%	105% to 120% of Nominal
	Debounce time	3 seconds	0.1 to 15 seconds
Emergency source frequency	Under frequency dropout	99%	95% to 99% of Pickup
	Under frequency pickup	90%	80% to 95% of Nominal
	Over frequency dropout	101%	101% to 115% of Pickup
	Over frequency pickup	110%	105% to 120% of Nominal
	Debounce time	3 seconds	0.1 to 15 seconds

Figure 6-9 Pickup and Dropout Settings



Source Parameter Setup, continued

Source Parameter Setup Screens Continued from Previous Page:

Normal Source Set Over Voltage Dropout ▼ ▲ ► Back	Dropout ??? % of Nominal 105-135% ▼ ▲ Save Back
Normal Source Set Debounce Time ▼ ▲ ► Back	Debounce Time ?? Seconds 0.1 - 9.9 Seconds ▼ ▲ Save Back
Normal Source Voltage Unbalance Enable/Disable ▼ ▲ ► Back	Voltage Unbalance Enable/Disable ▲ Save Back
Normal Source Voltage Unbalance Pickup ▼ ▲ ► Back	Pickup ??% 3-18% ▼ ▲ Save Back
Normal Source Voltage Unbalance Dropout ▼ ▲ ► Back	Dropout ??% 5-20% ▼ ▲ Save Back
Normal Source Set Under Frequency Pickup ▼ ▲ ► Back	Pickup ??? % of Nominal 80-95% ▼ ▲ Save Back
Normal Source Set Under Frequency Dropout ▼ ▲ ► Back	Dropout ??? % of Pickup 95-99% ▼ ▲ Save Back
Normal Source Set Over Frequency Pickup ▼ ▲ ► Back	Pickup ??? % of Nominal 105-120% ▼ ▲ Save Back
Normal Source Set Over Frequency Dropout ▼ ▲ ► Back	Dropout ??? % of Pickup 105-135% Nominal ▼ ▲ Save Back
Normal Source Set Debounce Time ▼ ▲ ► Back	Debounce Time ?? Seconds 0.1 - 15.0 Seconds ▼ ▲ Save Back

6.8 System Setup

6.8.1 Source Type/Source Type

Set the source type selection for the types of sources used:

- One utility source and one generator set
- Two generator sets
- Two separate utility sources
- One utility source and two generator sets for a three-source system (see Section 6.9)

6.8.2 Transition Type

The transition type is factory set for each model. Select standard or programmed transition, if necessary. Use programmed transition only for models KCP, KSP, KBP, or KGP.

Programmed-transition models stop momentarily in the OFF position during transfer. (The time in the OFF position can be adjusted using the transfer time delays. See Section 6.10.)

6.8.3 Rated Current

This value is factory-set for each unit and should not require adjustment. If necessary, enter the rated current from the transfer switch nameplate.

6.8.4 Three Source Engine Start Mode

See Section 6.9, Three-Source Systems.

6.8.5 Transfer Commit

The transfer commit function controls operation if the preferred source returns after a transfer to standby sequence has been initiated but not completed (i.e., preferred returns during the transfer time delay).

- Setting this function to Commit allows the complete transfer sequence to execute even if the preferred source returns before the load has been transferred to standby.
- Setting this function to No Commit causes the transfer sequence to be cancelled without transfer if the preferred source returns before the load has been transferred to standby.

6.8.6 Remote Test Loading

Select loaded or unloaded for a remote test sequence initiated by a remote test input.

6.8.7 Peak Shave TD Bypass

Peak Shave Operation. When the peak shave input is activated, the generator set starts immediately, bypassing the engine start time delay. The pre/post-transfer time delays, programmed-transition time delays, and in-phase monitor are active if enabled. The ATS transfers the load to the standby source.

Peak Shave TD Bypass. In normal operation, retransfer from standby to preferred is delayed (15 minutes default setting) to ensure that the preferred source is stable before transfer. The Peak Shave TD Bypass allows you to skip the retransfer time delay after peak shave operation.

When the peak shave input is removed, the ATS transfers back to the preferred source according to the Peak Shave TD Bypass setting:

- If the Peak Shave TD Bypass is *enabled*, the retransfer (standby to preferred) time delay is bypassed when the peak shave signal is removed. Notice that by enabling the TD bypass, you are ordering the system to skip the retransfer time delay.
- If the Peak Shave TD Bypass is *disabled*, the retransfer (standby to preferred) time delay executes before the ATS transfers back to the preferred source. Transfer is delayed by the retransfer time delay. The retransfer time delay is adjustable, with a 15-minute factory setting.

If the standby source is lost during peak shave operation, the unit transfers back to the preferred source.

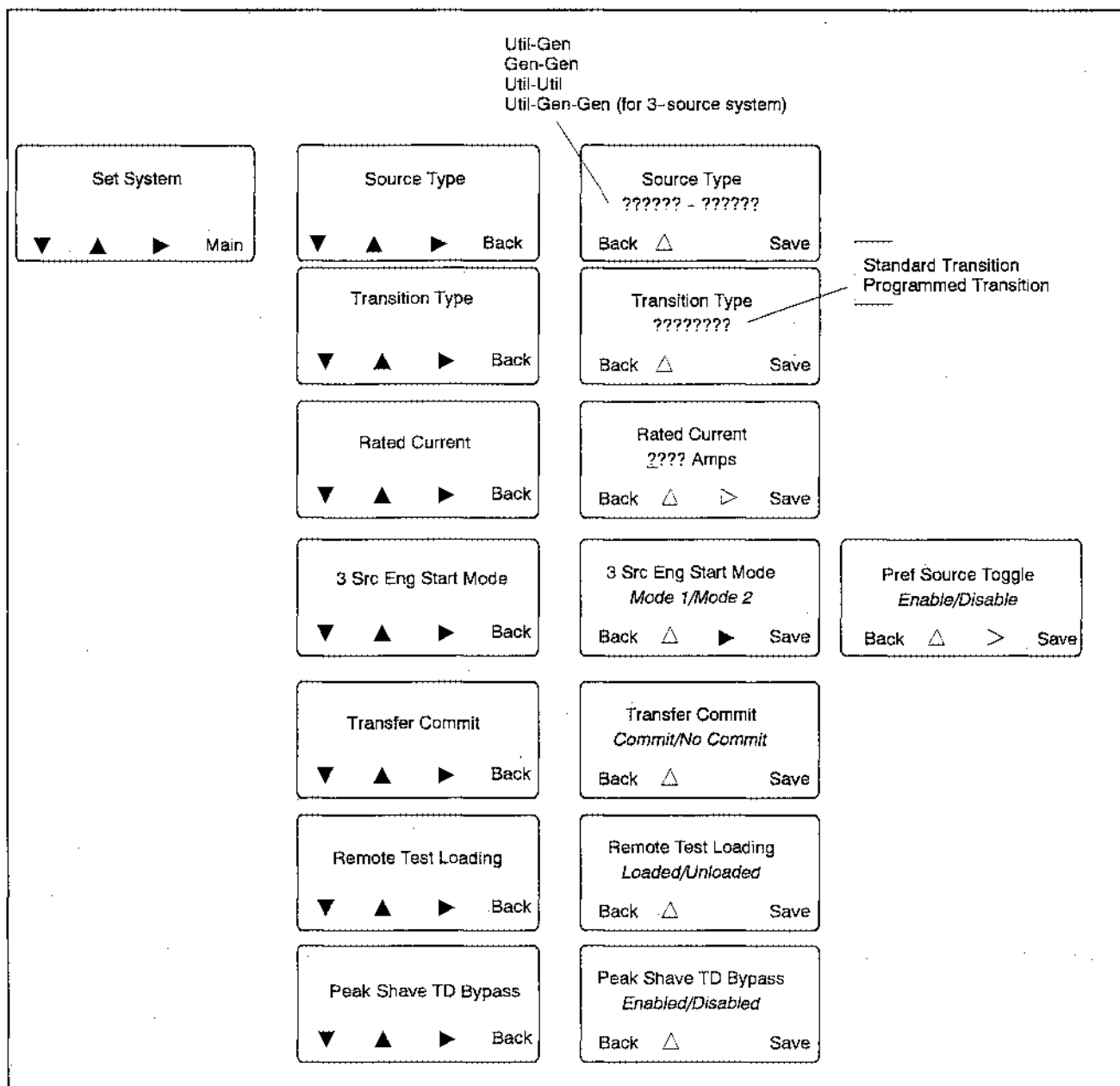


Figure 6-10 System Setup

6.9 Three-Source Systems

A three-source system provides the means to connect a utility and two generators to a single load. See Figure 6-11. Two generators and two transfer switches are required.

Note: The second transfer switch (ATS2) requires an external battery supply module (EBSM) to provide power to the controller.

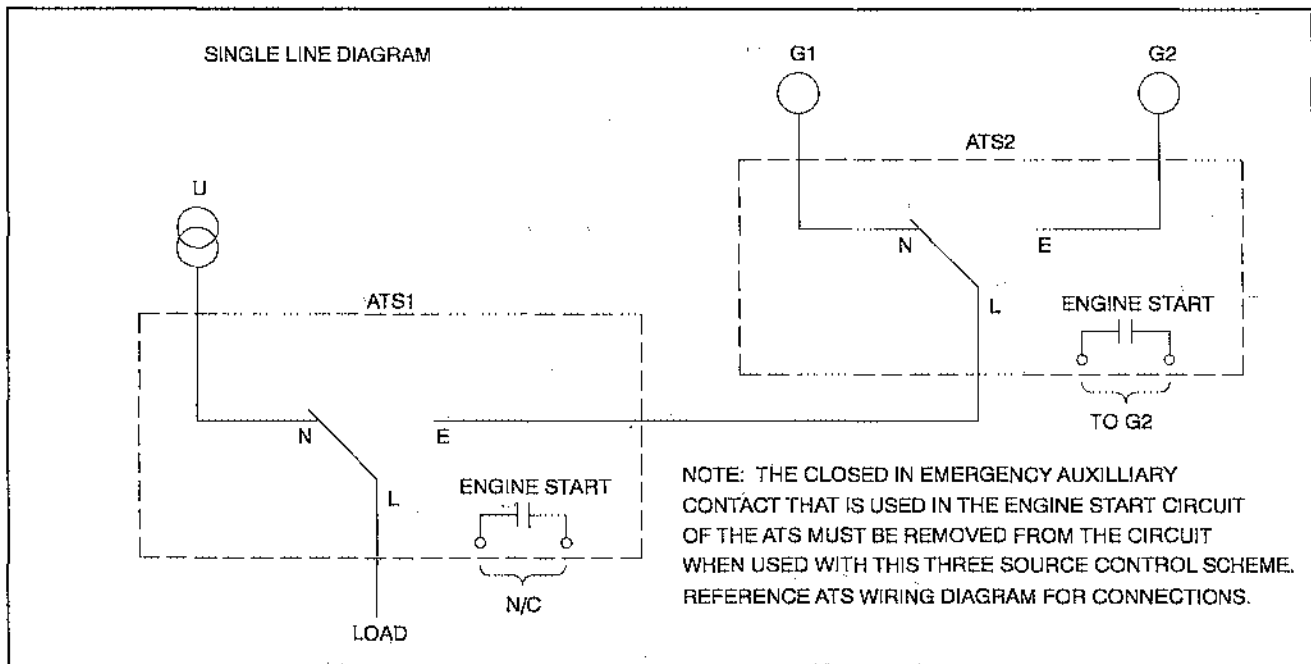
During normal operation, the utility source supplies the load with power. In the event of a utility failure, generator set G1 or G2 will supply the load as described in Sections 6.9.1 and 6.9.2.

6.9.1 Three Source Engine Start Mode

There are two modes of operation for three-source engine start. Select Mode 1 or Mode 2 on ATS2 as needed for the application.

Mode 1

In mode 1 there will be an attempt to start only the preferred source generator. If the preferred source does not achieve voltage and frequency within a fail to acquire time period, the standby engine start contact will close. The fail to acquire will be indicated. If the standby source subsequently fails to achieve voltage and frequency, a separate fail to acquire standby will be indicated.



LEGEND

ATS - AUTOMATIC TRANSFER SWITCH
 EBSM - EXTERNAL BATTERY SUPPLY MODULE
 G1 - GENERATOR #1
 G2 - GENERATOR #2
 K1 - NORMAL RELAY
 K2 - EMERGENCY RELAY
 LED1 - LIGHT EMITTING DIODE (BATTERY 1 REVERSED)
 LED2 - LIGHT EMITTING DIODE (BATTERY 1 REVERSED)
 LED3 - LIGHT EMITTING DIODE (BATTERY SUPPLYING POWER)
 MLB - MAIN LOGIC BOARD
 P(#) - CONNECTOR
 PIOM - PROGRAMMABLE INPUT/OUTPUT MODULE
 MLB - MAIN LOGIC BOARD
 TB(#) - TERMINAL BLOCK
 SW - SWITCH
 U - UTILITY

Note: ATS2 requires an external battery module to maintain power to the controller.

OPERATION

WHEN UTILITY FAILS ATS2 STARTS G1. ATS1 TRANSFERS TO THE EMERGENCY POSITION. IF G1 FAILS ATS2 WILL START G2 AND ATS2 WILL TRANSFER TO EMERGENCY. IF G1 RETURNS THEN ATS2 WILL RE-TRANSFER BACK TO NORMAL. ATS1 WILL RE-TRANSFER BACK TO NORMAL AFTER THE UTILITY RETURNS. WHEN THE UTILITY IS AVAILABLE, THE BATTERY SUPPLY MODULE WILL PROVIDE POWER TO THE CONTROLLER ON ATS2. THE 3 SOURCE SYSTEM DISABLE INPUT AND OUTPUT WILL PREVENT ATS2 FROM STARTING EITHER GENSET WHILE THE UTILITY SOURCE IS AVAILABLE.

THE BATTERY SUPPLY MODULE USES UP TO TWO BATTERY INPUTS (9-36VDC) AND PROVIDES A 12V OUTPUT THAT POWERS THE ATS CONTROLLER. THIS IS CONNECTED TO THE CONTROLLER BY SNAPPING IT TO AN EXISTING I/O MODULE OR THROUGH A HARNESS TO P3 ON THE CONTROLLER (WHEN AN I/O MODULE IS NOT USED). THE BATTERY SUPPLY MODULE WILL CONTINUALLY PROVIDE POWER TO THE CONTROLLER UNLESS THE ON/OFF INPUT ON THE BATTERY SUPPLY MODULE IS ENABLED.

THE ON/OFF INPUT ON TB1 OF THE BATTERY SUPPLY MODULE CAN BE USED IN CONJUNCTION WITH THE NORMALLY OPEN CONTACT OF A PROGRAMMABLE OUTPUT FROM AN INPUT/OUTPUT MODULE TO TURN THE BATTERY SUPPLY MODULE OFF WHEN A SOURCE IS AVAILABLE.

GM286275

Figure 6-11 Three-Source System Transfer Switch and Source Connections

Mode 2

In mode 2 both generators receive a start signal simultaneously. The ATS2 will transfer to the first generator set to achieve proper voltage and frequency. If the first source to available status is preferred, the engine start signal to the standby source will open immediately. If the standby source is the first to available status, the contactor will transfer to the standby position. When the preferred source generator output reaches available status, the controller will transfer to the preferred source and open the engine start contacts to the standby generator (after the cooldown delay has elapsed).

6.9.2 Preferred Source Toggle

The preferred source toggle function alternates between the two generator sets each time the three-source function is activated. If G1 is the preferred source during the first run, then G2 will be preferred during the next run. The preferred source selection will continue to alternate between G1 and G2 for each subsequent run.

6.9.3 Three Source System Test and Exercise

Unloaded Test

Unloaded testing is possible at each transfer switch. Initiating the unloaded test function at ATS1 starts and runs the preferred generator set attached to ATS2. Initiating the unloaded test function at ATS2 starts and runs the standby generator set.

Loaded Test

Loaded testing is also allowed at each transfer switch. Loaded testing of the standby generator set is only possible during a loaded test from ATS1 because the standby generator can only be connected to the load when ATS1 is connected to emergency. To initiate a loaded test of the standby generator set, first use ATS1 to start a loaded test of the preferred source generator set. Then use ATS2 to start a loaded test of the standby generator set.

Unloaded Exercise

The exercise program in ATS2 controls the operation of each generator. The exercise function does not require interaction with ATS1. If the utility is lost during an unloaded exercise event, the event is canceled and the load is transferred to the preferred generator set.

Loaded Exercise

The exercise program in ATS2 controls the operation of each generator. The loaded exercise event requires synchronization with a loaded exercise from ATS1. If the utility is lost during a loaded exercise event, the event is canceled and the load is transferred to the preferred generator set.

6.9.4 Three-Source System Setup

See Figure 6-11 and Figure 6-12 for connections during the following steps.

1. Connect the power sources to the transfer switches as described below. Refer to the transfer switch operation/installation manual or specification sheet for cable sizes. See Figure 6-11 for connections.
 - a. Connect the utility power source to the normal side of ATS1.
 - b. Connect the load to the load side of ATS1.
 - c. Connect the emergency side of ATS1 to the load side of ATS2.
 - d. Connect generator set 1 to the normal side of ATS2.
 - e. Connect generator set 2 to the emergency side of ATS2.
2. Three-source systems require the following input/output connections to control the engine start commands for generator sets 1 and 2. Observe the polarity of all connections shown in Figure 6-12. Use wire sizes from #14 AWG to #20 AWG for EBSM and I/O module connections.
 - a. Connect the ATS2 engine start contacts to the engine start circuit on generator set 2 (G2).

Note: See the Installation Section for the engine start contact locations. Engine start contacts are labeled with a decal.

 - b. Connect one ATS1 main logic board programmable output to one ATS2 main logic board programmable input as shown in Figure 6-12. This I/O connection will be set to Three-Source System Disable.
 - c. Connect one ATS2 main logic board programmable output to the engine start connection on generator set 1 (G1). The ATS1 programmable output will be set to Source N Start Signal.

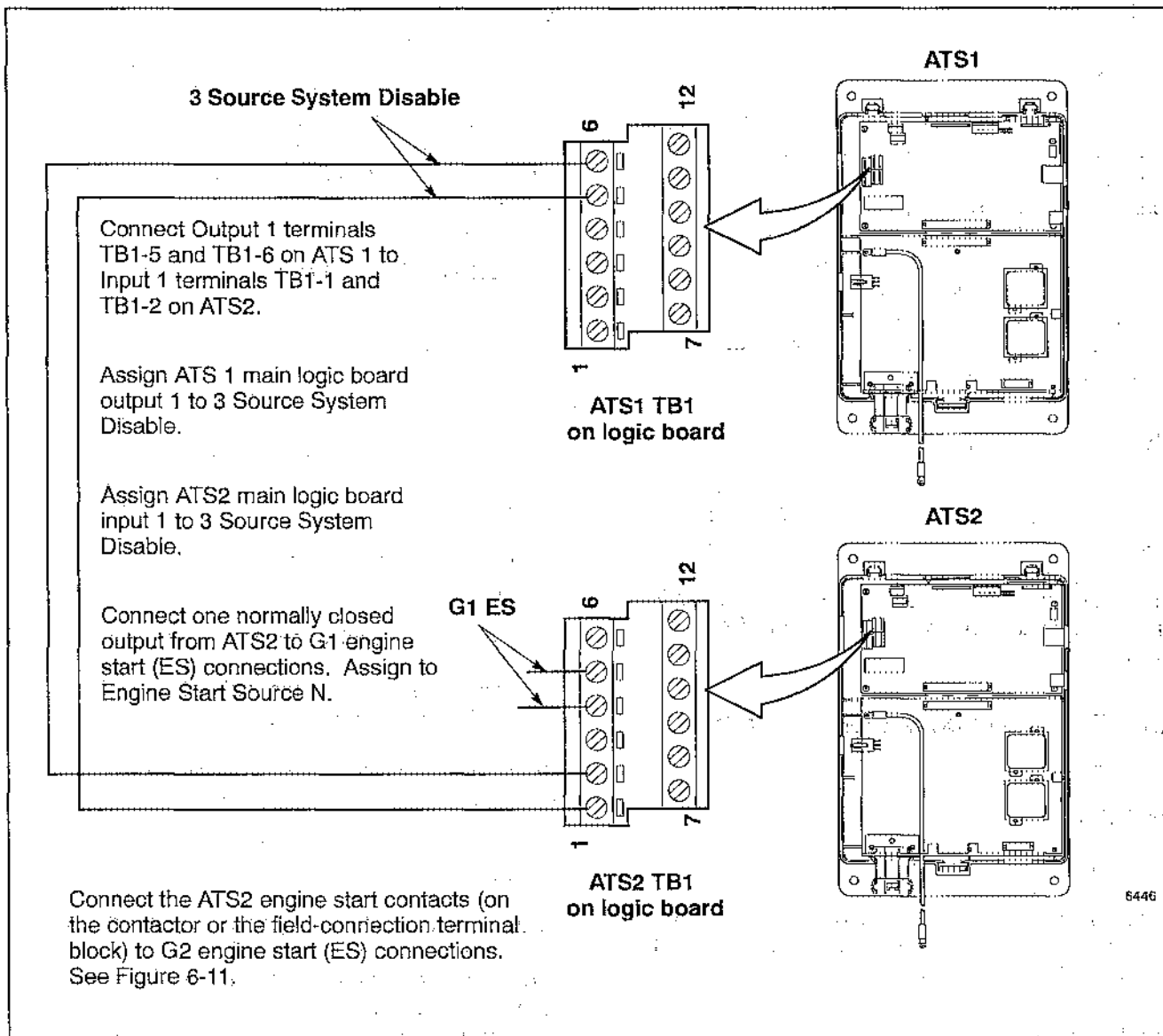


Figure 6-12 Input and Output Connections for Three-Source Systems

3. Connect battery power. Use #14-28 AWG wire to connect the generator set engine starting battery (or batteries) to the BATT1 terminals on terminal block TB13 on the EBSM. (Another battery(ies) can be connected to terminals BATT2 but is not required.) Follow the marking on the board for the positive (+) and negative (-) connections. See Figure 10-14 and Figure 10-15.

Note: If the battery connections are reversed, red LED1 or LED2 will light. Incorrect battery connections can damage the battery module.

4. Set voltage selector switch SW11-1 on the battery module to 12 or 24VDC.

Note: See Section 10.6 for more information on the EBSM.

5. Assign the ATS1 programmable output connected in step 2b. to Three-Source System Disable.
6. Assign the following inputs and outputs for the second transfer switch.
 - a. Assign ATS2 main logic board programmable input 1 to Three-Source System Disable.
 - b. Assign the ATS2 main logic board programmable output connected in step 2c. to Source N Start Signal.

6.9.5 ATS1 and ATS2 System Setup

Use the System Setup Screen on each transfer switch to set the following:

ATS1: Set the Source type to Util-Gen.

ATS2: Set the source type to Util-Gen-Gen. Set the 3 Src Engine Start Mode to Mode 1 or Mode 2 as described in Section 6.9.1.

The transfer switch settings are summarized in Figure 6-13.

Transfer Switch	Source Type	3 Src Engine Start Mode	Preferred Source Toggle	Inputs	Outputs
ATS1	Util-Gen	Not Required	Not Required	Not Required	Three Source System Disable
ATS2	Util-Gen-Gen	Mode 1 or Mode 2 (See Section 6.9.1)	Enable or Disable See Section 6.9.2	Three Source System Disable	Source N Start Signal

Figure 6-13 Transfer Switch Settings for Three-Source Systems

6.10 Time Delays

The engine start time delay and transfer time delays can prevent nuisance transfers caused by brief voltage dips or surges.

6.10.1 Time Delays

The factory settings and adjustment ranges for the time delays are shown in Figure 6-14.

The engine cooldown time delay holds the engine start contacts closed for a designated time after transfer to allow the generator set to run without load before shutting down.

Time Delay Description	Description/Note	Default Time	Adjustment Range
Engine Start, Source E	Emergency source – Util/Gen and Gen/Gen modes	3 sec	0-6 sec*
Engine Start, Source N	Normal source – Gen/Gen mode	3 sec	
Engine Cooldown, Source E	Emergency source – Util/Gen and Gen/Gen modes	5 sec	
Engine Cooldown, Source N	Normal source – Gen/Gen mode	2 sec	0-60 min
Fail to Acquire Stby	If the standby source does not reach acceptable voltage and stabilize within the allowed time, the Fail to Acquire Standby Source fault is activated.	1 min	
Xfr N>E	Transfer delay, preferred to standby	3 sec	
Load # Disc N>E	Pre-transfer to standby source	0 sec	
Load # Add N>E	Post-transfer to standby source	0 sec	
Xfr E>N	Transfer delay, standby to preferred	15 min	
Load # Disc E>N	Pre-transfer to preferred source	0 sec	
Load # Add E>N	Post-transfer to preferred source	0 sec	
In-Phase Xfr Fail	For in-phase monitoring: the time allowed for the two sources to come into synchronization within specified phase angle before a Fail to Synch fault is activated.	30 sec	
Xfr Off>E	Time in the OFF position (Preferred to Standby for programmed transition models only)	1 sec	
Xfr Off>N	Time in the OFF position (Standby to Preferred for programmed transition models only)	1 sec	
Fail to Acquire Pref	If the preferred source does not reach acceptable voltage and stabilize within the allowed time, the Fail to Acquire Preferred Source fault is activated.	1 min	

* The optional external battery module allows extended engine start time delays from 0-60 min.

Figure 6-14 Time Delay Settings

6.10.2 Pre/Post-Transfer Load Control Sequence

The pre/post-transfer load control time delays allow loads to be sequenced on and off prior to and following transfers. The pre-transfer signals are active only when both sources are available. The pre-transfer signals overlap the transfer time delays (Xfr N>E and E>N). The longer delay determines the time delay before transfer. Up to nine loads can be controlled with independent timing sequences for pre- and post-transfer delays in either direction of transfer.

See Section 6.11, Load Control, for more information.

6.11 Load Control

The controller allows control of up to 9 separate loads. The load control function allows selected loads to be disconnected from the source before transfer and reconnected to the source after transfer at different time intervals. The loads can be connected and disconnected at different times for each source. The pre-transfer signals are active only when both sources are available.

When the load control function is activated, the contacts open a programmed length of time before transfer to allow controlled disconnection of selected loads. After transfer, the contacts remain open for a programmed length of time and then close to allow controlled application of selected loads. For example, large motor loads such as an air conditioner can be delayed to start after other essential loads have been transferred.

The load control function is not activated if the controller detects no available source.

The pre-transfer signals overlap the preferred-to-standby and the standby-to-preferred time delays. See Figure 6-15. The longer delay determines the time delay before transfer.

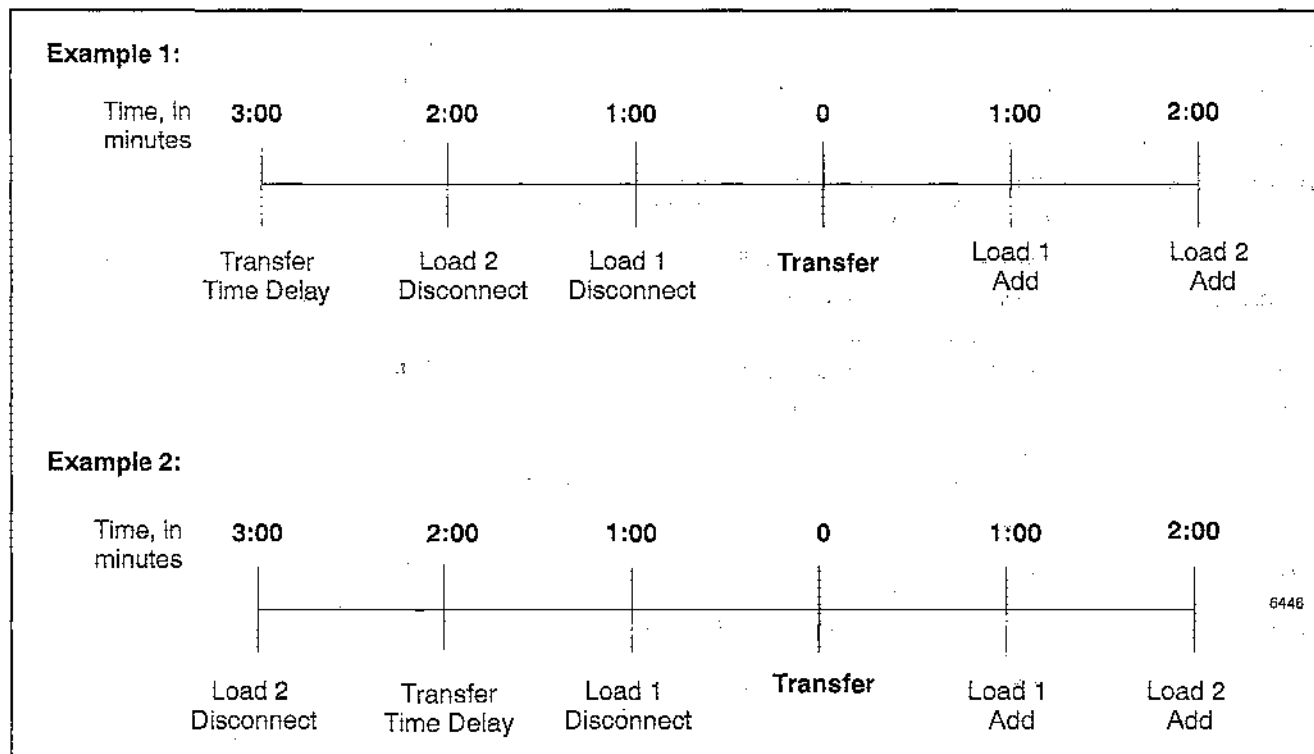


Figure 6-15 Load Control and Transfer Time Delays

Setting up the load control function requires the following steps:

- Connect each selected load to an output terminal on the main logic board or one of the input/output modules. The high power module accessory is available for high voltage or high current loads.
- Use the Set Inputs/Outputs screen to assign the connected output to one of the load control outputs 1-9.
- Use the Set Time Delays screen to set the following associated time delays. Record settings on the worksheet in Appendix C.
 - Load # Disc N>E: pre-transfer time delay disconnects loads a programmed time before transfer from Normal to Emergency. The pre-transfer delays operate during loaded test, loaded exercise, or programmed transfers for peak shave operation when the transfer is controlled.
 - Load # Add E>N: post-transfer time delay adds loads a programmed time after transfer to Normal. The post-transfer time delay allows delayed or staggered addition of selected loads to avoid starting numerous large motors or other large loads at the same time. Staggering the loads can prevent voltage dips as large loads come online.
 - Load # Disc E>N: pre-transfer time delay disconnects loads a programmed time before transfer from Emergency to Normal. When the normal source returns, selected loads can be disconnected from power at different times before transfer.

- Load # Add N>E: post-transfer time delay adds loads a programmed time after transfer to Emergency. The post-transfer time delay allows delayed or staggered addition of selected loads to avoid starting numerous large motors or other large loads at the same time. Staggering the loads can prevent voltage dips as large loads come online.
- Loads to Add: Enter the number of loads that have been connected to load control outputs for pre-transfer disconnect and delayed reconnect.

6.12 Programmable Inputs and Outputs

All of the inputs and outputs are unassigned until the installer or operator assigns a function to the I/O.

Note: Each programmable input and output requires a connection to the transfer switch. Do not change the programmable input/output assignments without verifying the transfer switch input and output connections.

The programmable inputs and outputs on the controller's main logic board and input/output (I/O) modules can be assigned to the functions shown in Figure 6-16 and Figure 6-17. Assign functions to the programmable inputs and outputs through the controller interface using the Setup Screen—Set Inputs/Outputs. Record setting in the worksheet in Appendix C for reference, if desired.

			
Programmable Inputs	LED	LED	Display Message
Bypass Contactor Disable	None	Flashing	Bypass Contactor Disable
Forced Transfer to OFF (programmed-transition models only; requires load shed accessory; not applicable to bypass/isolation switches)	None	Flashing	Forced Off
Inhibit Transfer (maintenance mode)	None	Flashing	Inhibit Transfer
Low Battery Voltage	Steady	None	Low Battery Voltage
Peak Shave Mode	None	None	Peak Shave
Remote End Time Delay	None	None	None
Remote Common Alarm	Steady	None	Remote Common Alarm
Remote Test	None	None	Normal test sequence screens. See Section 5.5.
Remote Monitor In #1-4	None	None	None
Three-Source System Disable	None	None	None

Figure 6-16 Available Programmable Inputs

Programmable Output	Type	See Section
Alarm Silenced	Monitor	10.5
Preferred Source Available	Monitor	6.7.4
Standby Source Available	Monitor	6.7.4
Contactor in Preferred Position	Monitor	—
Contactor in Standby Position	Monitor	—
Contactor in OFF position	Monitor	—
Contactor in Source N Position	Monitor	—
Contactor in Source E Position	Monitor	—
Not in Auto	Monitor	4.2.2
Load Control Active	Monitor	6.11
Low Battery (external battery)	Monitor	10.6
Exerciser Active	Monitor	6.14, 8.2.3
Test Mode Active	Monitor	8.3
Peak Shave Active	Monitor	6.8.7
Non-Emergency Transfer	Monitor	—
Battery Backup Low (not used) *	Monitor	*
Maintenance Mode	Monitor	6.2
Audible Alarm	Control	10.5
Load Bank Control Active	Control	6.12.4
Source N Start Signal	Control	6.12.4, 6.9
Source E Start Signal	Control	6.12.4
IPM Synching	Control	6.12.4, 6.7.1
Load Control Out 1-9	Control	6.11
Soft Control RDO #1-4	Control	6.12.4
3 Src Sys Disabled	Control	6.9
Common Alarm Active (1 and 2)	Fault	6.13
Source N Under Voltage	Fault	6.7.4
Source N Over Voltage	Fault	6.7.4
Source N Voltage Unbalance	Fault	6.7.4
Source N Loss of Phase	Fault	—
Source N (Phase) Rotation Error	Fault	—
Source N Over Frequency	Fault	6.7.4
Source N Under Frequency	Fault	6.7.4
Source E Under Voltage	Fault	6.7.4
Source E Over Voltage	Fault	6.7.4
Source E Voltage Unbalance	Fault	6.7.4
Source E Loss of Phase	Fault	—
Source E (Phase) Rotation Error	Fault	—
Source E Over Frequency	Fault	6.7.4
Source E Under Frequency	Fault	6.7.4
Fail to Acquire Standby	Fault	8.6
Fail to Acquire Preferred	Fault	8.6
Fail to Transfer	Fault	8.6
I/O Module Lost Comm	Fault	8.6
Aux Switch Fault	Fault	8.6
Aux Switch Open	Fault	8.6
* Do not use the Backup Battery Low output. A design improvement has eliminated the need for a backup battery.		

Figure 6-17 Available Programmable Outputs

Some inputs will trigger an indicator LED on the user interface and/or display a message on the LCD screen when they are activated. See Figure 6-16.

Input and output functions can also be assigned over Modbus using Monitor III software. Refer to Monitor III operation manual for instructions.

6.12.1 Main Logic Board Inputs and Outputs

There are two programmable inputs and two programmable outputs on the controller's main logic board. Additional inputs and outputs are available through the installation of optional input/output modules.

See the Installation Section for connection information for main logic board inputs and outputs.

6.12.2 Input/Output Modules

Input/output (I/O) modules are optional accessories. The standard I/O Module has two inputs and six outputs. The high-power I/O module has two inputs and three outputs. The I/O modules specifications are shown in Section 10.4.

See Section 10.4 for I/O module connection information.

6.12.3 Input Functions

Available input functions are shown in Figure 6-16.

All of the inputs may be assigned to either one or both of the common alarms.

Note: Switches equipped with the load shed accessory have one input factory-set to Forced Transfer to OFF. Do not change this setting.

Forced Transfer to OFF Input. This function requires the load shed accessory installed on a programmed-transition model transfer switch. The load shed accessory is not available for bypass/isolation switches. Activation of this input signals the transfer switch to transfer immediately from Source E to the OFF position. The transfer switch then transfers to Source N if it is available, executing the applicable time delays.

See Section 10.10 for more information about the load shed (forced transfer to OFF) function.

Remote Monitored Inputs. There are four remotely monitored input functions. These functions can be assigned to any of the inputs on either the main logic board or standard/high voltage/high current I/O boards. The state of any or all of these inputs can be monitored via Modbus messages only (i.e. through Monitor III software or other Modbus application).

Peak Shave/Area Protection Input. Starts the generator set and transfers to the standby source, ignoring the engine start time delay. The pre/post-transfer, delayed-transition time delays, and in-phase monitor will be active if enabled.

When the peak shave signal is removed, the load transfers back to the preferred source. The pre/post-transfer, delayed-transition, and engine cooldown time delays, along with the in-phase monitor if enabled, will be executed.

If the standby source is lost during peak shave, the unit will transfer back to the preferred source.

See Section 6.8.7 for information about the Peak Shave TD Bypass.

Remote Bypass Time Delay Input. Allows a remote signal to end an active time delay. The signal ends only the time delay that is active at the time the signal is applied. Repeated signals are required to end additional time delays. Does not end the programmed-transition time delays or an exerciser run.

6.12.4 Output Functions

Output functions are shown in Figure 6-17. Refer to the section number shown for more information about the function.

In-Phase Monitor Synch Output. Indicates that the in-phase monitor is waiting for the sources to come into phase prior to transfer. See Section 6.7.1 for more information about the in-phase monitor.

Load Control Output, 1-9. The pre/post-transfer load control time delays allow loads to be sequenced on and off prior to and following transfers. See Section 6.11 for more information about load control.

The pre- and post-transfer time delays can be adjusted through the Setup Screen—Set Time Delays. See Section 5.7.3.

Load Bank Control Output. The load bank control output is a C form contact that can be used to apply a load to the generator set during an unloaded exercise or test. The load bank control output is active during each unloaded test and unloaded exercise.

The load bank control output closes or opens a contact that can be used to signal the load bank controller to operate. Connect the normally open or normally closed output contact to the load bank controller as required for proper operation. Refer to the connection instructions provided by the load bank manufacturer.

If the Normal source is lost during an exercise period, the load bank control output is deactivated to remove the load bank and allow the transfer of the building load to the emergency source.

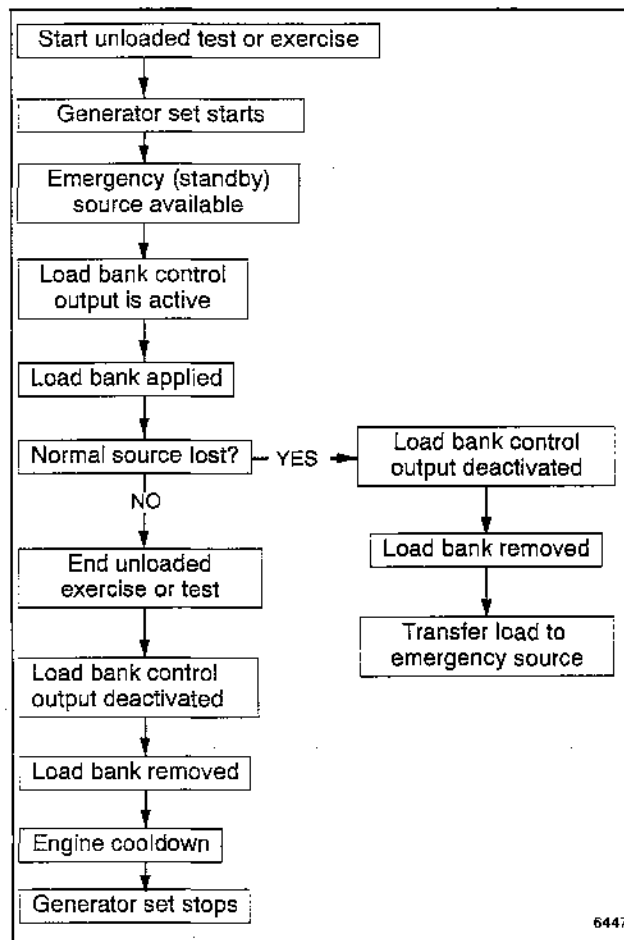


Figure 6-18 Load Bank Control Sequence

Software Controlled Outputs. There are four Software Controlled Output functions. These four functions can be assigned to any of the outputs on either the main logic board, or the standard/high voltage/high current I/O boards. The state of any or all of these four functions can be controlled and monitored via Modbus messages only.

Source N Engine Start Signal. Use if Source N is a generator set, especially for three-source systems. See Section 6.9 for more on three-source systems.

Source E Engine Start Signal. An alternative to the engine start contacts on the transfer switch.

Other Inputs and Outputs. Other input and output functions can be assigned to the programmable TB1 terminals. Refer to Figure 6-16 and Figure 6-17 for lists of available programmable inputs and outputs. Use the Set Inputs/Outputs Screen to change the input and output assignments if necessary. See Section 5.7.5.

Each of the defined inputs may be set to raise an alarm or simply monitor the input.

6.12.5 User-Defined I/O Function Descriptions

The controller can store a 19-character string description for each of the 9 user controllable/monitored I/Os. Use Monitor III software to enter descriptions. Descriptions are not used by the controller and are only available for reading and writing over Modbus.

6.12.6 Assigning Inputs and Outputs

Use the Input/Output Setup Screen to assign input and output functions on the main logic board and on optional I/O modules. See Figure 6-19.

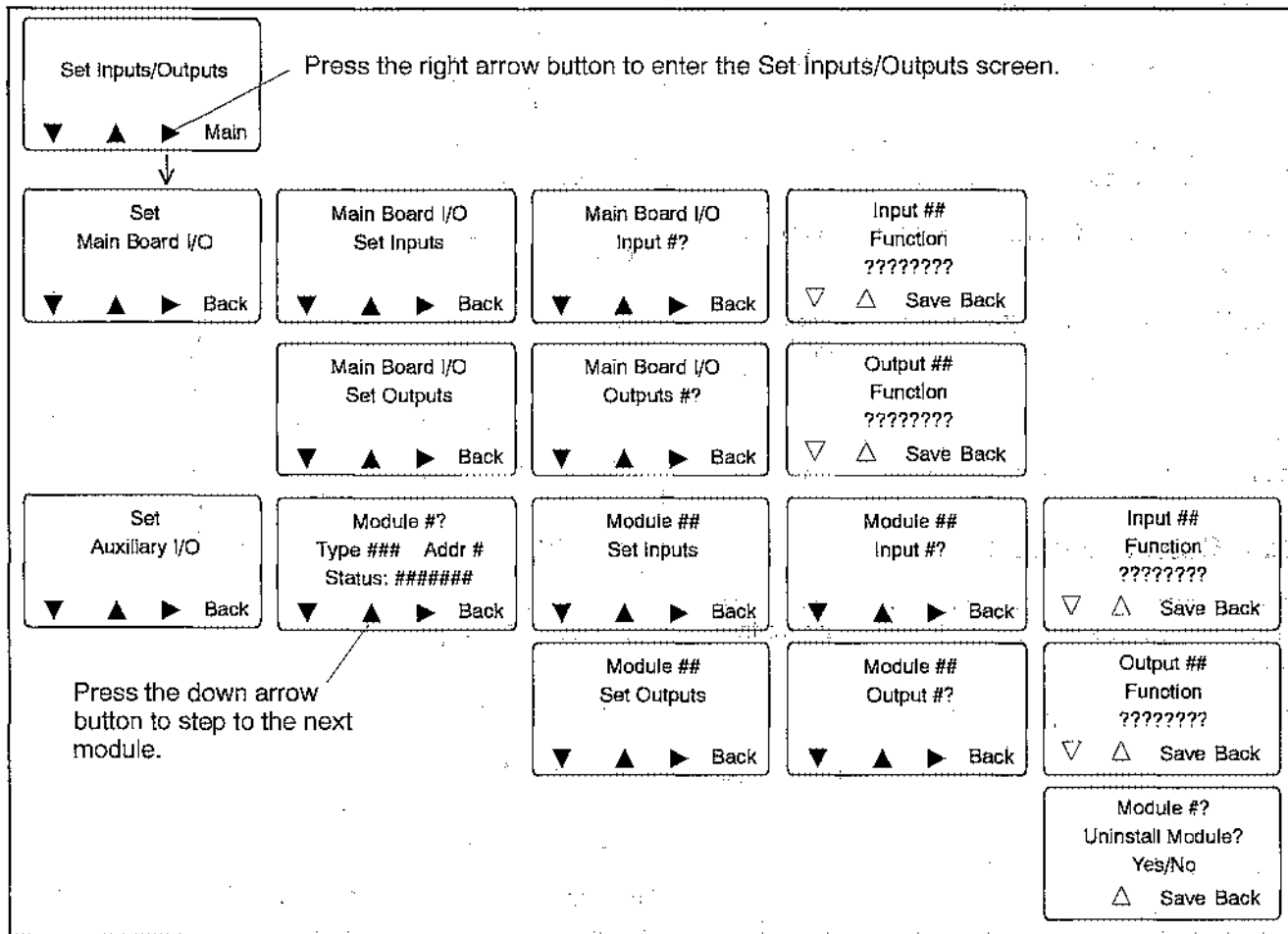


Figure 6-19 Assigning Inputs and Outputs

6.13 Common Alarms

Use the Common Alarms setup screen to assign events to the controller's common alarm groups. See Figure 6-20 for a list of functions that can be assigned to the common alarm and the audible alarm.

Alarm Descriptions	
Aux Switch Fault*	Src E Over Voltage
Aux Switch Open*	Src E Rotation Err *
Contactor in Off	Src E Under Freq
Contactor in Pref	Src E Under Voltage
Contactor in Src E	Src E Voltage Unbal
Contactor in Src N	Src N Loss of Phase
Contactor in Stby	Src N Over Freq
Exerciser Active	Src N Over Voltage
Fail to Acquire Pref *	Src N Rotation Err *
Fail to Acquire Stby *	Src N Under Freq
Fail to Transfer *	Src N Under Voltage
IPM Synching	Src N Voltage Unbal
Load Bank Ctl Active	Stby Src Available
Load Control Active	System Ready
External Battery Low *†	Test Mode Active
Non-Emergency Trans	Critical Service Required
Not in Auto	Man Transfer Waiting
Peak Shave Active †	Module Lost Comm *
Pref Src Available	Non-Critical Service Req
Remote Common Alarm *	Source E Available
Remote Monitor in #1-4	Source N Available
Src E Loss of Phase	MBUS-Control RDO #1-4
Src E Over Freq	
* Assigned to Critical Service Required alarm	
† Assigned to Non-Critical Service Required alarm	

Figure 6-20 Alarm Descriptions

6.13.1 Common Alarm Output

Functions can be assigned to two alarm groups. The groups can then be assigned to programmable outputs, if desired. Any function assigned to the Common Alarm triggers the Common Alarm programmable output. See Section 6.12, Programmable Inputs and Outputs, for more information about programmable outputs.

6.13.2 Audible Alarm

The audible alarm setting requires the Alarm Module accessory for operation. See Section 10.5 for more information about the alarm module.

6.13.3 Chicago Alarm

The Chicago Alarm function requires the alarm module accessory.

The Chicago alarm function is a programmable feature of the MPAC 1500 controller. The alarm is active when the transfer switch is in the Emergency position. The alarm can be silenced via the user interface, which will also activate a light indicating the alarm-silenced condition. The alarm silenced light is deenergized when the transfer switch returns to the Normal position.

For Chicago Alarm Mode, use the Common Alarm Setup screen to assign the necessary faults and conditions to the audible alarm. Be sure to assign the Contactor in Standby function to trigger the audible alarm.

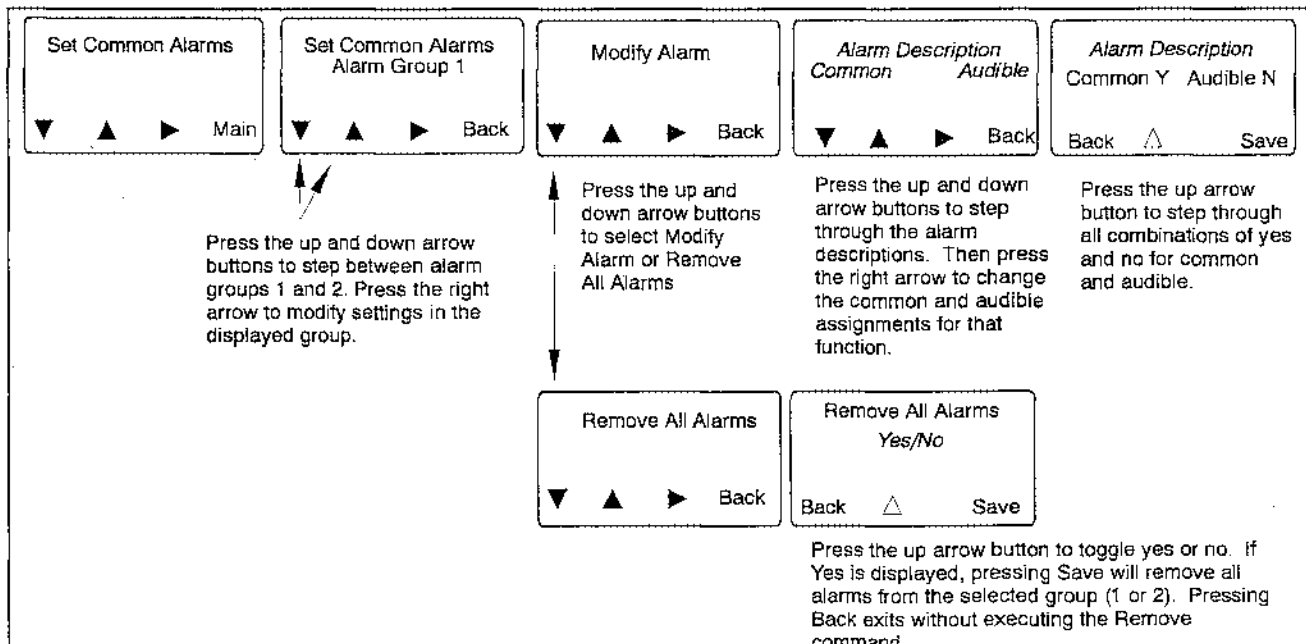


Figure 6-21 Setting Common Alarms

6.14 Exerciser

The exerciser uses a calendar-based scheduling system. Up to 21 different exercise events can be scheduled, each with different settings. Exerciser settings include the start date, start time, run duration, type (loaded or unloaded), interval, and repeat rate.

An exercise event can be temporarily disabled to prevent its execution and then reenabled later using the enable/disable setting.

The next scheduled exercise time and date are indicated on the main screen. (See Figure 5-1.)

If a system test or peak shave is active when the exercise is scheduled to occur, the exercise is skipped. A preferred-source failure during an exerciser period causes the exercise to be terminated and normal ATS operation to resume.

6.14.1 Setting Exerciser

See Figure 6-22 and Figure 6-23. Record settings on the worksheet in Appendix C if desired.

6.14.2 Source/Source Mode

In the Util-Gen mode, the exercise function occurs on the standby source. In Gen-Gen mode, the standby source generator set is exercised.

In a three-source system, there are two generators on the standby transfer switch. The exercise function is programmed and controlled by the standby transfer switch. For a loaded exercise, the standby transfer switch schedule is synchronized with the preferred transfer switch and the standby exercise occurs within the preferred transfer switch exercise period. This allows either generator set to run under the load designated by the utility exercise periods.

6.14.3 Load Bank Control

The load bank control output is active during an unloaded exercise or unloaded system test. If the contactor is transferred to the standby position, the load bank control will be deactivated. (Standby source is supplying power to the load).

Exerciser Parameter	Description
Event Number	Each scheduled exercise is called an event. Up to 21 different exercise events can be set, each with different settings for the parameters shown in this table.
Enable/Disable	Enable the event to allow it to run as scheduled. Disable an event to prevent it from running. The event remains on the calendar so that it can be enabled again at a later time. This allows you to temporarily prevent a scheduled exercise event from running, and then enable it again later without having to re-enter all the settings.
Loaded/Unloaded	A loaded exercise starts the generator set and transfers the electrical load from the normal source to the standby generator set. An unloaded exercise will start and run the generator set without transferring the load.
Interval	Daily, weekly, monthly, or day/month. This setting works with the repeat rate to set the time interval between exercise runs. The day/month selection allows you to set the exerciser to run on the same day every month. For example, the exerciser can be set to run the first Sunday of every month. Use caution with the day/month selection. For example, selecting day/month on the 5th Friday of the month will cause the exerciser to run only during months that have five Fridays.
Repeat Rate	The repeat rate works with the interval to set the time interval between exercise runs. For example, if Day is selected as the interval, and 5 is selected as the repeat rate, then the exercise will repeat every 5 days. Select a number between 1 and 12.
Duration	Enter the exercise run duration in hours:minutes. For example, a run time of 00:30 will run the generator set for 30 minutes. The maximum run time is 24 hours.
Start Date	Enter the date, month/date/year, of the first exercise event. Subsequent events will be scheduled based on the interval and repeat rate.
Start Time	Enter the desired start time of the exercise run in hours:minutes. The time settings range from 00:00 to 23:59, with 00:00=midnight.

Figure 6-22 Exerciser Settings

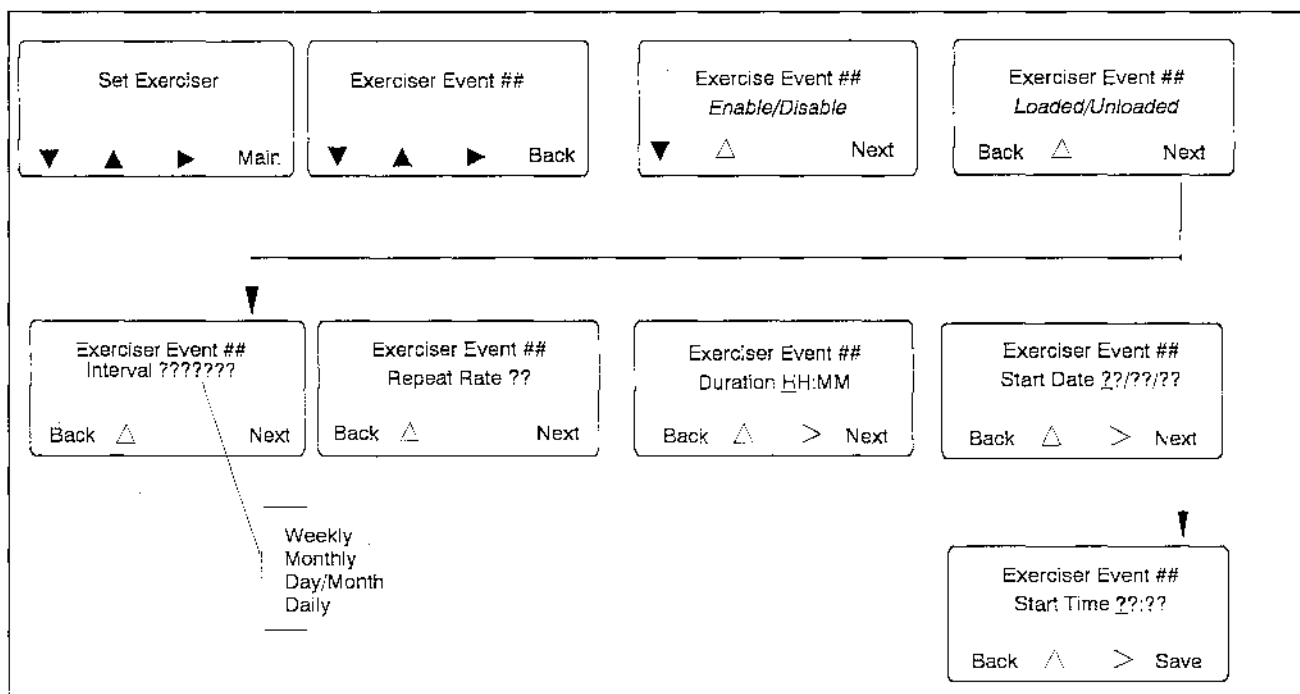


Figure 6-23 Setting the Exerciser

6.15 Set Passwords

Two passwords control access to the Test and Setup screens. Passwords are 4-digit numerical values ranging from 0000 to 9999. The default passwords are set to 0000. Change the passwords to prevent unauthorized access to the Test initiation screens and system settings.

Note: A DIP switch on the controller's main logic board allows the setup password to be disabled. The DIP switch does not disable the test password.

6.16 Communications

Use the communications setup screen to set the communication parameters for serial or ethernet connections. See Section 7, Communications, for instructions.

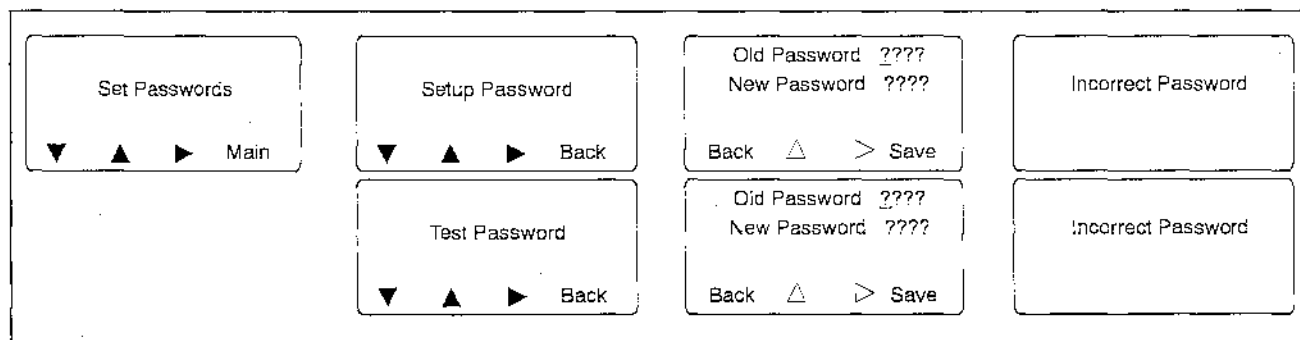
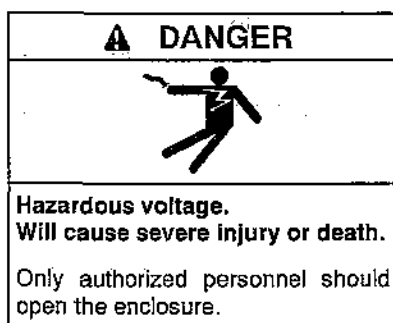


Figure 6-24 Setting/Changing Passwords

6.17 Calibration



Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically.
(600 volts and under)

The transfer switch voltage and current sensing (if equipped) are calibrated at the factory. If voltage recalibration is necessary, refer to the Test Section for instructions to check the voltages, and then use the Setup Screen-Calibration to enter the measured values. See Figure 6-25.

The current sensing accessory is required in order for the transfer switch to measure and display the current values. See Section 10.9. Use a clamp-on current sensing meter to measure the current and enter the measured values through the Setup Screen-Calibration shown below.

Calibration ▼ ▲ ► Main	Calibrate L - N Voltages Source N(E) ▼ ▲ ► Back	Calibrate L1 - L0 Voltage ▼ ▲ ► Back	L1 - L0 VAC ### Cal VAC 2 ? ? Back ▲ ► Save
	Calibrate L - L Voltages Source N(E) ▼ ▲ ► Back	Calibrate L1 - L2 Voltage ▼ ▲ ► Back	L1 - L2 VAC ### Cal VAC 2 ? ? Back ▲ ► Save
	Calibrate Load Current ▼ ▲ ► Back	Calibrate LA Current ▼ ▲ ► Back	LA Amps #### Cal Amps 2 ? ? ? Back ▲ ► Save

Figure 6-25 Calibration

Section 7 Communications

7.1 Introduction

The MPAC™ 1500 controller has three types of communications connections: an RS-485 serial port, an ethernet port, and a USB port.

Use Ethernet or serial connections to connect the transfer switch to a personal computer for system monitoring and control using Kohler® Monitor III software or other Modbus applications.

The controller uses Modbus® TCP/IP communication protocol over the Ethernet port. The controller uses Modbus® RTU communication protocol over the serial ports. The Modbus registers are available in the Modbus Protocol manual. See the List of Related Materials.

Note: Modbus® applications other than Monitor III software require a Modbus software driver written by a trained and qualified systems programmer.

The USB port is used for file transfer between the controller and a memory device. The USB port is a standard 4-pin USB connector. The USB Access screen appears when a device is connected to the USB port. See Section 7.4 for instructions to transfer files through the USB port.

7.2 Connections

See Figure 7-1 for the connector locations.

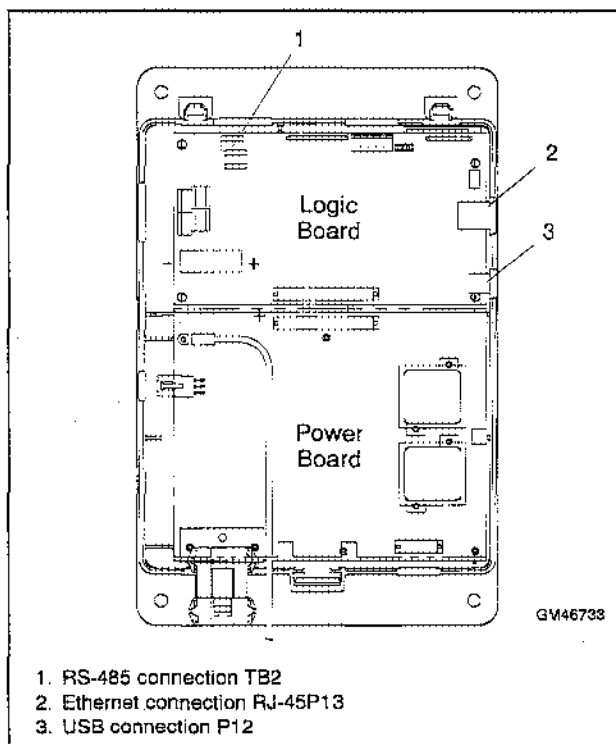


Figure 7-1 Communication Connections (controller cover removed for illustration only)

7.2.1 Serial Connections

Use serial connections to TB2 on the controller's logic board to connect the transfer switch to a personal computer, the optional ATS remote annunciator, or a Modbus network. System monitoring and control using Kohler® Monitor III software requires serial connection to a personal computer as described in this section. See Figure 7-1 for the location of TB2.

See Figure 7-2. Notice that a terminating resistor is recommended on the last device in a network. If there is only one device, a terminating resistor may be required depending on the cable distance and communication speed. Long cables and fast speeds will increase the need for a terminating resistor.

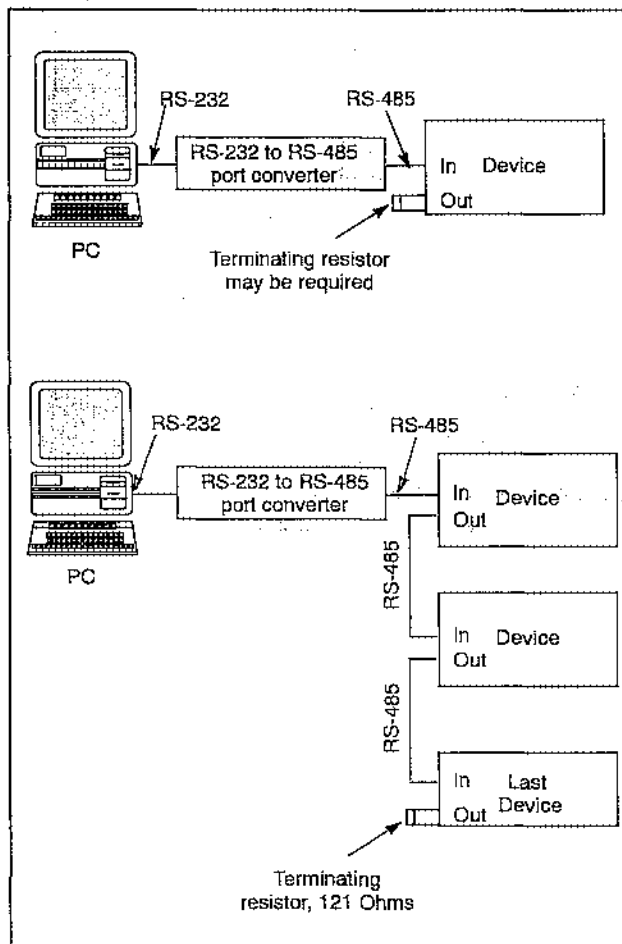


Figure 7-2 Serial Connections

The serial port is an isolated RS-485 port with connection speeds of 9.6, 19.2, and 57.6 kbps. Use shielded twisted-pair cable to connect to the RS-485 connectors on the main logic board terminal strip TB2 for serial connections. For connection to a PC, use an RS-485 to RS-232 converter GM41096 and connect to the PC's serial port.

Connect the Modbus input and output to the terminals shown in Figure 7-3. Use #12-24 AWG twisted-pair wire. Belden cable #9841 or equivalent is recommended. Connect the shield to ground. Tighten the connections to 0.5 Nm (4.4 in. lb.).

Use Modbus RTU (remote terminal unit) protocol for communication through the serial port. A map of the Modbus codes for this controller is available. Contact your local distributor/dealer.

Note: Modbus® applications other than Monitor III software require a Modbus software driver written by a trained and qualified systems programmer.

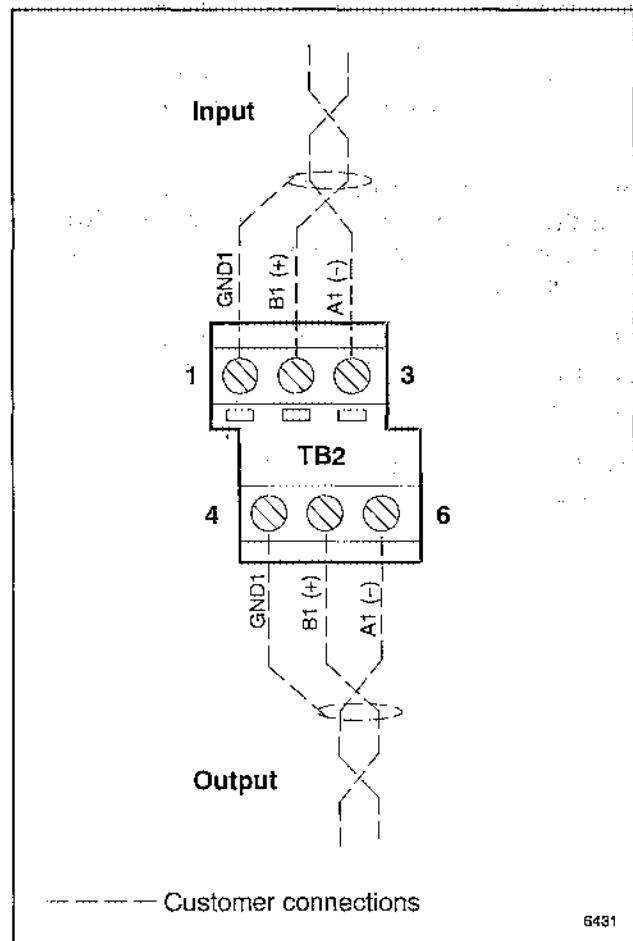


Figure 7-3 Main Logic Board Modbus RS-485 Connections to TB2

7.2.2 Ethernet Connections

The transfer switch can be connected to a building's ethernet network to communicate with personal computers connected to the same subnet. Work with the building's network manager to obtain an IP address and subnet mask information.

Ethernet Port. The ethernet port is a standard RJ-45 female plug on the controller's main logic board. See Figure 7-1 for the location of the Ethernet port. Use Category 5e or better cable to connect the controller to the building's network. The ethernet connection allows the controller to communicate with a personal computer on the network to run Monitor III Software or other Modbus applications.

Note: For an ethernet connection, obtain an IP address and subnet mask number from the local system administrator.

Use the Setup menus to assign a port number, IP address, and subnet mask number from the controller's front panel. The controller may have a default IP address assigned at the factory for test purposes. See Figure 7-4. **Change the IP address to an address owned by the user.** See Section 6.16 for instructions to set the communication parameters.

The series 1500 controller does not operate as a Modbus-to-Ethernet converter for other devices in a network. For multiple device networks connected to the personal computer through the Ethernet, use a Modbus-to-Ethernet converter for the other devices in the network. See Figure 7-5 and instruction sheet TT-1405, provided with the converter, for connection instructions.

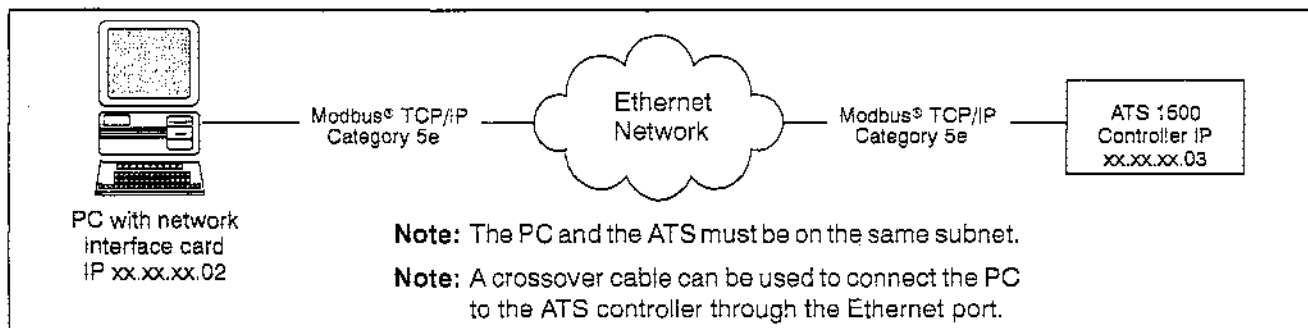


Figure 7-4 Remote Network (Ethernet) Connection

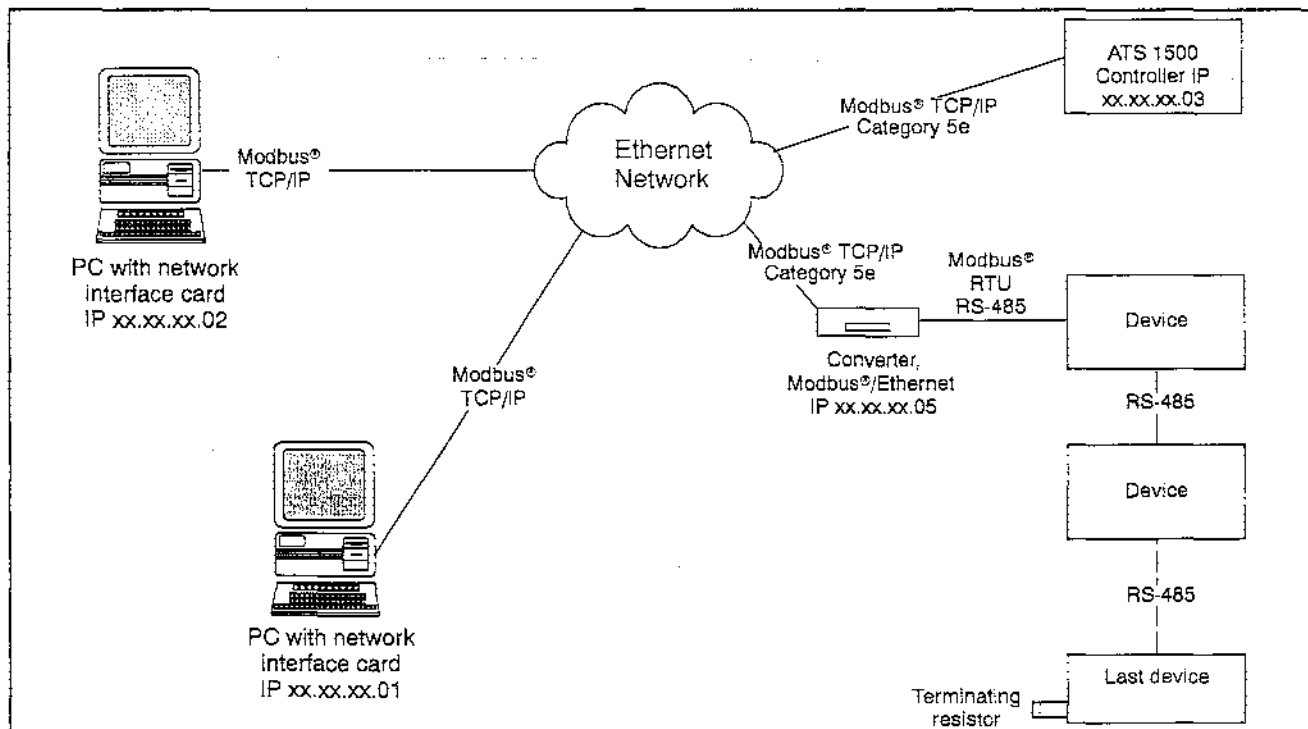


Figure 7-5 Ethernet Connections to Multiple-Device Network

The controller can communicate with up to eight (8) simultaneous TCP/IP (ethernet) connections. If anyone attempts to establish a ninth connection, the first connection that was established will be dropped. These eight connections do not include the RS-485 serial port. In the extreme case, eight users may be communicating with the controller via TCP/IP network connections and another may be communicating through the serial port, for a total of nine communication channels. As the controller is asked to communicate with more and more outside devices, its performance will slow down.

7.3 Communications Setup

Use the communications setup screen to set the communication parameters for serial or ethernet connections. See Figure 7-6. The controller uses Modbus® communication protocol.

The figure shows a graphical user interface for 'Communications Setup'. It consists of two main columns of boxes. The left column contains a vertical stack of seven menu boxes, each with a title and navigation arrows (down, up, right) and a 'Main' or 'Back' button. The right column contains seven corresponding configuration boxes with labels, values, and 'Back', 'Save', and 'Main' buttons. The configuration boxes are: 1. MODBUS Server TCP (Enabled/Disabled), 2. MODBUS Server Port # (Enabled/Disabled), 3. MODBUS Addr Port # (???, Save), 4. Baud Rate Port # (?????, Save), 5. MODBUS TCP Unit ID (???, Save), 6. IP Address (???.???.???.???, Save), 7. Subnet Mask (???.???.???.???, Save). A callout box points to the Baud Rate Port # field, listing values 9600, 19200, and 57600.

Figure 7-6 Communications Setup

7.3.1 Serial Communication

Set the following communication parameters for serial communication. Also see Figure 7-7.

Baud Rate. Required for serial connections. The baud rate must match the baud rate of the connected PC.

Modbus Server. Enable the serial port for Modbus communication.

Modbus Addr. Assign a unique address between 001 and 247 to the serial port.

Setting	Range	Needed for Connection Type:			Notes
		Serial	Remote Serial (modem)	Ethernet	
Modbus Server TCP	Enabled or Disabled			X	Enable for network communication through the ethernet port.
Modbus Server	Enabled or Disabled	X	X		Enable for Modbus communication through the serial port on the main logic board. See Section 7.2.
Modbus Addr	001-247 default 1	X	X		Address for the RS-485 serial port (on the logic board).
Baud Rate	9600, 19200, 57600	X	X		Baud rate in bits per second for serial communication between the controller and a personal computer's COM port.
Modbus TCP Unit ID	---	—	—	X	Factory-set to 3. A unit ID is required for Modbus over TCP communication. The unit ID for TCP communication is analogous to the Modbus address for serial communication through the RS-485 ports.
IP Address	—	—	—	X	Obtain from your local network administrator. Every device on the network must have a unique IP address.
Subnet Mask	—	—	—	X	Obtain from your local network administrator.
MAC Address	Factory-set	—	—	X	Hardware address, entered at the factory. Not adjustable. Appears only in the Communications View screen.

Figure 7-7 Communication Parameters

7.3.2 Ethernet Communication

Work with your local network administrator to set the following communication parameters for ethernet communication. Also see Figure 7-7.

Modbus Server TCP. Enable TCP if the transfer switch is connected to a network for TCP/IP communication (for example, ethernet communication).

Modbus Address. Assign a unique Modbus address to each device on the network. Monitor III software requires a unique Modbus address to identify the controller. Record the address to enter into Monitor III software.

Modbus TCP Unit ID. A unit ID is required for Modbus over TCP communication. The unit ID for TCP communication is analogous to the Modbus address for serial communication through the RS-485 ports.

IP Address and Subnet Mask. The transfer switch may have a default IP address assigned at the factory. **Change the IP address to an address owned by the user.** Obtain an IP address and subnet mask information from the local network administrator.

MAC address. The MAC hardware address is factory-set. It can be seen in the View>Communications Setup screens but not viewed or changed in the setup menus.

7.4 USB Port

The Universal Serial Bus (USB) port on the main logic board allows file transfer to and from a USB mass storage device (removeable drive). Figure 7-8 shows a typical device. The removeable drive must be compatible with the USB 2.0 and USB Mass Storage Device Class specifications.

Parameter settings, event history, and other information files can be saved to a memory device and then transferred to a personal computer for viewing and saving. Available controller files are shown in Figure 7-9.

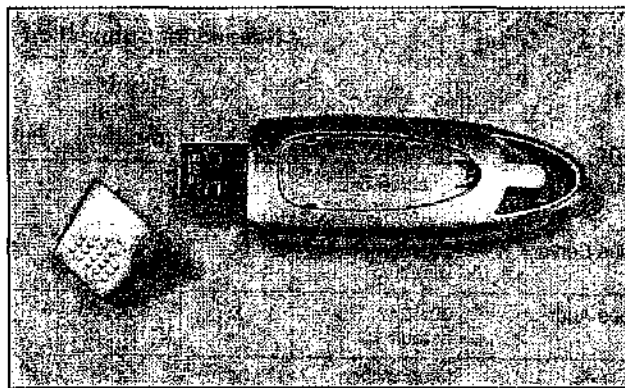


Figure 7-8 Typical Mass Storage Device

File name	Description	Download to Control	Upload to USB
MPAC1500v###.bin	Controller application program	X	
MPAC1500_#####.cfg	Parameter settings (configuration)	X	X
presentymmdd.his	Event history (ymmdd is year, month, day)		X
alarm_settings.alm	Common alarms		X
history_param.hstp	Internal use only		X
MPAC1500_cal.cal	Calibration		X
Param_back.bak	Internal use only		X
presentymmdd.raw	Internal use only		X
history_pback.hbak	Internal use only		X

Figure 7-9 Recognized File Types

Sections 7.4.2 through 7.4.4 contain more information about specific file types. See Section 8.8.5 for additional information about controller file maintenance.

7.4.1 File Transfer

The USB Access screen opens automatically when a device is connected to the controller's USB port. See Figure 7-10. Select Upload or Download as described in the following procedure.

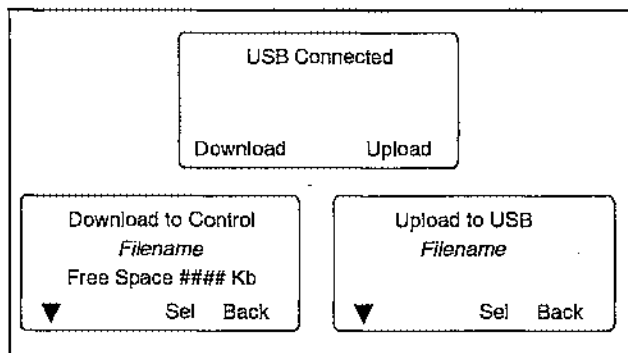


Figure 7-10 USB Access Screens

Procedure to Transfer Files

1. Insert the USB mass storage device into the USB port on the controller's main logic board. See Figure 7-1 for the port location.
2. Press the Download button to load new files from a memory device to the controller. Or, press the Upload button to load files from the controller through the USB port to a memory device.
3. Use the down button to scroll through the list of available files.
4. When the desired file is displayed, press the Sel button to select the file and start transferring the file.

Note: Do not disconnect the device from the USB port during file transfer.

A message on the display indicates when file transfer is complete.

7.4.2 Event History Files

The event history files can be opened with spreadsheet software. Event history files have filenames of the form presentymmdd.his, where yymmdd (year, month, day) is the date of the file as read from the controller.

- Event history files are updated periodically by the controller. See Section 8.8.5 for instructions to use the Force History Save command to save the most recent events to the event history file.
- Transfer (upload) the file from the controller to a USB storage device as instructed in Section 7.4.1.
- Use a personal computer to select the presentymmdd.his file on the storage device. Save the file to the computer, if desired.
- Use a spreadsheet program to open the file on the computer.

The resulting file includes the events with time and date formatted into spreadsheet columns. See Figure 7-11 for an example of an event history file viewed with spreadsheet software.

Date	Type	Description	Time	Delay1	Delay2
24/2005	39 STATUS	Contractor in Site N	5:27	0	0
24/2005	135 STATUS	Under Voltage L1-L2	5:27	0	0
24/2005	106 STATUS	Remote Common Alarm	5:27	0	0
24/2005	6 STATUS	Main DIP Switch	5:27	0	0
24/2005	10 STATUS	Manual Output Switch	5:27	0	0
24/2005	7 STATUS	Pad CP Switch	5:27	0	0
24/2005	2 STATUS	Test Bn	5:31	0	0
24/2005	39 STATUS	Contractor in Site N	6:15	0	0
24/2005	132 STATUS	Over Voltage L3-L4	6:15	0	9800
24/2005	131 STATUS	Under Voltage L1-L2	6:15	0	0
24/2005	106 STATUS	Remote Common Alarm	6:15	0	0
24/2005	9 STATUS	Main DIP Switch	6:15	0	0
24/2005	10 STATUS	Manual Output Switch	6:15	0	0
24/2005	7 STATUS	Pad CP Switch	6:15	0	0
24/2005	39 STATUS	Contractor in Site N	9:05	0	0
24/2005	132 STATUS	Over Voltage L3-L4	9:05	0	0
24/2005	131 STATUS	Under Voltage L1-L2	9:05	0	0
24/2005	106 STATUS	Remote Common Alarm	9:05	0	0

Figure 7-11 Sample Event History Spreadsheet File

7.4.3 Configuration files

The configuration (.cfg) file contains the transfer switch settings, including:

- System setup
- Source setup, including voltage and frequency pickup and dropouts
- Time delays
- Inputs and outputs
- Communications settings
- Calibration factors

The configuration file is automatically updated when the operator changes the transfer switch settings. A backup configuration file is also created automatically.

Configuration files from one transfer switch can be saved to a mass storage device and then loaded onto other transfer switches for quick setup of multiple switches. Serial numbers and descriptions entered through Monitor III software (or other Modbus application) are not changed by downloading configuration files to a transfer switch.

Check the settings and run a test sequence after loading the configuration file to verify correct operation. See Section 8.3 for instructions to run a test.

7.4.4 Controller Application Program

The controller application program can be updated through the USB port. Have an authorized distributor/dealer load an updated version of the controller application program, if necessary.

Notes

8.1 Introduction

This section contains operation instructions, including:

- Sequence of operation
- Main screen
- System status, warnings, and faults
- Passwords
- Running a test
- Other operation information.

8.2 Sequence of Operation

8.2.1 Controller Powerup Reset Sequence of Operation

Following is an explanation of the sequence of operation for the MPAC™ 1500 ATS Controller when power is initially applied to the controller or a controller reset occurs.

1. Controller self test is executed.
2. System parameters are downloaded from nonvolatile memory.
3. Contactor position and source availability are determined.
4. If neither source is acceptable, the contactor does not change position.
5. If both sources are available, the controller immediately transfers the contactor to the preferred source.
6. If only one source is available, the controller immediately transfers the contactor to that source, executing only the off-position and load control time delays.

If the available source is the preferred source, and the contactor was in the standby position, the contactor transfers to preferred, the engine cooldown time delay runs, and then the engine start contacts open.

If the available source is the preferred source and the contactor was already in the preferred position, the engine start contacts open immediately, bypassing the engine cooldown time delay.

8.2.2 Preferred Source Loss and Return

Following is an explanation of the sequence of operation for MPAC™ 1500 ATS Controller when Preferred Source failure is detected.

Preferred Source Fails

1. Load control contacts open.
2. Time delay engine start times out.
3. The generator is signaled to start.
4. The generator starts and the standby source becomes available.
5. Time delay preferred-to-standby times out.
6. Contactor transfers to standby.
7. Post-transfer load control sequences time out.
8. Load control contacts close.

Preferred Source Returns

1. Time delay standby-to-preferred and pre-transfer load control sequences time out.
2. Load control contacts open.
3. Contactor transfers to preferred source.
4. Post-transfer load control sequences and time delay engine cooldown time out.
5. Load control contacts close.
6. The generator is signaled to stop.

8.2.3 Exerciser Operation

Exerciser Accessory is Activated (Unloaded)

1. Exerciser timer begins.
2. The generator is signaled to start.
3. The generator starts and the standby source becomes available.
4. The load bank control is activated.

Exerciser Accessory is Deactivated (Unloaded)

1. The load bank control is deactivated.
2. Time delay engine cooldown times out.
3. The generator is signaled to stop.

Exerciser Accessory is Activated (Loaded)

1. Exerciser timer begins.
2. The generator is signaled to start.
3. The generator starts and the standby source becomes available.
4. Time delay preferred-to-standby and pre-transfer load control sequences time out.
5. Load control contacts open.
6. Contactor transfers to standby.
7. Post-transfer load control sequences time out.
8. Load control contacts close.

Emergency Source Fails (Normal Source is available)

1. Exerciser is deactivated.
2. Load control contacts open.
3. Contactor immediately transfers to preferred.
4. Immediate failure to acquire standby alarm.
5. Post-transfer load control sequences and time delay engine cooldown time out.
6. Load control contacts close.
7. Engine start contacts open.

Exerciser Accessory is Deactivated (Loaded)

1. Pre-transfer load control sequences time out.
2. Load control contacts open.
3. Contactor transfers to preferred.
4. Post-transfer load control sequences and time delay engine cooldown time out.
5. Load control contacts close.
6. The generator is signaled to stop.

8.2.4 Test Sequence

Test Function is Activated (Unloaded)

1. The generator set is signaled to start.
2. The generator starts and the standby source becomes available.
3. The load bank control is activated.

Test Function is Deactivated (Unloaded)

1. The load bank control is deactivated.
2. Time delay engine cooldown times out.
3. The generator is signaled to stop.

Test Function is Activated (Loaded)

1. The generator is signaled to start.
2. The generator starts and the standby source becomes available.
3. Time delay preferred-to-standby and pre-transfer load control sequences time out.
4. Load control contacts open.
5. Contactor transfers to standby.
6. Post-transfer load control sequences time out.
7. Load control contacts close.

Emergency Source Fails (Normal Source is available)

1. Test function is deactivated.
2. Load control contacts open.
3. Contactor immediately transfers to preferred.
4. Immediate failure to acquire standby alarm.
5. Post-transfer load control sequences and time delay engine cooldown time out.
6. Load control contacts close.
7. Engine start contacts open.

Test Function is Deactivated (Loaded)

1. Time delay standby-to-preferred and pre-transfer load control sequences time out.
2. Load control contacts open.
3. Contactor transfers to preferred.
4. Post-transfer load control sequences and time delay engine cooldown time out.
5. Load control contacts close.
6. The engine start contacts open, signalling the generator to stop.

8.3 System Test

Use the system test feature to:

- Start and run the generator set, or
- Simulate a preferred source failure, resulting in a transfer to the standby source.

See Section 5.5 for instructions to enter the test sequence menu and run a test.

A password is required to activate the system test, ensuring that only authorized personnel can start a test. Pressing the System Test designated pushbutton signals the controller to initiate the system test sequence.

Pressing the End Test designated pushbutton signals the controller to initiate the sequence to end the current test. Time delays will execute as programmed when the test is ended. Pressing the End Delay button will end the currently displayed time delay.

To check the source voltage and frequency while a test is running, press the Main button. Press the Test button to return to the test sequence screens.

During a system test, if the emergency source becomes unavailable based on its preset operating parameters, the fail to acquire standby signal is indicated immediately, and the test is terminated. If the contactor is in the standby position, it transfers immediately to the preferred position.

8.3.1 Unloaded System Test

When an unloaded test is initiated, the controller immediately signals the generator to start, without waiting for time delay engine start to time out. The contactor does not change position during an unloaded test, but if the normal source should fail, the contactor will transfer to the emergency source. The unloaded test feature will be available only with the Util-Genset and Genset-Genset modes of operation.

8.3.2 Loaded System Test

A loaded test actually simulates a preferred source failure, except that the engine start time delay is bypassed. The generator set is signaled to start immediately upon test activation. Load control signals are issued prior to transfer with their associated time delays. Since the loaded test transfer will be between two live sources, the in-phase monitor or closed transition feature will be activated if it is enabled. If the preferred source is lost during a loaded test with the contactor in the standby position, the test will continue to be active, even on restoration of preferred. If the standby source is lost and the preferred source is available, the test will be terminated, and the transfer switch will immediately transfer to the preferred source position, bypassing all time delays except the off-position requirements in a programmed-transition system.

When a loaded test is terminated normally, the retransfer sequence will be as though the preferred source has been restored after a failure. All time delays will be executed and an in-phase transfer will occur if enabled. The loaded test feature will be available with the Util-Genset, Util-Util and Genset-Genset modes of operation.

8.3.3 Auto-Loaded System Test

The auto-loaded test feature is a timed loaded test. The auto-loaded time delay determines how long after the transfer to standby to terminate the test and transfer back to the preferred source. The time is defaulted to 30 minutes and can be adjusted from 1 minute to 60 minutes.

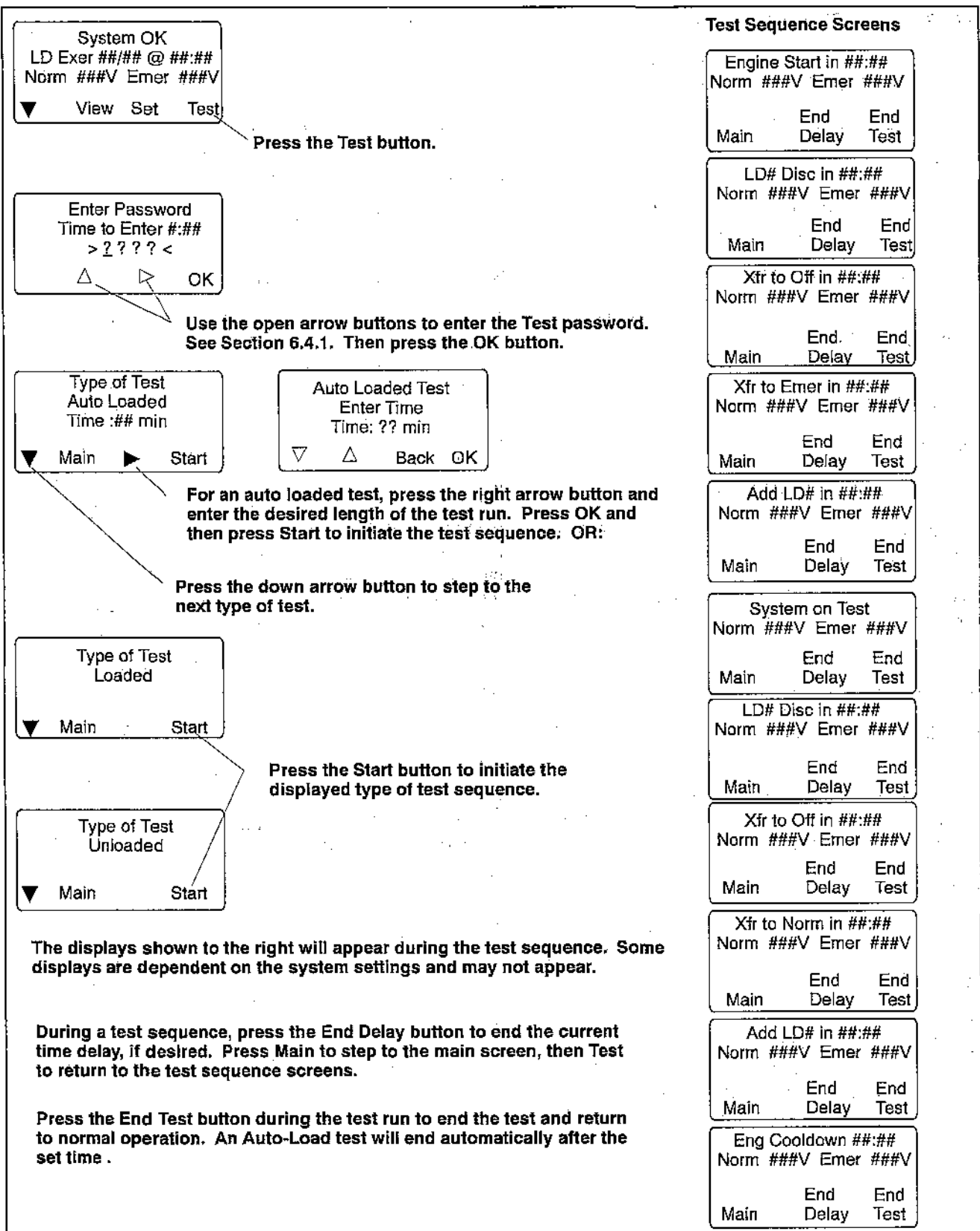


Figure 8-1 Test Sequence Screens

8.4 Exercise

Schedule exercise runs through the Set Exercise screen. See Section 6.14. To run the generator set at a time other than a scheduled exercise sequence, use the Test function. See Section 8.3 for instructions.

When a scheduled exercise is running, the screens shown in Figure 8-2 appear. Press Main to return to the main screen, if desired. Press the End button to end the exercise sequence before the scheduled stop time, if necessary.

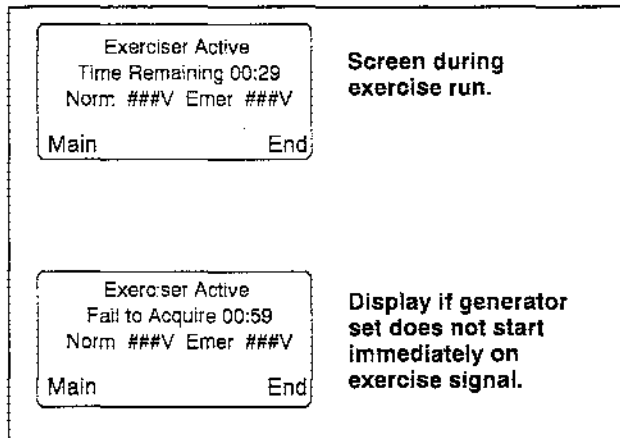


Figure 8-2 Exercise Sequence Screens

8.5 Lamp Test

To test the LEDs on the controller's user interface, go to the Main screen. Press the down arrow button once, then press the Lamp Test button and verify that the LCD screen and all 6 LEDs on the user interface illuminate. See Figure 8-3.

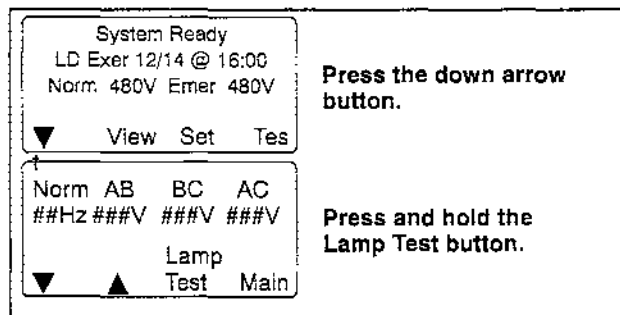


Figure 8-3 Lamp Test

8.6 Warnings and Faults

When a fault exists, the System Alert indicator flashes, a designated output and the common fault output are turned on, and an appropriate message is displayed to indicate the fault. See Figure 8-4 for the location of the System Alert indicator.

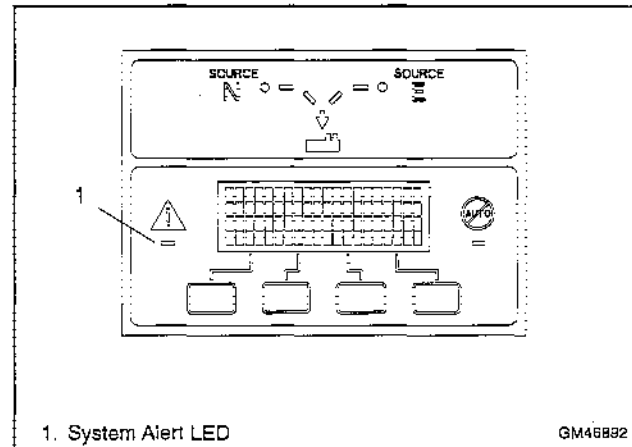


Figure 8-4 Fault Indication

ATS warnings and faults are shown in Figure 8-5. There are three types of warning/fault conditions:

Warning. Warnings automatically reset with a source availability change or a transfer request.

Fault Requiring Manual Reset. Under these conditions, normal ATS operation is halted. Active modes are turned off. If the contactor is in the preferred source position, the engine cooldown time delay

executes and the engine start contacts open, allowing the generator set to shut down. See Section 8.6.1 for instructions to reset faults.

Self Resetting Faults. Under these conditions, active modes are turned off. If the contactor is in the preferred source position, the engine cooldown time delay executes and the engine start contacts open, allowing the generator set to shut down. When the fault condition is corrected, the fault is automatically cleared from the controller and normal ATS operation continues.

Condition	Type	Description
Failure to Acquire Standby Source	Warning	The source voltage did not reach the acceptable range within a set time (see Time Delays). For example, the standby source generator set did not start.
Failure to Acquire Preferred Source	Warning	
IPM Synching (In-Phase Monitor Synching)	Warning (status)	The two sources did not come into phase within the Fail to Synchronize time delay. Note: If the sources do become in phase, the warning is automatically cleared and normal ATS operation continues.
External Battery Low	Warning	The voltage of the battery connected to the external battery supply module (EBSM) is low.
Failure to Transfer	Warning	The signal to transfer is sent to the contactor and the main shaft auxiliary switch fails to indicate a complete ATS position change. The controller will attempt to transfer the unit three times before the fault is indicated.
Auxiliary Switch Fault	Manual Reset Fault	The main shaft auxiliary switches indicate that the ATS is in more than one position, or the position changed when no signal was sent to initiate the change.
Auxiliary Switch Open	Manual Reset Fault	The main shaft auxiliary switches indicate that the ATS is in neither position (all inputs are open).
Src N (or Src E) Rotation Err	Self-Resetting Fault	The detected phase rotation of one or both sources does not match the preselected setting.
I/O Module Lost Comm	Self-Resetting Fault	An I/O device has stopped communicating or does not have a correct address specified. Fault resets if communication is reestablished.
Module Status Change	Manual Reset Fault	An accessory module has been disconnected OR a new module is detected. See Section 8.7.1 to reset.
Module Status Conflict	Manual Reset Fault	An accessory module has been replaced with a different type of module with the same address. See Section 8.7.2 to reset.
External Fault	Self-Resetting Fault	The external input dedicated to this condition is closed.

Figure 8-5 Warnings and Faults

8.6.1 Fault Reset

To clear a fault or warning condition and reset the System Alert LED, go to the Main screen and press the down arrow button to open the Reset screen. See Figure 8-4 and Figure 8-6. Then press the button labelled Reset. A fault reset does not change the controller settings.

See Section 8.7, Accessory Module Faults, for instructions to correct and reset faults related to the I/O modules and other accessory modules.

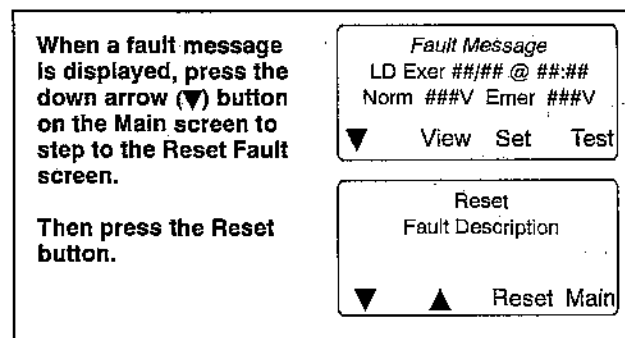


Figure 8-6 Fault Reset

8.7 Accessory Module Faults

8.7.1 Module Status Change

Module Connection (new or reconnected module)

Installing or reconnecting one or more accessory modules triggers the Module Status Change message. See Figure 8-7. Press the Reset button to display Reset New Module. Press the Reset button from that screen. The controller recognizes the module type(s). See Figure 8-8.

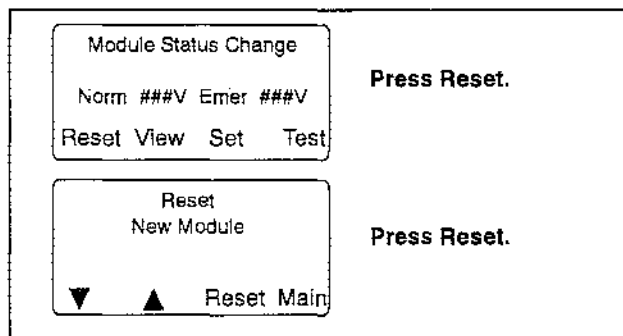


Figure 8-7 Screens after Module Connection

Module Type	Description
AOB	Switch/Alarm Module (alarm option board)
SOB	Standard I/O Module (standard option board)
POB	High-Power I/O Module (power option board)

Figure 8-8 Module Types

Navigate to the Set Input/Outputs>Set Aux I/O screen to check that the controller has recognized the connected modules.

See Section 6.12 for instructions to assign programmable inputs and outputs to I/O modules. Go to Section 6.13 for instructions to assign functions to the audible alarm for an Alarm Module.

Disconnected Module

If one or more accessory modules are disconnected from the controller, the message Module Status Change appears. See Figure 8-9. Pressing the Reset button displays the message Check Module Setup to Clear Fault. Use the following Module Uninstall Procedure to uninstall modules after disconnection.

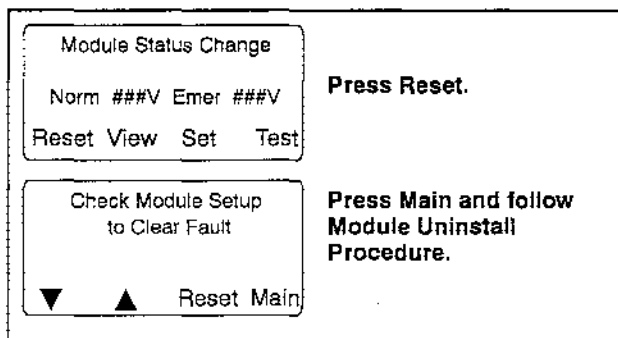


Figure 8-9 Screens after Module Disconnection

Module Uninstall Procedure

1. Press Main to return to the main screen.
2. Press Set to enter setup mode.
3. Enter the setup password.
4. Press the down arrow to step to the Set Inputs/Outputs screen.
5. Navigate to the Set Auxiliary I/O screen. See Figure 8-10. Press the right arrow button to see the status of module 1. Press the down arrow to step to the next module, if necessary, until the screen shows Status: Lost.
6. Press the right arrow button to move to the Uninstall Module screen. Verify that the screen says Uninstall Module Yes. (Press the open arrow button to toggle no/yes, if necessary.)

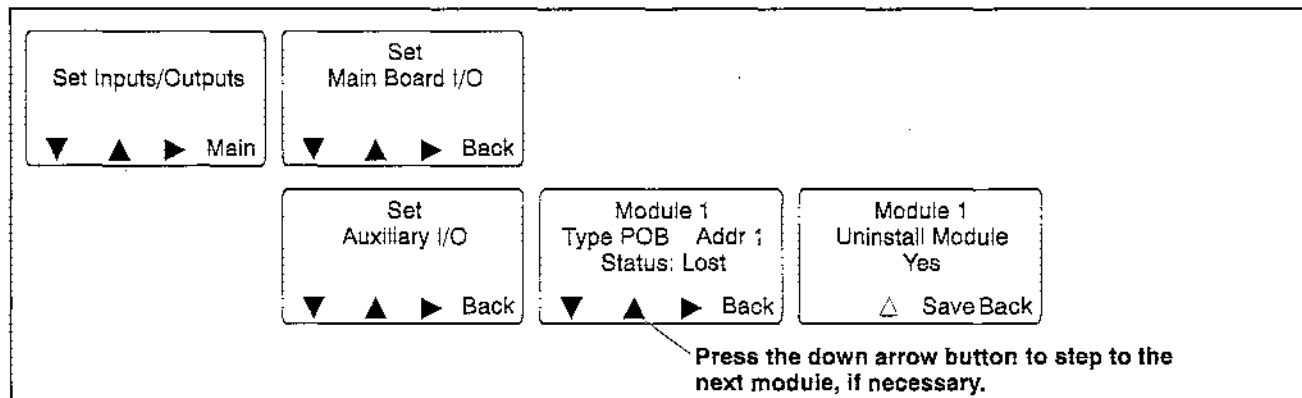


Figure 8-10 Uninstall Module

7. When Yes is displayed, press Save to uninstall the module.
8. Repeat the uninstall procedure for additional modules, if necessary.

Other Module Status Change Conditions

A *Module Status Change* message that cannot be cleared as described in this section may indicate a failure of the controller's real-time clock. Carefully follow the Module Connection or Module Uninstall procedures to attempt to reset the fault. If the fault cannot be reset, the controller's logic board may need to be replaced. Contact an authorized distributor/dealer for service.

8.7.2 Module Status Conflict

The message *Module Status Conflict* appears if one type of module is replaced with another type of module that has the same address. Follow the procedure below to resolve the conflict.

Procedure to Clear a Module Status Conflict

1. Disconnect power to the transfer switch.
2. Disconnect the module.
3. Close the enclosure door and reconnect power to the ATS. The display will show *Module Status Change*.
4. Press the button labelled Reset. The display will show Check Module Setup to Clear Fault.
5. Follow the procedure in Section 8.7.1 to uninstall the module through the ATS controller keypad.
6. Disconnect power to the ATS.
7. Connect the new module.
8. Close the enclosure door and reconnect power to the ATS. The display will show *Module Status Change*. See Figure 8-7.
9. Press the button labeled Reset to display *Reset New Module*. Press the reset button from that screen. The controller will now recognize the new module type.
10. Navigate to the Set Auxiliary I/O screen to check the status and settings for the new module. See Figure 8-10. Press the right arrow button to see the status of module 1. Press the down arrow to step to the next module, if necessary.

8.8 Reset Data

Be sure to read and understand the information in this section before resetting records or parameters.

Note: Resetting to the default parameters will reset **all** parameters to a factory default setting.

Use the Reset Data menus to set records or parameters back to factory default settings. See Figure 8-11.

1. Use the black arrow buttons to step to the desired screen.
2. Press the open up arrow button to toggle Yes or No until Yes is displayed.
3. Press Save to reset the records or parameters to the factory defaults. Pressing Back exits the screen without resetting.

8.8.1 Reset Maintenance Records

Reset the maintenance records after transfer switch service to update the last maintenance date and totals since reset that are displayed in the maintenance records screen.

8.8.2 Reset Event History

Resetting the event history **clears** the events from the event history log. The history lists the 100 most recent transfer switch events, including transfers and DIP switch setting changes as well as faults and alarms.

Note: The event history can be saved to a file before reset. See Section 8.8.5, File Maintenance.

8.8.3 Reset Default Parameters

Resetting to the default parameters will reset **all** parameters, **including the system voltage and frequency**, to a factory default setting. The default system voltage and frequency settings may not match the settings for your application.

The transfer switch will not operate correctly if the system voltage and frequency do not match the sources. Use the Set Sources screen to set the system voltage and frequency after resetting to the default parameters. See Section 6 for instructions.

Check the system operation to verify the settings after resetting.

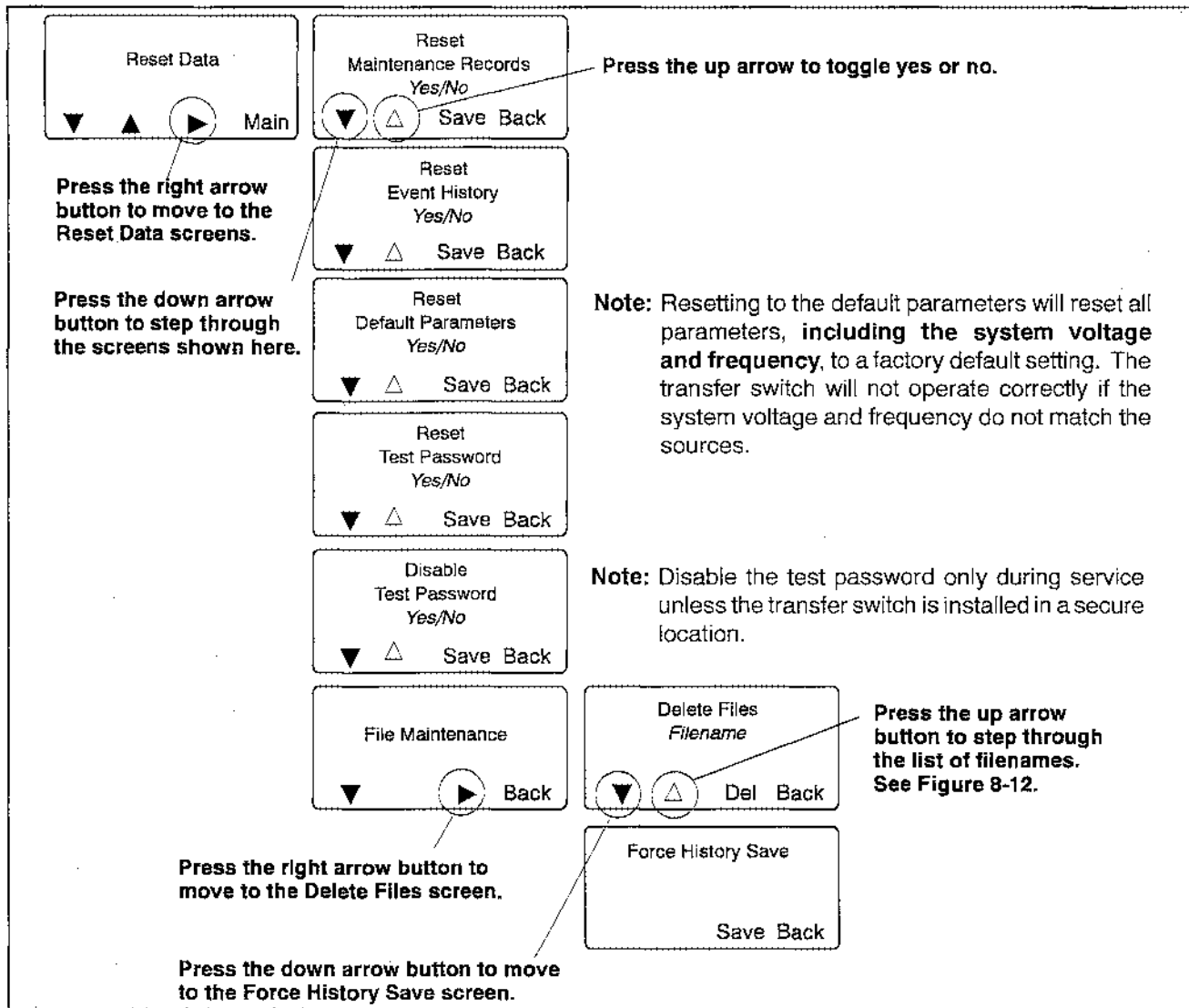


Figure 8-11 Reset Data

8.8.4 Reset and Disable Test Password

Reset the Test password to return the test password to the default, 0000.

Disable the test password to allow the user to start a test without entering a password.

Note: Disable the test password only during service unless the transfer switch is installed in a secure location.

8.8.5 File Maintenance

Delete Files. Use the File Maintenance>Delete Files command to remove unneeded files. Use the up arrow button to step through the list of files until the desired filename is displayed. Then press the Del button to delete the file. See Figure 8-12 and Figure 8-11. See Section 7.4 for more information about controller data files.

Force History Save. Event history files are periodically updated by the controller. Use the Force History Save

command to ensure that the most recent events are included before transferring the file to a mass storage device, if desired.

Event history files have filenames of the form presentymmdd.his, where yymmdd (year, month, day) is the date of the file as read from the controller. Refer to Section 7.4 for instructions to transfer files to a mass storage device for viewing on a personal computer.

File Name	Description
MPAC1500_#####.cfg	Parameter settings (configuration)
presentymmdd.his	Event history
alarm_settings.alm	Common alarms
MPAC1500_cal.cal	Calibration
history_param.hstp	Internal use only
Param_back.bak	Internal use only
presentymmdd.raw	Internal use only
history_pback.hbak	Internal use only

Figure 8-12 Files listed under File Maintenance>Delete Files

9.1 Introduction

Regular preventive maintenance ensures safe and reliable operation and extends the life of the transfer switch. Preventive maintenance includes periodic testing, cleaning, inspection, and replacement of worn or missing components. Section 9.4 contains a service schedule for recommended maintenance tasks.

A local authorized distributor/dealer can provide complete preventive maintenance and service to keep the transfer switch in top condition. Unless otherwise specified, have maintenance or service performed by an authorized distributor/dealer in accordance with all applicable codes and standards. See the Service Assistance section in this manual for how to locate a local distributor/dealer.

Keep records of all maintenance or service.

Replace all barriers and close and lock the enclosure door after maintenance or service and before reapplying power.

⚠ WARNING



**Accidental starting.
Can cause severe injury or death.**

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ DANGER



**Hazardous voltage.
Will cause severe injury or death.**

Disconnect all power sources before opening the enclosure.

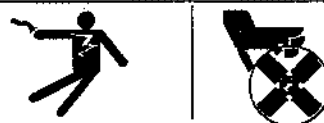
⚠ DANGER



**Hazardous voltage.
Will cause severe injury or death.**

Only authorized personnel should open the enclosure.

⚠ WARNING



**Hazardous voltage. Moving parts.
Can cause severe injury or death.**

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocutation is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Servicing the transfer switch. Hazardous voltage can cause severe injury or death. Deenergize all power sources before servicing. Turn off the main circuit breakers of all transfer switch power sources and disable all generator sets as follows: (1) Move all generator set master controller switches to the OFF position. (2) Disconnect power to all battery chargers. (3) Disconnect all battery cables, negative (-) leads first. Reconnect negative (-) leads last when reconnecting the battery cables after servicing. Follow these precautions to prevent the starting of generator sets by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer. Before servicing any components inside the enclosure: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Test circuits with a voltmeter to verify that they are deenergized.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

NOTICE

Hardware damage. The transfer switch may use both American Standard and metric hardware. Use the correct size tools to prevent rounding of the bolt heads and nuts.

NOTICE

Electrostatic discharge damage. Electrostatic discharge (ESD) damages electronic circuit boards. Prevent electrostatic discharge damage by wearing an approved grounding wrist strap when handling electronic circuit boards or integrated circuits. An approved grounding wrist strap provides a high resistance (about 1 megohm), *not a direct short*, to ground.

9.2 Testing

9.2.1 Weekly Generator Set Exercise

Use the exerciser to start and run the generator set under load once a week to maximize the reliability of the emergency power system. See Section 6.14 for instructions to program the exerciser.

9.2.2 Monthly Automatic Control System Test

Test the transfer switch's automatic control system monthly. See Section 3.5 for the test procedure.

- Verify that the expected sequence of operations occurs as the switch transfers the load to the emergency source when a preferred source failure occurs or is simulated.
- Observe the indicator LEDs included on the transfer switch to check their operation.
- Watch and listen for signs of excessive noise or vibration during operation.
- After the switch transfers the load to the standby source, end the test and verify that the expected sequence of operations occurs as the transfer switch retransfers to the preferred source and signals the generator set to shut down after a cooldown period.
- On programmed-transition units, verify that the time delay in the OFF position functions during transfer to the standby source and transfer back to the preferred source.

9.3 Inspection and Service

Contact an authorized distributor/dealer to inspect and service the transfer switch annually and also when any wear, damage, deterioration, or malfunction of the transfer switch or its components is evident or suspected.

9.3.1 General Inspection

External Inspection. Keep the transfer switch clean and in good condition by performing a weekly general external inspection of the transfer switch for any condition of vibration, leakage, excessive temperature, contamination, or deterioration. Remove accumulations of dirt, dust, and other contaminants from the transfer switch's external components or enclosure with a vacuum cleaner or by wiping with a dry cloth or brush.

Note: Do not use compressed air to clean the transfer switch because it can cause debris to lodge in the components and damage the switch.

Tighten loose external hardware. Replace any worn, missing, or broken external components with manufacturer-recommended replacement parts. Contact a local authorized distributor/dealer for specific part information and ordering.

Internal Inspection. Disconnect all power sources, open the transfer switch enclosure door, and inspect internal components monthly or when any condition noticed during an external inspection may have affected internal components.

Contact an authorized distributor/dealer to inspect and service the transfer switch if any of the following conditions are found inside the transfer switch.

- Accumulations of dirt, dust, moisture, or other contaminants
- Signs of corrosion
- Worn, missing, or broken components
- Loose hardware
- Wire or cable insulation deterioration, cuts, or abrasion

- Signs of overheating or loose connections: discoloration of metal, melted plastic, or a burning odor
- Other evidence of wear, damage, deterioration, or malfunction of the transfer switch or its components.

If the application does not allow a power interruption for the time required for the internal inspection, have an authorized distributor/dealer perform the internal inspection.

9.3.2 Other Inspections and Service

Have an authorized distributor/dealer perform scheduled maintenance, service, and other maintenance that ensures the safe and reliable operation of the transfer switch. See Section 9.4, Service Schedule, for the recommended maintenance items and service intervals.

Have an authorized distributor/dealer repair or replace damaged or worn internal components with manufacturer-recommended replacement parts.

9.4 Service Schedule

Follow the service schedule below for the recommended service intervals. Have all service performed by an authorized distributor/dealer except for activities designated by an X, which may be performed by the switch operator.

System Component or Procedure	See Section	Visually Inspect	Check	Adjust, Repair, Replace	Clean	Test	Frequency
Electrical System							
Check for signs of overheating or loose connections; discoloration of metal, melted plastic, or a burning odor	9.3.1	X	X				Y
Check the contactor's external operating mechanism for cleanliness; clean and relubricate if dirty *	9.3.1	X			D (clean and lube)		Y
Inspect wiring insulation for deterioration, cuts, or abrasion. Repair or replace deteriorated or damaged wiring	9.3.1	X	D	D			Y
Tighten control and power wiring connections to specifications	2		D			D	Y
Check the transfer switch's main power switching contacts' condition; clean or replace the main contacts or replace the contactor assembly as necessary	S/M	D		D	D		Y
Control System							
Exercise the generator set under load	9.2.1					X	W
Test the transfer switch's automatic control system	9.2.2 3.5	X				X	M
Test all indicators (LEDs) and all remote control systems for operation	3.4	X	D	D		D	Y
General Equipment Condition							
Inspect the outside of the transfer switch for any signs of excessive vibration, leakage, high temperature, contamination, or deterioration *	9.3.1	X			X		M
Check that all external hardware is in place, tightened, and not badly worn	9.3.1	X	X	X			M
Inspect the inside of transfer switch for any signs of excessive vibration, leakage, high temperature, contamination, or deterioration*	9.3.2	D	D		D		Y
Check that all internal hardware is in place, tightened, and not badly worn	9.3.2	X	D	D			Y
* Service more frequently if the transfer switch is operated in dusty or dirty areas.							
See Section: Read these sections carefully for additional information before attempting maintenance or service.							
Visually Inspect: Examine these items visually.							
Check: Requires physical contact with or movement of system components, or the use of nonvisual indications.							
Adjust, Repair, Replace: Includes tightening hardware and lubricating the mechanism. May require replacement of components depending upon the severity of the problem.							
Clean: Remove accumulations of dirt and contaminants from external transfer switch's components or enclosure with a vacuum cleaner or by wiping with a dry cloth or brush. <i>Do not use compressed air to clean the switch because it can cause debris to lodge in the components and cause damage.</i>							
Test: May require tools, equipment, or training available only through an authorized distributor/dealer.							
Symbols used in the chart:							
X= The transfer switch operator can perform these tasks.				W=Weekly			
D=An authorized distributor/dealer must perform these tasks.				M=Monthly			
S/M = Service Manual. An authorized distributor/dealer must perform these tasks.				Q=Quarterly			
				S=Semiannually (every six months)			
				Y=Yearly (annually)			

10.1 Introduction

This section describes the hardware options that will interface with the MPAC™ 1500 controls. The following accessories are available:

- Standard I/O module
- High Power I/O module
- Alarm Module with preferred source and Chicago alarm functions
- Supervised transfer control switch
- External battery module
- Current monitoring
- Load shed module
- User interface cover
- Line-to-neutral voltage monitoring
- Battery charger
- Logic disconnect switch
- Monitoring software
- Digital meter: V, A, kW, VA, VAR, PF, and Hz

10.2 Accessory Modules

The transfer switch uses a standard bus system for connecting accessory modules to the controller. This bus incorporates a standard serial communication interface for passing data back and forth between the main logic board and the assemblies on the expansion bus.

The mounting kit holds up to five optional modules. The maximum total current draw is 300 mA. See Figure 10-1. If an External Battery Module is installed, there is no current restriction. The External Battery Module, if used, must be the last board on the bus.

Module Current Draw Specifications, mA	
Alarm Module	75
Standard I/O Module	75
High Power I/O Module	100

Figure 10-1 Option Board Types

10.3 Accessory Module Mounting

Mount the accessory modules on the module mounting plate. Starting at the end of the module mounting assembly nearest the cable connection, install any I/O modules first, then install the alarm board, if used. The external battery module, if used, must be the last module. See Figure 10-2. The alarm board has a fixed Modbus address = 5.

Note: Some models may have the I/O module assembly installed with the cable connection end pointing to the side or the bottom. Regardless of the actual orientation of the assembly, the I/O modules must be installed closest to the cable connection, followed by the alarm module and then the external battery module, if used.

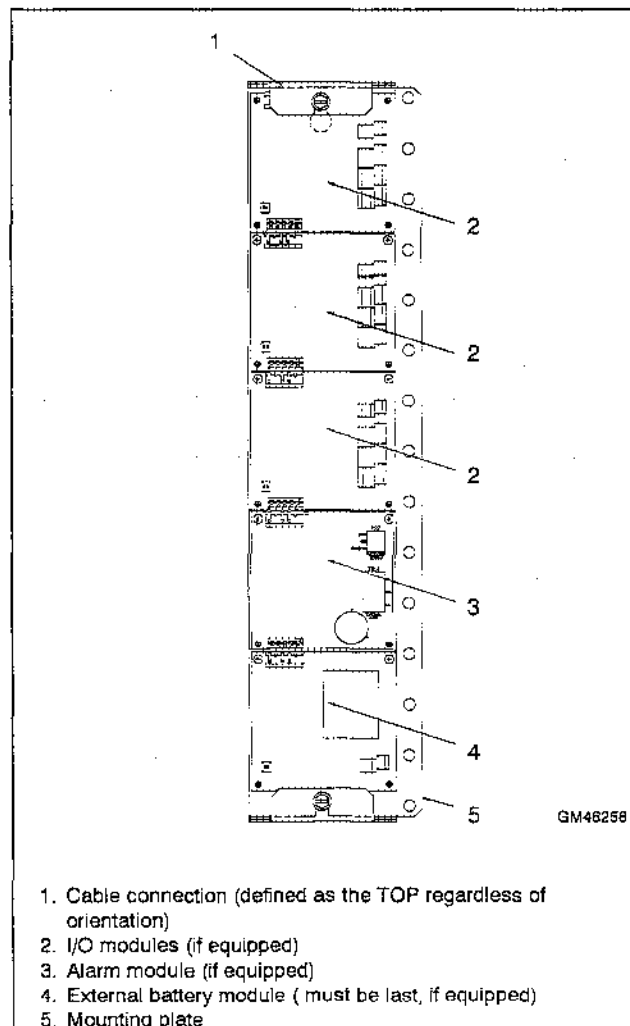


Figure 10-2 Module Mounting

10.4 Input/Output (I/O) Modules

Two types of input/output modules are available. The standard I/O Module has two inputs and six outputs. The high-power I/O module has two inputs and three outputs. See Figure 10-3 and Figure 10-4 for I/O module specifications.

Inputs	
Available Inputs	2
Input Definition	Contact Closure
Current	5 mA Max
Connection Type	Terminal Strip
Wire Size	#14-24 AWG
Max Distance	700 feet
Outputs	
Outputs Available	6
Contact Type	Form C (SPDT)
Contact Voltage Rating	2 A @ 30 VDC 500 mA @ 125 VAC
Connection Type	Terminal Strip
Wire Size	#14-24 AWG

Figure 10-3 Standard Input/Output Module

Inputs	
Available Inputs	2
Input Definition	Contact Closure
Current	5 mA Max
Connection Type	Terminal Strip
Wire Size	#14-24 AWG
Max Distance	700 feet
Outputs	
Outputs Available	3
Contact Type	Form C (SPDT)
Contact Voltage Rating	12 A @ 24 VDC 12 A @ 250 VAC 10 A @ 277 VAC 2 A @ 480 VAC
Connection Type	Terminal Strip
Wire Size	#14-24 AWG
Environmental Specifications	
Temperature	-40°C to 85°C (-40°F to 185°F)
Humidity	35% to 85% noncondensing

Figure 10-4 High-Power Input/Output Module

Use 14-24 AWG cable to connect to input and outputs. Each output is a form C SPDT contact.

LEDs on the module circuit board light to indicate that each input or output is active.

Note: Each I/O module must have unique address.

Use the address DIP switches on the I/O module to assign a unique (different) address to each module as shown in Figure 10-5. Assign addresses in order from 1 to 4. An LED for each DIP switch lights to indicate that the switch is closed.

The alarm module's fixed address is 5. The battery module's fixed address is 6.

Use the Set Inputs/Outputs screen to assign input and output functions. See Section 6.12 for instructions.

DIP Switch		Address
1	2	
Off	Off	1
On	Off	2
Off	On	3
On	On	4

Figure 10-5 Address DIP Switch Settings

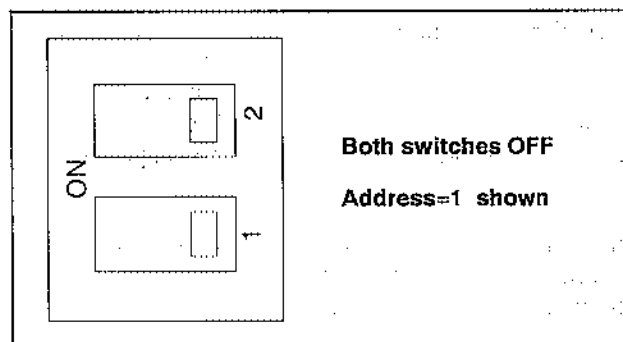


Figure 10-6 Address DIP Switches

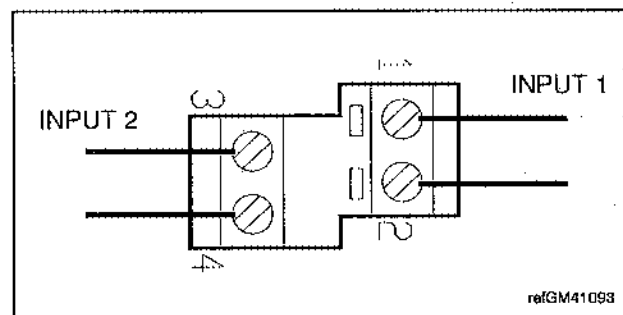


Figure 10-7 I/O Module Input Connections (TB1 or TB10)

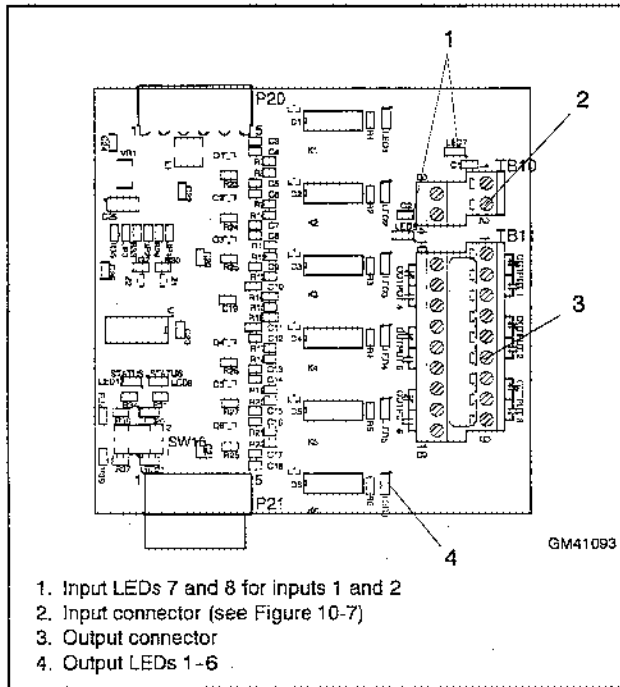


Figure 10-8 Standard I/O Module

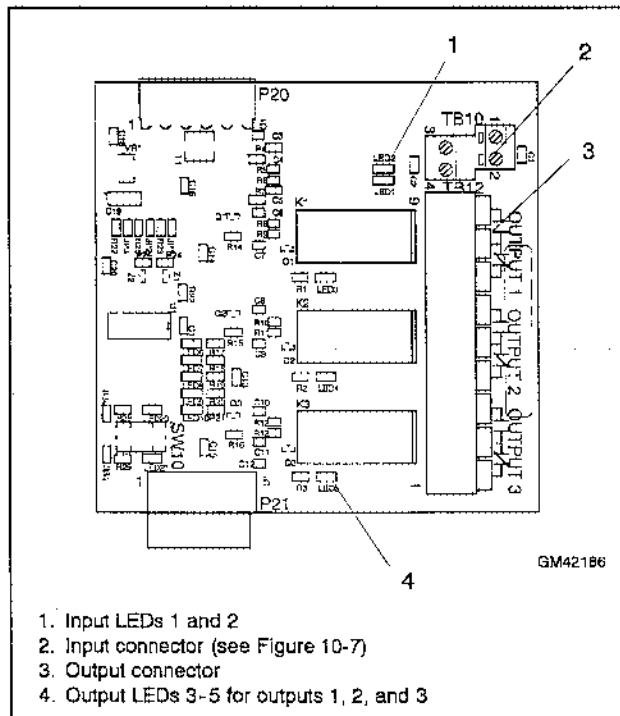


Figure 10-9 High-Power I/O Module

10.5 Alarm Module

The functions provided by this board are:

- 90 dB Audible alarm (any alarm function can be programmed to trigger the audible alarm)
- Chicago alarm operation
- Preferred source selection
- Supervised transfer control (supervised transfer control switch required)
- Connection for external alarm

The alarm board is equipped with a 90 dB audible alarm. The audible alarm can be set to sound under selected fault conditions through the Common Alarm Setup Screen.

The alarm board has a fixed address = 5.

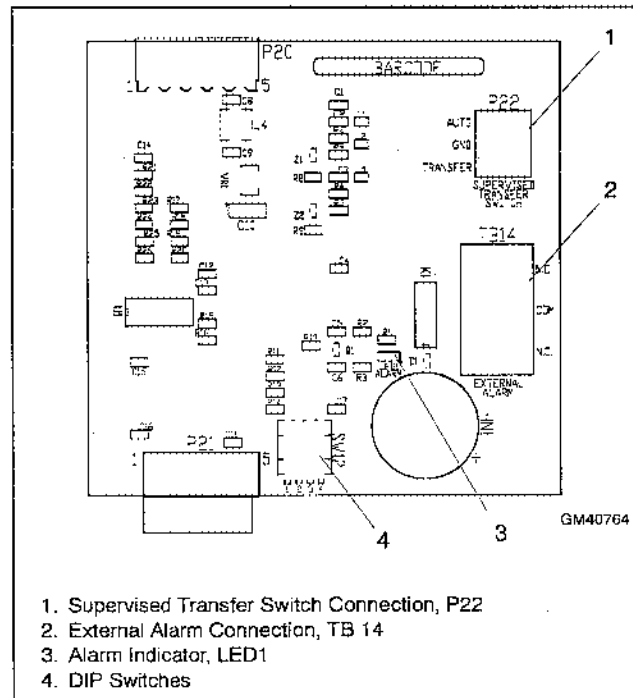


Figure 10-10 Alarm Module

10.5.1 Alarm Board DIP Switches

There are four DIP switches on the alarm module board. Two of the switches are not used at this time. See Figure 10-11. To enable the preferred source selection function, set DIP switch 1 to ON. If the supervised transfer switch is installed on the ATS, set DIP switch 2 to ON.

DIP Switch	Function
1	Preferred source selection enable
2	Supervised transfer enable
3	Not used
4	Not used

Figure 10-11 Alarm Board DIP Switches

10.5.2 External Alarm

A customer-supplied external alarm horn can be connected to the alarm module at terminal block TB14. Connect to the normally open or normally closed contact as recommended by the alarm manufacturer's instructions.

Item	Specification
Wire Size	#12-22 AWG Cu
Contact Voltage Rating	500 mA @ 120 VAC
	250 mA @ 240 VAC

Figure 10-12 External Alarm Connection Specifications

10.5.3 Audible Alarm Setup

Use the Common Alarms Setup screen to assign functions to the audible alarm. See Section 6.13 for instructions to set Audible Alarm: Y for each function that should trigger the alarm.

10.5.4 Alarm Operation

Normal Mode

In Normal Mode, the horn sounds anytime a fault event happens in the system. The horn continues to sound unless the alarm silence button is pressed. When the fault is cleared, the alarm silence is ended and reset for the next alarm.

Alarm Operation: Chicago Alarm Mode

Chicago Alarm mode requires the horn to sound and a lamp or LED to light when the switch is in the emergency (non-preferred) position. The horn continues to sound unless the alarm silence button is pressed. When the fault is cleared, the alarm silence is ended and reset for the next alarm.

For Chicago Alarm Mode, use the Common Alarm Setup screen to assign the necessary faults and conditions to the audible alarm. See Section 6.13. Be sure to assign the Contactor in Standby condition to trigger the audible alarm.

A remote alarm or indicator light can also be connected to the alarm board to indicate the alarm condition. See Section 10.5.2.

10.5.5 Alarm Silence Mode

In Alarm Silence Mode, the horn is disabled. Alarm Silenced appears on the display and the system alert LED lights.

The Alarm Silenced condition can be assigned to a programmable output. See Section 6.12 for instructions to assign outputs.

Instructions to Silence the Alarm in Normal and Chicago Alarm Modes:

When the alarm is activated, the word Alarm appears on the main display screen above the first button. See Figure 10-13. Press the Alarm button to open the Reset screen. Then press the button labeled Reset to silence the alarm.

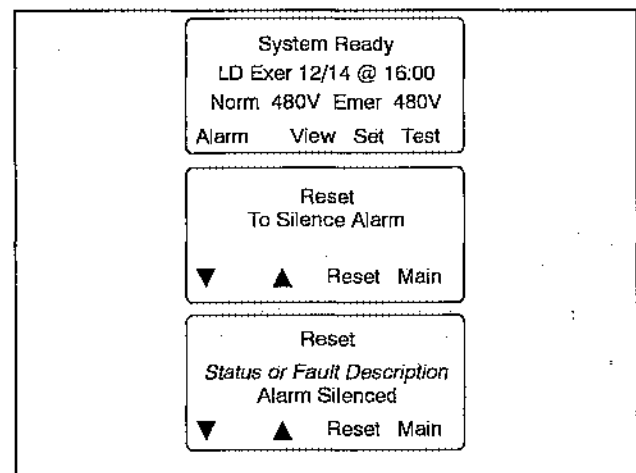


Figure 10-13 Alarm Silence

10.6 External Battery Supply Module (EBSM)

The external battery supply module kit allows connection to the generator set engine start battery(ies) or other batteries to provide 12 VDC power to the ATS controller. The external battery supply module kit is required for the following applications:

- **Systems using extended engine start time delays.** The EBSM provides power to the ATS controller during extended time delays longer than 15 seconds, when neither the Normal nor the Emergency source is available.
- **Three-source systems.** Three-source systems use two transfer switches and two standby power sources in addition to the preferred power source. The EBSM provides power to the second ATS controller when the preferred source (connected to ATS1) is supplying the load. See Section 6.9 for instructions to set up a three-source system.
- **Installations with frequent utility power outages.** The EBSM provides power to the ATS controller when neither source is available, preserving the controller's backup battery.

The EBSM produces 2 amps at 12 VDC with 9-36 VDC input. The EBSM input is reverse-polarity protected. The EBSM outputs a low battery voltage signal when the external battery voltage falls below 11 VDC for a 12-volt system or 22 VDC for a 24-volt system.

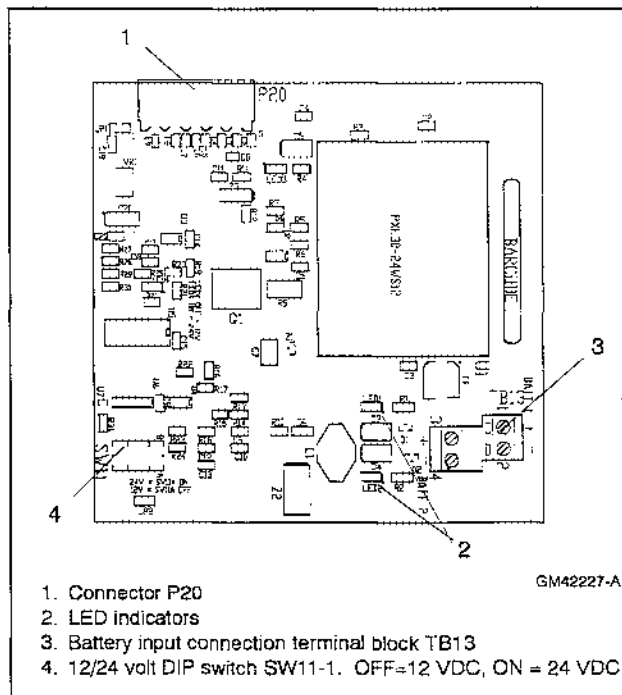


Figure 10-14 External Battery Supply Module

The external battery supply module kit includes one external battery supply circuit board and the circuit board mounting components. See Figure 10-14.

A module mounting kit is required for installation of the external battery supply module. The module connects to an adjacent I/O module or to the interface harness included with the I/O module mounting assembly kit. The I/O module mounting assembly kit allows the installation of up to four I/O modules plus one external battery supply module. Obtain a module mounting kit if one is not already installed and follow the instructions provided with the kits to install the mounting assembly and modules.

The battery voltage selection DIP switch SW11-1 allows selection between 12-volt and 24-volt systems for low battery voltage sensing and indication. Connect one or two batteries to the external battery supply module. Use a battery charger to maintain the battery(ies) connected to the EBSM.

DIP Switch SW11-1 Setting	Battery Voltage
OFF	12 VDC
ON	24 VDC

Figure 10-15 Battery Voltage Selection

Connection and Voltage Setting

1. Use #14-28 AWG wire to connect one or two batteries to terminal block TB13. (A second battery can be connected but is not required.) Follow the marking on the board for the positive (+) and negative (-) connections. See Figure 10-14 and Figure 10-15.

Note: If the battery connections are reversed, red LED1 or LED2 will light. See Figure 10-14.

2. Set voltage selector switch SW11-1 to 12 or 24VDC. See Figure 10-14 and Figure 10-15. Switch SW11-2 is not used.

Note: The EBSM has no address switches but must be the last board on the bus.

10.7 Supervised Transfer Control Switch

The supervised transfer control switch (AUTO/MANUAL/TRANSFER switch) is a three-position, key-operated switch that allows manual control of load transfers. The alarm module is required for installation and operation of the supervised transfer control switch. The switch connects to P22 on the alarm module. See Figure 10-10.

The switch has maintained AUTO and MANUAL positions and a momentary TRANSFER position. The key can be removed in either the AUTO or MANUAL position. The key cannot be removed when the switch is in the TRANSFER position. Figure 10-16 shows the switch.

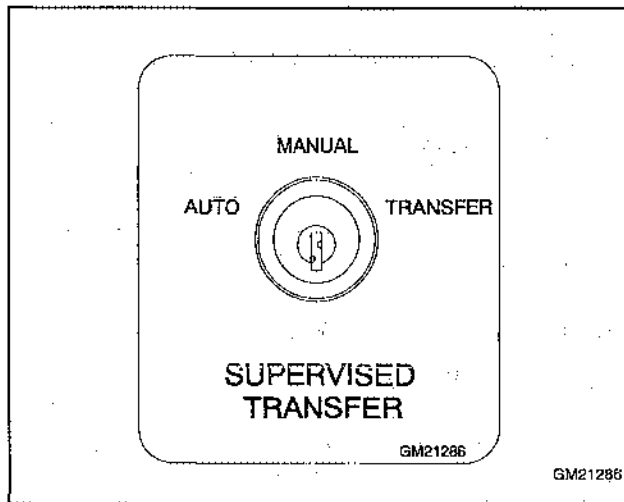


Figure 10-16 Supervised Transfer Control Switch

When the Supervised Transfer Control switch is in the AUTO position, the controller responds normally to transfer requests, and will automatically transfer to a source if that source is available.

The manual mode allows the system to run on the standby source indefinitely, even if the preferred source is available. In manual mode, the controller is inhibited from initiating a transfer sequence until the keyswitch is turned to the TRANSFER position.

It is not necessary to hold the switch in the TRANSFER position during the transfer sequence. Turn the switch to TRANSFER and release it to initiate transfer. The transfer sequence will proceed after the switch returns to the MANUAL position, executing all programmed time delays and transferring the load to the other source if it is available.

Automatic and Non-Automatic Transfer Switches.

The switch operation differs for automatic and non-automatic switches. An automatic transfer switch transfers automatically to an available source if the connected source is lost. A non-automatic transfer switch does not transfer automatically, even if the connected source is lost. Figure 10-17 summarizes the switch operation.

Note: Transfer switches are built and UL-labeled as automatic or non-automatic by the factory and cannot be converted in the field. The supervised transfer control switch must not be removed from non-automatic switches in the field.

Switch Position	Operation, Automatic Switches	Operation, Non-Automatic Switches
AUTO	- Automatically transfers to the standby source, when available, if the preferred source is lost - Transfers back to the preferred source when it becomes available	
MANUAL	- Automatically transfers to an available source if the connected source is lost - Does not automatically transfer back to preferred when both sources are available	- Enables the Not-in-Auto indicator - Transfers only when the switch is manually moved to the TRANSFER position: - Does not automatically transfer to an available source when the connected source is lost - Does not automatically transfer back to preferred when both sources are available
TRANSFER (momentary switch position)	- Can use to transfer when the switch is in the MANUAL position and both sources are available - Initiates transfer sequence to the other source, if available, including all programmed time delays - Operates pre- and post-transfer load control time delays if both sources are available	- Must use for all transfers when the switch is in the MANUAL position - Initiates transfer sequence to the other source, if available, including all programmed time delays - Operates pre- and post-transfer load control time delays if both sources are available

Figure 10-17 Supervised Transfer Control Switch Operation

10.7.1 Automatic Mode

In Automatic Mode with the Supervised Transfer Control Switch in the MANUAL Position, the contactor will automatically transfer to the available source if the connected source is not available. In this case, no user action is required to initiate the transfer.

Operation with Test and Peak Shave

In Automatic Mode with the Supervised Transfer Control Switch in the MANUAL position, a test, peak shave, or loaded exercise command will be recognized and a transfer sequence to the standby source will operate normally. However, ending the test or removing the peak shave signal will *not* cause a transfer back to the preferred source. Move the supervised transfer control switch to the TRANSFER position to initiate transfer back to the preferred source.

10.7.2 Non-Automatic Mode

In Non-Automatic Mode, any transfer to an acceptable source can only be accomplished with the Supervised Transfer Control Switch. If the Supervised Transfer Control switch is in the MANUAL Position, the controller is inhibited from initiating a transfer sequence until the switch is moved to the Transfer Position. This will prevent a transfer even if the source fails. To initiate a transfer sequence, move the switch to TRANSFER, then back to MANUAL. The transfer sequence proceeds when the switch returns to the MANUAL Position. The not-in-auto LED flashes while the controller is waiting for the TRANSFER signal. The display indicates that the supervised transfer mode is active.

Operation with Test and Peak Shave

In Non-Automatic Mode, the test, peak shave and loaded exercise signals are ignored when the Supervised Transfer Control Switch is in the MANUAL position.

10.8 Digital Meter

The digital power meter displays voltage, current, frequency, and power on both sources. See Figure 10-18. The meter also provides programmable visual alarms for high and low voltage and high current conditions. Programming menus are password-protected.

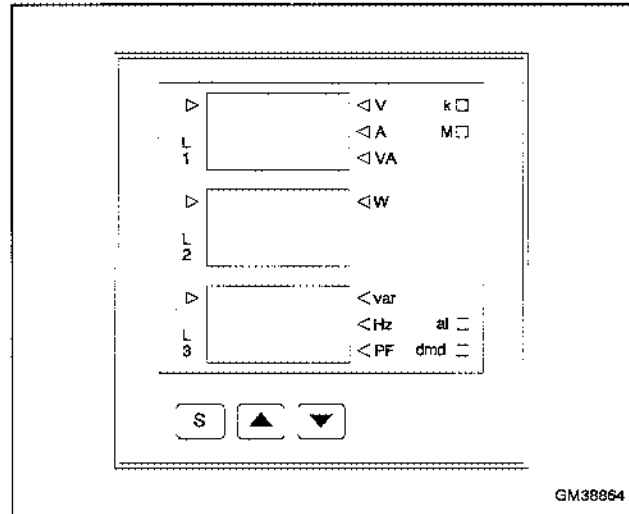


Figure 10-18 Digital Meter

The meter kit includes a 3-position selector switch. Use the switch to select the source to be monitored by the meter, Normal or Emergency. See Figure 10-19.

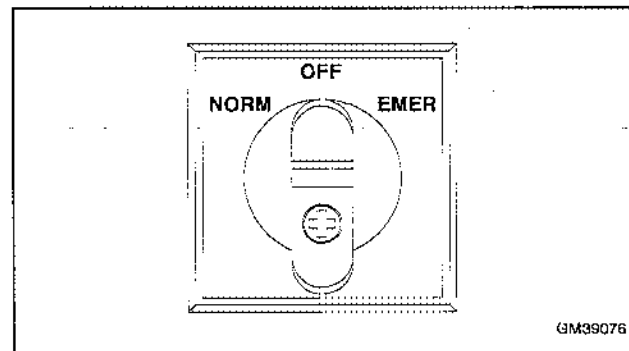


Figure 10-19 Three-Position Selector Switch

The meters are available factory-installed on transfer switches equipped with Series 1500 transfer switch controllers.

10.9 Current Sensing

The current sensing kit uses current transformers to measure the load bus current on all phases. Load current can then be displayed on the controller screen. See Section 5.3, Normal Operation Menus.

Use a clamp-on current sensing meter to calibrate the current. Store the measured current values using the Calibration screen. See Section 6.17.

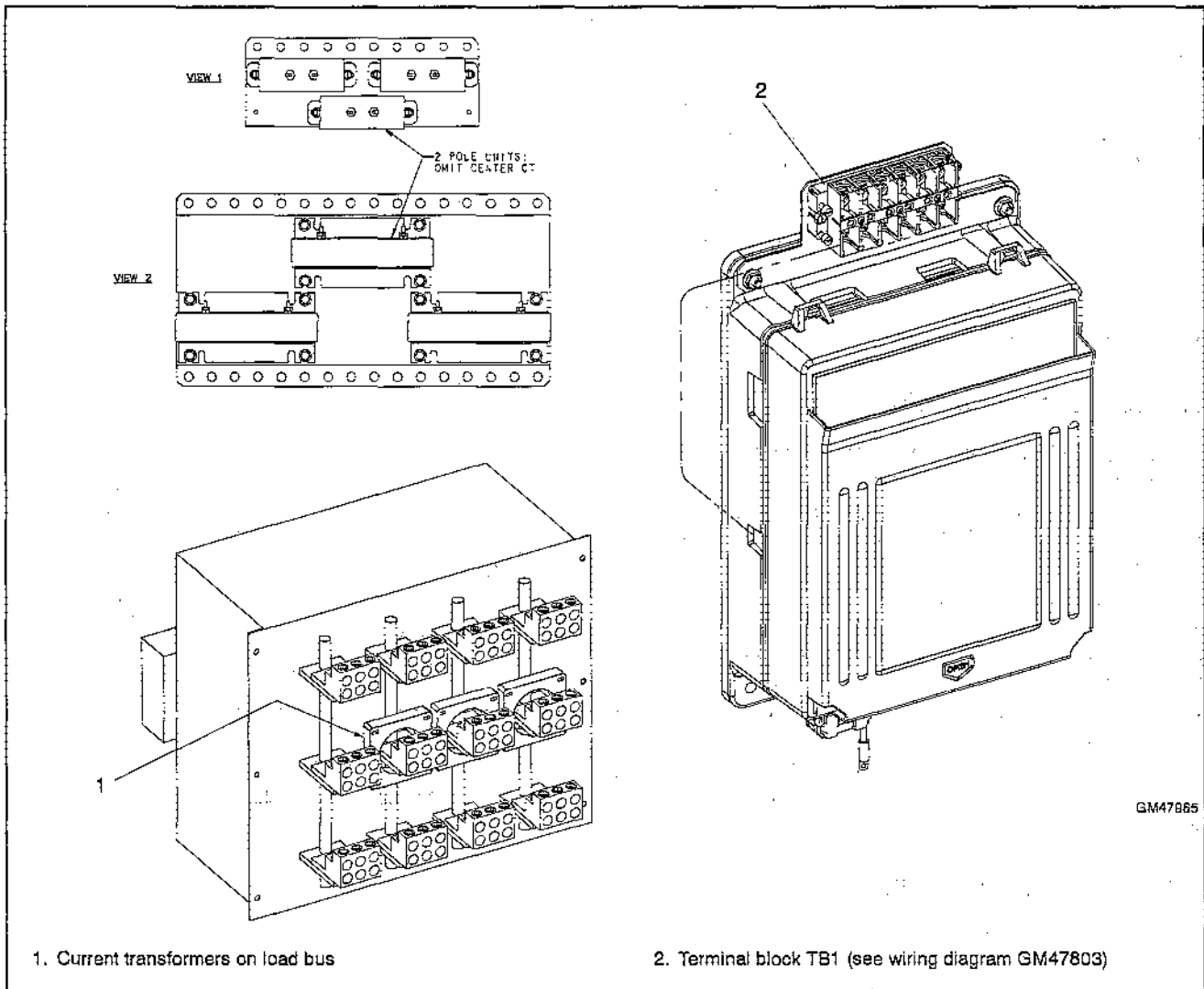


Figure 10-20 Current Sensing Kit

Figure 10-21 Current Sensing Wiring Diagram

10.10 Load Shed (Forced Transfer to OFF)

The load shed (forced transfer to OFF) accessory is available on 600 Amp programmed-transition model KSP transfer switches. The load shed accessory must be factory-installed.

10.10.1 Description

The load shed (forced transfer to off) accessory allows the removal of non-critical loads from the Source E generator set. The accessory requires an external signal (contact closure) to initiate transfer to the Off position.

When the forced transfer to off input is activated (contact closed), the contactor moves from Source E to the OFF position immediately, ignoring all time delays. If the normal source is available when the input is activated, the ATS transfers to the Off position and then to Source N. If Source N is not available, the ATS remains in the Off position until the input is deactivated. When the input is deactivated, the ATS transfers back to

Source N, if available, executing all programmed time delays. If Source N is not available, the ATS transfers to Source E.

The load shed (forced transfer to off) function only sheds loads connected to Source E. The preferred source selector switch position (if equipped) does not affect this function.

10.10.2 Connection

The load shed function requires an external signal (contact closure) to initiate transfer to the Off position. Connect the external contact to input #2 (terminals 7 and 8) on connector TB1 on the main logic board. See Figure 10-22. Use #12-24 AWG wire and tighten to 0.5 Nm (4.4 in. lb.)

Use the Input/Output setup screen to assign Main Board Input #2 to the forced transfer to Off function. If the external contact is connected to a different input connection on either the main logic board or an optional I/O module, assign the forced transfer to Off function to that input.

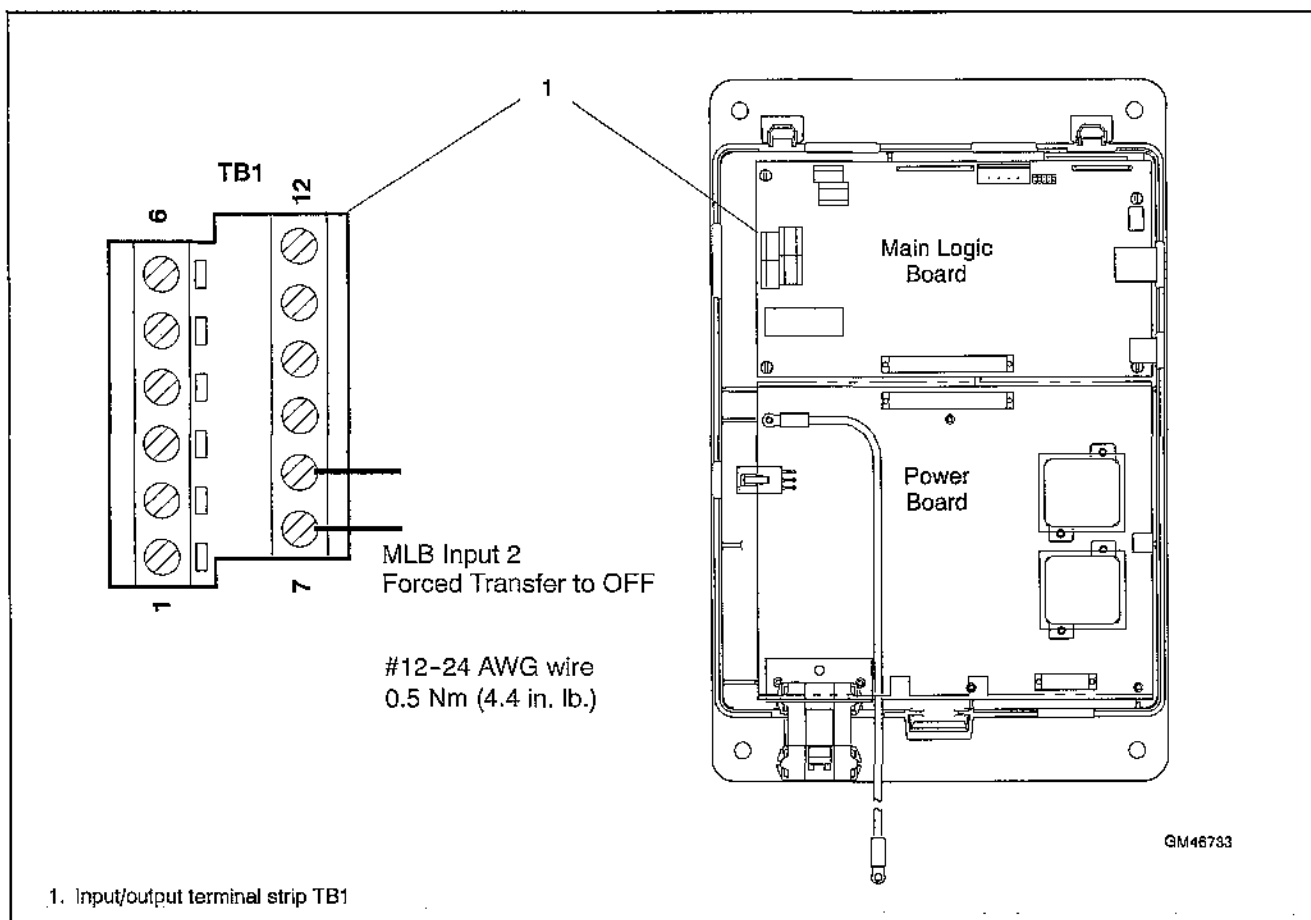


Figure 10-22 Forced Transfer to Off Input Connection (for factory-installed load shed kits)

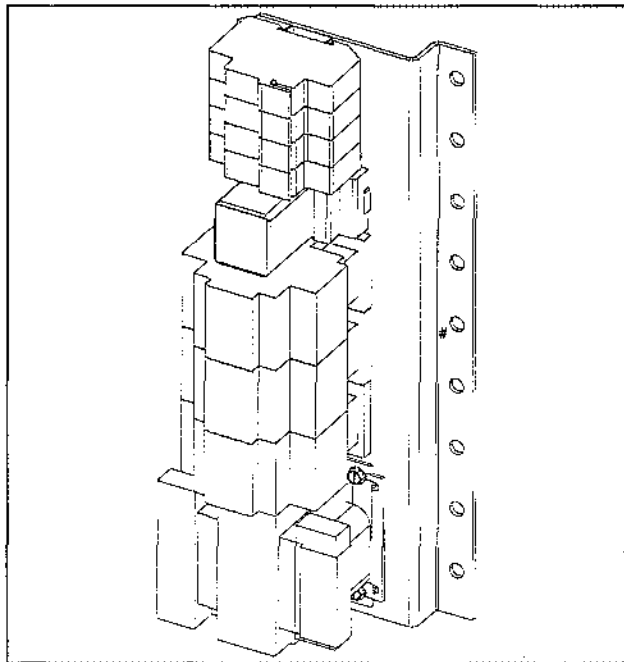


Figure 10-23 Load Shed Accessory (for identification)

10.11 User Interface Cover

The gasketed, hinged user interface cover prevents unauthorized access to the transfer switch controls and protects the user interface from harsh environmental conditions. Use a customer-supplied padlock to lock the cover.

The cover is available with or without a window for NEMA 1 enclosures. NEMA 3R enclosures include a windowless cover as standard equipment.

10.12 Line-to-Neutral Voltage Monitoring

Line-to-neutral voltage monitoring allows the display of the AN, BN, and CN RMS voltages in the normal operation menus. See Section 5.3. It is standard on 4-pole models and optional on 2-pole and 3-pole models.

The line-to-neutral monitoring kit is available factory-installed or as a loose kit. Refer to the instructions provided with the kit for field installation.

10.13 Logic Disconnect Switch

⚠ WARNING



**Accidental starting.
Can cause severe injury or death.**

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

The logic disconnect switch allows disconnection of power to the controller during maintenance and service.

The switch has two positions, auto and disconnect. The disconnect position disconnects the voltage sensing leads for normal and emergency (A, B, C, N) and the engine start signal.

Note: Disable the generator set before using the logic disconnect switch to disconnect power to the ATS controls.

Disconnecting power to the controls will cause the ATS to signal the generator set to start. Prevent the generator set from starting by moving the generator set master switch to OFF and disconnecting the battery charger and battery. Refer to the generator set operation manual for specific instructions.

10.14 Monitoring Program

Monitor III software allows power system monitoring and control using a personal computer connected to the controller through RS-485 connections or through a building's ethernet network. Refer to the Operation Manual provided with the software for instructions.

10.15 Battery Charger

The GM22502 is a 3-stage electronic battery charger designed for 12 or 24 VDC systems. It is designed to be used for lead acid batteries (flooded cell or AGM types) and gel cell batteries. The sealed and potted design is rainproof, lightweight, silent, and completely automatic. The charger contains internal, self-resetting short-circuit protection for the outputs and fuses for reversed-polarity protection.

The battery charger produces 12 VDC at 6 Amps or 24 VDC at 3 Amps. Red and green LEDs indicate that the unit is recharging or maintaining the battery.

WARNING



Sulfuric acid in batteries.
Can cause severe injury or death.

Wear protective goggles and clothing. Battery acid may cause blindness and burn skin.

WARNING



Explosion.
Can cause severe injury or death.
Relays in the battery charger cause arcs or sparks.

Locate the battery in a well-ventilated area. Isolate the battery charger from explosive fumes.

Battery electrolyte is a diluted sulfuric acid. Battery acid can cause severe injury or death. Battery acid can cause blindness and burn skin. Always wear splashproof safety goggles, rubber gloves, and boots when servicing the battery. Do not open a sealed battery or mutilate the battery case. If battery acid splashes in the eyes or on the skin, immediately flush the affected area for 15 minutes with large quantities of clean water. Seek immediate medical aid in the case of eye contact. Never add acid to a battery after placing the battery in service, as this may result in hazardous spattering of battery acid.

Battery acid cleanup. Battery acid can cause severe injury or death. Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled battery acid and continue to add the neutralizing solution to the spilled battery acid until all evidence of a chemical reaction (foaming) has ceased. Flush the resulting liquid with water and dry the area.

Battery gases. Explosion can cause severe injury or death. Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects. Remove all jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

Battery short circuits. Explosion can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Disconnect the battery before generator set installation or maintenance. Remove all jewelry before servicing the equipment. Use tools with insulated handles. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery. Never connect the negative (-) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together.

Figure 10-24 shows the battery charger. Refer to the transfer switch dimension drawing for the location of the battery charger.

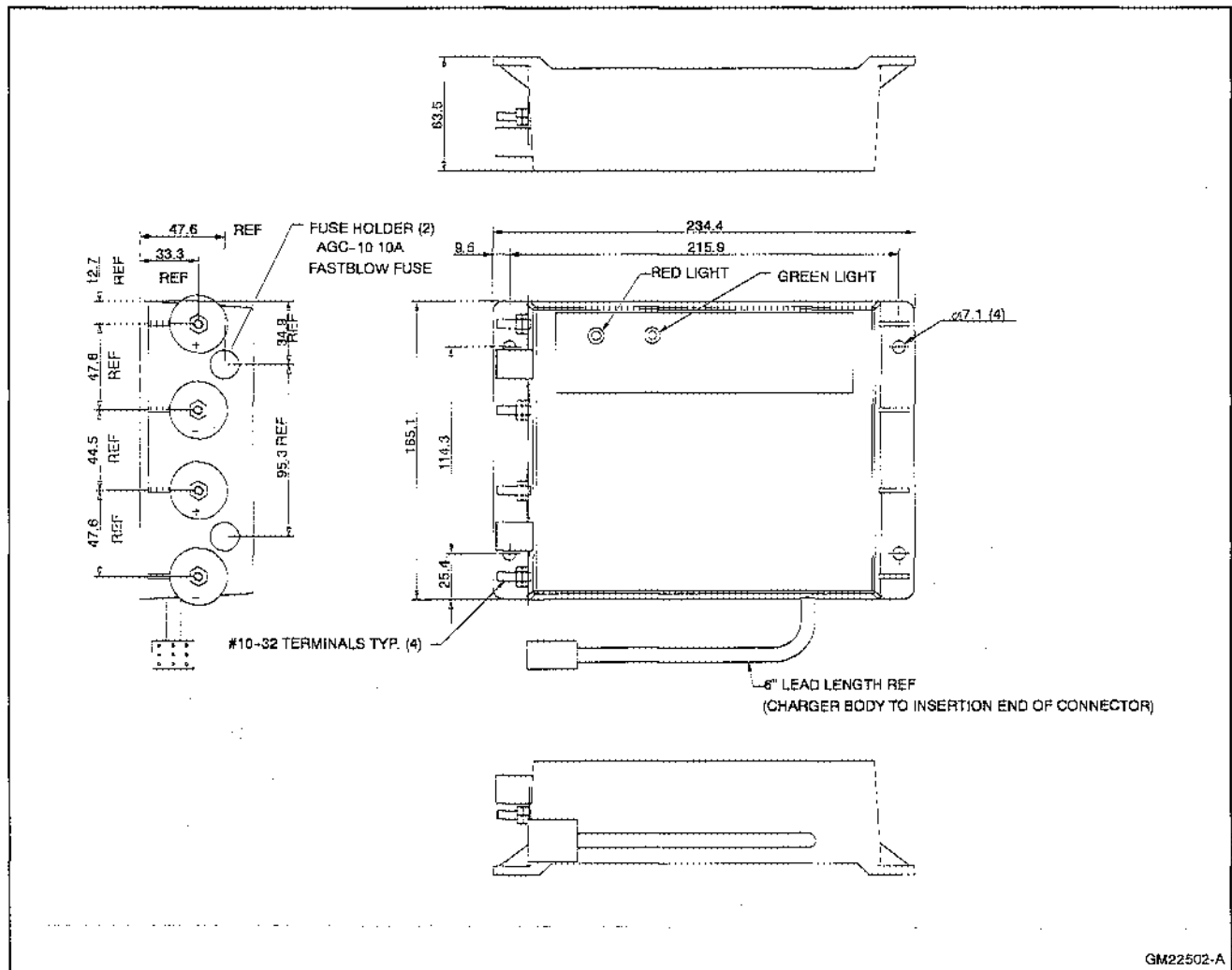


Figure 10-24 Battery Charger

10.15.1 Battery Charger Specifications

Figure 10-25 lists the battery charger specifications.

Output	
Charging	12 Volts DC (min.) at 6 Amps 24 Volts DC (min.) at 3 Amps
Maintaining	13.30 Volts DC at 0.1 Amps
Input	
Rated AC Voltage	208 VAC, AC connector pin 2 240 VAC, AC connector pin 4 480 VAC, AC connector pin 6 600VAC, AC connector pin 9
Current Draw	@ 50/ 60 Hz, 0.7 Amps Maximum
Maximum Recommended Battery Size	
Recharging	150 Amp-Hours
Maintenance only	300 Amp-Hours
Physical Dimensions	
Height	3.5 in. (8.9 cm)
Width	6.4 in. (16.3 cm)
Depth	2.1 in. (5.3 cm)
Weight	3.5 lb. (1.6 kg)

Figure 10-25 Battery Charger Specifications

10.15.2 Battery Charger Connection

The battery charger is powered by the load side of the transfer switch contactor through a factory-installed wiring harness with a 9-pin inline connector. Verify that the power to the ATS is disconnected before connecting or disconnecting the 9-pin connector to the battery charger.

Ring terminals for battery charger connections are included with the battery charger.

The installing technician must supply the cable with terminals between the battery charger and the battery. Figure 10-27 provides details regarding cable length and gauge. Using red cable for battery positive (+) and black cable for battery negative (-) is strongly recommended.

Use the following procedure to connect the battery charger.

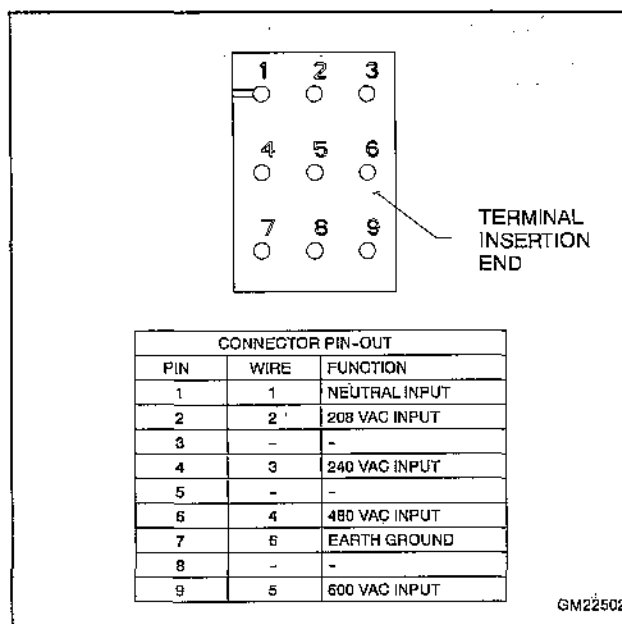
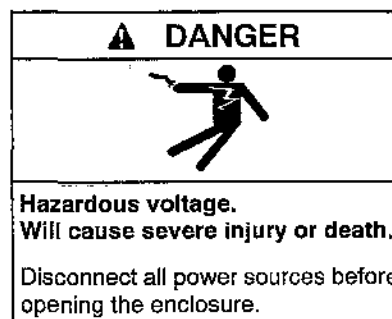


Figure 10-26 Battery Charger Power Connection

Battery Charger Connection Procedure



Connecting the battery and the battery charger. Hazardous voltage can cause severe injury or death. Reconnect the battery correctly, positive to positive and negative to negative, to avoid electrical shock and damage to the battery charger and battery(ies). Have a qualified electrician install the battery(ies).

1. Verify that power to the ATS is disconnected (switches or circuit breakers to the ATS are open).
2. Verify that the inline connector to the charger is disconnected.
3. Clean the battery terminals and check the battery according to the battery manufacturer's instructions.

- Determine the length of cable needed to connect the battery to the battery charger and refer to Figure 10-27 for the required wire size. The distances shown are the one-way distances from the charger to the battery.

Note: Use the recommended wire size to prevent overcharging the battery. Route AC and DC wiring in separate conduits.

- Remove the boots and ring terminals from the battery charger posts.

Maximum Distance	Wire Size	Battery Charger Terminal Size	Eyelet Terminal Part No.
4.5 m (15 ft.)	12 AWG	No. 10	X-283-11
7.5 m (25 ft.)	10 AWG		

Figure 10-27 Battery Cable and Terminal Specifications

- Slide a red boot onto the red cable and a black boot onto the black cable. Attach ring terminals and use a crimping tool to crimp the ring terminals tightly.
- Determine whether the generator set electrical system uses 12 or 24 volts. This information is shown on the generator set nameplate.
- Connect the jumpers as shown in Figure 10-28 for a 12-volt system or Figure 10-29 for a 24-volt system, reconnecting the jumper lead for 24-volt systems as shown. Place the jumper lead terminal between the two flat washers on the battery charger terminal.

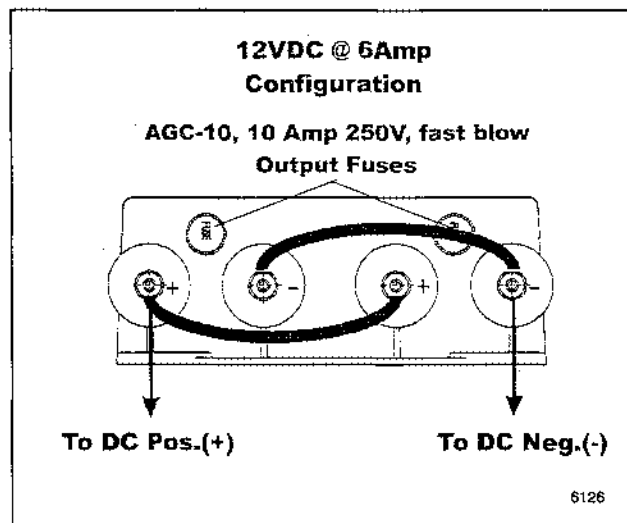


Figure 10-28 12-Volt Battery Charger Connections

Note: Battery chargers are configured for 12-volt systems at the factory. For 24-volt systems, reconnect the jumper lead as shown in Figure 10-29 and discard the second jumper lead.

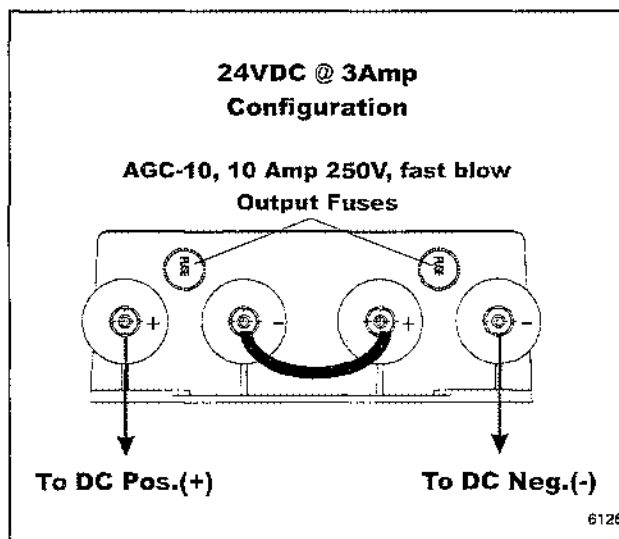


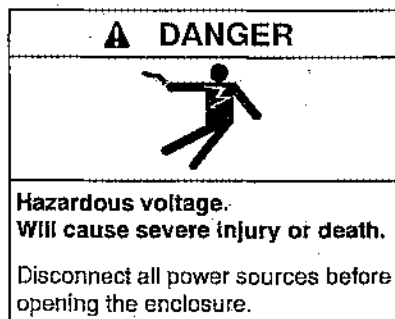
Figure 10-29 24-Volt Battery Charger Connections

- Connect the battery cables as shown in Figure 10-28 for 12 VDC systems or Figure 10-29 for 24 VDC systems.

Note: The positive (POS, P, +) battery post usually has a larger diameter than the negative (NEG, N, -) post.

- Connect the red POSITIVE terminal of the battery charger to the positive post of the battery.
 - Connect the black NEGATIVE terminal of the battery charger to the negative post of the battery.
- Slide the boots over the battery charger posts.
 - Connect the in-line connectors on the battery charger power cord.
 - Connect the charger to the battery according to the generator set or battery manufacturer's instructions, watching the polarity (+/-) of the connections.
 - Close the enclosure door and reconnect power to the transfer switch after the charger connections are complete.
 - Use a voltmeter to check the voltage at the battery and compare the readings to Figure 10-31 or Figure 10-32 to verify charger operation.

Battery Charger Disconnection Procedure



1. Before opening the transfer switch enclosure, disconnect power to the transfer switch by opening switches or circuit breakers to the transfer switch.

2. Disconnect the AC power cord at the in-line connector.
3. Remove the black (NEGATIVE) wire from the battery terminal first.
4. Remove the red (POSITIVE) wire from the battery terminal.

10.15.3 Battery Charger Operation

Red and green LEDs on the charger indicate the charge rate. Refer to Figure 10-30 for a description of the LED indicator operation. Figure 10-31 and Figure 10-32 show the 3-stage charging method for 12 VDC and 24 VDC configurations.

LED Indicators		Operating Condition
Red	Green	
On	Off	The battery is discharged and the charger is recharging at the BULK rate (stage 1). This charging rate is 6 Amps at 12V or 3 Amps at 24V. The measured voltage (with the charger on) is 11.8 to 14 Volts in 12VDC mode or 23.6 to 28VDC 24VDC mode. If the red LED stays on for more than 24 hours, refer to Problem 1 in the troubleshooting section in this manual.
On	On	The charger is charging at an ABSORPTION rate of between 1.5 and 5 Amps (stage 2). This mode of charging gradually "tops off" your battery, and reduces harmful sulfating. While both LED's are on, the voltage measured (with the charger on) should be approx. 14.0 to 14.5VDC in 12VDC mode or 28.0 to 29.0 in 24VDC mode. If both LED's stay on longer than 24 hours, refer to Problem 2 in the troubleshooting section in this manual.
Off	On	The charger is charging at a FLOAT or MAINTENANCE rate of less than 1.5 Amps, (stage 3). The battery is now 90% charged and ready for use. This "float" charging current will gradually decrease to as low as 0.1 Amps as the battery reaches 100% charge. The float rate maintains the battery at full charge without overcharging. If the green LED stays on when your battery is known to be low, refer to Problem 3 in the troubleshooting section in this manual.

Figure 10-30 Charger Operation

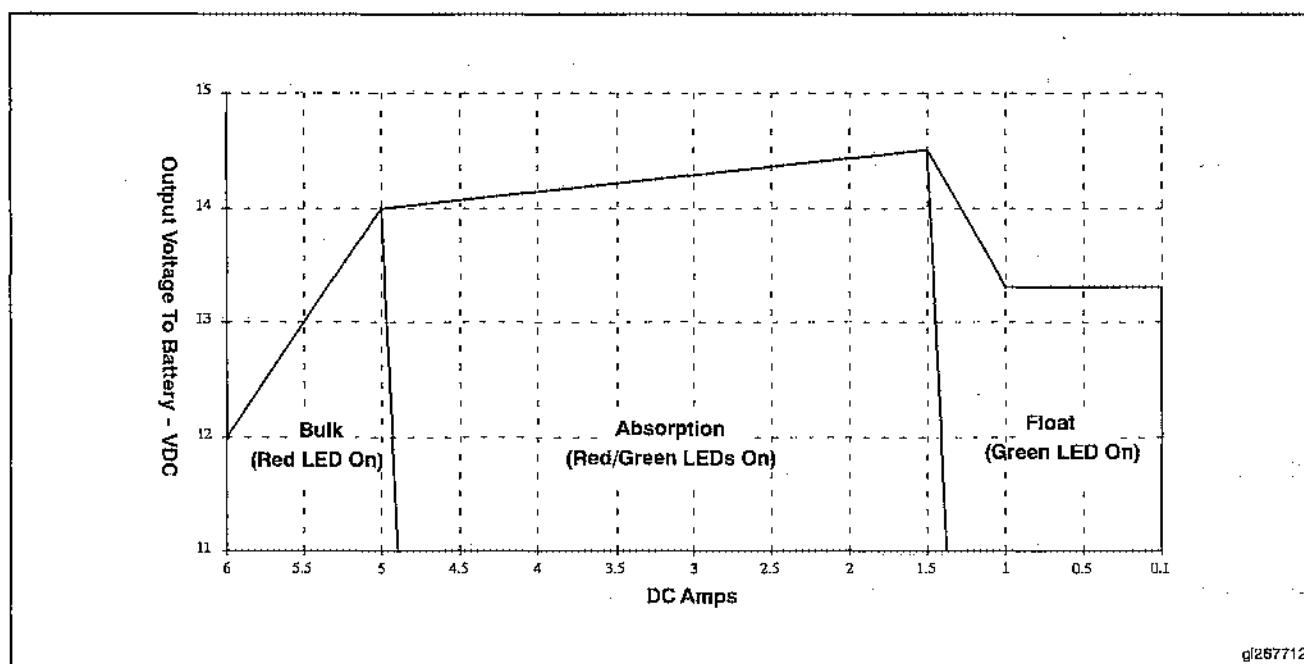


Figure 10-31 Charging Method, 12 VDC, 6 A Configuration

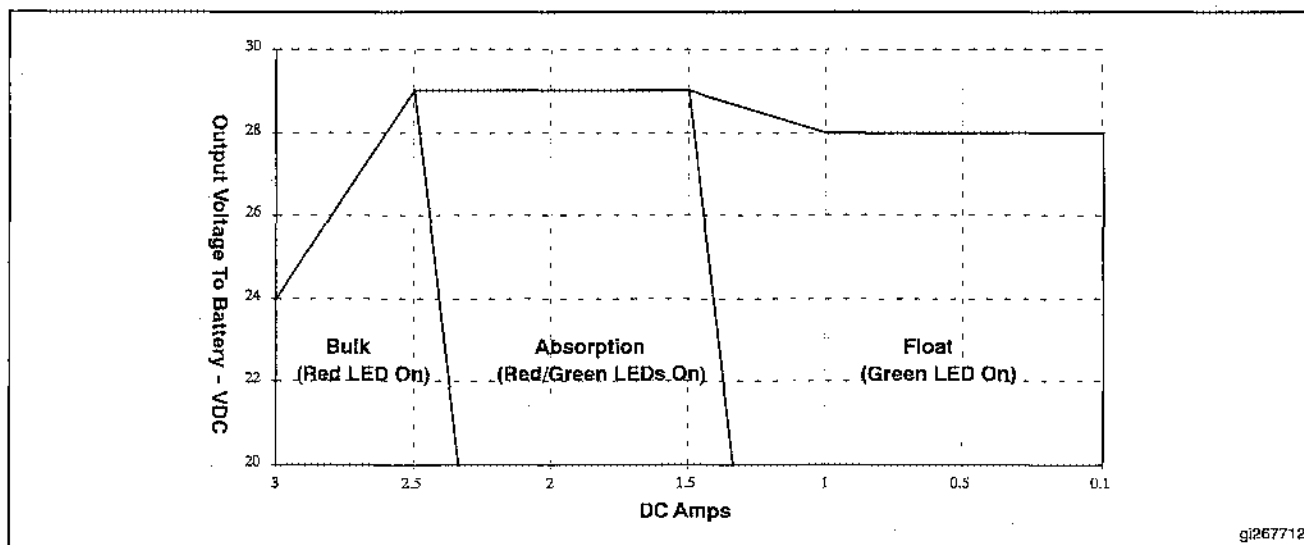


Figure 10-32 Charging Method, 24 VDC 3 A Configuration

10.15.4 Battery Charger Troubleshooting

Problem	Cause	Solution
Red LED stays on for more than 24 hours.	One or more defective or damaged cells.	Load test the battery and replace if necessary.
	Charger has reduced its output voltage below the normal level due to a DC overload or a DC short.	Remove the source of the overload or short. Disconnect the charger's black (NEGATIVE) ring terminal from the battery. Reapply AC power and the green LED only should now light.
	On-board DC systems are drawing more current than the charger can replace.	Turn off excessive DC equipment while charging.
The red and green LEDs stay on for more than 24 hours.	On-board DC systems are drawing between 1.5 – 5A.	Turn off excessive DC equipment while charging.
	One or more defective or damaged cells.	Load test the battery and replace if necessary.
	Extremely low AC voltage at the battery charger.	Apply a higher AC voltage source or reduce the length of the power cord.
Green LED stays on when the battery is known to be low.	Open DC output fuse.	Replace the DC output fuse with a Bussmann AGC-10.
	Faulty or contaminated terminal connections.	Clean and tighten or repair all terminal connections.
	One or more defective or damaged cells.	Load test the battery and replace if necessary.
Neither of the LEDs turn on when the AC power is applied.	No AC power available at the charger.	Connect AC power or reset the AC breaker on the main panel.
	Component failure.	Replace the charger.

Figure 10-33 Battery Charger Troubleshooting

Notes

Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

A, amp	ampere	cfm	cubic feet per minute	est.	estimated
ABDC	after bottom dead center	CG	center of gravity	E-Stop	emergency stop
AC	alternating current	CID	cubic inch displacement	etc.	et cetera (and so forth)
A/D	analog to digital	CL	centerline	exh.	exhaust
ADC	advanced digital control; analog to digital converter	cm	centimeter	ext.	external
adj.	adjust, adjustment	CMOS	complementary metal oxide substrate (semiconductor)	F	Fahrenheit, female
ADV	advertising dimensional drawing	cogen.	cogeneration	fglass.	fiberglass
Ah	amp-hour	com	communications (port)	FHM	flat head machine (screw)
AHWT	anticipatory high water temperature	coml	commercial	fl. oz.	fluid ounce
AISI	American Iron and Steel Institute	Coml/Rec	Commercial/Recreational	flex.	flexible
ALOP	anticipatory low oil pressure	conn.	connection	freq.	frequency
alt.	alternator	cont.	continued	FS	full scale
Al	aluminum	CPVC	chlorinated polyvinyl chloride	ft.	foot, feet
ANSI	American National Standards Institute (formerly American Standards Association, ASA)	crit.	critical	ft. lb.	foot pounds (torque)
AO	anticipatory only	CRT	cathode ray tube	ft./min.	feet per minute
APDC	Air Pollution Control District	CSA	Canadian Standards Association	ftp	file transfer protocol
API	American Petroleum Institute	CT	current transformer	g	gram
approx.	approximate, approximately	Cu	copper	ga.	gauge (meters, wire size)
AQMD	Air Quality Management District	cUL	Canadian Underwriter's Laboratories	gal.	gallon
AR	as required, as requested	CUL	Canadian Underwriter's Laboratories	gen.	generator
AS	as supplied, as stated, as suggested	cu. in.	cubic inch	genset	generator set
ASE	American Society of Engineers	cw.	clockwise	GFI	ground fault interrupter
ASME	American Society of Mechanical Engineers	CWC	city water-cooled	GND, $\oplus$	ground
assy.	assembly	cyl.	cylinder	gov.	governor
ASTM	American Society for Testing Materials	D/A	digital to analog	gph	gallons per hour
ATDC	after top dead center	DAC	digital to analog converter	gpm	gallons per minute
ATS	automatic transfer switch	dB	decibel	gr.	grade, gross
auto.	automatic	dB(A)	decibel (A weighted)	GRD	equipment ground
aux.	auxiliary	DC	direct current	gr. wt.	gross weight
avg.	average	DCR	direct current resistance	H x W x D	height by width by depth
AVR	automatic voltage regulator	deg., °	degree	HC	hex cap
AWG	American Wire Gauge	dept.	department	HCHT	high cylinder head temperature
AWM	appliance wiring material	DFMEA	Design Failure Mode and Effects Analysis	HD	heavy duty
bat.	battery	dia.	diameter	HET	high exhaust temp., high engine temp.
BBDC	before bottom dead center	D/EO	dual inlet/end outlet	hex	hexagon
BC	battery charger, battery charging	DIN	Deutsches Institut für Normung e. V. (also Deutsche Industrie Normenausschuss)	Hg	mercury (element)
BCA	battery charging alternator	DIP	dual inline package	HH	hex head
BCI	Battery Council International	DPDT	double-pole, double-throw	HHC	hex head cap
BDC	before dead center	DPST	double-pole, single-throw	HP	horsepower
BHP	brake horsepower	DS	disconnect switch	hr.	hour
blk.	black (paint color), block (engine)	DVR	digital voltage regulator	HS	heat shrink
blk. htr.	block heater	E, emer.	emergency (power source)	hsg.	housing
BMEP	brake mean effective pressure	ECM	electronic control module, engine control module	HVAC	heating, ventilation, and air conditioning
bps	bits per second	EDI	electronic data interchange	HWT	high water temperature
br.	brass	EFR	emergency frequency relay	Hz	hertz (cycles per second)
BTDC	before top dead center	e.g.	for example (<i>exempli gratia</i>)	IC	integrated circuit
Btu	British thermal unit	EG	electronic governor	ID	inside diameter, identification
Btu/min.	British thermal units per minute	EGSA	Electrical Generating Systems Association	IEC	International Electrotechnical Commission
C	Celsius, centigrade	EIA	Electronic Industries Association	IEEE	Institute of Electrical and Electronics Engineers
cal.	calorie	Ei/EO	end inlet/end outlet	IMS	improved motor starting
CAN	controller area network	EMI	electromagnetic interference	in.	inch
CARB	California Air Resources Board	emiss.	emission	in. H ₂ O	inches of water
CB	circuit breaker	eng.	engine	in. Hg	inches of mercury
cc	cubic centimeter	EPA	Environmental Protection Agency	in. lb.	inch pounds
CCA	cold cranking amps	EPS	emergency power system	Inc.	incorporated
ccw.	counterclockwise	ER	emergency relay	ind.	industrial
CEC	Canadian Electrical Code	ES	engineering special, engineered special	int.	internal
cert.	certificate, certification, certified	ESD	electrostatic discharge	int./ext.	internal/external
cfh	cubic feet per hour			I/O	input/output
				IP	iron pipe
				ISO	International Organization for Standardization
				J	joule
				JIS	Japanese Industry Standard

k	kilo (1000)	MTBO	mean time between overhauls	rms	root mean square
K	kelvin	mtg.	mounting	rnd.	round
kA	kiloampere	MTU	Motoren-und Turbinen-Union	ROM	read only memory
KB	kilobyte (2 ¹⁰ bytes)	MW	megawatt	rot.	rotate, rotating
KBus	Kohler communication protocol	mW	milliwatt	rpm	revolutions per minute
kg	kilogram	μF	microfarad	RS	right side
kg/cm ²	kilograms per square centimeter	N, norm.	normal (power source)	RTU	remote terminal unit
kgm	kilogram-meter	NA	not available, not applicable	RTV	room temperature vulcanization
kg/m ³	kilograms per cubic meter	nat. gas	natural gas	RW	read/write
KHz	kilohertz	NBS	National Bureau of Standards	SAE	Society of Automotive Engineers
KJ	kilojoule	NC	normally closed	scfm	standard cubic feet per minute
km	kilometer	NEC	National Electrical Code	SCR	silicon controlled rectifier
kOhm, kΩ	kilo-ohm	NEMA	National Electrical Manufacturers Association	s, sec.	second
kPa	kilopascal	NEPA	National Fire Protection Association	SI	<i>Système international d'unités</i> , International System of Units
kph	kilometers per hour	Nm	newton meter	SI/EO	side in/end out
kV	kilovolt	NO	normally open	sil.	silencer
kVA	kilovolt ampere	no., nos.	number, numbers	SN	serial number
KVAR	kilovolt ampere reactive	NPS	National Pipe, Straight	SNMP	simple network management protocol
KW	kilowatt	NPSC	National Pipe, Straight-coupling	SPDT	single-pole, double-throw
KWh	kilowatt-hour	NPT	National Standard taper pipe thread per general use	SPST	single-pole, single-throw
KWm	kilowatt mechanical	NPTF	National Pipe, Taper-Fine	spec	specification
KWth	kilowatt-thermal	NR	not required, normal relay	specs	specification(s)
L	liter	ns	nanosecond	sq.	square
LAN	local area network	OC	overcrank	sq. cm	square centimeter
L x W x H	length by width by height	OD	outside diameter	sq. in.	square inch
lb.	pound, pounds	OEM	original equipment manufacturer	SS	stainless steel
lbm/ft ³	pounds mass per cubic feet	OF	overfrequency	std.	standard
LCB	line circuit breaker	opt.	option, optional	stl.	steel
LCD	liquid crystal display	OS	oversize, overspeed	tach.	tachometer
ld. shd.	load shed	OSHA	Occupational Safety and Health Administration	TD	time delay
LED	light emitting diode	OV	overvoltage	TDC	top dead center
Lph	liters per hour	oz.	ounce	TDEC	time delay engine cooldown
Lpm	liters per minute	p., pp.	page, pages	TDEN	time delay emergency to normal
LOP	low oil pressure	PC	personal computer	TDES	time delay engine start
LP	liquefied petroleum	PCB	printed circuit board	TDNE	time delay normal to emergency
LPG	liquefied petroleum gas	pF	picofarad	TDOE	time delay off to emergency
LS	left side	PF	power factor	TDON	time delay off to normal
L _{wa}	sound power level, A weighted	ph., Ø	phase	temp.	temperature
LWL	low water level	PHC	Phillips® head Crimptite® (screw)	term.	terminal
LWT	low water temperature	PHH	Phillips® hex head (screw)	THD	total harmonic distortion
m	meter, milli (1/1000)	PHM	pan head machine (screw)	TIF	telephone influence factor
M	mega (10 ⁶ when used with SI units), male	PLC	programmable logic control	TIR	total indicator reading
m ³	cubic meter	PMG	permanent magnet generator	tol.	tolerance
m ³ /hr.	cubic meters per hour	pot	potentiometer, potential	turbo.	turbocharger
m ³ /min.	cubic meters per minute	ppm	parts per million	typ.	typical (same in multiple locations)
mA	milliampere	PROM	programmable read-only memory	UF	underfrequency
man.	manual	psi	pounds per square inch	UHF	ultrahigh frequency
max.	maximum	psig	pounds per square inch gauge	UL	Underwriter's Laboratories, Inc.
MB	megabyte (2 ²⁰ bytes)	pt.	pint	UNC	unified coarse thread (was NC)
MCCB	molded-case circuit breaker	PTC	positive temperature coefficient	UNF	unified fine thread (was NF)
MCM	one thousand circular mils	PTO	power takeoff	univ.	universal
meggar	megohmmeter	PVC	polyvinyl chloride	US	undersize, underspeed
MHz	megahertz	qt.	quart, quarts	UV	ultraviolet, undervoltage
mi.	mile	qty.	quantity	V	volt
mil	one one-thousandth of an inch	R	replacement (emergency)	VAC	volts alternating current
min.	minimum, minute	rad.	radiator, radius	VAR	voltampere reactive
misc.	miscellaneous	RAM	random access memory	VDC	volts direct current
MJ	megajoule	RDO	relay driver output	VFD	vacuum fluorescent display
mJ	millijoule	ref.	reference	VGA	video graphics adapter
mm	millimeter	rem.	remote	VHF	very high frequency
mOhm, mΩ	milliohm	Res/Coml	Residential/Commercial	W	watt
MOhm, MΩ	megohm	RFI	radio frequency interference	WCR	withstand and closing rating
MOV	metal oxide varistor	RH	round head	w/	with
MPa	megapascal	RHM	round head machine (screw)	w/o	without
mpg	miles per gallon	ry.	relay	wt.	weight
mph	miles per hour			xfrm	transformer
MS	military standard				
ms	millisecond				
m/sec.	meters per second				
MTBF	mean time between failure				

Appendix B Message Summaries

System Alert Message Summary

Fault	Type	Description
Failure to Acquire Standby Source	Warning	The source voltage did not reach the acceptable range within a set time (see Time Delays). For example, the standby source generator set did not start.
Failure to Acquire Preferred Source	Warning	
Failure to Transfer	Warning	The signal to transfer is sent to the contactor and the main shaft auxiliary switch fails to indicate a complete ATS position change. The controller will attempt to transfer the unit three times before the fault is indicated.
IPM Synching (In-Phase Monitor Synching)	Warning	The two sources did not come into phase within the Fail to Synchronize time delay. Note: If the sources do become in phase, the warning is automatically cleared and normal ATS operation continues.
Auxiliary Switch Fault	Manual Reset Fault	The main shaft auxiliary switches indicate that the ATS is in more than one position, or the position changed when no signal was sent to initiate the change.
Auxiliary Switch Open	Manual Reset Fault	The main shaft auxiliary switches indicate that the ATS is in neither position (all inputs are open).
Src N (or Src E) Rotation Err	Self-Resetting Fault	The detected phase rotation of one or both sources does not match the pre-selected setting.
I/O Module Lost Comm	Self-Resetting Fault	An I/O device has stopped communicating or does not have a correct address specified.
External Fault	Self-Resetting Fault	The external contact assigned to this input is closed.

Event History Message Summary

System History Message Summary	
Display Message	The Controller Has Detected the Following Condition
End Time Delay Btn	End delay button pressed.
Test Btn	Test button pressed.
Exercise Btn	End exercise button pressed during exercise run.
Lamp Test	Lamp test button pressed.
Service Req'd Reset	Reset button pressed to clear a fault that triggered the system alert LED.
Maint DIP Switch	Maintenance DIP switches closed (transfer inhibited for service).
Pwd DIP Switch	Password disable DIP switch closed.
Manual Option Switch	Supervised transfer switch changed position.
New Module	New I/O, alarm, or battery supply module detected.
Contactor in Off	Transfer switch moved to the OFF position (programmed-transition models only).
Contactor in Src N	Transfer switch moved to the Source N position.
Contactor in Src E	Transfer switch moved to the Source E position.
Low Battery	Output to indicate low voltage on the external battery (connected to the EBSM).
Exerciser Active	Scheduled exercise sequence running.
Fail to Acquire Pref	Preferred source not within acceptable voltage or frequency range.
Fail to Acquire Stby	Standby source not within acceptable voltage or frequency range.
Fail to Transfer	Transfer switch failed to transfer when signaled, according to position switches.
I/O Module Lost Comm	Communication with an installed I/O module has been lost.
Aux Switch Fault	The main shaft auxiliary switches indicate that the ATS is in more than one position, or the position changed when no signal was sent to initiate the change.
Aux Switch Open	The main shaft auxiliary switches indicate that the ATS is in neither position (all inputs are open).
Rem End Time Delay	Remote input assigned to remote end time delay is active (contact closed). The time delay running at the time of the signal ends.

System History Message Summary	
Display Message	The Controller Has Detected the Following Condition
Forced Trans to Off	Remote input assigned to forced transfer to OFF for load shed function (programmed-transition models only) is active (contact closed).
Peak Shave Mode	Peak shave mode is active (initiated by the forced transfer to OFF input).
Inhibit Transfer	Remote input assigned to inhibit transfer function is active (contact closed). Prevents transfer for maintenance or service.
Remote Test	External signal (contact closure) connected to a programmable input assigned to remote test. Signals the transfer switch to start a test sequence.
Low Battery Voltage	External battery (connected to the EBSM) voltage is low.
Remote Common Alarm	One or more conditions assigned to the common alarm is active.
Bypass Contactor Dis	Bypass/isolation switches only.
3 Src System Disable	A 3 Source System Disable input signal is active. See Section 6.9.
Over Frequency	Source frequency is above the over frequency dropout setting.
Under Frequency	Source frequency is below the under frequency dropout setting.
Phase Loss	One or more phases not detected.
Phase Rotation Error	Source ABC or BAC rotation does not match system setting.
Over Voltage L1-L2	Source voltage across L1 and L2 is above the over voltage dropout setting.
Over Voltage L2-L3	Source voltage across L2 and L3 is above the over voltage dropout setting.
Over Voltage L3-L1	Source voltage across L3 and L1 is above the over voltage dropout setting.
Under Voltage L1-L2	Source voltage across L1 and L2 is below the undervoltage dropout setting.
Under Voltage L2-L3	Source voltage across L2 and L3 is below the undervoltage dropout setting.
Under Voltage L3-L1	Source voltage across L3 and L1 is below the undervoltage dropout setting.
Voltage Imbalance	Source voltage imbalance detected.
Save History To File	Event history saved to a file.
Auto Loaded Test End	The auto load test sequence timer has expired, ending the test sequence.
Test Loaded Changed	The remote test loaded/unloaded setting was changed.
Pref Source Changed	The preferred source selection has been changed (optional accessory).
Reload Dflt Params	The system has been reset to the factory default settings (see Reset Data screen).
MODBUS Peak Shave	A peak shave command has been received through Monitor III or other Modbus application.
MODBUS Forced to OFF	A Transfer to OFF command has been received through Monitor III or other Modbus application.
MODBUS System Test	A Test command has been received through Monitor III or other Modbus application.
Battery Control Out	Battery control command turns off the battery 20 seconds after power is lost to preserve the controller's battery.
USB Connected	A device has been connected to the controller's USB port.
USB Disconnected	A device has been disconnected from the controller's USB port.

Appendix C Setup Worksheets

Record system settings on the worksheets in this section, if desired. System settings can be viewed on the controller's display and also saved to a file on a PC or a memory device. Refer to the Table of Contents to find instructions.

System Setup Record

System Setup	
Operation	☐ Util-Gen ☐ Gen-Gen ☐ Util-Util ☐ Util-Gen-Gen (3-source system)
Transition type	☐ Standard ☐ Programmed (delayed)
Rated Current _____ Amps	
3 Source Engine Start Mode	☐ Not Applicable (2-source system) ☐ Mode 1 (start preferred first) ☐ Mode 2 (start both) Preferred Source Toggle: ☐ Enabled ☐ Disabled
Transfer Commit	☐ Commit ☐ No Commit
Remote Test Loading	☐ Loaded ☐ Unloaded
Peak Shave Delay	☐ Enabled ☐ Disabled

Source Setup Record

Determine normal and emergency pickup and dropout setpoints that provide load protection. Enter normal and emergency pickup and dropout setpoints in the worksheet below. Program the new setpoints in the Source Setup Screen. See Section 6.7.

Record the setting in % and calculate the resulting voltage or frequency value. Note that some settings are a percentage of the nominal system voltage or frequency while others are a percentage of another setting.

Source Setup					
System Voltage:		Normal: _____ VAC ;	Emergency: _____ VAC		
System Frequency:		☐ 60 Hz	☐ 50 Hz		
Number of phases:		☐ Single-Phase	☐ Three-Phase		
Phase Rotation:		☐ ABC	☐ BAC	☐ None	
Inphase Monitor:		☐ Enabled	☐ Disabled	Inphase Monitor Angle: _____ Degrees	
Preferred Source:		☐ N	☐ E		
Source	Settings	Default Setting %	Adjustment Range Increments of 1%	New Setting	
				%	Value
N	Under voltage dropout	90%	75 to 98% of Pickup		
	Under voltage pickup	90%	85 to 100% of Nominal		
	Over voltage dropout	115% †	106 to 135% of Nominal †		
	Over voltage pickup	95%	95 to 100% of Dropout		
	Unbalance enable	Enable	Enable or disable		
	Unbalance drop out	20%	5 to 20%		
	Unbalance pick up	10%	3 to 18%		
	Debounce time	0.5 sec	0.1 to 9.9 seconds		
N *	Under frequency dropout	99%	95 to 99% of Pickup		
	Under frequency pickup	90%	80 to 95% of Nominal		
	Over frequency dropout	101%	101 to 115% of Pickup		
	Over frequency pickup	110%	105 to 120% of Nominal		
	Debounce time	3 sec	0.1 to 15 seconds		
E	Under voltage dropout	90%	75 to 98% of Pickup		
	Under voltage pickup	90%	85 to 100% of Nominal		
	Over voltage dropout	115% †	106 to 135% of Nominal †		
	Over voltage pickup	95%	95 to 100% of Dropout		
	Unbalance enable	Enable	Enable or disable		
	Unbalance drop out	20%	5 to 20%		
	Unbalance pick up	10%	3 to 18%		
	Debounce time	0.5 s	0.1 to 9.9 seconds		
E	Under frequency dropout	99%	95 to 99% of Pickup		
	Under frequency pickup	90%	80 to 95% of Nominal		
	Over frequency dropout	101%	101 to 115% of Pickup		
	Over frequency pickup	110%	105 to 120% of Nominal		
	Debounce time	3 sec	0.1 to 15 seconds		
* Normal source frequency settings apply to Gen-Gen mode only † For 600 volt applications, the over voltage is limited to 110% (660 volts)					

Time Delays

Complete the worksheet below by entering the desired time delay settings in minutes:seconds. Program new settings in the Time Delay setup menus. See Section 6.10.

The controller maintains control for approximately 20 seconds with no available power source. For extended engine start delays as long as 60 minutes, install the battery option board. If the objective is to increase the time delay before transferring to the emergency source, you may wish to increase the normal to emergency transfer time delay (Xfr N>E) instead of the engine start delay. Then the generator set will be supplying power to the controller until Xfr N>E ends.

Time Delay Description	Adjustment Range	Default Setting	New Setting
Engine Start, Source E	0-6 sec (0-60 min with external battery module)	00:03	
Engine Start, Source N	0-60 min	00:03	
Engine Cooldown, Source E		00:05	
Engine Cooldown, Source N		00:02	
Fail to Acquire Stby		01:00	
Xfr N>E		00:03	
Load # Disc N>E		00:00	
Load # Add N>E		00:00	
Xfr E>N		15:00	
Load # Disc E>N		00:00	
Load # Add E>N		00:00	
In-Phase Xfr Fail		00:30	
Xfr Off>E		00:01	
Xfr OFF>N		00:01	
Fail to Acquire Pref		01:00	

Programmable Input and Outputs

Record programmable input and output settings for the main logic board and optional I/O modules, if desired. See Section 6.12.

Main Logic Board

Main Logic Board Programmable Inputs and Outputs		
Input Number	Assigned Function	Notes
1		
2		
Output Number	Assigned Function	Notes
1		
2		

I/O Modules

I/O Module Programmable Inputs and Outputs		
Module Type: ☐ Standard ☐ High Power		
Address (1-4): _____		
Input Number	Assigned Function	Notes
1		
2		
Output Number	Assigned Function	Notes
1		
2		
3		
4 *		
5 *		
6 *		

* Outputs 4-6 are only available on standard I/O modules. High-power modules have 3 output connections.

I/O Module Programmable Inputs and Outputs		
Module Type: ☐ Standard ☐ High Power Address (1-4): _____		
Input Number	Assigned Function	Notes
1		
2		
Output Number	Assigned Function	Notes
1		
2		
3		
4 *		
5 *		
6 *		
* Outputs 4-6 are only available on standard I/O modules. High-power modules have 3 output connections.		

I/O Module Programmable Inputs and Outputs		
Module Type: ☐ Standard ☐ High Power Address (1-4): _____		
Input Number	Assigned Function	Notes
1		
2		
Output Number	Assigned Function	Notes
1		
2		
3		
4 *		
5 *		
6 *		
* Outputs 4-6 are only available on standard I/O modules. High-power modules have 3 output connections.		

I/O Module Programmable Inputs and Outputs		
Module Type: ☐ Standard ☐ High Power		
Address (1-4): _____		
Input Number	Assigned Function	Notes
1		
2		
Output Number	Assigned Function	Notes
1		
2		
3		
4 *		
5 *		
6 *		
* Outputs 4-6 are only available on standard I/O modules. High-power modules have 3 output connections.		

Load Control

Setting up the load control function requires a number of output assignments and time delay settings. Use the worksheet in this section to plan and record load control output settings and related time delays. See Section 6.11.

Load Control Setup					
Date:		ATS Name (optional):			
Loads to Add:		Normal:		Emergency:	
Transfer (Xfr) Time Delays		N>E:		E>N:	
Load Control Output #	Output Connection	Load Control Time Delays			
		Load Disconnect N>E	Add E>N	Load Disconnect E>N	Add N>E
0	Main #1 _____ Main #2 _____ I/O Mod # _____ Out # _____				
1	Main #1 _____ Main #2 _____ I/O Mod # _____ Out # _____				
2	Main #1 _____ Main #2 _____ I/O Mod # _____ Out # _____				
3	Main #1 _____ Main #2 _____ I/O Mod # _____ Out # _____				
4	Main #1 _____ Main #2 _____ I/O Mod # _____ Out # _____				
5	Main #1 _____ Main #2 _____ I/O Mod # _____ Out # _____				
6	Main #1 _____ Main #2 _____ I/O Mod # _____ Out # _____				
7	Main #1 _____ Main #2 _____ I/O Mod # _____ Out # _____				
8	Main #1 _____ Main #2 _____ I/O Mod # _____ Out # _____				

Exerciser Setup

Program up to 21 different exercise runs in the Set Exerciser setup screen. See Section 6.14.

Exerciser Worksheet							
Exercise Event #	Enabled/Disabled	Loaded/Unloaded	Interval: Weekly, Monthly, Day/Month, Daily	Repeat Rate	Duration HR:MN	Start Date mm/dd/yy	Start Time HR:MN
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							

Communications Setup

The transfer switch uses Modbus TCP/IP protocol to communicate with a personal computer running Monitor III software or other custom-designed* Modbus applications. Configure the system for communication through the RS-485 serial port or through the ethernet port. Complete the worksheet below and program communications settings in the Communications Setup screen. See Section 7.3.

* Other applications require a Modbus driver written for the specific application by a trained and qualified systems designer.

Communications Setup Worksheet			
Setting	Range	Setting	Notes
Modbus Server TCP	Enabled or Disabled		Enable for network communication through the ethernet port.
Modbus Server Port 1	Enabled or Disabled		Enable for Modbus communication through serial port 1 on the main logic board. See Section 7.2.
Modbus Server Port 2	Enabled or Disabled		Enable for Modbus communication through serial port 2 on the main logic board. See Section 7.2.
Modbus Addr Port 1	001-247		Address for RS-485 serial port 1 (on the main logic board). Each port must have a different address.
Modbus Addr Port 2	001-247		Address for RS-485 serial port 2 (on the main logic board). Each port must have a different address.
Baud Rate Port 1	9600, 19200, 57600		Baud rate in bits per second for serial communication between the controller and a personal computer's COM port.
Baud Rate, Port 2	9600, 19200, 57600		
Modbus TCP Unit ID			System ID number works as a password to allow modem communication only with software that has the correct System ID number. Relevant only for remote single and remote area network connections.
IP Address			Obtain from your local network administrator. Every device on the network must have a unique IP address.
Subnet Mask			Obtain from your local network administrator.

Appendix D Screen Summaries

This section lists the items shown in the View and Setup screens for quick reference.

View Screens

Main Screen

- System Status
- Next Exercise Time and Date
- Normal and Emergency Voltage
- Frequency
- Normal Source Voltage
- Lamp Test
- Emergency Source Voltage
- Current, Amps
- Time/Date
- Daylight Saving Time Info
- Preferred Source
- Source-Source Type
- Commit/No Commit to Transfer
- Standard/Programmed Transition
- Phase Rotation (3-phase only)
- In-Phase Monitoring Enabled/Disabled

Test Sequence Screens

- Enter Password
- Type of Test
 - Loaded/Unloaded/Auto Load
 - Auto Load Test Run Time
- Test Sequence Status Screens
 - Active Time Delay with Time Remaining
 - Source Voltages
 - End Delay Button
 - End Test Button

View Exerciser Sequence (during exercise run)

- Exerciser Active
- Source Voltages
- Time Remaining (in exercise run)
- End Exercise Button

View Event History

- Event Description
- Date and Time of event

View Maintenance Records

- Total Min Not Preferred
- Reset Min Not Preferred
- Total Min in Standby
- Reset Min in Standby
- Total Min Operation
- Reset Min Operation
- Total Transfers
- Reset Transfers
- Total Fail Transfer
- Reset Fail Transfer
- Total Loss Pref Tran
- Reset Lodd Pref Tran
- Transfer Time N>E
- Transfer Time E>N
- System Start Date
- Last Maint Date
- Last Loss Duration
- Last Loss Date/Time

View Exerciser Setup

- Exercise Event Number
- Enabled/Disabled
- Exercise Run Time
- Start Date
- Start Time
- Weekly/Biweekly
- Loaded/Unloaded

View System Setup

- Open/Programmed Transition
- Source Type: Util/Gen, Gen/Gen, Util/Util or Util/Gen/Gen
- In-Phase Monitor Enabled/Disabled
- Commit/No Commit to Transfer
- # I/O Modules Installed
- Rated Current
- 3 Src Engine Start Mode Mode1/Mode2
- Remote Test Loading Loaded/Unloaded
- Peak Shave Delay Enabled/Disabled

View Source Setup

- ABC/BAC Rotation (3-phase only)
 - System Voltage, Normal/Emergency
 - Frequency (Hz), Source N and E
 - Normal Under Voltage PU% and DO%
 - Normal Over Voltage PU% and DO%
 - Debounce Time, Seconds
 - Normal Under Frequency PU% and DO%
 - Debounce Time
 - Normal Voltage Unbalance Enable/Disable
 - Normal Voltage Unbalance PU% and DO%
 - Emergency Under Voltage PU% and DO%
 - Emergency Over Voltage PU% and DO%
 - Debounce Time
 - Emergency Under Frequency PU% and DO%
 - Emergency Over Frequency PU% and DO%
 - Debounce Time
 - Emergency Voltage Unbalance Enable/Disable
 - Emergency Voltage Unbalance PU% and DO%
-

View Time Delays

- Source N and E
 - Engine Start (gen set only)
 - Engine Cooldown
 - Load Disconnect N>E (E>N)
 - Xfr Off > N (Off > E) (programmed-transition only)
 - Xfr N>E (E>N)
 - Loads to Control (1-9)
 - Load Add N>E (E>N)
 - Load Disc E>N (N>E)
 - In Phase Xfr Fail Time Delay and Enabled/Disabled
 - Fail to Acquire Standby (Preferred)
-

View Inputs/Outputs

- Main Board I/O
 - Input Function Descriptions (2)
 - Output Function Descriptions (2)
 - Auxiliary Inputs/ Outputs
 - Aux I/O Module
 - Module Type and Address
 - Module Status
 - Input Function Descriptions
 - Output Function Descriptions
-

View Common Alarms

- Alarm Group (1 and 2)
- Alarm Description
- Audible (Yes or No)
- Common (Yes or No)

View Communications Setup

- Modbus Server TCP Enabled/Disabled
 - Modbus Server Port 1 and 2 Enable/Disabled
 - Modbus Address Port 1 and 2
 - Baud Rate Port 1 and 2 9600/19200/57600
 - Modbus TCP Unit ID
 - IP Address
 - Subnet Mask
 - MAC Address
-

View Control Parameters

- Code Version
- ATS Serial Number
- Controller Serial Number
- Contactor Serial Number
- Site Designation
- Load Description
- Branch Description
- Location

Setup Screens

Set Time/Date

- Set Time
 - Set Date
 - Set Automatic Daylight Saving Time
-

Set Exerciser

- Exerciser Event Enable/Disable
 - Exerciser Event Loaded/Unloaded
 - Exerciser Event Interval
 - Exerciser Event Repeat Rate
 - Exerciser Event Duration
 - Exerciser Event Start Date
 - Exerciser Event Start time
-

Set Time Delay

- Source N(E)
- Engine Start
 - External Battery? Y or N
- Engine Cooldown
- In Phase Transfer Fail
- Load Disconnect N>E (E>N)
- Transfer N>E (E>N)
- Transfer Off>E (Off>N)(programmed-transition only)
- Load Add E>N (N>E)
- Loads to Add (1-9)
- Fail to Acquire Preferred Source
- Fail to Acquire Standby Source

Set Source

- Phase Rotation ABC/BAC/Disabled
- In-Phase Monitor Enable/Disable
- In-Phase Monitor Angle
- Set Preferred Source Normal/Emergency
- Set Normal (Emergency) Source:
 - Number of Phases
 - Voltage
 - Frequency
 - Under Voltage Pickup
 - Under Voltage Dropout
 - Over Voltage Pickup
 - Over Voltage dropout
 - Voltage Debounce Time
 - Voltage Unbalance Enable/Disable
 - Voltage Unbalance Pickup
 - Voltage Unbalance Dropout
 - Under Frequency Pickup
 - Under Frequency Dropout
 - Over Frequency Pickup
 - Over Frequency Dropout
 - Frequency Debounce time

Set Input/Output

- Set Main Board I/O
 - Set Input Functions *
 - Set Output Functions †
- Set Auxiliary I/O (Modules)
 - Set Input Functions *
 - Set Output Functions †

* See Section Figure 2-13, Programmable Inputs.

† See Section 6.12, Programmable Inputs and Outputs.

Set Common Alarms

- Alarm Group 1 or 2
- Modify Alarm
 - Alarm Description
 - Common (Yes/No)
 - Audible (Yes/No)
- Remove All Alarms Yes/No

Set System

- Source Type: Utility/Generator, Generator/Generator, Utility/Utility, Utility/Generator/Generator (3-source system)
- Transition Type: Standard/Programmed
- Rated Current, Amps
- 3 Source Engine Start Mode
 - Mode1/Mode2
 - Preferred Source Toggle Enable/Disable
- Transfer Commit Commit/No Commit
- Remote Test Loading Loaded/Unloaded
- Peak Shave TD Bypass Enable/Disable

Set Communications

- Modbus Server TCP Enable/Disable
- Modbus Server Port 1 or 2 Enable/Disable
- Modbus Address Port 1 or 2
- Baud Rate Port 1 or 2 9600/19200/57600
- Modbus TCP Unit ID
- IP Address
- Subnet Mask

Set Passwords

- Setup Password
- Test Password

Calibration

- Line-Neutral Voltages, Source N and E
- Line-Line Voltages, Source N and E
- Load Current, LA, LB, and LC

Reset Data

- Reset Maintenance Records, Yes or No
- Reset Event History, Yes or No
- Reset Default Parameters, Yes or No
- Reset Exercise Setup, Yes or No
- Reset Test Password, Yes or No
- Disable Test Password, Yes or No
- File Maintenance
 - Delete Files
 - Force History Save

USB Access Screen (appears only when a device is connected to the USB port)

- Download to Controller
- Upload to USB

TP-6447 1/09c

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KOHLER® POWER SYSTEMS

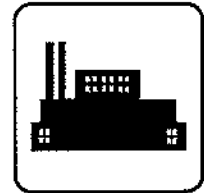
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TAB 2

Installation

Industrial Generator Sets



Models:

20-3250 kW

KOHLER®
POWER SYSTEMS

ISO 9001
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NATIONALLY REGISTERED

TP-5700 1/111

WARNING

Product Identification Information

[illegible]

Serial Number _____

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Notes

Safety Precautions and Instructions

IMPORTANT SAFETY INSTRUCTIONS. Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. **SAVE THESE INSTRUCTIONS.**

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

DANGER

Danger indicates the presence of a hazard that **will cause severe personal injury, death, or substantial property damage.**

WARNING

Warning indicates the presence of a hazard that **can cause severe personal injury, death, or substantial property damage.**

CAUTION

Caution indicates the presence of a hazard that **will or can cause minor personal injury or property damage.**

NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

Accidental Starting

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

Battery

WARNING



Sulfuric acid in batteries.
Can cause severe injury or death.

Wear protective goggles and clothing. Battery acid may cause blindness and burn skin.

WARNING



Explosion.
Can cause severe injury or death. Relays in the battery charger cause arcs or sparks.

Locate the battery in a well-ventilated area. Isolate the battery charger from explosive fumes.

Battery electrolyte is a diluted sulfuric acid. Battery acid can cause severe injury or death. Battery acid can cause blindness and burn skin. Always wear splashproof safety goggles, rubber gloves, and boots when servicing the battery. Do not open a sealed battery or mutilate the battery case. If battery acid splashes in the eyes or on the skin, immediately flush the affected area for 15 minutes with large quantities of clean water. Seek immediate medical aid in the case of eye contact. Never add acid to a battery after placing the battery in service, as this may result in hazardous spattering of battery acid.

Battery acid cleanup. Battery acid can cause severe injury or death. Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled battery acid and continue to add the neutralizing solution to the spilled battery acid until all evidence of a chemical reaction (foaming) has ceased. Flush the resulting liquid with water and dry the area.

Battery gases. Explosion can cause severe injury or death. Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects. Remove all jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

Battery short circuits. Explosion can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Disconnect the battery before generator set installation or maintenance. Remove all jewelry before servicing the equipment. Use tools with insulated handles. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery. Never connect the negative (-) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together.

Engine Backfire/Flash Fire

⚠ WARNING

Fire. Can cause severe injury or death.
Do not smoke or permit flames or sparks near fuels or the fuel system.

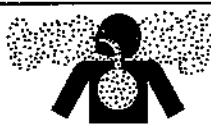
Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the fuel injection system, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or fuel system.

Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the generator set with the air cleaner removed.

Combustible materials. A fire can cause severe injury or death. Generator set engine fuels and fuel vapors are flammable and explosive. Handle these materials carefully to minimize the risk of fire or explosion. Equip the compartment or nearby area with a fully charged fire extinguisher. Select a fire extinguisher rated ABC or BC for electrical fires or as recommended by the local fire code or an authorized agency. Train all personnel on fire extinguisher operation and fire prevention procedures.

Exhaust System

⚠ WARNING

Carbon monoxide. Can cause severe nausea, fainting, or death.
The exhaust system must be leakproof and routinely inspected.

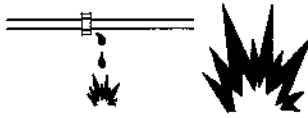
Generator set operation. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Avoid breathing exhaust fumes when working on or near the generator set. Never operate the generator set inside a building unless the exhaust gas is piped safely outside. Never operate the generator set where exhaust gas could accumulate and seep back inside a potentially occupied building.

Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness; mental fatigue, inability to concentrate
- or speak clearly, blurred vision
- Stomachache, vomiting, nausea

If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

Fuel System

⚠ WARNING

Explosive fuel vapors. Can cause severe injury or death.
Use extreme care when handling, storing, and using fuels.

⚠ WARNING



Avoid high pressure fluids. Can cause severe injury or death.

Do not work on high pressure fuel or hydraulic systems without protective equipment to protect hands, eyes, and body. Avoid the hazard by relieving pressure before disconnecting fuel injection pressure lines. Search for leaks using a piece of cardboard. Always protect hands, eyes, and body from high pressure fluids. If an accident occurs, seek medical attention immediately.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

Explosive fuel vapors can cause severe injury or death. Take additional precautions when using the following fuels:

Gasoline—Store gasoline only in approved red containers clearly marked GASOLINE.

Propane (LP)—Adequate ventilation is mandatory. Because propane is heavier than air, install propane gas detectors low in a room. Inspect the detectors per the manufacturer's instructions.

Natural Gas—Adequate ventilation is mandatory. Because natural gas rises, install natural gas detectors high in a room. Inspect the detectors per the manufacturer's instructions.

Fuel tanks. Explosive fuel vapors can cause severe injury or death. Gasoline and other volatile fuels stored in day tanks or subbase fuel tanks can cause an explosion. Store only diesel fuel in tanks.

Draining the fuel system. Explosive fuel vapors can cause severe injury or death. Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

Gas fuel leaks. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Check the LP vapor gas or natural gas fuel system for leakage by using a soap and water solution with the fuel system test pressurized to 6–8 ounces per square inch (10–14 inches water column). Do not use a soap solution containing either ammonia or chlorine because both prevent bubble formation. A successful test depends on the ability of the solution to bubble.

LP liquid withdrawal fuel leaks. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Check the LP liquid withdrawal gas fuel system for leakage by using a soap and water solution with the fuel system test pressurized to at least 90 psi (621 kPa). Do not use a soap solution containing either ammonia or chlorine because both prevent bubble formation. A successful test depends on the ability of the solution to bubble.

Hazardous Noise

⚠ CAUTION



Hazardous noise. Can cause hearing loss.

Never operate the generator set without a muffler or with a faulty exhaust system.

Engine noise. Hazardous noise can cause hearing loss. Generator sets not equipped with sound enclosures can produce noise levels greater than 105 dBA. Prolonged exposure to noise levels greater than 85 dBA can cause permanent hearing loss. Wear hearing protection when near an operating generator set.

Hazardous Voltage/ Moving Parts

⚠ DANGER



Hazardous voltage. Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

⚠ WARNING



Hazardous voltage. Moving parts. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

⚠ WARNING



Hazardous voltage. Backfeed to the utility system can cause property damage, severe injury, or death.

If the generator set is used for standby power, install an automatic transfer switch to prevent inadvertent interconnection of standby and normal sources of supply.

⚠ CAUTION



Welding the generator set.
Can cause severe electrical equipment damage.

Never weld components of the generator set without first disconnecting the battery, controller wiring harness, and engine electronic control module (ECM).

Grounding electrical equipment. **Hazardous voltage can cause severe injury or death.** Electrocutation is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Welding on the generator set. **Can cause severe electrical equipment damage.** Before welding on the generator set perform the following steps: (1) Remove the battery cables, negative (-) lead first. (2) Disconnect all engine electronic control module (ECM) connectors. (3) Disconnect all generator set controller and voltage regulator circuit board connectors. (4) Disconnect the engine battery-charging alternator connections. (5) Attach the weld ground connection close to the weld location.

Installing the battery charger. **Hazardous voltage can cause severe injury or death.** An ungrounded battery charger may cause electrical shock. Connect the battery charger enclosure to the ground of a permanent wiring system. As an alternative, install an equipment grounding conductor with circuit conductors and connect it to the equipment grounding terminal or the lead on the battery charger. Install the battery charger as prescribed in the equipment manual. Install the battery charger in compliance with local codes and ordinances.

Connecting the battery and the battery charger. **Hazardous voltage can cause severe injury or death.** Reconnect the battery correctly, positive to positive and negative to negative, to avoid electrical shock and damage to the battery charger and battery(ies). Have a qualified electrician install the battery(ies).

Servicing the day tank. **Hazardous voltage can cause severe injury or death.** Service the day tank electrical control module (ECM) as prescribed in the equipment manual. Disconnect the power to the day tank before servicing. Press the day tank ECM OFF pushbutton to disconnect the power. Notice that line voltage is still present within the ECM when the POWER ON light is lit. Ensure that the generator set and day tank are electrically grounded. Do not operate the day tank when standing in water or on wet ground because these conditions increase the risk of electrocution.

Short circuits. **Hazardous voltage/current can cause severe injury or death.** Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Engine block heater. **Hazardous voltage can cause severe injury or death.** The engine block heater can cause electrical shock. Remove the engine block heater plug from the electrical outlet before working on the block heater electrical connections.

Electrical backfeed to the utility. **Hazardous backfeed voltage can cause severe injury or death.** Install a transfer switch in standby power installations to prevent the connection of standby and other sources of power. Electrical backfeed into a utility electrical system can cause severe injury or death to utility personnel working on power lines.

Testing live electrical circuits. **Hazardous voltage or current can cause severe injury or death.** Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically. (600 volts and under)

Servicing the generator set when it is operating. **Exposed moving parts can cause severe injury or death.** Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

⚠ WARNING



Airborne particles.
Can cause severe injury or blindness.

Wear protective goggles and clothing when using power tools, hand tools, or compressed air.

Heavy Equipment

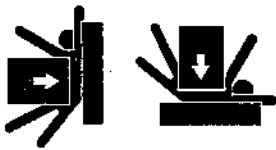
⚠ WARNING



Unbalanced weight. Improper lifting can cause severe injury or death and equipment damage.

Do not use lifting eyes.
Lift the generator set using lifting bars inserted through the lifting holes on the skid.

⚠ WARNING



Unbalanced and elevated weight. Improper lifting can cause severe injury or death and equipment damage.

Do not lift the generator set from the engine or alternator eyes. Never stand under a unit being lifted. Always maintain a safe distance from the unit being lifted.
See the lifting instructions in the installation manual that was provided with the unit.

Hot Parts

⚠ WARNING



Hot coolant and steam. Can cause severe injury or death.

Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure.

⚠ WARNING



Hot engine and exhaust system. Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

Servicing the engine heater. Hot parts can cause minor personal injury or property damage. Install the heater before connecting it to power. Operating the heater before installation can cause burns and component damage. Disconnect power to the heater and allow it to cool before servicing the heater or nearby parts.

Notice

NOTICE

This generator set has been rewired from its nameplate voltage to



246242

NOTICE

Voltage reconnection. Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/dealer.

NOTICE

Canadian installations only. For standby service connect the output of the generator set to a suitably rated transfer switch in accordance with Canadian Electrical Code, Part 1.

NOTICE

Electrostatic discharge damage. Electrostatic discharge (ESD) damages electronic circuit boards. Prevent electrostatic discharge damage by wearing an approved grounding wrist strap when handling electronic circuit boards or integrated circuits. An approved grounding wrist strap provides a high resistance (about 1 megohm), *not a direct short*, to ground.

Notes

This manual provides installation instructions for industrial generator sets. Operation manuals and wiring diagram manuals are available separately.

Some additional model-specific installation information may be included in the respective generator set controller operation manual.

Information in this publication represents data available at the time of print. Kohler Co. reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

Service Assistance

For professional advice on generator set power requirements and conscientious service, please contact your nearest Kohler distributor or dealer.

- Consult the Yellow Pages under the heading Generators—Electric.
- Visit the Kohler Power Systems website at KohlerPower.com.
- Look at the labels and stickers on your Kohler product or review the appropriate literature or documents included with the product.
- Call toll free in the US and Canada 1-800-544-2444.
- Outside the US and Canada, call the nearest regional office.

Headquarters Europe, Middle East, Africa (EMEA)

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India Regional Office
Bangalore, India
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Japan, Korea

North Asia Regional Office
Tokyo, Japan
Phone: (813) 3440-4515
Fax: (813) 3440-2727

Latin America

Latin America Regional Office
Lakeland, Florida, USA
Phone: (863) 619-7568
Fax: (863) 701-7131

Notes

Section 1 General

Industrial power systems give years of dependable service if installed using the guidelines provided in this manual and in applicable codes. Incorrect installation can cause continuing problems. Figure 1-1 illustrates a typical installation.

Your authorized generator set distributor/dealer may also provide advice about or assistance with your installation.

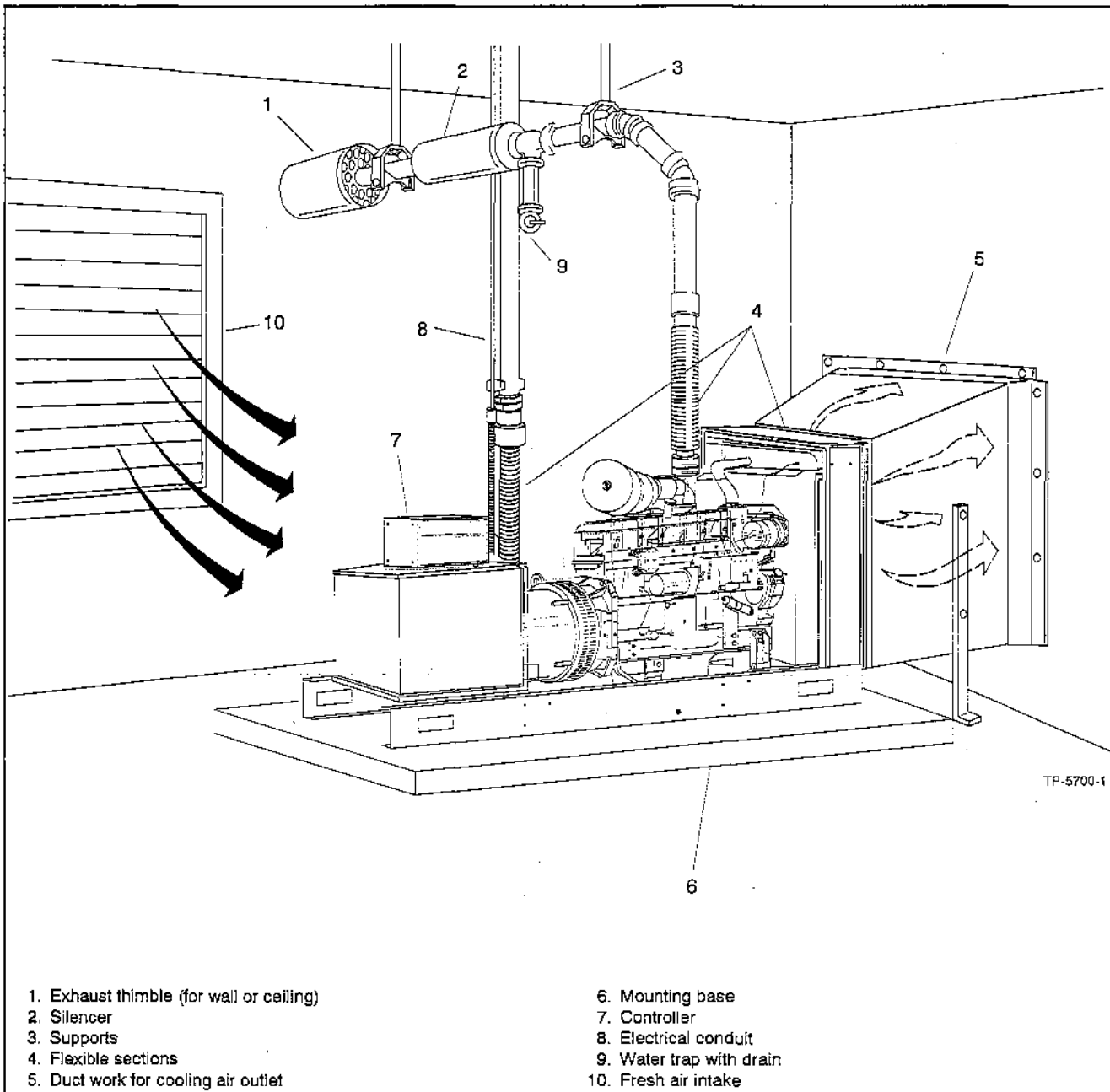


Figure 1-1 Typical Stationary-Duty Generator Set Installation

This manual references several organizations and their codes that provide installation requirements and guidelines such as the National Fire Protection Association (NFPA) and Underwriter's Laboratories Inc. (UL).

- NFPA 54 National Fuel Gas Code
- NFPA 70 National Electrical Code®; the National Electrical Code is a registered trademark of the NFPA
- NFPA 99 Standard for Health Care Facilities
- NFPA 101 Life Safety Code
- NFPA 110 Emergency and Standby Power Systems
- UL 486A-486B Wire Connectors
- UL 486E Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
- UL 2200 Stationary Engine Generator Assemblies

These organizations provide information specifically for US installations. Installers must comply with their respective national and local codes.

Before beginning generator set installation, record the following data from the generator set's specification sheet and keep this data accessible for reference during installation:

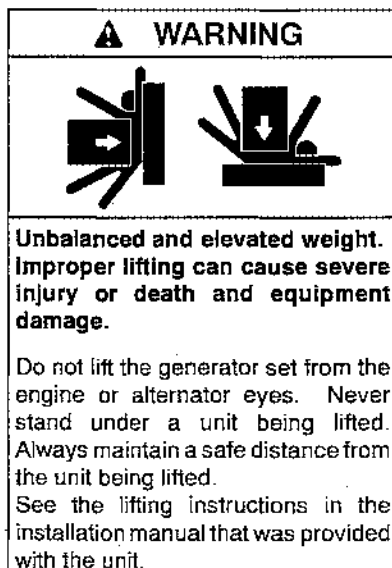
- Dimensions and weight (verify dimensions and weight using the submittal data)
- Exhaust outlet size and maximum allowable backpressure
- Battery CCA rating and quantity
- Fuel supply line size and fuel pressure requirement (gas models)
- Air requirements

Section 2 Loading and Transporting

The loading and transporting processes expose the generator set to many stresses and the possibility of improper handling. Therefore, after transporting industrial generator sets:

- Check the alignment of the radiator and supports to ensure that the radiator is evenly spaced from the generator and that supports are square and of even length. Check the radiator fan for uniform alignment and equal clearance within the radiator shroud. Adjust if necessary.
- After confirming the correct alignment, tighten the hardware to its specified torque. Reference Appendix C, General Torque Specifications.

2.1 Lifting



2.1.1 General Precautions

Follow these general precautions when lifting all generator sets and related equipment.

- Install proper size rigging at the skid lifting eyes providing a direct pull on the skid lifting eye. Make sure the rigging does not work as a pry bar lever against the lifting eye.
- Do not lift the generator set using the lifting eyes attached to the engine and/or alternator as these lifting eyes can not support the total weight of the generator set.
- Always protect cables, chains, and straps from sharp edges.

- Generator sets typically above 1000 kW may have reinforcing plates on the skid. Do not attach lifting hooks to the reinforcing plate. See Figure 2-1.

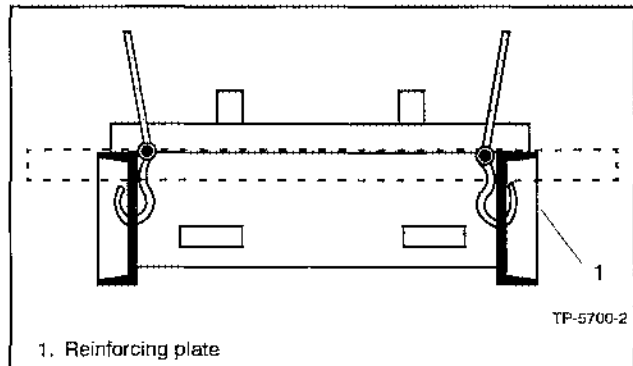


Figure 2-1 Lifting Hook Placement (above 1000 kW)

- Lifting should only be conducted by those trained and experienced in lifting and rigging to achieve a safe and effective lift. Consideration needs to be given to, but not necessarily limited to the following items:
 - Weight and center of gravity of the equipment being lifted
 - Weight and center of gravity of the lifting device
 - Boom angles
 - Selection of rated rigging
 - Stability of lifting foundation
 - Wind and weather conditions
 - Local or regional codes may require or restrict types of rigging.
- Use a spreader bar to prevent lifting cables from contacting air cleaners, shrouds, other protruding components. If the cables still do not clear these components, remove the components.

2.1.2 Weight and Center of Gravity

Refer to the respective specification sheet and/or the submittal drawing for the weight and center of gravity of all components being lifted. The total combined weight and center of gravity must be known to select the proper rigging. If the weight and center of gravity is not readily available, contact your distributor/dealer.

As applicable, determine with weights and center of gravity of the following components:

- Generator set
- Enclosure system (includes silencer, inlet baffles, louvers, etc.)
- Subbase fuel tank (lift only empty fuel tanks).

2.1.3 Lifting the Generator Set

The distributor/lifting contractor should choose one of the following methods to lift the generator set depending upon the location circumstances and the generator set's weight and size. Remove cover plates as needed to access the generator set skid lifting eyes.

Single Spreader Bar and Hook Method

Refer to Figure 2-2.

Double Spreader Bar and Hook Method

Refer to Figure 2-3.

Single Spreader Bar and Skid Lifting Bar Method

Refer to Figure 2-4.

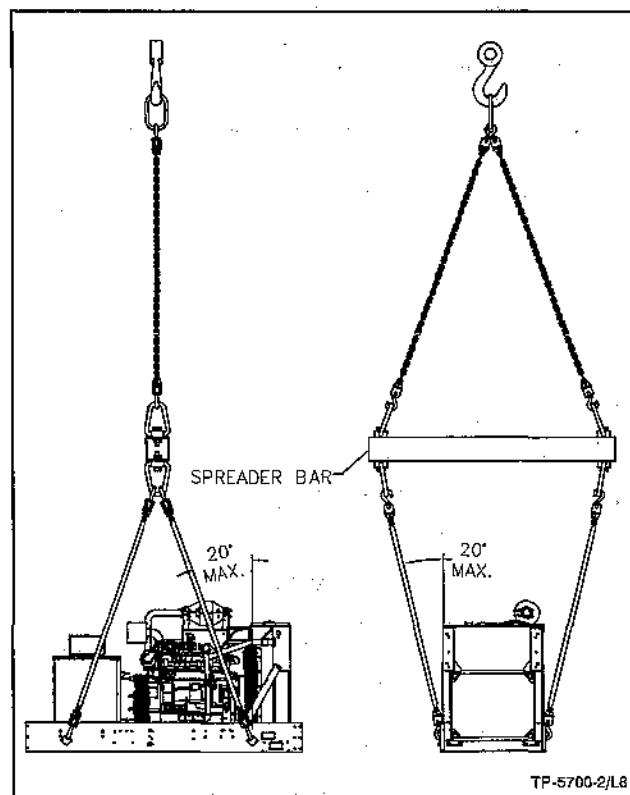


Figure 2-2 Single Spreader Bar and Hook Method

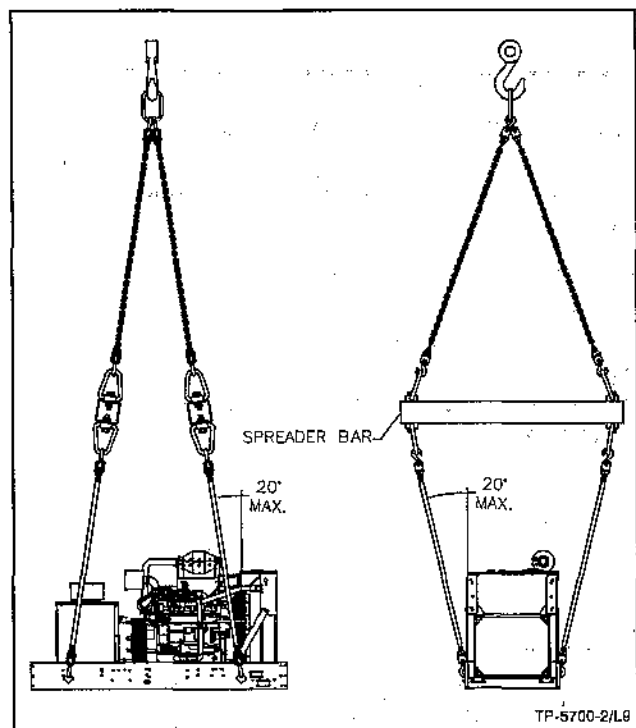


Figure 2-3 Double Spreader Bar and Hook Method

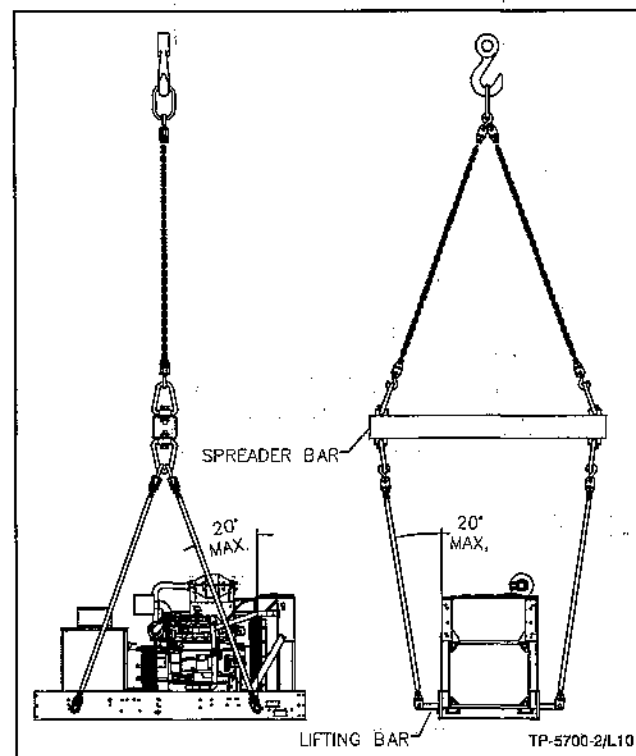


Figure 2-4 Single Spreader Bar and Skid Lifting Bar Method

Double Spreader Bar and Skid Lifting Bar Method

Refer to Figure 2-5.

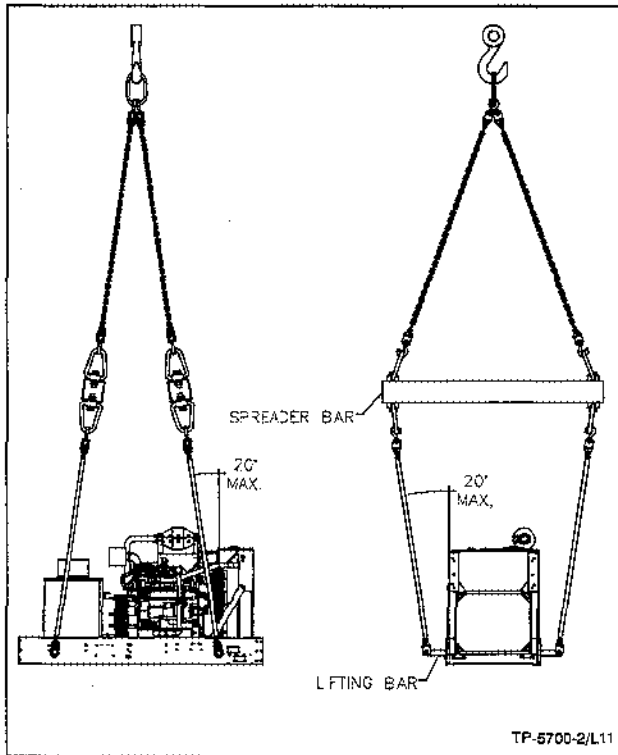


Figure 2-5 Double Spreader Bar and Skid Lifting Bar Method

2.1.4 Lifting the Subbase Fuel Tank

This section deals with lifting the subbase fuel tank as a single unit.

- The subbase fuel tank *must* have lifting eyes in order to use the following methods.
- The subbase fuel tank must be empty. Do not lift a fuel tank containing fuel (or any liquid).
- Remove any vent piping longer than 1 m (3.3 ft.) from the fuel tank. Do not lift a fuel tank with attached vent piping longer than 1 m (3.3 ft.).
- Attach one or two spreader bars as shown.

Fuel Tank with Single Spreader Bar Method

Refer to Figure 2-6.

Fuel Tank with Double Spreader Bar Method

Refer to Figure 2-7.

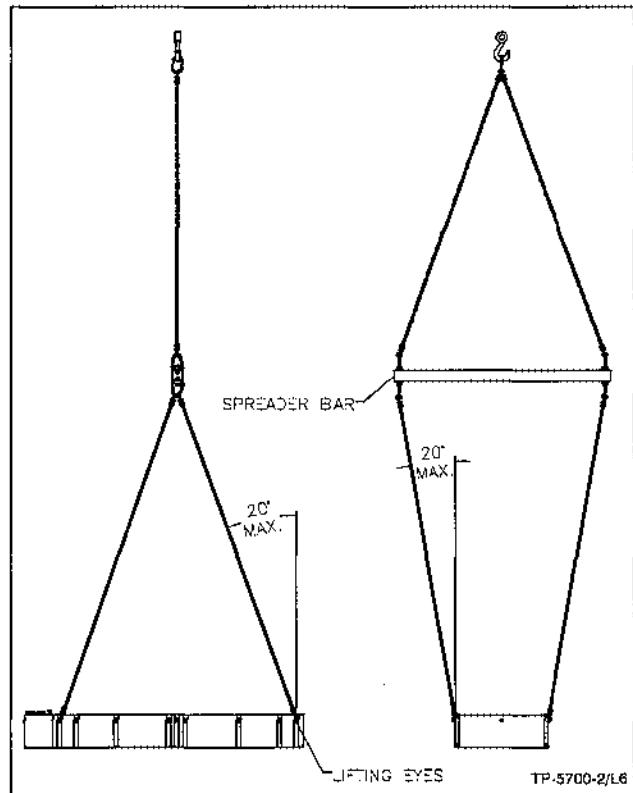


Figure 2-6 Fuel Tank with Single Spreader Bar Method

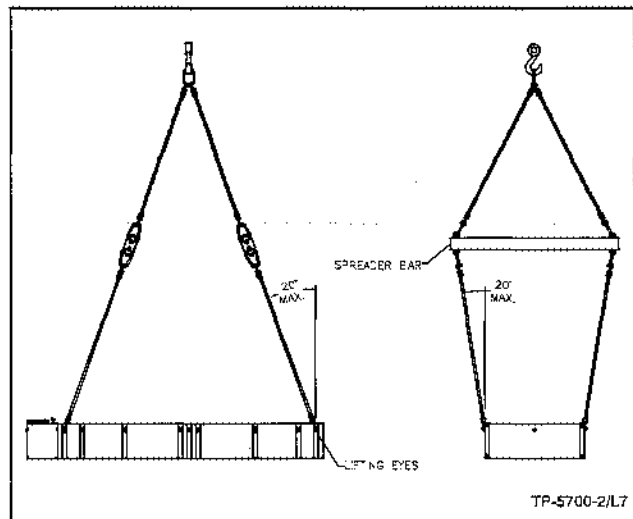


Figure 2-7 Fuel Tank with Double Spreader Bar Method

2.1.5 Lifting the Generator Set with Attached Enclosure

Enclosure Attached Directly to the Generator Set Skid

Refer to Figure 2-8. Lift the assembly by lifting on the skid as shown in 2.1.3 Lifting Methods for Generator Set.

Do not attach hoisting equipment to the enclosure.

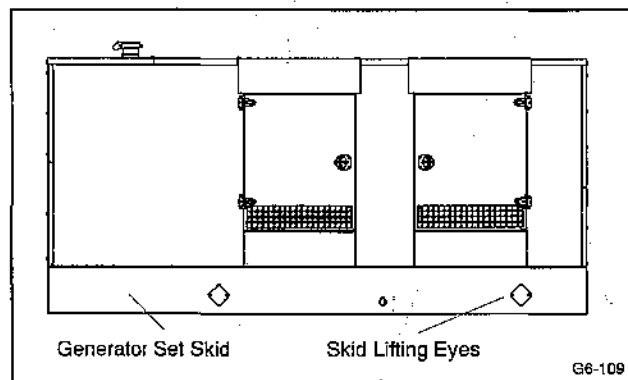


Figure 2-8 Typical Enclosure Attached Directly to the Generator Set Skid

Enclosure Attached Directly to the Subbase Fuel Tank

Refer to Figure 2-9. Lift the assembly by lifting on the subbase fuel tank lifting eyes. Lift using all of the lifting eyes provided on the subbase fuel tank. Select the procedure from the following illustrations based on the matching number of available subbase fuel tank lifting eyes.

Do not attach hoisting equipment to the enclosure.

Enclosure Attached to the Enclosure Base and Assembled to the Subbase Fuel Tank

Refer to Figure 2-10.

With the subbase fuel tank detached from the enclosure base, lift only the enclosure and generator set using the enclosure base lifting eyes. Lift using all of the lifting eyes provided on the enclosure base. Select the procedure from the following illustrations based on the matching number of available enclosure base lifting eyes.

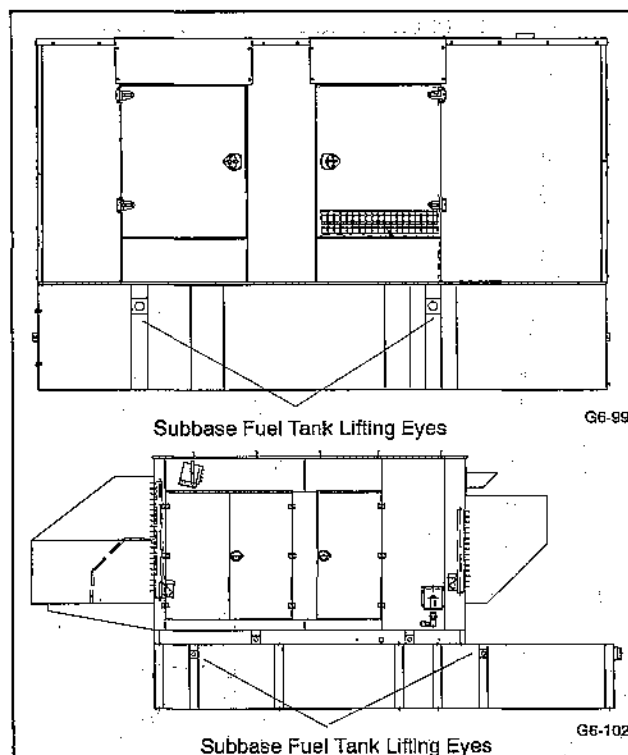


Figure 2-9 Typical Enclosure Attached Directly to the Subbase Fuel Tank

Lift the entire enclosure, generator set, and subbase fuel tank assembly by lifting on the subbase fuel tank lifting eyes. Lift using all of the lifting eyes provided on the subbase fuel tank. Select the procedure from the following illustrations based on the matching number of available subbase fuel tank lifting eyes. Do not attach hoisting equipment to the enclosure base.

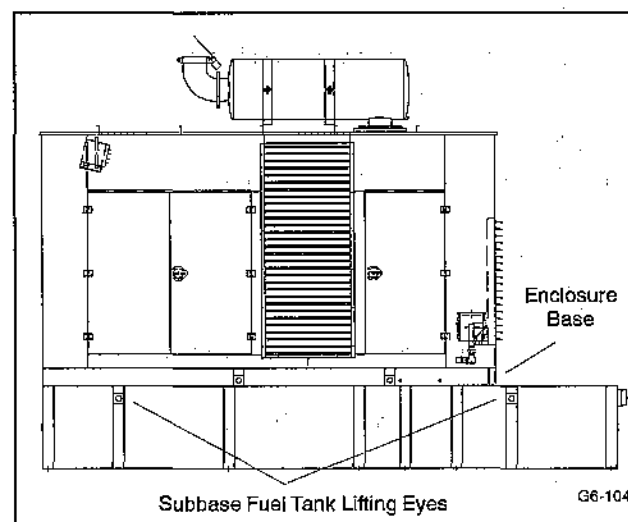


Figure 2-10 Typical Enclosure Attached to the Enclosure Base and Assembled to the Subbase Fuel Tank

2.1.6 Lifting the Generator Set, Enclosure, and Subbase Fuel Tank Assembly

When using the subbase fuel tank to lift the generator set and/or enclosure as a package, use ALL of the lifting eyes on the subbase fuel tank.

Hoisting using Four Eye Lifting Method

Apply the same lifting methods using single or double spreader bars as shown in 2.1.3 Lifting the Generator Set.

Hoisting using Six Eye Lifting Method

Apply one spreader bar and two chain falls (Figure 2-11) or three spreader bars and two chain falls (Figure 2-12) for six eye lifting.

- Install a pair of outer slings to the maximum angle as shown in Figure 2-11 and Figure 2-12.
- Remove the slack from the slings in the system but do not lift the unit.
- Install adjustable chain falls and strap or cable them from the spreader bar to the middle lifting eyes. Adjust to remove the slack.
- Check and remove any slack that has developed in the primary slings and check that all chains/straps/cables are carrying load.

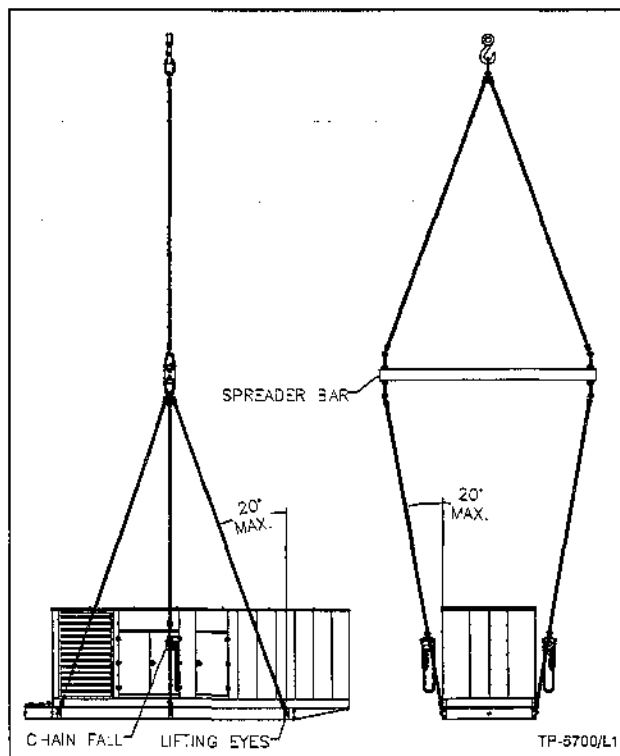


Figure 2-11 Six Eyes, Single Spreader Bar, and Two Chain Falls Lifting Method

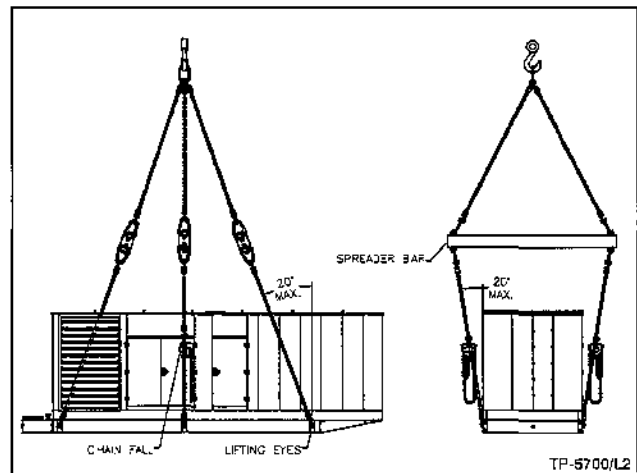


Figure 2-12 Six Eyes, Three Spreader Bars, and Two Chain Falls Lifting Method

Hoisting using Eight Eye Lifting Method

Apply two spreader bars and four chain falls (Figure 2-13) for eight eye lifting.

- Install a pair of outer slings up to the maximum angle as shown in Figure 2-13.
- Remove the slack from the slings in the system but do not lift the unit.
- Install adjustable chain falls and strap or cable them from the spreader bar to the middle lifting eyes. Adjust to remove the slack.
- Check and remove any slack that has developed in the primary slings and check that all chains/straps/cables are carrying load.

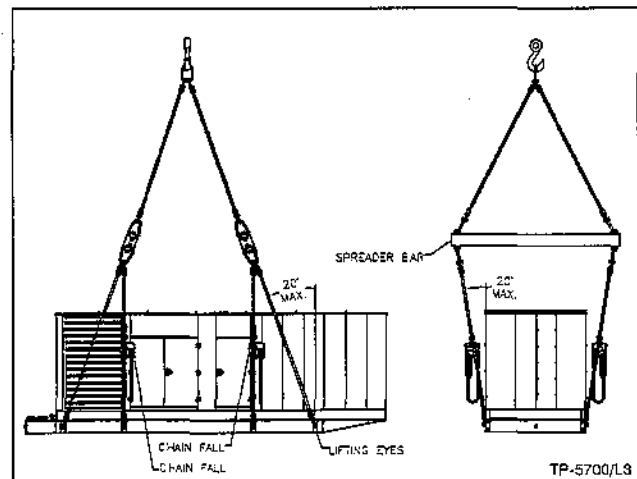


Figure 2-13 Eight Eyes, Two Spreader Bars, and Four Chain Falls Lifting Method

Hoisting using Ten Eye Lifting Method

Apply three spreader bars and six chain falls (Figure 2-14) for ten eye lifting.

- Install a pair of outer slings up to the maximum angle as shown in Figure 2-14.
- Remove the slack from the slings in the system but do not lift the unit.
- Install adjustable chain falls and strap or cable them from the spreader bar to the middle lifting eyes. Adjust to remove the slack.
- Check and remove any slack that has developed in the primary slings and check that all chains/straps/cables are carrying load.

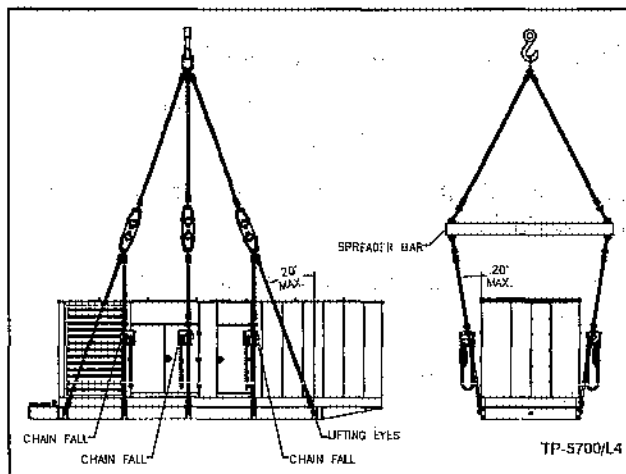


Figure 2-14 Ten Eyes, Three Spreader Bars, and Six Chain Falls Lifting Method

Hoisting using Twelve Eye Lifting Method

Apply three spreader bars and eight chain falls (Figure 2-15) for twelve eye lifting.

- Install a pair of outer slings up to the maximum angle as shown in Figure 2-15.
- Remove the slack from the slings in the system but do not lift the unit.
- Install adjustable chain falls and strap or cable them from the spreader bar to the middle lifting eyes. Adjust to remove the slack.
- Check and remove any slack that has developed in the primary slings and check that all chains/straps/cables are carrying load.

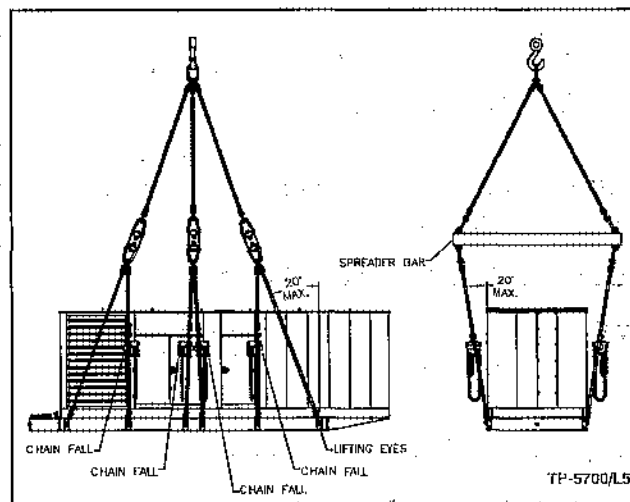


Figure 2-15 Twelve Eyes, Three Spreader Bars, and Eight Chain Falls Lifting Method

2.1.7 Lifting Single Point Lift Assemblies

Some units have an enclosure integral to the skid and attach a single point lifting eye located at the top and center of the enclosure. The entire assembly may be lifted with this eye.

2.2 Generator Set Transporting

Follow these guidelines when transporting the generator set:

- Select the transporting vehicle/trailer based on the dimensions and weight of the generator set as specified in the generator set dimension drawing or specification sheet. Ensure that the gross weight and overall height of the generator set and vehicle/trailer in transport does not exceed applicable transportation codes.
- Use low boy-type trailers that meet clearance requirements when transporting units larger than 1000 kW. Load large (unboxed) radiator-equipped generator sets with the radiator facing the rear to reduce wind resistance during transit. Secure fans to prevent fan rotation in transit.
- Securely fasten the generator set to the vehicle/trailer and cover. Even the heaviest of generator sets can move during shipment unless they are secured. Fasten the generator set to the vehicle/trailer bed with a correctly sized chain routed through the mounting holes of the generator set skid. Use chain tighteners to remove slack from the mounting chain. Cover the entire unit with a heavy-duty canvas or tarpaulin secured to the generator set or trailer.

3.1 Location Factors

Ideally, the generator set should be mounted on concrete at ground level. For above-ground installations, including roof installations, weight considerations are especially important. The building engineer determines whether the structure can support the weight of the generator set.

The location of the generator set must meet the following criteria.

General:

- Support the weight of the generator set and related equipment such as fuel storage tanks, batteries, radiators, and mounting pad(s). Keep in mind that the mounting pad weight may exceed the weight of the generator set.
- Meet applicable fire rating codes and standards.
- Position the generator set over a noncombustible surface. If the mounting surface directly under or near the generator set is porous or deteriorates from exposure to engine fluids, construct a containment pan for spilled fuel, oil, coolant, and battery electrolyte. Do not allow accumulation of combustible materials under the generator set.
- Permit vibration isolation and dampening to reduce noise and prevent damage.
- Be clean, dry, and not subject to flooding.
- Provide easy access for service and repair.

Indoor Installations:

- Allow adequate ventilation with a minimum amount of ductwork.
- Allow safe expulsion of exhaust.
- Allow for storage of sufficient fuel to sustain emergency operation. See the generator set specification sheet for fuel consumption.
- Allow for locating the fuel tank within the vertical lift capabilities of the fuel pump and any auxiliary pumps. See Section 6, Fuel Systems.

- Provide adequate protection to prevent injury in the stub-up area. If the stub-up area opening is exposed, provide a cover or fill in the area to avoid the risk of tripping or falling into the stub-up opening.
- Minimize the risk of public or unauthorized access.

Outdoor Installations:

- Select a location that provides adequate air flow. Avoid locations next to tall buildings that block normal air flow and cause air vacuum pockets. Avoid areas that are subject to high winds, excessive dust, or other airborne contaminants. High dust areas may require more frequent air cleaner maintenance. High temperature conditions affect generator set efficiency. Select a shaded area away from direct sunlight and/or other heat-producing equipment when practical.

3.2 Mounting Surface

Figure 3-1 shows typical mounting surface details for sizing the concrete surface beyond the generator set and allowing for clearances during generator set service. Follow the dimensional details provided in Figure 3-2, Figure 3-3, or Figure 3-4 depending upon the mounting method.

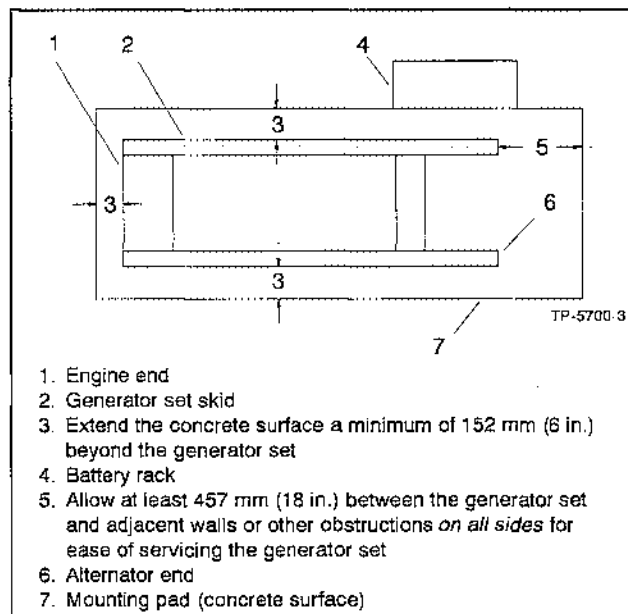


Figure 3-1 Mounting Surface Detail (top view)

3.2.1 Single-Pad Mounting

The manufacturer recommends a single, level concrete mounting pad as shown in Figure 3-2. This method provides maximum stability for the generator set; however, draining the oil and servicing the generator set may require raising the set from the pad.

Use an oil drain pump if clearance below the oil drain or extension is insufficient for a pan large enough to hold all the engine's oil.

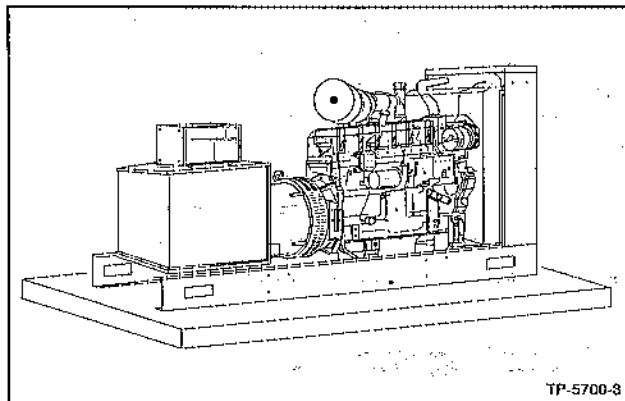


Figure 3-2 Single-Pad Mounting

3.2.2 Dual-Pad Mounting

The two-pad arrangement shown in Figure 3-3 provides easy access to conveniently drain the oil. Follow the oil draining considerations outlined in Section 3.2.1.

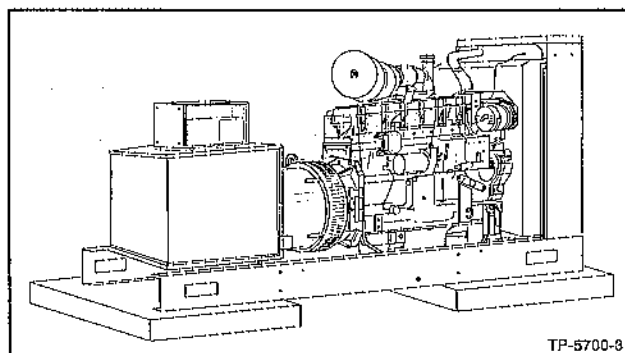


Figure 3-3 Dual-Pad Mounting

3.2.3 Four-Pad Mounting

The four-pad arrangement shown in Figure 3-4 provides more room under the engine for service than the previous two methods. Follow the oil draining considerations outlined in Section 3.2.1.

3.2.4 Mounting Pad Specifications

Mounting pad weight. The weight of the single mounting pad or combined weight of multiple mounting

pads should equal or exceed the combined weight of the generator set and attached accessories.

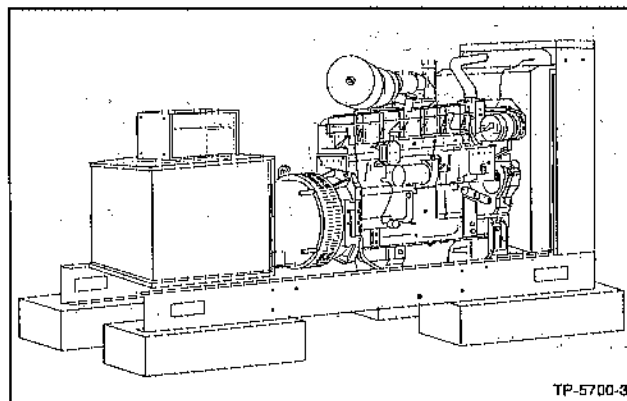


Figure 3-4 Four-Pad Mounting

To determine the weight of the mounting pad(s), determine the volume (length x width x height) of each pad in cubic meters (cubic feet). Multiply this result by 2400 kg (150 lb.) to determine a pad's weight. In multiple-pad installations, add the weights of all pads to determine the total mounting pad weight.

Mounting pad specifications. Mounting pad composition should follow standard practice for the required loading. Typical specifications call for 17238–20685 kPa (2500–3000 psi) concrete reinforced with eight-gauge wire mesh or No. 6 reinforcing bars on 305 mm (12 in.) centers. The top surface of the mounting pad on which the generator set mounts should be within a flatness of 3 mm (1/8 in.).

The recommended concrete mixture by volume is 1:2:3 parts of cement, sand, and aggregate, respectively. Surround the pad with a 200–250 mm (8–10 in.) layer of sand or gravel for proper support and isolation of a pad located at or below grade.

Anchor the generator set to the concrete using bolts cast into the surface of the pad. Otherwise, drill holes in the mounting pad and use expansion anchor bolts. Anchor the generator set skid or fuel tank (if equipped) using all of the provided anchor holes on the bottom of the skid.

Note: Refer to the generator set and accessory dimension drawings for conduit and fuel-line placement. The drawings give dimensions for electrical and fuel connection roughins and stubups.

3.3 IBC Seismic Installation

International Building Code (IBC) seismic installations involve additional mounting and installation considerations. Refer to respective seismic installation ADV drawing(s) for seismic isolator requirements.

3.4 Vibration Isolation

Use one of the vibration isolation types detailed in the following paragraphs. Also, connections between the generator set or its skid and any conduits, fuel lines, or exhaust piping must include flexible sections to prevent breakage and to isolate vibration. These connections are detailed in subsequent sections.

Isolator types. The two primary types of isolators are neoprene and spring-type. Figure 3-5 shows neoprene isolators between the engine-generator and the skid, referred to as integral vibration isolation mounting. Integral vibration isolation units come from the factory with neoprene vibration isolation. Neoprene isolators provide 90% vibration isolation efficiency and are often sufficient for installations at or below grade.

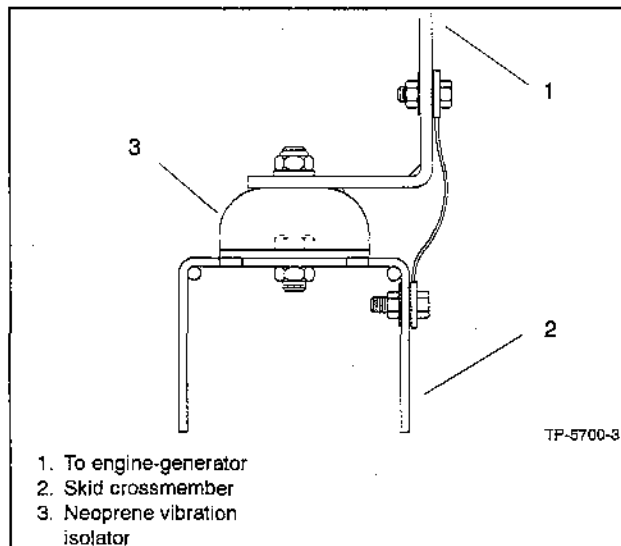


Figure 3-5 Neoprene-Type Integral Vibration Isolators

Figure 3-6 shows the spring-type isolator kit installed with direct-mounted units. Direct-mounted units have no factory vibration isolation. Spring-type isolators provide 98% vibration efficiency and are recommended for above grade installations and other locations where vibration sensitivity could be an issue.

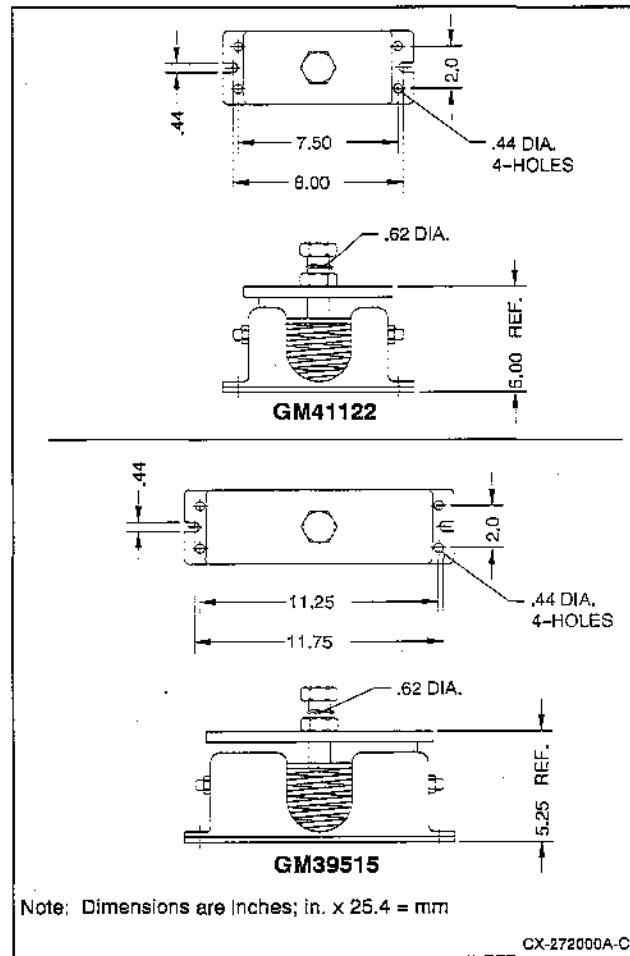


Figure 3-6 Vibration Spring Isolators

Generator sets with integral vibration isolation. Skids for generator sets 20 kW and larger use I or C section-fabricated steel with a width of 52–76 mm (2–3 in.) per channel. The length varies with the size of the unit, resulting in a static load on the generator set skid of 69–172 kPa (10–25 psi) if the total bottom surface of the channel is in contact with the mounting pad.

Generator sets with direct mounting. Larger generator sets typically mount directly to a structural steel base. For these units, install the recommended vibration isolators between the base and the mounting pad in the holes provided. Because of the reduced mounting surface area of these individual mounts, the static load on the mounting surface increases to the range of 345–690 kPa (50–100 psi).

Dual isolation. For applications involving integral vibration isolators and where the factory does not offer spring-type isolators as a standard accessory, spring-type isolators may be installed under the skid provided they equal the number of neoprene isolators, are inline front-to-back with the existing neoprene isolators, and additional support plates are installed, as required. See Figure 3-7.

3.5 Dual-Bearing Alternator Alignment

Generator sets equipped with dual-bearing alternators require alignment after mounting the generator set skid to a mounting pad. Refer to Service Bulletin SB-566 for details.

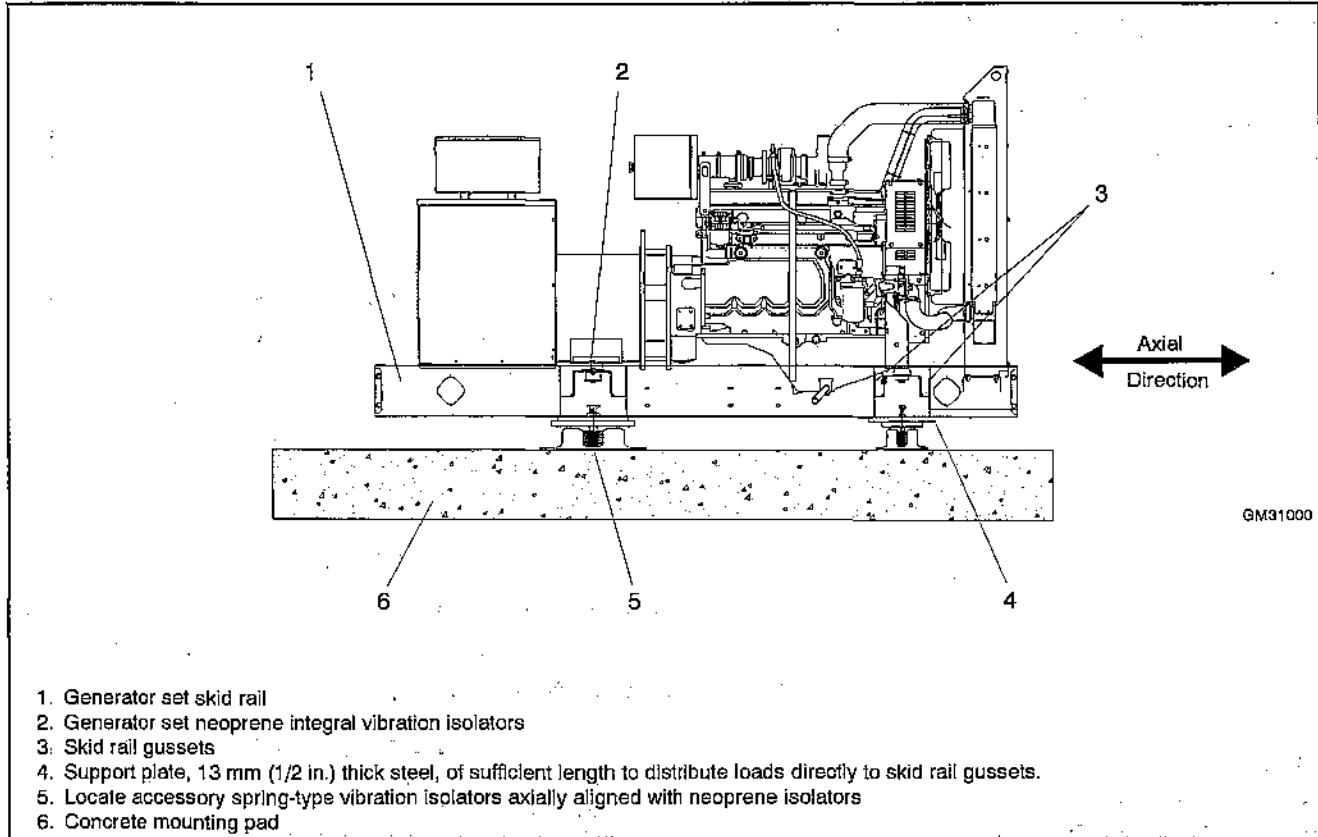


Figure 3-7 Accessory Vibration Mount Location

Section 4 Air and Cooling

4.1 General

Combustion and heat dissipation require an ample flow of clean, cool air regardless of whether the generator set is air- or liquid-cooled. Approximately 70% of the heat value of fuel consumed by an engine is lost through the cooling and exhaust systems.

Battery compartment ventilation. To prevent the accumulation of explosive gases, ventilate compartments containing batteries.

4.2 Air-Cooled Engines

Refer to the generator set specification sheet for air requirements. Generally, airflow requirements do not present a problem since air-cooled models are designed for outside installation.

When planning outside installation, consider how buildings and landscaping affect airflow. Also consider seasonal changes such as snow or foliage accumulation and potential flooding conditions. Follow a regular maintenance routine to remove snow and foliage accumulations.

4.3 Liquid-Cooled Engines

4.3.1 System Features

Generator sets designed for interior installation feature liquid cooling systems. The three most common liquid cooling systems are unit-mounted radiator, remote radiator, and city-water cooling. Observe the common installation considerations outlined below as well as the installation considerations for your generator set's cooling system as detailed in subsequent sections.

4.3.2 Installation Considerations

Intake and outlet openings. Provide air intake and air outlet openings for generator sets located in a building or enclosure. Keep air inlets and outlets clean and unobstructed. Position the air inlet into the prevailing wind and the air outlet in the opposite direction.

Ventilating fans. Some buildings tend to restrict airflow and may cause generator set overheating. Use ventilating fans and/or ductwork to increase airflow in the building if the generator set's cooling fan does not provide adequate cooling. See Figure 4-1. Remote radiator and city-water cooled models require ventilating fans. When using ductwork and ventilating fans, check the exhaust fan capacity in m^3/min . (cfm). If using exhaust fans, install fan-operated louvers with exhaust fans to regulate airflow. See Figure 4-2. Follow the fan manufacturer's recommendations to determine the size of the inlet and outlet openings.

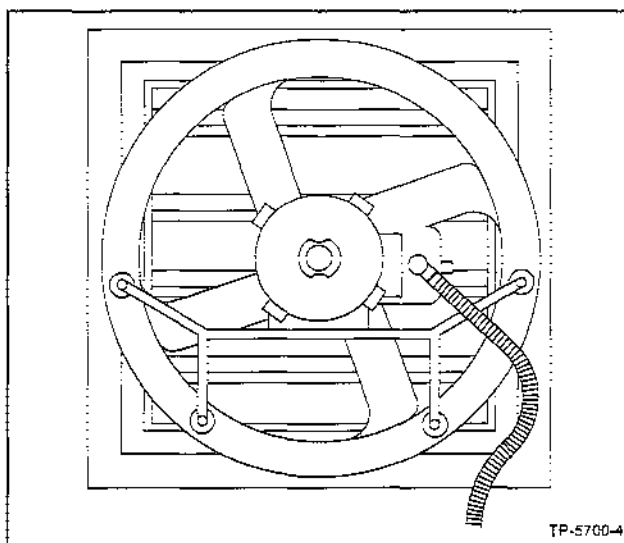


Figure 4-1 Ventilating Fan

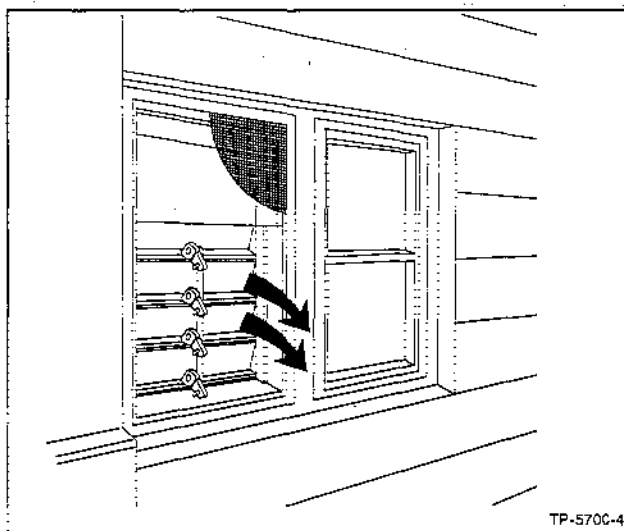


Figure 4-2 Exhaust Fan-Operated Louvers

Thermostatically-controlled louvers. Do not allow uncontrolled recirculation of air within an enclosure. The ventilation system must provide a temperature differential sufficient to prevent high engine temperature shutdown on even the hottest days.

In areas of great temperature variation, install movable louvers to thermostatically regulate airflow and room temperature. See Figure 4-3 and Figure 4-4. Refer to 4.4.2, Installation Considerations, Louver use for further information.

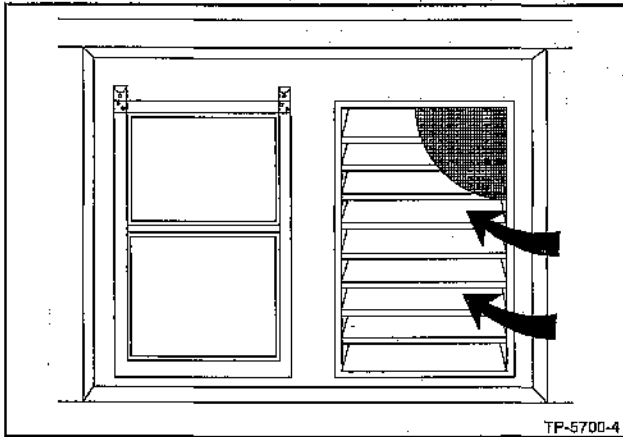


Figure 4-3 Stationary Air Inlet Louvers

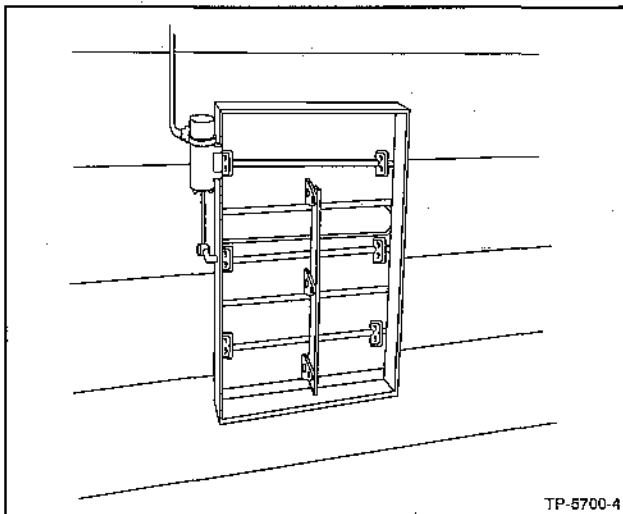


Figure 4-4 Moveable Air Inlet Louvers

In cold climate interior installations using controlled recirculation to recover heat, install thermostatically activated louvers and fans to prevent the generator set and engine room from overheating.

Electric louvers are usually connected to the optional generator set run relay. Typically, the louvers are energized to open when the generator set is operating. However, some louvers are energized to close and when deenergized are spring-actuated to open when the generator set is operating.

Filters. Install a furnace-type or similar filter in the inlet opening if the generator set operates in an atmosphere highly contaminated with impurities such as dust and chaff.

Air restrictions. When using a filter, screen, or other air restriction, increase the inlet opening size by the following amounts to compensate for diminished airflow:

- Louvers: Enlarge the opening 50%.
- Window screening: Enlarge the opening 80%.
- Furnace-type filters: Enlarge the opening 120%.

4.3.3 Recommended Coolant

All applications require antifreeze/coolant protection. Add antifreeze/coolant before starting the generator set or energizing the block heater(s). Most diesel engine manufacturers require the use of an inhibitor additive to the antifreeze/coolant.

Use a proper mixture of glycol (ethylene, propylene, or extended life organic acid), water, and supplemental coolant additive (SCA). The antifreeze/coolant and additive mixture reduces corrosion, sludge formation, and cavitation erosion and provides boil and freeze protection.

The generator set manufacturer recommends a solution of 50% ethylene glycol and 50% clean, softened water to provide freezing protection to -37°C (-34°F) and boiling protection to 129°C (256°F). A 50/50 solution also inhibits corrosion.

Refer to the engine manufacturer's operation manual for engine antifreeze/coolant specifications, concentration levels, and inhibitor selection recommendations.

4.4 Unit-Mounted Radiator Cooling

The unit-mounted radiator is the most common cooling system for engine-driven generator sets 20 kW and larger.

4.4.1 System Features

The system's major components include an engine-driven fan and circulating water pump, a radiator, and a thermostat. The pump circulates water through the engine until it reaches operating temperature. Then the engine thermostat opens, allowing water circulation through the radiator. The thermostat restricts water flow as necessary to prevent overcooling. The fan blows air from the engine side of the radiator across the cooling surface.

4.4.2 Installation Considerations

Figure 4-5 shows a typical unit-mounted radiator installation. Note the direction of airflow and refer to the figure as needed during installation.

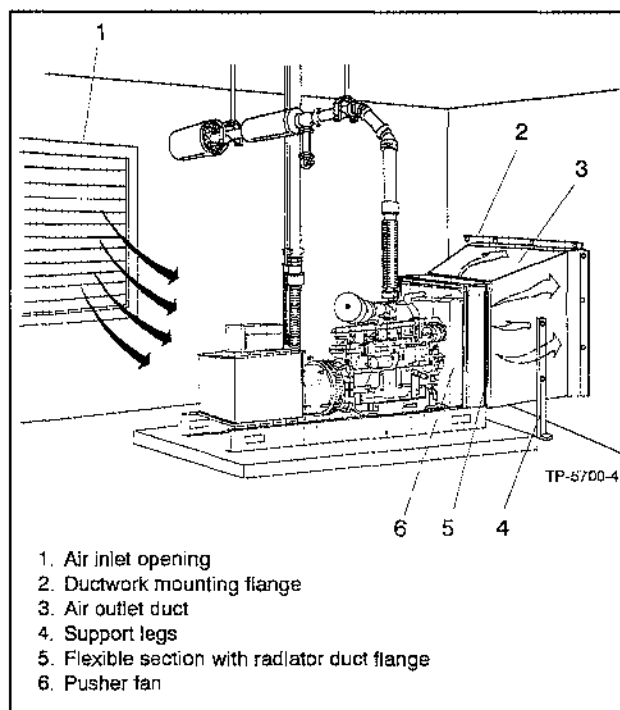


Figure 4-5 Radiator-Cooled Generator Set Installation

Avoid suction fan use. The alternator airflow should move in the same direction as the engine's standard pusher fan. Using a suction fan to reverse airflow is not recommended because it may interfere with the alternator cooling airflow. This in turn reduces the maximum engine power available because higher temperature combustion air is drawn into the air cleaner.

Use ductwork to direct airflow. Direct the radiator air outside the room or enclosure using sheet metal ductwork with structural supports. Keep ductwork as short, straight, and unobstructed as possible. Combined static pressure restrictions greater than 0.12 kPa or 13 mm (0.5 in.) water column on the radiator inlet and outlet openings cause reduced airflow and contribute to overheating especially in high ambient air temperatures. Use heavy canvas, silicone rubber, or similar flexible material for the connection between the radiator duct flange and the ductwork to reduce noise and vibration transmission.

Outlet and inlet location and sizing. Size the outlet duct area 150% larger than the radiator duct flange area. Size the inlet air opening at least as large but preferably 50% larger than the outlet.

If screens, louvers, or filters are used on either the inlet or outlet, increase the inlet or outlet size according to the recommendations given in Section 4.3.2, Installation Considerations.

Since the exhaust air of larger units is both high volume and high velocity, direct the exhaust flow away from areas occupied by people or animals.

Louver use. Design temperature-controlling louvers to prevent air inlet restrictions and air pressure reductions inside the building. Low building pressure can extinguish pilot lights on gas-fired appliances or cause problems with the building ventilation system.

Additionally, bringing large quantities of winter air into a building wastes building heat and risks frozen water pipes in normally heated spaces. Use dampers and controlled air outlet louvers as shown in Figure 4-6 to eliminate these problems and allow recovery of engine heat to reduce building heat loss. Close the louvers to the exterior and open the interior louvers when the outdoor temperature is below 18°C–21°C (65°F–70°F). Reverse the louver settings when the outdoor temperature is above 21°C–24°C (70°F–75°F).

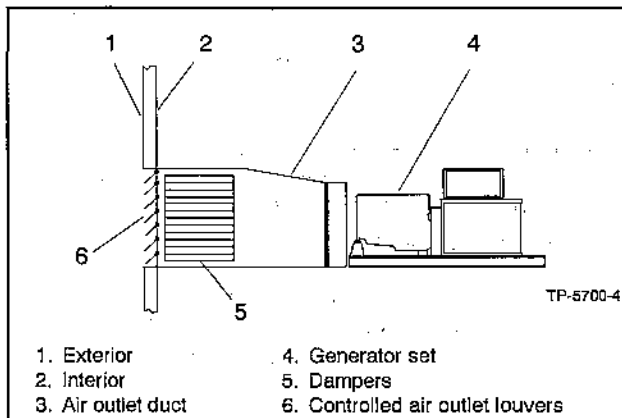


Figure 4-6 Air Control Louvers

4.5 Remote Radiator Cooling

A remote radiator system allows installation of generator sets in locations where it would otherwise be difficult to bring the volume of air required to cool a unit-mounted radiator. In these systems, the engine water pump pushes coolant through a radiator mounted remotely from the generator set and, typically, in an open area. An electric motor-driven fan mounted on the radiator circulates air across the radiator's cooling fins.

In order to assess a remote radiator cooling system, the cooling system designer needs the following data. From the respective generator set specification sheet, obtain the:

- Engine jacket water flow, Lpm (gpm)
- Cooling air required for generator set based on 14°C (25°F) rise and an ambient temperature of 29°C (85°F), m³/min: (cfm)
- Maximum static (vertical) head allowable above engine, kPa (ft. H₂O)

From the engine and/or radiator data sheet, obtain the:

- Maximum water pump inlet restriction kPa (psi)
- Maximum allowable coolant pressure differential external to engine kPa (psi)

The following subsections provide general design guidelines for a remote radiator system.

4.5.1 General

System limitations. Cooling systems are limited by radiator cap ratings. The maximum radiator operating pressure is 138 kPa (20 psi) and the maximum operating temperature is 121°C (250°F). Radiators are available for vertical or horizontal discharge. See Figure 4-7 and Figure 4-8.

Air requirements. Refer to the generator set specification sheet for radiator air and engine/alternator air requirements. Cooling air required for generator sets equipped with a remote radiator is based on a 14°C (25°F) rise and an ambient temperature of 29°C (85°F). The amount of air required to ventilate the generator set room or enclosure determines the size of the air inlet and outlet. Configure the ventilation air inlet and outlet so that air flows across the generator set.

Use a ventilating fan, if necessary, to dissipate alternator and engine heat loss.

Note: All remote radiators are sized for mounting in an open area with no additional external devices attached. Attached devices, confined installation, louvers, dampers, ductwork, or other inlet or outlet air restriction require resizing the radiator to compensate for reduced airflow.

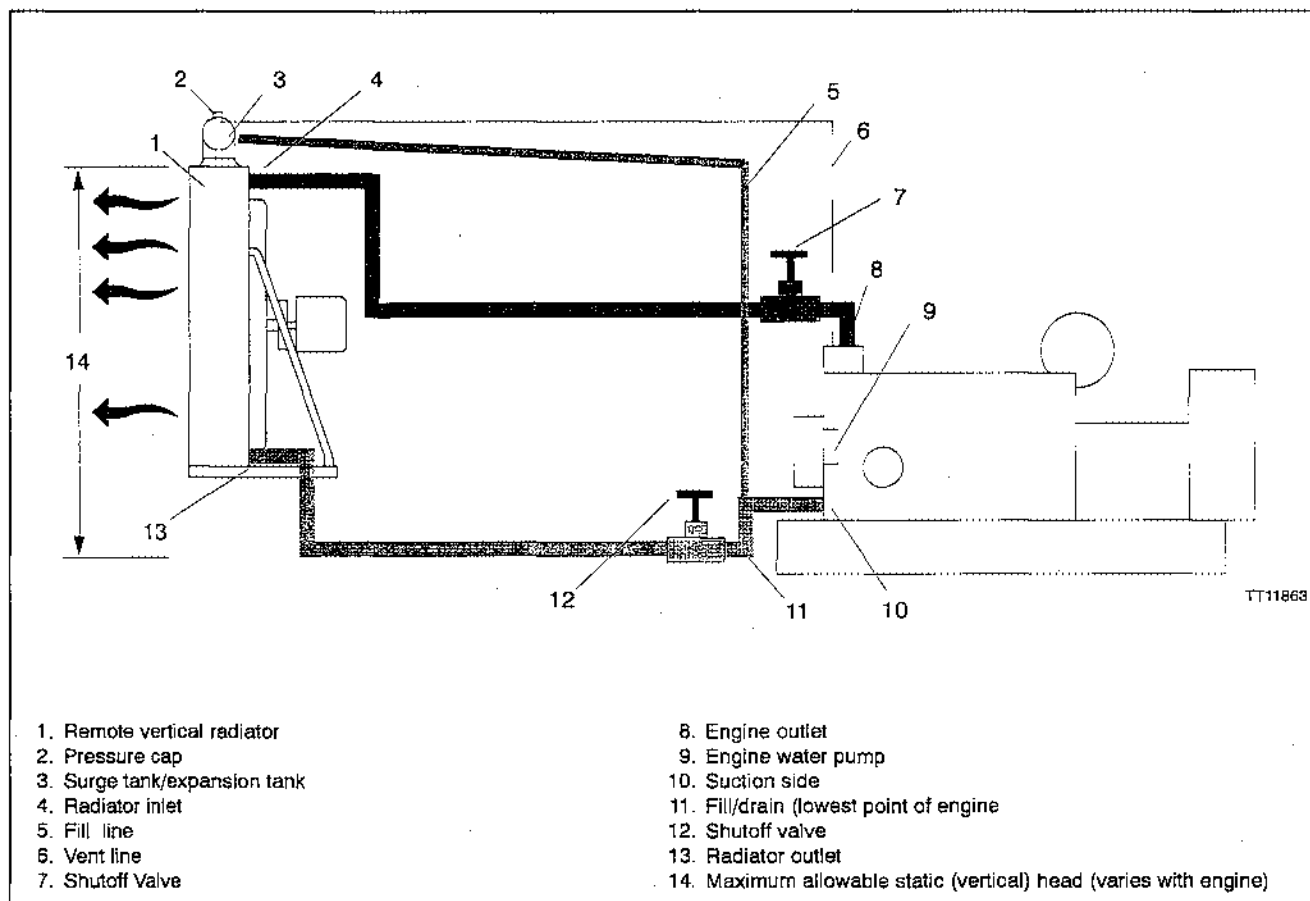


Figure 4-7 Remote Vertical Radiator System

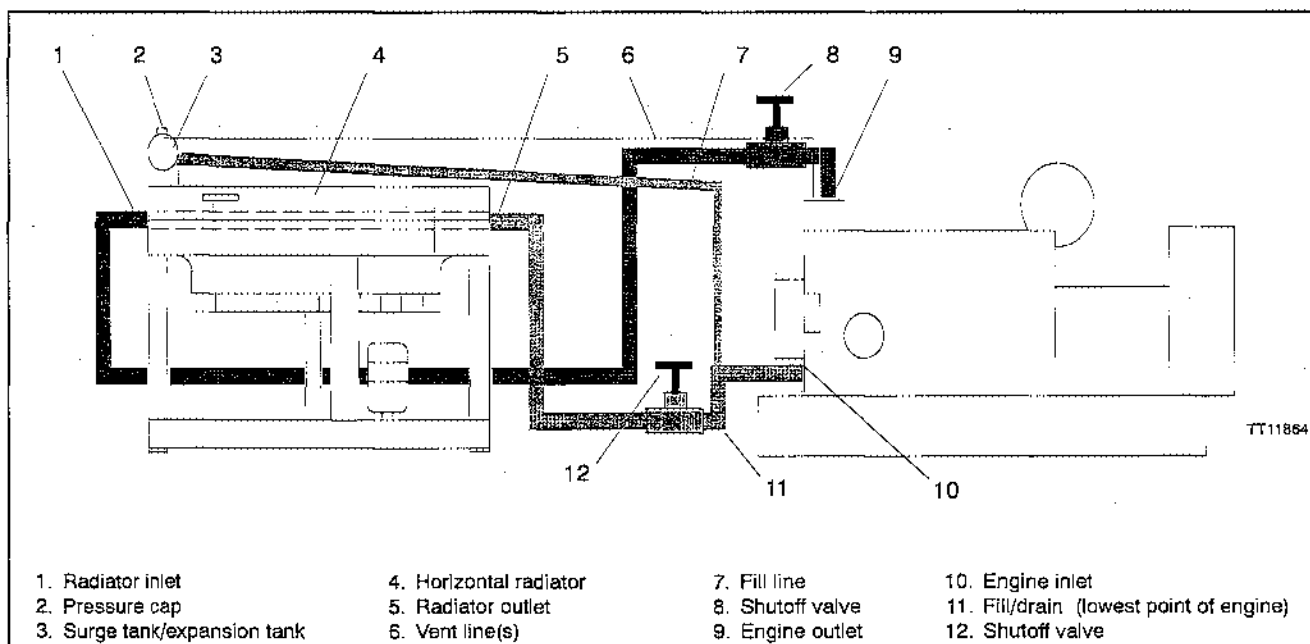


Figure 4-8 Remote Horizontal Radiator System

Static (vertical) head. If the vertical distance from the engine water pump to the radiator (known as *static head*) is within the engine manufacturer's recommendations, and the pressure drop through the piping and remote radiator does not exceed the engine manufacturer's limits, use the engine water pump to circulate water through the remote radiator. The allowable static head ranges from 5.2 m–15.2 m (17 ft.–50 ft.) and is listed on the generator set specification sheet. Exceeding the allowable static head causes excessive pressure on engine components resulting in problems such as leaking water pump seals.

Note: Size the pressure relief valve or cap to remain under the engine pressure limit.

Hot well tank/heat exchanger. When the static (vertical) head exceeds the distance stated in the specification sheet, use a hot well tank or heat exchanger and auxiliary circulating pump as shown in Figure 4-9 or Figure 4-10. Always wire the circulating pump in parallel with the remote radiator fan so that both operate whenever the generator set operates.

A partial baffle divides a hot well tank into two or more compartments. The engine pump forces heated water into the hot side, and the auxiliary pump then draws the water off and forces it into the radiator. After circulating through the radiator, coolant drains back to the cold side of the well where the engine water pump removes it. A hot well or heat exchanger also isolates head pressures from the engine.

Note: The water in the hot well tank drains into the radiator when the generator set is not running.

Note: Determine the size requirements of the remote radiator and hot well tank/heat exchanger for each application. Do not use a standard remote radiator with a hot well tank/heat exchanger.

4.5.2 Vent Lines

Route the vent lines at a continuous upward slope from the engine connection exit to the expansion tank. Port all vent lines individually into the expansion tank above the coolant level.

Locate the vent lines in the expansion tank to prevent splash on the coolant level sensor. Thoroughly vent the systems by installing vent lines to all the vent points on the engine and the charge air cooler circuits including the radiator core. Refer to the installation drawings for vent points.

Size the vent line the same as the connection point on the engine. The vent lines may be slightly larger; however, vent lines sized too large will increase fill line flow and possibly reduce head pressure applied to the engine water pump inlets.

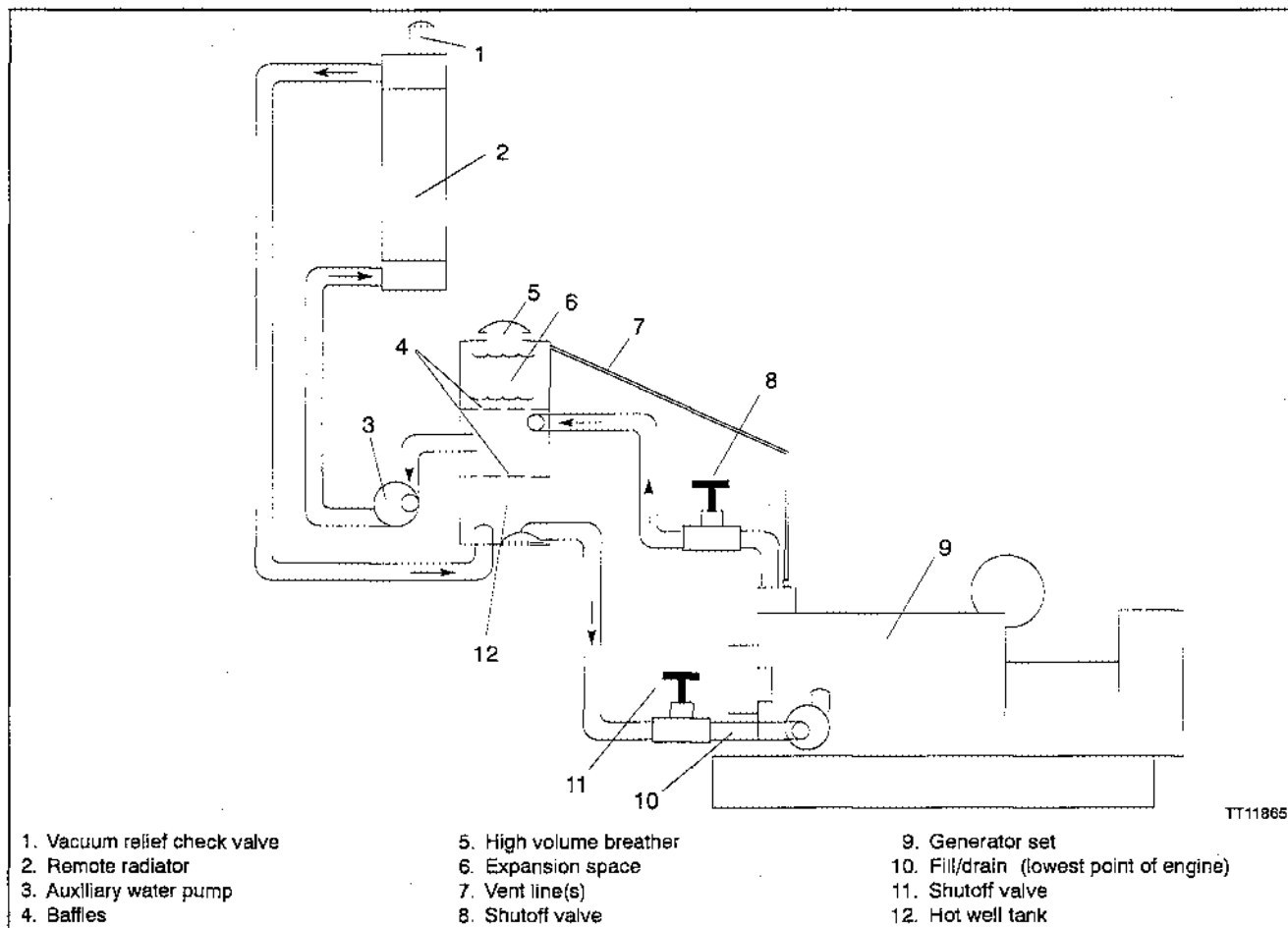


Figure 4-9 Compound Remote Radiator/Hot Well Tank Cooling System

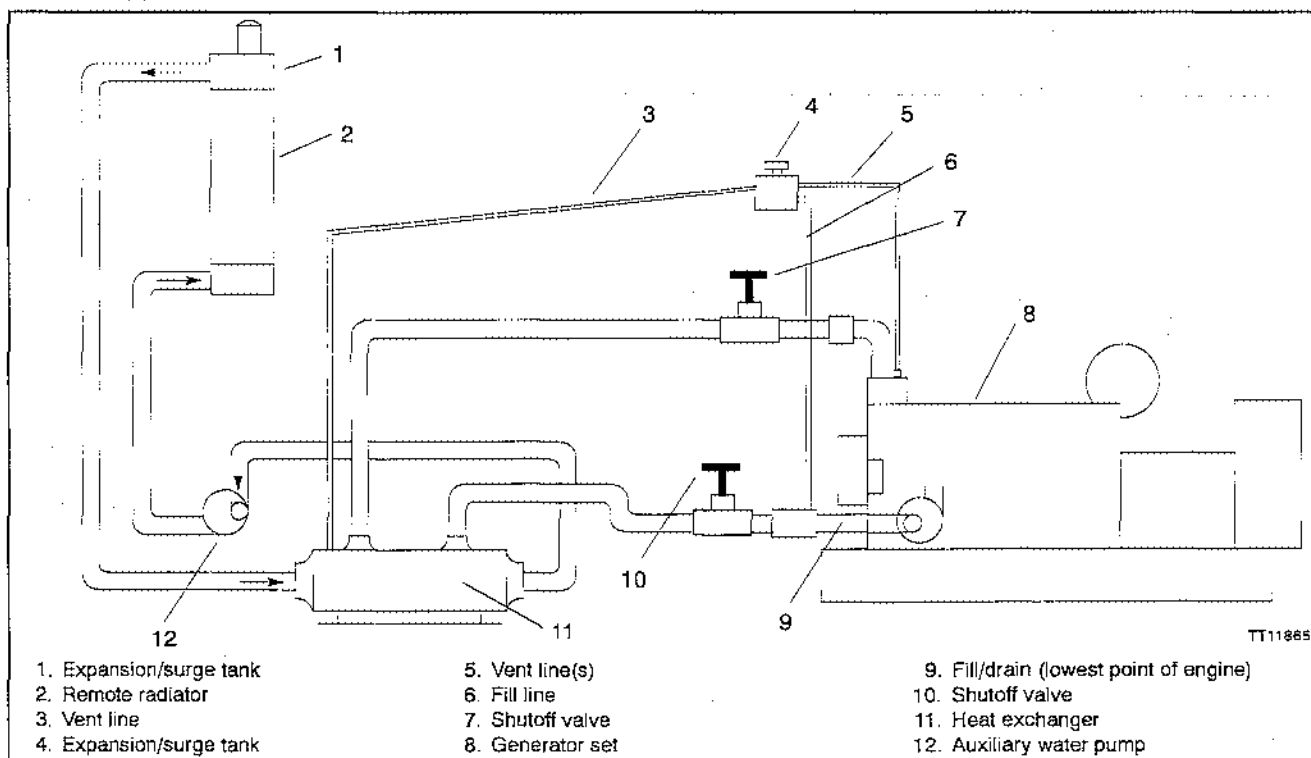


Figure 4-10 Compound Remote Radiator/Heat Exchanger Cooling System

4.5.3 Fill Lines (Balance or Static)

Connect the fill line(s) to the bottom of the expansion tank. Make the lines as short as possible, continuously descending, and connected directly *before* the engine water pump(s). To provide a positive head pressure to the engine water pump inlet, properly locate the fill line (or makeup line). See the installation drawings for the fill line connection points.

Connect the vent and fill lines to the expansion tank at the greatest possible distance from each other to prevent aeration and preheating of the coolant returning down the fill line.

The minimum fill line sizes cannot be smaller than the connection point on the engine. Do not allow fittings on the fill lines to reduce the effective size. If other cooling system components vent too much coolant to the expansion tank, larger diameter fill lines may be needed.

4.5.4 Location Considerations

When choosing the radiator's location:

- For economical installation and operation, locate the radiator as close as practical to the engine and at the same elevation to reduce piping, coolant, and wiring costs.
- Locate the radiator surge tank fill opening and vent line(s) at the highest point in the cooling system.
- Position the radiator no closer than one fan diameter from a wall, another radiator, or any other obstruction that would restrict air movement and future service access.
- Locate the radiator to prevent recirculation of the heated exhaust air back into the intake stream.
- Mount the radiator in an area where prevailing winds do not hamper free airflow.
- Locate the radiator where it is not subject to deep snow or ice accumulation, flooding, industrial fallout, leaf accumulation, heavy dust and chaff, or other detrimental seasonal or environmental conditions.
- For rooftop installations, do not locate the radiator near critical sound areas, building ventilation, or hood exhausts.

4.5.5 Installation Considerations

When installing the remote radiator:

- Use a remote radiator setup kit to aid installation. See Figure 4-11.
- Wire the cooling fan motor to the generator set output so that the fan operates whenever the generator set operates. There is no need for a thermostatic control of the fan motor because the engine thermostat prevents overcooling as it does on generator set-mounted radiator systems. Follow all applicable national and local codes when wiring the cooling fan.
- Follow the wiring diagram on the remote radiator's fan motor. The motor rotation must match the fan blade design. The manufacturer supplies most units with counterclockwise fan rotation as viewed from motor side. The fan is a blower type, moving air from the fan side of the radiator, through the core, and out the front side.
- Preferably, connect no devices to either side of the radiator. Resize the radiator if adding louvers or duct work to the radiator to compensate for reduced airflow.
- Ensure that the radiator is level and securely bolted to a firm, solid foundation.
- Brace the radiator as needed, especially in areas with strong winds.
- Use isolators to keep area vibration from affecting the radiator or to keep vibration produced by the radiator from affecting surrounding areas.
- Use hose clamps on all nonthreaded connections.

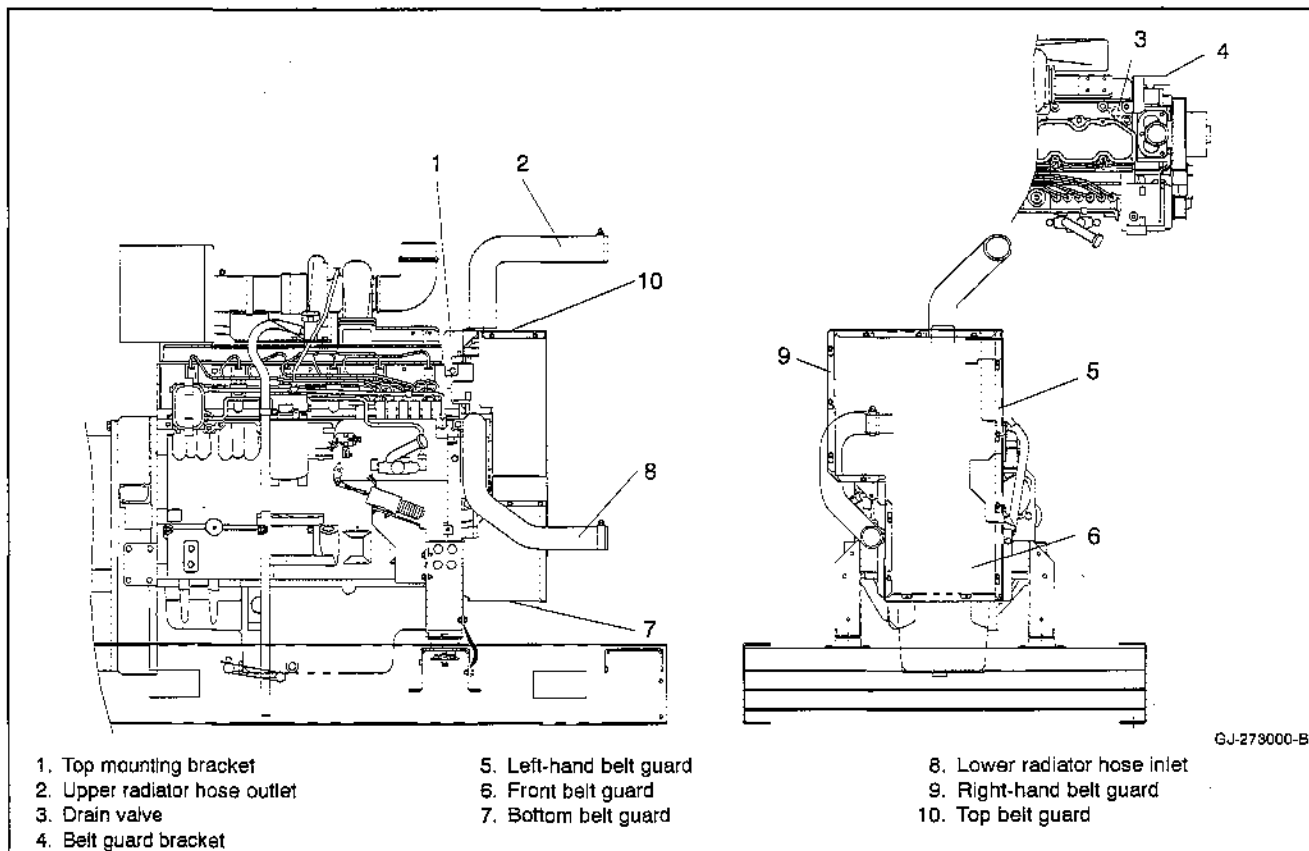


Figure 4-11 Remote Radiator Setup Kit, Typical

4.5.6 Surge (Expansion) Tank for Horizontal Discharge Radiator

A horizontal discharge remote radiator requires the use of a surge (expansion) tank as shown in Figure 4-8. Locate the tank at the highest point in the cooling system. The surge tank provides venting, surge/expansion protection, and filling/makeup functions.

- Equip the surge tank with a sight-glass gauge, overflow tube, and pressure cap.
- Size the surge tank to handle at least 6%–10% of the total cooling system volume. Follow the engine manufacturer's recommendation when available.
- Connect the main line from the surge tank to the highest point of the remote radiator. Most vertical core radiators have the surge tank as part of the radiator top tank. The setup illustrated in Figure 4-8 provides for radiator and engine deaeration and a positive pressure at the pump suction inlet.
- Use a strainer to filter dirt, scale, and core sand from the coolant line.

Piping. Size water piping between the engine and the remote radiator large enough to eliminate the need for a booster pump. If the cooling system requires a booster pump, contact your distributor/dealer.

Use piping of ample size and with as few short sweep bends or elbows, tees, and couplings as possible. Use long sweep elbows or long bends, if bends are required.

Installation. Support piping externally, not from the radiator or engine.

On standard remote radiators, connect radiator bottom outlets only to the suction side of the pump. Plumb the lines to prevent air from becoming trapped in the lines. Route piping in one general direction, either upward or downward. A combination of both upward and downward piping creates air pockets in the piping. Route vent lines to the expansion/surge tank without creating low spots in the lines.

Flexible connections. Provide flexible connections when connecting piping to the radiator assembly. Use hose clamps at all nonthreaded connections.

Shutoff valves. Locate shutoff valves between the engine and cooling system to allow for isolation of both the radiator and the engine. A shutoff valve eliminates the need to drain the entire cooling system during service.

4.5.7 Procedure to Fill with Deaeration

For radiators designed for full deaeration, fill the radiator according to the following procedure.

1. Fill the cooling system from the bottom when possible. Otherwise, fill the radiator at the filler neck.
2. Next, fill the radiator through one of the top tank or expansion/surge tank inlets located before the final hose connection.
3. Continue filling the system to cover the filler neck bottom until coolant appears in the sight glass located in the radiator top tank.
4. Check and correct any leaks in the system.

4.5.8 Procedure to Fill without Deaeration

For radiators designed without deaeration, fill the radiator according to the following procedure.

1. Initially, fill the radiator through one of the top tank inlets located before the final hose connection for faster and more complete fillup.
2. Fill the cooling system from the bottom when possible. Otherwise, fill the radiator at the filler neck with coolant covering the filler neck bottom until coolant appears in the sight glass located in the radiator top tank.
3. Check for and correct any leaks in the system.

4.5.9 Checks after Initial Startup

If any problems arise during startup, immediately shut down the generator set. See Figure 4-12, Cooling System Checklist. Even after a successful startup, shut down the generator set after 5-10 minutes and recheck the belt tension to make sure no hardware has loosened during operation. Perform another recheck after 8-12 hours of operation.

✓	Operation
	Verify the cooling fan's position in the fan shroud.
	Check the mounting hardware.
	Check the fan motor for free rotation.
	Check V-belts for alignment and tension.
	Fill the system with coolant and check all connections for tightness and leaks.
	Verify that all electrical connections are secure and that the power source matches the motor nameplate.
	Verify that no loose foreign material is in the fan's air stream.
	With the unit running, check for:
	fan clearance
	excessive vibration
	excessive noise
	coolant leaks

Figure 4-12 Cooling System Checklist

4.6 City Water Cooling

4.6.1 System Features

City water-cooling systems use city water and a heat exchanger for cooling. They are similar to remote radiator systems because they require less cooling air than unit-mounted radiator systems. Figure 4-13 shows some of the elements of a typical installation.

The heat exchanger limits the adverse effects of city water chemistry to one side of a heat exchanger, which is relatively easy to clean or replace, while engine coolant circulates in a closed system similar to the radiator system. The heat exchanger allows engine temperature control, permits the use of antifreeze and coolant conditioners, and is suited to the use of an engine block heater as a starting aid.

4.6.2 Installation Considerations

Vibration isolation requirements. Water inlet and outlet connections are mounted on the generator set skid and isolated from engine vibration by flexible sections. If the generator set is vibration-mounted to the skid and the skid is bolted directly to the mounting base, no additional flexible sections are needed between connection points on the skid and city water lines. If the generator set skid is mounted to the base with vibration isolators, use flexible sections between the connection points on the skid and city water lines.

Shutoff valve location. A solenoid valve mounted at the inlet connection point automatically opens when the generator set starts, providing the engine cooling system with pressurized water from city water mains. This valve automatically closes when the unit shuts down. Use an additional customer-supplied valve ahead of the entire system to manually shut off city water for generator set service.

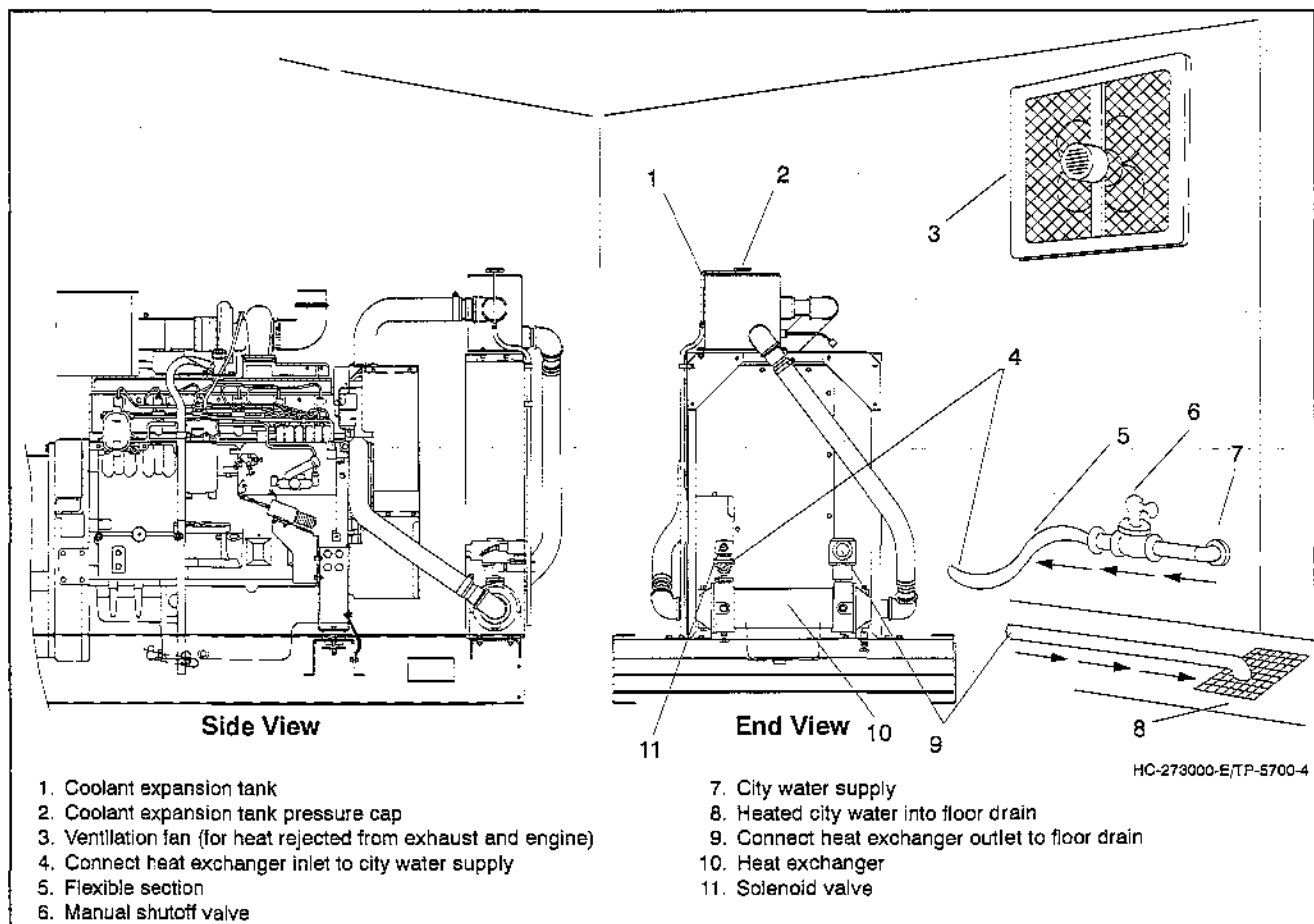


Figure 4-13 City-Water Cooling System with Heat Exchanger

4.7 Cooling Tower

A cooling tower system is a variation of a city water cooling with heat exchanger system. In warm, dry climates, a cooling tower is a suitable source of generator set cooling water.

A cooling tower system consists of the engine cooling system plus a raw-water system. The engine cooling system usually includes the engine water pump, a heat exchanger, a surge tank, and the engine water jacket. The raw-water system consists of the cooling tower, a raw-water pump, and the tube portion of the heat exchanger. A typical system is shown in Figure 4-14.

The engine cooling system circulates coolant through the heat exchanger outer shell. Raw water circulates through the heat exchanger tubes absorbing heat from the engine coolant. The heated raw water flows into a pipe at the top of the cooling tower and sprays down into the tower to cool by evaporation. Because some water is constantly being lost through evaporation, the system must provide makeup water.

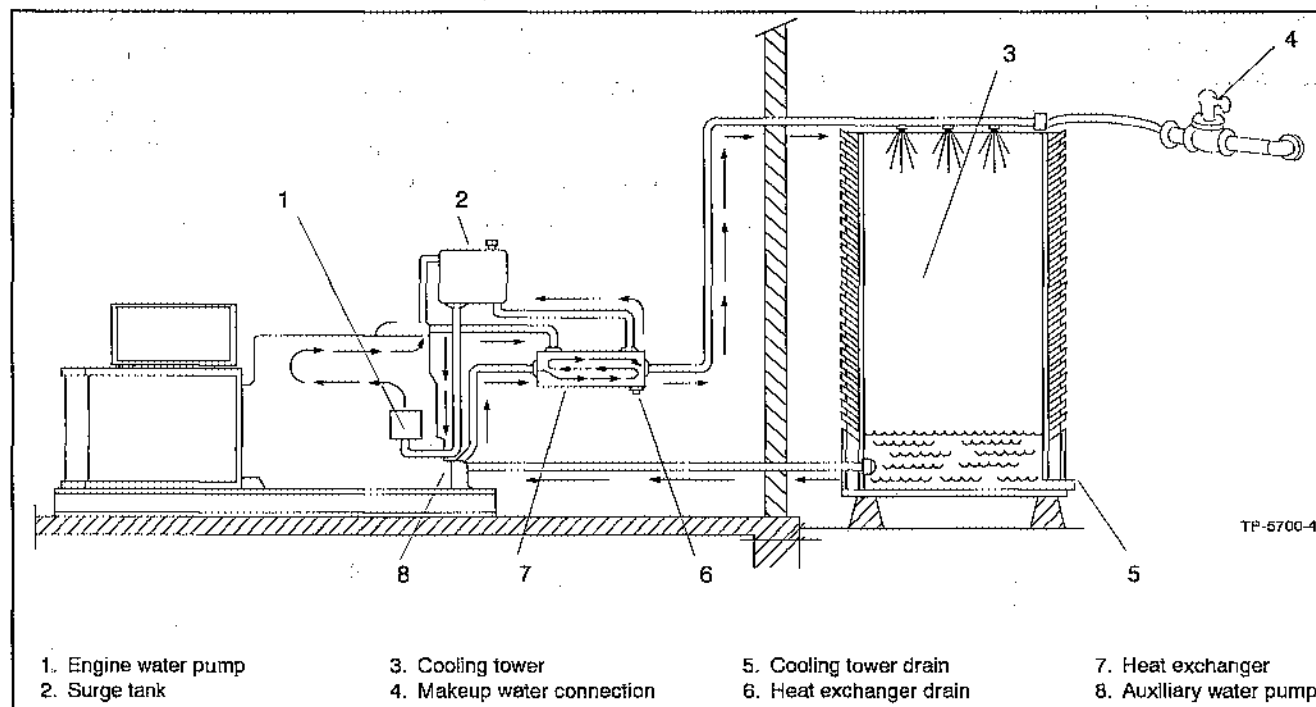


Figure 4-14 Cooling Tower System

4.8 Block Heaters

Block heaters are available as installed accessories on all generator sets. Generator sets installed in NFPA applications generally require use of a block heater. Equip generator sets with block heaters on all standby applications where the generator set is subject to temperatures below 0–20°C (32–68°F). See the respective generator set spec sheet for specific temperature recommendations. Connect the block heater to a power source that is energized when the generator set is not running.

The block heater thermostat is set to 43°C (110°F) on all generator sets models except the 1750/2000REOZMB. The 1750/2000REOZMB models have a thermostat setting of 50°C (122°F) for optimum operation. This adjustment is made by removing the thermostat cap.

Note: Block heater damage. The block heater will fail if the energized heater element is not immersed in coolant. Fill the cooling system before turning on the block heater. Run the engine until it is warm and refill the radiator to purge the air from the system before energizing the block heater.

Section 5 Exhaust System

Satisfactory generator set performance requires proper exhaust system installation. Figure 5-1 and Figure 5-2 show typical arrangements of recommended exhaust systems. The following sections detail exhaust system components.

5.1 Flexible Exhaust Line

Install a section of seamless stainless steel flexible exhaust line at least 305 mm (12 in.) long within 610 mm (2 ft.) of the engine exhaust outlet. See Figure 5-1 and Figure 5-2.

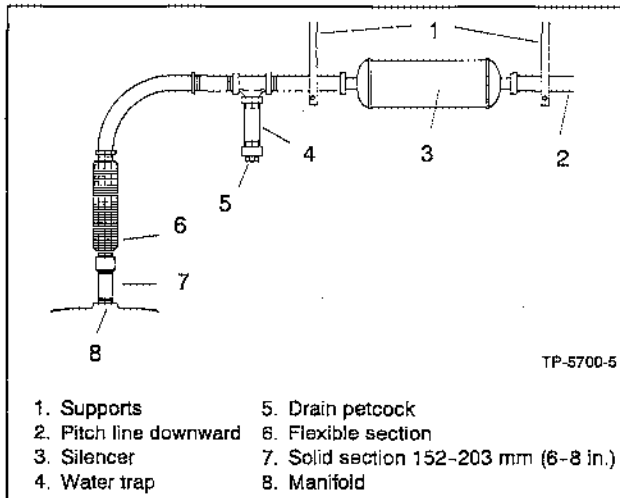


Figure 5-1 Exhaust System, End Inlet Silencer

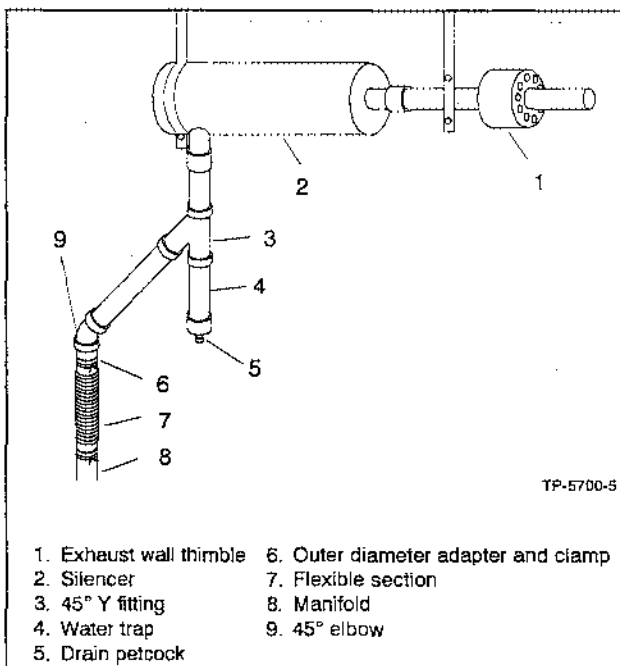


Figure 5-2 Exhaust System, Side Inlet Silencer

The flexible line limits stress on the engine exhaust manifold or turbocharger. Never allow the engine manifold or turbocharger to support the silencer or exhausting piping.

Note: Do not bend the flexible section or use it to compensate for misalignment between the engine exhaust and the exhaust piping.

When using threaded flexible exhaust connectors, place a 152-203 mm (6-8 in.) length of pipe between the flexible exhaust connectors and the exhaust manifold. See Figure 5-1. The pipe reduces the temperature of the flexible connection, simplifies flexible section removal, and reduces strain on the engine exhaust manifold.

5.2 Condensation Trap

Some silencers are equipped with a drain pipe plug for draining condensation; see Figure 5-3. Otherwise, install a wye- or tee-type condensation trap with a drain plug or petcock between the engine and the exhaust silencer as shown in Figure 5-4. The trap prevents condensed moisture in the engine exhaust from draining into the engine after shutdown. Periodically drain collected moisture from the trap.

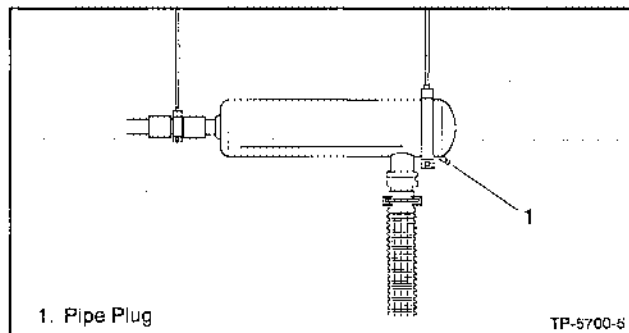


Figure 5-3 Silencer Condensation Drain Plug

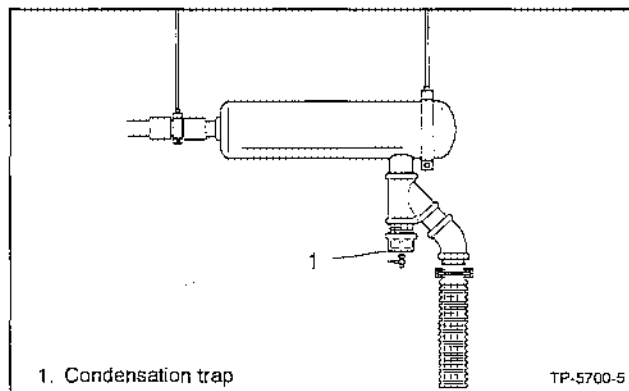


Figure 5-4 Condensation Trap

5.3 Piping

Note: Select piping with a diameter that is the same size as, or larger than, the manifold outlet's inside diameter.

- Keep exhaust lines as short and straight as possible.
- Use schedule 40 black-iron pipe.
- Use sweep elbows with a radius of at least three times the pipe diameter.
- Use exhaust piping that conforms to applicable codes.
- Support the exhaust piping securely, allowing for thermal expansion.
- Insulate the exhaust piping with high-temperature insulation to reduce the heat rejected by exhaust piping and consequently the amount of ventilating air required.

In general, exhaust temperatures measured at the engine's exhaust outlet are less than 538°C (1000°F), except for infrequent brief periods; therefore, low-heat appliance standards apply. Each generator set specification sheet provides exhaust temperatures.

For units with exhaust temperatures below 538°C (1000°F), route the exhaust piping a minimum of 457 mm (18 in.) from combustible material, including building materials and natural surroundings. If exhaust temperatures exceed 538°C (1000°F), the minimum distance is 914 mm (36 in.).

When planning exhaust silencer and piping placement, consider the location of combustible materials. If the proximity of the exhaust system to the combustible materials cannot be avoided, follow a regular maintenance schedule to ensure that combustible materials are kept away from the exhaust pipes after installation. Combustible materials include building materials as well as natural surroundings. Keep dry field grass, foliage, and combustible landscaping material a safe distance from the exhaust system.

5.4 Double-Sleeved Thimbles

If the exhaust pipe passes through a wall or roof, use a double-sleeved exhaust thimble to prevent the transmission of exhaust pipe heat to the combustible material. Figure 5-5 shows construction details of a typical double-sleeved thimble in which exhaust piping passes through a combustible structure. Sheet metal shops usually fabricate thimbles using installation engineer's specifications and drawings.

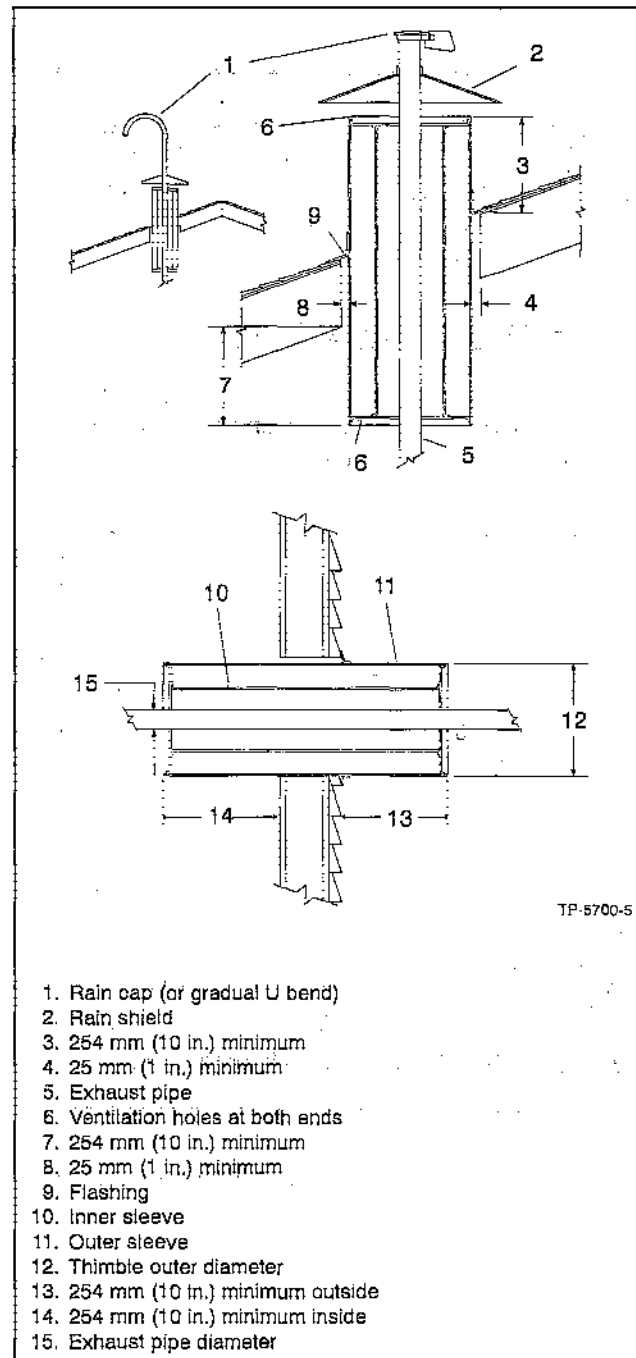


Figure 5-5 Double-Sleeved Thimbles and Rain Cap

Construct the thimble so it extends at least 254 mm (10 in.) both inside and outside the structure's surface. Openings at both ends of the thimble allow cooling air to circulate through the thimble. If screening is used on the outer end to keep birds and animals from entering the thimble, use a mesh large enough to allow unrestricted air circulation through the thimble. See Section 5.5 for additional exhaust outlet location and protection considerations.

5.5 Exhaust Outlet

Outlet location. Engine performance and efficiency depend on the location of the exhaust outlet. Direct the exhaust outlet away from the air inlet to prevent exhaust gases from entering the air inlet and clogging the dry-type air filter elements. Hot exhaust drawn through the radiator adversely affects engine cooling. Locate the exhaust outlet to prevent exhaust fumes from entering a building or enclosure.

Noise reduction. The exhaust outlet configuration affects the apparent noise level for people or animals in the vicinity. An upward-directed outlet seems quieter than one directed downward or horizontally. Additionally, a 30- to 45-degree angled cut at the end of a horizontal exhaust outlet pipe reduces turbulence at the outlet, thereby reducing the noise level.

Rain cap. To prevent precipitation from entering the exhaust pipe, install a rain cap on vertical outlets. See Figure 5-5. In a climate where freezing is common, do not use a rain cap. Instead, extend the exhaust piping at least 610 mm (24 in.) beyond the roof line and create a gradual U bend at the end to direct the exhaust outlet downward. Keep the pipe outlet at least 457 mm (18 in.) from the roof to prevent hot exhaust from igniting the roof material.

Note: Do not use a rain cap in areas subject to freezing temperatures.

5.6 Exhaust System Backpressure

Exhaust backpressure limits engine power and excessive backpressure causes serious engine damage. Excessive backpressure usually results from one or more of the following reasons:

- The exhaust pipe diameter is too small.
- The exhaust pipe is too long.
- The exhaust system has too many sharp bends.
- The exhaust silencer is too small.
- The exhaust silencer is not the correct design for the application.

Use the following procedure to verify that the installed exhaust system does not exceed the engine's maximum exhaust backpressure limit as specified in the generator set specification sheet.

Exhaust System Backpressure Calculation Procedure

Determine the total backpressure by calculating the effects of the individual exhaust system components and adding the results. Make calculations using either English or metric units. Exhaust pipe references are nominal pipe NPT (in.) sizes. The procedure shows an example with *italic* text. Calculations relate to end inlet silencers.

Note: When calculating backpressure drop for *side* inlet silencers, use the *end* inlet values shown and add 0.75 kPa (0.25 in. of mercury or 3.4 in. of water) to backpressure calculations.

1. Select the exhaust silencer type for the application—hospital, critical, residential, or industrial. See the silencer specification sheet for definitions for each exhaust silencer type. Confirm silencer type availability for your generator set with your authorized distributor/dealer, as some generator sets do not use all four types.

Example: Determine the silencer backpressure for the recommended critical silencer on a 230 kW, 60 Hz diesel generator set.

2. Refer to the generator set specification sheet for:
 - a. Engine exhaust flow at rated kW in m³/min. (cfm)
Example: 57.5 m³/min. (2030 cfm)
 - b. Maximum allowable backpressure in kPa (in. of Hg)
Example: 10.2 kPa (3.0 in. Hg)
3. Refer to the submittal catalog for:
 - a. The recommended critical silencer part number
Example: 343616
 - b. Silencer inlet diameter in mm (in.)
Example: 152 mm (6 in.)
 - c. Silencer inlet position (end or side)
Example: end inlet
 - d. The flexible exhaust adapter part number
Example: 343605
 - e. Flexible exhaust adapter, flexible section length
Example: 857 mm (33.75 in.)

4. Determine the exhaust gas velocity through the silencer as follows:

- Using the exhaust silencer inlet diameter determined in step 3, determine corresponding inlet area using Figure 5-6.

Example: 0.0187 m^2 (0.201 sq. ft.)

- Use this data to calculate the exhaust gas velocity. Divide the engine exhaust flow from step 2 in $\text{m}^3/\text{min.}$ (cfm) by the silencer inlet area m^2 (sq. ft.) to get flow velocity in m (ft.) per minute.

Example:

*$57.5 \text{ m}^3/\text{min.} / 0.0187 \text{ m}^2 = 3075 \text{ m/min.}$
 $(2030 \text{ cfm} / 0.201 \text{ sq. ft.} = 10100 \text{ ft./min.})$*

Nominal Pipe Size, in. NPT	Inlet Area, m^2	Inlet Area, ft^2
1	0.00056	0.0060
1 1/4	0.00097	0.0104
1 1/2	0.00131	0.0141
2	0.00216	0.0233
2 1/2	0.00308	0.0332
3	0.00477	0.0513
4	0.00821	0.0884
5	0.0129	0.139
6	0.0187	0.201
8	0.0322	0.347
10	0.0509	0.548
12	0.0722	0.777
14	0.0872	0.939
16	0.1140	1.227
18	0.1442	1.553

Figure 5-6 Cross Sectional Area for Standard Silencer Sizes

- Refer to Figure 5-7. Use the exhaust gas velocity determined in step 4 and find the exhaust gas velocity value in thousands on the bottom scale. Move vertically up until this value intersects the curve of the corresponding silencer type as determined in step 1. Move left on the horizontal axis and determine the backpressure drop value in kPa (in. of Hg).

Example: Exhaust velocity, 3075 m/min. (10100 ft./min.) intersects with critical silencer curve B and the corresponding backpressure value is approximately 2.8 kPa ($0.85 \text{ in. of mercury}$). Silencer type is end inlet from step 3 information with no additional backpressure drop value per the following note.

Note: When calculating backpressure drop for side inlet silencers, use the end inlet values shown and add 0.75 kPa ($0.25 \text{ in. of mercury}$ or 3.4 in. of water) to backpressure calculations.

Note: Refer to Figure 5-8 to calculate in inches of water and feet per minute.

- Total the number of elbows and flexible sections in the exhaust system between the engine and the exhaust system outlet. Compare the radius of the bend (R) to the pipe diameter where (D) is the nominal pipe diameter in inches. Determine the equivalent length in m (ft.) of straight pipe for the elbows and flexible sections from the following:

Bend Angle	Type	Bend Radius	Conversion Factor
90°	Close	$R = D$	$32 \times D^* / 12$
90°	Medium	$R = 2D$	$10 \times D^* / 12$
90°	Sweep	$R = 4D$	$8 \times D^* / 12$
45°	Close	$R = D$	$15 \times D^* / 12$
45°	Sweep	$R = 4D$	$9 \times D^* / 12$
	Flex Sections		$2 \times \text{Length}^\dagger / 12$

* Use the diameter of the silencer inlet in inches from step 3 for the initial calculation. If the results from step 9 indicate excessive backpressure drop, then recalculate using the larger-diameter pipe size selected.

† Use the flexible exhaust adapter length from step 3 and add any additional flex sections in the exhaust system expressed in inches.

Convert the equivalent pipe length calculated in feet to meters using $\text{ft.} \times 0.305 = \text{m}$, as needed.

Examples:

45° sweep elbows:

$9 \times 6.0 \text{ in.} / 12 = 4.5 \text{ equiv. ft. or } 1.4 \text{ equiv. m}$

90° close elbows:

$32 \times 6.0 \text{ in.} / 12 = 16.0 \text{ equiv. ft. or } 4.9 \text{ equiv. m}$

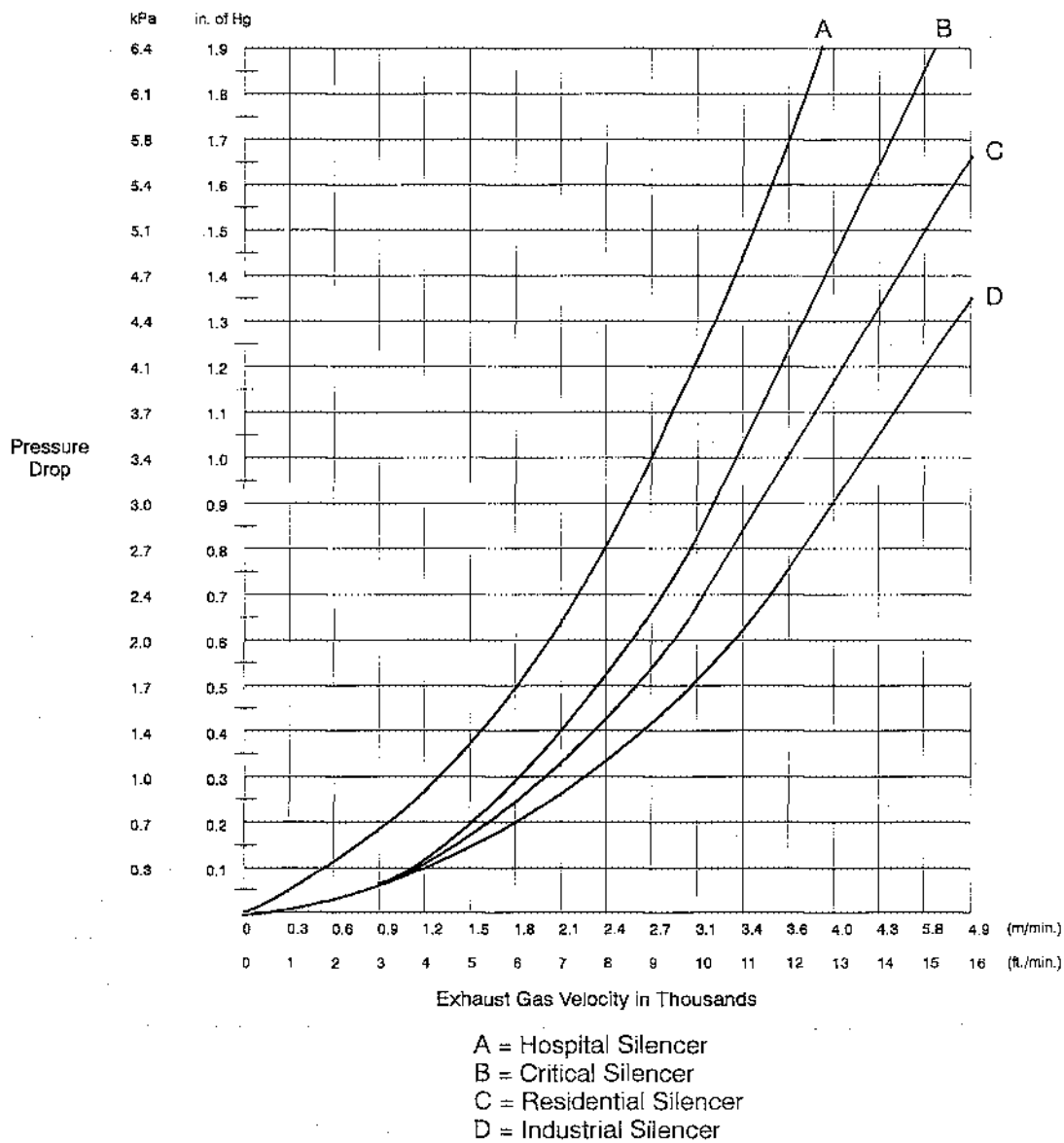
Flexible sections:

$2 \times 33.75 \text{ in.} / 12 = 5.6 \text{ equiv. ft. or } 1.7 \text{ equiv. m}$

Equivalent of straight pipe:

$4.5 + 16.0 + 5.6 = 26.1 \text{ equiv. straight ft.}$

$1.4 + 4.9 + 1.7 = 8.0 \text{ equiv. straight m}$



Note: When figuring the silencer pressure drop for side inlet, add 0.75 kPa (0.25 in. of mercury or 3.4 in. of water) to the backpressure.

Figure 5-7 Silencer Backpressure Drop (in. of Hg)

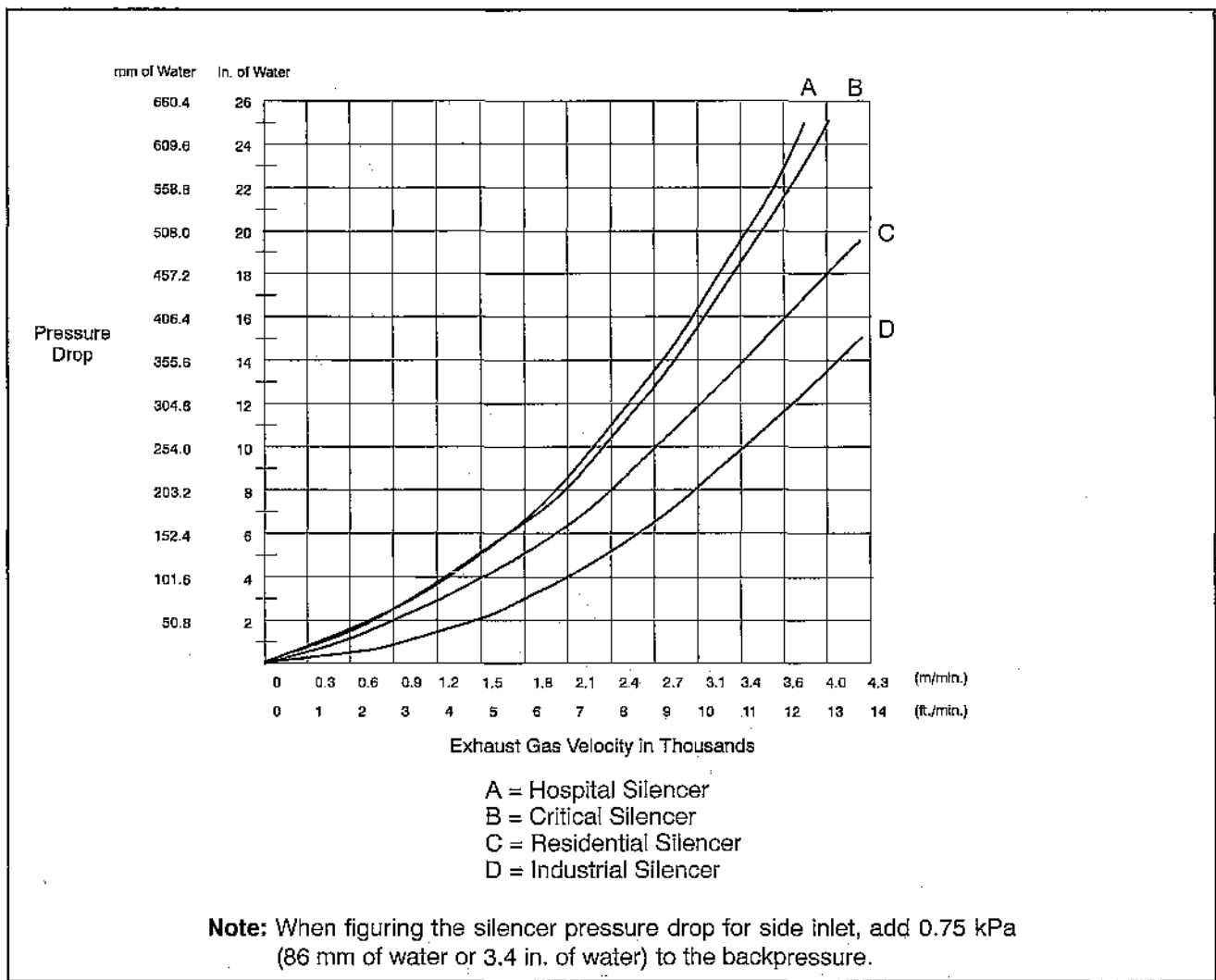


Figure 5-8 Silencer Backpressure Drop (in. of water)

7. Determine the total length of straight pipe used in the exhaust system. Add this calculation to the equivalent length for elbows and flexible sections obtained in step 6.

Example:

Straight pipe = 3.0 m (10 ft.).

Equivalent straight pipe from step 6: 8.0 m (26.1 ft.)

3.0 m + 8.0 m = 11.0 m or

10 ft. + 26.1 ft. = 36.1 ft. total

8. Refer to Figure 5-9 if the pipe size is 102 mm (4 in.) or less or Figure 5-10 if the pipe size is 127 mm (5 in.) or larger.

Place a straight edge across the chart with the edge in line with the pipe size in inches (D) on the right column from step 3 and the engine exhaust flow (Q) from step 2 on the left column.

Read backpressure kPa/m or in. of Hg/ft. (ΔP) from the center column. Calculate the total piping system backpressure by multiplying the total equivalent straight pipe in m (ft.) from step 7 by the kPa/m or in. of Hg/ft. of pipe from this step.

Example:

11.0 equiv. m $\times$ 0.04 kPa/m =

0.4 total system backpressure in kPa

36.1 equiv. ft. $\times$ 0.004 in. Hg/ft. =

0.14 total system backpressure in inches of Hg

9. Add the backpressure of the piping determined in step 8 to the backpressure of the silencer determined in step 5. The total should not exceed the engine manufacturer's maximum allowable system backpressure determined in step 2 or on the generator set's specification sheet. If the total exceeds the maximum, use a larger pipe size or silencer or both. Repeat the calculation if new components are selected to verify that the system backpressure would not exceed the limit using the larger component(s).

Example:

0.4 kPa (step 8) + 2.8 kPa (step 5) = 3.2 kPa

Maximum allowable backpressure = 10.2 kPa

3.2 < 10.2 backpressure drop is acceptable

0.14 in. Hg. (step 8) + 0.85 in. Hg. (step 5) =

0.99 in. Hg.

Maximum allowable backpressure = 3.0 in. of Hg.

0.99 < 3.0 backpressure drop is acceptable

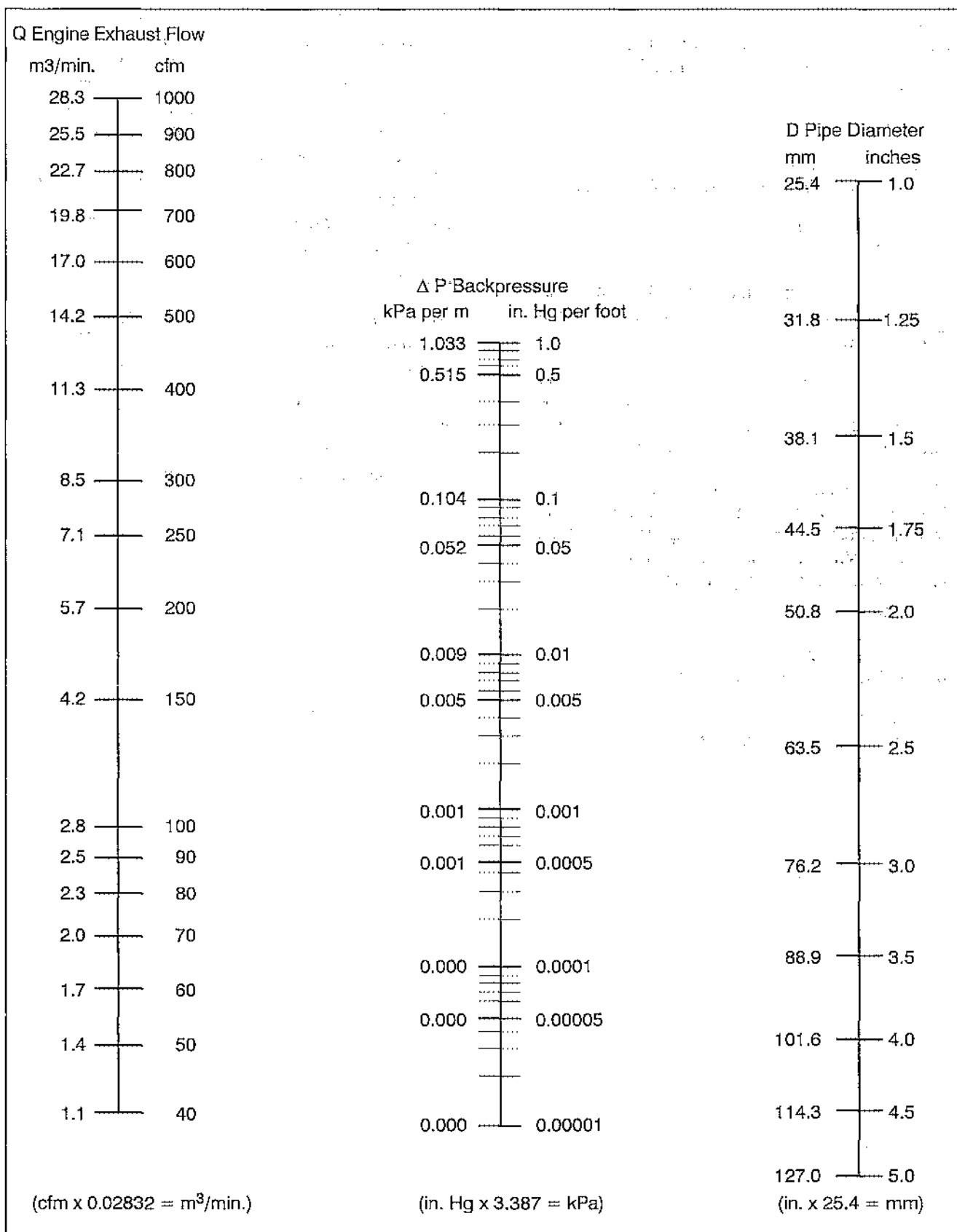


Figure 5-9 Backpressure using Pipe Size 4 in. (102 mm) or Less

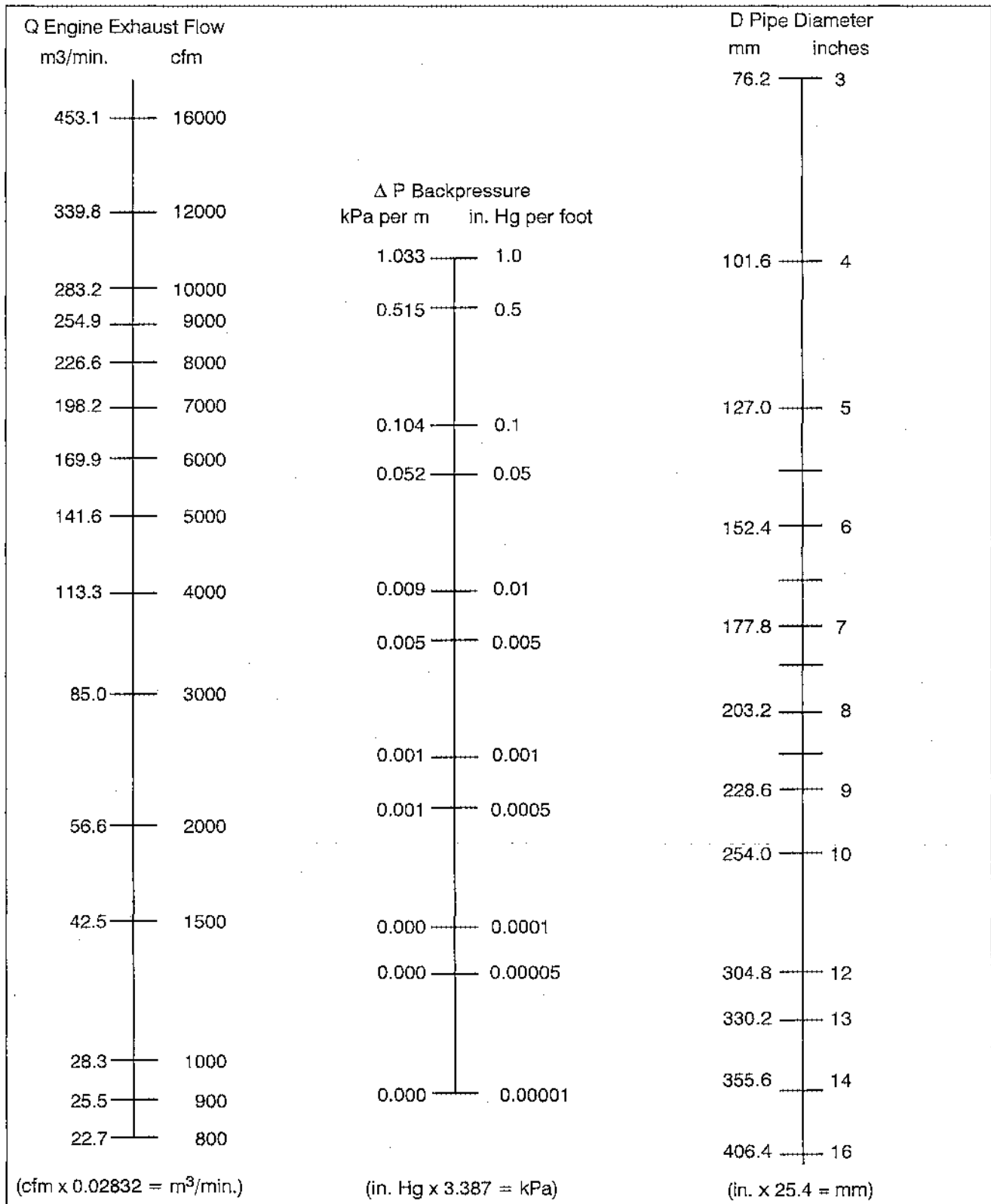


Figure 5-10 Backpressure using Pipe Size 5 in. (127 mm) or Larger

Notes

Comply with applicable state and local codes when installing any fuel system.

6.1 Diesel Fuel Systems

The main components of a typical diesel fuel system are a main fuel storage tank, a day tank, fuel lines, and an auxiliary fuel pump. See Figure 6-1.

6.1.1 Main Tank

Storage. Because it is less volatile than gas or gasoline, diesel fuel is safer to store and handle. Regulations for diesel storage tank placement are less stringent than the regulations for gas or gasoline storage. In some locations, large main tanks are permitted inside the building or enclosure.

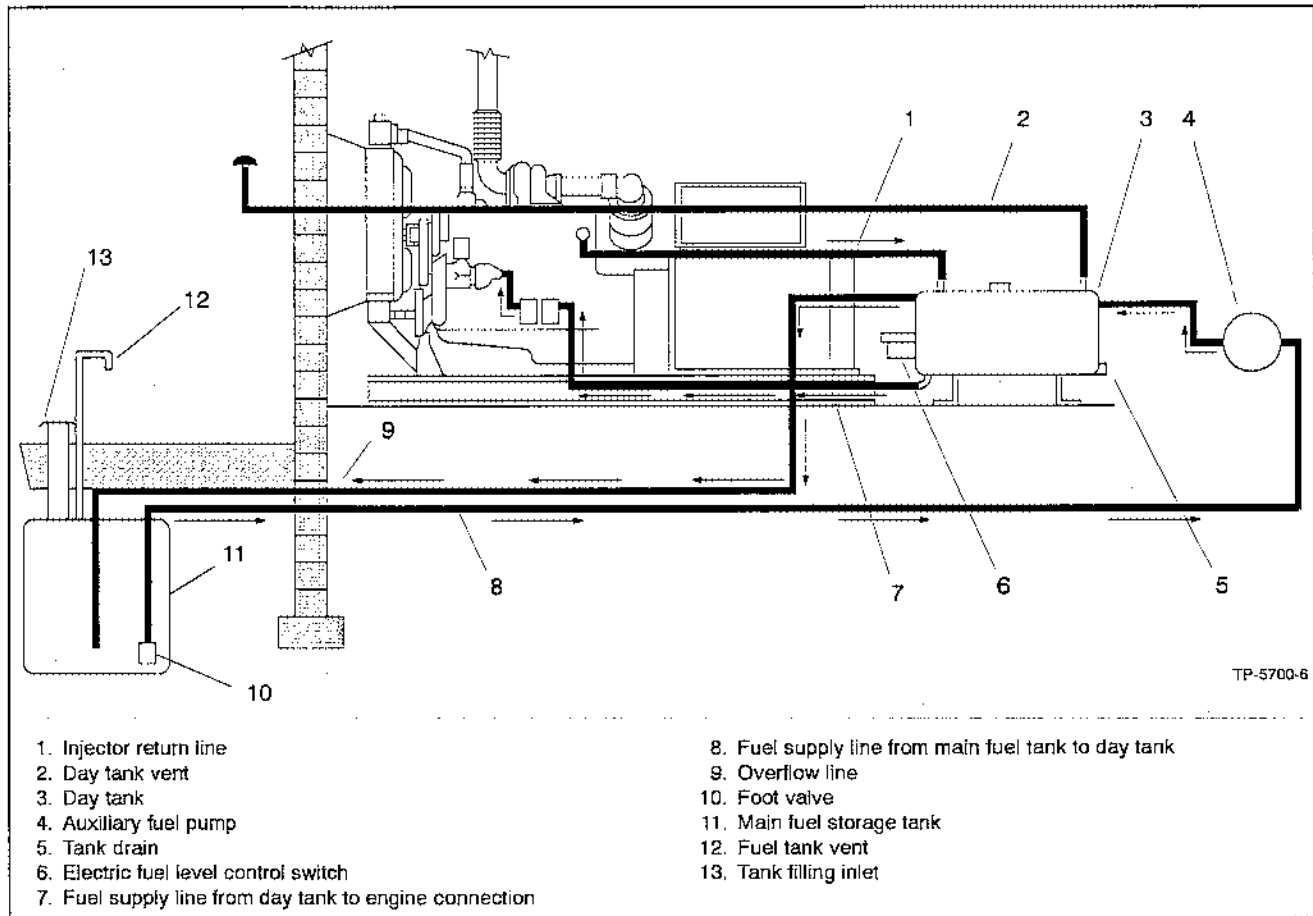


Figure 6-1 Diesel Fuel System

Tank location. Locate fuel storage tanks above ground or bury them underground in accordance with applicable codes. Figure 6-2 shows a commonly used above-ground subbase tank contained in the generator set mounting base.

Provide easy access to fuel filters and sediment drains for regular and frequent service. Clean fuel is especially important to diesel engines, which have easily clogged fuel injectors and pumps.

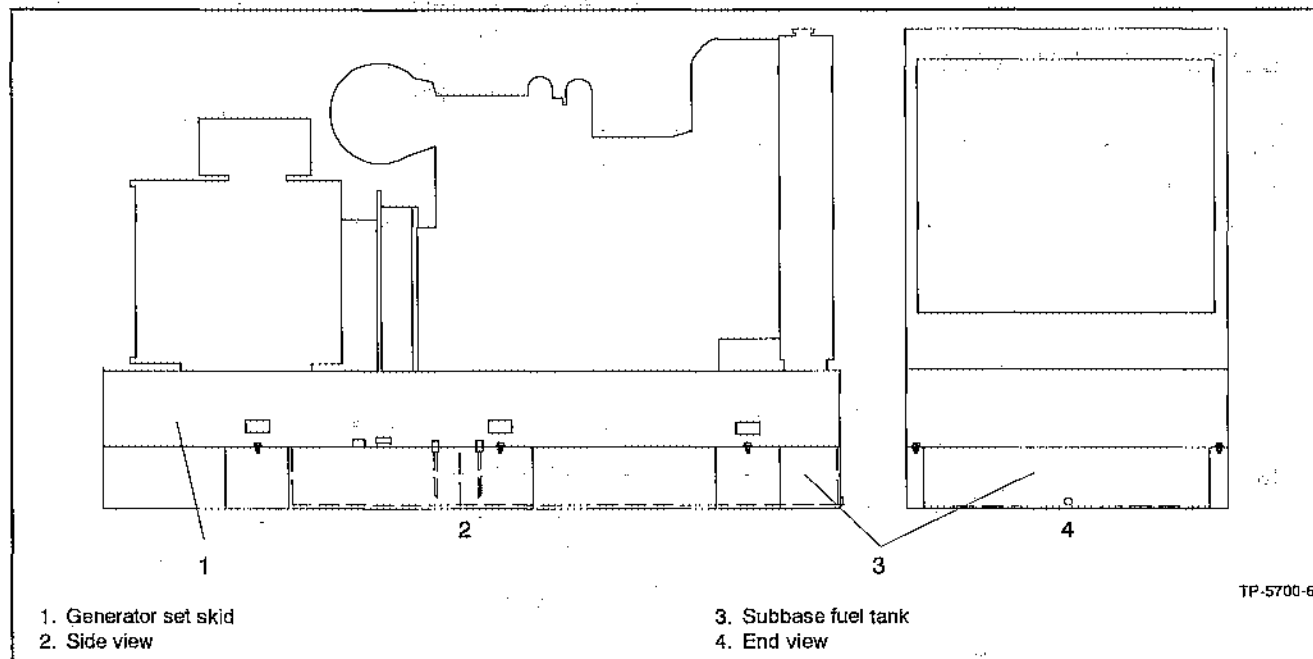


Figure 6-2 Subbase Fuel Tank

Tank size. Codes requiring standby power often specify a minimum onsite fuel supply. Such requirements are included in NFPA 70, National Electrical Code, and NFPA 99, Standard for Health Care Facilities. Diesel fuel deteriorates if stored for more than one year; therefore, size the tank to ensure that regular generator set exercising will use the tank's contents within one year. If there are no applicable code requirements, the manufacturer recommends a tank sized for eight hours of operation at rated load. Refer to the generator set specification sheet for fuel consumption data.

Tank venting. Vent the main fuel tanks to allow air and other gases to escape to the atmosphere without allowing dust, dirt, and moisture to enter the tank.

Fuel expansion. Never fill the tank more than 95% full to allow for fuel expansion. On overhead main tanks, use a fuel shutoff solenoid to prevent hydraulic lock or tank overflow caused by excessive static head fuel pressures.

Fuel alternatives. Most diesel engines operate satisfactorily on No. 2 domestic burner oil available in most parts of the US. If the site heating system is oil-fired, consider supplying the engine with fuel from the same tank used for heating oil to reduce costs and to ensure a continually fresh fuel supply for the engine. This practice necessitates that the fuel oil meets the engine manufacturer's minimum requirements for wax point, pour point, sulfur content, and cetane number as these factors influence cold weather starting and generator set power output. When supplying multiple applications from the same main fuel tank, provide each with a separate supply line.

6.1.2 Day Tanks

The terms *day tank* and *transfer tank* are interchangeable. Having a day tank adjacent to the engine allows the engine fuel transfer pump to easily draw fuel during startup and provides a convenient location to connect fuel injector return lines. See Figure 6-3.

Connect a float-switch-controlled solenoid antisiphon valve or a float valve to prevent siphoning fuel from the main storage tank if the main tank fuel level is above the day tank inlet.

Tank size. Standard tanks are available in sizes from 38-3952 L (10-1044 gal.) with or without integral electric fuel transfer pumps. Because engines are subject to fuel temperature deration above 38°C

(100°F) and are subject to damage if operated with fuel temperatures above 60°C (140°F), a day tank providing at least four hours of fuel consumption should be used to provide enough capacity to cool the fuel returning from the engine. If smaller day tanks are used, the generator set manufacturer may recommend installing a fuel cooler or routing engine fuel return lines to the main storage tank. See Figure 6-3.

Optional equipment includes fuel level gauges, manual priming pumps, float switches for pump control, float valves, rupture basins, and low level alarms. Remove the plastic shipping plugs and install metallic pipe plugs in all unused fuel tank ports to provide a liquid-tight seal.

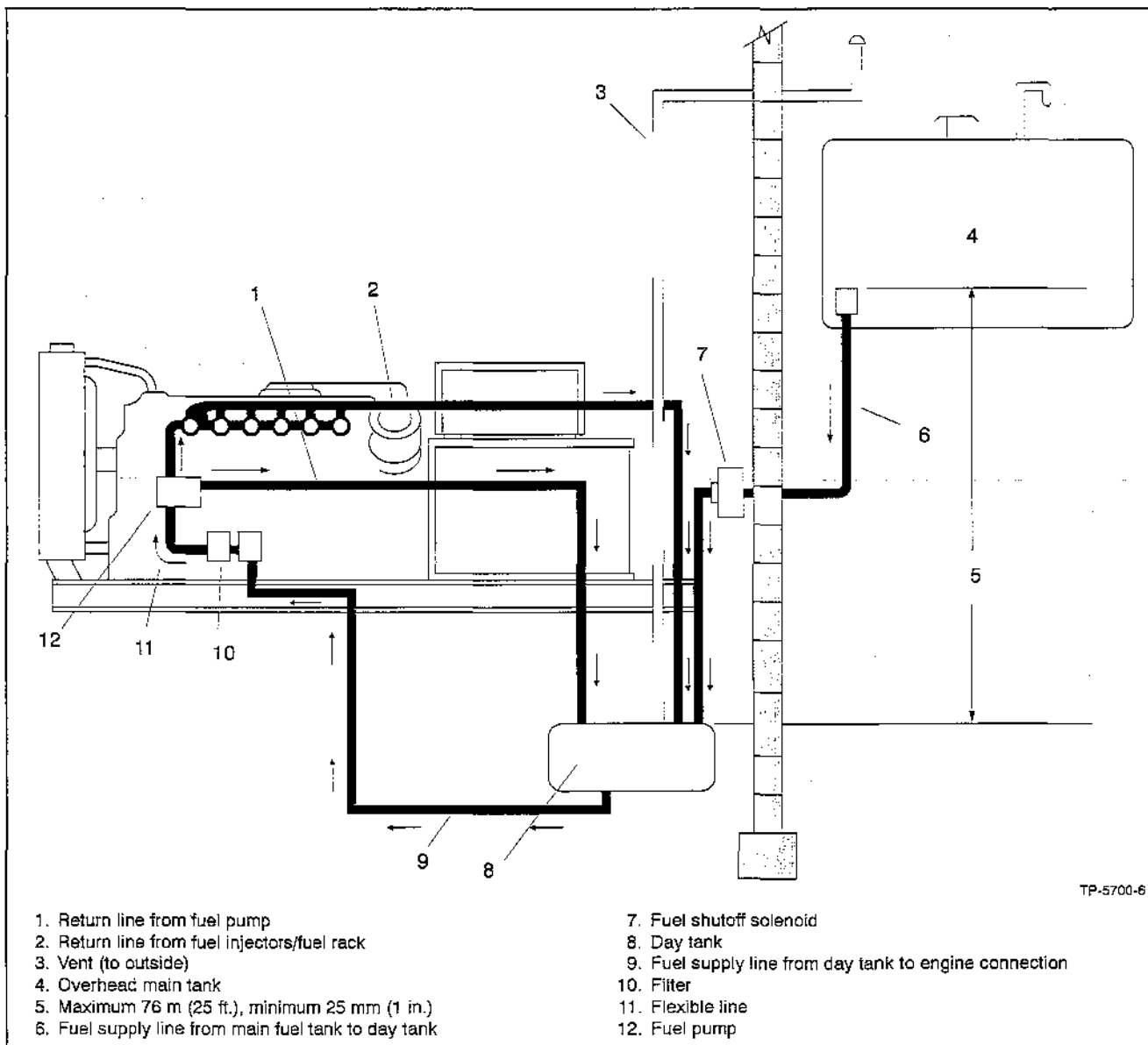


Figure 6-3 Diesel Fuel System with Overhead Main Tank and Day Tank

6.1.3 Fuel Lines

The following items describe fuel line selection and application. Never use the fuel piping or fuel line clamps to ground any electrical equipment.

Line type. Use Schedule 40 black-iron pipe, steel tubing, or copper tubing for diesel fuel systems. Diesel fuel reacts adversely with galvanized tanks and piping, producing flaking sediment that quickly clogs filters and causes fuel pump and fuel injector failure. Ensure that any flexible fuel lines used are approved for diesel fuel.

Line size. Use the smallest diameter fuel line that still delivers enough fuel to the engine with an acceptable pressure drop of 6.9 kPa (1.0 psi). Using oversize piping increases the chance of air introduction into the fuel system during engine priming, which increases the potential for fuel pump damage and hard starting.

Flexible connectors. Use flexible connections spanning a minimum of 152 mm (6 in.) between the stationary piping and the engine fuel inlet connection.

Return lines. A diesel system delivers more fuel to the injectors than the engine uses; therefore, a system has one supply line from the fuel tank and at least one return line from the fuel injectors. Size the fuel return lines no smaller than the fuel supply lines.

Route the return fuel line to either the day tank or the main storage tank. Place the return lines as far away from the pickup or fuel diptube as possible to prevent air entry and to keep warm fuel from being reintroduced to the engine. If fuel lines are routed to the day tank, note the day tank size requirements in Section 6.1.2, Day Tanks.

A properly designed fuel return line is unrestricted and as short as possible, and it allows gravity return of fuel to the storage tanks. In installations where gravity return is not possible, obtain approval of the design from the generator set supplier based upon the engine's specifications before installing a fuel system with static head pressure on the return lines. Fuel return line restriction can cause engine hydraulic lock or uncontrollable overspeed on some systems.

6.1.4 Auxiliary Fuel Pumps

Primary, engine-driven fuel pumps typically develop a maximum of 48 kPa (7 psi) pressure and draw fuel to approximately 1.2–1.4 m (4–5 ft.) vertically or 6 m (20 ft.) horizontally. When the main tank is located a greater distance from the engine or for a more reliable fuel system, use an auxiliary pump alone or in connection with a day tank. See Figure 6-3. Limit auxiliary fuel pump pressure to approximately 35 kPa (5 psi).

Use a shutoff solenoid valve wired into the engine run circuit or a check valve to help keep the fuel line primed. Install the check valve on the outlet side of the auxiliary fuel pump to minimize inlet restriction.

Auxiliary fuel pump options. On engines using less than 38 L (10 gal.) of fuel per hour (approximately 100 kW or less), connect an engine starting battery-powered electric fuel transfer pump in series with the engine-driven transfer pump. Locate the electric pump nearer to the fuel tank than to the engine. An auxiliary pump located at the fuel tank approximately doubles the horizontal and vertical distance limits of a single engine-driven pump.

On engines using more than 38 L (10 gal.) of fuel per hour or when drawing fuel more than 1.8 m (6 ft.) vertically or 12 m (40 ft.) horizontally, use an electric motor-driven positive displacement pump with a day tank and float switch. Electrically connect the fuel pump to the transfer switch load side for maximum reliability. This type of pump can typically lift fuel 5.5 m (18 ft.) or draw it horizontally up to 61 m (200 ft.).

Where vertical runs exceed 5.5 m (18 ft.) or horizontal runs exceed 61 m (200 ft.), remote-mount the pump adjacent to the fuel storage tank. This type of installation allows these pumps to push fuel over 305 m (1000 ft.) horizontally or more than 31 m (100 ft.) vertically and deliver adequate fuel for generator sets up to 2000 kW. Always connect a positive-displacement pump directly to a day tank and float switch to protect the engine fuel system from excessive fuel pressures.

6.2 Gasoline Fuel Systems

The main components of a typical gasoline fuel system are a fuel storage tank, fuel lines, and a fuel pump. See Figure 6-4.

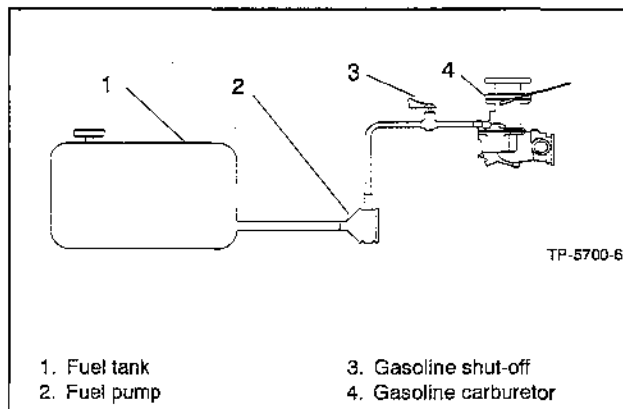


Figure 6-4 Gasoline Fuel System

6.2.1 Fuel Storage Tank

Gasoline fuel systems are usually limited to outdoor or portable trailer-mounted generator sets because codes typically restrict or prohibit storing more than 3.8 L (1.0 gal.) of gasoline inside a building.

If a fuel storage tank is located higher than the engine, install an antisiphon fuel solenoid valve or air bleed hole in the fuel tank dip tube (near the top of the tube inside the tank) to prevent siphoning.

Gasoline deteriorates after six months; therefore, use the smallest storage tank allowed by code.

6.2.2 Fuel Lines

Never use fuel piping to ground electrical equipment.

Line type. Use Schedule 40 black-iron pipe, steel tubing, or copper tubing for gasoline fuel systems. Do not use galvanized pipe and fittings.

Line size. Use the smallest diameter fuel line that will not restrict the required fuel flow.

Flexible connectors. Use flexible connections spanning a minimum of 152 mm (6 in.) between the stationary piping and the engine fuel inlet connection.

6.2.3 Fuel Pumps

Engine fuel pumps usually lift fuel up to 1.2 m (4 ft.) or draw it horizontally up to 6 m (20 ft.). Connect auxiliary engine starting battery-powered electric pumps in series with the engine-driven pump. See Figure 6-4. An auxiliary pump located at the fuel tank approximately doubles the horizontal and vertical distance limits of a single engine-driven pump. Limit auxiliary fuel pump pressure to approximately 35 kPa (5 psi).

6.3 Gas Fuel Systems, Common Components

Gas fuel systems operate on either LP (liquefied petroleum) or natural gas.

Note: Design and install gas fuel systems in accordance with NFPA 54, National Fuel Gas Code, and applicable local codes.

All gas systems include a carburetor, secondary gas regulator, electric gas fuel solenoid shutoff valve, and flexible fuel connector.

6.3.1 Gas Lines

Never use fuel piping to ground electrical equipment. The gas supplier is responsible for installation, repair, and alteration to gas piping.

Line type. Use Schedule 40 black-iron pipe for gas piping. Copper tubing may be used if the fuel does not contain hydrogen sulfide or other ingredients that react chemically with copper.

Line size. Size piping according to the requirements of the equipment. Refer to the generator set specification sheet or the dimension drawing for detailed information on your system. In addition to the actual fuel consumption, consider the following pressure loss factors:

- Pipe length
- Other appliances on the same fuel supply
- Number of fittings

Flexible connections. Rigid-mount the piping but protect it from vibration. Use flexible connections spanning a minimum of 152 mm (6 in.) between the stationary piping and the engine fuel inlet connection.

6.3.2 Gas Regulators

Gas regulators reduce high incoming fuel pressures to lower levels acceptable for engines. Refer to the generator set spec sheet for fuel supply pressures. Install a solenoid valve upstream from the gas regulator and the flexible fuel connector to prevent the accumulation of an explosive mixture of gas and air caused by leaks in the flexible connection or the gas regulator. The generator set installer normally wires the engine battery-powered solenoid valve to the engine starting controls to open the valve when the engine cranks or runs.

For UL compliance, the fuel solenoid valves are needed per UL 2200, Section 35.3.2.2.1.

The typical gas system uses two gas regulators:

- **Primary gas regulator.** Provides initial control of gas from the fuel supply. The primary gas regulator reduces the high pressure from a tank or transmission line to the low pressure required by the secondary gas regulator(s). Typically, the primary gas regulator is set at the higher pressure value when a range is given. The gas supplier typically provides the primary gas regulator, as conditions that dictate the type of gas regulator used vary depending on the method of supplying fuel. The supplier is also responsible for providing sufficient gas pressure to operate the primary gas regulator. Primary gas regulator must be vented to the outside if installed within any building.
- **Secondary gas regulator.** This low-pressure gas regulator is mounted on the engine and limits the maximum inlet pressure to engine. The engine operates satisfactorily at the lower pressure value when a range is given, but these lower pressures may result in poor response to load changes or a lack of power if the primary gas regulator is not near the engine.

Modification for fuel type. Many gas regulators are compatible with both natural gas and LP gas. Typically, the user installs the spring and retainer in the gas regulator when connecting to natural gas and removes it from the gas regulator when connecting to LP vapor gas. Refer to the appropriate generator set's operation manual and/or the decal attached to the generator set for information regarding spring/adjustment screw usage for specific models. Some models may require new diaphragm kits and/or inverting the gas regulator when changing fuel type.

Installation position for fuel type. The gas regulator functions normally pointing downward for both natural gas and LP gas. If only natural gas fuel is used, the gas regulator may be installed pointing upward.

Pressure testing. Some gas regulators provide for installation of a pressure gauge to test inlet and outlet pressures. If no such provision is available, install pipe tees in the fuel line to test pressure and use pipe plugs to plug unused openings.

6.4 LP Fuel Systems

Fuel characteristics. LP fuel exists as a vapor and a liquid in pressurized tanks. Since LP fuel does not deteriorate in storage, a large supply of fuel can be kept onsite indefinitely for operation during emergency conditions. This makes LP gas ideal for applications with uninterrupted (onsite) fuel supply requirements.

Fuel mixture. LP gas is propane, butane, or a mixture of the two gases. The ratio of butane to propane is especially important when the fuel flows from a large outdoor tank. A fuel supplier may fill the tank in the warm summer months with a mixture composed mainly of butane; however, this mixture may not provide sufficient vaporized pressure at cold temperatures to start and operate the engine. A local fuel supplier is likely to be the best source of information on what size tank is necessary to provide adequate fuel vapor.

The fuel mixture and vaporization pressure at the anticipated temperatures influence the selection of gas regulator equipment. Pure butane gas has little or no vaporization pressure in temperatures below 4°C (40°F). Even at 21°C (70°F), the pressure is approximately 124 kPa (18 psi). Some primary gas regulators do not operate at tank pressures below 207 kPa (30 psi) while others operate at incoming pressures as low as 20.7–34.5 kPa (3–5 psi).

Fuel consumption and tank size. Since LP fuel is supplied in pressurized tanks in liquid form, it must be converted to a vapor state before being introduced into the carburetor. The amount of vapor contained in 3.8 L (1.0 gal.) of liquid (LP) fuel is:

Butane Gas	0.88 m ³ (31.26 cu. ft.)
Propane Gas	1.03 m ³ (36.39 cu. ft.)

See the generator set specification sheets for fuel consumption at different loads, and contact your fuel supplier for information regarding tank sizes.

System types. Single-source gas fuel systems include LP gas vapor-withdrawal and LP gas liquid-withdrawal.

6.4.1 LP Gas Vapor-Withdrawal Systems

A vapor-withdrawal system draws on the fuel vapor that collects in the space above the liquid fuel. Consider the following during installation:

- Generally, allow 10%-20% of tank capacity for fuel expansion from a liquid to a vapor state. The liquid level in LP gas tanks must never exceed 90% of the tank capacity.
- Maintain air temperature surrounding the tank high enough to vaporize the liquid fuel.

Applications in colder climates may require an independent heat source to increase natural vaporization within the tank. Withdraw liquid fuel and vaporize it in an electrically heated, engine water jacket-heated, or LP gas-heated vaporizer. Figure 6-5 shows the components of the vapor-withdrawal system used in a typical stationary application. The LP gas regulator is typically installed in the inverted position (pointing downward).

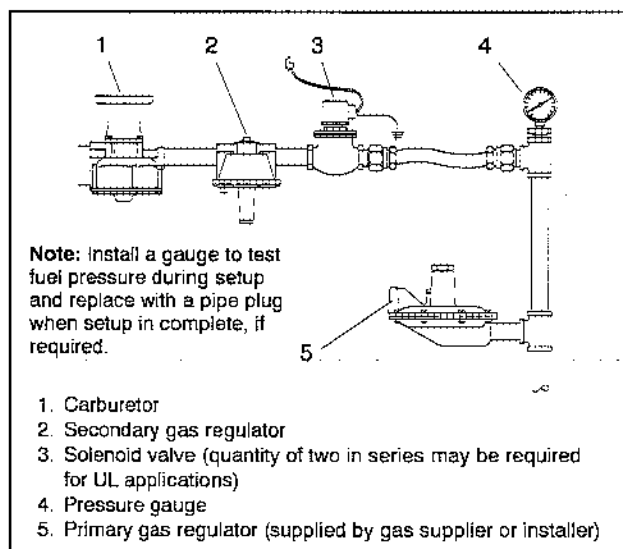


Figure 6-5 Typical LP Gas Vapor-Withdrawal System

6.4.2 LP Gas Liquid-Withdrawal Systems

LP liquid-withdrawal fuel systems are available for generator sets but are not recommended for automatic standby service. With liquid-withdrawal systems, liquid LP at 1034–1379 kPa (150–200 psi) flows to the engine. A combination of converters (vaporizers) and gas regulators then reduces the pressure to a usable level.

In Figure 6-6, a converter (a combination of a vaporizer and primary and secondary gas regulators) changes the liquid to vapor using heat from the engine's cooling system. For a period following startup, a liquid-withdrawal system may be unable to vaporize enough fuel for an engine running under load until the engine reaches operating temperature. The engine needs time to warm sufficiently to provide adequate heat to vaporize the fuel.

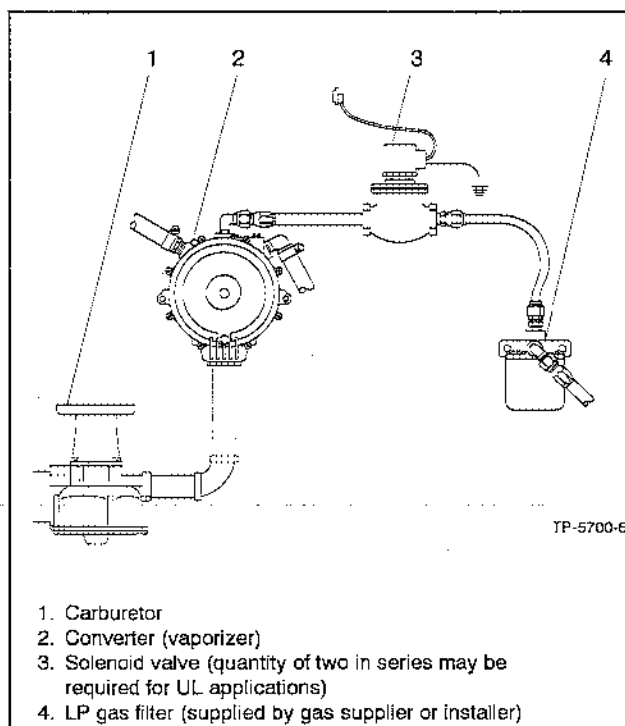


Figure 6-6 LP Gas Liquid Withdrawal System

Some codes prohibit gas fuel pressurization greater than 34.5 kPa (5 psi) inside buildings. This might preclude the use of a liquid-withdrawal system. To ensure code compliance, converters are sometimes located outside the building housing the generator set. However, the great length of pipe between the converter and the carburetor does not allow sufficient heat buildup and heat retention to maintain the fuel in its vapor state, which can cause startup problems.

6.5 Natural Gas Systems

The utility supplies natural gas in a vapor state. A natural gas fuel system consists of the same basic components and operates with the same general sequence as LP gas vapor-withdrawal systems. See Figure 6-7 and Figure 6-8. Note that when the heat content of the fuel falls below 1000 Btu, as it does with sewage-derived and some other natural gas fuels, the generator set will not produce its rated power. The natural gas regulator is typically installed in the upright position (pointing upward).

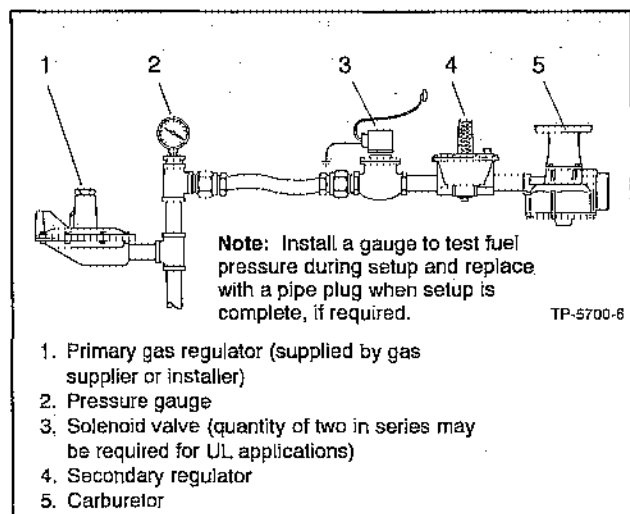


Figure 6-7 Natural Gas Fuel System with Pressure Gauge

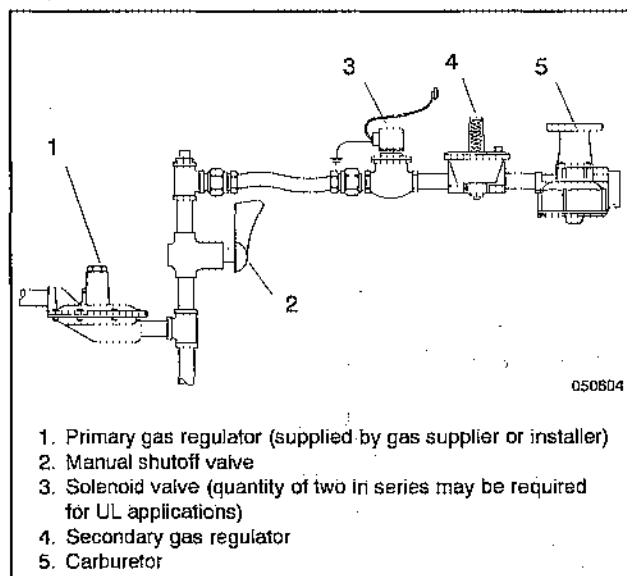


Figure 6-8 Natural Gas Fuel System without Pressure Gauge and with Manual Shutoff Valve

6.6 Combination Systems

Combination fuel source systems include:

- Natural gas and LP gas
- LP gas or natural gas and gasoline

6.6.1 Combination Natural Gas and LP Gas

Some applications use natural gas as the main fuel and LP gas as the emergency fuel when natural gas is not available.

The natural gas and *LP gas, liquid withdrawal* system uses a converter (vaporizer) to change the LP liquid to gas vapor. A pressure switch on the primary fuel source closes when fuel pressure drops, which energizes a relay that closes the primary fuel solenoid and opens the secondary or emergency fuel solenoid.

A separate LP gas load adjustment valve ensures the right fuel-to-air mixture in the carburetor. The load adjustment valve is located inline between the converter (vaporizer) and the carburetor. See Figure 6-9.

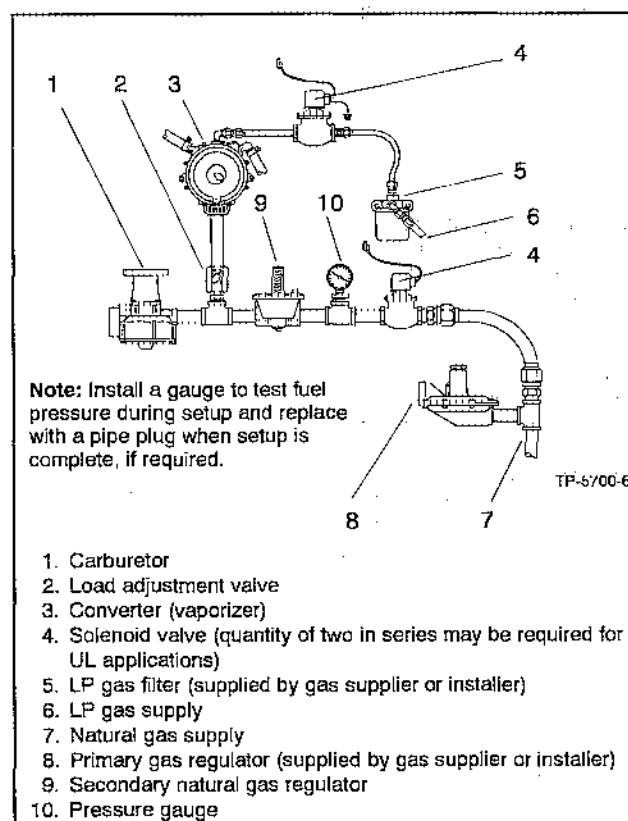


Figure 6-9 Natural Gas and LP Gas System, Liquid Withdrawal

The natural gas and *LP gas, vapor withdrawal* system contains a separate secondary gas regulator and solenoid valve for each fuel. The LP gas regulator typically mounts in the inverted position. A pressure switch on the primary fuel source closes when fuel pressure drops, which energizes a relay that closes the primary fuel solenoid and opens the secondary or emergency fuel solenoid. A separate LP gas load adjustment valve ensures the right fuel-to-air mixture in the carburetor.

The load adjustment valve is located inline between the secondary gas regulator and the carburetor. See Figure 6-10.

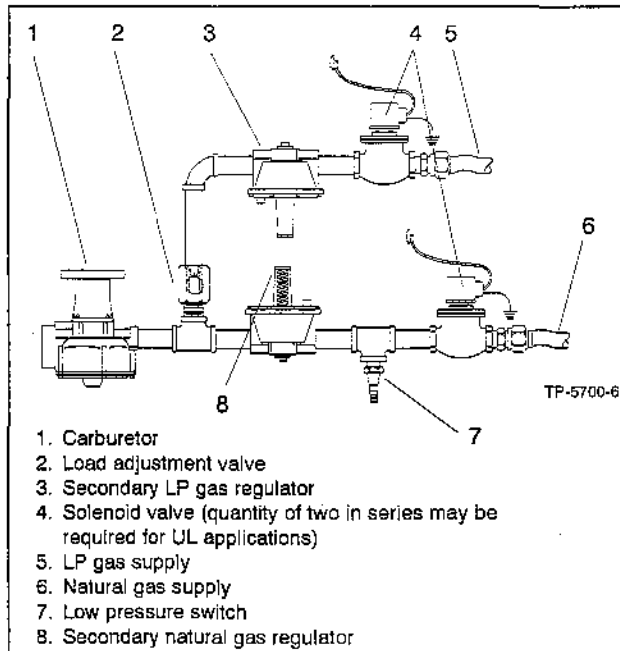


Figure 6-10 Natural Gas and LP Gas System, Vapor Withdrawal

6.6.2 Combination LP Gas or Natural Gas and Gasoline

Combination LP gas or natural gas and gasoline systems normally use a gas fuel as the primary fuel and use gasoline for emergency operation. Combination natural gas and gasoline fuel systems are sometimes used with gasoline as a standby fuel to meet code requirements for an onsite fuel supply. Since gasoline deteriorates after six months of storage, do not use a combination system unless it is operated on gasoline often enough to ensure that the fuel does not deteriorate and that the carburetor is not subsequently clogged by accumulated gum deposits.

These systems use either a combination gas-gasoline carburetor or a gasoline carburetor with a gas adapter. With the exception of the carburetor, the combination gas-gasoline systems use the same basic components as those in the natural and LP gas systems. See Figure 6-11.

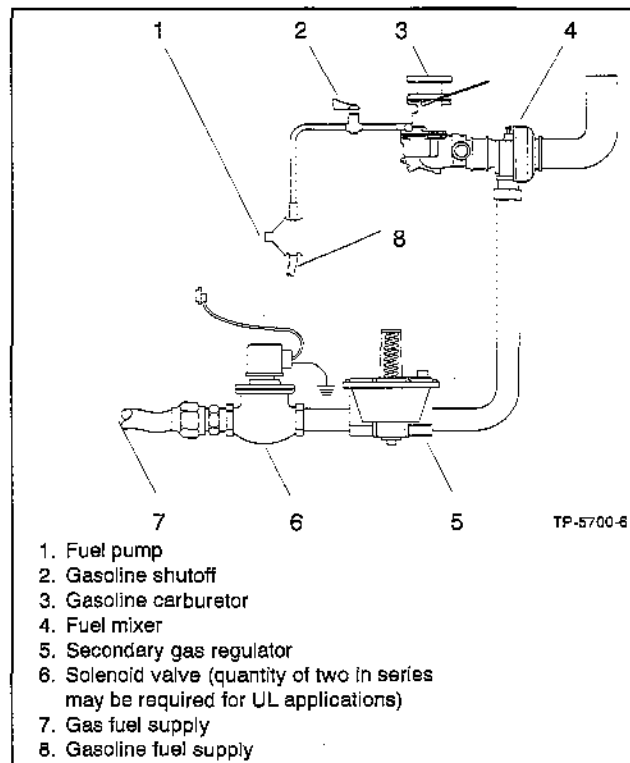


Figure 6-11 Combination Gas/Gasoline Fuel System

Change fuel supplies manually at the generator set. Most engines, especially the smaller models, operate successfully on gas or gasoline without extensive modification or complicated mechanical changeover. With a combination gas-gasoline fuel system, changeover involves a few simple steps as outlined in the generator set's operation manual.

When installing this combination system, follow the installation considerations outlined for LP gas, natural gas, and gasoline systems.

6.7 Pipe Size Requirements for Gas Fuel Systems

The type of fuel, the distance it must travel from gas meter/tank to fuel shutoff solenoid, and the amount consumed by the engine must be considered when determining fuel line pipe size.

To find the correction necessary for the different specific gravity of the particular fuel used, refer to Figure 6-12.

Fuel	Specific Gravity	Correction Factor
Sewage Gas	0.55	1.040
Natural Gas	0.65	0.962
Air	1.00	0.775
Propane (LP)	1.50	0.633
Butane	2.10	0.535

Figure 6-12 Fuel Correction Factors

Figure 6-13 is based on gas pressures of 3.4 kPa (0.5 psi, 13.8 in. water column) or less and a pressure drop of 0.12 kPa (0.018 psi, 0.5 in. water column) with a 0.60 specific gravity and with a normal amount of restriction from fittings. To calculate the correct pipe size for a specific installation, refer to the chart and follow the procedure outlined below.

Nominal Iron Pipe Size (IPS), in.	Internal IPS Diameter, mm (in.)	Length of Pipe, m (ft.)													
		3.0 (10)		6.1 (20)		9.1 (30)		12.2 (40)		15.2 (50)		18.3 (60)		21.3 (70)	
		Fuel Consumption Value, m ³ /hr. (ft ³ /hr.)													
1/4	9.25 (0.384)	1.2 (43)	0.82 (29)	0.68 (24)	0.57 (20)	0.51 (18)	0.45 (16)	0.42 (15)							
3/8	12.52 (0.493)	2.7 (95)	1.8 (65)	1.5 (52)	1.3 (45)	1.1 (40)	1.0 (36)	0.93 (33)							
1/2	15.80 (0.622)	5.0 (175)	3.4 (120)	2.7 (97)	2.3 (82)	2.1 (73)	1.9 (66)	1.7 (61)							
3/4	20.93 (0.824)	10.2 (360)	7.1 (250)	5.7 (200)	4.8 (170)	4.3 (151)	3.9 (138)	3.5 (125)							
1	26.64 (1.049)	19.3 (680)	13.2 (465)	10.6 (375)	9.1 (320)	8.1 (285)	7.4 (260)	6.8 (240)							
1 1/4	35.05 (1.380)	39.6 (1400)	26.9 (950)	21.8 (770)	18.7 (660)	16.4 (580)	13.9 (490)	13.0 (460)							
1 1/2	40.89 (1.610)	59.5 (2100)	41.3 (1460)	33.4 (1180)	28.0 (990)	25.5 (900)	22.9 (810)	21.2 (750)							
2	52.50 (2.067)	111.9 (3950)	77.9 (2750)	62.3 (2200)	53.8 (1900)	47.6 (1680)	43.0 (1520)	39.6 (1400)							
2 1/2	62.71 (2.469)	178.4 (6300)	123.2 (4350)	99.7 (3520)	85.0 (3000)	75.0 (2650)	68.0 (2400)	63.7 (2250)							
3	77.93 (3.068)	311.5 (11000)	218.0 (7700)	177.0 (6250)	150.0 (5300)	134.6 (4750)	121.8 (4300)	110.4 (3900)							
4	102.26 (4.026)	651.2 (23000)	447.4 (15800)	362.5 (12800)	308.7 (10900)	274.7 (9700)	249.1 (8600)	229.4 (8100)							

Nominal Iron Pipe Size (IPS), in.	Internal IPS Diameter, mm (in.)	Length of Pipe, m (ft.)													
		24.4 (80)		27.4 (90)		30.5 (100)		38.1 (125)		45.7 (150)		53.3 (175)		61.0 (200)	
		Fuel Consumption Value, m ³ /hr. (ft ³ /hr.)													
1/4	9.25 (0.364)	0.39 (14)	0.37 (13)	0.34 (12)	0.31 (11)	0.28 (10)	0.25 (9)	0.23 (8)							
3/8	12.52 (0.493)	0.88 (31)	0.82 (29)	0.76 (27)	0.68 (24)	0.62 (22)	0.57 (20)	0.54 (19)							
1/2	15.80 (0.622)	1.6 (57)	1.5 (53)	1.4 (50)	1.2 (44)	1.1 (40)	1.0 (37)	0.99 (35)							
3/4	20.93 (0.824)	3.3 (118)	3.1 (110)	2.9 (103)	2.6 (93)	2.4 (84)	2.2 (77)	2.0 (72)							
1	26.64 (1.049)	6.2 (220)	5.8 (205)	5.5 (195)	5.0 (175)	4.5 (160)	4.1 (145)	3.8 (135)							
1 1/4	35.05 (1.380)	13.0 (460)	12.2 (430)	11.3 (400)	10.2 (360)	9.2 (325)	8.5 (300)	7.9 (280)							
1 1/2	40.89 (1.610)	19.5 (690)	18.4 (650)	17.6 (620)	15.6 (550)	14.2 (500)	13.0 (460)	12.2 (430)							
2	52.50 (2.067)	36.8 (1300)	34.5 (1220)	32.6 (1150)	28.9 (1020)	26.9 (950)	24.1 (850)	22.7 (800)							
2 1/2	62.71 (2.469)	58.1 (2050)	55.2 (1950)	52.4 (1850)	46.7 (1650)	42.5 (1500)	38.8 (1370)	36.2 (1280)							
3	77.93 (3.068)	104.8 (3700)	97.7 (3450)	92.0 (3250)	83.5 (2950)	75.0 (2650)	69.4 (2450)	64.6 (2280)							
4	102.26 (4.026)	212.4 (7500)	203.9 (7200)	189.7 (6700)	169.9 (6000)	155.7 (5500)	141.6 (5000)	130.3 (4600)							

Note: When the fuel has a specific gravity of 0.7 or less no correction factor is necessary — use this table without a correction factor.

Figure 6-13 Maximum Flow Capacity of Pipe in Cubic Meters (Cubic Feet) of Gas per Hour

1. Refer to the fuel consumption on the generator set specification sheet. Note type of fuel used, generator set application rating, and the m^3/hr . (ft^3/hr .) consumption at 100% load.

Example:

80 kW, propane gas, 60 Hz standby rating = $12.0 \text{ m}^3/\text{hr}$. ($425 \text{ ft}^3/\text{hr}$.)

2. Refer to the Fuel Correction Factors in Figure 6-12. Locate the correction factor for specific gravity of the selected fuel.

When the fuel has a specific gravity of 0.7 or less no correction factor is necessary—use Figure 6-13 without a correction factor.

Example:

propane gas specific gravity = 1.50
fuel correction factor = 0.633.

3. Divide the consumption value from step 1 by the correction factor from step 2.

Example:

$12.0 \text{ m}^3/\text{hr}$. ($425 \text{ ft}^3/\text{hr}$.) divided by 0.633 = $19.0 \text{ m}^3/\text{hr}$. ($671 \text{ ft}^3/\text{hr}$.)

4. Determine the length of pipe between the gas meter/tank and the fuel shutoff solenoid at the generator set.

Example:

34.7 m (114 ft.).

5. Find the value closest to pipe length in the Length of Pipe column in Figure 6-13.

Example:

38.1 m (125 ft.).

Example:

At $28.9 \text{ m}^3/\text{hr}$. ($1020 \text{ ft}^3/\text{hr}$.) the pipe size = 2 in. IPS.

6. Move vertically down the table in Figure 6-13 from the determined value in Length of Pipe column.

Example:

38.1 m (125 ft.)

Stop at the value that is equal to or greater than corrected consumption value from step 3.

Example:

$28.9 \text{ m}^3/\text{hr}$. ($1020 \text{ ft}^3/\text{hr}$.)

7. Move to the left column from the value in step 6 to determine the correct pipe size.

Notes

Section 7 Electrical System

Before installing the generator set, provide for electrical connections through conduit to the transfer switch and other accessories for the generator set. Carefully install the selected generator set accessories. Route wiring to the generator set through flexible connections. Comply with all applicable codes when installing a wiring system.

AC circuit protection. All AC circuits must include circuit breaker or fuse protection. Select a circuit breaker for up to 125% of the rated generator set output current. The circuit breaker must open all ungrounded conductors. The circuit breaker or fuse must be mounted within 7.6 m (25 ft.) of the alternator output terminals.

⚠ WARNING

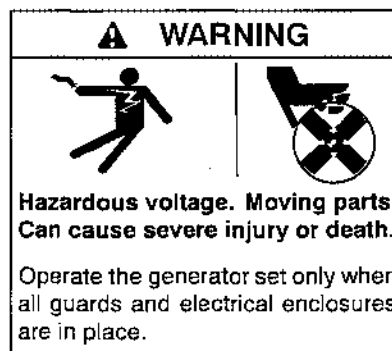


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Turn the generator set master switch and switchgear engine control switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by an automatic transfer switch or a remote start/stop switch.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.



Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

7.1 Generator Set Voltage Reconnection

To change the voltage of 10- or 12-lead generator sets, use the procedure shown in the operation manual containing the respective controller setup. Adjust the governor and voltage regulator for frequency changes. Consult the generator set service manual for frequency adjustment information.

Voltage reconnection. Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/dealer.

Equipment damage. Verify that the voltage ratings of the transfer switch, line circuit breakers, and other accessories match the selected line voltage.

Reconnect the generator set stator leads to change the output phase or voltage. Reference the connection schematics shown in Figure 7-1, Figure 7-2, Figure 7-3, and Figure 7-4.

Follow the safety precautions at the front of this manual and in the text and observe National Electrical Code (NEC) guidelines.

Figure 7-1 20-150 kW Permanent Magnet and Wound Field Single-Phase Alternators, ADV-5875A-M

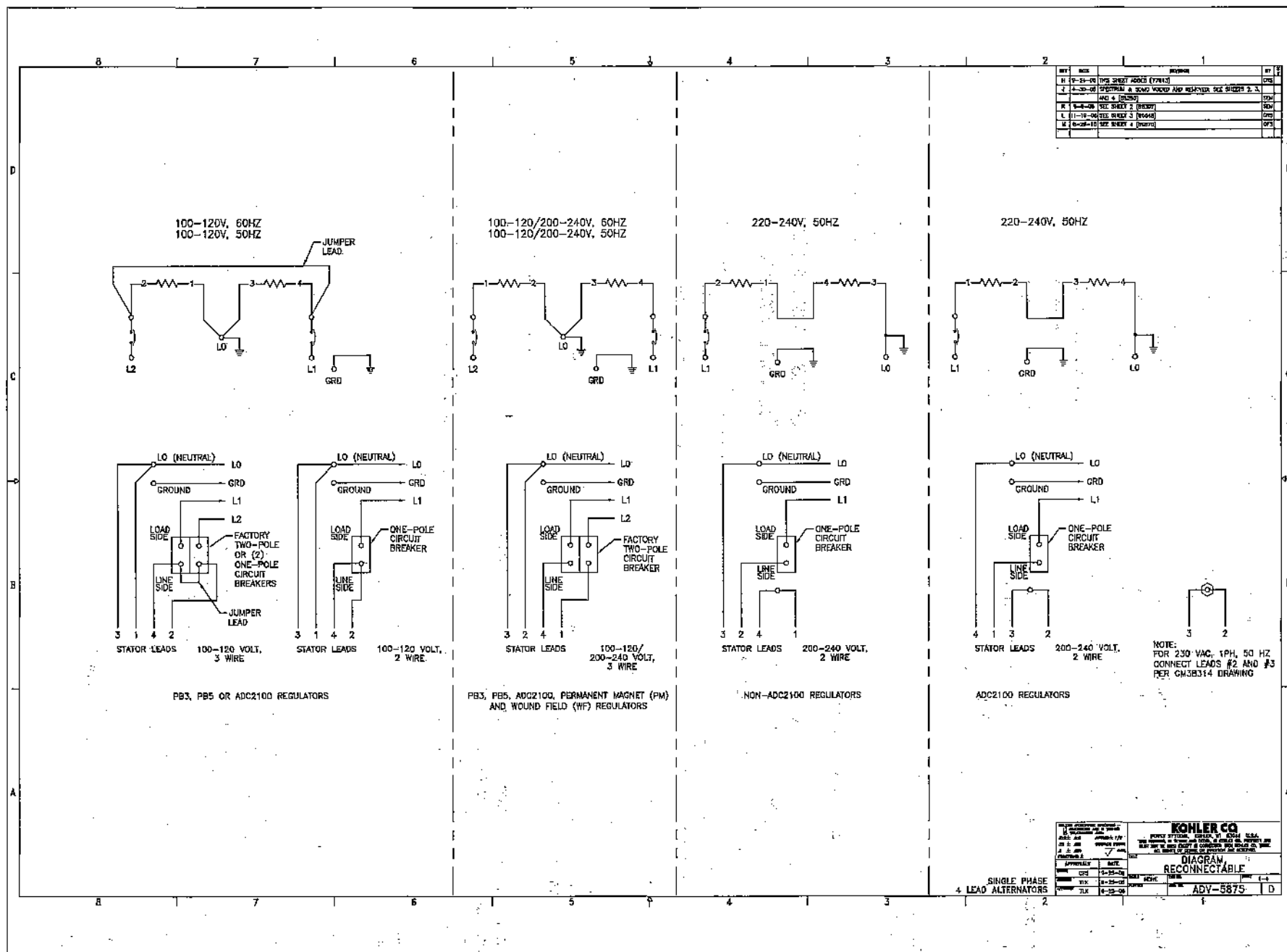


Figure 7-2 20-300 kW Permanent Magnet and 20-60 kW Wound Field Alternators, ADV-5875B-1M

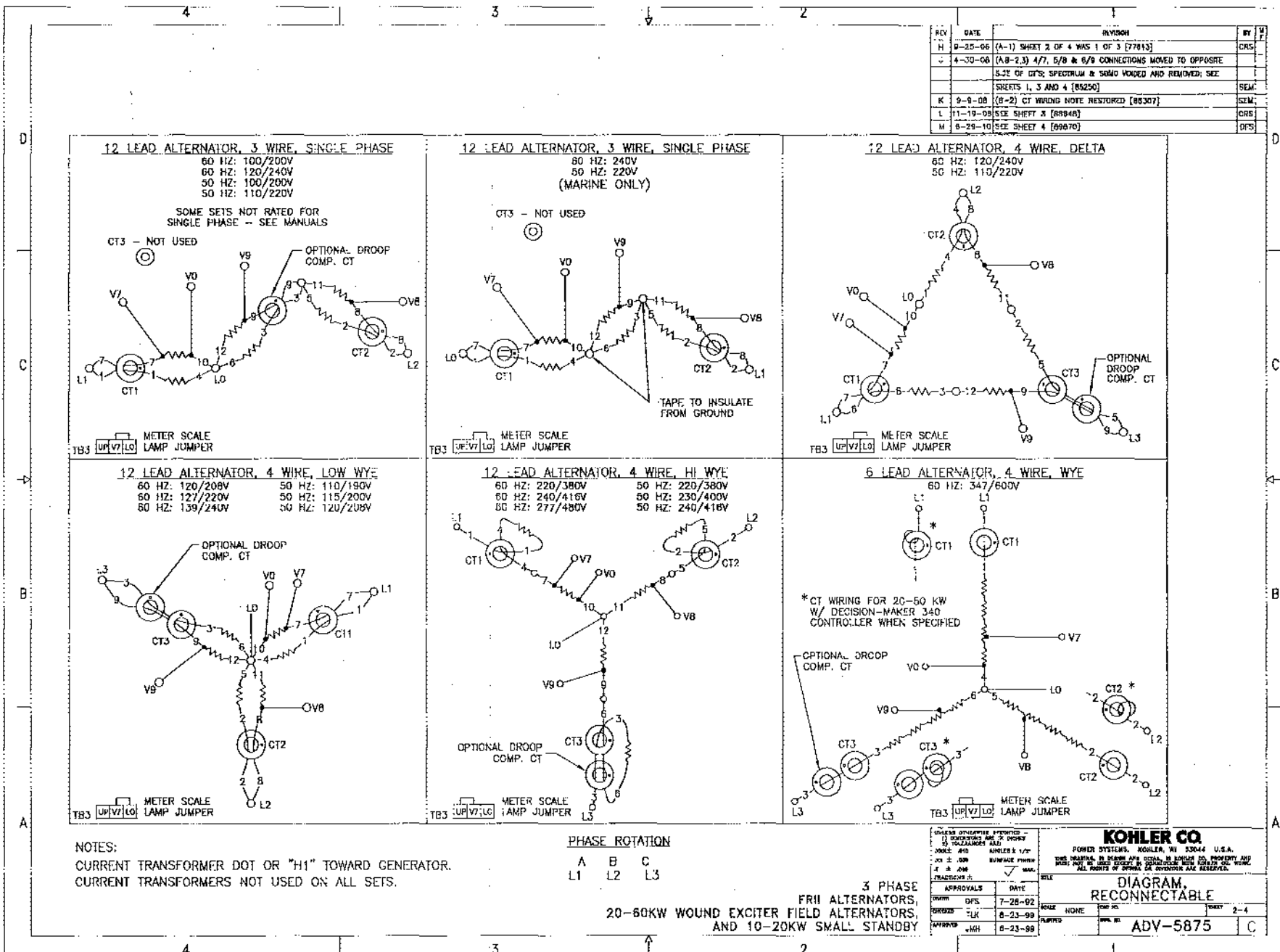


Figure 7-3 60 (with Oversize Alternator)-300 kW Wound Field Alternators, ADV-5875C-M

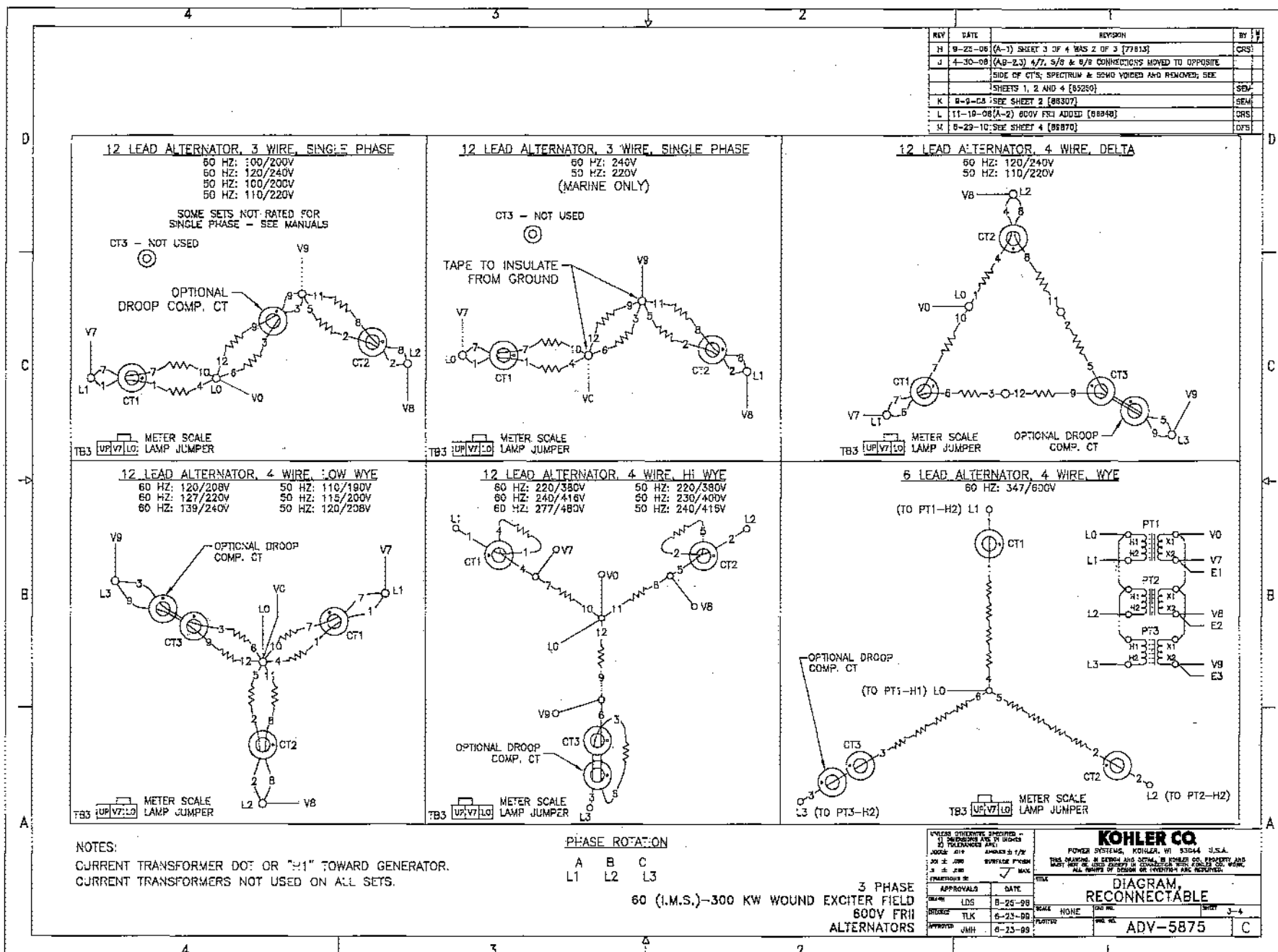
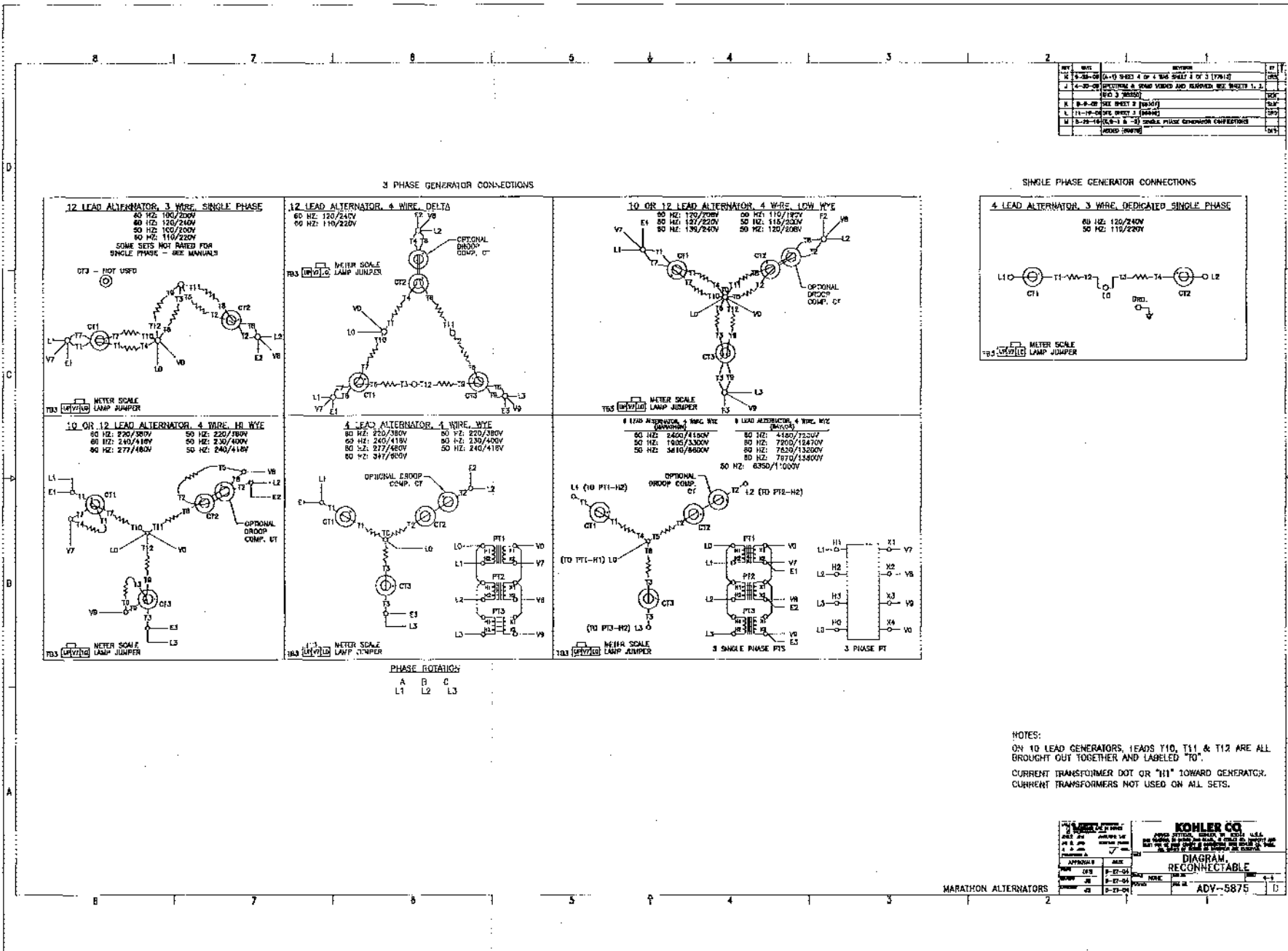


Figure 7-4 350-3250 kW Pilot-Excited, Permanent Magnet Alternator, ADV-5875D-M



7.2 Electrical Connections

Several electrical connections must be made between the generator set and other components of the system for proper operation. Because of the large number of accessories and possible combinations, this manual does not address specific applications. Refer to the submittal catalog accessory drawings and wiring diagrams for connection and location. Most field-installed accessory kits include installation instructions.

For customer-supplied wiring, select the wire temperature rating in Figure 7-5 based upon the following criteria:

- Select row 1, 2, 3, or 4 if the circuit rating is 110 amperes or less or requires #1 AWG (42.4 mm²) or smaller conductors.
- Select row 3 or 4 if the circuit rating is greater than 110 amperes or requires #1 AWG (42.4 mm²) or larger conductors.

Comply with applicable national and local codes when installing a wiring system.

Row	Temp. Rating	Copper (Cu) Only	Cu/Aluminum (Al) Combinations	Al Only
1	60°C (140°F) or 75°C (167°F)	Use No. * AWG, 60°C wire or use No. * AWG, 75°C wire	Use 60°C wire, either No. * AWG Cu, or No. * AWG Al or use 75°C wire, either No. * AWG Cu or No. * AWG Al	Use 60°C wire, No. * AWG or use 75°C wire, No. * AWG
2	60°C (140°F)	Use No. * AWG, 60°C wire	Use 60°C wire, either No. * AWG Cu or No. * AWG Al	Use 60°C wire, No. * AWG
3	75°C (167°F)	Use No. *† AWG, 75°C wire	Use 75°C wire, either No. *† AWG Cu or No. *† AWG Al	Use 75°C wire, No. *† AWG
4	90°C (194°F)	Use No. *† AWG, 90°C wire	Use 90°C wire, either No. *† AWG Cu or No. *† AWG Al	Use 90°C wire, No. *† AWG

* The wire size for 60°C (140°F) wire is not required to be included in the marking. If included, the wire size is based on ampacities for the wire given in Table 310-16 of the National Electrical Code®, in ANSI/NFPA 70, and on 115% of the maximum current that the circuit carries under rated conditions. The National Electrical Code® is a registered trademark of the National Fire Protection Association, Inc.

† Use the larger of the following conductors: the same size conductor as that used for the temperature test or one selected using the guidelines in the preceding footnote.

Figure 7-5 Terminal Markings for Various Temperature Ratings and Conductors

7.3 Load Lead Connections

Feed load leads to the generator junction box from one of several different areas. Generator sets rated 300 kW and below commonly use the bottom entry where conduit is stubbed up into the junction box from the concrete slab. Other methods include flexible conduit roughed into the sides or top of the junction box. When using flexible conduit, do not block the front or rear of the controller. See Figure 7-6.

Use a minimum of 13 mm (0.5 in.) spacing between the conduit bushing and any uninsulated live parts in the junction box. All conduit openings in the junction box must be made such that no metal particles including drill chips contaminate the components in the junction box.

Generator sets larger than 300 kW have the junction box mounted on the rear of the generator set. Larger sets may have oversized junction boxes supplied as an option or to accommodate bus bar connections. Refer to the generator set dimension drawing and/or the electrical contractor prints for detailed information including stub-up area recommendations.

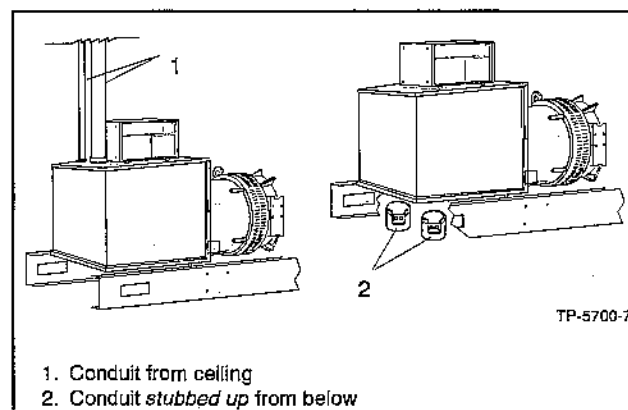


Figure 7-6 Typical Load Lead Connection

The four bus bars contained in the optional bus bar kits simplify the connection process by offering a neutral bus bar in addition to the three load bars. Optional bus lugs offer an array of terminal and wire connections.

7.4 Grounding and Grounded Conductor (Neutral) Connections

Connect the electrical system grounding conductor to the equipment grounding connector on the alternator. See Figure 7-7. Depending upon code requirements, the grounded conductor (neutral) connection is typically grounded.

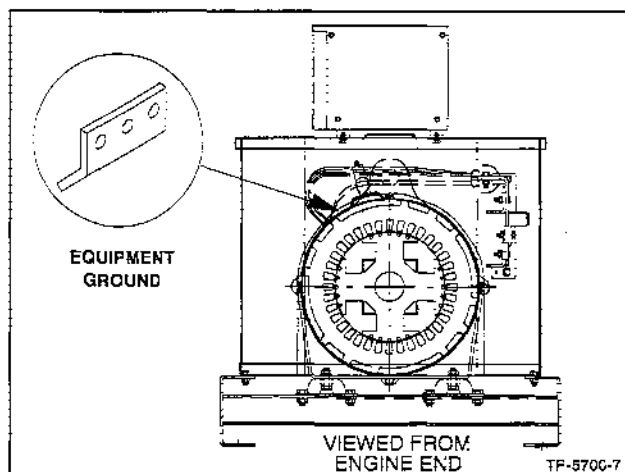


Figure 7-7 Generator Set Equipment Grounding Connection

Ungrounded neutral connections use an insulated standoff (not supplied) to isolate the neutral connection from the grounding connection. For grounding lug selection, see Figure 7-8.

The four bus bars contained in the optional bus bar kits simplify the connection process by offering a neutral bus bar in addition to the three load bars. Optional bus lugs offer an array of terminal and wire connections.

Generator sets are typically shipped from the factory with the neutral attached to the alternator in the junction box for safety reasons per NFPA 70. At installation, the neutral can remain grounded at the alternator or be lifted from the grounding stud and isolated if the installation requires an ungrounded neutral connection at the generator set. The generator set will operate properly in either configuration.

Various regulations and site configurations including the National Electrical Code® (NEC), local codes, and the type of transfer switch used in the application determine the grounding of the neutral at the generator set.

Allowable Ampacity, Amps	Min. Size of Equipment Copper Grounding Conductor, AWG or kcmil	Recommended Compression Lug, ILLSCO Part No. or Equivalent (UL Listed)
20	12	SLUH-90
60	10	SLUH-90
90	8	SLUH-90/125
100	8	SLUH-90/125
150	6	SLUH-90/125/225
200	6	SLUH-90/125/225
300	4	SLUH-90/125/225
400	3	SLUH-90/125/225
500	1	SLUH-125/225
600	1	SLUH-125/225
800	1/0	SLUH-225/300/400
1000	2/0	SLUH-225/300/400
1200	3/0	SLUH-225/300/400
1600	4/0	SLUH-225/300/400/650
2000	250	SLUH-225/300/400/650
2500	350	SLUH-300/400/650
3000	400	SLUH-400/650
4000	500	SLUH-400/650
5000	700	SLUH-650
6000	800	SLUH-650

Figure 7-8 Grounding Lug Selection

7.5 Terminal Connector Torque

Use torque values shown in Figure 7-9 or Figure 7-10 for terminal connectors. Refer to UL 486A-486B and UL 486E for information on terminal connectors for aluminum and/or copper conductors. See Section 7.2, Electrical Connections, for information on temperature rating of the customer-supplied wire. Comply with applicable national and local codes when installing a wiring system.

If a connector has a clamp screw such as a slotted, hexagonal head screw with more than one means of tightening, test the connector using both applicable torque values provided in Figure 7-10.

Socket Size Across Flats, mm (in.)	Tightening Torque, Nm (in. lb.)
3.2 (1/8)	5.1 (45)
4.0 (5/32)	11.4 (100)
4.8 (3/16)	13.8 (120)
5.6 (7/32)	17.0 (150)
6.4 (1/4)	22.6 (200)
7.9 (5/16)	31.1 (275)
9.5 (3/8)	42.4 (375)
12.7 (1/2)	56.5 (500)
14.3 (9/16)	67.8 (600)
Note: For values of slot width or length not corresponding to those specified, select the largest torque value associated with the conductor size. Slot width is the nominal design value. Slot length is to be measured at the bottom of the slot.	

Figure 7-9 Tightening Torque for Pressure Wire Connectors with Internal-Drive Socket-Head Screws

Wire Size for Unit Connection	Tightening Torque, Nm (in. lb.)			
	Slot Head 4.7 mm (No. 10) or Larger*		Hexagonal Head—External Drive Socket Wrench	
	Slot Width <1.2 mm (0.047 in.) Slot Length <6.4 mm (0.25 in.)	Slot Width >1.2 mm (0.047 in.) Slot Length >6.4 mm (0.25 in.)	Split-Bolt Connectors	Other Connections
18-10 (0.82-5.3)	2.3 (20)	4.0 (35)	9.0 (80)	8.5 (75)
8 (8.4)	2.8 (25)	4.5 (40)	9.0 (80)	8.5 (75)
6-4 (13.3-21.2)	4.0 (35)	5.1 (45)	18.6 (165)	12.4 (110)
3 (26.7)	4.0 (35)	5.6 (50)	31.1 (275)	16.9 (150)
2 (33.6)	4.5 (40)	5.6 (50)	31.1 (275)	16.9 (150)
1 (42.4)	—	5.6 (50)	31.1 (275)	16.9 (150)
1/0-2/0 (53.5-67.4)	—	5.6 (50)	43.5 (385)	20.3 (180)
3/0-4/0 (85.0-107.2)	—	5.6 (50)	56.5 (500)	28.2 (250)
250-350 (127-177)	—	5.6 (50)	73.4 (650)	36.7 (325)
400 (203)	—	5.6 (50)	93.2 (825)	36.7 (325)
500 (253)	—	5.6 (50)	93.2 (825)	42.4 (375)
600-750 (304-380)	—	5.6 (50)	113.0 (1000)	42.4 (375)
800-1000 (406-508)	—	5.6 (50)	124.3 (1100)	56.5 (500)
1250-2000 (635-1016)	—	—	124.3 (1100)	67.8 (600)
* For values of slot width or length not corresponding to those specified, select the largest torque value associated with the conductor size. Slot width is the nominal design value. Slot length is to be measured at the bottom of the slot.				
Note: If a connector has a clamp screw such as a slotted, hexagonal head screw with more than one means of tightening, test the connector using both applicable torque values.				

Figure 7-10 Tightening Torque for Screw-Type Pressure Wire Connectors

7.6 Batteries

Battery location. When determining the battery placement, ensure that the location:

- Is clean, dry, and not exposed to extreme temperatures
- Provides easy access to battery caps for checking the electrolyte level (when using maintenance type batteries)
- Is close to the generator set to keep cables short, ensuring maximum output

Refer to the submittal drawings for the generator set when choosing a battery rack. Figure 7-11 shows a typical battery system.

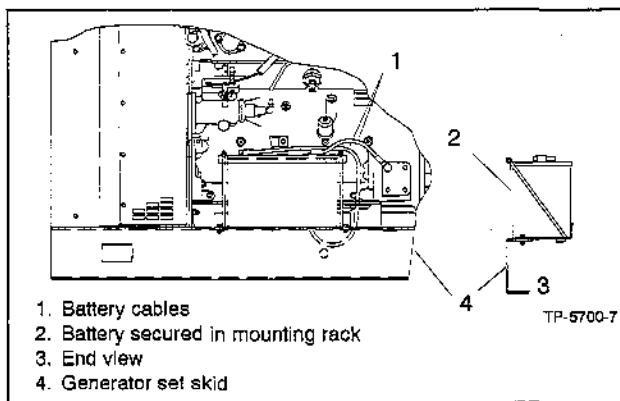


Figure 7-11 Typical Battery System, Side View

Battery type. Starting batteries are usually the lead-acid type and are sized according to the engine manufacturer's recommendation for a particular ambient temperature and required cranking time. NFPA 110 recommends cranking periods, including a single 45-second cycle for generator sets below 15 kW and three 15-second crank cycles separated by 15-second rests for larger models. Refer to the respective generator set specification sheet for the required battery cold-cranking ampere (CCA) rating.

Nickel-cadmium batteries are sometimes used for standby generator sets because of their long life (20 years). However, initial high cost, larger space requirements, and special charging requirements can offset this benefit. Therefore, conventional lead-acid batteries have proven satisfactory for the majority of generator set applications.

Battery cables. A UL 2200 listed generator set requires battery cables with positive (+) lead boots. Factory-supplied and optional battery cables include positive (+) lead boots. When battery cables are not factory-supplied, source battery cables with positive (+) lead boots for UL 2200 compliance.

Note: Some units are equipped with an insulating and reflective heat shield sleeve on the battery cables and other wires that are fastened to the starter solenoid. This sleeve is a conductive material and must be secured approximately 25 mm (1 in.) away from the exposed cable terminal.

7.7 Battery Chargers

Engine-driven, battery-charging alternators charge the batteries whenever the generator set operates. Engine-driven systems are normally capable of charge rates of 30 amps or more and can quickly restore the charge used in a normal cranking cycle.

When the engine is not operating, a very low charge rate from an AC-powered battery charger is usually sufficient to maintain a full charge on the batteries. Some small industrial generator sets have no battery-charging alternators and, therefore, require a separate AC-powered battery charger.

Select an automatic or manual battery charger with a high charge rate of 2 amps and a trickle charge rate up to 300 milliamps. The low maximum charge rate makes the charger ill-suited to restore fully discharged batteries. For full recovery capability independent of the engine-driven charging system, use an automatic float battery charger with a high charge rate of at least 10 amps.

Use separate, self-contained battery chargers or units built into the automatic transfer switch. Run leads from a transfer switch-mounted battery charger in conduit separate from the conduit that holds the generator load cables or remote engine-start circuits.

Note: Digital controllers with microprocessor circuitry and vacuum fluorescent displays typically draw more than 300 milliamps, making trickle charge battery chargers inappropriate for systems with these controllers. Select only automatic float/equalize battery chargers with a 3 amp or greater rating for units with digital controllers.

Battery failure is the most common reason for emergency generator set start failure. Two common battery failure causes are a manual charge rate set too low to maintain the battery and a manual charge rate set too high, resulting in loss of battery electrolyte. To avoid battery failure, use an automatic float charger, which varies the charge rate in response to battery condition.

For large engines with two starters, use either one bank of batteries and chargers for both starters or use separate battery systems. The latter system is preferable because it reduces the chance of a single component failure rendering the entire system inoperative.

7.8 Optional Accessories

The generator set manufacturer offers optional accessories that require connection to other components in the system. These accessories enable the generator set to meet standards for local and national codes, make operation and service more convenient, or satisfy specific customer installation requirements.

Accessories vary with each generator set model and controller. Accessories are available factory-installed and/or shipped loose. Some accessories are available only with the microprocessor and digital controllers. Obtain the most current list of accessories from the respective generator set specification sheet or by contacting your local authorized service distributor/dealer. The following sections detail a few common accessories and their functions.

Accessory kits generally include installation instructions. See the wiring diagrams manual for electrical connections not shown in this section. See the installation instructions and drawings supplied with the kit for information on the kit mounting location.

The instructions provided with the accessory kit supersede these instructions, if different. In general, run AC and DC wiring in separate conduit. Use shielded cable for all analog inputs. Observe all applicable national and local electrical codes during accessory installation.

Accessory wiring. To determine the appropriate size for the customer-supplied wiring of the engine battery-powered accessories, use the guidelines in Figure 7-12. Use 18-20 gauge wire for *signal wires* up to 305 m (1000 ft.).

Length, m (ft.)	Wire Gauge
30.5 (100)	18-20
152.4 (500)	14
304.8 (1000)	10

Figure 7-12 Wire Length and Size, Lead N and 42B

Match the wire terminals to the terminal strip conductor screw size. Use a maximum of two wire terminals per terminal strip screw unless otherwise noted on the respective accessory drawing or installation instruction.

Accessory connections. Do not direct-connect accessories to the controller terminal strip. Connect accessories to either a single-relay dry contact kit or ten-relay dry contact kit. Connect the dry contact kit(s) to the controller (customer) connection kit. Connect all accessories except the emergency stop kit to the connection kit terminal strip(s).

Terminal strips and available connections vary by controller. Refer to the respective controller operation manual and the accessory wiring diagrams in the wiring diagram manual for connection of kits. Field-installed accessories include installation instructions and/or wiring diagrams.

7.8.1 Audiovisual Alarm

An audiovisual alarm warns the operator at a remote location of fault shutdowns and prealarm conditions (except battery charger fault and low battery voltage) at the generator set. Audiovisual alarms include an alarm horn, an alarm silence switch, and a common fault lamp. See Figure 7-13.

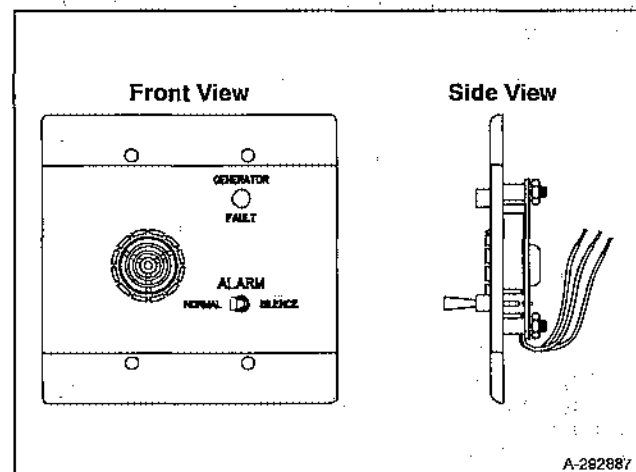


Figure 7-13 Audiovisual Alarm

7.8.2 Bus Bar Kits/Bus Lugs

The four bus bars contained in the optional bus bar kits simplify the connection process by offering a neutral bus bar in addition to the three load bars. Optional bus lugs offer an array of terminal and wire connections. See Figure 7-14.

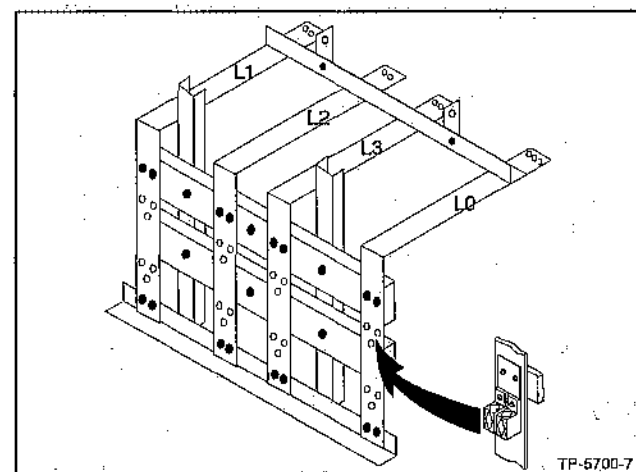


Figure 7-14 Bus Bar Kits/Bus Lugs

7.8.3 Common Failure Relay Kit

The common failure relay kit provides one set of contacts to trigger customer-provided warning devices if a fault occurs. The user defines common failure relay faults. Connect up to three defined common failure relay kits to the controller output. See Figure 7-15.

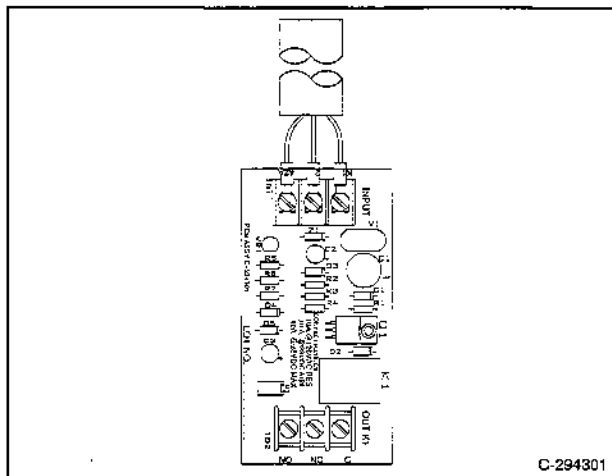


Figure 7-15 Common Failure Relay Kit

7.8.4 Controller (Customer) Connection Kit

The controller connection kit allows easy connection of controller accessories without accessing the controller terminal strip. The kit uses a wiring harness to link the controller terminal strip(s) with a remote terminal strip. With the exception of a few terminals, the remote terminal strip has connections similar to the controller. Connect all accessories except the emergency stop kit to the connection kit terminal strip(s).

7.8.5 Float/Equalize Battery Charger Kit with Alarm Option

The float/equalize battery charger with alarm option charges the engine start battery(ies) and connects to the controller for fault detection. Your distributor/dealer offers battery chargers for 12- or 24-volt models. See Figure 7-16.

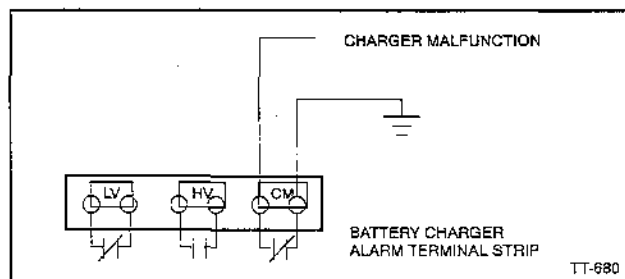


Figure 7-16 Float/Equalize Battery Charger Connections

7.8.6 Ground Fault Annunciation

A relay contact for customer connection indicates a ground fault condition and is part of a ground fault alarm. See Figure 7-17 for electrical connections. Use the instructions with the kit when provided to install and set up this accessory.

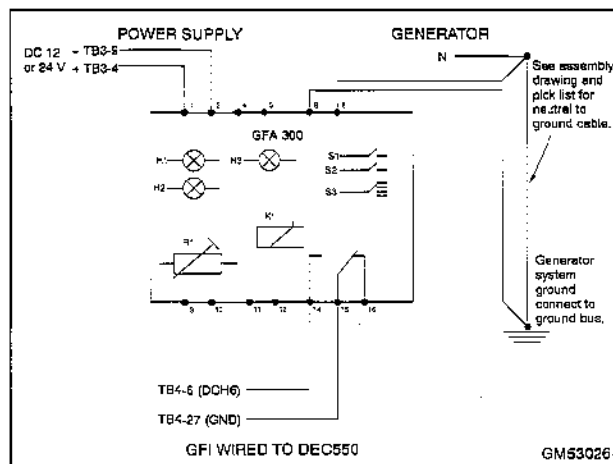


Figure 7-17 Ground Fault Connections

7.8.7 Line Circuit Breaker

The line circuit breaker interrupts generator output if an overload or short circuit occurs. Use the line circuit breaker to manually disconnect the generator set from the load during generator set service. See Figure 7-18.

The circuit breaker must open all ungrounded connectors. Refer to Service Bulletin 611 for circuit breaker instantaneous overcurrent trip adjustment information.

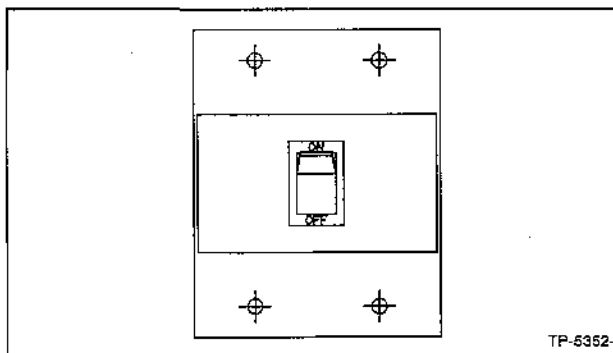


Figure 7-18 Line Circuit Breaker

7.8.8 Low Fuel (Level or Pressure) Switch

Some gaseous-fueled models offer a low fuel pressure switch. The low fuel pressure switch connects to the same terminal as the low fuel level switch on diesel- or gasoline-fueled models. See Figure 7-19.

Note: The main tank or the transfer/day tank includes the low fuel level switch. The fuel tank supplier typically provides the low fuel level switch.

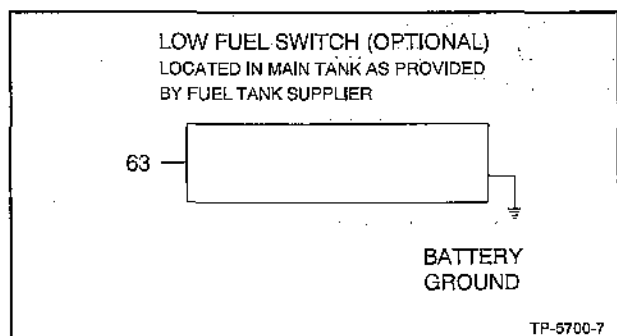


Figure 7-19 Low Fuel Switch (Level or Pressure)

7.8.9 Remote Annunciator Kit

A remote annunciator allows convenient monitoring of the generator set's condition from a remote location. See Figure 7-20.

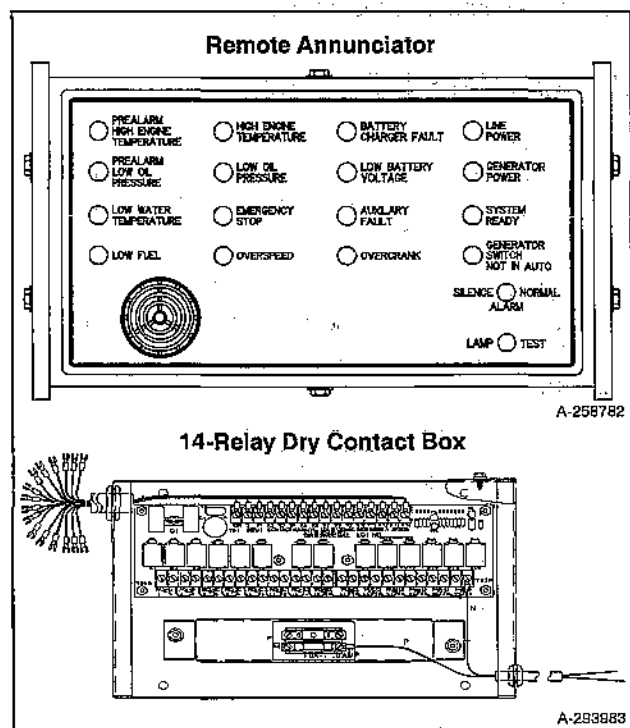


Figure 7-20 Remote Annunciator with 14-Relay Dry Contact Kit

The remote annunciator includes an alarm horn, an alarm silence switch, a lamp test, and the same lamp indicators (except air damper and auxiliary prealarm/high battery voltage) as the microprocessor controller, plus the following:

- **Line power.** Lamp illuminates to indicate that the power source is a commercial utility.
- **Generator set power.** Lamp illuminates to indicate that the power source is the generator set.

7.8.10 Remote Serial Annunciator (RSA)

The remote serial annunciator (RSA 1000) (Figure 7-21) monitors the condition of the generator set from a location remote from the generator set using RS 485 connection. If a generator alarm condition occurs, the remote annunciator alerts the operator through visual and audible signals.

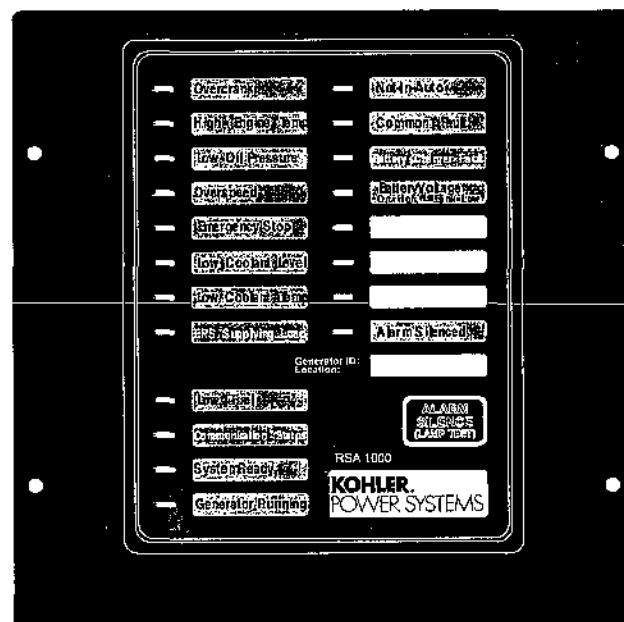


Figure 7-21 Remote Serial Annunciator (RSA 1000)

The remote serial annunciator kit includes components for flush and surface mounting. One RSA (master) can support up to a maximum of three additional RSAs (slaves). The RSA will function as master or slave by changing the DIP switch position on the RSA board. If a generator set fault occurs, the RSA 1000 horn activates and the corresponding LED illuminates.

Figure 7-22 shows the status of the system ready LED, generator running LED, communication status LED, common fault LED, common fault output, and horn for each fault or status condition. See Figure 7-23, Figure 7-24, and Figure 7-25 for RSA wiring connections.

The RSA requires connection to the controller Modbus® RS-485 port. If the RS-485 port is needed for switchgear monitoring or a wireless monitor, the RSA cannot be connected to the controller. If the RS-485 port is unavailable, please select an alternate annunciator kit.

Modbus® is a registered trademark of Schneider Electric.

Fault and Status Condition	Fault LEDs	System Monitoring LEDs and Functions					
		System Ready LED	Generator Running LED	Comm. Status LED	Common Fault LED	Common Fault Output	Horn
Overcrank Shutdown	Red	Red SF	Off	Green	Off	On	On
High Engine Temperature Warning	Yellow	Red SF	Green	Green	Off	On	On
High Engine Temperature Shutdown	Red	Red SF	Off	Green	Off	On	On
Low Oil Pressure Warning	Yellow	Red SF	Green	Green	Off	On	On
Low Oil Pressure Shutdown	Red	Red SF	Off	Green	Off	On	On
Overspeed Shutdown	Red	Red SF	Off	Green	Off	On	On
Emergency Stop	Red	Red SF	Off	Green	Off	On	On
Low Coolant Level	Red	Red SF	Off	Green	Off	On	On
Low Coolant Temperature	Yellow	Red SF	Off	Green	Off	On	On
Low Fuel—Level or Pressure *	Yellow	Red SF	Green	Green	Off	On	On
EPS Supplying Load (550 Controller)	Yellow	Green	Green	Green	Off	Off	Off
EPS Supplying Load (RSA)	Yellow	Green	Green or Off	Green	Off	Off	Off
System Ready	Green	Green	Green or Off	Green	Off	Off	Off
System Not Ready	Red	Red SF	Green or Off	Green	Off	On	On
No Device at Powerup	Red	Off	Off	Red SF	Off	On	On
Loss of Controller Comm. (Master RSA)	Red	Off	Off	Red FF	Off	On	On
Loss of Controller Comm. (Slave RSA)	Red	Off	Off	Red SF	Off	On	On
Not-In-Auto	Red	Red SF	Green or Off	Green	Off	On	On
Battery Charger Fault *	Yellow	Red SF	Green or Off	Green	Off	On	On
High Battery Voltage	Yellow	Green	Green or Off	Green	Off	Off	Off
Low Battery Voltage	Yellow	Green	Green or Off	Green	Off	Off	Off
User Input #1 (RSA)	Red	Green	Green or Off	Green	Off	On	On
User Input #2 (RSA)	Red	Green	Green or Off	Green	Off	On	On
User Input #1 (550 Controller)	Red	Red SF	Green or Off	Green	Off	On	On
User Input #2 (550 Controller)	Red	Red SF	Green or Off	Green	Off	On	On
User Input #3 (550 Controller)	Red	Red SF	Green or Off	Green	Off	On	On
Common Fault	Red	Green	Green or Off	Green	Red SF	On	On

SF = Slow Flash, FF = Fast Flash
 * May require optional kit or user-provided device to enable function and LED indication.

Figure 7-22 System Monitoring LEDs and Functions

TP-5700.1/11

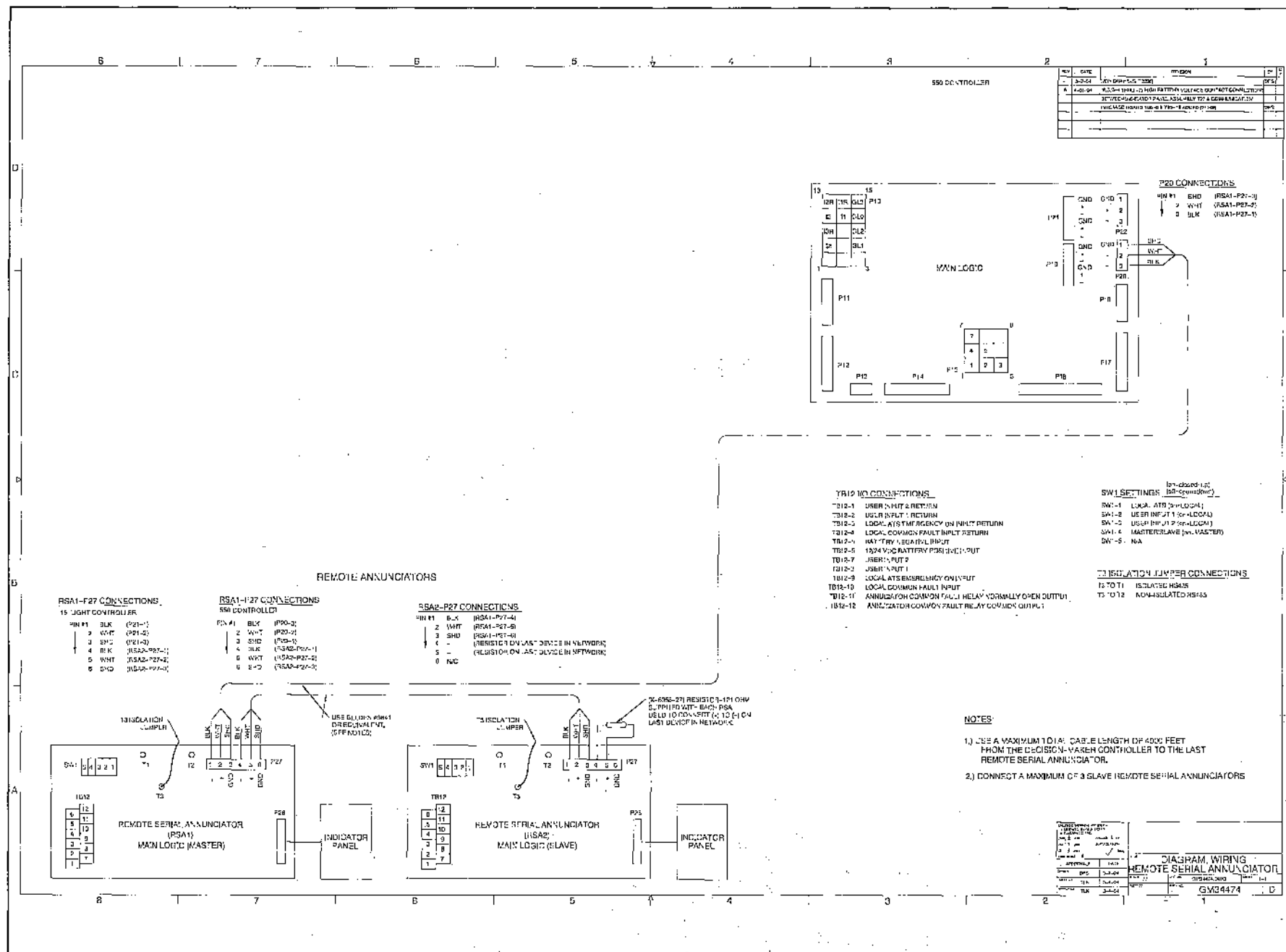


Figure 7-24 RSA Interconnection Diagram ADV-6990A-C

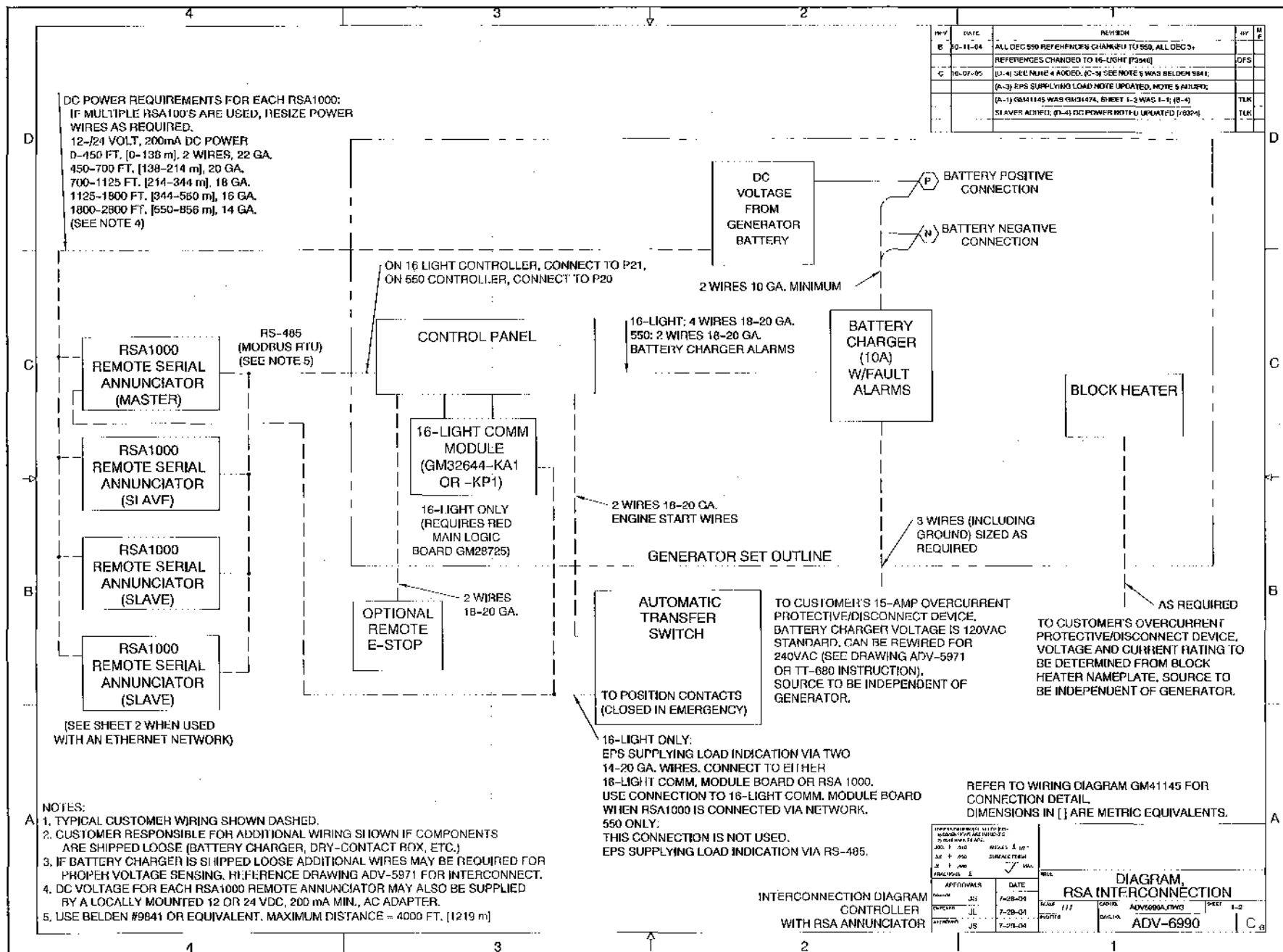
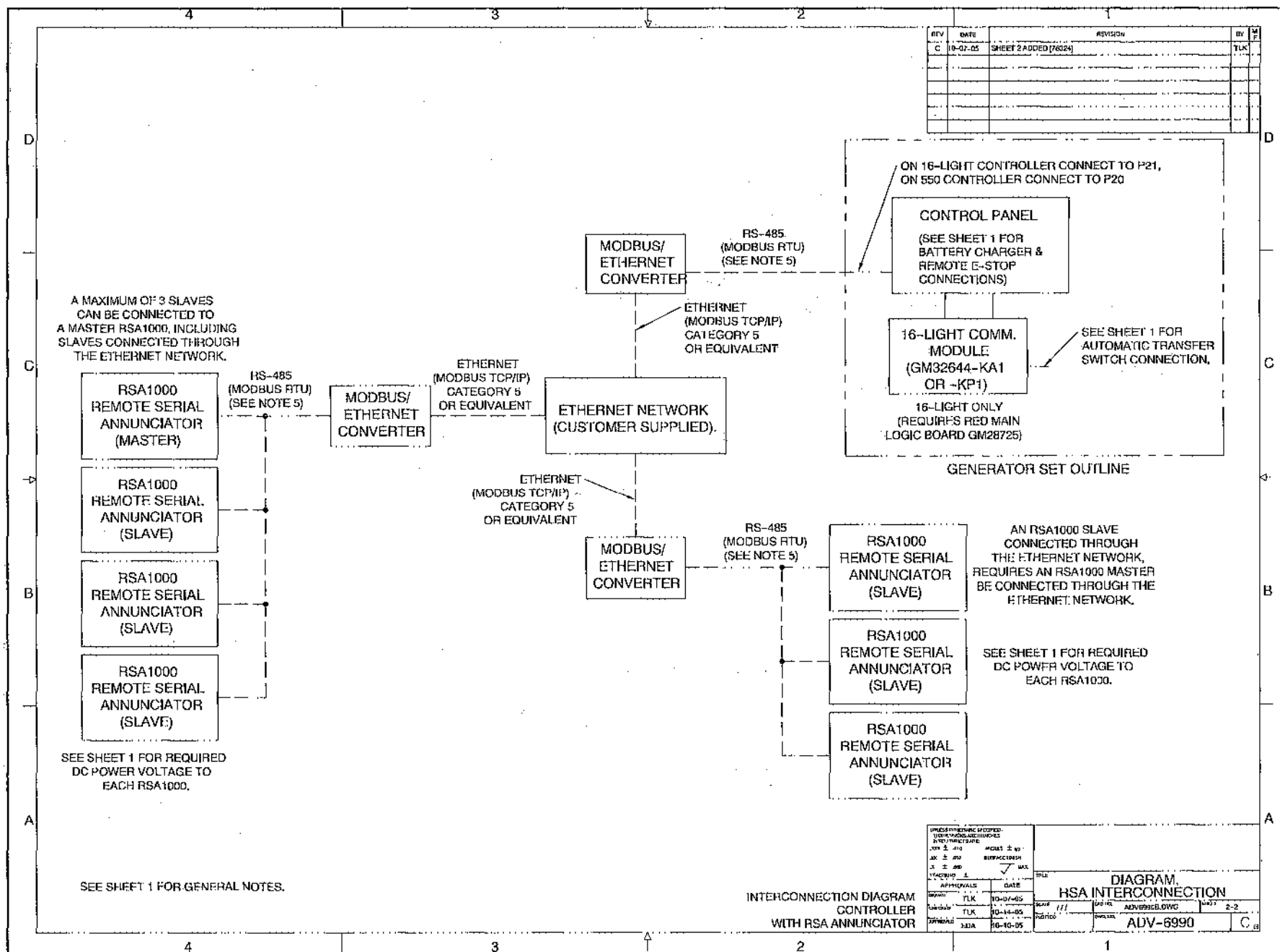


Figure 7-25 RSA Interconnection Diagram ADV-6990B-C



7.8.11 Remote Serial Annunciator (RSA II)

The RSA II is a remote serial annunciator (Figure 7-26 and Figure 7-27) that monitors the condition of the generator set and/or ATS from a remote location. The RSA II alerts the operator through visual and audible signals using LED indication and a horn. An alarm silence and lamp test switch are included.

An RSA II annunciator can be used for a single generator set (Figure 7-26) or with a combination of a generator set and automatic transfer switch (Figure 7-27). In systems using more than a single RSA II, one must be designated as the master device to broadcast to additional RSA II annunciators, designated as slave devices. Up to five RSA II slave devices can be used with an RSA II master device. All RSA II annunciators are factory set as the master device, but can be changed to a slave device using a PC and SiteTech™ software that connects to the RSA II front panel via a universal serial bus (USB) connection.

A PC with SiteTech™ software are required to make the RSA II functional. Use your SecurID to access KOHLERnet, click on the TechTools button, and follow the instructions to download the files. Refer to the SiteTech™ Software Operation Manual for more information.

The RSA II kits include components for surface mounting or flush mounting.

If the RSA II is used with an Ethernet communication network, order Modbus® Ethernet converter GM41143-KP2 and refer to TT-1405 Converters, Connections, and Controller Setup for Network Communication for system installation.

If the RSA II is used with a DEC 3+ controller, it will require a communication module board; refer to TT-1285 Program Loader Software instructions for downloading firmware version 1.23 and higher.

The RSA II requires connection to the controller Modbus® RS-485 port. When other network functions are required, such as switchgear communication, the RSA II must use an Ethernet network. If the RS-485 port is unavailable and Ethernet conversion is not an option, please select an alternate remote annunciator kit.

Figure 7-28 shows the status of the system ready LED, generator running LED, communication status LED, common fault LED, common fault output, and horn for each fault or status condition. See Figure 7-29 and Figure 7-30 for RSA Wiring connections.

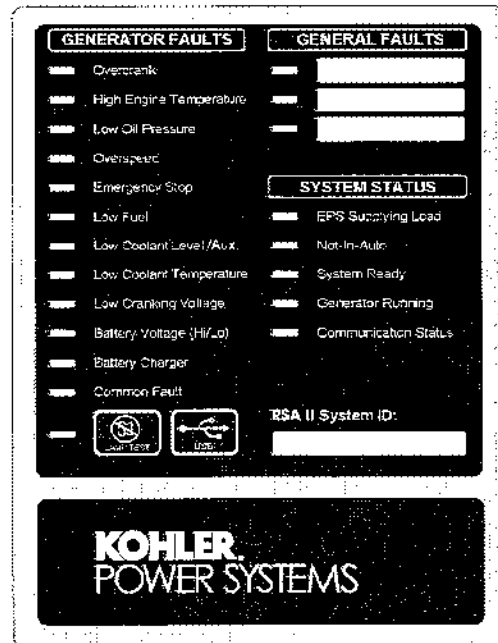


Figure 7-26 Remote Serial Annunciator (RSA II)

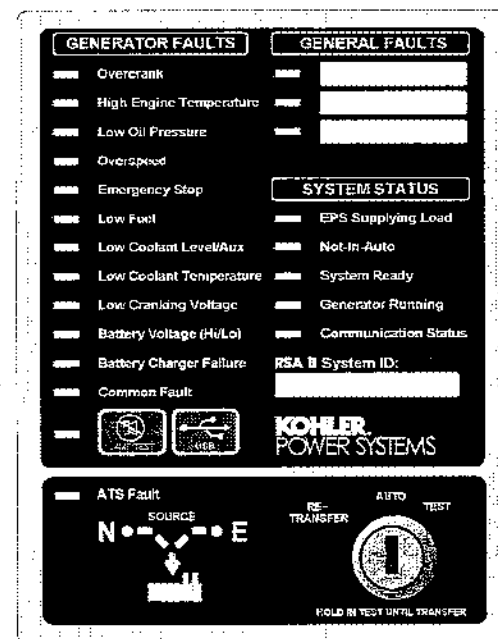


Figure 7-27 RSA II with ATS Controls

Fault and Status Condition	Fault LED	System Monitoring LEDs and Functions					
		System Ready LED	Generator Running LED	Communication Status LED	Common Fault LED	Common Fault Output	Horn
Overcrank Shutdown	Red	Red SF	Off	Green	Red SF	On	On
High Engine Temperature Warning *	Yellow	Red SF	Green	Green	Red SF	On	On
High Engine Temperature Shutdown	Red	Red SF	Off	Green	Red SF	On	On
Low Oil Pressure Warning *	Yellow	Red SF	Green	Green	Red SF	On	On
Low Oil Pressure Shutdown	Red	Red SF	Off	Green	Red SF	On	On
Overspeed Shutdown	Red	Red SF	Off	Green	Red SF	On	On
Emergency Stop *	Red	Red SF	Off	Green	Off	On	On
Low Coolant Level/Auxiliary Shutdown *	Red	Red SF	Off	Green	Red SF	On	On
Low Coolant Temperature *	Yellow	Red SF	Off	Green	Red SF	On	On
Low Fuel—Level or Pressure *	Yellow	Red SF	Off	Green	Red SF	On	On
EPS Supplying Load (RSA II)	Green	Green	Green or Off	Green	Off	Off	Off
System Ready	Green	Green	Green or Off	Green	Off	Off	Off
System Not Ready	Red	Red SF	Green or Off	Green	Off	On	On
Low Cranking Voltage	Yellow	Red SF	Off	Green	Red SF	On	On
(Loss of) Communication Status (Master RSA II)	Red	Off	Off	Red FF	Off	On	On
(Loss of) Communication Status (Slave RSA II)	Red	Off	Off	Red SF	Off	On	On
Not-In-Auto	Red	Red SF	Green or Off	Green	Red SF	On	On
Battery Charger Fault *	Yellow	Green	Green or Off	Green	Off	On	On
High Battery Voltage *	Yellow	Green	Green or Off	Green	Off	On	On
Low Battery Voltage *	Yellow	Green	Green or Off	Green	Off	Off	Off
User Input #1 (RSA II) Warning	Yellow	Green	Green or Off	Green	Off	On	On
User Input #1 (RSA II) Shutdown	Red	Green	Green or Off	Green	Off	On	On
User Input #2 (RSA II) Warning	Yellow	Green	Green or Off	Green	Off	On	On
User Input #2 (RSA II) Shutdown	Red	Green	Green or Off	Green	Off	On	On
User Input #3 (RSA II) Warning	Yellow	Green	Green or Off	Green	Off	On	On
User Input #3 (RSA II) Shutdown	Red	Green	Green or Off	Green	Off	On	On
Common Fault Warning	Yellow	Green	Green or Off	Green	Red SF	On	Off
Common Fault Shutdown	Red	Green	Green or Off	Green	Red SF	On	On
ATS Position N (RSA II with ATS only)	Green	Green	Green or Off	Green	Off	Off	Off
ATS Position E (RSA II with ATS only)	Red	Red SF	Green or Off	Green	Off	Off	On
ATS Available N (RSA II with ATS only)	Green	Green	Green or Off	Green	Off	Off	Off
ATS Available E (RSA II with ATS only)	Red	Red SF	Green or Off	Green	Off	Off	On
ATS Fault (RSA II with ATS only)	Yellow	Yellow	Green or Off	Green	Off	Off	On
ATS Fault (RSA II with ATS only)	Red	Red SF	Green or Off	Green	Off	Off	On

SF = Slow Flash (1 second intervals), FF = Fast Flash (200 ms intervals)
 * May require optional kit or user-provided device to enable function and LED indication.

Figure 7-28 System Monitoring LEDs and Functions

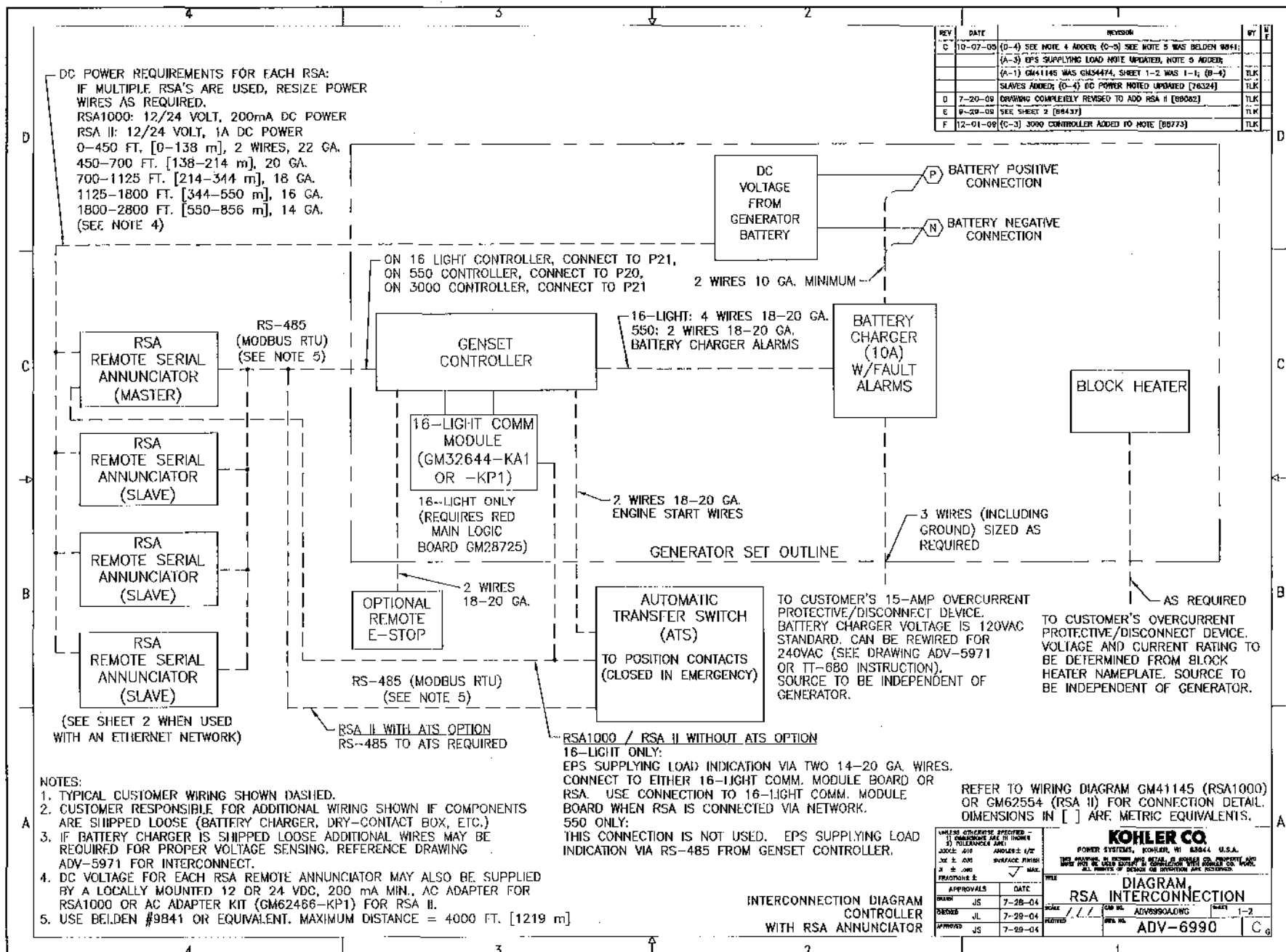
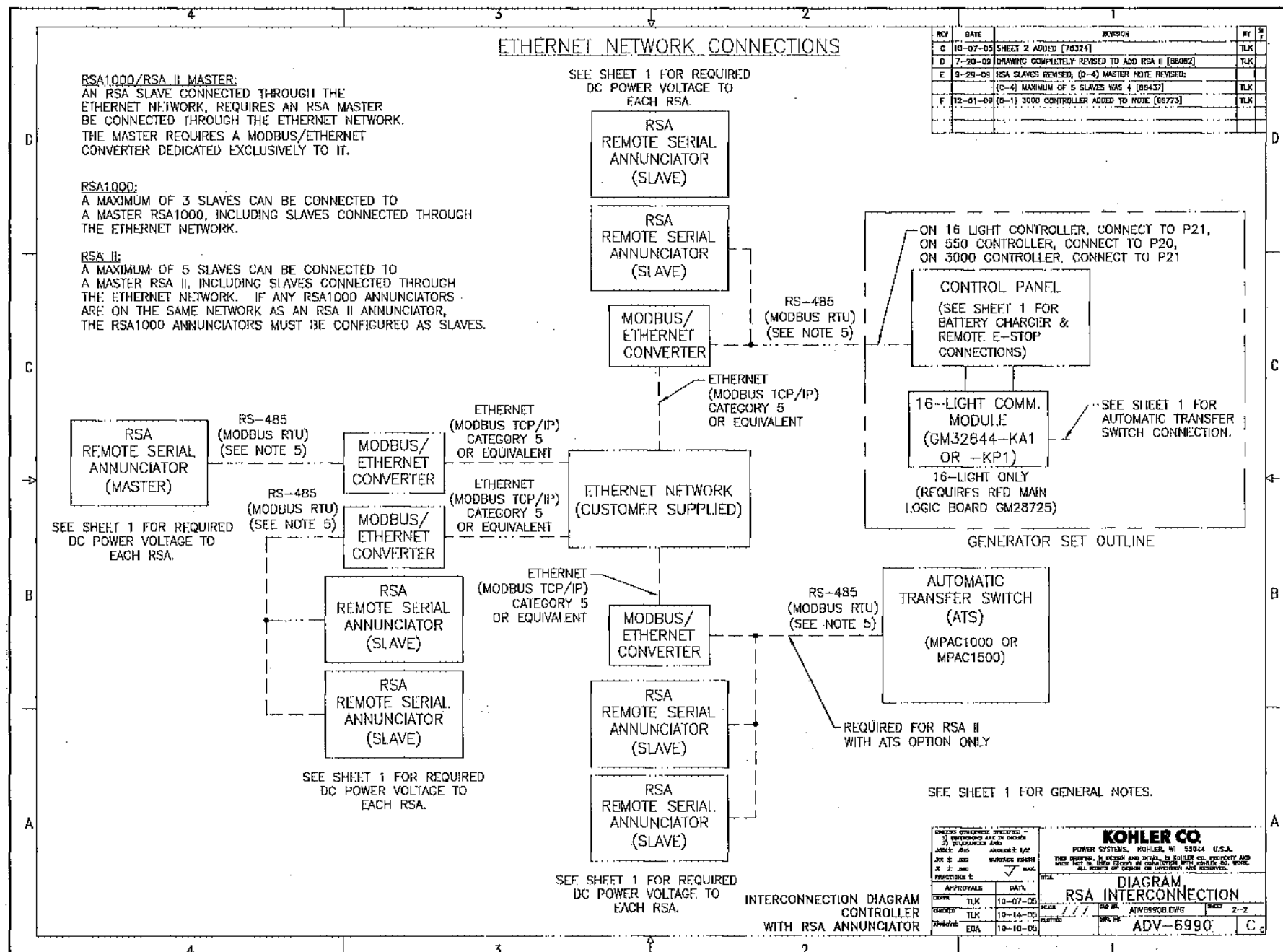


Figure 7-30 RSA II Interconnection Diagram ADV-6990B-F



7.8.12 Remote Emergency Stop Kit

Figure 7-31 shows the remote emergency stop switch. Activating the emergency stop switch in the remote emergency stop kit lights the controller lamp and shuts down the unit. Before restarting the generator set, reset the emergency stop switch by replacing the glass piece and reset the generator set by placing the master switch in the OFF/RESET position. The switch holds a single replacement glass piece. Order additional replacement glass as a service part.

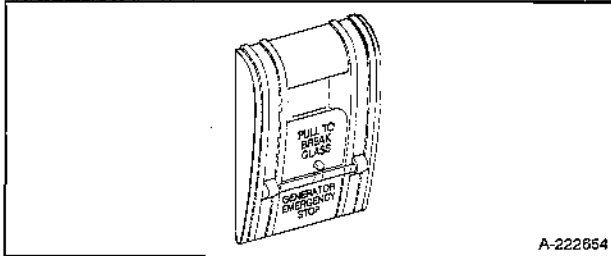


Figure 7-31 Emergency Stop Kit

7.8.13 Run Relay Kit

The run relay kit energizes only during generator set operation. The three sets of contacts typically control air intake and/or radiator louvers. However, alarms and other signaling devices can also connect to the contacts. See Figure 7-32.

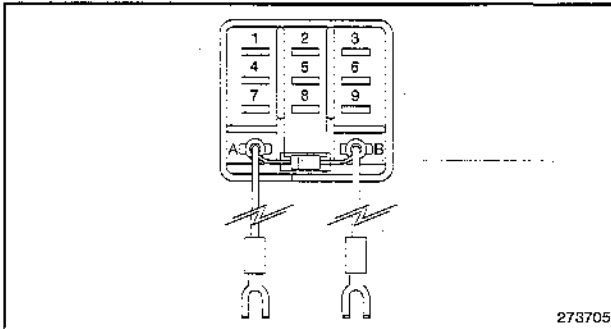


Figure 7-32 Run Relay Kit

7.8.14 Safeguard Breaker

The safeguard breaker senses output current on each generator phase and shuts off the AC voltage regulator if a sustained overload or short circuit occurs. It is not a line circuit breaker and does not disconnect the generator from the load. See Figure 7-33.

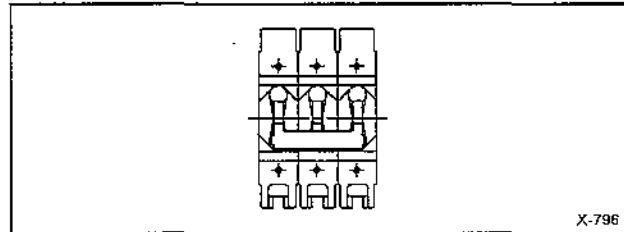


Figure 7-33 Safeguard Breaker

7.8.15 Single-Relay Dry Contact Kit

The single-relay dry contact kit has a common fault relay that uses one set of contacts to trigger customer-provided warning devices if a fault condition occurs. Any controller fault output can connect to the single-relay kit. The kit typically signals the following common fault conditions:

- Emergency stop
- High coolant temperature
- Low oil pressure
- Overcrank
- Overspeed
- Low oil pressure
- High engine temperature

A total of three dry contact kits may connect to a single controller output. Figure 7-34 shows the single-relay dry contact kit.

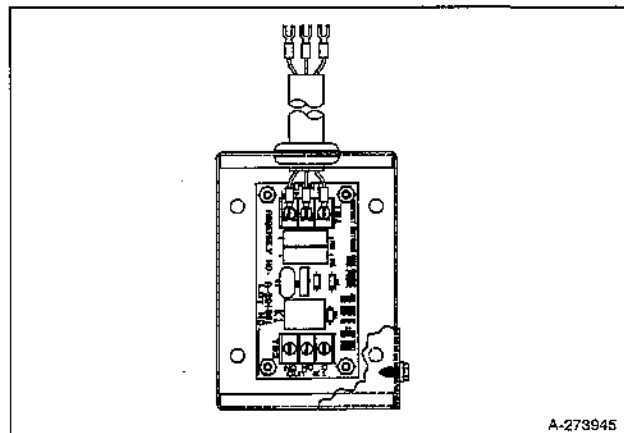


Figure 7-34 Single-Relay Dry Contact Kit

7.8.16 Ten-Relay Dry Contact Kit

The ten-relay dry contact kit allows monitoring of the generator set and/or activating accessories. The kit includes ten sets of relay contacts for connecting customer-provided devices to desired generator set functions. A total of three dry contact kits may connect to a single output on the controller. Refer to Figure 7-35 for an internal view of the contact kit.

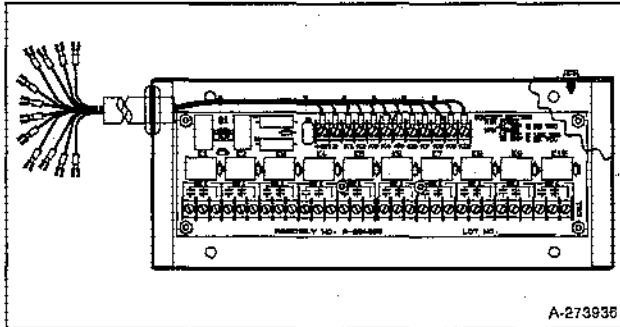


Figure 7-35 Ten-Relay Dry Contact Kit

Warning devices (lamp and/or audible alarms) and other accessories typically connect to the following controller outputs:

- Overspeed
- Overcrank
- High engine temperature
- Low oil pressure
- Low water temperature
- Auxiliary fault
- Air damper, if equipped
- Anticipatory high engine temperature
- Anticipatory low oil pressure
- Emergency stop

7.9 Wiring Connections

Although equipment and connections vary, Figure 7-36 shows examples of the options and wire connections necessary to make an industrial system operational. Always refer to the wiring diagram for details of wire size, location, and number.

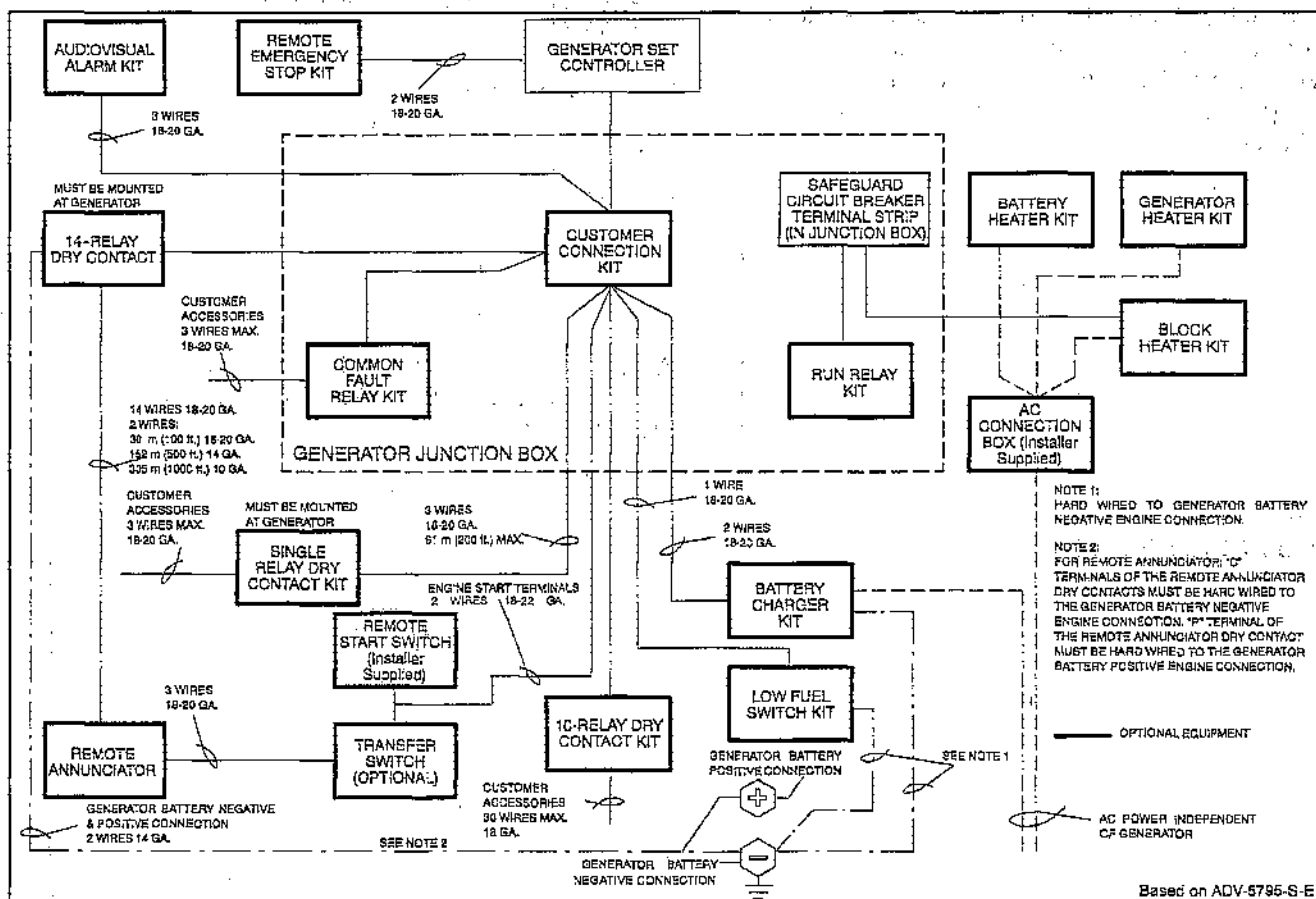


Figure 7-36 Generator Set Connections, Typical

Section 8 Remote Starting/Control, Voltage Regulation, and Paralleling Systems

This section provides information about changes and adjustments when the system involves remote starting/control systems, voltage regulation, and paralleling generator set applications. Use the respective switchgear literature as supplied with the unit. Some of the items mentioned are available generator set accessories.

Before installing the generator set, provide for electrical connections through conduit to the transfer switch and other accessories for the generator set. Carefully install the selected generator set accessories. Route wiring to the generator set through flexible connections. Comply with all applicable codes when installing a wiring system.

See Section 7, Electrical System for additional wiring information.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Turn the generator set master switch and switchgear engine control switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by an automatic transfer switch or a remote start/stop switch.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ WARNING



Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

8.1 Automatic Transfer Switches

A typical standby system has at least one automatic transfer switch connected to the generator set output to automatically transfer the electrical load to the generator set if the normal source fails. When normal power returns, the switch transfers the load back to the normal power source and then signals the generator set to stop.

The transfer switch uses a set of contacts to signal the engine/generator to start. When the normal source fails and the generator set master switch is in the AUTO position, the transfer switch contacts close to start the generator set.

The engine start terminals are usually located near the transfer switch contactor with an engine start decal identifying the terminals. Refer to the transfer switch decal, operation/installation manual, or wiring diagram manual to identify the engine start terminals prior to making connections.

Make connections to the transfer switch engine-start terminals and remote manual engine-start switch using wire run through conduit. Use separate conduits for engine-start leads, generator set load cables, battery charger leads, and remote annunciator wiring.

Use a minimum of 13 mm (0.5 in.) spacing between the conduit bushing and any uninsulated live parts in the ATS enclosure. All conduit openings in the ATS enclosure must be made such that no metal particles including drill chips contaminate the components in the ATS enclosure.

8.2 Decision-Maker® 550 Controller, Voltage Regulator and Paralleling Applications

The controller has a voltage regulation function that is internal to the processor.

See the Decision-Maker® 550 Controller Operation Manual for further details regarding voltage adjustment and paralleling operation setup.

8.3 Decision-Maker® 3000 Controller Voltage Regulator

The controller has a voltage regulation function that is internal to the processor.

See the Decision-Maker® 3000 Controller and SiteTech™ Operation Manuals for further details regarding voltage adjustment setup.

8.4 Decision-Maker® 6000 Controller Voltage Regulator and Paralleling Applications

The controller has a voltage regulation function that is internal to the processor.

See the Decision-Maker® 6000 Controller, Decision-Maker® Paralleling (DPS), and SiteTech™ Operation Manuals for further details regarding voltage adjustment and paralleling operation setup.

8.5 Reactive Droop Compensator

The reactive droop compensator is used to distribute the load evenly when two generator sets are used in parallel. A qualified electrician or technician should install these kits. See Figure 8-1 and Figure 8-2. Additional generator set connections are shown in Figure 7-1 through Figure 7-4.

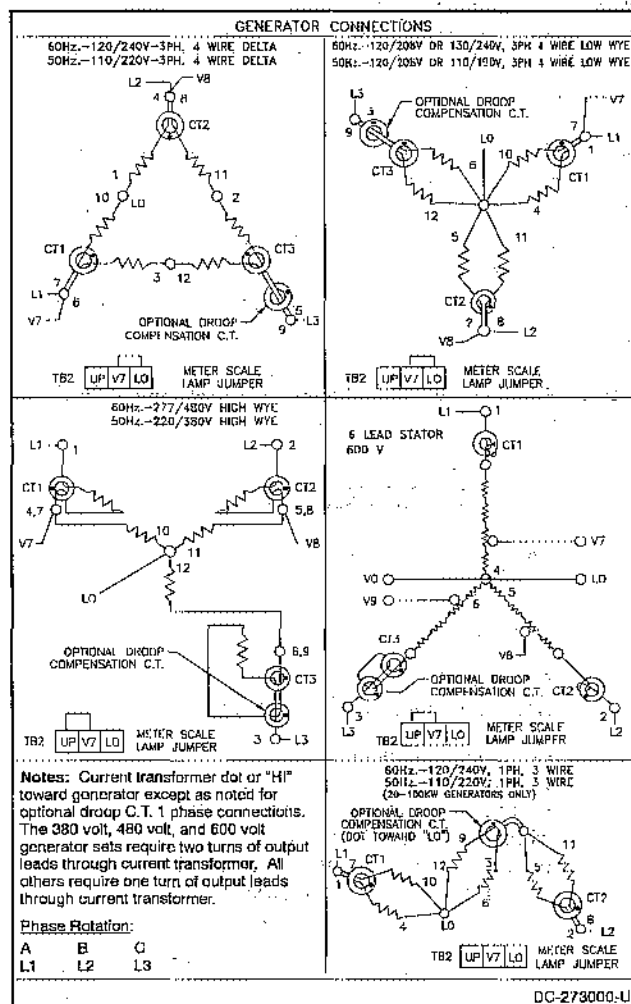
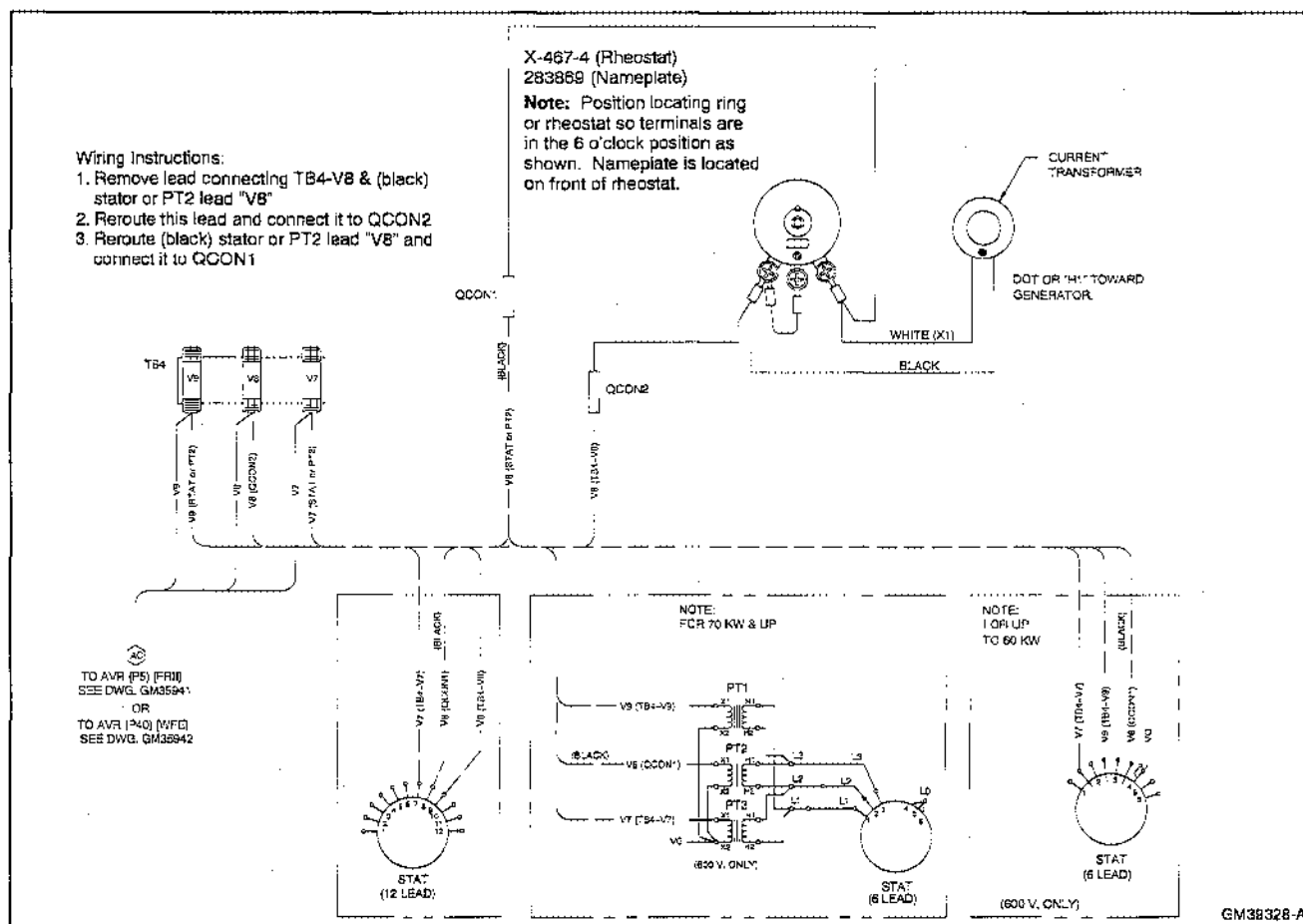


Figure 8-1 Generator Set Connections



Test Procedure

1. With the reactive droop rheostat set at minimum (full counterclockwise position), record the rpm or frequency and voltage at 1/4 load steps to full load on unit #1. Repeat Step 1 for unit #2.
2. Compare the readings and make final adjustments so that the voltage is within 1 volt at each load step and the speed is within 3 rpm or the frequency is within 0.1 Hz for each unit. Adjust the voltage using the local or remote voltage adjusting potentiometer. Adjust the speed at the governor or at the remote speed adjusting potentiometer.
3. Check the droop compensation on each unit as follows:
 - a. With unit #1 operating at the correct speed and voltage, apply a lagging power factor load. This load should preferably be 1/2 to full load and must be inductive, as resistance loads cannot be used.

$$\text{Rated Voltage} \times 0.04 \times \text{Actual Load} \\ (\text{expressed as a percent of full load}) \\ = \text{Voltage Drop}$$

- d. Repeat Steps 3 a., b., and c. for unit #2 and be certain the amount of voltage droop is equal at the same load point as on unit #1.
 - e. With this procedure, the two units will share reactive currents proportionately.
4. In addition to Steps 1-3, it is desirable to use the following procedure to check that the units are sharing the reactive load correctly.
 - a. Parallel the units at 1/2 to full load. Check the wattmeters to determine that each unit is carrying equal kW load or a load proportional to its capacity. If the loads are incorrect, adjust and recheck the governor throttle control to correctly balance loading. Engine speed will determine load sharing ability.
- Note:** Use wattmeters, not ammeters, to verify load balance.
- b. With the load balanced, check the ammeters to see that equal current is being produced or the current is proportional according to capacity of each generator set. If the currents are incorrect, adjust the reactive droop rheostat to

reduce the current of the unit(s) that has the highest reading. Adjust the rheostat to increase current on the unit(s) with the lower reading. Continue making minor adjustments until each unit supplies current proportional to its capacity as a proportion of the total system capacity.

- c. As a result of performing Steps 4 a. and b., the governors have been adjusted to balance the load and the reactive droop rheostat has been adjusted to balance the current. These settings would be optimum for parallel operation.

Note: The voltage must droop on lagging power factor loads (inductive loads). A little change in voltage is acceptable on unity power factor loads (resistive loads).

8.6 Remote Speed Adjustment

This kit provides remote engine speed adjustments with an approximate range of $\pm 5\%$ at 1800 rpm. This kit requires a generator set with an electronic governor. See Figure 8-3 and Figure 8-4.

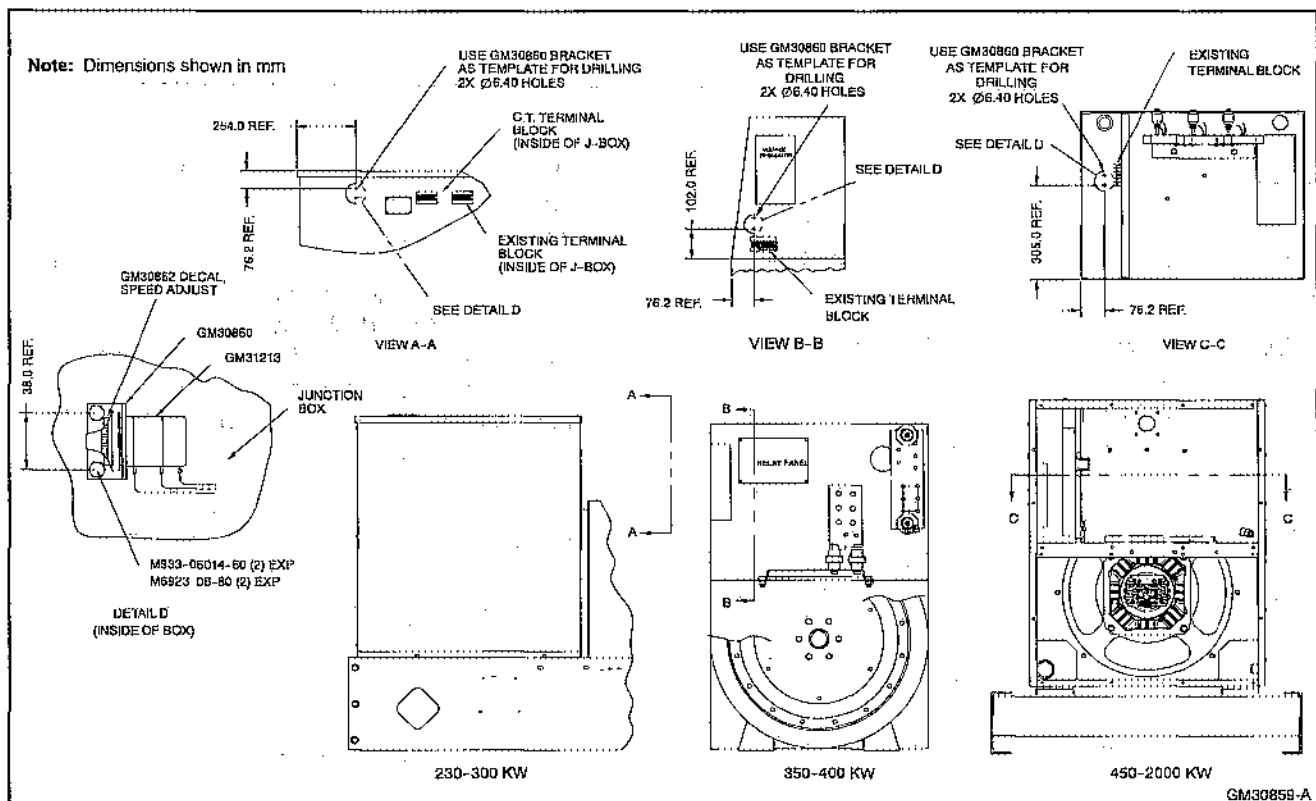


Figure 8-3 Remote Speed Potentiometer Installation

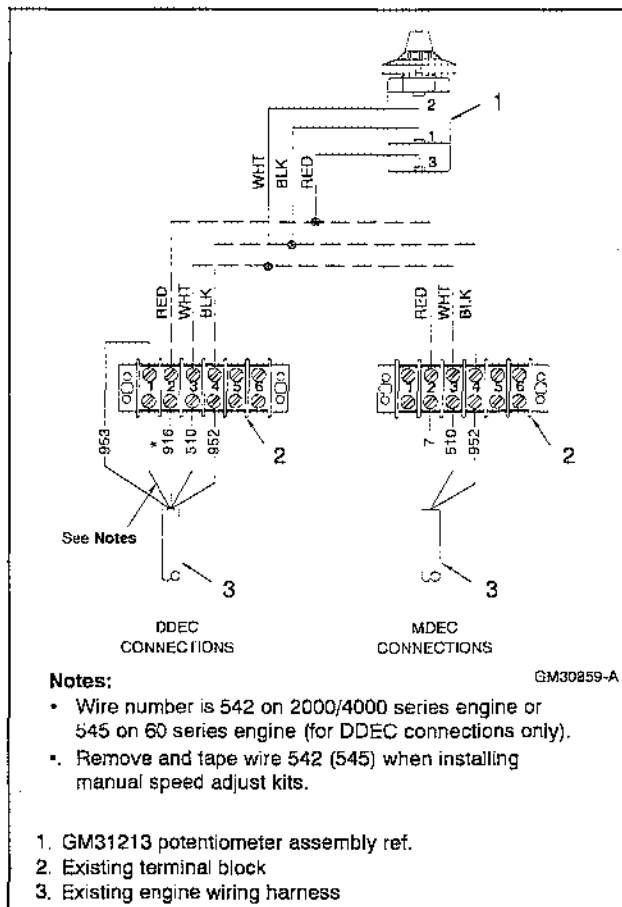


Figure 8-4 Remote Speed Adjusting Control Wiring Diagram

To program the 550 controller, MDEC-equipped DDC/MTU engines only, use the following instructions. See the 550 controller operation manual for further information, if necessary.

1. Go to Menu 14—PROGRAMMING MODE to enable LOCAL programming.
2. Go to Menu 7—GENERATOR SYSTEM.
3. Press MENU Down ↓ Key to access ENABLE VSG (variable governor speed) data.
4. Press the YES Key.
5. Press the ENTER ← Key to confirm entry.
6. Verify ENABLE VSG code YES appears on the display.
7. Go to Menu 14—PROGRAMMING MODE to change to programming mode OFF.

8.7 Remote Voltage Adjustment

This kit provides the ability to fine adjust the generator output voltage from a remote location. Use this kit on 20–300 kW 16-light controller models. The maximum recommended wire length from the potentiometer to the generator set is 15 ft. (4.6 m); 18-gauge twisted pair wire is recommended. Use a remote voltage regulator kit if further distance is required. See Figure 8-5 and Figure 8-6.

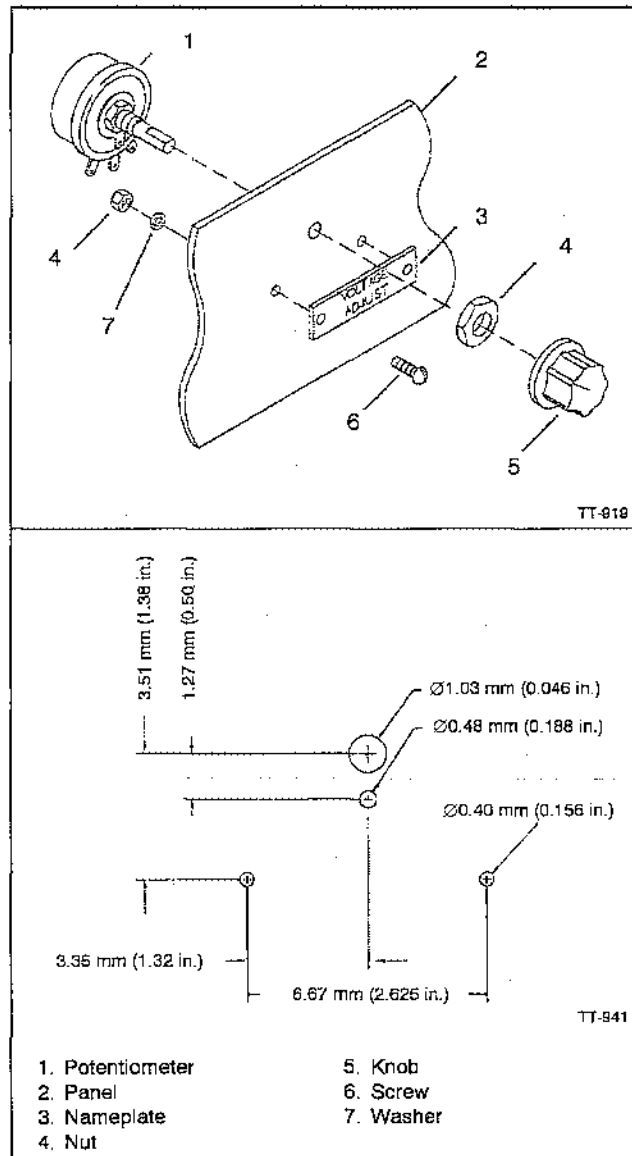


Figure 8-5 Potentiometer Installation

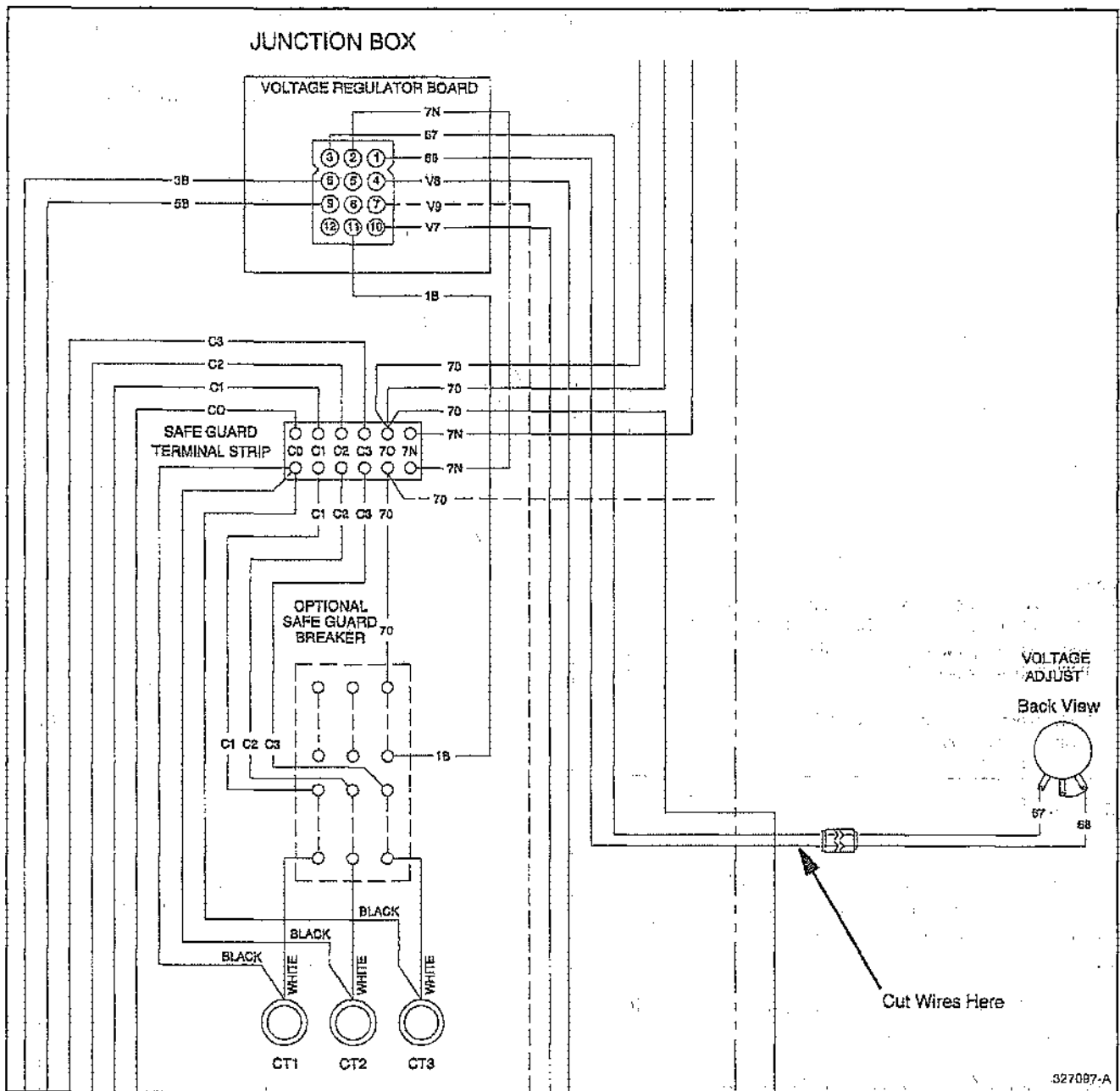


Figure 8-6 Disconnection of Controller Voltage Adjusting Potentiometer

8.8 Remote Wiring

Figure 8-7 is the assembly drawing for the 16-light controller and Figure 8-8 is the accessory interconnection diagram showing the remote wiring for the 550 controller.

8.9 Remote Voltage Regulator Kit

The remote mount voltage regulator kit is recommended whenever the voltage adjustment potentiometer is located beyond 4.3 m (15 ft.) from the generator set. Maximum distance between the generator set and voltage regulator is 287.4 m (1000 ft.). Maximum recommended distance between the voltage adjustment

potentiometer and the voltage regulator is 4.3 m (15 ft.). See Figure 8-9, Figure 8-10, and Figure 8-11 for 20–300 kW models. See Figure 8-12 for 350–2000 kW models.

Note: A remote voltage adjustment potentiometer kit is required when relocating the voltage regulator.

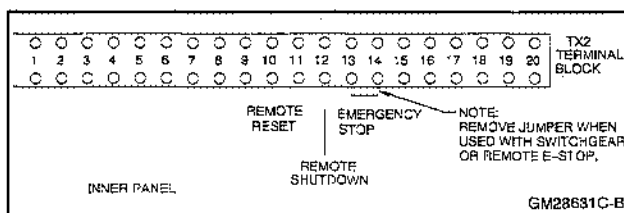


Figure 8-7 16-Light Controller Remote Wiring

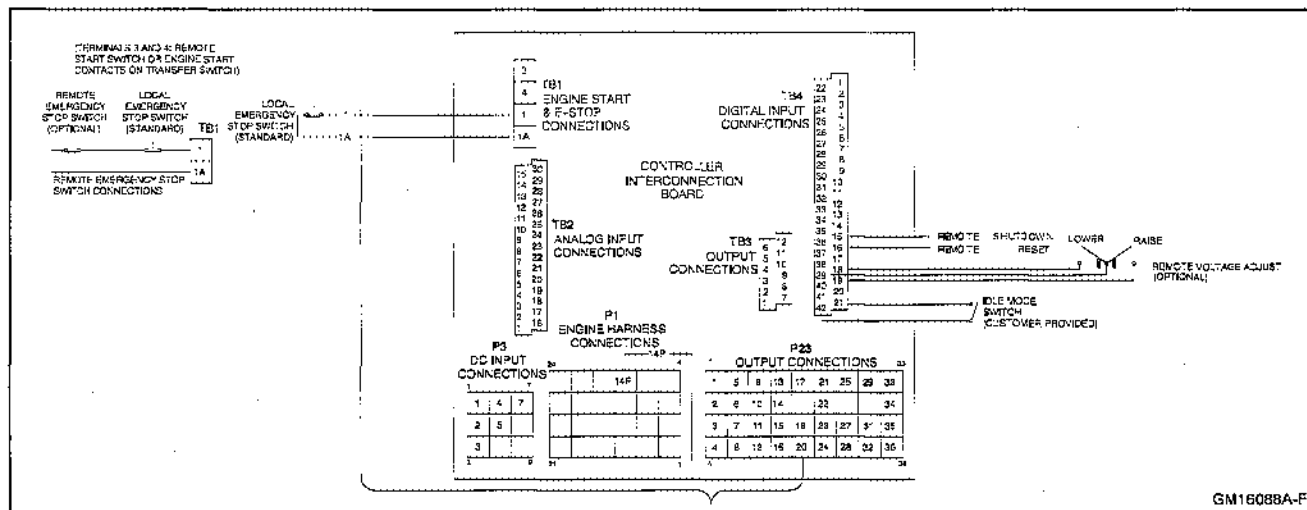


Figure 8-8 550 Controller Remote Wiring

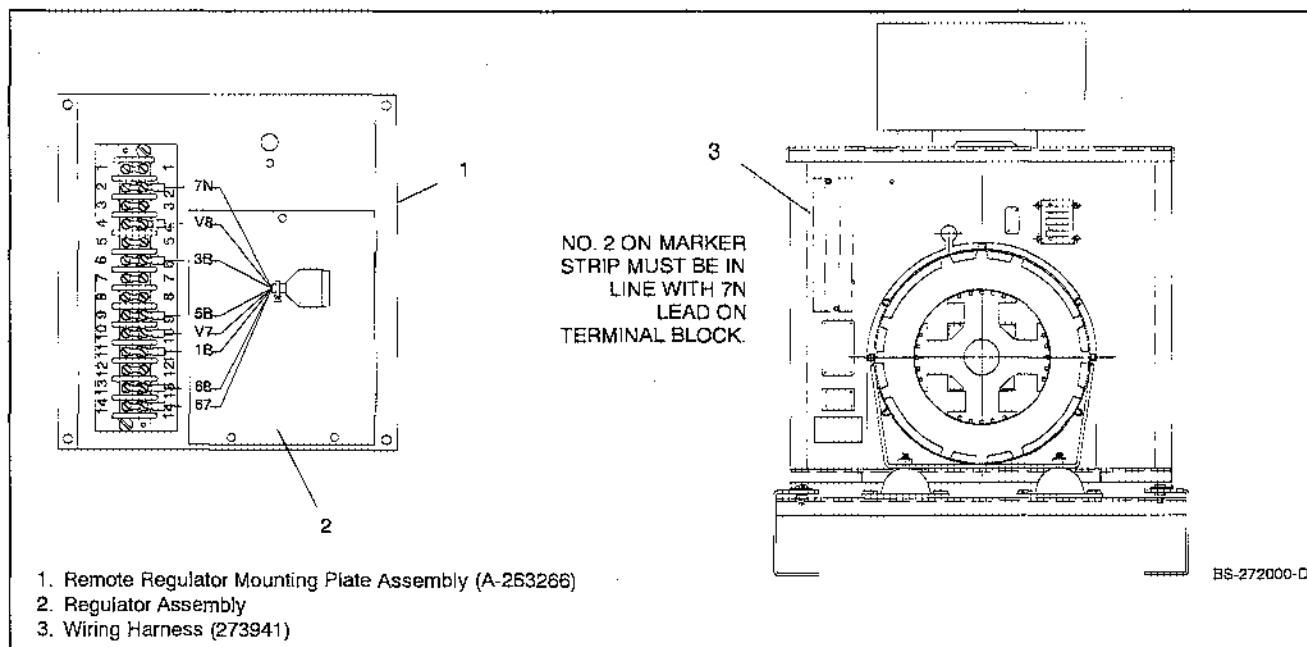


Figure 8-9 Remote Voltage Regulator Kit Installation, 20–300 kW

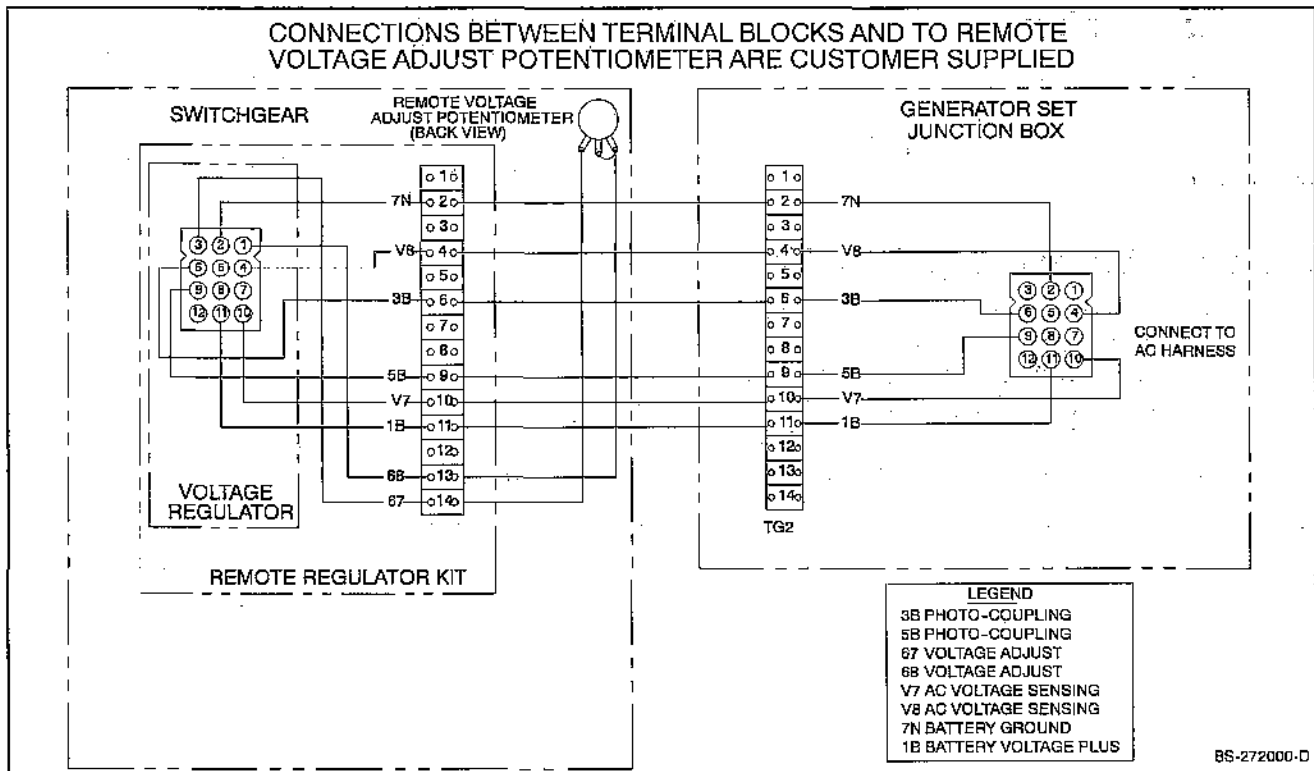


Figure 8-10 Wiring Diagram, 20-300 kW

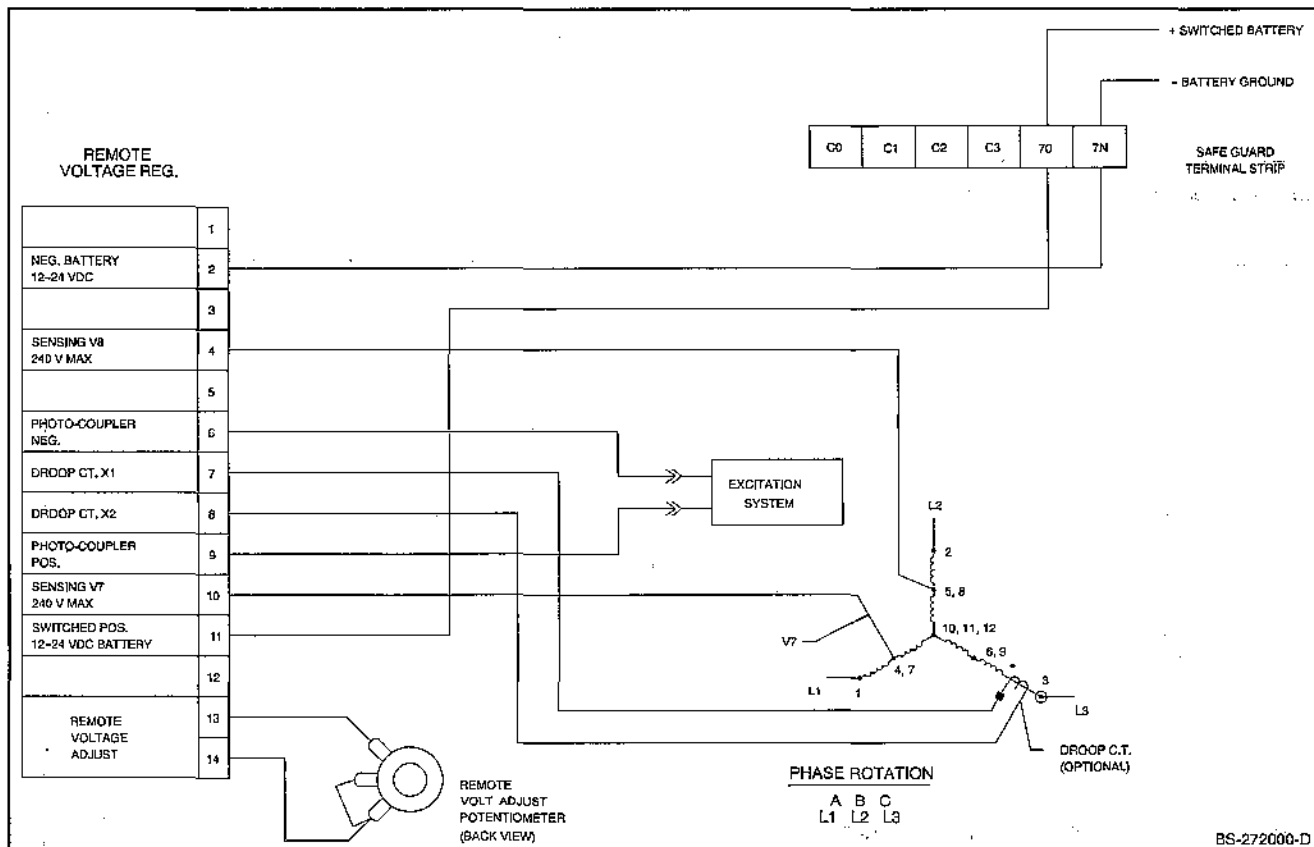


Figure 8-11 Schematic Diagram, 20-300 kW

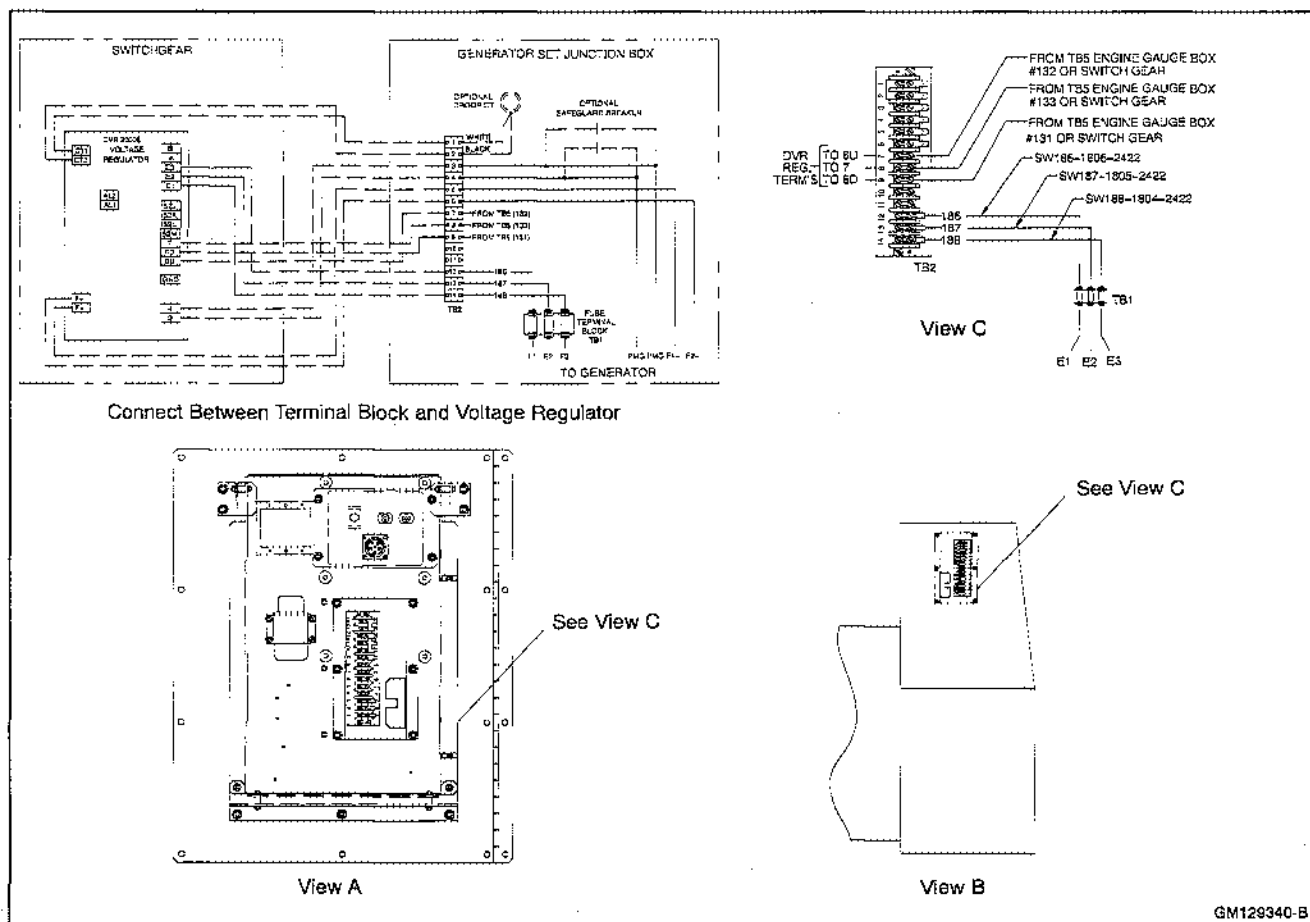


Figure 8-12 Remote Voltage Regulator Kit Installation, 350-2000 kW

8.10 Voltage Regulator

DVR 2000EC/Remote Voltage Regulator Kit, 350 kW and Above

The DVR 2000E is used with nonparalleling applications and the DVR 2000EC is used when paralleling is required.

If the voltage configuration is changed, make adjustments to the DVR 2000 voltage regulator at the voltage regulator. Remove the junction box cover to adjust the DVR 2000 voltage regulator. See Figure 8-13, Figure 8-14, and TP-5579, Operation Manual, DVR 2000 Voltage Regulator, for more information.

Use Figure 8-14 for installation and troubleshooting of the electrical wiring system.

DVR 2000™ is a trademark of Marathon Electric Mfg. Corp.

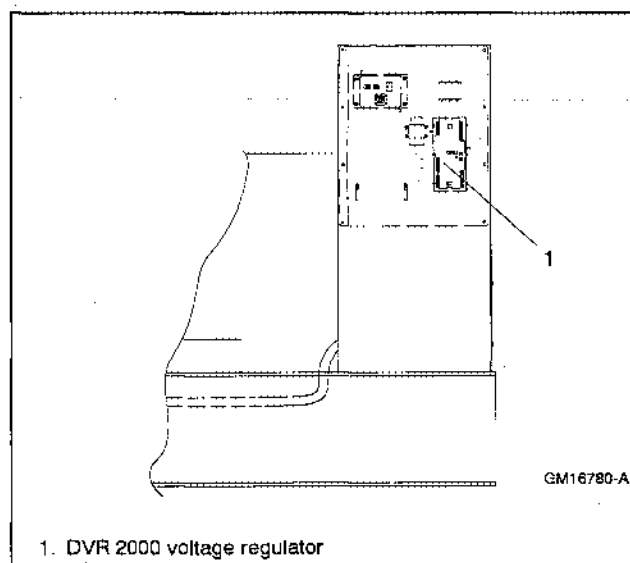


Figure 8-13 DVR 2000 Voltage Regulator Mounting Location

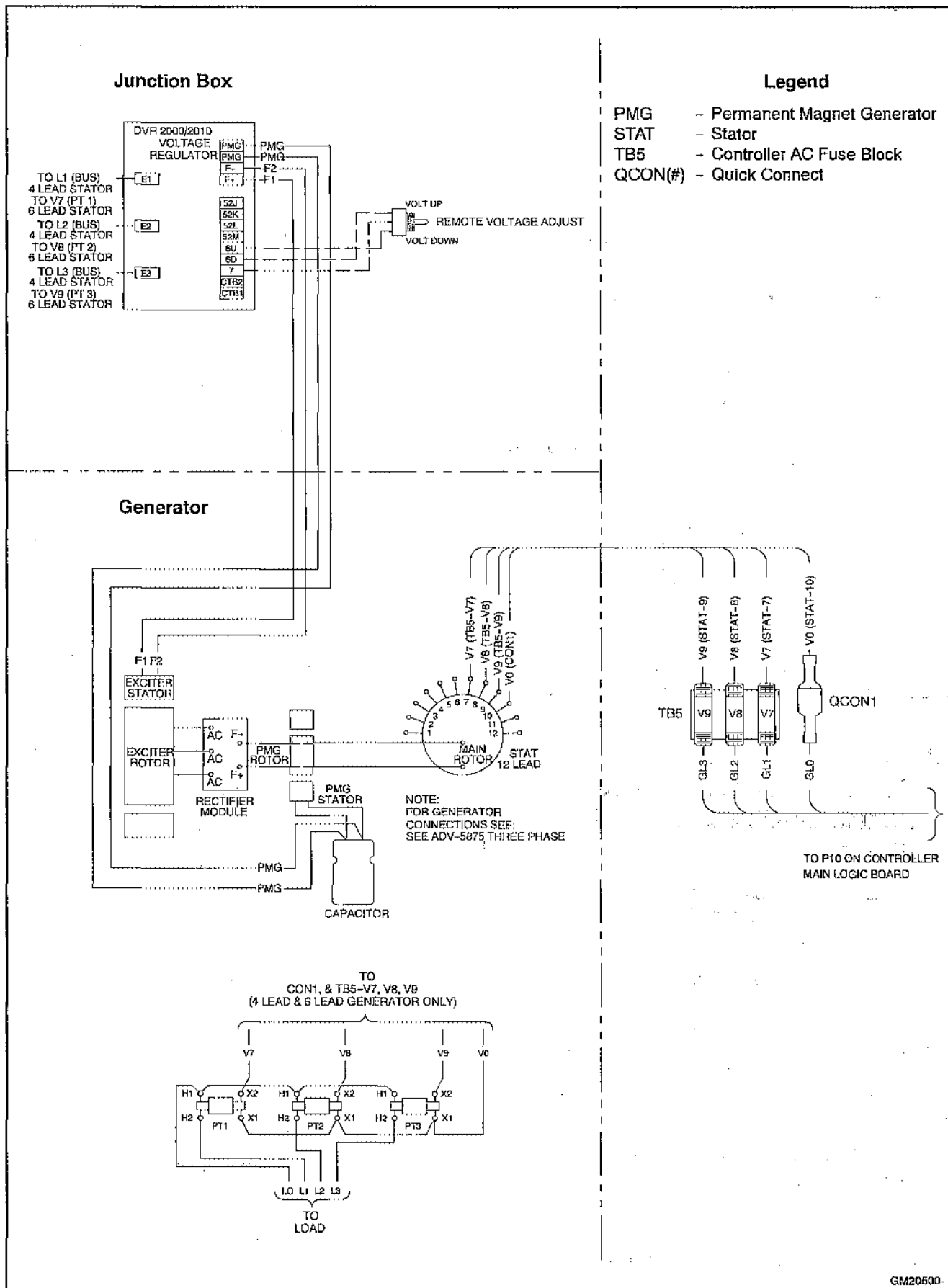


Figure 8-14 DVR 2000 Voltage Regulator/Alternator Interconnection Wiring Diagram

8.11 Voltage Regulator, PMG

If the voltage configuration is changed, use the following procedure to make adjustments to the voltage regulator used on PMG alternators.

The AVR monitors output voltage magnitude and frequency to supply current to the stationary LED board. The AVR circuit board includes volts/Hz and stability adjustment potentiometers. The volts/Hz adjustment is factory-set and normally requires no further adjustment. If operating the generator set under extreme loads results in voltage instability, adjust the potentiometers according to the following procedure. See Figure 8-15.

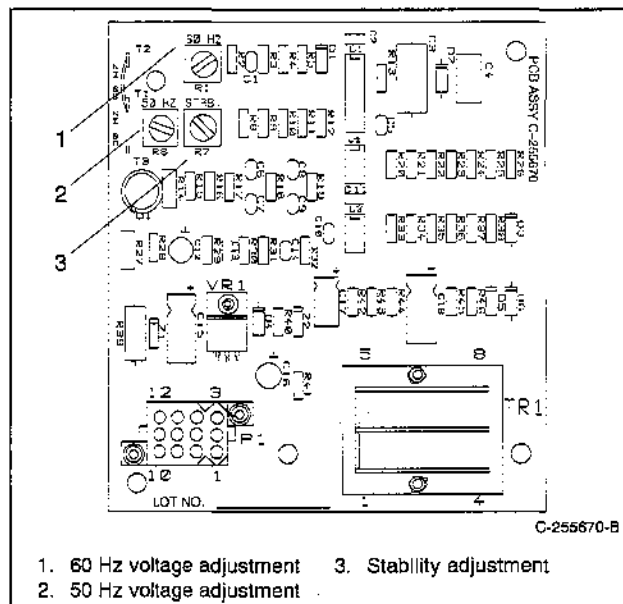


Figure 8-15 AVR Adjustment

Stability Potentiometer. Fine tunes voltage regulator to reduce light flicker.

Volt/Hz Potentiometer. This adjustment determines engine speed (Hz) at which generator output voltage will begin to drop.

Volt/Hz Potentiometer Adjustment Procedure

This adjustment determines engine speed (Hz) at which alternator output voltage will begin to drop.

1. Turn generator set master switch to OFF/RESET.
2. Turn stability potentiometer fully counterclockwise.
3. Connect a 100-watt light bulb across terminals V0 and V7 on controller terminal strip or across terminals on controller frequency meter.
4. Start generator set. With generator running at no load, observe light bulb flicker. Excessive light bulb flicker indicates poor stability.
5. Adjust stability potentiometer until minimum flicker is obtained.
6. Use controller voltage adjustment potentiometer (or remote voltage adjustment potentiometer) to make adjustments to the generator set while running under normal load (if required).
7. Adjust the engine speed to the desired cut-in frequency (factory setting is 57.5–58.0 Hz for 60 Hz models or 47.5–48.0 Hz for 50 Hz models) as measured on frequency meter. See the governor manual for information on engine adjustment.
8. Rotate the volts/Hz adjustment potentiometer clockwise until voltage level begins to drop (as measured on voltmeter). When set to these specifications, the generator set will attempt to maintain normal output until engine speed drops below the frequency set in the previous step (as load is applied).
9. Adjust the engine speed to obtain a full load engine speed of 1800 rpm (60 Hz) or 1500 rpm (50 Hz). Confirm and adjust the output voltage as needed.
10. Use controller voltage adjustment potentiometer (or remote voltage adjustment potentiometer) to make final adjustments to the generator set while running under normal load.
11. Readjust stability potentiometer (if necessary).

Notes

Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

A, amp	ampere	CG	center of gravity	exh.	exhaust
ABDC	after bottom dead center	CID	cubic inch displacement	ext.	external
AC	alternating current	CL	centerline	F	Fahrenheit, female
A/D	analog to digital	cm	centimeter	fglass.	fiberglass
ADC	advanced digital control; analog to digital converter	CMOS	complementary metal oxide substrate (semiconductor)	FHM	flat head machine (screw)
adj.	adjust, adjustment	cogen.	cogeneration	fl. oz.	fluid ounce
ADV	advertising dimensional drawing	com.	communications (port)	flex.	flexible
Ah	amp-hour	coml	commercial	freq.	frequency
AHWT	anticipatory high water temperature	Coml/Rec	Commercial/Recreational connection	FS	full scale
AISI	American Iron and Steel Institute	conn.	continued	ft.	foot, feet
ALOP	anticipatory low oil pressure	CPVC	chlorinated polyvinyl chloride	ft. lb.	foot pounds (torque)
alt.	alternator	crit.	critical	ft./min.	feet per minute
Al	aluminum	CRT	cathode ray tube	ftp	file transfer protocol
ANSI	American National Standards Institute (formerly American Standards Association, ASA)	CSA	Canadian Standards Association	g	gram
AO	anticipatory only	CT	current transformer	ga.	gauge (meters, wire size)
APDC	Air Pollution Control District	Cu	copper	gal.	gallon
API	American Petroleum Institute	cUL	Canadian Underwriter's Laboratories	gen.	generator
approx.	approximate, approximately	CUL	Canadian Underwriter's Laboratories	genset	generator set
AQMD	Air Quality Management District	cu. in.	cubic inch	GFI	ground fault interrupter
AR	as required, as requested	cw.	clockwise	GND, ⊕	ground
AS	as supplied, as stated, as suggested	CWC	city water-cooled	gov.	governor
ASE	American Society of Engineers	cyl.	cylinder	gph	gallons per hour
ASME	American Society of Mechanical Engineers	D/A	digital to analog	gpm	gallons per minute
assy.	assembly	DAC	digital to analog converter	gr.	grade, gross
ASTM	American Society for Testing Materials	dB	decibel	GRD	equipment ground
ATDC	after top dead center	dB(A)	decibel (A weighted)	gr. wt.	gross weight
ATS	automatic transfer switch	DC	direct current	H x W x D	height by width by depth
auto.	automatic	DCR	direct current resistance	HC	hex cap
aux.	auxiliary	deg., °	degree	HCHT	high cylinder head temperature
avg.	average	dept.	department	HD	heavy duty
AVR	automatic voltage regulator	DFMEA	Design Failure Mode and Effects Analysis	HET	high exhaust temp., high engine temp.
AWG	American Wire Gauge	dia.	diameter	hex	hexagon
AWM	appliance wiring material	DI/EO	dual inlet/end outlet	Hg	mercury (element)
bat.	battery	DIN	Deutsches Institut für Normung e. V. (also Deutsche Industrie Normenausschuss)	HH	hex head
BBDC	before bottom dead center	DIP	dual inline package	HHC	hex head cap
BC	battery charger, battery charging	DPDT	double-pole, double-throw	HP	horsepower
BCA	battery charging alternator	DPST	double-pole, single-throw	hr.	hour
BCI	Battery Council International	DS	disconnect switch	HS	heat shrink
BDC	before dead center	DVR	digital voltage regulator	hsg.	housing
BHP	brake horsepower	E, emer.	emergency (power source)	HVAC	heating, ventilation, and air conditioning
blk.	black (paint color), block (engine)	ECM	electronic control module, engine control module	HWT	high water temperature
blk. htr.	block heater	EDI	electronic data interchange	Hz	hertz (cycles per second)
BMEP	brake mean effective pressure	EFR	emergency frequency relay	IC	integrated circuit
bps	bits per second	e.g.	for example (<i>exempli gratia</i>)	ID	inside diameter, identification
br.	brass	EG	electronic governor	IEC	International Electrotechnical Commission
BTDC	before top dead center	EGSA	Electrical Generating Systems Association	IEEE	Institute of Electrical and Electronics Engineers
Btu	British thermal unit	EIA	Electronic Industries Association	IMS	improved motor starting
Btu/min.	British thermal units per minute	EI/EO	end inlet/end outlet	in.	inch
C	Celsius, centigrade	EMI	electromagnetic interference	in. H ₂ O	inches of water
cal.	calorie	emiss.	emission	in. Hg	inches of mercury
CAN	controller area network	eng.	engine	in. lb.	inch pounds
CARB	California Air Resources Board	EPA	Environmental Protection Agency	Inc.	Incorporated
CB	circuit breaker	EPS	emergency power system	ind.	industrial
cc	cubic centimeter	ER	emergency relay	int.	internal
CCA	cold cranking amps	ES	engineering special, engineered special	int./ext.	internal/external
ccw.	counterclockwise	ESD	electrostatic discharge	I/O	input/output
CEC	Canadian Electrical Code	est.	estimated	IP	iron pipe
cert.	certificate, certification, certified	E-Stop	emergency stop	ISO	International Organization for Standardization
cfh	cubic feet per hour	etc.	et cetera (and so forth)	J	joule
cfm	cubic feet per minute			JIS	Japanese Industry Standard
				k	kilo (1000)
				K	kelvin
				kA	kiloampere
				KB	kilobyte (2 ¹⁰ bytes)
				KBus	Kohler communication protocol

kg kilogram
kg/cm² kilograms per square centimeter
kgm kilogram-meter
kg/m³ kilograms per cubic meter
kHz kilohertz
kJ kilojoule
km kilometer
kOhm, kΩ kilo-ohm
kPa kilopascal
kph kilometers per hour
kV kilovolt
kVA kilovolt ampere
kVAR kilovolt ampere reactive
kW kilowatt
kWh kilowatt-hour
kWm kilowatt mechanical
kWth kilowatt-thermal
L liter
LAN local area network
L x W x H length by width by height
lb. pound, pounds
lbm/ft³ pounds mass per cubic feet
LCB line circuit breaker
LCD liquid crystal display
ld. shd. load shed
LED light emitting diode
Lph liters per hour
Lpm liters per minute
LOP low oil pressure
LP liquefied petroleum
LPG liquefied petroleum gas
LS left side
L_{wa} sound power level, A weighted
LWL low water level
LWT low water temperature
m meter, milli (1/1000)
M mega (10⁶ when used with SI units), male
m³ cubic meter
m³/hr. cubic meters per hour
m³/min. cubic meters per minute
mA milliampere
man. manual
max. maximum
MB megabyte (2²⁰ bytes)
MCCB molded-case circuit breaker
MCM one thousand circular mils
meggar megohmmeter
MHz megahertz
mi. mile
mil. one one-thousandth of an inch
min. minimum, minute
misc. miscellaneous
MJ megajoule
mJ millijoule
mm millimeter
mOhm, mΩ milliohm
MOhm, MΩ megohm
MOV metal oxide varistor
MPa megapascal
mpg miles per gallon
mph miles per hour
MS military standard
ms millisecond
m/sec. meters per second
MTBF mean time between failure
MTBO mean time between overhauls
mtg. mounting
MTU Motoren-und Turbinen-Union
MW megawatt

mW milliwatt
μF microfarad
N, norm. normal (power source)
NA not available, not applicable
nat. gas natural gas
NBS National Bureau of Standards
NC normally closed
NEC National Electrical Code
NEMA National Electrical Manufacturers Association
NFPA National Fire Protection Association
Nm newton meter
NO normally open
no., nos. number, numbers
NPS National Pipe, Straight
NPSC National Pipe, Straight-coupling
NPT National Standard taper pipe thread per general use
NPTEF National Pipe, Taper-Fine
NR not required, normal relay
ns nanosecond
OC overcrank
OD outside diameter
OEM original equipment manufacturer
OF overfrequency
opt. option, optional
OS oversize, overspeed
OSHA Occupational Safety and Health Administration
OV overvoltage
oz. ounce
p., pp. page, pages
PC personal computer
PCB printed circuit board
pF picofarad
PF power factor
ph., Ø phase
PHC Phillips® head CrimpTite® (screw)
PHH Phillips® hex head (screw)
PHM pan head machine (screw)
PLC programmable logic control
PMG permanent magnet generator
pot potentiometer, potential
ppm parts per million
PROM programmable read-only memory
psi pounds per square inch
psig pounds per square inch gauge
pt. pint
PTC positive temperature coefficient
PTO power takeoff
PVC polyvinyl chloride
qt. quart, quarts
qty. quantity
R replacement (emergency) power source
rad. radiator, radius
RAM random access memory
RDO relay driver output
ref. reference
rem. remote
Res/Com. Residential/Commercial
RFI radio frequency interference
RH round head
RHM round head machine (screw)
rly. relay
rms root mean square
rnd. round

ROM read only memory
rot. rotate, rotating
rpm revolutions per minute
RS right side
RTU remote terminal unit
RTV room temperature vulcanization
RW read/write
SAE Society of Automotive Engineers
scfm standard cubic feet per minute
SCR silicon controlled rectifier
s, sec. second
SI *Système international d'unités*, International System of Units
SI/EO side in/end out
sil. silencer
SN serial number
SNMP simple network management protocol
SPDT single-pole, double-throw
SPST single-pole, single-throw
spec specification
specs specification(s)
sq. square
sq. cm square centimeter
sq. in. square inch
SS stainless steel
std. standard
stl. steel
tach. tachometer
TD time delay
TDC top dead center
TDEC time delay engine cooldown
TDEN time delay emergency to normal
TDES time delay engine start
TDNE time delay normal to emergency
TDOE time delay off to emergency
TDON time delay off to normal
temp. temperature
term. terminal
THD total harmonic distortion
TIF telephone influence factor
TIR total indicator reading
tol. tolerance
turbo. turbocharger
typ. typical (same in multiple locations)
UF underfrequency
UHF ultrahigh frequency
UL Underwriter's Laboratories, Inc.
UNC unified coarse thread (was NC)
UNF unified fine thread (was NF)
univ. universal
US undersize, underspeed
UV ultraviolet, undervoltage
V volt
VAC volts alternating current
VAR voltampere reactive
VDC volts direct current
VFD vacuum fluorescent display
VGA video graphics adapter
VHF very high frequency
W watt
WCR withstand and closing rating
w/ with
w/o without
wt. weight
xfmr transformer

Appendix B Common Hardware Application Guidelines

Use the information below and on the following pages to identify proper fastening techniques when no specific reference for reassembly is made.

Bolt/Screw Length: When bolt/screw length is not given, use Figure 1 as a guide. As a general rule, a minimum length of one thread beyond the nut and a maximum length of $1/2$ the bolt/screw diameter beyond the nut is the preferred method.

Washers and Nuts: Use split lock washers as a bolt locking device where specified. Use SAE flat washers with whiz nuts, spirallock nuts, or standard nuts and preloading (torque) of the bolt in all other applications.

See Appendix E, General Torque Specifications, and other torque specifications in the service literature.

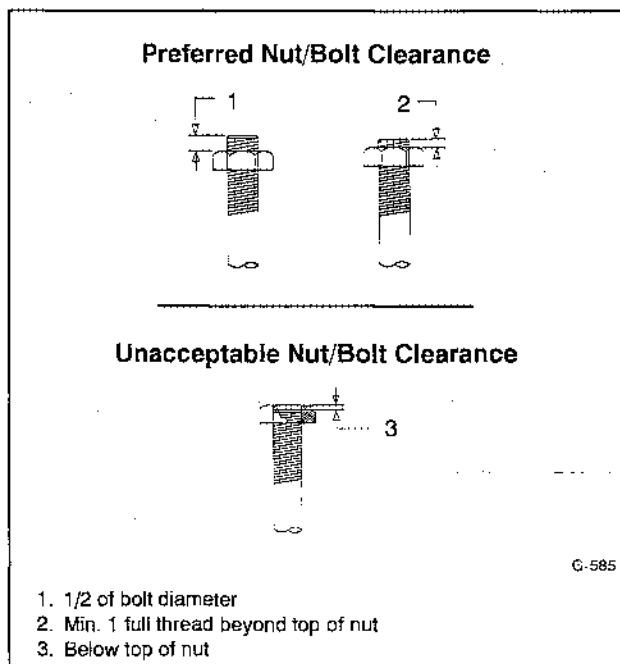


Figure 1 Acceptable Bolt Lengths

Steps for common hardware application:

1. Determine entry hole type: round or slotted.
2. Determine exit hole type: fixed female thread (weld nut), round, or slotted.

For round and slotted exit holes, determine if hardware is greater than $1/2$ inch in diameter, or $1/2$ inch in diameter or less. Hardware that is *greater than $1/2$ inch* in diameter takes a standard nut and SAE washer. Hardware *$1/2$ inch or less* in diameter can take a properly torqued whiz nut or spirallock nut. See Figure 2.

3. Follow these SAE washer rules after determining exit hole type:
 - a. Always use a washer between hardware and a slot.
 - b. Always use a washer under a nut (see 2 above for exception).
 - c. Use a washer under a bolt when the female thread is fixed (weld nut).
4. Refer to Figure 2, which depicts the preceding hardware configuration possibilities.

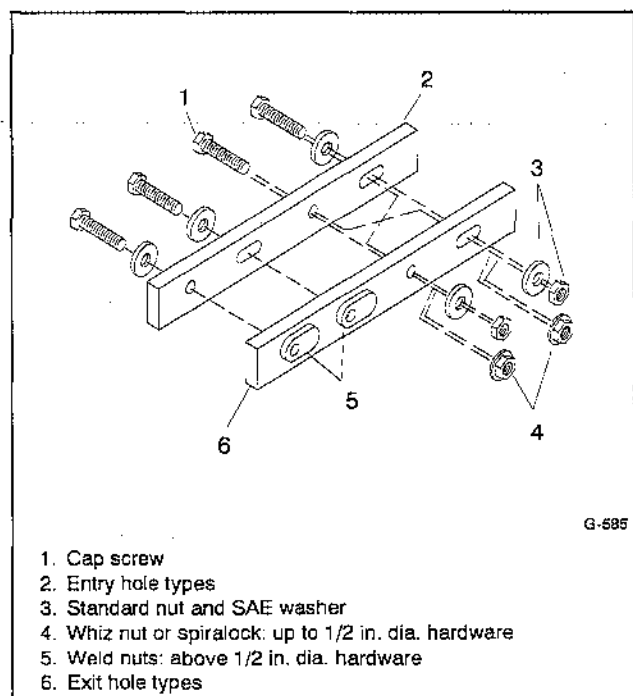


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

American Standard Fasteners Torque Specifications					
Size	Torque Measurement	Assembled into Cast Iron or Steel			Assembled into Aluminum Grade 2 or 5
		Grade 2	Grade 5	Grade 8	
8-32	Nm (in. lb.)	1.8 (16)	2.3 (20)	—	See Note 3
10-24	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	
10-32	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	
1/4-20	Nm (in. lb.)	6.8 (60)	10.8 (96)	14.9 (132)	
1/4-28	Nm (in. lb.)	8.1 (72)	12.2 (108)	16.3 (144)	
5/16-18	Nm (in. lb.)	13.6 (120)	21.7 (192)	29.8 (264)	
5/16-24	Nm (in. lb.)	14.9 (132)	23.1 (204)	32.5 (288)	
3/8-16	Nm (ft. lb.)	24 (18)	38 (28)	53 (39)	
3/8-24	Nm (ft. lb.)	27 (20)	42 (31)	60 (44)	
7/16-14	Nm (ft. lb.)	39 (29)	60 (44)	85 (63)	
7/16-20	Nm (ft. lb.)	43 (32)	68 (50)	95 (70)	
1/2-13	Nm (ft. lb.)	60 (44)	92 (68)	130 (96)	
1/2-20	Nm (ft. lb.)	66 (49)	103 (76)	146 (108)	
9/16-12	Nm (ft. lb.)	81 (60)	133 (98)	187 (138)	
9/16-18	Nm (ft. lb.)	91 (67)	148 (109)	209 (154)	
5/8-11	Nm (ft. lb.)	113 (83)	183 (135)	259 (191)	
5/8-18	Nm (ft. lb.)	128 (94)	208 (153)	293 (216)	
3/4-10	Nm (ft. lb.)	199 (147)	325 (240)	458 (338)	
3/4-16	Nm (ft. lb.)	222 (164)	363 (268)	513 (378)	
1-8	Nm (ft. lb.)	259 (191)	721 (532)	1109 (818)	
1-12	Nm (ft. lb.)	283 (209)	789 (582)	1214 (895)	

Metric Fasteners Torque Specifications, Measured in Nm (ft. lb.)					
Size (mm)	Assembled into Cast Iron or Steel			Assembled into Aluminum Grade 5.8 or 8.8	
	Grade 5.8	Grade 8.8	Grade 10.9		
M6 x 1.00	6.2 (4.6)	9.5 (7)	13.6 (10)	See Note 3	
M8 x 1.25	15 (11)	23 (17)	33 (24)		
M8 x 1.00	16 (11)	24 (18)	34 (25)		
M10 x 1.50	30 (22)	45 (34)	65 (48)		
M10 x 1.25	31 (23)	47 (35)	68 (50)		
M12 x 1.75	53 (39)	80 (59)	115 (85)		
M12 x 1.50	56 (41)	85 (63)	122 (90)		
M14 x 2.00	83 (61)	126 (93)	180 (133)		
M14 x 1.50	87 (64)	133 (98)	190 (140)		
M16 x 2.00	127 (94)	194 (143)	278 (205)		
M16 x 1.50	132 (97)	201 (148)	287 (212)		
M18 x 2.50	179 (132)	273 (201)	390 (288)		
M18 x 1.50	189 (140)	289 (213)	413 (305)		
M20 x 2.50	245 (181)	374 (276)	535 (395)		
M20 x 1.50	264 (195)	402 (297)	576 (425)		
M22 x 2.50	332 (245)	507 (374)	725 (535)		
M22 x 1.50	351 (259)	535 (395)	766 (565)		
M24 x 3.00	425 (314)	649 (479)	928 (685)		
M24 x 2.00	447 (330)	682 (503)	976 (720)		
M27 x 3.00	—	937 (692)	1341 (990)		
M27 x 2.00	—	985 (727)	1409 (1040)		
M30 x 3.50	—	1278 (943)	1829 (1350)		
M30 x 2.00	—	1349 (996)	1931 (1425)		

Notes:

1. The torque values above are general guidelines. Always use the torque values specified in the service manuals and/or assembly drawings when they differ from the above torque values.
2. The torque values above are based on new plated threads. Increase torque values by 15% if non-plated threads are used.
3. Hardware threaded into aluminum must have either two diameters of thread engagement or a 30% or more reduction in the torque to prevent stripped threads.
4. Torque values are calculated as equivalent stress loading on American hardware with an approximate preload of 90% of the yield strength and a friction coefficient of 0.125.

Appendix D Fuel Physical Properties

Physical Property @ 15°C (60°F)	Butane	Propane	Natural Gas	Manufactured or Sewage Gas	Gasoline	Diesel Fuel
Normal atmospheric state	Gas	Gas	Gas	Gas	Liquid	Liquid
Boiling point, Initial, °C (°F)	—	—	—	—	36 (97)	177 (350)
End, °C (°F)	0 (32)	42 (-44)	-162 (-259)	—	216 (420)	357 (675)
Heating value, Btu /gal. (net, LHV*)	94670	83340	63310	—	116400	130300
/gal. (gross)	102032	91500	—	—	124600	139000
/ft ³ (gas)	3264	2516	1000	600-700	6390	—
Density, Ft ³ of gas/gal.	31.26	36.39	57.75	—	19.5	—
Wt./gal. liquid, lb.	4.81	4.24	2.65	—	6.16	7.08
Octane Number Research	94	110+	110+	—	80-100	—
Motor	90	97	—	—	75-90	—

* Lower Heating Value

Figure 3 Engine Fuels, Physical Properties

Characteristic, LP Gas*	Butane	Propane
Formula	C ₄ H ₁₀	C ₃ H ₈
Boiling point, °C (°F)	0 (32)	-42 (-44)
Specific gravity of gas (air = 1.00)	2.00	1.53
Specific gravity of liquid (water = 1.00)	0.58	0.51
Btu/lb. of gas	21221	21591
Ft. ³ of vapor at 16°C (60°F)/lb. of liquid at 16°C (60°F)	6.506	8.547
Latent heat of vaporization at boiling point, Btu/gal.	808.0	785.0
Combustion Data:	31.02	23.86
Ft ³ air required to burn 1 ft. ³ of gas	N/A	-104 (-156)
Flash point, °C (°F)	482-538	493-549
Ignition temperature in air, °C (°F)	(900-1000)	(920-1020)
Max. flame temperature in air, °C (°F)	1991 (3615)	1979 (3595)
Limits of inflammability, percentage of gas in air mixture:		
At lower limit, %	1.9	2.4
At upper limit, %	8.6	9.6
Octane Number (ISO-Octane = 100)	92	Over 100

* Commercial quality. Figures shown in this chart represent average values.

Figure 4 Additional LP Gas Characteristics

Appendix E Gas Fuel Vapor Pressures

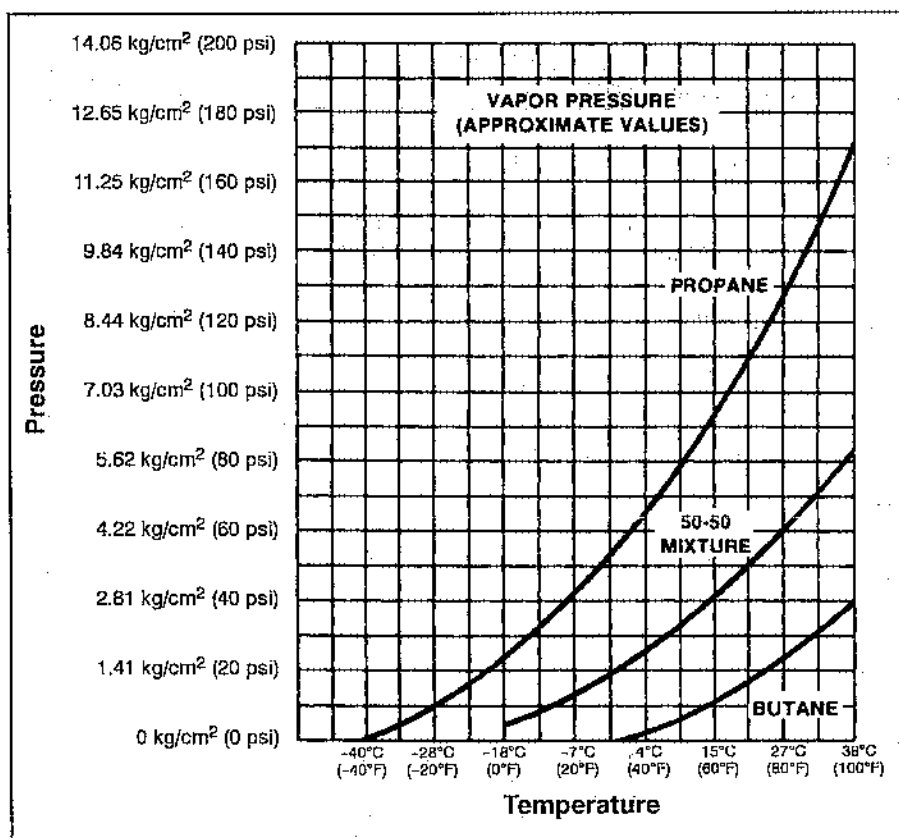


Figure 1 Vapor Pressures of LP Gases Graph

Temperature, °C (°F)	Approximate Pressure, kg/cm ² (PSIG)		
	Propane	50/50 Mixture	Butane
-40 (-40)	0.1 (1)	—	—
-36 (-33)	0.4 (5)	—	—
-28 (-20)	0.7 (10)	—	—
-23 (-10)	1.2 (17)	0.2 (3)	—
-18 (0)	1.7 (24)	0.4 (5)	—
-12 (10)	2.2 (32)	0.6 (8)	—
-7 (20)	3.0 (42)	0.9 (13)	—
-1 (30)	3.7 (52)	1.3 (19)	—
4 (40)	4.6 (65)	1.8 (26)	0.1 (2)
10 (50)	5.5 (78)	2.4 (34)	0.5 (7)
15 (60)	6.5 (93)	3.0 (42)	0.8 (12)
21 (70)	7.7 (109)	3.5 (50)	1.2 (17)
27 (80)	9.6 (136)	4.2 (60)	1.7 (24)
32 (90)	10.3 (147)	5.1 (72)	2.2 (32)
38 (100)	11.9 (169)	6.0 (85)	2.8 (40)
43 (110)	14.1 (200)	7.0 (100)	3.5 (50)

Figure 2 Vapor Pressures of LP Gases Table

Appendix F Gas Fuel System Installation Planning

Determining Propane Cylinder Quantity

Guide for Installing 100 lb. Cylinders

For continuous draws where temperatures may reach -18°C (-0°F). Assume the vaporization rate of 100 lb. cylinder as approximately 50000 Btu/hr.

$$\text{Number of cylinders/side} = \frac{\text{Total load in Btu}}{50000}$$

Example:

Assume total load = 20000 Btu/hour.

$$\text{Cylinders/side} = \frac{20000}{50000} = 4 \text{ cylinders/side}$$

The chart in Figure 1 shows the vaporization rate of containers in terms of the temperature of the liquid and the wet surface area of the container. When the temperature is lower or if the container contains less liquid, the vaporization rate of the container is a lower value.

Lb. of Propane in Cyl.	Maximum Continuous Draw In Btu/Hour At Various Temperatures In °C (°F)				
	-18°C (0°F)	-7°C (20°F)	4°C (40°F)	16°C (60°F)	21°C (70°F)
100	113000	167000	214000	277000	300000
90	104000	152000	200000	247000	277000
80	94000	137000	180000	214000	236000
70	83000	122000	160000	199000	214000
60	75000	109000	140000	176000	192000
50	64000	94000	125000	154000	167000
40	55000	79000	105000	131000	141000
30	45000	66000	85000	107000	118000
20	36000	51000	68000	83000	92000
10	28000	38000	49000	60000	66000

Figure 1 Vaporization Rate, 100 lb. Propane Cylinders, Approximate

Determining Propane Vaporization Capacity

Guide for ASME LP Gas Storage Containers

% of Container Filled	K Equals	Propane* Vaporization Capacity at -18°C (0°F) in Btu/Hr.†
60	100	D x L x 100
50	90	D x L x 90
40	80	D x L x 80
30	70	D x L x 70
20	60	D x L x 60
10	45	D x L x 45

* These formulae allow for the temperature of the liquid to refrigerate to -29°C (-20°F), producing a temperature differential of -7°C (20°F) for the transfer of heat from the air to the container's wetted surface and then into the liquid. The vapor space area of the vessel is not considered since its effect is negligible.

† D=outside diameter in inches
L=overall length in inches
K=constant for percent volume of liquid in container.

Figure 2 Propane Vaporization Capacity

Vaporizing Capacities for Other Air Temperatures

Multiply the results obtained with the formulae in Figure 2 by one of the factors in the following table for the prevailing air temperature.

Prevailing Air Temperature	Multiplier
-26°C (-15°F)	0.25
-23°C (-10°F)	0.50
-21°C (-5°F)	0.75
-18°C (0°F)	1.00
-15°C (5°F)	1.25
-12°C (10°F)	1.50
-9°C (15°F)	1.75
-7°C (20°F)	2.00

Figure 3 Propane Vaporization Temperature

Notes

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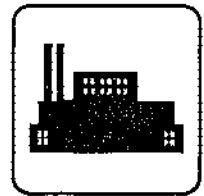
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TAB 3

Operation

Industrial Generator Sets



Models:

20-300 kW

Controller:

Decision-Maker® 3000

Software (Code) Version 1.2 or higher

KOHLER®
POWER SYSTEMS

ISO 9001
KOHLER
POWER SYSTEMS
NATIONALLY REGISTERED

TP-6694 11/10a

⚠ WARNING

Product Identification Information

This image shows a full page of primary-ruled notebook paper. It features ten sets of horizontal ruling lines, each consisting of two parallel lines with a dashed midline. Vertical margin lines are present on both the left and right sides, creating narrow margins. The paper is otherwise blank, with no handwriting or other markings.

Serial Number _____

Version No./Date Installed _____

Number and Description _____

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Safety Precautions and Instructions

IMPORTANT SAFETY INSTRUCTIONS. Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. **SAVE THESE INSTRUCTIONS.**

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

DANGER

Danger indicates the presence of a hazard that **will cause severe personal injury, death, or substantial property damage.**

WARNING

Warning indicates the presence of a hazard that **can cause severe personal injury, death, or substantial property damage.**

CAUTION

Caution indicates the presence of a hazard that **will or can cause minor personal injury or property damage.**

NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

Accidental Starting

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. **Accidental starting can cause severe injury or death.** Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

Battery

WARNING



Sulfuric acid in batteries.
Can cause severe injury or death.

Wear protective goggles and clothing. Battery acid may cause blindness and burn skin.

WARNING



Explosion.
Can cause severe injury or death.
Relays in the battery charger cause arcs or sparks.

Locate the battery in a well-ventilated area. Isolate the battery charger from explosive fumes.

Battery electrolyte is a diluted sulfuric acid. Battery acid can cause severe injury or death. Battery acid can cause blindness and burn skin. Always wear splashproof safety goggles, rubber gloves, and boots when servicing the battery. Do not open a sealed battery or mutilate the battery case. If battery acid splashes in the eyes or on the skin, immediately flush the affected area for 15 minutes with large quantities of clean water. Seek immediate medical aid in the case of eye contact. Never add acid to a battery after placing the battery in service, as this may result in hazardous spattering of battery acid.

Battery acid cleanup. Battery acid can cause severe injury or death. Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled battery acid and continue to add the neutralizing solution to the spilled battery acid until all evidence of a chemical reaction (foaming) has ceased. Flush the resulting liquid with water and dry the area.

Battery gases. Explosion can cause severe injury or death. Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects. Remove all jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

Battery short circuits. Explosion can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Disconnect the battery before generator set installation or maintenance. Remove all jewelry before servicing the equipment. Use tools with insulated handles. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery. Never connect the negative (-) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together.

Engine Backfire/Flash Fire

 WARNING

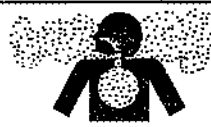
Fire. Can cause severe injury or death. Do not smoke or permit flames or sparks near fuels or the fuel system.

Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the generator set with the air cleaner removed.

Combustible materials. A fire can cause severe injury or death. Generator set engine fuels and fuel vapors are flammable and explosive. Handle these materials carefully to minimize the risk of fire or explosion. Equip the compartment or nearby area with a fully charged fire extinguisher. Select a fire extinguisher rated ABC or BC for electrical fires or as recommended by the local fire code or an authorized agency. Train all personnel on fire extinguisher operation and fire prevention procedures.

Exhaust System

 WARNING

Carbon monoxide. Can cause severe nausea, fainting, or death. The exhaust system must be leakproof and routinely inspected.

Generator set operation. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Avoid breathing exhaust fumes when working on or near the generator set. Never operate the generator set inside a building unless the exhaust gas is piped safely outside. Never operate the generator set where exhaust gas could accumulate and seep back inside a potentially occupied building.

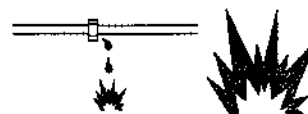
Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness, mental fatigue, inability to concentrate or speak clearly, blurred vision
- Stomachache, vomiting, nausea

If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

Fuel System

⚠ WARNING



Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

Explosive fuel vapors can cause severe injury or death. Take additional precautions when using the following fuels:

Propane (LP)—Adequate ventilation is mandatory. Because propane is heavier than air, install propane gas detectors low in a room. Inspect the detectors per the manufacturer's instructions.

Natural Gas—Adequate ventilation is mandatory. Because natural gas rises, install natural gas detectors high in a room. Inspect the detectors per the manufacturer's instructions.

Fuel tanks. Explosive fuel vapors can cause severe injury or death. Gasoline and other volatile fuels stored in day tanks or subbase fuel tanks can cause an explosion. Store only diesel fuel in tanks.

Draining the fuel system. Explosive fuel vapors can cause severe injury or death. Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

Gas fuel leaks. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Check the LP vapor gas or natural gas fuel system for leakage by using a soap and water solution with the fuel system test pressurized to 6-8 ounces per square inch (10-14 inches water column). Do not use a soap solution containing either ammonia or chlorine because both prevent bubble formation. A successful test depends on the ability of the solution to bubble.

LP liquid withdrawal fuel leaks. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Check the LP liquid withdrawal gas fuel system for leakage by using a soap and water solution with the fuel system test pressurized to at least 90 psi (621 kPa). Do not use a soap solution containing either ammonia or chlorine because both prevent bubble formation. A successful test depends on the ability of the solution to bubble.

Hazardous Noise

CAUTION



Hazardous noise.
Can cause hearing loss.

Never operate the generator set without a muffler or with a faulty exhaust system.

Engine noise. Hazardous noise can cause hearing loss. Generator sets not equipped with sound enclosures can produce noise levels greater than 105 dBA. Prolonged exposure to noise levels greater than 85 dBA can cause permanent hearing loss. Wear hearing protection when near an operating generator set.

Hazardous Voltage/ Moving Parts

DANGER



Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

WARNING



Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

WARNING



Hazardous voltage.
Backfeed to the utility system can cause property damage, severe injury, or death.

If the generator set is used for standby power, install an automatic transfer switch to prevent inadvertent interconnection of standby and normal sources of supply.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

Installing the battery charger. Hazardous voltage can cause severe injury or death. An ungrounded battery charger may cause electrical shock. Connect the battery charger enclosure to the ground of a permanent wiring system. As an alternative, install an equipment grounding conductor with circuit conductors and connect it to the equipment grounding terminal or the lead on the battery charger. Install the battery charger as prescribed in the equipment manual. Install the battery charger in compliance with local codes and ordinances.

Connecting the battery and the battery charger. Hazardous voltage can cause severe injury or death. Reconnect the battery correctly, positive to positive and negative to negative, to avoid electrical shock and damage to the battery charger and battery(ies). Have a qualified electrician install the battery(ies).

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Engine block heater. Hazardous voltage can cause severe injury or death. The engine block heater can cause electrical shock. Remove the engine block heater plug from the electrical outlet before working on the block heater electrical connections.

Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death. Install a transfer switch in standby power installations to prevent the connection of standby and other sources of power. Electrical backfeed into a utility electrical system can cause severe injury or death to utility personnel working on power lines.

Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically. (600 volts and under)

⚠ WARNING



Airborne particles. Can cause severe injury or blindness.

Wear protective goggles and clothing when using power tools, hand tools, or compressed air.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Heavy Equipment

⚠ WARNING



Unbalanced weight. Improper lifting can cause severe injury or death and equipment damage.

Do not use lifting eyes. Lift the generator set using lifting bars inserted through the lifting holes on the skid.

Hot Parts

⚠ WARNING



Hot coolant and steam. Can cause severe injury or death.

Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure.

⚠ WARNING



Hot engine and exhaust system. Can cause severe injury or death.

Do not work on the generator set until it cools.

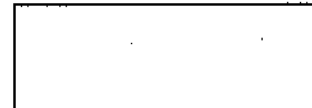
Servicing the alternator. Hot parts can cause severe injury or death. Avoid touching the alternator field or exciter armature. When shorted, the alternator field and exciter armature become hot enough to cause severe burns.

Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

Notice

NOTICE

This generator set has been rewired from its nameplate voltage to



246242

NOTICE

Voltage reconnection. Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/dealer.

NOTICE

Canadian installations only. For standby service connect the output of the generator set to a suitably rated transfer switch in accordance with Canadian Electrical Code, Part 1.

This manual provides operation instructions for 20 kW and larger generator sets equipped with the following controller:

- Decision-Maker® 3000, Software (Code) Version 1.2 or higher

Version 1.2 refers to the controller application software. To determine the generator set controller software version, go to the Overview menu.

Wiring diagram manuals are available separately. Refer to the engine operation manual for generator set engine scheduled maintenance information.

Information in this publication represents data available at the time of print. Kohler Co. reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

The equipment service requirements are very important to safe and efficient operation. Inspect the parts often and perform required service at the prescribed intervals. Maintenance work must be performed by appropriately skilled and suitably trained maintenance personnel familiar with generator set operation and service.

Abbreviations

This publication makes use of numerous abbreviations. Typically, the word(s) are spelled out along with the abbreviation in parentheses when shown for the first time in a section. Appendix A, Abbreviations, also includes many abbreviation definitions.

List of Related Materials

Separate literature contains communication and software information not provided in this manual. Figure 1 lists the available literature part numbers.

Literature Description	Literature Part No.
Controller Spec Sheet	G6-100
Generator Set/Controller Wiring Diagram Manual	Multiple Part Numbers Contact your Distributor/Dealer
Modbus® Communications Protocol Operation Manual	TP-6113
Service Parts Decision-Maker® 3000 Controller	TP-6781
SiteTech™ Software Operation Manual	TP-6701
Remote Serial Annunciator II (RSA II)	TT-1485
Converters, Connections, and Controller Setup for Network Communication	TT-1405

Figure 1 Related Literature

Several engine manufacturers provide engines with electronic controls. These electronic controls indicate engine fault codes in addition to the generator set controller. The engine operation and service literature provide information for identifying engine fault codes. For the latest literature part numbers, see the respective Parts Catalog.

SiteTech™ Software

Several instances in this manual make reference to SiteTech™ software which is required for programming the Decision-Maker® 3000 controller. SiteTech™ software is also needed for updating the controller application code. Contact your local distributor/dealer for assistance.

For professional advice on generator set power requirements and conscientious service, please contact your nearest Kohler distributor or dealer.

- Consult the Yellow Pages under the heading Generators—Electric.
- Visit the Kohler Power Systems website at KohlerPower.com.
- Look at the labels and stickers on your Kohler product or review the appropriate literature or documents included with the product.
- Call toll free in the US and Canada 1-800-544-2444.
- Outside the US and Canada, call the nearest regional office.

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Fax: (86) 10 6518 7955

East China Regional Office, Shanghai
Phone: (86) 21 6288 0500
Fax: (86) 21 6288 0550

India, Bangladesh, Sri Lanka

India Regional Office
Bangalore, India
Phone: (91) 80 3366208
(91) 80 3366231
Fax: (91) 80 3315972

Japan, Korea

North Asia Regional Office
Tokyo, Japan
Phone: (813) 3440-4515
Fax: (813) 3440-2727

Section 1 Specifications and Features

1.1 Introduction

The spec sheets for each generator set provide model-specific generator and engine information. The controller spec sheet provides specifications for this controller. Refer to the respective spec sheet for data not supplied in this manual. Refer to the generator set service manual, installation manual, engine operation manual, and engine service manual for additional specifications.

1.2 Controller Features

The controller features include the annunciator lamp, digital display and pushbutton/rotary selector dial, switches and controls, and fuses and terminal strip. The following paragraphs detail the features by general topics.

See Figure 1-1 for an illustration of the controller front panel.

The controller features, accessories, and menu displays depend upon the engine electronic control module (ECM) setup and features. Controller features apply to generator set models with ECM and non-ECM engines unless otherwise noted.

Note: Press the pushbutton/rotary selector dial to turn on the controller lights and display. The light and display turn off 60 minutes after the last entry when in the AUTO mode.

Note: After about 5 minutes of no user input (pushbutton/rotary selector dial or buttons), the menu is reset to the top of the main menus and auto-paging activates for the Overview submenus.

Note: Measurements display in metric or English units. Use the Generator Set System menu to change the measurement display.

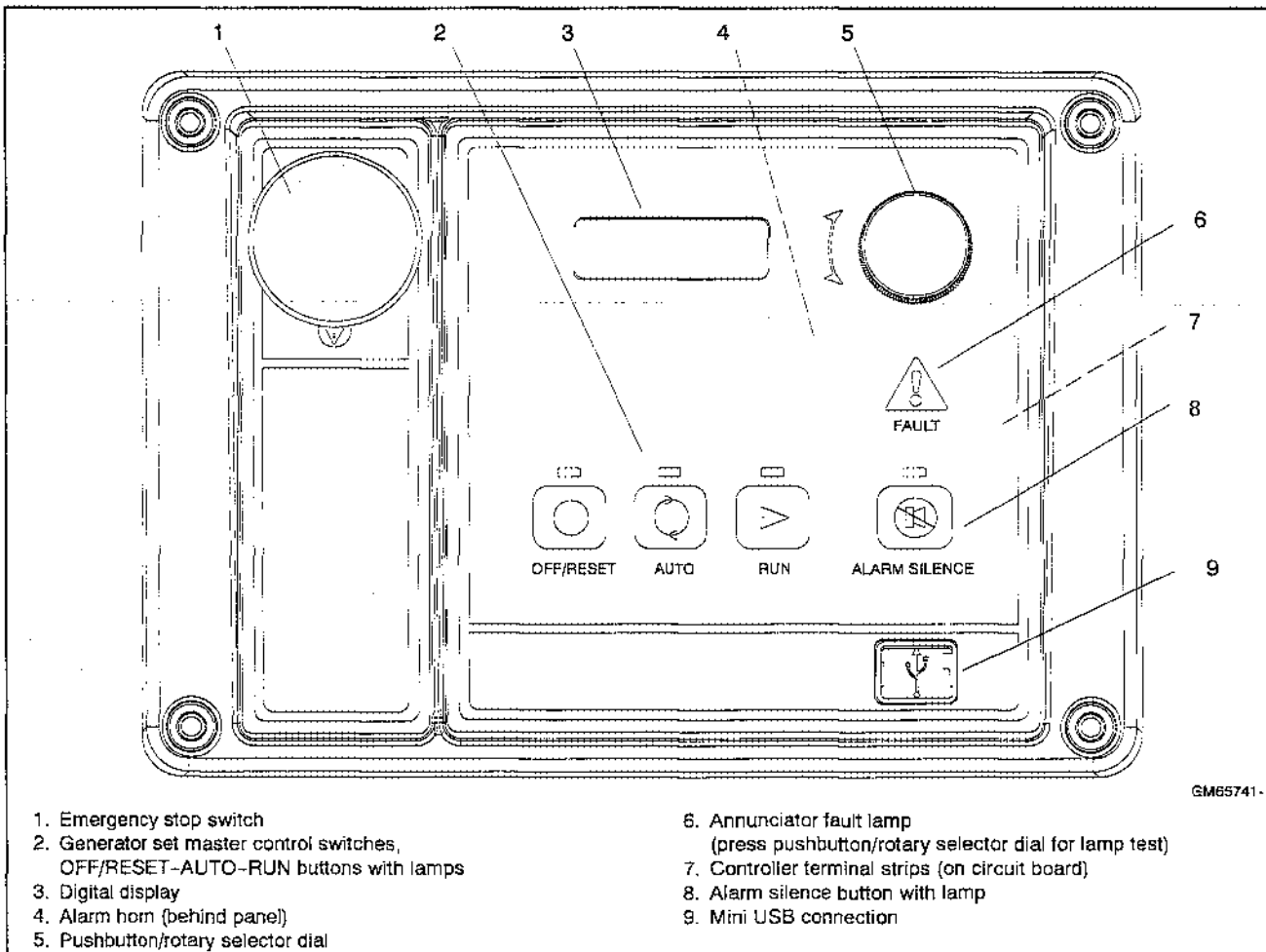


Figure 1-1 Decision-Maker® 3000 Controller with Digital Display and Pushbutton/Rotary Selector Dial

1.2.1 Switches and Controls

Note: **US/Metric Display** is selectable in Section 1.2.3—Digital Display—Generator Set System Menu.

Alarm Horn. The alarm horn alerts the operator or other attendants that a shutdown or warning condition exists.

Alarm (Horn) Silence. The alarm silence switch silences the alarm horn at the operator's discretion. Press the master control switch AUTO button *before* pressing the alarm silence button. The alarm horn cannot be silenced unless the master control switch AUTO button is pressed.

Note: Additional alarm silencing options are shown in Section 1.2.3—Digital Display—Generator Set System Menu.

Restore alarm horn switches at all locations including those on remote annunciator kits after correcting the fault shutdown to avoid reactivating the alarm horn. See Section 2—Operation, 2.3.8 Controller Resetting for resetting the controller.

Emergency Stop. The operator-activated pushbutton immediately shuts down the generator set in emergency situations. Reset the emergency stop switch after shutdown by pulling the emergency stop switch outward. *Use the emergency stop switch for emergency shutdowns only.* Use the master control switch OFF/RESET button for normal shutdowns.

Generator Set Master Control Switches (OFF/RESET-AUTO-RUN). These switches reset the controller fault lamps and start/stops the generator set. Additional information is shown in Section 2—Operation.

Lamp Test. Press and hold the Alarm Silence/Lamp Test button to test the controller indicator lamps, alarm horn, and digital display.

Pushbutton/Rotary Selector Dial. This control provides access to the menus for monitoring. Press the selector dial to activate the digital display and to select choices shown on the display. Rotate the dial to navigate through the menus.

The pushbutton/rotary selector dial has several features and functions:

- Momentarily press the dial to activate the digital display if dark.
- Rotate the dial to navigate through the main menus—turn clockwise to go forward (down) and counterclockwise to go back (up). The menus do not wrap to the beginning.

- Press the dial at a given main menu to access the submenus within the selected main menu.
- When in the submenu, rotate the dial to navigate through the submenu—clockwise to go forward (down) and counterclockwise to go back (up). The menus do not wrap to the beginning.
- Momentarily press the dial when in the submenu to make a user selection choice (if available) or to go back to the respective main menu.
- Press the dial for at least 3 seconds to return to the top of the main menus (Overview) regardless if you are in the main menus or submenus.
- After about 5 minutes of no user input (pushbutton/rotary selector dial or buttons), the menu resets to the top of the main menus and auto-paging activates for the Overview submenus.

1.2.2 Annunciator Lamps

The controller has a single annunciator fault lamp providing visual generator set status. In addition, each button has a corresponding lamp. See Figure 1-2.

Lamp/Button	Lamp Color
Alarm (Fault) Lamp	Yellow (Warning) or Red (Shutdown)
Off/Reset Button	Red
Auto Button	Green (System Ready)
Run Button	Yellow
Alarm Silence Button	Yellow

Figure 1-2 Annunciator Lamps

System Status Lamps (Master Control Switches)

The green lamp illuminates on the master control switch AUTO (automatic start) button indicating the system senses no faults and the unit is ready to start by remote command.

The red lamp illuminates on the master control switch OFF/RESET button indicating the generator set is stopped.

The yellow lamp illuminates on the master control switch RUN button indicating the generator set is cranking or running from a local command.

Only one of the three master control switch lamps will illuminate at any given time.

Alarm Silence Lamp. Red lamp illuminates indicating the alarm horn was silenced.

(System) Fault Lamp. Yellow lamp illuminates indicating a warning condition or red lamp illuminates indicating a shutdown condition. See System Warning Fault Lamp and System Shutdown Fault Lamp following for system fault conditions.

System Warning Fault Lamp. Yellow lamp identifies an existing fault condition that does not shut down the generator set. A continuing system warning fault condition may cause a system shutdown. Correct all system warnings as soon as practical.

See Section 2.3.5, System Fault Warning Lamp with Digital Displays, for definitions of the items listed. The following conditions cause a system warning:

- AC sensing loss
- Auxiliary input (analog or digital)
- Battery charger fault *
- Common fault
- Critical high fuel level (diesel-powered models only) *
- ECM diagnostics (multiple engine inputs)
- Default parameters loaded
- Fuel tank leak (diesel-powered models only) *
- Ground fault *
- High battery voltage
- High coolant temperature
- High fuel level (diesel-powered models only) *
- Input/output communication loss
- Low battery voltage
- Low coolant temperature
- Low cranking voltage
- Low engine oil level *
- Low fuel (level for diesel-powered models) *
- Low fuel (pressure for gas-powered models) *
- Low oil pressure
- Not-in-auto (master control switch)
- Speed sensor fault

* Requires optional input sensors.

System Shutdown Fault Lamp. Red lamp indicates that the generator set has shut down because of a fault condition. The unit will not start without resetting the controller, see Section 2.3.8, Controller Resetting procedure.

See Section 2.3.6, System Fault Shutdown Lamp with Digital Displays, for definitions of the items listed. The following conditions cause a system shutdown:

- AC sensing loss
- Alternator protection
- Auxiliary input (analog or digital)
- Common fault
- ECM communications loss
- ECM diagnostics (multiple engine inputs)
- ECM faults (model mismatch and address conflict)
- Emergency stop
- Engine over speed
- Engine under speed
- File system error (controller firmware fault)
- Fuel tank leak (diesel-powered models only) *
- High coolant temperature
- Internal failure
- kW overload
- Locked rotor (failed to crank)
- Low coolant level *
- Low engine oil level *
- Low fuel level (diesel-powered models only) *
- Low oil pressure
- Metering communication loss
- No coolant temperature signal
- No oil pressure signal
- Overcrank
- Overfrequency
- Overvoltage (each phase)
- Underfrequency
- Undervoltage (each phase)
- (Voltage) regulator communication loss

* Requires optional input sensors.

1.2.3 Digital Display

Press the pushbutton/rotary selector dial to turn on the controller lamps and display. The lamps and display turn off 60 minutes after the last entry.

The generator set must be running for some displays to indicate values. If the generator set is not running some values will display zero or N/A (not available).

The 12-character, 2-line backlit heated display provides generator set and engine data, system status, and fault information. See Figure 1-1. The digital display shows abbreviations in some instances, refer to 1.3.1 Status Event and Fault Specifications for the abbreviations and their full descriptions.

Note: US/Metric Unit Display is selectable in Generator Set System.

Note: After about 5 minutes of no user input (pushbutton/rotary selector dial or buttons), the menu resets to the top of the main menus and auto-paging activates for the Overview submenus.

There are 12 main menus with multiple submenus within each main menu. The main menus are:

- Overview
- Engine Metering
- Generator Metering
- GenSet Information
- GenSet Run Time
- GenSet System
- GenSet Calibration
- Voltage Regulation
- Digital Inputs
- Digital Outputs
- Analog Inputs
- Event Log

Overview Menu

When a new shutdown or warning fault occurs, the auto-paging display feature activates.

Software Version displays in the Overview menu. Use the version number to determine if an upgrade is needed and/or when troubleshooting the controller.

Active **Shutdowns** display if any are present. This alerts the user to single or multiple shutdown fault conditions. See 1.2.2—Annunciator Lamps—System Shutdown Fault Lamp for a list of possible shutdown faults.

Active **Warnings** display if any are present. This alerts the user to single or multiple warning fault conditions. See 1.2.2—Annunciator Lamps—System Warning Fault Lamp for a list of possible warning faults.

Engine Run Time displays the total run time hours.

Average Volts Line-to-Line value displays. For three-phase configurations the average line-to-line voltage of L1, L2, and L3 is displayed. Single-phase configurations show the L1-L2 voltage.

Frequency (Hz) value displays for the output AC voltage.

Current value displays as the average for three-phase configurations or the current value for L1-L2 with single-phase configurations.

Coolant Temperature displays for the engine coolant temperature.

Fuel Level displays the fuel tank level for diesel-powered models.

Fuel Pressure displays the fuel line pressure at the generator set inlet for gas-powered models.

Oil Pressure displays the engine oil pressure.

Battery displays the DC voltage of the engine starting battery(ies).

Engine Metering Menu

Engine Speed (Tachometer) displays the engine speed in RPM.

Oil Pressure displays the engine oil pressure. This value also shows in the Overview Menu.

Coolant Temperature displays the engine coolant temperature. This value also shows in the Overview Menu.

Fuel Level displays the fuel tank level for diesel-powered models. This value also shows in the Overview Menu.

Fuel Pressure displays the fuel line pressure at the generator set inlet for gas-powered models. This value also shows in the Overview Menu.

Battery displays the DC voltage of the engine starting battery(ies). This value also shows in the Overview Menu.

Generator Metering Menu

Total Power kVA and kW displays alternator output as actual output values.

Rated Power displays alternator output as a percentage of the entered data value.

Volts displays the alternator output AC voltages. The display shows all line-to-line and line-to-neutral voltage combinations for three-phase or single-phase configurations.

Current displays the alternator output AC amps. The display shows each line (L1/L2/L3) of three-phase models or L1/L2 current for single-phase models.

Frequency (Hz) value displays for the output AC voltage. This value also shows in the Overview Menu.

Generator Set Information Menu

GenSet M/N displays the generator set model number.

GenSet S/N displays the generator set serial number.

Controller S/N displays the controller serial number.

Generator Set Run Time Menu

Engine Run Time displays the total run time hours. This value also shows in the Overview Menu.

Engine Loaded displays the total loaded hours.

Engine Starts displays the total number of generator set startup events.

Total Energy displays the total kW hours.

Generator Set System Menu

The values in this menu are user-entered for the generator set configuration and are NOT measured values of the generator set.

Changes to the Generator Set System menu require the use of SiteTech™ software except for Measure Units and Alarm Silence selections.

System Voltage displays the programmer-entered L1/L2/L3 output voltage for three-phase or the L1/L2 output voltage for single-phase.

System Frequency displays the programmer-entered L1/L2/L3 output voltage frequency for three-phase or the L1/L2 output voltage frequency for single-phase.

System Phase displays the programmer-entered configuration as Single Phase, Single Phase Dog Leg, Three Phase Wye, or Three Phase Delta.

Power Rating displays the programmer entered kW value for the generator set.

Amp Rating displays the programmer entered current value for the generator set.

Power Type displays the programmer entered generator set application configuration as Standby or Prime.

Measure Units displays the user selected unit of measure as Metric or English.

Alarm Silence displays the user selected alarm silence method Always or Auto Only. The Always selection activates the alarm horn in any of the OFF/RESET-AUTO-RUN modes. The Auto Only selection activates the alarm horn only when in the Auto mode.

Note: Press the Alarm Silence/Lamp Test button to silence the alarm horn.

Generator Set Calibration Menu

The calibration values are reviewable at all times and provide the calibration of the voltage and current sensing logic. Changing the system voltage or replacing the circuit board requires a calibration adjustment. In order to review the values when the generator set is NOT running, enter Yes when the *Enter Calib?* is displayed. The user can review the values but attempting to change the values will cause a *Cannot calibrate* error message.

If the unit is NOT running and No is entered when the *Enter Calib?* is shown, the display returns to the Generator Set Calibration main menu and entry to the Generator Set Calibration menu is denied.

If the unit is running and Yes is entered when the *Enter Calib?* is shown, the display will show the following values for three-phase generator sets. Single-phase generator sets will only display items marked (*).

- Volts L1-L2 *
- Volts L2-L3
- Volts L3-L1
- Volts L1-N *
- Volts L2-N *
- Volts L3-N
- Current L1 *
- Current L2 *
- Current L3

The user can change individual values or can enter Yes when *Reset all calib?* is displayed. At the end of the Generator Set Calibration menu, *Exit calibration* is shown. Press the pushbutton/rotary selector dial to exit

this menu. Refer to the requirements shown with Generator Set Calibration in 2.3.7 Status and Notice Digital Displays.

Voltage Regulator Menu

The voltage regulator value is reviewable at all times. In order to review the value when the generator set is NOT running, enter Yes when the *Enter volt reg?* is displayed. The user can review the value but attempting to change the value will cause a *Cannot edit when stopped* error message.

If the unit is NOT running and No is entered when the *Enter volt reg?* is shown, the display returns to the Voltage Regulator main menu and entry to the Voltage Regulator menu is denied.

If the unit is running and Yes is entered when the *Enter volt reg?* is shown, the display will show the value.

The user can change the value at this time. At the end of the Voltage Regulator menu, *Exit voltage reg* is shown--press the pushbutton/rotary selector dial to exit this menu.

Digital Inputs Menu

This menu allows the user to review the settings. There are up to three digital inputs that are programmer selectable if not reserved by factory options.

There is an optional 2 input/5 output (I/O) module board available that can provide two additional digital (or analog) inputs.

The displays for digital inputs appear as shown below with Values true or false. Items shown in the digital display as True are active.

- DIn A1 (digital input A1) standard
- DIn A2 (digital input A2) standard
- DIn A3 (digital input A3) standard
- DIn B1 (digital input B1) with I/O module board
- DIn B2 (digital input B2) with I/O module board

Changes to the Digital Inputs menu requires the use of SiteTech™ software. The digital input can either open or close the circuit to activate.

Digital Outputs Menu

This menu allows the user to review the settings. There is one digital output standard with the controller that is programmer selectable. The one SPDT switch has 2 amp. contacts at 32 VDC or 0.5 amp. contacts at 120 VAC max.

There is an optional 2 input/5 output (I/O) module board available that can provide five digital outputs. The standard digital output on the controller is used to drive the optional I/O Module board and becomes factory reserved and no longer available as programmer selectable.

The displays for digital outputs appear as shown in the following list with Values as True or False. Items shown in the digital display as True are active.

- DOut A1 (digital output A1) standard
- DOut B1 (digital output B1) with I/O module board
- DOut B2 (digital output B2) with I/O module board
- DOut B3 (digital output B3) with I/O module board
- DOut B4 (digital output B4) with I/O module board
- DOut B5 (digital output B5) with I/O module board

Changes to the Digital Outputs menu requires the use of SiteTech™ software. The digital output can either open or close the circuit to activate.

Analog Inputs Menu

This menu allows the user to review the settings. There is one analog input that is programmer selectable if not reserved by factory options.

There is an optional 2 input/5 output (I/O) module board available that can provide two additional analog (or digital) inputs.

The displays for analog inputs appear as shown below with Values of 0-5 volts.

- AIn A1 (analog input A1) standard
(reserved and not user programmable)
- AIn A2 (analog input A2) standard
- AIn B1 (analog input B1) with I/O module board
- AIn B2 (analog input B2) with I/O module board

Changes to the Analog Inputs menu requires the use of SiteTech™ software.

Event Log Menu

This menu allows the user to review up to 1000 entries of system events including shutdown faults, warning faults, and status events. See 1.2.4 Controller Fault Diagnostics for a list of the items that appear on the Event Log.

1.2.4 Controller Fault Diagnostics

This table provides descriptions of the system events and their types—warning, shutdown, status, and notice.

Warnings show yellow fault lamp and signal an impending problem. **Shutdowns** show red fault lamp and stop the generator set. **Status** is an event that is not an alert but is part of the event history. **Notice** is an alert

that is NOT part of the event history. System events are available as a **Relay Output** as shown.

Throughout this manual there are examples of the display text. In some cases, the message words and phrases are abbreviated or shortened to accommodate the number of characters in the 12 x 2 digital display. See the following table for a full description of the system event display messages.

System Events Display Message List

Description	Display Message	Warning Function	Shutdown Function	Status/ Notice	Relay Output
Engine Functions					
Critically high fuel level (diesel-powered models only) *	Fuel Level Critically High	X			X
ECM communications loss	ECM Comm Err Shutdwn		X		X
ECM diagnostics (multiple inputs) †	ECM xxxxxx Warning	X			X
ECM diagnostics (multiple inputs) †	ECM xxxxxx Shutdwn		X		X
ECM faults (address conflict)	ECM Addr Err Shutdwn		X		X
ECM faults (model mismatch)	ECM Mismatch Shutdwn		X		X
Engine over speed	Eng Speed High Shutdwn		X‡		X
Engine start aid active	Starting Aid Notice			N	X
Engine under speed	Eng Speed Low Shutdwn		X		X
Fuel tank leak *	Fuel Leak Warning	X			X
Fuel tank leak *	Fuel Leak Shutdwn		X		X
High battery voltage	Battery High Warning	X			X
High coolant temperature	Coolnt Temp High Warning	X			X
High coolant temperature	Coolnt Temp High Shutdwn		X‡		X
High fuel level (diesel-powered models only) *	Fuel Level High Warning	X			X
Low battery voltage	Battery Low Warning	X			X
Low coolant level *	Coolant Lvl Low Shutdwn		X		X
Low coolant temperature	Coolant Temp Low Warning	X			X
Low cranking voltage	Lo Crank Vlt Warning	X			X
Low engine oil level *	Oil Level Low Warning	X			X
Low engine oil level *	Oil Level Low Shutdwn		X		X
Low fuel level (diesel models) *	Fuel Level Low Warning	X			X
Low fuel level (diesel models) *	Fuel Level Low Shutdwn		X		X
Low fuel pressure (gas models) *	Fuel Press Low Warning	X			X
Low oil pressure	Oil Press Low Warning	X			X
Low oil pressure	Oil Press Low Shutdwn		X‡		X
No coolant temperature signal	Temp Sig Loss Shutdwn		X		X
No oil pressure signal	Press Sig Loss Shutdwn		X		X
Overcrank	Over Crank Shutdwn		X‡		X
Speed sensor fault	Spd Sens Flt Warning	X			X
General Functions					
Alarm horn silenced	(Alarm Silence LED only)				X
Alarm silence, auto only (NFPA 110) or always	AlrmSilence: Auto Only or AlrmSilence: Always			S	No
Aux. inputs 0-5 VDC, 1 analog (2 additional inputs available with I/O module option)	Aux Input Warning	X			X
Aux. inputs 0-5 VDC, 1 analog (2 additional inputs available with I/O module option)	Aux Input Shutdwn		X		X
Auxiliary inputs, up to 3 digital (2 additional inputs available with I/O module option)	Aux Input Warning	X			X
Auxiliary inputs, up to 3 digital (2 additional inputs available with I/O module option)	Aux Input Shutdwn		X		X
Backup parameters loaded	Backup Pars Status			S	No
Battery charger fault *	Batt Chg Flt Warning	X			X

Description	Display Message	Warning Function	Shutdown Function	Status/ Notice	Relay Output
Chicago code active *	Auto Locked Notice			N	X
Common fault (includes ‡)	Common Fault Shutdwn		X	N	X
Common warning fault	Common Warrng	X		N	X
Default parameters loaded	Default Pars Warning	X			X
Emergency stop	Emerg Stop Shutdwn		X‡		X
Engine cooldown (delay) active	Eng Cooldown Notice			N	X
Engine start delay active	Start Delay Notice			N	X
Engine started	Engine Start Status			S	X
Engine stopped	Engine Stop Status			S	X
EPS supplying load	Emerg Pwr On Notice			N	X
File system error (controller fault)	File Error Shutdwn		X		X
Generator running	Gen Running Notice			N	X
Input/output (module option board) communication loss	OB1 Com Loss	X			X
Internal failure	Intern Error Shutdwn		X		X
Metering communication loss	MeterCommLos Shutdwn		X		X
NFPA 110 alarm active	NFPA Alarm Notice			N	X
Not in auto (master switch)	Not In Auto Warning	X			X
Remote start	Remote Start Status			S	X
System ready	System Ready Status			S	X
System timer failed	Timer Error Notice			N	X
Generator Functions					
AC sensing loss	AC Sens Loss Warning	X			X
AC sensing loss	AC Sens Loss Shutdwn		X		X
Alternator protection	Alt Protect Shutdwn		X		X
Ground fault input *	Ground Fault Warning	X			X
kW overload	Total Power High Shutdwn		X		X
Locked rotor (failed to crank)	Locked Rotor Shutdwn		X		X
Overfrequency	Freq High Shutdwn		X		X
Overvoltage (each phase)	Volts xx-xx High Shutdwn		X		X
Undertfrequency	Frequency Low Shutdwn		X		X
Undervoltage (each phase)	Volts xx-xx Low Shutdwn		X		X
(Voltage) regulator communication loss	RegCommLoss Shutdwn		X		X

* Some functions require optional input sensors or are engine ECM dependent on some generator set models.

† ECM inputs are engine manufacturer dependent.

‡ The Common Fault Shutdown includes the items marked X‡ in the Shutdown Function column.

1.2.5 Digital Display Circuit Board and Connections

The digital display circuit board provides:

- The backlit LCD (liquid crystal display) for monitoring the generator set functions and output values
- Master control switches with status lights
- Fault lamp
- Pushbutton/rotary selector dial to navigate the generator set displays
- Alarm horn and alarm silence switch/light
- Mini USB connector for PC setup using SiteTech™ software

See Figure 1-3 for the circuit board connections.

Circuit Board Connections

P9 Connector the 24-pin connector attaches directly to the main logic circuit board.

P10 Connector mini USB for PC upgrades located on the front panel using SiteTech™ software.

P11 Connector is a 20-pin connector (not used).

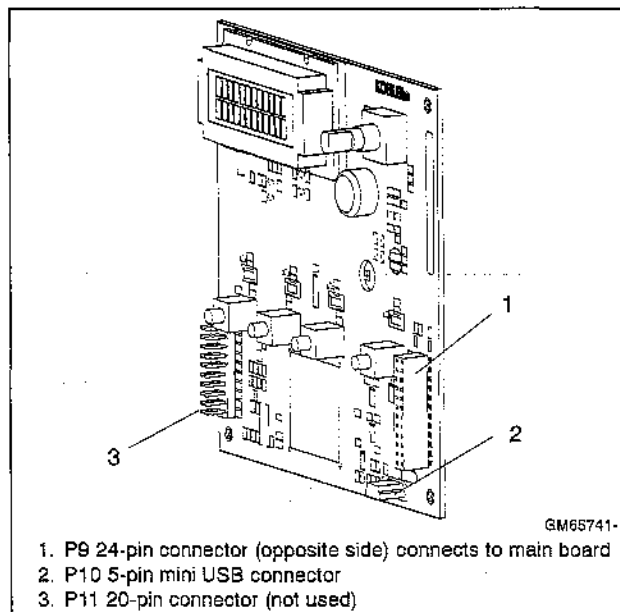


Figure 1-3 Digital Display Circuit Board Connectors

1.2.6 Main Logic Circuit Board

The main logic circuit board provides the terminal strips and connection sockets to connect the controller to the engine/generator, input/output connections, optional I/O module kit, and circuit protection fuses. See Figure 1-4 and Figure 1-5 for the circuit board connections. See Section 6, Accessories for more information.

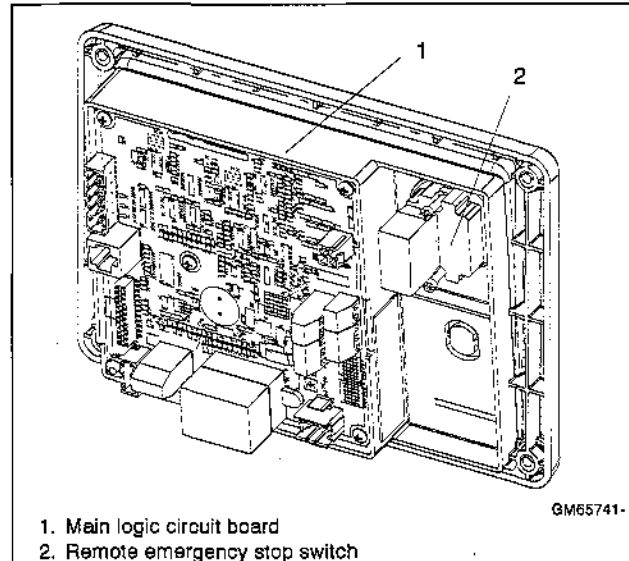


Figure 1-4 Main Circuit Board and Emergency Stop Switch

Circuit Board Connections

P1 (24-Pin) Connector for engine/generator wiring harness.

P2 (6-Pin) Connector for AC current.

(4) Push-on Connectors for V7/V8/V9/V0 for generator set output voltage connection.

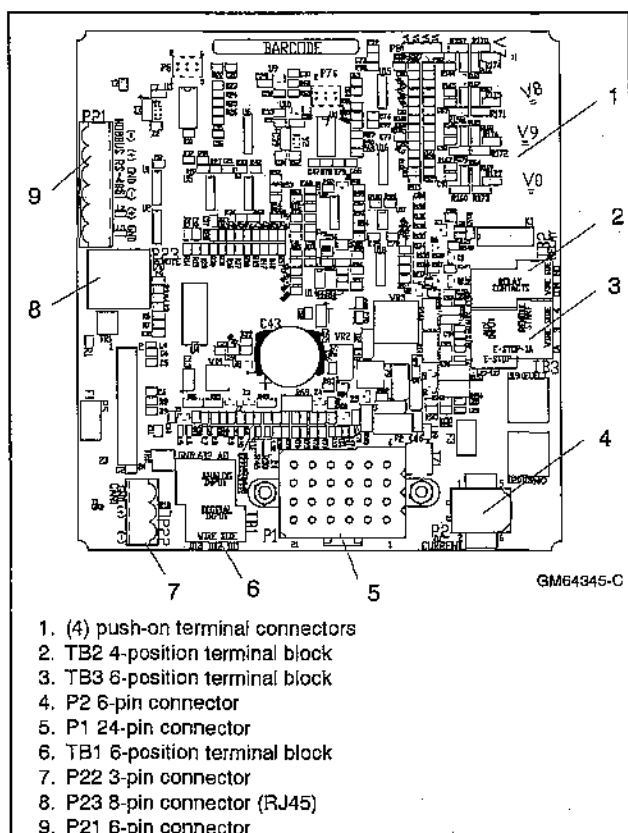


Figure 1-5 Main Circuit Board Connectors

P21 (6-Pin) Connector for (RS-485) connection of optional RSA.

P22 (3-Pin) Connector for engine ECM. Alternate CAN connection.

P23 (8-Pin) Connector (RJ45) for optional input/output (I/O) module circuit board.

Refer to Section 6.2, Accessory Connections for specific connections of the following terminal block connections.

TB1 (6-Position) Terminal Block for analog and digital inputs.

TB2 (4-Position) Terminal Block for K1 relay outputs.

TB3 (6-Position) Terminal Block for E-stop, remote start contacts, and aux. input connections.

1.2.7 Communication Port

The main logic circuit board contains a single mini USB communication port for PC connections. See Figure 1-6. Refer to the List of Related Materials in the Introduction for corresponding SiteTech™ software and/or communication installation information.

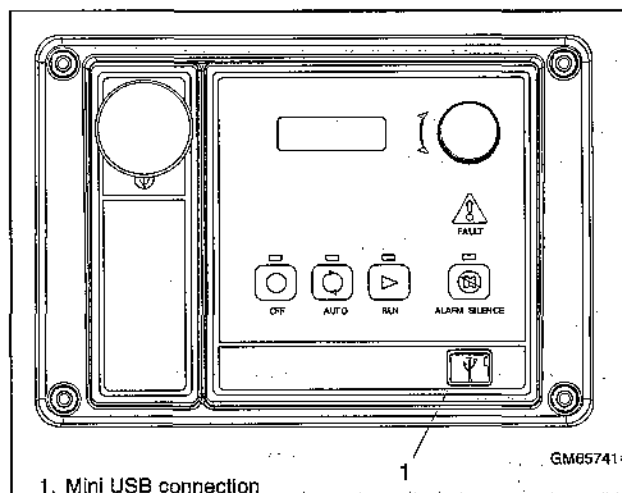


Figure 1-6 Communication Port

1.2.8 Fuses

AC Circuit Fuses (TB5). Fuses are located inside the generator set control box. See Figure 1-7

- **1.5-Amp (V7)** fuse protects L1 sensing input to interconnection circuit board.
- **1.5-Amp (V8)** fuse protects L2 sensing input to interconnection circuit board.
- **1.5-Amp (V9)** fuse protects L3 sensing input to interconnection circuit board.

DC Circuit Fuses are located on the controller circuit board. See Figure 1-8.

- **1-Amp (F1)** auto-resettable, fuse protects the controller circuits.
- **1-Amp (F2)** auto-resettable fuse protects the controller circuits.
- **12-Amp (F3)** non-replaceable fuse protects the engine/starting circuitry and accessories.

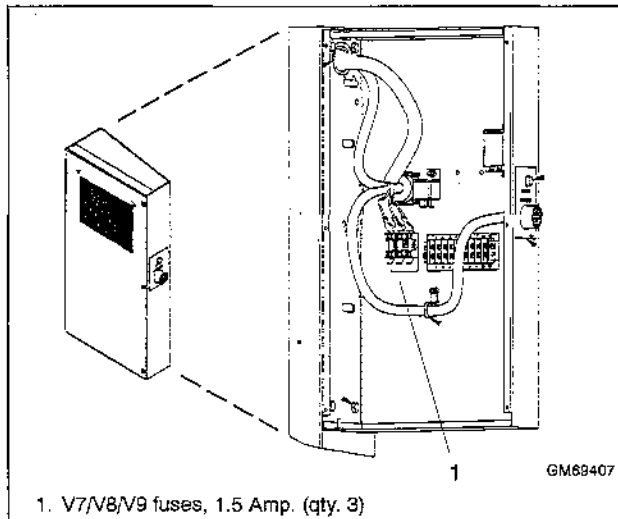


Figure 1-7 AC Circuit Fuses in Control Box

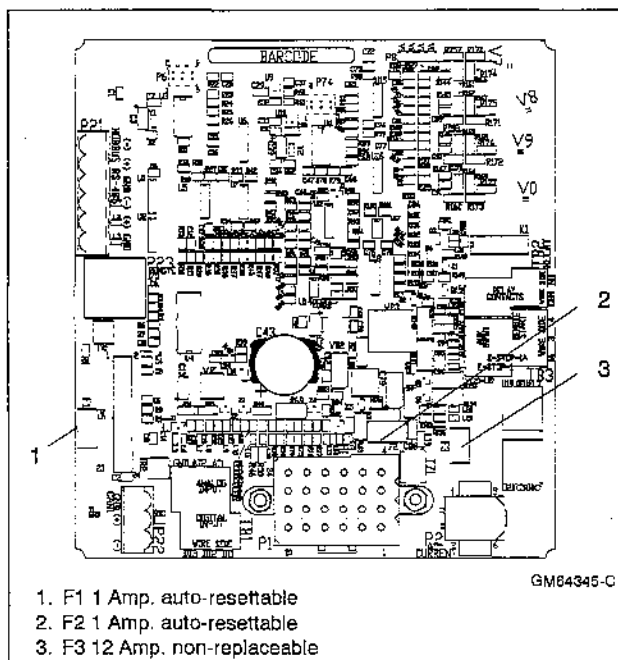


Figure 1-8 Controller Circuit Board and Connectors

1.3 Controller Logic Specifications

The controller logic specifications section is an overview of the various features and functions of the controller. Certain features function only when optional accessories are connected. See Section 2, Operation, for details.

The default selection time delays and digital outputs are factory set and adjustable. Data entries require using a PC and SiteTech™ software. See the SiteTech™ software operation manual for details.

Inhibit Time Delay. The inhibit time delay is the time period following crank disconnect during which the generator set stabilizes and the controller does not detect a fault or status event. Select the desired inhibit time delay from 0 to 60 seconds.

Time Delay (Shutdown or Warning). The time delay follows the inhibit time delay. The time delay is the time period between when the controller first detects a fault or status event and the controller warning or shutdown lamp illuminates. The delay prevents nuisance alarms. Select the desired time delay from 0 to 60 seconds.

1.3.1 Status Event and Fault Specifications

The Factory-Defined Settings List contains all status events and faults with ranges and time delays including items that do not have user adjustments.

Note: The engine ECM may limit the crank cycle even if the controller is set to a longer time period.

Factory-Defined Settings List

Description	Controller Display Message	Alarm Horn	Fault Lamp Warning Shutdown	Write Access Display SiteTech	GenSet Mode Always Running Stopped	Range Setting	Default Selection	Time Delay Range (sec.)	Default Time Delay (sec.)
Engine Functions									
Critically high fuel level (diesel-powered models only) *	Fuel Level Critically High	On	W			0-100%	95%	0-10	5
ECM communications loss	ECM Comm Err Shutdwn	On	S					Fixed	10
ECM diagnostics (multiple inputs) †	ECM xxxxxx Warning	On	W						
ECM diagnostics (multiple inputs) †	ECM xxxxxx Shutdwn	On	S						
ECM faults (address conflict)	ECM Addr Err Shutdwn	On	S						
ECM faults (model mismatch)	ECM Mismatch Shutdwn	On	S			0-255	0		
Engine over speed	Eng Speed High Shutdwn	On	S	S	A	105-120%	115%		
Engine start aid active	Starting Aid Notice								
Engine under speed	Eng Speed Low Shutdwn	On	S	S	A	75-95%	85%		
Fuel tank leak *	Fuel Leak Warning	On	W						
Fuel tank leak *	Fuel Leak Shutdwn	On	S						
High battery voltage	Battery High Warning	On	W	S	A	110-135%	125%	Fixed	10
High coolant temperature	Coolnt Temp High Warning	On	W					0-10 (0-30 inhibit)	0 (0 inhibit)
High coolant temperature	Coolnt Temp High Shutdwn	On	S					0-10 (0-30 inhibit)	0 (0 inhibit)
High fuel level (diesel-powered models only) *	Fuel Level High Warning	On	W			0-100%	90%	0-10	5
Low battery voltage	Battery Low Warning	On	W	S	A	80-105%	100%	Fixed	90
Low coolant level *	Coolant Lvl Low Shutdwn	On	S					Fixed	5
Low coolant temperature	Coolant Temp Low Warning	On	W			Fixed	16°C (60°F)	0-10 (0-30 inhibit)	5 (0 inhibit)
Low cranking voltage	Lo Crank Vlt Warning	On	W			Fixed	60%	Fixed	6
Low engine oil level *	Oil Level Low Warning	On	W						
Low engine oil level *	Oil Level Low Shutdwn	On	S						
Low fuel level (diesel models) *	Fuel Level Low Warning	On	W			0-100%	35%	0-10	10
Low fuel level (diesel models) *	Fuel Level Low Shutdwn	On	S			0-100%	5%	0-10	0
Low fuel pressure (gas models) *	Fuel Press Low Warning	On	W						
Low oil pressure	Oil Press Low Warning	On	W					Fixed (Fixed inhibit)	0 (30 inhibit)
Low oil pressure	Oil Press Low Shutdwn	On	S					Fixed (Fixed inhibit)	5 (30 inhibit)
No coolant temperature signal	Temp Sig Loss Shutdwn	On	S						
No oil pressure signal	Press Sig Loss Shutdwn	On	S					Fixed	5
Overcrank	Over Crank Shutdwn	On	S					Fixed	(30 inhibit)
Speed sensor fault	Spd Sens Flt Warning	On	W						

Description	Controller Display Message	Alarm Horn	Fault Lamp Warning Shutdown	Write Access Display SiteTech	GenSet Mode Always Running Stopped	Range Setting	Default Selection	Time Delay Range (sec.)	Default Time Delay (sec.)
General Functions									
Alarm silence, 0-Auto only (NFPA 110), 1-Always	AlarmSilenceMode			S	A	0-1	1		
Aux. inputs 0-5 VDC, 1 analog	Aux Input Warning	On	W			0-100%	100%	0-10	0
Aux. inputs 0-5 VDC, 1 analog	Aux Input Shutdwn	On	S			0-100%	100%	0-10	0
Auxiliary inputs, up to 3 digital (2 additional digital inputs available with I/O module option)	Aux Input Warning	On	W					0-10 (0-30 inhibit)	0 (0 inhibit)
Auxiliary inputs, up to 3 digital (2 additional digital inputs available with I/O module option)	Aux Input Shutdwn	On	S					0-10 (0-30 inhibit)	0 (0 inhibit)
Backup parameters loaded	Backup Pars Status								
Battery charger fault *	Batt Chg Flt Warning	On	W						
Chicago code active *	Auto Locked Notice								
Common fault	Common Fault Shutdwn	On	S						
Common warning	Common Waring	On	W						
Default parameters loaded	Default Pars Warning	On	W						
Emergency stop	Emerg Stop Shutdwn	On	S						
Engine cooldown (delay) active	Eng Cooldown Notice								
Engine start delay active	Start Delay Notice								
Engine started	Engine Start Status								
Engine stopped	Engine Stop Status								
EPS supplying load	Emerg Pwr On Notice								
File system error (controller fault)	File Error Shutdwn	On	S						
Generator running	Gen Running Notice								
Input/output (optional module board) communication loss	OB1 Com Loss	On	W						
Internal failure	Intern Error Shutdwn	On	S						
Measurement Units, 0-English, 1-Metric	Measurement Display			DS	A	0-1	1		
Metering communication loss	MeterCommLos Shutdwn	On	S						
NFPA 110 alarm active	NFPA Alarm Notice								
Not in auto (master control buttons)	Not In Auto Warning	On	W						
Prime power application, 0-Standby, 1-Prime	Power Type			DS	A	0-1	0		
Remote start	Remote Start Status								
System ready	System Ready Status								
System timer failed	Timer Error Notice								
Generator Functions									
AC sensing loss	AC Sens Loss Warning	On	W						
AC sensing loss	AC Sens Loss Shutdwn	On	S					Fixed	3
Alternator protection	Alt Protect Shutdwn	On	S						
Ground fault input *	Ground Fault Warning	On	W						
kW overload	Total Power High Shutdwn	On	S			Fixed	102%	Fixed	60
Locked rotor (failed to crank)	Locked Rotor Shutdwn	On	S	S	A			1-5	5
Overfrequency	Freq High Shutdwn	On	S			102-140%	110%	Fixed	10

Description	Controller Display Message	Alarm Horn	Fault Lamp Warning Shutdown	Write Access Display SiteTech	GenSet Mode Always Running Stopped	Range Setting	Default Selection	Time Delay Range (sec.)	Default Time Delay (sec.)
Overvoltage (each phase)	Volts (L1-L2, L2-L3, or L3-L1) High Shutdwn	On	S	S	A	105-135%	120%	2-10	2
Power rating	Pwr Rating			DS	S	10-5000	275		
System frequency	System Freq			DS	S	50-60	60		
System voltage	System Volt			DS	S	110-600	208		
Underfrequency	Frequency Low Shutdwn	On	S			80-95%	90%	Fixed	10 ST 60 LT
Undervoltage (each phase)	Volts (L1-L2, L2-L3, or L3-L1) Low Shutdwn	On	S	S	A	70-95%	80%	5-30	10
Voltage/phase configuration, 0-Single phase, 1-Single phase dogleg, 2-three phase wye, 3-three phase delta	SystemPhase			DS	S	0-3	2		
Voltage regulator average voltage adjustment	VR Volt Adj			DS	R	108-600	208		
(Voltage) regulator communication loss	RegCommLoss Shutdwn	On	S						
SiteTech Read/Write Display Only									
Current transformer ratio ‡				S	S	1-	1200		
ECM power				S	S	0-1	0		
Engine cooldown delay				S	A			0-600	300
Engine (cyclic) crank on				S	A			10-30	15
Engine (cyclic) crank pause				S	A			1-60	15
Engine ECM start delay				S	A			0-300	0
Engine idle duration				S	A			0-60	60
Engine no. of (cyclic) crank cycles				S	S	1-6	3		
Engine restart delay				S	A			1-10	10
Engine start aid delay				S	A			0-10	0
Engine start delay				S	A			0-300	0
System battery voltage ‡				S	S	12-24	12		
Voltage regulator gain				S	R	1-255	128		
Voltage regulator stability adjust				S	R	1-255	128		
Voltage regulator, volts per Hertz slope				S	R	1-10	5		
Voltage regulator, volts per Hertz cutin frequency				S	R	42-62	57.5		

* Some functions require optional input sensors or are engine ECM dependent on some generator set models.

† ECM inputs are engine manufacturer dependent.

‡ Changeable only by resetting the controller with a personality profile (SiteTech 1.4 or higher).

ST-Short Term, LT-Long Term

1.3.2 Voltage Regulator and Calibration Specifications

The controller has a voltage regulation function that is internal to the processor. This means that no external voltage regulator is necessary. The voltage regulation of the controller uses root mean square (rms) sensing for fast response to changes in indicated and regulated voltages resulting in excellent regulation accuracy.

1.3.3 Voltage Regulator Adjustments

The descriptions of the voltage regulator adjustments and features follow. Refer to the Factory-Defined Settings List shown in 1.3.1 for voltage regulator adjustments. See Appendix C, Voltage Regulator Definitions and Adjustments, for additional information and to customize adjustments for specific applications.

Voltage Adjustment. The voltage adjustment allows the user to enter the desired generator set output level. This regulated level setting is the average of the three line-to-line voltages in three-phase configurations or L1-to-L2 in single phase configurations.

Submenus display the individual line-to-line voltages. These voltages are for reference only and are relevant in unbalanced load conditions. The voltage adjust setpoint can be changed to accommodate an important phase in an unbalanced system.

Underfrequency Unload Frequency Setpoint. This adjustment affects the voltage droop (volts per Hz) when load is applied and underfrequency occurs. The underfrequency unload setting defines the setpoint where underfrequency starts. Any frequency below the setpoint causes the voltage to drop thus reducing the load allowing the engine speed to recover according to the underfrequency unload slope setting.

Engine speed recovery depends upon characteristics such as engine make, fuel type, load types, and operating conditions. The underfrequency unload setting should match the engine speed recovery characteristics for the application.

Underfrequency Unload Slope. This setting determines how much the voltage drops during an underfrequency condition. Typically, applying a large electrical load causes a dip in engine speed and frequency. The voltage regulator reduces voltage, allowing engine speed recovery. The volts-per-Hz setting determines the amount of voltage drop.

Regulator Gain. Regulator gain refers to the gain of the control system. Generally, the higher the gain the faster the system responds to changes and the lower the gain, the more stable the system.

If the voltage is slow to recover when loads are applied or removed, increase the regulator gain. If the voltage is unstable, decrease the regulator gain.

Notes

2.1 Prestart Checklist

To ensure continued satisfactory operation, perform the following checks or inspections before or at each startup, as designated, and at the intervals specified in the service schedule. In addition, some checks require verification after the unit starts.

Air Cleaner. Check for a clean and installed air cleaner element to prevent unfiltered air from entering engine.

Air Inlets. Check for clean and unobstructed air inlets.

Battery. Check for tight battery connections. Consult the battery manufacturer's instructions regarding battery care and maintenance.

Coolant Level. Check the coolant level according to the cooling system maintenance information.

Note: Block Heater Damage. The block heater will fail if the energized heater element is not immersed in coolant. Fill the cooling system before turning on the block heater. Run the engine until it is warm, and refill the radiator to purge the air from the system before energizing the block heater.

Drive Belts. Check the belt condition and tension of the radiator fan, water pump, and battery charging alternator belt(s).

Exhaust System. Check for exhaust leaks and blockages. Check the silencer and piping condition and check for tight exhaust system connections.

Inspect the exhaust system components (exhaust manifold, exhaust line, flexible exhaust, clamps, silencer, and outlet pipe) for cracks, leaks, and corrosion.

- Check for corroded or broken metal parts and replace them as needed.
- Check for loose, corroded, or missing clamps and hangers. Tighten or replace the exhaust clamps and/or hangers as needed.
- Check that the exhaust outlet is unobstructed.
- Visually inspect for exhaust leaks (*blowby*). Check for carbon or soot residue on exhaust components. Carbon and soot residue indicates an exhaust leak. Seal leaks as needed.

Fuel Level. Check the fuel level and keep the tank(s) full to ensure adequate fuel supply.

Oil Level. Maintain the oil level at or near, not over, the full mark on the dipstick.

Operating Area. Check for obstructions that could block the flow of cooling air. Keep the air intake area clean. Do not leave rags, tools, or debris on or near the generator set.

2.2 Exercising Generator Set

Operate the generator set under load once each week for one hour. Perform the exercise in the presence of an operator when the generator set does not have an automatic transfer switch with an exercise option.

During the exercise period apply a minimum of 35% load based on the nameplate standby rating, unless otherwise instructed in the engine operation manual.

The operator should perform all of the prestart checks before starting the manual exercise procedure. Start the generator set according to the starting procedure in Section 2.3, Controller Operation. While the generator set is operating, listen for a smooth-running engine and visually inspect generator set for fluid or exhaust leaks.

The generator set controller does not provide weekly scheduled exercise periods. For scheduled exercise periods, refer to the automatic transfer switch (if equipped) literature.

2.3 Controller Operation

The controller operation includes several types of starting and stopping functions as detailed in the following paragraphs. The controller master control switch buttons, lamps, and alarm horn functions are summarized in Figure 2-1.

Button Mode	Generator Set Status	Button Lamp	Fault Lamp	Alarm Horn	Alarm Silence Button	Alarm Horn Lamp	Controller Display
AUTO	Off	Green	---	Off	---	---	Scrolling Overview Menu Only
	On (or Cranking)		---	Off	---	---	
	Running and then Off		Red	On Off	---	---	Shutdown Message
OFF/RESET	Off	Red	Yellow	On Off	---	---	Not In Auto Warning
					Pressed	Yellow	
RUN (unit fails to start)	Off (or Cranking)	Yellow	Yellow	On Off	---	---	Not In Auto Warning
					Pressed	Yellow	
	Off		Red	On Off	---	---	Locked Rotor Shutdown (or other shutdown message)
					Pressed	Yellow	
RUN (unit starts)	Off (or Cranking)	Yellow	Yellow	On Off	---	---	Not In Auto Warning
	On				Pressed	Yellow	
	Running and then Off	Yellow	Red	On Off	---	---	Shutdown Message
					Pressed	Yellow	

Figure 2-1 Master Control Button Function Summary

2.3.1 Starting

Local Starting

Press the master control RUN button to start the generator set at the controller.

Note: The alarm horn sounds and the Not-In-Auto Warning display appears whenever the generator set master control button is not in the AUTO mode.

Note: The transient start/stop function of the controller prevents accidental cranking of the rotating engine. The generator set stops and recranks when the OFF/RESET button is momentarily pressed and then the RUN button is pressed.

Auto Starting

Press the master control AUTO button to allow startup by the automatic transfer switch or remote start/stop switch (connected to controller terminals 3 and 4).

Terminals 3 and 4 connect to a circuit that automatically starts the generator set crank cycle when an external source closes the circuit.

Note: The controller provides up to 30 seconds of programmable cyclic cranking and up to 60 seconds rest with up to 6 cycles. The default setting is 15 seconds cranking and 15 seconds rest for 3 cycles. Make cyclic cranking adjustments using SiteTech™ software.

Prime Power Switch

The controller has an optional prime power mode of operation. The prime power mode requires installation of an optional prime power switch kit. See Section 6, Accessories, for instructions on how to install the optional prime power switch kit. The prime power switch kit prevents engine starting battery drain when the generator set is shut down and no external battery charging is available.

Move the prime power switch located on the junction box to the CONTROLLER ON position before attempting to start the generator set. When the prime power mode is off, all controller functions including the digital display, LEDs, and alarm horn are operative.

Stop the generator set using the stopping procedures in Section 2.3.2 before placing the generator set in the prime power mode. Move the prime power switch located on the junction box to the CONTROLLER OFF position. When the generator set is in the prime power mode, all controller functions including the digital display, LEDs, alarm horn, and communications are inoperative.

2.3.2 Stopping (User Stopping and Fault Shutdown)

Normal Stopping

Run the generator set without load for 5 minutes to ensure adequate engine cooldown.

The controller has a programmable cooldown timer that functions only when the master control button is in the AUTO mode. To stop the generator set, press the generator set master control OFF/RESET button and wait until the generator set comes to a complete stop.

Note: The cooldown cycle times out before the generator set stops when a remote switch or automatic transfer switch initiates the generator set start/stop sequence.

Emergency Stopping

Use the controller emergency stop switch or optional remote emergency stop for immediate shutdown.

The emergency stop switch bypasses the time delay engine cooldown and immediately shuts down the generator set.

Note: Use the emergency stop switch(es) for emergency shutdowns only. Use the generator set master control OFF/RESET button for normal shutdowns.

The controller fault lamp lights and the unit shuts down when the local or remote emergency stop switch activates.

2.3.3 Emergency Stop Switch Resetting

Use the following procedure to reset the generator set after shutdown by a local or remote emergency stop

switch. Refer to Section 2.3.8, Controller Resetting procedure, to restart the generator set following a fault shutdown.

1. Investigate and correct the cause of the emergency stop.
2. Reset the optional remote emergency stop switch by replacing the glass piece, when equipped. Additional glass rods are available as a service part. Reset the controller emergency stop switch by pulling the switch dial outward.
3. Press the generator set master control OFF/RESET button.
4. After resetting all faults using the controller reset procedure in Section 2.3.8, press the generator set master control RUN or AUTO button to restart the generator set. The generator set will not crank until the reset procedure completes.

2.3.4 System Status Lamps

The (OFF/RESET-AUTO-RUN) master control buttons indicate the status condition with an integrated lamp at the button.

The green lamp illuminates on the master control AUTO (automatic start) button indicating the system senses no faults and the unit is ready to start by remote command.

The red lamp illuminates on the master control OFF/RESET button indicating the generator set is stopped.

The yellow lamp illuminates on the master control RUN button indicating the generator set is cranking or running from a local command.

Only one of the three master control button lamps will illuminate at any given time.

2.3.5 System Fault Warning Lamp with Digital Displays

The system FAULT lamp glows yellow and the alarm horn sounds indicating a warning fault but does not shut down the generator set. The fault lamp illuminates yellow and the alarm horn sounds when the fuel tank level on diesel-fueled models approaches empty. This fault requires an optional low fuel level switch for the lamp to function. The local display shows *Fuel Level Low Warning*. See Section 2.3.8, Controller Resetting procedure, for instructions on resetting a system warning.

When the system warning lamp is on and no message displays, rotate the selector dial to view messages. When the system warning continues, it may lead to a fault and cause a system shutdown.

Use the Silence Alarm button to silence the alarm horn at the operator's discretion.

If the controller is setup for an NEPA 110 application, press the AUTO button before silencing the alarm horn. The alarm horn cannot be silenced unless the master control button is in the AUTO mode. See 2.3.7 Status and Notice Digital Displays for more information.

Note: Text shown in *italics* in this section of the manual represents digital display messages.

AC Sensing Loss. The fault lamp illuminates yellow and the alarm horn sounds when the controller does not detect the nominal generator set AC output voltage after crank disconnect. The controller displays *AC Sens Loss Warning*.

Auxiliary Input (Warning). The fault lamp illuminates yellow and the alarm horn sounds when an auxiliary digital or analog input signals the controller. The digital inputs do not function during first the 30 seconds after startup. Use SiteTech™ software to define inputs as shutdowns or warnings. The local display shows *Aux Input Warning*.

Battery Charger Fault. The fault lamp illuminates yellow and the alarm horn sounds when the battery charger malfunctions. This fault feature requires an optional battery charger with a malfunction output for the lamp to function. Local display shows *Batt Chg Flt Warning*.

Common Warning. The fault lamp illuminates yellow and the alarm horn sounds when the controller is signaled by a common warning. Use SiteTech™ software to activate the common warning. The local display shows *Common Warng*. The common warning comprises all of the warnings under a single alert.

Critical High Fuel Level (diesel-powered models only). The fault lamp illuminates yellow and the alarm horn sounds when the fuel tank level on diesel models approaches full. This fault requires an optional critical high fuel switch and fuel tank for the lamp to function. The local display shows *Fuel Level Critically High*.

Default Parameters Loaded. The fault lamp illuminates yellow and the alarm horn sounds when the controller detects that the default parameter software was loaded using SiteTech™ software. The local display shows *Default Pars Warning*.

ECM Diagnostics (Multiple Engine Inputs). The fault lamp illuminates yellow and the alarm horn sounds when ECM diagnostics signals the controller. The local display shows *ECM xxxxx Warning*. The specific display (xxxxx) will be a brief message or fault code that is engine manufacturer dependant. The engine literature provides the fault code description and further information.

Fuel Tank Leak (diesel-powered models only). The fault lamp illuminates yellow and the alarm horn sounds when the fuel tank signals a leak of the inner tank. This fault requires an optional fuel tank leak switch for the lamp to function. The local display shows *Fuel Leak Warning*.

Ground Fault. The fault lamp illuminates yellow and the alarm horn sounds when a user-supplied ground fault detector signals the controller. The local display shows *Ground Fault Warning*.

High Battery Voltage. The fault lamp illuminates yellow and the alarm horn sounds when the battery voltage rises above the preset level for more than 10 seconds. The local display shows *Battery High Warning*. Figure 2-2 shows high battery voltage specifications. The high battery voltage feature monitors the battery and battery charging system in the generator set operating and off modes.

Engine Electrical System Voltage	High Battery Voltage Range	High Battery Voltage Default Setting
12	13.2-16.2	15
24	26.4-32.4	30

Figure 2-2 High Battery Voltage Specs

High Coolant Temperature. The fault lamp illuminates yellow and the alarm horn sounds when the engine coolant temperature approaches the shutdown range. The high coolant temperature warning does not function during the preset inhibit time delay period after startup. The local display shows *Coolnt Temp High Warning*.

High Fuel Level (diesel-powered models only). The fault lamp illuminates yellow and the alarm horn sounds when the fuel tank level on diesel models approaches near full. This fault requires an optional high fuel switch and fuel tank for the lamp to function. The local display shows *Fuel Level High Warning*.

Input/Output Communication Loss. The fault lamp illuminates yellow and the alarm horn sounds when the controller loses the input/output communication signal from the optional I/O module board. The local display shows *OB1 Com Loss*.

Low Battery Voltage. The fault lamp illuminates yellow and the alarm horn sounds when the battery voltage drops below a preset level for more than 90 seconds. The local display shows *Low Battery Warning*. See Figure 2-3 for low battery voltage specifications.

Engine Electrical System Voltage	Low Battery Voltage Range	Low Battery Voltage Default Setting
12	9.6-12.6	12
24	19.2-25.2	24

Figure 2-3 Low Battery Voltage Specs

The low battery voltage feature monitors the battery and battery charging system in the generator set operating and off modes. The controller logic inhibits the low battery voltage warning during the crank cycle.

Low Coolant Temperature. The fault lamp illuminates yellow and the alarm horn sounds when the engine coolant temperature is low. The low coolant temperature warning does not function during the preset inhibit time delay period after startup. The local display shows *Coolant Temp Low Warning*.

Low Cranking Voltage. The fault lamp illuminates yellow and the alarm horn sounds when the battery voltage drops below 60% of the nominal voltage (12 VDC or 24 VDC) for more than 6 seconds during the crank cycle. The local display shows *Lo Crank Vlt Warning*.

Low Engine Oil Level. The fault lamp illuminates yellow and the alarm horn sounds because of low engine oil level. This fault feature requires an optional low engine oil level sensor for the lamp to function. Local display shows *Oil Level Low Warning*.

Low Fuel Level (diesel-powered models only). The fault lamp illuminates yellow and the alarm horn sounds when the fuel tank level on diesel-fueled models approaches empty. This fault requires an optional low fuel level switch for the lamp to function. The local display shows *Fuel Level Low Warning*.

Low Fuel Pressure (gas-powered models only). The fault lamp illuminates yellow and the alarm horn sounds when low fuel pressure on gaseous-fueled models occurs. This fault requires an optional low fuel pressure switch for the lamp to function. The local display shows *Fuel Press Low Warning*.

Low Oil Pressure. The fault lamp illuminates yellow and the alarm horn sounds when the engine oil pressure approaches the shutdown range. The low oil pressure warning does not function during first the 30 seconds after startup. The local display shows *Oil Press Low Warning*.

Not in Auto (Generator Master Control Switches). The fault lamp illuminates yellow and the alarm horn sounds when the generator set master control button is in the RUN or OFF/RESET mode. The local display shows *Not In Auto Warning*.

Speed Sensor Fault. The fault lamp illuminates yellow and the alarm horn sounds when the speed signal is absent for one second while the generator set runs. The local display shows *Spd Sens Flt Warning*.

2.3.6 System Fault Shutdown Lamp With Digital Displays

The system FAULT lamp glows red, the alarm horn sounds, and the unit shuts down to indicate a fault shutdown under the following conditions. See Section 2.3.8, Controller Resetting procedure, for information on resetting a system shutdown.

Use the Alarm Off button to silence the alarm horn at the operator's discretion.

If the controller is setup for an NEPA 110 application, press the AUTO button before silencing the alarm horn. The alarm horn cannot be silenced unless the master control button is in the AUTO mode. See 2.3.7 Status and Notice Digital Displays for more information.

Note: Text shown in *italics* in this section of the manual represents digital display messages.

AC Sensing Loss. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the controller does not detect the nominal generator set AC output voltage for more than 3 seconds after crank disconnect. The controller displays *AC Sens Loss Shutdown*.

Alternator Protection. The fault lamp illuminates red and the unit shuts down because of an alternator overload or short circuit. The local display shows *Alt Protect Shutdown*. See Appendix D, Alternator Protection for more information.

Auxiliary Input (Shutdown). The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when an auxiliary digital or analog inputs signals the controller. The digital inputs do not function during first the 30 seconds after startup. Use SiteTech™ software to define inputs as shutdowns or warnings. The local display shows *Aux Input Shutdown*.

Common Fault. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the controller is signaled by a common fault. Use SiteTech™ software to activate the common fault shutdown. The local display shows *Common Fault Shutdown*. The common fault comprises the following shutdowns under a single alert.

- Emergency stop
- Engine over speed
- High coolant temperature
- Low oil pressure
- Overcrank

ECM Address Conflict. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the controller detects an error with the ECM address. The local display shows *ECMAddr Err Shutdown*.

ECM Communications Loss. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the ECM communication link is disrupted. The local display shows *ECM Comm Err Shutdown*.

ECM Diagnostics (Multiple Engine Inputs). The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when ECM diagnostics signals the controller. The local display shows *ECM xxxxx Shutdown*. The specific display (xxxxx) will be a brief message or fault code that is engine manufacturer dependant. The engine literature provides the fault code description and further information.

ECM Model Mismatch. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the controller detects an error with the ECM model. The local display shows *ECM Mismatch Shutdown*.

Emergency Stop. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the local or optional remote emergency stop switch activates. The local display shows *Emerg Stop Shutdown*.

Engine Over Speed. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down immediately when the governed frequency on 50 and 60 Hz models exceeds the over speed setting. The local display shows *Eng Speed High Shutdown*.

Engine Under Speed. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down immediately when the governed frequency on 50 and 60 Hz models drops below the under speed setting. The local display shows *Eng Speed Low Shutdown*.

File System Error. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the internal controller diagnostics detect a firmware file error. The local display shows *File Error Shutdown*.

Fuel Tank Leak (diesel-powered models only). The fault lamp illuminates red, the alarm horn sounds, when the fuel tank signals a leak of the inner tank. This fault requires an optional fuel tank leak switch for the lamp to function. The local display shows *Fuel Leak Shutdown*.

High Coolant Temperature. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down because of high engine coolant temperature. The high coolant temperature shutdown does not function during the preset inhibit time delay period after startup. The local display shows *Coolnt Temp High Shutdwn*.

Note: The high engine temperature shutdown function and the low coolant level shutdown function are independent. A low coolant level condition may not activate the high engine temperature switch.

Internal Fault. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the internal diagnostics detect a controller malfunction. The local display shows *Intern Error Shutdwn*.

kW Overload. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the generator set supplies more than 102% of the rated standby output kW for more than 60 seconds. The local display shows *Total Power High Shutdwn*.

Locked Rotor (failed to crank). If none of the speed sensing inputs show engine rotation within the preset time delay of initiating engine cranking, the ignition and crank circuits turn off for the preset period and the cycle repeats. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down after the second cycle of the preset period of cranking. The local display shows *Locked Rotor Shutdwn*.

Low Coolant Level. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down because of low coolant level. Shutdown occurs 5 seconds after low coolant level is detected. Local display shows *Coolant Lvl Low Shutdwn*.

Low Engine Oil Level. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down because of low engine oil level. This fault feature requires an optional low engine oil level sensor for the lamp to function. Local display shows *Oil Level Low Shutdwn*.

Low Fuel Level (diesel-powered models only). The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the fuel tank level on diesel-fueled models approaches empty. This fault requires an optional low fuel level switch for the lamp to function. The local display shows *Fuel Level Low Shutdwn*.

Low Oil Pressure. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down because of low oil pressure. The shutdown occurs 5 seconds after the low pressure condition is detected. The low oil pressure shutdown does not function during first the 30 seconds after startup. The local display shows *Oil Press Low Shutdwn*.

Metering Communications Loss. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the metering to controller communication link is disrupted. The local display shows *MeterCommLos Shutdwn*.

No Coolant Temperature Signal. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the engine coolant temperature sender circuit is open. The local display shows *Temp Sig Loss Shutdwn*.

No Oil Pressure Signal. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the engine oil pressure sender circuit is open for more than 5 seconds. The local display shows *Press Sig Loss Shutdwn*.

Overcrank. The fault lamp illuminates red, the alarm horn sounds, and cranking stops when the unit does not start within the defined cranking period. The local display shows *Over Crank Shutdwn*. See Section 2.3.1, Auto Starting, and Section 1.3.1, Status Event and Fault Specifications for cyclic crank specifications.

Note: The controller is equipped with an automatic restart function. When speed drops below 25 Hz (750 rpm) while the engine is running, the unit attempts to re crank. The unit then follows the cyclic cranking cycle and, when the engine fails to start, will shut down on an overcrank fault condition.

Overfrequency. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the frequency is above the overfrequency setting. The local display shows *Freq High Shutdwn*. See Figure 2-4.

Overfrequency Setting Range	Time Delay	Overfrequency Default Setting
102%-140% of nominal	10 sec.	110% of nominal

Figure 2-4 Overfrequency Specs

Overvoltage (Each Phase). The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the voltage exceeds the overvoltage setting for the preset time delay period. The local display shows *Volts (L1-L2, L2-L3, or L3-L1) High Shutdown*. See Figure 2-5 for overvoltage specifications.

Note: Overvoltage can damage sensitive equipment in less than one second. Install separate overvoltage protection on online equipment requiring faster than 2-second shutdown.

Overvoltage Setting Range	Time Delay Range	Overvoltage Default Setting
105%-135% of nominal	2-10 sec.	120% at 2 sec.

Figure 2-5 Overvoltage Specs

Underfrequency. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the frequency drops below the underfrequency setting. The local display shows *Frequency Low Shutdown*. See Figure 2-6 for underfrequency specifications.

Underfreq. Setting Range	Time Delay	Underfrequency Default Setting
80%-95% of nominal	10 sec. (short term) 60 sec. (long term)	90% of nominal

Figure 2-6 Underfrequency Specs

Undervoltage. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the voltage drops below the undervoltage setting for the time delay period. The local display shows *Volts (L1-L2, L2-L3, or L3-L1) Low Shutdown*. See Figure 2-7 for undervoltage specifications

Undervoltage Setting Range	Time Delay Range	Undervoltage Default Setting
70%-95% of nominal	5-30 sec.	80% of nominal at 10 sec.

Figure 2-7 Undervoltage Specs

(Voltage) Regulator Communications Loss. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the voltage regulator to controller communication link is disrupted. The local display shows *RegCommLos Shutdown*.

2.3.7 Status and Notice Digital Displays

Warnings and shutdown faults appear on the digital display and become part of the event history. Beyond the warnings and shutdowns there are several events which also appear on the digital display. Status is an event that is not an alert but is part of the event history. Notice is an alert that is not part of the event history.

The controller allows a selected number of changes by the user for setting up the controller application which are covered in this section.

Note: Text shown in *italics* in this section of the manual represents digital display messages.

Alarm Silence. This status message indicates whether the alarm horn can be silenced in any button mode (OFF/RESET-AUTO-RUN) or requires the AUTO button be pressed first compliant per NFPA 110. Use SiteTech™ software to change this setting. See Section 2.3.8, Controller Resetting procedure, for information on resetting the system.

The local display shows *AlarmSilence: Always* when the alarm horn can be silenced with the master control buttons in any position (default setting).

The local display shows *AlarmSilence: Auto Only* when the alarm horn can be silenced only when in the AUTO mode. The correct reset sequence requires pressing the OFF/RESET button, then pressing the AUTO button, and then pressing the ALARM SILENCE button.

Backup Parameters Loaded. This status message indicates that backup parameter firmware is now loaded on the controller using SiteTech™ software. The local display shows *Backup Pars Status*.

Chicago Code Active. This notice message indicates that a pass code is required to access the controller. Use SiteTech™ software to set up the feature. The local display shows *Auto Locked Notice*.

Emergency Power System (EPS) Supplying Load. This notice message indicates when the generator set supplies more than 1% of the rated standby output current. The local display shows *Emerg Pwr On Notice*.

Engine Cooldown (Delay) Active. This notice message indicates that the delay for engine cooldown is active where the generator set will continue to run after the OFF/RESET button is pressed. The unit will continue to run until the time delay times out. The local display shows *Eng Cooldown Notice*.

Engine Start Aid Active. This notice message indicates that the start aid is active and will energize an engine equipped preheat or ether system during the crank cycle. Use SiteTech™ software to set up this feature. The local display shows *Starting Aid Notice*.

Engine Start Delay Active. This notice message indicates that the delay for engine start is active where the generator set will not start right after the RUN button is pressed. The unit will start cranking after the time delay times out. The local display shows *Start Delay Notice*.

Engine Started. This status indicates that the generator set start circuit is closed allowing the engine to crank and run. The local display shows *Engine Start Status*.

Engine Stopped. This status indicates that the generator set start circuit is open causing the engine to shut down. The local display shows *Engine Stop Status*.

Generator Running. This notice indicates that the generator set has started and is running. The local display shows *Gen Running Notice*.

Generator Set Calibration (User Defined). This selectable display is in the GenSet Calibration Menu allowing the user to calibrate the controller and generator set. Use the Pushbutton/Rotary Selector Dial to navigate and select this feature.

Changes to this display must be done with the generator set running. The local display shows *Enter calib? No or Yes*. Select No to make no change. Select Yes to calibrate the following values:

- Volts L1-L2: x.x V
- Volts L2-L3: x.x V
- Volts L3-L1: x.x V
- Volts L1-N: x.x V
- Volts L2-N: x.x V
- Volts L3-N: x.x V
- Current L1: x.x A
- Current L2: x.x A
- Current L3: x.x A

The user can individually calibrate the values above or reset all of them. The local display shows *Reset all calib? No or Yes*. Select No to make no changes and exit GenSet Calibration. Select Yes to reset all of the values.

When calibrating voltage, the metered value and the number being entered as the calibrated value must be within 10% of the system operating voltage.

When calibrating current, the metered value must be at least 25% of the rated current on units smaller than 100 kW and at least 50 amps on units rated larger than 100 kW. The number being entered as the calibrated value must be within 10% of the metered value.

Measurement Units (User Defined). This selectable display is in the GenSet System Menu allowing the user to choose between Metric and English displays. Use the Pushbutton/Rotary Selector Dial to navigate and select this feature. Changes to this display can be done with the generator set running or stopped. The local display shows *Meas Units: Metric* or *Meas Units: English*.

NFPA 110 Alarm Active. This notice message indicates that the alarm for NFPA 110 is active. The fault lamp illuminates yellow (warning) or red (shutdown), the alarm horn sounds, and the units shuts down (if a shutdown fault is detected) when the NFPA 110 fault signals the controller. The local display shows the respective fault message. The NFPA 110 faults include:

- Battery charger fault
- EPS supplying load
- High battery voltage
- High coolant temperature shutdown
- High coolant temperature warning
- High engine speed
- Low battery voltage
- Low coolant level
- Low coolant temperature warning
- Low fuel (level or pressure)
- Low oil pressure shutdown
- Low oil pressure warning
- Master switch not in auto
- Overcrank

Remote Start. This status indicates that the generator set start circuit was closed from a remote location allowing the engine to crank and run. The remote location is typically a set of contacts on a transfer switch or remote start switch. The local display shows *Remote Start Status*.

System Ready. This status indicates that the generator set is in the AUTO mode and available to start if the start circuit is closed. The local display shows *System Ready*.

System Timer Failed. This notice indicates that the controller timer logic has failed to time out a designated function. The local display shows *Timer Error Notice*.

Voltage Regulator Adjustment (User Defined). This feature is in the Voltage Regulator Menu allowing the user to fine adjust the output voltage. Use the Pushbutton/Rotary Selector Dial to navigate and select this feature. Changes to this display must be done with the generator set running. The local display shows *Enter volt reg? No or Yes*. Select No to exit the voltage regulator menu. Select Yes to change the local display *VR Volt Adj: xxx.x V*.

2.3.8 Controller Resetting (Following System Shutdown or Warning)

Use the following procedure to restart the generator set after a system shutdown or to clear a warning lamp condition. This procedure includes the resetting of the optional remote annunciator.

Refer to Section 2.3.3, Emergency Stop Switch Reset Procedure, to reset the generator set after an emergency stop.

1. Disconnect the generator set load using the line circuit breaker or automatic transfer switch.
2. Correct the cause of the fault shutdown or warning. See the Safety Precautions and Instructions section of this manual before proceeding.
3. Start the generator set by pressing the generator set master control OFF/RESET button and then press the RUN button.

When equipped, the remote annunciator alarm horn sounds. Press the ALARM SILENCE/LAMP TEST button to stop the alarm horn. The lamp turns off.

4. Test operate the generator set to verify correction of the shutdown cause.
5. Press the generator set master control OFF/RESET button to stop the generator set.
6. Press the generator set master control AUTO button.
7. Silence the controller alarm horn by pressing the ALARM SILENCE button.
8. Reconnect the generator set load via the line circuit breaker or automatic transfer switch.
9. When equipped, the remote annunciator alarm horn sounds. Press the ALARM SILENCE/LAMP TEST button to stop the alarm horn. The lamp turns off.

2.4 Menu Displays

Use the Menu Summary List section after reading and understanding the features of the pushbutton/rotary selector dial. See Section 1.2.3, Digital Display.

The Menu Summary List provides a quick reference to the digital display data. Some digital display data may not be identical to your display due to generator set application differences. The closed bullet items represent main level data and the open bullet items are sub-level data. The Menu Summary List indicates items that are user selectable. Use SiteTech™ software for changing all other programmable information.

Section 2.6, Reviewing the Menu Displays, provides a digital display menu overview and explains the navigation using the pushbutton/rotary selector dial.

Menu Summary List (Legend: ● First level submenu, ○ second level submenu)

Overview Menu	Generator Metering Menu	GenSet System Menu	Voltage Regulator Menu
- Available as scrolling or fixed display text ● Software Version ● Active Shutdowns (if present) ● Active Warnings (if present) ● Engine Run Time ● Average Volts Line-to-Line ● Frequency ● Current ● Coolant Temperature ● Fuel Level (with diesel-powered models and optional fuel tank sender) ● Fuel Pressure (with gas-powered models and optional sender) ● Oil Pressure ● Battery DC Voltage	● Total Power KVA (shown as actual output values) ● Total Power kW (shown as actual output values) ● Rated Power ● Volts, L1-L2 ● Volts, L2-L3 ● Volts, L3-L1 ● Volts, L1-N ● Volts, L2-N ● Volts, L3-N ● Current, L1 ● Current, L2 ● Current, L3 ● Frequency	● System Volts ● System Frequency ● System Phase (Single Phase, Single Phase Dogleg, Three Phase Wye, or Three Phase Delta) ● Power Rating ● Amp Rating ● Power Type (Standby or Prime) ● Measurement Units (Metric or English) * ● Alarm Silence (Always or Auto Only)	● Enter Voltage Regulator? (Yes or No) * ○ Voltage Regulator Adjust ○ Exit Voltage Regulator
	GenSet Information Menu ● Generator Set Model No. ● Generator Set Serial No. ● Controller Serial No.	GenSet Calibration Menu ● Enter Calibration (Yes or No) * ○ Volts, L1-L2 ○ Volts, L2-L3 ○ Volts, L3-L1 ○ Volts, L1-N ○ Volts, L2-N ○ Volts, L3-N ○ Current, L1 ○ Current, L2 ○ Current, L3 ○ Reset Calibration ○ Reset All Calibration (Yes or No) ○ Exit Calibration	Digital Inputs Menu ● DI In A1 ● DI In A2 ● DI In A3 ● DI In B1 (with I/O Board) ● DI In B2 (with I/O Board)
Engine Metering Menu ● Engine Speed (Tachometer) ● Oil Pressure ● Coolant Temperature ● Fuel Level (with diesel-powered models and optional fuel tank sender) ● Fuel Pressure (with gas-powered models and optional sender) ● Battery DC Voltage	GenSet Run Time Menu ● Engine Run Time ● Engine Loaded ● Engine Starts ● Total Energy kWh		Digital Outputs Menu ● DOut A1 ● DOut B1 (with I/O Board) ● DOut B2 (with I/O Board) ● DOut B3 (with I/O Board) ● DOut B4 (with I/O Board) ● DOut B5 (with I/O Board)
			Analog Inputs Menu ● AI In A1 (factory reserved and not user programmable) ● AI In A2 ● AI In B1 (with I/O Board) ● AI In B2 (with I/O Board)
			Event Log Menu ● See 1.2.4 for a list of items that can appear in Event Log

* User-Defined Menu Displays

2.5 Monitoring and Programming Setup

The user programmer can access the controller data with the controller digital display or a personal computer (PC) with optional SiteTech™ software to monitor and/or program. Access the controller system with a PC using a USB cable with a mini USB plug. Refer to the Introduction, List of Related Materials for related software literature.

While this manual focuses on data access through the controller pushbutton/rotary selector dial and display, most data entries require input using a PC for initial setup. The PC entries typically include alpha characters such as digital input descriptions.

2.5.1 PC Communications

Communicate between a PC and the generator set controller logic using USB communication protocol. The

PC connections require optional SiteTech™ software. Contact your authorized distributor/dealer for assistance.

Local Single Connection

A PC connects to the USB port of the generator set controller using a mini USB connector. See Figure 2-8.

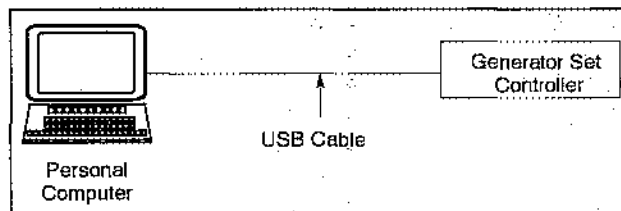


Figure 2-8 Local Single Connection

2.6 Reviewing Menu Displays

Use this section to review a summary of the generator set controller data. See Figure 2-9 for which menus provide data monitoring, data adjustments, or require SiteTech™ software to make data adjustments.

Use the pushbutton/rotary selector dial to navigate to the respective menus.

See Section 1, Specifications and Features, to review set point ranges and default settings for comparison to the actual setup.

Menus displaying the # symbol represent one of the following data types:

- System-calculated data
- System-measured data
- User-entered data

Note: The examples given on the following pages represent digital displays with the Measurement Units set to English.

2.6.1 Error Messages

Certain entries or attempted entries may cause the controller to display an error message.

Cannot Calibrate appears when attempting to calibrate the voltage and current values in the GenSet Calibration menu with the unit stopped. The unit must be running in order to make adjustments.

Cannot Edit When Stopped appears in the Voltage Regulator menu when attempting to change the VR Volt Adj value when the unit is not running.

Menu Name	Controller Viewable	Controller Adjustable	SiteTech Adjustable
Overview	X		
Engine Metering	X		
Generator Metering	X		
GenSet Information	X		X
GenSet Run Time	X		
GenSet System	X	X	X
GenSet Calibration	X	X	
Voltage Regulation	X	X	X
Digital Inputs	X		X
Digital Outputs	X		X
Analog Inputs	X		X
Event Log	X		

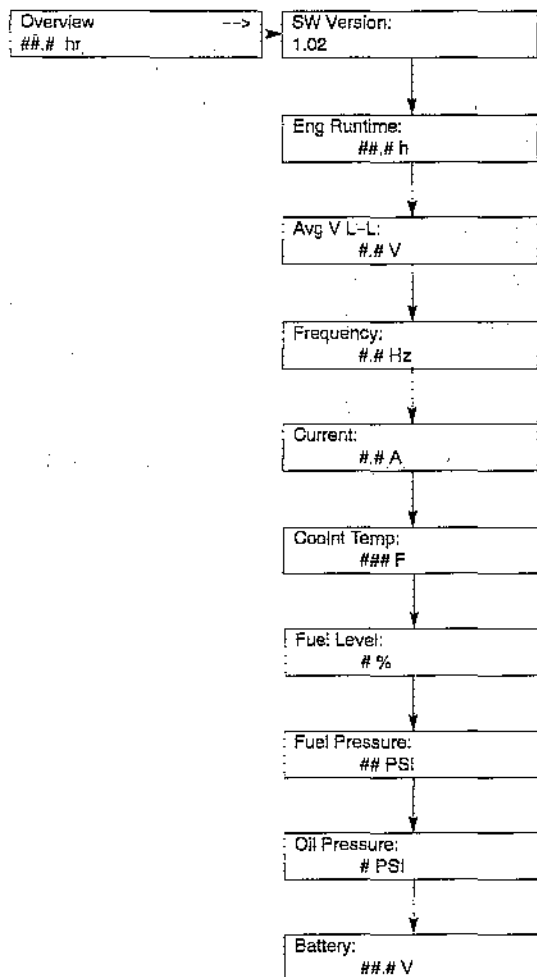
Figure 2-9 Menu Displays for Viewing and Adjusting

2.6.2 Overview

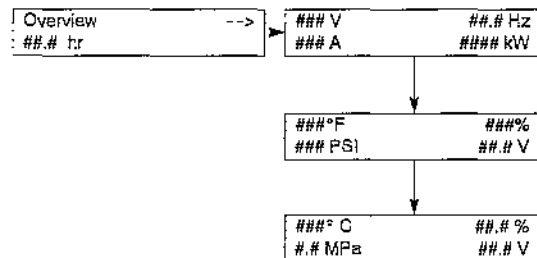
Displays basic and commonly sought after information about the generator set. This information scrolls automatically after about 5 minutes of no user input (pushbutton/rotary selector dial or button activity).

To change from auto scrolling to fixed display, press the rotary dial and the main menu will appear. Press the rotary dial again to select the first menu item Overview. Turn the rotary dial to select the desired fixed view.

Overview (Auto Scrolling Display)



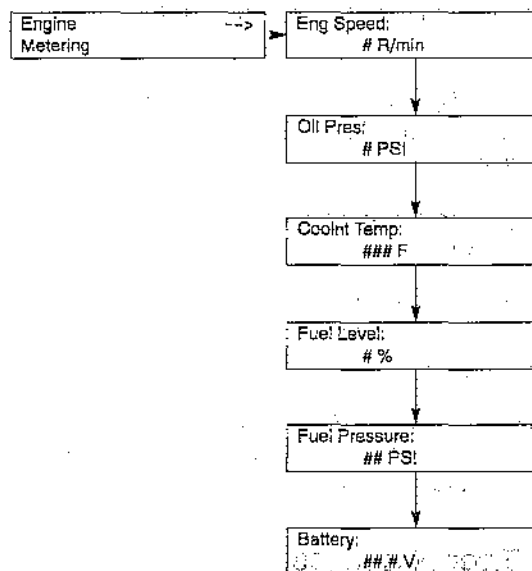
Overview (Fixed Display)



2.6.3 Engine Metering

Displays engine operating data as measured by the engine and other sensors.

Engine Metering

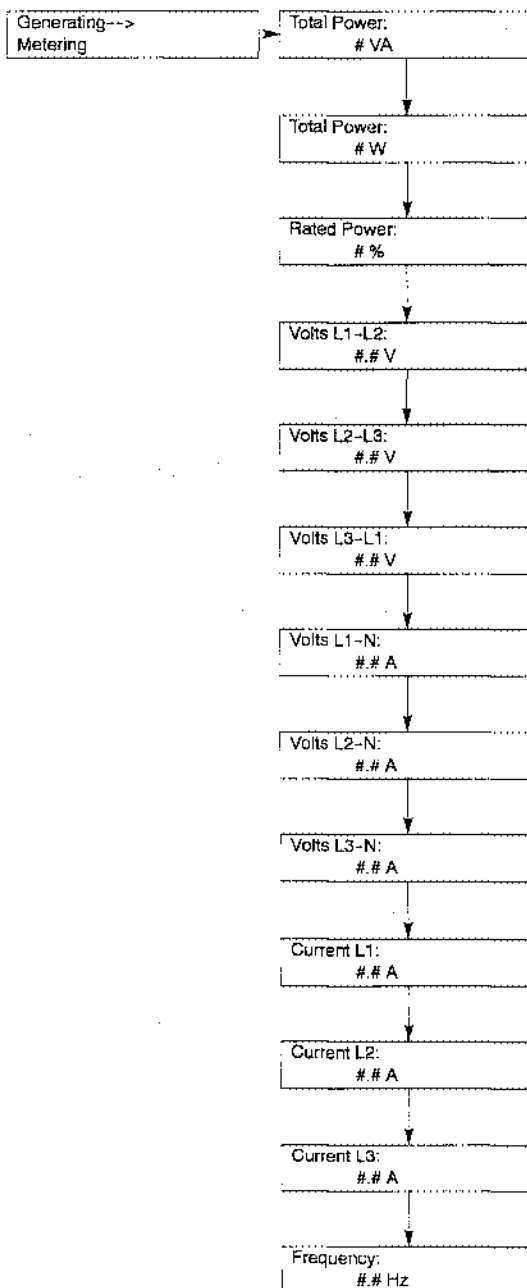


2.6.4 Generator Metering

Displays generator output data including line-to-line and line-to-neutral voltages, current, frequency, total kilowatts, and total kVA. The menu displays three-phase voltage and current readings when applicable.

All menu displays apply to both single-phase or three-phase voltages on the menu overview. The phase designation does not appear in the controller menu displays. Some displays will show 0 values when single-phase connections are shown.

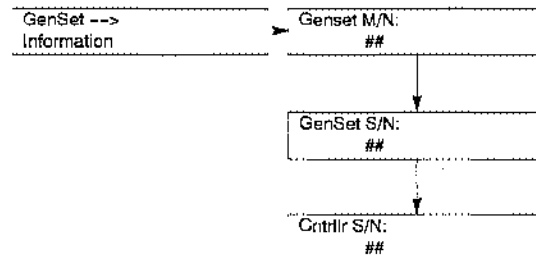
Generator Metering



2.6.5 GenSet Information

Displays generator set and controller information. Displayed data is factory entered.

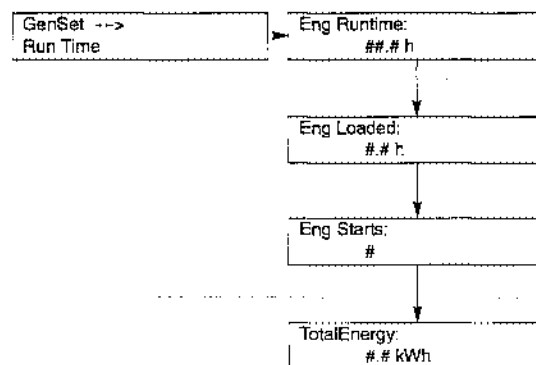
GenSet Information



2.6.6 GenSet Run Time

Displays the generator set's operating record including total run time loaded and unloaded, number of starts, and total energy kW hours.

GenSet Run Time



2.6.7 GenSet System

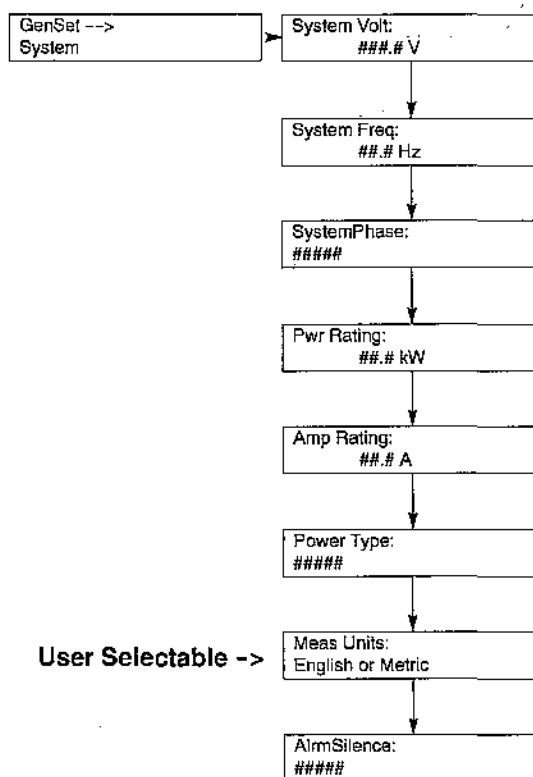
Display shows the generator set system data including voltage, frequency, phase connection, etc. Use the values entered in this menu to help determine shutdown values and time delays.

The programming user defines the data shown in the GenSet System menu. It is NOT data measured by the controller and associated sensing devices. The programming user defines these values for purposes of calibrating the control.

Some alternators are designed to operate at limited voltage, frequency, or phase connections and as a result some settings may have limited parameters.

Display for Measurement Units and is user selectable as English or Metric.

GenSet System



2.6.8 GenSet Calibration

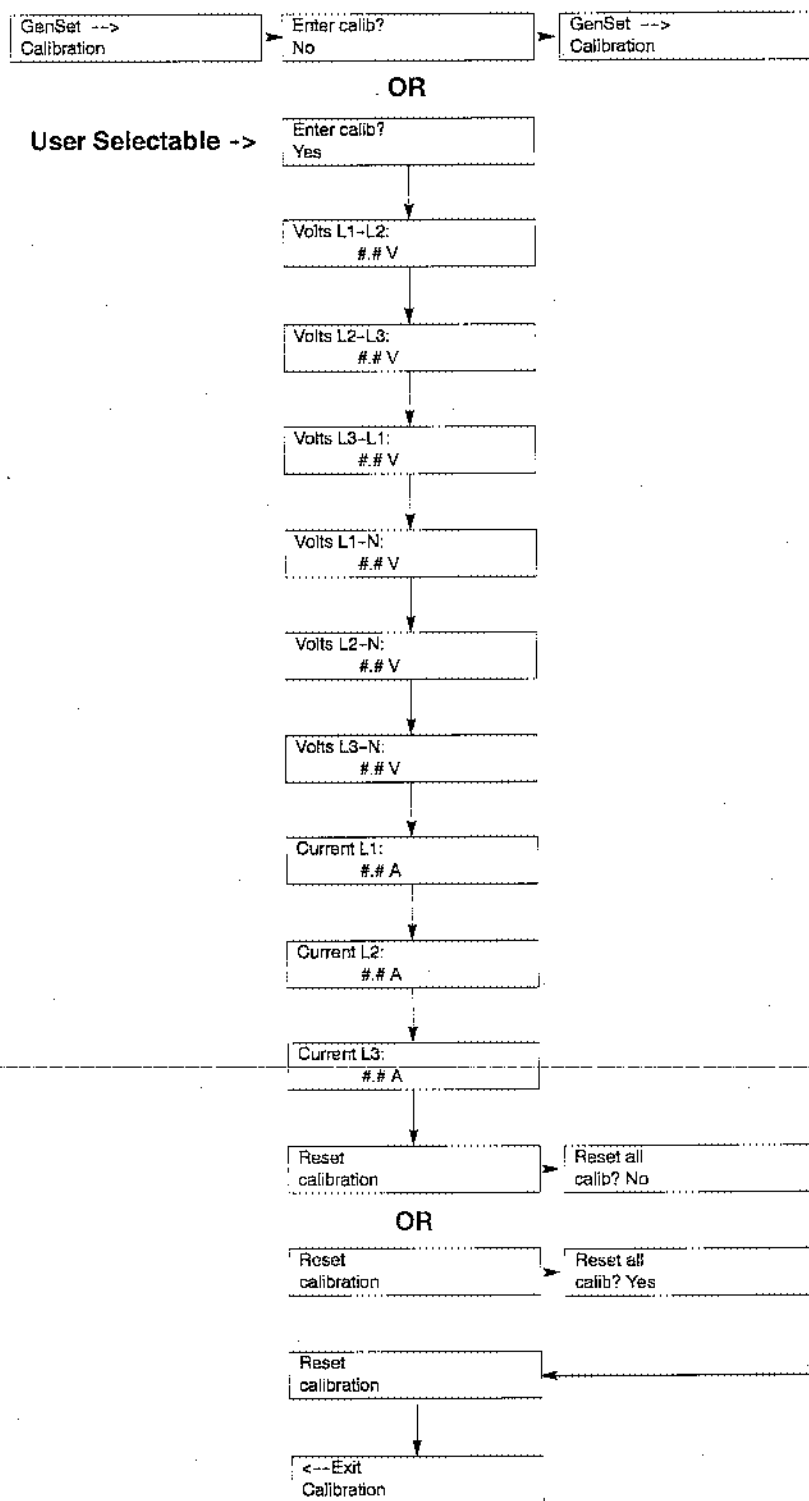
Display provides access to the calibration factors for metering (volts and amps). Changing the system voltage or replacing the main logic control circuit board requires calibration adjustment. Connect a meter with a minimum accuracy of 1% to the generator set output leads to calibrate the voltage-sensing logic.

The user can individually calibrate the values shown above or reset all of them. The local display Reset all calib? No or Yes. Select No to make no changes and exit GenSet Calibration. Select Yes to reset all of the values.

When calibrating voltage, the metered value and the number being entered as the calibrated value must be within 10% of the system operating voltage.

When calibrating current, the metered value must be at least 25% of the rated current on units smaller than 100 kW and at least 50 amps on units rated larger than 100 kW. The number being entered as the calibrated value must within 10% of the metered value.

GenSet Calibration



2.6.9 Voltage Regulator

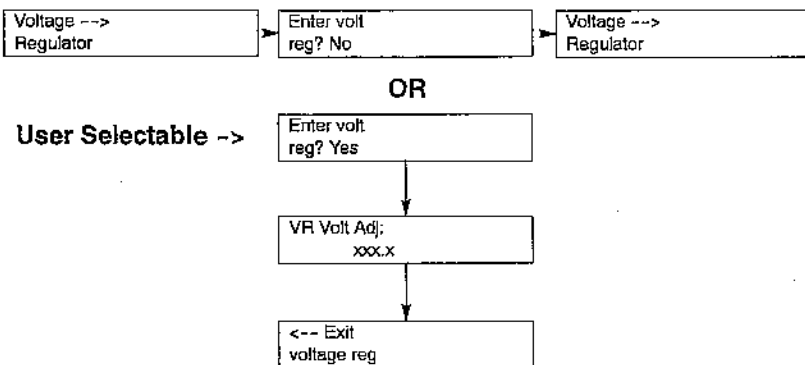
Displays the voltage regulator adjustment value. All other voltage regulator adjustments are changed using SiteTech™ software.

The voltage regulator value is reviewable at all times. In order to review the value when the generator set is NOT

running, enter Yes when the Enter volt reg? is displayed. The user can review the value but attempting to change the value will cause a Cannot edit when stopped error message.

If the unit is running and Yes is entered when the Enter volt reg? is shown, the display will show the value. The user can change the value at this time.

Voltage Regulator



2.6.10 Digital Inputs

Displays the selected programming user-defined digital notice, warning, and shutdown inputs. These inputs provide a multitude of choices for configuring customized auxiliary inputs. See Figure 2-10 for a list of digital input choices. For descriptions of the inputs listed refer to the following:

- 2.3.5 System Fault Warning Lamp with Digital Displays
- 2.3.6 System Fault Shutdown Lamp with Digital Displays
- 2.3.7 Status and Notice Digital Displays

There is an optional 2 input/5 output (I/O) module board available that can provide two additional digital (or analog) inputs.

The displays for digital inputs appear as shown below with Values true or false. Items shown in the display as True are active.

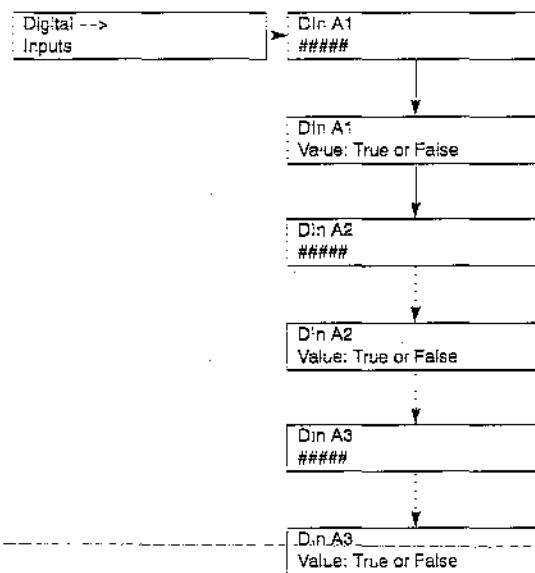
- DIn A1 (digital input A1) standard
- DIn A2 (digital input A2) standard
- DIn A3 (digital input A3) standard
- DIn B1 (digital input B1) with I/O module board
- DIn B2 (digital input B2) with I/O module board

All digital input selection and setup adjustments are done using SiteTech™ software. The following terms and descriptions are part of the setup procedure.

- **Enabled.** This menu indicates whether or not the input is enabled. If the input is not enabled, the controller will ignore this input signal.

- **Inhibit Time Delay.** The inhibit time delay is the time period following crank disconnect during which the generator set stabilizes and the controller does not detect the fault or status event. The controller will ignore the input until the inhibit time expires. If the inhibit time is set to zero, the input is monitored at all times, even when the generator is not running. The inhibit time delay range is from 0 to 60 seconds.
- **Time Delay (shutdown or warning).** The time delay follows the inhibit time delay. The time delay is the time period between when the controller first detects the fault or status event and the controller warning or shutdown lamp illuminates. The delay prevents any nuisance alarms. The time delay range is from 0 to 60 seconds.

Digital Inputs



Analog and Digital Inputs	Notice	Warning	Low Warning	High Warning	Critical High Warning	Shutdown	Low Shutdown	High Shutdown
Auxiliary Input		AD				AD		
Battery Charger Fault		AD						
Chicago Code Active	AD							
Engine Fuel Level			AD	D	D		D	
Fuel Tank Leak		AD				D		
Ground Fault		AD						
Low Engine Oil Level			AD				D	
Low Fuel Pressure			AD					

Figure 2-10 Analog and Digital Inputs

2.6.11 Digital Outputs

Displays the selected programming user-defined digital notice, warning, and shutdown outputs. These outputs provide a multitude of choices for configuring customized auxiliary outputs. See Figure 2-11 for a list of digital output choices. For descriptions of the outputs listed refer to the following:

- 2.3.5 System Fault Warning Lamp with Digital Displays
- 2.3.6 System Fault Shutdown Lamp with Digital Displays
- 2.3.7 Status and Notice Digital Displays

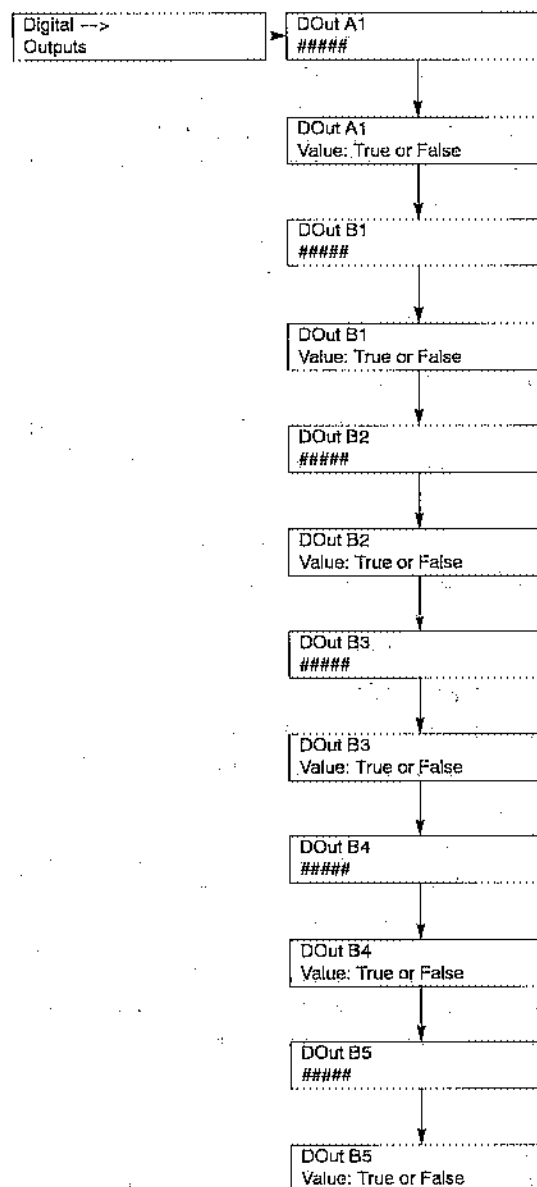
There is an optional 2 input/5 output (I/O) module board available that can provide five additional digital outputs.

The displays for digital outputs appear as shown below with Values true or false. Items shown in the display as True are active.

- DOut A1 (digital output A1) standard
- DOut B1 (digital output B1) with I/O module board
- DOut B2 (digital output B2) with I/O module board
- DOut B3 (digital output B3) with I/O module board
- DOut B4 (digital output B4) with I/O module board
- DOut B5 (digital output B5) with I/O module board

Use SiteTech™ software for digital output selection and setup adjustments. Each output is tied to a user-selectable function. The function can be a common fault, common warning, NFPA 110 alarm active, or a specific warning or shutdown.

Digital Outputs



Digital Outputs	Notice	Warning	Low Warning	High Warning	Critical High Warning	Shutdown	No Signal Shutdown	Low Shutdown	High Shutdown
AC Sensing Lost		X				X			
Alternator Protection						X			
Auxiliary Input		X				X			
Battery Charger Fault		X*							
Battery Voltage			X*	X*					
Chicago Code Active	X								
Common Fault	X								
Common Warning	X								
Cranking Voltage			X						
ECM Comm Loss						X			
Emergency Stop						X			
Engine Coolant Level								X*	
Engine Coolant Temperature			X*	X*			X*		X*
Engine Cooledown Active	X								
Engine Fuel Level			X*	X*	X*			X*	
Engine Oil Level			X					X	
Engine Oil Pressure			X*				X*	X*	
Engine Speed								X	X*
Engine Start Aid Active	X								
Engine Start Delay Active	X								
EPS Supplying Load	X								
Fuel Pressure			X*						
Fuel Tank Leak		X				X			
Generator Frequency Average								X	X
Generator Running	X								
Generator True Total Power									X
Generator Voltage L1-L2								X	X
Generator Voltage L2-L3								X	X
Generator Voltage L3-L1								X	X
Ground Fault		X							
Locked Rotor						X			
NFPA 110 Alarm Active	X								
Not In Auto		X*							
Overcrank						X*			
Speed Sensor Fault		X							
System Ready	X								

* NFPA 110 Defined Common Alarms

Figure 2-11 Digital Outputs with NFPA 110 Defined Common Alarms

2.6.12 Analog Inputs

Displays the selected programming user-defined analog notice, warning, and shutdown inputs. These inputs provide a multitude of choices for configuring customized auxiliary inputs. See Figure 2-10 for a list of analog input choices. For descriptions of the inputs listed refer to the following:

- 2.3.5 System Fault Warning Lamp with Digital Displays
- 2.3.6 System Fault Shutdown Lamp with Digital Displays
- 2.3.7 Status and Notice Digital Displays

There is an optional 2 input/5 output (I/O) module board available that can provide two additional analog (or digital) inputs.

The displays for analog inputs appear as shown below and have an acceptable operating range (0–5 VDC). The analog input selection typically requires entering four values—low warning, high warning, low shutdown, and high shutdown.

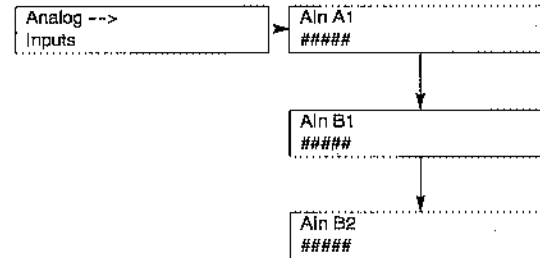
- AIn A1 (analog input A1) standard (reserved and not user programmable)
- AIn A2 (analog input A2) standard (Identified as A1 on SiteTech™ software)
- AIn B1 (analog input B1) with I/O module board
- AIn B2 (analog input B2) with I/O module board

All analog input selection and setup adjustments are done using SiteTech™ software. The following terms and descriptions are part of the setup procedure.

- **Enabled.** This menu indicates whether or not the input is enabled. If the input is not enabled, the controller will ignore this input signal.
- **Inhibit Time Delay.** The inhibit time delay is the time period following crank disconnect during which the generator set stabilizes and the controller does not detect the fault or status event. The controller will ignore the input until the inhibit time expires. If the inhibit time is set to zero, the input is monitored at all times, even when the generator is not running. The inhibit time delay range is from 0 to 60 seconds.

- **Time Delay (shutdown or warning).** The time delay follows the inhibit time delay. The time delay is the time period between when the controller first detects the fault or status event and the controller warning or shutdown lamp illuminates. The delay prevents any nuisance alarms. The time delay range is from 0 to 60 seconds.

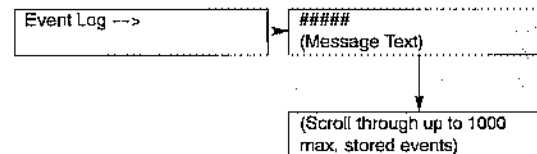
Analog Inputs



2.6.13 Event Log

Displays up to 1000 stored status, warning, and shutdown events. After the first 1000 events, each additional new event replaces the oldest event. See 1.2.4 Controller Fault Diagnostics for a list of possible events.

Event Log



Section 3 Scheduled Maintenance

Under normal operating conditions, the generator set's alternator requires no routine service. Consult Section 2.1, Prestart Checklist, for a list of routine checks.

3.1 Alternator Service

When operating the generator set under dusty or dirty conditions, use dry compressed air to blow dust out of the alternator while the generator set is running. Direct the stream of air through openings in the generator set end bracket.

3.2 Engine Service

Perform engine service at the intervals specified in the engine manufacturer's service literature. Contact an authorized service distributor/dealer to obtain service literature.

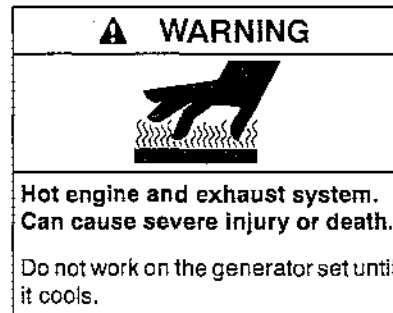
Note: Have maintenance work, including battery service, performed by appropriately skilled and suitably trained maintenance personnel familiar with generator set operation and service.



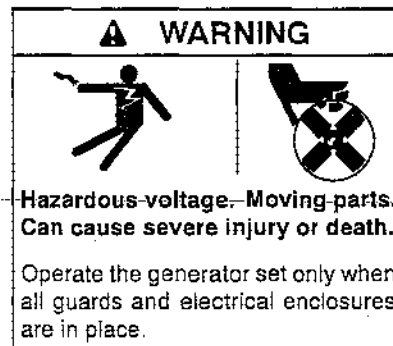
Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.



Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.



Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

3.3 Service Schedule

System—Component	Action					Interval
	Visually Inspect	Check	Change	Clean	Test	
Fuel System						
Day tank level	X	X				Weekly
Flexible lines and connections	X		R			Weekly
Fuel level switch	X				X	Weekly
Main tank supply level		X				Weekly
Solenoid valve operation	X				X	Weekly
Transfer pump operation	X				X	Weekly
Water in system, remove		•		•		Weekly
Filter(s)			•			Quarterly
Gasoline supply			R			Six Months
Fuel piping	X					Yearly
Tank vents and return lines for obstructions		X				Yearly
Lubrication System						
Oil level	•	•				Weekly
Crankcase breather	•		•			Quarterly
Change oil			•			First 50 Hrs., Then Every 250 Hrs.
Replace filter(s)*			•			
Cooling System						
Air cleaner to room/enclosure		X				Weekly
Block heater operation		X				Weekly
Coolant level	•	•				Weekly
Flexible hoses and connectors	X	X				Weekly
Water pump(s)	•					Weekly
Fan and alternator belts	•	•	R			Monthly
Coolant temperature protection level					•	Six Months
Air ducts, louvers		X		X		Yearly
Coolant			•			Yearly
Heat exchanger				X		Yearly
Louver motors and controls	X			X	X	Yearly
Radiator exterior				X		Yearly
Water supply to heat exchanger		X				Yearly
Exhaust System						
Drain condensate trap		X				Weekly
Leakage	X	X				Weekly
Insulation, fire hazards	X					Quarterly
Flexible connector(s)	X					Six Months
Excessive back pressure					X	Yearly
Hangers and supports	X					Yearly
DC Electrical System						
Battery charger operation, charge rate	X					Monthly
Battery electrolyte level		X				Monthly
Battery specific gravity, charge state					X	Monthly
Recharge after engine start		X				Monthly
Remove corrosion, clean and dry battery and rack	X			X		Monthly
Clean and tighten battery terminals	X	X				Quarterly
Tighten DC electrical connections		X				Six Months
• Follow procedures and frequencies indicated in the engine manufacturer's maintenance manual. If not indicated, follow this service schedule. Some items may not apply to all generator sets. R Replace as necessary. X Action * Service more frequently if operated in dusty areas.						

Service Schedule, continued

System—Component	Action					Interval
	Visually Inspect	Check	Change	Clean	Test	
AC Electrical System						
Controller lamp test	X				R	Weekly
General inspection	X					Weekly
Circuit breakers, fuses†	X	X	R	X	X	Monthly
Wire abrasions where subject to motion	X	X				Quarterly
Safety and alarm operation		X			X	Six Months
Tighten control and power wiring connections		X				Yearly
Transfer switch main contacts†	X			X		Yearly
Voltage-sensing device/relay adjustment†		•			•	Yearly
Wire-cable insulation breakdown	X				X	3 Years or 500 Hrs.
Engine and Mounting						
General inspection	•					Weekly
Governor operation, lubricate moving parts	•	•				Monthly
Air cleaner service		•	•			Six Months
Choke, carburetor adjustment		•				Six Months
Governor oil (mechanical governor only)		•				Yearly
Ignition components	•			•		Yearly
Injector pump and injector flow rate, pressure, spray pattern		•			•	Yearly
Valve clearance		•				3 Years or 500 Hrs.
Bolt torque		•			•	3 Years or 500 Hrs.
Remote Control System, etc.						
Compartment condition	X			X		Weekly
Remote control					X	Monthly
Run generator set					X	Monthly
Alternator						
General inspection	X					Weekly
Rotor and stator	X			X		Yearly
Bearing condition	X	X	R			Yearly
Exciter	X	X		X		Yearly
Voltage regulator	X	X		X		Yearly
Measure and record resistance readings of windings with insulation tester (Megger®, with SCR assembly or rectifier disconnected)					X	Yearly
Blow dust out of alternator*	X			•		2 Years or 300 Hrs.
General Condition of Equipment						
Any condition of vibration, leakage, noise, temperature, or deterioration	X	X		X		Weekly
Ensure that system is set for automatic operation	X					Weekly
Interior of equipment room or outdoor weather housing	X			X		Weekly
• Follow procedures and frequencies indicated in the engine manufacturer's maintenance manual. If not indicated, follow this service schedule. Some items may not apply to all generator sets. R Replace as necessary. X Action. * Service more frequently if operated in dusty areas. † Do not break manufacturer's seals or internally inspect these devices.						

Megger® is a registered trademark of Biddle Instruments.

3.4 Alternator Bearing Service

Have an authorized service distributor/dealer perform service.

3.4.1 20–300 kW Models

Replace the end bracket bearing every 10,000 hours of operation in standby and prime power applications. Service the bearing more frequently if the annual inspection indicates excessive rotor end play or bearing damage. Replace the tolerance ring, if equipped, following end bracket removal. The sealed end bracket bearing requires no additional lubrication.

3.5 Diesel Fuel Systems

3.5.1 Bleeding Air from Fuel System

Bleed air from the fuel system after fuel system maintenance, such as replacing the fuel filter(s). Use the hand prime pump kit, when equipped. The hand prime fuel pump eliminates the need for cranking the engine to bleed air from the fuel system.

Note: Bleed air from the fuel system according to the engine manufacturer's instructions. Trapped air in the fuel system causes difficult starting and/or erratic engine operation.

Note: Correct any fuel leaks encountered during the priming procedure.

1. Place the fuel valves in the fuel system prime position. Close the fuel valve located between the pipe tee and the engine. Open the fuel valves on each side of the fuel prime pump. See Figure 3-1.

Note: The illustration shows a generator set without a fuel/water separator. The valve location and position for a generator set equipped with a fuel/water separator is similar.

2. Loosen the bleed screw at the engine. Refer to the engine operation manual for location of the bleed screw(s). The bleed screw allows air to be expelled from the fuel system when the hand prime pump is operated.
3. Rotate the hand prime pump handle counterclockwise until fuel flows from the bleed screw. Stop pumping.
4. Tighten the bleed screw. Wipe up any fuel leakage.
5. Place the fuel valves in the normal operation position. Open the fuel valve located between the pipe tee and the engine. Close the fuel valves on each side of the fuel prime pump.

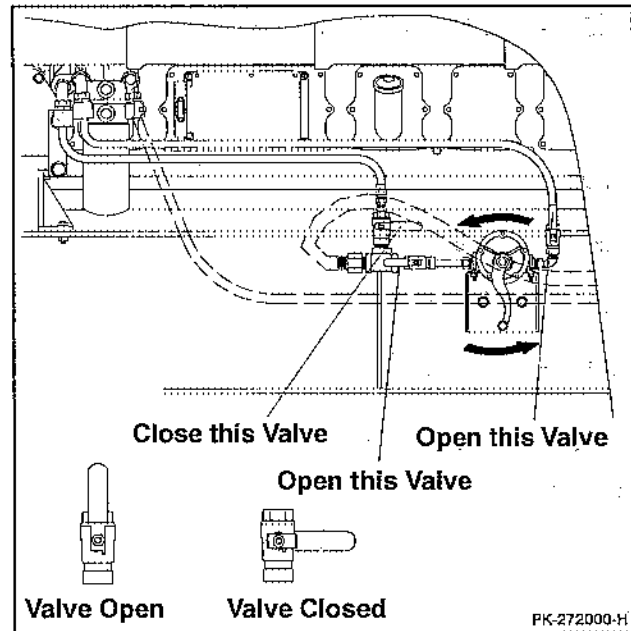


Figure 3-1 Hand Prime Pump with Valve Positions for Fuel Priming (generator set without a fuel/water separator shown), Typical

3.6 Gas Fuel Systems (REZG and REZX/RZX models)

This section describes natural gas and liquified petroleum gas (LPG) fuel systems that are not covered in the engine operation manual or engine service manual.

3.6.1 Gas Fuel System Concept (Single Fuel)

The gas fuel system uses a fuel valve with a solenoid to control the fuel flow to the fuel regulator. The generator set-mounted regulator reduces the fuel pressure as fuel passes to the fuel mixer. See Figure 3-2.

The fuel mixer controls the ratio of fuel to air under varying load and speed conditions. Because the fuel mixer receives fuel in a gaseous state, it does not have to vaporize the fuel.

3.6.2 LPG Liquid Withdrawal Fuel System Concept

With the LPG liquid withdrawal fuel system, pressurized liquid LPG fuel passes from the tank to a vaporizer. The vaporizer converts the liquid fuel to gas before sending it to the fuel mixer. The system also includes a fuel valve that shuts off the fuel flow when the engine stops. Contact an authorized service distributor/dealer for availability.

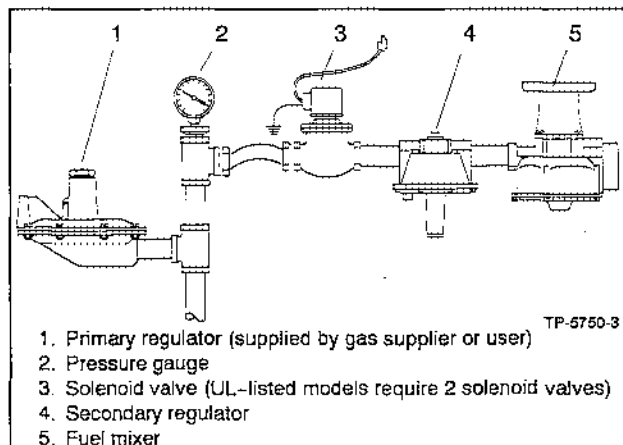


Figure 3-2 Fuel Regulator and Valve, Typical

3.6.3 Natural Gas and LPG Conversion

Most models operate on either natural gas or LPG fuel by performing the fuel conversion procedure. A hang tag on the fuel regulator may provide additional conversion setup information. Fuel conversion may decrease generator set output. Refer to the respective generator set spec sheet for ratings based on fuel selection. Changing fuel does not alter the emissions compliance of the generator set engine. Consult your local generator set distributor/dealer for additional information.

Note: If a gas-fueled model has the fuel type changed (LPG to natural gas or natural gas to LPG), order a new nameplate from an authorized distributor/dealer with the updated ratings and attach to the generator set.

To change the fuel type, change the electrical connections to the engine ECM. The engine ECM has fuel tables and spark advance curves programmed for both natural gas and LPG. The information shown below, in Figure 3-3, and in Figure 3-4 generally apply to all models and all fuels. Be sure to review the respective wiring diagram for your specific model for possible special applications.

Natural Gas Operation

- Disconnect lead 65 from lead N5.
- Disconnect lead 73B from the fuel valve.
- Connect lead 73A to the fuel valve.

LPG Vapor Operation

- Disconnect lead 73A from the fuel valve.
- Connect lead 73B to the fuel valve (LPG vapor)
- Connect lead 65 to lead N5 (ground).

LPG Liquid Withdrawal Operation

- Disconnect lead 73A from the fuel valve.
- Connect lead 73B to the fuel valve (LPG liquid withdrawal)
- Connect lead 65 to lead N5 (ground).

Auto Changeover Natural Gas/LPG Vapor Operation

- Disconnect lead 65 from N5.
- Connect lead N5 to LFP2 relay common terminal.
- Connect lead 73A to the fuel valve (natural gas).
- Connect lead 73B to the fuel valve (LPG vapor)

Eng. ECM	Natural Gas	LPG Vapor	LPG Liquid	Auto Changeover
73A	QCON-7 (NG fuel valve)	not used		QCON-7 (NG fuel valve)
N5	not used	65	65	LFP2-COM
73B	not used	QCON-10 (LPG fuel valve)		
65	not used	N5	N5	not used
63	LFP1-NC low fuel pressure sensor (if used)			
70E2	P6-B (15 amp fuse)			

Figure 3-3 Gas Fuel Electrical Connections

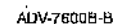
3.6.4 Fuel System Changeover Kits (Dual Fuel)

Automatic Changeover

A changeover fuel system kit provides automatic changeover from natural gas to LPG vapor. The primary and backup fuels each have a fuel valve. The primary fuel is natural gas; the backup fuel is LPG vapor. Before starting, both fuel valves are closed. When the generator set starts, the primary fuel valve opens. The primary fuel line has a pressure switch in series with a relay connected to the start/run circuit.

When the primary fuel pressure drops below 0.6 kPa (1.4 oz./in.²) or 6.4 cm (2.5 in.) water column, a relay opens the backup fuel valve and closes the primary fuel valve. When the primary fuel pressure rises above 0.6 kPa (1.4 oz./in.²) or 6.4 cm (2.5 in.) water column, the generator set uses the primary fuel. Contact an authorized service distributor/dealer for kit availability.

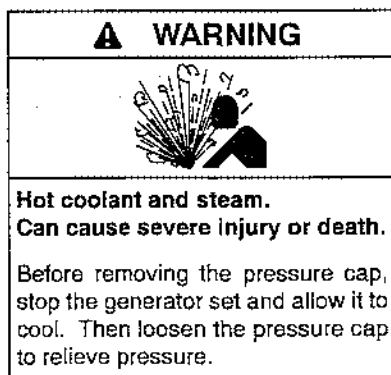
Emissions certified models use a single electronic-controlled pressure regulator (EPR) for both fuels. A tee fitting connects both fuels together upstream of the EPR. During operation when using the secondary fuel, it is normal for a small amount of secondary fuel to seep back through the primary fuel valve. To counter this situation, one of two methods is used depending upon the generator set model: (1) a second valve (identical to the primary fuel valve) is installed in a reverse configuration on the primary fuel side or (2) a small vent line is installed between the primary fuel inlet and the air intake through a solenoid valve.



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3.7 Cooling System

The cooling system maintenance information applies to radiator-cooled models which have a radiator with a pressure cap and coolant recovery tank.



Allow the engine to cool. Release pressure from the cooling system before removing the pressure cap. To release pressure, cover the pressure cap with a thick cloth and then slowly turn the cap counterclockwise to the first stop. Remove the cap after pressure has been completely released and the engine has cooled. Check the coolant level at the tank if the generator set has a coolant recovery tank.

Note: Engine damage. Bleed the air from the cooling system to prevent overheating and subsequent engine damage.

Note: Block heater damage. The block heater will fail if the energized heater element is not immersed in coolant. Fill the cooling system before turning on the block heater. Run the engine until it is warm, and refill the radiator to purge the air from the system before energizing the block heater.

3.7.1 Coolant Level Check

Check the coolant level in the coolant recovery tank. Maintain the coolant level between the high and low marks.

Note: Periodically check the coolant level by removing the pressure cap. Do not rely solely on the level in the coolant recovery tank. Add fresh coolant until the level is just below the overflow tube opening of the filler neck.

3.7.2 Cooling System Component Inspection

To prevent generator set shutdown or damage caused by overheating:

- Keep the cooling air inlets clean and unobstructed.
- Inspect the radiator's exterior for obstructions. Remove dirt and foreign material using a soft brush or cloth to avoid damaging the radiator fins.
- Check the hoses and connections for leaks. Replace any cracked, frayed, or spongy hoses.
- Check the condition and tension of the radiator fan and water pump belt(s). Follow the belt tension procedure in this manual and/or the engine operation manual.
- Check the pressure cap seal and replace a cracked or deteriorated cap. Remove dirt and other debris from the pressure cap and filler neck. The pressure cap raises the boiling point of the coolant, enabling higher operating temperatures. Replace a leaking pressure cap with one rated for the same pressure. The pressure cap rating usually appears on the pressure cap.

3.7.3 Procedure to Drain Cooling System

For optimum protection, drain, flush, and refill the cooling system at the intervals listed in the service schedule.

Note: Dispose of all waste materials (oil, fuel, coolant, filters, and gaskets) in an environmentally safe manner.

1. Deenergize the block heater, if equipped.
2. Remove the pressure cap to allow the entire system to drain and prevent air pockets from restricting coolant flow through the engine block.
3. Open the radiator and/or engine block coolant drain valve(s) and allow the system to drain.
4. If the inside of the radiator has mineral deposits or the used coolant contains dirt or grease, refer to Section 3.7.4, Procedure to Flush and Clean the Cooling System. If the cooling system does not have mineral deposits, go to Section 3.7.5, Procedure to Refill the Cooling System.

3.7.4 Procedure to Flush and Clean Cooling System

Use the instructions in the engine operation manual when available to flush and clean the cooling system. Otherwise, use the following procedure and the cooling system cleaner manufacturer's instructions.

1. Flush the cooling system with clean water.
2. If the inside of the radiator still has mineral deposits, use a radiator cleaner to remove the remaining deposits following the manufacturer's instructions.
3. Drain, clean, and flush the coolant recovery tank.

3.7.5 Procedure to Refill Cooling System

See the generator set spec sheet for coolant capacity.

Note: Do not add coolant to a hot engine. Adding coolant to a hot engine can cause the cylinder block or cylinder head to crack. Wait until the engine has cooled.

1. Remove the pressure cap.
2. Close the radiator and/or engine block coolant drain valve(s) and tighten the cooling system hose clamps.
3. Open the air-bleed petcocks, if equipped. Close the air-bleed petcocks when coolant begins to flow from them.
4. Add coolant additives or water pump lubricants according to the engine manufacturer's recommendations in the engine operation manual.
5. Fill the cooling system with the recommended coolant/antifreeze mixture of 50% ethylene glycol and 50% clean, softened water to inhibit rust/corrosion and prevent freezing.

A coolant solution of 50% ethylene glycol provides freezing protection to -37°C (-34°F) and overheating protection to 129°C (265°F). A coolant solution containing less than 50% ethylene glycol may not provide adequate freezing and overheating protection. A coolant solution containing more than 50% ethylene glycol can cause engine or component damage. Do not use alcohol or methanol antifreeze or mix them with the specified coolant. Refer to the engine operation manual for recommendations regarding the coolant mixture to use in extreme temperatures.

6. Replace the pressure cap.
7. Fill the coolant recovery tank to the low mark.
8. Operate generator set until the thermostat opens when the upper cooling system hose warms.
9. Stop the engine and allow it to cool.
10. Check and repair any coolant leaks.
11. Remove the pressure cap.
12. Add coolant to bring the coolant level to just below the overflow tube opening of the filler neck.
13. Replace the pressure cap.
14. Maintain the coolant level in the coolant recovery tank between the high and low marks.

Air pockets often form in the engine water jacket when the coolant system is refilled. Check the coolant level in the coolant recovery tank after each generator set operation and add coolant as necessary until the coolant level stabilizes. Then check the coolant at the interval specified in the service schedule.
15. Reenergize the block heater, if equipped.

3.8 Battery

⚠ WARNING



**Sulfuric acid in batteries.
Can cause severe injury or death.**

Wear protective goggles and clothing. Battery acid may cause blindness and burn skin.

Battery electrolyte is a diluted sulfuric acid. Battery acid can cause severe injury or death. Battery acid can cause blindness and burn skin. Always wear splashproof safety goggles, rubber gloves, and boots when servicing the battery. Do not open a sealed battery or mutilate the battery case. If battery acid splashes in the eyes or on the skin, immediately flush the affected area for 15 minutes with large quantities of clean water. Seek immediate medical aid in the case of eye contact. Never add acid to a battery after placing the battery in service, as this may result in hazardous spattering of battery acid.

Battery acid cleanup. Battery acid can cause severe injury or death. Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled battery acid and continue to add the neutralizing solution to the spilled battery acid until all evidence of a chemical reaction (foaming) has ceased. Flush the resulting liquid with water and dry the area.

Battery gases. Explosion can cause severe injury or death. Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects. Remove all jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the

battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

Battery short circuits. Explosion can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Disconnect the battery before generator set installation or maintenance. Remove all jewelry before servicing the equipment. Use tools with insulated handles. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery. Never connect the negative (-) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together.

Refer to this section for general battery information and maintenance. All generator set models use a negative ground with a 12-volt or 24-volt engine electrical system. Consult the generator set nameplate for the engine electrical system voltage. Consult the generator set spec sheet for battery capacity recommendations for replacement purposes. The wiring diagrams provide battery connection information. See Figure 3-5, Figure 3-6, and Figure 3-7 for typical battery configurations, including multiple battery configurations.

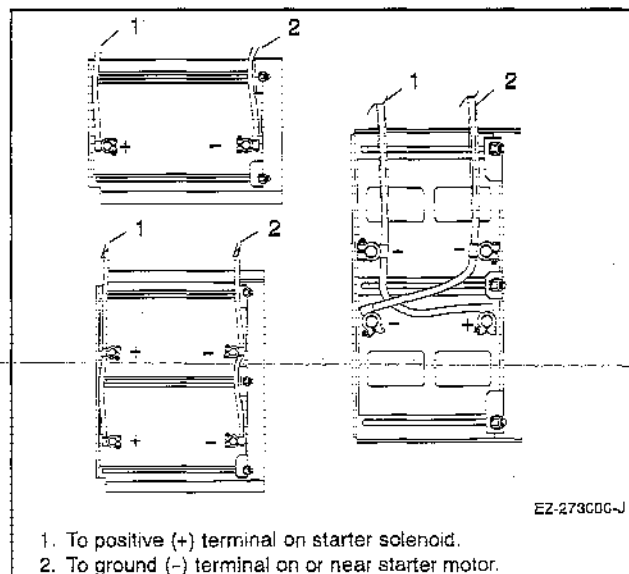


Figure 3-5 12-Volt Engine Electrical System Single Starter Motor Typical Battery Connection

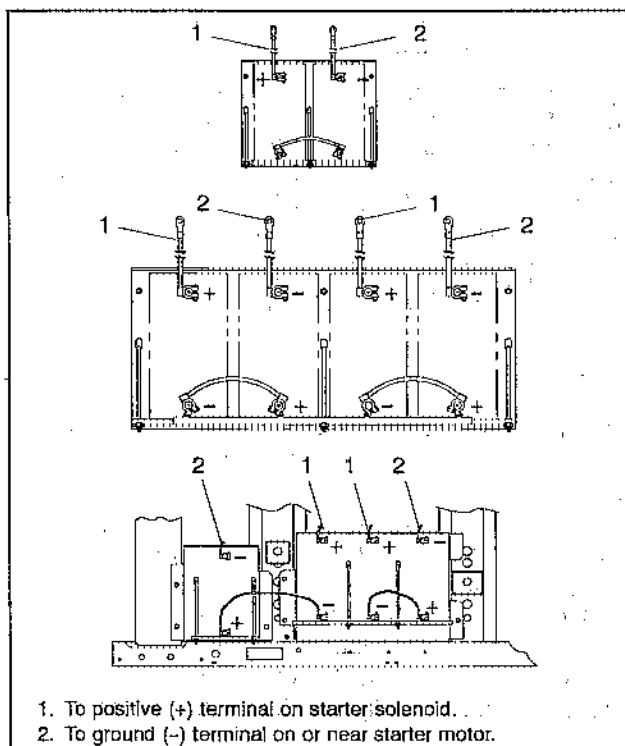


Figure 3-6 24-Volt Engine Electrical System Single Starter Motor Typical Battery Connection

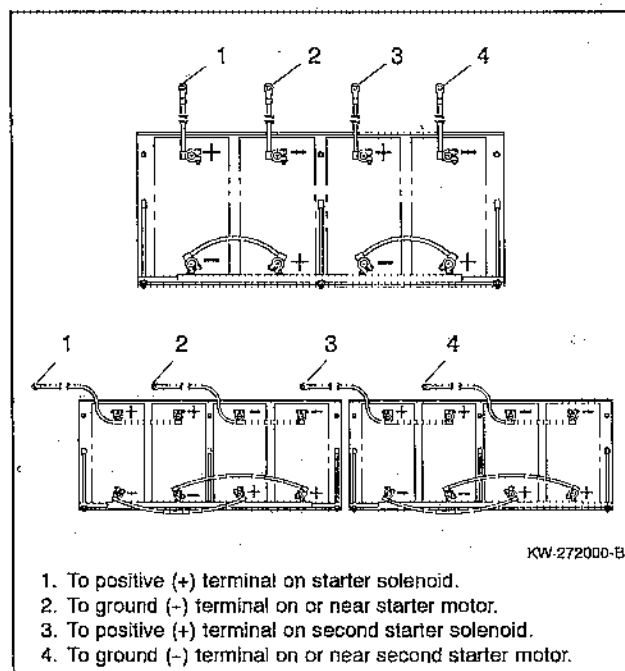


Figure 3-7 24-Volt Engine Electrical System Dual Starter Motors Typical Battery Connections

3.8.1 Clean Battery

Clean the battery and cables and tighten the battery terminals according to the service schedule recommendations. Clean the battery by wiping it with a damp cloth. Keep the electrical connections dry and tight.

If corrosion exists, disconnect the cables from the battery and remove the corrosion with a wire brush. Clean the battery and cables with a solution of baking soda and water. Do not allow the cleaning solution to enter battery cells. Flush the battery and cables with clean water and wipe the battery with a dry cloth.

After reconnecting the battery cables, coat the terminals with petroleum jelly, silicon grease, or other nonconductive grease.

3.8.2 Electrolyte Level Inspection

Check the electrolyte level and specific gravity of batteries that have filler caps. Maintenance-free batteries do not require electrolyte level checking or specific gravity testing.

Check the electrolyte level at the specified interval. Remove the filler caps and verify that the electrolyte level reaches the bottom of each filler hole. See Figure 3-8. Refill as necessary with distilled water or clean tap water. Do not add fresh electrolyte. Tighten the filler caps. After adding water during freezing temperatures, run the generator set 20-30 minutes to mix the electrolyte and the water to prevent battery damage from freezing.

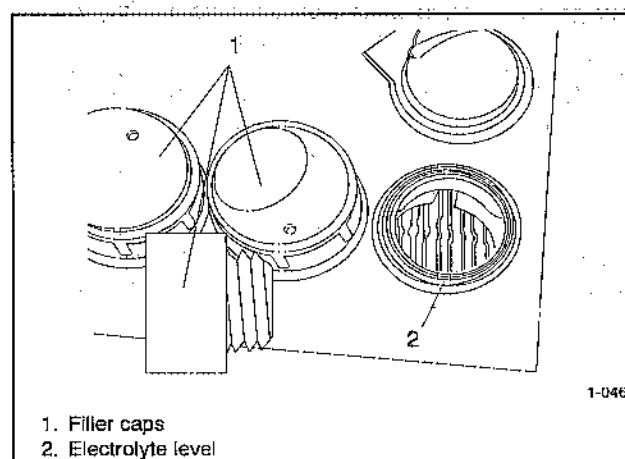


Figure 3-8 Battery Electrolyte Level Inspection

3.8.3 Specific Gravity Check

Use a battery hydrometer to check the specific gravity of the electrolyte in each battery cell of batteries with filler caps. Holding the hydrometer vertically, read the number on the glass bulb at the top of the electrolyte level or the number adjacent to the pointer. If the hydrometer used does not have a correction table, consult Figure 3-10. Determine the specific gravity and electrolyte temperature of the battery cells. Locate the temperature in Figure 3-10 and correct the specific gravity by the amount shown. The battery is fully charged if the specific gravity is 1.260 at an electrolyte temperature of 26.7°C (80°F). Maintain the specific gravities between cells within ± 0.01 of each other. Charge the battery if the specific gravity is below 1.215 at an electrolyte temperature of 26.7°C (80°F).

Note: Some battery testers have four or five beads in a test tube. Draw electrolyte into the tube as with the battery hydrometer described in this section or use the manufacturer's instructions. Use Figure 3-9 to interpret typical test results.

Number of Floating Beads	Battery Condition
5	Overcharged
4	Fully charged
3	A good charge
1 or 2	A low charge
0	A dead battery

Figure 3-9 Bead-Type Test Interpretation

3.8.4 Charge Battery

Use a battery charger to maintain a fully charged battery when the generator set is used in a standby application. The engine battery-charging alternator charges the battery while the generator set is running.

Note: If the generator set is in a temporary prime power application in which the generator set has periods of inactivity, the controller circuitry may drain the battery. If there is no power source for a battery charger, place the controller in the prime power mode, if equipped, or disconnect the battery from the generator set.

3.9 Storage Procedure

Perform the following storage procedure before taking a generator set out of service for three months or longer. Follow the engine manufacturer's recommendations, if available, for fuel system and internal engine component storage.

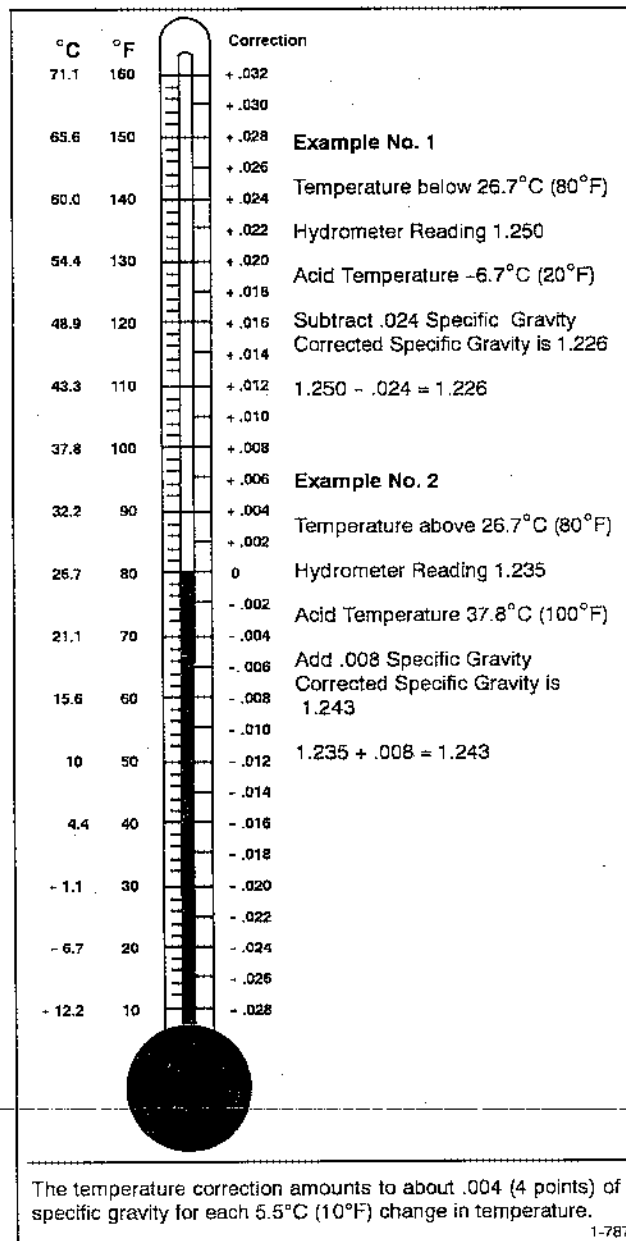


Figure 3-10 Specific Gravity Temperature Correction

3.9.1 Lubricating System

Prepare the engine lubricating system for storage as follows:

1. Run the generator set for a minimum of 30 minutes to bring it to normal operating temperature.
2. Stop the generator set.
3. With the engine still warm, drain the oil from the crankcase.
4. Remove and replace the oil filter.
5. Refill the crankcase with oil suited to the climate.

6. Run the generator set for two minutes to distribute the clean oil.
7. Stop the generator set.
8. Check the oil level and adjust, if needed.

3.9.2 Cooling System

Prepare the cooling system for storage as follows:

1. Check the coolant freeze protection using a coolant tester.
2. Add or replace coolant as necessary to ensure adequate freezing protection. Use the guidelines included in the engine operation manual.
3. Run the generator set for 30 minutes to redistribute added coolant.

3.9.3 Fuel System

Prepare the fuel system for storage as follows:

Diesel-Fueled Engines

1. Fill the fuel tank with #2 diesel fuel.
2. Condition the fuel system with compatible additives to control microbial growth.
3. Change the fuel filter/separator and bleed the fuel system. See the engine owner's manual.

Gas-Fueled Engines

1. Start the generator set.
2. With the generator set running, shut off the gas supply.
3. Run the generator set until the engine stops.
4. Stop the generator set.

3.9.4 Internal Engine Components (Gas-Fueled Engines)

If you have access to a fogging agent or SAE 10 oil prepare the pistons and cylinders for storage as follows:

1. Start the generator set.
2. While the engine is running, spray a fogging agent or SAE 10 engine oil into the air intake for about two minutes until the engine stops.

3. Stop the generator set.

If a fogging agent is not available perform the following:

1. Remove the spark plugs.
2. Pour 15 cc (0.5 oz.) of engine oil into each spark plug hole.

Ignition System Damage. Refer to the engine operation manual for ignition system precautions before cranking the engine while the spark plug wires are disconnected.

3. Crank the engine two or three revolutions to lubricate the cylinders.
4. Reinstall the spark plugs and torque them to specifications.

3.9.5 Exterior

1. Clean the exterior surface of the generator set.
2. Seal all engine openings except for the air intake with nonabsorbent adhesive tape.
3. To prevent impurities from entering the air intake and to allow moisture to escape from the engine, secure a cloth over the air intake.
4. Mask electrical connections.
5. Spread a light film of oil over unpainted metallic surfaces to inhibit rust and corrosion.

3.9.6 Battery

Perform battery storage after all other storage procedures.

1. Confirm that the generator set is stopped.
2. Disconnect the battery(ies), negative (-) lead first.
3. Clean the battery. Refer to Section 3.8.1 for the battery cleaning procedure.
4. Place the battery in a cool, dry location.
5. Connect the battery to a float/equalize battery charger or charge it monthly with a trickle battery charger. Refer to the battery charger manufacturer's recommendations.

Maintain a full charge to extend battery life.

Section 4 General Troubleshooting

This section contains generator set troubleshooting, diagnostic, and repair information.

Use the following charts to diagnose and correct common problems. First check for simple causes such as a dead engine starting battery or an open circuit breaker. The charts include a list of common problems, possible causes of the problem, recommended corrective actions, and references to detailed information or repair procedures.

Maintain a record of repairs and adjustments performed on the equipment. If the procedures in this manual do not explain how to correct the problem, contact an authorized distributor/dealer. Use the record to help describe the problem and repairs or adjustments made to the equipment.

4.1 General Troubleshooting Chart

Trouble Symptoms												Probable Causes	Recommended Actions	Section or Publication Reference*
Does not crank	Cranks but does not start	Starts hard	No or low output voltage	Stops suddenly	Lacks power	Overheats	Low oil pressure	High fuel consumption	Excessive or abnormal noise	Displays error message/locks up	Exercise run time and/or event records inoperative			
Controller														
x	x											Controller circuit board(s) inoperative	Replace the controller.	Gen. S/M
x	x											Controller circuit board(s) wiring fault	Check the wiring.	W/D
				x								Controller fault	Troubleshoot the controller.†	Gen. S/M
x	x			x								Controller fuse blown	Check for continuity across fuse. If fuse is blown, troubleshoot the controller wiring and replace circuit board.†	Section 1, W/D
x												Controller master control buttons inoperative	Replace the controller master control button circuit board.	—
x												Controller master control button in the OFF/RESET mode	Press the controller master control RUN or AUTO button.	Section 2
x												Engine start circuit open	Press the controller master control RUN button to test the generator set. Troubleshoot the auto start circuit and time delays.	Section 2, W/D, Gen. I/M, S/M ATS O/M, S/M
			x	x								Voltage regulation inoperative	Replace the junction box sensing fuses. If the fuse blows again, troubleshoot the controller.	W/D, Gen. S/M
										x		Controller firmware error	Review the controller display troubleshooting chart.	Section 4.2
Alternator														
			x									AC output circuit breaker open	Reset the breaker and check for AC voltage at the generator set side of the circuit breaker.	—
x												Transfer switch test switch in the OFF position	Move the transfer switch test switch to the AUTO position.	ATS O/M
			x									Transfer switch fails to transfer load	Move the ATS test switch to the AUTO position. Troubleshoot the transfer circuit and time delays.	ATS O/M, S/M
			x									Wiring, terminals, or pin in the exciter field open	Check for continuity.	Gen. S/M, W/D
			x									Main field (rotor) inoperative (open or grounded)	Test and/or replace the rotor.†	Gen. S/M
			x									Stator inoperative (open or grounded)	Test and/or replace the stator.†	Gen. S/M
									x			Vibration excessive	Tighten loose components.†	—
			x									Voltage regulator settings incorrect	Adjust the voltage regulator.	Section 1.3.3, SiteTech O/M

* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual

† Have an authorized service distributor/dealer perform this service.

Trouble Symptoms												Probable Causes	Recommended Actions	Section or Publication Reference*
Does not crank	Cranks but does not start	Starts hard	No or low output voltage	Stops suddenly	Lacks power	Overheats	Low oil pressure	High fuel consumption	Excessive or abnormal noise	Displays error message/locks up	Exercise run time and/or event records inoperative			
Electrical System (DC Circuits)														
x	x											Battery connections loose, corroded, or incorrect	Verify that the battery connections are correct, clean, and tight.	Section 3
x	x											Battery weak or dead	Recharge or replace the battery. The spec sheet provides recommended battery CCA rating.	Section 3, S/S
x	x											Starter/starter solenoid inoperative	Replace the starter or starter solenoid.	Eng. S/M
x				x								Engine harness connector(s) not locked tight	Disconnect the engine harness connector(s) then reconnect it to the controller.	W/D
				x								Fault shutdown	Reset the fault switches and troubleshoot the controller.	Section 2
Engine														
	x	x			x			x				Air cleaner clogged	Clean or replace the filter element.	Eng. O/M
	x	x				x		x	x			Compression weak	Check the compression.†	Eng. S/M
			x		x	x		x	x			Engine overload	Reduce the electrical load. See the generator set spec sheet for wattage specifications.	S/S
										x		Exhaust system leak	Inspect the exhaust system. Replace the inoperative exhaust system components.†	I/M
										x		Exhaust system not securely installed	Inspect the exhaust system. Tighten the loose exhaust system components.†	I/M
		x	x		x			x				Governor inoperative	Adjust the governor.†	Eng. S/M
					x					x		Valve clearance incorrect	Adjust the valves.†	Eng. S/M
										x		Vibration excessive	Tighten all loose hardware.	Eng. S/M
	x	x			x							Ignition system inoperative (gas models only)	Check the ignition system (spark plugs, spark plug wires, etc.).	Eng. O/M
x	x			x						x	x	Engine ECM and/or sensors	Troubleshoot the engine ECM and/or sensors.	Eng. O/M, Eng. S/M
* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual														
† Have an authorized service distributor/dealer perform this service.														

Trouble Symptoms												Probable Causes	Recommended Actions	Section or Publication Reference*
Does not crank	Cranks but does not start	Starts hard	No or low output voltage	Stops suddenly	Lacks power	Overheats	Low oil pressure	High fuel consumption	Excessive or abnormal noise	Displays error message/locks up	Exercise run time and/or event records inoperative			
Cooling System														
						x		x				Air openings clogged	Clean the air openings.	---
						x						Coolant level low	Restore the coolant to normal operating level.	Section 3
						x						Cooling water pump inoperative	Tighten or replace the belt. Replace the water pump.	Eng. O/M or S/M
				x								High temperature shutdown	Allow the engine to cool down. Then troubleshoot the cooling system.	Sec. 3, Eng. O/M
				x								Low coolant level shutdown, if equipped	Restore the coolant to normal operating level.	Section 3
						x						Thermostat inoperative	Replace the thermostat.	Eng. S/M
Fuel System														
	x	x			x							Air in fuel system (diesel only)	Bleed the diesel fuel system.	Eng. O/M
	x	x										Ether canister empty or system inoperative, if equipped (diesel only)	Replace or repair the ether starting system.	Eng. O/M
	x			x								Fuel tank empty or fuel valve shut off	Add fuel and move the fuel valve to the ON position.	---
	x				x			x				Fuel feed or injection pump inoperative (diesel only)	Rebuild or replace the injection pump.†	Eng. S/M
	x	x			x							Fuel or fuel injectors dirty or faulty (diesel only)	Clean, test, and/or replace the inoperative fuel injector.†	Eng. S/M
	x	x		x	x							Fuel filter restriction	Clean or replace the fuel filter.	Eng. O/M
	x											Fuel solenoid inoperative	Troubleshoot the fuel solenoid.†	Eng. S/M
	x				x							Fuel pressure insufficient (gas only)	Check the fuel supply and valves.†	S/S, Gen. O/M
	x	x			x			x				Fuel injection timing out of adjustment (diesel only)	Adjust the fuel injection timing.†	Eng. S/M
Lube System														
	x	x					x		x			Crankcase oil type incorrect for ambient temperature	Change the oil. Use oil with a viscosity suitable for the operating climate.	Eng. O/M
						x	x		x			Oil level low	Restore the oil level. Inspect the generator set for oil leaks.	Eng. O/M
				x								Low oil pressure shutdown	Check the oil level.	Eng. O/M
* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual														
† Have an authorized service distributor/dealer perform this service.														

4.2 Controller Display and Voltage Regulation Troubleshooting Chart

Trouble Symptoms	Probable Causes	Recommended Actions	Section or Publication Reference*
Controller Display and Voltage Regulator			
Display is black	No/low battery charge	Recharge/replace battery	Section 3, Battery
Display shows single segment	Low battery voltage	Recharge battery	Section 3, Battery
Display shows an error message	Controller firmware or pushbutton/rotary selector dial entry error	Review the Error Message Section	Section 2.6.1
Display locks up	No/low battery charge	Recharge/replace battery	Section 3, Battery
Output voltage ramps	Defective exciter winding	Troubleshoot alternator components †	Generator Service Manual
Output voltage unstable	Voltage regulation calibration incorrect	Readjust voltage regulation †	Section 1.3.3, SiteTech O/M
* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual † Have an authorized service distributor/dealer perform this service.			

Notes

Section 5 Voltage Reconnection

5.1 Introduction

Use the following voltage reconnection procedure to change the voltage of 10- and 12-lead generator sets. Frequency changes require voltage regulator and governor adjustments. Refer to the respective spec sheet to determine if frequency is fixed or field-convertible. If frequency is adjustable, refer to the engine service manual and/or governor literature for conversion information.

Refer to the following procedure and the connection schematics. Follow the safety precautions at the front of this manual and in the procedure text and observe National Electrical Code (NEC) guidelines.

NOTICE

Voltage reconnection. Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/dealer.

Note: Equipment damage. Verify that the voltage ratings of the transfer switch, line circuit breakers, and other accessories match the selected line voltage.

⚠ WARNING

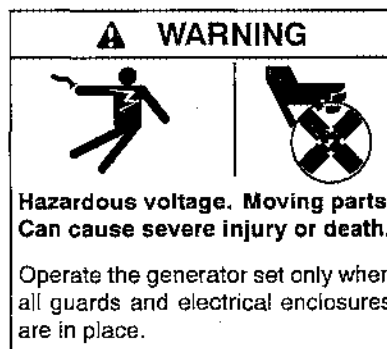


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Turn the generator set master switch and switchgear engine control switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by an automatic transfer switch or a remote start/stop switch.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.



Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

5.2 Voltage Reconnection Procedure

1. Press the generator set master control OFF/RESET button.
2. Disconnect the generator set engine starting battery, negative (-) lead first. Disconnect power to the battery charger (if equipped).
3. Use Figure 5-1, Figure 5-2, or Figure 5-3 to determine the generator set voltage configuration. Note the original voltage and reconnect as needed. Route leads through current transformers (CTs) and connect them according to the diagram for the desired phase and voltage.

Note: Position current transformers CT1, CT2, and CT3 with the dot or HI side CT marking toward the generator set.

4. Reconnect the battery, negative lead last.
5. Use SiteTech™ software to update the information.
6. Refer to 2.6.8 for generator set calibration at the controller.
7. Press the generator set master control RUN button to start the generator set. Check the digital display for correct voltages using 2.6.4 Generator Metering.
8. Press the generator set master control OFF/RESET button to stop the generator set after completing the voltage adjustments.

Figure 5-1 20-150 kW Permanent Magnet Single-Phase Alternators, ADV-5875A-M

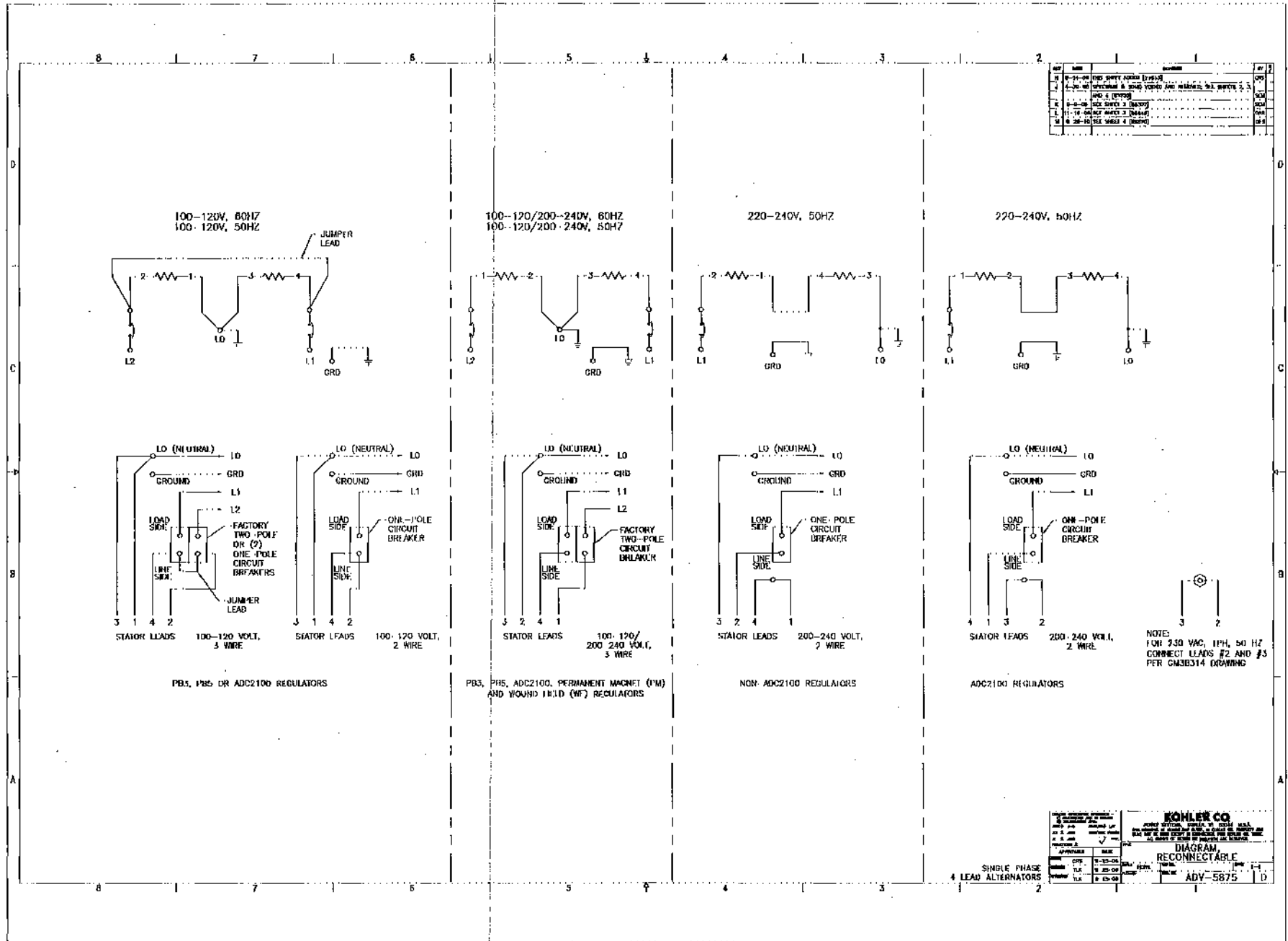


Figure 5-2 20-300 kW (190-480 Volt) Permanent Magnet Alternators, ADV-5875B-M

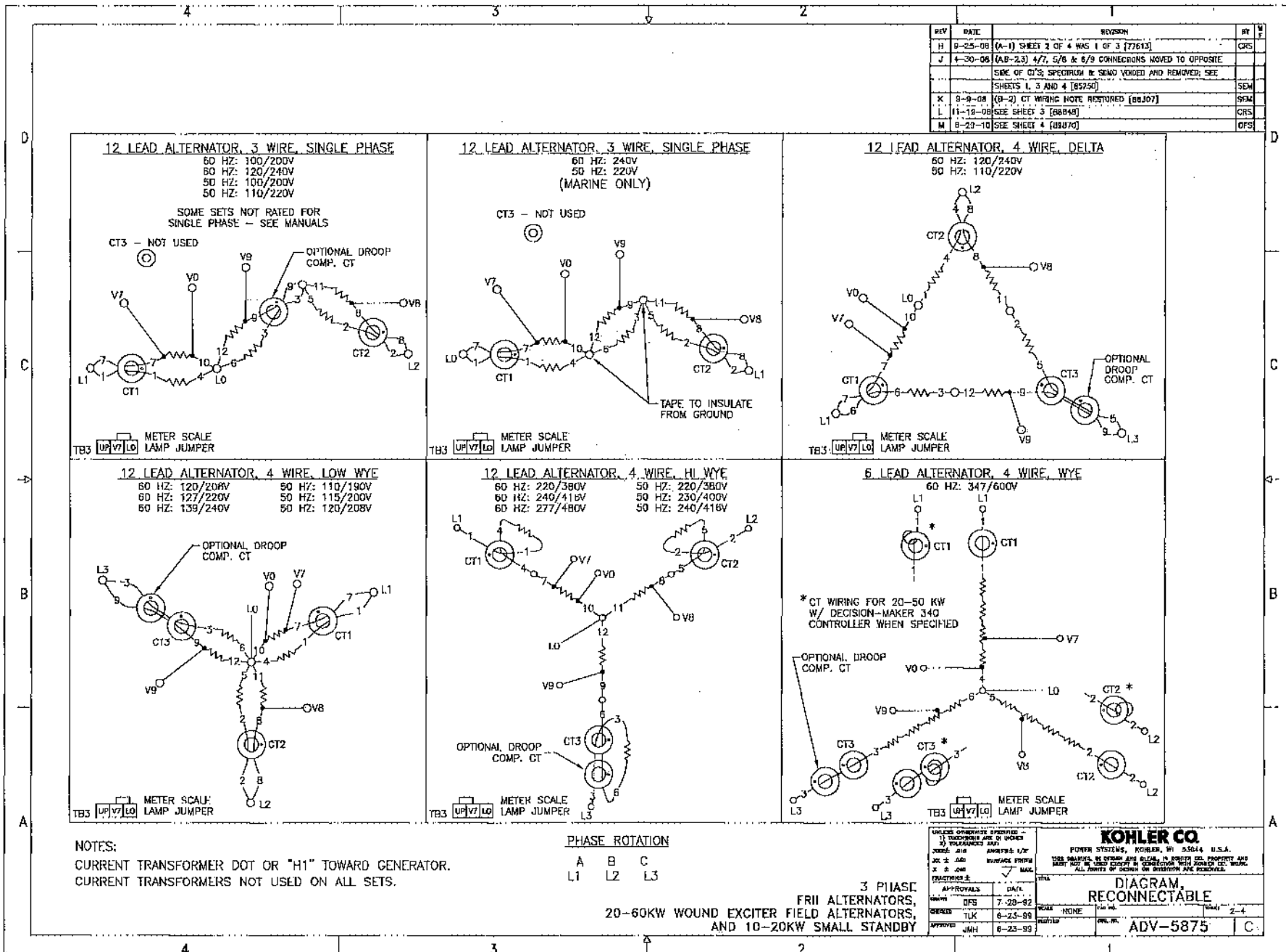
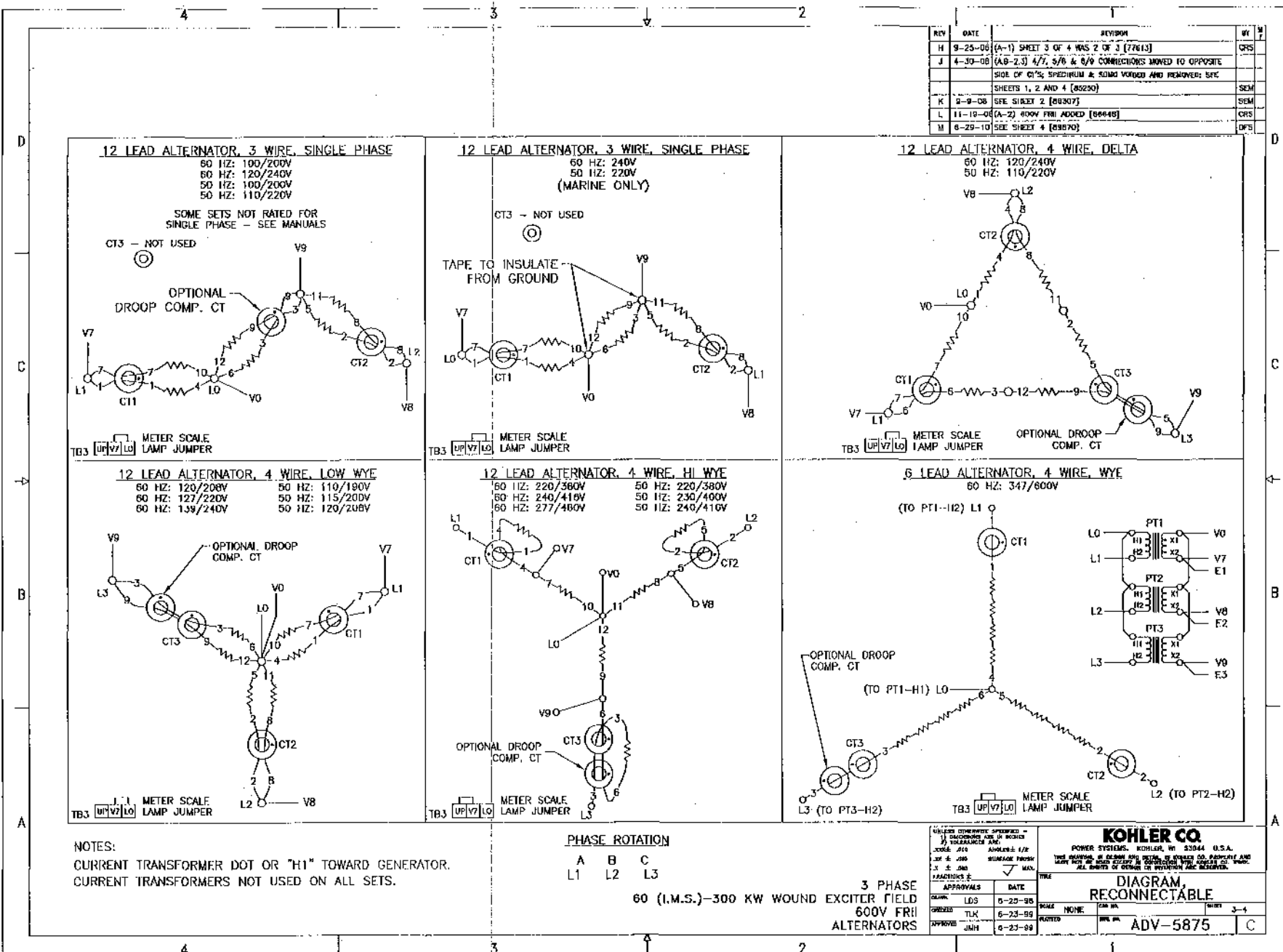


Figure 5-3 20-300 kW (600 Volt) Alternators, ADV-5875C-M



Notes

Section 6 Accessories

6.1 Accessories and Connections

Several accessories help finalize installation, add convenience to operation and service, and establish state and local code compliance.

Accessories vary with each generator set model and controller. Select factory-installed and/or shipped-loose accessories. See Figure 6-1 for a list of available kits. Obtain the most current accessory information from your local authorized service distributor/dealer.

This section illustrates several accessories available at print time of this publication. Accessory kits generally include installation instructions. See wiring diagrams manual for electrical connections not shown in this section. See the installation instructions and drawings supplied with kit for information on kit mounting location.

The instructions provided with the accessory kit supersede these instructions where there are differences. In general, run AC and DC wiring in separate conduit. Use shielded cable for all analog inputs. Observe all applicable national, state, and local electrical codes during accessory installation.

See Section 6.2, Accessory Connections, for terminal identification.

KIt Description
Common Fault/Failure (32A) Connections
Float/Equalize Battery Charger (with alarms)
Gas Fuel Valve
Input/Output Module Board
Low Fuel (Level) Switch
Low Fuel (Pressure) Switch
Prime Power Switch
Remote Emergency Stop
Remote Reset Feature
Remote Serial Annunciator
Run Relay
Shunt-Trip Line Circuit Breaker

Figure 6-1 Optional Accessories

6.1.1 Common Fault/Failure (32A) Relay Kit

The common fault relay is standard on the controller circuit board and located at the TB2 terminal strip connections. Contacts are rated at 2 amps at 32 VDC or 0.5 amps at 120 VAC max. See Figure 6-2 and Figure 6-3.

The optional common fault relay shown in Figure 6-3 as DCB2 has contacts rated at 10 amps at 28 VDC or 120 VAC and can be connected to user-supplied accessories.

The optional common fault relay shown in Figure 6-3 as DCB1 has contacts rated at .10 amps at 28 VDC or 120 VAC and is used to trigger the shunt-trip line circuit breaker kit (mentioned later in this section).

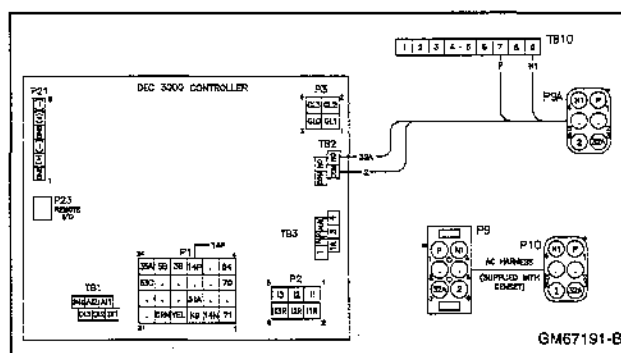


Figure 6-2 Common Fault Relay Wiring (Standard)

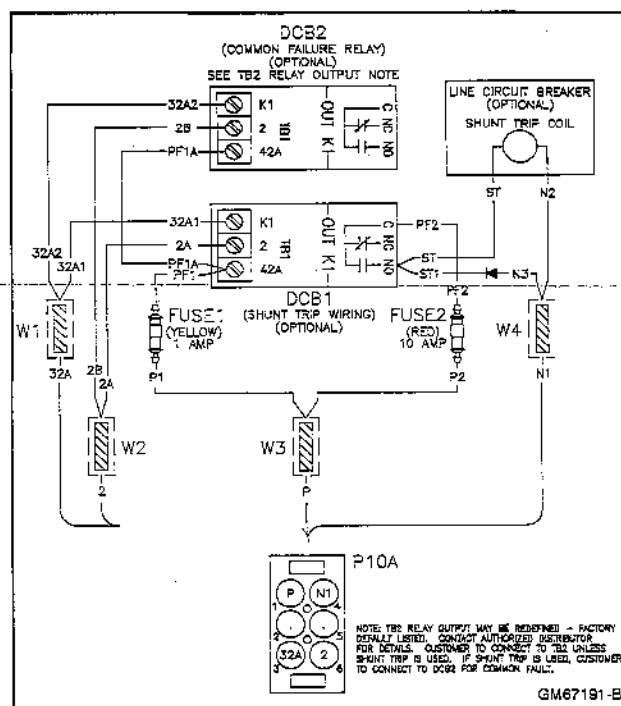


Figure 6-3 Common Fault Relay Kit and Shunt-Trip Relay Kit Wiring

6.1.2 Float/Equalize Battery Charger Kit with Alarm Option

The float/equalize battery charger with alarm option provides battery charging to the engine starting battery(ies) and connects to the controller for fault detection. Battery chargers for 12- or 24-volt models are available as a generator set accessory. See Figure 6-4 and Figure 6-5 for battery connections.

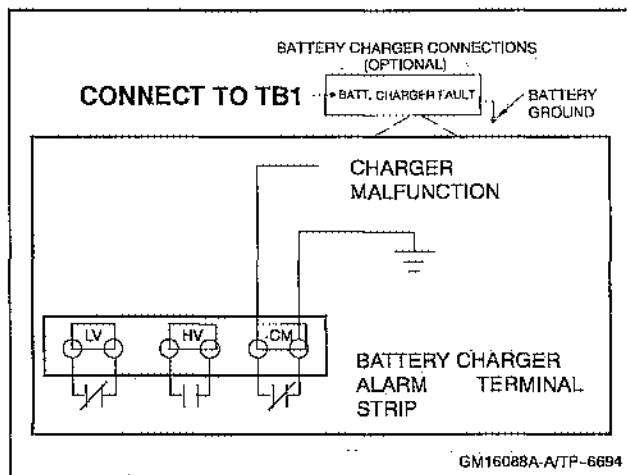


Figure 6-4 Float/Equalize Battery Charger Connections

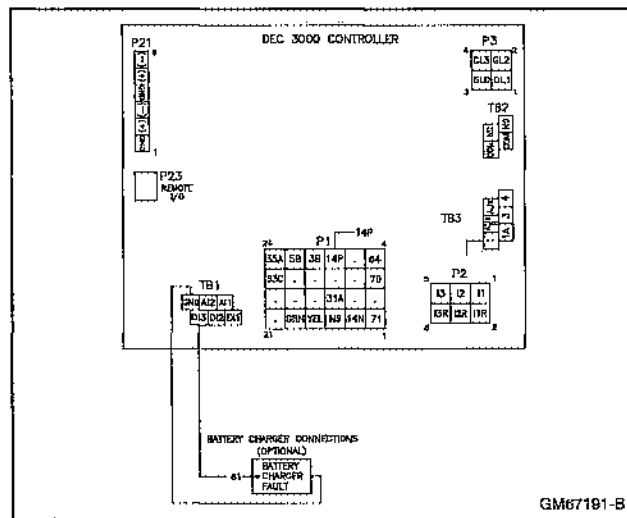


Figure 6-5 Battery Charger to Controller Connections

6.1.3 Gas Fuel Valve Kit

This section provides the wiring information for an *additional* gas fuel valve kit required for UL Approval. See Figure 6-6. Refer to the respective generator set wiring diagrams for additional information and for LP liquid applications.

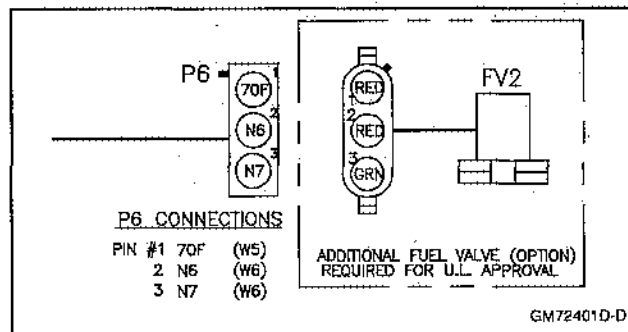


Figure 6-6 Gas Fuel Valve Kit Connections

6.1.4 Input/Output (I/O) Module Board

The I/O module board provides a generator set mounted panel with two analog or digital inputs and five digital outputs. See Figure 6-7 for circuit board components and electrical connections to the controller. See

Figure 6-8 for connections of analog inputs. Refer to Figure 6-27 for accessory connections.

See Section 6.2, Accessory Connections, for terminal identification.

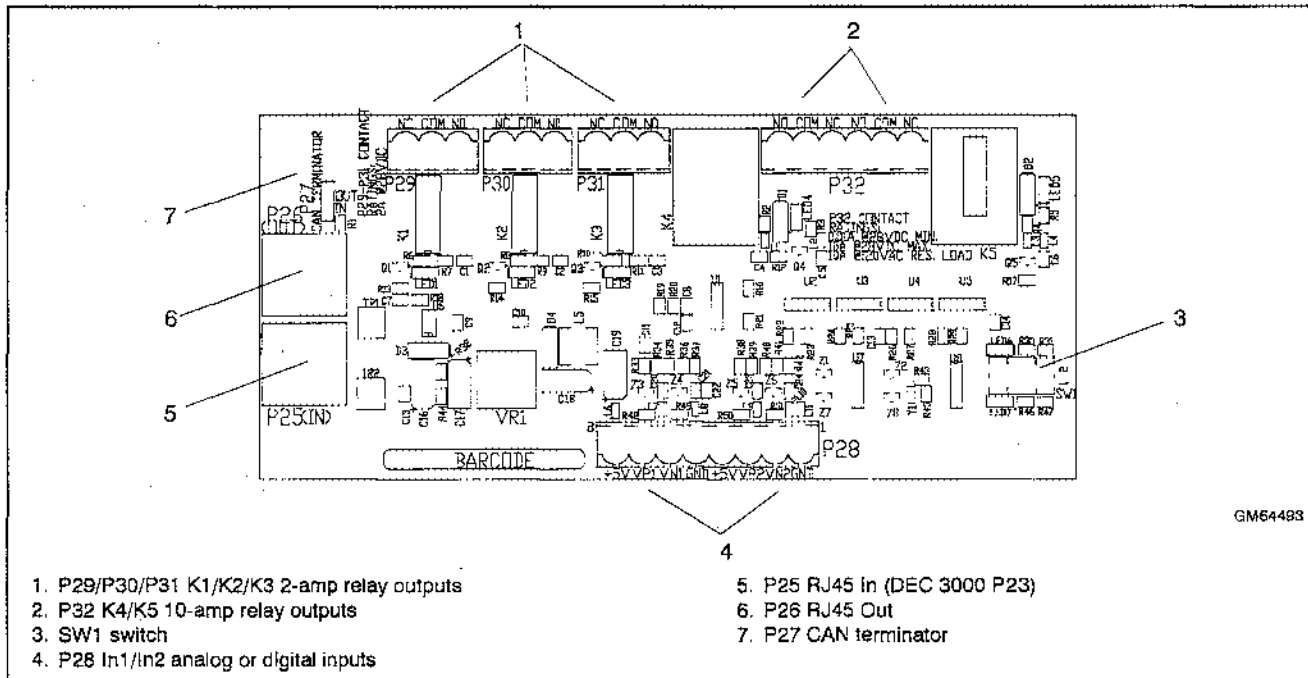


Figure 6-7 Input/Output (I/O) Module Board Kit

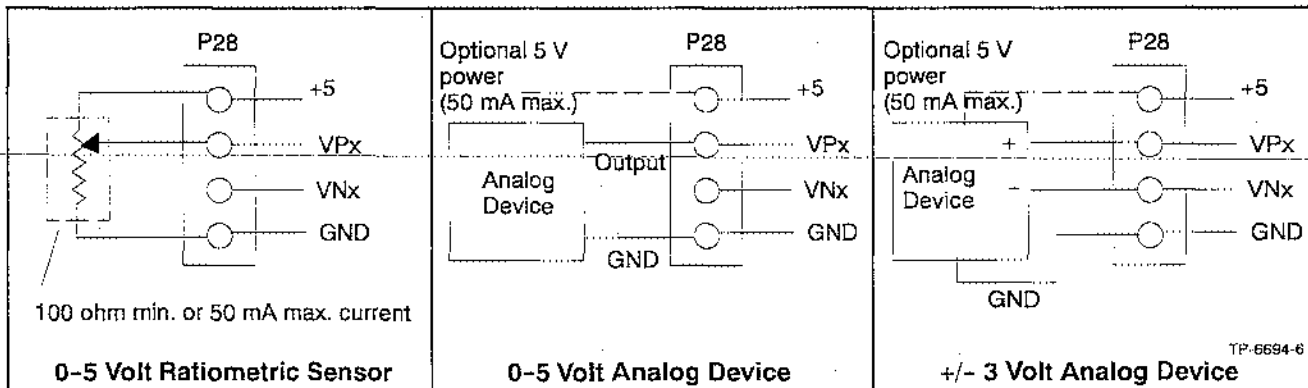


Figure 6-8 Analog Input Connections P28

6.1.5 Low Fuel (Level/Pressure) Switch

Some gas-fueled models offer a low fuel pressure switch. The low fuel pressure switch connects to the same controller terminal as the low fuel level switch on diesel-fueled models. See Figure 6-9, Figure 6-10, and Figure 6-11.

Note: The main tank or the transfer/day tank includes the low fuel level switch. The fuel tank supplier typically provides the low fuel level switch.

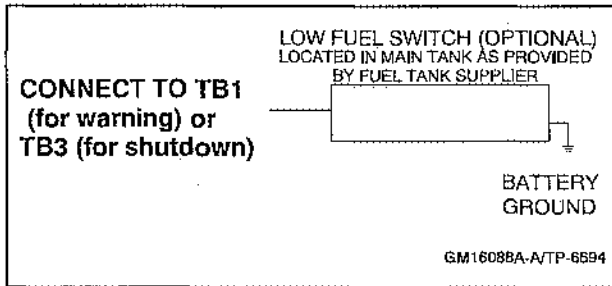


Figure 6-9 Low Fuel Switch (Level or Pressure)

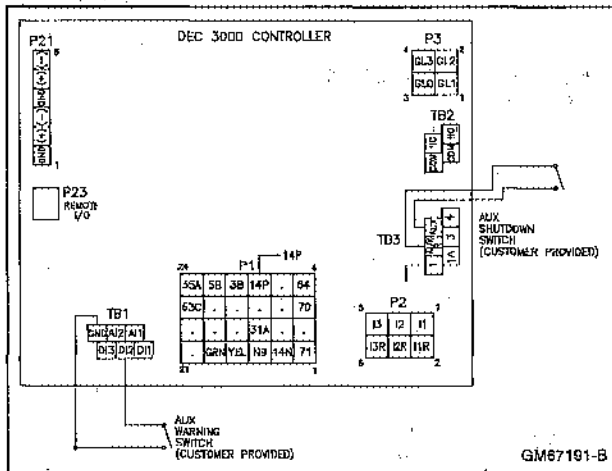


Figure 6-10 Low Fuel Switch Connection to Controller Connection

Switch Rating	12 volts DC minimum, 0.5 amp minimum
Wiring Recommendation	
Gauge	mm (ft.)
18-20	30.5 (100)
14	153 (500)
10	305 (1000)

Figure 6-11 Switch Rating & Wiring Recommendation

6.1.6 Prime Power Switch Kit

The prime power switch kit prevents battery drain during generator set non-operation periods and when the generator set battery cannot be maintained by an AC battery charger. See Figure 6-12 for an illustration of the kit and Figure 6-13 for the electrical connections.

Stop the generator set using the stopping procedures in Section 2.3.2, Stopping, before placing the generator set in the prime power mode. Move the prime power switch located on the junction box to the *DOWN* position. The controller including the digital display, LEDs, and alarm horn does not function when the generator set is in the prime power mode.

Move the prime power switch located on the junction box to the *UP* position. The generator set is now ready for starting.

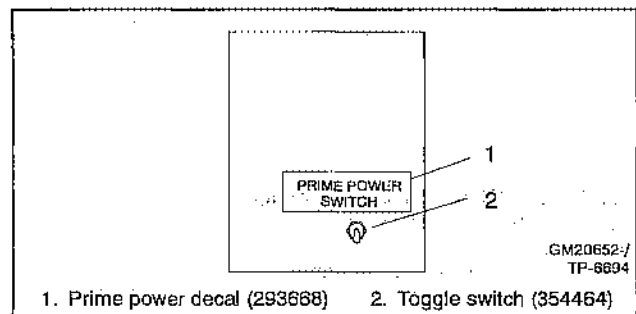


Figure 6-12 Prime Power Switch

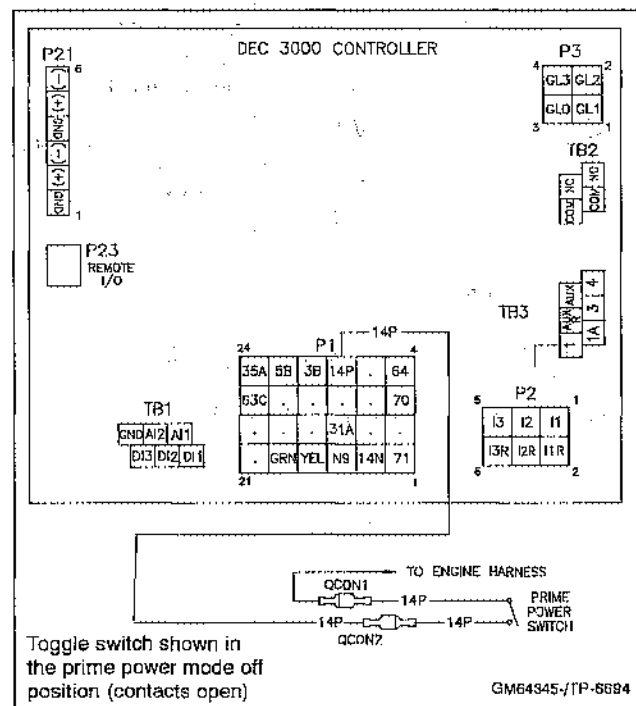


Figure 6-13 Prime Power Switch Connections

6.1.7 Remote Emergency Stop Kit

The emergency stop kit allows immediate shutdown of the generator set from a remote location. See Figure 6-14 and Figure 6-15. If the emergency stop switch activates, the EMERGENCY STOP lamp lights and the unit shuts down. Before attempting to restart the generator set, reset the emergency stop switch (by replacing the glass piece) and reset the generator set by pressing the master control switch OFF/RESET button.

Use the single glass piece located inside the switch for replacement and order additional glass pieces as service parts. See Section 2.3.3, Emergency Stop Switch Resetting.

See Section 6.2, Accessory Connections, for terminal identifications.

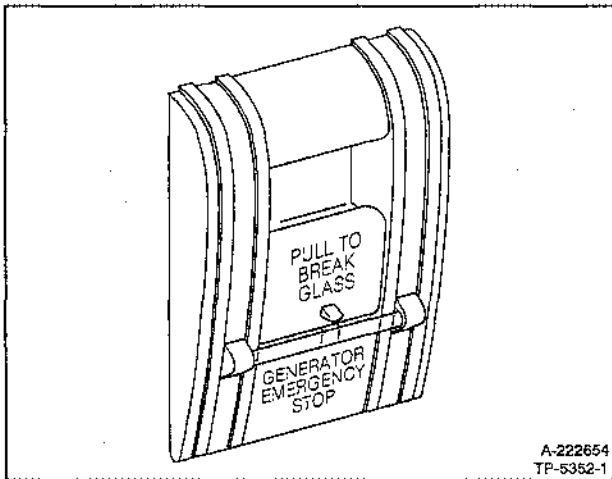


Figure 6-14 Emergency Stop Kit

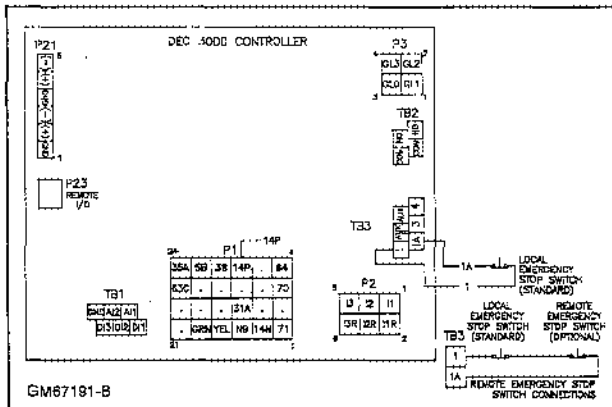


Figure 6-15 Remote Emergency Stop Kit Connections

6.1.8 Remote Reset Feature

The remote reset switch provides generator set controller resetting after a fault shutdown at a remote location. See Figure 6-16 and Figure 6-17 for user-supplied switch connection.

Press and hold the switch for 2-3 seconds and release to reset the generator set controller.

See Section 6.2, Accessory Connections, for terminal identifications.

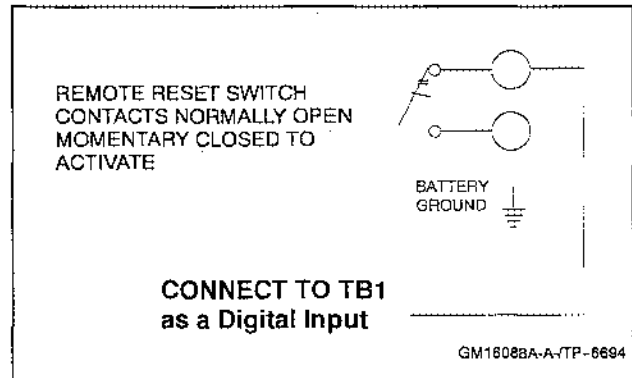


Figure 6-16 Remote Reset Switch Connections

Switch Rating	12 volts DC minimum, 1 amp minimum
Wiring Recommendation	
Gauge	m (ft.)
18-20	30.5 (100)
14	153 (500)
10	305 (1000)

Figure 6-17 Switch Rating and Wiring Recommendations

6.1.9 Remote Serial Annunciator

RSA II is an annunciator panel offered in several kit configurations to support Kohler power equipment. The RSA II is a remote serial annunciator Figure 6-18 and Figure 6-19 that monitors the condition of the generator set and/or ATS from a remote location. The RSA II alerts the operator through visual and audible signals using LED indication and a horn. An alarm silence and lamp test switch are included.

The RSA II meets NFPA 110, Level 1 applications that require remote controls and alarms be powered by a storage battery such as the engine starting battery. An AC adaptor kit is available when NFPA is not required.

The front panel decals include areas that can be used to identify user-selected fault inputs and identify associated power system equipment.

An RSA II annunciator can be used for a single generator set or with a combination of a generator set and automatic transfer switch. In systems using more than a single RSA II, one must be designated as the master device to broadcast to additional RSA II annunciators, designated as slave devices. Up to five RSA II slave devices can be used with an RSA II master device. All RSA II annunciators are factory set as the master device, but can be changed to a slave device using a PC and SiteTech™ software that connects to the RSA II front panel via a universal serial bus (USB) connection.

The RSA 1000 can be connected with the RSA II provided that the master remote annunciator is an RSA II.

Refer to TT-1485 Remote Serial Annunciator (RSA II) Kits for operation and installation instructions.

A PC with SiteTech™ software is required to make the RSA II functional. Use your SecurID to access KOHLERnet, click on the TechTools button, and follow the instructions to download the files. Refer to the SiteTech™ Software Operation Manual for more information.

The RSA II kits include components for surface mounting or flush mounting.

Figure 6-20 shows the status of the system ready LED, generator set running LED, communication status LED, common fault LED, common fault output, and horn for each fault or status condition.

If the RSA II is used with an Ethernet communication network, order Modbus® Ethernet converter GM41143-KP2 and refer to TT-1405 Converters, Connections, and Controller Setup for Network Communication for system installation.

Modbus® is a registered trademark of Schneider Electric.

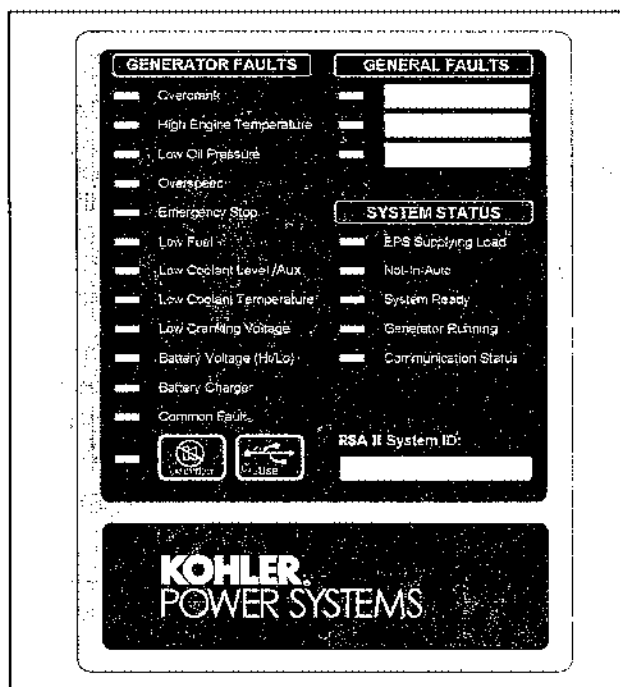


Figure 6-18 Remote Serial Annunciator (RSA II)

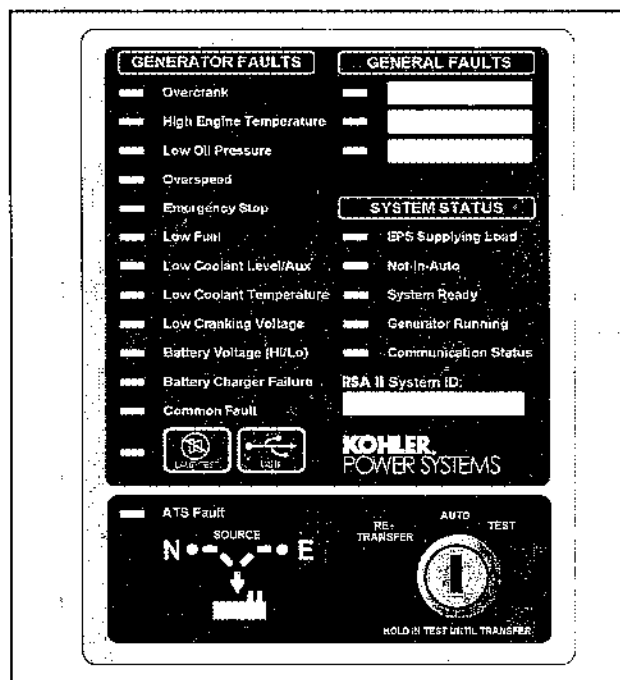


Figure 6-19 RSA II with ATS Controls

See Section 6.2, Accessory Connections, for terminal identifications.

Fault and Status Condition	System Monitoring LEDs and Functions						
	Fault LED	System Ready LED	Generator Running LED	Communication Status LED	Common Fault LED	Common Fault Output	Horn
Overcrank Shutdown	Red	Red SF	Off	Green	Red SF	On	On
High Engine Temperature Warning *	Yellow	Red SF	Green	Green	Red SF	On	On
High Engine Temperature Shutdown	Red	Red SF	Off	Green	Red SF	On	On
Low Oil Pressure Warning *	Yellow	Red SF	Green	Green	Red SF	On	On
Low Oil Pressure Shutdown	Red	Red SF	Off	Green	Red SF	On	On
Overspeed Shutdown	Red	Red SF	Off	Green	Red SF	On	On
Emergency Stop *	Red	Red SF	Off	Green	Off	On	On
Low Coolant Level/Auxiliary Shutdown *	Red	Red SF	Off	Green	Red SF	On	On
Low Coolant Temperature *	Yellow	Red SF	Off	Green	Red SF	On	On
Low Fuel—Level or Pressure *	Yellow	Red SF	Off	Green	Red SF	On	On
EPS Supplying Load (RSA II)	Green	Green	Green or Off	Green	Off	Off	Off
System Ready	Green	Green	Green or Off	Green	Off	Off	Off
System Not Ready	Red	Red SF	Green or Off	Green	Off	On	On
Low Cranking Voltage	Yellow	Red SF	Off	Green	Red SF	On	On
(Loss of) Communication Status (Master RSA II)	Red	Off	Off	Red FF	Off	On	On
(Loss of) Communication Status (Slave RSA II)	Red	Off	Off	Red SF	Off	On	On
Not-In-Auto	Red	Red SF	Green or Off	Green	Red SF	On	On
Battery Charger Fault *	Yellow	Green	Green or Off	Green	Off	On	On
High Battery Voltage *	Yellow	Green	Green or Off	Green	Off	On	On
Low Battery Voltage *	Yellow	Green	Green or Off	Green	Off	Off	Off
User Input #1 (RSA II) Warning	Yellow	Green	Green or Off	Green	Off	On	On
User Input #1 (RSA II) Shutdown	Red	Green	Green or Off	Green	Off	On	On
User Input #2 (RSA II) Warning	Yellow	Green	Green or Off	Green	Off	On	On
User Input #2 (RSA II) Shutdown	Red	Green	Green or Off	Green	Off	On	On
User Input #3 (RSA II) Warning	Yellow	Green	Green or Off	Green	Off	On	On
User Input #3 (RSA II) Shutdown	Red	Green	Green or Off	Green	Off	On	On
Common Fault Warning	Yellow	Green	Green or Off	Green	Red SF	On	Off
Common Fault Shutdown	Red	Green	Green or Off	Green	Red SF	On	On
ATS Position N (RSA II with ATS only)	Green	Green	Green or Off	Green	Off	Off	Off
ATS Position E (RSA II with ATS only)	Red	Red SF	Green or Off	Green	Off	Off	On
ATS Available N (RSA II with ATS only)	Green	Green	Green or Off	Green	Off	Off	Off
ATS Available E (RSA II with ATS only)	Red	Red SF	Green or Off	Green	Off	Off	On
ATS Fault (RSA II with ATS only)	Yellow	Yellow	Green or Off	Green	Off	Off	On
ATS Fault (RSA II with ATS only)	Red	Red SF	Green or Off	Green	Off	Off	On

SF = Slow Flash (1 second intervals), FF = Fast Flash (200 ms intervals)
 * May require optional kit or user-provided device to enable function and LED indication.

Figure 6-20 System Monitoring LEDs and Functions

6.1.10 Run Relay Kit

The run relay kit energizes only when the generator set runs. Use the run relay kit to control air intake and radiator louvers, alarms, and/or other signalling devices. See Figure 6-21 and Figure 6-22.

See Section 6.2, Accessory Connections, for terminal identifications.

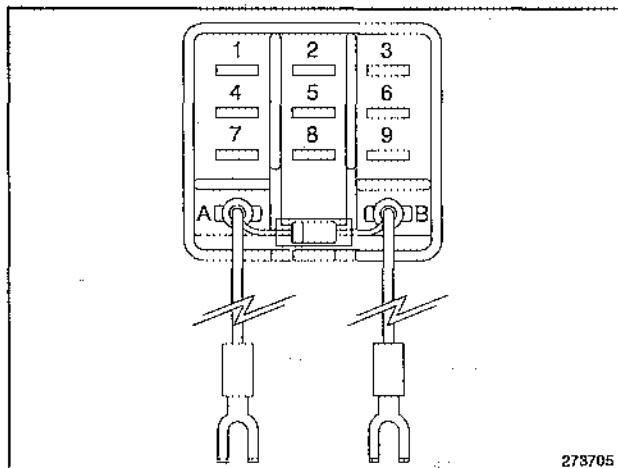


Figure 6-21 Run Relay Kit

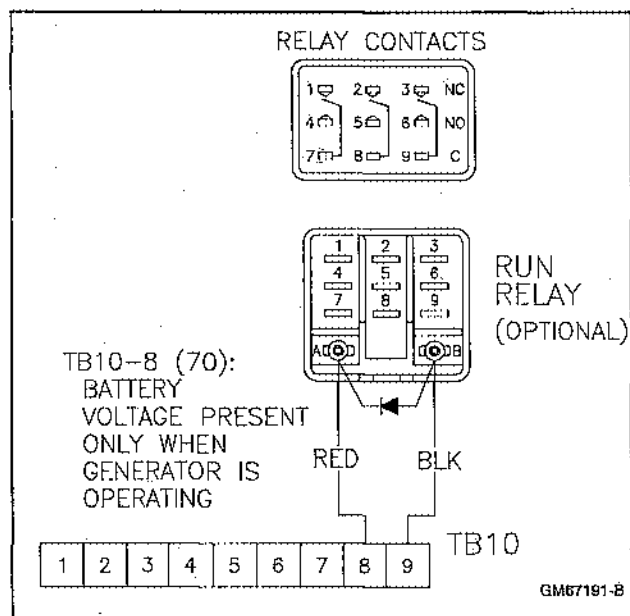


Figure 6-22 Run Relay Connections

6.1.11 Shunt-Trip Line Circuit Breaker

A shunt-trip line circuit breaker provides a 12- or 24-DC volt solenoid within the line circuit breaker case that can energize the trip mechanism. This feature allows the circuit breaker to be tripped by the common fault (32A). Connection requires a shunt-trip wiring kit and a dry contact kit. See Figure 6-23 and Figure 6-24.

The optional common fault relay shown in Figure 6-24 as DCB1 has contacts rated at 10 amps at 28 VDC or 120 VAC and is used to trigger the shunt-trip line circuit breaker kit.

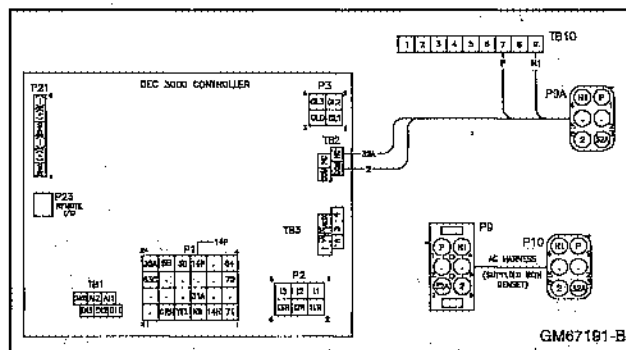


Figure 6-23 Shunt-Trip Wiring (Standard)

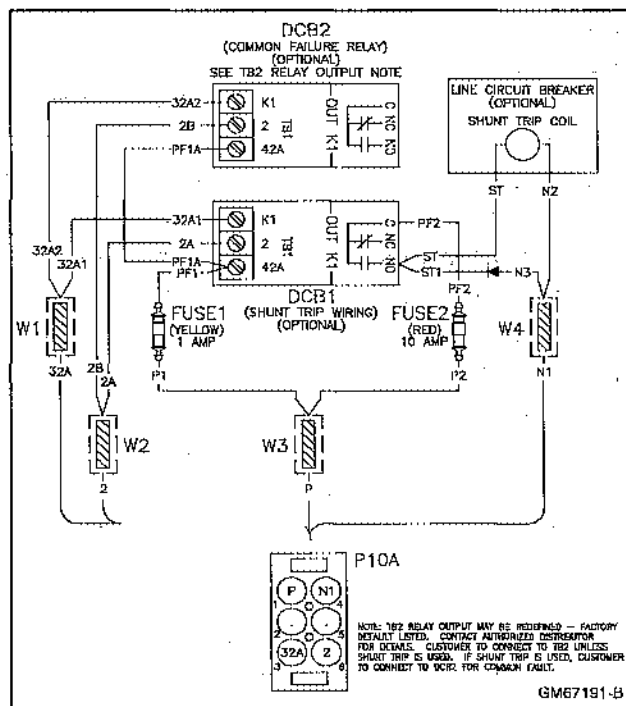


Figure 6-24 Shunt-Trip Relay Kit and Line Circuit Breaker Wiring (Shown with Common Fault/Failure Relay Kit)

6.2 Accessory Connections

The controller contains a circuit board equipped with terminal strip(s) for use in connecting external optional accessories including alarms, battery chargers, and remote switches. The optional I/O board provides an additional two analog or digital inputs and five digital outputs.

For specific information on accessory connections, refer to the accessory wiring diagrams in the wiring diagram manual and the instruction sheet accompanying the kit. See Figure 6-25, Figure 6-26, and Figure 6-28 for controller circuit board connections.

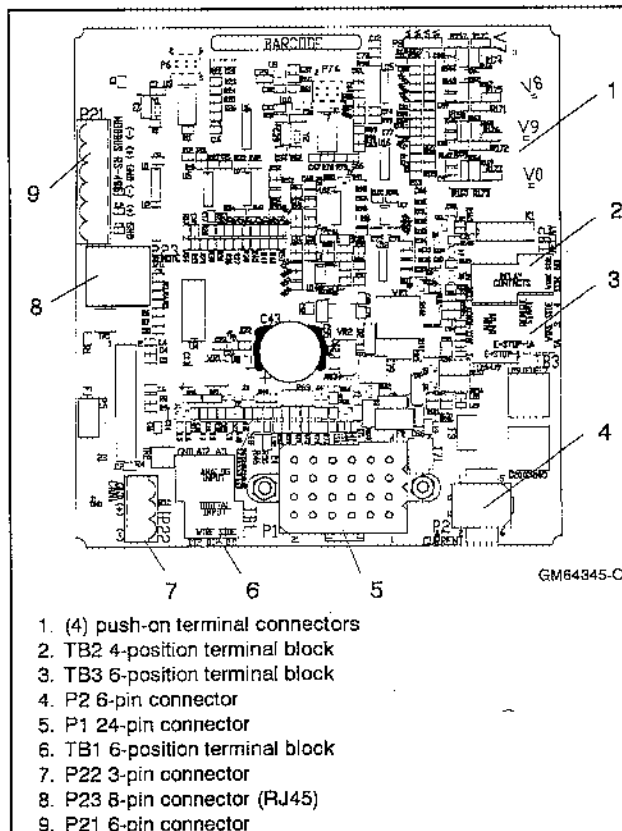


Figure 6-25 Controller Circuit Board Connections

TB1 Terminal Strip		
Analog and Digital Input Connections		
Terminal	Description	Connection
TB1-DI 1	DCH1	No Function
TB1-DI 2	DCH2	Aux. Warning Switch
TB1-DI 3	DCH3	Battery Charger Fault
TB1-AI 1	ACH1	No Function
TB1-AI 2	ACH2	No Function
TB1-GND	Ground	Common A/D Ground
TB2 Terminal Strip		
KI Relay Outputs		
Terminal	Description	Connection
TB2-COM	Common	User-Defined
TB2-COM	Common	Common Fault (2)
TB2-NO	Normally Open	Common Fault (32A)
TB2-NC	Normally Closed	User-Defined
TB3 Terminal Strip		
Accessory Power Output Connections		
Terminal	Description	Connection
TB3-1	E-Stop	E-Stop Ground
TB3-1A	E-Stop	E-Stop
TB3-3	Remote Start	Remote Start
TB3-4	Remote Start	Remote Start
TB3-AUX	Auxiliary	Aux. Shutdown Sw.
TB3-AUXR	Auxiliary-R	Aux. Shutdown Sw.

P1 24-Pin Connector		
Engine Wiring Harness		
Terminal	Description	Connection
P1-12	14P +12VDC	Prime Power Switch
P21 6-Pin Connector		
RS-485 (RSA II)		
Terminal	Description	Connection
P21-1	GND	Shield
P21-2	(+)	Red
P21-3	(-)	Black
P21-4	GND	Shield
P21-5	(+)	Red
P21-6	(-)	Black
TB1 Terminal Strip Designations		
Analog and Digital Input Connections		
Terminals on Board	Controller Designation	SiteTech Designation
TB1-DI 1	DIn A1	A1
TB1-DI 2	DIn A2	A2
TB1-DI 3	DIn A3	A3
TB1-AI 1	AIn A1	—
TB1-AI 2	AIn A2	A1
TB1-GND	—	—

Figure 6-26 Controller Connections

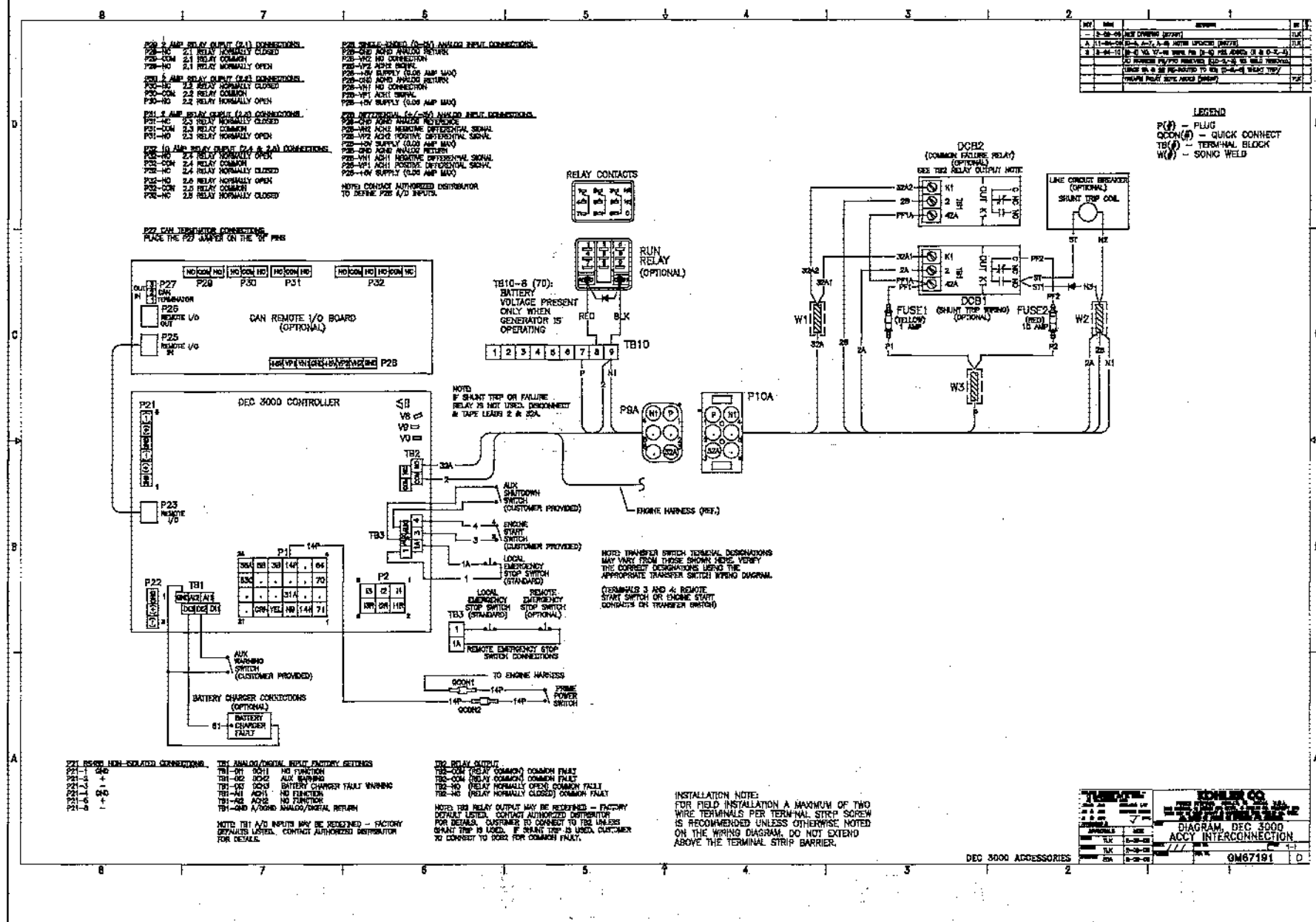
P25 Connector	
RJ45 Remote I/O In	
Connects to DEC 3000 P23	
P26 Connector	
RJ45 Remote I/O Out	
Open	
P27 Connector	
CAN Terminator	
Place the P27 jumper on the IN pins	
P28 Connector	
Single-Ended (0–5 V) Analog Input Connections	
Terminal	Description
P28–GND	AGND Analog Return
P28–VN1	NO Connection
P28–VP1	ACH1 Signal
P28–+5V	Supply (.05 amp max.)
P28–GND	AGND Analog Return
P28–VN2	NO Connection
P28–VP2	ACH2 Signal
P28–+5V	Supply (0.05 amp max.)
P28 Connector	
Differential (+/–3 V) Analog Input Connections	
Terminal	Description
P28–GND	AGND Analog Reference
P28–VN1	ACH1 Negative Differential Signal
P28–VP1	ACH1 Positive Differential Signal
P28–+5V	Supply (.05 amp max.)
P28–GND	AGND Analog Reference
P28–VN2	ACH2 Negative Differential Signal
P28–VP2	ACH2 Positive Differential Signal
P28–+5V	Supply (0.05 amp max.)
P29 Connector	
2 Amp. K1 Relay Output (2.1) Connections	
Terminal	Description
P29–NC	Normally Closed
P29–COM	Common
P29–NO	Normally Open

P30 Connector	
2 Amp. K2 Relay Output (2.2) Connections	
Terminal	Description
P30–NC	Normally Closed
P30–COM	Common
P30–NO	Normally Open
P31 Connector	
2 Amp. K3 Relay Output (2.3) Connections	
Terminal	Description
P31–NC	Normally Closed
P31–COM	Common
P31–NO	Normally Open
P32 Connector	
10 Amp. K4 Relay Output (2.4) Connections	
Terminal	Description
P32–NC	Normally Closed
P32–COM	Common
P32–NO	Normally Open
10 Amp. K5 Relay Output (2.5) Connections	
Terminal	Description
P32–NC	Normally Closed
P32–COM	Common
P32–NO	Normally Open

P28 Connector Designations		
Terminals on Board	Controller Designation	SiteTech Designation
P28–GND	DIn B1	B1
P28–VN1		
P28–VP1		
P28–+5V	Din B2	B2
P28–GND		
P28–VN2		
P28–VP2		
P28–+5V		

Figure 6-27 Input/Output Module Board Connections

Figure 6-28 Decision-Maker® 3000 Wiring Connections GM67191-B



Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

A, amp	ampere	cert.	certificate, certification, certified	ESD	electrostatic discharge
ABDC	after bottom dead center	cfh	cubic feet per hour	est.	estimated
AC	alternating current	cfm	cubic feet per minute	E-Stop	emergency stop
A/D	analog to digital	CG	center of gravity	etc.	et cetera (and so forth)
ADC	advanced digital control; analog to digital converter	CID	cubic inch displacement	exh.	exhaust
adj.	adjust, adjustment	CL	centerline	ext.	external
ADV	advertising dimensional drawing	cm	centimeter	F	Fahrenheit, female
Ah	amp-hour	CMOS	complementary metal oxide substrate (semiconductor)	FHM	flat head machine (screw)
AHWT	anticipatory high water temperature	com	communications (port)	fl. oz.	fluid ounce
AISI	American Iron and Steel Institute	coml	commercial	flex.	flexible
ALOP	anticipatory low oil pressure	Com/Rec	Commercial/Recreational	freq.	frequency
alt.	alternator	conn.	connection	FS	full scale
Al	aluminum	cont.	continued	ft.	foot, feet
ANSI	American National Standards Institute (formerly American Standards Association, ASA)	CPVC	chlorinated polyvinyl chloride	ft. lb.	foot pounds (torque)
AO	anticipatory only	crit.	critical	ft./min.	feet per minute
APDC	Air Pollution Control District	CSA	Canadian Standards Association	ftp	file transfer protocol
API	American Petroleum Institute	CT	current transformer	g	gram
approx.	approximate, approximately	Cu	copper	ga.	gauge (meters, wire size)
APU	Auxiliary Power Unit	dUL	Canadian Underwriter's Laboratories	gal.	gallon
AQMD	Air Quality Management District	CUL	Canadian Underwriter's Laboratories	gen.	generator
AR	as required, as requested	cu. in.	cubic inch	genset	generator set
AS	as supplied, as stated, as suggested	cw.	clockwise	GFI	ground fault interrupter
ASE	American Society of Engineers	CWC	city water-cooled	GND, 	ground
ASME	American Society of Mechanical Engineers	cyl.	cylinder	gov.	governor
assy.	assembly	D/A	digital to analog	gph	gallons per hour
ASTM	American Society for Testing Materials	DAC	digital to analog converter	gpm	gallons per minute
ATDC	after top dead center	dB	decibel	gr.	grade, gross
ATS	automatic transfer switch	dB(A)	decibel (A weighted)	GRD	equipment ground
auto.	automatic	DC	direct current	gr. wt.	gross weight
aux.	auxiliary	DCR	direct current resistance	H x W x D	height by width by depth
avg.	average	deg., °	degree	HC	hex cap
AVR	automatic voltage regulator	dept.	department	HCHT	high cylinder head temperature
AWG	American Wire Gauge	dia.	diameter	HD	heavy duty
AWM	appliance wiring material	DI/EO	dual inlet/end outlet	HET	high exhaust temp., high engine temp.
bat.	battery	DIN	Deutsches Institut für Normung e. V. (also Deutsche Industrie Normenausschuss)	hex	hexagon
BBDC	before bottom dead center	DIP	dual inline package	Hg	mercury (element)
BC	battery charger, battery charging	DPDT	double-pole, double-throw	HH	hex head
BCA	battery charging alternator	DPST	double-pole, single-throw	HHC	hex head cap
BCI	Battery Council International	DS	disconnect switch	HP	horsepower
BDC	before dead center	DVR	digital voltage regulator	hr.	hour
BHP	brake horsepower	E ² PROM	EEPROM, electrically-erasable programmable read-only memory	HS	heat shrink
blk.	black (paint color), block (engine)	E, emer.	emergency (power source)	hsg.	housing
blk. htr.	block heater	ECM	electronic control module, engine control module	HVAC	heating, ventilation, and air conditioning
BMEP	brake mean effective pressure	EDI	electronic data interchange	HWT	high water temperature
bps	bits per second	EFR	emergency frequency relay	Hz	hertz (cycles per second)
br.	brass	e.g.	for example (<i>exempli gratia</i>)	IBC	International Building Code
BTDC	before top dead center	EG	electronic governor	IC	integrated circuit
Btu	British thermal unit	EGSA	Electrical Generating Systems Association	ID	inside diameter, identification
Btu/min.	British thermal units per minute	EIA	Electronic Industries Association	IEC	International Electrotechnical Commission
C	Celsius, centigrade	EI/EO	end inlet/end outlet	IEEE	Institute of Electrical and Electronics Engineers
cal.	calorie	EMI	electromagnetic interference	IMS	improved motor starting
CAN	controller area network	emiss.	emission	in.	inch
CARB	California Air Resources Board	eng.	engine	in. H ₂ O	inches of water
CATS	Category 5 (network cable)	EPA	Environmental Protection Agency	in. Hg	inches of mercury
CB	circuit breaker	EPS	emergency power system	in. lb.	inch pounds
CC	crank cycle	ER	emergency relay	Inc.	incorporated
cc	cubic centimeter	ES	engineered special	Ind.	industrial
CCA	cold cranking amps			int.	internal
ccw.	counterclockwise			int./ext.	internal/external
CEC	Canadian Electrical Code			I/O	input/output
				IP	internet protocol
				ISO	International Organization for Standardization
				J	joule
				JIS	Japanese Industry Standard
				k	kilo (1000)

K	kelvin	NA	not available, not applicable	RTU	remote terminal unit
kA	kiloampere	nat. gas	natural gas	RTV	room temperature vulcanization
KB	kilobyte (2 ¹⁰ bytes)	NBS	National Bureau of Standards	RW	read/write
KBus	Kohler communication protocol	NC	normally closed	SAE	Society of Automotive Engineers
kg	kilogram	NEC	National Electrical Code	scfm	standard cubic feet per minute
kg/cm ²	kilograms per square centimeter	NEMA	National Electrical Manufacturers Association	SCR	silicon controlled rectifier
kgm	kilogram-meter	NFPA	National Fire Protection Association	s, sec.	second
kg/m ³	kilograms per cubic meter	Nm	newton meter	SI	<i>Système international d'unités</i> , International System of Units
kHz	kilohertz	NO	normally open	SI/EO	side in/end out
kJ	kilojoule	no., nos.	number, numbers	sil.	silencer
km	kilometer	NPS	National Pipe, Straight	SMTP	simple mail transfer protocol
kOhm, kΩ	kilo-ohm	NPSC	National Pipe, Straight-coupling	SN	serial number
kPa	kilopascal	NPT	National Standard taper pipe thread per general use	SNMP	simple network management protocol
kph	kilometers per hour	NPTF	National Pipe, Taper-Fine	SPDT	single-pole, double-throw
kV	kilovolt	NR	not required, normal relay	SPST	single-pole, single-throw
kVA	kilovolt ampere	ns	nanosecond	spec	specification
KVAR	kilovolt ampere reactive	OC	overcrank	specs	specification(s)
kW	kilowatt	OD	outside diameter	sq.	square
kWh	kilowatt-hour	OEM	original equipment manufacturer	sq. cm	square centimeter
kWm	kilowatt mechanical	OF	overfrequency	sq. in.	square inch
kWth	kilowatt-thermal	opt.	option, optional	SMS	short message service
L	liter	OS	oversize, overspeed	SS	stainless steel
LAN	local area network	OSHA	Occupational Safety and Health Administration	std.	standard
L x W x H	length by width by height	OV	overvoltage	stl.	steel
lb.	pound, pounds	oz.	ounce	tach.	tachometer
lbm/ft ³	pounds mass per cubic feet	p., pp.	page, pages	TB	terminal block
LCB	line circuit breaker	PC	personal computer	TCP	transmission control protocol
LCD	liquid crystal display	PCB	printed circuit board	TD	time delay
LED	light emitting diode	pF	picofarad	TDC	top dead center
Lph	liters per hour	PF	power factor	TDEC	time delay engine cooldown
Lpm	liters per minute	ph., Ø	phase	TDEN	time delay emergency to normal
LOP	low oil pressure	PHC	Phillips® head CrimpTite® (screw)	TDES	time delay engine start
LP	liquefied petroleum	PHH	Phillips® hex head (screw)	TDNE	time delay normal to emergency
LPG	liquefied petroleum gas	PHM	pan head machine (screw)	TDOE	time delay off to emergency
LS	left side	PLC	programmable logic control	TDON	time delay off to normal
L _{wa}	sound power level, A weighted	PMG	permanent magnet generator	temp.	temperature
LWL	low water level	pot	potentiometer, potential	term.	terminal
LWT	low water temperature	ppm	parts per million	THD	total harmonic distortion
m	meter, milli (1/1000)	PROM	programmable read-only memory	TIF	telephone influence factor
M	mega (10 ⁶ when used with SI units), male	psi	pounds per square inch	tol.	tolerance
m ³	cubic meter	psig	pounds per square inch gauge	turbo.	turbocharger
m ³ /hr.	cubic meters per hour	pt.	pint	typ.	typical (same in multiple locations)
m ³ /min.	cubic meters per minute	PTC	positive temperature coefficient	UF	underfrequency
mA	milliampere	PTO	power takeoff	UHF	ultrahigh frequency
man.	manual	PVC	polyvinyl chloride	UIF	user interface
max.	maximum	qt.	quart, quarts	UL	Underwriter's Laboratories, Inc.
MB	megabyte (2 ²⁰ bytes)	qty.	quantity	UNC	unified coarse thread (was NC)
MCCB	molded-case circuit breaker	R	replacement (emergency)	UNF	unified fine thread (was NF)
MCM	one thousand circular mils	rad.	power source	univ.	universal
meggar	megohmmeter	RAM	radiator, radius	URL	uniform resource locator (web address)
MHz	megahertz	RDO	random access memory	US	undersize, underspeed
mi.	mile	ref.	relay driver output	UV	ultraviolet, undervoltage
mil	one one-thousandth of an inch	rem.	reference	V	volt
min.	minimum, minute	Res/Coml	remote	VAC	volts alternating current
misc.	miscellaneous	RFI	Residential/Commercial radio frequency interference	VAR	voltampere reactive
MJ	megajoule	RH	round head	VDC	volts direct current
mJ	millijoule	RHM	round head machine (screw)	VFD	vacuum fluorescent display
mm	millimeter	rly.	relay	VGA	video graphics adapter
mOhm, mΩ	milliohm	rms	root mean square	VHF	very high frequency
MOhm, MΩ	megohm	rnd.	round	W	watt
MOV	metal oxide varistor	RO	read only	WCR	withstand and closing rating
MPa	megapascal	ROM	read only memory	w/	with
mpg	miles per gallon	rot.	rotate, rotating	WO	write only
mph	miles per hour	rpm	revolutions per minute	w/o	without
MS	military standard	RS	right side	wt.	weight
ms	millisecond	RTDs	Resistance Temperature Detectors	xfrm	transformer
m/sec.	meters per second				
mtg.	mounting				
MTU	Motoren-und Turbinen-Union				
MW	megawatt				
mW	milliwatt				
μF	microfarad				
N, norm.	normal (power source)				

Appendix B Programmer-Defined Settings

Use the table below to record programmer-defined settings during the generator set controller setup and calibration. The controller default settings and ranges provide guidelines. The table contains all faults with ranges and time delays including items that do not have adjustments. Some notices give the programmer a choice to make them active. Not adjustable programmer-defined settings result when the controller logic does not allow changes or the values are engine limited.

SiteTech™ setup software is required for programming the Decision-Maker® 3000 controller. Contact your local distributor/dealer for assistance.

Note: Inhibit time delay is the time delay period after crank disconnect.

Note: The engine ECM may limit the crank cycle even if the controller is set to a longer time period.

Programmer-Defined Settings

Description	Controller Display Message	Write Access Display SiteTech	GenSet Mode Always Running Stopped	Range Setting	Default Selection	Time Delay Range (sec.)	Default Time Delay (sec.)	Programmer-Defined Settings
Engine Functions								
Critically high fuel level (diesel-powered models only) *	Fuel Level Critically High			0-100%	95%	0-10	5	
ECM communications loss	ECM Comm Err Shutdwn					Fixed	10	Not adjustable
ECM diagnostics (multiple inputs) †	ECM xxxxxx Warning							Not adjustable
ECM diagnostics (multiple inputs) †	ECM xxxxxx Shutdwn							Not adjustable
ECM faults (address conflict)	ECM Addr Err Shutdwn							Not adjustable
ECM faults (model mismatch)	ECM Mismatch Shutdwn			0-255	0			
Engine over speed	Eng Speed High Shutdwn	S	A	105-120%	115%			
Engine start aid active	Starting Aid Notice							
Engine under speed	Eng Speed Low Shutdwn	S	A	75-95%	85%			
Fuel tank leak *	Fuel Leak Warning							Not adjustable
Fuel tank leak *	Fuel Leak Shutdwn							Not adjustable
High battery voltage	Battery High Warning	S	A	110-135%	125%	Fixed	10	Not adjustable
High coolant temperature	Coolant Temp High Warning					0-10 (0-30 inhibit)	0 (0 inhibit)	
High coolant temperature	Coolant Temp High Shutdwn					0-10 (0-30 inhibit)	0 (0 inhibit)	
High fuel level (diesel-powered models only) *	Fuel Level High Warning			0-100%	90%	0-10	5	
Low battery voltage	Battery Low Warning	S	A	80-105%	100%	Fixed	90	Not adjustable
Low coolant level *	Coolant Lvl Low Shutdwn					Fixed	5	Not adjustable
Low coolant temperature	Coolant Temp Low Warning			Fixed	16°C (60°F)	0-10 (0-30 inhibit)	5 (0 inhibit)	
Low cranking voltage	Lo Crank Vlt Warning			Fixed	60%	Fixed	6	Not adjustable
Low engine oil level *	Oil Level Low Warning							Not adjustable
Low engine oil level *	Oil Level Low Shutdwn							Not adjustable
Low fuel level (diesel models) *	Fuel Level Low Warning			0-100%	35%	0-10	10	
Low fuel level (diesel models) *	Fuel Level Low Shutdwn			0-100%	5%	0-10	0	

Description	Controller Display Message	Write Access Display SiteTech	GenSet Mode Always Running Stopped	Range Setting	Default Selection	Time Delay Range (sec.)	Default Time Delay (sec.)	Programmer-Defined Settings
Low fuel pressure (gas models) *	Fuel Press Low Warning							Not adjustable
Low oil pressure	Oil Press Low Warning					Fixed (Fixed inhibit)	0 (30 inhibit)	Not adjustable
Low oil pressure	Oil Press Low Shutdown					Fixed (Fixed inhibit)	5 (30 inhibit)	Not adjustable
No coolant temperature signal	Temp Sig Loss Shutdown							Not adjustable
No oil pressure signal	Press Sig Loss Shutdown					Fixed	5	Not adjustable
Overcrank	Over Crank Shutdown					Fixed	(30 inhibit)	Not adjustable
Speed sensor fault	Spd Sens Flt Warning							Not adjustable
General Functions								
Alarm silence, 0–Auto only (NFPA 110), 1–Always	AlarmSilenceMode	S	A	0–1	1			
Aux. inputs 0–5 VDC, 1 analog	Aux Input Warning			0–100%	100%	0–10	0	
Aux. inputs 0–5 VDC, 1 analog	Aux Input Shutdown			0–100%	100%	0–10	0	
Auxiliary inputs, up to 3 digital (2 additional digital inputs available with I/O module option)	Aux Input Warning					0–10 (0–30 inhibit)	0 (0 inhibit)	
Auxiliary inputs, up to 3 digital (2 additional digital inputs available with I/O module option)	Aux Input Shutdown					0–10 (0–30 inhibit)	0 (0 inhibit)	
Backup parameters loaded	Backup Pars Status							Not adjustable
Battery charger fault *	Batt Chg Flt Warning							Not adjustable
Chicago code active *	Auto Locked Notice							
Common fault	Common Fault Shutdown							Not adjustable
Common warning	Common Warn							Not adjustable
Default parameters loaded	Default Pars Warning							Not adjustable
Emergency stop	Emerg Stop Shutdown							Not adjustable
Engine cooldown (delay) active	Eng Cooldown Notice							
Engine start delay active	Start Delay Notice							
Engine started	Engine Start Status							Not adjustable
Engine stopped	Engine Stop Status							Not adjustable
EPS supplying load	Emerg Pwr On Notice							Not adjustable
File system error (controller fault)	File Error Shutdown							Not adjustable
Generator running	Gen Running Notice							Not adjustable
Input/output (optional module board) communication loss	OB1 Com Loss							Not adjustable
Internal failure	Intern Error Shutdown							Not adjustable
Measurement Units, 0–English, 1–Metric	Measurement Display	DS	A	0–1	1			
Metering communication loss	MeterCommLos Shutdown							Not adjustable
NFPA 110 alarm active	NFPA Alarm Notice							
Not in auto (master control buttons)	Not In Auto Warning							Not adjustable
Prime power application, 0–Standby, 1–Prime	Power Type	DS	A	0–1	0			
Remote start	Remote Start Status							Not adjustable

Description	Controller Display Message	Write Access Display SiteTech	GenSet Mode Always Running Stopped	Range Setting	Default Selectio n	Time Delay Range (sec.)	Default Time Delay (sec.)	Programmer- Defined Settings
System ready	System Ready Status							Not adjustable
System timer failed	Timer Error Notice							Not adjustable
Generator Functions								
AC sensing loss	AC Sens Loss Warning							Not adjustable
AC sensing loss	AC Sens Loss Shutdwn					Fixed	3	Not adjustable
Alternator protection	Alt Protect Shutdwn							Not adjustable
Ground fault input *	Ground Fault Warning							Not adjustable
kW overload	Total Power High Shutdwn			Fixed	102%	Fixed	60	Not adjustable
Locked rotor (failed to crank)	Locked Rotor Shutdwn	S	A			1-5	5	
Overfrequency	Freq High Shutdwn			102-140%	110%	Fixed	10	Not adjustable
Overvoltage (each phase)	Volts (L1-L2, L2-L3, or L3-L1) High Shutdwn	S	A	105-135%	120%	2-10	2	
Power rating	Pwr Rating	DS	S	10-5000	275			
System frequency	System Freq	DS	S	50-60	60			
System voltage	System Volt	DS	S	110-600	208			
Underfrequency	Frequency Low Shutdwn			80-95%	90%	Fixed	10 ST 60 LT	Not adjustable
Undervoltage (each phase)	Volts (L1-L2, L2-L3, or L3-L1) Low Shutdwn	S	A	70-95%	80%	5-30	10	
Voltage/phase configuration, 0-Single phase, 1-Single phase dogleg, 2-three phase wye, 3-three phase delta	SystemPhase	DS	S	0-3	2			
Voltage regulator average voltage adjustment	VR Volt Adj	DS	R	108-600	208			
(Voltage) regulator communication loss	RegCommLoss Shutdwn							Not adjustable
SiteTech Read/Write Display Only								
Current transformer ratio ‡		S	S	1	1200			
ECM power		S	S	0-1	0			
Engine cooldown delay		S	A			0-600	300	
Engine (cyclic) crank on		S	A			10-30	15	
Engine (cyclic) crank pause		S	A			1-60	15	
Engine ECM start delay		S	A			0-300	0	
Engine idle duration		S	A			0-60	60	
Engine no. of (cyclic) crank cycles		S	S	1-6	3			
Engine restart delay		S	A			1-10	10	
Engine start aid delay		S	A			0-10	0	
Engine start delay		S	A			0-300	0	
System battery voltage ‡		S	S	12-24	12			
Voltage regulator gain		S	R	1-255	128			
Voltage regulator stability adjust		S	R	1-255	128			
Voltage regulator, volts per Hertz slope		S	R	1-10	5			
Voltage regulator, volts per Hertz cutin frequency		S	R	42-62	57.5			

* Some functions require optional input sensors or are engine ECM dependent on some generator set models.

‡ ECM inputs are engine manufacturer dependent.

‡ Changeable only by resetting the controller with a personality profile (SiteTech 1.4 or higher).

ST-Short Term, LT-Long Term

Notes

Appendix C Voltage Regulator Definitions and Adjustments

The following definitions and adjustment/setting specifications are intended for users planning to adjust the voltage regulator beyond the default settings in order to customize the alternator for a specific application.

This information is not intended to be a comprehensive explanation of all the terms mentioned. There are numerous documents available that define these terms more completely than described herein. Any user planning to change the generator set controller adjustment settings or to apply the generator set to these types of applications should understand these terms.

This appendix contains references to other sections of this manual. Please refer to these sections for further information and explanation.

Paralleling generator sets can be a complicated and dangerous exercise. Application programming must be performed by appropriately skilled and suitably-trained personnel.

Definitions

Underfrequency Unloading

Underfrequency unloading is a function used in the alternator excitation control system to improve the overall generator set system (engine and alternator) response. In particular, underfrequency unloading relates to large-block-load applications. When applied to engine-driven alternators, large-block loads cause a subsequent transient torque load on the engine. This torque load can reduce the engine's speed below the normal operating point. Typically, the engine speed controller or governor will compensate for this by commanding an increase in fuel. If, however, the fuel system is inadequate to recover from a relatively large load, the speed may never recover. In these instances, other measures must be taken. This is where the underfrequency unloading occurs.

When the excitation control system detects a drop in the speed or electrical frequency below some predetermined point, the control system enters an unloading condition. This can be described as moving to a lower voltage regulation point. By reducing the output voltage of the alternator, the load on the generator set is reduced. This can be shown mathematically by Ohm's law, which states that power is equal to the voltage

squared divided by the impedance. As the voltage is reduced, the power delivered by the alternator decreases by a squared relationship. Since it is the power in the alternator that translates into engine torque, the engine load is also reduced.

By changing various parameters of this compensation technique, the controlling system can be tailored to match the performance capabilities of most engine and alternator combinations. The point at which the unloading begins to act or how much unloading occurs can be adjusted to impact maximum voltage droop, maximum speed droop, or time to recover. Some applications may not need unloading and, in these cases, set the unloading parameter to disable the function. These parameters are further described below. An example is provided to help clarify the relationship between these parameters.

Underfrequency Unload Slope

Underfrequency unload slope is the term used to describe the amount that the voltage is reduced, per-cycle-per-second or per-hertz (Hz), when in an underfrequency condition. The slope or schedule is sometimes called the volts-per-hertz slope. When the electrical frequency drops below the cut-in point (see below), the excitation control system temporarily reduces the regulated voltage to reduce the subsequent torque on the engine. The amount that the control system reduces voltage is defined as the product or multiplication of the slope and the amount of frequency or speed below the cut-in point. For every Hz below the cut-in point, the control system reduces the line-to-line voltage by an amount equal to the slope.

Because each engine responds differently to the various loads encountered, the slope may be adjusted to improve the system response. If, when large loads are applied to the generator set, the engine speed drops below the acceptable limit (as determined by the particular loads applied), the slope may need to be increased. Increasing the slope will cause the voltage to droop more during load applications, consequently reducing the load torque on the engine and allowing the speed to increase. If, however, the voltage drops below an acceptable lower limit (as determined by the particular loads connected to the generator set), a lower slope may work better. The underfrequency unloading function may be disabled by setting the slope to zero.

Frequency Setpoint or Cut-In Point

The point at which the underfrequency unloading begins to take effect is adjustable, allowing the system to be tailored for each application. Because the characteristics of the engine have the largest effect on the system's performance, the engine's response should determine the unloading point. The unloading setpoint is the frequency below which the excitation control will reduce the voltage so that the engine may begin to recover.

The cut-in point, or frequency setpoint, should be set 0.5–3.0 Hz lower than the normal steady-state band of operation. If the engine normally operates within a very narrow range of speeds close to the nominal, a setpoint of 0.5 to 1.0 Hz below nominal should be suitable. If the engine normally operates over a wide range of speeds, the setpoint may need to be 2.0–3.0 Hz from the nominal. The underfrequency unloading function can be eliminated by setting the cut-in point below the minimum expected operating frequency.

Example

A 90 kW load is applied to a 100 kW, 60 Hz generator set driven by a turbocharged diesel engine with an electronic control module (ECM). The speed drops 10% and takes 20 seconds to recover to at least 59.5 Hz. The voltage, meanwhile, drops from 480 to 460 and recovers to 480 within 15 seconds. Therefore, some underfrequency unloading should be provided. A good starting point would be a frequency setpoint or cut-in of 59 Hz. A slope of 15 volts per-cycle-per-second is appropriate as well. If after these adjustments the speed recovers very quickly, in about 5 seconds, but the voltage drops below 440 volts, the slope should be reduced to 12 volts per cycle. More adjusting may be required to get the most desirable compromise between speed and voltage.

Three-Phase Sensing

Three-phase sensing describes how the excitation control or voltage regulator determines the condition of the alternator output voltage. Early types of regulators sensed the voltage on just one phase of the alternator. Single-phase sensing is not uncommon today as most alternators are designed to produce balanced, equal voltage on all three phases. If the loads applied to the generator set including no load are equal and balanced, the output voltage on each phase will be nearly equal.

However, in some applications, individual phases may have unequal or unbalanced loads. In these cases, the output voltages will not be equal on each phase. In

general, the phase with the greatest load will have the lowest voltage while the phase with the least load will have the highest voltage. This is true regardless of the type of sensing used in the regulator system. A single-phase sensing excitation controller will keep the voltage of the sensed phase at the voltage adjustment value. A three-phase sensing system will average the three phases and hold the average to the adjustment setting. The average is the sum of the voltages of three phases divided by 3.

As stated above, three-phase sensing does not eliminate the unequal voltage phenomenon. Three-phase sensing balances the inequality of voltage between the phases to the desired value. In other words, if a system with unbalanced loads uses a single-phase control feedback, the voltage on the sensed phase would be at the setpoint while the other two phases would vary by their proportional loads. For example, if the sensed phase had rated load while the two other phases were only loaded at half the rated value, those two phases would have higher-than-rated voltage which may be undesirable. If a three-phase sensing feedback were utilized, the phase with rated load would be regulated to a voltage slightly below the rated voltage while the other two phases would be slightly above the rated voltage (but lower than in the previous case). The sum of the three, divided by 3, would be equal to the regulation setpoint.

In a single-phase system, line-to-line voltage is held equal to the line-to-line voltage adjust setting. In a three-phase system, the average of the three line-to-line voltage is regulated to the voltage adjust setting. In some cases, it may be desirable to keep one phase at a particular value. Modify the voltage adjust setting higher or lower accordingly for any unique requirements for the particular application.

Adjustment and Setting Specifications

Voltage Adjust

The voltage adjust is entered as the rated or otherwise desired line-to-line voltage. The average of the line-to-line voltages is then regulated to the corresponding value as previously described. The setting may be as fine as tenths of volts. The voltage adjust defaults to the rated system voltage whenever the system voltage is changed. The voltage adjust may be set to any value within $\pm 10\%$ of the system voltage. The upper limit is $\pm 10\%$ above the system voltage and the lower limit is $\pm 10\%$ below the system voltage.

As a reference, the present voltage adjust setting is displayed as well as the average value of the line-to-line voltages. The individual line-to-line voltages are also displayed on the subsequent menu screens. This allows the user to monitor any individual phase, if desired.

The voltage adjust setting may be changed by means other than the menu including user-defined digital input or remote communications. If voltage adjustment occurs, the new value will be displayed accordingly in the voltage adjust menu.

Underfrequency Unload Enable

The underfrequency unload enable menu is used to turn the underfrequency unload on or off. A YES entry will turn the feature on and the display will show ENABLED YES. A NO entry will turn the feature off and the display will show ENABLED NO. The underfrequency unload defaults to an enabled (ON) condition.

Frequency Setpoint

The frequency setpoint is the cut-in point for underfrequency unloading. At any operating frequency below the frequency setpoint, the output voltage will be reduced. The frequency may be entered with resolution to tenths of a Hz. The range of acceptable entries is 30 to 70 Hz. The default value is one cycle-per-second (or two for non-ECM engines) below the normal system frequency. The frequency setpoint changes to the default value if the system frequency changes. A setting of 30 Hz essentially disables the underfrequency unload feature because most engines do not normally drop to speeds this low, even during load applications.

Underfrequency Unload Slope

The slope determines how much voltage is reduced during an unloading condition. The line-to-line voltage is regulated to a value less than the voltage adjust setting by this amount for every cycle below the frequency setpoint. The voltage may be entered with resolution as fine as one-tenth of one volt. The default value is 2.0 volts per-cycle-per-second. A zero entry for the slope in effect turns the underfrequency unload feature off.

Notes

Appendix D Alternator Protection

The controller has built-in thermal protection for the alternator. This feature functions similarly to a thermal circuit breaker. When the output current exceeds the nominal rating for a short period of time the condition causes the fault shutdown. The amount of time at which current is over the rating is inversely related to the amount of current above the nominal rating. In other words, the higher the current, the shorter the acceptable time.

The current and time limits are defined by actual test data and are maintained in the personality parameter file. Although the equation for detecting a fault is proprietary, some of the important limits are shown below for informational purposes.

Rated Current	Time Delay
200%	40 seconds
300%	10 seconds
425%	5 seconds
950%	1 second

Notes

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Notes

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Extended Five-Year or Three Thousand (3000)-Hour Comprehensive Stationary Standby Limited Warranty

This Kohler Standby Generator System has been manufactured and inspected with care by experienced craftsmen. If you are the original purchaser, Kohler Co. warrants for five years or three thousand (3000) hours, whichever occurs first, that the system will be free from defects in material and workmanship if properly installed, maintained, and operated in accordance with Kohler Co.'s instruction manuals. A Kohler distributor, dealer, or authorized representative must perform startup.

This warranty is not effective unless a proper extended warranty registration form and warranty fee have been sent to Kohler Co. within one year of supervised startup.

During the warranty period, repair or replacement at Kohler Co.'s option will be furnished free of charge for parts, provided an inspection to Kohler Co.'s satisfaction discloses a defect in material and workmanship, and provided that the part or parts are returned to Kohler Co. or an authorized service station, if requested. This extended warranty expires five full years after date of startup or after 3000 hours of operation, whichever occurs first.

This warranty does not apply to malfunctions caused by damage, unreasonable use, misuse, or normal wear and tear while in your possession.

The following will **not** be covered by this warranty:

1. Normal engine wear, routine tuneups, tuneup parts, adjustments, and periodic service.
2. Damage caused by accidents, improper installation or handling, faulty repairs not performed by an authorized service representative, or improper storage.
3. Damage caused by operation with improper fuel or at speeds, loads, conditions, modifications, or installation contrary to published specifications or recommendations.
4. Damage caused by negligent maintenance such as:
 - a. Failure to provide the specified type and sufficient lubricating oil.
 - b. Failure to keep the air intake and cooling fin areas clean.
 - c. Failure to service the air cleaner.
 - d. Failure to provide sufficient coolant and/or cooling air.
 - e. Failure to perform scheduled maintenance as prescribed in supplied manuals.
 - f. Failure to exercise with load regularly.
5. Original installation charges and startup costs.
6. Starting batteries and the following related expenses:
 - a. Labor charges related to battery service.
 - b. Travel expense related to battery service.
7. Engine coolant heaters, heater controls, and circulating pumps after the first year.
8. Rental of equipment during performance of warranty repairs.
9. Non-Kohler-authorized repair shop labor without prior approval from the Kohler Co. Warranty Department.
10. Parts purchased from sources other than Kohler. Replacement of a failed Kohler part with a non-Kohler part voids warranty on that part.
11. Radiators replaced rather than repaired.
12. Fuel injection pumps not repaired locally by an authorized servicing dealer.
13. Engine fluids such as fuel, oil, or coolant/antifreeze.
14. Shop supplies such as adhesives, cleaning solvents, and rags.
15. Expenses incurred investigating performance complaints unless the problem is caused by defective Kohler materials or workmanship.
16. Maintenance items such as fuses, filters, spark plugs, loose/leaking clamps, and adjustments.

A Startup Notification form must be on file at Kohler Co. A Startup Notification form must be completed by Seller and received at Kohler Co. within 60 days after the date of initial startup. Standby systems not registered within 60 days of startup will automatically be registered by Kohler Co. using the Kohler Co. ship date as the startup date.

To obtain warranty service, call 1-800-544-2444 for your nearest authorized Kohler service representative, or write Kohler Co., Generator Service Department, Kohler, WI 53044 USA.

KOHLER CO. SHALL NOT BE LIABLE FOR SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OF ANY KIND including, but not limited to, incidental consequential labor costs, installation charges, telephone charges, or transportation charges in connection with the replacement or repair of defective parts.

This is our exclusive written warranty. We make no other express warranty, nor is anyone authorized to make any in our behalf.

ANY IMPLIED OR STATUTORY WARRANTY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS OF PURCHASE, is expressly limited to the duration of this warranty.

Some states do not allow limitations on how long an implied warranty lasts, or the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

KOHLER® POWER SYSTEMS

KOHLER CO. Kohler, Wisconsin 53044
Phone 920-565-3381, Fax 920-459-1646
For the nearest sales/service outlet in the
US and Canada, phone 1-800-544-2444
KohlerPowerSystems.com

TP-506* 12/99c

TAB 4

POWERTECH™ E
4.5 and 6.8 L
4045 and 6068
Tier 3 / Stage IIIA
OEM Diesel Engines

OPERATOR'S MANUAL
PowerTech™ E 4045TF285/HF285
and 6068HF285 OEM Diesel
Engines

OMRG37407 Issue 30Apr08 (ENGLISH)

CALIFORNIA
Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

If this product contains a gasoline engine:

** WARNING**

The engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects or other reproductive harm.

The State of California requires the above two warnings.

Introduction

Foreword

THIS MANUAL CONTAINS INFORMATION to operate and service the following **Tier 3 / Stage IIIA** emission-certified¹ engines:

Saran-built (France) Tier 3 Electronically Controlled Engines:

- CD4045TF285 (HPCR System; 2-Valve Head)
- CD4045HF285 (HPCR System; 2-Valve Head)
- CD6068HF285 (HPCR System; 2-Valve Head)

Torreón-built (Mexico) Tier 3 Electronically Controlled Engines:

- PE4045TF285 (HPCR System; 2-Valve Head)
- PE4045HF285 (HPCR System; 2-Valve Head)
- PE6068HF285 (HPCR System; 2-Valve Head)

READ THIS MANUAL carefully to learn how to operate and service your engine correctly. Failure to do so could result in personal injury or equipment damage.

THIS MANUAL SHOULD BE CONSIDERED a permanent part of your engine and should remain with the engine when you sell it.

MEASUREMENTS IN THIS MANUAL are given in both metric and customary U.S. unit equivalents. Use only correct replacement parts and fasteners. Metric and inch fasteners may require a specific metric or inch wrench.

WRITE ENGINE SERIAL NUMBERS and option codes in the spaces indicated in the Record Keeping Section. Accurately record all the numbers. Your dealer also needs these numbers when you order parts. File the identification numbers in a secure place off the engine.

SETTING FUEL DELIVERY beyond published factory specifications or otherwise overpowering will result in loss of warranty protection for this engine.

CERTAIN ENGINE ACCESSORIES such as radiator, air cleaner, and instruments are optional equipment on John Deere OEM Engines. These accessories may be provided by the equipment manufacturer instead of John Deere. This operator's manual applies only to the engine and those options available through the John Deere distribution network.

IMPORTANT: This manual covers only **POWERTECH™ E Tier 3/ Stage IIIA** emission certified 4.5 and 6.8 L OEM engines listed. (This is for both the U.S. EPA and European Union Council (EU) emission standards.)

NOTE: This manual covers engines provided to OEM (Original Equipment Manufacturers). For engines in Deere machines, refer to the machine operator's manual.

POWERTECH is a trademark of Deere & Company

¹Emission certified for United States as EPA Tier 3 and for European Union as Stage IIIA.

OURGP12.00001E9 --19-23APR08-1/1

Engine Owner

John Deere Engine Owner:

Don't wait until you need warranty or other service to meet your local John Deere Engine Distributor or Service Dealer. To register your engine for warranty via the Internet, use the following URL:

<http://www.johndeere.com/enginewarranty>

Learn who your dealer is and where he is. At your first convenience, go meet him. He'll want to get to know you and to learn what your needs might be.

Aux Utilisateurs De Moteurs John Deere:

N'attendez pas d'être obligé d'avoir recours à votre concessionnaire John Deere ou au point de service le plus proche pour vous adresser à lui. Pour enregistrer votre moteur pour la garantie via Internet, utilisez l'adresse suivante:

<http://www.johndeere.com/enginewarranty>

Renseignez-vous dès que possible pour l'identifier et le localiser. A la première occasion, prenez contact avec lui et faites-vous connaître. Il sera lui aussi heureux de faire votre connaissance et de vous proposer ses services le moment venu.

An Den Besitzer Des John Deere Motors:

Warten Sie nicht auf einen evt. Reparaturfall, um den nächstgelegenen John Deere Händler kennen zu lernen. Zur Registrierung Ihres Motors für die Garantie dient folgende Internet-Adresse:

<http://www.johndeere.com/enginewarranty>

Machen Sie sich bei ihm bekannt und nutzen Sie sein "Service Angebot".

Proprietario del motore John Deere:

Non aspetti fino al momento di far valere la garanzia o di chiedere assistenza per fare la conoscenza del

distributore dei motori John Deere o del concessionario che fornisce l'assistenza tecnica. Per registrare via Internet la garanzia del suo motore, si colleghi al seguente sito URL:

<http://www.johndeere.com/enginewarranty>

Lo identifichi e si informi sulla sua ubicazione. Alla prima occasione utile lo contatti. Egli desidera fare la sua conoscenza e capire quali potrebbero essere le sue necessità.

Propietario De Equipo John Deere:

No espere hasta necesitar servicio de garantía o de otro tipo para conocer a su Distribuidor de Motores John Deere o al Concesionario de Servicio. Registre su motor para la garantía en la siguiente dirección de internet: <http://www.johndeere.com/enginewarranty>

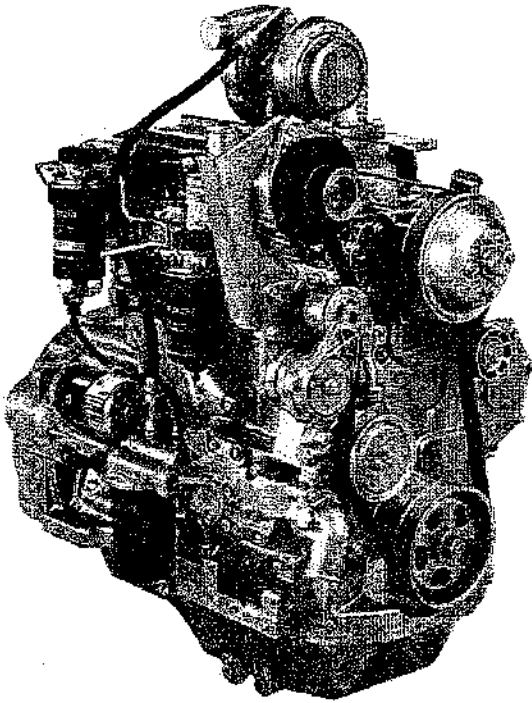
Aprenda quién es su distribuidor y donde él está situado. Cuando tenga un momento, vaya a visitarlo. A él le gustará conocerlo, y saber cuáles podrían ser sus necesidades.

Till ägare av John Deere motorer:

Ta reda på vem din återförsäljare är och besök honom så snart tillfälle ges. Vänta inte tills det är dags för service eller eventuellt garantiarbete. Din motor registrerar Du via Internet på <http://www.johndeere.com/enginewarranty>

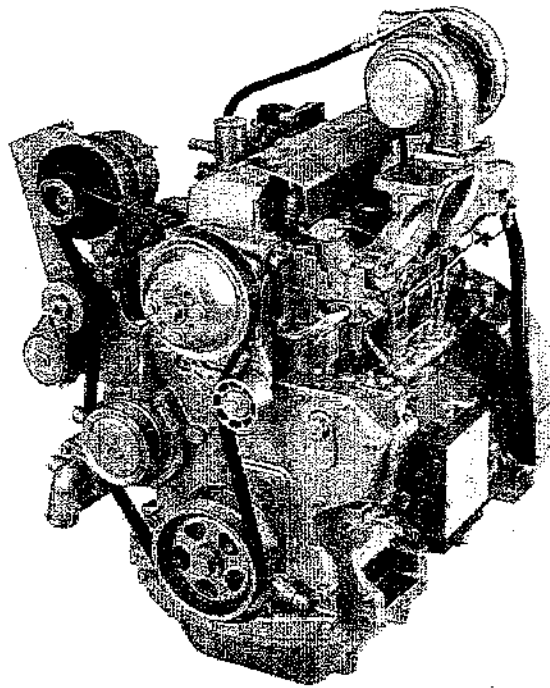
Din återförsäljare vill mycket gärna träffa dig för att lära känna dina behov och hur bäst han kan hjälpa dig.

**PowerTech™ E 4.5 L Engine With Electronic Fuel Systems (HPCR Fuel System)
(Two-Valve Cylinder Head)**



4045HF285 Engine

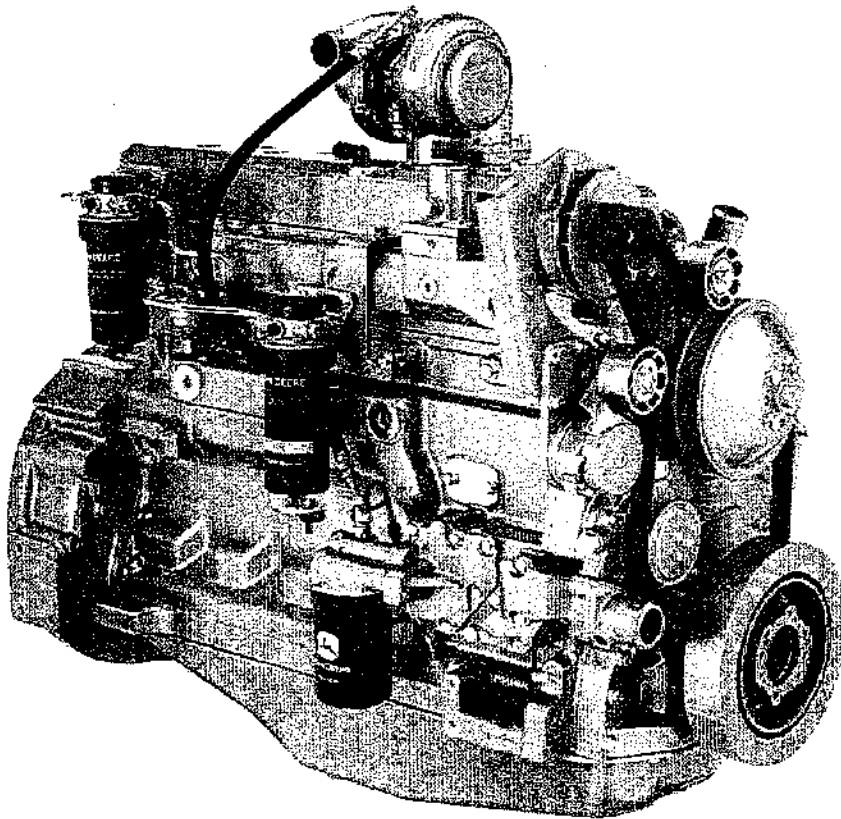
HG14632 -UN-13APR06



4045HF285 Engine

HG14633 -UN-13APR06

**PowerTech™ E 6.8 L Engine With Electronic Fuel Systems (HPCR Fuel System)
(Two-Valve Cylinder Head)**



6068HF285 Engine

RG14634 -UN-13APR06

PowerTech E is a trademark of Deere & Company

OURGP12.00001EB -19-22APR06-1/1

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Previous Editions
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Record Keeping

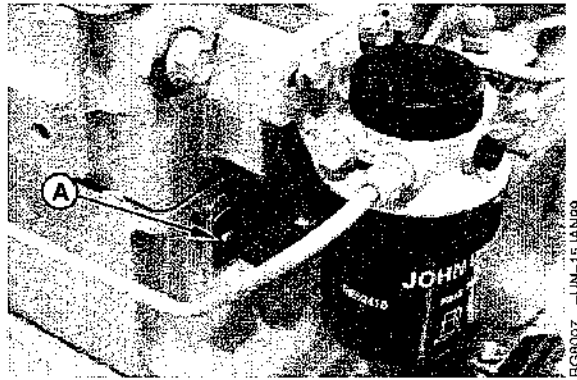
Engine Serial Number Plate

Each engine has a John Deere engine serial number. The first two digits identify the factory that produced the engine:

- "CD" = Saran, France
- "PE" = Torreon, Mexico

The engine's serial number plate (A) is located on the right-hand side of cylinder block behind the fuel filter.

A—Serial Number Plate



Engine Serial Number Plate

OURGP12.00001C3 -19-14MAR06-1/1

Record Engine Serial Number

Record all of the numbers and letters found on your engine serial number plate in the spaces provided below.

This information is very important for repair parts or warranty information.

Engine Serial Number (B)

Engine Model Number (C)



Saran Factory Engine Serial Number Plate

NOTE: Engine serial numbers on the 7th digit indicates the Emission Level as follows:

- "B" for non-certified engines
- "C" for Tier 1 / Stage I engines
- "G" for Tier 2 / Stage II engines
- "L" for Tier 3 / Stage IIIA engines



Torreon Factory Engine Serial Number Plate

OURGP12.00001C4 -19-14MAR06-1/1

Engine Option Codes

JOHN DEERE		NUMBER CD6068L123456	
			
6068HF285		6.8 L	171ECD ← (A)
1100 1200 1300 1400 1500 1600 1700 1800 1900 2100 2300 2400			
2500 2700 2800 2900 3000 3100 3500 4000 4300 5200 5500 5600			
5700 6000 6200 6400 6500 6600 7500 7600 8600 8700 8800			
Order: 2B00000000		000000	OPTION CODES
			

RG14630 -UN-18APR06

A—Engine Base Code

In addition to the serial number plate, OEM engines have an engine option code label affixed to the rocker arm cover. These codes indicate which of the engine options were installed on your engine at the factory. When in need of parts or service, furnish your authorized servicing dealer or engine distributor with these numbers.

The engine option code label includes an engine base code (A). This base code must also be recorded along with the option codes.

The first two digits of each code identify a specific group, such as alternators. The last two digits of each code identify one specific option provided on your engine, such as a 12-volt, 55-amp alternator.

NOTE: These option codes are based on the latest information available at the time of publication. The right is reserved to make changes at any time without notice.

If an engine is ordered without a particular component, the last two digits of that functional group option code will be 99, 00, or XX. The list on the next page shows only the first two digits of the code numbers. For future reference such as ordering repair parts, it is important to have these code numbers available. To ensure this availability, enter the third and fourth digits shown on your engine option code label in the spaces provided on the following page.

Continued on next page

OURGP12.00001C5 -19-14MAR06 -1/2

Record Keeping

NOTE: Your engine option code label may not contain all option codes if an option has been added after the engine left the producing factory.

If option code label is lost or destroyed, consult your servicing dealer or engine distributor selling the engine for a replacement.

An additional option code label may also be delivered with the engine. Place this sticker or tag, for reference, either on this page or in the engine owner's warranty booklet under **OPTION CODES** title.

Option Codes	Description
11_____	Rocker Arm Cover
12_____	Oil Fill Inlet
13_____	Crankshaft Pulley/Damper
14_____	Flywheel Housing
15_____	Flywheel
16_____	Fuel Injection Pump
17_____	Air Inlet
18_____	Air Cleaner
19_____	Oil Pan
20_____	Coolant Pump
21_____	Thermostat Cover
22_____	Thermostat
23_____	Fan Drive
24_____	Fan Belt
25_____	Fan
26_____	Engine Coolant Heater
27_____	Radiator
28_____	Exhaust Manifold
29_____	Crankcase Ventilator System
30_____	Starter Motor
31_____	Alternator
32_____	Instrument Panel
33_____	Tachometer
35_____	Fuel Filters
36_____	Front Plate
37_____	Fuel Transfer Pump
39_____	Thermostat Housing
40_____	Oil Dipstick
41_____	Belt-Driven Front Auxiliary Drive
43_____	Starting Aid
44_____	Timing Gear Cover With Gears
46_____	Cylinder Block With Liners and Camshaft
47_____	Crankshaft and Bearings
48_____	Connecting Rods and Pistons
49_____	Valve Actuating Mechanism

Option Codes	Description
50_____	Oil Pump
51_____	Cylinder Head With Valves
52_____	Auxiliary Gear Drive
53_____	Fuel Heater
55_____	Shipping Stand
56_____	Paint Option
57_____	Coolant Pump Inlet
59_____	Oil Cooler
60_____	Add-on Auxiliary Drive Pulley
62_____	Alternator Mounting Bracket
63_____	Low Pressure Fuel Line
64_____	Exhaust Elbow
65_____	Turbocharger
66_____	Coolant Temperature Switch
67_____	Electronic Sensors (Base Engine)
68_____	Crankshaft Rear Damper
69_____	Engine Serial Number Plate
71_____	Engine Oil Bypass Filter
72_____	ECU Electronic Software Option
74_____	Air Conditioning (Freon) Compressor
75_____	Air Restriction Indicator
76_____	Pressure Switches and Sensors
77_____	Timing Gear Cover
78_____	Air Compressor
79_____	Engine Certification
81_____	Primary Fuel Filter And Water Separator
83_____	Electronic Software (Vehicle Option)
84_____	Electrical Wiring Harness
86_____	Fan Pulley
87_____	Belt Tensioner
88_____	Oil Filter
95_____	Special Equipment (Factory Installed)
96_____	Engine Installation Kit
97_____	Special Equipment (Field Installed)
98_____	Shipping (Engine Hanger Straps)
99_____	Service Only Items

Engine Base Code (See "A" on previous page.)

OURGP12.00001CS -19-14MAR06-2/2

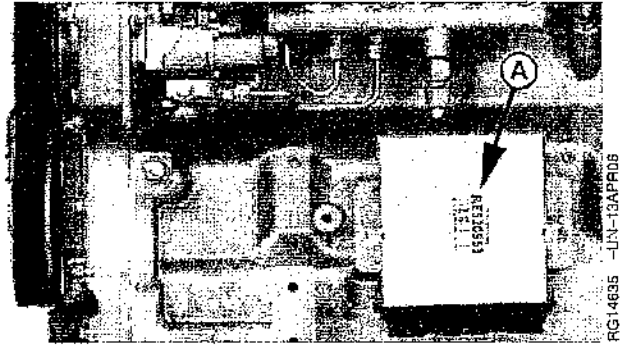
Record Engine Control Unit (ECU) Serial Number

Record the part number and serial number information found on the serial number label (A) on the Engine Control Unit (ECU) mounted on or near the engine.

Part No. _____

Serial No. _____

A—Serial Number Label



Record Engine Control Unit (ECU) Serial Number

OURGP12.00001EC -19-17MAR06-1/1

Record High-Pressure Fuel Pump Model Number

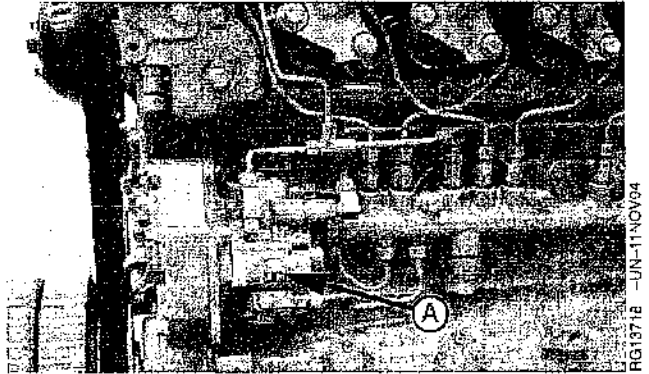
Record the high-pressure fuel pump model and serial number information found on the serial number plate (A).

Model No. _____ RPM _____

Manufacturer's No. _____

Serial No. _____

A—Serial Number Plate



Record High-Pressure Fuel Pump Serial Number

OURGP12.0000080 -19-16SEP04-1/1

Safety

Recognize Safety Information

is a safety-alert symbol. When you see this symbol on your machine or in this manual, be alert to the potential for personal injury.

Follow recommended precautions and safe operating practices.



DX,ALERT -19-29SEP98-1/1

T81389 -UN-07DEC88

Understand Signal Words

A signal word—DANGER, WARNING, or CAUTION—is used with the safety-alert symbol. DANGER identifies the most serious hazards.

DANGER or WARNING safety signs are located near specific hazards. General precautions are listed on CAUTION safety signs. CAUTION also calls attention to safety messages in this manual.

▲ DANGER

▲ WARNING

▲ CAUTION

DX,SIGNAL -19-03MAR93-1/1

TS187 -19-30SEP88

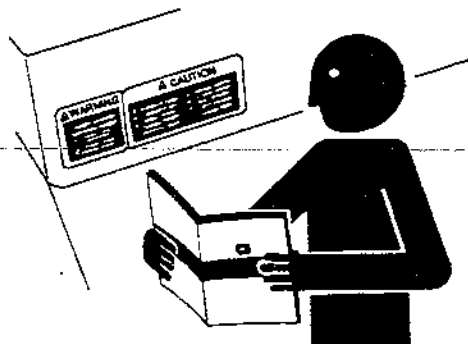
Follow Safety Instructions

Carefully read all safety messages in this manual and on your machine safety signs. Keep safety signs in good condition. Replace missing or damaged safety signs. Be sure new equipment components and repair parts include the current safety signs. Replacement safety signs are available from your John Deere dealer.

Learn how to operate the machine and how to use controls properly. Do not let anyone operate without instruction.

Keep your machine in proper working condition. Unauthorized modifications to the machine may impair the function and/or safety and affect machine life.

If you do not understand any part of this manual and need assistance, contact your John Deere dealer.

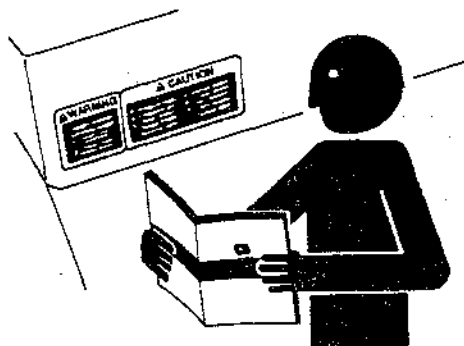


TS201 -UN-23AUG88

DX,READ -19-03MAR93-1/1

Replace Safety Signs

Replace missing or damaged safety signs. See the machine operator's manual for correct safety sign placement.



TS201 -UN-23AUG88

DX,SIGNS1 -19-04JUN90-1/1

Prevent Bypass Starting

Avoid possible injury or death from engine runaway.

Do not start engine by shorting across starter terminal. Engine will start with PTO engaged if normal circuitry is bypassed.

Start engine only from operator's station with PTO disengaged or in neutral.



Prevent Bypass Starting

RG5419 -UN-28FEB89

RG,RG34710,7508 -19-09JAN07-1/1

Handle Fuel Safely—Avoid Fires

Handle fuel with care: it is highly flammable. Do not refuel the machine while smoking or when near open flame or sparks.

Always stop engine before refueling machine. Fill fuel tank outdoors.

Prevent fires by keeping machine clean of accumulated trash, grease, and debris. Always clean up spilled fuel.



TS202 -UN-23AUG88

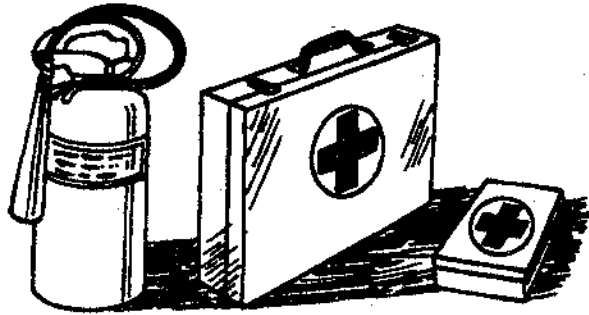
DX,FIRE1 -19-03MAR93-1/1

Prepare for Emergencies

Be prepared if a fire starts.

Keep a first aid kit and fire extinguisher handy.

Keep emergency numbers for doctors, ambulance service, hospital, and fire department near your telephone.



TS281 -JUN-23AUG88

DX.FIRE2 -19-03MAR93-1/1

Handle Starting Fluid Safely

Starting fluid is highly flammable.

Keep all sparks and flame away when using it. Keep starting fluid away from batteries and cables.

To prevent accidental discharge when storing the pressurized can, keep the cap on the container, and store in a cool, protected location.

Do not incinerate or puncture a starting fluid container.



TS1356 -JUN-18MAR92

DX.FIRE3 -19-16APR92-1/1

Handle Fluids Safely—Avoid Fires

When you work around fuel, do not smoke or work near heaters or other fire hazards.

Store flammable fluids away from fire hazards. Do not incinerate or puncture pressurized containers.

Make sure machine is clean of trash, grease, and debris.

Do not store oily rags; they can ignite and burn spontaneously.



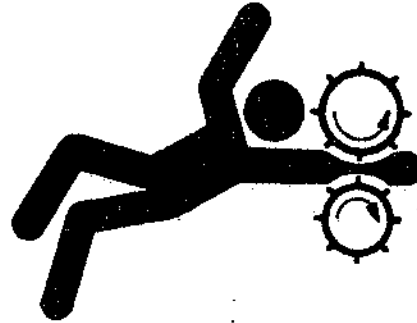
TS227 -JUN-23AUG88

DX.FLAME -19-29SEP98-1/1

Service Machines Safely

Tie long hair behind your head. Do not wear a necktie, scarf, loose clothing, or necklace when you work near machine tools or moving parts. If these items were to get caught, severe injury could result.

Remove rings and other jewelry to prevent electrical shorts and entanglement in moving parts.



TS228 -UN-23AUG88

DX, LOOSE -19-04JUN90-1/1

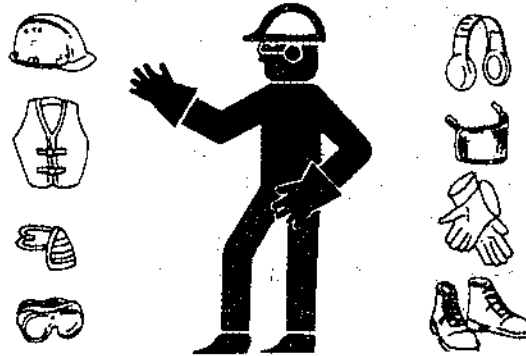
Wear Protective Clothing

Wear close fitting clothing and safety equipment appropriate to the job.

Prolonged exposure to loud noise can cause impairment or loss of hearing.

Wear a suitable hearing protective device such as earmuffs or earplugs to protect against objectionable or uncomfortable loud noises.

Operating equipment safely requires the full attention of the operator. Do not wear radio or music headphones while operating machine.



TS206 -UN-23AUG88

DX, WEAR -19-10SEP90-1/1

Protect Against Noise

Prolonged exposure to loud noise can cause impairment or loss of hearing.

Wear a suitable hearing protective device such as earmuffs or earplugs to protect against objectionable or uncomfortable loud noises.



TS207 -UN-23AUG88

DX, NOISE -19-03MAR90-1/1

Handle Chemical Products Safely

Direct exposure to hazardous chemicals can cause serious injury. Potentially hazardous chemicals used with John Deere equipment include such items as lubricants, coolants, paints, and adhesives.

A Material Safety Data Sheet (MSDS) provides specific details on chemical products: physical and health hazards, safety procedures, and emergency response techniques.

Check the MSDS before you start any job using a hazardous chemical. That way you will know exactly what the risks are and how to do the job safely. Then follow procedures and recommended equipment.

(See your John Deere dealer for MSDS's on chemical products used with John Deere equipment.)



TS1132 -UN-26NOV90

DX,MSDS.NA -19-03MAR93-1/1

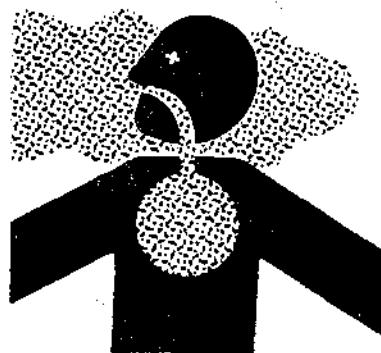
Handle Agricultural Chemicals Safely

Chemicals used in agricultural applications such as fungicides, herbicides, insecticides, pesticides, rodenticides, and fertilizers can be harmful to your health or the environment if not used carefully.

Always follow all label directions for effective, safe, and legal use of agricultural chemicals.

Reduce risk of exposure and injury:

- Wear appropriate personal protective equipment as recommended by the manufacturer. In the absence of manufacturer's instructions, follow these general guidelines:
 - Chemicals labeled '**Danger**': Most toxic. Generally require use of goggles, respirator, gloves, and skin protection.
 - Chemicals labeled '**Warning**': Less toxic. Generally require use of goggles, gloves, and skin protections.
 - Chemicals labeled '**Caution**': Least toxic. Generally require use of gloves and skin protection.
- Avoid inhaling spray or dusts.
- Always have soap, water, and towel available when working with chemicals. If chemical contacts skin, hands, or face, wash immediately with soap and water. If chemical gets into eyes, flush immediately with water.
- Wash hands and face after using chemicals and before eating, drinking, smoking, or urination.
- Do not smoke or eat while applying chemicals.
- After handling chemicals, always bathe or shower and change clothes. Wash clothing before wearing again.
- Seek medical attention immediately if illness occurs during or shortly after use of chemicals.
- Keep chemicals in original containers. Do not transfer chemicals to unmarked containers or to containers used for food or drink.
- Store chemicals in a secure, locked area way from human or livestock food. Keep children away.
- Always dispose of containers properly. Triple rinse empty containers and puncture or crush containers and dispose of properly.



A34471

TS220 -JUN-23AUG88

A34471 -JUN-11OCT88

Stay Clear of Rotating Drivelines

Entanglement in rotating driveline can cause serious injury or death.

Keep master shield and driveline shields in place at all times. Make sure rotating shields turn freely.

Wear close-fitting clothing. Stop the engine and be sure PTO driveline is stopped before making adjustments, connections, or performing any type of service on the engine or PTO-driven equipment.



Rotating Drivelines

TS1644 -UN-22AUG95

OUC1004,0000BD8 -19-15OCT07-1/1

Practice Safe Maintenance

Understand service procedure before doing work. Keep area clean and dry.

Never lubricate, service, or adjust machine while it is moving. Keep hands, feet, and clothing from power-driven parts. Disengage all power and operate controls to relieve pressure. Lower equipment to the ground. Stop the engine. Remove the key. Allow machine to cool.

Securely support any machine elements that must be raised for service work.

Keep all parts in good condition and properly installed. Fix damage immediately. Replace worn or broken parts. Remove any buildup of grease, oil, or debris.

On self-propelled equipment, disconnect battery ground cable (-) before making adjustments on electrical systems or welding on machine.

On towed implements, disconnect wiring harnesses from tractor before servicing electrical system components or welding on machine.



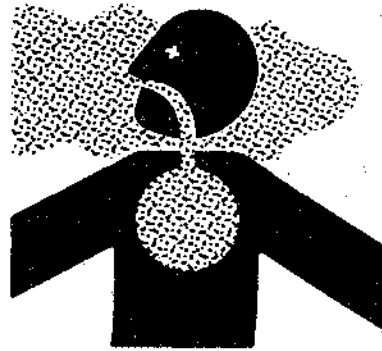
TS218 -UN-23AUG88

DX.SERV -19-17FEB99-1/1

Work In Ventilated Area

Engine exhaust fumes can cause sickness or death. If it is necessary to run an engine in an enclosed area, remove the exhaust fumes from the area with an exhaust pipe extension.

If you do not have an exhaust pipe extension, open the doors and get outside air into the area.



TS220 -JUN-23AUG88

DX,AIR -19-17FEB89-1/1

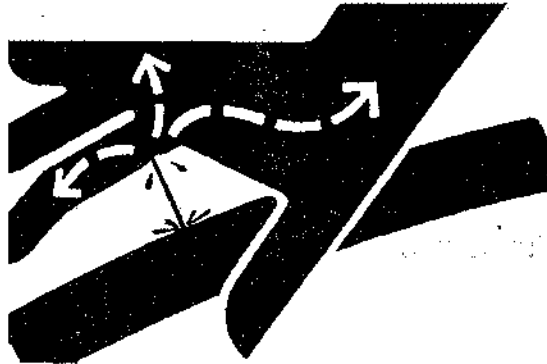
Avoid High-Pressure Fluids

Escaping fluid under pressure can penetrate the skin causing serious injury.

Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure.

Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury should reference a knowledgeable medical source. Such information is available from Deere & Company Medical Department in Moline, Illinois, U.S.A.



X9611 -JUN-23AUG88

DX,FLUID -19-03MAR93-1/1

Avoid Heating Near Pressurized Fluid Lines

Flammable spray can be generated by heating near pressurized fluid lines, resulting in severe burns to yourself and bystanders. Do not heat by welding, soldering, or using a torch near pressurized fluid lines or other flammable materials. Pressurized lines can accidentally burst when heat goes beyond the immediate flame area.



TS953 -JUN-15MAY90

DX,TORCH -19-10DEC04-1/1

Do Not Open High-Pressure Fuel System

High-pressure fluid remaining in fuel lines can cause serious injury. Do not disconnect or attempt repair of fuel lines, sensors, or any other components between the high-pressure fuel pump and nozzles on engines with High Pressure Common Rail (HPCR) fuel system.

Only technicians familiar with this type of system can perform repairs. (See your John Deere dealer.)



TS1343 -UN-18MAR92

DX.WW.HPCR1 -19-07JAN03-1/1

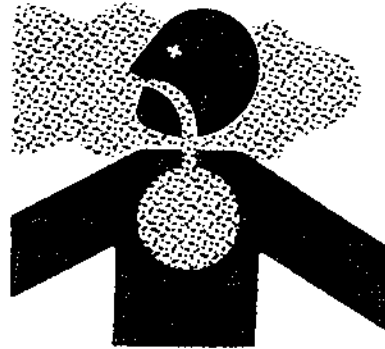
Remove Paint Before Welding or Heating

Avoid potentially toxic fumes and dust.

Hazardous fumes can be generated when paint is heated by welding, soldering, or using a torch.

Remove paint before heating:

- Remove paint a minimum of 100 mm (4 in.) from area to be affected by heating. If paint cannot be removed, wear an approved respirator before heating or welding.
 - If you sand or grind paint, avoid breathing the dust. Wear an approved respirator.
- If you use solvent or paint stripper, remove stripper with soap and water before welding. Remove solvent or paint stripper containers and other flammable material from area. Allow fumes to disperse at least 15 minutes before welding or heating.



TS220 -UN-23AUG88

Do not use a chlorinated solvent in areas where welding will take place.

Do all work in an area that is well ventilated to carry toxic fumes and dust away.

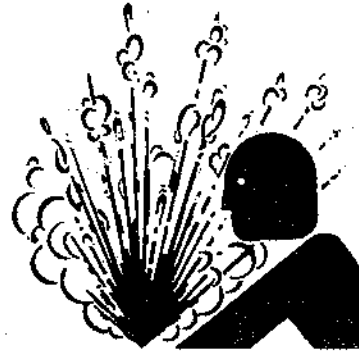
Dispose of paint and solvent properly.

DX.PAINT -19-24JUL02-1/1

Service Cooling System Safely

Explosive release of fluids from pressurized cooling system can cause serious burns.

Shut off engine. Only remove filler cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.



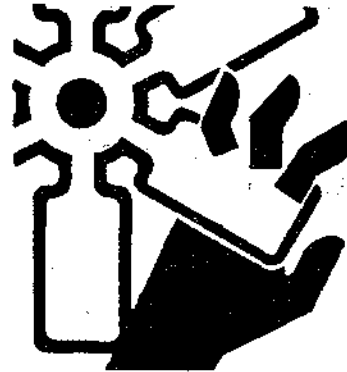
DX,PCAP --19-04JUN90-1/1

TS281 -UN-23AUG88

Install Fan Guards

Rotating cooling system fans can cause serious injury.

Keep fan guards in place at all times during engine operation. Wear close fitting clothes. Stop the engine and be sure fan is stopped before making adjustments or connections, or cleaning near the front of the engine.



Rotating Fan

OUOD006.000009D --19-23JAN07-1/1

TS577 -UN-21SEP89

Avoid Hot Parts

Avoid skin contact with exhaust manifolds, turbochargers and mufflers. Keep flammable materials clear of the turbocharger.

External dry exhaust parts become very hot during operation. Turbochargers and exhaust manifolds may reach temperatures as high as 600°C (1112°F) under full load. This may ignite paper, cloth or wooden materials. Parts on engines that have been at full load and reduced to no load idle will maintain approximately 150°C (302°F).



Hot Surface

OURGP12.0000135 --19-15OCT07-1/1

TS271 -UN-23AUG88

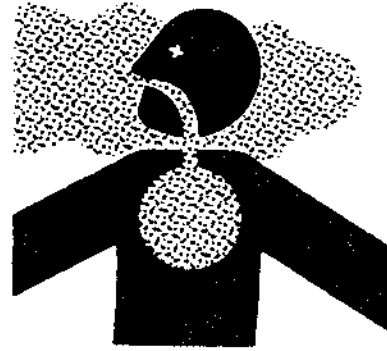
Avoid Harmful Asbestos Dust

Avoid breathing dust that may be generated when handling components containing asbestos fibers. Inhaled asbestos fibers may cause lung cancer.

Components in products that may contain asbestos fibers are brake pads, brake band and lining assemblies, clutch plates, and some gaskets. The asbestos used in these components is usually found in a resin or sealed in some way. Normal handling is not hazardous as long as airborne dust containing asbestos is not generated.

Avoid creating dust. Never use compressed air for cleaning. Avoid brushing or grinding material containing asbestos. When servicing, wear an approved respirator. A special vacuum cleaner is recommended to clean asbestos. If not available, apply a mist of oil or water on the material containing asbestos.

Keep bystanders away from the area.



TS220 -UN-23AUG88

DX.DUST -19-15MAR91-1/1

Prevent Battery Explosions

Keep sparks, lighted matches, and open flame away from the top of battery. Battery gas can explode.

Never check battery charge by placing a metal object across the posts. Use a volt-meter or hydrometer.

Do not charge a frozen battery; it may explode. Warm battery to 16°C (60°F).



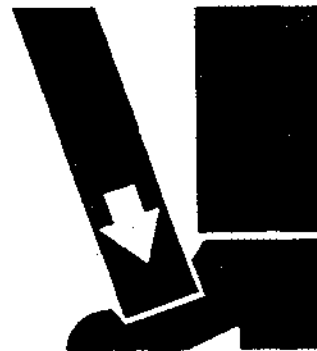
TS204 -UN-23AUG88

DX.SPARKS -19-03MAR93-1/1

Use Proper Lifting Equipment

Lifting heavy components incorrectly can cause severe injury or machine damage.

Follow recommended procedure for removal and installation of components in the manual.



TS226 -UN-23AUG88

DX.LIFT -19-04JUN90-1/1

Use Proper Tools

Use tools appropriate to the work. Makeshift tools and procedures can create safety hazards.

Use power tools only to loosen threaded parts and fasteners.

For loosening and tightening hardware, use the correct size tools. DO NOT use U.S. measurement tools on metric fasteners. Avoid bodily injury caused by slipping wrenches.

Use only service parts meeting John Deere specifications.



T5778 -JUN-08NOV09

DX,REPAIR -19-17FEB99-1/1

Handling Batteries Safely



CAUTION: Battery gas can explode. Keep sparks and flames away from batteries. Use a flashlight to check battery electrolyte level.

Never check battery charge by placing a metal object across the posts. Use a voltmeter or hydrometer.

Always remove grounded (—) battery clamp first and replace it last.



CAUTION: Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, eat holes in clothing, and cause blindness if splashed into eyes.

Avoid the hazard by:

1. Filling batteries in a well-ventilated area.
2. Wearing eye protection and rubber gloves.
3. Avoiding breathing fumes when electrolyte is added.
4. Avoiding spilling or dripping electrolyte.
5. Using proper jump start procedure.

If you spill acid on yourself:

1. Flush your skin with water.
2. Apply baking soda or lime to help neutralize the acid.
3. Flush your eyes with water for 15—30 minutes. Get medical attention immediately.

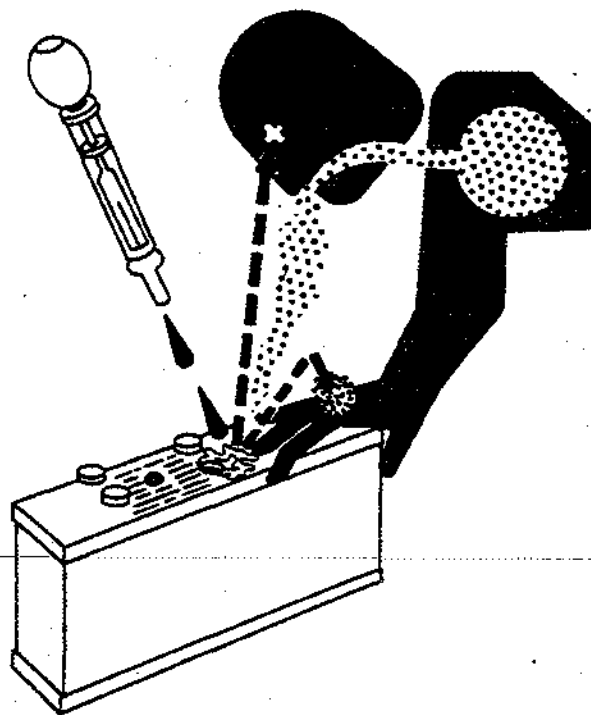
If acid is swallowed:

1. Do not induce vomiting.
2. Drink large amounts of water or milk, but do not exceed 2 L (2 qt.).
3. Get medical attention immediately.

WARNING: Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm. **Wash hands after handling.**



Explosion



Acid

TS204 -UN-23AUG88

TS203 -UN-23AUG88

Protect Against High Pressure Spray

Spray from high pressure nozzles can penetrate the skin and cause serious injury. Keep spray from contacting hands or body.

If an accident occurs, see a doctor immediately. Any high pressure spray injected into the skin must be surgically removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury should reference a knowledgeable medical source. Such information is available from Deere & Company Medical Department in Moline, Illinois, U.S.A.



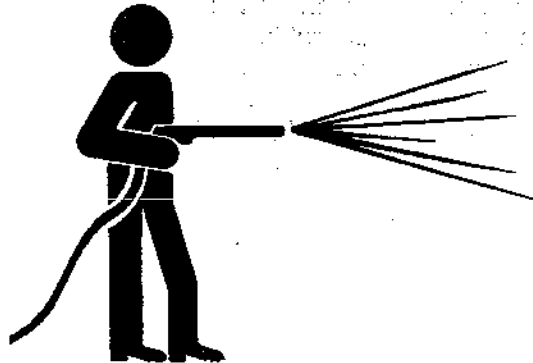
TS1343 -UN-16MAR92

DX,SPRAY -19-16APR92-1/1

Work in Clean Area

Before starting a job:

- Clean work area and machine.
- Make sure you have all necessary tools to do your job.
- Have the right parts on hand.
- Read all instructions thoroughly; do not attempt shortcuts.



T6642EJ -UN-18OCT88

DX,CLEAN -19-04JUN90-1/1

Illuminate Work Area Safely

Illuminate your work area adequately but safely. Use a portable safety light for working inside or under the machine. Make sure the bulb is enclosed by a wire cage. The hot filament of an accidentally broken bulb can ignite spilled fuel or oil.



TS223 -UN-23AUG88

DX,LIGHT -19-04JUN90-1/1

Dispose of Waste Properly

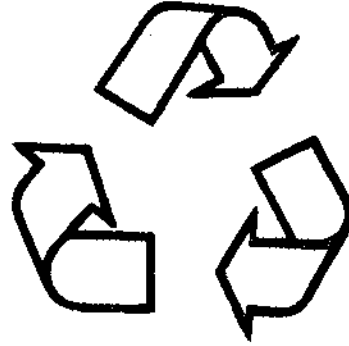
properly disposing of waste can threaten the environment and ecology. Potentially harmful waste used with John Deere equipment include such items as oil, fuel, coolant, brake fluid, filters, and batteries.

Use leakproof containers when draining fluids. Do not use food or beverage containers that may mislead someone into drinking from them.

Do not pour waste onto the ground, down a drain, or into any water source.

Air conditioning refrigerants escaping into the air can damage the Earth's atmosphere. Government regulations may require a certified air conditioning service center to recover and recycle used air conditioning refrigerants.

Inquire on the proper way to recycle or dispose of waste from your local environmental or recycling center, or from your John Deere dealer.



TS1133 -UN-26NOV90

DX.DRAIN -19-03MAR93-1/1

Fuels, Lubricants, and Coolant

Diesel Fuel

Consult your local fuel distributor for properties of the diesel fuel available in your area.

In general, diesel fuels are blended to satisfy the low temperature requirements of the geographical area in which they are marketed.

Diesel fuels specified to EN 590 or ASTM D975 are recommended. Renewable diesel is basically identical to petroleum diesel fuel that is created by Hydrotreating fats and oils. Renewable diesel that meets EN 590 or ASTM D975 is acceptable for use at all percentage mixture levels.

Required fuel properties

In all cases, the fuel shall meet the following properties:

Cetane number of 45 minimum. Cetane number greater than 50 is preferred, especially for temperatures below -20°C (-4°F) or elevations above 1500 m (5000 ft).

Cold Filter Plugging Point (CFPP) should be at least 5°C (9°F) below the expected lowest temperature or

Cloud Point below the expected lowest ambient temperature.

Fuel lubricity should pass a maximum scar diameter of 0.45 mm as measured by ASTM D6079 or ISO 12156-1.

Sulfur content:

- Diesel fuel quality and fuel sulfur content must comply with all existing emissions regulations for the area in which the engine operates.
- Use of diesel fuel with sulfur content less than 0.10% (1000 ppm) is **STRONGLY** recommended.
- Use of diesel fuel with sulfur content 0.10% (1000 ppm) to 0.50% (5000 ppm) may result in **REDUCED** oil and filter change intervals as shown in the table.
- **BEFORE** using diesel fuel with sulfur content greater than 0.50% (5000 ppm), contact your John Deere dealer.

IMPORTANT: Do not mix used diesel engine oil or any other type of lubricating oil with diesel fuel.

IMPORTANT: Improper fuel additive usage may cause damage on fuel injection equipment of diesel engines.

DX,FUEL1 -18-05OCT07-1/1

Lubricity of Diesel Fuel

Most diesel fuels manufactured in the United States, Canada, and the European Union have adequate lubricity to ensure proper operation and durability of fuel injection system components. However, diesel fuels manufactured in some areas of the world may lack the necessary lubricity.

IMPORTANT: Make sure the diesel fuel used in your machine demonstrates good lubricity characteristics.

Fuel lubricity should pass a maximum scar diameter of 0.45 mm as measured by ASTM D6079 or ISO 12156-1.

If fuel of low or unknown lubricity is used, add John Deere PREMIUM DIESEL FUEL CONDITIONER (or equivalent) at the specified concentration.

Lubricity of Biodiesel Fuel

Significant improvement in lubricity can occur with biodiesel blends up to B20. The gain in lubricity above a 20% blend is limited.

DX.FUEL5 -19-05OCT97-1/1

Handling and Storing Diesel Fuel



CAUTION: Handle fuel carefully. Do not fill the fuel tank when engine is running.

DO NOT smoke while you fill the fuel tank or service the fuel system.

Fill the fuel tank at the end of each day's operation to prevent water condensation and freezing during cold weather.

Keep all storage tanks as full as practicable to minimize condensation.

Ensure that all fuel tank caps and covers are installed properly to prevent moisture from entering.

Monitor water content of the fuel regularly.

When using bio-diesel fuel, the fuel filter may require more frequent replacement due to premature plugging.

Check engine oil level daily prior to starting engine. A rising oil level may indicate fuel dilution of the engine oil.

IMPORTANT: The fuel tank is vented through the filler cap. If a new filler cap is required, always replace it with an original vented cap.

When fuel is stored for an extended period or if there is a slow turnover of fuel, add a fuel conditioner to stabilize the fuel and prevent water condensation. Contact your fuel supplier for recommendations.

DX.FUEL4 -19-19DEC03-1/1

Testing Diesel Fuel

DIESELSCAN™ is a John Deere fuel analysis program that can be used to monitor the quality of your fuel. The DIESELSCAN analysis verifies fuel type, cleanliness, water content, suitability for cold weather operation, and whether the fuel meets specifications.

Check with your John Deere dealer for availability of DIESELSCAN kits.

DIESELSCAN is a trademark of Deere & Company

DX,FUEL6 -19-14NOV05-1/1

Bio-Diesel Fuel

Biodiesel is a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats. Biodiesel blends are biodiesel mixed with petroleum diesel fuel on a volume basis.

Biodiesel users in the U.S. are strongly encouraged to purchase biodiesel blends from a BQ-9000 Certified Marketer and sourced from a BQ-9000 Accredited Producer (as certified by the National Biodiesel Board). Certified Marketers and Accredited Producers can be found at the following website: <http://www.bq-9000.org>.

While 5% blends are preferred (B5), biodiesel concentrations up to a 20% blend (B20) in petroleum diesel fuel can be used in all John Deere engines. Biodiesel blends up to B20 can be used **ONLY** if the biodiesel (100% biodiesel or B100) meets ASTM D6751 (US), EN 14214 (EU), or equivalent specification. Expect a 2% reduction in power and a 3% reduction in fuel economy when using B20.

John Deere approved fuel conditioners containing detergent/dispersant additives are recommended when using lower biodiesel blends, but are required when using blends of B20 or greater.

John Deere engines can also operate on biodiesel blends above B20 (up to 100% biodiesel) **ONLY** if the biodiesel meets the EN 14214 specification (primarily available in Europe). Engines operating on biodiesel blends above B20 may not fully comply with all applicable emissions regulations. Expect up to a 12% reduction in power and an 18% reduction in fuel economy when using 100% biodiesel. John Deere approved fuel conditioners containing detergent/dispersant additives are required.

The petroleum diesel portion of biodiesel blends must meet the requirements of ASTM D975 (US) or EN 590 (EU) commercial standards.

Biodiesel blends up to B20 must be used within 90 days of the date of biodiesel manufacture. Biodiesel blends from B21 to B100 must be used within 45 days of the date of biodiesel manufacture.

Request a certificate of analysis from your fuel distributor to ensure that the fuel is compliant with the above specifications.

Consult your John Deere dealer for approved biodiesel fuel conditioners to improve storage and performance with biodiesel fuels.

When using biodiesel fuel, the engine oil level must be checked daily. If oil becomes diluted with fuel, shorten oil change intervals. Refer to Diesel Engine Oil and Filter Service Intervals for more details regarding biodiesel and engine oil change intervals.

The following must be considered when using biodiesel blends up to B20:

- Cold weather flow degradation
- Stability and storage issues (moisture absorption, oxidation, microbial growth)
- Possible filter restriction and plugging (usually a problem when first switching to biodiesel on used engines.)
- Possible fuel leakage through seals and hoses
- Possible reduction of service life of engine components

The following must also be considered when using biodiesel blends above B20.

- Possible coking and/or blocked injector nozzles, resulting in power loss and engine misfire if John Deere approved fuel conditioners containing detergent/dispersant additives are not used
- Possible crankcase oil dilution, requiring more frequent oil changes
- Possible corrosion of fuel injection equipment
- Possible lacquering and/or seizure of internal components
- Possible formation of sludge and sediments
- Possible thermal oxidation of fuel at elevated temperatures
- Possible elastomer seal and gasket material degradation (primarily an issue with older engines)

- Possible compatibility issues with other materials (including copper, lead, zinc, tin, brass, and bronze) used in fuel systems and fuel-handling equipment
- Possible reduction in water separator efficiency
- Potential high acid levels within fuel system
- Possible damage to paint if exposed to biodiesel

IMPORTANT: Raw pressed vegetable oils are **NOT** acceptable for use as fuel in any concentration in John Deere engines. Their use could cause engine failure.

DX FUEL7 -19-04OCT07-2/2

Minimizing the Effect of Cold Weather on Diesel Engines

John Deere diesel engines are designed to operate effectively in cold weather.

However, for effective starting and cold weather operation, a little extra care is necessary. The information below outlines steps that can minimize the effect that cold weather may have on starting and operation of your engine. See your John Deere dealer for additional information and local availability of cold weather aids.

Use Winter Blend Diesel Fuel

When temperatures fall below -10°C (14°F), winter blend diesel fuel is best suited for cold weather operation. Winter blend diesel fuel has a lower cloud point and a lower pour point.

Cloud point is the temperature at which wax will begin to form in the fuel and this wax causes fuel filters to plug. **Pour point** is the lowest temperature at which movement of the fuel is observed.

NOTE: On an average, winter blend diesel fuel has a lower BTU (heat content) rating. Using winter blend diesel fuel may reduce power and fuel efficiency, but should not cause any other engine performance effects. Check the grade of fuel being used before troubleshooting for low power complaints in cold weather operation.

Air Intake Heater

An air intake heater is an available option to aid cold weather starting.

Ether

An ether port on the intake is available to aid cold weather starting.



CAUTION: Do not use ether when (1) starting with an engine equipped with glow plugs or (2) when starting with an air intake heater.

Coolant Heater

An engine block heater (coolant heater) is an available option to aid cold weather starting.

Seasonal Viscosity Oil and Proper Coolant Concentration

Use seasonal grade viscosity engine oil based on the expected air temperature range between oil changes and a proper concentration of low silicate antifreeze as recommended. (See DIESEL ENGINE OIL and ENGINE COOLANT requirements this section.)

Diesel Fuel Flow Additive

Use John Deere Premium Diesel Fuel Conditioner (winter formula) which contains anti-gel chemistry, or equivalent to treat Grade No.2-D fuel during the cold weather season. This generally extends operability about 10°C (18°F) below its Cloud Point. For operability at temperatures further below, winter grade fuel (a blend of No.2-D and No.1-D, or straight No.1-D fuel) is best suited for cold weather operation.

IMPORTANT: Treat fuel when outside temperature drops below 0°C (32°F). For best results, use with untreated fuel. Follow all recommended instructions on label.



CAUTION: Do not use ether when starting with an air intake heater.

Biodiesel

When running with BIODIESEL blends wax formation can generate at warmer temperatures. Begin to use John Deere Premium Biodiesel Conditioner (winter) at 5°C (40°F) to treat biodiesel fuels during the cold weather season. Below 0°C (32°F) John Deere requires the use of B5 or lower blends. Below -10°C (14°F) John Deere requires the use of winter blend diesel fuel.

Winterfronts

Use of fabric, cardboard, or solid winterfronts is not recommended with any John Deere engine. Their use can result in excessive engine coolant, oil, and charge air temperatures. This can lead to reduced engine life, loss of power and poor fuel economy. Winterfronts may also put abnormal stress on fan and fan drive components potentially causing premature failures.

If winterfronts are used, they should never totally close off the grill frontal area. Approximately 25% area in the center of the grill should remain open at all times. At no time should the air blockage device be applied directly to the radiator core.

Radiator Shutters

If equipped with a thermostatically controlled radiator shutter system, this system should be regulated in such a way that the shutters are completely open by the time the coolant reaches 93°C (200°F) to prevent excessive intake manifold temperatures. Manually controlled systems are not recommended.

If air-to-air aftercooling is used, the shutters must be completely open by the time the intake manifold air temperature reaches the maximum allowable temperature out of the charge air cooler.

For more information, see your John Deere dealer.

DX,FUEL10 -19-04OCT07-2/2

Diesel Engine Break-In Oil

New engines are filled at the factory with John Deere ENGINE BREAK-IN OIL. During the break-in period, add John Deere ENGINE BREAK-IN OIL as needed to maintain the specified oil level.

Change the oil and filter after the first 100 hours of operation of a new or rebuilt engine.

After engine overhaul, fill the engine with John Deere ENGINE BREAK-IN OIL.

If John Deere ENGINE BREAK-IN OIL is not available, use a diesel engine oil meeting one of the following during the first 100 hours of operation:

- API Service Classification CE
- API Service Classification CD
- API Service Classification CC
- ACEA Oil Sequence E2
- ACEA Oil Sequence E1

After the break-in period, use John Deere PLUS-50™ or other diesel engine oil as recommended in this manual.

IMPORTANT: Do not use PLUS-50 oil or engine oils meeting any of the following during the first 100 hours of operation of a new or rebuilt engine:

API CJ-4	ACEA E7
API CI-4 PLUS	ACEA E6
API CI-4	ACEA E5
API CH-4	ACEA E4
API CG-4	ACEA E3
API CF-4	
API CF-2	
API CF	

These oils will not allow the engine to break-in properly.

PLUS-50 is a trademark of Deere & Company.

DX,ENOil4 -19-13SEP06-1/1

Diesel Engine Oil

Use oil viscosity based on the expected air temperature range during the period between oil changes.

John Deere PLUS-50™ oil is preferred.

Oils meeting one of the following specifications are also recommended:

- ACEA Oil Sequence E7
- ACEA Oil Sequence E6

Extended service intervals may apply when John Deere PLUS-50™, ACEA E7, or ACEA E6 engine oils are used. Consult your John Deere dealer for more information.

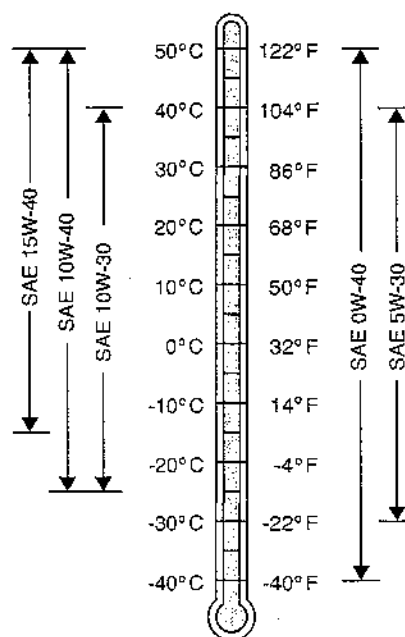
Other oils may be used if they meet one or more of the following:

- John Deere TORQ-GARD SUPREME™
- API Service Category CJ-4
- API Service Category CI-4 PLUS
- API Service Category CI-4
- ACEA Oil Sequence E5
- ACEA Oil Sequence E4

Multi-viscosity diesel engine oils are preferred.

Diesel fuel quality and fuel sulfur content must comply with all existing emissions regulations for the area in which the engine operates.

DO NOT use diesel fuel with sulfur content greater than 1.0% (10 000 ppm).



Oil Viscosities for Air Temperature Ranges

TS1691 -JUN-18JUL07

PLUS-50 is a trademark of Deere & Company
TORQ-GARD SUPREME is a trademark of Deere & Company

DX,ENQIL11 -19-26JUL07-1/1

Diesel Engine Oil and Filter Service Intervals

The oil and filter service intervals in the table below should be used as guidelines. Actual service intervals also depend on operation and maintenance practices. It is suggested to use oil analysis to determine the actual useful life of the oil and to aid in selection of the proper oil and filter service interval.

Oil and filter service intervals are based on a combination of oil pan capacity, type of engine oil and filter used, and sulfur content of the diesel fuel.

Diesel fuel sulfur level will affect engine oil and filter service intervals. Higher fuel sulfur levels reduce oil and filter service intervals as shown in the table.

- Use of diesel fuel with sulfur content less than 0.10% (1000 ppm) is strongly recommended.
- Use of diesel fuel with sulfur content 0.10% (1000 ppm) to 0.50% (5000 ppm) may result in **REDUCED** oil and filter change intervals as shown in the table.
- **BEFORE** using diesel fuel with sulfur content greater than 0.50% (5000 ppm), contact your John Deere dealer.
- **DO NOT** use diesel fuel with sulfur content greater than 1.00% (10 000 ppm).

IMPORTANT: If using **BIODIESEL** blends greater than **B20**, shorten oil change interval to half the recommended service interval or monitor engine oil using **OILSCAN** to ensure that fuel dilution does not exceed 5%.

Oil types (premium or standard) in the table include:

- "Premium Oils" include John Deere PLUS-50™, ACEA E7, or ACEA E6 oils.
- "Standard Oils" include John Deere TORQ-GARD SUPREME™, API CJ-4, API CI-4 PLUS, API CI-4, ACEA E5, or ACEA E4 oils.

Use of lower specification oils in Tier 3 engines may result in premature engine failure.

NOTE: The 500 hour extended oil and filter change interval is only allowed if all of the following conditions are met:

- Engine equipped with an extended drain interval oil pan
- Use of diesel fuel with sulfur content less than 0.50% (5000 ppm)
- Use of premium oil: John Deere PLUS-50, ACEA E7, or ACEA E6
- Perform engine oil analysis to determine the actual extended service life of ACEA E7 and ACEA E6 oils
- Use of an approved John Deere oil filter

Refer to the charts on the following pages to find the proper oil and filter service interval for your engine.

Using Charts to Find Oil and Filter Service Interval

1. Determine your engine model and power rating and find it in the left column of 4045 or 6068 chart.
2. Locate your engine oil pan option code (19__) on engine label.
3. In the chart column under your oil pan code, select whether you use premium oil (PLUS-50™ or equivalent) or standard grade oil.
4. Determine the sulfur content of your diesel fuel.
5. Now you can find the proper oil and filter change interval by lining up your power level and fuel sulfur content with oil pan/oil type column. The number indicates how frequently your oil and filter should be changed.

Example:

- Engine Model - 4045
- Engine Power - 118kW (158 hp)
- Oil Pan Code - 1976
- Oil Type - Premium
- Oil Filter - John Deere approved

- Fuel Sulfur Level - 0.10-0.20 (1000-2000 ppm)

In the 4045 chart under 118kW Power Rating, select the line for 0.10-0.20 "Fuel Sulfur Content" and move across to column for 1976 "oil pan option code", select "Prem Oil" and read **500** hour oil change interval.

4045 (4.5 L) Engine Oil and Filter Service Intervals in Hours of Operation									
Power Rating	Fuel Sulfur Content	Oil Pan Option Codes							
		1903		19AE, 19BC		1923		1976	
		Interval		Interval		Interval		Interval	
kW (hp)		Std Oil	Prem Oil	Std Oil	Prem Oil	Std Oil	Prem Oil	Std Oil	Prem Oil
86 (115)	Less Than 0.10% (1000 ppm)	250	500	250	500	250	500	250	500
	0.10% - 0.20% (1000 - 2000 ppm)	250	500	250	500	250	500	250	500
	0.20% - 0.50% (2000 - 5000 ppm)	250	500	250	500	250	500	250	500
	0.50% - 1.00% (5000 - 10,000 ppm)	125	250	125	250	125	250	125	250
93-104 (125-140)	Less Than 0.10% (1000 ppm)	250	500	250	500	250	500	250	500
	0.10% - 0.20% (1000 - 2000 ppm)	200	400	250	500	250	500	250	500
	0.20% - 0.50% (2000 - 5000 ppm)	175	350	250	500	250	500	250	500
	0.50% - 1.00% (5000 - 10,000 ppm)	125	250	250	500	250	500	250	500
118 (158)	Less Than 0.10% (1000 ppm)	250	375	250	500	250	500	250	500
	0.10% - 0.20% (1000 - 2000 ppm)	200	300	200	400	200	400	250	500
	0.20% - 0.50% (2000 - 5000 ppm)	150	275	175	350	175	350	250	500
	0.50% - 1.00% (5000 - 10,000 ppm)	125	175	125	250	125	250	125	250
Use of premium oil also requires use of an approved John Deere oil filter.									

Continued on next page

OURGP12.00001EE -19-22APR08-2/3

6068 (6.8 L) Engine Oil and Filter Service Intervals in Hours of Operation

Power Rating	Fuel Sulfur Content	Oil Pan Option Codes							
		1907, 1908, 1909, 1944		1956		19AC, 19AV		1961, 1968, 19AU	
		Interval		Interval		Interval		Interval	
kW (hp)		Std Oil	Prem Oil	Std Oil	Prem Oil	Std Oil	Prem Oil	Std Oil	Prem Oil
104-138 (140-185)	Less Than 0.10% (1000 ppm)	250	500	250	500	250	500	250	500
	0.10% - 0.20% (1000 - 2000 ppm)	250	500	250	500	250	500	250	500
	0.20% - 0.50% (2000 - 5000 ppm)	250	500	250	500	250	500	250	500
	0.50% - 1.00% (5000 - 10,000 ppm)	125	250	125	250	125	250	125	250
147-149 (197-200)	Less Than 0.10% (1000 ppm)	250	500	250	500	250	500	250	500
	0.10% - 0.20% (1000 - 2000 ppm)	200	400	250	500	250	500	250	500
	0.20% - 0.50% (2000 - 5000 ppm)	175	350	250	500	250	500	250	500
	0.50% - 1.00% (5000 - 10,000 ppm)	125	250	125	250	125	250	125	250
177 (237)	Less Than 0.10% (1000 ppm)	250	375	250	375	250	500	250	500
	0.10% - 0.20% (1000 - 2000 ppm)	200	300	200	300	250	500	250	500
	0.20% - 0.50% (2000 - 5000 ppm)	150	275	150	275	250	500	250	500
	0.50% - 1.00% (5000 - 10,000 ppm)	125	175	125	175	125	250	125	250

Use of premium oil also requires use of an approved John Deere oil filter.

OURGP12.00001EE -19-22APR08-3/3

Mixing of Lubricants

In general, avoid mixing different brands or types of oil. Oil manufacturers blend additives in their oils to meet certain specifications and performance requirements.

Consult your John Deere dealer to obtain specific information and recommendations.

Mixing different oils can interfere with the proper functioning of these additives and degrade lubricant performance.

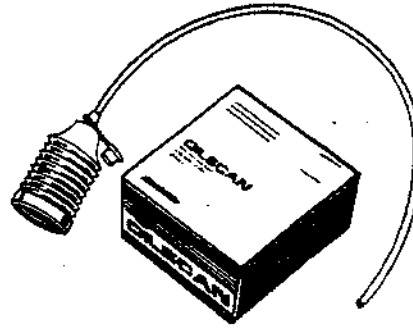
DXLUBMIX -19-18MAH86-1/1

OILSCAN™ and COOLSCAN™

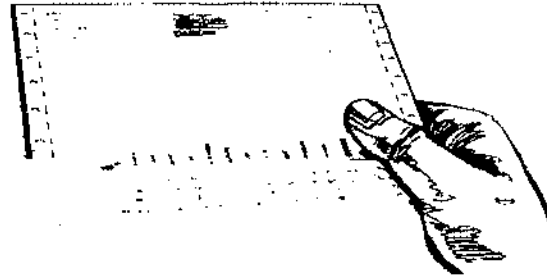
LSCAN™ and COOLSCAN™ are John Deere sampling programs to help you monitor machine performance and identify potential problems before they cause serious damage.

Oil and coolant samples should be taken from each system prior to its recommended change interval.

Check with your John Deere dealer for the availability of OILSCAN™ and COOLSCAN™ kits.



T6B2BAB -UN-15JUN89



T6B2BAB -UN-18OCT88

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COOLSCAN is a trademark of Deere & Company.

DX.OILSCAN -19-02DEC02-1/1

Alternative and Synthetic Lubricants

Conditions in certain geographical areas may require lubricant recommendations different from those printed in this manual.

Some John Deere brand coolants and lubricants may not be available in your location.

Consult your John Deere dealer to obtain information and recommendations.

Synthetic lubricants may be used if they meet the performance requirements as shown in this manual.

The temperature limits and service intervals shown in this manual apply to both conventional and synthetic oils.

Re-refined base stock products may be used if the finished lubricant meets the performance requirements.

DX.ALTER -19-15JUN00-1/1

Lubricant Storage

Your equipment can operate at top efficiency only when clean lubricants are used.

Use clean containers to handle all lubricants.

Whenever possible, store lubricants and containers in an area protected from dust, moisture, and other contamination. Store containers on their side to avoid water and dirt accumulation.

Make certain that all containers are properly marked to identify their contents.

Properly dispose of all old containers and any residual lubricant they may contain.

DX.LUBST -19-18MAR96-1/1

Oil Filters

Filtration of oils is critical to proper operation and lubrication.

Always change filters regularly as specified in this manual.

Use filters meeting John Deere performance specifications.

DX.FILT -19-18MAR96-1/1

Diesel Engine Coolant

The engine cooling system is filled to provide year-round protection against corrosion and cylinder liner pitting, and winter freeze protection to -37°C (-34°F). If protection at lower temperatures is required, consult your John Deere dealer for recommendations.

John Deere COOL-GARD™ Prediluted Coolant is preferred for service.

John Deere COOL-GARD Prediluted Coolant is available in a concentration of either 50% ethylene glycol or 55% propylene glycol.

Additional recommended coolants

The following engine coolant is also recommended:

- John Deere COOL-GARD Coolant Concentrate in a 40% to 60% mixture of concentrate with quality water.

John Deere COOL-GARD coolants do not require use of supplemental coolant additives, except for periodic replenishment of additives during the drain interval.

Other fully formulated coolants

Other fully formulated low silicate ethylene or propylene glycol base coolants for heavy-duty engines may be used if they meet one of the following specifications:

- ASTM D6210 prediluted (50%) coolant
- ASTM D6210 coolant concentrate in a 40% to 60% mixture of concentrate with quality water

Coolants meeting ASTM D6210 do not require use of supplemental coolant additives, except for periodic replenishment of additives during the drain interval.

Coolants requiring supplemental coolant additives

Other low silicate ethylene glycol base coolants for heavy-duty engines may also be used if they meet one of the following specifications:

- ASTM D4985 ethylene glycol base prediluted (50%) coolant
- ASTM D4985 ethylene glycol base coolant concentrate in a 40% to 60% mixture of concentrate with quality water

Coolants meeting ASTM D4985 require an initial charge of supplemental coolant additives, formulated for protection of heavy duty diesel engines against corrosion and cylinder liner erosion and pitting. They also require periodic replenishment of additives during the drain interval.

Other coolants

It is possible that neither John Deere COOL-GARD nor coolants meeting one of the coolant standards listed above is available in the geographical area where service is performed. If these coolants are unavailable, use a coolant concentrate or prediluted coolant with a quality additive package that provides cylinder liner cavitation protection and protects the cooling system metals (cast iron, aluminum alloys, and copper alloys such as brass) from corrosion.

The additive package must be part of one of the following coolant mixtures:

- ethylene glycol or propylene glycol base prediluted (40% to 60%) coolant
- ethylene glycol or propylene glycol base coolant concentrate in a 40% to 60% mixture of concentrate with quality water

Water quality

Water quality is important to the performance of the cooling system. Distilled, deionized, or demineralized water is recommended for mixing with ethylene glycol and propylene glycol base engine coolant concentrate.

IMPORTANT: Do not mix ethylene glycol and propylene glycol base coolants.

IMPORTANT: Do not use cooling system sealing additives or antifreeze that contains sealing additives.

DX,COOL3 -19-27OCT05-2/2

Drain Intervals for Diesel Engine Coolant

Drain the factory fill engine coolant, flush the cooling system, and refill with new coolant after the first 3 years or 3000 hours of operation.

Subsequent drain intervals are determined by the coolant used for service. At each interval, drain the coolant, flush the cooling system, and refill with new coolant.

When John Deere COOL-GARD™ is used, the drain interval may be extended to 5 years or 5000 hours of

operation, provided that the coolant is tested annually AND additives are replenished, as needed, by adding a supplemental coolant additive.

If John Deere COOL-GARD is used but the coolant is not tested OR additives are not replenished by adding a supplemental coolant additive, the drain interval is 3 years or 3000 hours of operation

If COOL-GARD is not used, the drain interval is reduced to 2 years or 2000 hours of operation.

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DX,COOL11 -19-19DEC03-1/1

Additional Information About Diesel Engine Coolants and Supplemental Coolant Additives

Engine coolants are a combination of three chemical components: ethylene glycol or propylene glycol antifreeze, inhibiting coolant additives, and quality water.

Coolant specifications

Some products, including John Deere COOL-GARD™ Prediluted Coolant, are fully formulated coolants that contain all three components in their correct concentrations. Do not add an initial charge of supplemental coolant additives to these fully formulated products.

Coolants meeting ASTM D6210 do not require an initial charge of supplemental coolant additives.

Some coolant concentrates, including John Deere COOL-GARD Coolant Concentrate, contain both glycol antifreeze and inhibiting coolant additives. Mix these products with quality water, but do not add an initial charge of supplemental coolant additives.

Coolants meeting ASTM D4985 require an initial charge of supplemental coolant additives.

Replenish coolant additives

The concentration of coolant additives is gradually depleted during engine operation. Periodic replenishment of inhibitors is required, even when John Deere COOL-GARD or another fully formulated coolant is used. Follow the recommendations in this manual for the use of supplemental coolant additives.

Why use supplemental coolant additives?

Operating without proper coolant additives will result in increased corrosion, cylinder liner erosion and pitting, and other damage to the engine and cooling system. A

simple mixture of ethylene glycol or propylene glycol and water will not give adequate protection.

Use of supplemental coolant additives reduces corrosion, erosion, and pitting. These chemicals reduce the number of vapor bubbles in the coolant and help form a protective film on cylinder liner surfaces. This film acts as a barrier against the harmful effects of collapsing vapor bubbles.

Avoid automotive-type coolants

Never use automotive-type coolants (such as those meeting ASTM D3306). These coolants do not contain the correct additives to protect heavy-duty diesel engines. They often contain a high concentration of silicates and may damage the engine or cooling system.

Water quality

Water quality is important to the performance of the cooling system. Distilled, deionized, or demineralized water is recommended for mixing with ethylene glycol and propylene glycol base engine coolant concentrate. All water used in the cooling system should meet the following minimum specifications for quality:

Chlorides	<40 mg/L
Sulfates	<100 mg/L
Total dissolved solids	<340 mg/L
Total hardness	<170 mg/L
pH	5.5 to 9.0

Freeze protection

The relative concentrations of glycol and water in the engine coolant determine its freeze protection limit.

Ethylene Glycol	Freeze Protection Limit
40%	-24°C (-12°F)
50%	-37°C (-34°F)
60%	-52°C (-62°F)
Propylene Glycol	Freeze Protection Limit
40%	-21°C (-6°F)
50%	-33°C (-27°F)
60%	-49°C (-56°F)

DO NOT use a coolant-water mixture greater than 60% ethylene glycol or 60% propylene glycol.

DX.COOL7 -19-19DEC03-2/2

Testing Diesel Engine Coolant

Testing Diesel Engine Coolant

Maintaining adequate concentrations of glycol and inhibiting additives in the coolant is critical to protect the engine and cooling system against freezing, corrosion, and cylinder liner erosion and pitting.

Test the coolant solution at intervals of 12 months or less and whenever excessive coolant is lost through leaks or overheating.

Coolant test strips

Coolant test strips are available from your John Deere dealer. These test strips provide a simple, effective

method to check the freeze point and additive levels of your engine coolant.

Compare the results to the supplemental coolant additive (SCA) chart to determine the amount of inhibiting additives in your coolant and whether more John Deere COOLANT CONDITIONER should be added.

COOLSCAN™ and COOLSCAN PLUS™

For a more thorough evaluation of your coolant, perform a COOLSCAN or COOLSCAN PLUS analysis, where available. See your John Deere dealer for information.

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COOLSCAN PLUS is a trademark of Deere & Company

DX.COOL9 -19-19DEC03-1/1

Operating in Warm Temperature Climates

John Deere engines are designed to operate using glycol base engine coolants.

Always use a recommended glycol base engine coolant, even when operating in geographical areas where freeze protection is not required.

IMPORTANT: Water may be used as coolant *in emergency situations only*.

Foaming, hot surface aluminum and iron corrosion, scaling, and cavitation will occur when water is used as the coolant, even when coolant conditioners are added.

Drain cooling system and refill with recommended glycol base engine coolant as soon as possible.

DX.COOL6 -19-18MAR96-1/1

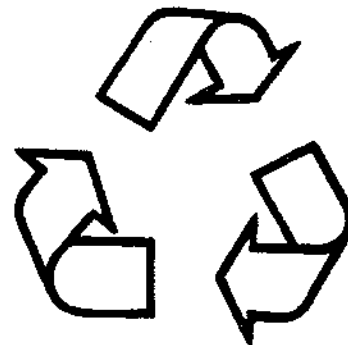
Disposing of Coolant

Improperly disposing of engine coolant can threaten the environment and ecology.

Use leakproof containers when draining fluids. Do not use food or beverage containers that may mislead someone into drinking from them.

Do not pour waste onto the ground, down a drain, or into any water source.

Inquire on the proper way to recycle or dispose of waste from your local environmental or recycling center, or from your John Deere engine distributor or servicing dealer.



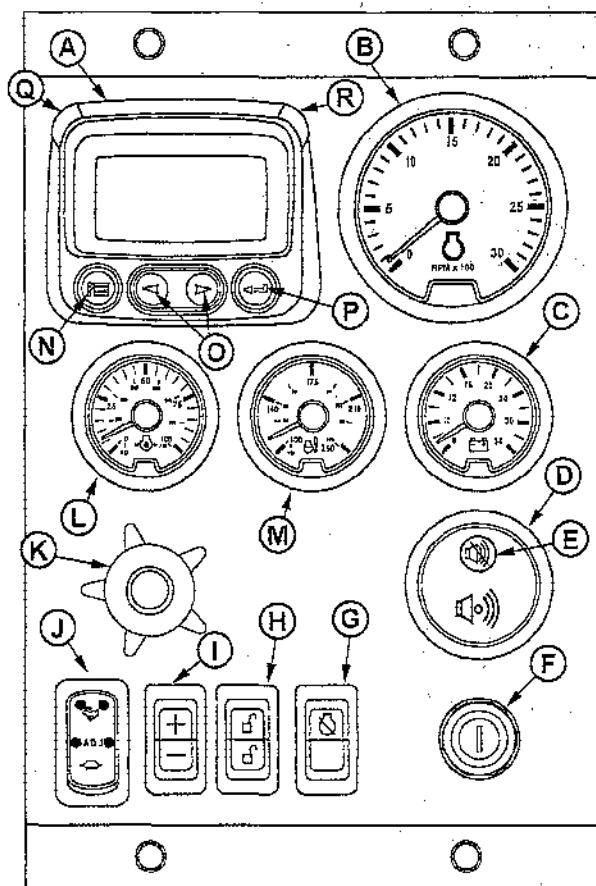
Recycle Waste

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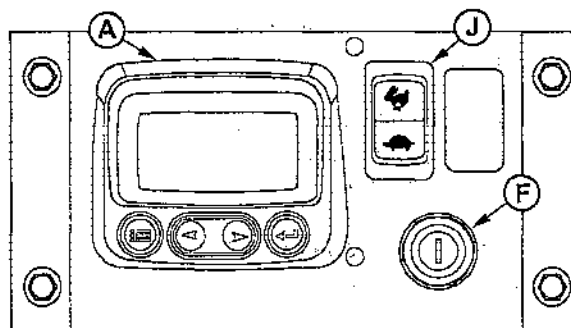
Instrument Panels

Instrument Panels



Full-Featured Instrument Panel

RG13276 -UN-28OCT03



Basic Instrument Panel

RG13277 -UN-22OCT03

A—Diagnostic Gauge/Hour Meter
B—Tachometer
C—Voltmeter (Optional)
D—Audible Alarm (Optional)
E—Audible Alarm Override Button

F—Key Switch
G—Override Shutdown Rocker Switch
H—Bump Enable Rocker Switch
I—Speed Select Rocker Switch
J—High-Low Speed Select Rocker Switch

K—Analog Throttle Control (Optional)
L—Oil Pressure Gauge
M—Coolant Temperature Gauge
N—Menu Key

O—Arrow Keys
P—Enter Key
Q—Amber "WARNING" Indicator Light
R—Red "STOP ENGINE" Indicator Light

John Deere **POWERTECH™** OEM Engines have an electronic control system, which has the following controls and gauges as shown. The following information applies only to those controls and gauges supplied by John Deere. Refer to your engine application manual for specific guidelines if John Deere-sourced controls and instrumentation are not used.

Following is a brief description of the available optional electronic controls and gauges found on John Deere provided instrument panels. Refer to manufacturer's literature for information on controls not provided by Deere.

Instrument Panel (Continued)**A—Diagnostic Gauge/Hour Meter**

The diagnostic gauge (A) displays diagnostic trouble codes (DTCs) as they are accessed. Other information on the engine can be accessed using the touch keys (N, O and P). The hour meter feature shows the operating hours of the engine and should be used as a guide for scheduling periodic maintenance. If the diagnostic gauge receives a trouble code from an engine control unit, the current display will switch to a warning or shutdown (depending on the severity of the code) screen that will display the trouble code number, the description of the code and the corrective action needed.

B—Tachometer

The tachometer (B) indicates engine speed in hundreds of revolutions per minute (rpm).

C—Voltmeter (Optional)

The voltmeter (C) indicates system battery voltage. The amber "Warning" light (Q) will illuminate when battery voltage is too low for proper operation of the fuel injection system.

D—Audible Alarm (Optional)

The audible alarm (D) will sound whenever low oil pressure, high coolant temperature, or water-in-fuel conditions exist. This includes all signals that light up the amber "warning" indicator (intermittent alarm) or the red "stop engine" indicator (steady alarm).

E—Audible Alarm Override Button

The optional audible alarm has an override button (E) that silences the audible alarm for approximately two minutes when pressed.

F—Key Start Switch

The three-position key start switch (F) controls the engine electrical system. When the key switch is turned clockwise to "START", the engine will crank.

When the engine starts, the key is released and returns to the "ON" (RUN) position.

G—Override Shutdown Rocker Switch

Switch will be present, but may not be active, depending on engine controller (ECU) options originally selected. If switch is active, pressing the upper half of the override shutdown switch (G) will override an engine shutdown signal. The switch must be pressed within 30 seconds to prevent undesired shutdown of engine. Pressing this switch will override the engine shutdown for 30 seconds at a time to move vehicle to a safe location.

H—Bump Speed Enable Rocker Switch

This is a three-position switch (H) with the center position as "OFF" (locked). With this switch in the "OFF" position, the speed select switch (I) is also locked, to prevent accidental changes in operating speed. Pressing upper or lower half of switch (H) will unlock or enable the bump speed switch to take effect using speed select switch (I).

I—Speed Select Rocker Switch

The speed select switch (I) is used to bump engine speed up (+) or down (-) in small increments during operation. This switch must be used with the bump speed enable switch (H) in the unlocked position (top or bottom half of button depressed).

J—High-Low Speed Select Rocker Switch

The high-low speed select switch (J) is used to set the engine operating speeds at slow (turtle) or fast (rabbit). Factory preset idle speeds can also be adjusted using bump speed enable switch (H) with speed select switch (I).

The basic instrument panel will have the high-low speed select switch only. Press and hold up (+) or down (-) to adjust engine speed as desired. The engine speed selected will not be held in the memory. To adjust engine speeds, See Changing Engine Speeds in Section 20.

How To Select Preset Operating Speeds (Bump Speeds)

First select Turtle (Slow) or Adj by pressing speed select switch (J) to "Turtle" (slow) or "Adj"(center). Then you can press either the upper or lower portion of the bump speed enable switch (H) to unlock the setting. The bump speed enable must be held down as the speed select switch (J) is used to change the setting by pressing (+) to increase speed or (-) to decrease speed.

Once the slow idle speed has been set, the bump speed enable switch must be pressed and released three times within two seconds to commit the new operating speed to memory. If not done, the engine's new speed will only be effective until the key switch is shut off. Then the speed will revert back to the previous setting.

The fast idle speed is not adjustable. It will always go back to the factory preset fast idle speed.

K—Analog Throttle Control (Optional)

The throttle control (K) is used to control engine speed. This control is available only on engines with analog throttle.

L—Engine Oil Pressure Gauge

The oil pressure gauge (L) indicates engine oil pressure. An audible alarm (D) warns the operator if engine oil pressure falls below a safe operating pressure.

M—Engine Coolant Temperature Gauge

The engine coolant temperature gauge (M) indicates engine coolant temperature. An audible alarm (D)

warns the operator if coolant temperature rises above the preset safe operating temperature.

N—Menu Key

The menu key is pressed to either enter or exit the menu screens on the diagnostic gauge.

O—Arrow Keys

Use the arrow keys (O) to change the display on the window of the diagnostic gauge and to access engine performance data.

Pressing the left arrow to scroll to the left or upward or the right arrow to scroll to the right or downward. This will allow you to view various engine parameters and any diagnostic trouble codes that occur.

Refer to the following story for accessing engine information on the diagnostic gauge using the touch keys.

P—Enter Key

The enter key is pressed to select the parameter that is highlighted on the screen.

Q—Amber "WARNING" Indicator Light

When light comes on, an abnormal condition exists. It is not necessary to shutdown engine immediately, but problem should be corrected as soon as possible.

R—Red "STOP ENGINE" Indicator Light

When light comes on, stop engine immediately or as soon as safely possible to prevent engine damage. Correct problem before restarting.

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Using Diagnostic Gauge to Access Engine Information

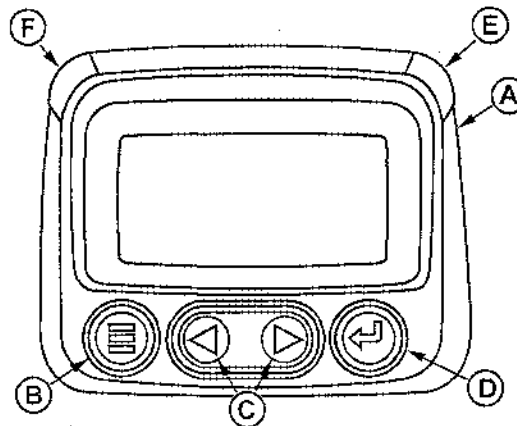
The diagnostic gauge (A) allows the operator to view many readouts of engine functions and trouble codes (DTCs). The gauge is linked to the electronic control system and its sensors. This allows the operator to monitor engine functions and to troubleshoot the engine systems when needed.

Press the menu key (B) to access the various engine functions in sequence. The displays can be selected as either customary English or metric units. The following menu of engine parameters can be displayed on the diagnostic gauge window:

- Engine hours
 - Engine rpm
 - System voltage
 - Percent engine load at the current rpm
 - Coolant temperature
 - Oil pressure
 - Throttle position
 - Intake manifold temperature
 - Current fuel consumption
 - Active service (diagnostic) codes
 - Stored service (diagnostic) codes from the engine
- Set the units for display
View the engine configuration parameters

NOTE: Engine parameters which can be accessed will vary with the engine application. Six languages for readouts are available and can be selected during setup of gauge.

The diagnostic gauge includes a graphical backlit Liquid Crystal Display (LCD) screen. The display can show either a single parameter or a quadrant display showing four parameters simultaneously. The diagnostic gauge uses two arrow keys (C) for scrolling through the engine parameter list and viewing the menu list and an enter key (D) for selecting highlighted items. The red (E) and amber (F) lights are used to signal active trouble code received by the diagnostic gauge.



Diagnostic Gauge (Later Engines)

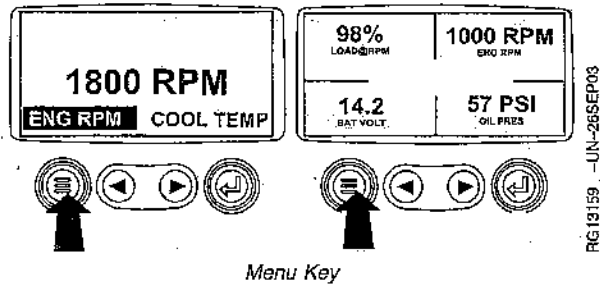
- A—Diagnostic Gauge
- B—Menu Key
- C—Arrow Keys
- D—Enter Key
- E—Red "STOP ENGINE" Indicator Light
- F—Amber "WARNING" Indicator Light

RG13132 -JUN-09SEP03

Main Menu Navigation

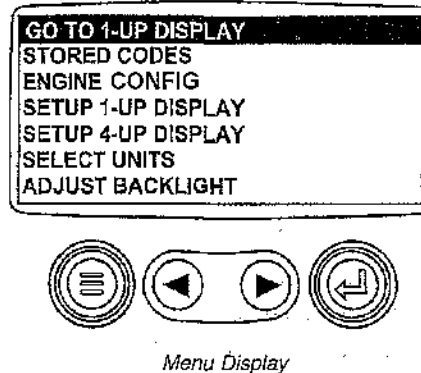
NOTE: The engine does not need to be running to navigate the diagnostic gauge screens. If engine start up is desired, See Starting The Engine. All of the engine values illustrated on the diagnostic gauge indicate the engine is running.

1. Turn the key switch to the ON position. Starting at the single or four engine parameter display, press the "Menu" key.



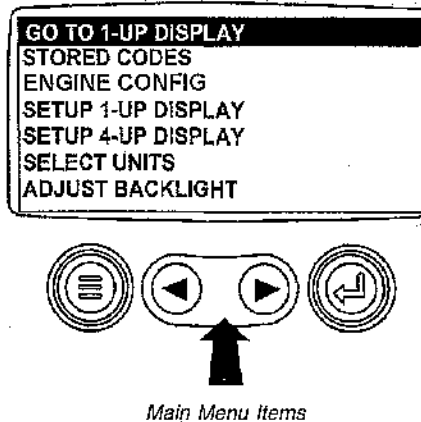
OURGP11.00000A9 -19-03SEP03-1/5

2. The first seven items of the "Main Menu" will be displayed.



OURGP11.00000A9 -19-03SEP03-2/5

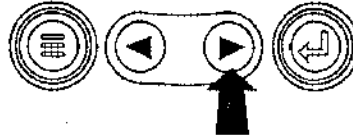
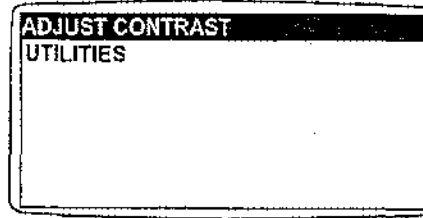
3. Pressing the "Arrow" keys will scroll through the menu selections.



Continued on next page

OURGP11.00000A9 -19-03SEP03-3/5

- Pressing the right arrow key will scroll down to reveal the last items of "Main Menu" screen, highlighting the next item down.

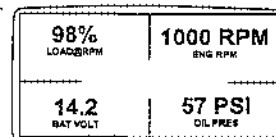
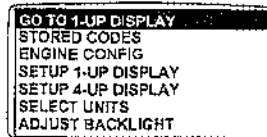


Last Items On Main Menu

RG13162 -JUN-26SEP03

OURGP11.00000A9 -19-03SEP03-4/5

- Use the arrow keys to scroll to the desired menu item or press the "Menu Button" to exit the main menu and return to the engine parameter display.



Use Arrow Buttons To Scroll / Quadrant Display

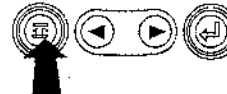
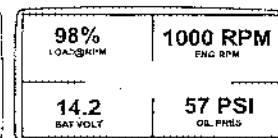
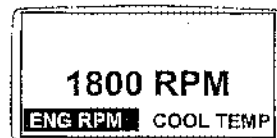
RG13163 -JUN-02OCT03

OURGP11.00000A9 -19-03SEP03-5/5

Engine Configuration Data

NOTE: The engine configuration data is a read only function.

NOTE: The engine does not need to be running to navigate the diagnostic gauge screens. If engine start up is desired, See Starting The Engine. All of the engine values illustrated on the diagnostic gauge indicate the engine is running.



Menu Key

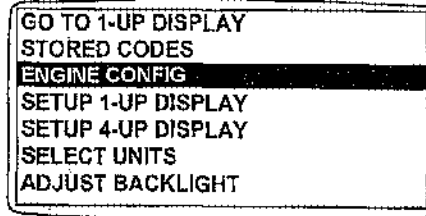
RG13159 -JUN-26SEP03

- Turn the key switch to the ON position. Starting at the single or four engine parameter display, press the "Menu" key.

Continued on next page

OURGP11.00000AB -19-03SEP03-1/6

2. The main menu will be displayed. Use the "Arrow" keys to scroll through the menu until "Engine Config" is highlighted.

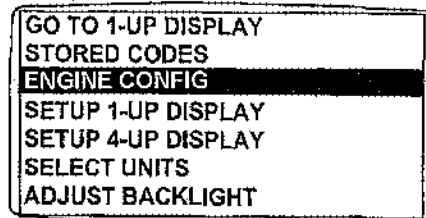


Select Engine Configuration

RG13164 -UN-070C103

OURGP11.00000AB -19-03SEP03-2/6

3. Once "Engine Config" menu item has been highlighted, press the "Enter" key to view the engine configuration data.

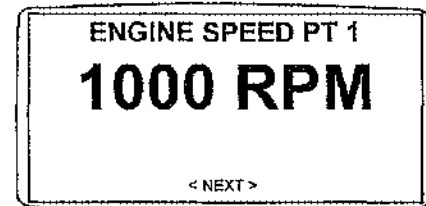


Enter Key

RG13165 -UN-020C103

OURGP11.00000AB -19-03SEP03-3/6

4. Use the "Arrow" keys to scroll through the engine configuration data.

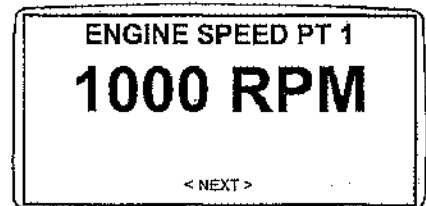


Use Arrow Keys To Scroll

RG13166 -UN-23SEP03

OURGP11.00000AB -19-03SEP03-4/6

5. Press the "Menu" key to return to the main menu.



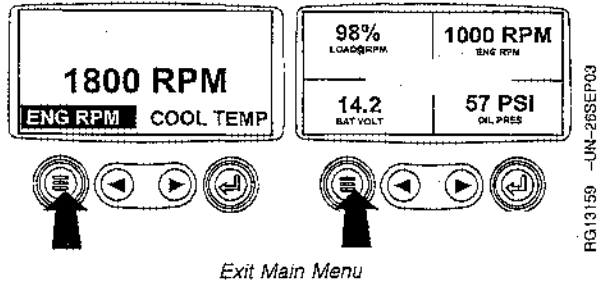
Return To Main Menu

RG13167 -UN-25SEP03

Continued on next page

OURGP11.00000AB -19-03SEP03-5/6

6. Press the "Menu" key to exit the main menu and return to the engine parameter display.

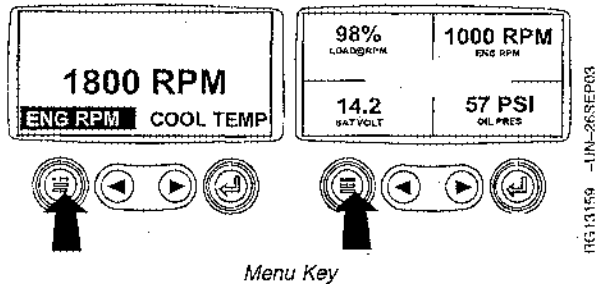


OURGP11.00000AB -19-03SEP03-6/6

Accessing Stored Trouble Codes

NOTE: The engine does not need to be running to navigate the diagnostic gauge screens. If engine start up is desired, See *Starting The Engine*. All of the engine values illustrated on the diagnostic gauge indicate the engine is running.

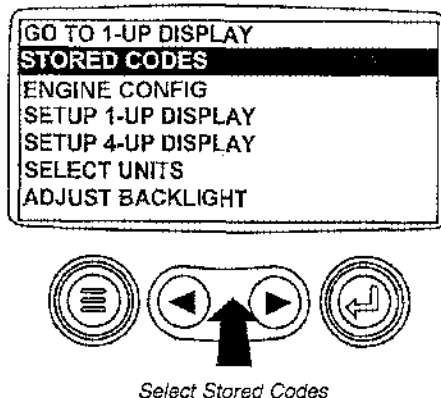
For description of trouble codes, see chart in *Troubleshooting Section*.



1. Turn the key switch to the ON position. Starting at the single or four engine parameter display, press the "Menu" key.

OURGP11.00000AC -19-03SEP03-1/6

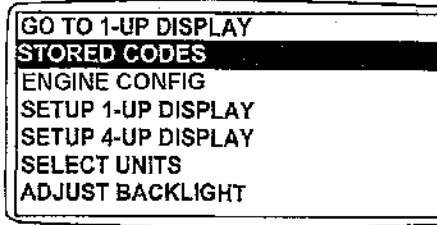
2. The main menu will be displayed. Use the "Arrow" keys to scroll through the menu until "Stored Codes" is highlighted.



Continued on next page

OURGP11.00000AC -19-03SEP03-2/6

3. Once the "Stored Codes" menu item has been highlighted press the "Enter" key to view the stored codes.

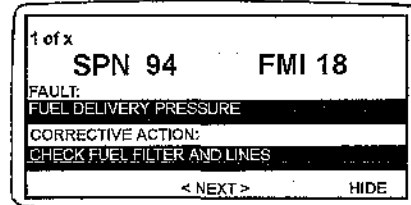


Enter Key

RG13169 -UN-02OCT03

OURGP11,00000AC -19-03SEP03-3/6

4. If the word "Next" appears above the "Arrow" keys, there are more stored codes that may be viewed. Use the "Arrow" key to scroll to the next stored code.

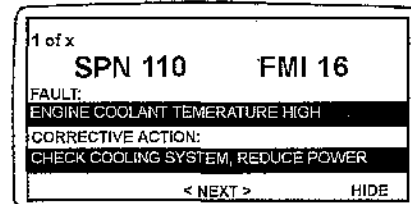


Use Arrow Keys To Scroll

RG13245 -UN-02OCT03

OURGP11,00000AC -19-03SEP03-4/6

5. Press the "Menu" key to return to the main menu.



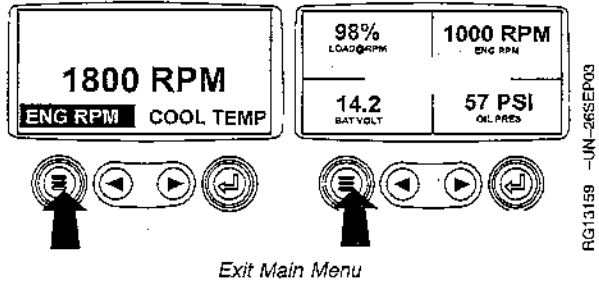
Return To Main Menu

RG13246 -UN-02OCT03

Continued on next page

OURGP11,00000AC -19-03SEP03-5/6

- Press the "Menu" key to exit the main menu and return to the engine parameter display.



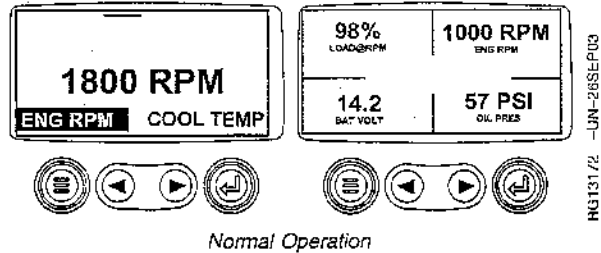
OURGP11,00000AC -19-03SEP03-6/6

Accessing Active Trouble Codes

NOTE: The engine does not need to be running to navigate the diagnostic gauge screens. If engine start up is desired, See Starting The Engine. All of the engine values illustrated on the diagnostic gauge indicate the engine is running.

For description of trouble codes, see chart in Troubleshooting Section.

- During normal operation the single or four parameter screen will be displayed.

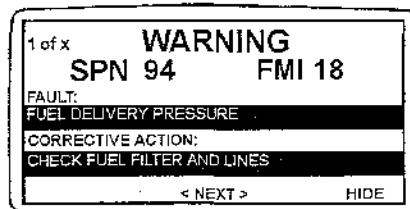


Normal Operation

OURGP11,00000AD -19-03SEP03-1/7

- When the diagnostic gauge receives a trouble code from an engine control unit, the single or four parameter screen will be replaced with the "Warning" message. The SPN and FMI number will be displayed along with a description of the problem and the corrective action needed.

IMPORTANT: Ignoring active trouble codes can result in severe engine damage.



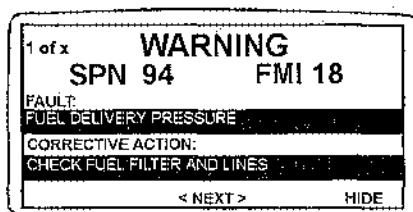
Active Trouble Codes Displayed

RG13240 -UN-30SEP03

Continued on next page

OURGP11,00000AD -19-03SEP03-2/7

3. If the word "Next" appears above the arrow keys, there are more trouble codes that can be viewed by using the arrow keys to scroll to the next trouble code.



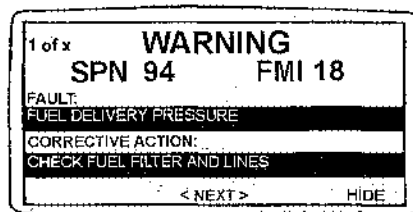
Use Arrow Keys To Scroll

RG13241 -UN-30SEP03

OURGP11.00000AD -19-03SEP03-3/7

IMPORTANT: Ignoring active trouble codes can result in severe engine damage.

4. To acknowledge and hide the code and return to the single or four parameter display, press the "Enter" Key.

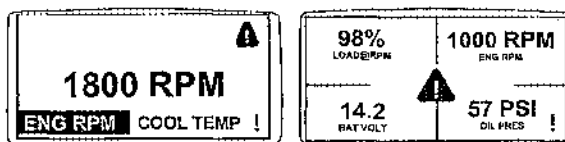


Hide Trouble Codes

RG13242 -UN-30SEP03

OURGP11.00000AD -19-03SEP03-4/7

5. The display will return to the single or four parameter display, but the display will contain the warning icon. Pressing the "Enter" key will redisplay the hidden trouble code.



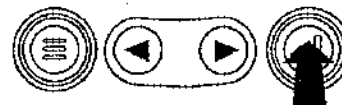
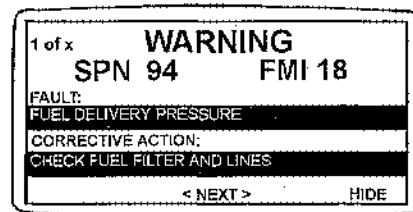
Active Trouble Code Icon

RG13176 -UN-26SEP03

OURGP11.00000AD -19-03SEP03-5/7

IMPORTANT: Ignoring active trouble codes can result in severe engine damage.

6. Pressing the "Enter" key once again will hide the trouble code and return the screen to the single or four parameter display.



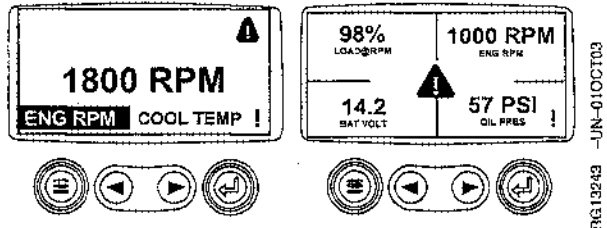
Enter Key

RG13242 -UN-30SEP03

Continued on next page

OURGP11.00000AD -19-03SEP03-6/7

- The single or four parameter screen will display the warning icon until the trouble code condition is corrected.

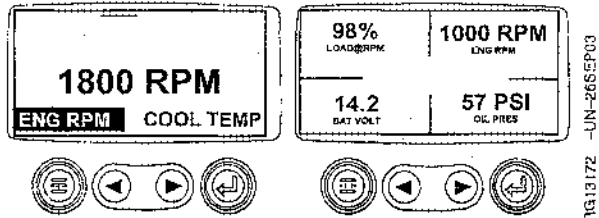


Active Trouble Code Condition

OURGP11.00000AD -19-03SEP03-7/7

Engine Shutdown Codes

- During normal operation the single or four parameter screen will be displayed.

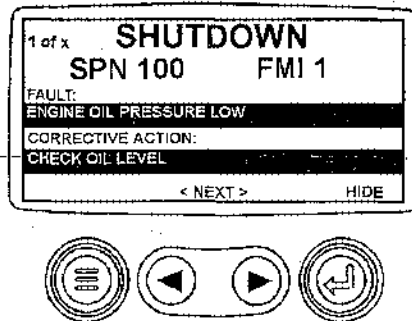


Normal Operation

OURGP11.00000AE -19-03SEP03-1/6

- When the diagnostic gauge receives a severe trouble code from an engine control unit, the single or four parameter screen will be replaced with the "Shutdown" message. The SPN and FMI number will be displayed along with a description of the problem and the corrective action needed.

If the word "Next" appears above the arrow keys, there are more trouble codes that can be viewed by using the arrow keys to scroll to the next trouble code.

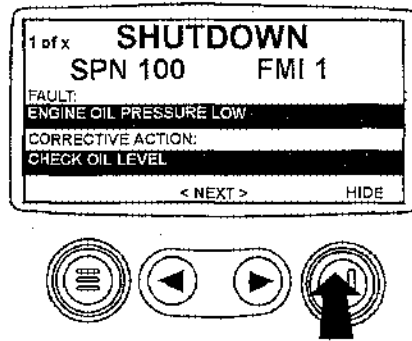


Shutdown Message

OURGP11.00000AE -19-03SEP03-2/6

- To acknowledge and hide the trouble code and return to the single or four parameter display, press the "Enter" key".

IMPORTANT: Ignoring the shutdown message can result in severe engine damage.



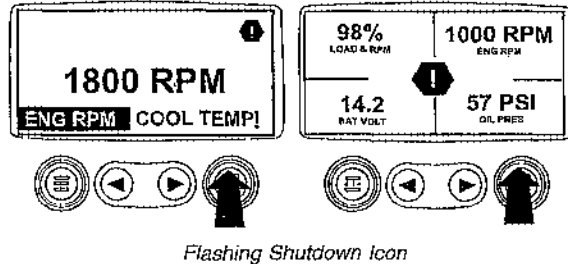
Hide Trouble Code

Continued on next page

OURGP11.00000AE -19-03SEP03-3/6

- The display will return to the single or four parameter display, but the display will contain the "Shutdown" icon. Pressing the "Enter" key will redisplay the hidden trouble code.

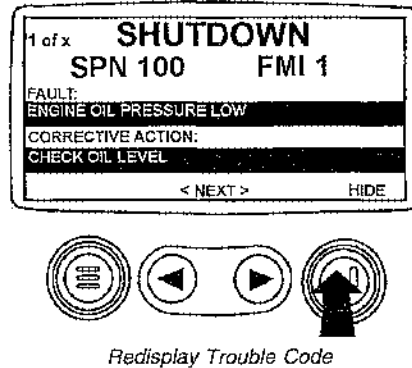
IMPORTANT: Ignoring the shutdown message can result in severe engine damage.



RG13179 -UN-26SEP03

OURGP11.00000AF -19-03SEP03-4/6

- Pressing the "Enter" key once again will hide the trouble code and return the screen to the single or four parameter display.

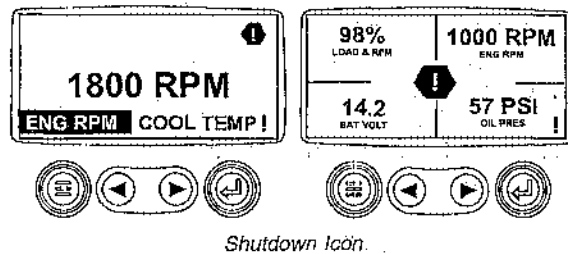


RG13239 -UN-26SEP03

OURGP11.00000AE -19-03SEP03-5/6

- The single or four parameter screen will display the shutdown icon until the trouble code condition is corrected.

IMPORTANT: Ignoring the shutdown message can result in severe engine damage.

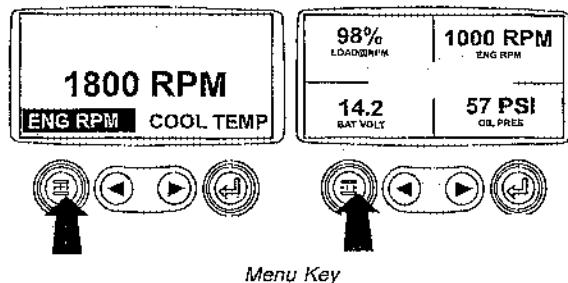


RG13180 -UN-26SEP03

OURGP11.00000AE -19-03SEP03-6/6

Adjusting Backlighting

- Turn the key switch to the ON position. Starting at the single or four engine parameter display, press the "Menu" key.

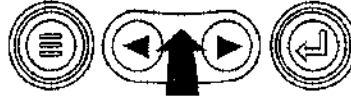
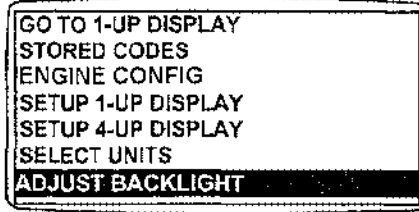


RG13159 -UN-26SEP03

Continued on next page

OURGP11.0000237 -19-21OCT03-1/6

2. The main menu will be displayed. Use the "Arrow" keys to scroll through the menu until "Adjust Backlight" is highlighted.

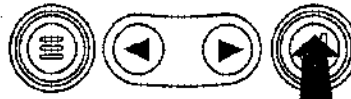
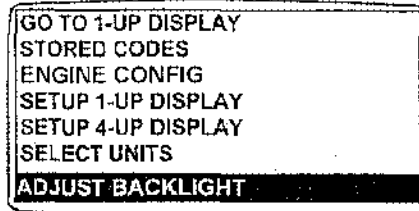


Select Adjust Backlight

RG13181 -UN-02OCT03

OURGP11.0000237 -19-21OCT03-2/6

3. Once the "Adjust Backlight" menu item has been highlighted, press the "Enter" key to activate the "Adjust Backlight" function.

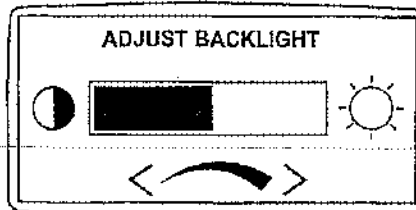


Press Enter Key

RG13182 -UN-02OCT03

OURGP11.0000237 -19-21OCT03-3/6

- Use the "Arrow" keys to select the desired backlight intensity.



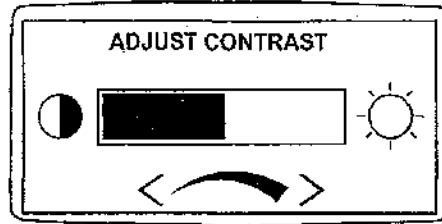
Adjust Backlight Intensity

RG13183 -UN-29SEP03

Continued on next page

OURGP11.0000237 -19-21OCT03-4/6

5. Press the "Menu" key to return to the main menu.

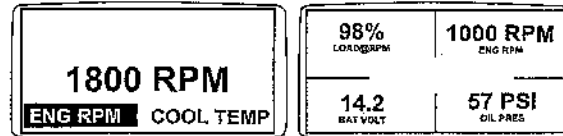


Return To Main Menu

PG13184 -UN-26SEP03

OURGP11.0000237 -19-21OCT03-5/6

6. Press the "Menu" key to exit the main menu and return to the engine parameter display.



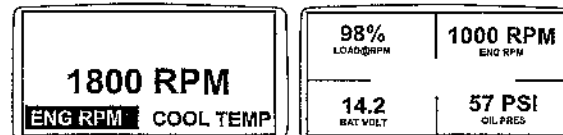
Exit Main Menu

PG13159 -UN-26SEP03

OURGP11.0000237 -19-21OCT03-6/6

Adjusting Contrast

1. Turn the key switch to the ON position. Starting at the single or four engine parameter display press the "Menu" key.



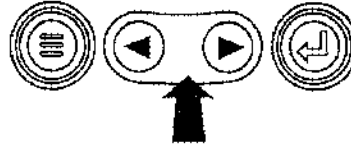
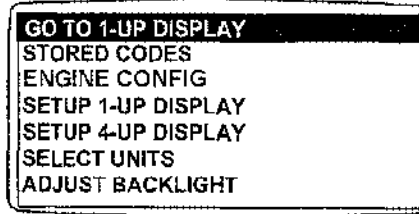
Menu Key

PG13159 -UN-26SEP03

Continued on next page

OURGP11.00000AF -19-03SEP03-1/8

2. The main menu will be displayed. Use the "Arrow" keys to scroll through the menu until "Adjust Contrast" is highlighted.

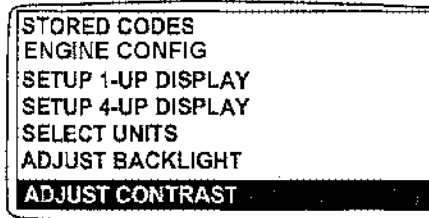


Select Adjust Contrast

RG13161 -UN-02OCT03

OURGP11.00000AF -19-03SEP03-2/6

3. Once the "Adjust Contrast" menu item has been highlighted, press the "Enter" key to activate the "Adjust Contrast" function.

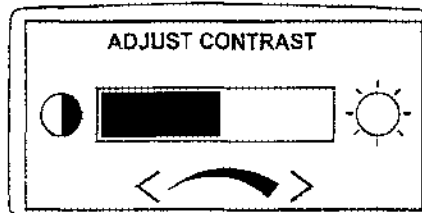


Press Enter Key

RG13185 -UN-02OCT03

OURGP11.00000AF -19-03SEP03-3/6

4. Use the "Arrow" keys to select the desired contrast intensity.



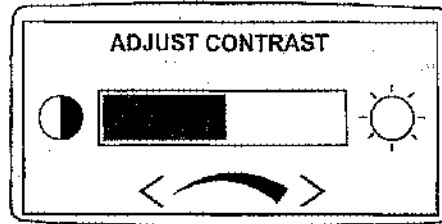
Adjust Contrast Intensity

Continued on next page

RG13186 -UN-29SEP03

OURGP11.00000AF -19-03SEP03-4/6

5. Press the "Menu" key to return to the main menu.

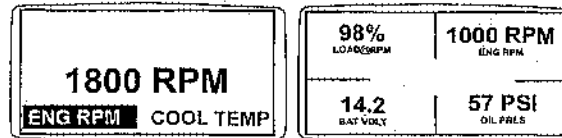


Return To Main Menu

RG13187 -UN-26SEP03

OURGP11.00000AF -19-03SEP03-5/6

6. Press the "Menu" key to exit the main menu and return to the engine parameter display.



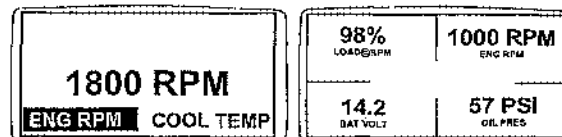
Exit Main Menu

RG13159 -UN-26SEP03

OURGP11.00000AF -19-03SEP03-6/6

Selecting Units Of Measurement

1. Turn the key switch to the ON position. Starting at the single or four engine parameter display, press the "Menu" key.



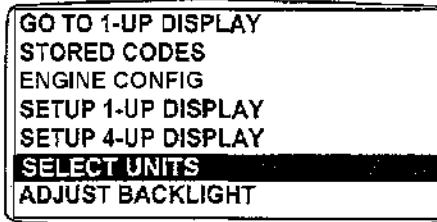
Menu Key

RG13159 -UN-26SEP03

Continued on next page

OURGP11.00000B0 -19-03SEP03-1/7

2. The main menu will be displayed. Use the "Arrow" keys to scroll through the menu until "Select Units" is highlighted.

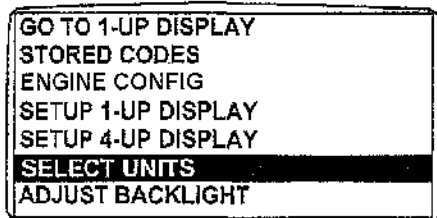


Select Units

RG13188 -UN-02OCT03

OURGP11.00000B0 -19-03SEP03-2/7

3. Once the "Select Units" menu item has been highlighted press the "Enter" key to access the "Select Units" function.



Press Enter Key

RG13189 -UN-02OCT03

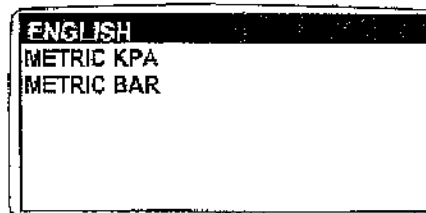
OURGP11.00000B0 -19-03SEP03-3/7

4. There are three choices for units of measurement, English, Metric kPa or Metric Bar.

English is for Imperial units, with pressures displayed in PSI and temperatures in °F.

Metric kPa and Metric bar are for SI units, with pressures displayed in kPa and bar respectively, and temperatures in °C.

Use the "Arrow" keys to highlight the desired units of measurement.



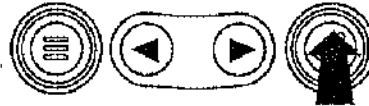
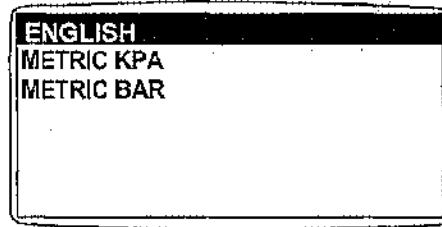
Select Desired Units

RG13190 -UN-26SEP03

Continued on next page

OURGP11.00000B0 -19-03SEP03-4/7

5. Press the "Enter" key to select the highlighted units.

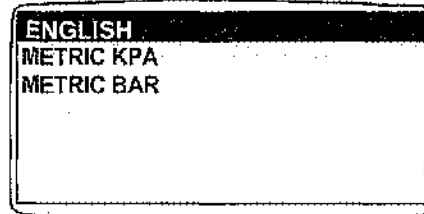


Press Enter Key to Select

RG13191 -UN-30SEP03

OURGP11.00000B0 -19-03SEP03-5/7

6. Press the "Menu" key to return to the main menu.

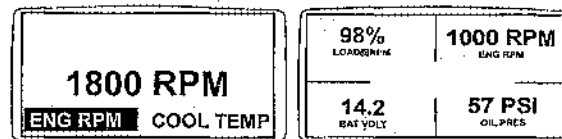


Return To Main Menu

RG13192 -UN-26SEP03

OURGP11.00000B0 -19-03SEP03-6/7

7. Press the "Menu" key to return to the engine parameter display.



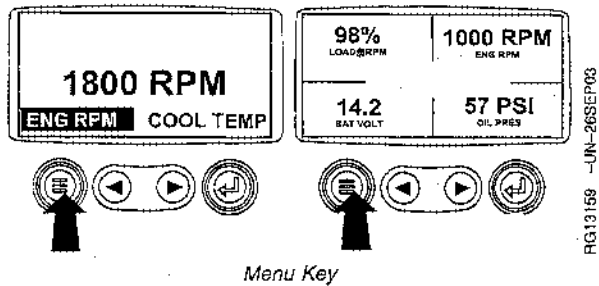
Press Menu Key

RG13159 -UN-26SEP03

OURGP11.00000B0 -19-03SEP03-7/7

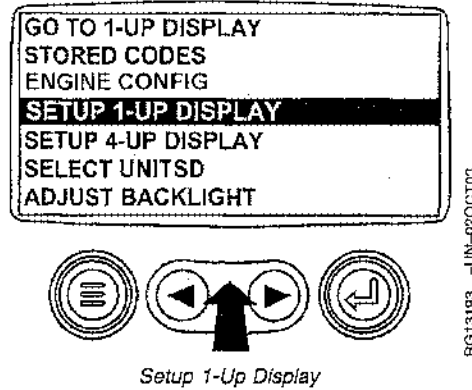
Setup 1-Up Display

Turn the key switch to the ON position. Starting at the single engine parameter display, press the "Menu" key.



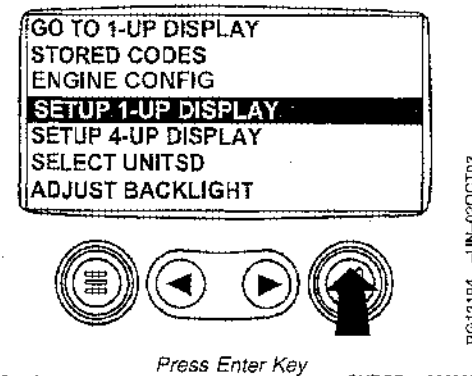
OURGP11.00000B1 -19-03SEP03-1/18

2. Use the "Arrow" keys to scroll through the menu until "Setup 1-Up Display" is highlighted.



OURGP11.00000B1 -19-03SEP03-2/18

3. Once "Setup 1-Up Display" menu item has been highlighted press the "Enter" key to access the "Setup 1-Up Display" function.

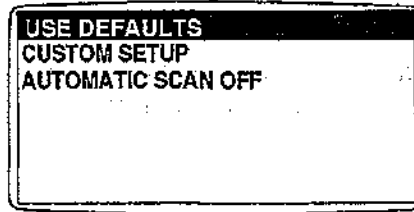


Continued on next page

OURGP11.00000B1 -19-03SEP03-3/18

4. Three options are available for modification of the 1-Up Display.

- a. **Use Defaults** – This option contains the following engine parameters for display: Engine Hours, Engine Speed, Battery Voltage, % Load, Coolant Temperature and Oil Pressure.
- b. **Custom Setup** – This option contains a list of engine parameters. Engine parameters from this list can be selected to replace any or all of the default parameters. This option can be used to add parameters available for scrolling in the 1-Up Display.
- c. **Automatic Scan** – Selecting the scan function will allow the 1-Up Display to scroll through the selected set of parameters one at a time, momentarily pausing at each.

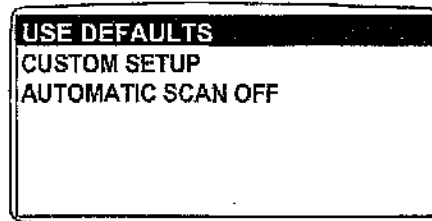


1-Up Display Options

RG13196 -UN-26SEP03

OURGP11.00000B1 -19-03SEP03-4/18

5. **Use Defaults** - To select "Use Defaults" use the Arrow keys to scroll to and highlight "Use Defaults" in the menu display.



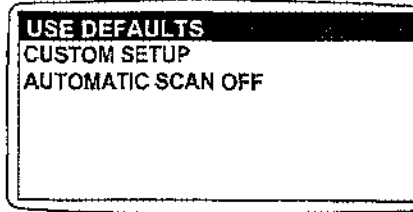
Select Defaults

RG13196 -UN-26SEP03

Continued on next page

OURGP11.00000B1 -19-03SEP03-5/18

6. Press the "Enter" key to activate the "Use Defaults" function.

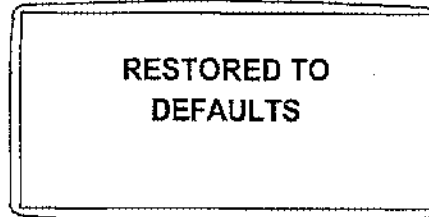


Defaults Selected

RG13197 -UN-29SEP03

OURGP11.0000031 -19-03SEP03-6/18

7. The display parameters are reset to the factory defaults, then the display will return to the "Setup 1-Up Display" menu.

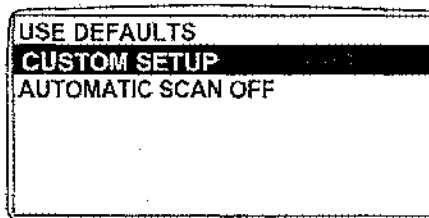


Restored To Defaults

RG13149 -UN-24SEP03

OURGP11.0000031 -19-03SEP03-7/18

8. **Custom Setup** - To perform a custom setup of the 1-Up Display, use the arrow buttons to scroll to and highlight "Custom Setup" on the display.



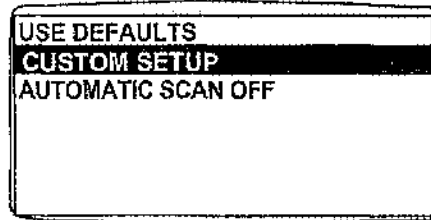
Select Custom Setup

RG13198 -UN-26SEP03

Continued on next page

OURGP11.0000031 -19-03SEP03-8/18

9. Press the "Enter" key to display a list of engine parameters.

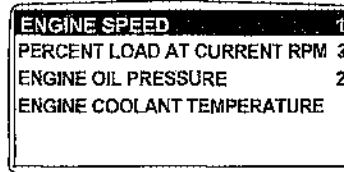


Engine Parameters

RG13:99 -UN-26SEP03

OURGP11.00000B1 -19-03SEP03-9/18

10. Use the "Arrow" keys to scroll to and highlight a selected parameter (parameter with a number to right of it).



This number indicates the order of display for the parameters and that the parameter is selected for display.

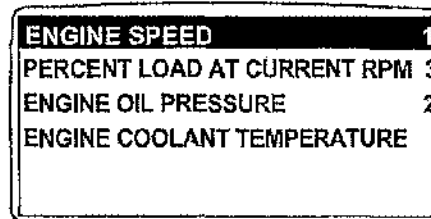


Select Parameters

RG13150 -UN-24SEP03

OURGP11.00000B1 -19-03SEP03-10/18

11. Press the "Enter" key to deselect the selected parameter, removing it from the list of parameters being displayed on the 1-Up Display.



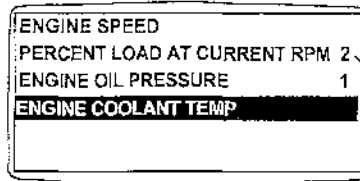
Deselect Parameters

RG13:3219 -UN-26SEP03

Continued on next page

OURGP11.00000B1 -19-03SEP03-11/18

12. Use the "Arrow" keys to scroll and highlight the desired parameter that has not been selected for display (parameter without a number to right of it).



Note that the numbers now indicate the new order of display for the parameters.

FIG 13151 UN-24SEP03

Select Desired Parameters

OURGP-1,000031 -19-03SEP03-12/18

13. Press the "Enter" key to select the parameter for inclusion in the Single Engine Parameter Display.
14. Continue to scroll through and select additional parameters for the custom 1-Up Display. Press the "Menu" key at any time to return to the "Custom Setup" menu.

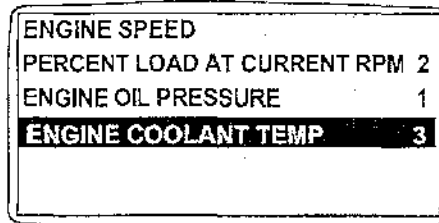


FIG 13220 UN-26SEP03

Select Parameters For Display

OURGP-1,000031 -19-03SEP03-13/18

15. **Automatic Scan** - Selecting the scan function will allow the 1-Up Display to scroll through the selected set of parameters one at a time. Use the "Arrow" keys to scroll to the "Automatic Scan" function.

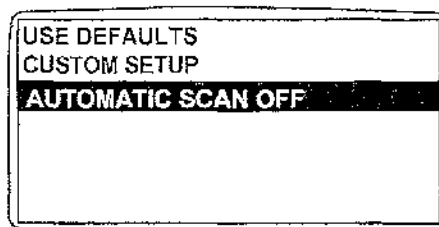


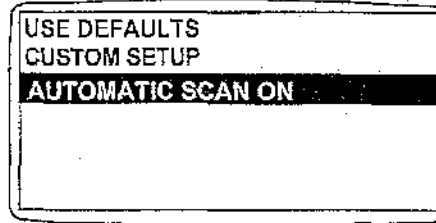
FIG 13221 UN-26SEP03

Automatic Scan Off

Continued on next page

OURGP-1,000031 -19-03SEP03 14/18

16. Press the "Enter" key to toggle the "Automatic Scan" function on.

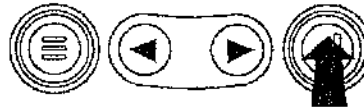
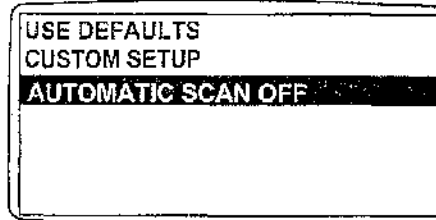


Automatic Scan On

RG13222 -UN-26SEP03

OURGP11.00000R1 19 03SEP03-15/18

17. Press the "Enter" key again to toggle the "Automatic Scan" function off.



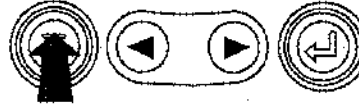
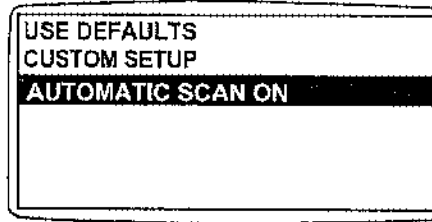
Automatic Scan Off

RG13223 -UN-26SEP03

Continued on next page

OURGP11.00000R1 19 03SEP03-16/18

18. Once the "Use Defaults", "Custom Setup" and "Automatic Scan" functions have been set, press the "Menu" key to return to the main menu.

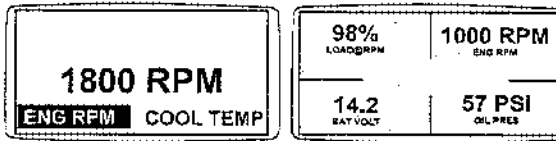


Menu Key

RG13224 -JUN-26SEP03

OURGP11.00000B1 -19-03SEP03-17/18

19. Press the "Menu" key to exit the main menu and return to the engine parameter display.



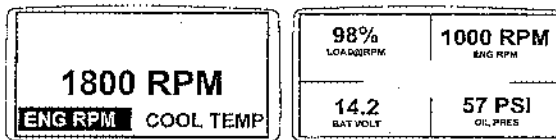
Exit Main Menu

RG13159 -JUN-26SEP03

OURGP11.00000B1 -19-03SEP03-18/18

Setup 4-Up Display

1. Turn the key switch to the ON position. From the single or four engine parameter display, press the "Menu" key.



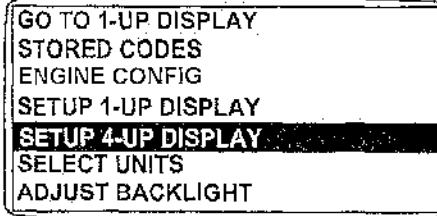
Menu Key

RG13159 -JUN-26SEP03

Continued on next page

OURGP11.00000B2 -19-03SEP03-1/14

2. The main menu will be displayed. Use the "Arrow" keys to scroll through the menu until "Setup 4-Up Display" is highlighted.

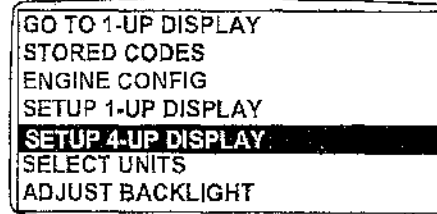


Select Setup 4-Up Display

RG13225 -UN-020CT03

OURGP11,000C0B2 -19-03SEP03 2/14

3. Once the "Setup 4-Up Display" menu item has been highlighted, press the "Enter" key to activate the "Setup 4-Up Display" menu.



Press Enter Key

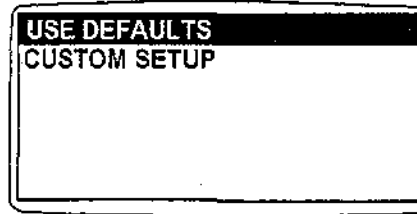
RG13226 -UN-020CT03

Continued on next page

OURGP11,000C0B2 -19-03SEP03 3/14

4. Two options are available for the 4-Up Display.

- a. **Use Defaults** – This option contains the following engine parameters for display: Engine Speed, Battery Voltage, Coolant Temperature and Oil Pressure.
- b. **Custom Setup** – This option contains a list of engine parameters. Engine parameters from this list can be selected to replace any or all of the default parameters.

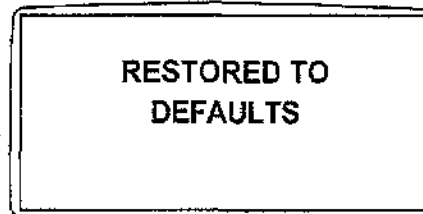


Select Factory Defaults

RG13244 -UN-02OCT03

OURGP11.00000B2 -19-03SEP03-4/14

5. To reset the display parameters to the factory defaults, scroll to and highlight "Use Defaults". Press the "Enter" key to activate the "Use Defaults" function. A message indicating the display parameters are reset to the factory defaults will be displayed, then the display will return to the "Setup 4-Up Display" menu.

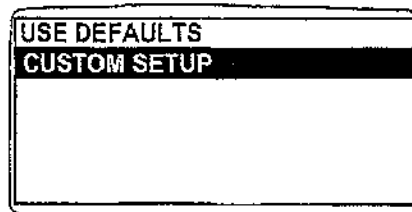


Restored To Defaults

RG13149 -UN-24SEP03

OURGP11.00000B2 -19-03SEP03-5/14

6. **Custom Setup** - To perform a custom setup of the 4-Up Display, use the arrow buttons to scroll to and highlight "Custom Setup" on the display.



Custom Setup

RG13227 -UN-26SEP03

Continued on next page

OURGP11.00000B2 -19-03SEP03-6/14

7. The quadrant with the highlighted parameter value is the current selected parameter. Use the "Arrow" keys to highlight the value in the quadrant you wish to change to a new parameter.

125°F COOL TEMP	1000 RPM ENG RPM
14.2 BAT VOLT	57 PSI OIL PRES



Select Parameters

RG13228 -UN-36SEP03

OURGP11.00000B2 -19-03SEP03-7/14

8. Press the "Enter" key and a list of engine parameters will be displayed.

125°F COOL TEMP	1000 RPM ENG RPM
14.2 BAT VOLT	57 PSI OIL PRES



List Of Engine Parameters

RG13229 -UN-26SEP03

OURGP11.00000B2 -19-03SEP03-8/14

9. The parameter that is highlighted is the selected parameter for the screen. Use the "arrow" keys to highlight the new parameter to be placed in the "4-Up Display".

ENGINE SPEED	3
ENGINE HOURS	
ENGINE COOLANT TEMPERATURE	1
BATTERY POTENTIAL	
ENGINE OIL TEMPERATURE	2
ENGINE OIL PRESSURE	4

The number to the right of the parameter indicates the quadrant in which it is displayed.
1. = Upper Left Quadrant
2. = Lower Left Quadrant
3. = Upper Right Quadrant
4. = Lower Right Quadrant



Select Desired Engine Parameter

RG13230 -UN-26SEP03

Continued on next page

OURGP11.00000B2 -19-03SEP03-9/14

10. Press the "Enter" key to change the selected parameter in the quadrant to the new parameter.

ENGINE SPEED	3
ENGINE HOURS	
ENGINE COOLANT TEMPERATURE	1
BATTERY POTENTIAL	2
ENGINE OIL TEMPERATURE	
ENGINE OIL PRESSURE	4



Enter Selected Parameter

OURGP11.00000B2 -19-03SEP03-10/14

RG13231 -UN-26SEP03

11. Use the "Menu" keys to return to the "4-Up Custom Setup" screen.

ENGINE SPEED	3
ENGINE HOURS	
ENGINE COOLANT TEMPERATURE	1
BATTERY POTENTIAL	
ENGINE OIL TEMPERATURE	2
ENGINE OIL PRESSURE	4

Note the number to the right of the selected parameter indicating that the parameter is now assigned to that display location.



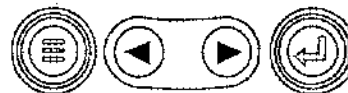
Return To 4-Up Custom Setup

OURGP11.00000B2 -19-03SEP03-11/14

RG13232 -UN-26SEP03

12. The selected quadrant has now changed to the new selected parameter.

125°F COOL TEMP	1000 RPM ENG RPM
143°F OIL TEMP	57 PSI OIL PRES



4-Up Display

Continued on next page

OURGP11.00000B2 -19-03SEP03-12/14

RG13153 -UN-24SEP03

13. Repeat the parameter selection process until all spaces are as desired.
14. Press the "Menu" key to return to the main menu:

125°F COOL TEMP	1000 RPM ENG RPM
143°F OIL TEMP	57 PSI OIL PRES



Return To Main Menu

RG13164 -UN-24SEP03

OURGP11.0000082 -19-03SEP03-13/14

15. Press the "Menu" key to exit the main menu and return to the engine parameter display.

GO TO 1-UP DISPLAY
STORED CODES
ENGINE CONFIG
SETUP 1-UP DISPLAY
SETUP 4-UP DISPLAY
SELECT UNITS
ADJUST BACKLIGHT

125% COOL TEMP	1000 RPM ENG RPM
143°F OIL TEMP	57 PSI OIL PRES



Select Remaining Parameters

RG13165 -UN-07OCT03

OURGP11.0000032 -19-03SEP03-14/14

Engine Operation

Engine Break-In Service

The engine is ready for normal operation. However, extra care during the first 100 hours of operation will result in more satisfactory long-term engine performance and life. DO NOT exceed 100 hours of operation with break-in oil.

1. This engine is factory-filled with John Deere ENGINE BREAK-IN OIL (SAE 10W-30). Operate the engine at heavy loads with minimal idling during the break-in period.
2. If the engine has significant operating time at idle, constant speeds, and/or light load usage, or makeup oil is required in the first 100 hour period, a longer break-in period may be required. In these situations, an additional 100 hour break-in period is recommended using a new change of John Deere ENGINE BREAK-IN OIL and a new John Deere oil filter.



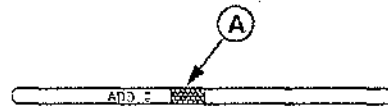
Check Engine Oil

RG13719 -UN-11NOV04

Continued on next page

OURGP12.00001C8 -19-14MAR06-1/4

IMPORTANT: DO NOT add makeup oil until the oil level is BELOW the ADD mark on dipstick. John Deere ENGINE BREAK-IN OIL (TY22041) should be used to make up any oil consumed during the break-in period.



Crosshatch Pattern On Dipstick

A—Crosshatch Pattern On Dipstick

3. Check engine oil level more frequently during engine break-in period. If oil must be added during this period, John Deere ENGINE BREAK-IN OIL is preferred. See ENGINE BREAK-IN OIL, in Fuels, Lubricants, and Coolant Section.

IMPORTANT: Do not use PLUS-50 oil or engine oils meeting any of the following during the first 100 hours of operation of a new or rebuilt engine:

API CI-4 PLUS	ACEA CF
API CI-4	ACEA E7
API CH-4	ACEA E6
API CG-4	ACEA E5
API CF-4	ACEA E4
API CF-2	ACEA E3

These oils will not allow the engine to break-in properly.

IMPORTANT: DO NOT fill above the crosshatch pattern (A) or the FULL mark, whichever is present. Oil levels anywhere within the crosshatch are considered in the acceptable operating range.

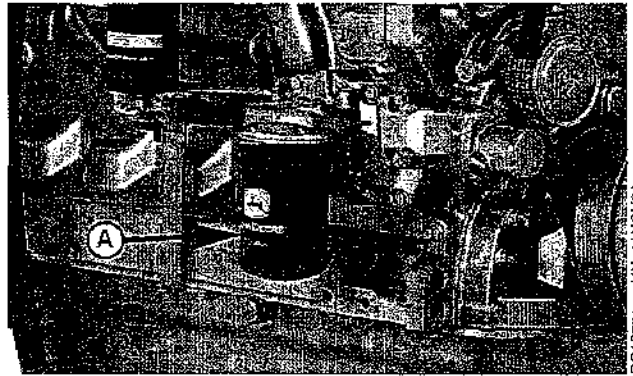
Specification

Engine—Oil Pressure at Full Load Rated Speed With Oil Warmed to 115°C (240°F)		345 ± 103 kPa (3.45 ± 1.03 bar)
		(50 ± 15 psi)
Minimum Oil Pressure at Slow Idle Speed		105 kPa (1.05 bar) (15 psi)
Coolant Temperature Range		82°–95°C (180°–204°F)

Continued on next page

OURGP12,00001C8 - 19-14MAR05-2/4

4. During the first 20 hours, avoid prolonged periods of engine idling or sustained maximum load operation. If engine will idle longer than 5 minutes, stop engine.
5. Before the first 100 hours (maximum), change engine oil and replace engine oil filter (A). (See CHANGING ENGINE OIL AND REPLACING FILTER in Lubrication and Maintenance/500 Hour/12 Month Section.) Fill crankcase with seasonal viscosity grade oil. (See DIESEL ENGINE OIL, in Fuels, Lubricants, and Coolant Section.)



Engine Oil Filter

A—Engine Oil Filter

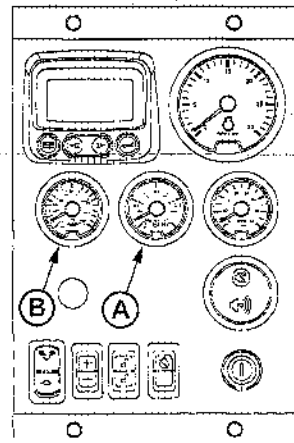
NOTE: Some increase in oil consumption may be expected when low viscosity oils are used. Check oil levels more frequently.

If air temperature is below -10°C (14°F), use an engine block heater.

OURGP12.00001C8 -19-14MAR06-3/4

6. Watch oil pressure gauge (B). Pressure at slow idle should be at least 103 kPa (1.03 bar) (15 psi) once engine is warmed up and should rise to at least 241 kPa (2.41 bar) (35 psi) at rated speed under full load.
7. Watch coolant temperature gauge (A) closely. If coolant temperature rises above 110°C (230°F), reduce load on engine. Unless temperature drops quickly, stop the engine and determine the cause before resuming operation.

NOTE: When the coolant temperature gauge reads approximately 115°C (239°F), the engine will shutdown automatically, if equipped with safety controls.



Watch Coolant Temperature and Oil Pressure On Panel

8. Check poly-vee belt for proper alignment and seating in pulley grooves.

A—Engine Coolant Temperature Gauge
B—Engine Oil Pressure Gauge

RG13720 -UN-11NOV04

OURGP12.00001C8 -19-14MAR06-4/4

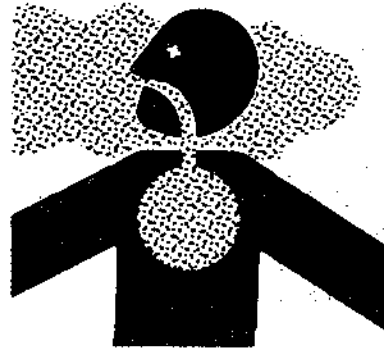
Starting the Engine

The following instructions apply to the optional controls and instruments available through the John Deere Parts Distribution Network. The controls and instruments for your engine may be different from those shown here; always follow manufacturer's instructions.

CAUTION: Before starting engine in a confined building, install proper outlet exhaust ventilation equipment. Always use safety approved fuel storage and piping.

NOTE: If temperature is below 0°C (32°F), it may be necessary to use cold weather starting aids (See *COLD WEATHER OPERATION*, later in this section).

1. Perform all prestarting checks outlined in Lubrication & Maintenance/Daily Section later in this manual.
2. Open the fuel supply shut-off valve, if equipped.
3. Disengage clutch (if equipped) controlling any engine drivelines.



Use Proper Ventilation

TS220 -JUN-23AUG88

Continued on next page

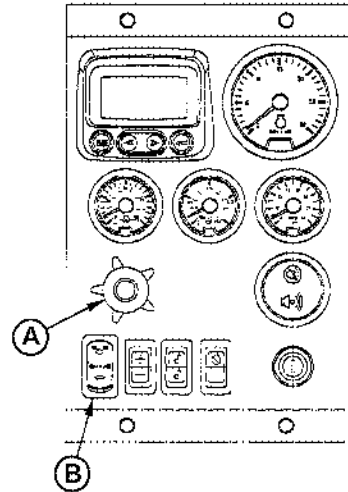
OURGP12.00001C9 -19-14MAR06-1/3

4. Set slow idle as follows:

Panels with high-low speed select rocker switch (B) only: Set slow speed by pressing lower half of switch.

Panels with optional analog throttle(s) (A) : Set high-low speed select rocker switch to slow (turtle), then push in on analog throttle handle or turn full counterclockwise to set analog throttle(s) to slow speed.

IMPORTANT: Do not operate the starter for more than 30 seconds at a time. To do so may overheat the starter. If the engine does not start the first time, wait at least 2 minutes before trying again. If engine does not start after four attempts, see Troubleshooting section.



Analog Throttle Control and Speed Select Switch On Panel

A—Analog Throttle Control (Optional)
B—Speed Select Rocker Switch

RG13722 -JUN-11NOV04

Continued on next page

OURGP12.00001C9 -19-14MAR06-2/3

5. Turn the key start switch (A) clockwise to crank the engine. When the engine starts, release the key switch so that it returns to the "ON" position.

IMPORTANT: If the key switch is released before the engine starts, wait until the starter and the engine stop turning before trying again. This will prevent possible damage to the starter and/or flywheel.

6. After engine starts, idle engine at not more than 1200 rpm until warm. (See WARMING ENGINE later in this section).

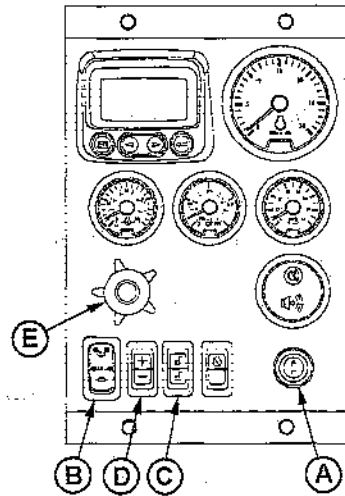
Panels with high-low speed select rocker switch (B) only: Set rpm using bump speed enable switch (C) with speed select rocker switch (D).

Panels with optional analog throttle (E): Set either high-low speed select switch (B) or analog throttle (E) to slow speed, and set desired speed with remaining control.

NOTE: Engine control unit (ECU) reads the higher of the high-low speed select rocker switch or the analog throttle speed settings.

7. Check all gauges for normal engine operation. If operation is not normal, stop the engine and determine the cause. (For normal gauge pressures and temperatures, see BREAK-IN SERVICE earlier in this section.)

NOTE: Hand throttle may have an analog potentiometer (E) for changing engine speeds (See "Changing Engine Speeds" later in this section).



Start And Idle Engine Controls On Panel

- A—Key Start Switch
- B—High-Low Speed Select Rocker Switch
- C—Bump Speed Enable Rocker Switch
- D—Speed Select Rocker Switch
- E—Analog Throttle Control (Optional)

RG13723 -JUN-11NOV04

OURGP12.00001C8 -19-14MAR06-3/3

Normal Engine Operation

Monitor engine coolant temperature and engine oil pressure. Temperatures and pressures will vary between engines and with changing operating conditions, temperatures, and loads.

Normal engine coolant operating temperature range is 82°—95°C (180°—204°F). If coolant temperature rises above 110°C (230°F), reduce load on engine. Unless temperature drops quickly, stop engine and determine cause before resuming operation.

Engine oil pressure should be at least 103 kPa (1.03 bar) (15 psi) at slow idle and should reach at least 241 kPa (2.41 bar) (35 psi) at rated speed under full load.

Operate the engine under a lighter load and at slower than normal speed for first 15 minutes after start-up. DO NOT run engine at slow idle.

IMPORTANT: Should the engine die while operating under load, immediately

remove load and restart the engine. Overheating of the turbocharger parts may occur when oil flow is stopped.

Stop engine immediately if there are any signs of part failure. Symptoms that may be early signs of engine problems are:

- Sudden drop in oil pressure
- Abnormal coolant temperatures
- Unusual noise or vibration
- Sudden loss of power
- Excessive black exhaust
- Excessive fuel consumption
- Excessive oil consumption
- Fluid leaks

OURGP12.00001CA -19-14MAR06-1/1

Warming Engine

These electronically-controlled engines will operate at an accelerated slow idle of 1050 rpm until the engine coolant warms up to 20° C (68° F). Then idle drops to 800 rpm.

IMPORTANT: To assure proper lubrication, operate engine at or below 1200 rpm with no load for 1–2 minutes. Extend this period 2–4 minutes when operating at temperatures below freezing.

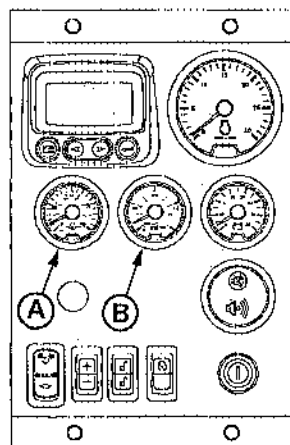
Engines used in generator set applications where the governor is locked at a specified speed may not have a slow idle function. Operate these engines at high idle for 1 to 2 minutes before applying the load. This procedure does not apply to standby generator sets where the engine is loaded immediately upon reaching rated speed.

1. Check oil pressure gauge (A) as soon as engine starts. If gauge needle does not rise above minimum oil pressure specification of 105 kPa (1.05 bar) (15.0 psi) within 5 seconds, stop the engine and determine the cause. Normal engine oil pressure is 345 ± 103 kPa (3.45 ± 1.03 bar) (50 ± 15 psi) at rated full load speed (1800–2400 rpm) with oil at normal operating temperature of 115°C (240°F).

NOTE: On certain engines, the oil pressure and coolant temperature gauges are replaced by indicator warning lights. The lights must be "OFF" when engine is running.

2. Watch coolant temperature gauge (B). Do not place engine under full load until it is properly warmed up. The normal engine coolant temperature range is 82°–95°C (180°–204°F).

NOTE: It is a good practice to operate the engine under a lighter load and at lower speeds than normal for the first few minutes after start-up.



Oil Pressure and Coolant Temperature Gauges On Panel

A—Engine Oil Pressure Gauge
B—Engine Coolant Temperature Gauge

RG13724 -JUN-11NOV04

Cold Weather Operation



CAUTION: DO NOT use starting fluid on engines equipped with air intake heaters or glow plugs. Ether injector starting fluid is highly flammable and may explode, causing serious injury.

DO NOT use starting fluid near fire, sparks, or flames. DO NOT incinerate or puncture a starting fluid container.



Handle Starting Fluid with Care

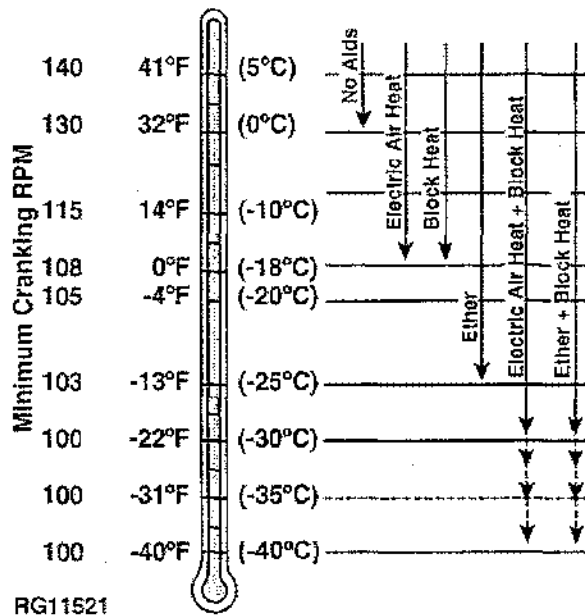
Engines may be equipped with intake air heaters, coolant heaters, fuel heaters, or ether injectors as cold weather starting aids.

Starting aids are required below 0°C (32°F). They will enhance starting performance above these temperatures and may be needed to start applications that have high parasitic loads during cranking and/or start acceleration to idle.

Using correct grade of oil (per engine and machine operator's manual) is critical to achieving adequate cold weather cranking speed.

Synthetic oils have improved flow at low temperatures, especially in arctic conditions.

Other cold weather starting aids are required at temperatures below -30°C (-22°F) or at altitudes above 1500 m (5000 ft). (See "Using a Booster Battery or Charger" later in this section.)



RG11521

Cold Weather Starting Guidelines

1. Follow steps 1—4 as listed under STARTING THE ENGINE, earlier in this section, then proceed as follows according to the instrument (gauge) panel on your engine.
2. **Engines Without Air Intake Heaters:** Manually activate ether injectors.

Continued on next page

OURGP12.00001CC -19-14MAR06-1/2

NOTE: Air intake heaters operate automatically through the ECU. The Engine Preheater Indicator light on these engines, located above the key switch, should always illuminate when the switch is turned ON. In warm weather, the light illuminates briefly as a light check. In cold weather, the light remains on during the automatic operation of the air intake heater or glow plugs. Operating time depends on temperature. Do not crank engine until light turns off.

Engines With Air Intake Heaters: Turn key ON, but DO NOT crank engine until Engine Preheater Indicator light turns off.

3. Follow remaining steps 5—6 as listed under earlier in this section.

Additional information on cold weather operation is available from your authorized servicing dealer.

OURGP12.00001CC. -19-14MAR06-2/2

Using a Booster Battery or Charger

12-volt booster battery can be connected in parallel with battery (ies) on the unit to aid in cold weather starting. ALWAYS use heavy duty jumper cables.

CAUTION: Gas given off by battery is explosive. Keep sparks and flames away from battery. Before connecting or disconnecting a battery charger, turn charger off. Make last connection and first disconnection at a point away from battery. Always connect **NEGATIVE (-)** cable last and disconnect this cable first.

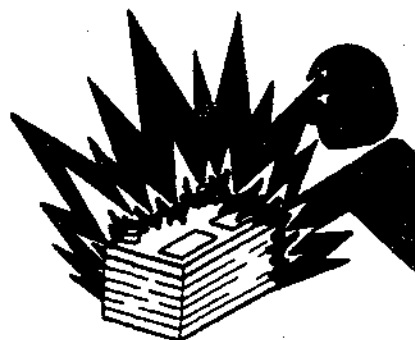
WARNING: Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm. Wash hands after handling.

IMPORTANT: Be sure polarity is correct before making connections. Reversed polarity will damage electrical system. Always connect positive to positive and negative to ground. Always use 12-volt booster battery for 12-volt electrical systems and 24-volt booster battery (ies) for 24-volt electrical systems.

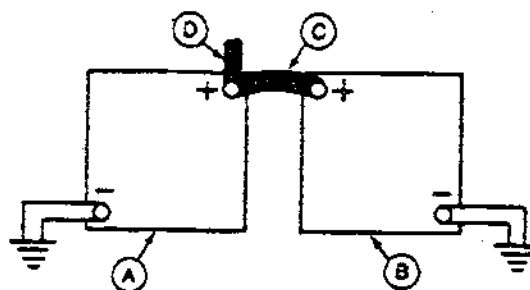
1. Connect booster battery or batteries to produce the required system voltage for your engine application.

NOTE: To avoid sparks, **DO NOT** allow the free ends of jumper cables to touch the engine.

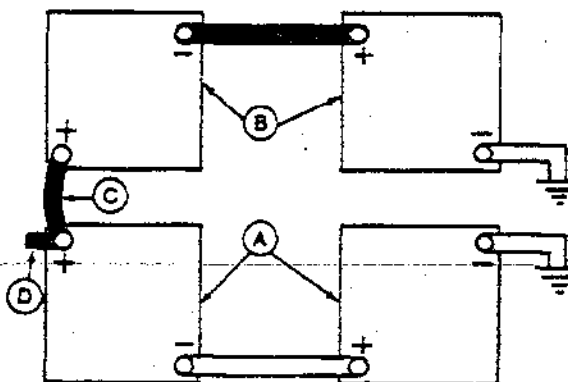
2. Connect one end of jumper cable to the **POSITIVE (+)** post of the booster battery.
3. Connect the other end of the jumper cable to the **POSITIVE (+)** post of battery connected to starter.
4. Connect one end of the other jumper cable to the **NEGATIVE (-)** post of the booster battery.
5. ALWAYS complete the hookup by making the last connection of the **NEGATIVE (-)** cable to a good ground on the engine frame and away from the battery (ies).



Exploding Battery



12-Volt System



24-Volt System

A—12-Volt Machine Battery (ies)
B—12-Volt Booster Battery (ies)
C—Booster Cable
D—Cable to Starting Motor

1S204 -UN-23AUG88

HC4678 -UN-14DEC88

HC4699 -UN-14DEC88

Continued on next page

RG, RG34710, 5564 -19-27JUL88-1/2

6. Start the engine. Disconnect jumper cables immediately after engine starts. Disconnect NEGATIVE (-) cable first.

RG, RG34710, 5564 -19-27JUL06-2/2

Avoid Excessive Engine Idling

Prolonged idling may cause the engine coolant temperature to fall below its normal range. This, in turn, causes crankcase oil dilution, due to incomplete fuel combustion, and permits formation of gummy deposits on valves, pistons, and piston rings. It also promotes rapid accumulation of engine sludge and unburned fuel in the exhaust system.

Once an engine is warmed to normal operating temperatures, engine should be idled at slow idle

speed. Slow idle speed for this engine is 850 rpm at factory. If an engine will be idling for more than 5 minutes, stop and restart later.

NOTE: Generator set applications where the governor is locked at a specified speed may not have a slow idle function. These engines will idle at no load governed speed (high idle).

RG, RG34710, 5562 -19-27JUL06-1/1

Changing Engine Speed

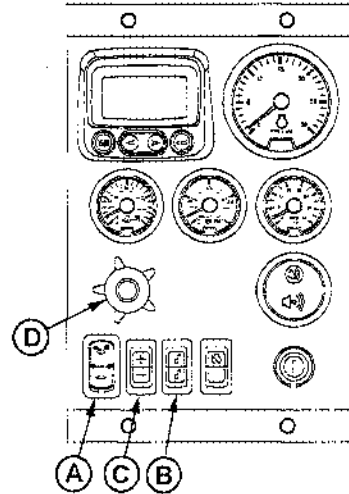
Changing from slow to fast speed using **Standard High-Low Speed Select Rocker Switch (A)** (If equipped):

- For slow speed, press lower half of switch (indicated by turtle symbol).
- For fast speed, press upper half of switch (indicated by rabbit symbol).

NOTE: To adjust preset fast or slow speeds for High-Low Speed Select Rocker Switch:

1. Select fast (rabbit) or slow (turtle) position on High-Low Speed Select Rocker Switch (A).
2. Press and hold top or bottom half of Bump Speed Enable Rocker Switch (B) while using Speed Select Rocker Switch (C).
3. Use Speed Select Rocker Switch (C) to bump engine speed up (+) or down (-).

NOTE: Once the speed has been set, the Bump Speed Enable Switch (B) must be pressed and released three times within two seconds to commit the new slow or fast speed to memory. If not done, the engine's new slow or fast speed will only be effective until the key switch is shut off. Then the speed will revert to its previous setting.



Changing Engine Speed On Panel

- A—High-Low Speed Select Rocker Switch
 B—Bump Speed Enable Rocker Switch
 C—Speed Select Rocker Switch
 D—Analog Throttle Control (Optional)

RG-3725 - JUN-11NDV04

Changing from slow to fast speed using **Adjustable High-Low Speed Select Rocker Switch (A)** (If equipped):

Adjustable **three-position** rocker switch (A) that can be used to select slow idle, fast idle, or an adjustable ("ADJ") intermediate speed.

- For slow speed, press lower half of rocker switch (indicated by turtle symbol).
- For fast speed, press upper half of rocker switch (indicated by rabbit symbol).

NOTE: To adjust preset fast or slow speeds with adjustable High-Low Speed Select Rocker Switch:

1. Select middle position (ADJ) or slow (turtle) position on the optional Adjustable Three-State Speed Select Rocker Switch (A).
2. Press and hold top or bottom half of Bump Speed Enable Rocker Switch (B) while using Speed Select Rocker Switch (C).
3. Use Speed Select Rocker Switch (C) to bump engine speed up (+) or down (-).

NOTE: Slow (turtle) position is factory preset at low engine idle, while middle (ADJ) position is factory set at high engine idle.

NOTE: Once the speed has been set, the Bump Speed Enable Switch (B) must be pressed and released three times within two seconds to commit the new slow or fast speed to memory. If not done, the engine's new slow or fast speed will only be effective until the key is shut off. Then the speed will revert to its previous setting.

Changing engine speed using optional analog potentiometer throttle (D)

NOTE: Pushing in on analog potentiometer will immediately take engine to slow idle speed.

1. Set High-Low Speed Select Rocker Switch (A) to low speed position.
2. Turn potentiometer throttle clockwise to increase speed or counterclockwise to decrease speed.

NOTE: Engine Control Unit (ECU) reads the higher of the High-Low Speed Select Rocker Switch or the Analog Throttle(s) Speed Settings. With High-Low switch at low speed, Analog Throttle(s) will control speed higher than low idle setting.

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OURGP12.00001CD -19-14MAR08-2/3

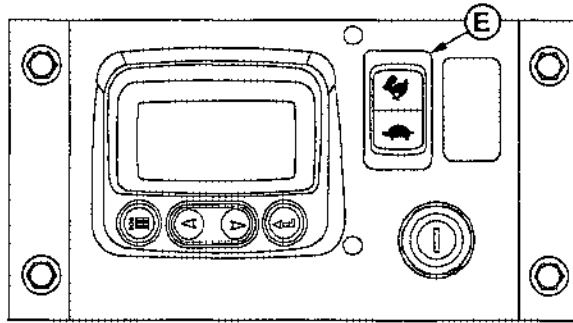
Changing engine speeds on engines equipped with Basic Instrument Panel

The basic instrument panel has a "ramp" throttle switch (E) with a spring loaded return to the center rest position (Off).

To increase the engine speed, press and hold upper half of rocker switch (E) (indicated by rabbit symbol) to increase or ramp up the engine speed to desired speed. Release the rocker switch.

Press lower half of rocker switch (indicated by turtle symbol) to decrease or ramp down the engine speed to desired speed. Release the rocker switch.

The settings will not be stored.



Changing Engine Speed With Basic Panel

E—High-Low Speed Select Rocker Switch

RG13289 -UN-300CT03

OURGP12.00001CD -19-14MAR06-3/3

Stopping The Engine

1. Disengage clutch, if equipped, controlling engine power driveline.

IMPORTANT: Before stopping an engine that has been operating at working load, idle engine at least 2 minutes at 1000—1200 rpm to cool hot engine parts.

Engines in generator set applications where the ECU is locked at a specified speed and no slow idle function is available, run engine for at least 2 minutes at fast idle and no load.

2. Run engine at 1000—1200 rpm for at least 2 minutes to cool.

Panels with High-Low Speed Select Rocker Switch (B) only: Set rpm using Bump Speed Enable Switch (C) with Speed Select Rocker Switch (D).

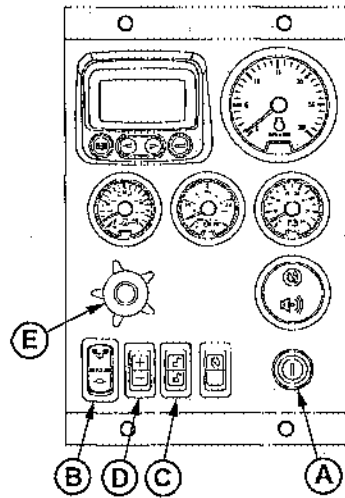
Panels with optional Analog Throttle (E): Set either High-Low Speed Select Switch (B) or Analog Throttle (E) to low idle, and set desired speed with remaining control.

NOTE: Engine Control Unit (ECU) reads the higher of the High-Low Speed Select Rocker Switch or the Analog Throttle(s) Speed settings.

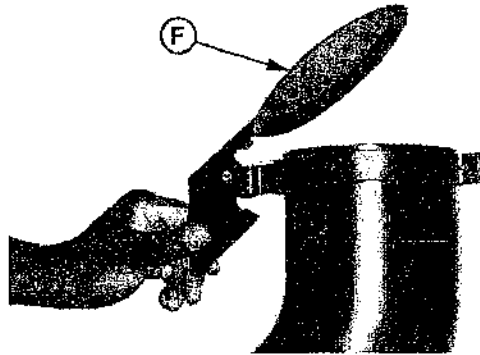
3. Push in on analog throttle potentiometer handle (if equipped) so that engine goes to slow idle, or set slow speed with High-Low Speed Select Rocker Switch.

4. Turn key switch (A) to "OFF" position to stop the engine. Remove ignition key.

IMPORTANT: Make sure that exhaust stack rain cap (F) is installed when engine is not running. This will prevent water and dirt from entering engine.



Stopping the Engine Controls



Exhaust Stack Rain Cap

- A—Key Switch
- B—High-Low Speed Select Rocker Switch
- C—Bump Speed Enable Switch
- D—Speed Select Rocker Switch
- E—Analog Throttle (Optional)
- F—Exhaust Stack Rain Cap

RG13723 -UN-11NOV04

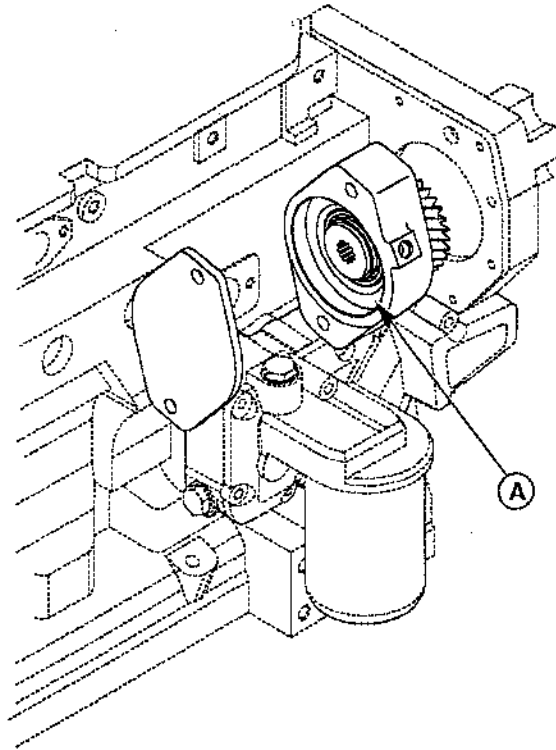
RG9933 -UN-18NOV59

Auxiliary Gear Drive Limitations

IMPORTANT: When attaching an air compressor, hydraulic pump, or other accessory to be driven by the auxiliary gear drive (A) (engine timing gear train at front of engine), power requirements of the accessory must be limited to values listed below:

- 30 kW (40 hp) Continuous Operation at 2500 rpm
- 37 kW (50 hp) Intermittent Operation at 2500 rpm

A—Auxiliary Gear Drive



Auxiliary Gear Drive

RG7634A -JUN-22-JAN99

RG, RG34710, 5555 -19-27JUL06-1/1

Generator Set (Standby) Applications

To assure that your engine will deliver efficient standby operation when needed, start engine and run at rated speed (with 50%—70% load) for 30 minutes every 2 weeks. DO NOT allow engine to run extended period of time with no load.

RG, RG34710, 5556 -19-27JUL06-1/1

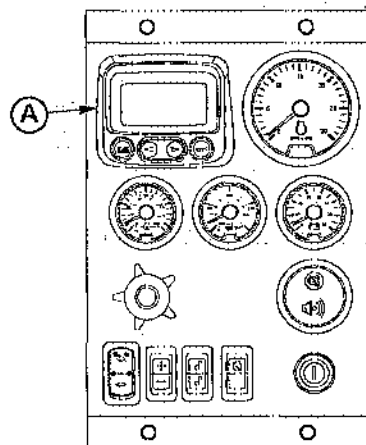
Lubrication and Maintenance

Observe Service Intervals

Using hour meter (A) on diagnostic gauge as a guide, perform all services at the hourly intervals indicated on following pages. At each scheduled maintenance interval, perform all previous maintenance operations in addition to the ones specified. Keep a record of hourly intervals and services performed, using charts provided in Lubrication and Maintenance Records section.

IMPORTANT: Recommended service intervals are for normal operating conditions. Service **MORE OFTEN** if engine is operated under adverse conditions. Neglecting maintenance can result in failures or permanent damage to the engine.

A—Hour Meter



Hour Meter On Panel

RG13728 -JUN-11NOV04

OURGP12.00001D0 -19-14MAR06-1/1

Use Correct Fuels, Lubricants, and Coolant

IMPORTANT: Use only fuels, lubricants, and coolants meeting specifications outlined in Fuels, Lubricants, and Coolant Section when servicing your John Deere Engine.

Consult your John Deere engine distributor, servicing dealer or your nearest John Deere Parts Network for recommended fuels, lubricants, and coolant. Also available are necessary additives for use when operating engines in tropical, arctic, or any other adverse conditions.



John Deere Parts Network

TS102 -JUN-23AUG88

DPSG,OUOE003.20 -19-27JUL06-1/1

Lubrication and Maintenance Service Interval Chart—Standard Industrial Engines

NOTE: The service intervals below are for standard industrial engines. See details in Sections which follow these charts.

Item	Lubrication and Maintenance Service Intervals			
	Daily	500 Hour/ 12 Month	2000 Hour/ 24 Month	As Required
Check Engine Oil and Coolant Level	•			
Check Fuel Filter/Water Bowl	•			
Check Air Cleaner Dust Unloader Valve & Restriction Indicator Gauge ^a	•			
Visual Walk Around Inspection	•			
Service Fire Extinguisher		•		
Check Engine Mounts		•		
Service Battery		•		
Change Engine Oil And Replace Oil Filter ^{b,c}		•		
Check Crankcase Vent System		•		
Check Air Intake Hoses, Connections, & System		•		
Replace Fuel Filter Elements		•		
Check Automatic Belt Tensioner and Belt Wear		•		
Check Engine Electrical Ground Connection		•		
Check Cooling System		•		
Coolant Solution Analysis-Add SCAs as required		•		
Pressure Test Cooling System		•		
Check Engine Speeds		•		
Check Crankshaft Vibration Damper (6.8 L Engines) ^d			•	
Flush and Refill Cooling System ^e			•	
Test Thermostats			•	
Check and Adjust Engine Valve Clearance			•	
Add Coolant				•
Replace Air Cleaner Elements				•
Replace Fan and Alternator Belts				•
Check Fuses				•

^aReplace primary air cleaner element when restriction indicator shows a vacuum of 625 mm (25 in.) H₂O.

^bDuring engine break-in, change the oil and filter for the first time before 100 hours of operation.

^cService intervals depend on sulfur content of the diesel fuel, oil pan capacity, and the oil and filter used, which means that intervals may be REDUCED. (See DIESEL ENGINE OIL AND FILTER SERVICE INTERVALS in Fuels, Lubricants, and Coolant Section.)

^dReplace crankshaft damper every 4500 hours or 60 months, whichever occurs first.

^eIf John Deere COOL-GARD is used, the flushing interval may be extended to 3000 hours or 36 months. If John Deere COOL-GARD is used and the coolant is tested annually AND additives are replenished as needed by adding a supplemental coolant additive, the flushing interval may be extended to 5000 hours or 60 months, whichever occurs first.

Continued on next page

OURGP12,00001D1 -19-14MAR06-1/2

Lubrication and Maintenance

Item	Lubrication and Maintenance Service Intervals			
	Daily	500 Hour/ 12 Month	2000 Hour/ 24 Month	As Required
Check Air Compressor (If Equipped)				•
Bleed Fuel System				•

OURGP12.00001D1 -19-14MAR06-2/2

Lubrication and Maintenance Service Interval Chart—Generator (Standby) Applications

NOTE: Use service intervals listed below for generator (standby) applications. Match service items below to titles in Lubrication and Maintenance Sections for procedures.

Item	Lubrication and Maintenance Service Intervals			
	Every 2 Weeks	500 Hours or 12 Months	2000 Hours or 24 Months	As Required
Operate Engine at Rated Speed and 50%–70% Load a Minimum of 30 Minutes	•			
Check Engine Oil and Coolant Level	•			
Check Fuel Filter/Water Bowl	•			
Check Air Cleaner Dust Unloader Valve & Restriction Indicator Gauge ^a	•			
Visual Walk Around Inspection	•			
Service Fire Extinguisher		•		
Check Engine Mounts		•		
Service Battery		•		
Change Engine Oil And Replace Oil Filter ^{b, c}		•		
Check Crankcase Vent System		•		
Check Air Intake Hoses, Connections, & System		•		
Replace Fuel Filter Elements		•		
Check Automatic Belt Tensioner and Belt Wear		•		
Check Engine Electrical Ground Connection		•		
Check Cooling System		•		
Coolant Solution Analysis-Add SCAs as required		•		
Pressure Test Cooling System		•		
Check Engine Speeds		•		
Check Crankshaft Vibration Damper (6.8 L Engines) ^d			•	
Flush and Refill Cooling System			•	
Test Thermostats			•	
Check and Adjust Engine Valve Clearance			•	
Add Coolant				•
Replace Air Cleaner Elements				•
Replace Fan and Alternator Belts				•
^a Replace primary air cleaner element when restriction indicator shows a vacuum of 625 mm (25 in.) H ₂ O.				
^b During engine break-in, change the oil and filter for the first time before 100 hours of operation.				
^c Service intervals depend on sulfur content of the diesel fuel, oil pan capacity, and the oil and filter used, which means that intervals may be REDUCED. (See DIESEL ENGINE OIL AND FILTER SERVICE INTERVALS in Fuels, Lubricants, and Coolant Section.)				
^d Replace crankshaft damper every 4500 hours or 60 months, whichever occurs first.				

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OURGP12.00001D2 --19-14MAR06-1/2

Lubrication and Maintenance

Item	Lubrication and Maintenance Service Intervals			
	Every 2 Weeks	500 Hours or 12 Months	2000 Hours or 24 Months	As Required
Check Fuses				•
Check Air Compressor (If Equipped)				•
Bleed Fuel System				•

OURGP12,00001D2 -19-14MAR06-2/2

Lubrication & Maintenance/Daily

Daily Prestarting Checks

Do the following BEFORE STARTING THE ENGINE for the first time each day:

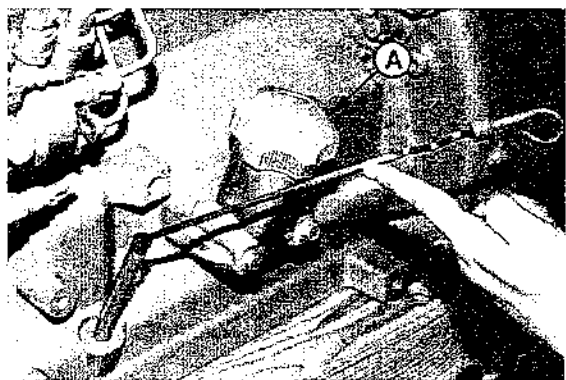
IMPORTANT: DO NOT add makeup oil until the oil level is **BELOW** the crosshatch marks on the dipstick.

1. Check engine oil level on dipstick. Add as required, using seasonal viscosity grade oil. (See DIESEL ENGINE OIL in Fuels, Lubricants, and Coolant Section for oil specifications.)

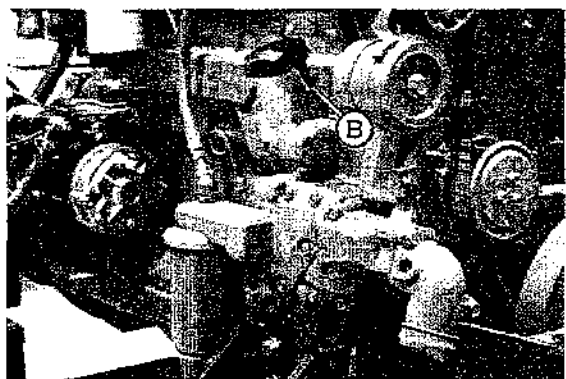
Depending on application, oil may be added at left (A) or right (B) side oil filler cap and rocker arm cover filler cap (C) locations.

IMPORTANT: DO NOT fill above the top mark on the dipstick. Oil levels anywhere within crosshatch (D) are considered in the acceptable operating range.

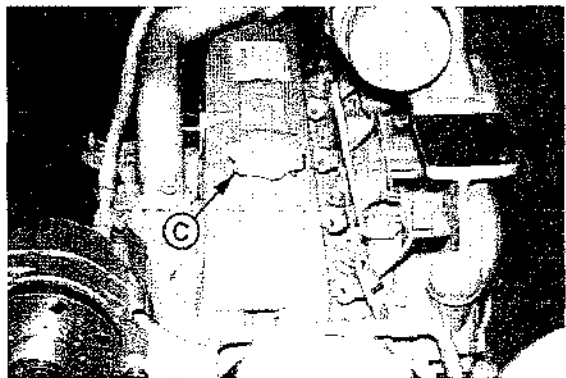
- A—Left Side Oil Filler Cap
- B—Right Side Oil Filler Cap
- C—Cover Oil Filler Cap
- D—Crosshatch On Dipstick



Left Side Oil Filler Cap

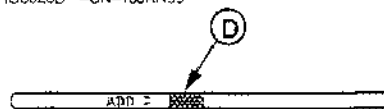


Right Side Oil Filler Cap



Rocker Arm Cover Filler Cap

RG8028B -UN-15JAN99



Crosshatch on Dipstick

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OURGP12.0000103 -18-14MAR06-1/4

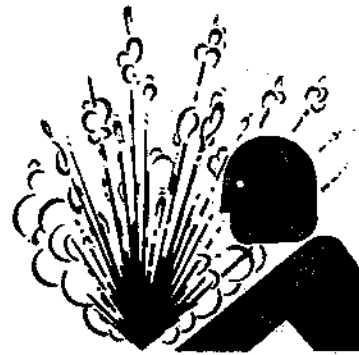
CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns.

Only remove filler cap when engine is cold or when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

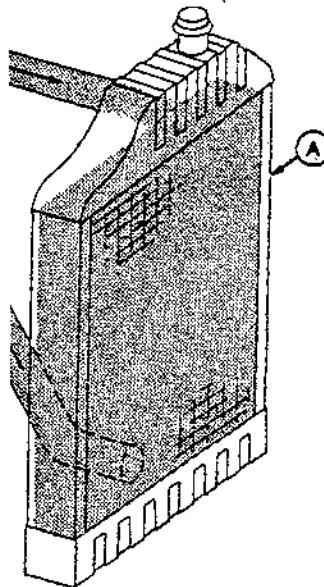
2. Check the coolant level when engine is cold. Coolant level should be at bottom of filler neck. Fill radiator (A) with proper coolant solution if level is low. (See **ADDING COOLANT** in Service As Required Section.) Check overall cooling system for leaks.

NOTE: Refer to your vehicle's operator's manual for recommendations for non-John Deere supplied accessories.

A—Fill Radiator



High-Pressure Fluids



Fill Radiator

RG4675 -JUN-14DEC88

TS281 -JUN-23AUG88

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OURGP12.00001D3 -19-14MAR06-2/4

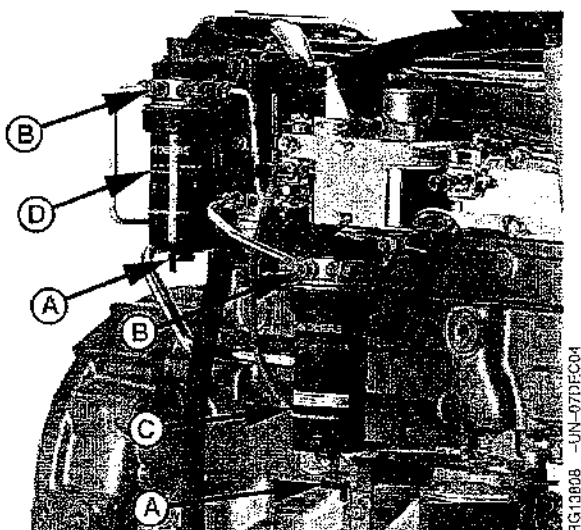
NOTE: Engine may be equipped with a water sensor at the fuel filter. An indicator light on the instrument panel will signal the operator that water should be drained from the filter bowl.

3. Check the fuel filters (C) and (D) for water or debris. If filter is fitted with a see-through bowl, drain as needed based on a daily visual inspection.

IMPORTANT: Drain water into a suitable container and dispose of properly.

- a. Loosen drain plugs (A) at bottom of fuel filters or bowls, if equipped, two or three turns.
- b. Loosen air bleed plug (B) two full turns on fuel filter mounting and drain water from bottom until fuel starts to drain out.
- c. When fuel starts to drain out, tighten drain plugs securely.

After draining water from the fuel filters, the filters must be primed by bleeding all air from the fuel system. See BLEEDING FUEL SYSTEM in Service As Required Section, later in this manual



Drain Fuel Filters

- A—Drain Plug
- B—Air Bleed Plug
- C—Primary Fuel Filter
- D—Final Fuel Filter

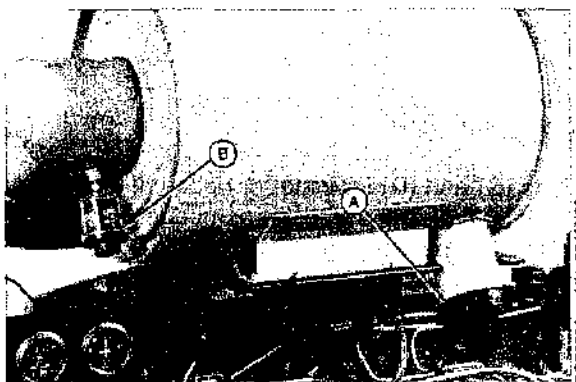
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ODRGP12,00001D3--19-14MAR05-3/4

4. If the air cleaner has an automatic dust unloader valve (A), squeeze the unloader valve on air cleaner assembly to clear away any dust buildup.

If equipped with air intake restriction indicator gauge (B), check gauge to determine if air cleaner needs to be serviced.

IMPORTANT: Maximum air intake restriction is 6.25 kPa (0.06 bar) (1.0 psi) (25 in. H₂O). A clogged air cleaner element will cause excessive intake restriction and a reduced air supply to the engine.



Dust Unloader Valve and Indicator Gauge

A—Dust Unloader Valve
B—Air Restriction Indicator

5. Make a thorough inspection of the engine compartment. Look for oil or coolant leaks, worn fan and accessory drive belts, loose connections and trash build-up. Remove trash buildup and have repairs made as needed if leaks are found.

NOTE: Wipe all fittings, caps, and plugs before performing any maintenance to reduce the chance of system contamination.

Inspect:

- Radiator for leaks and trash build-up.
- Air intake system hoses and connections for cracks and loose clamps.
- Fan, alternator, and accessory drive belts for cracks, breaks or other damage.
- Coolant pump for coolant leaks.

NOTE: It is normal for a small amount of leakage to occur as the engine cools down and parts contract. Excessive coolant leakage may indicate the need to replace the coolant pump seal. Contact your engine distributor or servicing dealer for repairs.

OURGP12.00001DS -19-14MAR06-4/4

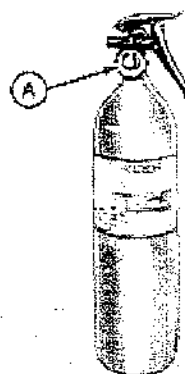
Lubrication & Maintenance/500 Hour/12 Month

Servicing Fire Extinguisher

fire extinguisher (A) is available from your authorized servicing dealer or engine distributor.

Read and follow the instructions which are packaged with it. The extinguisher should be inspected at least every 500 hours of engine operation or every 6 months. Once extinguisher is operated, no matter how long, it must be recharged. Keep record of inspections on the tag which comes with the extinguisher instruction booklet.

A—Fire Extinguisher



Fire Extinguisher

RW4918 JUN-15DEC88

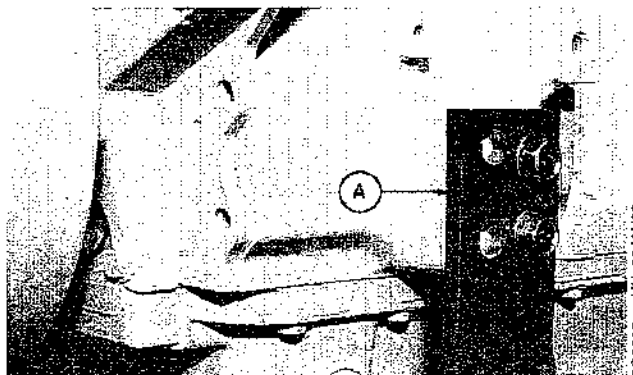
OURGP11.000015F -19-27JUL06-1/1

Checking Engine Mounts

Engine mounting is the responsibility of the vehicle or generator manufacturer. Follow manufacturer's guidelines for mounting specifications.

IMPORTANT: Use only Grade SAE 8 or higher grade of hardware for engine mounting.

1. Check the engine mounting brackets (A), vibration isolators, and mounting bolts on support frame and engine block for tightness. Tighten as necessary.
2. Inspect overall condition of vibration isolators, if equipped. Replace isolators, as necessary, if rubber has deteriorated or mounts have collapsed.



Engine Mounting

A—Mounting Bracket

RG9305 JUN-06JAN89

OURGP11.0000110 -19-11OCT06-1/1

Servicing Battery

CAUTION: Battery gas can explode. Keep sparks and flames away from batteries. Use a flashlight to check battery electrolyte level.

Never check battery charge by placing a metal object across the posts. Use a voltmeter or hydrometer.

Always remove grounded **NEGATIVE (-)** battery clamp first and replace it last.



Exploding Battery

TS204 -UN-23AUG88

WARNING: Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm. **Wash hands after handling.**

1. On regular batteries, check electrolyte level. Fill each cell to bottom of filler neck with distilled water.

NOTE: Low-maintenance or maintenance-free batteries should require little additional service. However, electrolyte level can be checked by cutting the center section of decal on dash-line, and removing cell plugs. If necessary, add clean, soft water to bring level to bottom of filler neck.

2. Keep batteries clean by wiping them with a damp cloth. Keep all connections clean and tight. Remove any corrosion, and wash terminals with a solution of 1 part baking soda and 4 parts water. Tighten all connections securely.

NOTE: Coat battery terminals and connectors with a mixture of petroleum jelly and baking soda to retard corrosion.

3. Keep battery fully charged, especially during cold weather. If a battery charger is used, turn charger off before connecting charger to battery(ies). Attach **POSITIVE (+)** battery charger lead to **POSITIVE (+)** battery post. Then attach **NEGATIVE (-)** battery charger lead to a good ground.

Continued on next page

RG, RG34710, 5568 -19-27JUL06-1/2

1 CAUTION: Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, eat holes in clothing, and cause blindness if splashed into eyes.

Avoid the hazard by:

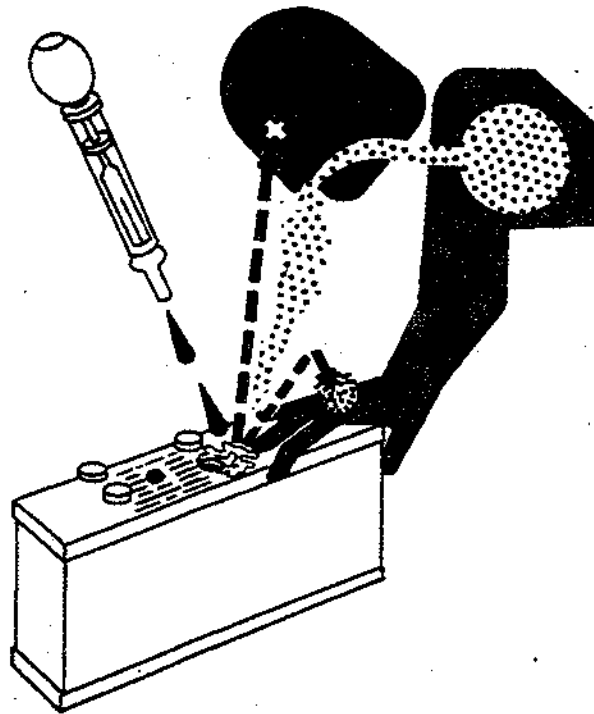
1. Filling batteries in a well-ventilated area.
2. Wearing eye protection and rubber gloves.
3. Avoiding breathing fumes when electrolyte is added.
4. Avoiding spilling or dripping electrolyte.
5. Use proper jump start procedure.

If you spill acid on yourself:

1. Flush your skin with water.
2. Apply baking soda or lime to help neutralize the acid.
3. Flush your eyes with water for 10–15 minutes. Get medical attention immediately.

If acid is swallowed:

1. Drink large amounts of water or milk.
2. Then drink milk of magnesia, beaten eggs, or vegetable oil.
3. Get medical attention immediately.



Sulfuric Acid

TS203 -JUN-20AUG88

In freezing weather, run engine at least 30 minutes to assure thorough mixing after adding water to battery.

If necessary to replace battery(ies), replacements must meet or exceed the following recommended capacities at -18°C (0°F):

Specification	
12 Volt Standard Duty Starter—	
Cold Cranking Amps	640
12 Volt Heavy Duty Starter—Cold	
Cranking Amps	800
24 Volt Standard Duty Starter—	
Cold Cranking Amps	570

Changing Engine Oil and Replacing Filter

IMPORTANT: Changing engine oil and filter every 500 hours or 12 months depends on the following requirements:

- Use of John Deere PLUS-50™ or ACEA-E7/E6 oil;
- Engine equipped with an extended drain interval oil pan
- Use of diesel fuel with sulfur content less than 0.50% (5000 ppm)
- Use of an approved John Deere oil filter

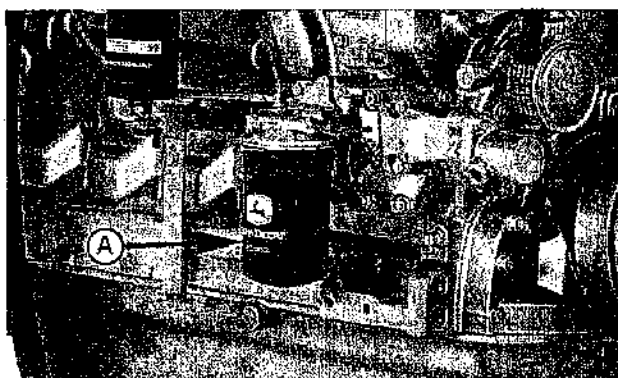
Unless all of the above conditions are met, oil change interval is **REDUCED**. Refer to **DIESEL ENGINE OIL AND FILTER SERVICE INTERVALS**, in Fuels, Lubricants and Coolant Section.

NOTE: During **break-in**, change engine oil and filter for the first time before **100 hours** maximum of operation.

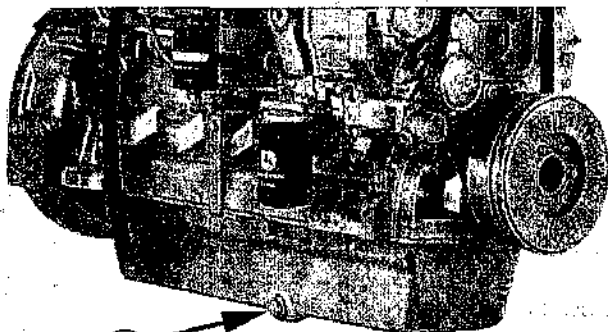
OILSCAN™ or OILSCAN PLUS™ is a John Deere sampling program to help you monitor machine performance and identify potential problems before they cause serious damage. OILSCAN™ and OILSCAN PLUS™ kits are available from your John Deere engine distributor or servicing dealer. Oil samples should be taken prior to the oil change. Refer to instructions provided with kit.

To change engine oil and oil filter:

1. Run engine approximately 5 minutes to warm up oil. Shut engine off.
2. Remove oil pan drain plug (B).
3. Drain crankcase oil from engine while warm.



Special Oil Filter



Oil Pan Drain Plug

A—Oil Filter
B—Oil Pan Drain Plug

PLUS-50 is a trademark of Deere & Company.
OILSCAN is a trademark of Deere & Company.
OILSCAN PLUS is a trademark of Deere & Company.

Continued on next page

OURGP12.00001EF -19-22MAR06-1/4

NOTE: Drain plug location may vary, depending on the application.

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4. Turn filter element (A) using a suitable filter wrench to remove. Discard oil filter element.

NOTE: Depending on engine application, oil filter may be located on either side of the engine in a high- or low-mount location.

IMPORTANT: Filtration of oils is critical to proper lubrication. Always change filter regularly. Use filter meeting John Deere performance specifications.

5. Apply clean engine oil to the new filter at the inner (B) and outer (C) seals and to filter threads.
6. Wipe both sealing surfaces of the header (D, E) with a clean rag. Ensure notches in dust seal (F) are properly installed in the slots in the housing. Replace dust seal if damaged.

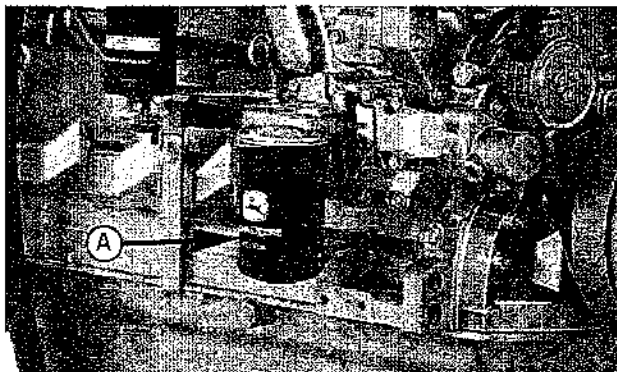
IMPORTANT: When installing filter element, **HAND TIGHTEN** only. A filter wrench may be used for **REMOVAL ONLY**. Be sure notches in dust seal (F) are properly installed in the slots in the housing.

7. Install and tighten oil filter by hand until firmly against dust seal (F). DO NOT apply an extra 3/4 to 1-1/4 turn after gasket contact as done with standard filters.

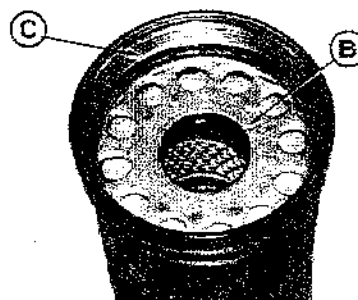
8. Tighten drain plug to specifications.

Specification

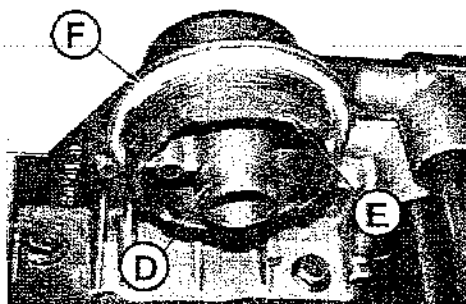
Oil Pan Drain Plug With Copper Washer—Torque	70 N•m (52 lb ft)
Oil Pan Drain Plug With O-Ring—Torque	50 N•m (37 lb ft)
Oil Pan Drain Plug With Packing (6068 Engine Code 1961, Steel Oil Pan)—Torque.....	40 N•m (29 lb ft)
Bi-Material Oil Pan Drain Plug—Torque	30 Nm (22 lb ft)



Oil Filter And Mounting Header



Oil Filter Seals



Filter And Mounting Header

- A—Oil Filter Element
- B—Inner Seal
- C—Outer Seal
- D—Sealing Surface On Header
- E—Sealing Surface On Header
- F—Dust Seal

Continued on next page

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9. Fill engine crankcase with correct John Deere engine oil through rocker arm cover oil filler cap (A) or oil filler cap on either side of engine depending on engine application. (See DIESEL ENGINE OIL in Fuels, Lubricants, and Coolant Section for determining correct engine oil.)

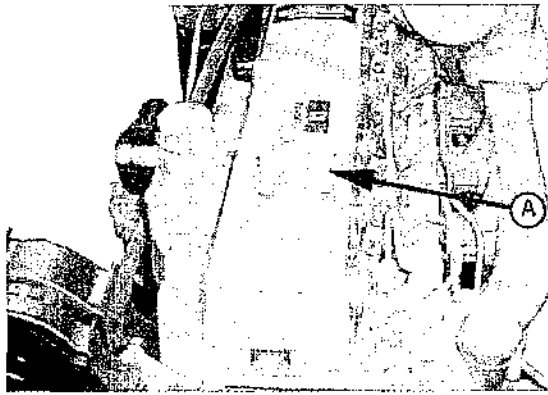
To determine the correct oil fill quantity for your engine, see ENGINE CRANKCASE OIL FILL QUANTITIES in the Specifications Section of this manual.

IMPORTANT: Immediately after completing any oil change, crank engine for 30 seconds without permitting engine to start. This will help insure adequate lubrication to engine components before engine starts.

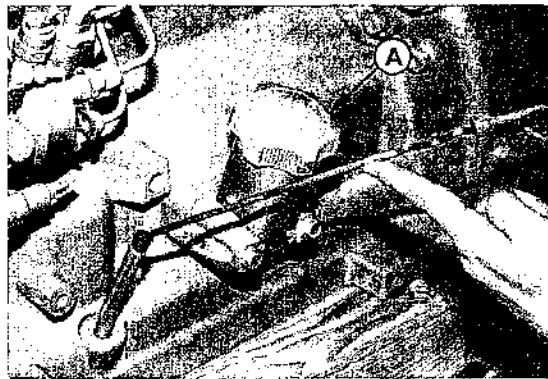
NOTE: Crankcase oil capacity may vary slightly. ALWAYS fill crankcase within crosshatch marks on dipstick. DO NOT overfill.

10. Start engine and run to check for possible leaks.
11. Stop engine and check oil level after 10 minutes. Oil level reading should be within crosshatch marks (B) on dipstick.

A—Oil Filler Cap
B—Crosshatch Marks on Dipstick



Rocker Arm Cover Oil Filler



Left Side Oil Filler

RG13730 -UN-11NOV04



Crosshatch Marks on Dipstick

RG11819 -UN-24OCT01

RG5009A -UN-16JUN03

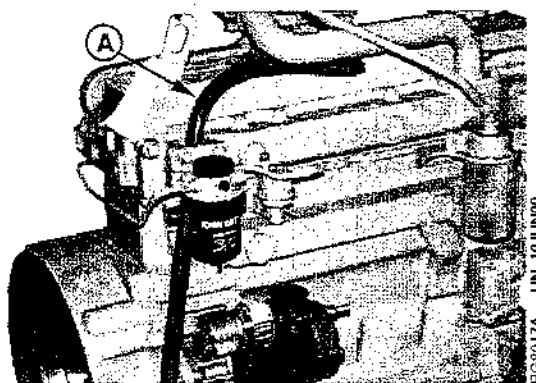
OURGP12.00001EF -19-22MAR06-4/4

Checking Crankcase Vent System

you operate the engine in dusty conditions, check the system at shorter intervals.

1. Remove and clean crankcase vent tube (A).
2. Install the vent tube. Be sure the O-ring fits correctly in the rocker arm cover for elbow adapter. Tighten hose clamp securely.

A—Crankcase Vent Tube



Crankcase Vent Tube

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Checking Air Intake System

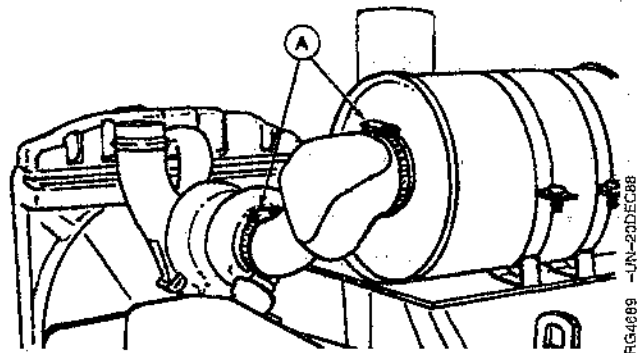
IMPORTANT: The air intake system must not leak. Any leak, no matter how small, may result in internal engine damage due to abrasive dirt and dust entering the intake system.

1. Inspect all intake hoses (piping) for cracks. Replace as necessary.
2. Check clamps (A) on piping which connect the air cleaner, engine and, if present, turbocharger. Tighten clamps as necessary. This will help prevent dirt from entering the air intake system through loose connections causing internal engine damage.
3. If engine has a rubber dust unloader valve (B), inspect the valve on bottom of air cleaner for cracks or plugging. Replace as necessary.

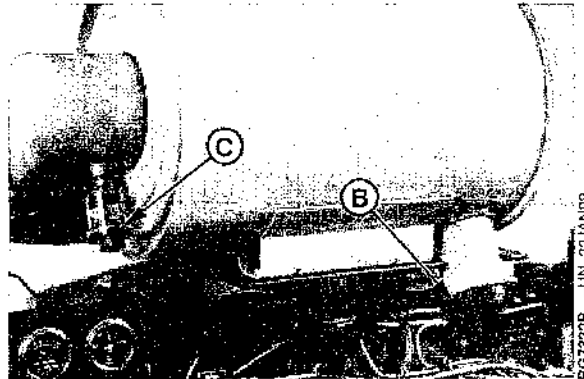
IMPORTANT: ALWAYS REPLACE primary air cleaner element when air restriction indicator shows a vacuum of 625 mm (25 in.) H₂O, is torn, or visibly dirty.

4. Test air restriction indicator (C) for proper operation. Replace indicator as necessary.

IMPORTANT: If not equipped with air restriction indicator, replace air cleaner elements at 500 Hours or 12 Months, whichever occurs first.



Check Clamps



Underloader Valve and Air Restriction Indicator

- A—Clamps
- B—Dust Unloader Valve
- C—Air Restriction Indicator

Replacing Fuel Filter Elements

Engines are equipped with a primary fuel filter (F) and a final fuel filter (B). Both filters are replaced at the same 500-hour interval.

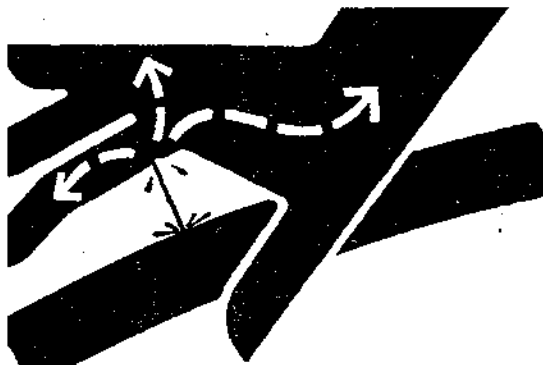
CAUTION: Escaping fluid under pressure can penetrate the skin causing serious injury. Relieve pressure before disconnecting fuel or other lines. Tighten all connections before applying pressure. Keep hands and body away from pinholes and nozzles which eject fluids under high pressure. Use a piece of cardboard or paper to search for leaks. Do not use your hand.

If any fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result. Doctors unfamiliar with this type of injury may call the Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.

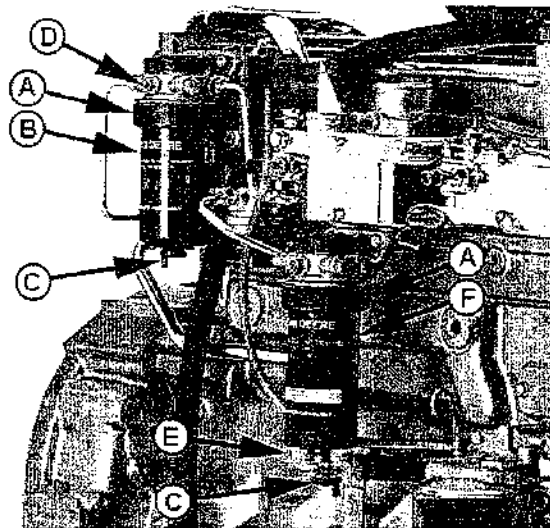
1. Close fuel shut-off valve, if equipped.
2. Thoroughly clean fuel filter assemblies and surrounding areas.
3. Disconnect water sensor wiring (if equipped).
4. Loosen drain plugs (C) and drain fuel into a suitable container.

NOTE: Lifting up on retaining ring (A) as it is rotated helps to get it past raised locators.

5. Firmly grasp the retaining ring (A) and rotate it clockwise 1/4 turn (when viewed from the top). Remove ring with filter element (B).
6. Inspect filter mounting base for cleanliness. Clean as required.



High-Pressure Fluids



Fuel Filters

- A—Retaining Ring
- B—Final Fuel Filter
- C—Drain Plug
- D—Bleed Plug
- E—Water Separator Bowl
- F—Primary Fuel Filter

NOTE: Raised locators on fuel filter canisters must be indexed properly with slots in mounting base for correct installation.

7. Install new filter elements onto mounting bases. Be sure elements are properly indexed and firmly seated on bases. It may be necessary to rotate filters for correct alignment.

If equipped with water separator bowl (E), remove filter element from separator bowl. Drain and clean separator bowl. Dry with compressed air. Install bowl onto new element. Tighten securely.

8. Align keys on filter element with slots in filter base.
9. Install retaining ring onto mounting base making certain dust seal is in place on filter base. Hand tighten ring counterclockwise (about 1/3 turn) until it "snaps" into the detent. DO NOT overtighten retaining ring.

NOTE: The proper installation is indicated when a "click" is heard and a release of the retaining ring is felt.

A plug is provided with the new element for plugging the used element.

10. Reconnect water sensor wiring (if equipped).
11. Open fuel shut-off valve and bleed the fuel system. (See BLEEDING FUEL SYSTEM in Service As Required Section.) Tighten bleed plug (D).

OURGP12,00001D4 -19-14MAR06-2/2

Checking Belt Tensioner Spring Tension and Belt Wear (Automatic Tensioner)

Belt drive systems equipped with automatic (spring) belt tensioners cannot be adjusted or repaired. The automatic belt tensioner is designed to maintain proper belt tension over the life of the belt. If tensioner spring tension is not within specification, replace tensioner assembly.

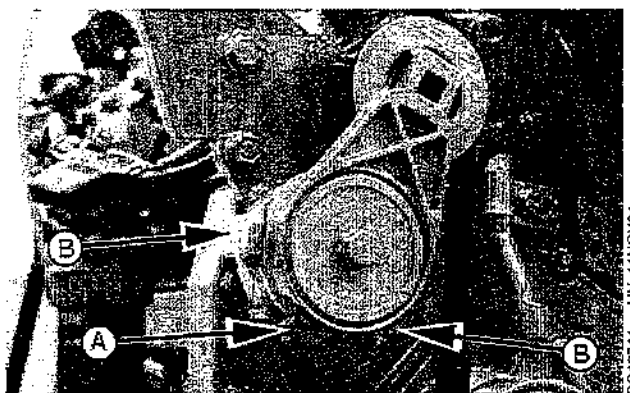
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Checking Belt Wear

The belt tensioner is designed to operate within the limit of arm movement provided by the cast stops (A and B) when correct belt length and geometry is used.

Visually inspect cast stops (A and B) on belt tensioner assembly.

If the tensioner stop on swing arm (A) is hitting the fixed stop (B), check mounting brackets (alternator, belt tensioner, idler pulley, etc.) and the belt length. Replace belt as needed (see REPLACING FAN AND ALTERNATOR BELTS in Service As Required Section).



Belt Tensioner

A—Cast Stop
B—Cast Stop

Continued on next page

OURGP12.00001D5 -19-14MAR06-2/3

Checking Tensioner Spring Tension

A belt tension gauge will not give an accurate measure of the belt tension when automatic spring tensioner is used. Measure tensioner spring tension using a torque wrench and procedure outlined below:

1. Release tension on belt using a long-handled 1/2 inch drive tool in square hole on tensioner arm. Remove belt from pulleys.

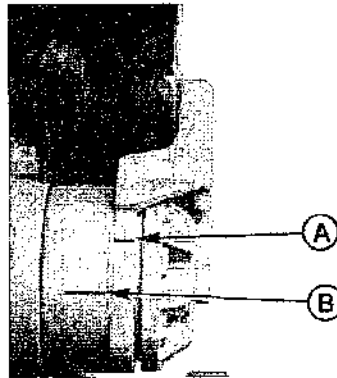
NOTE: While belt is removed, inspect pulleys and bearings. Rotate and feel for hard turning or any unusual sounds. If pulleys or bearings need replacement, see your John Deere dealer.

2. Release tension on tensioner arm and remove drive tool.
3. Put a mark (A) on swing arm of tensioner as shown.
4. Measure 21 mm (0.83 in.) from (A) and put a mark (B) on tensioner mounting base.
5. Install torque wrench (C) so that it is aligned with centers of pulley and tensioner. Rotate the swing arm using a torque wrench until marks (A and B) are aligned.
6. Record torque wrench measurement and compare with specification below. Replace tensioner assembly as required.

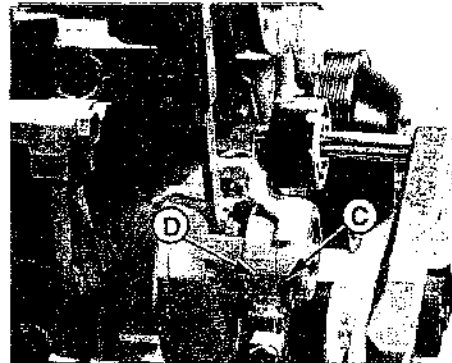
Specification

Spring Tension—Torque 18-22 N•m (13-16 lb-ft)

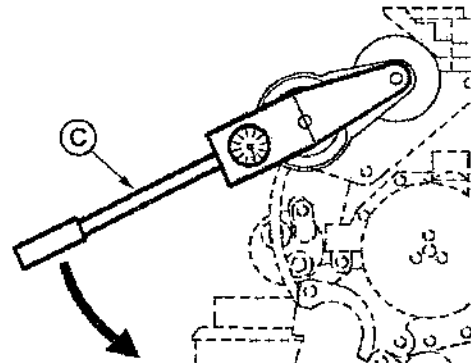
NOTE: Threads on belt tensioner roller cap screw are LEFT-HAND threads



Marks on Tensioner



Align Marks



Align Torque Wrench With Pulley and Tensioner

- A—Mark On Swing Arm
- B—Mark On Tensioner Mounting Base
- C—Torque Wrench

RG7977 -UN-14NOV97

RG8037C -UN-11SEP00

RG12085 -UN-28JAN02

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Checking Engine Electrical Ground Connections

Keep all engine ground connections clean and tight to prevent electrical arcing which can damage electronic components.

Also see precautions in Troubleshooting Section when welding on engine or machine.

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Checking Cooling System

CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns.

Shut off engine. Only remove filler cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

IMPORTANT: Air must be expelled from cooling system when system is refilled. Loosen temperature sending unit fitting at rear of cylinder head or plug in thermostat housing to allow air to escape when filling system. Retighten fitting or plug when all the air has been expelled.



High-Pressure Fluids

TS281 -UN-23AUG08

1. Visually check entire cooling system for leaks. Tighten all clamps securely.
2. Thoroughly inspect all cooling system hoses for hard, flimsy, or cracked condition. Replace hoses if any of the above conditions are found.
3. Inspect the coolant pump for wear or leakage.

OURGP11,0000151 -19-27JUL06-1/1

Replenishing Supplemental Coolant Additives (SCAs) Between Coolant Changes

IMPORTANT: Do not add supplemental coolant additives when the cooling system is drained and refilled with John Deere COOL-GARD™

NOTE: If system is to be filled with coolant that does not contain SCAs, the coolant must be precharged. Determine the total system capacity and premix with 3% John Deere Coolant Conditioner.

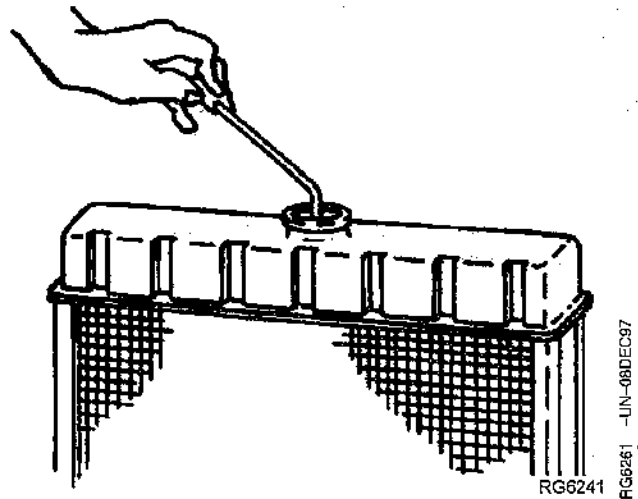
Through time and use, the concentration of coolant additives is gradually depleted during engine operation. Periodic replenishment of inhibitors is required, even when John Deere COOL-GARD™ is used. The cooling system must be recharged with additional supplemental coolant additives available in the form of liquid coolant conditioner.

Maintaining the correct coolant conditioner concentration (SCAs) and freeze point is essential in your cooling system to protect against rust, liner pitting and corrosion, and freeze-ups due to incorrect coolant dilution.

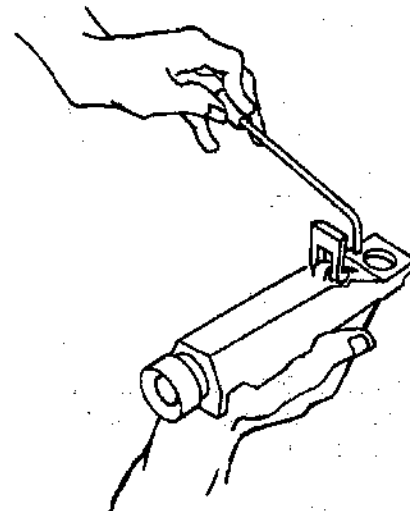
John Deere LIQUID COOLANT CONDITIONER is recommended as a supplemental coolant additive in John Deere engines.

DO NOT mix one brand of SCA with a different brand.

Test the coolant solution at 500 hours or 12 months of operation using either John Deere coolant test strips or a COOLSCAN™ or COOLSCAN PLUS™ analysis. If a COOLSCAN™ or COOLSCAN PLUS™ analysis is not available, recharge the system per instructions printed on label of John Deere Liquid Coolant Conditioner.



Radiator Coolant Check



JT07298 Coolant/Battery Tester

COOL-GARD is a trademark of Deere & Company
COOLSCAN is a trademark of Deere & Company
COOLSCAN PLUS is a trademark of Deere & Company

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IMPORTANT: ALWAYS maintain coolant at correct level and concentration. DO NOT operate engine without coolant even for a few minutes.

If frequent coolant makeup is required, the glycol concentration should be checked with JT07298 Coolant/Battery Tester to ensure that the desired freeze point is maintained. Follow manufacturer's instructions provided with Coolant/Battery Tester.

Add the manufacturer's recommended concentration of supplemental coolant additive. DO NOT add more than the recommended amount.

The use of non-recommended supplemental coolant additives may result in additive drop-out and gelation of the coolant.

If other coolants are used, consult the coolant supplier and follow the manufacturer's recommendation for use of supplemental coolant additives.

See DIESEL ENGINE COOLANTS AND SUPPLEMENTAL ADDITIVE INFORMATION for proper mixing of coolant ingredients before adding to the cooling system.

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Testing Diesel Engine Coolant

Maintaining adequate concentrations of glycol and inhibiting additives in the coolant is critical to protect the engine and cooling system against freezing, corrosion, and cylinder liner erosion and pitting.

Test the coolant solution at intervals of 12 months or less and whenever excessive coolant is lost through leaks or overheating.

Coolant Test Strips

Coolant test strips are available from your John Deere dealer. These test strips provide a simple, effective method to check the freeze point and additive levels of your engine coolant.

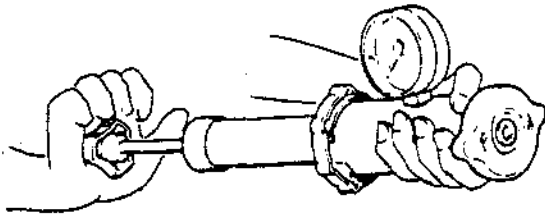
Compare the results to the supplemental coolant additive (SCA) chart to determine the amount of inhibiting additives in your coolant and whether more John Deere COOLANT CONDITIONER should be added.

COOLSCAN Or COOLSCAN PLUS

For a more thorough evaluation of your coolant, perform a COOLSCAN or COOLSCAN PLUS analysis. See your John Deere dealer for information about COOLSCAN or COOLSCAN PLUS.

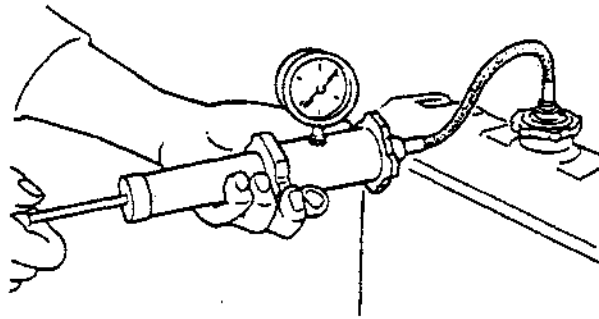
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Pressure Testing Cooling System



Test Radiator Cap

FIG0557 JUN-20JAN93



Test Cooling System

FIG0558 JUN-20JAN93



CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns.

Shut off engine. Only remove filler cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

NOTE: These tests apply only to John Deere radiators. For other brands, see manufacturers literature.

Test Radiator Cap

1. Remove radiator cap and attach to D05104ST Tester as shown.
2. Pressurize cap to specification listed. Gauge should hold pressure for 10 seconds at least to pressure listed if cap is acceptable.

If gauge does not hold pressure, replace radiator cap.

Specification

Radiator Cap Holding Pressure
(Not Opening For 10
Seconds)—Pressure..... 100 kPa (1.0 bar) (14.5 psi)

3. Remove the cap from gauge, turn it 180°, and retest cap. This will verify that the first measurement was accurate.

Test Cooling System

NOTE: Engine should be warmed up to test overall cooling system.

1. Allow engine to cool, then carefully remove radiator cap.
2. Fill radiator with coolant to the normal operating level.

IMPORTANT: DO NOT apply excessive pressure to cooling system, doing so may damage radiator and hoses.

3. Connect gauge and adapter to radiator filler neck. Pressurize cooling system to specification listed for radiator cap.
4. With pressure applied, check all cooling system hose connections, radiator, and overall engine for leaks.

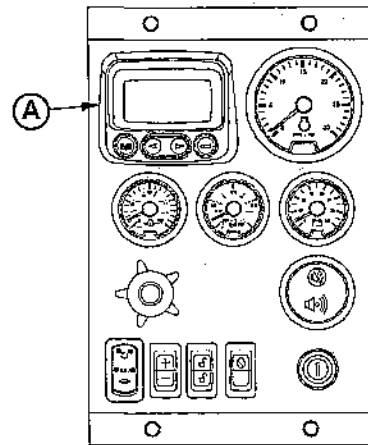
If leakage is detected, correct as necessary and pressure test system again.

If no leakage is detected, but the gauge indicated a drop in pressure, coolant may be leaking internally within the system or at the block-to-head gasket. Have your engine distributor or servicing dealer correct this problem immediately.

Checking and Adjusting Engine Speeds

If equipped with a tachometer (A) on the instrument panel, observe tachometer reading to verify engine speeds. (Refer to ENGINE POWER RATINGS AND FUEL SYSTEM SPECIFICATIONS in Specifications Section later in this manual for engine speed specifications.) If engine speed adjustment is required, see your authorized servicing dealer or engine distributor.

A—Tachometer



Using Tachometer to Check Engine Speeds

RG13728 JUN-11NOV04

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Lubrication & Maint./2000 Hour/24 Month

Checking Crankshaft Vibration Damper -Cylinder Engine Only)

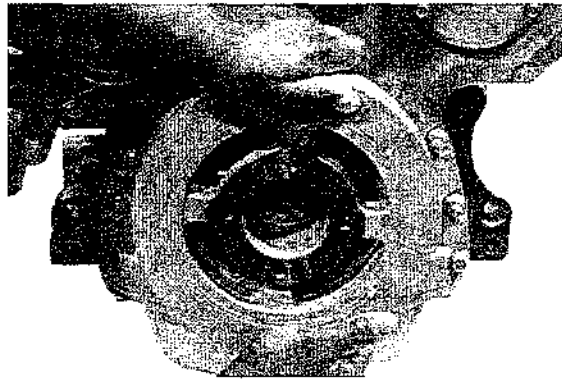
1. Remove belts (shown removed).
2. Grasp vibration damper with both hands and attempt to turn it in both directions. If rotation is felt, damper is defective and should be replaced.

IMPORTANT: The vibration damper assembly is not repairable and should be replaced every 4500 hours or 60 months, whichever occurs first.

3. Check vibration damper radial runout by positioning a dial indicator (A) so probe contacts damper outer diameter.
4. With engine at operating temperature, rotate crankshaft using either JD281A, JDE81-4, or JDE83 Flywheel Turning Tool.
5. Note dial indicator reading. If runout exceeds specifications given below, replace vibration damper.

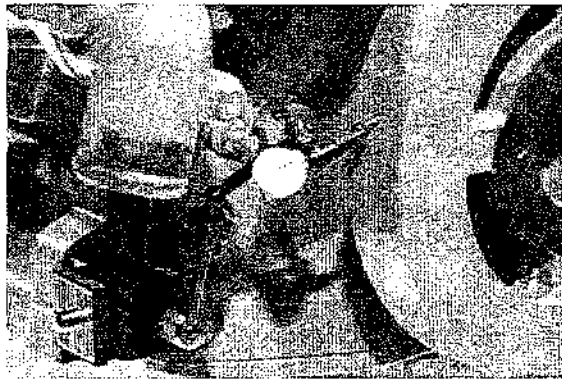
Specification

Vibration Damper—Maximum
Radial Runout..... 1.50 mm (0.060 in.)



Grasp Vibration Damper

RG7018 UN 15JAN99



Check Runout

RG7508 UN 23NOV97

RG RG34710,5595 -19 27JUL06 37

Flushing and Refilling Cooling System

CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns.

Shut off engine. Only remove filler cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

NOTE: When John Deere COOL-GARD is used, the drain interval is 3000 hours or 36 months. The drain interval may be extended to 5000 hours or 60 months of operation, **provided that the coolant is tested annually AND additives are replenished, as needed, by adding a supplemental coolant additive (SCA).**

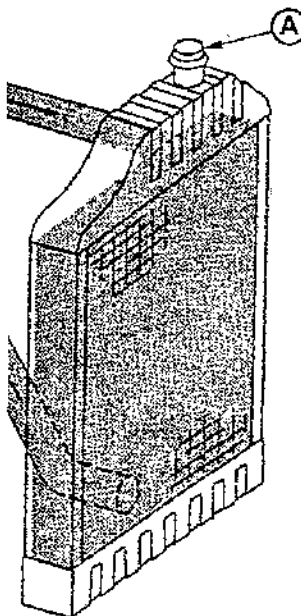
If COOL-GARD is not used, the flushing interval is 2000 hours or 24 months of operation.

Drain old coolant, flush the entire cooling system, test thermostats, and fill with recommended clean coolant per the following procedure.

1. Pressure test entire cooling system and pressure cap if not previously done. (See PRESSURE TESTING COOLING SYSTEM, in the Lubrication and Maintenance/500 Hour/12 Month Section.)
2. Slowly open the engine cooling system filler cap or radiator cap (A) to relieve pressure and allow coolant to drain faster.



High-Pressure Fluids



Radiator Cap

TS281 - JUN-23AUG88

RG12833 - JUN-18FEB03

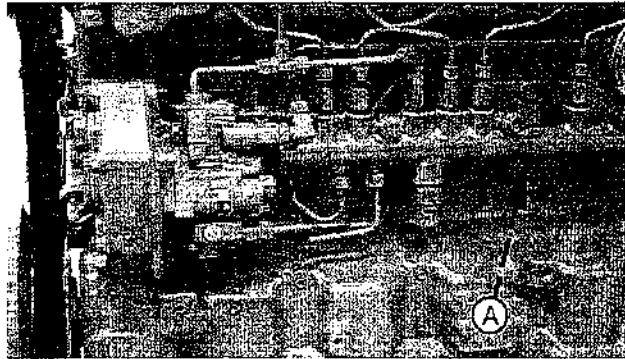
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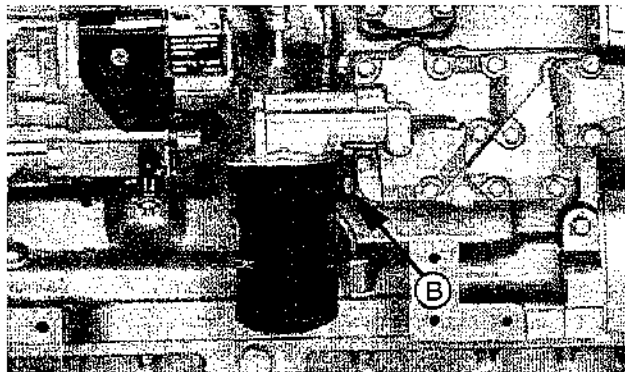
3. Open engine block drain plug (A) on left side of engine. Open coolant drain plug (B) on oil cooler on right side of engine. Drain all coolant from engine block.
4. Open radiator drain valve. Drain all coolant from radiator.
5. Remove thermostats at this time, if not previously done. Install cover (without thermostats) using old gasket and tighten cap screws to 47 N•m (35 lb-ft).
6. Test thermostat opening temperature. (See Inspecting Thermostats And Testing Opening Temperature in Service As Required Section.)
7. Close all drain valves and install plugs in block after coolant has drained.

CAUTION: Do not run engine longer than 10 minutes. Doing so may cause engine to overheat which may cause burns when radiator water is draining.

8. Fill the cooling system with clean water. Run the engine about 10 minutes to stir up possible rust or sediment.
9. Stop engine, pull off lower radiator hose and remove radiator cap. Immediately drain the water from system before rust and sediment settle.
10. After draining water, close drain valves. Reinstall radiator cap and radiator hose and clamp. Fill the cooling system with clean water and a heavy duty cooling system cleaner such as Fleetguard® RESTORE™ and RESTORE PLUS™. Follow manufacturer's directions on label.
11. After cleaning the cooling system, drain cleaner and fill with water to flush the system. Run the engine about 10 minutes, remove radiator cap and pull off lower radiator hose to drain out flushing water.



Engine Block Coolant Drain Plug



A—Engine Block Drain Plug
B—Oil Cooler Drain Plug

Fleetguard is a trademark of Cummins Engine Company, Inc.
RESTORE is a trademark of Fleetguard.
RESTORE PLUS is a trademark of Fleetguard.

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OURGP12.00C01C8 -19-14MAR08-2/3

12. Close all drain valves on engine and radiator and install plugs. Reinstall radiator hose and tighten clamps securely. Install thermostats using a new gasket. (See TESTING THERMOSTATS OPENING TEMPERATURE later in this section.)

IMPORTANT: Air must be expelled from cooling system when system is refilled. Loosen temperature sending unit fitting at rear of cylinder head or plug in thermostat housing to allow air to escape when filling system. Retighten fitting or plug after filling cooling system.

13. Add coolant to radiator until coolant touches bottom of filler neck. (See specification for capacity.) Install radiator cap.

Specification

4.5 L Engine—Coolant Capacity.....	8.5 L (9 qt)
6.8 L Engine—Coolant Capacity.....	11.9 L (13 qt)

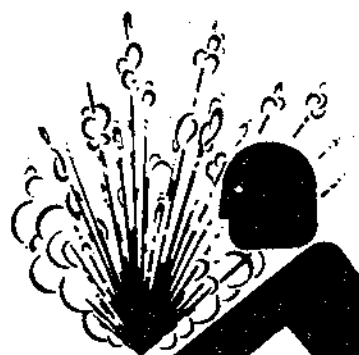
14. Run engine until it reaches operating temperature. This mixes the solution uniformly and circulates it through the entire system. The normal engine coolant temperature range is 82°—95°C (180° — 204°F).
15. After running engine, check coolant level and entire cooling system for leaks.
16. Inspect the fan belt for wear and check belt tension. (See Checking Belt Tensioner Spring Tension and Belt Wear in Lubrication and Maintenance 500 Hour/12 Month section.

OURGP12,00001D8 -19-14MAR06-3/3

Testing Thermostats Opening Temperature

Remove Thermostat(s)

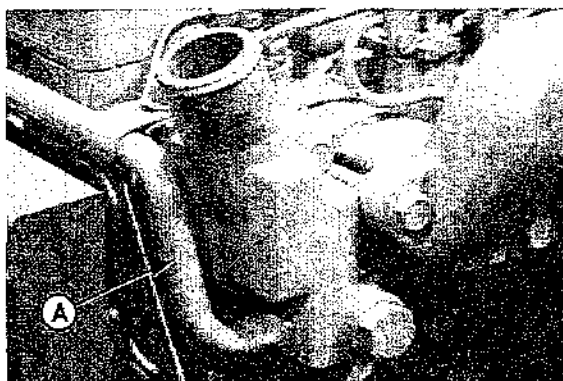
CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns. **DO NOT** drain coolant until it has cooled below operating temperature. Always loosen radiator pressure cap or drain valve slowly to relieve pressure.



High Pressure Fluids

1. Visually inspect area around thermostat housing for leaks.
2. Remove radiator pressure cap and partially drain cooling system.
3. Remove thermostat cover-to-coolant pump tube (A) and seal.

A—Cover-To-Coolant Pump Tube

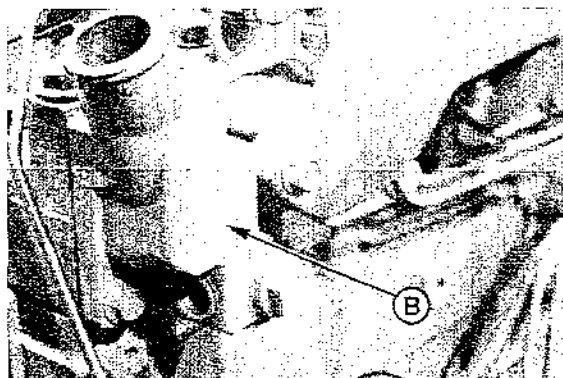


Thermostat Cover-to-Coolant Pump Tube

DPSG.RG34710.112 -19-27JUL06-1/5

4. Remove thermostat cover (B) with gasket.
5. Remove thermostat(s)
6. Remove and discard all gasket material. Clean gasket surfaces.
7. Clean and check cover for cracks or damage.

B—Thermostat Cover



Thermostat Cover

Continued on next page

DPSG.RG34710.112 -19-27JUL06-2/5

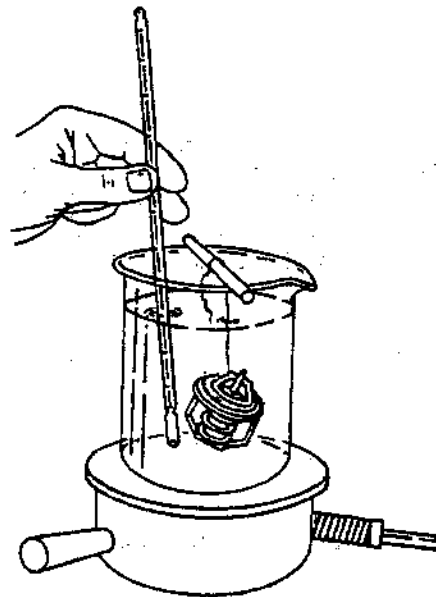
Testing Thermostats Opening Temperature

1. Remove thermostat(s).
2. Visually inspect thermostat(s) for corrosion or damage. If dual thermostats, replace as a matched set as necessary.

CAUTION: DO NOT allow thermostat or thermometer to rest against the side or bottom of container when heating water. Either may rupture if overheated.

3. Suspend thermostat and a thermometer in a container of water.
4. Stir the water as it heats. Observe opening action of thermostat and compare temperatures with the specification given in chart below.

NOTE: Due to varying tolerances of different suppliers, initial opening and full open temperatures may vary slightly from specified temperatures.



Testing Thermostat Opening Temperature

RG5971 -JUN-23NOV97

THERMOSTAT TEST SPECIFICATIONS

Rating	Initial Opening (Range)	Full Open (Nominal)
71°C (160°F)	69—72°C (156—162°F)	84°C (182°F)
77°C (170°F)	74—78°C (166—172°F)	89°C (192°F)
82°C (180°F)	80—84°C (175—182°F)	94°C (202°F)
89°C (192°F)	86—90°C (187—194°F)	101°C (214°F)
90°C (195°F)	89—93°C (192—199°F)	103°C (218°F)
92°C (197°F)	89—93°C (193—200°F)	105°C (221°F)
96°C (205°F)	94—97°C (201—207°F)	100°C (213°F)
99°C (210°F)	96—100°C (205—212°F)	111°C (232°F)

5. Remove thermostat and observe its closing action as it cools. In ambient air the thermostat should close completely. Closing action should be smooth and slow.
6. Replace any defective thermostat. On a dual thermostat engine, replace both thermostats.

Continued on next page

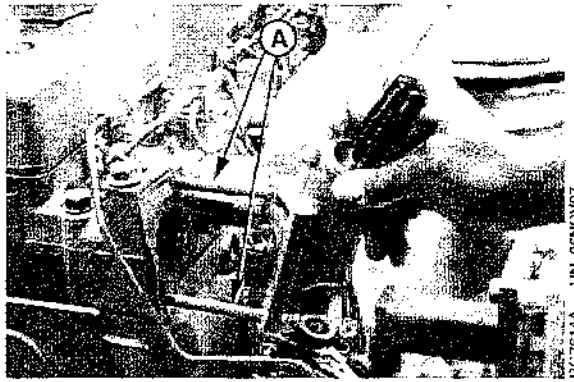
DPSG, RG34710, 112 -19-27JUL06-3/5

To Install Thermostats

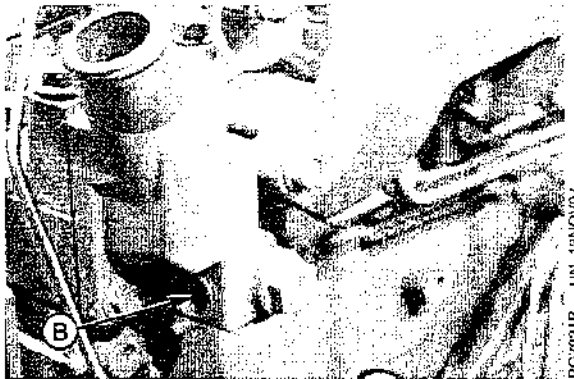
IMPORTANT: Install manifold gasket so that smaller (round) holes are at lower left and upper right corners of manifold (matching studs A).

1. Clean all gasket material from thermostat cover and housing mounting surfaces.
2. Using guide studs (A) to keep gasket in place, install a new gasket on cylinder head.
3. Install thermostat(s) with jiggle wire facing up in the 12 o'clock position.
4. Using a screwdriver to hold thermostat(s) in place, install thermostat(s) and coolant manifold/thermostat cover.
5. Tighten cover cap screws to 70 N•m (52 lb-ft).
6. Lubricate new O-ring with PT507 Multi-Purpose Grease. Install seal (B) in thermostat cover.

A—Guide Studs
B—Seal



Installing Thermostat Cover

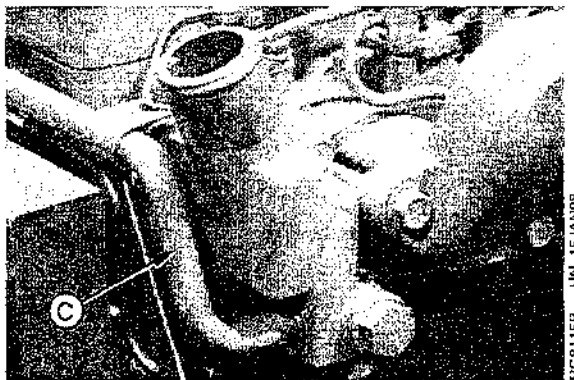


Thermostat Cover Seal

DPSG,R334710,1:2 -9-27JU,08-4/5

7. Install coolant manifold/thermostat cover-to-coolant pump tube (C). Tighten clamps.
8. If not already done, fill cooling system and check for leaks.

IMPORTANT: Air must be expelled from cooling system when filling. Loosen temperature sending unit fitting at rear of cylinder head or plug in thermostat housing to allow air to escape when filling system. Tighten fitting or plug when all air has been expelled.



Cover-To-Coolant Pump Tube

C—Cover-To-Coolant Pump Tube

DPSG,R334710,1:2 -9-27JU,08-5/5

Check and Adjust Valve Clearance

CAUTION: To prevent accidental starting of engine while performing valve adjustments, always disconnect **NEGATIVE (—)** battery terminal.

IMPORTANT: Valve clearance **MUST BE** checked and adjusted with engine **COLD**.

1. Remove rocker arm cover and crankcase ventilator tube.

IMPORTANT: Visually inspect contact surfaces of valve tips and rocker arm wear pads. Check all parts for excessive wear, breakage, or cracks. Replace parts that show visible damage.

Rocker arms that exhibit excessive valve clearance should be inspected more thoroughly to identify damaged parts.

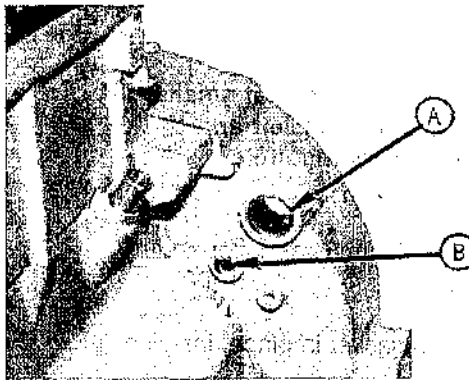
2. Remove plastic plugs or cover plate from engine timing/rotation hole (A) and timing pin hole (B).

NOTE: Some engines are equipped with flywheel housings which do not allow use of an engine flywheel rotation tool. These engines may be rotated from front nose of engine, using JDG966 Crankshaft Front/Rear Rotation Adapter.

3. Using JDE83 or JDG281A Flywheel Turning Tool, rotate engine flywheel in running direction (clockwise viewed from front) until No. 1 cylinder is at TDC compression stroke. Insert JDG1571 Timing Pin in flywheel.

If No.1 cylinder rocker arms are loose, the engine is at No. 1 TDC compression.

If No. 1 cylinder rocker arms are not loose, rotate engine one full revolution (360°) to No. 1 TDC compression.



Flywheel Housing Timing Holes

A—Timing/Rotation Hole
B—Timing Pin Hole

RG7408 -JUN-06AUG96

Continued on next page

OURGP12,00001D9 -19-14MAR06-1/5

4. With engine lock-pinned at TDC of No. 1 piston's compression stroke, check valve clearance to following specifications. (Use sequence for 4-cylinder or 6-cylinder engines as outlined on next page.)

Specification

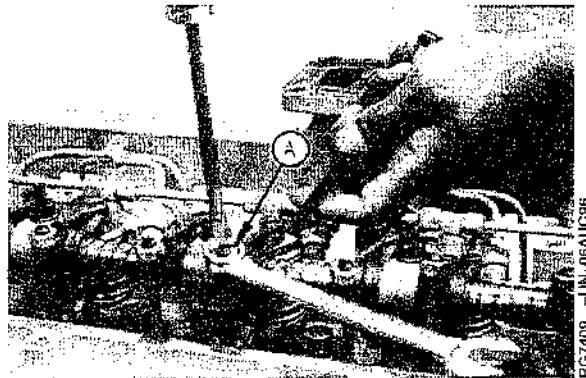
Intake Valve Clearance For	
Checking (Rocker Arm-to-Valve	
Tip) (Engine Cold)—Clearance	0.31—0.38 mm
	(0.012—0.015 in.)
Exhaust Valve Clearance For	
Checking (Rocker Arm-to-Valve	
Tip) (Engine Cold)—Clearance	0.41—0.48 mm
	(0.016—0.019 in.)

OURGP12.00001D9 -19-14MAR06-2/5

5. If valves need adjusting, use the appropriate valve clearance adjustment procedure on the next page and adjust to specifications below. Loosen the jam nut (A) on rocker arm adjusting screw. Turn adjusting screw until feeler gauge slips with a slight drag. Hold the adjusting screw from turning with screwdriver and tighten jam nut to specifications. Recheck clearance again after tightening jam nut. Readjust clearance as necessary.

Specification

Intake Valve Clearance For	
Adjusting (Rocker Arm-to-Valve	
Tip) (Engine Cold)—Clearance	0.36 mm (0.014 in.)
Exhaust Valve Clearance For	
Adjusting (Rocker Arm-to-Valve	
Tip) (Engine Cold)—Clearance	0.46 mm (0.018 in.)
Rocker Arm Adjusting Screw Jam	
Nut—Torque	27 N•m (20 lb-ft)



Adjusting Valves

A—Adjusting Screw Jam Nut

6. Replace rocker arm cover and crankcase ventilator tube.

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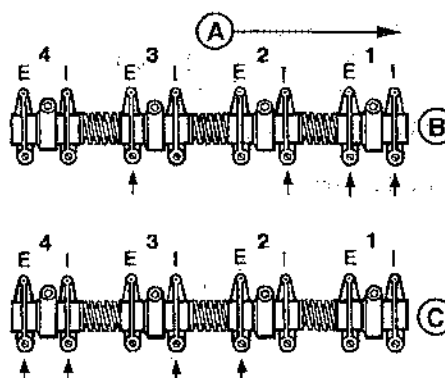
OURGP12.00001D9 -19-14MAR06-3/5

4-Cylinder Engine:

NOTE: Firing order is 1-3-4-2.

1. Using JDE81-4 Timing Pin, lock No. 1 piston at TDC compression stroke (B).
2. Adjust valve clearance on No. 1 and 3 exhaust valves and No. 1 and 2 intake valves.
3. Turn crankshaft 360°. Lock No. 4 piston at TDC compression stroke (C).
4. Adjust valve clearance on No. 2 and 4 exhaust valves and No. 3 and 4 intake valves.

A—Front of Engine
 B—No. 1 Piston TDC Compression
 C—No. 4 Piston TDC Compression
 E—Exhaust Valve
 I—Intake Valve



4-Cylinder Engine Valve Adjustment

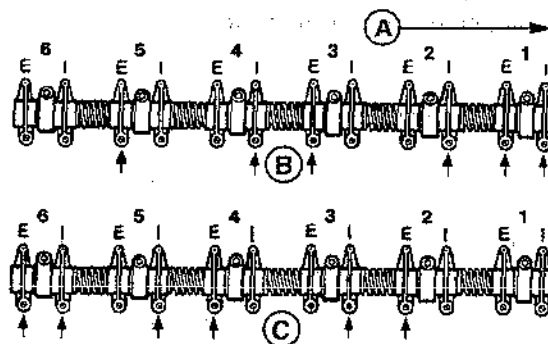
RG4776 -UN-31OCT87

OURGP12,00001D9 -19-14MAR06-4/5

6-Cylinder Engine:

NOTE: Firing order is 1-5-3-6-2-4.

1. Lock No. 1 piston at TDC compression stroke (B).
2. Adjust valve clearance on No. 1, 3 and 5 exhaust valves and No. 1, 2, and 4 intake valves.
3. Turn crankshaft 360°. Lock No. 6 piston at TDC compression stroke (C).
4. Adjust valve clearance on No. 2, 4 and 6 exhaust valves and No. 3, 5, and 6 intake valves.



6-Cylinder Engine Valve Adjustment

A—Front of Engine
 B—No. 1 Piston TDC Compression
 C—No. 6 Piston TDC Compression
 E—Exhaust Valve
 I—Intake Valve

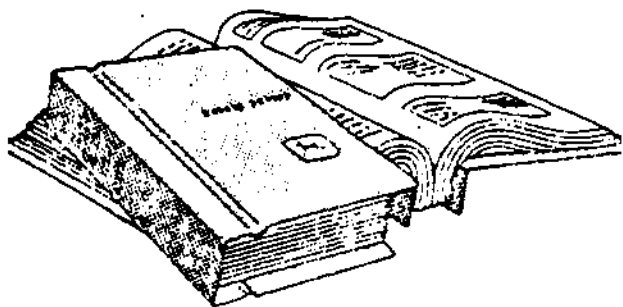
RG4777 -UN-31OCT87

OURGP12,00001D9 -19-14MAR06-5/5

Service as Required

Additional Service Information

This is not a detailed service manual. If you want more detailed service information, use the Publications Information in the back of this manual to order a component technical manual.



Component Technical Manual

RG-4624 UN-150K-288

RG.RG34710.6591 -19-27JUL08-1/1

Do Not Modify Fuel System

CAUTION: Do not open high-pressure fuel system.

High-pressure fluid remaining in fuel lines can cause serious injury. Do not disconnect or attempt repair of fuel lines, sensors, or any other components between the high-pressure fuel pump and nozzles on engines with High Pressure Common Rail (HPCR) fuel system.

Only technicians familiar with this type of system can perform repairs. (See your John Deere dealer.)

IMPORTANT: Never steam clean or pour cold water on an injection pump while it is still warm. To do so may cause seizure of pump parts.

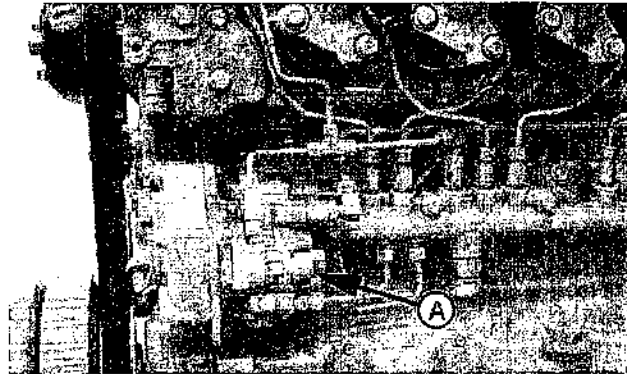
Modification or alteration of the high-pressure fuel pump (A), the injection timing, or the fuel injectors in ways not recommended by the manufacturer will terminate the warranty obligation to the purchaser.

In addition, tampering with fuel system which alters emission-related equipment on engines may result in fines or other penalties, per EPA regulations or other local emission laws.

Do not attempt to service injection pump or fuel injectors yourself. Special training and special tools are required. (See your authorized servicing dealer or engine distributor.)



High-Pressure Fuel Lines



Fuel System

A—High-Pressure Fuel Pump

TS1343 -UN-18MAR92

RG13735 -UN-11NOV04

OURGP12.00001DA -19-14MAR06-1/1

Adding Coolant



CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns.

Shut off engine. Only remove filler cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

IMPORTANT: Never pour cold liquid into a hot engine, as it may crack cylinder head or block. DO NOT operate engine without coolant for even a few minutes.

John Deere TY15161 Cooling System Sealer may be added to the radiator to stop leaks. DO NOT use any other stop-leak additives in the cooling system.

Air must be expelled from cooling system when coolant is added.

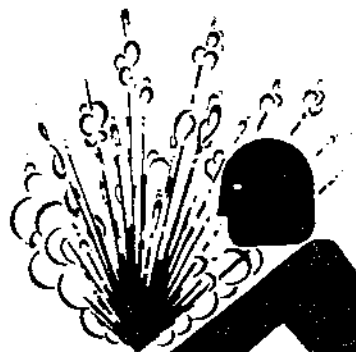
Coolant level should be maintained to the bottom of the radiator filler neck (A). If needed, as follows:

- 1. Loosen temperature sending unit fitting at rear of cylinder head or plug in side of thermostat housing to allow air to escape when filling system.

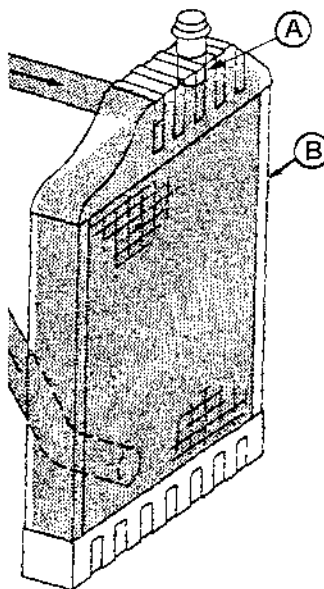
IMPORTANT: When adding coolant to the system, use the appropriate coolant solution. (See ENGINE COOLANT SPECIFICATIONS in Fuels, Lubricants, and Coolant Section for mixing of coolant ingredients before adding to cooling system.)

Do not overfill cooling system. A pressurized system needs space for heat expansion without overflowing at top of radiator.

2. Fill radiator (B) until coolant level touches bottom of radiator filler neck (A).



High-Pressure Fluids



Radiator and Coolant

A—Radiator Filler Neck
B—Radiator

REVISION UN 23AUG98
(RCS)

FIG 13295 UN 20NOV03

3. Tighten plugs and fittings when air has been expelled from system.
4. Run engine until it reaches operating temperature.

OURGP11,0000222 -19-27JUL06-2/2

Replacing Single Stage Air Cleaner

IMPORTANT: ALWAYS REPLACE air cleaner when air restriction indicator shows a vacuum of 625 mm (25 in.) H₂O, is torn, or visibly dirty.

NOTE: This procedure applies to John Deere single stage air cleaner kits. Refer to manufacturers' instructions for servicing air cleaners not supplied by John Deere.

1. If equipped, loosen body clamp.
2. Loosen clamp around outlet neck (A).
3. Remove air cleaner.
4. Install new filter so that overlap (B) of air cleaner outlet neck and engine intake pipe is to specification below.

Specification

Air Cleaner Neck to Engine
Intake—Overlap..... 38 mm (1.5 in.)

5. Tighten neck clamp (A) to specification below.

Specification

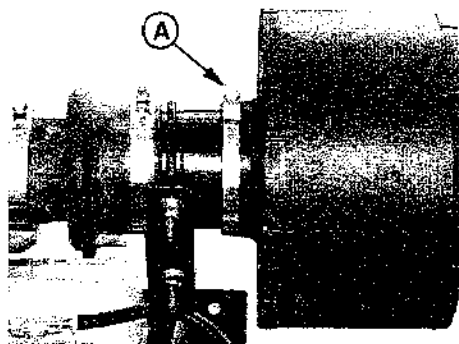
Cleaner Neck Clamp—Torque..... 6.8 N·m (60 lb-in.)

IMPORTANT: Do NOT overtighten body clamp. Overtightening may cause crushing of air cleaner body. Tighten body clamp only until snug.

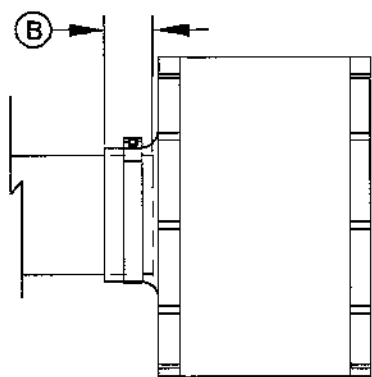
6. If equipped, tighten body clamp until snug.

IMPORTANT: Whenever the air cleaner has been serviced or removed, ALWAYS fully depress the air restriction indicator reset button (if equipped) to assure accurate readings.

7. If equipped, fully depress air restriction indicator reset button and release to reset indicator.



Single Stage Air Filter



Installation of Single Stage Air Cleaner

A—Outlet Neck Clamp
B—Filter to Engine Overlap

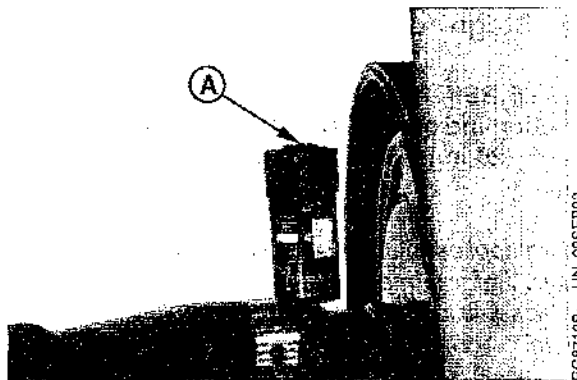
RG11310A -JUN-06SEP00

RG11320 -JUN-07SEP00

Replacing Axial Seal Air Cleaner Filter Element

IMPORTANT: ALWAYS REPLACE primary air cleaner element when air restriction indicator (A) shows a vacuum of 625 mm (25 in.) H₂O, is torn, or visibly dirty.

NOTE: This procedure applies to John Deere 2-stage axial seal air cleaner kits. Refer to manufacturers' instructions for servicing air cleaners not supplied by John Deere.



Air restriction Indicator

Continued on next page

OURGP11.000013A -19-27JUL06-1/2

1. Remove wing nut and remove canister cover shown in small illustration inset.
2. Remove wing nut (A) and remove primary element (B) from canister.
3. Thoroughly clean all dirt from inside canister.

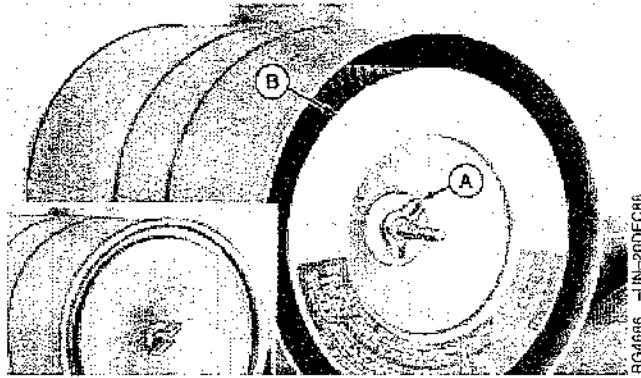
NOTE: Some engines may have a dust unloader valve (C) on the air cleaner. If equipped, squeeze valve tip to release any trapped dirt particles.

IMPORTANT: Remove secondary (safety) element (E) **ONLY** for replacement. **DO NOT** attempt to clean, wash, or reuse secondary element. Replacement of secondary element is usually necessary **ONLY** when primary element has a hole in it.

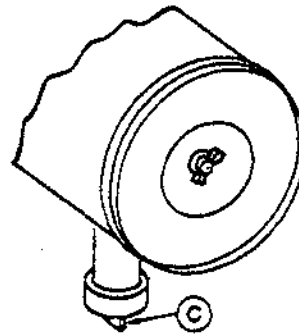
4. To replace secondary element, remove retaining nut (D) and secondary element (E). Immediately replace secondary element with new element to prevent dust from entering air intake system.
5. Install new primary element and tighten wing nut securely. Install cover assembly and tighten retaining wing nut securely.

IMPORTANT: Whenever the air cleaner has been serviced or had cover removed, **ALWAYS** fully depress the air restriction indicator reset button (if equipped) to assure accurate readings.

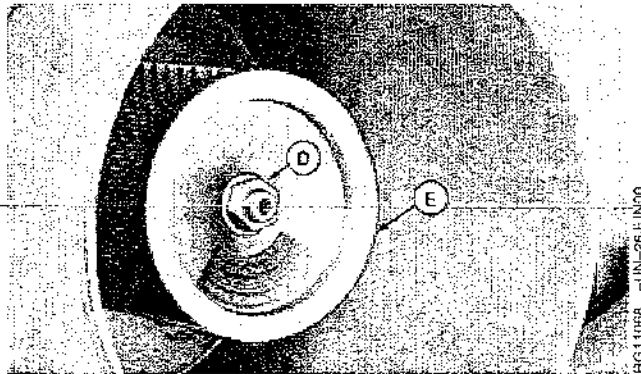
6. If equipped, fully depress air restriction indicator reset button and release to reset indicator.



Wing Nut and Primary Element



Dust Unloader Valve and Restriction Indicator



Retaining Nut and Secondary Element

- A—Wing Nut
- B—Primary Element
- C—Dust Unloader Valve
- D—Retaining Nut
- E—Secondary Element

OURGP11.000013A -19-27JU.06-2/2

Replacing Radial Seal Air Cleaner Filter Element

IMPORTANT: ALWAYS REPLACE primary air cleaner element when air restriction indicator shows a vacuum of 625 mm (25 in.) H₂O, is torn, or visibly dirty.

NOTE: This procedure applies to John Deere 2-stage radial seal air cleaner kits. Refer to manufacturers' instructions for servicing air cleaners not supplied by John Deere.

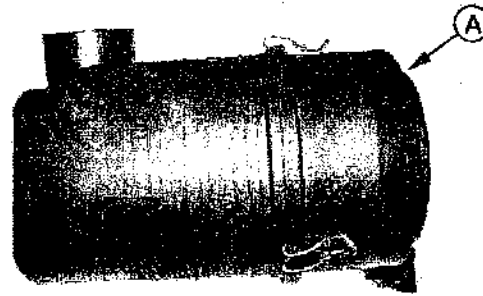
1. Unlatch and remove dust cup/cover (A) of air cleaner.
2. Move end of filter (B) back and forth gently to break seal.
3. Pull filter (B) off outlet tube and out of housing.
4. Thoroughly clean all dirt from inside housing and from outlet bore.

IMPORTANT: Remove secondary (safety) element (C) ONLY for replacement. DO NOT attempt to clean, wash, or reuse secondary element. Replacement of secondary element is usually necessary ONLY when primary element has a hole in it.

5. To replace secondary element (C), pull filter element out gently. Immediately replace secondary element with new element to prevent dust from entering air intake system.
6. Install new primary filter element. Apply pressure by hand at outer rim of filter.

IMPORTANT: Do NOT use latches on cover to force filter into air cleaner. Using cover to force filter will damage cleaner housing.

7. Close housing with dust unloader valve aimed down and latch latches.



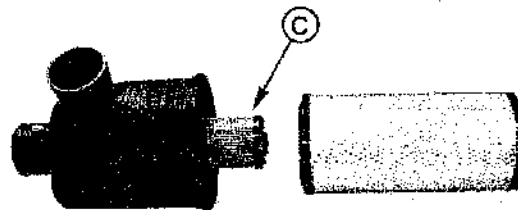
Dust Cup/Cover

RG11321A -UN-08SEP00



Primary Filter Element

RG11322A -UN-08SEP00



Secondary Filter Element

RG11327A -UN-08SEP00

- A—Dust Cap/Cover
- B—Primary Filter Element
- C—Secondary Filter Element

Continued on next page

RG41165,000008B -19-27JUL06-1/2

IMPORTANT: Whenever the air cleaner has been serviced or cover has been removed, **ALWAYS** fully depress the air restriction indicator reset button (if equipped) to assure accurate readings.

8. If equipped, fully depress air restriction indicator reset button and release to reset indicator.

RG41165,000008B -19-27JU,06-2/2

Replacing Fan and Alternator Belts

Refer to CHECKING BELT TENSIONER SPRING TENSION AND BELT WEAR in Lubrication and Maintenance/500 Hour/12 Month Section for additional information on the belt tensioner.

1. Inspect belts for cracks, fraying, or stretched out areas. Replace if necessary.
2. To replace belt with automatic tensioner, release tension on belt using a breaker bar and socket on tension arm.

To replace belt with manual tensioner, release tension at belt tensioner (See MANUAL BELT TENSIONER ADJUSTMENT in Lubrication and Maintenance/500 Hour/12 Month Section.)

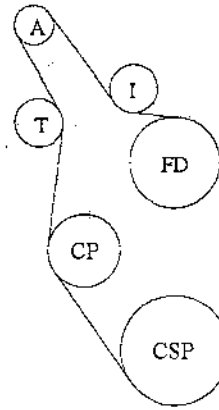
3. Remove poly-vee belt from pulleys and discard belt.

NOTE: While belt is removed, inspect pulleys and bearings. Rotate and feel for hard turning or any unusual sounds. If pulleys or bearings need replacement, see your John Deere dealer.

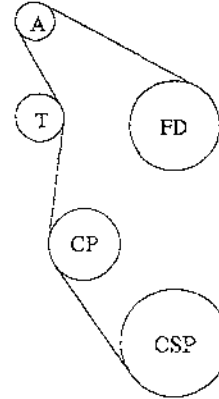
4. Install new belt, making sure belt is correctly seated in all pulley grooves. Refer to belt routing at right for your application.
5. Apply tension to belt with tensioner. Remove socket.
6. Install fan guard if removed.
7. Start engine and check belt alignment.

*Measured from crank centerline to fan drive center.

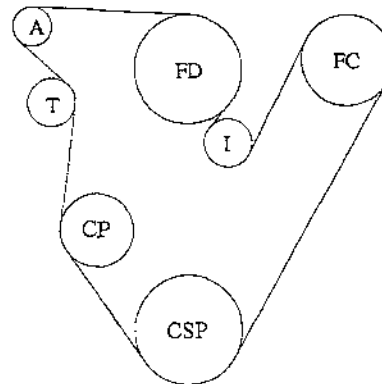
A—Alternator
CSP—Crankshaft Pulley
FC—Freon (A/C) Compressor
FD—Fan Drive
I—Idler Pulley
T—Tensioner
CP—Coolant Pump



290 mm (11.4 in.) Fan Height and Lower*



338 mm (13.3 in.) Fan Height and Higher* Without Freon Compressor*



402 mm (15.8 in.) Fan Height With Freon Compressor*

RG11950 -JUN-07NOV01

RG11951 -JUN-07NOV01

RG11952 -JUN-07NOV01

Checking Fuses

There are two fuses in the wiring harness. A 20 amp fuse is used for the ECU (see ENGINE WIRING DIAGRAM) and 30 amp fuses are used in all other locations.

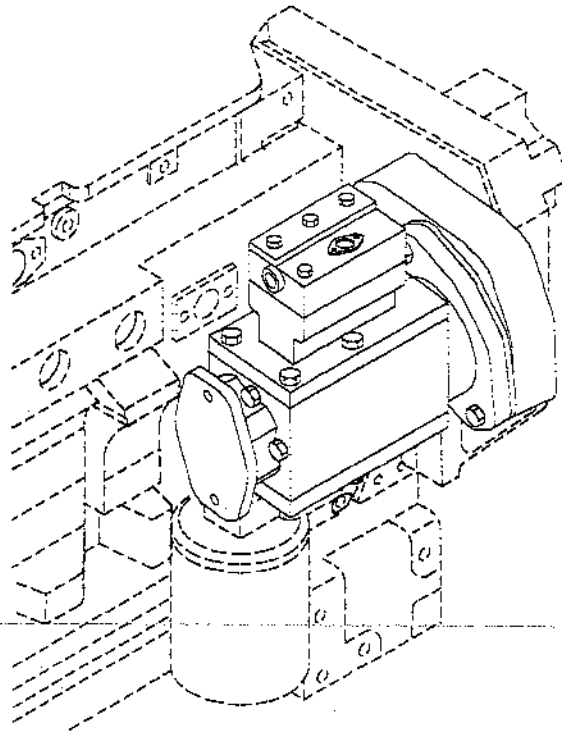
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Checking Air Compressors (If Equipped)

Air compressors are offered as options with John Deere OEM engines to provide compressed air to operate air-powered devices like vehicle air brakes.

Air compressors are engine-driven piston types. They are either air cooled or cooled with engine coolant. The compressors are lubricated with engine oil. The compressor runs continuously as gear or spline driven by the auxiliary drive of the engine but has "loaded" and "unloaded" operating modes. This is controlled by the vehicle's air system (refer to vehicle technical manual for complete air system checks and services).

See your John Deere engine distributor or servicing dealer for diagnostic and troubleshooting information. If diagnosis leads to an internal fault in the compressor, replace the complete compressor as a new or remanufactured unit.



Air Compressor (Optional)

RG12836 -JUN-27FEB03

OJRGF12.00001E0 -19-27JUL08-1/1

Bleed the Fuel System

⚠ CAUTION: High-pressure fluid remaining in fuel lines can cause serious injury. Do not disconnect or attempt repair of fuel lines, sensors, or any other components between the high-pressure fuel pump and nozzles on engines with High Pressure Common Rail (HPCR) fuel system. Only technicians familiar with this type of system can perform repairs. (See your John Deere dealer.)

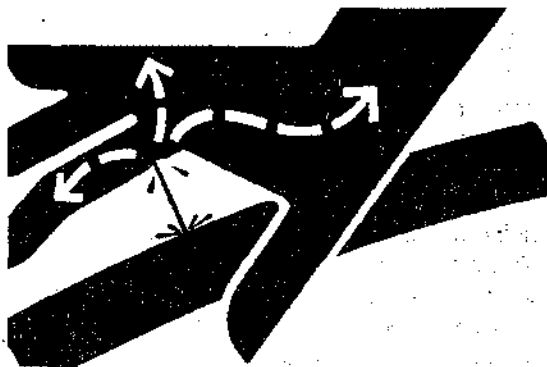
Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid hazards by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury may call the Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.

Any time the fuel system has been opened up for service (lines disconnected or filters removed), it will be necessary to bleed air from the system.



High-Pressure Fuel Lines



High Pressure Fluids

TS1843 -JUN-18-MAR92

X9811 -JUN-23-AUG98

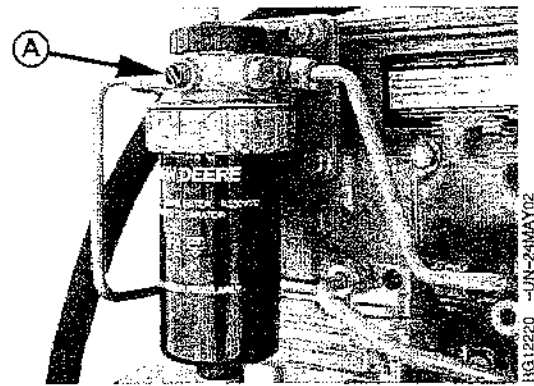
Continued on next page

OURGP12.00001DC - 19-14MAR06-1/3

IMPORTANT: Prevent fuel contamination. Do not crack any fuel lines to bleed the fuel system.

1. Loosen the air bleed vent screw (A) two full turns by hand on fuel filter base.

A—Bleed Vent Screw



Final Fuel Filter Bleed Vent Screw

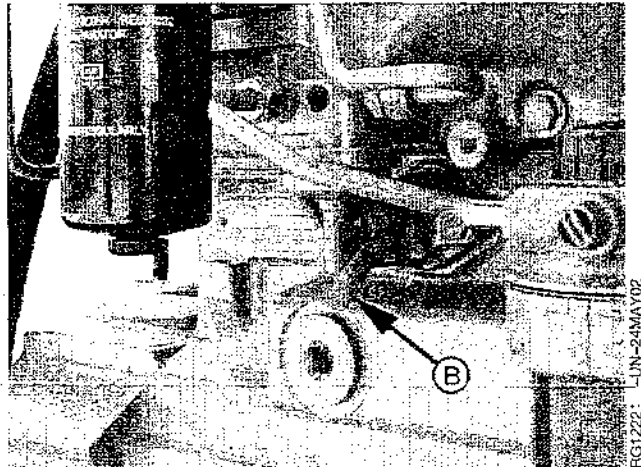
OURGP12.00001DC —19-14MAR06-2/3

2. Operate fuel supply pump primer lever (B), or primer button on fuel filter base (if equipped), until fuel flows out of bleed vent screw.
3. Tighten bleed vent screw securely. Continue operating primer until pumping action is not felt.

Start engine and check for leaks.

If engine will not start, repeat steps 1-4.

B—Primer Lever



Fuel Supply Pump Primer Lever

OURGP12.00001DC —19-14MAR06-3/3

Troubleshooting

General Troubleshooting Information

The following pages provide a list of possible engine problems that may be encountered accompanied by possible causes and corrections. The troubleshooting information is of a general nature; final design of the overall system for your engine application may be different. See your engine distributor or servicing dealer if you are in doubt.

A reliable program for troubleshooting engine problems should include the following basic diagnostic thought process:

- Know the engine and all related systems.
- Study the problem thoroughly.
- Relate the symptoms to your knowledge of engine and systems.
- Diagnose the problem starting with the easiest things first.
- Double-check before beginning the disassembly.
- Determine cause and make a thorough repair.
- After making repairs, operate the engine under normal conditions to verify that the problem and cause was corrected.

OUOD006.00000EA -19-31AUG07-1/1

Precautions For Welding On Engines Equipped With Electronic Engine Control Unit (ECU)

IMPORTANT: ALWAYS disconnect Electronic Control Unit (ECU) connectors and engine control system-to-machine ground before welding on engine or machine. High currents or electro-static discharge in electronic components from welding may cause permanent damage.

1. Remove the ground connection for the engine control system-to-machine frame.
2. Disconnect the connectors from the ECU.
3. Connect the welder ground close to the welding point and be sure ECU or other electronic components are not in the ground path.

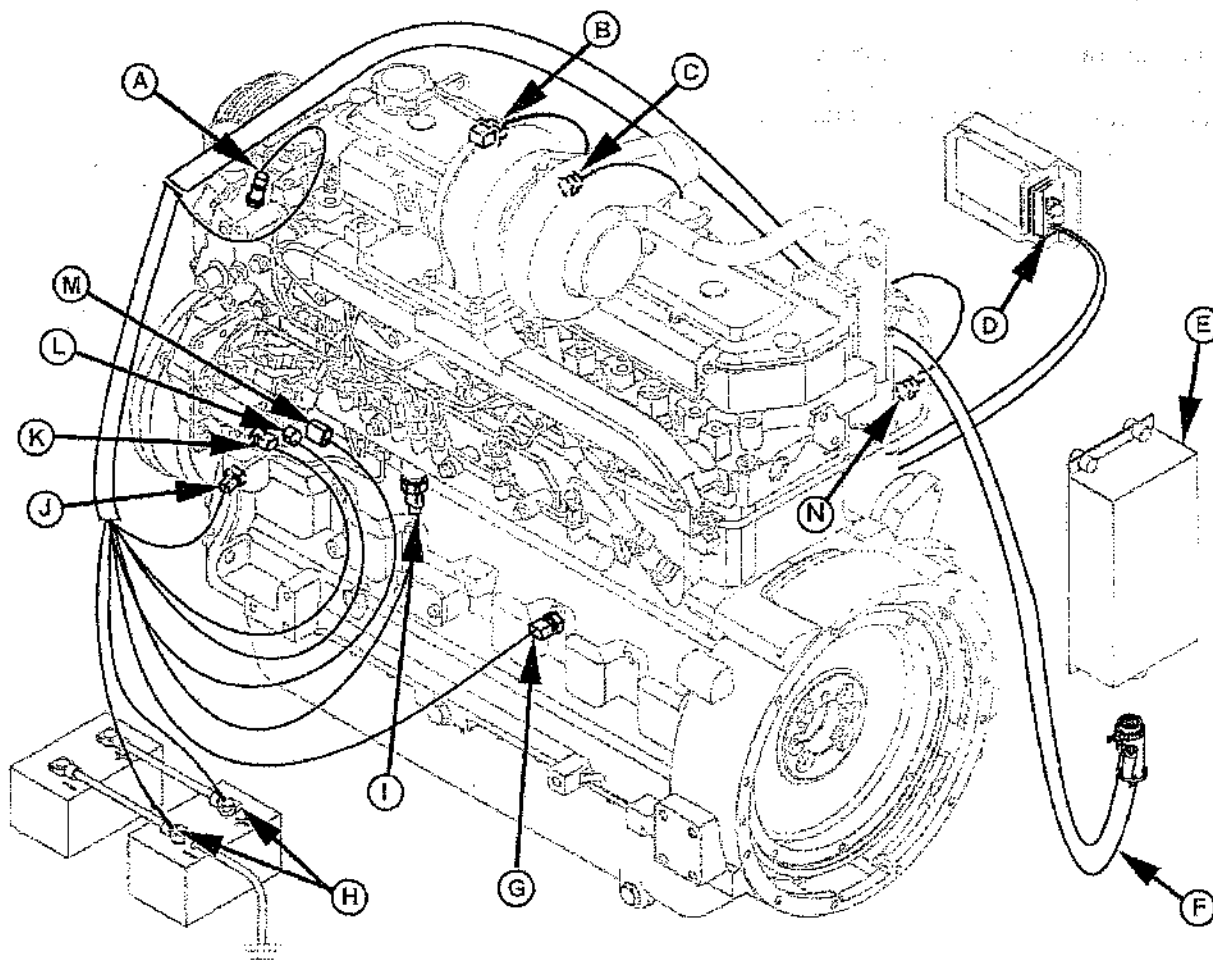
OUOD002.000016B -19-27JUL06-1/1

Precautions for Electrical System When Steam Cleaning Engine

IMPORTANT: Do not steam clean any electrical or electronic components while steam cleaning the engine as it could damage sensitive parts.

OURGP11,000012A -19-11OCT06-1/1

Engine Wiring Layout



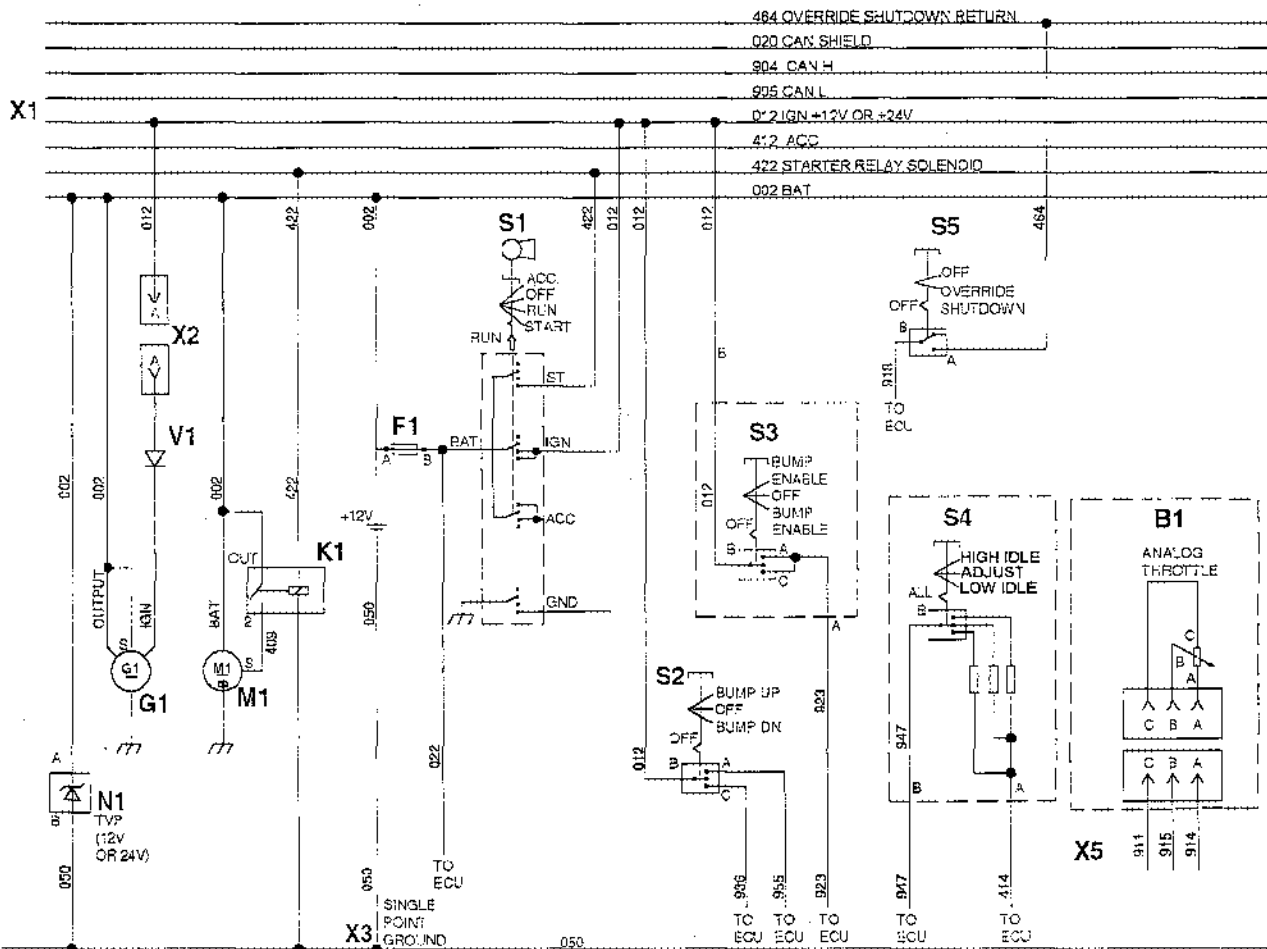
6068HF285 Engine Shown

A—Engine Coolant Temperature (ECT) Sensor	D—(ECU) Connector	H—Power and Ground Battery Connections	L—Pump Control Valve Solenoid
B—Electronic Injector Connector	E—Optional Instrument Panel	I—Fuel Rail Pressure Sensor	M—Fuel Temperature Sensor
C—Manifold Air Temperature (MAT) Sensor	F—Engine Wiring Harness	J—Crankshaft Position Sensor	N—Water-in-Fuel Sensor
	G—Engine Oil Pressure Sensor Connector	K—Pump Position Sensor	

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OURGP12.00001DD -19-15MAR06-1/1

Engine Wiring Diagram (With Full-Featured Electronic Instrument Panel)



SE-1 ENGINE START COMPONENTS

SE-2 INSTRUMENT PANEL (CONTINUED NEXT PAGE)

B1—Analog Throttle
F1—Fuse (20 Amp) (Harness)
G1—Alternator
K1—Starter Relay
M1—Starter Motor
N1—Transient Voltage Protector
P1—Optional Gauge
P2—Optional Gauge

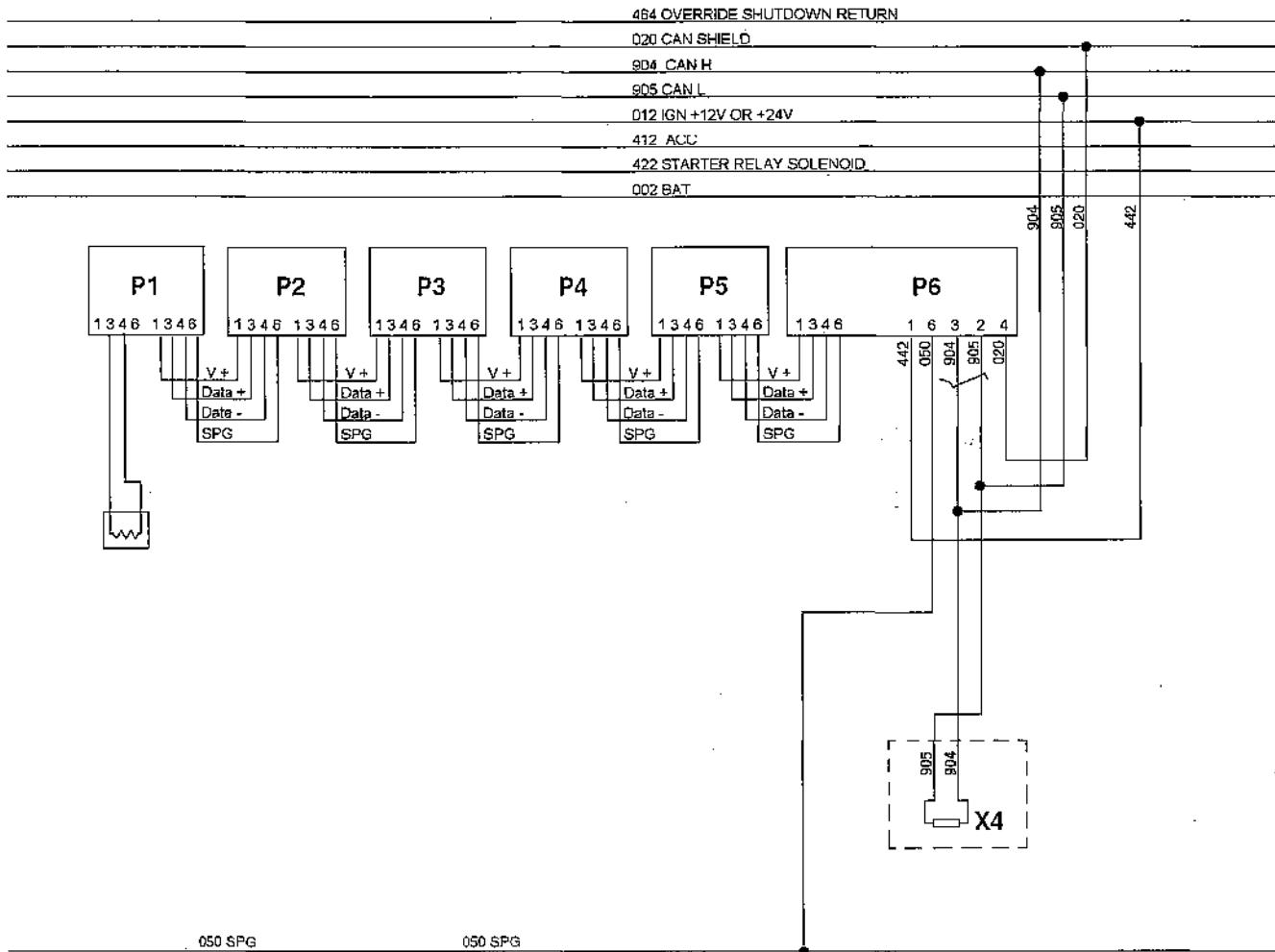
P3—Oil Pressure Gauge
P4—Coolant Temperature Gauge
P5—Tachometer Display
P6—Hour Meter/Diagnostic Gauge
S1—Ignition Key Switch
S2—Speed Select Switch (Momentary)

S3—Bump Enable Switch (Momentary)
S4—High-Low Speed Select Switch
S5—Override Shutdown Switch (Momentary)
V1—Diode
X1—Vehicle Harness Connector

X2—Alternator Harness Connector
X3—Single Point Ground
X4—CAN Terminator
X5—Analog Throttle Connector

OURGP12.000010E -19-15MAR06-1/1

Engine Wiring Diagram (With Full-Featured Electronic Instrument Panel)—Continued



SE-2 INSTRUMENT PANEL (CONTINUED)

B1—Analog Throttle
 F1—Fuse (20 Amp) (Harness)
 G1—Alternator
 K1—Starter Relay
 M1—Starter Motor
 N1—Transient Voltage Protector
 P1—Optional Gauge
 P2—Optional Gauge

P3—Oil Pressure Gauge
 P4—Coolant Temperature Gauge
 P5—Tachometer Display
 P6—Hour Meter/Diagnostic Gauge
 S1—Ignition Key Switch
 S2—Speed Select Switch (Momentary)

S3—Bump Enable Switch (Momentary)
 S4—High-Low Speed Select Switch
 S5—Override Shutdown Switch (Momentary)
 V1—Diode
 X1—Vehicle Harness Connector

X2—Alternator Harness Connector
 X3—Single Point Ground
 X4—CAN Terminator
 X5—Analog Throttle Connector

OURGP12.00001DF -19-15MAR06-1/1

PG19272 -UN-26JAN04

Instrument Panel Method for Retrieving Diagnostic Trouble Codes

IMPORTANT: Care should be used during diagnostic procedures to avoid damaging the terminals of connectors, sensors, and actuators. Probes should not be poked into or around the terminals or damage will result. Probes should only be touched against the terminals to make measurements.

Diagnosis of the Deere electronic control system on engines with Deere electronic instrument panel should be performed as follows:

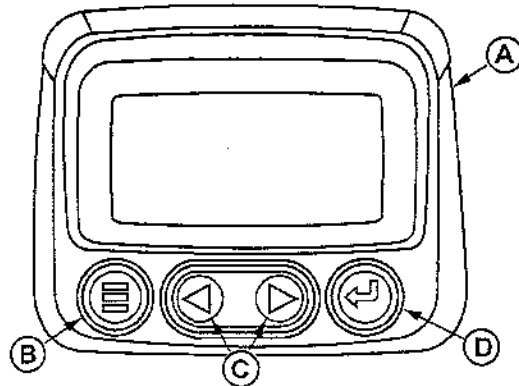
1. Make sure all engine mechanical and other systems not related to the electronic control system are operating properly. (See ENGINE TROUBLESHOOTING later in this section.)

NOTE: Diagnostic gauge (A) uses the menu key (B) to access various engine functions, two arrow keys (C) to scroll through the engine parameter list and view the menu list, and an enter key (D) for selecting highlighted items.

Read and record DTC(s) displayed on LCD of diagnostic gauge (A). For procedure to access diagnostic trouble codes, refer to "Using Diagnostic Gauge to Access Engine Information", earlier in this manual.

3. Go to the LISTING OF DIAGNOSTIC TROUBLE CODES (DTCs) later in this section, to interpret to the DTC(s) present.

4. Contact your nearest engine distributor or servicing dealer with a list of DTC(s) so that necessary repairs can be made.



Trouble Code Display On Instrument Panel

- A—Diagnostic Gauge
- B—Menu Key
- C—Arrow Keys
- D—Enter Key

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Displaying Of Diagnostic Trouble Codes (DTCs)

SPN/FMI CODES

Stored and active diagnostic trouble codes are output on the diagnostic gauge on the Deere electronic instrument panel according to the J1939 standard as a two-part code as shown on the tables on the following pages.

The first part is a Suspect Parameter Number (SPN) followed by a Failure Mode Identifier (FMI) code. In order to determine the exact failure, both parts (SPN and FMI) of the code are needed.

The SPN identifies the system or the component that has the failure; for example SPN 000110 indicates a failure in the engine coolant temperature circuit.

The FMI identifies the type of failure that has occurred; for example FMI 03 indicates value above normal. Combining SPN 000110 with FMI 03 yields a fault code "engine coolant temperature input voltage too high". A corrective action will also be displayed, "check sensor and wiring". If this check does not solve the engine fault, contact your servicing dealer.

Always contact your servicing dealer for help in correcting unsolved diagnostic trouble codes which are displayed for your engine.

OURGP12.00000F0 -19-11OCT06-1/1

Listing of Diagnostic Trouble Codes (DTCs)

JTE: Not all of these codes are used on all OEM engine applications

Trouble Codes

DTC's Listing in Ascending SPN/FMI Codes

SPN	FMI	Description of Fault	Corrective Action
000028	03	Throttle #3 Signal Out of Range High	Check Sensor and Wiring
	04	Throttle #3 Signal Out of Range Low	Check Sensor and Wiring
000029	03	Throttle #2 Signal Out of Range High	Check Sensor and Wiring
	04	Throttle #2 Signal Out of Range Low	Check Sensor and Wiring
000084	31	Vehicle Speed Signal Unreliable	Contact Servicing Dealer
000091	03	Throttle #1 Signal Out of Range High	Check Switch and Wiring
	04	Throttle #1 Signal Out of Range Low	Check Switch and Wiring
	09	Throttle #1 Communication Signal Erratic	Check Sensor and Wiring
000094	03	Low Pressure Fuel Signal Out of Range High	Check Sensor and Wiring
	04	Low Pressure Fuel Signal Out of Range Low	Check Sensor and Wiring
	10	Low Pressure Fuel Rate of Change Abnormal	Contact Servicing Dealer
	13	Low Pressure Fuel Out of Calibration	Contact Servicing Dealer
	17	High Pressure Fuel System Pressure Slightly Low	Contact Servicing Dealer
000097	00	Water in Fuel Continuously Detected	Contact Servicing Dealer
	03	Water-in-Fuel Signal Out of Range High	Check Sensor and Wiring
	04	Water-in-Fuel Signal Out of Range Low	Check Sensor and Wiring
	16	Water in Fuel Detected	Stop and Drain Water Separator
000100	01	Engine Oil Pressure Signal Extremely Low	Check Oil Level
	03	Engine Oil Pressure Signal Out of Range High	Check Sensor and Wiring
	04	Engine Oil Pressure Signal Out of Range Low	Check Sensor and Wiring
	18	Engine Oil Pressure Signal Moderately Low	Check Oil Level
000105	00	Intake Manifold Air Temperature Signal Extremely High	Check Air Cleaner, Aftercooler, or Room Temperature
	03	Intake Manifold Air Temperature Signal Out of Range High	Check Sensor and Wiring
	04	Intake Manifold Air Temperature Signal Out of Range Low	Check Sensor and Wiring
	16	Intake Manifold Air Temperature Signal Moderately High	Check Air Cleaner, Aftercooler, or Room Temperature
000107	00	Air Filter Pressure Differential Extremely High	Check for plugged air filter
000110	00	Engine Coolant Temperature Signal Extremely High	Check Cooling System, Reduce Power
	03	Engine Coolant Temperature Signal Out of Range High	Check Sensor and Wiring
	04	Engine Coolant Temperature Signal Out of Range Low	Check Sensor and Wiring
	15	Engine Coolant Temperature Signal Slightly High	Check Cooling System, Reduce Power
	16	Engine Coolant Temperature Signal Moderately High	Check Cooling System, Reduce Power
000111	01	Engine Coolant Level Low	Check Operator's Manual, "Adding Coolant"
000158	17	ECU Power Down Error (Internal ECU Problem)	Contact Servicing Dealer
000160	02	Axle Speed Signal Unreliable	Contact Servicing Dealer
000174	00	Fuel Temperature Signal Extremely High	Add Fuel or Switch Fuel Tanks
000174	03	Fuel Temperature Signal Out of Range High	Check Sensor and Wiring
	04	Fuel Temperature Signal Out of Range Low	Check Sensor and Wiring
	16	Fuel Temperature Signal Moderately High	Add Fuel or Switch Fuel Tanks
000189	00	Engine Speed Derate Condition Exists	Check Fault Codes or Contact Servicing Dealer

Continued on next page

OURGP12.000152 -13-15MAR06-1/3

Troubleshooting

SPN	FMI	Description of Fault	Corrective Action
000190	00	Engine Speed Extremely High	Reduce Engine Speed
	16	Engine Speed Moderately High	Reduce Engine Speed
000611	03	Injector Shorted to Power	Check Wiring
	04	Injector Shorted to Ground	Check Wiring
000620	03	Sensor Supply 2 Voltage High	Check Wiring
	04	Sensor Supply 2 Voltage Low	Check Wiring
000627	01	All Injector Currents Are Low	Check Battery Voltage and Wiring
000629	13	ECU Programming Error	Contact Service Dealer
000636	02	Engine Position Sensor Signal Unreliable	Check Sensor and Wiring
	08	Engine Position Sensor Signal Missing	Check Sensor and Wiring
	10	Engine Position Sensor Signal Rate of Change Abnormal	Check Sensor and Wiring
000637	02	Engine Timing Sensor Signal Unreliable	Check Sensor and Wiring
	07	Engine Timing and Position Sensors Out of Sync	Check Sensor and Wiring
	08	Engine Timing Sensor Signal Missing	Check Sensor and Wiring
	10	Engine Timing Signal Rate of Change Abnormal	Check Sensor and Wiring
000639	13	CAN Bus Error (Communication network problem)	Contact Servicing Dealer
000651	05	Injector Number 1 Circuit Has High Resistance	Check Injector Wiring or Injector Solenoid
	06	Injector Number 1 Circuit Has Low Resistance	Check Injector Wiring or Injector Solenoid
	07	Injector Number 1 Not Responding	Injector Failed or Flow Limiter Closed
000652	05	Injector Number 2 Circuit Has High Resistance	Check Injector Wiring or Injector Solenoid
	06	Injector Number 2 Circuit Has Low Resistance	Check Injector Wiring or Injector Solenoid
	07	Injector Number 2 Not Responding	Injector Failed or Flow Limiter Closed
000653	05	Injector Number 3 Circuit Has High Resistance	Check Injector Wiring or Injector Solenoid
	06	Injector Number 3 Circuit Has Low Resistance	Check Injector Wiring or Injector Solenoid
	07	Injector Number 3 Not Responding	Injector Failed or Flow Limiter Closed
000654	05	Injector Number 4 Circuit Has High Resistance	Check Injector Wiring or Injector Solenoid
	06	Injector Number 4 Circuit Has Low Resistance	Check Injector Wiring or Injector Solenoid
	07	Injector Number 4 Not Responding	Injector Failed or Flow Limiter Closed
000655	05	Injector Number 5 Circuit Has High Resistance	Check Injector Wiring or Injector Solenoid
	06	Injector Number 5 Circuit Has Low Resistance	Check Injector Wiring or Injector Solenoid
	07	Injector Number 5 Not Responding	Injector Failed or Flow Limiter Closed
000656	05	Injector Number 6 Circuit Has High Resistance	Check Injector Wiring or Injector Solenoid
	06	Injector Number 6 Circuit Has Low Resistance	Check Injector Wiring or Injector Solenoid
	07	Injector Number 6 Not Responding	Injector Failed or Flow Limiter Closed
000898	09	Vehicle Speed or Torque Message Unreliable	Contact Servicing Dealer
000970	31	External Shutdown Commanded	Not Engine Fault. Check Other Shutdown Devices
000971	31	External Fuel Derate Switch Active	Not Engine Fault. Check Other Shutdown Devices
001069	09	Tire Size Invalid	Contact Servicing Dealer
	31	Tire Size Error	Contact Servicing Dealer
001079	03	Sensor Supply 1 Voltage High	Check Wiring
	04	Sensor Supply 1 Voltage Low	Check Wiring
001080	03	Fuel Rail Pressure Sensor Supply Voltage High	Check Wiring
	04	Fuel Rail Pressure Sensor Supply Voltage Low	Check Wiring
001109	31	Engine Protection Shutdown Warning	Shut Down Engine, Check Fault Codes
001110	31	Engine Protection Shutdown	Shut Down Engine, Check Fault Codes
001347	03	High Pressure Fuel Pump Control Valve Signal Out of Range High	Contact Servicing Dealer
	05	High Pressure Fuel Pump Solenoid Number 1 Circuit Has High Resistance	Check Pump Wiring
	07	High Pressure Fuel Pump Not Able to Meet Required Rail Pressure	Check Fuel Filter and Lines
001568	02	Requested Torque Curve Signal Unreliable	Contact Servicing Dealer
001569	31	Engine in Derate Condition	Check Fault Codes

Continued on next page

OURGP12.00001E2 -19-15MAR06-2/3

SPN	FMI	Description of Fault	Corrective Action
002000	13	Security Violation	Contact Servicing Dealer

OURGP12.00001E2 -19-15MAR06-3/3

Intermittent Fault Diagnostics (With Electronic Controls)

Intermittent faults are problems that periodically "go away". A problem such as a terminal that intermittently doesn't make contact can cause an intermittent fault. Other intermittent may be set only under certain operating conditions such as heavy load, extended idle, etc. When diagnosing intermittent faults, take special note of the condition of wiring and connectors, since a high percentage of intermittent problems originate here. Check for loose, dirty or disconnected connectors. Inspect the wiring routing, looking for possible shorts caused by contact with external parts (for example, rubbing against sharp sheet metal edges). Inspect the connector vicinity, looking for wires that have pulled out of connectors, poorly positioned terminals, damaged connectors and corroded or damaged splices and terminals. Look for broken wires, damaged splices, and wire-to-wire shorts. Use good judgement if component replacement is thought to be required.

NOTE: The engine control unit (ECU) is the component **LEAST** likely to fail.

- If the problem is intermittent, try to reproduce the operating conditions that were present when the diagnostic trouble code (DTC) set.
- If a faulty connection or wire is suspected to be the cause of the intermittent problem: clear DTCs, then check the connection or wire by wiggling it while watching the diagnostic gauge to see if the fault resets.

Possible causes of intermittent faults:

- Faulty connection between sensor or actuator harness.
- Faulty contact between terminals in connector.
- Faulty terminal/wire connection.
- Electromagnetic interference (EMI) from an improperly installed 2-way radio, etc., can cause faulty signals to be sent to the ECU.

NOTE: Refer to wiring diagrams earlier in this section as a guide to connection and wiring.

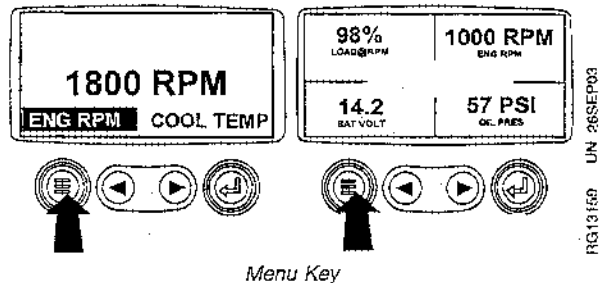
Suggestions for diagnosing intermittent faults:

OUOD007.0000036 -19-27JUL06-1/1

Displaying Diagnostic Gauge Software

NOTE: The following steps can be used to display the software version of the diagnostic gauge if needed by your dealer for troubleshooting. This is a read only function.

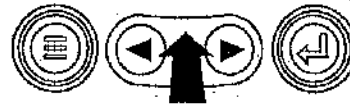
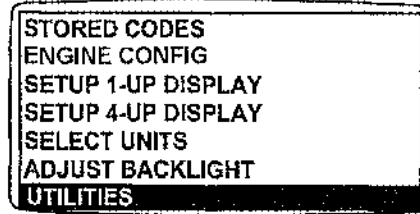
1. Starting at the single or four engine parameter display, press the "Menu" key.



Continued on next page

OURGP12.00001E3 -19-15MAR06-1/4

2. The main menu will be displayed. Use the "Arrow" key to scroll through the menu until "Utilities" is highlighted.

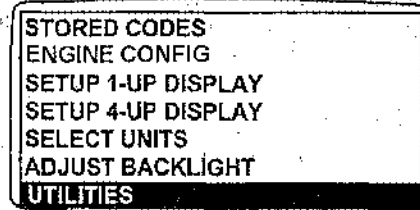


Select Utilities

RG13234 -UN-22OCT03

OURGP12.00001E3 -19-15MAR06-2/4

3. Once "Utilities" is highlighted, press "Enter" to activate the utilities function.



Select Utilities

RG13237 -UN-22OCT03

OURGP12.00001E3 -19-15MAR06-3/4

4. Scroll to the "Software Version". Press "Enter" to view the software version. Press the menu button twice to return to the main menu.



Software Version

RG13236 -UN-13OCT03

OURGP12.00001E3 -19-15MAR06-4/4

Engine Troubleshooting

JTE: Before troubleshooting the engine, first retrieve any fault codes on the diagnostic gauge display and perform the corrective actions. (See earlier in this section.) If any problems remain, use the following charts to solve engine problems.

Symptom	Problem	Solution
Engine cranks but will not start	Incorrect starting procedure.	Verify correct starting procedure.
	No fuel.	Check fuel in tank.
	Exhaust restricted.	Check and correct exhaust restriction.
	Fuel filter plugged or full of water.	Replace fuel filter or drain water from filter.
	Injection pump not getting fuel or air in fuel system.	Check fuel flow at supply pump or bleed fuel system.
	Faulty injection pump or nozzles.	Consult authorized diesel repair station for repair or replacement.
Engine hard to start or will not start	Engine starting under load.	Disengage PTO.
	Improper starting procedure.	Review starting procedure.
	No fuel.	Check fuel tank.
	Air in fuel line.	Bleed fuel line.
	Cold weather.	Use cold weather starting aids.
	Slow starter speed.	See "Starter Cranks Slowly".
	Crankcase oil too heavy.	Use oil of proper viscosity.
	Improper type of fuel.	Consult fuel supplier; use proper type fuel for operating conditions.
	Water, dirt, or air in fuel system.	Drain, flush, fill, and bleed system.
	Clogged fuel filter.	Replace filter element.

Symptom	Problem	Solution
	Dirty or faulty electronic fuel injectors.	Have authorized servicing dealer or engine distributor check injectors.
	Electronic fuel system problem (if equipped)	See your John Deere distributor or servicing dealer.
Engine knocks	Low engine oil level.	Add oil to engine crankcase.
	Low coolant temperature.	Remove and check thermostat.
	Engine overheating.	See "Engine Overheats".
	Engine cold	Wrong or defective thermostat. Remove and check thermostat.
Engine runs irregularly or stalls frequently	Low coolant temperature.	Remove and check thermostat.
	Clogged fuel filter.	Replace fuel filter element.
	Water, dirt, or air in fuel system.	Drain, flush, fill, and bleed system.
	Dirty or faulty injection nozzles.	Have authorized servicing dealer or engine distributor check injectors.
Below normal engine temperature	Electronic fuel system problem	See your John Deere distributor or servicing dealer.
	Defective thermostat.	Remove and check thermostat.
	Defective temperature gauge or sender.	Check gauge, sender, and connections.
Lack of power	Engine overloaded.	Reduce load.
	Intake air restriction.	Service air cleaner.
	Clogged fuel filter.	Replace filter elements.
	Improper type of fuel.	Use proper fuel.
	Overheated engine.	See "Engine Overheats".
	Below normal engine temperature.	Remove and check thermostat.

Continued on next page

OURGP12.00001E0 -19-10APR08-2/6

Troubleshooting

Symptom	Problem	Solution
	Improper valve clearance.	See your authorized servicing dealer or engine distributor.
	Dirty or faulty injection nozzles.	Have authorized servicing dealer or engine distributor check injectors.
	Injection pump out of time.	See your authorized servicing dealer or engine distributor.
	Electronic fuel system problem	See your John Deere distributor or servicing dealer.
	Turbocharger not functioning. (Turbocharger engines only.)	See your authorized servicing dealer or engine distributor.
	Leaking exhaust manifold gasket.	See your authorized servicing dealer or engine distributor.
	Defective aneroid control line.	See your authorized servicing dealer or engine distributor.
	Restricted fuel hose.	Clean or replace fuel hose.
	Low fast idle speed.	See your authorized servicing dealer or engine distributor.
Low oil pressure	Low oil level.	Add oil.
	Improper type of oil.	Drain, fill crankcase with oil of proper viscosity and quality.
High oil consumption	Crankcase oil too light.	Use proper viscosity oil.
	Oil leaks.	Check for leaks in lines, gaskets, and drain plug.
	Restricted crankcase vent tube.	Clean vent tube.
	Defective turbocharger.	See your authorized servicing dealer or engine distributor.
Engine emits white smoke	Improper type of fuel.	Use proper fuel.
	Low engine temperature.	Warm up engine to normal operating temperature.
	Defective thermostat.	Remove and check thermostat.

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OURGIP12.00001E0 -19-10APR08-3/6

Symptom	Problem	Solution
Engine emits black or gray exhaust smoke	Defective electronic fuel injectors	See your authorized servicing dealer or engine distributor.
	Improper type of fuel.	Use proper fuel.
	Clogged or dirty air cleaner.	Service air cleaner.
	Engine overloaded.	Reduce load.
	Defective electronic fuel injectors.	See your authorized servicing dealer or engine distributor.
	Electronic fuel system problem	See your authorized servicing dealer or engine distributor.
Engine overheats	Turbocharger not functioning.	See your authorized servicing dealer or engine distributor.
	Engine overloaded.	Reduce load.
	Low coolant level.	Fill radiator to proper level, check radiator and hoses for loose connections or leaks.
	Faulty radiator cap.	Have technician check.
	Stretched poly-vee belt or defective belt tensioner.	Check automatic belt tensioner and check belts for stretching. Replace as required.
	Low engine oil level.	Check oil level. Add oil as required.
	Cooling system needs flushing.	Flush cooling system.
	Defective thermostat.	Remove and check thermostat.
	Defective temperature gauge or sender.	Check coolant temperature with thermometer and replace, if necessary.
	Incorrect grade of fuel.	Use correct grade of fuel.
High fuel consumption	Improper type of fuel.	Use proper type of fuel.
	Clogged or dirty air cleaner.	Service air cleaner.

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OURGP12.00001E30 -19-10APR08-4/6

Symptom	Problem	Solution
	Engine overloaded.	Reduce load.
	Improper valve clearance.	See your authorized servicing dealer or engine distributor.
	Electronic fuel injectors dirty.	See your authorized servicing dealer or engine distributor.
	Electronic fuel system problem	See your authorized servicing dealer or engine distributor.
	Defective turbocharger.	See your authorized servicing dealer or engine distributor.
	Low engine temperature.	Check thermostat.
Undercharged electrical system	Excessive electrical load from added accessories.	Remove accessories or install higher output alternator.
	Excessive engine idling.	Increase engine rpm when heavy electrical load is used.
	Poor electrical connections on battery, ground strap, starter, or alternator.	Inspect and clean as necessary.
	Defective battery.	Test battery.
	Defective alternator.	Test charging system.
Battery uses too much water	Cracked battery case.	Check for moisture and replace as necessary.
Batteries will not charge	Defective battery.	Test battery.
	Battery charging rate too high.	Test charging system.
	Loose or corroded connections.	Clean and tighten connections.
	Sulfated or worn-out batteries.	See your authorized servicing dealer or engine distributor.
	Stretched poly-vee belt or defective belt tensioner.	Adjust belt tension or replace belts.
Starter will not crank	PTO engaged.	Disengage PTO.

Symptom	Problem	Solution
	Loose or corroded connections.	Clean and tighten loose connections.
	Low battery output voltage.	See your authorized servicing dealer or engine distributor.
	Faulty start circuit relay.	See your authorized servicing dealer or engine distributor.
	Blown main system fuse.	Replace fuse. (See Wiring Diagram.)
Starter cranks slowly	Low battery output.	See your authorized servicing dealer or engine distributor.
	Crankcase oil too heavy.	Use proper viscosity oil.
	Loose or corroded connections.	Clean and tighten loose connections.
Starter and hour meter functions; rest of electrical system does not function	Blown fuse on magnetic switch.	Replace fuse.
Entire electrical system does not function	Faulty battery connection.	Clean and tighten connections.
	Sulfated or worn-out batteries.	See your authorized servicing dealer or engine distributor.
	Blown main system fuse.	Replace fuse.

OURGP12,00001E0 -19-10A7P08-6/6

Storage

Engine Storage Guidelines

- John Deere engines can be stored outside for up to three (3) months with no long term preparation IF COVERED BY WATERPROOF COVERING. No outside storage is recommended without a waterproof covering.
2. John Deere engines can be stored in a standard overseas shipping container for up to three (3) months with no long term preparation.
 3. John Deere engines can be stored inside for up to six (6) months with no long term preparation.
 4. John Deere engines expected to be stored more than six (6) months MUST have long term storage preparation. (See PREPARING ENGINE FOR LONG TERM STORAGE, later in this section.)
 5. Long term storage includes the use of a stabilized rust preventive oil to protect internal metal components of the engine. This oil should be an SAE 10 oil with 1-4 percent morpholine or equivalent vapor corrosion inhibitor. These rust preventive oils are available from area distributors.

OURGP12.00000DF -19-11OCT06-1/1

Preparing Engine for Long Term Storage

The following storage preparations are used for long term engine storage up to one year. After that, the engine should be started, warmed up, and retreated for an extended storage period.

IMPORTANT: Any time your engine will not be used for over six (6) months, the following recommendations for storing it and removing it from storage will help to minimize corrosion and deterioration.

IMPORTANT: DO NOT USE BIODIESEL DURING MACHINE STORAGE. When using biodiesel blends, switch to petroleum diesel for long term storage. Before storage, operate engine on at least one complete tank of petroleum diesel fuel to purge the fuel system. Follow normal storage procedures once the fuel system has been purged.

1. Change engine oil and replace filter. (See CHANGE ENGINE OIL AND FILTER in Lubrication and Maintenance/500 Hour Section.) Used oil will not give adequate protection. Add one (1) ounce of rust preventive oil to the engine crankcase for every quart of oil. This rust preventive oil should be an SAE 10 oil with 1-4 percent morpholine or equivalent vapor corrosion inhibitor.
2. Ensure the machine fuel tank is filled with high quality petroleum diesel fuel. Filling the tank completely will ensure that water does not build up due to condensation. For storage of more than one year, use John Deere PREMIUM DIESEL FUEL CONDITIONER (or equivalent) at the specified concentration.
3. Service air cleaner. (See REPLACING AIR CLEANER FILTER ELEMENTS in Service As Required Section.)
4. Draining and flushing of cooling system is not necessary if engine is to be stored only for several months. However, for extended storage periods of a year or longer, it is recommended that the cooling system be drained, flushed, and refilled. Refill with appropriate coolant. (See RECOMMENDED ENGINE COOLANT in Fuels, Lubricants, and Coolant Section and ADDING COOLANT in Service As Required Section.)
5. Pour three (3) ounces of rust preventive oil into the turbocharger intake. (It may be necessary to temporarily install a short intake elbow on the turbocharger inlet to receive the oil.)
6. Prepare a tank with a solution of diesel fuel and rust preventive oil, at ten (10) ounces of rust preventive oil per gallon of diesel fuel.
7. Remove existing lines/plugs as required, and run a temporary line from the tank to the engine fuel intake, and another temporary line from the fuel return manifold to the tank, so rust preventive oil solution is circulated through the injection system during cranking.
8. Crank the engine several revolutions with starter (do not allow the engine to start). This will allow rust preventive oil solution to circulate.
9. Remove temporary lines installed in Step 6 above, and replace any lines/plugs previously removed.

Continued on next page

QUJD006.00000FC -19-04OCT07-1/2

NOTE: One gallon of fuel/oil solution can be used to treat 100 engines; two gallons to treat 200 engines, etc. The oil could then be replenished by adding an additional five (5) ounces of rust preventive oil per gallon of solution. However, starting over with a new solution is recommended to dispose of any water or other impurities.

10. Loosen, or remove and store, fan/alternator poly-vee belt.

11. Remove and clean batteries. Store them in a cool, dry place and keep them fully charged.

12. Disengage the clutch for any driveline.

13. Clean the exterior of the engine with salt-free water and touch up any scratched or chipped painted surfaces with a good quality paint.

14. Coat all exposed (machined) metal surfaces with grease or corrosion inhibitor if not feasible to paint.

15. Seal all openings on engine with plastic bags and tape.

16. Store the engine in a dry protected place. If engine must be stored outside, cover it with a waterproof canvas or other suitable protective material and use a strong waterproof tape.

QUOD006.00000FC -19-04OCT07-2/2

Removing Engine from Long Term Storage

Refer to the appropriate section for detailed services listed below or have your authorized servicing dealer or engine distributor perform services that you may not be familiar with.

1. Remove all protective coverings from engine. Unseal all openings in engine and remove covering from electrical systems.

2. Remove the batteries from storage. Install batteries (fully charged) and connect the terminals.

3. Install fan/alternator poly-vee belt if removed.

4. Fill fuel tank.

5. Perform all appropriate prestarting checks. (See DAILY PRESTARTING CHECKS in Lubrication and Maintenance/Daily Section.)

IMPORTANT: DO NOT operate starter more than 30 seconds at a time. Wait at least 2

minutes for starter to cool before trying again.

6. Crank engine for 20 seconds with starter (do not allow the engine to start). Wait 2 minutes and crank engine an additional 20 seconds to assure bearing surfaces are adequately lubricated.

7. Start engine and run at low idle and no load for several minutes. Warm up carefully and check all gauges before placing engine under load.

8. On the first day of operation after storage, check overall engine for leaks and check all gauges for correct operation.

NOTE: If using BIODIESEL blends after long term storage, frequency of fuel filter plugging may increase initially.

QUOD006.00000FD -19-02OCT07-1/1

Specifications

General OEM Engine Specifications

ITEM	4045TF285/HF285	6068HF285
Number of Cylinders	4	6
Bore	106 mm (4.19 in.)	106 mm (4.19 in.)
Stroke	127 mm (5.0 in.)	127 mm (5.0 in.)
Displacement	4.5 L (276 cu in.)	6.8 L (414 cu in.)
Compression Ratio	19.0:1	19.0:1
Aspiration	Turbocharged or Turbocharged and Air-to-Air Aftercooled	Turbocharged and Air-to-Air Aftercooled
Engine Firing Order	1-3-4-2	1-5-3-6-2-4
Valves Per Cylinder	1 Intake 1 Exhaust	1 Intake 1 Exhaust
Valve Clearance (Cold) Intake (Checking)	0.31-0.38 mm (0.012-0.015 in)	0.31-0.38 mm (0.012-0.015 in)
Exhaust (Checking)	0.41-0.48 mm (0.016-0.019 in)	0.41-0.48 mm (0.016-0.019 in)
Intake (Adjusting)	0.36 mm (0.014 in.)	0.36 mm (0.014 in.)
Exhaust (Adjusting)	0.46 mm (0.018 in.)	0.46 mm (0.018 in.)
Max. Crank Pressure	0.5 kPa (2 H ₂ O)	0.5 kPa (2 H ₂ O)
Vibration Damper Maximum Radial Runout	1.50 mm (0.060 in.)	1.50 mm (0.060 in.)
Battery Capacities (CCA) 12-Volt System	670	800
24-Volt System	570	570
Governor Regulation (Industrial)	7—10 %	7—10 %
Governor Regulation (Generator)	5%	5%
Thermostat Start To Open Temperature	82°C (180°F)	82°C (180°F)
Thermostat Fully Open Temperature	95°C (204°F)	95°C (204°F)
Coolant Capacity	8.5 L (9 qt)	11.9 L (13 qt)
Recommended Radiator Pressure Cap	100 kPa (14.5 psi)	100 kPa (14.5 psi)
Crankcase Oil Fill Capacity	See "Engine Crankcase Oil Fill Quantities" later in this section.	

Continued on next page

OURGP12.00001E4 -19-18APR08-1/2

Specifications

ITEM	4045TF285/HF285	6068HF285
Oil Pressure At Rated Speed, Full Load	345 ± 103 kPa 3.45 ± 1.03 bar (50 ± 15 psi)	345 ± 103 kPa 3.45 ± 1.03 bar (50 ± 15 psi)
Oil Pressure At Low Idle (Minimum)	103 kPa (15 psi)	103 kPa (15 psi)
Length	860 mm (33.9 in.)	1123 mm (44.2 in.)
Width	612 mm (24.1 in.)	657 mm (25.9 in.)
Height	1039 mm (40.9 in.)	1036 mm (40.8 in.)
Weight	491 kg (1083 lb)	608 kg (1340 lb)

OURC:P12.00001E4 -13-18APR08-2/2

Engine Power Ratings¹ And Fuel System Specifications²

Engine Model	Fuel System Option Codes	Electronic Software Option Codes	System Voltage	Power Rating @ Rated Speed kW (hp)	Rated Speed (rpm)	Slow Idle (rpm)	Fast Idle (rpm)
4045TF285		72RM	12V	74 (99)	2400	800	2600
		72RN	24V	74 (99)	2400	800	2600
		72RR	12V	63 (85)	2400	800	2600
		72RS	24V	63 (85)	2400	800	2600
		72RT	12V	63 (85)	2200	800	2400
		72RU	24V	63 (85)	2200	800	2400
		72RV	12V	74 (99)	1800	1150	1870
		72RW	24V	74 (99)	1800	1150	1870
4045HF285		72MV	12V	104 (140)	2400	800	2600
		72MW	24V	104 (140)	2400	800	2600
		72MX	12V	93 (125)	2400	800	2600
		72MY	24V	93 (125)	2400	800	2600
		72MZ	12V	93 (125)	2200	800	2400
		72NA	24V	93 (125)	2200	800	2400
		72NB	12V	86 (115)	2400	800	2600
		72NC	24V	86 (115)	2400	800	2600
		72ND	12V	86 (115)	2200	800	2400
		72NE	24V	86 (115)	2200	800	2400
		72NF	12V	94 (126)	1800	1150	1870
		72NG	24V	94 (126)	1800	1150	1870
		72NH	12V	118 (158)	1800	1150	1870
		72NJ	24V	118 (158)	1800	1150	1870
		72SQ	12V	99 (133)	1800	1150	1870
		72SR	24V	99 (133)	1800	1150	1870
6068HF285		72LX	12V	149 (200)	2400	800	2600
		72LY	24V	149 (200)	2400	800	2600
		72LZ	12V	138 (185)	2400	800	2600
		72MA	24V	138 (185)	2400	800	2600
		72MB	12V	138 (185)	2200	800	2400
		72MC	24V	138 (185)	2200	800	2400
		72MD	12V	129 (173)	2400	800	2600
		72ME	24V	129 (173)	2400	800	2600
		72MF	12V	129 (173)	2200	800	2400
		72MG	24V	129 (173)	2200	800	2400
		72MH	12V	116 (156)	2400	800	2600
		72MJ	24V	116 (156)	2400	800	2600

¹Power ratings are for bare engines without drag effect of cooling fan or accessories like air compressors.

²Engine speeds listed are preset to factory specification. Slow idle speed may be reset depending upon specific vehicle application requirements. Refer to your machine operator's manual for engine speeds that are different from those preset at the factory.

Continued on next page

OURGP12.00001E5 -19-18APR08-1/2

Specifications

Engine Model	Fuel System Option Codes	Electronic Software Option Codes	System Voltage	Power Rating @ Rated Speed kW (hp)	Rated Speed (rpm)	Slow Idle (rpm)	Fast Idle (rpm)
		72MK	12V	116 (156)	2200	800	2400
		72ML	24V	116 (156)	2200	800	2400
		72MM	12V	104 (139)	2400	800	2600
		72MN	24V	104 (139)	2400	800	2600
		72MP	12V	104 (139)	2200	800	2400
		72MQ	24V	104 (139)	2200	800	2400
		72MR	12V	147 (197)	1800	1150	1870
		72MS	24V	147 (197)	1800	1150	1870
		72MT	12V	177 (237)	1800	1150	1870
		72MU	24V	177 (237)	1800	1150	1870
		72WM	12V	129 (173)	2200	800	2400

OJRG P12,00001E5 -19-18APR08-2/2

Engine Crankcase Oil Fill Quantities

To determine the option code for the oil fill quantity of your engine, refer to the engine option code label affixed to the rocker arm cover. The first two digits of the code (19) identify the oil pan option group. The last two digits of each code identify the specific oil pan on your engine.

NOTE: Crankcase oil capacity may vary slightly from amount shown. ALWAYS fill crankcase to within crosshatch on dipstick. DO NOT overfill.

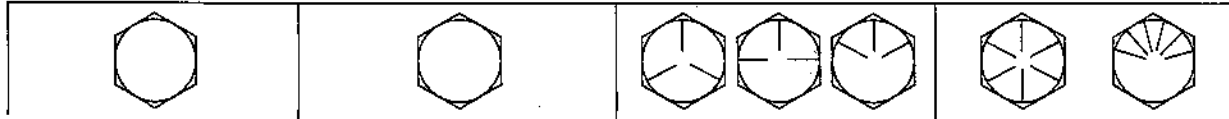
The following table lists engine crankcase oil fill quantities:

Engine Model	Oil Pan Option Code(s)	Crankcase Oil Capacity L (qt)
4045TF285/HF285	1903	12.0 (12.7)
	1923	15.0 (15.8)
	1976	20.5 (21.6)
	19AE	14.7 (15.5)
	19SC	14.7 (15.5)
6068HF285	1907	19.5 (20.1)
	1908	19.0 (20.1)
	1909	19.0 (20.1)
	1944	19.0 (20.1)
	1956	20.0 (21.1)
	1961	32.5 (34.4)
	1968	32.0 (33.8)
	19AC	27.0 (28.5)
	19AU	32.5 (34.4)
	19AV	27.0 (28.5)

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Unified Inch Bolt and Screw Torque Values

TS1671 -UN-01MAY03



Bolt or Screw	SAE Grade 1				SAE Grade 2 ^a				SAE Grade 5, 5.1 or 5.2				SAE Grade 8 or 8.2			
	Lubricated ^b		Dry ^c		Lubricated ^b		Dry ^c		Lubricated ^b		Dry ^c		Lubricated ^b		Dry ^c	
Size	N•m	lb-in	N•m	lb-in	N•m	lb-in	N•m	lb-in	N•m	lb-in	N•m	lb-in	N•m	lb-in	N•m	lb-in
1/4	3,7	33	4,7	42	6	53	7,5	66	9,5	84	12	106	13,5	120	17	150
													N•m	lb-ft	N•m	lb-ft
5/16	7,7	68	9,8	86	12	106	15,5	137	19,5	172	25	221	28	20,5	35	26
									N•m	lb-ft	N•m	lb-ft				
3/8	13,5	120	17,5	155	22	194	27	240	35	26	44	32,5	49	36	63	46
			N•m	lb-ft	N•m	lb-ft	N•m	lb-ft								
7/16	22	194	28	20,5	35	26	44	32,5	56	41	70	52	80	59	100	74
	N•m	lb-ft														
1/2	34	25	42	31	53	39	67	49	85	63	110	80	120	88	155	115
9/16	48	35,5	60	45	76	56	95	70	125	92	155	115	175	130	220	165
5/8	67	49	85	63	105	77	135	100	170	125	215	160	240	175	305	225
3/4	120	88	150	110	190	140	240	175	300	220	380	280	425	315	540	400
7/8	190	140	240	175	190	140	240	175	490	360	615	455	690	510	870	640
1	285	210	360	265	285	210	360	265	730	540	920	680	1030	760	1300	960
1-1/8	400	300	510	375	400	300	510	375	910	670	1150	850	1450	1075	1850	1350
1-1/4	570	420	725	535	570	420	725	535	1280	945	1630	1200	2050	1500	2600	1920
1-3/8	750	550	950	700	750	550	950	700	1700	1250	2140	1580	2700	2000	3400	2500
1-1/2	990	730	1250	930	990	730	1250	930	2250	1650	2850	2100	3600	2650	4550	3350

Torque values listed are for general use only, based on the strength of the bolt or screw. DO NOT use these values if a different torque value or tightening procedure is given for a specific application. For plastic insert or crimped steel type lock nuts, for stainless steel fasteners, or for nuts on U-bolts, see the tightening instructions for the specific application. Shear bolts are designed to fail under predetermined loads. Always replace shear bolts with identical grade.

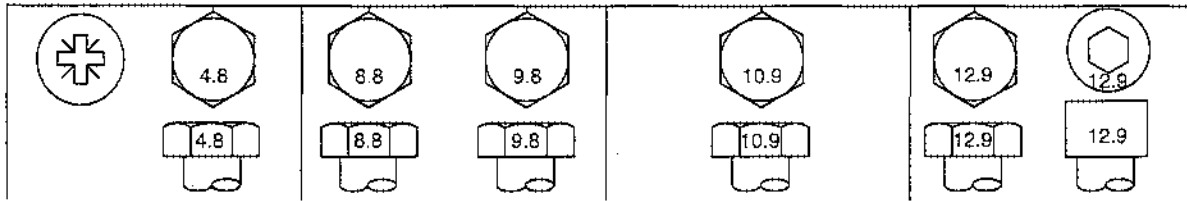
Replace fasteners with the same or higher grade. If higher grade fasteners are used, tighten these to the strength of the original. Make sure fastener threads are clean and that you properly start thread engagement. When possible, lubricate plain or zinc plated fasteners other than lock nuts, wheel bolts or wheel nuts, unless different instructions are given for the specific application.

^aGrade 2 applies for hex cap screws (not hex bolts) up to 6 in. (152 mm) long. Grade 1 applies for hex cap screws over 6 in. (152 mm) long, and for all other types of bolts and screws of any length.

^b"Lubricated" means coated with a lubricant such as engine oil, fasteners with phosphate and oil coatings, or 7/8 in. and larger fasteners with JDM F13C zinc flake coating.

^c"Dry" means plain or zinc plated without any lubrication, or 1/4 to 3/4 in. fasteners with JDM F13B zinc flake coating.

Metric Bolt and Screw Torque Values



TS1670 - JUN-01/MAY03

Bolt or Screw	Class 4.8				Class 8.8 or 9.8				Class 10.9				Class 12.9			
	Lubricated ^a		Dry ^b		Lubricated ^a		Dry ^b		Lubricated ^a		Dry ^b		Lubricated ^a		Dry ^b	
Size	N·m	lb-in	N·m	lb-in	N·m	lb-in	N·m	lb-in	N·m	lb-in	N·m	lb-in	N·m	lb-in	N·m	lb-in
M6	4.7	42	6	53	8.9	79	11.3	100	13	115	16.5	146	15.5	137	19.5	172
									N·m	lb-ft	N·m	lb-ft	N·m	lb-ft	N·m	lb-ft
M8	11.5	102	14.5	128	22	194	27.5	243	32	23.5	40	29.5	37	27.5	47	35
			N·m	lb-ft	N·m	lb-ft	N·m	lb-ft								
M10	23	204	29	21	43	32	55	40	63	46	80	59	75	55	95	70
	N·m	lb-ft														
M12	40	29.5	50	37	75	55	95	70	110	80	140	105	130	95	165	120
M14	63	46	80	59	120	88	150	110	175	130	220	165	205	150	260	190
M16	100	74	125	92	190	140	240	175	275	200	350	255	320	235	400	300
M18	135	100	170	125	265	195	330	245	375	275	475	350	440	325	560	410
M20	190	140	245	180	375	275	475	350	530	390	675	500	625	460	790	580
M22	265	195	330	245	510	375	650	480	725	535	920	680	850	625	1080	800
M24	330	245	425	315	650	480	820	600	920	680	1150	850	1080	800	1350	1000
M27	490	360	625	460	950	700	1200	885	1350	1000	1700	1250	1580	1160	2000	1475
M30	660	490	850	625	1290	950	1630	1200	1850	1350	2300	1700	2140	1580	2700	2000
M33	900	665	1150	850	1750	1300	2200	1625	2500	1850	3150	2325	2900	2150	3700	2730
M36	1150	850	1450	1075	2250	1650	2850	2100	3200	2350	4050	3000	3750	2770	4750	3500

Torque values listed are for general use only, based on the strength of the bolt or screw. DO NOT use these values if a different torque value or tightening procedure is given for a specific application. For stainless steel fasteners or for nuts on U-bolts, see the tightening instructions for the specific application. Tighten plastic insert or crimped steel type lock nuts by turning the nut to the dry torque shown in the chart, unless different instructions are given for the specific application.

Shear bolts are designed to fail under predetermined loads. Always replace shear bolts with identical property class. Replace fasteners with the same or higher property class. If higher property class fasteners are used, tighten these to the strength of the original. Make sure fastener threads are clean and that you properly start thread engagement. When possible, lubricate plain or zinc plated fasteners other than lock nuts, wheel bolts or wheel nuts, unless different instructions are given for the specific application.

^a"Lubricated" means coated with a lubricant such as engine oil, fasteners with phosphate and oil coatings, or M20 and larger fasteners with JDM F13C zinc flake coating.

^b"Dry" means plain or zinc plated without any lubrication, or M6 to M18 fasteners with JDM F13B zinc flake coating.

Lubrication and Maintenance Records

Using Lubrication and Maintenance Records

Refer to specific Lubrication and Maintenance Section for detailed service procedures.

1. Keep a record of the number of hours you operate your engine by regular observation of hour meter.
2. Check your record regularly to learn when your engine needs service.
3. DO ALL the services within an interval section. Write the number of hours (from your service records) and the date in the spaces provided. For a

complete listing of all items to be performed and the service intervals required, refer to the quick-reference chart near the front of the Lubrication and Maintenance Section.

IMPORTANT: The service recommendations covered in this manual are for the accessories that are provided by John Deere. Follow manufacturer's service recommendations for servicing engine driven equipment not supplied by Deere.

RG, RG34710, 5620 -19-27JUL06-1/1

Daily (Prestarting) Service

- Check engine oil level.
- Check coolant level.
- Check fuel filters/water bowls.
- Check air cleaner dust unloader valve and air restriction indicator, if equipped.
- Perform visual walkaround inspection.

RG, RG34710, 5621 -19-27JUL06-1/1

500 Hour/12 Month Service

- Service fire extinguisher.
- Check engine mounts.
- Service battery.
- Change engine oil and filter.¹
- Check crankcase vent system.
- Check air intake hoses, connections, and system.
- Replace fuel filter element.
- Check automatic belt tensioner and belt wear.
- Check engine electrical ground connection.
- Check cooling system.
- Coolant solution analysis – add SCAs as needed.
- Pressure test cooling system.
- Check engine speeds.

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¹If other than John Deere PLUS 50™ or ACEA E7, ACEA E6, ACEA E5 or ACEA E4 engine oil and the specified filter are used, the service interval for engine oil and filter is reduced (see DIESEL ENGINE OIL AND FILTER INTERVALS chart).

OURGP12.00001E7 -19-15MAR06-1/1

2000 Hour/24 Month Service

- Check crankshaft vibration damper (6-cylinder only).
- Flush and refill cooling system.¹
- Test thermostats.
- Check and adjust valve clearance.

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¹If John Deere COOL-GARD is used, the flushing interval may be extended to 3000 hours, or 36 months. If John Deere COOL-GARD is used and the coolant is tested annually AND additives are replenished as needed by adding a supplemental coolant additive, the flushing interval may be extended to 5000 hours or 60 months, whichever occurs first.

OURGP12.00001E8 -19-15MAR06-1/1

Service as Required

- Add coolant
- Service air cleaner.
- Replace poly-vee belts.
- Check fuses
- Check air compressor (if equipped)
- Bleed fuel system

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RG RG34710.5627 -19-27JUL06 -1/1

Emission System Warranty

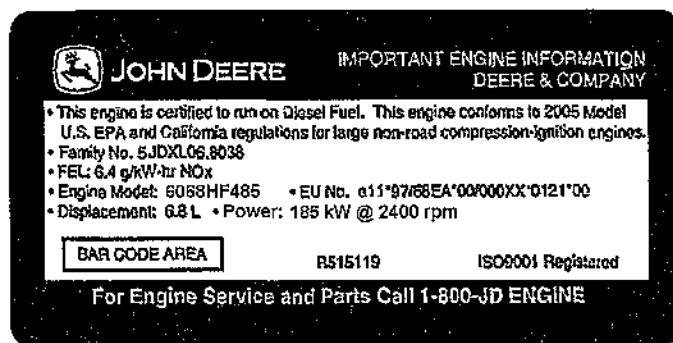
U.S. EPA Emissions Control Warranty Statement

Emissions control-related parts and components are warranted by John Deere for five years or 3000 hours of operation, whichever occurs first. John Deere further warrants that the engine covered by this warranty was designed, built, and equipped so as to conform at the time of sale with all U.S. emissions standards at the time of manufacture, and that it is free of defects in materials and workmanship which would cause it not to meet these standards within the period of five years or 3000 hours of operation, whichever occurs first.

Warranties stated in this manual refer only to emissions-related parts and components of your engine. The complete engine warranty, less emissions-related parts and components, is provided separately as the "John Deere New Off-Highway Engine Warranty".

RG, RG34710, 7629 -19-27JUL06-1/1

Emissions Control System Certification Label



Emissions Label



CAUTION: Statutes providing severe penalties for tampering with emissions controls may apply to the user or dealer.

The emissions warranty described below applies only to those engines marketed by John Deere that have been certified by the United States Environmental Protection Agency (EPA) and/or California Air Resources Board (CARB); and used in the United States and Canada in non-road equipment. The presence of an emissions label like the one shown signifies that the engine has been certified with the EPA and/or CARB. The EPA and CARB warranties

only apply to new engines having the certification label affixed to the engine and sold as stated above in the geographic areas. The presence of an EU number in the third line of the label signifies that the engine has been certified with the European Union countries per Directive 97/68/EC. The emissions warranty does not apply to the EU countries.

NOTE: The hp/kW rating on the engine emissions certification label specifies the gross engine hp/kW, which is flywheel power without fan. In most applications this will not be the same rating as the advertised vehicle hp/kW rating.

OURGP11.00000C9 -19-26APR06-1/1

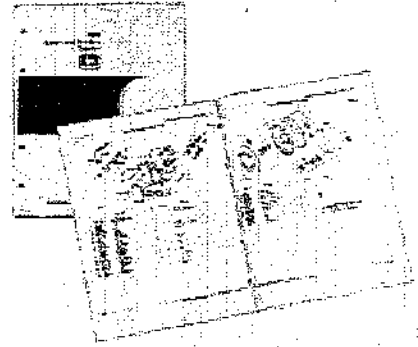
John Deere Service Literature Available

Technical Information

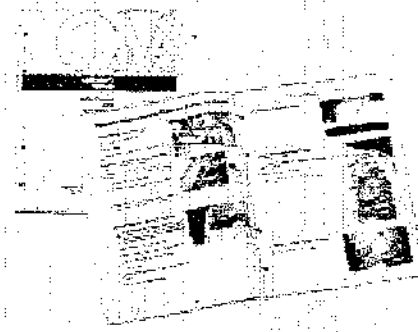
Technical information can be purchased from John Deere. Some of this information is available in electronic media, such as CD-ROM disks, and in printed form. There are many ways to order. Contact your John Deere dealer. Call **1-800-522-7448** to order using a credit card. Search online from <http://www.JohnDeere.com>. Please have available the model number, serial number, and name of the product.

Available information includes:

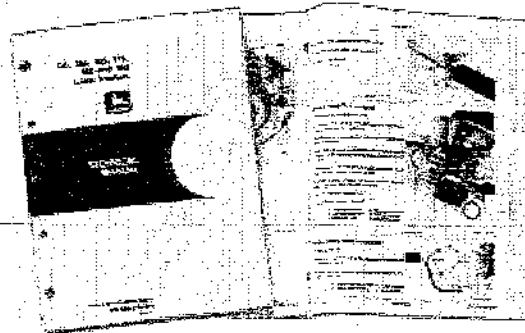
- **PARTS CATALOGS** list service parts available for your machine with exploded view illustrations to help you identify the correct parts. It is also useful in assembling and disassembling.
- **OPERATOR'S MANUALS** providing safety, operating, maintenance, and service information. These manuals and safety signs on your machine may also be available in other languages.
- **OPERATOR'S VIDEO TAPES** showing highlights of safety, operating, maintenance, and service information. These tapes may be available in multiple languages and formats.
- **TECHNICAL MANUALS** outlining service information for your machine. Included are specifications, illustrated assembly and disassembly procedures, hydraulic oil flow diagrams, and wiring diagrams. Some products have separate manuals for repair and diagnostic information. Some components, such as engines, are available in separate component technical manuals
- **FUNDAMENTAL MANUALS** detailing basic information regardless of manufacturer:
 - Agricultural Primer series covers technology in farming and ranching, featuring subjects like computers, the Internet, and precision farming.
 - Farm Business Management series examines "real-world" problems and offers practical solutions in the areas of marketing, financing, equipment selection, and compliance.
 - Fundamentals of Services manuals show you how to repair and maintain off-road equipment.



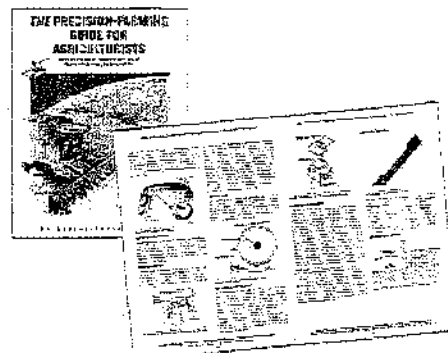
TS189 -UN-17JAN89



TS191 -UN-02DEC88



TS224 -UN-17JAN89



TS1663 -UN-10OCT97

Continued on next page

DX.SERV.LIT -19-31JUL03-1/2

- Fundamentals of Machine Operation manuals explain machine capacities and adjustments, how to improve machine performance, and how to eliminate unnecessary field operations.

DX,SEVLIT -19-31JUL03-2/2

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TAB 5

Service Parts

Engine

Engine Models:

John Deere 4024TF281
4024HF285
4045TF270
4045HF275
4045HF285
5030HF285

Generator Models:

20-60REOZJC
50/60REOZJB
50/60DSEJB
80/100REOZJC/D
80/100DSEJC/D

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Introduction

This manual lists service replacement parts for John Deere engines listed on the front cover.

At the time of print this manual applied to the engine models listed in the Specification Number Index. On occasion this manual may apply to engines not listed in the Specification Number Index.

Information in this publication represents data available at the time of print. The generator set manufacturer reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

This manual includes the following main sections:

Table of Contents. Lists the sections of the manual.

Introduction (and other information sections). Contains introductory material about part numbers, illustrations, and hardware.

Index. Lists the engine models and groups.

Group Parts Lists. List the part numbers of parts in the groups.

Numbering System Significance

This manual uses the following numbering systems:

Engine Model. The product identification number located on the engine nameplate. Engines break down into groups.

Group Number. A unique number representing a parts group needed to assemble an engine function. For example, Group 1 is the Air Intake group.

Variation Number. A group might have several variations. Each variation performs the same function with different parts lists. For example, a 12-volt alternator and 24-volt alternator both perform the same function, but, with different parts. Each difference requires a group variation or module number.

Part Number. The part number identifies an individual assembly, subassembly, component, or accessory kit.

Illustrations

Illustrations (or exploded-view drawings) best representing the widest range of variations accompany most groups in this manual. Illustrations do not depict all details and may not show all parts. Do not use illustrations for assembly or disassembly.

How to Find Part Numbers

Use the following steps to locate a service replacement part.

1. Locate the engine nameplate to **identify the engine model number**.
2. **Turn to the Specification Number Index.** The first column lists the engine model numbers. The headings identify the groups of parts that make up the engine.
3. **Identify the group** most likely to include the service part number.
4. **Find the group variation number** at the intersection of the model row and the group column. Note the variation number. If 2 or more variation numbers are listed, note all variation numbers.
5. **Page forward to locate the group** identified in step 3 or find the appropriate page in the Table of Contents.
6. **Find the part on the illustration** and note the item number of the part or **find the part description in the parts list**.
7. **Select the part number that corresponds to your group variation.** The first column lists the illustration item number. Find the variation(s) identified in the Specification Number Index in the appropriate column on the right side of the parts list table. Find the quantity used at the intersection of the item number row and the variation column. A blank space at the intersection means the variation/module does not use that part number.

Hardware References

Many common hardware items do not appear in parts manuals or will appear as common hardware entries. A common hardware entry lists the size of the hardware. For example, an item that appears as "Hardware, 3/8-16" in the text means that the piece is 3/8-16 size. Obtain common hardware locally.

Some hardware items require a specific size or some other characteristic. In that case, use the part number listed in the text.

When replacing hardware, do not substitute inferior grade hardware. Replacement hardware grade should be equal to or better than the grade of the manufacturer's original hardware.

Specification Number Index

Group Title	Air Intake	Water Pump	Water Pump Pulley	Water Pump Inlet	Thermostat	Fan Belt	Fan Drive	Fan Pulley	Belt Tensioner	Vent Tube	Camshaft	Valve Train	Rocker Arm Cover	Fuel Injection System
Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Variation Number														
20/30 Tier 3														
4024TF281	1703	2001	—	—	2201	2406	2301B	8603	8701	2999	4604	4907	1101B	1632
40/50 Tier 3														
4024HF285	—	2001	—	—	2201	2406	2301B	8603	8701	2999	4618	4907	1109	1662
60 Tier 3						or 2435 Check engine options nameplate.								
5030HF285 (4P)	—	2001	—	—	2201	2415	2301B	8603	8701	2999	4619	4908	1113	1646
5030HF285 (4V)	—	2001	—	—	2201	2415	2301B	8603	8701	2999	4619	4908	1113	1646

Group Title	Fuel Lines	Fuel Pump	Fuel Filter	Primary Fuel Filter	Crankshaft	Crankshaft Pulley	Piston & Connecting Rod	Flywheel	Flywheel Housing	Cylinder Head	Exhaust Manifold	Exhaust Elbow	Oil Filter	Dipstick
Group No.	15	16	17	17B	18	19	20	21	22	23	24	25	26	27
Variation Number														
20/30 Tier 3														
4024TF281	—	3701	3505	—	4701	1301	4806	1508	1415‡	5101	2806	—	8801	4003
40/50 Tier 3														
4024HF285	—	3712*	3540*	—	4703	1301	4814	1508	1401*	5105	2806	—	8801	4003
60 Tier 3														
5030HF285 (4P)	—	3712†	3543‡	—	4704	1303	4815	1508	1401	5106	2807	—	8801	4003
5030HF285 (4V)	—	3712†	3543†	—	4704	1303	4815	1508	1406B	5106	2807	—	8801	4003

* 4024HF285 engines with serial number PE4024L003825 and before used Fuel Pump variation code 3709, Fuel Filter variation code 3535, and Flywheel Housing variation code 1415. Check the engine nameplate to verify the variation code.

† 5030HF285 engines with serial number PE5030L003800 and before used Fuel Pump variation code 3709 and Fuel Filter variation code 3538. Check the engine nameplate to verify the variation code.

‡ 4024TF281 engines with serial number PE4024R001060 through PE4024R001475 inclusive used Flywheel Housing variation code 1408 and Sensor variation code 6702. Check the engine nameplate to verify the variation code.

Specification Number Index

Group Title										
	Oil Pan	Oil Cooler	Oil Pump	Cylinder Block	Front Plate	Timing Gear Cover	Turbocharger & Oil Lines	Starter Motor	Alternator	Alternator Brackets
Group No.	28	29	30	31	32	33	34	35	36	37
	Variation Number									
20/30 Tier 3										
4024TF281	1924	5903	5001	4604	—	4401	6526	3002	3102	6202
40/50 Tier 3										
4024HF285	1924	5903	5001	4616	—	4402	6553	3002	3102	6202
60 Tier 3										
5030HF285 (4P)	1902	5903	5001	4619	—	4402	6567	3002	3102	6202
5030HF285 (4V)	1902	5903	5001	4619	—	4402	6567	3002	3102	6202

Group Title							
	Short Block	Cylinder Head Gasket Set	Overhaul Gasket Set	Engine Sensors	Wiring Harness	Engine Balancer Shafts	Starting Aid (Glow Plugs)
Group No.	38	39	40	41	42	43	44
	Variation Number						
20/30 Tier 3							
4024TF281	3	—	3	6712†	—	—	4301
40/50 Tier 3							
4024HF285	—	—	2	6711	—	—	4315
60 Tier 3							
5030HF285 (4P)	—	—	2	6711	—	—	4316
5030HF285 (4V)	—	—	2	6711	—	—	4316

† 4024TF281 engines with serial number PE4024R001060 through PE4024R001475 inclusive used Flywheel Housing variation code 1408 and Sensor variation code 6702. Check the engine nameplate to verify the variation code.

Specification Number Index

Group Title	Air Intake Water Pump Water Pump Pulley Water Pump Inlet Thermostat Fan Belt Fan Drive Fan Pulley Belt Tensioner Vent Tube Camshaft Valve Train Rocker Arm Cover Fuel Injection System													
Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Variation Number													
50/60														
4045TF270, 12V	1701	4429A	2002A	5722	2112	240B	2314	8605	8711	2915	4616	4901	1101	164X
4045TF270, 24V	1701	4429A	2002A	5722	2112	240B	2314	8605	8711	2915	4616	4901	1101	164Y
80														
4045HF275, 12V	1783	4429B	2002A	5722	2102	2409	2301	8604	8702	2915	4616	4901	1101	163G
4045HF275, 24V	1783	4429B	2002A	5722	2102	2409	2301	8604	8702	2915	4616	4901	1101	161G
100														
4045HF275, 12V	1783	4429B	2002A	5722	2102	2409	2301	8604	8702	2915	4614	4901	1101	163W
4045HF275, 24V	1783	4429B	2002A	5722	2102	2409	2301	8604	8702	2915	4614	4901	1101	163Y
80/100 Tier 3														
4045HF285, 12V	1783	4446	2002B	5722	2156	24HA	2342	8605	8727	2997	4643	4901	1162	16A5
4045HF285, 24V	1783	4446	2002B	5722	2156	24HA	2342	8605	8727	2997	4643	4901	1162	16A5

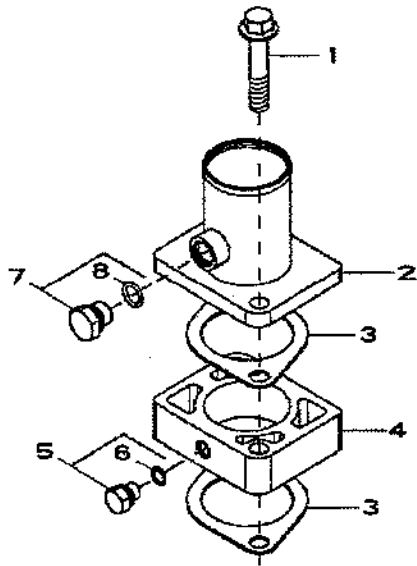
Group Title	Fuel Lines Fuel Pump Fuel Filter Primary Fuel Filter Crankshaft Crankshaft Pulley Piston & Connecting Rod Flywheel Flywheel Housing Cylinder Head Exhaust Manifold Exhaust Elbow Oil Filter Dipstick													
Group No.	15	16	17	17B	18	19	20	21	22	23	24	25	26	27
	Variation Number													
50/60														
4045TF270, 12V	—	3702	3563	—	4715	1328	4823	1509	1406	5102	2803	6401	8842	4002
4045TF270, 24V	—	3702	3563	—	4715	1328	4823	1509	1406	5102	2803	6401	8842	4002
80														
4045HF275, 12V	6313	3702	35BV	—	4715	1327	4822	1503	1406	5102	2803	6401	8842	4002
4045HF275, 24V	6313	3702	35BV	—	4715	1327	4822	1503	1406	5102	2803	6401	8842	4002
100														
4045HF275, 12V	6366	3702	35BV	—	4715	1327	4822	1503	1406	5102	2803	6401	8842	4002
4045HF275, 24V	6366	3702	35BV	—	4715	1327	4822	1503	1406	5102	2803	6401	8842	4002
80/100 Tier 3														
4045HF285, 12V	6386	3713	35ED	8170	4715	1328	4838	1503	1406	5122	2888	6438	8842	4002
4045HF285, 24V	6386	3713	35ED	8170	4715	1328	4838	1503	1406	5122	2888	6438	8842	4002

Specification Number Index

Group Title										
	<i>Oil Pan</i>	<i>Oil Cooler</i>	<i>Oil Pump</i>	<i>Cylinder Block</i>	<i>Front Plate</i>	<i>Timing Gear Cover</i>	<i>Turbocharger & Oil Lines</i>	<i>Starter Motor</i>	<i>Alternator</i>	<i>Alternator Brackets</i>
Group No.	28	29	30	31	32	33	34	35	36	37
	Variation Number									
50/60										
4045TF270, 12V	1904	5901	5001	4616	3618	4429	65HE	3006	3122	6211
4045TF270, 24V	1904	5901	5001	4616	3618	4429	65HE	3041	3104	6212
80										
4045HF275, 12V	1904	5901	5002	4616	3618	4429	65HE	3006	3138	6201
4045HF275, 24V	1904	5901	5002	4616	3618	4429	65HE	3041	3142	6201
100										
4045HF275, 12V	1904	5901	5002	4614	3618	4429	65HE	3006	3138	6201
4045HF275, 24V	1904	5901	5002	4614	3618	4429	65HE	3041	3142	6201
80/100 Tier 3										
4045HF285, 12V	19AE	5902	5001	4643	3612	4446	65RQ	3012	3138	6201
4045HF285, 24V	19AE	5902	5001	4643	3612	4446	65RQ	3041	3142	6201

Group Title						
	<i>Short Block</i>	<i>Cylinder Head Gasket Set</i>	<i>Overhaul Gasket Set</i>	<i>Engine Sensors</i>	<i>Wiring Harness</i>	<i>Engine Balancer Shafts</i>
Group No.	38	39	40	41	42	43
	Variation Number					
50/60						
4045TF270, 12V	1	1	1	—	—	—
4045TF270, 24V	1	1	1	—	—	—
80						
4045HF275, 12V	2	1	1	7635	8407	—
4045HF275, 24V	2	1	1	7635	8407	—
100						
4045HF275, 12V	2	1	1	7635	8407	—
4045HF275, 24V	2	1	1	7635	8407	—
80/100 Tier 3						
4045HF285, 12V	TBD	TBD	TBD	6730	8457	4501
4045HF285, 24V	TBD	TBD	TBD	6730	8457	4501

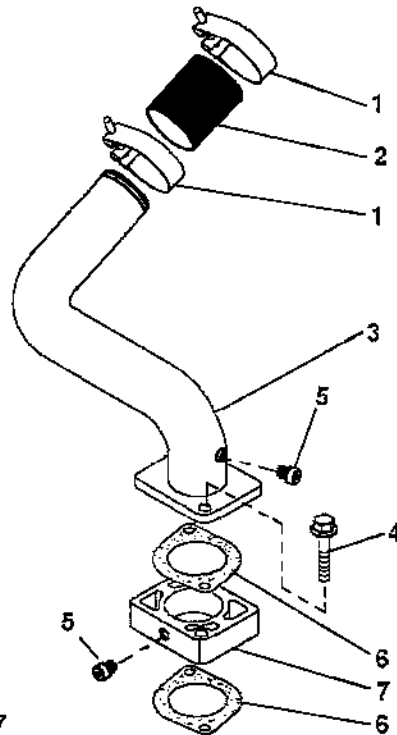
Group 1: Air Intake



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Item	Part Number	Description	Quantity Variation 1783
1	#	Screw	2
2	GM24517	Manifold, intake	1
3	223532	Gasket	1
4	GM17483	Spacer	1
5	GM24516	Fitting	1
6	#	O-ring, 8.1 x 1.6 mm	1
7	360013	Plug	1
8	GM21508	O-ring, 11.3 x 2.2 mm	1

Common hardware; procure locally.

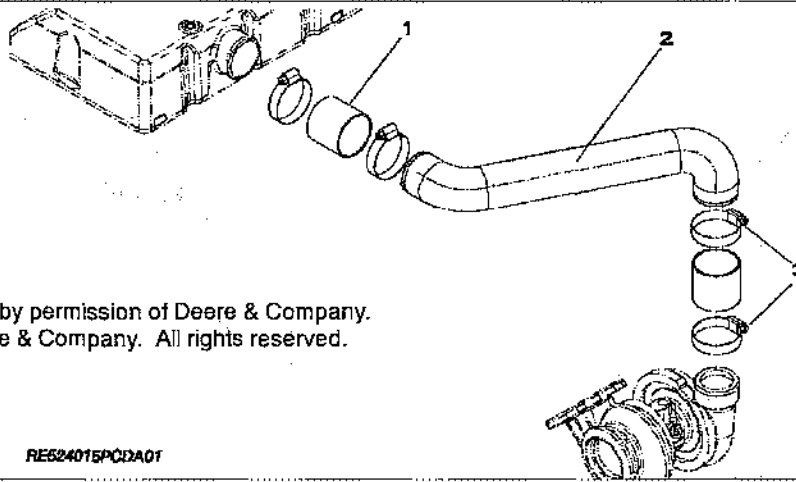


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Item	Part Number	Description	Quantity Variation 1701
1	GM18669	Clamp	2
2	GM32781	Hose	1
3	GM32826	Air intake	1
4	#	Screw, M10 x 50	2
5	GM24516	Fitting (includes O-ring)	2
6	223532	Gasket	2
7	GM17483	Spacer	1

Group 1: Air Intake

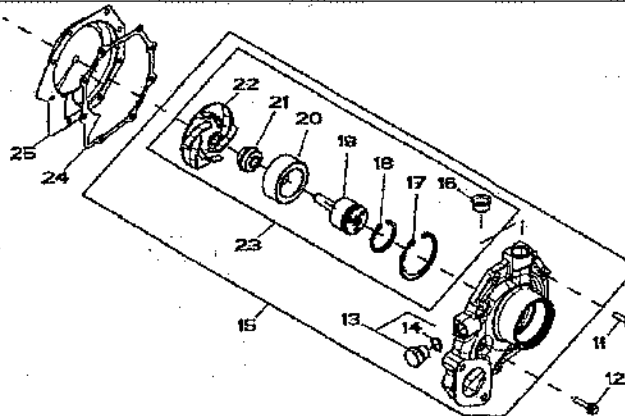


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RE524015PCDA01

Item	Part Number	Description	Quantity
			Variation 1703
1	GM63756	Hose, 49 mm	2
2	GM63769	Tube	1
3	GM18882	Clamp	4

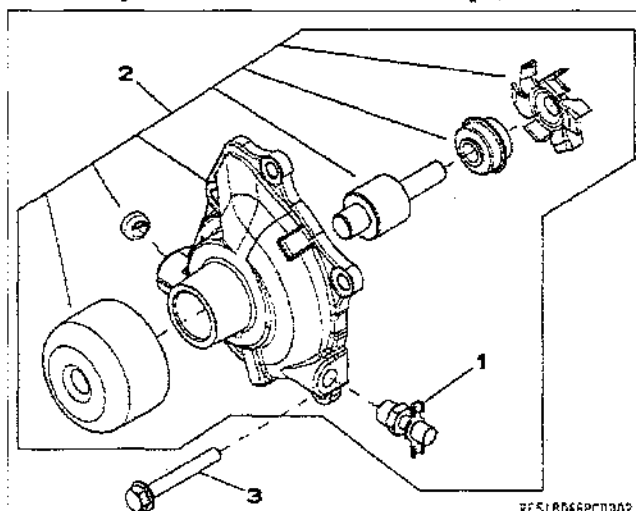
Group 2: Water Pump



Item	Part Number	Description	Quantity		
			4429A	Variation 4429B	4446
11	#	Screw, M6 x 25	5	5	5
12	#	Screw, M6 x 30	3	3	3
13	360014	Plug	2	1	1
14	360176	O-ring	1	1	1
15	GM29383	Pump, water	1		
15	GM29382	Pump, water (also order items 16 and 24)		1	1
16	360116	Gasket	1	1	1
17	X	Ring	1	1	1
18	360003	Ring, snap	1	1	1
19	X	Shaft	1	1	1
20	X	Ball bearing	1	1	1
21	X	Seal	1	1	1
22	X	Impeller	1	1	1
23	GM32829	Water pump kit (includes items 13, 14, 16-22, 25)	1		
23	GM17551	Water pump seal kit (includes items 13, 14, 16-22, 25)		1	
23	GM32944	Water pump kit (includes items 16-22)			1
24	360124	Gasket, water pump	1	1	1
25	GM17443	Filter (not shown)	2	2	

Common hardware; procure locally.
X Not sold separately.

Group 2: Water Pump, continued

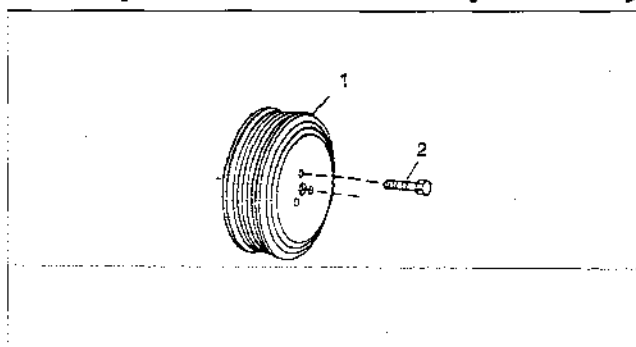


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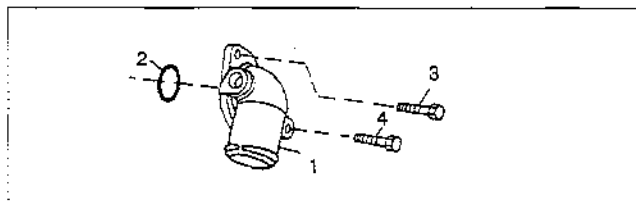
Item	Part Number	Description	Quantity	
			Variation	2001
1	223435	Drain valve		1
2	GM63808	Water pump		1
3	GM63706	Screw, M8 x 60		5
	GM63859	Sealant		1

Group 3: Water Pump Pulley



Item	Part Number	Description	Quantity	
			2002A	2002B
1	360085	Pulley, water pump	1	
1	360559	Pulley		1
2	#	Screw, M6 x 12	3	3

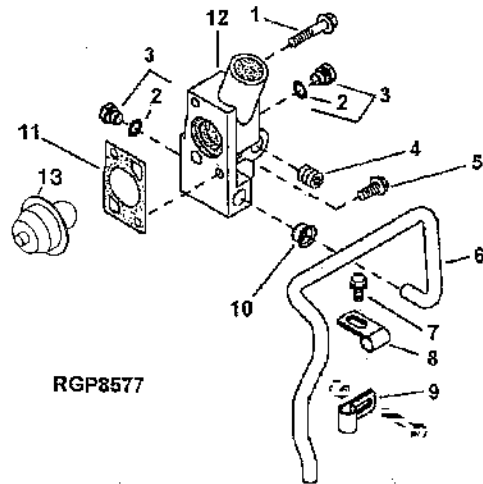
Group 4: Water Pump Inlet



Item	Part Number	Description	Quantity	
			Variation	5722
1	GM32792	Housing		1
	360014	Plug (includes O-ring 360176)		1
2	224172	O-ring		1
3	#	Screw, M8 x 25		1
4	#	Screw, M8 x 65		1

Common hardware; procure locally.

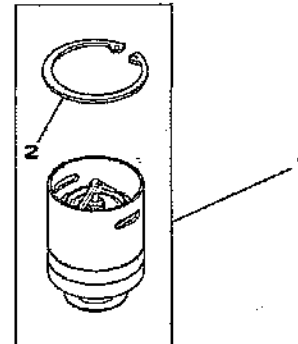
Group 5: Thermostat



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Item	Part Number	Description	Quantity Variation		
			2102	2112	2156
1	#	Screw, M10 x 70	1	1	
1	#	Screw, M10 x 50			1
2	GM21508	O-ring	2	2	2
3	360013	Plug	2	2	2
4	GM15403	Plug, pipe	3	3	
5	#	Screw, M10 x 30	1	1	1
6	360142	Tube	1		
6	GM23839	Tube		1	
6	GM43898	Tube			1
7	#	Screw, M12 x 25	1	1	
8	360120	Clamp	1	1	
9	360121	Clamp	1	1	1
10	360116	Gasket, water bypass tube	1	1	1
11	360484	Gasket	1	1	1
12	GM32786	Cover, thermostat	1	1	
12	GM49827	Cover, thermostat			1
13	GM32812	Thermostat	1	1	1

Common hardware; procure locally.

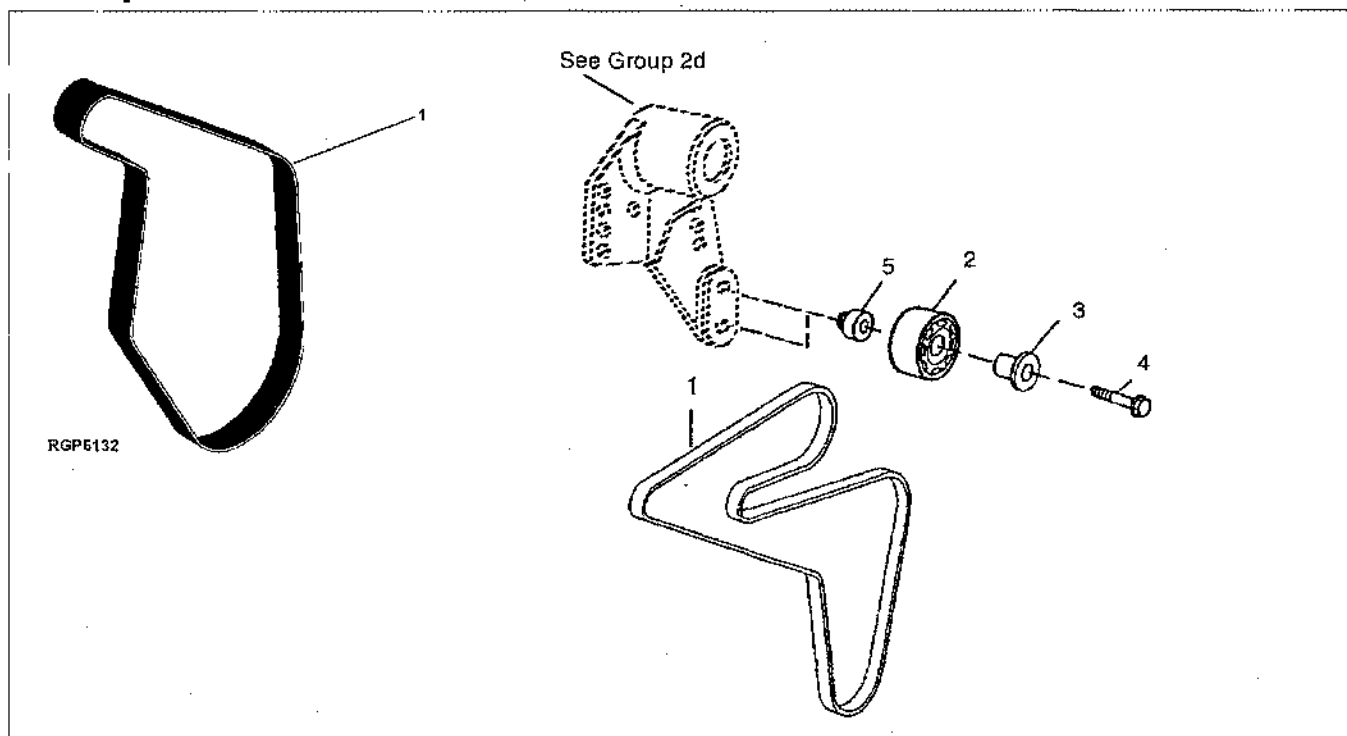


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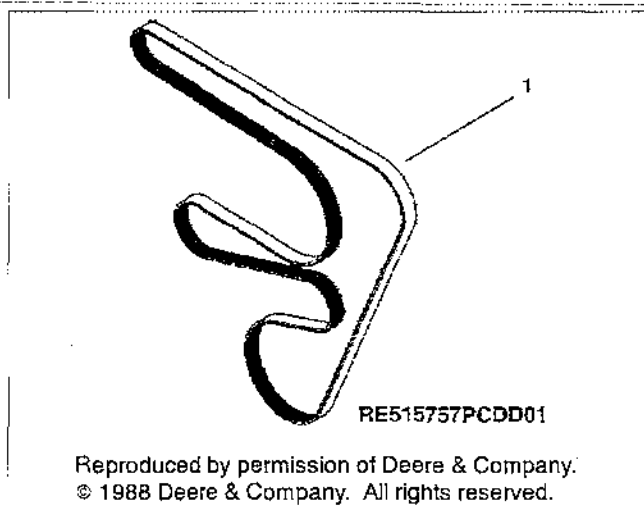
Item	Part Number	Description	Quantity Variation
			2201
1	GM63866	Thermostat kit	1
2	GM63780	Snap ring	1

Group 6: Fan Belt



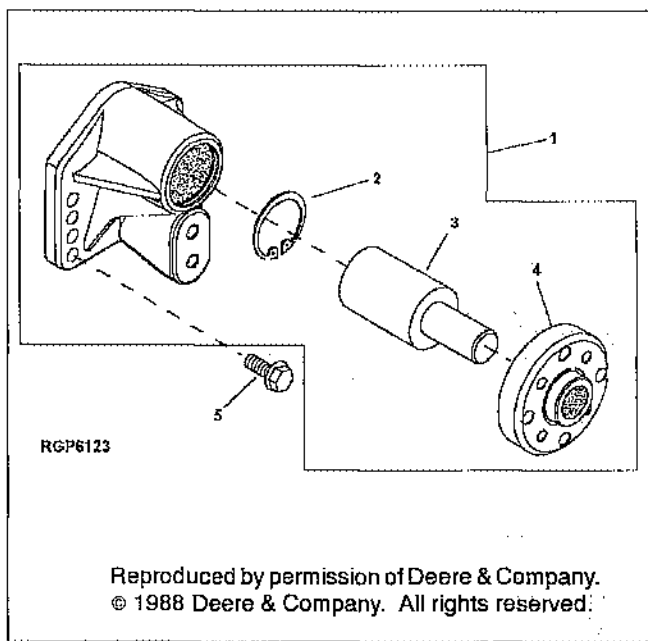
Item	Part Number	Description	Quantity		
			Variation		
			2409	240B	24HA
1	GM23828	V-belt, 1575 mm (8 rib)	1		
1	GM28308	V-belt, 1515 mm (8 rib)			
1	GM52514	V-belt, 1550 mm			1
2	GM17529	Pulley	1		1
3	GM17488	Sleeve	1		1
4	#	Screw, M10 x 65	1		1
5	GM23835	Spacer	1		1

Common hardware; procure locally.



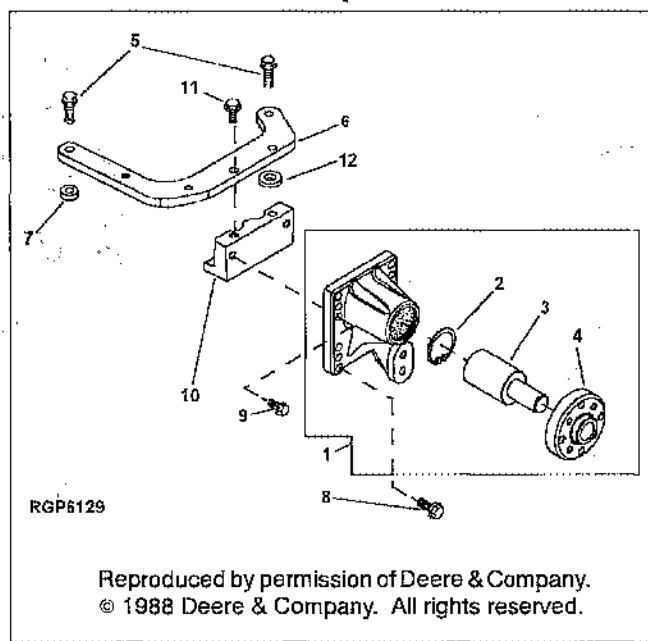
Item	Part Number	Description	Quantity		
			Variation		
			2406	2415	2435
1	GM63750	V-belt	1		
1	GM63761	V-belt		1	
1	GM71811	V-belt			1

Group 7: Fan Drive



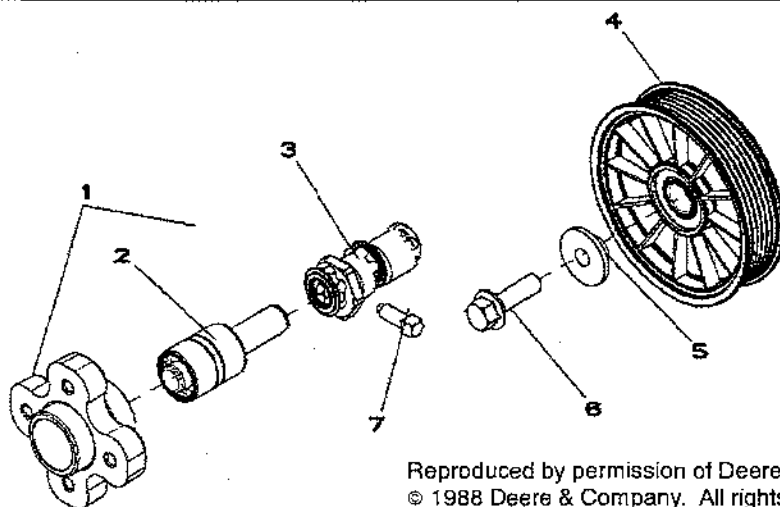
Item	Part Number	Description	Quantity
			Variation 2301
1	360030	Housing, bearing w/ bearing	1
2	360005	Ring, snap	1
3	X	Bearing (order item 1)	1
4	X	Hub (order item 1)	1
5	#	Screw, M10 x 35	4

Common hardware; procure locally.
X Not sold separately.



Item	Part Number	Description	Quantity	
			Variation 2314	Variation 2342
1	GM23844	Support	1	1
2	223730	Ring, snap	1	1
3	X	Shaft	1	1
4	X	Hub	1	1
5	#	Screw, M12 x 35	2	
6	GM23831	Bracket	1	
7	GM23826	Washer	1	
8	#	Screw, M10 x 35	4	
9	#	Screw, M10 x 30		4
10	#	Screw, M10 x 20	2	
11	GM23830	Spacer	1	
12	#	Screw, M10 x 30	2	
	GM23855	Washer	1	

Group 7: Fan Drive, continued

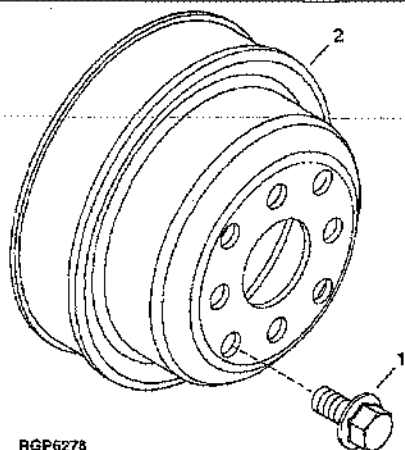


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Item	Part Number	Description	Quantity	
			Variation	2301B
1	GM63804	Hub	1	
2	GM63766	Ball bearing	1	
3	GM63758	Tube nut	1	
4	GM63867	Idler	1	
5	GM63730	Sleeve	1	
6	GM63708	Screw, M10 x 35	1	
7	#	Set screw	1	

Group 8: Fan Pulley

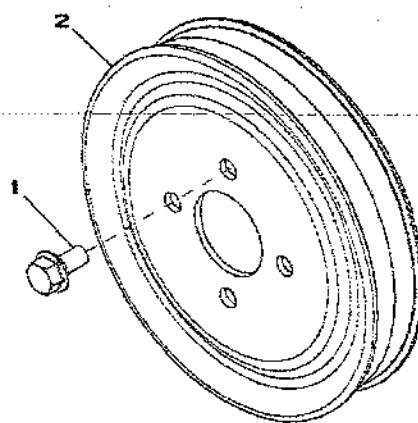


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Item	Part Number	Description	Quantity	
			Variation	8604
1	GM32765	Screw	4	4
2	360578	Pulley, fan	1	
2	360143	Pulley, fan		1

Common hardware; procure locally.

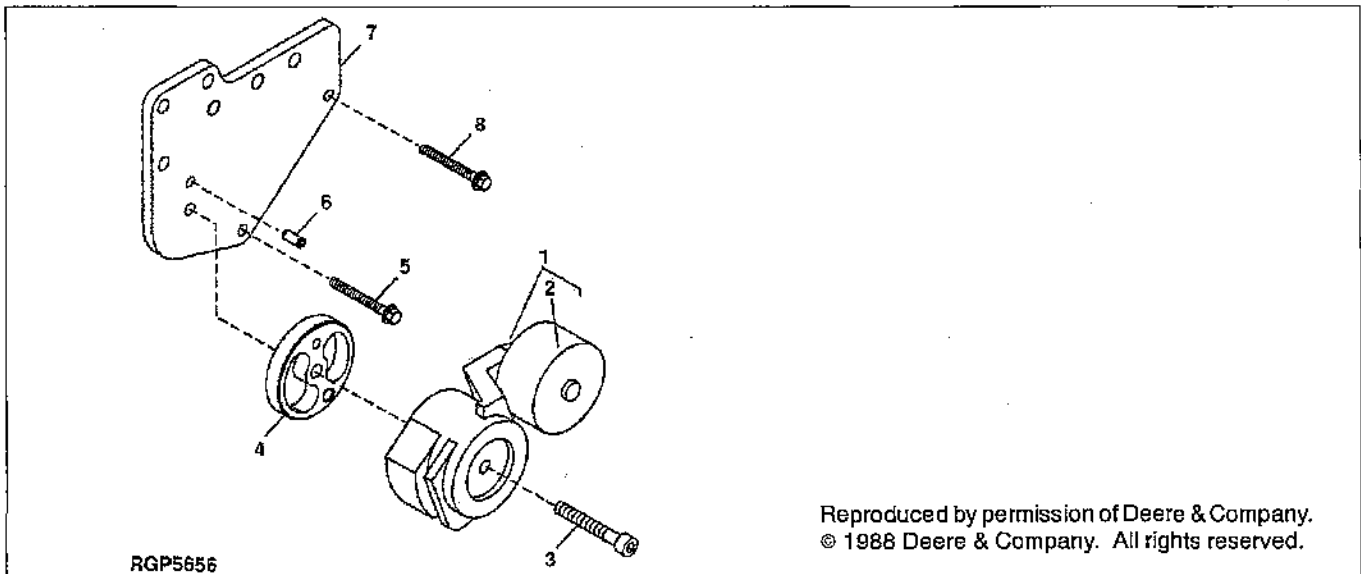


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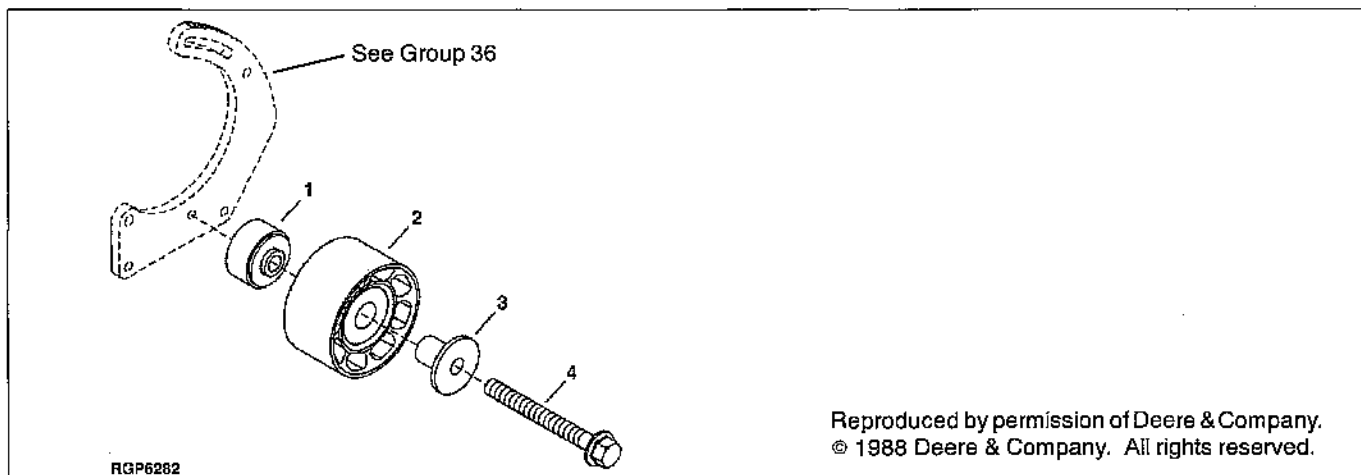
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Item	Part Number	Description	Quantity	
			Variation	8603
1	#	Screw, M8 x 16	4	
2	GM63744	Pulley	1	

Group 9: Belt Tensioner



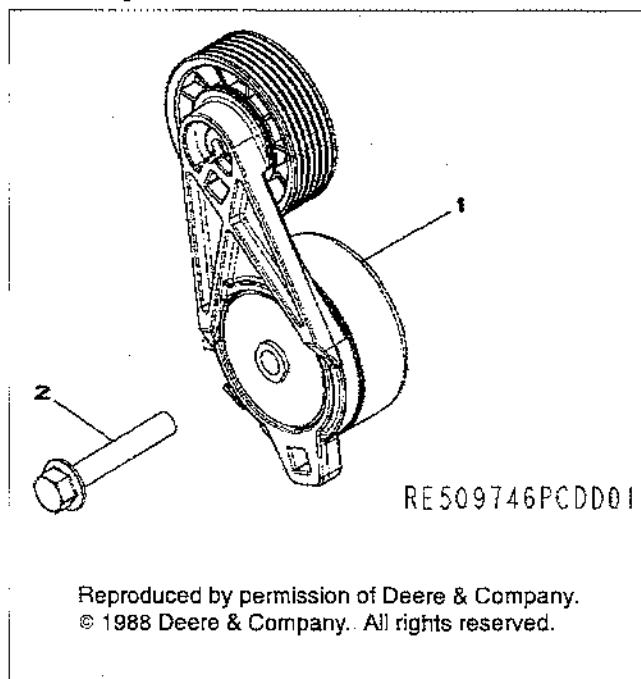
Item	Part Number	Description	Quantity Variation	
			8702	8727
1	GM49938	Tensioner	1	1
2	X	Bolt	1	1
3	#	Screw, M10 x 90	1	1
4	GM49836	Spacer	1	1
5	#	Screw, M8 x 60 mm	1	1
6	GM46601	Pin, spring	1	1
7	GM24521	Support	1	1
8	#	Screw, M8 x 60 mm	1	1



Item	Part Number	Description	Quantity Variation
			8711
1	GM23835	Spacer	1
2	GM17529	Pulley	1
3	GM17488	Sleeve	1
4	#	Screw, M10 x 60	1

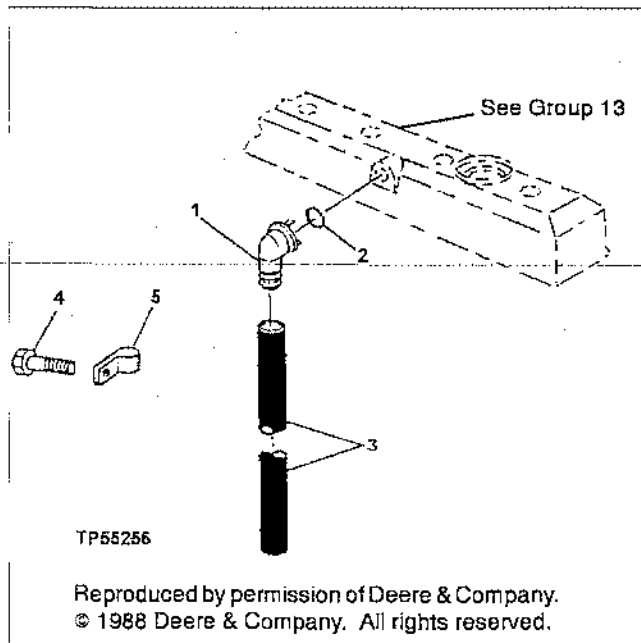
Common hardware; procure locally.
X Not sold separately.

Group 9: Belt Tensioner, continued



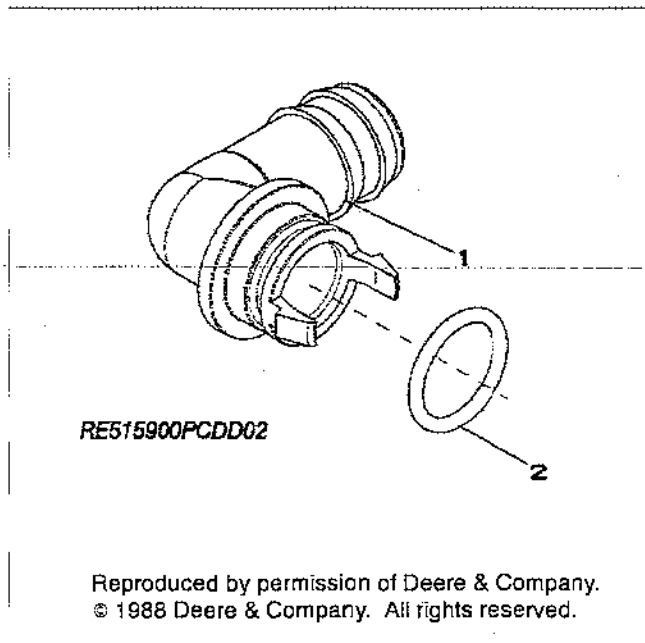
Item	Part Number	Description	Quantity
			Variation 8701
1	GM63812	Belt tensioner	1
2	#	Screw, M10 x 60	1

Group 10: Vent Tube



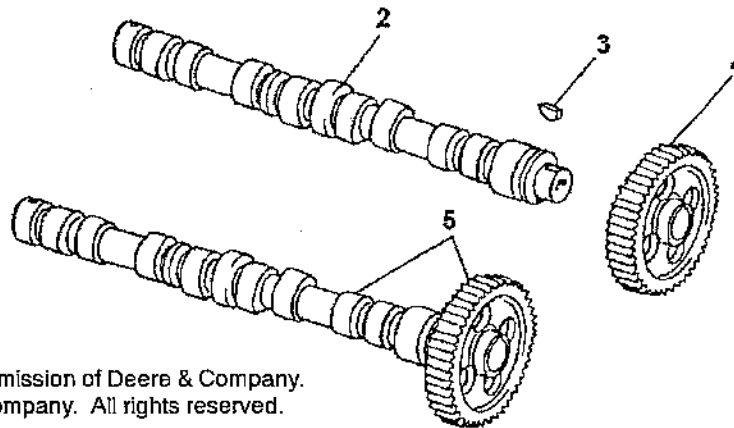
Item	Part Number	Description	Quantity	
			Variation 2915	2997
1	360098	Fitting, elbow	1	1
2	223851	O-ring	1	1
3	GM17459	Hose	1	
4	#	Screw, M8 x 20	1	
5	360530	Clamp	1	

Common hardware; procure locally.



Item	Part Number	Description	Quantity
			Variation 2999
1	360098	Fitting, elbow	1
2	223851	O-ring	1

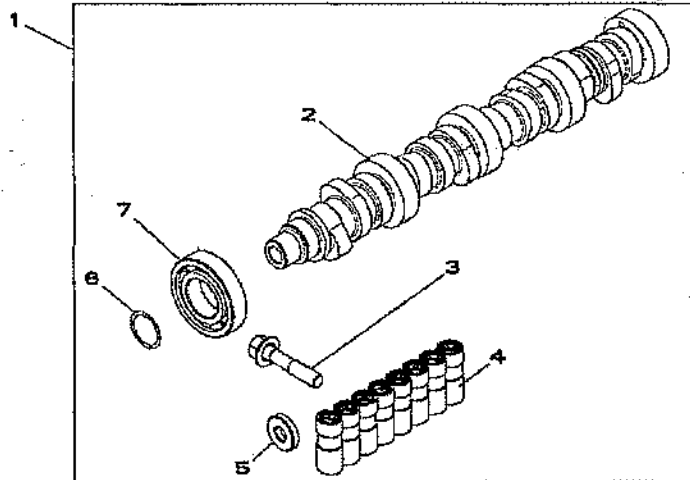
Group 11: Camshaft



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Item	Part Number	Description	Quantity		
			4614	Variation 4616	4643
2	X	Camshaft (order item 5)	1	1	
3	360158	Key, shaft	1	1	
4	X	Gear (order item 5)	1	1	
5	GM32813	Camshaft	1	1	
5	GM52516	Camshaft			1

X Not sold separately.

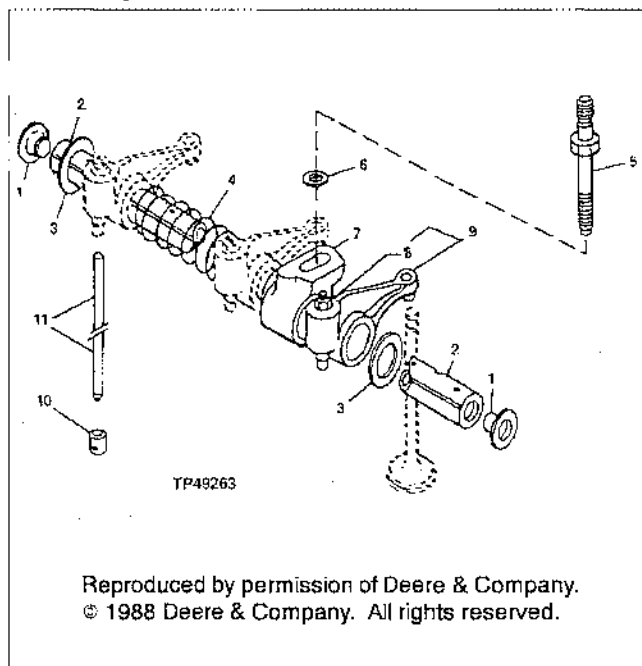


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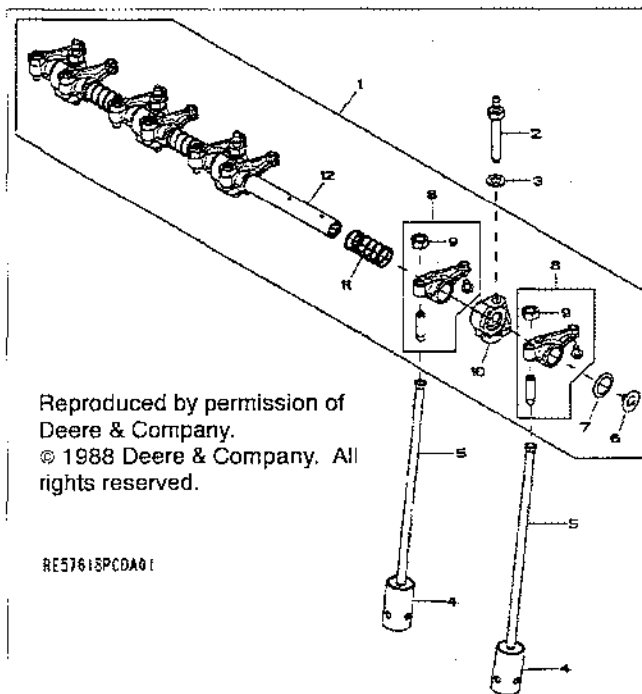
Item	Part Number	Description	Quantity		
			4604	Variation 4618	4619
1	GM63858	Cam kit	1	1	
1	GM63911	Cam kit		1	
1	GM63907	Cam kit			1
2		Camshaft	1	1	1
3	GM63752	Screw	1	1	1
4	GM63833	Follower	8	8	10
5	GM63748	Washer	1	1	1
6	GM63728	Shim	1	1	1
7	GM63821	Ball bearing	1	1	1

Group 12: Valve Train



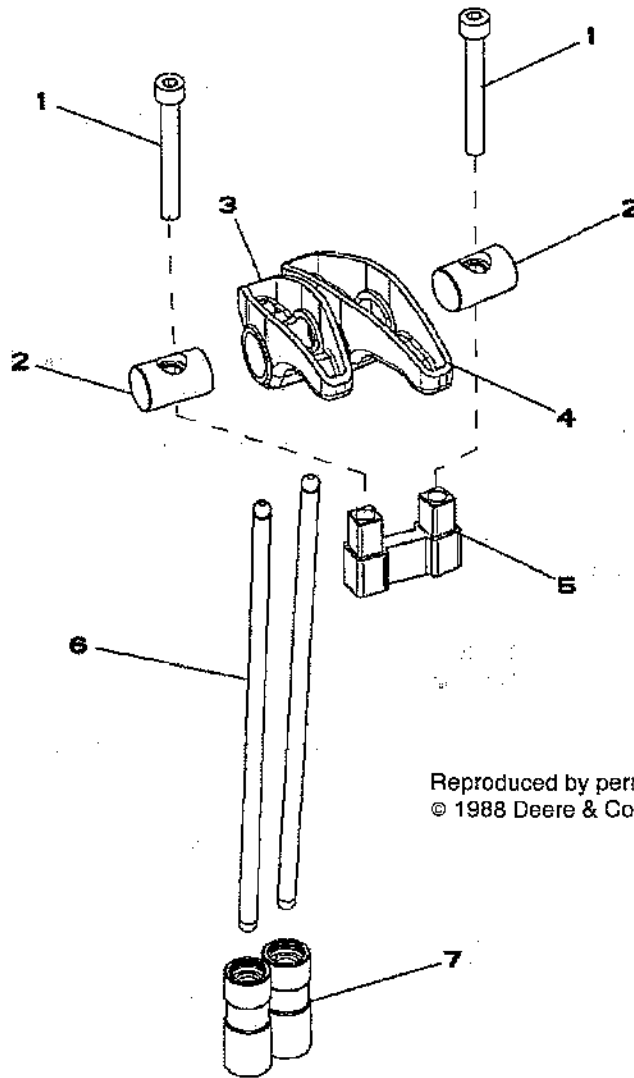
		Quantity	
Item	Part Number	Description	Variation 4901A
1	223480	Plug	2
2	360509	Shaft, rocker arm	1
3	223634	Washer	2
4	223632	Spring	3
5	360118	Stud	4
6	223756	Washer, 11 x 20 x 2 mm	4
7	360112	Support	4
8	#	Nut, M10	1
9	360072	Arm, rocker	8
10	360135	Tappet	8
11	352026	Rod, push	8

Common hardware; procure locally.



		Quantity	
Item	Part Number	Description	Variation 4901B
1	223481	Shaft	1
2	360118	Stud	4
3	#	Washer, 11 x 20 x 2 mm	6
4	360135	Tappet	8
5	352026	Rod, push	8
6	223480	Plug	2
7	223634	Washer	2
8	GM50611	Arm, rocker	8
9	#	Nut, M10	1
10	360112	Support	6
11	223632	Spring	5
12	360509	Shaft, rocker arm	1

Group 12: Valve Train



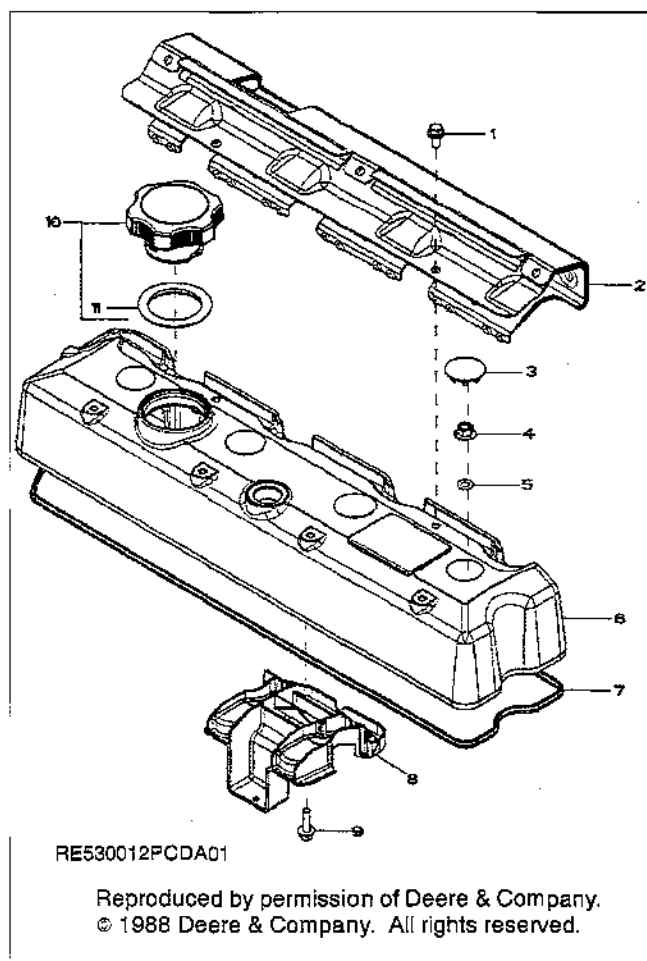
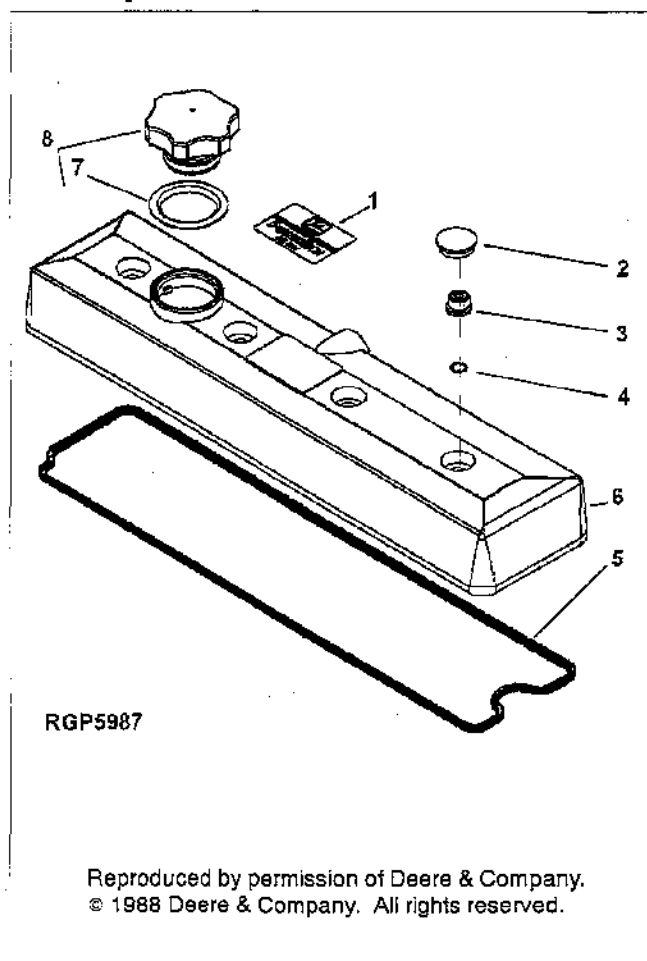
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Item	Part Number	Description	Quantity	
			Variation	
			4907	4908
1	#	Screw, M6 x 65	8	10
2	GM63753	Rocker arm shaft	8	10
3	GM63823	Rocker arm (intake valve)	4	5
4	GM63824	Rocker arm (exhaust valve)	4	5
5	GM63777	Pedestal	4	5
6	GM63820	Push rod	8	10
7	GM63833	Follower	8	10

Common hardware; procure locally.

Group 13: Rocker Arm Cover



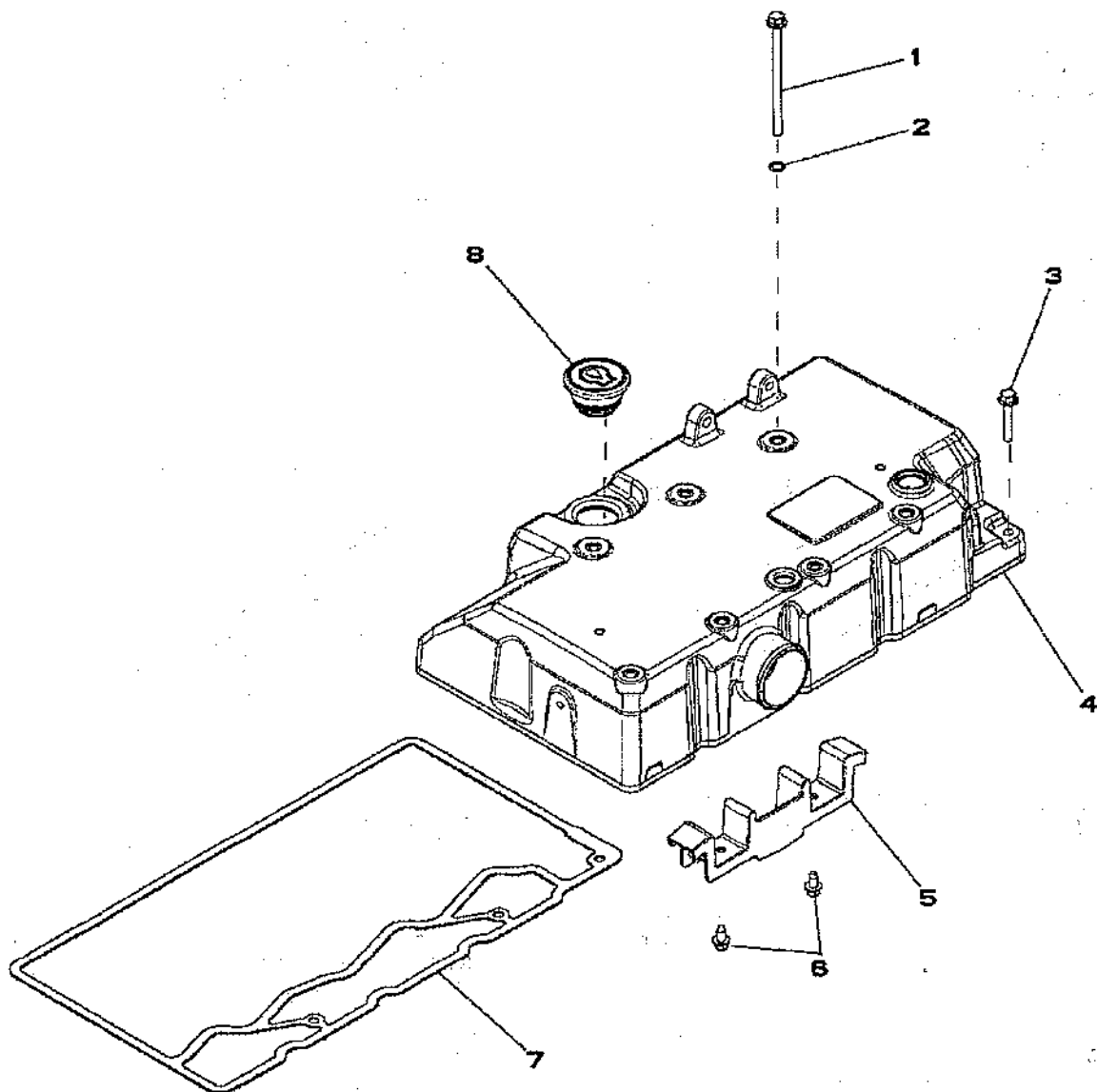
Item	Part Number	Description	Quantity Variation 1101
1	X	Medallion	1
2	360004	Plug	6
3	360138	Nut	6
4	360139	O-ring	6
5	360585	Gasket, rocker arm cover	1
6	360507	Cover, rocker arm	1
7	GM17493	Packing	1
8	360018	Cap, oil fill (includes packing)	1

X Not sold separately.

Item	Part Number	Description	Quantity Variation 1162
1	GM50057	Screw, M6 x 12	2
2	GM52517	Heat shield	1
3	360004	Plug	4
4	360138	Nut, M8	4
5	360139	O-ring	4
6	GM52518	Valve cover	1
7	GM52519	Gasket	1
8	GM50069	Deflector	1
9	#	Screw, M6 x 20	1
10	360018	Filler cap	1
11	GM17493	Packing	1

Common hardware; procure locally.

Group 13: Rocker Arm Cover



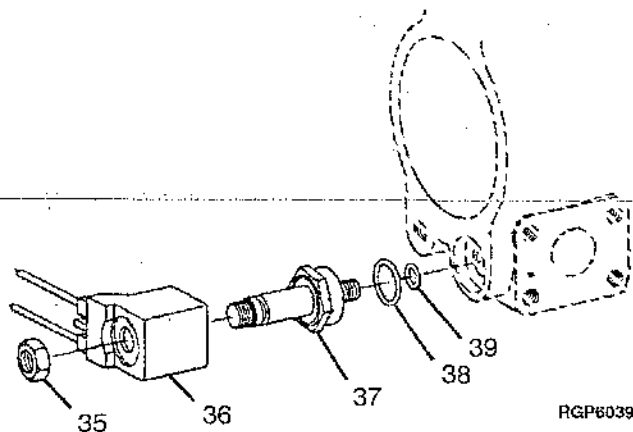
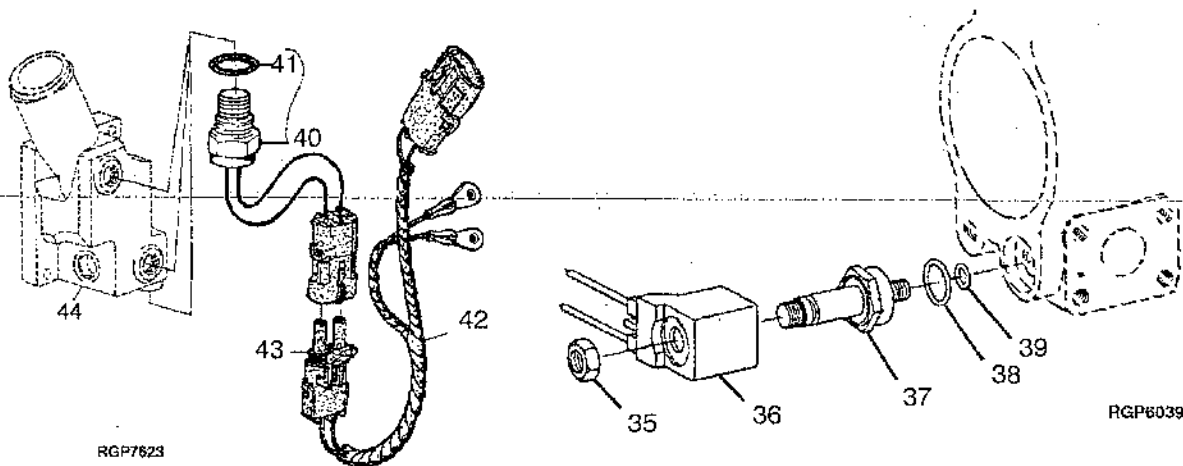
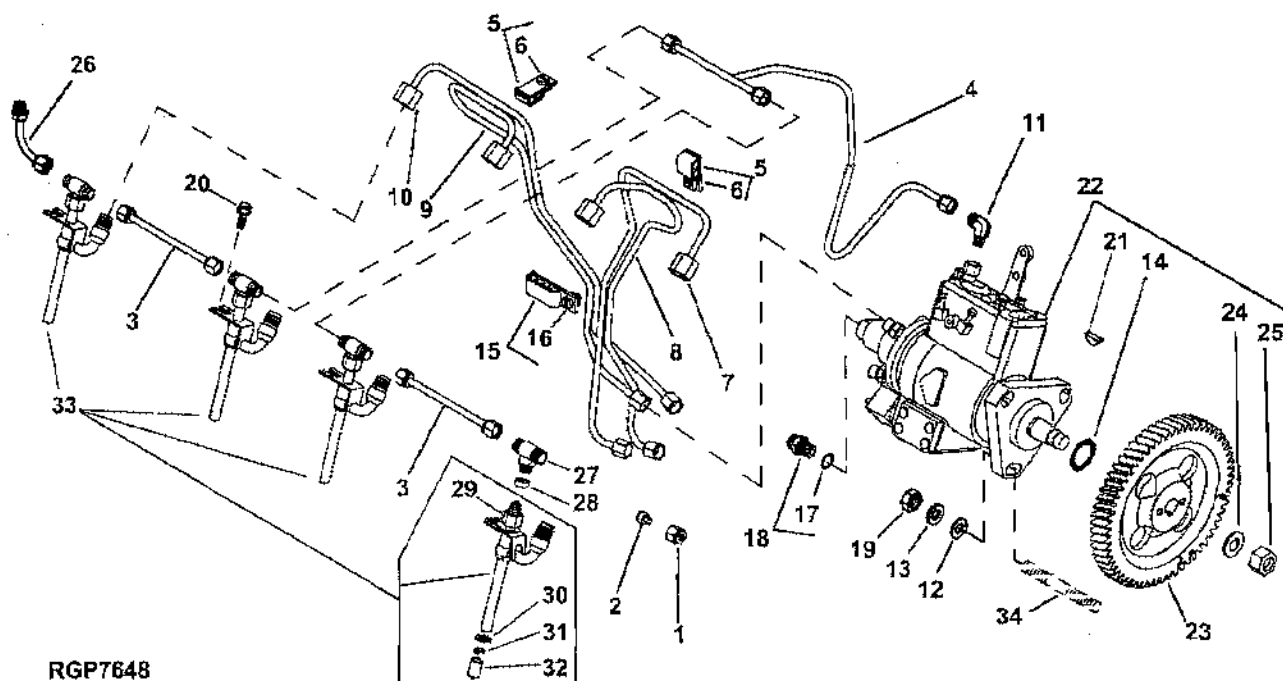
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Item	Part Number	Description	Quantity		
			Variation		
			1101B	1109	1113
1	GM63819	Screw	5	7	9
2	GM63709	O-ring	5	7	9
3	#	Screw, M6 x 35	1	1	1
4	GM63813	Valve cover	1		
4	GM63786	Valve cover		1	
4	GM63787	Valve cover			1
5	GM63722	Isolator	1		
5	GM63789	Isolator		1	1
6	#	Screw, M6 x 12	2	2	2
7	GM63705	Sealant	1		
7	GM63775	Gasket		1	
7	GM63774	Gasket			1
8	GM63726	Filler cap	1	1	1

Common hardware; procure locally.

Group 14: Fuel Injection Pump



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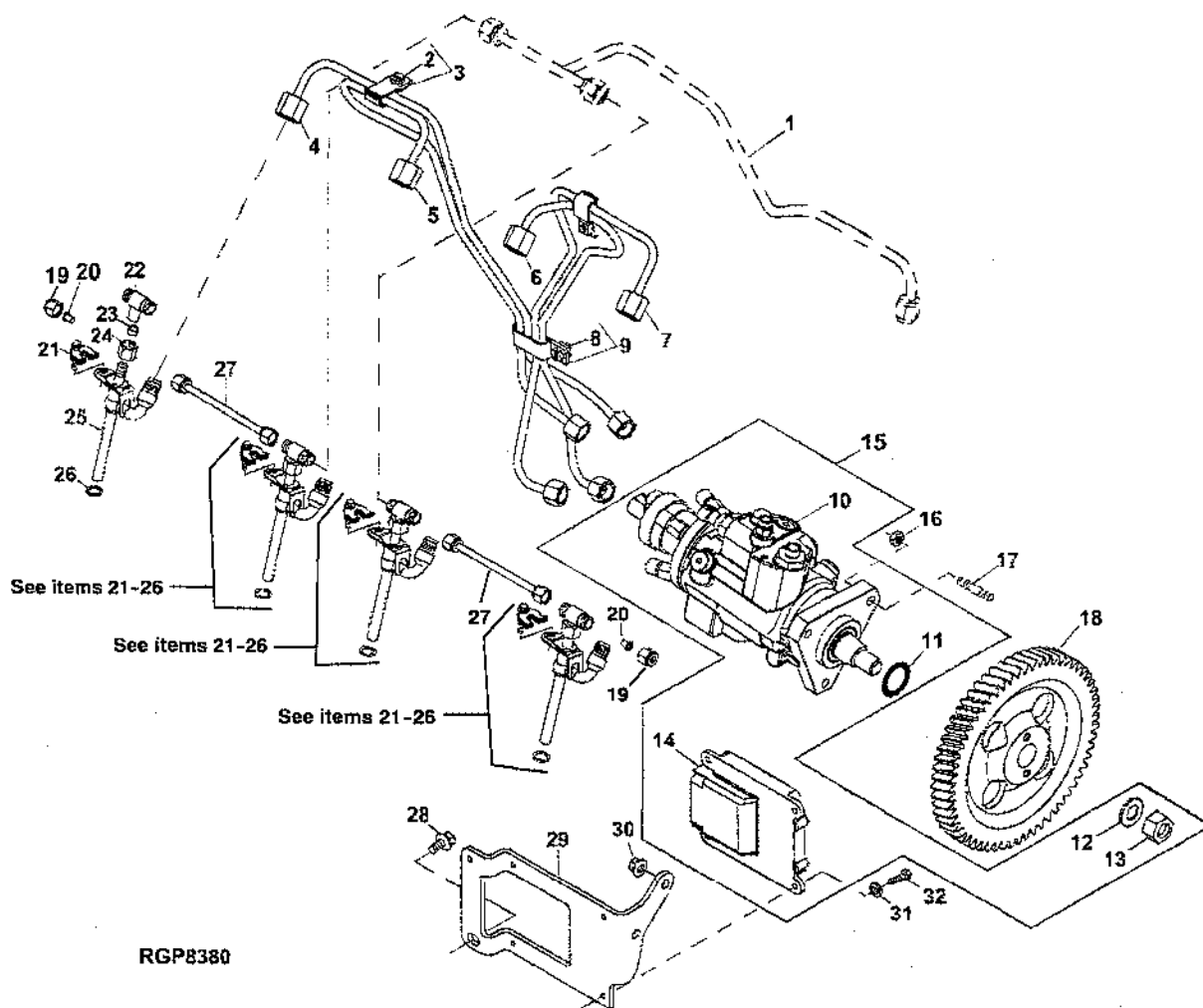
Group 14: Fuel Injection Pump

Item	Part Number	Description	Quantity	
			Variation	
			164X	164Y
1	360141	Nut	2	2
2	223710	Plug	2	2
3	223504	Tube	2	2
4	GM17549	Fuel line	1	1
5	223572	Clamp	2	2
6	#	Screw, M6 x 12	2	2
7	360536	Fuel line, no. 1	1	1
8	360537	Fuel line, no. 2	1	1
9	360538	Fuel line, no. 3	1	1
10	360539	Fuel line, no. 4	1	1
11	223937	Elbow fitting	1	1
12	#	Washer, lock, 8 mm	3	3
13	224338	Washer	3	3
14	GM17487	O-ring	1	1
15	223573	Clamp	1	1
16	#	Screw, M6 x 12	1	1
17	360178	O-ring	1	1
18	360037	Fitting	1	1
19	#	Nut, M8	3	3
20	360091	Screw	4	4
21	—	Not used	—	—
22	GM32841	Pump, fuel injection	1	—
22	GM32842	Pump, fuel injection	—	1
23	360153	Gear, 60 teeth	1	1
24	GM17456	Washer	1	1
25	224161	Nut	1	1
26	—	See Group 17	—	—
27	GM21513	Tee fitting	4	4
28	223518	Washer	4	4
29	223517	Tube nut	1	1
30	224265	Packing	1	1
31	GM17473	Washer (standard nozzle bore)	1	1
32	224257	Plug	1	1
33	360017	Injection nozzle	4	4
34	—	See Group 32	3	3
35	GM32791	Nut	1	1
36	GM32784	Solenoid valve coil	1	1
37	GM32783	Valve	1	1
38	GM32785	Seal	1	1
39	GM17487	O-ring	1	1
40	GM21509	Switch, temperature	1	1
41	GM21508	O-ring	1	1
42	GM21510	Wiring harness	1	1
43	X	Connector	1	1
44	—	See Group 5	1	1

Common hardware; procure locally.

X Not sold separately.

Group 14: Fuel Injection Pump, continued



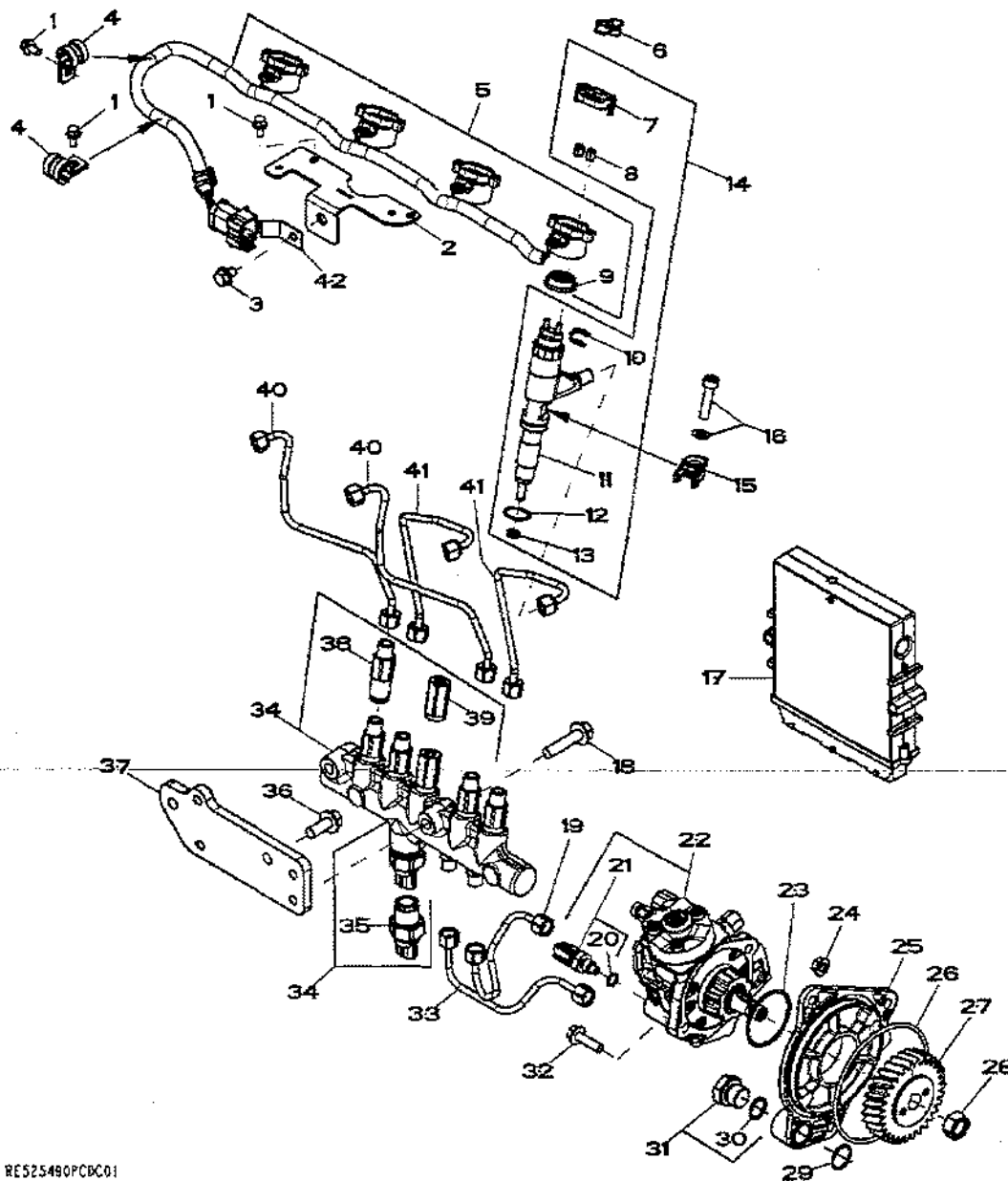
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Group 14: Fuel Injection Pump, continued

Item	Part Number	Description	Quantity Variation			
			163G	161G	163W	163Y
1	—	See Group 15	1	1	1	1
2	#	Screw	2	2	2	2
3	223572	Clamp	2	2	2	2
4	GM32818	Fuel line, no. 4	1	1	1	1
5	GM32817	Fuel line, no. 3	1	1	1	1
6	GM32816	Fuel line, no. 2	1	1	1	1
7	GM32815	Fuel line, no. 1	1	1	1	1
8	#	Screw	1	1	1	1
9	223573	Clamp	1	1	1	1
10	GM32839	Pump, fuel injection	1	1	1	1
11	GM17487	O-ring	1	1	1	1
12	GM17456	Washer	1	1	1	1
13	224181	Nut	1	1	1	1
14	GM32840	Controller, engine (ECU) 24 V		1		
14	GM32844	Controller, engine (ECU) 12 V	1		1	
14	GM32845	Controller, engine (ECU) 24 V				1
15	GM32835	Kit, pump/controller		1		
15	GM32834	Kit, pump/controller	1		1	
16	#	Nut, flange	3	3	3	3
17	—	See Group 32	1	1	1	1
18	GM32798	Gear	1	1	1	1
19	360141	Nut	2	2	2	2
20	223710	Plug	2	2	2	2
21	GM32825	Clamp	4	4	4	4
22	GM21513	Tee fitting	4	4	4	4
23	223518	Washer	4	4	4	4
24	223517	Tube nut	4	4	4	4
25	GM32819	Nozzle, injection	4	4		
25	360017	Nozzle, injection			4	4
26	224285	Packing	4	4	4	4
27	223504	Tube	2	2	2	2
27	223476	Sealing washer			2	2
28	#	Screw, M10 x 20	1	1	1	1
29	GM32793	Bracket	1	1	1	1
30	#	Nut, flange	2	2	2	2
31	#	Washer	4	4	4	4
32	#	Screw, cap	4	4	4	4

Common hardware; procure locally.

Group 14: Fuel Injection Pump, continued



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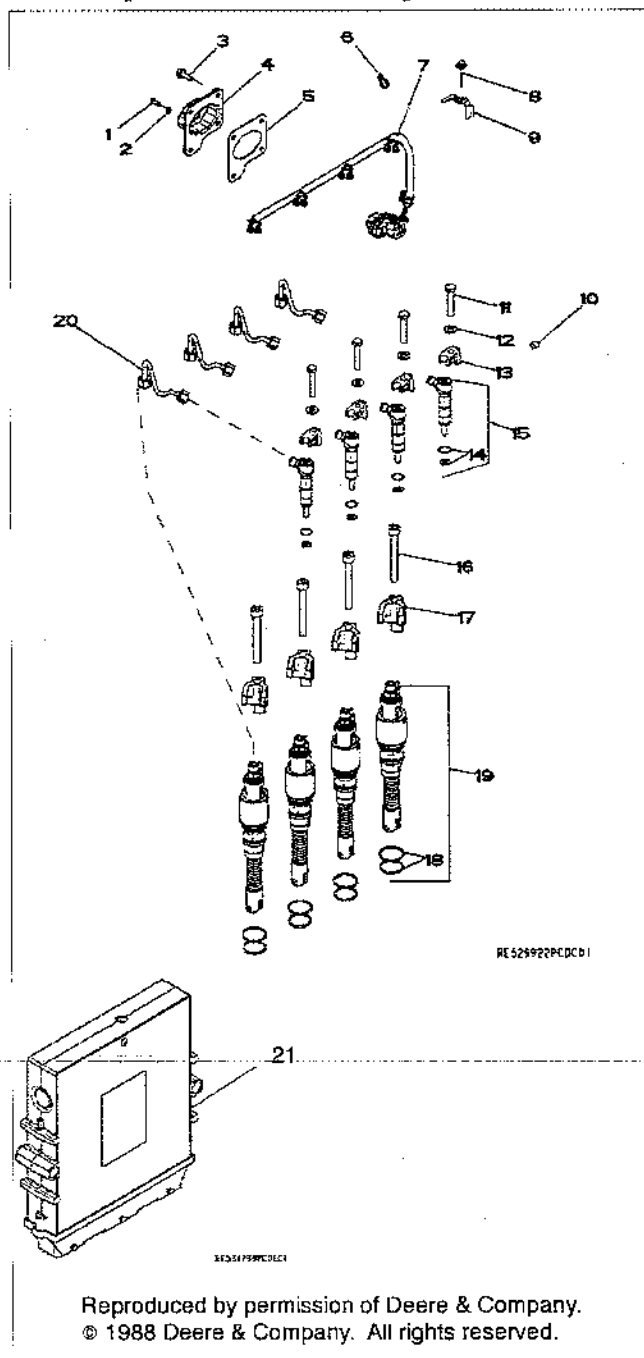
Group 14: Fuel Injection Pump, continued

Item	Part Number	Description	Quantity Variation 16A5
1	GM50033	Cap screw	1
2	GM49924	Bracket	1
3	GM50057	Screw	4
4	GM50086	Clamp	2
5	GM52520	Wiring harness	1
6	—	Cap	1
7	GM50065	Electrical connector cap	4
8	GM46621	Nut	8
9	GM49915	Seal	1
10	GM49918	Washer, sealing	AR
11	—	(Order item 14)	4
12	GM46681	O-ring	4
13	GM49927	Washer, sealing	4
14	GM52521	Kit, injector	4
15	GM49883	Clamp	4
16	GM50059	Screw with washer	4
17	GM50042	Engine controller	1
18	#	Screw, M10 x 45	2
19	GM50049	Fuel line	1
20	GM52522	O-ring	1
21	GM46641	Fuel temperature sensor	1
22	GM50052	Fuel injection pump	1
23	GM46643	O-ring	1
24	#	Flange nut, M8	3
25	GM46647	Adapter	1
26	GM46644	O-ring	1
27	GM46645	Gear	1
28	224161	Nut	1
29	GM46646	O-ring	1
30	360180	O-ring, 17.3 x 2.2 mm	1
31	360078	Plug, drain	1
32	#	Screw, M8 x 30	2
33	GM50050	Fuel line	1
34	GM52523	Rail	1
35	GM49988	Sensor	1
36	#	Screw, M10 x 25	2
37	GM52524	Bracket	1
38	GM46637	Restrictor	4
39	GM49936	Pressure relief valve	1
40	GM50044	Fuel line	2
41	GM50043	Fuel line	2
42	GM49889	Bracket	1

AR As Required

Common hardware; procure locally.

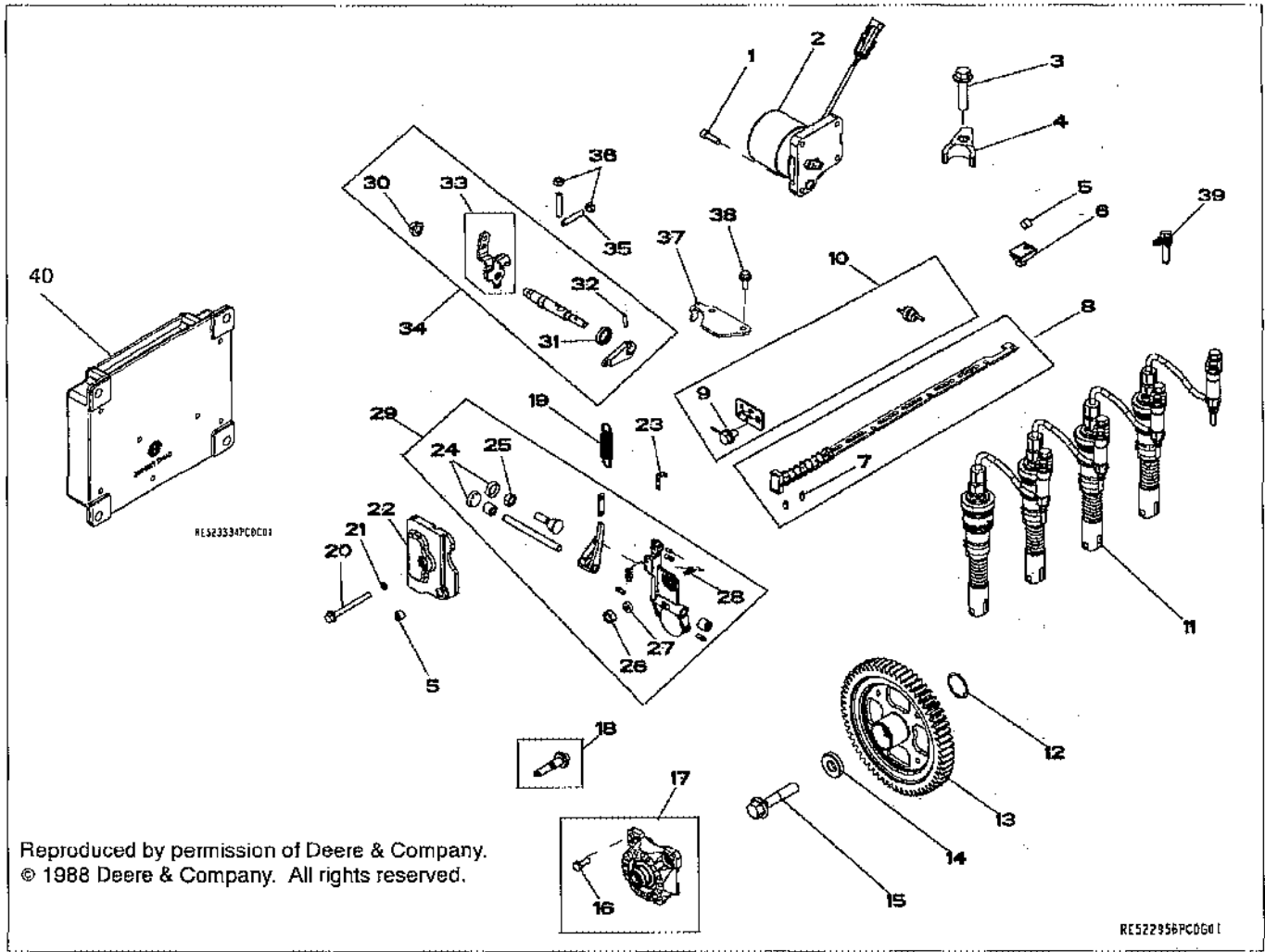
Group 14: Fuel Injection Pump, continued



Item	Part Number	Description	Quantity	
			Variation	
			1646	1662
1	#	Cap screw, M5 x 12	2	2
2	#	Washer	2	2
3	#	Screw, M6 x 20	4	4
4	GM63782	Cover	1	1
5	GM63784	Gasket	1	1
6	GM63754	Tie band	1	1
7	GM63883	Wiring harness	1	1
7	GM63884	Wiring harness	1	1
8	#	Screw, M6 x 12	1	1
9	GM63781	Bracket	1	1
10	#	Pipe plug, 3.175 mm (1/8 in.)	1	1
11	#	Cap screw, M8 x 45	4	4
12	224338	Washer	4	4
13	GM63773	Clamp	4	4
14	GM63893	Seal kit	4	4
15	GM63882	Injection nozzle	4	4
16	#	Screw, M10 x 85	4	4
17	—	Clamp	4	4
18	GM63890	O-ring kit	4	4
19	GM63902	Fuel injection pump	4	4
20	GM63879	Fuel line	4	4
21	GM63876	Engine controller	1	1

Common hardware; procure locally.

Group 14: Fuel Injection Pump, continued

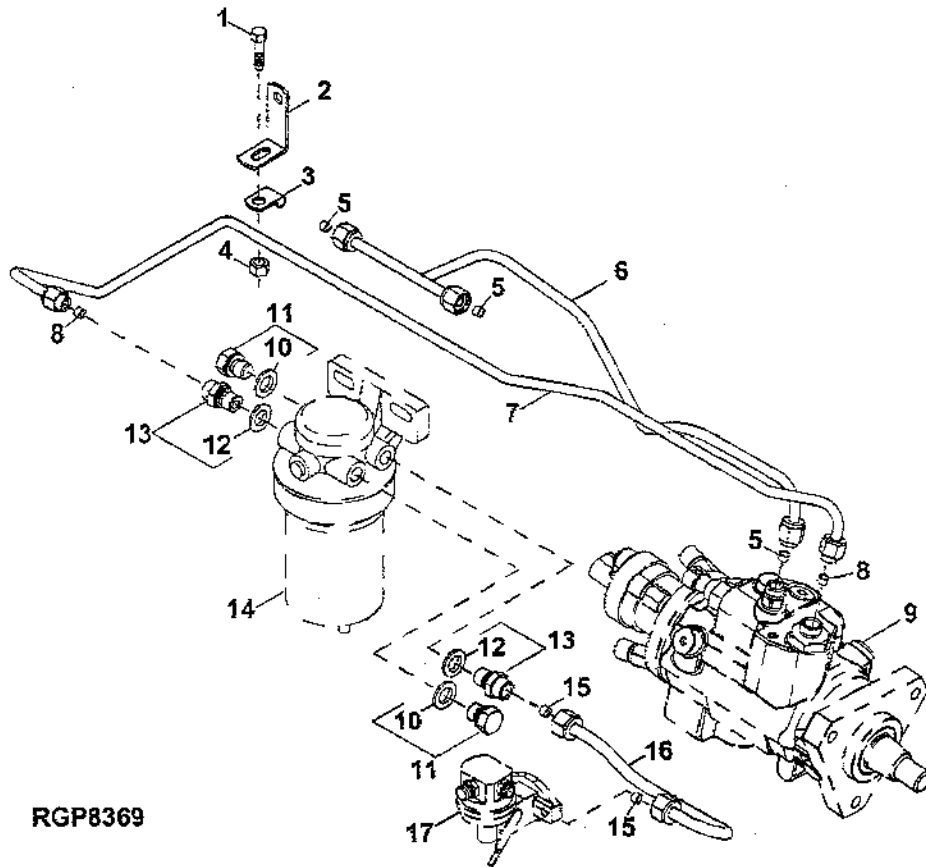


Item	Part Number	Description	Quantity		Item	Part Number	Description	Quantity	
			Variation	1632				Variation	1632
1	#	Screw, M6 x 20		4	21	223665	O-ring		2
2	GM63843	Actuator		1	22	GM63765	Cover		1
3	#	Screw, M10 x 45		4	23	GM63739	Leaf spring		1
4	GM63788	Clamp		4	24	GM63719	Plug		2
5	#	Pipe plug, 3.175 mm (1/8 in.)		2	25	#	Nut		1
6	GM63844	Rack		1	26	#	Nut, M8		1
7	#	Spring pin		2	27	—	Plate (order item 29)		1
8	GM63846	Rack kit		1	28	—	Screw (order item 29)		1
9	#	Screw, M8 x 12		1	29	GM63872	Governor kit		1
10	GM63837	Guide kit		1	30	#	Flange nut, M8		1
11	GM63887	Fuel pump		4	31	GM63807	Seal		1
	GM63840	Seal kit	AR		32	#	Spring pin		1
12	GM63728	Shim		1	33	GM63850	Lever		1
13	GM63714	Spur gear		1	34	GM63861	Throttle kit		1
14	GM63748	Washer		1	35	#	Set Screw, M6 x 35		2
15	GM63752	Screw		1	36	#	Nut, M6		2
16	#	Cap screw, M6 x 16		4	37	GM63760	Plate		1
17	GM63873	Flywheel kit		1	38	#	Screw, M6 x 16		2
18	GM63857	Magnet kit		1	39	GM63755	Clamp		4
19	GM63738	Extension spring		1	40	GM63847	Engine controller		1
20	#	Screw, M6 x 65		1					

AR As Required

Common hardware; procure locally.

Group 15: Fuel Lines



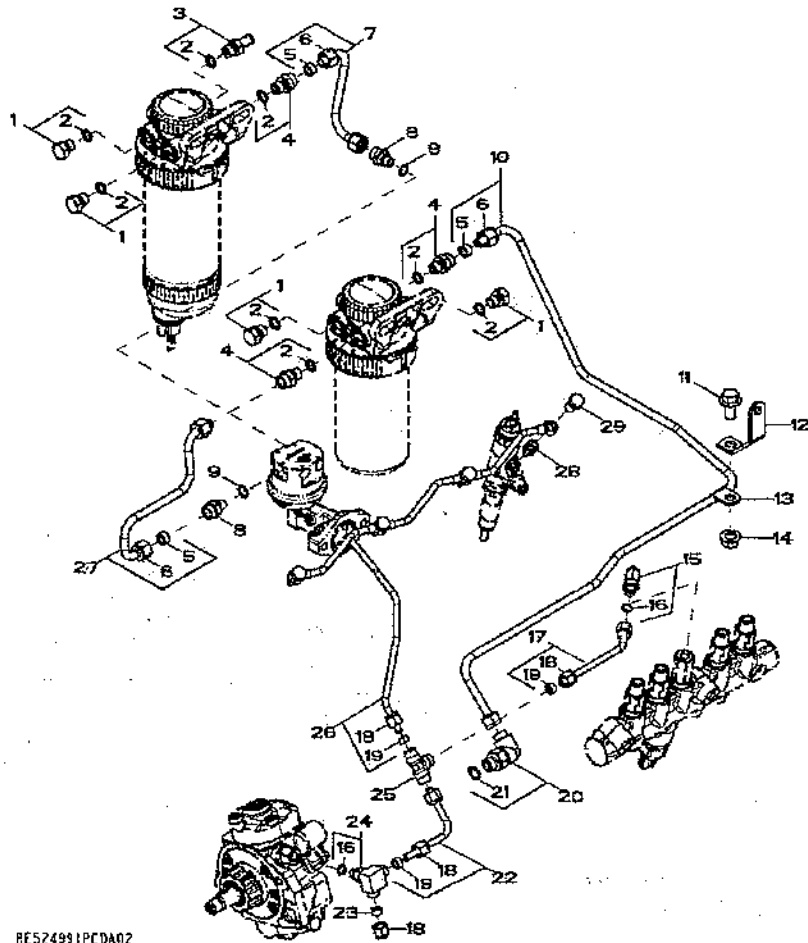
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Item	Part Number	Description	Quantity	
			Variation	
			6313	6366
1	#	Screw, M10 x 20	1	1
2	GM32797	Bracket	1	1
3	360171	Clamp	1	1
4	#	Flange nut, M10	1	1
5	223476	Sealing washer	3	3
6	GM32814	Line, fuel	1	1
6	GM32833	Line, fuel	1	1
7	GM32831	Line, fuel	1	1
8	GM17494	Sealing washer	4	4
9	—	See Group 14	1	1
10	360178	O-ring	2	2
11	360015	Plug	2	2
12	360178	O-ring	2	2
13	360037	Adapter	2	2
14	—	See Group 17	1	1
15	GM17494	Sealing washer	4	4
16	GM32830	Line, fuel	1	1
17	—	See Group 16	1	1

Common hardware; procure locally.

Group 15: Fuel Lines



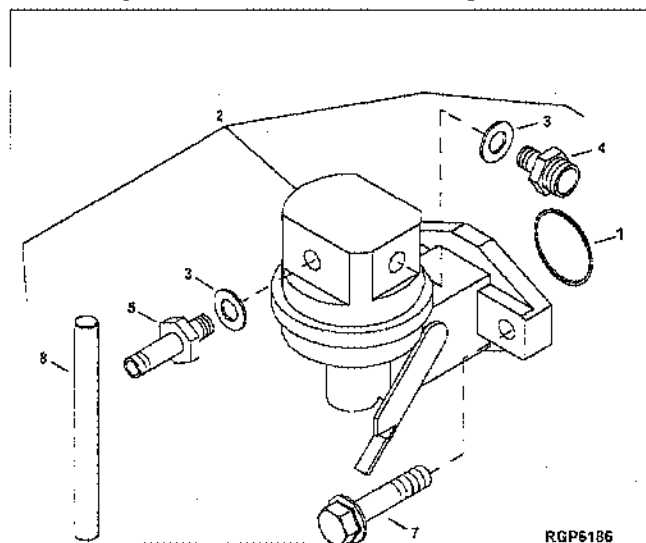
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Item	Part Number	Description	Quantity	Item	Part Number	Description	Quantity
			Variation 6386				Variation 6386
1	360015	Plug	4	16	GM32896	O-ring	1
2	360178	O-ring	1	17	GM50018	Fuel line	1
3	GM34530	Adapter	1	18	360141	Nut	7
4	360037	Fitting	3	19	223476	Packing	6
5	GM17494	Sealing washer	1	20	GM50037	Fitting, elbow	1
6	GM21453	Nut	1	21	GM21508	O-ring	1
7	GM52525	Fuel line	1	22	GM50079	Fuel line	1
8	GM17470	Fitting	2	23	223710	Plug	1
9	GM17471	O-ring	2	24	GM50026	Fitting	1
10	GM52526	Fuel line	1	25	223912	Tee fitting	1
11	GM32765	Screw	1	26	GM52527	Fuel line	1
12	GM49832	Bracket	1	27	GM32830	Line, fuel	1
13	360171	Clip	1	28	GM49918	Washer, sealing	4
14	#	Flange nut, M10	1	29	GM32896	Fitting	4
15	GM32920	Fitting	1				

Common hardware; procure locally.

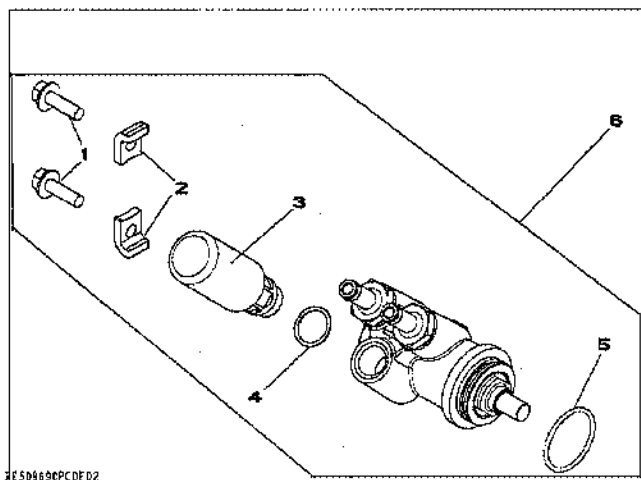
Group 16: Fuel Pump



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Item	Part Number	Description	Quantity	
			Variation	
			3702	3713
1	360119	O-ring	1	1
2	360071	Pump, fuel transfer	1	1
2	GM52528	Pump, fuel transfer		1
3	GM17471	O-ring	2	
4	GM17470	Fitting	1	
5	GM18722	Fitting	1	
7	GM17525	Screw, cap	2	2
8	360159	Rod, push	1	1

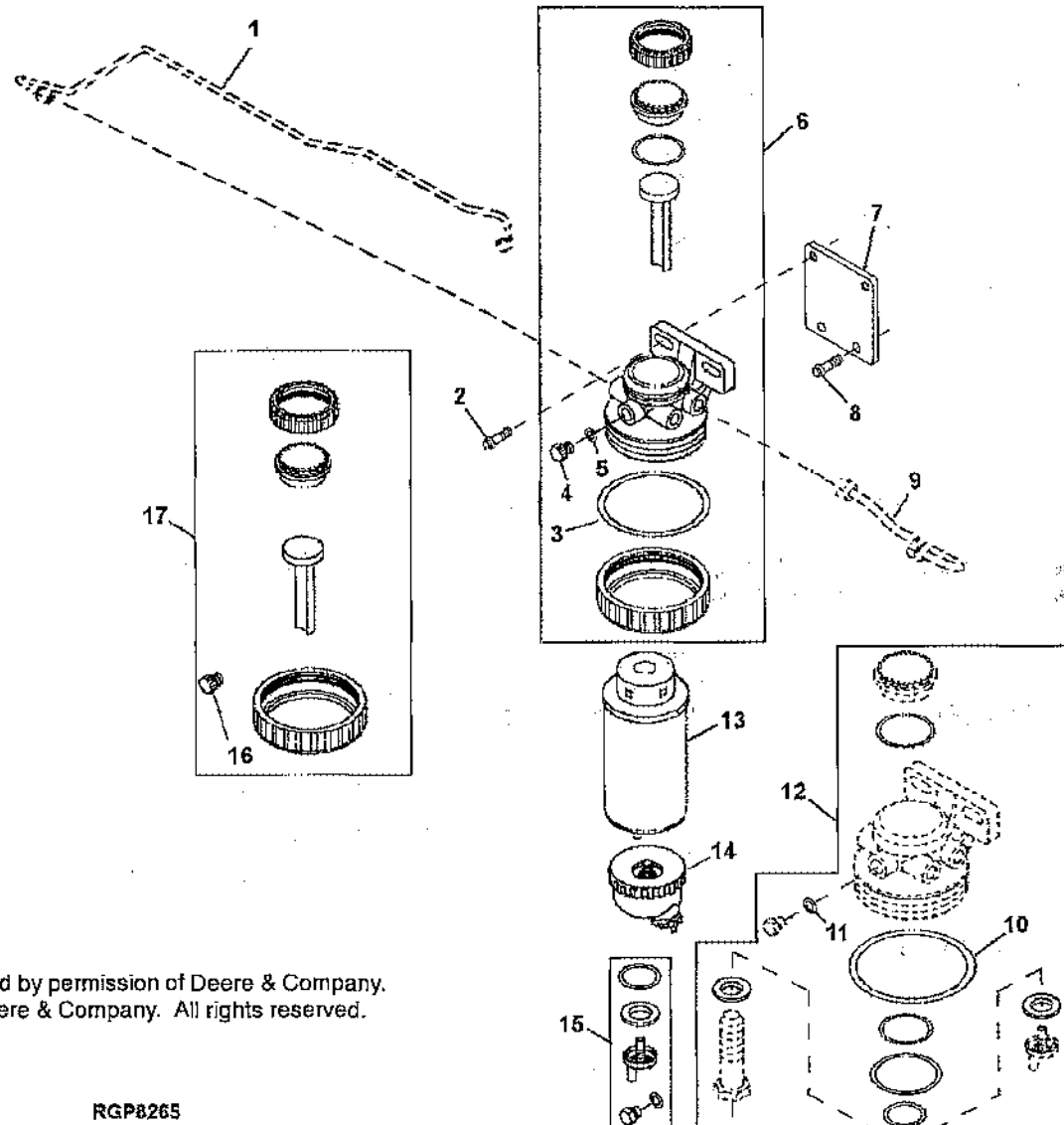
Common hardware; procure locally.



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Item	Part Number	Description	Quantity		
			Variation		
			3701	3709	3712
1	#	Screw, M6 x 20	2	2	2
2	—	Bracket	2		2
3	GM18867	Hand primer	1		1
4	223800	Washer	1		1
5	GM63802	O-ring kit	1	1	1
6	GM63891	Fuel pump	1		
6	GM64241	Fuel pump (w/d primer)		1	
6	GM63920	Fuel pump			1

Group 17: Fuel Filter



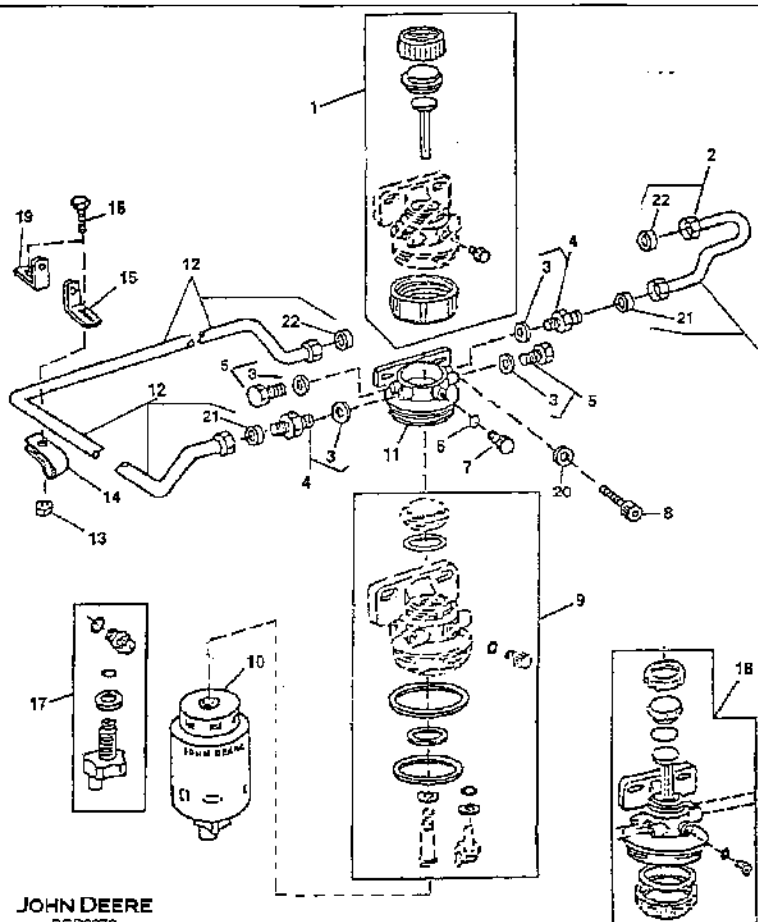
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RGP8265

Item	Part Number	Description	Quantity Variation 35BV
1	—	Fuel line (See Group 15)	1
2	#	Screw	2
3	222772	Seal	1
4	GM17444	Drain plug	1
5	352053	O-ring	1
6	GM32828	Seal kit	1
7	GM32800	Bracket	1
8	#	Screw, M10 x 20	2
9	—	Fuel line (See Group 15)	1
10	GM32836	Ring kit	1
11	352053	O-ring	1
12	GM32836	Ring kit	1
13	GM32827	Filter element	1
14	GM32731	Bowl, sediment	1
15	360048	Kit, bleed plug and drain valve	1
16	GM17444	Drain plug	1
17	222773	Seal kit	1

Common hardware; procure locally.

Group 17: Fuel Filter, continued



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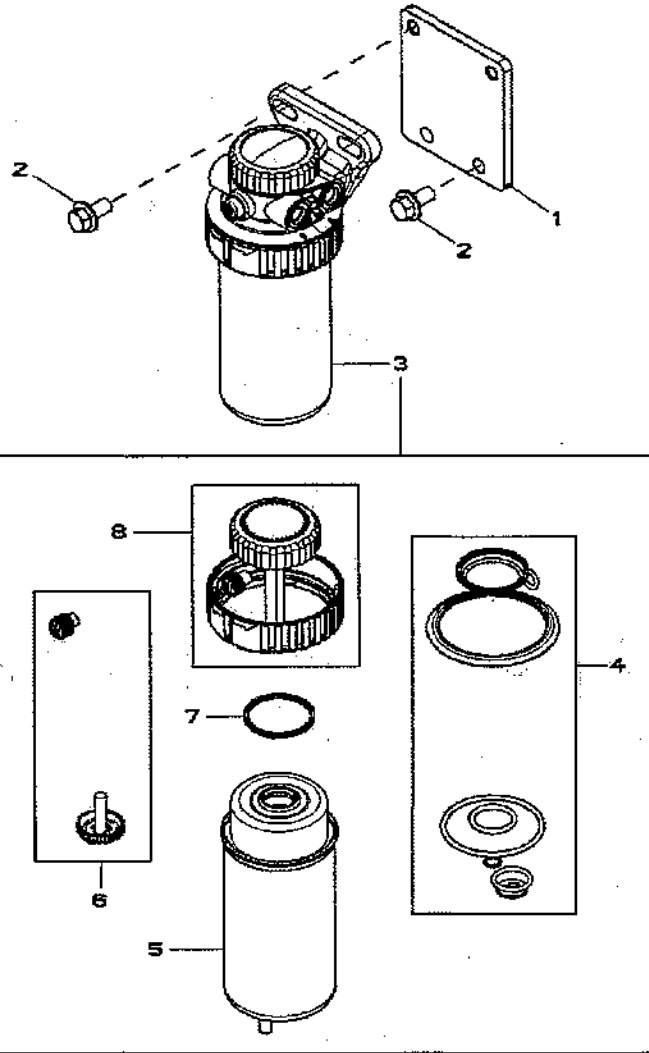
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Item	Part Number	Description	Quantity Variation 3563
1	222773	Seal kit	1
2	275502	Fuel line	1
2	GM17494	Washer	2
3	360178	O-ring	1
4	360037	Adapter	2
5	360015	Plug	1
6	X	O-ring (order item 17)	1
7	X	Plug (order item 17)	1
8	#	Screw, M10 x 25	2
9	222772	Kit	1
10	336661	Filter, fuel	1
11	GM17543	Kit	1
12	GM17534	Fuel line	1
13	#	Nut, M8	1
14	360171	Clamp	1
15	360088	Bracket	1
16	#	Screw, M8 x 16	1
17	360048	Kit	1
18	GM17543	Kit	1
19	223492	Strap	1
20	#	Washer, 10.5 x 8 x 1.6 mm	2
21	GM17494	Sealing washer	2
22	GM17494	Sealing washer	2
23	GM32731	Sediment bowl (not shown)	1

Common hardware; procure locally.

X Not sold separately

Group 17: Fuel Filter, continued



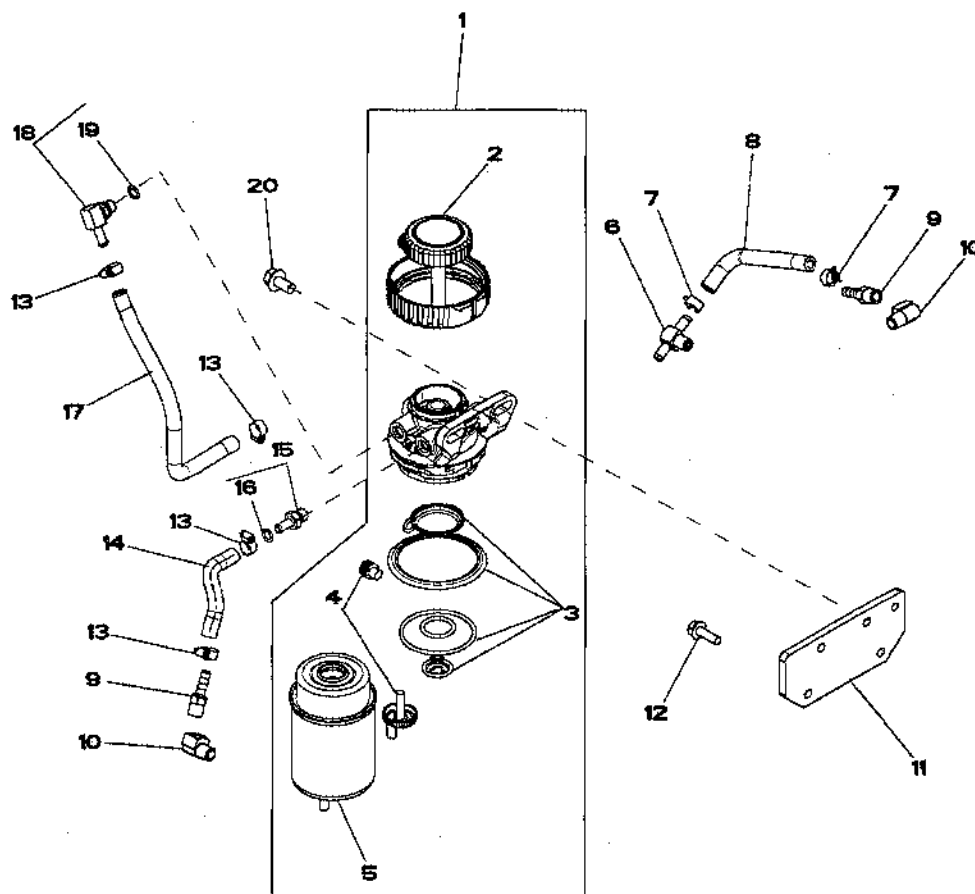
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Item	Part Number	Description	Quantity
			Variation 35ED
1	GM32800	Bracket	1
2	#	Screw, M10 x 20	4
3	GM50032	Filter	1
4	222772	Seal	1
5	GM50006	Filter element	1
6	360048	Kit, bleed plug and drain valve	1
7	GM32836	Ring kit	1
8	222773	Seal kit	1

Common hardware; procure locally.

Group 17: Fuel Filter, continued



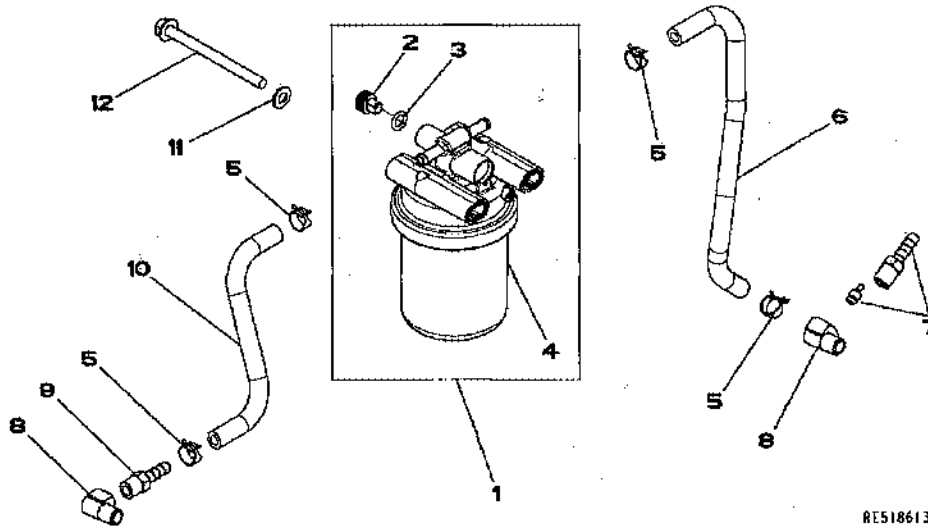
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Item	Part Number	Description	Quantity			
			Variation			
			3535	3538	3540	3543
1	GM64242	Filter (w/hand pump)	1	1		
1	GM63921	Filter			1	1
1	GM64243	Kit, hand pump (not shown)	1	1		
2	222773	Seal kit	1	1	1	1
3	222772	Seal kit	1	1	1	1
4	360048	Kit, bleed plug & drain valve	1	1	1	1
5	GM63894	Filter element	1	1	1	1
6	GM64244	Tee fitting	1	1		
6	GM63922	Tee fitting			1	1
7	GM63751	Hose clamp	2	2	2	2
8	GM63779	Hose	1	1	1	1
9	GM63897	Hose fitting	2	2	2	2
10	GM63896	Elbow fitting	2	2	2	2
11	GM63794	Bracket	1	1	1	1
12	#	Screw, M8 x 25	2	2	2	2
13	GM63929	Clamp	4	4	4	4
14	GM63797	Hose	1		1	
14	GM63796	Hose		1		1
15	GM63900	Fitting	1	1	1	1
16	360178	O-ring	1	1	1	1
17	GM63795	Hose	1	1	1	1
18	GM21454	Fitting, hose	1	1	1	1
19	360178	O-ring	1	1	1	1
20	#	Screw	2	2	2	2

Common hardware; procure locally.

Group 17: Fuel Filter, continued



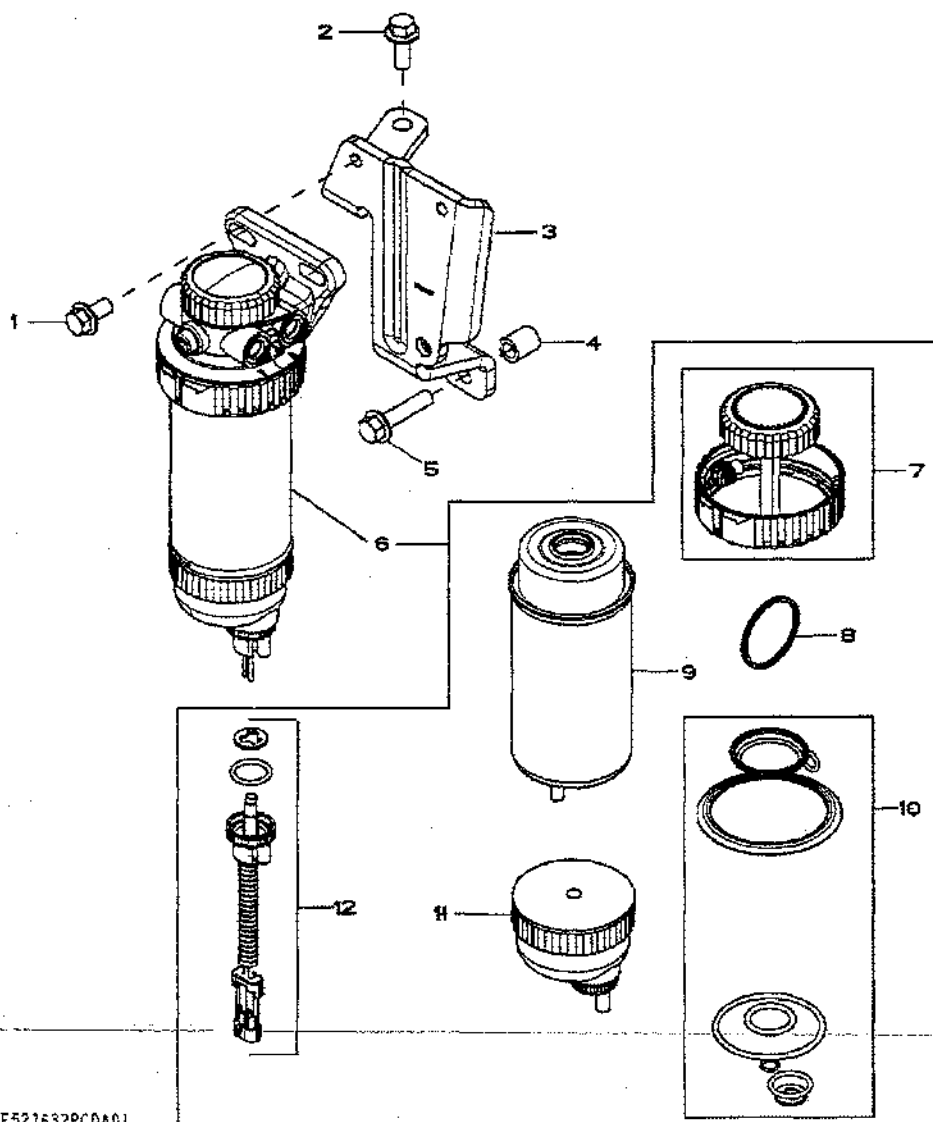
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Item	Part Number	Description	Quantity
			Variation 3505
1	GM63863	Fuel filter	1
2	GM17444	Drain plug	1
3	352053	Ring	1
4	GM63809	Fuel filter	1
5	GM63751	Hose clamp	4
6	GM21451	Hose	1
7	GM63810	Hose fitting	1
8	GM63896	Elbow fitting	2
9	GM63897	Hose fitting	1
10	GM21451	Hose	1
11	224338	Washer	2
12	#	Screw, M8 x 100	2

Common hardware; procure locally.

Group 17B: Primary Fuel Filter



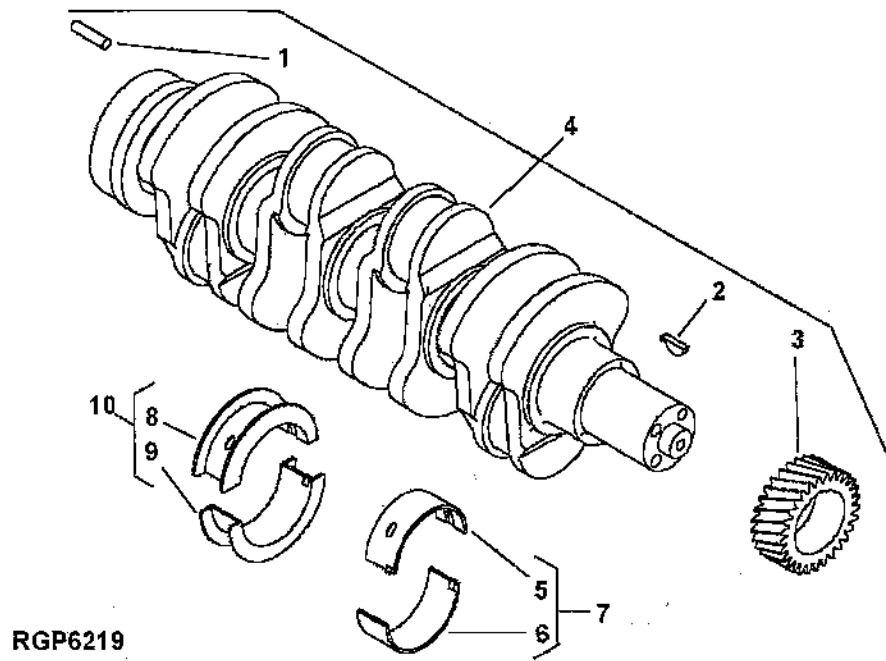
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Item	Part Number	Description	Quantity
			Variation 8170
1	#	Screw, M10 x 20	2
2	#	Screw, M10 x 25	1
3	GM52539	Bracket	1
4	GM52540	Spacer	1
5	#	Screw, M10 x 45	1
6	GM50073	Filter	1
7	222773	Seal kit	1
8	GM32836	O-ring kit	1
9	GM50074	Filter element	1
10	222772	Seal kit	1
11	GM32731	Sediment bowl	1
12	GM49940	Moisture sensor	1

Common hardware; procure locally.

Group 18: Crankshaft

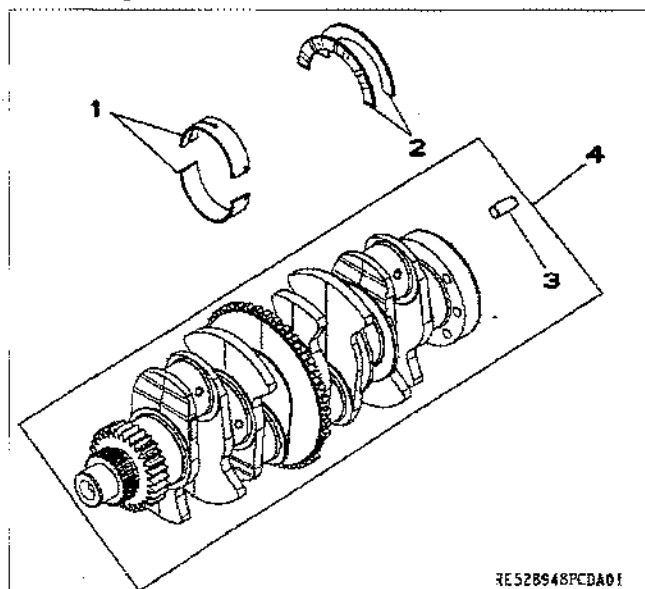


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Item	Part Number	Description	Quantity
			Variation 4715
1	223472	Dowel pin	1
2	360503	Key, shaft	1
3	360099	Gear 30 teeth	1
4	GM32811	Crankshaft	1
5	X	Bearing (not sold separately)	4
6	X	Bearing (not sold separately)	4
7	360049	Bearing kit, standard	4
7	360055	Bearing kit, undersize 0.254 mm	4
8	X	Bearing (not sold separately)	4
9	X	Bearing (not sold separately)	4
10	360050	Bearing, standard	1
10	360056	Bearing, undersize 0.254 mm	1
—	360581	Bolt, flywheel/crankshaft	4

X Not sold separately.

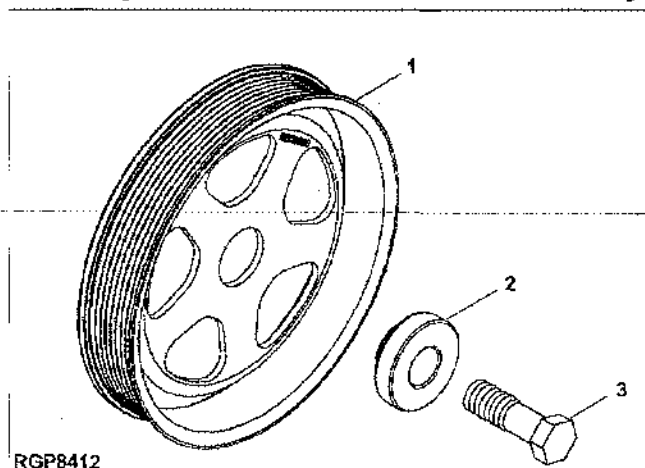
Group 18: Crankshaft, continued



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Item	Part Number	Description	Quantity		
			Variation		
			4701	4703	4704
1	GM63831	Bearing kit std	5	5	6
1	GM63855	Bearing kit, 0.25 US	5	5	5
2	GM63832	Thrust washer kit	1	1	1
3	223472	Dowel pin	1	1	1
4	GM63803	Crankshaft	1		
4	GM63868	Crankshaft		1	
4	GM63869	Crankshaft			1

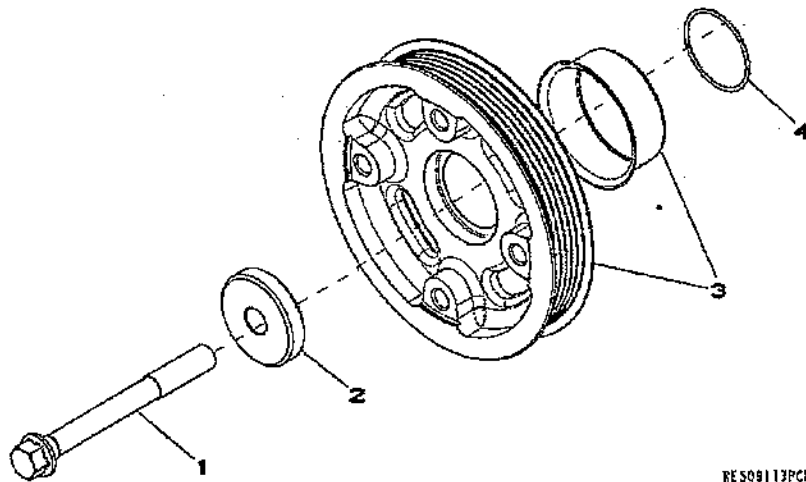
Group 19: Crankshaft Pulley



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Item	Part Number	Description	Quantity	
			Variation	
			1327	1328
1	GM37464	Pulley		1
1	GM32794	Pulley	1	
2	GM32801	Bushing	1	1
3	GM32764	Bolt	1	1

Group 19: Crankshaft Pulley

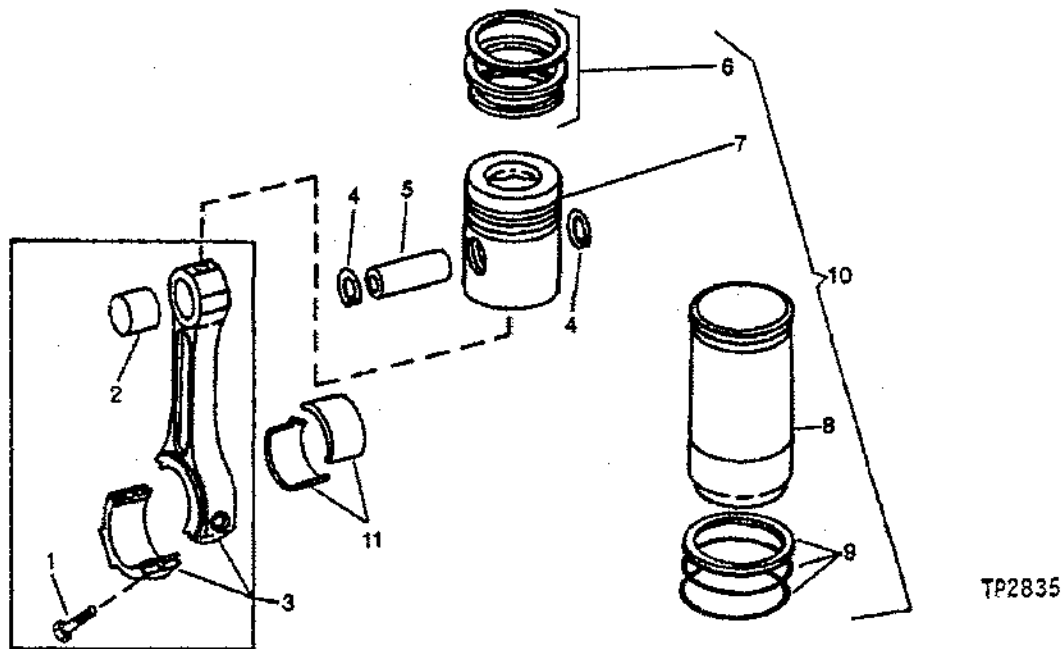


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Item	Part Number	Description	Quantity	
			Variation	
			1301	1303
1	GM63720	Cap screw, M12 x 110	1	1
2	GM63716	Bushing	1	1
3	GM63829	Pulley kit (also order seal 223422)	1	
3	GM63845	Pulley kit (also order seal 223422)		1
4	GM63924	O-ring	1	1

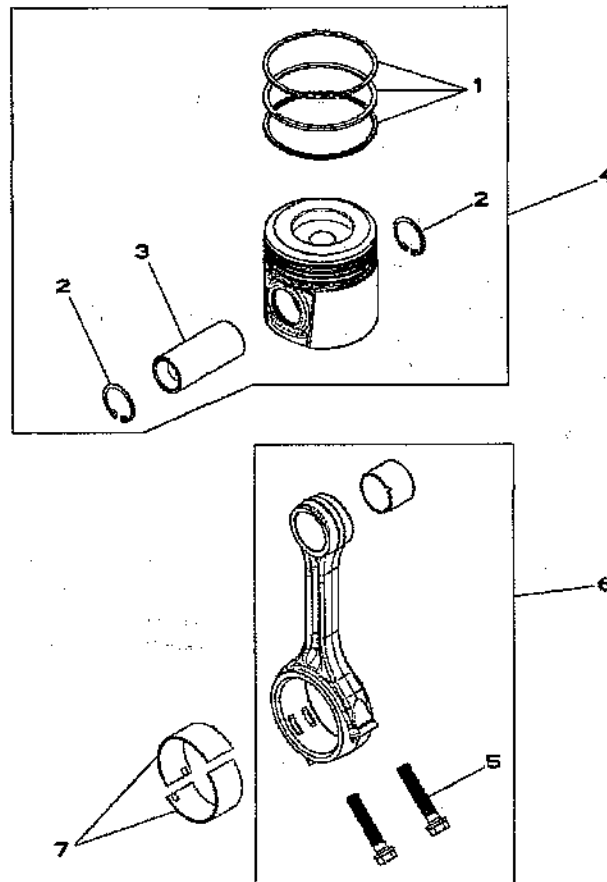
Group 20: Piston and Connecting Rod



Item	Part Number	Description	Quantity		
			4822	Variation 4823	4838
1	GM17477	Screw	8	8	8
2	GM17446	Bushing	6		4
2	GM17451	Bushing		6	
3	GM17610	Rod, connecting	4		4
3	GM17499	Rod, connecting		4	
4	223479	Ring, snap	8		8
4	223452	Ring, snap		8	
5	GM17450	Pin, piston	6		
5	360114	Pin, piston		6	
5	GM46667	Pin, piston			4
6	GM32821	Kit, piston ring	4	4	
6	GM50056	Kit, piston ring			4
7	X	Not sold separately	4	4	4
8	X	Not sold separately	4	4	4
9	223419	Kit, O-ring	4	4	4
10	GM32820	Kit, piston liner	4		
10	GM32823	Kit, piston liner		4	
10	GM50055	Kit, piston liner			4
11	360053	Bearing, standard	4	4	4
11	360054	Bearing, 0.25 mm undersize	4	4	4

X Not sold separately.

Group 20: Piston and Connecting Rod

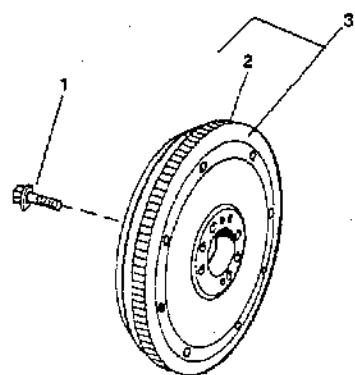


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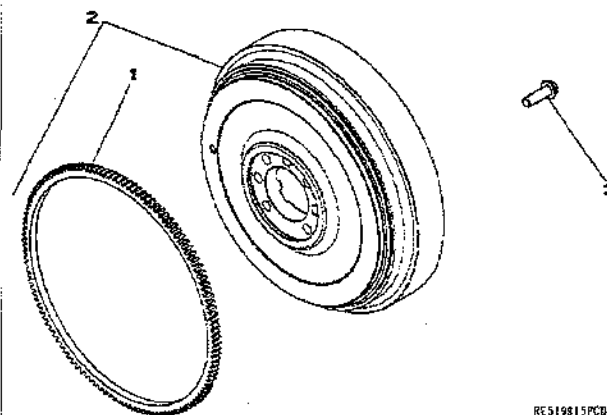
Item	Part Number	Description	Quantity		
			4806	Variation 4814	4815
1	GM63834	Piston ring kit std.	4		
1	GM63899	Piston ring kit std.		4	5
1	GM63853	Piston ring kit, 0.25 OS	4		
1	GM63913	Piston ring kit, 0.25 OS		4	5
1	GM63854	Piston ring kit, 0.50 OS	4		
1	GM63914	Piston ring kit, 0.50 OS		4	5
2	GM63704	Snap ring	8	8	8
3	GM63717	Piston pin	4	4	5
4	GM63842	Piston replacement kit std.	4		
4	GM63915	Piston replacement kit std.		4	5
4	GM63852	Piston replacement kit, 0.25 OS	4		
4	GM63916	Piston replacement kit, 0.25 OS		4	5
4	GM63854	Piston replacement kit, 0.50 OS	4		
4	GM63917	Piston replacement kit, 0.50 OS		4	5
5	GM63713	Screw, M10 x 49	8	8	10
6	GM63801	Connecting rod	4	4	5
7	GM63835	Bearing kit std.	4	4	5
7	GM63856	Bearing kit, 0.25 US		4	5

Group 21: Flywheel



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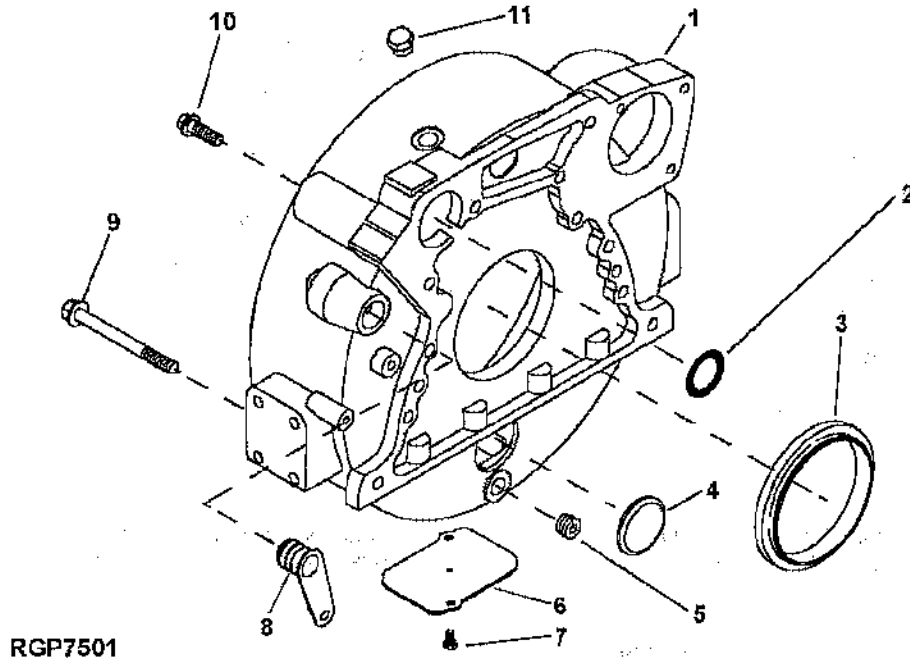
Item	Part Number	Description	Quantity	
			Variation	
			1503	1509
1	360581	Bolt	4	4
2	223750	Gear, 129 teeth	1	1
3	GM17501	Flywheel	1	
3	GM23840	Flywheel		1



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Item	Part Number	Description	Quantity	
			Variation	
			1508	
1	GM63759	Ring gear		1
2	GM63826	Flywheel		1
3	GM63818	Screw, M12 x 38		6

Group 22: Flywheel Housing

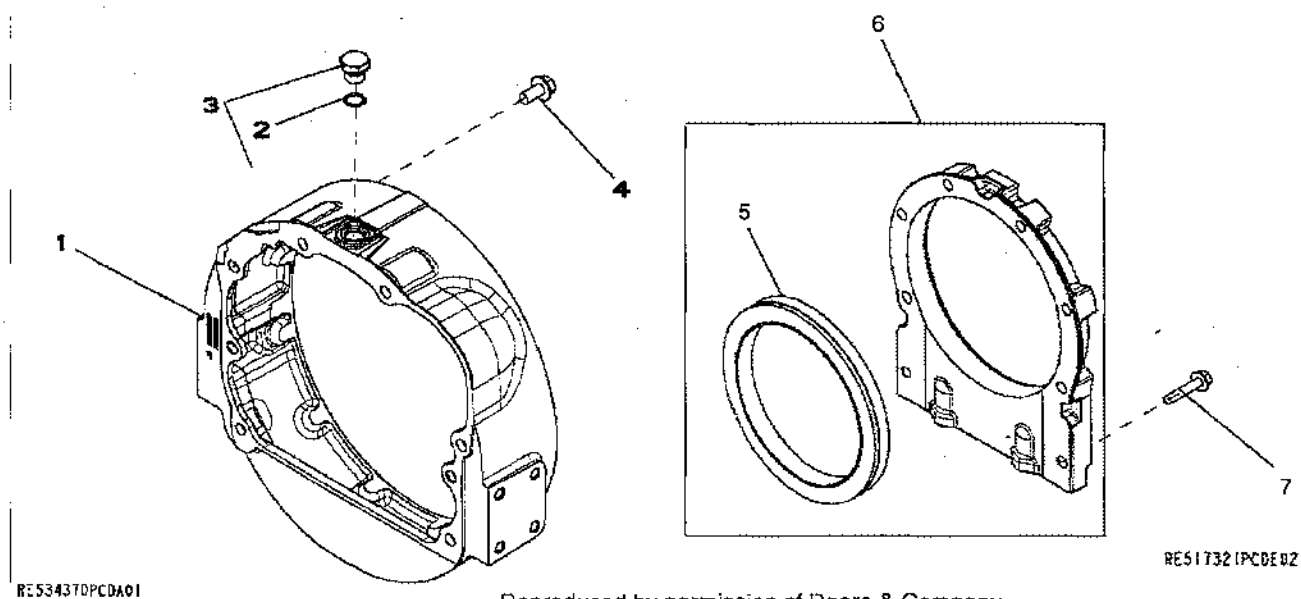


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Item	Part Number	Description	Quantity
			Variation 1406
1	GM24539	Housing, flywheel (order item 2 also)	1
2	GM24540	O-ring	1
3	223583	Seal	1
4	GM17553	Cap	1
5	GM15403	Plug, pipe, 1/2 in.	1
6	GM17449	Plate	1
7	#	Screw, cap	2
8	GM17453	Plug	1
9	#	Screw, M12 x 50	4
10	360581	Bolt	8
11	GM17468	Fitting	1

Common hardware; procure locally.

Group 22: Flywheel Housing, continued

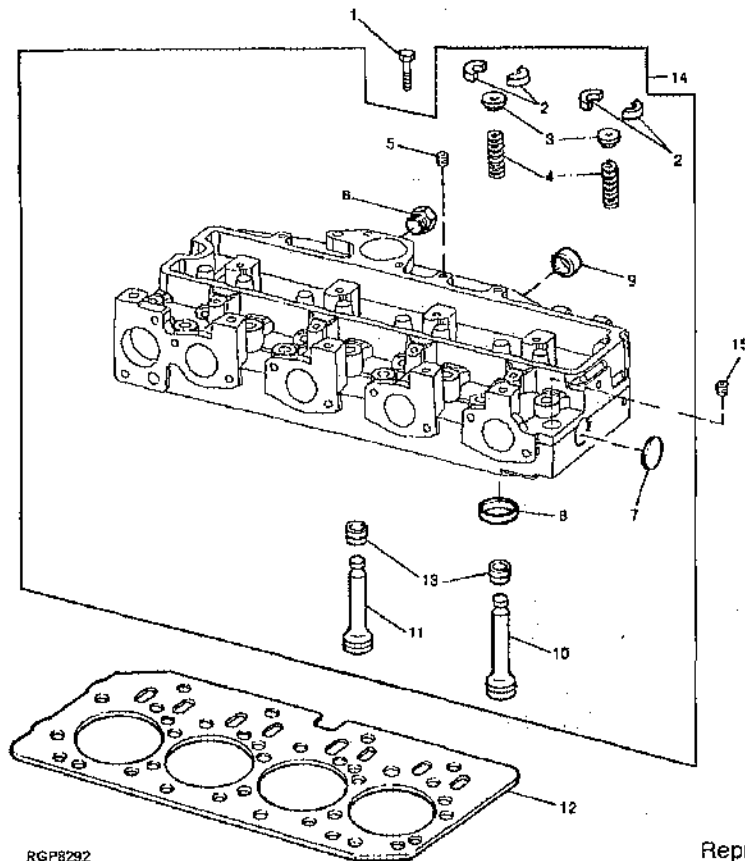


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Item	Part Number	Description	Quantity			
			Variation			
			1401	1406B	1408	1415
1	GM63793	Housing	1			
1	GM63740	Housing		1		
1	GM64245	Housing			1	
1	GM63792	Housing				1
2	360180	O-ring, 17.3 x 2.2 mm				1
3	360078	Plug, drain				1
4	#	Screw, M12 x 25	6	6	6	6
5	223583	Seal	1	1	1	1
6	GM64246	Seal kit	1	1	1	1
7	#	Screw, M6 x 30	8	8	8	8
	GM63705	Sealant	AR	AR	AR	AR

Common hardware; procure locally.

Group 23: Cylinder Head



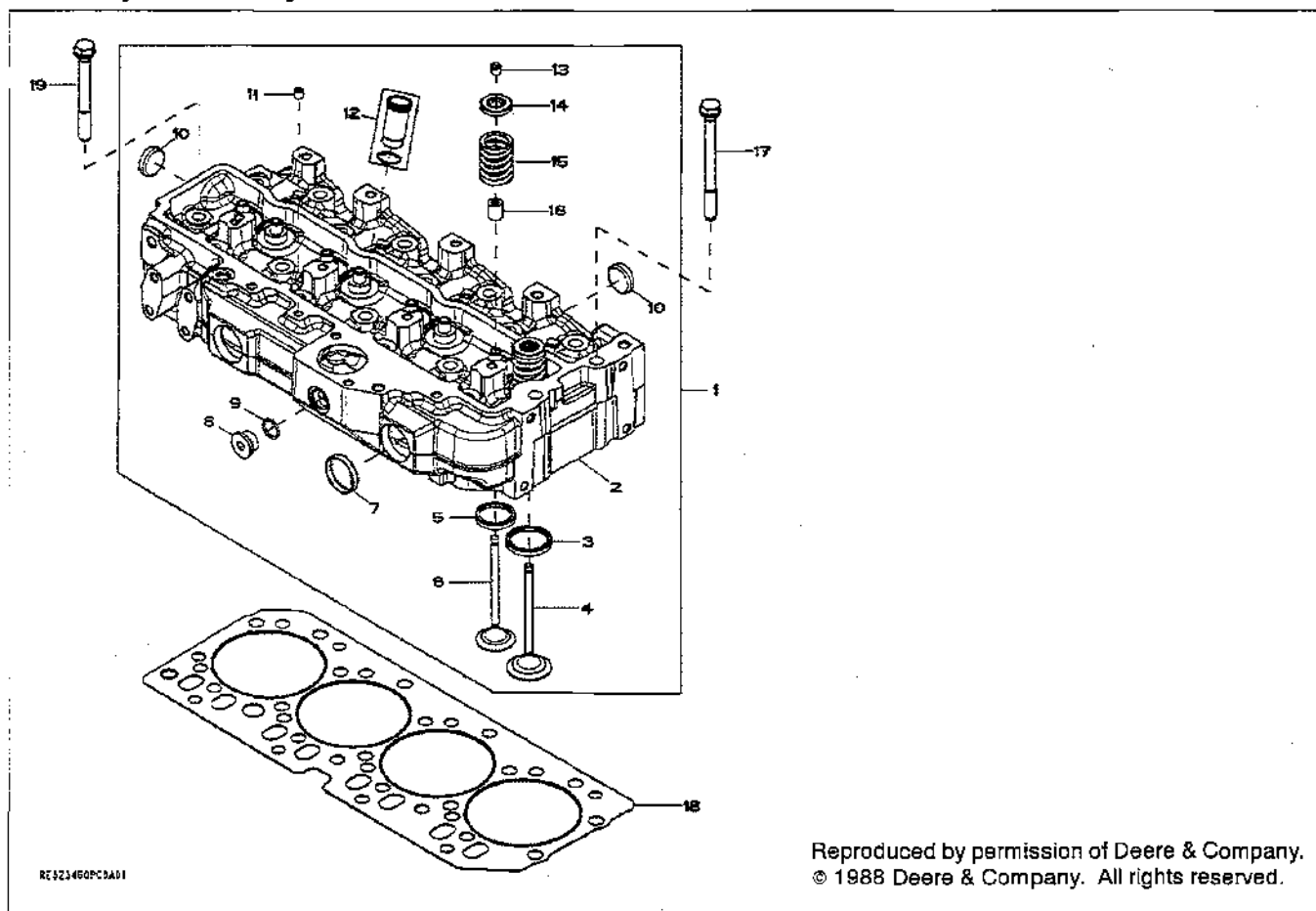
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Item	Part Number	Description	Quantity Variation 5102
1	224164	Screw, cap	18
2	224184	Lock	16
3	224176	Rotator	8
4	223455	Spring	8
5	224268	Plug, pipe	1
6	360174	Fitting	1
7	223746	O-ring	1
8	223448	Cap	1
9	GM21433	Insert, intake valve seat	4
10	GM21434	Insert, exhaust valve seat	4
11	224157	Cap	2
12	224156	Valve, exhaust, standard	4
13	224153	Valve, exhaust, 0.015 in., 0.381 mm, oversize	AR
14	224151	Valve, exhaust, 0.030 in., 0.762 mm, oversize	AR
15	224168	Valve, intake, standard	4
16	224193	Valve, intake, 0.015 in., 0.381 mm, oversize	AR
17	224197	Valve, intake, 0.030 in., 0.762 mm, oversize	AR
18	360531	Gasket, cylinder head	1
19	224243	Seal	8
20	360532	Head, cylinder	1
21	224268	Plug, pipe	1

AR As Required

Group 23: Cylinder Head, continued

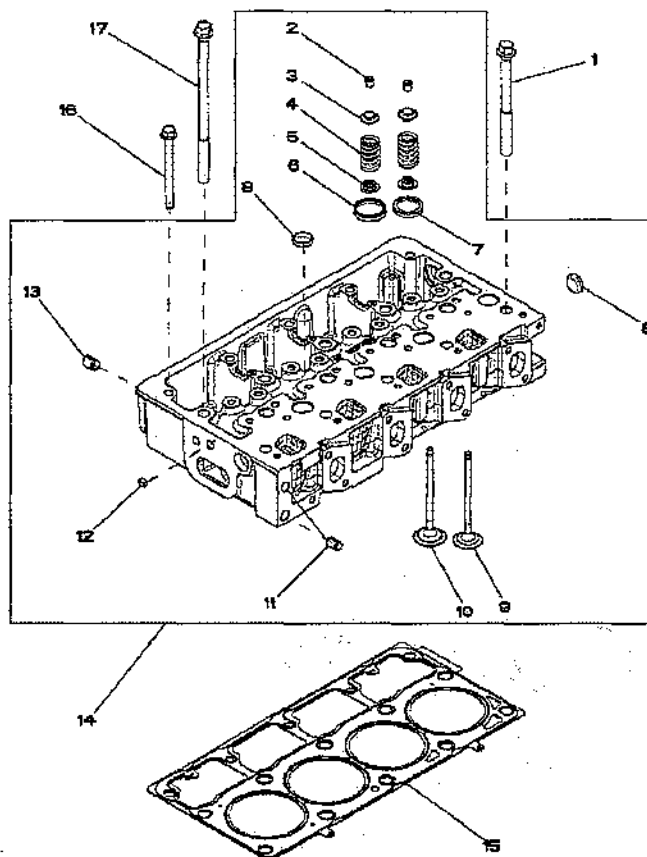


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Item	Part Number	Description	Quantity Variation 5122
1	GM52529	Cylinder head kit	1
2		Not sold separately	1
3	GM21433	Insert, valve	4
4	224168	Intake valve, standard	3
4	224193	Intake valve, 0.381 mm OS	AR
4	224197	Intake valve, 0.762 mm OS	AR
5	GM21434	Insert, valve	3
6	224156	Exhaust valve, std.	3
6	224153	Exhaust valve, 0.381 mm	AR
6	224151	Exhaust valve, 0.762 mm	AR
7	224157	Cap	3
8	360174	Fitting	1
9	223746	O-ring	1
10	223448	Cap	1
11	224268	Pipe plug	AR
12	GM50051	Sleeve	4
13	224184	Lock	16
14	224176	Rotator	8
15	223455	Spring	8
16	GM50076	Seal	8
17	GM46671	Screw, cylinder head	2
18	360531	Gasket, cylinder head	1
19	224164	Cap screw	26

AR As Required

Group 23: Cylinder Head, continued



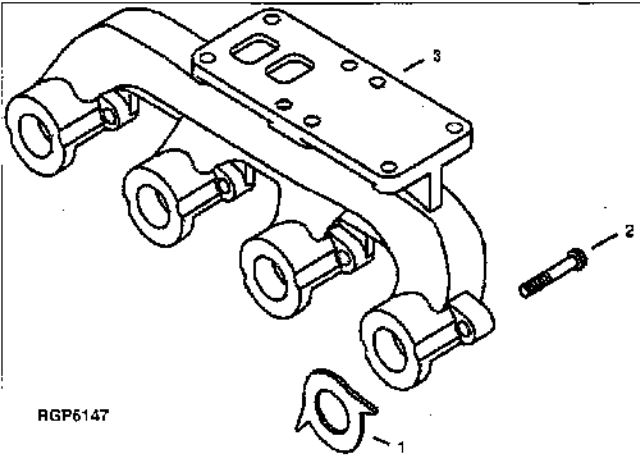
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Item	Part Number	Description	Quantity		
			5101	Variation 5105	5106
1	—	Screw (order bolt kit)	2	2	2
2	GM46672	Retainer	16	16	20
3	GM46673	Cap	8	8	10
4	GM63776	Spring		8	10
5	GM63710	Spring	8		
6	GM63892	Seal		8	10
7	GM63836	Seal	8		
8	GM63799	Valve seat insert		4	5
9	GM63800	Valve seat insert		4	5
10	GM63925	Plug	6	5	6
11	360517	Plug	5		
12	GM63712	Exhaust valve	4	4	5
13	GM63711	Intake valve	4	4	5
14	#	Spring pin, 11 x 16 mm	2	2	2
15	GM52777	Plug		1	1
16	#	Spring pin, 13 x 16 mm	2	2	2
17	GM63909	Cylinder head		1	
18	GM63806	Cylinder head	1		
19	GM63910	Cylinder head			1
20	GM63895	Engine cylinder head gasket, standard	1		
21	GM63878	Engine cylinder head gasket, standard		1	
22	GM63877	Engine cylinder head gasket, standard			1
23	GM63903	Engine cylinder head gasket, 0.25, 0.50 OS	1		
24	GM63904	Engine cylinder head gasket, 0.25, 0.50 OS		1	
25	GM63905	Engine cylinder head gasket, 0.25, 0.50 OS			1
26	#	Screw, M8 x 100	5	5	6
27	GM63747	Screw	8	8	10
28	GM63838	Bolt kit (includes items 1, 16, 17)	1	1	
29	GM63839	Bolt kit (includes items 1, 16, 17)			1

Common hardware; procure locally.

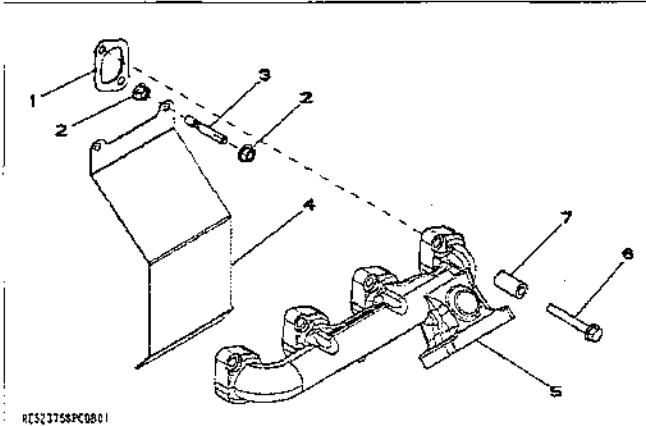
Group 24: Exhaust Manifold



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Item	Part Number	Description	Quantity	
			Variation	
			2803	2888
1	223547	Gasket	4	
1	GM49855	Gasket		4
2	#	Screw, M10 x 80	8	
2	GM49914	Screw, M10 x 80		8
3	360534	Manifold, exh. (4045TF275 eng.)	1	
3	GM32803	Manifold, exh. (4045TF270 eng.)	1	
3	GM52530	Manifold, exhaust		1

Common hardware; procure locally.

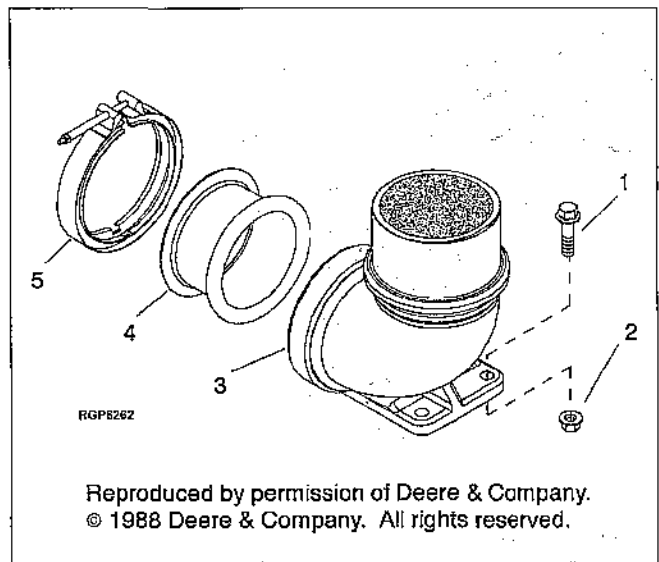


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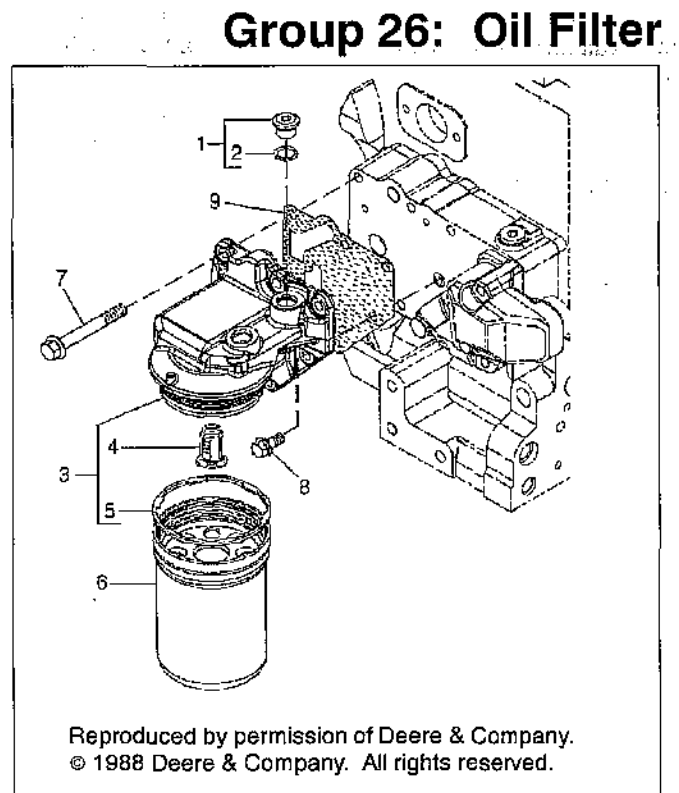
Item	Part Number	Description	Quantity	
			Variation	
			2806	2807
1	GM63737	Gasket	4	5
2	#	Flange nut, M8	4	5
3	GM63770	Stud	2	3
4	GM63771	Heat shield	1	1
5	GM63768	Exhaust manifold	1	
5	GM63772	Exhaust manifold		1
6	#	Screw, M8 x 60	6	7
7	GM63790	Spacer	6	7

Group 25: Exhaust Elbow

Item	Part Number	Description	Quantity	
			Variation 6401	6438
1	#	Screw, cap, M10 x 40	4	2
1	GM49897	Stud (not shown)		2
2	#	Nut, flange, M10	4	4
3	360117	Elbow, pipe	1	
3	GM49928	Elbow, pipe		1
4	223891	Adapter	1	1
5	224132	Clamp	1	1

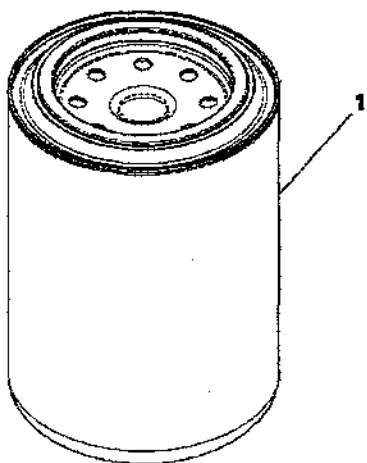


Item	Part Number	Description	Quantity
			Variation 8842
1	GM24535	Plug	1
2	360557	O-ring	1
3	GM32808	Filter head	1
4	GM32807	Valve	1
5	GM32787	Seal	1
6	GM32809	Filter, oil	1
7	#	Screw, M8 x 65	5
8	GM24536	Screw	1
9	GM24537	Gasket	1



Common hardware; procure locally.

Group 26: Oil Filter, continued

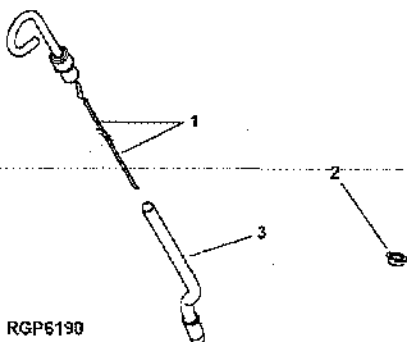


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Item	Part Number	Description	Quantity	
			Variation	8801
1	GM34935	Filter, oil	1	

Group 27: Dipstick

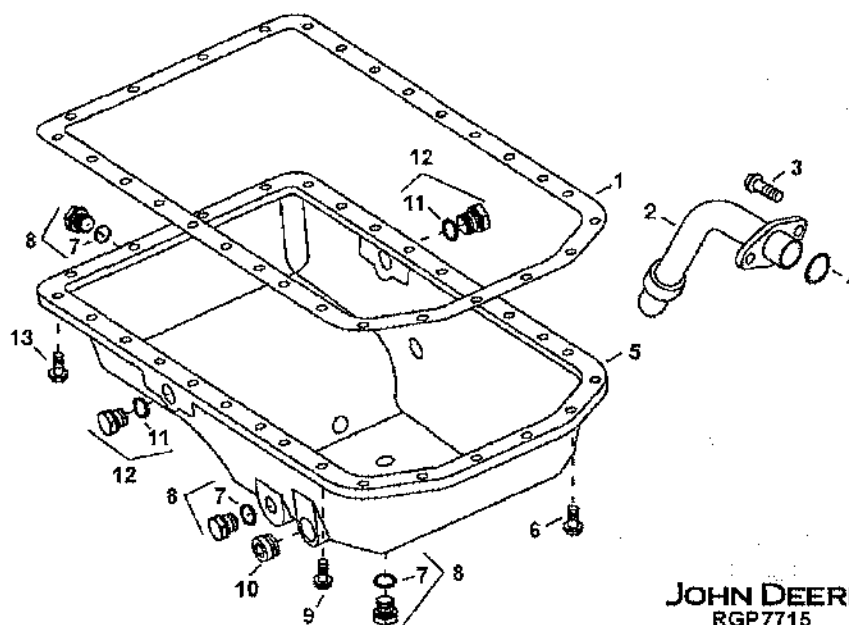


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Item	Part Number	Description	Quantity	
			4002	4003
1	360073	Dipstick	1	
1	GM63822	Dipstick		1
2	GM32789	Plug	1	
3	GM32788	Tube, dipstick	1	
3	GM63791	Tube, dipstick		1

Group 28: Oil Pan

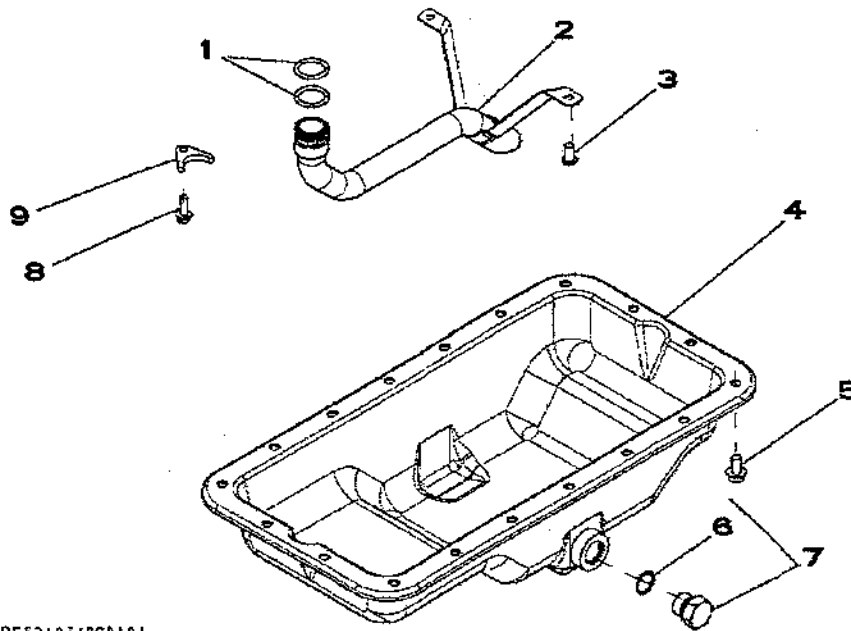


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Item	Part Number	Description	Quantity		
			1904	Variation 1923	19AE
1	360527	Gasket, oil pan	1	1	
1	GM50621	Gasket, oil pan			1
2	360523	Intake, oil pump	1		1
2	GM32846	Intake, oil pump		1	
3	#	Screw, M8 x 100	2	2	2
4	224035	O-ring	1	1	1
5	360529	Pan, oil	1		
5	GM32780	Pan, oil		1	
5	GM51536	Pan, oil			1
6	#	Screw, M8 x 30	6	6	6
7	360176	O-ring	3	1	3
8	360014	Plug	3	1	3
9	#	Screw, M8 x 25	18	18	
9	#	Screw, M8 x 16			18
10	#	Plug, pipe, 3/4 in.	1		1
11	GM17437	O-ring	2	2	2
12	GM17498	Fitting	2	2	2
13	#	Screw, M8 x 45	4	4	
13	#	Screw, M8 x 16			4

Common hardware; procure locally.

Group 28: Oil Pan, continued



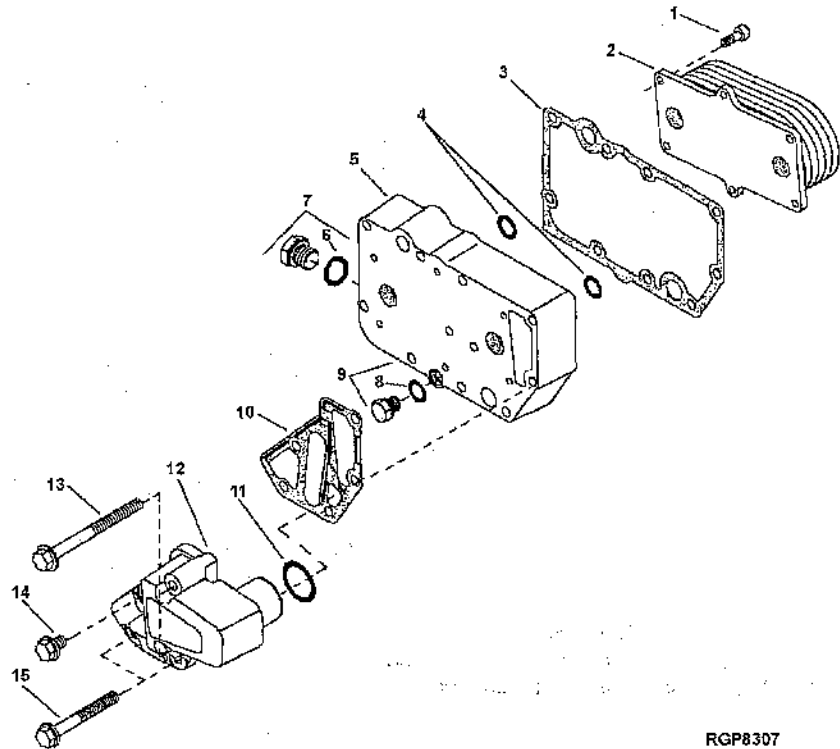
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Item	Part Number	Description	Quantity	
			Variation	
			1902	1924
1	223763	O-ring	2	2
2	GM63886	Tube	1	
2	GM63886	Tube		1
3	#	Screw	2	2
4	GM63814	Oil pan	1	
4	GM63815	Oil pan		1
5	#	Screw, M8 x 16	20	18
6	GM17437	O-ring	1	1
7	GM17498	Fitting	1	1
8	#	Screw, M6 x 20	1	1
9	GM63727	Clamp	1	1
....	GM63705	Sealant	AR	AR

Common hardware; procure locally.

Group 29: Oil Cooler



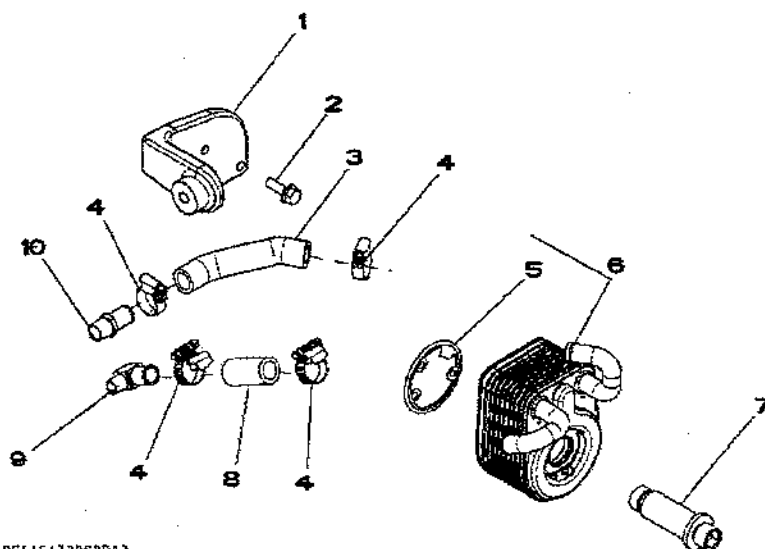
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Item	Part Number	Description	Quantity	
			Variation	
			5901	5902
1	#	Screw, M6 x 16	6	6
2	GM17531	Cooler, oil	1	
2	360560	Cooler, oil		1
3	360130	Gasket	1	1
4	360170	O-ring	2	2
5	360127	Housing	1	1
6	360176	O-ring	1	1
7	360014	Plug (includes O-ring)	1	1
8	360178	O-ring	1	1
9	360015	Plug (includes O-ring)	1	1
10	GM17479	Gasket	1	1
11	GM24543	O-ring	1	1
12	GM32790	Adapter	1	
12	GM49933	Adapter		1
13	#	Screw, M8 x 100	2	2
14	#	Screw, M8 x 20	1	1
15	#	Screw, M8 x 65	2	2

Common hardware; procure locally.

Group 29: Oil Cooler, continued



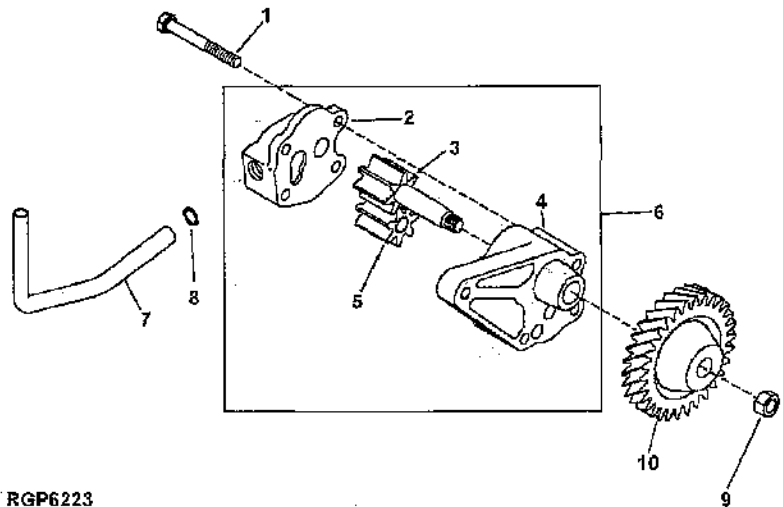
RE515473PCDD03

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Item	Part Number	Description	Quantity
			Variation 5903
1	GM63729	Bracket	1
2	#	Screw, M8 x 25	1
3	GM63735	Hose, inlet	1
4	GM21409	Clamp, hose	4
5	GM63732	Gasket	1
6	GM63817	Oil cooler	1
7	GM63731	Threaded nipple	1
8	GM63928	Hose, outlet, 52 mm	AR
9	GM63733	Fitting, hose	1
10	GM63736	Fitting, hose	1

Common hardware; procure locally.

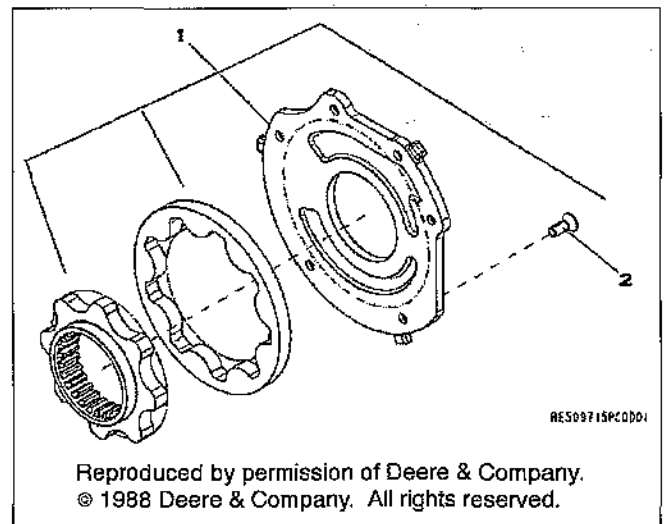
Group 30: Oil Pump



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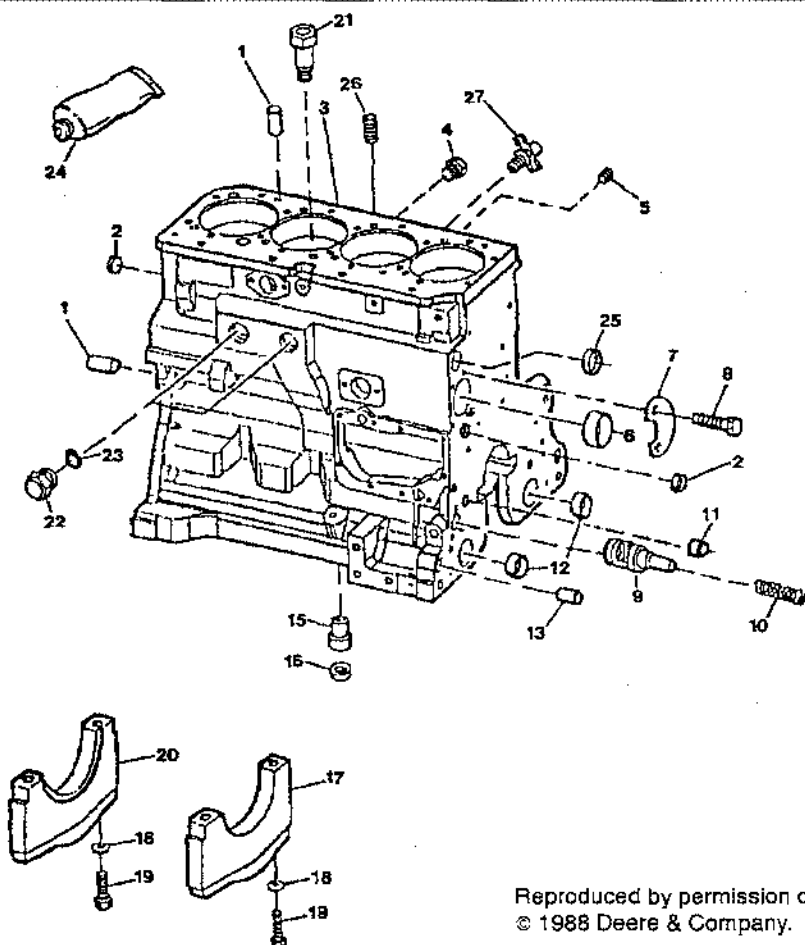
Item	Part Number	Description	Quantity	
			Variation	
			5001	5002
1	#	Screw, M8 x 65	2	2
2	—	Cover (not sold separately, order item 6)	1	1
3	—	Gear (not sold separately, order item 6)	1	1
4	—	Housing (not sold separately, order item 6)	1	1
5	—	Gear (not sold separately, order item 6)	1	1
6	360028	Pump, oil	1	1
7	360104	Tube	1	1
8	336458	O-ring	1	1
9	#	Nut, M12	1	1
10	360524	Gear, 30 teeth	1	1

Common hardware; procure locally.



Item	Part Number	Description	Quantity
			Variation
			5001B
1	—	Oil pump (order complete timing gear cover kit)	1
2	GM63816	Screw	6

Group 31: Cylinder Block

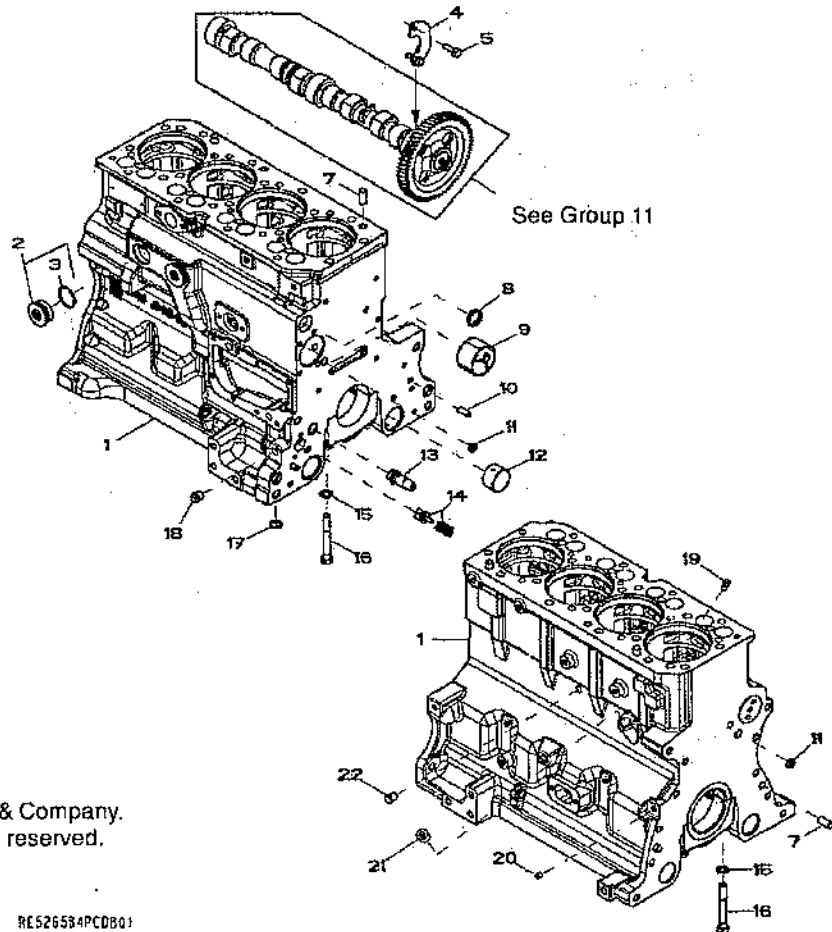


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Item	Part Number	Description	Quantity	
			Variation	
			4614	4616
1	223472	Pin, dowel	4	4
2	360517	Cap	2	2
2	360093	Plug	1	1
3	---	Block, cylinder (see short block)	1	1
4	223802	Plug, pipe	1	1
5	224268	Plug, pipe	5	5
6	352246	Bushing	1	1
7	360154	Plate, thrust	1	1
8	#	Screw, M8x 25	2	2
9	360103	Valve, engine oil bypass	1	1
10	360080	Spring	1	1
11	GM32810	Valve, bleed	1	1
12	350519	Bushing	6	6
13	352064	Pin, dowel	2	2
15	360087	Bushing	1	1
16	223512	O-ring	1	1
17	360084	Cap, main bearing	4	4
18	224089	Washer	10	10
19	223639	Screw, cap	10	10
20	360151	Cap, main thrust bearing	1	1
21	360146	Jet	4	4
22	GM32824	Plug	2	2
23	223988	O-ring	2	2
24	360173	Gasket	1	1
25	360093	Plug	1	1
26	GM15403	Plug, pipe	1	1
27	223435	Valve, drain	1	1

Common hardware; procure locally.

Group 31: Cylinder Block



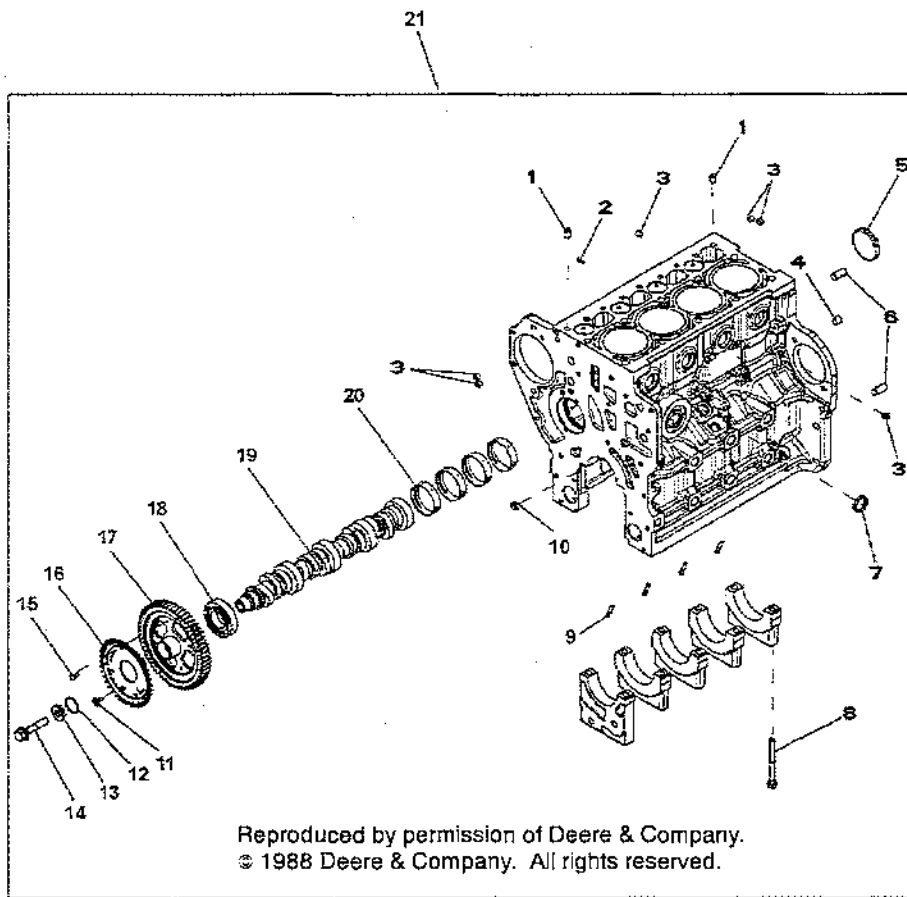
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RE526534PCD801

Item	Part Number	Description	Quantity Variation 4643
1	—	Block, cylinder	1
2	GM32824	Plug	2
3	223988	O-ring	1
4	360154	Plate, thrust	1
5	#	Screw, M8 x 25	2
7	223472	Pin, dowel	4
8	360093	Plug	1
9	352246	Bushing	1
10	352064	Pin, dowel	1
11	360517	Cap	1
12	360519	Bushing	6
13	GM32810	Valve	1
14	GM21420	Kit, valve	1
15	224089	Washer	10
16	223639	Cap screw	10
17	336458	O-ring	1
18	#	Plug, pipe, 3/8 in.-18 NPT	1
19	360146	Jet	4
20	224268	Plug, pipe	5
21	#	Plug, pipe, 1/2 in.-14 NPT	1
22	#	Plug, pipe, 1/4 in.-18 NPT	1

Common hardware; procure locally.

Group 31: Cylinder Block, continued

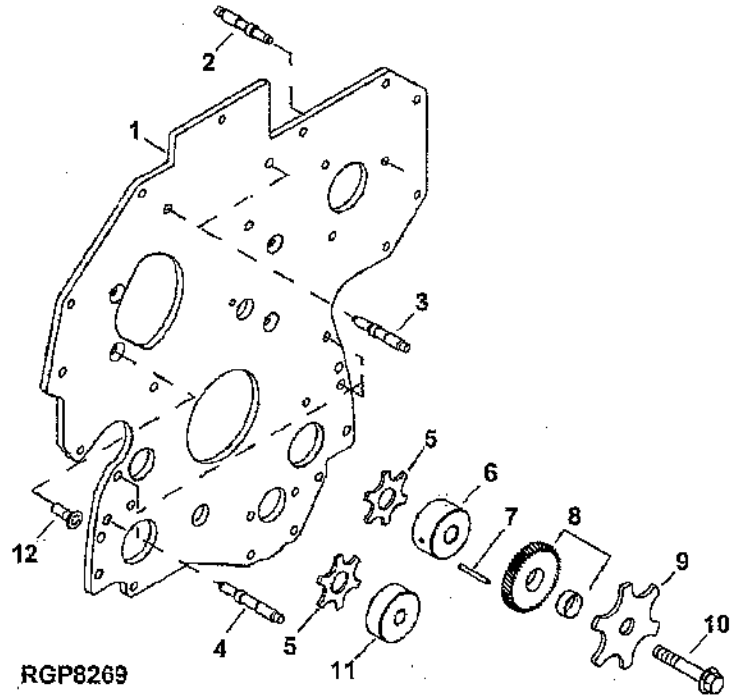


RE533671RGP01

Item	Part Number	Description	Quantity		
			Variation		
			4604	4618	4619
1	#	Spring pin, 11 x 18 mm	2	2	2
2	#	Spring pin, 4 x 16 mm	5	4	5
3	#	Plug, pipe, 3.175 mm (1/8 in.)	24	23	27
4	#	Plug, pipe, 6.350 mm (1/4 in.)	1	1	1
5	GM63723	Plug	1	1	1
6	223472	Pin, dowel	2	2	2
7	360093	Plug	6	6	7
8	GM63725	Screw	10	10	12
9	GM63724	Orifice	4	4	4
10	360517	Cap	1	1	1
11	#	Screw, M6 x 16		2	2
12	GM63728	Shim		1	1
13	GM63748	Washer		1	1
14	GM63752	Screw		1	1
15	#	Cap screw, M6 x 12	2	4	4
16	GM63778	Wheel		1	1
17	GM63783	Gear, spur		1	1
18	GM63821	Bearing, ball	1	1	1
19	GM63749	Camshaft	1		
19	GM63907	Camshaft		1	
20	GM63721	Bushing	4	4	4
21	—	Block, cylinder (see short block)	1		
21	GM63912	Block, cylinder		1	
21	GM63906	Block, cylinder			1

Common hardware; procure locally.

Group 32: Front Plate



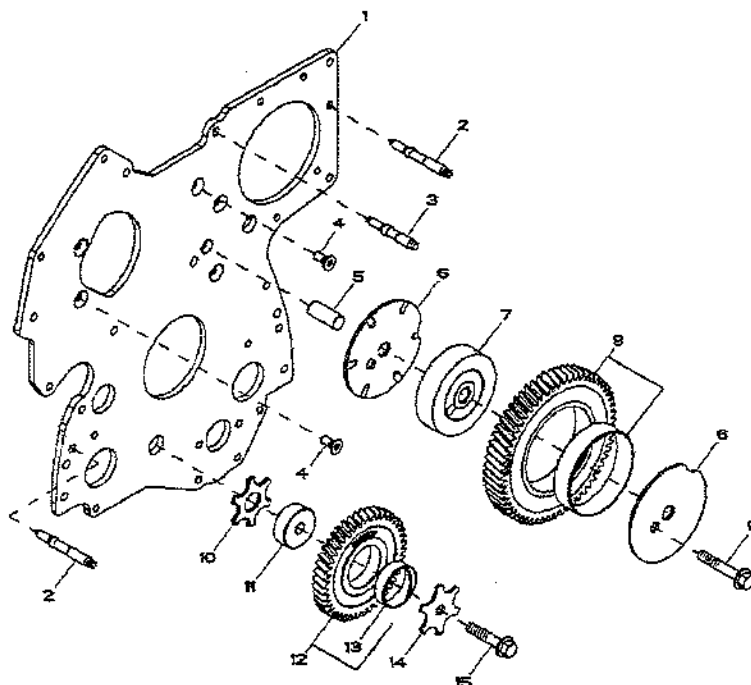
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RGP8269

Item	Part Number	Description	Quantity
			Variation 3618
1	GM23829	Plate, front	1
2	360092	Stud	3
3	360514	Stud	2
4	360140	Stud	4
5	336446	Washer, thrust	2
6	360101	Shaft, upper	1
7	360179	Pin, spring	1
8	360020	Gear	1
9	360147	Washer, thrust	1
10	#	Screw	1
11	360083	Shaft, lower	1
12	360516	Screw	4

Common hardware; procure locally.

Group 32: Front Plate, continued

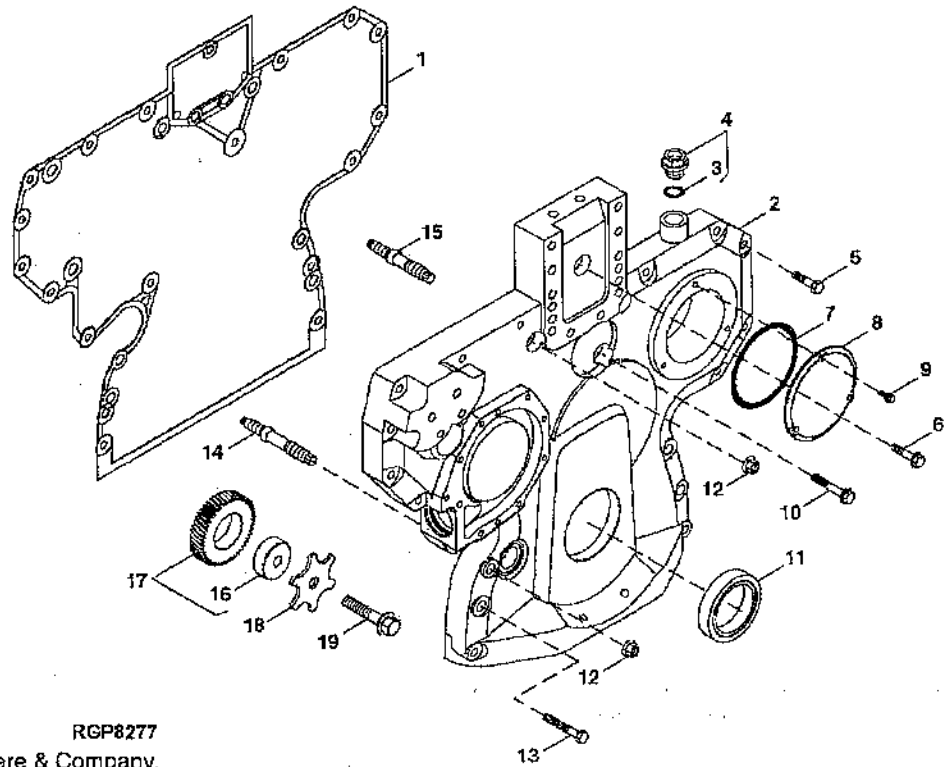


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Item	Part Number	Description	Quantity Variation 3612
1	GM46690	Plate	1
2	GM52531	Stud, 84mm	7
3	360514	Stud, 84mm	2
4	360516	Screw, M8 x 20	5
5	GM46693	Pin, dowel	1
6	GM46691	Washer, lock	2
7	GM46692	Shaft, upper	1
8	GM46694	Gear	1
9	#	Screw, M10 x 60	1
10	336446	Washer, thrust	1
11	360083	Shaft	1
12	360021	Gear	1
13	360082	Bushing	1
14	360148	Washer, thrust	1
15	#	Screw, M10 x 50	1

Common hardware; procure locally.

Group 33: Timing Gear Cover



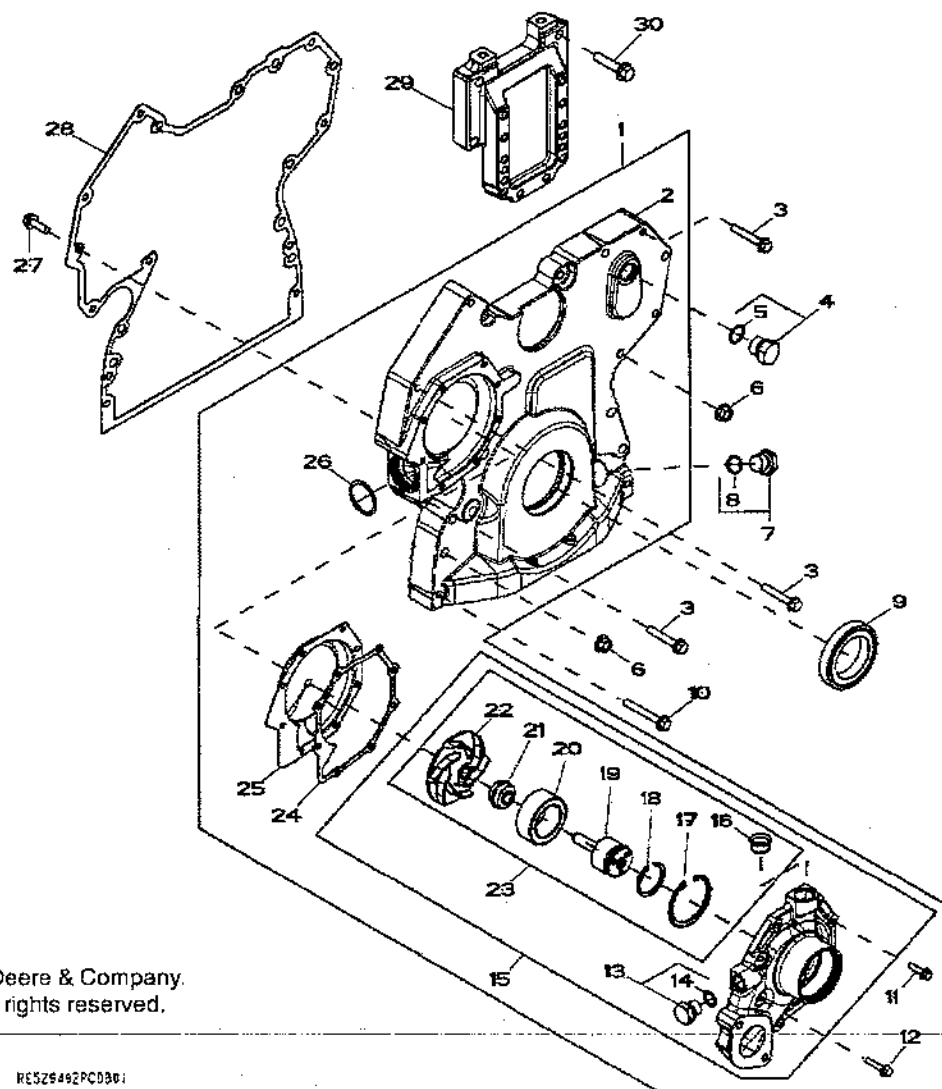
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Item	Part Number	Description	Quantity Variation 4429
1	360125	Gasket, gear cover	1
2	GM32796	Cover, gear	1
3	360180	O-ring, 17.3 x 2.2 mm	1
4	GM17508	Plug	1
5	360512	Screw	1
6	#	Screw, M8 x 35	1
7	360107	O-ring	1
8	360105	Cover	1
9	#	Screw, M6 x 16	3
10	360512	Screw	2
11	360181	Seal kit	1
12	#	Nut, flange	6
13	#	Screw	2
14	360140	Stud	4
15	360514	Stud	2
16	360082	Bushing	1
17	360021	Gear	1
18	360148	Washer, thrust	1
19	#	Screw	1

Common hardware; procure locally.

Group 33: Timing Gear Cover, continued



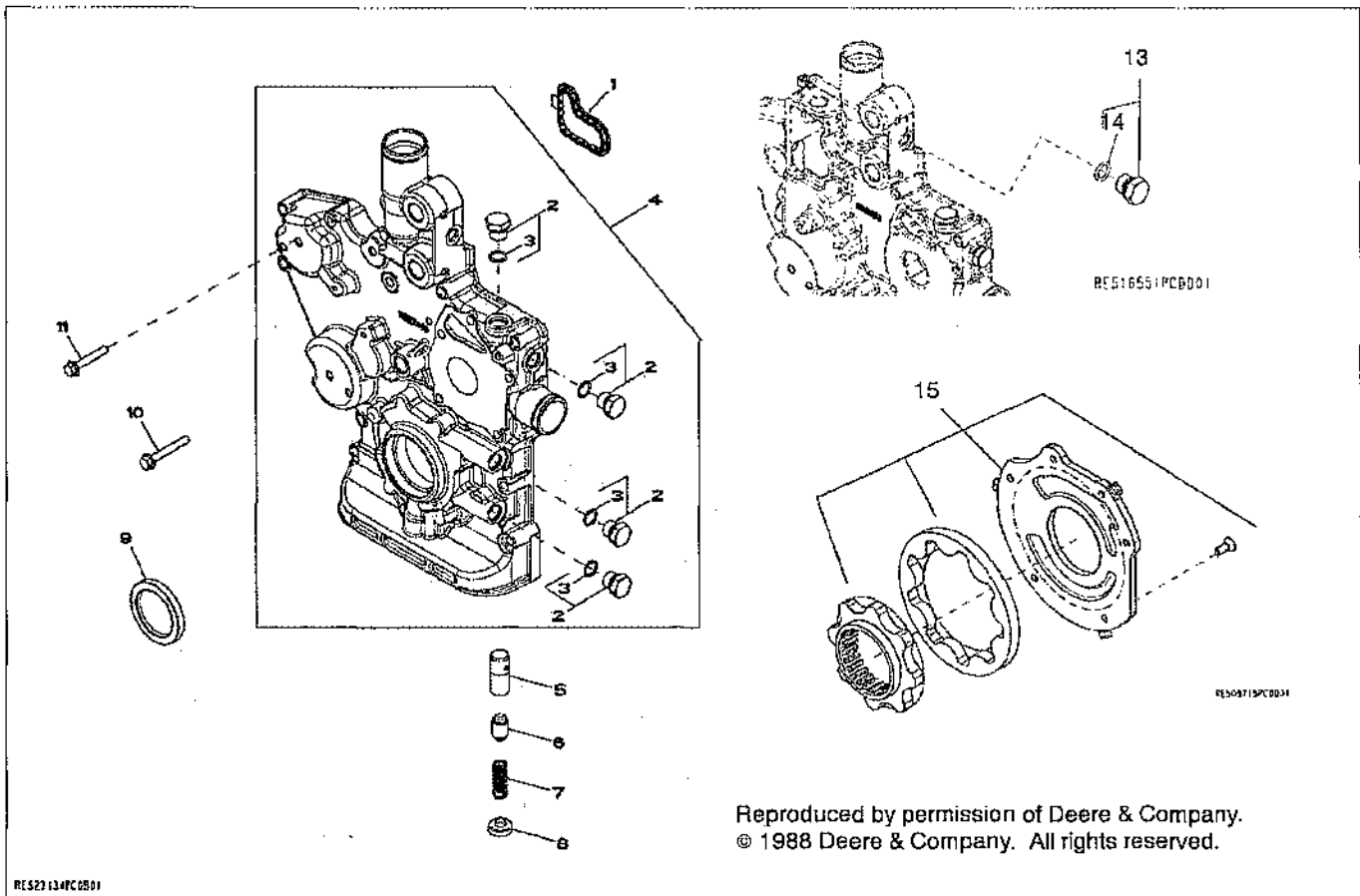
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RE526492PC0361

Item	Part Number	Description	Quantity Variation 4446
1	GM52532	Cover kit	1
2	—	Cover (order item 1)	1
3	#	Screw, M8 x 50	5
4	GM17498	Fitting	1
5	GM17437	O-ring	1
6	#	Nut, flange, M10	9
7	360078	Plug, drain	1
8	360180	O-ring, 17.3 X 2.2 mm	1
9	360181	Seal kit	1
10	#	Screw, M8 x 60	3
26	GM24543	O-ring	1
27	#	Screw, M8 x 25	1
28	GM52533	Gasket	1
29	GM52534	Support	1
30	#	Screw, M10 x 45	4

Common hardware; procure locally.

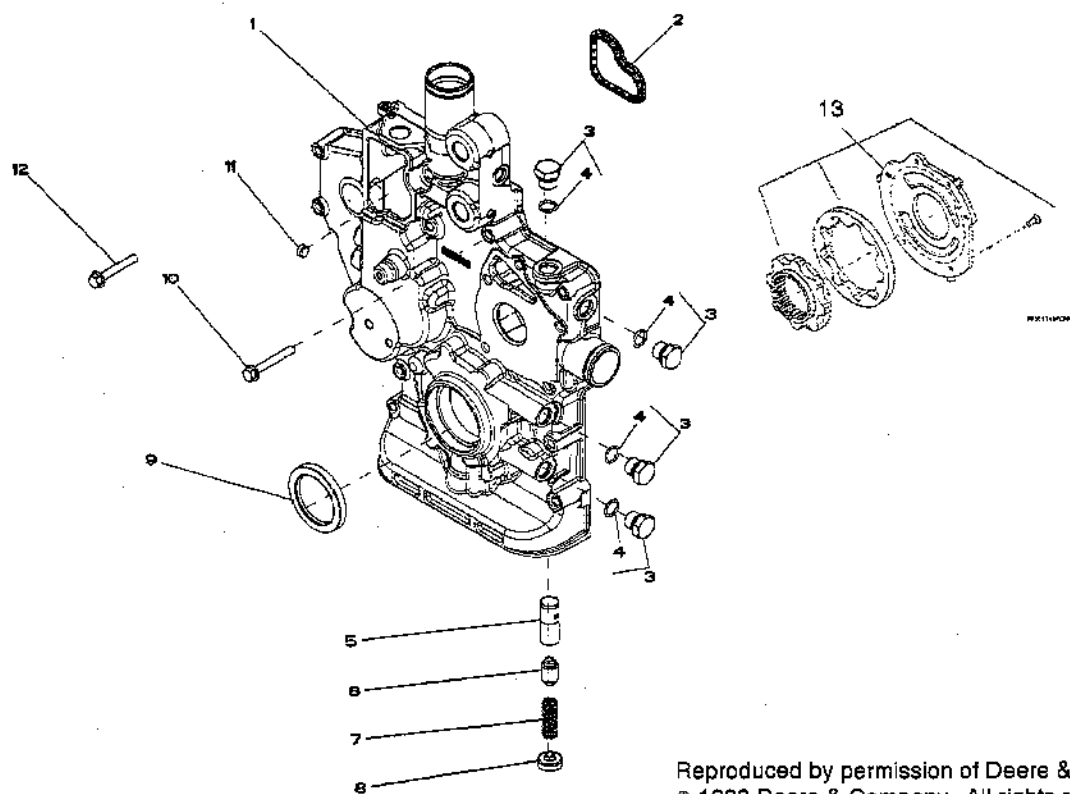
Group 33: Timing Gear Cover, continued



Item	Part Number	Description	Quantity
			Variation 4402
1	—	Seal	1
2	360014	Plug	14
3	360176	O-ring	4
4	GM63880	Cover (include items 2, 3)	1
5	GM63764	Valve seat	1
6	GM63745	Valve	1
7	GM63743	Spring, compression	1
8	GM63742	Plug	1
9	223422	Seal	1
10	GM63706	Screw, M8 x 60	1
11	#	Screw, M8 x 50	11
—	GM63705	Sealant	AR
13	360013	Plug	1
14	GM21508	O-ring	1
15	—	Pump, oil (order item 16)	1
16	GM64247	Cover kit (include items 2, 3, 5-9, 15)	1

Common hardware; procure locally.

Group 33: Timing Gear Cover, continued

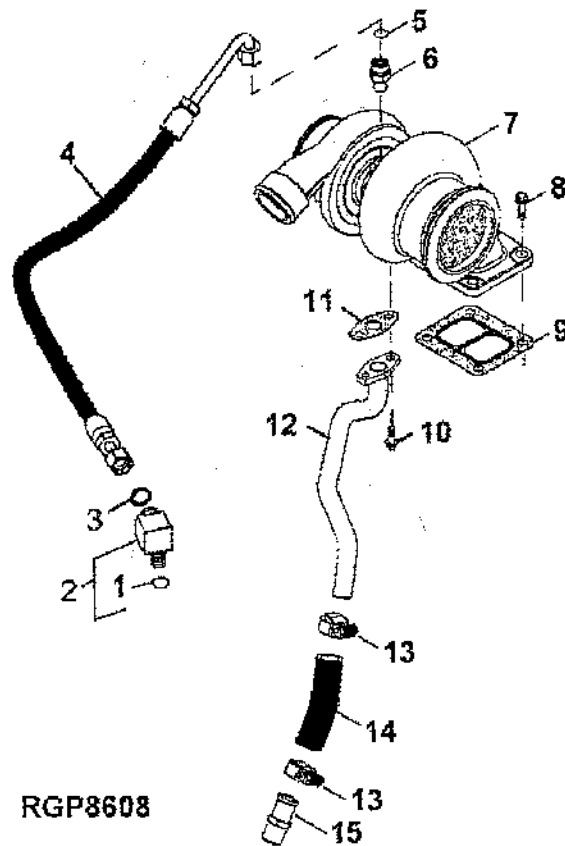


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Item	Part Number	Description	Quantity
			Variation 4401
1	—	Cover (order item 14)	1
2	GM63798	Gasket	1
3	360014	Plug	4
4	360176	O-ring	4
5	GM63764	Seat, valve	1
6	GM63745	Valve	1
7	GM63743	Spring, compression	1
8	GM63742	Plug	1
9	223422	Seal	1
10	GM63706	Screw, M8 x 60	1
11	GM63763	Plug	1
12	#	Screw, M8 x 55	11
—	GM63705	Sealant	AR
13	—	Pump, oil (order item 14)	1
14	GM63860	Cover kit (include items 2-9, 13)	1

Common hardware; procure locally.

Group 34: Turbocharger and Oil Lines



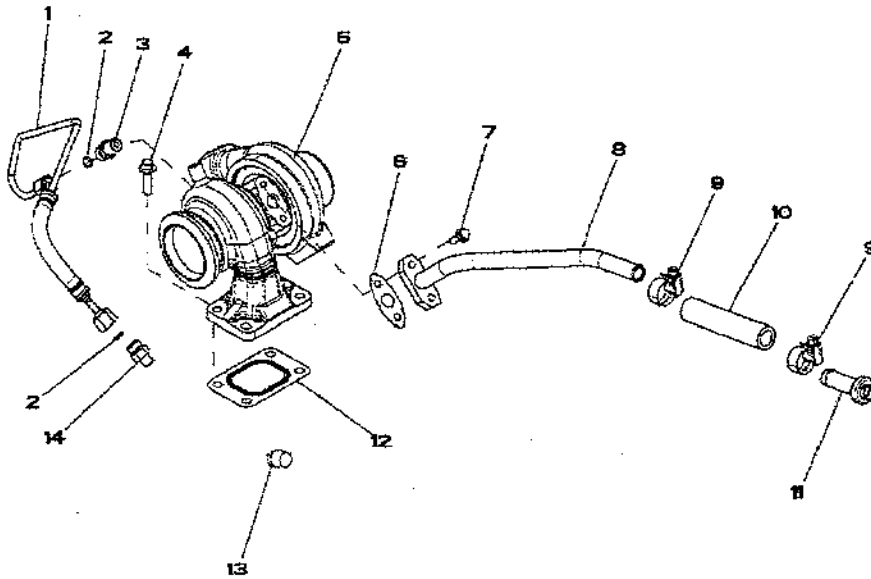
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RGP8608

Item	Part Number	Description	Quantity Variation	
			65HE	65RQ
1	360557	O-ring	1	1
2	360556	Fitting, elbow, 45 deg.	1	1
3	360555	O-ring	1	1
4	GM23842	Oil line	1	
4	GM52537	Oil line		1
5	360185	O-ring	1	1
6	360006	Adapter	1	1
7	GM32838	Turbocharger	1	
7	GM52535	Turbocharger		1
8	#	Screw	4	4
9	360137	Gasket, turbo to exhaust manifold	1	1
10	#	Screw, M8 x 20	2	2
11	360136	Gasket, turbo oil outlet tube	1	1
12	360558	Oil line	1	
12	GM52536	Oil line		1
13	360062	Clamp	2	2
14	224055	Hose	1	
14	GM49926	Hose		1
15	GM21492	Fitting, hose	1	1

Common hardware; procure locally.

Group 34: Turbocharger and Oil Lines, continued



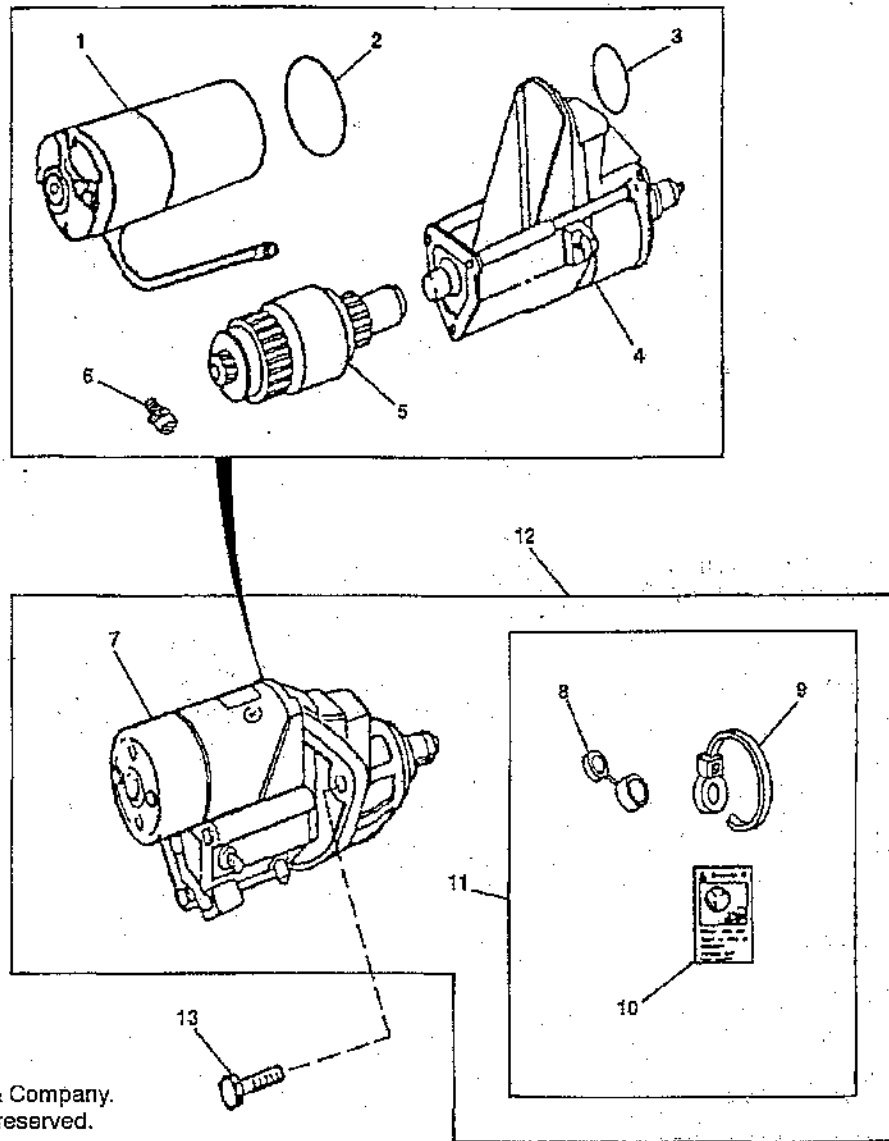
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RGP12604

Item	Part Number	Description	Quantity		
			Variation		
			6526	6553	6567
1	GM63848	Hose, hydraulic	1		
1	GM63889	Hose, hydraulic		1	1
2	GM17557	O-ring	1		
2	GM63923	O-ring		2	2
3	GM63927	Fitting, adapter		1	1
4	GM63746	Screw	4	4	4
5	GM21487	Turbocharger	1		
5	GM63898	Turbocharger		1	
5	GM63908	Turbocharger			1
6	GM63785	Gasket		1	1
7	#	Screw, M6 x 20		2	2
8	GM63849	Oil line	1		
8	GM63888	Oil line		1	1
9	360062	Clamp		2	2
10	GM63757	Hose	2	1	1
11	GM63851	Tube, oil	1	1	1
12	GM63734	Gasket	1	1	1
13	#	Plug, pipe, 6.350 mm (1/4 in.)	1	1	1
14	GM63926	Fitting, adapter	1	1	1

Common hardware; procure locally.

Group 35: Starter Motor

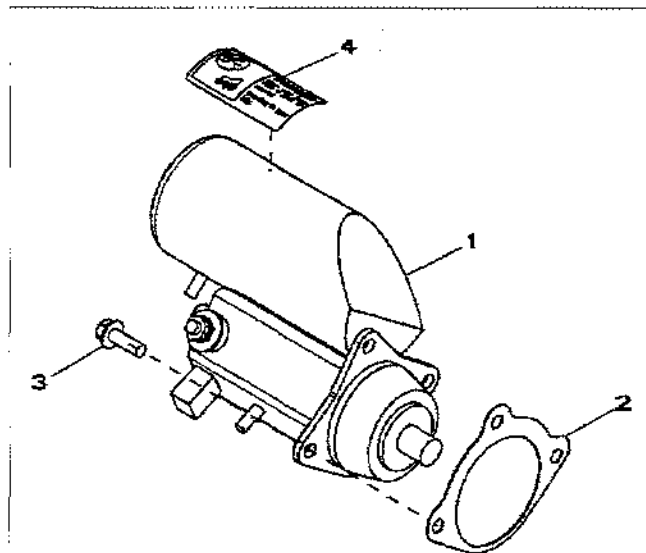


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Item	Part Number	Description	Quantity	
			Variation	
			3006	3041
1	—	Motor	1	1
2	GM17463	Seal	1	1
3	GM17464	O-ring	1	1
4	GM17544	Switch	1	
4	GM17546	Switch		1
5	GM17545	Clutch	1	
5	GM17547	Clutch		1
6	GM18874	Screw, with washer, M5 x 0.8	1	1
7	—	Motor, starter	1	1
8	—	Cover	1	1
9	GM17495	Tie band	1	1
10	GM17554	Label	1	1
11	GM17548	Kit	1	1
12	352390	Starter	1	
12	GM16801	Starter, 24 V		1
13	#	Screw, M10 x 30	3	3

Common hardware; procure locally.

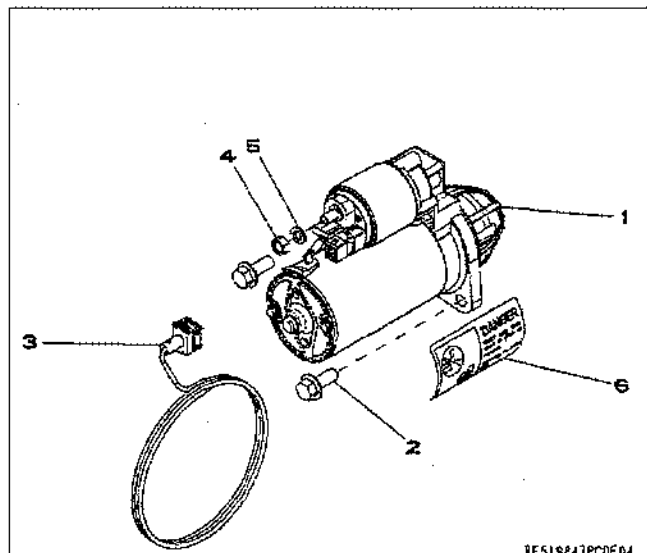
Group 35: Starter Motor, continued



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Item	Part Number	Description	Quantity
			Variation 3012
1	GM52538	Starter	1
2	223791	Gasket	1
3	#	Screw, M10 x 30	3
4	GM17554	Label	1
5	352140	Switch	
6	352116	Clutch	

Common hardware; procure locally.

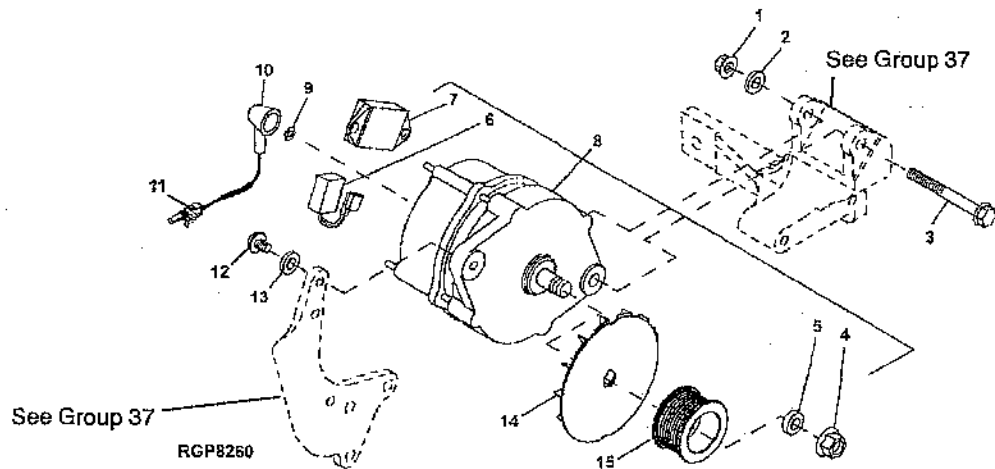


RES19247PC0F04

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Item	Part Number	Description	Quantity
			Variation 3002
1	GM63811	Motor, starter	1
2	#	Screw, M10 x 25	2
3	GM63862	Harness, wiring	1
4	#	Nut, M8	1
5	#	Washer, lock, 8 mm	1
6	GM17554	Label	1

Group 36: Alternator

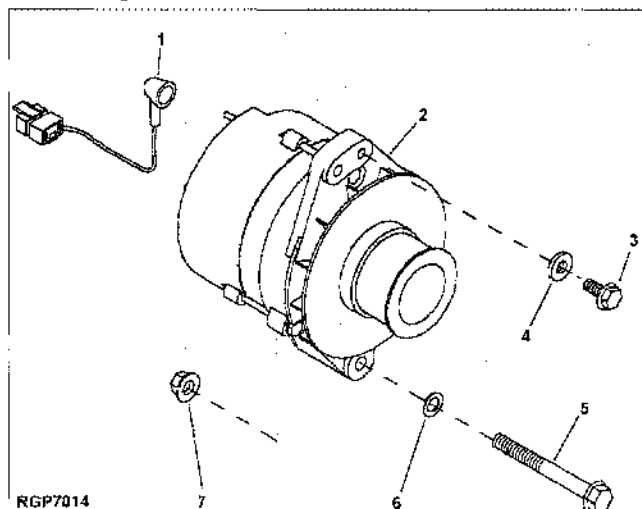


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Item	Part Number	Description	Quantity		
			3104	Variation 3138	3142
1	#	Nut, flange	1	1	1
2	360166	Washer	1	1	1
3	#	Screw	1	1	1
4	#	Nut		1	1
5	224331	Washer		1	1
6	360589	Capacitor	1	1	1
7	360591	Regulator		1	
7	360590	Regulator	1		1
8	360001	Alternator, 12 V		1	
8	GM17440	Alternator, 24 V			1
9	#	Nut	1	1	1
10	GM32923	Harness, wiring		1	1
10	GM50648	Harness, wiring	1		
11	GM32805	Connector	1	1	1
12	#	Screw, M8 x 25	1	1	1
13	GM18719	Washer	1	1	1
14	360588	Fan	1	1	1
15	GM17485	Pulley, alternator	1	1	1

Common hardware; procure locally.

Group 36: Alternator, continued

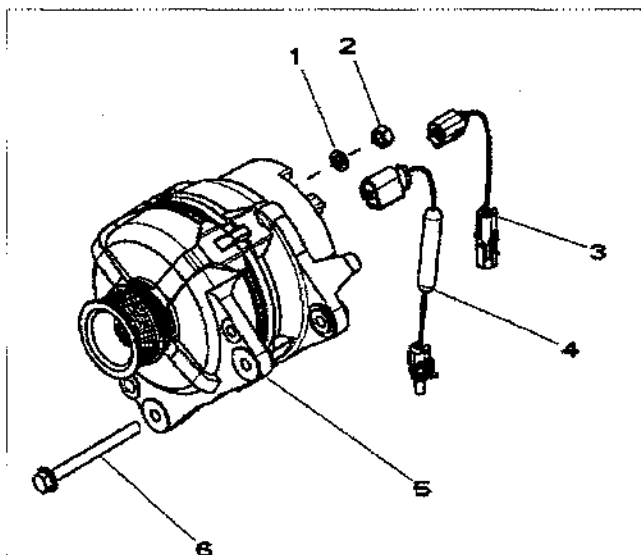


RGP7014

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Item	Part Number	Description	Quantity Variation 3122
1	GM21518	Harness, wiring	1
2	GM23850	Alternator	1
3	#	Screw, M8 x 25	1
4	GM32782	Washer	1
5	#	Screw, M10 x 100	1
6	360166	Washer, thrust	1
7	#	Nut, M10	1

Common hardware; procure locally.

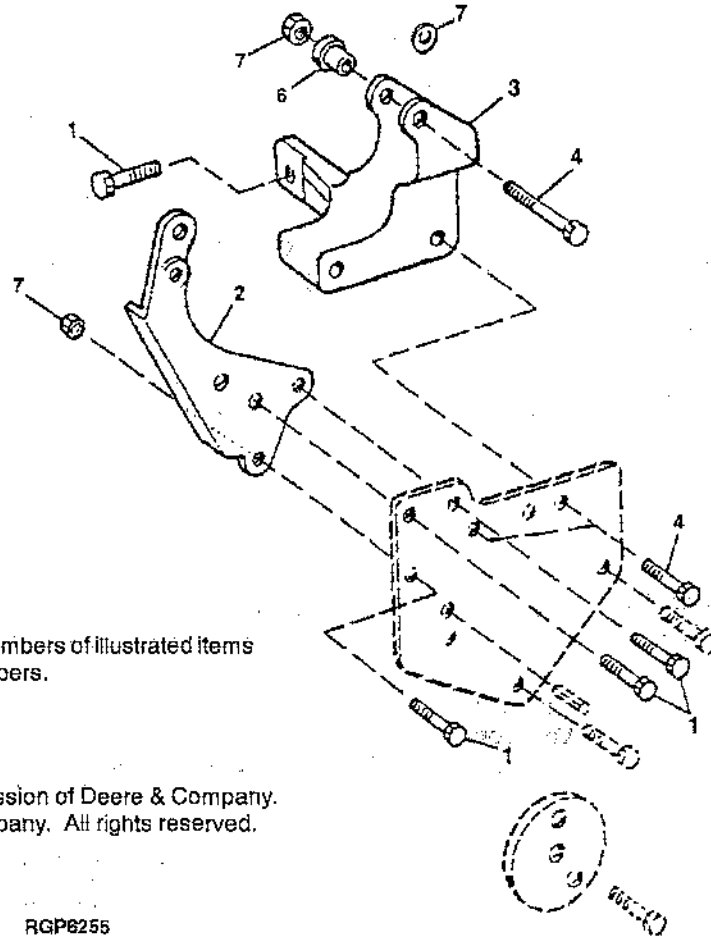


RES19848PCDE01

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Item	Part Number	Description	Quantity Variation 3102
1	#	Lock washer, 8 mm	1
2	#	Nut, M8	1
3	GM63828	Harness, wiring	1
4	GM63827	Harness, wiring	1
5	GM63881	Alternator	1
6	#	Screw, M8 x 90	2

Group 37: Alternator Mounting



See Group 9 for part numbers of illustrated items without reference numbers.

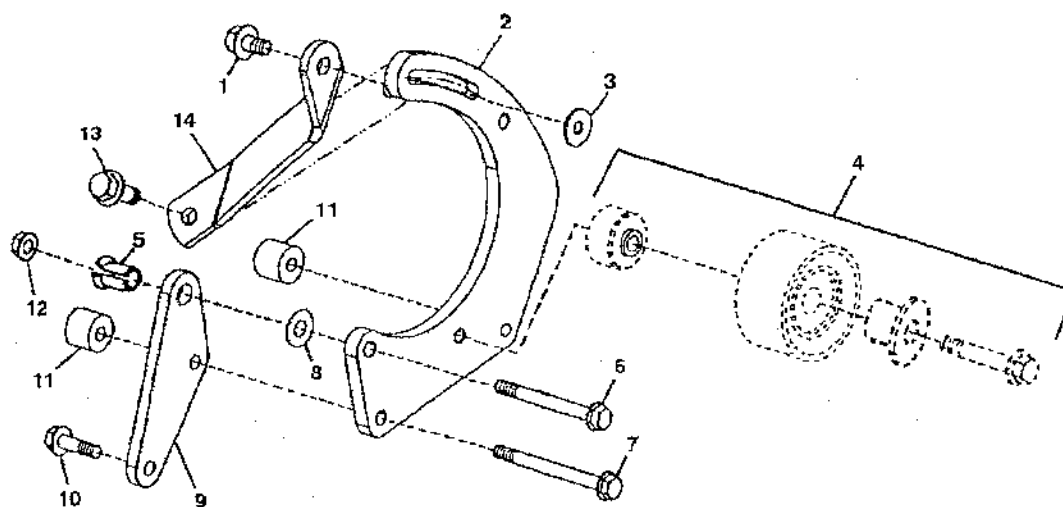
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RGP6255

Item	Part Number	Description	Quantity Variation 6201
1	#	Screw, M10 x 30	5
2	GM17455	Strap	1
3	360150	Bracket	1
4	#	Screw, cap, M10 x 25	2
6	360076	Bushing	1
7	#	Nut, flange, M10	3

Common hardware; procure locally.

Group 37: Alternator Mounting, continued



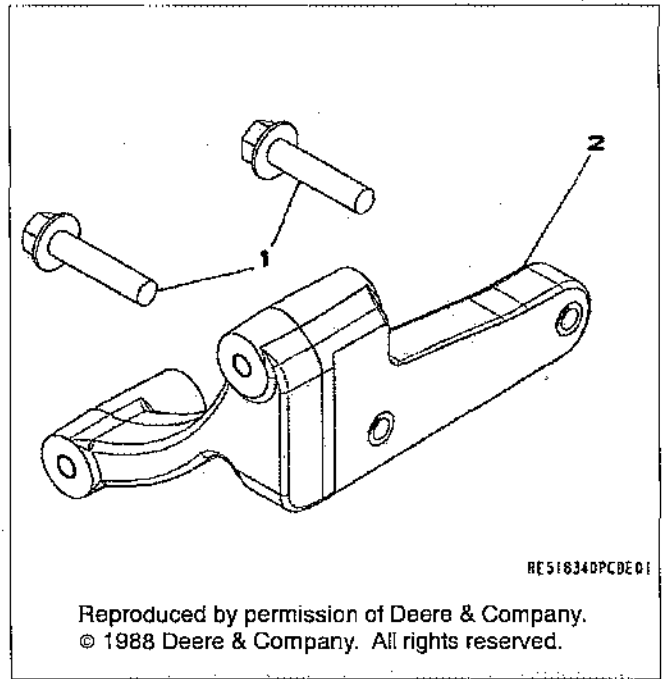
RGP9891

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Item	Part Number	Description	Quantity	
			Variation	
			6211	6212
1	#	Screw, M10 x 16	1	1
2	GM32795	Bracket	1	1
3	#	Washer, 8.4 x 24 x 2 mm	1	1
4		See Group 9	1	1
5	GM23838	Bushing	1	1
6	#	Screw, M8 x 80	1	1
7	#	Screw, M8 x 100	1	1
8	360166	Washer, thrust	1	1
9	GM23834	Bracket	1	1
10	#	Screw, M8 x 30	1	1
11	GM23837	Spacer	2	2
12	#	Nut, M8	1	1
13	#	Screw, M10 x 25	1	1
14	GM23836	Bracket	1	1

Common hardware; procure locally.

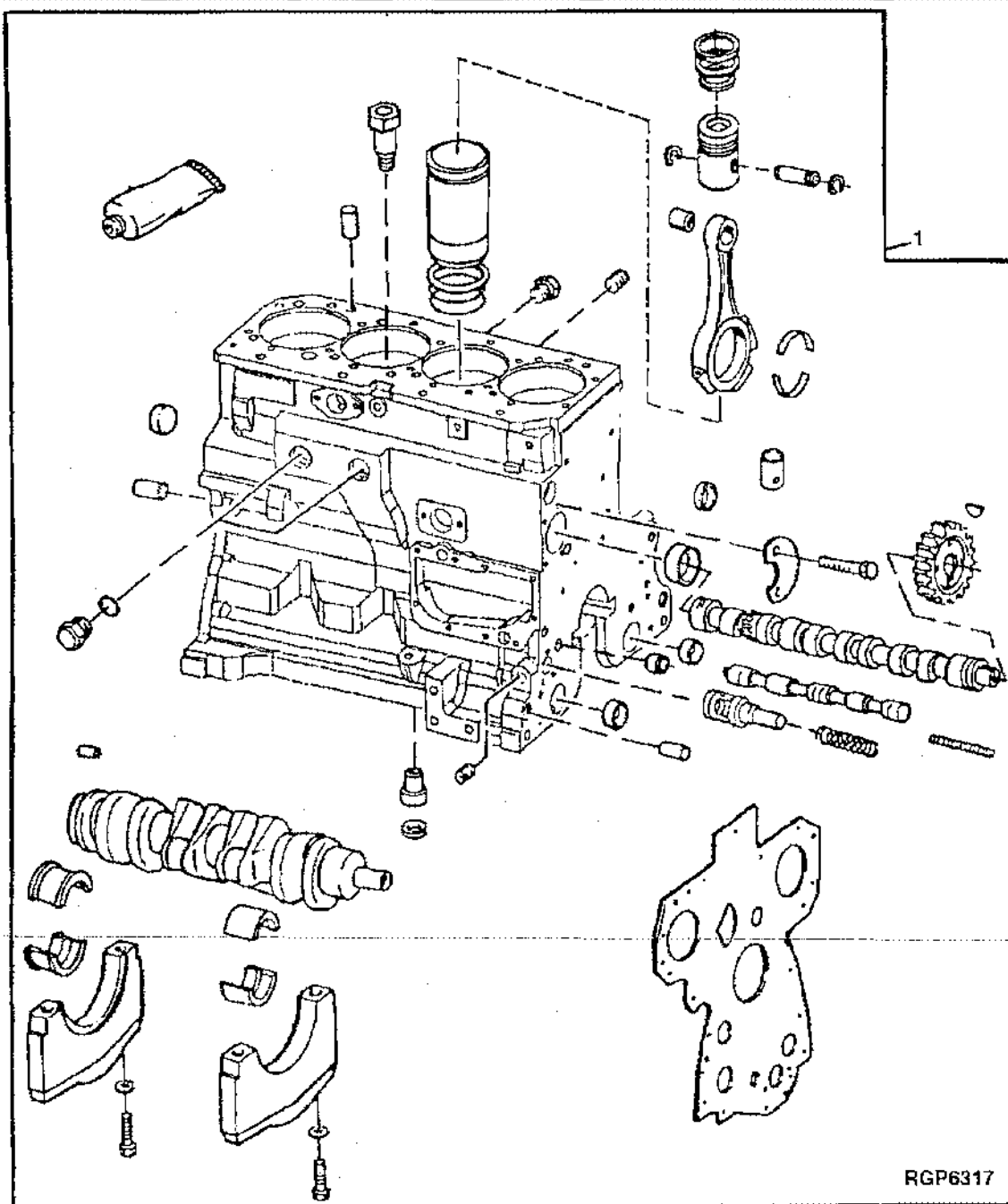
Group 37: Alternator Mounting, continued



Item	Part Number	Description	Quantity
			Variation 6202
1	#	Screw, M10x 45	2
2	GM63741	Bracket	1

Common hardware; procure locally.

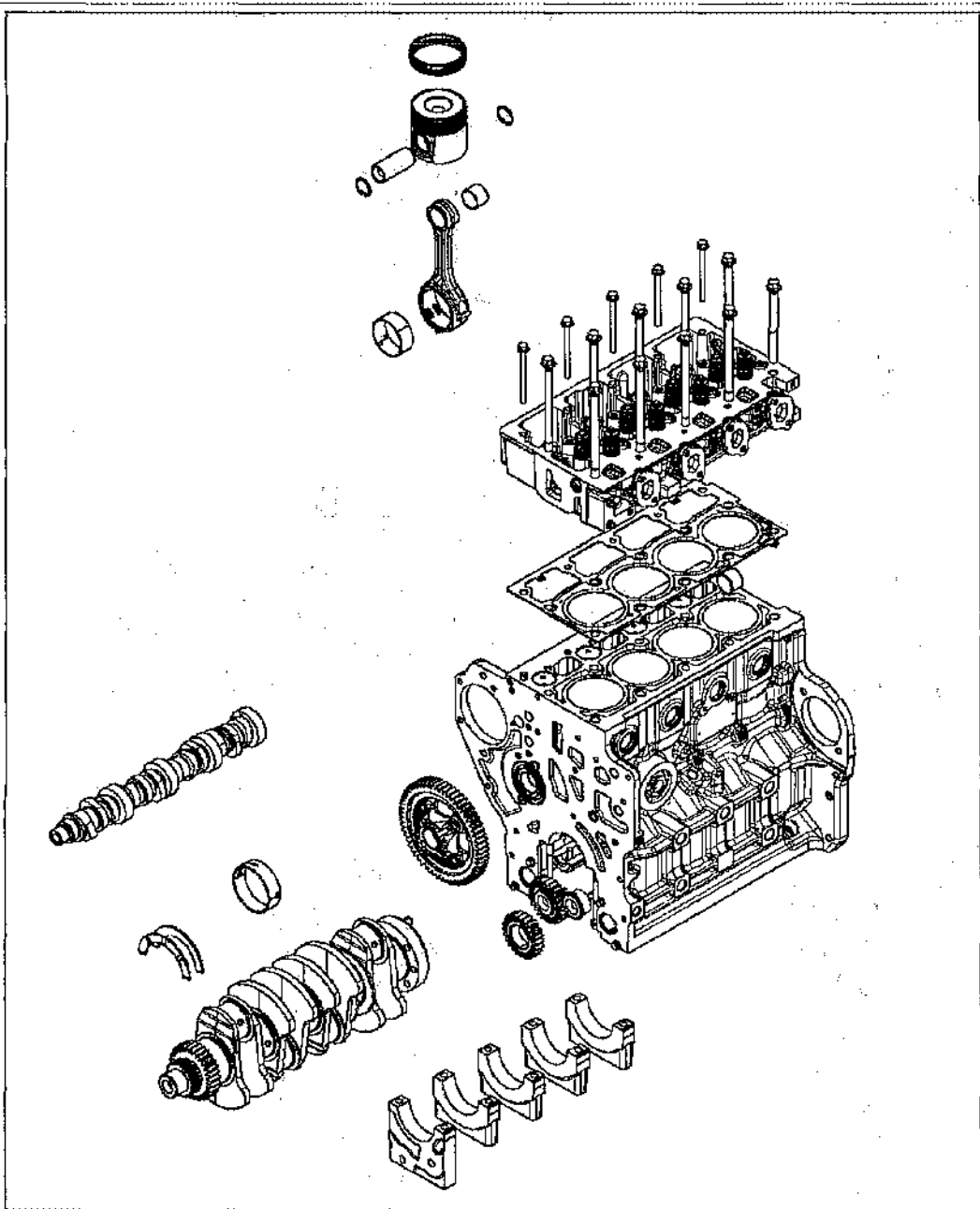
Group 38: Short Block



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Item	Part Number	Description	Quantity	
			Variation 1	Variation 2
1	GM32843	Block assembly, short (4045TF270)	1	
1	GM32832	Block assembly, short (4045HF275)		1

Group 38: Short Block

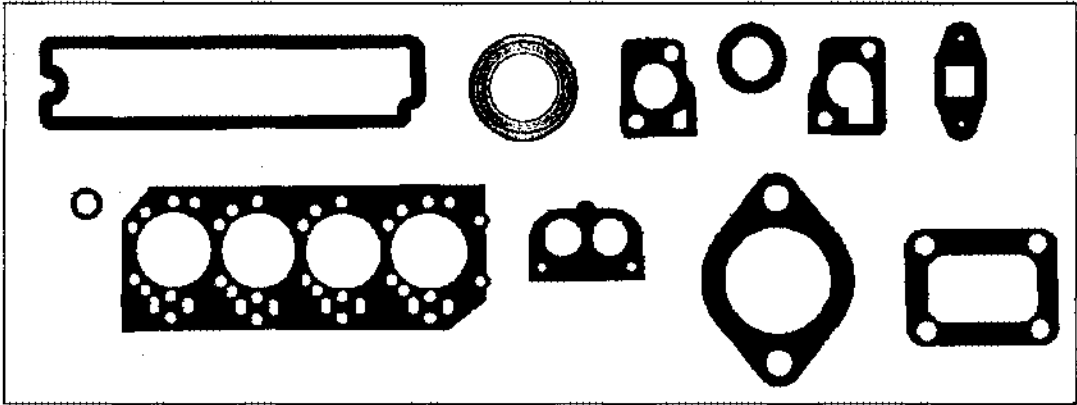


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RE528292RGP01

Item	Part Number	Description	Quantity
			Variation
1	GM63871	Complete block assembly	3
			1

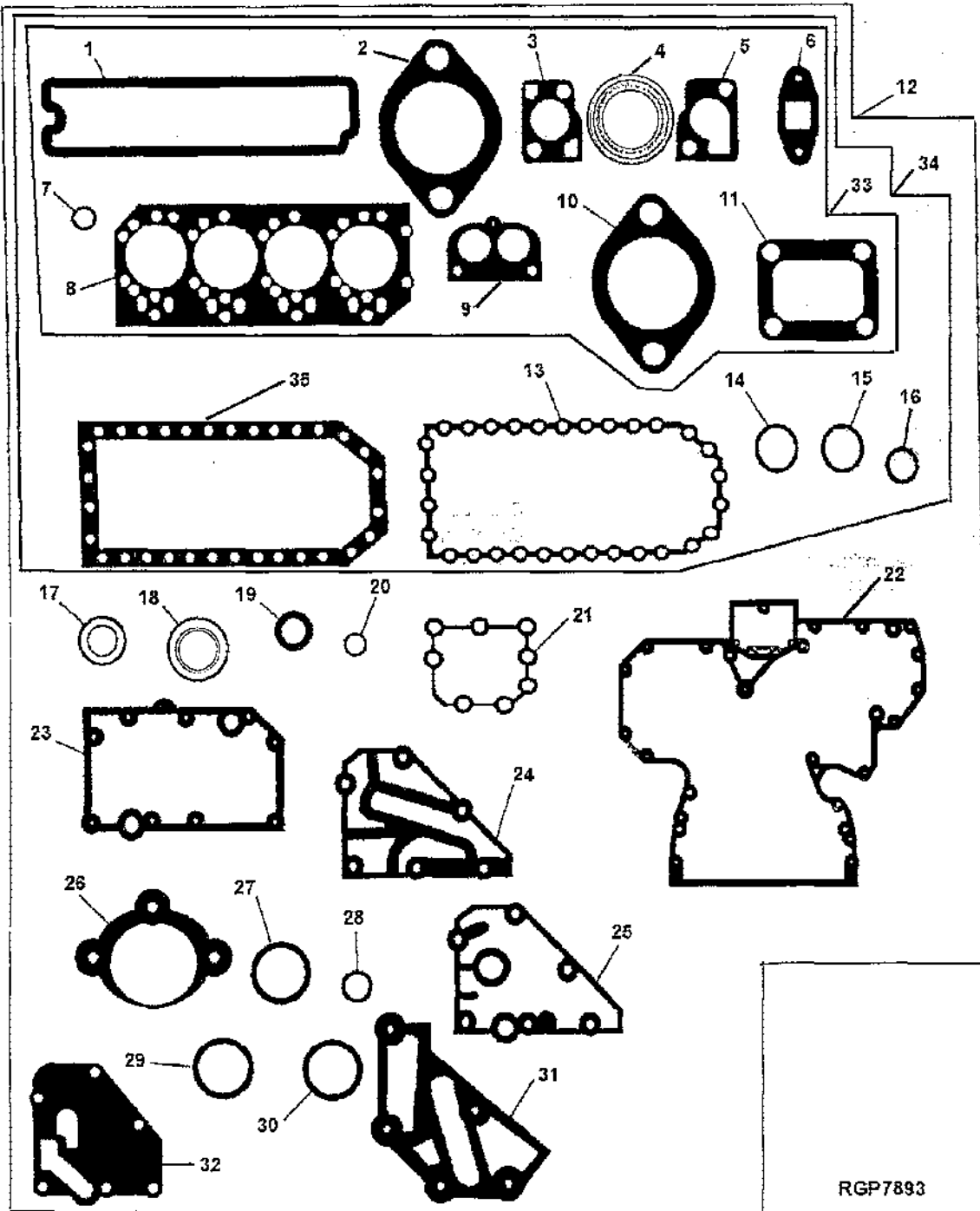
Group 39: Cylinder Head Gasket Set



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Item	Part Number	Description	Quantity
			Variation 9901
1	360586	Gasket kit, cylinder head	1

Group 40: Overhaul Gasket Set



RGP7893

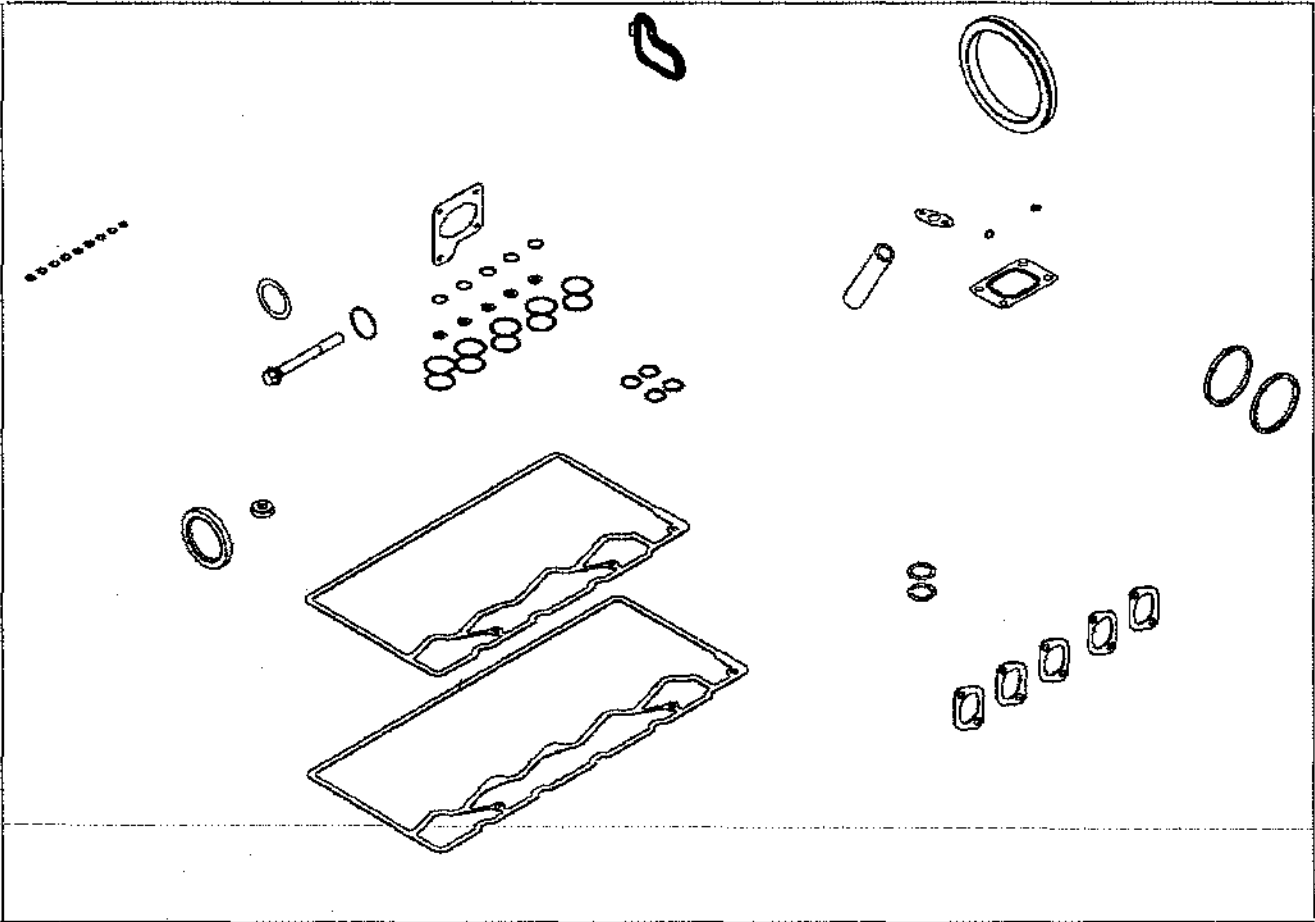
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Item	Part Number	Description	Quantity
			Variation
12	360587	Gasket kit (includes items 1-11, 13-34)	1

Group 40: Overhaul Gasket Set, continued

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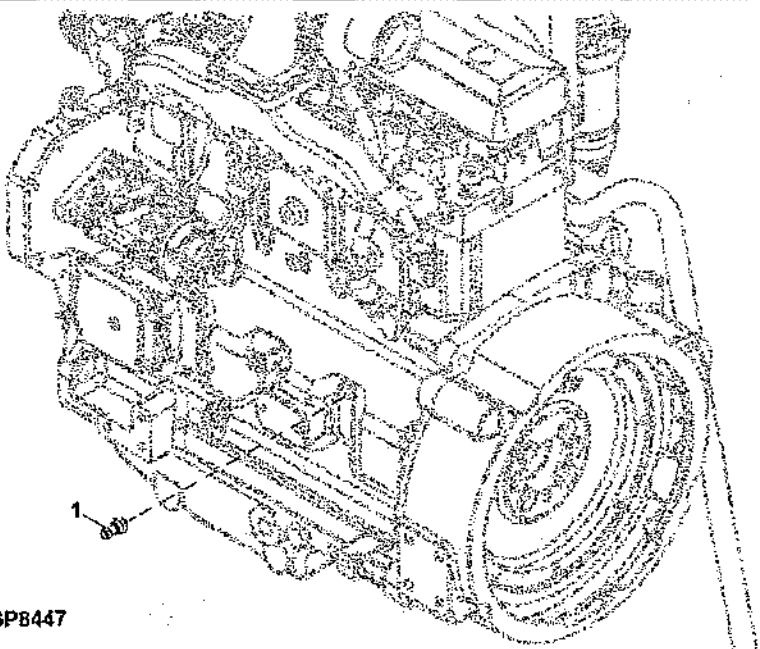
1



RE536448PCDA01

Item	Part Number	Description	Quantity	
			Variation	
			2	3
1	GM63919	Gasket kit	1	
1	GM64248	Gasket kit		1

Group 41: Engine Sensors

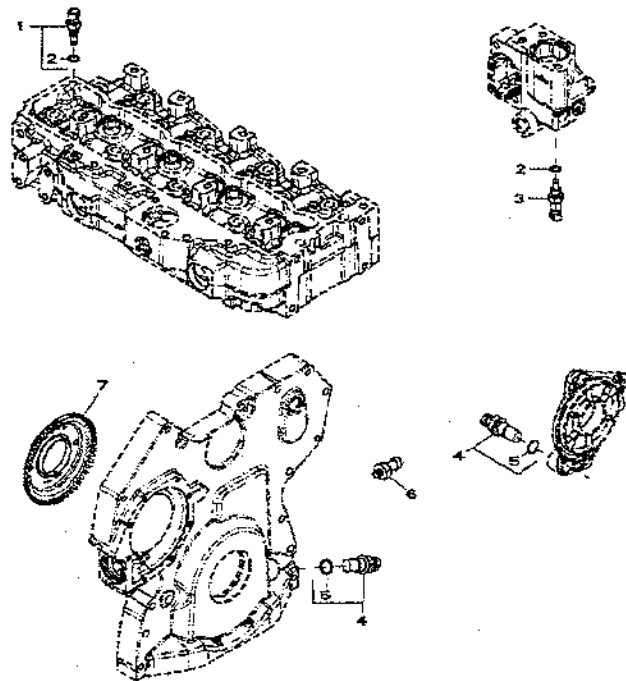


RGP8447

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Item	Part Number	Description	Quantity
			Variation 7635
1	GM32919	Sensor, engine oil pressure	1

Group 41: Engine Sensors, continued

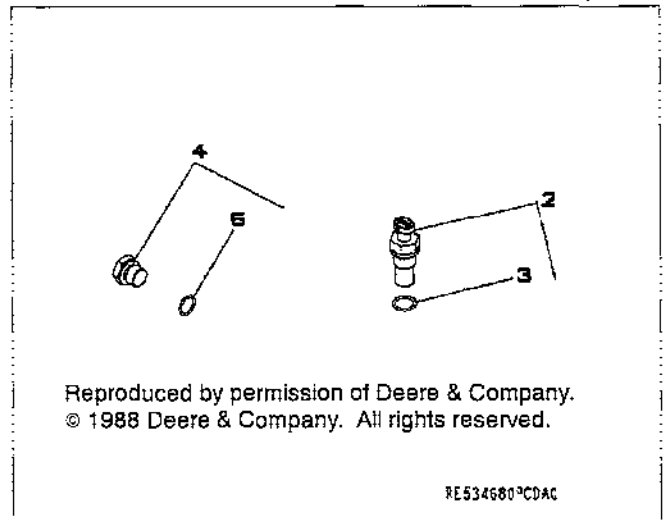
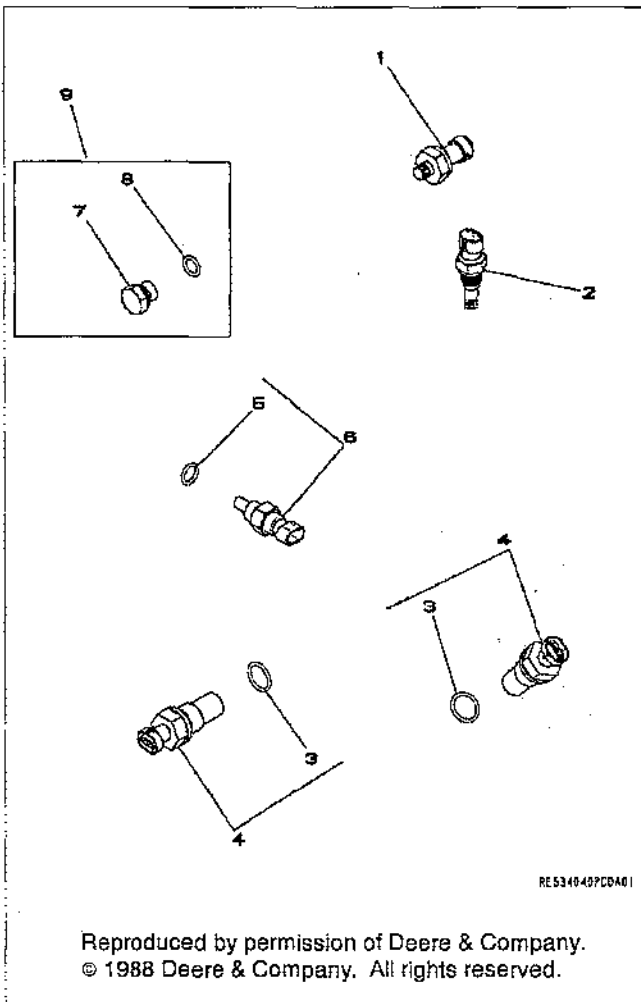


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KE521631 PCDAD1

Item	Part Number	Description	Quantity
			Variation 6730
1	GM50034	Thermocouple, air temperature	1
2	GM21508	O-ring	1
3	GM32955	Sensor, coolant temperature	1
4	GM50704	Sensor, engine speed	2
5	360180	O-ring 17.3 x 2.2 mm	2
6	GM32919	Sensor, pressure	1
7	GM49838	Wheel	1

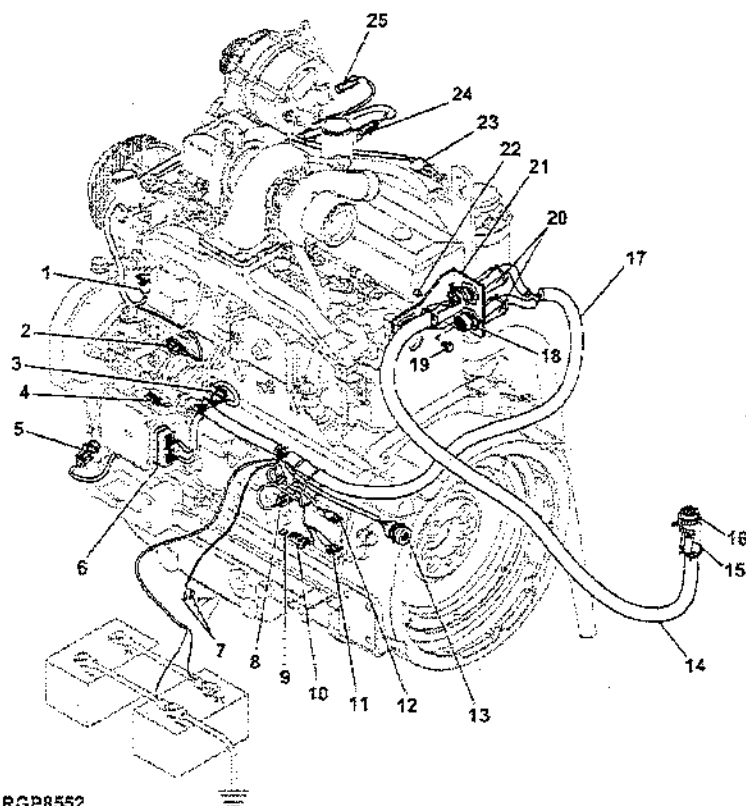
Group 41: Engine Sensors, continued



Item	Part Number	Description	Quantity	
			Variation 6702	Variation 6712
2	GM49939	Sensor		1
2	246040	Sensor (3/8-24)	1	
3	360180	O-ring, 17.3 x 2.2 mm		1
4	360078	Plug, drain	1	1
5	360180	O-ring, 17.3 x 2.2 mm	1	1

Item	Part Number	Description	Quantity
			Variation 6711
1	GM32919	Sensor, pressure	1
2	GM50034	Thermocouple, air temperature	1
3	360180	O-ring, 17.3 x 2.2 mm	1
4	GM49939	Sensor, engine speed	2
4	GM50704	Sensor, engine speed	2
5	GM21508	O-ring	1
6	GM50195	Sensor	1
7	GM63707	Drain plug	1
8	GM21508	O-ring	1
9	360013	Plug	1

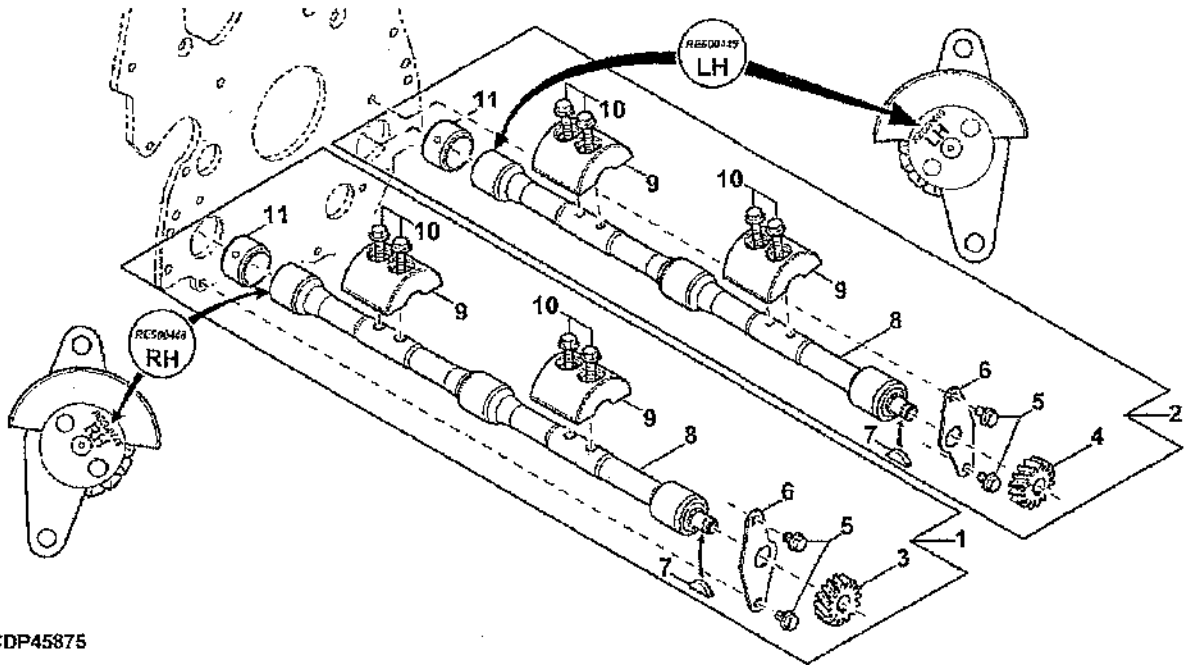
Group 42: Wiring Harness



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Item	Part Number	Description	Quantity Variation	
			8407	8457
1	GM32768	Connector	1	
2	GM32768	Connector	1	
3	GM32771	Connector	1	
4	GM32773	Connector	1	
5	GM32768	Connector	1	
6	GM32767	Connector	1	
7	GM32772	Connector	2	
8	GM32774	Connector	1	
9	GM32766	Fuse	1	
10	GM32778	Connector	1	
11	GM32806	Connector	1	
12	GM32769	Connector	1	
13	GM32775	Connector	1	
14	GM32837	Wiring harness	1	
15	GM32779	Connector	1	
16	GM32776	Connector	2	
17	GM32822	Wiring harness	1	
18	GM32777	Connector	1	
19	GM32765	Screw	1	
20	GM32779	Connector	2	
21	GM32802	Bracket	1	
22	GM32847	Bushing	1	
23	GM32770	Connector	1	
24	GM32768	Connector	1	
25	GM32804	Connector	1	

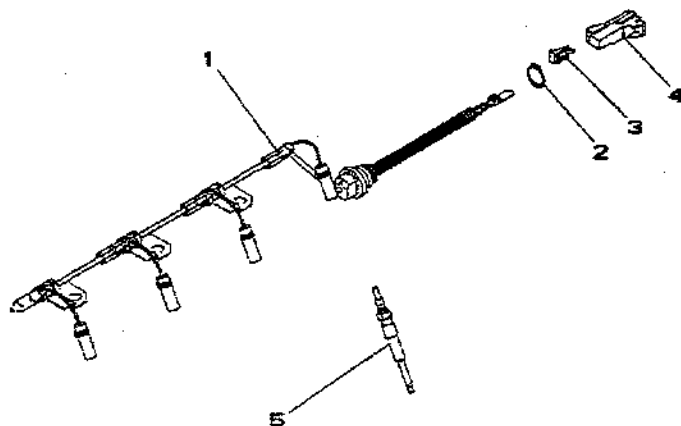
Group 43: Engine Balancer Shafts



Item	Part Number	Description	Quantity
			Variation 4501
1	GM50634	Balancer shaft, right hand	1
2	GM50635	Balancer shaft, left hand	1
3	360549	Gear, 15 teeth	1
4	360100	Gear, 30 teeth	1
5	#	Screw, M8 x 12	1
6	360547	Plate	1
7	360158	Key, shaft	1
8	—	Balancer shaft (order item 1)	1
8	—	Balancer shaft (order item 2)	1
9	GM50636	Weight	2
10	#	Screw, M8 x 40	4
11	360519	Bushing	3

Common hardware; procure locally.

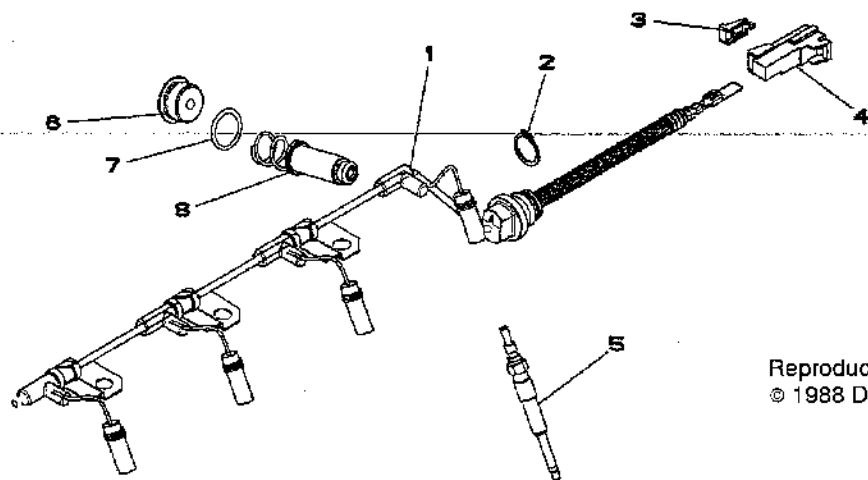
Group 44: Starting Aid (Glow Plugs)



RE52871 (PCDA01)

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Item	Part Number	Description	Quantity	
			Variation	
			4315	4316
1	GM63875	Wiring harness	1	
1	GM63874	Wiring harness		1
2	GM63703	Snap ring	1	1
3	GM63767	Differential lock	1	1
4	GM63762	Electrical connector cap	1	1
5	GM63805	Glow plug	4	4



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RE509133PCD6C3

Item	Part Number	Description	Quantity	
			Variation	
			4301	
1	GM63841	Wiring harness	1	
2	GM63703	Snap ring	1	
3	GM63767	Differential lock	1	
4	GM63762	Electrical connector cap	1	
5	GM63805	Glow plug	4	
6	GM63825	Fitting plug	1	
7	GM17437	O-ring	1	
8	GM63870	Thermostat	1	

Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

A, amp	ampere	cfm	cubic feet per minute	est.	estimated
ABDC	after bottom dead center	CG	center of gravity	E-Stop	emergency stop
AC	alternating current	CID	cubic inch displacement	etc.	et cetera (and so forth)
A/D	analog to digital	CL	centerline	exh.	exhaust
ADC	advanced digital control; analog to digital converter	cm	centimeter	ext.	external
adj.	adjust, adjustment	CMOS	complementary metal oxide substrate (semiconductor)	F	Fahrenheit, female
ADV	advertising dimensional drawing	cogen.	cogeneration	fglass.	fiberglass
Ah	amp-hour	com	communications (port)	FHM	flat head machine (screw)
AHWT	anticipatory high water temperature	coml	commercial	fl. oz.	fluid ounce
AISI	American Iron and Steel Institute	Coml/Rec	Commercial/Recreational	flex.	flexible
ALOP	anticipatory low oil pressure	conn.	connection	freq.	frequency
alt.	alternator	cont.	continued	FS	full scale
Al	aluminum	CPVC	chlorinated polyvinyl chloride	ft.	foot, feet
ANSI	American National Standards Institute (formerly American Standards Association, ASA)	crit.	critical	ft. lb.	foot pounds (torque)
AO	anticipatory only	CRT	cathode ray tube	ft./min.	feet per minute
APDC	Air Pollution Control District	CSA	Canadian Standards Association	ftp	file transfer protocol
API	American Petroleum Institute	CT	current transformer	g	gram
approx.	approximate, approximately	Cu	copper	ga.	gauge (meters, wire size)
AQMD	Air Quality Management District	cUL	Canadian Underwriter's Laboratories	gal.	gallon
AR	as required, as requested	CUL	Canadian Underwriter's Laboratories	gen.	generator
AS	as supplied, as stated, as suggested	cu. in.	cubic inch	genset	generator set
ASE	American Society of Engineers	cw.	clockwise	GFI	ground fault interrupter
ASME	American Society of Mechanical Engineers	CWC	city water-cooled	GND, ⊕	ground
assy.	assembly	cyl.	cylinder	gov.	governor
ASTM	American Society for Testing Materials	D/A	digital to analog	gph	gallons per hour
ATDC	after top dead center	DAC	digital to analog converter	gpm	gallons per minute
ATS	automatic transfer switch	dB	decibel	gr.	grade, gross
auto.	automatic	dB(A)	decibel (A weighted)	GRD	equipment ground
aux.	auxiliary	DC	direct current	gr. wt.	gross weight
avg.	average	DCR	direct current resistance	H x W x D	height by width by depth
AVR	automatic voltage regulator	deg., °	degree	HC	hex cap
AWG	American Wire Gauge	dept.	department	HCHT	high cylinder head temperature
AWM	appliance wiring material	DFMEA	Design Failure Mode and Effects Analysis	HD	heavy duty
bat.	battery	dia.	diameter	HET	high exhaust temp., high engine temp.
BBDC	before bottom dead center	DI/EO	dual inlet/end outlet	hex	hexagon
BC	battery charger, battery charging	DIN	Deutsches Institut für Normung e. V. (also Deutsche Industrie Normenausschuss)	Hg	mercury (element)
BCA	battery charging alternator	DIP	dual inline package	HH	hex head
BCI	Battery Council International	DPDT	double-pole, double-throw	HHC	hex head cap
BDC	before dead center	DPST	double-pole, single-throw	HP	horsepower
BHP	brake horsepower	DS	disconnect switch	hr.	hour
blk.	black (paint color), block (engine)	DVR	digital voltage regulator	HS	heat shrink
blk. htr.	block heater	E, emer.	emergency (power source)	hsg.	housing
BMEP	brake mean effective pressure	ECM	electronic control module, engine control module	HVAC	heating, ventilation, and air conditioning
bps	bits per second	EDI	electronic data interchange	HWT	high water temperature
br.	brass	EFR	emergency frequency relay	Hz	hertz (cycles per second)
BTDC	before top dead center	e.g.	for example (<i>exempli gratia</i>)	IC	integrated circuit
Btu	British thermal unit	EG	electronic governor	ID	inside diameter, identification
Btu/min.	British thermal units per minute	EGSA	Electrical Generating Systems Association	IEC	International Electrotechnical Commission
C	Celsius, centigrade	EIA	Electronic Industries Association	IEEE	Institute of Electrical and Electronics Engineers
cal.	calorie	EI/EO	end inlet/end outlet	IMS	improved motor starting
CAN	controller area network	EMI	electromagnetic interference	in.	inch
CARB	California Air Resources Board	emiss.	emission	in. H ₂ O	inches of water
CB	circuit breaker	eng.	engine	in. Hg	inches of mercury
cc	cubic centimeter	EPA	Environmental Protection Agency	in. lb.	inch pounds
CCA	cold cranking amps	ER	emergency power system	Inc.	incorporated
ccw.	counterclockwise	ES	engineering special, engineered special	ind.	industrial
CEC	Canadian Electrical Code	ESD	electrostatic discharge	int.	internal
cert.	certificate, certification, certified			int./ext.	internal/external
cfh	cubic feet per hour			I/O	input/output
				IP	iron pipe
				ISO	International Organization for Standardization
				J	joule
				JIS	Japanese Industry Standard

k	kilo (1000)	MTBO	mean time between overhauls	rms	root mean square
K	kelvin	mtg.	mounting	rnd.	round
kA	kiloampere	MTU	Motoren-und Turbinen-Union	ROM	read only memory
KB	kilobyte (2 ¹⁰ bytes)	MW	megawatt	rot.	rotate, rotating
KBus	Kohler communication protocol	mW	milliwatt	rpm	revolutions per minute
kg	kilogram	μF	microfarad	RS	right side
kg/cm ²	kilograms per square centimeter	N, norm.	normal (power source)	RTU	remote terminal unit
kgm	kilogram-meter	NA	not available, not applicable	RTV	room temperature vulcanization
kg/m ³	kilograms per cubic meter	nat. gas	natural gas	RW	read/write
kHz	kilohertz	NBS	National Bureau of Standards	SAE	Society of Automotive Engineers
kJ	kilojoule	NC	normally closed	scfm	standard cubic feet per minute
km	kilometer	NEC	National Electrical Code	SCR	silicon controlled rectifier
kOhm, kΩ	kilo-ohm	NEMA	National Electrical Manufacturers Association	s, sec.	second
kPa	kilopascal	NFPA	National Fire Protection Association	SI	<i>Système international d'unités</i> , International System of Units
kph	kilometers per hour	Nm	newton meter	SI/EO	side in/end out
kV	kilovolt	NO	normally open	sil.	silencer
kVA	kilovolt ampere	no., nos.	number, numbers	SN	serial number
KVAR	kilovolt ampere reactive	NPS	National Pipe, Straight	SNMP	simple network management protocol
kW	kilowatt	NPSC	National Pipe, Straight-coupling	SPDT	single-pole, double-throw
kWh	kilowatt-hour	NPT	National Standard taper pipe thread per general use	SPST	single-pole, single-throw
kWm	kilowatt mechanical	NPTF	National Pipe, Taper-Fine	spec	specification
kWth	kilowatt-thermal	NR	not required, normal relay	specs	specification(s)
L	liter	ns	nanosecond	sq.	square
LAN	local area network	OC	overcrank	sq. cm	square centimeter
L x W x H	length by width by height	OD	outside diameter	sq. in.	square inch
lb.	pound, pounds	OEM	original equipment manufacturer	SS	stainless steel
lbm/ft ³	pounds mass per cubic feet	OF	overfrequency	std.	standard
LCB	line circuit breaker	opt.	option, optional	stl.	steel
LCD	liquid crystal display	OS	oversize, overspeed	tach.	tachometer
ld. shd.	load shed	OSHA	Occupational Safety and Health Administration	TD	time delay
LED	light emitting diode	OV	overvoltage	TDC	top dead center
Lph	liters per hour	oz.	ounce	TDEC	time delay engine cooldown
Lpm	liters per minute	p., pp.	page, pages	TDEN	time delay emergency to normal
LOP	low oil pressure	PC	personal computer	TDES	time delay engine start
LP	liquefied petroleum	PCB	printed circuit board	TDNE	time delay normal to emergency
LPG	liquefied petroleum gas	pF	picofarad	TDOE	time delay off to emergency
LS	left side	PF	power factor	TDON	time delay off to normal
L _{wa}	sound power level, A weighted	ph., ∅	phase	temp.	temperature
LWL	low water level	PHC	Phillips® head CrimpTite® (screw)	term.	terminal
LWT	low water temperature	PHH	Phillips® hex head-(screw)	THD	total harmonic distortion
m	meter, milli (1/1000)	PHM	pan head machine (screw)	TIF	telephone-influence-factor
M	mega (10 ⁶ when used with SI units), male	PLC	programmable logic control	TIR	total indicator reading
m ³	cubic meter	PMG	permanent magnet generator	tol.	tolerance
m ³ /hr.	cubic meters per hour	pot	potentiometer, potential	turbo.	turbocharger
m ³ /min.	cubic meters per minute	ppm	parts per million	typ.	typical (same in multiple locations)
mA	milliampere	PROM	programmable read-only memory	UF	underfrequency
man.	manual	psi	pounds per square inch	UHF	ultrahigh frequency
max.	maximum	psig	pounds per square inch gauge	UL	Underwriter's Laboratories, Inc.
MB	megabyte (2 ²⁰ bytes)	pt.	pint	UNC	unified coarse thread (was NC)
MCCB	molded-case circuit breaker	PTC	positive temperature coefficient	UNF	unified fine thread (was NF)
MCM	one thousand circular mils	PTO	power takeoff	univ.	universal
meggar	megohmmeter	PVC	polyvinyl chloride	US	undersize, underspeed
MHz	megahertz	qt.	quart, quarts	UV	ultraviolet, undervoltage
mi.	mile	qty.	quantity	V	volt
mil	one one-thousandth of an inch	R	replacement (emergency) power source	VAC	volts alternating current
min.	minimum, minute	rad.	radiator, radius	VAR	voltampere reactive
misc.	miscellaneous	RAM	random access memory	VDC	volts direct current
MJ	megajoule	RDO	relay driver output	VFD	vacuum fluorescent display
mJ	millijoule	ref.	reference	VGA	video graphics adapter
mm	millimeter	rem.	remote	VHF	very high frequency
mOhm, mΩ	milliohm	Res/Coml	Residential/Commercial	W	watt
MOhm, MΩ	megohm	RFI	radio frequency interference	WCR	withstand and closing rating
MOV	metal oxide varistor	RH	round head	w/	with
MPa	megapascal	RHM	round head machine (screw)	w/o	without
mpg	miles per gallon	ry.	relay	wt.	weight
mph	miles per hour			xfrm	transformer
MS	military standard				
ms	millisecond				
m/sec.	meters per second				
MTBF	mean time between failure				

Appendix B Common Hardware Application Guidelines

Use the information below and on the following pages to identify proper fastening techniques when no specific reference for reassembly is made.

Bolt/Screw Length: When bolt/screw length is not given, use Figure 1 as a guide. As a general rule, a minimum length of one thread beyond the nut and a maximum length of 1/2 the bolt/screw diameter beyond the nut is the preferred method.

Washers and Nuts: Use split lock washers as a bolt locking device where specified. Use SAE flat washers with whiz nuts, spiralock nuts, or standard nuts and preloading (torque) of the bolt in all other applications.

See Appendix C, General Torque Specifications, and other torque specifications in the service literature.

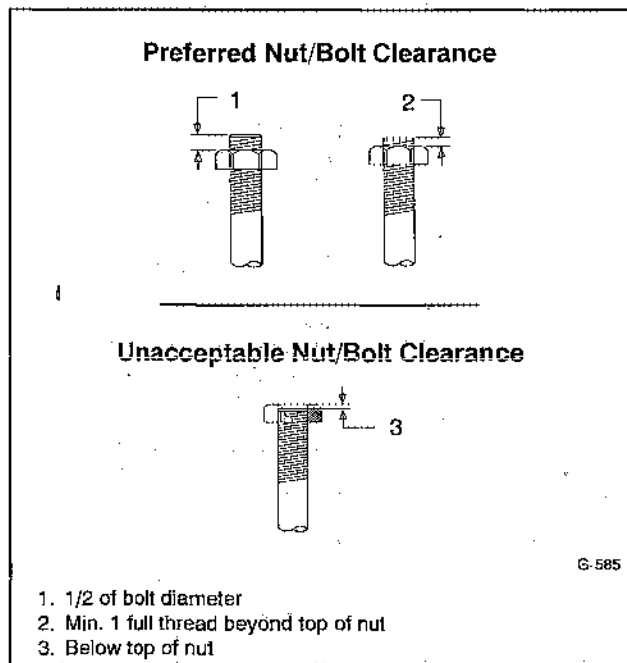


Figure 1 Acceptable Bolt Lengths

Steps for common hardware application:

1. Determine entry hole type: round or slotted.
2. Determine exit hole type: fixed female thread (weld nut), round, or slotted.

For round and slotted exit holes, determine if hardware is greater than 1/2 inch in diameter, or 1/2 inch in diameter or less. Hardware that is *greater than 1/2 inch* in diameter takes a standard nut and SAE washer. Hardware *1/2 inch or less* in diameter can take a properly torqued whiz nut or spiralock nut. See Figure 2.

3. Follow these SAE washer rules after determining exit hole type:
 - a. Always use a washer between hardware and a slot.
 - b. Always use a washer under a nut (see 2 above for exception).
 - c. Use a washer under a bolt when the female thread is fixed (weld nut).
4. Refer to Figure 2, which depicts the preceding hardware configuration possibilities.

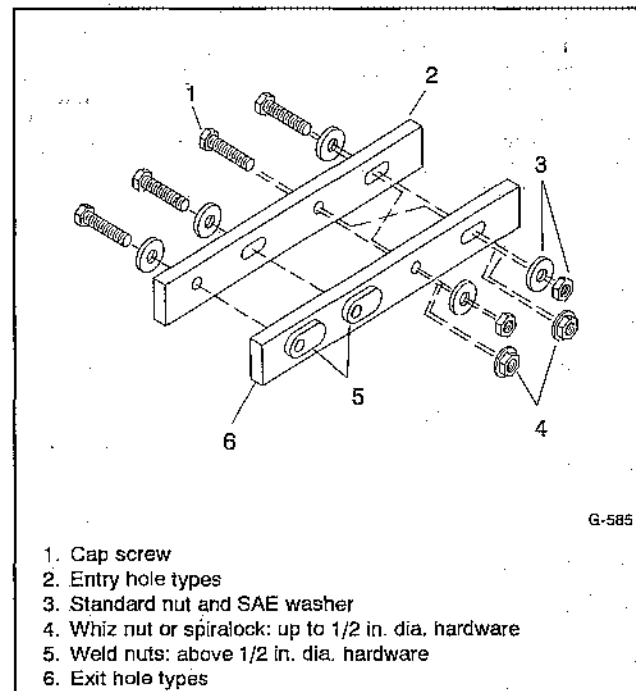


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

American Standard Fasteners Torque Specifications					
Size	Torque Measurement	Assembled into Cast Iron or Steel			Assembled into Aluminum Grade 2 or 5
		Grade 2	Grade 5	Grade 8	
8-32	Nm (in. lb.)	1.8 (16)	2.3 (20)	—	See Note 3
10-24	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	
10-32	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	
1/4-20	Nm (in. lb.)	6.8 (60)	10.8 (96)	14.9 (132)	
1/4-28	Nm (in. lb.)	8.1 (72)	12.2 (108)	16.3 (144)	
5/16-18	Nm (in. lb.)	13.6 (120)	21.7 (192)	29.8 (264)	
5/16-24	Nm (in. lb.)	14.9 (132)	23.1 (204)	32.5 (288)	
3/8-16	Nm (ft. lb.)	24.0 (18)	38.0 (28)	53.0 (39)	
3/8-24	Nm (ft. lb.)	27.0 (20)	42.0 (31)	60.0 (44)	
7/16-14	Nm (ft. lb.)	39.0 (29)	60.0 (44)	85.0 (63)	
7/16-20	Nm (ft. lb.)	43.0 (32)	68.0 (50)	95.0 (70)	
1/2-13	Nm (ft. lb.)	60.0 (44)	92.0 (68)	130.0 (96)	
1/2-20	Nm (ft. lb.)	66.0 (49)	103.0 (76)	146.0 (108)	
9/16-12	Nm (ft. lb.)	81.0 (60)	133.0 (98)	187.0 (138)	
9/16-18	Nm (ft. lb.)	91.0 (67)	148.0 (109)	209.0 (154)	
5/8-11	Nm (ft. lb.)	113.0 (83)	183.0 (135)	259.0 (191)	
5/8-18	Nm (ft. lb.)	128.0 (94)	208.0 (153)	293.0 (216)	
3/4-10	Nm (ft. lb.)	199.0 (147)	325.0 (240)	458.0 (336)	
3/4-16	Nm (ft. lb.)	222.0 (164)	363.0 (268)	513.0 (378)	
1-8	Nm (ft. lb.)	259.0 (191)	721.0 (532)	1109.0 (818)	
1-12	Nm (ft. lb.)	283.0 (209)	789.0 (582)	1214.0 (895)	

Metric Fasteners Torque Specifications, Measured in Nm (ft. lb.)					
Size (mm)	Assembled into Cast Iron or Steel			Assembled into Aluminum Grade 5.8 or 8.8	
	Grade 5.8	Grade 8.8	Grade 10.9		
M6 x 1.00	6.2 (4.6)	9.5 (7)	13.6 (10)	See Note 3	
M8 x 1.25	15.0 (11)	23.0 (17)	33.0 (24)		
M8 x 1.00	16.0 (11)	24.0 (18)	34.0 (25)		
M10 x 1.50	30.0 (22)	45.0 (34)	65.0 (48)		
M10 x 1.25	31.0 (23)	47.0 (35)	68.0 (50)		
M12 x 1.75	53.0 (39)	80.0 (59)	115.0 (85)		
M12 x 1.50	56.0 (41)	85.0 (63)	122.0 (90)		
M14 x 2.00	83.0 (61)	126.0 (93)	180.0 (133)		
M14 x 1.50	87.0 (64)	133.0 (98)	190.0 (140)		
M16 x 2.00	127.0 (94)	194.0 (143)	278.0 (205)		
M16 x 1.50	132.0 (97)	201.0 (148)	287.0 (212)		
M18 x 2.50	179.0 (132)	273.0 (201)	390.0 (288)		
M18 x 1.50	189.0 (140)	289.0 (213)	413.0 (305)		

Notes:

1. The torque values above are general guidelines. Always use the torque values specified in the service manuals and/or assembly drawings when they differ from the above torque values.
2. The torque values above are based on new plated threads. Increase torque values by 15% if non-plated threads are used.
3. Hardware threaded into aluminum must have either two diameters of thread engagement or a 30% or more reduction in the torque to prevent stripped threads.
4. Torque values are calculated as equivalent stress loading on American hardware with an approximate preload of 90% of the yield strength and a friction coefficient of 0.125.

Appendix D Common Hardware Identification

Screw/Bolts/Studs	
Head Styles	
Hex Head or Machine Head	
Hex Head or Machine Head with Washer	
Flat Head (FHM)	
Round Head (RHM)	
Pan Head	
Hex Socket Head Cap or Allen™ Head Cap	
Hex Socket Head or Allen™ Head Shoulder Bolt	
Sheet Metal Screw	
Stud	
Drive Styles	
Hex	
Hex and Slotted	
Phillips®	
Slotted	
Hex Socket	

Nuts	
Nut Styles	
Hex Head	
Lock or Elastic	
Square	
Cap or Acorn	
Wing	
Washers	
Washer Styles	
Plain	
Split Lock or Spring	
Spring or Wave	
External Tooth Lock	
Internal Tooth Lock	
Internal-External Tooth Lock	

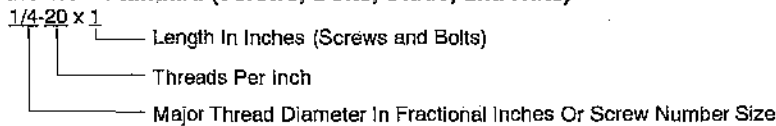
Hardness Grades	
American Standard	
Grade 2	
Grade 5	
Grade 8	
Grade 8/9 (Hex Socket Head)	
Metric	
Number stamped on hardware; 5.8 shown	

Allen™ head screw is a trademark of Holo-Krome Co.

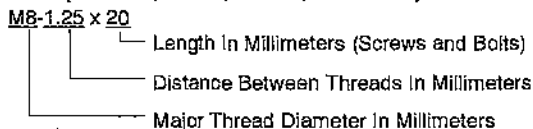
Phillips® screw is a registered trademark of Phillips Screw Company.

Sample Dimensions

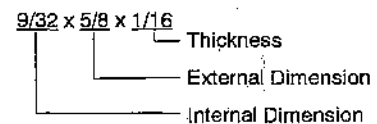
American Standard (Screws, Bolts, Studs, and Nuts)



Metric (Screws, Bolts, Studs, and Nuts)



Plain Washers



Lock Washers



Appendix E Common Hardware List

The Common Hardware List lists part numbers and dimensions for common hardware items.

American Standard

Part No.	Dimensions	Part No.	Dimensions	Part No.	Dimensions	Type		
Hex Head Bolts (Grade 5)		Hex Head Bolts, cont.		Hex Nuts				
X-465-17	1/4-20 x .38	X-6238-14	3/8-24 x .75	X-6009-1	1-8	Standard		
X-465-6	1/4-20 x .50	X-6238-16	3/8-24 x 1.25	X-6210-3	6-32	Whiz		
X-465-2	1/4-20 x .62	X-6238-21	3/8-24 x 4.00	X-6210-4	8-32	Whiz		
X-465-16	1/4-20 x .75	X-6238-22	3/8-24 x 4.50	X-6210-5	10-24	Whiz		
X-465-18	1/4-20 x .88	X-6024-5	7/16-14 x .75	X-6210-1	10-32	Whiz		
X-465-7	1/4-20 x 1.00	X-6024-2	7/16-14 x 1.00	X-6210-2	1/4-20	Spiralock		
X-465-8	1/4-20 x 1.25	X-6024-8	7/16-14 x 1.25	X-6210-6	1/4-28	Spiralock		
X-465-9	1/4-20 x 1.50	X-6024-3	7/16-14 x 1.50	X-6210-7	5/16-18	Spiralock		
X-465-10	1/4-20 x 1.75	X-6024-4	7/16-14 x 2.00	X-6210-8	5/16-24	Spiralock		
X-465-11	1/4-20 x 2.00	X-6024-11	7/16-14 x 2.75	X-6210-9	3/8-16	Spiralock		
X-465-12	1/4-20 x 2.25	X-6024-12	7/16-14 x 6.50	X-6210-10	3/8-24	Spiralock		
X-465-14	1/4-20 x 2.75	X-129-15	1/2-13 x .75	X-6210-11	7/16-14	Spiralock		
X-465-21	1/4-20 x 5.00	X-129-17	1/2-13 x 1.00	X-6210-12	1/2-13	Spiralock		
X-465-25	1/4-28 x .38	X-129-18	1/2-13 x 1.25	X-6210-15	7/16-20	Spiralock		
X-465-20	1/4-28 x 1.00	X-129-19	1/2-13 x 1.50	X-6210-14	1/2-20	Spiralock		
X-125-33	5/16-18 x .50	X-129-20	1/2-13 x 1.75	X-85-3	5/8-11	Standard		
X-125-23	5/16-18 x .62	X-129-21	1/2-13 x 2.00	X-88-12	3/4-10	Standard		
X-125-3	5/16-18 x .75	X-129-22	1/2-13 x 2.25	X-89-2	1/2-20	Standard		
X-125-31	5/16-18 x .88	X-129-23	1/2-13 x 2.50	Washers				
X-125-5	5/16-18 x 1.00	X-129-24	1/2-13 x 2.75					
X-125-24	5/16-18 x 1.25	X-129-25	1/2-13 x 3.00	Part No.	ID	OD	Thick.	Bolt/ Screw
X-125-34	5/16-18 x 1.50	X-129-27	1/2-13 x 3.50	X-25-46	.125	.250	.022	#4
X-125-25	5/16-18 x 1.75	X-129-29	1/2-13 x 4.00	X-25-9	.156	.375	.049	#6
X-125-26	5/16-18 x 2.00	X-129-30	1/2-13 x 4.50	X-25-48	.188	.438	.049	#8
230578	5/16-18 x 2.25	X-463-9	1/2-13 x 5.50	X-25-36	.219	.500	.049	#10
X-125-29	5/16-18 x 2.50	X-129-44	1/2-13 x 6.00	X-25-40	.281	.625	.065	1/4
X-125-27	5/16-18 x 2.75	X-129-51	1/2-20 x .75	X-25-85	.344	.687	.065	5/16
X-125-28	5/16-18 x 3.00	X-129-45	1/2-20 x 1.25	X-25-37	.406	.812	.065	3/8
X-125-22	5/16-18 x 4.50	X-129-52	1/2-20 x 1.50	X-25-34	.469	.922	.065	7/16
X-125-32	5/16-18 x 5.00	X-6021-3	5/8-11 x 1.00	X-25-26	.531	1.062	.095	1/2
X-125-35	5/16-18 x 5.50	X-6021-4	5/8-11 x 1.25	X-25-15	.656	1.312	.095	5/8
X-125-36	5/16-18 x 6.00	X-6021-2	5/8-11 x 1.50	X-25-29	.812	1.469	.134	3/4
X-125-40	5/16-18 x 6.50	X-6021-1	5/8-11 x 1.75	X-25-127	1.062	2.000	.134	1
X-125-43	5/16-24 x 1.75	273049	5/8-11 x 2.00					
X-125-44	5/16-24 x 2.50	X-6021-5	5/8-11 x 2.25					
X-125-30	5/16-24 x .75	X-6021-6	5/8-11 x 2.50					
X-125-39	5/16-24 x 2.00	X-6021-7	5/8-11 x 2.75					
X-125-38	5/16-24 x 2.75	X-6021-12	5/8-11 x 3.75					
X-6238-2	3/8-16 x .62	X-6021-11	5/8-11 x 4.50					
X-6238-10	3/8-16 x .75	X-6021-10	5/8-11 x 6.00					
X-6238-3	3/8-16 x .88	X-6021-9	5/8-18 x 2.50					
X-6238-11	3/8-16 x 1.00	X-6239-1	3/4-10 x 1.00					
X-6238-4	3/8-16 x 1.25	X-6239-8	3/4-10 x 1.25					
X-6238-5	3/8-16 x 1.50	X-6239-2	3/4-10 x 1.50					
X-6238-1	3/8-16 x 1.75	X-6239-3	3/4-10 x 2.00					
X-6238-6	3/8-16 x 2.00	X-6239-4	3/4-10 x 2.50					
X-6238-17	3/8-16 x 2.25	X-6239-5	3/4-10 x 3.00					
X-6236-7	3/8-16 x 2.50	X-6239-6	3/4-10 x 3.50					
X-6238-8	3/8-16 x 2.75	X-792-1	1-8 x 2.25					
X-6238-9	3/8-16 x 3.00	X-792-5	1-8 x 3.00					
X-6238-19	3/8-16 x 3.25	X-792-8	1-8 x 5.00					
X-6238-12	3/8-16 x 3.50							
X-6238-20	3/8-16 x 3.75							
X-6238-13	3/8-16 x 4.50							
X-6238-18	3/8-16 x 5.50							
X-6238-25	3/8-18 x 6.50							

Metric

Hex head bolts are hardness grade 8.8 unless noted.

Part No. Dimensions Hex Head Bolts (Partial Thread)

M931-05055-60	M5-0.80 x 55
M931-06040-60	M6-1.00 x 40
M931-06055-60	M6-1.00 x 55
M931-06060-60	M6-1.00 x 60
M931-06060-SS	M6-1.00 x 60
M931-06070-60	M6-1.00 x 70
M931-06070-SS	M6-1.00 x 70
M931-06075-60	M6-1.00 x 75
M931-06090-60	M6-1.00 x 90
M931-06145-60	M6-1.00 x 145
M931-06150-60	M6-1.00 x 150
M931-08035-60	M8-1.25 x 35
M931-08040-60	M8-1.25 x 40
M931-08045-60	M8-1.25 x 45
M931-08050-60	M8-1.25 x 50
M931-08055-60	M8-1.25 x 55
M931-08055-82	M8-1.25 x 55*
M931-08060-60	M8-1.25 x 60
M931-08070-60	M8-1.25 x 70
M931-08070-82	M8-1.25 x 70*
M931-08075-60	M8-1.25 x 75
M931-08080-60	M8-1.25 x 80
M931-08090-60	M8-1.25 x 90
M931-08095-60	M8-1.25 x 95
M931-08100-60	M8-1.25 x 100
M931-08110-60	M8-1.25 x 110
M931-08120-60	M8-1.25 x 120
M931-08130-60	M8-1.25 x 130
M931-08140-60	M8-1.25 x 140
M931-08150-60	M8-1.25 x 150
M931-08200-60	M8-1.25 x 200
M931-10040-82	M10-1.25 x 40*
M931-10040-60	M10-1.50 x 40
M931-10045-60	M10-1.50 x 45
M931-10050-60	M10-1.50 x 50
M931-10050-82	M10-1.25 x 50*
M931-10055-60	M10-1.50 x 55
M931-10060-60	M10-1.50 x 60
M931-10065-60	M10-1.50 x 65
M931-10070-60	M10-1.50 x 70
M931-10080-60	M10-1.50 x 80
M931-10080-82	M10-1.25 x 80*
M931-10090-60	M10-1.50 x 90
M931-10090-82	M10-1.50 x 90*
M931-10100-60	M10-1.50 x 100
M931-10110-60	M10-1.50 x 110
M931-10120-60	M10-1.50 x 120
M931-10130-60	M10-1.50 x 130
M931-10140-60	M10-1.50 x 140
M931-10180-60	M10-1.50 x 180
M931-10235-60	M10-1.50 x 235
M931-10260-60	M10-1.50 x 260
M960-10330-60	M10-1.25 x 330
M931-12045-60	M12-1.75 x 45
M960-12050-60	M12-1.25 x 50
M960-12050-82	M12-1.25 x 50*
M931-12050-60	M12-1.75 x 50
M931-12050-82	M12-1.75 x 50*
M931-12055-60	M12-1.75 x 55
M931-12080-60	M12-1.75 x 60
M931-12080-82	M12-1.75 x 60*
M931-12085-60	M12-1.75 x 65
M931-12075-60	M12-1.75 x 75
M931-12080-60	M12-1.75 x 80
M931-12090-60	M12-1.75 x 90
M931-12100-60	M12-1.75 x 100
M931-12110-60	M12-1.75 x 110

Part No. Dimensions Hex Head Bolts (Partial Thread), continued

M960-16090-60	M16-1.50 x 90
M931-16090-60	M16-2.00 x 90
M931-16100-60	M16-2.00 x 100
M931-16100-82	M16-2.00 x 100*
M931-16120-60	M16-2.00 x 120
M931-16150-60	M16-2.00 x 150
M931-20065-60	M20-2.50 x 65
M931-20090-60	M20-2.50 x 90
M931-20100-60	M20-2.50 x 100
M931-20120-60	M20-2.50 x 120
M931-20140-60	M20-2.50 x 140
M931-20160-60	M20-2.50 x 160
M931-22090-60	M22-2.50 x 90
M931-22120-60	M22-2.50 x 120
M931-22160-60	M22-2.50 x 160
M931-24090-60	M24-3.00 x 90
M931-24120-60	M24-3.00 x 120
M931-24160-60	M24-3.00 x 160
M931-24200-60	M24-3.00 x 200

Hex Head Bolts (Full Thread)

M933-04006-60	M4-0.70 x 6
M933-05030-60	M5-0.80 x 30
M933-05035-60	M5-0.80 x 35
M933-05050-60	M5-0.80 x 50
M933-06010-60	M6-1.00 x 10
M933-06012-60	M6-1.00 x 12
M933-06014-60	M6-1.00 x 14
M933-06016-60	M6-1.00 x 16
M933-06020-60	M6-1.00 x 20
M933-06025-60	M6-1.00 x 25
M933-06030-60	M6-1.00 x 30
M933-06040-60	M6-1.00 x 40
M933-06050-60	M6-1.00 x 50
M933-07025-60	M7-1.00 x 25
M933-08010-60	M8-1.25 x 10
M933-08012-60	M8-1.25 x 12
M933-08016-60	M8-1.25 x 16
M933-08020-60	M8-1.25 x 20
M933-08025-60	M8-1.25 x 25
M933-08030-60	M8-1.25 x 30
M933-08030-82	M8-1.25 x 30*
M933-10012-60	M10-1.50 x 12
M961-10020-60	M10-1.25 x 20
M933-10020-60	M10-1.50 x 20
M933-10025-60	M10-1.50 x 25
M961-10025-60	M10-1.25 x 25
M933-10025-82	M10-1.50 x 25*
M961-10030-60	M10-1.25 x 30
M933-10030-60	M10-1.50 x 30
M933-10030-82	M10-1.50 x 30*
M961-10035-60	M10-1.25 x 35
M933-10035-60	M10-1.50 x 35
M933-10035-82	M10-1.50 x 35*
M961-10040-60	M10-1.25 x 40

Part No. Dimensions Hex Head Bolts (Full Thread), continued

M933-12016-60	M12-1.75 x 16
M933-12020-60	M12-1.75 x 20
M961-12020-60F	M12-1.50 x 20
M933-12025-60	M12-1.75 x 25
M933-12025-82	M12-1.75 x 25*
M961-12030-60	M12-1.25 x 30
M933-12030-82	M12-1.75 x 30*
M961-12030-82F	M12-1.50 x 30*
M933-12030-60	M12-1.75 x 30
M933-12035-60	M12-1.75 x 35
M961-12040-82	M12-1.25 x 40*
M933-12040-60	M12-1.75 x 40
M933-12040-82	M12-1.75 x 40*
M961-14025-60	M14-1.50 x 25
M933-14025-60	M14-2.00 x 25
M961-14050-82	M14-1.50 x 50*
M961-16025-60	M16-1.50 x 25
M933-16025-60	M16-2.00 x 25
M961-16030-82	M16-1.50 x 30*
M933-16030-82	M16-2.00 x 30*
M933-16035-60	M16-2.00 x 35
M961-16040-60	M16-1.50 x 40
M933-16040-60	M16-2.00 x 40
M961-16045-82	M16-1.50 x 45*
M933-16045-82	M16-2.00 x 45*
M933-16050-60	M16-2.00 x 50
M933-16050-82	M16-2.00 x 50*
M933-16060-60	M16-2.00 x 60
M933-16070-60	M16-2.00 x 70
M933-18035-60	M18-2.50 x 35
M933-18050-60	M18-2.50 x 50
M933-18060-60	M18-2.50 x 60
M933-20050-60	M20-2.50 x 50
M933-20055-60	M20-2.50 x 55
M933-24060-60	M24-3.00 x 60
M933-24065-60	M24-3.00 x 65
M933-24070-60	M24-3.00 x 70

Pan Head Machine Screws

M7985A-03010-20	M3-0.50 x 10
M7985A-03012-20	M3-0.50 x 12
M7985A-04010-20	M4-0.70 x 10
M7985A-04016-20	M4-0.70 x 16
M7985A-04020-20	M4-0.70 x 20
M7985A-04050-20	M4-0.70 x 50
M7985A-04100-20	M4-0.70 x 100
M7985A-05010-20	M5-0.80 x 10
M7985A-05012-20	M5-0.80 x 12
M7985A-05016-20	M5-0.80 x 16
M7985A-05020-20	M5-0.80 x 20
M7985A-05025-20	M5-0.80 x 25
M7985A-05030-20	M5-0.80 x 30
M7985A-05080-20	M5-0.80 x 80
M7985A-05100-20	M5-0.80 x 100
M7985A-06100-20	M6-1.00 x 100

Flat Head Machine Screws

M965A-04012-SS	M4-0.70 x 12
M965A-05012-SS	M5-0.80 x 12
M965A-05016-20	M5-0.80 x 16
M965A-06012-20	M6-1.00 x 12

* This metric hex bolt's hardness is grade 10.9.

Metric, continued

Part No.	Dimensions	Type
Hex Nuts		
M934-03-50	M3-0.50	Standard
M934-04-50	M4-0.70	Standard
M934-04-B	M4-0.70	Brass
M934-05-50	M5-0.80	Standard
M934-06-60	M6-1.00	Standard
M934-06-64	M6-1.00	Std. (green)
M6923-06-80	M6-1.00	Spirallock
M982-06-80	M6-1.00	Elastic Stop
M934-08-60	M8-1.25	Standard
M6923-08-80	M8-1.25	Spirallock
M982-08-80	M8-1.25	Elastic Stop
M934-10-60	M10-1.50	Standard
M934-10-60F	M10-1.25	Standard
M6923-10-80	M10-1.50	Spirallock
M6923-10-62	M10-1.50	Spirallock†
M982-10-80	M10-1.50	Elastic Stop
M934-12-60	M12-1.75	Standard
M934-12-60F	M12-1.25	Standard
M6923-12-80	M12-1.75	Spirallock
M982-12-80	M12-1.75	Elastic Stop
M982-14-60	M14-2.00	Elastic Stop
M6923-16-80	M16-2.00	Spirallock
M982-16-80	M16-2.00	Elastic Stop
M934-18-80	M18-2.5	Standard
M982-18-60	M18-2.50	Elastic Stop
M934-20-80	M20-2.50	Standard
M982-20-80	M20-2.50	Elastic Stop
M934-22-80	M22-2.50	Standard
M934-24-80	M24-3.00	Standard
M982-24-60	M24-3.00	Elastic Stop
M934-30-80	M30-3.50	Standard

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
M125A-03-80	3.2	7.0	0.5	M3
M125A-04-80	4.3	9.0	0.8	M4
M125A-05-80	5.3	10.0	1.0	M5
M125A-06-80	6.4	12.0	1.6	M6
M125A-08-80	8.4	16.0	1.6	M8
M125A-10-80	10.5	20.0	2.0	M10
M125A-12-80	13.0	24.0	2.5	M12
M125A-14-80	15.0	28.0	2.5	M14
M125A-16-80	17.0	30.0	3.0	M16
M125A-18-80	19.0	34.0	3.0	M18
M125A-20-80	21.0	37.0	3.0	M20
M125A-24-80	25.0	44.0	4.0	M24

† This metric hex nut's hardness is grade 8.

