

KS-15954 DIESEL ENGINE-ALTERNATORS

350 KW (86630)

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1. GENERAL

1.1 Scope

1.11 This section covers installation and tests of 350 KW, four-cycle diesel engine-alternators under specification KS-15954. This set may be ordered for manual or automatic control. Other options are described under paragraph 1.5.

1.12 Paragraphs marked with an asterisk (*) apply only to automatically controlled sets. Other methods and requirements apply to both manual and automatic sets except where noted.

1.13 Tests in this section are based on the following circuit drawings:

SD-81666-01 Manual Power Plant Schematic
SD-81664-01 Manual Engine-Alternator
SD-81665-01 Automatic Power Plant Schematic
SD-81663-01 Automatic Engine-Alternator

1.2 Precautions

1.201 Observe general precautions listed in Handbook 0 and in Section 131 of this handbook.

1.202 Lethal voltages exist between line and neutral on those alternators rated 416-480 volts. At 480 volts the phase voltage, line to neutral, is 277 volts. The neutral on these alternators is insulated from the frame.

1.203 When any work is being done over or around the machine be sure all openings on the engine and alternator are closed or covered to prevent dust, dirt and other debris from entering the machine openings.

1.204 The exhaust system including turbocharger and water-cooled manifold become extremely hot during engine operation. These are insulated and guarded on the machine itself. Do not touch any part of the exhaust system until it cools.

1.205 Before doing any work on manual diesel, pull the 6A and 15A battery fuses in the diesel cabinet, disconnect the start battery B minus (-) lead or disable an air starting system by closing all valves in the air line from the tank to the engine.

*1.206 Before doing any work on automatic diesel turn OPERATION SELECTOR Switch to "OFF" position, then pull the 6A and 15A battery fuses in the diesel cabinet and disconnect the start battery B minus (-) lead or disable an air starting system by closing all valves in the air line from the tank to the engine.

1.207 Before doing any work in the control cabinet of manual diesel in addition to the operations shown in Paragraph 1.25 pull the fuses in the ac service cabinet feeding lines CA, CB and CC into the cabinet. On completion of work replace all fuses that were removed; replace B minus (-) lead on the battery or open all valves in the air line from the tank to the engine.

*1.208 Before doing any work in the control cabinet of automatic diesel in addition to the operations shown in Paragraph 1.26 pull the fuses in the ac service cabinet feeding lines CA, CB and CC into the cabinet and open the COMMERCIAL SUPPLY Breaker. On completion of work replace all fuses that were removed; close COMMERCIAL SUPPLY Breaker, replace the B minus (-) lead on battery or open all valves in the air line from the tank to the engine and turn the OPERATION SELECTOR Switch to the desired position.

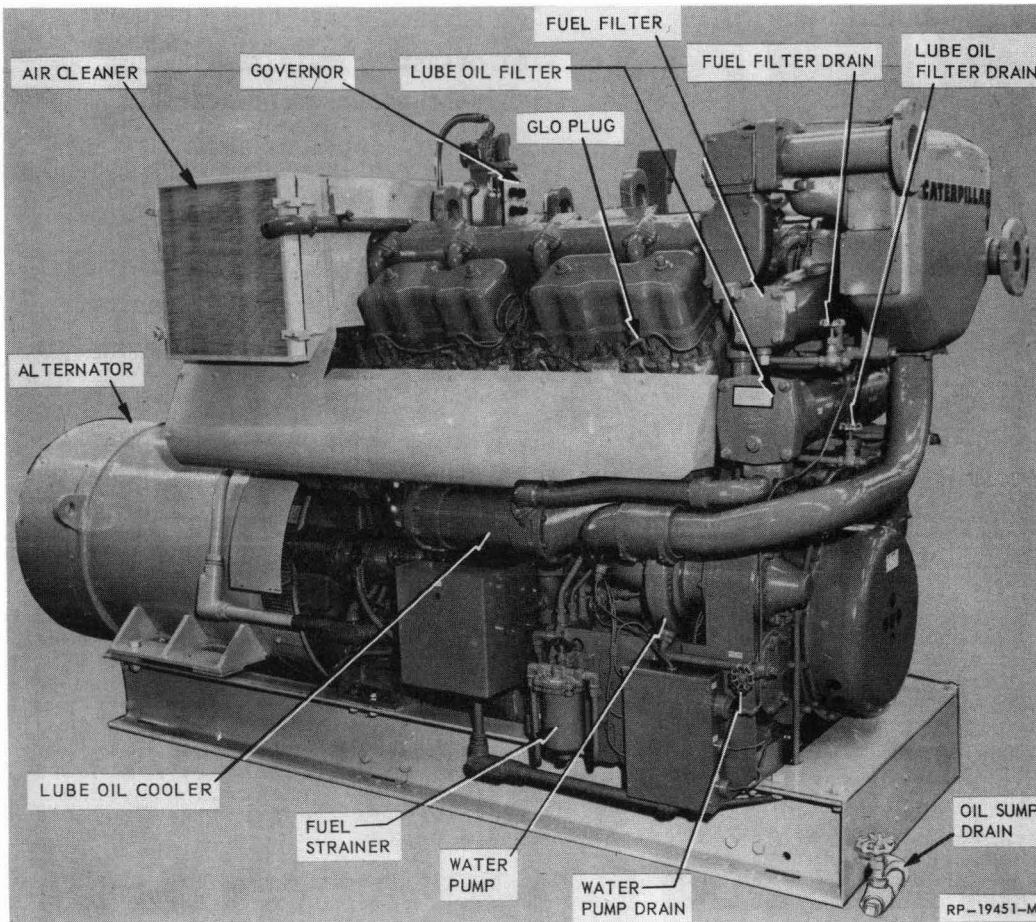


FIG. 1 KS-15954 ENGINE-ALTERNATOR - RIGHT SIDE
(EXPANSION TANK SUPPLIED ON EARLY MODELS)

1.209 Remove all filings, rust or other debris from exhaust pipe or silencer before installing. Should any of this material fall into the turbocharger serious damage to the turbocharger may result.

1.210 The installer must wear R-4296 Ear Protectors for hearing protection while the engine is running.

1.3 Supplier's Representative

1.31 A factory-trained man will be made available by the supplier for the initial start and test of the unit if the customer desires this service and will pay for this service.

1.32 The installer shall notify the Field Service at least 30 days in advance of the date that the factory-trained man will be required for the initial start and acceptance tests if this service is so desired by the customer.

1.4 Inspection

1.41 As soon as possible after the unit is received on the job remove shipping materials and make a complete inspection of the engine-alternator and associated equipment and parts. Examine

carefully for visible defects and damage. Remove alternator inspection plates and exciter guard to look for concealed damage and defects. Observe condition of bearings, commutator, brushes, etc. Examine interior of the control cabinet for concealed damage. Check that parts and tools were received.

1.42 Report any defects, damage or missing parts in accordance with authorized routines.

1.5 Description of Sets

1.51 The KS-15954 engine-alternator is pictured in Figures 1 and 2 and a typical control cabinet is shown in Figure 3.

1.52 The set can be furnished for manual starting and control or for automatic start and control. Equipment for automatic control will be furnished in the cabinet with the set except for remote transfer switches or other switching equipment furnished by the customer.

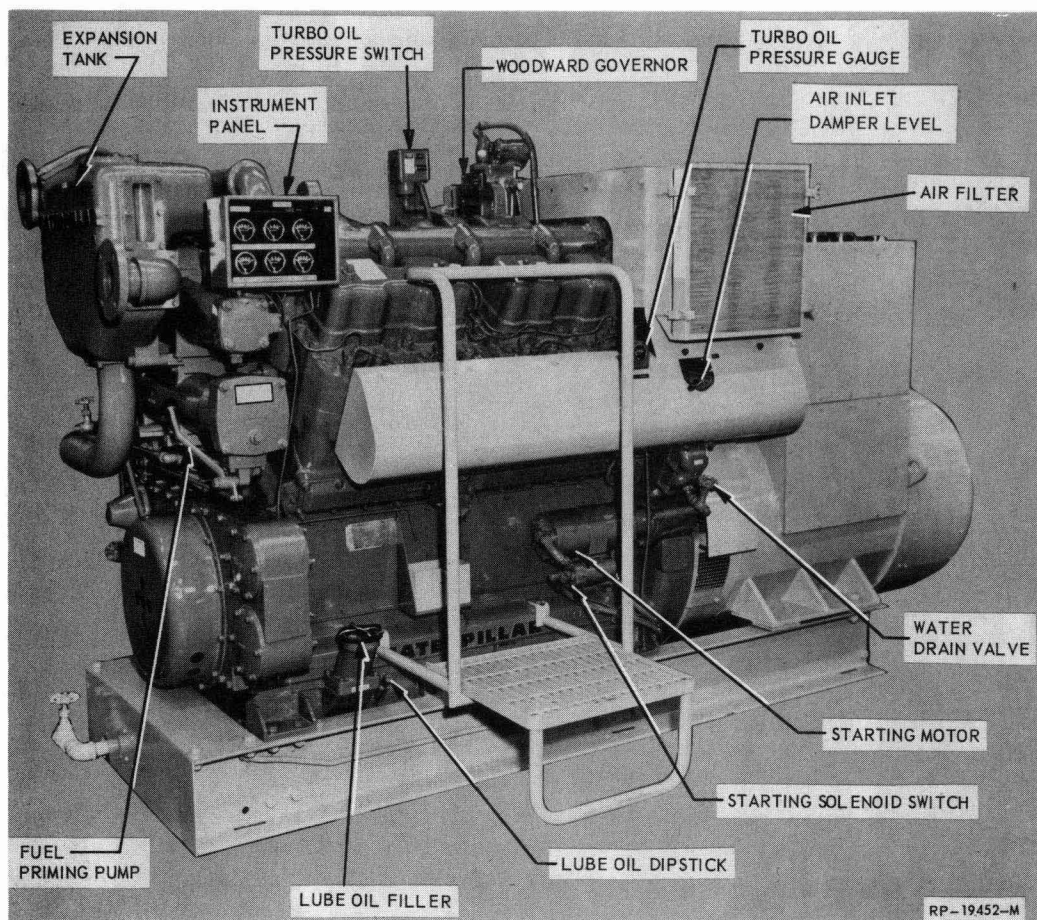


FIG. 2 KS-15954 ENGINE-ALTERNATOR - LEFT SIDE
(EXPANSION TANK SUPPLIED ON EARLY MODELS)

1.53 The following options are available:
208-240 volt or 416-480 volt
output, battery or air starting, cooling
by remote radiator or heat exchanger and
equipment for parallel operation.

1.54 All control cabinets require 48
volt dc alarm and control voltage
obtained from the engine start battery,
when one is furnished, or from central
office battery when air starting is used.
Audible and visual alarms on the cabinet
indicate engine troubles, proper operation,
power failure and return of commercial power.
Remote alarms can be transmitted in the
central office using an SD-81223-01 alarm
circuit, modified as necessary.

*1.55 An automatic set, under control
of the associated cabinet, starts
after a short delay when outside power fails
or drops to about 88% of nominal in any one
phase. The engine-alternator runs at no-
load for a short warm-up period and then
takes over office load when the control
operates a remote transfer switch. Power
return alarms indicate when outside power
returns or rises to 94% of nominal or higher.
Automatic transfer of load is not a standard
feature and the operator normally transfers
the load and shuts down the set.

1.56 Approximate dimensions and weights
are shown below:

ITEM	WEIGHT (Lbs.)	DIMENSIONS		
		Lgth. or Depth	Width	Height
Engine- Alternator	16,150	11'-3"	5'-3"	6'-11"
Exhaust Silencer (8M21)	235	4'-8"	1'-10"	Diameter
Remote Radiator	3,300	5'-9"	6'-1"	7'-5"
Control Cabinet	2,150	4'-0"	3'-0"	8'-2"
Air Compressor	800	3'-0"	2'-1"	2'-0"
Air Storage Tank	1,150	7'-6"	1'-4"	Diameter

NOTE: Length is 12'-1" for a unit with
heat exchanger cooling.

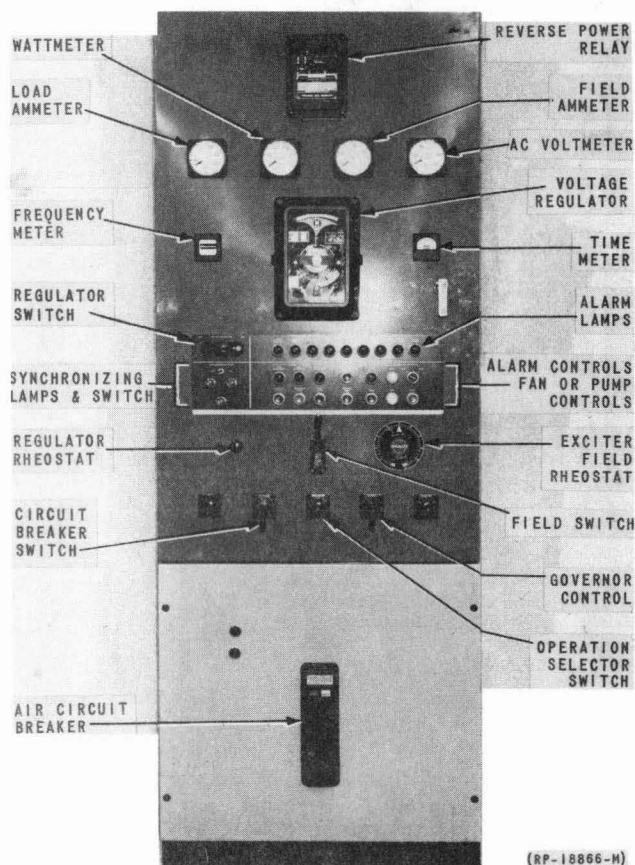


FIG. 3 KS-15954 CONTROL PANEL - AUTOMATIC SET (PAR. 2.7)

1.57 Trouble Shutdowns

1.571 When the diesel is running the following major troubles will stop the diesel. Transfer load back to commercial power, if it is available, light the associated alarm lamp and signal any other alarm circuits that are connected. The horn will also sound.

LUBE OIL PRESSURE: Lube oil pressure below 8-12 psi for period of 25-30 seconds.

LUBE OIL TEMPERATURE: Lube oil temperature reaches 232-238°F.

HIGH WATER TEMPERATURE: Engine water out temperature reaches 200-210°F.

OVERSPEED & REV. POWER: Engine speed reaches 1380-1440 rpm. Machine drawing about 100 KW in parallel.

1.572 During starting the diesel shuts down if it fails to crank and the cranking surge current continues for two or three seconds, the engine fails to start after cranking for a period of 30 seconds, or the turbo charger is not being lubricated. For the air starting system if the pressure in either the active or reserve air tank drops below 125±5 psi or the pressure in the line between the compressors and the air tank exceeds 265 to 270 psi the diesel will shut down. When any of these conditions occur the CRANK FAILURE lamp will light and the horn will sound.

2. TOOLS, TEST EQUIPMENT AND RECORDS

2.1 Tools and Test Equipment

Note	Quan.	Code	Description
	1	R-3404	Phase Sequence Indicator
	1	R-3076	Manometer, Water
	1	R-2705	Tachometer
	1	ITE-4824	Tachometer, Hasler
	1	R-2959	1/16" Allen Wrench
1	2	ITE-9501	Test Cords
1	1	ITE-1000	AC Voltmeter
2	1	ITE-4737	True RMS Voltmeter
3	1	ITE-4785	250 DW Three Phase AC Test Load
3	1	ITE-4782	150 KW AC/DC Test Load
4	X	R-3413	Wire and Lug Assembly
5	2	R-4296	Ear Protectors
	1	ITE-4137	AC Continuity Set

NOTE 1: For 208-240 volt sets.

NOTE 2: For 440-480 volt sets.

NOTE 3: Due to the heat produced by these loads they must be placed outside or in a ventilated area.

NOTE 4: In the 208-240 volt range, one set of 3 leads will be required to feed each load box. At 480 volts one set of three leads can be used to feed both load boxes. R-3413 leads are 50 ft. long but can be bolted together for longer runs.

NOTE 5: The installer must wear R-4296 Ear Protectors for hearing protection when the engine is running.

2.2 Records

ID-946	Engine-Alternator Test Record
SD-4-1275	Lubrication Record
SD-4-1285	Storage Battery Report

3. ENGINE-ALTERNATOR

FOREWORD: Check of mounting area and other operations in Paragraph 3.1 should be done before placing the machine.

3.1 General

3.11 Before machine is in place check general slope of mounting area. Refer to Section 129 in this Handbook for method of checking slope and to Handbook 30 for floor layout. Approximate dimensions of the engine-alternator are 12' by 5'-6" but the isolator support area is only 8'-0" x 3'-3". If the area slopes more than 1/4 inch in ten feet in any direction the customer should be requested to correct the condition.

3.12 Isolator mounting areas should not vary more than 1/4 inch from the general slope of the floor. The customer should be requested to correct any deviations greater than 1/4 inch. If the floor appears to be quite flat during check of the slope in Paragraph 3.11, a specific check of individual areas need not be made.

3.13 Remove any floor coverings such as asphalt tile or linoleum at all vibration isolator support points so that isolators rest directly on the concrete. Isolators are 11 3/4 inches long by 5 inches wide. Refer to Section 129 in this Handbook for operations involved.

3.14 When the machine is received, have the riggers move it into position. Whenever possible have the riggers raise the base and place the vibration isolators under the base. This requires raising the base slightly over five inches. The riggers will have jacking equipment, or, the four jack screws mounted in the base of the machine can be used. If the riggers will not place the isolators, ask them to put 2" x 2" x 4" sole plates, found in one of the crates, under the jack screws. The sole plates must

be stacked two deep (4 inches) under each jack screw, or it will be impossible to raise the base high enough to place the isolators.

3.15 Refer to Section 129 in this Handbook for information on placing and adjusting the vibration isolators.

3.2 Lubrication

3.21 Drain out any oil or residue in engine crankcase by removing the plug in the oil drain valve at the front of the engine and opening the valve.

3.22 Perform the following lubrication using S.A.E. 30 oil for temperatures above 32°F. and S.A.E. 10W for temperatures below 32°F. Superior 3 lubricants, required for engine crankcase, will be found in BSP 065-330-110 or in Section 1A in this handbook.

3.221 Close the drain valve and replace the pipe plug. Add sufficient Superior Series 3 lubricating oil (about 42 gallons) to the crankcase. Fill the crankcase up to the "Full with Engine Stopped" level on the dipstick.

3.222 Add oil as necessary to the cup on the top of the governor to bring the level up to the full mark on the governor sight gauge. Use only a good grade of 10W30 oil purchased locally.

3.223 The air starting motor oiler and air starting motor gear drive must be oiled initially. Remove plug on the oiler, which is just below the starting motor, fill oiler and replace the plug. Remove the plug on the starting motor, add oil to the top opening until it flows out the side opening. Replace the plug.

3.23 The alternator has one bearing with a grease cup provided. Take one turn down on this cup at installation and one turn every three months thereafter.

4. COOLING SYSTEMS

FOREWORD: Installation of remote radiator, associated water tanks and piping to within ten feet of the

engine is usually the customer's responsibility. If the Installer is to do any of this work refer to Section 132 in this handbook. Observe rust inhibitor and antifreeze information in Section 133.

4.1 Arrangements: Piping schematics of various cooling system arrangements are shown in Section 133 in this Handbook.

4.2 Capacities: Capacities are approximately as follows:

Engine	50 Gallons
Radiator	36 Gallons

NOTE: Quantities above do not include piping between radiator, engine and tanks nor that required by the tanks themselves, which may vary in size for each installation.

4.3 Filling Cooling Systems: When required to fill any of these systems, proceed in accordance with the following routines. When filling any system open vent cocks or plugs at high points of the system to remove any trapped air and prevent air locks.

4.31 Remote Radiator - No Tank

4.311 Close all drain valves and add water to the top of the radiator until water level reaches the top of the tank.

4.32 Remote Radiator - One Water Tank

4.321 Close all drain valves and operate other valves as indicated in Figure 2 of Section 133. Add water to drain tank (engine not running) until gauge glass on the tank is about 3/4 to 7/8 full.

4.33 Remote Radiator - Two Tanks and Auxiliary Pump

4.331 Close all drain valves and operate other valves as indicated in Figure 3 of Section 133. Add water to either tank (engine not running) until water level showing in both tank sight gauges is about 1/4 inch below the top of the gauge glass. See Paragraph 8.23 for water level adjustment with system running.

4.34 Heat Exchanger

4.341 Close all drain valves and add water to the surge tank on the engine until water level in the tank sight glass is at the half-full level.

5. STARTING SYSTEMS

5.1 Engine Starting Battery and Charger

5.11 Give the battery the initial charge indicated in engine starting battery section of Handbook 18. Where a KS-15661 charger is furnished, verify that correct input ac taps have been selected. The List 13 charger operates from a single-phase 120 volt source. Be sure the proper ac input lead is grounded. Adjust coarse and fine output taps as necessary. Refer to supplier's manual with the charger for this information. Install all fuses in the charger.

5.12 If control and alarm connections have been run from the battery to the control cabinet the control may be made inoperative during the charging period by removing 15 ampere fuse in the negative battery lead in a manual control cabinet and by turning OPERATION SELECTOR SWITCH on an automatic set to OFF. The ACD alarm lamp will light on the automatic set.

5.13 After completing the initial charge adjust charger to float battery within the following ranges:

Type of Battery	Float Volts
Lead-Acid (KS-15577) (24 Cells)	52.00-52.70
Nickel-Cadmium (KS-15578) (38 Cells)	53.30-54.00

5.2 Air Starting System

5.21 Refer to Section 134 in this Handbook on Air Starting Systems for information on installing, testing and operating these systems.

6. FUEL, VENTILATION AND EXHAUST SYSTEMS

6.1 Installation of fuel and exhaust piping to a point ten feet from the engine is usually the customer's responsibility. If the installer is responsible for any of this work refer to Section 132 in this Handbook.

6.2 Before connecting the exhaust system to the engine, drill and tap a 1/8-inch IPS manometer connection in the external exhaust line within one foot of the connection to the engine. The drill and tap for this operation is furnished in the R-3076 Manometer box. Provide an 1/8-inch pipe plug for the opening.

CAUTION: Be sure to remove all loose filings from inside the pipe or fitting and the burrs from the hole before connecting to the engine.

6.3 Ductwork for ventilation systems is usually provided by the customer. If the Installer is called upon to install motor-operated louvers in openings provided by the customer, refer to Section 22 in this Handbook before proceeding with the work.

6.4 Job-made ducts should be painted as specified by the telephone company.

7. CONTROL CABINET AND RELAYS

7.1 General

7.11 Lay out mounting area for cabinet and install, using job drawings and information in Handbook 30 on floor layout and in Handbook 18 on leveling and fastening to floor. A typical cabinet is shown in Figure 3.

7.12 Remove blocking from relays, voltage regulator and other apparatus.

7.13 Check all switches, fuses and fuse mountings in accordance with Section 3 in this handbook.

7.14 Check all components carefully for defects or damage and correct as necessary. Correct any loose connections.

7.2 Meters

7.21 Adjust pointers of all meters on the cabinet to zero by means of the zero-adjusting screws. Information on meters can be found in Section 20 of this handbook.

7.3 Timers

7.31 The timing relays, OCT, OPD, SDT and WUT are Agastat pneumatic timers. The first three timers have available range of 2 1/2 seconds to 50 seconds and WUT, a range of 10 seconds to 200 seconds. OPD setting will be 25-30 seconds; OCT setting will be 30 seconds; SDT setting is 20 seconds or as specified by customer's WUT setting will be 30 seconds or as specified by the customer but never less than 10 seconds.

7.4 Power Failure Relays

7.41 Refer to section 114 of this handbook as a reference for testing and adjusting these power failure relays, which are similar to the KS-15519 list #1. The Circuit Requirements indicate the connection for adjusting the relay.

7.5 Barring the Engine Over

7.51 Turn the engine over one or more turns with the barring tool on the ring gear only to be sure it is free to rotate.

CAUTION: Bar the engine over by using the barring tool on the ring gear only and not on the alternator cooling fan.

8. INITIAL START

FOREWORD: Water pump and radiator fan motor line connections can be made on a temporary basis until it is found that ac lines are correctly "phased out" and that the motors turn in the correct direction. (See Paragraph 8.21)

8.01 Open valves in the fuel suction line. Close exhaust system condensate drain valves when provided. The condensate drains will be opened on a periodic basis.

8.02 Prime the fuel system. Open the knurled knob bleed valve on the back of the fuel filter. This is just to the right and behind the engine gauge panel. Then open the hand pump valve which is to the left of the hand pump. Operate the hand pump handle and observe the fuel in the window next to the bleed valve. The fuel will go into the fuel drip can. Stop pumping when the fuel flow in the window is continuous without air bubbles. Close the bleed valve. Close the hand pump valve. Empty the fuel drip can.

8.03 Check that each bank of cylinders is set with compression ON. Observe indicator at the back end of the cylinder groups (behind each air cleaner) to see if the arrow head on the square-ended shaft points to ON. If arrow head points to

RELEASE, turn shaft with a wrench to the ON position.

*8.04 On automatic sets disconnect leads CB9, LB6, TR15 and TR16 on the control cabinet terminal strip (terminals TR5, TR2, TR15, and TR16) and tape the loose ends of the wires. This prevents accidental operation of the remote transfer switch.

8.05 Position controls, switches and rheostats on control cabinet as follows:

Control	Position
Air circuit Breaker (ACB)	OPEN
FIELD SWITCH	OFF
EXCITER FIELD RHEOSTAT	AUTO
SYNCHRONIZATION Switch	OFF
VOLTAGE REGULATOR Switch	ON
PUMP CONTROL Switch or	MAN
FAN CONTROL Switch	MAN
AUX WATER PUMP BREAKER	ON
FAN SUPPLY BREAKER	ON
*OPERATION SELECTOR SWITCH	OFF
COMMERCIAL SUPPLY BREAKER	ON

8.06 Open disconnect switches for remote radiator and water pump motors.

8.07 Operate the CONTROL LEVER on the engine panel to RUN position. This will reset the FRSW (Fuel Rack Solenoid Switch) on an automatic set and remove the FUEL RACK SOLENOID alarm indication. Check that the AIR SHUTDOWN DEVICE on the left side of the engine is in the RESET position.

8.08 No alarm lamps should be lit on a manual set and only ALARM CIRCUIT DISCONNECT lamp on an automatic set.

8.09 Position governor control knobs as follows:

SPEED DROOP	0
LOAD LIMIT	5-7

NOTE: SYNCHRONIZER and SYN INDICATOR knobs do not have a definite setting here.

8.10 Operate cooling system valves as indicated under "To Run Engine" on appropriate cooling system schematic in Section 133 of this handbook.

8.11 Connect starting battery or open air starting system valves.

8.12 Start the room ventilating fan when one is furnished or open windows or door as necessary to provide adequate ventilation.

8.13 For heat exchanger cooling set the line on the indicator of the thermostatic valve to THERMOSTATIC position. The indicator can be moved up or down by cranking the shaft on which it is mounted.

NOTE: The installer must wear R-4296 Ear Protectors for hearing protection when the engine is running.

8.14 Crank the engine as follows:

8.141 Manual Set: Operate the Pump Timer Switch on the left side of the engine instrument panel to ON. The turbocharger oil pump motor will start. When the turbocharger oil pressure reaches 14 pounds, push the start button on the engine instrument panel or pull up on the air valve control to start the engine.

*8.142 Automatic Sets: Turn OPERATION SELECTOR SWITCH to NO LOAD TEST Position. Engine cranking will start within 5 to 120 seconds depending on the setting of the start delay timer and the turbocharger lube oil pressure. Power Failure Lamp lights and alarm bell sounds. Bell can be silenced by pushing Alarm Off Audible.

8.15 If the engine cranks but does not start in about twenty seconds release START button, air valve handle or turn OPERATION SELECTOR SWITCH to OFF. Check for reason why engine will not start.

8.16 Wait two minutes before another starting attempt to allow the electric starting motors to cool. With the air starting system it will not be necessary to wait, but check air tank gauge pressures to be sure adequate pressure is available for the next starting attempt.

8.17 Allow the engine to run at slow speed for at least five minutes. During this period observe the lube oil pressure gauge which should indicate pressure. If no pressure is indicated shut the set down and investigate at once.

8.18 After the five minute warmup increase speed to 1200 rpm. Turn LOAD LIMIT knob on governor to 10 (full clockwise). Check speed with R-2705 Tachometer or ITE-4824 Tachometer, and adjust SYNCHRONIZER knob on the governor in FAST or SLOW direction to set speed at 1200 rpm.

8.19 Close FIELD SWITCH (ON). Turn VOLT ADJUSTING RHEOSTAT for desired output voltage.

8.20 With alternator voltage available use the R-3404 Phase Sequence Indicator and check that the alternator output voltage (on the alternator side of the SET Breaker) is 1-2-3 order. If it is not 1-2-3 order this will have to be corrected before starting the set again.

8.21 With engine-alternator power available check direction of rotation of radiator fan and auxiliary water pump motors. Have someone watch the pump or fan. Close associated disconnect switch. Push the LOW button for the fan and then immediately push the Stop button. Push the START button for the pump and then immediately push the STOP button.

NOTE 1: Arrows on the motor indicate correct direction of rotation. If either motor rotates in the wrong direction, remove power from the motor by opening the disconnect switch. Interchange two of the three motor leads at some convenient point between the disconnect switch and the motor. Then repeat the test in Paragraph 8.21 as a check.

NOTE 2: The engine may be shut down to interchange these leads if desired. However, it will be necessary to run the engine for at least ten minutes, or until the OIL TEMP INLET gauge registers at least 120°F.

8.22 After the radiator fan and water pump motors run the correct direction the associated MAN/AUTO Switches for them will be placed in the AUTO position and left there.

8.23 During this no-load run check the cooling system as follows:

8.231 Remote Radiator: Water level should not fall below 1/2 level in gauge glass on the radiator. Add water to top of radiator to bring water to 1/2 level in the gauge.

8.232 One Tank System: Observe gauge glass during engine operation and add water to the tank if level falls below bottom of the gauge to bring level to just above the bottom of the gauge.

8.233 Two Tank System: Observe level in hot water tank while auxiliary pump is running. The water level should always be at least 2 inches above the bottom of the sight glass in the hot water tank. If necessary, add water to the hot water tank to bring water level above this point.

8.234 Run the engine about 30 minutes. Observe engine panel gauges and check that pressures and temperatures meet requirements in Paragraph 11.3. Then shut down the engine by pushing the CONTROL LEVER to "SHUT-OFF" and holding it there until the engine stops. Turn OPERATION SELECTOR SWITCH to OFF for automatic sets.

8.24 Radiator fan and pump motors can now be permanently connected. Open disconnect switches for these motors, make the connections and leave the disconnect switches open until ready to start the engine again.

8.24 After shutdown operate cooling system valves as indicated in Section 113 of this handbook for the system furnished.

8.26 Check over the set for fuel, lube oil and water leaks and correct as necessary.

8.27 Correct any exhaust system leaks that may have been observed while running the engine.

8.28 Add lube oil before starting the engine again but wait approximately one hour before checking. Add sufficient lube oil to bring level to the "FULL WITH ENGINE STOPPED" position.

9. REVERSE POWER TEST

NOTE 1: This test will be made if the set has a reverse power relay (parallel sets only).

NOTE 2: This test requires an artificial load, preferably ITE-4782 although ITE-4785 may be used.

9.01 With the set shut down reverse the leads at terminals No. 5 and No. 6 on the Reverse Power Relay current coil.

9.02 Starting Procedure

9.021 Manual Set - With control positioned from previous test operate engine CONTROL LEVER to RUN position and PT switch to ON position. Pull up air start valve lever or push STARTING BUTTON when engine fires release lever or button.

9.022 Automatic Set - Turn OPERATION SELECTOR SWITCH to NO LOAD TEST position.

9.03 Apply the artificial load and increase the load to about 75 KW.

9.04 Increase the load from the 75 KW point in minimum steps available. Observe the engine alternator breaker trips and the set shuts down in the range of 95 KW - 115 KW. Record on the ID-946 Form the KW reading at which the set shuts down and the breaker trips.

9.05 Observe that the Reverse Power lamp goes on and the horn sounds at shutdown. Cancel all alarms as follows:

MANUAL Set - Operate ALARM CUTOFF Switch to remove all alarm indications.

AUTOMATIC Set - Turn the OPERATION SELECTOR Switch to "OFF" to remove all alarm indications.

9.06 Operate load toggle switches to "OFF".

9.07 With set shut down restore leads on terminals No. 5 and No. 6 of Reverse Power Relay to original connection.

9.08 Reset the Reverse Power Relay by pushing up the button in the lower left hand corner of the relay. Red-flag indication is removed.

9.09 When the set is started again it will be necessary to depress the BREAKER RESET Switch to charge the breaker as indicated by the breaker flag. It will not be possible to close the breaker if this operation is not performed.

9.10 Operate the CONTROL LEVER on the engine panel to RUN position. This will reset the FRSW (FUEL RACK SOLENOID SWITCH) on an automatic set and remove the FUEL RACK SOLENOID alarm indication. Check that the AIR SHUTDOWN DEVICE on the left side of the engine is in RESET position.

10. OVERSPEED TRIP TEST

CAUTION: Do not exceed 120% speed (1440 rpm) in this test.

NOTE 1: This test is for electrical overspeed trip. There is also a mechanical overspeed trip operating above the electrical shutdown. The mechanical overspeed is factory-adjusted and will not be checked. Readjustment of the mechanical shutdown must be done by a supplier's representative.

*10.01 Turn the OPERATION SELECTOR Switch to the "MANUAL" position.

10.02 On starting the set depress the BREAKER RESET Switch to charge the breaker as indicated by the breaker flag. It will not be possible to close the breaker if this operation is not performed.

10.03 Starting Procedure: refer to paragraph 9.02 but on the Automatic Set turn OPERATION SELECTOR SWITCH to MANUAL position.

10.04 After the speed and voltage are normal, disconnect linkage from the governor to the full pump by carefully removing nut and bolt at the governor end of the linkage.

10.05 The following operations require two men. One man will overspeed the engine by pushing downward on the disconnected linkage while the second man checks engine speed with a tachometer (R-2705). It will be necessary to remove the plug in the end housing of the exciter before the tachometer can be inserted in the end of the shaft.

10.06 Shutdown should occur in the range of 1380-1440 rpm. Record the speed at which the overspeed cut-off device operates to shutdown the engine on ID-946 form.

10.07 Reconnect the governor linkage (this will be a temporary basis if readjustment will be done.)

10.08 Cancel all alarms after shutdown.

10.081 Manual Set - Operate ALARM CUTOFF Switch to remove all alarm indications.

*10.082 Automatic Set - Turn the OPERATION SELECTOR Switch to "OFF" to remove all alarm indications.

10.09 Reopen engine inlet damper using the lever provided on left side of the engine.

10.10 If shutdown does not occur by 1440 rpm have the man at the governor reduce speed to as close to 1420 rpm as possible. Have this man or another man do the following:

10.001 Manual Set: Loosen the cap adjustment locking screw and slowly rotate the cap assembly in the clockwise direction until shutdown occurs.

*10.002 Automatic Set: Insert an 1/16" Allen wrench (R-2959) into adjusting screw No. 3. Turn adjusting screw slowly counterclockwise until shutdown occurs.

10.11 If shutdown occurs before 1380 rpm, do the following before restarting the engine:

10.111 Manual Set: Loosen the cap adjustment locking screw and rotate the cap assembly in the counterclockwise direction so that the slot shifts about 1/8" with relation to the locking screw.

*10.112 Automatic Set: Insert an 1/16" Allen wrench (R-2959) into adjusting screw No. 3. Turn adjusting screw clockwise direction 45° (1/4 turn).

10.12 If adjustment was necessary start the engine (Paragraphs 10.01 and 10.03) and repeat the operations in Paragraphs 10.04 through 10.09.

10.13 Reset FRS as in Paragraph 8.07.

11. FULL LOAD TEST

TIME: The Preliminary Full Load Test will be one hour in length at 350KW. (Before applying the 350 KW load stabilize the set by placing a 100 KW load for 15 minutes). The Final Acceptance Test will be 2-1/2 hours in length two hours at full load, and 1/2 hour at the normal load value or at full load. A customer's representative must witness the acceptance test.

LOAD: Artificial loads equal to the full capacity of the set connected either to the emergency bus or to the bus bar on the load side of the alternator circuit breaker.

PARALLEL: If the set is to be paralleled the Final Acceptance Test will be made in parallel in accordance with Section 130 in this handbook. Before proceeding to Section 130 verify that the short across secondary of cross-current compensating transformer (strap on to CCC resistor having a cardboard tag) is removed.

11.1 Preliminary Test

11.101 Remove the 1/8 pipe plug in the exhaust connection just above the turbocharger and connect the R-3076 Manometer. Adjust manometer as in Section 131.

11.102 Prepare the set for starting by repeating paragraph 9.02 but on the automatic set turn the OPERATION SELECTOR SWITCH to MANUAL position.

11.103 Observe gauges and thermometers on the engine set and pressure check during a 15 minute warm up at no load, then record all readings required on the first line of the ID-946 Form.

NOTE: No column is shown for the Generator Field Current. There is no need to read this and it has no requirement. Normal values are about 15 amperes at no load and 33 amperes at full load.

11.104 Check speed with the R-2705 or ITE-4824 Tachometer. Adjust SYNCHRONIZER knob on the governor to set the engine speed at 1210 rpm for a single set and at 1250 rpm for a set that is to be paralleled.

11.105 With no load on the set, close the current breaker. Apply 100 KW load. At this point adjust the alternator voltage to the desired value with the Volt Adjusting Rheostat.

11.106 When the temperature of the water out of the engine (gauge marked WATER TEMP OUTLET) reaches 145-155°F LTS switch should operate to start the fan on low speed. A switch marked HTS runs the radiator fan on high speed when engine water out temperature reaches 187-190°F. It runs on high until temperature drops to 175-180°F. then switches to low speed. Low Lamp and High Lamp light to indicate radiator fan speed.

11.1061 If an auxiliary water pump is furnished with a remote radiator observe the pump discharge pressure as read on the pressure gauge. The reading on this gauge must be equal to the head in feet which appears on the pump divided by 2.304. A switch marked WPS will operate in the range 145-155 F to start the water pump.

11.1062 If a heat exchanger is furnished, the temperature regulator requires no adjustments. Manual operation of the regulator valve is possible in case of damage to the regulator, see Paragraph 15.4. A switch marked WPS will operate in the range 145-155°F to start the water pump.

11.107 After 15 minutes at 100 KW re-adjust voltage if necessary, and again take a set of readings. This voltage is the one that will be used for the voltage check in Paragraph 11.32.

11.108 Apply 350 KW (see NOTE below) for 1 hour and take a set of readings every 30 minutes. Determine the exhaust back pressure with the R-3076 Manometer in accordance with Section 131 of this handbook during the last 1/2 hours.

NOTE: Engine power decreases as altitude above sea level increases. Derating is indicated below. The engine-alternator must be able to carry the load listed for the altitude.

Feet Above Sea Level	KW Output
Up to 5000'	350
7000'	325
9000'	300
10000'	287

11.109 Check to see if the alternator voltage across the LB6 and TR16 leads is in its specification range of either 208-240 volts or 416-480V with Voltmeter (ITE-4737).

11.110 Throughout the run check meters for evidence of internal damage or lack of freedom of movement.

11.111 Observe leaks during the run and tighten fittings, as necessary, to minimize leaks. If necessary to stop the set to correct a leak, do so and then start the set and run one hour, uninterrupted at full load.

11.112 Using the R-3404 Phase Sequence Indicator, check phase sequence of the engine-alternator leads on the discharge side of the alternator voltage available at the Remote Transfer Breaker Circuit cabinet. Check that alternator voltage is correctly "phased-out" with commercial power.

11.113 This test must meet requirements in Paragraph 11.3. After the test is completed, reduce load to minimum, open the circuit breaker and stop the set by depressing the EMERGENCY STOP button (this will test for emergency stopping). Be sure to leave the regulator and the governor set as they are.

*11.114 Turn OPERATION SELECTOR SWITCH to OFF position.

11.115 After shutdown correct leaks that have been observed.

11.116 It will be necessary to reopen the engine inlet damper using the lever provided on the left side of engine before the set can be restarted.

11.2 Final Acceptance Test

11.201 If office and building load is to be used it will be necessary to reconnect leads LB6, CB9, TR15 and TR16 in the automatic control cabinet so that the remote transfer breakers will operate.

11.202 Start the machine as in paragraph 9.02 but on the automatic set turn the OPERATION SELECTOR SWITCH to MANUAL position.

11.203 Allow engine to warm up for about 15 minutes at no-load (circuit breaker open). Check speed and adjust governor for 1210 rpm for a single set and 1250 rpm for a set to be paralleled.

11.204 Close the circuit breaker.

11.205 For manual sets add artificial loads that are going to be used for the test by operating their transfer switches to the emergency position. Apply 350 KW, full load.

11.206 For an automatic set turn Operation Selector Switch to LOAD TEST MANUAL position. This causes the remote automatic transfer switch to operate, apply 350 KW Artificial load, full load on the engine-alternator.

11.207 Run a few minutes at full load and then take a set of readings on the Test Record and then thereafter take readings every 30 minutes without changing speed or voltage throughout the run.

11.208 The engine-alternator shall meet all requirements in paragraph 11.3.

11.209 At the end of the Acceptance Test, reduce load to minimum. For a manual set operate the transfer switches for the various loads to commercial service position. For an automatic set, turn OPERATION SELECTOR SWITCH to AUTO position and then turn TRANSFER SWITCH RESTORE switch to RESET position. This causes customer's remote transfer switch to operate and throw the office load back on commercial power.

11.210 Open circuit breaker. Allow the engine to run a few minutes then shut down with the CONTROL LEVER.

11.211 Remove manometer connection and replace 1/8 inch pipe plug.

11.212 Disconnect the artificial load.

11.213 Correct any leaks that were observed.

11.3 Test Requirements

11.31 Speed shall stay within one of the following ranges, according to SPEED DROOP knob setting on the governor:

SPEED DROOP Setting	Speed Range - rpm
0	1200-1210
100	1200-1250

11.32 Voltage shall stay within ± 2 per cent of the voltage recorded after the machine has operated 15 minutes at 1/4 load. (Multiply this voltage by 0.02 to calculate allowed variation).

11.33 Fuel and lube oil pressures shall remain above the minimum values listed below. There are no adjustments for fuel and lube oil pressure.

	Minimum	Normal
Oil Pressure	20	25-35
Fuel Pressure	15	15-20

11.34 Temperatures at points listed below shall not exceed the maximum values shown.

	Maximum
Oil Cooler Inlet	225° F.
Engine Water Outlet	200° F.

11.35 Exhaust back pressure at full-load shall not exceed 20.4 inches of water (1-1/2 inches of mercury).

11.36 Meters shall evidence no lack of freedom of pointer movement or other defects.

*12 AUTOMATIC OPERATION TEST

12.1 General

12.11 Tests in this paragraph check automatic and routine cycles of an automatic set. It would be well to have the engine-alternator assume all or part of the office or building load it is expected to carry, with the customer's permission.

12.12 If the engine fails while carrying the load in Paragraph 12.4, the circuit breaker will open and the customer's automatic transfer switch will be activated to transfer load to outside power.

12.2 Preparation for Automatic Operation

12.21 Reconnect leads LB6, CB9, TR15 and TR16 in the control cabinet so that the remote transfer switch will operate.

12.22 Open the valve in the fuel line. Open air starting system valve. Operate cooling system valves as indicated in Section 133 in this handbook on the figure for the cooling system used under "To Run Engine".

12.23 Operate controls and switches to the following positions:

Control	Position
*OPERATION SELECTOR SWITCH	AUTO
COMMERCIAL POWER BREAKER	ON
MAIN LINE Breaker	Closed
VOLTAGE REGULATOR Switch	ON
EXCITER FIELD RHEOSTAT	AUTO
FIELD SWITCH	ON
AUX WATER PUMP Breaker	ON
FAN SUPPLY Breaker	ON
PUMP CONTROL Switch	AUTO
FAN CONTROL Switch	AUTO

NOTE: Governor LOAD LIMIT knob will be at 10. SPEED DROOP knob will be at 0 unless the set is to be paralleled, in which case SPEED DROOP will be at 100.

12.24 Close disconnect switches for remote radiator and auxiliary water pump. These normally remain closed.

12.3 No Load Test

12.31 Turn OPERATION SELECTOR SWITCH to NO LOAD TEST position. Signal is given to open radiator discharge louvers, if any.

12.32 Engine begins to crank after the start delay period (5-120 secs) specified by the customer. When cranking begins, PF lamp lights, the bell rings and a remote power failure alarm is given. Operate ALARM OFF AUDIBLE button; bell stops and BD lamp lights.

12.33 Engine fires, comes up to speed and signal is given to open intake louvers, if any.

12.34 The warm-up timer WUT will time out but transfer will not take place and PO alarm will not come in.

12.35 Allow the set to run about ten minutes. Then turn OPERATION SELECTOR SWITCH to AUTO. BD and PF lamps go out and power failure alarm to remote location is removed.

12.36 Shutdown the set by holding the CONTROL LEVER in the SHUT OFF position. Signals are given to close intake and radiator air discharge louvers, if any.

12.4 Full Load Test

12.41 Turn OPERATION SELECTOR SWITCH to LOAD TEST MANUAL position.

12.42 Engine begins to crank after the start delay period (5-120 seconds) specified by the customer. When cranking begins, PF lamp lights, the bell rings and a remote power failure alarm is given. Operate ALARM OFF AUDIBLE button; bell stops and BD lamp lights.

12.43 Engine fires, comes up to speed and signal is given to open intake louvers, if any.

12.44 When WUT operates the customer's remote transfer switch is energized to throw office load on the engine-alternator. WUT time can be 10 seconds to 5 minutes, as specified by the customer but it must not be less than 10 seconds. When transfer occurs PO lamp lights and a proper operation alarm is given. At this time a signal is also given to open radiator air discharge louvers, if any.

12.45 Allow the set to carry the load for ten or fifteen minutes. Then turn OPERATION SELECTOR SWITCH to AUTO. Bell sounds, indicating return of outside power. PF lamp goes out and remote power failure alarm is removed. Depress the TRANSFER SWITCH RESTORE and release.

12.46 Shut the set down with manual throttle. Signals are given to close intake and radiator air discharge louvers, if any.

12.5 Power Failure Test

12.51 Testing the automatic operation of the plant by acutally failing outside power is not a requirement and must be done only with the customer's permission. The loads will be without power for the total operating time or SDT and WUT timers. Operation is the same as in Paragraph 12.4 except that the OPERATION SELECTOR SWITCH remains in AUTO position.

13. TEST OF TROUBLE CONTROLS

13.1 Air Starting System

13.11 Check APS (Air Pressure Switch), APSR (Air Pressure Switch Reserve) and UHP (Ultra High Pressure) pressure switches in accordance with Section 134 in this handbook.

13.2 Electric Starting System

13.21 The operation of OLS (Overload) Solenoid) cannot be tested in the field.

13.22 When set fails to turn over, OLS contact will close in about two to three seconds leaving a visual indication by lighting the CF (Crank Failure) lamp.

13.23 Bar the engine set over to see that the shaft is free to turn.

13.24 The OLS must be manually reset after it operates.

13.3 LUBE OIL PRESSURE Alarm

13.31 Simulate low lube oil pressure with engine running at no-load with breaker closed. Remove cover of LOPS switch and short the terminals. LOP alarm should come in, circuit breaker should open and set will shut down. Turn OPERATION SELECTOR SWITCH to OFF to cancel alarms. Remove short across LOPS terminals and replace cover.

13.32 On manual set, check the LOPS with the engine running at no load with the breaker closed. Remove cover of the LOPS and short the terminals. LOP alarm should come in, circuit breaker should open and the engine set shut down. Depress the ALARM CUTOFF. Remove short and replace cover.

13.4 LUBE OIL TEMPERATURE Alarms

13.41 With the set running at no-load, circuit breaker closed, simulate operation of LOTA switch by removing the cover, and shorting the terminals. Circuit breaker opens, LUBE OIL TEMPERATURE alarm comes in and the set shuts down. On a manual set depress ALARM CUTOFF SWITCH to cancel the alarm; on an automatic set, turn OPERATION SELECTOR SWITCH TO OFF to cancel alarms. Remove short across LOTA terminals and replace the cover.

13.5 HIGH WATER TEMP. Alarm

13.51 With the engine running and circuit breaker closed operate FAN or PUMP CONTROL to OFF position. Engine jacket out water temperature will rise. Add some load to the machine. When engine water out temperature reaches 192-198°F, HIGH WATER TEMP. alarm comes in. Remove the load. Depress ALARM CUTOFF SWITCH to stop the horn. Turn PUMP or FAN CONTROL switch to AUTO to restore temperature to normal and extinguish the lamp.

13.52 The WTS switch cannot be tested because it is dangerous to run engine temperature up this high. Remove the switch cover and simulate closure of the switch by shorting the terminals. The breaker opens and the set shuts down. Depress ALARM CUTOFF SWITCH or turn OPERATION SELECTOR SWITCH to OFF to cancel alarms.

14. CHECK OF ENGINE ACCESSORIES

14.1 Cranking Cutout Switch

14.11 This switch is combined with FRS and overspeed trip switches and has three adjusting screws. Each adjusting screw is covered by a dust cover screw. Setting marked (1) is for the low range, 350-450 rpm (CCO) the one marked (2) is for the high range 1100-1120 (FR), and the one marked (3) is for overspeed trip.

14.12 Adjust CCO by removing the dust cap marked (1), and inserting a 1/16 inch Allen wrench into the adjusting screw and turn screw clockwise to increase operating point, counterclockwise to decrease operating point.

NOTE: Screw #3 was adjusted in Paragraph 10.10 for the Overspeed Trip Test.

14.2 Check of Glow Plugs

14.21 Glow plugs are furnished in each cylinder. These are operated from a 16 volt transformer in the control cabinet. The transformer primary connects to commercial power. The glow plugs are cut off when engine-alternator power is available by relay GP on manual sets and relay AP on automatic sets.

14.22 The glow plugs have to be checked frequently to determine if they are still good. This can be done with a Clamp-On Ammeter. Each glow plug draws about 7 amperes; clamp the ammeter around each glow plug lead in turn. Any plug that does not draw current is defective and should be replaced.

14.23 An alternate method of checking glow plugs is to remove each lead in turn and touch the lead to the plug. A good plug will show a spark, a burned-out plug will not spark.

14.3 Thermostatic Valve

14.31 This valve normally operates at THERMOSTATIC position by means of internal thermal elements. If these should fail the valve will have to be replaced. However, the valve can be operated manually. In this case, remove the hand crank, turn it up so that it can be used, and turn the indicator on the shaft toward CLOSE BY-PASS to lower water temperature or, toward CLOSE COOLER to raise water temperature.

15. ADJUSTMENTS - VOLTAGE REGULATOR

15.1 Voltage Regulator

15.11 Adjustments on the regulator should normally be done by an authorized supplier's representative. However, if hunting occurs due to the action of the voltage regulator, this can be reduced by adjusting the recall spring tension with the recall set screw. Refer to regulator supplier's bulletin with the control cabinet.

16. ADJUSTMENTS - GOVERNOR

16.1 **SPEED DROOP:** This knob controls decrease in engine speed from no-load to full-load, or the speed droop. Dial markings are 0 to 100, indicating percent of droop. A fixed amount of droop is available, about 38 rpm, with the knob at 100. For single set operation the knob should be set at 0, providing practically no speed change from no-load to full-load. This condition is called isochronous operation.

16.2 SYNCHRONIZER: This knob is a speed adjusting control and can be used to change engine speed when operating alone or to change the KW load on the set when it is operating in parallel. It has no particular setting.

16.3 SYN INDICATOR: This knob directly below the SYNCHRONIZER knob indicates the number of revolutions of that knob.

16.4 LOAD LIMIT: This knob restricts the angular shaft rotation of the governor which restricts the quantity of fuel that can be supplied to the engine and, therefore, the load that can be put on the engine. The control may also be used for shutting down the engine by turning it to zero.

CAUTION: Do not manually force engine linkage to increase fuel without first turning LOAD LIMIT knob to 10.

16.5 COMPENSATION: This is a needle valve adjustment under the large screw on the front of the governor. The pointer has no required setting and must not be moved except during a readjustment. This adjustment affects speed recovery of the engine after load changes and minimizes hunting. It has been properly set at the factory and should be changed only as a last resort if excessive hunting and slow speed recovery of the engine after load changes cannot be corrected by voltage regulator adjustment. If readjustment is required, refer to a Woodward governor bulletin or supplier's manual.

17. MAINTENANCE DURING INSTALLATION

17.1 Lubrication

17.11 At the beginning of each run and at eight hours intervals during a run, check crankcase oil level, alternator bearing oil level and oil level in the governor. Before a run, with engine idle, add sufficient lube oil to bring crankcase level to "FULL with ENGINE STOPPED" mark on the dip stick. While the engine is running crankcase level should be at "FULL with ENGINE RUNNING" mark on the dipstick.

17.12 Add sufficient 10W30 oil to the governor to bring the oil level in the gauge glass on the governor up to the mark.

17.2 Primary Fuel Strainer

17.21 At the beginning of each run and at eight hour intervals during a run turn handle of the primary fuel strainer one or more turns in a clockwise direction.

17.3 Fuel Drip Can

17.31 Empty fuel drip pan periodically during a run and after a run. About 1/2 gallon of fuel drips every two hours of running.

18. TROUBLE-SHOOTING

18.01 Irregular Engine Speed.

Water in the fuel.
Air in the fuel system.

Incorrect fuel.
Governor is not functioning properly.
Engine not fully warmed up.

18.02 Erratic voltage.

Loose connections.
Faulty voltage regulator.
Engine governor unstable.

18.03 No output voltage.

Loss of magnetism in exciter field poles.
Loose or open connections.
High contact resistance in the exciter brushes.
Reversed polarity of exciter field.

18.04 Lack of Power.

Improper engine adjustments.
Insufficient fuel.
Insufficient combustion air.

18.05 Smoky Exhaust.

Black of grey smoke.
Incompletely burned fuel.
Clogged air cleaner.
Improper fuel.
Insufficient combustion air.
Excessive exhaust back pressure.
Light load (less than 30%).

Blue Smoke.
Operating temperature too low (open thermostat).
Internal fuel or lube oil leaks.
Injection nozzles not operating properly.
Light load (less than 30%).

White Smoke.
Improper fuel.
Faulty injection nozzles.
Engine requires overhaul.

18.06 Engine knocks.

Lube oil diluted by fuel.
Injection timing incorrect.
Defective fuel injection pump.

18.07 Engine Overheats.

Thermostats fail to open.
Restricted passages in lube oil cooler.
Defective water pump.
Loose or broken fan belt.
Excessive KW load.
Clogged radiator passage.
Low coolant level.

18.08 Hard Starting.

Faulty glow plugs.
Incorrect lube oil.
Low battery output or low air pressure.
Siphoning of fuel from engine when it is idle.
Defective turbo-charger.
Engine overhaul required.
Air in fuel system.
Insufficient fuel pressure.
Clogged Air Cleaner.
Incorrect SAE rating of lube oil.

18.09 Hunting.

Engine not fully warmed up.
Defective voltage regulator.
Instability of the exciter.
Recall spring of the voltage
regualtor needs adjustment.

18.10 Vibration.

One cylinder is misfiring.
Excessive grease in alternator
bearings.
Loose electrical connections.

18.11 Low Lube Oil Pressure.

Insufficient lube oil in crankcase.
Defective lube oil pressure
regulator.
Leaks in lube oil line.
Defective lube oil pump.
Engine requires overhaul.
Clogged lube oil filters.

→ Arrowed lines indicate new or
changed information.

Manager, Product Engineering

Reason for change:

1. To include T.I. on barring the engine over.
2. To include the R-4296 Ear Protector.
3. To make minor changes.