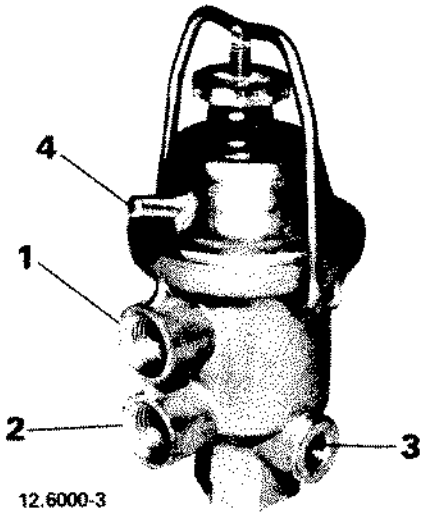
12.6000

## COLD STARTING AID

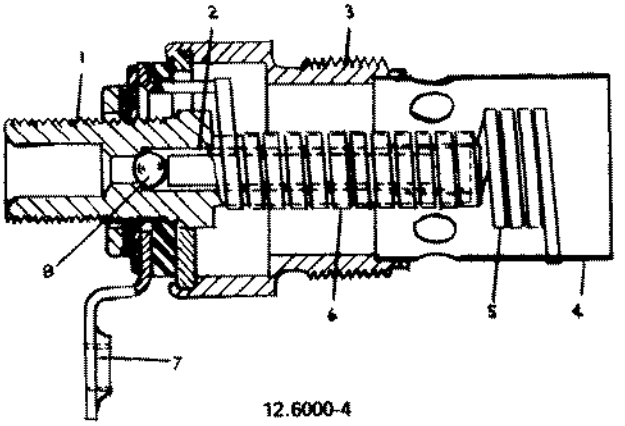
### COLD STARTING AID (DESCRIPTION)

1. The cold starting aid comprises a fuel tank connected by a pipeline to an igniter unit screwed into the intake manifold.
2. The supply tank is mounted on a bracket attached to the inlet manifold.
3. The tank incorporates a supply port (2) from the main fuel filter and a delivery orifice (3) to the igniter. Excess fuel is returned to the fuel tank from the upper port (1). The tank is vented through a pipe (4).



12.6000-3

4. The igniter is the CAV thermostart type 357. This unit comprises a tubular valve body secured to a holder screwed into the inlet manifold, and surrounded by a heater coil, an extension of which forms an igniter coil. The valve body houses a needle, the stem of which holds a ball valve in position against a preformed seat. The valve body and heater coil are enclosed by a perforated shield which projects into the manifold.
5. While the unit is cold, the ball valve is held closed. When the unit is switched on, the heat from the coil expands, opening the ball valve and permitting the entry of fuel. The fuel is vapourised by the heat of the valve body and when the engine is cranked the air is drawn into the manifold, the vapour is ignited by the coil extension and continues to burn, thus heating the inlet air. When the unit is switched off, the flow of air in the manifold cools the valve body rapidly and the valve closes.
6. To check the igniter for leakage, remove the unit from the manifold and clear the flame shield. Reconnect the fuel pipe to the igniter and run engine at a fast idle. Any sign of moistening inside or outside the flame shield indicates a faulty ball valve and therefore the igniter, being a sealed unit, must be renewed.



12.6000-4

1. Valve Body
2. Valve Stem
3. Valve Body Holder
4. Shield
5. Igniter Coil
6. Heater Coil
7. Feed Wire Terminal
8. Ball Valve

7. If the igniter is suspected of leaking only when the inlet manifold is under heavy depression, the fuel pipe should be disconnected from the igniter and blanked off, and the engine run at load. If the exhaust smoke is reduced the igniter is faulty.
8. The igniter must be removed from the engine before carrying out any electrical tests as a fire hazard exists when fuel contacts the glowing igniter element.

### COLD STARTING AID (REMOVAL)

9. To remove the fuel supply tank from its mounting bracket, disconnect the fuel pipes and the mounting bracket bolts from the fuel supply tank, and lift it from the mounting bracket.
10. The thermostart can be removed by disconnecting the terminal and the fuel supply pipe. Then unscrew the thermostart from the inlet manifold.

### COLD STARTING AID (INSPECTION AND OVERHAUL)

11. The thermostart is a sealed unit and servicing is confined to periodic cleaning of the flame shield by brushing of carbon deposit and ensuring all perforations are clear.

### COLD STARTING AID (REFITTING)

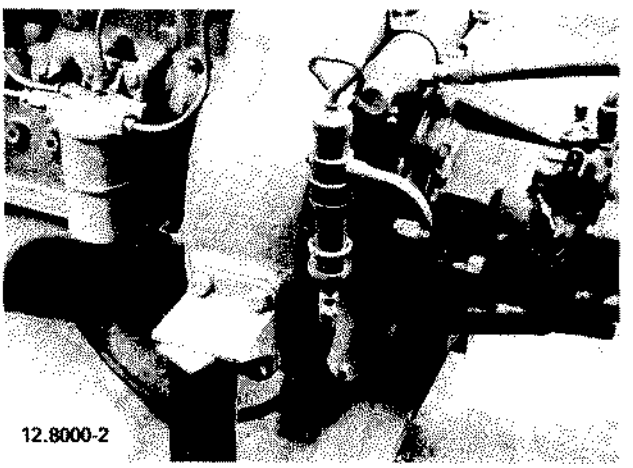
12. To refit the thermostart and fuel supply tank to the inlet manifold, reverse the procedure of the removal operations.
13. To start the engine, the thermostart control switch is switched on for 15 to 20 seconds and then the electric starter engaged. Both starter and thermostart switches should be released when the engine starts. If after 10 seconds cranking time the engine has not started, it is advantageous to stop cranking for 7 to 10 seconds leaving the thermostart energised, and then to resume.
14. When installing the unit, or if it has been standing for a long period, air should be vented from the fuel system by loosening the pipe union at the thermostart until fuel flows freely. Failure to do this may result in damage to the thermostart.

12.8000

## SUMP PUMP

### SUMP PUMP (DESCRIPTION)

1. The sump pump is used mainly on marine applications where the engine is situated in a confined space and where draining the sump in the conventional way would prove extremely difficult.
2. The pump is attached by two clips to a bracket which in turn is attached to the flywheel housing.



12.8000-2

3. The pump is connected to the sump by a hose assembly.

### SUMP PUMP (REMOVAL)

4. Place a tray beneath the pump to catch any surplus oil in the pump or hose assembly.
5. Disconnect the hose from the pump.
6. Remove the clip retaining screws and withdraw the pump from the engine.

### SUMP PUMP (INSPECTION AND OVERHAUL)

7. Servicing of the pump consists of a visual check for signs of damage or cracks and checking the plunger for wear.
8. The hose assembly should be checked for leaks and renewed if necessary.
9. Unscrew the pump cover and withdraw the complete plunger assembly.
10. Inspect the plunger for wear and renew the rubber washer if necessary. Care should be taken when removing the retaining bolt that the steel ball used as a non return valve is not lost.
11. Reassemble the plunger and return the complete plunger assembly into the pump body.

### SUMP PUMP (REFITTING)

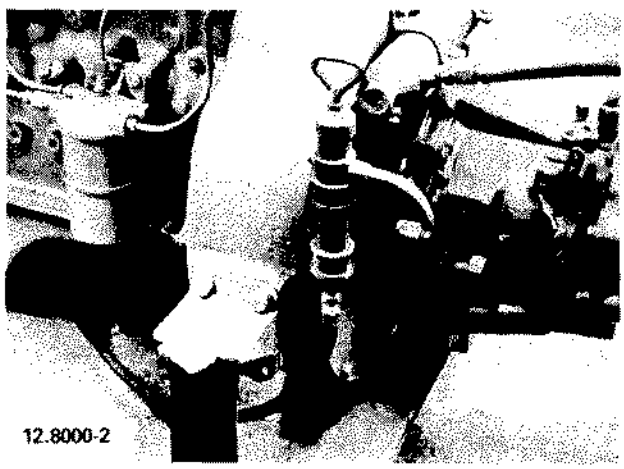
12. Replace the pump with the two retaining clips and tighten the nuts to a torque of 30-37 Nm (22-27 lb ft).
13. Reconnect the oil hose.

12.8000

## SUMP PUMP

### SUMP PUMP (DESCRIPTION)

1. The sump pump is used mainly on marine applications where the engine is situated in a confined space and where draining the sump in the conventional way would prove extremely difficult.
2. The pump is attached by two clips to a bracket which in turn is attached to the flywheel housing.



12.8000-2

3. The pump is connected to the sump by a hose assembly.

### SUMP PUMP (REMOVAL)

4. Place a tray beneath the pump to catch any surplus oil in the pump or hose assembly.
5. Disconnect the hose from the pump.
6. Remove the clip retaining screws and withdraw the pump from the engine.

### SUMP PUMP (INSPECTION AND OVERHAUL)

7. Servicing of the pump consists of a visual check for signs of damage or cracks and checking the plunger for wear.
8. The hose assembly should be checked for leaks and renewed if necessary.
9. Unscrew the pump cover and withdraw the complete plunger assembly.
10. Inspect the plunger for wear and renew the rubber washer if necessary. Care should be taken when removing the retaining bolt that the steel ball used as a non return valve is not lost.
11. Reassemble the plunger and return the complete plunger assembly into the pump body.

### SUMP PUMP (REFITTING)

12. Replace the pump with the two retaining clips and tighten the nuts to a torque of 30-37 Nm (22-27 lb ft).
13. Reconnect the oil hose.

12.0000

## SPECIFICATIONS

Dimensions quoted are the manufacturing limits for new parts except where maximum and minimum permissible figures are given.

**EXHAUSTER**

**Make & Type** ..... Clayton Dewandre REGA 1369A-2
..... Clayton Dewandre REGA 1427A
..... Clayton Dewandre REGA 1427A/1

**BEARINGS**

Fit in End Covers ..... 0.02 mm (0.0008 ins) Clearance to 0.005 mm (0.0002 ins) Interference
- Bearing Diameter 57.125-57.137 mm (2.2490-2.2495 ins)
- Cover Bore Diameter 57.132-57.145 mm (2.2493-2.2498 ins)

Fit on Shaft ..... 0.0025 mm (0.0001 ins) Clearance to 0.015 mm (0.0006 ins) Interference
- Bearing Bore Diameter 22.22-22.23 mm (0.8748-0.8752 ins)
- Shaft Diameter 22.228-22.235 mm (0.8751-0.8754 ins)

**DRIVING GEAR**

Fit on Shaft ..... Zero to 0.038 mm (0.0015 ins) Interference
- Gear Bore Diameter 21.94-21.96 mm (0.8637-0.8647 ins)
- Shaft Diameter 21.96-21.976 mm (0.8647-0.8652 ins)

**EXHAUSTER BODY**

Bore Diameter ..... 115.8367-115.9383 mm (4.5605-4.5645 ins)

**ROTOR SEALING PLATE**

Outside Diameter ..... 115.7732-115.8113 mm (4.5580-4.5595 ins)
Bore Diameter ..... 57.937-58.064 mm (2.281-2.286 ins)
Thickness ..... 6.35-6.60 mm (0.250-0.260 ins)
Spring Ring Gap in Body ..... 0.28-0.48 mm (0.011-0.019 ins)

**SC6 COMPRESSOR**

**Make & Type** ..... Clayton Dewandre, Single Cylinder, Air Cooled

**PISTON RINGS**

Ring Gap in Cylinder Bore ..... 0.051-0.152 mm (0.002-0.006 ins)
Clearance in Piston Groove ..... 0.013-0.064 mm (0.0005-0.0025 ins)

**PISTON**

Clearance in Cylinder Bore ..... 0.051-0.076 mm (0.002-0.003 ins)

**PISTON PIN**

Clearance in Connecting Rod Bush ..... 0.0381 mm (0.0015 ins)
Fit in Piston Bosses ..... Finger Push Fit

**CRANKSHAFT REAR MAIN BEARING**

Clearance on Crankshaft ..... 0.014-0.046 mm (0.00055-0.0018 ins)
Bush Bore Diameter ..... 25.394-25.413 mm (0.99975-1.0005 ins)

## SPECIAL EQUIPMENT SPECIFICATIONS 2

**CONNECTING ROD**
Bearing Clearance on Crankshaft ..... 0.0254-0.0762 mm (0.001-0.003 ins)

**CRANKSHAFT**
Crankpin Diameter ..... 22.1869-22.1996 mm (0.8735-0.8740 ins)
Main Journal Diameter ..... 25.367-25.380 mm (0.9987-0.9992 ins)

**SC9 COMPRESSOR**
**Make and Type** ..... Clayton Dewandre, Single Cylinder, Air Cooled

**PISTON RINGS**
Compression Ring Gap in Cylinder Bore ..... 0.2286-0.3556 mm (0.009-0.014 ins)
Scraper Ring Gap in Cylinder Bore ..... 0.254-0.381 mm (0.010-0.015 ins)
Compression Ring Clearance in Piston Groove ..... 0.0152-0.066 mm (0.0006-0.0026 ins)
Scraper Ring Clearance in Piston Groove ..... 0.0127-0.0635 mm (0.0005-0.0025 ins)

**PISTON**
Clearance in Cylinder Bore ..... 0.1905-0.2286 mm (0.0075-0.0090 ins)

**PISTON PIN**
Clearance in Connecting Rod Bush ..... 0.0051-0.0152 mm (0.0002-0.0006 ins)
Fit in Piston Bosses ..... Finger Push Fit

**CRANKSHAFT MAIN BEARINGS**
Clearance on Crankshaft ..... 0.0191-0.0572 mm (0.00075-0.00225 ins)
Bush Bore Diameter ..... 38.0937-38.1191 mm (1.49975-1.50075 ins)

**CONNECTING ROD**
Bearing Clearance on Crankshaft ..... 0.0127-0.0508 mm (0.0005-0.0020 ins)

**CRANKSHAFT**
Crankpin Diameter ..... 31.7246-31.7373 mm (1.2490-1.2495 ins)
Main Journal Diameter ..... 38.0619-38.0746 mm (1.4985-1.4990 ins)

**SAFETY VALVE**
Pressure Setting ..... 999-1068 KPa (145-155 psi)

**GOVERNOR VALVE**
Cut-Out Pressure ..... 813-841 KPa (118-122 psi)
Cut-In Pressure ..... 703-730 KPa (102-106 psi)

**HYDRAULIC PUMP**
**Make & Type** ..... Hobourn Eaton - Roller Type
Fluid Pressure ..... 5170 KPa (750 psi) minimum
Flow Control Valve Spring — Load at 20.83 mm (0.82 ins) ..... 3.6-4.1 Kg (8-9 lb)
Vanes & Carrier End Clearance ..... 0.05 mm (0.002 ins) maximum
Cam Insert Clearance in Body ..... 0.023-0.064 mm (0.0009-0.0025 ins)

**COLD START AID**
**Make & Type** ..... CAV Thermostart Type 357
Maximum Current Consumption 12v ..... 18 Amperes
Maximum Current Consumption 24v ..... 7.5 Amperes
Fuel Flow Rate Through Thermostart ..... 9 c.c. per minute (nominal)

**TORQUE WRENCH DATA**
Compressor Cylinder Head Nuts ..... 20-22 Nm (15-16 lb ft)
SC6 Compressor Connecting Rod Bolts ..... 5.1-5.4 Nm (3.75-4 lb ft)
SC9 Compressor Connecting Rod Bolts ..... 12-15 Nm (9-11 lb ft)
Hydraulic Pump Cover Screws ..... 19-22 Nm (14-16 lb ft)
Hydraulic Pump Flow Control Valve Cap ..... 41-48 Nm (30-35 lb ft)
Hydraulic Pump Gear Retaining Bolt ..... 20-27 Nm (15-20 lb ft)

| | |
|---|---|
| Fuel Pump Coupling Retaining Nut | 37 Nm (27 lb ft) |
| Timing Gear Shaft Housing | 19 Nm (14 lb ft) |
| Exhauster Retaining Bolts | 20-24 Nm (15-18 lb ft) |
| Sump Pump Retaining Nuts | 30-37 Nm (22-27 lb ft) |

# SECTION 13

## OPERATING INSTRUCTIONS

**Contents**

13.1000

## ENGINE OPERATING INSTRUCTIONS

### BEFORE STARTING A NEW ENGINE

1. Before the engine left the factory the cooling and lubricating systems were drained, and several other operations were carried out to prevent possible corrosion and other troubles occurring during storage or delivery to the customer.
2. Before using the engine for the first time the sequence of operations given below must be carefully followed. Any attempt to run the engine before carrying out this procedure, may result in serious damage.

### AIR CLEANER

3. Fill the air intake oil bath air cleaner to the indicated level, with viscosity S.A.E. 50 engine oil.

### LUBRICATION SYSTEM

4. Fill the engine oil pan to the "Full" mark on the dipstick. See Maintenance page 3 for oil specifications.
5. On six cylinder engines with CAV inline fuel injection pumps a third of a pint (200 cc) of engine oil must be added to the fuel injection pump cambox.
6. On both 220 and 330 cu in engines where a mechanical governor is fitted in conjunction with an inline fuel injection pump, the governor casing must be filled to the level plug opening with engine oil. D.P.A. fuel injection pumps are self lubricating.

### FUEL SYSTEM

7. See that there is fuel in the tank and then air vent the fuel system. This must be done whenever the fuel pipe lines are disconnected. The air venting procedure is as follows.

### ENGINES FITTED WITH A.C. FUEL FILTER & SIMMS "IN-LINE" FUEL INJECTION PUMP

8. Slacken the off centre plug in the filter head and operate the priming lever on the fuel lift pump. Continue operating the lever until fuel, free from air bubbles, is discharged. Tighten the plugs as fuel is being discharged.
9. Slacken the plugs directly above the pump side cover, operate lift pump until fuel free from air is being discharged. Tighten screw as air free fuel is being discharged.

### ENGINES FITTED WITH C.A.V. IN-LINE TYPE FUEL PUMP

10. Slacken the air vent plug at the top of the fuel filter.
11. Operate the priming lever of the fuel feed pump until fuel, free from air bubbles, is discharged from the air vent. Tighten the air vent plug as fuel is being discharged.
12. Similarly, slacken the two air vent plugs immediately above the fuel injection pump inspection cover and operate the priming lever until fuel, free from air bubbles, is being discharged from the air vents. Tighten the air vent plugs as fuel is being discharged.

### ENGINES FITTED WITH C.A.V. DISTRIBUTOR TYPE FUEL INJECTION PUMPS AND HYDRAULIC GOVERNORS

13. Slacken the spare outlet plug on the filter head and operate the fuel lift pump until air free fuel is discharged, tighten plug whilst fuel is still being discharged.
14. Slacken the banjo on the fuel pump which is attached to fuel pipe from filter, operate fuel lift pump until air free fuel is discharged, tighten banjo whilst fuel is still being discharged.
15. Slacken the vent valve fitted on one of the two hydraulic head locking screws, and the vent screw on the top of the governor housing. Operate the fuel lift pump until air free fuel is discharged. Tighten the housing vent screw and then the governor vent screw whilst air free fuel is still being discharged.
16. Slacken any two injector high pressure pipe unions at the injector end. Set the throttle to the fully open position and ensure the stop control is in the "run" position. Turn the engine with the starter motor until fuel free from air flows. Tighten the unions whilst fuel is flowing. There is a possibility that the engine may start and run on 4 cylinders, if it should the throttle should be returned to idle position and injectors tightened as above.

### ENGINES FITTED WITH D.P.A. FUEL INJECTION EQUIPMENT MECHANICAL GOVERNOR

17. Make provision for some spillage of fuel beneath engine and when an instruction calls for air free fuel allow sufficient to bleed to achieve this.
18. Ensure adequate fuel is within fuel tank and stop cock is open.
19. Slacken hexagonal headed bleed (9/16 in AF) on fuel filter head, operate priming lever on fuel lift pump, at the same time ensure any emergency stop fuel shut off is de-activated, and continue to operate priming lever until air free fuel flows from bleed, at which time bleed should be re-tightened.
20. Slacken hexagonal headed bleed screw (5/16 in AF) and operate priming lever until air free fuel is expelled from bleed screw. Re-tighten.

**NOTE.** Care should be exercised that the 5/16 in bleed screw is slackened and not the cam ring locking stud into which the bleed screw is threaded.

21. Slacken banjo pipe attachment, actuate priming lever until air free fuel is expelled and leave slightly slack at this point.
22. Slacken one or more injector pipes at the injector end, and the fuel pump end at No. 4 pressurising valve.
23. With the pipes slackened, set stop lever to run position, deactivate any automatic shut-down system and crank engine until air free fuel is expelled from the slackened pipes. Tighten all pipes except one high pressure pipe to No. 4 injector and its associated pressurising valve and attempt to start engine by cranking, and when engine commences to run re-tighten pressurising valve connection at the fuel pump end and injector end of the No. 4 injector

line. Operate speeder lever to required engine speed and check that no leaks exist in fuel system. Stop engine. Wipe clean any spilt fuel on engine or equipment.

## COOLING SYSTEM

24. Ensure that the coolant drain tap at the rear left hand side of the cylinder block is closed. Fill the cooling system with coolant taking care to vent external connections.
25. Check that the fan belts are tensioned correctly. A deflection of ½ inch (12 mm) should be obtained with a load of 8-10 lbs (3.6-5.4 kg), midway between the fan and alternator pulleys.

## VENTILATING SYSTEM

26. Ensure that the breather pipe hose clips are all secure.

## TRANSMISSIONS

27. If the engine is fitted with a Bedford standard automotive gearbox, it should be filled to the level of the filler plug opening, situated at the rear left hand side of the gearbox.
28. The grade of oil used depends on the ambient temperature, these are listed in table 1.
29. If an Allison transmission is fitted add 9.1 litres (2 imperial pints) of Dexron (R) transmission fluid.
30. Engines fitted with Parsons marine gearboxes should follow the procedure in paragraphs 31 to 34.
31. Parsons gearboxes should be filled with the same grade of oil as used in the engine.
32. The forward and reverse units can be filled through the filler situated on top of the gearbox close to the engine. The level can be checked using the dipstick located on the left hand side of the gearbox.
33. The reduction gearbox has a hexagon plug on top of the gearbox which is used as a filler. The level is checked by removing another hexagon plug on the left side of the rear face, the level being correct when the oil flows from this hole. Replace the plugs before starting engine.
34. Various models of Parsons marine gearboxes are used with varying quantities of oil shown in table 2.
35. On Paragon marine gearboxes the oil should be the same heavy duty oil that is used in the engine. The quantity of oil will vary dependent on the inclination of the marine gear, therefore when filling oil should be brought up to the FULL mark on the bayonet oil gauge.
36. Borg Warner Velvet Drive marine gearboxes should be filled with "Automatic transmission fluid Type "A" Suffix 'A' SAE 10W". The filler is located below the gear change lever on the rear left hand side of the gear case. The oil capacity varies depending on model and inclination angle, therefore the oil should be sufficient to reach the FULL mark on the dipstick.

**TABLE 1.**

| AMBIENT TEMPERATURE | GM SPECIFICATION | OIL GRADE |
|---|---|---|
| ABOVE 0°C (32°F) | 4519-M | SAE 90 |
| 0° to –31°C (32° to –25°F) | 4592-M | SAE 80 |
| BELOW –31°C (–25°F) | — | SAE 80 & 10% KEROSENE |

**TABLE 2**

| TYPE | QUANTITY |
|---|---|
| **'DA'** | |
| Reverse Gear | .568 Litres (1 Pint) |
| 2:1 Reduction Gear | .142 Litres (.25 Pint) |
| 3:1 Reduction Gear | .284 Litres (.5 Pint) |
| **Marinomatic 'DA' Mark III** | |
| Reverse Gear | .710 Litres (1.25 Pints) |
| 2:1 Reduction Gear (2 Wheel or R.H. Rotation) | .142 Litres (.25 Pint) |
| 3:1 Reduction Gear (2 Wheel or R.H. Rotation) | .227 Litres (.4 Pint) |
| **H.G.4 — Mark II** | |
| Hydraulic Reverse Gear | 2.272 Litres (4 Pints) |
| 30/100 and 35/100 2:1 Reduction Gear (Two Wheel) | .355 Litres (.625 Pint) |
| 30/100 and 35/100 2:1 Reduction Gear (Three Wheel) | .497 Litres (.875 Pint) |
| 30/100 and 35/100 3:1 Reduction Gear (Two Wheel) | .426 Litres (.75 Pint) |
| 30/100 and 35/100 3:1 Reduction Gear (Three Wheel) | .568 Litres (1 Pint) |
| 4/100 2:1 Reduction Gear (Two Wheel) | .426 Litres (.75 Pint) |
| 4/100 2:1 Reduction Gear (Three Wheel) | .568 Litres (1 Pint) |
| 4/100 3:1 Reduction Gear (Two Wheel) | .710 Litres (1.25 Pints) |
| 4/100 3:1 Reduction Gear (Three Wheel) | .825 Litres (1.5 Pints) |

## STARTING THE ENGINE

37. The method for starting the engine is dependent on the ambient temperature, and the type of fuel injection pump fitted.

### TEMPERATURES ABOVE 0°C (32°F) — INLINE FUEL INJECTION PUMP

38. Switch on.
39. Firmly operate the starter control and engine should start. It may sometimes be necessary, especially during cold weather, to keep the engine speed control almost fully open for a few moments after the engine starts, do not exceed 30 seconds. If engine does not start allow 60 seconds rest and attempt to start again. If after 4 attempts the engine will not run find out why.

### TEMPERATURES BETWEEN —8.4° To 0°C (15° To 32°F) — INLINE FUEL INJECTION PUMP

40. Place the throttle lever in the maximum position.
41. Set the excess fuel device on the injection pump. This device allows more fuel to be made available to the engine. To operate it on the 6 cylinder engine, pull the stop control bodily outwards. With the 4 cylinder engine push the shaft which protrudes through the stop control lever right up to the face of the lever. In each case this will set and hold the pump in the excess fuel position until the engine starts.
42. Switch on.
43. Operate the starter control and the engine should start. Keep the engine speed control almost fully open for a few moments after the engine starts.

### TEMPERATURES BELOW —8.4°C (15°F) — INLINE FUEL INJECTION PUMP

44. When the engine is used in a territory where the night temperature frequently falls below minus 8.4°C (15°F) a "Thermostart" heater should be fitted to the intake manifold.
45. Place the throttle lever in the maximum position.
46. Set the injection pump excess fuel device (see paragraph 41 above).
47. Switch on.
48. Firmly press in and hold depressed the "Thermostart" heater button.
49. After 10 seconds, with the throttle almost fully open, operate the starter control, still keeping the "Thermostart" heater button depressed. After a few seconds motoring the engine should start. Release both starter control and "Thermostart" button and maintain a reasonably high engine speed for a few moments.

### TEMPERATURES ABOVE 0°C (32°F) — D.P.A. FUEL INJECTION PUMP

50. On engines fitted with distributor type fuel pumps no excess fuel device is fitted as the fuel pump has a form of advance and retard mechanism built into it.
51. The starting procedure for temperatures above freezing is the same as for inline fuel pumps.

### TEMPERATURES BELOW 0°C (32°F) — D.P.A. FUEL INJECTION PUMP

52. The "Thermostart" control switch, which is spring loaded to the off position, is switched on for 15 to 20 seconds, and then the starter operated. Both starter and thermostart switches should be released when the engine starts. If after 10 seconds cranking time the engine has not started it is advantageous to stop cranking for 10 seconds leaving the Thermostart energised, and then resume cranking.

## RESTARTING A WARM ENGINE

53. When the engine is warm it can be restarted by switching on and then operating the starter control. This applies to all types of injection pumps, fitted on G.M. Bedford engines.
54. As soon as the engine is running, check that the oil pressure is present either by observing the indicator light or the oil pressure gauge.
55. **WARNING.** If the engine is equipped with a "Thermostart" cold starting aid do not use ether start aid. Ether applied while thermostart is in operation could cause a severe explosion.
56. Allow the engine to warm up thoroughly and then reset accurately the valve clearances to .013 in, with the engine running (see paragraph 3 of page 1 of engine tune-up section (14.0000).
57. Check engine for fuel, oil and coolant leaks, rectifying as necessary.

## RUNNING IN

58. The engine will run in under 75% load conditions more effectively than by light operation, however it is important to ensure that operating temperatures of 71°-77°C (160°-170°F) are reached before applying full load. During the first 30 hours of engine life, full load should only be applied for short periods up to 15 minutes if operating circumstances permit.
59. When a period of full load has been run the engine should run at light or no load at 1000-1500 RPM for 5 minutes before shutting down, this will allow high temperature parts of the engine to return to normal without distortion.
60. Do not idle for long periods, if engine is not required shut it down and heat will be retained longer than at idle.
61. After the first 20 hours of operation, the engine oil should be drained and refilled with an approved lubricant (see page 3 of routine maintenance).

## STOPPING THE ENGINE

62. To stop the engine move the engine stop control to the "stop" position, and hold it in this position until the engine stops. See that the control is returned to the running position after the engine has stopped.

13.1100

## OPERATING INSTRUCTIONS — A.C. POWER GENERATOR SET

1. These instructions cover the fundamental procedures for operating an alternating current power generator set. The operator should read these instructions before attempting to operate the unit.

### PREPARATION FOR STARTING

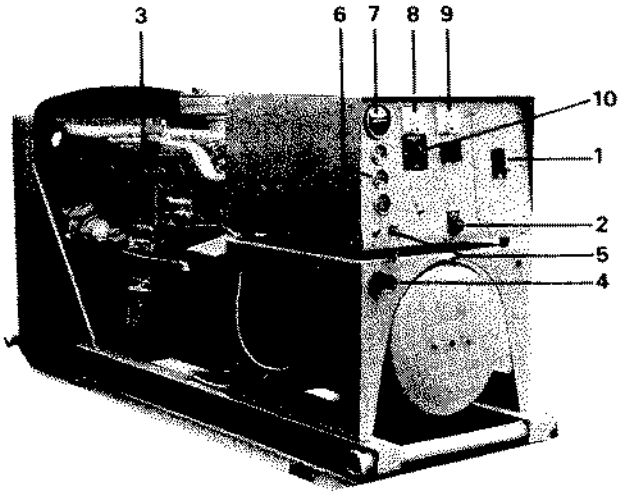
2. Before attempting to start a new or overhauled engine or an engine which has been in storage, perform all of the operations listed under "before starting a new engine" in section 13.1000. Before a routine start, see Daily operations in the lubrication and preventive maintenance chart in section 15.1000.
3. In addition to the Engine operating instructions, the following instructions also apply when operating an alternating current power generator set.
4. Before applying the set to a job it is essential to ensure that the correct frequency will be provided by the engine governor so that the engine can operate satisfactorily at synchronous speed, i.e.,

1500 RPM = 50 Hz, 1800 RPM = 60 Hz.

5. It is also essential that the terminal linkage within the cabinet be connected to provide the correct voltage, since the machine stator has star windings with centre taps, which permit the windings to be individually run in series or parallel.
6. Before connecting driven equipment or buss bars it is essential to ensure that phase rotation is correct, normally these are numbered 1, 2 & 3, or in colour coding, red, yellow, or white and blue. The correct phase rotation is essential if motors connected are to be driven in the correct direction, also it is the first essential if the set is to be paralleled with any other set.
7. For instructions on changing frequency or voltage see page 2 of control panel section (7.6000).
8. If is is suspected that the unit has been subjected to damp, the insulation resistance of the main stator winding should be checked and if this is less than 1M OHMS, the equipment should be slowly dried out until this insulation resistance is achieved.
9. The other windings within the equipment operate at low voltage, therefore, it should not normally be necessary to check the insulation resistance of these.
10. Check the earthing arrangements and ensure that the neutral lead is properly attached.
11. All annotations refer to 13.1100-11.
12. Place main breaker switch, item (1) in off position.
13. Turn the voltage regulator control, item (2) to its minimum position, fully anticlockwise.

### STARTING

14. Set engine governor stop control, item (3) to 'run' position.
15. Set throttle control, item (4) to midway position. Depress knob in centre of control, pull outer knob to desired position and release centre. Fine adjustment can be made by turning knob anticlockwise to increase speed and clockwise to decrease speed.




13.1100-11

1. Main Breaker
2. Regulator Control
3. Engine/Stop/Run
4. Engine Speed Control
5. Engine Start Switch
6. Oil Pressure Gauge
7. Frequency Meter
8. Voltmeter
9. Ammeter
10. Ammeter Selector Switch

16. Operate key switch, item (5) to crank engine and when it fires and runs, check oil pressure, item (6) is present.
17. If this is the initial start for the unit, leave engine operating at approximately 1500 RPM for a few moments and check for coolant, lube oil or fuel oil leaks. AT NO TIME MUST THE ENGINE BE RUN AT IDLE SPEED.
18. Run engine to synchronous speed as indicated on frequency tachometer, item (7) and if time permits allow speed to settle to remove the chill from the cooling system.

### PREPARING UNIT FOR LOAD

19. Set voltage 2% over required load voltage and frequency at 2 cycles per second above that required, if it is intended to take over more than ¾ load on switching in, proportionally lower settings for ½ and ¼ load and exactly on frequency and voltage for loads of less than ¼.
20. Ensure that no personnel are engaged on lines and switch main breaker, item (1) to 'on' position, check voltage on voltmeter (item 8) and frequency on frequency meter (item 7) and adjust as necessary. The load in amperes should be checked by reference to the ammeter (item 9) and each phase should be checked in turn by use of the selector (item 10).
21. Further slight adjustment may be required when engine alternator and regulator have achieved normal working temperature.

## PARALLELING

22. Successful parallel operation can only be achieved if all of the engine governors are of the same characteristic, and it is advantageous to utilize sets of similar alternators and voltage regulators.
23. Check phase rotation of buss to which set is to be connected.
24. Follow starting instructions in paragraphs 12 to 18 inclusive.
25. Switch all units to parallel run.
26. Close synchronising lamp switches.
27. Check frequency of units running on load at 50 or 60 Hz, whichever is applicable.
28. Adjust voltage on coming set to correct level.
29. Observe synchronising lamps alternating bright and dim in rotating pattern, adjust engine governor control to slow the rate of change to minimum and when a steady period of darkness exceeding ten seconds has been repeated three times place hand on breaker, item (1) and at commencement of next dark period on upper lamp count five seconds and close breaker.
30. Switch off synchronising lamps.
31. Adjust engine governor control, item (4) to indicate each set providing proportional share of load by ammeter, item (9).

**WARNING.** On no account should the voltage regulator control be varied whilst parallel operating sets.

## STOPPING

32. The procedure for stopping a power generator unit or taking a unit out of parallel is as follows:
33. Open main breaker, item (1).
34. Stop engines with stop control, item (3).

13.2000

## ENGINE OPERATING CONDITIONS

1. The engine operating charts are included as an aid for engine operation and trouble shooting. Any variations from the conditions as listed may indicate an abnormal situation in need of correction. Make sure that the readings represented are true values, and that instruments are accurate, before attempting to make corrections to the engine.

2. **NOTE 1.** Exhaust back pressures represent the restriction of flow in the EXTERNAL EXHAUST SYSTEM and should be measured at the outlet of the engine exhaust manifold. Pressures are read in inches of mercury.

3. **NOTE 2.** Restriction to air flow reduces the power output and life expectancy of any engine and therefore limits are set on the amount of restriction the air intake system may create.

4. **NOTE 3.** Fuel consumption figures are for fuel at specific gravity of 0.838.

**220 cu in ENGINES**

| | IDLE SPEED 550 RPM | 1000 RPM | 1500 RPM | 2000 RPM | 2600 RPM |
|---|---|---|---|---|---|
| **Lubrication System** | | | | | |
| Oil Pressure (P.S.I.) | | | | | |
| Normal | 15 (104 kpa) | | | 50 (375 kpa) | |
| Minimum (Safe Operation) | | | | 25 (172 kpa) | |
| Oil Temperature (°C) | | | | | |
| Normal | 93°-107° (200°-225°F) | 93°-107° (200°-225°F) | 93°-107° (200°-225°F) | 93°-107° (200°-225°F) | 93°-107° (200°-225°F) |
| **Air System** | | | | | |
| Air Inlet Restriction (Inches of Water) | | | | | |
| Clean Air Cleaner (Maximum) | | 2.3 (58 mm) | 6.0 (152 mm) | 9.6 (244 mm) | 12.0 (305 mm) |
| Dirty Air Cleaner (Maximum) | | 4.5 (114 mm) | 9.5 (241 mm) | 14.5 (368 mm) | 20.5 (521 mm) |
| Crankcase Pressure (Inches of Water) | | | | | |
| Up to Serial No. P&I 10932 | | 0.5 (13 mm) | 0.8 (20 mm) | 1.1 (28 mm) | 1.3 (33 mm) |
| From Serial No. P&I 10933 | | 2.5 (63.5 mm) | 5.0 (127 mm) | 6.0 (152 mm) | 6.0 (152 mm) |
| Exhaust Back Pressure (Inches of Mercury) | | 0.9 (23 mm) max | 2.0 (51 mm) max | 3.3 (84 mm) max | 6.0 (152 mm) max |
| **Fuel System** | | | | | |
| Fuel Consumption (Imp Gallons Per Hour) | | | | | 2.8 at 65 B.H.P. |
| Injector Delivery Pressure | 175 Atmospheres | 175 Atmospheres | 175 Atmospheres | 175 Atmospheres | 175 Atmospheres |
| **Cooling System** | | | | | |
| Coolant Temperature (°C) | | | | | |
| Normal | 93° (205°F) | 93° (205°F) | 93° (205°F) | 93° (205°F) | 93° (205°F) |
| **Compression** | | | | | |
| Compression Pressure (P.S.I.) | | | | | |
| Minimum at 68°F (20°C) | 450 | | | | |

## ENGINE OPERATING CONDITIONS 2

### 330 cu in ENGINES

| | IDLE SPEED 550 RPM | 1000 RPM | 1500 RPM | 2000 RPM | 2600 RPM |
|---|---|---|---|---|---|
| **Lubrication System** | | | | | |
| Oil Pressure (P.S.I.) | | | | | |
| Normal | 15 (104 kpa) | | | 50 (375 kpa) | |
| Minimum (Safe Operation) | | | | 25 (172 kpa) | |
| Oil Temperature (°C) | | | | | |
| Normal | 93°-107° (200°-225°F) | 93°-107° (200°-225°F) | 93°-107° (200°-225°F) | 93°-107° (200°-225°F) | 93°-107° (200°-225°F) |
| **Air System** | | | | | |
| Air Inlet Restriction (Inches of Water) | | | | | |
| Clean Air Cleaner (Maximum) | | 2.8 (71 mm) | 5.6 (142 mm) | 9.6 (244 mm) | 16.5 (419 mm) |
| Dirty Air Cleaner (Maximum) | | 5.5 (140 mm) | 10.5 (267 mm) | 15.2 (386 mm) | 22.5 (571 mm) |
| Crankcase Pressure (Inches of Water) | | | | | |
| Up to Serial No. P&I 7598 | | 0.3 (9 mm) | 0.9 (23 mm) | 1.6 (41 mm) | 3.0 (76 mm) |
| From Serial No. P&I 7599 | | 2.5 (63.5 mm) | 5.0 (127 mm) | 6.0 (152 mm) | 6.0 (152 mm) |
| Exhaust Back Pressure (Inches of Mercury) | | 0.5 (13 mm) | 1.3 (33 mm) | 2.2 (56 mm) | 3.75 (95 mm) |
| **Fuel System** | | | | | |
| Fuel Consumption (Imp Gallons Per Hour) | | | | | 2.8 at 65 B.H.P. |
| Injector Delivery Pressure | 175 Atmospheres | 175 Atmospheres | 175 Atmospheres | 175 Atmospheres | 175 Atmospheres |
| **Cooling System** | | | | | |
| Coolant Temperature (°C) | | | | | |
| Normal | 93° (205°F) | 93° (205°F) | 93° (205°F) | 93° (205°F) | 93° (205°F) |
| **Compression** | | | | | |
| Compression Pressure (P.S.I.) | | | | | |
| Minimum at 68°F (20°C) | 450 | | | | |

## 330T cu in ENGINES

| | IDLE SPEED 550 RPM | 1000 RPM | 1500 RPM | 2000 RPM | 2600 RPM |
|---|---|---|---|---|---|
| **Lubrication System** | | | | | |
| Oil Pressure (P.S.I.) | | | | | |
| Normal | 15 (104 kpa) | | | 50 (375 kpa) | |
| Minimum (Safe Operation) | | | | 25 (172 kpa) | |
| Oil Temperature (°C) | | | | | |
| Normal | 93°-107° (200°-225°F) | 93°-107° (200°-225°F) | 93°-107° (200°-225°F) | 93°-107° (200°-225°F) | 93°-107° (200°-225°F) |
| **Air System** | | | | | |
| Air Inlet Restriction (Inches of Water) | | | | | |
| Clean Air Cleaner (Maximum) | | 3.5 (89 mm) | 5.8 (147 mm) | 8.5 (216 mm) | 12.7 (323 mm) |
| Dirty Air Cleaner (Maximum) | | 5.5 (140 mm) | 10.5 (267 mm) | 15.2 (386 mm) | 22.5 (571 mm) |
| Crankcase Pressure (Inches of Water) | | 0.3 (9 mm) | 0.9 (23 mm) | 1.6 (41 mm) | 3.0 (76 mm) |
| Exhaust Back Pressure (Inches of Mercury) | | 0.5 (13 mm) | 0.75 (19 mm) | 1.1 (28 mm) | 1.6 (41 mm) |
| **Fuel System** | | | | | |
| Fuel Consumption (Imp Gallons Per Hour) | | | | | 2.8 at 65 B.H.P. |
| Injector Delivery Pressure | 175 Atmospheres | 175 Atmospheres | 175 Atmospheres | 175 Atmospheres | 175 Atmospheres |
| **Cooling System** | | | | | |
| Coolant Temperature (°C) | | | | | |
| Normal | 93° (205°F) | 93° (205°F) | 93° (205°F) | 93° (205°F) | 93° (205°F) |
| **Compression** | | | | | |
| Compression Pressure (P.S.I.) | | | | | |
| Minimum at 68°F (20°C) | 450 | | | | |

13.2100

## ENGINE RUN-IN INSTRUCTIONS

1. Following a complete overhaul or any major repair job involving the installation of piston rings, pistons or bearings, the engine should be "run-in" on a dynamometer prior to release to service.
2. The dynamometer is a device for applying specific loads to an engine. It permits the serviceman to physically and visually inspect and check the engine while it is operating. It is also an excellent method of detecting improper tune up, misfiring injectors, low compression and other malfunctions, and may save an engine from damage at a later date.
3. The operating temperatures within the engine affect the operating clearances between the various moving parts of the engine and determines to a degree how the parts will wear. Normal coolant temperature, 77°-96°C (170°-205°F) should be maintained throughout the run-in.
4. The rate of water circulation through the engine on a dynamometer should be sufficient to avoid having the engine outlet water temperature more than 10° higher than the water inlet temperature.
5. A thermostat is used in the engine to control the coolant flow. Therefore, be sure it is in place and fully operative or the engine will overheat during the run-in.
6. The run-in schedules are shown on pages 2, 3 and 4.

### DYNAMOMETER TEST AND RUN-IN PROCEDURES

7. The function of the dynamometer is to absorb and measure the engine output. Its basic components are a frame, engine mounts, the absorption unit, a heat exchanger and a torque loading and measuring device.
8. The engine is connected through a universal coupling to the absorption unit. The load on the engine may be varied from zero to maximum by decreasing or increasing the resistance in the unit.
9. The power absorbed is generally measured in torque (Nm or lb-ft) on a suitable scale. The value for a given engine speed will show the brake horsepower developed in the engine by the following formula.

$$BHP = (T \times RPM)/5250$$

where BHP = brake horsepower, T = torque and RPM = revolutions per minute.
10. Some dynamometers indicate direct brake horsepower readings. Therefore, the use of the formula is not required when using these units.
11. During the actual operation, all data taken should be recorded immediately onto an ENGINE TEST SCHEDULE (see sample on page 6).
12. Certain instrumentation is necessary so that data required to complete the engine test schedule may be obtained. The following list contains both the minimum amount of instruments and the proper location of the fittings on the engine so that the readings represent a true evaluation of engine conditions.

(a) Oil pressure gauge installed into the top of oil filter.
(b) Oil temperature gauge installed in the oil pan, or thermometer installed in the dipstick hole in the oil pan.
(c) Water temperature gauge installed in the thermostat housing or water outlet.
(d) Adaptor for connecting a pressure gauge or water manometer to the crankcase.
(e) Adaptor for connecting a pressure gauge or mercury manometer to the exhaust manifold at the flange.
(f) Adaptor for connecting a fuel pressure gauge to the fuel inlet passage.
(g) Adaptor for connecting a pressure gauge or mercury manometer to the turbocharger, if fitted.

13. In some cases, gauges reading in pounds per square inch are used for determining pressures while standard characteristics are given in inches of mercury or inches of water. It is important that the scale of these gauges are of a low range and finely divided if accuracy is desired. This is especially true of a gauge reading in PSI, the reading of which is to be converted into inches of water.
The following conversion factors may be helpful:

Inches of Water = PSI × 27.7 in
Inches of Mercury = PSI × 2.04 in

14. Before starting the run-in or starting the engine for any reason following an overhaul, it is of extreme importance to observe the instructions on starting in paragraphs 15 to 19 listed below.
15. Fill the lubrication system as outlined in section 13.1000.
16. Prime the fuel system as outlined in section 13.1000.
17. A preliminary valve clearance adjustment must be made, this is outlined in section 14.1000.
18. Check the injectors and governor timing as outlined in section 14.1000.
19. On turbocharged engines, remove the oil supply line and add clean engine oil to the oil inlet to ensure pre-lubrication of the turbocharger. Reconnect the oil lines and idle engine for at least one minute after starting and before increasing speed.
20. After performing these preliminary steps, ensure all water valves, fuel valves, etc. are open. Also inspect the exhaust system to ensure it is properly connected to the engine.
21. Start the engine with minimum dynamometer resistance.
22. The operator should be observant at all times so that any malfunction which may develop will be detected. Minor difficulties should be detected and corrected so that a major problem will not develop.
23. After the engine starts, if using a water brake type dynamometer, allow sufficient water, by means of the control loading valves, into the dynamometer absorption unit to show a reading of approximately 5 lb ft on the torque gauge (or 10-15 HP on a horsepower gauge). This is necessary, on some units, to lubricate the absorption unit seals and to protect them from damage.
24. Set the engine throttle at idle speed, check the lubricating oil pressure and check all connections to be sure there are no leaks.
25. Refer to the standard run-in schedule and the engine test schedule and follow the tests and run-in quoted.

## INTERLACE RUN-IN SCHEDULE 220/330 cu in 1500/1600/1700 RPM FULL LOAD SPEED

| RPM | TIME (Mins) | TOTAL TIME (Hrs/Mins) | 220 | | 330 | |
|---|---|---|---|---|---|---|
| | | | LBS | BHP | LBS | BHP |
| 1000 | 15 | 15 | 2.65 | 13.25 | 4.4 | 22.0 |
| 1200 | 6 | 21 | 2.71 | 16.25 | 4.33 | 26.0 |
| 1400 | 3 | 24 | 2.83 | 19.8 | 4.43 | 31.0 |
| Idle | 1 | 25 | 0 | 0 | 0 | 0 |
| 1000 | 6 | 31 | F.L. | F.L. | F.L. | F.L. |
| 1400 | 3 | 34 | 2.83 | 19.8 | 4.43 | 31.0 |
| Idle | 1 | 35 | 0 | 0 | 0 | 0 |
| 1500 | 3 | 38 | 4.3 | 32.25 | 6.5 | 48.8 |
| Idle | 1 | 39 | 0 | 0 | 0 | 0 |
| 1200 | 3 | 42 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 43 | 0 | 0 | 0 | 0 |
| 1500 | 3 | 46 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 47 | 0 | 0 | 0 | 0 |
| 1200 | 6 | 53 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 54 | 0 | 0 | 0 | 0 |
| 1500 | 6 | 1.00 | F.L. | F.L. | F.L. | F.L. |

## INTERLACE RUN-IN SCHEDULE 220/330 cu in 1800/1900 RPM FULL LOAD SPEED

| RPM | TIME (Mins) | TOTAL TIME (Hrs/Mins) | 220 | | 330 | |
|---|---|---|---|---|---|---|
| | | | LBS | BHP | LBS | BHP |
| 1000 | 15 | 15 | 2.65 | 13.25 | 4.4 | 22.0 |
| 1400 | 6 | 21 | 2.86 | 20.0 | 4.36 | 30.5 |
| 1800 | 3 | 24 | 2.89 | 26 | 4.17 | 37.5 |
| Idle | 1 | 25 | 0 | 0 | 0 | 0 |
| 1000 | 6 | 31 | F.L. | F.L. | F.L. | F.L. |
| 1800 | 3 | 34 | 2.89 | 26 | 4.17 | 37.5 |
| Idle | 1 | 35 | 0 | 0 | 0 | 0 |
| 1500 | 3 | 38 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 39 | 0 | 0 | 0 | 0 |
| 1500 | 3 | 42 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 43 | 0 | 0 | 0 | 0 |
| 1600 | 6 | 49 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 50 | 0 | 0 | 0 | 0 |
| 1800 | 3 | 53 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 54 | 0 | 0 | 0 | 0 |
| 1600 | 6 | 1.00 | F.L. | F.L. | F.L. | F.L. |

**INTERLACE RUN-IN SCHEDULE 220/330 cu in**
**2000/2100 RPM FULL LOAD SPEED**

| RPM | TIME (Mins) | TOTAL TIME (Hrs/Mins) | 220 | | 330 | |
|---|---|---|---|---|---|---|
| | | | LBS | BHP | LBS | BHP |
| 1000 | 15 | 15 | 2.65 | 13.25 | 4.4 | 22.0 |
| 1600 | 6 | 21 | 2.91 | 23.25 | 4.25 | 34.0 |
| 2000 | 3 | 24 | 2.85 | 28.5 | 4.1 | 41.0 |
| Idle | 1 | 25 | 0 | 0 | 0 | 0 |
| 1000 | 6 | 31 | F.L. | F.L. | F.L. | F.L. |
| 2000 | 3 | 34 | 2.85 | 28.5 | 4.1 | 41.0 |
| Idle | 1 | 35 | 0 | 0 | 0 | 0 |
| 1500 | 3 | 38 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 39 | 0 | 0 | 0 | 0 |
| 2000 | 3 | 42 | 2.85 | 28.5 | 4.1 | 41.0 |
| Idle | 1 | 43 | 0 | 0 | 0 | 0 |
| 1500 | 6 | 49 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 50 | 0 | 0 | 0 | 0 |
| 2000 | 3 | 53 | 4.28 | 42.75 | 6.15 | 61.5 |
| Idle | 1 | 54 | 0 | 0 | 0 | 0 |
| 1800 | 6 | 1.00 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 1.01 | 0 | 0 | 0 | 0 |
| 2000 | 3 | 1.04 | 4.28 | 42.75 | 6.15 | 61.5 |
| 1800 | 6 | 1.10 | F.L. | F.L. | F.L. | F.L. |

**INTERLACE RUN-IN SCHEDULE 220/330 cu in**
**2200/2300 RPM FULL LOAD SPEED**

| RPM | TIME (Mins) | TOTAL TIME (Hrs/Mins) | 220 | | 330 | |
|---|---|---|---|---|---|---|
| | | | LBS | BHP | LBS | BHP |
| 1000 | 15 | 15 | 2.65 | 13.25 | 4.4 | 22.0 |
| 1600 | 6 | 21 | 2.91 | 23.25 | 4.25 | 34.0 |
| 2000 | 3 | 24 | 2.85 | 28.5 | 4.1 | 41.0 |
| Idle | 1 | 25 | 0 | 0 | 0 | 0 |
| 1000 | 6 | 31 | F.L. | F.L. | F.L. | F.L. |
| 2000 | 3 | 34 | 2.85 | 28.5 | 4.1 | 41.0 |
| Idle | 1 | 35 | 0 | 0 | 0 | 0 |
| 1500 | 3 | 38 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 39 | 0 | 0 | 0 | 0 |
| 2000 | 3 | 42 | 2.85 | 28.5 | 4.1 | 41.0 |
| Idle | 1 | 43 | 0 | 0 | 0 | 0 |
| 1500 | 6 | 49 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 50 | 0 | 0 | 0 | 0 |
| 2000 | 3 | 53 | 2.85 | 28.5 | 4.1 | 41.0 |
| Idle | 1 | 54 | 0 | 0 | 0 | 0 |
| 1800 | 6 | 1.00 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 1.01 | 0 | 0 | 0 | 0 |
| 2200 | 3 | 1.04 | 2.8 | 30.75 | 4.05 | 44.5 |
| 2000 | 6 | 1.10 | F.L. | F.L. | F.L. | F.L. |

## INTERLACE RUN-IN SCHEDULE 220/330 cu in 2400/2500 RPM FULL LOAD SPEED

| RPM | TIME (Mins) | TOTAL TIME (Hrs/Mins) | 220 | | 330 | |
|---|---|---|---|---|---|---|
| | | | LBS | BHP | LBS | BHP |
| 1000 | 15 | 15 | 2.65 | 13.25 | 4.4 | 22.0 |
| 1600 | 6 | 21 | 2.91 | 23.25 | 4.25 | 34.0 |
| 2000 | 3 | 24 | 2.85 | 28.5 | 4.1 | 41.0 |
| Idle | 1 | 25 | 0 | 0 | 0 | 0 |
| 1000 | 6 | 31 | F.L. | F.L. | F.L. | F.L. |
| 2000 | 3 | 34 | 2.85 | 28.5 | 4.1 | 41.0 |
| Idle | 1 | 35 | 0 | 0 | 0 | 0 |
| 1500 | 3 | 38 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 39 | 0 | 0 | 0 | 0 |
| 2200 | 3 | 42 | 2.8 | 30.75 | 4.05 | 44.5 |
| Idle | 1 | 43 | 0 | 0 | 0 | 0 |
| 1500 | 6 | 49 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 50 | 0 | 0 | 0 | 0 |
| 2400 | 3 | 53 | 2.71 | 32.5 | 4.0 | 48.0 |
| Idle | 1 | 54 | 0 | 0 | 0 | 0 |
| 1800 | 6 | 1.00 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 1.01 | 0 | 0 | 0 | 0 |
| 2400 | 3 | 1.04 | 2.71 | 32.5 | 4.0 | 48.0 |
| 2200 | 6 | 1.10 | F.L. | F.L. | F.L. | F.L. |

## INTERLACE RUN-IN SCHEDULE 220/330 cu in 2600 RPM FULL LOAD SPEED

| RPM | TIME (Mins) | TOTAL TIME (Hrs/Mins) | 220 | | 330 | |
|---|---|---|---|---|---|---|
| | | | LBS | BHP | LBS | BHP |
| 1000 | 15 | 15 | 2.65 | 13.25 | 4.4 | 22.0 |
| 1600 | 6 | 21 | 2.91 | 23.25 | 4.25 | 34.0 |
| 2000 | 3 | 24 | 2.85 | 28.5 | 4.1 | 41.0 |
| Idle | 1 | 25 | 0 | 0 | 0 | 0 |
| 1000 | 6 | 31 | F.L. | F.L. | F.L. | F.L. |
| 2000 | 3 | 34 | 2.85 | 28.5 | 4.1 | 41.0 |
| Idle | 1 | 35 | 0 | 0 | 0 | 0 |
| 1500 | 3 | 38 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 39 | 0 | 0 | 0 | 0 |
| 2400 | 3 | 42 | 2.71 | 32.5 | 4.0 | 48.0 |
| Idle | 1 | 43 | 0 | 0 | 0 | 0 |
| 1500 | 6 | 49 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 50 | 0 | 0 | 0 | 0 |
| 2600 | 3 | 53 | 2.62 | 34.0 | 3.96 | 51.5 |
| Idle | 1 | 54 | 0 | 0 | 0 | 0 |
| 2000 | 6 | 1.00 | F.L. | F.L. | F.L. | F.L. |
| Idle | 1 | 1.01 | 0 | 0 | 0 | 0 |
| 2600 | 3 | 1.04 | 2.62 | 34.0 | 3.96 | 51.5 |
| 2400 | 6 | 1.10 | F.L. | F.L. | F.L. | F.L. |

## INTERLACE RUN-IN SCHEDULE
## 330 cu in TURBOCHARGED ENGINES
## 2600 RPM

| RPM | TIME (Mins) | TOTAL TIME (Hours/Mins) | LBS | BHP |
|---|---|---|---|---|
| 1000 | 15 | 15 | 4.4 | 22.0 |
| 1600 | 6 | 21 | 4.25 | 34.0 |
| 2000 | 3 | 24 | 4.1 | 41.0 |
| Idle | 1 | 25 | 0 | 0 |
| 1000 | 6 | 31 | 8.4 | 42.0 |
| 2000 | 3 | 34 | 4.1 | 41.0 |
| Idle | 1 | 35 | 0 | 0 |
| 1500 | 3 | 38 | 8.9 | 67.0 |
| Idle | 1 | 39 | 0 | 0 |
| 2400 | 3 | 42 | 4.0 | 48.0 |
| Idle | 1 | 43 | 0 | 0 |
| 1500 | 6 | 49 | 8.9 | 67.0 |
| Idle | 1 | 50 | 0 | 0 |
| 2600 | 3 | 53 | 3.96 | 51.5 |
| Idle | 1 | 54 | 0 | 0 |
| 2000 | 6 | 1.00 | 8.7 | 87.0 |
| Idle | 1 | 1.01 | 0 | 0 |
| 2600 | 3 | 1.04 | 3.96 | 51.5 |
| Idle | 1 | 1.05 | 0 | 0 |
| 1500 | 6 | 1.11 | F.L. | F.L. |
| Idle | 1 | 1.12 | 0 | 0 |
| 2600 | 3 | 1.15 | 7.0 | 91.0 |
| Idle | 1 | 1.16 | 0 | 0 |
| 2000 | 6 | 1.22 | F.L. | F.L. |
| Idle | 1 | 1.23 | 0 | 0 |
| 2600 | 3 | 1.26 | 7.0 | 91.0 |
| 2400 | 4 | 1.30 | F.L. | F.L. |

## DETROIT DIESEL ALLISON DIVISION OF GENERAL MOTORS LIMITED

## DIESEL ENGINE TEST SCHEDULE

ENGINE MODEL: T.S. NO:

FUEL PUMP: D.P.A. ☐ INLINE ☐ GOVERNOR TYPE: MECH. ☐ HYDRAULIC ☐ PNEUMATIC ☐

EQUIPMENT AND FITTINGS AS TESTED:

FAN ON ☐ OFF ☐ SILENCER TEST BED ☐ SPECIAL ☐ AIR CLEANER ON ☐ OFF ☐

RADIATOR ON ☐ OFF ☐ GEARBOX ON ☐ OFF ☐

OTHER AUXILIARIES TO BE FITTED FOR TEST:

RUN IN SCHEDULE: SEE SHEET 2 [SEE NOTE A(ITEM 1)]

1. RECORD: TEST CELL TEMP. AND BAROMETER
2. ENGINE WATER TEMP. IN ☐ OUT ☐ (TO BE BETWEEN 170° AND 205°F) (SEE NOTE B)
3. SET IDLE SPEED.....RPM
4. SET NO LOAD SPEED:.....RPM ± .....RPM
5. RECORD F.L. BHP AT ..... RPM TO BE BETWEEN [SEE NOTE A(ITEM 2)]
   MAX. .....LBS .....BHP AND MIN. .....LBS .....BHP
6. RECORD BOSCH SMOKE READING AT FULL LOAD AT .....RPM MUST NOT EXCEED.....
7. RECORD BHP AT:
8. RECORD FUEL CONSUMPTION AT:
9. RECORD LUB OIL PRESSURE AT: (MIN.....PSI AT MAX. RATED SPEED)
10. RECORD LUB OIL TEMP. (NOT TO EXCEED.....)
11. SEE NOTE C

    SPECIAL REQUIREMENTS:

    INHIBIT FOR:

NOTE A — PROTOTYPES APPROVED:

DATE:

For units marked PROTOTYPE on Sales/Work Order this Test Schedule must be deviated from as follows:-

1. Units should be run-in to prototype run-in schedule for .....RPM F.L. Speed.
2. Brake load to be between MAX. .....LBS .....BHP MIN. .....LBS .....BHP.

NOTE B MARINE ENGINES ONLY WATER TEMP "OUT" ONLY TO BE RECORDED.

NOTE C TURBOCHARGED ENGINES ONLY RECORD BOOST PRESSURE AT .....RPM
TO BE WITHIN .....INS HG AT .....RPM.

13.3000

## FUEL, OIL AND COOLANT SPECIFICATIONS

### FUEL OIL

1. The quality of fuel oil used for high speed diesel engine operation is a very important factor in obtaining satisfactory engine performance, long engine life and acceptable exhaust.

2. Fuel oil should be clean and free of contamination. Storage tanks should be inspected regularly for dirt, water or water emulsion sludge, and cleaned if contaminated. Storage instability of the fuel can lead to the formation of varnish or sludge in the tank. The presence of these contaminants from storage instability must be resolved with the fuel supplier.

3. Fuel oil used in all Bedford diesel engines should be to specification BS 2869 Class "A".

**TABLE 1. REQUIREMENTS FOR ENGINE FUELS**

| | CLASS A1 | CLASS A2 | Test Method | |
|---|---|---|---|---|
| | | | BS References § | Technically identical with |
| Viscosity kinematic at 37.8°C (100°F) centistokes ‡ | | | | |
| min | 1.6 | 1.6 | BS ..... | ASTM D445-1P71 |
| max | 6.0 | 6.0 | BS ..... | 1P41 |
| Cetane number, min | 50 | 45 | | |
| Carbon residue, Conradson % by weight, max | — | — | BS ..... | ASTM D189-1P13 |
| Carbon residue, Conradson on 10% residue % by weight, max | 0.2 | 0.2 | | |
| †Distillation recovery at 375°C or 675°F, % by volume, min | 90 | 90 | BS ..... | ASTM D86-1P123 (Paragraph 4) |
| Flash point closed, Pensky Martens, min | †55°C or 130°F | †55°C or 130°F | BS ..... | ASTM D93-1P34 |
| Water content % by volume, max | 0.05 | 0.5 | BS ..... | 1P74 |
| Sediment % by weight, max | 0.01 | 0.01 | BS ..... | ASTM D473-1P53 |
| Ash % by weight, max | 0.01 | 0.01 | BS ..... | ASTM D482-1P4 |
| Sulphur content % by weight, max | 0.05 | 1.0 | BS ..... | 1P63 |
| Copper corrosion test, max | 1 | 1 | | ASTM D130-1P154 |
| Cloud point, max | | | | — |
| Summer | 0°C (32°F) Mar/Nov inclusive | 0°C (32°F) Mar/Sep inclusive | | |
| Winter | †—7°C or 20°F Dec/Feb inclusive | †—7°C or 20°F Oct/Feb inclusive | BS ..... | ASTM D2500-1P219 (See Paragraph 7) |

† The alternative Celsius and Fahrenheit temperatures shown in this table are in some cases not exactly equivalent but are the closest whole number equivalents compatible with the test procedures. Such cases are indicated by the use of the term 'or' between the two values.

‡ An indication of the approximate viscosity equivalents in Redwood 1 seconds at the same temperature as given below:

| | | | |
|---|---|---|---|
| Kinematic viscosity, centistokes | 1.6 | 6.0 | 14.0 |
| Redwood 1, seconds | 30Φ | 41 | 65 |

The figure marked Φ represents the minimum flow time permissible for the Redwood 1 viscometer. The above values must not be regarded as accurate conversions from Redwood 1 seconds to kinematic viscosities.

§ Pending publication of the appropriate BS methods, the technically identical methods listed in the table are to be used for testing against the requirements of the British Standard.

4. Fuel selected must show at least 98 per cent by volume recovery when subjected to ASTM D-86-1P 123 distillation.
5. All diesel fuel oils contain a certain amount of sulphur. Too high a sulphur content results in excessive cylinder wear due to acid build-up in the lubricating oil. For most satisfactory engine life, fuels containing less than 0.5% sulphur should be used.
6. "Table 1. Requirements for engine fuels" will serve as a guide to the selection of the proper fuel for various applications. The fuels must be clean, completely distilled, stable and non-corrosive. DISTILLATION RANGE, CETANE NUMBER and SULPHUR CONTENT are three of the most important properties of diesel fuels that must be controlled to ensure optimum combustion and minimum wear. Engine speed, load and ambient temperature influence the selection of fuels with respect to distillation range and cetane number. The sulphur content of the fuel must be as low as possible to avoid excessive deposit formation, premature wear, and to minimize the sulphur dioxide exhausted into the atmosphere.
7. During cold weather engine operation, the cloud point (the temperature at which wax crystals begin to form in diesel fuel) should be 6°C (10°F) below the lowest expected fuel temperature to prevent clogging of the fuel filters by wax crystals.
8. At temperatures below —29°C (—20°F), consult an authorized Detroit Diesel Allison service outlet, since particular attention must be given to the cooling system, lubricating system, fuel system, electrical system and cold weather starting aids for efficient engine starting and operation.

## LUBRICATING OIL

9. Three considerations must be given when selecting lubricating oils for Bedford diesel engines, these are quality, high heat resistance and control of contaminants.

**Lubricating Quality**

10. The reduction of friction and wear by maintaining an oil film between moving parts is the primary requisite of a lubricant. Film thickness and its ability to prevent metal-to-metal contact of moving parts is related to oil viscosity. The optimums for Bedford Diesel engines are SAE 20 or 30 weight.

**High Heat Resistance**

11. Temperature is the most important factor in determining the rate at which deterioration or oxidation of the lubricating oil will occur. The oil should have adequate thermal stability at elevated temperatures, thereby precluding formation of harmful carbonaceous and/or ash deposits.

**Control of Contaminants**

12. The piston and compression rings must ride on a film of oil to minimize wear and prevent cylinder seizure. At normal rates of consumption, oil reaches a temperature zone at the upper part of the piston where rapid oxidation and carbonization can occur. In addition, as oil circulates through the engine, it is continuously contaminated by soot, acids and water originating from combustion. Until they are exhausted, detergent and dispersant additives aid in keeping sludge and varnish from depositing on engine parts. These additives in excessive quantities can result in detrimental ash deposits. If abnormal amounts of insoluble deposits form, particularly on the piston in the compression ring area, early engine failure may result.
13. Oil that is carried up the cylinder wall is normally consumed during engine operation. The oil and additives leave carbonaceous and/or ash deposits when subjected to the elevated temperatures of the combustion chamber. The amount of deposits is influenced by the oil composition, additive content, engine temperature, and oil consumption rate.
14. Detroit Diesel Allison lubricant recommendations are based on general experience with current lubricants of various types and give consideration to the commercial lubricants available.
15. Bedford diesel engines have given the best performance and experienced the longer service life with the oil performance levels given in the table below and having the ash and zinc limits shown in paragraphs 16 and 17.

**Ash Limit**

16. The sulphated ash limit of all the lubricants recommended for use in Bedford diesel engines should not exceed 1.000 per cent by weight, except lubricants that contain only barium detergent-dispersant salts where 1.500 per cent by weight is allowed. Lubricants having a sulphated ash content between 0.55 and 0.85 per cent by weight have been found excellent while lubricants having a sulphated ash content above 0.85 per cent by weight are prone to produce greater deposit levels in the ring belt and exhaust valve area of the engine.

| Specification | A.P.I. Letter Code | Oil Grade | Temperature Range | GM Spec |
|---|---|---|---|---|
| MIL-L-2104B | CC | SAE 30 | Above 31°C (90°F) | 4712-M |
| MIL-L-2104B | CC | SAE 20 or 20W | 31°C to —8°C (90°F to 10°F) | 4706-M |
| MIL-L-2104B | CC | SAE 10 | —8°C to —24°C (10°F to —10°F) | 4705-M |

**Zinc Content**

17. The zinc content, as zinc diorganodithiophosphate, of all the lubricants recommended shall be a minimum of 0.07 per cent by weight.

18. Multigrade oils are not recommended, investigations with some multigrade oils indicate they do not, generally, exhibit the anti-scuffing and anti-wear properties obtained from straight SAE grade oils operating in the same conditions. Neither fuel nor oil consumption rates were improved using multigrade oils.

**Oil Changes**

19. The oil should be changed approximately at 100 hour intervals under normal operating conditions, but note paragraphs 20 to 23.

20. Oil change intervals are dependent upon the various operating conditions of the engines and the sulphur content of the diesel fuel used. Oil drain intervals in all service applications may be increased or decreased with experience using a specific lubricant, while also considering the recommendations of the oil supplier.

## USED LUBE OIL ANALYSIS WARNING VALUES

21. The presence of ethylene glycol in the oil is damaging to the engine. Its presence and need for an oil change and for corrective maintenance action may be confirmed by glycol detector kits which are commercially available.

22. Fuel dilution of the oil may result from loose fuel connections or from prolonged engine idling. A fuel dilution exceeding 2.5 per cent by volume indicates an immediate need for an oil change and corrective maintenance action. Fuel dilution may be confirmed by ASTM D-322 test procedure performed by oil suppliers or independent laboratories.

23. In addition to the above considerations, if any of the following occur, the oil should be changed:

(a) The viscosity at 37.8°C (100°F) of a used oil sample is 40 per cent greater than the viscosity of the unused oil measured at the same temperature (ASTM D-445 and D-2161).

(b) The iron content is greater than 150 p.p.m.

(c) The pentane insolubles (total contamination) exceed 1.00 per cent by weight (ASTM D-893).

(d) The total base number (TBN) is less than 1.0 (ASTM D-664).

**NOTE.** The sulphur content of the diesel fuel used will influence the alkalinity of the lube oil. With high sulphur fuels, the oil drain interval will have to be shortened to avoid excessive acidity in the lube oil.

24. The lube oil filter element should be changed every 200 hours.

## STATEMENT OF POLICY ON FUEL AND LUBRICANT ADDITIVES

25. In answer to requests concerning the use of fuel and lubricating oil additives, the following excerpt has been taken from a policy statement of General Motors Corporation:

26. Therefore Detroit Diesel Allison does not recommend the use of any supplementary fuel or lubricant additives. These include all products marketed as fuel conditioners, smoke suppressants, masking agents, reodorants, tune-up compounds, top oils, break-in oils, graphitizers and friction-reducing compounds.

27. **NOTE.** The manufacturer's warranty applicable to Bedford Diesel engines provides in part that the provisions of such warranty shall not apply to any engine unit which has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow the manufacturer's fuel or lubricating recommendations may not be within the coverage of the warranty.

## SERVICE AND INSPECTION INTERVALS

28. Generally, operating conditions will vary for each engine application, even with comparable hours and, therefore, maintenance schedules can vary. A good rule of thumb for piston, ring, and liner inspections, however, would be 1500 hours for the first such inspection and at 1000 hour intervals thereafter.

## ENGINE COOLANT

29. Engine coolant is any solution which is circulated through the engine to provide the means for heat transfer from the different engine components. In general, water containing various materials in solution is used for this purpose.

30. The function of the coolant is basic to the design and to the successful operation of the engine. Therefore, coolant must be carefully selected and properly maintained.

31. A suitable coolant solution must meet the following basic requirements:

(a) Provide for adequate heat transfer.

(b) Provide a corrosion resistant environment within the cooling system.

(c) Prevent formation of scale or sludge deposits in the cooling system.

(d) Be compatible with the cooling system hose and seal materials.

(e) Provide adequate freeze protection during cold weather operation.

32. The first four requirements are satisfied by combining a suitable water with reliable inhibitors. When operating conditions dictate the need for freeze protection, a solution of suitable water and a permanent type antifreeze containing adequate inhibitors will provide a satisfactory coolant.

**Water**

33. Any water will produce a corrosive environment in the cooling system. Also, scale deposits may form on the internal surfaces of the cooling system due to the mineral content of the water. Therefore, water selected as a coolant should be properly treated with inhibitors to control corrosion and scale deposition.

34. To determine whether water is suitable as a coolant when inhibited, the following characteristics must be considered: concentration of chlorides, sulphates, total hardness and dissolved solids.

35. Chlorides and/or sulphates tend to accelerate corrosion, while hardness (percentage of magnesium and calcium present) causes deposits of scale. Total dissolved solids may cause scale deposits, sludge deposits, corrosion or a combination of these.

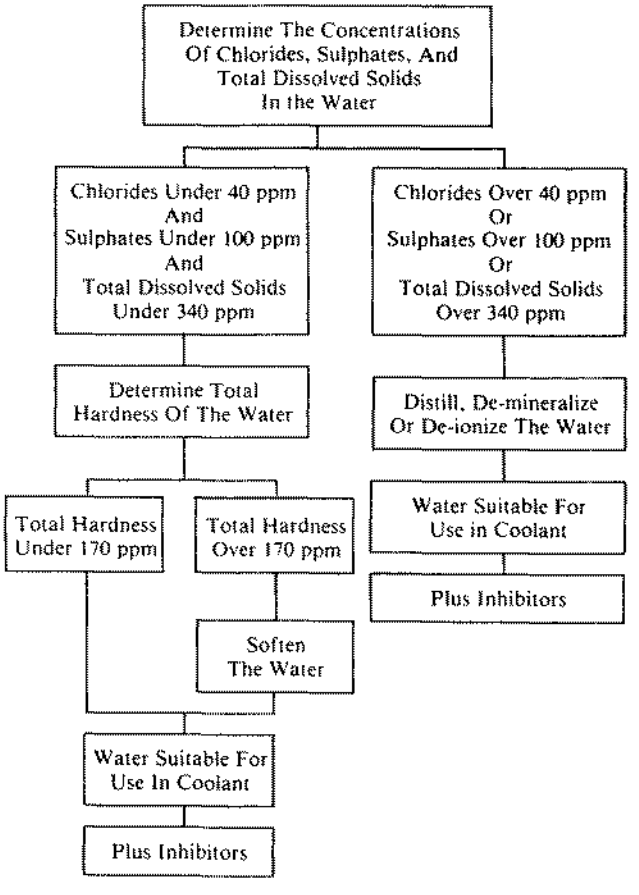
Chlorides, sulphates, magnesium and calcium are among but not necessarily all the materials which make up dissolved solids. Water, within the limits specified in tables 2 and 3 is satisfactory as an engine coolant when proper inhibitors are added.

**TABLE 2**

| | PARTS PER MILLION | GRAINS PER GALLON |
|---|---|---|
| Chlorides (Maximum) | 40 | 2.5 |
| Sulphates (Maximum) | 100 | 5.8 |
| Total Dissolved Solids (Maximum) | 340 | 20 |
| Total Hardness (Maximum) | 170 | 10 |

Refer to Table 3 for evaluation of water intended for use in a coolant solution.

**TABLE 3**




## INHIBITOR SYSTEMS

36. An inhibitor system is a combination of chemical compounds which provide corrosion protection, PH control, and which provide water softening abilities. Corrosion protection is discussed in paragraphs 37 to 42 inclusive. The PH control is used to maintain an acid free solution. The water softening ability deters formation of mineral deposits.

37. Corrosion Inhibitors are water soluble chemical compounds which protect the metallic surfaces of the cooling system against corrosive attack. Some of the more commonly used corrosion inhibitors are chromates, borates, nitrates and soluble oil. Depletion of all types of inhibitors occurs through normal operation and, therefore, strength levels must be maintained by the addition of inhibitors at prescribed intervals. Always follow the suppliers recommendations on inhibitor usage and handling.

**Chromates**

38. Sodium chromate and potassium dichromate are two of the best and most commonly used water system corrosion inhibitors. However, due to the toxic nature of these materials no chromate materials are now being used for ecological considerations.

39. Chromate inhibitors should not be used with permanent type antifreeze solutions. Chromium hydroxide (green slime), can result from chromate inhibitors and permanent type antifreeze. This material deposits on the cooling system passages and reduces the heat transfer rate, resulting in overheating. Engines which have operated with a chromate inhibited water system must be chemically cleaned before the addition of permanent antifreeze. A commercial heavy duty de-scaler should be used in accordance with the manufacturers recommendations for this purpose.

**Soluble Oil**

40. These require close attention relative to the concentration level due to adverse effects on heat transfer if the concentration exceeds 1% by volume.

41. Soluble oil is NOT recommended as a corrosion inhibitor.

**Non-Chromates**

42. Non chromate inhibitors (borates, nitrates, nitrides, etc.) provide corrosion protection in the cooling system with the basic advantage that they can be used with either water or a water and permanent antifreeze solution.

43. Inhibitor systems are available in various forms such as coolant filter elements, liquid and dry bulk inhibitor additives, and as an integral part of the permanent antifreeze. The system recommended for Bedford diesel engines is Nalcool 2000 which is a non-chromate liquid which is compatible both with water and Ethylene Glycol base antifreeze.

## ANTIFREEZE

44. To prevent damage to the engine due to freezing of water, a reliable antifreeze solution should be added to the cooling system during cold weather conditions. Only Ethylene Glycol type of antifreeze is recommended in Bedford Diesel engines. The use of an alcohol antifreeze is not recommended as it lowers the boiling point of the coolant and causes high losses due to evaporation.

45. A 20% solution of anti-freeze will safeguard a parked engine against cracking down to approximately 35° of frost (—3°F) or —22°C).

46. Complete protection against the formation of ice crystals in the solution is afforded down to approximately 17°F (—8°C) and the engine may be put to work immediately after starting up from cold without the fear of boiling.

47. From 17°F (—8°C) down to 7°F (—14°C) ice crystals will form and the solution becomes mushy. Within this temperature range the engine can be started, but not put to work immediately after starting up from cold. To prevent any danger from boiling, the radiator should be covered and the engine run at a fast speed for at least five minutes before commencing work.
48. At temperatures lower than 7°F (—14°C) the solution will be sufficiently hard to prevent the water pump from rotating and no attempt should be made to start the engine. To avoid damage it will be necessary to thaw out the engine before starting it.
49. Where temperature conditions warrant it, a 30% antifreeze solution should be used. This will give complete protection against the formation of ice down to 5°F (—15°C) and the engine may be put to work immediately after starting up.
50. A 50% solution of antifreeze will give complete protection down to a temperature of —30°F (—36°C).
51. When topping up the cooling system, it is essential that only anti-freeze solution of the correct strength should be used. The use of plain water will dilute the solution in the system and reduce the degree of protection. Do not overfill the system.
52. Do not forget to account for cabin heater circuits when determining the quantity of antifreeze required.
53. Antifreeze tends to loosen any rust from the water passages and the cooling system should be cleaned out to prevent this occurring.
54. After completing the cleaning process, but before filling with antifreeze solution, it is advisable to check the following:

(a) Water hoses for deterioration — renew if necessary
(b) Water hose connections for tightness
(c) Cylinder head nuts for tightness.

Any leakage of antifreeze solution past the cylinder head gasket will result in a "gummed up" engine and necessitate repairs.
55. When warm weather returns, the system should be drained and the process of cleaning and flushing repeated.
56. If a water filter is in the circuit ensure the correct element is used for antifreeze solutions.

# SECTION 14

## ENGINE TUNE-UP

**Contents**

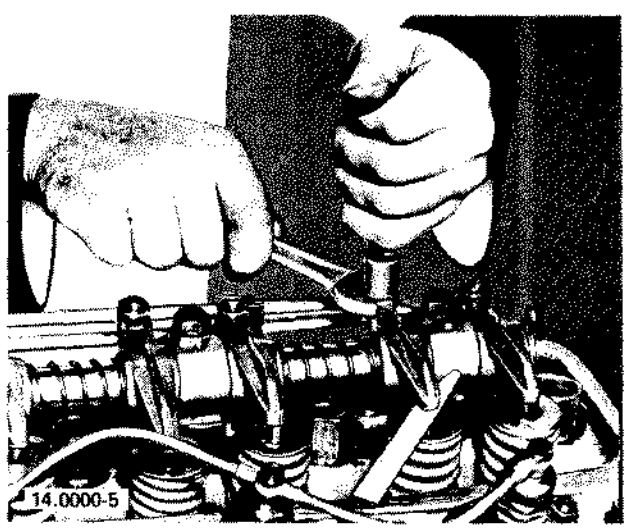
## 14.0000

## TUNE-UP PROCEDURES

1. There is no scheduled interval for performing an engine tune-up. As long as the engine is performing satisfactorily, no tune-up should be required. Minor adjustments to valves, injectors, etc. should only be required periodically to compensate for normal wear on parts.
2. The tune-up operations listed should be carried out with the engine at normal operating temperature. Since adjustments are usually made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperatures.

### VALVE CLEARANCES

3. Check the tightness of the rocker gear and check the valve clearance. To carry out these operations the engines must be thoroughly hot, and if it is not, it should be run at a fast idling speed for twenty minutes.
4. Remove the rocker cover and check the tightness of the rocker gear attachments to the cylinder head. Check the clearance between the valve stems and rocker arms with the engine running slowly. Adjustment for valve clearance is provided by a screw and nut at the push rod end of each valve rocker. The correct clearance when the engine is hot is .013 inches for all valves.
5. Insert a .013 inch feeler gauge between the end of the valve stem and the rocker arm. Slacken off the adjustment locknut and turn the adjuster by means of a screwdriver until it is nipping the gauge; then slacken it off slightly until the gauge can just be withdrawn. Finally tighten the locknut.




### INJECTOR TIMING

6. The injectors must be removed periodically from the engine to check their operation and, if necessary to clean and recondition them.
7. The period at which the injectors require attention depends on so many factors that it is impossible to quote one figure that will satisfy all conditions, however in no case should the interval between checks exceed 500 hours.
8. Depending on the operating conditions, cleanliness and quality of fuel, etc., the injectors may require servicing at more frequent intervals; in general, frequent periods of idling is more detrimental to injector condition than continuous operation, but experience is the only guide.
9. The need for servicing make itself apparent in various ways and the following symptoms can be taken as evidence of the need for attention to the injectors.
   (a) Black smoke from the exhaust.
   (b) Loss of performance.
   (c) Increased fuel consumption.
   (d) Heavy "Diesel Knock" on one or more cylinders.
   (e) Complete or intermittent misfiring.

10. When any of these symptoms are observed, the injectors should be removed and checked however short the time since the last check, as running with faulty injectors may be harmful to the engine. A quick method for locating a completely inoperative injector is by slackening off the high pressure pipe union nut of an injector while the engine is idling, thus cutting out the injector. If, after slackening the union nut, the engine revolutions do not vary, it may be assumed that the injector is faulty. Do this with each injector in turn. This method will enable a quick diagnosis to be made but it should not be regarded as final proof. The only completely satisfactory means of testing is by removal of the injectors and testing on the special equipment developed for this purpose. See section 2.1000 for injector overhaul and testing.

### GOVERNORS

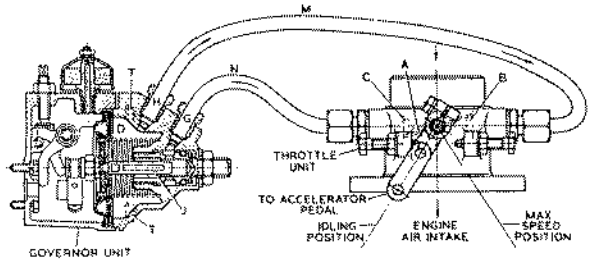
11. Several types of governors are used, dependent on the engine application. Since each governor has different characteristics, the tune-up procedure varies accordingly.
12. A list of these governors is shown in Table 1. below.

**TABLE 1.**

| Engine | Inline Governor | D.P.A. Hydraulic Governor | D.P.A. Mechanical Governor |
|---|---|---|---|
| 220 | 22° B.T.D.C. | — | 26° B.T.D.C. |
| 330 | 26° B.T.D.C. | 24° B.T.D.C. | 16° B.T.D.C. |
| 330T | 22° B.T.D.C. | 20° B.T.D.C. | 12° B.T.D.C. |

## TUNE-UP OF PNEUMATIC GOVERNORS

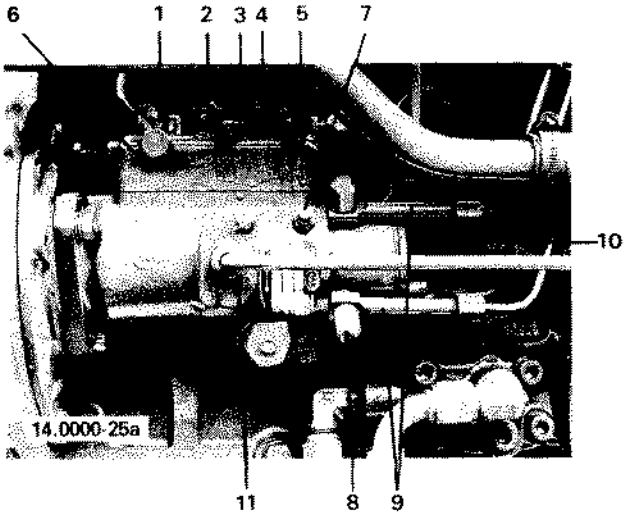
13. Adjust the exhaust valve clearances. (Paragraphs 3-5 inclusive).
14. Time the fuel injectors. (Paragraphs 6-10 inclusive).
15. Set the maximum speed stop on the throttle unit so that the engine develops the maximum specified speed, running light.



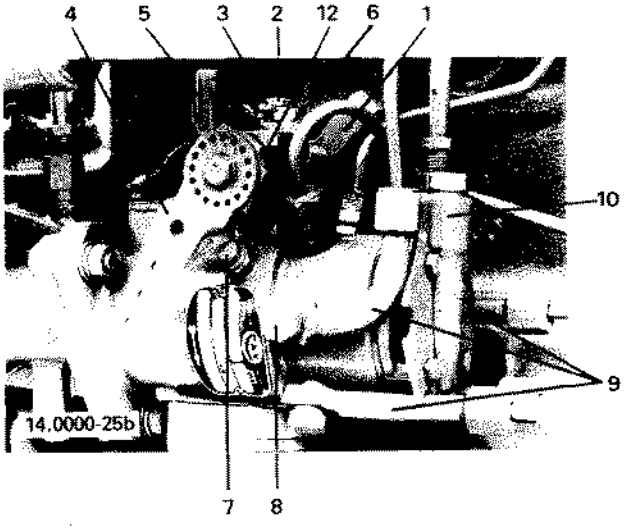

14.0000-15

A. Butterfly Throttle Valve
B. Intake Port. Engine Side of Throttle Unit
C. Outlet Port. Atmospheric Side of Throttle Unit
D. Chamber
G. Intake. Port-Governor Unit
H. Outlet. Port-Governor Unit
J. Damping Valve Guide
M. Suction Pipe-Governor Unit to Throttle Unit
N. Suction Pipe-Throttle Unit to Governor Unit
T. Governor Unit Retaining Screws (4 off)

16. Set the idling stop screw on the throttle unit to obtain slow running speed.
17. Slacken the locknut and adjust the damping valve guide 'J' until steady idling is obtained.
18. Care should be taken when adjusting the valve guide to keep the locknut finger tight against the governor housing, thus ensuring that no air leaks pass the screw threads.
19. Retighten the locknut.
20. Under no circumstances should the engine be run without the throttle unit (Venturi) inlet manifold or with either of the two suction pipes disconnected.
21. In dusty conditions of operation, the gauze pad in the air cleaners should be removed and washed in paraffin.
22. Use a new rocker cover gasket after tune-up is complete.




1. Shut Off Lever
2. Gov. Housing Vent. Screw
3. Idling Speed Screw
4. Throttle Lever
5. Maximum Speed Screw
6. Governor Housing
7. Hyd. Head Vent. Screw
8. Pressurising Valve
9. Injector Pipe Connections
10. Regulating Valve
11. Timing Cover




1. Shut Off Lever
2. Gov. Housing Vent. Screw
3. Idling Speed Screw
4. Throttle Lever
5. Maximum Speed Screw
6. Governor Housing
7. Hyd. Head Vent. Screw
8. Pressurising Valve
9. Injector Pipe Connections
10. Regulating Valve
12. Vernier Plate

## TUNE-UP OF MECHANICAL & HYDRAULIC D.P.A. GOVERNORS

23. Adjust exhaust valve clearances. (Paragraphs 3-5 inclusive).
24. Time the fuel injectors. (Paragraphs 6-10 inclusive).
25. To adjust the maximum engine speed, open throttle fully and then set the engine speed to the correct specification by adjusting the stop screw. Tighten the locknut and recheck the maximum speed.
26. To adjust the idling speed, slacken the stop screw lock nut and adjust the idling stop screw until the specified idling speed is obtained. The engine is then run to three quarters maximum speed and allowed to return to idle to check that the speed remains as specified.
27. Use a new rocker cover gasket after the tune-up is complete.

# SECTION 15

## PREVENTIVE MAINTENANCE – TROUBLESHOOTING – STORAGE

**Contents**

15.1000

## LUBRICATION AND PREVENTIVE MAINTENANCE

1. To obtain long life and best performance from Bedford Diesel Engines, the operator must adhere to the following schedule and instructions on lubrication and preventive maintenance.
2. The daily instructions pertain to routine or daily starting of an engine and not to a new engine or one that has not been operated for a considerable period of time. For new or stored engines, carry out instructions given under "Preparation for starting engine first time" in section 13.1.
3. The time intervals given in the chart on the following page are actual operating hours or miles of an engine. If the lubricating oil is changed immediately after an engine has been run for some time, most of the sediment will be in suspension and, therefore will drain readily.

| LUBRICATION AND PREVENTIVE MAINTENANCE CHART | | TIME INTERVAL | | | | | |
|---|---|---|---|---|---|---|---|
| | | Hours | Daily | 50 | 100 | 200 | 500 |
| Paragraph | OPERATION | Miles | Daily | 1500 | 3000 | 6000 | 15000 |
| 4 | Engine Oil Level | | X | | | | |
| 5-8 | Engine Oil Change | | | | X | | |
| 9-10 | Engine Oil Filter | | | | | X | |
| 11-12 | Engine Oil Leaks | | | | X | | |
| 13 | Coolant Level | | X | | | | |
| 14-15 | Cooling System Care | • | | | | | |
| 16 | Coolant Leaks | | X | | | X | |
| 17 | Fuel Filter | | X | | | | X |
| 18-19 | Fuel Tank Level | | X | | | X | |
| 20-21 | Fuel Oil Leaks | | | | X | | |
| 22-23 | Air Cleaner Care | • | | | X | | |
| 24 | Battery & Terminals | | | | | X | |
| 25 | Electrolyte Level | | | | X | | |
| 26-27 | Specific Gravity | | | | | X | |
| 28-30 | Fan Belt Tension | | | | | X | |
| 31 | Engine Mounts | | | | | X | |
| 32 | Exhaust System | | | | | | X |
| 33 | Valve Clearances | | | | | | X |
| 34 | Throttle Linkage | | | | X | | |
| 35 | Rockford Industrial Clutch | | X | X | | X | |
| 36 | In-Line Fuel Injection Pump | | | | X | | |
| 37-38 | Bedford Gear Box | | | | X | X | |
| 39-40 | Automotive Clutch | | | | | X | |
| 41-42 | Fuel Injectors | | | | | | X |
| 43 | Exhauster | | | | | | X |
| 44 | Allison Automatic Transmission | | X | | | | X |
| 45 | Marine Gear Boxes | • | | | | | |



• See items on following pages

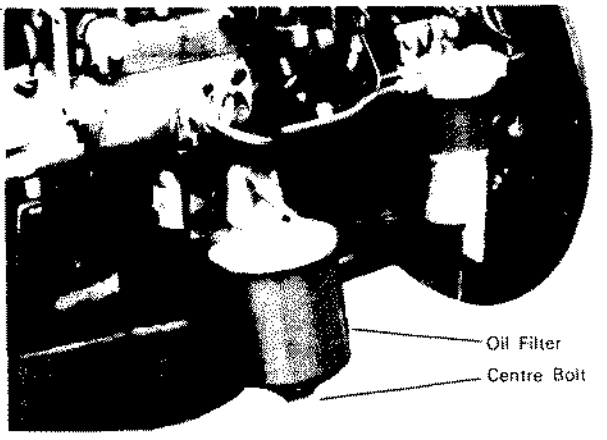
4. Check the oil level daily before starting the engine. Maintain the oil level at the full amount on the dipstick without overfilling. Do not operate the engine when the oil level is below the low mark.


15.1000-4

5. Following the Run-in period change the engine lubricating oil in a new engine every 100 hours. The drain interval may then be increased or decreased when recommended by a qualified laboratory or oil supplier based on an oil sample analysis.
6. Drain the engine lubricating oil while the engine is hot and the oil is thoroughly agitated. More impurities will be in suspension and will be drained from the crankcase.
7. Use oil of the correct grade as listed in the chart.
8. Good quality lubricants reduce carbon deposits and prevent battery overload by making starting easier and retain their lubricating qualities for longer periods.

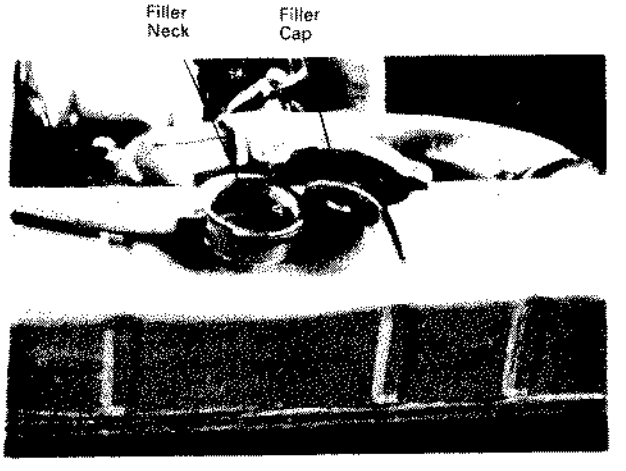
| LUBRICATING OIL SPECIFICATION | | |
|---|---|---|
| Ambient Temperature Conditions | Specifications | Oil Grade |
| Above 90°F (31°C) | MIL-2104-B | SAE 30 |
| 90°F to +10°F (+31°C to –8°C) | MIL-2104-B | SAE 20W |
| Below 10°F (–8°C) | Contact an authorized Bedford service outlet for instruction regarding sub zero operation | |

9. Install a new oil filter element and gasket every 200 hours. Check for oil leaks, with the engine running after every change.
10. The oil filter element should be changed at the oil change period if this interval is between 100 and 200 hours.




15.1000-10

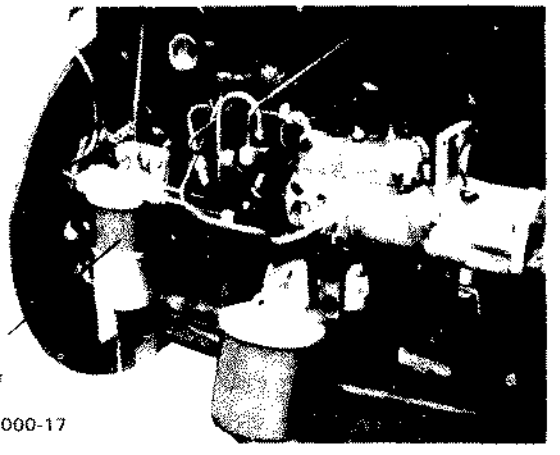
11. Check the complete lubricating systems for leaks every 100 hours and tighten connections that are leaking. In some cases new gaskets may be required to stop leakage.
12. Keep the engine exterior clean so that oil leaks can be detected as soon as they develop.
13. Check the coolant level in the radiator or heat exchanger tank daily and maintain it at approximately one inch below the filler neck.



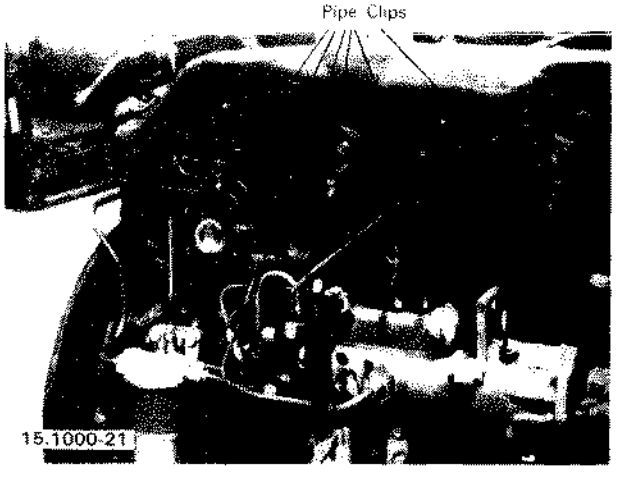

15.1000-13

14. Flush the cooling system each spring and autumn and clean the system when required with a commercial descaler, ventilating and rinsing afterwards according to the instructions on the container.
15. Fill the system with soft water adding a good grade of rust inhibitor or permanent type ethylene glycol anti-freeze.
16. Check the complete cooling system for leaks at least every 200 hours. When tightening hose connections to correct a leak, do not overtighten. Check below the engine daily for signs of leakage.

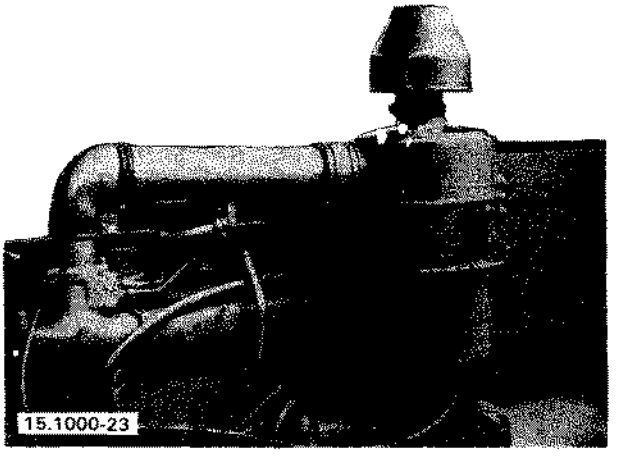
17. Install a new fuel filter element and gasket every 500 hours. A drain plug is provided on the combined water separator and filter to drain water and sediment daily.



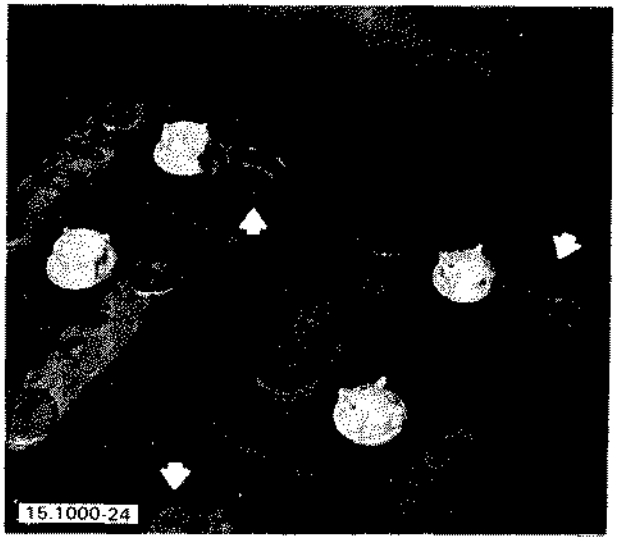

18. Check the fuel level in the supply tank daily before starting the engine. At the conclusion of the work day fill the fuel tank. This will minimize condensation.
19. Open the drain at the bottom of the fuel tank every 200 hours to drain off any water or sediment.
20. Check all fuel lines and connections from the supply tank to the injectors for leaks at least once every 100 hours.
21. Tighten loose connections being careful not to twist the fuel lines. Using a screwdriver check the screws securing the clips to the injector fuel lines for tightness.




22. Service both light duty and heavy duty air cleaners and check conditions of seals every 100 hours.
23. Complete service instructions for air cleaners are provided under Section 3 Air Cleaners.




24. Check the condition of the battery every 200 hours. The top should be dry and clean. The terminals (arrowed) should be scraped clean if corroded and they should be protected with a coat of petroleum jelly.

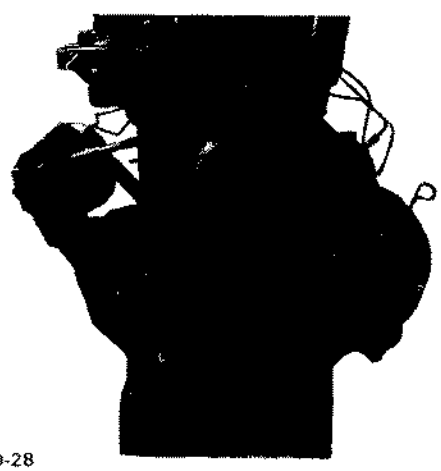



25. Check the electrolyte level in each battery every 100 hours and maintain the level just above the plates. In warm weather and in periods of high charge rate, check the electrolyte more frequently.

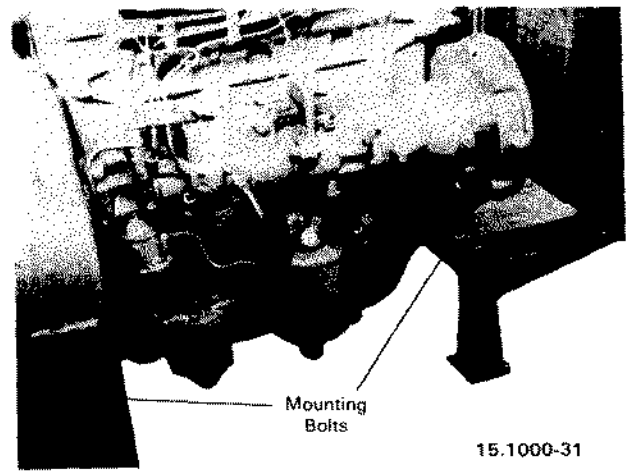
| SPECIFIC GRAVITY READINGS AT 86°F (28°C) | |
|---|---|
| Battery | Hydrometer |
| Fully Charged | 1.281 – 1.266 |
| Half Charged | 1.202 – 1.187 |
| Discharged | 1.111 – 1.098 |

26. Check the specific gravity of the electrolyte in each cell of the battery every 200 hours.

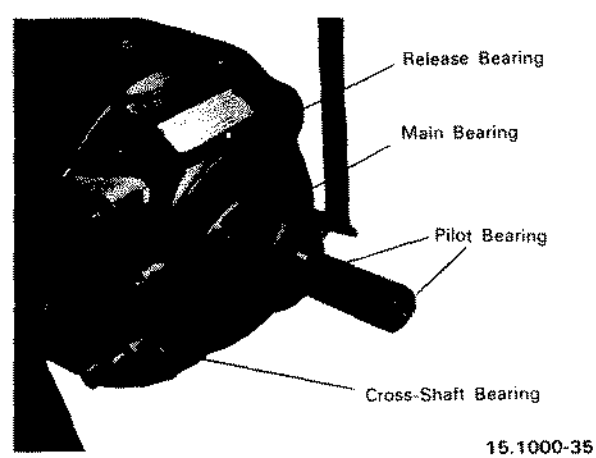

27. The hydrometer readings should be approximately the same for each cell. Any appreciable variation will require a more intensive check of battery cells by a qualified serviceman.
28. New drive belts will stretch in the early stages of operation. Check the tension of new belts after one hours operation, again at 50 hours and then at every 200 hours thereafter. Replace both belts when one is worn.



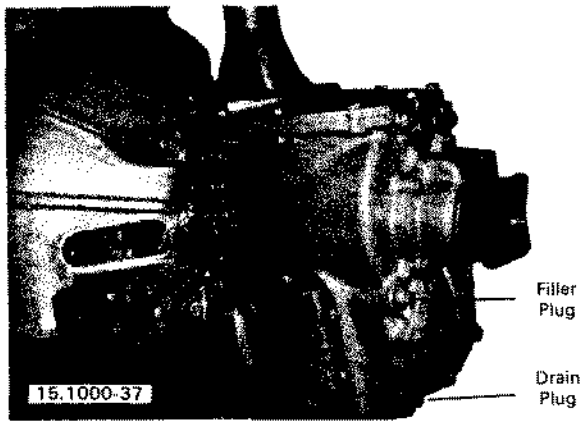

29. Adjust the belt tension so that a firm push with the thumb at a point midway between two pulleys will depress the belt $\frac{1}{2}''$. It is possible to check belt tension with a suitable spring balance applied to a point midway between the pulleys.
30. A pull of 5-7 lbs should deflect the belt $\frac{1}{2}''$.
31. Check nuts and bolts on the engine front and rear mounts every 200 hours to be sure they are tight.




32. Check the nuts and bolts securing the exhaust pipe to the manifold, the muffler to its support bracket and the tail pipe mountings every 200 hours.
33. Check the valve clearances every 500 hours. The correct valve clearance at normal operating temperatures is 0.013" for all valves. Adjust valves if required as outlined under Section 1.7100 page 3.
34. Using the same oil as in the engine crankcase, lubricate the throttle linkage between the operators control lever and fuel injection pump governor every 100 hours.
35. Lubricate the release bearing of the Rockford Industrial clutch daily and lubricate the main and pilot bearings every 50 hours. Check clutch adjustment every 200 hours. See Section 8, page 8.




36. Drain and refill the injection pump cambox with engine oil and check the level in the mechanical governor every 100 hours.
37. Check oil level in Bedford Gear Box every 100 hours. The level should be up to the bottom of the filler plug opening. Clean around the filler plug before removing it.




38. Every 200 hours check the four nuts which retain the gear box to the engine.
39. Check Bedford Automotive Clutch fork lever for travel every 200 hours.
40. The fork lever should have 3/16" (5mm) of free movement at the outer end of the fork.
41. Check operation of injectors. The injectors must be removed periodically from the engine to check their operation and if necessary clean and recondition them.
42. The period at which the injectors require attention depends on so many factors that it is impossible to quote one figure that will be satisfactory for all conditions, but in no case should the interval between checks exceed 500 hours. Complete instructions for checking injectors are given in Section 2.1000.
43. Clean exhauster strainer every 500 hours. Remove the large hexagon headed plug in the control box and wash the filter in kerosene. Shake dry, replace and check for leakage.
44. The oil level in the Allison MT Automatic Transmission should be checked daily and the oil and the filter changed every 500 hours.
45. The oil level should be checked in all marine gear boxes every 50 hours and replaced at the end of the season or every 300 hours of operation, which ever comes first.

15.2000

## TROUBLE SHOOTING

1. Satisfactory engine operation depends upon an adequate supply of air, compressed to a sufficiently high compression pressure, and the injection of the correct amount of fuel at the right time.
2. Lack of power, uneven running, excessive vibration and hard starting may be caused by either low compression, faulty injection of fuel or lack of sufficient air.

**Locating a Misfiring Cylinder**

3. Start the engine and run it at part load until it reaches normal operating temperatures.
4. Stop the engine and remove the valve rocker cover.
5. Check the valve clearances as detailed in Section 1.7100.
6. If the engine still misfires, the injectors should be removed and tested or substituted by a known 'good' injector.
7. If the installation of a new injector does not eliminate the misfiring, the compression pressure of the cylinder in question should be checked.

**Checking Compression Pressure**

8. The compression pressure can be checked with a suitable compression gauge and should be higher than the figures quoted in the table below.

| Engine | Minimum Acceptable Compression Pressure at 550 rpm & 68°F (20°C) | |
|---|---|---|
| | PSI | Kilopascal |
| 220 | 450 | 3100 |
| 330 | 450 | 3100 |
| 330T | 450 | 3100 |
| 466 | 500 | 3450 |

9. The engine should run at 550 rpm and not be revolved by the starting motor.
10. Low compression may result from any one of several causes,

a) Piston rings may be stuck or broken
b) Compression pressure may be leaking past the cylinder head gasket
c) The valve seats may be leaking
d) Compression pressure may be leaking through a damaged piston.

**Engine Out of Fuel**

11. The problem of restarting the engine after it has run out of fuel stems from the fact that after the fuel is exhausted from the fuel tank, fuel is pumped down from the fuel filter and lines before the fuel supply becomes insufficient to sustain engine firing.
12. Consequently these components must be re-filled with fuel and rid of air in order for the system to provide adequate fuel for the injectors.
13. Instruction for priming and venting the fuel system are given in Section 2.

**Crankcase Ventilation**

14. Crankcase ventilation is controlled by a connection to the engine air intake and/or a pressure relief valve.
15. The depression can be measured by means of a water manometer.
16. The crankcase ventilation system clears the crankcase of blow-by gasses.
17. The crankcase depression may be reduced by worn piston rings and worn cylinder liners, a hole or cracks in the piston crown or restriction in the pipework.

**Exhaust Back Pressure**

18. A slight pressure in the exhaust system is normal. However excessive exhaust back pressure seriously affects engine operation, by reduction of exhaust gas scavenging and higher temperatures.
19. Causes of high exhaust back pressure are usually a result of an inadequate or improper type of muffler, an exhaust pipe which is too long or too small in diameter, an excessive number of sharp bends in the exhaust system, or obstructions such as excessive carbon formation or foreign matter in the exhaust system.
20. The exhaust back pressure is measured in inches of mercury and may be checked with a manometer.
21. If there is no opening provided, drill an 11/32" hole in the exhaust manifold flange and tap the hole to accommodate a $\frac{1}{8}$" pipe plug.

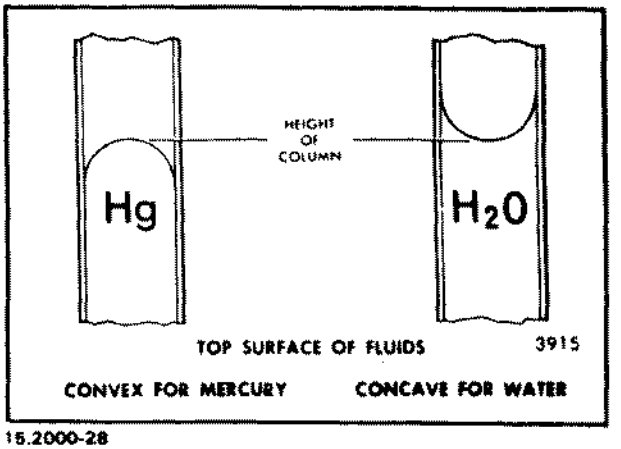
**Air Inlet Restriction**

22. Excessive restriction of the air inlet will affect the flow of air to the cylinders and result in poor combustion and lack of power.
23. Consequently the restriction must be kept as low as possible considering the size and capacity of the air cleaner. An obstruction in the air inlet system or dirty or damaged air cleaners will result in excessive restriction.
24. The air inlet restriction may be checked with a manometer in inches of water depression.

**Proper use of Manometer**

25. The U-tube manometer is a primary measuring device indicating pressure or vacuum by the difference in height of the columns of fluid.
26. Connect the manometer to the source of pressure, vacuum or differential pressure.
27. When the pressure is imposed, add the number of inches one column travels up to the amount the other column travels down to obtain the pressure reading.

28. The height of a column of mercury is read differently to that of a column of water. Mercury does not wet the inside surface; therefore, the top of the column has a convex meniscus (shape). Water wets the surface and therefore has a concave meniscus. A mercury column is read by sighting horizontally between the top of the convex mercury surface and the scale. A water manometer is read by sighting horizontally between the bottom of the concave water surface and the scale.




15.2000-28

29. Should one column of fluid travel further than the other, due to minor variations in the inside diameter of the tube or to the pressure imposed, the accuracy of the reading obtained is not impaired.

| | | |
|---|---|---|
| EXHAUST SMOKE ANALYSIS (Make checks with minimum water outlet temperature 70°C or 160°F) | BLACK OR GREY SMOKE | 1. **INCOMPLETELY BURNED FUEL**<br>High exhaust back pressure or a restricted air inlet causes insufficient air for combustion and will result in incompletely burned fuel.<br>High exhaust back pressure is caused by faulty exhaust piping or muffler restriction and should be measured at the exhaust manifold outlet with a manometer – Replace faulty parts.<br>Restricted air inlet is caused by a clogged air cleaner or piping defects and is also measured with a manometer. Clean these items and replace damaged piping.<br>Check injector sealing washers and that only one washer is fitted, also check securing nuts for correct torque.<br>Check injector operation on a test rig and make sure the correct type of injector is fitted.<br>2. **EXCESSIVE FUEL**<br>The fuel injection pump will have to be checked for correct output on special test equipment. |
| | WHITE SMOKE | 3. **MISFIRING CYLINDERS**<br>Check for faulty injectors and replace as necessary.<br>Check for low compression and consult hard starting chart. |
| | BLUE SMOKE | 4. **LUBRICATING OIL NOT BURNED IN CYLINDER**<br>Check for internal lubricating oil leaks and refer to HIGH lubricating oil consumption chart. |

| | | |
|---|---|---|
| HARD STARTING | ENGINE WILL NOT ROTATE | 1. **LOW BATTERY VOLTAGE**<br>Refer to items 2, 3 & 5 and perform operations listed.<br>2. **DEFECTIVE STARTING MOTOR SWITCH**<br>Replace the starting motor switch.<br>3. **INTERNAL SEIZURE**<br>Hand crank the engine at least one complete revolution. If the engine cannot be rotated a complete revolution, internal damage is indicated and the engine must be disassembled to ascertain the extent of the damage and the cause. |
| | LOW CRANKING SPEED | 4. **IMPROPER LUBRICATING OIL VISCOSITY**<br>Refer to Section 13 for lubricating oil specification for the recommended grade of oil.<br>5. **LOW BATTERY OUTPUT**<br>Recharge the battery if a light load test indicates low or no voltage. Replace the battery if it is damaged or will not hold a charge.<br>6. **LOOSE STARTER CONNECTIONS OR FAULTY STARTER**<br>Tighten the starter connections, inspect the starter commutator and brushes for wear. Replace the brushes if badly worn and overhaul the starter if the commutator is damaged. |
| | NO FUEL | 7. **AIR LEAKS OR FLOW OBSTRUCTION**<br>To check for air leaks, flow restriction or faulty fuel lift pump see NO FUEL OR INSUFFICIENT FUEL CHART.<br>8. **FUEL PUMP NOT AT MAXIMUM FUEL**<br>Check position of fuel pump operating lever for maximum fuel position. |
| | LOW COMPRESSION | 9. **EXHAUST VALVES STICKING OR BURNED**<br>Remove the cylinder head and recondition the exhaust valves.<br>10. **COMPRESSION RINGS WORN OR BROKEN**<br>Remove pistons from cylinder block and inspect the compression rings.<br>11. **CYLINDER HEAD GASKET LEAKING**<br>To check for cylinder head gasket leakage, remove the coolant filler cap and operate the engine. A steady flow of gasses from the coolant filler indicates whether a cylinder head gasket is damaged or the cylinder head is cracked. Remove the cylinder head and replace the gaskets or cylinder head.<br>12. **IMPROPER VALVE CLEARANCE ADJUSTMENT**<br>Adjust the exhaust and inlet valve clearances. |
| | INOPERATIVE STARTING AID | 13. **NO FUEL AT THERMOSTART IGNITER**<br>Check air vent on cap of thermostart igniter supply tank. Fuel cannot flow to the igniter if the air vent is blocked.<br>Check electrical connections to igniter from switch. Replace igniter if fuel and electrical supply is correct. |

| | | |
|---|---|---|
| ABNORMAL ENGINE OPERATION | UNEVEN RUNNING OR FREQUENT STALLING | 1. **LOW COOLANT TEMPERATURE**<br>Check the engine coolant temperature gauge and if the temperature does not reach 70°C or 160°F while the engine is operating, consult the abnormal engine coolant temperature chart.<br>2. **INSUFFICIENT FUEL**<br>Consult the no fuel or insufficient fuel chart.<br>3. **FAULTY INJECTORS**<br>Check the fuel injection pump timing and if correct remove the injectors and test, replace faulty injectors.<br>4. **LOW COMPRESSION PRESSURE**<br>Check the compression pressures within the cylinders and consult the Hard Starting chart if compression pressures are low. |
| | DETONATION | 5. **OIL PICKED UP BY AIRSTREAM**<br>Check specification of lubricating oil in the oil bath air cleaners for viscosity and correct level.<br>6. **LOW COOLANT TEMPERATURE**<br>See item 1 of this chart.<br>7. **FAULTY INJECTORS**<br>Check operation of injectors, look for sticking needles, broken injector nozzle tip or enlarged spray holes. |
| | LACK OF POWER | 8. **IMPROPER ENGINE ADJUSTMENTS**<br>Check fuel pump timing, valve clearances and valve timing. Improper valve timing will result in lack of power due to the valve being actuated at the wrong time in the engines operating cycle.<br>9. **INSUFFICIENT FUEL**<br>Consult the no fuel or insufficient fuel chart.<br>10. **INSUFFICIENT AIR**<br>Check for damaged or dirty air cleaners and clean or replace damaged parts.<br>11. **ENGINE APPLICATION**<br>Check that the engine has the required power for the application.<br>12. **HIGH AMBIENT AIR TEMPERATURE**<br>The engine horsepower is reduced by 2% for every 10°F (5½°C), rise above 85°F (30°C).<br>13. **HIGH ALTITUDE OPERATION**<br>The engine horsepower is reduced by 3½% for every 1000 feet (300m) above 500 feet (150m) up to 8000 feet (2500m). |

| | | |
|---|---|---|
| NO FUEL OR INSUFFICIENT FUEL | AIR LEAKS | 1. **LOW FUEL LEVEL**<br>The fuel tank should be filled to at least the level of the fuel suction pipe.<br>2. **LOOSE FUEL LINE CONNECTIONS**<br>Check for loose fuel line connections between the fuel lift pump and the fuel tank, check also the fuel suction line in the fuel tank.<br>3. **DAMAGED WATER SEPARATOR GASKET**<br>If a water separator is installed between the fuel tank and the lift pump check for a damaged sealing gasket. |
| | FUEL FLOW OBSTRUCTION | 4. **FUEL FILTER BLOCKED**<br>Check for a clogged fuel filter and replace as necessary.<br>5. **RESTRICTED FUEL LINES**<br>Check the complete low pressure fuel system for restriction of the fuel lines, replace all damaged pipes and fittings.<br>6. **TEMPERATURE LESS THAN 10°F ABOVE POUR POINT OF FUEL**<br>When fuel with a high pour point is used, the filters may 'freeze' and become blocked with wax particles.<br>Check that the correct grade of fuel is being used. |
| | FAULTY FUEL PUMP | 7. **NON RETURN VALVES NOT SEATING**<br>Check non return valves in fuel lift pump and repair as necessary.<br>8. **DAMAGED DIAPHRAGM**<br>Check that the fuel pump diaphragm is not cracked or split and replace as necessary.<br>9. **FUEL PUMP NOT OPERATING**<br>Check that the fuel pump operating arm is in contact with the cam on the camshaft and that the operating cam bushes are not worn excessively. Replace as necessary. |
| | FAULTY INSTALLATION | 10. **DIAMETER OF FUEL LINE TOO SMALL**<br>Minimum fuel line size for Bedfoed engines is 5/16" (8mm) outside diameter. Replace if smaller than this.<br>11. **FUEL PUMP LIFT TOO GREAT**<br>Maximum lift from the bottom of the fuel tank to the fuel lift pump is 5 feet. If the fuel pump lift is greater than this, reposition the fuel tank. |

| | | |
|---|---|---|
| HIGH LUBRICATING OIL CONSUMPTION | EXTERNAL LEAKS | 1. **OIL LINES OR CONNECTIONS LEAKING**<br>Tighten connections or replace defective parts.<br>2. **GASKET OR OIL SEAL LEAKS**<br>Replace defective gaskets or oil seals. |
| | OIL CONTROL AT CYLINDER | 3. **OIL CONTROL RINGS WORN, BROKEN OR IMPROPERLY INSTALLED**<br>Remove pistons from the cylinder block and inspect for defective parts and replace as necessary.<br>4. **SCORED LINERS, PISTONS OR OIL RINGS**<br>Overhaul engine.<br>5. **EXCESSIVE INSTALLATION ANGLE**<br>Check installation and maximum operating angle of engine and make sure that these are within specification and modify as required.<br>6. **EXCESSIVE OIL IN CRANKCASE**<br>Check that maximum oil level is not exceeded, rotating parts may dip in the oil causing splash and excessive oil consumption. |

| | | |
|---|---|---|
| LOW OIL PRESSURE (Make checks with minimum water outlet temperature of 70°C or 160°F) | LUBRICATING OIL | 1. **SUCTION LOSS** Check the oil level and bring it to the proper level on the dipstick or correct the installation angle.<br>2. **LUBRICATING OIL VISCOSITY** Refer to Section 13 lubricating oil specification for the recommended grade of oil. |
| | POOR CIRCULATION | 3. **PRESSURE REGULATOR VALVE NOT FUNCTIONING PROPERLY** Remove the pressure regulator valve and clean the valve and valve seat and inspect the valve spring. Replace defective parts.<br>4. **EXCESSIVE WEAR ON CRANKSHAFT BEARINGS** Replace the crankshaft bearings and renew the lubricating oil and filter. |
| | PRESSURE GAUGE | 5. **FAULTY GAUGE** Check the oil pressure with a master gauge and replace if necessary.<br>6. **GAUGE LINE OBSTRUCTED** Remove and clean the gauge line, replace it if necessary.<br>7. **ELECTRICAL INSTRUMENTS SENDING UNITS FAULTY** Repair or replace defective electrical units. |
| | OIL PUMP | 8. **INTAKE SCREEN PARTIALLY CLOGGED** Remove and clean the oil pan and intake screen. Change the oil filter and refill the sump with the correct grade of lubricating oil.<br>9. **RELIEF VALVE FAULTY** Remove and inspect the valve, valve seat and spring. Replace faulty parts.<br>10. **AIR LEAK IN PUMP SUCTION** Disassemble the suction pipe, inspect and replace seals or gaskets.<br>11. **PUMP WORN OR DAMAGED** Remove the pump, clean and replace defective parts. |

| | | |
|---|---|---|
| ABNORMAL ENGINE COOLANT OPERATING TEMPERATURE | ABOVE NORMAL | 1. **INSUFFICIENT HEAT TRANSFER**<br>Clean the cooling system with a good cooling system cleaner and thoroughly flush to remove scale deposits.<br>Clean the exterior of the radiator core to open plugged passages and permit normal air flow.<br>Adjust fan belts to the proper tension to prevent slippage.<br>Check for an improper size radiator or inadequate shrouding.<br>Repair or replace inoperative temperature controlled fan or inoperative shutters.<br>2. **POOR CIRCULATION**<br>Check the coolant level and fill to the filler neck if the coolant level is low.<br>Inspect for collapsed or disintegrated hoses. Replace faulty hoses.<br>Thermostat may be inoperative. Remove, inspect and test thermostat, replace if found faulty.<br>Check the water pump for loose or damaged impeller.<br>Check the flow of coolant through the radiator. A clogged radiator will cause an inadequate supply of coolant on the suction side of the pump. Clean the radiator core.<br>Remove the coolant filler cap and operate the engine, checking for combustion gases in the cooling system. The cylinder head must be removed and inspected for cracks and the head gaskets replaced if combustion gases are entering the cooling system. |
| | BELOW NORMAL | 3. **IMPROPER CIRCULATION**<br>The thermostat may not be closing. Remove inspect and test the thermostat. Install a new thermostat if necessary.<br>Check for an improperly installed heater. |

15.3000

## STORAGE

**Storage of Engines or Out of Season Lay-Up**

1. These procedures are for a period of 6 months only. If the engine is stored for a longer period than 6 months, these procedures must be repeated.
2. Prepare the engines for storage as follows:
   (a) Run the engine immediately prior to storage on inhibiting fluid Shell RF11 (American Diesel run-in fuel LF-4089 MOBIL TECREX) or equivalent which ensures protection for the whole of the fuel system.
   (b) Drain the engine lubricating oil from the oil pan and fill with oil, Shell ENSIS 20 (MIL-L-21260 grade 2.P10) or equivalent and run the engine for 10 minutes at 1000 rpm no load.
3. IMPORTANT: INJECTOR HOLDING DOWN NUTS MUST BE SLACKENED BEFORE THE FOLLOWING OPERATION IS CARRIED OUT AND RETIGHTENED AFTER THE OPERATION.
4. Insert a spray gun with a high pressure atomiser into the air intake elbow (with the butterfly valves in the full open position if used) and spray oil into the cylinder bores whilst motoring the engine for a period of 20 seconds. The total amount of oil should not exceed one fluid ounce or 30 millilitres.
5. Remove oil pan drain plug and drain the preserving lubricating oil from the oil pan.
6. Remove the fuel filter element and gasket and discard. Wash the filter shell in clean fuel oil and insert a new element. Fill the cavity between the element and the shell with the same rust preventive fuel oil as used in the fuel tank and reinstall the shell.
7. Drain and thoroughly flush the cooling system with clean soft water and refill with a rust-inhibited coolant. Then drain the system again.
8. Clean and service the air cleaner or silencer if needed.
9. Be sure the following items are adequately sealed:
   (a) Fuel feed pump or pre-filter inlet
   (b) Lubricating oil filler cap
   (c) Exhaust Manifold outlet
   (d) Water pump inlet and outlet
   (e) Air intake opening
   (f) Dipstick opening
   (g) Crankcase breather openings
   (h) Fuel return outlet
   (i) Oil pressure switch opening
   (j) Alternator, starter & terminals
10. Be sure the clutch is disengaged from the flywheel if so equipped.
11. Remove the valve rocker cover and spray the top of the cylinder head, valve and rocker assemblies, and underside of the rocker cover with preservative lubricating oil Shell ENSIS 20 (MIL-L-21260 grade 2.P10) or equivalent.
12. Remove battery and store it in a warm dry place. Clean and coat the battery connections with grease to prevent corrosion.
13. Heat exchanger models only: Drain the raw water from the cooling system as follows:
   (a) Drain the heat exchanger by removing the drain plug located on the end cap of the cylindrical position of the heat exchanger.
   (b) Drain the raw water pump by removing the end cover held by six retaining screws.

**Storage of New Engines**

14. All GM Bedford Diesel Engines when shipped from the factory are protected against rust, corrosion and other forms of deterioration for up to six months.
15. If a new engine is stored for a period in excess of six months, the engine fuel, lubrication, and air intake systems should be re-inhibited and sealed openings re-checked as outlined previously.

**Returning an Engine to Service Following Storage**

16. When preparing to start an engine that has been in storage follow the instructions outlined below. Failure to prepare an engine for start-up following prolonged storage can result in damage to components.

**Protective Coverings**

17. Remove the covers and tapes from all the openings of the engine, fuel tank and electrical equipment. Do not overlook the exhaust outlet.

**Air Cleaner**

18. If the engine is equipped with an oil bath cleaner, fill the cleaner bowl to the proper level with the same lubricating oil used in the engine crankcase.

**Cooling System**

19. Make sure the coolant drain cocks located at the left rear side of the cylinder block and at the bottom of the radiator are closed
20. Remove the filler cap and fill the cooling system with inhibited soft water or permanent Ethylene glycol Anti freeze. Add the coolant slowly to ensure a proper fill without trapping any air.
21. On the heat exchanger engines replace the raw water pump impeller if it was removed prior to storage.
22. Apply a suitable grease when installing the impeller to prevent wear during priming following engine start-up. Install the pump end cover with six attaching screws

**Lubricating System**

23. With the valve rocker cover removed, pour two quarts of recommended engine lubricating oil over the rocker arms and valve springs. Install the valve rocker cover and fill the engine crankcase to the 'full' mark on the dipstick.

**Fuel System**

24. Fill the fuel supply tank if the system is equipped

with a fuel supply valve it must be opened. To ensure prompt starting prime and vent the fuel system as outlined under Section 2.

**Marine Gear**

25. If a Marine gear box is installed, make sure the unit is filled to the proper level with the recommended grade of oil.

**Starting System**

26. Remove any protective grease from the starter and battery charging generator terminals. Connect the electrical leads to fully charged battery.