The purpose of this publication is to provide the service technician with information for troubleshooting, testing, and repair of major systems and components on the Groundsmaster 580-D, Model 30580, 30581, 30582, and 30583 (see NOTE above).

REFER TO THE TRACTION UNIT AND CUTTING UNIT OPERATOR’S MANUALS FOR OPERATING, MAINTENANCE AND ADJUSTMENT INSTRUCTIONS. Space is provided in Chapter 2 of this book to insert the Operator’s Manuals and Parts Catalogs for your machine. Replacement Operator’s Manuals are available on the internet at www.toro.com or by sending complete Model and Serial Number to:

The Toro Company
8111 Lyndale Avenue South
Minneapolis, MN 55420

The Toro Company reserves the right to change product specifications or this publication without notice.

NOTE: A NOTE will give general information about the correct operation, maintenance, service, testing or repair of the machine.

IMPORTANT: The IMPORTANT notice will give important instructions which must be followed to prevent damage to systems or components on the machine.

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Safety Instructions

The GROUNDSMASTER® 580-D meets or exceeds the American National Standards Institute’s safety standards for riding mowers. Although hazard control and accident prevention partially are dependent upon the design and configuration of the machine, these factors are also dependent upon the awareness, concern, and proper training of the personnel involved in the operation, transport, maintenance, and storage of the machine.

Improper use or maintenance by the operator or owner of the machine can result in injury. Reduce the potential for any injury by complying with the following safety instructions.

Before Operating

1. Read and understand the Operator’s Manual before starting and operating the machine. Become familiar with all controls and know how to stop quickly. A replacement Operator’s Manual is available on the Internet at www.Toro.com or by sending complete Model and Serial Number to:
   The Toro Company
   Attn. Technical Publications
   8111 Lyndale Avenue South
   Minneapolis, Minnesota 55420-1196.

   If you have questions about this Service Manual, please contact:
   The Toro Company
   Commercial Service Department
   8111 Lyndale Avenue South
   Minneapolis, Minnesota 55420-1196.

2. Never allow children to operate the machine or adults to operate it without proper instruction.

3. Become familiar with the controls and know how to stop the machine and engine quickly.

4. Keep all shields, safety devices and decals in place. If a shield, safety device or decal is malfunctioning, illegible or damaged, repair or replace it before operating the machine.

5. Always wear substantial shoes. Do not operate machine while wearing sandals, tennis shoes, sneakers or when barefoot. Do not wear loose fitting clothing that could get caught in moving parts and possibly cause personal injury.

6. Wearing safety glasses, safety shoes, long pants and a helmet is advisable and required by some local ordinances and insurance regulations.

7. Make sure the work area is clear of objects which might be picked up and thrown by the cutter blades.

8. Do not carry passengers on the machine. Keep everyone, especially children and pets, away from the areas of operation.
9. Since diesel fuel is highly flammable, handle it carefully:
   A. Use an approved fuel container.
   B. Do not remove fuel tank cap while engine is hot or running.
   C. Do not smoke while handling fuel.
   D. Fill fuel tank outdoors and only to within an inch (25 mm) from the top of the tank, not the filler neck.
   E. Do not overfill.
   F. Wipe up any spilled fuel.
10. Be sure interlock switches are adjusted correctly so engine cannot be started unless traction pedal is released – neutral position – and PTO switch is in NEUTRAL position.

While Operating

11. Check interlock switches daily for proper operation. If a switch malfunctions, replace or adjust it before operating the machine. The interlock system is for your protection, so do not bypass it. Replace all interlock switches every two years.
12. Do not run engine in a confined area without adequate ventilation. Exhaust is hazardous and could be deadly.
13. Sit on the seat when starting and operating the machine.
14. Before starting the engine each day, test warning lamps and signal lights to assure proper operation.
15. Pay attention when using the machine. To prevent loss of control:
   A. Mow only in daylight or when there is good artificial light.
   B. Watch for holes or other hidden hazards.
   C. Be extremely careful when operating close to sand traps, ditches, creeks, steep hillsides or other hazards.
   D. Reduce speed when making sharp turns. Avoid sudden stops and starts.
   E. Look to the rear to assure no one is behind the machine before backing up.
   F. Watch for traffic when near or crossing roads. Always yield the right-of-way.
   G. Reduce speed when driving downhill.
16. Keep hands, feet and clothing away from moving parts and the cutting units.
17. This product may exceed noise levels of 85 dB(A) at the operator position. Ear protectors are recommended, for prolonged exposure, to reduce the potential of permanent hearing damage.
18. Do not touch engine, turbocharger, radiator, muffler or exhaust pipe while engine is running or soon after it is stopped. These areas could be hot enough to cause burns.
19. Before getting off the seat:
   A. Move traction pedal to neutral.
   B. Set parking brake.
   C. Disengage cutting units and wait for blades to stop.
   D. Stop engine and remove key from switch.
   E. Do not park on slopes unless wheels are chocked or blocked.
20. If a cutting blade strikes a solid object or vibrates abnormally, stop immediately, turn engine off, set parking brake and wait for all motion to stop. Inspect for damage. Repair or replace any damaged parts before operating.
Maintenance and Service

21. Before servicing or making adjustments, stop engine and remove key from the switch.

22. Assure entire machine is properly maintained and in good operating condition. Frequently check all nuts, bolts and screws.

23. Frequently check all hydraulic line connectors and fittings. Assure all hydraulic hoses and lines are in good condition before applying pressure to the system.

24. If the Groundsmaster 580-D loses power and needs to be moved, either by-pass the hydraulic pump or unlock the front wheel hubs. Unlocking the front wheels disables the machine braking system. Block the wheels before unlocking the hubs to keep the machine from moving. To tow the machine, connect to the towing vehicle with a rigid towing device. Do not use chains, cables or other non-rigid devices for towing. Lock the hubs when towing is completed.

25. Keep body and hands away from pin hole leaks or nozzles that eject high pressure hydraulic fluid. Use cardboard or paper to find hydraulic leaks. Hydraulic fluid escaping under pressure can penetrate skin and cause injury. Fluid accidentally injected into the skin must be surgically removed within a few hours by a doctor or gangrene may occur.

26. Before any hydraulic system maintenance, stop engine and lower cutting units to the ground so all pressure is relieved.

27. For major repairs or other assistance, contact your local Toro Distributor.

28. To reduce potential fire hazard, keep engine area free of excessive grease, grass, leaves and dirt.

29. If engine must be running to perform maintenance or an adjustment, keep hands, feet, clothing and other parts of the body away from cutting units and other moving parts. Keep everyone away.

30. Do not overspeed the engine by changing governor setting. Maximum engine speed is 2750 rpm. To assure safety and accuracy, have an Authorized Toro Distributor check maximum engine speed.

31. Shut engine off before checking or adding oil to the crankcase.

32. Disconnect battery before servicing the machine. If battery voltage is required for troubleshooting or test procedures, temporarily connect the battery.

33. For optimum performance and safety, use genuine Toro replacement parts and accessories. Replacement parts and accessories made by other manufacturers could be dangerous and may void the product warranty of The Toro Company.
Safety and Instruction Decals

Numerous safety and instruction decals are affixed to the Groundsmaster 580-D. If any decal becomes illegible or damaged, install a new decal. Part numbers for replacement decals are listed in your Parts Catalog. Order replacement decals from your Authorized Toro Distributor.
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Product Records

Insert Operator’s Manual and Parts Catalog for your Groundsmaster 580-D at the end of this chapter. Additionally, if any optional equipment or accessories have been installed to your Groundsmaster, insert the Installation Instructions, Operator’s Manuals and Parts Catalogs for those options at the end of this chapter.

Maintenance

Maintenance procedures and recommended service intervals for the Groundsmaster 580-D are covered in the Operator’s Manual. Refer to that publication when performing regular equipment maintenance.
Equivalents and Conversions

Decimal and Millimeter Equivalents

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1 mm = 0.03937 in. 0.001 in. = 0.0254 mm

U.S to Metric Conversions

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Product Records and Maintenance  Page 2 - 2  Groundsmaster 580 - D
# Torque Specifications

Use these torque values when specific torque values are not given. DO NOT use these values in place of specified values. Torque values listed are for lubricated threads. Plated threads are considered to be lubricated.

## Capscrew Markings and Torque Values - U.S. Customary

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## Capscrew Markings and Torque Values – Metric

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# Chapter 3

## Engine (Model 30580)

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**NOTE:** This Chapter provides engine information for TORO Model 30580. See Chapter 3A for Model 30581 or Chapter 3B for Model 30582.

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General Information

This chapter gives information about specifications, maintenance, troubleshooting, testing and repair of the diesel engine used in the Groundsmaster® 580-D mower.

Most repairs and adjustments require tools which are commonly available in many service shops. Special tools are described in the Special Tools section. The use of some specialized test equipment is explained; however, the cost of the test equipment and the specialized nature of some repairs may dictate that the work be done at a qualified diesel engine repair facility.

The engine used in the Groundsmaster® 580-D mower is manufactured by Mitsubishi Heavy Industries Limited. Service and repair parts for Mitsubishi engines are supplied through TORO Distributors. Repair parts may be ordered by TORO Part Number. If no parts list is available be sure to provide your dealer or distributor with the TORO Model Number and Serial Number.

Engine Serial Number Location

The engine serial number is stamped on the side of the crankcase (Fig. 1).

Figure 1

Stopping the Engine

Important: Before stopping the engine after mowing or full load operation, cool the turbocharger by allowing the engine to idle at low speed for 5 minutes. Failure to do so may lead to turbocharger failure.
Figure 2
Specifications

NOTE: Some specifications are included in the service procedures later in this chapter.

Specifications, standards and measurements are listed as: metric (U.S.).

Definition of Terms

The following terms are used when listing dimensions and specifications:

STANDARD CLEARANCE – Indicates clearance to be attained between mating parts at time of reassembly.

REPAIR LIMIT – A part that has reached this limit must be repaired or adjusted.

SERVICE LIMIT – A part which has reached this limit must be replaced.

NOMINAL VALUE – Indicates the standard dimension of a part.

ASSEMBLY STANDARD – Indicates the dimension of a part, the dimension to be attained at time of reassembly, or for standard performance.
# General Specifications – Mitsubishi S4FT

<table>
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<tr>
<th>General</th>
<th>Water-cooled, 4-stroke cycle, diesel</th>
</tr>
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<tbody>
<tr>
<td>No. of cylinders – arrangement</td>
<td>4-in line</td>
</tr>
<tr>
<td>Type of combustion chamber</td>
<td>Direct injection</td>
</tr>
<tr>
<td>Valve mechanism</td>
<td>Overhead – special heat resistant alloy</td>
</tr>
<tr>
<td>Bore x stroke (mm)</td>
<td>98 x 98 (3.86 x 3.86)</td>
</tr>
<tr>
<td>Piston displacement (litre)</td>
<td>2.96 (180.6)</td>
</tr>
<tr>
<td>Compression ratio</td>
<td>17:1</td>
</tr>
<tr>
<td>Fuel (ASTM specification)</td>
<td>Grade No. 2 diesel fuel</td>
</tr>
<tr>
<td>Firing order</td>
<td>1-3-4-2</td>
</tr>
<tr>
<td>Direction of rotation</td>
<td>Counterclockwise as viewed from flywheel side</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Overall length (mm)</th>
<th>806 (31.73)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall width (mm)</td>
<td>524 (20.63)</td>
</tr>
<tr>
<td></td>
<td>Overall height (mm)</td>
<td>853 (33.58)</td>
</tr>
<tr>
<td>Weight (dry) (kg)</td>
<td>275 (606)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Engine proper</th>
<th>Type of cylinder sleeves</th>
<th>cast iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of piston rings</td>
<td>Compression ring</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Oil ring</td>
<td>1 (w/spring expander)</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Valve timing</th>
<th>Inlet valves</th>
<th>Open</th>
<th>B.T.D.C. 10°</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Close</td>
<td>A.B.D.C. 50°</td>
<td></td>
</tr>
<tr>
<td>Exhaust valves</td>
<td>Open</td>
<td>B.B.D.C. 54°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Close</td>
<td>A.T.D.C. 10°</td>
<td></td>
</tr>
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<th>Air cleaner Type</th>
<th>Paper element</th>
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<td>Turbocharger Type</td>
<td>TC06</td>
</tr>
</tbody>
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<th>Engine Oil API service classification</th>
<th>CD</th>
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</thead>
<tbody>
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<td></td>
<td>Refill capacity – incl. filter (litre)</td>
<td>8 (8.4)</td>
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Groundmaster® 580-D  Page 3 - 7  Specifications
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<th><strong>Type</strong></th>
<th><strong>Trochoid</strong></th>
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<td><strong>Oil pump</strong></td>
<td>Speed ratio to crankshaft</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Delivery capacity liter/min (gpm) at 1800 engine rpm</td>
<td>23 (6.1)</td>
</tr>
<tr>
<td><strong>Relief valve</strong></td>
<td>Type</td>
<td>Piston valve</td>
</tr>
<tr>
<td></td>
<td>Opening pressure kg/cm (psi)</td>
<td>3 ± 0.2 (42.7 ± 2.8)</td>
</tr>
<tr>
<td><strong>Oil filter</strong></td>
<td>Type</td>
<td>Full flow cartridge type, paper element</td>
</tr>
<tr>
<td><strong>Oil filter relief valve</strong></td>
<td>Opening pressure kg/cm (psi)</td>
<td>1.0 ± 0.2 (14.2 ± 2.8)</td>
</tr>
<tr>
<td><strong>Oil jet check valve</strong></td>
<td>Opening pressure kg/cm (psi)</td>
<td>$1.2^{+0.3}<em>{-0.2}$ ($17^{+4.3}</em>{-2.8}$)</td>
</tr>
<tr>
<td><strong>Refill capacity liter (U.S. gal)</strong></td>
<td>4.6 (1.2)</td>
<td></td>
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<td>Speed ratio to crankshaft</td>
<td>1.3:1</td>
</tr>
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<td></td>
<td>Delivery capacity liter/min (gpm) at 3000 engine rpm</td>
<td>180 (11.5)</td>
</tr>
<tr>
<td><strong>Fan belt</strong></td>
<td>Type</td>
<td>Low-edge, cog, B type V-belt</td>
</tr>
<tr>
<td><strong>Thermostat</strong></td>
<td>Type</td>
<td>Expanding wax type</td>
</tr>
<tr>
<td></td>
<td>Valve opening temperature °C (°F)</td>
<td>77 °C (170 °F)</td>
</tr>
<tr>
<td><strong>Injection pump</strong></td>
<td>Type</td>
<td>Bosch A - Inline</td>
</tr>
<tr>
<td></td>
<td>Manufacturer</td>
<td>NIPPONDENSO</td>
</tr>
<tr>
<td></td>
<td>Diameter of plunger mm (in.)</td>
<td>9.0 (0.354)</td>
</tr>
<tr>
<td><strong>Feed pump</strong></td>
<td>Type</td>
<td>Bosch, piston</td>
</tr>
<tr>
<td></td>
<td>Manufacturer</td>
<td>NIPPONDENSO</td>
</tr>
<tr>
<td></td>
<td>Cam lift mm (in.)</td>
<td>1.5 (0.059)</td>
</tr>
<tr>
<td><strong>Governor</strong></td>
<td>Type</td>
<td>Bosch mechanical</td>
</tr>
<tr>
<td></td>
<td>Manufacturer</td>
<td>NIPPONDENSO</td>
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<td>-------------</td>
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</tr>
<tr>
<td></td>
<td>Type of nozzle holder</td>
<td>Bosch, hole</td>
</tr>
<tr>
<td></td>
<td>Type of nozzle tip</td>
<td>Bosch DLLA (multi-hole)</td>
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<tr>
<td></td>
<td>Manufacturer</td>
<td>NIPPONDENSO</td>
</tr>
<tr>
<td></td>
<td>No. of spray holes</td>
<td>4 each</td>
</tr>
<tr>
<td></td>
<td>Diameter of spray hole mm (in.)</td>
<td>0.3 (0.01)</td>
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<td></td>
<td>Spray angle</td>
<td>155 °</td>
</tr>
<tr>
<td></td>
<td>Valve opening pressure kg/cm (psi)</td>
<td>220 (3128) or 180 (2560)</td>
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<tr>
<td></td>
<td>Fuel filter</td>
<td>Type</td>
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<td></td>
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<td>Cartridge, paper element</td>
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<td>12 V – negative ground</td>
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<td>Starter</td>
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<tr>
<td>Manufacturer</td>
<td>MITSUBISHI ELECTRIC</td>
</tr>
<tr>
<td>Type</td>
<td>Solenoid – Pinion shift</td>
</tr>
<tr>
<td>Alternator</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>35 amp with internal regulator</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>MITSUBISHI ELECTRIC</td>
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## Service & Overhaul Standards

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<tr>
<td>Maximum rpm (no load)</td>
<td>2750 ± 50 rpm</td>
<td></td>
<td>Adjust governor setting</td>
</tr>
<tr>
<td>Minimum rpm</td>
<td>1150 ± 50 rpm</td>
<td></td>
<td>Adjust governor setting</td>
</tr>
<tr>
<td>Compression</td>
<td>27 kg/cm (384 psi) at 150 – 200 rpm</td>
<td>24 kg/cm (341 psi)</td>
<td>Oil and water temp. 20 – 30°C (68 – 66°F)</td>
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<td>Lube oil pressure</td>
<td>3 – 4 kg/cm (43 – 57 psi) at 1500 rpm</td>
<td>2 kg/cm (28.4 psi)</td>
<td>Oil temperature 60 – 70°C (140 – 158°F)</td>
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<tr>
<td>1 kg/cm (14.2 psi) minimum at idling</td>
<td></td>
<td>0.5 kg/cm (7 psi)</td>
<td></td>
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<td>Valve timing</td>
<td>In. valves open</td>
<td>28° A.T.D.C.</td>
<td>Values are only for checking valve timing, actual timing during operation will differ.</td>
</tr>
<tr>
<td></td>
<td>In. valves close</td>
<td>12° A.B.D.C.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ex. valves open</td>
<td>19° B.B.D.C.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ex. valves close</td>
<td>25° B.T.D.C.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 3° (crank angle)</td>
<td></td>
</tr>
<tr>
<td>Valve clearance</td>
<td>0.25 (0.0098)</td>
<td></td>
<td>Both inlet and exhaust valves check cold.</td>
</tr>
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<td>Fuel injection timing</td>
<td>16° B.T.D.C.</td>
<td></td>
<td></td>
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<tr>
<td>Fan drive belt tension</td>
<td>12 (1/2) deflection at point midway between alternator and water pump pulleys.</td>
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<td>Adjust at alternator</td>
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In.: Inlet  Ex.: Exhaust
### Inspection point

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<th>Remarks</th>
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<td>Crankcase</td>
<td>Warp of gasketed surface</td>
<td>0.05 (0.0020), maximum</td>
<td>0.20 (0.0079)</td>
</tr>
<tr>
<td>Cylinder sleeves</td>
<td>Inside diameter 98.000 – 98.035 (3.8583 – 3.8596)</td>
<td>99.200 (3.9055)</td>
<td>Refinish replacement sleeves to +0.25 (+0.0098) or +0.50 (+0.0197) oversize honing. Use matching oversize pistons and piston rings.</td>
</tr>
<tr>
<td></td>
<td>Out-of-round 0.015 (0.00059), maximum</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Taper 0.05 (0.0020), maximum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main bearings</td>
<td>Journal oil clearance 0.050 – 0.115 (0.0020 – 0.0045)</td>
<td>0.200 (0.0079)</td>
<td>If service limit is reached, regrind journals and use undersize bearings: Undersize bearings: -0.25 (-0.0098), -0.50 (-0.0197) and -0.75 (-0.0295)</td>
</tr>
<tr>
<td></td>
<td>Journal end play 0.100 – 0.264 (0.0039 – 0.0104)</td>
<td>0.300 (0.01181)</td>
<td>Replace thrust plate.</td>
</tr>
<tr>
<td>Tappet guides</td>
<td>Inside diameter 22.000 – 22.021 (0.8661 – 0.8670)</td>
<td>22.100 (0.8701)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Side clearance on tappets 0.035 – 0.086 (0.0014 – 0.0034)</td>
<td>0.120 (0.00472)</td>
<td>If replaced tappets do not bring specification into tolerance the bore is worn excessively.</td>
</tr>
<tr>
<td>Camshaft bushings</td>
<td>Clearance on journals 0.04 – 0.09 (0.0016 – 0.0035)</td>
<td>0.15 (0.0059)</td>
<td></td>
</tr>
<tr>
<td>Cylinder head</td>
<td>Warp of gasketed surface 0.05 (0.002), maximum</td>
<td>0.20 (0.008)</td>
<td>Resurface if minor.</td>
</tr>
<tr>
<td>Valves and valve guides</td>
<td>Diameter of valve stems</td>
<td>Inlet valves 7.955 – 7.940 (0.3132 – 0.3126)</td>
<td>7.900 (0.3110)</td>
</tr>
<tr>
<td></td>
<td>Exhaust valves 7.940 – 7.920 (0.3126 – 0.3118)</td>
<td>7.850 (0.3091)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stem and guide clearance</td>
<td>Inlet valves 0.055 – 0.085 (0.0022 – 0.0034)</td>
<td>0.150 (0.0059)</td>
</tr>
<tr>
<td></td>
<td>Exhaust valves 0.070 – 0.105 (0.0028 – 0.0041)</td>
<td>0.200 (0.0079)</td>
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</tr>
</tbody>
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Specifications
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<th>Nominal value</th>
<th>Assembly standard [standard clearance]</th>
<th>Serviceable limits</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle</td>
<td>30°</td>
<td>0.2 – 0.6</td>
<td>1.1 (0.043)</td>
<td></td>
</tr>
<tr>
<td>Valve sinkage</td>
<td></td>
<td>Inlet: 0.4 (0.016)</td>
<td>(.008 – .024)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exhaust: 0.5 (0.020)</td>
<td>0.3 – 0.7 (0.012 – 0.028)</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>1.2 (0.047)</td>
<td>1.06 – 1.34 (.0315 – .0525)</td>
<td>1.6 (0.063)</td>
<td>Refacing is permissible up to 1.2 (0.047)</td>
</tr>
<tr>
<td>Valve margin</td>
<td>2.13 (0.0839)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Valve springs          |              |                                        |                    |                          |
| Outer springs          |              |                                        |                    |                          |
| Free length            | 56.40 (2.2205)| 55.00 (2.1654)                         | Difference in angle between ends with respect to center line. |
| Squareness             | 2°, maximum |                                        |                    |                          |
| Test force/length under test force | 23.9 ± 1.2 kg/44 (52.7 ± 2.6 lb/1.73) | 21.2 kg/44 (46.7 lb/1.73) |                    |
| Inner springs          |              |                                        |                    |                          |
| Free length            | 40.8 (1.606) | 39.8 (1.567)                           | Difference in angle between ends with respect to center line. |
| Squareness             | 1.5°, maximum |                                        |                    |                          |
| Test force/length under test force | 6 ± 0.3 kg/36.5 (13 ± 0.7 lb/1.437) | 4.6 kg/36.5 (10 lb/1.437) |                    |

<p>| Rocker arms            |              |                                        |                    |                          |
| Inside diameter of rocker bushings | 20.000 – 20.021 (0.78740 – 0.78823) | 20.000 – 20.021 (0.78740 – 0.78823) | 20.000 – 20.021 (0.78740 – 0.78823) |
| Diameter of rocker shafts | 19.984 – 19.966 (0.78677 – 0.78606) | 19.984 – 19.966 (0.78677 – 0.78606) | 19.984 – 19.966 (0.78677 – 0.78606) |
| Clearance of bushings on shaft | 20 (0.79) [ 0.016 – 0.055 ] (0.00063 – 0.00217) | 20 (0.79) [ 0.016 – 0.055 ] (0.00063 – 0.00217) | 20 (0.79) [ 0.016 – 0.055 ] (0.00063 – 0.00217) | 20 (0.79) [ 0.016 – 0.055 ] (0.00063 – 0.00217) |
|-------------------|--------------|----------------------------------------|--------------------------|---------------------------|---------|
| Valve pushrods    | Runout (bend)| 0.4 (0.016), maximum                   |                          |                           | Runout measured with pushrod supported at centerlines of its spherical ends. |
|                   | Runout       | 0.02 (0.0008), maximum                 | 0.05 (0.0020)            |                           |         |
|                   | Diameter of journals | 75 (2.95) | -0.03 (-0.0012) | -0.15 (-0.0059) | -0.90 (-0.3354) |         |
|                   | Diameter of crankpins | 5.8 (2.28) | -0.035 (-0.00138) | -0.20 (-0.0079) |                           |         |
| Crankshaft        | Center to center between journal and crankpin | 49 (1.93) | ± 0.05 (± 0.0020) |                           |         |
|                   | Parallelism between journal and crankpin | Runout: 0.01 (0.0004), maximum (over crankpin length) |                           |                           |         |
|                   | Out-of-roundness of journals and crankpins | 0.01 (0.0004), maximum | 0.03 (0.0012) |                           |         |
|                   | Taper of journals and crankpins | 0.01 (0.0004), maximum | 0.03 (0.0012) |                           |         |
|                   | Filler radius of journals and crankpins | 3R (0.12) | ± 0.2 (± 0.008) |                           |         |
|                   | End play     | 37 (1.46) | [0.100 - 0.264] (0.00394 - 0.01039) | [0.300] (0.01181) | If repair limit is reached, replace thrust plates. If repair limit is exceeded, use oversize thrust plates: Oversize thrust plates: +0.15 (+0.0059), +0.30 (+0.0118) and +0.45 (+0.0177) |         |
|------------------|--------------|----------------------------------------|--------------------------|---------------------------|---------|
| <strong>Pistons</strong>      |              |                                        |                          |                           |         |
| Outside diameter (at skirt) |            |                                        |                          |                           |         |
| Standard         | 98 (3.86)   | 97.975 – 97.945 (3.85728 – 3.85609)    | 97.760 (3.84881)         |                           |         |
| 0.25 (0.0098) oversize |            | 98.225 – 98.195 (3.86712 – 3.86594)    | 98.010 (3.85865)         |                           | At right angles to piston pin at skirt. |
| 0.50 (0.0197) oversize |            | 98.475 – 98.445 (3.87696 – 3.87578)    | 98.280 (3.86850)         |                           |         |
| Protrusion above crank case |          | 0.65 – 1.05 (0.0256 – 0.0413)           |                          |                           | Check bearing clearance. |
| Variance in weight per engine |            | ± 3 gram (± 0.1 oz)                     |                          |                           |         |
| <strong>Piston rings</strong> |              |                                        |                          |                           |         |
| Side clearance in ring grooves |          |                                        |                          |                           |         |
| No. 1 ring 2.5 (0.098) | [ 0.030 – 0.070 ] (0.00118 – 0.00276) | [ 0.200 ] (0.00737) |                          | If repair limit is reached, replace piston rings. If repair limit is exceeded, replace piston. |
| No. 2 ring 2.0 (0.079) | [ 0.025 – 0.060 ] (0.00098 – 0.00236) | [ 0.150 ] (0.00591) |                          |                           |         |
| Oil ring 4.5 (0.177) | [ 0.025 – 0.060 ] (0.00098 – 0.00236) | [ 0.150 ] (0.00591) |                          |                           |         |
| End gap 0.35 – 0.50 (0.0138 – 0.0197) | 1.50 (0.0591) | [ 0.200 ] (0.00737) | [ 0.050 ] (0.00197) |                          |         |
| <strong>Piston pins</strong> |              |                                        |                          |                           |         |
| Outside diameter | 32.000 – 31.984 (1.25984 – 1.25921) |                          |                          |                           |         |
| Clearance in piston | 32 (1.28) | [ 0 – 0.016 ] (0 – 0.00063) | [ 0.050 ] (0.00197) |                          | If repair limit is reached, replace pin. If repair limit is exceeded, replace piston. |
| Clearance in bushing | 32 (1.26) | [ 0.020 – 0.051 ] (0 – 0.00201) | [ 0.080 ] (0.00316) |                          | Replace pin or bushing. Ream if necessary. |
| <strong>Connecting rod</strong> |              |                                        |                          |                           |         |
| Inside diameter of bushings | 32.048 – 32.020 (1.26173 – 1.26063) |                          |                          |                           |         |
| Twist/bend | 0.05/100 (0.0020/3.94), maximum | 0.15 (0.0059) |                          |                           |         |</p>
<table>
<thead>
<tr>
<th>Clearance of connecting rod bearings on crankpins</th>
<th>58 (2.28)</th>
<th>[ 0.035 – 0.100 ] (0.00136 – 0.00394)</th>
<th>[ 0.200 ] (0.00787)</th>
<th></th>
<th>If repair limit is reached, replace bearings. If repair limit is exceeded, regrind crankpins and use undersize bearings.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecting rod</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>End play</td>
<td>40 (1.57)</td>
<td>[ 0.15 – 0.35 ] (0.0059 – 0.0138)</td>
<td>[ 0.50 ] (0.020)</td>
<td>Replace connecting rod.</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>± 5g (± 0.2 oz)</td>
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<tr>
<td>Fly-wheel</td>
<td></td>
<td></td>
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<tr>
<td>Radial runout</td>
<td>0.15 (0.0059), maximum</td>
<td></td>
<td>0.50 (0.020)</td>
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<tr>
<td>Face runout</td>
<td>0.15 (0.0059), maximum</td>
<td></td>
<td>0.50 (0.020)</td>
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<tr>
<td>Runout</td>
<td></td>
<td>0.02 (0.0008), maximum</td>
<td>0.50 (0.020)</td>
<td>Straighten by cold working or replace.</td>
<td></td>
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<tr>
<td>Camshaft</td>
<td></td>
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<tr>
<td>Cam lift</td>
<td></td>
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<tr>
<td>Inlet</td>
<td>D₁</td>
<td>D₁ – D₂ = 6.689 (0.26335)</td>
<td></td>
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<tr>
<td></td>
<td>46.911+0.1</td>
<td></td>
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<tr>
<td></td>
<td>0.3</td>
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<tr>
<td></td>
<td>(1.84659+0.xxx)</td>
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<td></td>
<td>0.012</td>
<td></td>
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<tr>
<td></td>
<td>D₁</td>
<td>D₁ – D₂ = 7.344 (0.26913)</td>
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<tr>
<td></td>
<td>46.256+0.1</td>
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<td>0.3</td>
<td></td>
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<td></td>
<td>(1.82110+0.xxx)</td>
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<tr>
<td></td>
<td>-0.002</td>
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<tr>
<td>Exhaust</td>
<td></td>
<td>D₁ – D₂ = 6.844 (0.26945)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Diameter of journals</td>
<td>54</td>
<td>53.96 – 53.94 (2.1244 – 2.1236)</td>
<td>53.90 (21.220)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 1, 2</td>
<td>53</td>
<td>52.96 – 52.94 (2.0850 – 2.0842)</td>
<td>52.90 (20.827)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 3</td>
<td>53</td>
<td>52.96 – 52.94 (2.0850 – 2.0842)</td>
<td>52.90 (20.827)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 (0.20)</td>
<td>[ 0.050 – 0.112 ] (0.00197 – 0.00441)</td>
<td>[ 0.300 ] (0.01181)</td>
<td>Replace thrust plates.</td>
<td></td>
</tr>
<tr>
<td>Camshaft idler gear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearance of shaft in bushing</td>
<td>36</td>
<td>[ 0.025 – 0.075 ] (0.00986 – 0.00295)</td>
<td>[ 0.100 ] (0.00394)</td>
<td>Replace bushing.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 (1.42)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>End play</td>
<td>[ 0 – 0.10 ]</td>
<td>(0 – 0.0039)</td>
<td>0.35 (0.0138)</td>
<td>Replace thrust plates.</td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Length of thrust journal of shaft and boss</td>
<td>26</td>
<td>[ 0.05 – 0.20 ] (0.0020 – 0.0079)</td>
<td>[ 0.40 ] (0.0157)</td>
<td>Replace thrust plates.</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------</td>
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<td>----------------------------------------------</td>
</tr>
<tr>
<td>Camshaft idler gear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Replace gears.</td>
</tr>
<tr>
<td>Fit of shaft in crankcase bore</td>
<td>30 (1.18)</td>
<td>[ 0.009T - 0.045T ] (0.00035T - 0.00177T)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timing gear backlash</td>
<td></td>
<td></td>
<td>[ 0.03 - 0.17 ] (0.0012 - 0.0067)</td>
<td>[ 0.25 ] (0.0098)</td>
<td></td>
</tr>
<tr>
<td>Outer rotor to inner rotor clearance</td>
<td></td>
<td>[ 0.013 - 0.150 ] (0.00051 - 0.00591)</td>
<td>[ 0.250 ] (0.00984)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotor to cover clearance</td>
<td></td>
<td>[ 0.04 - 0.09 ] (0.0016 - 0.0036)</td>
<td>[ 0.15 ] (0.0059)</td>
<td></td>
<td></td>
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<tr>
<td>Outer rotor to case clearance</td>
<td>[ 0.20 - 0.28 ] (0.0079 - 0.0110)</td>
<td>[ 0.50 ] (0.0197)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Diameter of main shaft</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>13,000 - 12,985 (0.51181 - 0.51122)</td>
<td>[ 0.032 - 0.074 ] (0.00126 - 0.00291)</td>
<td>[ 0.150 ] (0.00591)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearance of main shaft in pump case</td>
<td></td>
<td></td>
<td></td>
<td>[ ± 0.2 kg/cm² (± 2.8 psi) ]</td>
<td></td>
</tr>
<tr>
<td>Relief valve</td>
<td></td>
<td>[ ± 0.2 kg/cm² (± 19.6 kPa) ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening pressure</td>
<td>3.0 kg/cm² (42.7 psi) [294 kPa]</td>
<td></td>
<td>Make shim adjustment. Pressure varies by 0.15 kg/cm² (2.1 psi) per 1 mm (0.04 in.) thickness of shim.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fit of bearing inner races on pump shaft</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front</td>
<td>17 (0.67)</td>
<td>[ 0.01T - 0.017T ] (0.00047 - 0.00067T)</td>
<td>[ 0.01T - 0.017T ] (0.00047 - 0.00067T)</td>
<td>Replace pump case or pump assembly.</td>
<td></td>
</tr>
<tr>
<td>Rear</td>
<td></td>
<td></td>
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<tr>
<td>Fit of bearing outer races in pump case</td>
<td></td>
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<td></td>
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<tr>
<td>Front</td>
<td>47 (1.85)</td>
<td>[ 0.01L - 0.025L ] (0.00043L - 0.00098L)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rear</td>
<td>40 (1.57)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radial clearance of bearings</td>
<td>17 (0.67)</td>
<td>0.010 - 0.025</td>
<td>0.010 - 0.025</td>
<td>0.045 (0.00177)</td>
<td>Replace bearings if they fail to rotate smoothly when slowly turned.</td>
</tr>
<tr>
<td>Inside diameter of spacer for shaft</td>
<td>17 (0.67)</td>
<td>0.010 - 0.025</td>
<td>0.010 - 0.022</td>
<td>0.045 (0.00177)</td>
<td></td>
</tr>
<tr>
<td>Clearance of impeller on both sides</td>
<td>0.5 - 1.0</td>
<td>(0.020 - 0.039)</td>
<td></td>
<td>[ 0.001 - 0.017 ] (0.00004 - 0.00067)</td>
<td>Replace impeller if any sign of rubbing contact is noted.</td>
</tr>
<tr>
<td>Unit seal</td>
<td></td>
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</tr>
<tr>
<td>Protrusion of carbon</td>
<td>1.5 (0.059)</td>
<td></td>
<td></td>
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<tr>
<td>Height (free state)</td>
<td>21.8 (0.858)</td>
<td>± 1 (± 0.04)</td>
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<tr>
<td>Thermostat</td>
<td></td>
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<tr>
<td>Valve opening temp./valve lift at 90°C</td>
<td>76.5°C (169.7°F)</td>
<td>± 2°C (± 3.6°F)</td>
<td></td>
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<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Valve opening pressure</td>
<td>220 or 180 kg/cm² (3128 or 2560 psi)</td>
<td>+5 – +15 kg/cm² (+71 – +213 psi)</td>
<td></td>
<td></td>
<td>Make shim adjustment. Pressure varies by 10 kg/cm² (142.2 psi) per 0.1 mm (0.004 in.) thickness of shim.</td>
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<tr>
<td>Spray angle</td>
<td>155°</td>
<td></td>
<td></td>
<td></td>
<td>Test by means of hand tester, using diesel fuel, at 20°C (68°F). If spray pattern is poor even after nozzle is washed in clean diesel fuel, replace nozzle tip.</td>
</tr>
<tr>
<td>Oil-tightness of needle valve seat</td>
<td>Seat shall hold a test pressure 20 kg/cm² (284.4 psi) lower than valve opening pressure for 10 seconds.</td>
<td></td>
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<td></td>
<td>Wash or replace nozzle tip</td>
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</tr>
<tr>
<td>Diameter of commutator</td>
<td></td>
<td>32 (1.26)</td>
<td></td>
<td>31 (1.22)</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>[38.7 (1.524)]</td>
<td></td>
<td>[37.7 (1.484)]</td>
<td></td>
</tr>
<tr>
<td>Brush</td>
<td>Length</td>
<td>18 (0.71)</td>
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<td></td>
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<td></td>
<td></td>
<td>[17 (0.67)]</td>
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<tr>
<td></td>
<td>Spring pressure</td>
<td>3.5 (7.7)</td>
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<tr>
<td></td>
<td>kg (lb)</td>
<td>[2.5 (5.5)]</td>
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<td></td>
<td>Thrust gap of pinion shaft</td>
<td>0.5 (0.020)</td>
<td></td>
<td>0, minimum</td>
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<td></td>
<td>Pinion gap</td>
<td>0.5 - 2.0</td>
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<tr>
<td></td>
<td></td>
<td>[0.020 - 0.079]</td>
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<td>[0.1 - 2.5 (0.004 - 0.098)]</td>
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<tr>
<td>Alternator</td>
<td>Brush length</td>
<td>18 (0.71)</td>
<td></td>
<td>8 (0.31)</td>
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<tr>
<td></td>
<td>Brush spring tension</td>
<td></td>
<td></td>
<td>210 grams (0.5 lb)</td>
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<tr>
<td></td>
<td>Outside diameter of slip ring</td>
<td>33 (1.30)</td>
<td></td>
<td>32.4 (1.276)</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>No-load characteristics</th>
<th>Locked characteristics</th>
<th>Magnetic switch operating voltage</th>
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</thead>
<tbody>
<tr>
<td>Voltage V</td>
<td>Current A</td>
<td>Speed rpm</td>
</tr>
<tr>
<td>Starter</td>
<td>11</td>
<td>130, max.</td>
</tr>
</tbody>
</table>

Unit: mm (in.)
## Tightening Torque

**Important Bolts and Nuts**

<table>
<thead>
<tr>
<th>Secured part or component</th>
<th>Thread dia.-pitch mm</th>
<th>Width across flats</th>
<th>Tightening torque</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder head bolts</td>
<td>12 – 1.75</td>
<td>19</td>
<td>12 ± 0.5</td>
<td>67 ± 4</td>
</tr>
<tr>
<td>Rocker shaft brackets</td>
<td>8 – 1.25</td>
<td>12</td>
<td>1.5 ± 0.5</td>
<td>11 ± 4</td>
</tr>
<tr>
<td>Main bearing caps</td>
<td>14 – 2</td>
<td>22</td>
<td>10.4 ± 0.5</td>
<td>75 ± 4</td>
</tr>
<tr>
<td>Connecting rod caps</td>
<td>12 – 1.25</td>
<td>17</td>
<td>8.5 ± 0.5</td>
<td>61 ± 4</td>
</tr>
<tr>
<td>Flywheel</td>
<td>12 – 1.25</td>
<td>17</td>
<td>8.5 ± 0.5</td>
<td>61 ± 4</td>
</tr>
<tr>
<td>Camshaft thrust plate</td>
<td>8 – 1.25</td>
<td>12</td>
<td>1.8</td>
<td>13</td>
</tr>
<tr>
<td>Front plate</td>
<td>10 – 1.5</td>
<td>14</td>
<td>1.8</td>
<td>13</td>
</tr>
<tr>
<td>Timing gear case bolts</td>
<td>10 – 1.5</td>
<td>14</td>
<td>1.8</td>
<td>13</td>
</tr>
<tr>
<td>Timer cover</td>
<td>8 – 1.25</td>
<td>12</td>
<td>1.3 ± 0.3</td>
<td>9 ± 2</td>
</tr>
<tr>
<td>Crankshaft pulley</td>
<td>24 – 1.5</td>
<td>36</td>
<td>40 ± 0.5</td>
<td>289 ± 4</td>
</tr>
<tr>
<td>Idler thrust plate</td>
<td>10 – 1.25</td>
<td>14</td>
<td>3.5</td>
<td>25</td>
</tr>
<tr>
<td>Oil pan</td>
<td>8 – 1.25</td>
<td>12</td>
<td>0.7</td>
<td>5</td>
</tr>
<tr>
<td>Oil pan drain plug</td>
<td>12 – 1.25</td>
<td>19</td>
<td>10 ± 0.5</td>
<td>72 ± 4</td>
</tr>
<tr>
<td>Oil pump mounting bolts</td>
<td>12 – 1.75</td>
<td>17</td>
<td>5.5 ± 0.5</td>
<td>40 ± 4</td>
</tr>
<tr>
<td>Nozzle gland</td>
<td>8 – 1.25</td>
<td>12</td>
<td>2.2</td>
<td>16</td>
</tr>
<tr>
<td>Injection nozzle retaining nuts</td>
<td>15 – 0.5</td>
<td>14</td>
<td>3</td>
<td>22</td>
</tr>
<tr>
<td>Injection pump delivery valve holders</td>
<td>10 – 1.5</td>
<td>14</td>
<td>3.5 – 4.0</td>
<td>25 – 29</td>
</tr>
<tr>
<td>Injection pump gear</td>
<td></td>
<td></td>
<td>8.5 – 10.0</td>
<td>61 – 72</td>
</tr>
<tr>
<td>Starter B terminal</td>
<td>8 – 1.25</td>
<td>12</td>
<td>1.0 – 1.2</td>
<td>7 – 9</td>
</tr>
</tbody>
</table>

Remarks: apply engine oil to threads of parts specified as [Wet] in Remarks column.
### General Bolts and Nuts

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Pitch</th>
<th>With spring washer</th>
<th>Without spring washer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>kg.m</td>
<td>lb.ft</td>
</tr>
<tr>
<td>8 mm</td>
<td>1.0</td>
<td>1.8</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>1.25</td>
<td>1.8</td>
<td>13</td>
</tr>
<tr>
<td>10 mm</td>
<td>1.25</td>
<td>3.6</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>3.4</td>
<td>25</td>
</tr>
<tr>
<td>12 mm</td>
<td>1.25</td>
<td>6.5</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>1.75</td>
<td>6.0</td>
<td>43</td>
</tr>
<tr>
<td>14 mm</td>
<td>1.5</td>
<td>10.4</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>9.8</td>
<td>71</td>
</tr>
<tr>
<td>16 mm</td>
<td>1.5</td>
<td>15.8</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>15.0</td>
<td>108</td>
</tr>
<tr>
<td>18 mm</td>
<td>1.5</td>
<td>22.9</td>
<td>166</td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>20.7</td>
<td>150</td>
</tr>
</tbody>
</table>
## Sealants

<table>
<thead>
<tr>
<th>Application point</th>
<th>Mating parts</th>
<th>Sealant</th>
<th>How to use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil pan gasket</td>
<td>Front and rear bearing cap seats of crankcase</td>
<td>ThreeBond 1104 Permatex No. 2</td>
<td>Apply to front and rear lower sides (bearing cap seats).</td>
</tr>
<tr>
<td>• Plugs for water and oil holes in crankcase</td>
<td>• Crankcase</td>
<td>Hermeseal H-1 Locktite 567 Thread Sealant</td>
<td>Apply to holes before installing plugs.</td>
</tr>
<tr>
<td>• Plug for water hole in cylinder head</td>
<td>• Cylinder head</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screw plug for crankcase main oil gallery (taper plug)</td>
<td>Crankcase</td>
<td>Loctite 271</td>
<td>Apply to threads.</td>
</tr>
<tr>
<td>Water bypass hose and pipe</td>
<td>Thermostat cover, elbow and water pump</td>
<td>Loctite 271</td>
<td>Apply to threads.</td>
</tr>
<tr>
<td>Front and rear bearing cap side seals of crankcase</td>
<td>Bearing caps (front and rear side seal contact surfaces)</td>
<td>ThreeBond 1105D Permatex No. 2</td>
<td>Apply to crankcase before installing front and rear bearing caps.</td>
</tr>
<tr>
<td>Timing gear case gasket</td>
<td>Timing gear</td>
<td>ThreeBond 1102 Permatex No. 2</td>
<td>Apply to gasket surface of timing gear case.</td>
</tr>
</tbody>
</table>
Special Tools

Part numbers for special tools listed in this manual are Mitsubishi part numbers. Contact a local Mitsubishi Engine Distributor or:

Mitsubishi Engine North America
610 Supreme Drive
Bensonville, IL 60106

Some special tools can also be ordered from the TORO SPECIAL TOOLS AND APPLICATIONS GUIDE (COMMERCIAL PRODUCTS). Some tools may also be available from a local supplier.

<table>
<thead>
<tr>
<th>Tool name</th>
<th>Mitsubishi Part No.</th>
<th>Shape</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idler shaft puller</td>
<td>34491-02300</td>
<td></td>
<td>Idler shaft removal</td>
</tr>
<tr>
<td>Idler bushing puller</td>
<td>30091-07300</td>
<td></td>
<td>Idler bushing removal/Installation</td>
</tr>
<tr>
<td>Socket</td>
<td>34491-00300</td>
<td></td>
<td>Camshaft thrust plate removal/installation</td>
</tr>
<tr>
<td>Universal extension</td>
<td>30091-01101</td>
<td></td>
<td>PE-A type fuel injection pump removal/installation</td>
</tr>
<tr>
<td>Cranking handle</td>
<td>30691-11800</td>
<td></td>
<td>Engine cranking</td>
</tr>
<tr>
<td>Tool name</td>
<td>Mitsubishi Part No.</td>
<td>Shape</td>
<td>Use</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------------------------</td>
<td>------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Valve guide installer</td>
<td>34491-00400</td>
<td></td>
<td>Valve guide installation</td>
</tr>
<tr>
<td>Valve guide remover</td>
<td>31391-10500</td>
<td></td>
<td>Valve guide removal</td>
</tr>
<tr>
<td>Valve spring pusher</td>
<td>30691-04500</td>
<td></td>
<td>Valve spring removal/ installation</td>
</tr>
<tr>
<td>Insert caulk-ing tool</td>
<td>(For exhaust) 36791-00200</td>
<td></td>
<td>Valve seat installation</td>
</tr>
<tr>
<td></td>
<td>(For inlet) 36791-00300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleeve installer</td>
<td>34491-02100</td>
<td></td>
<td>Cylinder sleeve installation</td>
</tr>
<tr>
<td>Piston ring pliers</td>
<td>31391-12900</td>
<td></td>
<td>Piston ring removal/Installation</td>
</tr>
<tr>
<td>Piston guide</td>
<td>34491-02200</td>
<td></td>
<td>Piston installation</td>
</tr>
<tr>
<td>Tool name</td>
<td>Mitsubishi Part No.</td>
<td>Shape</td>
<td>Use</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------</td>
<td>-------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Adaptor</td>
<td>36791-00100</td>
<td></td>
<td>Engine compression pressure measurement</td>
</tr>
<tr>
<td>Puller assembly</td>
<td>64309-12900</td>
<td></td>
<td>Crankshaft gear, camshaft gear, crankshaft pulley and water pump pulley removal</td>
</tr>
<tr>
<td>Compression gauge</td>
<td>33391-02100</td>
<td></td>
<td>Compression pressure measurement</td>
</tr>
<tr>
<td>Crankshaft sleeve installer</td>
<td>30691-13010</td>
<td></td>
<td>Oil seal sleeve on crankshaft rear side installation</td>
</tr>
<tr>
<td>Cone removing Tool</td>
<td>34791-01100</td>
<td></td>
<td>For removing crankshaft pulley</td>
</tr>
</tbody>
</table>
# Troubleshooting

Giving immediate attention to any indication of a problem can prevent major failures, and increase the life of the engine. Never make more than one adjustment at a time, then locate the trouble by a process of elimination. Remember the cause is usually SIMPLE, rather than mysterious and complicated.

## Engine Fails to Start

<table>
<thead>
<tr>
<th>Problem/ Probable Cause</th>
<th>Possible Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Slow cranking speed.</td>
<td>Use correct oil.</td>
</tr>
<tr>
<td>Engine oil viscosity too high.</td>
<td>Charge the battery.</td>
</tr>
<tr>
<td>Battery is discharged.</td>
<td>Replace the battery.</td>
</tr>
<tr>
<td>Battery plates sulfated.</td>
<td>Clean the terminals/repair tighten cables.</td>
</tr>
<tr>
<td>Battery terminal dirty or poor connection</td>
<td>Repair or replace starter.</td>
</tr>
<tr>
<td>Starter Failure.</td>
<td></td>
</tr>
<tr>
<td>• Fuel not reaching injection pump.</td>
<td>Clean or replace fuel lines.</td>
</tr>
<tr>
<td>Fuel lines clogged or damaged.</td>
<td>Replace filter element(s).</td>
</tr>
<tr>
<td>Fuel filter or fuel/water separator clogged.</td>
<td>Bleed system; correct cause of air in system.</td>
</tr>
<tr>
<td>Air in fuel system.</td>
<td>Clean or replace filter.</td>
</tr>
<tr>
<td>Fuel feed pump filter clogged.</td>
<td>Repair or replace check valve.</td>
</tr>
<tr>
<td>Defective check valve in fuel feed pump.</td>
<td>Replace spring.</td>
</tr>
<tr>
<td>Piston spring in fuel feed pump broken.</td>
<td>Repair or replace push rod or tappet.</td>
</tr>
<tr>
<td>Push rod or tapped in fuel feed pump sticking.</td>
<td></td>
</tr>
<tr>
<td>• Fuel injection pump.</td>
<td>Repair and adjust throttle cable.</td>
</tr>
<tr>
<td>Faulty throttle cable connection.</td>
<td>Inspect and repair control rack.</td>
</tr>
<tr>
<td>Control rack defective or sticking.</td>
<td>Replace camshaft bearing.</td>
</tr>
<tr>
<td>Damaged camshaft bearing.</td>
<td>Correct or replace plunger.</td>
</tr>
<tr>
<td>Plunger worn or sticking.</td>
<td></td>
</tr>
<tr>
<td>• Fuel injection nozzle</td>
<td>Replace gasket if necessary. Tighten retaining bolt.</td>
</tr>
<tr>
<td>Fuel leakage; loose nozzle retaining bolt.</td>
<td>Adjust nozzle.</td>
</tr>
<tr>
<td>Low nozzle opening pressure.</td>
<td>Replace spring.</td>
</tr>
<tr>
<td>Nozzle pressure spring broken.</td>
<td>Replace pressure pin.</td>
</tr>
<tr>
<td>Nozzle pressure pin worn or damaged.</td>
<td>Clean or replace nozzle tip.</td>
</tr>
<tr>
<td>Clogged or damaged nozzle tip.</td>
<td></td>
</tr>
<tr>
<td>• Injection pump out of timing.</td>
<td>Adjust Injection timing.</td>
</tr>
<tr>
<td>Improperly retarded injection timing.</td>
<td>Check timing to engine and correct.</td>
</tr>
<tr>
<td>Incorrect timing; improper installation of pump.</td>
<td>Replace key.</td>
</tr>
<tr>
<td>Pump camshaft key damaged.</td>
<td>Adjust tappets to get specified timing.</td>
</tr>
<tr>
<td>Improper tappet adjustment.</td>
<td></td>
</tr>
<tr>
<td>• Low compression.</td>
<td>Adjust valve clearance.</td>
</tr>
<tr>
<td>Valve seat surface rough, or burnt.</td>
<td>Replace the spring.</td>
</tr>
<tr>
<td>Valve spring broken.</td>
<td>Replace the gasket.</td>
</tr>
<tr>
<td>Leaking cylinder head gasket.</td>
<td>Overhaul the engine.</td>
</tr>
<tr>
<td>Piston rings seized.</td>
<td>Overhaul the engine.</td>
</tr>
<tr>
<td>Piston rings and cylinder worn.</td>
<td></td>
</tr>
<tr>
<td>• Governor lever position incorrect.</td>
<td>Adjust governor lever.</td>
</tr>
<tr>
<td>• Governor spring broken or disconnected.</td>
<td>Repair governor spring.</td>
</tr>
</tbody>
</table>

---

Troubleshooting  Page 3 - 26  Groundsmaster® 580-D
### Low Power

<table>
<thead>
<tr>
<th>Problem/ Probable Cause</th>
<th>Possible Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Low compression.</td>
<td>Refer to Engine Fails to Start - Low compression.</td>
</tr>
<tr>
<td>• Injection pump out of timing.</td>
<td>Check and adjust timing.</td>
</tr>
<tr>
<td>Excessively advanced timing (knocking).</td>
<td>Check and adjust timing.</td>
</tr>
<tr>
<td>Excessively retarded timing (black smoke).</td>
<td></td>
</tr>
<tr>
<td>• Lack of fuel.</td>
<td>Inspect fuel line connections.</td>
</tr>
<tr>
<td>Air in fuel system.</td>
<td>Clean/replace filters.</td>
</tr>
<tr>
<td>Filter(s) clogged.</td>
<td>Clean the fuel tank.</td>
</tr>
<tr>
<td>Fuel tank is contaminated.</td>
<td>Repair or replace fuel feed pump.</td>
</tr>
<tr>
<td>Feed pressure too low.</td>
<td></td>
</tr>
<tr>
<td>• Fuel injection nozzle</td>
<td>Replace gasket if necessary.</td>
</tr>
<tr>
<td>Fuel leakage; loose nozzle retaining bolt.</td>
<td>Tighten retaining bolt.</td>
</tr>
<tr>
<td>Low nozzle opening pressure.</td>
<td>Adjust nozzle.</td>
</tr>
<tr>
<td>Nozzle pressure spring broken.</td>
<td>Replace spring.</td>
</tr>
<tr>
<td>Nozzle pressure pin worn or damaged.</td>
<td>Replace pressure pin.</td>
</tr>
<tr>
<td>Clogged or damaged nozzle tip.</td>
<td>Clean or replace nozzle tip.</td>
</tr>
<tr>
<td>• Fuel injection pump faulty.</td>
<td>Replace gasket if necessary and tighten.</td>
</tr>
<tr>
<td>Fuel leakage from delivery valve holder.</td>
<td>Repair or replace delivery valve.</td>
</tr>
<tr>
<td>Defective fuel delivery valve seat.</td>
<td>Replace spring.</td>
</tr>
<tr>
<td>Delivery valve spring broken.</td>
<td>Replace plunger.</td>
</tr>
<tr>
<td>Plunger worn or damaged.</td>
<td>Adjust fuel delivery.</td>
</tr>
<tr>
<td>Large spread in fuel delivery.</td>
<td>Adjust fuel injection pump delivery timing.</td>
</tr>
<tr>
<td>Injection delivery not at specified intervals.</td>
<td>Replace roller.</td>
</tr>
<tr>
<td>Tappet roller worn.</td>
<td>Replace bearing.</td>
</tr>
<tr>
<td>Camshaft bearing worn or damaged.</td>
<td>Adjust full load stopper.</td>
</tr>
<tr>
<td>Governor full load stopper out of adjustment.</td>
<td></td>
</tr>
<tr>
<td>• Air cleaner is clogged.</td>
<td>Service air cleaner.</td>
</tr>
<tr>
<td>• Engine overheats.</td>
<td>Check coolant.</td>
</tr>
<tr>
<td>Low or incorrect coolant level.</td>
<td>Adjust belt tension.</td>
</tr>
<tr>
<td>Improper belt tension.</td>
<td>Replace water pump.</td>
</tr>
<tr>
<td>Radiator and/or screen clogged.</td>
<td>Adjust injection timing.</td>
</tr>
<tr>
<td>Injection timing incorrect.</td>
<td>Add engine oil.</td>
</tr>
<tr>
<td>Engine oil level is low.</td>
<td>Replace thermostat.</td>
</tr>
<tr>
<td>• Turbocharger/exhaust system.</td>
<td>Check line from manifold to turbocharger gas inlet.</td>
</tr>
<tr>
<td>Leaking exhaust gas.</td>
<td>Decarbon muffler.</td>
</tr>
<tr>
<td>High back pressure; carbon build up in muffler.</td>
<td>Check air hoses from turbocharger to intake manifold.</td>
</tr>
<tr>
<td>Boost air leaking.</td>
<td>Clean compressor.</td>
</tr>
<tr>
<td>Dirty compressor.</td>
<td>Clean, repair or replace turbocharger.</td>
</tr>
<tr>
<td>Rotor does not spin.</td>
<td></td>
</tr>
</tbody>
</table>
## Abnormal Engine Noises

<table>
<thead>
<tr>
<th>Problem/ Probable Cause</th>
<th>Possible Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Unusually loud knocking.</td>
<td>Check and adjust timing.</td>
</tr>
<tr>
<td>• Improper injection timing.</td>
<td>Clean and/or repair nozzle.</td>
</tr>
<tr>
<td>• Faulty fuel nozzle spray pattern; after dribble.</td>
<td>Adjust opening pressure.</td>
</tr>
<tr>
<td>• High nozzle opening pressure.</td>
<td>Adjust fuel delivery.</td>
</tr>
<tr>
<td>• Incorrect fuel delivery to a some nozzles.</td>
<td>Refer to Engine Fails to Start - Low compression.</td>
</tr>
<tr>
<td>• Poor compression or overcooled engine.</td>
<td></td>
</tr>
<tr>
<td>• Turbocharger</td>
<td></td>
</tr>
<tr>
<td>• Damaged bearings.</td>
<td>Repair or replace turbocharger. Could be caused by continual use of deteriorated engine oil or inadequate oil supply because of clogged filter or pipe. Can also be cause by excessive quick cold starting or hot engine shut-downs.</td>
</tr>
<tr>
<td>• Rubbing parts.</td>
<td>Repair or replace turbocharger. Evidence of rubbing contact on rotating parts indicates loss of balance in rotating mass or a distorted shaft, caused by worn bearing or airborne or gasborne object hitting compressor or turbine wheel.</td>
</tr>
<tr>
<td>• Crankshaft and main bearing.</td>
<td></td>
</tr>
<tr>
<td>• Worn crankshaft.</td>
<td>Repair or replace crankshaft; inspect bearings.</td>
</tr>
<tr>
<td>• Worn or damaged bearings.</td>
<td>Replace bearings; inspect crankshaft.</td>
</tr>
<tr>
<td>• Connecting rod and bearings.</td>
<td></td>
</tr>
<tr>
<td>• Connecting rod bearing worn.</td>
<td>Replace bearing; inspect crankshaft.</td>
</tr>
<tr>
<td>• Worn crankpin.</td>
<td>Repair or replace crankshaft; inspect bearing.</td>
</tr>
<tr>
<td>• Twisted connecting rod.</td>
<td>Replace connecting rod.</td>
</tr>
<tr>
<td>• Piston, piston pin, and piston rings.</td>
<td></td>
</tr>
<tr>
<td>• Cylinder is worn.</td>
<td>Overhaul engine.</td>
</tr>
<tr>
<td>• Piston pin is worn.</td>
<td>Replace piston and pin, inspect cylinder rod, and rings.</td>
</tr>
<tr>
<td>• Rocker arm mechanism and relative parts.</td>
<td></td>
</tr>
<tr>
<td>• Camshaft is worn.</td>
<td>Replace camshaft.</td>
</tr>
<tr>
<td>• Excessive valve clearance.</td>
<td>Adjust the valve clearance.</td>
</tr>
<tr>
<td>• Worn timing gear.</td>
<td>Replace the timing gear; inspect mating gears.</td>
</tr>
</tbody>
</table>
### Excessive Oil Consumption

<table>
<thead>
<tr>
<th>Problem/ Probable Cause</th>
<th>Possible Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Oil leaks.</td>
<td></td>
</tr>
<tr>
<td>Oil seals worn.</td>
<td>Check for wear, and replace of worn.</td>
</tr>
<tr>
<td>Gaskets leaking.</td>
<td></td>
</tr>
<tr>
<td>Loose fasteners.</td>
<td>Replace the gasket.</td>
</tr>
<tr>
<td>Drain plug is loose.</td>
<td>Retighten fasteners.</td>
</tr>
<tr>
<td>Pipe plugs at oil pump loose.</td>
<td>Tighten the plug.</td>
</tr>
<tr>
<td>Oil leak from turbocharger gas outlet pipe or inlet air pipe.</td>
<td>Tighten the plugs.</td>
</tr>
<tr>
<td>• Burning oil.</td>
<td>Service air cleaner; clogged air cleaner causing negative pressure on suction side, drawing in lubricating oil.</td>
</tr>
<tr>
<td>Ring end gaps in wrong position.</td>
<td>Stagger end gaps properly.</td>
</tr>
<tr>
<td>Connecting rod bend or twisted.</td>
<td>Overhaul the engine.</td>
</tr>
<tr>
<td>Piston rings worn.</td>
<td>Replace the rings. Overhaul the engine.</td>
</tr>
<tr>
<td>Faulty valve stem seal.</td>
<td>Replace valve stem seal.</td>
</tr>
<tr>
<td>Valves or valve guides worn.</td>
<td>Replace valves or valve guides.</td>
</tr>
</tbody>
</table>

### Engine Runs Rough

<table>
<thead>
<tr>
<th>Problem/ Probable Cause</th>
<th>Possible Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Injection pump mechanism.</td>
<td></td>
</tr>
<tr>
<td>Irregular injection pump volume</td>
<td>Repair or replace injection pump.</td>
</tr>
<tr>
<td>Faulty control rack function.</td>
<td>Repair or replace injection pump.</td>
</tr>
<tr>
<td>Worn delivery valve.</td>
<td>Replace delivery valve.</td>
</tr>
<tr>
<td>Faulty injection nozzle.</td>
<td>Repair or replace nozzle.</td>
</tr>
<tr>
<td>• Governor mechanism.</td>
<td></td>
</tr>
<tr>
<td>Governor lever binding.</td>
<td>Inspect/repair governor.</td>
</tr>
<tr>
<td>Stretched or weak governor spring.</td>
<td>Replace the spring.</td>
</tr>
</tbody>
</table>

### Excessive Smoke

<table>
<thead>
<tr>
<th>Problem/ Probable Cause</th>
<th>Possible Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Black smoke.</td>
<td></td>
</tr>
<tr>
<td>Excessive fuel delivery.</td>
<td>Adjust fuel delivery.</td>
</tr>
<tr>
<td>Excessively advanced fuel injection.</td>
<td>Check and adjust timing.</td>
</tr>
<tr>
<td>Intake air restriction.</td>
<td>Service air cleaner.</td>
</tr>
<tr>
<td>Large spread in fuel delivery.</td>
<td>Adjust fuel delivery.</td>
</tr>
<tr>
<td>Faulty spray pattern from injector nozzle.</td>
<td>Clean and/or repair nozzle.</td>
</tr>
<tr>
<td>• White smoke</td>
<td></td>
</tr>
<tr>
<td>Excessively retarded fuel injection timing.</td>
<td>Check and adjust fuel injection timing.</td>
</tr>
<tr>
<td>Water in fuel.</td>
<td>Check and clean fuel system.</td>
</tr>
<tr>
<td>Lubricant entering engine combustion chamber.</td>
<td>Check turbocharger for lubricant leakage from damaged turbocharger piston ring.</td>
</tr>
<tr>
<td>Overcooled engine.</td>
<td>Replace thermostat.</td>
</tr>
</tbody>
</table>
General Overhaul Instructions

Determining When to Overhaul the Engine

Engine compression is the most common means of determining when to overhaul the engine, although constant monitoring of the engine oil and fuel consumption may limit the repair required by catching the need for repair earlier.

The following items will be noted when compression pressure drops:

A. Low power or loss of power.
B. Increase in fuel consumption.
C. Increase in lubricating oil consumption.
D. Excessive blowby through breather due to worn cylinder sleeves, pistons, etc.
E. Excessive blowby due to poor seating of worn inlet and exhaust valves.
F. Hard starting.
G. Excessive abnormal noise.

Among the items listed above, B. and F. symptoms alone may be caused by a fuel injection pump improperly adjusted with respect to injection quantity or injection timing, worn injection pump plungers, faulty injection nozzles, or poor care of the battery, starter, and alternator. Item C. could be caused by a misadjusted valve on an engine with limited use.

Disassembly Precautions

1. Use the right tools and instruments.
2. Place the disassembled and cleaned parts in the order in which they were removed in preparation for reassembly.
3. Pay attention to orientation marks on assemblies, components and parts. If necessary, mark items to aid reassembly.
4. Carefully check each part’s condition during removal or cleaning.
5. Use a hoist, jack, or some other means of assistance when lifting or carrying heavy or awkward components.

Reassembly Precautions

1. Use the right tools and instruments.
2. Clean all engine parts before reinstalling.
3. Use only quality and clean lubricating oils and greases during assembly.
4. Use a torque wrench to tighten parts when tightening torques are specified.
5. Replace gaskets and O-rings during assembly. Use the proper sealants where specified.
Testing Compression Pressure

1. Remove the injection nozzle from the cylinder to be measured.

2. Attach the gauge adaptor and compression gauge (Fig. 4).

3. Crank the engine and note the compression gauge reading when the engine begins to rotate at the specified speed (150-200 RPM).

4. If the compression pressure is lower than the Repair Limit, the engine should be inspected to find the cause of loss or overhauled.

**IMPORTANT:** Be sure to measure the compression pressure on all cylinders. Do not measure the compression pressure on two or three cylinders and judge the remaining cylinders from those readings.

The compression pressure varies with change of engine rpm. Always check engine rpm at the time of measuring the compression pressure.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression pressure</td>
<td>27 kg/cm (384 psi)</td>
<td>24 kg/cm (341 psi)</td>
</tr>
</tbody>
</table>

**NOTE:** Measure the compression pressure with the engine rotating at 150-200 rpm.

**IMPORTANT:** Take compression readings periodically as part of the regular maintenance routine. Changes in the readings may be used to catch a problem before it becomes severe.

**NOTE:** The compression readings may be slightly beyond the assembly standard in a new or recently overhauled engine. The readings will stabilize as the rings and valves seat.
Adjustments

Valve Clearance

Inspect and adjust the valve clearance when the engine is cold.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve clearance</td>
<td>0.25 mm (0.01 in.)</td>
</tr>
<tr>
<td>(cold)</td>
<td>Inlet</td>
</tr>
<tr>
<td></td>
<td>Exhaust</td>
</tr>
</tbody>
</table>

1. Inspecting valve clearance

A. Inspect valve clearance by firing order. Turn the crankshaft to the specified crank angle in normal direction of rotation to bring the piston to its top dead center on compression stroke.

<table>
<thead>
<tr>
<th>Firing Order</th>
<th>Crank angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3-4-2</td>
<td>180°</td>
</tr>
</tbody>
</table>

B. Top dead center on the compression stroke of the piston is identified by the timing mark "0" on the crankshaft pulley. With the "0" aligned with the pointer on the gear case, inlet and exhaust valve rocker arms will not be pushed up by their pushrods.

C. Insert a feeler gauge between the rocker arm and valve cap. The valve clearance should be .0098 in (.25 mm).

2. Adjusting valve clearance

A. Loosen the adjusting screw lock nut and adjust the clearance by turning the screw.

B. After adjusting the clearance, tighten the lock nut. Inspect the clearance again to make sure that it has not changed.
Primming / Bleeding Fuel System

1. Open hood latches, raise hood and secure it in raised position with prop rod (Fig. 7). Open left side panel latch and remove side panel.

2. Loosen air bleed screw at top of fuel filter/water separator (Fig. 8). Fuel will flow out around the screw. When a solid stream of fuel flows out around screw, tighten screw.

NOTE: If fuel tank is over half full, gravity will fill fuel filter and fuel will flow out of fuel bleed screw when open. If tank is less than half full, fill tank.

3. Loosen air vent plug on engine fuel filter approximately 1-1/2 turns (Fig. 9).

4. Rotate priming pump counterclockwise until spring in pump releases and handle extends. Operate pump up and down until a solid stream of fuel flows out around filter plug, then tighten plug (Fig. 9).

5. Loosen air vent plug on injection pump approximately 1-1/2 turns (Fig. 10). Operate priming pump until solid stream of fuel flows from vent hole, then tighten vent plug.

6. Push priming pump handle down to compress spring and rotate clockwise to lock in closed position.

7. Try to start the engine. If engine starts, install left side panel, lower hood and continue operation. If engine does not start, repeat steps 2 - 6.
Fuel Injection Timing

1. Bringing No.1 piston to top dead center on compression stroke

   A. Rotate the crankshaft in the direction of normal rotation.

   B. Stop rotating when the timing mark "O" on the crankshaft pulley is aligned with the pointer.

   C. Remove the valve cover and inspect the No. 1 cylinder push rods. The intake and exhaust valve push rods should be loose. If they are under tension, rotate the crankshaft 360 degrees (one full revolution) and check again.

2. Inspecting fuel injection timing

   A. Remove the delivery valve holder from No. 1 pumping element of injection pump. Take delivery valve and spring out of the holder and reassemble the holder to the pump. Leave feed line disconnected.

   B. Turn the crankshaft to position the No. 1 piston to about 60 degrees before top dead center on the compression stroke.

   C. Operate the priming pump to allow fuel to flow out from the delivery valve holder. Slowly move the engine crankshaft in the direction of normal rotation until the fuel just stops flowing.

   D. Check that the 16° BTDC timing mark on the crankshaft pulley is aligned with the pointer, indicating that the fuel injection is properly timed.

3. Adjusting fuel injection timing

   A. To advance the pump timing, shift the injection pump toward the crankcase. To retard, shift the pump away from the crankcase.

   B. Each mark on the injection pump coupling equals 6 degrees of crank angle (Fig. 14).
No-load Minimum Idling Speed And Maximum Speed

**CAUTION**

No-load minimum idling speed and maximum speed set for each engine on the test bench at the factory and the set bolts are sealed. These settings are to be inspected and adjusted at an authorized shop only.

When inspecting and adjusting these settings, be on standby to operate the engine stop lever manually in the event of engine overspeed.

For inspection and adjustment, warm up the engine thoroughly until the coolant and oil temperature rises to 70 degrees C (158 degrees F).

1. Engine starting

   A. Move speed control lever to full throttle. Operate key switch to crank the engine.

   B. Immediately after the engine starts, move speed control lever to half throttle to warm engine.

   C. When the engine is noted to be running with a steady speed, move speed control lever to the idling speed position.

2. Idling set

   A. Hold speed control lever at the idle position.

   **IMPORTANT:** If the engine exhibits excessive vibration, shift the idle setting to a lower or higher idling level. The acceptable range is 1100-1200 rpm.
B. Turning the set bolt clockwise raises the idle speed.

C. If engine speed fluctuates at idle speed, turn the idle sub-spring adjusting screw clockwise to internally make slight contact with tension lever. The speed may rise slightly but should stop fluctuating.

IMPORTANT: When adjusting the screw, be sure to move it just enough to eliminate the unstable condition. Overadjusting the idle sub-spring screw is likely to result in engine overspeeding when the load is disengaged during operation.

3. Rack set (maximum engine output)

A. Hold speed control lever at the position for the indicated output and speed (2750 rpm).

B. Under this condition, check to be sure that the engine is running in a steady state.

C. With the engine running in a steady condition, adjust the full-load stopper bolt, as follows:

D. Reposition the full-load stopper bolt by tightening or loosening to push in or pull out the fuel control rack in order to find out just where the engine produces the rated output.

NOTE: Turning the full-load stopper bolt clockwise will increase the injection quantity (engine output).

E. Having positioned the stopper bolt for the rated output, back it off slowly while observing the speed which will be above the rated speed. Stop backing it off just when the speed begins to fall from the rated level. Secure the stopper bolt rack set bolt in that position with its lock nut.

F. At that time, the speed control lever should be at the position mentioned in A. above.

4. Governor set (maximum engine speed)

A. Hold speed control lever at the indicated maximum speed position while applying full load to the engine.

B. Run in governor set bolt maximum speed set bolt slowly until its forward end comes in contact with speed control lever held as above. Secure the bolt right there by tightening its lock nut.
5. Adjustment of speed regulation (governor notch adjustment)

A. This adjustment increases or decreases the pre-tension of the governor spring.

B. To gain access to the adjusting screw, remove the plug at the top of the governor housing. Move speed control lever all the way to the low idle set bolt.

C. Tightening the adjusting screw increases the pre-tension of the governor spring to narrow speed range; loosening it decreases the governor spring pre-tension to widen the speed range.

D. Changing the setting of this adjusting screw affects the governor set for limiting the maximum engine speed. After making a governor notch adjustment, be sure to re-adjust the governor set as explained earlier.

IMPORTANT: The adjustable range is 20-notches 5 rotations. Never loosen the screw by more than 20 notches from the fully tightened position or the control action of the governor may not function.

Throttle Linkage Adjustment

The throttle lever must not touch end of the slot during full range of motion from idle (SLOW) to full engine rpm (FAST) (Fig. 21).

1. For proper throttle lever operation, tighten nut so length of spring is 1.75 ± 0.06 in. long (Fig. 22).
2. Loosen jam nut and tighten adjusting nut (Fig. 23) so governor lever touches low and high speed set bolts without throttle lever touching end of slot at either FAST or SLOW position (Fig. 21).

**Fuel Stop Solenoid Adjustment**

Loosen jam nut on on front ball joint. With solenoid held IN as far as possible and engine stop lever held BACK as far as possible, adjust rod until it just fits in ball joint on solenoid. Then lengthen rod by turning it counterclockwise three (3) turns.

NOTE: Rod length must be adjusted so solenoid is fully bottomed out when energized or it will not hold in with HOLD coil energized.

**Fan Drive Belt Inspection And Adjustment**

To inspect belt tension, apply thumb pressure to the belt midway between the pulleys. If the tension is incorrect, loosen the bolt (Item 1), make the adjustment, then tighten the bolt.
Engine Removal and Installation

Removing Engine

1. Open hood latches, raise hood and secure it in raised position with prop rod (Fig. 26). Open side panel latches and remove side panels.

2. Remove E-clip from each gas spring bracket (Fig. 27). Do not remove gas spring rod end from bracket at this time.

3. Use a hoist or two (2) other people to help hold hood. Remove four (4) capscrews securing hood to hinges (Fig. 28), disconnect gas spring rod ends from brackets and lift hood off of machine.

4. Remove drain plug from oil pan and drain oil from engine. Disconnect two (2) oil cooler hoses from right side of engine near oil filter. Put caps on open hose ends. Remove hose clamps securing oil cooler hoses to engine.

Groundsmaster® 580-D
5. Drain coolant by opening drain valve or loosening hose clamp and disconnecting lower coolant hose from radiator (Fig. 29). Loosen hose clamps and remove lower radiator hose from engine and radiator. Remove drain plug from left rear of engine block to drain coolant.

6. Remove four (4) capscrews to disconnect drive shaft from engine crankshaft pulley (Fig. 30).

7. Open drain valve on bottom of fuel tank and drain fuel from tank (Fig. 31).
8. Disconnect fuel line from "IN" fitting on fuel filter/water separator (Fig. 32). Disconnect throttle cable from governor lever. Remove two (2) cap screws and keps nuts and remove throttle cable bracket from left rear engine mount. Leave throttle cable attached to bracket. Leave engine run solenoid attached to engine mount.

9. Starting at PTO solenoids, disconnect all wiring harness connectors, ground straps, cables and clamps from engine, brackets and hydraulic PTO manifold block (Fig. 33). Pull wiring harness out from right side of engine.

10. Remove two (2) cap screws and pull battery tray out (Fig. 33). Disconnect cables from batteries.

11. Remove six (6) cap screws and remove rear panel (Fig. 33).

12. Push battery tray approximately half way and align tangs on battery tray with notches on rail, then lift up rear of battery tray and pull completely out of machine (Fig. 34).

13. Remove four (4) cap screws from PTO pump and pull PTO pump shaft out of drive coupling (Fig. 34). Leave hydraulic lines attached to pump.
14. Loosen hose clamps and remove upper radiator hose (Fig. 35). Loosen hose clamps and remove air cleaner intake hose.

15. Remove engine cooling fan and fan coupler (Fig. 35). Remove hydraulic reservoir breather hose clamp from fan shroud. Remove fan shroud.

16. Use two (2) hanger bolts on engine to connect a short length of chain to use as a sling. One bolt is on left rear of engine where ground strap from battery is connected (Fig. 35). Other bolt is at front right of engine next to alternator (Fig. 36).

NOTE: It may be desirable to remove engine accessories before removing engine from chassis. (See Engine Accessory Removal and Installation section of this chapter.)

17. Remove four (4) large capscrews securing engine mount brackets to engine mounts (Fig. 35, 36)

18. Connect hoist or block and tackle chain at center of short section of chain. One person should operate hoist or block and tackle and two (2) other people should help guide engine out of chassis. Remove engine from chassis. Be careful when removing engine to prevent damage to engine, radiator, hydraulic tubing or other parts. Mount engine in an engine rebuilding stand.

19. Put caps or plugs on any hydraulic lines that are disconnected to prevent contamination.

---

**Installing Engine**

1. To install the engine, reverse steps 1 - 19 under Removing Engine.

2. Install a new engine oil filter. Fill engine with correct oil. Fill cooling system with a 50/50 solution of ethylene glycol antifreeze and clean, soft water. Check for oil and coolant leaks and repair as necessary.

3. Fill fuel tank and bleed fuel system.

4. Start engine and check for oil or coolant leaks.

5. Check engine speed and adjust governor lever if necessary for correct idle and maximum engine speed.
Engine Accessory Removal and Installation

This section explains the procedures and tips for removal and installation of the accessories—the preliminary process to go through for overhauling the engine.

Preparatory Steps

A. Shut off fuel supply and disconnect the electrical wiring from the engine.

B. Loosen the drain on left rear side of crankcase and drain coolant.

C. Loosen the oil pan drain plug and drain engine oil.

WARNING

Hot engine fluid can cause personal injury if it contacts the skin. Use caution when draining the fluids.

Engine Accessory Removal

1. Removing turbocharger
   
   A. Disconnect pipe (2) between turbocharger (1) and air cleaner.
   
   B. Disconnect turbocharger lubricating oil pipe (3) and drain pipe (4).
   
   C. Remove turbocharger from exhaust manifold.

2. Removing fuel injection pipes

   A. Remove pipe clamps. Disconnect and remove injection pipes.

   IMPORTANT: Be sure to put caps on the openings of the injection pump and nozzle holders to prevent dust from getting into the fuel system.
3. Removing fuel injection nozzles

Take off nozzle gland (1) and remove nozzle (2) complete with gasket (3).

Figure 38

4. Removing fuel filter and inlet and exhaust manifolds

A. Disconnect fuel hose (1) from fuel filter. Remove filter (2) by unscrewing its mounting bolts.

B. Remove inlet manifold (3) and exhaust manifold (4) by unscrewing mounting bolts.

Figure 39

5. Removing fuel injection pump

Disconnect oil feed pipe (1) and remove cover (2). Remove injection pump (4) from the timing gear case by unscrewing two mounting bolts (3).

Figure 40
6. Removing thermostat

A. Disconnect bypass hose (1).

B. Unscrew elbow attaching bolts, and remove elbow (2), thermostat (3) and gasket (4).

NOTE: At reassembly, install thermostat with its air vent hole facing upward.

7. Removing water pump

A. Remove fan (1). Slacken fan belt (2) and remove it from water pump (4).

B. Disconnect oil pipe (3).

C. Remove water pump by unscrewing its mounting bolts.

8. Removing alternator

A. Disconnect harness (1) and unscrew belt adjusting plate bolt (2).

B. Remove alternator (4) by unscrewing mounting bolts (3).

9. Removing starter

Disconnect harness (1) and remove starter (3) by unscrewing mounting bolts (2).
10. Removing oil filter

Remove oil filter (2) complete with its bracket by unscrewing mounting bolts (1).

![Figure 45]

11. Removing oil pan and oil pump

A. Remove oil pan (2) by unscrewing mounting bolts (1).

B. Remove oil pump (4) by unscrewing mounting bolt (3).

NOTE: Camshaft gear may interfere with pump drive gear and hinder removal. Remove pump by turning crankshaft slightly.

![Figure 46]
Engine Accessory Installation

To install the engine accessories, use reverse of the removal procedures. After installation take the following steps:

1. Installing fuel injection pump

   Make sure that matching marks on pump drive gear and other gears are aligned with those on idler gear as shown.

   NOTE: When these matching marks are all aligned, No. 1 cylinder piston is at top dead center on compression stroke.

2. Refill the engine with recommended oil to the specified level.

3. Refill the cooling system with coolant.

4. Check each pipe connection for oil or coolant leaks.

5. Prime the fuel system.

6. After installing the fuel injection pump, inspect and adjust the injection timing.

Figure 47
Cylinder Head And Valves

Disassembly

Figure 49

1. Rocker cover
2. Eye bolt
3. Oil pipe
4. Adjusting screw
5. Bolt (short)
6. Bolt (long)
7. Valve cap
8. Snap ring
9. Washer
10. Inlet rocker arm
11. Rocker shaft bracket
12. Exhaust rocker arm
13. Rocker shaft spring
14. Rocker shaft
15. Valve pushrod
16. Cylinder head bolt
17. Cylinder head
18. Valve cotter
19. Upper retainer
20. Outer valve spring
21. Valve
22. Valve stem seal
23. Cylinder head gasket
1. Removing rocker shaft assembly

   A. Loosen the adjusting screw of each rocker about one rotation.

   B. Loosen the rocker bracket short bolt and long bolt in that order, and remove the rocker shaft assembly from the cylinder head.

   IMPORTANT: If these bolts are loosened in reverse order, the rocker shaft bracket may become damaged.

2. Disassembling rocker shaft assembly.

   Position the disassembled rocker in the order removed, and install them in that order at the time of reassembly. This is for reproducing the same rocker shaft-to-rocker arm clearance as before.

3. Removing cylinder head

   Unscrew the cylinder head bolts and lift the head off the crankcase.

   IMPORTANT: When removing the gasket from the crankcase, be careful not to damage the mounting surface of crankcase.

   If any cylinder head parts are out of order, check the cylinder head bolts for tightening torque with a torque wrench before removing the head bolts.
4. Removing valves and valve springs

Using a valve spring compressor, compress the valve spring squarely and remove the valve keepers.

NOTE: If the valves are to be reused, mark them for their locations to aid installation at the time of reassembly.

---

**Inspection and Repair**

Rocker arms, rocker bushings and rocker shafts

1. Measuring rocker bushing inside diameter and rocker shaft diameter.

Determine the clearance between the bushing and shaft on the basis of the measurements. If the Repair limit is reached, replace the bushing. If it is exceeded, replace both bushing and shaft.

<table>
<thead>
<tr>
<th>Item</th>
<th>Nominal Value</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocker bushing inside diameter</td>
<td>20.000</td>
<td>- 20.021</td>
<td>(0.78740 - 0.78823)</td>
</tr>
<tr>
<td>Rocker shaft diameter</td>
<td>19.984</td>
<td>- 19.966</td>
<td>(0.78677 - 0.78606)</td>
</tr>
<tr>
<td>Rocker shaft-to-bushing clearance</td>
<td>20 (0.79)</td>
<td>0.016</td>
<td>0.070 (0.00276)</td>
</tr>
</tbody>
</table>

Unit: mm (in).

Measuring rocker bushing and rocker shaft
2. Replacing rocker bushings

When installing a replacement bushing, align the oil holes in the bushing and rocker arm.

Valves, Valve Guides and Valve Seats

1. Measuring valve stem diameter

If the Service limit is exceeded, or if the stem is abnormally worn excessively, replace the valve.

Unit: mm (in.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet</td>
<td>7.955</td>
<td>7.900</td>
</tr>
<tr>
<td></td>
<td>7.940</td>
<td>(0.31319)</td>
</tr>
<tr>
<td></td>
<td>7.920</td>
<td>(0.31260)</td>
</tr>
<tr>
<td>Valve stem</td>
<td></td>
<td>7.850</td>
</tr>
<tr>
<td>diameter</td>
<td></td>
<td>(0.30905)</td>
</tr>
<tr>
<td>Exhaust</td>
<td>7.940</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.920</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.850</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.31319)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.31260)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.31181)</td>
<td></td>
</tr>
</tbody>
</table>

2. Measuring valve stem-to-guide clearance

The valve guide wears more rapidly at the ends than through the center. Measure the guide at its ends and in two directions at right angles to each other. If the Service limit is exceeded, replace the guide.
3. Replacing valve guides

A. Using a valve guide remover, remove the worn guide.

B. To install a replacement guide, use valve guide installer to position the new guide at the proper depth.
4. Inspecting valve face

Coat the valve face lightly with red lead and, using valve lapper, check the valve contact with its seat. If the contact is not uniform, or if the valve is defective or the Repair limit is exceeded, repair or replace the valve and valve seat.

**IMPORTANT:** Check the valve face after inspecting or replacing the valve guide.

Press the valve into the seat without rotating it.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve seat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angle</td>
<td>30 degrees</td>
<td></td>
</tr>
<tr>
<td>Valve sinkage</td>
<td>(0.4 \pm 0.2) (0.016\pm 0.008) [IN]</td>
<td>(1.1) (0.043)</td>
</tr>
<tr>
<td></td>
<td>(0.5 \pm 0.02) (0.020\pm 0.008) [EX]</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>(1.2 \pm 0.14) (0.047\pm 0.0055)</td>
<td>(1.6) (0.063)</td>
</tr>
<tr>
<td>Valve margin</td>
<td>2.13 (0.0839)</td>
<td>Up to 1.2 (0.047) by refacing</td>
</tr>
</tbody>
</table>

Figure 54

Good

Bad

Valve contact with its seat

Valve seat angle

Valve sinkage

Valve seat width

Valve margin
5. Refacing valves

If the valve face is worn, it may be refaced.

IMPORTANT: Regrind valve angle at 30 degrees.

If the valve margin is less than the Repair limit when ground, replace the valve.

6. Refacing the valve seats

A. Using a valve seat cutter or valve seat grinder, cut the valve seat.

B. Lap the valve to the seat.

IMPORTANT: Cut or grind the valve seat only as necessary for refacing.

If the seat width is in excess of the Repair limit as a result of wear or cutting, replace the valve seat.

If the valve sinkage exceeds the Repair limit after refacing, replace the valve seat.

7. Replacing valve seats

A. Weld a plate of about 5 mm 0.20 in. thickness to the valve seat. Insert a shaft into the valve guide hole from the upper side of cylinder head, and drive the seat off the head as shown.

IMPORTANT: When welding the plate, be careful not to permit spatters to come in contact with the machined surfaces of cylinder head.

B. Measure dimensions of valve seat holes in the cylinder head before installing valve seats and make sure that they are as specified.
C. Chill the valve seat in liquid nitrogen about -170 degrees C (-247 degrees F) for more than 4 minutes with the cylinder head kept at normal temperature, or heat the cylinder head to 80 degrees C to 100 degrees C (176 degrees F to 222 degrees F) with the valve seat chilled in ether or alcohol containing dry ice.

D. Use a valve seat installing tool to install the valve seat.

8. Lapping valves in valve seats.

Be sure to lap the valves in the valve seats after the seats have been replaced.

IMPORTANT: Do not permit the compound to come in contact with the valve stem.

Use 120 to 150 grit for initial lapping and 200 grit for finish lapping.

Valve Springs

Measuring squarness and free length

If the squarness or free length exceeds the Service limit, replace the spring.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer spring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free length</td>
<td>56.40 (2.2205)</td>
<td>55.00 (2.1654)</td>
</tr>
<tr>
<td>Squarness deg</td>
<td>2, maximum</td>
<td></td>
</tr>
<tr>
<td>Test force/length under test force kgf (lbf)</td>
<td>23.9 ± 1.2 (52.7 ± 2.6)</td>
<td>21.2 (46.7)</td>
</tr>
<tr>
<td>Inner spring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free length</td>
<td>40.8 (1.606)</td>
<td>39.8(1.567)</td>
</tr>
<tr>
<td>Squarness deg</td>
<td>1.5, maximum</td>
<td></td>
</tr>
<tr>
<td>Test force/length under test force kgf (lbf)</td>
<td>6 ± 0.3 (13 ± 0.7)</td>
<td>4.6 (10)</td>
</tr>
</tbody>
</table>
Cylinder Head

Measuring surface warpage

Measure warpage with a straightedge and a feeler gauge. If the warpage exceeds the Repair limit, reface the surface with a surface grinder.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder head gasketed</td>
<td>0.05 (0.0020),</td>
<td>0.020 (0.0079)</td>
</tr>
<tr>
<td>surface warpage</td>
<td>maximum</td>
<td></td>
</tr>
</tbody>
</table>

Valve Pushrods

If the runout exceeds the Assembly standard, replace the pushrods.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve pushrod runout</td>
<td>0.04 (0.016),</td>
</tr>
<tr>
<td></td>
<td>maximum</td>
</tr>
</tbody>
</table>
Reassembly sequence

17→24→23→22→21→20→19→18→16→15
14→13→12→11→9→8→7→6→5→3→2→4→1
1. Installing valve stem seal

After installing the stem seal to the valve guide, make sure that the seal is properly fitted in the groove of the guide.

IMPORTANT: Do not apply any oil or sealant to the mating face of stem seal that comes in contact with the valve guide. When installing the stem seal, coat the valve stem with engine oil to insure initial lubrication of the stem seal lip.

2. Installing valves and valve springs

A. Install the valve spring and retainer to the valve guide with spring compressor and install the retainers.

B. Using a soft hammer, give light blows to the valve stem top several times to make sure that the spring and retainer are properly installed.
3. Installing cylinder head

A. Screw two guide bolts into the crankcase to hold the gasket in place.

B. Place the cylinder head on the crankcase as guided by the two guide bolts. Apply engine oil to the threads of cylinder head bolts and insert the bolts into the head.

IMPORTANT: Do not apply any sealant to the cylinder head bolts.

C. Tighten the cylinder head bolts to the specified torque in the sequence shown.

S4F : No. of bolts: 17

Frontside ←

<table>
<thead>
<tr>
<th>Tightening torque</th>
<th>12 ± 0.5 (87 ± 4)</th>
</tr>
</thead>
</table>

4. Reassembling rocker shafts

The rocker arms for inlet valves are different in dimension from those for exhaust valves. After installing the arms, make sure that they move freely.

Exhaust

Inlet

Figure 60
5. Installing rocker shaft assembly.

Tighten the long bolt (1) and short bolt (2) in that order (by following the reverse of loosening order).

6. Adjusting valve clearance

(See Valve Clearance in the Adjustments section of this chapter.)
Figure 62

1. Flywheel
2. Flywheel housing
3. Oil seal
4. Oil pan
5. Oil pump
6. Crankshaft pulley
7. Timing gear case
8. Oil seal
9. Deflector plate
10. Thrust plate
11. Idler
12. Camshaft gear
13. Thrust plate
14. Camshaft
15. Tappet
16. Front plate
1. Removing flywheel
   A. Unscrew the flywheel mounting bolts.
   B. Install the jacking bolts into the holes provided in the flywheel uniformly and remove the flywheel.

2. Removing flywheel housing
   Unscrew the housing mounting bolts and remove the housing.

3. Removing oil pan and oil pump
   Unscrew the oil pan mounting bolts and remove the oil pan. Then, remove the oil pump by unscrewing its bolt. (See Accessory Removal and Installation section of this chapter.)

4. Removing timing gear case
   Remove the crankshaft pulley and timing gear case.

   NOTE: The crankshaft pulley uses a tapered cone to secure the pulley to the crankshaft. Use Mitsubishi Special Tool 34791-01100 for pulley removal.
5. Measuring backlash and end play

Measure the backlash and end play on each gear to obtain the data for parts replacement. (See Inspection and Repair in this section of the book.)

6. Removing timing gears

Be sure to align the timing marks for each pair of gears before removing or installing the gears.

7. Removing idler

Remove the idler by turning it in the direction of helix of gear teeth.

8. Removing crankshaft

Position the camshaft gear so that its two jacking bolt holes come to top and bottom. Unscrew the thrust plate bolts and remove the camshaft from the crankcase.

After removing the camshaft, remove the tappets.
9. Removing the camshaft gear

Using a puller, remove the gear from the camshaft. Now, the thrust plate can be removed.

NOTE: It is not necessary to remove camshaft gear unless camshaft gear or thrust plate require replacement.

10. Removing front plate

Unscrew two front plate mounting bolts and remove the plate from the crankcase.

---

**Inspection and Repair**

1. Measuring camshaft end play

If the end play exceeds the Repair limit, replace the thrust plate.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camshaft end play</td>
<td>0.050 – 0.112 (0.00197 – 0.00441)</td>
<td>0.300 (0.01181)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)
2. Measuring cam lift

Using a micrometer, measure the cam lift. If it exceeds the Service limit, replace the camshaft.

<table>
<thead>
<tr>
<th>Item</th>
<th>Nominal Value</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet</td>
<td>D₁ = 46.911 + 0.1 - 0.3 (1.84689 + 0.0004 - 0.012)</td>
<td>D₁ - D₂ = 6.689 (0.26335)</td>
<td>D₁ - D₂ = 6.189 (0.24366)</td>
</tr>
<tr>
<td>Cam lift</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exhaust</td>
<td>D₁ = 46.255 + 0.1 - 0.3 (1.82110 + 0.0004 - 0.012)</td>
<td>D₁ - D₂ = 7.344 (0.28913)</td>
<td>D₁ - D₂ = 6.844 (0.28945)</td>
</tr>
</tbody>
</table>

3. Measuring camshaft runout

If the runout exceeds the Repair limit, straighten the camshaft by means of a press, or replace it with a new one.

IMPORTANT: Set up a dial gauge on the camshaft and turn the camshaft. One half (1/2) of the gauge indication is the runout.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camshaft runout</td>
<td>0.02 (0.0008), maximum</td>
<td>0.05 (0.0020)</td>
</tr>
</tbody>
</table>
4. Measuring camshaft journal diameter

If the journals exceed the Service limit, replace the camshaft bearings.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camshaft journal diameter</td>
<td>53.96 - 53.94 (2.1244 - 2.1236)</td>
<td>53.90 (2.1220)</td>
</tr>
<tr>
<td>No.3</td>
<td>52.96 - 52.94 (2.0850 - 2.0842)</td>
<td>52.90 (2.0827)</td>
</tr>
<tr>
<td>Camshaft journal-to-bushing clearance</td>
<td>0.04 - 0.09 (0.0016 - 0.0035)</td>
<td>0.15 (0.0059) (Repair limit)</td>
</tr>
</tbody>
</table>

5. Replacing camshaft bushings

To install bushings, align the bushing oil holes with those from oil gallery and drive the bushings in.

Tappets

1. Inspection

Check the cam contact face of each tappet for abnormal wear and replace if necessary.
2. Measuring tappet-to-guide clearance

If the clearance exceeds the Assembly standard, replace the tappet.

Unit: mm (in.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tappet hole diameter</td>
<td>22.000</td>
<td></td>
<td>22.100</td>
</tr>
<tr>
<td></td>
<td>22.021</td>
<td></td>
<td>(0.87008)</td>
</tr>
<tr>
<td></td>
<td>(0.86614)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.86697</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tappet-to-guide clearance</td>
<td>0.035</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.086</td>
<td></td>
<td>(0.0047)</td>
</tr>
<tr>
<td></td>
<td>(0.00138)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.00339</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Timing Gears

Measuring backlash

Set up a dial gauge so that it contacts the pitch circle of the gear and move one gear back and forth to measure the backlash between the gears. If the backlash exceeds the Repair limit, replace the gears.

Unit: mm (in.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timing gear backlash</td>
<td>0.03 – 0.17</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>(0.012 – 0.0067)</td>
<td>(0.0098)</td>
</tr>
</tbody>
</table>

Idler, Idler Bushing and Idler Shaft

1. Measuring idler end play

Measure the end play with a feeler gauge or dial gauge. If the end play exceeds the Repair limit, replace the thrust plate.

Unit: mm (in.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idler end play</td>
<td>0 – 0.10</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>(0 – 0.0039)</td>
<td>(0.0138)</td>
</tr>
</tbody>
</table>
2. Measuring idler bushing inside diameter and idler shaft diameter

If the idler shaft-to-bushing clearance exceeds the Standard clearance, replace the bushing.

<table>
<thead>
<tr>
<th>Item</th>
<th>Nominal value</th>
<th>Standard clearance</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idler shaft-to-bushing clearance</td>
<td>36 (1.42)</td>
<td>0.025 - 0.075 (0.00098 - 0.00295)</td>
<td>0.100 (0.00394)</td>
</tr>
</tbody>
</table>

3. Replacing idler bushing

When installing the bushing, press it in until its end face is flush with that of gear boss.

4. Replacing idler shaft

Use a puller to remove the idler shaft.

Flywheel and Ring Gear

1. Measuring flywheel runout

With the flywheel installed on the engine, measure its runout. If the runout exceeds the Assembly standard, check for improper installation or foreign matter lodged in the mounting face.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runout</td>
<td>0.15 (0.0059), maximum</td>
<td>0.50 (0.020)</td>
</tr>
</tbody>
</table>
2. Replacing ring gear

Check the ring gear for broken teeth, corrosive wear, or other defects, and replace the gear if defective. To remove, proceed as follows:

A. Removal

1) Heat the ring gear uniformly with an acetylene torch.

2) Using a bar, give light hammer blows to the outer segment of ring gear.

B. Installation

Heat a replacement ring gear up to about 100 degrees C (212 degrees F) in a piston heater and press the gear onto the flywheel so that the starter pinion would engage chamfered teeth.

Crankshaft Pulley

Inspecting V-belt groove

Inspect the groove for wear. Wrap a new belt around the pulley, pressing it in the groove as far as it goes, and see if the top surface of the belt is above the top of the pulley.

If the top surface of the belt is uniformly above the top of the pulley all the way around, it is not necessary to replace the pulley.

If the top surface of the belt sinks into the groove more than 1.6 mm (1/16 in.), replace the pulley.
Reassembling sequence

16→15→14→11→10→9→7→6→5→4→2→1
13→12  8  3

Figure 73

Reassembly
Reassembling Sequence
1. Installing camshaft gear and thrust plate

Install thrust plate onto camshaft. Heat the gear for installation.

2. Installing camshaft

Carefully insert the camshaft into the crankcase. Install and tighten the thrust plate bolts.

3. Installing idler

Install the idler while aligning the timing marks on each pair of gears, and install thrust plate with bolt.

4. Installing oil seal

To install the oil seal, use an installer.
5. Inspecting and adjusting timing gears after installation.

After installing the timing gears, be sure to inspect and adjust them as follows:

**Inspecting Timing Gear Backlash and End Play**

After installing the timing gears, inspect the backlash between the gears in mesh and the end play of each gear (Page 3 - 67).

**Inspecting Valve Timing**

It is not necessary to inspect the valve timing, provided that all matching marks on the timing gears are aligned. However, the timing may be verified as follows:

Using a 3 mm (0.12 in.) thick smooth steel plate, add 3 mm (0.12 in.) clearance to the inlet and exhaust valves of No. 1 cylinder. Then insert a 0.05 mm (0.0020 in.) feeler gauge between the top of valve cap and rocker and slowly turn the crankshaft, trying to find a position where the feeler gauge is firmly gripped (the valve starts opening) and a position where the gauge is just ungripped (the valve starts closing.) Check to make sure that these positions coincide with the angular positions shown in the valve timing diagram with 3 mm (0.12 in.) clearance added to valves.
Pistons, Connecting Rods, Crankshaft & Block

Disassembly

Figure 79

1. Nut
2. Connecting rod cap
3. Connecting rod bearing
4. Top compression ring
5. Second compression ring
6. Oil ring
7. Snap ring
8. Piston pin
9. Piston
10. Connecting rod
11. Bearing cap bolt
12. Main bearing cap
13. Side seal
14. Thrust plate
15. Main bearing (lower shell)
16. Crankshaft
17. Main bearing (upper shell)
18. Check valve (w/turbocharger)
19. Crankcase
1. Removing connecting rod caps
   A. Unscrew the nuts securing the cap and remove cap.
   B. Mark the removed connecting rod bearings for identification of cylinder numbers and whether upper or lower shells.

2. Preparing to remove pistons
   A. Lay the crankcase on its side.
   B. Remove all carbon deposits from the upper areas of cylinder sleeves. Carbon deposits, if any, will make it difficult to pull the pistons out. Use a ridge reamer if necessary.

3. Removing pistons
   Bring the piston assembly to top dead center position. Use a hammer handle and push the assembly out of the crankcase.

4. Removing piston rings
   Use a piston ring pliers to remove the rings.
5. Removing piston pin
   A. Using snap ring pliers, remove the snap rings.
   B. Remove the piston pin and separate the piston from the connecting rod.
   C. If it is difficult to pull out the pin, heat the piston to expand the pin bore.

6. Removing main bearing caps
   Unscrew the bolts securing the cap and remove the cap complete with main bearing. To remove the front and rear main bearing, caps may require a puller.

   **IMPORTANT:** When removing the caps, be careful not to damage the bearings. After removing the caps and bearings, mark each combination for its location so that it is installed to the same crankshaft journal.

7. Removing crankshaft
   Slowly lift the crankshaft out of the crankcase.
Inspection and Repair

Crankcase and cylinder sleeves.

1. Measuring warpage of crankcase gasketed surface

Measure the warpage with a straightedge and feeler gauge. If the warpage exceeds the Assembly standard, grind the surface with a surface grinder. Grind the crankcase only enough to remove the warpage.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warpage of crankcase gasketed surface</td>
<td>0.05 (0.0020), maximum</td>
<td>0.20 (0.0079)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)

2. Measuring cylinder sleeve inside diameter

A. Measure the sleeve in two directions inline and perpendicular to the crankshaft and at three positions, top, middle, and bottom, as shown.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder sleeve inside diameter</td>
<td>98.00</td>
<td>98.200</td>
<td>99.200</td>
</tr>
<tr>
<td></td>
<td>- 98.035</td>
<td>(3.88613)</td>
<td>(3.90500)</td>
</tr>
<tr>
<td></td>
<td>(3.85826)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 98.065</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out of round</td>
<td>0.015, maximum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taper</td>
<td>0.05, maximum</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unit: mm (in.)

B. If the inside diameter reaches the Repair limit, bore the sleeve to the specified oversize.

C. Hone the sleeve to +0.25 mm (+0.0098 in.) or +0.5 mm (+0.0197 in.) oversize accurate within 0 to 0.035 mm (0.00138 in.). Use pistons and piston rings of the same oversize.

D. If any sleeve is unevenly worn, determine the oversize on the basis of the maximum wear noted to ensure perfect roundness in the oversized bore.

NOTE: Refinish all sleeves to the same oversize.

If the sleeve is found in good condition, with the wear far less than the Repair limit, replace the piston rings, and ream off “ridge” at the top of the sleeve. Hone the bore if necessary.
3. Replacing cylinder sleeve

If one sleeve exceeds the Service limit in inside diameter or it is defective, with the other sleeves in good condition, replace that sleeve only.

Removing Cylinder Sleeve

A. Set up a boring machine on the crankcase by aligning it with the center of the less-worn area of the sleeve at the bottom.

B. Bore the sleeve until its stock thickness is about 0.5 mm (0.02 in.).

C. Break and remove the sleeve, being careful not to damage the inside surface of the crankcase.

Installing a New Cylinder Sleeve

A. Press the sleeve into the crankcase, leaving a protrusion of 0.3 to 0.5 mm (0.012 to 0.020 in.) at the top. Machine sleeve flush with the crankcase top.

B. Bore and hone the sleeve to 98 +0.035 mm (3.86 +0.00138 in.).
Pistons and Piston Rings

1. Measuring piston diameter

   A. Using a micrometer, measure each piston perpendicular to the piston pin. If the diameter exceeds the Service limit, replace the piston.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piston diameter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>97.975 – 97.945</td>
<td>97.760</td>
</tr>
<tr>
<td></td>
<td>(3.85728 – 3.85609)</td>
<td>(3.84881)</td>
</tr>
<tr>
<td>0.25 (0.0098)</td>
<td>98.225 – 98.195</td>
<td>98.010</td>
</tr>
<tr>
<td>oversize</td>
<td>(3.86712 – 3.86594)</td>
<td>(3.85865)</td>
</tr>
<tr>
<td>0.50 (0.0197)</td>
<td>98.475 – 98.445</td>
<td>98.260</td>
</tr>
<tr>
<td>oversize</td>
<td>(3.87696 – 3.87578)</td>
<td>(3.86850)</td>
</tr>
<tr>
<td>Variance in weight per engine gram (oz)</td>
<td>± 3 (± 0.1)</td>
<td></td>
</tr>
</tbody>
</table>

   B. Piston weight is stamped on the top of each piston. If any pistons have to be replaced, select new pistons so that the variance in weight among pistons per engine is within the Assembly standard.

2. Measuring piston ring end gap

   Place the ring in a new or master sleeve, and measure the gap. If the gap exceeds the Service limit, replace all rings as a set.

   Inside diameter of a master cylinder sleeve:

   \[
   98 +0.035 \text{ mm (3.86 } +0.00138 \text{ in.)}
   \]

   NOTE: Place the piston ring in the master sleeve by pushing it squarely with the use of piston.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piston ring end gap</td>
<td>0.30 – 0.50</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>(0.0118 – 0.0197)</td>
<td>(0.0591)</td>
</tr>
</tbody>
</table>
3. Measuring piston ring side clearance

Insert new piston rings into the ring grooves in the piston and measure the clearance of each ring with a feeler gauge and straightedge as shown.

<table>
<thead>
<tr>
<th>Item</th>
<th>Nominal value</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1 ring</td>
<td>2.5 (0.098)</td>
<td>0.030</td>
<td>0.200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 0.070</td>
<td>(0.00787)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.00118)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 0.00276</td>
<td></td>
</tr>
<tr>
<td>No. 2 ring</td>
<td>2.0 (0.079)</td>
<td>0.025</td>
<td>0.150</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 0.060</td>
<td>(0.00591)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.00098)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 0.00236</td>
<td></td>
</tr>
<tr>
<td>Oil ring</td>
<td>4.5 (0.177)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unit: mm (in.)

4. Measuring piston pin and hole diameters

If the Repair limit is reached, replace the piston pin. If it is exceeded, replace the piston.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piston pin diameter</td>
<td>32.000 – 31.984</td>
<td>1.25921</td>
</tr>
<tr>
<td></td>
<td>(1.25984 – 1.25921)</td>
<td></td>
</tr>
<tr>
<td>Piston pin-to-hole clearance</td>
<td>0 – 0.016</td>
<td>0.050</td>
</tr>
<tr>
<td></td>
<td>(0 – 0.00063)</td>
<td>(0.00197)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)

5. Measuring piston protrusion

Measure protrusion of each piston and, if it is not within the Assembly standard, inspect the various parts for clearance.

A. Determine the top dead center of piston with a dial gauge.

B. Set up the dial gauge at the top of crankcase, and set the gauge pointer to zero (0.).

C. Measure the protrusion at three places on the piston head, and average the three measurements to determine the protrusion. Subtract the protrusion from the "as-installed" thickness of cylinder head gasket to determine the clearance between the piston top and cylinder head.
### Important Information

**Assembly Standard**

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piston protrusion</td>
<td>0.65 – 1.05</td>
</tr>
<tr>
<td></td>
<td>(0.0256 – 0.0413)</td>
</tr>
<tr>
<td>&quot;As-installed&quot; thickness of</td>
<td>1.6 ± 0.15</td>
</tr>
<tr>
<td>cylinder head gasket</td>
<td>(0.063 ± 0.0059)</td>
</tr>
</tbody>
</table>

**Connecting Rods, Connecting Rod Bearings and Small-end Bushings**

1. **Measuring connecting rod bearing-to-crankpin clearance**

Measure the crankpin diameter and bearing inside diameter to determine the clearance between the two. If the clearance exceeds the Repair limit, replace the bearing. If the crankpin is worn excessively or unevenly, grind the crankpin, and use undersize bearing.

The two bearing undersizes are -0.25 mm -0.0098 in. and -0.50 mm -0.0197 in.

**NOTE:** To measure the bearing inside diameter, install upper and lower shells to the connecting rod and tighten the cap bolts to the specified torque.

**Repair Limit**

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crankpin diameter</td>
<td>58 -0.035</td>
<td>- 0.20 (- 0.0079)</td>
</tr>
<tr>
<td></td>
<td>-0.055</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.28 -0.0014 )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.002</td>
<td></td>
</tr>
<tr>
<td>Connecting rod bearing-to-crankpin</td>
<td>0.035 – 0.10</td>
<td>0.20 (0.0079)</td>
</tr>
<tr>
<td>clearance</td>
<td>(0.0014 – 0.0039)</td>
<td></td>
</tr>
</tbody>
</table>
2. Measuring connecting rod bushing-to-piston pin clearance

Measure the piston pin diameter and bushing inside diameter to determine the clearance between the two. If the clearance exceeds the Repair limit, replace the pin or bushing whichever is badly worn.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piston pin bushing inside diameter</td>
<td>32.048 – 32.020</td>
<td>(1.2617 – 1.2606)</td>
</tr>
<tr>
<td>Connecting rod bushing-to-piston pin clearance</td>
<td>0.020 – 0.051</td>
<td>0.080</td>
</tr>
<tr>
<td></td>
<td>(0.0008 – 0.0020)</td>
<td>(0.0032)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)

3. Replacing connecting rod bushing

A. To remove the bushing for replacement, use a connecting rod bushing puller.

B. Align the oil holes in the replacement bushing and connecting rod.

C. Press the bushing into position from the chamfered side of connecting rod.

D. After installing the bushing, insert the piston pin to make sure that the pin rotates freely.

4. Inspecting connecting rods for bend and twist

A. Measure "C" and "l". If the measurement at "C" is larger than 0.06 mm (0.0020 in.) per 100 mm (3.9 in.) of "l", straighten the rod with a press, or replace.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecting rod bend and twist</td>
<td>0.05/100</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>(0.0020/3.9), maximum</td>
<td>(0.0059)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)

5. Inspecting connecting rod bearings

Inspect each bearing shell for wiped overlay, scratching, burning, pitting and other damage. If any of these are present, replace the shell.
6. Measuring connecting rod end play

Install the connecting rod to the mating crankpin and tighten the cap to the specified torque. Use a feeler gauge, measure the end play. If the end play exceeds the Service limit, replace the connecting rod.

<table>
<thead>
<tr>
<th>Item</th>
<th>Nominal value</th>
<th>Standard clearance</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecting rod end play</td>
<td>40 (1.57)</td>
<td>0.15</td>
<td>0.50 (0.0197)</td>
</tr>
<tr>
<td></td>
<td>- 0.35</td>
<td>(0.0059)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 0.0138</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Variance in weight among connecting rods per engine

When replacing connecting rods, make sure that the variance in weight among connecting rods per engine is within the Assembly standard shown below.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variance in weight per engine</td>
<td>± 5g (± 0.2 oz), maximum</td>
</tr>
</tbody>
</table>

**Figure 88**

**Crankshaft**

1. Measuring journal diameter

Using a micrometer, measure the journal in two positions, 1 and 2, and in two directions, A and B, to determine the wear, out of round and taper. If any of the Repair limits is exceeded, regrind the journal to the undersize or replace the crankshaft.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standards</th>
<th>Repair limit</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crankshaft journals Diameter</td>
<td>75 (-0.03)</td>
<td>-0.15 (-0.0059)</td>
<td>-0.90 (-0.0354)</td>
</tr>
<tr>
<td></td>
<td>(2.95 (-0.0012)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.0020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out of round</td>
<td>0.01 (0.0004),</td>
<td>0.03 (0.0012)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>maximum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taper</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. Measuring crankpin diameter

Using a micrometer, measure the crankpin in two positions, 1 and 2, and in two directions, A and B, to determine the wear, out of round and taper. If any of the Repair limits is exceeded, regrind the crankpin to the undersize or replace the crankshaft.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>58 - 0.035</td>
<td>- 0.20</td>
</tr>
<tr>
<td></td>
<td>- 0.055</td>
<td>(-0.0079)</td>
</tr>
<tr>
<td></td>
<td>(2.95 - 0.0138)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 0.00217</td>
<td></td>
</tr>
<tr>
<td>Crankpins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out of round</td>
<td>0.01 (0.0004),</td>
<td>0.03 (0.0012)</td>
</tr>
<tr>
<td></td>
<td>maximum</td>
<td></td>
</tr>
<tr>
<td>Taper</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Grinding crankshaft

If the crankshaft is ground to any of the undersizes and refinished to a dimension which is 0.100 to 0.120 mm 0.00394 to 0.00472 in. smaller than the undersize, it is not necessary to check the bearing contact pattern.

**Crankshaft grinding dimensions**

<table>
<thead>
<tr>
<th>Undersize</th>
<th>Refinishing dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crankshaft journal</td>
<td></td>
</tr>
<tr>
<td>0.25 (0.0098)</td>
<td>74.65 - 74.63 (2.939 - 2.938)</td>
</tr>
<tr>
<td>0.50 (0.0197)</td>
<td>74.40 - 74.38 (2.929 - 2.928)</td>
</tr>
<tr>
<td>Crankpin</td>
<td></td>
</tr>
<tr>
<td>0.25 (0.0098)</td>
<td>57.65 - 57.63 (2.2697 - 2.2686)</td>
</tr>
<tr>
<td>0.50 (0.0197)</td>
<td>57.40 - 57.38 (2.2598 - 2.2591)</td>
</tr>
</tbody>
</table>

When grinding the journals and crankpins, be sure to produce the same fillet radius as the original one. They should have a hardness of 620 or more in terms of Vickers Hardness Number. If necessary, reharden the journals and crankpins, and inspect them for cracks by conducting a magnaflux magnetic particle test.
4. Measuring crankshaft end play

Install the thrust plates in position and secure the main bearing caps. Under this condition, measure the end play the end clearance of thrust plates in the journal. If the end play exceeds the Assembly standard, replace the thrust plates.

<table>
<thead>
<tr>
<th>Item</th>
<th>Nominal value</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crankshaft end play</td>
<td>37 (1.46)</td>
<td>0.100 (0.004)</td>
<td>0.300 (0.011)</td>
</tr>
</tbody>
</table>

5. Measuring crankshaft runout

Support the crankshaft on its front and rear journal in V-blocks and measure the runout at the center journal, using a dial gauge. Depending on the amount of runout, repair the crankshaft by grinding or straightening with a press. If the runout exceeds the Repair limit, replace the crankshaft.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crankshaft runout</td>
<td>0.02 (0.0008), maximum</td>
<td>0.05 (0.0020)</td>
</tr>
</tbody>
</table>

6. Replacing crankshaft gear

A. Using gear puller, remove the gear from the crankshaft.

NOTE: Do not remove the gear by driving with a hammer.

B. To install, heat the gear to about 100 degrees C 212 degrees F. Place the new gear on the crankshaft by aligning the key with the notch of the gear and lightly tap into position with a soft-faced hammer.

Figure 74
7. Replacing rear oil seal

If the seal shows a sign of oil leaks, replace it with a replacement oil seal with sleeve.

To install the sleeve, apply oil to the inside surface of the sleeve and drive it onto the crankshaft using a sleeve installer.

Main bearings

1. Inspection

Inspect each bearing shell for abnormal contact, scratching, corrosion, wiped overlay, and other defects. Also check for a sign of poor seating in the bore of the crankcase or bearing cap.

![Scratching, corrosion, wiped overlay](image)

Figure 89

2. Measuring main bearing clearance

Fit the bearing shells to the crankcase and bearing cap and tighten the cap bolts to the specified torque. Measure the inside diameter of the bearing in two positions, front and back, along the longitudinal axis of crankshaft, in the criss-cross directions to take an average. Obtain the difference between the journal diameter and this inside diameter to determine the clearance.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main bearing-to-journal clearance</td>
<td>0.050 – 0.015 (0.002 – 0.0045)</td>
<td>0.200 (0.007)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)

![Measuring main bearing inside diameter](image)

3. Replacing main bearings

If the clearance exceeds the Repair limit, replace the bearings or refinish the crankshaft and use undersize bearings. If the crankshaft is refinished in compliance with any of the undersizes, it is not necessary to inspect the bearing contact pattern.
Reassembly

Reassembling sequence

19→18→17→14→16→15→12→11→13
9→8→10→7→6→5→4→3→2→1

1. Install main bearings

A. Install each upper shell in the crankcase by fitting its locking lip in the recess. The oil holes in the shell and crankcase will be aligned when the shell is so installed.

B. Apply a thin coat of engine oil to the inside surface of each shell.

C. Install the thrust plate in position.

Installing main bearing upper shell
2. Installing crankshaft
   A. Wash the crankshaft with cleaning solvent and dry.
   B. Hold the crankshaft in horizontal position and carefully place it on the crankcase.
   C. Apply a thin coat of engine oil to the journals of the crankshaft.

3. Installing main bearing caps
   A. Apply engine oil to each lower shell and fit it to the bearing cap.
   B. Apply sealant to the mating face of the front and rear caps.
   NOTE: Apply sealant to the sides of the bearing caps where seals are to be installed only.

   C. Install the bearing caps to the crankcase, making sure that they are flush with the crankcase walls on the front and rear sides.
   D. Coat the side seals with soapy water and insert them into the grooves in each bearing cap. Using the face of a screwdriver, push in the seals, bringing their rounded corners on the outer side and taking care not to twist the seals.
   E. Apply sealant to the side seal joint.

4. Installing bearing cap bolts
   Apply engine oil to the bolts and tighten them to the specified torque.
5. Measuring crankshaft end play

Install the thrust plates in position and secure the main bearing caps. Under this condition, measure the end play (the end clearance of thrust plates in the journal). If the end play exceeds the Assembly standard, replace the thrust plates.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crankshaft end play</td>
<td>0.100</td>
<td>0.300</td>
</tr>
<tr>
<td></td>
<td>-0.254</td>
<td>(0.0118)</td>
</tr>
<tr>
<td></td>
<td>(0.0039)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.010</td>
<td></td>
</tr>
</tbody>
</table>

Figure 95

6. Lay the crankcase on its side

Figure 96

7. Installing piston rings

A. Using a piston ring pliers, install the piston rings on the piston.

NOTE: Each piston ring is marked “R” on the side to be UP when installed on the piston.
B. Install the oil ring with its end gap positioned at 180 degrees to that of spring expander. Attach teflon tube to the expander close to the oil ring end gap.

8. Prepare to install pistons

   Clean the cylinder sleeve bore surface with a clean cloth and apply engine oil to the surface.

9. Installing connecting rod bearings and caps

   A. Insert the bolts into the cap by settling the flat of bolt head in place on the cap.

   B. Install the upper shell of the bearing in the rod by fitting its locking lip in the groove and apply engine oil to the inside surface of the shell.
10. Installing pistons

A. Apply engine oil to the piston rings and reposition the rings by keeping their end gaps away from the direction of piston pin and thrust side.

![Diagram showing piston ring gap directions](Figure 100)

B. Bring the crankpin to which the piston is to be installed to top dead center position. Using a piston installer insert the piston assembly into the crankcase, with the matching mark of the connecting rod on the camshaft side.

![Diagram showing piston installation](Figure 101)

C. After resting the big end of connecting rod on the crankpin, turn crankshaft 180 degrees (bottom dead center) and install the cap.

![Diagram showing connecting rod cap installation](Figure 102)

11. Installing connecting rod caps

A. Install the lower shell of the bearing in the cap. Apply engine oil to the inside surface of the shell.

B. Install the cap by tightening the nuts to the specified torque.

![Diagram showing connecting rod cap installation](Figure 103)
Exhaust Manifold

Inspection

A. Inspect flanges for cracks.

B. Inspect flanges for warpage. If the warpage exceeds the Assembly standard, repair the flanges or replace the manifold.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warpage of exhaust manifold flanges</td>
<td>0.2 (0.008), maximum</td>
</tr>
</tbody>
</table>

Unit: mm (in.)

Inspecting exhaust manifold flanges for warpage
Turbocharger
Disassembly

Figure 105

1. Coupling assembly  
2. Turbine housing  
3. Snap ring  
4. Compressor cover  
5. Lock nut  
6. Compressor wheel  
7. Snap ring  
8. Insert  
9. Oil deflector  
10. Piston ring  
11. Thrust sleeve  
12. Thrust bearing  
13. Thrust ring  
14. Shaft & turbine wheel  
15. Piston ring  
16. Turbine back plate  
17. Bearing  
18. Snap ring  
19. O-ring  
20. O-ring  
21. Bearing housing

IMPORTANT: The compressor wheel vanes and turbine wheel vanes can be easily distorted. Be careful to prevent damage when handling compressor wheel and turbine wheel.
1. Removing turbine housing

Loosen coupling assembly (Item 1), as shown, and separate turbine housing (Item 2) from bearing housing (Item 21).

NOTE: Mark the compressor cover (Item 4), bearing housing (Item 21) and turbine housing (Item 2) before disassembling. When reassembling, make sure the marks are aligned.

2. Removing compressor cover

A. Lay compressor cover (Item 4) on a flat surface. Use a snap ring pliers (Item A) to remove snap ring.

Hold down snap ring while compressing ring ends with snap rings, so ring does not fly off if ring ends slip off pliers.

B. Use a plastic hammer to lightly tap around compressor cover (Item 4) to remove bearing housing (Item 21).

IMPORTANT: When removing compressor cover (Item 4), be careful not to hit compressor wheel against cover.
3. Removing compressor wheel

A. Hold turbine housing (Item 2) in a vise. Fit removed bearing housing (Item 21) to housing so shaft and turbine wheel is in turbine housing and compressor wheel (Item 6) is on top.

While holding turbine wheel boss, loosen locknut from shaft.

B. Hold turbine wheel stationary and turn compressor wheel (Item 6) back and forth to lift it off the shaft.

4. Removing inner snap ring

Use a snap ring pliers (Item A) to remove the snap ring (Item 7).

![Figure 109]

![Figure 110]

![Figure 111]

![Figure 112]

**CAUTION**

Hold down snap ring while compressing ring ends, so snap ring does not fly off, if ring ends slip off pliers.

5. Removing insert, oil deflector and other parts

Use two screwdrivers to gently lift insert (Item 8) off bearing housing (Item 21). Remove the piston ring (Item 10), oil deflector (Item 9), thrust sleeve (Item 11), thrust bearing (Item 12), and thrust ring (Item 13).
6. Removing shaft and turbine wheel, and bearings

A. Hold turbine housing in a vise. With one hand holding shaft and the other hand holding bearing housing (Item 21), carefully lift bearing housing (Item 21), complete with shaft and turbine wheel (Item 14), off turbine housing. Be careful not to damage the turbine wheel vanes (Item 2).

B. Disassemble the shaft and turbine wheel (Item 14), piston ring (Item 15), turbine back plate (Item 16), bearing (Item 17), snap ring (Item 18), o-ring (Item 19) and o-ring (Item 20) from the bearing housing (Item 21).
Cleaning and Inspection

1. Cleaning

A. Inspect the parts for signs of burning or other damage.

B. Wash parts in cleaning solvent. Make sure all parts are clean of oily material.

C. Dry the clean parts thoroughly with compressed air.

D. Remove scale-like deposits with a bristle brush. After removing deposits with brush, wash parts in solvent again and dry.

E. Apply clean engine oil to surfaces of moving parts to prevent corrosion.
2. Inspection

A. Bearing housing

Measure inside diameter of bearing bores in housing. If measurement exceeds service limit, replace housing.

Unit: mm (in.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside diameter of bearing bores in housing</td>
<td>15.686 (0.61756)</td>
</tr>
</tbody>
</table>

B. Bearing

1) Measure outside diameter of bearing. If measurement exceeds service limit, replace bearing.

Unit: mm (in.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside diameter of bearing</td>
<td>15.574 (0.61315)</td>
</tr>
</tbody>
</table>

2) Measure inside diameter of bearing. If measurement exceeds service limit, replace bearing.

Unit: mm (in.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside diameter of bearing</td>
<td>9.04 (0.3559)</td>
</tr>
</tbody>
</table>

3) Measure length of bearing. If measurement is less than service limit, replace bearing.

Unit: mm (in.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of bearing (Model TC)</td>
<td>9.34 (0.3677)</td>
</tr>
</tbody>
</table>
C. Shaft and turbine wheel

1) Measure inside diameter of shaft journals. If measurement is less than service limit, replace shaft & turbine wheel and piston ring.

<table>
<thead>
<tr>
<th>Item</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of shaft journals</td>
<td>8.994 (0.35409)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)

2) Use a dial indicator and V-block to measure runout of shaft. If measurement exceeds service limit, replace shaft & turbine wheel.

<table>
<thead>
<tr>
<th>Item</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runout of turbine wheel &amp; shaft</td>
<td>0.015 (0.00059)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)

**IMPORTANT:** Do not attempt to straighten a distorted shaft. Replace shaft & turbine wheel if shaft is distorted.

3) Check surfaces of shaft journals. If surfaces are rough, install in a lathe and lightly polish journals with #400 sandpaper and engine oil at 300 to 600 rpm. Install in lath by tightening shaft in chucks at its center.

D. Insert

Put a new piston ring in groove of insert, and measure end gap of ring. If gap measurement exceeds standard clearance, replace insert.

<table>
<thead>
<tr>
<th>Item</th>
<th>Standard clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>End gap of piston ring</td>
<td>0.05 - 0.15</td>
</tr>
<tr>
<td></td>
<td>(0.0020 - 0.00059)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)
Reassembly

Reassembling sequence

21 → 18 → 17 → 16 → 13 → 12 → 19
15 → 14 → 7 → 6 → 5 → 20 → 4 → 3 → 2 → 1
9 → 11 → 10 → 8

NOTE: When reassembling the turbocharger, replace the piston ring (Item 10), piston ring (Item 15), O-ring (Item 19), and O-ring (Item 20).

IMPORTANT: After installing an overhauled turbocharger on the engine, disconnect the run solenoid electrical connector (so the engine will not start) and crank the engine with the starter to permit engine oil to flow to the turbocharger.

IMPORTANT: Replace the compressor wheel or shaft & turbine wheel assembly if the blades are badly distorted or damaged. It is not necessary to make a replacement if a single blade has minor distortion or scratches. Never attempt to re-shape the distorted blade.
1. Installing shaft & turbine wheel, and bearings

   A. Reassemble the bearing housing (Item 21), snap ring (Item 18), bearing (Item 17), turbine back plate (Item 16), piston ring (Item 15), and shaft & turbine wheel (Item 14).

   IMPORTANT:

   Apply engine oil to the inside and outside surfaces of bearing when installing bearing to shaft.

   Apply engine oil to piston ring when installing to shaft & turbine wheel. Be careful not to twist or expand ring more than is necessary for installation.

   Make sure to insert shaft & turbine wheel straight into turbine back plate and bearing housing.

   When installing bearing, make sure that the end with six (6) holes is on the compressor wheel side.

   B. Temporarily install reassembled bearing housing (Item 21) to turbine housing (Item 2), and install coupling assembly (Item 1) by tightening its nut temporarily.
2. Installing thrust bearing

Apply engine oil to inside and outside surfaces of thrust ring (Item 13) and thrust bearing (Item 12), and install the ring and bearing in place.

3. Installing o-ring

Apply engine oil to o-ring (Item 19) and install it in place.

4. Reassembling insert subassembly

A. Assemble the oil deflector (Item 9) to the thrust sleeve (Item 11). Install the piston ring (Item 10) to the thrust sleeve. Install the insert.

IMPORTANT:

When installing piston ring to thrust sleeve, be careful not to expand the ring more than necessary or to twist the end gap.

Apply Molykote to the piston ring fitted on thrust sleeve, and install sleeve to insert, taking care not to damage ring.

B. Install insert subassembly to bearing housing (Item 21).
5. Installing snap ring

A. Use a snap ring pliers to install snap ring (Item 7) to bearing housing (Item 21), with tapered side of snap ring facing up.

B. Use light blows from a hammer and screwdriver to fit the ring in the groove of the bearing housing.

IMPORTANT: Be careful not to damage bearing housing when fitting snap ring to groove in bearing housing with hammer and screwdriver.

6. Measuring clearance between turbine wheel and turbine housing

Set up a dial indicator on shaft & turbine wheel as shown (Fig. 134). Move shaft in axial direction to measure clearance. If clearance measurement is not within standard clearance, disassemble the parts and find the cause.

Unit: mm (in.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Standard clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearance between shaft &amp; turbine wheel and turbine housing</td>
<td>0.42 - 1.10 (0.0165 - 0.0433)</td>
</tr>
</tbody>
</table>

7. Installing compressor wheel

Install compressor wheel (Item 6). Apply Molykote to locknut and tighten it to the specified torque.
8. Measuring axial play of shaft & turbine wheel

Set up a dial indicator on shaft & turbine wheel (Item 14) as shown (Fig. 136). Move compressor wheel (Item 6) in axial direction to measure end play. If measurement is not within standard clearance, disassemble parts and find cause.

Unit: mm (in.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Standard clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial play of shaft &amp; turbine wheel</td>
<td>0.057 - 0.103 (0.00224 - 0.00406)</td>
</tr>
</tbody>
</table>

9. Measuring clearance between turbine back plate and turbine wheel

Remove turbine housing from bearing housing (Item 21), and install compressor cover (Item 4). Use feeler gauges to measure clearance between turbine back plate (Item 16) and turbine wheel. If measurement is not within standard clearance, disassemble parts and find cause.

NOTE: Measure clearance at tips of vanes with two (2) feeler gauges.

Unit: mm (in.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Standard clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearance between turbine back plate and turbine wheel</td>
<td>0.37 - 0.85 (0.0146 - 0.0335)</td>
</tr>
</tbody>
</table>

10. Installing compressor cover

Install compressor cover (Item 4), making sure that it is in correct position with respect to turbine housing. Apply grease to o-ring (Item 20) when installing it.
11. Installing snap ring

Use a snap ring pliers to install snap ring (Item 3) to compressor cover (Item 4), with its tapered side facing up.

![Figure 139](image)

12. Installing turbine housing

Install turbine housing (Item 2) to bearing housing (Item 21), making sure it is in correct position with respect to the housing.

![Figure 140](image)

13. Installing coupling assembly

Apply Molykote to threads of nut in coupling assembly (Item 1), and tighten nut to specified torque.

![Figure 141](image)

0.4 - 0.5 kgf-m
(2.9 - 3.6 lbf-ft)
Lubrication System

Description

Figure 142
Oil Pump

Disassembly

![Diagram of Oil Pump Disassembly](image)

Figure 143

1. Oil pump case cover
2. Spacer
3. Pin
4. Outer rotor
5. Taper pin
6. Pump drive gear
7. Pin
8. Inner rotor
9. Outer rotor
10. Pin
11. Inner rotor
12. Main shaft
13. Oil pump case

Worn or broken gear teeth
1. Removing main shaft

Take off the taper pin and remove the drive gear from the main shaft. Pull the main shaft complete with the inner rotors from the pump case.

2. Removing inner rotors

Remove the pin and separate the inner rotors from the main shaft.

Inspection and Repair

1. Measuring outer rotor-to-inner rotor clearance

If the clearance exceeds the Service limit, replace the outer and inner rotors as an assembly.

Unit: mm (in.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer rotor-to-</td>
<td>0.013 – 0.150</td>
<td>0.250</td>
</tr>
<tr>
<td>inner rotor clearance</td>
<td>(0.0005 – 0.0059)</td>
<td>(0.0098)</td>
</tr>
</tbody>
</table>

Measuring outer rotor-to-inner rotor clearance
2. Measuring rotor-to-cover clearance (end play of rotors)

If the clearance exceeds the Repair limit, replace the rotors or grind the mating faces of the case and cover.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotor-to-cover clearance (end play of rotors)</td>
<td>0.04 – 0.09</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>(0.0016 – 0.0035)</td>
<td>(0.0059)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)

3. Measuring outer rotor-to-pump case clearance

If the clearance exceeds the Service limit, replace the rotor or case whichever is badly worn.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer rotor-to-pump case clearance</td>
<td>0.20 – 0.28</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>(0.0079 – 0.0110)</td>
<td>(0.0197)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)

4. Measuring main shaft-to-pump case clearance

Measure the diameter of main shaft and the inside diameter of pump case to determine the clearance between the two. If the clearance exceeds the Service limit, replace the main shaft or the pump assembly.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of main shaft</td>
<td>13.000 – 12.985</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.51118 – 0.5112)</td>
<td></td>
</tr>
<tr>
<td>Main shaft-to-pump case clearance</td>
<td>0.032 – 0.074</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>(0.0013 – 0.0029)</td>
<td>(0.0059)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)
Reassembly

Reassembling sequence

12→11→10→8→7→13→9→6→5→4→3→2→13

NOTE: When using replacement (new) main shaft and drive gear at the time of reassembling the pump, drill dowel pin hole in and through the shaft and gear.

When tightening the cover bolts, be sure that the matching marks on the cover and case are aligned. Failure to match the marks will result in misalignment and internal damage during operation.
Oil Filter

Disassembly and Inspection

1. Filter element
2. Center screw
3. Filter case
4. Relief valve

Clogged or torn element
Replace element every 500 hours.

Cracks, distortion

Apply engine oil to O-ring when installing element.

Figure 147

Relief Valve

Inspection

1. Check the valve seat for abnormal contact. Also check the spring for weakness or damage.

2. Measure the relief valve opening pressure. If it exceeds the Assembly standard, make an adjustment by tightening or loosening the adjusting screw.

Unit: kgf/cm² (psi)

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relief valve opening pressure</td>
<td>3 ± 0.2 (42.7 ± 2.8)</td>
</tr>
</tbody>
</table>

Figure 148

Hydraulic pressure outlet

Adjusting screw

Groundsmaster® 580-D

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Lubrication System
1. Removing impeller

The impeller is right-hand-threaded. To remove the impeller, turn it counterclockwise (in the direction of the arrow).
2. Removing shaft

Remove the oil seal and snap ring and pull out the shaft complete with bearings from the pulley side.

![Figure 150]

**Inspection**

A. Inspect the pump operation by slowly rotating it. If it is erratic in rotation, replace the bearings.

B. Visually inspect the impeller for corrosion or broken blade. Replace the impeller if defective. Also check the impeller for signs of rubbing contact with the pump case and rear cover. If such a contact is evident, replace the impeller and bearings.

C. Inspect the seal condition. Replace the seal if any sign of leakage is noted during operation.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon protrusion</td>
<td>1.5 (0.059)</td>
<td>0</td>
</tr>
<tr>
<td>Free-state height</td>
<td>21.8 ± 1 (0.858 ± 0.04)</td>
<td></td>
</tr>
</tbody>
</table>

Unit: mm (in.)

- Floating seat (carbon)
- Seal ring (ceramic)
- 1.5 mm (0.059 in.)

Unit seal
Reassembly

Reassembling sequence

13→12→11→10→9→8→7→6→5→4→3→2→1

NOTE: After reassembling the pump, operate it by means of the pulley and belt, making sure that it runs smoothly without any sign of rubbing contact with the pump case or cover.

1. Installing unit seal

   To install the seal, use a seal installer.

   Do not reuse a seal which has been removed from the pump case.

2. Installing oil seal

   To install the seal, use seal installer.
Thermostat

Inspection

Immerse the thermostat in heated water to test it for thermostatic action. If the valve fails to operate properly, replace the thermostat.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature at which valve starts opening</td>
<td>76.5 C 170°F</td>
</tr>
<tr>
<td>Temperature at which valve opens fully</td>
<td>90 C 195°F</td>
</tr>
<tr>
<td>Valve stroke</td>
<td>9(0.35)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)

NOTE: Stir the water in the bath with a stick to maintain uniform temperature during test.

Radiator, Fan, and Fan Belt

Inspection

Figure 155

Distorted or cracked blade
Dirt buildup on fins, scale deposit and rust formation in water passage
Change in length, deterioration, cracks

Figure 154

Temperature

<table>
<thead>
<tr>
<th>(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>76.5</td>
</tr>
<tr>
<td>90</td>
</tr>
<tr>
<td>±2</td>
</tr>
</tbody>
</table>

Groundsmaster® 580-D

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Cooling System
Fuel System

Description

Figure 156

Fuel filter
Fuel injection nozzle
Check valve
Fuel leak-off pipe
Fuel injection pump
Fuel feed pump

To fuel tank
From fuel tank
Fuel Injection Nozzles

Disassembly

Figure 157

1. Retaining nut
2. Nozzle tip
3. Straight pin
4. Tip packing
5. Pressure pin
6. Pressure spring
7. Washer
8. Nozzle body
Inspection and Repair

1. Injection pressure

A. Set up the nozzle on the tester. Operate the tester handle several times to prime the pipe and nozzle.

B. Slowly operate the handle all the way up and down, completing each cycle in about a second, while observing the pressure gauge indication.

C. As the nozzle begins to spray fuel the needle of the gauge will register the injection pressure.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injection pressure</td>
<td>180 - 220</td>
</tr>
<tr>
<td>(valve opening pressure)</td>
<td>(2500 - 3100 psi)</td>
</tr>
</tbody>
</table>

Unit: kg/cm² (psi)

![Testing injection nozzle](image)

**WARNING**

Never expose your hand or other part of the body to fuel spray or the spray hole during the test.

D. If the pressure is out of specification, the nozzle may be shim adjusted.

**NOTE:** Increasing or decreasing shim thickness by 0.1 mm (0.004 in.) raises or drops injection pressure by about 10 kg/cm² (142 psi). Shims for this adjustment are available in 20 sizes, from 1.0 mm (0.039 in.) up to 1.95 mm (0.0768 in.) in an increment of 0.05 mm (0.0020 in.)

![Figure 158](image)

2. Spray pattern

A. At the time of testing the injection pressure, inspect each nozzle for clogged spray holes, fuel leaks from the holes, and incorrect spray pattern.

B. The nozzle should spray fuel from its four orifices at the same time in a good straight cone of 155 degrees, consisting of finely atomized fuel particles.

![Figure 159](image)
3. Washing or replacing nozzle tip.

A. Loosen the retaining nut and remove the nozzle tip. Wash the needle valve and body.

IMPORTANT: Use care to prevent damage to nozzle tip during disassembly.

B. Wash the nozzle tip in clean solvent. After washing, assemble the needle valve and body with clean diesel fuel.

IMPORTANT: The needle valve and body are finely finished. Do not interchange the combination or set of the valve and body.

C. Tighten the retaining nut to the specified torque.

D. If the spray pattern is still bad after the nozzle has been adjusted and cleaned, replace the nozzle tip.

IMPORTANT: Do not touch the sliding surface of the needle valve.

NOTE: New nozzle tips are coated with Vaseline for preservation. Be sure to wash thoroughly first in solvent and then in diesel fuel before assembly.

Reassembly

Reassembling sequence

8 → 7 → 6 → 5 → 4 → 3 → 2 → 1
Fuel Feed Pump

Figure 162

1. Screw
2. Pump assembly
3. Gasket
4. Spring
5. Valve
6. Block
7. Tappet
8. Roller
9. Ring
10. Pin
11. Housing assembly
12. Washer
13. Filter
14. Screw
15. Plug
16. Washer
17. Spring
18. Piston
19. Rod
20. Support
Testing

1. Leakage

Plug or cap outlet of feed pump and connect hose from air compressor to inlet of feed pump. Submerge feed pump in a container of diesel fuel and apply air pressure of 2 kg/cm² (28 psi) to the feed pump inlet for one minute. Air leakage from tappet bore should not exceed 50 cc/min.

2. Suction performance

A. Pump should be capable of delivering fuel within 30 seconds when operating priming pump up and down at 60 to 100 strokes per minute.

B. Pump should be capable of delivering fuel within 40 seconds when cranking engine (150 injection pump rpm).

3. Pressure and fuel delivery

A. Drive pump at 1000 injection pump rpm. Feed pressure of fuel and fuel delivery quantity should be approximately 1.5 kg/cm² (21 psi) and more than 600 cc/minute (36 oz/min).

B. With outlet of feed pump closed, drive pump at 600 injection pump rpm. Feed pump pressure should be more than 2 kg/cm² (28 psi).

Repair

1. Disassemble and inspect parts for wear. Replace parts if worn or damaged. Priming pump cannot be disassembled and must be replaced as a unit.

2. Install new gaskets when reassembling.
Fuel Injection Pump

NOTE: Special equipment is required for testing and adjustment of injection pump. It is recommended that you see an authorized Nippondenso service dealer for repair work on the fuel injection pump - especially during the warranty period. Repairs made by non-authorized dealers COULD void the pump warranty. Also, contact the Nippondenso service dealer BEFORE removing the pump from the engine.

IMPORTANT: Clean the injection pump and the area around the injection pump before removing or servicing it. DO NOT spray water onto a hot injection pump. (See the Accessory Removal and Installation section of this chapter for pump removal and installation instructions.)

Figure 163

1. Plate  
2. Rack  
3. Washer  
4. Valve  
5. Gasket  
6. Bearing  
7. Plate  
8. Ring  
9. Packing  
10. Screw  
11. Screw  
12. Pinion  
13. Sleeve  
14. Seat  
15. Spring  
16. Seat  
17. Plate  
18. Pin  
19. Body  
20. Bushing  
21. Roller  
22. Plug  
23. E-ring  
24. Screw
Disassembly and Assembly Precautions

1. Cleanliness is very important when servicing fuel injection equipment. Clean the exterior of the injection pump and visually inspect it for damage.

2. When removing plunger from barrel, smoothly pull it out. Always service the pump element and delivery valve assembly as complete units. These parts should not be mixed as they are “matched sets”.

3. Overtightening the delivery valve holder will cause damage to the pump housing and malfunctions of moving parts (i.e. control rack). Tighten delivery valve holder to correct torque with a torque wrench.

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery valve holder tightening</td>
<td>3.5 - 40.0 kg-m (25 - 29 ft-lb)</td>
</tr>
<tr>
<td>torque</td>
<td></td>
</tr>
</tbody>
</table>

4. When assembling pump housing, put each plunger in correct location. At that time, marking on plunger vane must face outward toward cover plate opening in pump housing. Control helix of plunger has to align with barrel port as shown. Improper installation can cause excessive fuel injection or uncontrolled fuel injection quantity.

5. Control rack should slide smoothly back and forth. Sliding resistance should be less than 50 grams at 1000 pump rpm and less than 120 grams at 0 pump rpm. Sticking of control rack can be caused by scratches on rack and control pinion, friction between control pinion and pump housing and overtightening of delivery valve holder.

6. Camshaft endplay should be within specified value. If endplay is out of specification, adjust with shims.

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injection pump camshaft endplay</td>
<td>0.003 - 0.05 mm (0.0012 - 0.0020 in.)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Injection Pump Testing

1. Delivery valve tightness

   A. Use a new pump element.

   B. Install a 0-300 kg/cm² (5000 psi) pressure gauge to delivery valve holder. Hold control rack in idling position. Drive pump at 200 rpm. Delivery pressure should be more than 150 kg/cm² (2133 psi).

2. Delivery valve retraction

   A. Wash delivery valve thoroughly in diesel fuel.

   B. Pull up on delivery valve and close the bore at valve housing bottom with thumb. When valve is released, it should drop quickly and stop where relief plunger of delivery valve closes the valve housing bore. If defective, replace delivery valve assembly as a set.

   Figure 165

Governor

NOTE: Special tools and equipment are required for repair, testing and adjustment of governor. It is recommended that you see an authorized Nippondenso service dealer for repair work on the governor - especially during the warranty period. Repairs made by non-authorized dealers could void the governor warranty. Also, contact the Nippondenso service dealer BEFORE removing the governor from the engine.

(See No-Load Minimum and Maximum Speed in the Adjustments section of this chapter for additional information.)
General Overhaul Information

Oil seals

When installing oil seals, carefully observe the following points:

1. Driving oil seals into housing

   A. Make sure that seal lip is not damaged and position it correctly with respect to oil compartment.

   B. Apply a small amount of grease to the surface of oil seal to be fitted into housing bore.

   C. Using a tool of the type shown to guide seal lip, drive oil seal squarely. Never give any hammer blows directly to oil seal since this will damage the seal, resulting in oil leakage.

![Oil seal driver]

2. Driving oil seals onto shafts

   A. Apply a thin coat of grease to oil seal lip.

   B. Use an oil seal guide of the type shown when driving oil seal over stepped portion, splines, threads or keyway to prevent damage to seal lip.

![Oil seal guide]
O-rings

Use an O-ring guide of the type shown when installing O-ring over stepped portion, splines, threads or keyway to prevent damage to the ring. Apply a thin coat of grease to O-ring.

Bearings

When installing a rolling bearing, be sure to give a push to the race, inner or outer, by which the bearing is fitted. Be sure to use a bearing driver of the type shown.

2. Use a press whenever possible to minimize shock to bearing and to assure proper installation.
Lock Plates

Bend lock plate against one of the flats of nut or bolt heads as shown.

Split Pins and Spring Pins

Generally, spring pins are to be replaced at the time of disassembly. Drive each spring into position so that it does not get out of place after subsequent installation of parts has been completed.
General Information

The engine used in the Groundsmaster 580–D mower is manufactured by Mitsubishi Heavy Industries Limited. Service and repair parts for Mitsubishi engines are supplied through TORO Distributors. Repair parts may be ordered by TORO part number. If no parts list is available be sure to provide your Distributor with the TORO model number and serial number.

General maintenance procedures are described in your Toro Operator’s Manual.

Information on engine troubleshooting, testing, disassembly and reassembly is provided in the Mitsubishi S4S–DT Engine Service Manual, Part No. 95866SL.

Note: Refer to Chapter 3 – Engine (Model 30580) for information regarding engine removal and installation.

Stopping the Engine

IMPORTANT: Before stopping the engine after mowing or full load operation, cool the turbocharger by allowing the engine to idle at low speed for 5 minutes. Failure to do so may lead to turbocharger failure.
### Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make / Designation</td>
<td>Mitsubishi Model S4S–DT&lt;br&gt;4 cycle, 4 cylinder Diesel Engine</td>
</tr>
<tr>
<td>Number of Cylinders</td>
<td>4</td>
</tr>
<tr>
<td>Total Displacement</td>
<td>3331 cc (203.3 cu. in.)</td>
</tr>
<tr>
<td>Fuel</td>
<td>Diesel Fuel No. 2-D</td>
</tr>
<tr>
<td>Fuel Capacity</td>
<td>28 U.S. gallon (106 liter)</td>
</tr>
<tr>
<td>Idle Speed (no load)</td>
<td>1150 +/- 50 RPM</td>
</tr>
<tr>
<td>High Idle (no load)</td>
<td>2750 +/- 50 RPM</td>
</tr>
<tr>
<td>Engine Oil (do not use multi-viscosity oils)</td>
<td>API Service Classification CD or better&lt;br&gt;-20 to 20°F (-29 to -7°C) SAE 10&lt;br&gt;20 to 105°F (-7 to 41°C) SAE 30&lt;br&gt;105°F (41°C) and above SAE 40</td>
</tr>
<tr>
<td>Oil Capacity</td>
<td>10.6 U.S. quart (10 liter) with filter</td>
</tr>
</tbody>
</table>
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MITSUBISHI S4S-Y2DT61TG SERVICE MANUAL

General Information

The engine used in the Groundsmaster 580-D Models 30582 and 30583 mower is manufactured by Mitsubishi Heavy Industries Limited. Service and repair parts for this Mitsubishi engine are supplied through TORO Distributors. Repair parts may be ordered by TORO part number. If no parts list is available be sure to provide your Distributor with the TORO model number and serial number.

General maintenance procedures are described in your Operator’s Manual. Information on engine troubleshooting, testing, disassembly and reassembly is identified in the Mitsubishi S4S-Y2DT61TG Service Manual that is included at the end of this section.

Note: Refer to Chapter 3 – Engine (Model 30580) for information regarding engine removal and installation.

Stopping the Engine

IMPORTANT: Before stopping the engine after mowing or full load operation, cool the turbocharger by allowing the engine to idle at low speed for 5 minutes. Failure to do so may lead to turbocharger failure.
### Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make / Designation</td>
<td>Mitsubishi Model S4S-DT</td>
</tr>
<tr>
<td></td>
<td>4 cycle, OHV, Liquid Cooled, Turbocharged Diesel Engine</td>
</tr>
<tr>
<td>Number of Cylinders</td>
<td>4</td>
</tr>
<tr>
<td>Total Displacement</td>
<td>3331 cc (203.3 cu. in.)</td>
</tr>
<tr>
<td>Fuel</td>
<td>Diesel Fuel No. 2-D</td>
</tr>
<tr>
<td>Fuel Capacity</td>
<td>28 U.S. gallon (106 liter)</td>
</tr>
<tr>
<td>Idle Speed (no load)</td>
<td>1100 ± 50 RPM</td>
</tr>
<tr>
<td>High Idle (no load)</td>
<td>2700 ± 50 RPM</td>
</tr>
<tr>
<td>Engine Oil</td>
<td>See Operator's Manual for Oil Recommendations</td>
</tr>
<tr>
<td>Oil Capacity</td>
<td>10.5 U.S. quart (10 liter) with filter</td>
</tr>
</tbody>
</table>
Chapter 4

Hydraulic System

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NOTE: See Chapter 9 - Foldout Diagrams for Hydraulic Schematics

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VICKERS GEAR PUMP OVERHAUL MANUAL
HALDEX/BARNES G20 & G30 SERIES HYDRAULIC GEAR PUMPS INSPECTION/SERVICING
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EATON CHAR-LYNN 4000 COMPACT SERIES DISC VALVE GEROLER MOTOR REPAIR INFORMATION
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traction Drive Pump</td>
<td>Variable displacement axial piston pump with servo assisted manual displacement control (MDC)</td>
</tr>
<tr>
<td>Main relief pressure</td>
<td>5000 ± 250 psi (344.8 ± 7.2 bar)</td>
</tr>
<tr>
<td>Charge relief pressure (Pump S/N below A-96-01-XXXXX)</td>
<td>230 ± 10 psi (15.9 ± 0.7 bar)</td>
</tr>
<tr>
<td>Charge relief pressure (Pump S/N above A-96-01-XXXXX)</td>
<td>285 ± 10 psi (15.9 ± 0.7 bar)</td>
</tr>
<tr>
<td>Front Wheel Motor (2 used)</td>
<td>Variable displacement axial piston motor</td>
</tr>
<tr>
<td></td>
<td>Mow/Transport speed, elec./hyd. solenoid actuated</td>
</tr>
<tr>
<td>PTO (Deck Drive) Pump</td>
<td>Two section, external gear type</td>
</tr>
<tr>
<td>PTO (Deck Drive) Valve Block</td>
<td>Toro, cartridge logic, elec./hyd. solenoid actuated</td>
</tr>
<tr>
<td>Relief pressure (3 relief valves: front deck, right deck, left deck)</td>
<td>3000 to 3200 psi (206.9 to 220.7 bar)</td>
</tr>
<tr>
<td>Deck Drive Motor (3 used)</td>
<td>External gear type</td>
</tr>
<tr>
<td>Lift Control Valve</td>
<td>3 spool</td>
</tr>
<tr>
<td>Lift circuit relief pressure (S/N below 240000000)</td>
<td>1500 ± 50 psi (103.4 ± 3.4 bar)</td>
</tr>
<tr>
<td>Lift circuit relief pressure (S/N above 240000000)</td>
<td>2000 ± 50 psi (137.9 ± 3.4 bar)</td>
</tr>
<tr>
<td>NOTE: Lift pressure when measured at the LIFT test port is Lift Circuit Relief Pressure + Counterbalance Pressure</td>
<td></td>
</tr>
<tr>
<td>Float/Traction Assist Manifold Block</td>
<td>Toro, cartridge logic</td>
</tr>
<tr>
<td>Counterbalance pressure</td>
<td>400 ± 25 psi (27.6 ± 1.7 bar)</td>
</tr>
<tr>
<td>“Traction Plus” counterbalance pressure</td>
<td>600 ± 25 psi (41.4 ± 1.7 bar)</td>
</tr>
<tr>
<td>“Traction Plus” shift pressure</td>
<td>2000 ± 50 psi (137.9 ± 3.4 bar)</td>
</tr>
<tr>
<td>Lift/Steering Pump</td>
<td>External gear type w/priority flow divider</td>
</tr>
<tr>
<td>Steering relief pressure</td>
<td>1500 ± 50 psi (103.4 ± 3.4 bar)</td>
</tr>
<tr>
<td>Steering Control</td>
<td>Hydraulic power steering control unit</td>
</tr>
<tr>
<td>Hydraulic Oil</td>
<td>Refer to Operator’s Manual for hydraulic oil recommendations</td>
</tr>
<tr>
<td>Reservoir Capacity</td>
<td>32 U.S. gallon (121.1 liter)</td>
</tr>
<tr>
<td>System Capacity</td>
<td>40 U.S. gallon (151.4 liter)</td>
</tr>
<tr>
<td>Oil Filter</td>
<td>Screw-on cartridge type, 5 micron, 50 psi (3.4 bar) bypass</td>
</tr>
</tbody>
</table>

**Note:** When measuring lift circuit relief pressure, counterbalance pressure, and “Traction Plus” counterbalance pressure on machines with serial numbers above 250000000, pressures will be approximately 125 psi (8.6 bar) higher than the specifications listed above. Refer to the Testing section in this chapter for detailed information.
Hydraulic Hoses

Hydraulic hoses are subject to extreme conditions such as, pressure differentials during operation and exposure to weather, sun, chemicals, very warm storage conditions or mishandling during operation or maintenance. These conditions can cause damage or premature deterioration. Some hoses, such as deck motor hoses, are more susceptible to these conditions than others. Inspect the hoses frequently for signs of deterioration or damage.

When replacing a hydraulic hose, be sure that the hose is straight (not twisted) before tightening the fittings. This can be done by observing the imprint on the hose. Use two wrenches; one to hold the hose straight and one to tighten the hose swivel nut onto the fitting.

WARNING

Before disconnecting or performing any work on the hydraulic system, all pressure in the system must be relieved by lowering the front deck to the ground, raising or lowering the wing decks completely, and stopping the engine.

Keep body and hands away from pin hole leaks or nozzles that eject hydraulic fluid under high pressure. Use paper or cardboard, not hands, to search for leaks. Hydraulic fluid escaping under pressure can have sufficient force to penetrate the skin and do serious damage. If fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type of injury or gangrene may result.

Hydraulic Fitting Installation

O-Ring Face Seal

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches, or any foreign material (Fig. 2).

2. Make sure the O-ring is installed and properly seated in the groove. It is recommended that the O-ring be replaced any time the connection is opened.

3. Lubricate the O-ring with a light coating of oil.

4. Put the tube and nut squarely into position on the face seal end of the fitting and tighten the nut until finger tight.

5. Mark the nut and fitting body. Hold the body with a wrench. Use another wrench to tighten the nut to the correct flats from finger tight (F.F.F.T.). The markings on the nut and fitting body will verify that the connection has been tightened.

<table>
<thead>
<tr>
<th>Size</th>
<th>F.F.F.T.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 (1/4 in. nominal hose or tubing)</td>
<td>0.75 ± 0.25</td>
</tr>
<tr>
<td>6 (3/8 in.)</td>
<td>0.75 ± 0.25</td>
</tr>
<tr>
<td>8 (1/2 in.)</td>
<td>0.75 ± 0.25</td>
</tr>
<tr>
<td>10 (5/8 in.)</td>
<td>1.00 ± 0.25</td>
</tr>
<tr>
<td>12 (3/4 in.)</td>
<td>0.75 ± 0.25</td>
</tr>
<tr>
<td>16 (1 in.)</td>
<td>0.75 ± 0.25</td>
</tr>
</tbody>
</table>
SAE Straight Thread O-Ring Port (Non-adjustable)

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches, or any foreign material.

2. Always replace the O-ring seal when this type of fitting shows signs of leakage.

3. Lubricate the O-ring with a light coating of oil.

4. Install the fitting into the port and tighten it down full length until finger tight (Fig. 3).

5. Tighten the fitting to the correct flats from finger tight (F.F.F.T.).

<table>
<thead>
<tr>
<th>Size</th>
<th>F.F.F.T.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 (1/4 in. nominal hose or tubing)</td>
<td>1.00 ± .25</td>
</tr>
<tr>
<td>6 (3/8 in.)</td>
<td>1.50 ± .25</td>
</tr>
<tr>
<td>8 (1/2 in.)</td>
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</tr>
<tr>
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<td>1.50 ± .25</td>
</tr>
<tr>
<td>16 (1 in.)</td>
<td>1.50 ± .25</td>
</tr>
</tbody>
</table>

SAE Straight Thread O-Ring Port (Adjustable)

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches, or any foreign material (Fig. 4).

2. Always replace the O-ring seal when this type of fitting shows signs of leakage.

3. Lubricate the O-ring with a light coating of oil.

4. Turn back the jam nut as far as possible. Make sure the back up washer is not loose and is pushed up as far as possible (Step 1).

5. Install the fitting into the port and tighten finger tight until the washer contacts the face of the port (Step 2).

6. To put the fitting in the desired position, unscrew it by the required amount, but no more than one full turn (Step 3).

7. Hold the fitting in the desired position with a wrench and turn the jam nut with another wrench to the correct flats from finger tight (F.F.F.T.) (Step 4).

<table>
<thead>
<tr>
<th>Size</th>
<th>F.F.F.T.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 (1/4 in. nominal hose or tubing)</td>
<td>1.00 ± .25</td>
</tr>
<tr>
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<tr>
<td>12 (3/4 in.)</td>
<td>1.50 ± .25</td>
</tr>
<tr>
<td>16 (1 in.)</td>
<td>1.50 ± .25</td>
</tr>
</tbody>
</table>
Pushing or Towing (Pump By-Pass Method)

In an emergency, the machine can be moved a short distance by opening the by-pass valve on the variable displacement hydraulic pump and pushing or towing the machine.

NOTE: The machine can be moved longer distances by disengaging the planetary wheel drives. (See Disengage Planetary Wheel Drive For Towing in the General Information section of Chapter 6 - Wheels, Brakes and Steering.)

IMPORTANT: Do not push or tow the machine faster than 2 - 3 mph because internal transmission damage may occur. The by-pass valve must be open whenever the machine is pushed or towed by this method. TORO does not recommend this process be used as standard procedure.

1. The by-pass valve is located on the left side of the variable displacement pump (Fig. 5). With the engine off, rotate the valve 1/2 to 1 turn counterclockwise to open and allow oil to by-pass internally. Because fluid is by-passed, the machine can be moved - slowly - without damaging the transmission.

2. Rotate the valve clockwise until it is securely seated before starting the engine. Do not exceed 8 ft-lb torque to close the valve.

IMPORTANT: Running the engine with the by-pass valve open will cause the transmission to overheat.

Draining and Refilling System

IMPORTANT: Drain and refill the reservoir (Fig. 1) and change oil filter (Fig. 6) if component failure was severe or system is contaminated. (See Hydraulic Reservoir and Filter section of this chapter.)
Hydraulic Flow Diagrams

Typical Circuits – Engine Running

Traction Circuit – NEUTRAL

The traction pump is a variable-displacement piston pump driven by a drive shaft off the front of the engine crankshaft. The operator sets the displacement of the pump with the foot pedal. The pump swash plate returns to neutral when the foot pedal is released.

An integral charge pump provides a constant supply of charge oil to the pump and closed loop circuit for lubrication and to make up for oil that is lost due to internal leakage in the pump and motors. Oil from internal leakage returns to the reservoir through case drain lines. This constant replacement of oil provides cooling for the closed loop system. Charge pressure is limited by a relief valve in the traction pump. Charge pressure may be monitored at the CHARGE PUMP test port.

The wheel motors have two displacement positions: low speed and high speed. The motor swash plates are held in the low speed position by springs. When the two-speed solenoid is energized the spool is shifted to direct charge pressure to the wheel motors. This shifts the motor swash plates to the high speed range.

Hydraulic pressure to the wheel motors may be monitored at the TRACTION FORWARD and TRACTION REVERSE test ports.

Steering / Lift Circuit – Steering NEUTRAL

The single section gear pump is mounted on the variable displacement traction pump and is driven by the traction pump shaft. A priority flow divider in the pump directs priority oil flow to the steering orbitrol control valve.

When the steering wheel is not being turned, oil flows through the control spool in the steering valve and returns to reservoir. Oil is blocked in both steering cylinders, keeping the wheels in their straight or turned condition.

A relief valve in the pump limits pressure in the steering circuit. Hydraulic pressure to the steering valve may be monitored at the POWER STEERING test port.

Steering / Lift Circuit – LIFT All Decks

Oil flow from the pump that is not required for steering is directed through the float/traction assist manifold block to the lift valve.

The flow control cartridge in the float/traction assist manifold block provides a constant flow of oil to the lift valve. Excess oil exits the float/ traction assist manifold block, and is directed through the case drain ports of the wheel motors to the reservoir.

The lift valve is an open-center valve which has three sets of spools. The operator sets the position of the spools with three levers on the control panel. Holding a lever in the UP position directs oil through the float/ traction assist manifold block to the lift cylinder(s). The cylinder(s) raise the deck. Oil displaced from the other port of the cylinder(s) returns to reservoir. Displaced oil from the front deck cylinders returns directly to reservoir. Displaced oil from each wing deck cylinder flows through the lift valve to the float/ traction manifold block and is directed through the wheel motor case drain ports to reservoir. A cold oil by-pass valve allows oil exiting the float/ traction assist manifold block to return directly to reservoir instead of through the wheel motor case drain ports if pressure exceeds 15 psi.

Oil pressure is limited by a relief valve in the lift valve. Lift circuit hydraulic pressure may be monitored at the DECK LIFT test port.

PTO Circuit – All Decks OFF

The PTO circuit is powered by a two-section gear pump, which is driven directly off the engine flywheel. Oil from the rear section of the pump is directed to port P1 of the PTO valve block. Oil from the front section of the pump is directed to port P2 of the PTO valve block.

A solenoid valve and two logic cartridges control each deck motor. In the OFF condition the solenoid valve is de-energized, which blocks return oil flow from the deck motor through the brake logic cartridge and allows oil to flow through the bypass (main) logic cartridge to port T of the valve block. Return oil from port T is directed through the oil cooler and return filter to the hydraulic reservoir. The return filter is equipped with a bypass valve. If the filter becomes clogged, the bypass valve opens, allowing unfiltered oil to enter the reservoir.

NOTE: If the deck was operating and the solenoid valve goes to the OFF condition, the brake relief valve provides braking action for the deck motor after return oil flow from the deck motor is blocked by the brake logic cartridge.

Hydraulic pressure to the drive motors may be monitored at the LEFT, FRONT, and RIGHT DECK DRIVE test ports.
Typical Circuits – Mowing

Traction Circuit – FORWARD

Pushing the top of the traction pedal shifts the pump swash plate to create a flow of high pressure oil. This oil is directed to the forward inlets of the left and right wheel motors, driving the machine forward. Return oil from the motors flows back to the traction pump and is re-used in the closed-loop traction circuit.

An integral charge pump provides a constant supply of charge oil to the pump and closed loop circuit for lubrication and to make up for oil that is lost due to internal leakage in the pump and motors. Oil from internal leakage returns to the reservoir through case drain lines. This constant replacement of oil provides cooling for the closed loop system. Charge pressure is limited by a relief valve in the traction pump. Charge pressure may be monitored at the CHARGE PUMP test port.

If the 2 speed solenoid valve is energized, charge pressure is directed to the shift valve in each wheel motor which shifts the motor swash plate to transport speed. A spring in each wheel motor shift valve keeps the swash plate in the low speed position when the 2 speed solenoid valve is de-energized.

Oil pressure to the wheel motors is limited by two relief valves in the traction pump (one for forward traction, and one for reverse). If oil pressure exceeds the relief setting, oil flows through the relief valve to the low pressure side of the pump. Hydraulic pressure to the wheel motors may be monitored at the TRACTION FORWARD and TRACTION REVERSE test ports.

Steering / Lift Circuit – RIGHT Turn

A priority flow divider in the pump directs priority oil flow to the steering orbitrol control valve.

Turning the steering wheel to the right meters oil to both steering cylinders. The cylinder rod for the right wheel retracts, and the cylinder rod for the left wheel extends. Cylinder rod movement sends return oil back through the steering valve to the reservoir.

A relief valve in the pump limits pressure in the steering circuit. Hydraulic pressure to the steering valve may be monitored at the POWER STEERING test port.

Steering / Lift Circuit – Decks FLOATING

Oil flow from the pump that is not required for steering is directed through the float/traction assist manifold block to the lift valve.

The flow control cartridge in the float/traction assist manifold block provides a constant flow of oil to the lift valve. Excess oil exits the float/traction assist manifold block, and is directed through the case drain ports of the wheel motors to the reservoir.

A detent plunger holds the lift valve spools in a free-float position after the levers are released to neutral from the lower position, allowing the decks to follow ground contours.

After oil leaves the lift valve, it is directed through the counterbalance relief cartridge in the traction assist manifold block then through the case drain ports of the wheel motors to reservoir. The counterbalance relief cartridge creates back-pressure through the lift valve to the lift port of the lift cylinders, causing a counterbalance effect. If forward traction pressure exceeds 2,000 psi (such as when climbing a hill) the traction plus shift cartridge directs oil from the return side of the lift valve to the "traction plus" relief cartridge. The "traction plus" relief cartridge creates a higher back pressure through the lift valve resulting in more deck weight being transferred to the traction unit.

Hydraulic counterbalance pressure may be monitored at the DECK LIFT test port.

PTO Circuit – ALL Decks ON

The PTO circuit is powered by a two-section gear pump, which is driven directly off the engine flywheel. The rear section of the pump provides oil for the front deck, and the front section of the pump provides oil for the left and right wing decks.

A solenoid valve and two logic cartridges control each deck motor. When the solenoid is energized, the solenoid valve spool shifts, blocking oil flow through the bypass (main) logic cartridge. Oil flow is directed out of the valve block to the deck motor.

Return oil from the motor is directed back to the valve block, through the brake logic cartridge, out port T and through the oil cooler and return filter to the hydraulic reservoir. The return filter is equipped with a bypass valve. If the filter becomes clogged, the bypass valve opens, allowing unfiltered oil to enter the reservoir.

Hydraulic pressure is limited by relief valves in the PTO valve block. Hydraulic pressure to each drive motor may be monitored at the LEFT, FRONT, and RIGHT DECK DRIVE test ports.
Special Tools

NOTE: Order special tools from the TORO SPECIAL TOOLS AND APPLICATIONS GUIDE (COMMERCIAL PRODUCTS). Some tools may be listed in the Groundsmaster 580-D Parts Catalog. Some tools may also be available from a local supplier.

Hydraulic Pressure Test Kit

Used to take various hydraulic pressure readings for diagnostic tests. Quick disconnect fittings provided attach directly to mating fittings on machine test ports without tools. A high pressure hose is provided for remote readings. Contains one each, 1,000, 5,000 and 10,000 PSI gauges. Use gauges as recommended in Testing section of this chapter.

Seal Installation Tools

Information about seal installation tools for traction pump, traction motor and PTO pump are provided in component manuals at the end of this chapter.
Troubleshooting

The cause of an improperly functioning hydraulic system is best diagnosed with the use of proper testing equipment and a thorough understanding of the complete hydraulic system.

A hydraulic system with an excessive increase in heat or noise is a potential failure. Should either of these conditions be noticed, immediately stop the machine, turn off the engine, locate the cause of the trouble, and correct it before allowing the machine to be used again. Continued use of an improperly functioning hydraulic system could lead to extensive internal component damage.

The charts that follow contain detailed information to assist in troubleshooting. There may possibly be more than one cause for a machine malfunction. All causes should be checked in the order in which they are listed on the charts.

Refer to the Testing section of this Chapter for precautions and specific test procedures.

---

System Operates Hot

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excessive uphill operation in high range.</td>
<td>Operate in low range.</td>
</tr>
<tr>
<td>Low engine RPM.</td>
<td>Adjust - use tachometer.</td>
</tr>
<tr>
<td>Hydraulic oil level too low.</td>
<td>Fill to proper level.</td>
</tr>
<tr>
<td>Cooling system not operating properly.</td>
<td>Clean screen, oil cooler &amp; radiator. Repair fan or belt.</td>
</tr>
<tr>
<td>Traction pump bypass (tow) valve open or damaged.</td>
<td>Close or repair.</td>
</tr>
<tr>
<td>Kinked or severely bend hose or tubing.</td>
<td>Replace kinked or bent hose or tubing.</td>
</tr>
<tr>
<td>Traction circuit charge pressure to low - TEST NO. 2.</td>
<td>Inspect charge relief valve and repair or adjust if necessary.</td>
</tr>
<tr>
<td></td>
<td>Inspect charge pump and repair or replace if necessary.</td>
</tr>
<tr>
<td>Traction pressure too low - TEST NO. 1.</td>
<td>Inspect check / high pressure relief valve(s) and replace if necessary.</td>
</tr>
<tr>
<td></td>
<td>Check traction pump and motor(s) for damage or excessive wear and repair or replace if necessary.</td>
</tr>
<tr>
<td>Traction working pressure too high - TEST NO. 1.</td>
<td>Inspect brakes for binding and adjust or repair if necessary.</td>
</tr>
<tr>
<td></td>
<td>Check for other cause of excessive machine load and correct.</td>
</tr>
</tbody>
</table>
Neutral Difficult or Impossible to Find

See Troubleshooting section of SUNDSTRAND SAUER M46-AXIAL PISTON PUMPS AND MOTORS SERVICE MANUAL

Machine Travels In One Direction Only

See Troubleshooting section of SUNDSTRAND SAUER M46-AXIAL PISTON PUMPS AND MOTORS SERVICE MANUAL

Traction Response Is Sluggish

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brakes dragging.</td>
<td>Inspect brakes and adjust or repair if necessary.</td>
</tr>
<tr>
<td>Also see Troubleshooting section of SUNDSTRAND SAUER M46-AXIAL PISTON PUMPS AND MOTORS SERVICE MANUAL.</td>
<td></td>
</tr>
</tbody>
</table>

Machine Will Not Travel In Either Direction

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planetary wheel drive hubs disengaged.</td>
<td>Install disengage covers so dimple on cover is facing out.</td>
</tr>
<tr>
<td>Drive shaft between engine and transmission disconnected or failed.</td>
<td>Connect or replace drive shaft.</td>
</tr>
<tr>
<td>Coupling(s) between wheel motor and planetary wheel drive failed.</td>
<td>Inspect coupling and repair if necessary.</td>
</tr>
<tr>
<td>Brakes engaged.</td>
<td>Inspect brakes and adjust or repair if necessary. NOTE: Electrical interlock system should shut engine down if parking brake is engaged when traction pedal is pushed down.</td>
</tr>
<tr>
<td>Also see Troubleshooting section of SUNDSTRAND SAUER M46-AXIAL PISTON PUMPS AND MOTORS SERVICE MANUAL.</td>
<td></td>
</tr>
</tbody>
</table>
### Machine Will Not Go Into High Range

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck(s) down.</td>
<td>Raise deck(s).</td>
</tr>
<tr>
<td>Traction circuit charge pressure too low - TEST NO. 2.</td>
<td>Inspect charge relief valve and repair or adjust if necessary.</td>
</tr>
<tr>
<td></td>
<td>Inspect charge pump and repair or replace if necessary. NOTE: If the charge pump is in good condition, the general condition of the traction pump and wheel motors might be suspected of wear and inefficiency, i.e. charge pump cannot keep up with internal leakage.</td>
</tr>
<tr>
<td>Two-speed shift valve not shifting.</td>
<td>Check for electrical problems. (See Troubleshooting section of Chapter 5 - Electrical System).</td>
</tr>
<tr>
<td></td>
<td>Check solenoid shift spool for damage or binding and replace solenoid valve if necessary.</td>
</tr>
<tr>
<td>Hydraulic wheel motors not shifting to high range.</td>
<td>If correct charge pressure is available to wheel motor from two-speed shift valve, repair or replace wheel motor.</td>
</tr>
</tbody>
</table>

### Machine Goes Into High Range But Top Speed Is Too Slow

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traction control rod out of adjustment.</td>
<td>Adjust so when traction control rod is all the way back, front of traction pedal hits floor.</td>
</tr>
<tr>
<td>One wheel motor not shifting.</td>
<td>Repair or replace damaged wheel motor.</td>
</tr>
</tbody>
</table>

### Machine Does Not Go Into Low Range

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical problems.</td>
<td>See Troubleshooting section of Chapter 5 - Electrical System.</td>
</tr>
<tr>
<td>Two-speed shift valve spool damaged or binding.</td>
<td>Replace two-speed shift solenoid valve.</td>
</tr>
</tbody>
</table>
### Engine Shuts Off When On Side Hill Or Down Hill

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic oil level too low.</td>
<td>Fill to proper level.</td>
</tr>
<tr>
<td>Seat lifting off seat switch.</td>
<td>Instruct operator to sit back in seat during operation</td>
</tr>
<tr>
<td></td>
<td>Check seat plate hinges and seat support pin and repair if faulty.</td>
</tr>
<tr>
<td>Electrical problems.</td>
<td>See Troubleshooting section of Chapter 5 - Electrical System.</td>
</tr>
</tbody>
</table>

### No Decks Operate

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic oil level too low.</td>
<td>Fill to proper level.</td>
</tr>
<tr>
<td>Low engine RPM.</td>
<td>Adjust engine rpm - use tachometer.</td>
</tr>
<tr>
<td>Electrical problem.</td>
<td>See Troubleshooting section of Chapter 5 - Electrical System.</td>
</tr>
<tr>
<td>Low or no PTO (deck) drive pressure for all decks - TEST NO. 6.</td>
<td>Check for restriction in pump intake line or strainer and repair if necessary.</td>
</tr>
<tr>
<td></td>
<td>Check for damaged PTO pump shaft. Repair or replace pump if necessary.</td>
</tr>
</tbody>
</table>

### All Decks Operate Slowly

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low engine RPM.</td>
<td>Adjust engine rpm - use tachometer.</td>
</tr>
<tr>
<td>Hydraulic oil level too low.</td>
<td>Fill to proper level.</td>
</tr>
<tr>
<td>Low PTO (deck) drive pressure for all decks - TEST NO. 6.</td>
<td>Check for restriction in pump intake line or strainer and repair if necessary.</td>
</tr>
<tr>
<td></td>
<td>Repair or replace PTO pump.</td>
</tr>
<tr>
<td>Cause</td>
<td>Correction</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Deck drive belt slipping or drive motor pulley is damaged/disconnected.</td>
<td>Inspect and adjust or replace belt or pulley.</td>
</tr>
<tr>
<td>Electrical problem.</td>
<td>See Troubleshooting section of Chapter 5 - Electrical System.</td>
</tr>
</tbody>
</table>
| Low or no PTO (deck) drive pressure for affected deck - TEST NO. 6.    | Inspect solenoid valve (SV) for damage or sticking in off position and clean or replace if necessary. (Interchange solenoid valves with another deck. If problem follows suspected bad valve, replace valve.)
|                                                 | Inspect bypass logic cartridge (BY) for plugged orifice, damage, or sticking, and clean or replace if necessary. (Interchange cartridge with another deck circuit. If problem follows suspected bad cartridge, replace cartridge.) NOTE: If affected deck is a wing deck, interchange cartridges with the front deck circuit for proper diagnosis. |
|                                                 | Inspect bypass relief cartridge (R_BY) for damage or sticking in open position and clean or replace if necessary. (Interchange relief cartridges with another deck circuit. If problem follows suspected bad cartridge, attempt to adjust, then replace cartridge if necessary.) NOTE: If affected deck is a wing deck, interchange cartridges with the front deck circuit for proper diagnosis. |
|                                                 | Repair or replace PTO pump. NOTE: Rear section of pump drives front deck. Front section of pump drives both wing decks. Pump is not the problem if only one wing deck is affected. |
| Damaged deck drive motor.                       | Interchange deck drive motors with another deck. If problem follows suspected bad motor, repair or replace motor. NOTE: If affected deck is a wing deck, interchange motor with the front deck for proper diagnosis. |
### One Deck Operates Slowly and/or Loses Power in Heavy Cutting

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck drive belt slipping or drive pulley damaged.</td>
<td>Inspect belt and adjust or replace belt or drive pulley.</td>
</tr>
</tbody>
</table>
| Low PTO (deck) drive pressure for affected deck - TEST NO. 6. | Remove cap from affected bypass relief cartridge (R_BY) and adjust screw to get correct pressure.  
Inspect bypass relief cartridge (R_BY) for damage or sticking and clean or replace if necessary. (Interchange cartridge with another deck circuit. If problem follows suspected bad cartridge, replace cartridge). NOTE: If affected deck is a wing deck, interchange cartridges with the front deck circuit for proper diagnosis.  
Repair or replace PTO pump. NOTE: Rear section of pump drives front deck. Front section of pump drives both wing decks. Pump is not the problem if only one wing deck is affected. |
| Inefficient or damaged deck drive motor.         | Interchange deck drive motors with another deck. If problem follows suspected bad motor, repair or replace motor. NOTE: If affected deck is a wing deck, interchange motor with the front deck for proper diagnosis. |

### Right Wing Deck Blades “Creep” When System is Cold, or Right Deck Runs Briefly When Raised or Off If Left Wing is On

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orifice in PTO valve block plugged or restricted.</td>
<td>Remove orifice and clean or replace if necessary.</td>
</tr>
</tbody>
</table>

### Steering Problems

See Troubleshooting section of REPAIR INFORMATION, STEERING CONTROL UNITS, CHAR-LYNN.
### One Deck Will Not Stop Operating

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical problem.</td>
<td>See Troubleshooting section of Chapter 5 - Electrical System.</td>
</tr>
<tr>
<td>Solenoid valve (SV_) sticking.</td>
<td>Inspect solenoid valve (SV_) for damage or sticking in off position and clean or replace valve if necessary. (Interchange solenoid valves with another deck. If problem follows suspected bad valve, replace valve.)</td>
</tr>
<tr>
<td>Faulty brake logic cartridge (BR_).</td>
<td>Inspect brake logic cartridge (BR_) for plugged orifice, damage, or sticking, and clean or replace if necessary. (Interchange cartridge with another deck circuit. If problem follows suspected bad cartridge, replace cartridge.)</td>
</tr>
<tr>
<td>Faulty brake relief cartridge (R_BR).</td>
<td>Inspect brake relief cartridge (R_BR) for damage, or sticking, and clean or replace if necessary. (Interchange cartridge with another deck circuit. If problem follows suspected cartridge, replace cartridge.)</td>
</tr>
</tbody>
</table>

### One Deck Stops Too Slowly

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brake relief cartridge (R_BR) out of adjustment.</td>
<td>Remove cap from affected brake relief cartridge (R_BR) and adjust screw to get correct pressure.</td>
</tr>
<tr>
<td>Faulty brake logic cartridge (BR_)</td>
<td>Inspect brake logic cartridge (BR_) for plugged orifice, damage, or sticking, and clean or replace if necessary. (Interchange cartridge with another deck circuit. If problem follows suspected bad cartridge, replace cartridge.)</td>
</tr>
<tr>
<td>Faulty or sticking brake relief cartridge (R_BR).</td>
<td>Inspect brake relief cartridge (R_BR) for damage, or sticking, and clean or replace if necessary. (Interchange cartridge with another deck circuit. If problem follows suspected cartridge, replace cartridge.)</td>
</tr>
</tbody>
</table>
### Deck(s) Do Not Lift or Lift Too Slowly

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic oil level too low.</td>
<td>Fill to proper level.</td>
</tr>
<tr>
<td>Low engine RPM.</td>
<td>Adjust engine rpm - use tachometer.</td>
</tr>
<tr>
<td>Lift arm or cylinder pivots binding.</td>
<td>Lubricate bushings. Inspect for damage. Repair or replace damaged parts.</td>
</tr>
<tr>
<td>Internal leakage of lift cylinder(s)</td>
<td>Check lift cylinder(s) and repair or replace if necessary.</td>
</tr>
<tr>
<td>Low lift pressure - TEST NO. 4.</td>
<td>Check for restriction in pump intake line or strainer and repair if necessary.</td>
</tr>
<tr>
<td></td>
<td>Check lift cylinder(s) for internal leakage and repair or replace if necessary.</td>
</tr>
<tr>
<td></td>
<td>Clean relief valve in lift control valve and adjust if necessary by adding required shims.</td>
</tr>
<tr>
<td></td>
<td>Inspect lift valve for internal leakage or improper operation and repair or replace if necessary.</td>
</tr>
<tr>
<td></td>
<td>Inspect steering/lift pump for wear or damage and repair or replace if necessary.</td>
</tr>
<tr>
<td>Faulty flow control cartridge in float/traction assist manifold block.</td>
<td>Remove flow control cartridge and check for spool being stuck open. Make sure spool moves freely. Replace if necessary.</td>
</tr>
<tr>
<td>Plugged orifice in float/traction assist manifold block.</td>
<td>Remove and check each orifice (2) for being plugged.</td>
</tr>
</tbody>
</table>

### Decks “Chatter” While Lowering

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counterbalance pressure too high - TEST NO. 5.</td>
<td>Remove cap and adjust the counterbalance relief valve screw until correct pressure is attained.</td>
</tr>
<tr>
<td>Faulty shift cartridge in float/traction assist manifold block.</td>
<td>Remove shift cartridge for affected deck (right or left) and check spool for sticking. Make sure spool moves freely. Replace shift valve cartridge if necessary.</td>
</tr>
</tbody>
</table>
### Wing Decks Raise By Themselves When Climbing a Hill

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Traction Plus&quot; pressure too high - TEST NO. 5.</td>
<td>Remove cap and adjust the &quot;traction plus&quot; relief valve screw until correct pressure is attained.</td>
</tr>
</tbody>
</table>

### Deck Weight is Not Transferred to Traction Unit When Climbing a Hill

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Traction Plus&quot; pressure too low - TEST NO. 5.</td>
<td>Remove &quot;traction plus&quot; relief cartridge and check for spool sticking open or plugged orifice. Make sure spool moves freely. Replace cartridge if necessary.</td>
</tr>
<tr>
<td></td>
<td>Remove cap and adjust &quot;traction plus&quot; relief valve screw until correct pressure is attained.</td>
</tr>
<tr>
<td>&quot;Traction Plus&quot; shift pressure too high - TEST NO. 5.</td>
<td>Remove cap and adjust the shift cartridge screw until correct shift pressure is attained.</td>
</tr>
</tbody>
</table>

### Wing Decks Cut at Uneven Height on Level Ground

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counterbalance pressure not correct - TEST NO. 5.</td>
<td>Remove cap and adjust the counterbalance relief valve screw until correct pressure is attained.</td>
</tr>
</tbody>
</table>

### Front Deck Drops With Lift Valve in Centered Position

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal leakage of lift cylinder(s)</td>
<td>Check lift cylinder(s) and repair or replace if necessary.</td>
</tr>
<tr>
<td>Lift cylinder hydraulic lines or fittings leaking.</td>
<td>Check for leaks. Correct any leaks by replacing o-rings and tightening connection properly. Replace lines or fittings if necessary.</td>
</tr>
<tr>
<td>Faulty lift valve lockout assembly.</td>
<td>Check for damaged o-rings on lockout plugs or seats and repair if necessary.</td>
</tr>
<tr>
<td></td>
<td>Check for damaged or worn lockout poppet assembly and replace if necessary.</td>
</tr>
<tr>
<td></td>
<td>Check for broken lockout spring and replace if necessary.</td>
</tr>
</tbody>
</table>
Testing

The most effective method for isolating problems in the hydraulic system is by using hydraulic test equipment such as pressure gauges and flow meters in the circuits during various operational checks. (See the Special Tools section in this Chapter.)

1. Thoroughly clean the machine before disconnecting or disassembling any hydraulic components. Always keep in mind the need for cleanliness when working on hydraulic equipment.

2. Put caps or plugs on any hydraulic lines left open or exposed during testing or removal of components.

3. The engine must be in good operating condition. ALWAYS use a tachometer when making a hydraulic test. Engine speed will affect the accuracy of the tester readings.

4. To prevent damage to tester or components, the inlet and the outlet hoses must be properly connected, and not reversed (tester with pressure and flow capabilities).

5. To minimize the possibility of damaging components, completely open the load valve by turning it counterclockwise (tester with pressure and flow capabilities).

6. Install fittings finger tight, far enough to insure that they are not cross-threaded, before tightening with a wrench.

7. Position the tester hoses so that rotating machine parts will not make contact with them and result in hose or tester damage.

8. Check the oil level in the reservoir.

9. Check the control linkage for improper adjustment, binding or broken parts.

10. All hydraulic tests should be made with the hydraulic oil at normal operating temperature (hoses warm to the touch).

**WARNING**

Failure to use gauges with the recommended pressure (psi) rating as listed in the test procedures could result in damage to the gauge and possible personal injury from leaking hot oil.

**Before Performing Hydraulic Tests**

All obvious areas such as oil supply, filter, binding linkage, loose fasteners, or improper adjustments must be checked before assuming that a hydraulic component is the source of the problem being experienced.

**WARNING**

Before disconnecting or performing any work on the hydraulic system, all pressure in the system must be relieved by lowering the front deck to the ground, completely raising or lowering the wing decks and shutting the engine OFF.

Keep body and hands away from pin hole leaks or nozzles that eject hydraulic fluid under high pressure. Use paper or cardboard, not hands, to search for leaks. Hydraulic fluid escaping under pressure can have sufficient force to penetrate skin and do serious damage. If fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type of injury or gangrene may result.
TEST NO. 1: Traction Circuit Working Pressure and Relief Pressure

WORKING Pressure Test:

1. Connect a 10,000 psi gauge to traction circuit test port for function to be checked (TRACTION FORWARD shown) (Fig. 9).

2. Operate machine while monitoring gauge.

   RANGE OF TESTER READINGS: 220 - 5,250 PSI

3. If working pressure is too low, do traction circuit relief pressure test.

RELIEF Pressure Test:

1. Hydraulic oil must be at operating temperature.

2. Connect a 10,000 psi gauge to traction circuit test port for function to be checked (TRACTION FORWARD shown) (Fig. 9).

3. Start the engine and adjust throttle so engine speed is 2,500 rpm.

4. Release parking brake.

5. Engage traction pedal to set machine in motion.

6. Maintain traction pedal engagement while momentarily engaging service brake to bring machine to a stop and read gauge.

   TESTER READING TO BE 5,000 ± 250 PSI.

7. If traction pressure is too low, inspect traction pump check/high pressure relief valves. If problem occurs in one direction only, interchange the check/relief valves to see if the problem changes to other the direction. If so, one check/relief valve cartridge is either malfunctioning or does not have the proper setting. Clean or replace valves as necessary. These cartridge type valves are factory set, and are not adjustable. If check valves and relief valves are in good condition, replace or overhaul traction pump. (See the SUNDSTRAND SAUER M46 AXIAL PISTON PUMPS AND MOTORS SERVICE MANUAL.)
TEST NO. 2: Traction Circuit Charge Pressure

1. Hydraulic oil must be at operating temperature.

2. Connect a 1,000 psi gauge onto charge pressure test port (Fig. 10).

3. Start the engine and put throttle at idle position (approx. 1,200 rpm) with no load on the system.

   TESTER READING TO BE:
   
   230 ± 10 PSI (Pump S/N Below A-96-01-XXXXX)
   285 ± 10 PSI (Pump S/N A-96-01-XXXXX & Up)

4. If there is no pressure or pressure is too low, check for restriction in pump intake line. Inspect charge relief valve and valve seat. Charge pressure can be adjusted by changing shim thickness behind the spring. Check for sheared charge pump key. If necessary, check for internal damage or worn parts in charge pump.

5. Also with pressure gauge still connected to the charge pressure test port, take a gauge reading while operating the machine in forward and reverse. Start the engine and put the throttle at full engine speed. Apply the brakes and push the traction pedal forward, then reverse.

6. If pressure is good under no load, but drops below specification when under traction load, the piston pump and/or traction motor(s) should be suspected of wear and inefficiency. When the pump and/or traction motor(s) are worn or damaged, the charge pump is not able to keep up with internal leakage in the traction circuit components.
TEST NO. 3: Steering Circuit Working Pressure and Relief Pressure

WORKING Pressure Test:

1. Connect a 5,000 psi gauge onto POWER STEERING test port (Fig. 11).
2. Operate the machine while monitoring gauge.
   
   RANGE OF TESTER READINGS 0 - 1,550 psi.
3. If working pressure is too high or too low, perform relief pressure test.

RELIEF Pressure Test:

1. Hydraulic oil must be at operating temperature.
2. Connect a 5,000 psi gauge onto POWER STEERING test port (Fig. 11).
3. Start the engine and adjust throttle so engine speed is 2,500 rpm.
4. Turn steering wheel until heavy resistance is felt indicating that cylinders have reached maximum stroke.
5. Momentarily hold steering wheel against resistance and read gauge.
   
   TESTER READING TO BE 1,500 ± 50 PSI.
6. If pressure is too high, remove cap and adjust relief valve screw. If pressure is too low, check for restriction in pump intake line. Check steering cylinder(s) for internal leakage. If cylinder is not leaking, inspect relief valve. Adjust relief valve if necessary by removing cap and adjusting relief valve screw. If pressure is still too low, repair or replace steering pump.
TEST NO. 4: Lift Circuit Working Pressure and Relief Pressure

**WORKING Pressure Test**

1. Connect a 5,000 psi gauge to the LIFT test port.
   a. On machines with serial number below 250000000, the LIFT test port is located on the outside of the control console (Fig. 12).
   b. On machines with serial number above 250000000, the LIFT test port is located underneath the center of the machine (Fig. 12A).

2. Operate the machine while monitoring gauge.
   **TESTER READING TO BE:**
   - 375 to 2,000 PSI (S/N below 240000000).
   - 375 to 2,500 PSI (S/N between 240000001 and 240999999).
   - 500 to 2,625 PSI (S/N above 250000000).

3. If working pressure is too high or too low, perform relief pressure test.

**RELIEF Pressure Test**

1. Hydraulic oil must be at operating temperature.

2. Connect a 5,000 psi gauge to the LIFT test port.
   a. On machines with serial number below 250000000, the LIFT test port is located on the outside of the control console (Fig. 12).
   b. On machines with serial number above 250000000, the LIFT test port is located underneath the center of the machine (Fig. 12A).

3. Start the engine and adjust throttle so engine speed is 2,500 RPM.

4. Engage the lift control lever into the LIFT position. Momentarily hold lever in engaged position after full cylinder extension and read gauge.
   **TESTER READING TO BE:**
   - 1,500 to 2,000 PSI (S/N below 240000000).
   - 2,000 to 2,500 PSI (S/N between 240000001 and 240999999).
   - 2,125 to 2,625 PSI (S/N above 250000000).

5. If pressure is too high, inspect relief valve in lift control valve. If necessary, adjust relief valve by removing the required shim(s). If pressure is too low, check for restriction in pump intake line. Check lift cylinder(s) for internal leakage. If cylinder is not leaking, clean relief valve, and adjust if necessary by adding required shim(s). If pressure is still too low, repair or replace steering/lift pump.

**NOTE:** Always set counterbalance pressure to correct amount before attempting to adjust lift relief pressure (see TEST 5).

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**Groundsmaster 580-D**

**Page 4** - Rev. F  **Testing**
TEST NO. 5: Counterbalance Pressure

IMPORTANT: To prevent damage to test gauge, raise all decks before connecting 1,000 psi gauge to LIFT test port.

NOTE: Hydraulic oil must be at operating temperature for these tests or pressure reading will be too high.

COUNTERBALANCE Pressure Test

1. Connect a 1,000 psi gauge to the LIFT test port.
   a. On machines with serial number below 250000000, the LIFT test port is located on the outside of the control console (Fig. 13).
   b. On machines with serial number above 250000000, the LIFT test port is located underneath the center of the machine (Fig. 14).

2. Start the engine and adjust throttle so engine speed is 2,500 RPM.

   TESTER READING TO BE:
   400 to 425 PSI (S/N below 250000000).
   525 to 550 PSI (S/N above 250000000).

3. If pressure is incorrect, locate counterbalance relief cartridge on control manifold (Fig. 15). Remove cap on counterbalance relief valve and adjust the relief valve screw until correct counterbalance pressure is attained.

“TRACTION PLUS” COUNTERBALANCE Pressure Test

1. Connect a 1,000 psi gauge to the LIFT test port.
   a. On machines with serial number below 250000000, the LIFT test port is located on the outside of the control console (Fig. 13).
   b. On machines with serial number above 250000000, the LIFT test port is located underneath the center of the machine (Fig. 14).

2. Start the engine and adjust throttle so engine speed is 2,500 RPM. Move GROUND SPEED switch to HIGH RANGE.

3. Engage service brake, momentarily push traction pedal in the FORWARD direction and read the gauge.

   TESTER READING TO BE:
   600 to 650 PSI (S/N below 250000000).
   725 to 775 PSI (S/N above 250000000).

4. If pressure is incorrect, locate “Traction Plus” relief cartridge on control manifold (Fig. 15). Remove cap on “Traction Plus” relief valve and adjust the relief valve screw until correct “Traction Plus” pressure is attained.
**“TRACTION PLUS” SHIFT Pressure Test**

1. Connect a 1,000 psi gauge to the LIFT test port. Connect a 5,000 psi gauge to TRACTION FORWARD test port.
   
   a. On machines with serial number below 250000000, the LIFT and TRACTION FORWARD test ports are located on the outside of the control console (Fig. 13).
   
   b. On machines with serial number above 250000000, the LIFT and TRACTION FORWARD test ports are located underneath the center of the machine (Figs. 14 and 14A).

2. Start the engine and adjust throttle so engine speed is 2,500 RPM. Move GROUND SPEED switch to LOW RANGE.

3. While watching gauges, engage service brake and slowly push traction pedal in the FORWARD direction. Note pressure at TRACTION FORWARD PORT when pressure at LIFT port shifts from Counterbalance pressure to “Traction Plus” pressure (see Counterbalance and “Traction Plus” Pressure Tests above).

   TESTER READING TO BE 2,000 to 2,050 PSI.

4. If SHIFT pressure is incorrect, locate “TRACTION PLUS” shift cartridge on control manifold. Remove cap on “TRACTION PLUS” shift cartridge and adjust the cartridge screw until correct SHIFT pressure is obtained (Fig. 15).

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**Figure 15**

1. Counterbalance relief cartridge
2. “Traction Plus” relief cartridge (upper)
3. “Traction Plus” shift cartridge (lower)
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Diagnosing Cutting Performance Problems

Over a period of time, the seals in the deck motors can deteriorate and wear from heat and contamination. A leaking motor seal will by-pass oil to the case drain line and make the motor less efficient. Eventually enough oil loss will occur and cause the deck motor to stall in heavy cutting conditions. Continued operation with a motor in an inefficient condition can generate so much heat that the cartridge seals in the hydraulic manifold block can be affected, compounding the problem.

If the deck motors slow during operation, use the following procedure to analyze the problem:

1. Make sure deck drive area is clean, drive belt is at proper tension and belts are free of grease.

2. Check the hydraulic oil for water contamination and replace as necessary (appears cloudy or milky).

3. Make sure deck drive hydraulic circuit working and relief pressures are within specification.

4. Check PTO manifold block logic cartridges and relief valves for burnt or hardened o-rings. Replace o-rings as necessary.

5. Test deck motor for internal leakage (see Deck Motor Internal Leakage Test on the next page).
Deck Motor Internal Leakage Test

NOTE: Test only one deck at a time. Decks not being tested should be in the raised position so the deck will not operate when the PTO is engaged.

1. Determine which deck motor is turning slow. The left and right decks are powered in series by the same circuit, therefore one deck could affect the other.

2. To prevent deck blades from rotating, remove one outer blade from the deck to be tested and install a longer blade (P/N 29-5530) from a Groundmaster 72 inch deck. Put the front cutting edge of the longer blade against the deck housing (Fig. 15B).

3. Remove the case drain line (smallest of the three lines) from the deck motor (Fig. 15C).

4. Connect a flow meter in line with the case drain (oil flow will be away from the motor).

5. With the other decks in the raised position, start the engine and engage the PTO. Move the throttle to full speed position and note the oil flow exiting the motor through the case drain line. If the flow exceeds 1.5 GPM, the deck motor should be repaired or replaced.

NOTE: If one motor shows excessive case drain flow, other motors may also be in a similar condition. Failure to test all three motors may lead to repeat failures.

Alternate Deck Motor Test
(If a flow meter is not available)

1. Do steps 1 – 3 as described above, except disconnect the case drain line from the bulkhead instead of the motor. Put a cap on the bulkhead fitting.

2. Put the case drain line from the motor into a 5 gallon container and secure the line in place.

3. Start the engine and engage the PTO for exactly 15 seconds at full throttle, then disengage the PTO and stop the engine.

4. Measure the amount of oil in the container. Multiply the amount collected by 4 to get the gallons per minute flow discharged from the case drain line. If the flow exceeds 1.5 GPM, the deck motor should be repaired or replaced.

NOTE: If one motor shows excessive case drain flow, other motors may also be in a similar condition. Failure to test all three motors may lead to repeat failures.
TEST NO. 6: Deck Drive Circuit Working Pressure and Relief Pressure

WORKING Pressure Test:

1. Connect a 5,000 psi gauge onto DECK DRIVE test port for circuit to be checked (Fig. 16).

2. Do mowing operation while monitoring gauge.

   RANGE OF TESTER READINGS 0 - 3,200 psi.

3. If working pressure is too high or too low, perform relief pressure test. Normal pressure during operation is 1,500 - 2,000 psi. However gauge may show a pressure spike during initial engagement.

RELIEF Pressure Test:

NOTE: Hydraulic oil must be at operating temperature to get a correct pressure reading.

1. Start engine and raise all decks.

2. Turn engine OFF.

3. To prevent deck blades from rotating on deck to be tested: Remove one outer blade from deck to be tested and install a longer blade (P/N 29-5530) from Groundsmaster 72 in. deck (Fig. 16a). Loosen belt and turn spindle to put front (cutting) edge of blade against deck housing. Make sure deck drive belts are properly adjusted and in good condition before performing test.

4. Start engine and move throttle to approximately 3/4 speed (2,000 rpm). Lower only deck to be tested.

   DANGER

   Deck blades of other decks will rotate if lowered while DECK DRIVE / PTO switch is ENGAGED. Other blades on deck being tested will rotate if belt on spindle with longer blade breaks or slips. Keep clear of rotating blades to prevent personal injury.

5. Engage DECK DRIVE / PTO switch and read gauge.

   TESTER READING TO BE 3,000 + 200 – 0 PSI.

6. If pressure is too high, remove cap for affected bypass (main) relief valve and adjust screw to get correct pressure (Fig. 17). If pressure is too low, check for restriction in pump intake line. Remove cap from affected bypass (main) relief valve and adjust screw to get correct pressure. Inspect bypass (main) logic cartridge and clean or replace if necessary. If pressure is still too low, pump or motor should be suspected of inefficiency, wear or damage. Remove pump or motor and repair or replace.
Traction Control Neutral Adjustment

If machine moves when traction pedal and pump lever are in neutral position, adjustment is required.

1. Park machine on a level surface, engage parking brake, raise wing decks completely, lower front deck to ground and turn engine OFF.

2. Actuate pump lever (with foot pedal) to make sure that foot pedal and linkage operate freely. Correct if necessary.

3. Put blocks at front and rear of all four wheels. Disengage the two (2) planetary wheel drives. (See Disengage Planetary Wheel Drive in the General Information section of Chapter 6 - Wheels, Brakes and Steering.)


5. With engine OFF, loosen nut on carriage bolt and allow bearing to locate cam (Fig. 18). Carefully tighten nut on carriage bolt.

6. Loosen screws to allow neutral device bracket to move; but not freely (Fig. 18). Adjust neutral device bracket so that 40 ± 5 in-lb of torque on control lever just starts to rotate cam. Tighten screws.

7. Adjust neutral switch. (see Neutral Switch Adjustment in the Adjustments section of Chapter 5 - Electrical System.)

8. Adjust traction control rod. (See Traction Control Rod Adjustment in this section.)

9. Make sure planetary wheel drives are engaged after doing these procedures.
Traction Control Rod Adjustment

1. Park machine on a level surface, engage parking brake, raise wing decks completely, lower front deck to ground and turn engine OFF.

2. Remove cotter key and slotted nut from ball joint at traction pedal (Fig. 19). Disconnect ball joint from traction pedal.

3. Loosen jam nut and adjust ball joint so that when control rod is all the way back, front of traction pedal hits the floor. Tighten jam nut.

4. Connect ball joint to traction pedal. Tighten slotted nut until ball joint is tight against traction pedal then loosen nut until next slot aligns with hole in ball joint and install cotter pin.

Cruise Control Adjustment

1. Park machine on a level surface, engage parking brake, raise wing decks completely, lower front deck to ground and turn engine OFF.

2. With engine off, turn ignition key switch to ON position. Push traction pedal part way down and engage cruise control.

3. With cruise control engaged, traction pedal should move with approximately 40 lb. of force at front tip of traction pedal.

4. If force required is less than 35 lb. or more than 45 lb., loosen jam nut and turn setscrew one turn and check force again – turn counterclockwise for less force and clockwise for more force (Fig. 20). After correct force is achieved, hold setscrew in position and tighten jam nut.

NOTE: Machines with serial numbers above 90001 do not use a jam nut and setscrew. On these machines, locate collar so there is from .060 to .120 inch (1.5 to 3.0 mm) clearance between cruise control coil and clutch plate.
Traction Drive System Repairs

Mow/Transport Solenoid Service

1. Park machine on a level surface, engage parking brake, raise wing decks completely, lower front deck to ground and turn engine OFF.

2. Disconnect solenoid electrical connector.

3. Remove nut from solenoid.

4. Remove cover and solenoid coil.

5. Remove solenoid spool.

6. Inspect valve for sticking, damage or wear and replace if necessary.

7. Reverse steps 2 - 5 to install solenoid valve.

NOTE: See Testing section of Chapter 5 - Electrical System for information on testing solenoid coil.
Variable Displacement Pump Removal and Installation

1. Park machine on a level surface, engage parking brake, raise wing decks completely, lower front deck to ground and turn engine OFF.

2. Move seat forward. Remove upper and lower grill from in front of radiator. Disconnect four (6) latches and remove radiator cowl. Disconnect four (4) latches and remove lower grill support.

3. Remove cotter pin and disconnect control rod from pump (Fig. 22).

4. Remove two (2) capscrews securing steering/auxiliary pump to variable displacement pump (Fig. 23). Pull steering auxiliary pump away from variable displacement pump. Do not disconnect hydraulic lines from steering/auxiliary pump.

5. Loosen two capscrews on pump yoke end of drive shaft. Pull pump yoke end of drive shaft off pump input shaft (Fig. 24).
6. Disconnect all hydraulic lines from the variable displacement pump. Put caps or plugs on all open hydraulic lines to prevent contamination.

7. Remove two (2) capscrews and nuts securing variable displacement pump to frame and lift pump out of machine (Fig. 25).

8. Put caps or plugs on all open ports of the pump to prevent contamination.

9. Reverse steps 2 - 8 to install the pump.

NOTE: Install drive shaft to pump so center line of clamping bolts on drive shaft yoke is over center line of splines on transmission input shaft (Fig. 24).

10. Prime pump after installing. (See Priming After Pump Overhaul or Replacement in this section of the book.). Do traction control neutral adjustment. (See Traction Control Neutral Adjustment in the Adjustments section of this chapter.)

**After Repair or Replacement**

1. Check oil level in hydraulic reservoir and add correct oil if necessary.

2. Disconnect fuel stop solenoid electrical connector to prevent fuel delivery to engine cylinders (Fig. 26).

3. Turn ignition key switch to engage starter for 10 seconds to prime pumps. Repeat this procedure five (5) times for a total cranking time of 60 seconds.


5. Engage parking brake. Start engine a let idle at low speed for minimum of 30 seconds.

6. Check for hydraulic oil leaks. Shut off engine and correct leaks if necessary. Check oil level in hydraulic reservoir and add correct oil if necessary.

7. Disengage parking brake and operate machine slowly in forward and reverse.

8. With machine in neutral there should be no movement of wheels or "whining noise" from pump. Do traction control neutral adjustment if necessary. (See Traction Control Neutral Adjustment in the Adjustments section of this chapter.)

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NOTE: Refer to the Sauer/Sundstrand M46-Axial Piston Pumps and Motors Service Manual at the end of this chapter for traction pump service procedures.
Wheel Motor Removal and Installation

1. Park machine on a level surface, engage parking brake, raise wing decks completely, lower front deck to ground and turn engine OFF.

2. Remove planetary wheel drive. (See Planetary Wheel Drive Removal and Installation in Chapter 6 - Wheels, Brakes and Steering.)

3. Disassemble wheel brakes, remove wheel brake housing and remove wheel motor shaft cup rings. (See Wheel Brake Service, Brake Housing Removal, and Wheel Motor Shaft Cup Ring Service in the Repairs section of Chapter 6 - Wheels, Brakes and Steering.)

4. Disconnect all hydraulic lines from the wheel motor and lower wheel motor out of machine. Put caps or plugs on all open hydraulic lines and wheel motor ports to prevent contamination.

5. Reverse steps 2 - 4 to install the wheel motor.

6. After installing motor and brakes, adjust service brakes. (See Service Brake Adjustment in the Adjustments section of Chapter 6 - Wheels, Brakes and Steering).

After Repair or Replacement

1. Start engine and operate machine slowly in forward and reverse.

2. Check for hydraulic oil leaks. Shut off engine and correct leaks if necessary. Check oil level in hydraulic reservoir and add correct oil if necessary.

NOTE: For Service and Repair Procedures of the front wheel motors used on the Groundsmaster 580-D, see the Sundstrand Sauer M46-Axial Piston Pumps and Motors Repair Manual that follows this Chapter.
PTO System Repairs

PTO Valve Block Service

1. Park machine on a level surface, engage parking brake, raise or lower wing decks completely, lower front deck to ground and turn engine OFF.

2. Open hood latches, raise hood and secure it in raised position with prop rod. Open left side panel latch and remove side panel.

3. Ports on valve block are marked for easy identification of components. Example: SV1 is front deck solenoid valve and R1BY is front deck bypass (main) relief cartridge. (See Hydraulic Flow Diagrams to identify function of hydraulic lines and cartridges at each port location.)

NOTE: For troubleshooting purposes, relief valve cartridges, logic cartridges and solenoid valves can be interchanged with those of different circuits. For example, interchange BY1 with BY2 to determine faulty bypass (main) logic cartridge.

4. If necessary PTO valve block can be removed:

   A. Disconnect battery cables. Remove battery tray and batteries.
   B. Disconnect and cap or plug hydraulic lines.
   C. Disconnect solenoid electrical connectors.
   D. Remove two capscrews and remove hood prop rod bracket from block.
   E. Remove four capscrews from bottom of block and lift block out of machine.

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Figure 27

1. Solenoid valve (SV2 shown)
2. Bypass (main) relief cartridge (R3BY shown)
3. Bypass (main logic cartridge) (BY2 shown)
4. Brake relief cartridge (R2BR shown)
5. Brake logic cartridge (BR2 shown)
6. Orifice
PTO Valve Block Service (S/N 50001 & UP)

1. Solenoid valve (SV2 shown)
2. Bypass (main) relief cartridge (R3BY shown)
3. Bypass (main) logic cartridge (BY2 shown)
4. Brake relief cartridge (R2BR shown)
5. Brake logic cartridge (BR2 shown)
6. Orifice

Figure 27A
PTO Solenoid Valve Service (S/N 50001 & UP)

1. Clean valve block to prevent contamination when valve cartridge is removed.

2. Remove cartridge valve:
   A. Remove nut from solenoid.
   B. Remove solenoid coil and o-ring at each end of solenoid coil.
   C. Use a deep socket to remove cartridge valve.

   NOTE: Use care when handling valve cartridges, because slight bending or distortion of stem tube can cause binding and malfunction.

3. Visually inspect port in block for damage to sealing areas, damaged threads or contamination.

4. Visually inspect cartridge for damaged seals and contamination.
   A. O-rings and backup rings must be arranged properly on the valve for proper operation and sealing. Replace any damaged seals.
   B. Contamination may cause valves to stick or hang up. Contamination can become lodged in small valve orifices or seal areas on poppet type valves causing malfunction.
   C. If cartridge valve seals appear pitted or damaged, the hydraulic system may be overheating or there may be water in the system.

5. Clean and check for proper valve operation:
   A. Use clean mineral spirits to clean cartridge valve. Submerge the valve in clean mineral spirits and use a probe to push the internal spool in and out 20 to 30 times to flush out contamination. Mineral spirits does not affect the o-ring material. Particles as fine as talcum powder can affect the operation of high pressure hydraulic valves.

Cartridge Installation

1. Lubricate all o-rings with clean hydraulic oil.

2. Carefully thread cartridge into the port by hand. Valve cartridge should go in easily without binding.

3. Use a torque wrench and deep socket to tighten cartridge valves to the torque specified in Figure 27A. Excessive torque may cause the spool to bind and malfunction.

   NOTE: Use care when handling solenoid valve cartridges because slight bending or distortion of stem tube can cause binding and malfunction.

4. Install solenoid coil. Make sure there is an o-ring at each end of the coil. Apply "Loctite 242" or equivalent to threads of stem tube before installing nut. Tighten nut to a torque of 15 in-lb (1.7 N·m).

5. If problem still exists, remove valve and clean again or replace valve.
PTO Solenoid Valve Replacement

1. Disconnect electrical connector from affected solenoid valve (Fig. 28).
2. Remove nut from solenoid (Fig. 27).
3. Remove cover.
4. Remove solenoid coil.
5. Remove solenoid spool.
6. Inspect valve for sticking, damage or wear and replace if necessary.

7. Reverse steps 1 - 5 to install solenoid valve. It is recommended to replace seals when reinstalling a used solenoid valve. Install seals as shown (Fig. 29).

NOTE: See Testing section of Chapter 5 - Electrical System for information on testing solenoid coil.

NOTE: When installing solenoid valve into manifold, torque solenoid valve 35 Ft-lbs (47.1 N-m).

Cartridge Replacement

1. Remove affected cartridge (Fig. 30). Inspect cartridge for sticking, plugged orifice, damage or wear and replace if necessary. It is recommended to replace seals when reinstalling a used cartridge.

2. Check relief pressure after installing new bypass (main) relief cartridges (port R_BY). (See TEST NO. 6 - Deck Drive Circuit Working Pressure and Relief Pressure in Testing section of this chapter).

NOTE: When installing a cartridge valve into manifold, torque valve as specified in Figures 27 and 27A.
PTO Pump Removal and Installation

1. Park machine on a level surface, engage parking brake, raise or lower wing decks completely, lower front deck to ground and turn engine OFF.

2. Open hood latches, raise hood and secure it in raised position with prop rod. Open side panel latches and remove side panels.

3. Remove two (2) capscrews and pull battery tray out (Fig. 31). Disconnect cables from batteries.

4. Remove six (6) capscrews and remove rear panel.

5. Push battery tray in approximately half way and align tangs on battery tray with notches on rail, then lift up rear of battery tray and pull completely out of machine.

6. Drain hydraulic oil from reservoir. Disconnect hydraulic lines from pump. Put caps or plugs on disconnected lines and fittings to prevent contamination.

NOTE: If hydraulic reservoir is not drained, a large amount of hydraulic oil will drain from reservoir when pump suction line is removed.

7. Remove four (4) capscrews from pump and pull pump shaft out of drive coupling to remove pump.

8. Reverse steps 2 - 7 to install PTO hydraulic pump.

IMPORTANT: Be careful when connecting high pressure hoses to special fittings on pump to prevent excessive stress on fittings and possible hydraulic oil leakage. Hold fitting with a wrench while tightening hose with another wrench.

Figure 31

1. Notch on battery tray rail (2)
2. PTO hydraulic pump
3. Capscrew (4)

After Pump Repair or Replacement

1. Check oil level in hydraulic reservoir and add correct oil if necessary.

2. Disconnect fuel stop solenoid electrical connector (Fig. 26) to prevent fuel delivery to engine cylinders.

3. Turn ignition key switch to engage starter for 10 seconds to prime pump. Repeat this procedure five (5) times for a total cranking time of 60 seconds.


5. Engage parking brake. Start engine a let idle at low speed for minimum of 30 seconds.

6. Check for hydraulic oil leaks. Shut off engine and correct leaks if necessary. Check oil level in hydraulic reservoir and add correct oil if necessary.
PTO Pump Repair (Models 30580 and 30581)

Figure 31A

1. Coupler
2. Adapter section
3. Gland
4. Retainer
5. Flex plate
6. O-ring
7. Center section
8. Idler gear
9. Gear
10. O-ring
11. Rear cover
12. Lockwasher (16 used)
13. Capscrew (4 used)
14. Capscrew (4 used)
15. O-ring
16. Port section
17. Gear
18. Shaft end cover
19. Plug
20. Shaft seal
21. Retaining ring
22. Seal
23. Nut
24. Stud

Note: For service and repair procedures of the PTO pump used on models 30580 and 30581, see the Vickers Gear Pump Overhaul Manual that follows this chapter.
Note: For service and repair procedures of the PTO pump used on models 30582 and 30583, see the Hall-Corr Barnes G20 and G30 Series Hydraulic Gear Pumps Service Manual that follows this chapter.
Deck Motor Removal and Installation

Removing Deck Motor

1. Park machine on a level surface, engage parking brake, lower wing decks and front deck to ground, then turn engine OFF.

2. Remove deck covers and loosen belt tension. (See Belt Tension Adjustment in Chapter 7 - Cutting Units).

3. Disconnect hydraulic lines from motor. Put caps or plugs on hydraulic lines and motor ports.

4. Remove flange head screws separate plate and motor assembly from deck. To separate from wing deck, rotate plate end toward traction unit (Fig. ). Tip plate, motor and pulley assembly on its side and remove from deck.

5. Remove set screws from taper lock bushing (Fig. ). Install one (1) setscrew into hole that is threaded on side of taper lock. Tighten setscrew until taper lock is loose from inside of pulley hub.

6. Slide pulley and taper lock off motor output shaft. Remove key that positions pulley on shaft. Remove setscrew from side of taper lock.

7. Remove two flange lock nuts and carriage bolts to remove motor from plate.

Installing Deck Motor

1. Install motor by securing to plate with carriage bolts and flange lock nuts.

2. Put pulley on work bench, hub side up. Slide taper lock, small end first, into pulley hub.

3. Insert key into keyway of motor shaft. Slide pulley, with taper lock, onto motor shaft while aligning key and keyway. Large hub on pulley must face away from motor.

4. Rotate pulley to get non-threaded holes in taper lock to line up with two threaded holes on hub of pulley. Start threading setscrews into two holes and tighten them alternately and evenly until both setscrews are tight.

5. Using a brass drift pin or sleeve and hammer, hit taper lock firmly. Tighten setscrews to 55 in-lb. Continue to hit taper lock and tighten setscrews until the 55 in-lb of torque will not turn the setscrews.

6. Fill recessed socket head in each setscrew, and other taper lock holes with grease to prevent dirt from packing into holes.

7. Reverse steps 2 - 4 under Removing Deck Motor to install motor plate and pulley assembly.
1. Plug ports and wash exterior with mineral spirits or solvent. Clean parts and work area.

2. Use caution when using a vise to prevent distorting or damaging parts.

3. Never pry components apart. Light tapping with a plastic hammer on mounting ears will separate body from cover (Fig. 35).

4. Inspect parts and replace all worn or damaged parts.

5. All parts must be free from burrs, scoring, nicks, etc. Lap body on a flat plate if necessary. Rub wear plates on 220/320 grit wet/dry paper if necessary. Excess scoring of plate requires installation of new plates.

6. Gears should always be replaced in sets if necessary.

7. Extreme care must be used when replacing shaft seal. It must be installed square with seal bore and with metal case to outside of motor. Be careful to prevent drive shaft keyway from cutting the new seal. Use a "bullet" type seal protector or put tape over the keyway. Apply grease to lips of seal before installing over shaft.

8. Apply grease to o-rings to retain in body and cover groove during assembly.

9. Rotate drive shaft before and after tightening bolts. Torque all bolts and capscrews evenly to avoid distortion.

Disassembly

1. Use a marker or scribe to make a line across the body and mounting flange for proper reassembly (put mark along drive shaft side of body and flange as shown).

2. Remove key (8) from shaft.

3. Remove nuts (1) and washers (2).

4. Use a soft face hammer to lightly tap the mounting flange to disengage it from the body. Slide the flange off of the shaft.

5. Remove O-ring seal (5).

6. Remove retaining ring (6) and push the shaft seal (3) squarely out of the mounting flange, taking care not to damage any sealing surfaces.

NOTE: Before disassembling internal components, mark the load plates for proper reassembly. Mark on an area away from the seal location. Mark “F” for flange end and “B” for body end.

7. Remove the load plates (4) from the gears. Remove the load seals (7) from the load plates.

Inspection and Repair

1. Wash each of the components with cleaning solvent or mineral spirits and dry with a lint free cloth or compressed air.

2. Body: Inspect the body bore cut-in where gears wipe into the body. The cut-in should be bright and polished in appearance with a depth of less than .08 mm. Replace the motor if the surface is scored, has a matt appearance or shows signs that the tip of the gears have dug in and torn away the surface material. Inspect for damage to port threads and body O-ring recesses.
Check the shaft seal recess for scoring or damage that could result in oil leakage around the outside diameter of the shaft seal.

**NOTE:** Replacement shaft seals can be refitted with Loctite hydraulic sealant to overcome slight damage to this area.

3. Load Plates: The side faces which are against the gears should be perfectly flat showing no signs of scoring. Typically there are bright polished areas on this surface caused by loading against the gear side faces. This is often more noticeable on the low pressure side. The load plates should be replaced if there is any general scoring, fine scoring with a dull appearance, or tearing of the surface material. Often there is an area where the tips of the opposing gears have wiped an overlap with a half moon shape. There must be no noticeable wear step; it is critical that the load plate side face is completely flat to the gear side face. The load plate bearing liners should not show any scoring or other damage. The general outside area of the load plate should not show any significant wear.

4. Gears: The gear faces should be examined for bruising or scoring. Operation with contaminated hydraulic fluid will often show scoring between the root of the gear and the journal that leaves a wear step. If a wear step can be felt, along the root diameter, by drawing a sharp pointed tool across the surface from the journal outwards toward the tip of the gear, then the gear is unserviceable and the motor should be replaced.

The gear teeth should be carefully examined for bruising or pitting.

The journal bearing surfaces should be completely free from scoring or bruising. The surface should appear highly polished and smooth to the touch.

Examine the area where the shaft seal lips run on the driveshaft, this shows up as a polished ring or rings. If a noticeable groove can be felt or there is scoring, the shaft is unserviceable and the motor should be replaced.

**Reassembly**

**NOTE:** Install new seals when reassembling the motor. Use petroleum jelly to hold seals and O-rings in place during assembly.

1. Install new load seals (7) on the load plate (4) you marked “B”. Install load plate (4) into body.
2. Put body on work bench so gear openings face up.
3. Install gears into their original positions in the body. **NOTE:** Install gear with driveshaft into the side of the body you marked in step 1 under Disassembly.
4. Install new load seals (7) on the load plate (4) you marked “F”. Install load plate into mounting flange.
5. Install new O-ring seal (6) in mounting flange.
6. Install mounting flange over drive shaft and onto the body.
7. Install washers (2) and nuts (1). Tighten nuts evenly in a crossing pattern to a torque of 70 ± ft-lb.
8. Install shaft seal.

**Shaft Seal Installation**

1. Apply grease to seal bore in mounting flange. **NOTE:** If using Loctite hydraulic sealant to overcome slight damage to the seal bore area, do not apply grease.
2. Pack lips of new shaft seal (3) with high melting point grease.
3. Install Mylar sleeve from seal kit onto drive shaft, checking to make sure that the sleeve covers all sharp edges of the shaft.
4. Slide new shaft seal onto shaft down to flange housing with the exposed spring side of the seal facing the motor.
5. Press the shaft seal in until it bottoms squarely in the bore.
6. Put on protective eyewear, such as safety glasses or a face shield, then install the retaining ring (6).

**Running-in**

A motor which has been rebuilt with new load plates, must be run-in before it is subjected to full load conditions. Ideally this should be done on a test stand where pressure can be gradually applied. If a test stand is not available, install the motor on the machine and operate the cutting deck at low speed with no load for at least one minute. Gradually increase speed, running for one minute at a time at each speed until you reach full engine RPM. Stop the machine and check to make sure the motor is not running hotter than the others.
Wing Deck Hose Replacement (S/N 50001 & Up)

Routing of wing deck hoses through the wing arms requires accurate hose positioning or the hoses can be damaged as the wing decks are raised and lowered.

In order to reduce hose damage due to incorrect routing, a Hose Routing Kit (P/N 93-9956) is available for previously manufactured products (S/N 80101 - 49999). The kit contains all the parts, hoses and instructions necessary to re-route the wing deck hoses external to the arms. The external routing reduces the possibility of damage due to incorrect routing. Current production will includes the external hose routing.

Figure 36A
Wing Deck Motor Hydraulic Hose Replacement

IMPORTANT: If deck motor hydraulic hoses are installed incorrectly the hose may rub against the lift arm and in extreme cases could be stretched tight between the traction unit and cutting unit. These conditions could cause the hose to fail.

To Get Correct Hose Position

1. Lower cutting unit to the ground. Loosen cap screws that secure hoses to hose clamps.

2. Loosen hose connections at motor until ends are free to rotate.

3. Extend protective hose covers (between hose clamp and motor) to full length. Pull hoses through until protective covers touch clamp. Tighten clamp screws to retain hoses.

4. Inspect routing of hoses through “window” in outer lift arm. If hoses make contact with lift arm in this area, pivot 90° formed end of hoses (motor end) until clearance is obtained between hoses and “window” (Fig. 36). Hoses should be approximately parallel to motor centerline.

5. Make sure that clearance remains between “window” and hoses when cutting unit is raised to transport position. If a hose tightens when deck is raised, pivot hose end toward traction unit.

6. Extend protective covers at traction unit end of hoses to protect them from wear and damage.
Auxiliary (Lift/Counterbalance) System Repairs

Float/Traction Assist Manifold Block Service

1. Park machine on a level surface, engage parking brake, raise or lower wing decks completely, lower front deck to ground and turn engine OFF.

2. Remove control housing.

3. Ports on valve block are marked for easy identification of components. (See Hydraulic Flow Diagrams to identify function of hydraulic lines and cartridges at each port location.)

Torque all cartridges to 35 Ft-lbs (47.5 N-m)

Figure 37

1. Counterbalance relief cartridge
2. "Traction Plus" relief cartridge
3. "Traction Plus" shift cartridge
4. Lift/lower shift cartridge
5. Flow control cartridge
6. Orifice (0.047)
7. Orifice (0.120)
Cartridge Replacement

1. Remove affected cartridge (Fig. 37, 38). Inspect cartridge for sticking, plugged orifice, damage or wear and replace if necessary. It is recommended to replace seals when reinstalling a used cartridge.

2. Check pressure after installing new counterbalance relief cartridge, "traction plus" relief cartridge, or "traction plus" shift cartridge. (See TEST NO. 5 - Counterbalance Pressure in Testing section of this chapter.).

NOTE: When installing cartridge into float/traction assist manifold, torque cartridge to 35 ft-lbs (47.5 N-m). If cartridge is overtightened, cartridge damage may occur.

Figure 38
(Control housing removed)

1. Counterbalance relief cartridge
2. "Traction Plus" relief cartridge
3. "Traction Plus" shift cartridge
4. Lift/lower shift cartridge (right deck)
5. Lift/lower shift cartridge (left deck)
6. Flow control cartridge
7. Orifice (0.047)
8. Orifice (0.120)
Steering/Auxiliary Pump Removal and Installation

1. Park machine on a level surface, engage parking brake, raise or lower wing decks completely, lower front deck to ground and turn engine OFF.

2. Move seat forward. Remove upper and lower grill from in front of radiator. Disconnect six (6) latches and remove radiator cowl. Disconnect four (4) latches and remove lower grill support.

3. Disconnect all hydraulic lines from the steering/auxiliary pump (Fig. 39). Put caps or plugs on all open hydraulic lines to prevent contamination.

4. Remove two (2) capscrews securing steering/auxiliary pump to variable displacement pump. Pull steering auxiliary pump away from variable displacement pump and lift pump out of machine.

5. Put caps or plugs on all open ports of the pump to prevent contamination.

6. Reverse steps 2 - 5 to install the pump.

After Repair or Replacement

1. Check oil level in hydraulic reservoir and add correct oil if necessary.

2. Disconnect fuel stop solenoid electrical connector (Fig. 26) to prevent fuel delivery to engine cylinders.

3. Turn ignition key switch to engage starter for 10 seconds to prime pump. Repeat this procedure five (5) times for a total cranking time of 60 seconds.


5. Engage parking brake. Start engine a let idle at low speed for minimum of 30 seconds. Increase engine speed and turn steering wheel fully left and right several times. Raise and lower cutting units several times.

6. Check for hydraulic oil leaks. Shut off engine and correct leaks if necessary. Check oil level in hydraulic reservoir and add correct oil if necessary.
Steering/Auxiliary Pump Repair (Models 30582 and 30583)

Disassembly

1. Plug pump ports and clean the outside of the pump thoroughly. After cleaning, remove plugs and drain any oil out of the pump.

2. Use a marker or scribe to make a diagonal mark across the front body, gear plate and rear cover for reassembly purposes (Fig. 39B).

**IMPORTANT:** Avoid using excessive clamping pressure on the pump housing to prevent distorting the housing.

3. Clamp mounting flange of pump in a vise. Loosen all cap screws.

4. Remove pump from the vise and remove cap screws.

**IMPORTANT:** To prevent component damage, never pry components apart. Light tapping with a plastic hammer on drive shaft should separate pump.

5. Carefully remove front body. Lift front body straight up to allow drive shaft and idler gear to remain in rear cover. Remove front wear plate. Identify intersecting gear teeth of drive shaft and idler gear with a marker to ensure proper gear placement during assembly.

6. Carefully remove idler gear and drive gear.

7. Remove gear plate and rear wear plate from rear cover.

8. Remove and discard pre-load seal, load seal and sealing rings.

**IMPORTANT:** Make sure not to damage the counter bore when removing the shaft seal from the front body.

9. Remove shaft seal from the front body.

**Note:** Rear cover assembly includes priority flow divider valve and steering relief valve. These components are retained in the cover with tamper proof plugs. Disassembly of rear cover is not recommended.

Inspection

1. Remove nicks and burrs from all parts with emery cloth.

2. Inspect gear plate for excessive scoring, gouges or wear. Evidence of damage indicates need for component replacement.

3. Inspect front body and rear cover for damage or wear.
4. Inspect drive shaft gear and idler gear (Fig. 39C):
   A. Drive shaft spline should be free of twisted or broken teeth.
   B. Gear shafts should be free of rough surfaces and excessive wear at bushing points and sealing areas. Scoring, rough surfaces or wear on gear shafts indicates need for replacement.
   C. Gear teeth should be free of excessive scoring and wear. Any broken or nicked gear teeth must be replaced.
   D. Inspect gear face edge for sharpness. Sharp edges of gears will mill into wear plates and, thus, must be replaced.

Assembly

Note: When assembling the pump, check the marker or scribe marks on each part to make sure that parts are properly aligned during assembly (Fig. 39B).

1. Lubricate new sealing rings, pre-load seal and load seal with a thin coat of petroleum jelly. Lubricate all other internal parts freely with clean hydraulic oil.
2. Install new shaft seal in front body. Seal should be pressed into place until it reaches the bottom of the bore. Grease seal lip.
3. Place rear cover on a flat surface.
4. Install the sealing ring into the rear cover groove. Follow by placing the rear wear plate on the cover. Make sure to position the wear plate as shown in Figure 39A with the bronze side toward the gear position. Lubricate the exposed side of the rear wear plate with clean hydraulic oil.
5. Lubricate the drive shaft and idler gear with clean hydraulic oil and install the gears into the proper bearings in the rear cover. Make sure to align the gears using mark placed during disassembly.
6. Install locating dowels in rear cover.
7. Carefully install gear plate making sure to align scribe marks on the gear plate and rear cover.
8. Lubricate bronze side of front wear plate with clean hydraulic oil. Place the front wear plate on the drive shaft and idler gear. Make sure to position the wear plate as shown in Figure 39A with the bronze side toward the gears.
9. Install new pre-load seal, load seal and sealing ring to the front body.

IMPORTANT: To prevent shaft seal damage during assembly, use seal protector or tape on drive shaft splines.

10. Gently slide the front body onto the assembly. Make sure to align scribe marks on the front body and gear plate. Firm hand pressure should be sufficient to engage the dowels.
11. Check to make sure that pump component surfaces are flush. If gaps exist between components, check assembly for a shifted seal or sealing ring. Correct before proceeding.
12. Install cap screws and hand tighten to secure assembly.
13. Place mounting flange of the pump into a vise and alternately torque the screws from 360 to 380 in-lbs (40.7 to 42.9 N·m).
14. Remove pump from vise.
15. Place a small amount of clean hydraulic oil in the inlet of the pump and rotate the drive shaft one revolution. If any binding is noted, disassemble the pump and check for assembly problems.
1. Plug ports and wash exterior with mineral spirits or solvent. Clean parts and work area.

2. Use caution when using a vise to prevent distorting or damaging parts.

3. Never pry components apart. Light tapping with a plastic hammer on drive shaft will separate body from cover without burring. IMPORTANT: Put hand over cover assembly while tapping drive shaft to prevent dropping parts or disengaging gear mesh when separation of parts occurs.

4. All parts must be free from burrs, scores, nicks, etc.

5. Before removing gear set, apply marking dye to mating teeth to retain “timing” when reassembling.

6. Use complete pump repair kit when rebuilding pump.

7. Extreme care must be used when replacing shaft seal. It must be installed square with seal bore and with metal case to outside of pump. Great care must be taken to prevent the drive shaft spline from cutting the new seal. Use a “bullet” type sleeve or tape over the keyway and grease lips of seal before installing.
8. Lap gears. Replace as set if necessary. Put oil on the inside cover and insert the gear set, maintaining the original timing and locations.

9. Apply grease to wearplate and slip over shafts with bronze side facing gears.

10. Mating surfaces of body and cover must be clean, free of oil and dry.

11. Assemble body to cover making certain that none of the parts become displaced. Insert and hand tighten all capscrews.

12. Rotate drive shaft before tightening capscrews. Tighten capscrews to a torque of 360 to 380 in-lb.


Flow Divider Cover

1. Refer to illustration to disassemble, inspect, and assemble the flow divider cover (Fig. 40).

2. Inspect parts for wear or damage. Repair as necessary.

3. Use complete repair kit when rebuilding pump and flow divider.

4. When installing flow divider cover to pump, tighten capscrews evenly to a torque of 190 to 210 in-lb.

---

Front Lift Cylinder Removal and Installation

1. Park machine on a level surface, engage parking brake, raise or lower wing decks completely, lower front deck to ground and turn engine OFF.

2. Clean cylinder and surrounding area thoroughly. Disconnect hydraulic lines and plug to prevent contamination from entering hydraulic system.

3. Remove nut and bolt securing front of cylinder (Fig. 41). Remove cotter pins and cylinder pin securing rear of cylinder.

4. Remove cylinder.

5. Check condition of bushings and replace if worn or damaged before installing cylinder. Reverse steps 2 - 4 to install cylinder.

6. After installation of cylinder, start engine, and raise and lower cutting unit several times. Check cylinder for leaks. Check oil level in hydraulic reservoir and add correct oil if necessary.

---

Front Lift Cylinder Repair

IMPORTANT: To prevent damage when clamping cylinder barrel or rod in a vise, clamp only on pivot ends.

1. After removing cylinder, pump oil out of cylinder into a drain pan by SLOWLY moving rod and piston in and out of cylinder bore.

2. Plug ports and clean outside of cylinder.

3. Mount cylinder in a vise so shaft end of cylinder is tilted up slightly. Do not close vise so firmly that cylinder tube could become distorted.

4. Use a snap ring pliers to remove retaining ring (Fig. 42).

5. Grasp clevis end of shaft and use a twisting and pulling motion to carefully extract piston, shaft, and head from cylinder barrel.

6. Securely mount piston, shaft, and head into vise and remove nut.

IMPORTANT: Do not clamp vise jaws against smooth shaft surface; the shaft will become damaged.

8. Remove all seals and O-rings.

9. Wash parts in a safe solvent. Dry parts with compressed air. DO NOT wipe them dry with a cloth or paper as lint and dirt may remain.

10. Carefully inspect internal surface of barrel for damage (deep scratches, out-of-round, etc.). Replace entire cylinder if barrel is damaged. Inspect head, shaft, and piston for evidence of excessive scoring, pitting, or wear. Replace any damaged parts.

11. Use a complete seal repair kit when rebuilding the cylinder. Put a coating of oil on all new seals, and O-rings. Install the new seals and O-rings.

12. Install head onto shaft.

13. Install piston onto shaft and tighten hex nut.

14. Put a coating of oil on all cylinder parts to ease assembly.

15. Slide shaft assembly into cylinder tube.

16. Install head into tube and install retaining ring.
Wing Lift Cylinder Removal and Installation

1. Park machine on a level surface, engage parking brake, raise or lower wing decks completely, lower front deck to ground and turn engine OFF.

2. Clean cylinder and surrounding area thoroughly. Disconnect hydraulic lines and plug to prevent contamination from entering hydraulic system.

3. Remove nut and bolt securing rod end of cylinder to lift arm (Fig. 43). Remove cotter pin securing barrel end of cylinder to frame.

4. Remove cylinder.

5. Check condition of bushing in rod end of cylinder and replace if worn or damaged before installing cylinder. Reverse steps 2 - 4 to install cylinder.

6. After installation of cylinder, start engine, and raise and lower cutting unit several times. Check cylinder for leaks. Check oil level in hydraulic reservoir and add correct oil if necessary.

Wing Lift Cylinder Repair

IMPORTANT: To prevent damage when clamping cylinder barrel or rod in a vise, clamp only on pivot ends.

1. After removing cylinder, pump oil out of cylinder into a drain pan by SLOWLY moving rod and piston in and out of cylinder bore.

2. Plug ports and clean outside of cylinder.

3. Mount cylinder in a vise so shaft end of cylinder is tilted up slightly. Do not close vise so firmly that cylinder tube could become distorted.

4. Unscrew collar (Fig. 44).

NOTE: Some cylinders may be of a different design and have a large retaining ring securing the head instead of a threaded collar. Use a snap ring pliers to remove retaining ring. See the parts catalog for identification of parts. The two different cylinders are interchangeable but internal parts are different. Both cylinders use the same seal repair kit.

5. Grasp clevis end of shaft and use a twisting and pulling motion to carefully extract piston, shaft, and head from cylinder barrel.

6. Securely mount piston, shaft, and head into vise and remove nut.

IMPORTANT: Do not clamp vise jaws against smooth shaft surface; the shaft will become damaged.

7. Remove piston. Slide cushion and head off of shaft.

8. Remove all seals and O-rings.

9. Wash metal parts in a safe solvent. Dry parts with compressed air. DO NOT wipe them dry with a cloth or paper as lint and dirt may remain.

10. Carefully inspect internal surface of barrel for damage (deep scratches, out-of-round, etc.). Replace entire cylinder if barrel is damaged. Inspect head, shaft, and piston for evidence of excessive scoring, pitting, or wear. Replace any damaged parts.

11. Use a complete seal repair kit when rebuilding the cylinder. Put a coating of oil on all new seals, and O-rings. Install the new seals and O-rings.

12. Install head and cushion onto shaft.
13. Install piston with o-ring onto shaft and tighten hex nut.

14. Put a coating of oil on all cylinder parts to ease assembly.

15. Slide shaft assembly into cylinder tube.

16. Install head into tube and install collar (or retaining ring).

---

Figure 44

1. Shaft w/clevis
2. Collar
3. Dust seal
4. Head
5. Back-up ring
6. O-ring seal
7. Back-up ring
8. Wear ring
9. Steel ring
10. Cushion
11. O-ring seal
12. Piston
13. Locknut
14. Wear ring
15. Grease fitting
16. Barrel w/clevis
17. O-ring seal
Lift Control Valve Removal and Installation

1. Park machine on a level surface, engage parking brake, raise or lower wing decks completely, lower front deck to ground and turn engine OFF.

2. Remove control housing.

3. Thoroughly clean valve and surrounding area.

4. Mark hydraulic lines for ease in identification during reassembly.

5. Remove hydraulic lines. Cap open ends of lines or fittings to prevent contamination of hydraulic system.

6. Remove cotter pins and disconnect control lever linkage from valve.

7. Remove two (2) capscrews and nuts securing valve to bracket and remove valve.

8. Reverse steps 2 - 6 to install valve.

Lift Control Valve Repair

1. Plug all ports and clean outside of valve.

2. Remove spool caps (Fig. 46, Item 30). Do not remove retaining rings from spools.

3. Remove spools (Item 13) from valve body (Item 8). NOTE: Spools and spool bores are a matched set. Be sure each spool is identified with the correct spool bore in body.

4. Remove bushings (Item 25) and o-rings (Item 12) from spools.

5. Remove lockout plugs (Item 11) and port adapter plugs (Item 32) from valve body.

6. Remove plungers (Item 31, 37). IMPORTANT: Check location and position of plungers when removing from body to assure proper assembly.

7. Remove relief valve plug (Item 16), shims (Items 18, 19, 20), spring (Item 21) and poppet (Item 22) from body. NOTE: Do not remove poppet seat (Item 23). Seat has been set to a predetermined depth and locked in place.

8. Remove wiper seals (Item 24) and o-rings (Item 12) from body spool bores.

9. Remove plug (Item 6).

10. Remove detent plunger plug (Item 1), detent spring (Item 3) and detent plunger (Item 4). Remove discs (Item 2) from plug.

11. Remove all o-rings and back-up washers from all plugs and seats.

12. Inspect all parts for nicks, burrs, roughness or excessive wear or breakage. If spools have excessive wear, the valve is non-serviceable as the spools and spool bores are matched and damaged spools cannot be replaced.

13. Thoroughly clean and dry all parts. Metal parts should be lightly oiled before assembly. NOTE: All o-rings, back-up washers and nylon poppets should be replaced as new items.


15. Install relief valve components and new o-ring on plug.

16. Install plungers (Items 31 and 37). NOTE: Check location and positioning of plungers during installation.

17. Install seats (Item 35), poppets (Item 34), springs (Item 33) and port adapter plugs (Item 32) into valve body.
18. Install plugs (Item 6) with new o-rings.

19. Install detent plunger (Item 4), detent spring (Item 3), disc, and detent plunger plug (Item 1) with new o-ring and tighten to a torque of 20 - 30 in-lb.

20. Slide bushings (tem 25) over spools, slide new o-ring (Item 12) over spool and position next to bushing. Dip spools in oil and install spool assemblies in proper location.

21. Install spool caps (Item 30) into proper location in valve body and tighten to a torque of 20 - 25 ft-lb.

22. Install lockout plugs (Item 11) with new backup washers and o-rings.

---

Figure 46

1. Detent plug
2. Disc
3. Detent spring
4. Detent plunger
5. O-ring
6. Plug
7. O-ring
8. Body
9. O-ring
10. Back-up washer
11. Lockout plug
12. O-ring
13. Spool
14. Locknut
15. Washer
16. Relief plug
17. O-ring
18. Washer
19. Washer
20. Washer
21. Spring
22. Poppet
23. Seat
24. Wiper seal
25. Bushing
26. Washer
27. Spring
28. Spacer
29. Retaining ring
30. Spool cap
31. Plunger
32. Port adapter plug
33. Spring
34. Poppet
35. Seat
36. O-ring
37. Plunger
Steering System Repairs

Steering Cylinder Removal and Installation

1. Park machine on a level surface, engage parking brake, raise or lower wing decks completely, lower front deck to ground and turn engine OFF.

2. Clean cylinder and surrounding area thoroughly. Disconnect hydraulic lines and plug to prevent contamination from entering hydraulic system.

3. Remove cotter keys from castle nut on each end of cylinder (Fig. 47).

4. Remove castle nuts and remove cylinder.

5. Reverse steps 2 - 4 to install cylinder.

6. After installation of cylinder, start engine and turn steering wheel fully left and right several times. Check cylinder for leaks. Check oil level in hydraulic reservoir and add correct oil if necessary.

Ball Joint Adjustment

Ball joint (Fig. 48, Item 2) must be adjusted on cylinder shaft so steering arms hit stops on rear axle in either direction. Toe-in must be adjusted first. (See Steering Cylinder Adjustment in the Adjustments section of Chapter 6 - Wheels, Brakes and Steering.)

Steering Cylinder Repair

IMPORTANT: To prevent damage when clamping cylinder barrel or rod in a vise, clamp only on pivot ends.

1. After removing cylinder, pump oil out of cylinder into a drain pan by SLOWLY moving rod and piston in and out of cylinder bore.

2. Plug ports and clean outside of cylinder.

3. Mount cylinder in a vise so piston rod end of cylinder is tilted up slightly. Do not close vise so firmly that cylinder tube could become distorted.

4. Use a snap ring pliers to remove retaining ring (Fig. 48).

5. Grasp clevis end of piston rod and use a twisting and pulling motion to carefully extract piston, piston rod, and head from cylinder barrel.

6. Securely mount piston, piston rod, and head into vise and remove nut.

IMPORTANT: Do not clamp vise jaws against smooth piston rod surface; the piston rod will become damaged.

7. Remove piston. Slide head off of piston rod.

8. Remove all seals and O-rings.

9. Wash parts in a safe solvent. Dry parts with compressed air. DO NOT wipe them dry with a cloth or paper as lint and dirt may remain.

10. Carefully inspect internal surface of barrel for damage (deep scratches, out-of-round, etc.). Replace entire cylinder if barrel is damaged. Inspect head, piston rod, and piston for evidence of excessive scoring, pitting, or wear. Replace any damaged parts.

11. Use a complete repair kit when rebuilding the cylinder. Put a coating of oil on all new seals, and O-rings. Install the new seals and O-rings.
12. Install head onto piston rod.

13. Install piston onto piston rod with o-ring seal (Item 10) and tighten hex nut.

14. Put a coating of oil on all cylinder parts to ease assembly.

15. Slide piston rod assembly into cylinder tube.

16. Install head into tube and install retaining ring.
Steering Control Unit Removal and Installation

1. Park machine on a level surface, engage parking brake, raise or lower wing decks completely, lower front deck to ground and turn engine OFF.

2. Remove steering tower cover.

3. Thoroughly clean steering control unit and surrounding area.

4. Mark hydraulic lines for ease in identification during reassembly.

5. Remove hydraulic lines. Cap open ends of lines or fittings to prevent contamination of hydraulic system.

6. Remove four (4) capscrews and remove steering control unit from bracket.

6. Reverse steps 2 - 5 to install steering control unit.

Figure 49
(Steering tower cover removed)

1. Steering control unit
2. Capscrew and lock washer (4)
3. Steering gear bracket
Steering Control Unit Repair (Models 30580 and 30581)

For service of the steering control unit on Models 30580 and 30581, see the Eaton Char-Lynn Steering Control Units Repair Information at the end of this chapter.

Steering Control Unit Repair (Model 30582 and 30583)

Disassembly (Fig. 49A)

NOTE: Cleanliness is extremely important when repairing steering control units. Work in a clean area. Before disconnecting the hydraulic lines, clean the port area of the steering valve assembly. Before disassembly, drain the oil, then plug the ports and thoroughly clean the exterior. During repairs, always protect machined surfaces.

1. Remove the seven cap screws from the steering valve assembly.
2. Remove end cap, geroter, spacer, geroter drive, wear plate, seal ring, and o-rings from housing.
3. Remove the plug and relief valve.
4. Slide the spool and sleeve assembly from the housing.
5. Remove the thrust bearing and bearing races (2).
6. Remove the quad seal.
7. Use a small blade screwdriver to carefully pry the dust seal from the housing. Be careful to not damage the dust seal seat in the housing.
8. Remove the pin that holds the spool and sleeve together.

Figure 49A
9. Carefully slide the spool out of the sleeve. The centering springs and spring retaining ring will stay with the spool as it is removed.

**CAUTION**

The centering springs are under tension. Remove the retaining ring carefully.

10. Remove the spring retaining ring and centering springs from the spool.

**Reassembly (Fig. 49A)**

Check all mating surfaces. Replace any parts with scratches or burrs that could cause leakage. Wash all metal parts in clean solvent. Blow them dry with pressurized air. Do not wipe parts dry with paper towels or cloth. Lint in a hydraulic system will cause damage.

**NOTE:** Always use new seals and O-rings when reassembling the steering control unit.

**IMPORTANT:** During reassembly, lubricate the new seals with petroleum jelly. Also, lubricate machined surfaces and bearings with clean hydraulic fluid.

1. Install the quad seal:
   
   A. Put one of the bearing races and sleeve into the housing.
   
   B. Together, the housing and bearing race create a groove into which the quad seal will be installed.
   
   C. Hold the bearing race tightly against the input end of the housing by pushing on the gerotor end of the sleeve.
   
   D. Fit the quad seal into its seat through the input end of the housing. Be sure the seal is not twisted.
   
   E. Remove the sleeve and bearing race.

2. Lubricate and install the dust seal.

3. Install the centering springs in the spool. It is best to install the two flat pieces first. Next, install the curved pieces, three at a time.

4. Fit the retaining ring over the centering springs.

5. Apply a light coating of clean hydraulic fluid to the spool and slide it into the sleeve. Be sure the centering springs fit into the notches in the sleeve.

6. Install the pin.

7. Apply a light coating of petroleum jelly to the inner edge of the dust and quad seals.

8. Put the thrust bearing and races into the housing. The thrust bearing goes between the two races (Fig. 49B).

**IMPORTANT:** Do not damage the dust or quad seals when installing the spool and sleeve assembly.

9. Apply a light coating of clean hydraulic fluid to the spool and sleeve assembly and slide carefully the assembly into the housing.

10. Clamp the housing in a vise. Use only enough clamping force to hold the housing securely.

11. Lubricate and install a new O-ring seal in the groove in the housing.

12. Install the wear plate and align screw holes in the wear plate with threaded holes in the housing.

**NOTE:** The holes in the wear plate are symmetrical.

13. Install the gerotor drive, making sure the slot in the drive engages the pin.


15. Install the gerotor and align the screw holes.

16. Lubricate and install new O-ring in gerotor ring groove.

17. Lubricate and install new O-ring and seal ring in gerotor star groove.

18. Install the spacer.

19. Install the end cap and seven cap screws. Tighten the cap screws, in a crossing pattern, from 140 to 160 in-lb (16 to 18 N-m).

20. Remove the steering control unit from the vise.

21. Install the relief valve and plug. Tighten the plug to 150 in-lb (17 N-m).
Hydraulic Reservoir and Filter

Flushing The Hydraulic System

IMPORTANT: Drain and refill reservoir, change oil filter and flush hydraulic system if component failure was severe or system is contaminated (oil appears milky or black or contains metal particles.

1. Put drain pan under reservoir. Remove drain plug and drain cap, one at a time, and let oil drain into pan (Fig. 52). Inspect o-rings on plug and cap, and replace, if damaged. Install drain plug and cap.

2. Inspect and clean reservoir. (See Inspecting Reservoir Parts in this section of the book.)

3. Put drain pan under filter and remove filter (Fig. 51). Coat o-ring of replacement filter with clean hydraulic oil. Install filter and tighten by hand until filter element is firmly seated against filter head.

4. With machine on a level surface, fill reservoir with hydraulic oil until oil level is midway up in sight glass (Fig. 50). Install fill cap.

5. Disconnect fuel stop solenoid electrical connector to prevent fuel delivery to engine cylinders (Fig. 26).

6. Turn ignition key switch to engage starter for 10 seconds. Repeat this procedure five (5) times for a total cranking time of 60 seconds.

7. Connect injection pump fuel stop solenoid electrical connector.

8. Engage parking brake. Start engine a let idle at low speed for minimum of two (2) minutes.

9. Increase engine speed to high idle for minimum of one (1) minute under no load.

10. Raise and lower cutting units several times.

11. Turn steering wheel fully left and right several times.

12. Engage cutting units and run under no load for five (5) minutes.

13. Disengage parking brake and operate machine in forward and reverse.

14. Shut off engine and check for hydraulic oil leaks. Check oil level in hydraulic reservoir and add correct oil if necessary.

15. Replace hydraulic filter again after first 10 - 15 hours of operation, or sooner if hydraulic filter warning light comes on.
Inspecting Reservoir Parts

1. Clean filler screen, suction screen and reservoir with clean solvent (Fig. 54).

2. Inspect reservoir for leaks, cracks or other damage.

3. Replace hoses and fittings if worn or leaking.

4. Replace breather with new part (Fig. 53).

Figure 53
1. Hydraulic system breather

Figure 54

1. O-ring
2. Sight gauge
3. Level sensing unit
4. Hydraulic tank
5. Capscrew
6. Lockwasher
7. Flat washer
8. Suction hose adapter
9. Lockwasher
10. Capscrew
11. Hose clamp
12. Suction hose
13. Hose clamp
14. Auxiliary suction hose
15. Hose clamp
16. O-ring
17. Suction screen
18. Drain plug
19. O-ring
20. Hydraulic tube
21. O-ring
22. Hydraulic fitting
23. O-ring
24. Sealing strip
25. Filler gasket
26. Filler screen
27. Filler cap flange
28. Filler cap ass'y
29. Hose vent
30. Hose clamp
31. Hydraulic vent tube

Hydraulic Reservoir and Filter

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Groundsmaster® 580-D
# Chapter 5

**Electrical System** (Model 30580, S/N Below 30101)

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**Note:** Additional troubleshooting information for older machines equipped with the Controller Update Kit is available in Chapter 8 – Electrical System (S/N 30101 & Up).
Wiring Schematics and Diagrams

Controller Logic Chart

Each line on the chart shows the possible combination of inputs to satisfy logic for output.

Example: To get power output at pin 19 (start) of controller, there must be input of 12 volts at pin 1 (start switch) and the controller must sense a path to ground at pin 3 (traction neutral switch closed).

NOTE: Red lights (LED's) on controller indicate when the following inputs are made (switch closed to ground) indicating a "safe" condition:

- Seat Occupied
- Traction Neutral
- Front Deck Down
- Left Deck Down
- Right Deck Down

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</tr>
<tr>
<td>FRONT DECK DOWN</td>
<td>8</td>
</tr>
<tr>
<td>RIGHT DECK DOWN</td>
<td>9</td>
</tr>
<tr>
<td>LEFT DECK DOWN</td>
<td>10</td>
</tr>
<tr>
<td>PARKING BRAKE</td>
<td>11</td>
</tr>
<tr>
<td>HI RANGE ENGAGE/DISENGAGE</td>
<td>12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CRUISE</th>
<th>FRONT DECK</th>
<th>RIGHT DECK</th>
<th>LEFT DECK</th>
<th>MONITOR/GAUGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**KEY**

- **X** denotes input closed to ground
- **O** denotes input open to ground
- **@** denotes input required to close to ground momentary only
- **●** denotes input of 12 volts D.C.
- ***** denotes input of internal logic
- **□** denotes input status not relevant
Run (with operator)

1) Start
2) Hi Range Engage
3) Run (no operator)
4) Cruise Engage
5) Front Deck Engage
6) Right Deck Engage
7) Left Deck Engage
8) Gauges ON

**KEY:**

X = CLOSED, O = OPEN, P = OUTPUT ON,
B = MUST BE CLOSED ONLY IF HI TEMP SWITCH IS CLOSED.
M = MOMENTARILY CLOSED

**INPUTS**

0 Hi Range Disengage
1 Key Run
2 Traction Neutral
3 Seat Switch
4 High Coolant Temp
5 High Temp Override
6 Cruise Control Enable
7 PTO Engage
8 PTO Disengage
9 PTO Engagement
10 Front Deck Down
11 Right Deck Down
12 Left Deck Down
13 Hi Range Engage
14 Hyd. Oil Level (x=ok)
15 Cruise Control Engage
16 Service Brake (x=off)
17 Parking Brake (x=off)
18 AO Start Key

**OUTPUTS**

0
1 Front Deck Engage
2 Right Deck Engage
3 Left Deck Engage
4 Gauge Power ON
5
6 Cruise Control Clutch
7 ETR Hold / Alt
8
9
10
11
12
13
14
15
16
17
18

**LOGIC GRID**

Groundsmaster 580-D

**GROUNDSMASTER S/N Below 30101**
Special Tools

NOTE: Order special tools from the TORO SPECIAL TOOLS AND APPLICATIONS GUIDE (COMMERCIAL PRODUCTS). Some tools may be available from a local supplier.

Continuity Tester

Battery powered test lamp which is helpful in testing for continuity of circuits and electrical components when the current is off (Fig. 1).

Volt - Ohm - Amp Meter

The meter (Fig. 2) can test electrical components and circuits for current, resistance, or voltage draw.
Skin-Over Grease

Special non-conductive grease which forms a light protective skin to help waterproof electrical switches and contacts. Recommended for all interlock system connections (Fig. 3).

Figure 3
Troubleshooting

\[\text{CAUTION}\]

Remove all jewelry, especially rings and watches, before doing any electrical troubleshooting or testing. Disconnect the battery cables unless the test requires battery voltage.

For effective troubleshooting and repairs, you MUST have a good understanding of the electrical circuits and components used on this machine. (See Electrical Schematics and Diagrams section of this chapter.)

Study the operating characteristics preceding the electrical failure to help identify the area of difficulty. Try to isolate the failure to a specific functional system; then check that area, repairing one component at a time. Attempting to repair more than one system at one time will lead to confusion.

Possible Causes and Corrections in the troubleshooting charts should be checked in the order in which they are listed.

If the machine being repaired has any interlock switches by-passed, they must be reconnected for proper troubleshooting and safety.

---

### Starting Problems

<table>
<thead>
<tr>
<th>Condition</th>
<th>Possible Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>All electrical is dead, including gauges.</td>
<td>Low battery charge.</td>
<td>Charge batteries. Replace batteries if they will not hold a charge.</td>
</tr>
<tr>
<td></td>
<td>Circuit breaker open.</td>
<td>Find cause for open circuit breaker and correct. Push circuit breaker button to reset.</td>
</tr>
<tr>
<td></td>
<td>5A Control Power (key switch) fuse open.</td>
<td>Check fuse and replace if fuse is open. If fuses burn out often, find and correct cause.</td>
</tr>
<tr>
<td></td>
<td>Faulty diode.</td>
<td>Replace diode.</td>
</tr>
<tr>
<td></td>
<td>Faulty key switch wiring.</td>
<td>Repair wiring.</td>
</tr>
<tr>
<td></td>
<td>Faulty key switch.</td>
<td>Check key switch and replace if necessary.</td>
</tr>
<tr>
<td>Starter solenoid clicks, but starter will not crank. (If solenoid clicks, problem is not in interlock system or controller.)</td>
<td>Low battery charge.</td>
<td>Charge batteries. Replace batteries if they will not hold a charge.</td>
</tr>
<tr>
<td></td>
<td>Loose or corroded battery cables.</td>
<td>Clean and tighten or repair as necessary.</td>
</tr>
<tr>
<td></td>
<td>Loose or corroded ground.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Faulty wiring at starter.</td>
<td>Repair wiring.</td>
</tr>
<tr>
<td></td>
<td>Loose starter mounting bolts.</td>
<td>Clean mounting surface and tighten bolts.</td>
</tr>
<tr>
<td></td>
<td>Faulty starter.</td>
<td>Repair or replace starter.</td>
</tr>
<tr>
<td></td>
<td>Faulty starter solenoid.</td>
<td>Replace starter solenoid.</td>
</tr>
<tr>
<td>Condition</td>
<td>Possible Cause</td>
<td>Correction</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Nothing happens when start attempt is made (control panel lights and gauges DO operate with ignition key switch in ON position).</td>
<td>Low battery charge.</td>
<td>Charge batteries. Replace batteries if they will not hold a charge.</td>
</tr>
<tr>
<td></td>
<td>Faulty ignition (key) switch.</td>
<td>Replace switch.</td>
</tr>
<tr>
<td></td>
<td>Faulty wiring between ignition (key) switch and controller.</td>
<td>Repair wiring.</td>
</tr>
<tr>
<td></td>
<td>With foot off traction pedal, Traction Neutral LED on controller OFF (must be ON to start).</td>
<td>Adjust or repair traction control linkage if necessary. Check traction neutral switch and adjust or replace if necessary. Check neutral switch wiring and repair if necessary. Replace controller.</td>
</tr>
<tr>
<td></td>
<td>5A Start Relay fuse open.</td>
<td>Check fuse and replace if fuse is open. If fuses burn out often, find and correct cause.</td>
</tr>
<tr>
<td></td>
<td>Faulty wiring between controller and start relay.</td>
<td>Repair wiring.</td>
</tr>
<tr>
<td></td>
<td>Faulty ground on start relay.</td>
<td>Repair wiring.</td>
</tr>
<tr>
<td></td>
<td>Start relay faulty.</td>
<td>Replace start relay.</td>
</tr>
<tr>
<td></td>
<td>Faulty wiring between start relay and starter solenoid.</td>
<td>Repair wiring.</td>
</tr>
<tr>
<td></td>
<td>Starter solenoid faulty.</td>
<td>Replace starter solenoid.</td>
</tr>
<tr>
<td></td>
<td>Faulty controller.</td>
<td>Replace controller.</td>
</tr>
<tr>
<td>Starter and/or run solenoid shifts in and out when start attempt is made. (If solenoid clicks, problem is not in interlock system or controller.)</td>
<td>Low battery charge.</td>
<td>Charge batteries. Replace batteries if they will not hold a charge.</td>
</tr>
<tr>
<td></td>
<td>Diode faulty</td>
<td>Replace diode.</td>
</tr>
<tr>
<td></td>
<td>Capacitor faulty.</td>
<td>Replace capacitor.</td>
</tr>
<tr>
<td>Condition</td>
<td>Possible Cause</td>
<td>Correction</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>-------------------------------------------------------</td>
<td>--------------------------------------------------------------</td>
</tr>
<tr>
<td>Engine starts, but dies when ignition key switch is released from start position.</td>
<td>Run solenoid out of adjustment.</td>
<td>Adjust run solenoid.</td>
</tr>
<tr>
<td></td>
<td>5A Run Solenoid/Alternator fuse open.</td>
<td>Check fuse and replace if open. If fuses burn out often, find and correct cause.</td>
</tr>
<tr>
<td></td>
<td>Run solenoid faulty.</td>
<td>Replace run solenoid.</td>
</tr>
<tr>
<td></td>
<td>Run solenoid wiring faulty.</td>
<td>Repair wiring.</td>
</tr>
<tr>
<td></td>
<td>Faulty hydraulic oil level switch (oil level is correct).</td>
<td>Replace low hydraulic oil level switch.</td>
</tr>
<tr>
<td></td>
<td>Faulty hydraulic oil level circuit wiring.</td>
<td>Repair wiring.</td>
</tr>
<tr>
<td></td>
<td>Faulty high engine water temperature shut-down switch (engine not overheated).</td>
<td>Replace high engine water temperature shut-down switch.</td>
</tr>
<tr>
<td></td>
<td>Faulty high engine water temperature shut-down circuit wiring.</td>
<td>Repair wiring.</td>
</tr>
<tr>
<td>Starter cranks but engine will not start.</td>
<td>Engine not cranking fast enough.</td>
<td>Check batteries and cable connections. Charge batteries. Replace batteries if they won’t accept a charge. Repair wiring if necessary.</td>
</tr>
<tr>
<td></td>
<td>Run solenoid out of adjustment</td>
<td>Adjust run solenoid.</td>
</tr>
<tr>
<td></td>
<td>Faulty run solenoid.</td>
<td>Replace run solenoid.</td>
</tr>
<tr>
<td></td>
<td>Problem is not electrical.</td>
<td>See Troubleshooting section of Chapter 3 - Engine.</td>
</tr>
<tr>
<td>Starter cranks, but should not when traction pedal is depressed.</td>
<td>With traction pedal depressed, Traction Neutral LED on controller is ON (should be OFF).</td>
<td>Check traction neutral switch adjustment and adjust if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check traction neutral switch and replace if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check traction neutral switch wiring and repair if faulty.</td>
</tr>
<tr>
<td></td>
<td>Faulty controller.</td>
<td>Replace controller.</td>
</tr>
</tbody>
</table>

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Troubleshooting
<table>
<thead>
<tr>
<th>Condition</th>
<th>Possible Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine continues to run, but should not, when ignition key is turned off.</td>
<td>Engine fuel lever stuck in &quot;on&quot; position.</td>
<td>Check operation of run solenoid and adjust or replace if necessary.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Make sure fuel stop lever moves without sticking and repair if necessary.</td>
</tr>
<tr>
<td></td>
<td>Ignition switch faulty.</td>
<td>Replace ignition switch.</td>
</tr>
<tr>
<td></td>
<td>Controller faulty.</td>
<td>Replace controller.</td>
</tr>
<tr>
<td>Engine continues to run, but should not, when traction pedal is engaged with no operator on seat.</td>
<td>With operator off seat, Seat Occupied LED on controller ON (should be OFF).</td>
<td>Check seat plate hinges and seat support pin and repair if faulty. Check for waterlogged seat.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check seat switch and replace if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check seat switch wiring and repair if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Replace controller.</td>
</tr>
<tr>
<td></td>
<td>With traction pedal depressed, Traction Neutral LED on controller is ON (should be OFF).</td>
<td>Check traction neutral switch adjustment and adjust if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check traction neutral switch and replace if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check traction neutral switch wiring and repair if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Replace controller.</td>
</tr>
<tr>
<td></td>
<td>Faulty controller.</td>
<td>Replace controller.</td>
</tr>
<tr>
<td>Condition</td>
<td>Possible Cause</td>
<td>Correction</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
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<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Cruise control will not engage.</td>
<td>Cruise control out of adjustment (cruise engaged light comes on).</td>
<td>Adjust cruise control.</td>
</tr>
<tr>
<td></td>
<td>5A Cruise fuse open.</td>
<td>Check fuse and replace if open. If fuses burn out often, find and correct cause.</td>
</tr>
<tr>
<td></td>
<td>Service brake pedal or switch out of adjustment.</td>
<td>Adjust brake pedal and/or switch.</td>
</tr>
<tr>
<td></td>
<td>Faulty service brake switch.</td>
<td>Replace switch.</td>
</tr>
<tr>
<td></td>
<td>Cruise control coil faulty.</td>
<td>Test coil. Replace coil if faulty.</td>
</tr>
<tr>
<td></td>
<td>Faulty ground from cruise control coil housing to frame.</td>
<td>Remove coil housing and clean it and frame. Tighten fasteners.</td>
</tr>
<tr>
<td></td>
<td>Cruise control switch faulty.</td>
<td>Replace switch.</td>
</tr>
<tr>
<td></td>
<td>Cruise control actuating button faulty.</td>
<td>Replace actuating button.</td>
</tr>
<tr>
<td></td>
<td>15A Deck Supply fuse open.</td>
<td>Check fuse and replace if open. If fuses burn out often, find and correct cause (sign of faulty controller).</td>
</tr>
<tr>
<td></td>
<td>Faulty wiring.</td>
<td>Check wiring to cruise control coil, cruise control switch, actuating button, and service brake switch. Repair faulty wiring.</td>
</tr>
<tr>
<td></td>
<td>Faulty controller.</td>
<td>Replace controller.</td>
</tr>
<tr>
<td>With cruise control engaged, traction pedal does not return to neutral when service brake pedal is depressed.</td>
<td>Service brake pedal or switch out of adjustment.</td>
<td>Adjust brake pedal and/or switch.</td>
</tr>
<tr>
<td></td>
<td>Service brake switch faulty.</td>
<td>Replace switch.</td>
</tr>
<tr>
<td></td>
<td>Problem is not electrical (traction control linkage binding).</td>
<td>Repair linkage.</td>
</tr>
<tr>
<td></td>
<td>Faulty controller.</td>
<td>Replace controller.</td>
</tr>
<tr>
<td>Condition</td>
<td>Possible Cause</td>
<td>Correction</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>High range ground speed will not engage, or disengages while transporting.</td>
<td>Deck(s) lowered.</td>
<td>Raise deck(s) all the way up.</td>
</tr>
<tr>
<td></td>
<td>5A 2-Speed Solenoid fuse open.</td>
<td>Check fuse and replace if open. If fuses burn out often, find and correct cause.</td>
</tr>
<tr>
<td></td>
<td>With all decks up, Deck Down LED on controller is ON (all should be OFF).</td>
<td>Check deck interlock switch and replace if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check deck interlock switch wiring and repair if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Replace controller.</td>
</tr>
<tr>
<td></td>
<td>Faulty two speed solenoid coil.</td>
<td>Replace solenoid coil.</td>
</tr>
<tr>
<td></td>
<td>Faulty ground speed switch.</td>
<td>Replace switch.</td>
</tr>
<tr>
<td></td>
<td>Faulty wiring.</td>
<td>Check wiring to ground speed switch and two-speed solenoid. Repair faulty wiring.</td>
</tr>
<tr>
<td></td>
<td>Problem not electrical.</td>
<td>See Troubleshooting section of Chapter 4 - Hydraulic System.</td>
</tr>
<tr>
<td></td>
<td>Faulty controller.</td>
<td>Replace controller.</td>
</tr>
<tr>
<td>High range ground speed remains engaged, but should not, when deck(s) lowered.</td>
<td>With deck(s) down, Deck Down LED(s) on controller OFF (should be ON).</td>
<td>Check deck interlock switch and replace if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check deck interlock switch wiring and repair if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Replace controller.</td>
</tr>
<tr>
<td></td>
<td>Problem is not electrical.</td>
<td>Check for two-speed shift valve spool binding or damage.</td>
</tr>
<tr>
<td></td>
<td>Faulty controller.</td>
<td>Replace controller.</td>
</tr>
<tr>
<td>Condition</td>
<td>Possible Cause</td>
<td>Correction</td>
</tr>
<tr>
<td>-----------</td>
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</tr>
<tr>
<td>Engine kills during operation, but restarts.</td>
<td>Seat lifting off seat switch.</td>
<td>Instruct operator to sit back in seat during operation. Check seat plate hinges and seat support pin and repair if faulty.</td>
</tr>
<tr>
<td></td>
<td>With operator on seat, Seat Occupied LED on controller is OFF (should be ON).</td>
<td>Check seat switch and replace if faulty. Check seat switch wiring and repair if faulty. Replace controller.</td>
</tr>
<tr>
<td></td>
<td>Faulty ignition switch.</td>
<td>Replace switch.</td>
</tr>
<tr>
<td></td>
<td>Faulty ignition switch wiring.</td>
<td>Repair wiring.</td>
</tr>
<tr>
<td></td>
<td>Faulty low hydraulic oil level switch (oil level not too low).</td>
<td>Replace switch.</td>
</tr>
<tr>
<td></td>
<td>Faulty low hydraulic oil level wiring. (oil level not too low).</td>
<td>Repair wiring.</td>
</tr>
<tr>
<td></td>
<td>Faulty controller.</td>
<td>Replace controller.</td>
</tr>
<tr>
<td>Engine kills when traction pedal is depressed.</td>
<td>Parking brake on.</td>
<td>Disengage parking brake.</td>
</tr>
<tr>
<td></td>
<td>Seat lifting off seat switch.</td>
<td>Instruct operator to sit back in seat during operation. Check seat plate hinges and seat support pin and repair if faulty.</td>
</tr>
<tr>
<td></td>
<td>With operator on seat, Seat Occupied LED on controller is OFF (should be ON).</td>
<td>Check seat switch and replace if faulty. Check seat switch wiring and repair if faulty. Replace controller.</td>
</tr>
<tr>
<td></td>
<td>Faulty parking brake switch.</td>
<td>Replace parking brake switch.</td>
</tr>
<tr>
<td></td>
<td>Faulty parking brake switch wiring.</td>
<td>Repair wiring.</td>
</tr>
<tr>
<td>Batteries do not charge.</td>
<td>Alternator belt slipping.</td>
<td>Adjust belt tension.</td>
</tr>
<tr>
<td></td>
<td>Faulty wiring.</td>
<td>Check and repair wiring.</td>
</tr>
<tr>
<td></td>
<td>Malfunctioning alternator.</td>
<td>Repair or replace alternator.</td>
</tr>
<tr>
<td></td>
<td>Faulty battery(s).</td>
<td>Replace battery(s).</td>
</tr>
</tbody>
</table>
# Deck Operation Problems

<table>
<thead>
<tr>
<th>Condition</th>
<th>Possible Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck(s) remain engaged, but should not, with no operator on seat.</td>
<td>With operator off seat, Seat Occupied LED on controller ON (should be OFF).</td>
<td>Check seat plate hinges and seat support pin and repair if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check for waterlogged seat.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check seat switch and replace if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check seat switch circuit wiring and repair if faulty.</td>
</tr>
<tr>
<td></td>
<td>Controller faulty.</td>
<td>Replace controller.</td>
</tr>
<tr>
<td>Deck(s) run, but should not, when raised (but shut off with PTO switch).</td>
<td>With deck(s) raised, Deck Down LED(s) on controller ON (should be OFF).</td>
<td>Check deck interlock switch(s) and replace if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check deck interlock switch wiring and repair if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Make sure switch(s) screwed in all the way.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check for damaged pivot shaft or bushings and repair if damaged.</td>
</tr>
<tr>
<td></td>
<td>Faulty controller.</td>
<td>Replace controller.</td>
</tr>
<tr>
<td>Deck(s) run, but should not, when raised (does not shut off with PTO switch).</td>
<td>Hydraulic problem.</td>
<td>See Troubleshooting section of Chapter 4 - Hydraulic System.</td>
</tr>
<tr>
<td>Deck engages, but should not when lowered (all decks were raised and off).</td>
<td>Faulty deck drive/PTO switch</td>
<td>Replace switch.</td>
</tr>
<tr>
<td></td>
<td>Faulty deck drive/PTO switch wiring.</td>
<td>Repair wiring.</td>
</tr>
<tr>
<td></td>
<td>Faulty controller.</td>
<td>Replace controller.</td>
</tr>
<tr>
<td>Condition</td>
<td>Possible Cause</td>
<td>Correction</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------------------------------------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>No decks operate.</td>
<td>Deck solenoid coil wiring connectors disconnected.</td>
<td>Connect wiring connectors.</td>
</tr>
<tr>
<td></td>
<td>Seat lifting off seat switch.</td>
<td>Instruct operator to sit back in seat during operation. Check seat plate hinges and seat support pin and repair if faulty.</td>
</tr>
<tr>
<td></td>
<td>With operator on seat, Seat Occupied LED on controller OFF (should be ON).</td>
<td>Check seat switch and replace if faulty. Check seat switch wiring and repair if faulty. Replace controller.</td>
</tr>
<tr>
<td></td>
<td>15A Deck Supply fuse open.</td>
<td>Check fuse and replace if open. If fuses burn out often, find and correct cause (sign of faulty controller).</td>
</tr>
<tr>
<td></td>
<td>Faulty wiring between 15A deck supply fuse and controller.</td>
<td>Repair wiring.</td>
</tr>
<tr>
<td></td>
<td>Faulty deck drive/PTO switch or wiring.</td>
<td>Check deck drive/PTO switch and wiring. Replace switch or repair wiring if faulty.</td>
</tr>
<tr>
<td></td>
<td>Hydraulic problem.</td>
<td>See Troubleshooting section of Chapter 4 - Hydraulic System.</td>
</tr>
<tr>
<td></td>
<td>Faulty controller.</td>
<td>Replace controller.</td>
</tr>
<tr>
<td>Condition</td>
<td>Possible Cause</td>
<td>Correction</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>----------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>One or two decks do not operate.</td>
<td>With deck(s) down, Deck Down LED(s) on controller OFF (should be ON).</td>
<td>Check deck interlock switch and replace if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check deck interlock switch wiring and repair if faulty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Make sure switch(s) screwed in all the way.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check for damaged pivot shaft or bushings and repair if damaged.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Replace controller.</td>
</tr>
<tr>
<td>5A Deck solenoid fuse open.</td>
<td></td>
<td>Check fuse and replace if open. If fuses burn out often, find and correct cause.</td>
</tr>
<tr>
<td>Faulty deck solenoid coil.</td>
<td></td>
<td>Replace solenoid coil(s).</td>
</tr>
<tr>
<td>Faulty wiring between controller and deck solenoid coil.</td>
<td></td>
<td>Make sure wiring connector at solenoid is connected. Repair faulty wiring.</td>
</tr>
<tr>
<td>Hydraulic problem.</td>
<td></td>
<td>See Troubleshooting section of Chapter 4 - Hydraulic System.</td>
</tr>
<tr>
<td>Faulty controller.</td>
<td></td>
<td>Replace controller.</td>
</tr>
</tbody>
</table>
Verify Interlock System Operation

⚠️ CAUTION
Do not disconnect or bypass interlock switches. Check switch operation daily to assure interlock system is functioning correctly. If a switch is malfunctioning, replace it before operating the machine. To ensure maximum safety, replace all switches after every two years or 1000 hours of operation, whichever comes first.

The interlock switches in conjunction with the controller, prevent the engine from starting if the traction pedal is not in neutral. The interlock system will also stop the engine if the operator leaves the seat or parking brake is on with the traction pedal out of neutral. The PTO will not engage if the seat is unoccupied, the engine is shut-off or all three (3) cutting units are raised.

To check interlock system operation:

1. Drive the machine slowly to a large, relatively level open area. Lower cutting units and stop engine.

2. Sit on seat. Depress traction pedal in both forward and reverse positions and try to start engine. If engine cranks, there is a malfunction that must be repaired immediately. If engine does not crank, proceed to step 3.

3. Sit on seat, engage parking brake and turn ignition switch to ON. Hold traction pedal about halfway down, switch cruise control to ON and push SET button. Cruise Engaged light should come on and traction pedal should hold position indicating cruise control is functioning correctly. Depress the service brake pedal. The traction pedal should return to neutral position and the Cruise Engaged light should shut off, indicating the interlock is working correctly; proceed to step 4. If the pedal did not return to neutral and the light did not turn off, there is a malfunction in the safety interlock system that should be corrected before operating the machine.

4. Sit on seat. Engage parking brake and start engine. Raise off seat and attempt to move PTO switch to ENGAGE position. The PTO should not engage, indicating the interlock is working correctly; proceed to step 5. If the PTO did engage, there is a malfunction in the safety interlock system that should be corrected before operating the machine.

5. Set on the seat and depress the service brake pedal. With the engine running, raise off the seat and slowly depress traction pedal. The engine should stop, indicating the interlock system is working correctly; proceed to step 6. If the engine did not stop, there is a malfunction in the safety interlock system that should be corrected before operating the machine.

6. Sit on the seat and engage the parking brake. With the engine running, slowly depress the traction pedal. The engine should stop, indicating the interlock is working correctly; proceed to step 7. If the engine did not stop, there is a malfunction in the safety interlock system that should be corrected before operating the machine.

7. Sit on seat. With the engine running, parking brake set and all three (3) cutting units fully lowered, place the PTO switch in ENGAGE position. Raise the right hand cutting unit. The cutting blades of the right hand unit should stop, indicating the interlock is working correctly; proceed to step 8. If the blades did not stop, there is a malfunction in the safety interlock system that should be corrected before operating the machine.

8. Raise the left hand cutting unit. The cutting blades of the left hand unit should stop, indicating the interlock is working correctly; proceed to step 9. If the blades did not stop, there is a malfunction in the safety interlock system that should be corrected before operating the machine.

9. Raise the front cutting unit. The cutting blades of the front unit should stop, indicating the interlock is working correctly; proceed to step 10. If the blades did not stop, there is a malfunction in the safety interlock system that should be corrected before operating the machine.

10. Lower the front cutting unit. The cutting blades should not engage, indicating the Interlock is working correctly; proceed to step 11. If the blades did engage, there is a malfunction in the safety interlock system that should be corrected before operating the machine.

11. Sit on the seat, engage parking brake and start engine. Raise all three (3) cutting units. Position High/Low Range ground speed selector in High Range. The High Range indicator light should come on. Lower one of the cutting units. The High Range indicator light should go off, indicating the interlock is working correctly. If the light did not go out, there is a malfunction in the safety interlock system that should be corrected before operating the machine.
Testing

It is often to the technician's advantage to leave the components intact in the electrical system, and by studying the electrical troubleshooting charts and schematics, determine which component is at fault. However, this section will define given components, and the tests that can be performed on those components, when those parts are disconnected from the electrical system.

For accurate resistance and/or continuity checks, electrically disconnect the component being tested from the circuit (e.g. unplug the seat switch connector before doing a continuity check).

Ignition Key Switch

The ignition (key) switch has three positions (OFF, START and RUN). The terminals are marked as shown in Figure 4.

The circuitry of the ignition switch is shown in the chart (Fig. 5). With the use of a continuity tester, the switch functions may be tested to determine whether all circuits are being completed while the key is moved to each position.

<table>
<thead>
<tr>
<th>POSITION</th>
<th>CONTINUITY AMONG TERMINALS</th>
<th>OTHER CIRCUITS MADE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. OFF</td>
<td>NONE</td>
<td>NONE</td>
</tr>
<tr>
<td>2. RUN</td>
<td><img src="circle_b+ia" alt="Diagram" /></td>
<td><img src="circle_xy" alt="Diagram" /></td>
</tr>
<tr>
<td>3. START</td>
<td><img src="circle_b+is" alt="Diagram" /></td>
<td>NONE</td>
</tr>
</tbody>
</table>

Figure 4

Figure 5
Controller

The controller senses the condition of various switches, such as the seat switch, deck down switches, neutral switch, etc., and directs power output to allow certain machine functions, such as engine run, front deck engage, etc. (See Controller Logic Chart in the Wiring Schematics and Diagrams section of this chapter for possible combinations of inputs to satisfy controller logic for output.)

Because of the solid state circuitry built into the controller, there is no method to test it directly. The controller may be damaged if an attempt is made to test it with an electrical test device, such as a volt-ohm meter.

Lights (LED's) on the controller indicate the condition of the interlock switches. The LED's, in conjunction with the following tests for interlock switches, should be used to help isolate a problem in a switch, wiring or the controller. (See Troubleshooting section of this chapter.)

Note: If machine is equipped with Controller Update Kit, refer to Chapter 8 - Electrical System (S/N 30101 & Up).

Seat Switch

The seat switch is normally open (NO) and closes with the operator on the seat.

1. Raise the seat to get access to the seat switch.

2. Disconnect the seat switch wire connector and install a continuity tester or ohm meter between the two leads of the seat switch.

3. Lower the seat. The continuity tester should show no continuity.

3. Have the operator sit on the seat, slowly depressing the seat switch. The continuity tester should show continuity as the seat approaches the bottom of its travel.

NOTE: Make sure the compression spring and pin hold the seat up off the seat switch when there is no operator on the seat.
Traction (Neutral) Switch

The traction switch is a normally closed (NC) switch and opens when traction pedal is depressed in either direction. The switch is located on the bottom of the variable displacement pump.

IMPORTANT: The traction switch has three (3) terminals. Make sure the wires are connected to the “COMMON” and “NO” terminals.

Test the switch by connecting a continuity tester across the two terminals that have wires connected. With the engine turned off, slowly push the traction pedal in a forward and reverse direction while watching the continuity tester. There should be indications that the traction switch is making and breaking contact. Allow the traction pedal to return to neutral. There should be continuity across the terminals. (See Replacing the Traction Switch in the Repairs section of this chapter for replacement and adjustment procedures.)

Deck Down Switches

Each deck down switch is normally closed (NC) and open when the deck is raised.

1. Disconnect the deck switch wire connector and install a continuity tester or ohm meter between the two leads of the deck switch.

2. With the deck in the lowered position the tester should show continuity. With the deck in the raised position, the tester should show no continuity.

NOTE: For proper operation the switch must be screwed all the way in. A damaged pivot shaft or bushings could cause the switch to not open and close properly.

NOTE: Debris in the switch could cause the switch to not open and close properly.
Service Brake Switch

The service brake switch is normally open (NO) and is closed when pedal is NOT depressed.

1. Disconnect the service brake switch wire connector and install a continuity tester or ohm meter between the two leads of the switch.

2. With the pedal in the completely raised position the tester should show continuity. When the pedal is depressed, the tester should show no continuity.

Parking Brake Switch

The common and normally closed (NC) terminals are closed when the parking brake knob is pulled up (parking brake engaged).

The common and normally open (NO) terminals are closed when the parking brake knob is down (parking brake released).

1. Sit on the seat and apply parking brake. With ignition key switch ON parking brake light should be on.

2. If the light does not come on, replace the bulb and test again.

3. If the light still does not come on there is a problem in the switch or wiring.

4. Release the parking brake. The parking brake should go off.

5. If the light does not go off when the parking brake is released there is a problem in the switch or wiring.
Start Relay

To test the start relay (Fig. 12), disconnect the relay wire connector and install a continuity tester between the relay terminals (terminals 30 and 87) (Fig. 13). The relay should make and break continuity as 12 V.D.C. is connected and disconnected between the winding terminals (terminals 85 and 86).

Figure 12
1. Start relay

Figure 13
Fuel Stop Solenoid

The Groundsmaster 580-D has an energize to run fuel stop solenoid. The solenoid will move the fuel stop lever to stop injector pump fuel delivery if the RUN circuit is open.

1. Open hood latches, raise hood and secure it in raised position with prop rod. Open left side panel latch and remove side panel.

2. Disconnect the wire connector.

3. Connect a 12 volt battery so the positive (+) battery terminal is connected to red lead (terminal A -hold) and white lead (terminal B-pull). Connect the negative (-) battery terminal to black lead (terminal C-common). The plunger should retract to move the fuel stop lever all the way to the fuel delivery position.

IMPORTANT: Do not connect terminal B (pull) for more than 30 seconds or damage to the solenoid coil could result.

4. With the battery connected the same as step 2, disconnect the battery from solenoid terminal B (pull). The plunger should remain pulled in.

5. Disconnect the battery from terminal A (hold). The plunger should return to the extended position and move the fuel lever to the stop position.

6. Check the solenoid spring tension. The spring must have enough force to quickly move the fuel stop lever to the off position when solenoid is de-energized.

NOTE: If solenoid retracts when terminal B (pull) is energized but will not stay retracted when only terminal A (hold) terminal is energized, rod may require adjustment. Rod length must be adjusted so solenoid is fully bottomed out when energized to remain in ON position with only HOLD coil energized.

To Test While Connected to Wire Harness

1. Open hood latches, raise hood and secure it in raised position with prop rod. Open left side panel latch and remove side panel.

2. Remove cotter pin and washer to disconnect fuel stop solenoid from rod.

3. Hold fuel stop lever to prevent fuel delivery. Have operator sit in seat and turn the key switch to the START position and quickly release it to the ON position. The solenoid plunger should retract when ignition key switch is turn to START and stay retracted as the key is released to the ON position.

4. Turn the key switch to the OFF position. The solenoid plunger should extend.

NOTE: If solenoid works properly when disconnected from fuel stop lever, but will not stay retracted with only HOLD coil energized when connected, rod may require adjustment. Rod length must be adjusted so solenoid is fully bottomed out when energized to remain in ON position with HOLD coil energized.

Figure 14

1. Fuel stop solenoid
2. Engine stop lever
3. Rod
4. Ball joint
Battery

1. Use a volt-ohm meter to measure the voltage between the battery terminals.

2. If the voltage is less than 12.3 Volts D.C., the battery should be charged.

Warning Indicator Lights

1. Sit on the seat and apply parking brake. Turn ignition key switch ON and push TEST button (Fig. 15). All lights should come on.

2. If a light does not come on, replace the bulb and test again.

3. If a light still does not come on there is a problem in the wiring or a bridge rectifier is faulty.

Hourmeter

Test the hourmeter by disconnecting the wires and applying 12 V.D.C. between the terminals.

Temperature and Fuel Level Gauges

To test a gauge, use a commercial gauge tester. If a commercial gauge tester is not available, substitute a new gauge or test the sending unit.
Engine Temperature Switches and Gauge Sender

High Temperature Warning Switch

NOTE: Confirm bulb function by doing warning indicator lights test.

1. Lower the coolant level in the engine and remove the high temperature shut-down switch (Fig. 16).

2. Put the switch in a container of oil with a thermometer and heat the oil (Fig. 17).

3. The switch is normally open (NO) and should close at approximately 215°F.

⚠️ CAUTION

Handle hot oil with care to prevent personal injury or fire.

High Temperature Shut-Down Switch

1. Lower the coolant level in the engine and remove the high temperature shut-down switch (Fig. 16).

2. Put the switch in a container of oil with a thermometer and heat the oil (Fig. 17).

3. The switch is normally open (NO) and should close at approximately 230°F.

Temperature Gauge Sender

1. Lower the coolant level in the engine and remove the temperature gauge sender (Fig. 16).

2. Put the switch in a container of oil with a thermometer and heat the oil (Fig. 17a).

90.5 - 117.5 ohm at 160°F
21.3 - 26.3 ohm at 207°F
Hydraulic Oil Temperature Warning Switch

NOTE: Confirm bulb function by doing warning indicator lights test.

1. Remove the hydraulic oil temperature warning switch (Fig. 18).

2. Put the switch in a container of oil with a thermometer and heat the oil (Fig. 17).

3. The switch is normally open (NO) and should close at approximately 215°F.

Engine Oil Pressure Switch

The switch is normally closed (NC) and opens with pressure.

The switch opens at approximately 8 psi.

NOTE: Confirm bulb function by doing warning indicator lights test.

1. Turn ignition key switch ON. Oil pressure lamp should be on.

If bulb is not on:

1. Disconnect wire from switch and touch wire to a good ground.

2. If lamp comes on, replace switch.

3. If lamp does not come on check wiring between lamp and switch for continuity.

If lamp is on with engine running:

1. Shut off engine immediately.

2. Check switch by disconnecting wire. Light should go out.

3. If light is still on, check for short circuit in wiring.

4. If lamp is still on, check for problem at test switch or bridge rectifier.

5. Install test gauge in engine oil pressure switch port. Start engine and check for 30 psi minimum at 1500 rpm. If engine pressure is good, replace switch. If engine pressure is low, DO NOT operate.
2-Speed (Mow/Transport) Solenoid

1. Disconnect the wire connector.

2. Connect a 12 volt battery so the positive (+) battery terminal is connected to blue/white lead. Connect the negative (-) battery terminal to black lead. The valve spool should retract completely as 12 V.D.C. is applied between leads.

3. If valve spool does not retract check for binding or damage in valve.

4. If valve operates smoothly replace solenoid coil.

Figure 20
1. 2-speed (mow/transport) solenoid

PTO (Deck) Solenoids

1. Disconnect the wire connector.

2. Connect a 12 volt battery so the positive (+) battery terminal is connected to red solenoid lead. Connect the negative (-) battery terminal to black lead. The valve spool should retract completely as 12 V.D.C is applied between leads.

3. If valve spool does not retract check for binding or damage in valve.

4. If valve operates smoothly, but does not retract when 12 V.D.C is applied to solenoid leads, replace solenoid.

Figure 21
1. Front deck solenoid (port SV1)
2. Left wing deck solenoid (port SV3)
3. Right wing deck solenoid (port SV2)

Cruise Control

1. Disconnect the wire connector.

2. Connect a 12 volt battery so positive (+) battery terminal is connected to lead coming out of cruise control coil. Connect negative (-) battery terminal to mounting flange on coil assembly. The clutch plate should pull into contact with the coil assembly.

Figure 22
1. Cruise control
Hydraulic Oil Level Sensing Unit

NOTE: Confirm bulb function by warning indicator lights test.

The low oil level WARNING circuit is normally open (NO) and closes in a low oil condition.

The low oil level SHUT DOWN circuit is normally closed (NC) and opens with low oil condition to shut down engine.

1. Disconnect wiring connector and remove low hydraulic oil level switch from reservoir (Fig. 23).

2. Install a continuity tester or ohm meter between yellow leads of sensing unit (warning switch).

3. With upper float raised, the tester should show no continuity. With the upper float lowered, the tester should show continuity. Snap rings on tube may be repositioned if float under or overtravels the desired position.

4. Install a continuity tester or ohm meter between red leads of sensing unit (shut-down switch).

5. With lower float raised, the tester should show continuity. With lower float lowered, the tester should show no continuity. Snap rings on tube may be repositioned if float under or overtravels the desired position.

Fuel Gauge Sender

1. Disconnect wire and remove the fuel gauge sender from the fuel tank (Fig. 24).

2. Install an ohm meter between the terminal and base.

3. With arm completely down (empty), resistance should be 240-260 ohms.

4. With arm completely up (full), resistance should be 29-34 ohms.

NOTE: Bend float arm, if necessary, to get proper gauge reading for 1/2 full tank.

⚠ CAUTION

Make sure the sending unit is completely dry (no fuel on it) before testing. Perform test away from fuel tank to prevent an explosion or fire from sparks.
Hydraulic Oil Filter Warning Switch

The oil filter warning switch is normally open (NO) and closes if the bypass valve in the oil filter housing opens.

NOTE: Confirm bulb function by doing warning indicator lights test.

If light is on with engine running:

NOTE: Oil may bypass filter when cold (light should go out as oil temperature increases.

1. Stop engine.
2. Replace hydraulic filter element.

If light is still on with engine running, or is on with engine off and ignition key switch ON:

1. Check switch by disconnecting wire. Light should go out.
2. If light goes out, switch or by-pass valve is faulty.
3. If light is still on, check for short circuit in wiring.
4. If light is still on, check for problem with test switch or bridge rectifier.

Air Cleaner Warning Switch

The air cleaner warning switch is normally open (NO) and closes when the air cleaner is restricted (high vacuum).

NOTE: Confirm bulb function by doing warning indicator lights test.

If light is on with engine running:

1. Stop engine.
2. Replace or clean air filter element.

If light is still on with engine running or is on with engine off and ignition key switch ON:

1. Check switch by disconnecting wires. Light should go out.
2. If light goes out, switch is faulty.
3. If light is still on, check for short circuit in wiring.
4. If light is still on, check for problem with test switch or bridge rectifier.
Repairs

IMPORTANT: Before welding on the machine, disconnect the negative (−) battery cables from the battery and DISCONNECT THE ELECTRICAL CONNECTORS FROM THE CONTROLLER to prevent damage to the electrical system.

Battery Service

1. Unlatch hood and left hand engine side panel. Raise and prop hood open and remove left side panel.

2. Remove capscrews securing battery tray and slide tray out (Fig. 27).

IMPORTANT: To prevent damage to the electrical components, do not operate the engine with the battery cables disconnected.

Keep the terminals and entire battery case clean. To clean the battery, wash the entire case with a solution of baking soda and water. Rinse with clear water. Do not get the soda solution into the battery because damage to the battery will result. Coat the battery posts and cable connectors with skin-over grease, or petroleum jelly to prevent corrosion.

Check for loose battery hold-downs. A loose battery may crack or cause the container to wear and leak acid.

Check the electrolyte solution to make sure the level is above the plates (Fig. 28). If the level is low (but above the plates inside the battery), add water so the level is to the bottom of the cap tubes. If the level is below the plates, add water only until the plates are covered and then charge the battery. After charging, fill the battery to the proper level.

![Figure 27](image)

Electrolyte Specific Gravity

- Fully charged: 1.250 - 1.280
- Discharged: less than 1.240

Battery Specifications

Two (2) BCI Group 26 SMF-5 Batteries

Each battery:
- 530 Amp Cranking Performance at 0°F (-17 °C)
- 85 min. Reserve Capacity at 80°F (27 °C)

![Figure 28](image)

**WARNING**

Do not charge a frozen battery because it can explode and cause injury. Let the battery warm to 60°F (15.5°C) before connecting to a charger.

Charge the battery in a well-ventilated place so that gases produced while charging can dissipate. Since the gases are explosive, keep open flame and electrical spark away from the battery; do not smoke. Nausea may result if the gases are inhaled. Unplug the charger from the electrical outlet before connecting or disconnecting the charger leads from the battery posts.
Fuses and Circuit Breakers

The electrical system is protected by nine 5 Amp and single 10 and 15 amp fuses located under the control panel to the operator’s right.

NOTE: It is not always possible to see if a fuse is faulty. It is recommended that you check for faulty fuses with a continuity tester, not visually.

A 40 Amp circuit breaker with reset button is also under the control panel for protection of the entire wiring circuit. The button can be pressed to reset the circuit breaker, if total loss of electrical functions occurs. However, the reason for the malfunction should first be found and corrected.

Figure 29

1. Control panel
2. Fuse block
3. Circuit breaker reset button

IMPORTANT
Use correct fuses.
Wrong fuses can cause damage to controller and void warranty.
Traction (Neutral) Switch Replacement and Adjustment

1. Remove the two wires that are connected to the traction switch (bottom of transmission) (Fig. 30).

2. Have a helper push the traction pedal down into either the FORWARD or REVERSE position; this will take the switch adjusting screw tension off of the switch. Loosen two (2) screws and remove the switch.

3. Install new switch. DO NOT over-tighten screws as the switch case could break.

NOTE: Have a helper hold the traction pedal down while installing the switch.

4. Reconnect the two wires to the new switch. Make sure that one wire is connected to the “COMMON” terminal, and one wire is connected to the “NORMALLY OPEN” terminal.

IMPORTANT: The traction switch has three (3) terminals. If the two (2) wires are not connected to the “COMMON” and “NORMALLY OPEN” (NO) terminals, the engine will be unable to start and the safety interlock circuit will not function properly.

---

1. Traction (neutral) switch
2. Adjusting screw

---

5. Coat the switch connectors with skin-over grease.

6. Check traction control neutral adjustment. (See Traction Control Neutral Adjustment in the Adjustments section of Chapter 4 - HYdraulIC SYSTEM.

7. Make sure traction pedal is neutral position. Loosen jam nut and rotate switch adjusting screw until there is a gap between head of screw and switch button.

8. Rotate adjusting screw until it contacts the switch button. Continue to rotate screw until circuit is completed (switch “clicks”). After switch clicks, rotate adjusting screw an additional 1 turn. Tighten jam nut.

9. Actuate traction pedal in both FORWARD and REVERSE to assure that switch “clicks” in both directions.
Controller Replacement

IMPORTANT: Before doing any welding on the machine, disconnect the negative (−) battery cables from the battery and DISCONNECT THE ELECTRICAL CONNECTORS FROM THE CONTROLLER to prevent damage to the electrical system.

1. Stop the engine and disconnect the negative (−) battery cables from the battery.

2. Disconnect the POWER and I/O connectors from the controller.

3. Remove nuts securing controller to frame and remove controller.

4. Install controller and secure to frame with nuts removed in step 3.

![Figure 31](image)

1. Controller

![WARNING]

To prevent possible personal injury, or damage to electrical system when installing controller, make sure POWER connector is installed correctly. If you attempt to install it upside down, the engine will immediately begin to crank, or will crank as soon as the battery cables are connected.

5. Connect I/O and POWER connectors to controller.

6. Connect battery cables.
Solenoid Valve Coil Replacement

1. Park machine on a level surface, engage parking brake, raise wing decks completely, lower front deck to ground and turn engine OFF.

2. Disconnect solenoid electrical connector.

3. Remove nut from solenoid.

4. Remove cover and solenoid coil.

5. Install new solenoid coil and secure with nut.


---

Figure 32

1. 2-speed (mow/transport solenoid)

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Figure 33

1. Front deck solenoid valve (port SV1)
2. Left wing deck solenoid valve (port SV3)
3. Right wing deck solenoid valve (port SV2)
Starter

Disassembly

Note: For models 30581 and 30582, starter repair information is included in the appropriate Mitsubishi Diesel Engine Service Manual found after chapter 3A (model 30581) or chapter 3B (model 30582).
Inspection and Repair

1. Armature

A. Testing armature for short circuits

Place the armature on a growler and slowly revolve it with a hacksaw blade held above the armature core. The hacksaw blade vibrates against the core when it is above a slot containing a shorted winding. Replace the armature if shorted.

B. Testing armature for grounded circuits

If there is continuity between the commutator and shaft (or core), the armature is grounded and should be replaced.

C. Inspecting commutator

a. Support the armature in V-blocks and measure the runout of commutator with a dial gauge. If the runout exceeds the Repair limit, repair the commutator by turning it in a lathe within the Service limit for the outside diameter. If the commutator surface is rough, smooth it with a sandpaper of 300 to 500 grit.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Repair limit</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commutator runout</td>
<td>0.03 (0.0012)</td>
<td>0.05 (0.0020)</td>
<td>0.05 (0.0020)</td>
</tr>
</tbody>
</table>

b. Measure the outside diameter of commutator. If it is smaller than the Service limit, replace the armature.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside diameter of commutator</td>
<td>32 (1.26)</td>
<td>31 (1.22)</td>
</tr>
</tbody>
</table>
c. Measure the depth of each mica between segments with a depth gauge. If the depth exceeds the Repair limit, recondition the mica.

<table>
<thead>
<tr>
<th>Item</th>
<th>Repair limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commutator mica depth</td>
<td>0.2 (0.008), maximum</td>
</tr>
</tbody>
</table>

Unit: mm (in.)

2. Field coil

A. Testing for open circuits

If there is not continuity between the lead wire and positive (+) brush, the field coil is open and the yoke assembly should be replaced.

B. Testing for grounded circuits

If there is continuity between the yoke and positive (+) brush, check the insulation and repair or replace the yoke assembly.

3. Brushes and holders

A. Wear of brushes

Measure the brush length and, if it is less than the Service limit, replace the brushes. If the brushes are unevenly worn or rough, recondition them with a sandpaper of 300 to 500 grit.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brush length</td>
<td>18 (0.71)</td>
<td>11 (0.43)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)
B. Brush spring tension

Test the spring tension (test force) using a new brush. In this test, read the load at the moment that the spring moves off the brush. If the tension is below the Service limit, replace the spring.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brush spring tension</td>
<td>3.5 (0.138)</td>
<td>2.3 (0.091)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)

Figure 43

C. Testing brush holders for insulation

If there is continuity between the positive (+) brush holder and negative (-) holder plate, replace the brush holder assembly.

Figure 44

4. Overrunning Clutch

Make sure that the pinion shaft turns smoothly when turned in the direction of driving (clockwise) and that it locks when turned in the opposite direction. If not, replace the overrunning clutch.

Figure 45
5. Pinion thrust gap

The pinion thrust gap is the play exhibited by the pinion shaft when it is moved in the thrust direction. Measure the thrust gap in the following manner. If it is out of specification, select the adjusting washer and adjust the gap.

A. When the pinion is removed:

Install the gear on the pinion shaft. Insert the shaft into the center bracket and lock the shaft with the washer and ring. Under this condition, move the shaft in the axial direction and measure the thrust gap.

B. When the pinion is installed:

Install the pinion shaft and gear between the front and center brackets and temporarily tighten the bolt. Under this condition, move the shaft in the axial direction and measure the thrust gap.

Unit: mm (in.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinion thrust gap</td>
<td>0.5 (0.020), maximum</td>
</tr>
<tr>
<td></td>
<td>[Below 0 not permissible]</td>
</tr>
</tbody>
</table>
Reassembling sequence

17 → 16 → 15 → 11 → 12 → 14 → 10 → 13 → 9 → 8 → 7 → 6 → 5 → 4 → 3 → 2 → 1

Inspection and testing after reassembly

1. Pinion gap adjustment

A. If the assembled starter is wired as shown, the pinion will shift and turn slowly. Remove the connector from the M terminal to stop the pinion.

B. Under this condition, lightly push in the pinion toward the armature and measure the movement (gap) of the pinion.

C. To adjust the gap, increase or decrease the packing fitted to the magnetic switch. Increasing the packing decreases the pinion gap.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinion gap</td>
<td>0.5 – 2.0 (0.025 – 0.079)</td>
</tr>
</tbody>
</table>
IMPORTANT: Do not test the starter continuously for more than 20 seconds or the switch coil will overheat.

2. No-load test

After adjusting the pinion gap, hook up the starter as shown and test it for no-load characteristics.

NOTE: Use wires as thick as possible and tighten each terminal securely.

<table>
<thead>
<tr>
<th>Voltage (V)</th>
<th>Current (A)</th>
<th>Speed (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>130, maximum</td>
<td>4000</td>
</tr>
</tbody>
</table>

3. Magnetic switch

A. Testing coil for open circuits

If there is no continuity between S and M terminals and between S terminal and body (ground), replace the switch.

B. Inspecting contacts for continuity.

If there is continuity between M and B terminals, replace the switch.

C. Inspecting contacts for poor contact action

Inspect for voltage drop. If voltage drop is excessive, the contacts are damaged.
Alternator
Disassembly

Figure 53
1. Screw
2. Nut
3. Pulley (with fan)
4. Spacer
5. Rotor
6. Bearing
7. Screw
8. Bearing
9. Front bracket
10. Stator
11. Brush holder set
12. Rectifier assembly
13. Plate
14. Rear bracket

Note: For models 30581 and 30582, starter repair information is included in Chapter 8 - Electrical System (S/N 30101 & Up) and in the Mitsubishi Diesel Engine Service Manual found after chapter 3A (model 30581).

Inspection and Repair

1. Brushes

Replace the brushes if they are worn down to the wear limit line.

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brush length</td>
<td>18 (0.71)</td>
<td>8 (0.31)</td>
</tr>
</tbody>
</table>

Unit: mm (in.)

Figure 54
2. Field coil

Measure the resistance between the slip rings. If the resistance is out of specification, replace the rotor.

Figure 55

3. Stator coil

Inspect for continuity between the lead wires. If no continuity is noted, the coil is open-circuited. Also check for continuity between the lead wire and coil. If any continuity is noted, the coil is grounded.

Figure 56

4. Rectifier

Inspect the resistance between the lead wire and heat sink on each diode by connecting the positive (+) side lead wire and negative (-) side lead wire of the tester to the diode. If the resistance is infinite in both cases, the diode is open-circuited. If it is nearly zero in both cases, the diode is short-circuited. If the diode is open- or short-circuited, replace the rectifier.

Figure 57
Reassembly

Reassembling sequence

14→13→12→11→10→9→8→7→6→5→4→3→2→1

Push the brush into the holder, and hold it there by inserting a 2 mm (0.08 in.) diameter wire into the hole in the brush. Then install the rotor. Remove the wire after installing the rotor.
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</tbody>
</table>

See Chapter 4 - Hydraulic System for information about the steering hydraulic pump, steering control unit and hydraulic steering cylinders.
Specifications

**Planetary Wheel Drive Weight:** Approx. 95 lb.

**Planetary Wheel Drive Oil Capacity:** Fill to bottom of check/drain plug hole when check/drain plug is at either 3 or 9 o’clock position (Fig. 1).

**Planetary Wheel Drive Lubricant:** API GL-5, SAE 80W or 90W Gear Lubricant.

**Brake System:** Enclosed, multiple hydraulic disc service brakes operated by right foot pedal. Mechanical steering brakes with two pedals which lock together for parking brake function. Dynamic braking through closed-loop hydrostatic drive system.

**Brake Fluid:** DOT 3 hydraulic brake fluid. Check and add fluid at master cylinder reservoir (Fig. 2).

**Rear Wheel Toe-in:** 0.00 to 0.12 in. toe-in (wheels in straight ahead position).

**Front Wheel Lug Nut Torque:** 60 - 70 ft-lb.

**Rear Wheel Lug Nut Torque:** 30 - 35 ft-lb.

**Tire Pressure:**
Normal mowing conditions – 15 psi front; 13 psi rear.
Wet and/or soft conditions – 12 psi front; 9 psi rear.
Dry and/or hard conditions – 18 psi front and rear.

**IMPORTANT:** Do not operate in HIGH RANGE for extended periods when tire pressure is less than 20 psi because tires may be damaged.
Disengage Planetary Wheel Drive For Towing

In an emergency, the Groundsmaster 580-D can be moved by unlocking the front wheel hubs and towing the machine.

⚠️ DANGER

There is no effective braking of the machine with the wheel hubs disengaged. Machine will roll with front wheel hubs disengaged unless machine is on a level surface or wheels are blocked. Do not unlock the wheel hubs without either blocking the wheels or connecting the machine to a towing vehicle with a rigid towing device.

NOTE: The machine can also be moved slowly a short distance by opening the by-pass valve on the variable displacement hydraulic pump and pushing or towing the machine (See Pushing or Towing in the General Information section of Chapter 4 - Hydraulic System).

1. Block the wheels or connect the machine to a towing vehicle with a rigid towing device.

2. Remove bolts securing disengage covers to both front wheel hubs (Fig. 3).

3. Install disengage covers so dimple on cover is facing in towards hub. Wheel hubs are now unlocked.

4. Lock the wheel hubs immediately after towing is completed. Remove disengage covers and reinstall so dimple on cover is facing away from hub.

⚠️ CAUTION

Do not remove wheel blocks or towing devices until wheel hubs are securely locked.
Bleeding Service Brakes

If service brake pedal bottoms out or loses solid feel, bleed brakes.

1. Fill master cylinder with fluid (Fig. 2). Push brake pedal with short strokes until bubbling stops inside master cylinder reservoir (Fig. 4).

2. Install a hose on right hand bleed screw (Fig. 5). Bleed screw is on wheel brake actuator. Have open end of hose submerged in a glass container of clean brake fluid.

3. Loosen bleed screw. Depress brake pedal so brake fluid flows out of bleed screw, through hose and into container. Continue pushing brake pedal and adding brake fluid to master cylinder reservoir until bubbling stops in container at bleed screw. Tighten bleed screw as pedal is depressed.

4. Repeat steps 2 and 3 for left hand bleed screw. Pedal should then have a solid feel, and pedal travel should not exceed 3 inches.

NOTE: To flush the system, continue bleeding at each actuator and adding fluid to master cylinder reservoir until old fluid is replaced by new fluid.

5. After bleeding is completed, make sure master cylinder reservoir is filled and cover is secured in place.
Adjustments

Service Brake Adjustment

Adjust the service brakes when there is excessive “free travel” that is not caused by air in the system (Fig. 6). Free travel is the distance the brake pedal moves before braking resistance is felt.

Excessive free travel could also indicate that brake disks require replacement. Service brake actuators must be adjusted again after brake disks are replaced.

1. To reduce free travel of service brake pedal, adjust service brake actuators:

   A. Use a 3/8 in. drive 9/16 in. deep well socket wrench to tighten adjusting nut on end of actuator until brakes are tight (Fig. 7).
   
   B. Put a mark on the socket so you can count the number of rotations. Loosen the adjusting nut three (3) complete turns.
   
   C. Repeat steps A and B for the actuator at the other wheel brake.
   
   D. Check steering/parking brake pedal free play and adjust if there is more than one (1) in. of “free travel”. Free travel is the distance the brake pedal moves before braking resistance is felt. (See Steering/Parking Brake Adjustment in this section of the book.)

2. Adjust service brake pedal (Fig. 8).

   A. Remove cotter pin and clevis pin to disengage clevis from brake pedal.
   
   B. Loosen jam nut on clevis. With brake pedal completely raised, turn brake rod until clevis pin just slips through hole in brake pedal, then turn clevis one turn clockwise on brake rod.
   
   C. Connect clevis to brake pedal with clevis pin and cotter pin. Tighten jam nut.
   
   D. Adjust switch, so that switch opens when pedal is pushed down 0.50 ± 0.25 in.
Steering/Parking Brake Adjustment

Adjust the brakes when there is more than one (1) in. of "free travel". Free travel is the distance the brake pedal moves before braking resistance is felt (Fig. 9).

If the cable reaches the end of its adjustment range, or the brakes become ineffective, the brake disks require replacement. Brake pedals must be adjusted again after brake disks are replaced.

1. Disengage the lock arm from the left brake pedal so both pedals operate independently.

2. To reduce free travel of brake pedals, tighten the brakes:

   A. Remove cover from front of steering tower.

   B. Loosen top jam nut on threaded end of brake cable (Fig. 10).

   C. Tighten bottom jam nut to move cable down until brake pedals have 1/2 to 1 in. of free travel.

   D. Tighten top jam nut after brakes are adjusted correctly.

---

**Figure 9**

**Figure 10**

1. Jam nuts
Rear Wheel Toe-in Adjustment

1. Put rear wheels in straight ahead position.

2. Measure center-to-center distance (at axle height) at front and rear of steering tires (Fig. 11). Front measurement should be 0 to 0.12 in. less than rear measurement.

3. If adjustment is required, loosen tie rod clamps (Fig. 12).

4. Turn tie rod to get 0.00 to 0.12 in. toe-in (measured at front of tires). Measurement must be taken at the same height from the ground both front and rear.

5. After adjusting, slots in tie rod and clamps should face down.

6. Tighten clamps.
Steering Cylinder Adjustment

NOTE: Adjust toe-in before adjusting steering cylinder ball joints (See Rear Wheel Toe-in Adjustment).

Ball joint must be located on cylinder shaft so that steering arms hit stops in either direction (Fig. 13).

1. If adjustment is required, loosen clamp (Fig. 14).

2. Turn cylinder shaft so steering arm hits stop on rear axle before cylinder shaft is fully retracted.

3. Tighten clamp.

Figure 13

1. Steering arm
2. Steering stop

Figure 14

1. Clamp
2. Ball joint
3. Cylinder shaft
Rear Wheel Bearing Adjustment

1. Jack up rear of machine until wheel is off floor. Support machine with jack stands or blocks to prevent it from falling.

2. Remove dust cap from end of wheel spindle. Remove cotter pin retaining slotted nut in place (Fig. 15).

3. Rotate wheel by hand and tighten slotted nut until bearing binds SLIGHTLY. Then, loosen nut until nearest slot and hole in spindle are aligned. Reinstall cotter pin to retain slotted nut in place.

4. Remove jack stands or blocks and lower machine to floor. Put a coating of grease on inside of dust cap. Install dust cap on end of wheel spindle.

Rear Axle Pivot Adjustment

Tighten nut to eliminate any axial movement of rear axle while still allowing free rotation (Fig. 16).
Reparaciones

Servicio de Cargador trasero de Eje

1. Elevar la parte trasera del equipo hasta que el neumático esté fuera del suelo. Soporte el equipo con soportes de palanca o bloques para prevenir que caiga.

2. Retire la tapa de polvo del final del eje de la polea (Fig. 17).

3. Retire la cebolla, el perno de retención y la arandela. Deslice la polea fuera del eje de la polea.

4. Retire la tapa de la polea.

5. Retire las conos de ambos lados de la polea. Lave las bolas en solvente. Asegúrese de que los conos estén en buenas condiciones de funcionamiento. Lave el interior de la polea. Verifique las bolas para ver si tienen ralladuras, arañazos u otros daños notables. Reemplace las partes dañadas.

6. Si los conos fueron retirados de la polea, presionelos hacia el interior hasta que lleguen al soporte.

7. Sumeel bolas con grasa. Use el grasa No. 2 de propósito general de base de litio con aditivo E.P. Instale una bolla en un compartimiento de rodillos del lado inalámbrico de la polea. Lubrique el interior de la nueva tapa de lip para luego presionarla hacia la polea.

**IMPORTANTE**: La tapa de lip debe ser presionada de manera que esté alineada con el final del eje. La parte superior de la tapa de lip debe estar orientada hacia el cojinete.

8. Sumeel interior de la polea con grasa (no al nivel completo). Instale el cono de reparación hacia el interior del eje de la polea.

9. Deslice el eje de la polea sobre el eje de la polea y asegúrelo en su lugar con una arandela y un perno de retención. NO apriete el perno de retención.

10. Ajuste la preajustación en los cojinetes. (Vea Regulación de la preajustación del cargador trasero en la sección "Ajustes" de este capítulo.)
Planetary Wheel Drive Removal and Installation

1. Loosen wheel lug nuts (Fig. 18).

2. Jack up machine and support with jack stands of proper capacity.

3. Remove wheel lug nuts and remove wheel.

NOTE: Put a drain pan below planetary wheel drive to catch oil. If oil has not been drained, approximately 8 oz. of oil will drain out as wheel drive is pulled away from hydraulic motor coupling.

4. Remove eight (8) capscrews and lockwashers securing planetary wheel drive to brake housing (Fig. 19). Pull wheel drive out approximately 1/2 in. and allow oil to drain out.

5. Remove planetary wheel drive (Fig. 20).

6. Before installing planetary wheel drive make sure o-ring is installed on brake housing cap. Replace o-ring if damaged.

7. Reverse steps 1 - 4 to install planetary wheel drive. Install so breather is up. It will be necessary to rotate wheel drive when installing to align splines on input shaft with hydraulic motor coupling.

8. Tighten wheel lug nuts in a crossing pattern to a torque of 60 - 70 ft-lb.

9. Check planetary wheel drive oil level and add correct oil as necessary.
Planetary Wheel Drive Disassembly

1. Put assembly upright on face of spindle (Fig. 21, Item 3).

2. Remove two (2) bolts (Item 14) and remove disengage cover (Item 18).

3. Remove eight (8) bolts (Item 17) and remove large cover (Item 19). Plunger (Item 22) usually remains with cover. Remove plunger and O-ring (Item 21) from cover on end of input shaft (Item 2).

4. A thrust washer (Item 23) will usually remain in position on thrust face of cover.

5. Remove sun gear (Item 13) and thrust washer (Item 12) from end of input shaft.

6. Remove primary carrier (Item 15).

NOTE: Primary and secondary carrier assemblies must be replaced as complete assemblies. Individual parts are not serviceable.

7. Remove secondary carrier assembly (Item 20). It may be necessary to remove the ring gear (Item 24) first, if difficulty is encountered in removing the carrier.

8. Remove input shaft (Item 2) from spindle (Item 3). Remove the retaining rings, washers and spring from input shaft only if replacement is required.

9. Remove six (6) bolts (Item 10) from hub and ring gear and remove ring gear (Item 24). It may be necessary to strike ring gear with a rubber mallet to loosen from hub.

10. Use a snap ring expander to remove large retaining ring (Item 28) from in front of tapered bearing. Lift hub (Item 8) from spindle. If bearings are not a loose fit, it may be necessary to press spindle from hub.

11. Remove oil seal (Item 4) and bearing cones (Items 5 and 9) from hub. Inspect bearing cups (Item 6) in position and remove only if replacement is required.
Planetary Wheel Drive Assembly

1. Press a new bearing cup (Item 6) in each side of hub (Item 8).

2. Assemble a bearing cone (Item 5) into cup (Item 6) at seal end of hub and press a new seal (Item 4) into hub.

3. Put spindle (Item 3) upright on bench. Lubricate lips of seal (Item 4) and lower hub onto spindle. Hub (Item 8) should be centered as it is lowered over spindle to prevent seal damage.

4. Assemble bearing cone (Item 9) over spindle and into bearing cup (Item 6). Select the thickest retaining ring (Item 28) that can be assembled into ring groove of spindle shaft above bearing cone. Bearing should have from 0.000 - 0.006 in. end play when proper retaining ring is installed.

5. Assemble a retaining ring (Item 25) in groove opposite pilot end of input shaft (Item 2). Assemble a washer (Item 26), spring (Item 27), a second washer (Item 26) and a second retaining ring (Item 25) in the middle groove of input shaft.

6. Assemble the splined end of the input shaft down into spindle.

7. Assemble secondary carrier splines over splined end of spindle.

8. Apply a bead of RTV compound to hub face that mates with ring gear (Item 24). Apply RTV compound in a continuous bead, which is centered on mating surface and goes around inside of each bolt hole. Assemble the end of ring gear having six (6) bolt holes against hub with bolt holes of hub and ring gear aligned. Install six (6) bolts and tighten to a torque of 39 - 49 ft-lb. If grade 8 bolts are used, the bolts should be tightened to a torque of 52 - 60 ft-lb.

9. Assemble the primary carrier and sun gear into ring gear. It will be necessary to rotate carrier and pinion to align sun gear teeth with secondary pinion and primary pinions with ring gear teeth. Assemble the small sun gear (Item 13) over input shaft. Rotate sun gear to align shaft to gear splines and gear teeth.

10. Assemble the small thrust washer (Item 12) over input shaft and against shoulder of shaft.

11. Install an o-ring (Item 21) in groove of the disengage plunger (Item 22). Assemble plunger over end of input shaft and against thrust washer.

12. Lubricate the o-ring in groove of engage plunger. Assemble the thrust washer (Item 23) with tangs engaged with cover (Item 19). Apply a bead of RTV compound to end face of ring gear. Apply RTV compound in a continuous bead, which is centered on mating surface and goes around inside of each bolt hole. Assemble cover over plunger as holes of cover and ring gear are aligned. Install the eight (8) bolts (Item 17) and tighten to a torque of 20 - 25 ft-lb.

13. Assemble the disengage cover (Item 18) with dimpled center facing out. Install the two (2) bolts (Item 14) and tighten to a torque 10 - 20 ft-lb.
Wheel Brake Service

1. Remove planetary wheel drive. (See Planetary Wheel Drive Removal and Installation in this Chapter.)

2. Remove four (4) capscrews and lock washers from brake housing cap (Fig. 22).

3. Remove brake housing cap and outer brake disc (Fig. 23).

4. Remove four (4) capscrews and remove cover from brake actuator housing (Fig. 23).

5. Remove cotter key and clevis pin to disconnect brake cable clevis (Fig. 24).
6. Remove brake actuating disc assembly and inner brake disc (Fig. 25).

7. Inspect brake actuating disc assembly for proper operation and repair as necessary (Fig. 26).

8. Inspect braking surface of brake housing (Fig. 25) and brake housing cap (Fig. 23). Replace parts as necessary.

9. Oil leakage from planetary wheel drive in area of inner brake disc, may indicate that oil seal in brake housing cap requires replacement or wheel motor shaft cup rings require replacement. Inspect oil seal in brake housing cap and replace if necessary (Fig. 26). Inspect cup rings on hydraulic wheel motor shaft and replace if necessary. (See Wheel Motor Shaft Cup Ring Service in this section of the book.)

10. Reverse steps 1 - 6 to install new brake discs and assemble wheel brakes.

11. Adjust the brakes. (See Service Brake Adjustment and Steering/Parking Brake Adjustment in the Adjustments section of this chapter.)

Figure 25

Figure 26
1. Wheel & tire  6. Oil seal  11. Actuating disk assembly
5. Bearing 10. Disc (2) 15. Hydraulic wheel motor
Brake Housing Removal

1. Do steps 1 - 6 under Wheel Brake Service.

2. Remove four allen head capscrews to disconnect brake actuator housing from brake housing (Fig. 27). Be careful not to damage the brake tube line when moving the brake actuator housing away from the brake housing.

NOTE: Removing one of the allen head capscrews will require the use of a special tool. This tool can be made by cutting off a short section of allen wrench. Insert the short piece of allen wrench into the capscrew head and remove the capscrew by turning the short section of allen wrench with a combination wrench.

3. Remove two (2) capscrews, lockwashers and flat washers securing hydraulic wheel motor to brake housing (Fig. 26).

4. Remove two (2) capscrews and lockwashers securing brake housing to frame. Remove brake housing (Fig. 28).

5. Reverse steps 1 - 4 to install brake housing.

Wheel Motor Shaft Cup Ring Service

If there is oil leakage from planetary wheel drive in area of inner brake disc, wheel motor shaft cup rings may require replacement.

1. Do steps 1 - 8 under Wheel Brake Service.

2. Remove cup rings from motor shaft (Fig. 29).

3. Apply a coating of hydraulic oil to new cup rings before installing. Install new cup rings on motor shaft with lips facing the motor.

IMPORTANT: Put a seal protector on motor shaft or apply tape on the shaft before installing cup rings. Be careful to prevent shaft spline from damaging the new cup rings.

4. Reverse steps 1 - 8 to install new brake discs and assemble wheel brakes.
Brake Actuator Seal Replacement

1. Loosen wheel lug nuts (Fig. 18). Jack up machine and support with jack stands of proper capacity. Remove wheel lug nuts and remove wheel.

2. Remove service brake adjusting nut (Fig. 7).

3. Disconnect brake tube line from fitting on actuator (Fig. 27).

4. Remove cotter key and clevis pin to disconnect brake actuator end yoke (Fig. 24).

5. Loosen four (4) long capscrews securing actuator to actuator housing. Remove actuator and end yoke from brake actuator housing.

6. Remove end yoke and collar from actuator.

7. There is spring pressure against the retaining ring (Fig. 30). Use a socket tool to push in flat washer and remove retaining ring.

8. Remove flat washer and spring. Pull piston out.

9. Remove packing and back-up rings from piston and housing.

10. Install new packing and back-up rings on piston and in housing as shown in Figure 30. Be careful to prevent damage to packing and back-up rings during installation.

11. Reverse steps 1 - 9 to reassemble and install brake actuator. Replace gaskets if necessary. Make sure collar is installed before installing locknut (adjusting nut) on end yoke.

12. Bleed the system and adjust the service brakes. (See Bleeding Service Brakes in the General Information section of this chapter and Service Brake Adjustment in the Adjustments section.)

---

**Figure 30**

1. Back-up ring
2. Packing
3. Bleeder screw
4. Housing
5. Packing
6. Back-up ring
7. Piston
8. Spring
9. Flat washer
10. Retaining ring
11. Seat insert
Master Cylinder Service

1. Disconnect brake line from rear of master cylinder.

2. Remove three (3) capscrews and locknuts securing master cylinder to frame. Remove master cylinder.

3. Remove rod boot (Fig. 31, Item 1).

4. The piston is held against the retaining ring by spring pressure. Use a rod to push the piston in and then remove the retaining ring.

5. Remove the piston assembly (Items 3 - 8).

NOTE: Piston assembly parts (Items 3 - 8) are not serviced separately and must be replaced as a complete assembly.

6. Reverse Steps 1 - 5 to reassemble the master cylinder.

7. Fill the master cylinder with DOT 3 brake fluid and bleed the system. (See Bleeding Service Brakes in the General Information section of this chapter.)
# Cutting Units

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## Specifications

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<tr>
<th>ITEM</th>
<th>SPECIFICATION</th>
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</thead>
<tbody>
<tr>
<td>Total cutting width</td>
<td>192 in.</td>
</tr>
<tr>
<td>Outboard unit cutting width (2)</td>
<td>57 in.</td>
</tr>
<tr>
<td>Front unit cutting width</td>
<td>92 in.</td>
</tr>
<tr>
<td>Height of cut range</td>
<td>Low range: 1 to 4 in.</td>
</tr>
<tr>
<td>Height range: 2-1/2 to 5-1/2 in.</td>
<td></td>
</tr>
<tr>
<td>Height of cut adjustment</td>
<td>1/2 in. increments</td>
</tr>
<tr>
<td>Blade bolt torque</td>
<td>140 - 165 ft-lb</td>
</tr>
<tr>
<td>Spindle bolt torque</td>
<td>140 - 160 ft-lb</td>
</tr>
<tr>
<td>Spindle end play</td>
<td>.006 max.</td>
</tr>
<tr>
<td>Spindle rolling torque</td>
<td>10 in-lb max.</td>
</tr>
<tr>
<td>Blade plane (with cutting unit leveled above measuring plane)</td>
<td>0.125 in. max.</td>
</tr>
<tr>
<td>Lowest tips (tip to tip) of adjacent blades</td>
<td>in same plane within 0.250 in.</td>
</tr>
<tr>
<td>All tips of any two adjacent blades - rotated to any position</td>
<td>in same plane within 0.375 in.</td>
</tr>
<tr>
<td>All blade tips of same cutting unit- rotated to any position</td>
<td></td>
</tr>
<tr>
<td>Tie rod spring length (outboard cutting unit break-away adjustment)</td>
<td>8.38 ± 0.12 in.</td>
</tr>
</tbody>
</table>

**NOTE:** Refer to Operator's Manual for additional information regarding Cutting Unit service procedures.
Adjustments

Height-of-Cut Adjustment

The height-of-cut is adjustable from 1 to 5-1/2 in., in 1/2 in. increments. Positioning the castor wheel axles in the top holes of the castor forks (Fig. 1) allows high range height-of-cut settings from 2-1/2 to 5-1/2 in.

1. Start engine, position the machine on a level surface, lower cutting units to a point where castor wheels can be removed from arms, set lift levers in neutral, set parking brake and shut engine off. Remove ignition key to prevent accidental start up.

2. Position castor wheel axles on all cutting units in the same hole in the castor forks (high range or low range).

3. On the front cutting unit, remove the hairpin cotter and clevis pins from the rear castor pivot arms (Fig. 2). Align the pivot arm holes with selected height-of-cut bracket holes in the cutting unit frames, insert clevis pins and install the hairpin cotters (Fig. 2).

4. On all remaining castor wheel assemblies, remove lynch pin from castor fork shafts (Fig. 3). Remove castor fork shaft and spacer assembly from the castor arm (Fig. 3). Place spacers onto castor spindle to desired height-of-cut setting and install castor fork shaft in arm (Fig. ). Install remaining spacers onto shaft and secure assemblies with the lynch pin (Fig. 3). Washers must remain on same side of castor arm before and after height-of cut change.

NOTE: Install lynch pins with wire loop facing to the rear. This will help prevent the lynch pin from catching on branches or brush and coming off (Fig. 3).
Skid Adjustment

After initial set up or if height-of-cut is changed, cutting unit skids should be adjusted. Adjust skids by loosening flange lock nuts (Fig. 4), positioning skid at specified height (see chart below) and retightening flange lock nuts.

Front Cutting Unit

All H.O.C. – Skid 3/8 in. to 1/2 in. above level surface

Outboard Cutting Units

1 in. H.O.C. – Skid all the way up
1-1/2 to 3 in. H.O.C. – Skid 1/2 to 1 in. above level surface.
1-1/2" to 3" H.O.C. – Skid all the way down.

Figure 4

1. Skid
Mismatch Adjustments

If there is a mismatch between the blades or cutting units, the grass will appear streaked or uneven when it is cut. Perform steps 1 - 5 in order as listed. DETAILED INSTRUCTIONS FOR STEPS 2, 3 AND 4 ARE LISTED ON THE NEXT PAGE.

NOTE: All measurements are from floor surface to blade tip. USE A FLAT 4 X 8 FT. SHEET OF 3/4 IN. PLYWOOD TO GET A FLAT FLOOR SURFACE.

1. Adjust all cutting units to highest height-of-cut. Position castor wheel axles in lower castor fork holes (Fig. 5, 6). On front cutting unit, reposition two rear castor’s clevis pins to highest height-of-cut setting (Fig. 5). Move all castor spacers to the underside of the castor arms (Fig. 6). Do not move washers. Leave them in their original position.

2. Check each outboard cutting unit and center section of front cutting unit for cutting BLADE mismatch (page 7-5). Adjust by adding or removing washers between spindle housing and bottom of cutting unit.

3. Check each outboard cutting unit and center section of front cutting unit for CUTTING UNIT mismatch (page 7-5). To match cutting blade height, transfer washers from one side of a castor wheel arm to the other.

4. Check for front cutting unit WING and WING BLADE mismatch (page 7-5). Adjust wings by adding or removing shims between rubber pad and bracket (Fig. 7). Adjust blades by adding or removing washers between spindle housing and bottom of cutting unit.

5. Compare BLADE HEIGHT DIMENSIONS OF ALL CUTTING UNITS. Blade heights must be within 3/8 in. of one another. If they are not, determine which cutting unit height can be changed to compensate for difference and either transfer washers from bottom to top to lower unit, or from top to bottom to raise. Transfer an equal number of washers at all castor wheel locations to keep cutting unit level - two on front unit, four on outboard units.
Cutting BLADE Mismatch

1. Lower cutting unit onto flat surface.

2. Rotate blade so ends face forward and backward. Measure from flat surface to front tip of cutting blade and record dimension. Rotate same blade so opposite end faces forward and repeat measurement. Difference between the two measurements must not exceed 1/8 in. If difference exceeds 1/8 in, the blade is bent. Replace it. Use same procedures to measure all blades.

3. Rotate blade so ends face forward and backward. Measure from flat surface to front of cutting blade and compare measurements. Maximum difference allowed between any two adjacent blades is 1/4 in. Maximum difference allowed between the highest and lowest blade measurement is 3/8 in. If measurements are not within specification, add shims between the and spindle housing; proceed to step 5. If measurements meet specification, proceed to step 4.

4. Rotate blades so ends line up with one another. Ends of adjacent blades must be within 1/8 in of each other. If ends are not within 1/8 in. of one another, add shims between spindle housing and bottom of deck; proceed to step 5.

5. Remove locknuts securing spindle housing to deck in area where shims are to be added. To lower a blade, add a shim (Part No. 3256-24), to each mounting bolt, between spindle housing and deck. Repeat step 4. Continue process until blade ends are within the required dimensions. IMPORTANT: Do not exceed three (3) shims at any hole location. If more than one (1) shim is added to any hole location, install decreased amounts of shims in adjacent holes.

CUTTING UNIT Mismatch

1. Lower cutting unit onto flat surface.

2. Rotate blade so ends face forward and backward. Measure from plywood to front end of blade and record dimension. Repeat procedure for all blades and compare measurements. All blade heights on same cutting unit should be within 1/4 in. of one another. If blade heights are within 1/4 in., proceed to step 4. If blade heights are not within 1/4 in., proceed to step 3.

3. To match blade height, transfer washers from one side of a castor wheel arm to the other. If end is to be lowered, transfer one or both washers from the underside to the top. If end is to be raised, transfer washer(s) from the top to the underside. Each washer is 1/8 in. thick. Repeat measurement of blade tip height and record new dimensions.

4. Repeat steps 1 - 2 on remaining cutting units, and step 3, if necessary. If washers are transferred on a outboard cutting unit castor arm, be sure to transfer the same number on both ends of the castor arm.

Front Cutting Unit WING and WING BLADE Mismatch

1. Lower front cutting unit onto the flat surface.

2. Rotate blades so ends face forward and backward. Measure from plywood to front end of blade and record dimension. Repeat procedure for all blades and compare measurements. Blade heights between each wing and center section should be within 1/4 in. of one another. If blade heights are within 1/4 in., proceed to step 4. If blade heights are not within 1/4 in., proceed to step 3.

3. To match blade height, between each wing and center section add or remove shim (Part No. 42-6200) between rubber pad and bracket (Fig. 9). To lower wing, remove shim. To raise wing, add shim. Each shim is 1/8 in. thick. Repeat measurement of blade tip height and record new dimensions.

4. Rotate wing blade so ends face forward and backward. Measure from flat surface to front tip of cutting blade and record dimension. Rotate same blade so opposite end faces forward and repeat measurement. Difference between the two measurements must not exceed 1/8 in. If difference exceeds 1/8 in, the blade is bent. Replace it. Use same procedures to measure other wing blade.

5. Rotate blade so ends face forward and backward. Measure from flat surface to front of cutting blade and record dimension. Repeat procedure for all blades of front cutting unit and compare measurements. Maximum difference allowed between any two adjacent blades is 1/4 in. Maximum difference allowed between the highest and lowest blade measurement is 3/8 in. If measurements are not within specification, add shims between the deck and spindle housing; proceed to step 7. If measurements meet specification, proceed to step 6.

6. Rotate blades so ends line up with one another. Ends of adjacent blades must be within 1/8 in of each other. If ends are not within 1/8 in. of one another, add shims between spindle housing and bottom of deck; proceed to step 7.

7. Remove locknuts securing spindle housing to deck in area where shims are to be added. To lower a blade, add a shim (Part No. 3256-24), to each mounting bolt, between spindle housing and deck. Repeat step 6. Continue process until blade tips are within the required dimensions. IMPORTANT: Do not exceed three (3) shims at any hole location. If more than one (1) shim is added to any hole location, install decreased amounts of shims in adjacent holes.
Belt Tension Adjustment

**IMPORTANT:** After first ten hours of operation, check new belts for proper tension; thereafter, check tension every 50 hours.

**Front Cutting Unit (S/N below 220000000)**

*Note:* Belts for wing unit spindles are tensioned by spring loaded idlers and normally do not require tensioning.

1. Position machine on level surface, lower cutting unit to shop floor, engage parking brake, shut engine off and remove key from ignition switch.
2. Remove deck covers.
3. Note position of shoulder bolts in slots in tension plate. Optimum belt tension will be maintained when the flanges on the shoulder bolts are 1/8 in. (3 mm) from the pulley ends of the slots (Fig. 9A). If the shoulder bolt flanges are more than 3/8 in. (9 mm) from the pulley end of the slots, an adjustment should be made.
4. To adjust, loosen jam nuts (Fig. 9B) and extend tension arm until the shoulder bolt flanges are within 1/8 in. (3 mm) of the pulley end of the slots (Fig. 9A).

*Note:* When the shoulder bolt flanges are positioned 1/8 in. (3 mm) from the pulley end of the slots, the length of the compression spring (Fig. 8) will be approximately 5 in. (127 mm).
5. Tighten jam nuts to secure adjustment. Install deck covers.

**Front Cutting Unit (S/N 220000001 and above) (Fig. 9C)**

1. Position machine on level surface, lower cutting unit to shop floor, engage parking brake, stop engine and remove key from ignition switch.
2. Remove deck covers.
3. Loosen jam nut and relieve tension on springs with tensioner bolt.
4. Loosen four (4) cap screws securing slide plate to motor mount.
5. Tighten tensioner bolt until springs are compressed to dimension shown in Figure 9C.
6. Tighten jam nut to secure adjustment.
7. Tighten four (4) cap screws securing slide plate to motor mount.
8. Install deck covers.
Outboard Cutting Units

1. Remove deck covers. To check belt tension, apply 8 lb. (35.5 N) force at mid-span of belt and check deflection. There should be approximately 5/16 in. (7.9 mm) deflection. If deflection is incorrect, proceed to step 2. If deflection is correct, proceed to step 3.

2. To tension belts, loosen flange locknut at top of idler pulley (Fig. 10). Slide pulley against belt until proper tension is reached. Hold pulley in position and tighten locknut.

3. Install deck covers.

---

Front Cutting Unit Lift Arm Ball Joint Adjustment

Ball joint must be threaded into each lift arm so there is a distance of 2 in. (50.8 mm) from end of lift arm to center line of ball joint (Fig. 11). Tighten jam nut on ball joint against end of lift arm.
Outboard Cutting Unit Tie Rod Adjustment

Outer lift arm of outboard cutting unit must rest on rubber pad when in raised position.

1. Raise outboard cutting unit so inner lift arm rests on rubber pad (Fig. 12).

2. Loosen jam nuts and adjust tie rod (Fig. 12a) until outer lift arm, contacts rubber pad (Fig. 12). Tie rod assembly must be rotated so that rollers face hydraulic hoses when lift arms are raised. Tighten jam nuts.

Outboard Cutting Unit Spring (Break-away) Adjustment

Loosen jam nut and tighten adjusting nut so spring is 8.38 ± 0.12 in. long (Fig. 13). Hold adjusting nut and tighten jam nut.
Blade Service

Note: Although not needed for normal maintenance procedures, the front cutting unit can be pivoted (tilted) to a fully upright position (Fig. 14).

To Pivot (Tilt) Cutting Unit Upright:

1. Position front cutting unit so rear castor wheels just clear the floor, set parking brake and shut engine off.

2. Remove cutting unit tilt link from tool box under traction unit floor. Remove klik pins from weldments on traction unit frame and cutting unit lift arm.

3. Remove hairpin cotters and clevis pins from the two (2) rear castor assemblies (Fig. 15). Set the left hand clevis pin aside and insert the right hand clevis pin into the most forward holes in the castor wheel arm on the right side of the unit (Fig. 16). The castor arm and pin should be resting on top of the unit.

4. Sit on seat, start the engine and raise the cutting unit to the full up position so the spring latch on the left lift arm disengages from the cutting unit. Stop the engine and remove the key from the ignition switch.

5. Fit cutting unit tilt link over weldment on the right side of traction unit and secure with klik pin. Position link so it clears when cutting unit is raised. Keep remaining klik pin handy to secure opposite end of link to cutting unit arm weldment (Fig 16).

6. Use at least one other person to tilt the cutting unit. Grasp the front of the unit and lift it to an upright position (Fig 14).

7. Hold the unit upright, fit link end over pin on cutting unit lift arm weldment and secure with klik pin.

CAUTION

The cutting unit is too heavy for one person to pivot up or down. Use at least one other person to assist in lifting or lowering the unit. Always use proper lifting techniques and hold unit securely when pivoting it up or down.

Note: If machine is equipped with a cab enclosure, take care when pivoting front cutting unit to prevent deck motor from contacting cab windshield.
To Pivot Cutting Unit down into Operating Position:

1. With the help of an assistant, hold the unit upright, remove the klik pin securing the link end and remove link end from the weldment.

2. Pivot (tilt) the cutting unit downward.

3. Sit on seat, start engine and lower the cutting unit so castor wheels just clear the floor.

4. Remove the height-of-cut pin from the right castor wheel arm. Insert it and the left height-of-cut pin in the proper height-of-cut holes in the castor arms and cutting unit.

Blade Bolt Torque

Check blade bolt torque daily or after blade strikes a solid object. However, if solid object causes blade to be damaged or bent, replace it; refer to Removing Cutting Unit Blade, below.

1. Raise cutting units to transport position, engage parking brake, shut engine off and remove key from ignition switch.

2. Hold blade with a thickly padded glove or rag. Use a torque wrench to tighten blade bolts on all cutting units to a torque of 140 - 165 ft-lb.

Removing Cutting Unit Blade

Replace the blade if a solid object is hit, the blade is out of balance or bent. Always use genuine TORO replacement blades to ensure safety and optimum performance. Never use blades made by other manufacturers because they could be dangerous.

⚠️ CAUTION

Do not try to straighten a bent blade. Never weld a broken or cracked blade. Always use a new TORO blade to assure continued safety certification of the product.

1. Raise cutting unit to transport position, engage parking brake, shut the engine off and remove key from ignition.

2. Using a rag or thickly padded glove, grasp end of blade. Remove blade bolt, lockwasher, anti-scalp cup and blade from spindle assembly (Fig. 17).

3. When re-assembling, make sure blade sail is facing up. Torque the blade bolt to 140-165 ft-lb.

Figure 17

1. Cutting blade
2. Blade bolt and lockwasher
3. Anti - scalp cup
4. Carriage bolt and flange locknut (6)
Inspecting and Sharpening Blade

1. Raise cutting units to transport position, engage parking brake, shut engine off and remove key from ignition switch.

2. Carefully examine cutting ends of the blade, especially where the flat and sail (curved part) meet (Fig. 18). Since sand and abrasive material can wear the metal connecting the flat and sail portions, check the blade before using the machine. If wear is noticed (Fig. 18), replace the blade.

⚠️ CAUTION

If the blade is allowed to wear, a slot will form between the sail and flat part of the blade (Fig. 18). Part of the blade may eventually break off and be thrown from under the housing, possibly resulting in serious injury to yourself or bystanders.

3. Examine cutting edges of all blades. Sharpen cutting edges that are dull or nicked. To assure sharpness, sharpen only the top side of the cutting edge while maintaining the original cutting angle (Fig. 19). If the same amount of metal is removed from both cutting edges, the blade will remain balanced.

4. To check blade for being straight and parallel, remove from cutting unit. Lay blade on level surface and check its ends. Blade ends must be slightly lower than blade center and cutting edge lower than heel to the blade. If so, it will produce good quality-of-cut and require minimal engine power to turn. By contrast, a blade with ends higher than blade center, or with cutting edge higher than the blade heel, is warped or bent and must be replaced.

5. When re-assembling, make sure blade sail is facing up. Torque the blade to 140-165 ft-lb.
Belt Replacement

**Front Cutting Unit (S/N below 220000000)**

1. Position machine on level surface, lower cutting unit to shop floor, engage parking brake, shut engine off and remove key from ignition switch.

*Note:* Wing spindle drive belts must be removed before removing center section belt.

2. Remove belt covers. Lift each wing to release idler pulley tension and slip belt off pulleys (Fig. 20).

3. Loosen jam nuts securing tension arm until compression spring on idler assembly is relaxed (Fig. 21).

4. Remove flange head screws securing gearbox plate and separate plate and drive motor assembly from the cutting unit (Fig. 20). Be careful not to bend, twist, kink or damage flexible hydraulic lines.

5. Remove old belt. Position new belt in pulleys and assemble gear box and plate assembly to cutting unit.

6. Adjust belt tension (See Belt Tension Adjustment in the Adjustments section of this chapter).

7. Install wing drive belts. Lift wings to allow belts to slip over outer drive spindle pulleys and install belt covers.

**Front Cutting Unit (S/N 220000001 and above) (Fig. 21A)**

1. Position machine on level surface, lower cutting unit to shop floor, engage parking brake, stop engine and remove key from ignition switch.

*Note:* Wing spindle drive belts must be removed before removing center section belt.

2. Remove belt covers. Lift each wing to release idler pulley tension and slip belt off pulleys.

3. Loosen jam nut and relieve tension on springs with tensioner bolt.

4. Loosen four (4) capscrews securing slide plate to motor mount.

*Note:* Do not loosen motor mount adjusting screws during belt replacement.

5. Remove four (4) capscrews securing motor mount to cutting deck. Position motor mount to allow belt removal taking care not to bend, twist, kink or damage flexible hydraulic lines.

6. Replace belt(s) as required. Install belts on pulleys as shown in Figure 21B.

7. Position motor mount onto deck while routing belt around drive pulley. Be careful not to bend, twist, kink or damage flexible hydraulic lines.

8. Secure motor mount to cutting deck with four (4) capscrews.
9. Check and adjust the drive pulley height as follows:
   A. Slide the height gauge under the drive pulley (not under the hub).
   B. Loosen jam nuts on three (3) motor mount adjusting screws. Equally tighten or loosen adjusting screws until bottom of pulley rests on height gauge (approximately 1 1/2 in. (38.1 mm)).
   C. Tighten jam nuts to secure adjustment. Remove height gauge.

10. Adjust belt tension (See Belt Tension Adjustment in the Adjustments section of this chapter).

11. Tighten four (4) cap screws securing slide plate to motor mount.

12. Check distance between idler arm and idler stop screw (Fig. 21C). Distance should be approximately .380 in. (9.7 mm). If necessary, adjust as follows:
   A. Loosen jam nuts on idler stop screw.
   B. Adjust stop screw until distance between idler arm and idler stop screw is approximately .380 in. (9.7 mm).
   C. Tighten jam nuts to secure adjustment.

13. Install deck covers.

**Outboard Cutting Units**

1. Position machine on level surface, lower cutting unit to shop floor, engage parking brake, stop engine and remove key from ignition switch.

   **Note:** To remove lower belt, the other two belts must be removed first.

2. Remove deck covers. Loosen flange locknuts on idler pulleys and slide pulleys away from belts.

3. Remove flange head screws securing gearbox plate to deck. To separate plate and drive motor assembly from deck, rotate plate end toward traction unit. Tip plate, motor and pulley assembly on its side and remove from deck. Be careful not to bend, twist, kink or damage flexible hydraulic lines.

4. Remove belt(s). Position new belts in pulleys and assemble gearbox and plate assembly to deck.

5. Adjust belt tension (See Belt Tension Adjustment in the Adjustments section of this chapter).
Separating Cutting Units From Traction Unit

Front Cutting Unit

1. Position machine on level surface, lower cutting unit to shop floor, engage parking brake, shut engine off and remove key from ignition switch.

2. Remove belt covers and relieve belt tension on all belts (Fig. 23).

3. Remove flange head screws securing gearbox plate and separate plate and drive motor assembly from the cutting unit (Fig. 23). Be careful not to bend, twist, kink or damage flexible hydraulic lines.

4. Remove hex head screws and flange locknuts securing each lift arm to the castor arm and separate from the arm (Fig. 23).

5. Roll the cutting unit away from the traction unit.

6. To re-install cutting unit, assemble in reverse order.

CAUTION

If the engine is started with the front cutting unit removed, hydraulic system counterbalance pressure will cause the lift arms to raise quickly. Warn personnel to keep away from the lift arms before starting the engine.

Outboard Cutting Units

1. Position machine on level surface, lower cutting unit to shop floor, engage parking brake, shut engine off and remove key from ignition switch.

2. Remove belt covers. Relieve tension for belt on hydraulic motor pulley (Fig. 24).

3. Remove flange head screws securing gearbox plate to cutting unit. To separate plate and drive motor assembly from cutting unit, rotate front end of plate toward traction unit (Fig. 26). Tip plate, motor and pulley assembly on its side and remove from cutting unit. Be careful not to bend, twist, kink or damage flexible hydraulic lines.

4. Remove locknut securing cutting unit pivot shaft into cutting unit clevis and lift bar (Fig. 24).

5. Move the cutting unit away from the machine.

6. To re-install cutting unit, assemble in reverse order.
Spindle Service

Removing Spindle Housing Assembly

1. Lower cutting unit to ground and engage parking brake. Turn engine off and remove key from ignition switch.
2. Remove belt cover from top of spindle housing to be serviced. Loosen belt tension and remove belt from spindle.
3. Raise cutting unit to transport position, turn engine off and remove key from ignition switch. Make sure that parking brake is engaged.
4. Using a rag or thickly padded glove, grasp end of blade. Remove blade bolt, lock washer, anti-scalp cup and blade from spindle assembly.
5. Remove six (6) carriage bolts and flange nuts holding spindle housing assembly to cutting unit housing. Lift spindle housing assembly from cutting unit.

Disassembly (Fig. 25)

1. Remove lock nut and thrust washer retaining pulley on spindle shaft. Slide pulley from shaft.
2. If equipped, remove o-ring from top of spindle shaft.
3. Press the spindle shaft out of the housing using an arbor press. The spindle shaft spacer remains on the spindle shaft as the shaft is being removed.
4. Remove oil seals from spindle housing. Note position of seal lips for assembly purposes.
5. Remove the bearing cones, inner bearing spacer and spacer ring from the spindle housing.
6. Using a punch and hammer, drive both of the bearing cups out of the spindle housing. Also, drive the large spacer out of the housing.
7. The large snap ring can remain inside the spindle housing. Removal of the large snap ring is very difficult.

Assembly (Fig. 25)

Important: If new bearings will be installed into a used spindle housing that has the original large snap ring installed, discard the large snap ring that comes with the new bearing set because it is not necessary to replace the original large snap ring in the spindle housing. However, new bearings with their matched spacer set, spacer ring and large snap ring must always be installed when the spindle housing is being replaced.

NOTE: A replacement bearing set contains bearings, a matched spacer set, spacer ring and large snap ring (Fig. 26). These parts cannot be purchased separately.

1. If large snap ring was removed or if replacing the spindle housing, install large snap ring into groove in bore of spindle housing. Make sure snap ring is seated in housing groove.
2. Using an arbor press, push outer bearing spacer into top of spindle housing; tightly against snap ring. The spacer must contact the snap ring to be sure of the correct assembly of components.

3. Thoroughly oil the bearing cups. Use an arbor press to push the bearing cups into the top and bottom of the spindle housing. The top bearing cup must contact the spacer that was installed in step 2, and the bottom bearing cup must contact the snap ring. Make sure that the assembly is correct by supporting the first cup and pressing the second cup against it (Fig. 27).

4. Apply a film of grease on lips of both seals. Pack the bearing cones with grease.

5. Install bearing cone and seal into bottom of spindle housing. BOTTOM SEAL MUST HAVE THE LIP FACING OUT so old grease can be purged during spindle lubrication.

6. Slide spacer ring and inner bearing spacer into spindle housing. Install bearing cone and seal into top of spindle housing. UPPER SEAL MUST HAVE THE LIP FACING IN.

7. Check the spindle shaft to make sure it is free of burrs and nicks that could possibly cut the seals. Thoroughly lubricate the shaft and seal lips.

8. Slide spindle shaft spacer onto spindle shaft. Carefully slide spindle shaft through spindle housing. The bottom seal and spindle shaft spacer should fit together when the spindle is fully installed.

9. If equipped, position o-ring to top of spindle shaft.

10. Push pulley onto splines of spindle shaft and secure spindle assembly with thrust washer and lock nut. Tighten the lock nut from 140 to 160 ft-lb (190 to 217 N-m). Rotate the spindle shaft to be sure that the shaft rotates freely.

11. Attach a hand grease gun to grease fitting and fill cavity with grease until grease starts to come out of lower seal. NOTE: Pneumatic grease guns can cause air pockets when filling large cavities with grease and therefore, are not recommended to be used for proper greasing of spindle housings.

**Installing Spindle Housing Assembly**

1. Position spindle assembly to cutting unit. Secure the spindle assembly in place with six (6) carriage bolts and flange nuts.

2. Install the belt (see Belt Replacement in this section). Check and adjust belt tension (see Inspecting and Adjusting Cutting Unit Belt Tension in the Adjustments section).

3. Reinstall the belt covers.

4. Position blade (blade sail facing up) and anti-scalp cup to spindle shaft. Secure with lock washer and blade bolt. Torque bolt from 140 to 165 ft-lb (190 to 217 N-m).
Chapter 8
Models 30580 (S/N 30101 & Up), 30581, 30582 and 30583
Electrical System

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Note: Only new and changed information is provided in this Chapter. The Troubleshooting section of this chapter is also useful for older machines equipped with the Controller Update Kit. See Chapter 5 - Electrical System (Model 30580, S/N Below 30101) for additional electrical system information.

Note: Some wiring harness differences exist between Models 30580 (S/N 30101 and Up), 30581, 30582 and 30583. The wiring diagrams for all models are provided in Chapter 9 - Foldout Diagrams.
## CONTROLLER LOGIC GRID

**KEY:** X = CLOSED, O = OPEN, P = OUTPUT ON, M = MOMENTARILY CLOSED, B = MUST BE CLOSED ONLY IF HI TEMP SWITCH IS CLOSED.

### INPUTS

<table>
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<tr>
<th>ACTIONS</th>
<th>0 Hi Range Disengage</th>
<th>1 Parking Brake (X=OFF)</th>
<th>2 Key Run</th>
<th>3 Traction Neutral</th>
<th>4 Seat Switch</th>
<th>5 High Coolant Temp</th>
<th>6 High Temp Override</th>
<th>7 Cruise Control Enable</th>
<th>8 PTO Engage</th>
<th>9 PTO Disengage</th>
<th>10 Front Deck Down</th>
<th>11 Right Deck Down</th>
<th>12 Left Deck Down</th>
<th>13 Hi Range Engage</th>
<th>14 Hyd. Oil Level (x=ok)</th>
<th>15 Cruise Control Engage</th>
<th>16 Service Brake (x=off)</th>
<th>17 Not Used</th>
<th>Key In Start</th>
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<td>1) Start</td>
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### OUTPUTS

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<thead>
<tr>
<th>ACTIONS</th>
<th>0 Not Used</th>
<th>1 Not Used</th>
<th>2 Right Deck Engage</th>
<th>3 Left Deck Engage</th>
<th>4 Gauge Power ON</th>
<th>5 Front Deck Engage</th>
<th>6 Cruise Control Clutch</th>
<th>7 ETR Hold / Alt</th>
<th>8 Not Used</th>
<th>9 Output Fail</th>
<th>10 Harness</th>
<th>11 Not Used</th>
<th>12 Start</th>
<th>13 Hi Range Engage</th>
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<tr>
<td>1) Start</td>
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</table>
WIRING DIAGRAM: CONSOLE GAUGE PANEL

CONNECTS TO MAIN WIRE HARNESS

FUEL GAGE

BLK
WHT
YLW/RED

TEMP GAGE

BLK
WHT
YLW/RED

ENG WATER TEMP
ENG OIL PRESS
VOLT METER
HYD OIL FILTER
AIR FILTER
HYD OIL TEMP
HYD OIL LON
GAUGE CLUSTER

“PUSH TO TEST” SWITCH

“PUSH TO SILENCE” SWITCH

HOURMETER

“PUSH TO TEST” SWITCH
Special Tools

Order special tools from your Toro Distributor. Some tools may be listed in the Parts Catalog for the Groundsmaster 580-D. Some tools may also be available from a local supplier.

Digital Multimeter

The Digital Multimeter can test electrical components and circuits for current, resistance, or voltage drop. Obtain Digital Multimeter from a local supplier.

Note: Toro recommends the use of a DIGITAL multimeter when testing electrical circuits. The high impedance (internal resistance) of a digital meter will ensure that excess current is not allowed through the meter. Excess current can cause damage to a circuit that is not designed to carry it.

Inductive Ammeter (AC/DC Current Transducer - Hall Effect)

Use this tool, connected to a Digital multimeter for doing current draw tests. This tool can be useful when checking glow plug and starter circuits. Obtain Inductive Ammeter from a local supplier.

Skin-Over Grease

Special non-conductive grease which forms a light protective skin to help waterproof electrical switches and contacts.

Toro P/N 505-165
Diagnostic ACE Display

The diagnostic display is connected to the wiring harness connector located under the control panel to help the user verify correct electrical functions of the machine.

Diagnostic ACE Display, Toro P/N **85-4750**
Decal, V1.0, Toro P/N **88-1860**
(S/N Below 30101 with Controller Update Kit)
Decal, V2.0, Toro P/N **92-4087**
(S/N 30101 & Up)
**Electrical System Quick Checks**

**Battery Test (Open Circuit Test)**

Use a multimeter to measure the voltage between the battery terminals.

Set the multimeter to the DC volts setting. The battery should be at a temperature of 60° to 100° F (16° to 38° C). The ignition key should be in the OFF position and all accessories turned off. Connect the positive (+) meter lead to the positive battery post and the negative (-) meter lead to the negative battery post. Use the table to the right to determine charge level of the battery.

**NOTE:** This test provides a relative condition of the battery. Load testing of the battery will provide additional and more accurate information.

<table>
<thead>
<tr>
<th>Voltage Measured</th>
<th>Battery Charge Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.68 v (or higher)</td>
<td>Fully charged (100%)</td>
</tr>
<tr>
<td>12.45 v</td>
<td>75% charged</td>
</tr>
<tr>
<td>12.24 v</td>
<td>50% charged</td>
</tr>
<tr>
<td>12.06 v</td>
<td>25% charged</td>
</tr>
<tr>
<td>11.89 v</td>
<td>0% charged</td>
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</tbody>
</table>

**Charging System Test**

This is a simple test used to determine if the charging system is functioning. It will tell you if the charging system has an output, but not its capacity.

Use a multimeter set to the DC volts position. Connect the positive (+) meter lead to the positive battery post and the negative (-) meter lead to the negative battery post. Leave the multimeter test leads connected to the battery and record the battery voltage.

**NOTE:** Upon starting the engine, the battery voltage will drop and then should increase once the engine is running.

**NOTE:** Depending upon the condition of the battery charge and battery temperature, the charging system voltage will increase at different rates as the battery charges.

Start the engine and run at 2700 RPM (high idle). Allow the battery to charge for at least 3 minutes. Record the battery voltage.

After allowing the engine to run for at least three (3) minutes, battery voltage should be at least 0.5 volts higher than initial battery voltage (see example in table to the right).

**NOTE:** While engine is running, if battery voltage exceeds 16 volts, the regulator in the charging system should be inspected.

After allowing the engine to run for at least three (3) minutes, if battery voltage does not increase at least 0.5 volts, additional testing of the battery and/or charging system should be performed.

<table>
<thead>
<tr>
<th>Acceptable voltage increase:</th>
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</thead>
<tbody>
<tr>
<td>Initial Battery Voltage</td>
</tr>
<tr>
<td>= 12.25 v</td>
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<tr>
<td>Battery Voltage after 3 Minute Charge</td>
</tr>
<tr>
<td>= 12.80 v</td>
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<tr>
<td>Difference</td>
</tr>
<tr>
<td>= +0.55 v</td>
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</table>
Troubleshooting

For all electrical problems, use of the Quick Reference Troubleshooting Guide is recommended. Using the Diagnostic ACE Display allows you to quickly find the source of the electrical problem.

If the machine has any interlock switches bypassed, they must be reconnected for proper troubleshooting and safety.

Quick Reference Troubleshooting Guide

Diagnostic Lamp
The Groundsmaster 580-D is equipped with a diagnostic lamp that indicates if the Electronic Controller Unit (ECU) is functioning correctly. The diagnostic light will be on when the ECU is functioning correctly and the ignition switch is to the ON position. The light will flash if the ECU detects any of the following malfunctions in the electrical system:

1. An electrically “open” condition.
2. An electrically “shorted” condition.
3. There is an over temperature condition in the ECU circuitry.

Diagnostic ACE Display
The Groundsmaster 580-D is equipped with an ECU that controls most of the machine functions. The controller determines which function is required for various input switch conditions (i.e. seat switch, ignition switch, etc.) by producing various outputs to actuate solenoids or relays.

Each of the input switches, output solenoids, and relays must be connected and functioning properly for the ECU to properly control the machine.

The Diagnostic ACE display will help the user verify correct electrical functions of the machine.

Verify Input Functions

1. Park machine on a level surface, lower the cutting units, stop the engine and engage the parking brake.
2. Locate wire harness and loopback connector. Carefully unplug loopback connector from harness connector.
3. Connect Diagnostic ACE display connector to the harness connector. Make sure correct overlay decal is positioned on Diagnostic ACE display.
4. Turn ignition switch to ON; do not start machine.
**Note:** The red text on the overlay decal refers to input switches and the green text refers to output switches.

5. The Inputs Displayed LED on lower right column of the Diagnostic ACE should be lighted. If the Outputs Displayed LED is lighted, press and release Toggle Input/Output button on Diagnostic ACE to change to the Inputs Displayed LED. **Do not hold button down.**

**Note:** The Diagnostic ACE will illuminate a LED associated with each input when its associated input switch is closed.

6. Change each switch individually from open to closed (i.e., sit on seat, engage traction pedal, etc.).

   A. Observe that the appropriate LED on Diagnostic ACE blinks **on** and **off** when its corresponding switch is opened and closed. Check each switch that can be actuated by hand.

   B. Now start engine and raise and lower each cutting unit. Note the appropriate LED on the Diagnostic ACE (i.e. LED is illuminated when cutting unit is lowered and LED is not illuminated when cutting unit is raised.

7. If switch is closed and appropriate LED does not turn on, check all wiring and connections to switch and/or check switch with an ohm meter. Replace any defective switches and repair any defective wiring.

**Verify Output Function**

The Diagnostic ACE also has the ability to detect which output solenoids or relays are turned on. This is a quick way to determine if a machine malfunction is electrical or hydraulic.

1. Park machine on a level surface, lower the cutting units, stop the engine and engage the parking brake.

2. Locate wire harness and connectors near controller. Carefully unplug loopback connector from harness connector.

3. Connect the Diagnostic ACE connector to the harness connector. Make sure correct overlay decal is positioned on Diagnostic ACE.

4. Turn Ignition switch to ON; do not start machine.

**Note:** The red text on the overlay decal refers to input switches and the green text refers to output switches.

5. The Outputs Displayed LED on the lower right column of the Diagnostic ACE should be lighted. If the Inputs Displayed LED is lighted, press Toggle Input/Output button on the Diagnostic ACE to change the LED to Outputs Displayed.

**Note:** It may be necessary to toggle between Inputs Displayed and Outputs Displayed several times to do the following step. To toggle back and forth, press Toggle Input/Output button once. This may be done as often as required. **Do not hold button down.**

6. Operate desired function switch on the machine. The appropriate output LED’s should illuminate to indicate that the ECU is turning on that function.

**Note:** If any output LED is blinking, this indicates an electrical problem with that OUTPUT. Repair or replace defective electrical parts immediately. To reset a blinking LED, turn ignition switch to OFF and then back to ON.

If output LED’s are not blinking and not lighted, verify that the required input switches are in their necessary positions to allow that function to occur. Verify correct switch position or output.

If the output LED’s are on as specified with the machine not functioning properly, a non-electrical problem exits. Repair as necessary.

If each input switch is in the correct position and functioning correctly with the output LED’s not correctly lighted, an ECU problem exits. If this condition occurs, contact your Toro Distributor for assistance.

**Note:** Due to electrical system constraints, the output LED’s for “START”, “MONITOR” and “ETR/ALT” may not blink even though an electrical problem may exist for those functions. If the machine problem appears to be with one of these functions, be certain to check the electrical circuit with a volt/ohm meter to verify that no electrical problem exists to these functions.

If electronic controller experiences an output failure for either the cruise control or one of the cutting units, the controller will disable the machine function.

Indications that this is the cause of the problem include:

A. Flashing green diagnostic light.

   B. Diagnostic ACE will illuminate the “output fail” LED.

   C. Diagnostic ACE will flash which output failed.

   D. Machine will not respond to ignition key inputs.

The above indicates an ECU problem, contact your local Authorized TORO Distributor for assistance.

If each output switch is in the correct position and functioning correctly, but the output LED’s are not correctly illuminated, this indicates an ECU problem. If this occurs, contact your Toro Distributor for assistance.
Retrieving Stored Faults

**Note:** The machine may require installation of updated software for this function to operate. This required software was installed on machines starting with S/N 70001. Older machines can have new software installed. Contact your Toro Distributor for assistance.

1. Turn ignition switch to OFF. Unplug loopback connector and connect Diagnostic ACE to the ECU harness connector.
2. Move PTO switch to the ENGAGED position and hold.
3. Turn Ignition switch to ON while continuing to hold the PTO switch in the ENGAGED position until the top left light on the Diagnostic ACE comes on (approximately 2 seconds).
4. Make sure Diagnostic ACE is set to OUTPUTS.
5. Release the PTO switch.

There will be 8 records displayed. The fault is displayed on the 8th record. Each record will be displayed for 10 seconds. Records will repeat until the Ignition switch is turned to OFF. The machine will not start in this mode.

6. Observe Diagnostic ACE for the playback of the retained fault in the ECU memory. The problem circuit will be flashing.

Clearing Fault Memory

Once a fault is repaired, it must be cleared from the ECU memory so any future fault can then be stored.

1. Turn Ignition switch to OFF.
2. Move the PTO switch to the ENGAGED position and hold.
3. Depress and hold Temp Override button OR the Cruise Set button.
4. Turn Ignition switch ON while holding the PTO switch in the ENGAGED position, and keeping the High Temp Override button or Cruise Set button depressed. Maintain this condition until the green lamp on the ECU starts to flash (approximately 2 seconds).
5. Release the PTO Switch and button. Turn Ignition switch to OFF. Fault memory is now cleared.

**IMPORTANT:** The Diagnostic ACE display must not be left connected to the machine. After using the Diagnostic ACE, disconnect it from the machine and reconnect loopback connector to the harness connector. The machine will not operate without the loopback connector installed to the harness. Store Diagnostic ACE in a dry, secure location.
Component Identification and Testing

See Chapter 5 - Electrical System (S/N Below 30101) for additional Component Identification and Testing information. Only components that are different or new information is provided in this Chapter.

Electronic Control Unit (ECU)

The Toro electronic control unit (ECU) senses the condition of various switches, such as the seat switch, cutting unit down switches, traction neutral switch, etc., and directs power output to allow certain machine functions, such as engine run, cutting units engage, etc.

Because of the solid state circuitry built into the controller, there is no method to test it directly. The controller may be damaged if an attempt is made to test it with an electrical test device, such as a volt-ohm meter.

IMPORTANT: Before welding on the machine, disconnect both battery cables from the battery, disconnect both wire harness connectors from the electronic control unit and disconnect the terminal connector from the alternator to prevent damage to the electrical system.

Neutral Switch (Model 30582 and 30583)

The neutral switch on model 30582 and 30583 is closed when the traction pedal is in the neutral position. The switch threads into the mounting cover on the bottom of the hydrostat (Fig. 8).

Note: For model 30580 and model 30581 neutral switch information, refer to Traction (Neutral) Switch Testing and Traction (Neutral) Switch Replacement and Adjustment in Chapter 5.

1. Make sure the engine is off.
2. Disconnect electrical connector from the switch.
3. Check the continuity of the switch by connecting a multimeter (ohms setting) across the connector terminals.
4. With the traction pedal in the neutral position, there should be continuity between the switch terminals.
5. With the traction pedal in the forward or backward position, there should be no continuity between the switch terminals.
Seat Switch (S/N Between 30101 and 80000)

The seat switch is a proximity type, normally open (NO) reed switch that closes when the operator is on the seat. With the operator on the seat, the magnet on the bottom of the seat activates the reed switch causing it to close and complete the circuit.

1. Raise the seat to get access to the seat switch wiring connector.

2. Disconnect the seat switch wiring connector and install a continuity tester or ohm meter between the two leads of the seat switch.

3. Lower the seat. The continuity tester should show no continuity.

Note: Make sure the compression spring holds the seat up off the seat switch when there is no operator on the seat.

4. Have the operator sit on the seat, slowly depressing the seat switch magnet. The continuity tester should show continuity as the seat approaches the bottom of its travel.

Seat Switch (S/N 80001 and Up)

The seat switch is normally open and closes when the operator is on the seat. The switch and its electrical connector are located directly under the seat.

1. Make sure the engine and ignition switch is Off.

2. Disconnect switch harness connector from the machine wire harness.

3. Check the continuity of the switch by connecting a multimeter (ohms setting) across the switch harness connector terminals.

4. With no operator in the seat, there should be no continuity between the terminals.

5. Press directly onto the seat switch through the seat cushion. There should be continuity as the seat cushion approaches the bottom of its travel.

6. Connect switch harness connector to the machine wire harness.

If switch removal is necessary, remove seat plate with seat from seat adjusters. Remove switch from bottom of seat.
Engine Temperature Switches (S/N 80001 and Up)

The high temperature warning and shutdown switches are located near the engine thermostat housing (Fig. 11).

The high temperature warning switch has a green/red wire attached it.

The high temperature shutdown switch has an orange/black wire attached it.

**Note:** Information on the GM 580-D temperature gauge sender is included in Chapter 5.

**Circuit Test**

If a problem with either switch system is encountered, the following procedure can be used to determine if the problem is related to the switch or the switch circuit:

1. Locate switch to be tested. Start engine.
2. Use a jumper wire to ground the switch terminal.
   - A. If the warning switch terminal is grounded, the control panel warning indicator should illuminate and the audible alarm should sound.
   - B. If the shutdown switch terminal is grounded, the engine should stop running.
3. If the results with the grounded switch terminal are not correct, the switch circuit needs repair (see electrical schematics and diagrams in Chapter 9 – Foldout Diagrams). If the results with the grounded switch terminal are correct, the switch should be tested.

**Switch Test**

![Image of engine components]

1. Lower coolant level in the engine and remove the switch that is to be tested.
2. Put switch in a container of oil with a thermometer and slowly heat the oil (Fig. 12).

**CAUTION**

Make sure engine is cool before removing the temperature warning switch.

1. Caution: Handle the hot oil with extreme care to prevent personal injury or fire.

3. Check continuity of the switch with a multimeter (ohms setting). The high temperature warning and shutdown switches are both normally open and should close when oil temperature reaches:
   - A. High temperature warning switch should close when oil temperature reaches 212°F (100°C).
   - B. High temperature shutdown switch should close when oil temperature reaches 232°F (111°C).
4. Replace switch if necessary.

6. Install switch to the water flange.

   - A. Clean threads of cylinder head and switch thoroughly. Apply thread sealant to the threads of the switch.
   - B. Screw switch into the cylinder head and tighten.
   - C. Connect wire harness wire to switch.

7. Fill engine cooling system (see Operator’s Manual).
Service and Repairs

See Chapter 5 – Electrical System (S/N Below 30101) for additional Service and Repairs information. Only changed and new information is provided in this Chapter.

Circuit Protection

On model 30580 (S/N 30101 and up), one 5 Amp fuse and two 15 Amp fuses are used for circuit protection. In addition, a 40 Amp circuit breaker with reset button is used for protection of the entire wiring circuit. The fuses and circuit breaker are located under the control panel to the right of the seat (Fig. 13). If total loss of electrical function occurs, find and correct the malfunction before pressing the reset button.

On models 30581, 30582 and 30583, one 5 Amp fuse and two 15 Amp fuses are used for circuit protection. The fuses are located under the control panel to the right of the seat. In addition, four (4) fusible links are used in the wire harness rather than the circuit breaker that was used on model 30580. The fusible links attach to the starter motor terminal (Fig. 14). Replacement fusible links are identified in the Parts Catalog. See wire harness drawings in Chapter 9 – Foldout Diagrams for additional information.

IMPORTANT: Do not install fuses in fuse block on left side of instrument panel. Fuses should be installed in this fuse block only if machine is equipped with a road light kit.

Fuses can be removed to check continuity. The test meter should read **less than 1 ohm**.
Battery Service

The batteries are the heart of the electrical system. With regular and proper service, battery life can be extended. Additionally, battery and electrical component failure can be prevented.

Note: Battery information for Model 30580 (S/N below 30101) is included in Chapter 5.

Electrolyte Specific Gravity

Fully charged: 1.265 corrected to 80° F (26.7° C)
Discharged: less than 1.240

Battery Specifications (S/N Between 30101 and 220000200)

BCI Group LTV24 Battery (2 batteries required)
650 Amp Cranking Performance at 0° F (-17.8° C)
125 Minute Reserve Capacity at 80° F (26.7° C)

Battery Specifications (S/N 220000201 and Up)

BCI Group 34 Battery (2 batteries required)
690 Amp Cranking Performance at 0° F (-17.8° C)
100 Minute Reserve Capacity at 80° F (26.7° C)

Wear safety goggles and rubber gloves when working with electrolyte. Charge the battery in a well ventilated so gases produced while charging can dissipate. Since the gases are explosive, keep open flame and electrical spark away from the battery; do not smoke. Nausea may result if the gases are inhaled. Unplug charger from electrical outlet before connecting to, or disconnecting charger leads from battery posts.

Electrical System (S/N 30101 & Up) (Rev. E)
2. Conduct a hydrometer test of the battery electrolyte.

**IMPORTANT:** Make sure the area around the cells is clean before opening the battery caps.

A. Measure the specific gravity of each cell with a hydrometer. Draw electrolyte in and out of the hydrometer barrel prior to taking a reading to warm-up the hydrometer. At the same time take the temperature of the cell.

B. Temperature correct each cell reading. For each 10° F (5.5° C) above 80° F (26.7° C) add 0.004 to the specific gravity reading. For each 10° F (5.5° C) below 80° F (26.7° C) subtract 0.004 from the specific gravity reading.

Example: Cell Temperature 100° F

<table>
<thead>
<tr>
<th>Cell Gravity</th>
<th>ADD (20° above 80° F)</th>
<th>Correction to 80° F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.245</td>
<td>0.008</td>
<td>1.253</td>
</tr>
</tbody>
</table>

C. If the difference between the highest and lowest cell specific gravity is 0.050 or greater or the lowest cell specific gravity is less than 1.225, charge the battery. Charge at the recommended rate and time given in Charging or until all cells specific gravity is 1.225 or greater with the difference in specific gravity between the highest and lowest cell less than 0.050. If these charging conditions can not be met, replace the battery.

3. Perform a high-discharge test with an adjustable load tester.

This is one of the most reliable means of testing a battery as it simulates the cold-cranking test. A commercial battery load tester is required to perform this test.

![CAUTION]

Follow the manufacturer's instructions when using a battery tester.

A. Check the voltage across the battery terminals prior to testing the battery. If the voltage is less than 12.0 VDC, recharge the battery.

B. If the battery has been charged, apply a 150 amp load for 15 seconds to remove the surface charge. Use a battery load tester following the manufacturer's instructions.

C. Make sure the battery terminals are free of corrosion.

D. Measure the temperature of the center cell.

E. Connect a battery load tester to the battery terminals following the manufacturer's instructions. Connect a digital multimeter to the battery terminals.

F. Apply a test load of one half the Cranking Performance rating (see Fig. 17) of the battery for 15 seconds.

G. Take a voltage reading at 15 seconds, then remove the load.

H. Using the table below, determine the minimum voltage for the cell temperature reading.

<table>
<thead>
<tr>
<th>Minimum Voltage</th>
<th>Battery Electrolyte Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.6</td>
<td>70° F (and up)</td>
</tr>
<tr>
<td>9.5</td>
<td>60° F</td>
</tr>
<tr>
<td>9.4</td>
<td>50° F</td>
</tr>
<tr>
<td>9.3</td>
<td>40° F</td>
</tr>
<tr>
<td>9.1</td>
<td>30° F</td>
</tr>
<tr>
<td>8.9</td>
<td>20° F</td>
</tr>
<tr>
<td>8.7</td>
<td>10° F</td>
</tr>
<tr>
<td>8.5</td>
<td>0° F</td>
</tr>
</tbody>
</table>

I. If the test voltage is below the minimum, replace the battery. If the test voltage is at or above the minimum, return the battery to service.
Charging

To minimize possible damage to the battery and allow the battery to be fully charged, the slow charging method is presented here. This charging method can be accomplished with a constant current battery charger which is available in most shops.

**CAUTION**

Follow the manufacturer's instructions when using a battery charger.

1. Determine the battery charge level from either its open circuit voltage or specific gravity.

<table>
<thead>
<tr>
<th>Battery Charge Level</th>
<th>Open Circuit Voltage</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>12.68</td>
<td>1.265</td>
</tr>
<tr>
<td>75%</td>
<td>12.45</td>
<td>1.225</td>
</tr>
<tr>
<td>50%</td>
<td>12.24</td>
<td>1.190</td>
</tr>
<tr>
<td>25%</td>
<td>12.06</td>
<td>1.155</td>
</tr>
<tr>
<td>0%</td>
<td>11.89</td>
<td>1.120</td>
</tr>
</tbody>
</table>

2. Determine the charging time and rate using the manufacturer's battery charger instructions or the following table.

<table>
<thead>
<tr>
<th>Reserve Capacity (Minutes)</th>
<th>Battery Charge Level (Percent of Fully Charged)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>75%</td>
</tr>
<tr>
<td>80 or less</td>
<td>3.8 hrs at 3 amps</td>
</tr>
<tr>
<td>81 to 125</td>
<td>5.3 hrs at 4 amps</td>
</tr>
<tr>
<td>126 to 170</td>
<td>5.5 hrs at 5 amps</td>
</tr>
<tr>
<td>171 to 250</td>
<td>5.8 hrs at 6 amps</td>
</tr>
<tr>
<td>above 250</td>
<td>6 hrs at 10 amps</td>
</tr>
</tbody>
</table>

3. **Following the manufacturer’s instructions**, connect the charger cables to the battery. Make sure a good connection is made.

4. Charge the battery following the manufacturer’s instructions.

5. Occasionally check the temperature of the battery electrolyte. If the temperature exceeds 125°F (51.6°C) or the electrolyte is violently gassing or spewing, the charging rate must be lowered or temporarily stopped.

6. Three hours prior to the end of the charging, measure the specific gravity of a battery cell once per hour. The battery is fully charged when the cells are gassing freely at a low charging rate and there is less than a 0.003 change in specific gravity for three consecutive readings.
Alternator

The alternator used on the Groundsmaster 580-D is belt driven and attaches to the engine. If testing determines that alternator is not functioning properly, bench inspection should be performed.

Note: For information on disassembly and assembly of the alternator used on models 30581, 30582 and 30583, see the Mitsubishi S4S-DT Service Manual that follows Chapter 3A – Engine (Model 30581).

Brushes

Replace the alternator brushes if they are worn to the service limit (Fig. 18).

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Brush Length (New)</th>
<th>Brush Length (Service Limit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30581 (50 Amp Alternator)</td>
<td>.728” (18.5mm)</td>
<td>.280” (7 mm)</td>
</tr>
<tr>
<td>30581 (w/AC Kit) (75 Amp Alternator)</td>
<td>.716” (18.2 mm)</td>
<td>.280” (7 mm)</td>
</tr>
<tr>
<td>30582 &amp; 30583 (100 Amp Alternator)</td>
<td>.728” (18.5mm)</td>
<td>.197” (5 mm)</td>
</tr>
</tbody>
</table>

Field Coil

Measure the resistance between the slip rings (Fig. 19). If the resistance is outside of the assembly standard, replace the rotor.

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Field Coil Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>30581</td>
<td>2.4 Ohms</td>
</tr>
<tr>
<td>30581 (with AC Kit)</td>
<td>3.0 Ohms</td>
</tr>
<tr>
<td>30582 &amp; 30583</td>
<td>2.8 Ohms</td>
</tr>
</tbody>
</table>

Stator Coil

Check for continuity between the lead wires (Fig. 20). If no continuity exists (infinite resistance), the coil has an open circuit and needs to be replaced.

Check for continuity between the lead wires and the stator core laminations. If continuity exists (no resistance), the stator coil is grounded and needs to be replaced.

Rectifier

Test the resistance between each diode lead wire and heatsink (Fig. 21). To test, connect the positive (+) multimeter test lead to the diode and the negative (−) multimeter test lead to the heat sink, record resistance and then switch test lead location.
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This page is intentionally blank.
RxBR pressure = 600 psi for models with
Charge pressure = 230 psi for piston pumps

NOTE: Hydraulic Schematic differences exist
serial numbers below 70000
with serial numbers below A-96-01-xxxx
as follows:

Hydraulic Schematic

Groundsmaster 580-D
(2WD Machines)

Hydraulic Schematic
Model 30580 (S/N 30101 and up)
Wire Harness Diagram

Groundsmaster 580-D
Wire Harness Diagram
Model 30580 (S/N 30101 and up)
Groundsmaster 580-D
Wire Harness Drawing
Models 30582 (S/N Above 250000000) and 30583
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