JOHN DEERE
WORLDWIDE COMMERCIAL & CONSUMER EQUIPMENT DIVISION

ProGator™
2020 and 2030 Utility Vehicle

TM1759 FEB07

TECHNICAL MANUAL

JOHN DEERE

North American Version
Litho in U.S.A.

INTRODUCTION

Manual Description

This technical manual is written for an experienced technician and contains sections that are specifically for this product. It is a part of a total product support program.

The manual is organized so that all the information on a particular system is kept together. The order of grouping is as follows:

- Table of Contents
- Specifications and Information
- Identification Numbers
- Tools and Materials
- Component Location
- Schematics and Harnesses
- Theory of Operation
- Operation and Diagnostics
- Diagnostics
- Tests and Adjustments
- Repair
- Other

NOTE: Depending on the particular section or system being covered, not all of the above groups may be used.

The bleed tabs for the pages of each section will align with the sections listed on this page. Page numbering is consecutive from the beginning of the Safety section through the last section.

We appreciate your input on this manual. If you find any errors or want to comment on the layout of the manual please contact us.

INTRODUCTION

Recognize Safety Information

MIF

This is the safety-alert symbol. When you see this symbol on your machine or in this manual, be alert to the potential for personal injury.

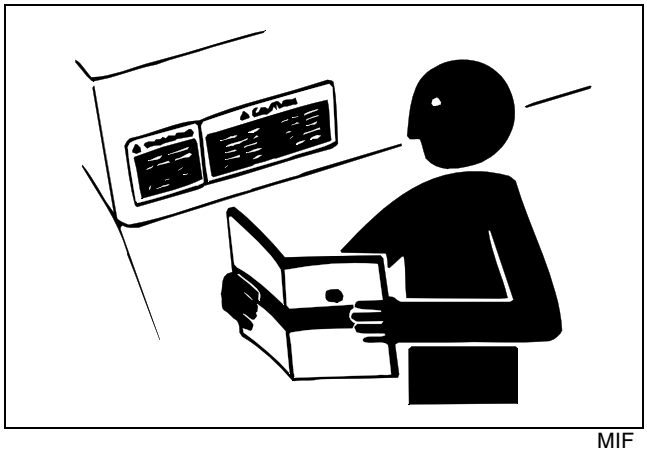
Follow recommended precautions and safe servicing practices.

Understand Signal Words

A signal word - DANGER, WARNING, or CAUTION - is used with the safety-alert symbol. DANGER identifies the most serious hazards.

DANGER or WARNING safety signs are located near specific hazards. General precautions are listed on CAUTION safety signs. CAUTION also calls attention to safety messages in this manual.

Replace Safety Signs



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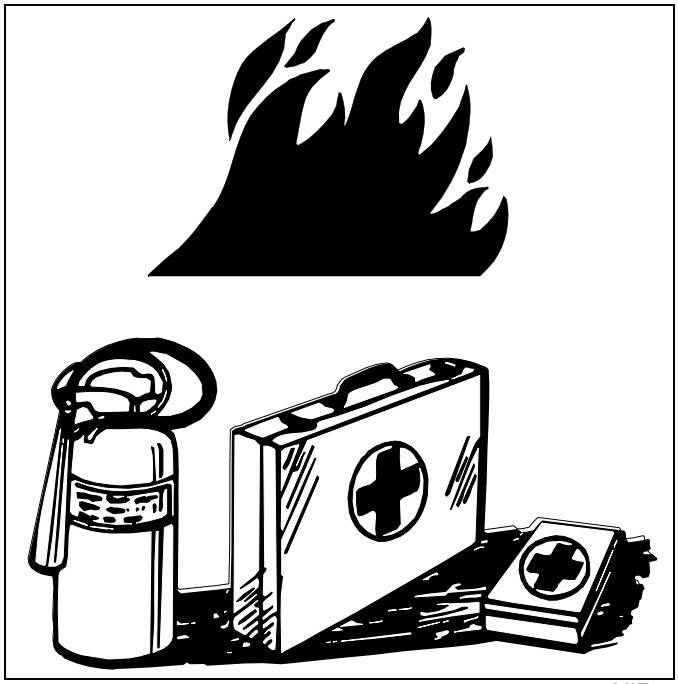
Replace missing or damaged safety signs. See the machine operator's manual for correct safety sign placement.

Handle Fluids Safely - Avoid Fires

Be Prepared for Emergencies



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When you work around fuel, do not smoke or work near heaters or other fire hazards.

Store flammable fluids away from fire hazards. Do not incinerate or puncture pressurized containers.

Make sure machine is clean of trash, grease, and debris.

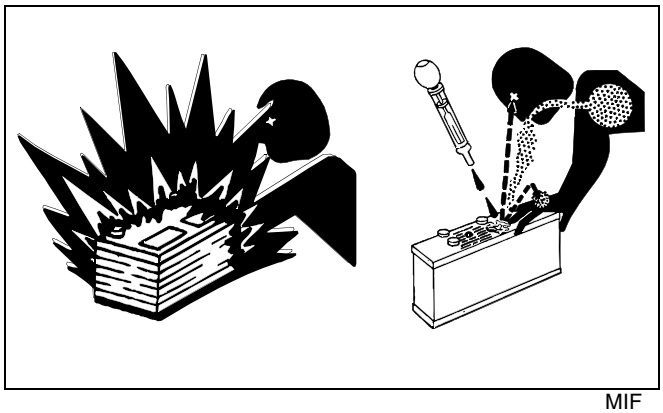
Do not store oily rags; they can ignite and burn spontaneously.

Be prepared if a fire starts.

Keep a first aid kit and fire extinguisher handy.

Keep emergency numbers for doctors, ambulance service, hospital, and fire department near your telephone.

Use Care in Handling and Servicing Batteries



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Prevent Battery Explosions

- Keep sparks, lighted matches, and open flame away from the top of battery. Battery gas can explode.
- Never check battery charge by placing a metal object across the posts. Use a volt-meter or hydrometer.
- Do not charge a frozen battery; it may explode. Warm battery to 16°C (60°F).

Prevent Acid Burns

- Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, eat holes in clothing, and cause blindness if splashed into eyes.

Avoid acid burns by:

1. Filling batteries in a well-ventilated area.
2. Wearing eye protection and rubber gloves.
3. Avoiding breathing fumes when electrolyte is added.
4. Avoiding spilling or dripping electrolyte.
5. Use proper jump start procedure.

If you spill acid on yourself:

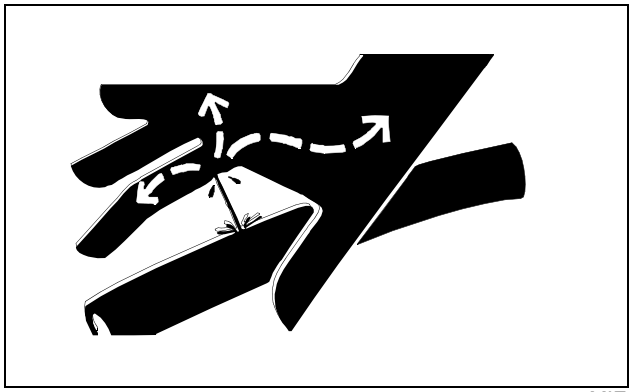
1. Flush your skin with water.
2. Apply baking soda or lime to help neutralize the acid.
3. Flush your eyes with water for 10-15 minutes.
4. Get medical attention immediately.

If acid is swallowed:

1. Drink large amounts of water or milk.
2. Then drink milk of magnesia, beaten eggs, or vegetable oil.
3. Get medical attention immediately.

Use Care Around High-Pressure Fluid Lines

Avoid High-Pressure Fluids



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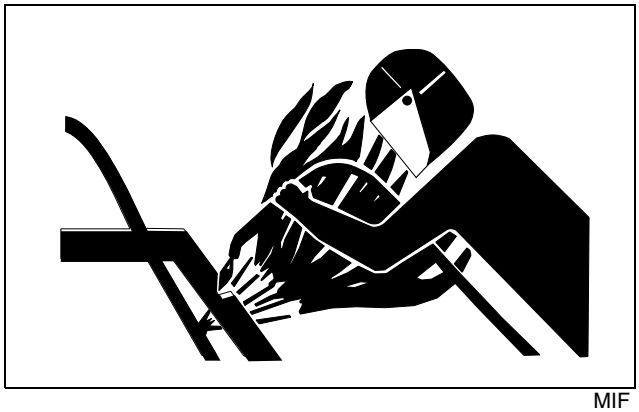
Escaping fluid under pressure can penetrate the skin causing serious injury.

Avoid injury from escaping fluid under pressure by stopping the engine and relieving pressure in the system before disconnecting or connecting hydraulic or other lines. Tighten all connections before applying pressure.

Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury should reference a knowledgeable medical source. Such information is available from Deere & Company Medical Department in Moline, Illinois, U.S.A.

Avoid Heating Near Pressurized Fluid Lines



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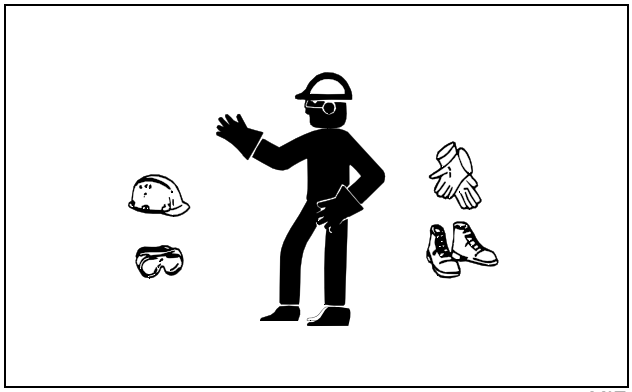
Flammable spray can be generated by heating near pressurized fluid lines, resulting in severe burns to yourself and bystanders. Do not heat by welding, soldering, or using a torch near pressurized fluid lines or other flammable materials. Pressurized lines can be accidentally cut when heat goes beyond the immediate flame area.

Use Safe Service Procedures

Wear Protective Clothing



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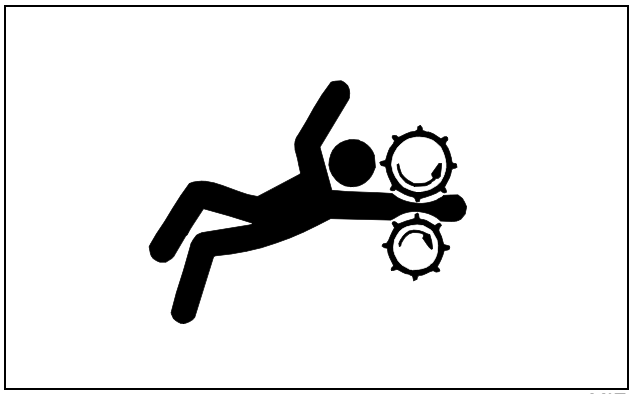
Wear close fitting clothing and safety equipment appropriate to the job.

Prolonged exposure to loud noise can cause impairment or loss of hearing. Wear a suitable hearing protective device such as earmuffs or earplugs to protect against objectionable or uncomfortable loud noises.

Operating equipment safely requires the full attention of the operator. Do not wear radio or music headphones while operating machine.

Service Machines Safely



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Tie long hair behind your head. Do not wear a necktie, scarf, loose clothing, or necklace when you work near machine tools or moving parts. If these items were to get caught, severe injury could result.

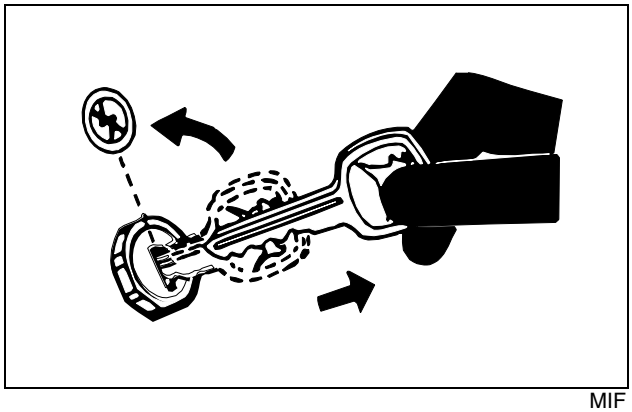
Remove rings and other jewelry to prevent electrical shorts and entanglement in moving parts.

Use Proper Tools

Use tools appropriate to the work. Makeshift tools and procedures can create safety hazards. Use power tools only to loosen threaded parts and fasteners. For loosening and tightening hardware, use the correct size tools. **DO NOT** use U.S. measurement tools on metric fasteners.

Avoid bodily injury caused by slipping wrenches. Use only service parts meeting John Deere specifications.

Park Machine Safely



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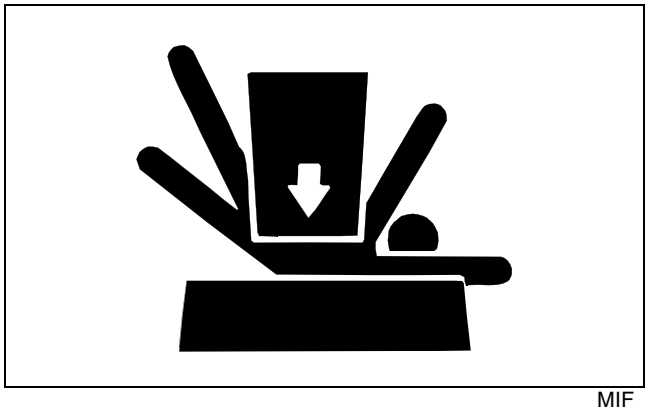
Before working on the machine:

1. Lower all equipment to the ground.
2. Stop the engine and remove the key.
3. Disconnect the battery ground strap.
4. Hang a “DO NOT OPERATE” tag in operator station.

Support Machine Properly and Use Proper Lifting Equipment



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If you must work on a lifted machine or attachment, securely support the machine or attachment.

Do not support the machine on cinder blocks, hollow tiles, or props that may crumble under continuous load. Do not work under a machine that is supported solely by a jack. Follow recommended procedures in this manual.

Lifting heavy components incorrectly can cause severe injury or machine damage. Follow recommended procedure for removal and installation of components in the manual.

Work in Clean Area

Before starting a job:

1. Clean work area and machine.
2. Make sure you have all necessary tools to do your job.
3. Have the right parts on hand.
4. Read all instructions thoroughly; do not attempt shortcuts.

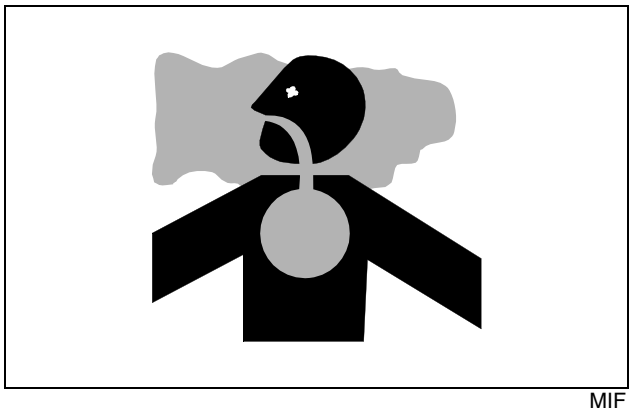
Using High Pressure Washers

Directing pressurized water at electronic/electrical components or connectors, bearings, hydraulic seals, fuel injection pumps or other sensitive parts and components may cause product malfunctions. Reduce pressure and spray at a 45 to 90 degree angle.

Illuminate Work Area Safely

Illuminate your work area adequately but safely. Use a portable safety light for working inside or under the machine. Make sure the bulb is enclosed by a wire cage. The hot filament of an accidentally broken bulb can ignite spilled fuel or oil.

Work in Ventilated Area



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Engine exhaust fumes can cause sickness or death. If it is necessary to run an engine in an enclosed area, remove the exhaust fumes from the area with an exhaust pipe extension.

If you do not have an exhaust pipe extension, open the doors and get outside air into the area.

WARNING: California Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

Gasoline engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

Remove Paint before Welding or Heating

Avoid potentially toxic fumes and dust. Hazardous fumes can be generated when paint is heated by welding, soldering, or using a torch. Do all work outside or in a well ventilated area. Dispose of paint and solvent properly. Remove paint before welding or heating: If you sand or grind paint, avoid breathing the dust. Wear an approved respirator. If you use solvent or paint stripper, remove stripper with soap and water before welding. Remove solvent or paint stripper containers and other flammable material from area. Allow fumes to disperse at least 15 minutes before welding or heating.

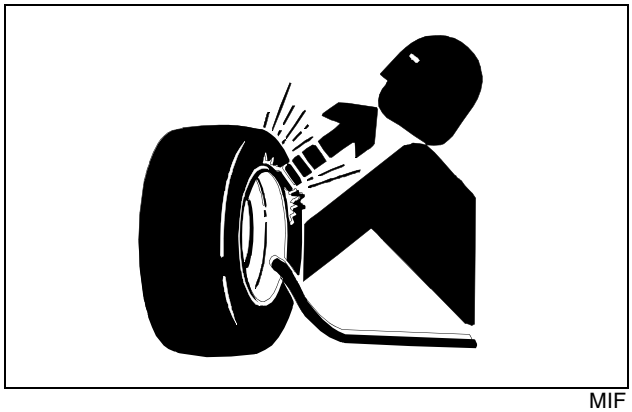
Avoid Harmful Asbestos Dust

Avoid breathing dust that may be generated when handling components containing asbestos fibers. Inhaled asbestos fibers may cause lung cancer.

Components in products that may contain asbestos fibers are brake pads, brake band and lining assemblies, clutch plates, and some gaskets. The asbestos used in these components is usually found in a resin or sealed in some way. Normal handling is not hazardous as long as airborne dust containing asbestos is not generated.

Avoid creating dust. Never use compressed air for cleaning. Avoid brushing or grinding material containing asbestos. When servicing, wear an approved respirator. A special vacuum cleaner is recommended to clean asbestos. If not available, apply a mist of oil or water on the material containing asbestos. Keep bystanders away from the area.

Service Tires Safely



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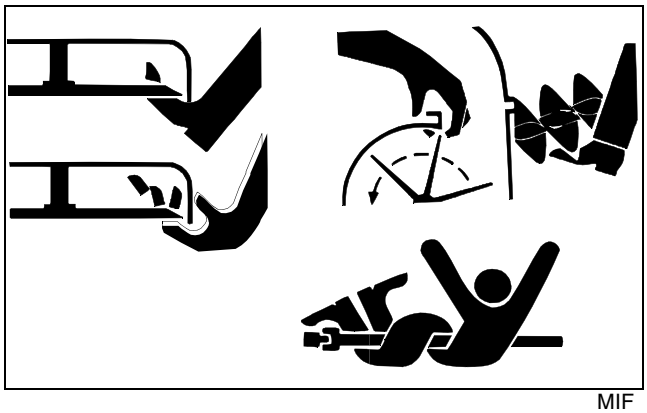
Explosive separation of a tire and rim parts can cause serious injury or death.

Do not attempt to mount a tire unless you have the proper equipment and experience to perform the job. Always maintain the correct tire pressure. Do not inflate the tires above the recommended pressure. Never weld or heat a wheel and tire assembly. The heat can cause an increase in air pressure resulting in a tire explosion. Welding can structurally weaken or deform the wheel.

When inflating tires, use a clip-on chuck and extension hose long enough to allow you to stand to one side and NOT in front of or over the tire assembly. Use a safety cage if available.

Check wheels for low pressure, cuts, bubbles, damaged rims or missing lug bolts and nuts.

Avoid Injury from Rotating Blades, Augers, and PTO Shafts



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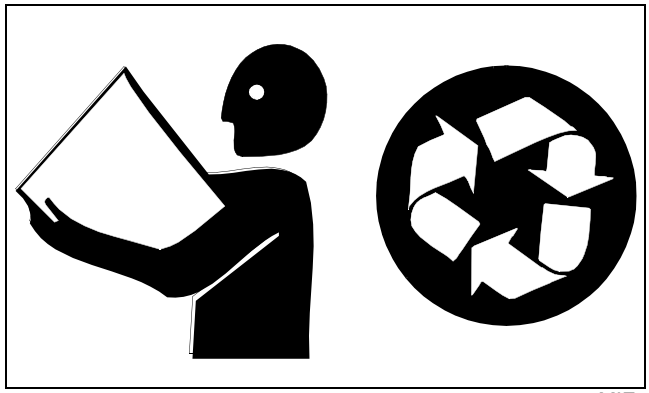
Keep hands and feet away while machine is running. Shut off power to service, lubricate or remove mower blades, augers or PTO shafts.

Handle Chemical Products Safely



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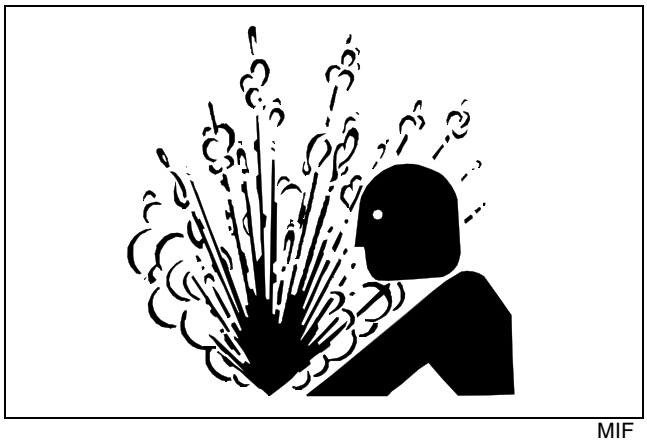
Direct exposure to hazardous chemicals can cause serious injury. Potentially hazardous chemicals used with John Deere equipment include such items as lubricants, coolants, paints, and adhesives.

A Material Safety Data Sheet (MSDS) provides specific details on chemical products: physical and health hazards, safety procedures, and emergency response techniques. Check the MSDS before you start any job using a hazardous chemical. That way you will know exactly what the risks are and how to do the job safely. Then follow procedures and recommended equipment.

Dispose of Waste Properly

Improperly disposing of waste can threaten the environment and ecology. Potentially harmful waste used with John Deere equipment include such items as oil, fuel, coolant, brake fluid, filters, and batteries. Use leakproof containers when draining fluids. Do not use food or beverage containers that may mislead someone into drinking from them. Do not pour waste onto the ground, down a drain, or into any water source. Inquire on the proper way to recycle or dispose of waste from your local environmental or recycling center, or from your John Deere dealer.

Service Cooling System Safely



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Explosive release of fluids from pressurized cooling system can cause serious burns.

Shut off machine. Only remove filler cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

Live with Safety

MIF

Before returning machine to customer, make sure machine is functioning properly, especially the safety systems. Install all guards and shields.

Table of Contents

General Specifications

Vehicle Specifications

Gas Engine

Make	John Deere/Yanmar
Model	3TG72-JUV
Type	4-cycle gasoline
Machine Model Used On	2020
Bore	72 mm (2.84 in.)
Stroke	72 mm (2.84 in.)
Cylinders	3
Valves	Overhead
Displacement	879 cm^3 (53.6 cu in.)
Maximum Torque (@ 2300 RPM)	64.5 N•m (47.6 lb ft)
Lubrication	Full pressure
Oil Filter	Full flow, spin-on filter
Crankcase Capacity with Oil Filter	3.2 L (3.5 qt)
Oil Capacity (with Filter) (Approximately)	2.2 L (2.3 qt)
Cooling System	Liquid with pump and radiator
Fuel Filter	Replaceable (in-line type)
Air Filter	Dry replaceable primary and secondary elements

Diesel Engine

Make	Yanmar
Model	3TNE74C-JUV S.N. (-100030) 3TNE74C-EJUV S.N. (100031-)
Type	4-cycle diesel
Machine Model Used On	2030
Bore	74 mm (2.91 in.)
Stroke	78 mm (3.07 in.)
Cylinders	3
Valves	Overhead
Displacement	1.006 L (61.4 cu. in.)
Maximum Torque @2400 RPM	61.7 N•m (45.5 lb-ft)
Firing Order	1-3-2
Direction of Rotation	Counterclockwise (viewed from flywheel)
Combustion System	Indirect injection type
Compression Ratio	23 to 1
Oil Capacity (with Filter) (Approximate)	2.7 L (2.8 qt)
Cooling	Liquid with pump and radiator
Governor	Centrifugal
Slow Idle (No-Load)	1450±50 rpm
High Idle (No-Load)	3450±50 rpm
Fuel Filter	Replaceable element fuel water separator
Air Filter	Dry replaceable primary and secondary elements
Weight (Approximate)	100 kg (220 lb)

Electrical System

Type	Alternator, Internally Regulated
Alternator Capacity	55 amp
Battery Voltage	12 Volts DC
Cold Cranking Amps @ 0°F	500
Ignition	CDI

Powertrain

Input Shaft OD

#1 F.W. Pilot Bearing	11.942-11.968 mm (0.4702-0.4712 in.)
#2 Clutch Sleeve CMP	19.948-20.000 mm (0.7854-0.7874 in.)
#3 Bearing #6205	24.9935-25.0065 mm (0.9840-0.9845 in.)
#4 F4:33 & F5:36 Gear, Bearing #222617	21.979-22.000 mm (0.8653-0.8661 in.)
#5 Bearing 6304U	20.002-20.015 mm (0.7875-0.7880 in.)

Input Shaft Assembly Bore ID

#1 C/H Case Bore, Bearing #6205	52.000-52.046 mm (2.0472-2.0491 in.)
#2 F4:33 & F5:36 Gear, Case Bore, Bearing #222617	26.020-26.033 mm (1.0244-1.0249 in.)
#3 T/A Case Bore, Bearing 6304U	26.020-26.033 mm (1.0244-1.0249 in.)

Reduction Shaft OD

#1 Bearing #6305	25.002-25.015 mm (0.9843-0.9848 in.)
#2 R, F1, F2, F3 Gears (39T, 50T, 44T, 37T)	29.987-30.000 mm (1.1806-1.1811 in.)
#3 Bearing #6205U	25.002-25.015 mm (0.9843-0.9848 in.)

Reduction Shaft Assembly Bore ID

#1 C/H Bore, Bearing #6305	62.000-62.030 mm (2.4409-2.4421 in.)
#2 R, F1, F2, F3 (39T, 50T, 44T, 37T) Case Bore	35.009-35.034 mm (1.3783-1.3793 in.)
#3 T/A Case Bore, Bearing #6205U	52.000-52.030 mm (2.0472-2.0484 in.)

Counter Shaft OD

#1 T.R. Bearing 30306	30.002-30.015 mm (1.1812-1.1817 in.)
#2 T.R. Bearing 32208	40.002-40.018 mm (1.5749-1.5755 in.)

Counter Shaft Assembly Bore ID

#1 C/H Bore T.R. Bearing 30306	72.000-72.030 mm (2.8346-2.8358 in.)
#2 T/A Case Bore T.R. Bearing #32208	80.000-80.030 mm (3.1496-3.1508 in.)

MFWD Assembly Bore ID

#1 C/H Bore MFWD, Bi-Directional Clutch	112.00-112.05 mm (4.4094-4.4114 in.)
#2 T/A Case Bore, MFWD Bi-Directional Clutch	52.000-52.024 mm (2.0474-2.0482 in.)

Reverse Shaft OD

#1 Shaft (29T)	19.987-20.000 mm (0.7869-0.7874 in.)

Reverse Shaft Assembly Bore ID

#1 C/H Bore (Reverse Shaft)	20.000-20.013 mm (0.7874-0.7879 in.)
#2 Gear Bore (29T) (Needle Bearing Part)	24.007-24.028 mm (0.9452-0.9460 in.)

Axle Shaft OD

#1 Bearing #6208 . . . . . 39.992-40.008 mm (1.5745-1.5751 in.)
#2 Bearing #2208 . . . . . 39.992-40.008 mm (1.5745-1.5751 in.)
#3 Flange . . . . . 79.900-80.000 mm (3.1457-3.1496 in.)

Axle Shaft Assembly Bore ID

#1 Axle Housing Bore, Bearing #6208 . . . . . 80.000-80.030 mm (3.1457-3.1508 in.)
#2 Axle Housing Bore, Bearing #2208 . . . . . 80.000-80.030 mm (3.1457-3.1508 in.)

Clutch Shaft OD

#1 Shaft . . . . . 14.957-15.000 mm (0.5889-0.5906 in.)

Clutch Shaft Bore ID

#1 C/H Bore . . . . . 15.050-15.100 mm (0.5925-0.5945 in.)
#2 C/H Fork Bore . . . . . 15.016-15.043 mm (0.5912-0.5922 in.)

Clutch Fork

Pin Thickness . . . . . 19.200-20.200 mm (0.7559-0.7953 in.)
Wear Limit . . . . . 0.50 mm (0.197 in.)
Fork R-1, 2-3, 4-5, Thickness . . . . . 6.700-6.900 mm (0.2638-0.2717 in.)
Wear Limit . . . . . 0.50 mm (0.197 in.)
Shifter Groove Width . . . . . 6.950-7.150 mm (0.2736-0.2815 in.)

Clutch Fork Shaft OD

R-1, 2-3, 4-5 . . . . . 14.957-15.000 mm (0.5889-0.5906 in.)

Clutch Fork Shaft Bore ID

#1 C/H Bore. . . . . 15.100-15.150 mm (0.5945-0.5965 in.)
#2 T/A Case Bore . . . . . 15.100-15.200 mm (0.5945-0.5984 in.)

Clutch Sleeve Groove Width

Clutch Fork Pin . . . . . 20.500-21.000 mm (0.8071-0.8268 in.)

Selector Arm Pin Diameter . . . . . 11.800-11.900 mm (0.4646-0.4658 in.)
Wear Limit . . . . . 0.50 mm (0.197 in.)

Selector Arm Fork Groove Width

Pin Part . . . . . 12.100-12.300 mm (0.4764-0.4843 in.)

Selector Shaft OD

#1 Cover A and B . . . . . 14.900-14.950 mm (0.5866-0.5886 in.)
#2 Switch and Selector Arm . . . . . 14.957-15.000 mm (0.5889-0.5906 in.)
#3 Control Arm . . . . . 14.900-14.950 mm (0.5866-0.5886 in.)

Selector Shaft Assembly Bore ID

#1 Cover A and B Bore. . . . . 15.016-15.043 mm (0.5912-0.5922 in.)
#2 Selector Arm Bore . . . . . 15.016-15.043 mm (0.5912-0.5922 in.)
#3 Switch Arm . . . . . 15.000-15.027 mm (0.5906-0.5916 in.)
#4 Switch Arm Bore . . . . . 15.000-15.027 mm (0.5906-0.5916 in.)

Differential Lock Shaft OD . . . . . 19.948-20.000 mm (0.7854-0.7874 in.)

Differential Lock Shaft Assembly Bore ID

#1 T/A Case Bore . . . . . 20.100-20.200 mm (0.7913-0.7953 in.)
#2 Differential Lock Fork Bore . . . . . 20.050-20.100 mm (0.7894-0.7913 in.)
#3 Axle Housing L Bore . . . . . 20.020-20.053 mm (0.7882-0.7895 in.)
#4 Differential Lock Arm Bore . . . . . 20.000-20.052 mm (0.7874-0.7894 in.)

Differential Lock Fork Thickness . . . . . 8.800-9.000 mm (0.3465-0.3543 in.)
Wear Limit . . . . . 0.50 mm (0.197 in.)

Differential Lock Shifter

Pin OD . . . . . 11.018-11.029 mm (0.4338-0.4342 in.)
Pin Hole Bore ID . . . . . 11.400-11.600 mm (0.4488-0.4567 in.)

Differential Lock Slider Groove Width

Differential Lock Fork Part . . . . . 9.100-9.300 mm (0.3583-0.3661 in.)

Differential Lock Fork V Groove Diameter

Spring Pin Part . . . . . 8.500-9.000 mm (0.3346-0.3543 in.)

Differential Pinion Shaft OD

Shaft OD . . . . . 21.967-21.980 mm (0.8648-0.8654 in.)

Differential Pinion Shaft Bore ID

#1 Differential Case Bore . . . . . 22.000-22.021 mm (0.8661-0.8670 in.)
#2 Differential Pinion Gear Bore . . . . . 22.040-22.061 mm (0.8677-0.8685 in.)

Differential Case OD

#1 Bearing 6212 . . . . . 60.002-60.021 mm (2.3623-2.3630 in.)
#2 Bearing 6210 . . . . . 50.002-50.018 mm (1.9686-1.9692 in.)

Differential Assembly Bore ID

#1 Axle Housing L Bore, Bearing 6212 . . . . . 110.000-110.035 mm (4.3307-4.3321 in.)
#2 Transaxle Case Bore, Bearing 6210 . . . . . 90.000-90.035 mm (3.5433-3.5447 in.)

Axle Housing Collar OD

Brake Assembly Component . . . . . 81.910-81.990 mm (3.2248-3.2280 in.)

Hydraulics

Lift/Lower System (Auxiliary)

Type . . . . . Open system
Working Pressure . . . . . 17 000 kPa (2466 psi)
Pump Flow (Gasoline Engine @ 3520 RPM) . . . . . 25.9 liters/min (6.84 gpm)
Pump Flow (Diesel Engine @ 3450 RPM) . . . . . 25.3 liters/min (6.68 gpm)

Steering System

Type	**Open system**
Working Pressure	**7500 kPa (1088 psi)**
Pump Flow (Gasoline Engine @ 3520 RPM)	**11.5 liters/min (3.04 gpm)**
Pump Flow (Diesel Engine @ 3450 RPM)	**11.2 liters/min (2.96 gpm)**
Steering Control Unit	**7000-7500 kPa (1015-1088 psi)**
System Capacity	**11.4 L (3.0 gal)**

Brake System

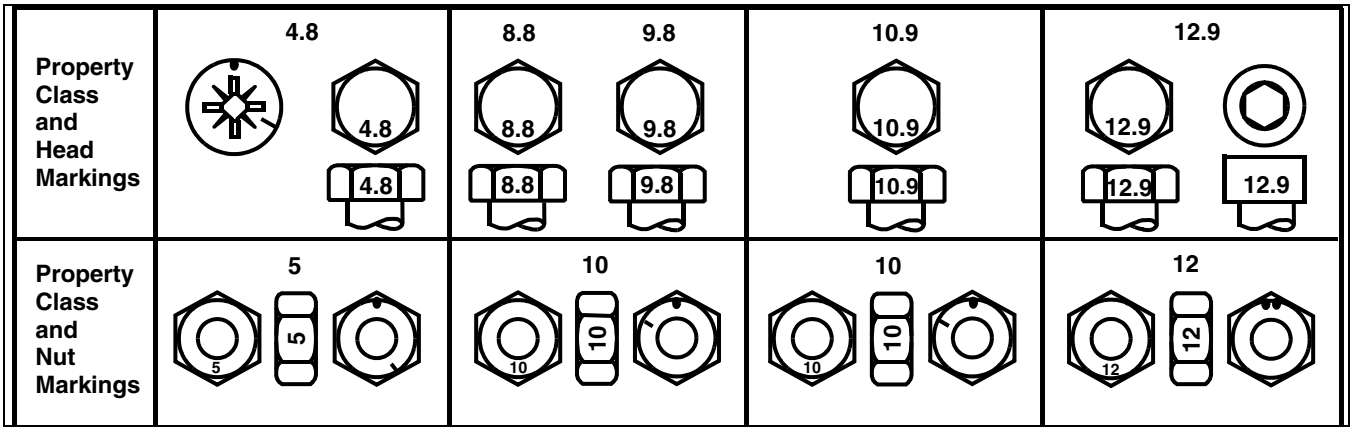
Brake Lining Thickness (Nominal)	**4.1 mm (0.16 in.)**
Brake Fluid Quantity	**0.7 L (24 oz)**
Brake Drum Diameter (Maximum)	**221.21 mm (8.709 in.)**

Miscellaneous

Tire Pressure	**69-97 kPa (10-14 psi)**
Tire Pressure with HD200 Sprayer (minimum)	**83 kPa (12 psi)**
Tire Pressure with HD300 Sprayer (minimum)	**110 kPa (16 psi)**

General Information

Metric Fastener Torque Values



MIF

	Class 4.8				Class 8.8 or 9.8				Class 10.9				Class 12.9			
	Lubricated a		Dry a		Lubricated a		Dry a		Lubricated a		Dry a		Lubricated a		Dry a	
SIZE	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft
M6	4.8	3.5	6	4.5	9	6.5	11	8.5	13	9.5	17	12	15	11.5	19	14.5
M8	12	8.5	15	11	22	16	28	20	32	24	40	30	37	28	47	35
M10	23	17	29	21	43	32	55	40	63	47	80	60	75	55	95	70
M12	40	29	50	37	75	55	95	70	110	80	140	105	130	95	165	120
M14	63	47	80	60	120	88	150	110	175	130	225	165	205	150	260	109
M16	100	73	125	92	190	140	240	175	275	200	350	225	320	240	400	300
M18	135	100	175	125	260	195	330	250	375	275	475	350	440	325	560	410
M20	190	140	240	180	375	275	475	350	530	400	675	500	625	460	800	580
M22	260	190	330	250	510	375	650	475	725	540	925	675	850	625	1075	800
M24	330	250	425	310	650	475	825	600	925	675	1150	850	1075	800	1350	1000
M27	490	360	625	450	950	700	1200	875	1350	1000	1700	1250	1600	1150	2000	1500
M30	675	490	850	625	1300	950	1650	1200	1850	1350	2300	1700	2150	1600	2700	2000
M33	900	675	1150	850	1750	1300	2200	1650	2500	1850	3150	2350	2900	2150	3700	2750
M36	1150	850	1450	1075	2250	1650	2850	2100	3200	2350	4050	3000	3750	2750	4750	3500

DO NOT use these hand torque values if a different torque value or tightening procedure is given for a specific application. Torque values listed are for general use only and include a ±10% variance factor. Check tightness of fasteners periodically. DO NOT use air powered wrenches.

Shear bolts are designed to fail under predetermined loads. Always replace shear bolts with identical grade.

Fasteners should be replaced with the same grade. Make sure fastener threads are clean and that you properly start thread engagement. This will prevent them from failing when tightening.

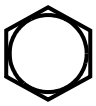
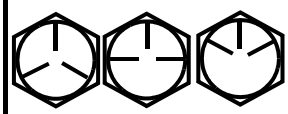
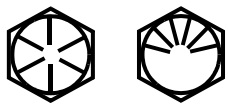
When bolt and nut combination fasteners are used, torque values should be applied to the NUT instead of the bolt head.

Tighten toothed or serrated-type locknuts to the full torque value.

a *"Lubricated" means coated with a lubricant such as engine oil, or fasteners with phosphate and oil coatings. "Dry" means plain or zinc plated (yellow dichromate - Specification JDS117) without any lubrication.*

Reference: JDS - G200.

Inch Fastener Torque Values

SAE Grade and Head Markings	**No Marks**  **1 or 2[b]**	 **5 5.1 5.2**	 **8 8.2**
SAE Grade and Nut Markings	**No Marks**  **2**	 **5**	 **8**

MIF

	Grade 1				Grade 2b				Grade 5, 5.1 or 5.2				Grade 8 or 8.2			
	Lubricated a		Dry a		Lubricated a		Dry a		Lubricated a		Dry a		Lubricated a		Dry a	
SIZE	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft
1/4	3.7	2.8	4.7	3.5	6	4.5	7.5	5.5	9.5	7	12	9	13.5	10	17	12.5
5/16	7.7	5.5	10	7	12	9	15	11	20	15	25	18	28	21	35	26
3/8	14	10	17	13	22	16	27	20	35	26	44	33	50	36	63	46
7/16	22	16	28	20	35	26	44	32	55	41	70	52	80	58	100	75
1/2	33	25	42	31	53	39	67	50	85	63	110	80	120	90	150	115
9/16	48	36	60	45	75	56	95	70	125	90	155	115	175	130	225	160
5/8	67	50	85	62	105	78	135	100	170	125	215	160	215	160	300	225
3/4	120	87	150	110	190	140	240	175	300	225	375	280	425	310	550	400
7/8	190	140	240	175	190	140	240	175	490	360	625	450	700	500	875	650
1	290	210	360	270	290	210	360	270	725	540	925	675	1050	750	1300	975
1-1/8	470	300	510	375	470	300	510	375	900	675	1150	850	1450	1075	1850	1350
1-1/4	570	425	725	530	570	425	725	530	1300	950	1650	1200	2050	1500	2600	1950
1-3/8	750	550	950	700	750	550	950	700	1700	1250	2150	1550	2700	2000	3400	2550
1-1/2	1000	725	1250	925	990	725	1250	930	2250	1650	2850	2100	3600	2650	4550	3350

DO NOT use these hand torque values if a different torque value or tightening procedure is given for a specific application. Torque values listed are for general use only and include a ±10% variance factor. Check tightness of fasteners periodically. DO NOT use air powered wrenches.

Shear bolts are designed to fail under predetermined loads. Always replace shear bolts with identical grade.

Fasteners should be replaced with the same grade. Make sure fastener threads are clean and that you properly start thread engagement. This will prevent them from failing when tightening.

When bolt and nut combination fasteners are used, torque values should be applied to the NUT instead of the bolt head.

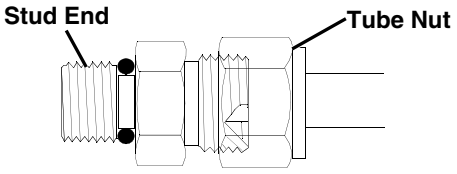
Tighten toothed or serrated-type locknuts to the full torque value.

a *"Lubricated" means coated with a lubricant such as engine oil, or fasteners with phosphate and oil coatings. "Dry" means plain or zinc plated (yellow dichromate - Specification JDS117) without any lubrication*.

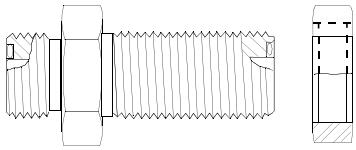
b *"Grade 2" applies for hex cap screws (Not Hex Bolts) up to 152 mm (6 in.) long. "Grade 1" applies for hex cap screws over 152 mm (6 in.) long, and for all other types of bolts and screws of any length.*

Reference: JDS - G200

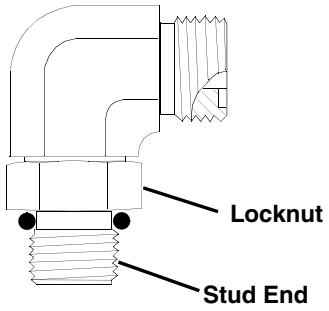
Face Seal Fittings With Inch Stud Ends Torque



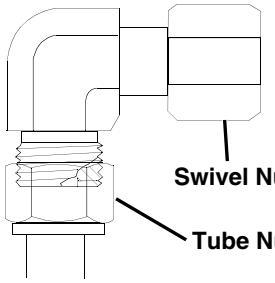
Stud Straight and Tube Nut



Bulkhead Union and Bulkhead Locknut



90 Adjustable Stud Elbow



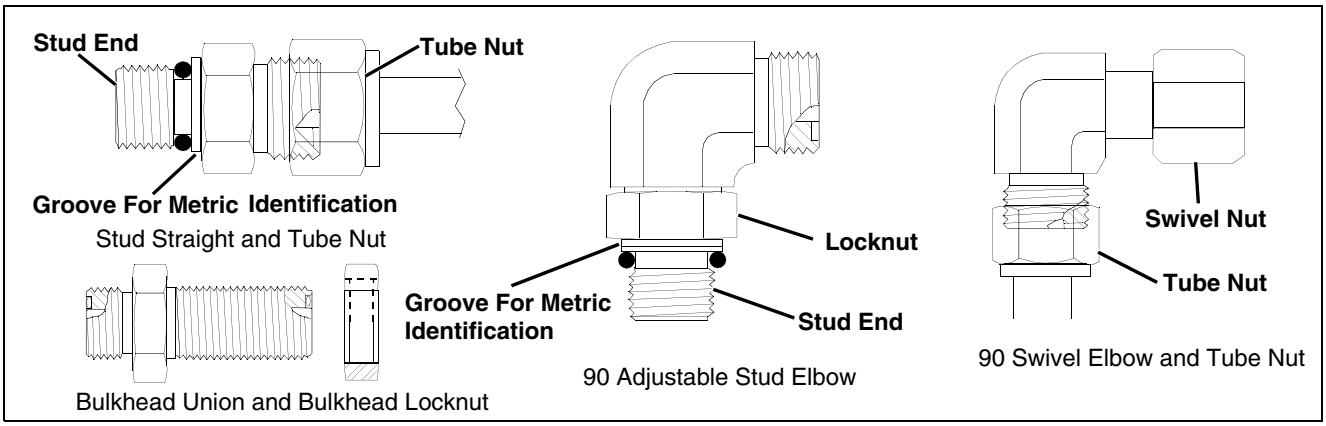
90 Swivel Elbow and Tube Nut

MIF

Nominal Tube OD/Hose ID				Face Seal Tube/Hose End					O-Ring Stud Ends		
Metric Tube OD	Inch Tube OD			Thread Size	Tube Nut/ Swivel Nut Torque		Bulkhead Locknut Torque		Thread Size	Straight Fitting or Locknut Torque	
mm	Dash Size	in.	mm	in.	N•m	lb-ft	N•m	lb-ft	in.	N•m	lb-ft
5	-3	0.188	4.76						3/8-24	8	6
6	-4	0.250	6.35	9/16-18	16	12	12	9	7/16-20	12	9
8	-5	0.312	7.94						1/2-20	16	12
10	-6	0.375	9.52	11/16-16	24	18	24	18	9/16-18	24	18
12	-8	0.500	12.70	13/16-16	50	37	46	34	3/4-16	46	34
16	-10	0.625	15.88	1-14	69	51	62	46	7/8-14	62	46
19	-12	0.750	19.05	1-3/16-12	102	75	102	75	1-1/16-12	102	75
22	-14	0.875	22.22	1-3/16-12	102	75	102	75	1-3/16-12	122	90
25	-16	1.000	25.40	1-7/16-12	142	105	142	105	1-5/16-12	142	105
32	-20	1.25	31.75	1-11/16-12	190	140	190	140	1-5/8-12	190	140
38	-24	1.50	38.10	2-12	217	160	217	160	1-7/8-12	217	160

NOTE: Torque tolerance is +15%, -20%

Face Seal Fittings With Metric Stud Ends Torque

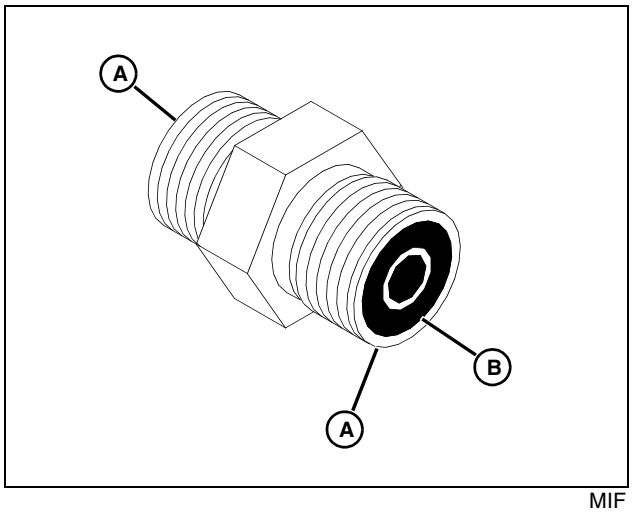


MIF

Nominal Tube OD/Hose ID				Face Seal Tube/Hose End						O-Ring Stud Ends, Straight Fitting or Locknut					
Metric Tube OD	Inch Tube OD			Thread Size	Hex Size	Tube Nut/ Swivel Nut Torque		Bulkhead Locknut Torque		Thread Size	Hex Size	Steel or Gray Iron Torque		Aluminum Torque	
mm	Dash Size	in.	mm	in.	mm	N•m	lb-ft	N•m	lb-ft	mm	mm	N•m	lb-ft	N•m	lb-ft
6	-4	0.250	6.35	9/16-18	17	16	12	12	9	M12X1.5	17	21	15.5	9	6.6
8	-5	0.312	7.94												
										M14X1.5	19	33	24	15	11
10	-6	0.375	9.52	11/16-16	22	24	18	24	18	M16X1.5	22	41	30	18	13
12	-8	0.500	12.70	13/16-16	24	50	37	46	34	M18X1.5	24	50	37	21	15
16	-10	0.625	15.88	1-14	30	69	51	62	46	M22X1.5	27	69	51	28	21
	-12	0.750	19.05	1-3/16-12	36	102	75	102	75	M27X2	32	102	75	46	34
22	-14	0.875	22.22	1-3/16-12	36	102	75	102	75	M30X2	36				
25	-16	1.000	25.40	1-7/16-12	41	142	105	142	105	M33X2	41	158	116	71	52
28										M38X2	46	176	130	79	58
32	-20	1.25	31.75	1-11/16-12	50	190	140	190	140	M42X2	50	190	140	85	63
38	-24	1.50	38.10	2-12	60	217	160	217	160	M48X2	55	217	160	98	72

NOTE: Torque tolerance is +15%, -20%

O-Ring Face Seal Fittings



MIF

1. Inspect the fitting sealing surfaces (A). They must be free of dirt or defects.

2. Inspect the O-ring (B). It must be free of damage or defects.

3. Lubricate O-rings and install into groove using petroleum jelly to hold in place during assembly.

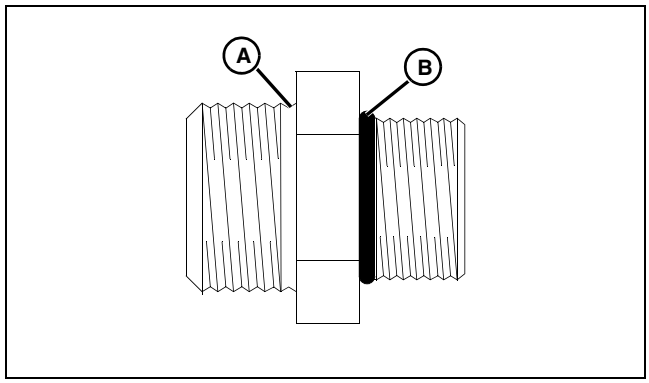
4. Index angle fittings and tighten by hand pressing joint together to insure O-ring remains in place.

IMPORTANT: Avoid damage! DO NOT allow hoses to twist when tightening fittings. Use two wrenches to tighten hose connections; one to hold the hose, and the other to tighten the swivel fitting.

5. Tighten fitting or nut to torque value shown on the chart per dash size stamped on the fitting.

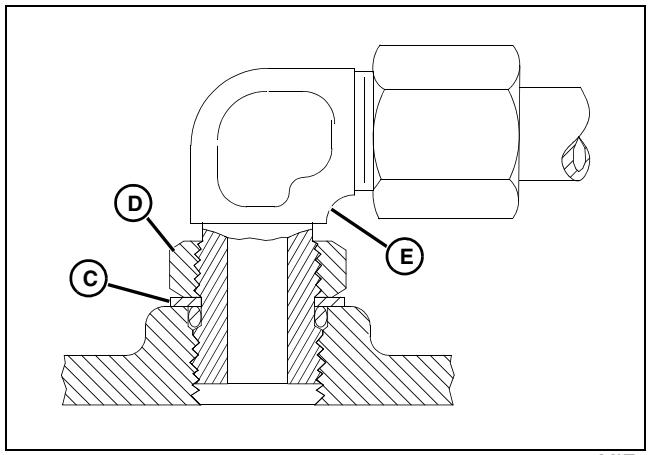
O-Ring Boss Fittings

1. Inspect boss O-ring boss seat. It must be free of dirt and defects. If repeated leaks occur, inspect for defects with a magnifying glass. Some raised defects can be removed with a slip stone.



MIF

2. Put hydraulic oil or petroleum jelly on the O-ring (B). Place electrical tape over the threads to protect O-ring from nicks. Slide O-ring over the tape and into the groove (A) of fitting. Remove tape.



MIF

3. For angle fittings, loosen special nut (D) and push special washer (C) against threads so O-ring can be installed into the groove of fitting.

4. Turn fitting into the boss by hand until special washer or washer face (straight fitting) contacts boss face and O-ring is squeezed into its seat.

5. To position angle fittings (E), turn the fitting counter-clockwise a maximum of one turn.

6. Tighten straight fittings to torque value shown on chart. For angle fittings, tighten the special nut to value shown in the chart while holding body of fitting with a wrench.

Straight Fitting or Special Nut Torques

Thread Size	Torque[a]		Number of Flats[b]
	N•m	lb-ft	
3/8-24 UNF	8	6	2
7/16-20 UNF	12	9	2
1/2-20 UNF	16	12	2
9/16-18 UNF	24	18	2
3/4-16 UNF	46	34	2
7/8-14 UNF	62	46	1-1/2
1-1/16-12 UN	102	75	1
1-3/16-12 UN	122	90	1
1-5/16-12 UN	142	105	3/4
1-5/8-12 UN	190	140	3/4
1-7/8-12 UN	217	160	1/2

[a]Torque tolerance is ± 10 percent.

[b]To be used if a torque wrench cannot be used. After tightening fitting by hand, put a mark on nut or boss; then tighten special nut or straight fitting the number of flats shown.

Metric Fastener Torque Value - Grade 7 (Special)

Size	Steel or Gray Iron Torque	Aluminum Torque
	N•m (lb-ft)	N•m (lb-ft)
M6	11 (8)	8 (6)
M8	24 (18)	19 (14)
M10	52 (38)	41 (30)
M12	88 (65)	70 (52)
M14	138 (102)	111 (82)
M16	224 (165)	179 (132)

Gasoline

4 - Cycle Engines

CAUTION: Avoid Injury! Gasoline is HIGHLY FLAMMABLE, handle it with care. DO NOT refuel machine while: indoors, always fill gas tank outdoors; machine is near an open flame or sparks; engine is running, STOP engine; engine is hot, allow it to cool sufficiently first; smoking.
Help prevent fires: fill gas tank to bottom of filler neck only; be sure fill cap is tight after fueling; clean up any gas spills IMMEDIATELY; keep machine clean and in good repair - free of excess grease, oil, debris, and faulty or damaged parts; any storage of machines with gas left in tank should be in an area that is well ventilated to prevent possible igniting of fumes by an open flame or spark, this includes any appliance with a pilot light. To prevent fire or explosion caused by STATIC ELECTRIC DISCHARGE during fueling:•ONLY use a clean, approved POLYETHYLENE PLASTIC fuel container and funnel WITHOUT any metal screen or filter.

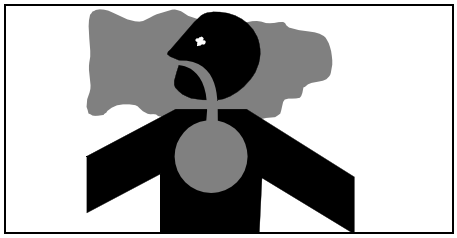
To avoid engine damage:

- DO NOT mix oil with gasoline;
- **ONLY use clean, fresh unleaded gasoline with an octane rating (anti-knock index) of 87 or higher**;
- fill gas tank at the end of each day's operation to help prevent condensation from forming inside a partially filled tank;
- keep up with specified service intervals.

Use of alternative oxygenated, gasohol blended, unleaded gasoline is acceptable as long as:

- the ethyl or grain alcohol blends DO NOT exceed 10% by volume or
- methyl tertiary butyl ether (MTBE) blends DO NOT exceed 15% by volume

RFG (reformulated) gasoline is acceptable for all machines designed for use of regular unleaded fuel. Older machines (that were designed for leaded fuel) may see some accelerated valve and seat wear.



MIF

IMPORTANT: Avoid damage! California Proposition 65 Warning: Gasoline engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

Gasoline Storage

IMPORTANT: Avoid damage! Keep all dirt, scale, water or other foreign material out of gasoline.

Keep gasoline stored in a safe, protected area. Storage of gasoline in a clean, properly marked ("UNLEADED GASOLINE") POLYETHYLENE PLASTIC container WITHOUT any metal screen or filter is recommended. DO NOT use de-icers to attempt to remove water from gasoline or depend on fuel filters to remove water from gasoline. Use a water separator installed in the storage tank outlet. BE SURE to properly discard unstable or contaminated gasoline. When storing the machine or gasoline, it is recommended that you add **John Deere Gasoline Conditioner and Stabilizer (TY15977)** or an equivalent to the gasoline. BE SURE to follow directions on container and to properly discard empty container.

Diesel Fuel

CAUTION: Avoid Injury! California Proposition 65 Warning: Diesel engine exhaust and some of its elements from this product are known to the State of California to cause cancer, birth defects, or other reproductive harm.

In general, diesel fuels are blended to satisfy the low air temperature requirements of the geographical area in which they are sold.

In North America, diesel fuel is usually specified to **ASTM D975** and sold as either **Grade 1** for cold air temperatures or **Grade 2** for warm air temperatures.

If diesel fuels being supplied in your area DO NOT meet any of the above specifications, use diesel fuels with the following equivalent properties:

- **Cetane Number 40 (minimum)**

A cetane number **greater than 50 is preferred**, especially for air temperatures below -20°C (-4°F) or elevations above 1500 m (5000 ft).

- **Cold Filter Plugging Point (CFPP)**

The air temperature at which diesel fuel **begins to cloud or jell** - at least 5°C (9°F) below the expected low air temperature range.

- **Sulfur Content of 0.05% (maximum)**

Diesel fuels for highway use in the United States now require sulfur content to be **less than 0.05%.**

If diesel fuel being used has a sulfur content **greater than 0.05%, reduce the service interval for engine oil and filter by 50%.**

Consult your local diesel fuel distributor for properties of the diesel fuel available in your area.

Diesel Fuel Lubricity

Diesel fuel must have adequate lubricity to ensure proper operation and durability of fuel injection system components. Fuel lubricity should pass a **minimum of 3300 gram load level** as measured by the **BOCLE** scuffing test.

Diesel Fuel Storage

IMPORTANT: Avoid damage! DO NOT USE GALVANIZED CONTAINERS - diesel fuel stored in galvanized containers reacts with zinc coating in the container to form zinc flakes. If fuel contains water, a zinc gel will also form. The gel and flakes will quickly plug fuel filters and damage fuel injectors and fuel pumps.

It is recommended that diesel fuel be stored **ONLY** in a clean, approved **POLYETHYLENE PLASTIC** container **WITHOUT** any metal screen or filter. This will help prevent any accidental sparks from occurring. Store fuel in an area that is well ventilated to prevent possible igniting of fumes by an open flame or spark, this includes any appliance with a pilot light.

IMPORTANT: Avoid damage! Keep all dirt, scale, water or other foreign material out of fuel.

Keep fuel in a safe, protected area and in a clean, properly marked **("DIESEL FUEL")** container. **DO NOT** use de-icers to attempt to remove water from fuel. **DO NOT** depend on fuel filters to remove water from fuel. It is recommended that a water separator be installed in the storage tank outlet. **BE SURE** to properly discard unstable or contaminated diesel fuel and/or their containers when necessary.

4 - Cycle Gasoline Engine Oil

Use the appropriate oil viscosity based on the expected air temperature range during the period between recommended oil changes. Operating outside of these recommended oil air temperature ranges may cause premature engine failure.

The following John Deere oils are PREFERRED:

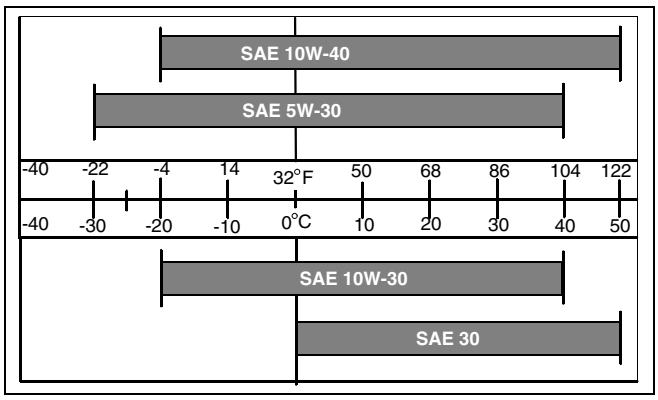
- **PLUS - 4® - SAE 10W-40**;
- **TORQ - GARD SUPREME® - SAE 5W-30**.

The following John Deere oils are **also recommended**, based on their specified temperature range:

- **TURF - GARD® - SAE 10W-30;**
- **PLUS - 4® - SAE 10W-30;**
- **TORQ - GARD SUPREME® - SAE 30.**

Other oils may be used if above John Deere oils are not available, provided they meet one of the following specifications:

- SAE 10W-40 - API Service Classifications SG or higher;
- SAE 5W-30 - API Service Classification SG or higher;
- SAE 10W-30 - API Service Classifications SG or higher;
- SAE 30 - API Service Classification SC or higher.



4 - Cycle Diesel Engine Oil

Use the appropriate oil viscosity based on the expected air temperature range during the period between recommended oil changes. Operating outside of these recommended oil air temperature ranges may cause premature engine failure.

The following John Deere oils are PREFERRED**:**

- **PLUS-50® - SAE 15W-40;**
- **TORQ-GARD SUPREME® - SAE 5W-30**.

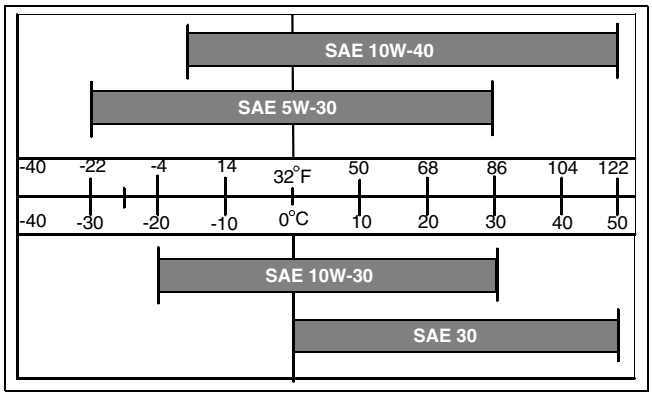
The following John Deere oils are **also** recommended, based on their specified temperature range:

- **TURF-GARD® - SAE 10W-30;**
- **PLUS-4® - SAE 10W-30;**
- **TORQ-GARD SUPREME® - SAE 30.**

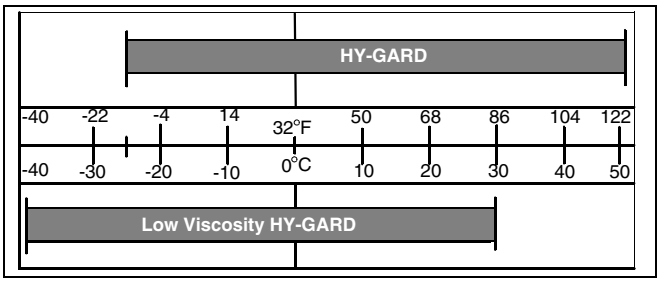
Other oils may be used if above John Deere oils are not available, provided they meet one of the following specifications:

- SAE 15W-40 - API Service Classifications CF - 4 or higher;
- SAE 5W-30 - API Service Classification CC or higher;
- SAE 10W-30 - API Service Classification CF or higher;
- SAE 30 - API Service Classification CF or higher.

IMPORTANT: Avoid damage! If diesel fuel with sulfur content greater than 0.5% is used, reduce the service interval for oil and filter by 50%.



Transaxle Oil



Use oil viscosity based on the expected air temperature range during the period between oil changes.

John Deere HY-GARD™ transmission and hydraulic oil is recommended for most normal operating temperatures.

NOTE: For temperatures below -13° C (0° F) John Deere low viscosity HY-GARD™ may be used. If used at temperatures above -13° C (0° F) some brake squeal may be heard due to lower viscosity of the oil at higher temperatures.

IMPORTANT: Avoid damage! Mixing of LOW VISCOSITY HY-GARD™ and HY-GARD™ oils is permitted. DO NOT mix any other oils in this transaxle. DO NOT use engine oil or "Type F" (Red) Automatic Transmission Fluid in this transaxle.

Other oils may be used if they meet John Deere standards JDM J20C and JDM J20D.

Alternative Lubricants

Use of alternative lubricants could cause reduced life of the component.

If alternative lubricants are to be used, it is recommended that the factory fill be thoroughly removed before switching to any alternative lubricant.

Synthetic Lubricants

Synthetic lubricants may be used in John Deere equipment if they meet the applicable performance requirements (industry classification and/or military specification) as shown in this manual.

The recommended air temperature limits and service or lubricant change intervals should be maintained as shown in the operator's manual, unless otherwise stated on lubricant label.

Avoid mixing different brands, grades, or types of oil. Oil manufacturers blend additives in their oils to meet certain specifications and performance requirements. Mixing different oils can interfere with the proper functioning of these additives and degrade lubricant performance.

Lubricant Storage

All machines operate at top efficiency only when clean lubricants are used. Use clean storage containers to handle all lubricants. Store them in an area protected from dust, moisture, and other contamination. Store drums on their sides. Make sure all containers are properly marked as to their contents. Dispose of all old, used containers and their contents properly.

Mixing of Lubricants

In general, avoid mixing different brands or types of lubricants. Manufacturers blend additives in their lubricants to meet certain specifications and performance requirements. Mixing different lubricants can interfere with the proper functioning of these additives and lubricant properties which will downgrade their intended specified performance.

Oil Filters

IMPORTANT: Avoid damage! Filtration of oils is critical to proper lubrication performance. Always change filters regularly.

The following John Deere oil filters are PREFERRED:

- AUTOMOTIVE AND LIGHT TRUCK ENGINE OIL FILTERS.

Most John Deere filters contain pressure relief and anti-drainback valves for better engine protection.

Other oil filters may be used if above recommended John Deere oil filters are not available, provided they meet the following specification:

- ASTB Tested In Accordance With SAE J806.

Brake Fluid

The following John Deere heavy duty brake fluid is PREFERRED for all drum and disc brakes:

- Brake Fluid - DOT3

Other brake fluids may be used if the above John Deere brake fluid is not available and they provide the following:

- DOT3 certified.
- Conforms to Motor Vehicle Safety Standard No. 116.

- Minimum wet boiling point 140°C (284°F).
- Minimum dry boiling point 232°C (450°F) to prevent vapor lock.

Engine Coolant

The engine cooling system when filled with a proper dilution mixture of anti-freeze and deionized or distilled water provides year-round protection against corrosion, cylinder or liner pitting, and winter freeze protection down to **-37°C (-34°F)**.

The following John Deere coolant is **PREFERRED**:

- **COOL-GARD® PRE-DILUTED SUMMER COOLANT (TY16036)**.

This coolant satisfies specifications for “Automobile and Light Duty Engine Service” and is safe for use in John Deere Lawn and Grounds Care/Golf and Turf Division equipment, including aluminum block gasoline engines and cooling systems.

The above preferred pre-diluted anti-freeze provides:

- adequate heat transfer
- corrosion-resistant chemicals for the cooling system
- compatibility with cooling system hose and seal material
- protection during extreme cold and extreme hot weather operations
- chemically pure water for better service life
- compliance with ASTM D4656 (JDM H24C2) specifications

If above preferred pre-diluted coolant is not available, the following John Deere concentrate is recommended:

- **COOL-GARD® CONCENTRATED SUMMER COOLANT (TY16034).**

If either of above recommended engine coolants are available use any Automobile and Light Duty Engine Service ethylene glycol base coolant, meeting the following specification:

- ASTM D4985 (JDM H24A2) Gas Engines.
- ASTM D3306 (JDM H24C1) Diesel Engines.

Read container label completely before using and follow instructions as stated.

IMPORTANT: Avoid damage! To prevent engine damage, DO NOT use pure anti-freeze or less than a 50% anti-freeze mixture in the cooling system. DO NOT mix or add any additives/ conditioners to the cooling system in Lawn and Grounds Care/Golf and Turf Division equipment. Water used to dilute engine coolant concentrate must be of high quality - clean, clear, potable water (low in chloride and hardness - Table 1) is generally acceptable. DO NOT use salt water. Deionized or distilled water is ideal to use. Coolant that is not mixed to these specified levels and water purity can cause excessive scale, sludge deposits, and increased corrosion potential.

Property	Requirements
Total Solids, Maximum	340 ppm (20 grns/gal)
Total Hardness, Maximum	170 ppm (10 grns/gal)
Chloride (as Cl), Maximum	40 ppm (2.5 grns/gal)
Sulfate (as SO4), Maximum	100 ppm (5.8 grns/gal)

Mix 50 percent anti-freeze concentrate with 50 percent distilled or deionized water. This mixture and the pre-diluted mixture (TY16036) will protect the cooling system down to **-37°C (-34°F)** and up to **108°C (226°F)**.

Certain geographical areas may require lower air temperature protection. See the label on your anti-freeze container or consult your John Deere dealer to obtain the latest information and recommendations.

Engine Coolant Drain Interval

When using John Deere Pre-Diluted (TY16036) Automobile and Light Duty Engine Service coolants, drain and flush the cooling system and refill with fresh coolant mixture every 36 months or 3,000 hours of operation, whichever comes first.

When using John Deere Concentrate (TY16034) Automobile and Light Duty Engine Service coolants, drain and flush the cooling system and refill with fresh coolant mixture every 24 months or 2,000 hours of operation, whichever comes first.

If above John Deere Automobile and Light Duty Engine Service coolants are not being used; drain, flush, and refill the cooling system according to instructions found on product container or in equipment operator’s manual or technical manual.

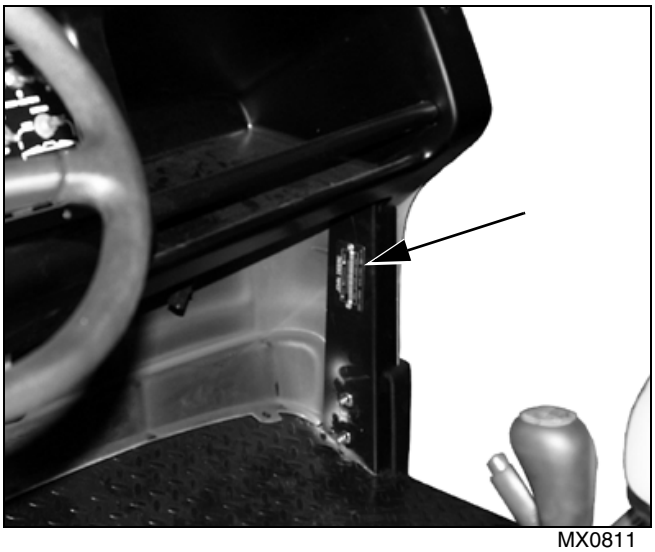
Product Identification

Identification Numbers

When ordering parts or submitting a warranty claim, it is IMPORTANT that you include the product identification number, and the component product identification numbers.

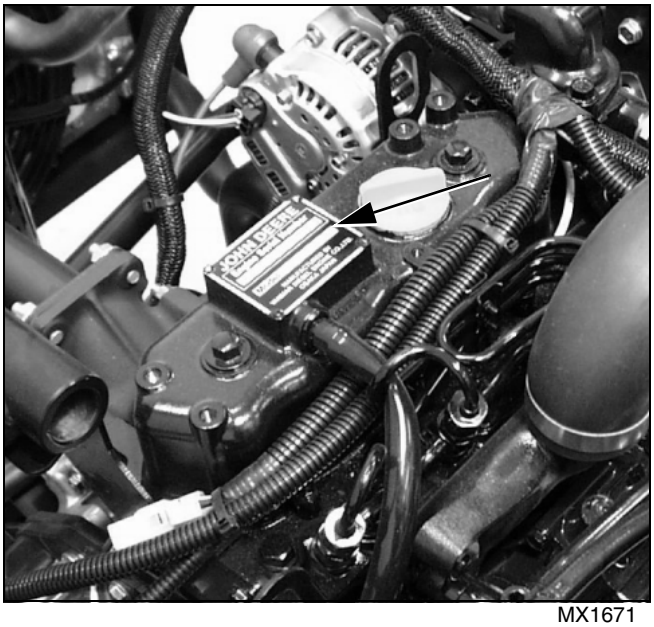
The location of the product identification numbers and component product identification numbers are shown.

Product Identification Number Locations



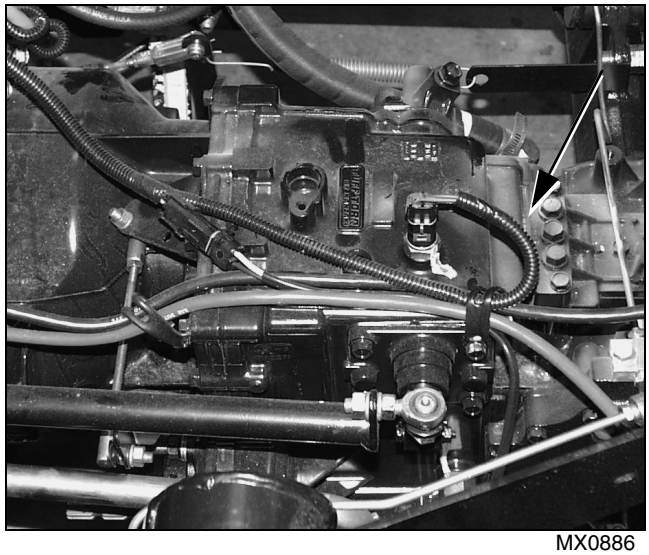
MX0811

Picture Note: Machine Product Identification Number



MX1671

Picture Note: Engine Product Identification Number



MX0886

Picture Note: Transaxle Product Identification Number

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Specifications

General Specifications

Make	John Deere/Yanmar
Model	3TG72-JUV
Type	4-cycle gasoline
Machine Model Used On	2020
Bore	72 mm (2.84 in.)
Stroke	72 mm (2.84 in.)
Cylinders	3
Valves	Overhead
Displacement	879 cm^3 (53.6 cu in.)
Maximum Torque (@ 2300 RPM)	64.5 N•m (47.6 lb ft)
Lubrication	Full pressure
Oil Filter	Full flow, spin-on filter
Crankcase Capacity with Oil Filter	3.2 L (3.5 qt)
Oil Capacity (with Filter) (Approximately)	2.2 L (2.3 qt)
Cooling System	Liquid with pump and radiator
Fuel Filter	Replaceable (in-line type)
Air Filter	Dry replaceable primary and secondary elements

Test and Adjustment Specifications

Engine

Fast Idle Speed	3570±50 rpm
Slow Idle Speed	1450±50 rpm
Electric Choke Engine Serial Number	-CH3009G007962
Manual Choke Engine Serial Number	CH3009G007963-
Throttle Start Position	4 mm (0.0157 in.)
Valve Clearance	0.15-0.25 mm (0.006-0.010 in.)
Cylinder Compression (Min)	772 kPa (112 psi)
Compression Differential (Max)	97 kPa (14 psi)
Fuel Pump Pressure (Min)	10.4 kPa (1.5 psi)
Fuel Pump Flow (Min in 15 Seconds)	105 mL (3.5 oz)
Oil Pressure (Min @ Fast Idle)	290 ± 50 kPa (42 ± 7 psi)
Thermostat Begin Open Temperature	71° C (160° F)
Thermostat Fully Open Temperature	85° C (184° F)
Spark Plug Gap	0.76 mm (0.030 in.)

Repair Specifications

Cylinder Head

Cylinder Head Distortion (Nominal)	0.05 mm (0.002 in.)
Cylinder Head Distortion (Max)	0.10 mm (0.004 in.)
Mill Cylinder Head No More Than	0.2 mm (0.008 in.)
Rocker Arm Shaft OD	11.966-11.984 mm (0.4711-0.4718 in.)
Rocker Arm Shaft OD Wear Limit	11.955 mm (0.4706 in.)
Rocker Arm ID	12.00-12.02 mm (0.472-0.473 in.)

Rocker Arm ID Wear Limit	12.09 mm (0.476 in.)
Rocker Arm-to-Shaft Oil Clearance	0.016-0.054 mm (0.0006-0.0021 in.)
Rocker Arm-to-Shaft Clearance Wear Limit	0.135 mm (0.006 in.)
Minimum Push Rod Length	141 mm (5.55 in.)
Push Rod Bend	0.0-0.3 mm (0.0-0.012 in.)

Valve Seat Width

Intake Valve	1.43 mm (0.056 in.)
Intake Valve Wear Limit	1.98 mm (0.078 in.)
Exhaust Valve	1.73 mm (0.068 in.)
Exhaust Valve Wear Limit	2.27 mm (0.089 in.)
Valve Recession (Max)	0.60 mm (0.024 in.)
Intake Valve Face Margin	0.99-1.29 mm (0.038-0.050 in.)
Exhaust Valve Face Margin	0.95-1.25 mm (0.037-0.049 in.)
Valve Face Margin Wear Limit	0.51 mm (0.020 in.)
Intake Valve Face Angle	30°
Exhaust Valve Face Angle	45°
Intake Valve Stem OD	6.96-6.98 mm (0.274-0.275 in.)
Intake Valve Stem OD Wear Limit	6.90 mm (0.272 in.)
Exhaust Valve Stem OD	6.95-6.96 mm (0.273-0.276 in.)
Exhaust Valve Stem OD Wear Limit	6.9 mm (0.272 in.)
Valve Guide ID	7.01-7.02 mm (0.275-0.276 in.)
Valve Guide ID Wear Limit	7.08 mm (0.279 in.)
Valve Guide Height	9.00 mm (0.354 in.)

Valve Guide-to-Valve Stem Oil Clearance

Intake	0.030-0.060 mm (0.001-0.002 in.)
Exhaust	0.045-0.075 mm (0.002-0.003 in.)
Wear Limit (Both)	0.15 mm (0.006 in.)
Maximum Spring Inclination	1.0 mm (0.039 in.)
Valve Spring Free Length (Nominal)	36.9 mm (1.453 in.)

Oil Pump

Oil Pressure Valve Spring Free Length	43.5-48.5 mm (1.7-1.9 in.)
Oil Pressure Valve Spring Test Length (@ 20.5 N [9.6 lb-force])	27.5 mm (1.08 in.)
Oil Pump Gear Backlash	0.11-0.19 mm (0.004-0.008 in.)
Oil Pump Gear Backlash (Max)	0.3 mm (0.012 in.)
Rotor Shaft-to-Backing Plate Clearance	0.013-0.043 mm (0.0005-0.002 in.)
Rotor Shaft-to-Backing Plate Clearance Wear Limit	0.2 mm (0.008 in.)
Rotor Recess	0.03-0.09 mm (0.001-0.004 in.)
Rotor Recess Wear Limit	0.25 mm (0.010 in.)
Outer Rotor-to-Pump Body Clearance	0.10-0.16 mm (0.004-0.006)
Outer Rotor-to-Pump Body Clearance Wear Limit	0.25 mm (0.006 in.)
Inner Rotor-to-Outer Rotor Clearance Wear Limit	0.25 mm (0.010 in.)

Timing Gear Wear Specifications

Idler Gear Bushing Diameter	20.08 mm (0.791 in.)
Idler Shaft Diameter	19.9 mm (0.783 in.)
Idler Shaft Oil Clearance	0.1 mm (0.004 in.)
Governor Gear Backlash (New)	0.11-0.30 mm (0.004-0.012 in.)
Governor Gear Backlash (Max)	0.38 mm (0.015 in.)

Camshaft

Backlash for All Timing Gears (Except Crankshaft Gear-to-Oil Pump Gear)	0.04-0.12 mm (0.002-0.005 in.)
Oil Pump Gear Backlash (Max)	0.3 mm (0.012 in.)
Camshaft End Play	0.05-0.15 mm (0.002-0.006 in.)
Camshaft End Play (Max)	0.4 mm (0.016 in.)
Camshaft Bend	0.00-0.02 mm (0.00-0.0008 in.)
Camshaft Bend (Max)	0.05 mm (0.002 in.)
Camshaft Lobe Height	33.95-34.05 mm (1.336-1.341 in.)
Camshaft Lobe Height Wear Limit	33.75 mm (1.329 in.)

Camshaft Bearing Journals

Timing Gear End Journal OD	39.94-39.96 mm (1.572-1.573 in.)
Timing Gear End Journals OD Wear Limit	39.85 mm (1.569 in.)
Intermediate Journals OD	39.91-39.94 mm (1.571-1.572 in.)
Intermediate Journal OD Wear Limit	39.85 mm (1.569 in.)
Flywheel End Journal OD	39.91-39.94 mm (1.571-1.572 in.)
Flywheel End Journal OD Wear Limit	39.85 mm (1.569 in.)
Camshaft Bushing ID	40.000-40.065 mm (1.5748-1.5774 in.)
Camshaft Bushing ID Wear Limit	40.100 mm (1.5787 in.)
Camshaft Bushing ID Oil Clearance	0.040-0.085 mm (0.002-0.003 in.)
Camshaft Intermediate Bore ID	40.000-40.025 mm (1.5748-1.5757 in.)
Camshaft Intermediate Bore ID Wear Limit	40.100 mm (1.5787 in.)
Camshaft Intermediate Bore ID Oil Clearance	0.065-0.115 mm (0.003-0.005 in.)
Camshaft Flywheel End Bore ID	40.000-40.025 mm (1.5748-1.5757 in.)
Camshaft Flywheel End Bore ID Wear Limit	40.100 mm (1.5787 in.)
Camshaft Flywheel End Bore ID Oil Clearance	0.040-0.125 mm (0.002-0.005 in.)

Crankshaft

Crankshaft Connecting Rod Journal OD	39.97-39.98 mm (1.573-1.574 in.)
Crankshaft Connecting Rod Journal OD Wear Limit	39.92 mm (1.572 in.)
Crankshaft Main Bearing Journal OD	43.97-43.98 mm (1.7311-1.7315 in.)
Crankshaft Main Bearing Journal OD Wear Limit	43.92 mm (1.7291 in.)
Main Bearing ID	44.000-44.0420 mm (1.7323-1.7339 in.)
Main Bearing ID Wear Limit	44.070 mm (1.7350 in.)
Crankshaft Main Bearing Oil Clearance	0.020-0.072 mm (0.0008-0.0028 in.)
Crankshaft Main Bearing Clearance Wear Limit	0.15 mm (0.006 in.)
Connecting Rod Bearing Oil Clearance	0.020-0.072 mm (0.0008-0.0028 in.)
Connecting Rod Bearing Clearance Wear Limit	0.15 mm (0.006 in.)
Connecting Rod Side Play (Max)	0.80 mm (0.031 in.)

Connecting Rod

Crankshaft Connecting Rod Journal OD	39.97-39.98 mm (1.573-1.574 in.)
Crankshaft Connecting Rod Journal OD Wear Limit	39.92 mm (1.572 in.)
Connecting Rod Bearing ID (Max)	40.07 mm (1.577 in.)
Piston Pin Bushing ID	21.025-21.038 mm (0.828-0. 828 in.)
Piston Pin Bushing ID Wear Limit	21.10 mm (0.831 in.)
Piston Pin-to-Bushing Oil Clearance	0.000-0.018 mm (0.0000-0.0007 in.)
Piston Pin-to-Bushing Clearance Wear Limit	0.045 mm (0.0018 in.)

Piston Ring Groove Side Clearance

Top Piston Ring	0.075-0.110 mm (0.0029-0.0043 in.)
Top Piston Ring (Max)	0.20 mm (0.008 in.)
Second Piston Ring	0.030-0.065 mm (0.0012-0.0026 in.)
Second Piston Ring (Max)	0.20 mm (0.008 in.)
Oil Control Ring	0.020-0.055 mm (0.0008-0.0022 in.)
Oil Control Ring (Max)	0.20 mm (0.008 in.)

Piston Ring End Gap

Top Ring End Gap (Max)	1.25 mm (0.049 in.)
Second Ring End Gap (Max)	1.25 mm (0.049 in.)
Oil Control Ring End Gap (Max)	1.90 mm (0.075 in.)

Piston

Piston Pin OD	20.99-21.00 mm (0.826-0.827 in.)
Piston Pin OD Wear Limit	20.90 mm (0.823 in.)
Piston Pin Bore ID	21.00-21.01 mm (0.827-0.827 in.)
Piston Pin Bore ID Wear Limit	21.02 mm (0.828 in.)
Piston Pin-to-Bore Clearance	0.000-0.017 mm (0.00-0.0018 in.)
Piston Pin-to-Bore Wear Limit	0.12 mm (0.005 in.)
Piston OD Wear Limit	71.90 mm (2.831 in.)
Piston Measurement Distance	6 mm (0.236 in.)
Piston-to-Cylinder Clearance (Max)	0.015 mm (0.006 in.)

Cylinder Block

Cylinder Bore (Standard Size)	72.00-72.03 mm (2.834-2.836 in.)
Cylinder Bore Wear Limit (Standard Size)	72.15 mm (2.841 in.)
Piston-to-Cylinder Clearance (Max)	0.15 mm (0.006 in.)
Cylinder Roundness	0.00-0.01 mm (0.00-0.0004 in.)
Cylinder Roundness (Max)	0.03 mm (0.001 in.)
0.25 mm (0.010 in.) Oversize Bore ID	72.25-72.28 mm (2.844-2.845 in.)
0.25 mm (0.010 in.) Oversize Bore ID Wear Limit	72.45 mm (2.852 in.)

Torque Specifications

NOTE: Use appropriate torque wrench which will read within the inch pound range given, or convert inch pounds to foot pounds as follows: 12 Inch-pounds = 1 Foot-pounds

Camshaft Thrust Plate Cap Screw	**11 N•m (96 lb-in.)**
Connecting Rod Cap Screw	**23 N•m (203 lb-in.)**
Crankshaft Main Bearing Cap Screw	**78 N•m (58 lb-ft)**
Cylinder Head Cap Screw	
Initial	**30.9 N•m (23 lb-ft)**
Final	**61.3 N•m (45 lb-ft)**
Rocker Arm Cover Special Nut	**18 N•m (160 lb-in.)**
Rocker Arm Support Cap Screw and Nut	**26 N•m (226 lb-in.)**
Flywheel Cap Screw	**83.4 N•m (62 lb-ft)**
Clutch Cover Cap Screw	**28 N•m (20 lb-ft)**
Timing Gear Housing Cap Screw	**9 N•m (78 lb-in.)**
Timing Gear Housing Cover Cap Screw	**9 N•m (78 lb-in.)**
Crankshaft Pulley Cap Screw Torque	**88 N•m (65 lb-ft)**
Manifold	
Intake Manifold Cap Screw	**11 N•m (97 lb-in.)**
Carburetor Mounting Cap Screw	**21 N•m (180 lb-in.)**
Exhaust Manifold Cap Screw	**26 N•m (230 lb-in.)**
Muffler Flange Nut	**24.4 N•m (216 lb-in.)**
Oll Pan Cap Screws Threading in Block	**11 N•m (96 lb-in.)**
Oil Pan Cap Screws Threading in Aluminum	**9 N•m (78 lb-in.)**
Oil Pressure Switch	**7.9 N•m (70 lb-in.)**
Oil Pump Attaching Cap Screw	**11 N•m (96 lb-in.)**
Oil Pressure Valve Spring Retaining Nut	**30 N•m (22 lb-ft)**
Spark Plug	**20 N•m (180 lb-in.)**
Starting Motor Mounting Cap Screw	**24 N•m (216 lb-in.)**
Thermostat Cover Cap Screw	**20 N•m (177 lb-in.)**
Subframe Mounting Cap Screw	**80 N•m (60 lb-ft)**
Coolant Pump	
Plate Screw	**9 N•m (78 lb-in.)**
Pulley Cap Screw	**11 N•m (96 lb-in.)**
Attaching Cap Screw	**20 N•m (177 lb-in.)**

Tools and Materials

Special or Required Tools

Special or Required Tools

Tool Name	Tool No.	Tool Use
Reaming Tool (7.05 mm)	D20020WI	Used to clean or size valve guides.
Valve Spring Compressor	JDM70	Used to remove and install valve springs.
Tachometer or Digital Pulse Tachometer	JT05719 or JT07270	Used for low idle adjustment and to check fast idle.
Pressure Test Kit	JDG356	Used to check fuel pump pressure.
Spark Plug Ground	JDM74A5	Used to prevent accidental engine starting during tests.
Compression Gauge	JDM59	Used for cylinder compression test.
Connector	JT03349	Used for oil pressure test.
Hose Assembly	JT03017	Used for oil pressure test.
0-700 kPa (0-100 psi) Gauge	JT07034	Used for oil pressure test.
Dial Indicator	NA	Used for valve lift, end play, and backlash measurements.
PLASTIGAGE® Bearing Clearance Measurement Tool	NA	Used to measure clearance.

Other Materials

Other Material

Part No.	Part Name	Part Use
NA	Abrasive Sheets/ Pads	Used to clean cylinder head.

Other Material

Part No.	Part Name	Part Use
TY15130 (U.S.)	Form-in-Place Gasket	Seals crankcase extension housing, rear oil seal case, timing gear cover, and flywheel housing to engine block. Seals oil pan to timing gear housing and engine block.

Diagnostics

Gas Engine Troubleshooting

Symptom: Engine Will Not Crank

(1) Proper starting procedure being used is correct for conditions?

Yes - Go to step (2).

No - Use correct procedure for conditions See the Operator's Manual.

(2) Battery 12.7 VDC or higher?

Yes - Go to step (3).

No - Charge and check battery. (See "Battery Test" on page 305.)

(3) No open circuits in wiring?

Yes - Go to step (4).

No - Repair or replace as needed. (See "Common Circuit Tests" on page 185.)

(4) Starting motor functioning properly?

No - Repair or replace starting motor.

CAUTION: Avoid injury! To avoid electric shock, DO NOT hold spark plug. Instead, make sure to hold plug cap.

Symptom: Engine Hard to Start

(1) Does engine continue to run when key switch is released from the START position?

Yes - Go to step (2).

No - Ignition start diode may be faulty. (See "Diode Test" on page 325.)

No - Ignition switch may be faulty. (See "Key Switch Test" on page 315.)

(2) Perform spark output test. Is adequate spark available at all spark plugs?

Yes - Go to step (3).

No - Ignition coil or high tension lead may be faulty. (See "Ignition Coil Test" on page 326.)

No - Pulser coil may be faulty. (See "Pulser Coil Test" on page 327.)

No - Start diode may be faulty. (See "Diode Test" on page 325.)

Symptom: Engine Hard to Start

(3) Are spark plugs fouled or is insulation cracked?

Yes - Replace spark plugs.

No - Go to step (4) if problem continues..

(4) Is the fuel tank filled with fresh, clean fuel of the correct grade?

Yes - Go to step (5).

No - Fill the tank with fresh, clean fuel of the correct type. (See "Gasoline" on page 19.)

(5) Are the fuel hoses and fuel filter free of obstructions?

Yes - Go to step (6).

No - Clear fuel lines and/or replace fuel filter.

(6) Is the fuel tank cap breather hole free of obstructions?

Yes - Go to step (7).

No - Clear obstructions from breather hole.

(7) Is choke operating correctly?

Yes - Go to step (8).

No - Test and adjust choke coil. (See "Choke Coil Test" on page 325. See "Replace Choke Cover (Electric Choke)" on page 50.)

(8) Does the fuel pump operate within specifications? (Perform fuel pump flow rate test. (See "Test Fuel Pump Flow" on page 43.)

Yes - Go to step (9).

No - Replace the fuel pump. (See "Remove and Install Fuel Pump" on page 51.)

(9) Is fuel shutoff solenoid operating properly? (Perform fuel shutoff solenoid test. (See "Fuel Shutoff Solenoid Test - Gasoline Engine" on page 324.)

Yes - Go to step (10).

No - Replace fuel shutoff solenoid. (See "Inspect Carburetor" on page 46.)

(10) Are air filter elements in good condition, not clogged?

Yes - Go to step (11).

No - Clean and/or replace air filter elements.

Symptom: Engine Hard to Start

(11) Is the carburetor operating and/or adjusted properly?

Yes - Go to step (12).

No - See “Inspect Carburetor” on page 46.

(12) Engine oil of correct viscosity and type?

Yes - Go to step (13).

No - Replace engine oil with oil of proper viscosity and type. Replace oil filter.

(13) Is engine compression within specifications? (Preform cylinder compression test. See “Test Cylinder Compression” on page 41.)

No - Proceed as directed in “Results”.

CAUTION: Avoid injury! To avoid electric shock, DO NOT hold spark plug. Instead, make sure to hold cap.

Symptom: Engine Malfunctions at Low Speed

(1) Perform spark output test. Is adequate spark available at all spark plugs?

Yes - Go to step (2).

No - Ignition coil or high tension lead may be faulty. (See “Ignition Coil Test” on page 326.)

No - Pulser coil may be faulty. (See “Pulser Coil Test” on page 327.)

(2) Are spark plugs fouled or is insulation cracked?

Yes - Replace spark plugs.

No - Go to step (3) if problem continues..

(3) Are carburetor-to-intake manifold connections tight?

Yes - Go to step (4).

No - Flange nuts may be loose. Tighten flange nuts.

No - Gasket may be damaged. Replace gasket. (See “Remove and Install Carburetor” on page 45.)

(4) Are the fuel hoses and fuel filter free of obstructions?

Yes - Go to step (5).

No - Clear fuel lines and/or replace fuel filter.

Symptom: Engine Malfunctions at Low Speed

(5) Is the fuel tank cap breather hole free of obstructions?

Yes - Go to step (6).

No - Clear obstructions from breather hole.

(6) Start engine and run it at slow idle. Is exhaust free of unusual black smoke?

Yes - Go to step (7).

No - Check for plugged air filter elements.

No - Over-rich carburetor slow idle circuit. Adjust idle mixture screw.

No - Check for damaged float valve or misadjusted float. (See “Inspect Carburetor” on page 46.)

No - Choke not opening completely. (See “Choke Coil Test” on page 325. See “Replace Choke Cover (Electric Choke)” on page 50.)

(7) Gradually open throttle valve by hand. Does engine accelerate smoothly through all throttle positions?

Yes - Go to step (8).

No - Passages in carburetor may be plugged. Clean the carburetor.

(8) Stop engine and check valve clearance. Is clearance within specifications?

Yes - Go to step (9).

No - Adjust valve clearance. (See “Adjust Valve Clearance” on page 40.)

(9) Is alignment of timing gears correct?

No - Align timing gears. (See “Remove and Install Camshaft” on page 69.)

Symptom: Engine Runs Erratically

(1) Perform spark output test. Is adequate spark available at all spark plugs?

Yes - Go to step (2).

No - Ignition coil or high tension lead may be faulty. (See “Ignition Coil Test” on page 326.)

No - Pulser coil may be faulty. (See “Pulser Coil Test” on page 327.)

No - Ballast resistor may be faulty or connections may be loose. (See “Ignition Ballast Resistor Test” on page 327.)

Symptom: Engine Runs Erratically

(2) Are spark plugs fouled or is insulation cracked?

Yes - Go to step (3).

No - Go to next step.

(3) Are carburetor-to-intake manifold connections tight?

Yes - Go to step (4).

No - Flange nuts may be loose. Tighten flange nuts.

No - Gasket may be damaged. Replace gasket. (See "Remove and Install Carburetor" on page 45.)

(4) Are the fuel hoses and fuel filter free of obstructions?

Yes - Go to step (5).

No - Clear fuel lines and/or replace fuel filter.

(5) Is the fuel tank cap breather hole free of obstructions?

Yes - Go to step (6).

No - Clear obstructions from breather hole.

(6) Is the fuel system operating and/or adjusted properly?

Yes - Go to step (7).

No - Air or vapor lock in fuel line. Bleed the fuel line.

No - Fuel line is pinched or sucking air. Repair as necessary.

No - Carburetor fitted with high altitude jetting. Replace with correct main jets.

No - Plugged air and/or fuel passages in carburetor. Clean the carburetor. (See "Inspect Carburetor" on page 46.)

(7) Is the governor system operating properly?

No - Governor linkage may be incorrectly adjusted. (See "Adjust Throttle Cable and Governor - S.N. (-020056)" on page 38.)

No - Governor spring may be faulty. Replace spring.

No - Governor flyweight assembly may be faulty. (See "Remove and Inspect Governor" on page 72.)

Symptom: Oil Consumption Is Excessive

(1) Is engine compression within specifications? (Perform cylinder compression test. See "Test Cylinder Compression" on page 41.)

Yes - Go to step (2).

No - Proceed as directed in "Results".

(2) Is the engine oil level correct?

Yes - Go to step (3).

No - Engine oil level may be too high. Drain engine oil and refill to proper level.

(3) Is the engine oil viscosity correct?

Yes - Go to step (4).

No - Drain engine oil and refill with proper viscosity. (See "4 - Cycle Gasoline Engine Oil" on page 21.)

(4) Is the engine oil drain plug properly tightened, free of leakage?

Yes - Go to step (5).

No - Tighten drain plug.

(5) Is the crankcase breather tube free of obstructions?

Yes - Go to step (6).

No - Clean breather tube.

(6) Are valve stems and/or valve guides in good condition, not worn?

Yes - Go to step (7).

No - Inspect valves and valve guides. Replace parts as needed. (See "Inspection and Replacement" on page 60.)

(7) Is drain-back hole in the tappet chamber free of obstructions?

Yes - Go to step (8).

No - Clear drain-back hole.

(8) Are areas around crankshaft oil seals free of leakage?

No - Replace oil seals. (See "Remove and Install Crankshaft Front Oil Seal" on page 66. See "Remove and Install Crankshaft Rear Oil Seal" on page 87.)

Symptom: Engine Has Low Power

(1) Perform spark output test. Is adequate spark available at all spark plugs?

Yes - Go to step (2).

No - Ignition coil or high tension lead may be faulty. (See “Ignition Coil Test” on page 326.)

No - Pulser coil may be faulty. (See “Pulser Coil Test” on page 327.)

(2) Are spark plugs fouled or is insulation cracked?

Yes - Replace spark plugs.

No - Go to step (3) if problem continues..

(3) Does the engine run within normal operating temperature, does not overheat?

Yes - Go to step (4).

No - Engine load may be excessive. Reduce engine load.

No - Dirty or clogged intake screen, radiator fins or core. Clean or repair as necessary.

(4) Does the engine run smoothly, does not knock?

Yes - Go to step (5).

No - There may be too much or too little engine oil in crankcase. Drain and fill engine oil to proper level.

No - Fuel may be stale. Drain fuel tank and refill with fresh fuel.

No - Engine load may be excessive. Adjust load on engine.

No - Engine may have excessive carbon deposits. Remove carbon deposits.

(5) Is the lubrication system operating normally? (Perform engine oil pressure test. See “Test Oil Pressure” on page 44.)

Yes - Go to step (6).

No - Engine oil may have excessive contamination. Drain and fill engine oil to proper level.

(6) Is engine exhaust free of any unusual smoke?

Yes - Go to step (7).

No - Crankcase may have too much engine oil. Drain/fill engine oil to proper level.

No - Air cleaner may be clogged. Clean or replace air cleaner elements.

No - Carburetor float misadjusted. (See “Inspect Carburetor” on page 46.)

Symptom: Engine Has Low Power

No - Carburetor float valve damaged. (See “Inspect Carburetor” on page 46.)

No - Carburetor may be fitted with high altitude jetting. Install correct main jets.

No - Carbon deposits may be present in exhaust port and muffler. Remove carbon deposits.

(7) Is engine compression within specifications? (Perform cylinder compression test. See “Test Cylinder Compression” on page 41.)

No - Proceed as directed in “Results”.

Symptom: Fuel Consumption Is Excessive

(1) Perform spark output test. Is adequate spark available at all spark plugs?

Yes - Go to step (2).

No - Ignition coil or high tension lead may be faulty. (See “Ignition Coil Test” on page 326.)

No - Pulser coil may be faulty. (See “Pulser Coil Test” on page 327.)

(2) Are spark plugs fouled or is insulation cracked?

Yes - Replace spark plugs.

No - Go to step (3) if problem continues..

(3) Is engine compression within specifications? (Perform cylinder compression test. See “Test Cylinder Compression” on page 41.)

Yes - Go to step (4).

No - Proceed as directed in “Results”.

(4) Is the engine free of excessive loads?

Yes - Go to step (5).

No - Reduce engine load.

(5) Is choke fully open?

Yes - Go to step (6).

No - Adjust or repair choke.

(6) Are air filter elements in good condition, not clogged?

Yes - Go to step (7).

No - Clean and/or replace air filter elements.

Symptom: Fuel Consumption Is Excessive

(7) Is the carburetor float properly adjusted, float valve not damaged?

No - Adjust carburetor float. (See “Inspect Carburetor” on page 46.)

No - Replace carburetor float valve if damaged. (See “Inspect Carburetor” on page 46.)

Tests and Adjustments

Adjust Throttle Cable and Governor - S.N. (-020056)

Reason

To make sure the throttle cable moves the throttle lever through its full range of movement.

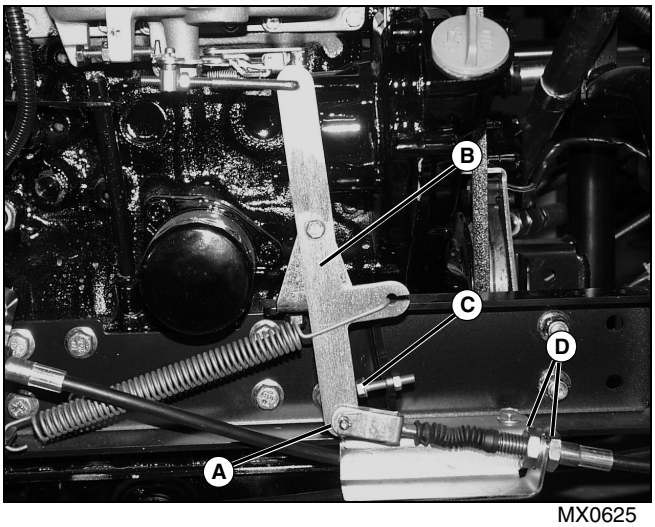
Special or Required Tools

Tool Name	Tool No.	Tool Use
Digital Pulse Tachometer	JT07270	Used to check engine rpm's.

Procedure

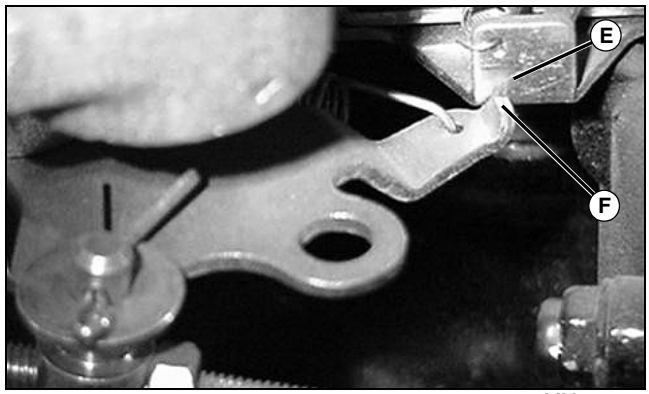
1. Park machine on a level surface and lock park brake.
2. Shut off engine, remove key.

CAUTION: Avoid injury! Stay clear of rotating parts during tests.



MX0625

3. Disconnect throttle cable (A).
4. Start engine, move throttle lever (B) to fast idle position against stop (C) and check rpms with digital pulse tachometer.
5. If fast idle speed is above or below specified rpm, loosen locknut on throttle arm stop, and adjust stop until specified rpm is obtained. Shut off engine.
6. Reconnect throttle cable.
7. Depress throttle pedal all the way to floor.
8. With throttle pedal in full throttle position, throttle arm should be touching arm stop. If throttle arm does not contact stop, or if throttle arm contacts stop before throttle pedal contacts floor, loosen adjustment nuts (D) and adjust cable until throttle arm is contacting arm stop when throttle pedal is contacting floor.
9. Tighten throttle cable adjusting nuts.



MX18115

NOTE: After adjustment, be sure throttle lever (F) touches stop (E) when in the slow idle position. If not, adjust slow idle. (See "Adjust Slow Idle Speed" on page 40.)

Specifications

Fast Idle Speed. . . . . .3570±50 rpm

Adjust Throttle Cable and Governor - S.N. (020057-)

Reason

To make sure the throttle cable moves the throttle lever through its full range of movement.

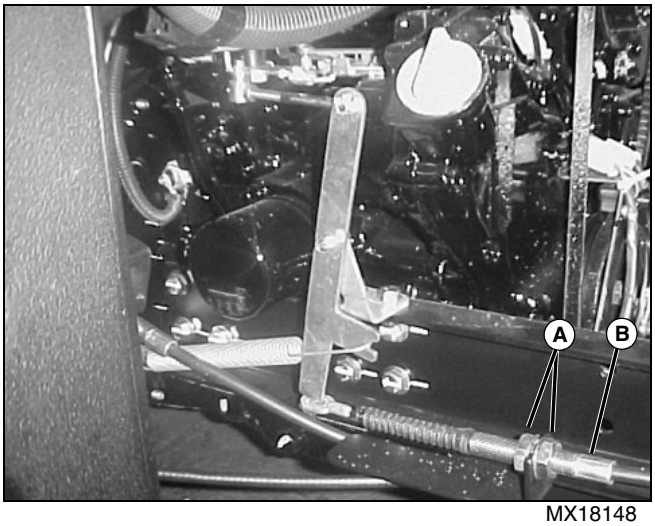
Special or Required Tools

Tool Name	Tool No.	Tool Use
Digital Pulse Tachometer	JT07270	Used to check engine rpm's.

Procedure

1. Park machine on a level surface and lock park brake.
2. Shut off engine, remove key.

CAUTION: Avoid injury! Stay clear of rotating parts during tests.



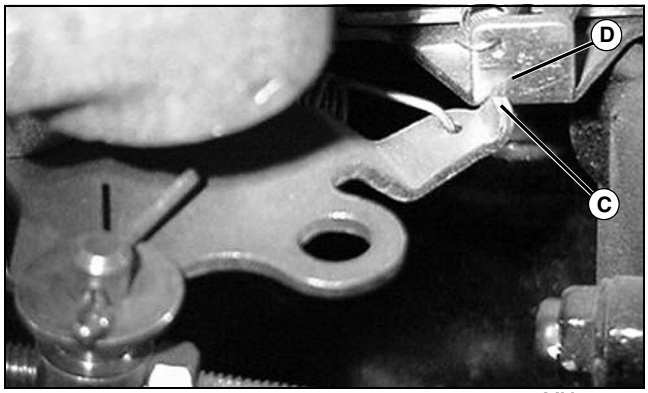
MX18148

3. Start engine and depress throttle pedal all the way to floor.

4. Check engine rpm with JT07270 Digital Pulse Tachometer.

5. If fast idle speed is above or below specified rpm, loosen adjusting nuts (A), and adjust throttle cable (B) until specified rpm is obtained. Shut off engine.

6. Tighten throttle cable adjusting nuts.



MX18115

NOTE: After adjustment, be sure throttle lever (C) touches stop (D) when in the slow idle position. If not, adjust slow idle. (See "Adjust Slow Idle Speed" on page 40.)

Specifications

Fast Idle Speed . . . . . 3570±50 rpm

Adjust Choke Cable (Manual Choke)

Reason

To set proper choke to prevent spark plug fouling, misfire, or poor performance.

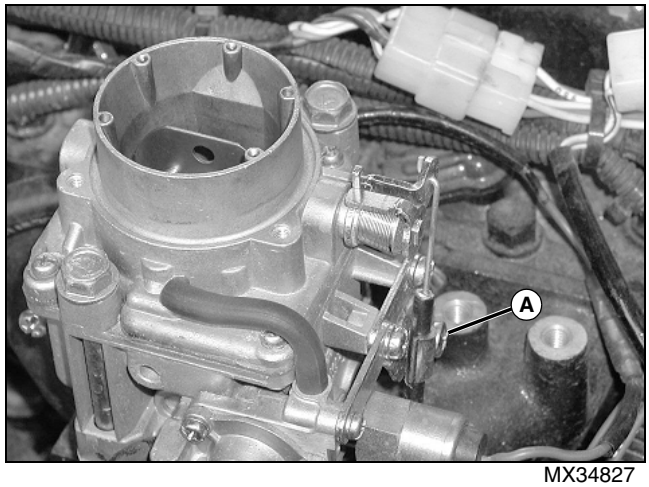
Engine Serial NumberCH3009G007963-

Procedure

1. Move transaxle shift lever to NEUTRAL. Lock park brake.

2. Shut off engine, remove key.

3. Remove air intake from carburetor.



MX34827

4. Loosen cable clamp screw (A).

5. Adjust cable so choke plate is fully open when the choke knob is raise 2 - 3 mm (0.08 - 0.12 in.).

6. Tighten cable clamp screw.

7. Verify function of choke knob in fully open and closed positions. Adjust if necessary.

8. Install air intake hose.

Adjust Slow Idle Speed

Reason

To set engine slow idle rpms.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Digital Pulse Tachometer	JT07270	Used to check engine rpm's.

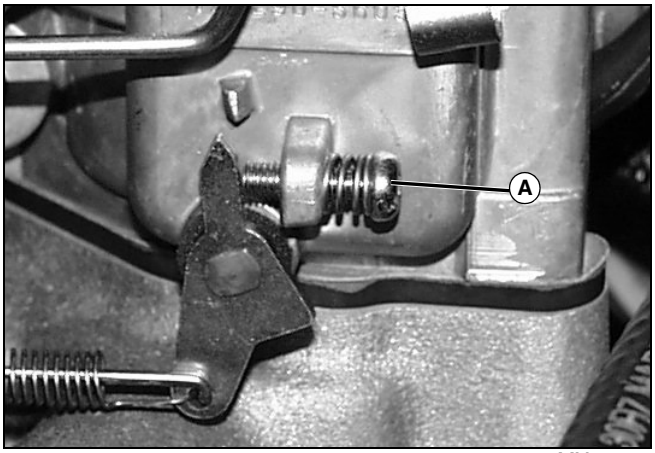
Procedure

1. Move transaxle shift lever to NEUTRAL. Lock park brake.

IMPORTANT: Avoid damage! DO NOT remove air cleaner for tests.

2. Start and warm engine.

3. Use a digital pulse tachometer to check engine slow idle rpm at spark plug wire.



MX0669

4. Turn slow idle stop screw (A) in either direction until specified slow idle speed is reached.

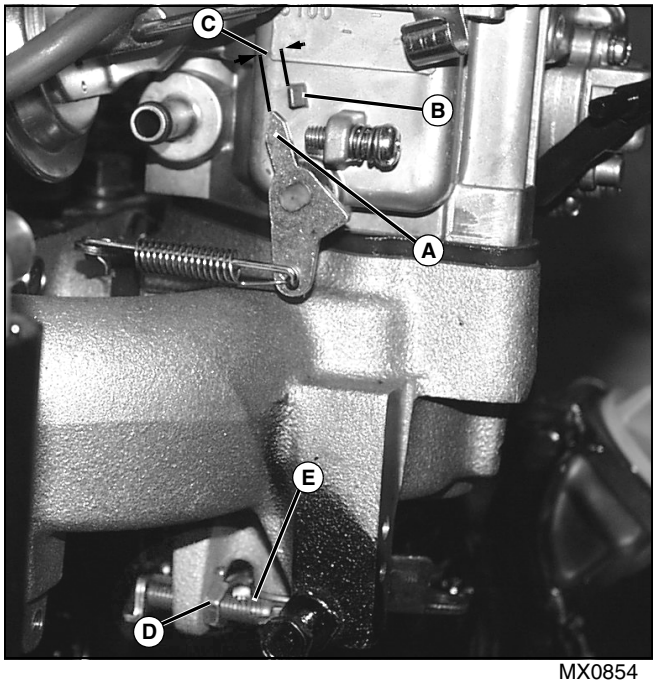
5. Move throttle between slow idle and fast idle several times. Check slow idle rpm. It may be necessary to adjust slow idle stop screw again.

Specifications

Slow Idle Speed . . . . . 1450±50 rpm

Adjust Throttle Start Position Screw

1. With engine OFF press accelerator pedal to at least 1/2 throttle and hold or block pedal.



MX0854

2. Measure distance between pointer (A) on throttle shaft, and pointer (B) on carburetor. If distance (C) is not within specification, loosen locknut (D) and adjust screw (E) until distance is correct.

3. Hold screw and tighten locknut.

Specifications

Throttle Start Position . . . . . 4 mm (0.0157 in.)

Adjust Valve Clearance

Reason

To be sure valves are fully opening at the correct time, but not remaining open too long or wearing valve train unnecessarily.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Feeler Gauge	NA	Used to measure valve clearance.

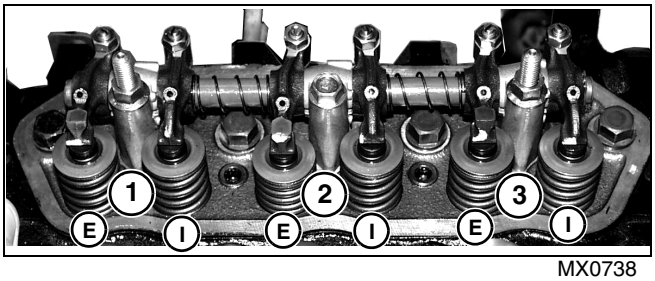
Procedure

1. Engine must be cool (room temperature) before valve clearance is checked.

2. Be sure ignition key is OFF before attempting to turn engine by hand.

3. Remove rocker arm cover.

NOTE: Top Dead Center (TDC) is when the piston is at it's highest point of travel in the cylinder on the compression stroke. The valves must be checked with piston at or near TDC. Number one cylinder is located at rear of engine (flywheel side).



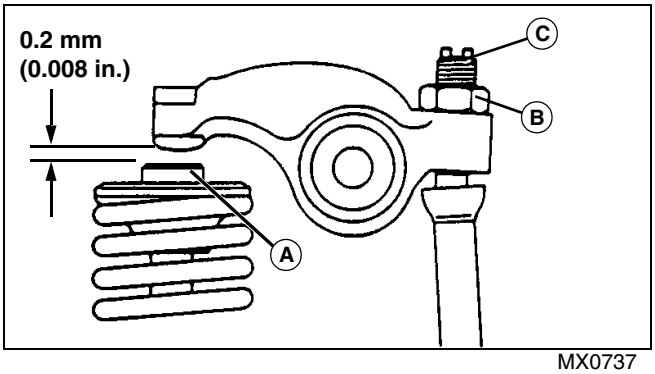
MX0738

Picture Note: I = Intake, E = Exhaust

4. Using a 17 mm wrench, turn the crankshaft pulley in the direction of engine rotation while watching the rocker arms of the number one cylinder. When the intake valve has completely closed (raised up), turn the crankshaft an additional 1/2 turn.

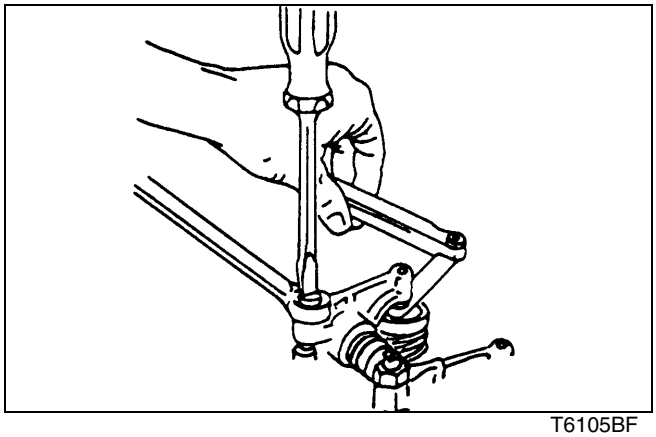
5. Try to move rocker arms and/or push rods for the cylinder to be adjusted.

- If both rocker arms and push rods are loose, the piston is near TDC on the compression stroke and you may proceed to step 6.
- If rocker arms and/or push rods are not loose, repeat step four.



MX0737

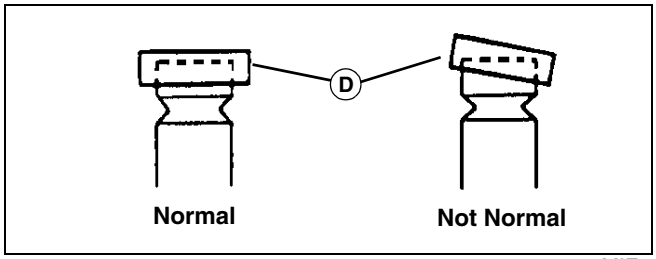
6. Slide 0.2 mm (0.008 in.) feeler gauge between valve cap (A) and rocker arm. There should be a slight drag on the feeler gauge when the clearance is correct.



T6105BF

7. To adjust valves, loosen locknut (B) and turn adjusting screw (C) until blade of feeler gauge has a slight drag when inserted between rocker arm and valve cap. Hold adjusting screw while tightening locknut.

8. Recheck valve clearance after tightening locknut.



MIF

9. Check that valve cap (D) on end of valve stem remained seated on valve and inside valve spring retainer.

10. Repeat steps 4-9 for number two and three cylinders.

11. Install rocker arm cover.

Specifications

Valve Clearance . . . . . 0.15-0.25 mm (0.006-0.010 in.)

Test Cylinder Compression

Reason

To check pressure capacity of piston rings and cylinder bore for efficient engine operation.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Compression Gauge	JDM59	Used for cylinder compression test.

Procedure

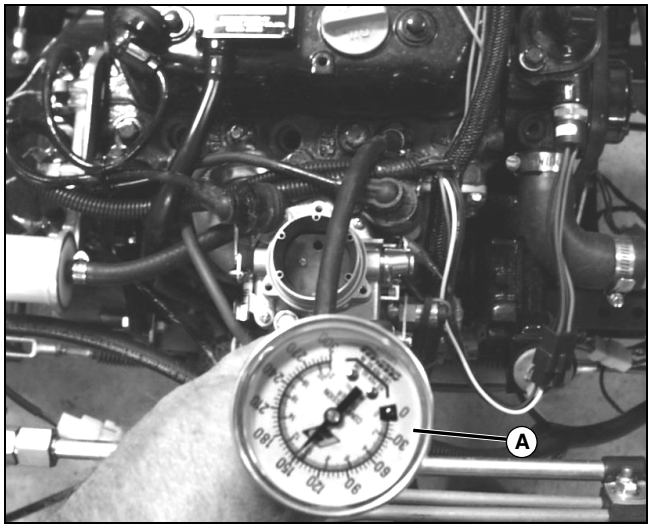
1. Warm engine to operating temperature.

CAUTION: Avoid injury! Engine will be HOT. Do not touch with bare skin, especially the exhaust pipe or muffler while making test.

2. Move transaxle shift lever to NEUTRAL. Lock park brake.

NOTE: The choke assembly must be loosened or removed to get a socket on the number 3 spark plug.

3. Remove air cleaner tube and remove spark plugs.



MX0745

4. Install compression gauge (A) into spark plug holes (one at a time) and crank engine with starter for four or five compression strokes.

5. Record reading for each cylinder.

Results

- Minimum compression pressure should be to specification.
- Compression differential between cylinders should not exceed specification.
- If compression is low, squirt about one half ounce of clean engine oil into cylinder through spark plug hole and retest compression. If compression significantly increases the piston rings/cylinder are worn.
- If compression does not change with oil added to cylinders, check valves and head gasket for leaks.

Specifications

Cylinder Compression (Min) . . . . . 772 kPa (112 psi)
Compression Differential (Max) . . . . . 97 kPa (14 psi)

Test Fuel Pump Pressure

Reason

To determine fuel pump pressure and flow to the carburetor.

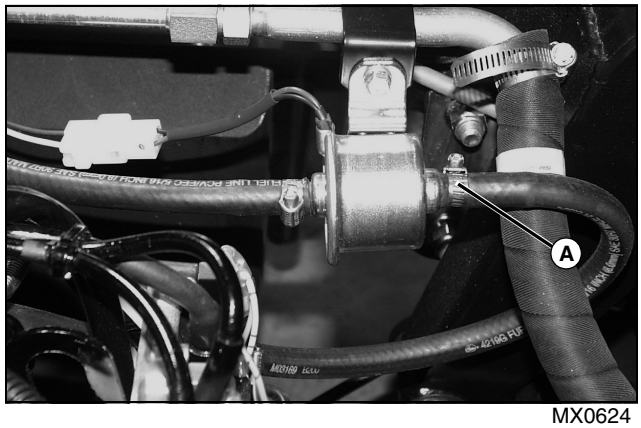
Special or Required Tools

Tool Name	Tool No.	Tool Use
Pressure Test Kit	JDG356	Used to check fuel pump pressure.

Procedure

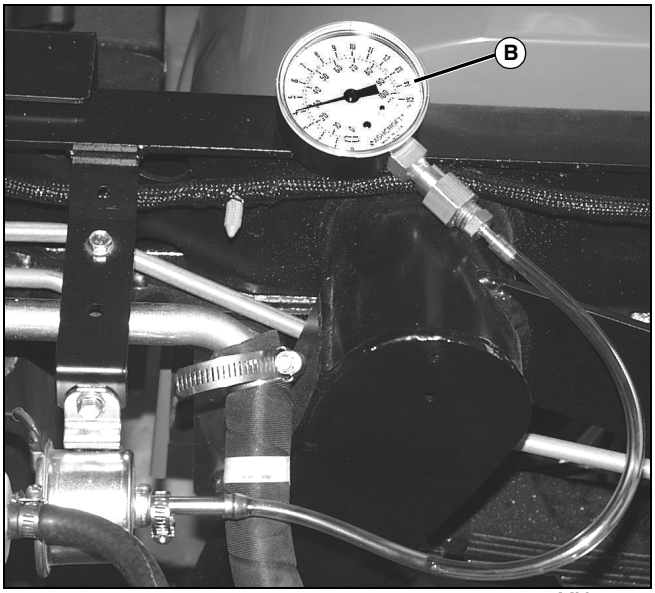
1. Park machine on level surface, turn key switch OFF, shift transmission to NEUTRAL, and LOCK park brake.
2. Allow engine to cool.
3. Check for sufficient fuel in tank to perform test.

CAUTION: Avoid injury! Gasoline is extremely flammable. DO NOT SMOKE. Always work in a well ventilated area away from open flame or spark producing equipment; including equipment that utilizes pilot lights.



MX0624

4. Disconnect hose from fuel pump outlet (A). Wipe up any spilled fuel immediately.



MX0740

5. Connect JDG356 Pressure Gauge (B) to fuel pump outlet.

6. Turn key switch to ON position. Fuel pump should make a clicking sound. If fuel pump does not make clicking sound, check for voltage at fuel pump connector. If no voltage is present, see electrical section for diagnosis of electrical problem.

7. Run fuel pump for 15 seconds and observe pressure reading on gauge.

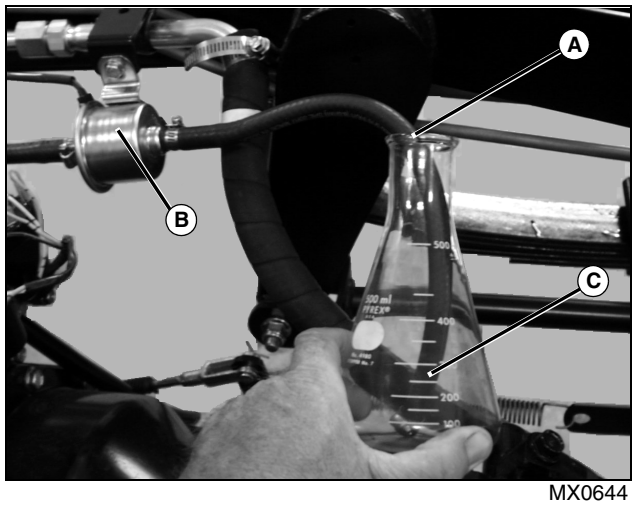
Results

- If fuel pressure is below specification, check inlet hose for kink or blockage.
- If no blockage is found in inlet hose or stand pipe in tank, replace fuel pump.

Specifications

Fuel Pump Pressure (Min) . . . . . 10.4 kPa (1.5 psi)

Test Fuel Pump Flow



MX0644

1. Remove fuel pump outlet hose (A) from filter (B) and put hose into a graduated container (C).

2. Turn key to on position for 15 seconds and record flow.

3. Remove test equipment, reconnect hose to fuel filter.

Results

- If fuel pump pressure and flow DO meet specifications, replace filter, check carburetor inlet tube, inlet needle, and float for proper function, obstructions, varnish/sticking conditions, or other problems. (See “Inspect Carburetor” on page 46.)
- If fuel pump pressure or flow DO NOT meet specifications, check fuel lines, fuel tank, pickup tube, and fill cap vent for restrictions and retest.
- If after retest, fuel pump pressure or flow DO NOT meet specifications, replace fuel pump.

Specifications

Fuel Pump Flow . . . . . 105 mL (3.5 oz)

Test Oil Pressure

Reason

To verify that the engine has enough oil pressure to lubricate the internal engine components.

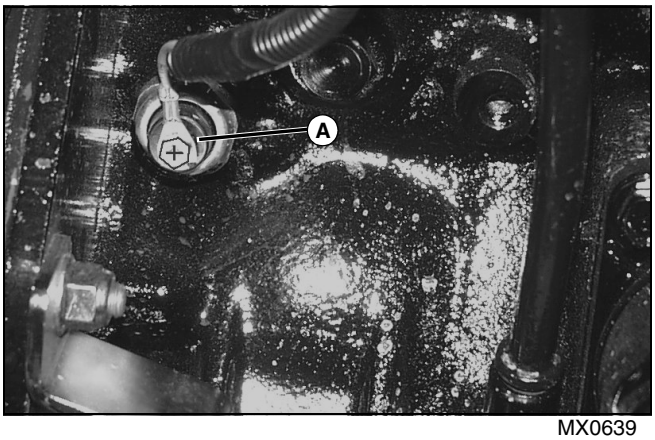
Special or Required Tools

Tool Name	Tool No.	Tool Use
Connector	JT03349	Used for oil pressure test.
Hose Assembly	JT03017	Used for oil pressure test.
0-700 kPa (0-100 psi) Gauge	JT07034	Used for oil pressure test.

NOTE: The connector, hose assembly, coupler, and gauge are found in other SERVICEGARD™ test kits.

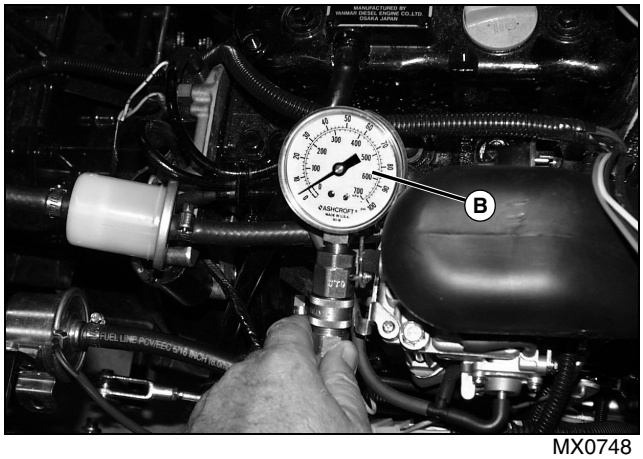
Procedure

1. Perform test procedure with engine level.
2. Stop engine.



MX0639

3. Disconnect and remove oil pressure switch (A).



MX0748

4. Install connector, hose assembly, and gauge (B) in to oil pressure switch port.
5. Check crankcase oil level and adjust to full mark.

IMPORTANT: Avoid damage! If oil pressure is below 69 kPa (10 psi) after 5 seconds of running: STOP engine immediately and correct cause before continuing.

6. Start engine and monitor oil pressure during start up.
7. Warm-up engine by running at MEDIUM idle for five minutes.

CAUTION: Avoid injury! Engine components are HOT. DO NOT touch with bare skin. Wear protective eye glasses and clothing.

8. Record oil pressure readings at FAST idle.
9. Stop engine and allow to cool.
10. Remove hose assembly, and gauge.
11. Install oil pressure switch.
12. Run engine for 30 seconds and stop engine.
13. Check crankcase oil level and adjust to full mark.

Results

If oil pressure readings are not within specification at FAST idle, inspect and/or replace the following:

- Oil pump assembly (See “Remove and Install Oil Pressure Regulating Valve” on page 64. See “Remove and Install Oil Pump” on page 65.)
- Oil suction screen
- Oil passages
- Bearing wear
- Oil seals

Specifications

Oil Pressure (Min @ Fast Idle) 290 ± 50 kPa (42 ± 7 psi)

Repair

Remove and Install Carburetor

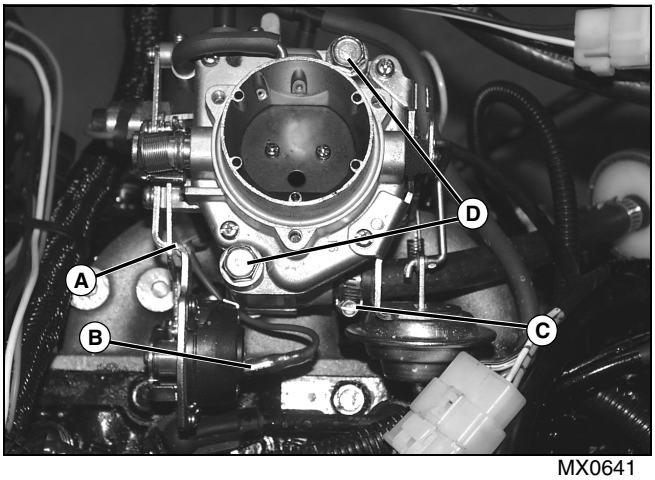
CAUTION: Avoid injury! DO NOT attempt to disassemble or adjust the engine CARB/EPA Certified Emissions Carburetor unless you are a factory trained technician with authorization to service CARB/EPA Certified Emissions Carburetors.

CAUTION: Avoid injury! Gasoline is extremely flammable. DO NOT SMOKE. Always work in a well ventilated area away from open flame or spark producing equipment; including equipment that utilizes pilot lights.

Procedure

1. Turn ignition switch OFF and disconnect battery negative (-) ground cable.

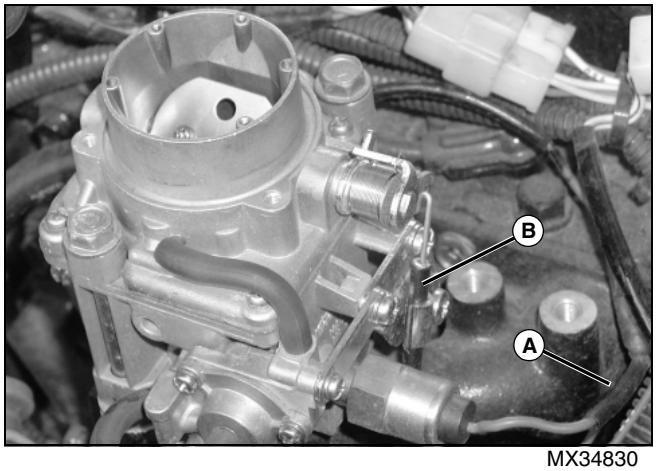
2. Loosen clamp and remove air filter tube from top of carburetor.



MX0641

Picture Note: Carburetor with electric choke

3. Carburetor with Electric Choke: Disconnect wires to fuel shut-off solenoid wire (A) and electric choke (B).

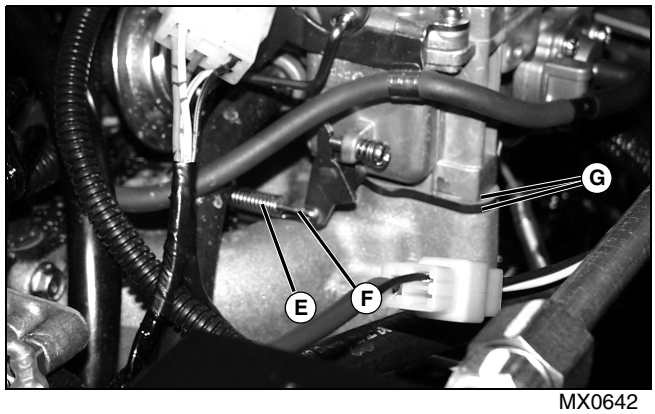


MX34830

Picture Note: Carburetor with manual choke

4. Carburetor with Manual Choke: Disconnect wires to fuel shut-off solenoid wire (A). Disconnect choke cable (B).

5. Loosen fuel line clamp (C) and disconnect fuel line.



MX0642

6. Disconnect spring (E) and linkage rod (F) from throttle lever.

7. Loosen cap screws (D) and remove carburetor.

8. Remove and discard gaskets (G).

Installation

1. Clean gasket mating surfaces and install new gaskets.

2. Connect linkage rod and spring, and install carburetor.

3. Tighten cap screws securing carburetor to specification.

4. Connect fuel line and tighten clamp.

5. Connect wires to fuel shutoff solenoid and choke heater.

Specifications

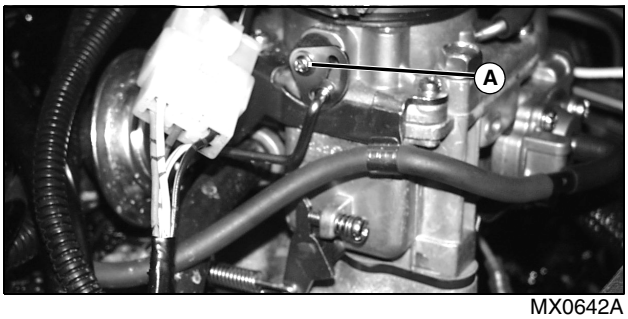
Carburetor Mounting
Cap Screw Torque . . . . . 21 N•m (180 lb-in.)

Inspect Carburetor

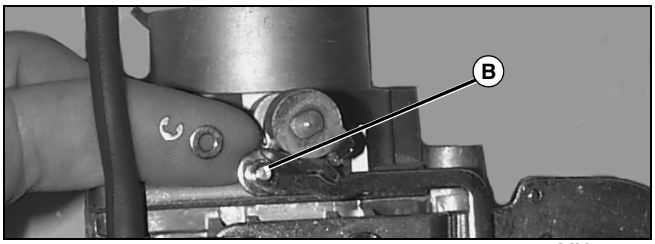
CAUTION: Avoid injury! Gasoline is extremely flammable. DO NOT SMOKE. Always work in a well ventilated area away from open flame or spark producing equipment; including equipment that utilizes pilot lights.

CAUTION: Avoid injury! DO NOT attempt to disassemble or adjust the engine CARB/EPA Certified Emissions Carburetor unless you are a factory trained technician with authorization to service CARB/EPA Certified Emissions Carburetors.

Procedure



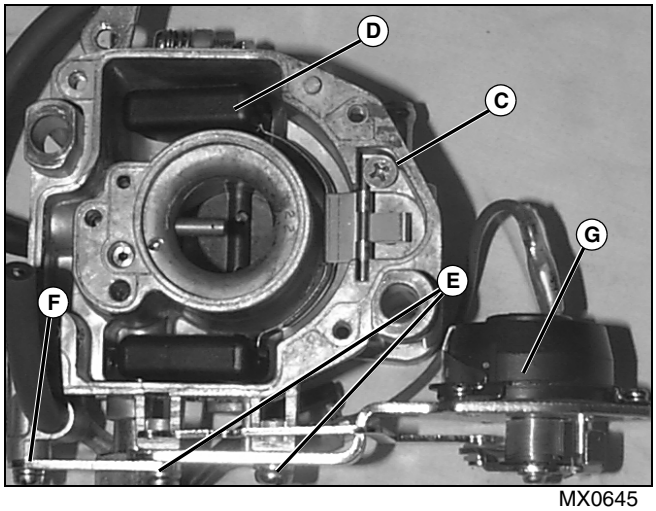
MX0642A



MX0651

1. Carburetor with Electric Choke: Disconnect choke pull off linkage (A), and disconnect link from choke (B).

2. Remove four screws and lift off top of carburetor.



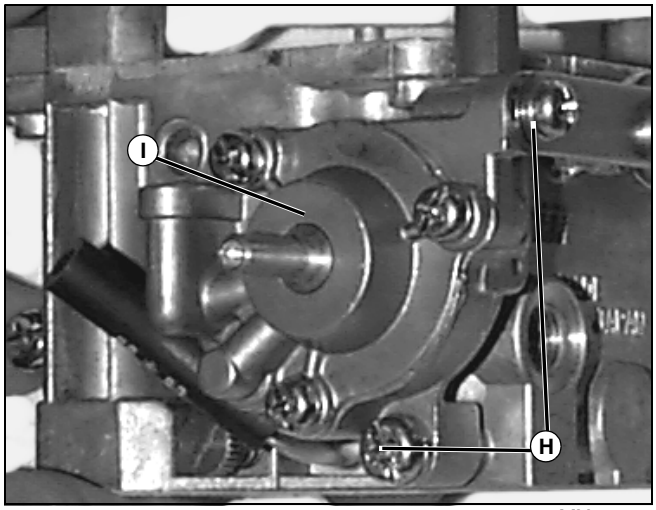
MX0645

Picture Note: Carburetor with Electric Choke Shown

3. Remove screw (C) and lift out float and inlet needle (D).

4. Remove screws (E), loosen screw (F).

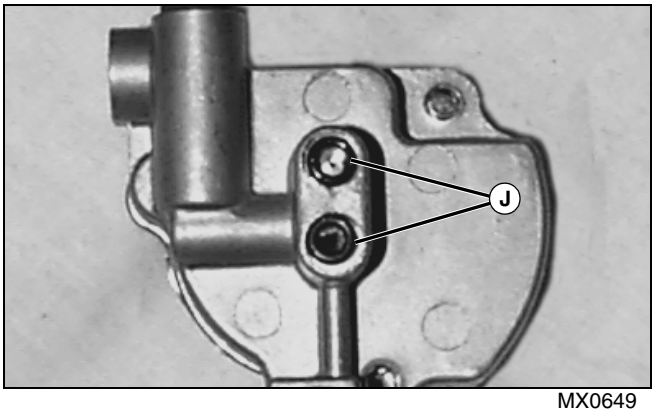
5. Carburetor with Electric Choke: Remove choke bi-metal housing (G).



MX0650

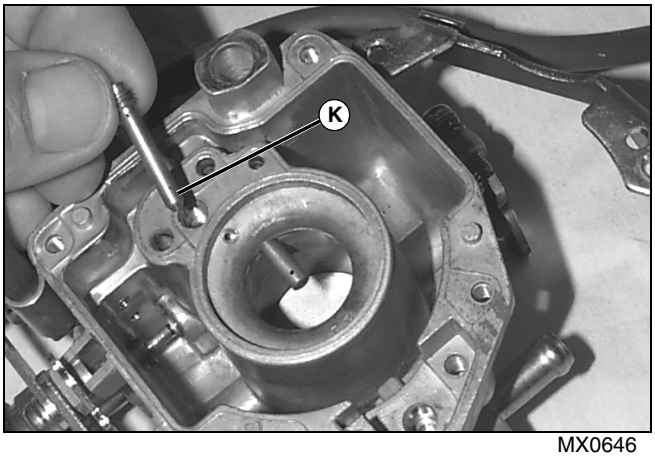
6. Remove screws (H), and accelerator pump (I).

NOTE: Install U-rings with flat side of rings towards carburetor body.



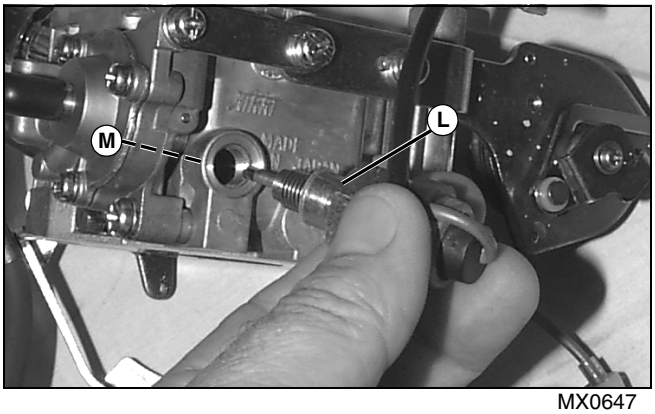
MX0649

7. Replace U-rings (J) between accelerator pump and carburetor body. Place small amount of grease on U-rings to keep them from falling off during assembly.



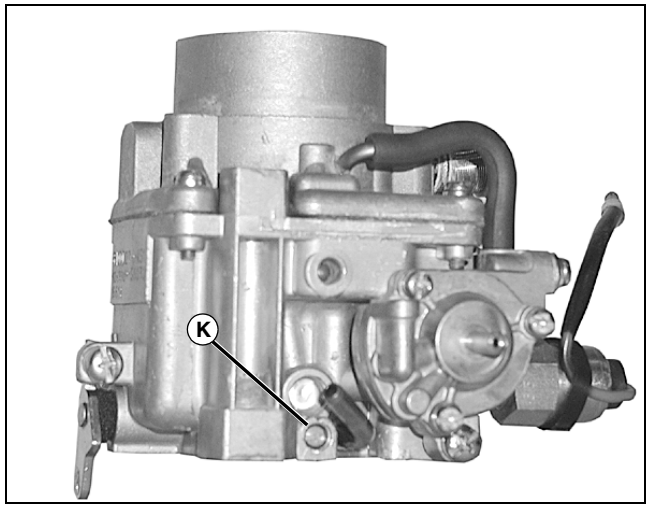
MX0646

8. Remove low speed jet (K).



MX0647

9. Remove fuel solenoid (L) and main jet (M) that is accessible through fuel solenoid hole.



MX23968

10.Remove idle mixture screw plug (K). Note position of slot in idle screw head and turn in (clockwise) until it lightly seats. Record the number of turns for assembly. Remove screw and spring.

11.Low idle mixture screw has a precision taper. If screw is grooved, bent, or broken, this may indicate seat damage and carburetor may need to be replaced.

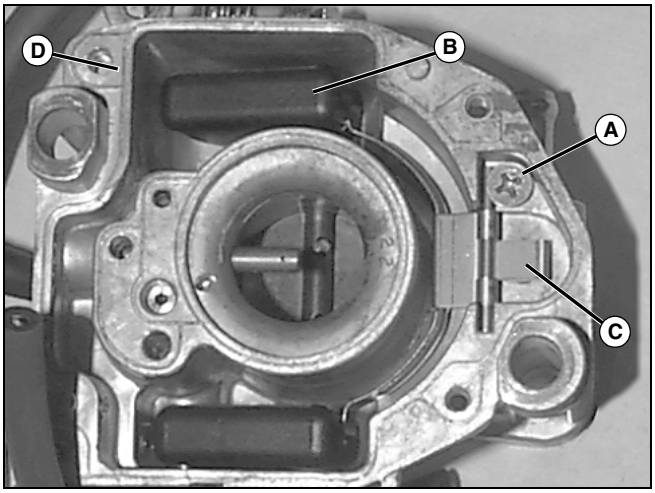
12.Clean carburetor using pressurized carburetor cleaner and compressed air. Clean out all passages. Clean all gasket mating surfaces.

13.If throttle and choke valves were removed, install screws slightly loose. Apply pressure on shafts to center plates in bore, then tighten screws.

Assembly

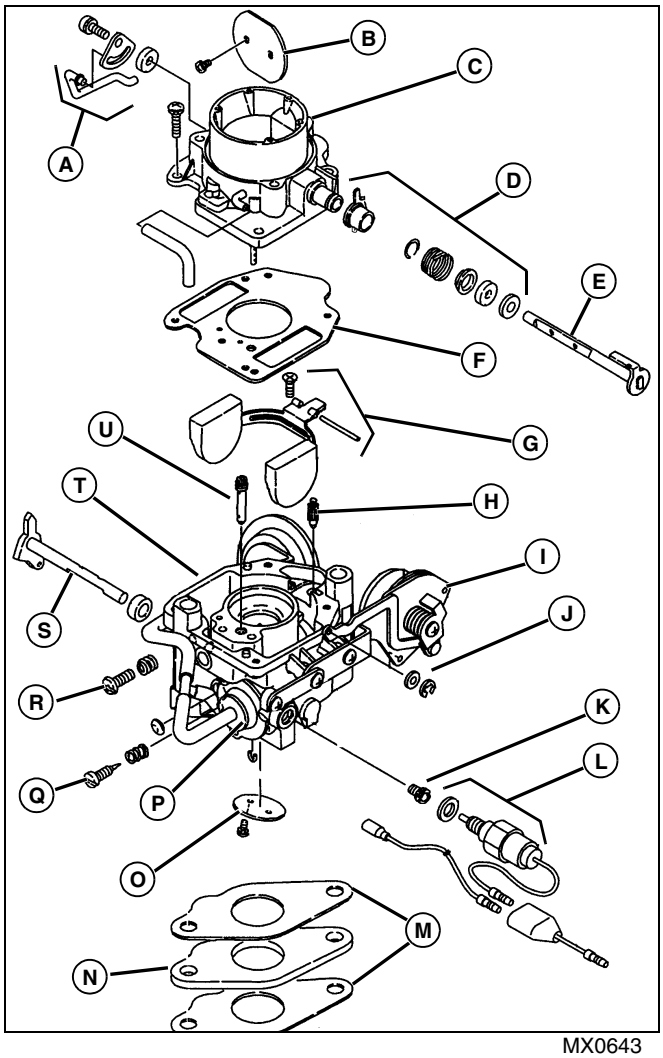
1. Assemble in the reverse order of disassembly.

2. Install spring and idle mixture screw, and tighten until it lightly seats. Back out screw the same number of turns as recorded in disassembly step. Following carburetor installation and final adjustments, install tamper-resistant plug.



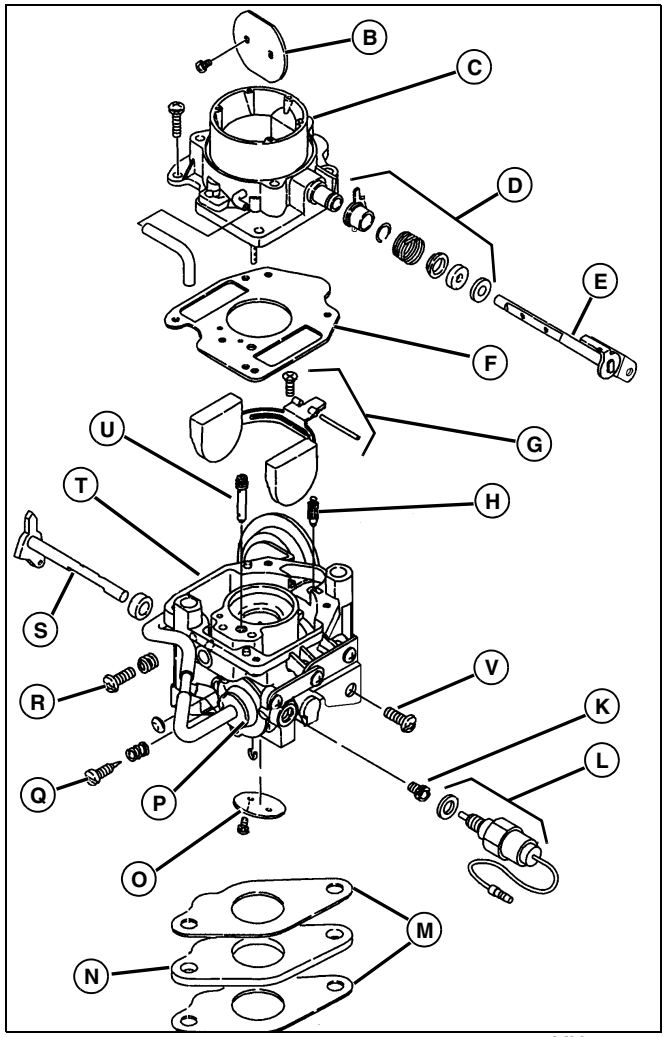
MX34828

3. Install float assembly (B), and retaining screw (A). Press down on tab (C) and check float level. Top of floats (B) should be even with top edge of carburetor (D). If not even with top of carburetor, adjust by bending tab (C).



MX0643

Picture Note: Carburetor with Electric Choke



MX34829

Picture Note: Carburetor with Manual Choke

A - Pull Off Linkage (electric choke only)
B - Choke Valve
C - Air Horn
D - Lever Spring and Felt
E - Choke Shaft
F - Gasket
G - Float and Hinge Pin
H - Needle Valve
I - Electric Choke Assembly (electric choke only)
J - Circlip and Washer
K - Main Jet
L - Fuel Shutoff Solenoid with Packing
M - Gaskets
N - Spacer
O - Throttle Valve
P - Accelerator Pump
Q - Idle Mixture Screw
R - Idle Speed Screw

S - Throttle Shaft

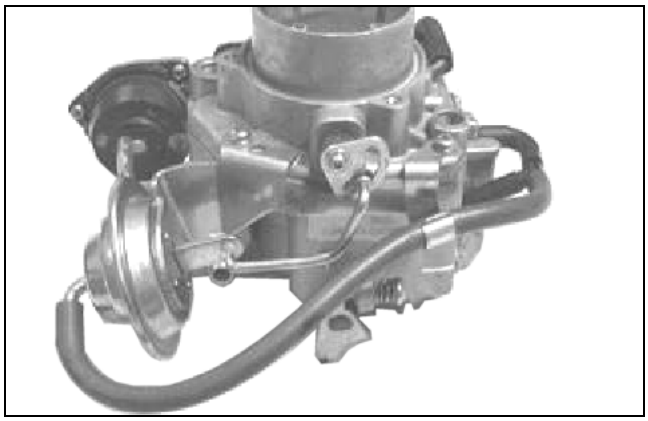
T - Carburetor Body

U - Idle Jet

V - Choke Cable Clamp Screw (Manual Choke Only)

4. Carburetor with Electric Choke: Install automatic choke assembly.

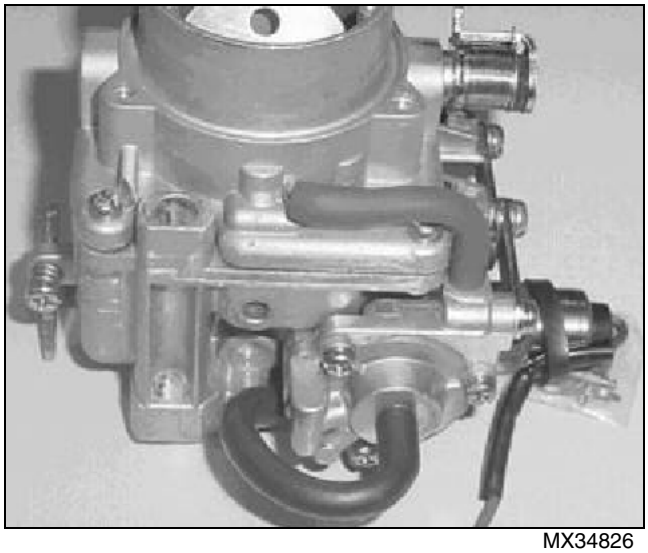
- Install pull off linkage.



MX34825

- Connect vacuum lines.
- Connect both electric leads (fuel shutoff solenoid and electric choke).

5. Carburetor with Manual Choke: Connect choke cable and bracket to carburetor.



MX34826

- Connect vacuum lines.
- Connect fuel shutoff solenoid lead.
- Adjust choke cable. See “Adjust Choke Cable (Manual Choke)” on page 39.

6. On the CARB/EPA Certified Emissions Carburetor there is a limiter cap on the idle mixture screw, This is pre-set by manufacturer - only turn screw (limited to maximum 1/4 turn in either direction) until smooth slow idle is obtained.

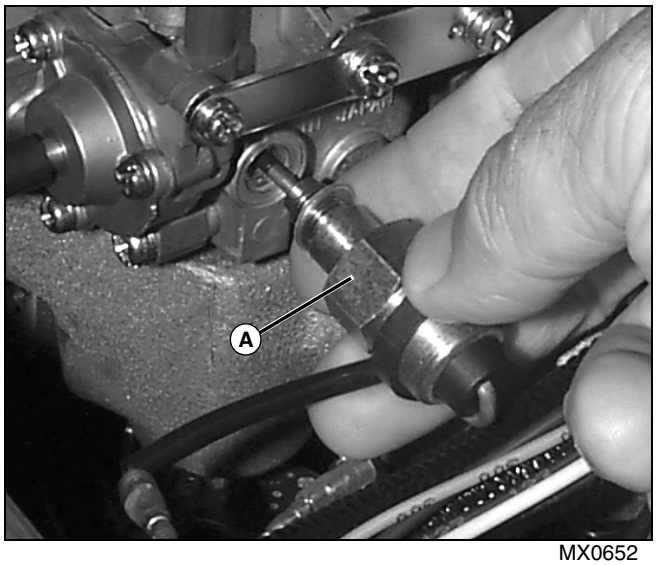
Install High Altitude Jet

CAUTION: Avoid injury! DO NOT attempt to disassemble or adjust the engine CARB/EPA Certified Emissions Carburetor unless you are a factory trained technician with authorization to service CARB/EPA Certified Emissions Carburetors.

NOTE: High altitude jet can be installed with carburetor on machine.

Procedure

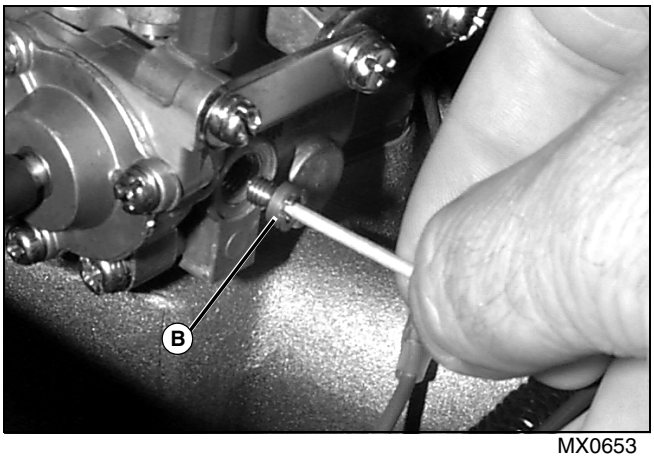
1. Park machine on level surface, turn key switch off, shift transmission to neutral, and lock park brake.
2. Allow engine to cool.
3. Place suitable container under carburetor to catch fuel that will drain from carburetor.



MX0652

4. Disconnect and remove fuel shut off solenoid (A).

NOTE: Care must be taken not to loosen main jet too far, otherwise jet will fall into carburetor bowl and carburetor will have to be disassembled.



MX0653

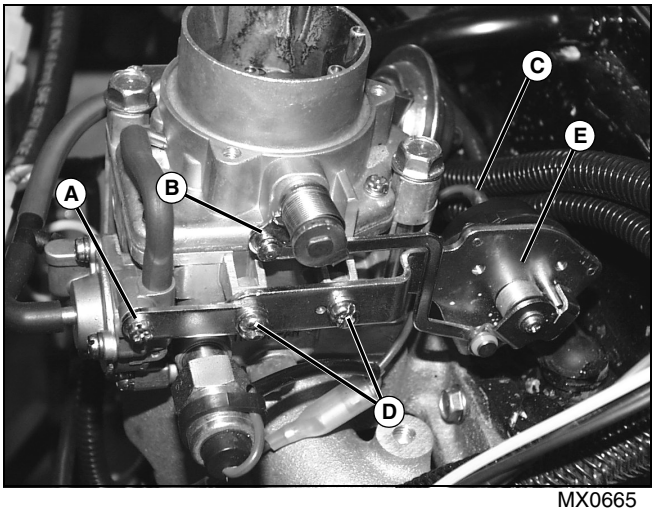
5. Loosen main jet (B) 1/2 turn only with screwdriver.

6. Place a round toothpick snugly into main jet and remove main jet.

7. Installation of new jet is the reverse procedure of removal.

Replace Choke Cover (Electric Choke)

NOTE: Index marks on electric choke cover cannot be seen with choke assembly mounted to carburetor. The choke assembly must be removed to adjust/ replace choke cover.

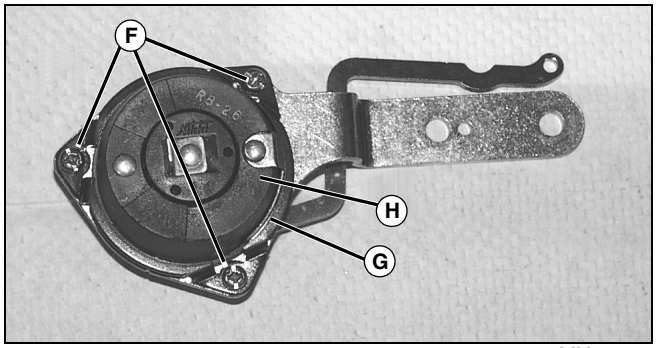


MX0665

1. Loosen screw (A).

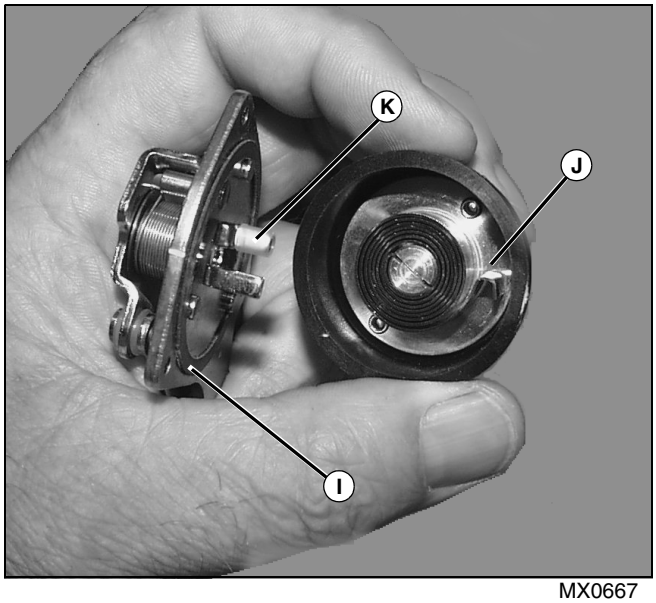
2. Remove circlip and washer (B), disconnect wire (C), and remove screws (D).

3. Remove choke assembly (E) from carburetor.



MX0666

4. Remove screws (F), bracket (G), and choke cover (H).

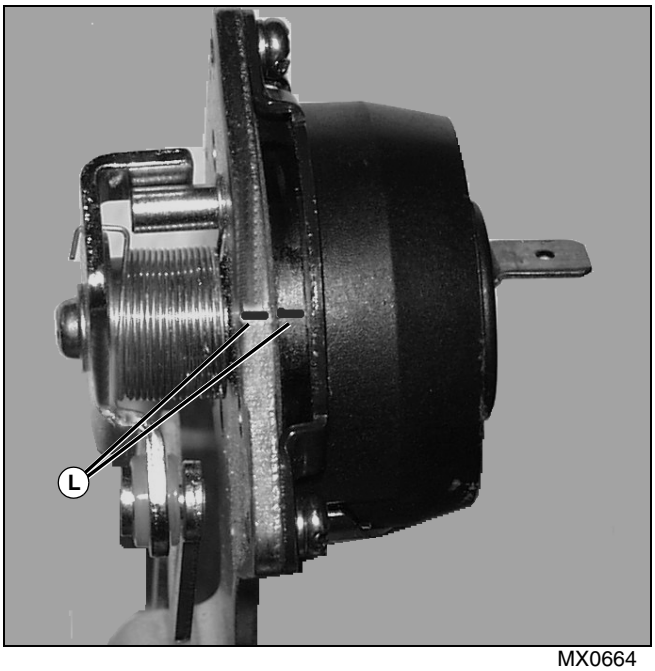


MX0667

5. Clean gasket material from bracket and replace gasket (I).

6. When installing cover, make sure hook on bi-metal spring (J) is in between tabs on choke lever (K).

NOTE: The marks would be facing the number three spark plug if the choke assembly was installed on the carburetor.

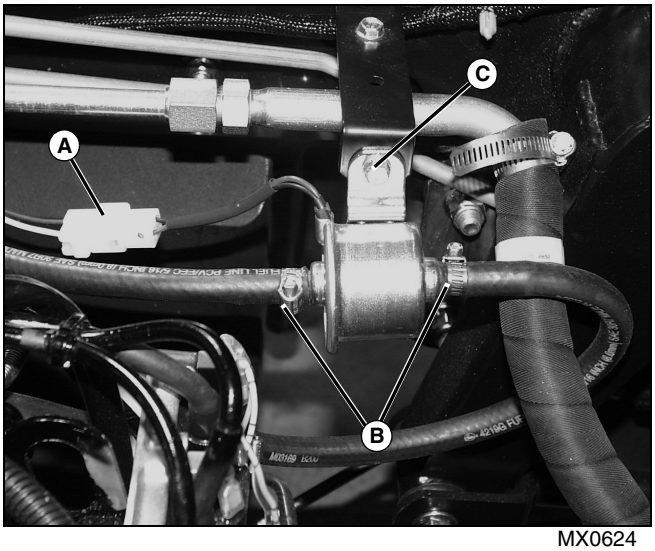


MX0664

7. Locate index marks on cover and bracket, align marks (L) and tighten screws on choke cover.

Remove and Install Fuel Pump

Procedure



MX0624

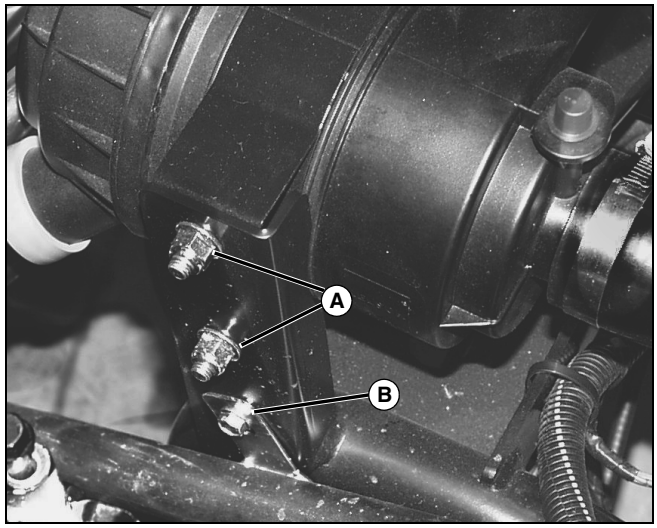
1. Disconnect wire connector (A).
2. Loosen clamps and remove fuel lines (B).
3. Remove cap screw (C) from fuel pump and remove pump.
4. Install components in reverse order of removal.

Remove and Install Engine

Removal

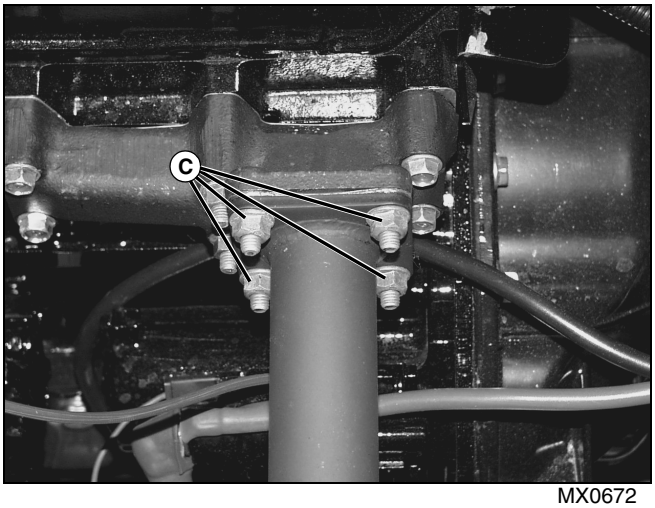
CAUTION: Avoid injury! USE CAUTION AROUND MOVING PARTS. STOP engine. Remove ignition key. Wait for all moving parts to STOP.

1. Park vehicle on a hard, level surface. Lock parking brake.
2. Disconnect battery negative (-) cable from the battery.
3. Remove cargo box or any attachments that may be limiting engine access.
4. Drain coolant from radiator.



MX0670

5. Disconnect air intake tube from carburetor. Remove air filter bracket retaining cap screws and nuts (A), and remove air filter assembly.
6. Remove coolant pipe retaining cap screw (B).

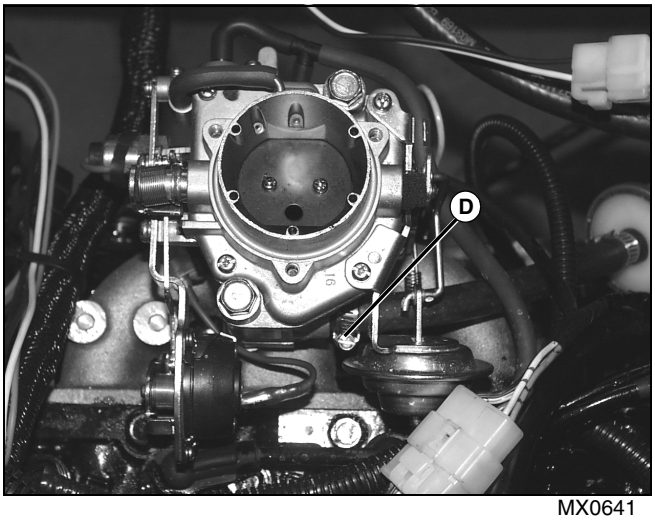


MX0672

7. Remove four nuts (C) securing the muffler to the exhaust manifold and the two cap screws securing muffler bracket to engine.

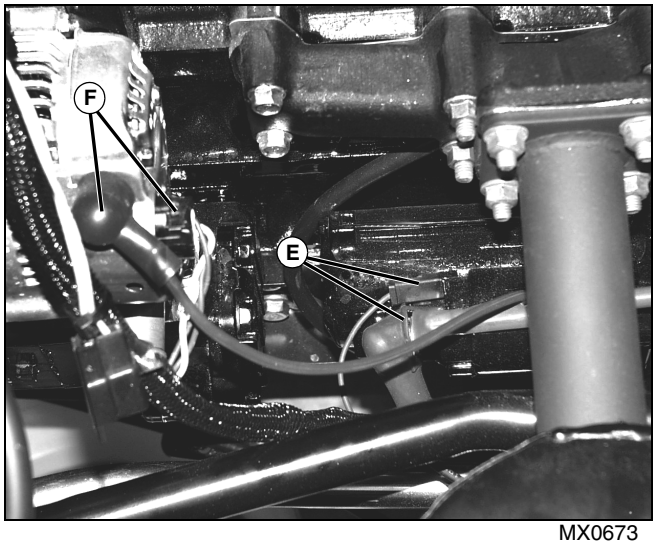
8. Remove clamp from tailpipe and remove muffler.

CAUTION: Avoid injury! Gasoline is extremely flammable. DO NOT SMOKE. Always work in a well ventilated area away from open flame or spark producing equipment; including equipment that utilizes pilot lights.



MX0641

9. Disconnect fuel hose (D) from carburetor. Plug end of fuel hose.



MX0673

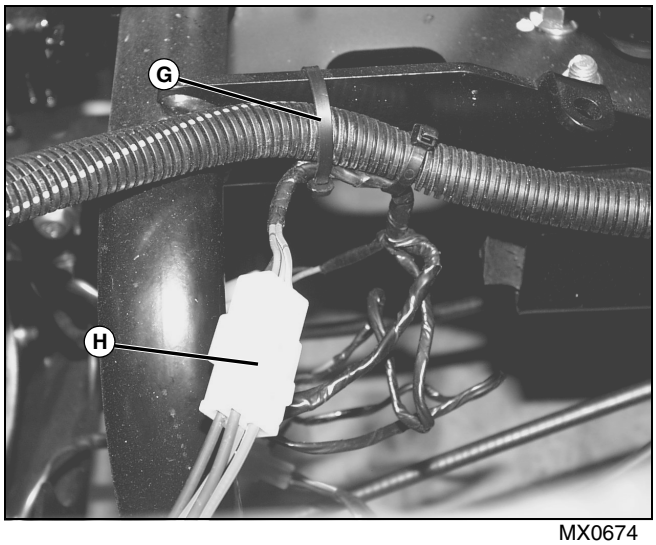
10.Disconnect positive (+) battery cable (E) and wires from starting motor solenoid.

11.Disconnect positive wire and plug (F) from alternator.

12.Disconnect ground wires and battery negative (-) cable from engine ground bracket.

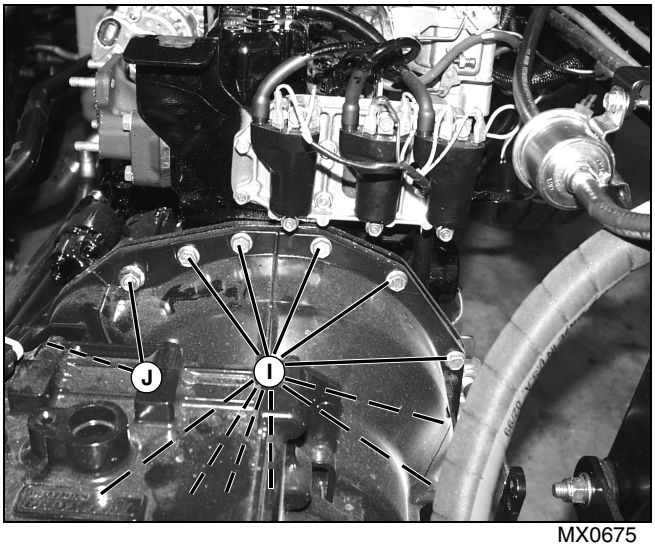
13.Disconnect oil sender, temperature sender, electric choke heater, and speed sensor.

NOTE: Disconnect pulser coils at the four wire connection as shown. If the pulser coils have to be disconnected at their individual two wire connections, mark connections to avoid changing the firing order



MX0674

14.Cut wire tie (G) and disconnect pulser coil electrical connector (H) from engine.

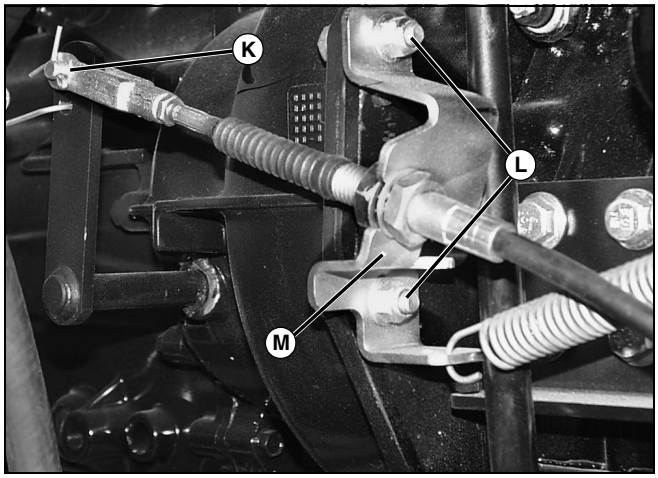


MX0675

15.Support front of transaxle and support engine with hoist while removing cap screws (I) from bellhousing.

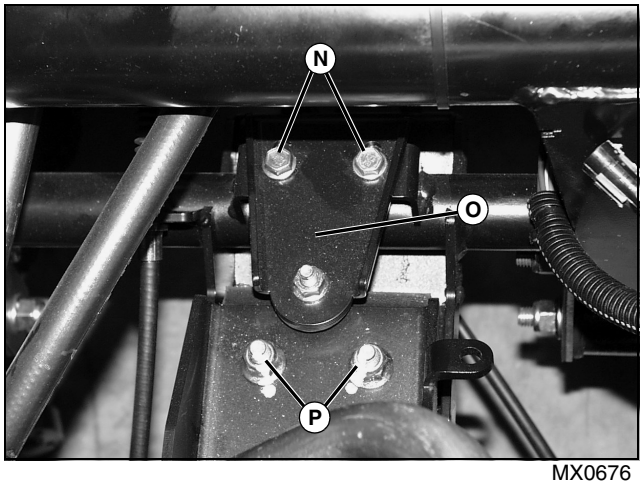
NOTE: It is not necessary to remove starter from backplate.

16.Remove nuts (J) from starter mounting cap screws.



MX0671

17.Remove pin (K) from clutch lever. Remove cap screws (L) and clutch cable bracket (M).

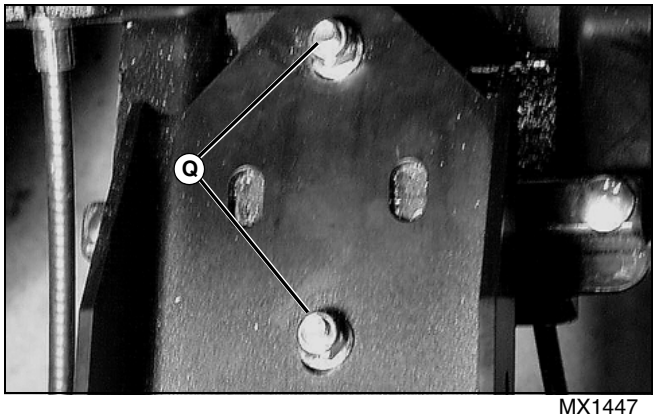


MX0676

18.Remove cap screws (N) and subframe snubber (O).

19.Remove top or bottom nuts (P) from the subframe isolator.

NOTE: On models after S.N. (020000-), subframe snubber has been replaced by mount configuration shown below.



MX1447

20.Remove bolts (Q) from subframe from engine.

21.Slide engine forward and raise from machine.

Installation

Installation is the reverse of removal.

1. Clean muffler flange and exhaust manifold surfaces of any old gasket material. Install a new muffler gasket.

2. Tighten engine to subframe mounting cap screws to specification.

3. Install muffler flange nuts and tighten to specification.

4. Attach throttle lever to engine controls. Retain with cotter pin and washer.

5. Connect all engine wiring harness connectors.

6. Connect coolant hoses. (See “Cooling System Hose Routing” on page 54.)

7. Attach battery negative (-) cable and ground wires to engine ground bracket.

8. Attach battery positive (+) cable and solenoid exciter wire to starting motor solenoid.

9. Attach fuel line to carburetor. Retain with hose clamp.

10.Fill engine to proper level with oil of correct specifications.

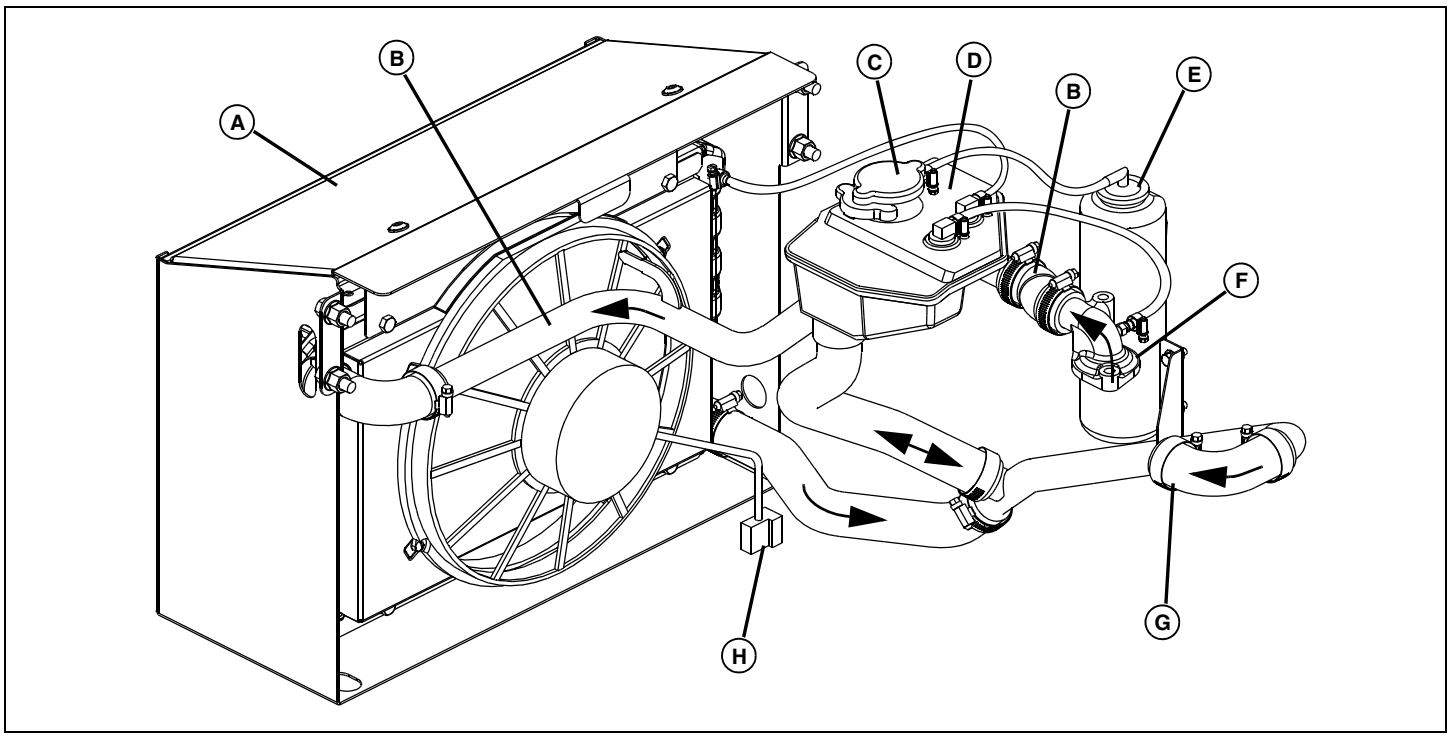
11.Fill coolant to correct level.

12.Attach negative (-) cable to battery.

Specifications

Subframe Mounting Cap
Screw Torque . . . . . 80 N•m (60 lb-ft)
Muffler Flange Nut Torque. . . . . 24.4 N•m (216 lb-in.)

Cooling System Hose Routing



MIF

A - Radiator
B - Upper Radiator Hose
C - Pressure Cap
D - De-Aeration Tank
E - Coolant Recovery Tank
F - Engine Thermostat Housing
G - Lower Radiator Hose (Suction Line to Engine Coolant Pump)
H - Electric Fan Connector

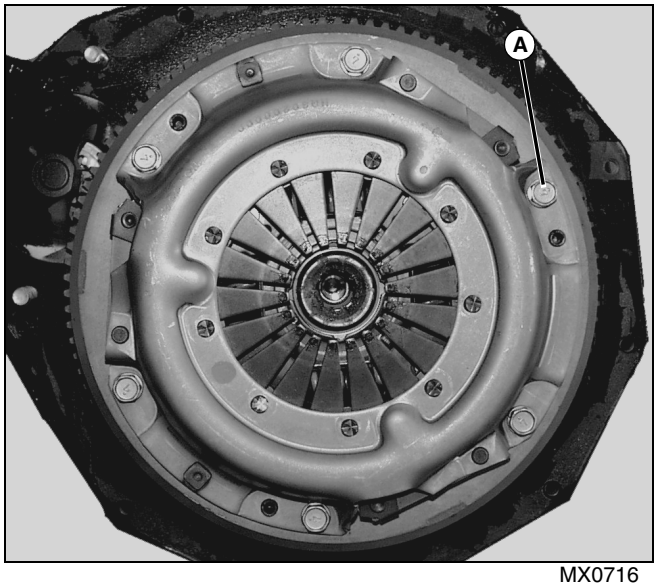
Remove and Install Clutch and Flywheel

Special or Required Tools

Tool Name	Tool No.	Tool Use
Clutch Alignment Tool	JDG1331	Used to align clutch disc.

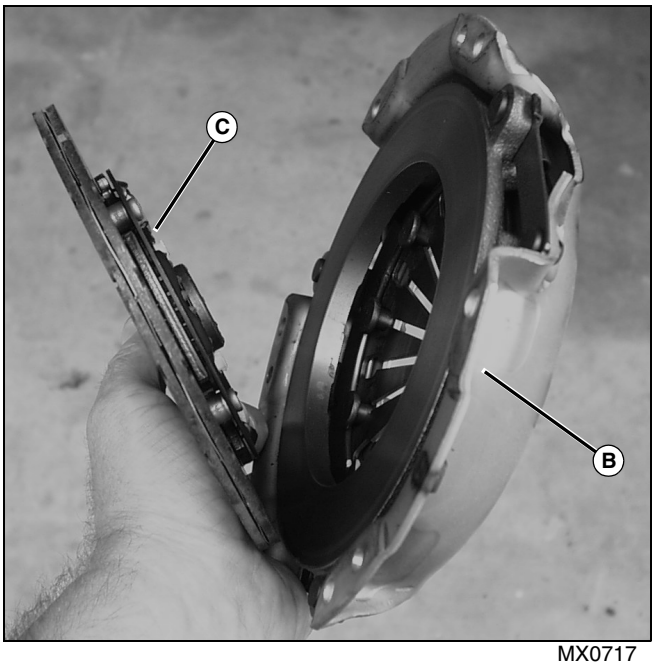
Removal

1. Remove engine. (See “Remove and Install Engine” on page 51.)



MX0716

2. Alternately loosen cap screws (A) on clutch cover.

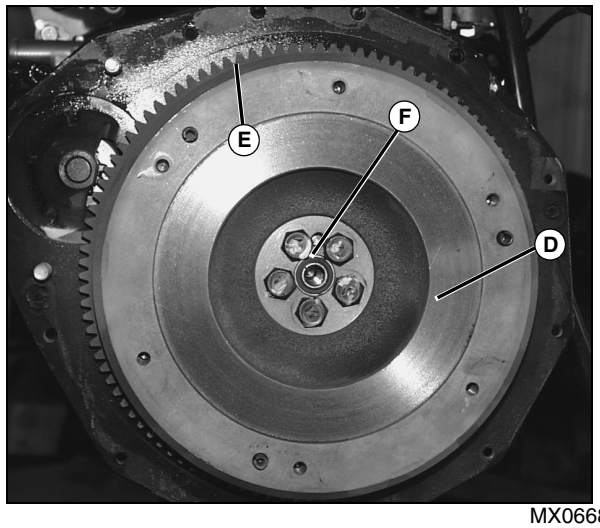


MX0717

3. Remove clutch cover (B) and clutch disc (C) from flywheel.

NOTE: Flywheel is heavy! Be careful when removing.

4. Remove flywheel.



MX0668

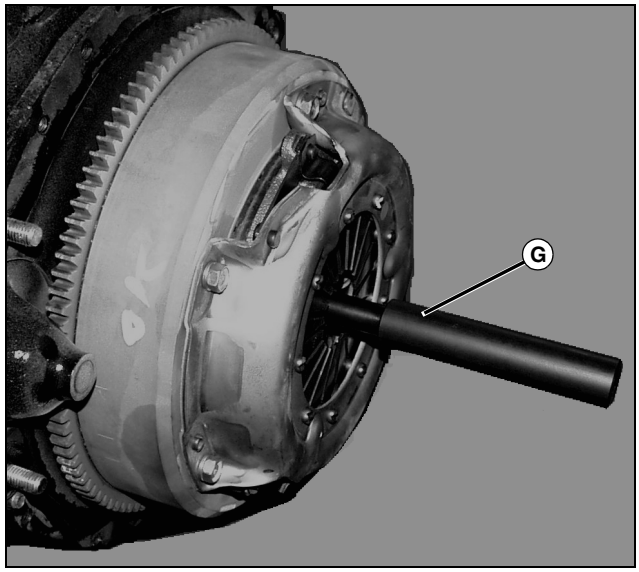
5. Inspect flywheel for cracks or grooves on clutch wear area (D). Check ring gear (E) for chips and broken teeth. Check pilot bearing (F) for smooth operation. Replace parts as necessary.

Installation

1. Make sure flywheel and crankshaft mating surfaces are clean.

2. Install flywheel and tighten cap screws to specifications

3. Install clutch disc with raised side of hub toward clutch cover. Install clutch cover. Do not tighten cap screws.



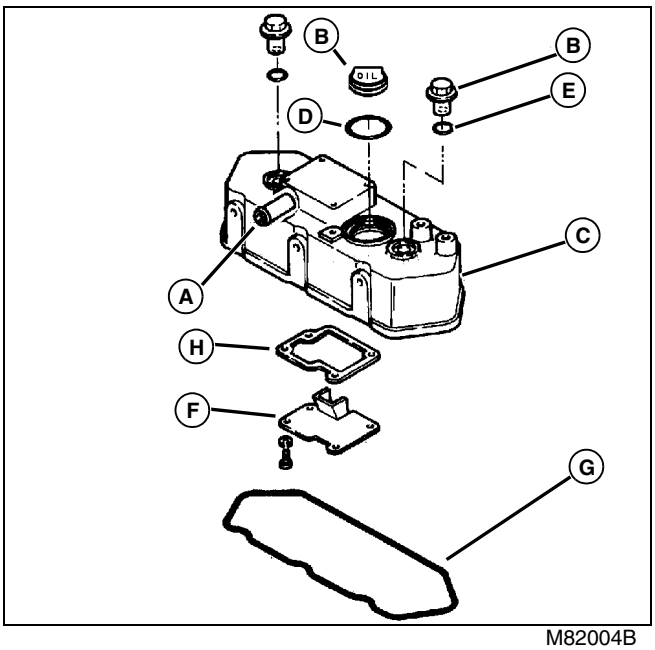
MX0747

4. Using JDG1331 Clutch Alignment Tool (G) or an equivalent, align clutch disc and alternately tighten clutch cover cap screws to specification.

Specifications

Clutch Cover Cap Screw Torque . . . 23 N•m (200 lb-in.)
Flywheel Cap Screw Torque . . . . . 83 N•m (63 lb-ft)

Remove and Install Rocker Arm Cover



M82004B

1. Remove crankcase breather tube from breather fitting (A) on rocker cover.
2. Remove two special nuts (B) securing cover to cylinder head.
3. Remove rocker cover (C).
4. Inspect O-rings (D) and (E) for wear or damage. Replace if necessary.
5. Disassemble breather baffle (F) and clean all parts.
6. Replace gaskets (G) and (H).

Assembly

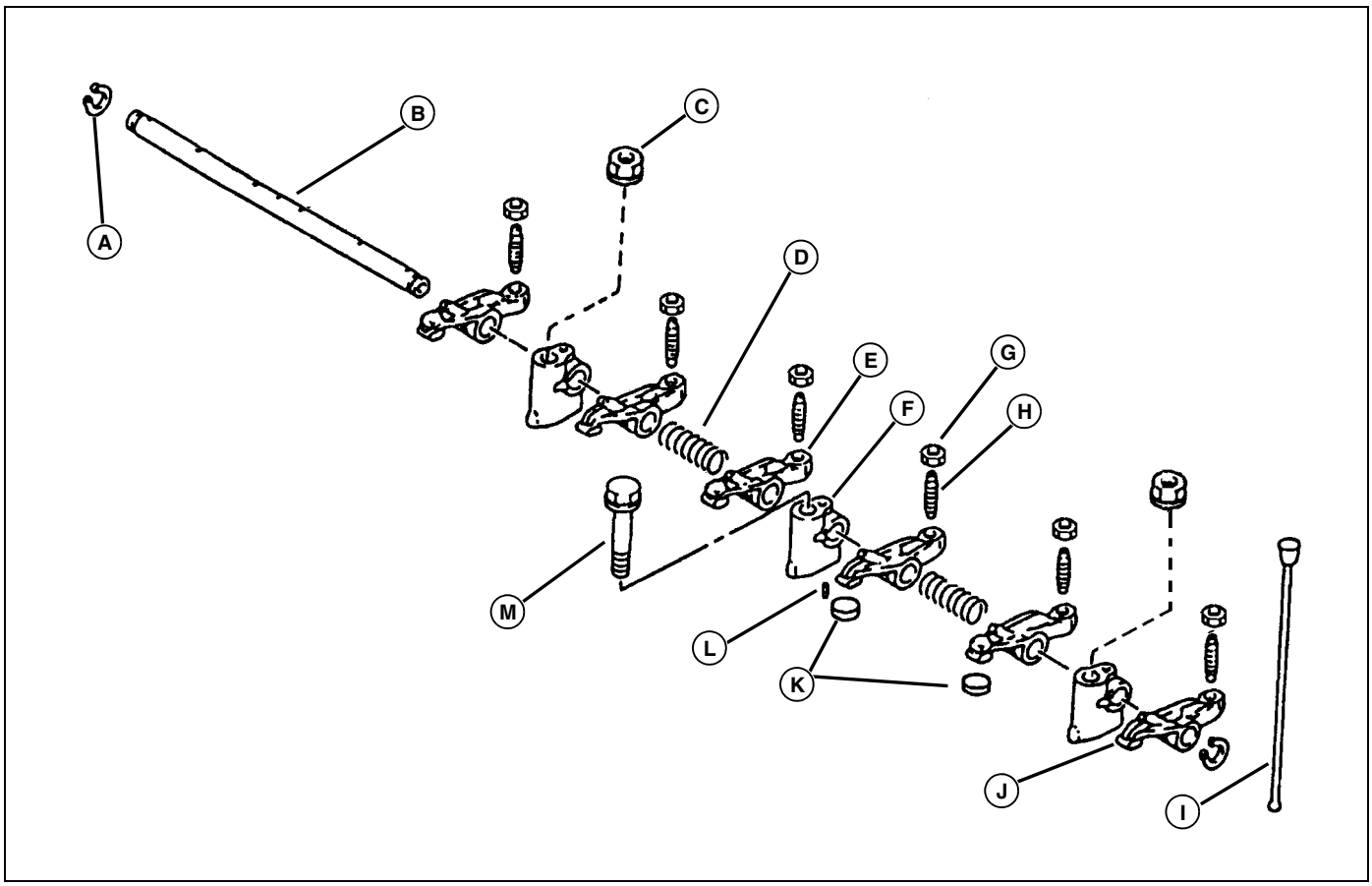
Assemble in the reverse order of disassembly.

- Tighten special nuts to specification.

Specifications

Rocker Cover Special Nut Torque . . 18 N•m (160 lb-in.)

Remove and Install Rocker Arm and Push Rods



M82257A

A - Snap Ring
B - Rocker Shaft
C - Nut
D - Spring
E - Exhaust Rocker Arm
F - Shaft Support
G - Locknut
H - Adjusting Screw
I - Push Rod
J - Intake Rocker Arm
K - Valve Caps
L - Set Screw
M - Cap Screw

Rocker Arm Removal

1. Remove rocker arm cover. (See “Remove and Install Rocker Arm Cover” on page 56.)

2. Alternately loosen and remove two rocker arm mounting nuts (C) and center cap screw (M).

3. Pull rocker arm assembly straight up off of mounting studs on cylinder head.

Rocker Arm Disassembly

1. Mark all parts for location before disassembly to aid assembly.

2. Remove snap rings (A) from rocker shaft (B) and slide components off of rocker shaft.

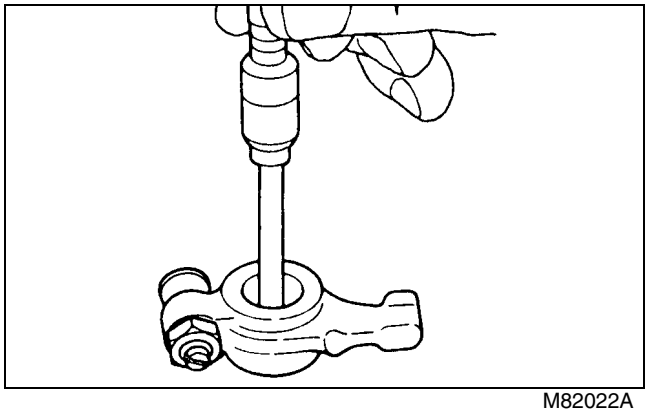
3. Remove set screw (L) from center support. Remove rocker shaft from center support (F).

4. Clean all parts.

Rocker Arm Inspection

M35262

1. Measure outer diameter of rocker arm shaft.



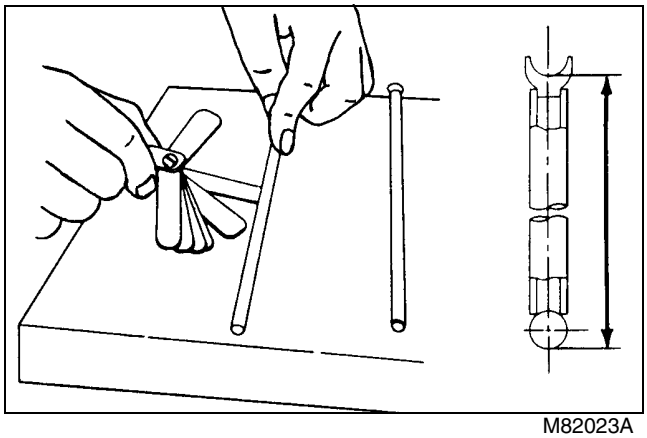
M82022A

2. Measure inside diameter of rocker arms, and rocker shaft supports:

Replace rocker arms or supports if ID is more than wear limit.

If shaft and support/arm clearance (support and/or arm ID minus shaft OD) exceed wear limit, replace all parts.

Push Rod Inspection



M82023A

1. Lay push rod on flat surface and roll while checking for a gap under center of rod. Use feeler gauge to check dimension. Replace push rod if not within specifications.

2. Check the surface of the adjusting screw that contacts the push rod for wear, replace push rod or adjusting screw if worn.

3. Check the rocker arm to valve stem cap contact surface for wear. Replace rocker arm if worn.

Rocker Arm Assembly

1. Assemble rocker shaft into center support, aligning set screw hole in support with hole in rocker shaft.

2. Be sure rocker arms are installed in same order as removed.

Rocker Arm Installation

IMPORTANT: Avoid damage! Be sure valve caps are in place on end of valve stems before installing rocker arms.

1. Align rocker arm supports with studs on cylinder head. Align rockers with valve stems.

2. Install push rods in block and align into rocker arms.

3. Install mounting nuts on rocker arm supports and evenly tighten nuts to pull rocker assembly to head. Tighten to specification.

4. Adjust valve clearance. (See “Adjust Valve Clearance” on page 40.)

5. Install rocker arm cover. (See “Remove and Install Rocker Arm Cover” on page 56.)

Specifications

Rocker Arm Shaft
OD . . . . . 11.966-11.984 mm (0.4711-0.4718 in.)
Rocker Arm Shaft
OD Wear Limit . . . . . 11.955 mm (0.4706 in.)
Rocker Arm ID . . . . . 12.00-12.02 mm (0.472-0.473 in.)
Rocker Arm ID Wear Limit. . . . . 12.09 mm (0.476 in.)
Rocker Arm-to-Shaft
Oil Clearance . . . . . 0.016-0.054 mm (0.0006-0.0021 in.)
Rocker Arm-to-Shaft
Clearance Wear Limit. . . . . 0.135 mm (0.006 in.)
Minimum Push Rod Length. . . . . 141 mm (5.55 in.)
Push Rod Bend . . . . . 0.0-0.3 mm (0.0-0.012 in.)
Rocker Arm Support Nut and
Cap Screw Torque . . . . . 26 N•m (226 lb-in.)

Remove and Install Cylinder Head

Removal

1. Park machine on level surface, transmission in neutral, park brake locked, engine off.

2. Disconnect negative battery cable from battery.

3. Allow engine to cool, and cooling system pressure to return to zero. Drain coolant from drain valve.

4. Remove muffler and tailpipe from exhaust manifold. (See “Remove and Install Engine” on page 51.)

5. Remove upper and lower radiator hoses from coolant pump.

6. Remove coolant temperature sensor wire from sensor.

7. Remove upper alternator bracket and fan belt from coolant pump.

8. Remove coolant pump.

9. Disconnect spark plug wires from spark plugs.

10.Remove rocker arm cover. (See “Remove and Install Rocker Arm Cover” on page 56.)

11.Remove rocker arm assembly, push rods, and valve caps from cylinder head. (See “Rocker Arm Removal” on page 57.)

12.Loosen and remove cylinder head bolts.

13.Using lift brackets and hoist, pull head straight up from block.

14.Remove exhaust and intake manifolds. (See “Remove and Install Intake Manifold” on page 59.)

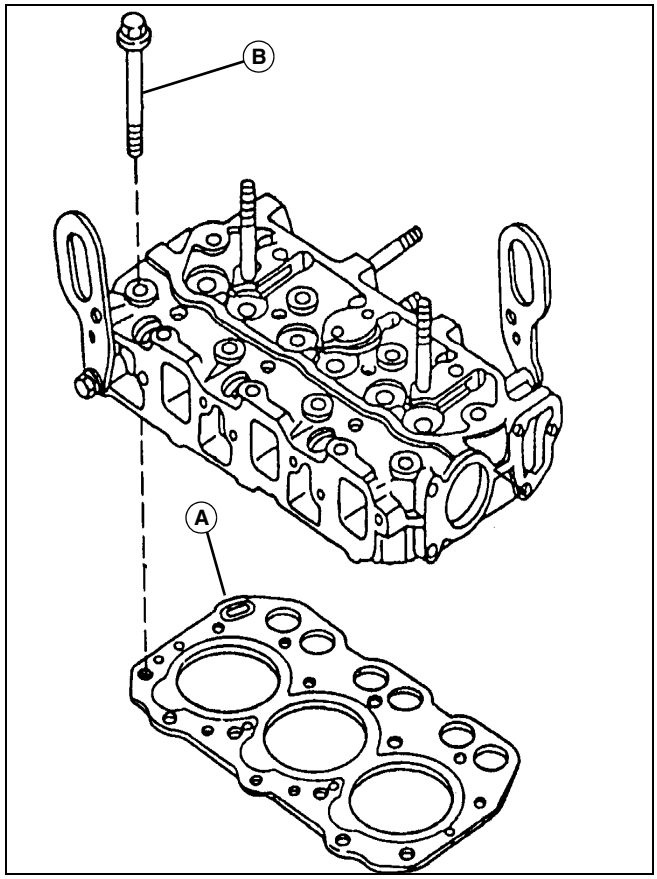
15.Disassemble and inspect cylinder head and valves. (See “Recondition Cylinder Head” on page 60.)

Installation

1. Clean all threads in top of cylinder block with a flat bottom tap, and blow debris from hole.

2. Clean top of cylinder block and check for flatness.

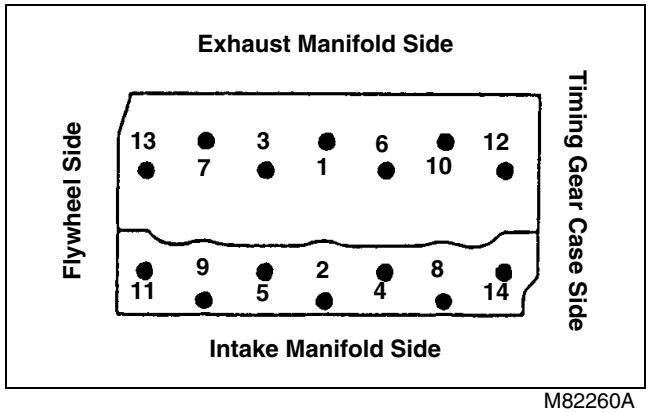
IMPORTANT: Avoid damage! Oil passage in gasket (A) must be located over oil passage in cylinder block.



M82259A

3. Place a new cylinder head gasket on cylinder block with locating pins on front and rear of block inside holes in gasket. Lineup oil port on left rear of block with oil port (A) in gasket.

4. Clean threads of cylinder head bolts and dip in clean oil before installing. Install all bolts finger tight before tightening with wrench.



M82260A

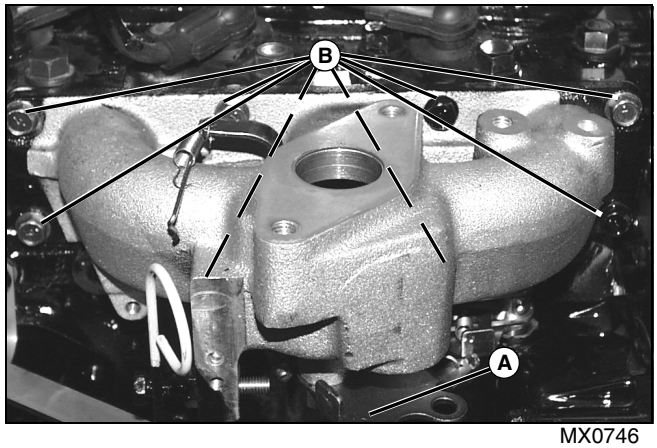
5. Tighten in sequence shown above in two steps of torque from specifications below.

Specifications

Initial Torque . . . . . 30.9 N•m (23 lb-ft)
Final Torque . . . . . 61.3 N•m (45 lb-ft)

IMPORTANT: Avoid damage! Cylinder head mounting cap screws must be checked for proper torque after 50 hours of engine operation.

Remove and Install Intake Manifold



MX0746

1. Remove carburetor. (See “Remove and Install Carburetor” on page 45.)

2. Disconnect throttle linkage from bellcrank on bottom of manifold (A).

3. Remove eight intake manifold mounting cap screws (B) and remove intake manifold.

4. Remove gasket and clean mating surfaces. Check flange for flatness with straight edge. Check manifold for cracks or damage.

5. Install new gasket and install manifold on cylinder head.

6. Tighten all mounting cap screws to specification.

Specifications

Intake Manifold Cap Screw Torque . . 11 N•m (97 lb-in.)

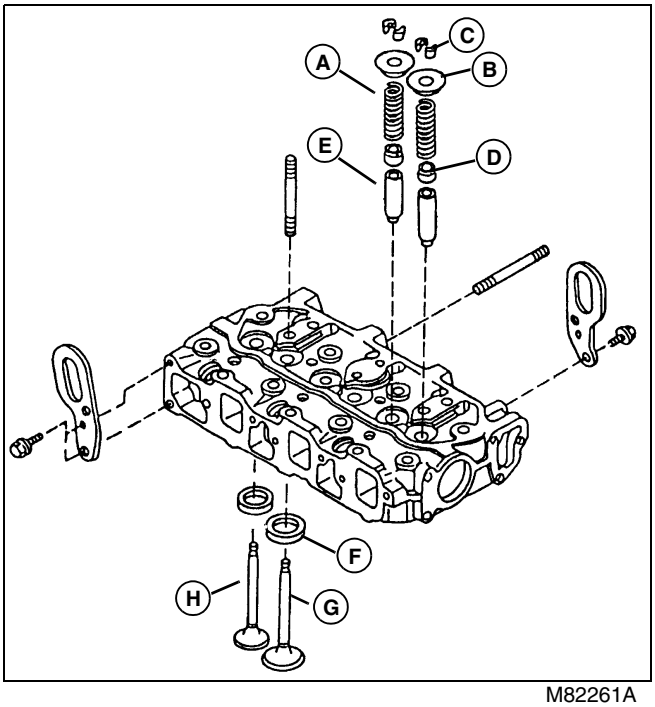
Recondition Cylinder Head

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or in the European Microfiche Tool Catalog (MTC).

Special or Required Tools

Tool Name	Tool No.	Tool Use
Valve Spring Compressor	JDE138	Used to compress valve springs.
Reaming Tool (7.05 mm)	D20020WI	Used to clean or size valve guides.
Valve Guide Driver	JDE504	Used to remove and install valve guides.

Disassembly and Assembly



M82261A

1. Compress valve springs (A) using JDE138 Valve Spring Compressor.

NOTE: It may be necessary to tap on valve spring retainer (B) while initially operating compressor to break retainer free from valve stem.

2. Remove collet halves (C) from retainer.

3. Slowly release compressor and valve spring.

4. Remove valve spring retainer (B), valve spring, stem seal (D), and valve (G or H) from head.

5. Intake and exhaust valve guides (E) and seats (F) are press fit. Remove guides only if replacement is necessary.

6. Inspect all parts for wear or damage. Clean all carbon deposits and measure all parts for proper clearances.

7. Apply clean engine oil on intake (G) and exhaust valve (H) stems during assembly.

IMPORTANT: Avoid damage! DO NOT reuse stem seals (D). Used seals will leak.

8. Install new stem seals (D).

9. Install springs with smaller pitch end or paint mark toward cylinder head.

NOTE: If new valves are installed, measure valve recession. (See "Intake and Exhaust Valves" on page 61.)

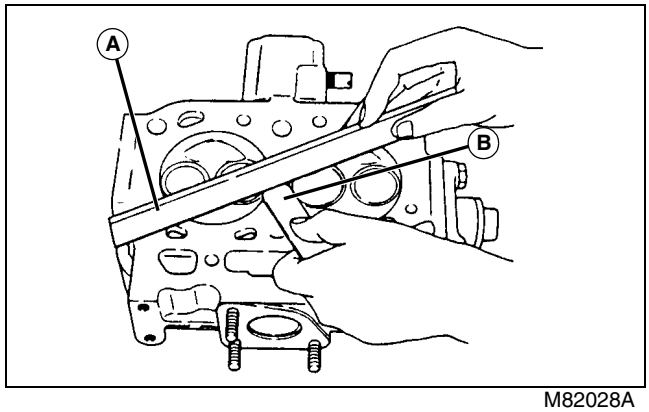
10.Use valve spring compressor to compress spring and retainer, and install collets.

11.After each valve has been assembled, tap on top of valve stem with a plastic hammer to seat retainer.

Inspection and Replacement

Before inspection, thoroughly clean all components of carbon or dirt.

Cylinder Head

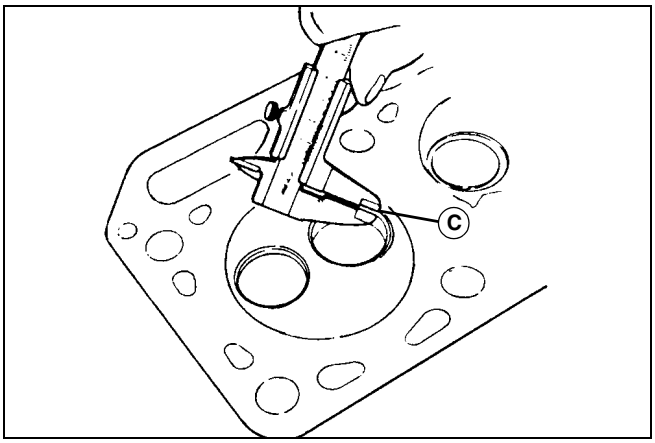


M82028A

- Measure cylinder head flatness. Place a straight edge (A) along each of the four sides and each diagonal. Measure clearance between straight edge and combustion surface with a feeler gauge (B).

If distortion exceeds the wear limit, resurface or replace cylinder head. Remove only enough metal to make cylinder head flat; but do not remove more than specification.

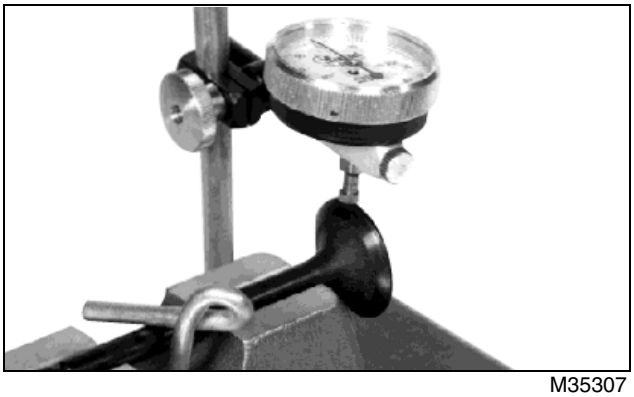
- Measure valve recession. (See “Intake and Exhaust Valves” on page 61.)



M82029A

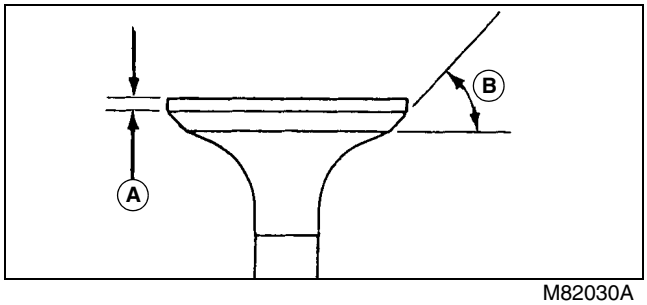
- Measure valve seat width (C).
- If necessary, grind valve seats to meet specifications. (See “Valve Seat Grinding” on page 62.)

Intake and Exhaust Valves



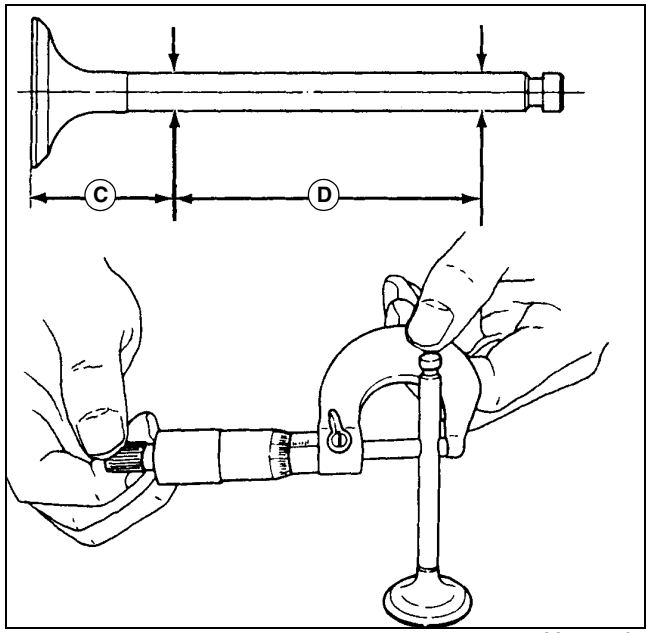
M35307

- Check valve for out-of-round, bent or warped condition using a valve inspection center and dial indicator. Replace valve if necessary.



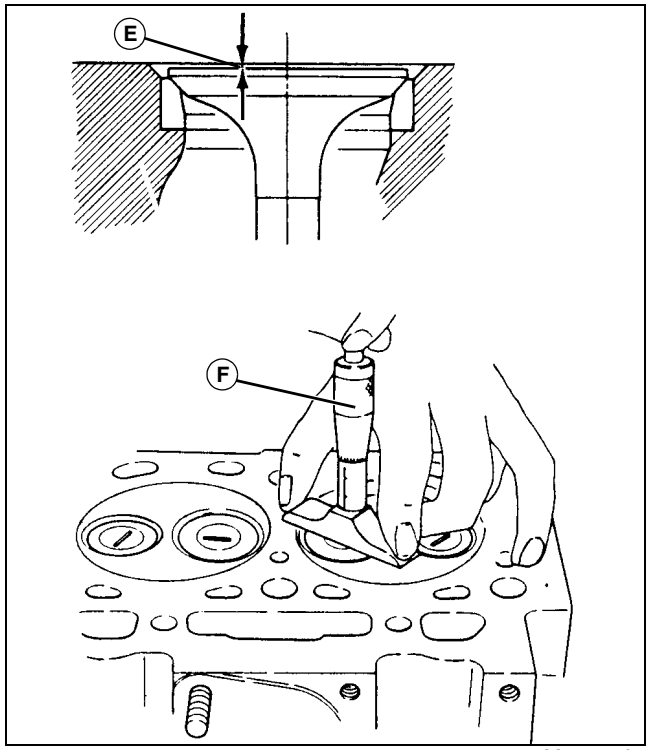
M82030A

- If valve faces are worn, burned or pitted, grind valves to proper face angle (B). If valve face margin (A) is less than specification after grinding, replace valve.



M82031A

- Measure valve stem diameter at the two locations shown above (C and D). Replace valve if measurement exceeds wear limit.

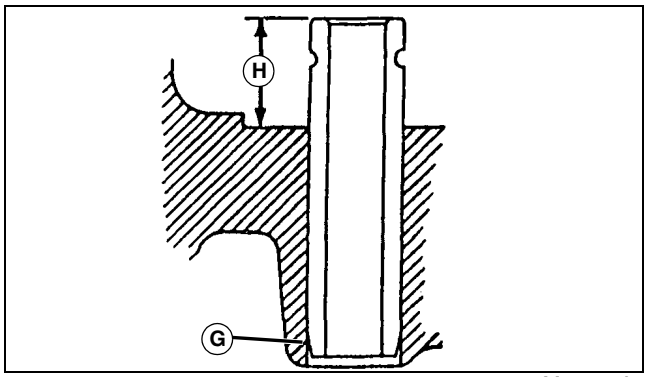


M82032A

- Measure valve recession (E) using a depth gauge (F). Replace valve or cylinder head if measurement exceeds wear limit.

Valve Guide Measurement

- Clean valve guides using a valve guide brush.
- Measure valve guide inside diameter using a ball or telescoping snap gauge.
- If valve guide inside diameter exceeds wear limit, replace guide.
- If valve guide inside diameter is less than wear limit, determine guide-to-stem clearance (valve guide diameter minus valve stem diameter).
- If clearance exceeds 0.127 mm (0.005 in.), but is less than 0.178 mm (0.007 in.), knurl valve guides using a 7 mm valve guide knurling tool.
- If clearance exceeds 0.20 mm (0.008 in.), replace valve guides.

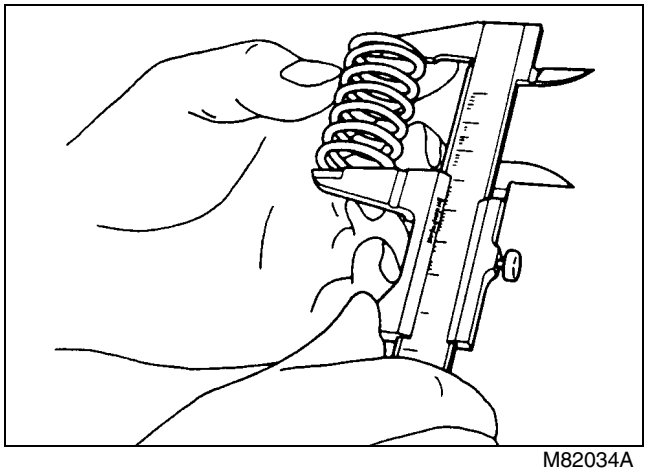


M82193A

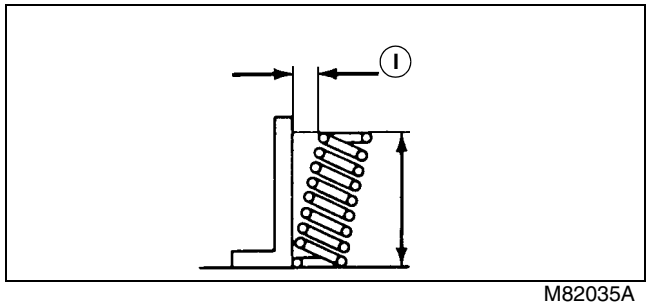
- Install valve guides with tapered end (G) down. Push valve guides down until top of valve guides are projecting the specified height (H) from the valve spring seat in the cylinder head.

Ream inside diameter of valve guides using a D20020WI 7 mm Valve Guide Reamer.

Valve Springs


M82034A

- Measure spring free length. Replace spring if measurement exceeds specification.



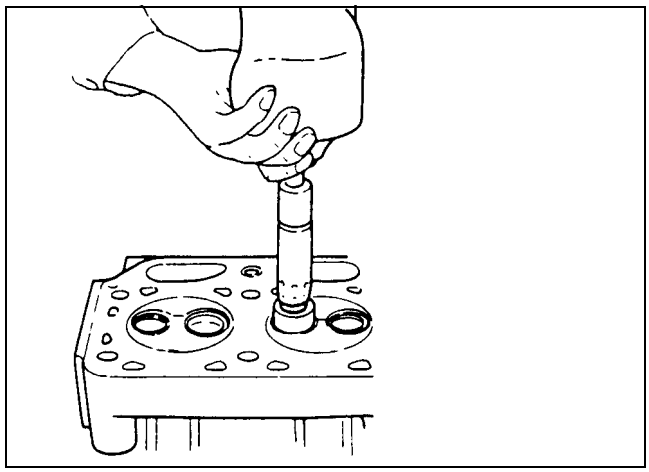
M82035A

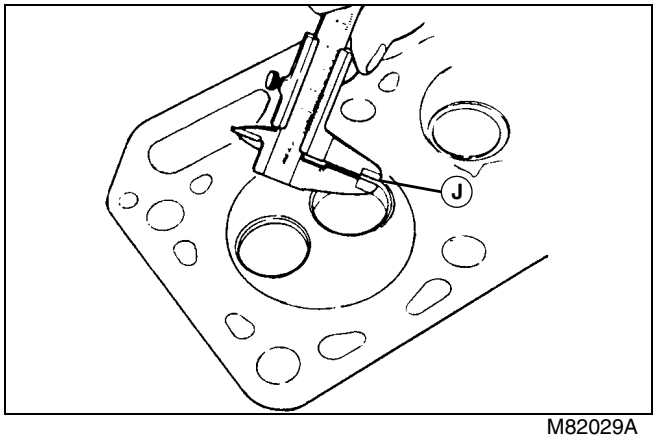
- Measure spring inclination. Replace spring if measurement (I) exceeds specification.

Valve Seat Grinding

NOTE: LIGHTLY grind valve seats only for a few seconds to avoid excessive valve seat width. If valve guide is to be replaced, always replace guide before grinding valve seat, as seat grinder pilot is centered by guide.

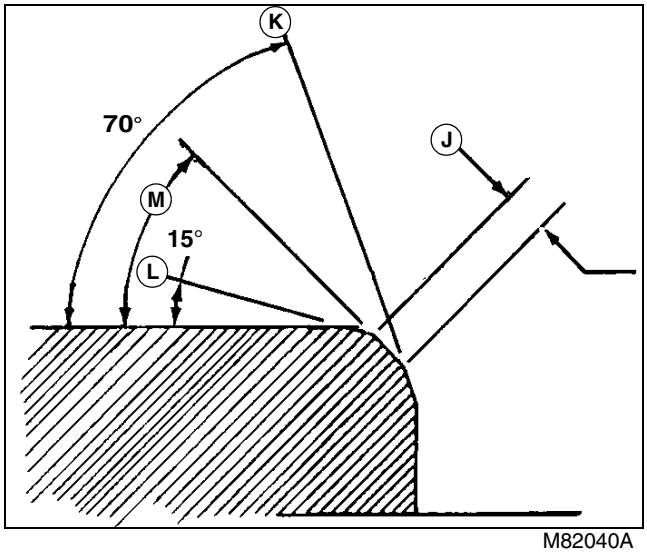
1. Grind intake valve seat using a 30° seat grinder, and exhaust valve seat using a 45° seat grinder. Follow tool manufacturers instructions.


M82039A



M82029A

2. Measure valve seat width (J) after grinding.



M82040A

3. If seat (J) is too wide after grinding, grind lower seat surface (K) using a 70° seat grinder until seat width is close to specifications.

4. Grind upper seat surface (L) using a 15° seat grinder until seat width is narrowed to specifications.

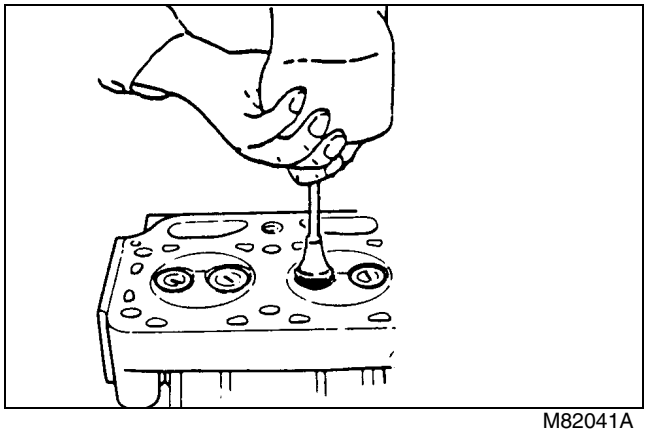
5. Dimension (M) is 30° for intake and 45° for exhaust seat.

6. If valve seats are ground, measure valve recession and check contact pattern between the seat and valve with bluing dye.

7. Lap valves. (See "Valve Lapping" on page 63.)

NOTE: If valve recession exceeds maximum specifications replace cylinder head

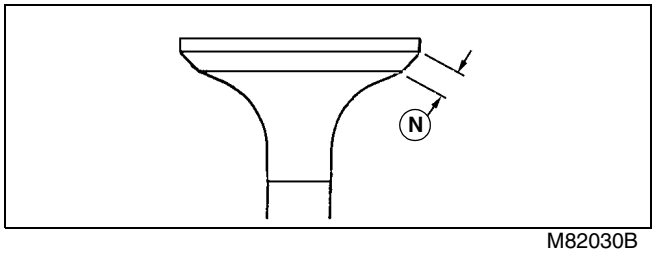
Valve Lapping


M82041A

If seat does not make proper contact, lap the valve into the seat:

1. Apply small amount of fine lapping compound to face of valve.

2. Turn valve to lap valve to seat.



M82030B

3. Lift valve from seat every 8 to 10 strokes. Lap until a uniform ring appears around the surface (N) of the valve face.

4. Wash all parts in solvent to remove lapping compound. Dry parts.

5. Check position of lap mark on valve face. Lap mark must be at or near center of valve face.

Specifications

Cylinder Head
Distortion (Nominal) . . . . . 0.05 mm (0.002 in.)
Cylinder Head
Distortion (Max) . . . . . 0.10 mm (0.004 in.)
Mill Cylinder Head No More Than . . . 0.2 mm (0.008 in.)

Valve Seat Width

Intake Valve. . . . . 1.43 mm (0.056 in.)
Intake Valve Wear Limit . . . . . 1.98 mm (0.078 in.)
Exhaust Valve. . . . . 1.73 mm (0.068 in.)
Exhaust Valve Wear Limit . . . . . 2.27 mm (0.089 in.)
Valve Recession (Max). . . . . 0.60 mm (0.024 in.)

Intake Valve
Face Margin . . . . . 0.99-1.29 mm (0.038-0.050 in.)
Exhaust Valve
Face Margin . . . . . 0.95-1.25 mm (0.037-0.049 in.)
Valve Face Margin Wear Limit. . . . . 0.51 mm (0.020 in.)
Intake Valve Face Angle . . . . . 30°
Exhaust Valve Face Angle. . . . . 45°

Valve Stem Measuring Points

Distance C. . . . . 20 mm (0.787 in.)
Distance D. . . . . 40 mm (1.575 in.)

Intake Valve Stem
OD . . . . . 6.96-6.98 mm (0.274-0.275 in.)
Intake Valve Stem
OD Wear Limit . . . . . 6.90 mm (0.272 in.)
Exhaust Valve Stem
OD . . . . . 6.95-6.96 mm (0.273-0.276 in.)
Exhaust Valve Stem
OD Wear Limit . . . . . 6.9 mm (0.272 in.)

Valve Guide ID. . . . . 7.01-7.02 mm (0.275-0.276 in.)
Valve Guide ID Wear Limit . . . . . 7.08 mm (0.279 in.)
Valve Guide Height . . . . . 9.00 mm (0.354 in.)

Valve Guide-to-Valve Stem Oil Clearance

Intake . . . . . 0.030-0.060 mm (0.001-0.002 in.)
Exhaust . . . . . 0.045-0.075 mm (0.002-0.003 in.)
Wear Limit (Both) . . . . . 0.15 mm (0.006 in.)

Maximum Spring Inclination . . . . . 1.0 mm (0.039 in.)
Valve Spring Free Length (Nominal) . . . . . 36.9 mm (1.453 in.)

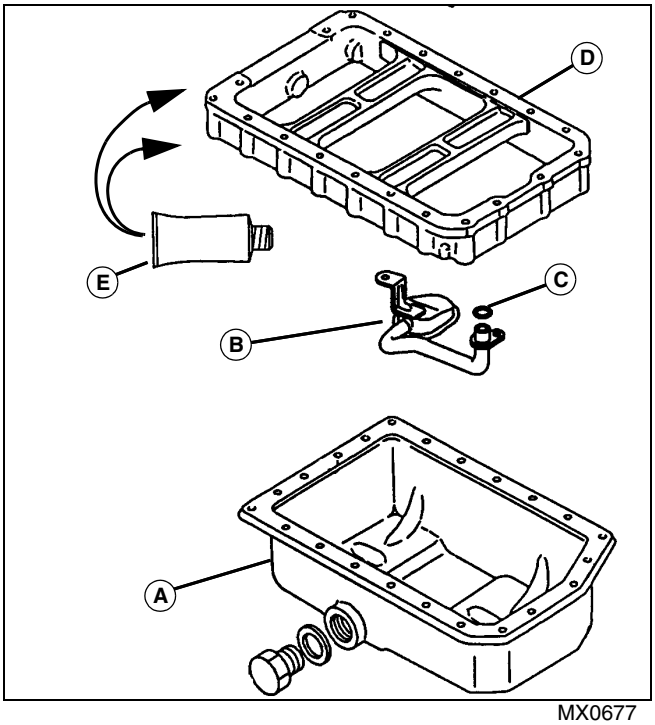
Remove and Install Oil Pan, Crankcase Extension, and Strainer

Other Material

Part No.	Part Name	Part Use
TY15130 (U.S.)	Form-in-Place Gasket	Applied to mating surfaces of crankcase extension.

Removal

IMPORTANT: Avoid damage! If spacer is to be removed for lower engine access, engine must be removed from machine. Rear crankshaft oil seal housing cap screws thread into spacer, and flywheel must be removed for access to cap screws.



MX0677

1. Remove oil pan cap screws and oil pan (A).
2. Remove cap screws for strainer and remove strainer (B) and O-ring (C).
3. If crankcase extension (D) is being removed, remove four lower cap screws in rear oil seal housing, and one cap screw in front. Remove crankcase extension.

Installation

1. Clean gasket mating surfaces and apply John Deere Form-In-Place Gasket (E) on all mating surfaces.
2. Install crankcase extension, replace O-ring on strainer, and install strainer.

NOTE: Fill engine with proper engine oil. (See Specifications section.)

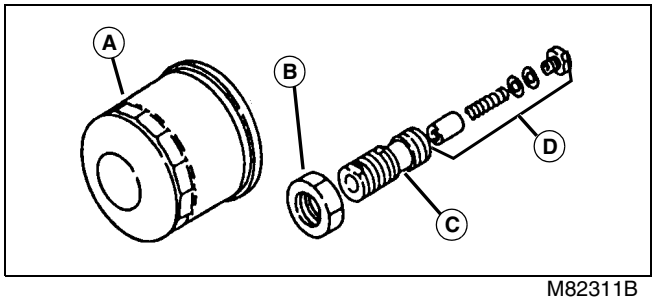
3. Install oil pan. Tighten cap screws to specification.

Specifications

Oil Pan Cap Screw (Threading in Block) Torque . . . . . 11 N•m (96 lb-in.)
Oil Pan Cap Screw (Threading in Aluminum) Torque . . . . . 9 N•m (78 lb-in.)
Crankcase Oil Capacity . . . . . 2.1 L (2.2 qt)

Remove and Install Oil Pressure Regulating Valve

Removal



M82311B

1. Remove oil filter (A).
2. Remove retaining nut (B) and valve assembly (C).

NOTE: Valve components (D) are not serviced individually. Replace complete regulating valve if any components are defective.

3. Check spring free and compressed length.
4. Inspect all parts for wear or damage. Replace complete valve if necessary.

Installation

Installation is done in the reverse order of removal.

Specifications

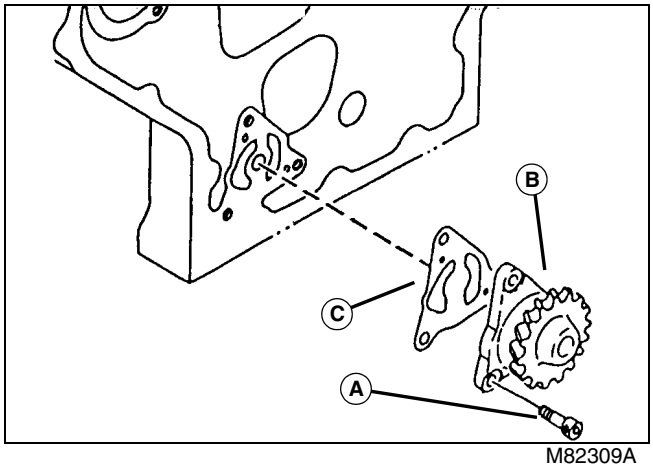
Oil Pressure Valve Spring
Free Length . . . . . 43.5-48.5 mm (1.7-1.9 in.)
Oil Pressure Valve Spring Test Length
(@ 20.5 N [9.6 lb-force]) . . . . . 27.5 mm (1.08 in.)
Oil Pressure Valve Spring
Retaining Nut Torque . . . . . 30 N•m (22 lb-ft)

Remove and Install Oil Pump

Removal and Installation

1. Remove timing gear cover. See “Remove and Install Timing Gear Cover” on page 67

2. Check oil pump gear backlash. Replace entire oil pump assembly if backlash is more than specification.

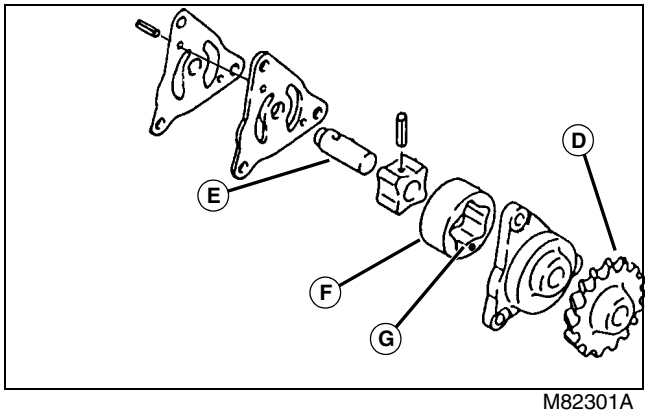


M82309A

3. Remove three mounting cap screws (A), oil pump (B), and gasket (C).

4. Inspect all parts for wear or damage. (See “Disassembly and Assembly” on page 65.)

Disassembly and Assembly



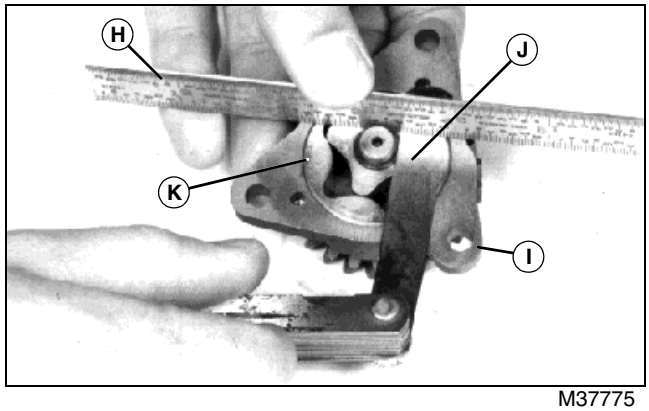
M82301A

- Gear (D) is press fit on rotor shaft (E). Remove gear using a knife edge puller and a press.
- Inspect parts for wear or damage. (See “Inspection” on page 65.)
- Coat all parts with clean engine oil.
- Install outer rotor (F) with identification mark (G) facing toward gear.

Inspection

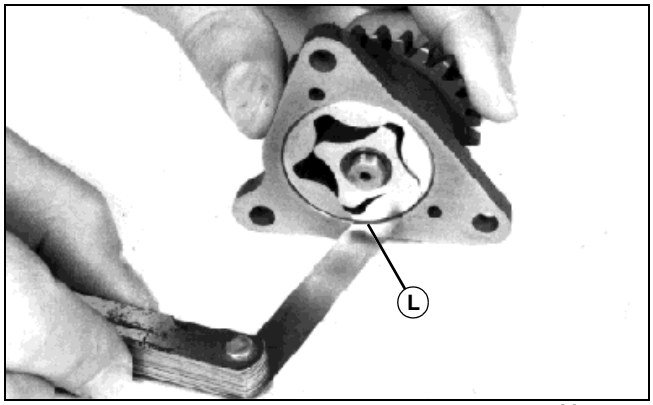

M35555

1. Measure the inside diameter of the rotor shaft bore in the backing plate, and subtract the outside diameter of the rotor shaft. If the clearance is more than wear limit, replace entire assembly.



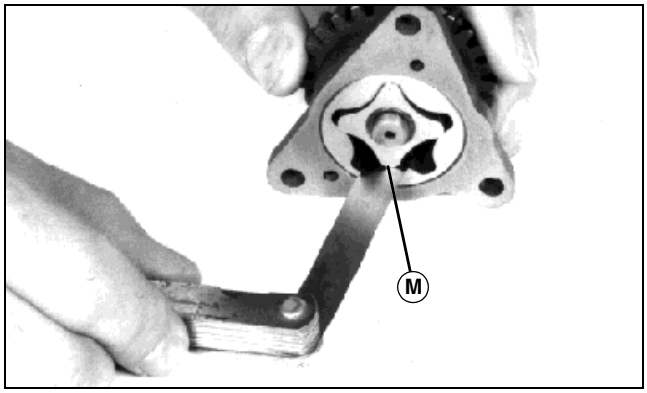
M37775

2. Lay a straight edge (H) across pump housing (I). Using a feeler gauge (J), check recess of inner and outer rotor (K). If rotor recess is beyond wear limit, replace rotor assembly.



M37776

3. Check outer rotor-to-pump housing clearance (L). If clearance is more than wear limit, replace entire assembly.



M37777

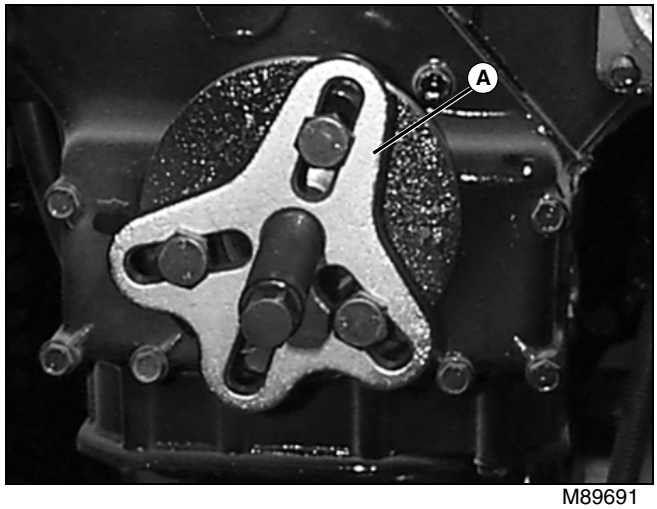
4. Check inner-to-outer rotor clearance (M). If clearance exceeds wear limit, replace rotor assembly.

Specifications

Oil Pump Gear Backlash (Max) . . . . . 0.3 mm (0.012 in.)
Rotor Shaft-to-Backing Plate Clearance . . . . . 0.013-0.043 mm (0.0005-0.002 in.)
Rotor Shaft-to-Backing Plate Clearance Wear Limit . . . . . 0.2 mm (0.008 in.)
Rotor Recess . . . . . 0.03-0.09 mm (0.001-0.004 in.)
Rotor Recess Wear Limit . . . . . 0.25 mm (0.010 in.)
Outer Rotor-to-Pump Body Clearance . . . . . 0.10-0.16 mm (0.004-0.006)
Outer Rotor-to-Pump Body Clearance Wear Limit . . . . . 0.25 mm (0.006 in.)
Inner Rotor-to-Outer Rotor Clearance Wear Limit . . . . . 0.25 mm (0.010 in.)
Oil Pump Attaching Cap Screw Torque . . . . . 11 N•m (96 lb-in.)
Oil Pan Cap Screw Torque (Threading in Block) . . . . . 11 N•m (96 lb-in.)
Oil Pan Cap Screw Torque (Threading in Aluminum) . . . . . 9 N•m (78 lb-in.)

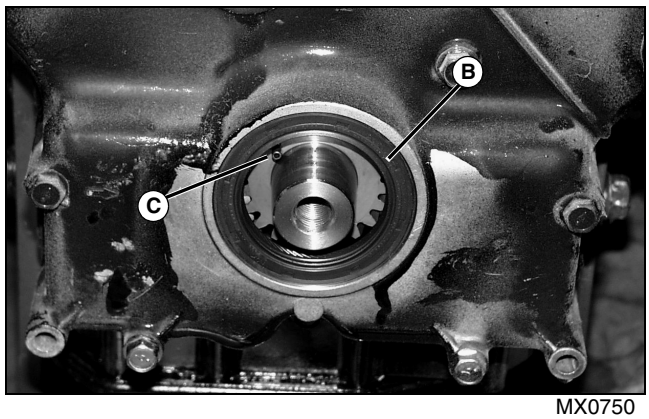
Remove and Install Crankshaft Front Oil Seal

1. Park machine with engine off, transmission in neutral, park brake locked.
2. Remove skid shield from sub frame.
3. Remove alternator/coolant pump belt.



M89691

4. Remove crankshaft pulley cap screw. Install puller (A) to crankshaft pulley and remove pulley.



MX0750

5. Carefully pry oil seal (B) from timing cover.
6. Install new oil seal using a driver set. Install seal with lip toward engine. Install seal flush with surface of cover.
7. Coat lip of seal with clean engine oil.
8. Install crankshaft pulley on crankshaft, lining up pin (C) on crankshaft timing gear with hole in crankshaft pulley.
9. Install flat washer and cap screw. Tighten cap screw to specification.
10. Install alternator/coolant pump belt and adjust belt.

Specifications

Crankshaft Pulley Cap Screw Torque. . 88 N•m (65 lb-ft)

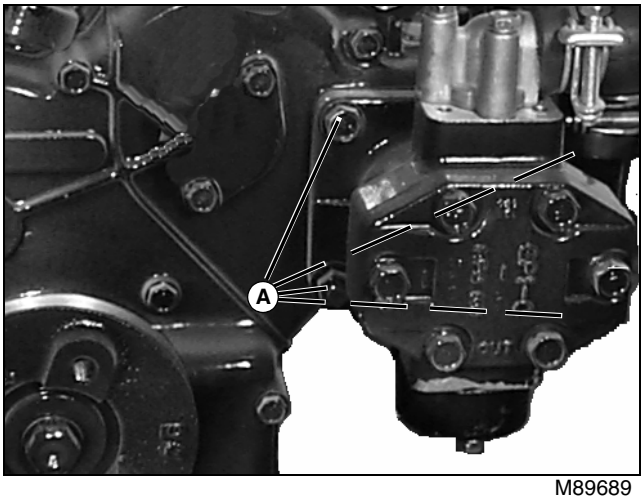
Remove and Install Timing Gear Cover

Other Material

Part No.	Part Name	Part Use
TY15130 (U.S.)	Form-in-Place Gasket	Seals timing cover, timing gear housing, and oil pan mating surfaces.

Removal and Installation

1. Drain coolant and remove lower coolant tube from coolant pump.



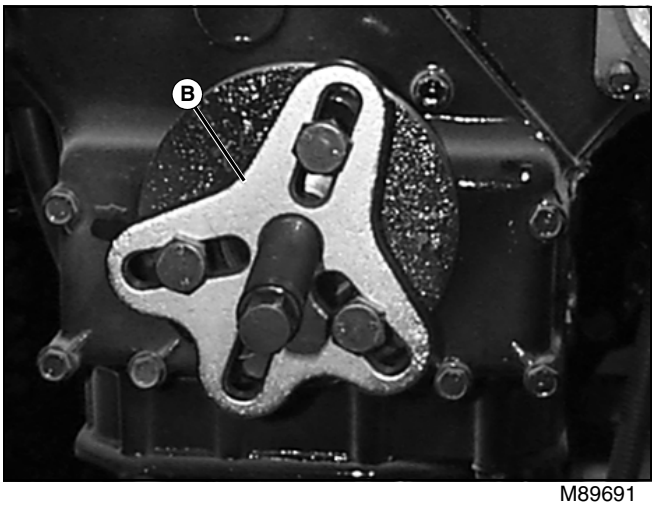
M89689

2. Remove front hydraulic pump cap screws and nuts (A).

3. Remove skid shield from sub frame.

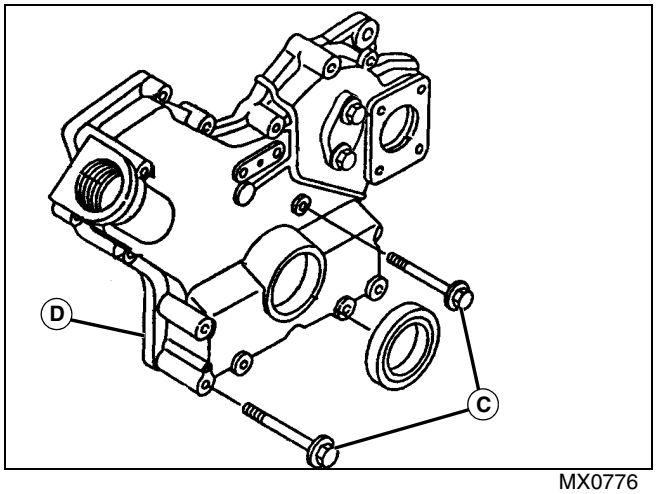
4. Remove lower alternator bracket, loosen top cap screw, remove alternator belt and move alternator away from cover.

5. Remove crankshaft pulley mounting cap screw and washer.



M89691

6. Install puller (B) to crankshaft pulley and remove pulley.



MX0776

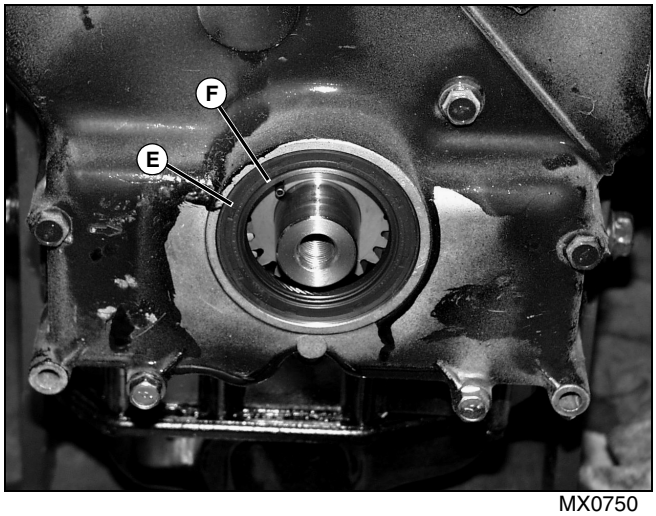
7. Remove timing cover mounting cap screws (C).

8. Remove timing gear cover (D).

9. Clean all old gasket material from timing cover, and timing cover housing on block.

10. Apply a thin bead of John Deere Form-In-Place Gasket Sealer to timing cover prior to installation

11. Tighten all timing cover mounting cap screws to specification.



MX0750

12. Replace crankshaft oil seal (E).

13. Install crankshaft pulley, lining up pin on crankshaft (F) with hole in pulley. Install flat washer and cap screw. Tighten to specification.

14. Install new gasket and hydraulic pump.

15. Install alternator and drive belt. Adjust belt tension.

16. Install skid shield on subframe.

Specifications

Timing Cover Mounting Cap Screw Torque . . . . . 9 N•m (78 lb-in.)

Crankshaft Pulley Cap Screw Torque . . . . . 88 N•m (65 lb-ft)

Check Timing Gear Backlash

Reason

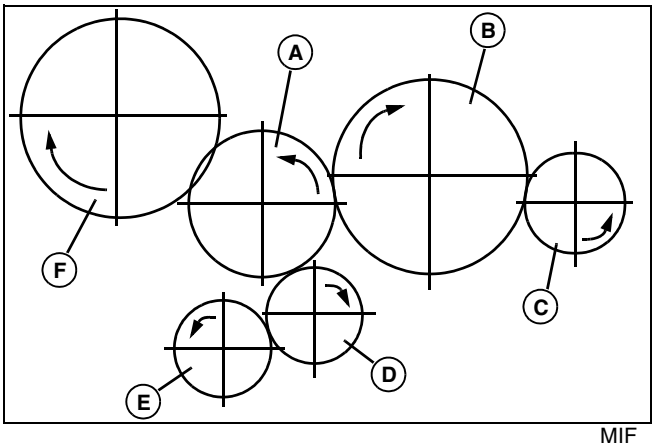
To check wear of timing gear teeth, resulting in excessive noise, improper valve timing, and poor engine performance.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Dial Indicator	NA	Used for backlash measurements.

Procedure

1. Remove timing gear cover.



MIF

A - Idler Gear
B - Camshaft Gear
C - Hydraulic Pump/PTO Gear
D - Crankshaft Gear
E - Oil Pump
F - Governor Gear

2. Place dial indicator magnetic base on cylinder block with tip of indicator on tooth of gear being measured.

3. Holding opposite gear stationary, move measured gear back and forth while measuring backlash between meshed gears.

Results

If backlash exceeds specifications, replace worn gears as a complete set: Idler Gear, Camshaft Gear, Crankshaft Gear, Oil Pump Gear, Governor Gear, Hydraulic Pump Drive Gear.

Specifications

Backlash for All Timing Gears (Except Crankshaft Gear-to-Oil Pump Gear) . 0.04-0.12 mm (0.002-0.005 in.)
Crankshaft Gear-to-Oil Pump Gear Backlash . . . 0.11-0.19 mm (0.004-0.008 in.)
Oil Pump Gear Backlash (Max) . . . . . 0.3 mm (0.012 in.)

Check Camshaft End Play

Reason

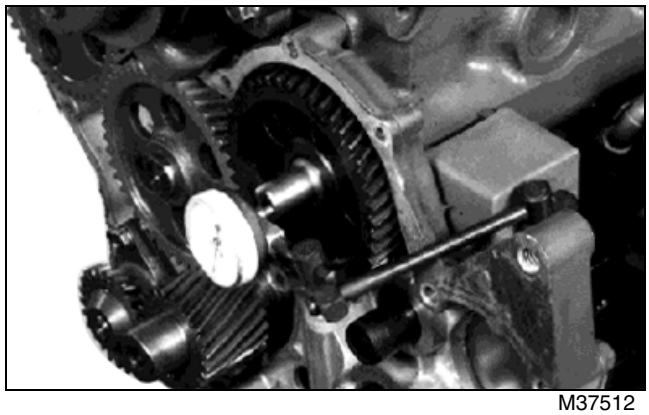
To determine proper side clearance between camshaft gear and camshaft thrust plate, to prevent excessive camshaft-to-camshaft follower wear.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Dial Indicator	NA	Used to measure camshaft end play.

Procedure

1. Remove timing gear cover. (See “Remove and Install Timing Gear Cover” on page 67.)



M37512

2. Fasten dial indicator base to cylinder block and position indicator tip on end of camshaft.

3. Push camshaft toward the rear as far as possible.

4. Zero the dial indicator.

5. Pull camshaft forward as far as possible.

Results

If camshaft end play exceeds specification, remove camshaft and inspect thrust plate, camshaft, and camshaft gear for wear. Replace parts as needed.

Specifications

Camshaft End Play. . . . . 0.05-0.15 mm (0.002-0.006 in.)
Camshaft End Play (Max) . . . . . 0.4 mm (0.016 in.)

Remove and Install Camshaft

Special or Required Tools

Tool Name	Tool No.	Tool Use
Magnetic Follower Holder Kit	D15001NU	Used to hold cam followers away from camshaft.

Other Material

Part No.	Part Name	Part Use
TY15130 (U.S.)	Form-in-Place Gasket	Seals timing cover, timing gear housing, and oil pan mating surfaces.

IMPORTANT: Avoid damage! Always replace camshaft followers when installing a new camshaft. Always replace camshaft when replacing camshaft followers. The components wear as a set and replacing one will accelerate the wear of the other.

Removal

1. Remove rocker arm assembly and push rods. (See "Remove and Install Rocker Arm and Push Rods" on page 57.)

2. Remove timing gear cover. (See "Remove and Install Timing Gear Cover" on page 67.)

3. Check camshaft end play.

4. Check backlash of timing gears. (See "Check Timing Gear Backlash" on page 68.)

NOTE: If camshaft is being removed with cylinder head installed, use a magnetic follower holder tool, or turn engine until oil pan is upward, to hold cam followers away from camshaft.

5. Hold cam followers away from camshaft using a Magnetic Follower Holder Kit such as D15001NU.

NOTE: Due to the odd number of teeth on the idler gear, timing marks will only align periodically.

6. Remove idler gear.

IMPORTANT: Avoid damage! DO NOT allow camshaft lobes to hit bearing surfaces while removing camshaft. Machined surfaces can be damaged.

7. Remove two cap screws holding camshaft mounting flange to block (through holes in camshaft gear).

8. Inspect all parts for wear or damage. (See "Camshaft Inspection" on page 70.)

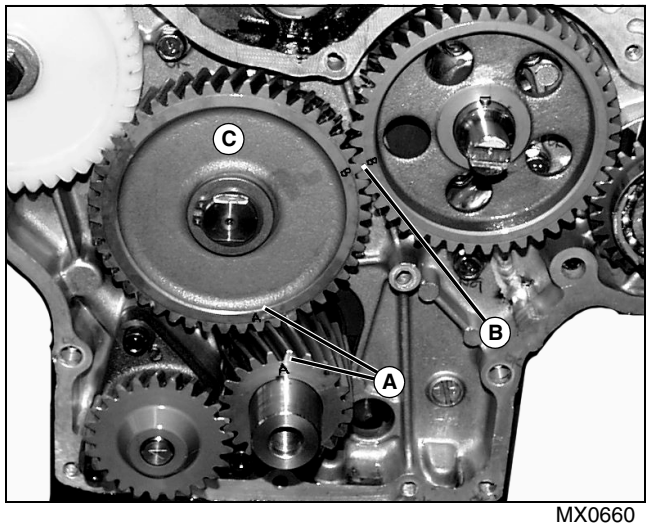
Installation

IMPORTANT: Avoid damage! DO NOT allow camshaft lobes to hit bearing surfaces while installing camshaft. Machined surfaces can be damaged.

NOTE: Apply clean engine oil on all parts during installation.

1. Install camshaft into cylinder block, being careful not to allow camshaft lobes to scratch camshaft bushings. Align camshaft gear timing marks with timing marks on idler gear.

2. Install two camshaft thrust plate cap screws through holes in cam gear. Tighten to specification.



MX0660

3. Align timing marks (A) and (B) with gears on crankshaft and camshaft while installing idler gear (C).

4. Install timing gear cover. (See "Remove and Install Timing Gear Cover" on page 67.)

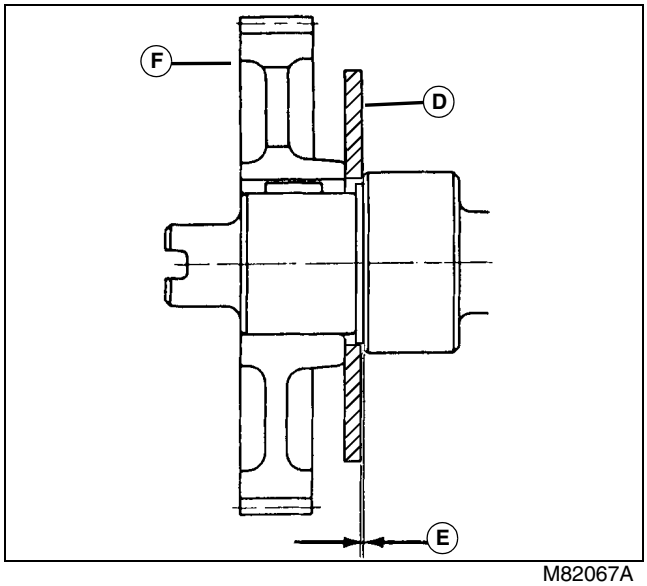
5. If cam followers were removed, replace into same holes as removed.

6. Install push rods and rocker arm assembly. (See "Remove and Install Rocker Arm and Push Rods" on page 57.)

Camshaft End Play Measurement

Check camshaft end play while camshaft is installed in cylinder block using a dial indicator, as described above. (See "Check Camshaft End Play" on page 68.)

To check camshaft end play while camshaft is removed from cylinder block, use a feeler gauge between camshaft thrust plate (D) and front side of first camshaft bearing journal, as shown below.



M82067A

If end play (E) is excessive, remove gear and replace thrust plate.

Camshaft Gear Removal

1. Inspect gear (F) for chipped or broken teeth. Replace if necessary.

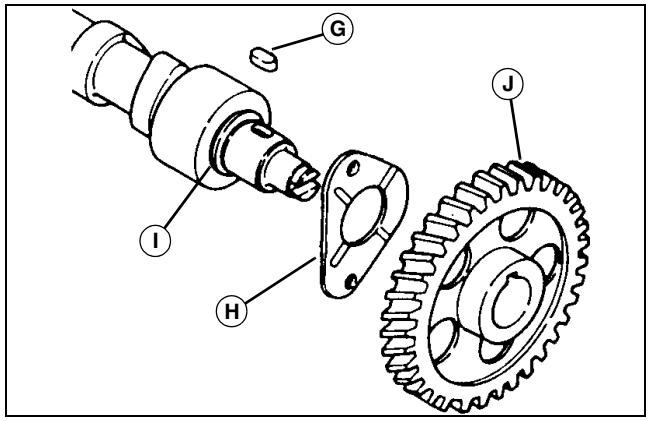
2. Remove gear from camshaft using a knife-edge puller and an arbor press. Place flat side of puller against camshaft gear.

Camshaft Gear Installation

CAUTION: Avoid injury! DO NOT heat oil over 182° C (360° F). Oil fumes or oil can ignite above 193° C (380° F). Use a thermometer. Do not allow a flame or heating element to come in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

1. Heat gear to approximately 150°C (300°F).

IMPORTANT: Avoid damage! Be sure thrust plate is not trapped between camshaft gear and stepped shoulder while gear is being pressed on.



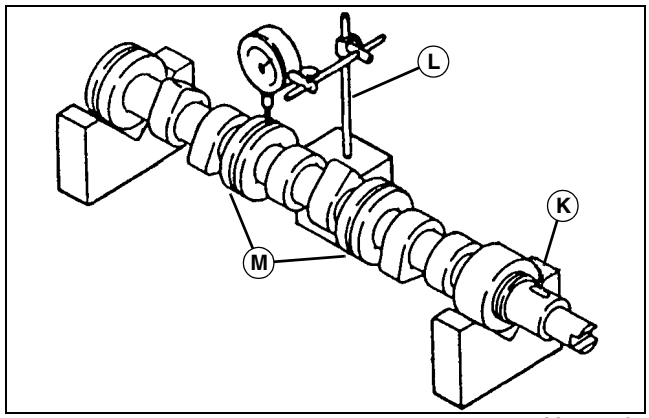
M82068A

2. Install key (G) into slot of camshaft.

3. Install thrust plate (H) onto camshaft, centering onto stepped shoulder (I). (Thrust plate has no “front” or “rear” side.)

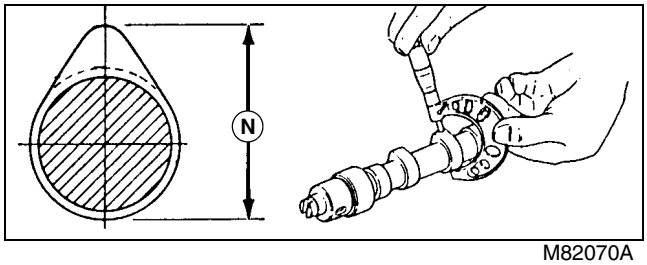
4. Install heated camshaft gear (J) with longer hub of camshaft gear facing camshaft. Align slot in gear with key in shaft. Press camshaft into gear until hub of gear is tight against camshaft shoulder. See “Important” above. Thrust plate must spin freely on camshaft.

Camshaft Inspection



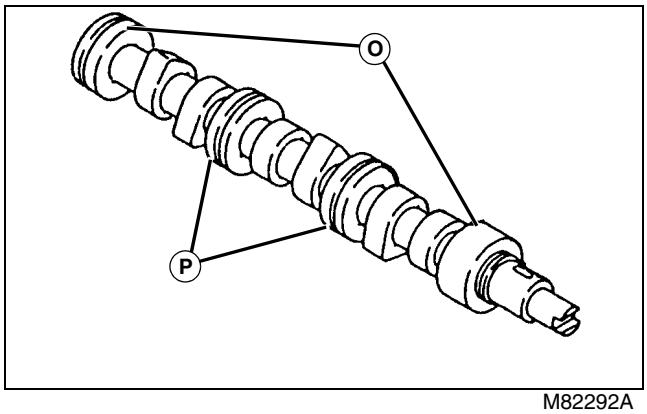
M82291A

1. Inspect camshaft for bend by using a pair of V-blocks (K) and a dial indicator (L). Turn camshaft slowly and read variation of camshaft bearing journals (M) on indicator. If variation is greater than wear limit, replace camshaft.



M82070A

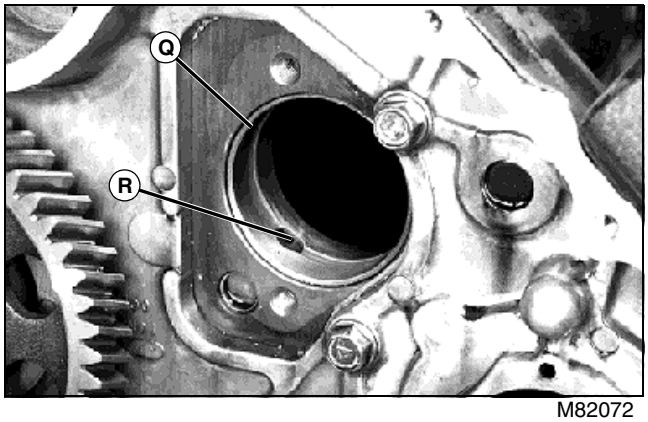
2. Measure camshaft lobe height (N) using a micrometer. If lobe height is less than wear limit, or if there are chips or scratches in lobes or bearing journals, replace camshaft.



M82292A

3. Measure camshaft end journals (O) and intermediate journal (P) outside diameters.

- If journal diameters are less than wear limit, replace camshaft.



M82072

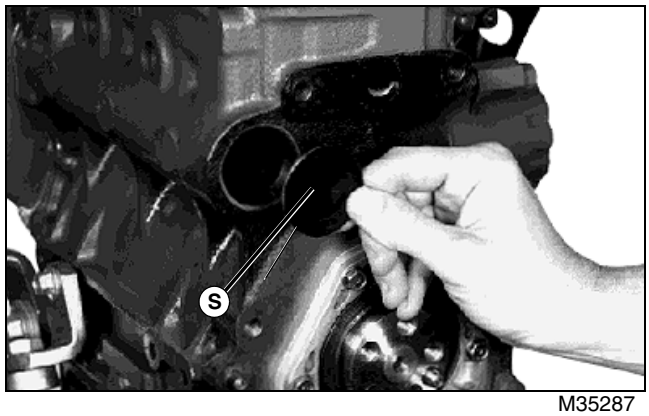
4. Measure camshaft bushing ID (Q) at gear housing end.

- If bushing ID exceeds wear limit, replace bushing.
- If bushing oil clearance (bushing ID minus camshaft journal OD) exceeds specification, replace bushing, camshaft or both.

To replace bushing:

Remove and replace bushing using a bushing driver. Be careful not to push bushing inside of engine. Align oil holes (R) in new bushing and cylinder block.

NOTE: Engine backplate must be removed to measure camshaft intermediate and flywheel end bearing diameters.

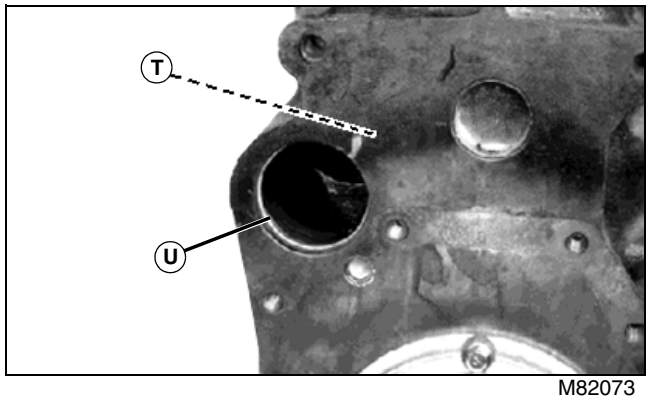


M35287

5. Measure intermediate and flywheel end camshaft bore diameters using the following procedures:

a. Remove engine backplate.

b. Remove plug (S).



M82073

c. Measure intermediate (T) and flywheel end (U) camshaft bore diameters.

- If bore diameter exceeds wear limit, replace cylinder block.
- If bore clearance (bore ID minus camshaft journal OD) exceeds oil clearance specification, replace camshaft, cylinder block, or both.

6. Apply John Deere Form-In Place Gasket, or an equivalent, on outer edge of plug. Install plug until it bottoms in bore.

7. Install engine backplate.

Specifications

Camshaft End Play. . . . . 0.05-0.15 mm (0.002-0.006 in.)
Camshaft End Play (Max) . . . . . 0.4 mm (0.016 in.)
Camshaft Bend. . . . . 0.00-0.02 mm (0.00-0.0008 in.)
Camshaft Bend (Max) . . . . . 0.05 mm (0.002 in.)

Camshaft Lobe
Height . . . . . 33.95-34.05 mm (1.336-1.341 in.)
Camshaft Lobe Height
Wear Limit . . . . . 33.75 mm (1.329 in.)

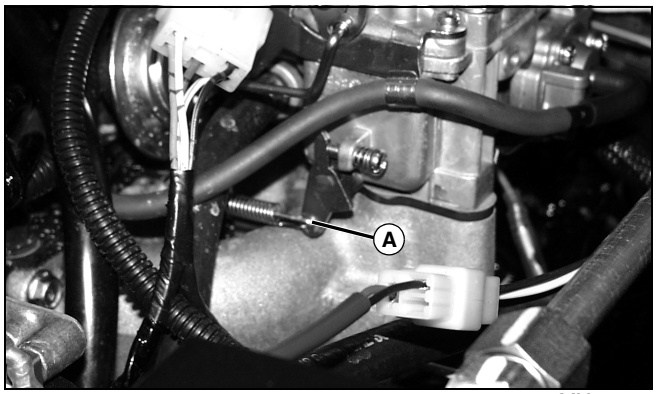
Camshaft Bearing Journals

Timing Gear End Journal
OD . . . . . 39.94-39.96 mm (1.572-1.573 in.)
Timing Gear End Journal
OD Wear Limit. . . . . 39.85 mm (1.569 in.)
Intermediate Journal
OD . . . . . 39.91-39.94 mm (1.571-1.572 in.)
Intermediate Journal
OD Wear Limit. . . . . 39.85 mm (1.569 in.)
Flywheel End Journal
OD . . . . . 39.91-39.94 mm (1.571-1.572 in.)
Flywheel End Journal
OD Wear Limit. . . . . 39.85 mm (1.569 in.)

Camshaft Bushing
ID . . . . . 40.000-40.065 mm (1.5748-1.5774 in.)
Camshaft Bushing
ID Wear Limit. . . . . 40.100 mm (1.5787 in.)
Camshaft Bushing
ID Oil Clearance . . . . . 0.040-0.085 mm (0.002-0.003 in.)
Camshaft Intermediate
Bore ID. . . . . 40.000-40.025 mm (1.5748-1.5757 in.)
Camshaft Intermediate
Bore ID Wear Limit . . . . . 40.100 mm (1.5787 in.)
Camshaft Intermediate
Bore ID Oil Clearance. 0.040-0.125 mm (0.002-0.005 in.)
Camshaft Flywheel End
Bore ID. . . . . 40.000-40.025 mm (1.5748-1.5757 in.)
Camshaft Flywheel End
Bore ID Wear Limit . . . . . 40.100 mm (1.5787 in.)
Camshaft Flywheel End
Bore ID Oil Clearance. 0.040-0.125 mm (0.002-0.005 in.)
Camshaft Thrust Plate
Cap Screw Torque . . . . . 11 N•m (96 lb-in.)

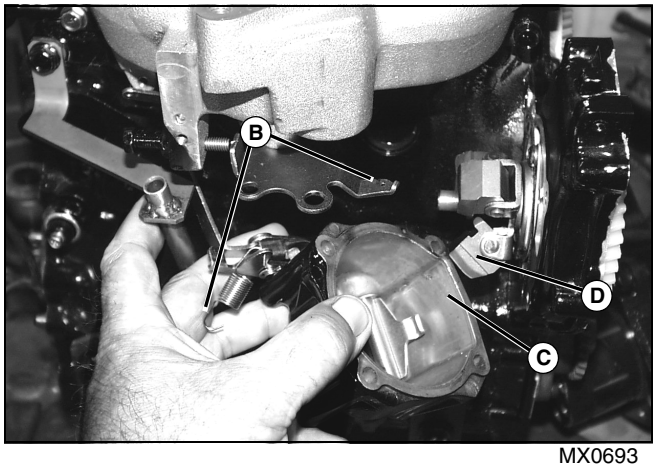
Remove and Inspect Governor

Procedure



MX0642

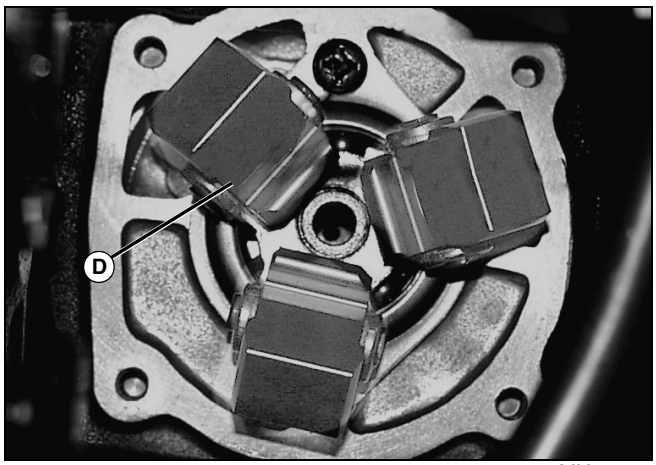
1. Remove cap screws securing carburetor to intake manifold. Turn carburetor to disconnect spring and governor link (A).



MX0693

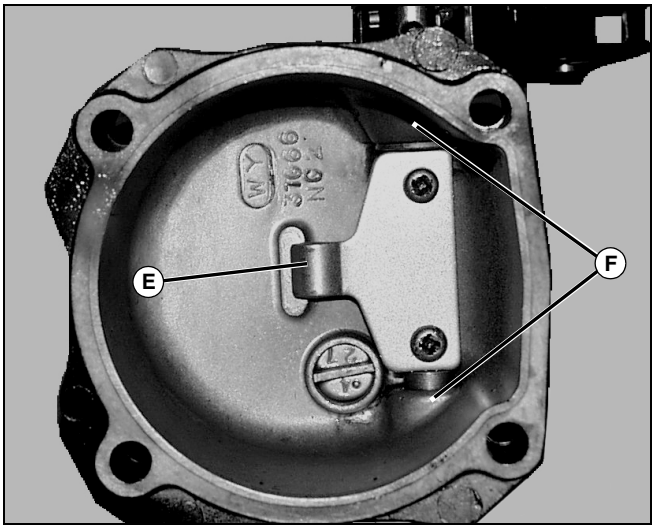
2. Disconnect spring (B).

3. Remove four cap screws, governor cover and linkage (C).



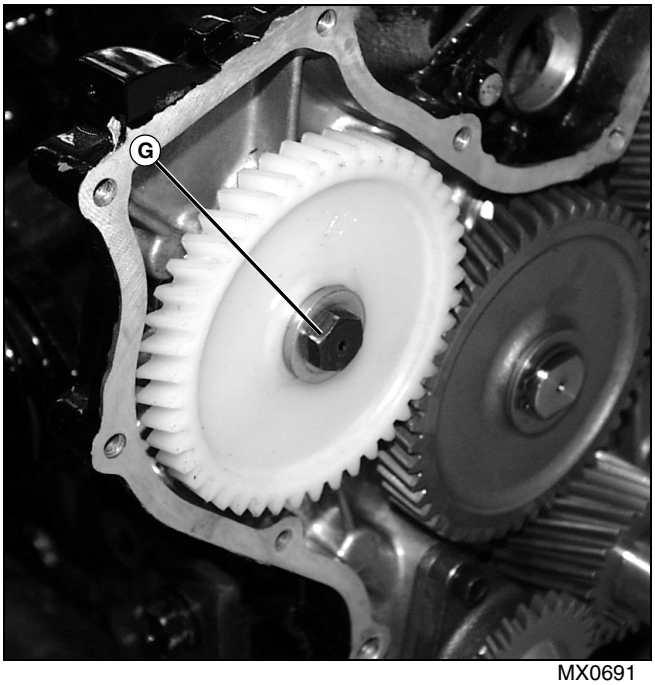
MX0706

4. Inspect governor weights (D) and remove spindle.



MX0710

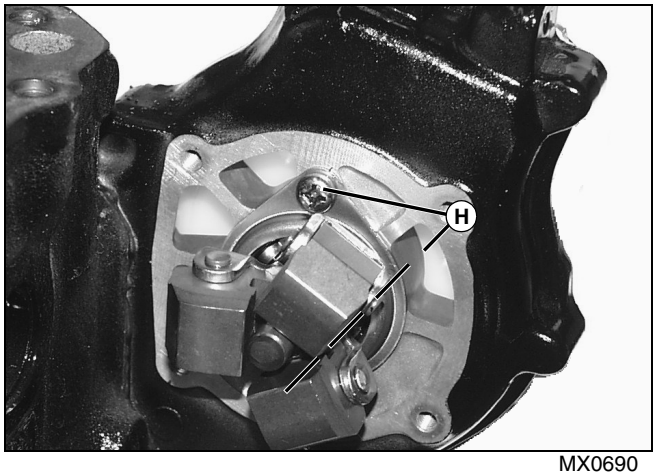
5. Inspect yoke (E), and governor cover shaft bores (F) for wear



MX0691

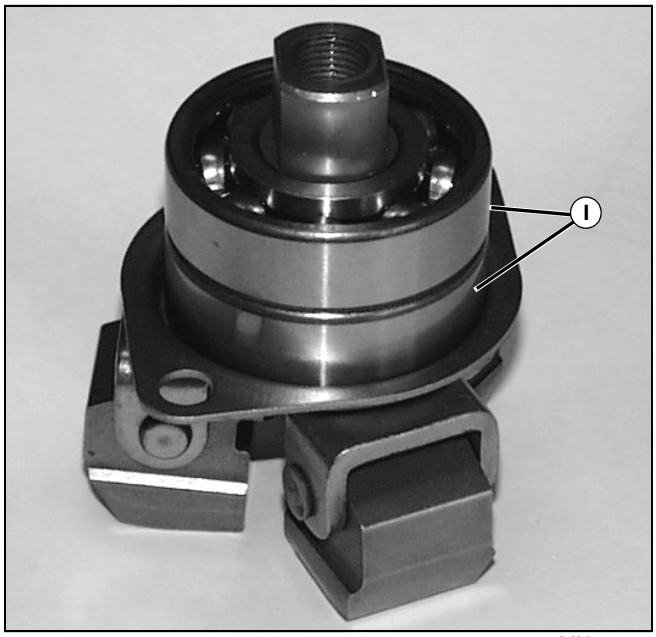
6. Remove timing gear cover and remove cap screw (G) from governor gear.

7. Slide governor gear from shaft assembly.



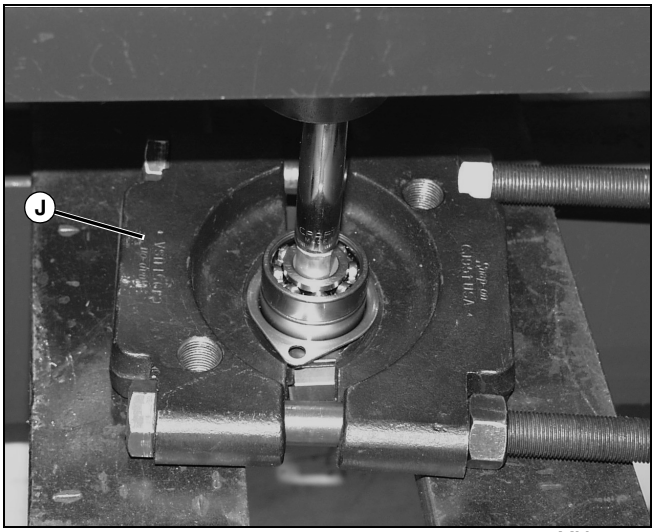
MX0690

8. Remove two screws from bearing retainer (H) and remove weight/shaft assembly from housing.



MX0708

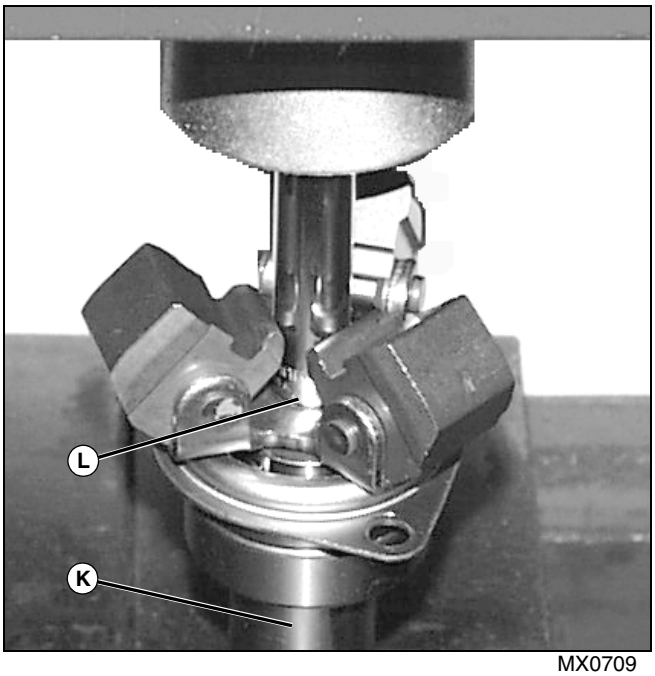
9. Turn bearings (I) by hand and check for smooth operation. Visually inspect for damaged balls or cages. Replace as required.



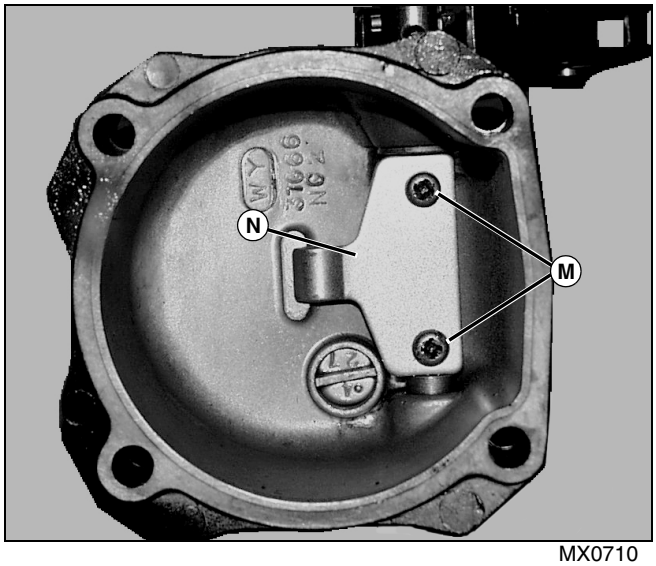
MX0707

10.If replacement is required, remove bearings with a knife edge puller (J) and a press as shown.

NOTE: When pressing bearings on, support the inner race of the bearing with an appropriate size socket (K) that will support the inner race and allow the shaft to come through. Press the weight/shaft assembly down from inside the weights on the flat part of weight support (L). Do not press on, or support, by the weights or damage will occur to weight assembly!

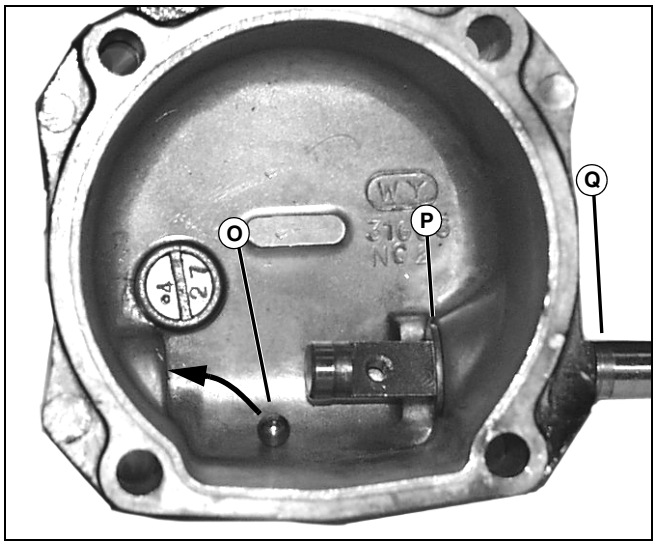


MX0709



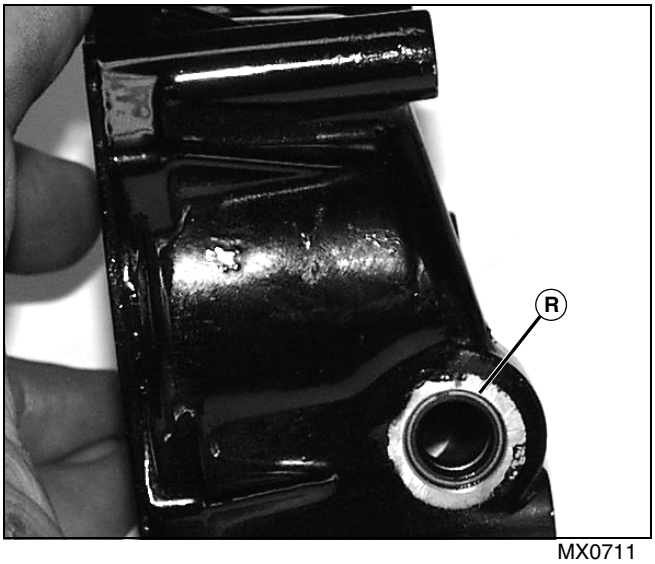
MX0710

11.Remove screws (M), and yoke (N).



MX0712

12.Observe location of ball (O) and washer (P) for reassembly. Check shaft (Q) for wear. Replace parts as required.



MX0711

13.Remove oil seal (R). Check shaft bores for wear. Replace oil seal.

Assembly

Assemble in the reverse order of disassembly.

Repair Piston and Connecting Rod

1. Remove oil pan, strainer tube, and spacer. (See “Remove and Install Oil Pan, Crankcase Extension, and Strainer” on page 64.)

2. Remove cylinder head. (See “Remove and Install Cylinder Head” on page 58.)

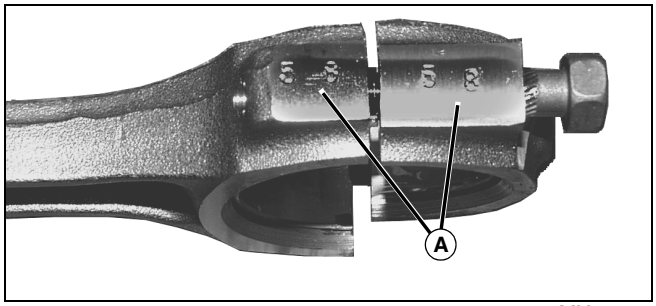
3. Check cylinder bore for ridges. Ridges can damage piston and rings if ridge is not removed. If necessary, remove ridge from top of cylinder bore using a ridge reamer.

4. Measure connecting rod side play. (See “Check Connecting Rod Side Play” on page 77.)

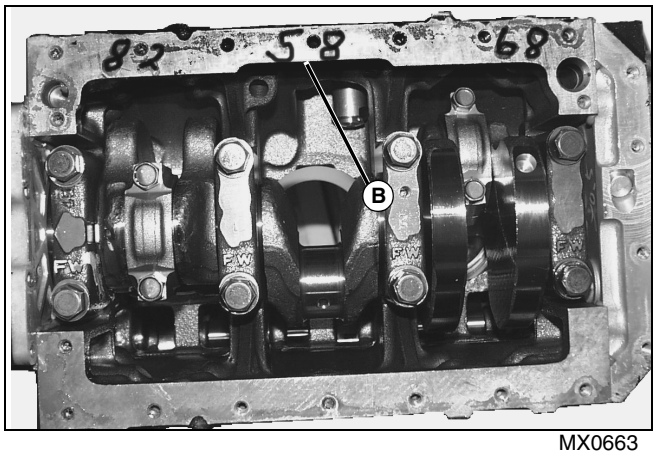
5. Measure connecting rod bearing clearance. (See “Check Connecting Rod Bearing Clearance” on page 77.)

IMPORTANT: Avoid damage! Keep connecting rods and caps together. Rods and caps are a matched set. Note matching numbers (A) on each part.

Pistons and cylinders are matched. Pistons must be installed in the cylinders from which they are removed.



MX0662



MX0663

6. Remove two cap screws, connecting rod cap, and bearing inserts.

Note connecting rod matching numbers (A) in relation to the cylinders. Mark the block on the side the numbers face with corresponding numbers (B).

7. Push piston and connecting rod out of cylinder bore using a wooden dowel.

8. Disassemble and inspect all parts for wear or damage. (See “Inspection and Replacement” on page 80.)

Check Crankshaft Main Bearing Clearance

Reason

To measure oil clearance between main bearing and crankshaft journal.

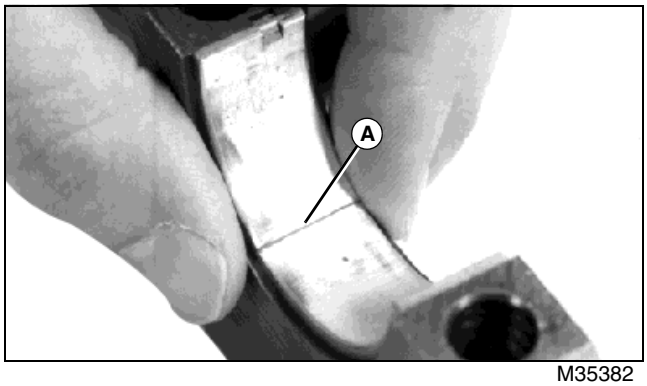
Special or Required Tools

Tool Name	Tool No.	Tool Use
PLASTIGAGE® Bearing Clearance Measurement Tool	NA	Used for clearance measurements.

Procedure

IMPORTANT: Avoid damage! Main bearing caps must be installed on the same main bearing and in the same direction to prevent crankshaft and main bearing damage.

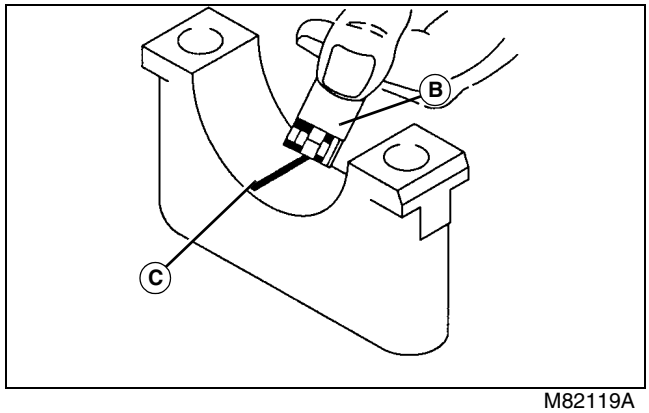
1. Remove main bearing cap.
2. Wipe oil from bearing insert and crankshaft journal.



M35382

3. Put a piece of PLASTIGAGE (A), or an equivalent, along the full length of the bearing insert approximately 6 mm (0.250 in.) off center.
4. Install main bearing cap and cap screws. Tighten cap screws to specification. DO NOT turn crankshaft.
5. Remove cap screws and main bearing cap.

NOTE: The flattened PLASTIGAGE will be found on either the bearing insert or crankshaft journal.



M82119A

6. Use the graduation marks on the envelope (B) to compare the width of the flattened PLASTIGAGE (C) at its widest point.
7. Determine main bearing clearance. The number within the graduation marks indicates the bearing clearance in inches or millimeters depending on which side of the envelope is used.
8. Remove PLASTIGAGE.

Results

If clearance exceeds specification, measure crankshaft main bearing journals. (See “Inspection and Repair” on page 86.) If bearing journals are within specification, replace bearing inserts.

Specifications

Main Bearing Cap Screw Torque . . . . . 78 N•m (58 lb-ft)
Crankshaft Main Bearing Oil Clearance . . . . . 0.020-0.072 mm (0.0008-0.0028 in.)
Crankshaft Main Bearing Clearance Wear Limit. . . . . 0.15 mm (0.006 in.)

Check Connecting Rod Bearing Clearance

Reason

To measure oil clearance between connecting rod bearing and crankshaft journal.

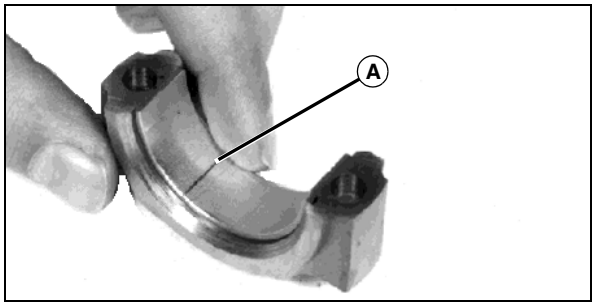
Special or Required Tools

Tool Name	Tool No.	Tool Use
PLASTIGAGE® Bearing Clearance Measurement Tool	NA	Used for clearance checks.

Procedure

IMPORTANT: Avoid damage! Connecting rod caps must be installed on the same connecting rod and in the same direction to prevent cranskshaft and connecting rod damage.

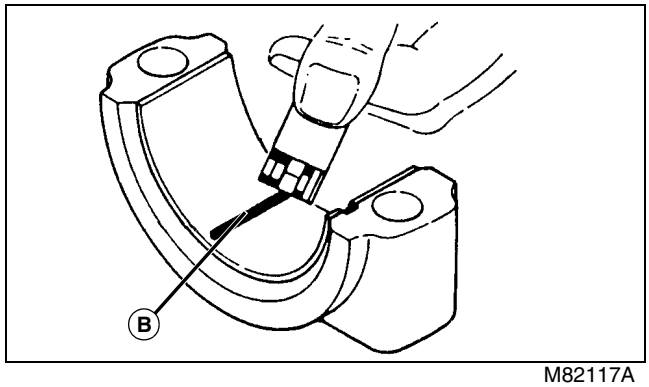
1. Remove connecting rod cap.
2. Wipe oil from bearing insert and crankshaft journal.



M35351

3. Put a piece of PLASTIGAGE (A), or an equivalent, along the full length of the bearing insert approximately 6 mm (0.250 in.) off center.
4. Turn crankshaft approximately 30° from bottom dead center.
5. Install connecting rod end cap and original cap screws. Tighten cap screws to specification. DO NOT turn crankshaft.
6. Remove cap screws and connecting rod cap.

NOTE: The flattened PLASTIGAGE will be found on either the bearing insert or crankshaft journal.



M82117A

7. Use the graduation marks on the envelope to compare the width of the flattened PLASTIGAGE (B) at its widest point.
8. Determine bearing clearance. The number within the graduation marks indicates the bearing clearance in inches or millimeters depending on which side of the envelope is used.
9. Remove PLASTIGAGE.

Results

If clearance exceeds specification, replace bearing inserts.

Specifications

Connecting Rod Cap
Cap Screw Torque . . . . . 23 N•m (203 lb-in.)
Connecting Rod Bearing
Oil Clearance . . . . . 0.020-0.072 mm (0.0008-0.0028 in.)
Connecting Rod Bearing
Clearance Wear Limit. . . . . 0.15 mm (0.006 in.)

Check Connecting Rod Side Play

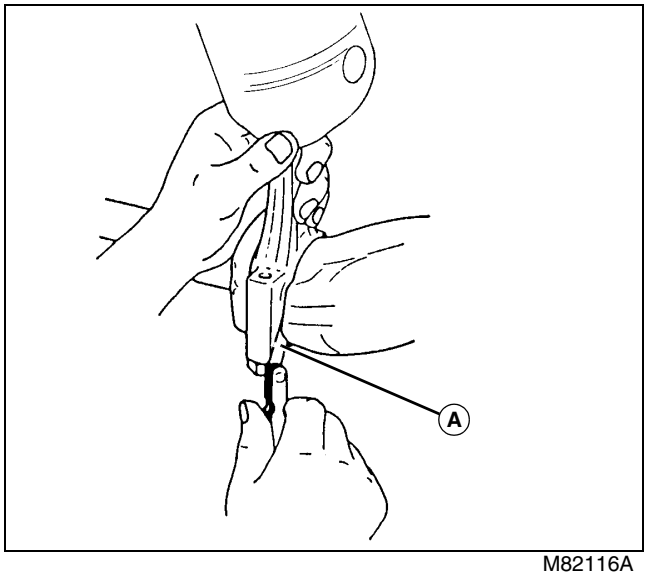
Reason

To determine proper side clearance between the crankshaft and the connecting rod.

NOTE: The engine must be removed from the tractor to perform this test.

Procedure

1. Remove the oil pan, crankcase extension, oil pick-up, and balancer assembly. (See “Remove and Install Oil Pan, Crankcase Extension, and Strainer” on page 64.)



M82116A

2. Insert a feeler gauge (A) between the connecting rod cap and the crankshaft.

Results

If the side play exceeds specification, replace the connecting rod and/or crankshaft.

Specifications

Connecting Rod Side Play (Max) . . 0.80 mm (0.031 in.)

Repair Piston

Installation

Special or Required Tools

Tool Name	Tool No.	Tool Use
Piston Ring Compressor	NA	Used to install pistons.

1. If new piston rings were installed, deglaze cylinder bore. (See “Deglazing” on page 83.)

2. Install piston rings so piston ring end gaps are staggered 120° apart.

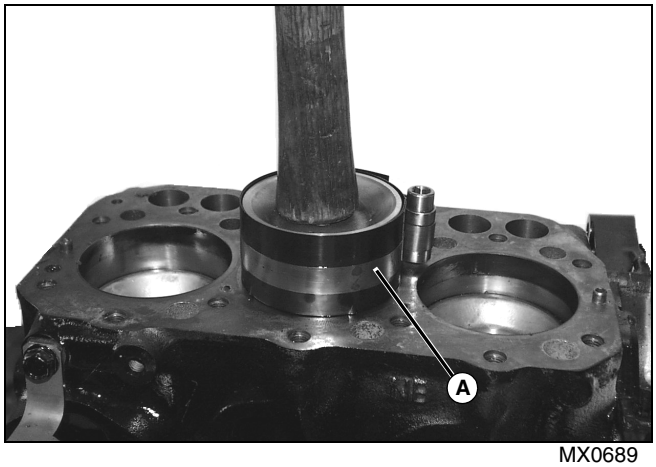
IMPORTANT: Avoid damage! Pistons must be installed in cylinders from which they were removed and in the same direction. Be careful not to damage crankshaft rod journal while installing piston.

3. Coat cylinder, piston skirt, rod, and cap bearing surfaces with oil.

IMPORTANT: Avoid damage! DO NOT touch bearing insert surfaces. Oil and acid from your finger will corrode the bearing surface.

4. Install bearing inserts on connecting rod and rod cap, aligning tangs with grooves.

IMPORTANT: Avoid damage! Connecting rod caps must be installed on the same connecting rods they were removed from.



MX0689

5. Install ring compressor on piston and install piston and connecting rod into the cylinder from which it was removed. Make sure matching numbers on connecting rod are facing away from the camshaft.

6. Install the connecting rod caps using matching numbers.

7. Dip entire connecting rod cap screws in clean engine oil. Install new cap screws and tighten to specifications.

8. If a new piston and connecting rod were installed, stamp a number corresponding to the cylinder number on the connecting rod cap and connecting rod.

9. Install cylinder head. (See “Remove and Install Cylinder Head” on page 58.)

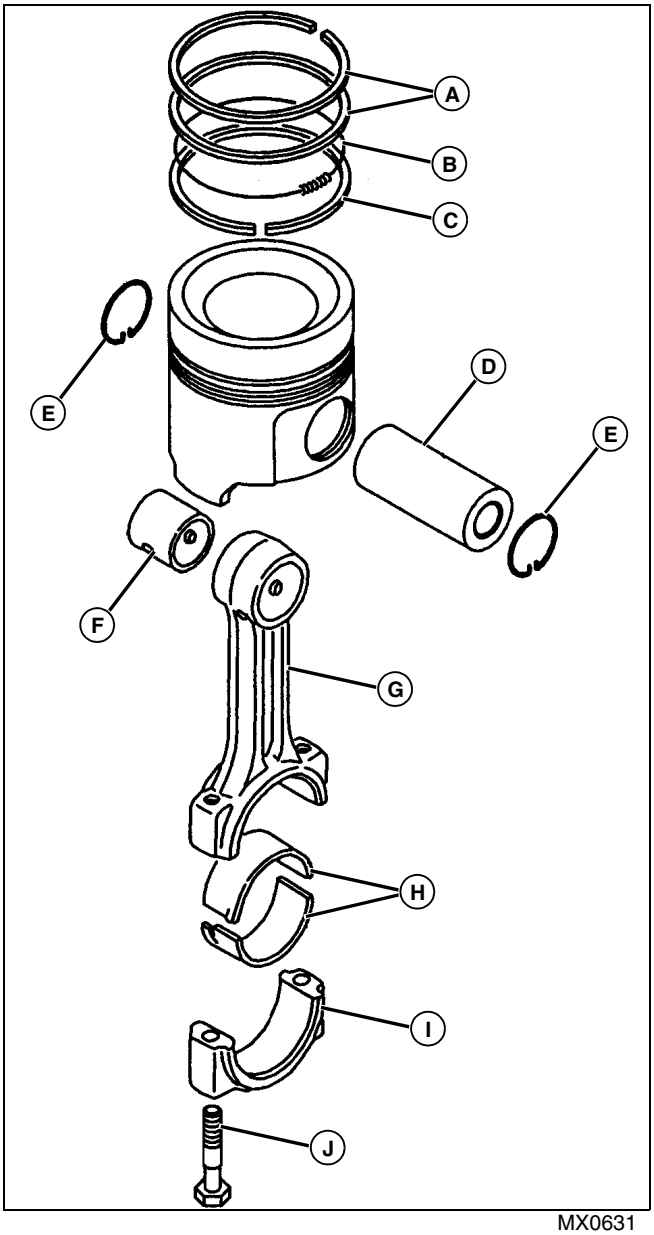
10.Install oil pan, spacer, and strainer tube. (See “Remove and Install Oil Pan, Crankcase Extension, and Strainer” on page 64.)

Disassembly

IMPORTANT: Avoid damage! Pistons must be installed on the same connecting rod they were removed from.

- Mark each piston and connecting rod to aid in assembly.
- Piston pin bushing is press fit in connecting rod. Remove bushing only if replacement is necessary. (See “Inspection and Replacement” on page 80.)

• Inspect all parts for wear or damage. Replace as necessary.



MX0631

A - Compression Rings
B - Oil Ring Expander
C - Oil Ring
D - Piston Pin
E - Snap Rings
F - Piston Pin Bushing
G - Connecting Rod
H - Bearing Inserts
I - Connecting Rod Cap
J - Bolt

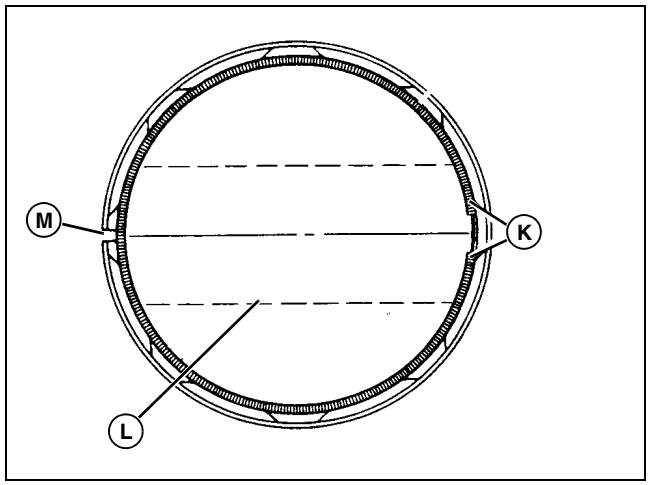
Assembly

IMPORTANT: Avoid damage! Pistons must be installed on the same connecting rod they were removed from.

NOTE: Apply clean engine oil to all parts during assembly.

1. Assemble piston to connecting rod with piston size mark on same side as connecting rod “punched” alignment mark. If a new connecting rod is used, assemble piston to connecting rod with piston size mark opposite connecting rod bearing insert groove.

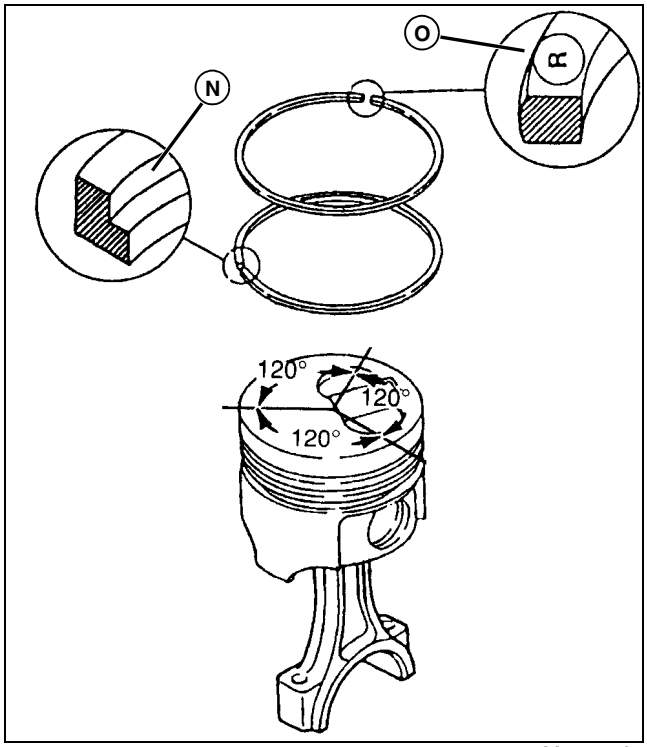
2. Install piston pin and retaining/snap rings.



M82046A

3. Install oil ring expander in bottom ring groove of piston with ends (K) above either end of piston pin (L).

4. Install oil ring over expander with ring gap (M) opposite (180°) of expander ends.



M82276A

5. Install second compression ring, with groove (N) on the inside diameter toward top of piston, in middle groove. Turn ring until gap is 120° away from oil ring gap.

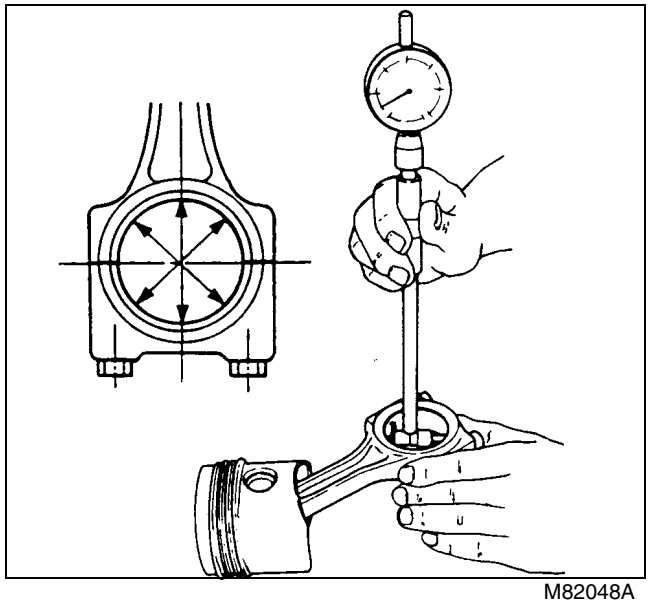
6. Install first compression ring (chrome plated), with manufacturer's mark (O) (near ring gap) toward top of piston, in top groove. Turn ring until gap is 120° away from second ring gap.

Inspection and Replacement

1. Inspect all parts for wear or damage. Replace as necessary.

2. Measure crankshaft connecting rod journal diameter. (See “Remove and Install Crankshaft and Main Bearings” on page 85.)

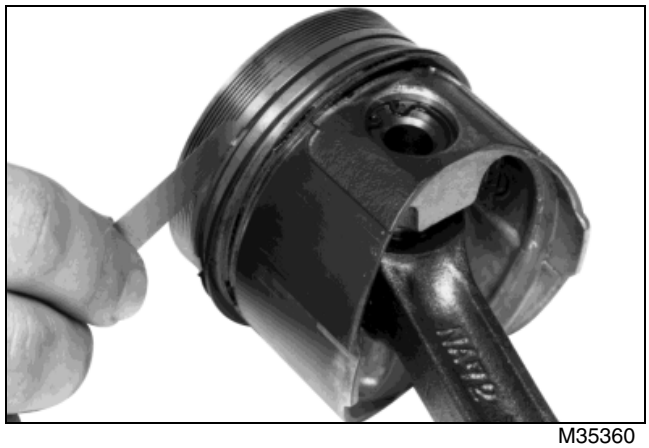
3. Install connecting rod cap and bearing inserts on connecting rod. Install old connecting rod cap screws and tighten to specification.


M82048A

4. Measure connecting rod bearing diameter.

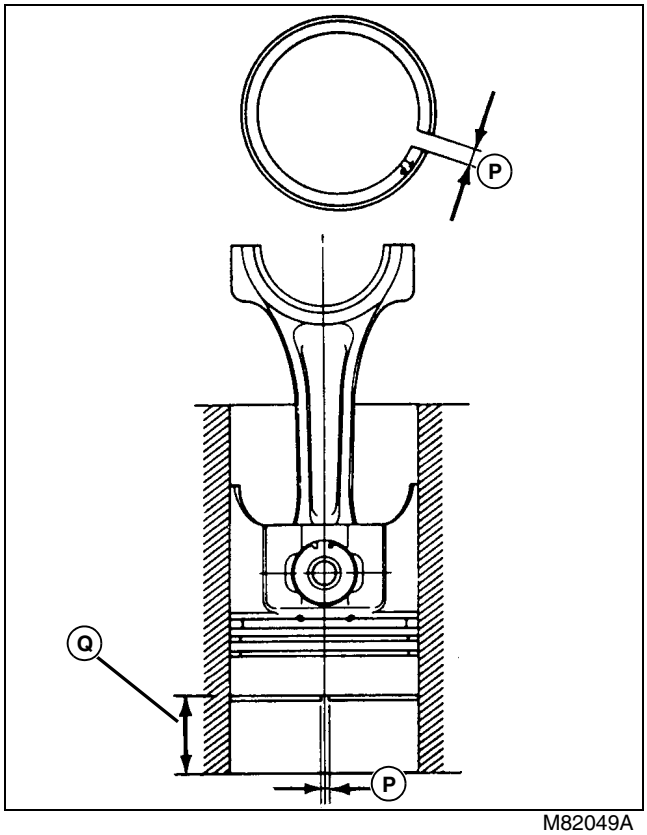
If bearing diameter exceeds wear limit and crankshaft is within specification, replace bearing inserts.

If crankshaft journal OD does not meet minimum specification, grind crankshaft connecting rod journals and install undersized bearing inserts, or replace bearing inserts and crankshaft.


M35360

5. With rings installed on piston, measure piston ring groove clearance. Measure several places around each piston.

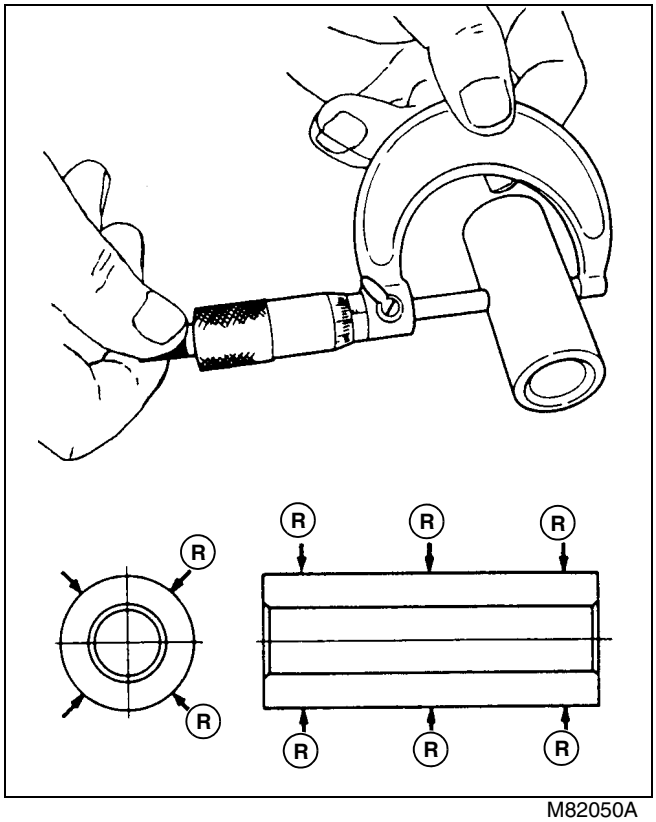
If clearance exceeds maximum limit, replace rings or piston.



M82049A

6. Measure piston ring end gap (P). Push ring into cylinder bore, using a piston, until ring is approximately 30 mm (1.181 in.) (Q) from bottom of cylinder bore.

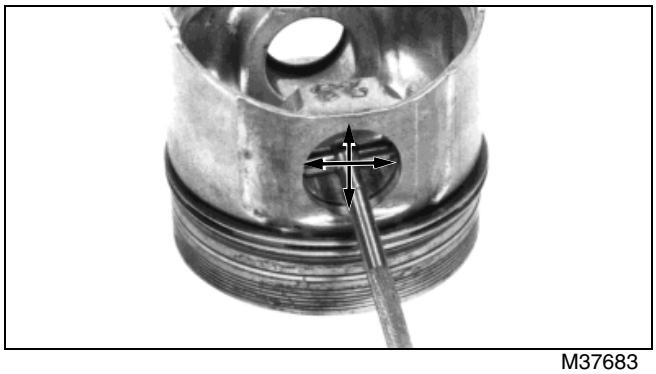
If end gap exceeds wear limit, replace rings.



M82050A

7. Measure piston pin diameter. Measure diameter at six places (R).

If pin diameter is less than wear limit at any measurement, replace pin.

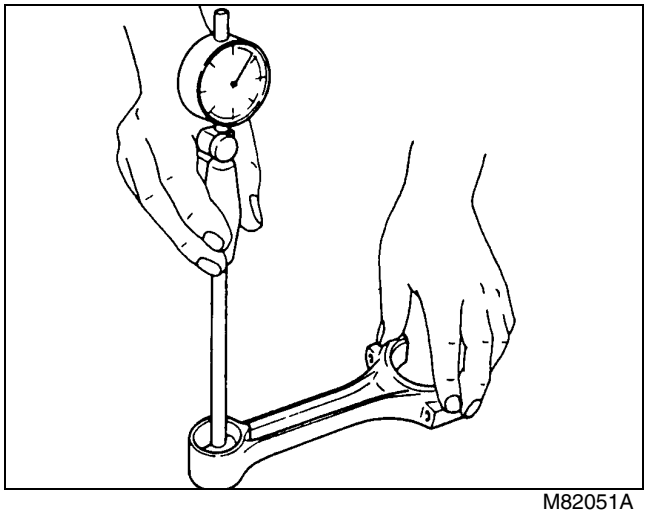


M37683

8. Measure piston pin bore diameter in two directions, 90° to each other, and at each side of the piston.

If piston pin bore exceeds wear limit, replace piston.

If bore clearance (bore ID minus pin OD) exceeds specification, replace piston, piston pin or both.



M82051A

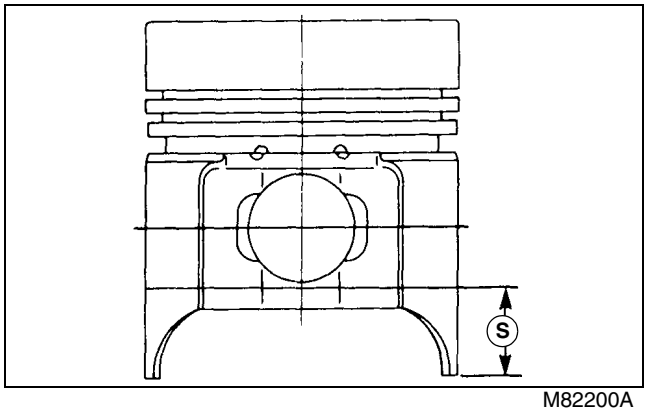
9. Measure piston pin bushing diameter in connecting rod.

If bushing diameter exceeds wear limit, replace bushing.

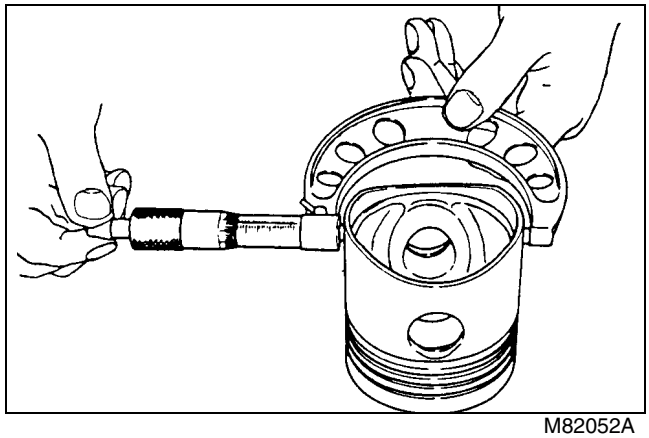
If bushing clearance (bushing ID minus pin OD) exceeds specification, replace bushing, piston pin or both.

Piston pin bushing is press fit. Replace bushing using a driver set. When installing bushing, make sure to align oil hole in bushing with hole in connecting rod.

NOTE: If engine has had a previous major overhaul, oversize pistons and rings may have been installed. Oversize pistons are available in 0.25 mm (0.010 in.) oversize.



M82200A



M82052A

10.Measure piston diameter perpendicular to piston pin bore at distance (S).

If piston diameter is less than wear limit, install a new piston.

11.Measure cylinder bore diameter. (See “Repair Cylinder Bore” on page 83.)

Specifications

Connecting Rod Cap
Cap Screw Torque . . . . . 23 N•m (203 lb-in.)
Connecting Rod Bearing
Clearance . . . . . 0.020-0.072 mm (0.0008-0.0028 in.)
Connecting Rod Bearing
Clearance Wear Limit . . . . . 0.15 mm (0.006 in.)
Connecting Rod Side Play (Max) . . 0.80 mm (0.031 in.)
Crankshaft Connecting Rod
Journal OD . . . . . 39.97-39.98 mm (1.573-1.574 in.)
Crankshaft Connecting Rod
Journal OD Wear Limit . . . . . 39.92 mm (1.572 in.)
Connecting Rod Bearing ID (Max) 40.07 mm (1.577 in.)
Piston Pin Bushing
ID . . . . . 21.025-21.038 mm (0.828-0. 828 in.)
Piston Pin Bushing
ID Wear Limit . . . . . 21.10 mm (0.831 in.)
Piston Pin-to-Bushing Oil
Clearance . . . . . 0.000-0.018 mm (0.0000-0.0007 in.)
Piston Pin-to-Bushing
Clearance Wear Limit . . . . . 0.045 mm (0.0018 in.)

Piston Ring Groove Side Clearance

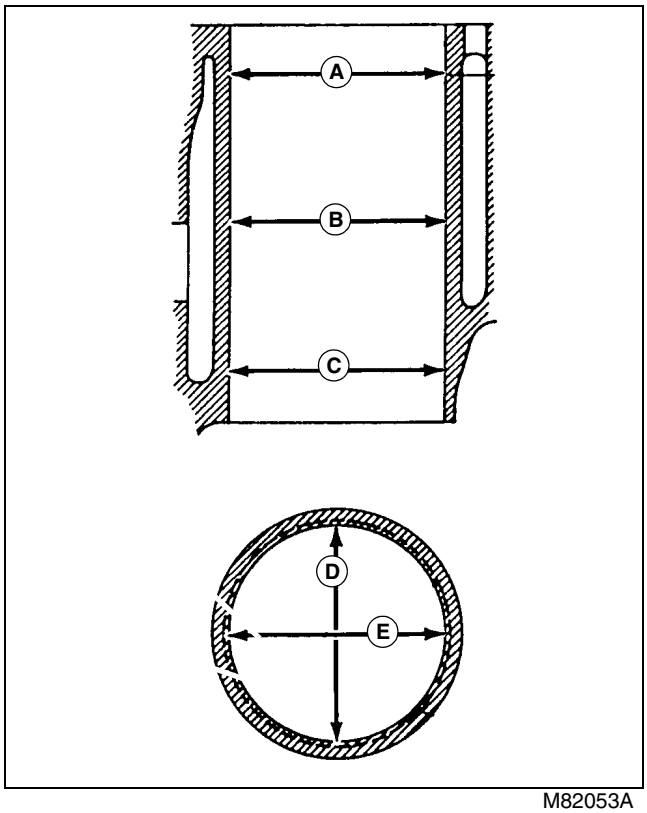
Top Piston Ring . . . . 0.075-0.110 mm (0.0029-0.0043 in.)
Top Piston Ring (Max) . . . . . 0.20 mm (0.008 in.)
Second Piston
Ring . . . . . 0.030-0.065 mm (0.0012-0.0026 in.)
Second Piston Ring (Max) . . . . . 0.20 mm (0.008 in.)
Oil Control Ring . . . 0.020-0.055 mm (0.0008-0.0022 in.)
Oil Control Ring (Max) . . . . . 0.20 mm (0.008 in.)

Top Ring End Gap (Max) . . . . . 1.25 mm (0.049 in.)
Second Ring End Gap (Max) . . . . . 1.25 mm (0.049 in.)
Oil Control Ring End Gap (Max) . . . 1.90 mm (0.075 in.)
Piston Pin OD . . . . . 20.99-21.00 mm (0.826-0.827 in.)
Piston Pin OD Wear Limit . . . . . 20.90 mm (0.823 in.)
Piston Pin Bore ID . . . 21.00-21.01 mm (0.827-0.827 in.)
Piston Pin Bore ID Wear Limit. . . . 21.02 mm (0.828 in.)
Piston Pin-to-Bore Clearance . . . . . 0.000-0.017 mm (0.00-0.0018 in.)
Piston Pin-to-Bore Wear Limit . . . . . 0.12 mm (0.005 in.)
Piston OD Wear Limit. . . . . 71.90 mm (2.831 in.)
Piston Measurement Distance F . . . . . 6 mm (0.236 in.)
Cylinder Bore (Max) . . . . . 72.15 mm (2.841 in.)
Piston-to-Cylinder Clearance (Max) . . . . . 0.015 mm (0.006 in.)

Repair Cylinder Bore

Inspection

NOTE: If engine has had a previous major overhaul, oversize pistons and rings may have been installed.



M82053A

Measure cylinder bore diameter at three positions; top (A), middle (B), and bottom (C). At these three positions, measure in both directions: along crankshaft center line (E), and direction of crankshaft rotation (D).

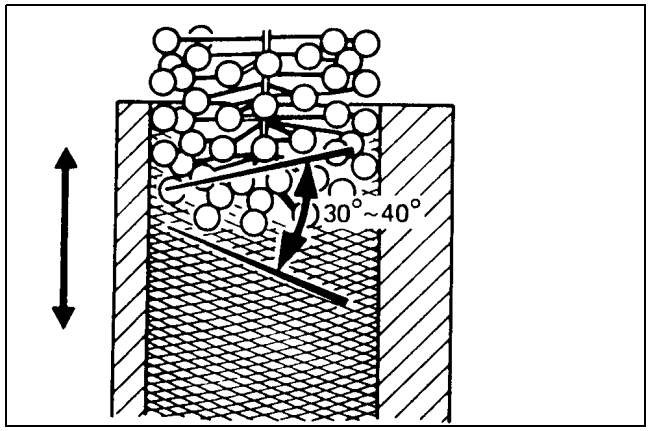
Cylinder Bore ID

- If cylinder bore exceeds wear limit, replace cylinder block or have cylinder rebored. (See “Reboring” on page 83.)
- If cylinder is rebored, oversize pistons and rings must be installed. Pistons and rings are available in 0.25 mm (0.010 in.) oversize.
- If clearance (cylinder bore ID minus piston OD) exceeds specification, replace cylinder block, piston or both; or rebore cylinder and install oversize piston and rings.

Deglazing

IMPORTANT: Avoid damage! If cylinder bores are to be deglazed with crankshaft installed in engine, put clean shop towels over crankshaft to protect journal and bearing surfaces from any abrasives.

1. Deglaze cylinder bores using a flex-hone with 180 grit stones.



M82054A

2. Use flex-hone as instructed by manufacturer to obtain a 30-40° cross-hatch pattern as shown.

IMPORTANT: Avoid damage! DO NOT use gasoline, kerosene, or commercial solvents to clean cylinder bores. Solvents will not remove all abrasives from cylinder walls.

3. Remove excess abrasive residue from cylinder walls using a clean dry rag. Clean cylinder walls using clean white rags and warm soapy water. Continue to clean cylinder until white rags show no discoloration.

Reboring

NOTE: The cylinder block can be rebored to use oversize pistons and rings. Pistons and rings are available in 0.25 mm (0.010 in.) oversize. (See this group for cylinder bore ID specifications.)

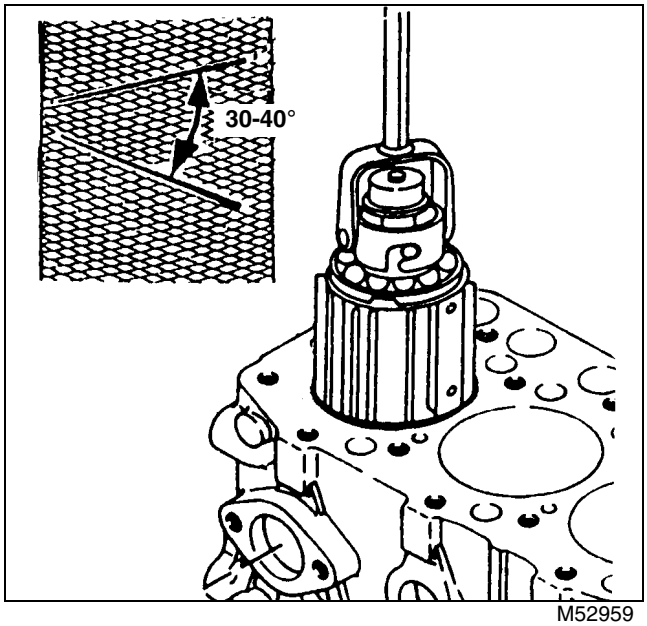
1. Align center of bore to drill press center.

IMPORTANT: Avoid damage! Check stone for wear or damage. Use a rigid hone with 300 grit stones.

2. Adjust hone so lower end is even with lower end of cylinder bore.

3. Adjust rigid hone stones until they contact narrowest point of cylinder.

4. Coat cylinder with honing oil. Hone should turn by hand. Adjust if too tight.



M52959

5. Run drill press at about 250 rpm. Move hone up and down in order to obtain a 30-40° crosshatch pattern.

NOTE: Measure bore when cylinder is cool.

6. Stop press and check cylinder diameter.

NOTE: Finish should not be smooth. It should have a 30-40° crosshatch pattern.

7. Remove rigid hone when cylinder is within 0.03 mm (0.001 in.) of desired size.

8. Use a flex hone with 180 grit stones for honing to final size.

9. Check bore for size, taper and out-of-round. (See “Repair Cylinder Bore” on page 83.)

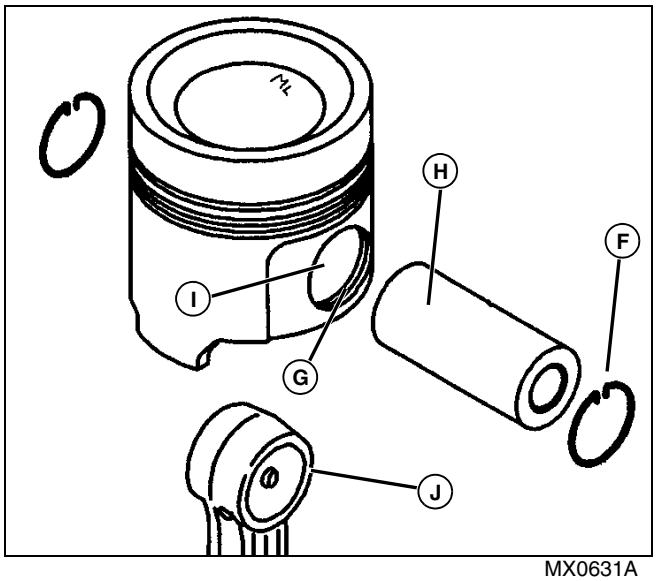
IMPORTANT: Avoid damage! DO NOT use solvents to clean cylinder bore. Solvents will not remove all metal particles and abrasives produced during honing.

10.Clean cylinder thoroughly using warm soapy water until clean white rags show no discoloration.

11.Dry and oil cylinder walls immediately to prevent the formation if rust.

IMPORTANT: Avoid damage! Retaining rings (F) should be installed with end gap pointing up.

NOTE: Install piston pin before retaining ring to prevent possible scoring of bore.



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12.Install one piston pin retaining ring (F) in groove of piston bore (G).

13.Install pin (H) through piston bore (I) and connecting rod (J). Pin should install easily with thumb pressure.

14.Install remaining retaining ring (F) in opposite side.

Specifications

Cylinder Bore
(Standard Size) . . . . . 72.00-72.03 mm (2.834-2.836 in.)
Cylinder Bore
Wear Limit (Standard Size) . . . . . 72.15 mm (2.841 in.)
Piston-to-Cylinder
Clearance (Max) . . . . . 0.15 mm (0.006 in.)
Cylinder Roundness . . . 0.00-0.01 mm (0.00-0.0004 in.)
Cylinder Roundness (Max) . . . . . 0.03 mm (0.001 in.)
0.25 mm (0.010 in.) Oversize
Bore ID . . . . . 72.25-72.28 mm (2.844-2.845 in.)
0.25 mm (0.010 in.) Oversize
Bore ID Wear Limit . . . . . 72.45 mm (2.852 in.)

Remove and Install Crankshaft and Main Bearings

Removal

1. Check crankshaft end play.

2. Remove flywheel. (See “Remove and Install Clutch and Flywheel” on page 55.)

3. Remove rear oil seal case. (See “Remove and Install Crankshaft Rear Oil Seal” on page 87.)

4. Remove timing gear cover, timing gears, timing gear housing, and flywheel of engine.

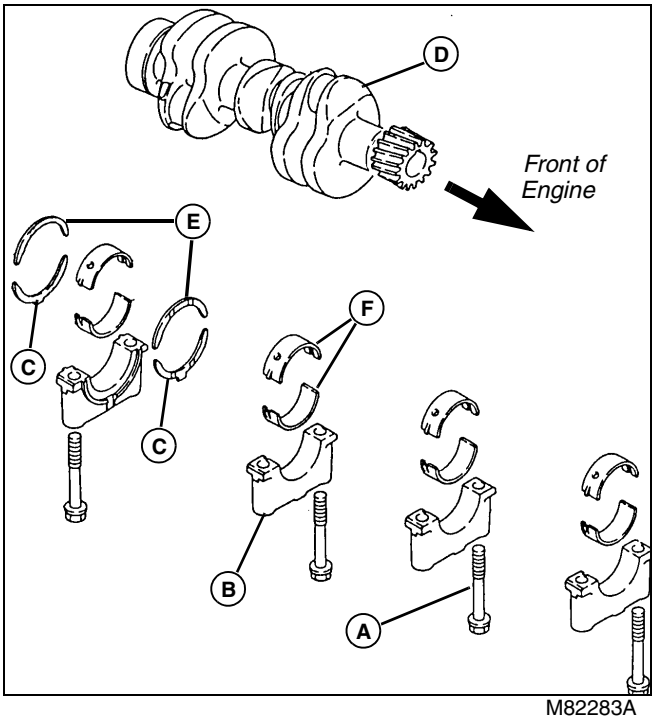
5. Check crankshaft bearing clearance. (See “Inspection and Repair” on page 86.).

IMPORTANT: Avoid damage! Connecting rod end caps must be installed on the same connecting rods from which they were removed. Note alignment marks on caps and rods.

6. Remove connecting rod cap screws and end caps.

7. Push pistons and connecting rods away from crankshaft.

IMPORTANT: Avoid damage! Main bearing caps must be installed on the same main bearings from which they were removed.



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8. Remove main bearing cap screws (A), caps (B), and thrust bearings (C).

9. Remove crankshaft (D).

10. Remove block thrust bearings (E) and main bearing inserts (F).

11. Inspect all parts for wear or damage. (See “Inspection and Repair” on page 86.)

Installation

IMPORTANT: Avoid damage! DO NOT touch bearing insert surfaces. Oil and acid from your finger will corrode the bearing surface.

NOTE: Apply clean engine oil on all parts during installation.

1. Install bearing inserts drilled with oil passage in cylinder block bearing bores, aligning tangs with slots in bores.

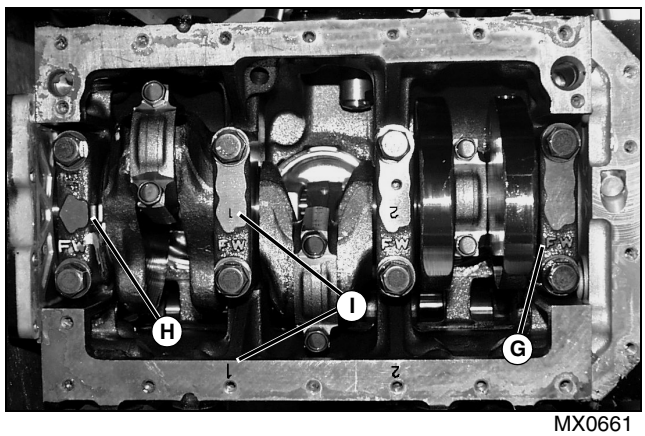
2. Apply grease to smooth side of thrust bearing to hold them in place on block. Install block thrust bearings with oil grooves facing away from engine block.

3. Install crankshaft.

4. Install smooth bearing inserts in main bearing caps, aligning tangs with slots in caps.

5. Apply grease to smooth side of thrust bearings to hold them in place on bearing cap during assembly. With oil grooves facing away from cap, install thrust bearings on main bearing cap.

NOTE: Main bearing caps have the letters FW cast on the camshaft side (G). Both correspond to their location on the engine block. The flywheel end bearing (H) has the thrust bearing inserts. The two center bearing caps have the number 1, and 2, on them, which correspond to the numbers stamped in the block (I). The main bearing cap at gear train end does not have a number.



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6. Install main bearing caps in their original locations with FW toward camshaft side of engine.

IMPORTANT: Avoid damage! DO NOT use high speed power tools or air wrenches to tighten main bearing cap screws.

7. Dip entire main bearing cap screws in clean engine oil. Install cap screws and tighten. DO NOT tighten to specifications.

8. Using a soft-faced hammer, tap the front end of the crankshaft then the rear end of the crankshaft to align the thrust bearings.

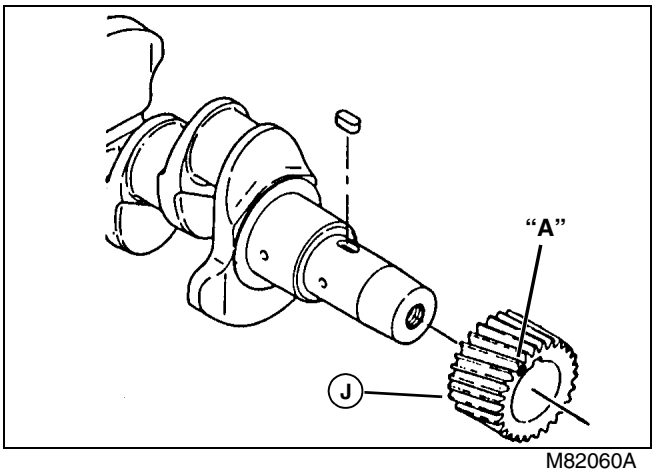
9. Tighten main bearing cap screws to specifications. When tightening, start at center main bearing cap and work your way out, alternating to the ends. Turn crankshaft by hand after each cap is tightened. If it does not turn easily, disassemble the parts and find the cause.

Inspection and Repair

1. Inspect crankshaft gear for chipped or broken teeth. Replace if necessary. To replace gear:

a. Remove gear from crankshaft using a knife-edge puller and a press.

CAUTION: Avoid injury! DO NOT heat oil over 182° C (360° F). Oil fumes or oil can ignite above 193° C (380° F). Use a thermometer. Do not allow a flame or heating element to come in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.



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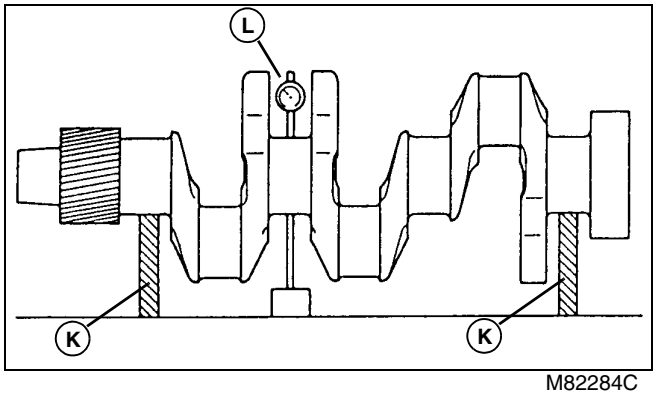
b. Heat gear to approximately 150°C (300°F). Install gear (J) with timing mark "A" toward press table. Align slot in gear with key in shaft. Press crankshaft into gear until gear is tight against crankshaft shoulder.



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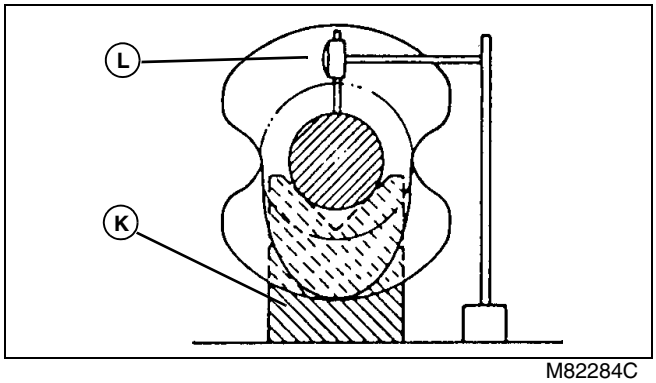
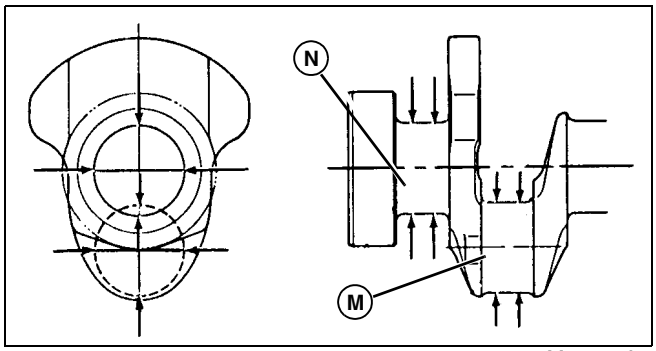


M82284C

2. Inspect crankshaft for bend using V-blocks (K) and a dial indicator (L). Turn crankshaft slowly and read variation on indicator. If variation is greater than 0.02 mm (0.0008 in.), replace crankshaft.

NOTE: If engine has had a previous major overhaul, journals may have been ground and undersized bearing inserts installed.



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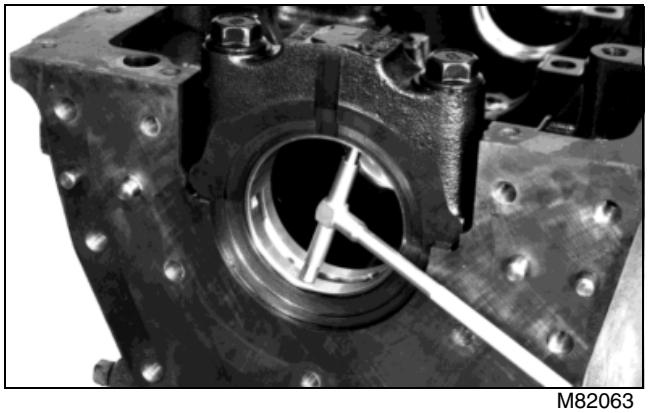
3. Measure crankshaft connecting rod journals (M) and main bearing journal (N) diameters. Measure several places around each journal.

If journal diameter is less than wear limit, replace crankshaft or have journals ground undersize by a qualified machine shop.

If journals are ground, undersize bearing inserts must be installed. Bearing inserts are available in 0.25 mm (0.010 in.) undersize.



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4. Install bearing inserts and main bearing cap on main bearing. Tighten main bearing cap screws to specification.

5. Measure main bearing ID.

- If bearing ID exceeds wear limit, replace bearing inserts.
- If bearing clearance (bearing ID minus crankshaft main bearing journal OD) exceeds specification, replace bearing inserts, crankshaft, or have crankshaft journals ground undersize by a qualified machine shop and install undersized bearing inserts.

NOTE: Bearing inserts are available in 0.25 mm (0.010 in.) undersize.

6. Clean and inspect oil passages in main bearing journals, connecting rod journals and main bearing bores in cylinder block.

7. Inspect crankshaft for cracks or damage. Replace if necessary.

Specifications

Crankshaft Connecting Rod Journal OD . . . . . 39.97-39.98 mm (1.573-1.574 in.)
Crankshaft Connecting Rod Journal OD Wear Limit. . . . . 39.92 mm (1.572 in.)
Crankshaft Main Bearing Journal OD . . . . . 43.97-43.98 mm (1.7311-1.7315 in.)
Crankshaft Main Bearing Journal OD Wear Limit. . . . . 43.92 mm (1.7291 in.)
Main Bearing ID . . . . . 44.000-44.0420 mm (1.7323-1.7339 in.)
Main Bearing ID Wear Limit. . . . . 44.070 mm (1.7350 in.)
Crankshaft Main Bearing Oil Clearance. . . . . 0.020-0.072 mm (0.0008-0.0028 in.)
Crankshaft Main Bearing Clearance Wear Limit . . . . . 0.15 mm (0.006 in.)
Main Bearing Cap Screw Torque. . . . . 78 N•m (58 lb-ft)

Remove and Install Crankshaft Rear Oil Seal

Special or Required Tools

Tool Name	Tool No.	Tool Use
Clutch Alignment Tool	JDG1331	Used to align clutch plate with pilot bearing.

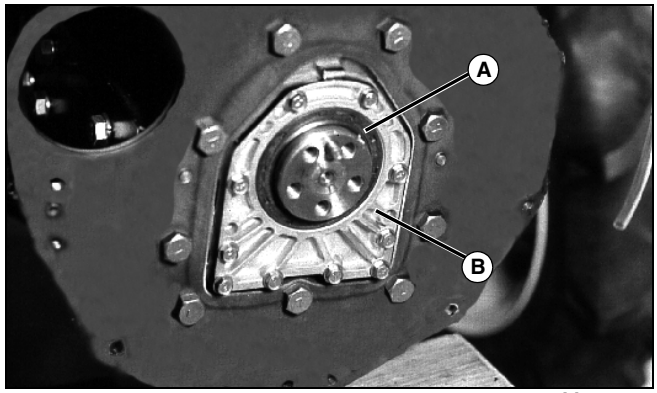
1. Remove engine. (See “Remove and Install Engine” on page 51.)

2. Remove clutch cover and clutch plate from flywheel. Note longer center hub of clutch plate is facing clutch cover.

IMPORTANT: Avoid damage! FLYWHEEL IS HEAVY! Do not remove flywheel mounting cap screws unless flywheel is secure. Use a hoist and lift rings to lift flywheel from crankshaft.

3. Remove five flywheel mounting cap screws and remove flywheel from crankshaft.

NOTE: It is not necessary to remove oil seal case to remove oil seal.



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4. Carefully pry oil seal (A) from oil seal case (B).

5. Replace oil seal using a driver set. Install seal with lip toward cylinder block. Install seal flush with surface of oil seal case.

NOTE: If oil seal has worn a groove in crankshaft at oil seal contact point, seal can be installed 3 mm (0.120 in.) deeper into oil seal case.

Remove and Install Rear Oil Seal Case

NOTE: It is not necessary to remove oil seal case to remove oil seal.

MX0749

1. Remove oil seal case-to-cylinder block cap screws.
2. Pry oil seal case from engine block.
3. Clean all old gasket material from oil seal case and engine block.
4. Install seal case with form-in-place gasket sealer on mating surfaces to engine block.
5. Install new oil seal after oil seal case is installed.
6. Install flywheel onto crankshaft, aligning crankshaft pin into flywheel mounting flange. Tighten mounting bolts to specification.
7. Install clutch plate with longer center hub facing out.
8. Install clutch cover over clutch plate, lining up locating pin on flywheel. Loosely install six mounting cap screws through clutch cover and into flywheel. Using a Clutch Alignment Tool JDG1331, align clutch plate with pilot bearing. Tighten clutch cover bolts alternately in two equal steps to final torque specification.
9. Install engine. (See “Remove and Install Engine” on page 51.)

Specifications

Flywheel Mounting
Cap Screw Torque . . . . . 83.4 N•m (62 lb-ft)
Clutch Cover Cap Screw Torque . . . . . 28 N•m (20 lb-ft)

ENGINE - DIESEL TABLE OF CONTENTS

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Specifications

General Specifications

Make	Yanmar
Model	3TNE74C-JUV S.N. (-100030) 3TNE74C-EJUV S.N. (100031-)
Type	4-cycle diesel
Machine Model Used On	2030
Bore	74 mm (2.91 in.)
Stroke	78 mm (3.07 in.)
Cylinders	3
Valves	Overhead
Displacement	1.006 L (61.4 cu. in.)
Maximum Torque @ 2400 RPM	61.7 N•m (45.5 lb-ft)
Firing Order	1-3-2
Direction of Rotation	Counterclockwise (viewed from flywheel)
Combustion System	Indirect injection type
Compression Ratio	23 to 1
Oil Capacity (with Filter) (Approximate)	2.7 L (2.8 qt)
Cooling	Liquid with pump and radiator
Governor	Centrifugal
Slow Idle (No-Load)	1450±50 rpm
High Idle (No-Load)	3450±50 rpm
Fuel Filter	Replaceable element fuel water separator
Air Filter	Dry replaceable primary and secondary elements
Weight (Approximate)	100 kg (220 lb)

Operational Test Specifications

Cylinder Compression Pressure

Compression Pressure	3432±98 kPa (498±14 psi)
Minimum Compression Pressure	2746±98 kPa (398±14 psi)
Difference between Cylinders	197-294 kPa (29-43 psi)

Intake and Exhaust Valve

Valve Clearance	0.15-0.25 mm (0.006-0.010 in.)
Valve Lift	7.5 mm (0.300 in.)

Fuel Injection Nozzle Opening Pressure	11 800 + 1000/-0 kPa (1712 + 145/-0 psi)
Leakage at 11 032 kPa (1600 psi)	No leakage for a minimum of 10 seconds

Chatter and Spray Pattern at 11 800±1000 kPa (1712±145 psi)

Slow Hand Lever Movement	Chatter sound
Slow Hand Lever Movement	Fine stream, 5-10° spray pattern
Fast Hand Lever Movement	Fine atomized spray, 5-10° spray pattern

Cooling System

Thermostat Opening Temperature (Begin Opening)	69.5-72.5 °C (157-163 °F)
Thermostat Opening Temperature (Fully Open)	85 °C (184 °F)
Minimum Lift Height (Above 85 °C [185 °F])	8 mm (0.315 in.)

Belt Tightening

Applied Force . . . . . 98 N (22 lb-force)
Deflection . . . . . 10-15 mm (0.400-0.600 in.)

Radiator Cap Relief Valve Opening Pressure . . . . . 83-96 kPa (12-14 psi)

Cooling System Pressure Test

Maximum Pressure. . . . . 0.9 kg/cm^2 (90 kPa) (13 psi)
Minimum Pressure after 15 Seconds . . . . . 90 kPa (13 psi)

Fuel Transfer Pump Pressure (Minimum). . . . . 21 kPa (3 psi)
Fuel Transfer Pump Flow Volume (Minimum in 30 seconds) . . . . . 207 mL (7 oz)

Engine Oil Pressure

2650 RPM. . . . . 290±50 kPa (42±7 psi)
1000 RPM. . . . . 60 kPa (9 psi)

Oil Relief Valve Opening Pressure . . . . . 294-392 kPa (43-57 psi)
Oil Pressure Switch Opening Pressure . . . . . 3-4 kPa (6-9 psi)

Repair Specifications

Rocker Arm Assembly

Rocker Arm Shaft Outside Diameter . . . . . 11.966-11.984 mm (0.471-0.472 in.)
Wear Limit . . . . . 11.95 mm (0.470 in.)

Rocker Arm and Shaft Support Bushings

Inside Diameter. . . . . 12.00-12.020 mm (0.472-0.473 in.)
Wear Limit . . . . . 12.09 mm (0.476 in.)
Oil Clearance. . . . . 0.016-0.054 mm (0.0006-0.002 in.)
Wear Limit . . . . . 0.14 mm (0.006 in.)
Push Rod Length . . . . . 114-115 mm (4.488-4.528 in.)
Push Rod Bend. . . . . 0.0-0.03 mm (0.0-0.001 in.)

Cylinder Head

Piston-to-Cylinder Head Clearance . . . . . 0.66-0.78 mm (0.026-0.031 in.)
Cylinder Head Distortion (Nominal) . . . . . 0.000-0.05 mm (0.000-0.002 in.)
Maximum Distortion . . . . . 0.15 mm (0.006 in.)
Maximum Amount of Metal To Be Removed . . . . . 0.20 mm (0.008 in.)

Valve Seats

Intake Valve Seat Width . . . . . 1.44 mm (0.057 in.)
Wear Limit . . . . . 1.98 mm (0.078 in.)
Exhaust Valve Seat Width . . . . . 1.77 mm (0.070 in.)
Wear Limit . . . . . 2.27 mm (0.089 in.)

Valve Seat Angles

Exhaust Valve	45°
Intake Valve	30°
Lower Seat Surface	70°
Upper Seat Surface	15°

Intake and Exhaust Valves

Valve-to-Rocker Arm Clearance (Check when Cold)

Intake and Exhaust	0.15-0.25 mm (0.006-0.010 in.)

Valve Face Margin

Intake	0.99-1.29 mm (0.004-0.005 in.)
Exhaust	0.95-1.25 mm (0.004-0.005 in.)
Wear Limit	0.50 mm (0.002 in.)

Valve Grind Angles

Intake	30°
Exhaust	45°
Intake Valve Stem Diameter	6.96-6.98 mm (0.274-0.275 in.)
Wear Limit	6.90 mm (0.272 in.)
Exhaust Valve Stem Diameter	6.95-6.96 mm (0.273-0.276 in.)
Wear Limit	6.90 mm (0.272 in.)
Intake Valve Recession	0.40-0.60 mm (0.016-0.024 in.)
Wear Limit	1.0 mm (0.039 in.)
Exhaust Valve Recession	0.75-0.95 mm (0.030-0.0374 in.)
Wear Limit	1.0 mm (0.039 in.)

Valve Guides

Valve Guide ID	7.01-7.02 mm (0.275-0.276 in.)
Wear Limit	7.08 mm (0.279 in.)

Stem-to-Guide Oil Clearance

Intake	0.030-0.060 mm (0.001-0.002 in.)
Exhaust	0.045-0.075 mm (0.002-0.003 in.)
Wear Limit	0.18 mm (0.007 in.)
Valve Guide Installed Height	9 mm (0.354 in.)

Valve Springs

Spring Free Length	37.4 mm (1.472 in.)
Maximum Spring Inclination	1.0 mm (0.032 in.)
Valve Spring Tension (Measured with Spring Compressed 1.0 mm [0.039 in.])	2.37-1.87 kg (5.22-4.12 lb)

Valve Timing

Intake Valve

Opens	7°-17° BTDC
Closes	35°-45° ABDC

Exhaust Valve

Opens	**40°-50° BBDC**
Closes	**8°-18° ATDC**

Valve Stem OD Measuring Points

Distance O	**20 mm (0.787 in.)**
Distance P	**40 mm (1.575 in.)**

Connecting Rod

Big End Bearing Inside Diameter	**43.00-43.02 mm (1.693-1.694 in.)**
Big End Bearing Thickness	**1.487-1.500 mm (0.058-0.059 in.)**
0.25 mm (0.010 in.) Oversize Bearing Thickness	**1.625 mm (0.064 in.)**
Big End Bearing Oil Clearance	**0.033-0.059 mm (0.001-0.002 in.)**
Wear Limit	**0.15 mm (0.006 in.)**
Connecting Rod Side Play	**0.20-0.40 mm (0.008-0.016 in.)**
Connecting Rod Side Play Wear Limit	**0.55 mm (0.0217 in.)**
Connecting Rod Cap Screw Torque	**23-28 N•m (17-20 lb-ft)**
Twist and Parallelism per 100 mm (6 in.)	**0.00-0.03 mm (0.00-0.001 in.)**
Wear Limit per 100 mm (6 in.)	**0.08 mm (0.005 in.)**

NOTE: For Connecting Rod Small End Specifications, see "Piston Pin" on page 95.

Top Piston Ring Specifications

Piston Groove Width	**1.550-1.570 mm (0.061-0.062 in.)**
Ring Width	**1.470-1.490 mm (0.058-0.059 in.)**
Minimum Side Clearance	**0.060-0.100 mm (0.002-0.004 in.)**
Ring End Gap	**0.200-0.400 mm (0.008-0.016 in.)**
Wear Limit	**1.5 mm (0.059 in.)**

2nd Piston Ring Specifications

Piston Groove Width	**1.520-1.535 mm (0.059-0.060 in.)**
Ring Width	**1.410-1.490 mm (0.055-0.056 in.)**
Minimum Side Clearance	**0.090-0.125 mm (0.004-0.005 in.)**
Ring End Gap	**0.200-0.400 mm (0.008-0.015 in.)**
Wear Limit	**1.5 mm (0.059 in.)**

Oil Control Ring Specifications

Piston Groove Width	**3.010-3.025 mm (0.118-0.119 in.)**
Ring Width	**2.970-2.990 mm (0.117-0.118 in.)**
Minimum Side Clearance	**0.020-0.055 mm (0.0008-0.002 in.)**
Ring End Gap	**0.150-0.350 mm (0.006-0.014 in.)**
Wear Limit	**1.5 mm (0.059 in.)**

Piston Pin

Outside Diameter	**20.991-21.000 mm (0.826-0.827 in.)**
Wear Limit	**20.90 mm (0.823 in.)**
Connecting Rod Bushing ID	**21.025-21.038 mm (0.828-0.828 in.)**
Wear Limit	**21.10 mm (0.831 in.)**
Piston Pin-to-Rod Bushing Oil Clearance	**0.025-0.047 mm (0.001-0.002 in.)**
Wear Limit	**0.2 mm (0.008 in.)**
Piston Pin Bore (In Piston) Inside Diameter	**21.000-21.008 mm (0.827-0.827 in.)**
Wear Limit	**21.02 mm (0.828 in.)**
Piston Pin-to-Piston Oil Clearance	**0.000-0.017 mm (0.0-0.0007 in.)**
Wear Limit	**0.12 mm (0.005 in.)**
Connecting Rod Bore ID (Bushing Removed)	**23.000-23.021 mm (0.905-0.906 in.)**

Piston Outside Diameter

NOTE: Measured 24 mm (0.945 in.) up from bottom of piston skirt, perpendicular to piston pin.

Standard Piston

Outside Diameter	**73.955-73.985 mm (2.912-2.913 in.)**
Wear Limit	**73.90 mm (2.909 in.)**

0.25 mm (0.010 in.) Oversize Piston

Outside Diameter	**74.210-74.225 mm (2.921-2.922 in.)**
Wear Limit	**74.15 mm (2.919 in.)**

Cylinder Bore Inside Diameter

Standard Bore	**74.00-74.03 mm (2.913-2.915 in.)**
Wear Limit	**74.20 mm (2.921 in.)**
0.25 mm (0.010 in.) Oversize Cylinder Bore ID	**74.25-74.275 mm (2.923-2.924 in.)**
Wear Limit	**74.45 mm (2.931 in.)**
0.50 mm (0.020 in.) Oversize Cylinder Bore ID	**74.50-74.53 mm (2.933-2.935 in.)**
Wear Limit	**74.70 mm (2.941 in.)**
Piston-to-Cylinder Clearance	**0.030-0.060 mm (0.001-0.002 in.)**
Cylinder Roundness	**0.00-0.01 mm (0.00-0.0004 in.)**
Wear Limit	**0.03 mm (0.001 in.)**
Cylinder Taper	**0.00-0.01 mm (0.00-0.0004 in.)**
Wear Limit	**0.03 mm (0.001 in.)**
Deglazing	**30-40° crosshatch pattern**
Reboring	**30-40° crosshatch pattern**

Crankshaft

Connecting Rod Crankpin Journal OD	39.970-39.980 mm (1.573-1.574 in.)
Wear Limit	39.91 mm (1.571 in.)
Connecting Rod Bearing Inside Diameter	43.000-43.016 mm (1.693-1.694 in.)
Connecting Rod Bearing Thickness	1.487-1.500 mm (0.058-0.059 in.)
0.25 mm (0.010 in.) Oversize Bearing Thickness	1.625 mm (0.064 in.)
Connecting Rod Bearing Oil Clearance	0.033-0.059 mm (0.001-0.002 in.)
Wear Limit	0.15 mm (0.006 in.)
Main Bearing Journal Outside Diameter	43.970-43.980 mm (1.728-1.732 in.)
Wear Limit	43.90 mm (1.728 in.)
Main Bearing ID	40.000-40.042 mm (1.575-1.577 in.)
Main Bearing ID Wear Limit	40.07 mm (1.578 in.)
Main Bearing Insert Thickness	1.987-2.000 mm (0.078-0.079 in.)
0.25 mm (0.010 in.) Under Size Bearing Thickness	2.125 mm (0.084 in.)
Main Bearing Oil Clearance	0.020-0.072 mm (0.0008-0.0028 in.)
Wear Limit	0.15 mm (0.0059 in.)
Thrust Bearing Insert Thickness	1.93-1.98 mm (0.076-0.078 in.)
0.25 mm (0.010 in.) Oversize Thrust Bearing Thickness	2.125 mm (0.084 in.)
Crankshaft Maximum Bend	0.02 mm (0.0008 in.)
Crankshaft End Play	0.090-0.271 mm (0.004-0.011 in.)
Crankshaft End Play Wear Limit	0.33 mm (0.0129 in.)

Camshaft

Camshaft End Play	0.05-0.25 mm (0.002-0.010 in.)
Camshaft Bend (Nominal)	0.00-0.02 mm (0.00-0.0008 in.)
Maximum	0.05 mm (0.002 in.)

Front Journal OD

Standard	39.94-39.96 mm (1.572-1.573 in.)
Wear Limit	39.85 mm (1.569 in.)

Intermediate Journal OD

Standard	39.91-39.94 mm (1.572-1.573 in.)
Wear Limit	39.85 mm (1.569 in.)

Rear Journal OD

Standard	39.91-39.94 mm (1.572-1.573 in.)
Wear Limit	39.85 mm (1.569 in.)

Camshaft Bearings

Front Bushing ID . . . . . 40.000-40.065 mm (1.575-1.578 in.)
Intermediate and Rear Bore ID . . . . . 40.000-40.025 mm (1.575-1.576 in.)
Camshaft Bushing Wear Limit. . . . . . 40.10 mm (1.579 in.)
Camshaft Bushing Oil Clearance . . . . . 0.040-0.085 mm (0.002-0.003 in.)

Cylinder Block Bore ID. . . . . . 43.00-43.025 mm (1.693-1.694 in.)
Wear Limit . . . . . 43.10 mm (1.697 in.)
Clearance . . . . . 0.040-0.125 mm (0.002-0.005 in.)

Intake and Exhaust Cam Lobe Height . . . . . 33.950-34.050 mm (1.33-1.34 in.)
Wear Limit . . . . . 33.75 mm (1.329 in.)

Cam Followers

Outside Diameter . . . . . 20.927-20.960 mm (0.824-0.825 in.)
Wear Limit . . . . . 20.90 mm (0.823 in.)

Camshaft Follower Bore Inside Diameter . . . . . 21.000-21.021mm (0.827-0.828 in.)
Wear Limit . . . . . 21.05 mm (0.829 in.)

Oil Clearance. . . . . . 0.040-0.094 mm (0.002-0.004 in.)
Wear Limit . . . . . 0.15 mm (0.006 in.)

Timing Gear Backlash

All Except Crankshaft Gear-to-Oil Pump Gear . . . . . 0.04-0.12 mm (0.0016-0.0047 in.)
Crankshaft Gear-to-Oil Pump Gear . . . . . 0.11-0.19 mm (0.0040-0.008 in.)

Idler Gear

Shaft Outside Diameter . . . . . 19.959-19.980 mm (0.786-0.787 in.)
Wear Limit . . . . . 19.93 mm (0.785 in.)

Bushing Inside Diameter . . . . . 20.000-20.021 mm (0.787-0.788 in.)

Oil Clearance. . . . . . 0.020-0.062 mm (0.0008-0.002 in.)
Wear Limit . . . . . 0.15 mm (0.006 in.)

Idler Gear Side Play . . . . . 0.1-0.3 mm (0.004-0.012 in.)

Flywheel Maximum Distortion . . . . . 0.02 mm (0.0008 in.)

Oil Pump

Crankshaft Gear-to-Oil Pump Gear Backlash . . . . . 0.11-0.19 mm (0.0040-0.008 in.)

Rotor Shaft-to-Backing Plate Clearance

Standard . . . . . 0.013-0.043 mm (0.0005-0.002 in.)
Wear Limit . . . . . 0.2 mm (0.008 in.)

Rotor Recess

Standard . . . . . 0.03-0.09 mm (0.001-0.004 in.)
Wear Limit . . . . . 0.13 mm (0.005 in.)

Outer Rotor-to-Pump Body Clearance

Standard . . . . . **0.10-0.16 mm (0.004-0.006)**
Wear Limit . . . . . **0.25 mm (0.006 in.)**

Oil Pressure Regulating Valve

Spring

Compressed Length @12 N (2.7 lb) . . . . . **14.70 mm (0.580 in.)**
Free Length . . . . . **21.90-24.50 mm (0.860-0.960 in.)**

Fuel Injection Pump Camshaft

Lobe Height (Min) . . . . . **30.90 mm (1.217 in.)**

Fuel Control and Governor Linkage

Governor Shaft OD (Minimum) . . . . . **7.90 mm (0.311 in.)**

Governor Shaft Bore ID

Wear Limit . . . . . **8.15 mm (0.321 in.)**
Clearance . . . . . **0.18 mm (0.007 in.)**
Sleeve ID (Maximum) . . . . . **8.20 mm (0.323 in.)**

Fuel Injection Nozzles

Separator Plate Nozzle Contact Surface Maximum Wear . . . . . **0.10 mm (0.0039 in.)**

Alternator

Drive Belt Tension . . . . . **10-15 mm (0.394-0.591 in.)**

Fuel Injection Pump Static Timing

Injection Pump Timing . . . . . **14° BTDC (Before Top Dead Center)**
Distance on Outer Surface of Crankshaft Pulley for Every 0.1 mm (0.004 in.) of Shim Thickness . . . . . **1° 0.9 mm (0.035 in.)**
Total Shim Pack Thickness (New Shims) . . . . . **0.5 mm (0.020 in.)**

Torque Specifications

Cylinder Head

First Tightening	30.8 N•m (23 lb-ft)
Final Tightening	61.3 N•m (45 lb-ft)
Rocker Arm Mounting Nut	26 N•m (226 lb-in.)
Rocker Arm Cover Nut	18 N•m (160 lb-in.)

Timing Gear Cover

Aluminum Housing-to-Block Mounting Cap Screw	11 N•m (97 lb-in.)
Cast Iron Housing-to-Block Mounting Cap Screw	9 N•m (80 lb-in.)
Crankshaft Pulley Cap Screw	88 N•m (65 lb-ft)
Injector Pump-to-Timing Cover Cap Screw	20 N•m (15 lb-ft)
Fan Mounting Cap Screw	11 N•m (96 lb-in.)

Timing Gear Housing

Aluminum Housing-to-Block	11 N•m (97 lb-in.)
Cast Iron Housing-to-Block	9 N•m (80 lb-in.)

Connecting Rod Cap Screw	25 N•m (18 lb-ft)
Main Bearing Cap Screw	81 N•m (60 lb-ft)
Flywheel Mounting Cap Screw	84 N•m (62 lb-ft)
Clutch Cover Cap Screw Torque	23 N•m (200 lb-in.)
Camshaft Thrust Plate Cap Screw	11 N•m (96 lb-in.)
Glow Plug	15-20 N•m (11-15 lb-ft)
Governor Weight Support Nut	69-74 N•m (51-55 lb-ft)
Thermostat Housing Cap Screw	18 N•m (160 lb-in.)
Alternator Shaft Nut	27 N•m (20 lb-ft)
Exhaust Manifold Cap Screw and Nut	25.5 N•m (19 lb-ft)
Intake Manifold Cap Screw	11 N•m (97 lb-in.)
Fuel Injection Pump Mounting Nut	20 N•m (180 lb-in.)
Fuel Injection Pump Camshaft Bearing Retaining Screw	20 N•m (180 lb-in.)
Delivery Valve Fitting Torque (Top of Injection Pump)	42 N•m (31 lb-ft)
Fuel Injector Leak-Off Fitting Nut	40 N•m (30 lb-ft)
Fuel Injector Nozzle Line Fitting	40 N•m (30 lb-ft)
Fuel Injector Nozzle	50 N•m (37 lb-ft)
Rear Oil Seal Case-to-Block Cap Screw	11 N•m (96 lb-in.)
Oil Pan-to-Seal Case Cap Screw	9 N•m (78 lb-in.)
Oil Pan-to-Block	11 N•m (96 lb-in.)
Oil Pan-to-Seal Case	9 N•m (78 lb-in.)
Oil Pan-to-Timing Gear Housing	9 N•m (78 lb-in.)
Oil Strainer-to-Block	11 N•m (96 lb-in.)
Oil Pressure Regulating Valve Housing-to-Valve Body Retaining Nut	30 N•m (22 lb-ft)
Oil Pump Mounting Cap Screw	25 N•m (18 lb-ft)
Engine Back Plate Mounting Cap Screw	91 N•m (67 lb-ft)
Engine-to-Subframe Cap Screw	75 N•m (55 lb-ft)

Tools and Materials

Special or Required Tools

Special or Required Tools

Tool Name	Tool No.	Tool Use
Digital Tachometer or Digital Pulse Tachometer	JT05719 or JT07270	Used to set slow idle engine rpm and check fast idle rpm.
Diesel Fuel Injection Nozzle Tester	D01109AA	Used for fuel injection nozzle test.
Adapter Set	D01110AA	Used for fuel injection nozzle test.
Straight Adapter	23622	Used for fuel injection nozzle test.
Nozzle Cleaning Kit	JDF13	Used to clean fuel injection nozzles.
Fuel Pump Pressure Test Kit	JDG356	Used for fuel transfer pump pressure test.
Compression Gauge Assembly	JT01682	Used for cylinder compression check.
Adapter	JDG472	Used for cylinder compression check. Used to connect compressed air source to cylinder injection port
Belt Tension Gauge	JDG529, or JDST28	Used to adjust the coolant pump/ alternator drive belt tension.
Adapter	JDG472	Used for radiator bubble test.
Cooling System Pressure Pump	D05104ST	Used for cooling system pressure test.
Radiator Pressure Test Kit Adapters	JDG692	Used for cooling system pressure test.
Hose Assembly	JT03017	Used for engine oil pressure test.
Pressure Gauge (100 psi)	JT05577	Used for engine oil pressure test.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Connector	JT03349	Used for engine oil pressure test.
Valve Spring Compressor	JDE138	Used to remove valves.
Valve Guide Driver	JDE504	Used to remove valves.
Clutch Alignment Tool	JDG1331	Used to install clutch.
Dial Indicator	NA	Used for valve lift, end play, and backlash measurements.
PLASTIGAGE® Bearing Clearance Measurement Tool	NA	Used for clearance measurements.

NOTE: Order tools according to information given in the U.S. SERVICE-GARD™ Catalog or in the European Microfiche Tool Catalog (MTC).

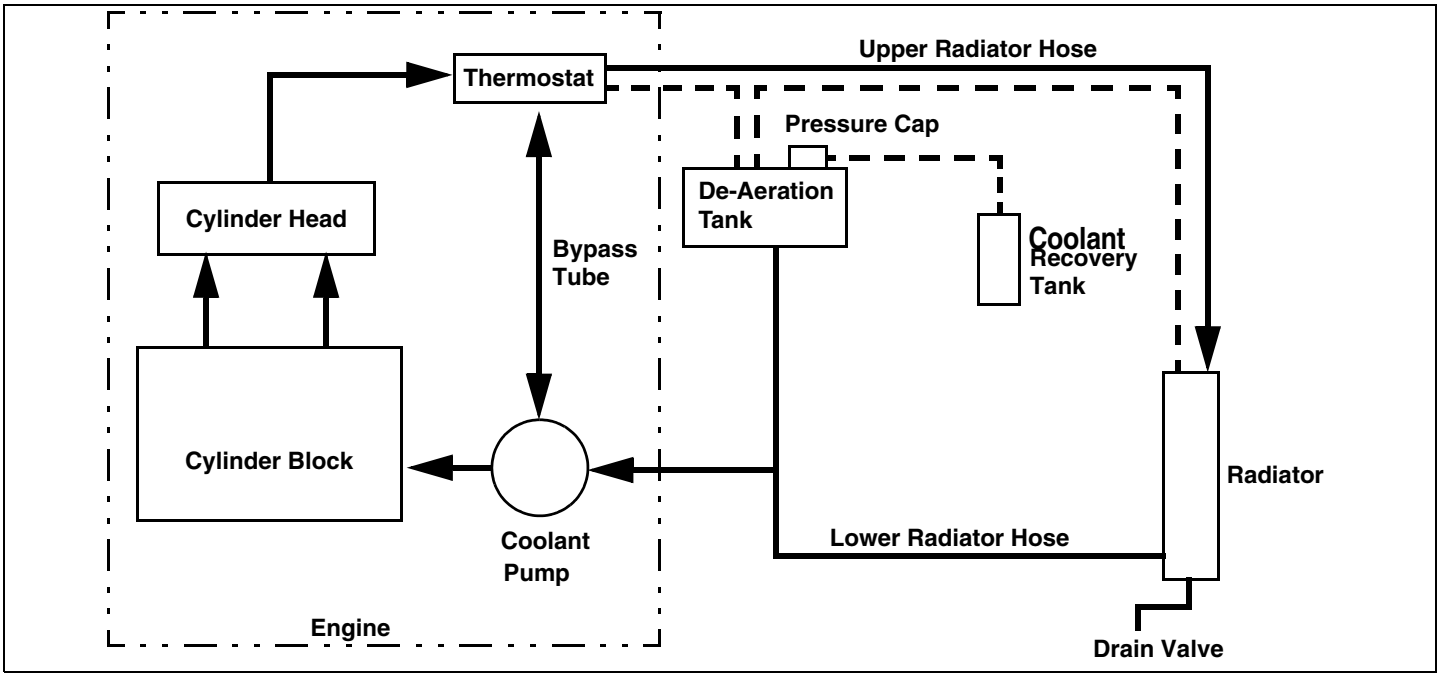
Other Materials

Other Material

Part No.	Part Name	Part Use
TY15130 (U.S.)	Form-in-Place Gasket	Seals crankcase extension housing, rear oil seal case, timing gear cover, and flywheel housing to engine block. Seals oil pan to timing gear housing and engine block.

Theory of Operation

Cooling System Theory of Operation



MIF

Function

The cooling system allows the engine to rise to full operating temperature when engine is started cold, but keeps the engine from overheating once the engine reaches operating temperature.

When operating temperature has been reached, coolant is circulated from the hot engine to the radiator to prevent engine overheating. The cooling system is pressurized, which raises the boiling point of the coolant, and allows more heat to be carried away from the engine.

Theory of Operation

The cooling system includes the following components:

Radiator, upper and lower water hoses, pressure cap, de-aeration tank, coolant recovery tank, coolant pump, thermostat, electric fan, and drain valve.

When the engine is started cold, the thermostat is closed. The impeller type coolant pump pulls coolant from the cylinder head and through the bypass tube (located inside the coolant pump housing). The coolant pump then pushes the coolant into the cylinder block water jacket. The coolant absorbs heat from the cylinder walls, and is then pushed up into the cylinder head, and sucked back into the coolant pump. This provides a fast warm-up period, as engine heat is retained and evenly distributed throughout the engine.

Once the engine has reached operating temperature, the thermostat opens, and the hot coolant from the cylinder head passes through the thermostat to the radiator. As coolant flows through the tubes of the radiator core, heat is transferred from the coolant to the air stream being drawn through the core by the electric fan. When the coolant reaches the bottom of the radiator, it is sucked through the lower radiator hose into the coolant pump, and pushed back into the cylinder block. The de-aeration tank accepts water from the lower radiator hose. The de-aeration tank also allows air to accumulate and be purged during operation and when filling the system.

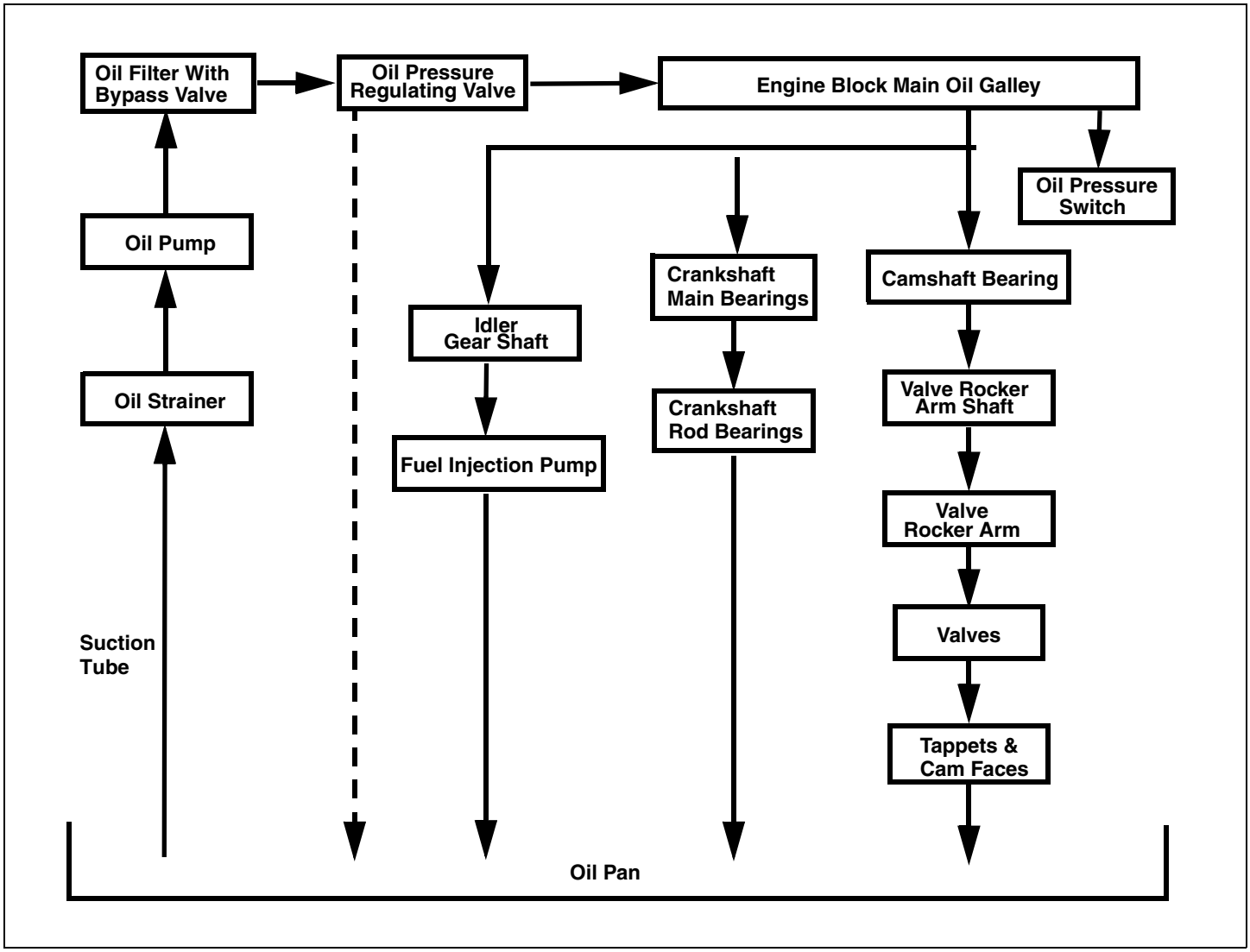
When coolant system pressure exceeds 88.3±14.7 kPa (12.8±2.2 psi), the spring in the pressure cap is pushed open to allow coolant to discharge into the coolant recovery tank. Any air in the system is purged through the de-aeration tank and cap. After shutdown, when engine is cooling, a vacuum is produced in the cooling system, and coolant is drawn back out of the coolant recovery tank through a small valve in the bottom of the pressure cap.

The fan draws air through a removable debris guard on the front of the radiator, through the radiator and hydraulic oil cooler (if equipped).

Two electrical coolant temperature sensors are located in the coolant pump housing. One operates the temperature gauge on the dashboard. The other operates the electric fan and the coolant temperature warning lamp.

The radiator can be drained through a drain valve on the bottom of the radiator. The coolant recovery tank can be drained by simply lifting it out of its holder and pouring it out.

Lubrication System Theory of Operation



MIF

Function

A full pressure system lubricates engine parts with clean oil.

Theory of Operation

The pressure lubrication system consists of a positive displacement gear-driven pump, oil strainer, full flow oil filter, oil pressure regulating valve, and an electrical oil pressure warning switch.

The oil pump is mounted on the timing gear housing of the engine, under the timing gear cover, and is driven by the crankshaft. The oil pump draws oil from the oil pan through the strainer and suction tube. The oil is then pumped through an oil passage to the oil filter, oil pressure regulating valve, and through the engine block main oil galley.

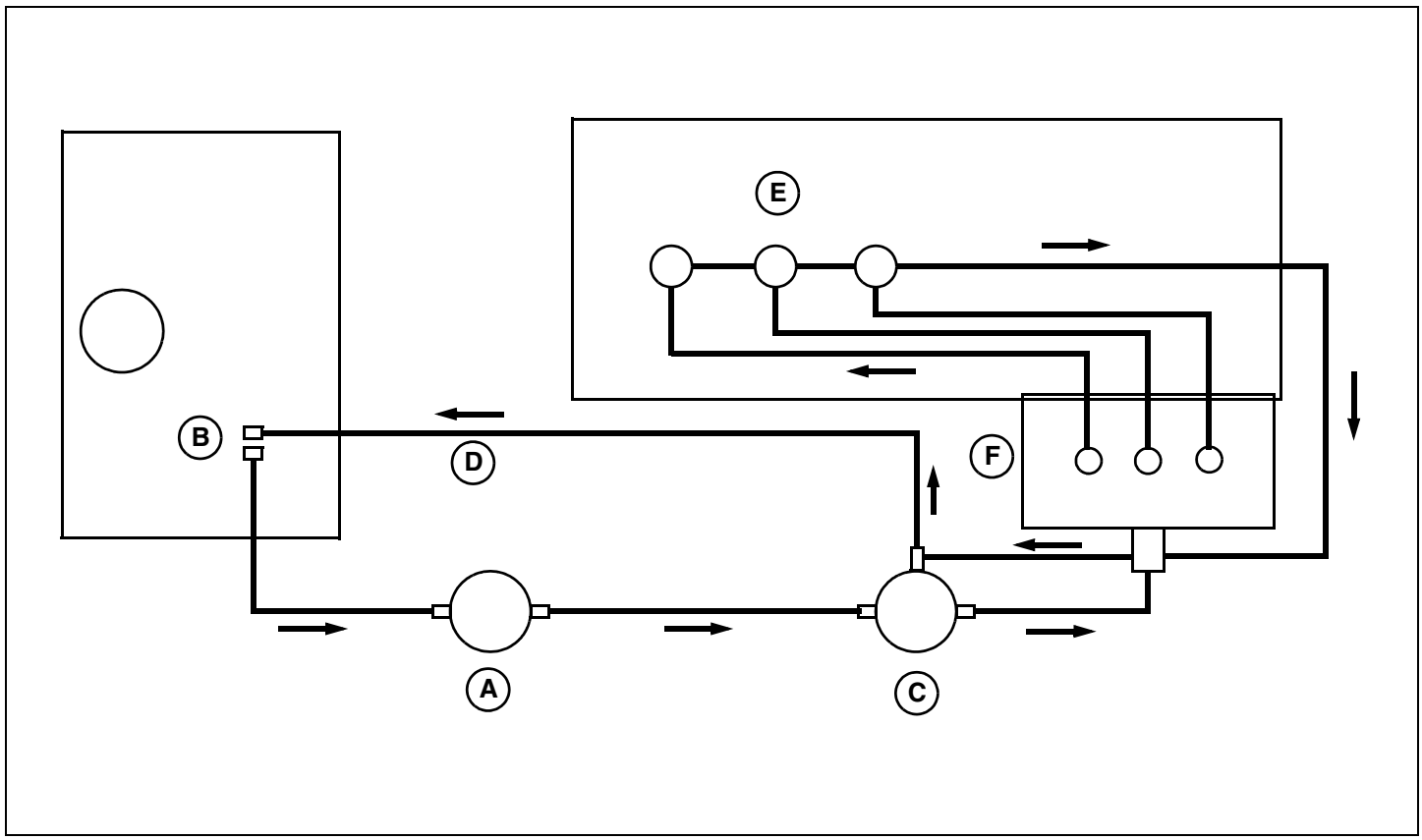
From the main oil galley, oil is pushed to the crankshaft main bearing journals and idler gear shaft. Drilled cross-passages in the crankshaft distribute the oil from the main bearings to the connecting rod bearing journals.

Lube oil holes in the main bearing oil grooves send oil through drilled passages to the camshaft bearings.

A drilled passage from the rear camshaft bearing through the cylinder block and cylinder head supplies lubricating oil to the rocker arm shaft. The hollow shaft distributes oil to the rocker arms, tappets and valves.

If oil pressure drops below specification, a pressure switch activates the engine oil pressure light to alert the operator to shut down the engine.

Fuel System Theory of Operation



MIF

Function

The fuel system supplies clean fuel to injection pump and nozzles, and circulates unused fuel back to the tank. An instrument panel mounted electric fuel gauge shows the operator amount of fuel remaining.

Theory of Operation

The electric transfer pump (A) draws fuel from the fuel tank (B) and supplies fuel to the fuel filter (C). Fuel flows from the outlet on the fuel tank to the combination bowl fuel filter/water separator/fuel shutoff valve (C). The filter is self priming and excess air is returned to the tank through a return hose (D). Excess fuel is returned from the fuel filter to the tank.

Excess leak-off fuel from the injectors (E) is returned to the fuel injection pump (F).

The engine speed is controlled by the throttle pedal and/or hand throttle lever. The throttle linkage is connected to the injection pump/governor control lever.

The fuel shutoff solenoid has two coils inside; one pull-in, and one hold-in coil. The hold-in coil is energized whenever the key switch is in the on or start position. The pull-in coil is energized only when in the start position and oil pressure switch closed.

The fuel shutoff solenoid controls the flow of fuel inside the injection pump. When the solenoid is energized (ignition key to START and RUN position), the solenoid pulls in and the allows fuel to be pumped to the injectors. When the key is turned off, return springs on the shutoff shaft, extend the solenoid, moving the shutoff linkage to the shutoff position.

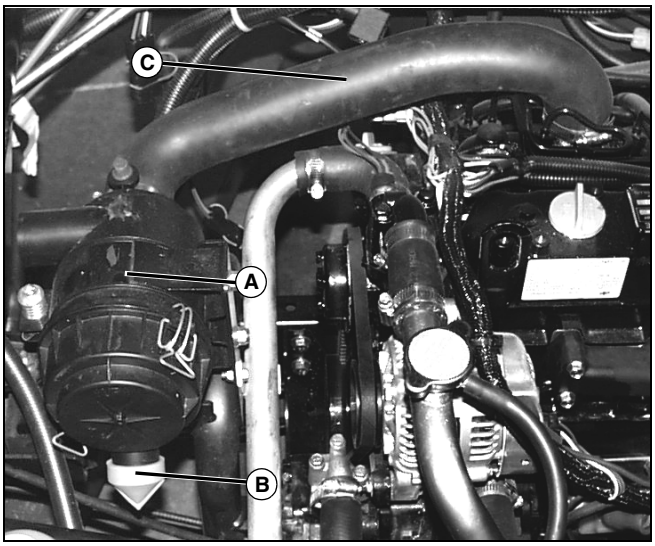
When the key switch is turned OFF, the fuel shutoff solenoid stops the flow of fuel inside the fuel injector pump by forcing the governor rack linkage to a no fuel position, causing the fuel injector pump to stop suppling fuel to the injectors.

The injection pump meters fuel as determined by the governor and delivers it at high pressure to the injection nozzles. The injection nozzle prevents flow until high pressure is reached, opening the valve and spraying atomized fuel into the pre-combustion swirl chamber. Injection lines have trapped fuel inside whenever injection is not taking place.

A small amount of fuel leaks past the nozzle valve to lubricate the fuel injection nozzle. This leakage combines with excess fuel from the injection pump and is returned to tank. Any air in the fuel system is bled out with return fuel to the fuel tank.

A float-type fuel level sensor mounted on the top of the tank drives a instrument panel mounted gauge, informing the operator of the fuel level.

Air Intake System Theory of Operation



MX0766

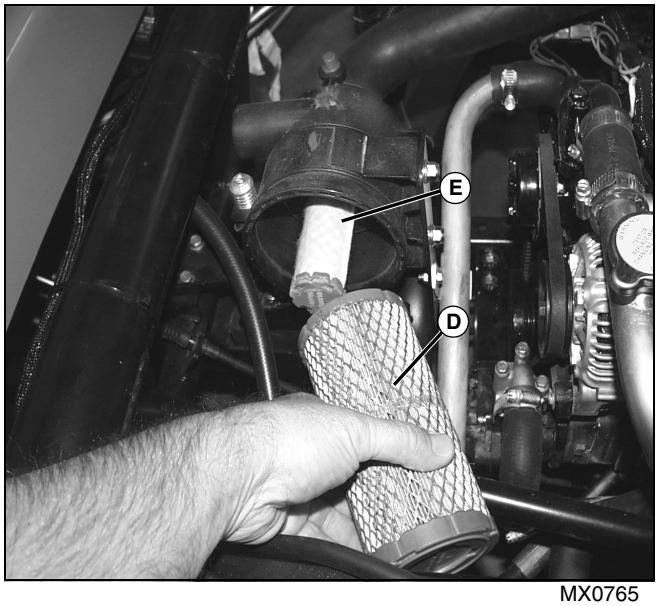
Function

The air intake system filters air needed for combustion. The system components include: Air cleaner housing (A), unloader valve (B), primary air filter element (D), secondary air filter element (E), outlet tube (C), and clamps.

Theory of Operation

Air enters the air filter inlet tube and into the air filter housing, and is directed into the side of a shield. This starts a high-speed centrifugal motion of air which continues around the element until it reaches the far end of the air filter housing, to an unloader valve.

Most of the dust is separated from the air by centrifugal force that causes heavy dust particles to enter the opening at the top of the unloader valve. The remaining air enters the primary air filter element. The primary filter element filters the larger dirt particles before the air enters the secondary air filter element. The finer dirt particles are filtered in the secondary air filter before the air enters the intake manifold.



MX0765

The dirt that is deposited in the unloader valve is removed by the rubber diaphragm at the base of the air cleaner. When the engine is running, a pulsing action is created in the intake system by each intake stroke of the engine. This pulsing action causes the rubber diaphragm to open and close, thus emptying the unloader valve. The operator can squeeze the valve to let the large particles out.

Diagnostics

Diesel Engine Troubleshooting

CAUTION: Avoid Injury! The engine may start to rotate at any time. Keep hands away from all moving parts when testing.

Coolant in the radiator is extremely hot during operation.

Symptom: Engine Will Not Start

(1) Proper starting procedure being used is correct for conditions.

Yes - Go to step (2).

No - Use correct procedure for conditions. See the Operator's Manual.

(2) Battery 12.7 VDC or higher?

Yes - Go to step (3).

No - Charge and check battery. (See "Battery Test" on page 305.)

(3) No open circuits in wiring?

Yes - Go to step (4).

No - Repair or replace as needed. (See "Common Circuit Tests" on page 185.)

(4) Starting motor functioning properly?

Yes - Go to step (5).

No - Repair or replace starting motor. (See "Starting Motor" on page 329.)

(5) Engine oil of correct viscosity and type?

Yes - Go to step (6).

No - Replace engine oil with oil of proper viscosity and type. Replace oil filter.

(6) No water in fuel?

Yes - Go to step (7).

No - Drain and replace fuel.

(7) Fuel filter not clogged?

Yes - Go to step (8).

No - Replace fuel filter. (See "Remove and Install Fuel Filter-Water Separator" on page 166.)

Symptom: Engine Will Not Start

(8) No air leak in fuel system?

Yes - Go to step (9).

No - Repair fuel system.

(9) Fuel lines not plugged, pinched or cracked?

Yes - Go to step (10).

No - Repair or replace fuel lines as needed.

(10) Correct volume of fuel supplied to injection pump?

Yes - Go to step (11).

No - Replace fuel transfer pump.

(11) Intake and/or exhaust valve clearance correct?

Yes - Go to step (12).

No - Adjust valve clearance. (See "Adjust Valve Clearance" on page 116.)

(12) Is injection pump timing correct?

Yes - Go to step (13).

No - Correctly time injector pump. (See "Adjust Injection Pump Timing" on page 121.)

(13) Intake and/or exhaust valve not seized?

Yes - Go to step (14).

No - Replace valve and check valve guide. (See "Recondition Cylinder Head" on page 130.)

(14) Piston rings not broken or seized?

Yes - Go to step (15).

No - Replace rings. Check piston and cylinder. (See "Inspection and Replacement" on page 152 and "Repair Cylinder Bore" on page 155.)

(15) Piston rings, piston, or cylinder not worn?

Yes - Go to step (16).

No - Replace piston and/or rings, bore or hone cylinder. (See "Inspection and Replacement" on page 152 and "Repair Cylinder Bore" on page 155.)

(16) Crankshaft pin or bearing not seized?

No - Regrind crankshaft and replace bearings. (See "Remove and Install Crankshaft and Main Bearings" on page 156.)

Symptom: Engine Starts But Does Not Continue Running - No Exhaust Smoke

(1) Engine oil of proper viscosity and type?

Yes - Go to step (2).

No - Replace engine oil filter and oil of proper viscosity and type.

(2) Fuel filter not clogged?

Yes - Go to step (3).

No - Replace fuel filter. (See “Remove and Install Fuel Filter-Water Separator” on page 166.)

(3) No air leak in fuel system?

Yes - Go to step (4).

No - Repair fuel system.

(4) Fuel lines not plugged, pinched or cracked?

Yes - Go to step (5).

No - Repair or replace fuel lines as needed.

(5) Correct volume of fuel supplied to injection pump?

Yes - Go to step (6).

No - Replace fuel transfer pump.

(6) Valve clearance proper?

Yes - Go to step (7).

No - Adjust valve clearance. (See “Adjust Valve Clearance” on page 116.)

(7) Crankshaft pin or bearing not seized?

No - Regrind crankshaft and replace bearings. (See “Remove and Install Crankshaft and Main Bearings” on page 156.)

Symptom: Engine Starts But Does Not Continue Running - Excess Exhaust Smoke

(1) No water in fuel?

Yes - Go to step (2).

No - Drain and replace fuel.

(2) Fuel filter not clogged?

Yes - Go to step (3).

No - Replace fuel filter. (See “Remove and Install Fuel Filter-Water Separator” on page 166.)

Symptom: Engine Starts But Does Not Continue Running - Excess Exhaust Smoke

(3) Intake and/or exhaust valve not seized?

Yes - Go to step (4).

No - Replace valve and check valve guide. (See “Recondition Cylinder Head” on page 130.)

(4) Piston rings not broken or seized?

Yes - Go to step (5).

No - Replace rings. Check piston and cylinder. (See “Inspection and Replacement” on page 152 and “Repair Cylinder Bore” on page 155.)

(5) Piston rings, piston or cylinder not worn?

No - Replace piston and/or rings, bore or hone cylinder. (See “Inspection and Replacement” on page 152 and “Repair Cylinder Bore” on page 155.)

Symptom: Low Engine Output - Exhaust Color NORMAL

(1) Correct type of fuel being used?

Yes - Go to step (2).

No - Drain and replace fuel.

(2) Proper type and viscosity of oil being used?

Yes - Go to step (3).

No - Replace engine oil and filter.

(3) Fuel filter not clogged?

Yes - Go to step (4).

No - Replace fuel filter. (See “Remove and Install Fuel Filter-Water Separator” on page 166.)

(4) Fuel lines not clogged, cracked, or pinched?

Yes - Go to step (5).

No - Clean or replace fuel lines.

(5) No air leakage into fuel system?

Yes - Go to step (6).

No - Repair fuel supply system.

(6) Proper volume of fuel to injection pump?

Yes - Go to step (7).

No - Check or replace fuel transfer pump.

Symptom: Low Engine Output - Exhaust Color NORMAL

(7) Intake and exhaust valve clearance correct?

Yes - Go to step (8).

No - Adjust valve clearance. (See “Adjust Valve Clearance” on page 116.)

(8) Intake or exhaust valves not leaking compression?

Yes - Go to step (9).

No - Grind valves and seats. (See “Recondition Cylinder Head” on page 130.)

(9) Intake or exhaust valves not seized?

Yes - Go to step (10).

No - Replace valve and check valve guide. (See “Recondition Cylinder Head” on page 130.)

(10) Cylinder head gasket not leaking compression?

No - Replace head gasket. (See “Remove and Install Cylinder Head” on page 128.) Resurface head and block if necessary.

Symptom: Low Engine Output - Exhaust Color WHITE

(1) Correct type of fuel?

Yes - Go to step (2).

No - Drain and replace fuel.

(2) No water in fuel?

Yes - Go to step (3).

No - Drain and replace fuel.

(3) Even volume of fuel being injected?

Yes - Go to step (4).

No - Repair or replace fuel injector pump or fuel injectors. (See “Remove and Install Fuel Injection Pump” on page 170. See “Remove and Install Fuel Injection Nozzle” on page 167.)

(4) Proper spray pattern from injectors?

Yes - Go to step (5).

No - Clean or replace fuel injector nozzles. (See “Remove and Install Fuel Injection Nozzle” on page 167.)

Symptom: Low Engine Output - Exhaust Color WHITE

(5) Intake or exhaust valve stems not worn?

Yes - Go to step (6).

No - Replace valve guides and valves. (See “Recondition Cylinder Head” on page 130.)

(6) Is injection pump timing correct?

Yes - Go to step (7).

No - Correctly time injector pump. (See “Adjust Injection Pump Timing” on page 121.)

(7) Piston rings installed correctly?

Yes - Go to step (8).

No - Install piston rings correctly. (See “Repair Piston and Connecting Rod” on page 149.)

(8) Piston ring ends staggered?

Yes - Go to step (9).

No - Stagger piston ring ends. (See “Repair Piston and Connecting Rod” on page 149.)

(9) Piston, rings, or cylinder not worn?

Yes - Go to step (10).

No - Replace pistons and rings, bore or hone cylinders. (See “Inspection and Replacement” on page 152 and “Repair Cylinder Bore” on page 155.)

(10) Piston rings not broken or seized?

No - Replace rings. Replace pistons if damaged. Bore cylinder if damaged. (See “Inspection and Replacement” on page 152 and “Repair Cylinder Bore” on page 155.)

Symptom: Low Engine Output - Exhaust Color BLACK

(1) Is engine NOT being run under high altitude or high temperature conditions?

Yes - Go to step (2).

No - Reduce load.

(2) Correct type of fuel?

Yes - Go to step (3).

No - Drain and replace fuel.

(3) Air filter elements not clogged?

Yes - Go to step (4).

No - Clean or replace air filter elements.

Symptom: Low Engine Output - Exhaust Color BLACK

(4) Exhaust pipe not clogged?

Yes - Go to step (5).

No - Clean exhaust pipe.

(5) Engine running cool enough?

Yes - Go to step (6).

No - Check thermostat. (See “Remove and Install Thermostat” on page 126 and “Test Thermostat” on page 121.) Replace if faulty. Adjust fan belt tension. (See “Adjust Coolant Pump-Alternator Drive Belt” on page 122.)

(6) Cooling system filled to correct level?

Yes - Go to step (7).

No - Check for leaks and fill system to correct level.

(7) Correct volume of fuel being injected?

Yes - Go to step (8).

No - Replace faulty fuel injector pump or fuel injectors. (See “Remove and Install Fuel Injection Pump” on page 170. See “Remove and Install Fuel Injection Nozzle” on page 167.)

(8) Correct pattern from fuel injectors?

Yes - Go to step (9).

No - Clean or replace fuel injector nozzles. (See “Remove and Install Fuel Injection Nozzle” on page 167.)

(9) Is injector pump timing correct?

Yes - Go to step (10).

No - Correctly time injector pump. (See “Adjust Injection Pump Timing” on page 121.)

(10) Intake or exhaust valves not leaking compression?

Yes - Go to step (11).

No - Grind valves and seats. (See “Recondition Cylinder Head” on page 130.)

(11) Intake or exhaust valve not seized?

No - Replace valve and check valve guide. (See “Recondition Cylinder Head” on page 130.)

Symptom: Exhaust Color WHITE under Load

(1) Correct type of fuel?

Yes - Go to step (2).

No - Drain and replace fuel.

(2) No water in fuel?

Yes - Go to step (3).

No - Drain and replace fuel.

(3) Engine not running too cool?

Yes - Go to step (4).

No - Check thermostat. (See “Remove and Install Thermostat” on page 126 and “Test Thermostat” on page 121.) Replace if faulty.)

(4) Correct volume of fuel being injected?

Yes - Go to step (5).

No - Replace faulty fuel injector pump or fuel injectors. (See “Remove and Install Fuel Injection Pump” on page 170. See “Remove and Install Fuel Injection Nozzle” on page 167.)

(5) Correct pattern from fuel injectors?

Yes - Go to step (6).

No - Clean or replace fuel injector nozzles. (See “Remove and Install Fuel Injection Nozzle” on page 167.)

(6) Is injector pump timing correct?

Yes - Go to step (7).

No - (See “Adjust Injection Pump Timing” on page 121.)

(7) Piston rings installed correctly?

Yes - Go to step (8).

No - Install piston rings correctly. (See “Repair Piston and Connecting Rod” on page 149.)

(8) Pistons, rings, or cylinders not worn?

Yes - Go to step (9).

No - Replace pistons and rings, bore or hone cylinders. (See “Inspection and Replacement” on page 152 and “Repair Cylinder Bore” on page 155.)

(9) Piston rings not broken or seized?

No - Replace rings. Check pistons and cylinders. (See “Inspection and Replacement” on page 152 and “Repair Cylinder Bore” on page 155.)

Symptom: Exhaust Color BLACK under Load

(1) Is engine NOT being run under high altitude or high temperature conditions?

Yes - Go to step (2).

No - Reduce load.

(2) Correct type of fuel?

Yes - Go to step (3).

No - Drain and replace fuel.

(3) Air filter elements not clogged?

Yes - Go to step (4).

No - Clean or replace air filter elements.

(4) Exhaust pipe not clogged?

Yes - Go to step (5).

No - Clean exhaust pipe.

(5) Even volume of fuel being injected?

Yes - Go to step (6).

No - Replace faulty fuel injector pump or fuel injectors. (See “Remove and Install Fuel Injection Pump” on page 170. See “Remove and Install Fuel Injection Nozzle” on page 167.)

(6) Correct volume of fuel being injected?

Yes - Go to step (7).

No - Replace faulty fuel injector pump or fuel injectors. (See “Remove and Install Fuel Injection Pump” on page 170. See “Remove and Install Fuel Injection Nozzle” on page 167.)

(7) Proper spray pattern from injectors?

Yes - Go to step (8).

No - Clean or replace fuel injector nozzles. (See “Remove and Install Fuel Injection Nozzle” on page 167.)

(8) Is injector pump timing correct?

Yes - Go to step (9).

No - (See “Adjust Injection Pump Timing” on page 121.)

(9) Intake or exhaust valves not leaking compression?

Yes - Go to step (10).

No - Grind valves and seats. (See “Recondition Cylinder Head” on page 130.)

Symptom: Exhaust Color BLACK under Load

(10) Intake or exhaust valves not seized?

No - Replace valve and check valve guide. (See “Recondition Cylinder Head” on page 130.)

Symptom: Exhaust Temperature Too High

(1) Cooling system filled to correct level?

Yes - Go to step (2).

No - Check for leaks and fill system to correct level.

(2) Engine running cool enough?

Yes - Go to step (3).

No - Check thermostat. (See “Remove and Install Thermostat” on page 126 and “Test Thermostat” on page 121.) Replace if faulty. Adjust fan belt tension. (See “Adjust Coolant Pump-Alternator Drive Belt” on page 122.)

(3) Exhaust pipe not clogged?

Yes - Go to step (4).

No - Clean exhaust pipe.

(4) Correct volume of fuel being injected?

Yes - Go to step (5).

No - Replace faulty fuel injector pump or fuel injectors. (See “Remove and Install Fuel Injection Pump” on page 170. See “Remove and Install Fuel Injection Nozzle” on page 167.)

(5) Intake or exhaust valve clearance correct?

Yes - Go to step (6).

No - Adjust valve clearance. (See “Adjust Valve Clearance” on page 116.)

(6) Intake or exhaust valves not leaking compression?

Yes - Go to step (7).

No - Grind valves and seats. (See “Recondition Cylinder Head” on page 130.)

(7) Piston rings not broken or seized?

No - Replace rings. Check pistons and cylinders. (See “Inspection and Replacement” on page 152 and “Repair Cylinder Bore” on page 155.)

Symptom: Engine Runs Rough - Misfiring

(1) Intake or exhaust valve clearance correct?

Yes - Go to step (2).

No - Adjust valve clearance.

(2) Correct volume of fuel being injected?

Yes - Go to step (3).

No - Replace faulty fuel injector pump or fuel injectors. (See “Remove and Install Fuel Injection Pump” on page 170. See “Remove and Install Fuel Injection Nozzle” on page 167.)

(3) Is injector pump timing correct?

Yes - Go to step (4).

No - See “Adjust Injection Pump Timing” on page 121.

(4) Backlash of timing gear not excessive?

Yes - Go to step (5).

No - Repair gears as needed.

(5) Combustion chambers clean of foreign matter?

Yes - Go to step (6).

No - Clean combustion chambers. (See “Remove and Install Cylinder Head” on page 128.)

(6) Intake or exhaust valves not leaking compression?

Yes - Go to step (7).

No - Grind valves and seats. (See “Recondition Cylinder Head” on page 130.)

(7) Intake or exhaust valves not seized?

Yes - Go to step (8).

No - Replace valve and check valve guide. (See “Recondition Cylinder Head” on page 130.)

(8) Piston rings not broken or seized?

No - Replace rings. Check pistons and cylinders. (See “Inspection and Replacement” on page 152 and “Repair Cylinder Bore” on page 155.)

Symptom: Engine Runs Rough - Uneven Combustion Sound

(1) Correct type of fuel being used?

Yes - Go to step (2).

No - Drain and replace fuel.

Symptom: Engine Runs Rough - Uneven Combustion Sound

(2) No water in fuel?

Yes - Go to step (3).

No - Drain and replace fuel. Check fuel filter.

(3) Even volume of fuel being injected?

Yes - Go to step (4).

No - Replace faulty fuel injector pump or fuel injectors. (See “Remove and Install Fuel Injection Pump” on page 170. See “Remove and Install Fuel Injection Nozzle” on page 167.)

(4) Proper spray pattern from injectors?

Yes - Go to step (5).

No - Clean or replace fuel injector nozzles. (See “Remove and Install Fuel Injection Nozzle” on page 167.)

(5) Air filter elements not clogged?

Yes - Go to step (6).

No - Clean or replace air filter elements.

(6) Exhaust pipe not clogged?

No - Clean exhaust pipe.

Symptom: Engine Runs Rough - Engine Surges DURING IDLING

(1) No water in fuel?

Yes - Go to step (2).

No - Drain and replace fuel. Check fuel filter.

(2) Even volume of fuel injected?

Yes - Go to step (3).

No - Replace faulty fuel injector pump or fuel injectors. (See “Remove and Install Fuel Injection Pump” on page 170. See “Remove and Install Fuel Injection Nozzle” on page 167.)

(3) Proper spray pattern from injectors?

Yes - Go to step (4).

No - Clean or replace fuel injector nozzles. (See “Remove and Install Fuel Injection Nozzle” on page 167.)

(4) Piston rings not broken or seized?

No - Replace rings. Check pistons and cylinders. (See “Inspection and Replacement” on page 152 and “Repair Cylinder Bore” on page 155.)

Symptom: Engine Runs Rough - Engine Surges UNDER LOAD

(1) No water in fuel?

Yes - Go to step (2).

No - Drain and replace fuel. Check fuel filters.

(2) Even volume of fuel injected?

Yes - Go to step (3).

No - Replace faulty fuel injector pump or fuel injectors. (See “Remove and Install Fuel Injection Pump” on page 170. See “Remove and Install Fuel Injection Nozzle” on page 167.)

(3) Proper spray pattern from injectors?

Yes - Go to step (4).

No - Clean or replace fuel injector nozzles. (See “Remove and Install Fuel Injection Nozzle” on page 167.)

(4) Piston rings not broken or seized?

No - Replace rings. Check pistons and cylinders.

Symptom: Engine Runs Rough - Excessive Engine Vibration

(1) Even volume of fuel injected?

Yes - Go to step (2).

No - Replace faulty fuel injector pump or fuel injectors. (See “Remove and Install Fuel Injection Pump” on page 170. See “Remove and Install Fuel Injection Nozzle” on page 167.)

(2) Proper spray pattern from injectors?

Yes - Go to step (3).

No - Clean or replace fuel injector nozzles. (See “Remove and Install Fuel Injection Nozzle” on page 167.)

(3) Piston rings not broken or seized?

Yes - Go to step (4).

No - Replace rings. Check pistons and cylinders. (See “Inspection and Replacement” on page 152 and “Repair Cylinder Bore” on page 155.)

(4) Crankshaft pin or bearing not worn or seized?

Yes - Go to step (5).

No - Regrind crankshaft and replace bearings. (See “Remove and Install Crankshaft and Main Bearings” on page 156.)

Symptom: Engine Runs Rough - Excessive Engine Vibration

(5) Connecting rod bolts tightened properly?

No - Replace damaged components. Tighten to correct specification.

Symptom: Engine Runs Rough - Poor Return to Low Speed

(1) Go to symptom “Engine Runs Rough”.

Symptom: Excessive Fuel Consumption

(1) Engine not running too cool?

Yes - Go to step (2).

No - Check thermostat. (See “Remove and Install Thermostat” on page 126 and “Test Thermostat” on page 121.) Replace if faulty.

(2) Correct volume of fuel being injected?

Yes - Go to step (3).

No - Replace faulty fuel injector pump or fuel injectors. (See “Remove and Install Fuel Injection Pump” on page 170. See “Remove and Install Fuel Injection Nozzle” on page 167.)

(3) Correct pattern from fuel injectors?

Yes - Go to step (4).

No - Clean or replace fuel injector nozzles. (See “Remove and Install Fuel Injection Nozzle” on page 167.)

(4) Intake or exhaust valves not leaking compression?

No - Check valve clearance or grind valves and seats. (See “Adjust Valve Clearance” on page 116 or “Recondition Cylinder Head” on page 130.)

Symptom: Excessive Oil Consumption

(1) Engine oil of correct viscosity and type?

Yes - Go to step (2).

No - Replace engine oil with oil of prover viscosity and type. (See “Diesel Fuel” on page 20.) Replace oil filter.

(2) No external or internal oil leak?

Yes - Go to step (3).

No - Repair as needed.

Symptom: Excessive Oil Consumption

(3) Intake or exhaust valve stems not worn?

Yes - Go to step (4).

No - Replace valve guides and valves. (See "Recondition Cylinder Head" on page 130.)

(4) Piston rings installed correctly and properly staggered?

Yes - Go to step (5).

No - Install piston rings correctly. (See "Repair Piston and Connecting Rod" on page 149.)

(5) Pistons, rings, or cylinders not worn?

Yes - Go to step (6).

No - Replace pistons and rings, bore or hone cylinders. (See "Inspection and Replacement" on page 152 and "Repair Cylinder Bore" on page 155.)

(6) Piston rings not broken or seized?

Yes - Go to step (7).

No - Replace rings. Check pistons and cylinders. (See "Inspection and Replacement" on page 152 and "Repair Cylinder Bore" on page 155.)

(7) No foreign matter in combustion chamber?

No - Clean head and top of piston. Check for damage.

Symptom: Fuel Oil in Crankcase

(1) Correct volume of fuel being injected?

Yes - Go to step (2).

No - Replace faulty fuel injector pump or fuel injectors. (See "Remove and Install Fuel Injection Pump" on page 170. See "Remove and Install Fuel Injection Nozzle" on page 167.)

(2) Intake or exhaust valve not seized or broken?

Yes - Go to step (3).

No - Replace valve and check valve guide. (See "Recondition Cylinder Head" on page 130.)

(3) Piston rings not broken or seized?

Yes - Go to step (4).

No - Replace rings. Check pistons and cylinders. (See "Inspection and Replacement" on page 152 and "Repair Cylinder Bore" on page 155.)

Symptom: Fuel Oil in Crankcase

(4) Pistons rings, piston, or cylinders not worn?

No - Replace pistons and rings, bore or hone cylinders. (See "Inspection and Replacement" on page 152 and "Repair Cylinder Bore" on page 155.)

Symptom: Coolant in Crankcase

(1) Cylinder head gasket not leaking?

Yes - Go to step (2).

No - Replace head gasket. (See "Remove and Install Cylinder Head" on page 128.) Resurface head and block if necessary.

(2) Is cylinder block not cracked?

No - Replace cylinder block.

Symptom: Low Oil Pressure

(1) Oil at correct level?

Yes - Go to step (2).

No - Add oil.

(2) Engine oil of correct viscosity and type?

Yes - Go to step (3).

No - Replace engine oil with oil of prover viscosity and type. (See "Diesel Fuel" on page 20.) Replace oil filter.

(3) No external or internal oil leak?

Yes - Go to step (4).

No - Repair as needed.

(4) Oil pressure relief valve not worn or damaged?

Yes - Go to step (5).

No - Clean or replace relief valve. (See "Remove and Install Oil Pressure Regulating Valve" on page 164.)

(5) Crankshaft pin or bearing not worn?

Yes - Go to step (6).

No - Regrind crankshaft and replace bearings. (See "Remove and Install Crankshaft and Main Bearings" on page 156.)

(6) Connecting rod bolts tightened properly?

Yes - Go to step (7).

No - Replace damaged components. Tighten to correct specification.

Symptom: Low Oil Pressure

(7) Is engine oil pump not worn excessively?

No - Replace oil pump. (See “Remove and Install Oil Pump” on page 162)

Symptom: Engine Is Overheating

(1) Is engine NOT being run under high altitude or high temperature conditions?

Yes - Go to step (2).

No - Reduce load on engine.

(2) Cooling system filled to correct level?

Yes - Go to step (3).

No - Check for leaks and fill system to correct level.

(3) Is radiator clear of debris?

Yes - Go to step (4).

No - Clean radiator fins.

(4) Is radiator core free from blockage?

Yes - Go to step (5).

No - Clean or replace radiator.

(5) Is thermostat operating correctly?

Yes - Go to step (6).

No - Check thermostat. (See “Remove and Install Thermostat” on page 126 and “Test Thermostat” on page 121.) Replace if faulty.

(6) Is cylinder head gasket not leaking?

Yes - Go to step (7).

No - Replace head gasket. (See “Remove and Install Cylinder Head” on page 128.) Resurface head and block if necessary.

(7) Is cylinder block not cracked?

No - Replace cylinder block.

Symptom: Low Engine Coolant Temperature

(1) Is thermostat operating correctly?

No - Check thermostat. (See “Remove and Install Thermostat” on page 126 and “Test Thermostat” on page 121.) Replace if faulty.

Symptom: Low Compression

(1) Engine oil of correct viscosity and type?

Yes - Go to step (2).

No - Replace engine oil of correct viscosity and type. Replace oil filter.

(2) Intake or exhaust valves not leaking compression?

Yes - Go to step (3).

No - Check valve clearance or grind valves and seats. (See “Adjust Valve Clearance” on page 116 or “Recondition Cylinder Head” on page 130.)

(3) Intake or exhaust valve stems not worn?

Yes - Go to step (4).

No - Replace valve guides and valves. (See “Recondition Cylinder Head” on page 130.)

(4) Intake or exhaust valve not seized?

Yes - Go to step (5).

No - Replace valve guides and valves. (See “Recondition Cylinder Head” on page 130.)

(5) Pistons, rings, or cylinders not worn or seized?

Yes - Go to step (6).

No - Replace rings. Check pistons and cylinders. (See “Inspection and Replacement” on page 152 and “Repair Cylinder Bore” on page 155.)

(6) Piston rings installed correctly and properly staggered?

No - Install piston rings correctly. (See “Repair Piston and Connecting Rod” on page 149.)

Tests and Adjustments

Adjust Throttle Linkage

Reason

To ensure that throttle linkage, and foot pedal linkage is adjusted correctly, and allows full high idle and slow idle position of governor throttle lever.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Digital Tachometer	JT05719	Used to set slow idle engine rpm and check fast idle rpm.

Procedure

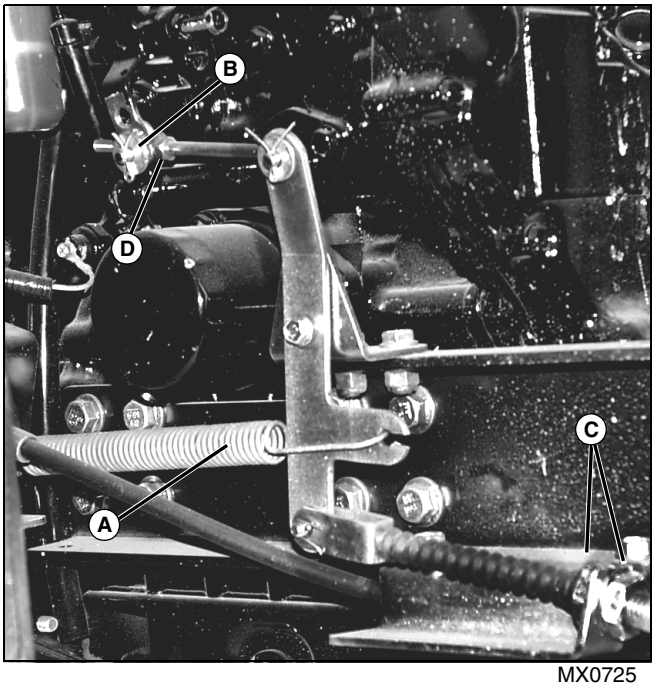
1. Park machine on level surface, turn key switch off, shift transmission to neutral, and park brake locked.

2. Place a small piece of reflective tape on outside edge of crankshaft pulley.

3. Start engine and run for 5 minutes or until engine is at operating temperature.

4. With engine running, depress throttle pedal all the way to the floor and check engine speed using JT05719 Digital Tachometer.

5. If fast idle is not within specifications, shut engine off.



MX0725

Picture Note: Early Model Shown

6. Disconnect spring (A).

7. Remove cotter pin and washer (B) from throttle adjustment pin, and disconnect from governor lever.

8. Push throttle pedal to the floor. If pedal will not go all the way to the floor, loosen jam nuts (C) and adjust cable.

9. With accelerator pedal on floor, hold governor throttle lever to high idle position and check alignment of adjustment pin and hole in lever.

10. If pin does not align with hole in throttle lever loosen locknut (D) on adjustment pin and adjust until pin aligns with hole in throttle lever.

11. Install washer and cotter pin onto throttle rod adjusting pin and tighten locknut.

Specifications

Fast Idle Speed. . . . . .3450±50 rpm

Adjust Slow Idle

Reason

To achieve proper slow idle rpm setting. Provides adequate rpm to keep engine running smoothly without stalling.

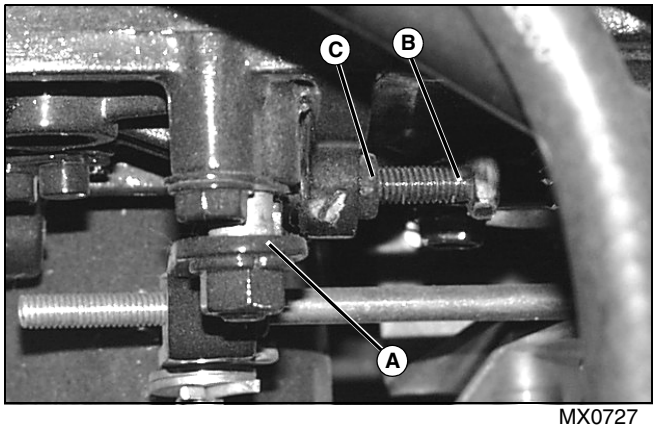
Special or Required Tools

Tool Name	Tool No.	Tool Use
Digital Tachometer	JT05719	Used to set slow idle engine rpm and check fast idle rpm.

Procedure

1. Place a small piece of reflective tape on outside edge of crankshaft pulley.

2. Start engine and run for 5 minutes or until engine is at operating temperature.



MX0727

3. Make sure throttle pedal is in low idle position. Check that governor throttle lever (A) is against slow idle stop screw (B). If not, adjust throttle linkage. (See “Adjust Throttle Linkage” on page 114.)

4. Use JT05719 Hand Held Digital Tachometer to check engine speed at front crankshaft pulley.

5. If slow idle rpm is not according to specifications, loosen locknut (C) and adjust slow idle stop screw until specified speed is obtained. After adjustment, hold adjustment screw while tightening locknut, and recheck engine slow idle speed.

Specifications

Slow Idle Speed . . . . . 1450±50 rpm

Adjust Fast Idle

CAUTION: Avoid injury! The FAST idle adjustment is pre-set by the engine manufacturer to comply with strict California Air Resources Board/ Environmental Protection Agency (CARB/ EPA) emissions requirements and is NOT adjustable. Tampering with the FAST idle adjustment may result in severe fines or penalties.

IMPORTANT: Avoid damage! DO NOT attempt to adjust the FAST idle setting. It is NOT adjustable.

If it is determined that either the fuel injection pump or governor assembly are in need of repair, they must be replaced ONLY as complete assemblies. Only an authorized factory trained technician is allowed to remove and install these assemblies. If replacement is necessary, remove and install the fuel injection pump and/or governor assembly as complete, individual assemblies.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Digital Tachometer	JT05719	Used to set slow idle engine rpm and check fast idle rpm.

Because the FAST idle speed is NOT adjustable, the throttle cable adjustment becomes very critical to proper engine operation. Therefore, first MAKE SURE that the throttle cable obtains its full range of motion, stop-to-stop, before performing any diagnostic procedures.

CAUTIONS

NOTE: ANY TAMPERING with the following items could put the engine out of EPA compliance and you could be subject to a fine of up to $25,000 a day for every day unit is out of EPA compliance.

- Torque capsule is NOT adjustable on any Year 2000 EPA diesel engines.
- High speed is NOT adjustable on any Year 2000 EPA diesel engines.

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- Injection pump timing should not be changed.

Fast Idle Check Procedure

1. Place a small piece of reflective tape on crankshaft pulley.

NOTE: Make sure air cleaner is clean and not restricted. Replace air cleaner element as necessary.

2. Start engine and run for 5 minutes to obtain normal operating temperature.

3. Move throttle pedal to fast idle position.

4. Use JT05719 Digital Tachometer to check engine speed at crankshaft pulley.

Results

- If fast idle speed does not meet specifications, adjust throttle cable as needed. (See “Adjust Throttle Linkage” on page 114.)
- If engine still does not meet fast idle speed specifications, have injection pump inspected by an EPA authorized diesel service (ADS) center.

Specifications

Fast Idle Speed. . . . . 3450±50rpm

Test Cylinder Compression

Reason

To determine the condition of the pistons, rings, cylinder walls and valves.

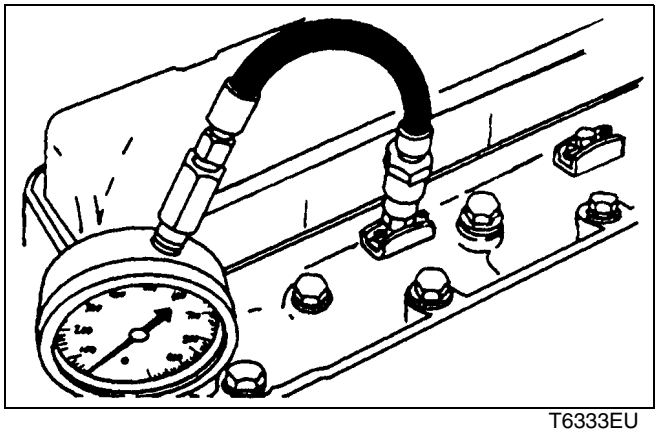
Special or Required Tools

Tool Name	Tool No.	Tool Use
Compression Gauge Assembly	JT01682	Used for cylinder compression check.
Adapter	JDG472	Used for cylinder compression check.

Procedure

1. Run engine for 5 minutes to bring to operating temperature. Shut off engine.

2. Remove injection nozzles.



T6333EU

3. Remove heat protector from end of fuel injection nozzle, and install on JDG472 adapter.

4. Install JT01682 Compression Gauge Assembly and JDG472 Adapter in injection port.

5. Disconnect fuel shutoff solenoid electrical connector on rear of governor.

IMPORTANT: Avoid damage! DO NOT overheat starting motor during test.

6. Crank engine for three seconds with starting motor.

7. Record pressure reading for each cylinder.

Results

- If pressure reading is below specification, squirt clean engine oil into cylinders through injector ports and repeat test.

- If pressure increases significantly, check piston, rings, and cylinder walls for wear or damage.

- If pressure does not increase significantly after retest, check for leaking valves, valve seats or cylinder head gasket.

Specifications

Compression Pressure

Standard . . . . . 3432±98 kPa (498±14 psi)
Minimum Pressure . . . . . 2746±98 kPa (398±14 psi)
Maximum Difference between Cylinders . . . . . 197-294 kPa (29-43 psi)
Minimum Cranking Speed . . . . . 250 rpm

NOTE: Pressure listed is for 300 meters (1000 ft) above sea level. Reduce specification an additional 4% for each 300 meters (1000 ft) of altitude above this level.

Adjust Valve Clearance

Reason

To be sure valves are fully opening at the correct time, but not remaining open too long or wearing valve train unnecessarily.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Feeler Gauge	NA	Used to measure clearance.

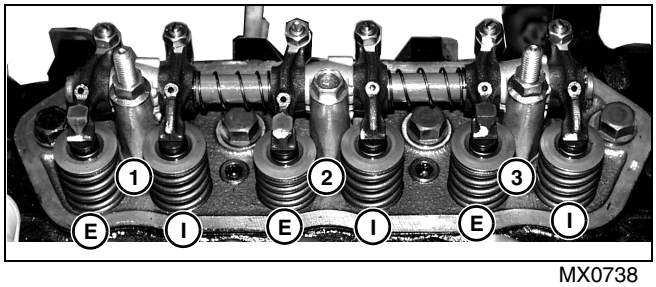
Procedure

1. Engine must be cool (room temperature) before valve clearance is checked.

2. Be sure ignition key is OFF before attempting to turn engine by hand.

3. Remove rocker arm cover.

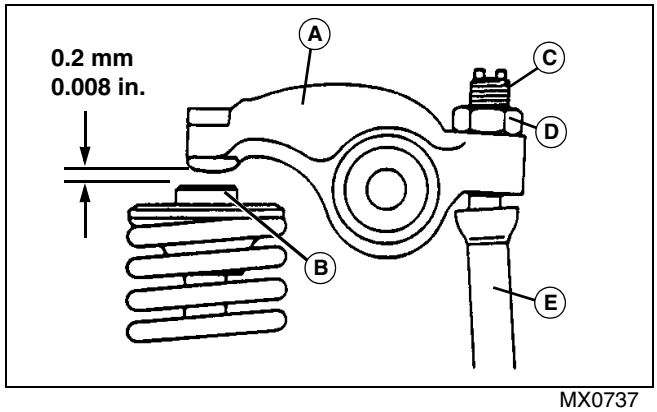
NOTE: Top Dead Center (TDC) is when the piston is at it's highest point of travel in the cylinder on the compression stroke (both valves closed). The valves must be checked with piston at or near TDC. Number one cylinder is located at rear of engine (flywheel side).



MX0738

Picture Note: I=Intake, E=Exhaust

4. Using a 17 mm wrench, turn the crankshaft pulley in the direction of engine rotation while watching the rocker arms of the number one cylinder. When the intake valve has completely closed (raised up), turn the crankshaft an additional 1/2 turn.



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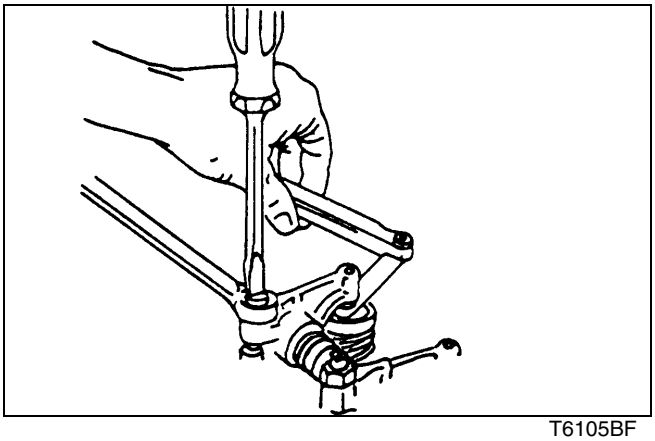
5. Try to move rocker arms and/or push rods for the cylinder to be adjusted:

- If both rocker arms (A) and push rods (E) are loose, the piston is near TDC on the compression stroke and you may proceed to step 6.
- If both rocker arms are not loose, repeat step 4.

6. Slide 0.2mm (0.008 in.) feeler gauge between valve cap (B) and rocker arm (A). There should be a slight drag on the feeler gauge when the clearance (F) is correct.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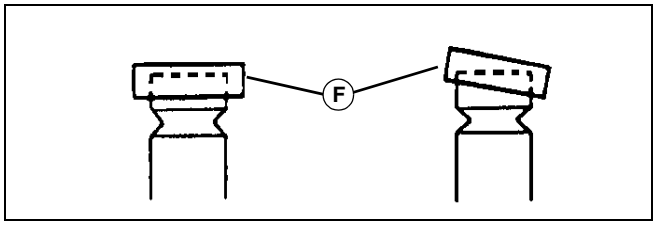
7. To adjust valves, loosen locknut (D) and turn adjusting screw (C) until blade of feeler gauge has a slight drag when inserted between rocker arm and valve cap. Hold adjusting screw while tightening locknut.

8. Recheck valve clearance after tightening locknut to ensure it is to specification.



MIF

Picture Note: Left Is Normal, Right Is Not Normal

9. Check that valve cap (F) on end of valve stem remained seated on valve and inside valve spring retainer.

10. Repeat steps 4-9 for number two and three cylinders.

11. Install rocker arm cover.

Specifications

Valve Clearance

Intake and Exhaust . . . . 0.15-0.25 mm (0.006-0.010 in.)

Check Valve Lift

Reason

To test for excessive wear on camshaft lobes, cam followers, rocker arms, valve stems, valve caps, or bent push rods.

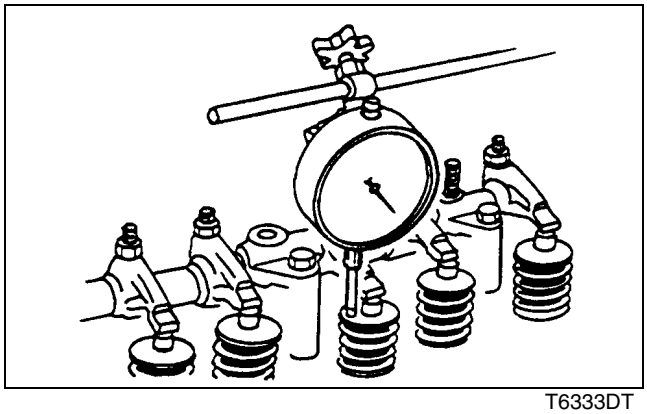
Special or Required Tools

Tool Name	Tool No.	Tool Use
Dial Indicator with Magnetic Base	NA	Used to measure valve movement.

Procedure

1. Remove rocker arm cover.

2. Check that valve clearance is within specification. Adjust if necessary.



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3. Fasten dial indicator to engine and position indicator tip on valve retainer. Valve must be fully closed and rocker arm must move freely.

4. Zero the dial indicator.

5. Rotate crankshaft while observing dial indicator as valve is moved to the full open (down) position.

6. Repeat for each valve.

Results

If valve lift is less than specification, remove and inspect camshaft, camshaft followers, push rods, valve caps and stems, and/or rocker arms for wear or damage.

Specifications

Valve Lift . . . . . 7.5 mm (0.300 in.)

Test Fuel Injection System

CAUTION: Avoid injury! DO NOT attempt to adjust the fuel injection pump timing. For most engine problems, the fuel injection pump timing will not have to be adjusted. If the engine performed well at one time, then performance dropped, the fuel injection timing is NOT the problem. Fuel injection timing, once set by the engine manufacturer, should NOT change during the life of the engine.

IMPORTANT: Avoid damage! Fuel injection pump timing should NOT change during the life of the engine unless the pump has been altered illegally, or there is excessive wear to the camshaft injection pump cam lobes and lifters.

First check the fuel quality, fuel supply, fuel injectors, air intake system, and engine compression in all cylinders before considering fuel injection timing problems.

If all other possibilities have been rules out and it is determined that the fuel injection pump and governor assembly are in need of repair, they must be replaced ONLY as complete assemblies.

Only an authorized factory trained technician is allowed to remove and install these assemblies.

Reason

To stop fuel flow to the cylinders (one at a time), while engine is running, to determine what effect that cylinder has on overall engine performance.

Procedure

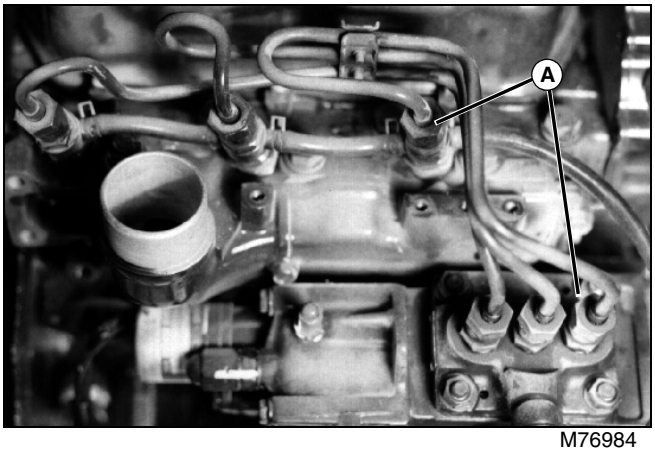
1. Park unit on level surface, park brake locked, transmission in neutral.

2. Access engine, remove air cleaner hose to intake manifold.

CAUTION: Avoid injury! This test will cause diesel fuel to be released from fuel system. Injection pump is capable of producing extremely high pressure. Eye protection must be worn. Do not open fuel injector connectors more than 1/8 of a turn. Do not place hands near injectors during test. Do not allow any debris to enter intake manifold during test. Do not smoke.Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting high pressure lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury should reference a knowledgeable source. Such information is available from the Deere & Company Medical Department in Moline, Illinois, U.S.A.

3. Start engine and run at slow idle.



M76984

4. Using two 17 mm open end wrenches, loosen nut (A) on one high pressure fuel injector line, either at the injector nozzle or at injection pump, while holding lower nut stationary with second wrench. Only loosen nut 1/8 of a turn (45°).

5. Listen for engine speed to drop and exhaust noise to change.

6. Tighten nut and allow engine to return to original speed before loosening next cylinder's fuel line nut.

7. Compare sound and speed of each cylinder as it is disabled.

8. Tighten fuel line nuts and stop engine.

Results

- When fuel flow is stopped to a cylinder, engine rpm should drop, engine should begin to vibrate and run rough, and exhaust noise will be uneven until fuel flow is restored.

If test produces the results described above, but engine performance remains poor, test the following:

- Clogged air cleaner elements, leaking air filter outlet hoses or clamps.
- Restriction in exhaust system.
- Presence of coolant or diesel fuel in crankcase oil.

If defeating a single cylinder has no effect on overall engine performance, test the following:

- Fuel injector nozzle opening pressure, spray pattern, and leakage and for that cylinder (See "Test Fuel Injection Nozzle" on page 119).
- Cylinder compression or cylinder leakage test.
- Fuel transfer pump pressure.
- Fuel shutoff solenoid is opening fully.
- Fuel control and governor linkage flyweights allowing full fuel flow to injector pump.
- Injection pump timing correct.

If the above test results are within specifications, remove injection pump and have tested at an Authorized Diesel Service (ADS) Center.

Test Fuel Injection Nozzle

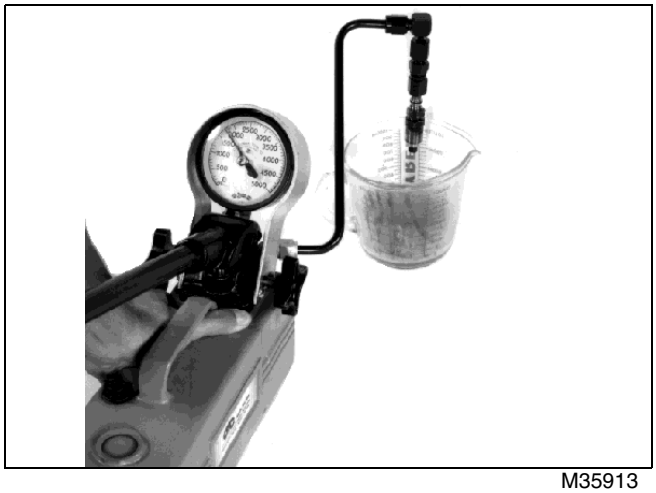
Reason

To determine opening pressure, leakage, chatter and spray pattern of the fuel injection nozzle.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Diesel Fuel Injection Nozzle Tester	D01109AA	Used for fuel injection nozzle test.
Adapter Set	D01110AA	Used for fuel injection nozzle test.
Straight Adapter	23622	Used for fuel injection nozzle test.
Container	NA	Used to catch fuel.

Connections


M35913

Connect fuel injection nozzle to D01109AA Diesel Fuel Injection Nozzle Tester using parts from D01110AA Adapter Set and 23622 Straight Adapter.

IMPORTANT: Avoid damage! Use clean, filtered diesel fuel when testing injection nozzles for best results.

Procedure 1

Test fuel injection nozzle opening pressure following the nozzle tester manufacturer's instructions. Ensure opening pressure is to specification.

Procedure 1 Results

If pressure reading does not meet specification, disassemble injection nozzle and inspect nozzle assembly for contamination or stuck valve. If necessary, add or remove shims to change opening pressure.

Procedure 2

Test fuel injection nozzle leakage following the nozzle tester manufacturer's instructions.

1. Dry nozzle completely using a lint-free cloth.
2. Pressurize nozzle to 11 032 kPa (1600 psi).
3. Watch for leakage from nozzle spray orifice. Leakage time should be a minimum of 10 seconds.

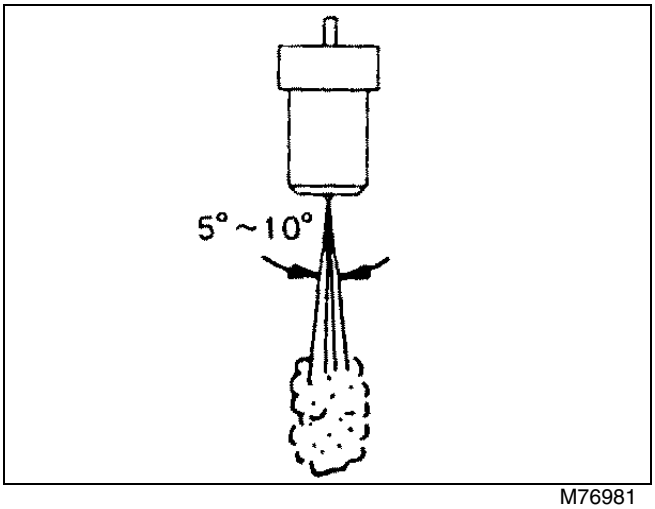
Procedure 2 Results

If leakage time does not meet specification, disassemble injection nozzle and inspect nozzle assembly for contamination. Inspect valve seating surface. Replace nozzle assembly if necessary.

Procedure 3

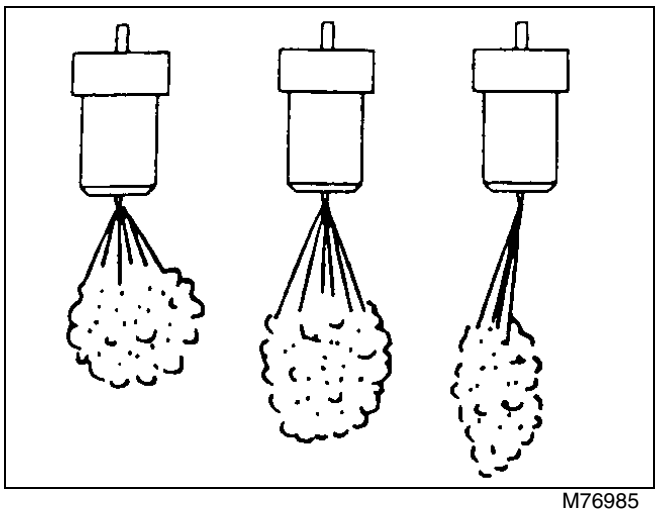
Test fuel injection nozzle chatter and spray pattern following the nozzle tester manufacturer's instructions.

1. Pressurize nozzle to 11800±1000 kPa (1712±145 psi)
2. Listen for “chatter” sound and watch spray pattern. Ensure “chatter” and spray pattern are to specification.



M76981

Picture Note: Correct Injection Angle



M76985

Picture Note: Incorrect Injection Angle

Results

- If nozzle chatter or spray pattern does not meet specifications, disassemble injection nozzle and inspect nozzle assembly for contamination. See “Cleaning and Inspection” on page 169. Inspect valve seating surface. Replace nozzle assembly if necessary.
- If there is excessive difference in spray angle or injection angle, incomplete atomizing or sluggish starting/stopping of injection, disassemble injection nozzle and inspect nozzle assembly for contamination. See “Cleaning and Inspection” on page 169. Replace nozzle assembly if necessary.

Specifications

Fuel Injection Nozzle
Opening Pressure . . . 11 800±1000 kPa (1712±145 psi)
Slow Hand Lever Movement . . . . . Chatter sound
Slow Hand Lever Movement . . . . . Fine stream spray pattern
Fast Hand Lever Movement . . . . . Fine atomized spray pattern

Adjust Injection Pump Timing

CAUTION: Avoid injury! DO NOT attempt to adjust the fuel injection pump timing. For most engine problems, the fuel injection pump timing will not have to be adjusted. If the engine performed well at one time, then performance dropped, the fuel injection timing is NOT the problem. Fuel injection timing, once set by the engine manufacturer, should NOT change during the life of the engine.

NOTE: Fuel injection pump timing should NOT change during the life of the engine unless the pump has been altered illegally, or there is excessive wear to the camshaft injection pump cam lobes and lifters.

Check these items FIRST as possible cause of engine problem:

- Fuel quality. Go to a higher cetane rated fuel.
- Check compression. A new engine with low compression and non-seated rings will not fire as cleanly as an older engine with seated rings. Engine must be broken-in.
- Check for dirty injector. Crack individual injector fuel lines and note performance change. Test suspect injectors.
- Verify glow plug circuit is working correctly.
- Check throttle cable adjustment. Reference proper procedure.
- Check for plugged fuel filter.
- Check fuel transfer pump pressure.

IMPORTANT: Avoid damage! If all other possibilities have been ruled out and it is determined that the fuel injection pump and governor assembly are in need of repair, they must be replaced ONLY as complete assemblies.

Only an authorized factory trained technician is allowed to remove and install these assemblies.

- Have pump tested by an EPA Authorized Diesel Service (ADS) Center. When reinstalling an injection pump sent out for service, use the same thickness of shim that was removed. Shim thickness is 0.8 mm (0.031 in.).

Test Thermostat

Reason

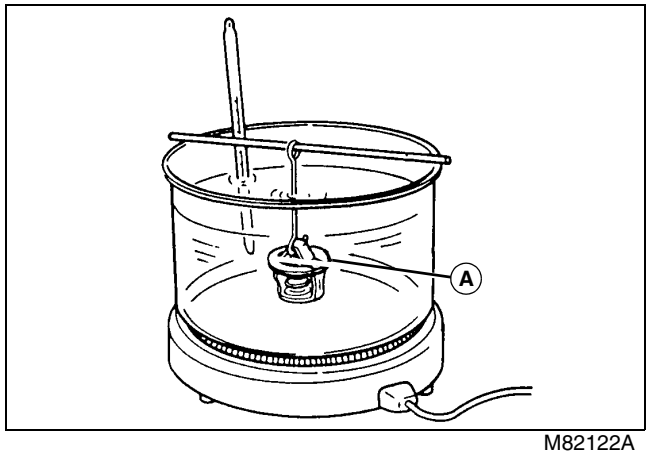
To determine opening temperature of thermostat.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Thermometer	NA	Used to measure temperature for thermostat test.
Glass Container	NA	Used for thermostat test.
Heating Unit	NA	Used to heat container of water.

Procedure

CAUTION: Avoid injury! DO NOT allow thermostat or thermometer to rest against the side or bottom of glass container when heating water. Either may rupture if overheated.



M82122A

1. Suspend thermostat (A) and a thermometer in a container of water.
2. Heat and stir the water. Observe opening action of thermostat and compare temperatures with specifications.
3. Remove thermostat and observe its closing action as it cools.

Results

- If thermostat does not open according to specifications, replace.
- If closing action is not smooth and slow, replace thermostat.

Specifications

Begin Opening . . . . . 69.5-72.5° C (157-163° F)
Fully Open . . . . . 85° C (184° F)
Minimum Lift Height
(Above 85° C [185° F]) . . . . . 8 mm (0.315 in.)

Adjust Coolant Pump-Alternator Drive Belt

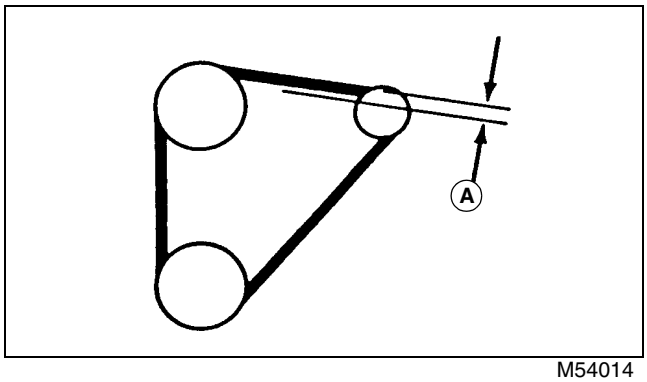
Reason

To keep proper tension on belt to drive coolant pump and alternator. To prevent shortened belt and bearing life.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Belt Tension Gauge	JDG529 or JDST28	Used to adjust the coolant pump/ alternator drive belt tension.
Straight Edge	NA	Used to adjust the coolant pump/ alternator drive belt tension.

Procedure



M54014

1. Access engine.

2. Check belt tension (A) between coolant pump and alternator using belt tension gauge and a straight edge.

Results

If deflection is not within specifications:

- Loosen top and bottom alternator mounting cap screws.
- Apply force only to right side of alternator housing until tension is correct.
- Tighten alternator mounting hardware.

Specifications

Belt Tightening

Applied Force . . . . . 98 N (22 lb-force)
Deflection . . . . . 10-15 mm (0.400-0.600 in.)

Test for Exhaust Gas in Coolant

Reason

To determine if compression pressure is leaking from combustion cylinder into water jacket of cylinder block.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Adapter	JDG472	Used to connect compressed air source to cylinder injection port.

Procedure

CAUTION: Avoid injury! Coolant may be above boiling temperature and under pressure in cooling system. DO NOT remove pressure cap when system is hot. Escaping steam will burn unprotected skin. Always wear protective clothing and goggles when servicing cooling system.

1. With coolant at proper level and radiator cap tight, run engine for 5 minutes to bring to operating temperature.

2. Squeeze top radiator hose to verify system pressure has dropped.

3. Remove cap from recovery tank.

4. Check for bubbles coming from overflow hose at bottom of tank.

If bubbles are present, isolate source of compression leak:

- Remove injection nozzles.
- Install JDG472 Adapter in injection port of cylinder to be tested.
- Move piston to bottom of stroke with intake and exhaust valves closed.
- Connect hose from compressed air source to adapter. Do not exceed rated pressure of hoses and tools being used. Do not exceed 355 psi pressure cylinder pressure.
- Check for bubbles in coolant recovery tank, or air escaping from muffler, air cleaner or oil fill opening.
- Repeat for each cylinder.

Results

- If bubbles are present, check for cracks in cylinder head and block. Check for damaged head gasket.
- If air escapes from muffler, check for worn exhaust valve.
- If air escapes from air cleaner, check for worn intake valve.
- If air escapes from engine oil fill, check for worn piston rings.

Test Radiator Cap Pressure

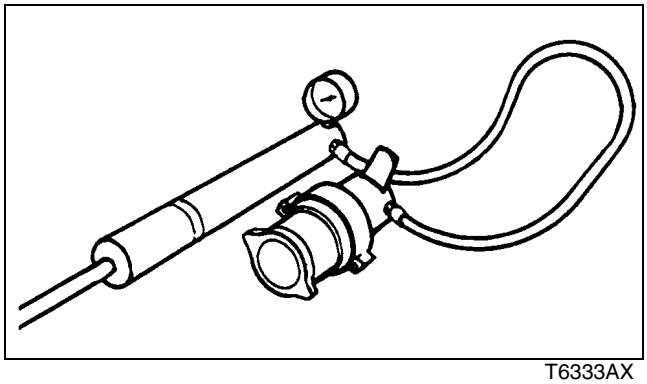
Reason

To test radiator cap spring and seal for correct opening pressure range.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Cooling System Pressure Pump	D05104ST	Used for cooling system pressure test.
Radiator Pressure Test Kit (Adapters)	JDG692	Used for cooling system pressure test.

Procedure



T6333AX

1. Install radiator cap on appropriate adapter.
2. Attach adapter to D05104ST Pressure Pump.
3. Apply pressure. Pressure valve in cap should open according to specification.

Results

If cap leaks, relieve pressure and retighten cap. Test again. Replace cap if pressure is not within specification.

Specifications

Radiator Cap Relief Valve
Opening Pressure. . . . . 83-96 kPa (12-14 psi)

Test Cooling System Pressure

Reason

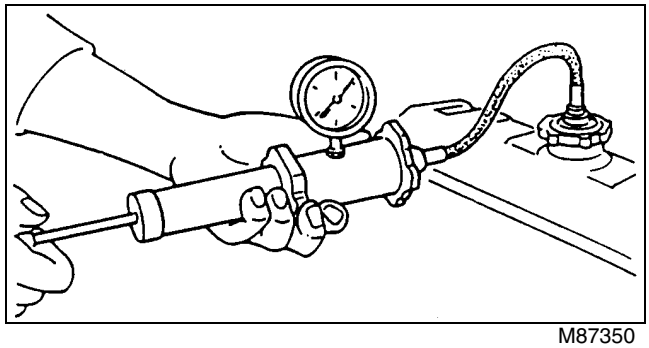
To inspect cooling system for leaks.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Cooling System Pressure Pump	D05104ST	Used for cooling system pressure test.
Radiator Pressure Test Kit (Adapters)	JDG692	Used for cooling system pressure test.

Procedure

CAUTION: Avoid injury! Coolant may be above boiling temperature and under pressure in cooling system. DO NOT remove pressure cap when system is hot. Escaping steam will burn unprotected skin. Always wear protective clothing and goggles when servicing cooling system.



M87350

1. Check cooling system is cool and squeeze top radiator hose to check system pressure has dropped.
2. Remove cap. Top off coolant if low. Attach D05104ST Pressure Pump to hose.
3. Pressurize system with tester to 15 psi.
4. Check for leaks throughout cooling system.

Results

- Pressure should hold to specifications. If pressure decreases, check for leaks. Repair leaks or replace parts as necessary.
- If leakage continues after all external leaks have been stopped, a defective head gasket, cracked block, or cylinder head may be the cause.

Specifications

Maximum Pressure. . . . . 0.9 kg/cm^2 (90 kPa) (13 psi)
Minimum Pressure after 15 Seconds . . . 90 kPa (13 psi)

Engine Oil Pressure Test

Reason

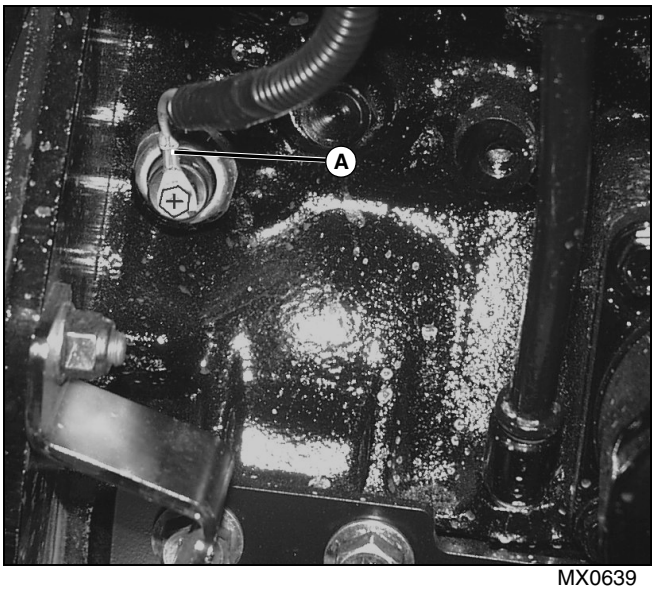
To determine if engine bearings or lubrication system components are worn.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Hose Assembly	JT03017	Used for engine oil pressure test.
Pressure Gauge (100 psi)	JT05577	Used for engine oil pressure test.
Connector	JT03349	Used for engine oil pressure test.

Procedure

1. Park vehicle in neutral, engine off, and park brake locked.



MX0639

2. Remove wire (A) to oil pressure switch.
3. Unscrew oil pressure switch from block.
4. Install JT03349 Connector into block.
5. Connect hose assembly and pressure gauge.

IMPORTANT: Avoid damage! Stop running engine if no oil pressure is present.

6. Start engine. If pressure reading is below 69 kPa (10 psi), STOP ENGINE.
7. Run engine approximately five minutes to heat oil, then check oil pressure at fast idle.

Results

- If oil pressure is not within specifications, inspect oil pressure regulating valve parts for wear or damage. (See “Remove and Install Oil Pressure Regulating Valve” on page 164.) Add or remove shims as necessary.
- If oil pressure does not increase, engine may be worn beyond specifications. (See “Diesel Engine Troubleshooting” on page 105.)

Specifications

Engine Oil Pressure
@ 2650 rpm. . . . . 290±50 kPa (42±7 psi)
Engine Oil Pressure
@ 1000 rpm. . . . . 60 kPa (9 psi)

Test Fuel Transfer Pump Pressure

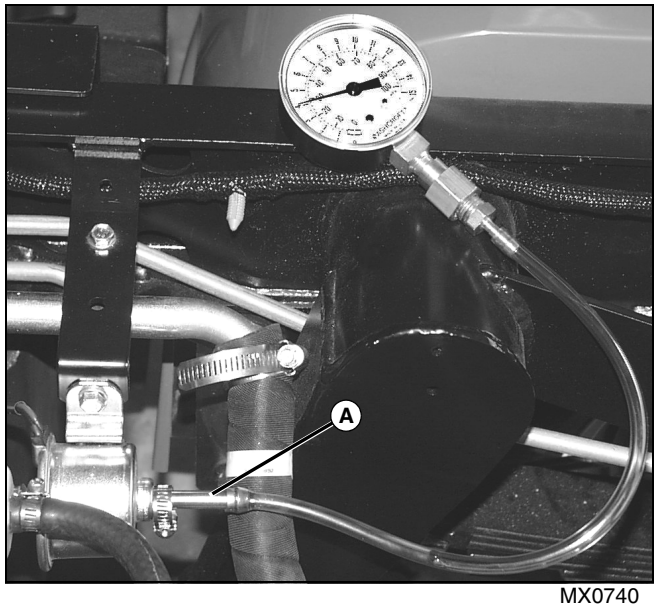
Reason

To determine fuel pump operating pressure.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Fuel Pump Pressure Test Kit	JDG356	Used for fuel pump pressure test.

Procedure



MX0740

1. Park unit on level surface, park brake locked, transmission in neutral, engine off.

2. Disconnect fuel supply hose from fuel pump outlet.

3. Install test gauge as shown to outlet end of fuel pump (A).

4. Turn key switch to ON position and note reading on gauge.

Results

If pressure is below specification, replace fuel pump.

Specifications

Fuel Transfer Pump Pressure (Min) . . . . . 21 kPa (3 psi)

Test Fuel Transfer Pump Flow

Reason

To determine fuel transfer pump output volume.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Graduated Container	NA	Used to measure fuel amount.

Procedure

1. Park unit on level surface, park brake locked, transmission in neutral, engine off.

MX0644

2. Disconnect fuel supply hose (A) from fuel filter.

3. Place hose in graduated container (B). Turn key switch to ON position for 30 seconds.

Results

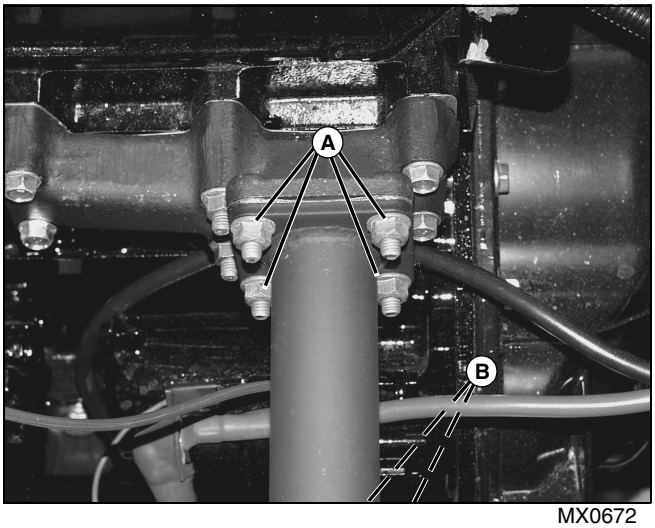
If fuel volume is below specification, replace fuel transfer pump.

Specifications

Fuel Transfer Pump Flow Volume (Min in 30 seconds) . . . . . 207 mL (7 oz)

Repair

Remove and Install Muffler

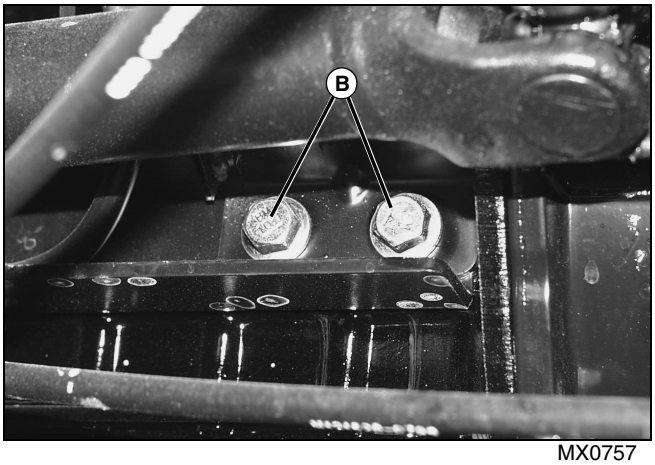


MX0672

1. Allow muffler to cool, or wear protective gloves before working on muffler. Access muffler.

2. Remove tailpipe hanger clamp near rear axle and clamp from muffler outlet and remove tailpipe.

3. Remove four nuts (A) holding muffler to exhaust manifold.



MX0757

4. Remove cap screws (B) from lower muffler support, and remove muffler from engine.

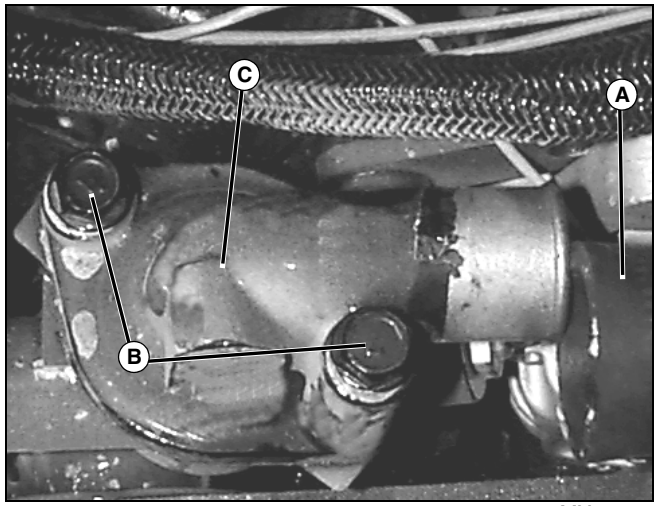
5. Clean sealing surfaces of muffler flange and exhaust manifold and replace gasket before installation.

Remove and Install Thermostat

1. Park unit with park brake locked, transmission in neutral, and engine off.

2. Allow engine to cool before attempting to service cooling system.

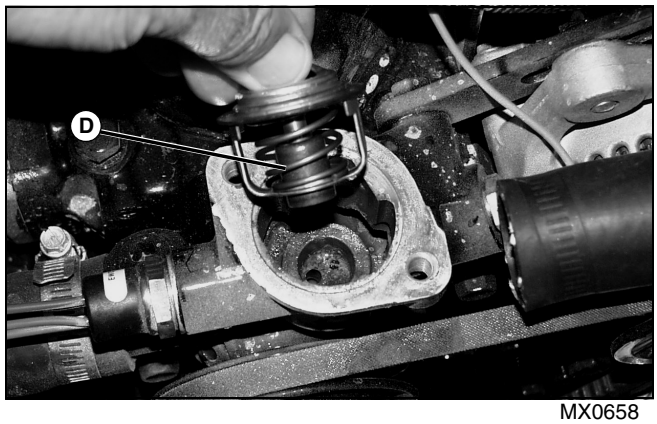
3. Open radiator cap. Place container under radiator drain and drain coolant.



MX0656

4. Loosen clamp and slide hose (A) from thermostat housing.

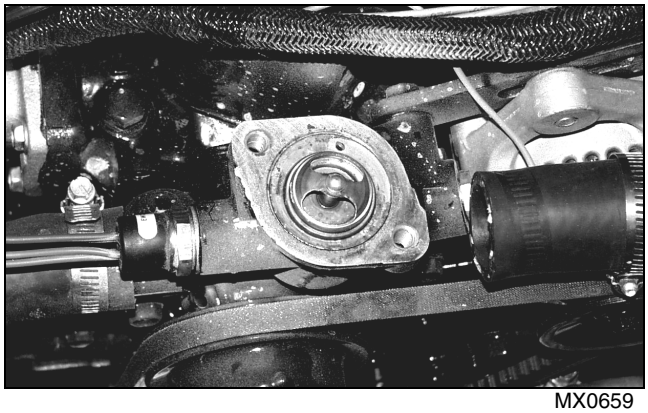
5. Remove two cap screws (B) holding thermostat housing to coolant pump. Remove housing (C).



MX0658

6. Remove thermostat (D).

7. Test or replace thermostat. (See “Test Thermostat” on page 121.)



MX0659

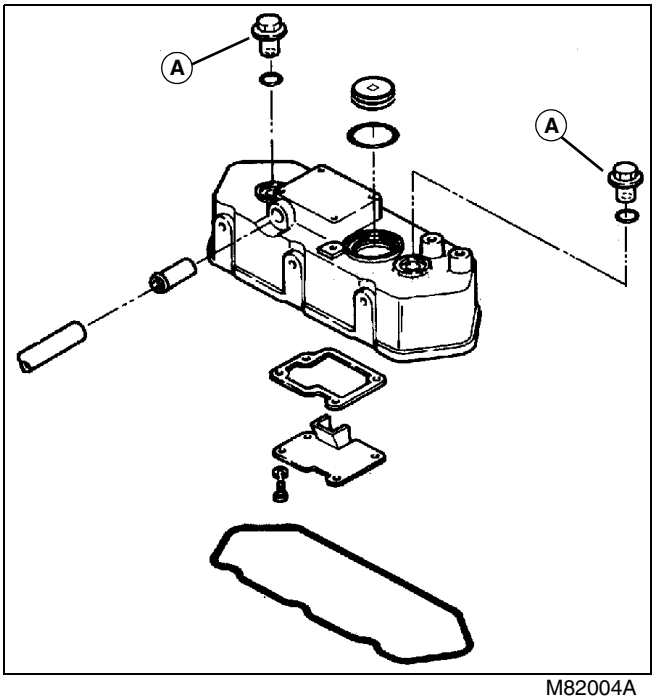
8. When installing thermostat, install as shown with spring facing down. Thermostat is offset and only fits in one direction. Make sure it is installed as shown and fits down in recess.

9. Replace gasket and tighten cap screws to specification.

Specifications

Thermostat Housing
Cap Screw Torque . . . . . 18 N•m (160 lb-in.)

Remove and Install Rocker Arm Cover



M82004A

1. Remove crankcase breather tube from breather fitting on rocker cover.

2. Remove two special nuts (A) securing cover to cylinder head.

3. Remove rocker cover.

4. Inspect O-ring seals for wear or damage. Replace if necessary.

5. Disassemble breather baffle and clean all parts.

6. Install new gasket.

7. Install cover. Tighten special nuts to specification.

Specifications

Rocker Arm Cover
Special Nut Torque. . . . . 18 N•m (160 lb-in.)

Repair Rocker Arms and Push Rods

Rocker Arm Removal

1. Remove rocker arm cover. (See “Remove and Install Rocker Arm Cover” on page 127.)

2. Remove three M8 rocker arm mounting nuts.

3. Pull rocker arm assembly straight up off of mounting studs on cylinder head.

Rocker Arm Disassembly

IMPORTANT: Avoid damage! Any components that are to be reused must be installed in their original location. Be sure to mark each component as it is removed from the engine.

1. Mark all parts for location before disassembly to aid assembly.

2. Remove end retaining rings and slide components off of rocker shaft.

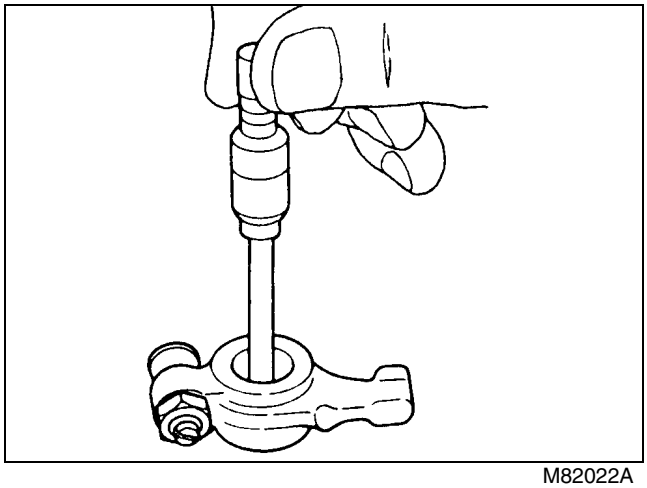
3. Remove set screw from center support. Remove rocker shaft from center support.

4. Clean all parts of varnish and oil.

Rocker Arm Inspection

M35262

1. Measure outer diameter of rocker arm shaft. Replace rocker arm shaft if less than wear limit specification.



M82022A

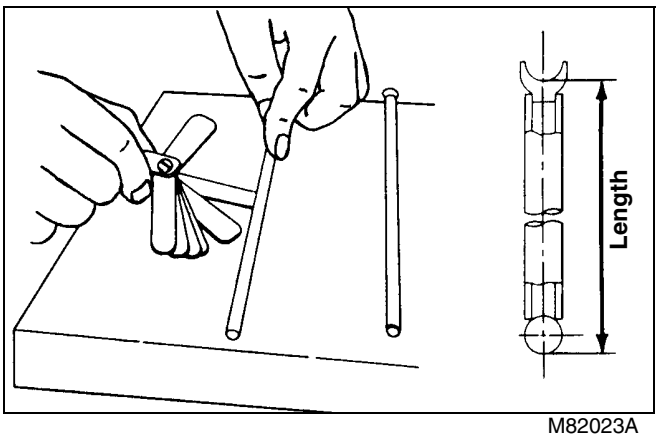
2. Measure inside diameter of rocker arms, and rocker shaft supports.

Results

Replace rocker arms or supports if ID is more than wear limit specification.

If shaft and support/arm clearance (support and/or arm ID minus shaft OD) exceed wear limit specification, replace all parts.

Push Rod Inspection



M82023A

1. Lay push rod on flat surface (such as glass) and roll while checking for a gap under center of rod. Use feeler gauge to check dimension. Replace push rod if not within specifications.

2. Check the surface of the adjusting screw that contacts the push rod for wear, replace push rod and/or adjusting screw if worn.

3. Check the rocker arm to valve stem cap contact surface for wear. Replace rocker arm if worn.

Rocker Arm Assembly

1. Assemble rocker shaft into center support, aligning set screw hole in support with hole in rocker shaft.

2. Be sure rocker arms are installed in same order as removed.

Rocker Arm Installation

IMPORTANT: Avoid damage! Be sure valve caps are in place on end of valve stems before installing rocker arms.

1. Align rocker arm supports with studs on cylinder head. Align rockers with valve stems.

2. Install push rods in block and align into rocker arms.

3. Install mounting nuts on rocker arm supports and evenly tighten nuts to pull rocker assembly to head. Tighten to specification.

4. Adjust valve clearance. (See “Adjust Valve Clearance” on page 116.)

5. Install rocker arm cover. (See “Remove and Install Rocker Arm Cover” on page 127.)

Specifications

Rocker Arm Shaft
OD (Standard) . . . . . 11.966-11.984 mm (0.471-0.472 in.)
Wear Limit . . . . . 11.95 mm (0.470 in.)

Rocker Arm and Shaft Support Bushings

Inside Diameter
(Standard) . . . . . 12.00-12.020 mm (0.472-0.473 in.)
Wear Limit . . . . . 12.09 mm (0.476 in.)

Oil Clearance . . . . . 0.016-0.054 mm (0.0006-0.002 in.)
Wear Limit . . . . . 0.14 mm (0.006 in.)

Push Rod Length . . . . . 114-115 mm (4.488-4.528 in.)
Push Rod Bend . . . . . 0.0-0.03 mm (0.0-0.001 in.)
Rocker Arm Mounting Nut Torque . . . 26 N•m (226 lb-ft)

Remove and Install Cylinder Head

Removal

1. Park machine on level surface, transmission in neutral, park brake locked, engine off.

2. Disconnect negative battery cable from battery.

3. Shut off fuel valve on fuel filter.

4. Allow engine to cool, and cooling system pressure to return to zero. Drain coolant from drain valve on left side of radiator.

5. Remove muffler from exhaust manifold. (See “Remove and Install Muffler” on page 126.)

6. Remove upper and lower radiator hoses from coolant pump.

7. Disconnect wiring from coolant temperature sensors.

8. Remove upper alternator bracket and fan belt from coolant pump.

9. Remove coolant pump. (See “Remove and Install Coolant Pump” on page 165.)

10.Remove high pressure fuel lines and fuel leak-off line running from fuel injection pump to nozzles.

11.Disconnect glow plug wiring harness from engine harness.

12.Remove rocker arm cover. (See “Remove and Install Rocker Arm Cover” on page 127.)

IMPORTANT: Avoid damage! Any components that are to be reused must be installed in their original location. Be sure to mark each component as it is removed from the engine.

13.Remove rocker arm assembly, push rods, and valve caps from cylinder head. (See “Repair Rocker Arms and Push Rods” on page 127.)

14.Loosen and remove cylinder head bolts.

15.Using lift brackets and hoist, pull head straight up from block.

16.Remove exhaust and intake manifolds. (See “Remove and Install Exhaust Manifold” on page 130 and “Remove and Install Intake Manifold” on page 130.)

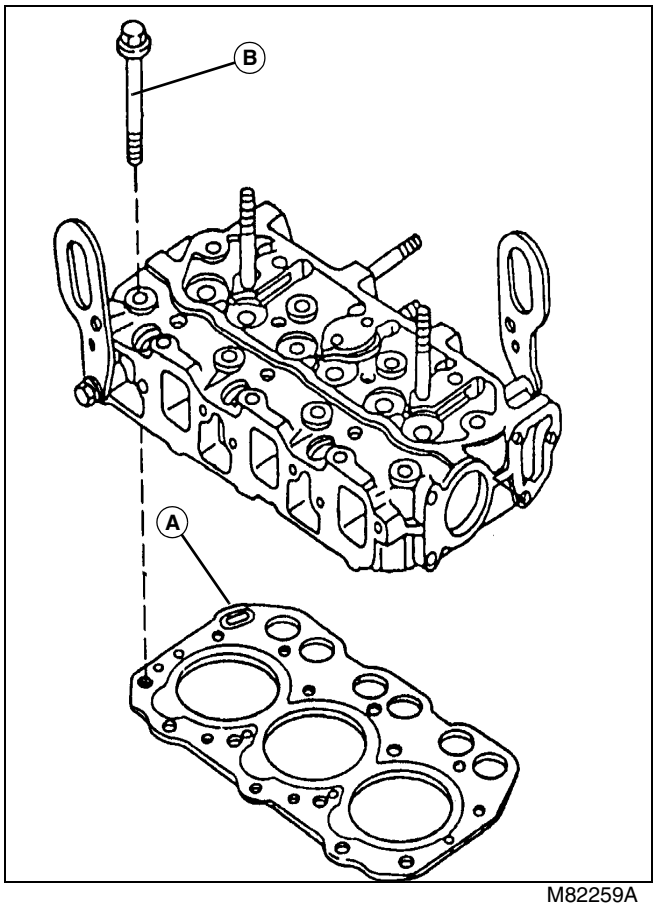
17.Disassemble and inspect cylinder head and valves. (See “Recondition Cylinder Head” on page 130.)

Installation

1. Clean all threads in top of cylinder block with a flat bottom tap, and blow debris from hole.

2. Clean top of cylinder block and check for flatness.

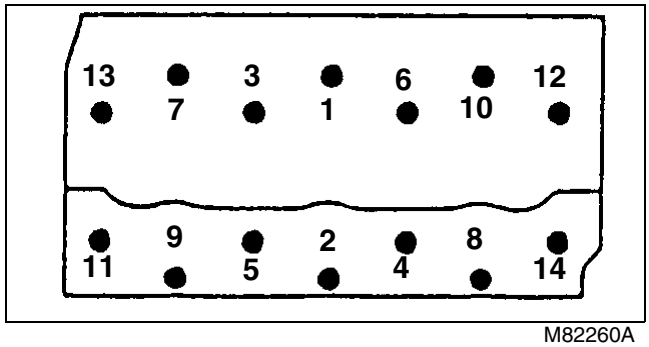
IMPORTANT: Avoid damage! Oil passage in gasket (A) must be located over oil passage in cylinder block.



M82259A

3. Place a new cylinder head gasket on cylinder block with locating pins on front and rear of block inside holes in gasket. Lineup oil port on left rear of block with oil port in gasket.

4. Clean threads of cylinder head bolts (B) and dip in clean oil before installing. Install all bolts finger tight before tightening with wrench.



M82260A

5. Tighten cylinder head bolts in sequence shown above in two steps of torque from specifications below.

Specifications

Initial Torque . . . . . 30.8 N•m (23 lb-ft)
Final Torque . . . . . 61.3 N•m (45 lb-ft)

IMPORTANT: Avoid damage! Cylinder head mounting cap screws must be checked for proper torque after 50 hours of engine operation.

Remove and Install Intake Manifold

1. Remove cylinder head (See "Remove and Install Cylinder Head" on page 128.)

2. Remove four M6 x 20 intake manifold mounting cap screws.

3. Remove gasket and clean mating surfaces. Check flange for flatness with straight edge.

4. Tighten all mounting cap screws to specification.

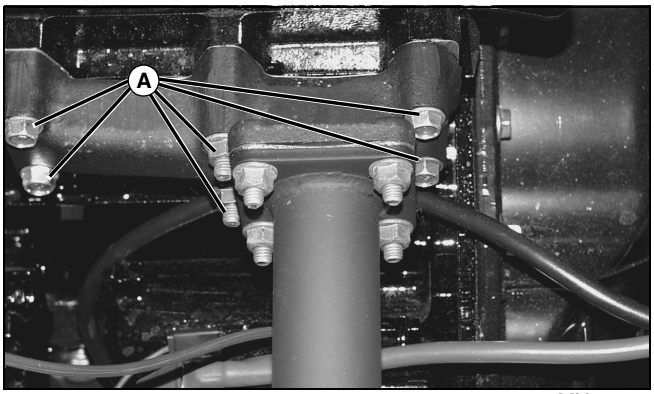
Specifications

Intake Manifold Mounting Cap Screw Torque . . . . . 11 N•m (97 lb-in.)

Remove and Install Exhaust Manifold

1. Remove muffler and gasket. (See "Remove and Install Muffler" on page 126.)

2. Remove four cap screws and two nuts (A) holding exhaust manifold to cylinder head.



MX0672

3. Remove manifold, check for cracks or warpage.

4. Clean gasket mating surfaces, install new gasket.

5. Install manifold, tighten all cap screws to specification.

Specifications

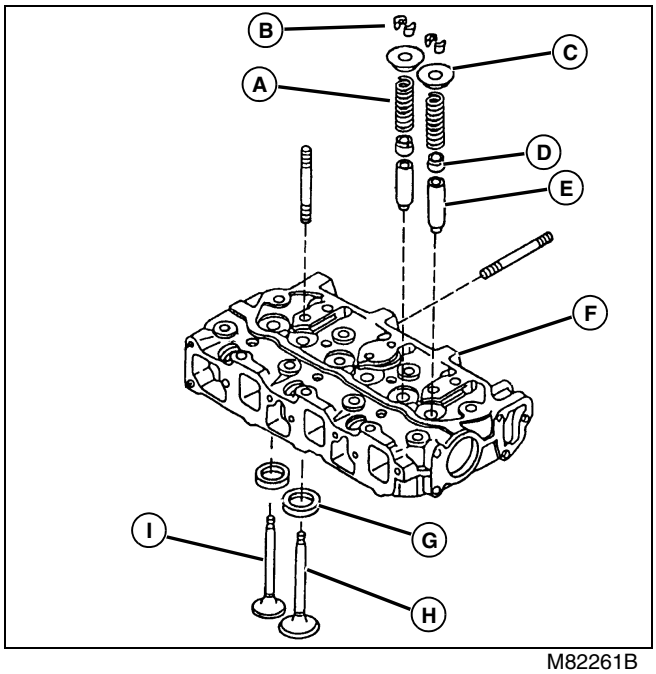
Exhaust Manifold Cap Screw and Nut Torque . . . . . 25.5 N•m (19 lb-ft)

Recondition Cylinder Head

Special or Required Tools

Tool Name	Tool No.	Tool Use
Valve Spring Compressor	JDE138	Used to remove valves.
Valve Guide Driver	JDE504	Used to remove valves.

Disassembly and Assembly



M82261B

1. Compress valve springs (A) using JDE138 valve spring compressor

NOTE: It may be necessary to tap on valve spring retainer (C) while initially operating compressor to break retainer free from valve stem.

2. Remove collet halves (B) from retainer.

3. Slowly release compressor and valve spring.

4. Remove valve spring retainer (C), valve spring (A), stem seal (D), and valve (H or I) from head (F).

5. Intake and exhaust valve guides (E) and seats (G) are press fit. Remove guides and seats only if replacement is necessary.

6. Inspect all parts for wear or damage. Clean all carbon deposits and measure all parts for proper clearances.

IMPORTANT: Avoid damage! DO NOT reuse stem seals if removed. Used seals will leak.

7. Apply clean engine oil on intake and exhaust valve stems during assembly.

8. If new valves are being installed, measure valve recession. (See “Valve Recession Measurement” on page 134.)

9. Install springs with smaller pitch end or paint mark toward cylinder head.

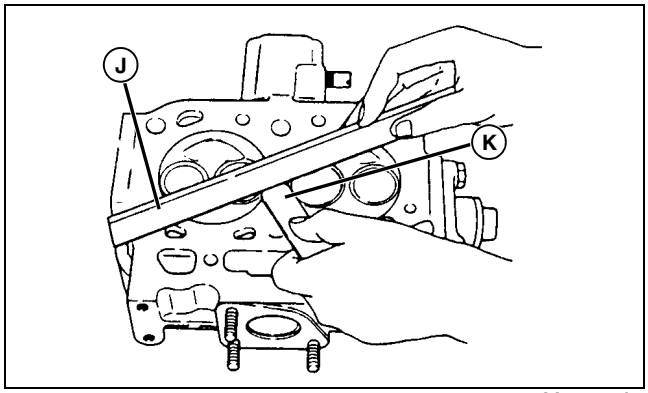
10.Use valve spring compressor to compress spring and retainer, and install collet as removed.

11.After each valve has been assembled, tap on top of valve stem with a plastic hammer to seat retainer.

Inspection and Replacement

Before inspection, thoroughly clean all components of carbon or dirt.

Cylinder Head



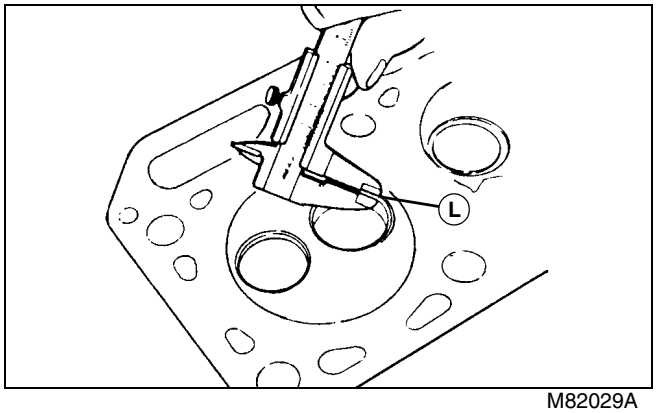
M82028A

- Measure cylinder head flatness. Place a straight-edge (J) along each of the four sides and each diagonal. Measure clearance between straight edge and mating surface with a feeler gauge (K).

If distortion exceeds the wear limit, resurface or replace cylinder head. Remove only enough metal to make cylinder head flat; but do not remove more than 0.20 mm (0.008 in.).

- If cylinder head was resurfaced, measure piston-to-cylinder head clearance. (See “Check Piston-to-Cylinder Head Clearance” on page 149.)

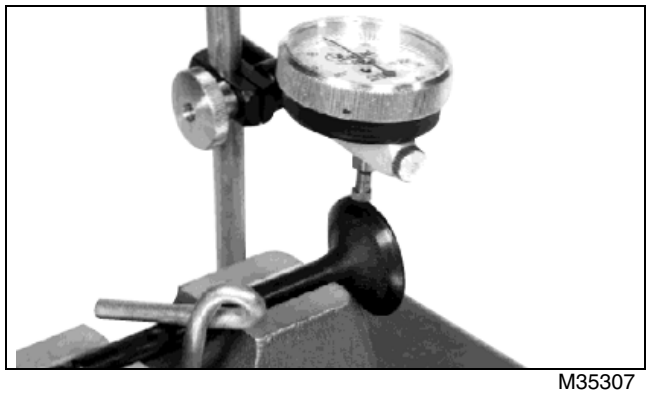
- Measure valve recession. (See “Valve Recession Measurement” on page 134.)



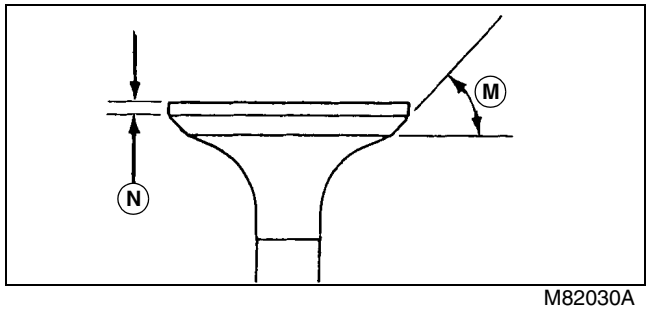
M82029A

- Measure valve seat width (L). If necessary, grind valve seats to meet specifications. (See “Valve Seat Grinding” on page 133.)

Intake and Exhaust Valves

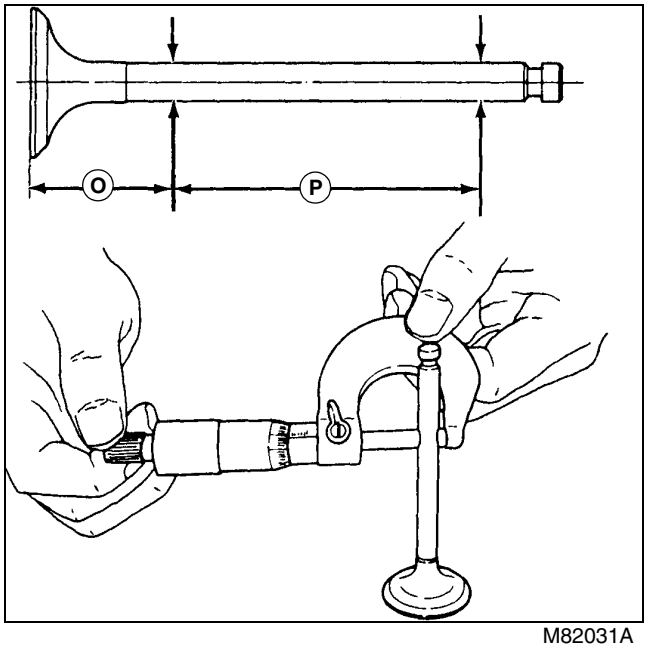

M35307

- Check valve for out-of-round, bent or warped condition using a valve inspection center and dial indicator. Replace valve if necessary.



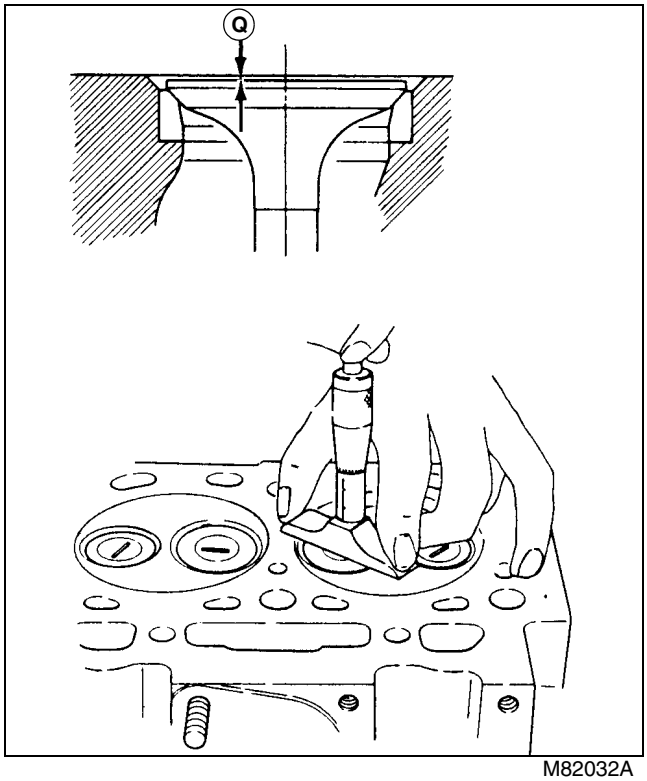
M82030A

- If valve faces are worn, burned or pitted, grind valves to proper face angle (M). If valve face margin (N) is less than specification after grinding, replace valve.



M82031A

• Measure valve stem diameter at two locations. The first location (O) is 20 mm (0.787 in.) from the top of the valve, and the second location (P) is 40 mm (1.575 in.) from the first. Replace valve if measurement exceeds wear limit.



M82032A

• Measure valve recession (Q) using a depth gauge. Replace valve or cylinder head if measurement exceeds wear limit.

Valve Guide Measurement

• Clean valve guides using a valve guide brush.

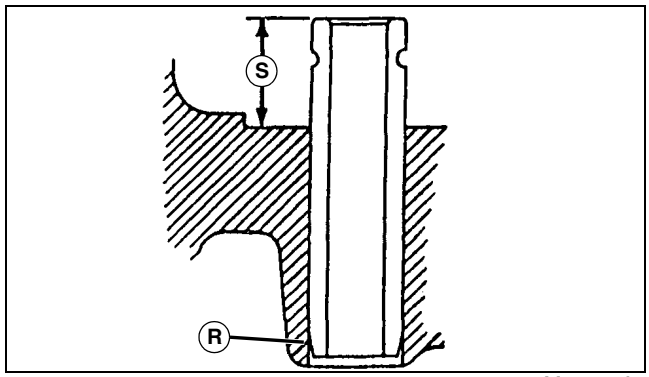
• Measure valve guide inside diameter using a ball or telescoping snap gauge.

• If valve guide inside diameter exceeds wear limit, knurl or replace guide.

• If valve guide inside diameter is within specification, determine guide-to-stem clearance (Valve guide diameter minus valve stem diameter).

• If clearance exceeds 0.127 mm (0.005 in.), but is less than 0.178 mm (0.007 in.), knurl valve guides using a 7 mm valve guide knurling tool.

• If clearance exceeds 0.20 mm (0.008 in.), replace valve guides.

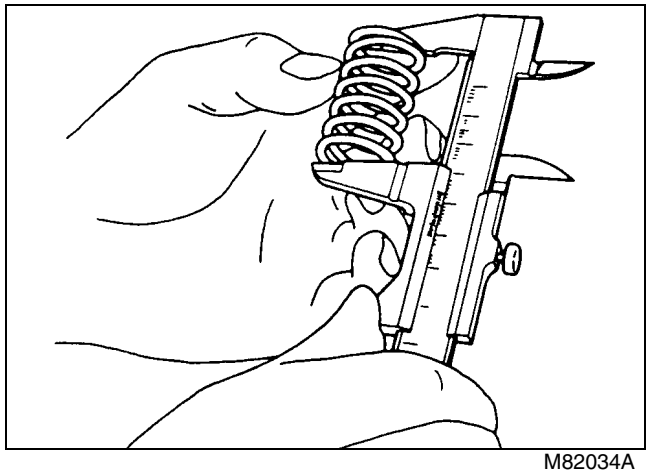


M82193A

• Install valve guides with tapered end (R) down. Push valve guides down until top of valve guides are projecting the specified height (S) from the valve spring seat in the cylinder head.

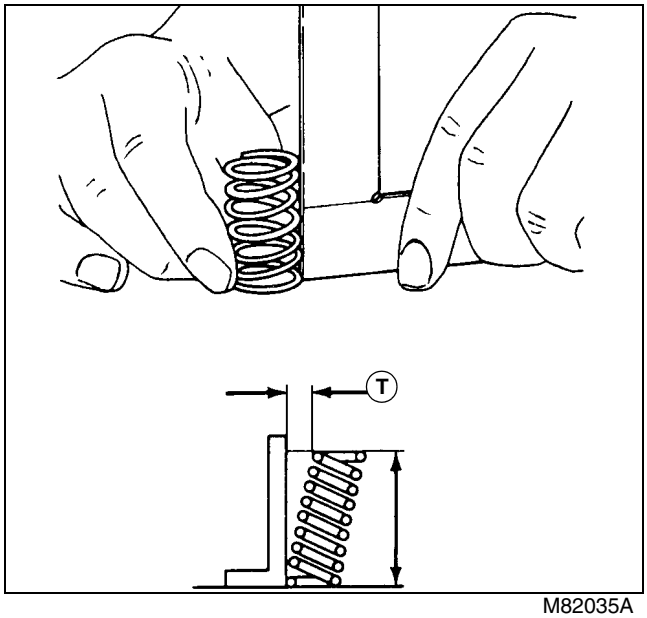
Ream inside diameter of valve guides using a 7 mm valve guide reamer.

Valve Springs



M82034A

• Measure spring free length. Replace spring if measurement exceeds specification.



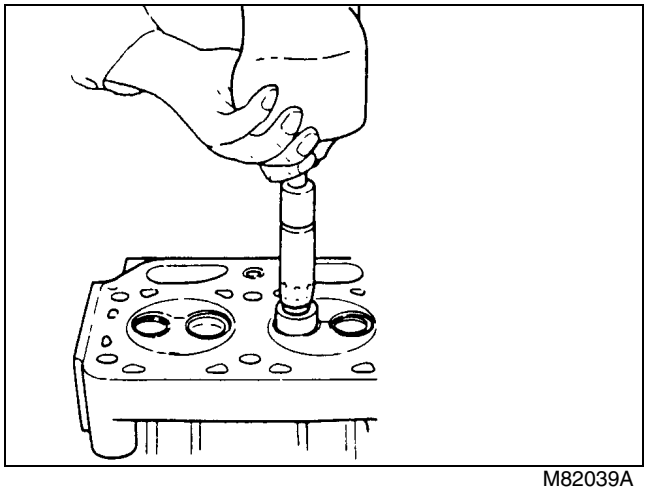
M82035A

• Measure spring inclination (T). Replace spring if measurement exceeds specification.

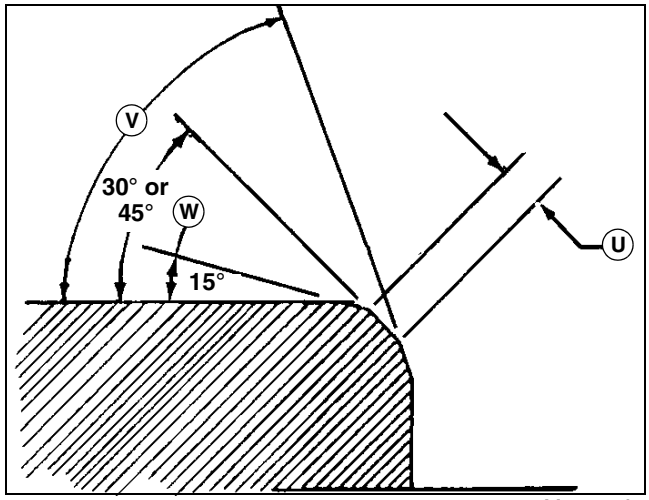
Valve Seat Grinding

NOTE: LIGHTLY grind valve seats only for a few seconds to avoid excessive valve seat width. If valve guide is to be replaced, always replace guide before grinding valve seat, as seat grinder pilot is centered by guide.

1. Grind intake valve seat using a 30° seat grinder, and exhaust valve seat using a 45° seat grinder. Follow tool manufacturers instructions.


M82039A

2. Measure valve seat width after grinding.



M82040A

3. If seat width (U) is too wide after grinding, grind lower seat surface (V) using a 70° seat grinder until seat width is close to specifications.

4. Grind upper seat surface (W) using a 15° seat grinder until seat width is narrowed to specifications.

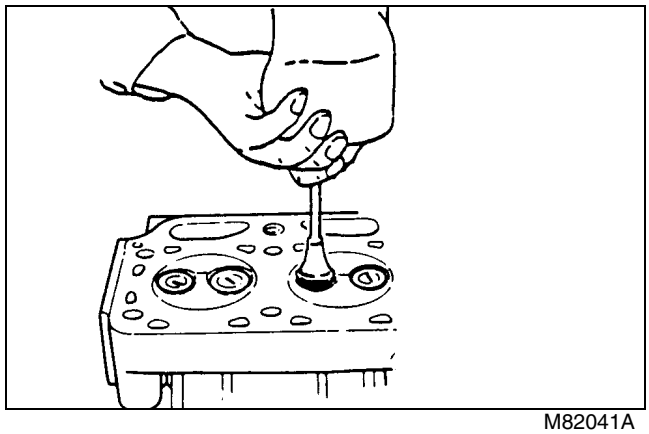
5. If valve seats are ground, measure valve recession and check contact pattern between the seat and valve with bluing dye.

6. Lap valves. (See procedure in this group.)

NOTE: If valve recession exceeds maximum specifications or seats cannot be reconditioned, replace cylinder head

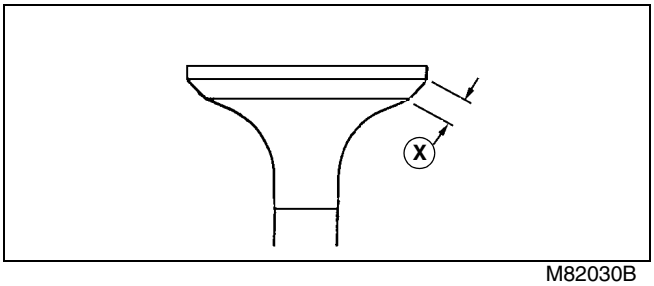
Valve Lapping

NOTE: Use a rubber type lapping tool for valves without a lapping tool groove slit.


M82041A

If seat does not make proper contact, lap the valve into the seat:

1. Apply small amount of fine lapping compound to face of valve.



M82030B

2. Turn valve to lap valve to seat.

3. Lift valve from seat every 8 to 10 strokes. Lap until a uniform ring appears around the surface of the valve face (X).

4. Wash all parts in solvent to remove lapping compound. Dry parts.

5. Check position of lap mark on valve face. Lap mark must be on or near center of valve face.

Specifications

Cylinder Head Distortion (Nominal) . . . . . 0.05 mm (0.002 in.)
Cylinder Head Distortion (Max) . . . . . 0.15 mm (0.006 in.)
Intake Valve Seat Width . . . . . 1.44 mm (0.057 in.)
Intake Valve Wear Limit . . . . . 1.98 mm (0.078 in.)
Exhaust Valve Seat Width . . . . . 1.77 mm (0.070 in.)
Exhaust Valve Wear Limit . . . . . 2.27 mm (0.089 in.)

Valve Face Margin

Intake . . . . . 0.99-1.29 mm (0.004-0.005 in.)
Exhaust . . . . . 0.95-1.25 mm (0.004-0.005 in.)
Wear Limit . . . . . 0.50 mm (0.002 in.)

Valve Face Angle

Intake . . . . . 30°
Exhaust . . . . . 45°

Valve Stem Measuring Points

Distance O . . . . . 20 mm (0.787 in.)
Distance P . . . . . 40 mm (1.575 in.)

Intake Valve Stem Diameter . . . . . 6.96-6.98 mm (0.274-0.275 in.)
Intake Valve Stem Wear Limit . . . . . 6.90 mm (0.272 in.)
Exhaust Valve Stem Diameter . . . . . 6.95-6.96 mm (0.273-0.276 in.)
Exhaust Valve Stem Wear Limit . . . . . 6.9 mm (0.272 in.)

Valve Recession Measurement

Intake Valve. . . . . 0.40-0.60 mm (0.016-0.024 in.)
Wear Limit . . . . . 1.0 mm (0.039 in.)
Exhaust Valve . . . . . 0.75-0.95 mm (0.030-0.037 in.)
Wear Limit . . . . . 1.0 mm (0.039 in.)

Valve Guide Inside Diameter . . . . . 7.01-7.02 mm (0.275-0.276 in.)
Valve Guide Wear Limit . . . . . 7.08 mm (0.279 in.)

Valve Guide-to-Valve Stem Oil Clearance

Intake. . . . . 0.030-0.060 mm (0.001-0.002 in.)
Exhaust . . . . . 0.045-0.075 mm (0.002-0.003 in.)
Wear Limit (Both) . . . . . 0.18 mm (0.007 in.)

Valve Guide Height. . . . . 9 mm (0.354 in.)
Valve Spring Free Length . . . . . 37.4 mm (1.472 in.)
Maximum Spring Inclination . . . . . 1.0 mm (0.039 in.)

Remove and Install Engine

Removal

CAUTION: Avoid injury! USE CAUTION AROUND MOVING PARTS. STOP engine. Remove ignition key. Wait for all moving parts to STOP.

1. Park vehicle on a hard, level surface. Lock park brake.

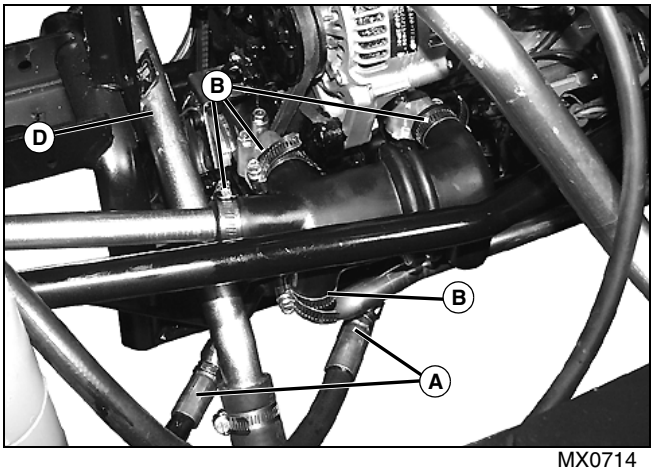
2. Stop engine. Cycle hydraulic valves to release any hydraulic pressure.

3. Disconnect battery negative (-) cable from the battery.

4. Remove cargo box or any attachments that may be limiting engine access.

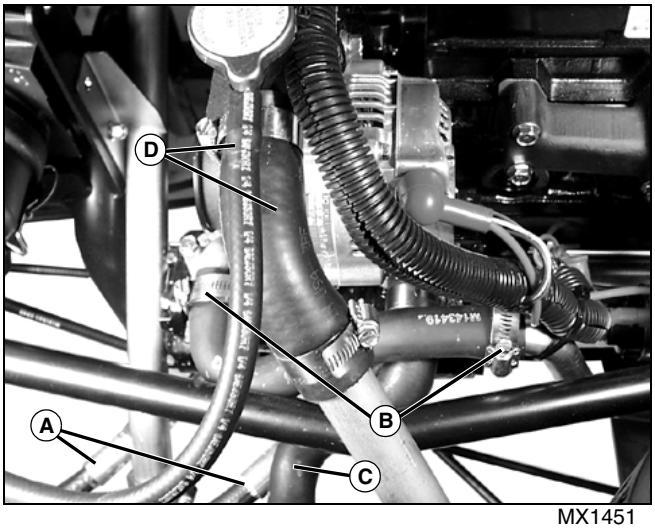
5. Drain coolant from radiator.

6. Place a suitable container under hydraulic pumps to catch oil from lines, filter and pumps.



MX0714

Picture Note: Early Model Manifold Shown



MX1451

Picture Note: Auxiliary Hydraulic Kit Installed

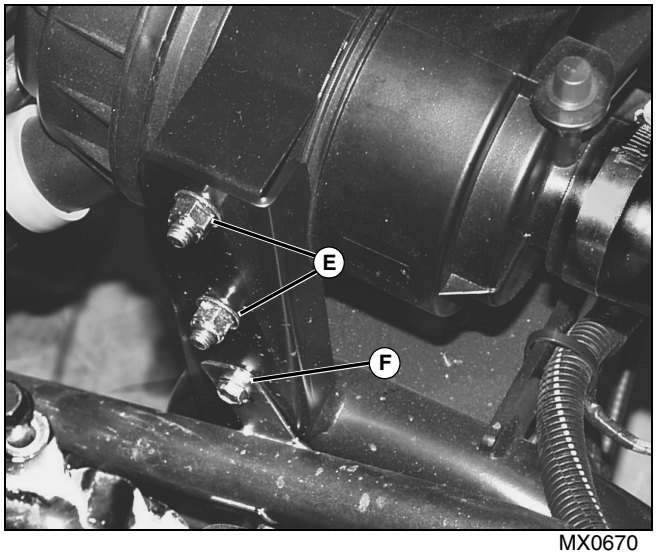
7. Remove the two pressure lines (A) from the bottom of the pumps.

8. Loosen hose clamps (B) securing rubber intake manifold to pumps. Remove manifold.

9. Disconnect suction hose C).

10.Disconnect coolant lines (D)

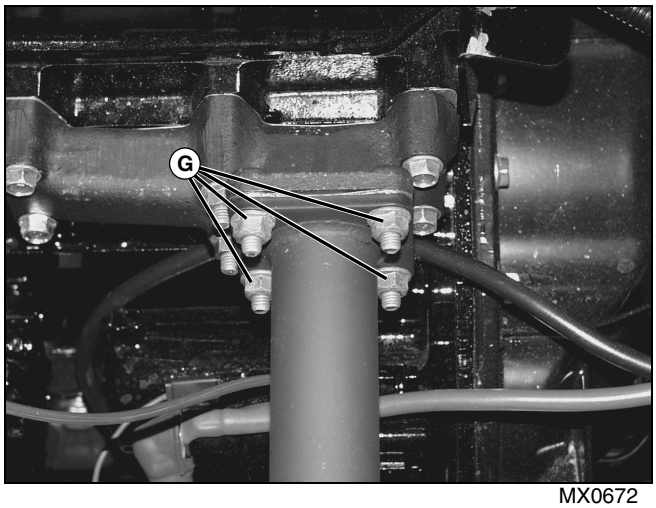
11.Disconnect auxiliary hydraulic lines, if equipped.



MX0670

12.Disconnect air intake tube from intake manifold. Remove air filter bracket retaining cap screws and nuts (E), and remove air filter assembly.

13.Remove coolant pipe retaining cap screw (F).

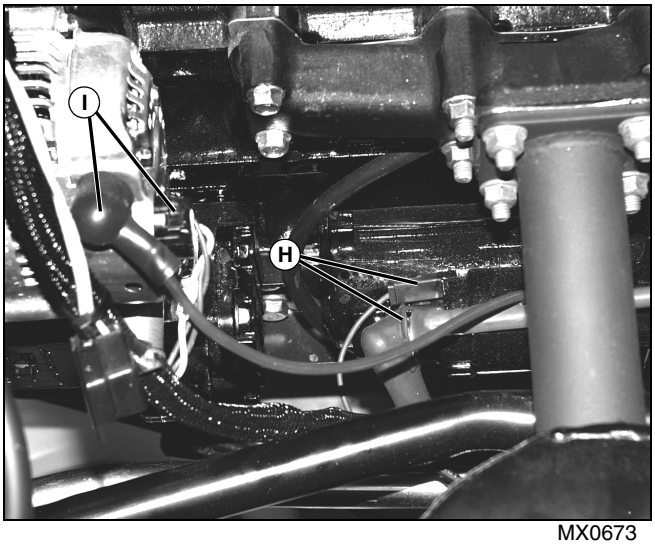


MX0672

14.Remove four nuts (G) securing the muffler to the exhaust manifold and the two cap screws securing muffler bracket to engine.

15.Remove clamp from tailpipe and remove muffler.

16.Disconnect fuel hose from fuel filter. Plug end of fuel hose.



MX0673

17.Disconnect positive (+) battery cable and wires (H) from starting motor solenoid.

18.Disconnect positive wire and plug (I) from alternator.

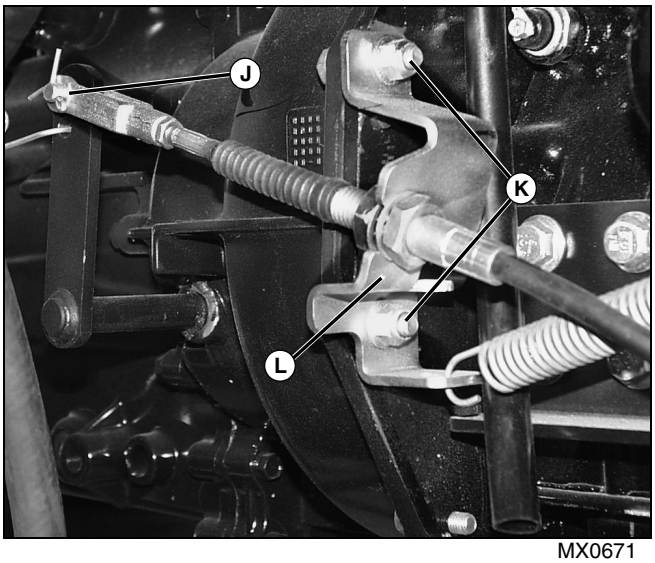
19.Disconnect ground wires and battery negative (-) cable from engine ground bracket.

20.Disconnect oil sender, temperature sensors, fuel shutoff solenoid, glow plugs, and speed sensor.

21.Support front of transaxle and support engine with hoist while removing cap screws from bellhousing.

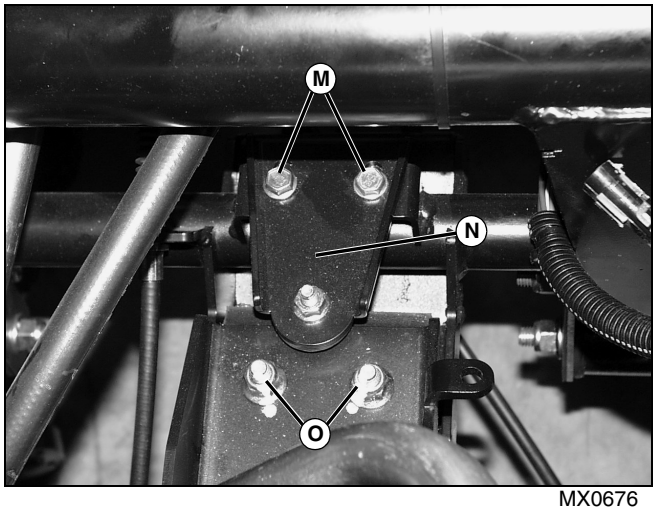
22.Remove nuts from starter mounting cap screws.

NOTE: It is not necessary to remove starter from backplate.



MX0671

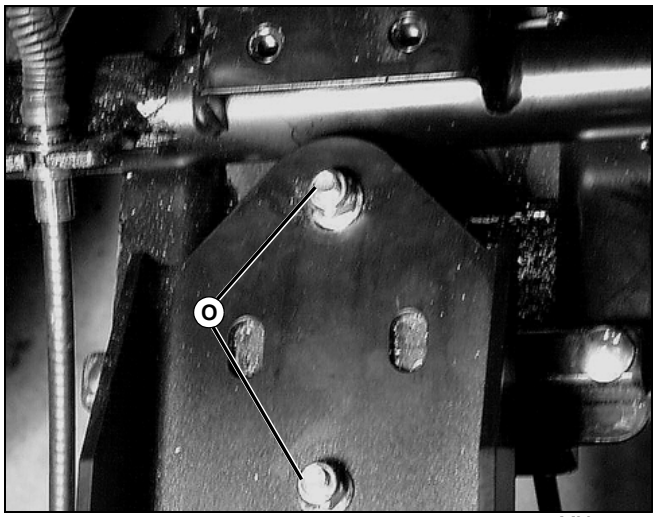
23.Remove pin (J) from clutch lever. Remove cap screws (K) and clutch cable bracket (L).



MX0676

24.Remove cap screws (M) and subframe snubber (N).

NOTE: On models after S.N. (020000-), subframe snubber has been replaced by mount configuration shown below.



MX1447

25.Remove nuts (O) from the subframe isolator.

26.Remove subframe from engine.

27.Slide engine forward and raise from machine.

Installation

Installation is the reverse of removal.

1. Clean muffler flange and exhaust manifold surfaces of any old gasket material. Install a new muffler gasket.

2. Tighten engine to subframe mounting cap screws to specification.

3. Install muffler flange nuts and tighten to specification.

4. Attach throttle lever to engine controls. Retain with cotter pin and washer.

5. Connect all engine wiring harness connectors.

6. Attach battery negative (-) cable and ground wires to engine ground bracket.

7. Attach battery positive (+) cable and solenoid exciter wire to starting motor solenoid.

8. Attach fuel line to carburetor. Retain with hose clamp.

9. Fill engine to proper level with oil of correct specifications.

10. Attach negative (-) cable to battery.

Specifications

Engine-to-Subframe Mounting
Cap Screw Torque . . . . . 75 N•m (55 lb-ft)
Muffler Flange Nut Torque . . . . . 24.4 N•m (216 lb-in.)

Remove and Install Crankshaft Rear Oil Seal

Special or Required Tools

Tool Name	Tool No.	Tool Use
Clutch Alignment Tool	JDG1331	Used to align clutch plate with pilot bearing.

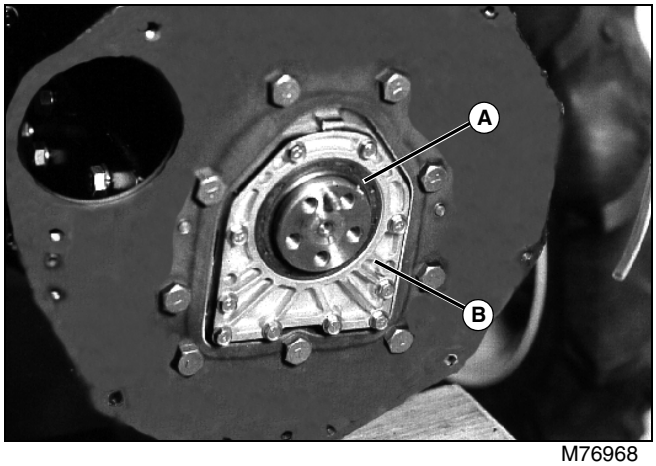
1. Remove engine. (See “Remove and Install Engine” on page 134.)

2. Remove flywheel. (See “Remove and Install Clutch and Flywheel” on page 159.)

IMPORTANT: Avoid damage! FLYWHEEL IS HEAVY! Do not remove flywheel mounting cap screws unless flywheel is secure. Use a hoist and lift rings to lift flywheel from crankshaft.

3. Remove five flywheel mounting cap screws and remove flywheel from crankshaft.

NOTE: It is not necessary to remove oil seal case to remove oil seal.



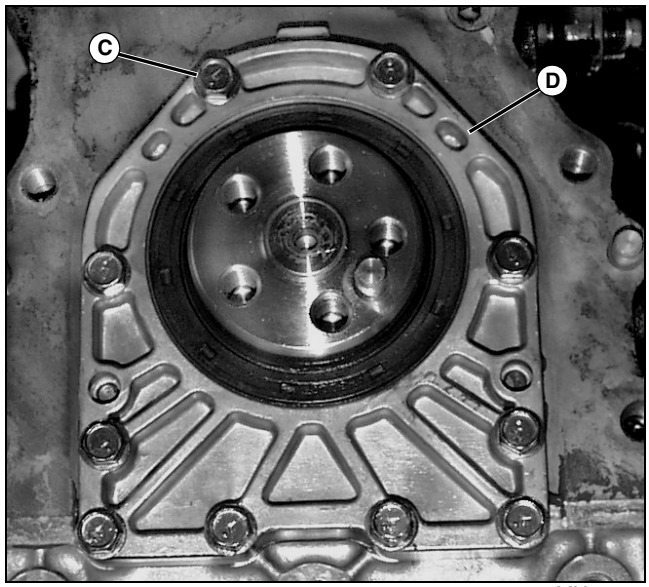
M76968

4. Carefully pry oil seal (A) from oil seal case (B).

5. Replace oil seal using a driver set. Install seal with lip toward cylinder block. Install seal flush with surface of oil seal case.

NOTE: If oil seal has worn a groove in crankshaft at oil seal contact point, seal can be installed 3 mm (0.120 in.) deeper into oil seal case.

Rear Oil Seal Case Removal and Installation



MX0749

1. Remove oil seal case-to-cylinder block cap screws (C).

2. Pry oil seal case (D) from engine block.

3. Clean all old gasket material from oil seal case and engine block.

4. Install seal case with form-in-place gasket sealer on mating surfaces to engine block.

5. Install new oil seal after oil seal case is installed.

6. Install flywheel onto crankshaft, aligning crankshaft pin into flywheel mounting flange. Tighten mounting bolts to specification.

7. Install clutch plate with longer center hub facing out.

8. Install clutch cover over clutch plate, lining up locating pin on flywheel. Loosely install six mounting bolts through clutch cover and into flywheel. Using a JDG1331 Clutch Alignment Tool, align clutch plate with pilot bearing. Tighten clutch cover bolts alternately in two equal steps to final torque specified.

9. Install engine. (See “Remove and Install Engine” on page 134.)

Specifications

Flywheel Mounting Cap Screw Torque . . . . . 84 N•m (62 lb-ft)

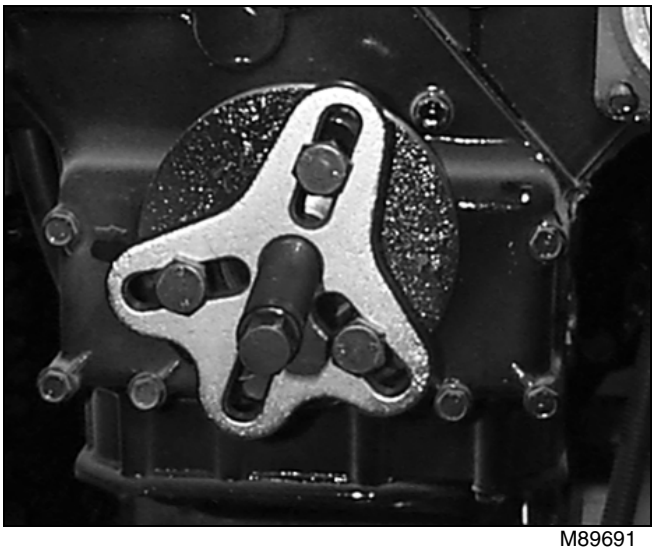
Clutch Cover Cap Screw Final Torque . . . . . 28 N•m (20lb-ft)

Remove and Install Crankshaft Front Oil Seal

1. Park machine with engine off, transmission in neutral, park brake locked.

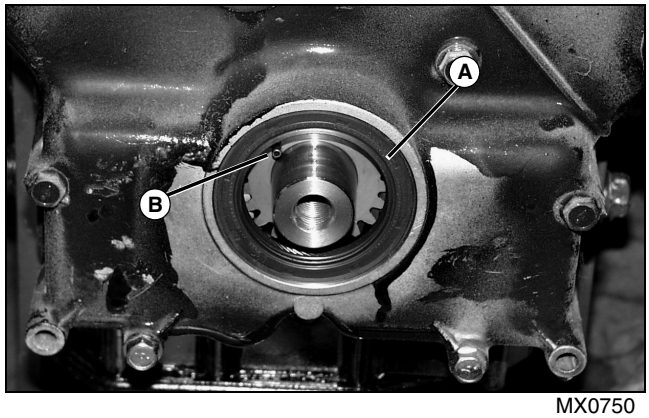
2. Remove skid shield from sub frame.

3. Remove alternator/coolant pump belt.



M89691

4. Remove crankshaft pulley cap screw and washer. Install puller to crankshaft pulley and remove.



MX0750

5. Carefully pry oil seal (A) from timing cover.

6. Install new oil seal using a driver set. Install seal with lip toward engine. Install seal flush with surface of cover.

7. Coat lip of seal with clean engine oil.

8. Install crankshaft pulley on crankshaft, lining up pin (B) on crankshaft timing gear with hole in crankshaft pulley.

9. Install flat washer and cap screw. Tighten cap screw to specification.

10. Install alternator/coolant pump belt and adjust belt.

Specifications

Crankshaft Pulley Cap Screw Torque . . . . . 88 N•m (65 lb-ft)

Remove and Install Timing Gear Cover

Other Material

Part No.	Part Name	Part Use
TY15130 (U.S.)	Form-in-Place Gasket	Seals timing gear cover to engine block.

Removal and Installation

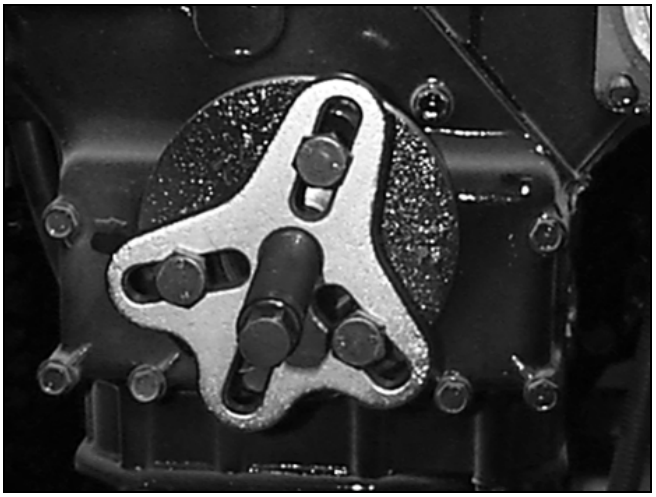
1. Drain coolant and remove lower coolant tube from coolant pump.

2. Remove front hydraulic pump.

3. Remove skid shield from sub frame.

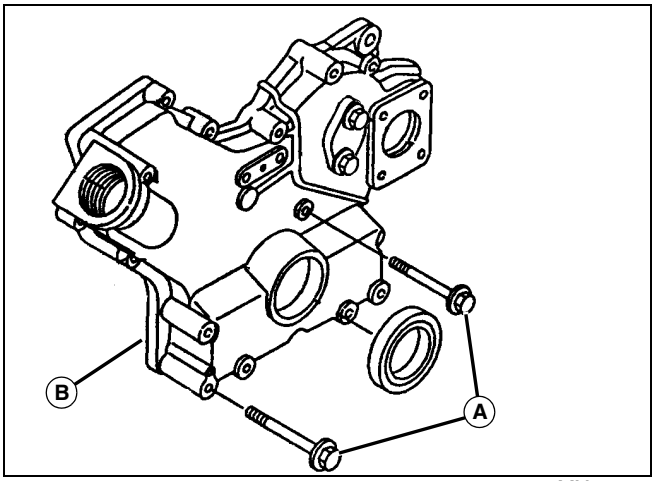
4. Remove lower alternator bracket, loosen top cap screw, remove alternator belt and move alternator away from cover.

5. Remove crankshaft pulley cap screw and washer.



M89691

6. Install puller to crankshaft pulley and remove pulley.



MX0776

7. Remove timing cover mounting cap screws (A).

8. Remove timing gear cover (B).

9. Clean all old gasket material from timing cover, and timing cover housing on block.

10.Apply a thin bead of John Deere Form-in-Place Gasket Sealer to timing cover prior to installation.

11.Tighten all timing gear cover mounting cap screws to specification.

12.Install crankshaft pulley, lining up pin on crankshaft. Install flat washer and bolt. Tighten to specification.

13.Install new gasket and hydraulic pump.

14.Install alternator and drive belt. Adjust belt tension.

15.Install skid shield on subframe.

Specifications

Timing Gear Cover Cap Screw Torque

Aluminum Housing-to-Block. . . . . 11 N•m (97 lb-in.)
Cast Iron Housing-to-Block. . . . . 9 N•m (80 lb-in.)

Crankshaft Pulley Cap Screw Torque. . 88 N•m (65 lb-ft)

Check Camshaft End Play

Reason

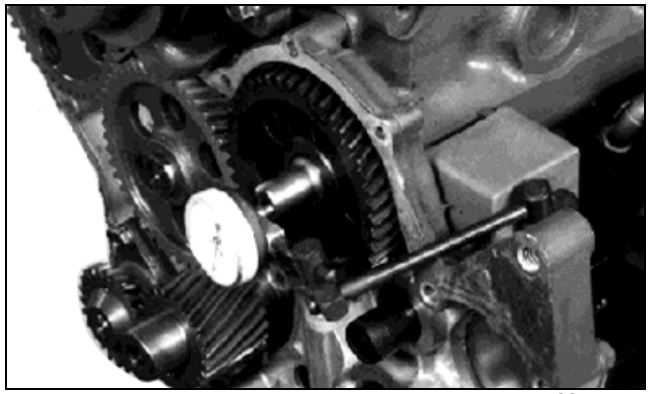
To determine proper side clearance between camshaft gear and camshaft thrust plate, to prevent excessive camshaft-to-camshaft follower wear.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Dial Indicator	NA	Used for valve lift, end play, and backlash measurements.

Procedure

1. Remove timing gear cover. (See “Remove and Install Timing Gear Cover” on page 138.)



M37512

2. Fasten dial indicator base to cylinder block and position indicator tip on end of camshaft.

3. Push camshaft toward the rear as far as possible.

4. Zero the dial indicator.

5. Pull camshaft forward as far as possible.

Results

- If camshaft end play exceeds specification, remove camshaft and inspect thrust plate, camshaft, and camshaft gear for wear. Replace parts as needed.

Specifications

Camshaft End Play. . . . . 0.05-0.25 mm (0.002-0.010 in.)

Check Timing Gear Backlash

Reason

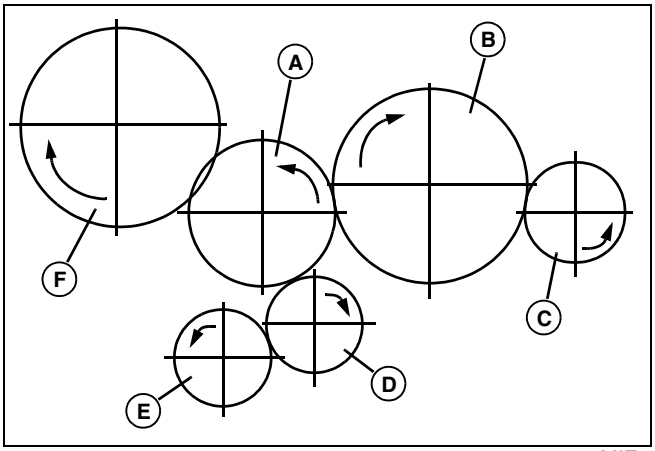
To check wear of timing gear teeth, resulting in excessive noise, improper valve timing, and poor engine performance.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Dial Indicator	NA	Used for valve lift, end play, and backlash measurements.

Procedure

1. Remove timing gear cover. (See “Remove and Install Timing Gear Cover” on page 138.)



MIF

Gear Functions

A. Idler Gear

B. Camshaft Gear

C. Hydraulic Pump/PTO Gear

D. Crankshaft Gear

E. Oil Pump

F. Injector Pump Camshaft

2. Place dial indicator magnetic base on cylinder block with tip of indicator on tooth of gear being measured.

3. Holding opposite gear stationary, move measured gear back and forth while measuring backlash between meshing gears.

Results

- If backlash exceeds specification, replace worn gears as a complete set.

Specifications

Backlash for All Timing Gears (Except Crankshaft Gear-to-Oil Pump Gear) . . . . . 0.04-0.12 mm (0.002-0.005 in.)

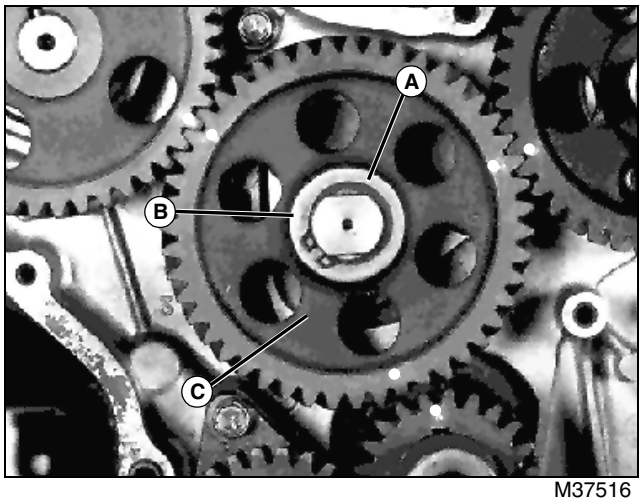
Crankshaft Gear-to-Oil Pump Gear Backlash (Standard) . . . . . 0.11-0.19 mm (0.004-0.008 in.)

Remove and Install Idler Gear

1. Remove timing gear cover. (See “Remove and Install Timing Gear Cover” on page 138.)

2. Check backlash of timing gears. (See “Check Timing Gear Backlash” on page 140.)

NOTE: Due to the odd number of teeth on the idler gear, timing marks will only align periodically. When all timing marks on gears align, the piston closest to the coolant pump (No. 3) is at TDC on compression stroke. (No. 1 cylinder is closest to the flywheel.)



M37516

3. Rotate crankshaft and align timing marks.

NOTE: Timing mark on crankshaft gear is on front of tooth used for timing, but since gear is spiral cut, it will appear to not be aligned with mark on idler gear.

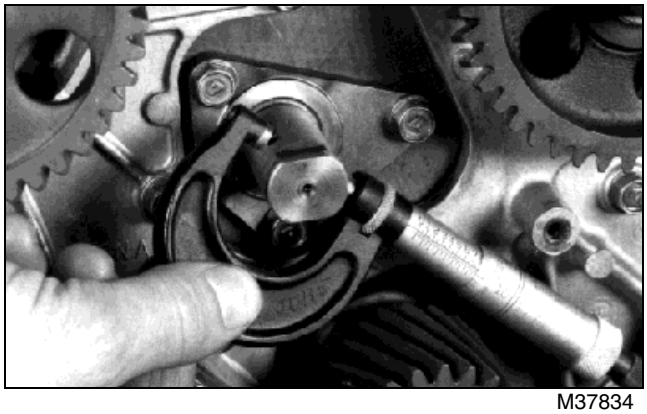
4. Remove snap ring (A), washer (B) and gear (C).

5. Inspect all parts as outlined below.

6. Installation is done in the reverse order of removal. It is not necessary to time oil pump gear.

Inspection and Replacement

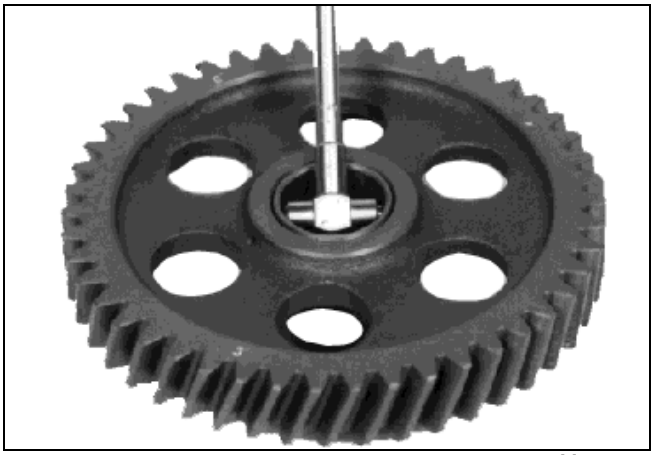
- Inspect gear for chipped or broken teeth. Replace if necessary.



M37834

- Measure idler gear shaft diameter.

If shaft diameter is less than wear limit, replace idler gear shaft.



M35492

- Measure idler gear bushing diameter.

If bushing diameter exceeds wear limit, replace bushing.

To replace bushing:

Replace bushing using a driver set. Align oil holes in bushing and idler gear. Install bushing flush with surface of idler gear.

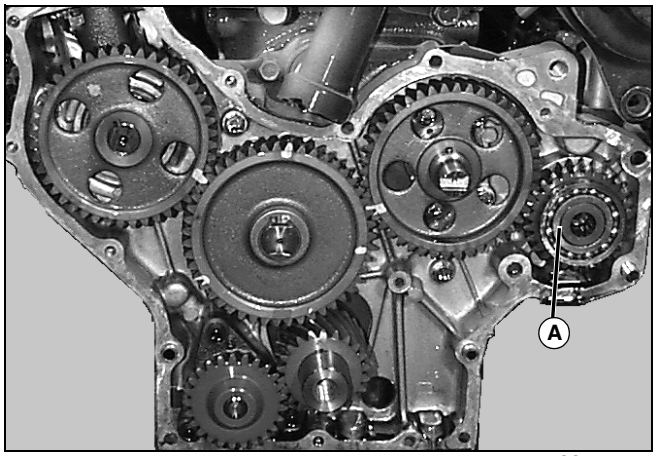
If bushing oil clearance (bushing ID minus shaft OD) exceeds specification, replace bushing, shaft or both.

Specifications

Idler Gear Shaft
Outside Diameter . . . . 19.96-19.98 mm (0.786-0.787 in.)
Idler Gear Shaft
Wear Limit . . . . . 19.93 mm (0.785 in.)

Idler Gear Bushing
Inside Diameter. . . . . 20.00-20.02 mm (0.787-0.788 in.)
Idler Gear Bushing
Oil Clearance. . . . . 0.020-0.062 mm (0.001-0.002 in.)
Idler Gear Bushing
Wear Limit . . . . . 0.15 mm (0.006 in.)

Remove and Install Hydraulic Pump Drive Gear



M89693

1. Remove timing gear cover. (See “Remove and Install Timing Gear Cover” on page 138.)

2. Pull hydraulic pump drive gear (A) from timing gear housing and inspect for worn or damaged teeth. Inspect bearings for wear or damage, replace as necessary.

Repair Camshaft Followers

Camshaft Follower Removal

1. Remove cylinder head. (See “Remove and Install Cylinder Head” on page 128.)

IMPORTANT: Avoid damage! Cam followers must be installed in the same bores from which they were removed. Put a mark on each cam follower and cylinder block bore to aid in installation.

Always replace all camshaft followers when installing a new camshaft. Always replace camshaft when installing new followers.

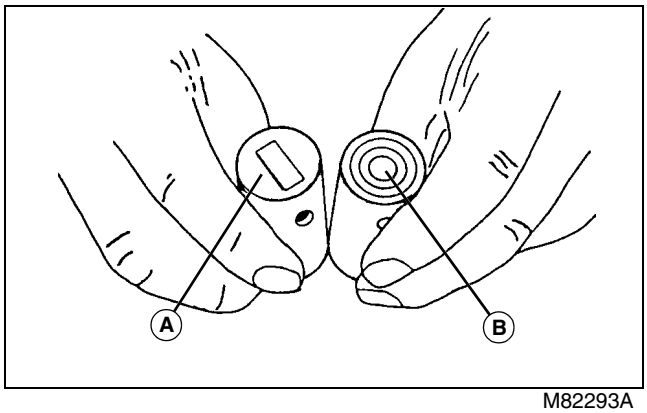
2. Remove cam followers from cylinder block with magnetic pick-up tool.

3. Inspect all parts for wear or damage. (See Inspection procedures below.)

4. Apply clean engine oil on all parts during installation.

5. Install cam followers after camshaft is installed. Installation is done in the reverse order of removal.

Cam Follower Inspection



M82293A

- Inspect cam follower contact surface for abnormal wear (A). Normal wear (B) has light circular lines and flat surface.

M35268

- Measure cam follower diameter.

If outside diameter is less than wear limit, replace cam follower.

- Measure cam follower bore diameter in cylinder block.

If cam follower bore diameter exceeds wear limit, replace cylinder block.

If tappet-to-bore oil clearance (bore ID minus follower OD) exceeds specification, replace cam follower, cylinder block or both.

Specifications

Cam Follower
Outside Diameter . . . . 20.93-20.96 mm (0.824-0.825 in.)
Cam Follower Wear Limit. . . . . 20.90 mm (0.823 in.)

Cam Follower Bore
Inside Diameter. . . . . 21.00-21.02 mm (0.827-0.828 in.)
Cam Follower Bore Wear Limit . . . 21.05 mm (0.829 in.)
Tappet-to-Bore
Oil Clearance. . . . . 0.04-0.09 mm (0.002-0.004 in.)
Tappet-to-Bore Wear Limit. . . . . 0.15 mm (0.006 in.)

Repair Camshaft

Special or Required Tools

Tool Name	Tool No.	Tool Use
Camshaft Magnetic Follower Holder Kit	D15001NU	Used to hold cam followers away from camshaft.

Camshaft Removal

IMPORTANT: Avoid damage! Always replace camshaft when replacing camshaft followers. Always replace camshaft followers when installing new camshaft. The components wear as a set and replacing only one will accelerate the wear of the other.

1. Remove engine. (See “Remove and Install Engine” on page 134.)

2. Remove rocker arm assembly and push rods. (See “Repair Rocker Arms and Push Rods” on page 127.)

3. Remove timing gear cover. (See “Repair Rocker Arms and Push Rods” on page 127.)

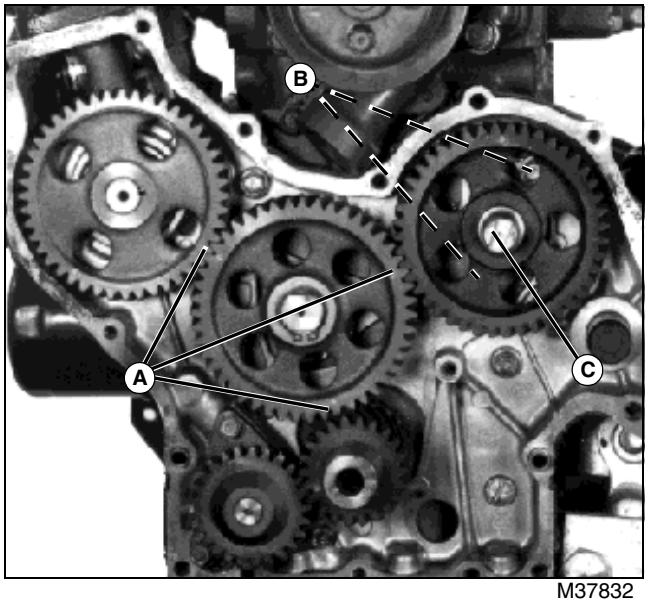
4. Check camshaft end play. (See “Check Camshaft End Play” on page 139.)

5. Check backlash of timing gears. (See “Check Timing Gear Backlash” on page 140.)

NOTE: If camshaft is being removed with cylinder head installed, use a magnetic follower holder tool, or turn engine until oil pan is upward, to hold cam followers away from camshaft.

6. Hold cam followers away from camshaft using a magnetic follower holder kit such as D15001NU.

NOTE: Due to the odd number of teeth on the idler gear, timing marks will only align periodically.



M37832

7. Rotate crankshaft and align timing marks (A).

IMPORTANT: Avoid damage! DO NOT allow camshaft lobes to hit bearing surfaces while removing camshaft. Machined surfaces can be damaged.

8. Remove two cap screws (B) holding camshaft mounting flange to block (through holes in camshaft gear).

9. Remove camshaft.

10.Inspect all parts for wear or damage. (See “Camshaft Inspection” on page 144.)

Camshaft Installation

IMPORTANT: Avoid damage! DO NOT allow camshaft lobes to hit bearing surfaces while installing camshaft. Machined surfaces can be damaged.

NOTE: Apply clean engine oil on all parts during installation.

1. Rotate crankshaft to align timing marks.

2. Install camshaft (C) into cylinder block, being careful not to allow camshaft lobes to scratch camshaft bushings. Align camshaft gear timing marks with timing marks on idler gear.

3. Install two camshaft thrust plate cap screws through holes in cam gear. Tighten to specification.

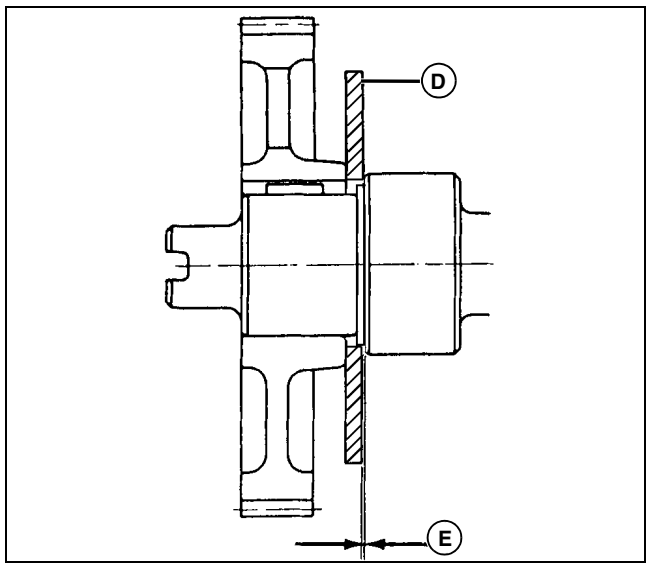
4. Install timing gear cover. (See “Remove and Install Timing Gear Cover” on page 138.)

5. If cam followers were removed, replace into same holes as removed.

6. Install push rods and rocker arm assembly. (See “Repair Rocker Arms and Push Rods” on page 127.)

Camshaft End Play Measurement

1. Check camshaft end play while camshaft is installed in cylinder block using a dial indicator, as described in “Check Camshaft End Play” on page 139.



M82067A

2. To check camshaft end play while camshaft is removed from cylinder block: Use a feeler gauge between camshaft thrust plate (D) and front side of first camshaft bearing journal, as shown below.

3. If end play (E) is excessive, remove gear and replace thrust plate.

Camshaft Gear Removal

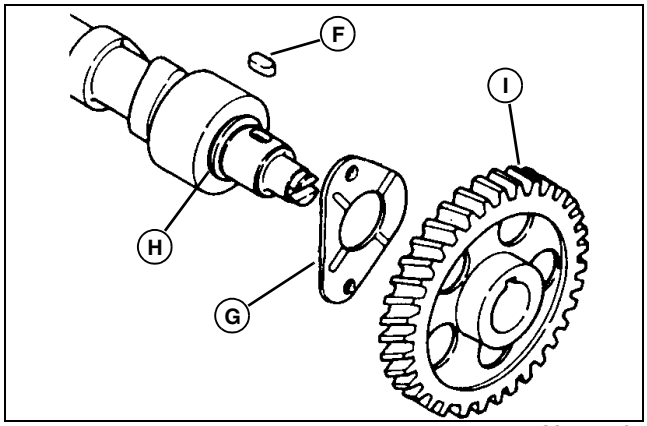
1. Inspect gear for chipped or broken teeth. Replace if necessary.

2. Remove gear from camshaft using a knife-edge puller and an arbor press. Place flat side of puller against camshaft gear.

Camshaft Gear Installation

CAUTION: Avoid injury! DO NOT heat oil over 182° C (360° F). Oil fumes or oil can ignite above 193° C (380° F). Use a thermometer. Do not allow a flame or heating element to come in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

1. Heat gear to approximately 150° C (300° F).



M82068A

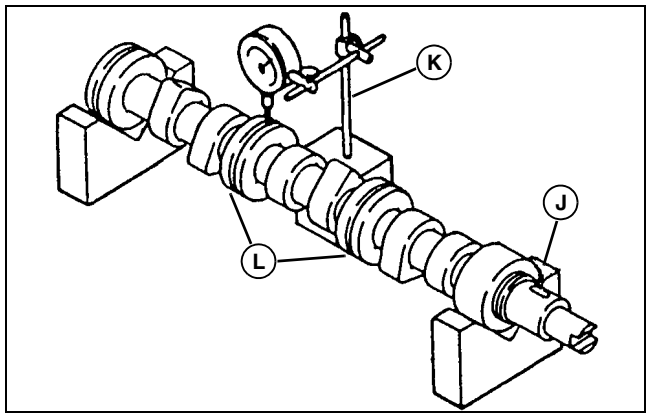
2. Install key (F) into slot of camshaft.

IMPORTANT: Avoid damage! Be sure thrust plate is not trapped between camshaft gear and stepped shoulder while gear is being pressed on.

3. Install thrust plate (G) onto camshaft, centering onto stepped shoulder (H). (Thrust plate has no “front” or “rear” side.)

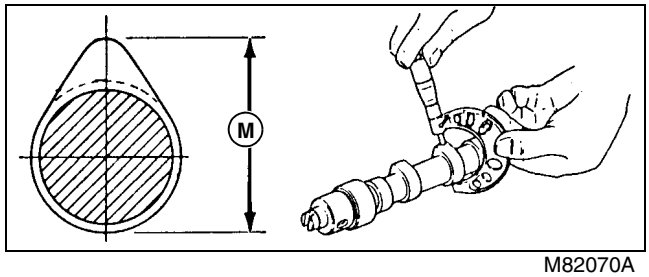
4. Install heated camshaft gear (I) with longer hub of camshaft gear facing camshaft. Align slot in gear with key in shaft. Press camshaft into gear until hub of gear is tight against camshaft shoulder. Thrust plate must spin freely on camshaft.

Camshaft Inspection



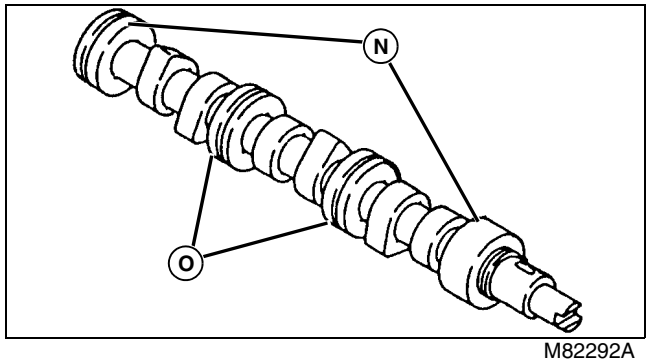
M82291A

1. Inspect camshaft for bend by using a pair of V-blocks (J) and a dial indicator (K). Turn camshaft slowly and read variation of camshaft bearing journals (L) on indicator. If variation is greater than wear limit, replace camshaft.



M82070A

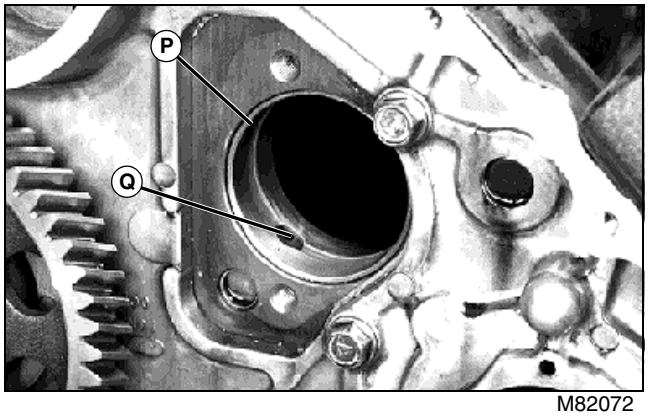
2. Measure camshaft lobe height (M) using a micrometer. If lobe height is less than wear limit, or if there are chips or scratches in lobes or bearing journals, replace camshaft.



M82292A

3. Measure camshaft end journals (N) and intermediate journal (O) outside diameters.

If journal diameters are less than wear limit, replace camshaft.



M82072

4. Measure camshaft bushing diameter (P) at gear housing end.

If bushing diameter exceeds wear limit, replace bushing.

If bushing oil clearance (bushing ID minus camshaft journal OD) exceeds specification, replace bushing, camshaft or both.

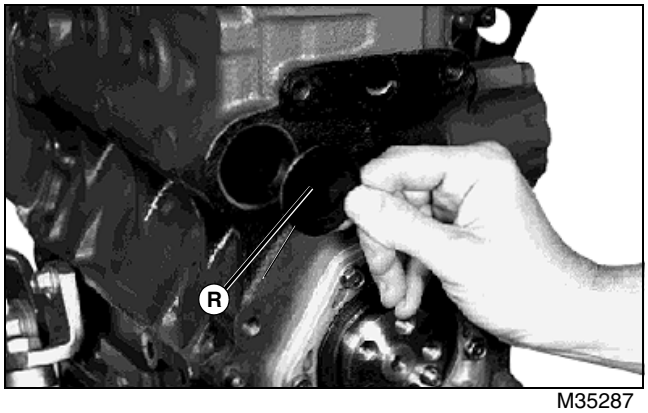
To replace bushing:

Remove and replace bushing using a bushing driver. Be careful not to push bushing inside of engine. Align oil holes (Q) in new bushing and cylinder block.

NOTE: Engine back plate must be removed to measure camshaft intermediate and flywheel end bearing diameters.

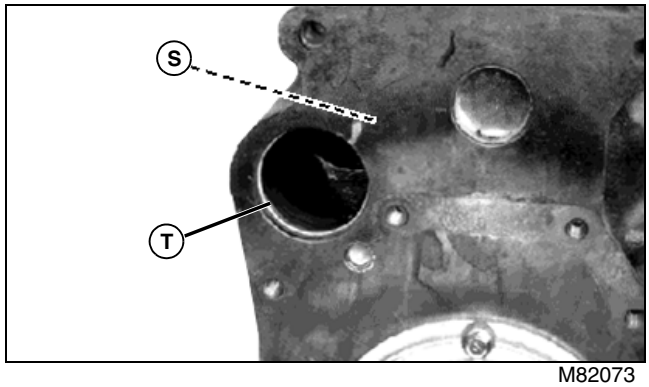
5. Measure intermediate and flywheel end camshaft bore diameters using the following procedures:

- Remove engine back plate.



M35287

- Remove plug (R).
- Measure intermediate and flywheel end camshaft bore diameters.



M82073

Measure flywheel side bore (T) diameter and water pump side bore (S).

If bore diameter exceeds wear limit, replace cylinder block.

If bore clearance (bore ID minus camshaft journal OD) exceeds oil clearance specification, replace camshaft, cylinder block, or both.

- Apply John Deere Form-in Place Gasket, or an equivalent, on outer edge of plug. Install plug until it bottoms in bore.
- Install engine back plate.

Specifications

Camshaft Thrust Plate
Cap Screw Torque . . . . . 11 N•m (96 lb-in.)
Camshaft End Play. . . . . 0.05-0.25 mm (0.002-0.010 in.)
Camshaft Bend. . . . . 0.00-0.02 mm (0.00-0.0008 in.)
Camshaft Bend (Max) . . . . . 0.05 mm (0.002 in.)
Camshaft Lobe
Height . . . . . 33.95-34.05 mm (1.336-1.341 in.)
Camshaft Lobe Wear Limit . . . . . 33.75 mm (1.329 in.)

Front Journal OD

Standard . . . . . 39.94-39.96 mm (1.572-1.573 in.)
Wear Limit. . . . . 39.85 mm (1.569 in.)

Intermediate Journal OD

Standard . . . . . 39.91-39.94 mm (1.572-1.573 in.)
Wear Limit. . . . . 39.85 mm (1.569 in.)

Rear Journal OD

Standard . . . . . 39.91-39.94 mm (1.572-1.573 in.)
Wear Limit. . . . . 39.85 mm (1.569 in.)

Camshaft Bearings

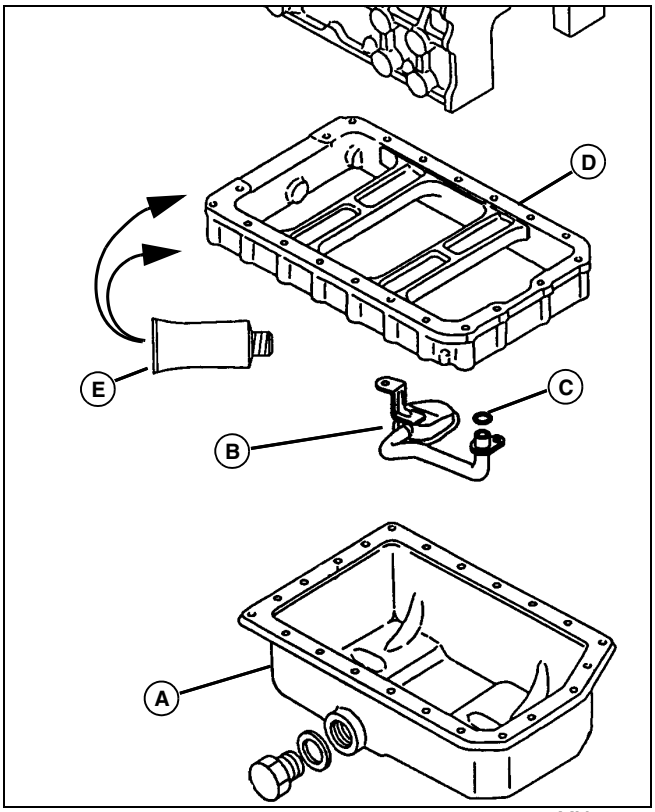
Front Bushing ID . . 40.000-40.065 mm (1.575-1.578 in.)
Intermediate and
Rear Bore ID . . . . . 40.000-40.025 mm (1.575-1.576 in.)

Camshaft Bushing
Wear Limit . . . . . 40.10 mm (1.579 in.)
Camshaft Bushing
Oil Clearance. . . . . 0.040-0.085 mm (0.002-0.003 in.)

Remove Oil Pan, Crankcase Extension, and Strainer

Removal

IMPORTANT: Avoid damage! If spacer is to be removed for lower engine access, engine must be removed from machine. Rear crankcase oil seal housing cap screws thread into spacer, and flywheel must be removed for access to cap screw.



MX0677

1. Remove oil pan cap screws and oil pan (A).

2. Remove cap screws for strainer and remove strainer (B) and O-ring (C).

3. If crankcase extension (D) is being removed, remove four lower cap screws in rear oil seal housing, and one cap screw in front. Remove crankcase extension (D).

Check Connecting Rod Side Play

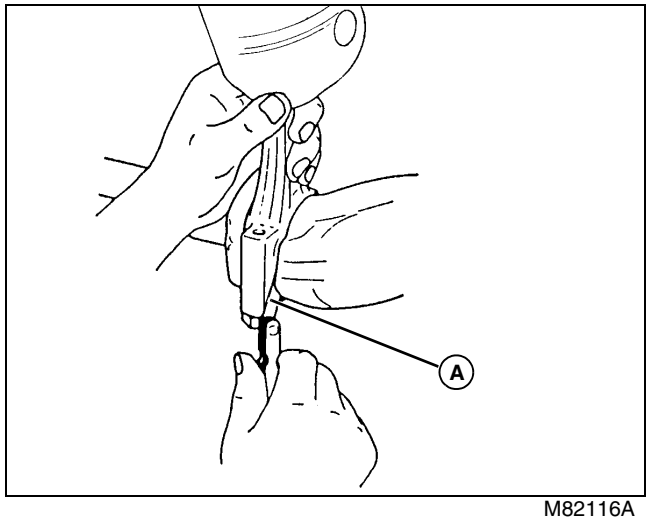
Reason

To determine proper side clearance between crankshaft and connecting rod.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Feeler Gauge	NA	Used to measure connecting rod side play.

Procedure



M82116A

1. Insert a feeler gauge blade (A), between connecting rod cap and crankshaft. Increase thickness of blade until a drag is felt while pulling feeler gauge blade between connecting rod and crankshaft.

Results

If side play exceeds wear limit, replace connecting rod and connecting rod cap.

Specifications

Connecting Rod
Side Play . . . . . 0.20-0.40 mm (0.008-0.016 in.)
Connecting Rod
Side Play Wear Limit . . . . . 0.55 mm (0.0217 in.)

Check Crankshaft End Play

Reason

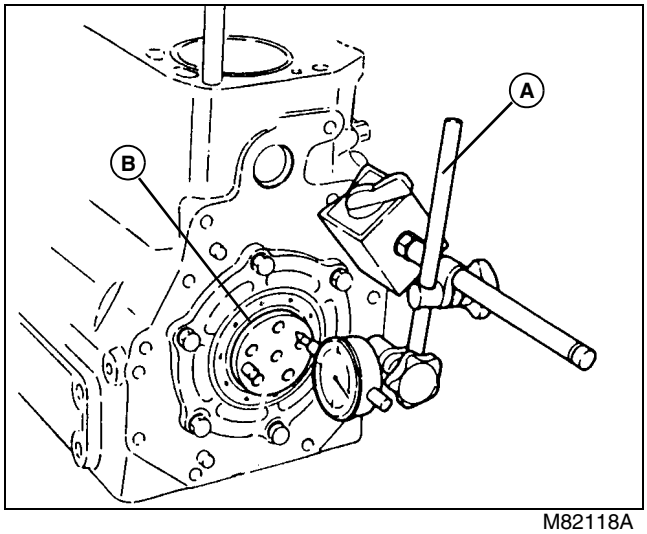
To determine proper side clearance between crankshaft and engine block.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Dial Indicator	NA	Used to measure crankshaft end play.

Procedure

NOTE: Crankshaft end play can be measured at front end or rear end of crankshaft. The flywheel is removed to show detail.



M82118A

1. Fasten dial indicator (A) to engine block and position indicator tip on end of crankshaft (B).

IMPORTANT: Avoid damage! Do not use excessive force when moving crankshaft to avoid damaging bearings.

2. Push crankshaft toward rear as far as possible.

3. Zero the dial indicator.

4. Using a bar, gently pry the crankshaft as far forward as possible.

Results

If end play exceeds wear limit, replace thrust bearings.

Specifications

Crankshaft End Play. . . . 0.09-0.27 mm (0.004-0.011 in.)
Crankshaft End Play
Wear Limit . . . . . 0.33 mm (0.0129 in.)

Check Connecting Rod Bearing Clearance

Reason

To measure oil clearance between connecting rod bearing and crankshaft journal.

Special or Required Tools

Tool Name	Tool No.	Tool Use
PLASTIGAGE® Bearing Clearance Measurement Tool	NA	Used for clearance measurements.

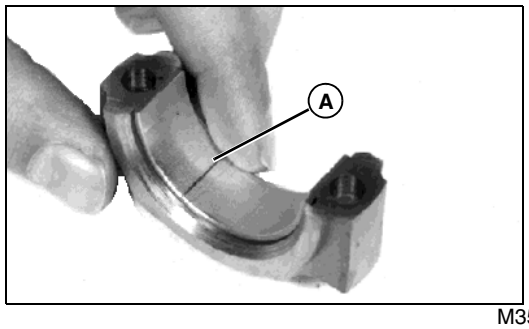
Procedure

IMPORTANT: Avoid damage! Connecting rod caps must be installed on the same connecting rod and in the same direction to prevent crankshaft and connecting rod damage.

1. Remove connecting rod cap.

2. Wipe oil from bearing insert and crankshaft journal.

3. Turn crankshaft to approximately 30° from bottom dead center.



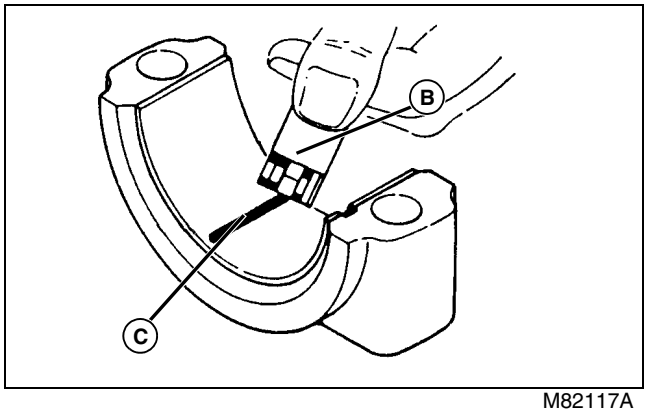
M35351

4. Put a piece of PLASTIGAGE (A), or an equivalent, along the full length of the bearing insert approximately 6 mm (0.250 in.) off center.

5. Install connecting rod end cap and original cap screws. Tighten cap screws to specification. DO NOT turn crankshaft.

6. Remove cap screws and connecting rod cap.

NOTE: The flattened PLASTIGAGE will be found on either the bearing insert or crankshaft journal.



M82117A

7. Use the graduation marks on the envelope (B) to compare the width of the flattened PLASTIGAGE (C) at its widest point.

8. Determine bearing clearance. The number within the graduation marks indicates the bearing clearance in inches or millimeters depending on which side of the envelope is used.

9. Remove PLASTIGAGE.

Results

If clearance exceeds specification, measure crankshaft connecting rod journals. (See “Inspection and Replacement” on page 158.) Replace bearing inserts and/or recondition crankshaft.

Specifications

Connecting Rod Cap Screw Torque . . 25 N•m (18 lb-ft)
Connecting Rod Bearing Clearance . . . . . 0.03-0.06 mm (0.001-0.002 in.)
Connecting Rod Bearing Clearance Wear Limit . . . . . 0.15 mm (0.006 in.)

Check Crankshaft Main Bearing Clearance

Reason

To measure oil clearance between main bearing and crankshaft journal.

Special or Required Tools

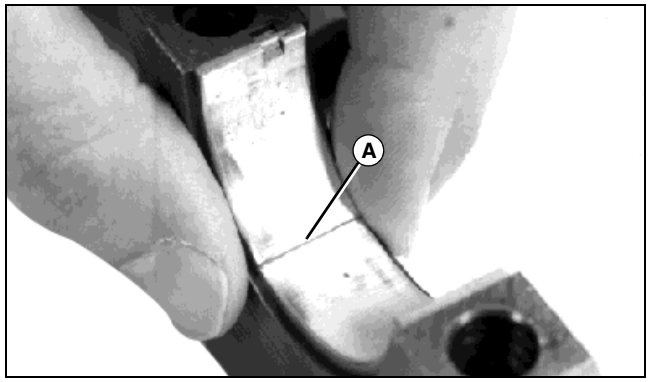
Tool Name	Tool No.	Tool Use
PLASTIGAGE® Bearing Clearance Measurement Tool	NA	Used for clearance measurements.

Procedure

IMPORTANT: Avoid damage! Main bearing caps must be installed on the same main bearing and in the same direction to prevent crankshaft and main bearing damage.

1. Remove main bearing cap.

2. Wipe oil from bearing insert and crankshaft journal.



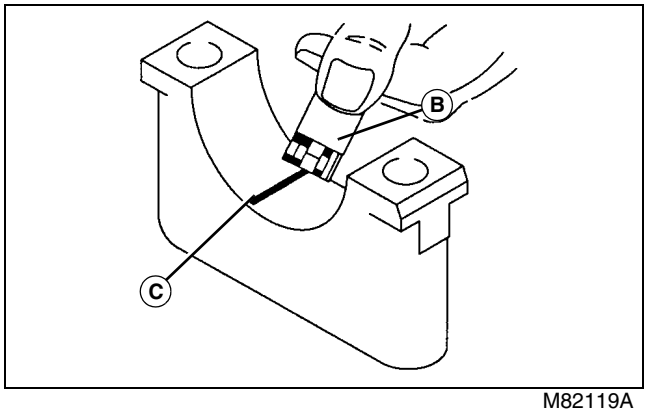
M35382

3. Put a piece of PLASTIGAGE (A), or an equivalent, along the full length of the bearing insert approximately 6 mm (0.250 in.) off center.

4. Install main bearing cap and cap screws. Tighten cap screws to specification. DO NOT turn crankshaft.

5. Remove cap screws and main bearing cap.

NOTE: The flattened PLASTIGAGE will be found on either the bearing insert or crankshaft journal.



M82119A

6. Use the graduation marks on the envelope (B) to compare the width of the flattened PLASTIGAGE (C) at its widest point.

7. Determine main bearing clearance. The number within the graduation marks indicates the bearing clearance in inches or millimeters depending on which side of the envelope is used.

8. Remove PLASTIGAGE.

Results

If clearance exceeds specification, measure crankshaft main bearing journals. (See “Inspection and Replacement” on page 158.) If bearing journals are within specification, replace bearing inserts.

Specifications

Main Bearing Cap Screw Torque. . . . . 81 N•m (60 lb-ft)
Main Bearing Oil Clearance . . . . . 0.033-0.059 mm (0.0013-0.0023 in.)
Wear Limit . . . . . 0.15 mm (0.0059 in.)

Check Piston-to-Cylinder Head Clearance

1. Place small pieces of clay in three positions on the flat part of the piston head.

2. Install cylinder head and old gasket. Install cylinder head cap screws and tighten in proper sequence to specified torque. (See “Remove and Install Cylinder Head” on page 128.)

3. Slowly turn crankshaft one complete revolution.

4. Remove cylinder head and gasket.

5. Measure thickness of flattened pieces of clay. Calculate average thickness of clay pieces to obtain piston-to-cylinder head clearance specification.

If clearance is less than specifications, replace cylinder head.

Specifications

Piston-to-Cylinder Head Clearance . . . . . 0.66-0.78 mm (0.026-0.031 in.)

Repair Piston and Connecting Rod

Special or Required Tools

Tool Name	Tool No.	Tool Use
Piston Ring Compressor	NA	Used to install pistons.

Removal

1. Remove oil pan, strainer tube, and spacer.

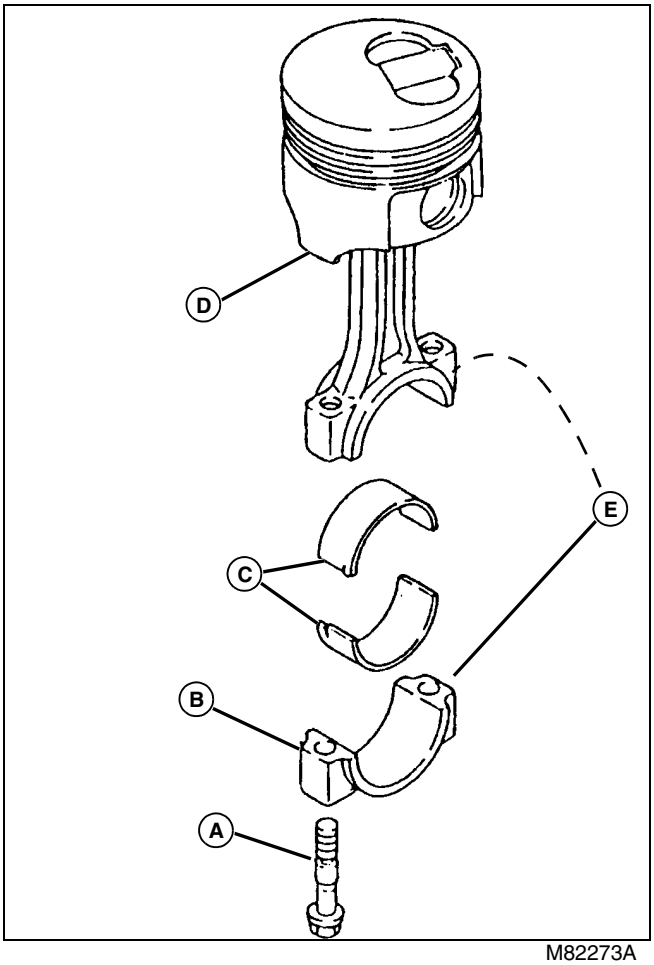
2. Remove cylinder head. (See “Remove and Install Cylinder Head” on page 128.)

3. Check cylinder bore for ridges. Ridges can damage piston and rings if not removed prior to removing the pistons. If necessary, remove ridge from top of cylinder bore using a ridge reamer.

4. Measure connecting rod side play. (See “Check Connecting Rod Side Play” on page 146.)

5. Measure connecting rod bearing clearance. (See “Check Connecting Rod Bearing Clearance” on page 147.)

IMPORTANT: Avoid damage! Keep connecting rods and caps together. Rods and caps are a matched set. Note alignment marks on each part.



M82273A

6. Remove two cap screws (A), connecting rod cap (B), and bearing inserts (C).

IMPORTANT: Avoid damage! Pistons and cylinders are matched. Pistons must be installed in the cylinders from which they are removed.

7. Note connecting rod alignment marks (E) in relation to the cylinders. Starting at flywheel end with cylinder number one, then two, etc.

8. Push piston and connecting rod (D) out of cylinder bore using a wooden dowel.

9. Disassemble and inspect all parts for wear or damage. (See “Disassembly” on page 151.)

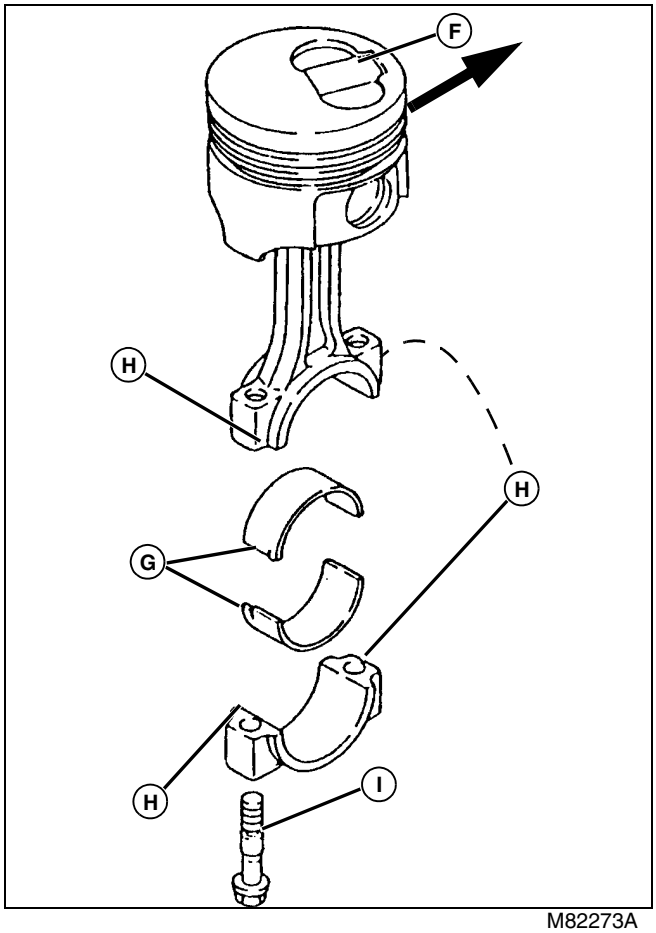
Installation

IMPORTANT: Avoid damage! Never reuse connecting rod cap screws; replace with new.

Pistons must be installed in cylinders from which they were removed and in the same direction. Be careful not to damage crankshaft rod journal while installing piston.

NOTE: Apply clean engine oil on all parts during installation.

1. If new piston rings were installed, deglaze cylinder bore. (See “Deglazing” on page 155.)



M82273A

Picture Note: Arrow Indicates Fuel Injection Pump Side

2. Install piston and connecting rod into the cylinder from which it was removed, with alignment mark on connecting rod (E) and/or with piston size mark on top of piston (F) toward fuel injection pump.

IMPORTANT: Avoid damage! Do not touch bearing insert surfaces. Oil and acid from your finger will corrode the bearing surface.

3. Install bearing inserts on connecting rod and rod cap, aligning tangs (G) with grooves (H).

IMPORTANT: Avoid damage! Connecting rod caps must be installed on the same connecting rods they were removed from.

4. Match the connecting rods to caps using alignment marks (H). Install caps.

5. Dip new connecting rod cap screws (I) in clean engine oil. Install cap screws and tighten to specification.

6. If a new piston and connecting rod were installed, stamp a number corresponding to the cylinder number on the connecting rod cap and connecting rod.

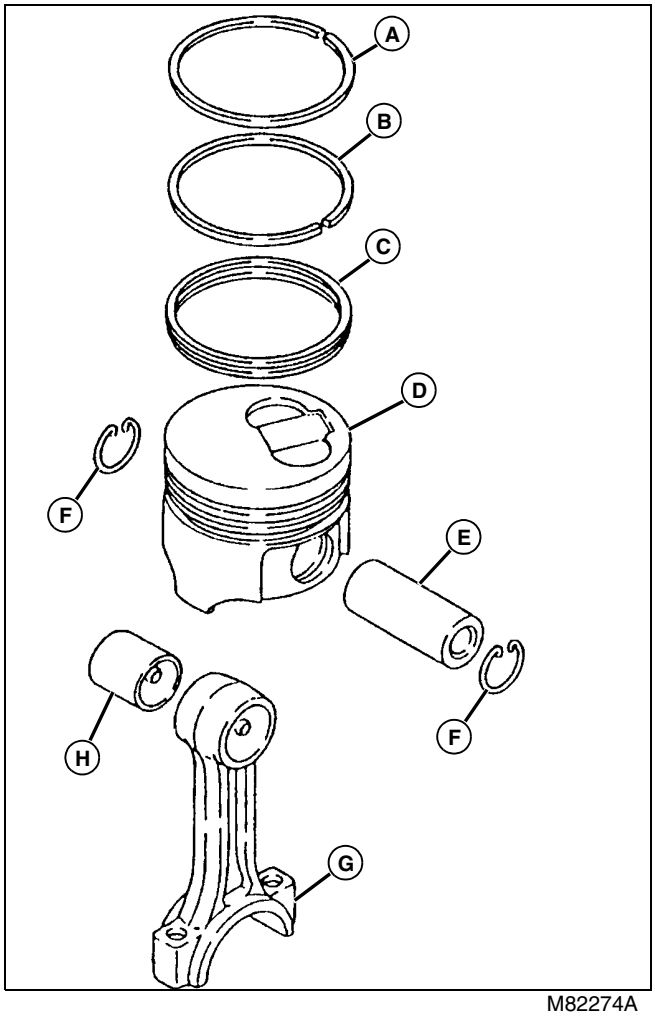
7. Install oil pan and strainer tube.

8. Install cylinder head. (See “Remove and Install Cylinder Head” on page 128.)

Disassembly

IMPORTANT: Avoid damage! Pistons must be installed on the same connecting rod they were removed from.

- Mark each piston and connecting rod to aid in assembly.
- Piston pin bushing is press fit in connecting rod. Remove bushing only if replacement is necessary. (See “Inspection and Replacement” on page 152.)
- Inspect all parts for wear or damage. Replace as necessary.



M82274A

A - First Compression Ring
B - Compression Ring
C - Oil Ring with Expander
D - Piston
E - Piston Pin
F - Retaining Ring
G - Connecting Rod
H - Piston Pin Bushing

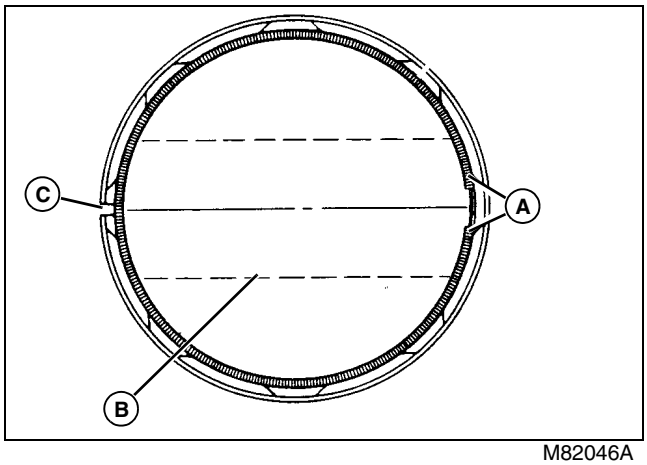
Assembly

IMPORTANT: Avoid damage! Pistons must be installed on the same connecting rod they were removed from.

NOTE: Apply clean engine oil to all parts during assembly.

1. Assemble piston to connecting rod with piston size mark on same side as connecting rod “punched” alignment mark. If a new connecting rod is used, assemble piston to connecting rod with piston size mark opposite connecting rod bearing insert groove.

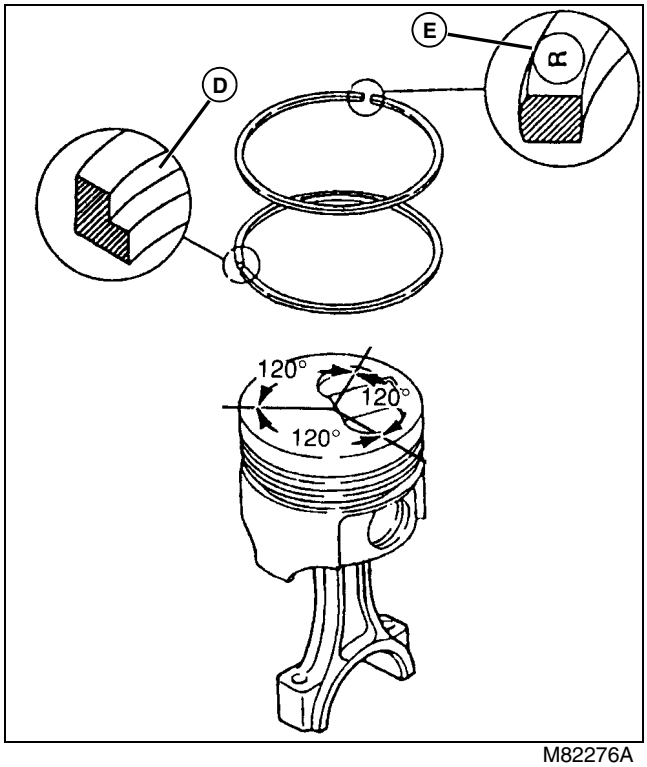
2. Install piston pin and retaining/snap rings.



M82046A

3. Install oil ring expander in bottom ring groove of piston with ends (A) above either end of piston pin (B).

4. Install oil ring over expander with ring gap (C) opposite (180°) of expander ends.



M82276A

5. Install second compression ring, with groove (D) on inside diameter toward top of piston, in middle groove. Turn ring until gap is 120° away from oil ring gap.

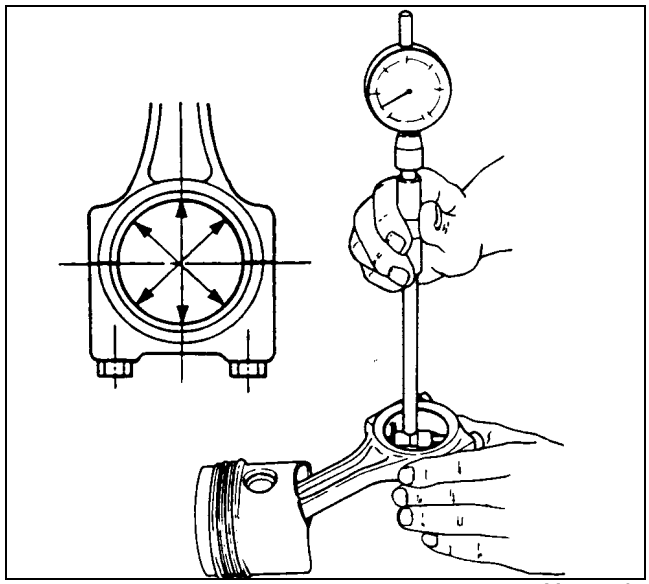
6. Install first compression ring (chrome plated), with manufacturer's mark (E) (near ring gap) toward top of piston, in top groove. Turn ring until gap is 120° away from second ring gap.

Inspection and Replacement

1. Inspect all parts for wear or damage. Replace as necessary.

2. Measure crankshaft connecting rod journal diameter. (See “Inspection and Replacement” on page 158.)

3. Install connecting rod cap and bearing inserts on connecting rod. Install old connecting rod cap screws and tighten to specifications.

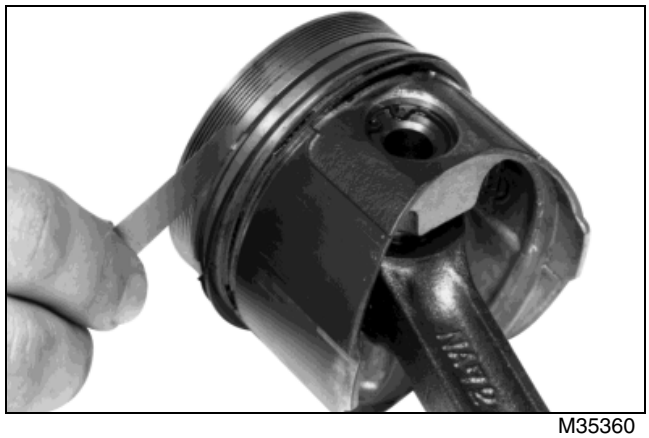


M82048A

4. Measure connecting rod bearing diameter.

If bearing diameter exceeds wear limit and crankshaft is within specification, replace bearing inserts.

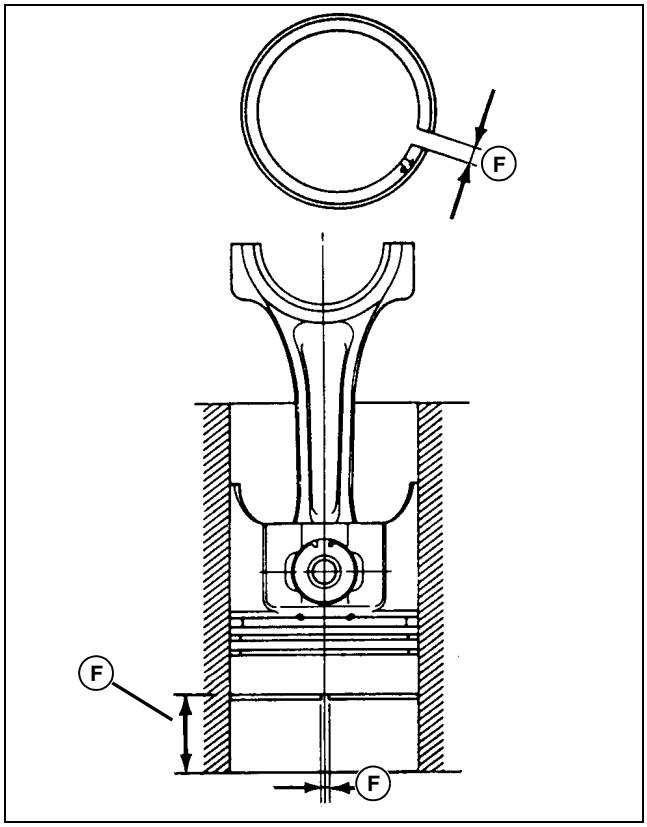
If bearing clearance with new bearing inserts (bearing ID minus crankshaft journal OD) exceeds specification, replace connecting rod.



M35360

5. With rings installed on piston, measure piston ring groove clearance. Measure several places around each piston.

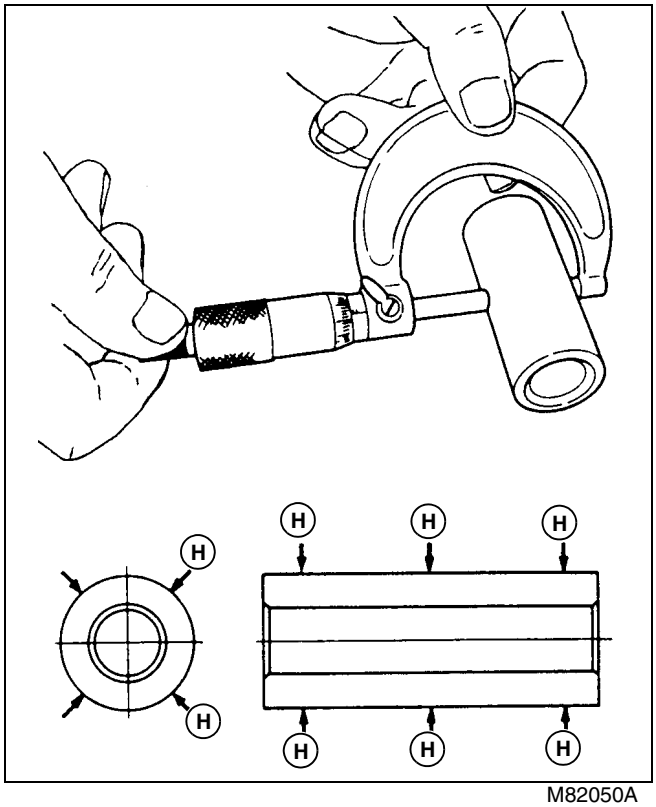
If clearance exceeds maximum limit, replace rings or piston.



M82049A

6. Measure piston ring end gap (F). Push ring into cylinder bore, using a piston, until ring is approximately 30 mm (1.181 in.) (G) from bottom of cylinder bore.

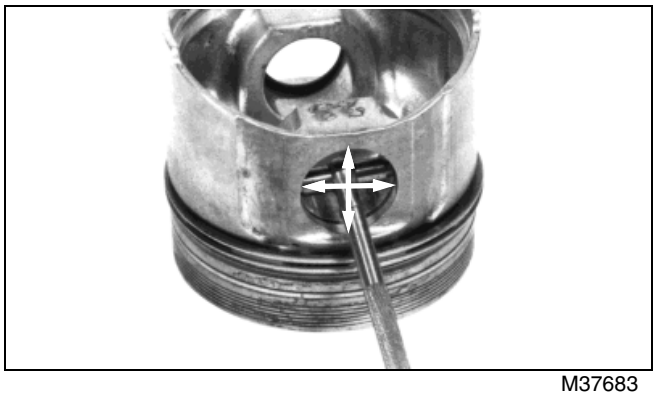
If end gap exceeds wear limit, replace rings.



M82050A

7. Measure piston pin diameter. Measure diameter at six places (H).

If pin diameter is less than wear limit, replace pin.

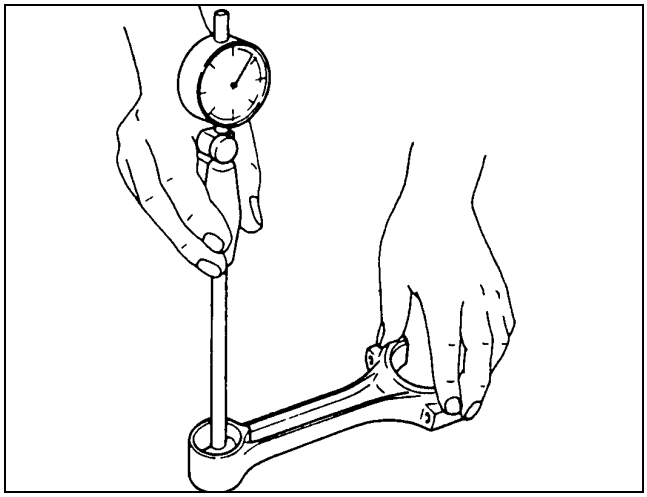


M37683

8. Measure piston pin bore diameter in two directions, 90° to each other, and at each side of the piston.

If piston pin bore exceeds wear limit, replace piston.

If bore clearance (bore ID minus pin OD) exceeds specification, replace piston, piston pin, or both.



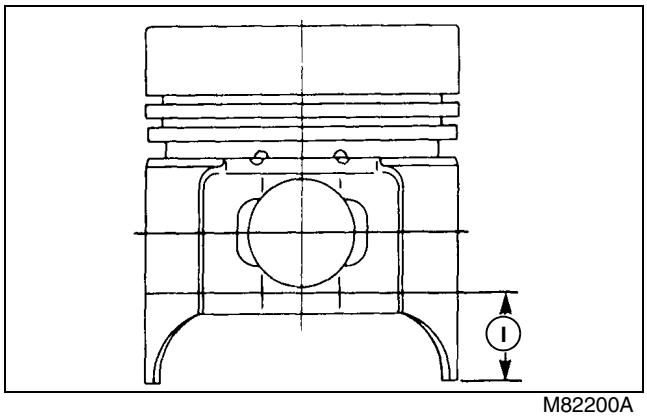
M82051A

9. Measure piston pin bushing diameter in connecting rod.

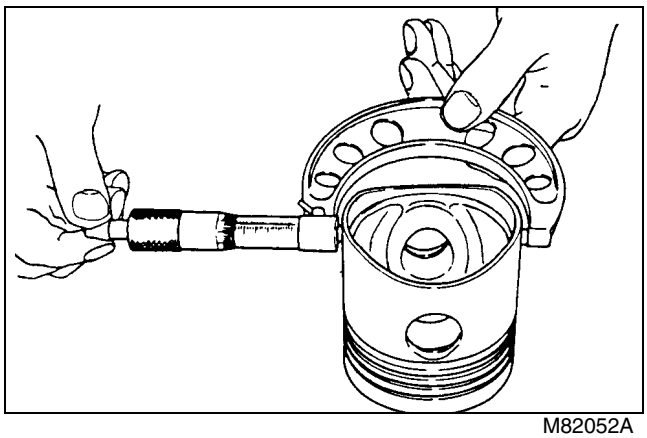
If bushing diameter exceeds wear limit, replace bushing.

If bushing clearance (bushing ID minus pin OD) exceeds specification, replace bushing, piston pin, or both.

Piston pin bushing is press fit. Replace bushing using a driver set. When installing bushing, make sure to align oil hole in bushing with hole in connecting rod.



M82200A



M82052A

10.Measure piston diameter perpendicular to piston pin bore at distance (I).

If piston diameter is less than wear limit, install a new piston.

NOTE: If engine has had a previous major overhaul, oversize pistons and rings may have been installed. Oversize pistons are available in 0.25 mm (0.010 in.), and 0.50 mm (0.020 in.) sizes.

11.Measure cylinder bore diameter. (See “Repair Cylinder Bore” on page 155.)

Specifications

Connecting Rod Cap Screw Torque . . . 25 N•m (18 lb-ft)

Connecting Rod Big End
Bearing ID . . . . . 43.00-43.02 mm (1.693-1.694 in.)
Standard Bearing
Thickness . . . . . 1.487-1.500 mm (0.058-0.059 in.)
Oversize (0.25 mm (0.010 in.)
Bearing Thickness . . . . . 1.625 mm (0.064 in.)
Oil Clearance . . . . . 0.033-0.059 mm (0.001-0.002 in.)
Oil Clearance Wear Limit . . . . . 0.15 mm (0.006 in.)

Piston Ring Groove Side Clearance

Top Piston Ring . . . . . 0.060-0.100 mm (0.002-0.004 in.)
Second Piston Ring . . 0.090-0.125 mm (0.004-0.005 in.)
Oil Control Ring . . . 0.020-0.055 mm (0.0008-0.0022 in.)

Piston Ring End Gap

Top and Second
Piston Ring . . . . . 0.20-0.40 mm (0.008-0.016 in.)
Oil Control Ring . . . . . 0.15-0.35 mm (0.006-0.014 in.)
Wear Limit . . . . . 1.50 mm (0.059 in.)

Piston Pin OD

Standard . . . . . 20.99-21.00 mm (0.826-0.827 in.)
Wear Limit . . . . . 20.90 mm (0.823 in.)

Piston Pin Bore ID

Standard . . . . . 21.00-21.01 mm (0.827-0.827 in.)
Wear Limit . . . . . 21.02 mm (0.828 in.)
Oil Clearance . . . . . 0.000-0.017 mm (0.00-0.0018 in.)
Wear Limit . . . . . 0.12 mm (0.005 in.)

Piston Pin Bushing Inside Diameter

Standard . . . . . 21.025-21.038 mm (0.82775-0.82826 in.)
Wear Limit . . . . . 21.10 mm (0.831 in.)
Oil Clearance . . . . . 0.025-0.047 mm (0.001-0.002 in.)
Wear Limit . . . . . 0.2 mm (0.008 in.)

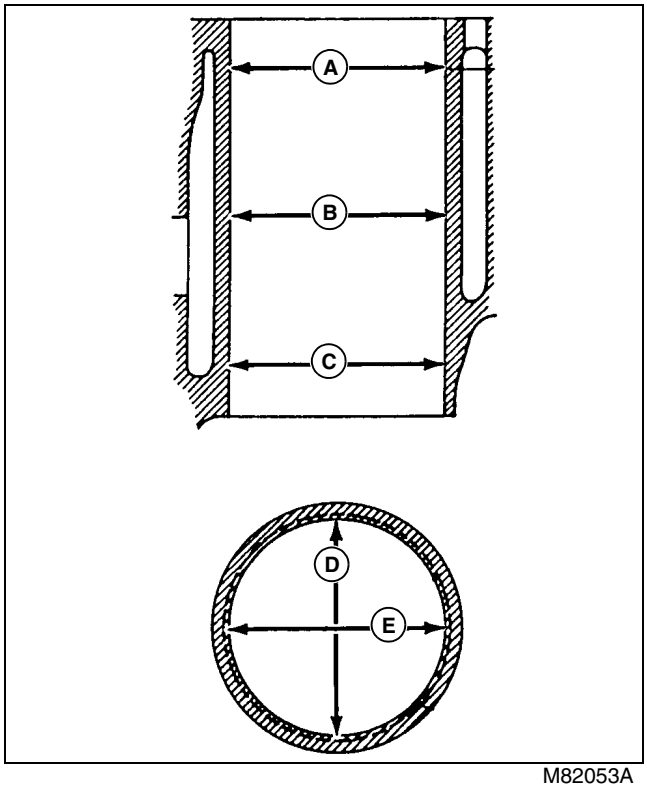
Piston OD

Distance I. . . . . 24 mm (0.945 in.)
Standard Size
Piston. . . . . 73.96-73.98 mm (2.912-2.913 in.)
Standard Size
Piston Wear Limit . . . . . 73.90 mm (2.91 in.)
Oversize Piston
(0.25 mm [0.010 in.]) . . 74.21-74.23 mm (2.921-2.922 in.)
Oversize Piston
Wear Limit . . . . . 74.15 mm (2.919 in.)

Repair Cylinder Bore

Inspection

NOTE: If engine has had a previous major overhaul, oversize pistons and rings may have been installed.



M82053A

Measure cylinder bore diameter at three positions; top (A), middle (B), and bottom (C). At these three positions, measure in both directions; along crankshaft center line (D), and direction of crankshaft rotation (E).

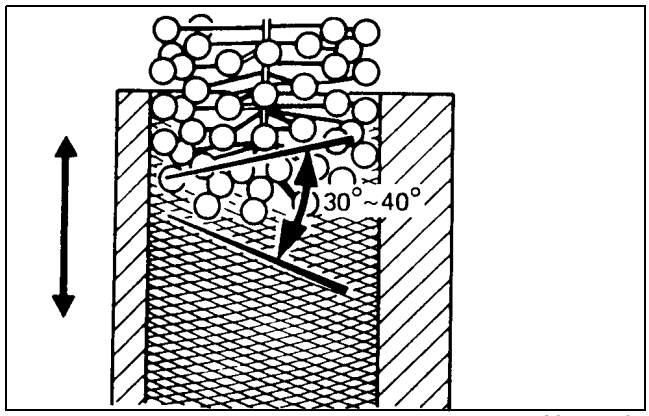
- If cylinder bore exceeds wear limit, replace cylinder block or have cylinder rebored. (See “Reboring” on page 155.)
- If cylinder is rebored, oversize pistons and rings must be installed. Pistons and rings are available in 0.25 mm (0.010 in.).
- If clearance (cylinder bore ID minus piston OD) exceeds specification, replace cylinder block, piston or both; or rebore cylinder and install oversize piston and rings.

Deglazing

IMPORTANT: Avoid damage! If cylinder bores are to be deglazed with crankshaft installed in engine, put clean shop towels over crankshaft to protect journal and bearing surfaces from any abrasives.

1. Deglaze cylinder bores using a flex-hone with 180 grit stones.
2. Use flex-hone as instructed by manufacturer to obtain a **30-40° cross-hatch pattern** as shown.

IMPORTANT: Avoid damage! Do not use gasoline, kerosene, or commercial solvents to clean cylinder bores. Solvents will not remove all abrasives from cylinder walls.



M82054A

3. Remove excess abrasive residue from cylinder walls using a clean dry rag. Clean cylinder walls using clean white rags and warm soapy water. Continue to clean cylinder until white rags show no discoloration.
4. Dry and oil cylinder walls immediately to prevent the formation if rust.

Reboring

NOTE: The cylinder block can be rebored to use oversize pistons and rings. Pistons and rings are available in 0.25 mm (0.010 in.) and 0.50 mm (0.020 in.) oversize. (See this group for cylinder bore ID specifications.)

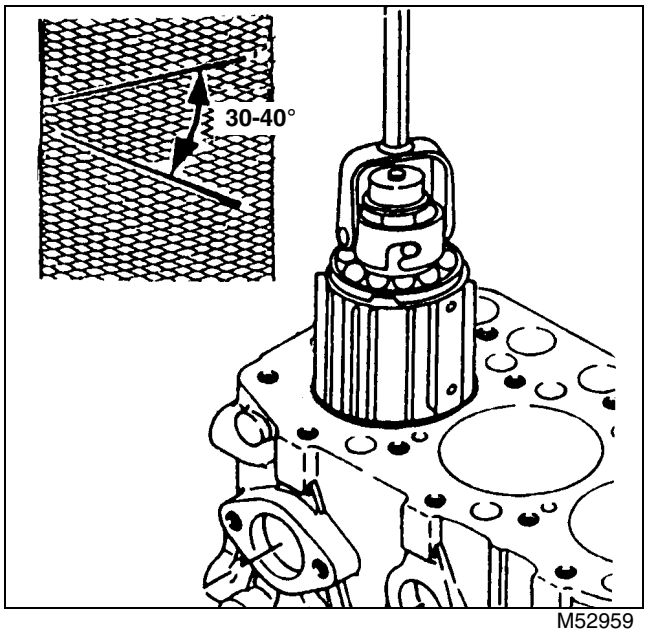
1. Align center of bore to drill press center.

IMPORTANT: Avoid damage! Check stone for wear or damage. Use a rigid hone with 300 grit stones.

2. Adjust hone so lower end is even with lower end of cylinder bore.

3. Adjust rigid hone stones until they contact narrowest point of cylinder.

4. Coat cylinder with honing oil. Hone should turn by hand. Adjust if too tight.



M52959

5. Run drill press at about 250 RPM. Move hone up and down in order to obtain a **30-40° crosshatch pattern.**

NOTE: Measure bore when cylinder is cool.

6. Stop press and check cylinder diameter.

NOTE: Finish should not be smooth. It should have a 30-40° crosshatch pattern.

7. Remove rigid hone when cylinder is within 0.03 mm (0.001 in.) of desired size.

8. Use a flex hone with 180 grit stones for honing to final size.

9. Check bore for size, taper and out-of-round. (See Inspection procedures.)

IMPORTANT: Avoid damage! Do not use solvents to clean cylinder bore. Solvents will not remove all metal particles and abrasives produced during honing.

10.Clean cylinder thoroughly using warm soapy water until clean white rags show no discoloration.

11.Dry and oil cylinder walls immediately to prevent the formation if rust.

Specifications

Cylinder Bore ID

Standard Size Bore . . 74.00-74.03 mm (2.913-2.915 in.)
Wear Limit . . . . . 74.20 mm (2.921 in.)
Piston-to-Cylinder Clearance . . . . . 0.030-0.060 mm (0.002 in.)
Cylinder Roundness . 0.00-0.01 mm (0.0000-0.0004 in.)
Wear Limit. . . . . 0.03 mm (0.001 in.)

0.25 mm (0.010 in.) Oversize Bore ID

Standard . . . . . 74.25-74.28 mm (2.923-2.925 in.)
Wear Limit. . . . . 74.45 mm (2.931 in.)

0.50 mm (0.020 in.) Oversize Bore ID

Standard . . . . . 74.50-74.53 mm (2.933-2.935 in.)
Wear Limit. . . . . 74.70 mm (2.941 in.)

Remove and Install Crankshaft and Main Bearings

Removal

1. Check crankshaft end play. (See “Check Crankshaft End Play” on page 147.)

2. Remove flywheel. (See “Remove and Install Clutch and Flywheel” on page 159.)

3. Remove rear oil seal case. (See “Remove and Install Crankshaft Rear Oil Seal” on page 137.)

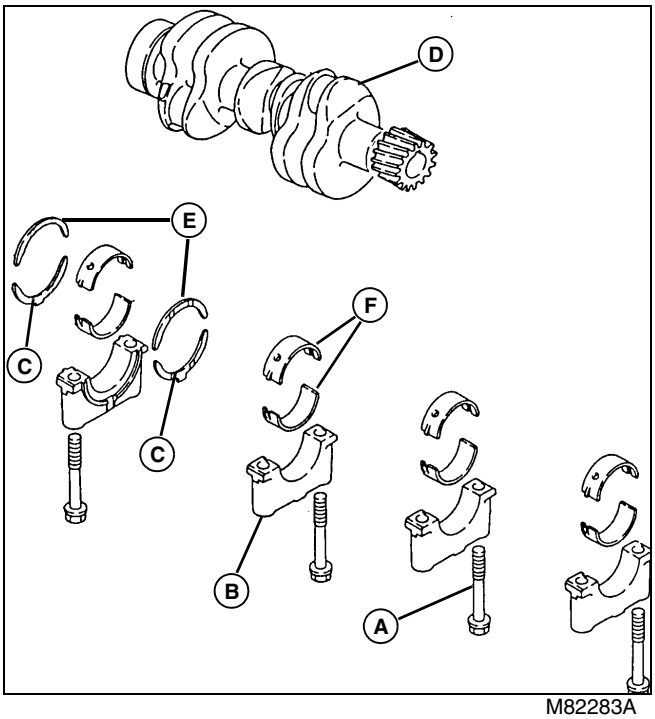
4. Remove timing gear cover, timing gears, and timing gear housing. (See “Remove and Install Timing Gear Cover” on page 138.)

5. Check crankshaft bearing clearance. (See “Check Crankshaft Main Bearing Clearance” on page 148.)

IMPORTANT: Avoid damage! Connecting rod end caps must be installed on the same connecting rod from which they were removed. Note alignment marks on caps and rods.

6. Remove connecting rod cap screws and end caps. Push pistons and connecting rods away from crankshaft

IMPORTANT: Avoid damage! Main bearing caps must be installed on the same main bearings from which they were removed.



M82283A

7. Remove main bearing cap screws (A), caps (B) and cap thrust bearings (C).

8. Remove crankshaft (D).

9. Remove block thrust bearings (E) and main bearing inserts (F).

10.Inspect all parts for wear or damage. (See Inspection and Replacement procedure.)

Installation

IMPORTANT: Avoid damage! Main bearing caps must be installed on the same main bearings from which they were removed.

IMPORTANT: Avoid damage! Do not touch bearing insert surfaces. Oil and acid from your finger will corrode the bearing surface.

NOTE: Apply clean engine oil on all parts during installation.

1. Install bearing inserts drilled with oil passage in cylinder block bearing bores, aligning tangs with slots in bores.

2. Install block thrust bearings with oil grooves facing away from engine block.

NOTE: Main bearing caps have "raised arrows" that are stamped with numbers. Both correspond to their location on the engine block. The number "1" main bearing bore is at flywheel end. Install bearing caps beginning with number 1, then 2, etc. The main bearing cap at gear train end does not have a number. Also install bearing caps with the "arrow" toward the flywheel end.

3. Install crankshaft.

4. Install smooth bearing inserts in main bearing caps, aligning tangs with slots in caps.

5. Install cap thrust bearings, with oil grooves facing away from cap, in the number "1" main bearing cap.

6. Install main bearing caps in their original locations with arrows pointing toward flywheel side of engine.

IMPORTANT: Avoid damage! DO NOT use high speed power tools or air wrenched to tighten main bearing cap screws.

7. Dip entire main bearing cap screws, in clean engine oil. Install cap screws and tighten. DO NOT tighten to specifications.

8. Using a soft-faced hammer, tap the front end of the crankshaft then the rear end of the crankshaft to align the thrust bearings.

9. Tighten main bearing cap screws to specifications. When tightening, start at center main bearing cap and work your way out, alternating to the ends. Turn crankshaft by hand after each bearing cap is tightened. If it does not turn easily, disassemble the parts and find the cause.

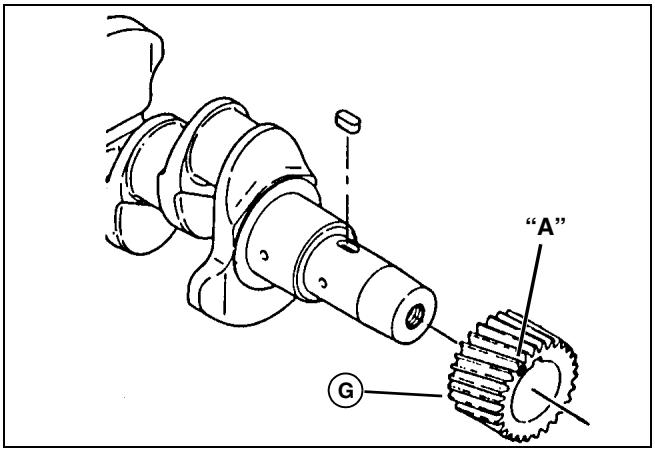
Inspection and Replacement

1. Inspect crankshaft gear for chipped or broken teeth. Replace if necessary.

To replace gear:

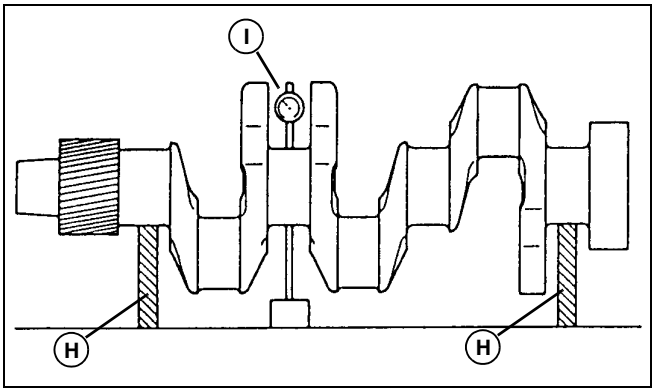
- Remove gear from crankshaft using a knife-edge puller and a press.

CAUTION: Avoid injury! DO NOT heat oil over 182° C (360° F). Oil fumes or oil can ignite above 193° C (380° F). Use a thermometer. Do not allow a flame or heating element to come in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

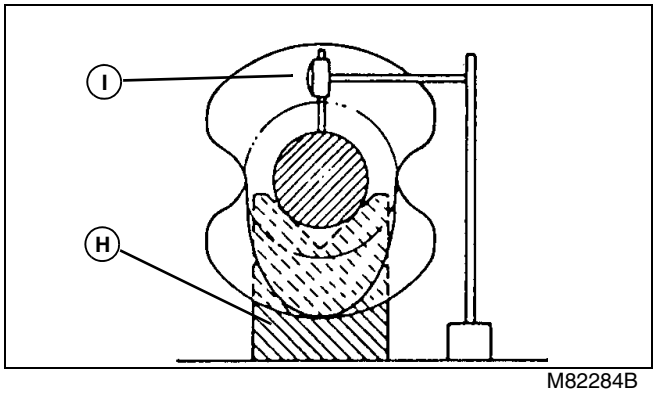


M82060A

- Heat gear to approximately 150°C (300°F). Install gear (G) with timing mark "A" toward press table. Align slot in gear with key in shaft. Press crankshaft into gear until gear is tight against crankshaft shoulder.



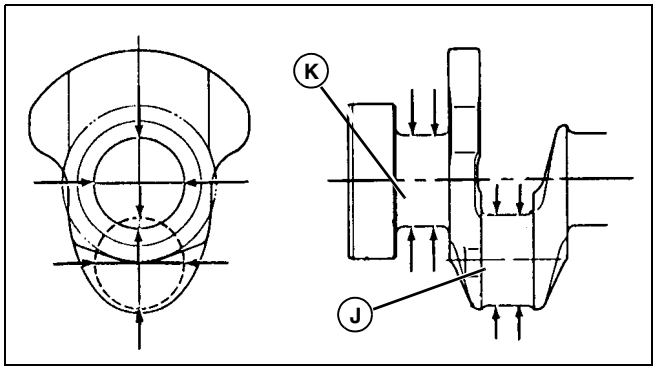
M82284C



M82284B

2. Inspect crankshaft for bend using V-blocks (H) and a dial indicator (I). Turn crankshaft slowly and read variation on indicator. If variation is greater than 0.02 mm (0.0008 in.), replace crankshaft.

NOTE: If engine has had a previous major overhaul, journals may have been ground and undersized bearing inserts installed.

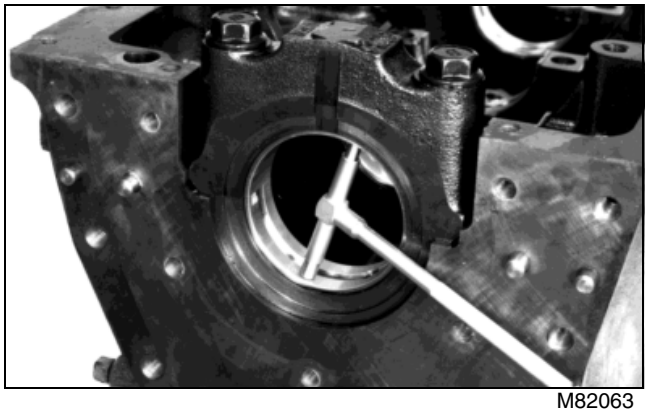


M82062A

3. Measure crankshaft connecting rod journals (J) and main bearing journal (K) diameters. Measure several places around each journal.

If journal diameter is less than wear limit, replace crankshaft or have journals ground undersize by a qualified machine shop.

If journals are ground, undersize bearing inserts must be installed. Bearing inserts are available in 0.25 mm (0.010 in.) undersize.


M82063

4. Install bearing inserts and main bearing cap on main bearing. Tighten main bearing cap screws to specification.

5. Measure main bearing diameter.

If bearing diameter exceeds wear limit, replace bearing inserts.

If bearing clearance (bearing ID minus crankshaft main bearing journal OD) exceeds specification, replace bearing inserts and crankshaft or have crankshaft journals ground undersize by a qualified machine shop and install undersized bearing inserts.

Bearing inserts are available in 0.25 mm (0.010 in.) undersize.

6. Clean and inspect oil passages in main bearing journals, connecting rod journals and main bearing bores in cylinder block.

7. Inspect crankshaft for cracks or damage. Replace if necessary.

Specifications

Crankshaft Connecting Rod Journal OD . . . . . 39.97-39.98 mm (1.573-1.574 in.)
Crankshaft Connecting Rod Journal OD Wear Limit. . . . . 39.91 mm (1.571 in.)
Crankshaft Main Bearing Journal OD . . . . . 43.97-43.98 mm (1.728-1.732 in.)
Crankshaft Main Bearing Journal OD Wear Limit. . . . . 43.90 mm (1.728 in.)
Main Bearing ID . . . 40.000-40.042 mm (1.575-1.577 in.)
Main Bearing ID Wear Limit. . . . . 40.07 mm (1.578 in.)
Main Bearing Oil Clearance. . . . . 0.020-0.072 mm (0.0008-0.0028 in.)
Wear Limit . . . . . 0.25 mm (0.0098 in.)
Main Bearing Insert Thickness . . . . . 1.99-2.00 mm (0.0783-0.0787 in.)
0.25 mm (0.010 in.) Under Size Bearing Thickness . . . . . 2.125 mm (0.084 in.)
Main Bearing Cap Screw Torque. . . . . 81 N•m (60 lb-ft)

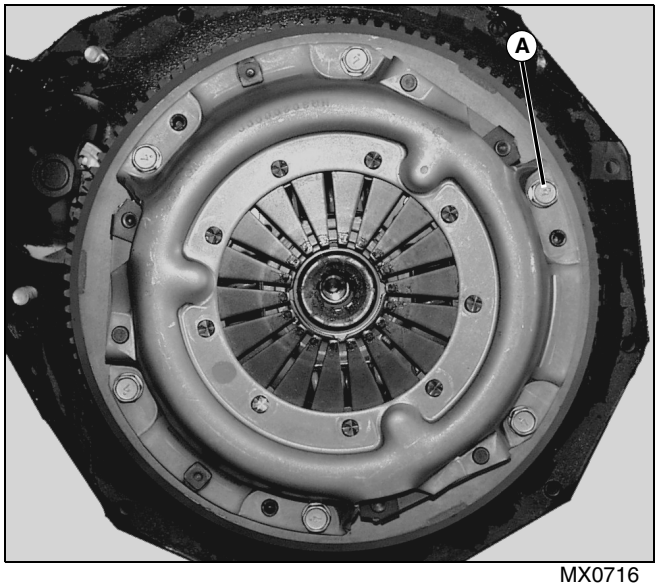
Remove and Install Clutch and Flywheel

Special or Required Tools

Tool Name	Tool No.	Tool Use
Clutch Alignment Tool	JDG1331	Used to install clutch.

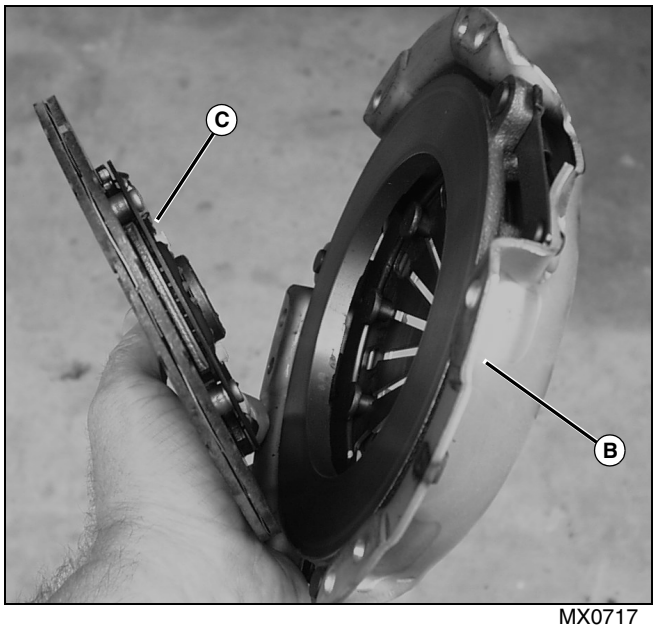
Procedure

1. Remove engine. (See “Remove and Install Engine” on page 134.)



MX0716

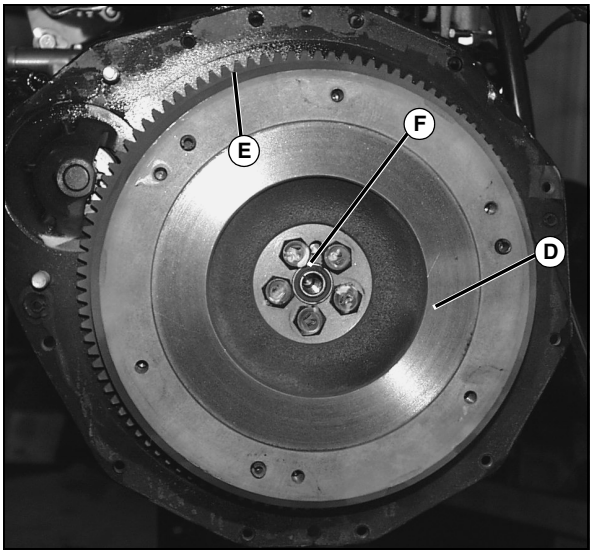
2. Alternately loosen cap screws (A) on clutch cover.



MX0717

3. Remove clutch cover (B) and clutch disc (C) from flywheel.

NOTE: Flywheel is heavy! Be careful when removing.



MX0668

4. Remove flywheel.

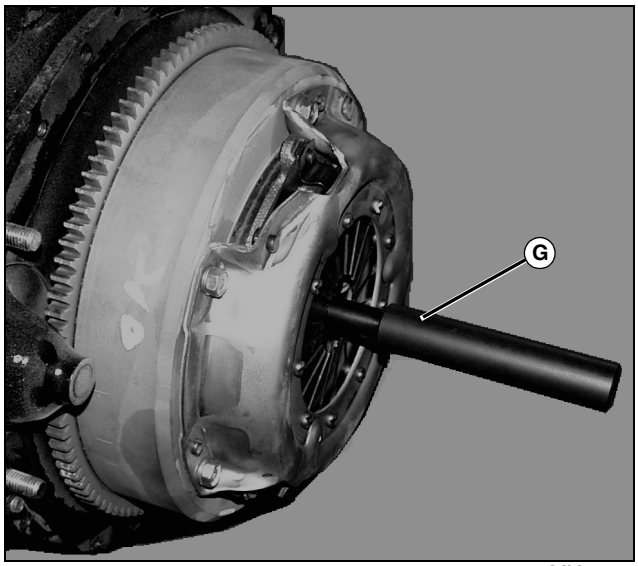
5. Inspect flywheel for cracks or grooves on clutch wear area (D). Check ring gear (E) for chips and broken teeth. Check pilot bearing (F) for smooth operation. Replace parts as necessary.

Installation

1. Make sure flywheel and crankshaft mating surfaces are clean.

2. Install flywheel and tighten cap screws to specification.

3. Install clutch disc with raised side of hub toward clutch cover. Install clutch cover. Do not tighten cap screws.



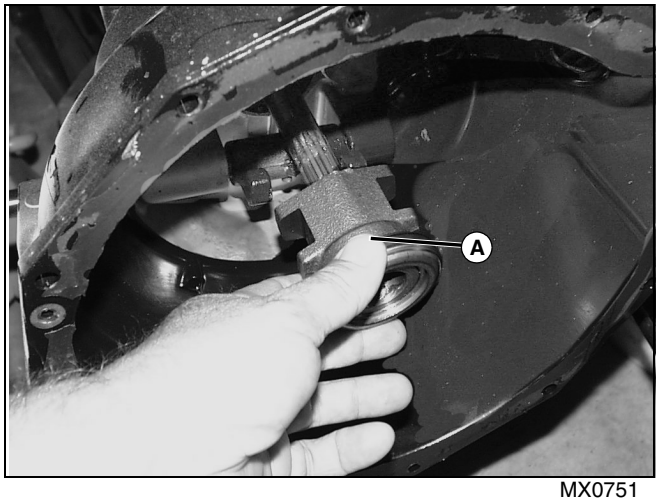
MX0747

4. Using JDG1331 clutch alignment tool (G) or an equivalent, align clutch disc and alternately tighten clutch cover cap screws to specification.

Specifications

Flywheel Mounting
Cap Screw Torque . . . . . 84 N•m (62 lb-ft)
Clutch Cover Cap Screw Torque. . . . 23 N•m (200 lb-in.)

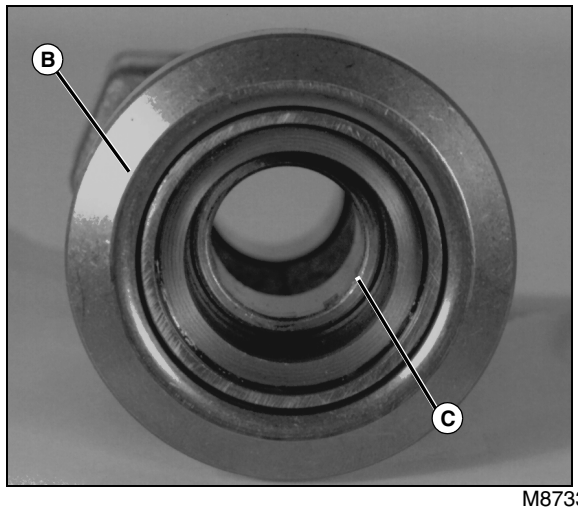
Replace Clutch Release Bearing



MX0751

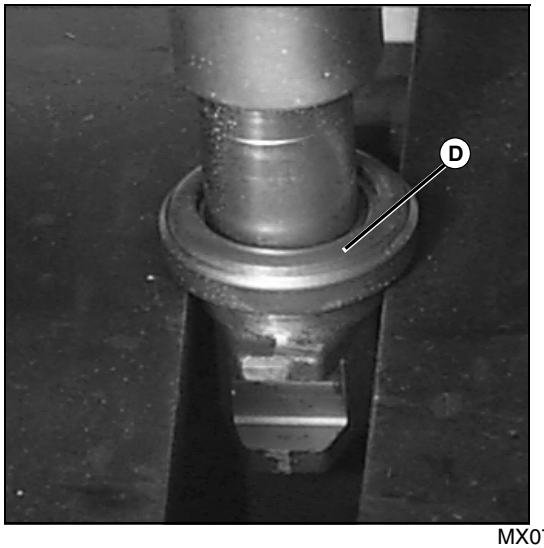
1. Pull release bearing sleeve (A) forward to remove from release yoke.

NOTE: The bushings in the release bearing sleeve are not serviceable. If they are worn, replace entire sleeve assembly.



M87332

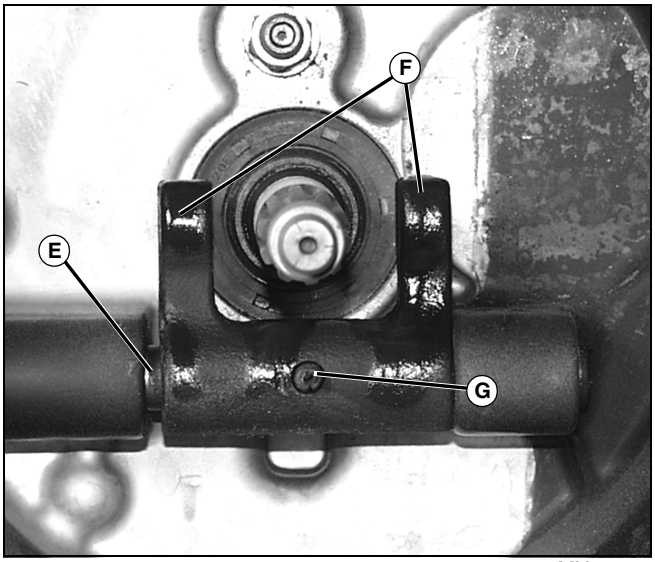
2. Inspect release bearing assembly (B) and bushings (C) for wear or damage.



MX0752

3. If replacement is necessary, press release bearing (D) off of sleeve.

4. Press release bearing (D) on sleeve until it bottoms on sleeve.



MX0754

5. Inspect shaft (E) and yoke (F) for wear or damage. To replace any of these, mark shaft and yoke for reassembly purposes and drive out spring pin (G) holding yoke to shaft and remove shaft.

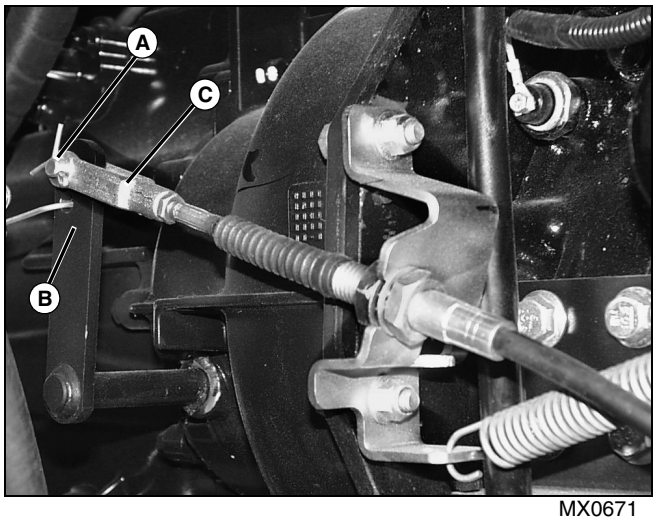
NOTE: Lubricate sparingly to avoid slinging excess grease onto clutch disc.

6. Lubricate input shaft and release bearing bushings, and yoke prior to assembly.

Installation

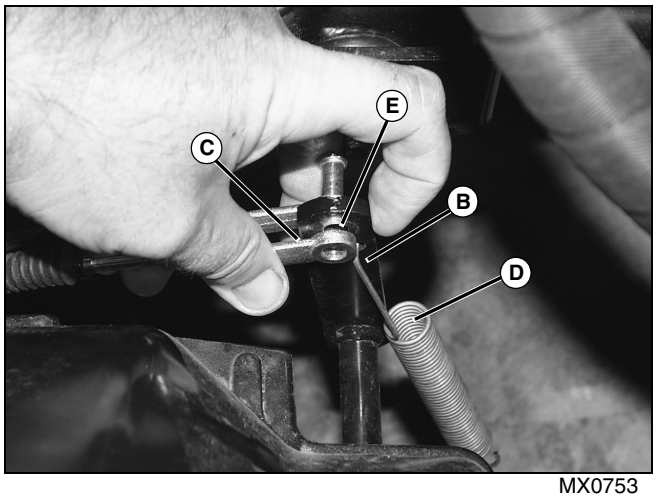
Make sure the clutch shaft arm and yoke are both facing “up” before installing spring pins.

Adjust Clutch



MX0671

1. Remove pin (A) from clutch arm (B) and clevis (C).



MX0753

2. Disconnect spring (D), and pull clutch arm (B) and clevis (C) toward each other and check alignment of holes.

NOTE: Make sure enough force is being applied to clevis to pull clutch pedal to the top of its travel, or block clutch pedal up to the top of its travel.

3. If holes (E) do not line up, loosen locknut on clevis and adjust clevis until holes align.

4. Install pin and connect return spring.

5. Have an assistant depress clutch pedal, and measure clutch arm free travel at the clevis pin hole and record the measurement.

6. Measure the total travel of the clutch arm and record measurement.

7. Subtract the freeplay measurement from the total travel measurement to get clutch disengagement travel.

8. Clutch disengagement travel should be 12.5mm-18.5mm (0.5-0.73 in.) If clutch disengagement travel is not within specification, loosen locknut on clevis and adjust to proper specification. Retighten locknut.

Remove and Install Timing Gear Housing

Other Material

Part No.	Part Name	Part Use
TY15130 (U.S.)	Form-in-Place Gasket	Used to seal oil pan to timing gear housing and engine block.

Removal

1. Remove engine. (See “Remove and Install Engine” on page 134.)

2. Remove timing gear cover. (See “Remove and Install Timing Gear Cover” on page 138.)

3. Remove fuel injector lines from engine.

4. Remove engine camshaft. (See “Camshaft Removal” on page 142.)

5. Remove coolant pump. (See “Remove and Install Coolant Pump” on page 165.)

6. Remove oil pan. (See “Remove Oil Pan, Crankcase Extension, and Strainer” on page 146.)

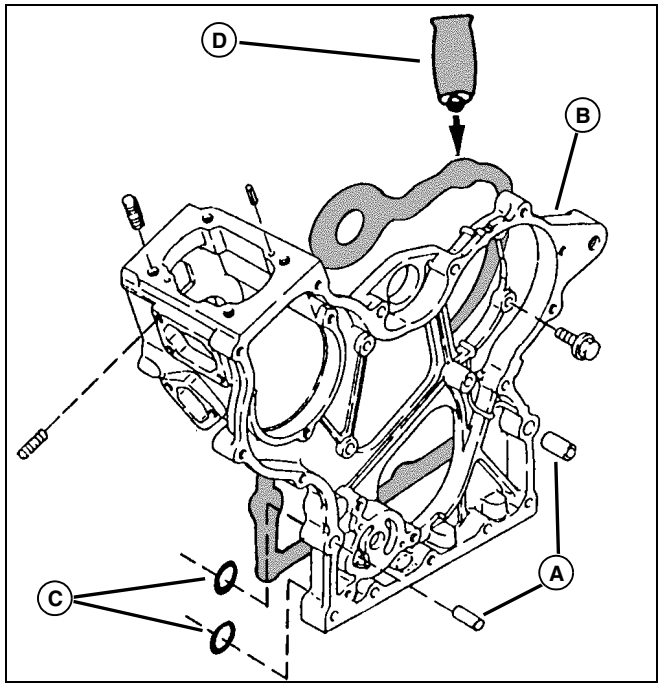
7. Remove timing gear housing mounting cap screws and remove housing from cylinder block

8. Remove fuel injection pump and governor, if replacing timing housing.

Installation

Installation is done in the reverse order of removal.

1. Clean all parts of old gasket sealer, gasket material, oil, and dirt before attempting installation.



M82299A

2. Install alignment dowels (A) in timing gear housing (B).

3. Replace o-rings (C) behind oil pump.

4. Apply John Deere TY15130 Form-in-Place Gasket (D) to timing housing when installing to cylinder block.

5. Tighten mounting cap screws to specification.

Specifications

Aluminum Housing-to-Block Mounting Cap Screw Torque. . . . . 11 N•m (97 lb-in.)

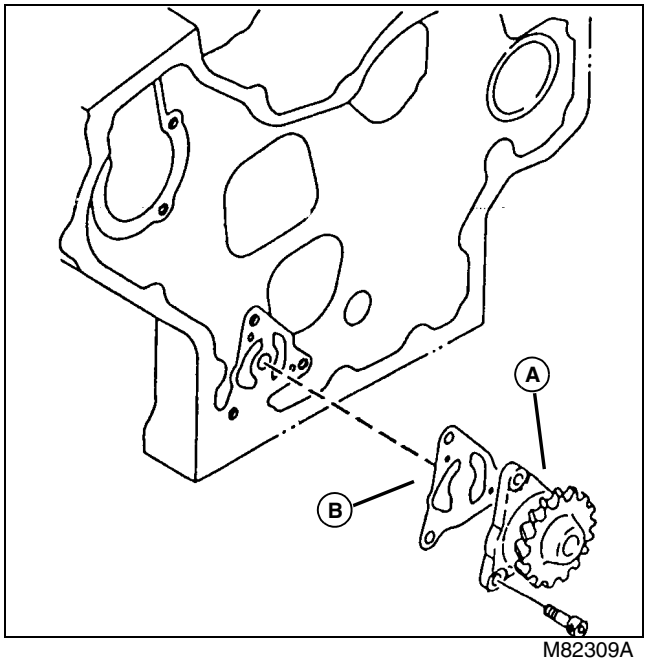
Cast Iron Housing-to-Block Mounting Cap Screw Torque. . . . . 9 N•m (80 lb-in.)

Remove and Install Oil Pump

Removal and Installation

1. Remove timing gear cover. (See “Remove and Install Timing Gear Cover” on page 138.)

2. Check oil pump gear backlash. (See “Check Timing Gear Backlash” on page 140.) Replace entire oil pump assembly if backlash is more than specification.



M82309A

3. Remove three mounting cap screws, oil pump (A), and gasket (B).

4. Inspect all parts for wear or damage.

Disassembly and Assembly

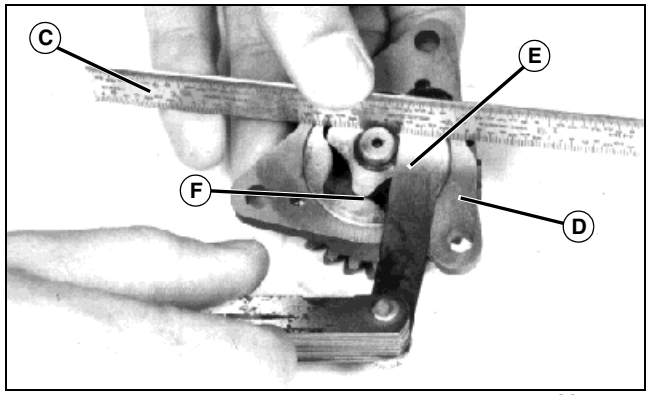
- Inspect parts for wear or damage. (See Inspection procedures.)
- Coat all parts with clean engine oil.
- Install outer rotor with identification mark facing toward inside of housing assembly.

Inspection

1. Measure the inside diameter of the rotor shaft bore in the backing plate.

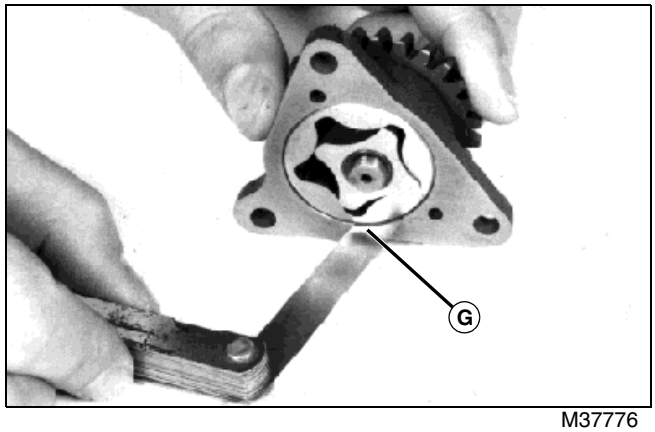

M35555

2. Measure the outside diameter of the rotor shaft. Subtract the shaft measurement from the bore measurement to determine clearance. If the clearance is more than wear limit, replace entire assembly.



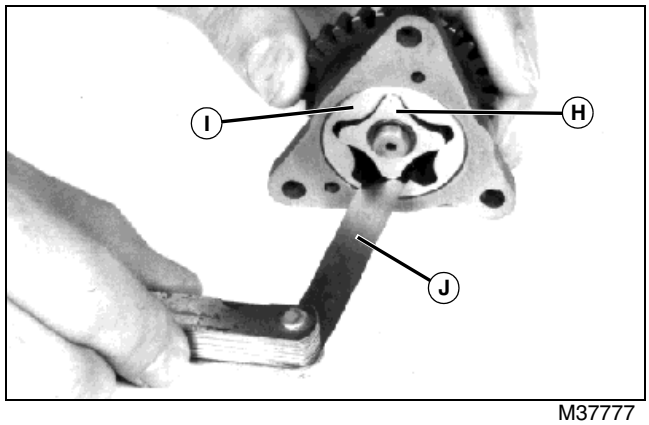
M37775

3. Lay a straight-edge (C) across pump housing (D). Using a feeler gauge (E), check recess of inner and outer rotor (F). If rotor recess is beyond wear limit, replace oil pump assembly.



M37776

4. Check outer rotor-to-pump housing clearance (G). If clearance is more than wear limit, replace oil pump assembly.



M37777

5. Check clearance between inner rotor (H), and outer rotor (I) with feeler gauge (J). If clearance is more than 0.15 mm (0.006 in.),replace oil pump assembly.

Specifications

Crankshaft Gear-to-Oil Pump Gear Backlash . . 0.11-0.19 mm (0.0040-0.008 in.)

Rotor Shaft-to-Backing Plate Clearance

Standard . . . . . 0.013-0.043 mm (0.0005-0.002 in.)
Wear Limit . . . . . 0.2 mm (0.008 in.)

Rotor Recess

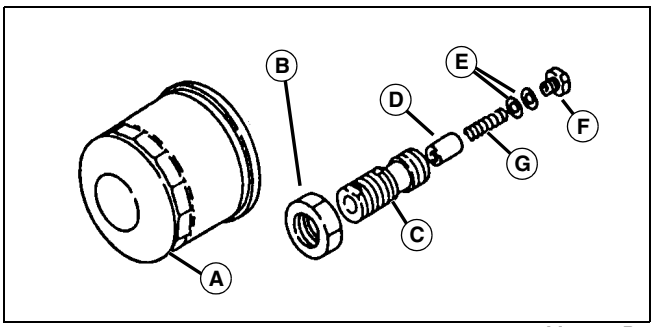
Standard . . . . . 0.03-0.09 mm (0.001-0.004 in.)
Wear Limit . . . . . 0.13 mm (0.005 in.)

Outer Rotor-to-Pump Body Clearance

Standard . . . . . 0.10-0.16 mm (0.004-0.006)
Wear Limit . . . . . 0.25 mm (0.006 in.)

Remove and Install Oil Pressure Regulating Valve

Removal



M82311B

1. Remove oil filter (A).
2. Remove retaining nut (B) and valve assembly (C).

NOTE: Valve components D through G are not serviced individually. Replace complete regulating valve if any components are defective.

3. Inspect all parts for wear or damage. Replace complete valve if any parts are bad.

Installation

Installation is done in the reverse order of removal.

- Tighten retaining nut to specification.

Specifications

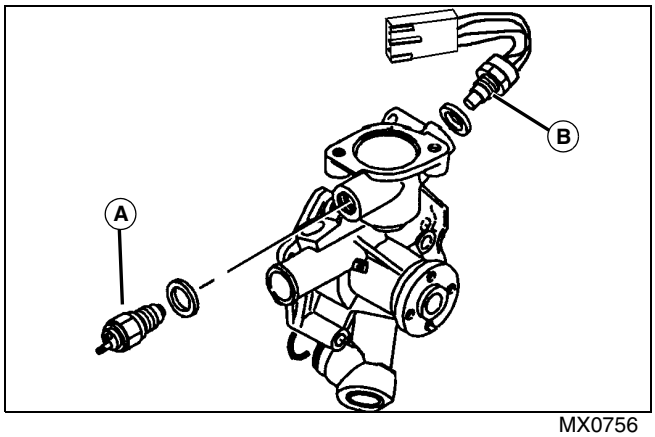
Oil Pressure Regulating Valve Retaining Nut Torque . . . . . 30 N•m (22 lb-ft)

Replace Coolant Temperature Sensors

Replacement

1. Open engine drain valve to drain coolant level to below coolant sensor level.
2. Disconnect wiring lead.

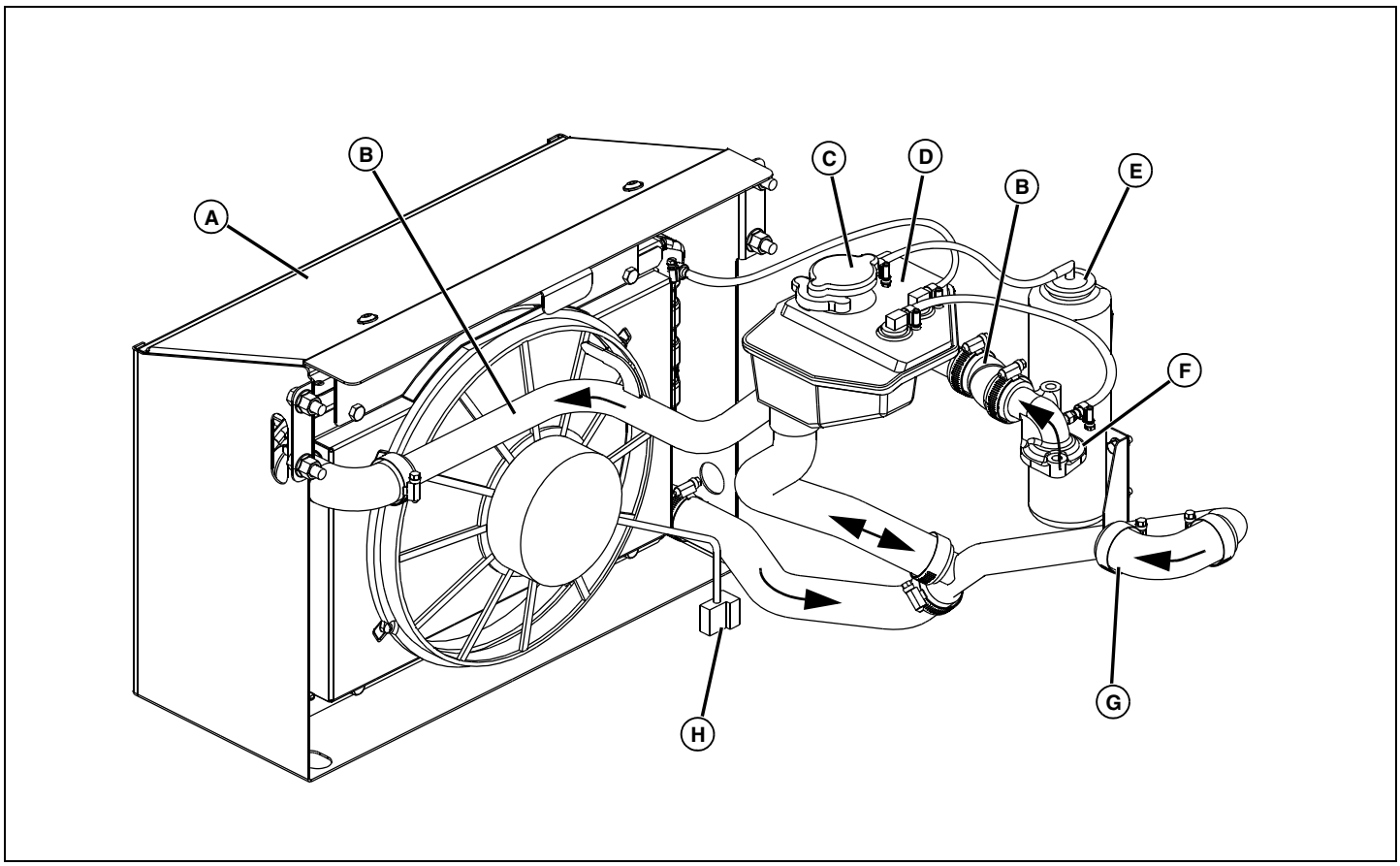
NOTE: Sensor (A) is for temperature gauge. Sensor (B) is for over temperature indicator light and cooling fan.



MX0756

3. Remove sensor and washer.
4. Test sensor. (See “Engine Coolant Temperature Sensor Test” on page 312.)
5. Installation is done in reverse order of removal. Replace copper washer.

Cooling System Hose Routing



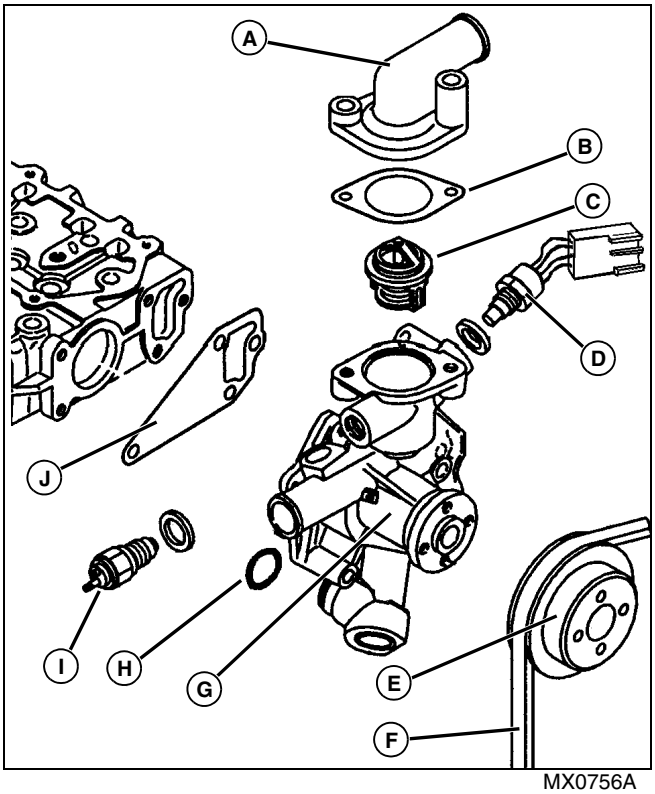
MIF

- **A - Radiator**
- **B - Upper Radiator Hose**
- **C - Pressure Cap**
- **D - De-Aeration Tank**
- **E - Coolant Recovery Tank**
- **F - Engine Thermostat Housing**
- **G - Lower Radiator Hose (Suction Line to Engine Coolant Pump)**
- **H - Electric Fan Connector**

Remove and Install Coolant Pump

Removal and Installation

1. Park unit on level surface, park brake engaged.
2. Allow engine to cool and pressure in cooling system to drop before working on coolant pump.
3. Disconnect negative (-) battery cable from battery.
4. Open engine drain valve to drain coolant from cylinder block and radiator.
5. Disconnect upper and lower radiator hoses from coolant pump.
6. Loosen alternator mounting bolts and remove coolant pump/alternator drive belt.



MX0756A

A - Thermostat Housing
B - Gasket
C - Thermostat
D - Over Temperature Light and Fan Switch
E - Pulley
F - Belt
G - Coolant Pump
H - O-Ring
I - Temperature Gauge Sensor
J - Gasket

7. Disconnect coolant temperature switch leads. Remove switches from coolant pump if pump is to be replaced.

8. Remove four cap screws and remove pulley.

9. Remove pump mounting cap screws, pump and gasket.

10. Inspect all parts for wear or damage.

11. Clean cylinder block mating surfaces of all old gasket material.

12. Installation is done in the reverse order of removal.

13. Install coolant temperature switches. (See “Replace Coolant Temperature Sensors” on page 164.)

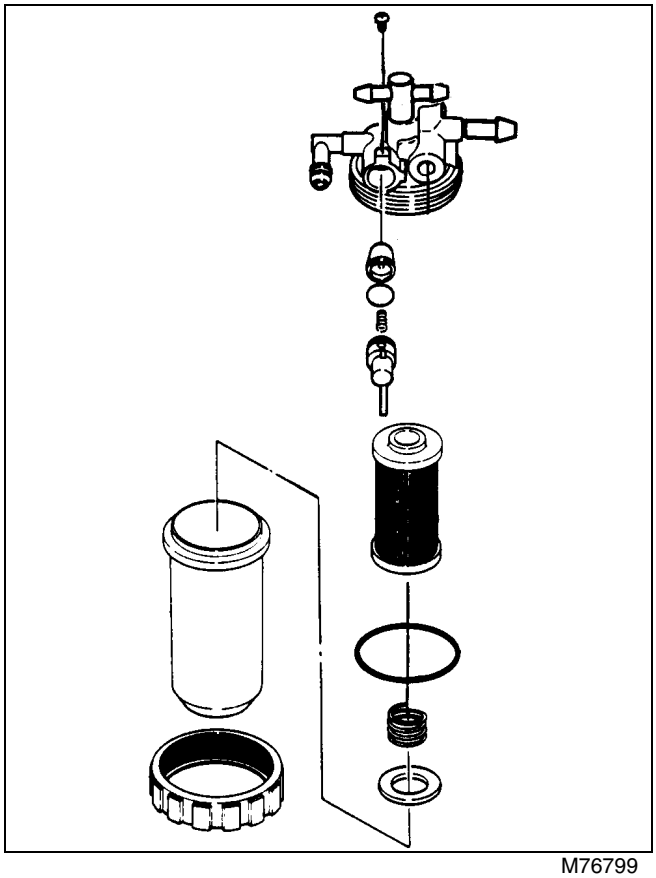
14. Install thermostat (See “Remove and Install Thermostat” on page 126.)

15. Adjust coolant pump/alternator drive belt tension.

Remove and Install Fuel Filter-Water Separator

Removal

1. Remove fuel lines from fuel filter assembly.
2. Remove fuel return line from fuel filter assembly.
3. Remove nut securing filter assembly to mounting stud.
4. Slide fuel filter off of mounting stud.



M76799

Installation

Installation is done in the reverse order of removal.

Remove and Install Fuel Injection Nozzle

Special or Required Tools

Tool Name	Tool No.	Tool Use
Nozzle Cleaning Kit	JDF13	Used to clean fuel injection nozzles.

Removal

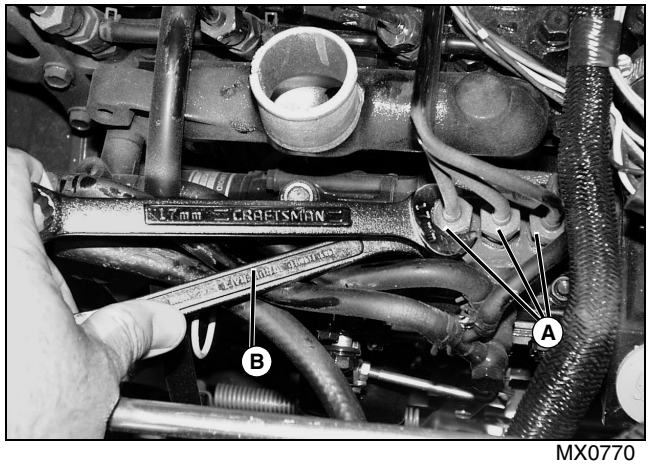
CAUTION: Avoid injury! Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury should reference a knowledgeable source. Such information is available from the Deere & Company Medical Department in Moline, Illinois, U.S.A.

IMPORTANT: Avoid damage! Never steam clean or pour cold water on injection pump while pump is running, or engine is warm. Doing so can damage the pump.

When removing injection lines, DO NOT turn pump delivery valve fittings. Turning fittings may damage pump internally. Always use a backup wrench when removing lines.

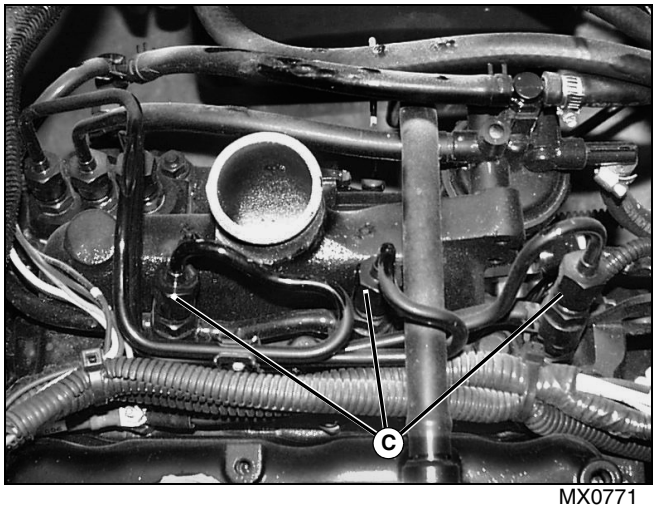
1. Clean the injection pump lines and area around the pump using a parts cleaning solvent or steam cleaner.

NOTE: Nozzles are matched to the cylinders. If removing more than one nozzle, tag nozzles, according to the cylinder from which it was removed.



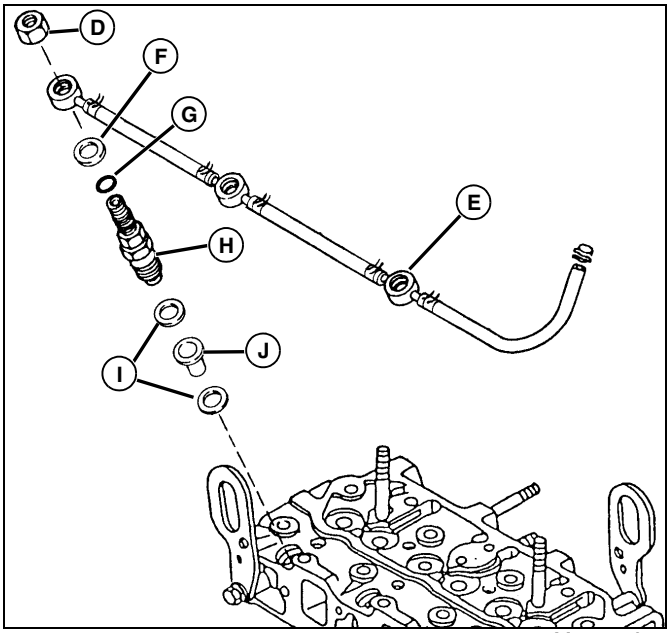
MX0770

2. Loosen fuel line connectors (A) at injection pump to release pressure in the fuel system. When loosening connectors, use a backup wrench (B) to prevent delivery valves from turning.



MX0771

3. Remove fuel line nuts at injector nozzles (C) and remove injector lines.



M82323A

4. Remove nut (D) from each injector. Remove leak-off hoses and fittings (E).

5. Remove bronze washers (F) and O-rings (G).

6. Remove injection nozzle (H), washers (I) and heat protector (J).

7. Test injection nozzles. (See “Test Fuel Injection Nozzle” on page 119.)

Installation

Installation is done in the reverse order of removal.

1. Replace heat protectors, washers, and O-rings.

2. Tighten injector nozzle body (H) to specification.

3. Tighten leak-off fitting nut (D) to specification.

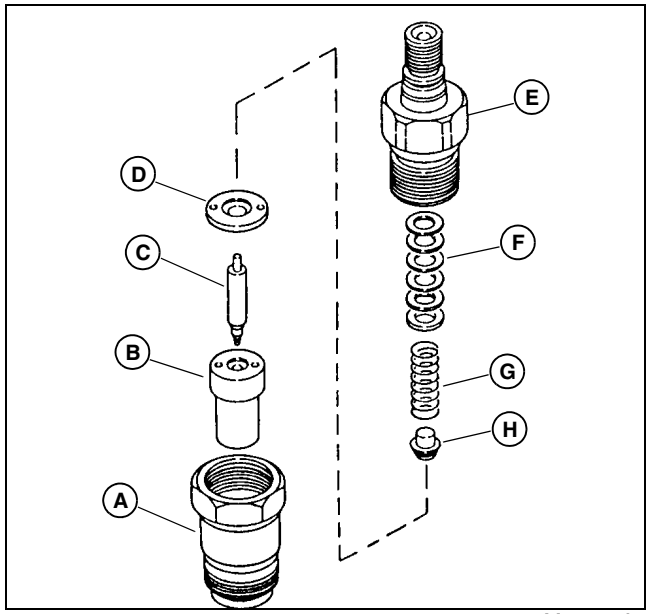
4. Tighten fuel lines to specification.

Repair

IMPORTANT: Avoid damage! If injection nozzles are disassembled to be cleaned, the same number and thickness of shims must be installed.

NOTE: If servicing more than one nozzle, keep parts for each nozzle separate from one another.

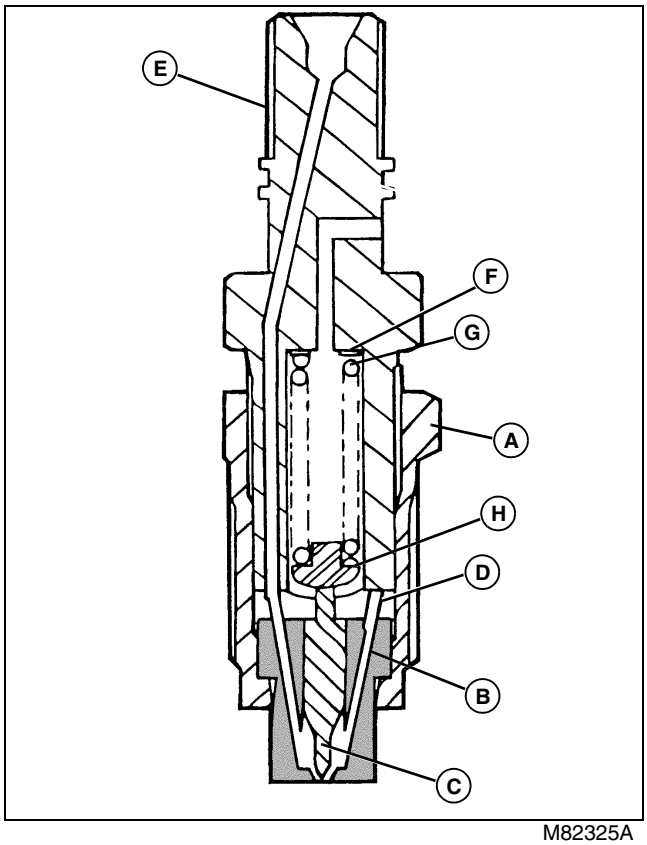
- Clean and inspect nozzle assembly. (See “Cleaning and Inspection” on page 169.)
- After assembly is complete, test injection nozzle. (See “Test Fuel Injection Nozzle” on page 119.)



M82324A

A - Nozzle Fitting
B - Nozzle Body
C - Nozzle Valve
D - Separator Plate
E - Injector Body
F - Shim(s) (As required)
G - Spring
H - Spring Seat

Injection Nozzle Cross Section



M82325A

- **A - Nozzle Fitting**
- **B - Nozzle Body**
- **C - Nozzle Valve**
- **D - Separator Plate**
- **E - Injector Body**
- **F - Shim(s) (As required)**
- **G - Spring**
- **H - Spring Seat**

Cleaning and Inspection

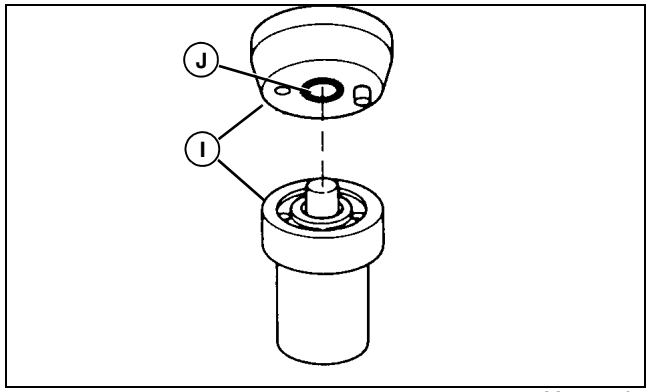
NOTE: To clean nozzles properly, JDF13 Nozzle Cleaning Kit is recommended. The Cleaning Kit is available through the John Deere SERVICEGARD™Catalog.

1. Remove anticorrosive grease from new or reconditioned nozzles by washing them thoroughly in diesel fuel.

IMPORTANT: Avoid damage! Never use a steel brush to clean nozzles as this will distort the spray hole.

2. Remove carbon from used nozzles, and clean by washing in diesel fuel. If parts are coated with hardened carbon or lacquer, it may be necessary to use a brass wire brush (supplied in JDF13 Nozzle Cleaning Kit).

3. After removing carbon or lacquer from the exterior of nozzle, inspect sealing surfaces between separator plate and nozzle body for nicks or scratches.



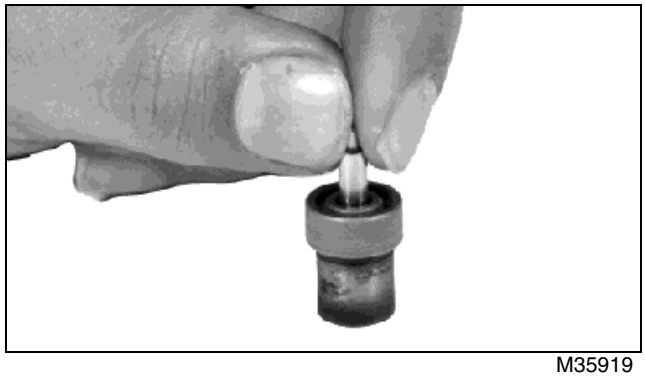
M82326A

4. Inspect condition of separator plate and nozzle body. Contact area of separator plate (I) (both parts) must not be scored or pitted. Use an inspection magnifier (No. 16487 or equivalent) to aid in making the inspection.

5. Check nozzle contact surface (J) on separator plate for wear. If contact surface is more than 0.10 mm (0.0039 in.), replace nozzle assembly.

6. Inspect the piston (large) part of nozzle valve to see that it is not scratched or scored and that lower (tip) end of valve is not broken. If any of these conditions are present, replace the nozzle assembly.

7. Further inspect the nozzle assembly by performing a slide test. Use the following procedure:



M35919

- Dip the nozzle valve in clean diesel fuel. Insert valve in nozzle body.
- Hold nozzle vertical, and pull valve out about 1/3 of its engaged length.
- Release valve. Valve should slide down to its seat by its own weight.

Replace nozzle assembly if the valve does not slide freely to its seat.

Specifications

Injector Nozzle Body Torque . . . . . 50 N•m (37 lb-ft)
Leak-Off Fitting Nut Torque . . . . . 40 N•m (30 lb-ft)
Fuel Line Torque . . . . . 40 N•m (30 lb-ft)

Remove and Install Fuel Injection Pump

CAUTION: Avoid injury! Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury should reference a knowledgeable source. Such information is available from the Deere & Company Medical Department in Moline, Illinois, U.S.A.

Removal

CAUTION: Avoid injury! DO NOT attempt to remove the CARB/EPA Certified Emissions fuel injection pump unless you are a factory trained technician with authorization to service CARB/EPA Certified Emissions engines.

IMPORTANT: Avoid damage! Never steam clean or pour cold water on injection pump while the pump is running or warm.

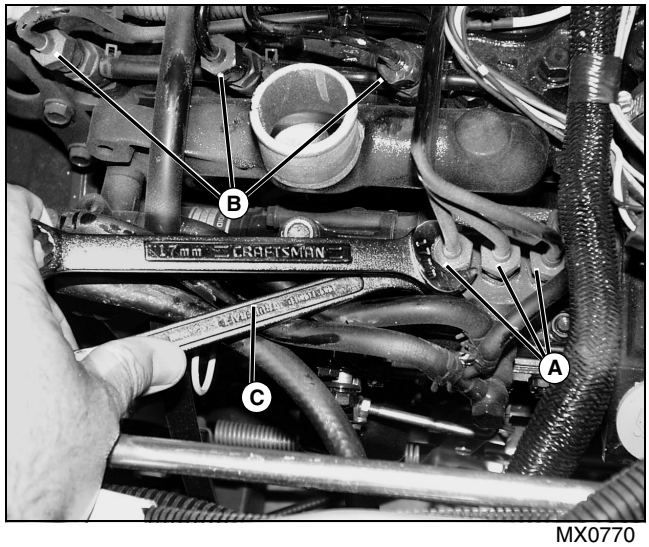
1. Park unit on level surface, park brake locked, ignition key off, transmission in neutral.

2. Turn the fuel shut-off valve on the fuel filter/water separator to the CLOSED (“C”) position.

3. Clean the injection pump lines and area around the pump using a parts cleaning solvent or steam cleaner.

4. Remove air cleaner hose.

IMPORTANT: Avoid damage! When removing injection lines, DO NOT turn pump delivery valve fittings. Turning fittings may damage pump internally. Always use a backup wrench when removing lines.

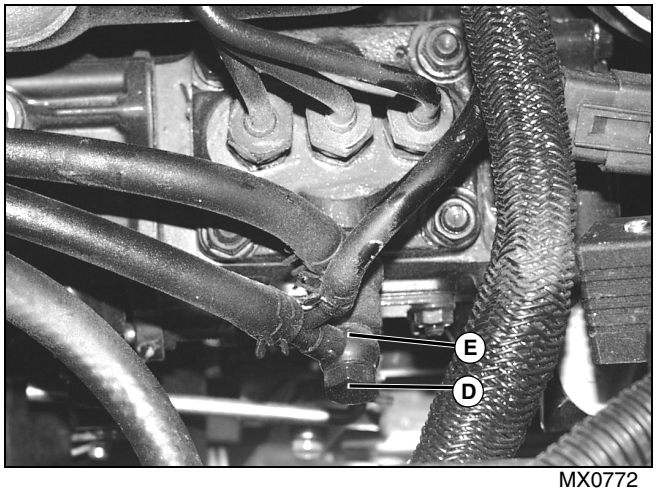


MX0770

5. Loosen fuel line nuts at fuel injection pump (A) and on the injector nozzles (B). When loosening connectors on the injector pump, use a backup wrench (C) to keep delivery valves from loosening.

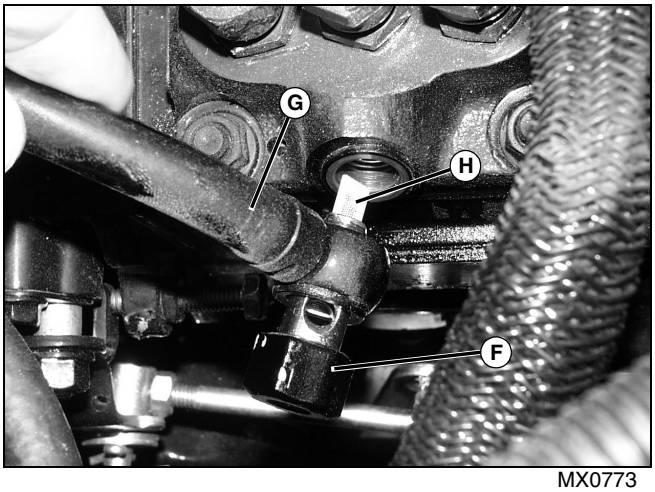
6. Remove injector lines.

NOTE: Note location of copper washers on each side of both fittings as they are removed.



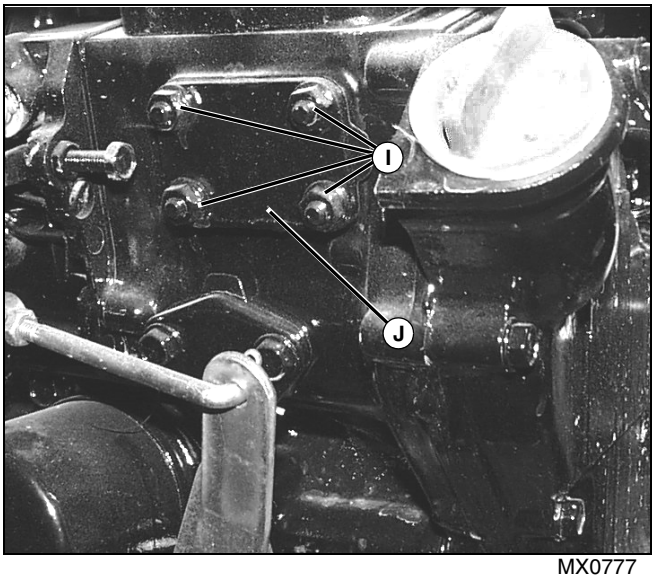
MX0772

7. Remove bolt (D) and return line fitting (E) from injection pump.



MX0773

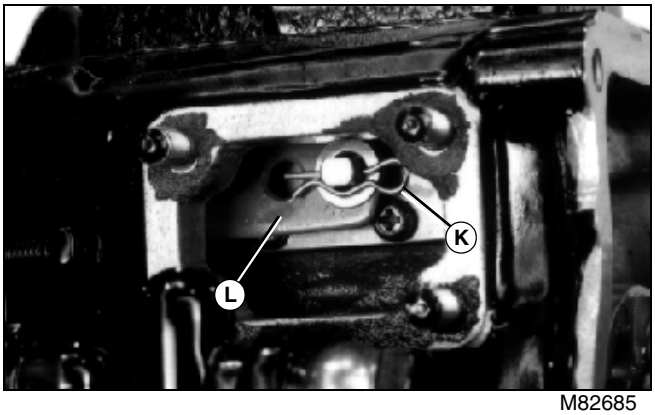
8. Remove special bolt (F) and fuel supply line (G). Be careful not to damage screen (H).



MX0777

9. Remove four nuts (I) and cover (J).

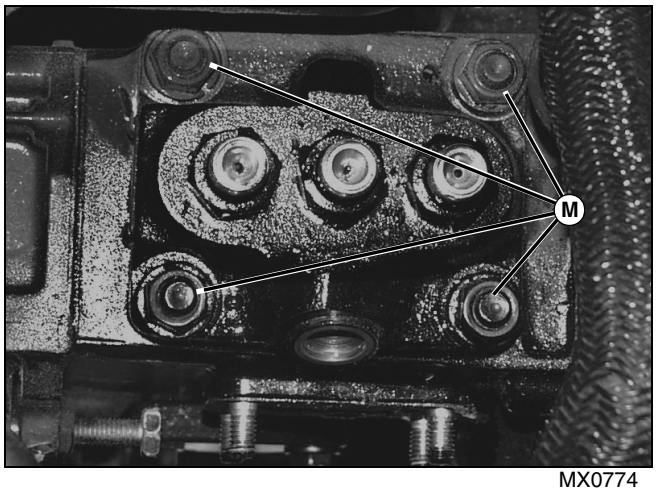
NOTE: Washer behind spring pin may or may not be fixed to linkage. Do not drop pin or washer during removal.



M82685

10.Remove spring pin (K) and washer, if removable. Disconnect governor linkage (L) from injection pump.

IMPORTANT: Avoid damage! If injection pump is being removed to be serviced or replaced, the same thickness of new shims must be installed when pump is assembled. New shims must be used.

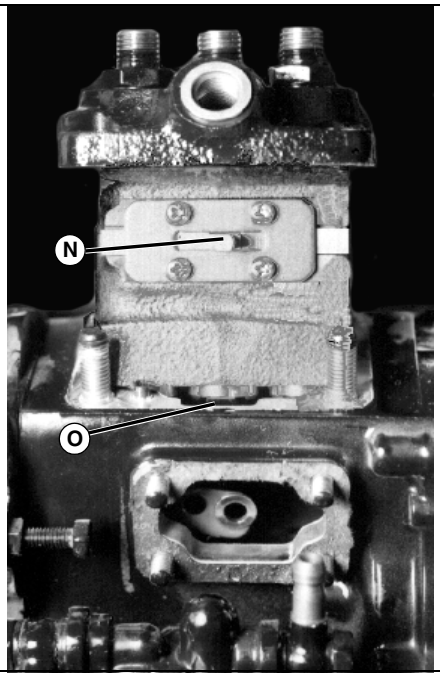


MX0774

11.Remove four mounting nuts (M) and washers from injector pump mounting flange.

CAUTION: Avoid injury! DO NOT attempt to adjust the CARB/EPA Certified Emissions fuel injection pump unless you are a factory trained technician with authorization to service CARB/ EPA Certified Emissions engines.

IMPORTANT: Avoid damage! Do not pry fuel injection pump from governor housing with sharp edge tool. Timing shims and/or housing may be damaged. Make sure rack pin (N) is lined up with notch (O) in center of housing, or it may catch and break pin.



M76983

12.Carefully pull injector pump straight up from governor housing. Make sure rack pin (N) is lined up with notch (O) in center of housing.

Installation

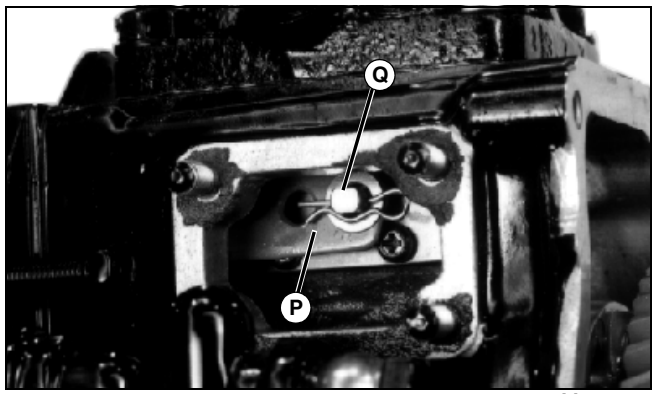
Installation is done in the reverse order of removal.

CAUTION: Avoid injury! DO NOT attempt to adjust the CARB/EPA Certified Emissions fuel injection pump unless you are a factory trained technician with authorization to service CARB/ EPA Certified Emissions engines.

IMPORTANT: Avoid damage! If a serviced or replacement fuel pump is installed, measure old shim thickness and install new shims of the same thickness.

NOTE: Governor linkage has two holes. Connect governor linkage to injection pump rack using hole at end of linkage.

Do not drop pin or washer into housing during installation. Place a small amount of engine assembly grease on washer to help keep it in place while assembling



M82685

- Install shims on top of governor housing to match thickness of original shims.
- When connecting governor linkage (P) to injection pump rack (Q), attach link to rack at hole in end of linkage.
- If new injection pump is being installed, check and adjust injection pump timing. (See “Adjust Injection Pump Timing” on page 121.)

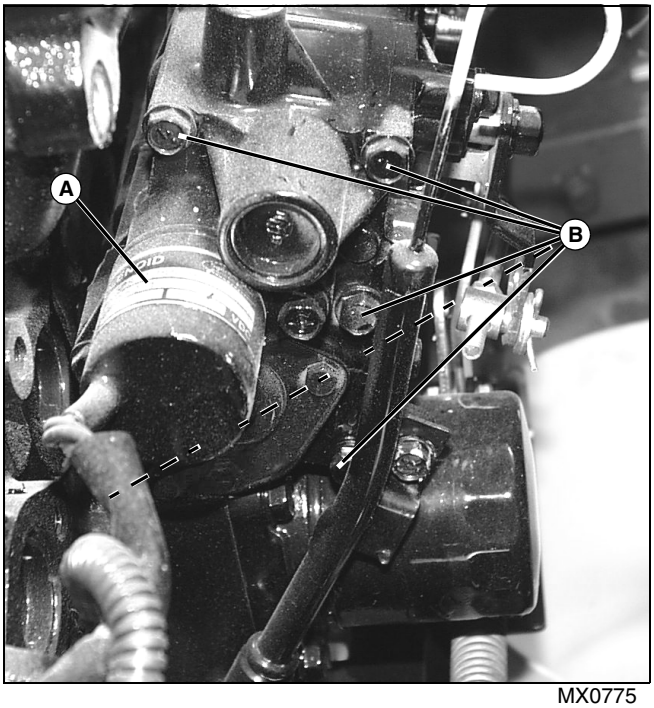
Repair Fuel Injection Pump Camshaft

Removal

1. Remove timing gear cover. (See “Remove and Install Timing Gear Cover” on page 138.)

2. Remove fuel injection pump. (See “Remove and Install Fuel Injection Pump” on page 170.)

3. Remove fuel transfer pump.

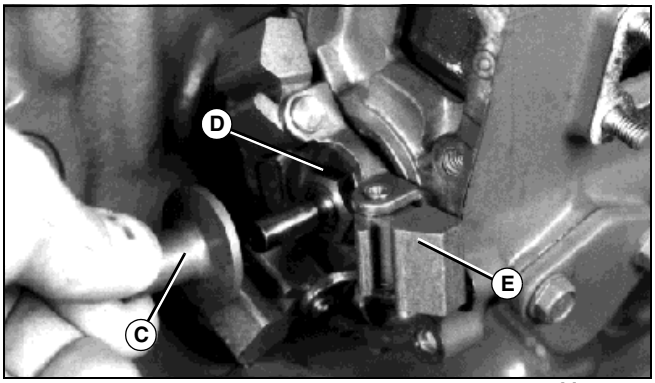


MX0775

4. Disconnect electrical lead and remove fuel shutoff solenoid (A).

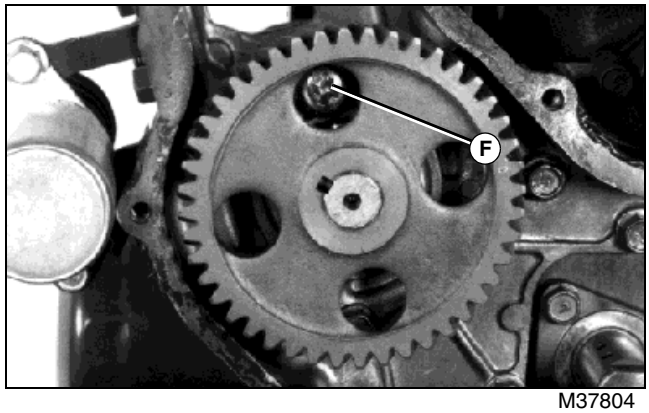
5. Remove five remaining cap screws (B) attaching governor assembly to timing gear housing.

6. Remove governor housing assembly.



M37755

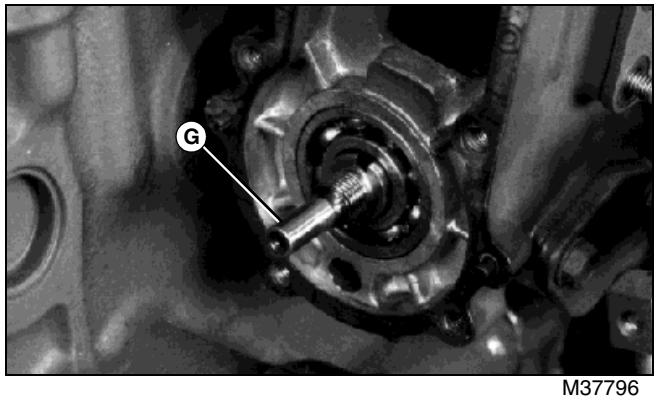
7. Remove sleeve (C), nut (D) and governor weights (E) from end of injection pump camshaft.



M37804

8. Remove bearing retaining screw (F).

IMPORTANT: Avoid damage! DO NOT allow fuel injection pump camshaft lobes to hit bearing surfaces while removing camshaft. Machined surfaces may be damaged.



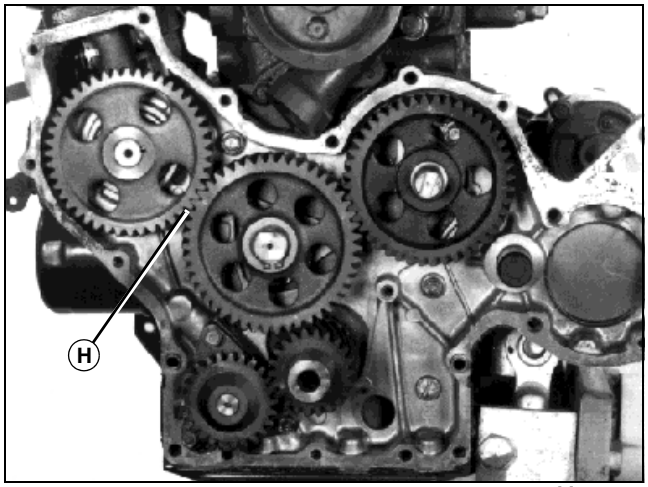
M37796

9. Carefully tap the rear of camshaft (G) with a plastic hammer to remove camshaft from housing.

10. Disassemble and inspect all parts for wear or damage. (See “Inspection” on page 174.)

Installation

Installation is done in reverse order of removal.



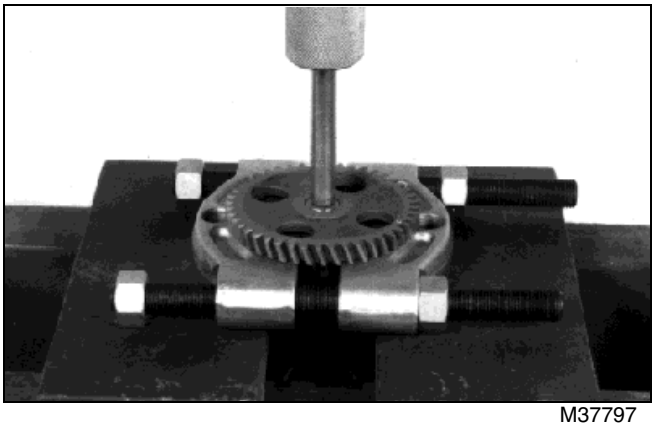
M37832

- Align timing marks (H) on injection pump gear and idler gear when installing camshaft.
- After installing camshaft assembly into housing, tap on end of camshaft gear with a plastic hammer to seat bearings in bores.

Disassembly

IMPORTANT: Avoid damage! Hold camshaft while removing gear and bearing. Shaft can be damaged if dropped.

NOTE: Gear and bearings are press fit on shaft.



M37797

1. Remove gear using knife edge puller and a press.
2. Remove key.
3. Remove bearings using a knife edge puller and a press.
4. Inspect all parts for wear or damage. (See “Inspection” on page 174.)

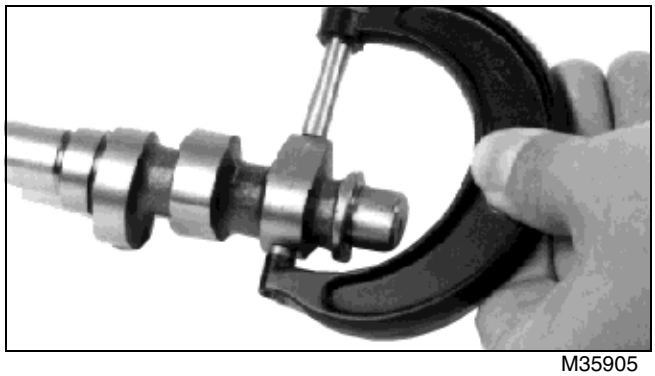
Assembly

IMPORTANT: Avoid damage! When pressing bearings apply pressure on the inner bearing race only.

NOTE: Install large bearing on gear end.

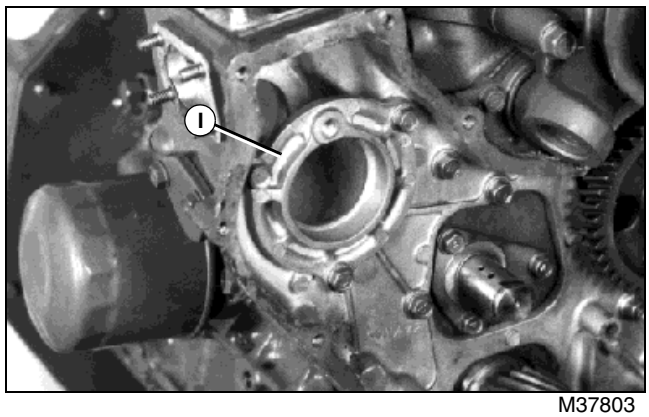
1. Install bearings on ends of camshaft using a 3/4 in. deep well socket and a press. Press until bearing races bottom on camshaft shoulders.
2. Install key.
3. Put camshaft gear on a flat surface and press camshaft assembly into gear. Press until gear shoulder bottoms against inner bearing race.

Inspection



M35905

- Measure height of each camshaft lobe. Replace camshaft if lobe height is less than specification.



M37803

- Inspect camshaft bearing supports (I) in timing gear housing. Check for cracks, damage or indications that bearings have spun in support.

If rear bearing bore is damaged, replace timing gear housing.

If front bearing bore is damaged, remove three cap screws and replace support.

- Inspect all parts for wear or damage. Replace as necessary.

Specification

Fuel Injection Pump Camshaft

Lobe Height (Min) . . . . . 30.90 mm (1.217 in.)

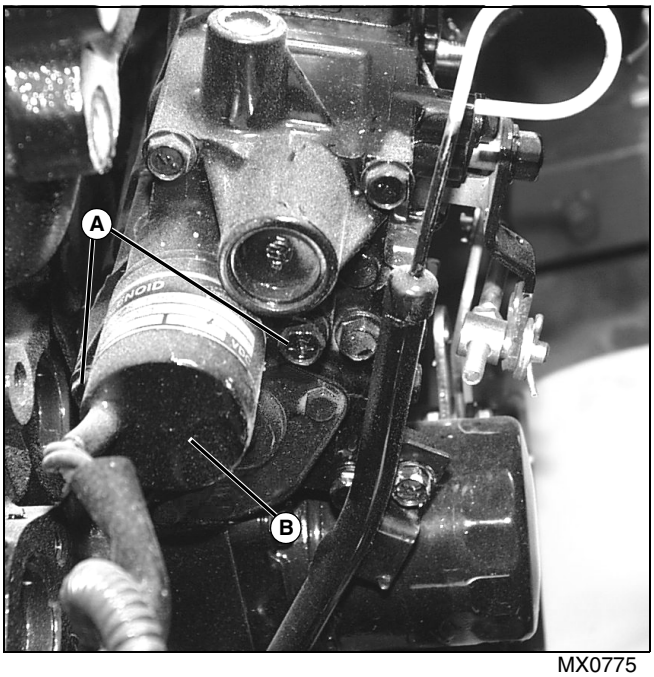
Remove and Install Fuel Shutoff Solenoid

Removal

1. Park unit on level surface, park brake locked, ignition key off, transmission in neutral.

2. Clean around the fuel shutoff solenoid using a parts cleaning solvent or steam cleaner.

3. Disconnect the electrical lead to the fuel shutoff solenoid.



MX0775

4. Remove the two solenoid mounting cap screws (A) and remove solenoid (B) from governor housing.

5. Test fuel solenoid. (See “Fuel Shutoff Solenoid Test - Diesel Engine” on page 324.)

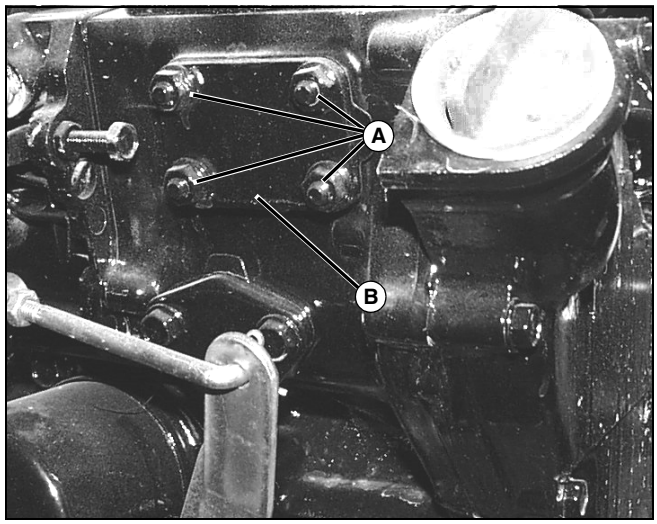
Installation

Installation is in reverse of removal.

- Check condition of O-ring on solenoid before installing.

Repair Fuel Control and Governor Linkage

Removal

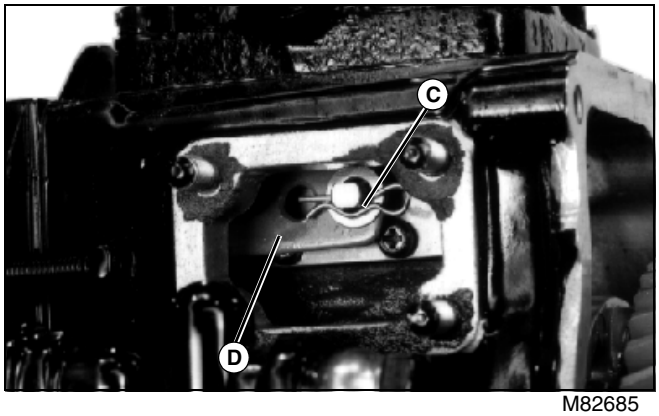


MX0777

1. Disconnect and remove fuel shutoff solenoid.

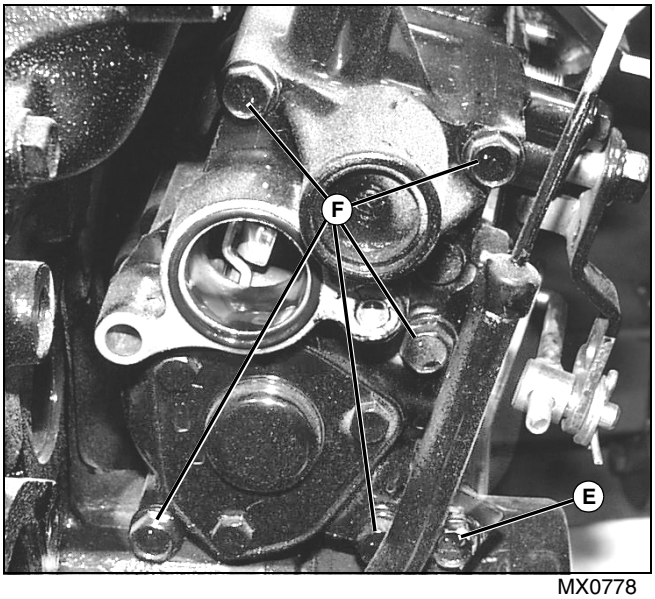
2. Remove four nuts (A), governor linkage cover (B) and gasket.

NOTE: Washer may or may not be fixed to linkage. Do not drop pin or washer during removal.



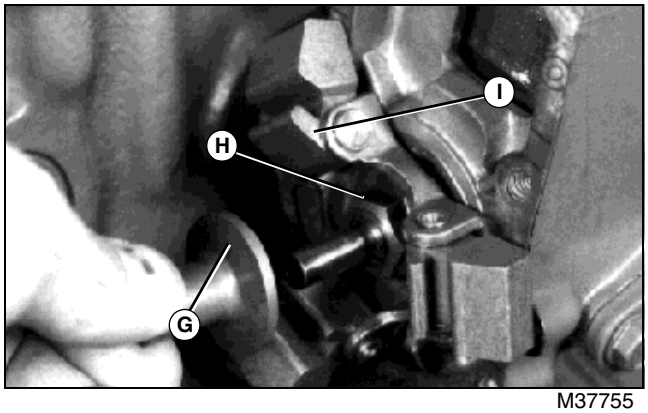
M82685

3. Remove pin and washer (C) to disconnect governor linkage (D).



MX0778

4. Remove cap screw (E) securing dipstick tube and remove dipstick tube.
5. Remove five cap screws (F) attaching governor housing.
6. Remove governor housing and gasket.



M37755

7. Remove sleeve (G).
8. Remove nut (H) and governor weights (I).
9. Disassemble and inspect all parts for wear or damage.

Installation

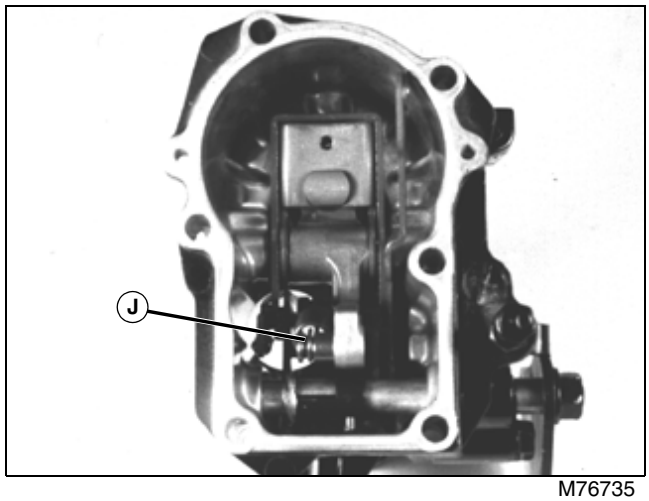
Installation is done in the reverse order of removal.

- Governor linkage has two holes. Connect governor linkage to injection pump rack using hole closest to front of engine.

NOTE: Do not drop pin or washer into housing during installation. Place a small amount of engine assembly grease on washer to help keep it in place while assembling.

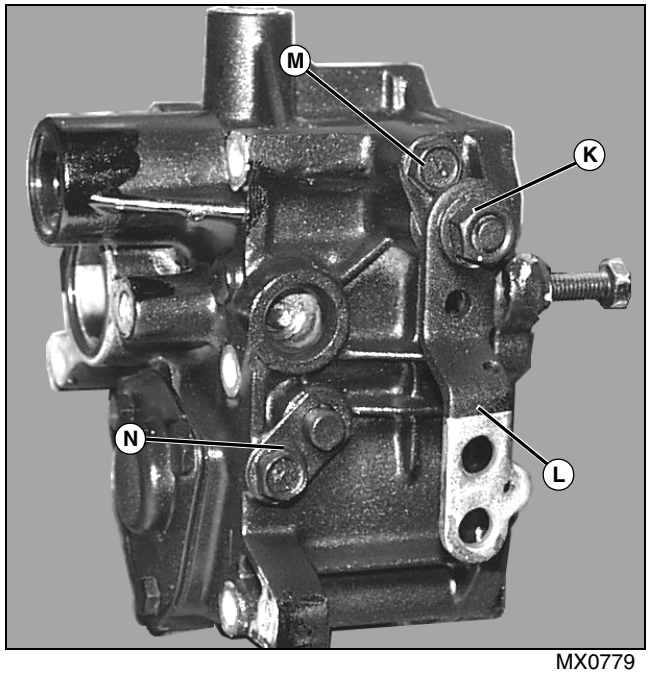
- Check and adjust slow idle settings. (See “Adjust Slow Idle” on page 114.)

Disassembly



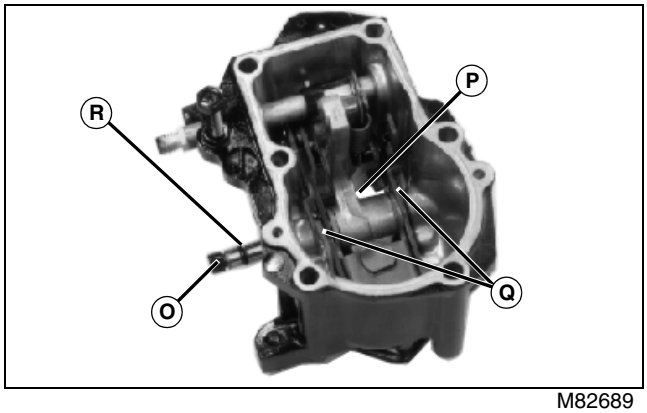
M76735

1. Remove spring (J).



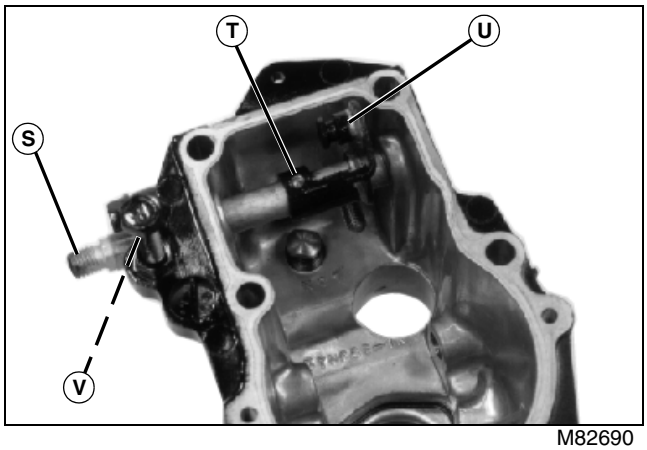
MX0779

2. Remove nut (K) and throttle lever (L).
3. Remove cap screw and throttle shaft retaining plate (M).
4. Remove cap screw and governor shaft retaining plate (N).



M82689

5. Remove governor shaft (O), governor linkage assembly (P), shims (Q), and O-ring (R).

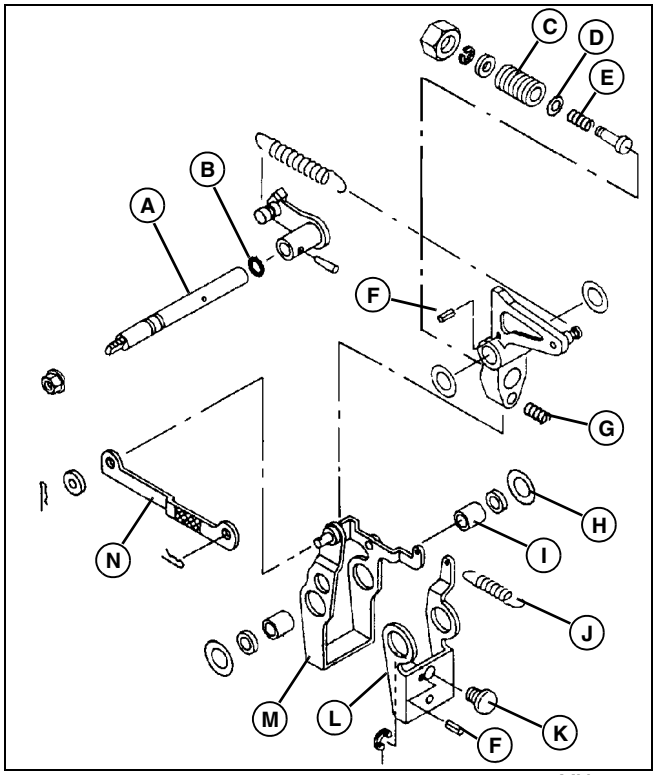


M82690

6. Rotate throttle shaft assembly (S) as shown.

7. Remove tapered pin (T) from tapered hole using a punch.

8. Remove throttle shaft (S), shaft lever (U), and O-ring (V).



MX0762

A - Throttle Shaft
B - O-Ring
C - Adjuster Stud
D - Shim(s) (As required)
E - Spring
F - Spring Pin
G - Spring
H - Shim
I - Bushing
J - Spring
K - Pin
L - Governor Lever
M - Bracket
N - Governor Link

9. Disassemble governor linkage assembly.

10.Inspect all parts for wear or damage. Replace as necessary. (See Fuel Control and Governor Linkage Inspection.)

Assembly

Assembly is done in the reverse order of disassembly.

- Apply clean engine oil on all internal parts.
- When installing throttle shaft:

Install new O-ring, throttle shaft, and shaft lever.

Install tapered pin in tapered hole.

• Slow idle adjustments are made after engine has been installed in the machine. (See “Adjust Slow Idle” on page 114.)

Inspection

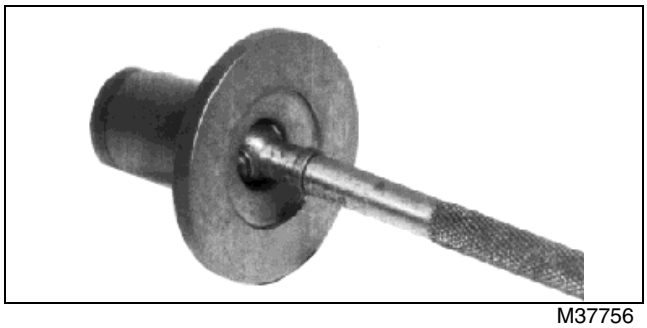
M37763

1. Measure governor shaft diameter. If OD is less than 8.01 mm (0.315 in.), replace governor shaft.

2. Measure governor shaft bore diameter in governor linkage.

If shaft bore exceeds wear limit, replace governor linkage.

If bore clearance (bore ID minus shaft OD) exceeds specification, replace governor shaft, governor linkage or both.



M37756

3. Measure inside diameter of sleeve. If ID is more than 9.00 mm (0.354 in.), replace sleeve.

M37757

4. Measure injection pump camshaft diameter.

If camshaft diameter is less than wear limit, replace injection pump camshaft.

If clearance (sleeve ID minus camshaft OD) exceeds specification, replace sleeve, injection pump camshaft or both.

Specifications

Governor Shaft Bore ID

Wear Limit	**8.50 mm (0.299 in.)**
Clearance	**0.09 mm (0.003 in.)**

Injection Pump Camshaft OD

Wear Limit	**7.90 mm (0.311 in.)**
Clearance	**0.15 mm (0.006 in.)**

ELECTRICAL TABLE OF CONTENTS

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Specifications

Specifications

Battery

Voltage	12 VDC
Rating	45 amp-hr
BCI Group	55
CCA Rating -18° C (0° F)	500 Amps
Reserve Capacity (Minutes)	38
Specific Gravity	1.280 or above
Electrolyte Required Fill (Approximately)	2.0 qt (1.9L)
Load Test (Minimum)	340 amps for 15 seconds

Starting Motor

Type	Solenoid Shift
Starting Motor Current Draw While Cranking Engine (Max)	150 amps
Starting Motor Current Draw (Max) (No Load at 4300 RPM)	60 amps
Starting Motor RPM (Min at No Load)	4000 rpm

Alternator

Rating (Standard)	40 amps
Unregulated Amperage (Min)	50 amps
Regulated Voltage	12.4-13.2 VDC
Regulated Voltage (Max)	14.7 VDC
Unregulated Voltage	50 VAC

Electric and Manual Choke - Gasoline

Electric Choke Engine Serial Number	-CH3009G007962
Manual Choke Engine Serial Number	CH3009G007963-

Fuel Shut-Off Solenoid - Diesel

Voltage	12 VDC
Pull-in Voltage	6.8 VDC
Hold Voltage	3.0 VDC

Sensors

Fuel Gauge Resistance (Variable)	33-240 ohms
Fuel Gauge Voltage Drop across Gauge (Full-Empty)	5.72-0.87 VDC
Engine Oil Pressure Switch Closes At	49 kPa (7.1 psi)

Engine Coolant Temperature Sensor

Resistance at 71°C (160°F)	100 ohms
Resistance at 82°C (180°F)	80 ohms
Resistance at 93°C (200°F)	60 ohms
Resistance at 71°C (240°F)	100 ohms

ELECTRICAL SPECIFICATIONS

Lighting

Headlights (Dual Halogen)	**37.5 Watts**
Tail Light	**5 Watts, dual element, bayonet base**
Hazard Lights (Front)	**2 candle power, single element, 14 VDC (max), Type 194**
Hazard Lights (Rear)	**32 candle power, single element, 14 VDC (max), Type 1156**
Instrument Panel Lamps	**0.2 candle power, single element, 14 VDC (max), Type PC194**

Ignition

Ignition Ballast Resistor Resistance	**1.5 ohms**
Ignition Coil Primary Resistance	**4.6 ohms**
Ignition Coil Secondary Resistance	**16,500 ohms**
Choke Coil Resistance	**10.5 ohms**

General Information

Operation and Diagnostics

The operation and diagnostics stories divide the electrical system into individual circuits by function. Each circuit is isolated from the main wiring schematic and only shows the components that are used in it. The story contains information on function, operating conditions, and theory of operation. The circuit schematics are drawn with the components in the operating position, with the power, or battery positive, into them across the top and the ground, or battery negative, across the bottom.

Diagnostic Information

The diagnostic procedures is used to test the complete circuit regardless of the problem or complaint. Select a symptom or system from the quick check or troubleshooting chart and follow the test procedures under that heading.

The diagnostic procedure lists:

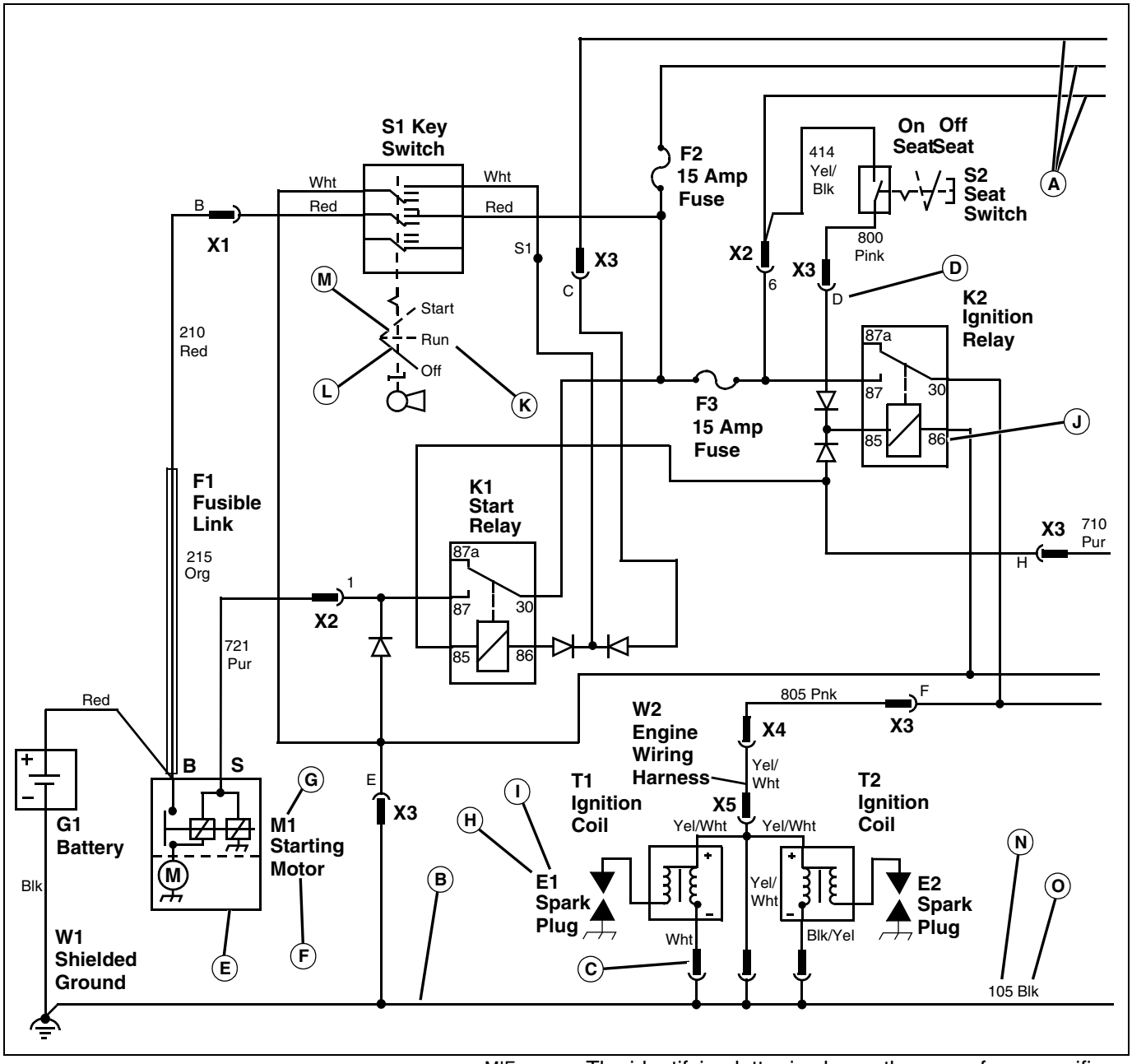
- Test conditions
- Test sequence
- Test location
- Normal reading
- Check or test to perform if reading is not normal

When performing the test or check, be sure to set your machine up to the test conditions listed and follow the sequence carefully. performing the test or check. If the results of the test or check are not normal, perform the test, The diagram that accompanies each test procedure is drawn to resemble machine components. The key letter on the art matches the letter in the procedure and the leader line points to the exact point the test is to be made.

Wire Color Abbreviation Chart

Blk	**Black**
Blu	**Blue**
Brn	**Brown**
Grn	**Green**
Gry	**Gray**
Org	**Orange**
Pnk	**Pink**
Pur	**Purple**
Red	**Red**
Tan	**Tan**
Wht	**White**
Yel	**Yellow**
Blk/Wht	**Black/White**
Blu/Wht	**Blue/White**
Brn/Wht	**Brown/White**
Brn/Yel	**Brown/Yellow**
Dk Blu	**Dark Blue**
Dk Brn/Lt Grn	**Dark Brown/Light Green**
Dk Brn/Red	**Dark Brown/Red**
Dk Brn/Yel	**Dark Brown/Yellow**
Dk Grn	**Dark Green**
Lt Blue	**Light Blue**
Lt Grn	**Light Green**
Org/Wht	**Orange/White**
Pnk/Blk	**Pink/Black**
Pur/Wht	**Purple/White**
Red/Blk	**Red/Black**
Red/Wht	**Red/White**
Wht/Blk	**White/Black**
Wht/Red	**White/Red**
Yel/Blk	**Yellow/Black**
Yel/Red	**Yellow/Red**
Yel/Wht	**Yellow/White**

Reading Electrical Schematics



MIF

The schematic is made up of individual circuits laid out in a sequence of related functions. It is formatted with all power wires (A) across the top and all ground wires (B) across the bottom. Current flow is generally from top to bottom through each circuit and component. All components are shown in the off position. The diagram does not list connector (C) information unless needed to avoid confusion. If the connector is shown, the number next to it is the terminal pin location (D) in the connector.

Each component is shown by a symbol (E), its name (F), and an identification code (G). The identification code contains a device identifying letter (H) and number (I).

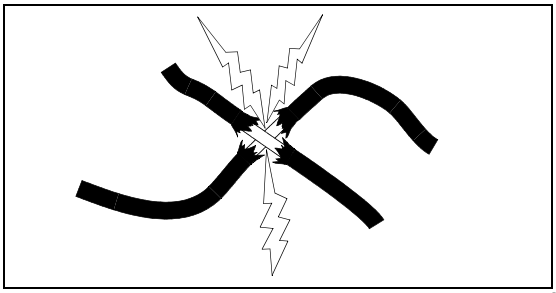
The identifying letter is always the same for a specific component, but the identifying numbers are numbered consecutively from upper left to lower right. The terminal designation (J) is placed directly inside or outside the symbol next to the connecting wire path. Switch positions (K) are also placed directly inside or outside the symbol. The solid line (L) shows the position the switch is currently in and dash lines (M) represent other switch positions.

The circuit number (N) and wire color (O) of the wires are shown directly next to the wire path.

The same component name and identification code are used consistently on all diagrams in this section. Components can be easily cross-referenced.

Common Circuit Tests

Shorted Circuit



MIF

A shorted circuit may result in the wrong component operating (i.e. improper wire-to-wire contact). To test for a shorted or improperly wired circuit:

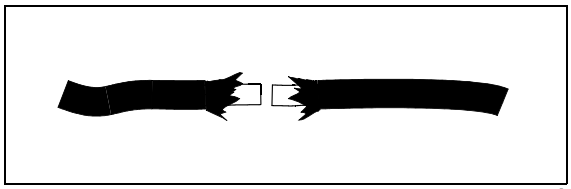
1. Turn component switch on.

2. Start at the controlling switch of the component that should not be operating.

3. Follow the circuit and disconnect wires at connectors until component stops operating.

4. Shorted or improper connections will be the last two wires disconnected.

High Resistance or Open Circuit



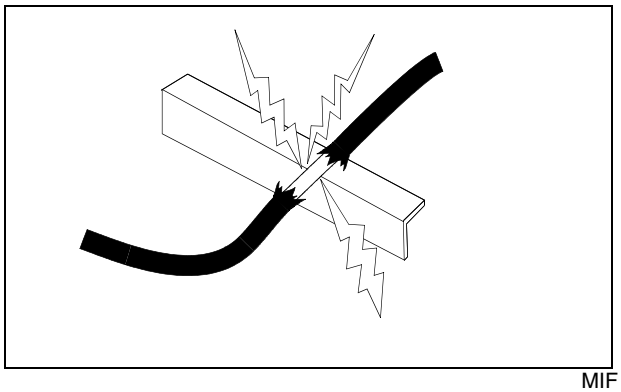
MIF

1. High resistance or open circuits usually result in slow, dim or no component operation (i.e. poor, corroded, or disconnected connections). Voltage at the component will be low when the component is in operation. To test for high resistance and open circuits:

2. Check all terminals and grounds of the circuit for corrosion.

3. If terminals are not corroded or loose, the problem is in the component or wiring.

Grounded Circuit



MIF

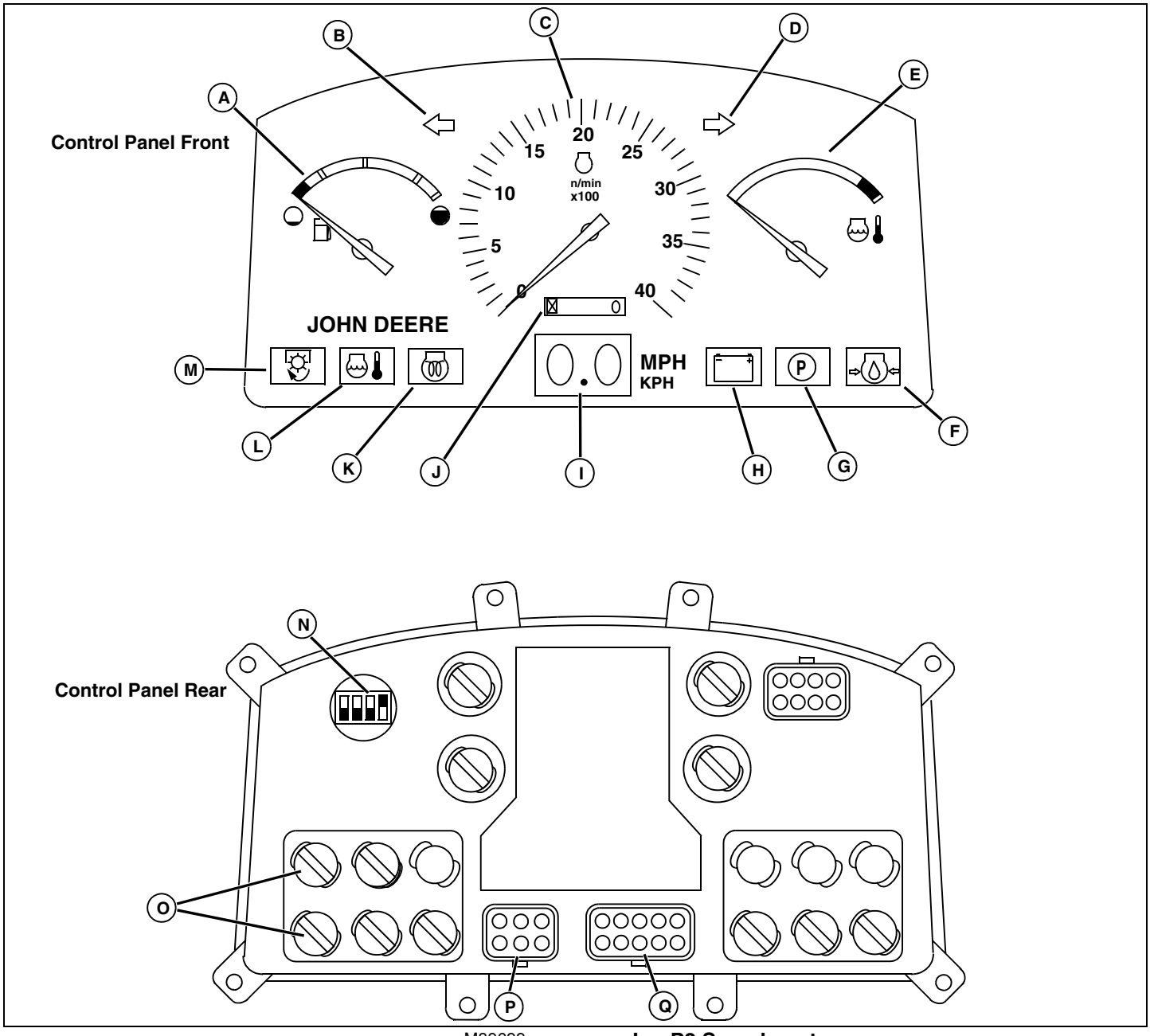
Grounded circuits usually result in no component operation or a blown fuse.

Conductors for 12 Volt Circuits

Standard Conductors For 12 Volt Circuits						
SAE Wire Size (Gauge)	20	18	16	14	12	10
Metric Wire Size (mm)	0.5	0.8	1.0	2.0	3.0	5.0
Typical Stranding	7 X 28	16 X 30	19 X 29	19 X 27	19 X 25	19 X 23
Minimum Conductor Area In Circular Mils	1072	1537	2336	3702	5833	9343

Component Location

Component Location - Instrument Panel

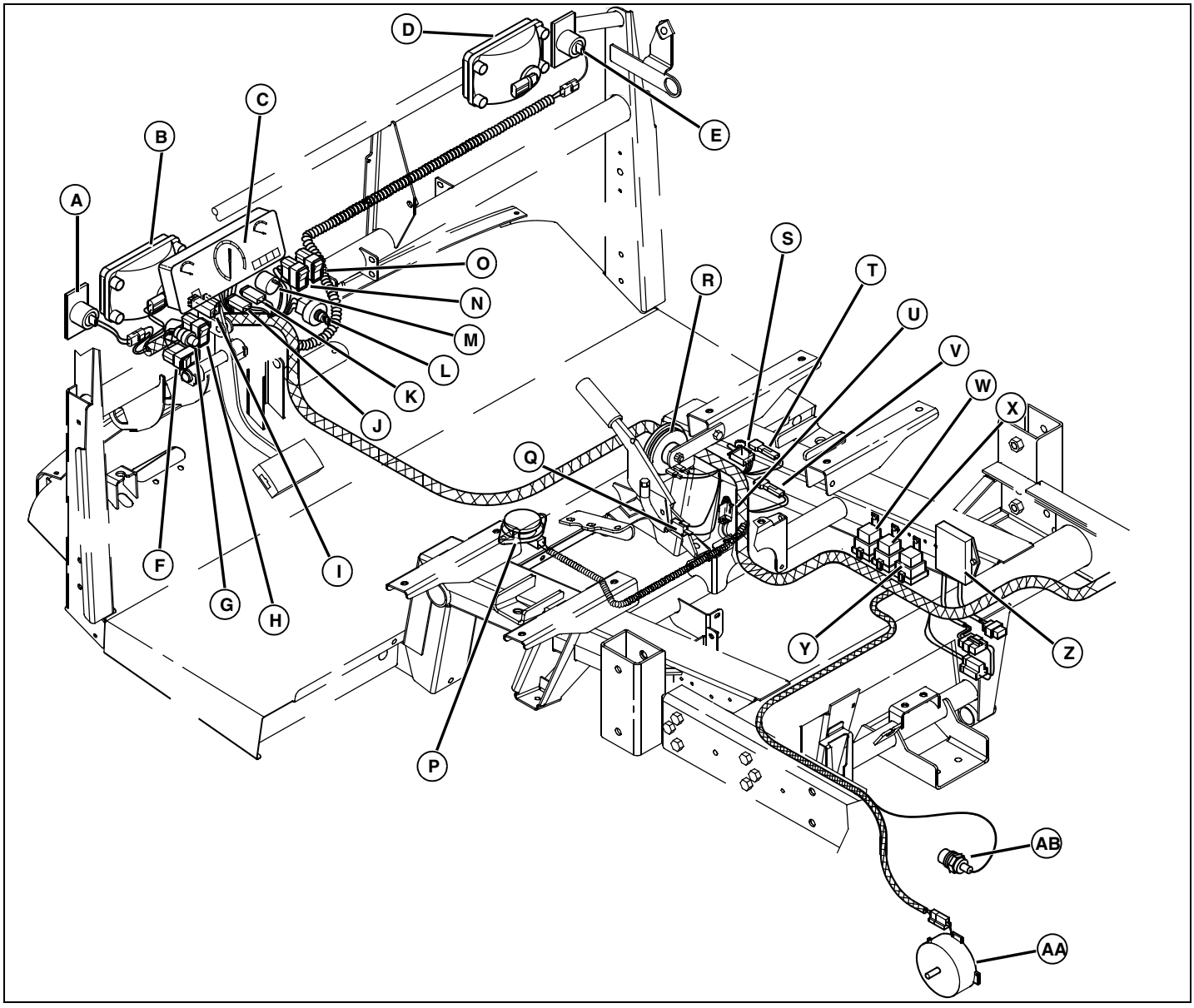


M89699

A - P4 Fuel Gauge
B - H5 LH Turn Signal/Hazard Light
C - P1 Engine Tachometer
D - H8 RH Turn Signal/Hazard Light
E - P3 Coolant Temp Gauge
F - H6 Engine Oil Pressure Light
G - H7 Parking Brake Light
H - H4 Discharge Light
I - P2 Speedometer
J - P5 Hour Meter
K - H10 Preheat Light (Diesel)
L - H3 Coolant Temperature Light
M - H2 PTO Engaged Light
N - Tach/Speed Calibration Switch
O - Indicator Lights
P - X4 Connector
Q - X3 Connector

ELECTRICAL COMPONENT LOCATION

Component Location

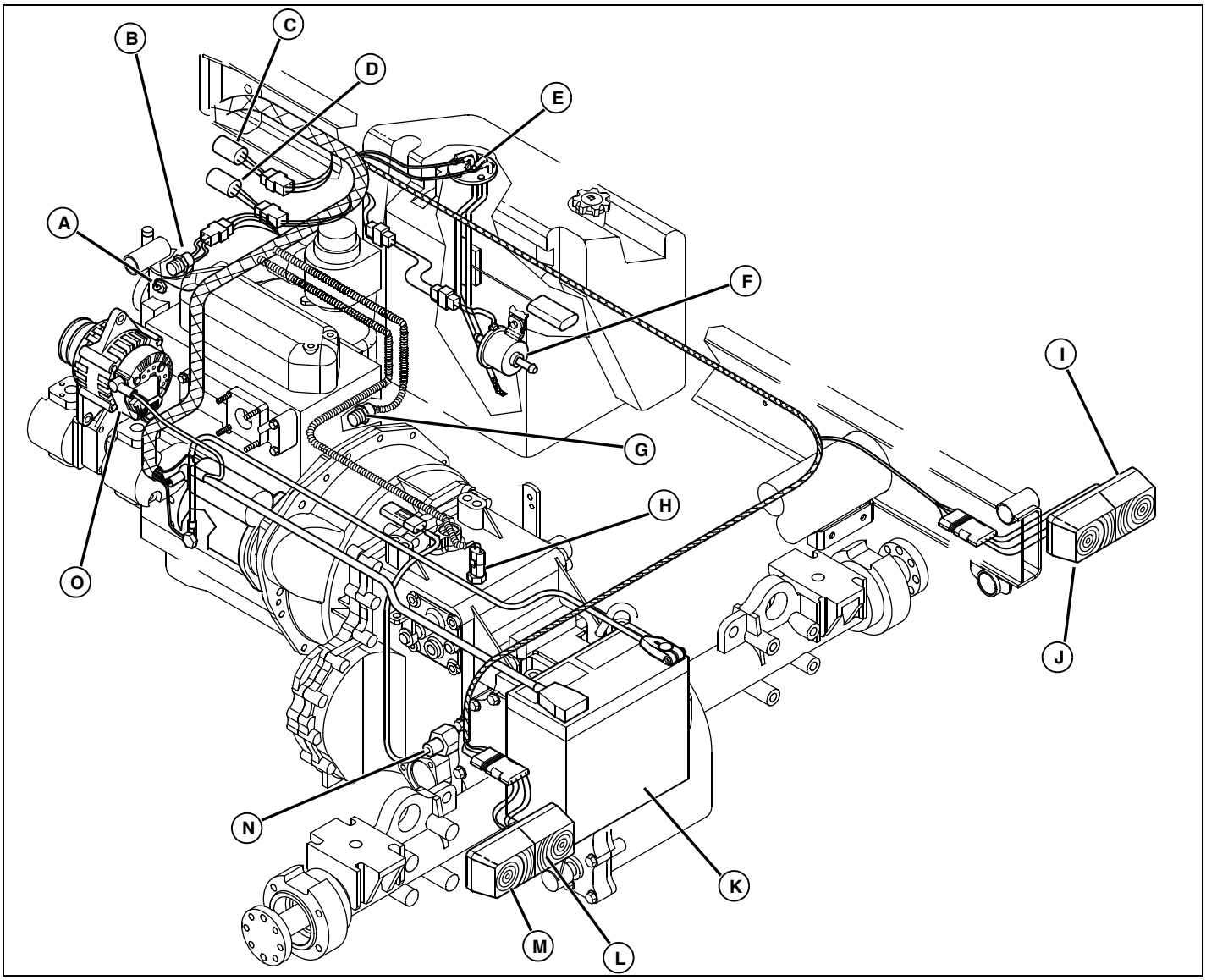


MIF

A - E7 LH Turn Signal
B - E5 LH Headlight
C - Instrument Panel
D - E6 RH Headlight
E - E8 RH Turn Signal
F - S9 Turn Signal Switch
G - S8 Horn Switch
H - S11 Headlight Switch
I - S5 Brake Switch
J - F2 10 Amp Fuse
K - F1 25 Amp Fuse
L - S1 Key Switch
M - K4 Flasher
N - S12 Work Light Switch
O - S10 Hazard Switch
P - S4 Seat Switch
Q - S3 Park Brake Switch
R - H1 Horn
S - S6 Mechanical PTO Switch
T - V1 Seat Diode
U - S7 PTO Engaged Sensor Switch
V - V2 PTO Diode
W - K1 Start Relay
X - K2 Seat Relay
Y - K3 Radiator Fan Relay
Z - A2 Ignition Module
AA- M2 Radiator Fan Motor
AB- B9 Hydraulic Oil Over temperature Switch

ELECTRICAL COMPONENT LOCATION

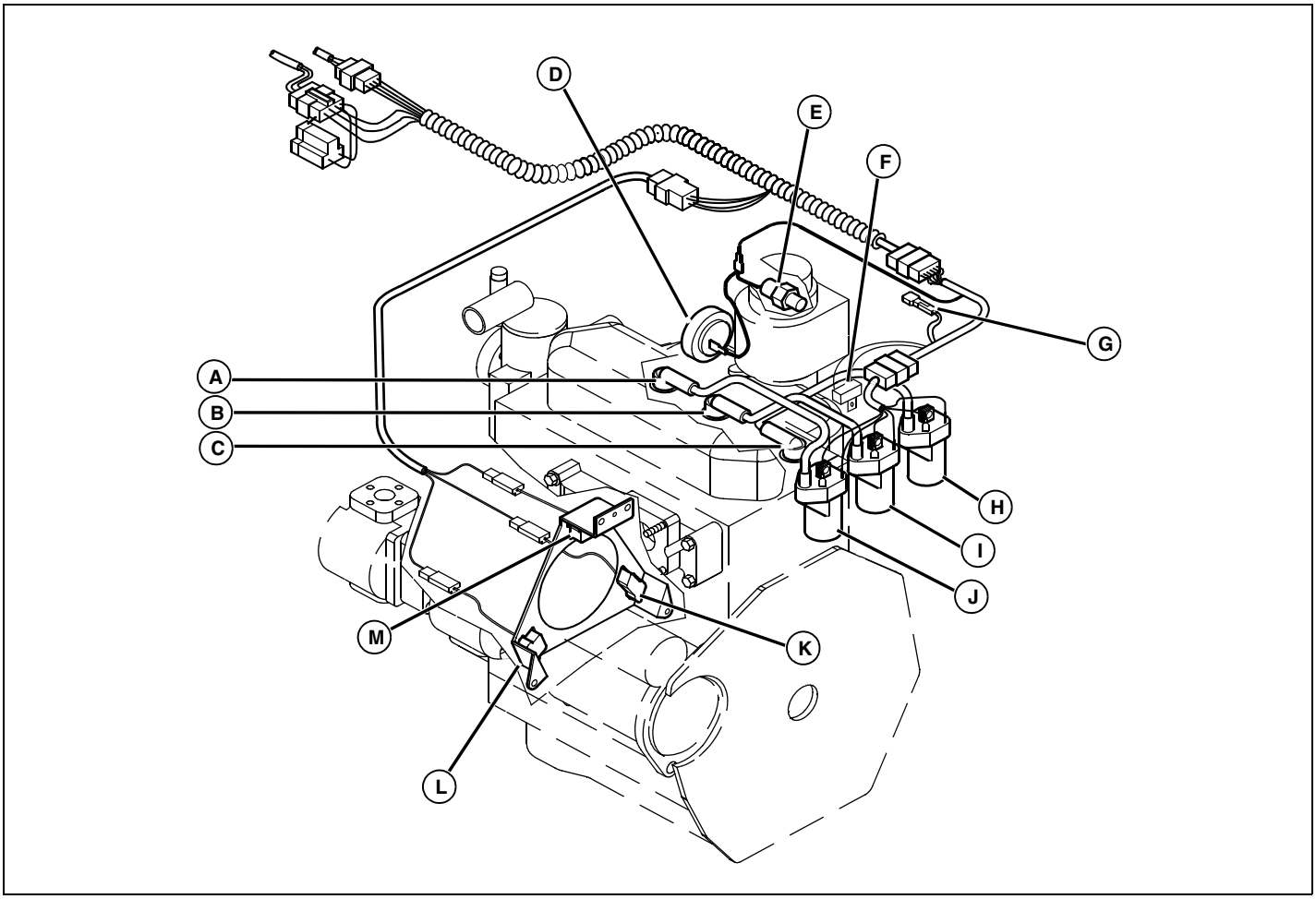
Component Location



MIF

A - B3 Engine Coolant Sensor
B - B1 Fan/Over Temp Switch
C - A1 Seat Delay Module (Old Harness)
D - A3 Off Delay Module
E - B2 Fuel Gauge Sensor
F - M3 Fuel Pump
G - B4 Engine Oil Pressure Switch
H - S2 Neutral Switch
I - E3 RH Tail Light
J - E4 RH Hazard Light
K - G1 Battery
L - E2 LH Hazard Light
M - E1 LH Tail Light
N - T1 Speed Sensor
O - G2 Alternator

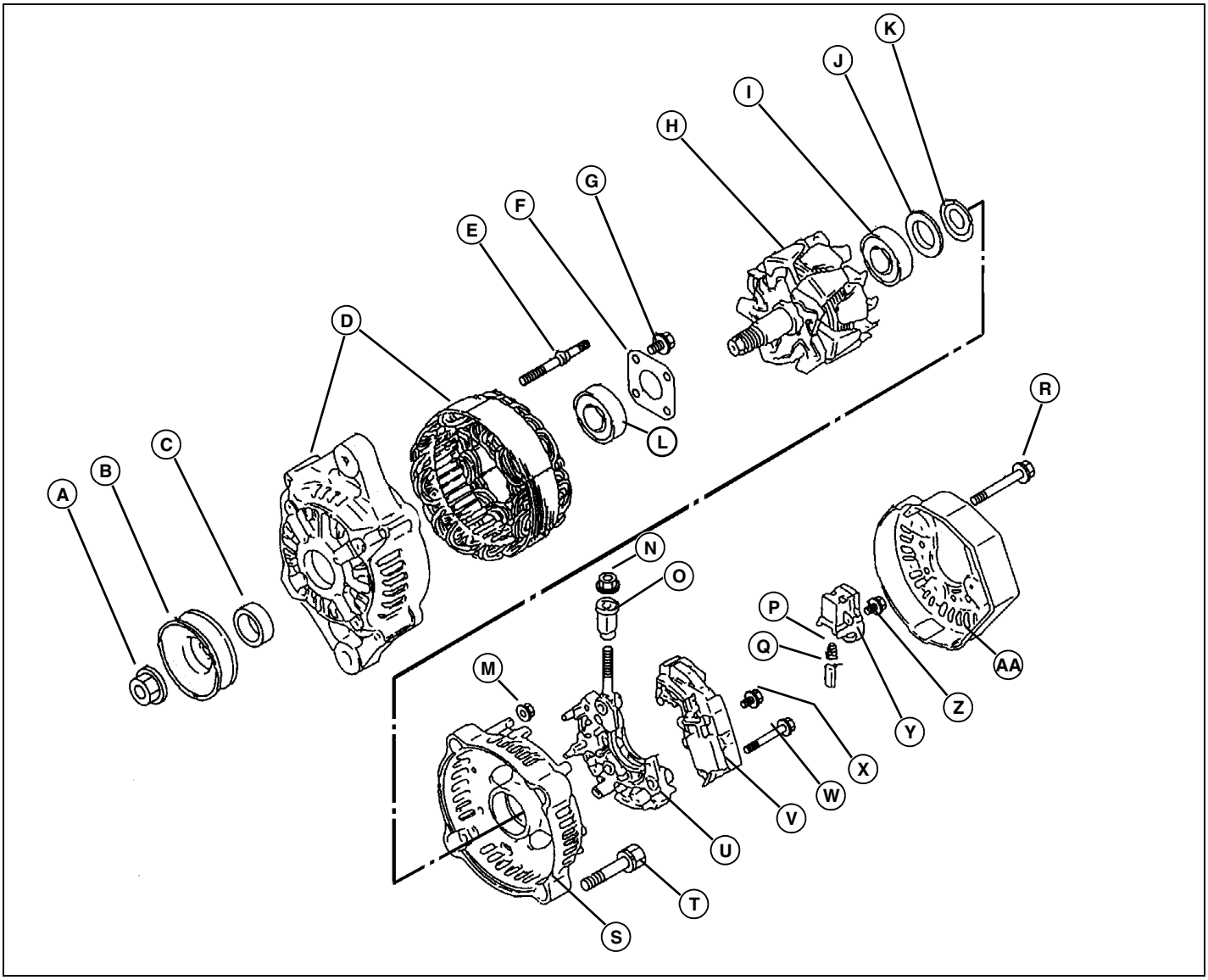
Component Location - Gasoline Engine



MIF

A - E12 Spark Plug
B - E13 Spark Plug
C - E14 Spark Plug
D - B5 Electric Choke Coil
E - Y2 Fuel Shutoff Solenoid
F - R4 Ignition Ballast Resistor
G - V3 Start Diode
H - T4 Ignition Coil #3
I - T3 Ignition Coil #2
J - T2 Ignition Coil #1
K - B7 Pulser Coil #2
L - B8 Pulser Coil #1
M - B6 Pulser Coil #3

Alternator Component Location



M91878

A - Nut
B - Pulley
C - Spacer
D - Frame Assembly
E - Stud
F - Plate
G - Screw (4 used)
H - Rotor
I - Bearing
J - Bearing Cover
K - Thrust Washer
L - Bearing
M - Nut (2 used)
N - Nut
O - Bushing
P - Spring
Q - Brush
R - Cap Screw
S - Rear Frame
T - Cap Screw
U - Holder
V - Voltage Regulator
W - Cap Screw with Washer (2 used)
X - Screw
Y - Brush Holder
Z - Screw (6 used)
AA- Rear Cover

Schematics and Harnesses

Electrical Schematic and Wiring Harness Legend

Serial Number Breaks

2020 Gas Engine Vehicle Main Wiring Harness

TC2020 2 Wheel Drive (Old). . . . . -020347
TC2020 2 Wheel Drive (New) 020348-
TC2020 4 Wheel Drive (Old). . . . . -020078
TC2020 4 Wheel Drive (New) 020079-

Components

A1 - Seat Delay Module (SE1, W1) OLD HARNESS
A2 - Solid State Ignition Module (SE5, W5)
A3 - Off Delay Module (SE5, W5)
A4 - Glow Plug Timer Module (SE3, W1)(Diesel)
B1 - Fan/Over Temperature Switch (SE3, W1)
B2 - Fuel Gauge Sensor (SE3, W1)
B3 - Engine Coolant Temperature Sensor (SE4, W1)
B4 - Engine Oil Pressure Switch (SE4, W1)
B5 - Electric Choke Coil (SE5, W8)
B6 - Pulser Coil #3 (SE5, W9)
B7 - Pulser Coil #2 (SE5, W9)
B8 - Pulser Coil #1 (SE5, W9)
B9 - Hydraulic Oil Over-Temperature Switch (SE3, W1)
E1 - LH Tail Light (SE3, W2)
E2 - LH Hazard Light (SE3, W2)
E3 - RH Tail Light (SE3, W2)
E4 - RH Hazard Light (SE3, W2)
E5 - LH Headlight (SE3, W1)
E6 - RH Headlight (SE3, W1)
E7 - LH Turn Signal Light (SE3, W3)
E8 - RH Turn Signal Light (SE3, W3)
E9 - LH Work Light (option) (SE3, W4)
E10 - Center Work Light (option) (SE3, W4)
E11 - RH Work Light (option) (SE3, W4)
E12 - Spark Plug (SE5, W6)
E13 - Spark Plug (SE5, W6)
E14 - Spark Plug (SE5, W6)
F1 - Fuse - 25 amp (SE1, W1)
F2 - Fuse - 10 amp (SE1, W1)
G1 - Battery (SE1, W1)
G2 - Alternator (SE2, W1)
H1 - Horn (SE3, W1)
H2 - PTO Engaged Light (SE4, W1)
H3 - Engine Coolant Temperature Light (SE4, W1)
H4 - Discharge Light (SE4, W1)
H5 - LH Turn Signal Indicator Light (SE4, W1)
H6 - Engine Oil Pressure Light (SE4, W1)
H7 - Park Brake Light (SE4, W1)
H8 - RH Turn Signal Indicator Light (SE4, W1)
H9 - Instrument Panel Light (SE4, W1)
H10 - Engine Preheat Light (SE4, W1)(Diesel)
K1 - Start Relay (SE1, W1)
K2 - Seat Relay (SE3, W1)
K3 - Radiator Fan Relay (SE3, W1)
K4 - Turn Signal Flasher (SE3, W1)
M1 - Starting Motor (SE1, W1)
M2 - Radiator Fan Motor (SE3, W1)
M3 - Fuel Pump (SE3, W1)
P1 - Engine Tachometer (SE4, W1)
P2 - Speedometer (SE4, W1)
P3 - Engine Coolant Temperature Gauge (SE4, W1)
P4 - Fuel Gauge (SE4, W1)
P5 - Hour Meter (option) (SE4, W1)
R1 - Glow Plug (SE3, W1)(Diesel)
R2 - Glow Plug (SE3, W1)(Diesel)
R3 - Glow Plug (SE3, W1)(Diesel)
R4 - Ignition Ballast Resistor, (SE5, W12)(Gas Engine)
S1 - Key Switch (SE1, W1)
S2 - Neutral Switch (SE1, W1)
S3 - Park Brake Switch (SE1, W1)
S4 - Seat Switch (SE2, W1)
S5 - Brake Switch (SE3, W1)
S6 - Mechanical PTO Switch (option) (SE3, W1)
S7 - PTO Engaged Sensor Switch (SE3, W1)
S8 - Horn Switch (SE3, W1)
S9 - Turn Signal Switch (SE3, W1)
S10 - Hazard Lights Switch (SE3, W1)
S11 - Headlight Switch (SE3, W1)
S12 - Work Light Switch (option) (SE3, W1)

T1 - Speed Sensor (SE3, W1)

T2 - Ignition Coil #1 (SE5, W6)

T3 - Ignition Coil #2 (SE5, W6)

T4 - Ignition Coil #3 (SE5, W6)

V1 - Seat Diode (SE1, W1)

V2 - PTO Diode (SE2, W1)

V3 - Start Diode ()(Gas Engine)

W1 - Battery Frame Ground (SE1, W1)

Y1 - Starting Motor Solenoid (SE1, W1)

Y2 - Fuel Shutoff Solenoid (SE5, W7)(Gasoline)

Y3 - Fuel Shutoff Solenoid (SE2, W1)(Diesel)

Connectors

X1 - W1 Main Wiring Harness to V1 Seat Diode (SE1, W1)

X2 - W1 Main Wiring Harness to A1 Seat Delay Module (SE2, W1) Old Harness

X3 - W1 Main Wiring Harness to Instrument Panel (SE3, W1; SE4, W1)

X4 - W1 Main Wiring Harness to Instrument Panel (SE2, W1; SE3, W1; SE4, W1)

X5 - W1 Main Wiring Harness to W5 Engine Wiring Harness (SE3, W1; SE5, W5) (Old Harness)

X6 0- W1 Main Wiring Harness to V2 PTO Diode (SE3, W1)

X7 - W1 Main Wiring Harness to PTO Wiring Harness (SE3, W1)

X8 - W1 Main Wiring Harness to M2 Radiator Fan Motor (SE3, W1)

X9 - W1 Main Wiring Harness to B1 Fan/Over Temperature Switch (SE3, W1)

X10 - W1 Main Wiring Harness to Hydro Over Temperature (option) (SE3, W1)

X11 - W1 Main Wiring Harness to Auxiliary Power (SE3, W1)

X12 - Main Wiring Harness to M3 Fuel Pump (SE3, W1)

X13 - Main Wiring Harness to W2 Tail Light Wiring Harness (SE3, W1)

X14 - Main Wiring Harness to W2 Tail Light Wiring Harness (SE3, W1)

X15 - Main Wiring Harness to T1 Speed Sensor (SE3, W1)

X16 - Main Wiring Harness to Auxiliary Speed Output (SE3, W1)

X17 - Main Wiring Harness to W3 LH Turn Signal Wiring Harness (SE3, W1)

X18 - Main Wiring Harness to W4 Work Lights Wiring Harness (option) (SE3, W1)

X19 - W4 Work Lights Wiring Harness to E9 LH Work Light (SE3, W4)

X20 - W4 Work Lights Wiring Harness to E10 Center Work Light (SE3, W4)

X21 - W4 Work Lights Wiring Harness to E11 RH Work Light (SE3, W4)

X22 - Main Wiring Harness to W3 RH Turn Signal Wiring Harness (SE3, W1)

X23 - (Old Harness) W5 Engine Wiring Harness to W12 Ignition Ballast Resistor Harness (SE5, W5)(Gasoline)

X23 - (New Harness) W1 Main Wiring Harness to W12 Ignition Ballast Resistor Harness (SE5, W5)(Gasoline)

X24 - W6 Engine Wiring Harness to W7 Engine Wiring Harness (SE5, W6)(Gasoline)

X25 - W7 Engine Wiring Harness to W8 Engine Wiring Harness and Y2 Fuel Shutoff Solenoid (SE5, W7)(Gasoline)

X26 - W5 Engine Wiring Harness to A2 Solid State Ignition Module (SE5, W5)(Gasoline)

X27 - W5 Engine Wiring Harness to A3 Off Delay Module (SE5, W5)(Gasoline)

X28 - W9 Engine Wiring Harness to A2 Solid State Ignition Module (SE5, W5)(Gasoline)

X29 - W9 Engine Wiring Harness to W10 Engine Wiring Harness (SE5, W5)(Gasoline)

X30 - W10 Engine Wiring Harness to B6 Pulser Coil #3 (SE5, W9)(Gasoline)

X31 - W10 Engine Wiring Harness to B7 Pulser Coil #2 (SE5, W9)(Gasoline)

X32 - W10 Engine Wiring Harness to B8 Pulser Coil #1 (SE5, W9)(Gasoline)

X33 - W1 Main Wiring Harness to W11 Engine Glow Plugs Wiring Harness (SE3, W1)(Diesel)

X34 - W12 Ignition Ballast Resistor Harness to W6 Engine Wiring Harness (SE5, W6, W12)(Gasoline)

Serial Number Breaks

2020 Gas Engine Vehicle Main Wiring Harness

TC2020 2 Wheel Drive (Old). . . . . -020347
TC2020 2 Wheel Drive (New) 020348-
TC2020 4 Wheel Drive (Old). . . . . -020078
TC2020 4 Wheel Drive (New) 020079-

Wiring Harnesses

W1 - Main Wiring Harness

W2 - Tail Light Wiring Harness

W3 - Turn Signal Wiring Harness

W4 - Work Lights Wiring Harness

W5 - Engine Wiring Harness (Gasoline) (Old Harness)

W6 - Engine Wiring Harness (Gasoline)

W7 - Engine Wiring Harness (Gasoline)

W8 - Engine Wiring Harness (Gasoline)

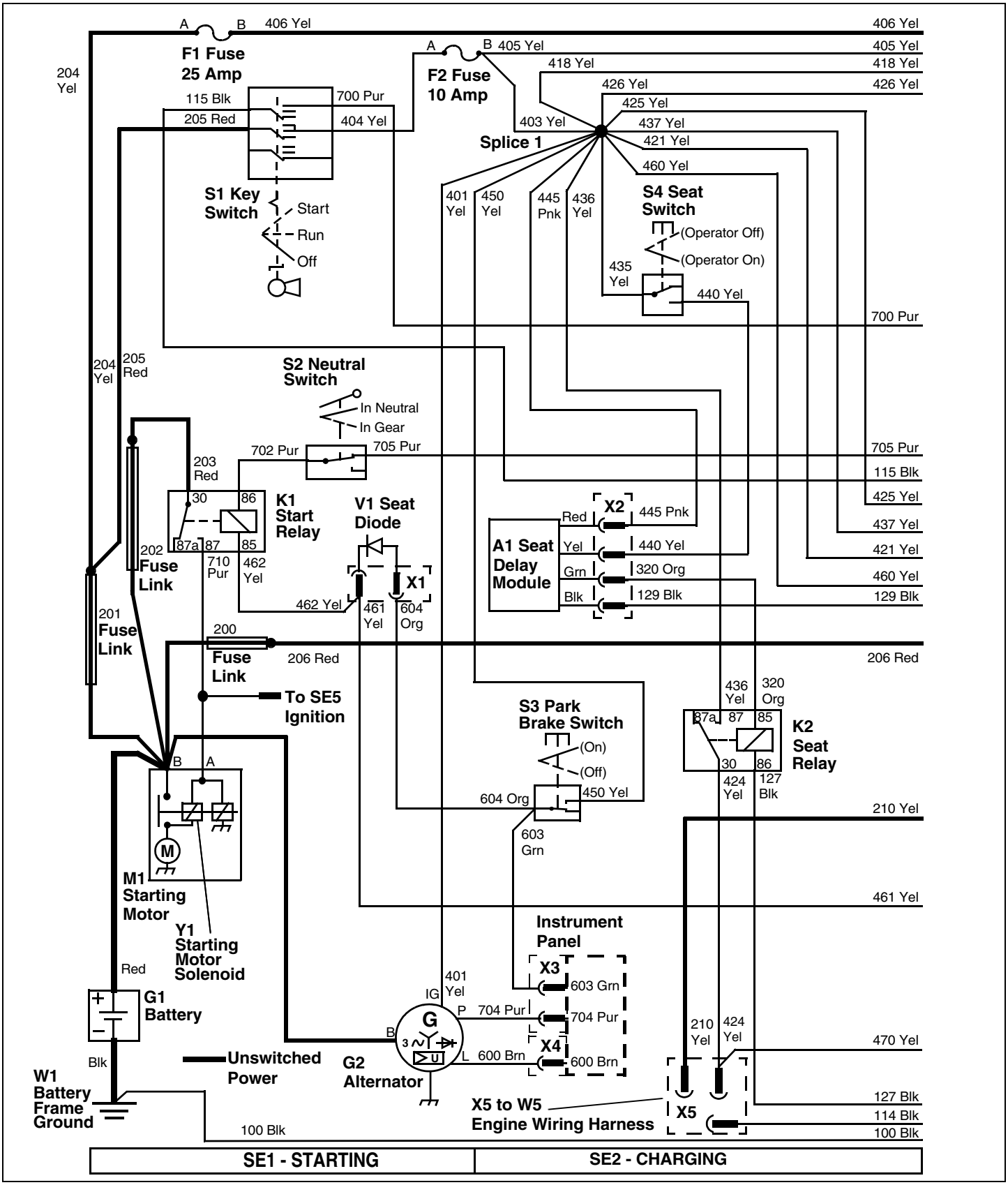
W9 - Engine Wiring Harness (Gasoline) (Old Harness)

W10 - Engine Wiring Harness (Gasoline)

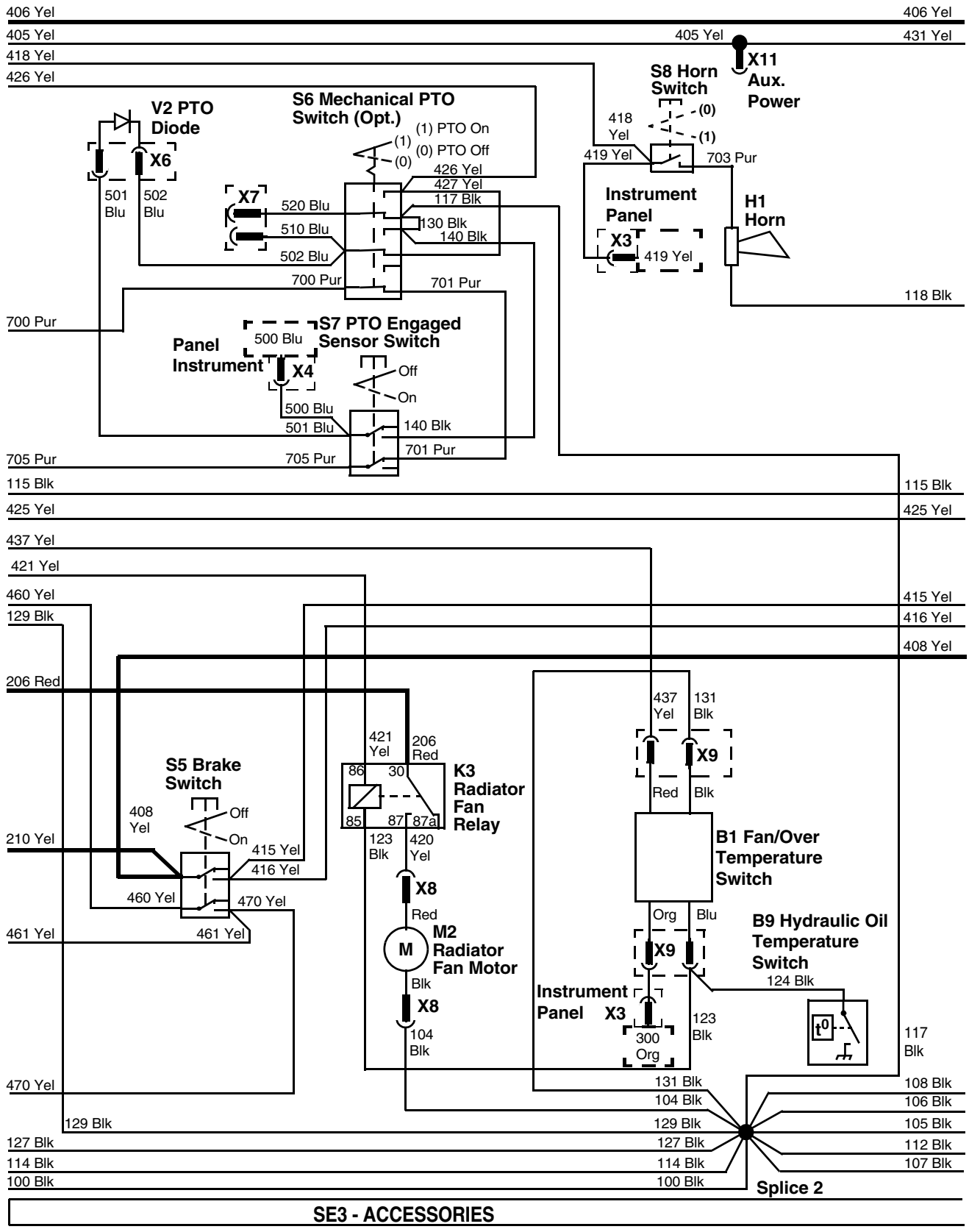
W11 - Engine Wiring Harness (Diesel)

W12 - Ignition Ballast Resistor Harness (Gasoline)

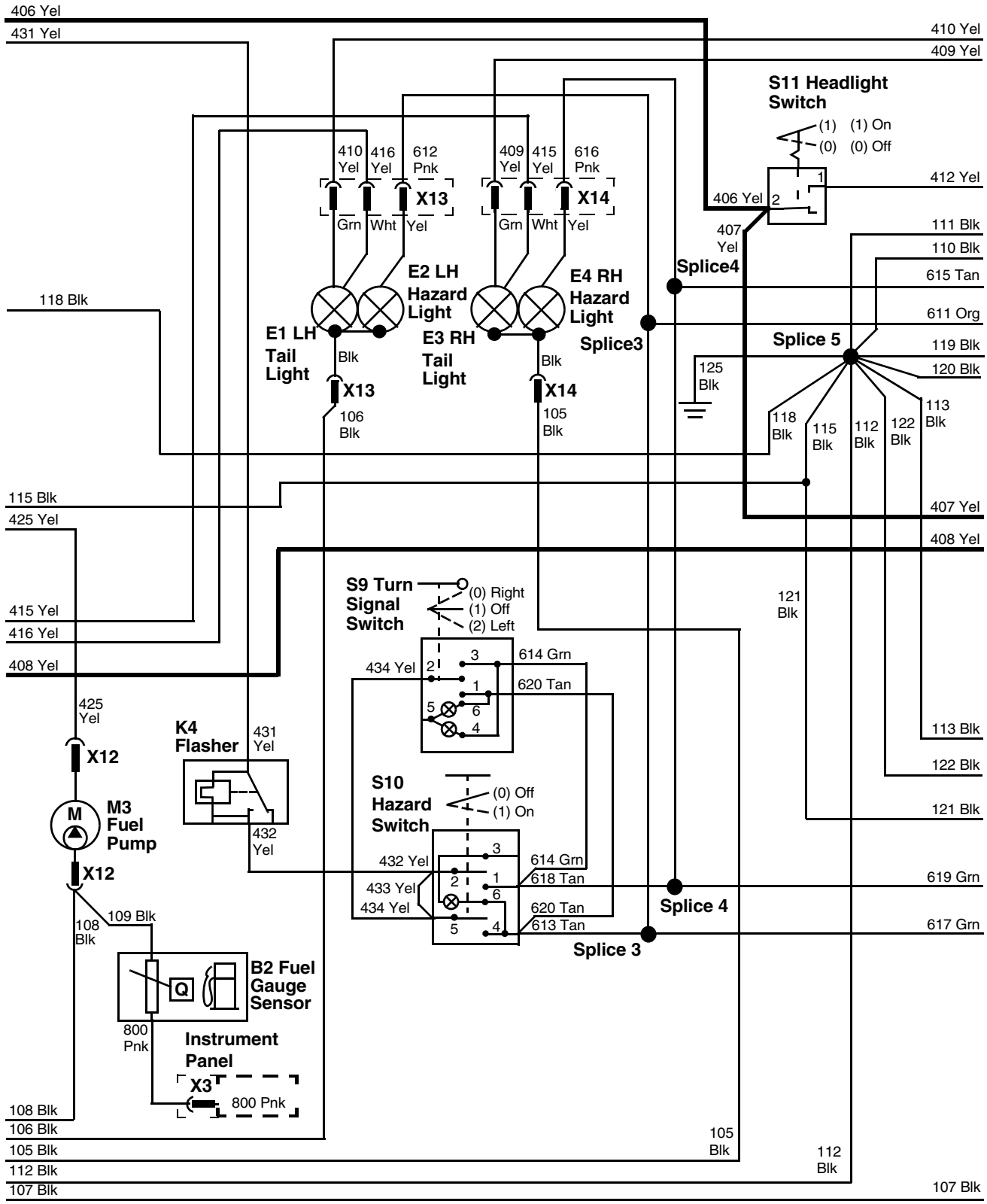
W1 Main Wiring Schematic - Gasoline Engine (Old)



MIF


406 Yel
405 Yel
418 Yel
426 Yel
406 Yel
405 Yel
431 Yel
X11
Aux. Power
S8 Horn Switch
(0)
(1)
418 Yel
419 Yel
703 Pur
V2 PTO Diode
X6
501 Blu
502 Blu
S6 Mechanical PTO Switch (Opt.)
(1) PTO On
(0) PTO Off
426 Yel
427 Yel
117 Blk
130 Blk
140 Blk
X7
520 Blu
510 Blu
502 Blu
700 Pur
701 Pur
Instrument Panel
X3
419 Yel
H1 Horn
118 Blk
700 Pur
S7 PTO Engaged Sensor Switch
500 Blu
Panel Instrument
X4
Off
On
500 Blu
501 Blu
140 Blk
701 Pur
705 Pur
705 Pur
115 Blk
425 Yel
437 Yel
421 Yel
460 Yel
129 Blk
206 Red
415 Yel
416 Yel
408 Yel
S5 Brake Switch
408 Yel
Off
On
210 Yel
415 Yel
416 Yel
460 Yel
470 Yel
461 Yel
461 Yel
421 Yel
206 Red
86
30
85
87
87a
K3 Radiator Fan Relay
123 Blk
420 Yel
X8
Red
M
M2 Radiator Fan Motor
Blk
X8
104 Blk
437 Yel
131 Blk
X9
Red
Blk
B1 Fan/Over Temperature Switch
Org
Blu
X9
B9 Hydraulic Oil Temperature Switch
124 Blk
Instrument Panel X3
300 Org
123 Blk
117 Blk
470 Yel
131 Blk
104 Blk
129 Blk
127 Blk
114 Blk
100 Blk
108 Blk
106 Blk
105 Blk
112 Blk
107 Blk
Splice 2
SE3 - ACCESSORIES

MIF



SE3 - ACCESSORIES

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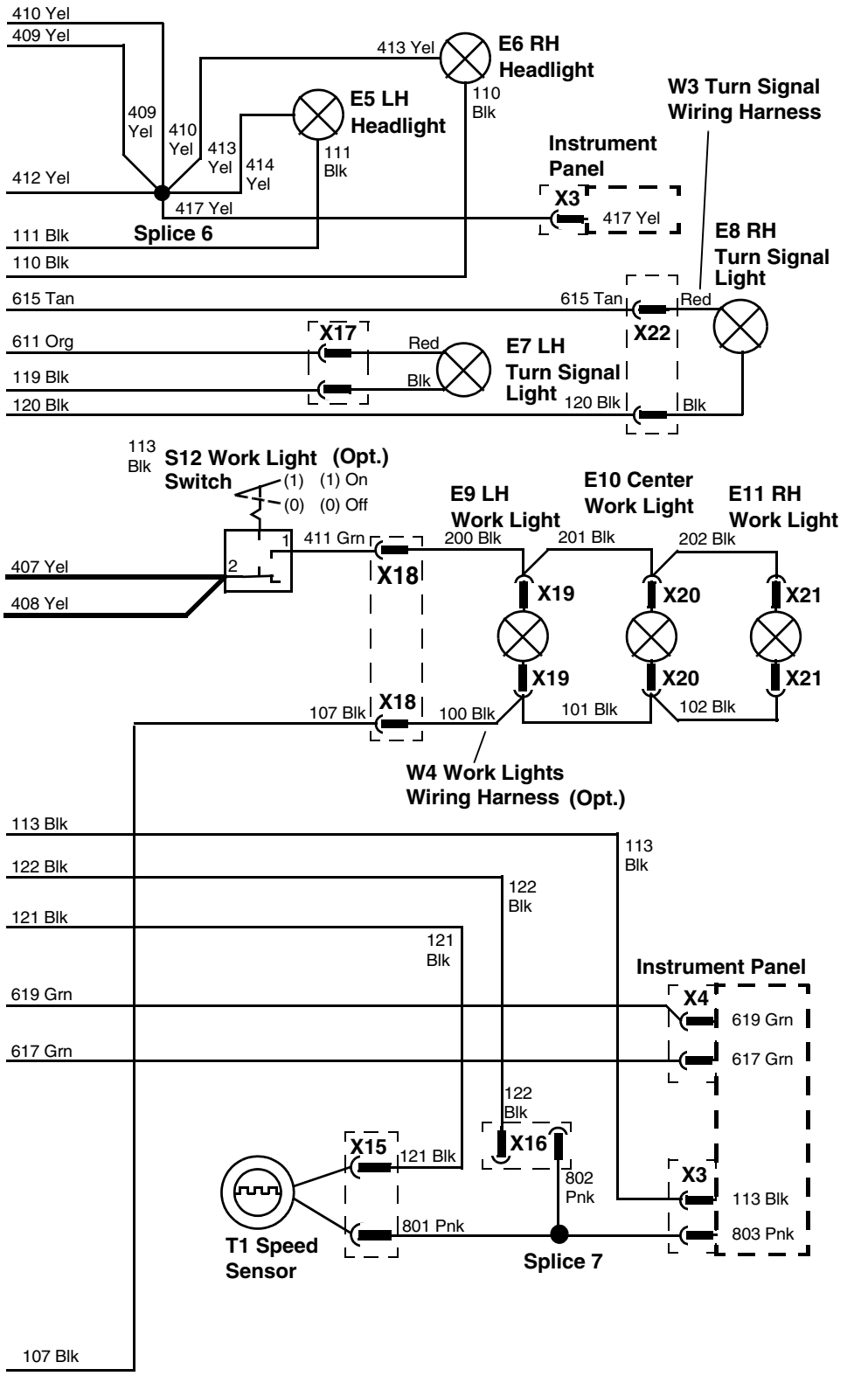

SE3 - ACCESSORIES

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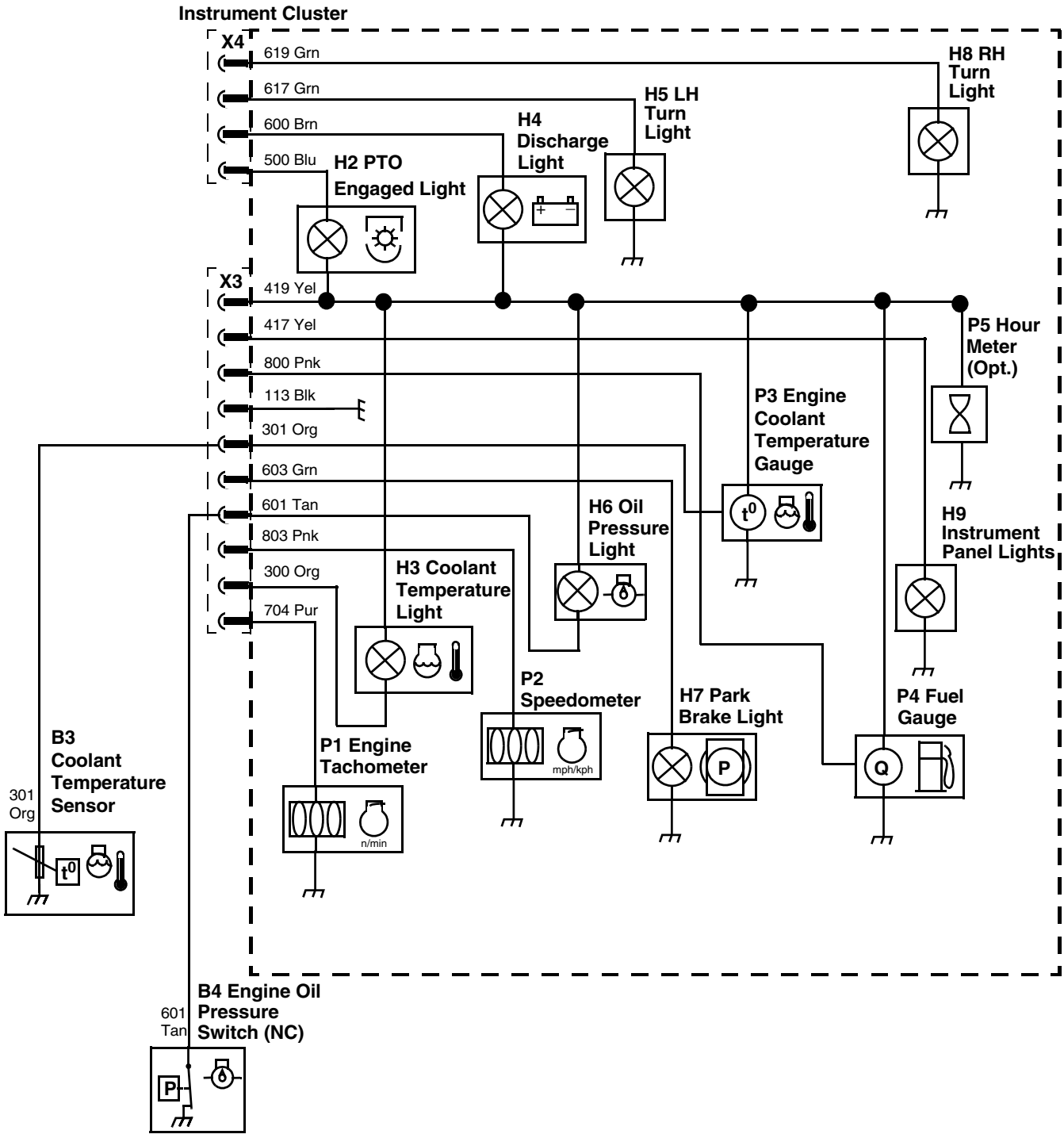
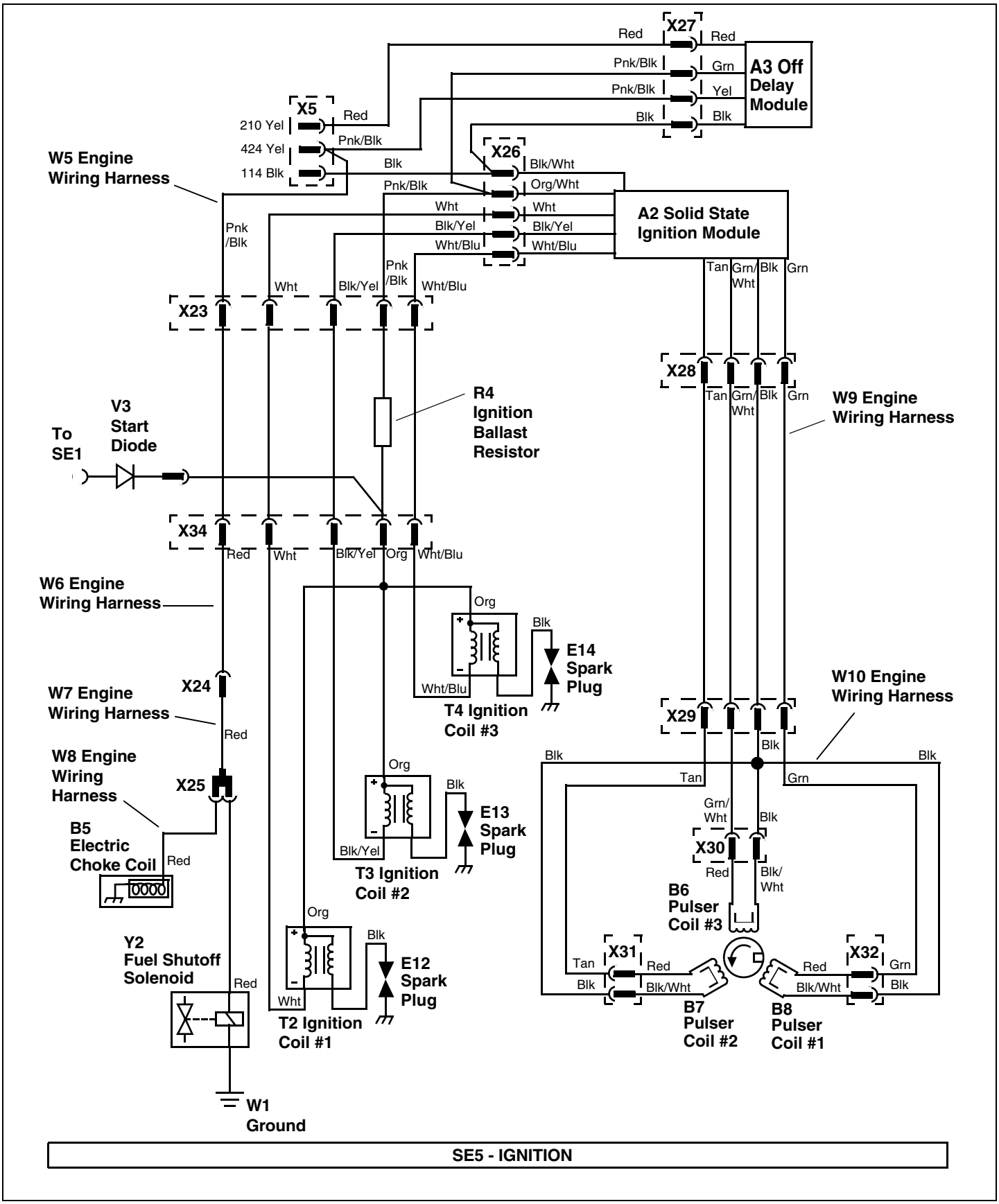


SE4 - INSTRUMENTATION

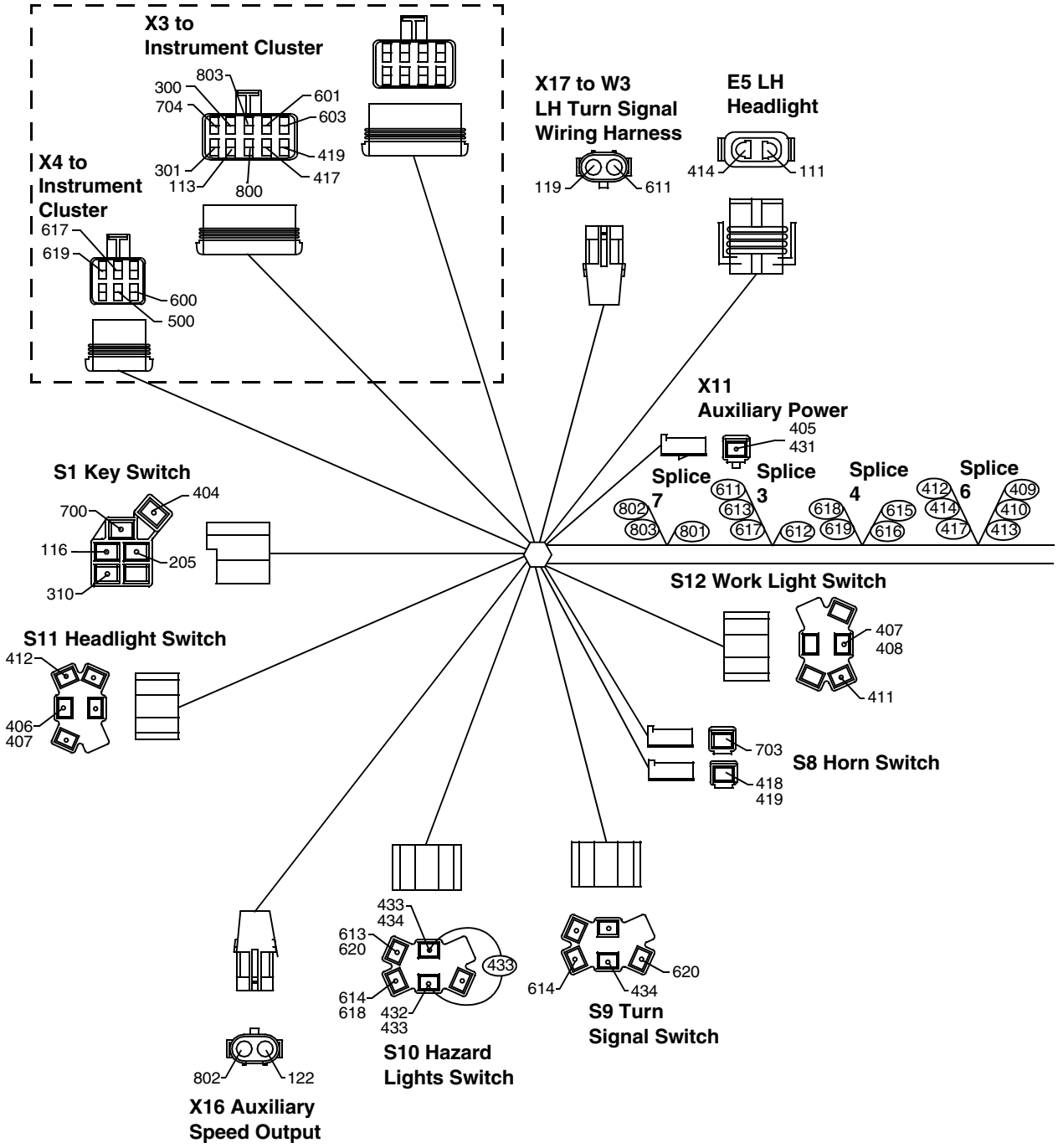
MIF



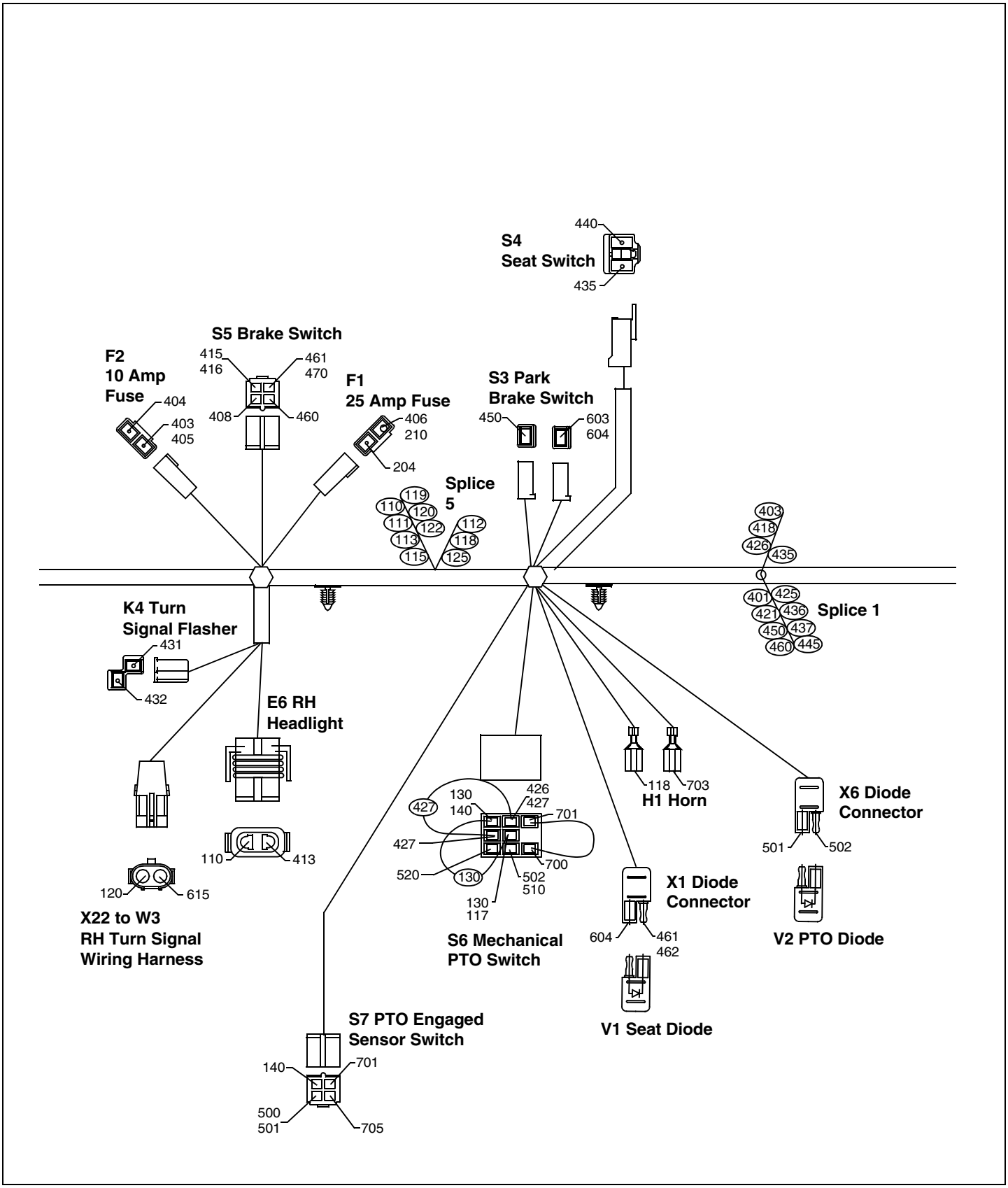
SE5 - IGNITION

MIF

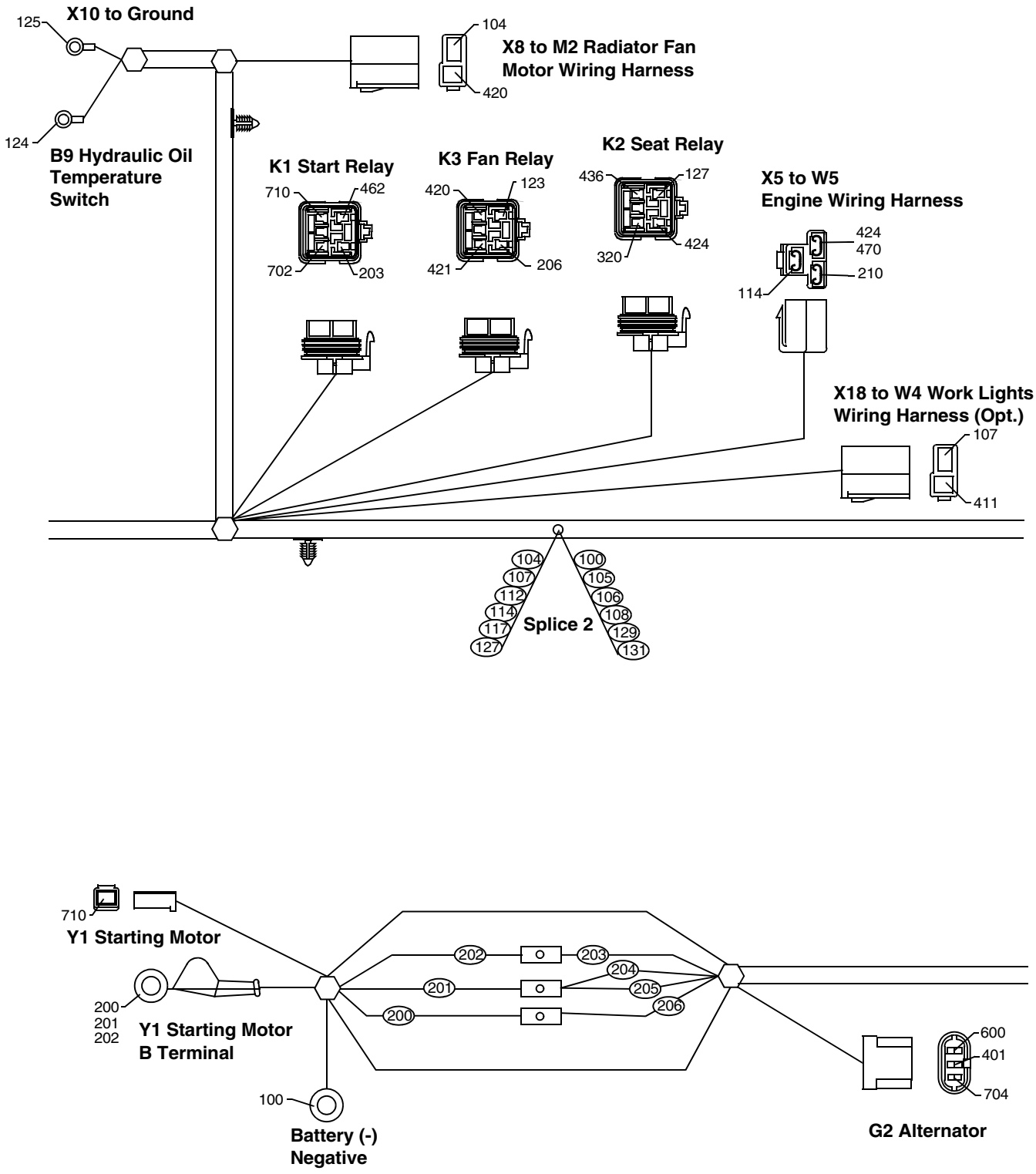
W1 Main Wiring Harness - Gasoline Engine (Old)



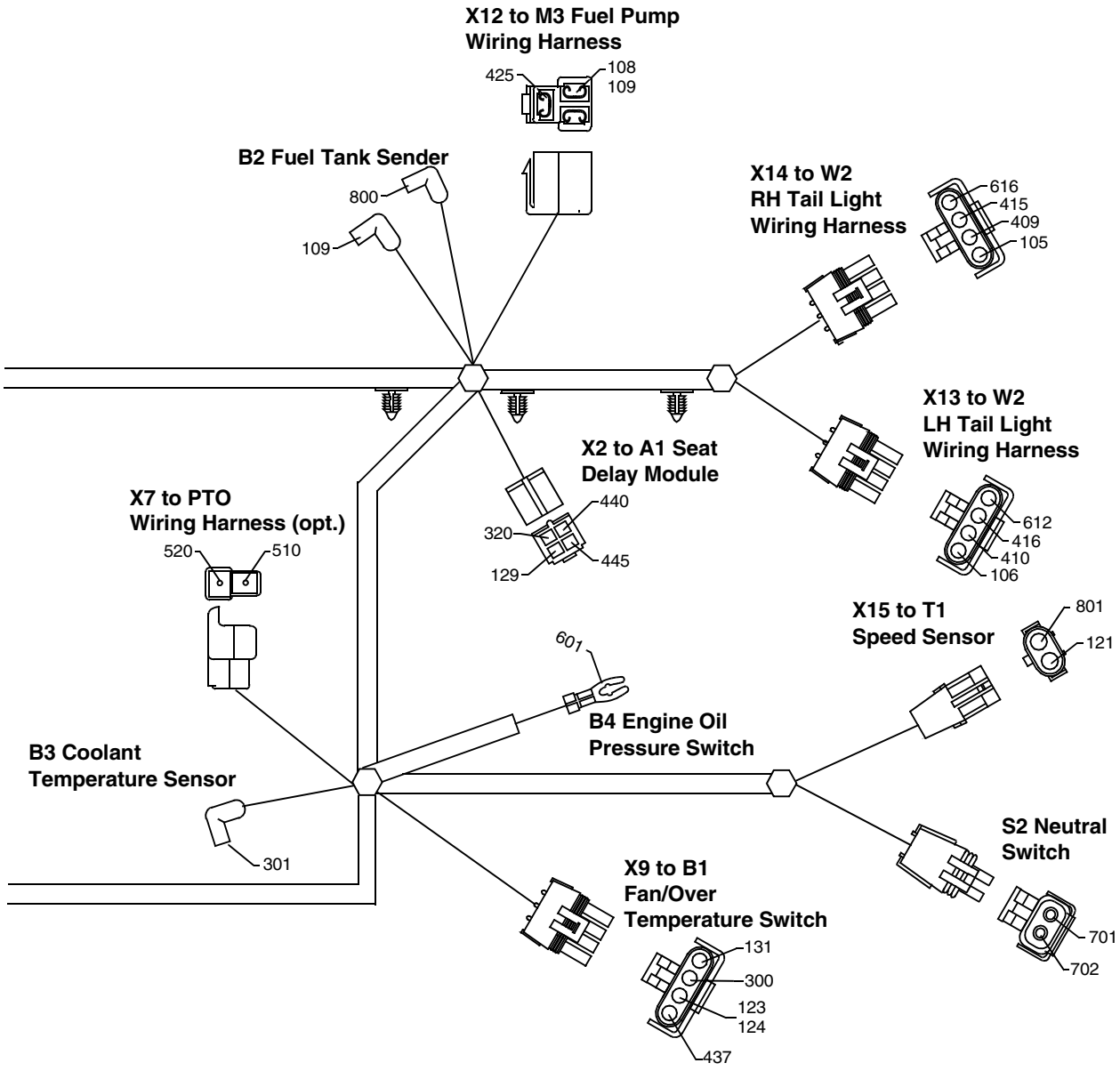
MIF


S4
Seat Switch
440
435
S5 Brake Switch
415
416
461
470
408
460
F2
10 Amp
Fuse
404
403
405
F1
25 Amp Fuse
406
210
204
S3 Park
Brake Switch
450
603
604
Splice
5
119
110
120
111
122
112
113
118
115
125
403
418
426
435
401
425
421
436
450
437
460
445
Splice 1
K4 Turn
Signal Flasher
431
432
E6 RH
Headlight
110
413
120
615
X22 to W3
RH Turn Signal
Wiring Harness
426
130
427
140
427
701
427
700
520
130
502
510
130
117
S6 Mechanical
PTO Switch
118
703
H1 Horn
X6 Diode
Connector
501
502
X1 Diode
Connector
604
461
462
V2 PTO Diode
V1 Seat Diode
S7 PTO Engaged
Sensor Switch
140
701
500
501
705

MIF

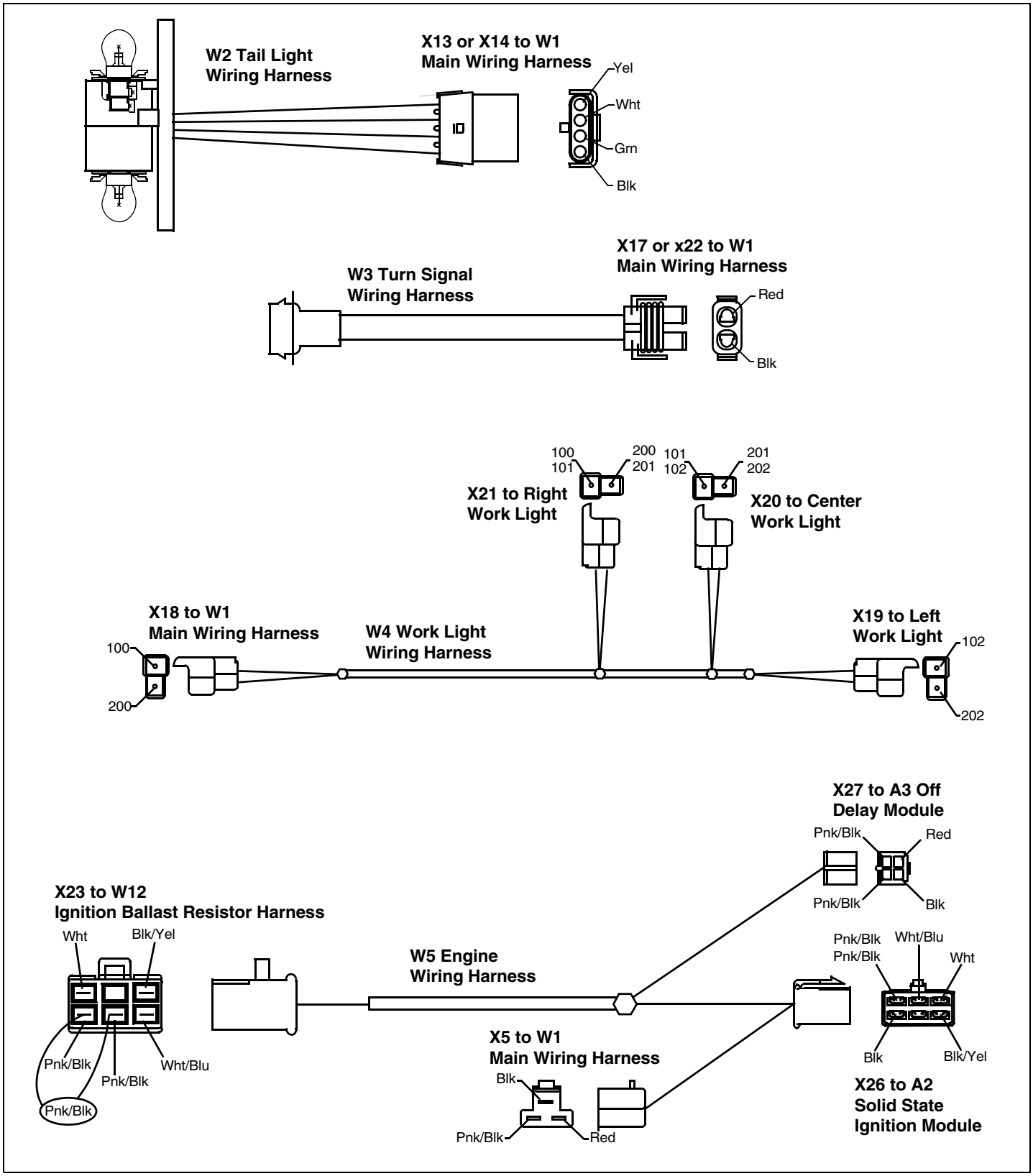

X10 to Ground
125
124
B9 Hydraulic Oil Temperature Switch
104
X8 to M2 Radiator Fan Motor Wiring Harness
420
K1 Start Relay
710
462
702
203
K3 Fan Relay
420
123
421
206
K2 Seat Relay
436
127
424
320
X5 to W5 Engine Wiring Harness
424
470
210
114
X18 to W4 Work Lights Wiring Harness (Opt.)
107
411
104
107
112
114
117
127
Splice 2
100
105
106
108
129
131
710
Y1 Starting Motor
200
201
202
Y1 Starting Motor B Terminal
202
203
204
201
205
206
200
100
Battery (-) Negative
600
401
704
G2 Alternator

MIF


X12 to M3 Fuel Pump
Wiring Harness
425
108
109
B2 Fuel Tank Sender
800
109
X14 to W2
RH Tail Light
Wiring Harness
616
415
409
105
X13 to W2
LH Tail Light
Wiring Harness
612
416
410
106
X2 to A1 Seat
Delay Module
440
320
445
129
X7 to PTO
Wiring Harness (opt.)
520
510
X15 to T1
Speed Sensor
801
121
601
B4 Engine Oil
Pressure Switch
B3 Coolant
Temperature Sensor
301
S2 Neutral
Switch
701
702
X9 to B1
Fan/Over
Temperature Switch
131
300
123
124
437

MIF

W2-W12 Wiring Harnesses - Gasoline Engine (Old)



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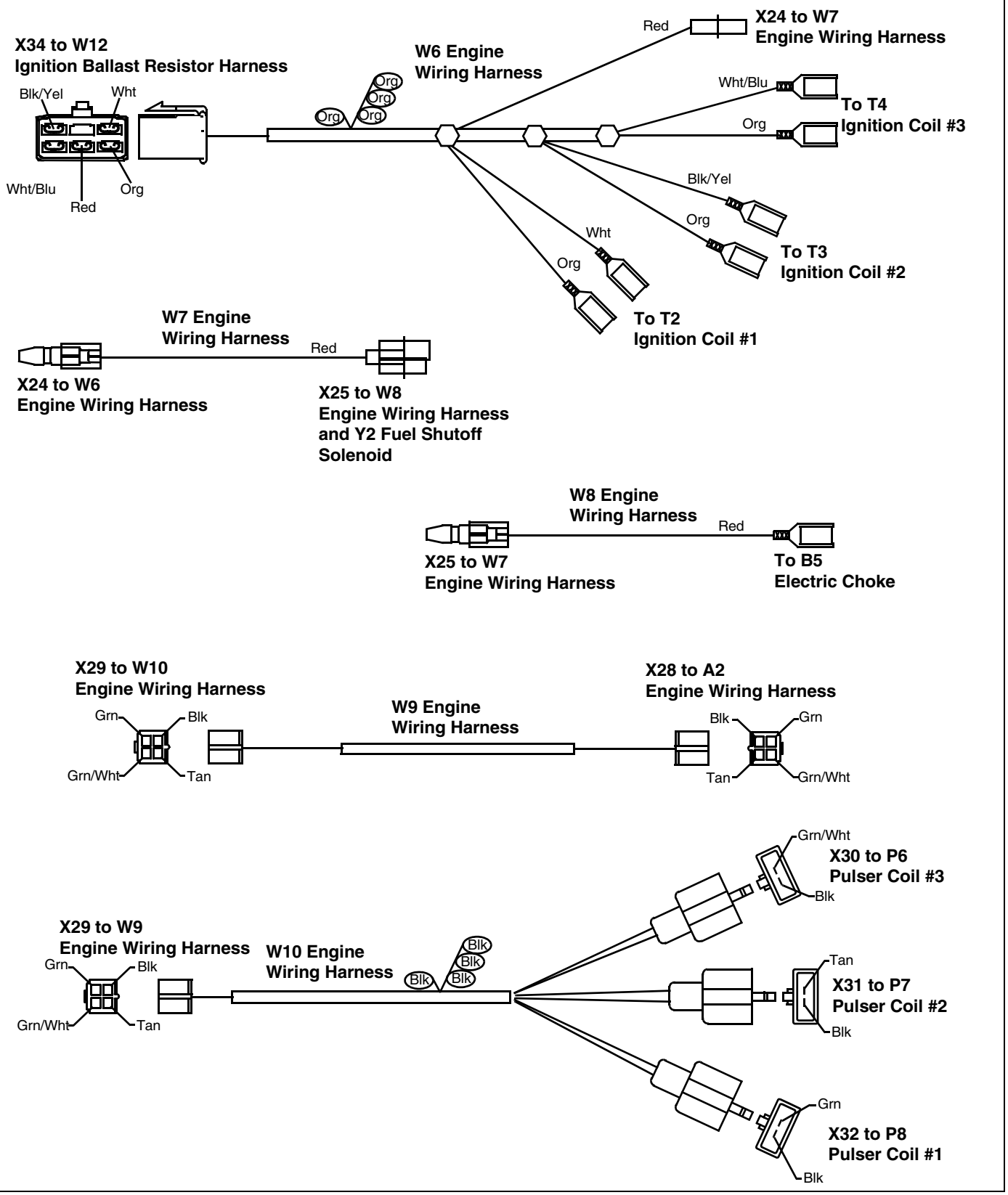
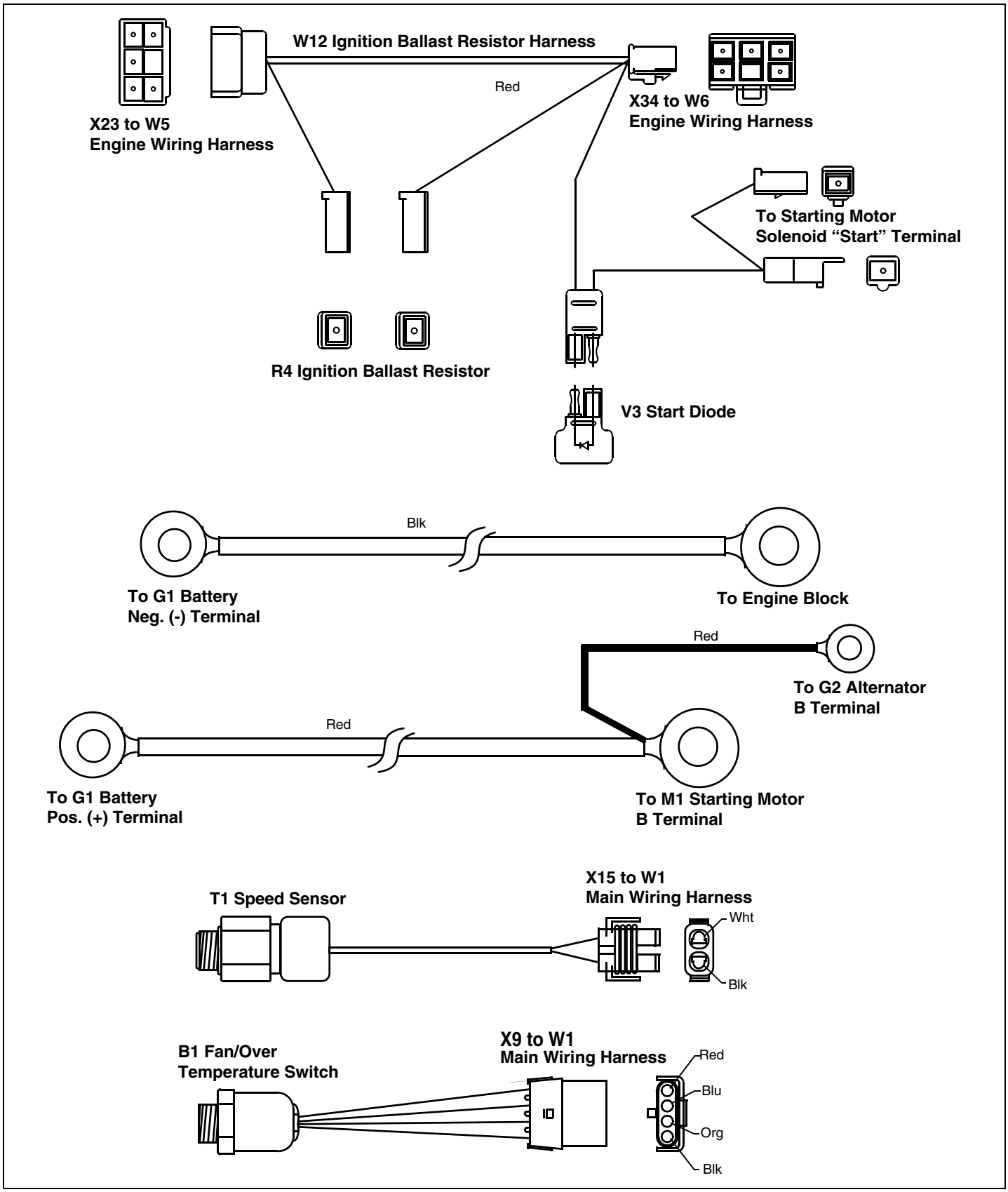
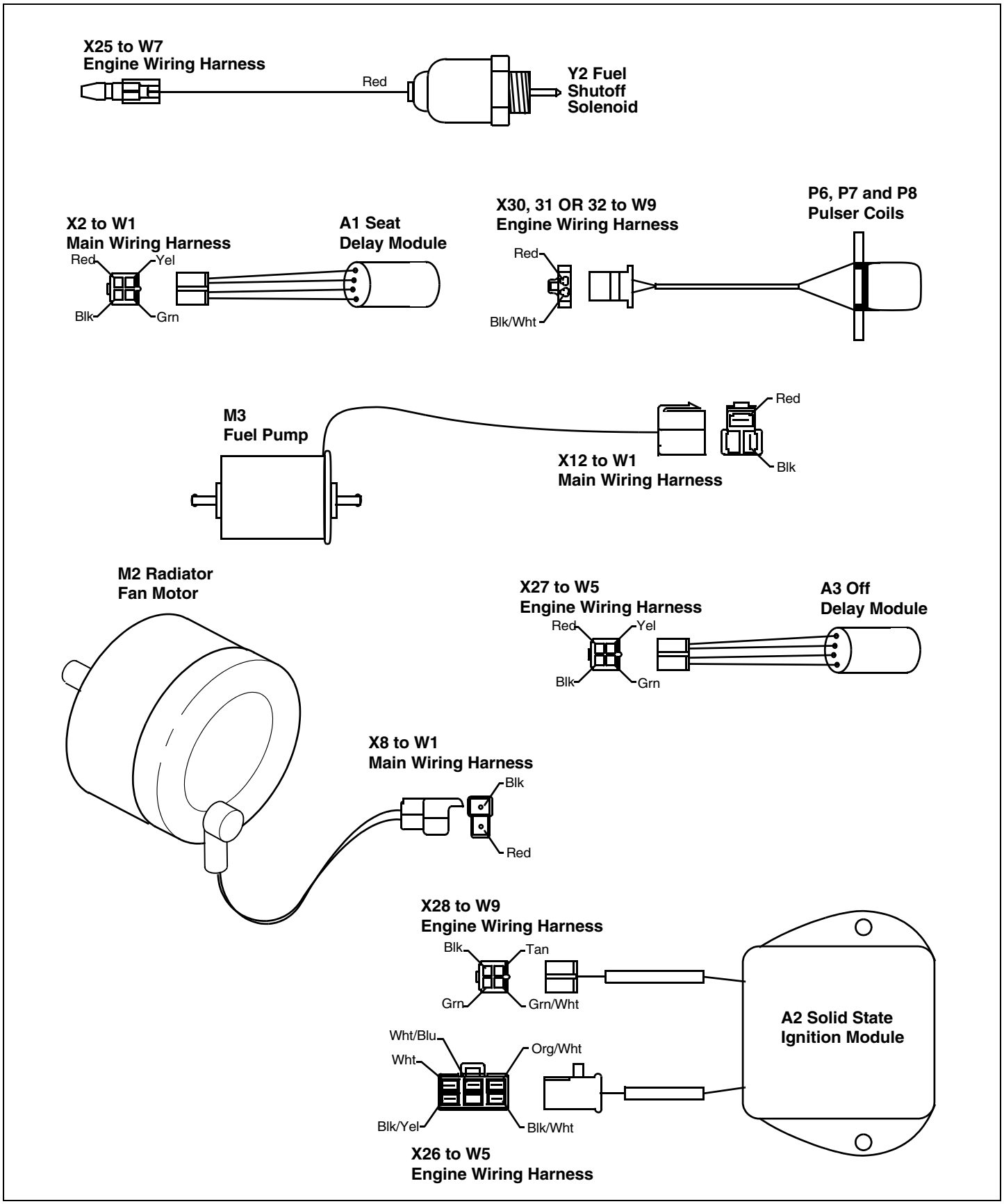

X34 to W12
Ignition Ballast Resistor Harness
Blk/Yel
Wht
Wht/Blu
Org
Red
W6 Engine
Wiring Harness
Org
Org
Org
Org
Red
X24 to W7
Engine Wiring Harness
Wht/Blu
To T4
Ignition Coil #3
Org
Blk/Yel
Org
To T3
Ignition Coil #2
Wht
Org
To T2
Ignition Coil #1
W7 Engine
Wiring Harness
Red
X24 to W6
Engine Wiring Harness
X25 to W8
Engine Wiring Harness
and Y2 Fuel Shutoff
Solenoid
W8 Engine
Wiring Harness
Red
X25 to W7
Engine Wiring Harness
To B5
Electric Choke
X29 to W10
Engine Wiring Harness
Grn
Blk
Grn/Wht
Tan
W9 Engine
Wiring Harness
X28 to A2
Engine Wiring Harness
Blk
Grn
Tan
Grn/Wht
X29 to W9
Engine Wiring Harness
Grn
Blk
Grn/Wht
Tan
W10 Engine
Wiring Harness
Blk
Blk
Blk
Blk
Grn/Wht
X30 to P6
Pulser Coil #3
Blk
Tan
X31 to P7
Pulser Coil #2
Blk
Grn
X32 to P8
Pulser Coil #1
Blk

MIF


W12 Ignition Ballast Resistor Harness
Red
X23 to W5
Engine Wiring Harness
X34 to W6
Engine Wiring Harness
To Starting Motor
Solenoid "Start" Terminal
R4 Ignition Ballast Resistor
V3 Start Diode
Blk
To G1 Battery
Neg. (-) Terminal
To Engine Block
Red
To G2 Alternator
B Terminal
Red
To G1 Battery
Pos. (+) Terminal
To M1 Starting Motor
B Terminal
T1 Speed Sensor
X15 to W1
Main Wiring Harness
Wht
Blk
B1 Fan/Over
Temperature Switch
X9 to W1
Main Wiring Harness
Red
Blu
Org
Blk

MIF


X25 to W7
Engine Wiring Harness
Red
Y2 Fuel
Shutoff
Solenoid
X2 to W1
Main Wiring Harness
Red
Yel
Blk
Grn
A1 Seat
Delay Module
X30, 31 OR 32 to W9
Engine Wiring Harness
Red
Blk/Wht
P6, P7 and P8
Pulser Coils
M3
Fuel Pump
X12 to W1
Main Wiring Harness
Red
Blk
M2 Radiator
Fan Motor
X27 to W5
Engine Wiring Harness
Red
Yel
Blk
Grn
A3 Off
Delay Module
X8 to W1
Main Wiring Harness
Blk
Red
X28 to W9
Engine Wiring Harness
Blk
Tan
Grn
Grn/Wht
Wht/Blu
Wht
Org/Wht
Blk/Yel
Blk/Wht
A2 Solid State
Ignition Module
X26 to W5
Engine Wiring Harness

MIF

Wire Color Codes - Gasoline Engines (Old)

2020 Gas Engine Vehicle Main Wiring Harness

TC2020 2 Wheel Drive . . . . . -020347
TC2020 4 Wheel Drive . . . . . -020078

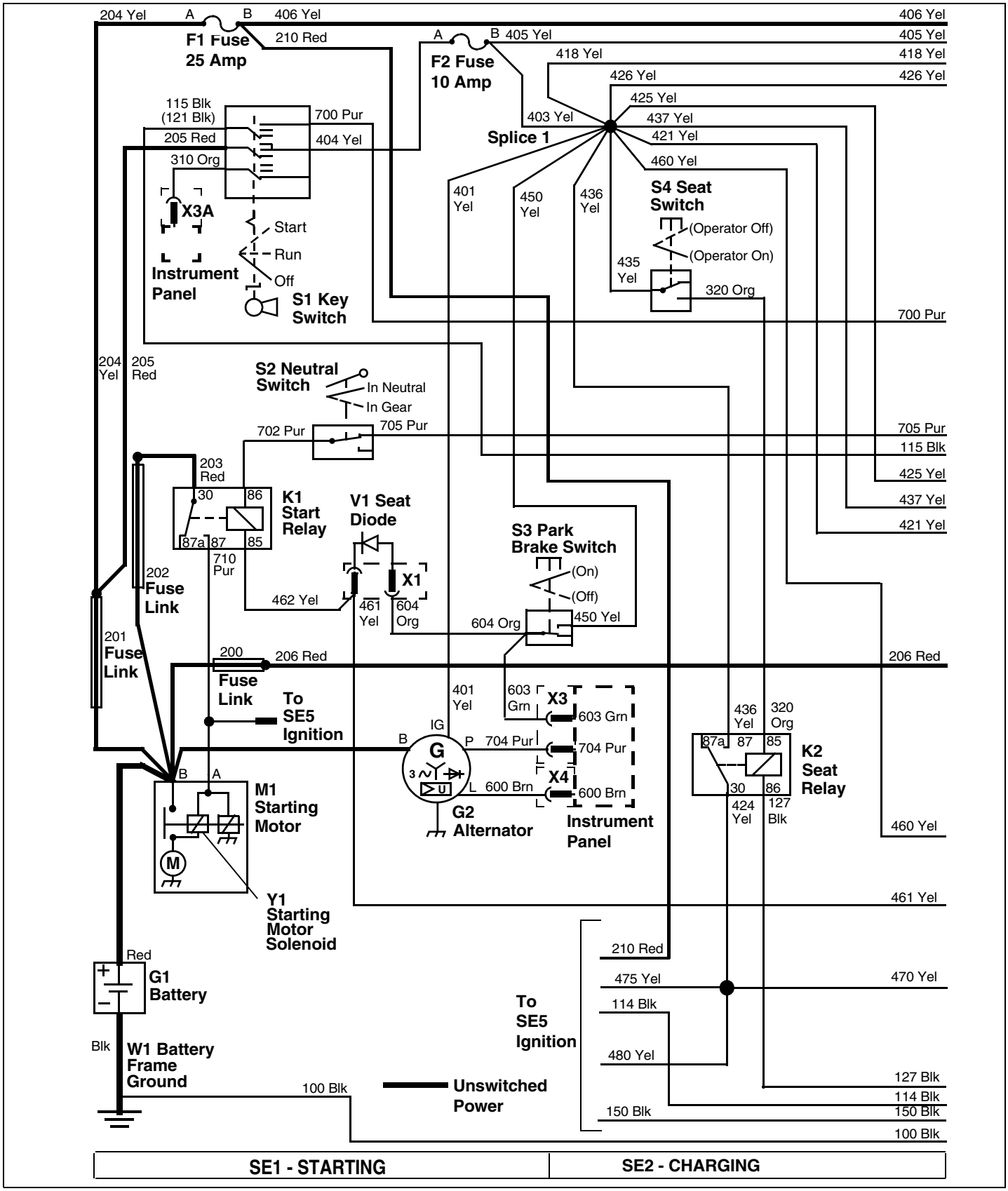
Circuit Number	Wire Size	Color	Termination Points
100	5.0	Blk	W1, Splice #2
104	3.0	Blk	Splice #2, X8
105	0.8	Blk	Splice #2, X14
106	0.8	Blk	Splice #2, X13
107	1.0	Blk	Splice #2, X18
108	0.8	Blk	Splice #2, X12
109	0.8	Blk	X12, B2
110	1.0	Blk	Splice #5, E6
111	1.0	Blk	Splice #5, E5
112	5.0	Blk	Splice #2, Splice #5
113	0.8	Blk	Splice #5, X3
114	3.0	Blk	Splice #2, X5
115	1.0	Blk	Splice #5, S1
117	1.0	Blk	Splice #2, S6
118	0.8	Blk	Splice #5, H1
119	1.0	Blk	Splice #5, X17
120	1.0	Blk	Splice #5, X22
121	0.8	Blk	S1, X15
122	0.8	Blk	Splice #5, X16
123	0.8	Blk	X9, K3
124	0.8	Blk	X9, X10
125	0.8	Blk	Splice #5, X10
127	0.8	Blk	Splice #2, K2
129	0.8	Blk	Splice #2, X2
130	1.0	Blk	S6, S6
131	1.0	Blk	Splice #2, X9
140	1.0	Blk	S6, S7

Circuit Number	Wire Size	Color	Termination Points
200	1.0	Fuse Link	Y1, Wire 206
201	2.0	Fuse Link	Y1, Wires 204 and 205
202	1.0	Fuse Link	Y1, Wire 203
203	3.0	Red	fuse Link 202, K1
204	3.0	Yel	fuse Link 201, F1
205	5.0	Red	fuse Link 201, S1
206	3.0	Red	fuse Link 200, K3
210	2.0	Yel	S5, X5
300	0.8	Org	X9, X3
301	0.8	Org	B3, X3
320	0.8	Org	K2, X2
401	0.8	Yel	Splice #1, G2
403	2.0	Yel	Splice #1, F2
404	2.0	Yel	S1, F2
405	1.0	Yel	F2, X11
406	3.0	Yel	F1, S11
407	2.0	Yel	S11, S12
408	2.0	Yel	S12, S5
409	1.0	Yel	Splice #6, X14
410	1.0	Yel	Splice #6, X13
411	1.0	Grn	S12, X18
412	3.0	Yel	Splice #6, S11
413	1.0	Yel	Splice #6, E6
414	1.0	Yel	Splice #6, E5
415	0.8	Yel	S5, X14
416	0.8	Yel	S5, X13
417	0.8	Yel	Splice #6, X3
418	0.8	Yel	Splice #1, S8
419	0.8	Yel	S8, X3
420	3.0	Yel	K3, X8

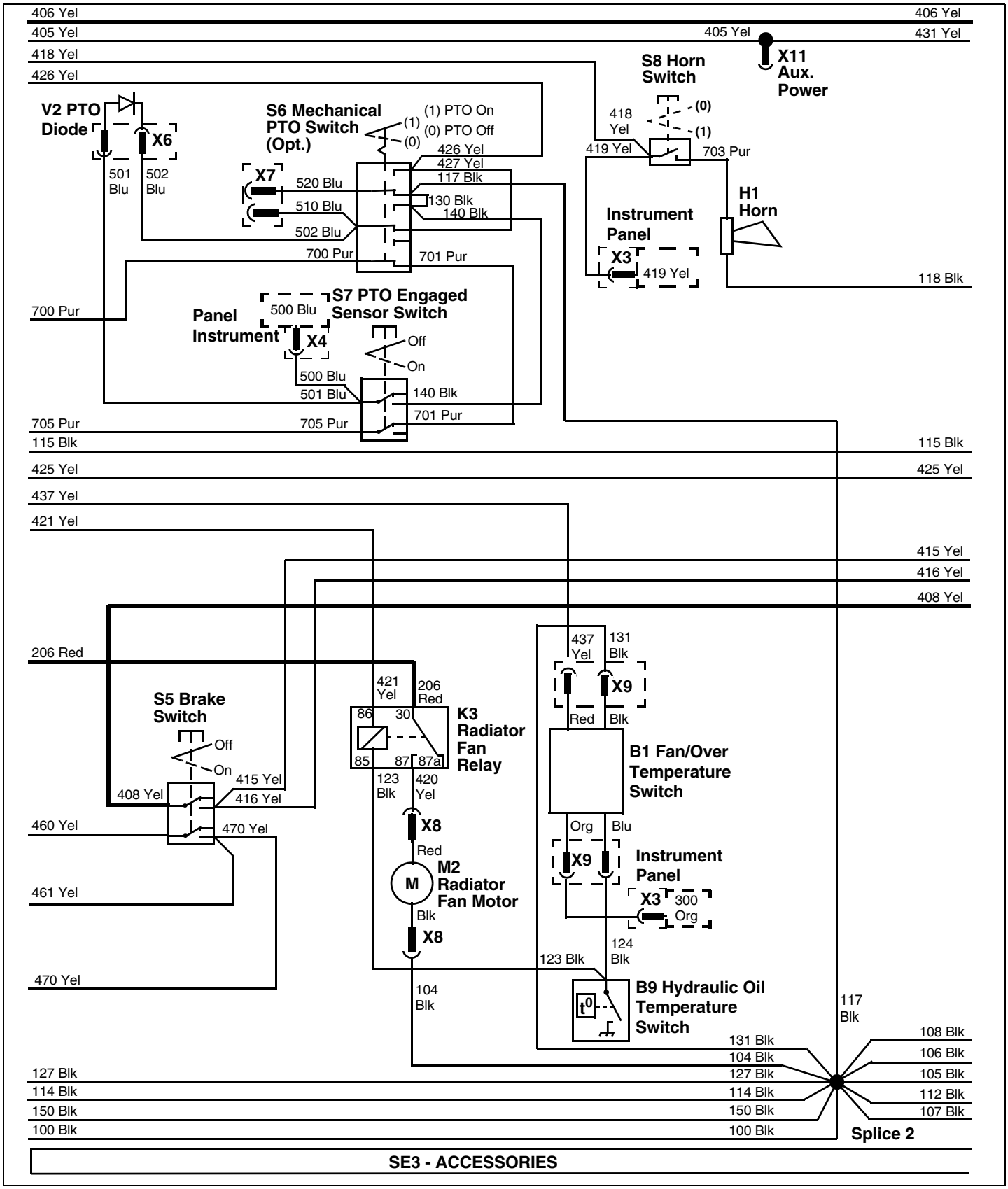
Circuit Number	Wire Size	Color	Termination Points
421	0.8	Yel	K3, Splice #1
424	1.0	Yel	X5, K2
425	0.8	Yel	Splice #1, X12
426	1.0	Yel	Splice #1, S6
427	1.0	Yel	S6, S6
431	1.0	Yel	X11, K4
432	1.0	Yel	K4, S10
433	1.0	Yel	S10, S10
434	1.0	Yel	S10, S9
435	0.8	Yel	Splice #1, S4
436	0.8	Yel	Splice #1, K2
437	1.0	Yel	Splice #1, X9
440	0.8	Yel	X2, S4
445	0.8	Pnk	Splice #1, X2
450	0.8	Yel	Splice #1, S3
460	1.0	Yel	Splice #1, S5
461	0.8	Yel	S5, X1
462	0.8	Yel	X1, K1
470	1.0	Yel	S5, X5
500	0.8	Blu	X4, S7
501	0.8	Blu	S7, X6
502	0.8	Blu	X6, S6
510	1.0	Blu	X7, S6
520	1.0	Blu	X7, S6
600	0.8	Brn	G2, X4
601	0.8	Tan	B4, X3
603	0.8	Grn	X3, S3
604	0.8	Org	S3, X1
611	0.8	Org	X17, Splice #3
612	0.8	Pnk	Splice #3, X13
613	0.8	Tan	S10, Splice #3
614	0.8	Grn	S9, S10

Circuit Number	Wire Size	Color	Termination Points
615	0.8	Tan	X22, Splice #4
616	0.8	Pnk	Splice #4, X14
617	0.8	Grn	Splice #3, X4
618	0.8	Tan	Splice #4, S10
619	0.8	Grn	Splice #4, X4
620	0.8	Tan	S9, S10
700	1.0	Pur	S1, S6
701	0.8	Pur	S6, S7
702	0.8	Pur	S2, K1
703	0.8	Pur	S8, H1
704	0.8	Pur	G2, X3
705	0.8	Pur	S7, S2‘
710	3.0	Pur	K1, Y1
800	0.8	Pnk	B2, X3
801	0.8	Pnk	Splice #7, X15
802	0.8	Pnk	Splice #7, X16
803	0.8	Pnk	Splice #7, X3

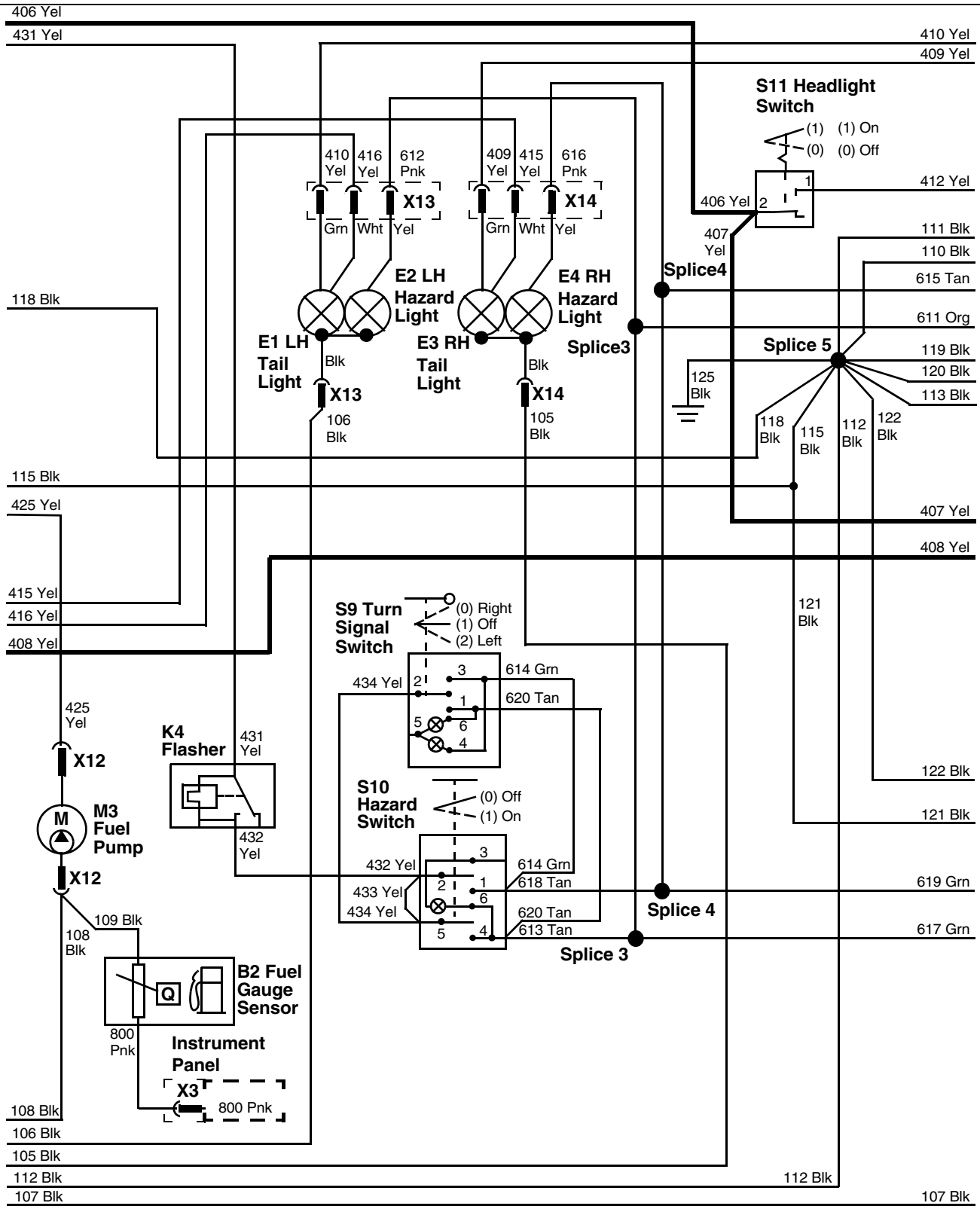
W1 Main Schematic - Gasoline Engine (New)



MIF


406 Yel
405 Yel
418 Yel
426 Yel
V2 PTO Diode
X6
501 Blu
502 Blu
S6 Mechanical PTO Switch (Opt.)
(1) PTO On
(0) PTO Off
X7
520 Blu
510 Blu
502 Blu
426 Yel
427 Yel
117 Blk
130 Blk
140 Blk
700 Pur
701 Pur
S8 Horn Switch
405 Yel
X11 Aux. Power
406 Yel
431 Yel
418 Yel
419 Yel
703 Pur
H1 Horn
Instrument Panel
X3
419 Yel
118 Blk
700 Pur
Panel Instrument
500 Blu
X4
S7 PTO Engaged Sensor Switch
Off
On
500 Blu
501 Blu
140 Blk
701 Pur
705 Pur
705 Pur
115 Blk
115 Blk
425 Yel
425 Yel
437 Yel
421 Yel
415 Yel
416 Yel
408 Yel
206 Red
S5 Brake Switch
Off
On
408 Yel
415 Yel
416 Yel
460 Yel
470 Yel
461 Yel
470 Yel
421 Yel
206 Red
86
30
85
87
87a
K3 Radiator Fan Relay
123 Blk
420 Yel
X8
Red
M
M2 Radiator Fan Motor
Blk
X8
104 Blk
437 Yel
131 Blk
X9
Red
Blk
B1 Fan/Over Temperature Switch
Org
Blu
X9
Instrument Panel
X3
300
Org
124 Blk
123 Blk
B9 Hydraulic Oil Temperature Switch
117 Blk
131 Blk
104 Blk
127 Blk
114 Blk
150 Blk
100 Blk
108 Blk
106 Blk
105 Blk
112 Blk
107 Blk
127 Blk
114 Blk
150 Blk
100 Blk
Splice 2
SE3 - ACCESSORIES

MIF



SE3 - ACCESSORIES

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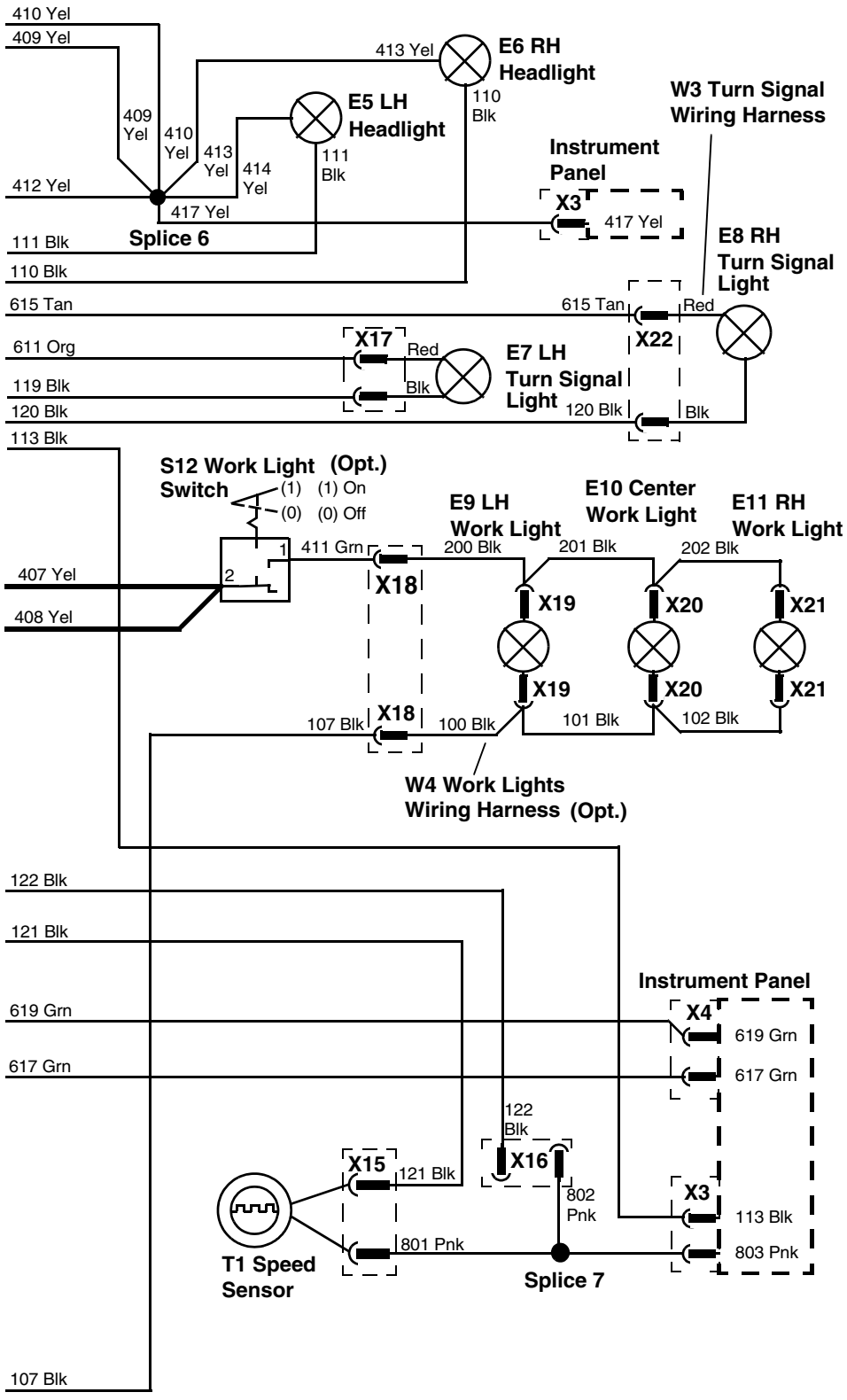

SE3 - ACCESSORIES

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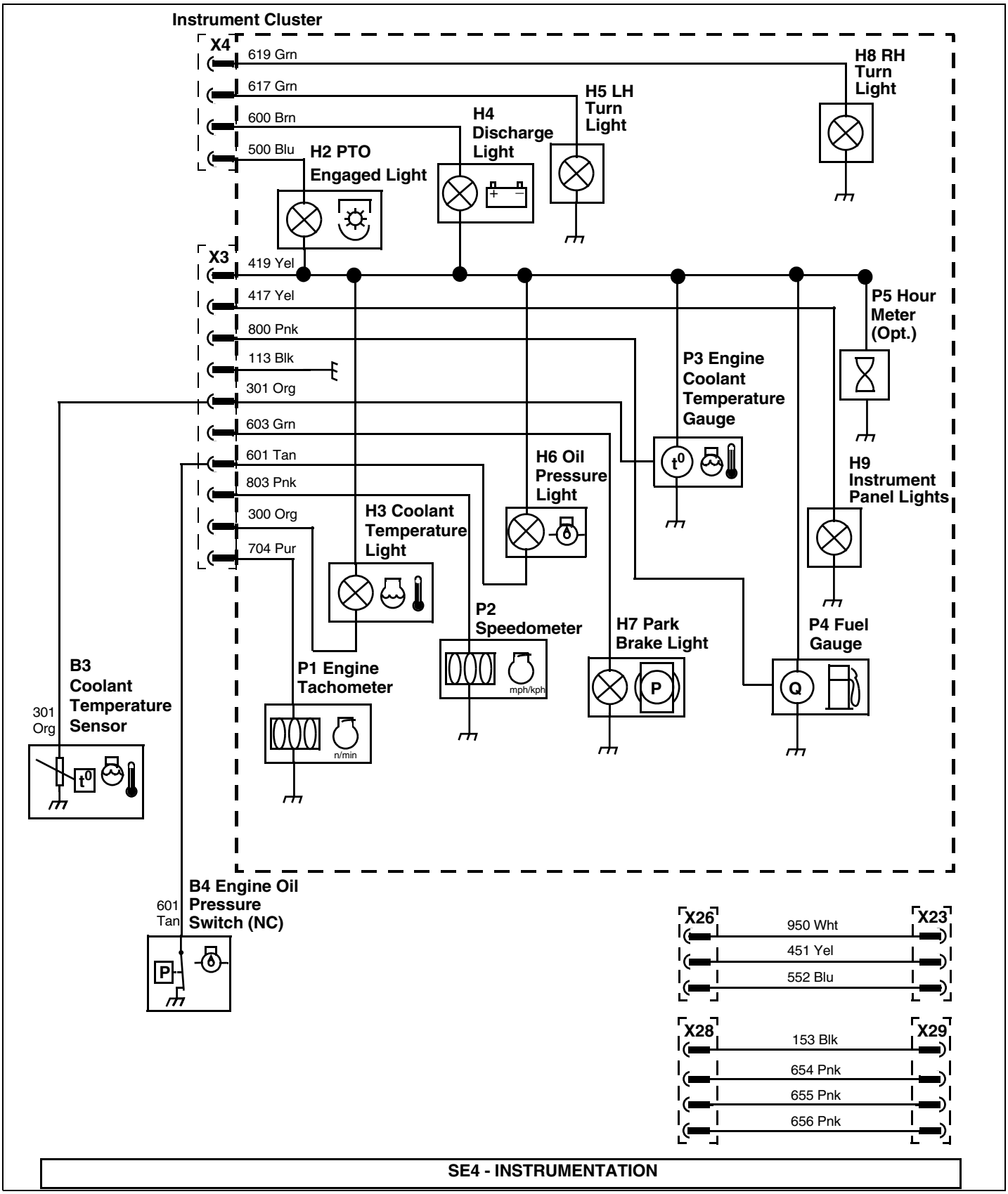
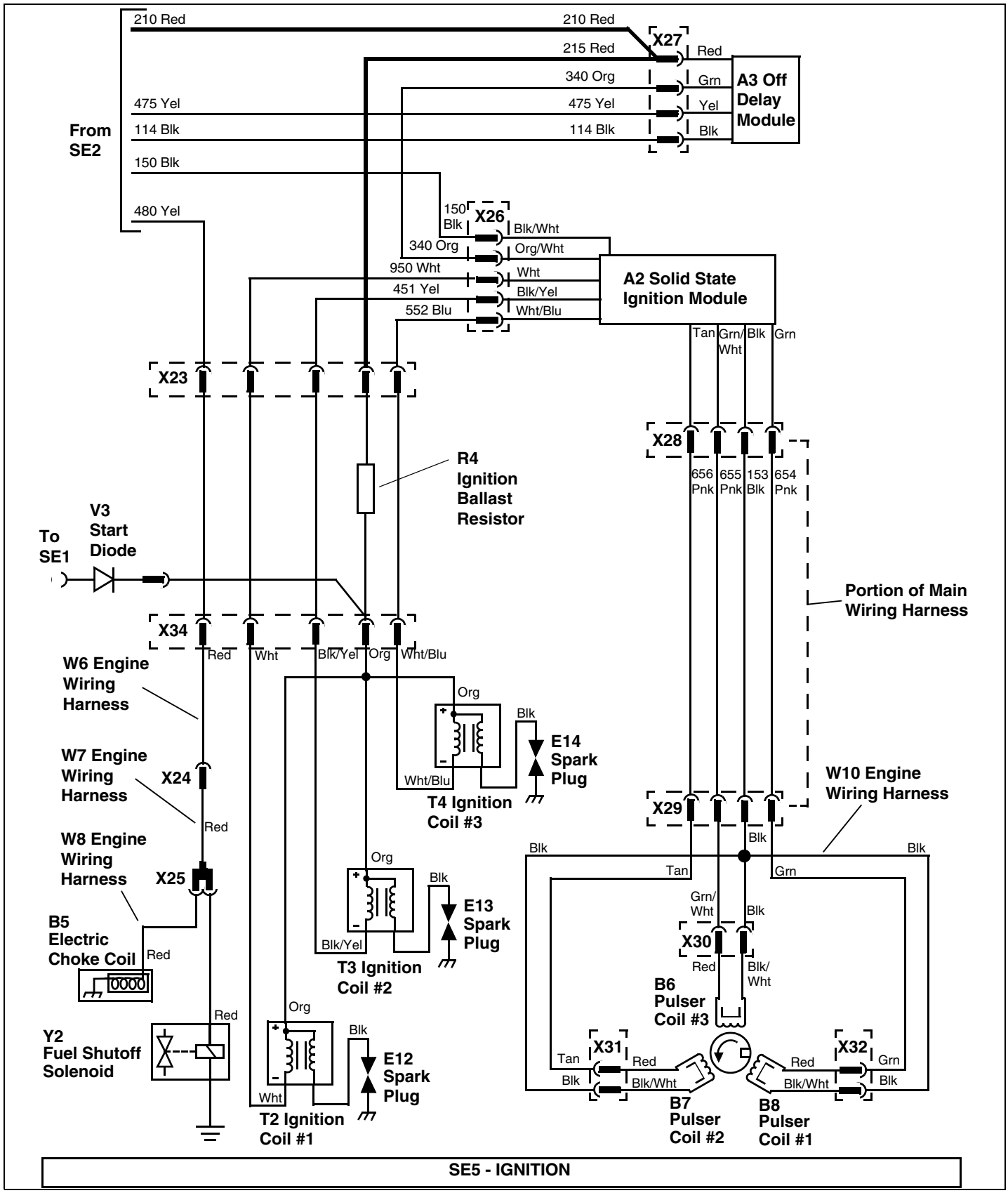

Instrument Cluster
X4
619 Grn
617 Grn
600 Brn
500 Blu
H2 PTO Engaged Light
H4 Discharge Light
H5 LH Turn Light
H8 RH Turn Light
X3
419 Yel
417 Yel
800 Pnk
113 Blk
301 Org
603 Grn
601 Tan
803 Pnk
300 Org
704 Pur
P5 Hour Meter (Opt.)
P3 Engine Coolant Temperature Gauge
H6 Oil Pressure Light
H9 Instrument Panel Lights
H3 Coolant Temperature Light
P2 Speedometer
mph/kph
H7 Park Brake Light
P4 Fuel Gauge
P1 Engine Tachometer
n/min
B3 Coolant Temperature Sensor
301 Org
B4 Engine Oil Pressure Switch (NC)
601 Tan
X26
950 Wht
451 Yel
552 Blu
X23
X28
153 Blk
654 Pnk
655 Pnk
656 Pnk
X29
SE4 - INSTRUMENTATION

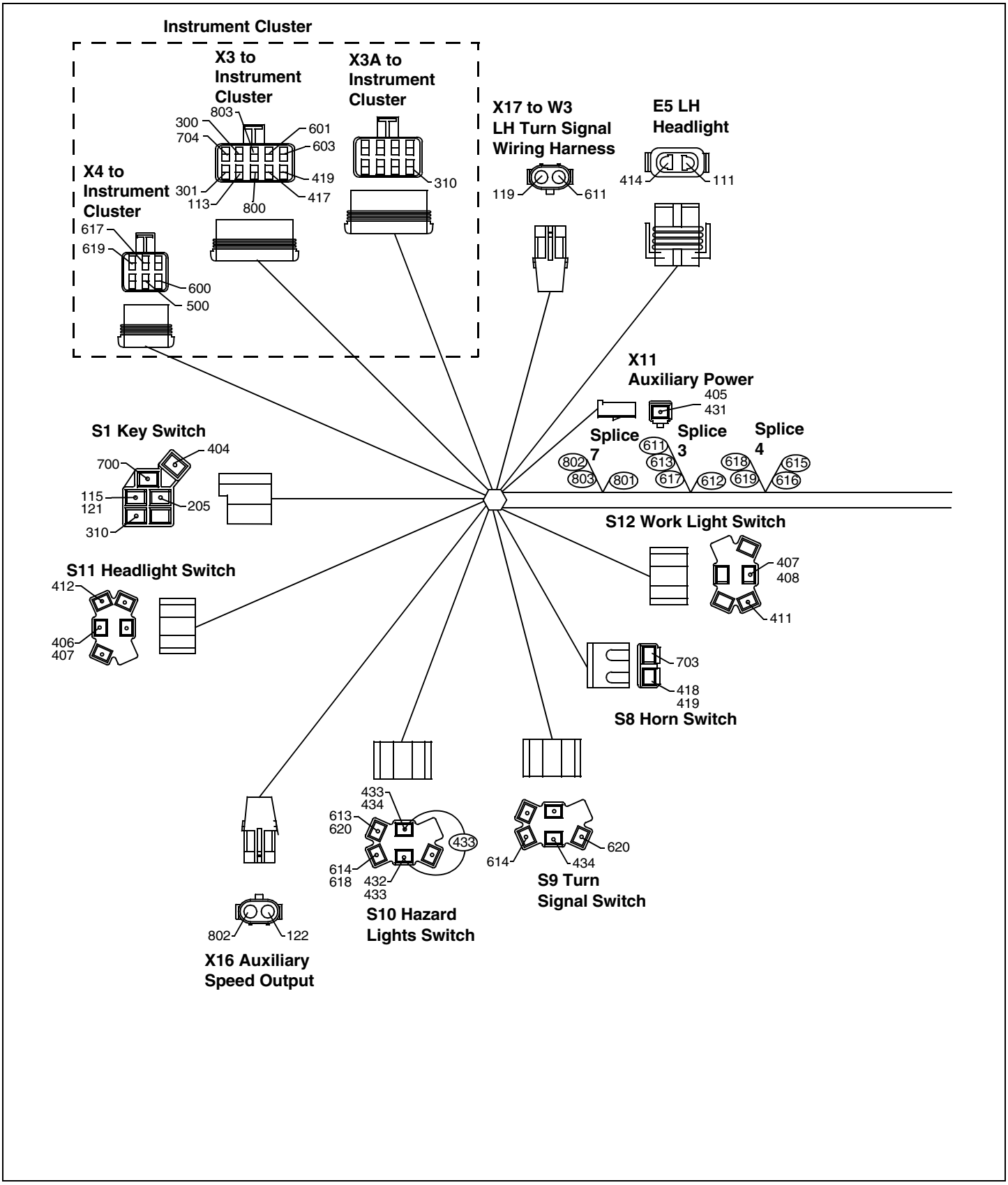
MIF



SE5 - IGNITION

MIF

W1 Main Wiring Harness - Gasoline Engine (New)



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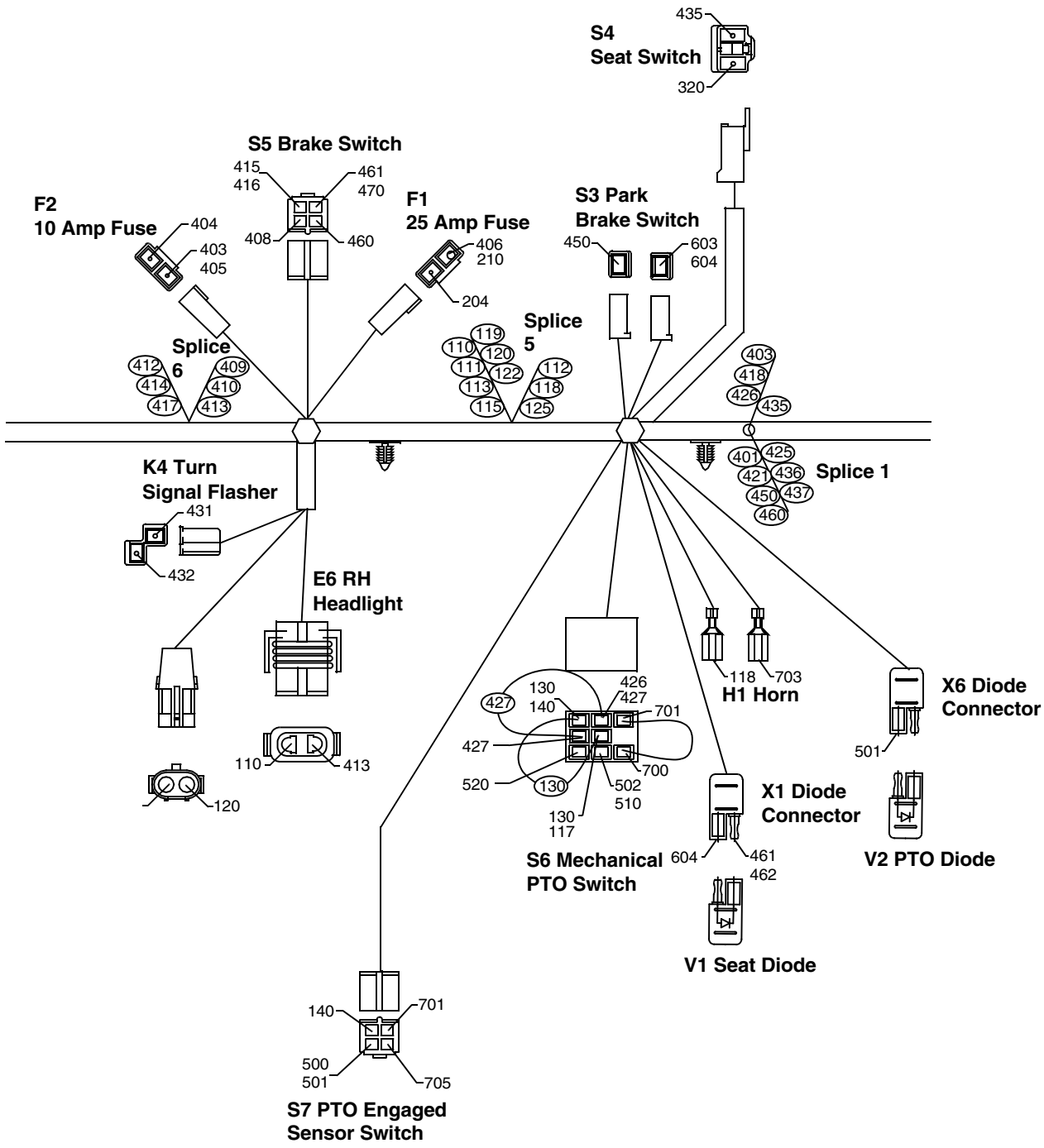
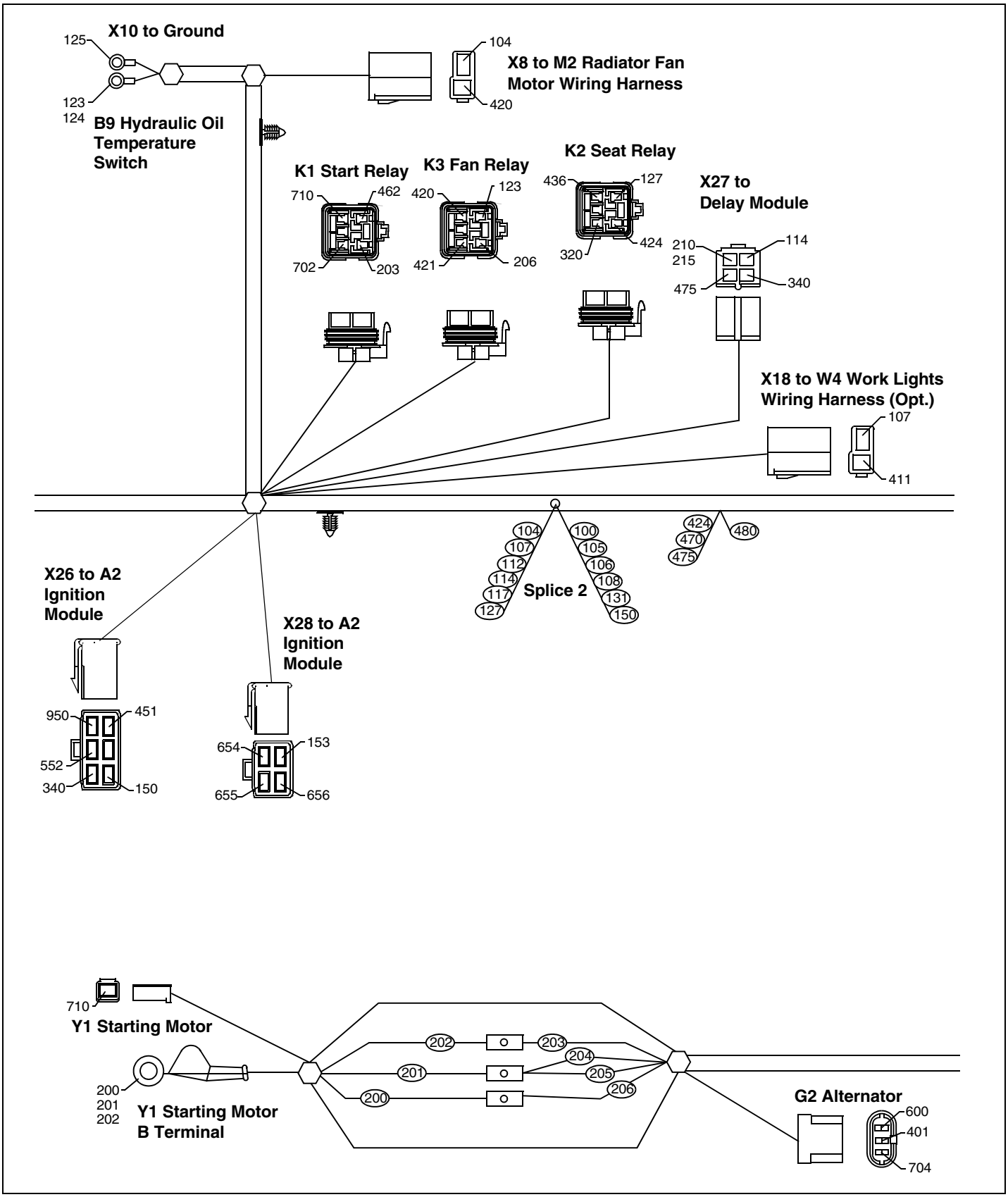
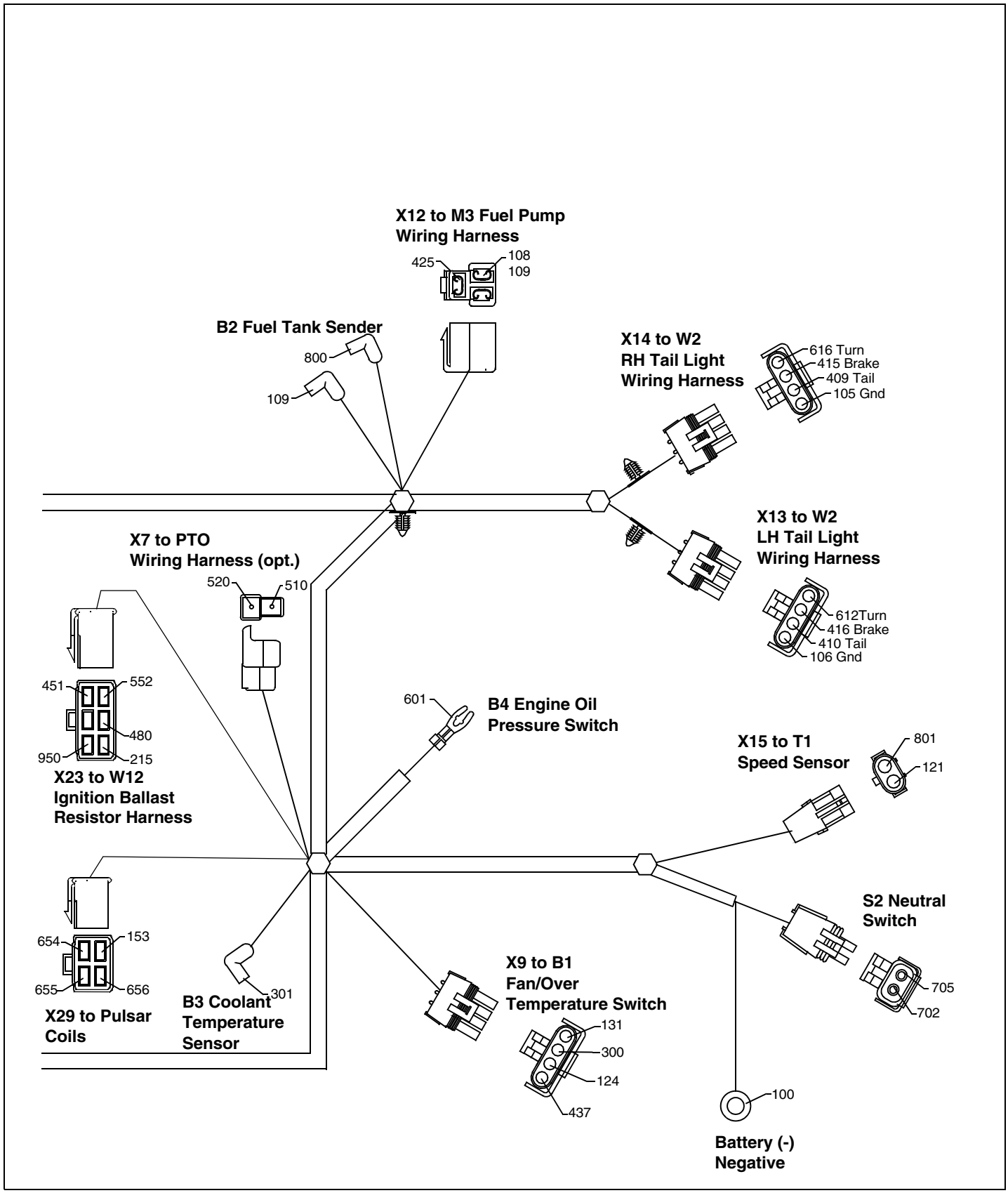

S4
Seat Switch
435
320
S5 Brake Switch
415
416
461
470
408
460
F2
10 Amp Fuse
404
403
405
F1
25 Amp Fuse
406
210
204
S3 Park
Brake Switch
450
603
604
Splice
6
412
414
417
409
410
413
Splice
5
119
120
122
110
111
113
115
112
118
125
403
418
426
435
401
425
421
436
450
437
460
Splice 1
K4 Turn
Signal Flasher
431
432
E6 RH
Headlight
110
413
120
130
140
426
427
427
701
427
700
520
130
502
510
130
117
118
703
H1 Horn
X6 Diode
Connector
501
X1 Diode
Connector
604
461
462
V2 PTO Diode
S6 Mechanical
PTO Switch
V1 Seat Diode
140
701
500
501
705
S7 PTO Engaged
Sensor Switch

MIF

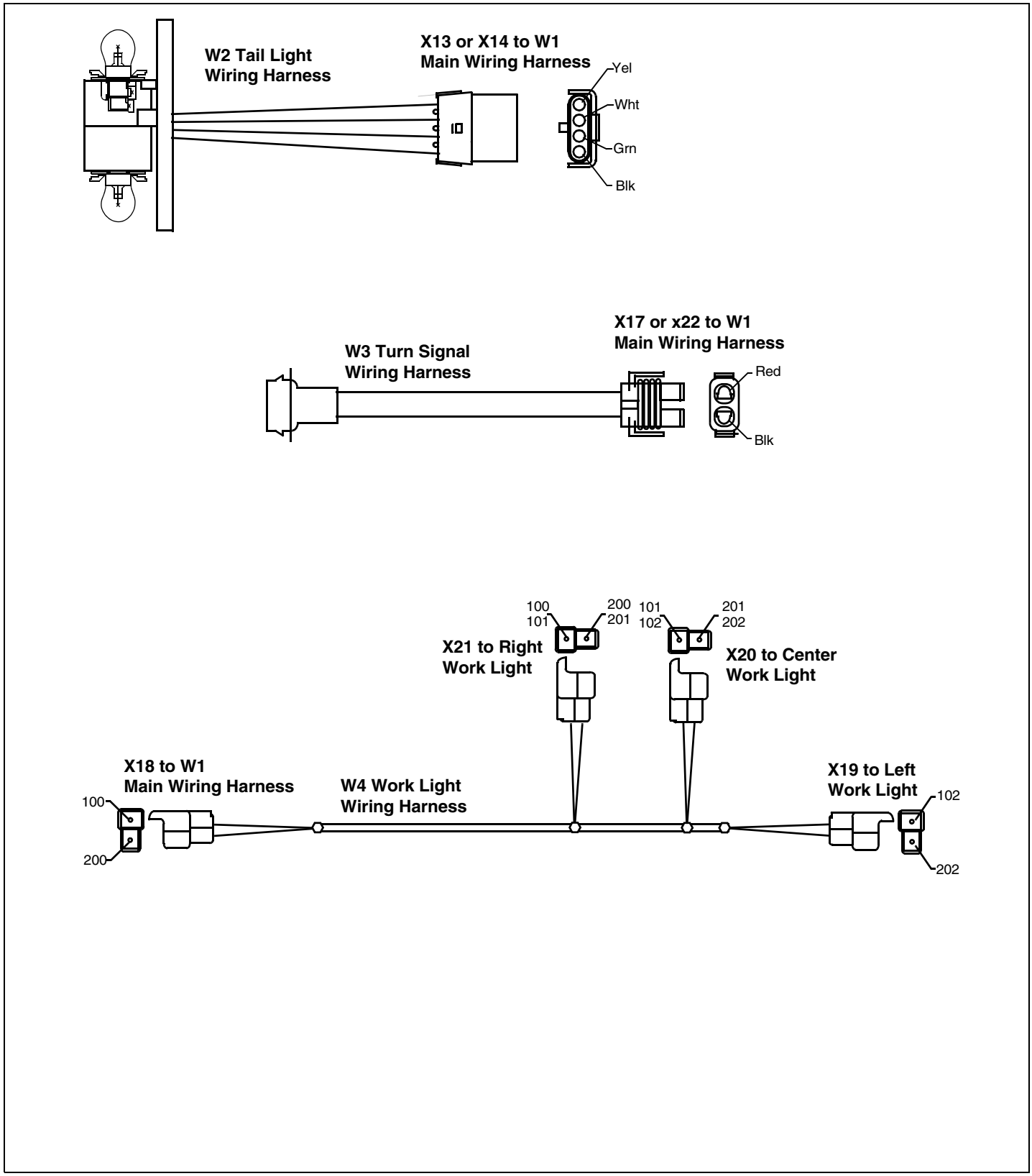

X10 to Ground
125
123
124
B9 Hydraulic Oil Temperature Switch
104
X8 to M2 Radiator Fan Motor Wiring Harness
420
K1 Start Relay
710
462
702
203
K3 Fan Relay
420
123
421
206
K2 Seat Relay
436
127
424
320
X27 to Delay Module
210
215
114
475
340
X18 to W4 Work Lights Wiring Harness (Opt.)
107
411
104
107
112
114
117
127
100
105
106
108
131
150
Splice 2
424
470
475
480
X26 to A2 Ignition Module
950
451
552
340
150
X28 to A2 Ignition Module
654
153
655
656
710
Y1 Starting Motor
200
201
202
Y1 Starting Motor B Terminal
202
203
204
201
205
206
200
G2 Alternator
600
401
704

MIF


X12 to M3 Fuel Pump
Wiring Harness
425
108
109
B2 Fuel Tank Sender
800
109
X14 to W2
RH Tail Light
Wiring Harness
616 Turn
415 Brake
409 Tail
105 Gnd
X13 to W2
LH Tail Light
Wiring Harness
612Turn
416 Brake
410 Tail
106 Gnd
X7 to PTO
Wiring Harness (opt.)
520
510
451
552
480
950
215
X23 to W12
Ignition Ballast
Resistor Harness
601
B4 Engine Oil
Pressure Switch
X15 to T1
Speed Sensor
801
121
654
153
655
656
X29 to Pulsar
Coils
B3 Coolant
Temperature
Sensor
301
X9 to B1
Fan/Over
Temperature Switch
131
300
124
437
S2 Neutral
Switch
705
702
100
Battery (-)
Negative

MIF

W2-W12 Wiring Harnesses - Gasoline Engine (New)



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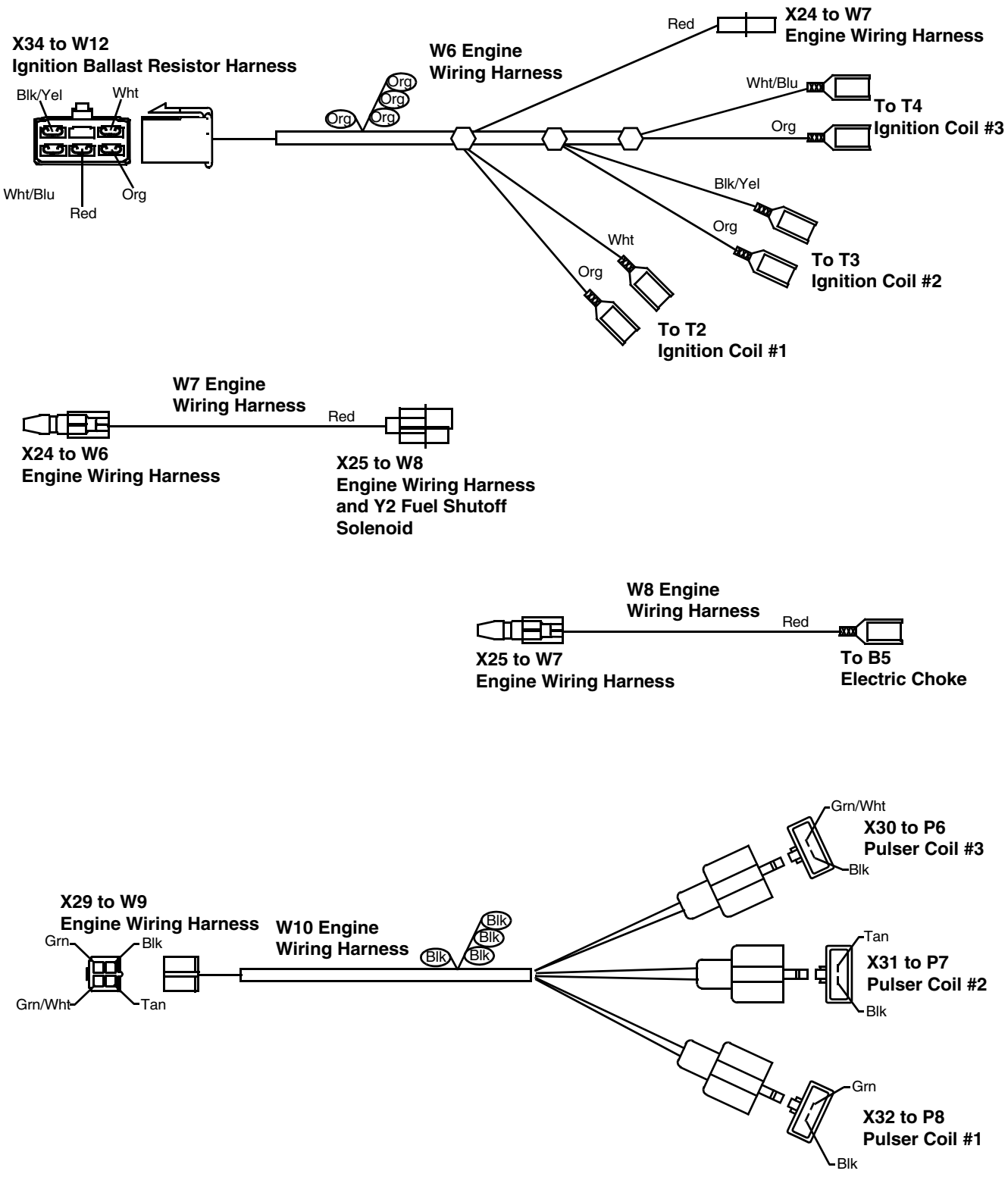
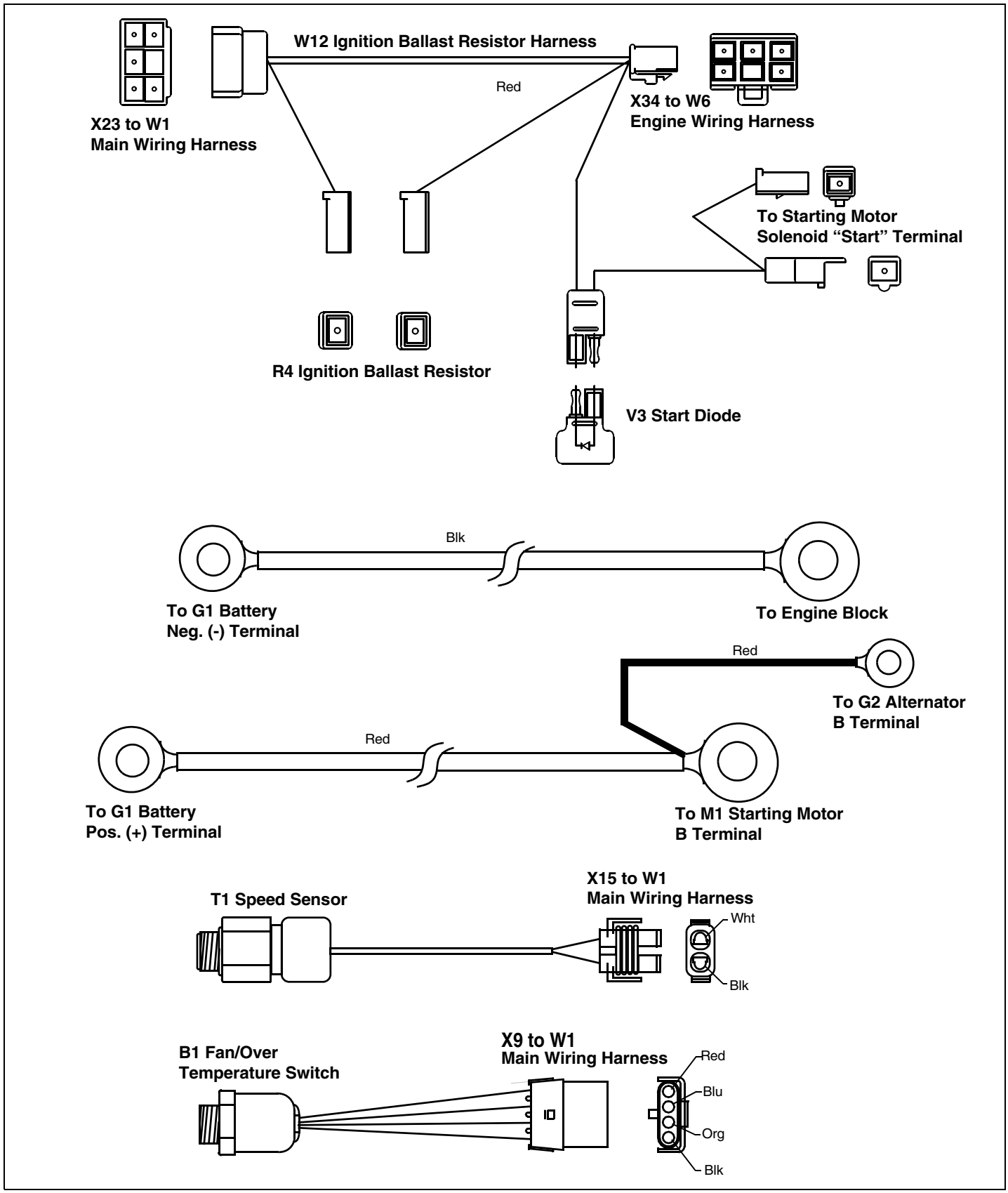
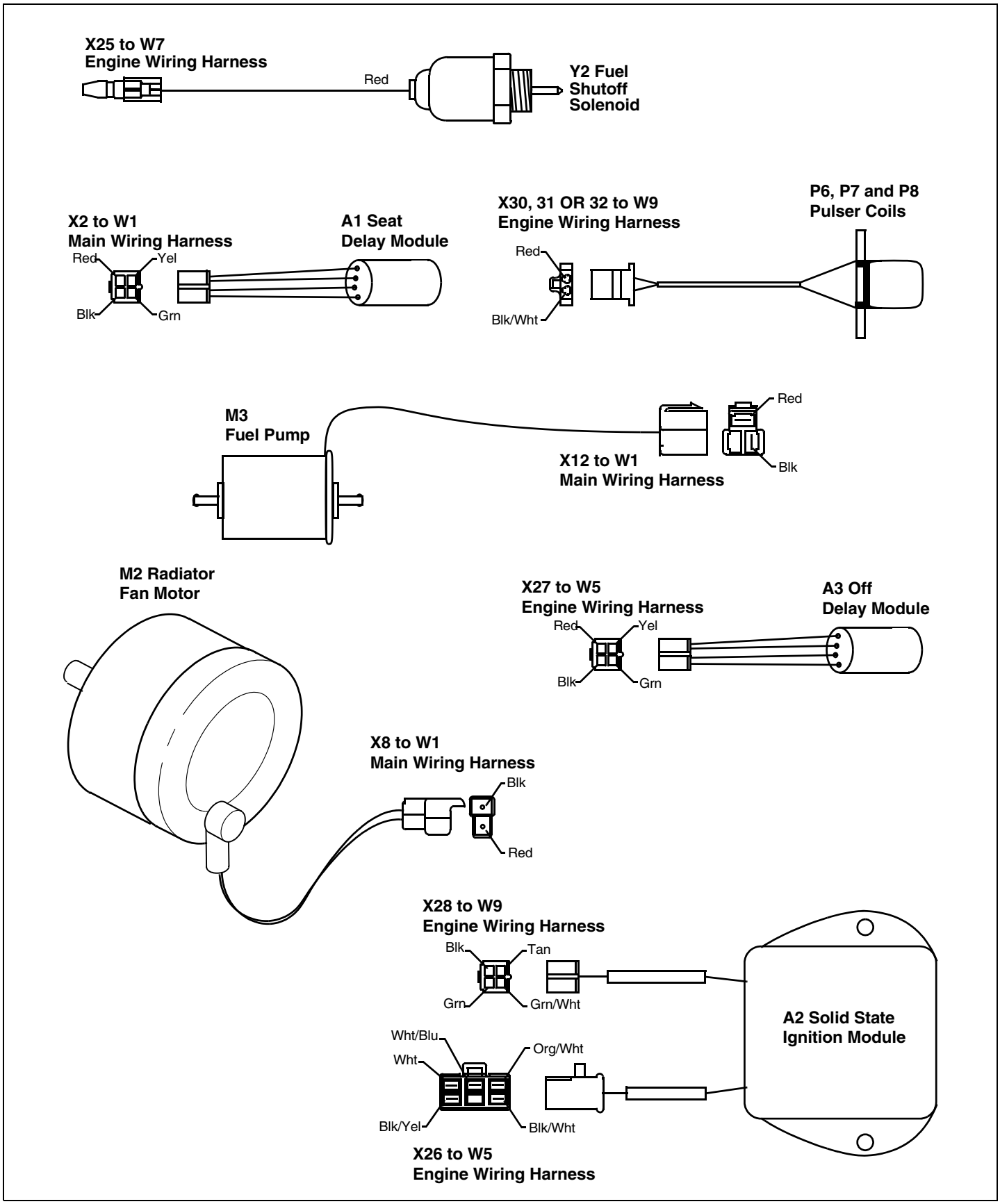

X34 to W12
Ignition Ballast Resistor Harness
Blk/Yel
Wht
Wht/Blu
Org
Red
W6 Engine
Wiring Harness
Org
Org
Org
Red
X24 to W7
Engine Wiring Harness
Wht/Blu
To T4
Ignition Coil #3
Org
Blk/Yel
Org
To T3
Ignition Coil #2
Wht
Org
To T2
Ignition Coil #1
W7 Engine
Wiring Harness
Red
X24 to W6
Engine Wiring Harness
X25 to W8
Engine Wiring Harness
and Y2 Fuel Shutoff
Solenoid
W8 Engine
Wiring Harness
Red
X25 to W7
Engine Wiring Harness
To B5
Electric Choke
X29 to W9
Engine Wiring Harness
Grn
Blk
Grn/Wht
Tan
W10 Engine
Wiring Harness
Blk
Blk
Blk
Blk
Grn/Wht
X30 to P6
Pulser Coil #3
Blk
Tan
X31 to P7
Pulser Coil #2
Blk
Grn
X32 to P8
Pulser Coil #1
Blk

MIF


W12 Ignition Ballast Resistor Harness
Red
X23 to W1
Main Wiring Harness
X34 to W6
Engine Wiring Harness
To Starting Motor
Solenoid "Start" Terminal
R4 Ignition Ballast Resistor
V3 Start Diode
Blk
To G1 Battery
Neg. (-) Terminal
To Engine Block
Red
To G2 Alternator
B Terminal
Red
To G1 Battery
Pos. (+) Terminal
To M1 Starting Motor
B Terminal
T1 Speed Sensor
X15 to W1
Main Wiring Harness
Wht
Blk
B1 Fan/Over
Temperature Switch
X9 to W1
Main Wiring Harness
Red
Blu
Org
Blk

MIF


X25 to W7
Engine Wiring Harness
Red
Y2 Fuel
Shutoff
Solenoid
X2 to W1
Main Wiring Harness
Red
Yel
Blk
Grn
A1 Seat
Delay Module
X30, 31 OR 32 to W9
Engine Wiring Harness
Red
Blk/Wht
P6, P7 and P8
Pulser Coils
M3
Fuel Pump
X12 to W1
Main Wiring Harness
Red
Blk
M2 Radiator
Fan Motor
X27 to W5
Engine Wiring Harness
Red
Yel
Blk
Grn
A3 Off
Delay Module
X8 to W1
Main Wiring Harness
Blk
Red
X28 to W9
Engine Wiring Harness
Blk
Tan
Grn
Grn/Wht
Wht/Blu
Wht
Org/Wht
Blk/Yel
Blk/Wht
A2 Solid State
Ignition Module
X26 to W5
Engine Wiring Harness

MIF

Wire Color Codes - Gasoline Engines (New)

2020 Gas Engine Vehicle Main Wiring Harness

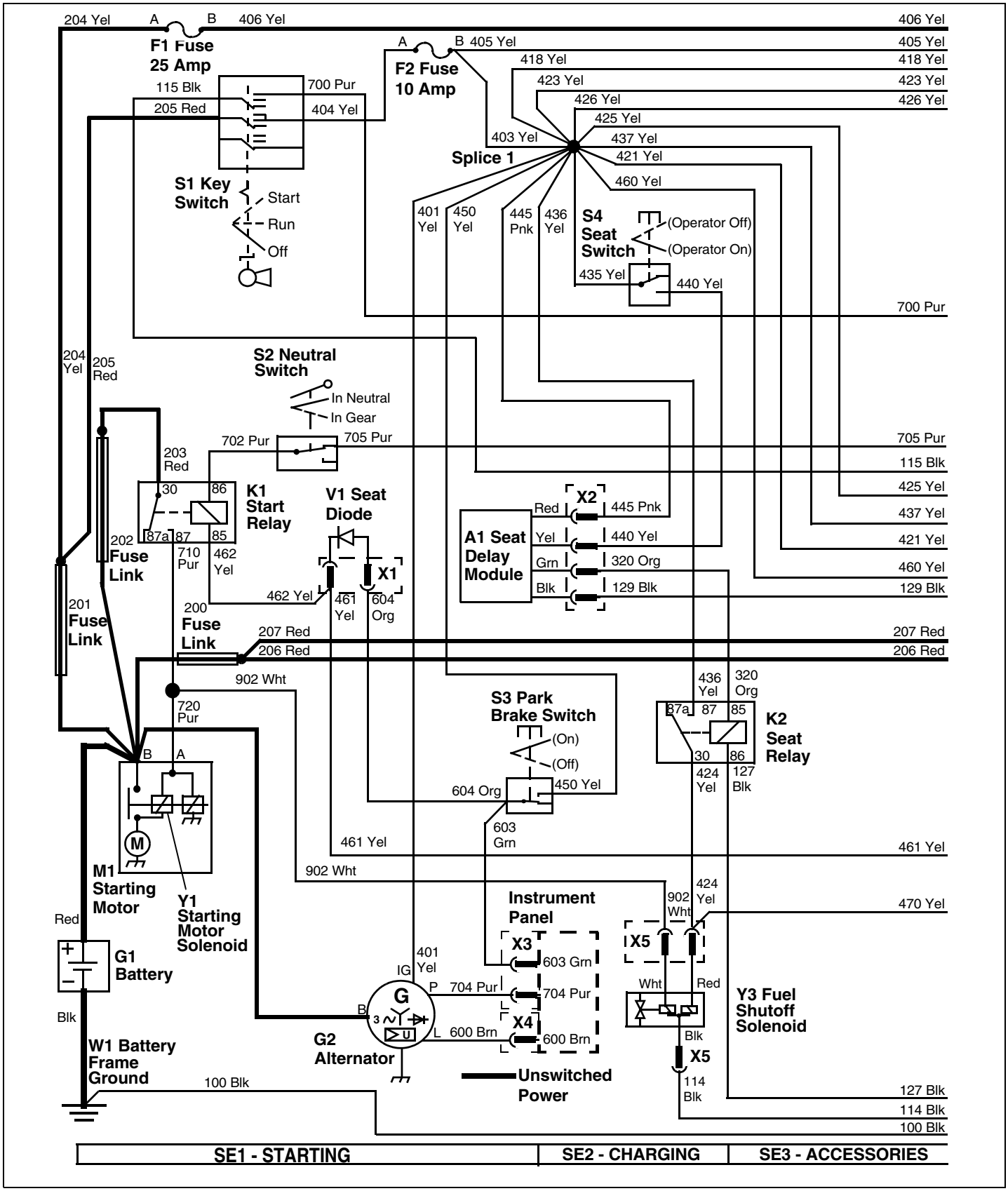
TC2020 2 Wheel Drive 020348-
TC2020 4 Wheel Drive 020079-

Circuit Number	Wire Size	Color	Termination Points
100	5.0	Blk	W1, Splice #2
104	3.0	Blk	Splice #2, X8
105	0.8	Blk	Splice #2, X14
106	0.8	Blk	Splice #2, X13
107	1.0	Blk	Splice #2, X18
108	0.8	Blk	Splice #2, X12
109	0.8	Blk	X12, B2
110	1.0	Blk	Splice #5, E6
111	1.0	Blk	Splice #5, E5
112	5.0	Blk	Splice #2, Splice #5
113	0.8	Blk	Splice #5, X3
114	3.0	Blk	Splice #2, X27
115	1.0	Blk	Splice #5, S1
117	1.0	Blk	Splice #2, S6
118	0.8	Blk	Splice #5, H1
119	1.0	Blk	Splice #5, X17
120	1.0	Blk	Splice #5, X22
121	0.8	Blk	S1, X15
122	0.8	Blk	Splice #5, X16
123	0.8	Blk	X10, K3
124	0.8	Blk	X9, X10
125	0.8	Blk	Splice #5, X10
127	0.8	Blk	Splice #2, K2
130	1.0	Blk	S6, S6
131	1.0	Blk	Splice #2, X9
140	1.0	Blk	S6, S7
150	1.0	Blk	Splice #2, X26
153	1.0	Blk	X28, X29
200	1.0	Fuse Link	Y1, Wire 206
201	2.0	Fuse Link	Y1, Wires 204 and 205
202	1.0	Fuse Link	Y1, Wire 203
203	3.0	Red	fuse Link 202, K1
204	3.0	Yel	fuse Link 201, F1
205	5.0	Red	fuse Link 201, S1
206	3.0	Red	fuse Link 200, K3
210	2.0	Red	F1, X27
215	1.0	Red	X27, X23
300	0.8	Org	X9, X3
301	0.8	Org	B3, X3
310	0.8	Org	S1, X3A
320	0.8	Org	K2, S4
340	1.0	Org	X26, X27
401	0.8	Yel	Splice #1, G2
403	2.0	Yel	Splice #1, F2
404	2.0	Yel	S1, F2
405	1.0	Yel	F2, X11
406	3.0	Yel	F1, S11
407	2.0	Yel	S11, S12
408	2.0	Yel	S12, S5
409	1.0	Yel	Splice #6, X14
410	1.0	Yel	Splice #6, X13
411	1.0	Grn	S12, X18
412	3.0	Yel	Splice #6, S11
413	1.0	Yel	Splice #6, E6
414	1.0	Yel	Splice #6, E5
415	0.8	Yel	S5, X14
416	0.8	Yel	S5, X13

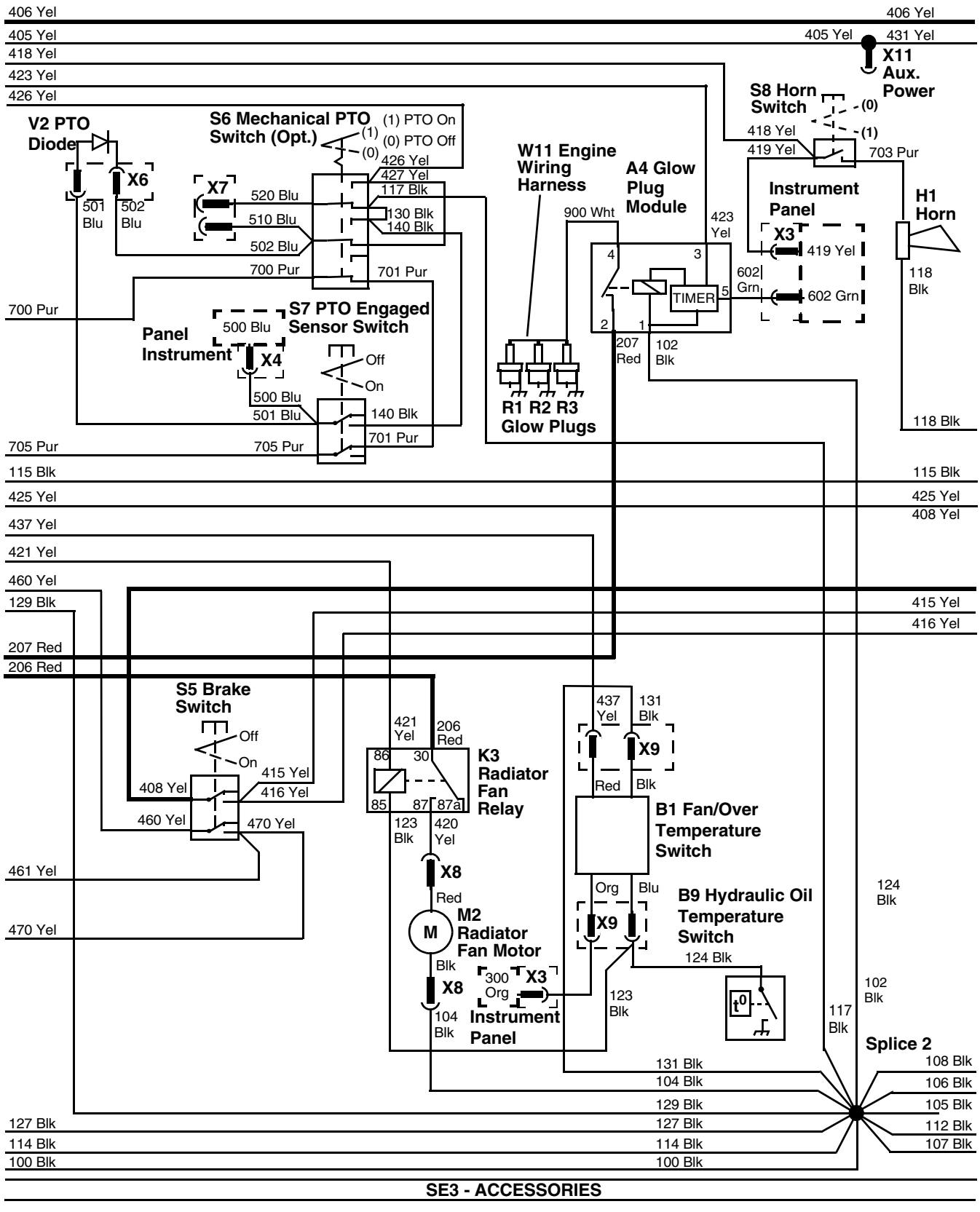
Circuit Number	Wire Size	Color	Termination Points
417	0.8	Yel	Splice #6, X3
418	0.8	Yel	Splice #1, S8
419	0.8	Yel	S8, X3
420	3.0	Yel	K3, X8
421	0.8	Yel	K3, Splice #1
424	1.0	Yel	K2, Splice #8
425	0.8	Yel	Splice #1, X12
426	1.0	Yel	Splice #1, S6
427	1.0	Yel	S6, S6
431	1.0	Yel	X11, K4
432	1.0	Yel	K4, S10
433	1.0	Yel	S10, S10
434	1.0	Yel	S10, S9
435	0.8	Yel	Splice #1, S4
436	0.8	Yel	Splice #1, K2
437	1.0	Yel	Splice #1, X9
450	0.8	Yel	Splice #1, S3
451	1.0	Yel	X23, X26
460	1.0	Yel	Splice #1, S5
461	0.8	Yel	S5, X1
462	0.8	Yel	X1, K1
470	1.0	Yel	S5, Splice #8
475	1.0	Yel	X27, Splice #8
480	1.0	Yel	Splice #8, X23
500	0.8	Blu	X4, S7
501	0.8	Blu	S7, X6
502	0.8	Blu	X6, S6
510	1.0	Blu	X7, S6
520	1.0	Blu	X7, S6
552	1.0	Blu	X23, X26
600	0.8	Brn	G2, X4
601	0.8	Tan	B4, X3

Circuit Number	Wire Size	Color	Termination Points
603	0.8	Grn	X3, S3
604	0.8	Org	S3, X1
611	0.8	Org	X17, Splice #3
612	0.8	Pnk	Splice #3, X13
613	0.8	Tan	S10, Splice #3
614	0.8	Grn	S9, S10
615	0.8	Tan	X22, Splice #4
616	0.8	Pnk	Splice #4, X14
617	0.8	Grn	Splice #3, X4
618	0.8	Tan	Splice #4, S10
619	0.8	Grn	Splice #4, X4
620	0.8	Tan	S9, S10
654	1.0	Pnk	X28, X29
655	1.0	Pnk	X28, X29
656	1.0	Pnk	X28, X29
700	1.0	Pur	S1, S6
701	0.8	Pur	S6, S7
702	0.8	Pur	S2, K1
703	0.8	Pur	S8, H1
704	0.8	Pur	G2, X3
705	0.8	Pur	S7, S2‘
710	3.0	Pur	K1, Y1
800	0.8	Pnk	B2, X3
801	0.8	Pnk	Splice #7, X15
802	0.8	Pnk	Splice #7, X16
803	0.8	Pnk	Splice #7, X3
950	1.0	Wht	X23, X26

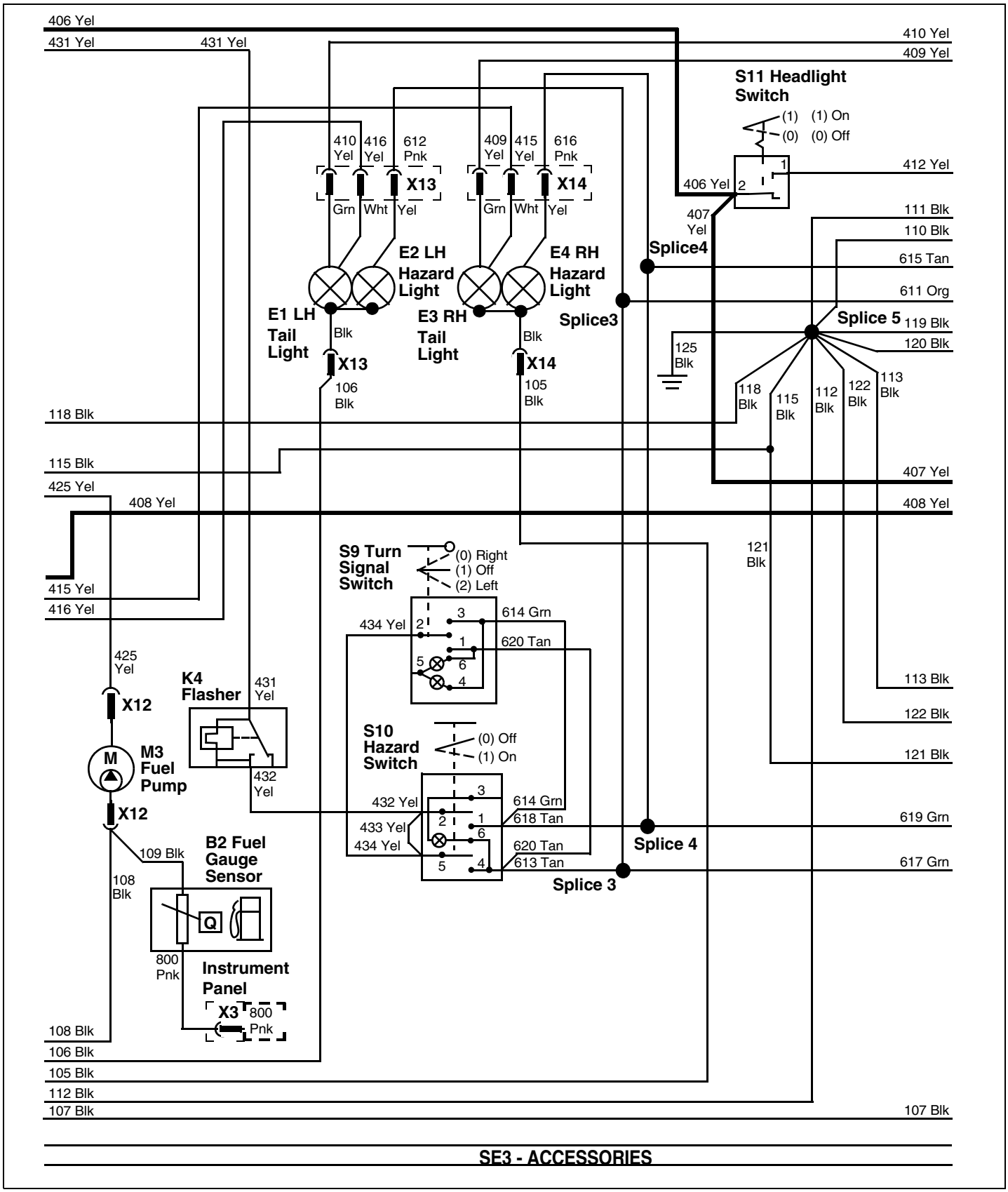
W1 Main Wiring Schematic - Diesel Engine



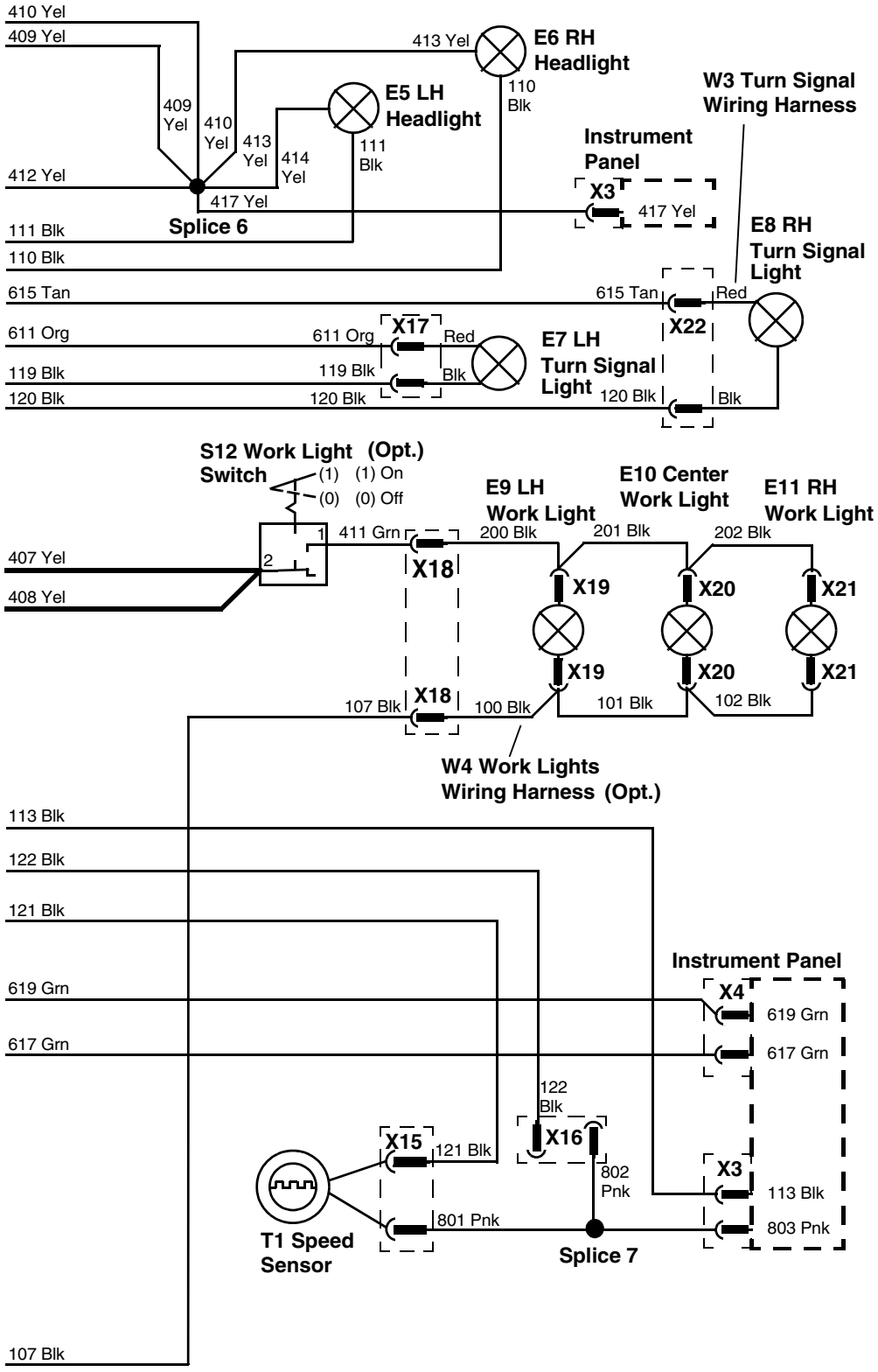
MIF


406 Yel
405 Yel
418 Yel
423 Yel
426 Yel
V2 PTO Diode
X6
501 Blu
502 Blu
S6 Mechanical PTO Switch (Opt.)
(1) PTO On
(0) PTO Off
X7
520 Blu
510 Blu
502 Blu
426 Yel
427 Yel
117 Blk
130 Blk
140 Blk
700 Pur
701 Pur
700 Pur
Panel Instrument
500 Blu
X4
S7 PTO Engaged Sensor Switch
Off
On
500 Blu
501 Blu
140 Blk
701 Pur
705 Pur
705 Pur
W11 Engine Wiring Harness
R1 R2 R3 Glow Plugs
900 Wht
A4 Glow Plug Module
4
3
2
1
TIMER
5
423 Yel
207 Red
102 Blk
602 Grn
602 Grn
Instrument Panel
X3
419 Yel
S8 Horn Switch
(0)
(1)
418 Yel
419 Yel
703 Pur
405 Yel
431 Yel
X11 Aux. Power
406 Yel
H1 Horn
118 Blk
118 Blk
115 Blk
425 Yel
437 Yel
421 Yel
460 Yel
129 Blk
207 Red
206 Red
115 Blk
425 Yel
408 Yel
415 Yel
416 Yel
S5 Brake Switch
Off
On
408 Yel
415 Yel
416 Yel
460 Yel
470 Yel
461 Yel
470 Yel
421 Yel
206 Red
86
30
85
87
87a
K3 Radiator Fan Relay
123 Blk
420 Yel
X8
Red
M
M2 Radiator Fan Motor
Blk
X8
104 Blk
300 Org
X3
Instrument Panel
437 Yel
131 Blk
X9
Red
Blk
B1 Fan/Over Temperature Switch
Org
Blu
X9
B9 Hydraulic Oil Temperature Switch
124 Blk
123 Blk
124 Blk
102 Blk
117 Blk
Splice 2
131 Blk
104 Blk
129 Blk
127 Blk
114 Blk
100 Blk
108 Blk
106 Blk
105 Blk
112 Blk
107 Blk
SE3 - ACCESSORIES

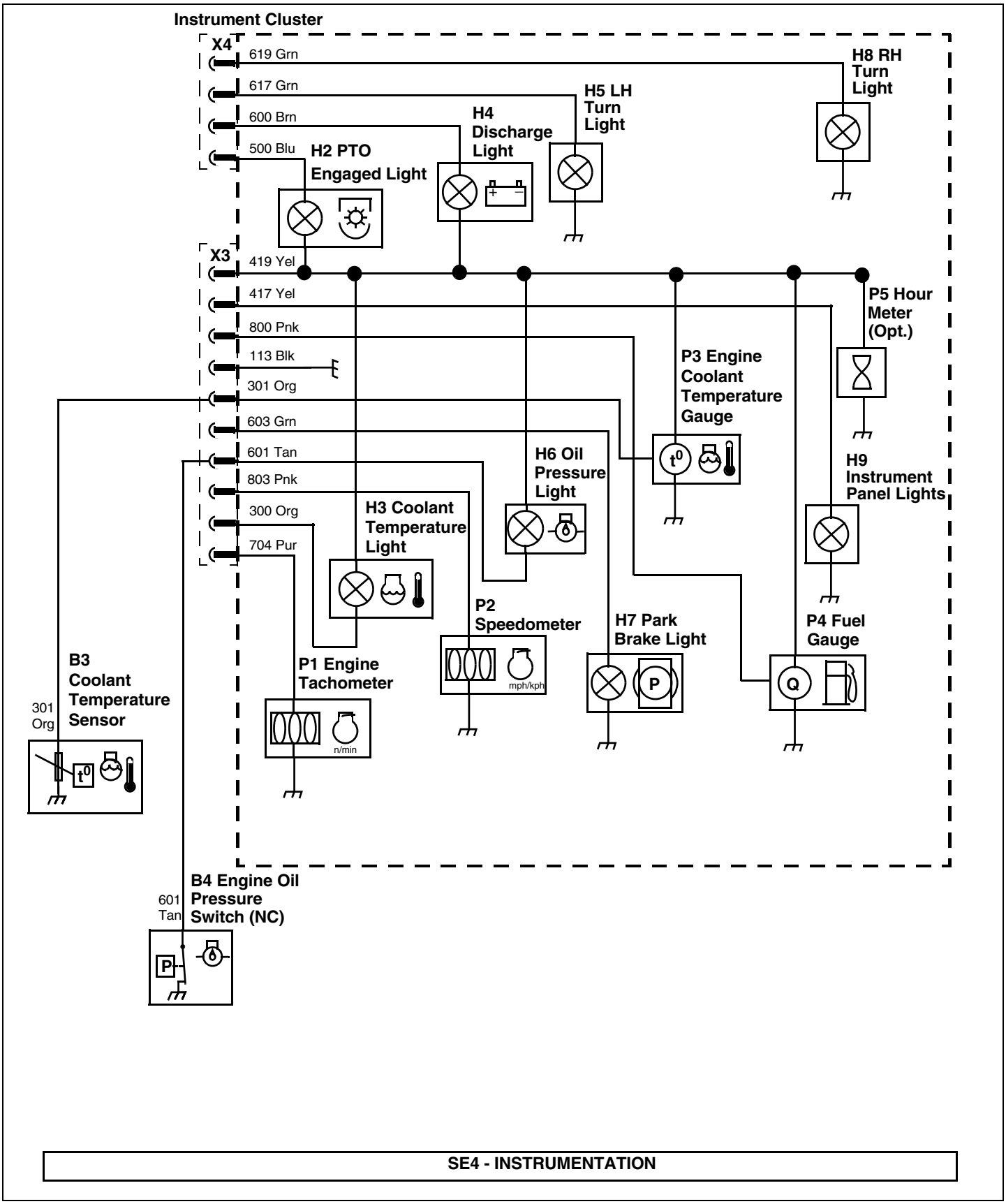
MIF


406 Yel
431 Yel
431 Yel
410 Yel
409 Yel
S11 Headlight Switch
(1) (1) On
(0) (0) Off
410 Yel
416 Yel
612 Pnk
X13
Grn Wht Yel
409 Yel
415 Yel
616 Pnk
X14
Grn Wht Yel
406 Yel
412 Yel
407 Yel
111 Blk
110 Blk
615 Tan
611 Org
Splice4
E2 LH Hazard Light
E4 RH Hazard Light
E1 LH Tail Light
E3 RH Tail Light
Splice3
Splice 5
119 Blk
120 Blk
125 Blk
118 Blk
115 Blk
112 Blk
122 Blk
113 Blk
Blk
X13
106 Blk
X14
105 Blk
118 Blk
115 Blk
425 Yel
408 Yel
407 Yel
408 Yel
S9 Turn Signal Switch
(0) Right
(1) Off
(2) Left
121 Blk
415 Yel
416 Yel
434 Yel
614 Grn
620 Tan
425 Yel
X12
K4 Flasher
431 Yel
113 Blk
122 Blk
S10 Hazard Switch
(0) Off
(1) On
M
M3 Fuel Pump
X12
121 Blk
432 Yel
432 Yel
614 Grn
618 Tan
433 Yel
434 Yel
620 Tan
613 Tan
619 Grn
Splice 4
617 Grn
109 Blk
B2 Fuel Gauge Sensor
108 Blk
Q
800 Pnk
Instrument Panel
X3
800 Pnk
Splice 3
108 Blk
106 Blk
105 Blk
112 Blk
107 Blk
107 Blk
SE3 - ACCESSORIES

MIF


410 Yel
409 Yel
413 Yel
E6 RH Headlight
110 Blk
E5 LH Headlight
409 Yel
410 Yel
413 Yel
414 Yel
111 Blk
412 Yel
417 Yel
Splice 6
111 Blk
110 Blk
W3 Turn Signal Wiring Harness
Instrument Panel
X3
417 Yel
E8 RH Turn Signal Light
615 Tan
615 Tan
Red
X22
611 Org
611 Org
X17
Red
E7 LH Turn Signal Light
119 Blk
119 Blk
Blk
120 Blk
120 Blk
120 Blk
Blk
S12 Work Light (Opt.) Switch
(1) (1) On
(0) (0) Off
E9 LH Work Light
E10 Center Work Light
E11 RH Work Light
1
411 Grn
200 Blk
201 Blk
202 Blk
407 Yel
2
X18
X19
X20
X21
408 Yel
X19
X20
X21
107 Blk
X18
100 Blk
101 Blk
102 Blk
W4 Work Lights Wiring Harness (Opt.)
113 Blk
122 Blk
121 Blk
Instrument Panel
X4
619 Grn
619 Grn
617 Grn
617 Grn
122 Blk
X16
X15
121 Blk
802 Pnk
X3
113 Blk
801 Pnk
803 Pnk
T1 Speed Sensor
Splice 7
107 Blk
SE3 - ACCESSORIES

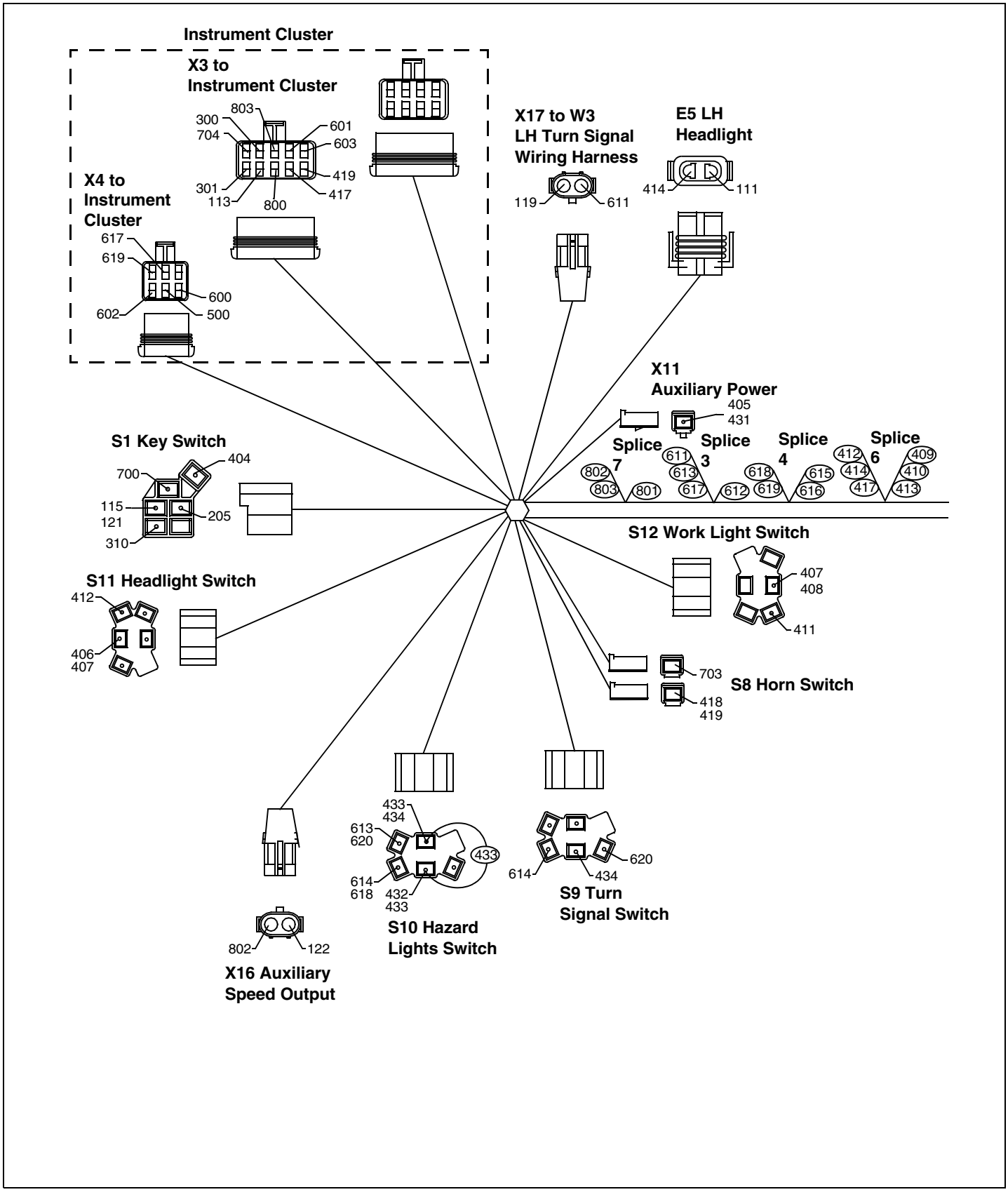
MIF



SE4 - INSTRUMENTATION

MIF

W1 Main Wiring Harness - Diesel Engine



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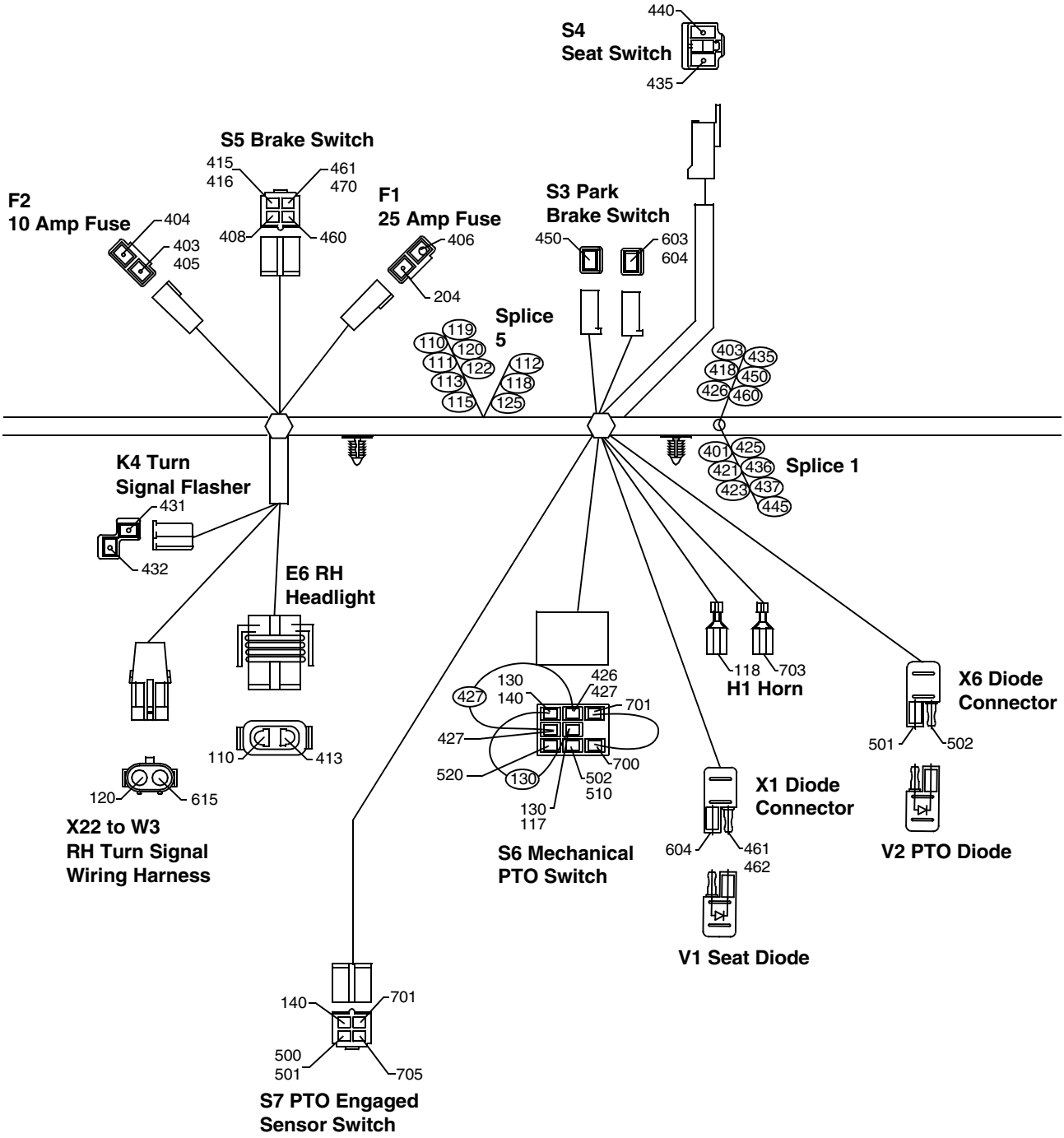
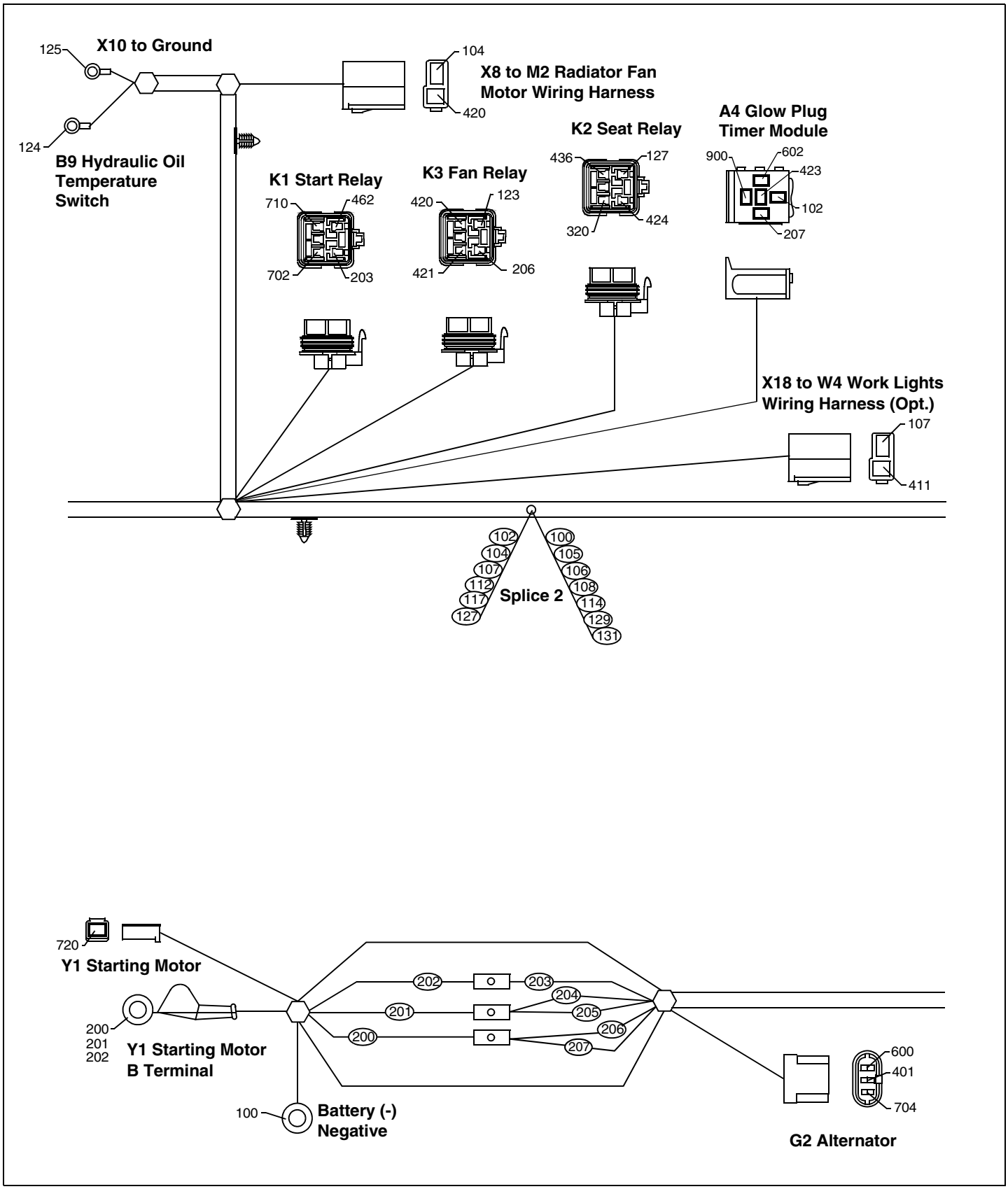
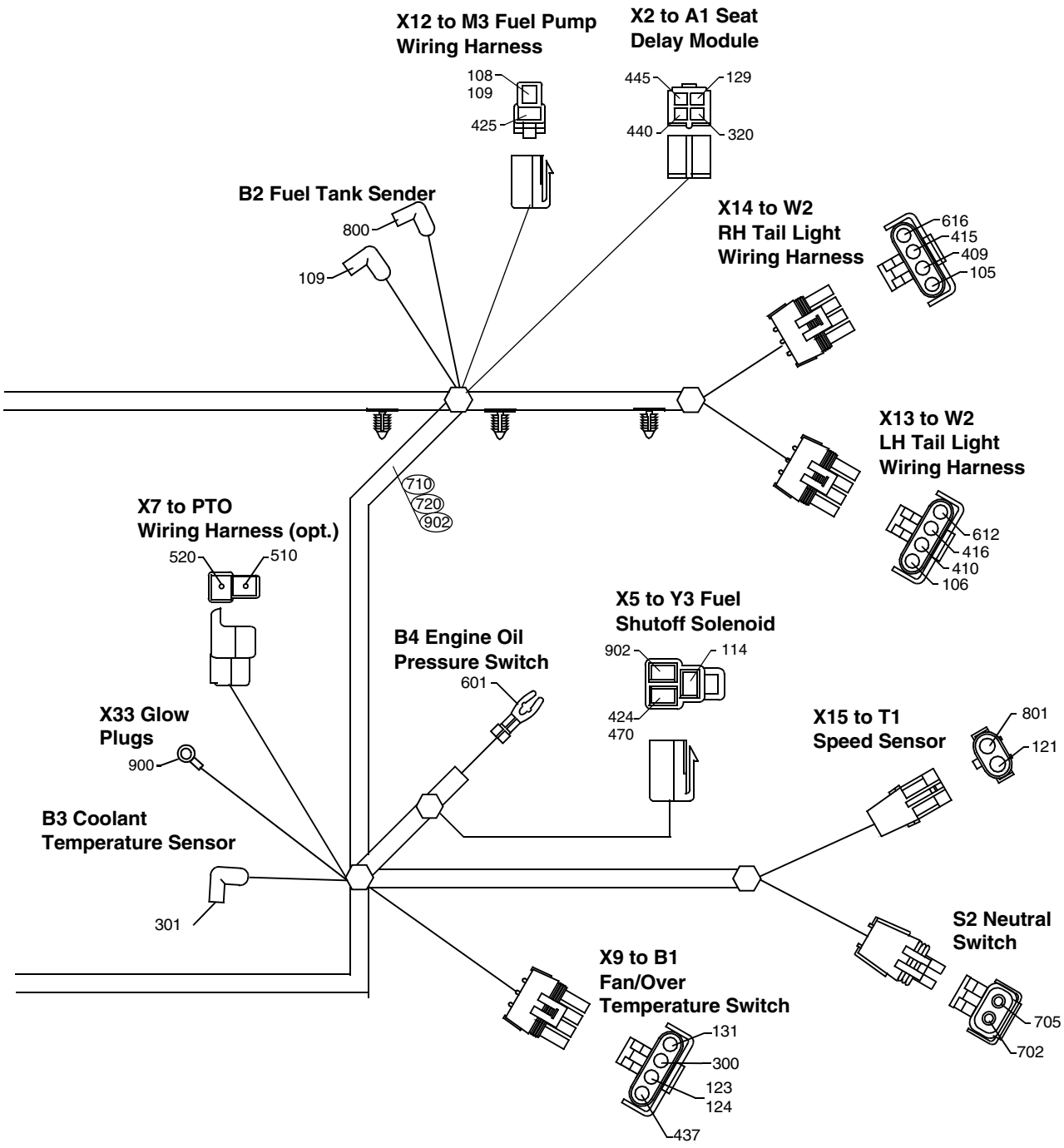

S4
Seat Switch
440
435
S5 Brake Switch
415
416
461
470
408
460
F2
10 Amp Fuse
404
403
405
F1
25 Amp Fuse
406
204
S3 Park
Brake Switch
450
603
604
Splice
5
119
110
120
111
122
112
113
118
115
125
403
435
418
450
426
460
401
425
421
436
423
437
445
Splice 1
K4 Turn
Signal Flasher
431
432
E6 RH
Headlight
110
413
120
615
X22 to W3
RH Turn Signal
Wiring Harness
130
140
426
427
427
701
427
520
130
700
502
510
130
117
S6 Mechanical
PTO Switch
118
703
H1 Horn
X6 Diode
Connector
501
502
V2 PTO Diode
X1 Diode
Connector
604
461
462
V1 Seat Diode
140
701
500
501
705
S7 PTO Engaged
Sensor Switch

MIF

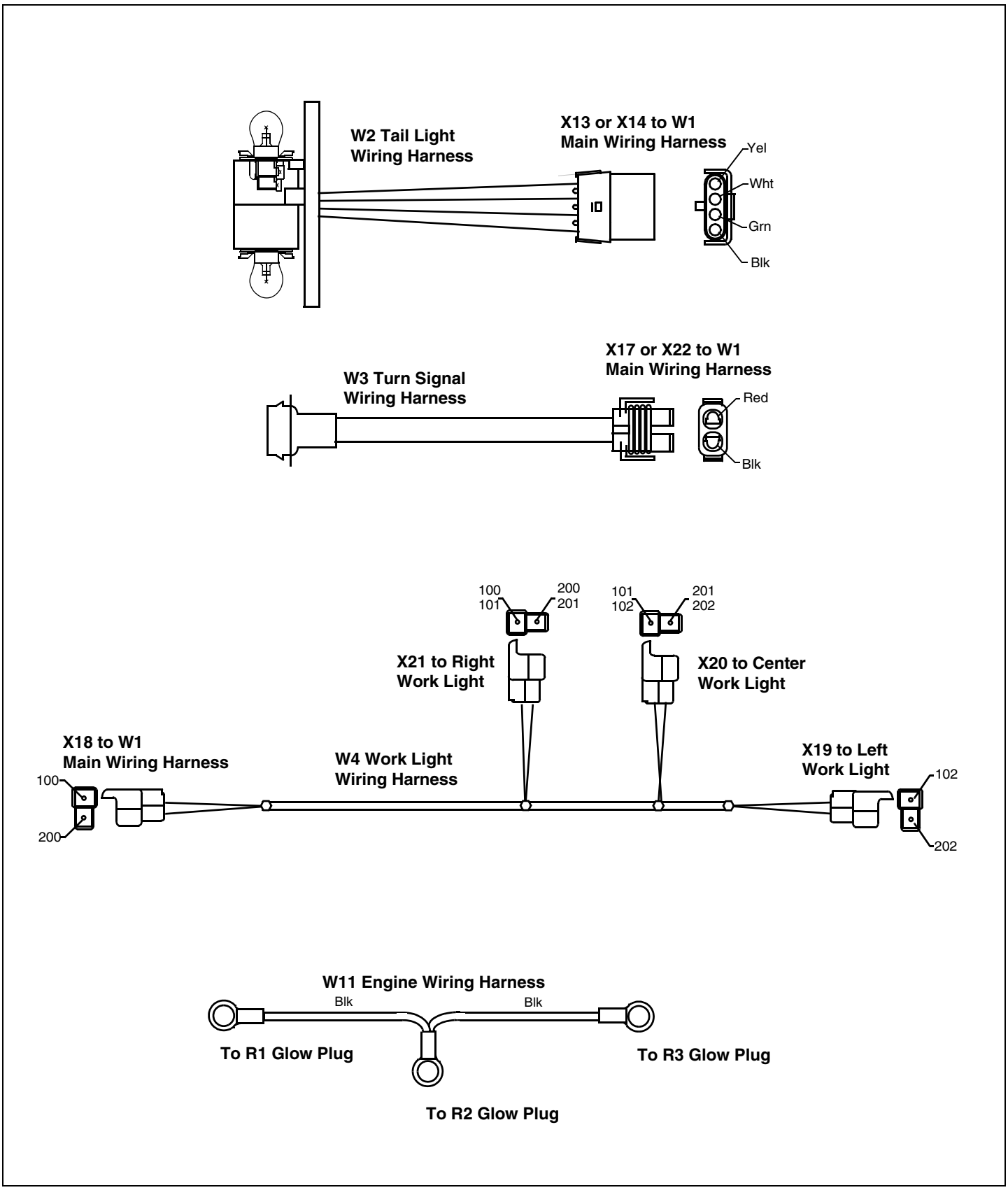

125
X10 to Ground
124
B9 Hydraulic Oil Temperature Switch
104
X8 to M2 Radiator Fan Motor Wiring Harness
420
K1 Start Relay
710
462
702
203
K3 Fan Relay
420
123
421
206
K2 Seat Relay
436
127
320
424
A4 Glow Plug Timer Module
900
602
423
102
207
X18 to W4 Work Lights Wiring Harness (Opt.)
107
411
Splice 2
102
104
107
112
117
127
100
105
106
108
114
129
131
720
Y1 Starting Motor
200
201
202
Y1 Starting Motor B Terminal
202
203
201
204
205
200
206
207
100
Battery (-) Negative
600
401
704
G2 Alternator

MIF

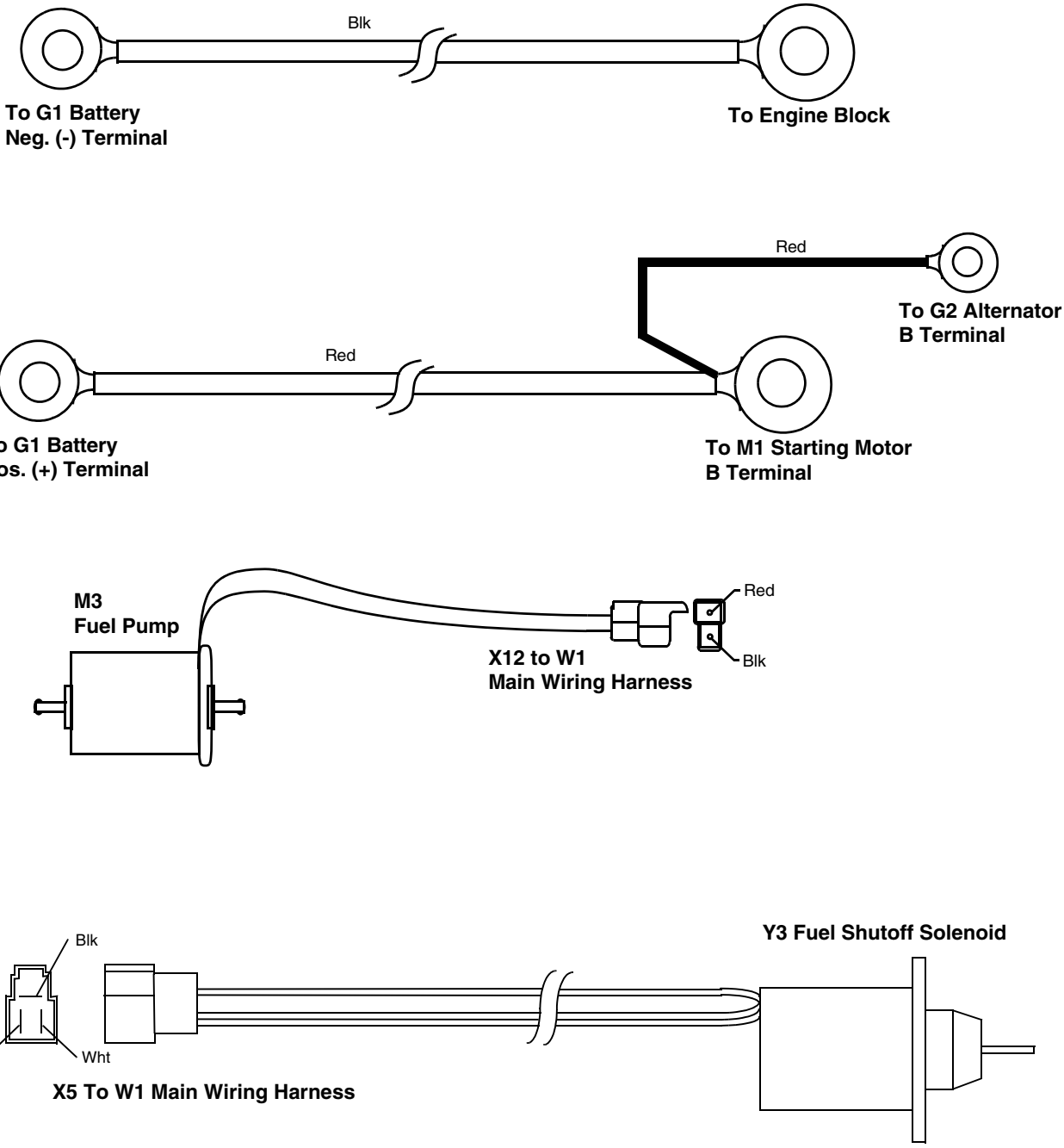

X12 to M3 Fuel Pump
Wiring Harness
108
109
425
X2 to A1 Seat
Delay Module
445
129
440
320
B2 Fuel Tank Sender
800
109
X14 to W2
RH Tail Light
Wiring Harness
616
415
409
105
X13 to W2
LH Tail Light
Wiring Harness
612
416
410
106
710
720
902
X7 to PTO
Wiring Harness (opt.)
520
510
X5 to Y3 Fuel
Shutoff Solenoid
902
114
424
470
B4 Engine Oil
Pressure Switch
601
X33 Glow
Plugs
900
X15 to T1
Speed Sensor
801
121
B3 Coolant
Temperature Sensor
301
S2 Neutral
Switch
X9 to B1
Fan/Over
Temperature Switch
131
300
123
124
437
705
702

MIF

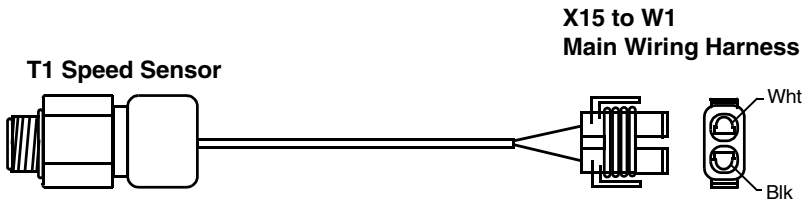
W2-W11 Wiring Harnesses - Diesel Engine

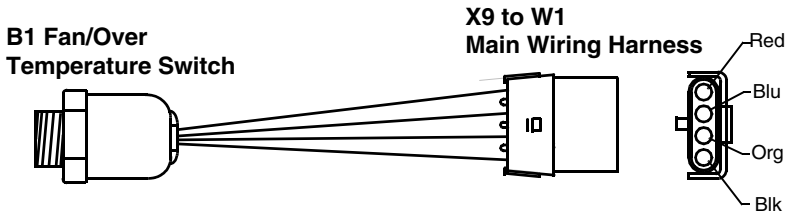


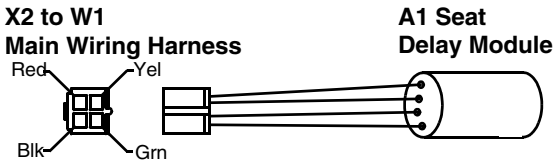
MIF

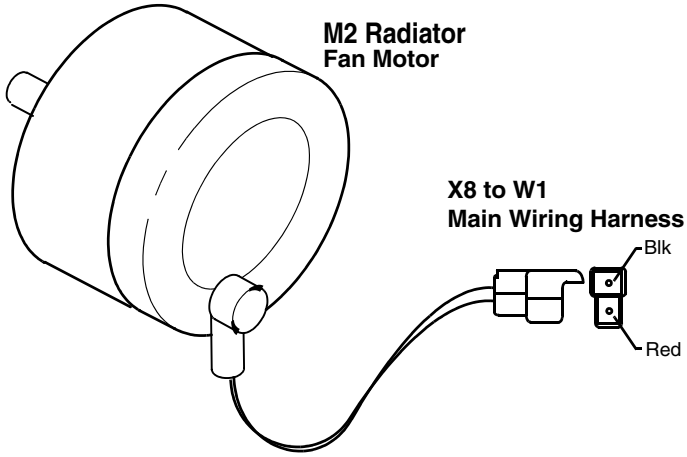

Blk
To G1 Battery
Neg. (-) Terminal
To Engine Block
Red
To G2 Alternator
B Terminal
Red
To G1 Battery
Pos. (+) Terminal
To M1 Starting Motor
B Terminal
M3
Fuel Pump
Red
Blk
X12 to W1
Main Wiring Harness
Y3 Fuel Shutoff Solenoid
Blk
Red
Wht
X5 To W1 Main Wiring Harness

MIF


X15 to W1
Main Wiring Harness
T1 Speed Sensor
Wht
Blk


X9 to W1
Main Wiring Harness
B1 Fan/Over
Temperature Switch
Red
Blu
Org
Blk


X2 to W1
Main Wiring Harness
A1 Seat
Delay Module
Red
Yel
Blk
Grn


M2 Radiator
Fan Motor
X8 to W1
Main Wiring Harness
Blk
Red

MIF

Wire Color Codes - Diesel Engine

Circuit Number	Wire Size	Color	Termination Points
100	5.0	Blk	W1, Splice #2
102	0.8	Blk	Splice #2, A4
104	3.0	Blk	Splice #2, X8
105	0.8	Blk	Splice #2, X14
106	0.8	Blk	Splice #2, X13
107	1.0	Blk	Splice #2, X18
108	0.8	Blk	Splice #2, X12
109	0.8	Blk	X12, B2
110	1.0	Blk	Splice #5, E6
111	1.0	Blk	Splice #5, E5
112	5.0	Blk	Splice #2, Splice #5
113	0.8	Blk	Splice #5, X3
114	3.0	Blk	Splice #2, X5
115	1.0	Blk	Splice #5, S1
117	1.0	Blk	Splice #2, S6
118	0.8	Blk	Splice #5, H1
119	1.0	Blk	Splice #5, X17
120	1.0	Blk	Splice #5, X22
121	0.8	Blk	S1, X15
122	0.8	Blk	Splice #5, X16
123	0.8	Blk	X9, K3
124	0.8	Blk	X9, X10
125	0.8	Blk	Splice #5, X10
127	0.8	Blk	Splice #2, K2
129	0.8	Blk	Splice #2, X2
130	1.0	Blk	S6, S6
131	1.0	Blk	Splice #2, X9
140	1.0	Blk	S6, S7
200	1.0	Fuse Link	Y1, Wire 206 and 207
201	2.0	Fuse Link	Y1, Wires 204 and 205
202	1.0	Fuse Link	Y1, Wire 203
203	3.0	Red	fuse Link 202, K1
204	3.0	Yel	fuse Link 201, F1
205	5.0	Red	fuse Link 201, S1
206	3.0	Red	fuse Link 200, K3
207	5.0	Red	fuse Link 200, A4
300	0.8	Org	X9, X3
301	0.8	Org	B3, X3
320	0.8	Org	K2, X2
401	0.8	Yel	Splice #1, G2
403	2.0	Yel	Splice #1, F2
404	2.0	Yel	S1, F2
405	1.0	Yel	F2, X11
406	3.0	Yel	F1, S11
407	2.0	Yel	S11, S12
408	2.0	Yel	S12, S5
409	1.0	Yel	Splice #6, X14
410	1.0	Yel	Splice #6, X13
411	1.0	Grn	S12, X18
412	3.0	Yel	Splice #6, S11
413	1.0	Yel	Splice #6, E6
414	1.0	Yel	Splice #6, E5
415	0.8	Yel	S5, X14
416	0.8	Yel	S5, X13
417	0.8	Yel	Splice #6, X3
418	0.8	Yel	Splice #1, S8
419	0.8	Yel	S8, X3
420	3.0	Yel	K3, X8
421	0.8	Yel	K3, Splice #1

Circuit Number	Wire Size	Color	Termination Points
423	0.8	Yel	Splice #1, A4
424	1.0	Yel	X5, K2
425	0.8	Yel	Splice #1, X12
426	1.0	Yel	Splice #1, S6
427	1.0	Yel	S6, S6
431	1.0	Yel	X11, K4
432	1.0	Yel	K4, S10
433	1.0	Yel	S10, S10
434	1.0	Yel	S10, S9
435	0.8	Yel	Splice #1, S4
436	0.8	Yel	Splice #1, K2
437	1.0	Yel	Splice #1, X9
440	0.8	Yel	X2, S4
445	0.8	Pnk	Splice #1, X2
450	0.8	Yel	Splice #1, S3
460	1.0	Yel	Splice #1, S5
461	0.8	Yel	S5, X1
462	0.8	Yel	X1, K1
470	1.0	Yel	S5, X5
500	0.8	Blu	X4, S7
501	0.8	Blu	S7, X6
502	0.8	Blu	X6, S6
510	1.0	Blu	X7, S6
520	1.0	Blu	X7, S6
600	0.8	Brn	G2, X4
601	0.8	Tan	B4, X3
602	0.8	Grn	A4, X4
603	0.8	Grn	X3, S3
604	0.8	Org	S3, X1
611	0.8	Org	X17, Splice #3
612	0.8	Pnk	Splice #3, X13
613	0.8	Tan	S10, Splice #3

Circuit Number	Wire Size	Color	Termination Points
614	0.8	Grn	S9, S10
615	0.8	Tan	X22, Splice #4
616	0.8	Pnk	Splice #4, X14
617	0.8	Grn	Splice #3, X4
618	0.8	Tan	Splice #4, S10
619	0.8	Grn	Splice #4, X4
620	0.8	Tan	S9, S10
700	1.0	Pur	S1, S6
701	0.8	Pur	S6, S7
702	0.8	Pur	S2, K1
703	0.8	Pur	S8, H1
704	0.8	Pur	G2, X3
705	0.8	Pur	S7, S2‘
710	3.0	Pur	K1, Splice #8
720	3.0	Pur	Splice #8, Y1
800	0.8	Pnk	B2, X3
801	0.8	Pnk	Splice #7, X15
802	0.8	Pnk	Splice #7, X16
803	0.8	Pnk	Splice #7, X3
900	5.0	Wht	A4, R1, R2 and R3
902	3.0	Wht	Splice #8, X5

Operation and Diagnostics

Use of Dielectric Grease

Whenever non-sealed harness connectors on the machine are disconnected, apply dielectric grease to the ends before reassembling. Clean excess grease from the connector. Do not use grease on sealed connectors.

Theory of Operation Information

The theory of operation stories divide the electrical system into individual circuits by function. Each circuit is isolated from the main wiring schematic and only shows the components that are used in it. The story contains information on function, operating conditions, and theory of operation. The circuit schematics are drawn with the components in the operating position, with the power, or battery positive, into them across the top and the ground, or battery negative, across the bottom.

Diagnostic Information

The diagnostic procedures is used to test the complete circuit regardless of the problem or complaint. Select a symptom or system from the diagnostic chart and follow the test procedures under that heading.

The diagnostic procedure lists:

- Test conditions
- Test location
- A question regarding the normal reading
- Check or test to perform based on yes or no answers

When performing the test or check, be sure to set your machine up to the test conditions listed and follow the sequence carefully.

Power Circuit Operation - Gasoline Engine

Function

The power circuit provides unswitched power to the primary components whenever the battery is connected and switched power to the operational components whenever the key switch is in either the RUN or START position.

NOTE: Changes made to the engine harness and main wiring harness resulted in two schematics. This will affect diagnosis and troubleshooting procedures. Changes are noted in the text and on the schematics. Be aware of the serial number for the vehicle being serviced. Serial breaks for the harness change are as follows:

Old Harness:

2-Wheel Drive S.N. (-020347)

4-Wheel Drive S.N. (-020078)

New Harness:

2-Wheel Drive S.N. (020348-)

4-Wheel Drive S.N. (020079-)

Unswitched Power

Voltage must be present at the following components with the key switch in the OFF position:

- G1 Battery Positive Terminal
- Y1 Starting Motor Solenoid Terminal “B”
- G2 Alternator Terminal “B”
- K3 Radiator Fan Relay 206 Red wire
- F1 Fuse 25 amp
- S11 Headlight Switch 406 and 407 Yel wires
- S12 Work Light Switch 407 and 408 Yel wires
- S5 Brake Switch 408 Yel wire
- X5 Engine Connector 210 Yel wire OLD HARNESS
- X27 Delay Module Connector 210 Red wire NEW HARNESS
- X23 Engine Coil Connector 215 Red wire NEW HARNESS
- S1 Key Switch 205 Red wire
- K1 Start Relay 203 Red wire

The positive battery cable connects the battery to the starting motor solenoid. The starting motor solenoid “B” terminal is used as the 12-Volt DC tie point for the rest of the electrical system.

The battery cables and the starting motor solenoid tie point connections must be good for the vehicle electrical system to work properly. The ground cable and positive cable connections are equally important. Proper starting motor operation depends on these cables and connections to carry high current.

With the exception of the “B” terminal of the alternator, the electrical circuit is protected by fuse links beyond the starting motor solenoid tie point. The fuse link is a short piece of wire that is designed to fail if current load is too high or a short occurs.

Switched Power - Run

In addition to the voltage present at the locations of the unswitched power circuits, voltage must be present at the components listed below with the key switch in the RUN position.

In addition the following operating conditions will apply:

- Transmission in NEUTRAL
- Park Brake DISENGAGED
- PTO DISENGAGED
- Operator NOT ON the seat
- Turn Signal and Hazard Light Switches OFF
- Headlights and Work Lights OFF
- and the Engine cool

Voltage must be present at the following components:

- S1 Key Switch 404 Yel wire
- F2 Fuse 10 amp
- S5 Brake Switch 460 Yel wire
- X11 Auxiliary Power Connector
- K4 Flasher 431 and 432 Yel wires
- S10 Hazard Lights Switch 432, 433 and 434 Yel wires
- S9 Turn Signal Switch 434 Yel wire
- 403 Yel wire to Splice #1, the 400 series wires
- G2 Alternator 401 Yel wire
- S8 Horn Switch 418 and 419 Yel wires
- X3 Connector to Instrument Panel 419 Yel wire
- K3 Radiator Fan Relay 421 Yel wire
- B1 Fan/Over Temperature Switch 437 Yel wire
- X12 Fuel Pump Connector 425 Yel wire
- S3 Park Brake Switch 450 Yel wire
- S4 Seat Switch 435 Yel wire
- K2 Seat Relay 436 Yel wire
- X2 Seat Delay Module Connector 445 Pnk wire OLD HARNESS
- S6 PTO Switch 426 and 427 Yel wires
- X7 PTO Wiring Harness Connector 510 Blu wire

With voltage present at the components listed above the vehicles operating circuits will be prepared for operation. In addition, with the various switches positioned as described above, no relays or additional circuits will be activated.

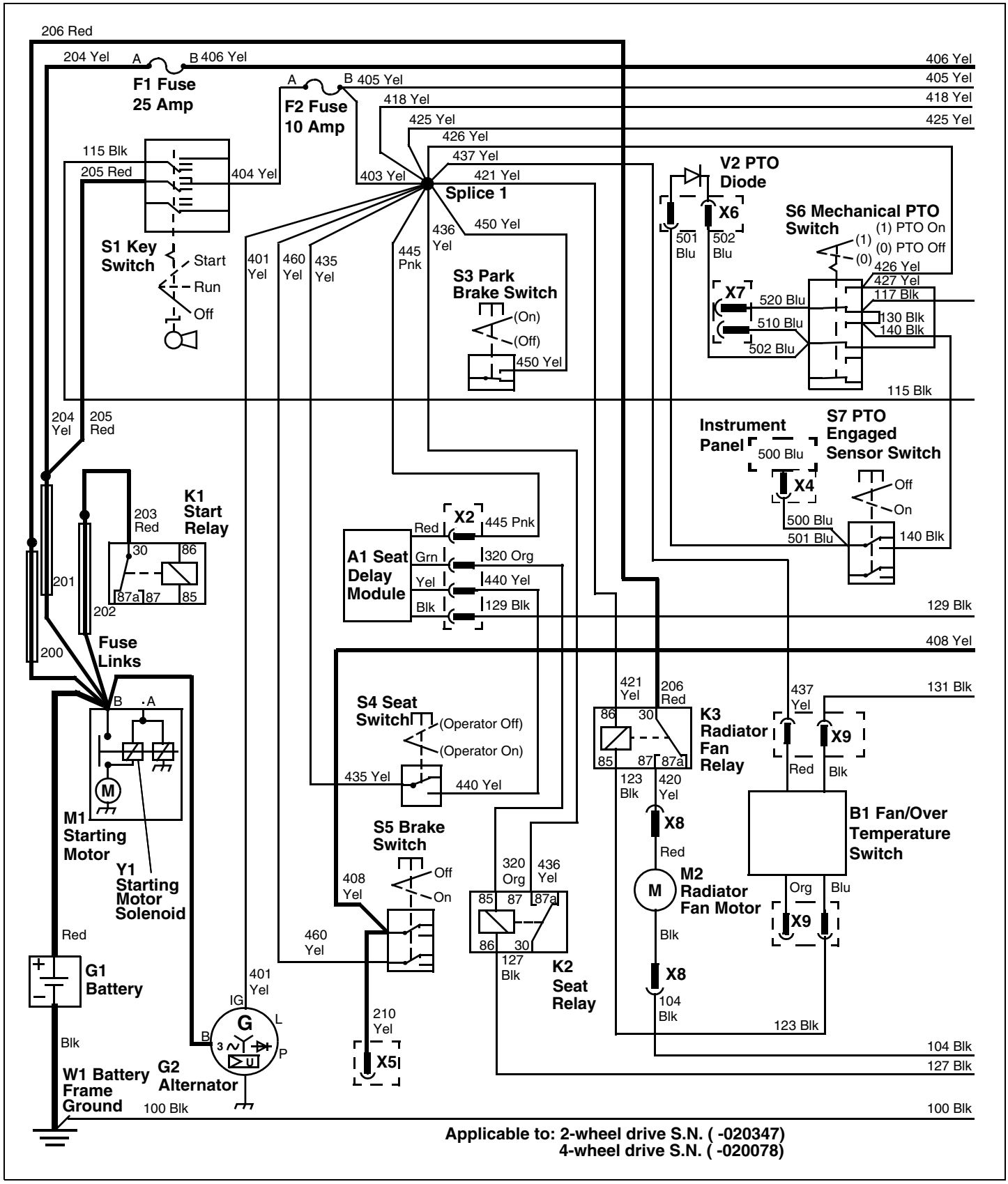
Unswitched Ground Circuits

Continuity to the battery negative (-) terminal must also be present at the following components for the operational circuits to function properly:

- W1 Battery to Frame connection
- G2 Alternator Case
- S1 Key Switch 115 Blk wire
- S6 PTO Switch 117, 130 and 140 Blk wires
- X2 Seat Delay Module Connector 129 Blk wire OLD HARNESS
- K2 Seat Relay 127 Blk wire
- X5 Engine Connector 114 Blk wire OLD HARNESS
- X26 Ignition Module Connector 150 Blk wire NEW HARNESS
- X27 Delay Module Connector 114 Blk wire NEW HARNESS
- X12 Fuel Pump Connector 108 Blk wire
- X9 Fan/Over Temperature Switch Connector 131 Blk wire
- X8 Radiator Fan Connector 104 Blk wire
- B2 Fuel Gauge Sensor 109 Blk wire
- X3 Instrument Panel connector 113 Blk wire
- X15 Speed Sensor Connector 121 Blk wire
- X16 Auxiliary Speed Output Connector 122 Blk wire
- X13 LH Tail Light Connector 106 Blk wire
- X14 RH Tail Light Connector 105 Blk wire
- E5 LH Headlight 111 Blk wire
- X17 LH Front Turn Signal Connector 119 Blk wire
- E6 RH Headlight 110 Blk wire
- X22 RH Front Turn Signal Connector 120 Blk wire
- H1 Horn 118 Blk wire
- X18 Work Light Connector 107 Blk wire

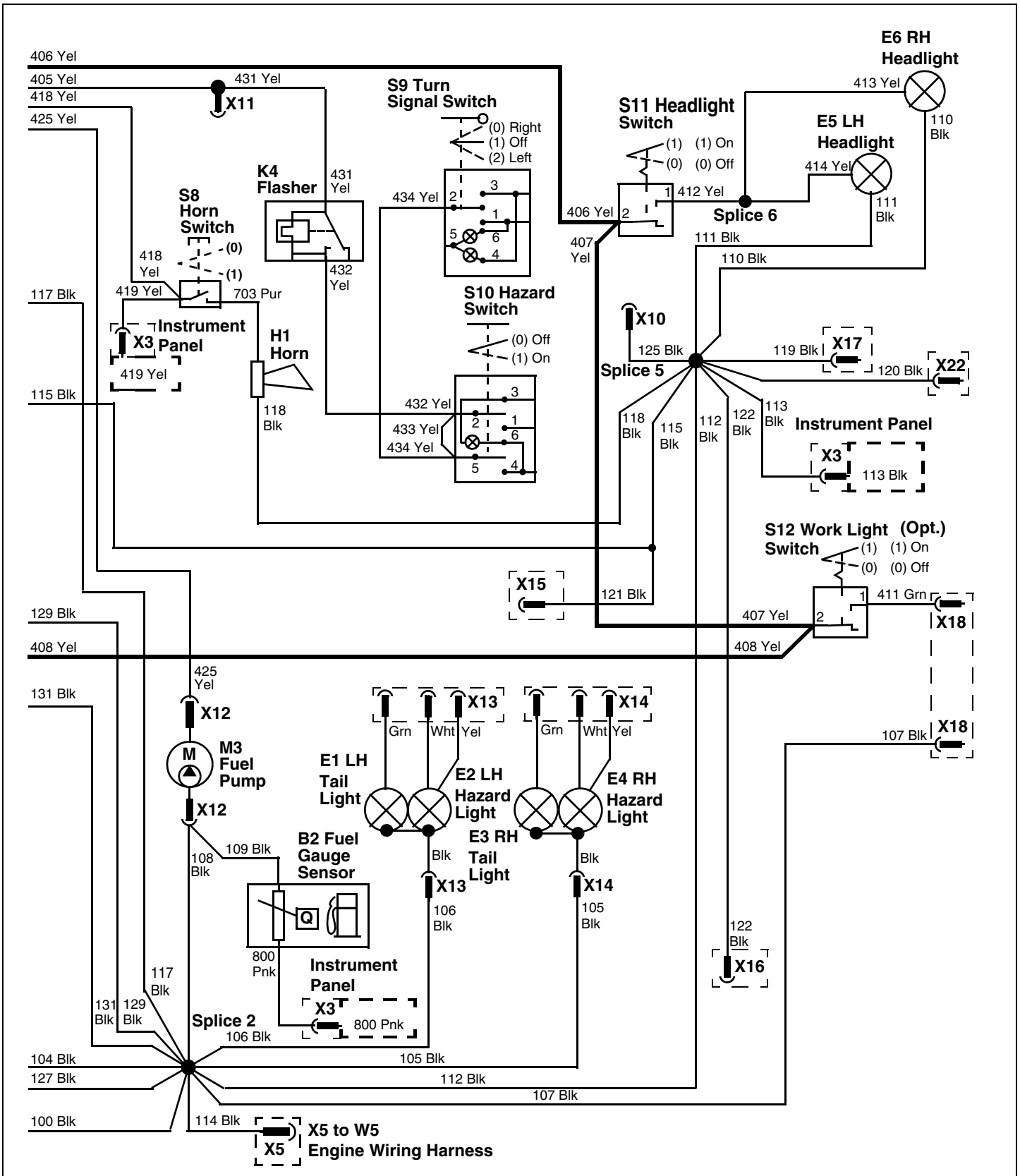
The ground circuits are needed to complete the current path back to the battery for each operation. These ground circuits are unswitched and must have continuity to ground at all times.

Power Circuit Schematic - Gasoline Engine (Old)



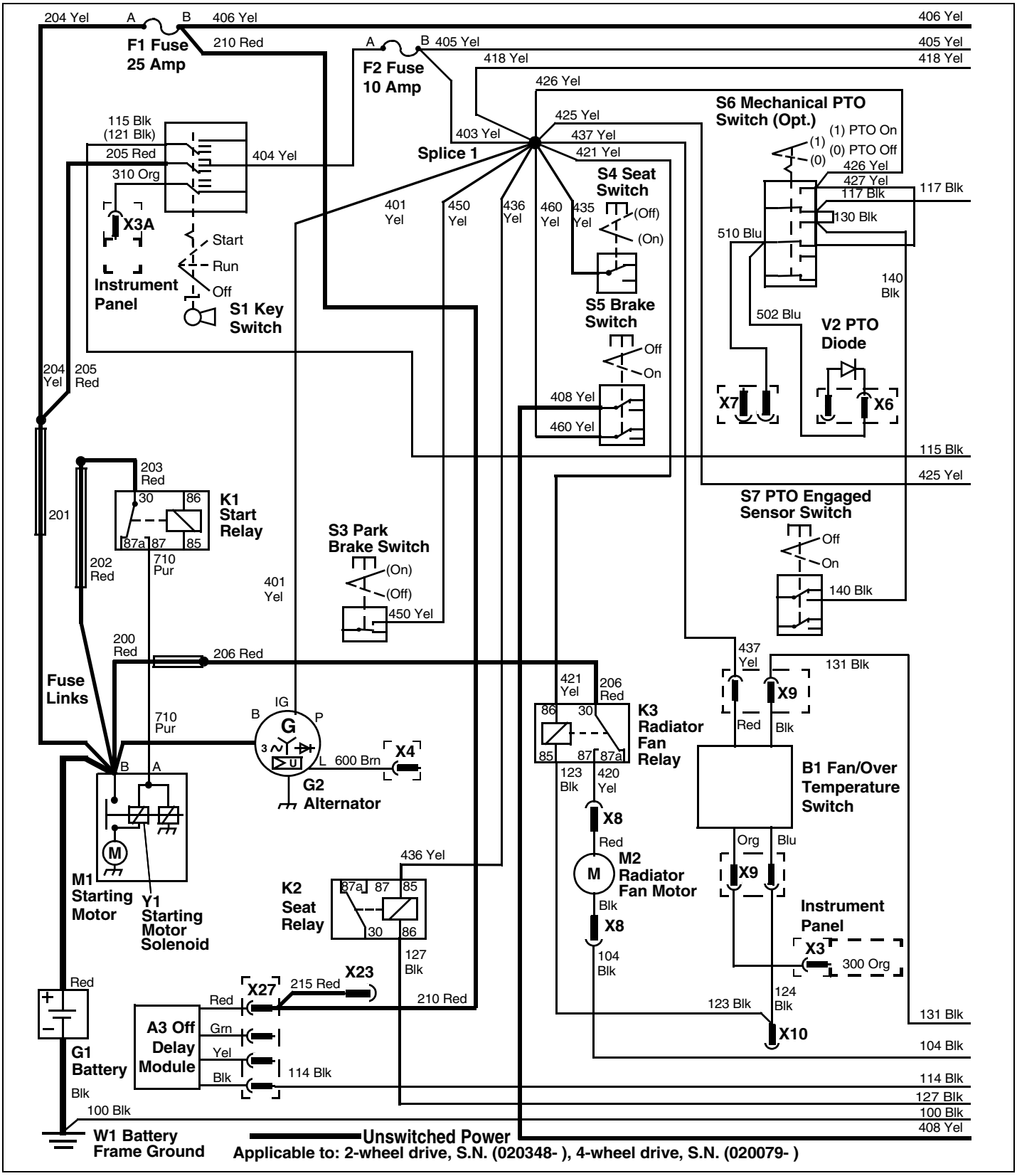
Applicable to: 2-wheel drive S.N. (-020347)
4-wheel drive S.N. (-020078)

MIF


406 Yel
405 Yel
418 Yel
425 Yel
431 Yel
X11
S9 Turn Signal Switch
(0) Right
(1) Off
(2) Left
S11 Headlight Switch
(1) (1) On
(0) (0) Off
E6 RH Headlight
413 Yel
110 Blk
E5 LH Headlight
414 Yel
111 Blk
412 Yel
Splice 6
406 Yel
407 Yel
111 Blk
110 Blk
K4 Flasher
431 Yel
432 Yel
434 Yel
S8 Horn Switch
(0)
(1)
418 Yel
419 Yel
703 Pur
117 Blk
Instrument Panel
X3
419 Yel
H1 Horn
118 Blk
S10 Hazard Switch
(0) Off
(1) On
432 Yel
433 Yel
434 Yel
X10
125 Blk
Splice 5
119 Blk
X17
120 Blk
X22
115 Blk
118 Blk
115 Blk
112 Blk
122 Blk
113 Blk
Instrument Panel
X3
113 Blk
S12 Work Light (Opt.) Switch
(1) (1) On
(0) (0) Off
X15
121 Blk
411 Grn
X18
129 Blk
407 Yel
408 Yel
408 Yel
425 Yel
X12
131 Blk
M3 Fuel Pump
X12
X13
Grn Wht Yel
X14
Grn Wht Yel
E1 LH Tail Light
E2 LH Hazard Light
E3 RH Tail Light
E4 RH Hazard Light
107 Blk
X18
B2 Fuel Gauge Sensor
108 Blk
109 Blk
Blk
X13
106 Blk
Blk
X14
105 Blk
122 Blk
X16
800 Pnk
Instrument Panel
X3
800 Pnk
117 Blk
131 Blk
129 Blk
Splice 2
106 Blk
104 Blk
105 Blk
127 Blk
112 Blk
107 Blk
100 Blk
114 Blk
X5
X5 to W5 Engine Wiring Harness

MIF

Power Circuit Schematic - Gasoline Engine (New)



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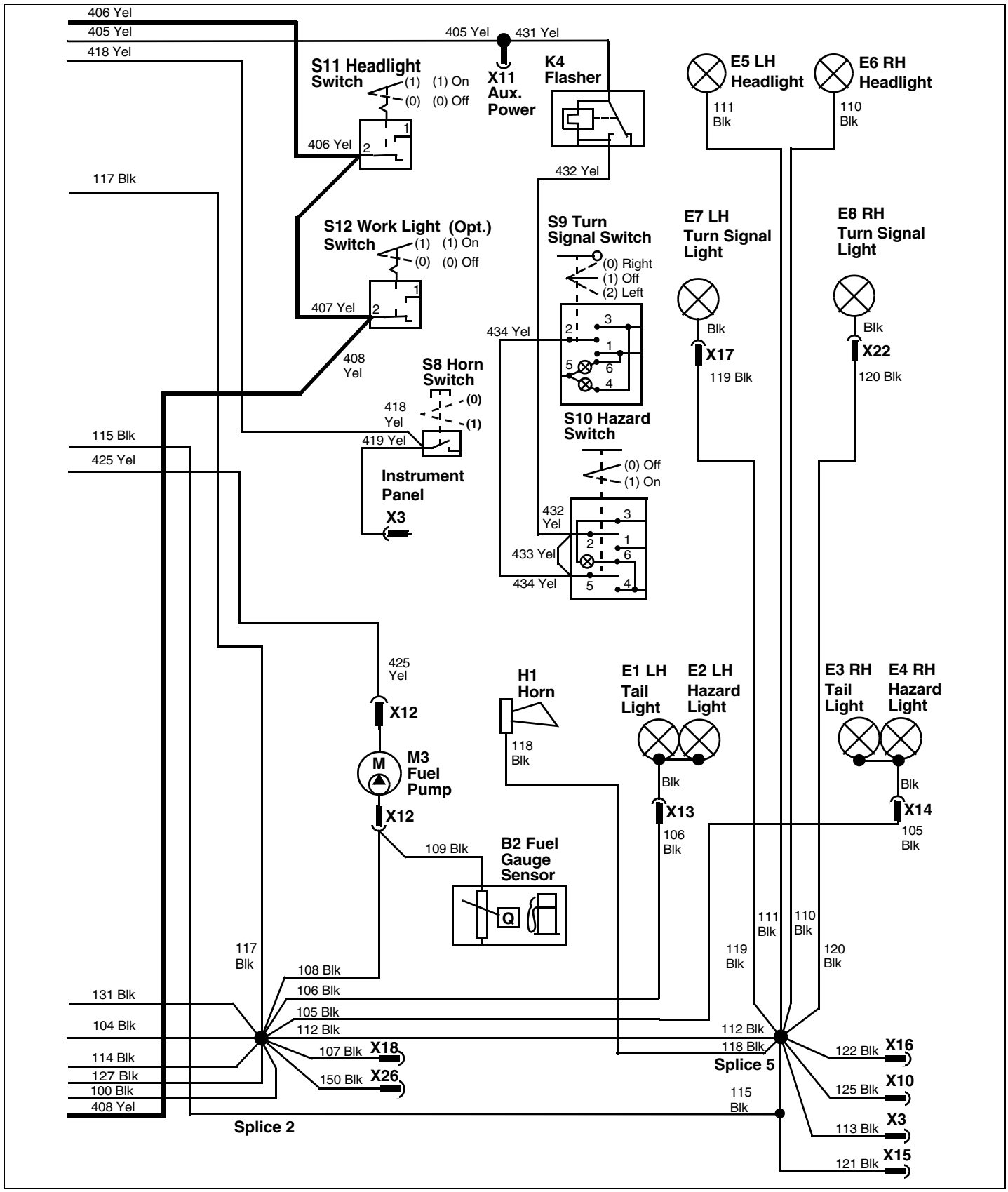

406 Yel
405 Yel
418 Yel
405 Yel
431 Yel
S11 Headlight Switch
(1) (1) On
(0) (0) Off
X11 Aux. Power
K4 Flasher
E5 LH Headlight
E6 RH Headlight
111 Blk
110 Blk
406 Yel
432 Yel
117 Blk
S12 Work Light (Opt.) Switch
(1) (1) On
(0) (0) Off
S9 Turn Signal Switch
(0) Right
(1) Off
(2) Left
E7 LH Turn Signal Light
E8 RH Turn Signal Light
407 Yel
434 Yel
Blk
X17
119 Blk
Blk
X22
120 Blk
408 Yel
S8 Horn Switch
418 Yel
419 Yel
S10 Hazard Switch
(0) Off
(1) On
115 Blk
425 Yel
Instrument Panel
X3
432 Yel
433 Yel
434 Yel
425 Yel
X12
H1 Horn
118 Blk
E1 LH Tail Light
E2 LH Hazard Light
E3 RH Tail Light
E4 RH Hazard Light
M
M3 Fuel Pump
X12
Blk
X13
106 Blk
Blk
X14
105 Blk
109 Blk
B2 Fuel Gauge Sensor
Q
111 Blk
110 Blk
117 Blk
119 Blk
120 Blk
108 Blk
106 Blk
105 Blk
112 Blk
131 Blk
104 Blk
114 Blk
127 Blk
100 Blk
408 Yel
107 Blk X18
150 Blk X26
112 Blk
118 Blk
Splice 5
122 Blk X16
125 Blk X10
113 Blk X3
121 Blk X15
115 Blk
Splice 2

MIF

Power Circuit Diagnosis - Gasoline Engine

Test Conditions:

- Key switch in OFF position.
- Park brake ENGAGED.
- PTO DISENGAGED.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Power Circuit - Gasoline Engine

(1) Alternator (G2) case. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (2).

No - Test black battery cable to frame ground connections.

(2) Key Switch (S1) - wire 115 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (3).

No - Test wires 115, 112, and 100 black and connections.

(3) PTO Switch (S6) - wire 130 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (4).

No - Test wires 130, 117 black and connections.

(4) Models 2020 2wd S.N. (-020347) and 2020 4wd S.N. (-020078), Seat Delay Module (A1) - wire 129 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (5).

No - Test wire 129 black and connections.

(5) Seat Relay Connector - wire 127 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (6).

No - Test wire 127 black and connections.

(6) Models 2020 2wd S.N. (-020347) and 2020 4wd S.N. (-020078), Engine Wire Harness Connector (X5) - wire 114 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (7).

No - Test wire 114 black and connections.

System: Power Circuit - Gasoline Engine

(7) Models 2020 2wd S.N. (020348-) and 2020 4wd S.N. (020079-), Off Delay Module (A3) - wire 114 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (8).

No - Test wire 114 black and connections.

(8) Fuel Pump Connector (X12) - wire 108 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (9).

No - Test wire 108 black and connections.

(9) Fan/Over Temperature Switch Connector (X9) - wire 131 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (10).

No - Test wire 131 black and connections.

(10) Radiator Fan Connector (X8) - wire 104 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (11).

No - Test wire 104 black and connections.

(11) Fuel Gauge sensor (B2) - wire 109 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (12).

No - Test wire 109 black and connections.

(12) Instrument Panel Connector (X3) - wire 113 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (13).

No - Test wire 113 black and connections.

(13) Speed Sensor Connector (X15) - wire 121 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (14).

No - Test wire 121 black and connections.

(14) Auxiliary Speed Output Connector (X16) - wire 122 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (15).

No - Test wire 122 black and connections.

System: Power Circuit - Gasoline Engine

(15) Left Tail Light (E1) - wire 106 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (16).

No - Test wire 106 black and connections.

(16) Right Tail Light (E3) - wire 105 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (17).

No - Test wire 105 black and connections.

(17) Left Headlight (E5) - wire 111 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (18).

No - Test wire 111 black and connections.

(18) Left Turn Signal Connector (X17) - wire 119 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (19).

No - Test wire 119 black and connections.

(19) Right Headlight (E6) - wire 110 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (20).

No - Test wire 110 black and connections.

(20) Right Turn Signal Connector (X22) - wire 120 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (21).

No - Test wire 120 black and connections.

(21) Horn (H1) - wire 118 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (22).

No - Test wire 118 black and connections.

(22) Work Lights Connector (X18) - wire 107 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (23).

No - Test wire 107 black and connections.

System: Power Circuit - Gasoline Engine

(23) Starting motor solenoid - terminal B. Is battery voltage present?

Yes - Go to step (24).

No - Test red cable and connections.

(24) Alternator (G2) - terminal B. Is battery voltage present?

Yes - Go to step (25).

No - Test red cable and connections.

(25) Radiator Fan Relay (K3) - wire 206 red. Is battery voltage present?

Yes - Go to step (26).

No - Test wire 206 red and fuse link 200 and connections.

(26) Brake Switch (S5) - wire 408 yellow. Is battery voltage present?

Yes - Go to step (27).

No - Test wires 408, 407, 406 yellow and connections.

(27) Fuse (F1) - wire 204 yellow. Is battery voltage present?

Yes - Go to step (28).

No - Test Fuse (F1), wire 204 yellow, fuse link 201 and connections.

(28) Key Switch (S1) - wire 205 red. Is battery voltage present?

Yes - Go to step (29).

No - Test wire 205 red, fuse link 201 and connections.

(29) Start Relay (K1) - wire 203 red. Is battery voltage present?

Yes - Go to step (30).

No - Test wire 203 red, fuse link 202 and connections.

(30) Models 2020 2wd S.N. (020348-) and 2020 4wd S.N. (020079-), Off Delay Module (A3) - wire 210 red. Is battery voltage present?

Yes - Go to step (31).

No - Test fuse (F1), wires 210 red, 204 yellow, fuse link 201 and connections.

System: Power Circuit - Gasoline Engine

(31) Key Switch (S1) - wire 404 yellow. Place key switch in RUN position. Is battery voltage present?

Yes - Go to step (32).

No - Test key switch.

(32) Fuse (F2) - wire 404 yellow. Is battery voltage present?

Yes - Go to step (33).

No - Test wire 404 yellow and connections.

(33) Brake Switch (S5) - wire 460 yellow. Is battery voltage present?

Yes - Go to step (34).

No - Test fuse (F2), wire 460 yellow and connections.

(34) Auxiliary Power Connector (X11) - wire 405 yellow. Is battery voltage present?

Yes - Go to step (35).

No - Test wire 405 yellow and connections.

(35) Flasher (K4) - wire 432 yellow. Is battery voltage present?

Yes - Go to step (36).

No - Test wire 431 yellow and connections.

(36) Hazard Light Switch (S10) - wire 432 yellow. Is battery voltage present?

Yes - Go to step (37).

No - Test wire 432 yellow and connections. If OK, replace flasher.

(37) Turn Signal Switch (S9) - wire 434 yellow. Is battery voltage present?

Yes - Go to step (38).

No - Test wires 434, 433 yellow and connections.

(38) Alternator (G2) - wire 401 yellow. Is battery voltage present?

Yes - Go to step (39).

No - Test wire 401 yellow and connections.

(39) Instrument Panel Connector (X3) - wire 419 yellow. Is battery voltage present?

Yes - Go to step (40).

No - Test wires 419, 418 yellow and connections.

System: Power Circuit - Gasoline Engine

(40) Radiator Fan Relay (K3) - wire 421 yellow. Is battery voltage present?

Yes - Go to step (41).

No - Test wire 421 yellow and connections.

(41) Fan/Over Temperature Switch Connector (X9) - wire 437 yellow. Is battery voltage present?

Yes - Go to step (42).

No - Test wire 437 yellow and connections.

(42) Fuel Pump Connector (X12) - wire 425 yellow. Is battery voltage present?

Yes - Go to step (43).

No - Test wire 425 yellow and connections.

(43) Park Brake Switch (S3) - wire 450 yellow. Is battery voltage present?

Yes - Go to step (44).

No - Test wire 450 yellow and connections.

(44) Seat Switch (S4) - wire 435 yellow. Is battery voltage present?

Yes - Go to step (45).

No - Test wire 435 yellow and connections.

(45) Seat Relay (K2) - wire 436 yellow. Is battery voltage present?

Yes - Go to step (46).

No - Test wire 436 yellow and connections.

(46) Models 2020 2wd S.N. (-020347) and 2020 4wd S.N. (-020078), Seat Delay Module (A1) - wire 445 pink. Is battery voltage present?

Yes - Go to step (47).

No - Test wire 445 pink and connections.

(47) PTO Switch (S6) - wire 426 yellow. Is battery voltage present?

Yes - Go to step (48).

No - Test wire 426 yellow and connections.

(48) PTO Connector (X7) - wire 510 blue. Is battery voltage present?

No - Test wire 510 blue and connections.

Power Circuit Operation - Diesel Engine

Function

The power circuit provides unswitched power to the primary components whenever the battery is connected and switched power to the operational components whenever the key switch is in either the RUN or START position.

Unswitched Power

Voltage must be present at the following components with the key switch in the OFF position:

- G1 Battery Positive Terminal
- Y1 Starting Motor Solenoid Terminal “B”
- G2 Alternator Terminal “B”
- K3 Radiator Fan Relay 206 Red wire
- A4 Glow Plug Timer Module 207 Red wire
- F1 Fuse 25 amp
- S11 Headlight Switch 406 and 407 Yel wires
- S12 Work Light Switch 407 and 408 Yel wires
- S5 Brake Switch 408 Yel wire
- S1 Key Switch 205 Red wire
- K1 Start Relay 203 Red wire

The positive battery cable connects the battery to the starting motor solenoid. The starting motor solenoid “B” terminal is used as the 12-Volt DC tie point for the rest of the electrical system.

The battery cables and the starting motor solenoid tie point connections must be good for the vehicle electrical system to work properly. The ground cable and positive cable connections are equally important. Proper starting motor operation depends on these cables and connections to carry high current.

With the exception of the “B” terminal of the alternator, the electrical circuit is protected by the fuse link beyond the starting motor solenoid tie point. The fuse link is a short piece of wire that is designed to fail if current load is too high or a short occurs.

Switched Power - Run

In addition to the voltage present at the locations of the unswitched power circuits, voltage must be present at the components listed with the key switch in the RUN position.

In addition the following operating conditions will apply:

- Transmission in NEUTRAL
- Park Brake ENGAGED
- PTO DISENGAGED
- Operator NOT ON the seat
- Turn Signal and Hazard Light Switches OFF
- Headlights and Work Lights OFF
- and the Engine cool

Voltage must be present at the following components:

- S1 Key Switch 404 Yel wire
- F2 Fuse 10 amp
- S5 Brake Switch 460 Yel wire
- X11 Auxiliary Power Connector
- K4 Flasher 431 and 432 Yel wires
- S10 Hazard Lights Switch 432, 433 and 434 Yel wires
- S9 Turn Signal Switch 434 Yel wire
- 403 Yel wire to Splice #1, the 400 series wires
- G2 Alternator 401 Yel wire
- S8 Horn Switch 418 and 419 Yel wires
- X3 Connector to Instrument Panel 419 Yel wire
- K3 Radiator Fan Relay 421 Yel wire
- A4 Glow Plug Timer Module 423 Yel wire
- B1 Fan/Over Temperature Switch 437 Yel wire
- X12 Fuel Pump Connector 425 Yel wire
- S3 Park Brake Switch 450 Yel wire
- S4 Seat Switch 435 Yel wire
- K2 Seat Relay 436 Yel wire
- X2 Seat Delay Module Connector 445 Pnk wire
- S6 PTO Switch 426 and 427 Yel wires
- X7 PTO Wiring Harness Connector 510 Blu wire

With voltage present at the components listed above the vehicles operating circuits will be prepared for operation. In addition, with the various switches positioned as described above, no relays or additional circuits will be activated.

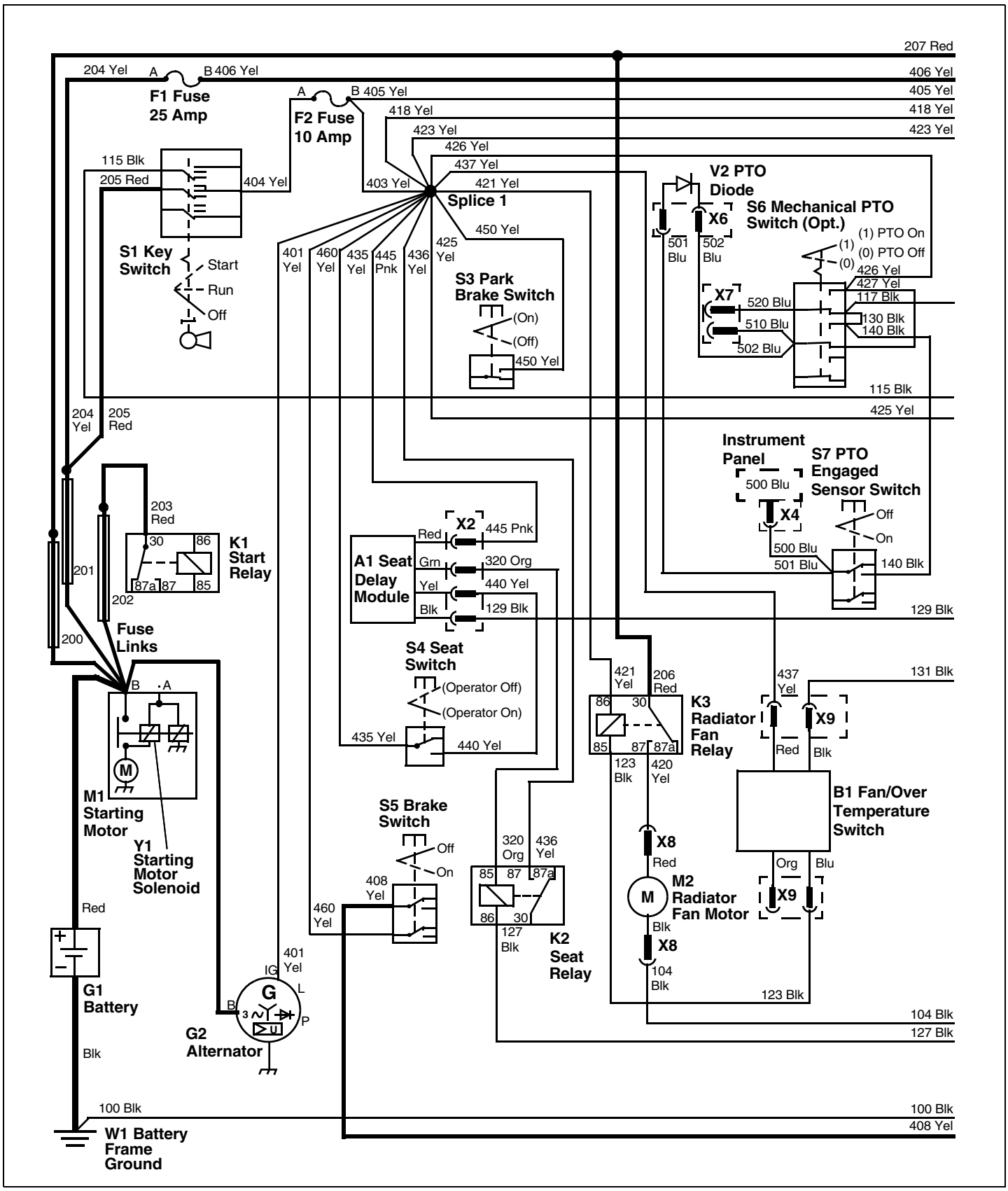
Unswitched Ground Circuits

Continuity to the battery negative (-) terminal must also be present at the following components for the operational circuits to function properly:

- W1 Battery to Frame connection
- G2 Alternator Case
- S1 Key Switch 115 Blk wire
- S6 PTO Switch 117 and 130 Blk wires
- X2 Seat Delay Module Connector 129 Blk wire
- K2 Seat Relay 127 Blk wire
- X5 Engine/Fuel Shutoff Solenoid Connector 114 Blk wire
- A4 Glow Plug Timer Module 102 Blk wire
- X12 Fuel Pump Connector 108 Blk wire
- X9 Fan/Over Temperature Switch Connector 131 Blk wire
- X8 Radiator Fan Connector 104 Blk wire
- B2 Fuel Gauge Sensor 109 Blk wire
- X3 Instrument Panel connector 113 Blk wire
- X15 Speed Sensor Connector 121 Blk wire
- X16 Auxiliary Speed Output Connector 122 Blk wire
- X13 LH Tail Light Connector 106 Blk wire
- X14 RH Tail Light Connector 105 Blk wire
- E5 LH Headlight 111 Blk wire
- X17 LH Front Turn Signal Connector 119 Blk wire
- E6 RH Headlight 110 Blk wire
- X22 RH Front Turn Signal Connector 120 Blk wire
- H1 Horn 118 Blk wire
- X18 Work Light Connector 107 Blk wire

The ground circuits are needed to complete the current path back to the battery for each operation. These ground circuits are unswitched and must have continuity to ground at all times.

Power Circuit Schematic - Diesel Engine



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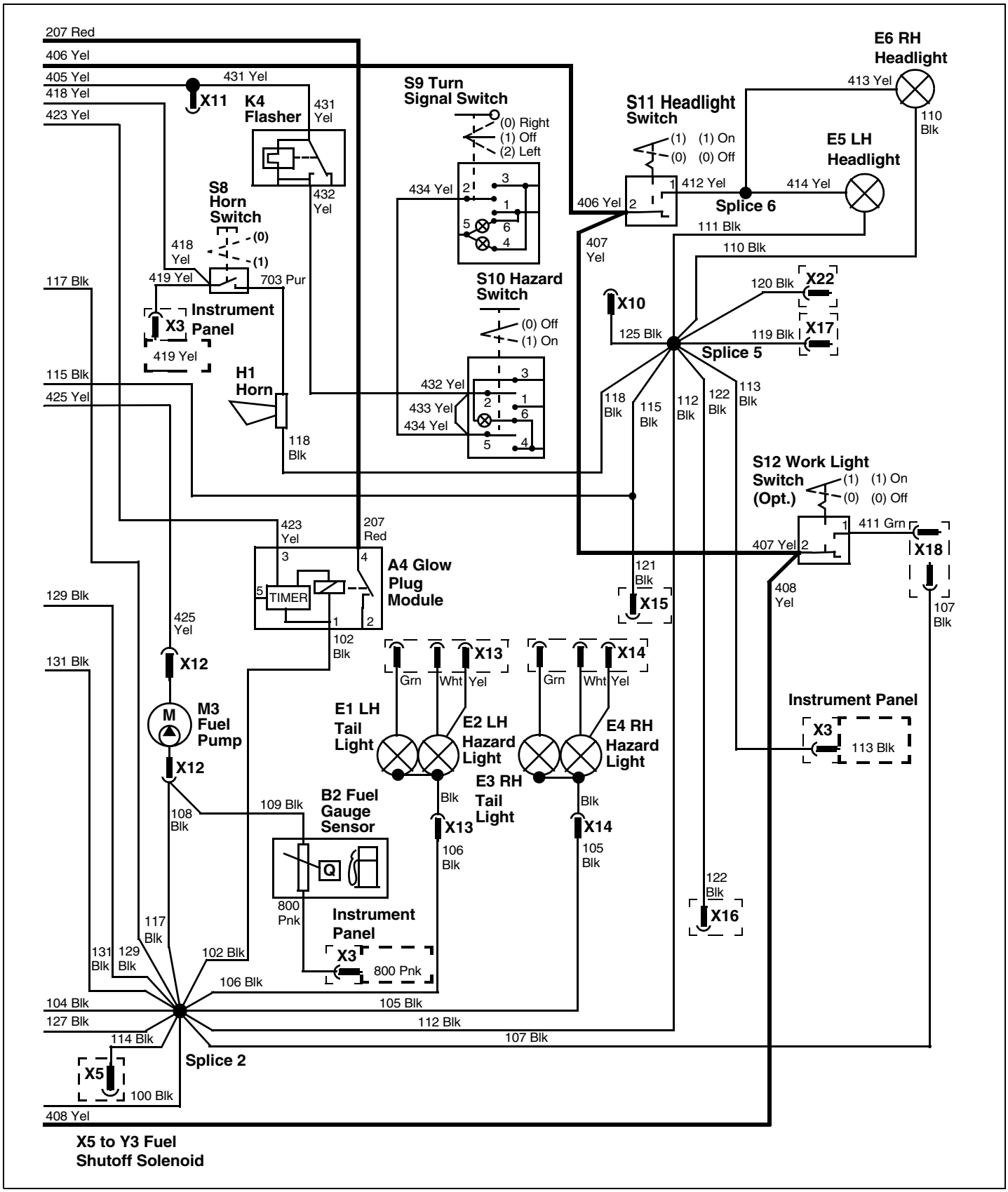

207 Red
406 Yel
405 Yel
418 Yel
423 Yel
431 Yel
X11
K4 Flasher
431 Yel
432 Yel
S8 Horn Switch
(0)
(1)
418 Yel
419 Yel
703 Pur
117 Blk
Instrument Panel
X3
419 Yel
115 Blk
425 Yel
H1 Horn
118 Blk
S9 Turn Signal Switch
(0) Right
(1) Off
(2) Left
434 Yel
S10 Hazard Switch
(0) Off
(1) On
432 Yel
433 Yel
434 Yel
S11 Headlight Switch
(1) (1) On
(0) (0) Off
406 Yel
412 Yel
Splice 6
414 Yel
E6 RH Headlight
413 Yel
110 Blk
E5 LH Headlight
111 Blk
110 Blk
407 Yel
120 Blk
X22
X10
125 Blk
119 Blk
X17
Splice 5
118 Blk
115 Blk
112 Blk
122 Blk
113 Blk
S12 Work Light Switch (Opt.)
(1) (1) On
(0) (0) Off
411 Grn
X18
407 Yel
408 Yel
107 Blk
121 Blk
X15
423 Yel
207 Red
A4 Glow Plug Module
TIMER
102 Blk
129 Blk
425 Yel
X12
131 Blk
M3 Fuel Pump
M
X12
X13
Grn
Wht
Yel
X14
Grn
Wht
Yel
E1 LH Tail Light
E2 LH Hazard Light
E3 RH Tail Light
E4 RH Hazard Light
Instrument Panel
X3
113 Blk
109 Blk
B2 Fuel Gauge Sensor
Q
108 Blk
Blk
X13
106 Blk
Blk
X14
105 Blk
800 Pnk
Instrument Panel
X3
800 Pnk
122 Blk
X16
117 Blk
131 Blk
129 Blk
102 Blk
106 Blk
104 Blk
105 Blk
127 Blk
112 Blk
114 Blk
107 Blk
Splice 2
X5
100 Blk
408 Yel
X5 to Y3 Fuel Shutoff Solenoid

MIF

Power Circuit Diagnosis - Diesel Engine

Test Conditions:

- Key switch in OFF position.
- Park brake ENGAGED.
- PTO DISENGAGED.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Power Circuit - Diesel Engine

(1) Alternator (G2) case. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (2).

No - Test black battery cable to frame ground connections.

(2) Key Switch (S1) - wire 115 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (3).

No - Test wires 115, 112, and 100 black and connections.

(3) PTO Switch (S6) - wire 130 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (4).

No - Test wires 130, 117 black and connections.

(4) Seat Delay Module (A1) - wire 129 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (5).

No - Test wire 129 black and connections.

(5) Seat Relay Connector - wire 127 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (6).

No - Test wire 127 black and connections.

(6) Fuel Shutoff Connector (X5) - wire 114 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (7).

No - Test wire 114 black and connections.

System: Power Circuit - Diesel Engine

(7) Glow Plug Timer Module (A4) - wire 102 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (8).

No - Test wire 102 black and connections.

(8) Fuel Pump Connector (X12) - wire 108 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (9).

No - Test wire 108 black and connections.

(9) Fan/Over Temperature Switch Connector (X9) - wire 131 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (10).

No - Test wire 131 black and connections.

(10) Radiator Fan Connector (X8) - wire 104 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (11).

No - Test wire 104 black and connections.

(11) Fuel Gauge sensor (B2) - wire 109 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (12).

No - Test wire 109 black and connections.

(12) Instrument Panel Connector (X3) - wire 113 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (13).

No - Test wire 113 black and connections.

(13) Speed Sensor Connector (X15) - wire 121 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (14).

No - Test wire 121 black and connections.

(14) Auxiliary Speed Output Connector (X16) - wire 122 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (15).

No - Test wire 122 black and connections.

System: Power Circuit - Diesel Engine

(15) Left Tail Light (E1) - wire 106 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (16).

No - Test wire 106 black and connections.

(16) Right Tail Light (E3) - wire 105 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (17).

No - Test wire 105 black and connections.

(17) Left Headlight (E5) - wire 111 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (18).

No - Test wire 111 black and connections.

(18) Left Turn Signal Connector (X17) - wire 119 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (19).

No - Test wire 119 black and connections.

(19) Right Headlight (E6) - wire 110 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (20).

No - Test wire 110 black and connections.

(20) Right Turn Signal Connector (X22) - wire 120 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (21).

No - Test wire 120 black and connections.

(21) Horn (H1) - wire 118 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (22).

No - Test wire 118 black and connections.

(22) Work Lights Connector (X18) - wire 107 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (23).

No - Test wire 107 black and connections.

System: Power Circuit - Diesel Engine

(23) Starting Motor Solenoid - terminal B. Is battery voltage present?

Yes - Go to step (24).

No - Test red cable and connections.

(24) Alternator (G2) - terminal B. Is battery voltage present?

Yes - Go to step (25).

No - Test red cable and connections.

(25) Radiator Fan Relay (K3) - wire 206 red. Is battery voltage present?

Yes - Go to step (26).

No - Test wire 206 red and fuse link 200 and connections.

(26) Glow Plug Module (A4) - wire 207 red. Is battery voltage present?

Yes - Go to step (27).

No - Test wire 207 red and fuse link 200 and connections.

(27) Fuse (F1) - wire 204 yellow. Is battery voltage present?

Yes - Go to step (28).

No - Test Fuse (F1), wire 204 yellow, fuse link 201 and connections.

(28) Brake Switch (S5) - wire 408 yellow. Is battery voltage present?

Yes - Go to step (29).

No - Test wires 408, 407, 406 yellow and connections.

(29) Key Switch (S1) - wire 205 red. Is battery voltage present?

Yes - Go to step (30).

No - Test wire 205 red, fuse link 201 and connections.

(30) Start Relay (K1) - wire 203 red. Is battery voltage present?

Yes - Go to step (31).

No - Test wire 203 red, fuse link 202 and connections.

System: Power Circuit - Diesel Engine

(31) Key Switch (S1) - wire 404 yellow. Place key switch in RUN position. Is battery voltage present?

Yes - Go to step (32).

No - Test key switch.

(32) Fuse (F2) - wire 404 yellow. Is battery voltage present?

Yes - Go to step (33).

No - Test wire 404 yellow and connections.

(33) Brake Switch (S5) - wire 460 yellow. Is battery voltage present?

Yes - Go to step (34).

No - Test fuse (F2), wire 460 yellow and connections.

(34) Auxiliary Power Connector (X11) - wire 405 yellow. Is battery voltage present?

Yes - Go to step (35).

No - Test wire 405 yellow and connections.

(35) Flasher (K4) - wire 431 yellow. Is battery voltage present?

Yes - Go to step (36).

No - Test wire 431 yellow and connections.

(36) Hazard Light Switch (S10) - wire 432 yellow. Is battery voltage present?

Yes - Go to step (37).

No - Test wire 432 yellow and connections. If OK, replace flasher.

(37) Turn Signal Switch (S9) - wire 434 yellow. Is battery voltage present?

Yes - Go to step (38).

No - Test wires 434, 433 yellow and connections.

(38) Alternator (G2) - wire 401 yellow. Is battery voltage present?

Yes - Go to step (39).

No - Test wire 401 yellow and connections.

(39) Instrument Panel Connector (X3) - wire 419 yellow. Is battery voltage present?

Yes - Go to step (40).

No - Test wires 419, 418 yellow and connections.

System: Power Circuit - Diesel Engine

(40) Radiator Fan Relay (K3) - wire 421 yellow. Is battery voltage present?

Yes - Go to step (41).

No - Test wire 421 yellow and connections.

(41) Fan/Over Temperature Switch Connector (X9) - wire 437 yellow. Is battery voltage present?

Yes - Go to step (42).

No - Test wire 437 yellow and connections.

(42) Fuel Pump Connector (X12) - wire 425 yellow. Is battery voltage present?

Yes - Go to step (43).

No - Test wire 425 yellow and connections.

(43) Glow Plug Timer Module (A4) - wire 423 yellow. Is battery voltage present?

Yes - Go to step (44).

No - Test wire 450 yellow and connections.

(44) Park Brake Switch (S3) - wire 450 yellow. Is battery voltage present?

Yes - Go to step (45).

No - Test wire 450 yellow and connections.

(45) Seat Switch (S4) - wire 435 yellow. Is battery voltage present?

Yes - Go to step (46).

No - Test wire 435 yellow and connections.

(46) Seat Relay (K2) - wire 436 yellow. Is battery voltage present?

Yes - Go to step (47).

No - Test wire 436 yellow and connections.

(47) Seat Delay Module (A1) - wire 445 pink. Is battery voltage present?

Yes - Go to step (48).

No - Test wire 445 pink and connections.

(48) PTO Switch (S6) - wire 426 yellow. Is battery voltage present?

Yes - Go to step (49).

No - Test wire 426 yellow and connections.

(49) PTO Connector (X7) - wire 510 blue. Is battery voltage present?

No - Test wire 510 blue and connections.

Cranking Circuit Operation - Gasoline Engine

Function

To energize the starting motor solenoid and lock the starting motor to crank the engine.

Operating Conditions

- Key switch in START position
- Transmission in NEUTRAL
- PTO DISENGAGED
- and either:
  - the Park Brake Engaged

  or
  - the Operator ON the seat

  or
  - the Brake Engaged

NOTE: The operator must be properly seated in the left seat to operate the vehicle with both the brake and park brake disengaged.

NOTE: Changes made to the engine harness and main wiring harness resulted in two schematics. This will affect diagnosis and troubleshooting procedures. Changes are noted in the text and on the schematics. Be aware of the serial number for the vehicle being serviced. Serial breaks for the harness change is as follows:

OLD HARNESS:

2-Wheel Drive S.N. (-020348)

4-Wheel Drive S.N. (-020079)

NEW HARNESS:

2-Wheel Drive S.N. (020348-)

4-Wheel Drive S.N. (020079-)

Theory of Operation

To energize the starting motor solenoid Y1 and the starting motor M1, the start relay K1 must be energized. The start relay K1 receives voltage to the common terminal from the 203 Red wire and the 202 fuse link. When the start relay K1 coil is energized the contacts close and connect the 203 Red wire to the 710 Pur wire. The 710 Pur wire supplies voltage to the starting motor solenoid Y1 causing it to energize, suppling voltage to the starting motor M1 cranking the engine.

To energize the start relay K1, both the voltage input and the ground side are switched and must be activated.

Power to the start relay K1 for the cranking process can be supplied by any one of three circuits:

- the brake switch S5
- the seat relay K2
- the park brake switch S3

Power is supplied to the fuse link 201, 205 Red wire, S1 key switch, 404 Yel wire, F2 10 amp fuse, and 403 Red wire to splice #1 for the 400 series wires.

From splice #1, power is supplied to the S4 seat switch through the 435 Yel wire, the A1 seat delay module through the 445 Pnk wire, the K2 seat relay through the 436 Yel wire, and the S3 park brake switch through the 450 Yel wire. Engaging either the park brake switch, brake switch or the seat switch, will supply voltage to the start relay K1 as well as suppling voltage to the ignition system and the fuel shutoff solenoid.

CAUTION: Avoid injury! To avoid injury, ALWAYS lock park brake when starting the engine.

Park Brake Switch

If the operator has the park brake switch S3 engaged, then power is supplied to the 604 Org and 603 Grn wires. The 603 Grn wire supplies power to the instrument panel to illuminate the park brake light H7 while the 604 Org wire supplies power across the V1 diode to the 462, 461, 470 and 424 Yel wires. The 462 Yel wire supplies power to the start relay K1, and the 461, 470 and 424 Yel wires combine to supply power across the X5 connector to the Pnk/Blk wire of the W5 engine wire harness. The Pnk/Blk wire supplies power to the Org/Wht wire of the A2 ignition module and the Org wires to all three ignition coils as well as the red wires to the B5 electric choke and the Y2 fuel shutoff solenoid.

Seat Switch (OLD HARNESS)

When the operator is in the seat and has the seat switch S4 depressed, power is supplied from the 435 Yel wire to the 440 Yel wire and the Yel wire of the A1 seat delay module. With power also supplied to the seat delay module from the 445 Pnk wire the seat delay module will supply power to the K2 seat relay. With signal power being supplied to the seat relay through the 320 Org wire the relay is energized and will supply power from the 436 Yel wire to the 424, 470, 461 and Yel wires. The 470, 461 and 462 Yel wires combine to supply power to the start relay K1. The 424 Yel wire supplies power across the X5 connector to the Pnk/Blk wire of the W5 engine wire harness. The Pnk/Blk wire supplies power to the Org/Wht wire of the A2 ignition module and the Org wires to all three ignition coils as well as the red wires to the B5 electric choke and the Y2 fuel shutoff solenoid.

Seat Switch (NEW HARNESS)

When the operator is in the seat and the contacts of S4 are closed, power is supplied to the K2 Seat Relay control coil by the 435 Yel wire, through the seat switch to the 320 Org wire, to the 85 terminal of the seat relay. When the seat relay energizes, power is supplied to the K1 start relay coil via the 436, 424, 470, 461, and 462 Yel wires. The K2 seat relay, when energized, also provides power for the A3 off seat delay module, A2 ignition module, the B5 electric choke heater coil and the Y2 carburetor fuel shutoff solenoid.

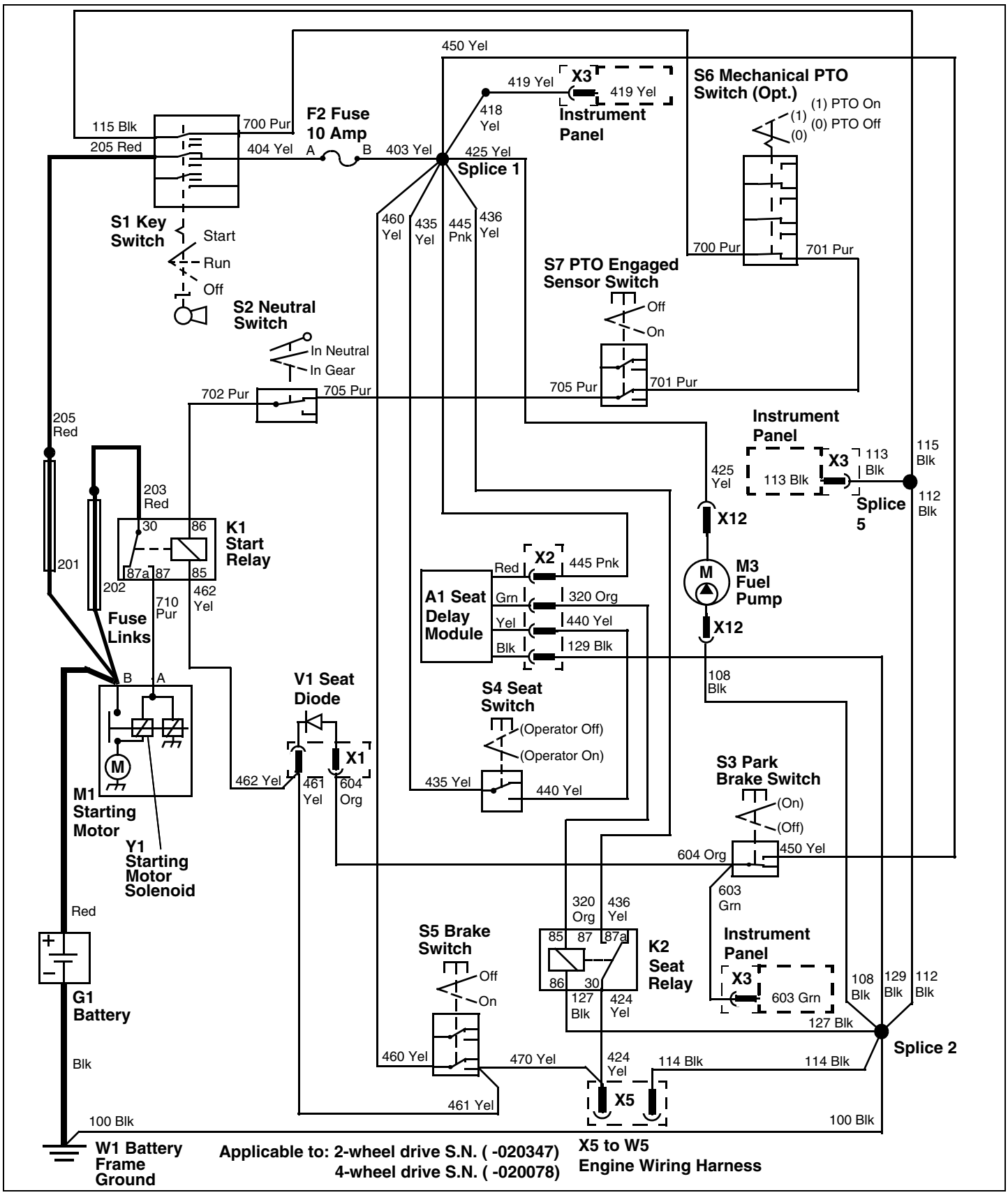
Brake Switch

If the operator has the brake switch S5 engaged, then power is supplied from the 460 Yel wire to the 461, 470, 462 and 424 Yel wires. The 461 and 462 Yel wires connect to supply power to the start relay K1 while the 470 and 424 Yel wires supply power across the X5 connector to the Pnk/Blk wire of the W5 engine wire harness. The Pnk/Blk wire supplies power to the Org/Wht wire of the A2 ignition module and the Org wires to all three ignition coils as well as the red wires to the B5 electric choke and the Y2 fuel shutoff solenoid.

Switching the Ground

The ground side of the start relay K1 coil is provided from the 702 Pur wire, S2 neutral switch, 705 Pur wire, S7 PTO engaged sensor switch, 701 Pur wire, S6 mechanical PTO switch, 700 Pur wire, S1 key switch, 115, 112 and 100 Blk wires to the W1 frame ground.

Cranking Circuit Schematic - Gasoline Engine (Old)



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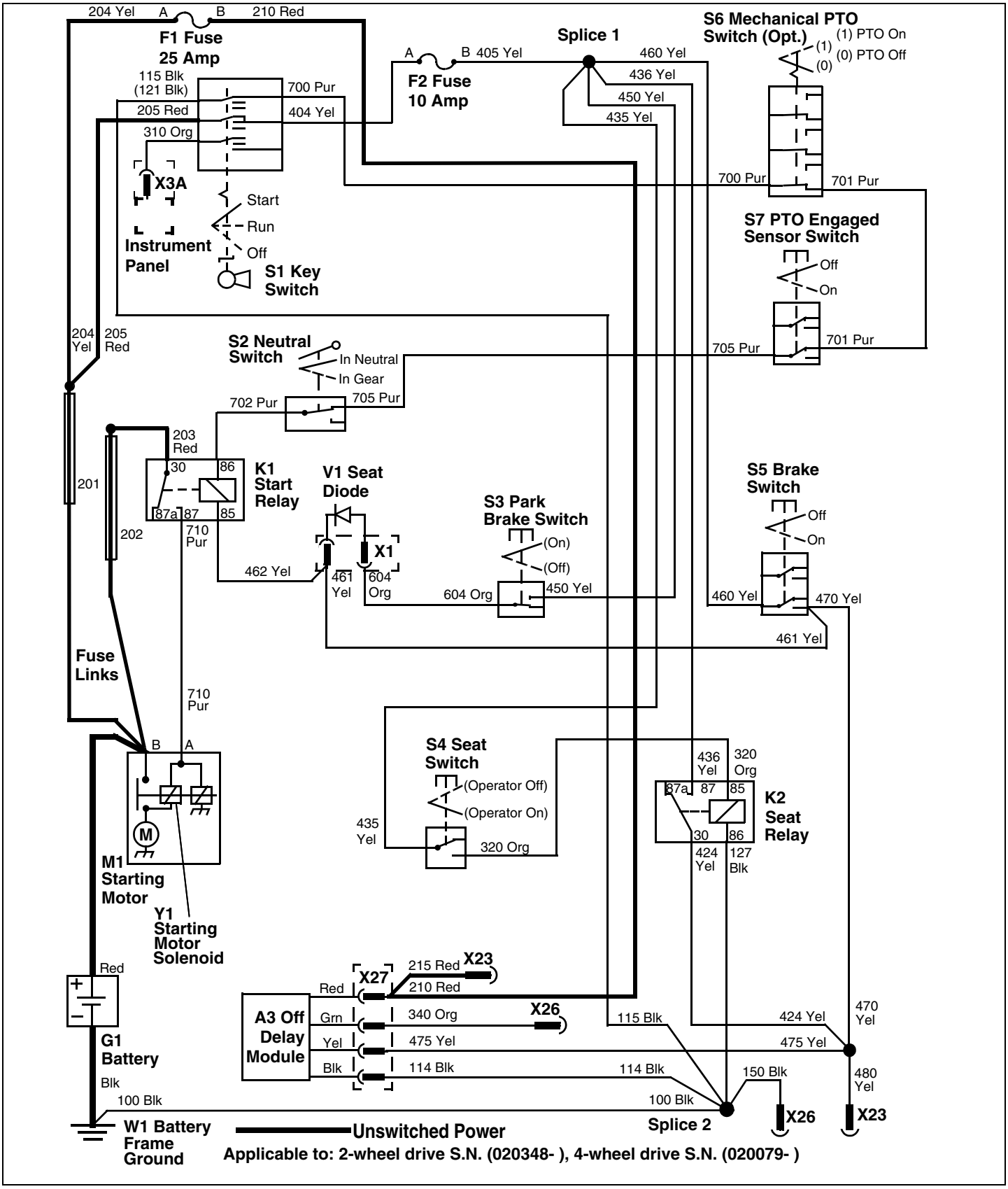
Cranking Circuit Schematic - Gasoline Engine (New)



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Cranking Circuit (Operator OFF Seat) Diagnosis - Gasoline Engine

Test Conditions:

- Park brake ENGAGED.
- Key switch in START position.
- Operator OFF seat.
- Transmission in NEUTRAL.
- PTO DISENGAGED.
- Engine Wiring Harness Connector (X5) disconnected.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Cranking Circuit (Operator OFF Seat) - Gasoline Engine

(1) Key Switch (S1) - wire 404 yellow. Is battery voltage present?

Yes - Go to step (2).

No - Test key switch. Test wire 205 red and fuse link 201.

(2) Fuse (F2) - wire 404 yellow. Is battery voltage present?

Yes - Go to step (3).

No - Test wire 404 yellow and connections.

(3) Fuse (F2) - wire 403 yellow. Is battery voltage present?

Yes - Go to step (4).

No - Test fuse (F2).

(4) Fuel Pump Connector (X12) - wire 425 yellow. Is battery voltage present?

Yes - Go to step (5).

No - Test wires 425, 403 yellow and connections.

(5) Fuel Pump Connector (X12) - wire 108 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (6).

No - Test wire 108 black and connections. If ground circuit tests good, replace fuel pump.

System: Cranking Circuit (Operator OFF Seat) - Gasoline Engine

(6) Park Brake Switch (S3) - wire 450 yellow. Is battery voltage present?

Yes - Go to step (7).

No - Test wire 450 yellow and connections.

(7) Park Brake Switch (S3) - wire 604 orange. Is battery voltage present?

Yes - Go to step (8).

No - Replace park brake switch.

(8) Seat Diode (V1) - wire 604 orange. Is battery voltage present?

Yes - Go to step (9).

No - Test wire 604 orange and connections.

(9) Seat Diode (V1) - wire 461 yellow. Is battery voltage present?

Yes - Go to step (10).

No - Replace diode.

(10) Start Relay (K1) - wire 462 yellow. Is battery voltage present?

Yes - Go to step (11).

No - Test wire 462 yellow and connections.

(11) Key Switch (S1) - wire 115 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (12).

No - Test wire 115 black and connections.

(12) Key Switch (S1) - wire 700 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (13).

No - Replace key switch.

(13) Mechanical PTO Switch (S6) - wire 700 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (14).

No - Test wire 700 purple and connections.

System: Cranking Circuit (Operator OFF Seat) - Gasoline Engine

(14) Mechanical PTO Switch (S6) - wire 701 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (15).

No - For models without optional mechanical PTO switch (S6), test jumper wire and connections.

No - For models with optional mechanical PTO switch (S6), replace PTO switch.

(15) PTO Engaged Sensor Switch (S7) - wire 701 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (16).

No - Test wire 701 purple and connections.

(16) PTO Engaged Sensor Switch (S7) - wire 705 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (17).

No - Replace PTO engaged sensor switch.

(17) Neutral Switch (S2) - wire 705 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (18).

No - Test wire 705 purple and connections.

(18) Neutral Switch (S2) - wire 702 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (19).

No - Replace neutral switch.

(19) Start Relay (K1) - wire 702 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (20).

No - Test wire 702 purple and connections.

(20) Start Relay (K1). Cycle key switch between RUN and START positions. Does start relay click when switch is cycled?

Yes - Go to step (21).

No - Replace start relay.

System: Cranking Circuit (Operator OFF Seat) - Gasoline Engine

(21) Start Relay (K1) - wire 203 red. Place key switch to START position. Is battery voltage present?

Yes - Go to step (22).

No - Test wire 203 red, fuse link 202 and connections.

(22) Start Relay (K1) - wire 710 purple. Is battery voltage present?

Yes - Go to step (23).

No - Replace start relay.

(23) Starting motor solenoid - wire 710 purple. Is battery voltage present?

Yes - Test starting motor solenoid. (See “Inspection and Test” on page 330.)Test starting motor. (See “Starting Motor Amperage Draw Test” on page 310.)

No - Test wire 710 purple and connections.

Cranking Circuit (Operator ON Seat) Diagnosis - Gasoline Engine

ProGator

2020 2wd	**Serial No. (-020347)**
2020 4wd	Serial No. (-020078)

Test Conditions:

- Park brake DISENGAGED
- Key switch in START position
- Operator ON seat
- Transmission in NEUTRAL
- PTO DISENGAGED
- Engine Wiring Harness Connector (X5) disconnected.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Cranking Circuit (Operator ON Seat) - Gasoline Engine

(1) Key Switch (S1) - wire 404 yellow. Is battery voltage present?

Yes - Go to step (2).

System: Cranking Circuit (Operator ON Seat) - Gasoline Engine

No - Test key switch. Test wire 205 red and fuse link 201.

(2) Fuse (F2) - wire 404 yellow. Is battery voltage present?

Yes - Go to step (3).

No - Test wire 404 yellow and connections.

(3) Fuse (F2) - wire 403 yellow. Is battery voltage present?

Yes - Go to step (4).

No - Test Fuse (F2).

(4) Seat Switch (S4) - wire 435 yellow. Is battery voltage present?

Yes - Go to step (5).

No - Test wire 435 yellow and connections.

(5) Seat Switch (S4) - wire 440 yellow. Is battery voltage present?

Yes - Go to step (6).

No - Replace seat switch.

(6) Seat Delay Module (A1) - wire 440 yellow. Is battery voltage present?

Yes - Go to step (7).

No - Test wire 440 yellow and connections.

(7) Seat Delay Module (A1) - wire 445 pink. Is battery voltage present?

Yes - Go to step (8).

No - Test wire 445 pink and connections.

(8) Seat Delay Module (A1) - wire 129 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (9).

No - Test wire 129 black and connections.

(9) Seat Delay Module (A1) - wire 320 orange. Is battery voltage present?

Yes - Go to step (10).

No - Replace seat delay module.

(10) Seat Relay (K2) - wire 320 orange. Is battery voltage present?

Yes - Go to step (11).

No - Test wire 320 orange and connections.

System: Cranking Circuit (Operator ON Seat) - Gasoline Engine

(11) Seat Relay (K2) - wire 127 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (12).

No - Test wire 127 black and connections.

(12) Seat Relay (K2) - wire 436 yellow. Is battery voltage present?

Yes - Go to step (13).

No - Test wire 436 yellow and connections.

(13) Seat Relay (K2) - wire 424 yellow. Is battery voltage present?

Yes - Go to step (14).

No - Replace seat relay.

(14) Engine Wiring Harness Connector (X5) - wire 424 yellow. Is battery voltage present?

Yes - Go to step (15).

No - Test wire 424 yellow and connections.

(15) Brake Switch (S5) - wire 470 yellow. Is battery voltage present?

Yes - Go to step (16).

No - Test wire 470 yellow and connections.

(16) Seat Diode (V1) - wire 461 yellow. Is battery voltage present?

Yes - Go to step (17).

No - Test wire 461 yellow and connections.

(17) Start Relay (K1) - wire 462 yellow. Is battery voltage present?

Yes - Go to step (18).

No - Test wire 462 yellow and connections.

(18) Key Switch (S1) - wire 115 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (19).

No - Test wire 115 black and connections.

(19) Key Switch (S1) - wire 700 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (20).

No - Replace key switch.

System: Cranking Circuit (Operator ON Seat) - Gasoline Engine

(20) Mechanical PTO Switch (S6) - wire 700 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (21).

No - Test wire 700 purple and connections.

(21) Mechanical PTO Switch (S6) - wire 701 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (22).

No - For models without optional mechanical PTO switch, test jumper wire and connections.

No - For models with optional mechanical PTO switch, replace PTO switch.

(22) PTO Engaged Sensor Switch (S7) - wire 701 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (23).

No - Test wire 701 purple and connections.

(23) PTO Engaged Sensor Switch (S7) - wire 705 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (24).

No - Replace PTO engaged sensor switch.

(24) Neutral Switch (S2) - wire 705 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (25).

No - Test wire 705 purple and connections.

(25) Neutral Switch (S2) - wire 702 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (26).

No - Replace neutral switch.

(26) Start Relay (K1) - wire 702 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (27).

No - Test wire 702 purple and connections.

System: Cranking Circuit (Operator ON Seat) - Gasoline Engine

(27) Start Relay (K1). Cycle key switch between RUN and START positions. Does start relay click when the key switch is cycled?

Yes - Go to step (28).

No - Replace start relay.

(28) Start Relay (K1) - wire 203 red. Place key switch in START position. Is battery voltage present?

Yes - Go to step (29).

No - Test wire 203 red, fuse link 202 and connections.

(29) Start Relay (K1) - wire 710 purple. Is battery voltage present?

Yes - Go to step (30).

No - Replace start relay.

(30) Starting motor solenoid - wire 710 purple. Is battery voltage present?

Yes - Test starting motor solenoid. (See “Inspection and Test” on page 330.)Test starting motor. (See “Starting Motor Amperage Draw Test” on page 310.)

No - Test wire 710 purple and connections.

Cranking Circuit (Operator ON Seat) Diagnosis - Gasoline Engine

ProGator

2020 2wd	**Serial No. (020348-)**
2020 4wd	Serial No. (020079-)

Test Conditions:

- Park brake DISENGAGED.
- Key switch in START position.
- Operator ON seat.
- Transmission in NEUTRAL.
- PTO DISENGAGED.
- Engine Wiring Harness Connector (X5) disconnected.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Cranking Circuit (Operator ON Seat) - Gasoline Engine

(1) Key Switch (S1) - wire 404 yellow. Is battery voltage present?

Yes - Go to step (2).

No - Test key switch. Test wire 205 red and fuse link 201.

(2) Fuse (F2) - wire 404 yellow. Is battery voltage present.

Yes - Go to step (3).

No - Test wire 404 yellow and connections.

(3) Fuse (F2) - wire 403 yellow. Is battery voltage present?

Yes - Go to step (4).

No - Test Fuse (F2).

(4) Seat Switch (S4) - wire 435 yellow. Is battery voltage present?

Yes - Go to step (5).

No - Test wire 435 yellow and connections.

(5) Seat Switch (S4) - wire 320 orange. Is battery voltage present?

Yes - Go to step (6).

No - Replace seat switch.

(6) Seat Relay (K2) - wire 320 orange. Is battery voltage present?

Yes - Go to step (7).

No - Test wire 320 orange and connections.

(7) Seat Relay (K2) - wire 127 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (8).

No - Test wire 127 black and connections.

(8) Seat Relay (K2) - wire 436 yellow. Is battery voltage present?

Yes - Go to step (9).

No - Test wire 436 yellow and connections.

(9) Seat Relay (K2) - wire 424 yellow. Is battery voltage present?

Yes - Go to step (10).

No - Replace seat relay.

System: Cranking Circuit (Operator ON Seat) - Gasoline Engine

(10) Off Delay Module (A3) - wire 475 yellow. Is battery voltage present?

Yes - Go to step (11).

No - Test wire 475 yellow and connections.

(11) Off Delay Module (A3) - wire 210 red. Is battery voltage present?

Yes - Go to step (12).

No - Test wire 210 red and connections.

No - Test Fuse (F1), wire 204 yellow and fuse link 201.

(12) Off Delay Module (A3) - wire 114 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (13).

No - Test wire 114 black and connections.

(13) Off Delay Module (A3) - wire 340 orange. Is battery voltage present?

Yes - Go to step (14).

No - Replace off delay module.

(14) Engine Wiring Harness Connector (X23) - wire 480 yellow. Is battery voltage present?

Yes - Go to step (15).

No - Test wires 424, 480 yellow and connections.

(15) Brake Switch (S5) - wire 470 yellow. Is battery voltage present?

Yes - Go to step (16).

No - Test wire 470 yellow and connections.

(16) Seat Diode (V1) - wire 461 yellow. Is battery voltage present?

Yes - Go to step (17).

No - Test wire 461 yellow and connections.

(17) Start Relay (K1) - wire 462 yellow. Is battery voltage present?

Yes - Go to step (18).

No - Test wire 462 yellow and connections.

System: Cranking Circuit (Operator ON Seat) - Gasoline Engine

(18) Key Switch (S1) - wire 115 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (19).

No - Test wire 115 black and connections.

(19) Key Switch (S1) - wire 700 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (20).

No - Replace key switch.

(20) Mechanical PTO Switch (S6) - wire 700 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (21).

No - Test wire 700 purple and connections.

(21) Mechanical PTO Switch (S6) - wire 701 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (22).

No - For models without optional mechanical PTO switch, test jumper wire and connections.

No - For models with optional mechanical PTO switch, replace PTO switch.

(22) PTO Engaged Sensor Switch (S7) - wire 701 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (23).

No - Test wire 701 purple and connections.

(23) PTO Engaged Sensor Switch (S7) - wire 705 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (24).

No - Replace PTO engaged sensor switch.

(24) Neutral Switch (S2) - wire 705 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (25).

No - Test wire 705 purple and connections.

System: Cranking Circuit (Operator ON Seat) - Gasoline Engine

(25) Neutral Switch (S2) - wire 702 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (26).

No - Replace neutral switch.

(26) Start Relay (K1) - wire 702 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (27).

No - Test wire 702 purple and connections.

(27) Start Relay (K1). Cycle key switch between RUN and START positions. Does start relay click when the key switch is cycled?

Yes - Go to step (28).

No - Replace start relay.

(28) Start Relay (K1) - wire 203 red. Place key switch in START position. Is battery voltage present?

Yes - Go to step (29).

No - Test wire 203 red, fuse link 202 and connections.

(29) Start Relay (K1) - wire 710 purple. Is battery voltage present?

Yes - Go to step (30).

No - Replace start relay.

(30) Starting motor solenoid - wire 710 purple. Is battery voltage present?

Yes - Test starting motor solenoid.(See “Inspection and Test” on page 330.)Test starting motor. (See “Starting Motor Amperage Draw Test” on page 310.)

No - Test wire 710 purple and connections.

Starting and Fuel Shut-Off Solenoid Circuit Operation - Diesel Engine

Function

To energize the starting motor solenoid and lock the starting motor to crank the engine and lock the fuel shutoff solenoid to allow the engine to start and run.

Operating Conditions

- Key switch in START position, (RUN position once the engine is running)
- Transmission in NEUTRAL
- PTO DISENGAGED
- and either:
  - Park Brake Engaged

  or
  - Operator ON the seat

  or
  - Brake Engaged

NOTE: The operator must be properly seated in the left seat to operate the vehicle with both the brake and park brake disengaged.

Theory of Operation

To energize the starting motor solenoid Y1 and the starting motor M1, the start relay K1 must be energized. The start relay K1 receives voltage to the common terminal from the 203 Red wire and the 202 fuse link. When the start relay K1 coil is energized the contacts close and connect the 203 Red wire to the 710 and 720 Pur wire and 902 Wht wire. The 720 Pur wire supplies voltage to the starting motor solenoid Y1 causing it to energize. This supplies voltage to the starting motor M1, cranking the engine while the 920 Wht wire supplies voltage to the fuel shutoff solenoid Y3 pull in coil. To energize the start relay K1, both the voltage input and the ground side are switched and must be activated.

Power to the start relay K1 for the cranking process can be supplied by any one of three circuits:

- the brake switch S5
- the seat relay K2
- the park brake switch S3.

Power is supplied to the fuse link 201, 205 Red wire, S1 key switch, 404 Yel wire, F2 10 amp fuse, and 403 Red wire to splice #1 for the 400 series wires.

From splice #1, power is supplied to the S4 seat switch through the 435 Yel wire, the A1 seat delay module through the 445 Pnk wire, the K2 seat relay through the 436 Yel wire, and the S3 park brake switch through the 450 Yel wire. Engaging either the park brake switch, brake switch or the seat switch, will supply voltage to the start relay K1 as well as suppling voltage to hold in coil of the fuel shutoff solenoid Y3.

CAUTION: Avoid injury! To avoid injury, ALWAYS lock park brake when starting the engine.

Park Brake Switch

If the operator has the park brake switch S3 engaged, then power is supplied to the 604 Org and 603 Grn wires. The 603 Grn wire supplies power to the instrument panel to illuminate the park brake light H7 while the 604 Org wire supplies power across the V1 diode to the 462, 461, 470 and 424 Yel wires. The 462 Yel wire supplies power to the start relay K1, and the 461, 470 and 424 Yel wires combine to supply power across the X5 connector to the hold in coil of the Y3 fuel shutoff solenoid.

Seat Switch

When the operator is in the seat and has the seat switch S4 depressed, power is supplied from the 435 Yel wire to the 440 Yel wire and the Yel wire of the A1 seat delay module. With power also supplied to the seat delay module from the 445 Pnk wire the seat delay module will supply power to the K2 seat relay. With signal power being supplied to the seat relay through the 320 Org wire the relay is energized and will supply power from the 436 Yel wire to the 424, 470, 461 and Yel wires. The 470, 461 and 462 Yel wires combine to supply power to the start relay K1. The 424 Yel wire supplies power across the X5 connector to the hold in coil of the Y3 fuel shutoff solenoid.

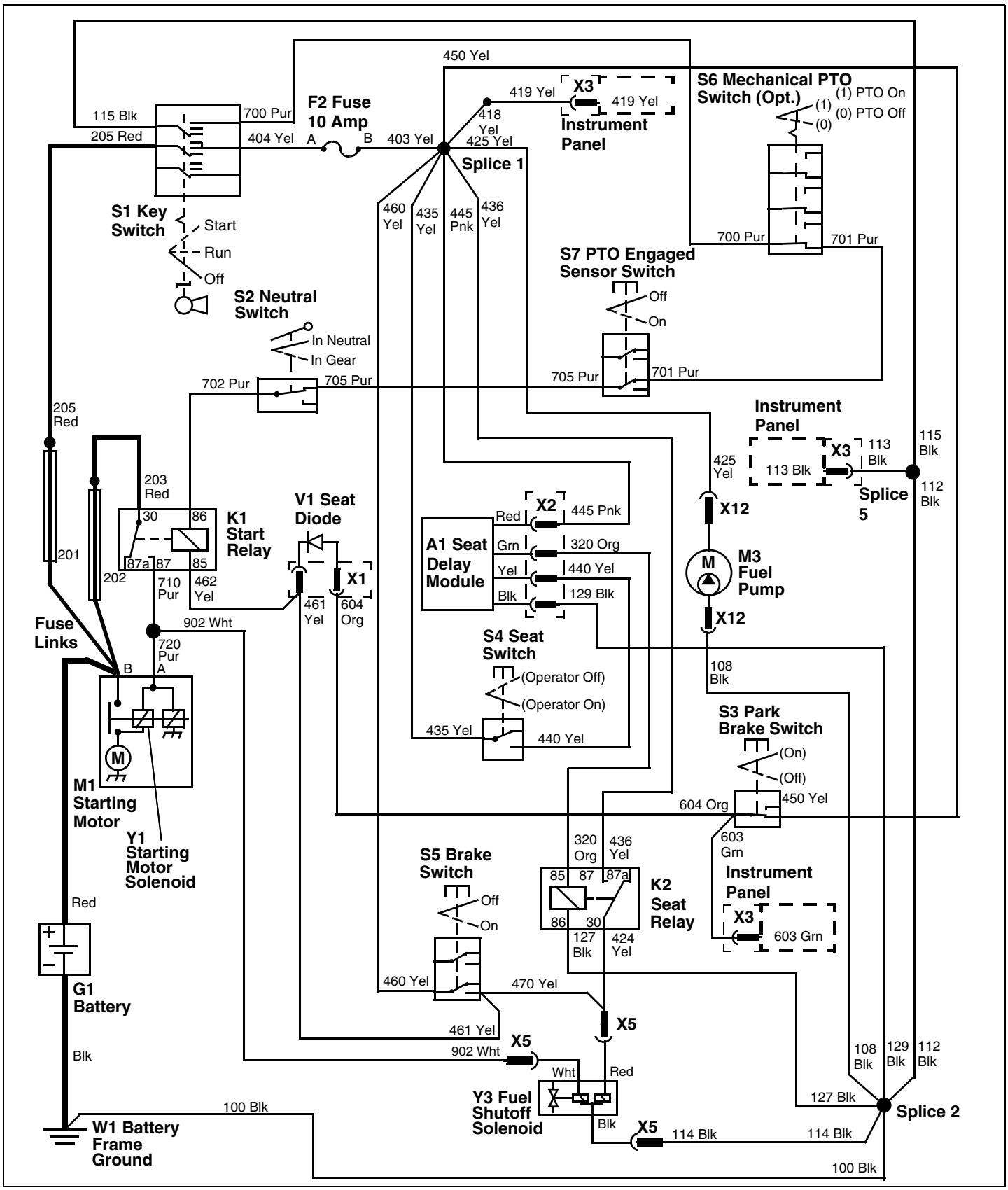
Brake Switch

If the operator has the brake switch S5 engaged, then power is supplied from the 460 Yel wire to the 461, 470, 462 and 424 Yel wires. The 461 and 462 Yel wires connect to supply power to the start relay K1 while the 470 and 424 Yel wires supply power across the X5 connector to the hold in coil of the Y3 fuel shutoff solenoid.

Switching the Ground

The ground side of the start relay K1 coil is provided from the 702 Pur wire, S2 neutral switch, 705 Pur wire, S7 PTO engaged sensor switch, 701 Pur wire, S6 mechanical PTO switch, 700 Pur wire, S1 key switch, 115, 112 and 100 Blk wires to the W1 frame ground.

Starting and Fuel Solenoids Circuit Schematic - Diesel Engine



MIF

Starting and Fuel Shutoff Solenoid Circuit (Operator OFF Seat) Diagnosis - Diesel Engine

Test Conditions:

- Park brake ENGAGED
- Key switch in START position
- Operator OFF seat
- Transmission in NEUTRAL
- PTO DISENGAGED
- Fuel Shutoff Solenoid Connector (X5) disconnected.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Starting and Fuel Shutoff Solenoid Circuit (Operator OFF Seat) - Diesel Engine

(1) Key Switch (S1) - wire 404 yellow. Is battery voltage present?

Yes - Go to step (2).

No - Test key switch. Test wire 205 red and fuse link 201.

(2) Fuse (F2) - wire 404 yellow. Is battery voltage present?

Yes - Go to step (3).

No - Test wire 404 yellow and connections.

(3) Fuse (F2) - wire 403 yellow. Is battery voltage present?

Yes - Go to step (4).

No - Test fuse (F2).

(4) Fuel Pump Connector (X12) - wire 425 yellow. Is battery voltage present?

Yes - Go to step (5).

No - Test wires 425, 403 yellow and connections.

(5) Fuel Pump Connector (X12) - wire 108 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (6).

No - Test wire 108 black and connections. If ground circuit tests good, replace fuel pump.

System: Starting and Fuel Shutoff Solenoid Circuit (Operator OFF Seat) - Diesel Engine

(6) Park Brake Switch (S3) - wire 450 yellow. Is battery voltage present?

Yes - Go to step (7).

No - Test wire 450 yellow and connections.

(7) Park Brake Switch (S3) - wire 604 orange. Is battery voltage present?

Yes - Go to step (8).

No - Replace park brake switch.

(8) Seat Diode (V1) - wire 604 orange. Is battery voltage present?

Yes - Go to step (9).

No - Test wire 604 orange and connections.

(9) Seat Diode (V1) - wire 461 yellow. Is battery voltage present?

Yes - Go to step (10).

No - Replace diode.

(10) Start Relay (K1) - wire 462 yellow. Is battery voltage present?

Yes - Go to step (11).

No - Test wire 462 yellow and connections.

(11) Key Switch (S1) - wire 115 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (12).

No - Test wire 115 black and connections.

(12) Key Switch (S1) - wire 700 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (13).

No - Replace key switch.

(13) Mechanical PTO Switch (S6) - wire 700 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (14).

No - Test wire 700 purple and connections.

System: Starting and Fuel Shutoff Solenoid Circuit (Operator OFF Seat) - Diesel Engine

(14) Mechanical PTO Switch (S6) - wire 701 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (15).

No - For models without optional Mechanical PTO Switch (S6), test jumper wire and connections.

No - For models with optional Mechanical PTO Switch (S6), replace PTO switch.

(15) PTO Engaged Sensor Switch (S7) - wire 701 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (16).

No - Test wire 701 purple and connections.

(16) PTO Engaged Sensor Switch (S7) - wire 705 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (17).

No - Replace PTO engaged sensor switch.

(17) Neutral Switch (S2) - wire 705 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (18).

No - Test wire 705 purple and connections.

(18) Neutral Switch (S2) - wire 702 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (19).

No - Replace neutral switch.

(19) Start Relay (K1) - wire 702 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (20).

No - Test wire 702 purple and connections.

(20) Start Relay (K1). Cycle key switch between RUN and START positions. Does start relay click when switch is cycled?

Yes - Go to step (21).

No - Replace start relay.

System: Starting and Fuel Shutoff Solenoid Circuit (Operator OFF Seat) - Diesel Engine

(21) Start Relay (K1) - wire 203 red. Place key switch to START position. Is battery voltage present?

Yes - Go to step (22).

No - Test wire 203 red, fuse link 202 and connections.

(22) Start Relay (K1) - wire 710 purple. Is battery voltage present?

Yes - Go to step (23).

No - Replace start relay.

(23) Starting motor solenoid - wire 710 purple. Is battery voltage present?

Yes - Go to step (24).

No - Test wire 710 purple and connections.

No - If test are good, test starting motor solenoid. (See “Inspection and Test” on page 330.)Test starting motor. (See “Starting Motor Amperage Draw Test” on page 310.)

(24) Fuel Shutoff Solenoid Connector (X5) - wire 424 yellow. Is battery voltage present?

Yes - Go to step (25).

No - Test wire 424 yellow and connections.

(25) Fuel Shutoff Solenoid Connector (X5) - wire 902 white. Is battery voltage present?

Yes - Go to step (26).

No - Test wire 902 white and connections.

(26) Fuel Shutoff Solenoid Connector (X5) - wire 114 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

No - Test wire 114 black and connections.

Starting and Fuel Shutoff Solenoid Circuit (Operator ON Seat) Diagnosis - Diesel Engine

Test Conditions:

- Park brake DISENGAGED.
- Key switch in START position.
- Operator ON seat.
- Transmission in NEUTRAL.
- PTO DISENGAGED.
- Engine Wiring Harness Connector (X5) disconnected.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Starting and Fuel Shutoff Solenoid Circuit (Operator ON Seat) - Diesel Engine

(1) Key Switch (S1) - wire 404 yellow. Is battery voltage present?

Yes - Go to step (2).

No - Test key switch. Test wire 205 red and fuse link 201.

(2) Fuse (F2) - wire 404 yellow. Is battery voltage present?

Yes - Go to step (3).

No - Test wire 404 yellow and connections.

(3) Fuse (F2) - wire 403 yellow. Is battery voltage present?

Yes - Go to step (4).

No - Test Fuse (F2).

(4) Seat Switch (S4) - wire 435 yellow. Is battery voltage present?

Yes - Go to step (5).

No - Test wire 435 yellow and connections.

(5) Seat Switch (S4) - wire 440 yellow. Is battery voltage present?

Yes - Go to step (6).

No - Replace seat switch.

(6) Seat Delay Module (A1) - wire 440 yellow. Is battery voltage present?

Yes - Go to step (7).

No - Test wire 440 yellow and connections.

System: Starting and Fuel Shutoff Solenoid Circuit (Operator ON Seat) - Diesel Engine

(7) Seat Delay Module (A1) - wire 445 pink. Is battery voltage present?

Yes - Go to step (8).

No - Test wire 445 pink and connections.

(8) Seat Delay Module (A1) - wire 129 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (9).

No - Test wire 129 black and connections.

(9) Seat Delay Module (A1) - wire 320 orange. Is battery voltage present?

Yes - Go to step (10).

No - Replace seat delay module.

(10) Seat Relay (K2) - wire 320 orange. Is battery voltage present?

Yes - Go to step (11).

No - Test wire 320 orange and connections.

(11) Seat Relay (K2) - wire 127 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (12).

No - Test wire 127 black and connections.

(12) Seat Relay (K2) - wire 436 yellow. Is battery voltage present?

Yes - Go to step (13).

No - Test wire 436 yellow and connections.

(13) Seat Relay (K2) - wire 424 yellow. Is battery voltage present?

Yes - Go to step (14).

No - Replace seat relay.

(14) Engine Wiring Harness Connector (X5) - wire 424 yellow. Is battery voltage present?

Yes - Go to step (15).

No - Test wire 424 yellow and connections.

(15) Brake Switch (S5) - wire 470 yellow. Is battery voltage present?

Yes - Go to step (16).

No - Test wire 470 yellow and connections.

System: Starting and Fuel Shutoff Solenoid Circuit (Operator ON Seat) - Diesel Engine

(16) Seat Diode (V1) - wire 461 yellow. Is battery voltage present?

Yes - Go to step (17).

No - Test wire 461 yellow and connections.

(17) Start Relay (K1) - wire 462 yellow. Is battery voltage present?

Yes - Go to step (18).

No - Test wire 462 and connections.

(18) Key Switch (S1) - wire 115 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (19).

No - Test wire 115 black and connections.

(19) Key Switch (S1) - wire 700 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (20).

No - Replace key switch.

(20) Mechanical PTO Switch (S6) - wire 700 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (21).

No - Test wire 700 purple and connections.

(21) Mechanical PTO Switch (S6) - wire 701 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (22).

No - For models without optional mechanical PTO switch, test jumper wire and connections.

No - For models with optional mechanical PTO switch, replace PTO switch.

(22) PTO Engaged Sensor Switch (S7) - wire 701 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (23).

No - Test wire 701 purple and connections.

(23) PTO Engaged Sensor Switch (S7) - wire 705 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (24).

No - Replace PTO engaged sensor switch.

System: Starting and Fuel Shutoff Solenoid Circuit (Operator ON Seat) - Diesel Engine

(24) Neutral Switch (S2) - wire 705 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (25).

No - Test wire 705 purple and connections.

(25) Neutral Switch (S2) - wire 702 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (26).

No - Replace neutral switch.

(26) Start Relay (K1) - wire 702 purple. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (26).

No - Test wire 702 purple and connections.

(27) Start Relay (K1). Cycle key switch between RUN and START positions. Does start relay click when the key switch is cycled?

Yes - Go to step (28).

No - Replace start relay.

(28) Start Relay (K1) - wire 203 red. Place key switch in START position. Is battery voltage present?

Yes - Go to step (29).

No - Test wire 203 red, fuse link 202 and connections.

(29) Start Relay (K1) - wire 710 purple. Is battery voltage present?

Yes - Go to step (30).

No - Replace start relay.

(30) Starting motor solenoid - wire 710 purple. Is battery voltage present?

Yes - Go to step (31).

No - Test wire 710 purple and connections.

No - Test starting motor solenoid. (See “Inspection and Test” on page 330.)Test starting motor. (See “Starting Motor Amperage Draw Test” on page 310.)

(31) Fuel Shutoff Solenoid Connector (X5) - wire 424 yellow. Is battery voltage present?

Yes - Go to step (32).

No - Test wire 424 yellow and connections.

System: Starting and Fuel Shutoff Solenoid Circuit (Operator ON Seat) - Diesel Engine

(32) Fuel Shutoff Solenoid Connector (X5) - wire 902 white. Is battery voltage present?

Yes - Go to step (33).

No - Test wire 902 white and connections.

(33) Fuel Shutoff Solenoid Connector (X5) - wire 114 black. Measure resistance to ground. Is there less than 0.1 ohm.

No - Test wire 114 black and connections.

Ignition Circuit Operation - Gasoline Engine (Old)

Function

To create a spark at the proper time within the engine cylinders to ignite the air fuel mixture.

Operating Conditions

- Key Switch in the RUN or START position
- and either:
  - Operator ON seat

  or
  - Operator OFF seat and Park Brake ENGAGED

Theory of Operation

For the engine to run, the off delay module A3 must receive power from the unswitched power circuit and the switched power circuits must also provide power to the off delay module, ignition and fuel shutoff solenoid.

Power is supplied to the fuse link 201, 204 Yel and 205 Red wires. The 204 Yel wire provides power to the off delay module through the 25 amp fuse F1, 406, 407, 408 and 210 Yel wires. The 204 Yel wire provides power to the S1 key switch, 404 Yel wire, F2 10 amp fuse, and 403 Red wire to splice #1 for the 400 series wires. From splice #1, power is supplied to the S4 seat switch through the 435 Yel wire, the A1 seat delay module through the 445 Pnk wire, the K2 seat relay through the 436 Yel wire, and the S3 park brake switch through the 450 Yel wire.

When the operator is in the seat and has the seat switch S4 depressed, power is supplied from the 435 Yel wire to the 440 Yel wire and the Yel wire of the A1 seat delay module. With power also supplied to the seat delay module from the 445 Pnk wire the seat delay module will supply power to the K2 seat relay through the 320 Org wire. With signal power being supplied to the seat relay through the 320 Org wire the relay is energized and will supply power from the 436 Yel wire to the 424 Yel wire. The 424 Yel wire supplies power across the X5 connector to the Pnk/Blk wire of the W5 engine wire harness and the off delay module.

If the operator has the park brake engaged, then power is supplied to the 604 Org and 603 Grn wires. The 603 Grn wire supplies power to the instrument panel to illuminate the park brake light while the 604 Org wire supplies power across the V1 diode to the 461, 470 and 424 Yel wires. The 424 Yel wire supplies power across the X5 connector to the Pnk/Blk wire of the W5 engine wire harness and the off delay module.

The Pnk/Blk wire supplies signal power to the off delay module and the red wires to the B5 electric choke and the Y2 fuel shutoff solenoid. From the off delay module the Pnk/Blk wire supplies power to the Org/Wht wire of the A2 ignition module and R4 ignition ballast resistor. To prevent the ignition coils from overheating, current flows through R4 ignition ballast resistor to the three ignition coils (Org wire).

When the key switch is in the START position, current flows from K1 start relay, through V3 start diode, to the ignition coils (T1, T2, T3), bypassing the ballast resistor and providing full battery voltage during startup. Once the key switch is returned to the RUN position, V3 start diode prevents ignition current from passing to the starter motor.

With the ignition circuit energized and the engine rotating, the pulsar coils will induce the trigger signals into the ignition module which in turn will signal the ignition coils when to send current to the spark plugs to ignite the air fuel mixture. See “Cranking Circuit Operation - Gasoline Engine” on page 256

The triggering signals are generated as the indent on the outside edge of the front flywheel moves past each of the pulser coils (B1, B2 and B3). These triggering signals are transferred to the ignition module (A2). The ignition module acts as an electronic switch controlling the timing of the flow of current to the primary windings of the ignition coils (T1, T2 and T3).

The ignition coils consist of iron cores with 2 sets of wires wound around them. The primary windings are connected to the ignition module. The secondary windings are connected to the spark plugs (E1, E2 and E3) through high tension leads. There are many more windings in the secondary windings of the coils than in the primary windings. As the flywheel rotates prior to the spark plugs firing, the ignition module allows current from the battery to the primary windings of the ignition coils. When a signal from the pulser coil is received at the ignition module, current flow to the primary winding is stopped. As the voltage in the primary winding drops from battery voltage to 0 volts, a strong magnetic field is created around the wires of both the primary and secondary windings. This strong magnetic field generates a voltage in the secondary windings of the coil. The voltage generated in the secondary windings is much higher than the battery voltage that was applied to the primary windings due to the greater number of windings. The high voltage of the secondary windings creates a spark at the spark plug (E1, E2 or E3).

Engine Shutoff Function

Shut the engine off by removing power from the off delay module A3, solid state ignition module A2, ignition coils T1, T2 and T3 and the fuel shutoff solenoid Y2.

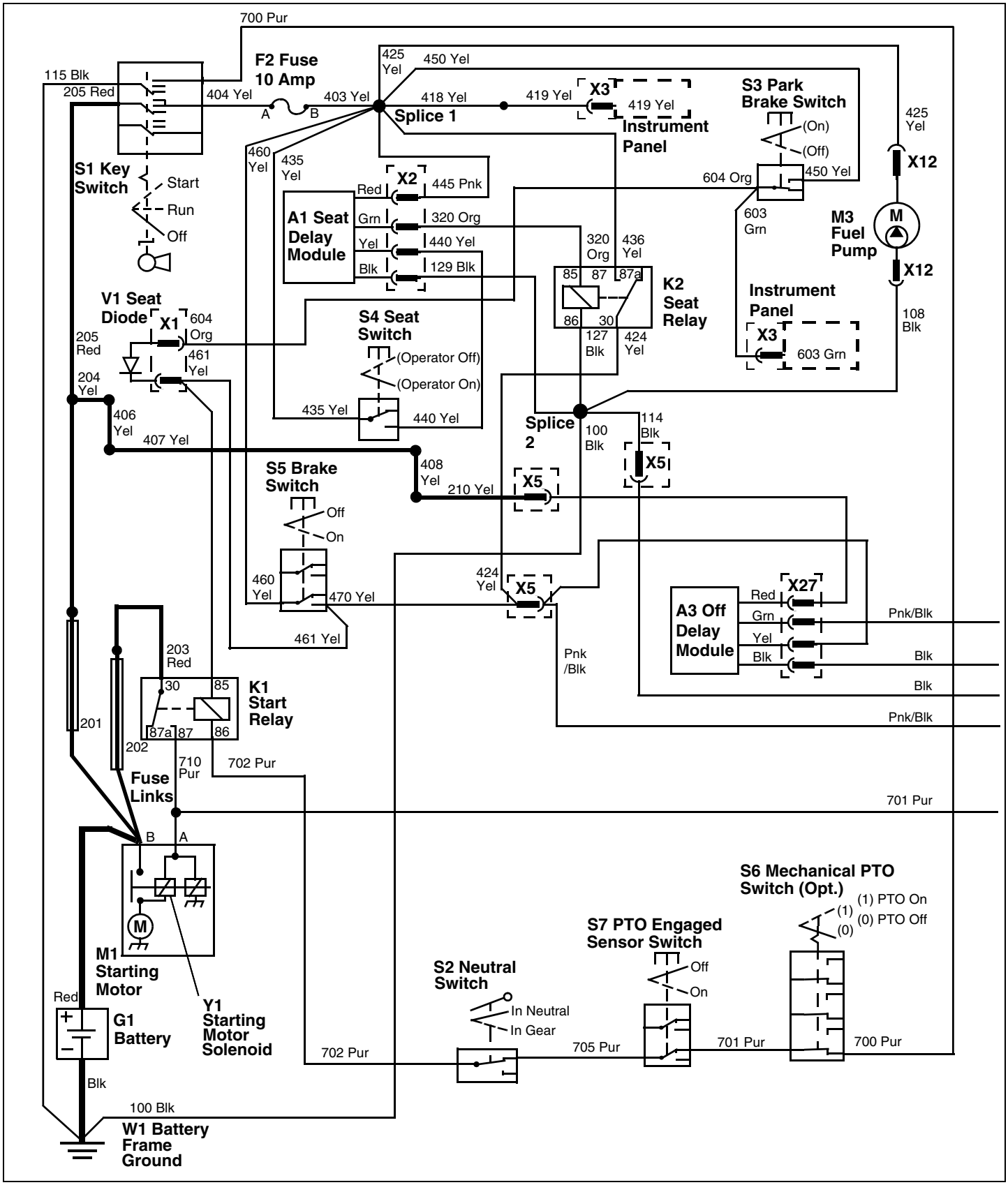
Engine MUST STOP if:

- Operator turns the key switch to the OFF position

or;

- Operator gets out of seat without engaging the parking brake.

Ignition Circuit Schematic - Gasoline Engine (Old)



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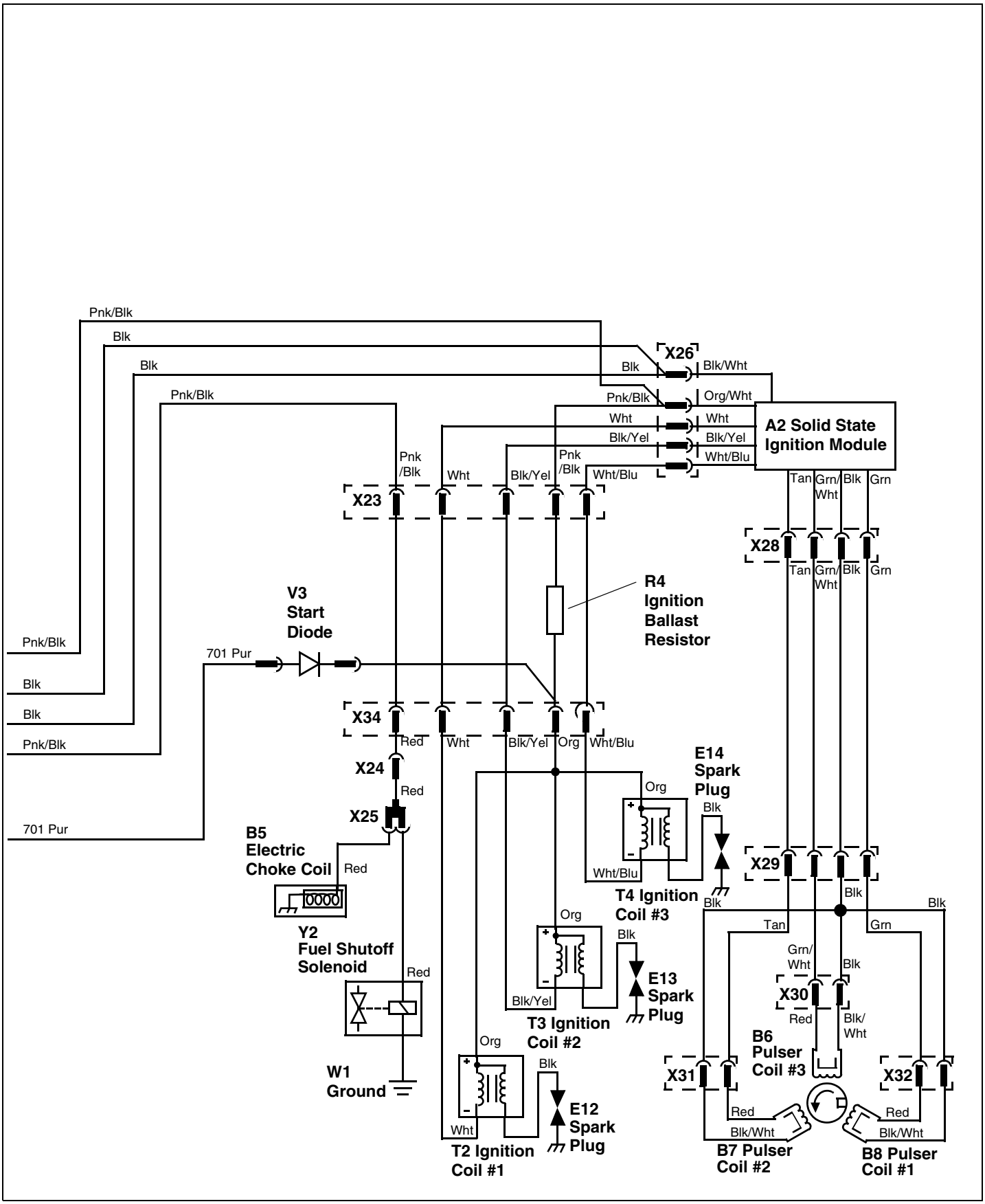
Pnk/Blk
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Blk
Pnk/Blk
Pnk/Blk
Blk
Blk
Pnk/Blk
701 Pur
701 Pur
X26
Blk
Blk/Wht
Pnk/Blk
Org/Wht
Wht
Wht
Blk/Yel
Blk/Yel
Wht/Blu
A2 Solid State Ignition Module
Tan
Grn/ Wht
Blk
Grn
X28
Tan
Grn/ Wht
Blk
Grn
X23
Pnk /Blk
Wht
Blk/Yel
Pnk /Blk
Wht/Blu
R4 Ignition Ballast Resistor
V3 Start Diode
X34
Red
Wht
Blk/Yel
Org
Wht/Blu
X24
Red
X25
E14 Spark Plug
Org
Blk
Wht/Blu
T4 Ignition Coil #3
X29
Blk
Blk
Blk
B5 Electric Choke Coil
Red
0000
Y2 Fuel Shutoff Solenoid
Red
Org
Blk
Blk/Yel
T3 Ignition Coil #2
E13 Spark Plug
Tan
Grn
Grn/ Wht
Blk
X30
Red
Blk/ Wht
B6 Pulser Coil #3
X31
X32
Red
Red
Blk/Wht
Blk/Wht
B7 Pulser Coil #2
B8 Pulser Coil #1
W1 Ground
Org
Blk
Wht
T2 Ignition Coil #1
E12 Spark Plug

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Ignition Circuit Operation - Gasoline Engine (New)

New Harness:

2-Wheel Drive S.N. (020348-)

4-Wheel Drive S.N. (020079-)

Electric and Manual Choke - Gasoline

Electric Choke Engine Serial Number -CH3009G007962
Manual Choke Engine Serial Number. CH3009G007963-

Ignition Function

To create a spark at the proper time within the engine cylinders to ignite the air fuel mixture.

Operating Conditions

- Key Switch in the RUN or START position
- and either:
  - Operator ON seat

  or
  - Operator OFF seat and Park Brake ENGAGED

Theory of Operation

For the engine to run, the off delay module A3 must receive power from the unswitched power circuit and the switched power circuits must also provide power to the off delay module, ignition and fuel shutoff solenoid.

Power is supplied from the fuse link 201 Red wire to the 205 Red wire and the 204 Yel wire. Unswitched power for the A3 off delay module continues through the F1 fuse and the 210 Red wire. The 215 Red wire provides power for the ignition coil primary circuit. No current will be flowing until the A3 off delay module and the A2 ignition module are energized from switched power sources.

With the operator on the seat, switched power comes from the S1 key switch, 404 Yel wire, F2 fuse, 403, and 435 Yel wires, through the S4 seat switch contacts to the 320 Org wire and to the K2 seat relay coil. This energizes the K2 relay. As the relay activates power is sent to the A3 off delay module via the 436, 424, and 475 Yel wires. Power is then sent from the off delay module on wire 340 Org to the A2 ignition module. This turns on the ignition module.

The K2 seat relay also sends power to the B5 electric choke heater coil and the Y2 fuel shut off solenoid via the 480 Yel wire.

Current to the ignition coils (T1, T2, T3) flows through the 215 Red wire to R4 ignition ballast resistor. To prevent the ignition coils from overheating, current flows through R4 ignition ballast resistor to the three ignition coils (Org wire).

When the key switch is in the START position, current flows from K1 start relay, through V3 start diode, to the ignition coils (T1, T2, T3), bypassing the ballast resistor and providing full battery voltage during startup. Once the key switch is returned to the RUN position, V3 start diode prevents ignition current from passing to the starter motor.

With the ignition circuit energized and the engine rotating, the pulsar coils will induce the trigger signals into the ignition module which in turn will signal the ignition coils when to send current to the spark plugs to ignite the air fuel mixture. (See “Cranking Circuit Operation - Gasoline Engine” on page 256.)

The triggering signals are generated as the indent on the outside edge of the front flywheel moves past each of the pulser coils (B1, B2 and B3). These triggering signals are transferred to the ignition module (A2). The ignition module acts an electronic switch controlling the timing of the flow of current to the primary windings of the ignition coils (T1, T2 and T3).

The ignition coils consist of iron cores with 2 sets of wires wound around them. The primary windings are connected to the ignition module. The secondary windings are connected to the spark plugs (E1, E2 and E3) through high tension leads. There are many more windings in the secondary windings of the coils than in the primary windings.

As the flywheel rotates prior to the spark plugs firing, the ignition module allows current from the battery to the primary windings of the ignition coils. When a signal from the pulser coil is received at the ignition module, current flow to the primary winding is stopped. As the voltage in the primary winding drops from battery voltage to 0 volts, a strong magnetic field is created around the wires of both the primary and secondary windings. This strong magnetic field generates a voltage in the secondary windings of the coil. The voltage generated in the secondary windings is much higher than the battery voltage that was applied to the primary windings due to the greater number of windings. The high voltage of the secondary windings creates a spark at the spark plug (E1, E2, or E3).

Engine Shutoff Function

Shut the engine off by removing power from the off delay module A3; solid state ignition module A2; ignition coils T1, T2, and T3; and the fuel shutoff solenoid Y2.

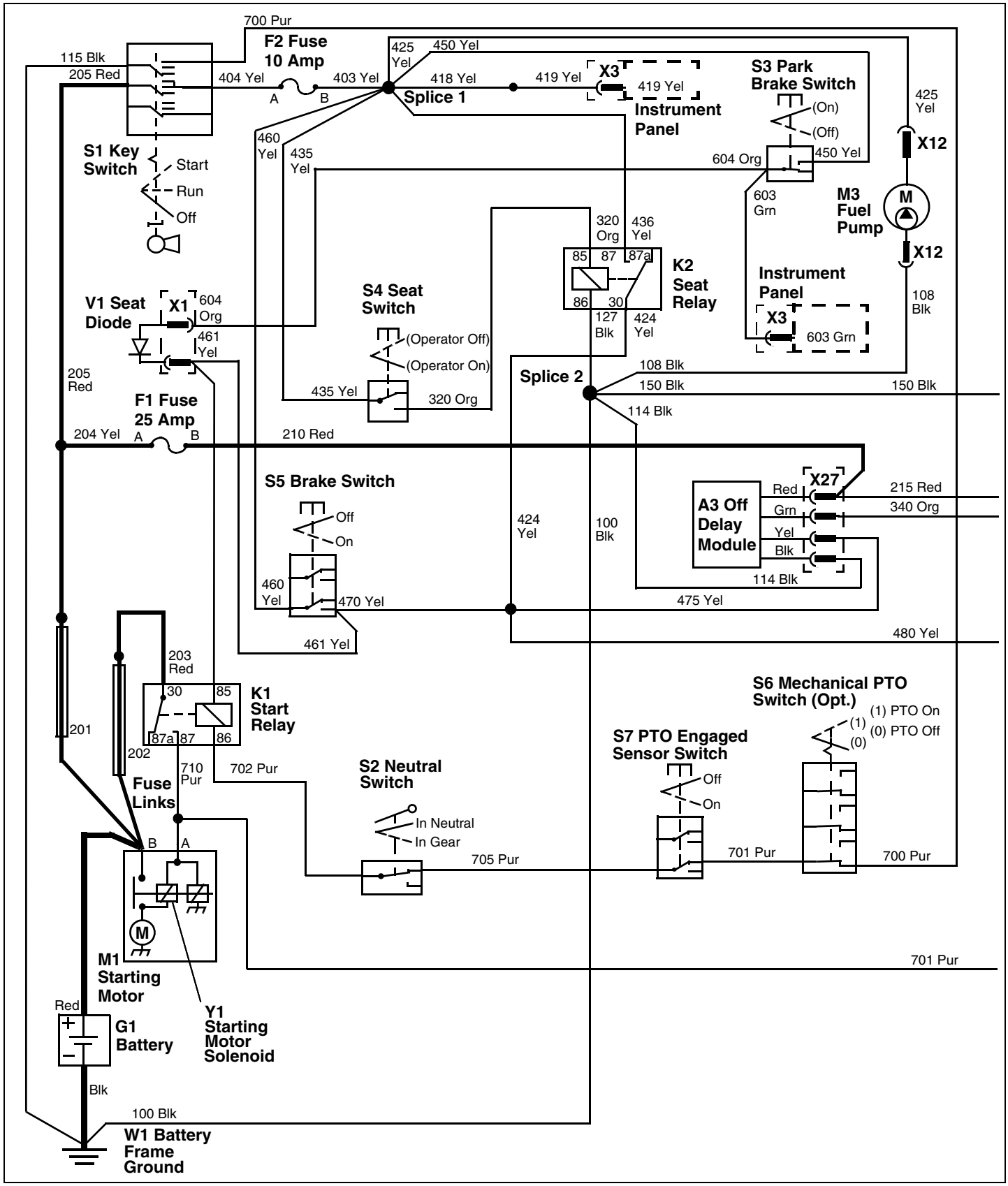
Engine MUST STOP if:

- Operator turns the key switch to the OFF position

or

- Operator gets out of seat without engaging the parking brake.

Ignition Circuit Schematic - Gasoline Engine (New)



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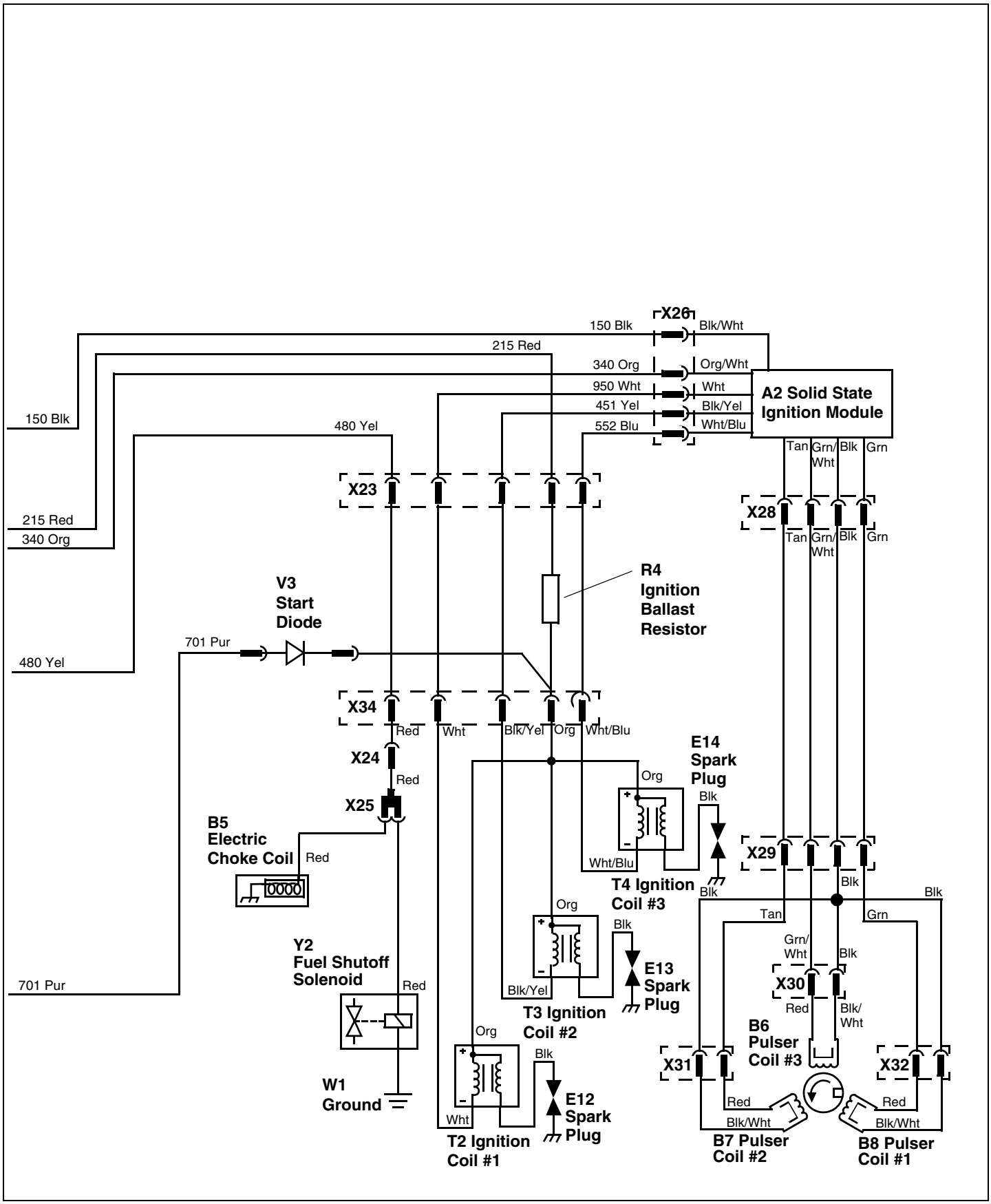
X26
150 Blk
Blk/Wht
215 Red
340 Org
Org/Wht
950 Wht
Wht
451 Yel
Blk/Yel
552 Blu
Wht/Blu
A2 Solid State Ignition Module
Tan
Grn/Wht
Blk
Grn
X23
X28
150 Blk
215 Red
340 Org
480 Yel
R4 Ignition Ballast Resistor
V3 Start Diode
701 Pur
480 Yel
X34
Red
Wht
Blk/Yel
Org
Wht/Blu
X24
Red
X25
E14 Spark Plug
Org
Blk
B5 Electric Choke Coil
Red
Wht/Blu
T4 Ignition Coil #3
X29
Blk
Tan
Grn
Grn/Wht
Blk
X30
Red
Blk/Wht
Y2 Fuel Shutoff Solenoid
701 Pur
Red
T3 Ignition Coil #2
E13 Spark Plug
B6 Pulser Coil #3
X31
X32
W1 Ground
E12 Spark Plug
T2 Ignition Coil #1
B7 Pulser Coil #2
B8 Pulser Coil #1

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Ignition Circuit Diagnosis - Gasoline Engine

ProGator

2020 2wd	**Serial No. (-020347)**
2020 4wd	Serial No. (-020078)

Test Conditions:

- Key switch in OFF position.
- Operator OFF seat.
- Park brake ENGAGED.
- PTO DISENGAGED.
- Transmission in NEUTRAL position.
- Engine cool to avoid burns.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Ignition Circuit - Gasoline Engine

(1) Inspect spark plugs. Are spark plugs free of fouling?

Yes - Go to step (2).

No - Adjust air gap. Replace spark plugs.

(2) Engine Connector (X5) - wire 210 yellow. Is battery voltage present?

Yes - Go to step (3).

No - Test wire 210 yellow and connections. (See “Power Circuit Diagnosis - Gasoline Engine” on page 246.)

(3) Engine Connector (X5) - wire 424 yellow. Place key switch to RUN position. Is battery voltage present?

Yes - Go to step (4).

No - (See “Cranking Circuit (Operator OFF Seat) Diagnosis - Gasoline Engine” on page 260.)

(4) Engine Connector (X5) - wire 114 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (5).

No - Test wire 114 black and connections.

(5) Ignition Module Connector (X26) - black wire. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (6).

No - Test black wire and connections.

System: Ignition Circuit - Gasoline Engine

(6) Ignition Module Connector (X26) - pink/black wire. Is battery voltage present?

Yes - Go to step (7).

No - Test engine wire harness pink/black wire and connections and Off Delay Module (A3).

(7) Fuel Shutoff Solenoid (Y2) - red wire. Is battery voltage present?

Yes - Go to step (8).

No - Test engine wire harness pink/black and red wires and connections.

(8) Ignition coils - orange wires. Is voltage present?

Yes - Go to step (9).

No - Test engine wire harness orange wires and connections and Off Delay Module (A3).

No - Test wire 215 Red, ignition ballast resistor (R4), and ignition ballast resistor harness (W12) and connections.

(9) Ignition coils - orange wires while cranking engine. Is battery voltage present?

Yes - Go to step (10).

No - Test wire 701 Pur, start diode (V3), and ignition ballast resistor harness (W12) and connections.

(10) Engine Connector (X5) - wire 424 yellow. Disengage park brake and have operator ON seat. Is battery voltage present?

Yes - Go to step (11).

No - (See “Cranking Circuit (Operator OFF Seat) Diagnosis - Gasoline Engine” on page 260.)

(11) Spark plug tester (installed). Lock park brake and have operator OFF seat. Place key switch to START position. Is there indication of spark?

Yes - Repeat this step for remaining spark plugs.

No - If no spark present, test ignition coils and ignition module and pulser coils. (See “Ignition Coil Test” on page 326, “Ignition Module Test” on page 325, and “Pulser Coil Test” on page 327.) If spark present, check spark plug gap and condition of spark plugs.

Ignition Circuit Diagnosis - Gasoline Engine

ProGator

2020 2wd	**Serial No. (020348-)**
2020 4wd	Serial No. (020079-)

Test Conditions:

- Key switch in OFF position.
- Operator OFF seat.
- Park brake ENGAGED.
- PTO DISENGAGED.
- Transmission in NEUTRAL position.
- Engine cool to avoid burns.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Ignition Circuit - Gasoline Engine

(1) Inspect spark plugs. Are spark plugs free of fouling?

Yes - Go to step (2).

No - Adjust air gap. Replace spark plugs.

(2) Off Delay Module (A3) - wire 210 red. Is battery voltage present?

Yes - Go to step (3).

No - Test wire 210 red and connections.

(3) Ignition coils - orange wires. Is voltage present?

Yes - Go to step (4).

No - Test engine wire harness orange wires and connections and Off Delay Module (A3).

No - Test ignition ballast resistor (R4), start diode (V3), and ignition ballast resistor harness (W12) and connections.

(4) Ignition coils - orange wires while cranking engine. Is battery voltage present?

Yes - Go to step (4).

No - Test wire 701 Pur, start diode (V3), and ignition ballast resistor harness (W12) and connections.

(5) Off Delay Module (A3) - wire 475 yellow. Place key switch to ON position. Is battery voltage present?

Yes - Go to step (6).

No - Test wire 475 yellow and connections.

System: Ignition Circuit - Gasoline Engine

(6) Off Delay Module (A3) - wire 114 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (7).

No - Test wire 114 black and connections.

(7) Off Delay Module (A3) - wire 340 orange. Is battery voltage present?

Yes - Go to step (8).

No - Test wire 340 orange and connections.

(8) Ignition Module Connector (X26) - wire 340 orange. Is battery voltage present?

Yes - Go to step (9).

No - Test wire 340 orange and connections.

(9) Ignition Module Connector (X26) - wire 150 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (10).

No - Test wire 150 black and connections.

(10) Ignition Coil Connector (X23) - wire 480 yellow. Is battery voltage present?

Yes - Go to step (11).

No - Test wire 480 yellow and connections.

(11) Off Delay Module (A3) - wire 475 yellow. Is battery voltage present?

Yes - Go to step (12).

No - Test wire 475 yellow and connections.

(12) Spark plug tester (installed). Lock park brake and have operator OFF seat. Place key switch START position. Is there indication of spark?

Yes - Repeat this step for remaining spark plugs.

No - If no spark present, test ignition coils and ignition module and pulser coils. (See “Ignition Coil Test” on page 326, “Ignition Module Test” on page 325, and “Pulser Coil Test” on page 327.) If spark present, check spark plug gap and condition of spark plugs.

Charging Circuit Operation

Function

To maintain battery voltage between 12.4 and 13.2 volts.

Operating Conditions

- Key switch in RUN position.
- Engine running.

Theory of Operation

The charging system consists of the G2 alternator with an integrated voltage regulator/rectifier. Charging output is controlled by a regulator/rectifier. The status of the charge rate is indicated by the H4 discharge light.

With the key switch in the RUN position, battery sensing circuit current flows from battery positive terminal to the starting motor solenoid “B” terminal, fuse link 201, 205 Red wire, S1 key switch, 404 Yel wire, F2 10 amp fuse, 403 and 401 Yel wires to the alternator voltage regulator/rectifier. The battery sensing circuit allows the voltage regulator/rectifier to monitor battery voltage.

A rotating permanent magnet in the alternator induces AC current in the alternator stator coils. The AC current flows to the voltage regulator/rectifier. The voltage regulator/rectifier converts AC current to DC current needed to charge the battery.

If battery voltage is low, the regulator/rectifier allows DC current to flow to the battery to charge it through the battery charging circuit (Red wire). When the battery is fully charged, the voltage regulator/rectifier stops current flow to the battery.

If the alternator output current falls below system usage or is insufficient to maintain a preset voltage, the voltage regulator/rectifier provides a ground path to turn on the discharge light through the X3 connector and the 600 Brn wire.

The alternator is grounded through the mounting hardware to the engine.

If the voltage regulator is grounded to the alternator cover, the alternator produces unregulated amperage. See “Unregulated Amperage Test - 55 Amp Alternator” on page 308

Tachometer Circuit Operation

Function

To indicate engine rpm to the operator.

Operating Conditions

- Key switch in RUN position.
- Engine running.

Theory of Operation

Pulsed current flows from the "P" terminal of the alternator to the control panel (X3 connector) through the 704 Pur wire. As the pulse current increases or decreases with the increase or decrease in engine rpm, the tachometer P1 will display the change in engine rpm.

The ground circuit is provide by the 113, 112 and 100 Blk wires back to the W1 frame ground.

Hour Meter Circuit Operation

Function

To indicate to the operator the number of hours the vehicle has been in use.

Operating Conditions

- Key switch in RUN or START position.

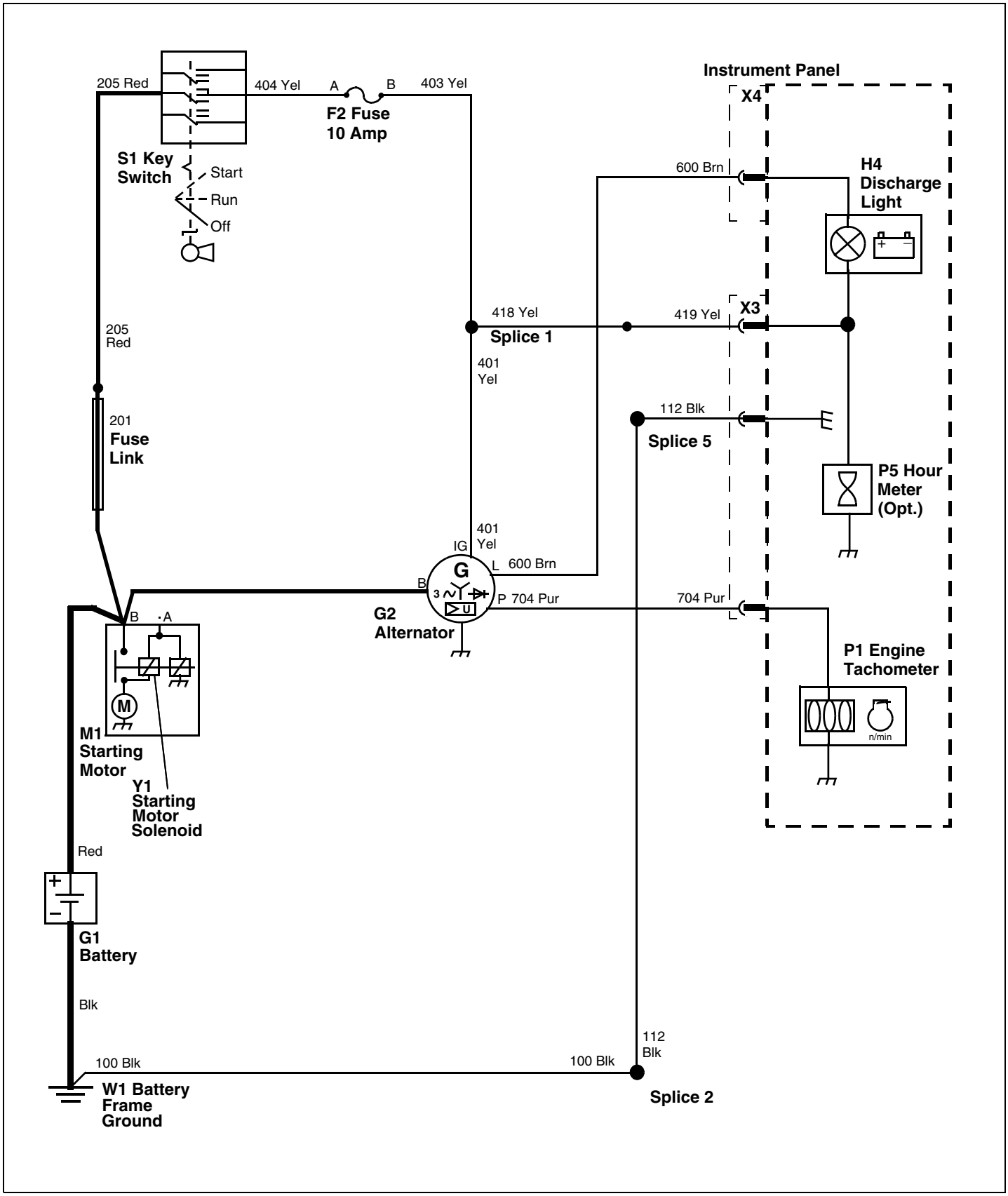
Theory of Operation

The hour meter operates when the S1 key switch is in either the RUN or START position.

The hour meter is integrated into the control panel and is supplied power through the 419, 418 and 403 Yel wires, F2 10 amp fuse, 404 Yel wire, S1 key switch, 205 Red wire and the fuse link 201.

The ground circuit is provide by the 113, 112 and 100 Blk wires back to the W1 frame ground.

Charging, Tachometer and Hour Meter Circuits Schematic



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Charging, Tachometer and Hour Meter Circuit Diagnosis

Test Conditions:

- Key switch in OFF position.
- Park brake ENGAGED.
- Transmission in NEUTRAL position.
- PTO DISENGAGED.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Charging, Tachometer and Hour Meter Circuit

(1) Battery (G1) - positive (+) terminal. Is battery voltage present?

Yes - Go to step (2).

No - Test battery. (See “Battery Test” on page 305.)

(2) Starting Motor Solenoid (Y1) - terminal B. Is battery voltage present?

Yes - Go to step (3).

No - Test starting motor cable connections.

(3) Alternator (G2) - terminal B. Is battery voltage present?

Yes - Go to step (4).

No - Test red cable between starter motor and alternator and connections.

(4) Alternator (G2) connector - wire 401 yellow. Disconnect alternator connector. Place key switch to RUN position. Is battery voltage present?

Yes - Go to step (5).

No - Test wires 401, 403, 404 yellow and connections. Test Fuse (F2).

(5) Instrument Panel Connector (X3) - wire 419 yellow. Disconnect Instrument Panel Connectors (X3 and X4). Is battery voltage present?

Yes - Go to step (6).

No - Test Fuse (F2). Test wires 419, 418, 403 and connections.

(6) Instrument Panel Connector (X3) - wire 704 purple. Is 0.4 V present?

Yes - Go to step (7).

No - Test wire 704 purple and connections.

System: Charging, Tachometer and Hour Meter Circuit

(7) Instrument Panel Connector (X4) - wire 600 brown. Is voltage 0.45 V?

Yes - Go to step (8).

No - Test wire 600 brown and connections.

(8) Alternator (G2) - terminal B. Connect Instrument Panel Connectors (X3 and X4). Start engine. Is voltage 12.2-14.8 V?

Yes - Go to step (9).

No - Test voltage regulator. (See “Regulated Amperage and Voltage Tests” on page 308.)

(9) Battery (G1) - positive (+) terminal. Is voltage 12.4-13.2 V?

No - Check for excessive load on electrical system.

Brake Light Circuit Operation

Function

To provide power from the brake switch to the tail lights to illuminate the brake light elements.

Operating Conditions

- Brake pedal depressed.

Theory of Operation

The brake switch is a double pole switch with one pole used in the ignition circuit, and the other pole used to supply power to the brake lights. (See “Ignition Circuit Operation - Gasoline Engine (Old)” on page 272.)

The brake switch S5 receives unswitched voltage to operate the brake lights from the 201 fuse link, 204 Yel wire, F1 25 amp fuse, 406, 407, and 408 Yel wires. When the brake pedal is depressed the contacts close and connect the 408 Yel wire to the 415 and 416 Yel wires.

The 415 Yel wire supplies voltage to the right brake light while the 416 Yel wire supplies voltage to the left brake light.

The ground path is provided by the 105 Blk wire from the right brake light and the 106 Blk wire from the left brake light to the 100 Blk wire and the W1 frame ground.

Park Brake Light Circuit Operation

Function

To provide power from the park brake switch to the instrument panel to illuminate the park brake light.

Operating Conditions

- Key switch in RUN position.
- Park Brake ENGAGED.

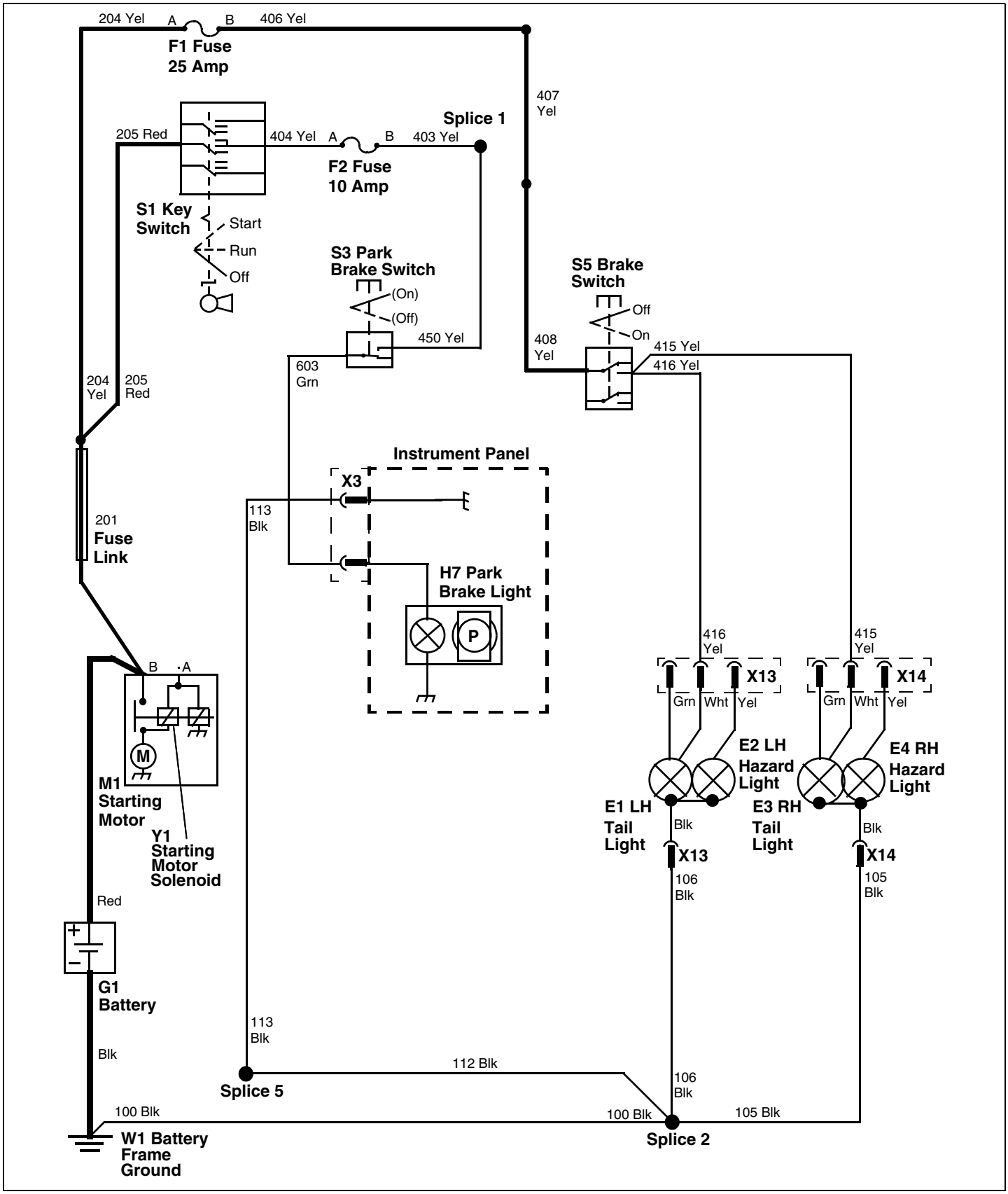
Theory of Operation

The park brake switch S3 is activated by the park brake lever. When the park brake lever is disengaged, the park brake switch is held in the open position. When the park brake lever is engaged, the park brake switch is released and its contacts close allowing current to flow across it.

Switched voltage is supplied to the park brake switch common terminal from the 450 Yel wire. With the park brake lever engaged, voltage is supplied to the 603 Grn and the 604 Org wires. The 604 Org wire supplies voltage across the V1 diode to the ignition circuit, while the 603 Grn wire supplies voltage to the park brake light H7. (See “Ignition Circuit Operation - Gasoline Engine (Old)” on page 272.)

The ground path for the park brake light is provided by the 113, 112 and 100 Blk wires and the W1 frame ground.

Brake and Park Brake Light Circuit Schematic



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Brake and Park Brake Light Circuit Diagnosis

Test Conditions:

- Key switch in OFF position.
- Brake pedal RELEASED position.
- Park brake ENGAGED.
- Transmission in NEUTRAL position.
- PTO DISENGAGED.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Brake and Park Brake Light Circuit

(1) Instrument Panel Connector (X3) - wire 113 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (2).

No - Test wires 133, 112, 100 black and connections.

(2) Left Tail Light (E1) - wire 106 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (3).

No - Test wires 106, 100 black and connections.

(3) Right Tail Light (E3) - wire 105 black. Measure resistance to ground. Is there less than 0.1 ohm resistance?

Yes - Go to step (4).

No - Test wires 105, 100 black and connections.

(4) Brake Switch (S5) - wire 408 yellow. Is battery voltage present?

Yes - Go to step (5).

No - Test Fuse (F1).

No - Test wires 408, 407, 406, 204 yellow, fuse link 201 and connections.

(5) Brake Switch (S5) - wires 415 and 416 yellow. With brake pedal DEPRESSED, is battery voltage present?

Yes - Go to step (6).

No - Replace brake switch.

(6) Left Tail Light (E1) - wire 416 yellow. Is battery voltage present?

Yes - Go to step (7).

No - Test wire 416 yellow and connections. Test light bulb. (See “Bulb Test” on page 315.)

System: Brake and Park Brake Light Circuit

(7) Right Tail Light (E3) - wire 415 yellow. Is battery voltage present?

Yes - Go to step (8).

No - Test wire 415 yellow and connections. Test light bulb. (See “Bulb Test” on page 315.)

(8) Park Brake Switch (S3) - wire 450 yellow. Place key switch in RUN position. Is battery voltage present?

Yes - Go to step (9).

No - Test Fuse (F2).

No - Test wires 450, 403 yellow and connections.

(9) Park Brake Switch (S3) - wire 603 green. Is battery voltage present?

Yes - Go to step (10).

No - Replace park brake switch.

(10) Instrument Panel Connector (X3) - wire 603 green. Is battery voltage present?

Yes - Test light bulb. (See “Bulb Test” on page 315.)

No - Test wire 603 green and connections.

Signal Lights Circuit Operation

Function

To illuminate the signal lights on one side of the vehicle to indicate the intent to turn one direction or another.
or
To illuminate all four signal lights to warn other people to use extra caution as they near the vehicle.

Operating Conditions

- Key Switch in Run position

Theory of Operation

The signal light switches have power available to them whenever a charged battery is properly connected to the electrical system and the key switch is in the RUN or START position.

Switched power is provided to the signal lights circuit through the 201 Red wire, 204 Yel wire, F1 25 amp fuse, 405 and 431 Yel wires to the flasher K4.

The flasher K4 in turn provides intermittent voltage to the 432, 433 and 434 Yel wires connected to the turn signal switch S9 and the hazard switch S10.

Turn Signal Switch S9 Left Position

With the turn signal switch in the LEFT position, intermittent voltage flows through the turn signal switch S9 to the 620 and 613 Tan wires, 611 Org wire, 612 Pnk wire and the 617 Grn wire. The 620 Tan wire connects with the 613 Tan wire at the hazard switch S10. The hazard switch will also supply intermittent voltage to the 613 Tan wire when in the ON position. The 613 Tan wire splices together with the 611 Org, 612 Pnk and 617 Grn wires. The 611 Org wire provides intermittent voltage to the left front turn signal while the 612 Pnk wire provides intermittent voltage to the left rear turn signal and the 617 Grn wire provides intermittent voltage to the left turn signal indicator light in the instrument panel.

Turn Signal Switch S9 Right Position

With the turn signal switch in the RIGHT position, intermittent voltage flows through the turn signal switch S9 to the 614 Grn wire, 618 Tan wire, 615 Tan wire, 616 Pnk wire and the 619 Grn wire. The 614 Grn wire connects with the 618 Tan wire at the hazard switch S10. The hazard switch will also supply intermittent voltage to the 618 Tan wire when in the ON position. The 618 Tan wire splices together with the 615 Tan, 616 Pnk and 619 Grn wires. The 615 Tan wire provides intermittent voltage to the right front turn signal while the 616 Pnk wire provides intermittent voltage to the right rear turn signal and the 619 Grn wire provides intermittent voltage to the right turn signal indicator light in the instrument panel.

Hazard Switch S10 ON Position

With the hazard switch in the ON position, intermittent voltage flows through the hazard switch S10 to both the left and right turn signal output circuits.

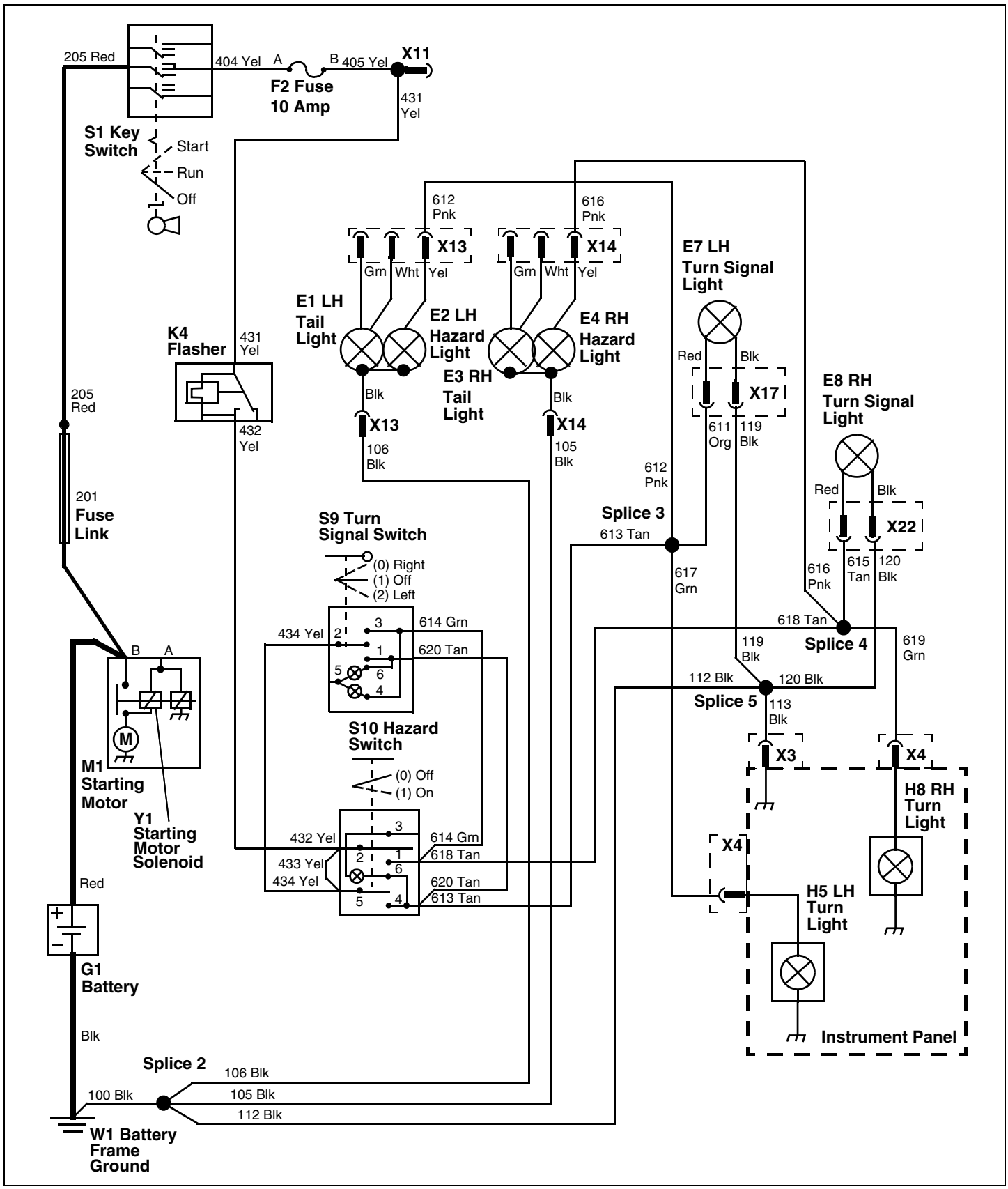
For the left circuit the 613 Tan wire splices together with the 611 Org, 612 Pnk and 617 Grn wires. The 611 Org wire provides intermittent voltage to the left front turn signal while the 612 Pnk wire provides intermittent voltage to the left rear turn signal and the 617 Grn wire provides intermittent voltage to the left turn signal indicator light in the instrument panel.

For the right circuit the 618 Tan wire splices together with the 615 Tan, 616 Pnk and 619 Grn wires. The 615 Tan wire provides intermittent voltage to the right front turn signal while the 616 Pnk wire provides intermittent voltage to the right rear turn signal and the 619 Grn wire provides intermittent voltage to the right turn signal indicator light in the instrument panel.

Because the hazard switch is supplied intermittent voltage before the turn signal switch and provides voltage to the lights after the turn signal switch, the hazard switch will over ride the turn signals and cause all four signal lights to flash when it is in the ON position regardless of the position of the turn signal switch.

Each of the lights is also connected to the unswitched ground circuit to complete the electrical circuit.

Signal Light Circuit Schematic



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Signal Lights Circuit Diagnosis

Test Conditions:

- Key switch in OFF position.
- Park brake ENGAGED.
- Signal switches OFF.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Signal Lights Circuit

(1) Instrument Panel Connector (X3) - wire 113 black. Measure ground resistance. Is there less than 0.1 ohm of resistance?

Yes - Go to step (2).

No - Test wires 133, 112, 100 black and connections.

(2) Left Tail Light (E1) - wire 106 black. Measure ground resistance. Is there less than 0.1 ohm of resistance?

Yes - Go to step (3).

No - Test wires 106, 100 black and connections.

(3) Right Tail Light (E3) - wire 105 black. Measure ground resistance. Is there less than 0.1 ohm of resistance?

Yes - Go to step (4).

No - Test wires 105, 100 black and connections.

(4) Left Turn Signal Light (E7) - wire 119 black. Measure ground resistance. Is there less than 0.1 ohm of resistance?

Yes - Go to step (5).

No - Test wire 119 black and connections.

(5) Right Turn Signal Light (E8) - wire 120 black. Measure ground resistance. Is there less than 0.1 ohm of resistance?

Yes - Go to step (6).

No - Test wire 120 black and connections.

(6) Turn Signal Flasher (K4) - wire 431 yellow. Place key switch to RUN position. Is battery voltage present?

Yes - Go to step (7).

No - Test wire 431 yellow and connections.

System: Signal Lights Circuit

(7) Hazard Switch (S10) - wire 432 yellow. Is battery voltage present?

Yes - Go to step (8).

No - Test wire 432 yellow and connections.

(8) Turn Signal Switch (S9) - wire 434 yellow. Is battery voltage present?

Yes - Go to step (9).

No - Test wires 434, 433 yellow and connections.

(9) Right Hazard Light (E4) - wire 616 pink. Place turn signal switch to RIGHT position. Is pulsing voltage present?

Yes - Go to step (10).

No - Test wires 616 pink, 618 tan, 614 green and connections. Test light bulb. (See “Bulb Test” on page 315.)

No - If pulsing voltage is not present, replace Flasher (K4).

(10) Right Turn Signal Light (E8) - wire 615 tan. Is pulsing voltage present?

Yes - Go to step (11).

No - Test wire 615 tan and connections. Test light bulb. (See “Bulb Test” on page 315.)

(11) Instrument Panel Connector (X4) - wire 619 tan. Is pulsing voltage present?

Yes - Go to step (12).

No - Test wire 619 tan and connections. Test Right Turn Indicator (H8) light bulb. (See “Bulb Test” on page 315.)

(12) Left Hazard Light (E2) - wire 612 pink. Place Turn Signal Switch (S9) to LEFT position. Is pulsing voltage present?

Yes - Go to step (13).

No - Test wires 613, 620 tan, 612 pink and connections. Test light bulb. (See “Bulb Test” on page 315.)

No - If pulsing voltage is not present, replace Flasher (K4).

(13) Left Turn Signal Light (E7) - wire 611 orange. Is pulsing voltage present?

Yes - Go to step (14).

No - Test wire 611 orange and connections. Test light bulb. (See “Bulb Test” on page 315.)

System: Signal Lights Circuit

(14) Instrument Panel Connector (X4) - wire 617 green. Is pulsing voltage present?

Yes - Go to step (15).

No - Test wire 617 green and connections. Test Right Turn Indicator (H5) light bulb. (See “Bulb Test” on page 315.)

(15) Hazard Switch (S10) - wires 614 green and 618 tan. Place Turn Signal Switch (S9) to OFF position. Is pulsing voltage present?

No - Test hazard switch. (See “Hazard Lights Switch Test” on page 321.)

Headlights Circuit Operation

Function

To provide voltage to the headlights, tail lights and instrument panel lights to illuminate them for added visibility.

Operating Conditions

- Headlight switch in ON position.

Theory of Operation

The headlight switch S11 receives voltage from the unswitched power circuit wire 406 Yel. When the headlight switch is in the ON position, power is supplied to the 412 Yel wire to splice #6 and the 409, 410, 413, 414 and 417 Yel wires. (See “Power Circuit Operation - Gasoline Engine” on page 240.)

The 409 Yel wire supplies voltage to the right rear tail light.

The 410 Yel wire supplies voltage to the left rear tail light.

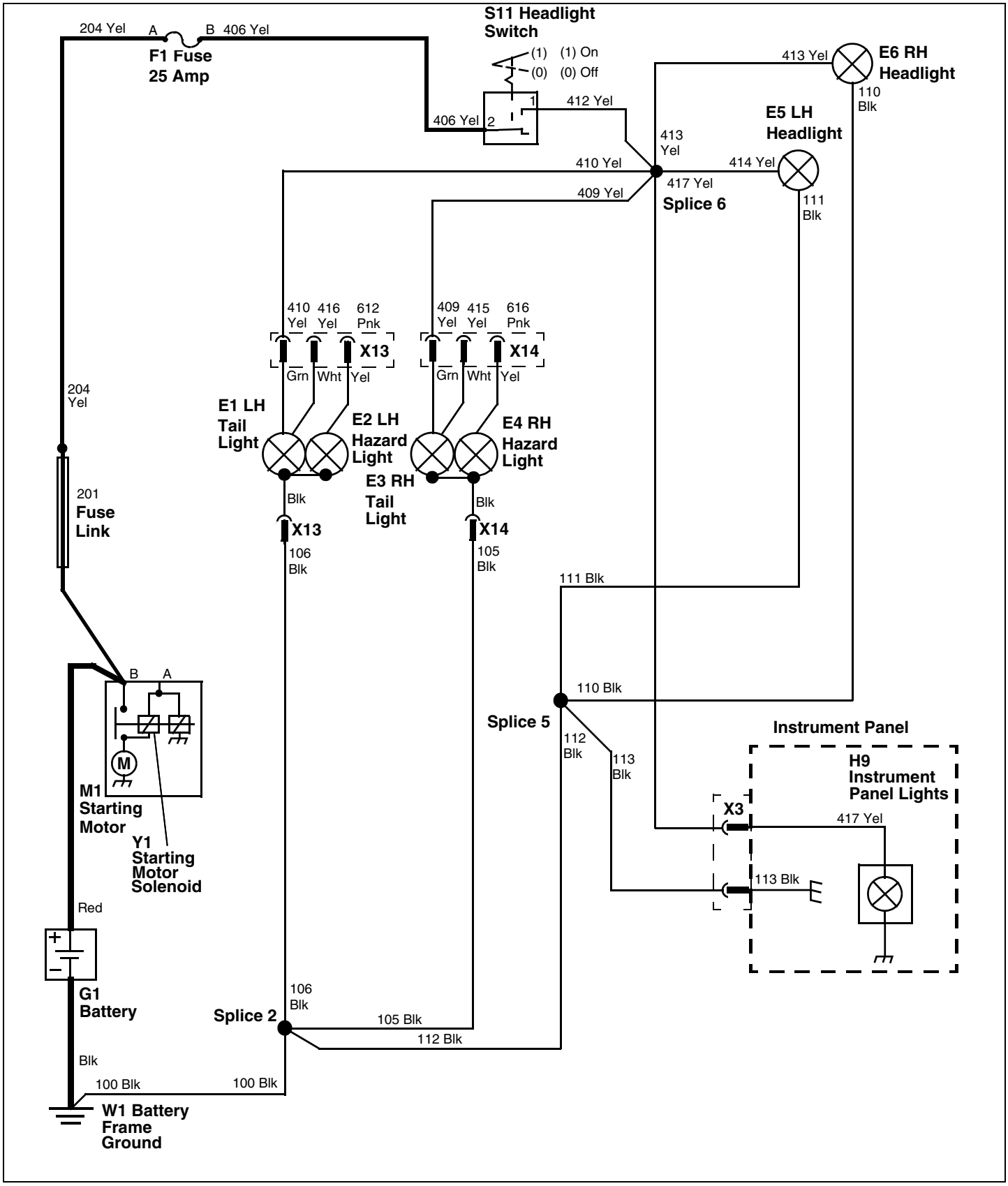
The 413 Yel wire supplies voltage to the right front headlight.

The 414 Yel wire supplies voltage to the left front headlight.

The 417 Yel wire supplies voltage to the instrument panel light.

Each of the lights are connected to the unswitched ground circuit to complete the electrical circuit. (See “Power Circuit Operation - Gasoline Engine” on page 240.)

Headlights Circuit Schematic



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Headlights Circuit Diagnosis

NOTE: If no lights come ON, check Fuse (F1) and Headlight Switch (S11) first. If at least one light comes ON, check the bulbs of the lights that did not come ON before performing any of the following tests.

Test Conditions:

- Key switch in OFF position.
- Park brake ENGAGED.
- Headlights switch in OFF position.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Headlights Circuit

(1) Headlight Switch (S11) - wire 406 yellow. Is battery voltage present?

Yes - Go to step (2).

No - Test Fuse (F1). If fuse is good, test wires 406 and 204 yellow, 201 fuse link and connections.

(2) Headlight Switch (S11) - wire 412 yellow. Place headlight switch in the ON position. Is battery voltage present?

Yes - Go to step (3).

No - Test headlight switch. (See “Headlight and Work Light Switch Test” on page 315.)

(3) Right Headlight (E6) - wire 413 yellow. Is battery voltage present?

Yes - Go to step (4).

No - Test wires 413, 412 yellow and connections.

(4) Left Headlight (E5) - wire 414 yellow. Is battery voltage present?

Yes - Go to step (5).

No - Test wires 414, 412 yellow and connections.

(5) Left Tail Light (E1) - wire 410 yellow. Is battery voltage present?

Yes - Go to step (6).

No - Test wires 410, 412 yellow and connections.

(6) Right Tail Light (E3) - wire 409 yellow. Is battery voltage present?

Yes - Go to step (7).

No - Test wires 409, 412 yellow and connections.

System: Headlights Circuit

(7) Instrument Panel Connector (X3) - wire 417 yellow. Is battery voltage present?

Yes - Go to step (8).

No - Test wires 417, 412 yellow and connections.

(8) Instrument Panel Connector (X3) - wire 113 black. Place Headlight Switch (S11) in OFF position. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (9).

No - Test wires 113, 112, 100 black and connections.

(9) Right Tail Light (E3) - wire 105 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (10).

No - Test wires 105, 100 black and connections.

(10) Left Tail Light (E1) - wire 106 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (11).

No - Test wires 106, 100 black and connections.

(11) Left Head Light (E5) - wire 111 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (12).

No - Test wires 111, 112, 100 black and connections.

(12) Right Head Light (E6) - wire 110 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

No - Test wires 110, 112, 100 black and connections.

Work Lights Circuit Operation

Function

To provide voltage to the work lights to illuminate them for added visibility.

Operating Conditions

- Work Light switch in ON position.

Theory of Operation

The work light switch S12 receives voltage from the unswitched power circuit wire 407 Yel. When the work light switch is in the ON position, power is supplied to the 411 Grn wire to the X18 connector and the 200, 201 and 202 Blk wires of the W4 work lights wiring harness. (See “Power Circuit Operation - Gasoline Engine” on page 240.)

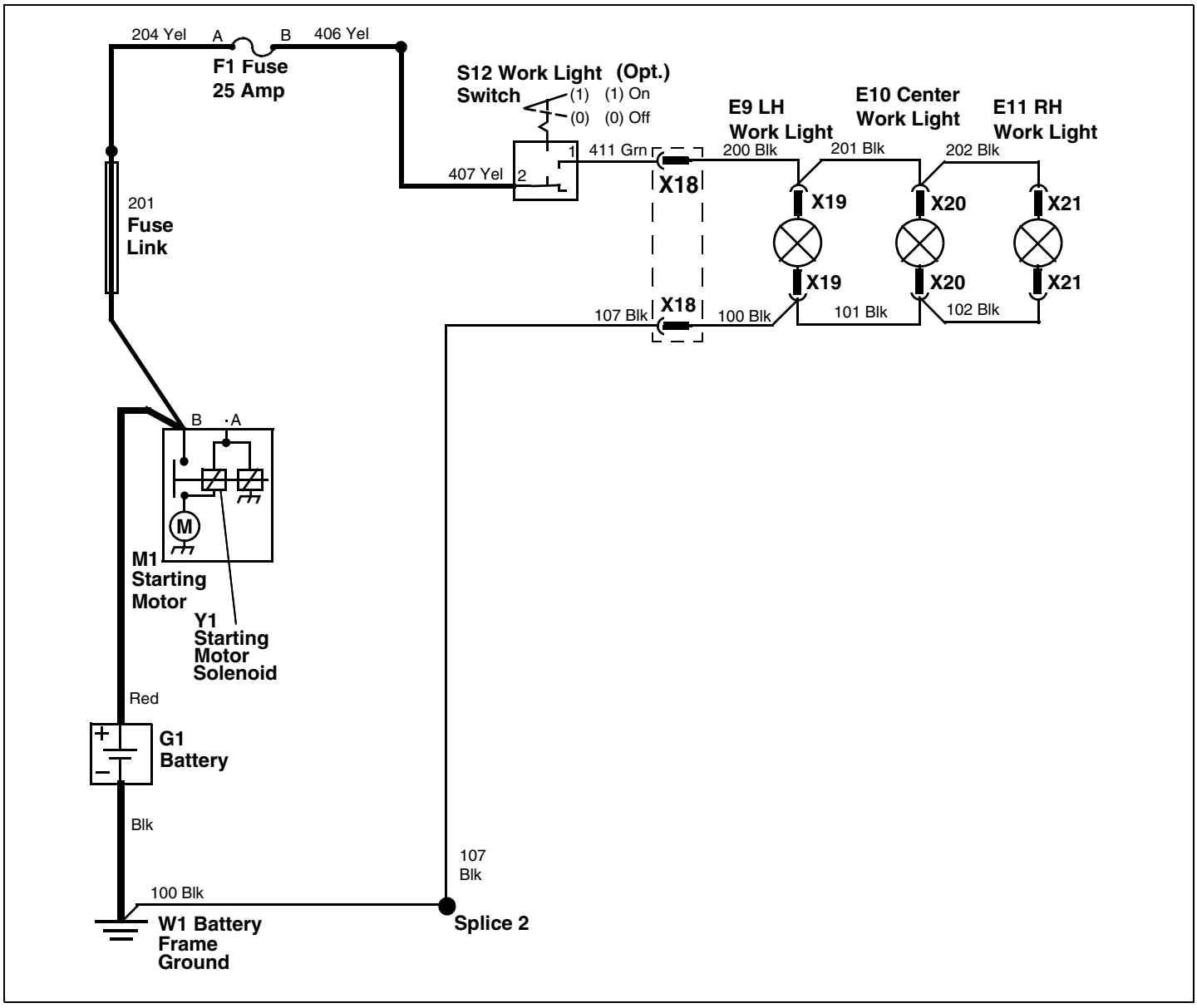
The 200 Blk wire supplies voltage to the left work light.

The 201 Blk wire supplies voltage to the center work light.

The 202 Blk wire supplies voltage to the right work light.

Ground is provided by the 102, 101, and 100 Blk wires of the W4 work lights wiring harness and the X18 connector back to the unswitched ground circuit of the W1 main wiring harness to complete the electrical circuit. (See “Power Circuit Operation - Gasoline Engine” on page 240.)

Work Lights Circuit Schematic



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Work Lights Circuit Diagnosis

NOTE: If no lights come ON, check Fuse (F1) and Work Light Switch (S12) first. If at least one light comes ON, check the bulbs of the lights that did not come ON before performing any of the following tests.

Test Conditions:

- Key switch in OFF position.
- Park brake ENGAGED.
- Work Lights switch in OFF position.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Work Lights Circuit

(1) Work Light Switch (S12) - wire 407 yellow. Is battery voltage present?

Yes - Go to step (2).

No - Test Fuse (F1). If fuse is good, test wires 407 and 406 yellow and connections.

(2) Work Light Switch (S12) - wire 411 green. Place work light switch in ON position. Is battery voltage present?

Yes - Go to step (3).

No - Test work light switch. (See “Headlight and Work Light Switch Test” on page 315.)

(3) Work Light Harness Connector (X18) - wire 411 green. Is battery voltage present?

Yes - Go to step (4).

No - Test wire 411 green and connections.

(4) Right Work Light Connector (X21) - wire 202 black. Is battery voltage present?

Yes - Go to step (5).

No - Test wires 202, 201, 200 black and connections.

(5) Work Light Harness Connector (X18) - wire 107 black. Place work light switch in OFF position. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (6).

No - Test wires 107, 100 black and connections.

(6) Right Work Light Connector (X21) - wire 102 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

No - Test wires 102, 101, 100 black and connections.

Radiator Fan Circuit Operation

Function

To energize the fan motor relay turning the fan motor on. This draws fresh air through the radiator to remove heat from the engine coolant. Should the coolant temperature exceed the normal operating range an indicator light on the instrument panel will warn the operator.

Operating Conditions

- Key switch in RUN position.
- Coolant temperature above 91°C (196°F) to turn on the radiator fan motor and above 110°C (230°F) to illuminate the coolant temperature warning light.

Theory of Operation

The radiator fan circuit consists of five main components which are:

- the radiator fan relay K3
- the radiator fan motor M2
- the fan/over temperature switch B1
- the coolant temperature light H3
- the hydraulic oil temperature switch B9 (if the auxiliary hydraulic kit is installed).

The fan/over temperature switch is a double pole temperature sensor that switches one set of contacts at approximately 91°C (196°F) and the other set of contacts at approximately 110°C (230°F). The lower temperature circuit is used to turn the radiator fan motor on and off as needed to draw air through the radiator to remove heat from the engine coolant. The higher temperature circuit is used to turn the coolant temperature light on if the coolant temperature continues to rise above the normal operating range of the engine.

The radiator fan and over temperature circuit is provided voltage from three sources.

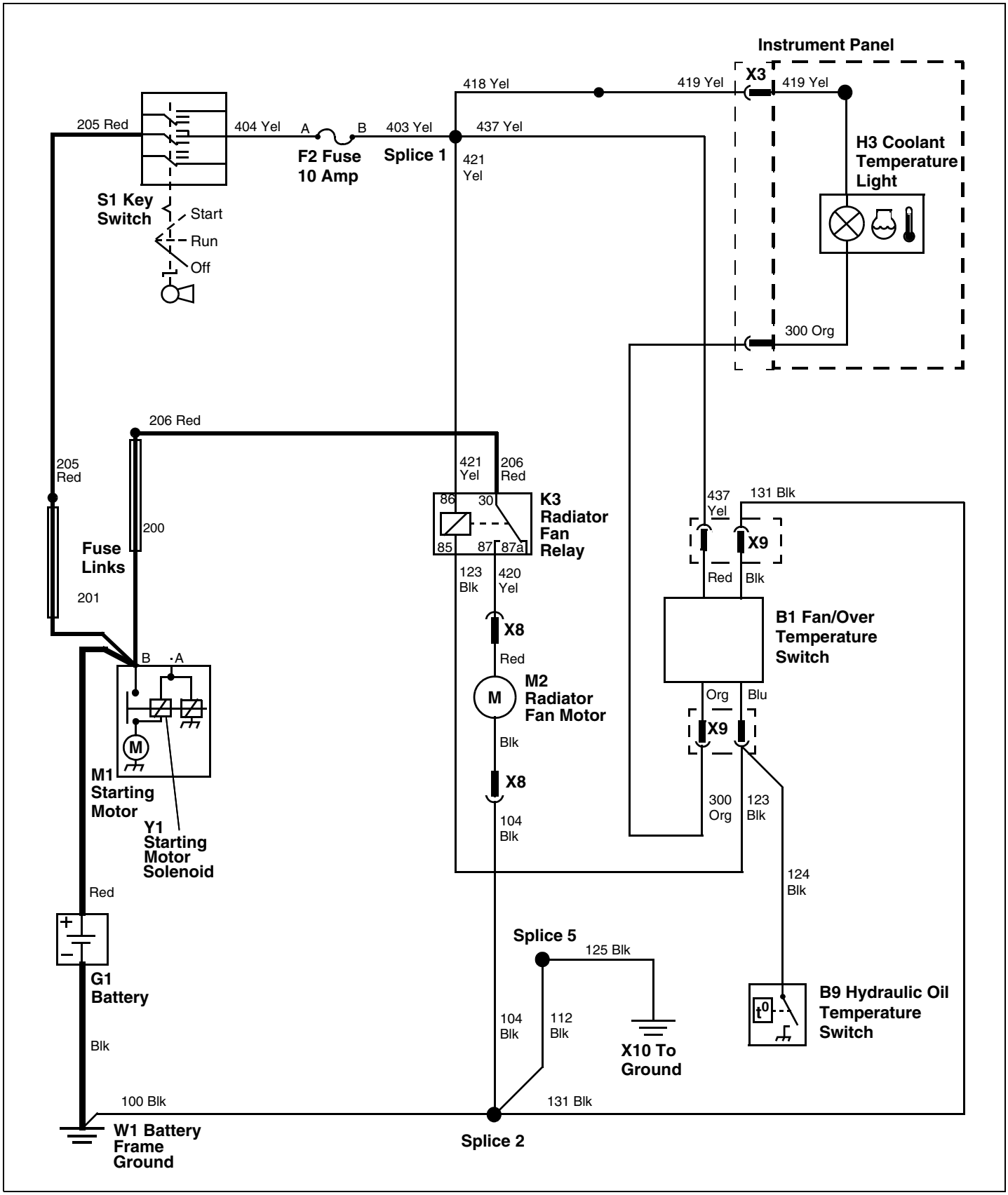
The radiator fan relay K3 has unswitched power supplied from the 206 Red wire to the common (30) terminal, and switched power supplied to the relay coil (86) terminal. When the coolant temperature rises above approximately 91°C (196°F) the 123 Blk wire connected to the other relay coil terminal (85) is connected to the unswitched ground circuit on wire 131 Blk by the B1 fan/over temperature switch. The K3 radiator fan relay then closes its contact and provides voltage from the 206 Red wire (30 terminal) to the 420 Yel wire (87 terminal) across the X8 connector to the fan motor M2 Red wire. The fan motor Blk wire provides the path to ground through the X8 connector, 104 and 100 Blk wires to W1 frame ground.

If the coolant temperature rises above approximately 110°C (230°F) the B1 fan/over temperature switch contacts close and provide a ground path for the 300 Org wire. This will illuminate the coolant temperature light H3.

If the hydraulic fluid temperature exceeds approximately 71°C (160°F) the B9 hydraulic oil temperature switch closes. This provides a ground path for the 123 Blk wire. The ground will allow the K3 fan relay to be energized tuning on the radiator fan. When the oil cools to approximately 66°C (150°F) the B9 temperature switch will open.

NOTE: If the B9 hydraulic oil temperature switch is not installed, the 124 Blk wire is tied to the 125 Blk wire and the K3 radiator fan relay is energized any time the key switch is in the On position.

Radiator Fan Circuit Schematic



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Radiator Fan Circuit Diagnosis

Test Conditions:

- Key switch in OFF position.
- Park brake ENGAGED.
- Radiator Fan Motor Connector (X8) disconnected.
- Fan/Over Temperature Switch Connector (X9) disconnected.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Radiator Fan Motor and Relay Circuit

(1) Fan Motor Connector (X8) - wire 104 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (2).

No - Test wires 104, 100 black and connections.

(2) Fan/Over Temperature Switch Connector (X9) - wire 131 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (3).

No - Test wires 131, 100 black and connections.

(3) Radiator Fan Relay (K3) - wire 206 red. Is battery voltage present?

Yes - Go to step (4).

No - Test wire 206 red, 200 fuse link and connections.

(4) Radiator Fan Relay (K3) - wire 421 yellow. Place key switch to RUN position. Is battery voltage present?

Yes - Go to step (5).

No - Check Fuse (F2). If fuse is good, test wires 421, 403, 404 yellow and connections.

(5) Fan/Over Temperature Switch Connector (X9) - wire 437 yellow. Is battery voltage present?

Yes - Go to step (6).

No - Test wires 437, 403 yellow and connections.

(6) Radiator Fan Motor (M2). Connector a jumper wire from battery positive (+) terminal to Radiator Motor Connector (X8) - wire 420 yellow. Does fan motor operate?

Yes - Go to step (7).

No - Replace radiator fan motor.

System: Radiator Fan Motor and Relay Circuit

(7) Radiator Fan Motor (M2). Remove jumper wire from Radiator Motor Connector (X8) and battery positive (+) terminal. Connect Radiator Fan Motor Connector (X8). Connect a jumper wire from Fan/ Over Temperature Switch Connector (X9) - wire 123 black to ground. Does the fan motor operate?

Yes - Test Fan/Over Temperature Switch (B1). (See “Fan-Over Temperature Switch Test” on page 319.)

No - Test Radiator Fan Relay (K3). (See “Start, Seat, and Engine Fan Relay Test” on page 312.) If relay is good, test wires 123 black and 420 yellow and connections.

(8) Hydraulic Oil Temperature Switch (B9). Measure resistance between the switch base and ground. Is the resistance less than 0.1 ohm?

Yes - Test ground wire 125 Blk and connections.

No - Go to step (9) if problem continues..

(9) Hydraulic Oil Temperature Switch (B9). Connect jumper wire from wire terminal to ground. Does the coolant fan operate?

Yes - Test hydraulic oil temperature switch. See “Hydraulic Oil Temperature Switch Test” on page 320.

No - Test Radiator Fan Relay (K3). (See “Start, Seat, and Engine Fan Relay Test” on page 312.) If relay is good, test wires 123 black and 420 yellow and connections.

Test Conditions:

- Key switch in RUN position.
- Park brake ENGAGED.
- Fan/Over Temperature Switch Connector (X9) disconnected.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Coolant Temperature Light Circuit

(1) Instrument Panel Connector (X3) - wire 419 yellow. Is battery voltage present?

Yes - Go to step (2).

No - Check Fuse (F2). If fuse is good, test wires 419, 418, 403, 404 yellow and connections.

System: Coolant Temperature Light Circuit

(2) Fan/Over Temperature Switch Connector (X9) - wire 300 orange. Is battery voltage present?

Yes - Test fan/over temperature switch. (See “Fan-Over Temperature Switch Test” on page 319.)

No - Test wire 300 orange and connections. If wire and connections are good, test bulb. (See “Bulb Test” on page 315.)

Engine Oil Pressure Light

Function

To alert operator of low engine oil pressure.

Operating Condition

- Key switch must be in RUN or START position.

Theory of Operation

With the engine OFF and key in RUN position, engine oil pressure will be below 49 kPa (7.1 psi). The oil pressure switch will be in the normally closed position. The closed position completes a circuit path to ground and illuminates the H6 engine oil pressure light. This informs the operator that the light is functional.

The light goes out when the engine oil pressure is at or above 49 kPa (7.1 psi), opens the B4 engine oil pressure switch, and removes the ground circuit from the engine oil pressure light H6.

Engine Coolant Temperature Gauge

Function

To inform the operator of the engine and coolant operating temperature.

Operating Condition

- Key switch must be in RUN or START position.

Theory of Operation

The engine coolant temperature sensor is a variable resistor, providing a ground circuit path for the temperature gauge. As the engine coolant heats, the resistance increases. The temperature gauge circuit is part of the vehicle control panel. The engine coolant temperature sensor resistance is 46-481 ohms.

Fuel Gauge

Function

Inform the operator of the approximate fuel level in the fuel tank.

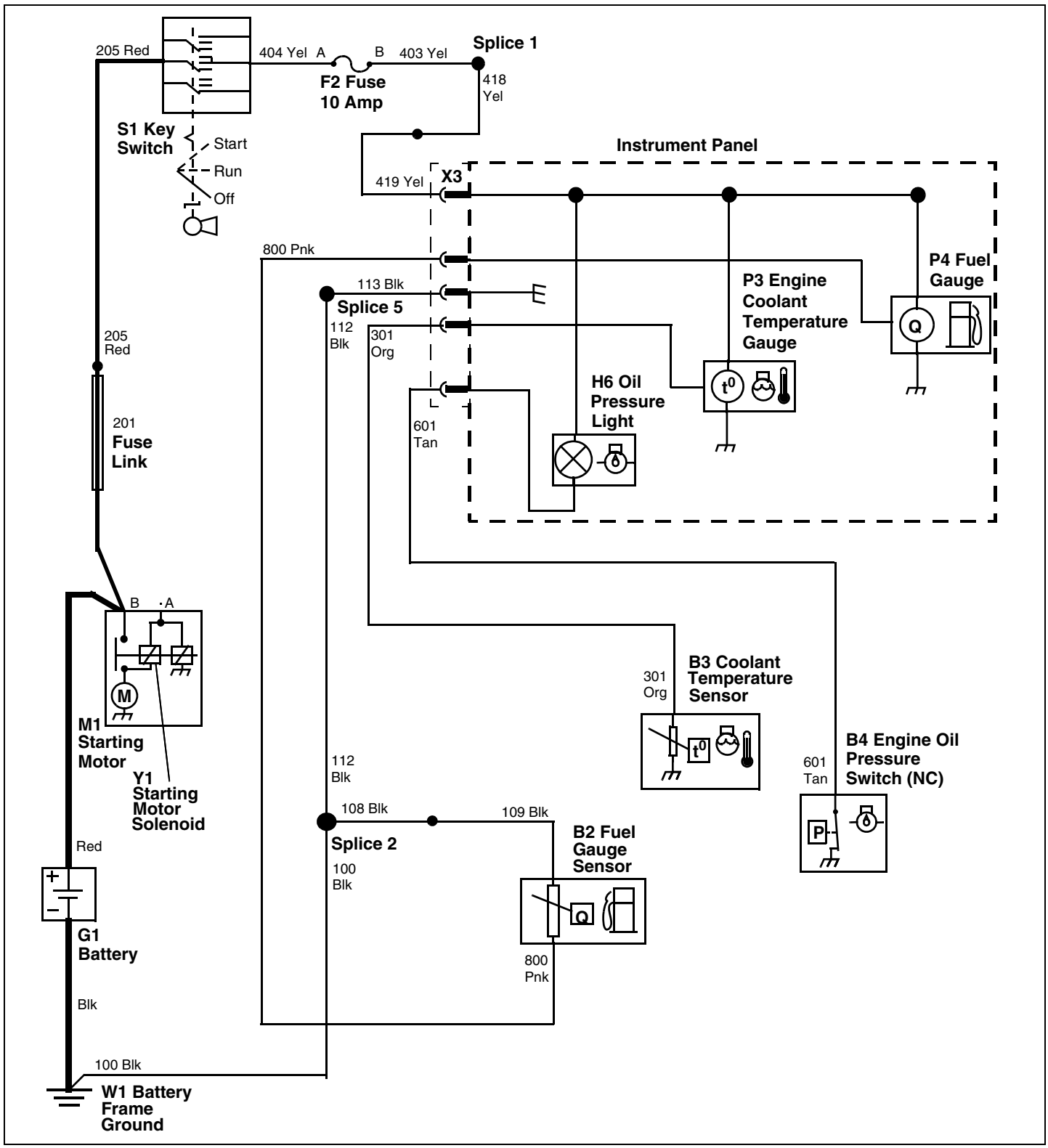
Operating Condition

- Key switch must be in RUN or START position.

Theory of Operation

The fuel level in the fuel tank is measured by the B2 fuel gauge sensor. The sensor is a variable resistor. The resistance is set by movement of a mechanical linkage connected to a float in the fuel tank. The 5 to 95 ohm variable resistance creates a variable voltage difference across the P4 fuel gauge. The voltage difference ranges from approximately 0.8 VDC (fuel tank FULL) to approximately 5.7 VDC (fuel tank EMPTY).

Control Panel Gauges Schematic



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Control Panel Gauges and Warning Light Circuits Diagnosis

Test Conditions:

- Key switch in OFF position.
- Park brake ENGAGED.
- Instrument Panel Connector (X3) disconnected.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Fuel Gauge Circuit

(1) Fuel Gauge Sensor Switch (B2) - wire 109 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (2).

No - Test wires 109, 108, 100 black and connections.

(2) Instrument Panel Connector (X3) - wire 800 pink. Measure resistance to ground. Is resistance between 5 ohms (empty tank) and 95 ohms (full tank)?

Yes - Go to step (3).

No - Test wire 800 pink and connections. If wire is good, test fuel gauge sensor (B2). (See “Fuel Gauge Sensor Test” on page 323.)

(3) Instrument Panel Connector (X3) - wire 113 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (4).

No - Test wires 113, 112, 100 black and connections.

(4) Instrument Panel Connector (X3) - wire 419 yellow. Place key switch to RUN position. Is battery voltage present?

Yes - Replace instrument panel.

No - Check Fuse (F2). If fuse is good, test wires 419, 418, 403, 404 yellow and connections.

Test Conditions:

- Key switch in RUN position with engine OFF and cool.
- Park brake ENGAGED.
- Instrument Panel Connector (X3) disconnected.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Engine Coolant Temperature Gauge Circuit

(1) Instrument Panel Connector (X3) - wire 301 orange. Measure resistance to ground. Is resistance approximately 46 ohms?

Yes - Go to step (2).

No - Test wire 301 orange and connections. If wire is good, test coolant temperature sensor. (See “Engine Coolant Temperature Sensor Test” on page 312.)

(2) Instrument Panel Connector (X3) - wire 113 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (3).

No - Test wires 113, 112, 100 black and connections.

(3) Instrument Panel Connector (X3) - wire 419 yellow. Place key switch to RUN position. Is battery voltage present?

Yes - Replace instrument panel.

No - Check Fuse (F2). If fuse is good, test wires 419, 418, 403, 404 yellow and connections.

Test Conditions:

- Key switch in OFF position.
- Park brake ENGAGED.
- Instrument Panel Connector (X3) disconnected.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: Engine Oil Pressure Switch Circuit

(1) Instrument Panel Connector (X3) - wire 601 tan. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (2).

No - Test wire 601 tan and connections. If wire is good, test oil pressure switch. (See “Engine Oil Pressure Switch Test” on page 313.)

(2) Instrument Panel Connector (X3) - wire 419 yellow. Place key switch to ON position. Is battery voltage present?

Yes - Replace instrument panel.

No - Check Fuse (F2). If fuse is good, test wires 419, 418, 403, 404 yellow and connections.

PTO Circuit Operation

Function

To function as an interlock in the cranking circuit to prevent the engine from cranking if either PTO system is engaged, and to lock the electric PTO clutch while illuminating the PTO engaged light on the instrument panel.

Operating Conditions

- Key switch in RUN position
- Engine running

Theory of Operation

The PTO circuit is two switch system to allow for operation of both an electric PTO clutch and a hydraulic PTO pump. Both switches must be in the OFF position for the cranking circuit to be functional. See “Cranking Circuit Operation - Gasoline Engine” on page 256

With the S6 mechanical PTO switch in the OFF position switched power is provided to the PTO circuit through the 201 fuse link, 205 Red wire, S1 key switch, 404 Yel wire, F2 10 amp fuse, 403, 426 and 427 Yel wires, S6 mechanical PTO switch (normally closed contacts), 510 blu wire to the PTO coil. The ground path is from the PTO coil, 520 Blu wire, S6 mechanical PTO switch (normally closed contacts), 117 and 100 Blk wires to ground.

With the S6 mechanical PTO switch in the ON position switched power is provided from the 426 Yel wire across the S6 mechanical PTO switch (normally open contacts) to the 520 Blu wire, PTO coil, 510 Blu wire, S6 mechanical PTO switch (normally open contacts), 130, 117 and 100 Blk wires.

With the S6 mechanical PTO switch in the ON position the PTO engaged light is illuminated by providing a ground for the PTO engaged light through the 510 Blu wire, S6 mechanical PTO switch (normally open contacts), 130, 117 and 100 Blk wires.

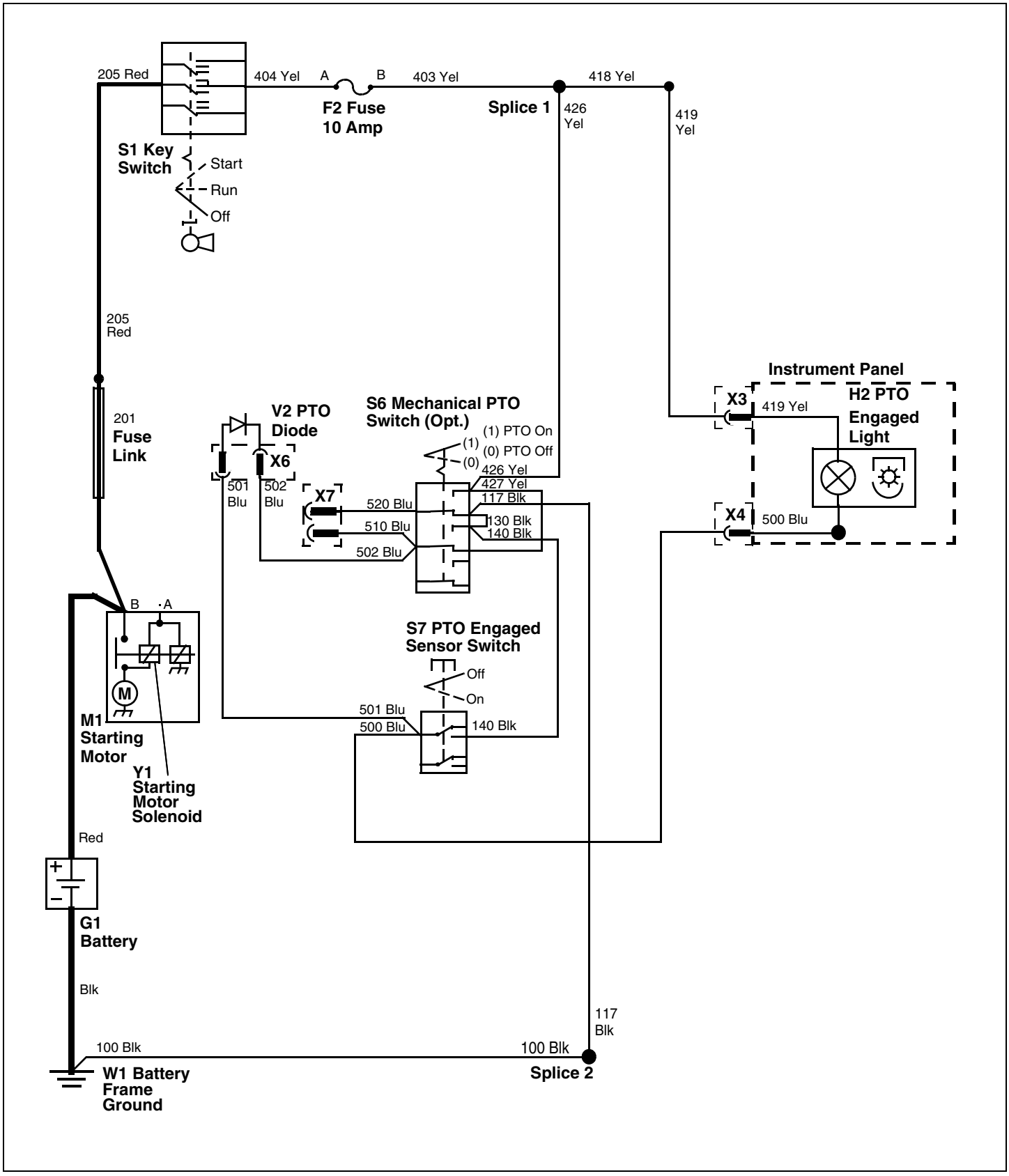
Power for the PTO engaged light is provided from the 201 fuse link, 205 Red wire, S1 key switch, 404 Yel wire, F2 10 amp fuse, 403, 418 and 419 Yel wires, to the instrument panel across the PTO engaged light to the 500 and 501 Blu wires, V2 diode and the 502 Blu wire to the 510 Blu wire.

The S7 PTO engaged sensor switch is activated when the hydraulic PTO system is engaged. This switch interlocks the cranking circuit and provides a alternate path to ground for the PTO engaged light.

NOTE: On later model vehicles S.N. (020001-) the PTO switch bracket is adjustable.

The operating circuit for the PTO engaged light when the hydraulic PTO is engaged is provided from the 201 fuse link, 205 Red wire, S1 key switch, 404 Yel wire, F2 10 amp fuse, 403, 418 and 419 Yel wires, to the instrument panel across the PTO engaged light to the 500 Blu wire, S7 PTO engaged sensor switch to the 140, 130, 117 and 100 Blk wires to ground.

PTO Circuit Schematic



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PTO Circuit Diagnosis

Test Conditions:

- Key switch in OFF position.
- Park brake ENGAGED.
- PTO disengaged.
- Meter negative (-) lead on battery negative (-) terminal or chassis ground.

System: PTO Circuit

(1) PTO Engaged Sensor Switch (S7) - wire 140 black. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (2).

No - Test wires 140, 130, 117, 100 black and connections.

(2) PTO Coil Connector (X7) - wire 520 blue. Measure resistance to ground. Is there less than 0.1 ohm of resistance?

Yes - Go to step (3).

No - Test Mechanical PTO Switch (S6). (See “PTO Switch Continuity” on page 322.) If switch is good, test wires 520 blue, 117, 100 black and connections.

(3) Key Switch (S1) - wire 404 yellow. Place key switch to RUN position. Is battery voltage present.

Yes - Go to step (4).

No - Test key switch. (See “Key Switch Test” on page 315.) If key switch is good, test wire 205 red, fuse link 201 red and connections.

(4) Instrument Panel Connector (X3) - wire 419 yellow. Is battery voltage present?

Yes - Go to step (5).

No - Check Fuse (F2). If fuse is good, test wires 419, 418, 404, 403 yellow and connections.

(5) PTO Diode Connector (X6) - wire 502 blue. Disconnect PTO Diode (V2). Is battery voltage present?

Yes - Go to step (6).

No - Test Mechanical PTO Switch (S6). (See “PTO Switch Continuity” on page 322.) If switch is good, test wires 502 blue, 427, 426 yellow and connections.

System: PTO Circuit

(6) PTO Diode (V2) - wire 501 blue. Is battery voltage present?

Yes - Test PTO diode. (See “Diode Test” on page 325.)

No - Test wires 501, 502 blue and connections. If wires and connections are good, test bulb. (See “Bulb Test” on page 315.)

Tests and Adjustments

Ground Circuit Test

Reason

To check for open circuits, loose terminal wire crimps, poor connections, or corrosion in the ground circuit.

NOTE: The voltmeter method checks ground connections under load.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to test battery circuits.
Voltmeter	NA	Used to test battery voltage.

Procedure - Ohmmeter Method

1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.

5. Remove the hood, seat base cover.

6. Connect ohmmeter negative (black) lead to negative terminal of battery. Connect meter positive (red) lead to negative terminal of battery and record reading.

7. Connect ohmmeter red lead to ground terminal of circuit or component to be tested that is closest to the battery negative terminal. Resistance reading must be the same or very close to as the battery negative terminal reading. Work backward from the battery frame ground on the ground side of the problem circuit until the resistance reading increases above 0.1 ohms. The problem is between the last two test points. If a problem is indicated, disconnect the wiring harness connector to isolate the wire or component and check resistance again. Maximum allowable resistance in the circuit is 0.1 ohms. Check both sides of the connectors closely, as disconnecting and connection may temporarily solve problem.

MX0704

Picture Note: S.N. (-020000) Shown; On S.N. (020001-), Ground Screw Is Attached to Transaxle

Procedure - Voltmeter Method

1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.

5. Remove the hood, seat base cover.

6. Connect voltmeter negative (black) lead to negative terminal of battery.

7. Connect voltmeter positive (red) lead to ground terminal of circuit (A) or component to be tested. Be sure that component circuit is activated (See appropriate circuit operation description) so that voltage will be present at the component. Record voltage. Voltage must be greater than 0, but less than 1.0 volt. Some components will have a very small voltage reading on the ground side and still be operating correctly.

Results

- If voltage is 0, the component is open.
- If voltage is greater than 1.0 volt, the ground circuit is bad. Check for open wiring, loose terminal wire crimps, poor connections, or corrosion in the ground circuit.

Battery Test

CAUTION: Avoid injury! Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, eat holes in clothing, and cause blindness if splashed into the eyes. Avoid the hazard by:

1. Filling batteries in a well-ventilated area.

2. Wearing eye protection and rubber gloves.

3. Avoiding breathing fumes when electrolyte is added.

4. Avoid spilling or dripping electrolyte.

5. Use proper jump start procedure.

If you spill acid on yourself:

1. Flush your skin with water.

2. Apply baking soda or lime to help neutralize the acid.

3. Flush your eyes with water for 15-30 minutes. Get medical attention immediately.

If acid is swallowed:

1. Do not induce vomiting.

2. Drink large amounts of water or milk, but do not exceed 1.9 L (2 qts.)

3. Get medical attention immediately.

Reason

To check condition of battery and determine battery voltage.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Hydrometer	NA	Used to check condition of battery.
Voltmeter	NA	Used to determine battery voltage.
Battery Tester	JT05685	Used to check condition of battery.

Procedure

1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Raise cargo box, or remove the optional component installed on vehicle as needed to provide access to battery.

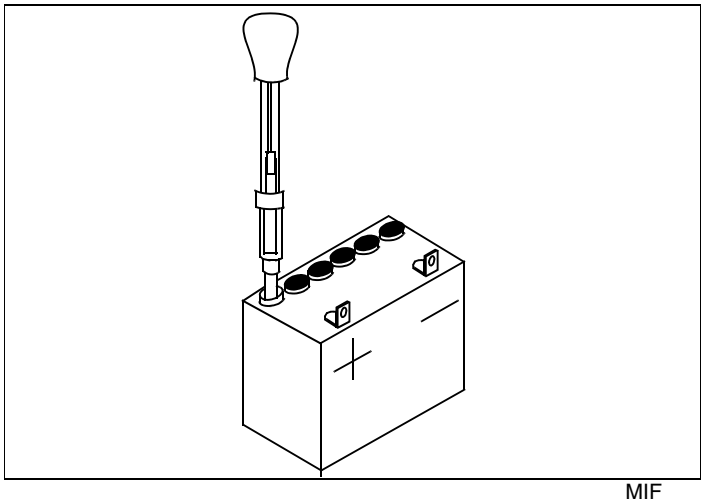
5. Clean cable ends, battery terminals and top of battery.

6. Remove battery. It may be necessary to remove the battery box to allow for the battery to be removed.

7. Inspect battery terminals and case for breakage or cracks.

8. Check electrolyte level in each battery cell. Add clean, soft water as needed. If water is added, charge battery for 20 minutes at 10 amps.

9. Remove surface charge by placing a small load on the battery for 15 seconds.



MIF

10. Use an hydrometer to check for a minimum specific gravity of 1.225 with less than 50 point variation in each cell.

- If all cells are less than 1.175, charge battery at 10 amp rate.
- If all cells are less than 1.225 with less than 50 point variation, charge battery at 10 amp.
- If all cells are more than 1.225 with less than 50 point variation, load test battery.
- If more than 50 point variation between cells, replace battery.

11. Use a voltmeter or JT05685 Battery Tester to check for a minimum battery voltage of 12.4 volts.

- If battery voltage is less than 12.4 VDC, charge battery.
- If battery voltage is more than 12.4 VDC, test specific gravity. (See Step 10.)

12. Install battery.

Charge Battery

Reason

To increase battery charge after the battery has been discharged.

Special or Required Tools

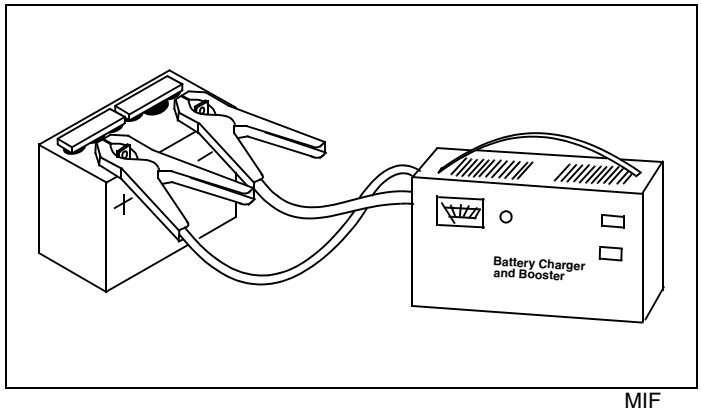
Tool Name	Tool No.	Tool Use
Battery Charger	NA	Used to increase battery charge after the battery has been discharged.

Procedure

NOTE: See "Battery Test" on page 305 before charging battery.

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.
5. Clean cable ends, battery terminals and top of battery.
6. Remove battery.
7. Connect variable rate charger to battery.
8. Start charger at SLOW rate. Increase charge rate ONE setting at a time. Check charger ammeter after 1 minute at each setting. Maintain 10 amp charge rate. Use boost setting as necessary.
9. Check if battery is accepting 10 amp charge rate after 10 minutes at boost setting.
   - If battery WILL NOT accept 10 amp charge after 10 minutes at boost setting, replace battery.
   - If battery is accepting 10 amp charge after 10 minutes at boost setting, and battery did NOT need water, go to Steps 12 and 13.
   - If battery is accepting 10 amp charge after 10 minutes at boost setting, but battery DID need water or all cells were BELOW 1.175, go to Steps 11 and 12.

IMPORTANT: Avoid damage! Decrease charge rate if battery gases or bubbles excessively or becomes too warm to touch.



MIF

10. Set charger at 15-25 amps.
11. Check specific gravity after 30 minutes (60 minutes for maintenance-free battery).
    - If MORE THAN 50 point variation between cells, replace battery.
    - If LESS THAN 50 point variation between cells, go to Step 12.

NOTE: If battery was discharged at slow or unknown rate, charge battery at 10-15 amps for 6-12 hours. (Maintenance-free battery: 4-8 hours).

12. Continue to charge battery until specific gravity is 1.230-1.265 points.
13. Load test battery.
14. Install battery.

Load Test Battery

Reason

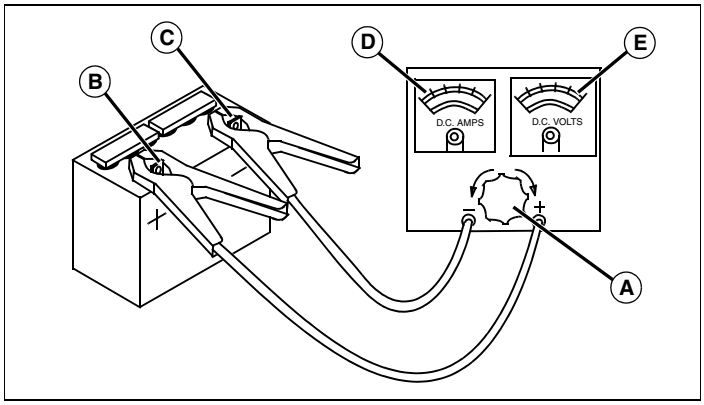
To check condition of battery under load.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Battery Tester	JT05685	Used to check condition of battery under load.

Procedure

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.
5. Clean cable ends, battery terminals and top of battery.
6. Remove battery.



MIF

7. Turn load knob (A) counterclockwise to OFF position.

8. Connect tester positive (red) cable to battery positive (+) terminal (B).

9. Connect tester negative (black) cable to battery negative (-) terminal (C).

10. Turn load knob of tester clockwise (in) until amperage reading (D) is equal to:

- Cold cranking amperage rating of battery (use blue scale).
  -or-
- Three times ampere hour rating (use black scale).

11. Hold for 15 seconds and read condition of battery at DC Volts scale (E). Turn load knob of tester counterclockwise (out) into OFF position.

Results

- If battery DOES NOT pass test and has NOT been charged, charge battery and retest.
- If battery DOES NOT pass test and HAS BEEN charged, replace battery.

Unregulated Voltage Output Test

Reason

To measure alternator output.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Voltmeter	NA	Used to measure alternator output.

Procedure

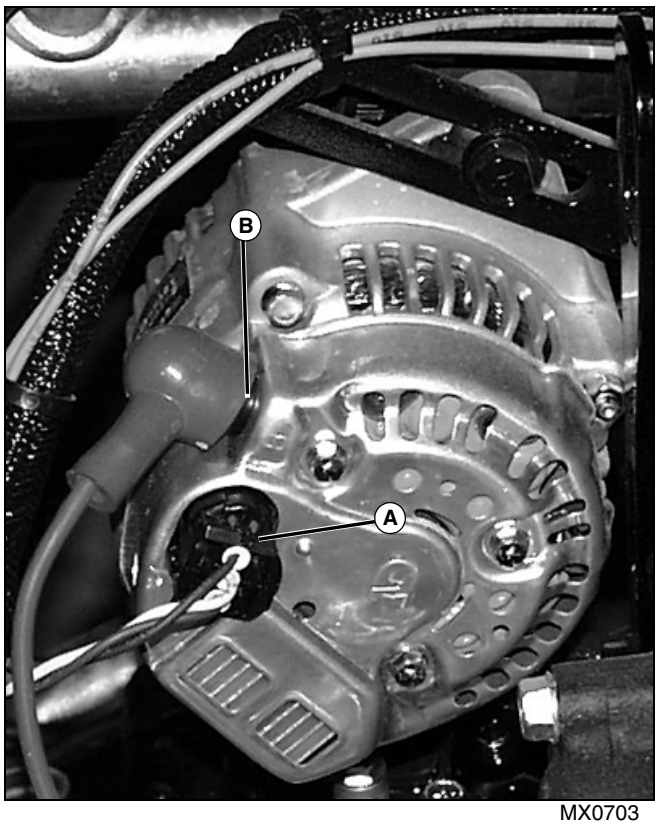
1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.

CAUTION: Avoid injury! Engine parts may be hot. Allow engine to cool before servicing.



MX0703

5. Disconnect three pin connector (A) from alternator.

6. Connect voltmeter, set to read AC voltage, to alternator outputs (B).

7. Start and run engine at fast idle. The meter should read a minimum of 50 volts AC at FAST idle (3570 rpm).

If reading is BELOW specification, test alternator.

Specifications

Slow Idle . . . . . .32 VAC
Fast Idle. . . . . .50 VAC

Unregulated Amperage Test - 55 Amp Alternator

Reason

To determine charging output of the alternator stator.

Special or Required Tools

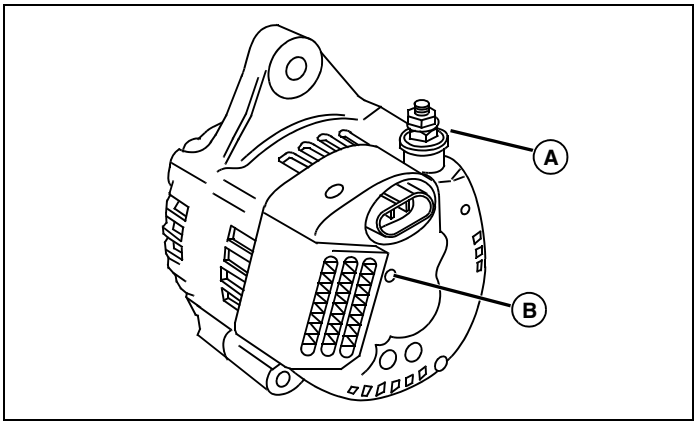
Tool Name	Tool No.	Tool Use
Current Gun	JT05712	Used to measure charging output.

Procedure

1. Put JT05712 Current Gun over Red wire connected to the alternator output terminal (A). Set current gun for DC current.

IMPORTANT: Avoid damage! Perform this test quickly to prevent damage to the battery. DO NOT apply full load to battery for more than 10 seconds.

2. Start and run engine at 3570 rpm.



MIF

3. Insert a small Phillips screwdriver through the hole (B) in rear cover of alternator to ground the regulator to the rear cover. Read amperage on current gun.

Results

If reading does not meet specification, verify voltage at the alternator regulated terminal and good alternator ground. If voltage and ground are OK, replace the alternator.

Specifications

Minimum Unregulated Amperage . . . . . 40 amps

Regulated Amperage and Voltage Tests

Reason

To determine the regulated voltage (charging) output of the regulator/rectifier.

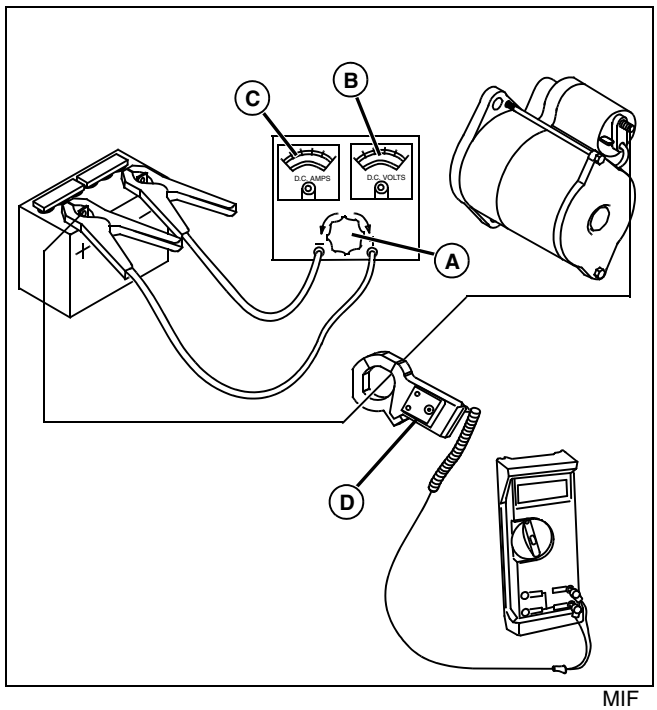
Special or Required Tools

Tool Name	Tool No.	Tool Use
Current Gun	JT05712	Used to measure current.
Voltmeter	NA	Used with current gun.
Battery Tester	JT05685	Used to check battery while under load.

Procedure

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.
5. Disconnect three pin connector from alternator.

NOTE: Battery must be in a good state of charge.



MIF

6. Connect JT05712 Current Gun (D) to voltmeter and put around positive (red) battery cable going to starter. Set current gun for DC current.

IMPORTANT: Avoid damage! Turn load knob (A) fully counterclockwise (out) into OFF position BEFORE making any test connections.

7. Connect battery tester to battery.

IMPORTANT: Avoid damage! Perform this test quickly to prevent damage to the battery. DO NOT apply full load to battery for more than 5-10 seconds.

8. Turn load knob clockwise (in) until voltage on voltage tester scale reads 11 volts for 5 seconds only to partially drain battery.

9. Quickly turn load knob completely counter-clockwise (out) to OFF position.

10.Start and run engine at fast idle (3570 rpm). Battery voltage should read between 12.2-14.7 volts DC.

11.Turn load knob clockwise (in) until voltage on tester voltage scale (B) reads 11 volts and look at current gun for a minimum reading of 13.5 amps.

12.Quickly turn load knob completely counterclockwise (out) to OFF position.

13.After load test, voltage scale (B) should return to a maximum of 14.7 volts DC.

Results

- If current gun amp reading is BELOW specification, test for unregulated voltage output. If unregulated voltage output test meets specifications and you have verified voltage to ground to regulator/rectifier, replace regulator/rectifier.
- If at any time voltage increase exceeds 14.7 volts DC, replace regulator/rectifier.

Specifications

Regulated Voltage (Max) . . . . . .14.7 VDC

Starting Motor Solenoid Test

Reason

To determine if starting motor is operating properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Jumper Wire	NA	Used to make temporary connection

Procedure

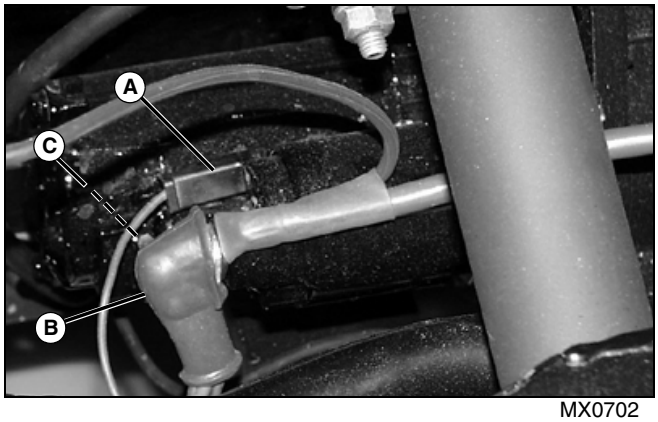
1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.

5. Disconnect fuel shutoff solenoid wire connector.



MX0702

6. Disconnect wire 710 Pur from starting motor solenoid terminal (A).

7. Connect jumper wire to positive (+) battery terminal and briefly jump to starting motor solenoid terminal (A).

Results

- Starting motor runs - solenoid is good, test cranking circuit wiring.
- Starting motor DOES NOT run - go to next step.

8. Remove rubber boot from terminal (B).

9. Remove plastic cover from terminal (C) (hidden in figure).

10.Connect jumper wire between starting motor solenoid large terminals (B and C).

Results

- Starting motor runs - replace starter.
- Starting motor DOES NOT run - check battery cables, then replace starting motor.

Starting Motor Amperage Draw Test

Reason

To determine the amperage required to crank the engine and check starter motor operation under load.

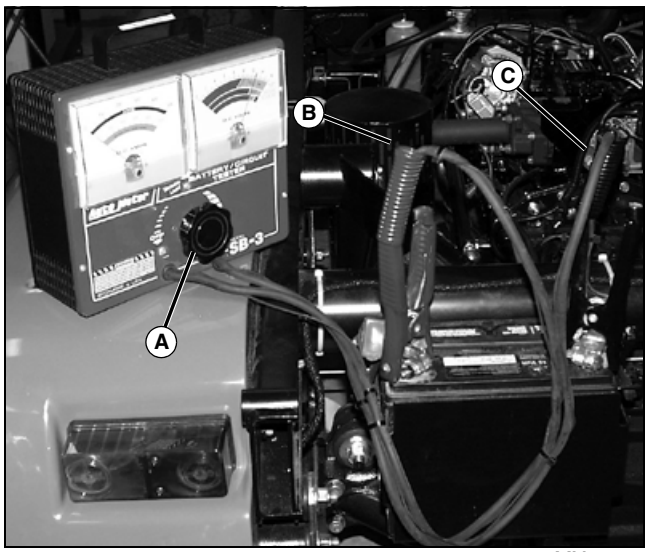
Special or Required Tools

Tool Name	Tool No.	Tool Use
Battery Tester	JT05685	Used to check battery while under load.

Procedure

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.
5. Test ground connections and battery.
6. Disconnect fuel shutoff solenoid connector.

IMPORTANT: Avoid damage! Turn load knob (A) fully counterclockwise before making any test connections.



MX0701

7. Connect JT05685 Battery Tester red lead (B) to battery positive (+) terminal.
8. Connect JT05685 Battery Tester black lead (C) to battery negative (-) terminal.
9. Crank engine and read voltage.
10. Turn key switch to the OFF position. Adjust load knob until battery voltage reads the same as when cranking.
11. Read amperage on meter.
12. Turn load knob fully counterclockwise.

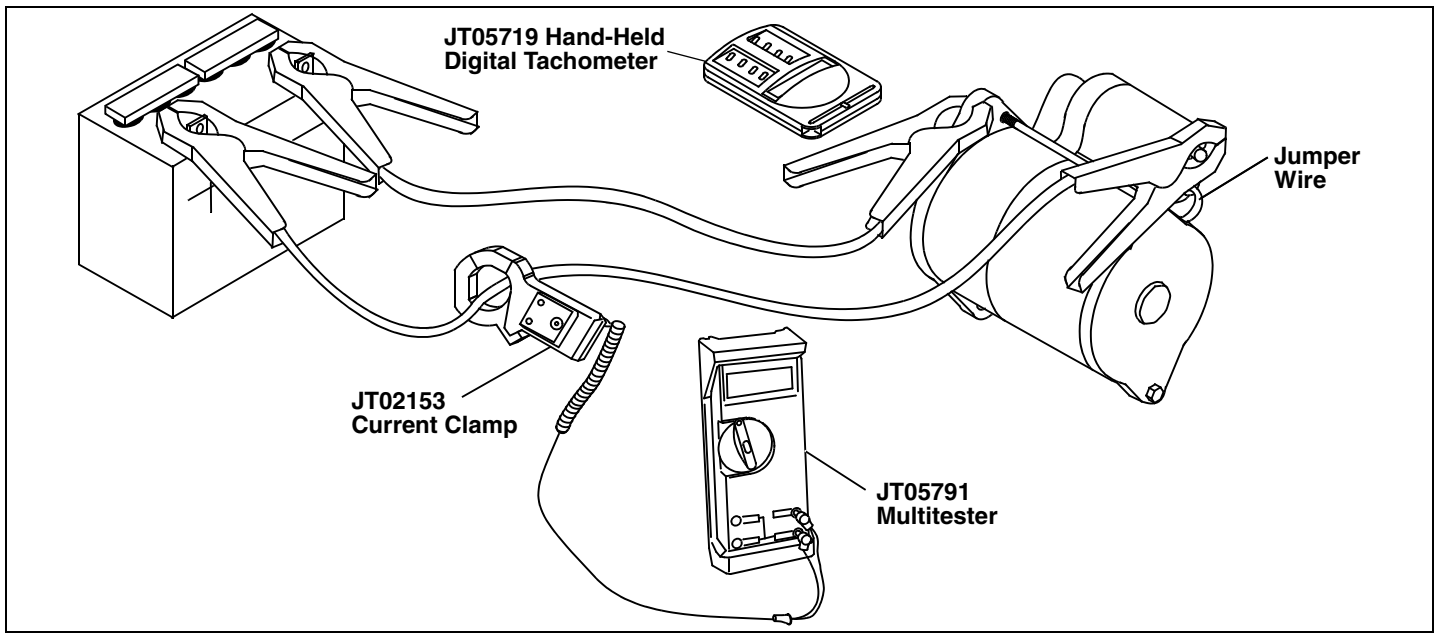
Results

- If amperage is greater than specification, test starting motor no-load rpm and amperage to determine if the starting motor is binding or damaged.
- If the starting motor is good, check internal engine components for binding or damage.

Specifications

Starting Motor Current Draw while Cranking Engine. . . . . 150 amps

Starting Motor Current Draw and RPM Tests



MIF

Reason

To determine if starter is binding or has excessive amperage draw under no-load.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Current Clamp	JT02153	Used to measure starter current draw.
Multitester	JT05791	Used with current clamp.
Tachometer	JT05719	Used to measure starter rpm.
Jumper Cables	NA	Used to connect battery to starter.
Jumper Wire	NA	Used to energize starter solenoid.

Procedure

NOTE: Check that battery is fully charged and of proper size to ensure accuracy of test.

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.
5. Remove starting motor assembly from vehicle and place starting motor in vice.
6. Connect jumper cables to a 12-volt battery.
7. Connect positive (+) cable to solenoid battery terminal on starting motor.
8. Connect negative (-) cable to starting motor body.
9. Attach current gun to positive (+) cable.

IMPORTANT: Avoid damage! Complete this test in 20 seconds or less to prevent starting motor damage.

10. Use a jumper wire to briefly connect positive (+) starting motor terminal to solenoid terminal. Starting motor should lock and run.
11. Read and record starting motor amperage and rpm.
    - If solenoid “clicks” or chatters and starting motor does not turn, replace starting motor.
    - If pinion gear engages and starting motor doesn’t turn, replace starting motor.
    - If starting motor engages and runs, but amperage is more than 60 amps at 4300 rpm, repair or replace starting motor.
    - If free-running rpm is less than 4000 rpm, repair or replace starting motor.

Specifications

Starting Motor Current Draw (Max)
(No Load @ 4300 RPM) . . . . . 60 amps
Starting Motor RPM (Min at No Load) . . . . . 4000 rpm

Start, Seat, and Engine Fan Relay Test

Reason

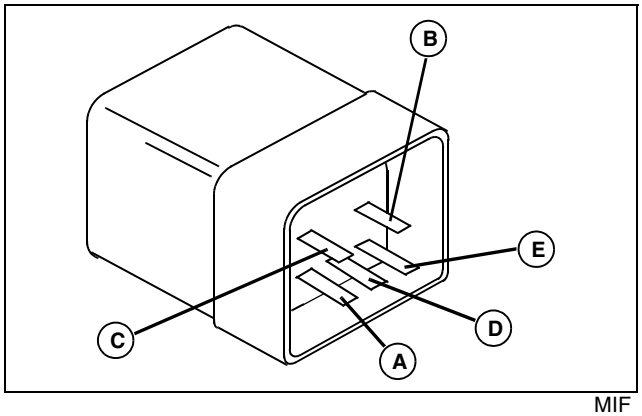
To check relay terminal continuity in the energized and de-energized condition.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter or Continuity Tester	NA	Used to measure resistance or continuity between terminals.
12-Volt Battery and Jumper Wires	NA	Used to energize relay.

Procedure

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Slide under the vehicle behind the right front wheel and locate the relays mounted on the inside frame rail.
5. Disconnect relay connector from harness.



MIF

6. Check terminal continuity using an ohmmeter or continuity tester.
   - There should be continuity between terminals (A) and (B), and between terminals (C) and (D).
   - There should NOT be continuity between any other terminals.
7. Connect a jumper wire from battery positive (+) terminal to relay terminal. Connect a jumper wire from relay terminal and ground (-).
   - There should be continuity between terminals and (E).
   - If continuity is NOT correct, replace relay.

Engine Coolant Temperature Sensor Test

Reason

To verify engine coolant temperature sensor is functioning properly.

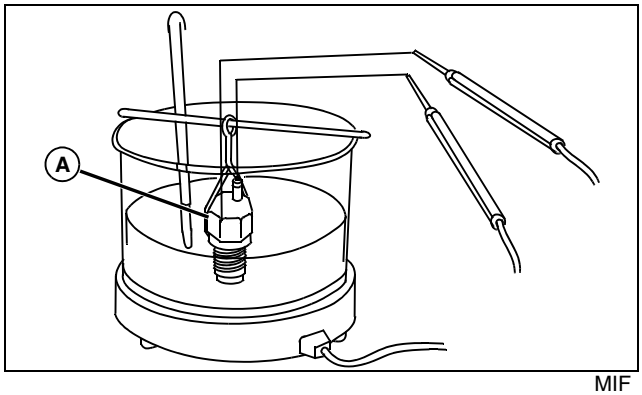
Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance and continuity.

Procedure

NOTE: Perform test with engine at room temperature.

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.
5. Disconnect wire 301 Org from engine coolant temperature sensor.
6. Measure resistance between terminal and sensor body.
7. If resistance does not meet specification, replace coolant temperature switch.
8. Drain engine coolant and remove coolant temperature sensor.



MIF

9. Place sensor (A) in water/coolant solution.
10. Bring solution to specified temperatures while measuring resistance of sensor. If resistance does not meet specification, replace coolant temperature sensor.

Specifications

Resistance at 71°C (160°F) . . . . . 100 ohms
Resistance at 82°C (180°F) . . . . . 80 ohms
Resistance at 93°C (200°F) . . . . . 60 ohms
Resistance at 116°C (240°F) . . . . . 40 ohms

Engine Oil Pressure Switch Test

Reason

To determine if engine oil pressure switch is functioning properly, to warn operator that oil pressure has dropped below minimum operating pressure.

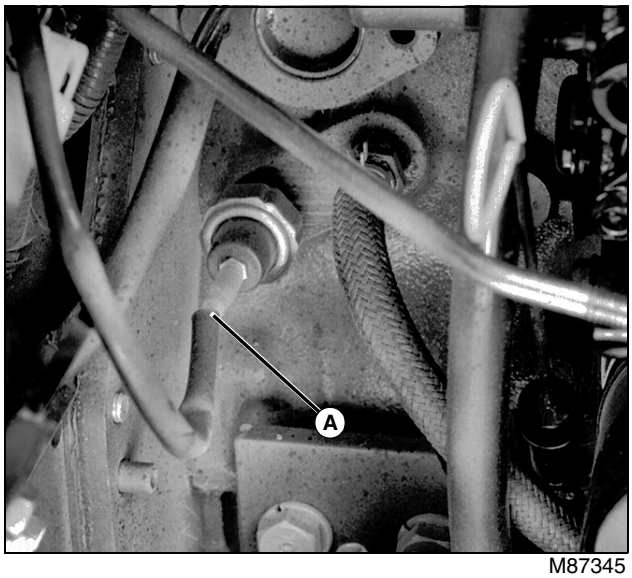
Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance and continuity.

Procedure

NOTE: Perform test with engine at room temperature.

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.



M87345

5. Disconnect 601 Tan wire from oil pressure switch (A).
6. Connect black lead of ohmmeter to engine block and red lead of ohmmeter to terminal of switch.
7. Measure resistance between terminal and engine block.
   - There should be continuity between terminal and ground.

NOTE: Be sure to apply Pipe Sealant with TEFLON® to threads of switch anytime it is installed.

   - If there is NO continuity between terminal and ground, replace the switch.

8. Start and run engine.
9. Measure resistance between terminal and engine block.
   - There should be NO continuity between terminal and ground.
   - If the switch DOES have continuity to engine block (ground) with engine running, check oil pressure. (See “Test Oil Pressure” on page 44 for gasoline engines, and “Engine Oil Pressure Test” on page 124 for diesel engines.)
   - If oil pressure is to specification, replace the oil pressure switch.

Glow Plug Relay Test

Reason

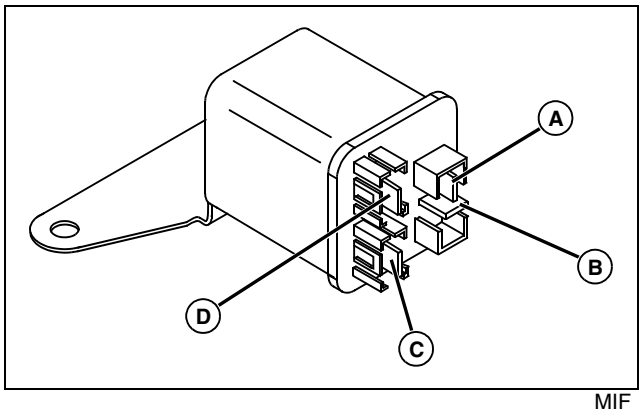
To check relay terminal continuity in the energized and de-energized condition.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter or Continuity Tester	NA	Used to measure resistance or continuity between terminals.
12-Volt Battery and Jumper Wires	NA	Used to energize relay.

Procedure

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Slide under the vehicle behind the right front wheel and locate the relays mounted on the inside frame rail.
5. Disconnect glow plug relay connector from harness.



MIF

6. Check terminal continuity using an ohmmeter or continuity tester.

- There should be continuity between terminals (A) and (B).
- There should NOT be continuity between any other terminals.

7. Connect a jumper wire from battery positive (+) terminal to relay terminal. Connect a jumper wire from relay terminal and ground (-).

- There should be continuity between terminals (C) and (D).
- If continuity is NOT correct, replace relay.

Glow Plug Test

Reason

To test operation of glow plugs.

Special or Required Tools

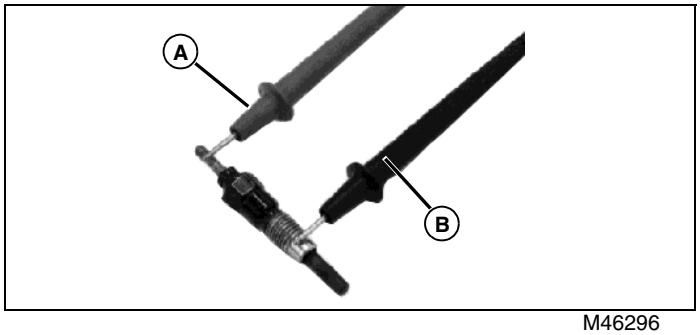
Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance.

Procedure

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.

NOTE: Cover glow plug hole to prevent debris from entering cylinder when glow plug is removed.

5. Remove glow plug lead. Remove glow plug.



M46296

6. Check continuity across terminal (A) and glow plug body (B). If glow plug does not have proper resistance, replace glow plug.

Specifications

Glow Plug Resistance . . . . . .0.3-0.5 ohms

Fuse Test

Reason

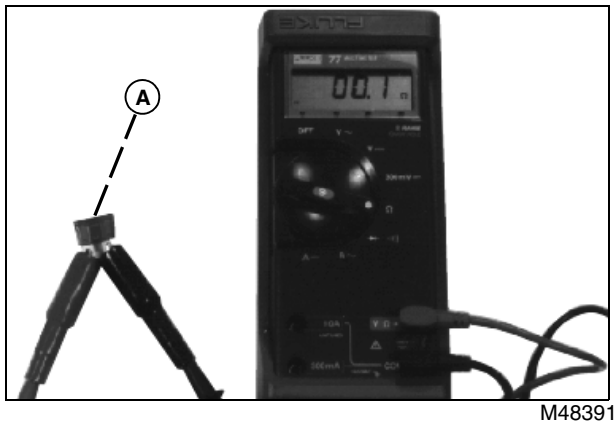
To verify that the fuse has continuity.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter or Continuity Tester	NA	Used to measure resistance or continuity.

Procedure

1. Remove fuse from connector.



M48391

2. Check visually for broken filament (A).
3. Connect ohmmeter or continuity tester to each end of fuse.
4. Check for continuity. If continuity is not indicated, replace fuse.

Bulb Test

Reason

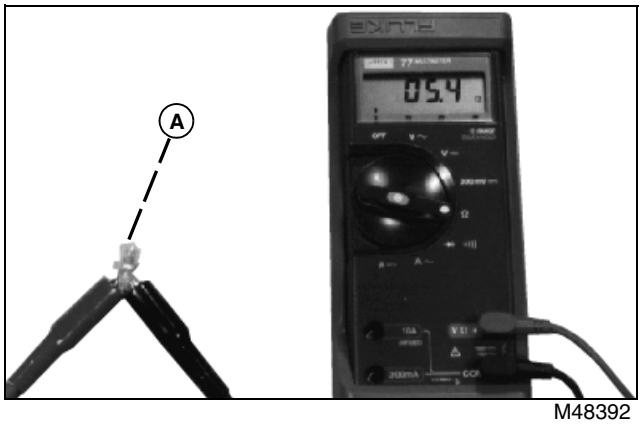
To verify that the bulb has continuity.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter or Continuity Tester	NA	Used to measure resistance or continuity.

Procedure

1. Remove bulb from socket.



M48392

2. Check visually for broken filament (A).

3. Connect ohmmeter or continuity tester to each terminal of bulb.

4. Check for continuity. If continuity is not indicated, replace bulb.

Key Switch Test

Reason

To verify key switch functions are operating properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter or Continuity Tester	NA	Used to measure resistance or continuity.

Procedure

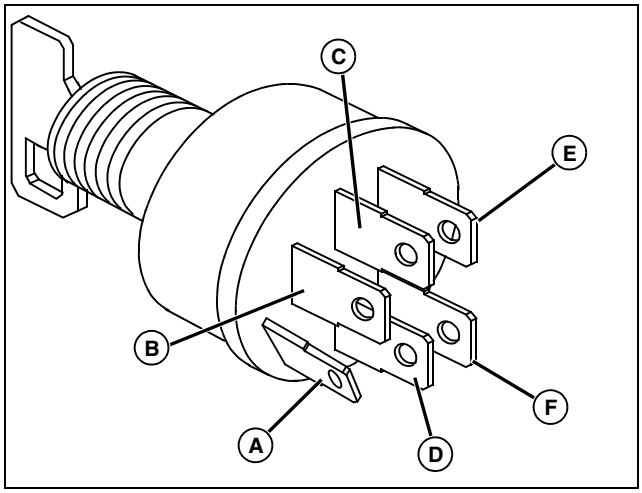
1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Remove the grill from the front of the vehicle. Remove the entire hood if necessary. (See “Remove and Install Hood” on page 456.)

5. Disconnect key switch connector from harness.



MIF

6. Use an ohmmeter or continuity tester to test switch continuity in OFF, RUN, and START positions. If any continuity is NOT correct, replace the switch.

Key Switch Continuity

Switch Position and Terminal Continuity

OFF . . . . . E and F
RUN . . . . . A and D
START . . . . . A and D; B and C

Headlight and Work Light Switch Test

Reason

To make sure the headlight and work light switch terminals have continuity when the switch is ON.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter or Continuity Tester	NA	Used to measure resistance or continuity.

Procedure

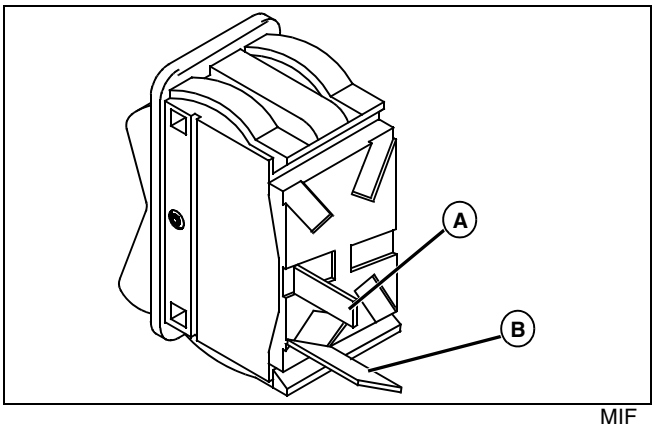
1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Remove the grill from the front of the vehicle. Remove the entire hood if necessary. (See “Remove and Install Hood” on page 456.)

5. Disconnect light switch from harness.



MIF

6. Move light switch to the ON and then the OFF position. Check continuity between terminals (A and B).

- **Terminals should have continuity with switch ON.**
- **Terminals should NOT have continuity with switch OFF.**
- If continuity is NOT correct, replace light switch.

Seat Switch Test

Reason

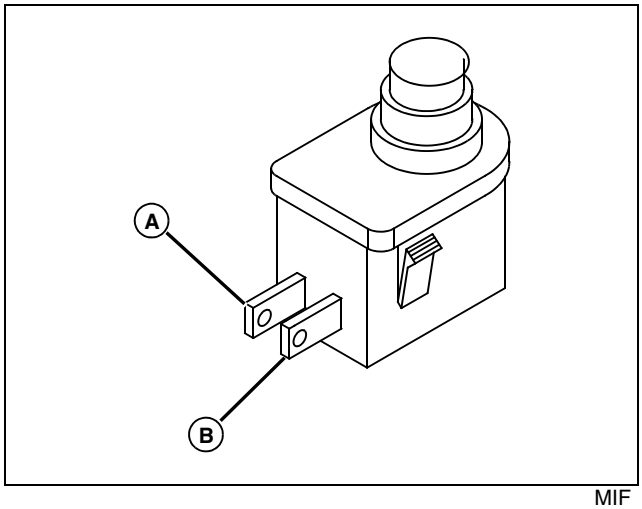
To verify seat switch functions are operating properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter or Continuity Tester	NA	Used to measure resistance or continuity.

Procedure

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Disconnect the wiring harness from the under the driver side seat switch.
5. Remove the seat(s). (See “Remove and Install Seat” on page 457.)



MIF

6. Check continuity across both switch terminals (A) and (B). There should be no continuity.
7. Depress seat switch plunger. Continuity should exist between terminals (A) and (B). If continuity is not correct, replace seat switch.

Seat Delay Module Test

Reason

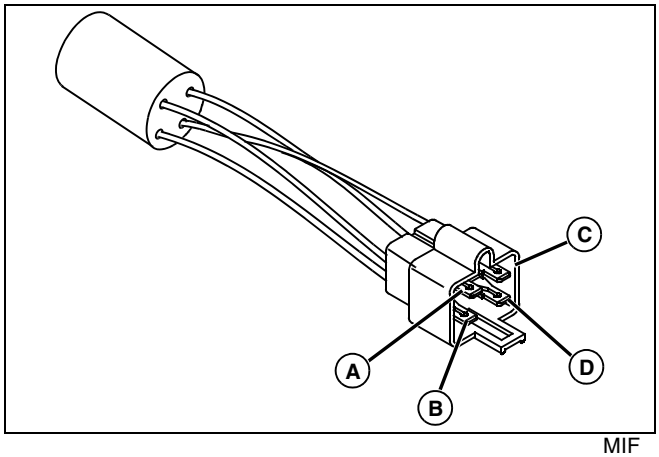
To verify the seat delay module is functioning properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance or continuity.

Procedure

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Slide under the vehicle between the fuel tank and the right front wheel and locate the seat delay module mounted on the inside frame rail.
5. Disconnect seat switch connector from harness.



MIF

6. Set the multimeter to measure ohms, use the chart to sequentially test continuity across each terminal combination.

The red lead position of the meter is listed down the side and the black lead position of the meter is listed across the top of the chart.

Black Red	A	B	C	D
A		5.3m	O.L.	1.7m
B	O.L.		O.L.	O.L.
C	O.L.	2.43m		O.L.
D	O.L.	2.69m	O.L.	

If continuity is not correct, replace the seat delay module.

Brake Switch Test

Reason

To determine proper operation of the brake switch.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance or continuity.

Procedure

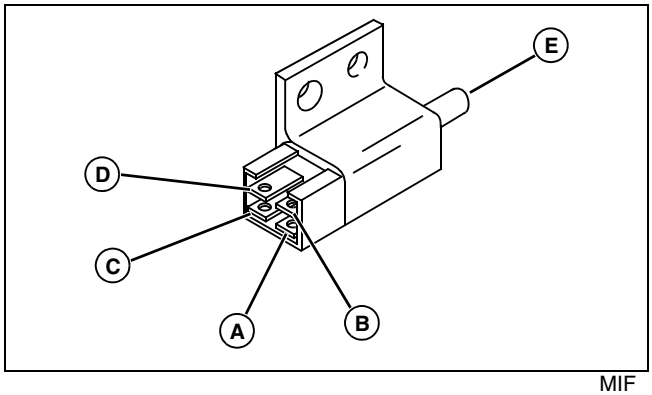
1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Remove the grill from the front of the vehicle. Remove the entire hood if necessary. (See “Remove and Install Hood” on page 456.)

5. Remove connector from brake switch.



MIF

6. Connect meter leads to pairs of switch posts and compare to specifications.

7. Press and release plunger (E) of switch.

If brake switch does not pass all tests, replace switch.

Specifications

Switch plunger
not pressed. . . . . .continuity between posts A and B
Switch plunger
not pressed. . . . . .continuity between posts C and D
Switch plunger
pressed . . . . . no continuity between posts A and B
Switch plunger
pressed . . . . . no continuity between posts C and D

Park Brake Switch Test

Reason

To determine proper operation of park brake switch.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance or continuity.

Procedure

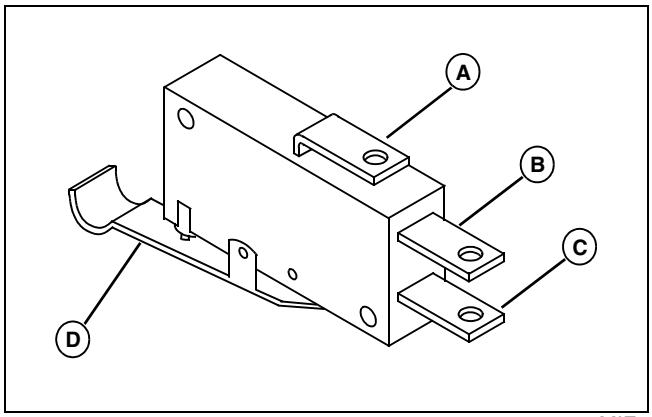
1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Remove the control plate located between the seats. (See “Remove and Install Control Plate” on page 456.)

5. Remove connector from park brake switch.



MIF

6. Connect one lead of the meter to the COM terminal (A) of the switch.

7. Connect the other lead of the meter to terminal (B) and then (C) of the switch.

8. Press and release the switch lever (D) and note the results.

If the park brake switch does not pass both tests, replace switch.

Specifications

Switch lever
not pressed . . . . . .continuity between post A and B
Switch lever
not pressed . . . . . no continuity between post A and C
Switch lever
pressed . . . . . no continuity between post A and B
Switch lever
pressed . . . . . .continuity between post A and C

Horn Switch Test

Reason

To verify the horn switch is operating properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter or Continuity Tester	NA	Used to measure resistance or continuity.

Procedure

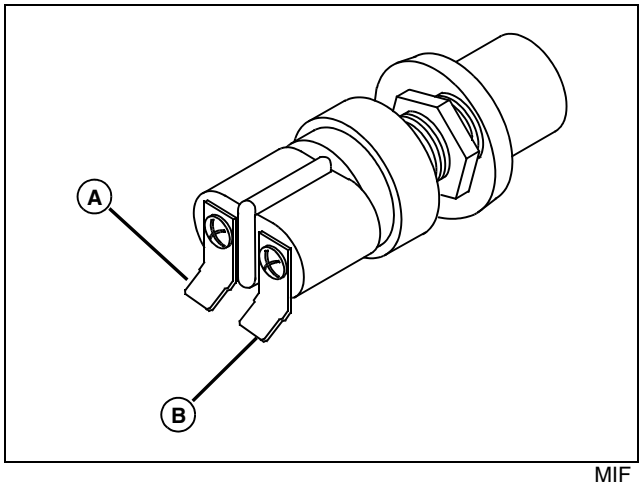
1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Remove the grill from the front of the vehicle. Remove the entire hood if necessary. (See “Remove and Install Hood” on page 456.)

5. Disconnect the horn switch connectors from the switch.



MIF

6. With the button released, check continuity across both switch terminals (A) and (B). There should be no continuity.

7. Depress the horn switch button. Continuity should exist between both terminals (A) and (B).

If continuity is not correct, replace horn switch.

Neutral Switch Test

Reason

To verify transmission neutral switch is operating properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter or Continuity Tester	NA	Used to measure resistance or continuity.

Procedure

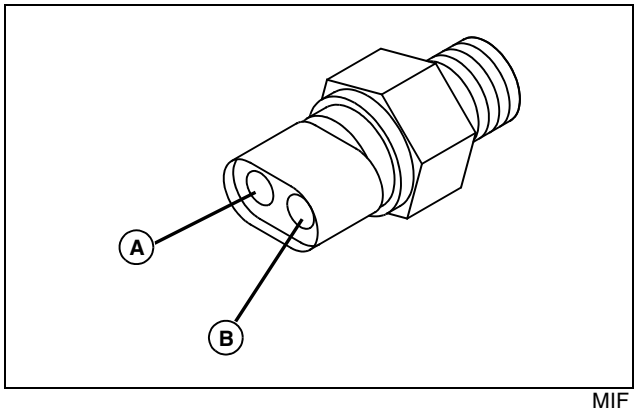
1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.

5. Disconnect transmission neutral switch from harness.



MIF

6. Check for continuity between terminals (A) and (B). If no continuity exists, ensure that transmission selector lever is in NEUTRAL. Replace transmission neutral switch.

7. With the transmission in neutral, check continuity across both switch terminals (A) and (B). There should be continuity.

8. With the transmission shifted into any gear, check continuity across both switch terminals (A) and (B). There should be NO continuity.

If continuity is not correct, replace transmission neutral switch.

Fan-Over Temperature Switch Test

Reason

To verify the fan/over temperature switch is operating properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance.

Procedure

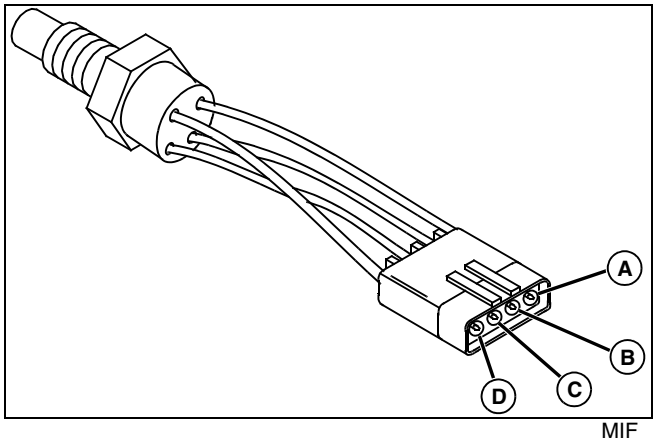
1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.

5. Disconnect the fan/over temperature switch connector from harness.



MIF

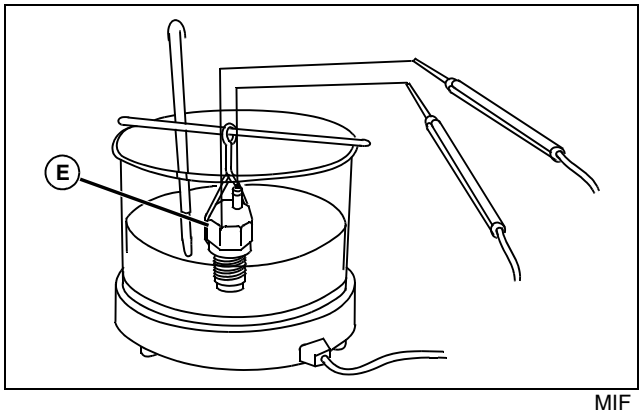
6. Check continuity across all switch terminals with the engine cold.

7. Set the multimeter to measure ohms, use the chart to sequentially test continuity across each terminal combination.

The red lead position of the meter is listed down the side and the black lead position of the meter is listed across the top of the chart.

Black Red	A	B	C	D
A		4.62m	4.62m	1.36m
B	O.L.		O.L.	O.L.
C	O.L.	O.L.		O.L.
D	O.L.	2.62m	2.62m	

8. If the continuity is not correct, remove switch and test in a heated solution of antifreeze as specified below.



MIF

9. Drain engine coolant and remove fan/over temperature switch. Reconnect to main engine harness.

10. Disconnect engine fuel pump electrical connector.

11.Turn key switch to the “RUN” position and place switch (E) in antifreeze solution heated to approximately 91°C (196°F). Measure voltage between terminal (A) and ground. Battery voltage will be present until first switch activates. When switch activates, voltage should drop to 0 volts and the radiator fan should turn on.

- Voltage should drop to 0 volts.
- If the voltage is not correct, replace switch.

12.Continue heating the switch (E) in antifreeze solution to approximately 110°C (230°F). Measure voltage between terminal (C) and ground while switch is heated above specification. Battery voltage will be present until second switch activates. Then voltage should drop to 0 volts and the over temperature light will illuminate.

- Voltage should drop to 0 volts.
- If voltage is not correct, replace switch.

Hydraulic Oil Temperature Switch Test

Reason

To verify the hydraulic oil temperature switch is operating properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance.

Procedure

1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.

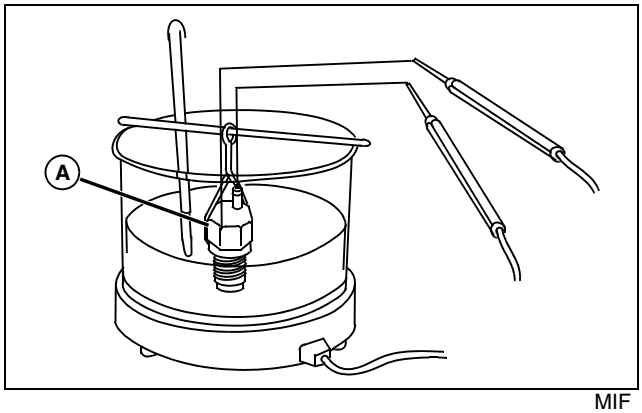
5. Disconnect the fan/over temperature switch connector from harness.

6. Check continuity across all switch terminals with the engine cold.

7. Set the multimeter to measure ohms, test continuity through switch.

If the continuity is not infinite, remove switch and test in a heated solution of antifreeze as specified below.

8. Drain oil and remove temperature switch.



MIF

9. Place switch in antifreeze solution heated to approximately 63°C (145°F). Measure resistance between end terminal and switch body.

10.Continue heating the switch in antifreeze solution to approximately 77°C (170°F). Measure resistance between end terminal and switch body while switch is heated above specification. The resistance should drop to 0 ohms when the switch closes.

11.Allow antifreeze solution to cool. Measure resistance between end terminal and switch body while switch is cooled below specification. The resistance should increase to infinite ohms when the switch opens.

Specifications

Switch Closes (approximately) . . . . . 71° C (160° F)
Switch Opens (approximately) . . . . . 66° C (150° F)

Turn Signal Switch Test

Reason

To verify turn signal switch functions are operating properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance.

Procedure

1. Park machine on level surface.

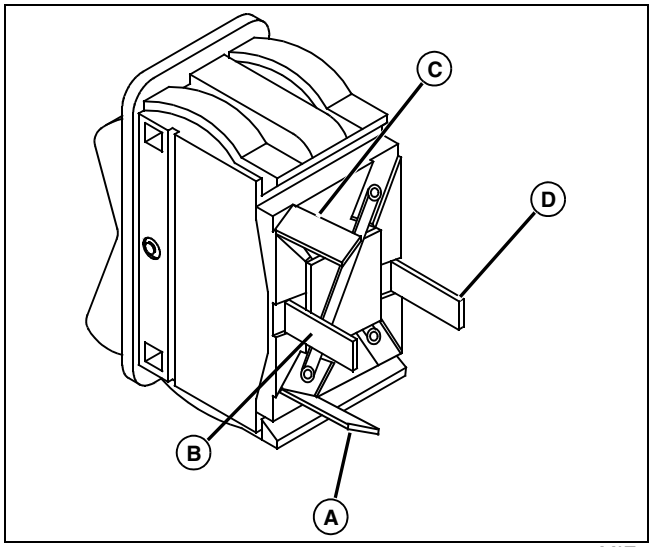
2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Remove the grill from the front of the vehicle. Remove the entire hood if necessary. (See “Remove and Install Hood” on page 456.)

5. Disconnect turn signal switch connector from harness.

6. Use an ohmmeter to test switch continuity in OFF, RIGHT and LEFT positions.



MIF

7. Set the multimeter to measure ohms, use the chart to sequentially test continuity across each terminal combination.

The red lead position of the meter is listed down the side and the black lead position of the meter is listed across the top of the chart.

OFF Position

Black Red	A	B	C	D
A		-	35.3	17.8
B	-		-	-
C	35.3	-		17.8
D	17.8	-	17.8	

Right Turn Position

Black Red	A	B	C	D
A		0.2	35.3	17.8
B	0.2		35.3	17.8
C	35.3	35.3		17.8
D	17.8	17.8	17.8	

Left Turn Position

Black Red	A	B	C	D
A		35.3	35.3	17.8
B	35.3		0.2	17.8
C	35.3	0.2		17.8
D	17.8	17.8	17.8	

8. If any continuity is NOT correct, replace the turn signal switch.

Hazard Lights Switch Test

Reason

To verify hazard switch functions are operating properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance.

Procedure

1. Park machine on level surface.

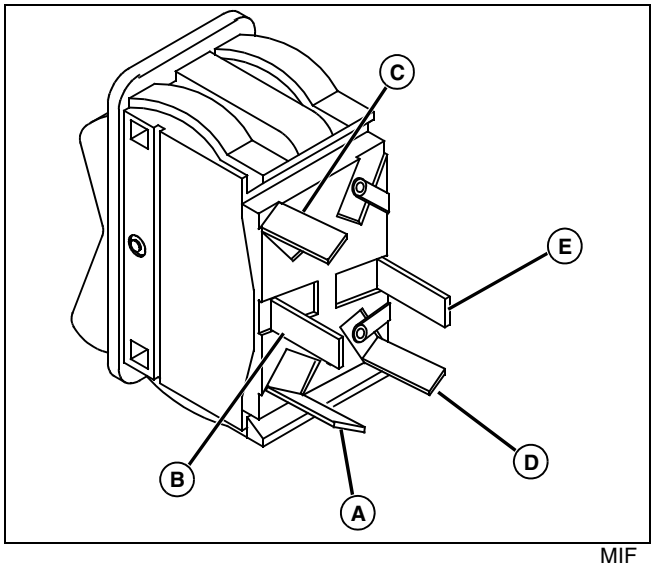
2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Remove the grill from the front of the vehicle. Remove the entire hood if necessary. (See “Remove and Install Hood” on page 456.)

5. Disconnect hazard lights switch connector from harness.

6. Use an ohmmeter to test switch continuity in the OFF and ON positions.



MIF

7. Set the multimeter to measure ohms, use the chart to sequentially test continuity across each terminal combination.

The red lead position of the meter is listed down the side and the black lead position of the meter is listed across the top of the chart.

OFF Position

Black / Red	A	B	C	D	E
A		-	-	-	-
B	-		-	-	-
C	-	-		17.8	-
D	-	-	17.8		-
E	-	-	-	-	

ON Position

Black / Red	A	B	C	D	E
A		0.2	-	-	-
B	0.2		-	-	-
C	-	-		17.8	17.8
D	-	-	17.8		0.2
E	-	-	17.8	0.2	

8. If any continuity is NOT correct, replace the hazard lights switch.

Mechanical PTO Switch Test

Reason

To verify PTO switch functions are operating properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter or Continuity Tester	NA	Used to measure resistance or continuity.

Procedure

1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

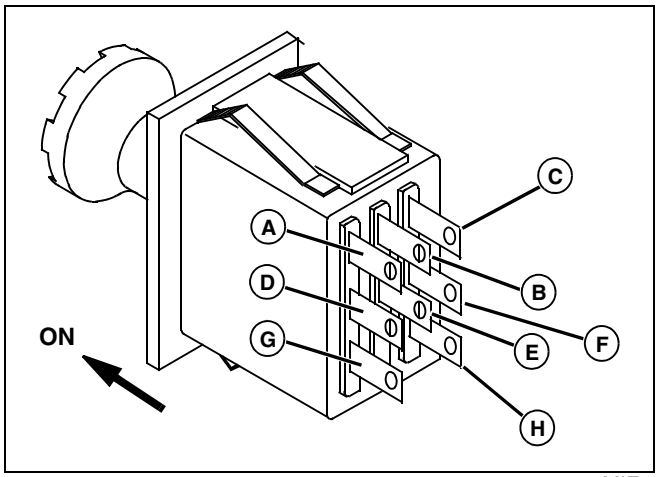
4. Remove the control plate located between the seats. (See “Remove and Install Control Plate” on page 456.)

5. Disconnect PTO switch connector from harness.

6. Use an ohmmeter or continuity tester to test switch continuity.

If continuity is NOT correct, replace the switch.

PTO Switch Continuity



MIF

Switch Position and Terminal Continuity

OFF . . . . . A and C
OFF . . . . . D and F
OFF . . . . . G and H
ON . . . . . A and B
ON . . . . . D and E

PTO Engaged Sensor Switch Test

Reason

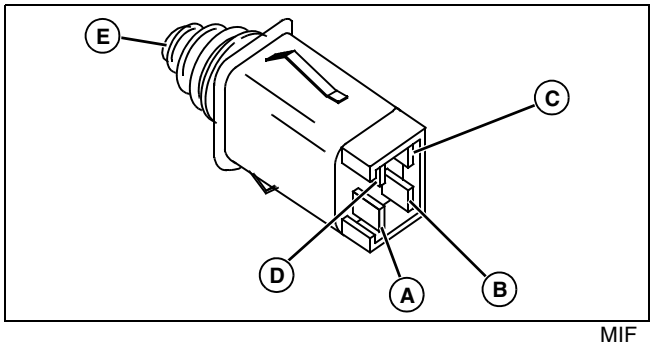
To verify PTO switch functions are operating properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter or Continuity Tester	NA	Used to measure resistance or continuity.

Procedure

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Remove the control plate located between the seats. (See “Remove and Install Control Plate” on page 456.)
5. Disconnect PTO engaged sensor switch connector from harness.
6. Use an ohmmeter or continuity tester to test switch continuity.



MIF

7. Connect meter leads to pairs of switch posts and compare to specifications.

NOTE: On new vehicles S.N. (2001-) PTO switch bracket is adjustable. If continuity is correct, adjust switch to close when PTO lever is set.

8. Press and release plunger (E) of switch.

If continuity is NOT correct, replace the switch.

Specifications

Switch plunger not pressed . . . . . .continuity between posts A and B
Switch plunger not pressed . . . . . no continuity between posts C and D
Switch plunger pressed . . . . . no continuity between posts A and B
Switch plunger pressed . . . . . .continuity between posts C and D

Fuel Gauge Sensor Test

Reason

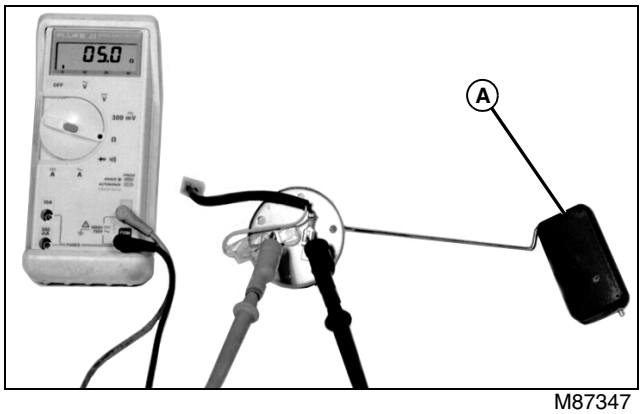
To verify that the fuel gauge sensor is operating properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance.

Procedure

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Turn key switch to ON position.
5. Disconnect red wire from fuel sensor and check fuel gauge. The fuel gauge must drop to EMPTY.
6. Short the red wire to the black wire connector on the fuel sensor. The gauge must rise to FULL. If not, test the fuel sensor ground circuit.
7. If the gauge does not correctly indicate fuel levels based on the two tests above, proceed to step 8.
8. Disconnect fuel gauge sensor wires.
9. Remove sensor from fuel tank.



M87347

10. Using an ohmmeter connected to fuel gauge sensor contacts, check if continuity exists between terminals. If continuity exists, measure resistance across terminals as float (A) and float arm are moved through full range of motion.
11. If resistance does not meet specifications, replace fuel gauge sensor.

Specifications

Variable Resistance . . . . . .5-95 ohms

Fuel Shutoff Solenoid Test - Diesel Engine

Reason

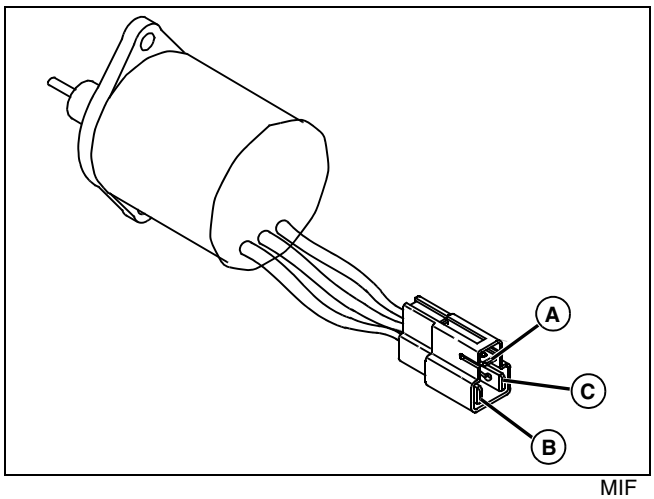
To verify fuel shutoff solenoid is functioning properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance.

Procedure

1. Park machine on level surface and turn start switch OFF.
2. Shift lever in NEUTRAL and park brake LOCKED.
3. Cargo box RAISED and LOCKED.
4. Disconnect fuel shutoff solenoid connector.



MIF

5. Measure and record the resistance across each combination of terminals as listed below.

The red lead position of the meter is listed down the side and the black lead position of the meter is listed across the top of the chart.

Black Red	Blk Wire (A)	Red Wire (B)	Wht Wire (C)
Blk Wire (A)		12	0.4
Red Wire (B)	12		12.4
Wht Wire (C)	0.4	12.4	

6. If continuity is NOT correct, replace fuel shutoff solenoid.

Fuel Shutoff Solenoid Test - Gasoline Engine

Reason

To determine if the fuel shutoff plunger retracts when the solenoid is energized.

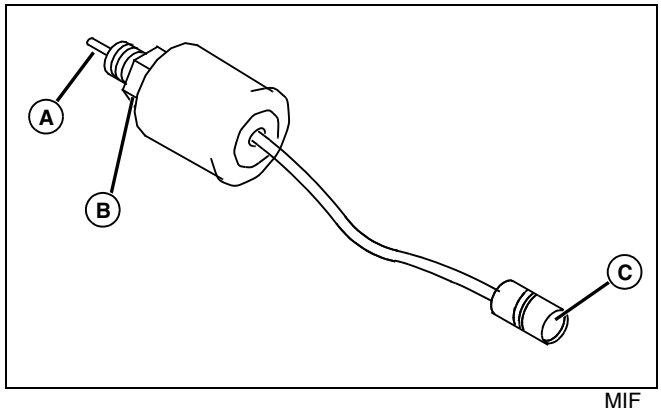
Special or Required Tools

Tool Name	Tool No.	Tool Use
2 Jumper Wires	NA	Used to energize fuel shutoff solenoid.

Procedure

CAUTION: Avoid injury! Keep gasoline away from sparks, flame, or hot engine parts or personal injury can result.

1. Disconnect fuel shutoff solenoid connector.
2. Remove fuel shutoff solenoid, washer and float bowl.



MIF

3. Connect a jumper wire from the battery positive (+) terminal to solenoid terminal (C).

NOTE: It may be necessary to push plunger (A) inward slightly for plunger to retract.

4. Connect a jumper wire from the battery negative (-) terminal to solenoid threads (B). Plunger should now retract with the solenoid energized.
5. Remove jumper wire from the battery negative (-) terminal. Plunger should extend.

If plunger does not move, replace solenoid.

Choke Coil Test

Reason

To determine if the choke coil is operating properly.

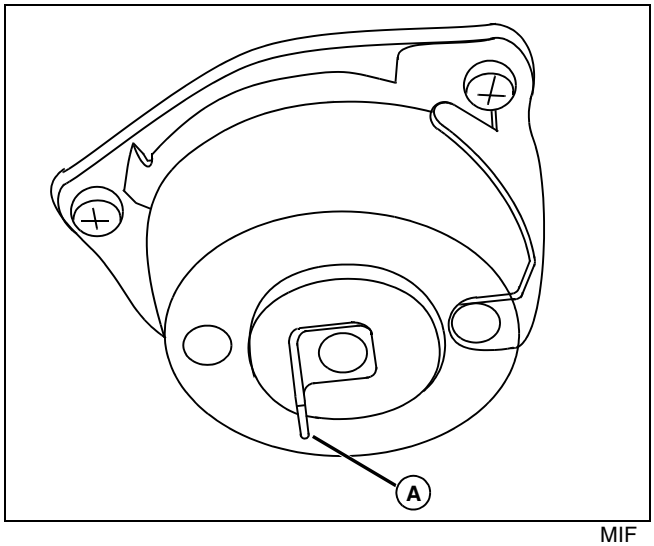
Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance.

Procedure

1. Disconnect wire to the choke coil.

2. Measure resistance between choke terminal (A) and the frame.



MIF

3. If resistance does not meet specification, replace choke coil.

If continuity is not correct, replace choke coil.

Specifications

Choke Coil Resistance. . . . . .10.5 ohms

Diode Test

Reason

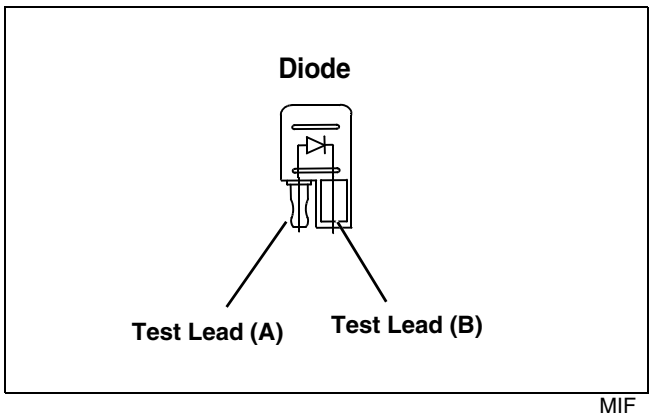
To verify that diode has proper continuity.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter or Continuity Tester	NA	Used to measure resistance or continuity.

Procedure

1. Remove diode from connector.



MIF

2. Connect ohmmeter red (+) lead to pin (A) of diode. Connect ohmmeter black (-) lead to pin (B) of diode. Check for continuity.

3. Reverse test leads. Check for continuity.

Diode must have continuity in one direction only. Replace defective diode.

Ignition Module Test

Reason

To determine if the ignition module is defective.

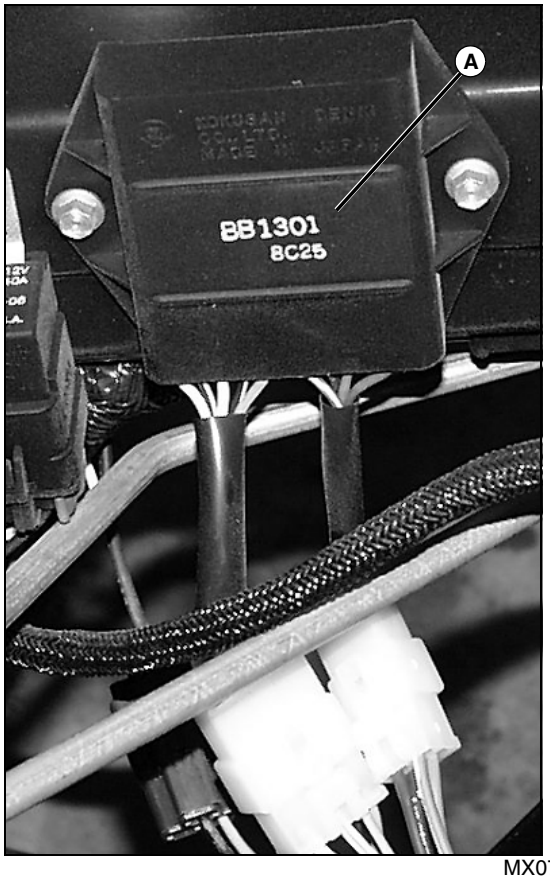
Procedure

1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Slide under the vehicle behind the right front wheel and locate the ignition module mounted on the inside frame rail.



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5. The ignition module (A) is very sensitive to the type of ohmmeter used to check resistance. Due to variations in ohmmeters, the best way to determine if the ignition module is good is to replace the questionable ignition module with a known good module.

If the new ignition module does not solve the problem, check other ignition components.

Ignition Coil Test

Reason

Check the windings of the ignition coil.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance.

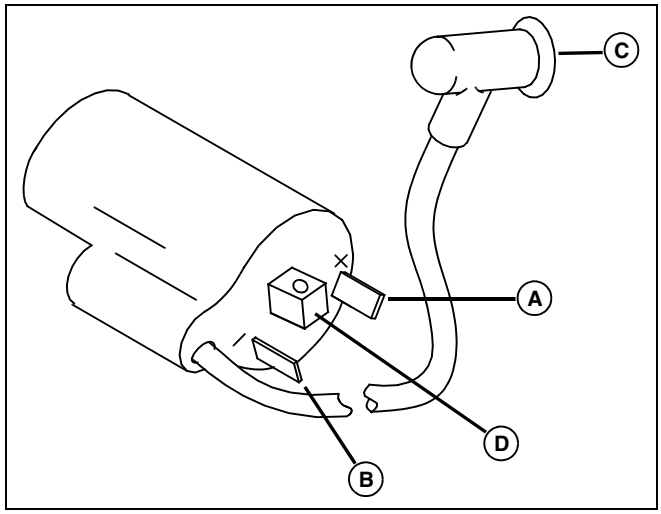
Procedure

1. Park machine on level surface.

2. Turn all switches to the OFF position.

3. Lock park brake, place gear shift in neutral position and disengage differential lock.

4. Raise cargo box, or remove the optional component installed on the vehicle as needed to provide clearance.



5. Disconnect wires from ignition coil primary terminals (A and B)

6. Connect one ohmmeter lead to coil positive (+) (wide) terminal (A).

7. Connect other ohmmeter lead to coil negative (-) terminal (B).

8. Measure resistance across primary windings.

9. Connect one ohmmeter lead to coil positive (+) terminal (A).

10. Connect other ohmmeter lead to high tension lead (C).

11. Measure resistance across secondary windings.

12. Connect one ohmmeter lead to coil positive (+) terminal (A) or negative (-) terminal (B).

NOTE: Do not connect ohmmeter lead to ignition coil mounting screws, as this will result in an inaccurate reading.

13. Connect other ohmmeter lead to coil core (D).

14. Measure resistance from primary leads to coil core. There should be no continuity (open circuit) between coil primary terminals and coil core.

15. Connect one ohmmeter lead to high tension lead (C).

NOTE: Do not connect ohmmeter lead to ignition coil mounting screws, as this will result in an inaccurate reading

16. Connect other ohmmeter lead to coil core (D).

17. Measure resistance from high tension lead to coil core. There should be no continuity (open circuit) between high tension lead and coil core.

18. Repeat test procedures on other ignition coils.

- If the ohmmeter readings are not within specifications, replace coil.

- If ohmmeter readings are within specifications, the coils are probably good. If system still does not perform properly after all tests/checks, replace coil with a good coil.

Specifications

Ignition Coil Primary Resistance . . . . . .4.6 ohms
Ignition Coil Secondary Resistance . . . . . .16,500 ohms

Pulser Coil Test

Reason

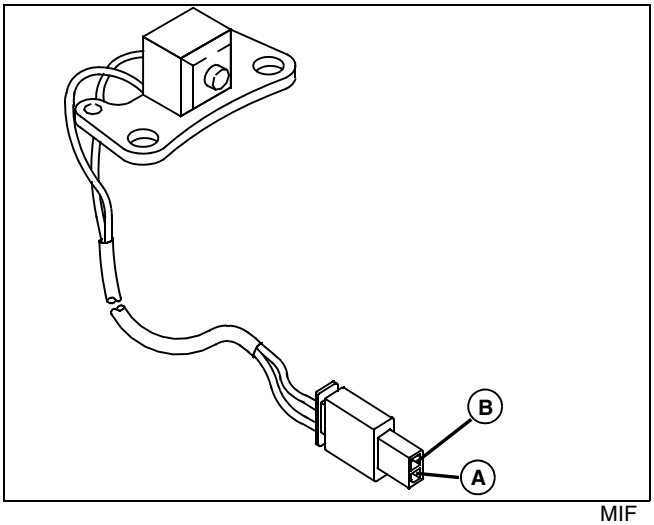
To check if the pulser coil is operating properly.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance.

Procedure

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Slide under the vehicle between the fuel tank and the right front wheel. Locate the pulser coils mounted on a bracket around the end of the crankshaft.
5. Set ohmmeter to 1x ohms scale.
6. Disconnect pulser connector.



MIF

7. Connect one meter lead to each terminal (A) and (B) on the connector.
8. Measure resistance. If the pulser coil is out of specification, replace pulser coil/harness assembly.

Specifications

Pulser Coil Resistance . . . . . 20 ohms

Ignition Ballast Resistor Test

Reason

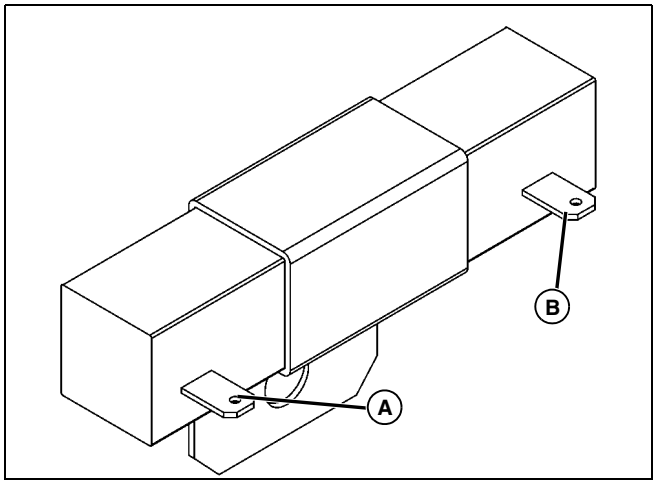
To check the condition of the ignition ballast resistor.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Ohmmeter	NA	Used to measure resistance.

Procedure

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Disconnect both leads from the ignition ballast resistor.
5. Set ohmmeter to 1x ohms scale.



MX14986

6. Connect one meter lead to each terminal (A) and (B) on the resistor.
7. Measure resistance.
8. Connect one lead to engine ground. Resistance should measure infinity. Repeat with other terminal on resistor.

Replace the ignition ballast resistor if the readings are out of specification.

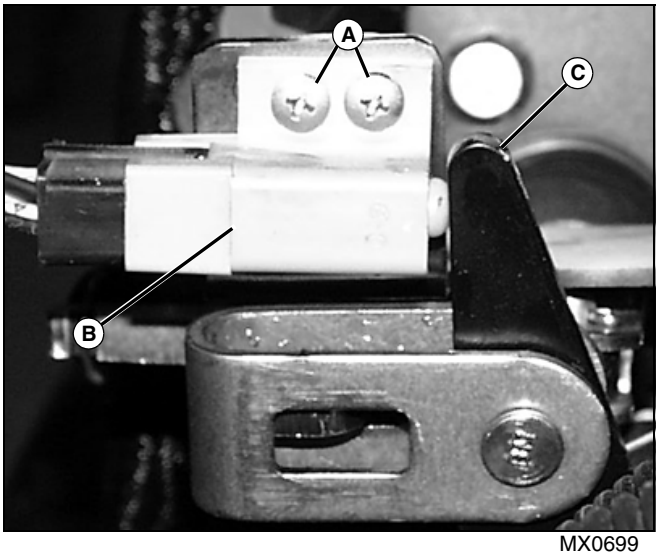
Specifications

Ignition Ballast Resistor Resistance . . . . . 1.5 ohms

Brake Switch Adjustment

Procedure

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Remove the grill from the front of the vehicle. Remove the entire hood if necessary. (See “Remove and Install Hood” on page 456.)



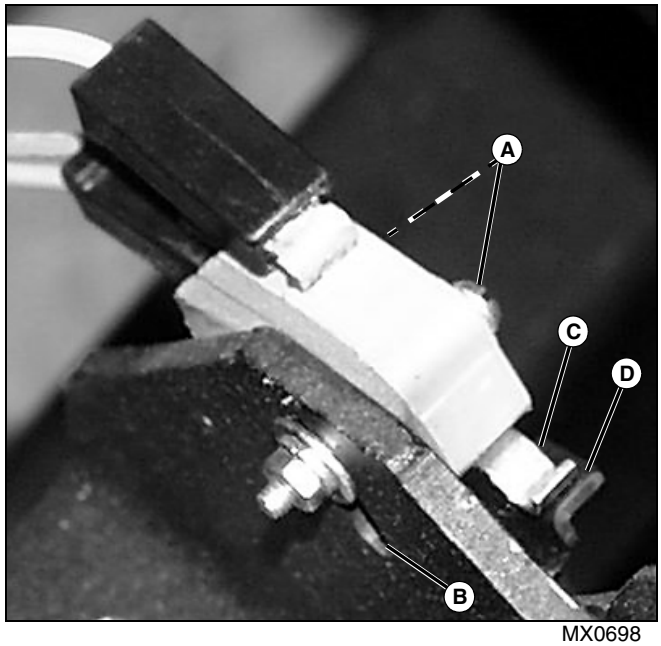
MX0699

5. Loosen the two screws (A) securing the brake switch (B) to the mounting bracket. Slide the switch away from, (toward the front of the vehicle), the brake arm (C).
6. Hold the brake pedal in the released (up) position and slide the brake switch against the brake arm until the plunger is fully depressed.
7. Hold the switch in this position and tighten the two screws securely.

Parking Brake Switch Adjustment

Procedure

1. Park machine on level surface.
2. Turn all switches to the OFF position.
3. Lock park brake, place gear shift in neutral position and disengage differential lock.
4. Remove the control plate located between the seats. (See “Remove and Install Control Plate” on page 456.)



MX0698

5. Loosen the two mounting screws (A) enough to allow the park brake switch to pivot and slide in the adjustment slot (B).
6. Place park brake lever in the released position.
7. Pivot the switch down until the switch wand (C) contacts the park brake bracket (D) and is fully engaged.
8. Tighten the two mounting screws securely.

Repair

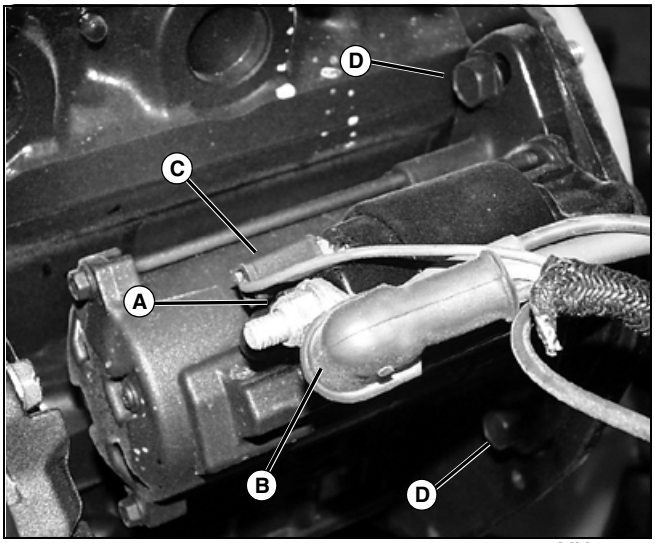
Starting Motor

Removal

1. Park vehicle on a hard, level surface. Lock parking brake.

NOTE: Disconnect negative (-) battery cable first.

2. Disconnect negative (-) battery cable at the battery.



MX0697

3. Remove nut (A) from starting motor solenoid battery terminal.

4. Remove positive (+) battery cable and wires (B) from solenoid terminal.

5. Disconnect purple wire (C) from solenoid signal terminal.

6. Remove two cap screws (D) and starter.

Installation

Installation is done in the reverse order of removal.

NOTE: Connect negative (-) battery cable last.

- Tighten cap screws to specifications.
- Clean all battery cable connections before installing cable.

Analyze Condition

The starter overheats because of:

- Long cranking.
- Armature binding.

The starter operates poorly because of:

- Armature binding.
- Dirty or damaged starter drive.
- Badly worn brushes or weak brush springs.
- Excessive voltage drop in cranking system.
- Battery or wiring defective.
- Shorts, opens, or grounds in armature.

NOTE: Starter repair is limited to brushes, end caps, and starter drive. Fields in starter are permanent magnets and are not serviceable. If housing or armature is damaged, replace starter.

Disassembly

1. Mark body and covers for correct alignment during reassembly.

2. Remove the two nuts securing the solenoid to the front cover.

3. Tip the terminal end of the solenoid in toward the starter housing while pulling the solenoid away from the front cover.

4. Remove the two screws from the end cover.

5. Remove the through bolts securing the starting motor body together.

6. Carefully pull the sections apart.

7. Inspect parts for wear or damage.

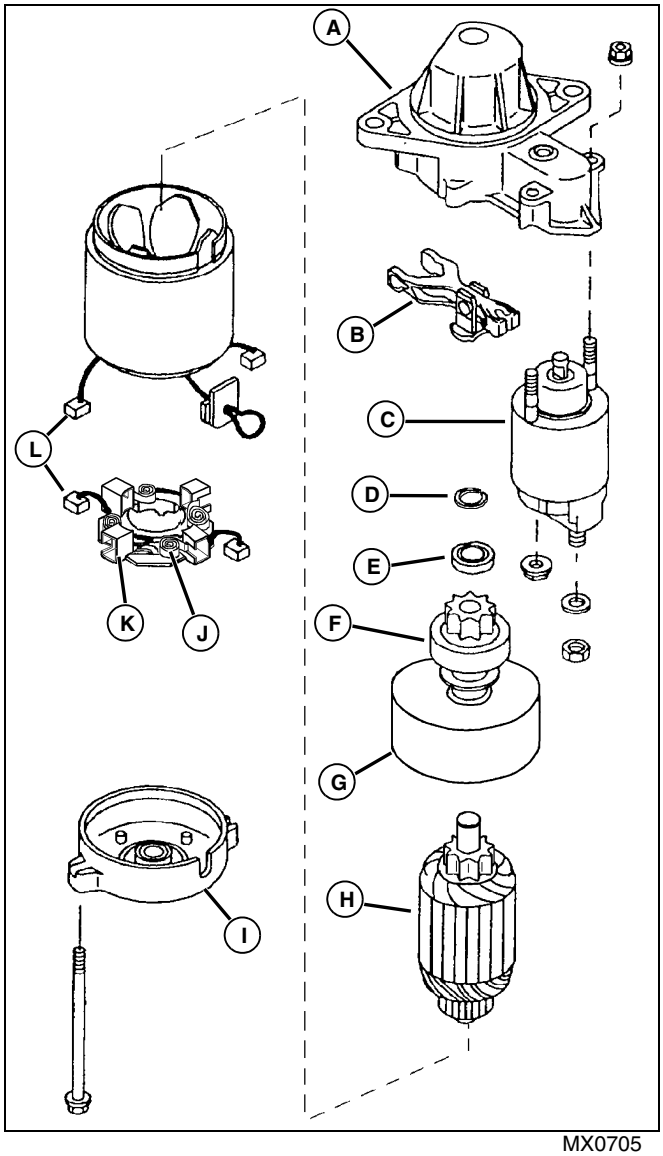
8. Test solenoid, starter armature and brushes. (See “Inspection and Test” on page 330.)

Assembly

Assembly is done in the reverse order of disassembly.

Apply a thin coat of multipurpose grease to:

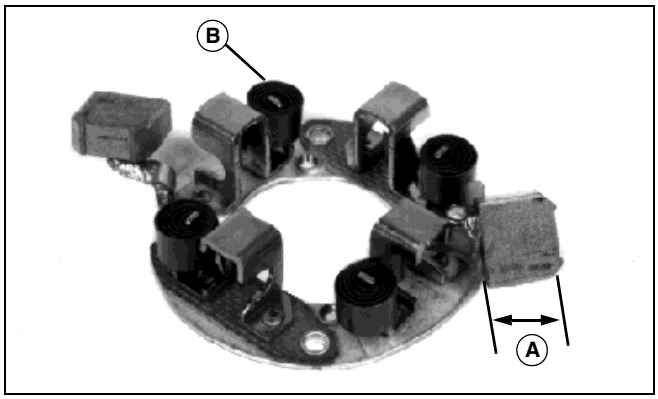
- Sliding surfaces of armature and solenoid shift lever.
- Armature shaft spline.
- Points where shaft contacts cover.



MX0705

A - Front Cover
B - Shift Lever
C - Solenoid
D - Retaining Clip
E - Pinion Stopper
F - Pinion
G - Planetary Gear Assembly
H - Armature
I - End Cover
J - Brush Spring
K - Brush Holder
L - Brush

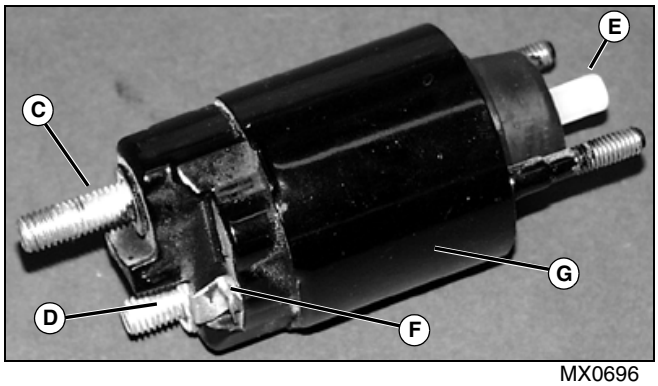
Inspection and Test



M82234

1. Measure field coil brush lengths (A). If any one brush length is less than 10.5 mm (0.413 in.), replace all four brushes.

2. Inspect brush springs (B) for wear or damage. Replace if necessary.



MX0696

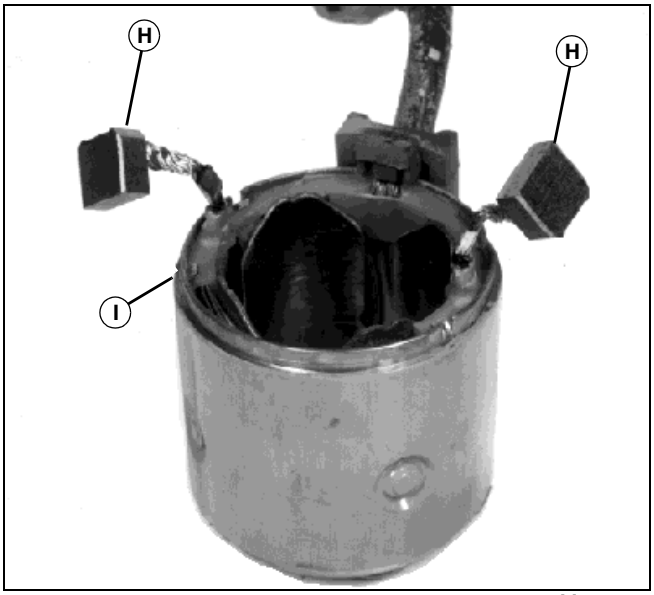
3. Test solenoid terminals (C and D) for continuity. There should be no continuity.

4. Depress switch plunger (E). There should be continuity when plunger is fully depressed.

5. Test for open circuits between terminal (D) and tang (F). There should be continuity.

6. Test for open circuits between tang (F) and body (G). There should be continuity.

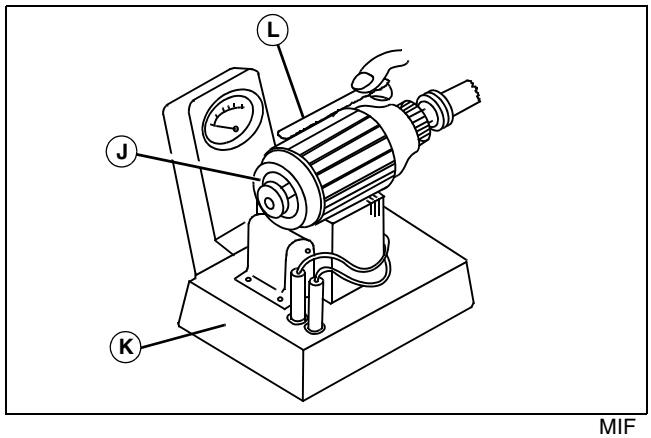
7. If solenoid fails any test, it is defective and must be replaced.



M82235

8. Test for grounded field winding:
   - Touch one probe of tester to field coil brush (H) and other probe to field coil housing (I).
   - Be sure the brush lead is not touching the frame. If there is continuity, the coil is grounded and the field coil housing assembly must be replaced.
9. Test for open field coil:
   - Touch one probe of tester to each field coil brush (H).
   - If there is no continuity, the field coil is open and the field coil housing assembly must be replaced.

IMPORTANT: Avoid damage! DO NOT clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.

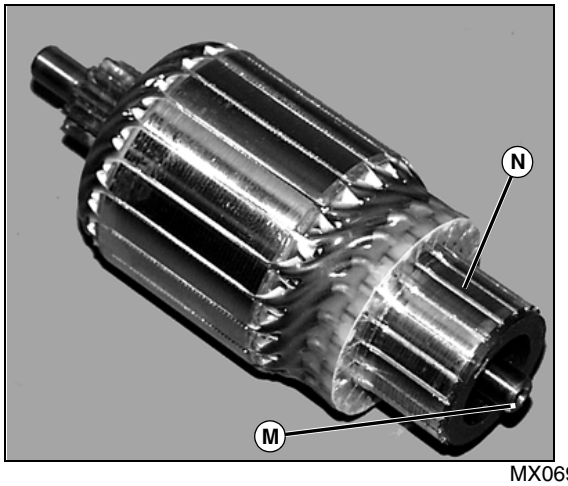


MIF

10.Locate short circuits by rotating armature (J) on a growler (K) while holding a hacksaw blade or steel strip (L) on armature. The hacksaw blade will vibrate in area of short circuit.

NOTE: Shorts between bars are sometimes caused by dirt or copper between bars. Inspect for this condition.

11.If test indicates short-circuited windings, clean the commutator of dust and fillings. Check armature again. If test still indicates short circuit, replace armature.



MX0695

12.Test for grounded windings using an ohmmeter. Touch one probe to the armature shaft (M) and the other probe on each commutator bar (N). Armature windings are connected in parallel, so each commutator bar needs to be checked. If test shows continuity, a winding is grounded and the armature must be replaced.

13.Test for open circuited windings using an ohmmeter. Touch one probe on a commutator bar (N) and the other probe on each remaining commutator bar. Armature windings are connected in parallel, so each commutator bar needs to be checked. If test shows no continuity, there is an open circuit and armature must be replaced.

Starting Motor Cap Screw Torque . 24 N•m (216 lb-in.)

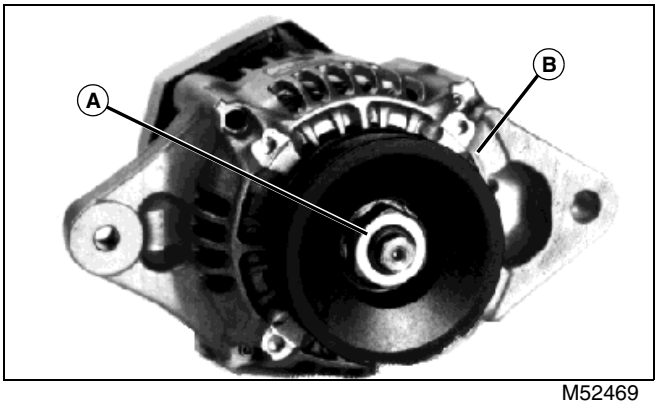
Alternator

Special or Required Tools

Tool Name	Tool No.	Tool Use
Volt-Ohm-Amp Meter	NA	Used to read continuity.
Bearing Puller Set	NA	Used to remove pulley.
Sandpaper (No. 00 or 400-Grit Silicon Carbide Paper)	NA	Used to polish slip rings.

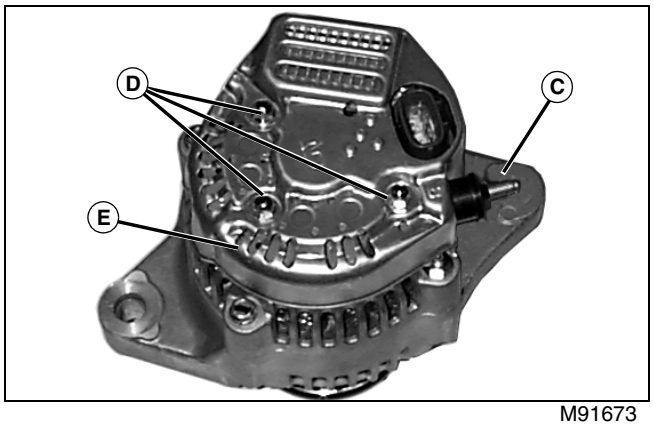
Disassembly

NOTE: Clamp pulley in soft jaw vise and use air impact wrench to remove pulley nut.



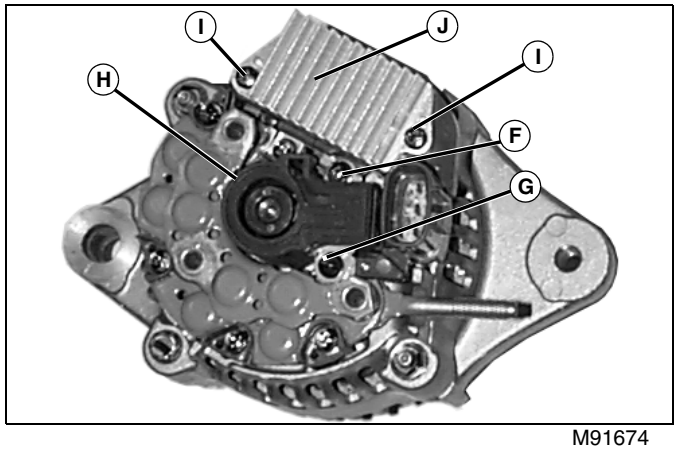
M52469

1. Remove pulley nut (A).
2. Use puller to remove pulley (B).



M91673

3. Remove nut, washer and insulator from battery terminal post (C).
4. Remove three screws (D) securing cover to body. Remove cover (E).

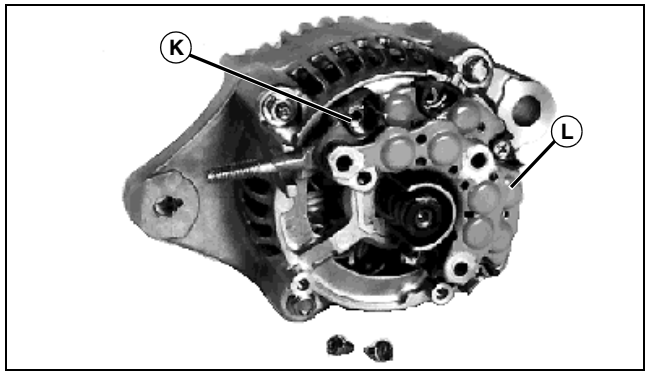


M91674

5. Remove the short screw (F) and the long screw (G) securing brush holder and cover (H) to body. Remove brush holder and cover.

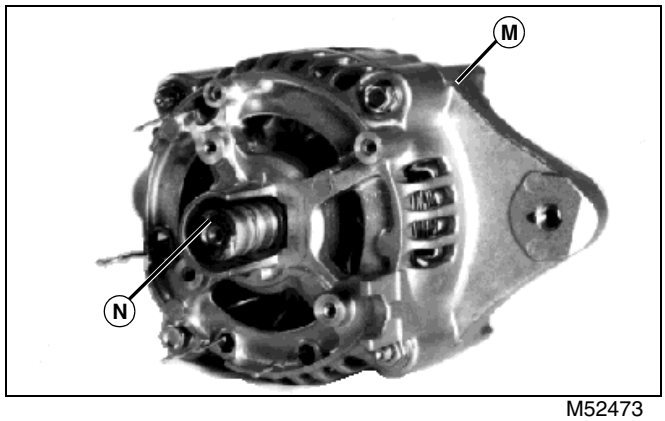
NOTE: Remember location of short screw on regulator tab.

6. Remove the two screws (I) securing regulator to body. Remove regulator (J).



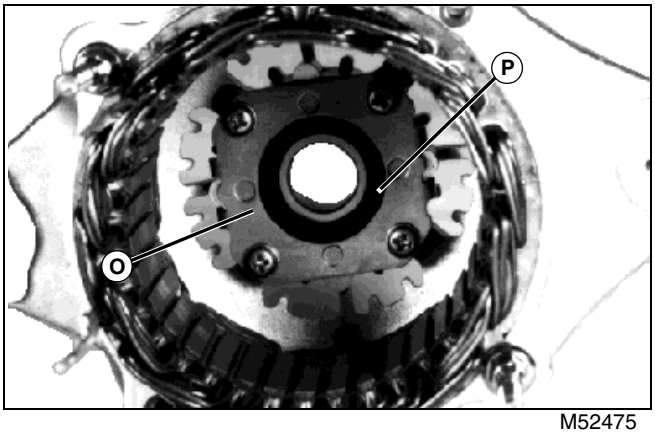
M52471

7. Remove screw and straighten wire leads (K).
8. Remove rectifier (L).



M52473

9. Remove rear case assembly (M).
10. Press rotor shaft (N) from rear case.

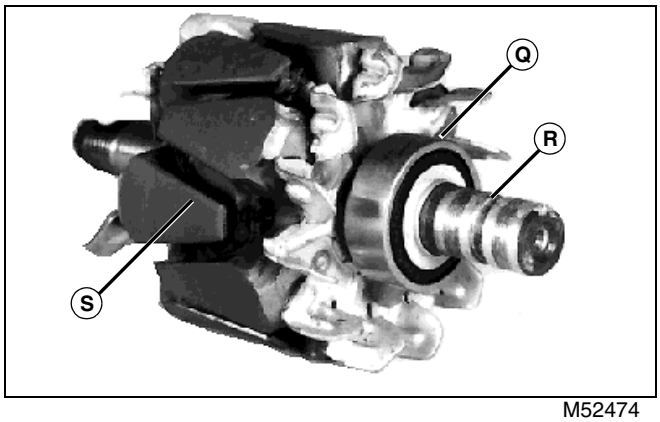


M52475

11.Remove retainer plate (O).

12.Press bearing (P) from case.

Inspection



M52474

1. Inspect bearing (Q) for smooth rotation. Replace if necessary.

2. Inspect slip rings (R) for dirt or rough spots. If necessary, use No. 00 sandpaper or 400-grit silicon carbide paper to polish rings.

3. Measure outer diameter of slip rings. Replace rotor if less than 14 mm (0.55 in.).

4. Check continuity between slip rings using ohmmeter or continuity tester. Replace rotor assembly if there is no continuity.

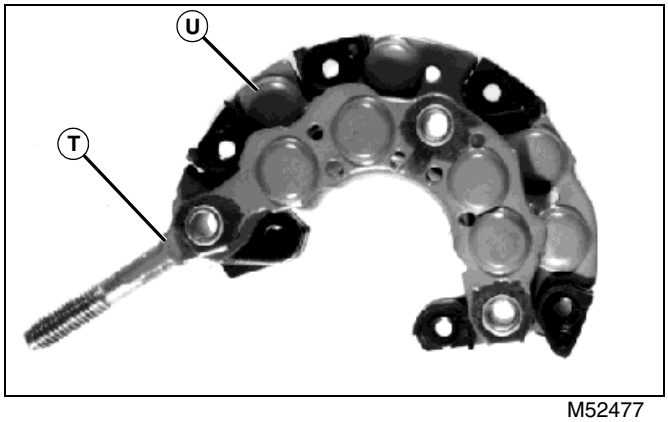
5. Check continuity between slip rings and rotor core (S). Replace rotor assembly if there is continuity.

NOTE: Use an ohmmeter that is sensitive to 0-1 ohm.

6. Inspect stator for defective insulation, discoloration, or burned odor.

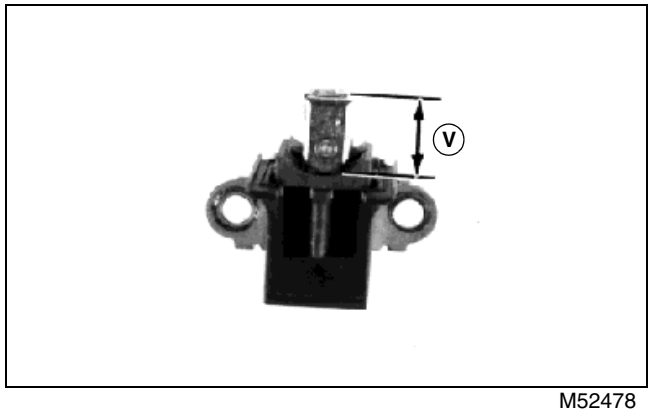
7. Check for continuity between each stator lead and body. Replace stator if there is continuity.

NOTE: Set ohmmeter to the k-ohm range.



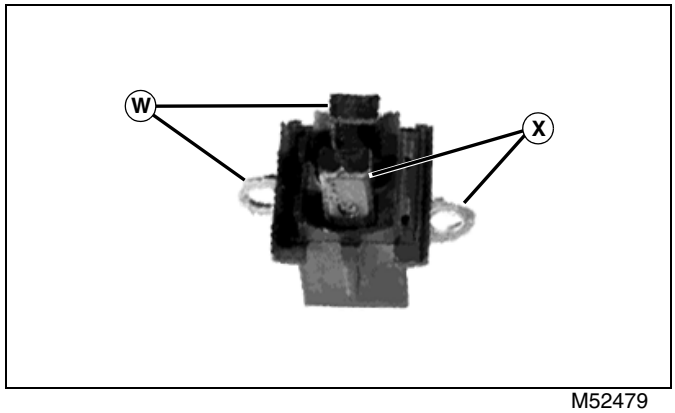
M52477

8. Check continuity between main lead (T) and each diode lead (U). Reverse ohmmeter leads and recheck. There is continuity in one direction, but not the other. Replace diodes or rectifier plate if bad.



M52478

9. Measure length of brush protruding from holder. Dimension is 4.5 mm (0.17 in.) minimum. Replace brushes if worn below minimum. Maximum exposed new brush length is 10.5 mm (0.41 in.).



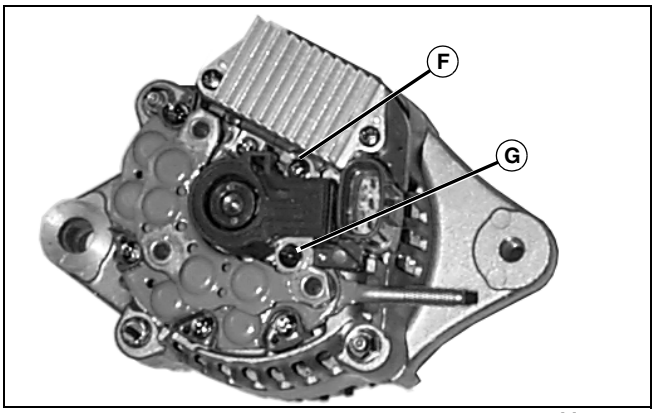
M52479

10.Check continuity between brush and terminal (W). Check continuity between brush and terminal (X). There should be continuity only at these points.

Assembly

Assembly procedure is the reverse of disassembly.

NOTE: Check that rotor fan does not contact case and that rotor assembly turns smoothly in bearing.



M91674

IMPORTANT: Avoid damage! Check that short screw (F) is installed in regulator tab. Longer screw (G) will contact frame and will cause damage to the charging system.

Clamp pulley in soft jaw vise. Install pulley nut.

Specifications

Exposed Brush Length (Min). . . . . 4.5 mm (0.17 in.)
Exposed Brush Length (Max) . . . . . 0.5 mm (0.41 in.)
Rotor Slip Ring Diameter (Min) . . . . . 14 mm (0.55 in.)
Pulley Nut Torque . . . . . 69 N•m (51 lb-ft)
Belt Deflection
at 98 N (22 lb-force) . . . . . 10-15 mm (0.4-0.6 in.)

POWER TRAIN - GEAR TABLE OF CONTENTS

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POWER TRAIN - GEAR TABLE OF CONTENTS

Specifications

General Specifications

NOTE: The following dimensions are measurements from components and are not intended to reflect wear.

Input Shaft OD

#1 F.W. Pilot Bearing . . . . . 11.942-11.968 mm (0.4702-0.4712 in.)
#2 Clutch Sleeve CMP . . . . . 19.948-20.000 mm (0.7854-0.7874 in.)
#3 Bearing #6205 . . . . . 24.9935-25.0065 mm (0.9840-0.9845 in.)
#4 F4:33 & F5:36 Gear, Bearing #222617 . . . . . 21.979-22.000 mm (0.8653-0.8661 in.)
#5 Bearing 6304U . . . . . 20.002-20.015 mm (0.7875-0.7880 in.)

Input Shaft Assembly Bore ID

#1 C/H Case Bore, Bearing #6205 . . . . . 52.000-52.046 mm (2.0472-2.0491 in.)
#2 F4:33 & F5:36 Gear, Case Bore, Bearing #222617 . . . . . 26.020-26.033 mm (1.0244-1.0249 in.)
#3 T/A Case Bore, Bearing 6304U . . . . . 26.020-26.033 mm (1.0244-1.0249 in.)

Reduction Shaft OD

#1 Bearing #6305 . . . . . 25.002-25.015 mm (0.9843-0.9848 in.)
#2 R, F1, F2, F3 Gears (39T, 50T, 44T, 37T). . . . . 29.987-30.000 mm (1.1806-1.1811 in.)
#3 Bearing #6205U . . . . . 25.002-25.015 mm (0.9843-0.9848 in.)

Reduction Shaft Assembly Bore ID

#1 C/H Bore, Bearing #6305. . . . . 62.000-62.030 mm (2.4409-2.4421 in.)
#2 R, F1, F2, F3 (39T, 50T, 44T, 37T) Case Bore . . . . . 35.009-35.034 mm (1.3783-1.3793 in.)
#3 T/A Case Bore, Bearing #6205U. . . . . 52.000-52.030 mm (2.0472-2.0484 in.)

Counter Shaft OD

#1 T.R. Bearing 30306. . . . . 30.002-30.015 mm (1.1812-1.1817 in.)
#2 T.R. Bearing 32208. . . . . 40.002-40.018 mm (1.5749-1.5755 in.)

Counter Shaft Assembly Bore ID

#1 C/H Bore T.R. Bearing 30306 . . . . . 72.000-72.030 mm (2.8346-2.8358 in.)
#2 T/A Case Bore T.R. Bearing #32208. . . . . 80.000-80.030 mm (3.1496-3.1508 in.)

MFWD Assembly Bore ID

#1 C/H Bore MFWD, Bi-Directional Clutch . . . . . 112.00-112.05 mm (4.4094-4.4114 in.)
#2 T/A Case Bore, MFWD Bi-Directional Clutch . . . . . 52.000-52.024 mm (2.0474-2.0482 in.)

Reverse Shaft OD

#1 Shaft (29T) . . . . . 19.987-20.000 mm (0.7869-0.7874 in.)

Reverse Shaft Assembly Bore ID

#1 C/H Bore (Reverse Shaft) . . . . . 20.000-20.013 mm (0.7874-0.7879 in.)
#2 Gear Bore (29T) (Needle Bearing Part) . . . . . 24.007-24.028 mm (0.9452-0.9460 in.)

Axle Shaft OD

#1 Bearing #6208 . . . . . 39.992-40.008 mm (1.5745-1.5751 in.)
#2 Bearing #2208 . . . . . 39.992-40.008 mm (1.5745-1.5751 in.)
#3 Flange. . . . . 79.900-80.000 mm (3.1457-3.1496 in.)

POWER TRAIN - GEAR SPECIFICATIONS

Axle Shaft Assembly Bore ID

#1 Axle Housing Bore, Bearing #6208 . . . . . 80.000-80.030 mm (3.1457-3.1508 in.)
#2 Axle Housing Bore, Bearing #2208 . . . . . 80.000-80.030 mm (3.1457-3.1508 in.)

Clutch Shaft OD

#1 Shaft . . . . . 14.957-15.000 mm (0.5889-0.5906 in.)

Clutch Shaft Bore ID

#1 C/H Bore . . . . . 15.050-15.100 mm (0.5925-0.5945 in.)
#2 C/H Fork Bore . . . . . 15.016-15.043 mm (0.5912-0.5922 in.)

Clutch Fork

Pin Thickness . . . . . 19.200-20.200 mm (0.7559-0.7953 in.)
Wear Limit . . . . . 0.50 mm (0.197 in.)
Fork R-1, 2-3, 4-5, Thickness . . . . . 6.700-6.900 mm (0.2638-0.2717 in.)
Wear Limit . . . . . 0.50 mm (0.197 in.)
Shifter Groove Width . . . . . 6.950-7.150 mm (0.2736-0.2815 in.)

Clutch Fork Shaft OD

R-1, 2-3, 4-5 . . . . . 14.957-15.000 mm (0.5889-0.5906 in.)

Clutch Fork Shaft Bore ID

#1 C/H Bore. . . . . 15.100-15.150 mm (0.5945-0.5965 in.)
#2 T/A Case Bore . . . . . 15.100-15.200 mm (0.5945-0.5984 in.)

Clutch Sleeve Groove Width

Clutch Fork Pin . . . . . 20.500-21.000 mm (0.8071-0.8268 in.)

Selector Arm Pin Diameter . . . . . 11.800-11.900 mm (0.4646-0.4658 in.)
Wear Limit . . . . . 0.50 mm (0.197 in.)

Selector Arm Fork Groove Width

Pin Part . . . . . 12.100-12.300 mm (0.4764-0.4843 in.)

Selector Shaft OD

#1 Cover A and B . . . . . 14.900-14.950 mm (0.5866-0.5886 in.)
#2 Switch and Selector Arm . . . . . 14.957-15.000 mm (0.5889-0.5906 in.)
#3 Control Arm . . . . . 14.900-14.950 mm (0.5866-0.5886 in.)

Selector Shaft Assembly Bore ID

#1 Cover A and B Bore. . . . . 15.016-15.043 mm (0.5912-0.5922 in.)
#2 Selector Arm Bore . . . . . 15.016-15.043 mm (0.5912-0.5922 in.)
#3 Switch Arm. . . . . 15.000-15.027 mm (0.5906-0.5916 in.)
#4 Switch Arm Bore . . . . . 15.000-15.027 mm (0.5906-0.5916 in.)

Differential Lock Shaft OD . . . . . **19.948-20.000 mm (0.7854-0.7874 in.)**

Differential Lock Shaft Assembly Bore ID

#1 T/A Case Bore . . . . . **20.100-20.200 mm (0.7913-0.7953 in.)**
#2 Differential Lock Fork Bore . . . . . **20.050-20.100 mm (0.7894-0.7913 in.)**
#3 Axle Housing L Bore . . . . . **20.020-20.053 mm (0.7882-0.7895 in.)**
#4 Differential Lock Arm Bore . . . . . **20.000-20.052 mm (0.7874-0.7894 in.)**

Differential Lock Fork Thickness . . . . . **8.800-9.000 mm (0.3465-0.3543 in.)**
Wear Limit . . . . . **0.50 mm (0.197 in.)**

Differential Lock Shifter

Pin OD . . . . . **11.018-11.029 mm (0.4338-0.4342 in.)**
Pin Hole Bore ID . . . . . **11.400-11.600 mm (0.4488-0.4567 in.)**

Differential Lock Slider Groove Width

Differential Lock Fork Part . . . . . **9.100-9.300 mm (0.3583-0.3661 in.)**

Differential Lock Fork V Groove Diameter

Spring Pin Part . . . . . **8.500-9.000 mm (0.3346-0.3543 in.)**

Differential Pinion Shaft OD

Shaft OD . . . . . **21.967-21.980 mm (0.8648-0.8654 in.)**

Differential Pinion Shaft Bore ID

#1 Differential Case Bore . . . . . **22.000-22.021 mm (0.8661-0.8670 in.)**
#2 Differential Pinion Gear Bore . . . . . **22.040-22.061 mm (0.8677-0.8685 in.)**

Differential Case OD

#1 Bearing 6212 . . . . . **60.002-60.021 mm (2.3623-2.3630 in.)**
#2 Bearing 6210 . . . . . **50.002-50.018 mm (1.9686-1.9692 in.)**

Differential Assembly Bore ID

#1 Axle Housing L Bore, Bearing 6212 . . . . . **110.000-110.035 mm (4.3307-4.3321 in.)**
#2 Transaxle Case Bore, Bearing 6210 . . . . . **90.000-90.035 mm (3.5433-3.5447 in.)**

Axle Housing Collar OD

Brake Assembly Component . . . . . **81.910-81.990 mm (3.2248-3.2280 in.)**

Washer and Collar Thickness

Input Shaft Assembly

F4 Gear Side (33T) 22 X 33 X 2 . . . . . **1.90-2.10 mm (0.0748-0.0827 in.)**
F5 Gear Side (36T) 22 X 34 X 2 . . . . . **1.90-2.10 mm (0.0748-0.0827 in.)**

Reduction Shaft Assembly

R Gear Side (39T) 26 X 41 X 3 . . . . . **2.90-3.10 mm (0.1142-0.1220 in.)**
F1 Gear Side (50T) 30 X 43 X 3(2) . . . . . **1.90-2.10 mm (0.0748-0.0827 in.)**
F2 Gear Side (44T) 30 X 42 X 2 . . . . . **1.90-2.10 mm (0.0748-0.0827 in.)**
F3 Gear Side (37T) 30 X 42 X 3.2 . . . . . **3.10-3.30 mm (0.1220-0.1299 in.)**

POWER TRAIN - GEAR SPECIFICATIONS

Reverse Shaft Assembly

R Gear Both Sides (29T) 20 X 34 X 2.5	**2.40-2.50 mm (0.0945-0.0984 in.)**

Counter Shaft Assembly

MFWD Gear Side (40T) 30 X 38 X 4 Collar	**3.90-4.10 mm (0.1535-0.1614 in.)**
Spiral Pinion Side 40 X 50 X 9 Collar	**8.90-9.10 mm (0.3504-0.3583 in.)**

Differential

Gear Washer	**0.95-1.05 mm (0.0374-0.0413 in.)**
Pinion Washer	**0.95-1.05 mm (0.0374-0.0413 in.)**

Axle Shaft Assembly

6208 Bearing Side 40 X 52 X 2.3 Collar	**2.17-2.43 mm (0.0854-0.0957 in.)**
2208 Bearing Side 41 X 51 X 6 Collar	**5.90-6.00 mm (0.2323-0.2362 in.)**

Differential Lock Assembly

Transaxle Case Side 19.5 X 1.6 Washer	**1.50-1.70 mm (0.0591-0.0669 in.)**
Axle Housing Left Side 20 X 32 X 3.2 Spacer	**3.05-3.35 mm (0.1201-0.1319 in.)**

Selector Shaft Assembly

Liner 4 Pieces	**1.90-2.10 mm (0.0748-0.0827 in.)**

Synchronizer Assembly

Synchro Key Thickness	**4.90-5.10 mm (0.1929-0.2008 in.)**
F4, F5 Synchro Ring Key Groove Width	**8.30-8.50 mm (0.3268-0.3346 in.)**
R, F1-F3 Synchro Ring Key Groove Width	**9.00-9.20 mm (0.3543-0.3622 in.)**
Synchronizer Wear Limit	**0.1 mm (0.004 in.)**

Torque Specifications

Fasteners

M6 Bolt and Nut . . . . . 10 N•m (88 lb-in.)
M8 Bolt. . . . . 25 N•m (220 lb-in.)
M10 Bolt and Nut . . . . . 52 N•m (38 lb-ft)
M12 Bolt. . . . . 88 N•m (65 lb-ft)
M14 Drain Plug . . . . . 49 N•m (36 lb-ft)
M36 Countershaft Assembly Locknut . . . . . 167 N•m (123 lb-ft)
Clutch Housing Cap Screw Torque. . . . . 23-29 N•m (17-22 lb-ft)
Spring Shackle Cap Screw Torque . . . . . 102 N•m (75 lb-ft)
Leaf Spring U-Bolt Nut Torque . . . . . 129 N•m (95 lb-ft)
38T Gear Locknut Torque (Early Production - Staked Collar) . . . . . 166 N•m (123 lb-ft)
38T Gear Locknut Torque (Later Production - Locked Collar) . . . . . 166 N•m (123 lb-ft)
Reverse Idler Shaft Nut Torque . . . . . 44-59 N•m (33-43 lb-ft)
Transaxle Housing Cap Screw Torque . . . . . 23-29 N•m (17-21 lb-ft)
Ring Gear Retaining Cap Screw Torque. . . . . 78-98 N•m (58-72 lb-ft)
Axle Housing Cap Screw Torque (Left Side) . . . . . 23-29 N•m (17-22 lb-ft)
Axle Housing Cap Screw Torque (Right Side) . . . . . 44-59 N•m (33-43 lb-ft)

Capacities

System Capacity. . . . . 11.4 L (3.0 gal)
Transaxle Capacity . . . . . 7.0-7.8 L (1.85-2.06 gal)

Tools and Materials

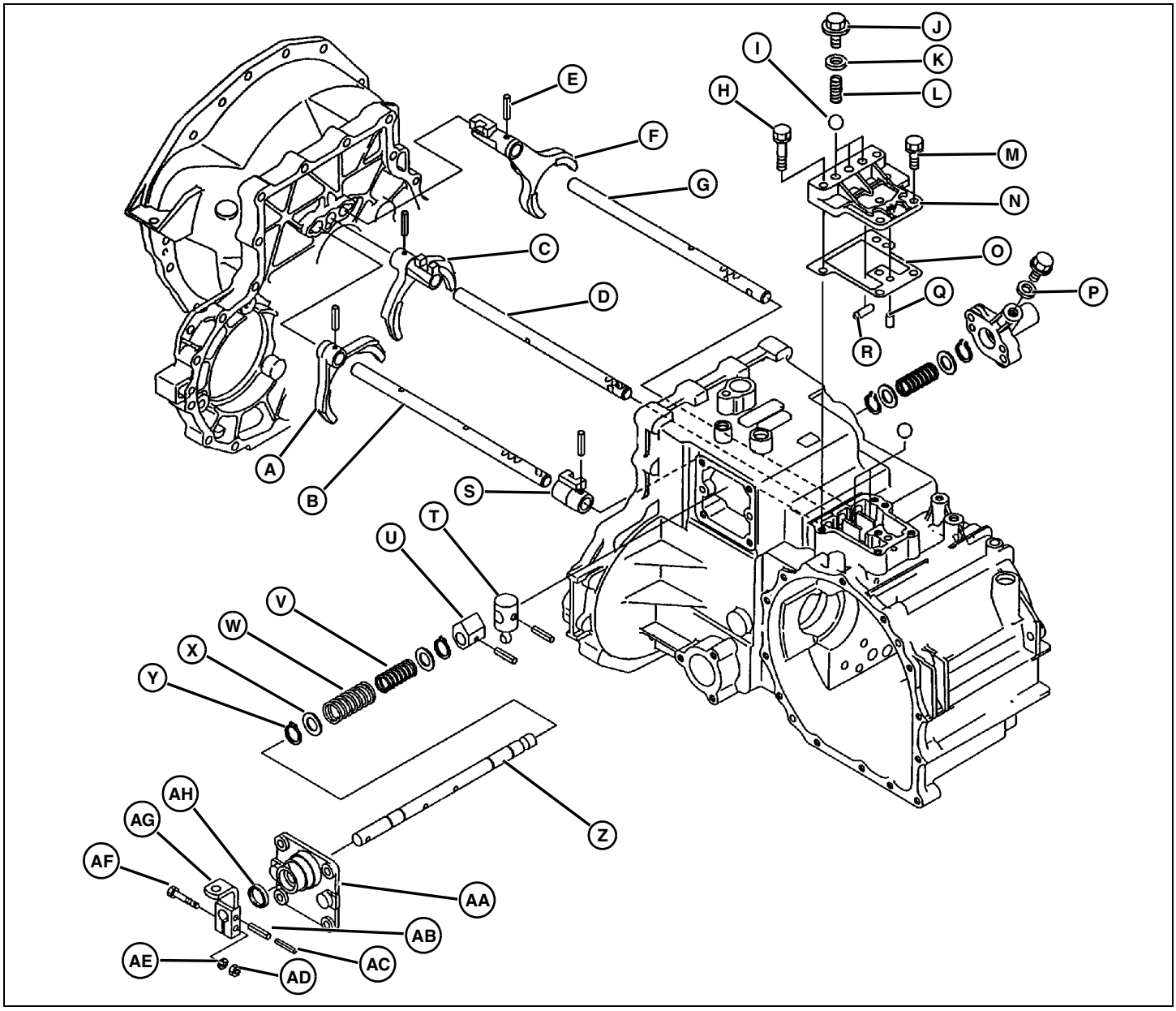
Other Materials

Other Material

Part No.	Part Name	Part Use
TY15130	Form-in-Place Gasket	Applied to covers before installation.
T43512 (U.S.) TY9473 (Canada)	Thread Lock and Sealer (Medium Strength)	Applied to threads of ring gear retaining cap screws.

Component Location

Shifter Shafts Component Location

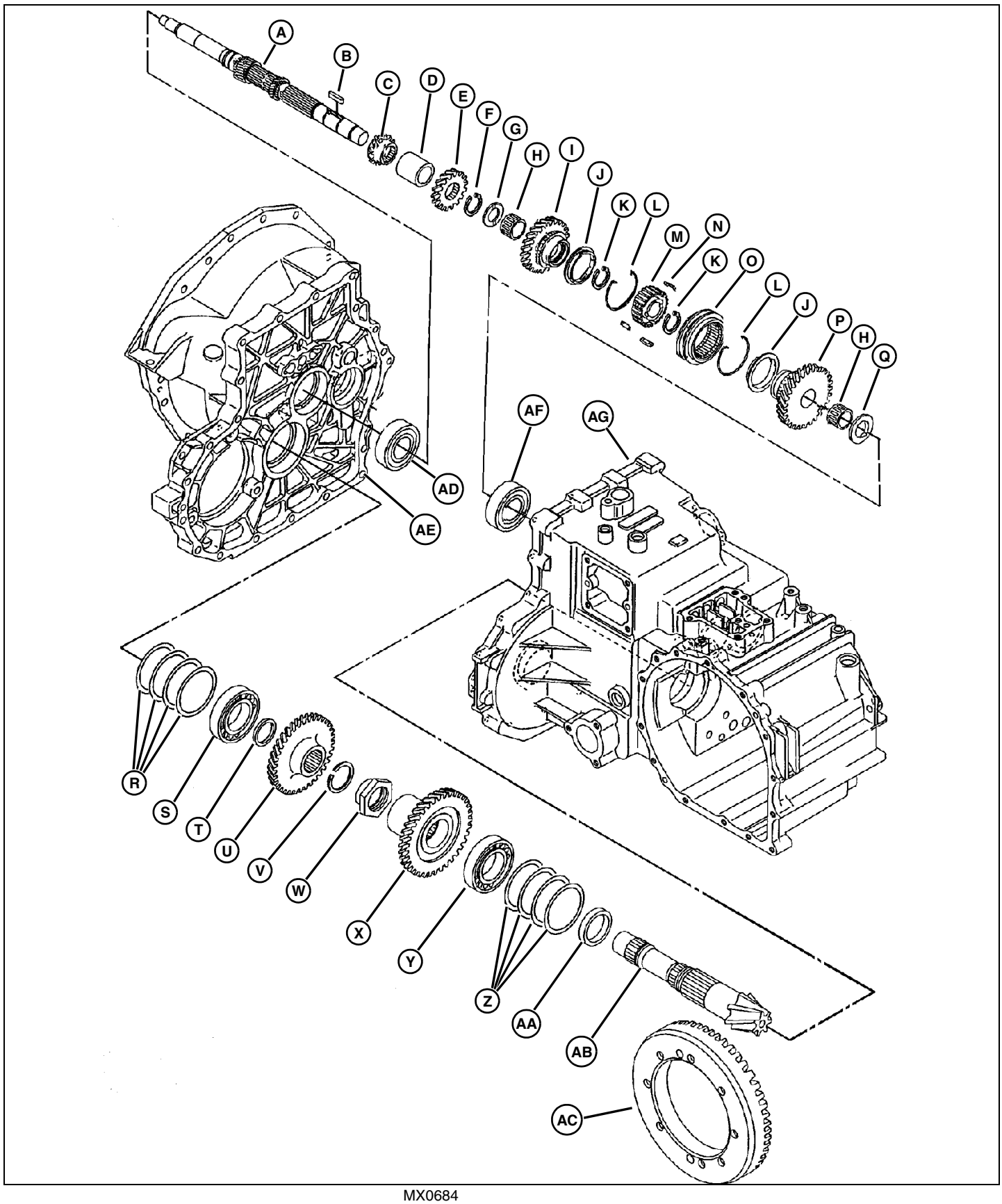


MX0683

A - Shifter Fork (R-1)
B - Shifter Shaft (R-1)
C - Shifter Fork (2-3)
D - Shifter Shaft (2-3)
E - Spring Pin (6 used)
F - Shifter Fork (4-5)
G - Shifter Shaft (4-5)
H - Cap Screw with Washer (2 used)
I - Detent Ball (5 used)
J - Bolt (4 used)
K - Seal (4 used)
L - Spring (3 used)
M - Cap Screw with Washer (3 used)
N - Cover
O - Gasket
P - Seal
Q - Pin (2 used)
R - Pin
S - Shift Collar (R-1)
T - Shift Fork
U - Shift Arm

V - Spring (2 used)
W - Spring
X - Spacer (4 used)
Y - Snap Ring (4 used)
Z - Selector Shaft
AA- Cover
AB- Spring Pin
AC- Spring Pin
AD- Nut
AE- Washer
AF- Bolt
AG- Control Arm
AH- Seal

Input Shaft and Pinion Component Location

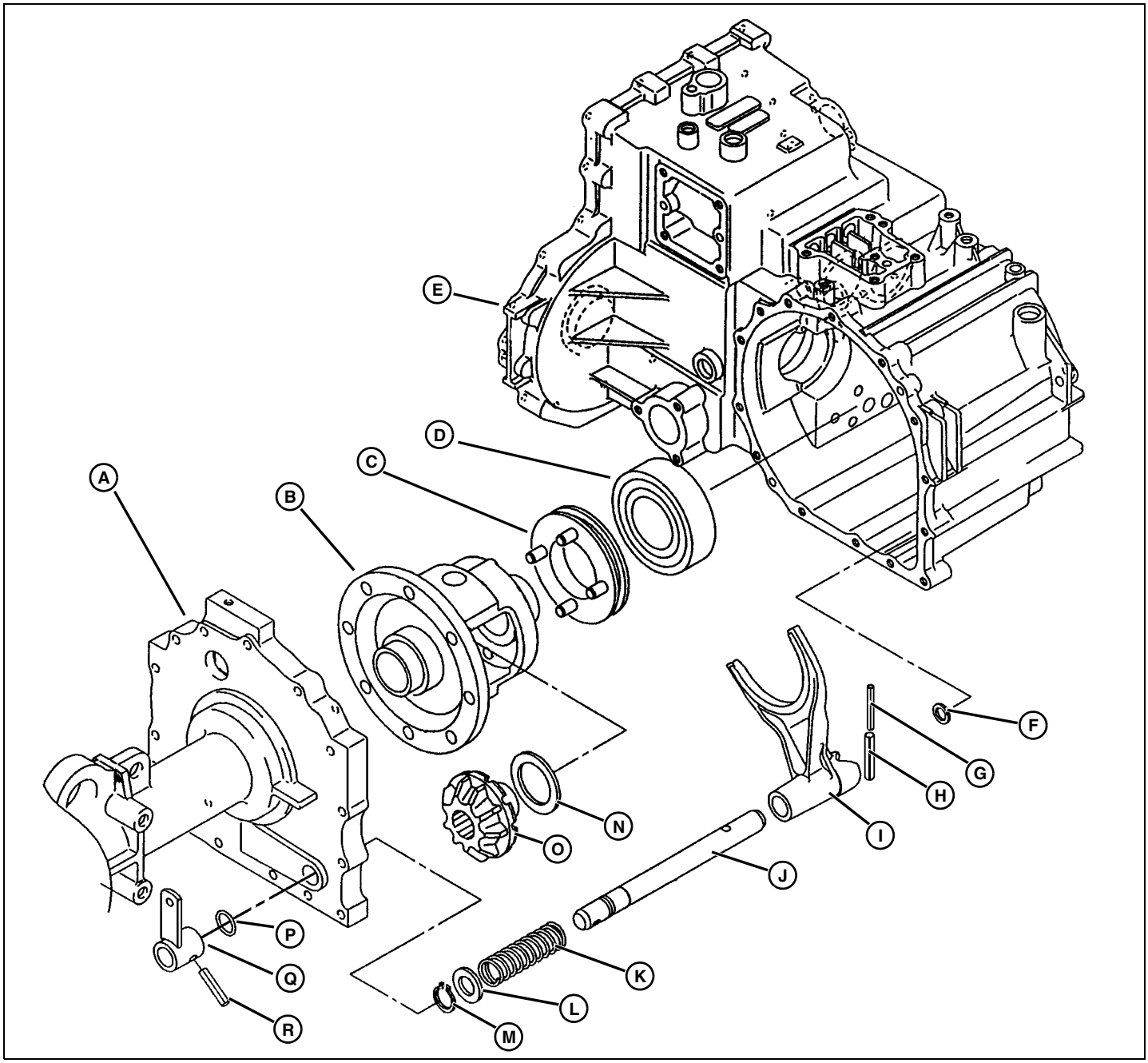


MX0684

POWER TRAIN - GEAR COMPONENT LOCATION

A - Input Shaft
B - Shaft Key
C - Gear (16T)
D - Bushing
E - Gear (23T)
F - Ring
G - Washer
H - Needle Bearing (2 used)
I - Gear (33T)
J - Ring (2 used)
K - Spring (2 used)
L - Spring (2 used)
M - Hub
N - Key (3 used)
O - Shift Collar
P - Gear (36T)
Q - Washer
R - Shim (As required)
S - Bearing
T - Bushing
U - Gear (40T) (4WD)
V - Snap Ring
W - Locknut
X - Gear (36T)
Y - Bearing
Z - Shim (As required - cone point dimension adjustment)
AA- Bushing
AB- Pinion
AC- Ring Gear
AD- Ball Bearing
AE- Clutch Housing
AF- Ball Bearing
AG- Transaxle Case

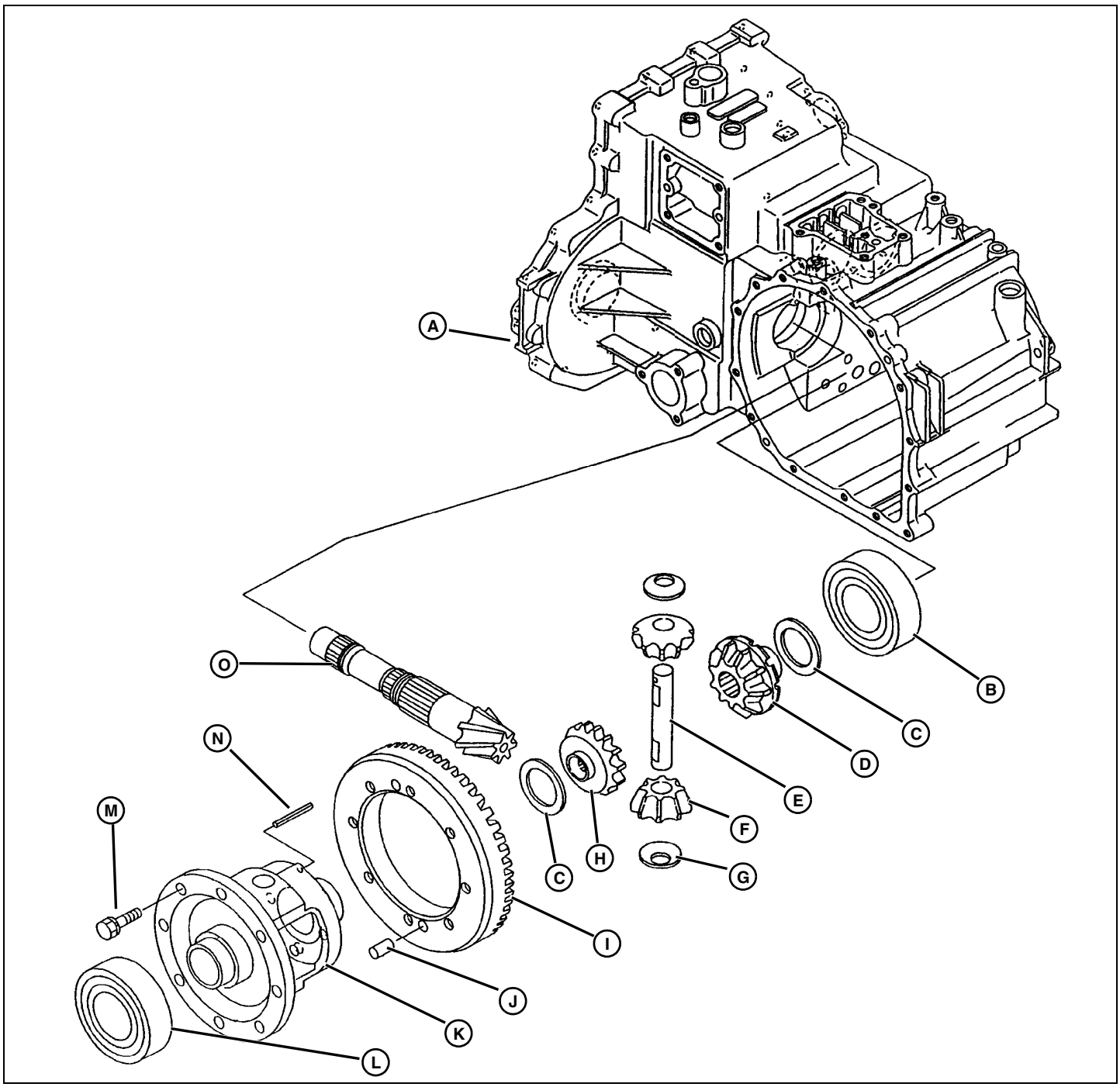
Differential Lock Component Location



MX0685

A - Housing
B - Differential Case
C - Lock Collar
D - Bearing
E - Transaxle Case
F - Washer
G - Spring Pin
H - Spring Pin
I - Lock Fork
J - Shaft
K - Spring
L - Washer
M - Snap Ring
N - Washer (2 used)
O - Side Lock Gear
P - Seal
Q - Lock Arm
R - Spring Pin

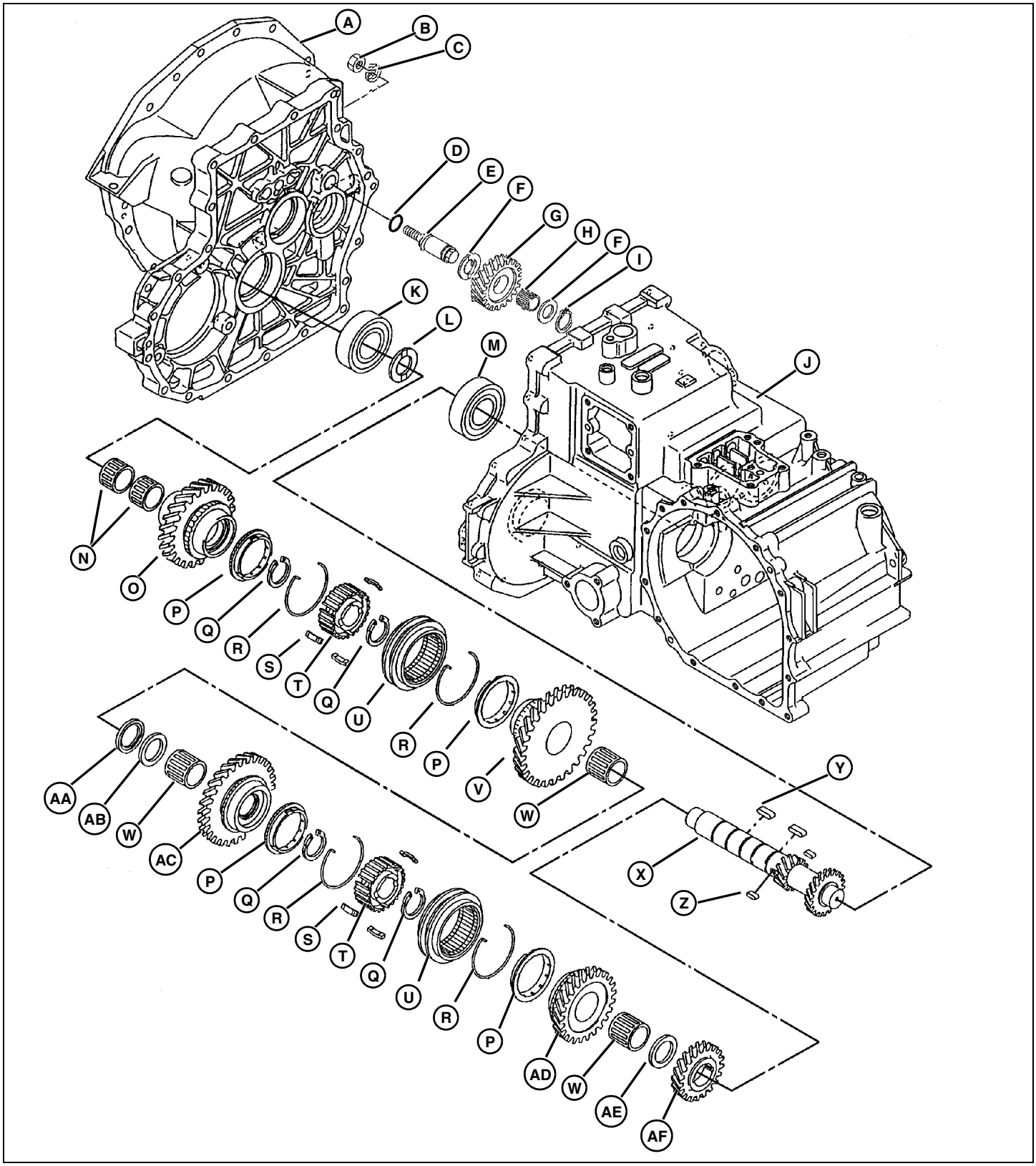
Differential Component Location



MX0686

A - Transaxle Case
B - Bearing
C - Washer (2 used)
D - Side Lock Gear
E - Pinion Shaft
F - Pinion Gear (2 used)
G - Washer
H - Side Gear
I - Ring Gear
J - Pin (2 used)
K - Differential Case
L - Bearing
M - Bolt (12 used)
N - Spring Pin
O - Pinion

Reverse and Reduction Shaft Component Location

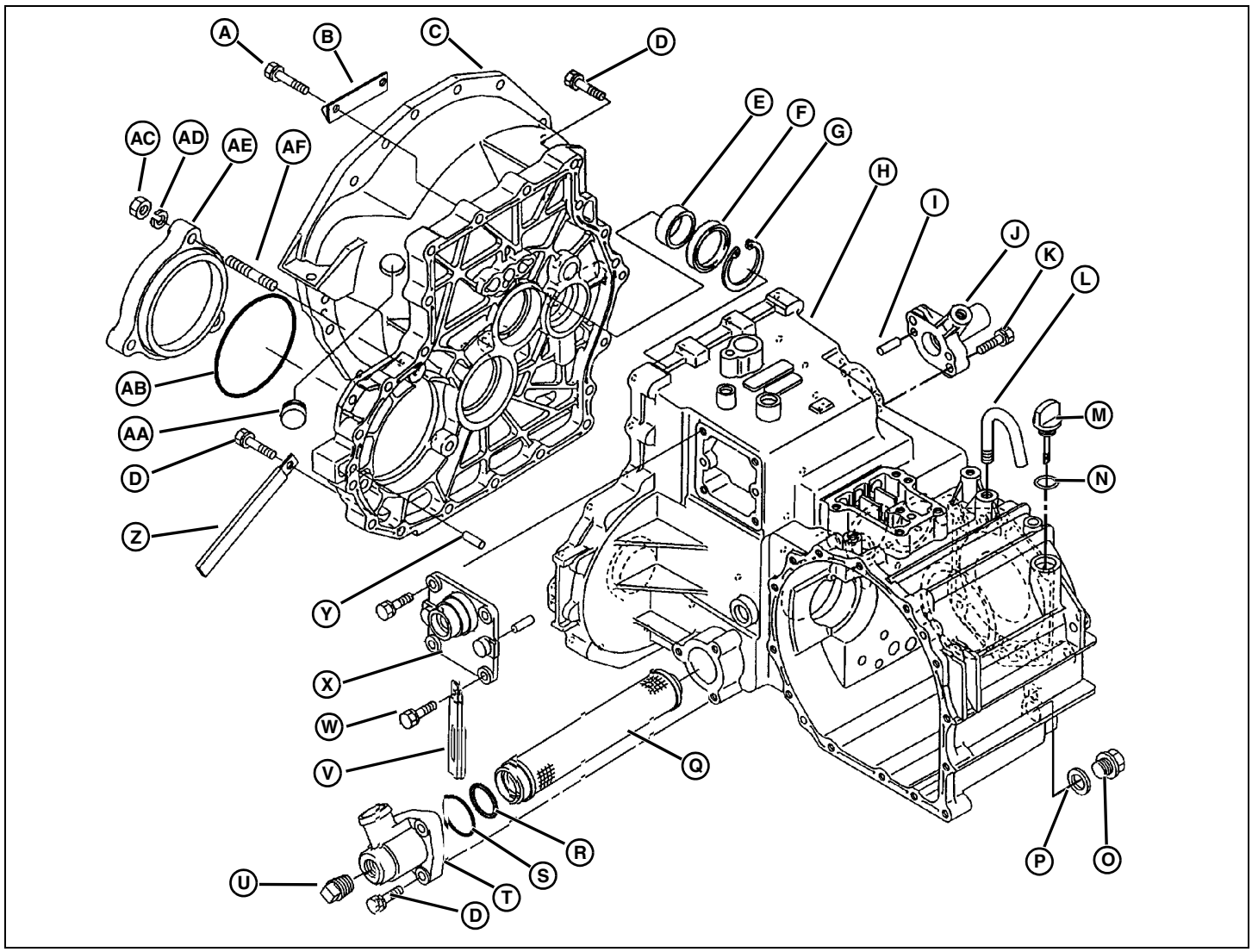


MX0687

POWER TRAIN - GEAR COMPONENT LOCATION

A - Clutch Housing
B - Nut
C - Seal
D - Side Lock Gear
E - Reverse Shaft
F - Washer (2 used)
G - Reverse Gear (29T)
H - Needle Bearing
I - Snap Ring
J - Transaxle Case
K - Ball Bearing
L - Washer
M - Ball Bearing
N - Needle Bearing (2 used)
O - Reduction Gear (39T)
P - Ring (4 used)
Q - Snap Ring (5 used)
R - Spring (4 used)
S - Key (6 used)
T - Hub (2 used)
U - Shift Collar (2 used)
V - Reduction Gear (50 T)
W - Needle Bearing (3 used)
X - Reduction Shaft
Y - Key (2 used)
Z - Key (2 used)
AA- Washer
AB- Washer
AC- Reduction Gear (44T)
AD- Reduction Gear (37T)
AE- Washer
AF- Reduction Gear (28T)

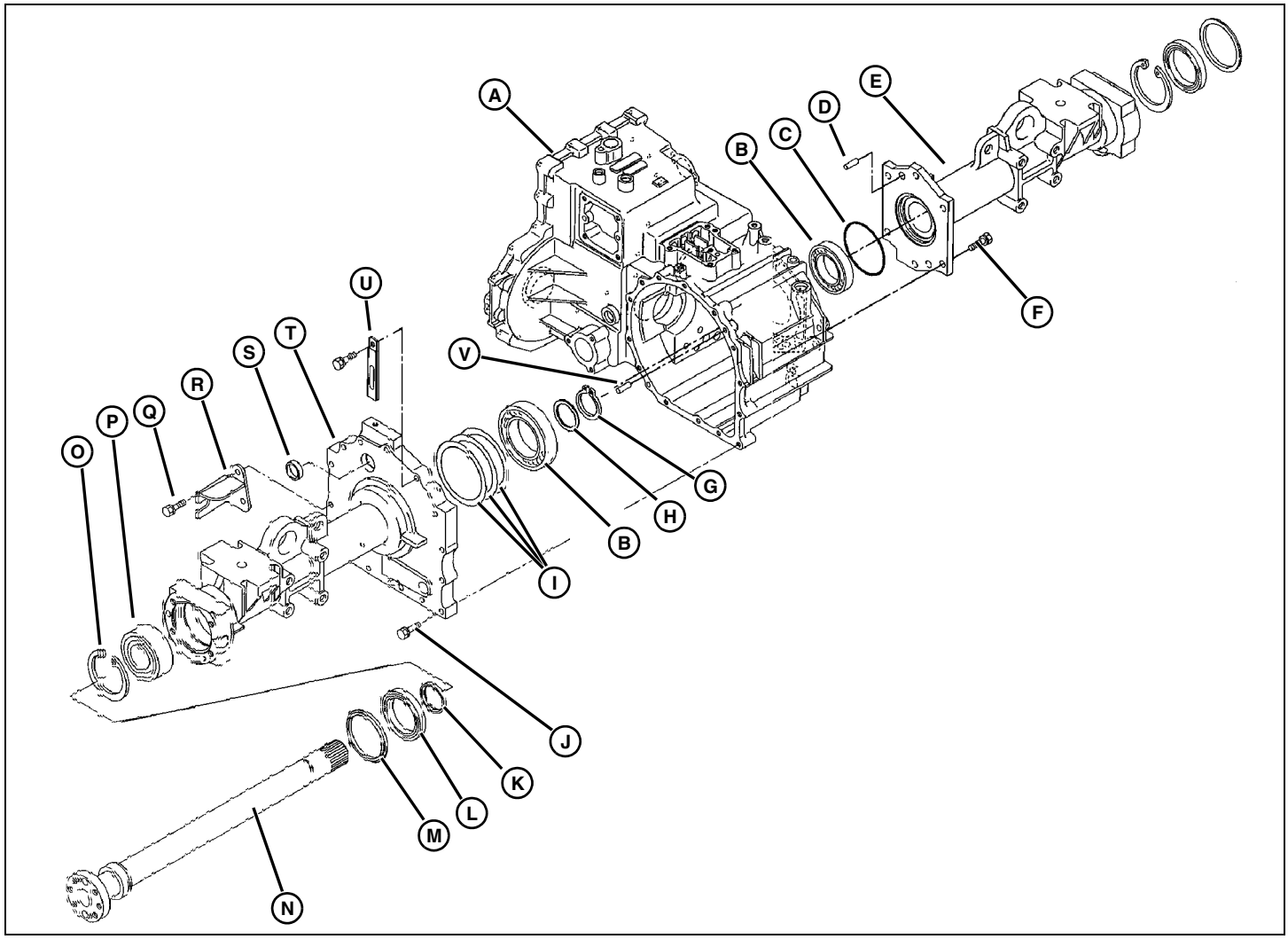
Transaxle Case Component Location



MX0688

A - Cap Screw with Washer (2 used)
B - Bracket
C - Clutch Housing
D - Cap Screw with Washer (23 used)
E - Sleeve
F - Seal
G - Snap Ring
H - Transaxle Case
I - Pin (4 used)
J - Cover
K - Screw (2 used)
L - Fitting
M - Dip Stick
N - O-Ring
O - Drain Plug
P - Gasket
Q - Strainer
R - O-Ring
S - Seal
T - Adapter
U - Drain Plug
V - Clamp
W - Cap Screw with Washer (4 used)
X - Cover
Y - Pin (2 used)
Z - Clamp
AA- Cap (2 used)
AB- Seal
AC- Nut (3 used)
AD- Lock Washer (3 used)
AE- Cover
AF- Stud (3 used)

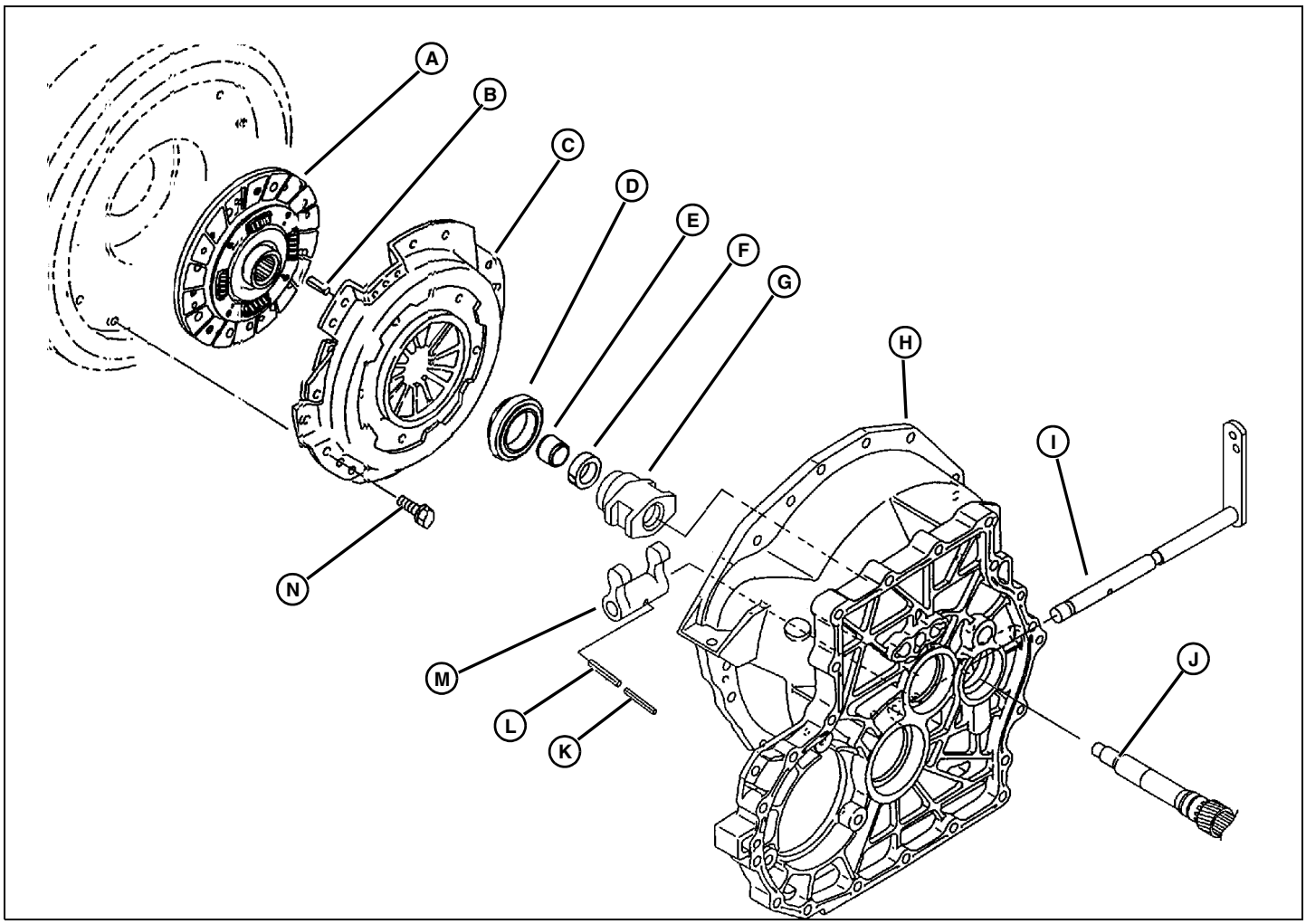
Axle Housing Component Location



MX0692

A - Transaxle Case
B - Bearing (2 used)
C - O-Ring
D - Pin (2 used)
E - Axle Housing (Right side)
F - Cap Screw (6 used)
G - Snap Ring (2 used)
H - Bushing (2 used)
I - Shim Kit (used for backlash adjustment)
J - Cap Screw with Washer (12 used)
K - Bushing (2 used)
L - Seal (2 used)
M - Bushing (2 used)
N - Axle (Left axle shown)
O - Snap Ring (2 used)
P - Bearing (2 used)
Q - Cap Screw with Washer (2 used)
R - Differential Lock Bracket
S - Cap
T - Axle Housing (Left side)
U - Clamp
V - Pin (2 used)

Clutch Assembly Component Location



MX0678

A - Clutch Disc
B - Pin (3 used)
C - Pressure Plate
D - Bearing
E - Bushing
F - Seal
G - Sleeve
H - Clutch Housing
I - Shaft
J - Input Shaft
K - Spring Pin
L - Spring Pin
M - Clutch Fork
N - Bolt (6 used)

Theory of Operation

Transaxle

Function

The transaxle consists of a five forward speed and one reverse speed transmission. The output shaft of the transmission is the pinion shaft of the differential. Power goes through the pinion shaft and ring gear, through the bevel gears to the axles and wheels.

Theory

Primary Drive

The transaxle is a synchronized five speed manual shift transmission with reverse.

The higher the number of the gear selected, the faster the ground speed of the vehicle. The low speeds provide precise ground speeds for use with implements. Neutral allows the ground drive gear train to be disengaged from the engine and still allow use of the PTO to operate implements without the danger of vehicle movement. Reverse allows movement of the vehicle in the reverse direction.

Once the shift lever has been moved from the neutral position to gear selection, power goes through the selected gear, pinion shaft to the rear differential and axles to the rear wheels. If equipped with four wheel drive, through the bi-directional clutch, front wheel drive shaft, to the front wheel drive differential and front wheels. The bi-directional clutch automatically transmits power to the front differential only when a difference in front and rear wheel speed is detected.

A rear differential lock is also provided to maximize rear wheel traction. When the rear differential lock is engaged it locks the spider gears in the rear differential carrier causing both rear wheels to turn simultaneously regardless of traction conditions. The differential lock should only be used under extreme conditions as it can impair steering.

Diagnostics

Drive Train Troubleshooting

Symptom: Machine Will Not Move in Forward or Reverse

(1) Park brake disengaged (OFF)?

Yes - Go to step (2).

No - Disengage park brake.

(2) Park brake cable properly adjusted and not binding?

Yes - Go to step (3).

No - Repair or replace cable and adjust. (See “Adjust Park Brake Cable” on page 447.)

(3) Shift lever and/or linkage moves freely and isn't loose, binding or damaged?

Yes - Go to step (4).

No - Repair or replace as needed.

(4) Clutch pedal, bellcrank and cable move freely and are not binding or damaged?

Yes - Go to step (5).

No - Repair or replace as needed.

(5) Is clutch properly adjusted?

Yes - Go to step (6).

No - Adjust clutch. (See “Adjust Clutch” on page 161 in the Diesel Engine section.)

(6) Is clutch fully engaging and not slipping?

Yes - Go to step (7).

No - Remove and repair clutch. (See “Remove and Install Clutch and Flywheel” on page 159 in the Diesel Engine section.)

(7) Are splines on input shaft and clutch disc not worn or damaged?

Yes - Go to step (8).

No - Replace clutch disk and/or input shaft.

(8) Transaxle quiet and spinning freely when clutch is engaged?

No - Repair or replace as needed. (See “Remove and Install Transaxle” on page 357 and “Disassemble Transaxle” on page 360.)

Symptom: Low Power/Erratic Drive

(1) Park brake cable properly adjusted and not binding?

Yes - Go to step (2).

No - Repair or replace cable and adjust. (See “Adjust Park Brake Cable” on page 447.)

(2) Clutch pedal, bellcrank and cable move freely and are not binding or damaged?

Yes - Go to step (3).

No - Check clutch release bearing. Repair as required.

(3) Is clutch properly adjusted?

Yes - Go to step (4).

No - Adjust clutch. (See “Adjust Clutch” on page 161 in the Diesel Engine section.)

(4) Is clutch fully engaging and not slipping?

Yes - Go to step (5).

No - Remove and repair clutch. (See “Remove and Install Clutch and Flywheel” on page 159 in the Diesel Engine section.)

(5) Are friction surfaces of clutch and clutch cover free of oil and grease contamination?

Yes - Go to step (6).

No - Clean or replace components as necessary. Locate and correct source of contamination.

(6) Are splines on input shaft and clutch disc not worn or damaged?

Yes - Go to step (7).

No - Replace clutch disk or input shaft.

(7) Transaxle quiet and spinning freely when clutch is engaged?

No - Repair or replace as needed. (See “Remove and Install Transaxle” on page 357 and “Disassemble Transaxle” on page 360.)

Symptom: Jerky and Aggressive Engagement

(1) Clutch pedal, bellcrank and cable move freely and are not binding or damaged?

Yes - Go to step (2).

No - Check clutch release bearing. Repair or replace as needed.

Symptom: Jerky and Aggressive Engagement

(2) Is clutch properly adjusted?

Yes - Go to step (3).

No - Adjust clutch. (See “Adjust Clutch” on page 161 in the Diesel Engine section.)

(3) Is clutch fully engaging and not slipping?

Yes - Go to step (4).

No - Remove and repair clutch. (See “Remove and Install Clutch and Flywheel” on page 159 in the Diesel Engine section.)

(4) Are friction surfaces of clutch and clutch cover free of oil and grease contamination?

Yes - Go to step (5).

No - Clean or replace components as necessary. Locate and correct source of contamination.

(5) Are splines on input shaft and clutch disc not worn or damaged?

No - Replace clutch disk and/or input shaft.

Symptom: Shifts Hard

(1) Shift lever and/or linkage moves freely and isn't loose, binding or damaged?

Yes - Go to step (2).

No - Repair or replace as needed.

(2) Clutch pedal, bellcrank and cable move freely and are not binding or damaged?

Yes - Go to step (3).

No - Check clutch release bearing. Repair or replace as needed.

(3) Is clutch properly adjusted?

Yes - Go to step (4).

No - Adjust clutch. (See “Adjust Clutch” on page 161 in the Diesel Engine section.)

(4) Transaxle quiet and spinning freely when clutch is engaged?

No - Repair or replace as needed. (See “Remove and Install Transaxle” on page 357 and “Disassemble Transaxle” on page 360.)

Symptom: Noisy Operation

(1) Is clutch properly adjusted?

Yes - Go to step (2).

No - Adjust clutch. (See “Adjust Clutch” on page 161 in the Diesel Engine section.)

(2) Is noise NOT present when clutch pedal is depressed?

Yes - Go to step (3).

No - Possible failing release bearing. (See “Replace Clutch Release Bearing” on page 160 in the Diesel Engine section.)

(3) Is the engine and transaxle mounting hardware tightened correctly?

Yes - Go to step (4).

No - Tighten hardware to specification.

(4) Transaxle quiet and spinning freely when clutch is engaged?

No - Repair or replace as needed. (See “Remove and Install Transaxle” on page 357 and “Disassemble Transaxle” on page 360.)

Symptom: Front Wheels Lock Up on MFWD Vehicles When Changing Direction from Reverse to Forward.

(1) Did vehicle come to a complete stop before shifting?

Yes - Go to step (2).

No - Changing direction while in motion or on an incline may cause the 4WD clutch to lock up. Vehicle must completely stop before shifting.

(2) Was vehicle on a hill when changing direction?

No - Possible failed 4WD clutch. Repair as required.

Symptom: MFWD Not Functioning

(1) With all four wheels off the ground, transmission in a forward gear, and engine running, does drive shaft rotate?

Yes - Go to step (2).

No - Inspect transaxle or bi-directional clutch.

(2) With all four wheels off the ground, transmission in a forward gear, and engine running, do the front wheel(s) rotate?

Yes - Go to step (3).

No - Inspect MFWD differential or slip clutch.

Symptom: MFWD Not Functioning

(3) With all four wheels off the ground, transmission in neutral, and engine stopped (key switch OFF), manually rotate one front wheel. Does the opposing front wheel rotate in the opposite direction?

Yes - Go to step (4).

No - Repair the MFWD differential. (See “Remove and Disassemble MFWD Differential” on page 378.)

(4) With all four wheels off the ground, transmission in neutral, and engine stopped (key switch OFF), hold one front wheel while manually rotating the other front wheel. Does the drive shaft rotate?

Yes - Go to step (5).

No - Repair the MFWD slip clutch. (See “Remove and Install MFWD Differential Clutch” on page 377.)

(5) With both rear wheels OFF the ground, both front wheels ON the ground, transmission in neutral, and engine stopped (key switch OFF), try to manually rotate the drive shaft. Does the drive shaft rotate?

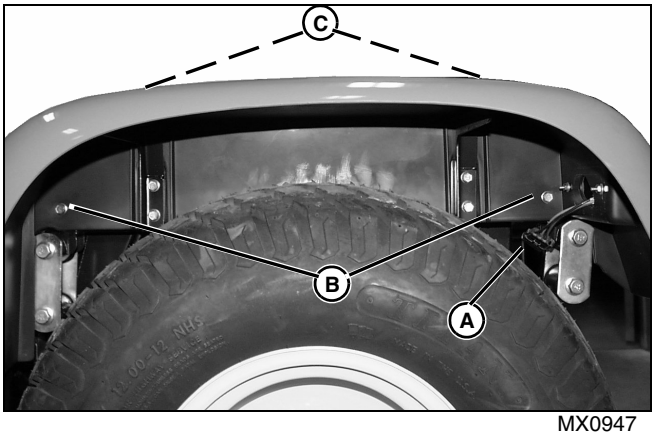
Yes - Repair the MFWD slip clutch. (See “Remove and Install MFWD Differential Clutch” on page 377.)

Repair

Remove and Install Transaxle

NOTE: The rear frame of the machine will have to be lifted to clear transaxle as it is rolled out. Park machine where it will be accessible to a lift.

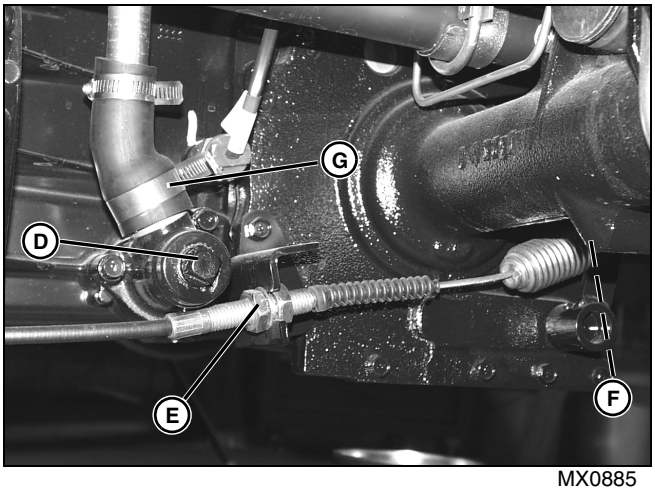
1. Park machine safely.



MX0947

2. Disconnect tail light plug (A), remove cap screws (B), and hex head screws (C), from top of rear fenders.

3. Remove rear fenders.

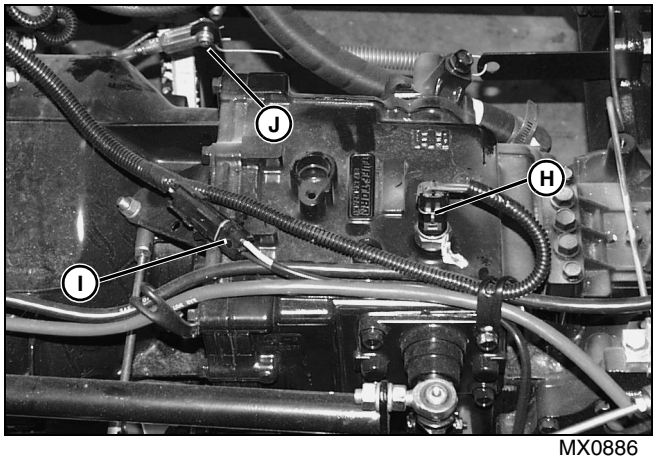


MX0885

4. Remove plug (D) and drain oil from transaxle.

5. Loosen nuts (E) on differential lock cable and pull cable away from bracket. Disconnect spring (F) from lever.

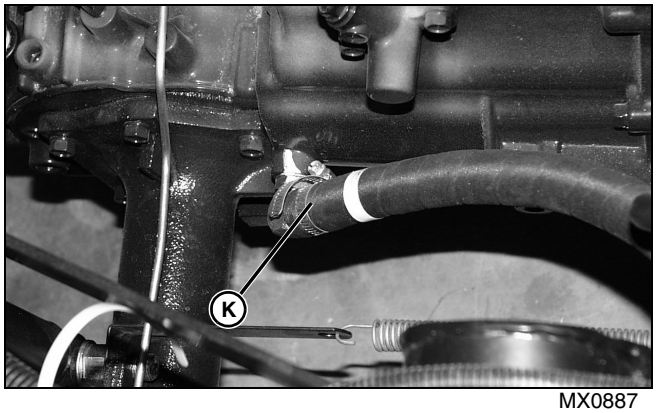
6. Disconnect hydraulic oil suction line (G).



MX0886

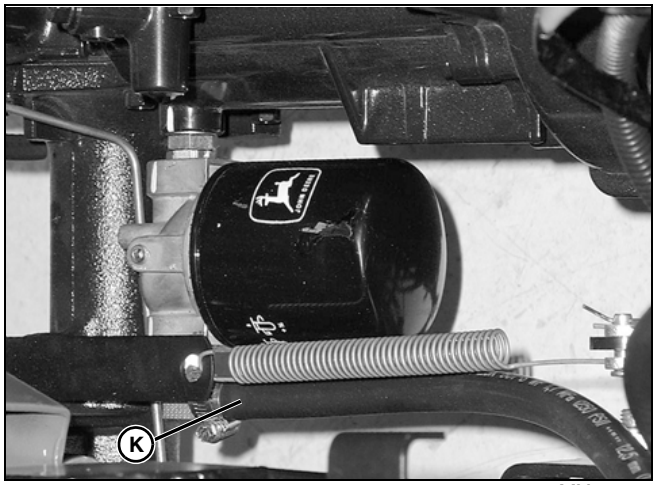
7. Disconnect neutral switch (H) and speedometer sensor (I).

8. Disconnect clutch cable yoke (J) from lever.



MX0887

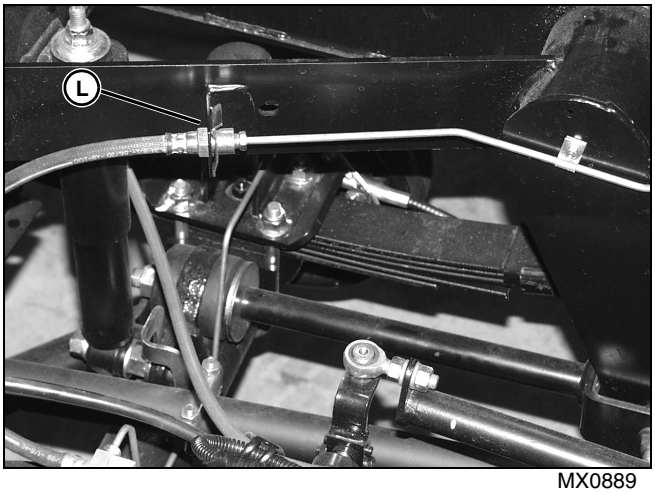
Picture Note: Shown with Standard Hydraulics



MX8595

Picture Note: Shown with Auxiliary Hydraulics

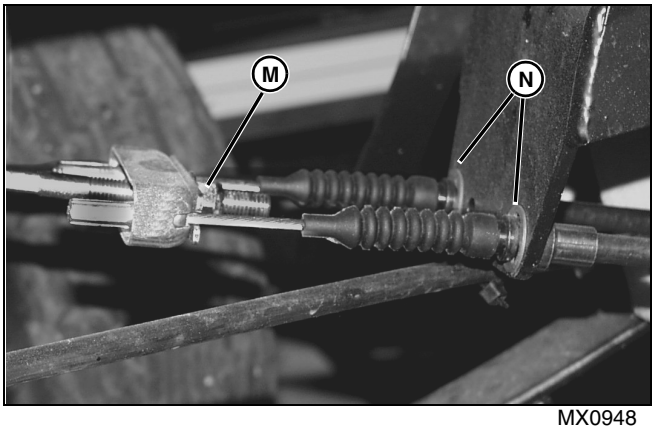
9. Remove hydraulic pump return line (K).



MX0889

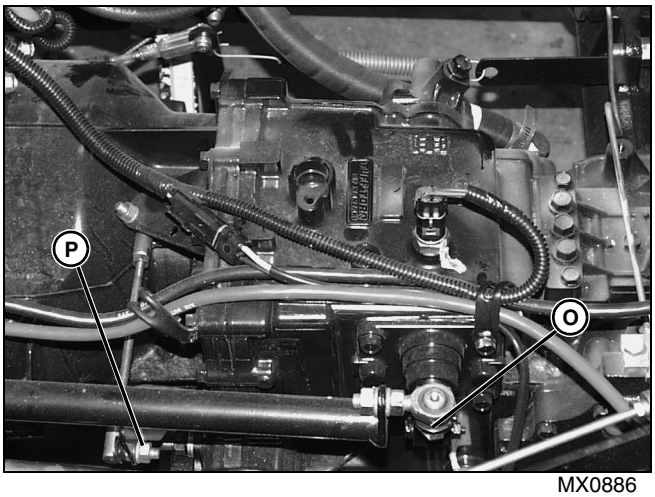
Picture Note: S.N. (020000-) Shown

10.Disconnect brake hose (L) and cap ends.



MX0948

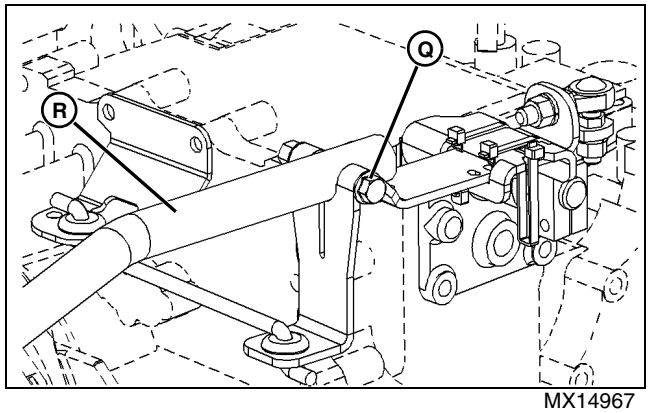
11.Loosen nut (M), remove clips (N), and remove park brake cables from balancer and bracket.



MX0886

Picture Note: S.N. (-035000) Shown

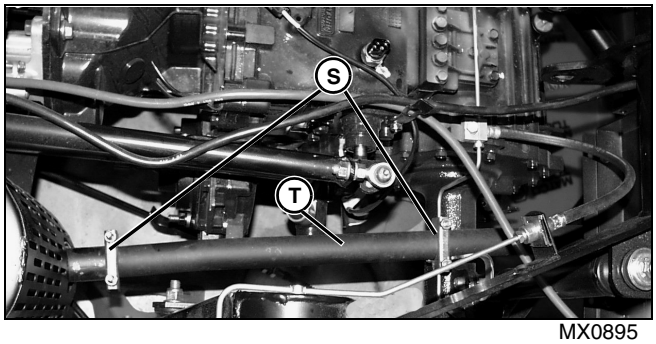
12. S.N. (-035000): Disconnect shifter tube (O) from lever on transaxle. Remove rod (P) from reaction link.



MX14967

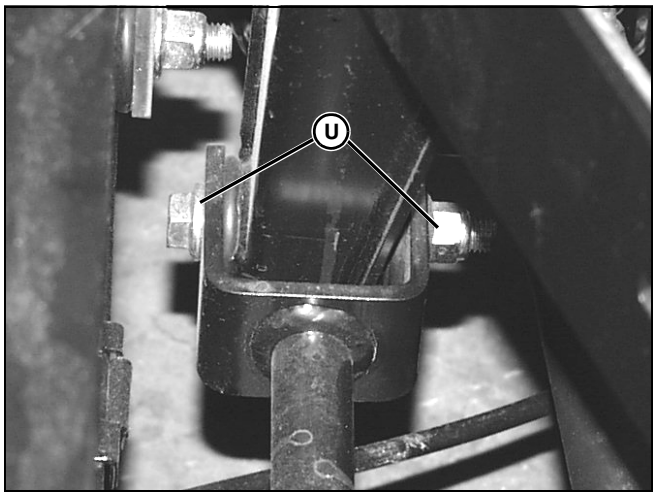
Picture Note: S.N. (035001-) Shown

13.S.N. (035000-): Remove cap screw and nut Q) and disconnect shifter tube (R) from shift lever.



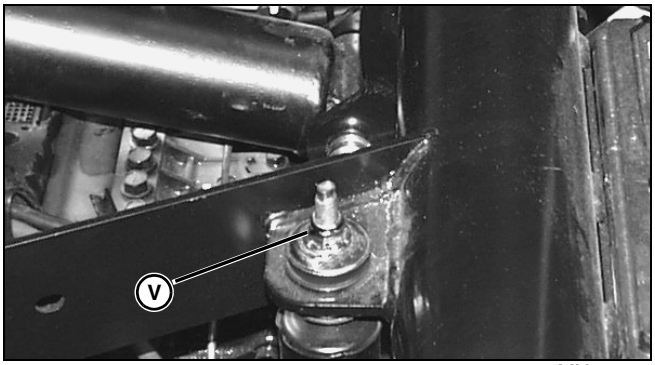
MX0895

14.Remove clamps (S) and tailpipe (T).



MX0951

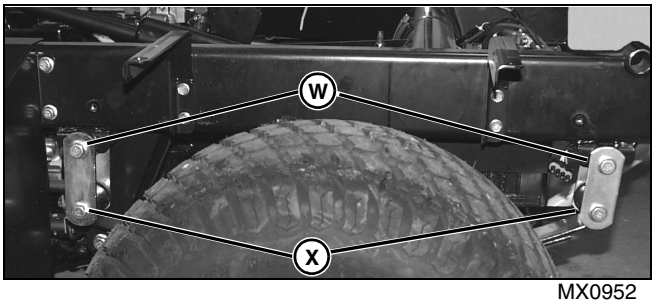
15.**S.N. (-035000):** Remove cap screws and nuts (U) from front of torque arms. (Not required for S.N. [035001-].)



MX0949

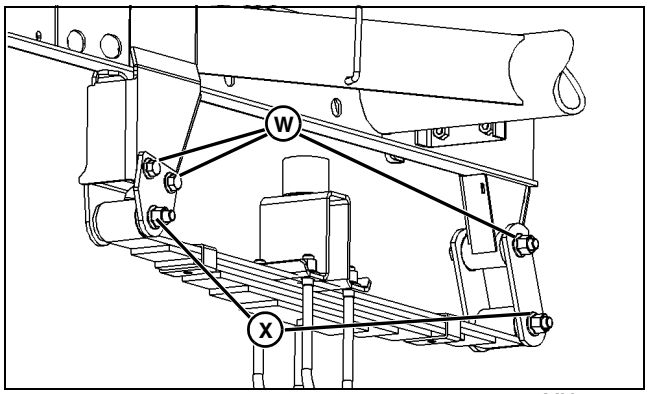
16.Remove nuts (V), from upper shock mounts and push shocks down to clear frame.

17.Support vehicle frame.



MX0952

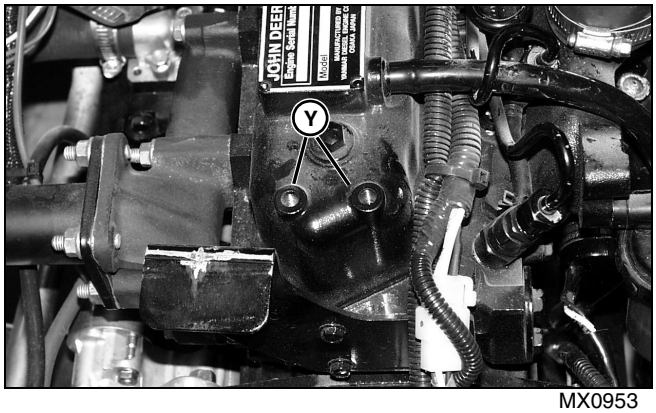
Picture Note: S.N. (-035000)



MX14968

Picture Note: S.N. (035001-) Shown

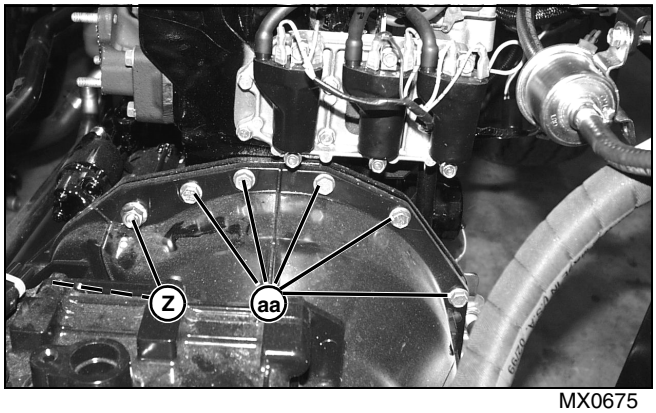
18. Remove cap screws (W) from top of spring shackles, and loosen bottom cap screws (X).



MX0953

19.A support for rear of engine can be fabricated by using a piece of angle iron. Cut angle iron long enough to rest across frame rails, then drill holes in angle iron to match threaded holes in rear of valve cover (Y). Install cap screws to support engine.

20.Place floor jack under clutch housing to support front of transaxle.



MX0675

21.Remove nuts from starter mounting cap screws (Z) and total of eleven clutch housing cap screws (aa).

22.Roll transaxle back from engine until input shaft is clear of clutch.

23.Raise rear of machine and remove transaxle.

Installation

1. Install transaxle in the reverse order of removal.

2. If clutch has been disturbed, check alignment with JDG1331 clutch alignment tool before installing transaxle.

3. Tighten clutch housing cap screws to specification.

4. Tighten spring shackle cap screws to specification.

5. After installing brake line, bleed brakes and fill master cylinder reservoir with approved DOT 3 brake fluid.

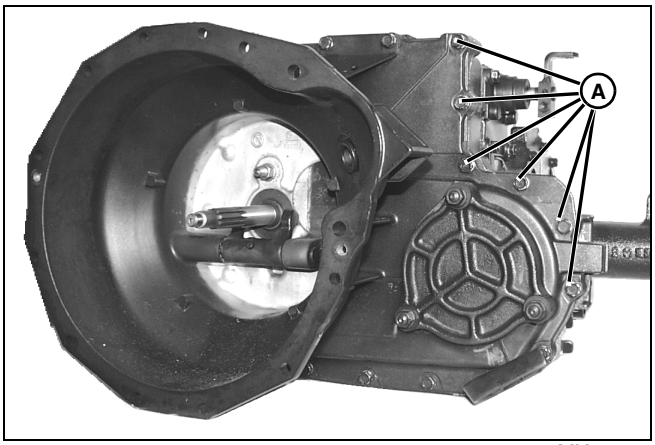
6. Fill transaxle with oil until oil reaches “full” mark on dipstick.

NOTE: If transaxle leaf spring is removed or replaced, spring attaching U-bolts must be tightened correctly. Tighten U-bolt locknuts to specification in a criss-cross pattern using multiple passes. Allow one revolution of nut during each pass to ensure even U-bolt preload.

Specifications

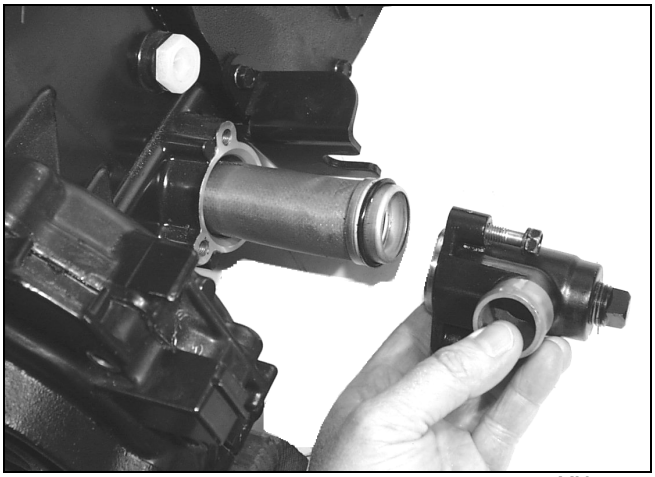
Clutch Housing Cap
Screw Torque . . . . . 23-29 N•m (17-22 lb-ft)
Spring Shackle Cap
Screw Torque . . . . . 102 N•m (75 lb-ft)
Leaf Spring U-Bolt Nut Torque . . . . . 129 N•m (95 lb-ft)

Disassemble Transaxle



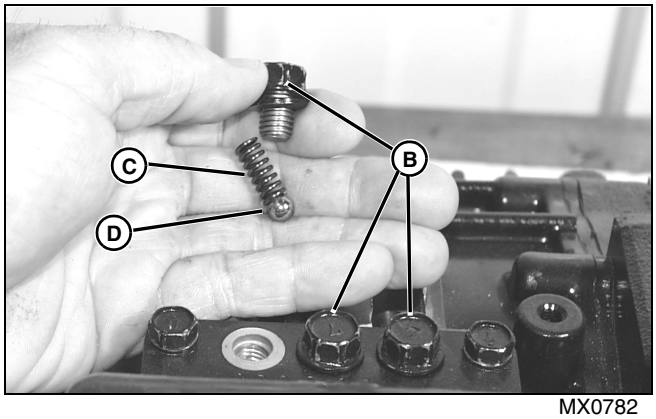
MX0780

1. Remove cap screws (A) (total of 20) securing clutch housing to transaxle case.



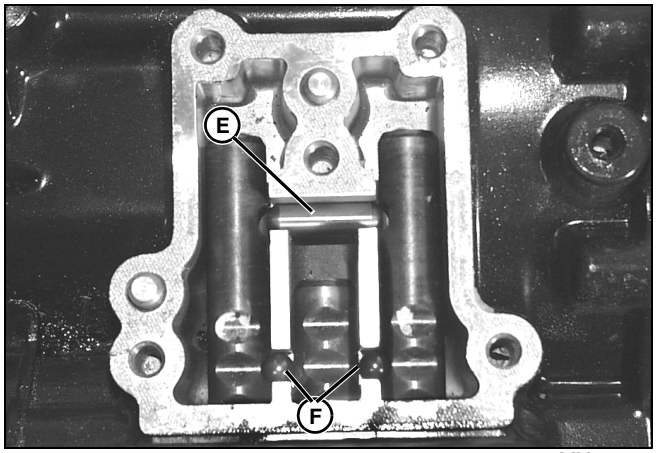
MX0946

2. Remove elbow and screen.



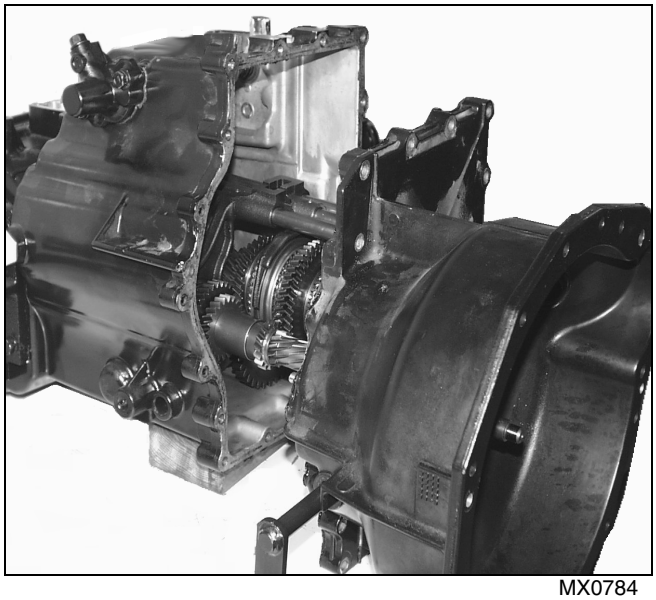
MX0782

3. Remove three cap screws (B) from shaft cover.
4. With a magnet, remove springs (C), and balls (D).
5. Remove shaft cover.



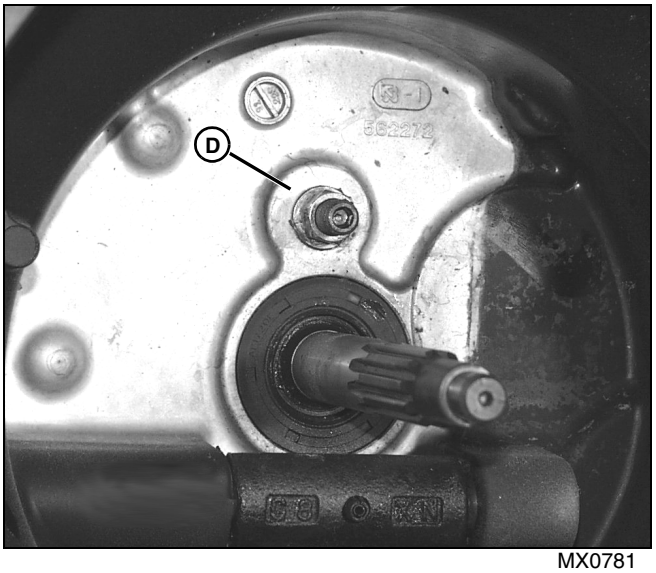
MX0783

6. Remove pin (E) and balls (F) from shift shafts.



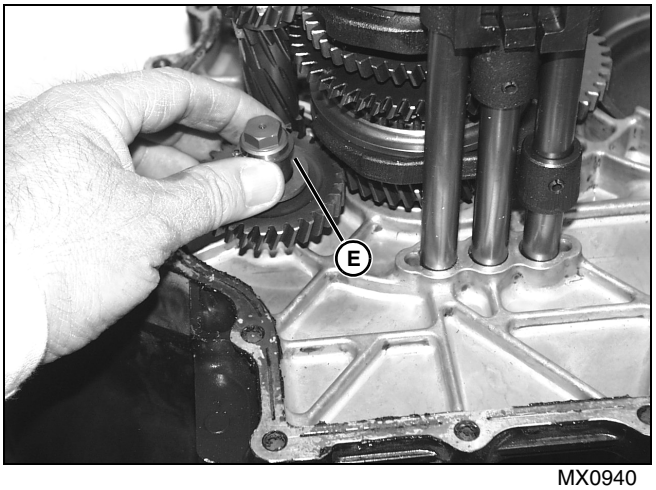
MX0784

7. Remove clutch cover and all transmission components as an assembly.



MX0781

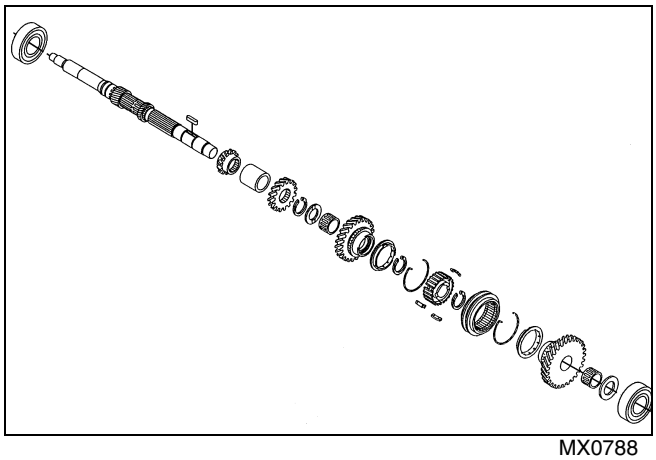
8. Remove nut (D).



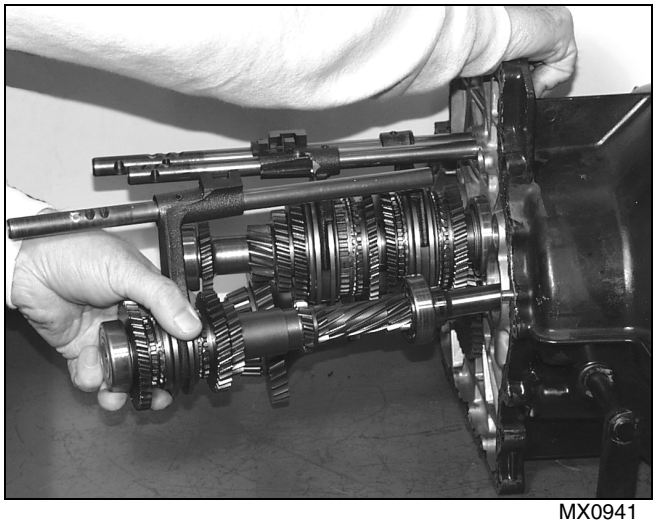
MX0940

9. Remove reverse idler gear and shaft (E).

Disassemble and Assemble Input Shaft



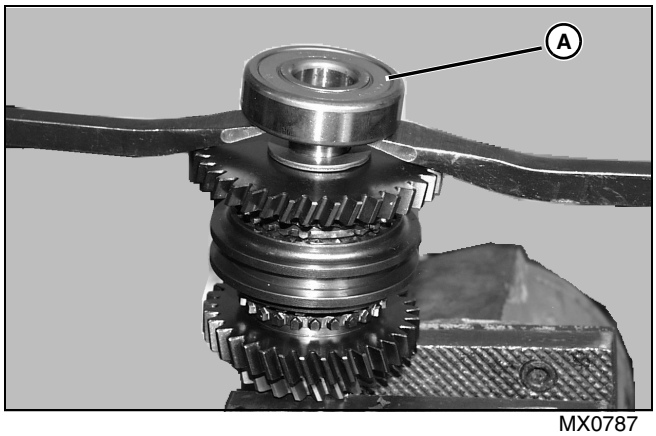
MX0788



MX0941

1. Simultaneously pull all three shafts out just enough that input shaft can be removed.

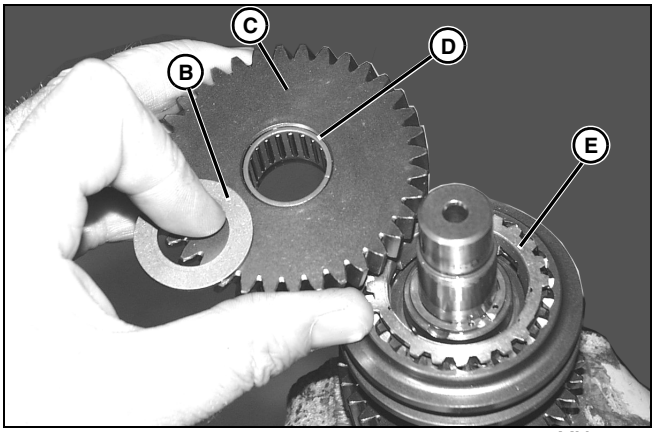
NOTE: Bearing (A) is sealed only on one side. Sealed side must face away from gear, as shown, when reassembled.



MX0787

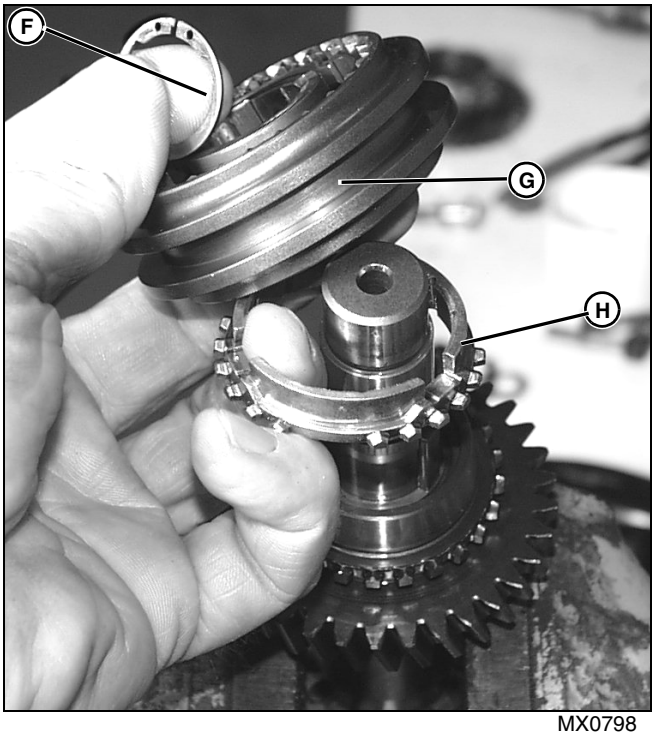
2. Remove bearing (A) from end of shaft.

NOTE: Oil grooves in washer (B) face toward gear.



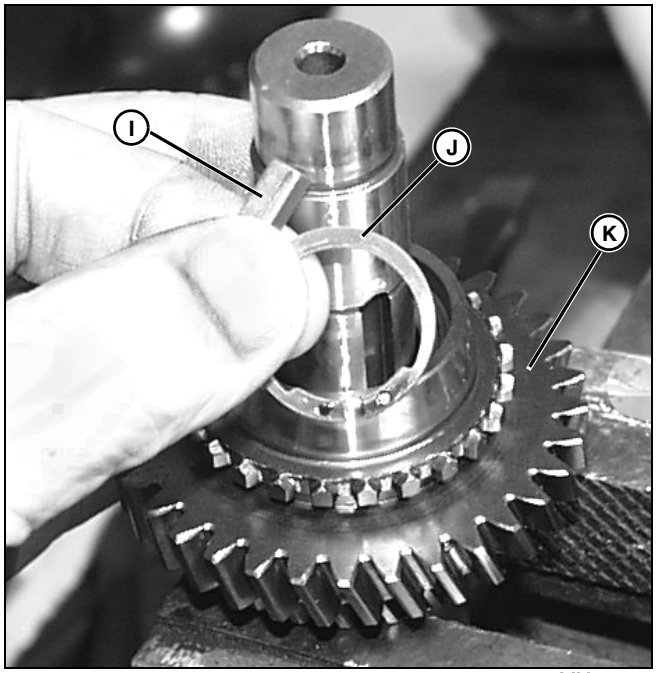
MX0789

3. Remove washer (B), gear (C), bearing (D), and synchronizer (E).



MX0798

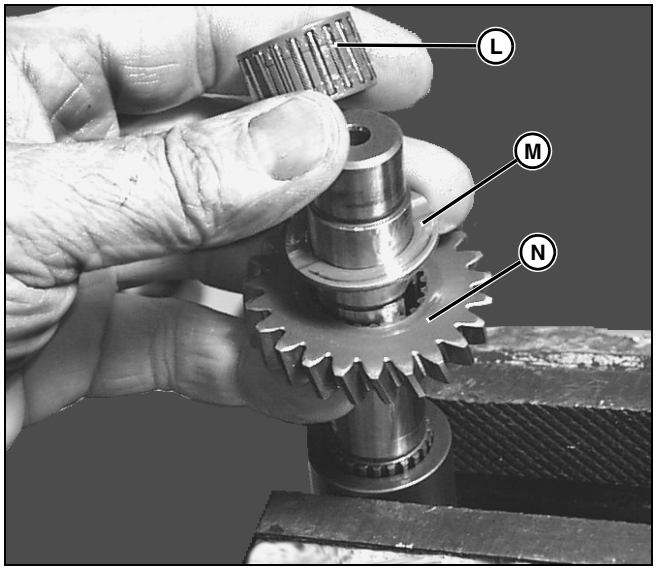
4. Remove snap ring (F), sliding clutch (G) and bottom synchronizer (H).



MX0799

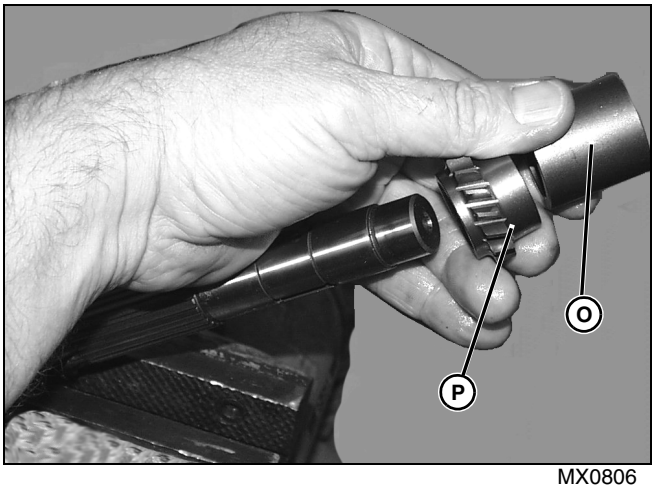
5. Remove shaft key (I), snap ring (J), and gear (K).

NOTE: Oil grooves in washer (M) face up as shown.



MX0805

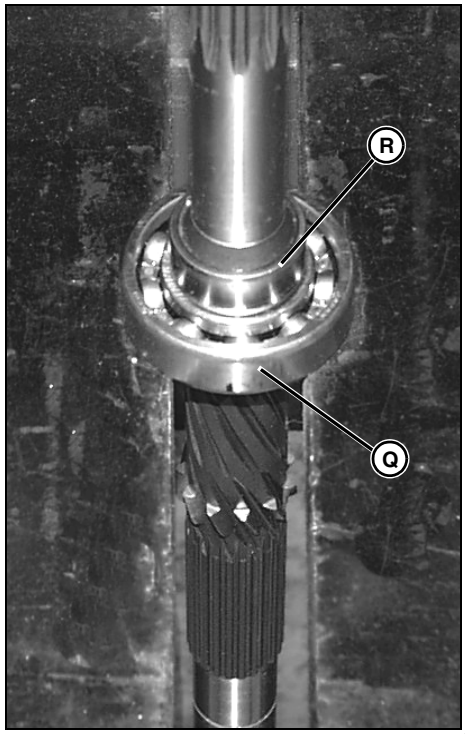
6. Remove bearing (L), washer (M), and gear (N), from the shaft. Machines with serial numbers above (001369-) have a snap ring between washer and gear.



MX0806

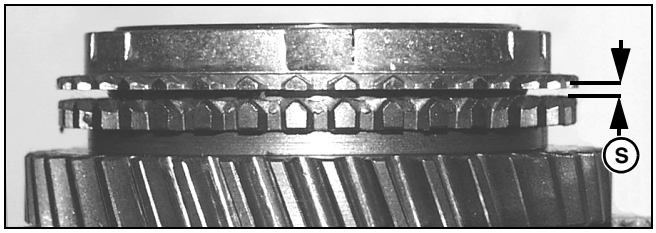
7. Remove spacer (O) and gear (P).

NOTE: If seal sleeve (S) is removed, it must be replaced with a new one.



MX0807

8. Press off bearing (Q) and seal sleeve (R).
9. Clean all parts and inspect for wear or damage.



MX0812

10.Check gap (S) between synchronizer and gear. As synchronizer wears, gap gets smaller. When synchronizer has worn enough that the gap is 0.1 mm (0.004 in.) or less, or the synchronizer is touching the gear, replace synchronizer. Check for any damage on synchronizer teeth and gear teeth. Replace parts as needed.

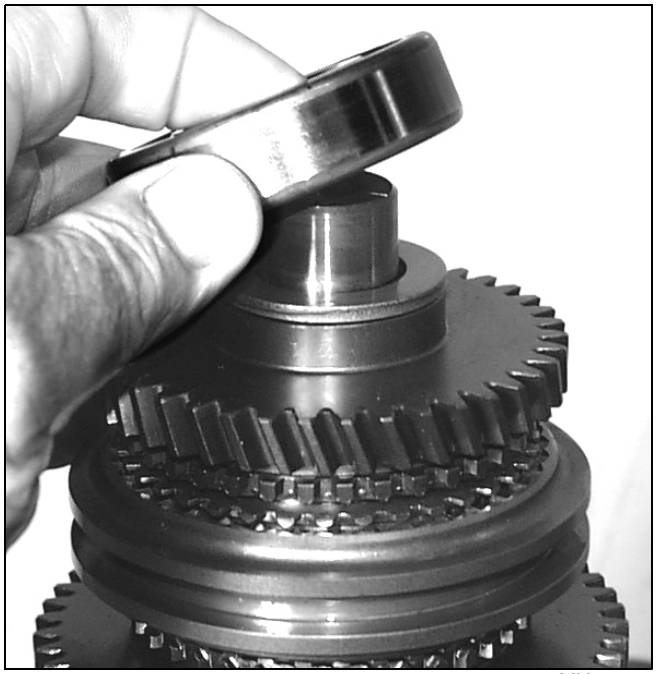
Assembly

Assemble in the reverse order of disassembly.

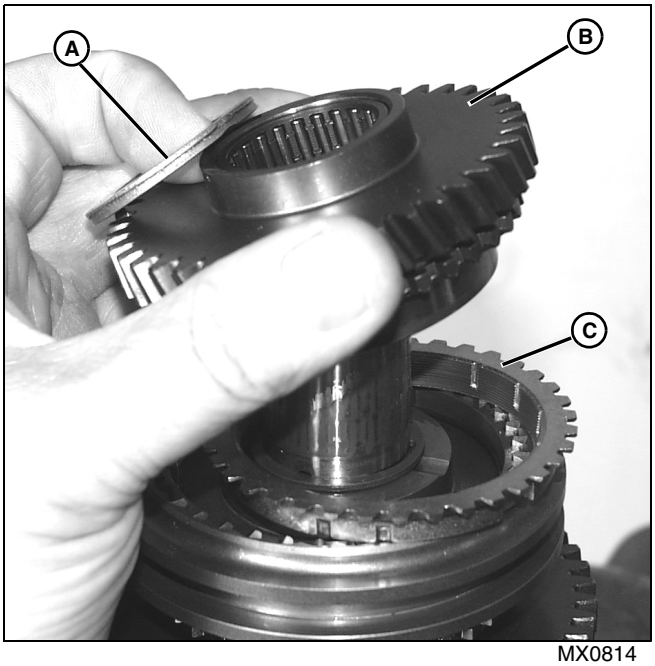
Specifications

Synchronizer Wear Limit . . . . . 0.1 mm (0.004 in.)

Disassemble and Assemble Reduction Shaft

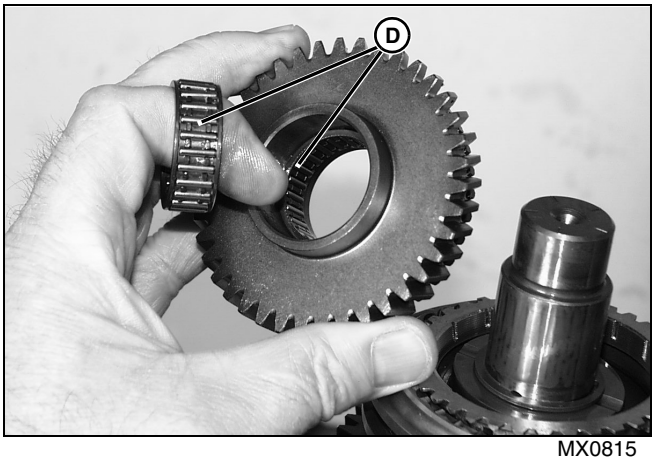

MX0813

1. Use a press or two small pry bars and remove bearing from shaft.



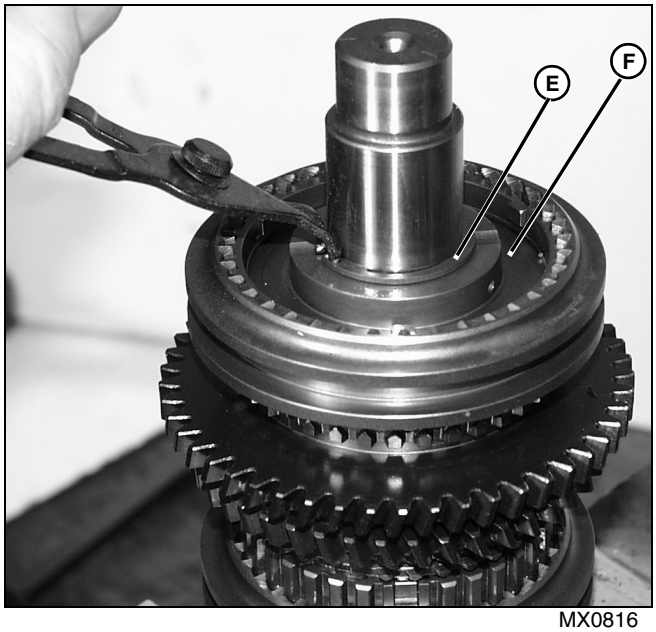
MX0814

2. Remove washer (A), 39T gear (B), and synchronizer (C).



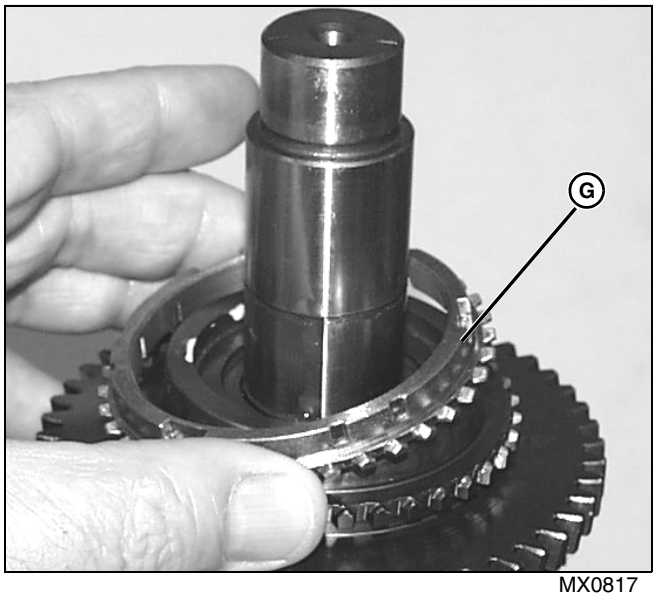
MX0815

3. Remove bearings (D). Check bearings and inner bore of gear for wear/damage.



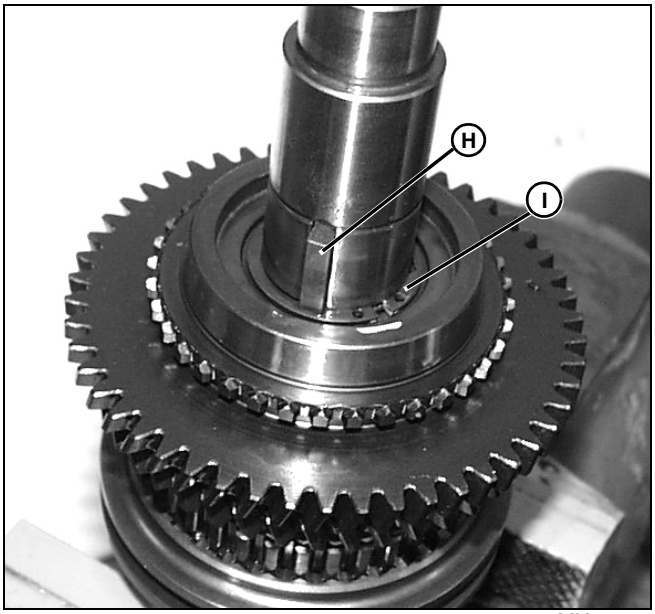
MX0816

4. Remove snap ring (E), and sliding clutch (F).



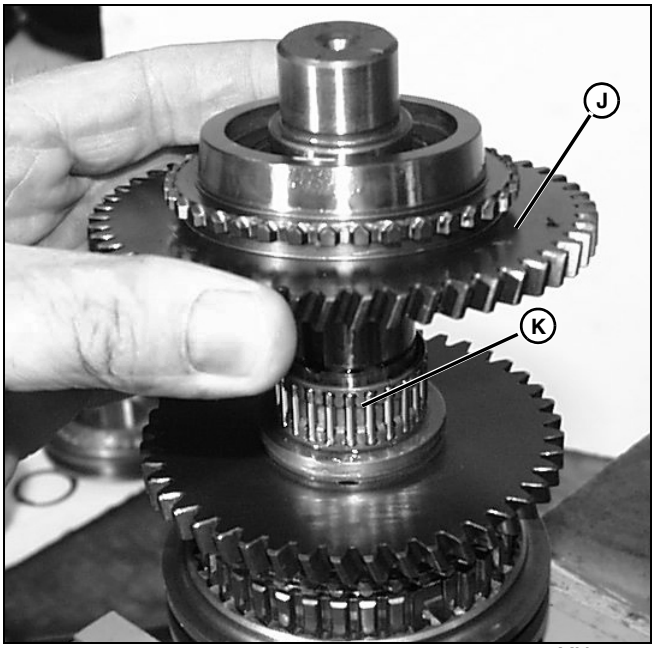
MX0817

5. Remove synchronizer (G).



MX0818

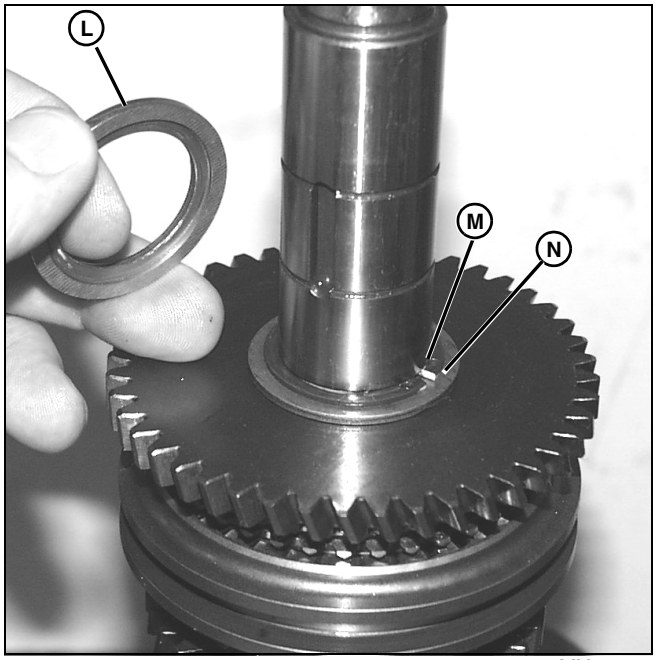
6. Remove key (H) and snap ring (I).



MX0819

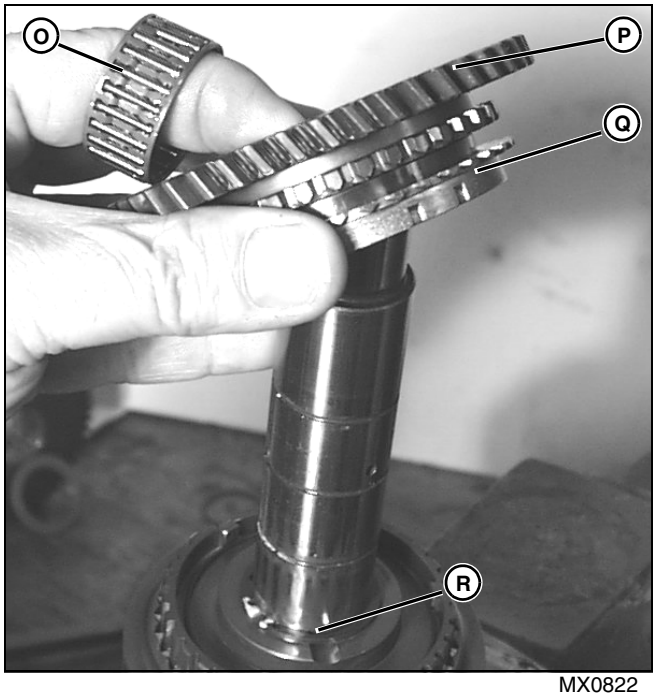
7. Remove 50T gear (J) and bearing (K) from shaft.

NOTE: Note that groove in washer (L) goes toward snap ring (M).



MX0820

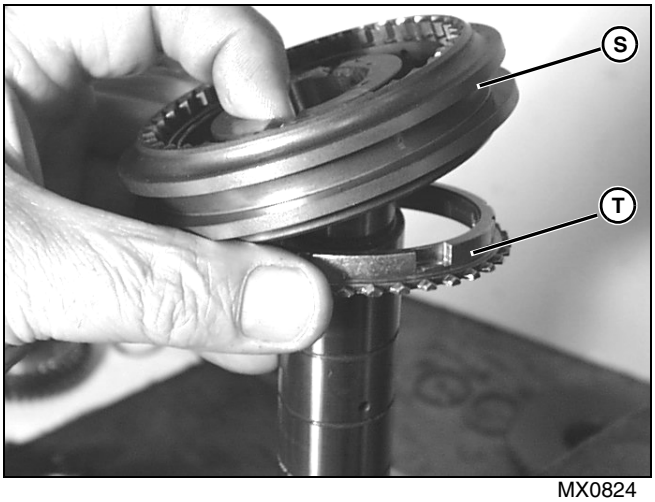
8. Remove washer (L), snap ring (M), and washer (N).



MX0822

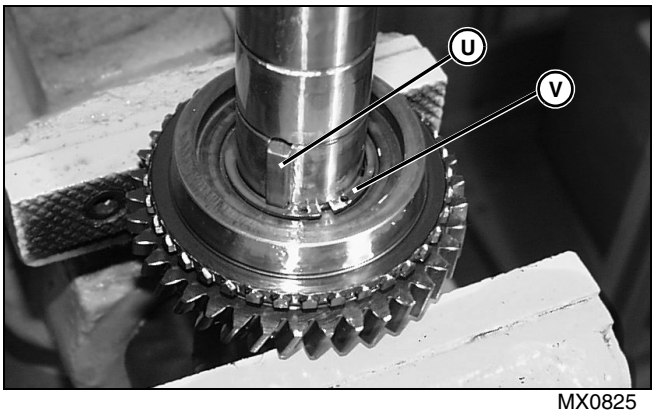
9. Remove bearing (O), 44T gear (P), and synchronizer (Q).

10. Remove snap ring (R).



MX0824

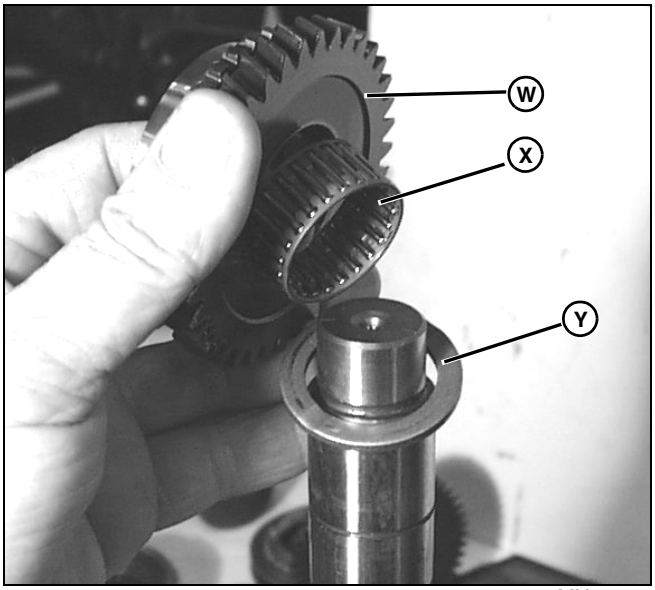
11.Remove sliding clutch (S) and synchronizer (T).



MX0825

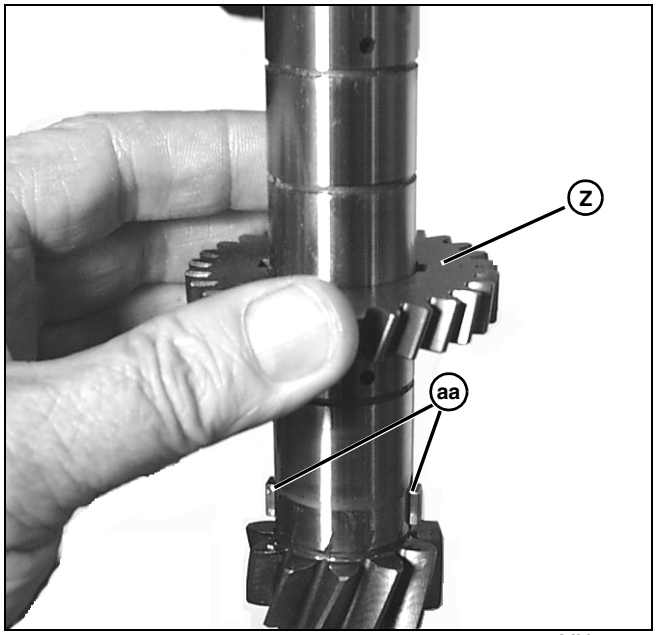
12.Remove key (U) and snap ring (V).

NOTE: Note that oil grooves on washer (Y) face gear (W).



MX0826

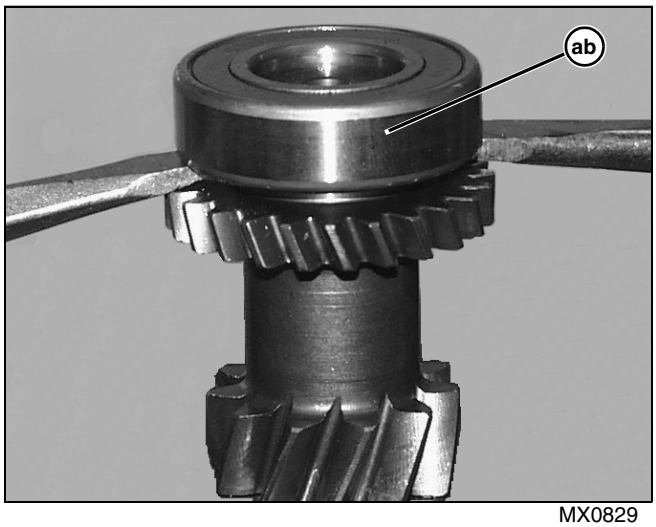
13.Remove 27T gear (W), bearing (X), and washer (Y).



MX0827

14.Remove 28T gear (Z) and keys (aa).

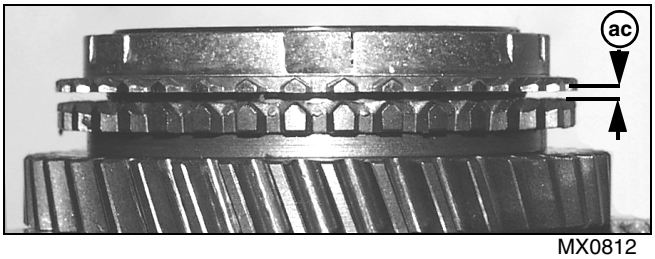
NOTE: Note that sealed end of bearing faces away from gear.



MX0829

15.Remove bearing (ab) from shaft.

16.Clean all parts and inspect for wear or damage.



MX0812

17.Check gap (ac) between synchronizer and gear. As synchronizer wears, gap gets smaller. When synchronizer has worn enough that the gap is only 0.1 mm (0.004 in.) or less, replace synchronizer. Check for any damage on synchronizer teeth and gear teeth. Replace parts as needed.

Assembly

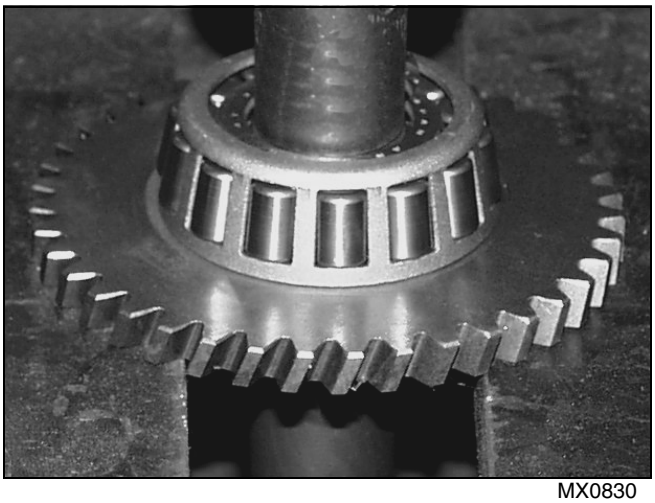
Assemble in the reverse order of disassembly.

Specifications

Synchronizer Wear Limit . . . . . 0.1 mm (0.004 in.)

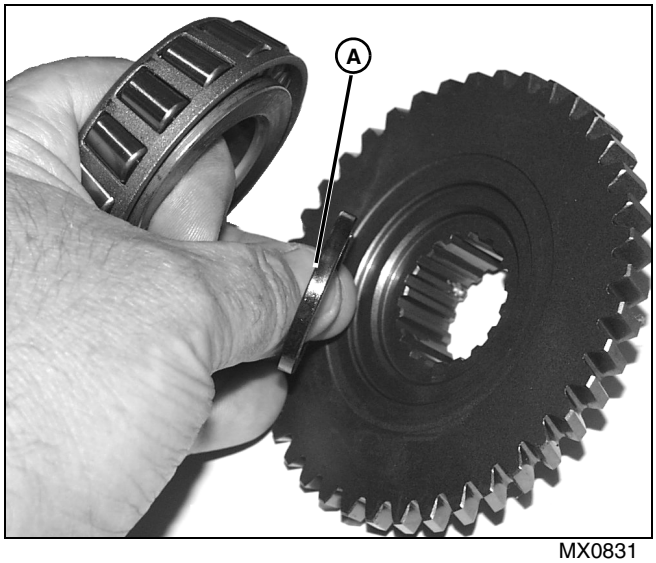
Disassemble and Assemble Countershaft

NOTE: Note position of spacer (A) between bearing and gear.

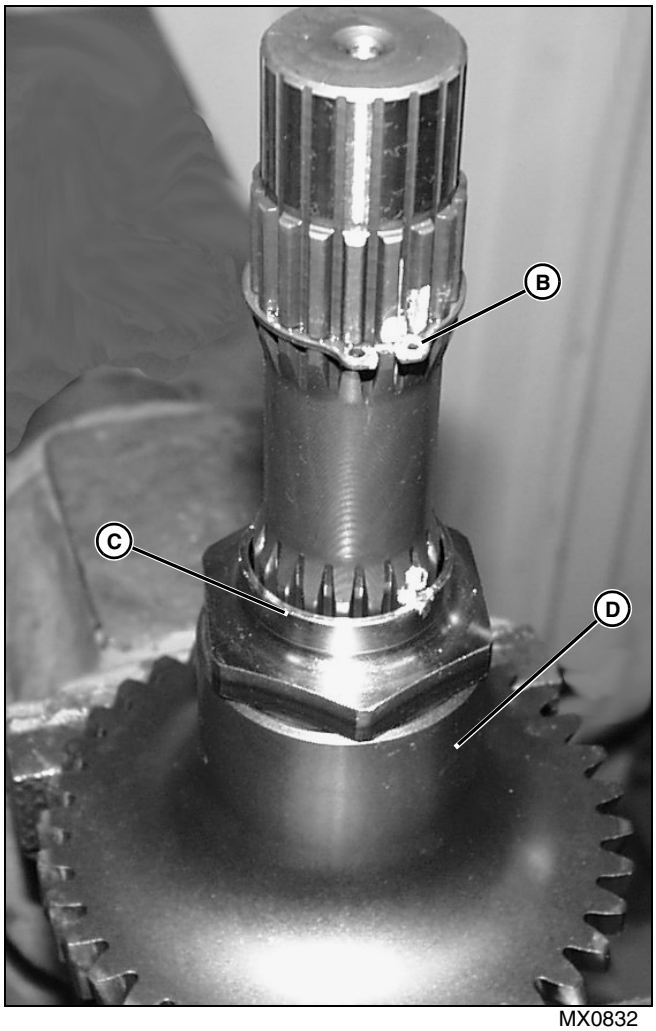

MX0830

1. Press bearing and 40T gear from countershaft.

NOTE: Locknut is staked into the splines in three places. Use a small tapered punch or similar tool to bend the edge of the locknut back enough to clear splines before attempting to remove locknut, or damage to splines will result. Do not re-use locknut, always replace it with a new one.



MX0831

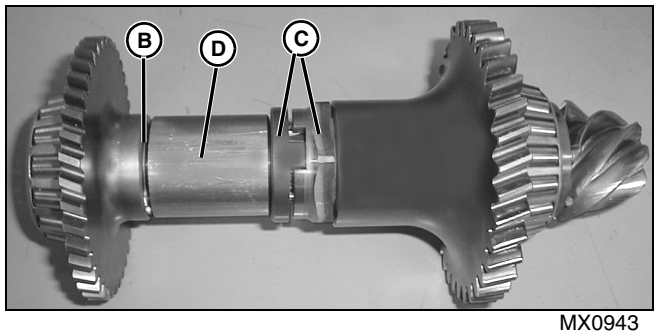


MX0832

Picture Note: Early Production Countershaft Shown

2. Remove snap ring (B) and locknut (C).

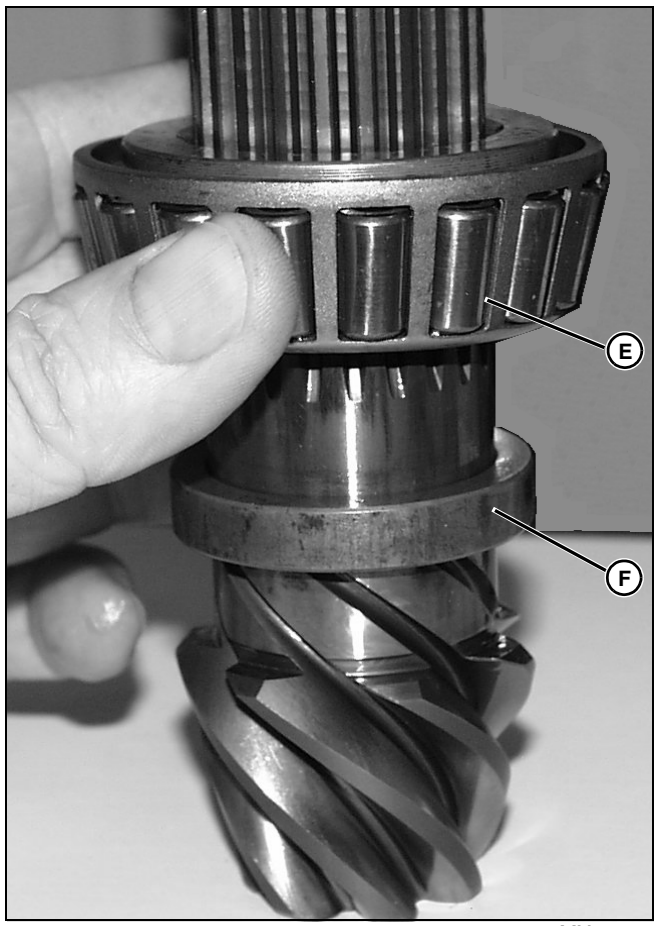
3. Remove 36T gear (D).



MX0943

Picture Note: Later Production Countershaft Shown

4. Remove bearing, 40T gear, and snap ring (B), using the same procedure as above. Then slide off spacer (D), and remove locker and nut (C).



MX0833

5. Press bearing (E) from shaft and remove spacer (F).

Assembly

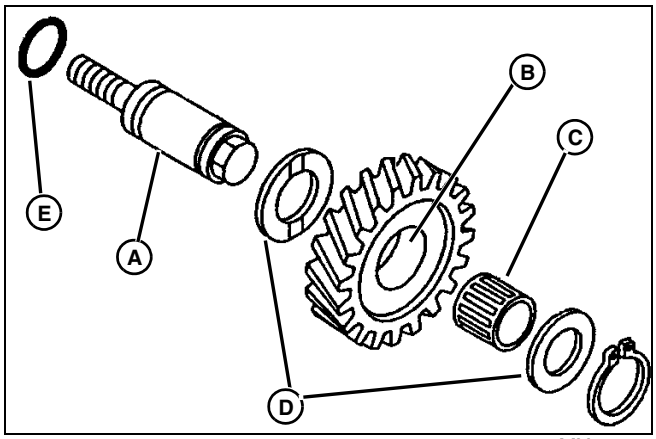
Assemble in the reverse order of disassembly.

- Early Production - Tighten locknut on 38T gear to specification and stake collar on locknut into splines in three places 120° apart.
- Later Production - Tighten locknut on 38T gear to specification and install locker on a spline where it will lock into slots on locknut. Install spacer.

Specifications

38T Gear Locknut Torque
(Early Production - Staked Collar) . . 166 N•m (123 lb-ft)
38T Gear Locknut Torque
(Later Production - Locker Collar) . . 166 N•m (123 lb-ft)

Disassemble and Assemble Reverse Idler Shaft and Gear



MX0862

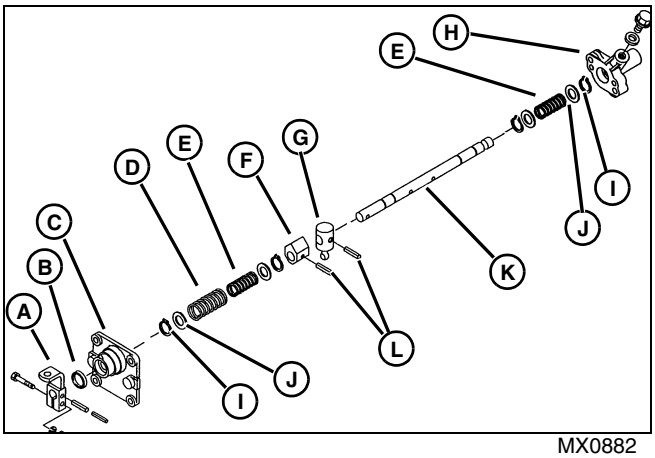
1. Disassemble reverse gear and shaft assembly.
2. Inspect shaft (A), inner bore of gear (B), and bearing (C) for wear or damage. Replace parts as needed.
3. When assembling make sure oil grooves on washers (D) are facing toward the gear and the raised side of gear hub is facing the threaded end of the shaft.
4. Replace O-ring (E).

Disassemble and Assemble Shifter

Other Material

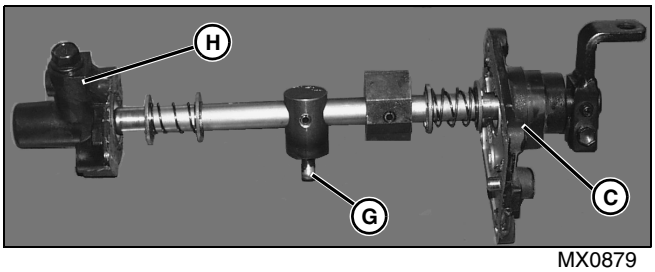
Part No.	Part Name	Part Use
TY15130 (U.S.)	Form-in-Place Gasket	Applied to covers before installation.

NOTE: Shifter does not need to be removed for transaxle service unless a problem is suspected. Shifter can be removed with transaxle in the vehicle.



MX0882

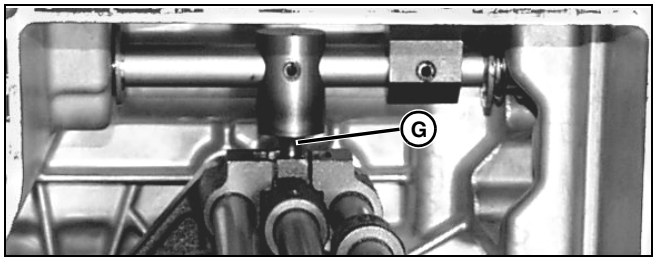
1. If transaxle is assembled, place lever in reverse position (lever A out and back).
2. Remove cap screws securing covers (C and H).
3. Remove cover (H).
4. Remove cover (C) and shaft assembly (K).
5. Check shifter for worn or broken parts (A-L), replace as needed.



MX0879

Assembly

1. Replace shaft seal (B).



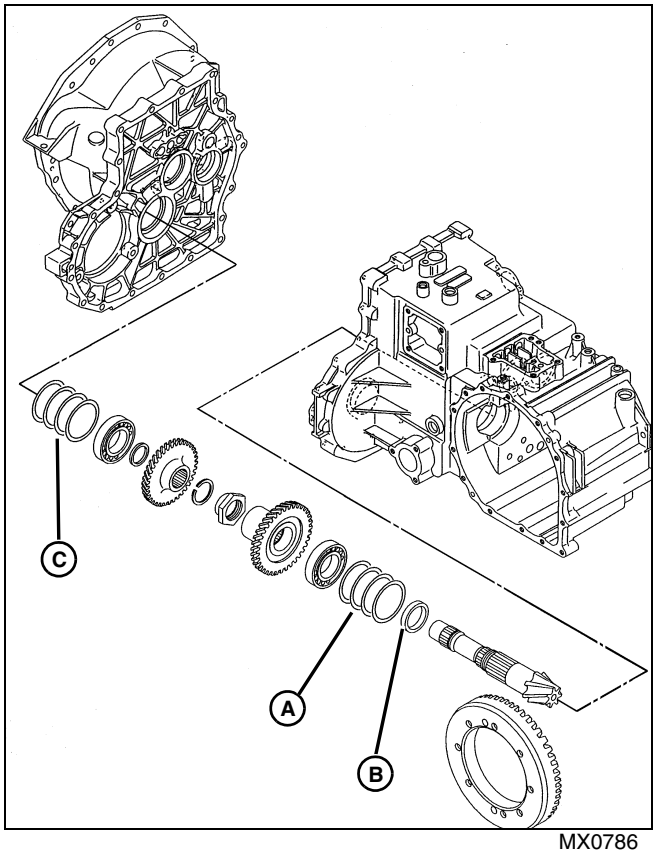
MX0869A

2. Install shaft assembly into transaxle. If transaxle is assembled, place outermost shift shaft to front (reverse) position. Make sure lever (G) is engaged in slot in shift shafts.
3. Apply TY15130 John Deere Form-in-Place Gasket to the covers (C and H) and install covers.
4. Check shifting for proper operation.

Countershaft Shimming Procedure

NOTE: This procedure needs to be performed only when countershaft, bearings or transaxle cases have been changed. If none of these parts have been changed, install original shims in original positions.

Countershaft and ring gear are a matched set and must be replaced as a set.

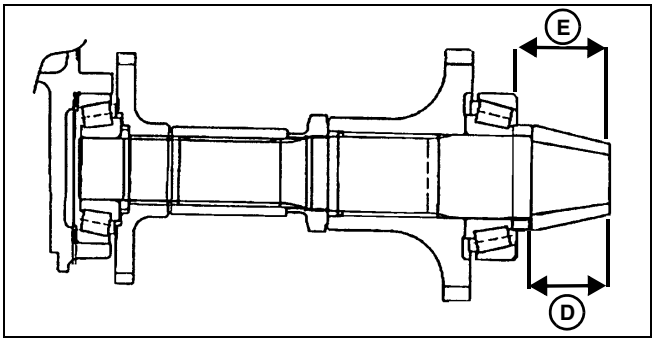


MX0786

- Shims (A) and spacer (B) set pinion depth.

- Shims (C) set bearing preload.

To determine thickness of shims for pinion depth:



MX0913

1. Measure width of gear (D).

2. Hold bearing race against bearing cone and measure distance between end of outer bearing race (E) and end of gear.

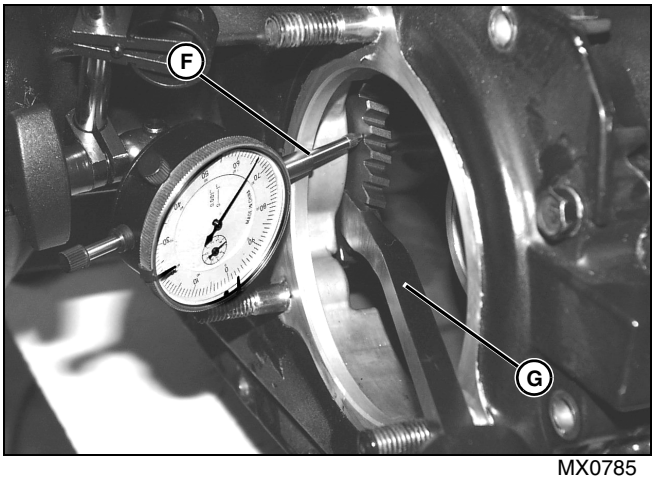
3. Subtract measurement D from measurement E.

4. Subtract 6.25 mm (0.246 in.) from difference calculated in step 3.

5. This is the thickness of shims to be placed between the bearing race and the transaxle case.

6. Install the countershaft into the transaxle case with the shims installed behind the pinion gear end bearing race, and without any shims behind the bearing race in the front cover.

7. Install the front cover with five or six cap screws and tighten to specification.



MX0785

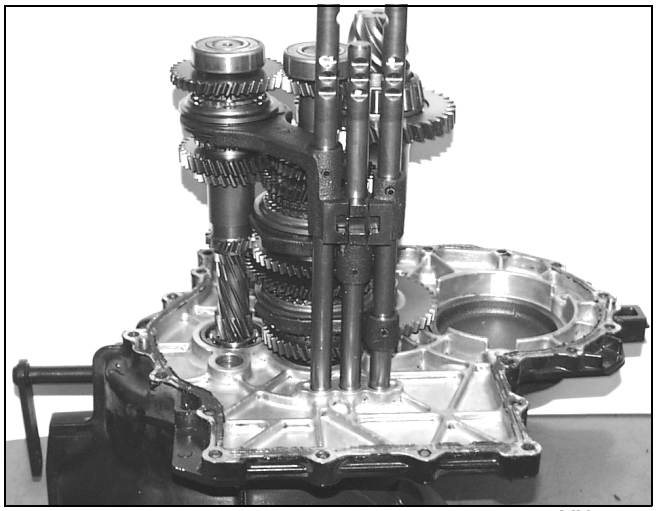
8. Install dial indicator (F) to transaxle case and countershaft gear as shown.

9. Using a small pry bar or large screwdriver (G) pry countershaft back and zero dial indicator. Pry countershaft forward and record measurement of total travel. Add 0.1mm (0.003 in.). This is the thickness of shims to be installed behind the front cover bearing race.

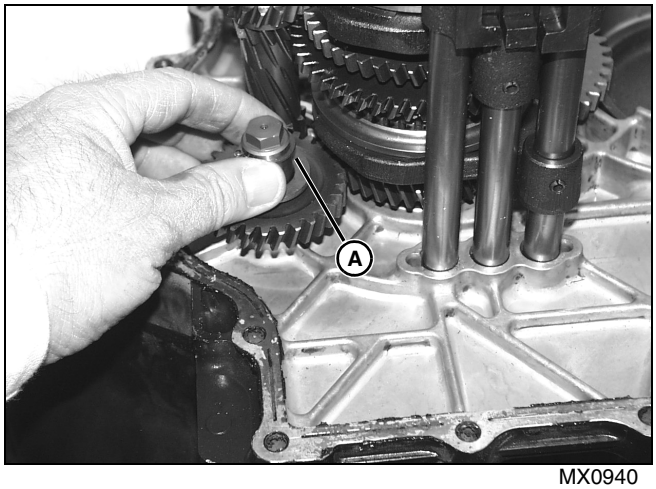
Assemble Transaxle

Other Material

Part No.	Part Name	Part Use
TY15130 (U.S.)	Form-in-Place Gasket	Applied to front cover mating surface before installation.


MX0944

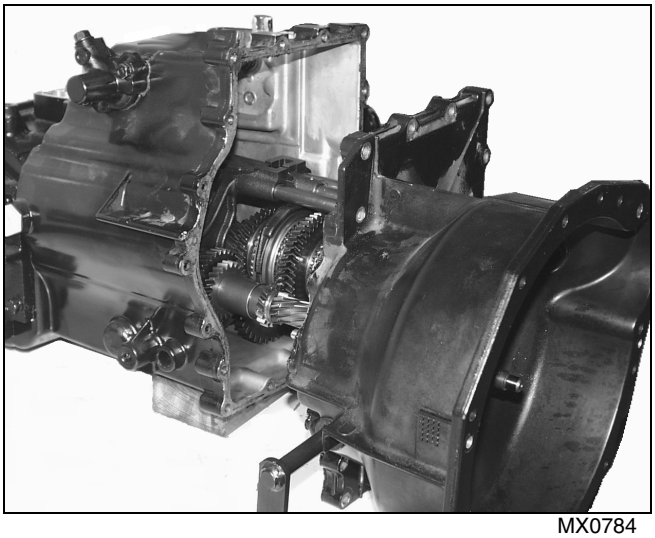
1. Group the three shafts and shift forks together and install them into the clutch housing.



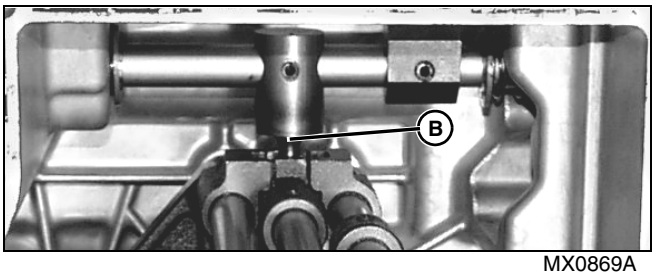
MX0940

2. Lubricate the O-ring on the reverse idler shaft and install reverse idler (A). Make sure extended hub side of gear is toward clutch housing and oil grooves in washers are facing gear. Apply medium strength thread lock to threads and install washer and nut on reverse idler shaft and tighten to specification.

3. Apply thin bead of TY15130 John Deere Form-in-Place Gasket to front cover mating surface.


MX0784

4. Slide clutch cover and gear shafts into transaxle case far enough to get shift shafts started in their bores.

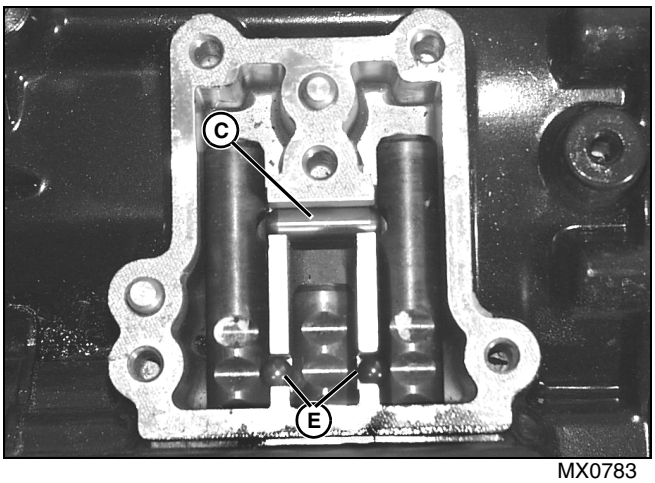


MX0869A

5. While sliding shift shafts in, make sure shift lever (B) engages in slots in shift rods.

6. Replace input shaft seal.

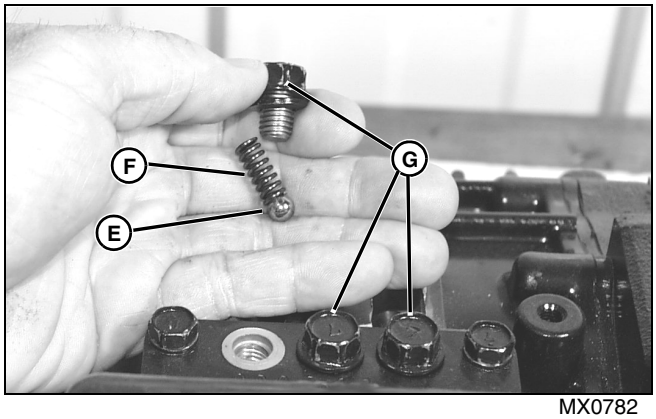
7. Seat the front cover on the transaxle housing and install cap screws. Tighten cap screws to specifications.



MX0783

8. Install pin (C) and balls (D) to shift shafts.

9. Install detent cover.



MX0782

10. Install balls (E) and springs (F).

11.Install three cap screws (G).

Specifications

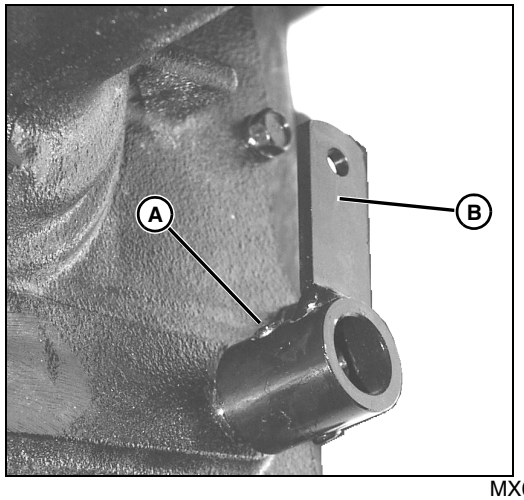
Reverse Idler Shaft Nut Torque. 44-59 N•m (33-43 lb-ft)
Transaxle Housing
Cap Screw Torque . . . . . 23-29 N•m (17-21 lb-ft)

Remove and Install Differential

Other Material

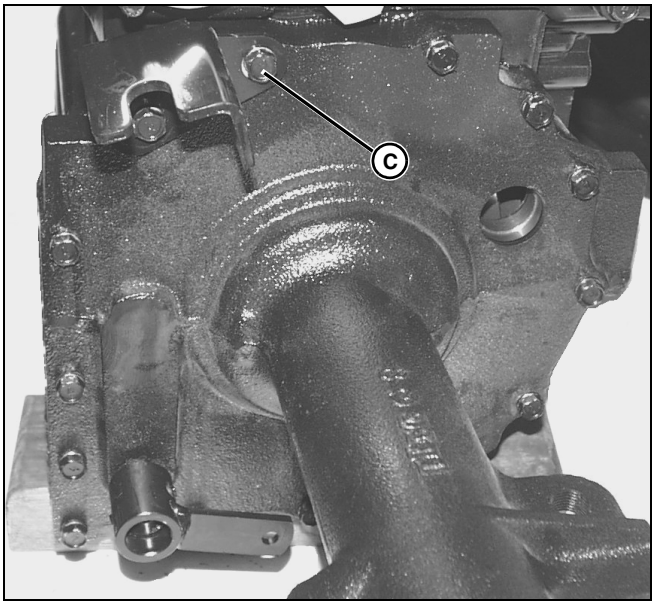
Part No.	Part Name	Part Use
T43512 (U.S.) TY9473 (Canada)	Thread Lock and Sealer (Medium Strength)	Applied to threads of ring gear retaining cap screws.

Disassembly



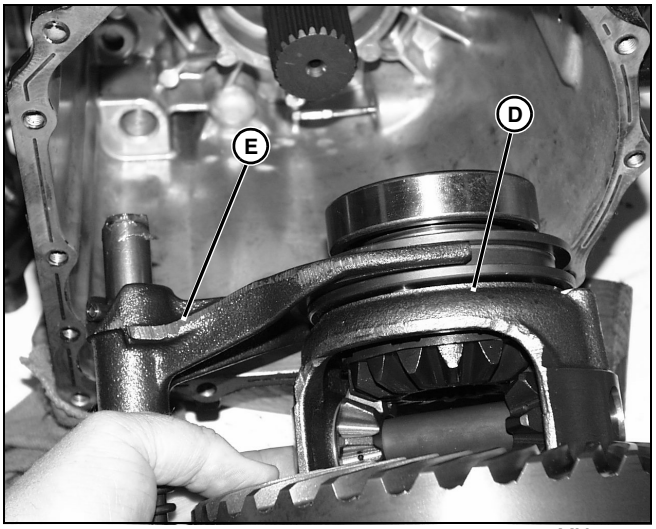
MX0852

1. Remove roll pin (A) and lever (B) from differential lock shaft.



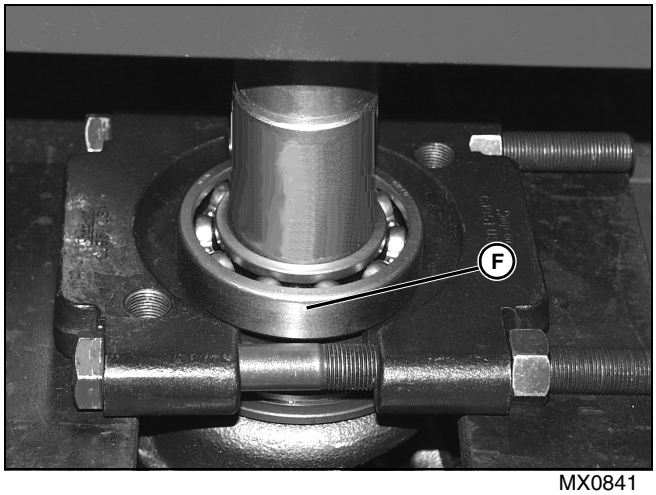
MX0853

2. Remove 14 cap screws (C) securing left axle housing to transaxle case and remove axle housing.



MX0851

3. Remove differential carrier (D) and differential lock shifter (E) from housing as an assembly.

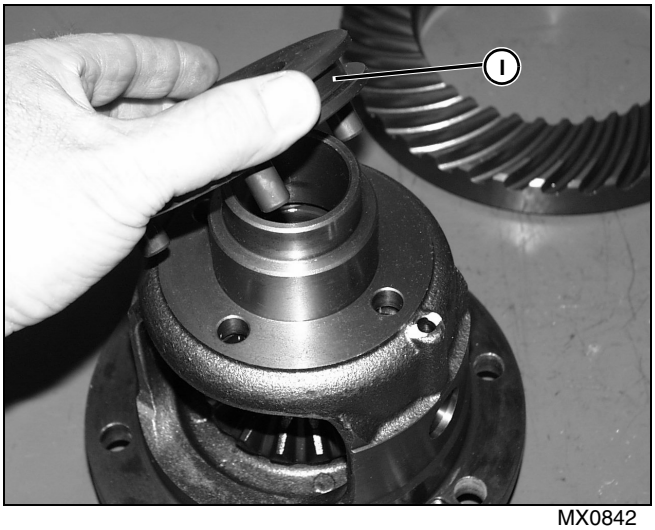


MX0841

4. Press bearing (F) off of each end of differential carrier.

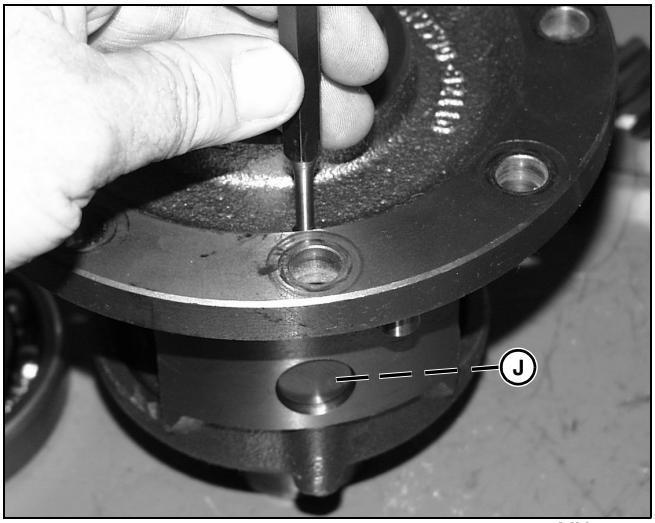
MX0848

5. Remove eight cap screws (G) securing ring gear to carrier and remove ring gear. If ring gear is tight on the carrier, install two M8 x 1.25 cap screws in threaded holes (H) and alternately tighten to push ring gear off of carrier.



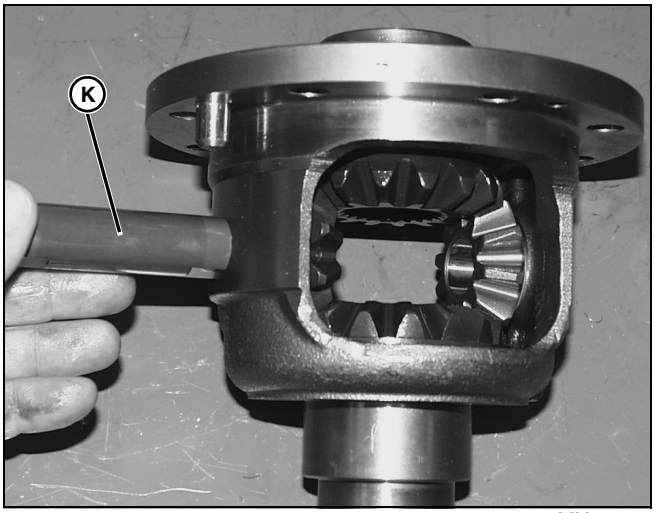
MX0842

6. Remove differential lock (I).



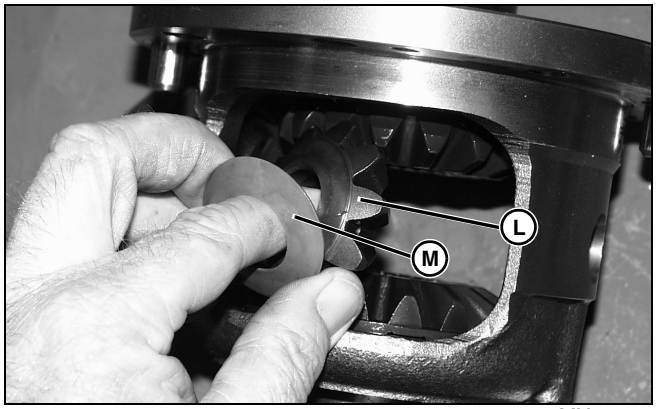
MX0843

7. Remove roll pin (J) securing bevel gear shaft to carrier.



MX0844

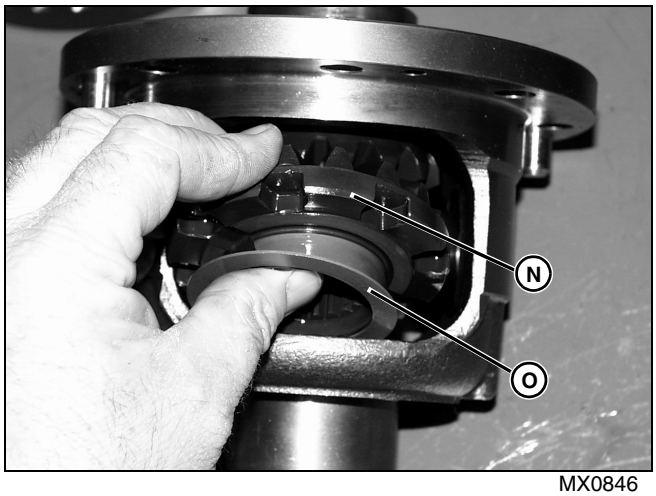
8. Remove shaft (K).



MX0845

9. Remove beveled gears (L) and washers (M).

NOTE: Note that gear (N) with notches goes on differential lock side.



MX0846

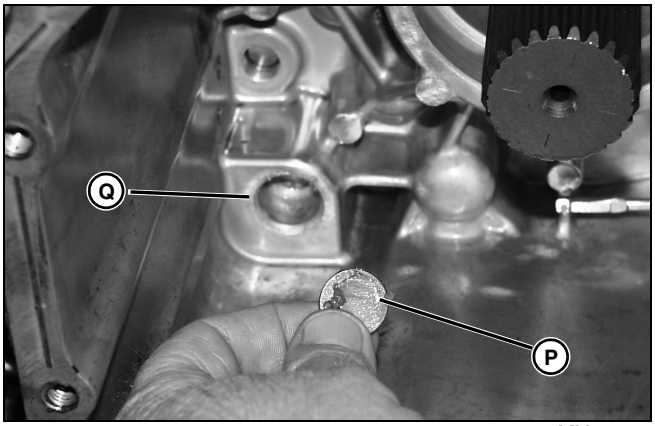
10. Remove axle drive gears (N) and washers (O).

11. Clean all parts and inspect for wear or damage. Check all gears for chipped/cracked teeth. Replace parts as needed.

Assembly

Assemble in the reverse order of disassembly.

- Apply TY9370 John Deere Medium strength thread lock and sealer to threads on ring gear retaining cap screws and tighten to specification.



MX0850

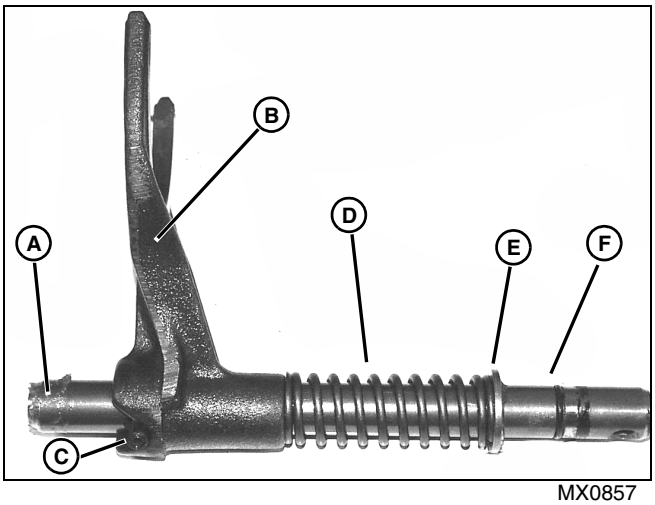
- Apply grease to spacer (P) and install in hole (Q) before installing differential lock fork and differential.
- Install differential lock fork and differential.

Specifications

Ring Gear Retaining
Cap Screw Torque . . . . . 78-98 N•m (58-72 lb-ft)

Disassemble and Assemble Differential Lock Fork

CAUTION: Avoid injury! Fork has strong spring tension against it. Use a vice to cage spring force before removing roll pins or snap ring. Slowly release tension on spring to avoid injury.



MX0857

1. Put end of shaft (A) in a soft jaw vice with fork (B) against sides of vice jaws. Push on other end of shaft until spring tension is off of roll pins and tighten vice.

2. Remove roll pins (C) and, while holding shaft, slowly loosen vice and relieve tension from spring (D).

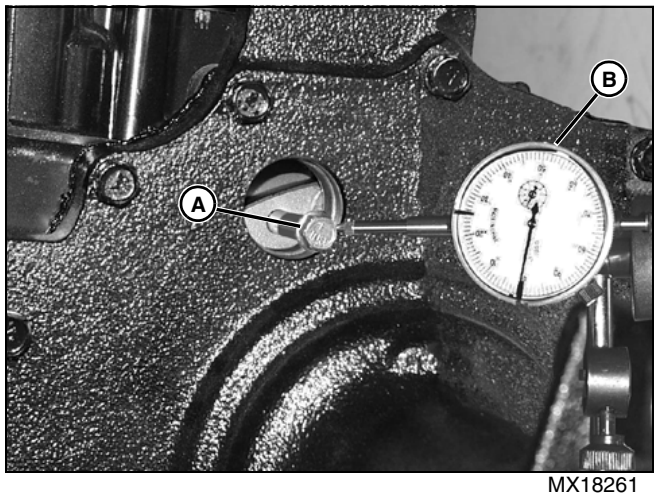
3. Inspect parts, check snap ring and washer (E), replace any worn/broken parts. Always replace O-ring (F).

Assembly

Assemble in the reverse order of disassembly.

Check Ring Gear Backlash

1. Remove plug from left axle housing and rotate axle or input shaft until one of the threaded holes in the differential carrier is centered in the hole.

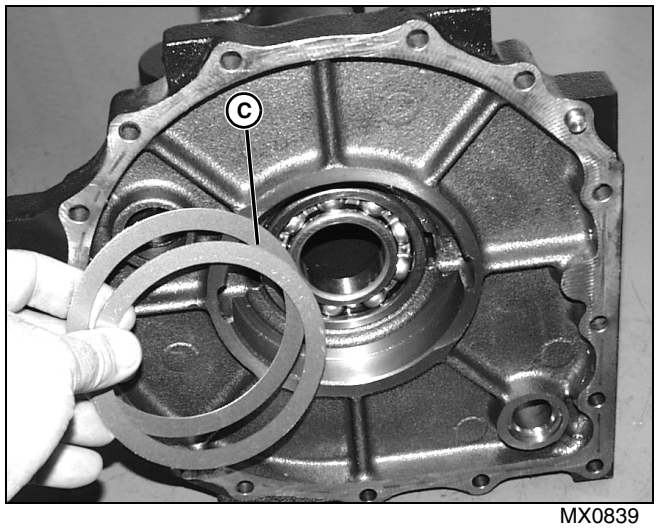


MX18261

2. Install M8 x 1.25 cap screw (A) into hole in carrier and bottom lightly against ring gear. Install dial indicator (B) to measure travel of cap screw.

3. Place transmission in gear and hold input shaft.

4. Rotate ring gear back and forth with cap screw and record reading on dial indicator.



MX0839

5. If measurement is not within specification, remove left axle housing and add or remove shims (C) in bearing bore to get backlash to specification. Adding shims decreases backlash, removing shims increases backlash.

6. If necessary, repeat step 5 until backlash is within specification.

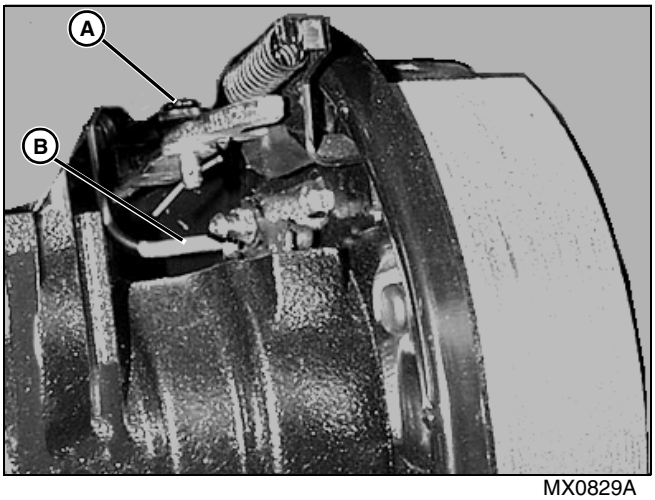
Specifications

Backlash . . . . . 0.17-0.23 mm (0.007-0.009 in.)

Remove and Install Axle Shaft/Replace Seal

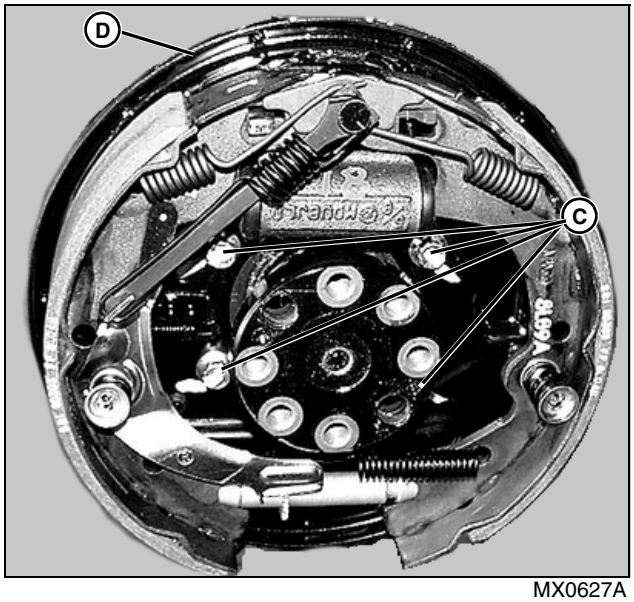
Other Material

Part No.	Part Name	Part Use
TY15130 (U.S.)	Form-in-Place Gasket	Applied to axle housing mating surface before installation.



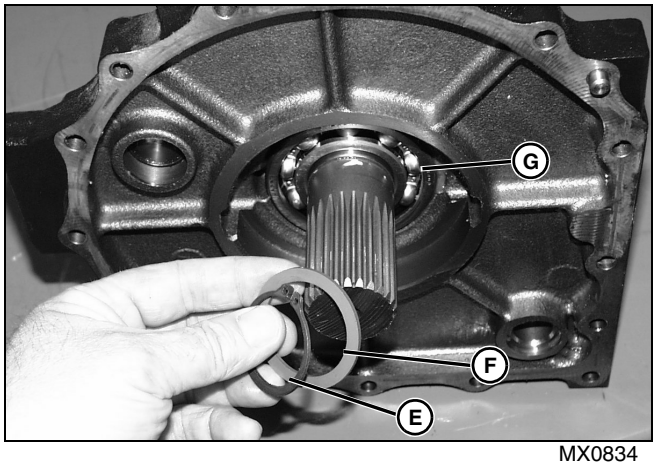
MX0829A

1. Disconnect park brake cable (A) and brake line (B).



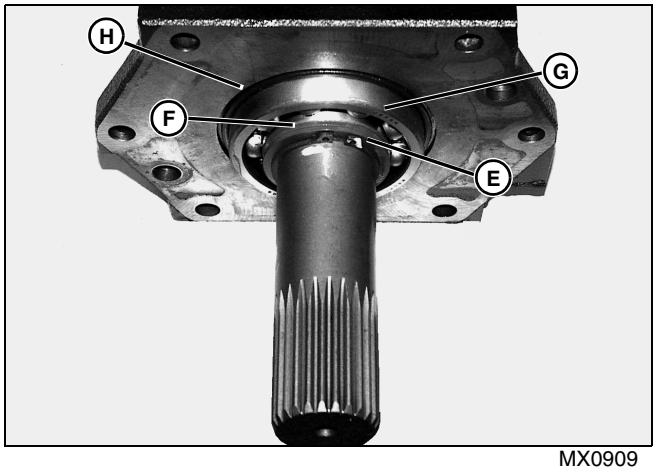
MX0627A

2. Remove four cap screws (C) and brake backplate and shoe assembly (D) from axle housing.



MX0834

Picture Note: Left Side Shown



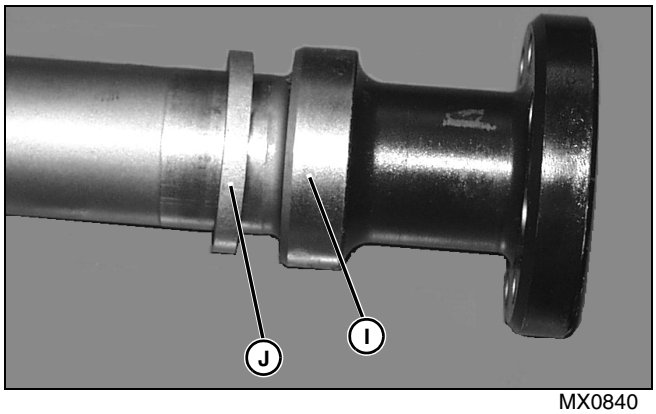
MX0909

Picture Note: Right Side Shown

3. Remove snap ring (E) and spacer(s) (F) from splined end of axle shaft.

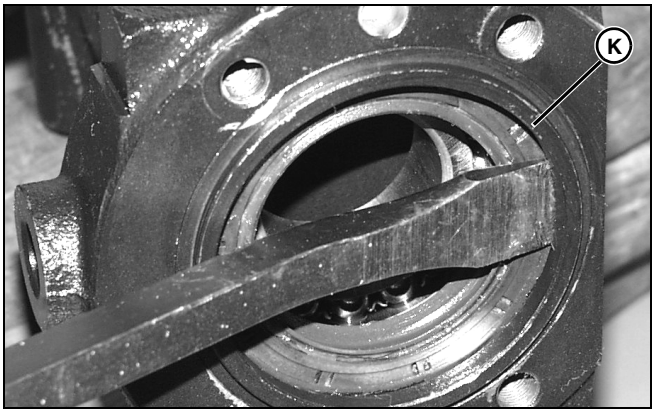
4. Using a soft hammer, drive axle in through bearing (G) and pull out through outer bearing.

5. On right side, replace O-ring (H) during reassembly.



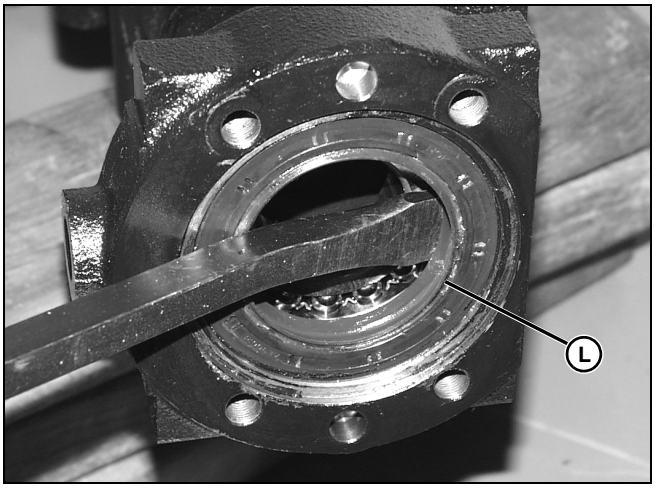
MX0840

6. Check seal contact area (I) for wear or damage. If spacer (J) is removed, make sure chamfer on inside is facing toward wheel end of axle during reassembly.



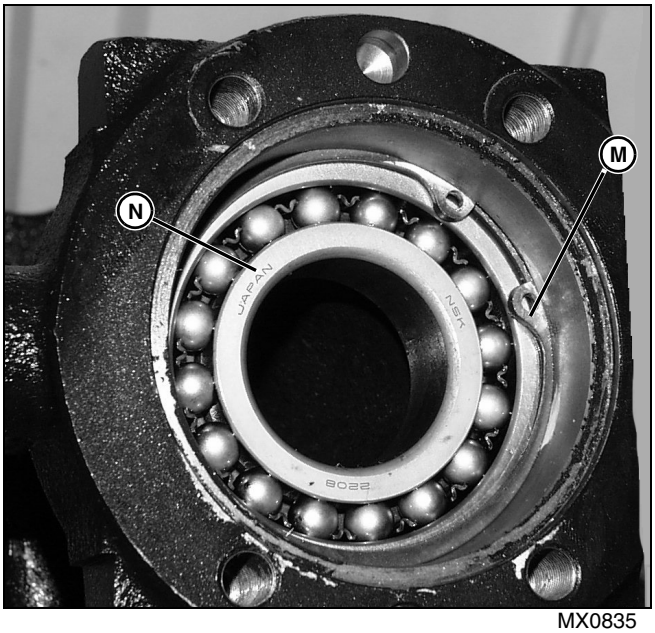
MX0836

7. Remove seal retaining ring (K).



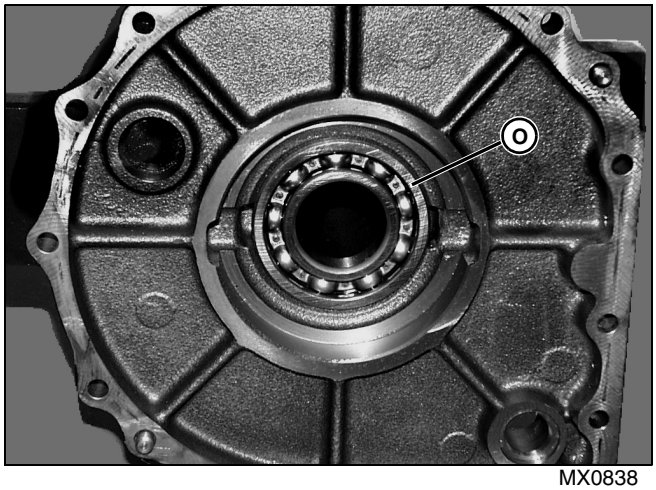
MX0837

8. Remove oil seal (L).



MX0835

9. Remove snap ring (M) and bearing (N).



MX0838

10. Remove inner bearing (O) from axle housing.

11. Clean all parts, inspect for wear or damage.

Assembly

Assemble in the reverse order of disassembly.

- On the left side axle housing, apply a thin bead of TY15130 John Deere Form in Place Gasket to mating surfaces. Tighten cap screws to specification.
- The right side axle housing is sealed by the O-ring. Replace the O-ring. Tighten cap screws to specification.
- Install original shims in original positions unless differential ring gear or bearings have been replaced.
- If ring gear and countershaft or differential bearings have been replaced, see “Countershaft Shimming Procedure” on page 369, and “Check Ring Gear Backlash” on page 374.

Specifications

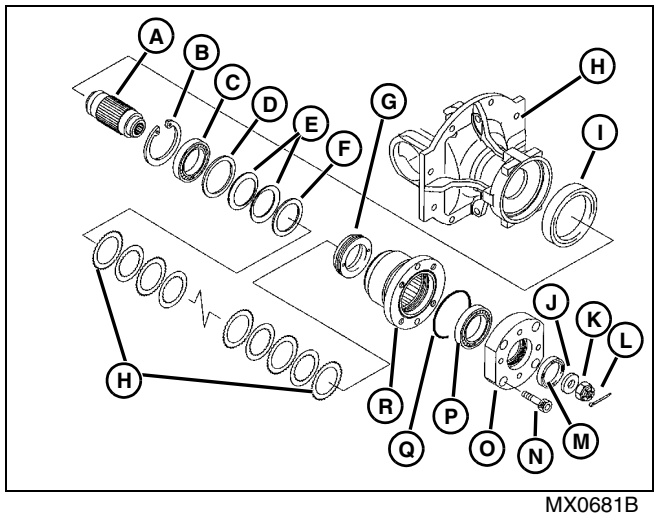
Axle Housing Cap Screw Torque (Left Side)	**23-29 N•m (17-22 lb-ft)**
Axle Housing Cap Screw Torque (Right Side)	**44-59 N•m (33-43 lb-ft)**

Remove and Install MFWD Differential Clutch

Special or Required Tools

Tool Name	Tool No.	Tool Use
Clutch Retaining Nut Spanner Wrench	JDG1336	Used to remove nut from clutch housing.

Removal



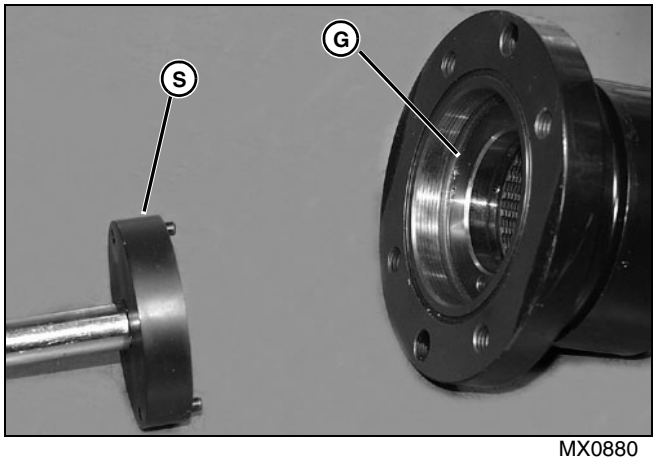
MX0681B

1. Remove the cotter pin (L), nut (K) and washer (J) from the pinion shaft.

2. Remove four cap screws (N) and remove the coupling (O) from the clutch housing (R). Remove and inspect bearing (P) and replace seals (Q and M).

3. Pull the clutch housing assembly from the differential carrier. Remove snap ring (B), and remove bearing (C), bushing (D), spring plates (E), and plate (F) from the clutch housing (R).

4. Remove bearing (C) from shaft (A) if required.



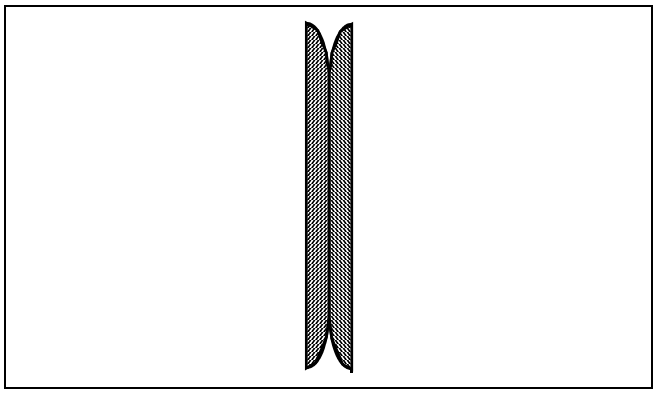
MX0880

5. Mark the location of the clutch retaining nut (G). Use JDG1336 Spanner Wrench (S) to remove nut from the clutch housing. The nut is staked in position.

6. Remove the clutch pack (H). Note that there are 17 externally splined clutch plates that alternate with 16 internally splined clutch plates.

7. Clean and inspect all components. Replace any unserviceable components.

Installation



MIF

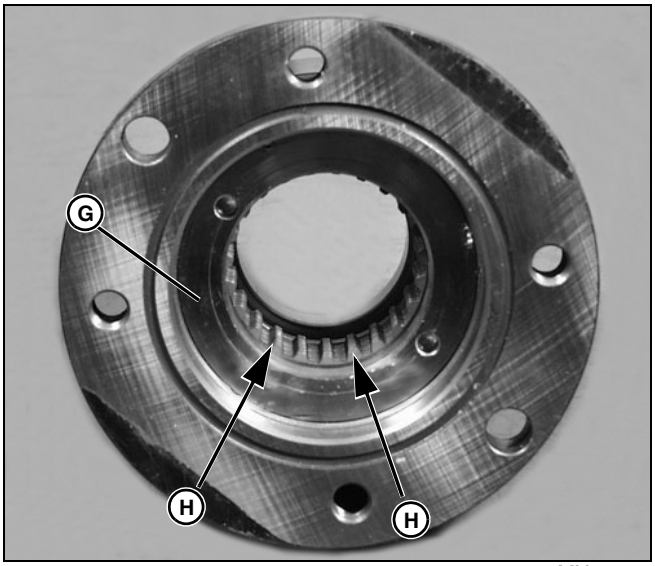
Picture Note: Clutch Spring Plate Orientation

1. Install the plate, spring plates, bushing, and bearing to the housing, and secure with snap ring.

NOTE: The convex faces of the clutch spring plates MUST face each other (see diagram).

2. Apply MFWD oil to both sides of the clutch discs.

3. Install the clutch discs to the housing, beginning with an externally splined clutch disc. Alternate internally splined and externally splined discs to complete the installation. The last disc on each end should be externally splined.



MX0881

4. Use JDG1336 Spanner Wrench to install the clutch retaining nut (G) to the original position marked in the clutch housing. Stake the nut to the housing.

IMPORTANT: Avoid damage! Return the retaining nut (G) to its original position in the housing. If the original position cannot be determined, set the nut as close to the original position as possible, and verify the breakaway torque 570-625 N•m (420-460 lb-ft). This procedure should be attempted with engineering support.

NOTE: Align the internally splined clutch discs (H) to aid when inserting the shaft to the housing. See arrows in photo MX0881.

5. Install shaft to clutch assembly. It may be necessary to press the shaft into the bearing.

6. Install the clutch assembly to the differential carrier.

7. Install the bearing to the clutch housing and install the coupling.

8. Install the washer nut and cotter pin to the pinion. Tighten the pinion nut to specification, and check the rotation of the pinion.

Specifications

Pinion Nut Torque. . . . . 61-80 N•m (45-59 lb-ft)

Remove and Disassemble MFWD Differential

Removal

1. Remove both CV axles from the MFWD.

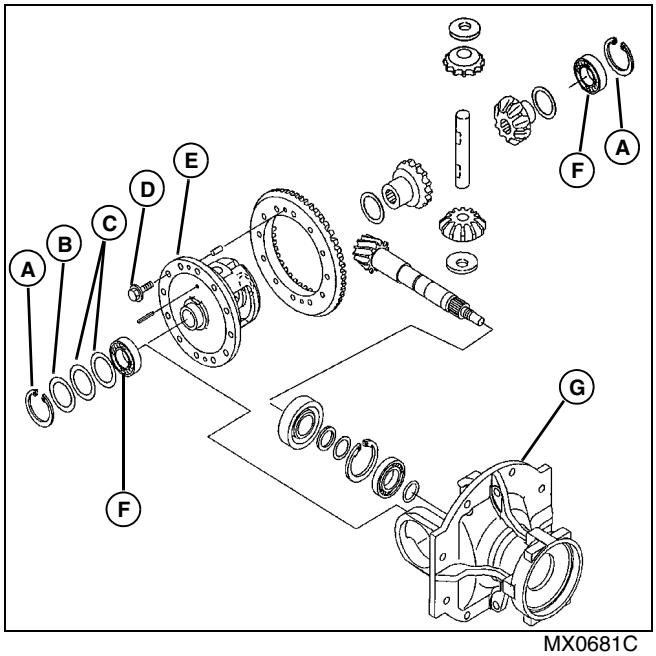
2. Remove the MFWD drive shaft.

3. Remove the MFWD differential clutch assembly from the pinion shaft.

4. Remove eight cap screws fastening the differential cover to the MFWD housing.

5. Remove the differential carrier from the MFWD housing.

Disassembly

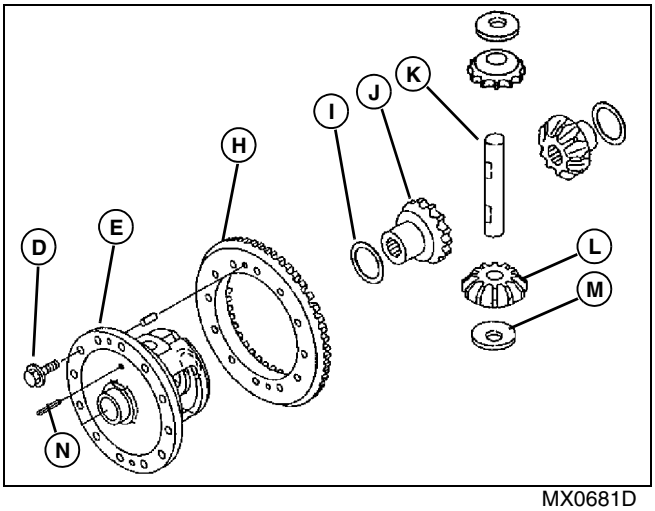


MX0681C

1. Remove the snap rings (A) from the differential carrier. Save washer (B) and any shims (C) from the ring gear side of the differential carrier (G).

2. Remove both ball bearings (F) from the differential case (E) and differential carrier.

3. Remove the differential case assembly by pulling it through the reliefs in the back of the differential carrier.



MX0681D

4. Remove twelve cap screws (D). Remove the ring gear (H) from the differential case (E).

5. Drive the spring pin (N) from the pinion shaft (K), and remove the pinion bevel gears (L), bevel gears (J) and washers (I and M) from the differential housing.

6. Clean and inspect all parts and check for wear. Replace any unserviceable parts.

Assembly

1. Install the pinion bevel gears and washers to the pinion shaft. Install the pinion shaft assembly and bevel gears and washers to the differential case.

2. Install the spring pin to the pinion shaft.

3. Install the ring gear to the differential case. Tighten the ring gear cap screws to specifications.

4. Place the differential case into the differential carrier.

5. Install the bearing and snap ring to the side of the differential carrier opposite the ring gear.

6. Install the bearing, shims (if used), washer and snap ring to the ring gear side of the differential carrier.

NOTE: If the original ring and pinion set is being reused, reuse the original shim(s) or replace with new shims of the same thickness as the original shims. (See "MFWD Back Lash Adjustment" on page 380 if gear set is replaced.)

Installation

Installation is the reverse of removal.

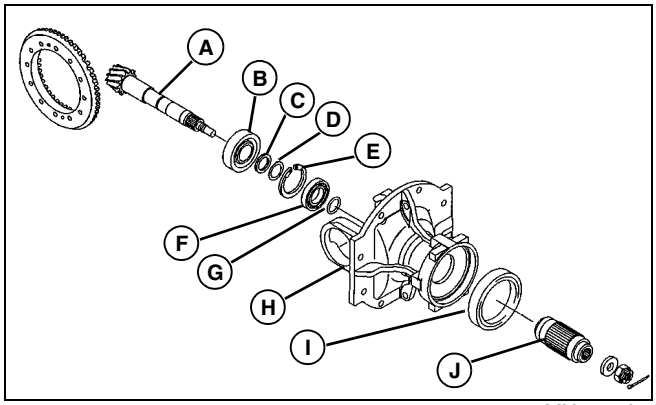
NOTE: The ring gear and pinion are not serviced separately. If either the ring gear or pinion is worn or damaged BOTH must be replaced.

Specifications

Ring Gear Cap Screw Torque . . 30-39 N•m (22-28 lb-ft)

Remove and Install MFWD Pinion Assembly

Removal



MX0682A

1. Remove the differential case and differential clutch from the differential carrier. (See "Remove and Disassemble MFWD Differential" on page 378 and "Remove and Install MFWD Pinion Assembly" on page 379.)

2. If necessary, remove the clutch shaft (J) from the pinion (A).

3. Press the pinion (A), bearing (B), bushing (C) and shim (D) from the differential carrier (H).

NOTE: Do not discard the pinion shim(s) at this time.

4. Remove the snap ring (E) and bearing (F) from the differential carrier.

NOTE: The ring and pinion are serviced as a set. If either the ring or pinion has wear or damage, both must be replaced.

5. Clean and inspect all parts and check parts for wear. Replace any unserviceable parts. (See "MFWD Back Lash Adjustment" on page 380 if gear set is replaced.)

6. Replace seals (G and I).

Installation

1. Install bearing (F) and snap ring (E) to the differential carrier.

2. Install the bearing (B), bushing (C) and shim(s) (D) to the pinion.

NOTE: If installing the original ring and pinion set reuse the original shim(s) or replace with new shims of the original thickness.

3. Install the pinion assembly to the differential carrier. Check for smooth rotation of the pinion.

NOTE: The pinion and ring gear are not serviced separately. If either the ring gear or pinion is worn or damaged BOTH must be replaced.

4. Install the differential case and differential clutch to the differential carrier. (See “Remove and Disassemble MFWD Differential” on page 378 and “Remove and Install MFWD Pinion Assembly” on page 379.)

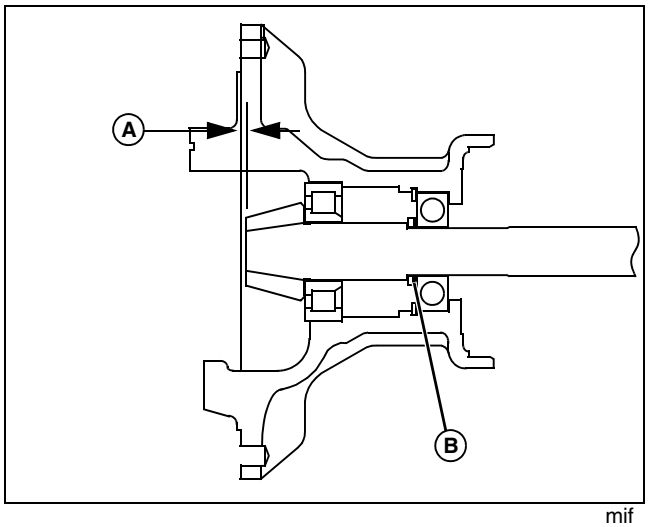
MFWD Back Lash Adjustment

Purpose

To set cone distance and backlash if gear set is changed.

Procedure

1. Assemble pinion assembly without installing shim(s) (D). (See “Remove and Install MFWD Pinion Assembly” on page 379.)



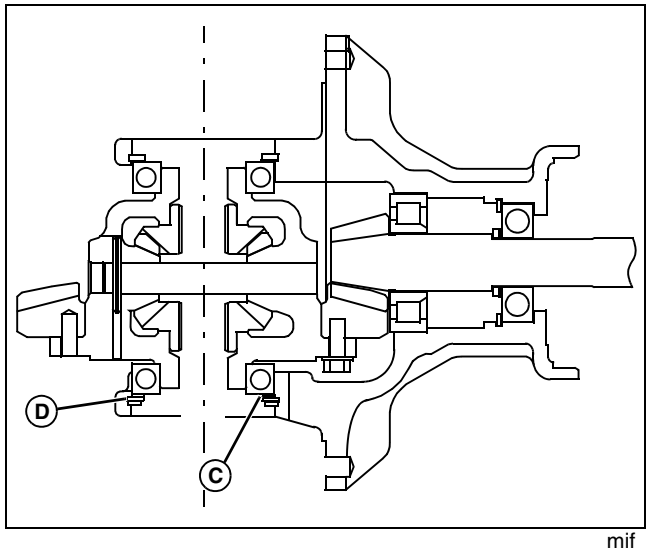
mif

2. Measure the distance (A) from the pinion cone end to the housing case front.

3. Add shim(s) (B) so measured distance meets cone distance specification.

4. Install differential assembly. (See “Remove and Install MFWD Differential Clutch” on page 377.)

5. Measure differential ring gear backlash.



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6. Install shim(s) (C) between washer (D) and bearing so back lash meets specification.

Specifications

Cone Distance . . . . . 2.1 ± 0.05 mm (0.083 ± 0.002 in.)
Back Lash . . . . . 0.17 - 0.23 mm (0.007 - 0.009 in.)

Table of Contents

HYDRAULICS TABLE OF CONTENTS

Specifications

General Hydraulic Specifications

Lift/Lower System (Auxiliary)

Type	**Open system**
Working Pressure	**17 000 kPa (2466 psi)**
Pump Flow (Gasoline Engine @ 3520 RPM)	**25.9 liters/min (6.84 gpm)**
Pump Flow (Diesel Engine @ 3450 RPM)	**25.3 liters/min (6.68 gpm)**

Steering System

Type	**Open system**
Working Pressure	**7500 kPa (1088 psi)**
Pump Flow (Gasoline Engine @ 3520 RPM)	**11.5 liters/min (3.04 gpm)**
Pump Flow (Diesel Engine @ 3450 RPM)	**11.2 liters/min (2.96 gpm)**
Steering Control Unit	**7000-7500 kPa (1015-1088 psi)**
System Capacity	**11.4 L (3.0 gal)**

Test and Adjustment Specifications

Steering System Leakage Test at Fast Idle

Torque Applied to Steering Shaft	**6.8 N•m (60 lb-in.)**
Maximum Right Turn RPM	**5 rpm**

Relief Valve Pressure Settings

Lift/Lower and Auxiliary PTO Control Valve	**16 553-17 243 kPa (2400-2500 psi)**

Auxiliary Pump Flow

Pump Flow (Gas Engine @ 3570 RPM)	**28.0 liters/min (7.4 gpm)**
Pump Flow (Diesel Engine @ 3450 RPM)	**27.1 liters/min (7.2 gpm)**

Hydraulic Cycle Time Test

Gasoline Engine	**2.5 seconds**
Diesel Engine	**2.5 seconds**

Repair Specifications

NOTE: The following dimensions do not reflect wear.

Hydraulic Pump

Input Shaft Bearing OD	**17.93-18.06 mm (0.7059-0.7110 in.)**
Idler Gear Shaft Bearing OD	**17.93-18.06 mm (0.7059-0.7110 in.)**
Bushing ID	**18.00-18.06 mm (0.7087-0.7110 in.)**

Thrust Plate

Thick	**1.98-2.00 mm (0.0780-0.0787 in.)**
Thin	**1.18-1.20 mm (0.0465-0.0472 in.)**

Torque Specifications

Hydraulic Pump

Hydraulic Pump-to-Engine . . . . . 26 N•m (22 lb-ft)
Intake and Pressure Fitting Socket Head Cap Screw . . . . . 6.8 N•m (60 lb-in.)

Hydraulic/PTO Control Valve

Hex Head Valve-to-Frame Cap Screw . . . . . 16.7 N•m (147 lb-in.)

Steering Control Unit (SCU)

SCU-to-Frame Cap Screw . . . . . 30-38 N•m (22-28 lb-ft)
Pressure and Return Hose Fitting-to-SCU . . . . . 40-57 N•m (30-42 lb-ft)
Steering Hose Fitting-to-SCU . . . . . 17-24 N•m (150-212 lb-in.)
Adapter Fitting-to-SCU. . . . . 14-19 N•m (124-168 lb-ft)

Tools and Materials

Special or Essential Tools

Special or Required Tools

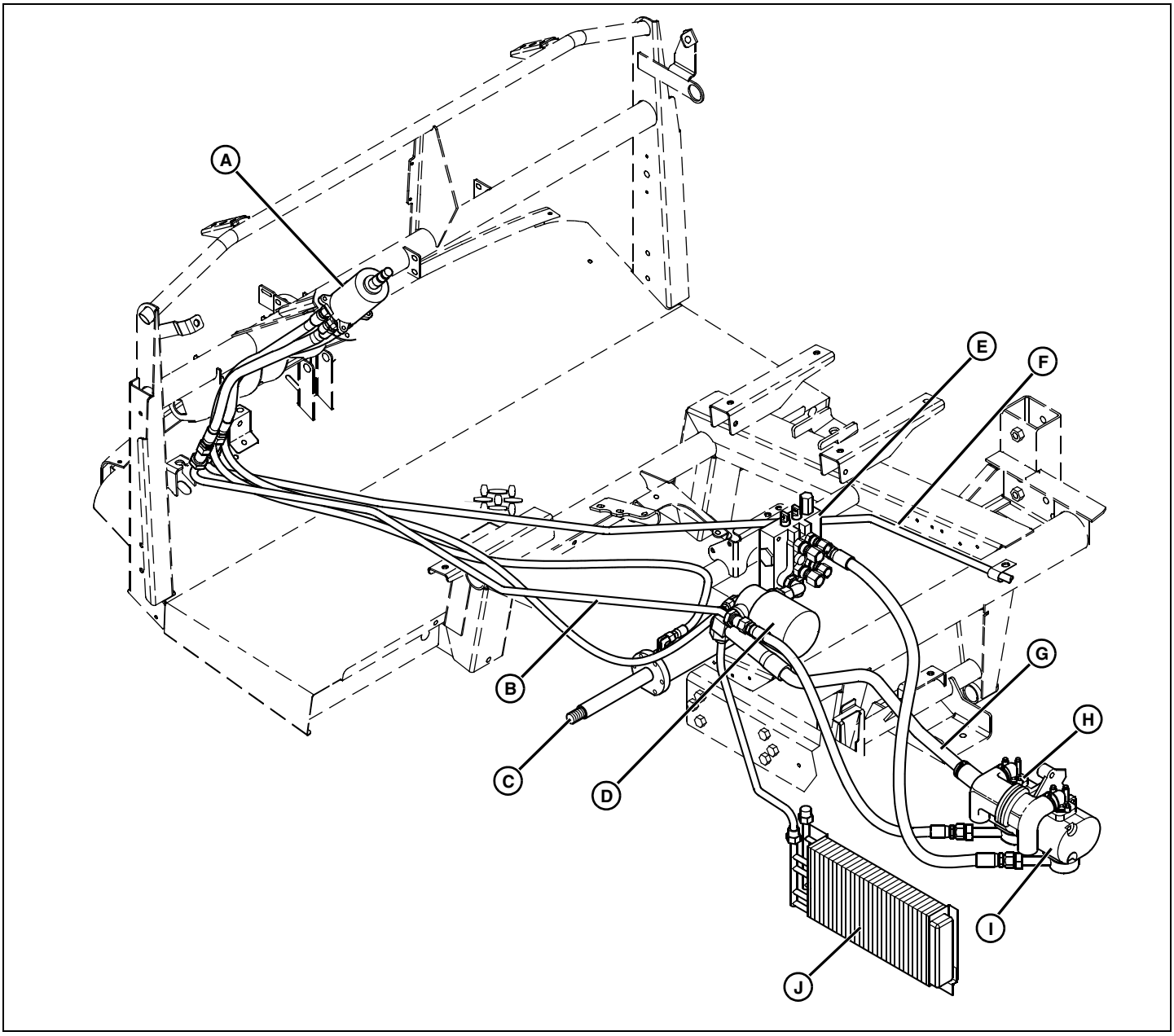
Tool Name	Tool No.	Tool Use
3000 psi Gauge	JT03345	Measure system pressure.
Hose with Coupler	JT03017	Measure system pressure.
Connector, 1/4 M NPT x 7/16-20M 37°	JT05486	Measure system pressure.
Internal Half of Coupler	AM105467	Measure system pressure.
Pump Test Fitting	JDG694	Test system flow.
Flowmeter	JT05469	Test system flow.

Component Location

Hydraulic System Components

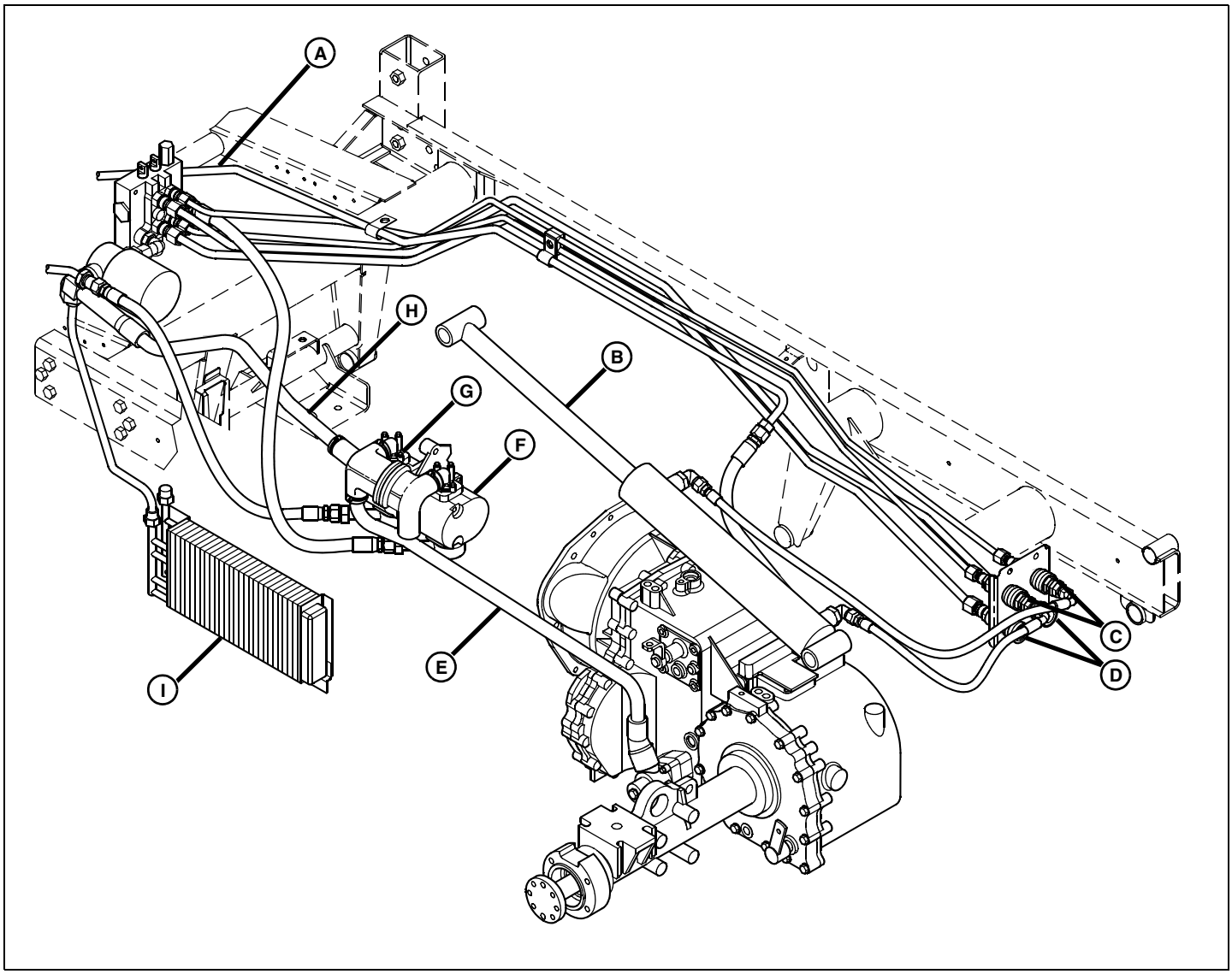
ProGator

Serial No. (-020000)



MIF

A - Steering Control Unit
B - Pressure Line
C - Steering Cylinder
D - Filter (Kit)
E - Control Valve
F - Return Line to Sump (Steering)
G - Return Line to Pump (Auxiliary)
H - Steering Pump
I - Auxiliary Pump
J - Oil Cooler (Kit)



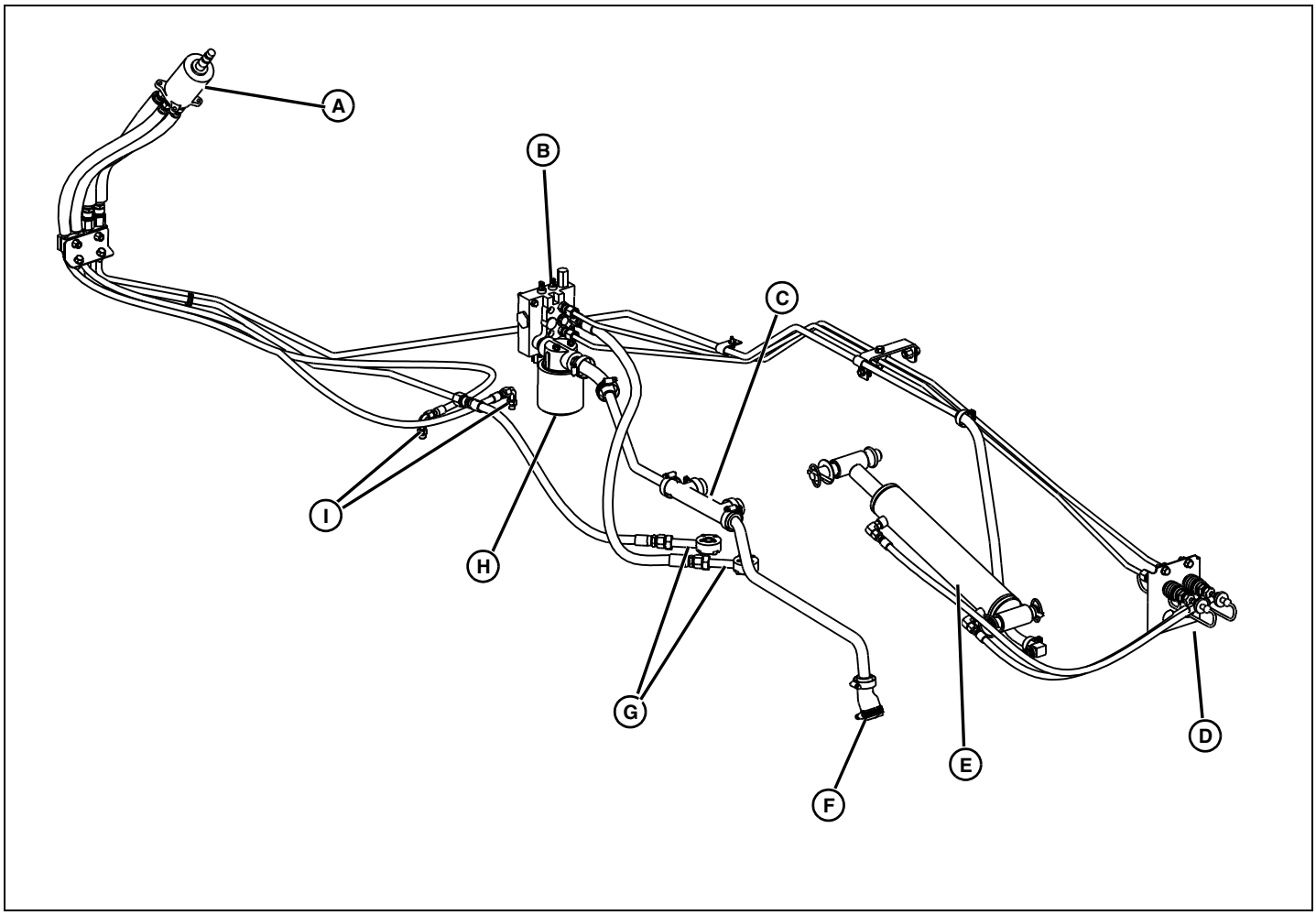
MIF

A - Return Line to Sump (Steering)
B - Lift Cylinder
C - Lift Cylinder Ports (Kit)
D - Auxiliary Ports (Kit)
E - Suction Line from Sump
F - Auxiliary Pump
G - Steering Pump
H - Return Line to Pump (Auxiliary)
I - Oil Cooler (Kit)

Base Hydraulic System

ProGator

Serial No. (020001-)



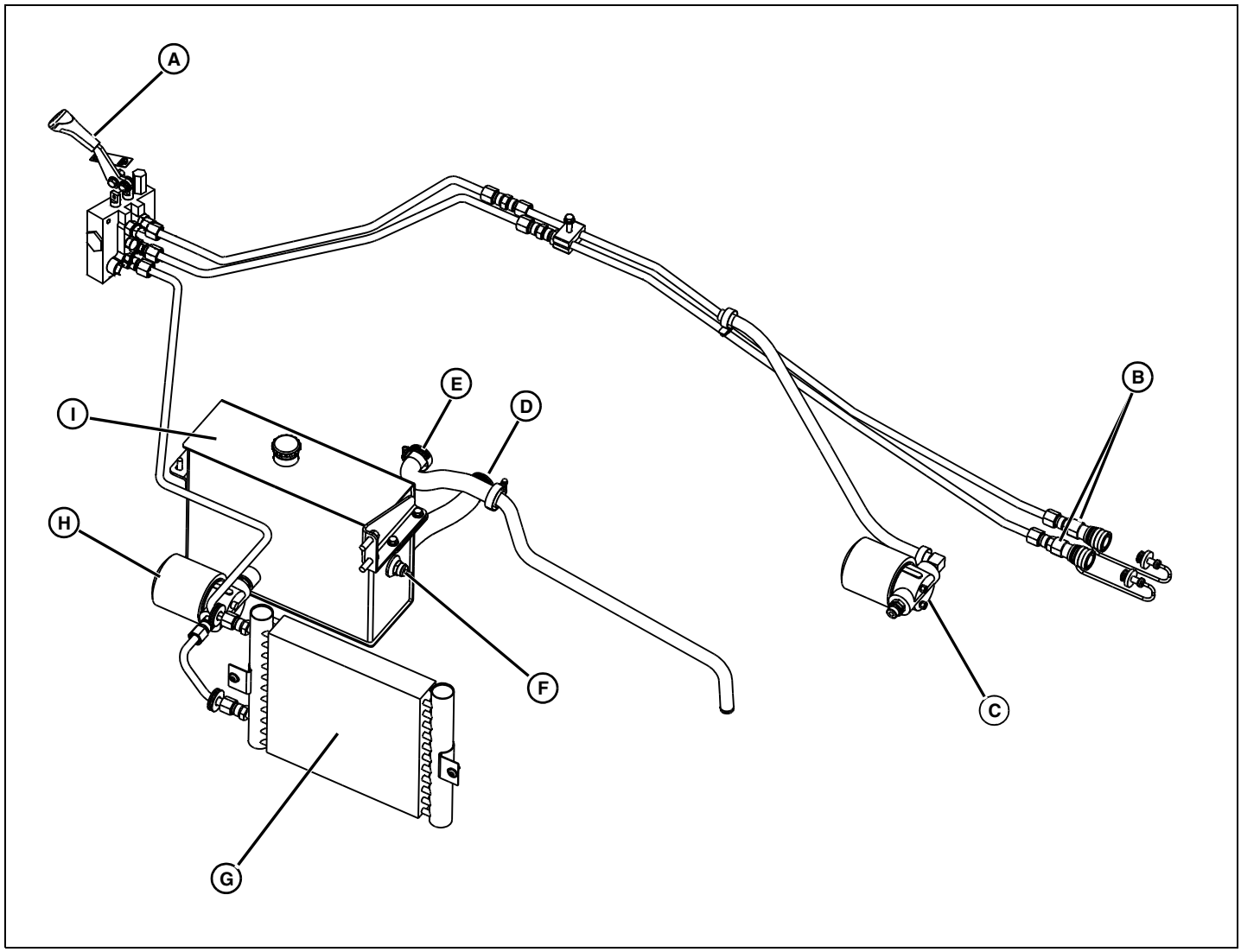
MIF

A - Steering Control Unit
B - Control Valve
C - Pump Inlet Manifold
D - Lift Cylinder Ports
E - Lift Cylinder
F - Suction Line from Transaxle
G - Pump Outlet Connections
H - Filter
I - Hoses to Steering Cylinder

Auxiliary Hydraulic System

ProGator

Serial No. (020001-)

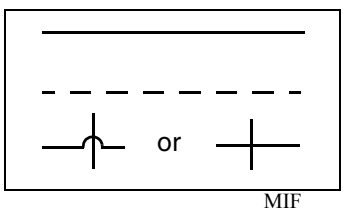


MIF

A - Control Lever and Valve
B - Auxiliary Ports
C - Suction Filter Manifold
D - Auxiliary Pump Inlet
E - Steering Pump Inlet
F - Oil Temperature Switch
G - Oil Cooler
H - Auxiliary System Filter
I - Auxiliary System Reservoir

Schematics and Harnesses

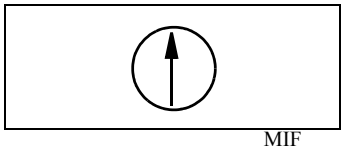
Hydraulic Symbols



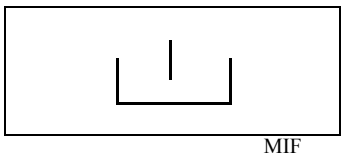
Working (Main) Lines

Pilot Control Lines

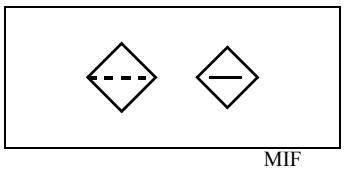
Crossing Lines



Fixed Displacement Pump

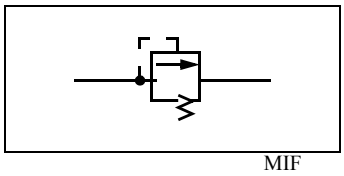


Vented Reservoir with Return above Fluid Level

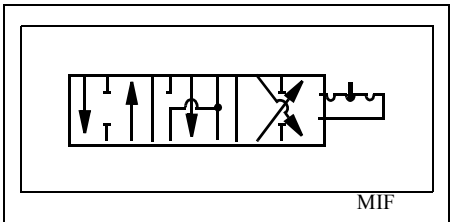


Strainer (left)

Filter (right)

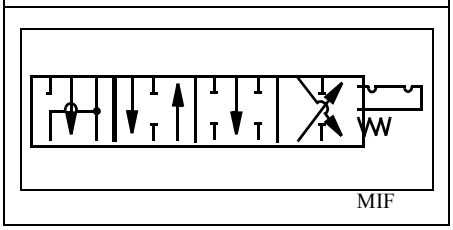


Pressure Relief Valve



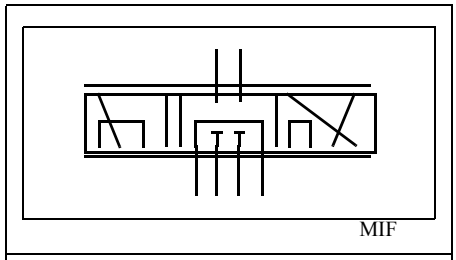
Three Position,

Six Connection Valve with Detents



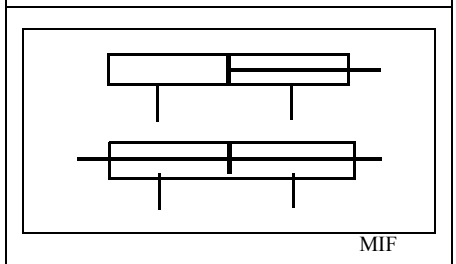
Four Position,

Spring Return with Detented Float



Three Position,

Six Connection Valve with Infinite Positioning

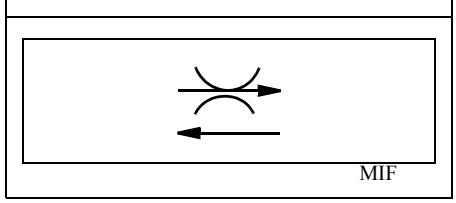


Double Acting,

Single Rod Cylinder

Double Acting,

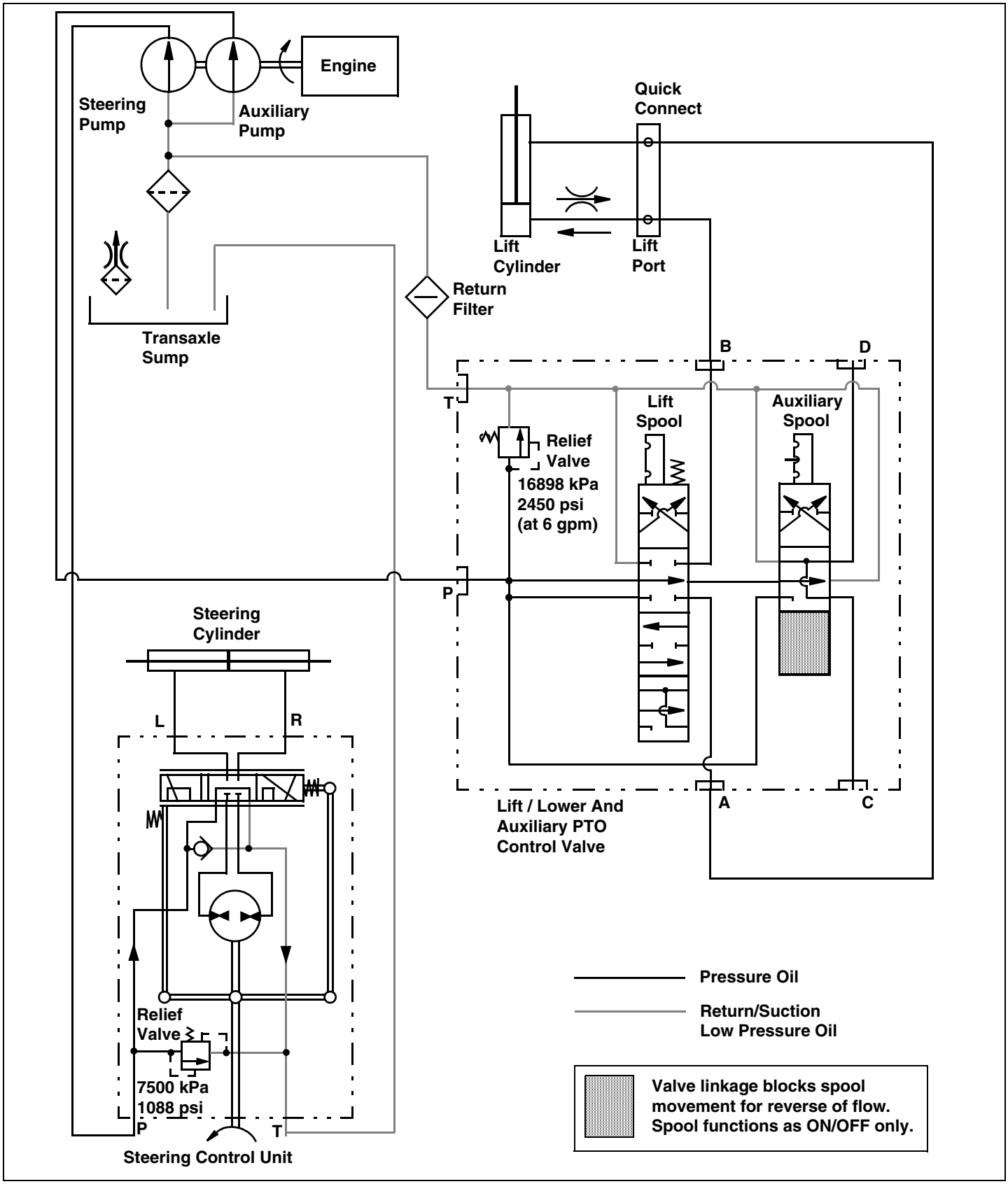
Double Rod Cylinder



One Way Flow Restrictor

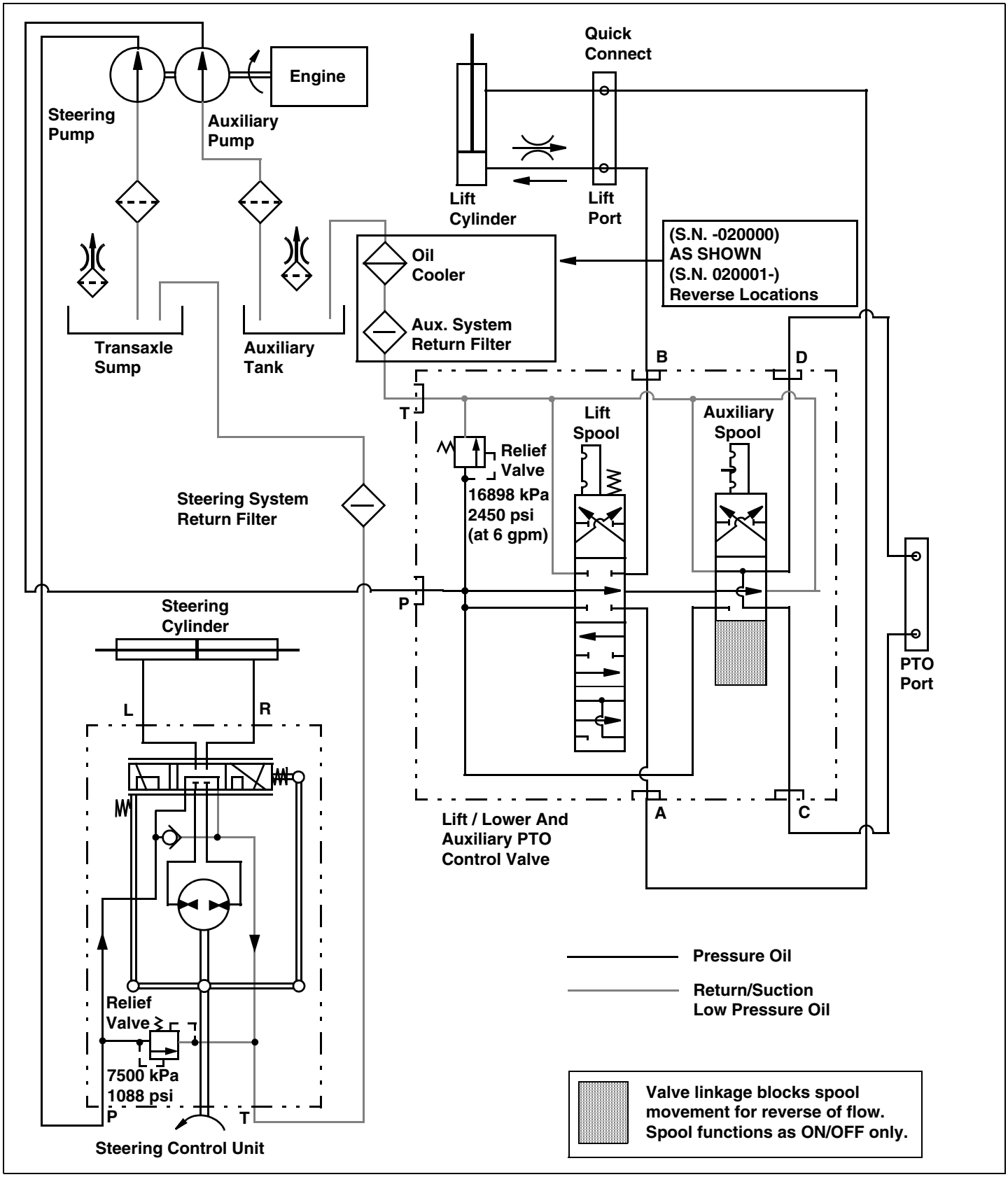
(Orifice Plate)

Standard Hydraulic System Schematic



MIF

Hydraulic System Schematic with Auxiliary Kit



MIF

Theory of Operation

Theory of Operation

The hydraulic system consists of two functional systems, the steering system and the PTO system.

The steering system is run from the front hydraulic pump mounted to the engine drive housing.

NOTE: Both of the hydraulic oil pumps are secured to the engine drive housing. The hydraulic pumps drive gear shafts are splined to a gear in the engine housing. The gear that drives the pump input gear(s) is run at an rpm that is reduced from the engine rpm by a ratio of 1: 0.815. (Example: 3530 engine rpm X 0.815 = 2877 pump rpm)

Hydraulic oil is pumped to the SCU. The SCU controls the steering cylinder by routing pressurized oil to either the left or right side of the steering cylinder and relieving pressure on the other side of the cylinder. Relief oil (low pressure) is returned to the transaxle sump through the steering system return filter (if equipped).

NOTE: The steering system filter is not installed with the standard system.

The PTO system is run from the rear hydraulic pump mounted to the engine drive housing. High pressure hydraulic oil is pumped to the hydraulic/PTO control valve.

The lift cylinder control spool (in the hydraulic PTO control valve) routes high pressure hydraulic oil to either the lift side of the cargo box lift cylinder or the lower side of the cargo box cylinder. While one side of the cargo box lift cylinder is being pressurized, the other side is opened to the hydraulic return system. To prevent the lift cylinder and cargo box from lowering too fast, the rate of descent is limited by an orifice in the lift side of the cylinder.

The standard hydraulic system control valve contains two spools: the lift/lower cylinder control spool and the auxiliary control spool. Unless the auxiliary hydraulic kit is installed in the vehicle, the auxiliary control spool is not used.

When the auxiliary hydraulic kit is installed, the auxiliary control spool controls high pressure hydraulic oil to an added set of hydraulic PTO ports at the rear of the vehicle. Low pressure return oil from the PTO port flows through the auxiliary spool.

The front hydraulic pump supplies hydraulic pressure to the steering control unit (SCU). The SCU utilizes an open center control valve to operate the steering cylinder. When the steering wheel is turned, the SCU directs hydraulic pressure to the appropriate steering cylinder hose, pushing the steering cylinder ram, which pivots the front spools and wheels. The SCU has a relief valve that operates at 7000-7500 kPa (1015-1088 psi). The SCU and steering cylinder are not serviceable, and must be replaced as complete units.

Diagnostics

Hydraulics Troubleshooting

Symptom: Jerky Hydraulic Operation

(1) Is hydraulic oil at proper level?

Yes - Go to step (2).

No - Fill reservoir to proper level with recommended oil.

(2) Are all fittings tight, keeping air out of the system?

Yes - Go to step (3).

No - Tighten fittings and bleed air from system.

(3) Is pump suction strainer free of obstructions?

Yes - Go to step (4).

No - Clean suction strainer and auxiliary strainer (if equipped). (See “Remove and Replace Transaxle Oil Strainer” on page 405.)

(4) Is lift/auxiliary control valve working properly?

Yes - Go to step (5).

No - Check for sticking spools. (See “Service Hydraulic/PTO Control Valve” on page 406.)

No - Check system relief valve. (See “Adjust System Pressure Relief” on page 396.)

(5) Is auxiliary pump operating properly?

No - Perform “Test Auxiliary Pump Flow - S.N. (- 030000) and S.N. (030001-) with Auxiliary Hydraulic Kit Installed” on page 398. Proceed as directed in “Results”.

Symptom: Hydraulic Functions Do Not Operate

(1) Is hydraulic oil at proper level?

Yes - Go to step (2).

No - Fill reservoir to proper level with recommended oil.

(2) Is lift/auxiliary control valve working properly?

Yes - Go to step (3).

No - Check for sticking spools. (See “Service Hydraulic/PTO Control Valve” on page 406.)

No - Check system relief valve. (See “Adjust System Pressure Relief” on page 396.)

No - Check lift cylinder for leakage.

Symptom: Hydraulic Functions Do Not Operate

(3) Are steering and auxiliary pumps operating properly?

No - Perform “Test Steering System” on page 400.

No - Perform “Test Auxiliary Pump Flow - S.N. (- 030000) and S.N. (030001-) with Auxiliary Hydraulic Kit Installed” on page 398. Proceed as directed in “Results”.

Symptom: Lift Cylinder Will Not Retract

(1) Are control levers and linkage adjusted properly?

Yes - Go to step (2).

No - Adjust levers to give full spool travel in both directions.

(2) Is lift/auxiliary control valve working properly?

Yes - Go to step (3).

No - Check for sticking spools. (See “Service Hydraulic/PTO Control Valve” on page 406.)

(3) Is lift cylinder operating properly?

No - Replace lift cylinder.

Symptom: Lift Cylinder Will Not Lift Rated Load

(1) Is hydraulic oil at proper level?

Yes - Go to step (2).

No - Fill reservoir to proper level with recommended oil.

(2) Are all fittings tight, keeping air out of the system?

Yes - Go to step (3).

No - Tighten fittings and bleed air from system.

(3) Is pump suction strainer free of obstructions?

Yes - Go to step (4).

No - Clean suction strainer and auxiliary strainer (if equipped). (See “Remove and Replace Transaxle Oil Strainer” on page 405.)

(4) Is lift/auxiliary control valve working properly?

Yes - Go to step (5).

No - Check for sticking spools. (See “Service Hydraulic/PTO Control Valve” on page 406.)

No - Check system relief valve. (See “Adjust System Pressure Relief” on page 396.)

Symptom: Lift Cylinder Will Not Lift Rated Load

No - Check lift cylinder for leakage.

(5) Is auxiliary pump operating properly?

No - Perform “Test Auxiliary Pump Flow - S.N. (- 030000) and S.N. (030001-) with Auxiliary Hydraulic Kit Installed” on page 398. Proceed as directed in “Results”.

Symptom: Lift Cylinder Oscillates

(1) Is hydraulic oil at proper level?

Yes - Go to step (2).

No - Fill reservoir to proper level with recommended oil.

(2) Are all fittings tight, keeping air out of the system?

Yes - Go to step (3).

No - Tighten fittings and bleed air from system.

(3) Is lift/auxiliary control valve working properly?

Yes - Go to step (4).

No - Check for sticking spools. (See “Service Hydraulic/PTO Control Valve” on page 406.)

No - Check system relief valve. (See “Adjust System Pressure Relief” on page 396.)

(4) Is auxiliary pump operating properly?

No - Perform “Test Auxiliary Pump Flow - S.N. (- 030000) and S.N. (030001-) with Auxiliary Hydraulic Kit Installed” on page 398. Proceed as directed in “Results”.

Symptom: Lift Cylinder Will Not Support Load with Engine Off

(1) Is lift/auxiliary control valve working properly?

Yes - Go to step (2).

No - Check for sticking spools. (See “Service Hydraulic/PTO Control Valve” on page 406.)

No - Check system relief valve. (See “Adjust System Pressure Relief” on page 396.)

(2) Is lift cylinder operating properly?

No - Check lift cylinder for leakage. Replace cylinder as necessary.

Symptom: Attachment Motor Connected to PTO Ports, Operates Under Speed

(1) Is hydraulic oil at proper level?

Yes - Go to step (2).

No - Fill reservoir to proper level with recommended oil.

(2) Are all fittings tight, keeping air out of the system?

Yes - Go to step (3).

No - Tighten fittings and bleed air from system.

(3) Is pump suction strainer free of obstructions?

Yes - Go to step (4).

No - Clean suction strainer and auxiliary strainer (if equipped). (See “Remove and Replace Transaxle Oil Strainer” on page 405.)

(4) Are control levers and linkage adjusted properly?

Yes - Go to step (5).

No - Adjust levers to give full spool travel in both directions.

(5) Is lift/auxiliary control valve working properly?

Yes - Go to step (6).

No - Check for sticking spools. See “Service Hydraulic/PTO Control Valve” on page 406.)

No - Check system relief valve. (See “Adjust System Pressure Relief” on page 396.)

No - Check lift cylinder for leakage.

(6) Is auxiliary pump operating properly?

No - Perform “Test Auxiliary Pump Flow - S.N. (- 030000) and S.N. (030001-) with Auxiliary Hydraulic Kit Installed” on page 398. Proceed as directed in “Results”.

Symptom: Attachment Motor Connected to PTO Ports, Does Not Operate

(1) Is hydraulic oil at proper level?

Yes - Go to step (2).

No - Fill reservoir to proper level with recommended oil.

(2) Are PTO quick couplers connected?

Yes - Go to step (3).

No - Connect couplers.

Symptom: Attachment Motor Connected to PTO Ports, Does Not Operate

(3) Are control levers and linkage adjusted properly?

Yes - Go to step (4).

No - Adjust levers to give full spool travel in both directions.

(4) Is lift/auxiliary control valve working properly?

Yes - Go to step (5).

No - Check for sticking spools. See “Service Hydraulic/PTO Control Valve” on page 406.)

No - Check system relief valve. (See “Adjust System Pressure Relief” on page 396.)

No - Check lift cylinder for leakage.

(5) Is auxiliary pump operating properly?

No - Perform “Test Auxiliary Pump Flow - S.N. (- 030000) and S.N. (030001-) with Auxiliary Hydraulic Kit Installed” on page 398. Proceed as directed in “Results”.

Symptom: Attachment Motor Connected to PTO Ports, Turns in Wrong Direction

(1) Are PTO quick couplers connected to the correct ports?

No - Connect couplers correctly.

Symptom: High Steering Wheel Effort

(1) Is hydraulic oil at proper level?

Yes - Go to step (2).

No - Fill reservoir to proper level with recommended oil.

(2) Are all fittings tight, keeping air out of the system?

Yes - Go to step (3).

No - tighten fittings and bleed air from system.

(3) Is pump suction strainer free of obstructions?

Yes - Go to step (4).

No - Clean suction strainer and auxiliary strainer (if equipped). (See “Remove and Replace Transaxle Oil Strainer” on page 405.)

Symptom: High Steering Wheel Effort

(4) Is steering control valve working properly?

Yes - Go to step (5).

No - Perform “Test Steering System” on page 400.

No - See “Steering Control Unit (SCU)” on page 409.

(5) Is steering pump operating properly?

No - See “Disassemble and Assemble Hydraulic Pump” on page 404.

Symptom: No Steering Function

(1) Is hydraulic oil at proper level?

Yes - Go to step (2).

No - Fill reservoir to proper level with recommended oil.

(2) Are all fittings tight, keeping air out of the system?

Yes - Go to step (3).

No - Tighten fittings and bleed air from system.

(3) Is pump suction strainer free of obstructions?

Yes - Go to step (4).

No - Clean suction strainer and auxiliary strainer (if equipped). (See “Remove and Replace Transaxle Oil Strainer” on page 405.)

(4) Is steering control valve working properly?

Yes - Go to step (5).

No - Perform “Test Steering System” on page 400.

No - See “Steering Control Unit (SCU)” on page 409 in this section.

(5) Is steering cylinder operating properly?

Yes - Go to step (6).

No - Perform“Test Steering Cylinder Leakage” on page 401.

(6) Is steering pump operating properly?

No - See “Disassemble and Assemble Hydraulic Pump” on page 404.

Tests and Adjustments

Adjust System Pressure Relief

Reason

To make sure that the hydraulic system pressure relief valve is correctly set.

Special or Required Tools

Tool Name	Tool No.	Tool Use
3000 psi Gauge	JT03345	Measure system pressure.
Hose with Coupler	JT03017	Measure system pressure.
Connector, 1/4 M NPT x 7/16-20M 37°	JT05486	Measure system pressure.
Male Quick Coupler	AM105467	Measure system pressure.
T-fitting	61H1029	Measure system pressure.
Hose	AM127387	Measure system pressure.
Adapter	61H1171	Measure system pressure.
Female Quick Coupler	AM105466	Measure system pressure.

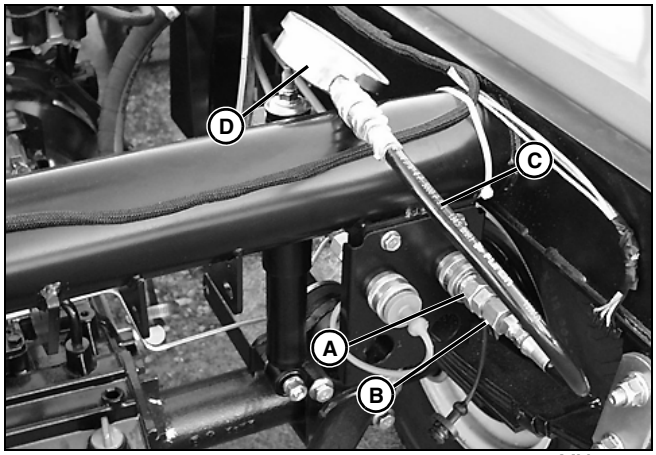
Procedure

CAUTION: Avoid injury! Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury may call Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.

IMPORTANT: Avoid damage! Oil in system should be at normal operating temperature.

1. Install pressure gauge as follows:

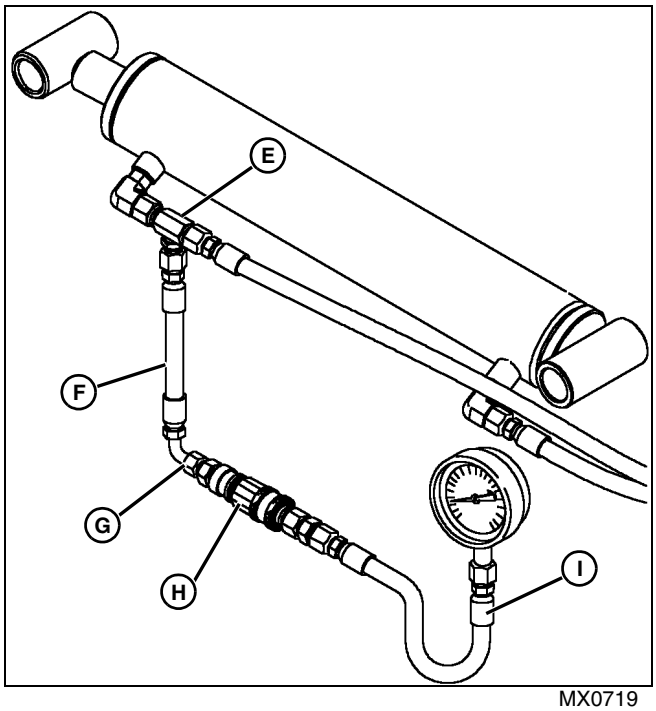
S.N. (-030000) or S.N. (030001-) With Auxiliary Hydraulic Kit Installed



MX0719

- Assemble AM105467 Coupler (A), JT05486 Connector (B), JT03017 Hose (C), and JT03345 Pressure Gauge (D) in pressure port.

S.N. (030001-) Without Auxiliary Hydraulic Kit Installed.



MX0719

- Assemble 61H1029 T-fitting (E), AM127387 Hose (F), 61H1171 Adapter (G), and AM105466 Female Quick Coupler (H). Connect to rod end at hydraulic cylinder.
- Attach JT03345 Pressure Gauge (I) to quick coupler.

2. Start engine and run at fast idle.

IMPORTANT: Avoid damage! The following step puts the hydraulic pump into relief. DO NOT operate in this condition for more than 5 seconds!

3. Activate hydraulic/PTO valve handle in down position, read pressure gauge, and release.

Results

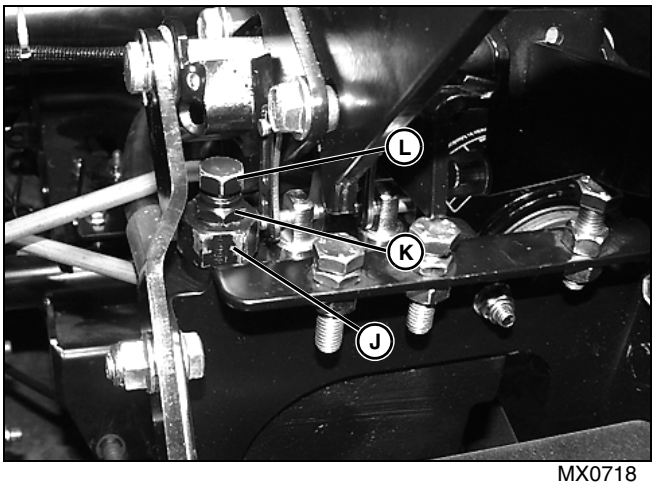
System pressure should be approximately 16 553-17 926 kPa (2400-2500 psi). If not, adjust as follows.

Adjustment

1. Remove control panel cover to gain access to relief valve.

2. Adjust as follows:

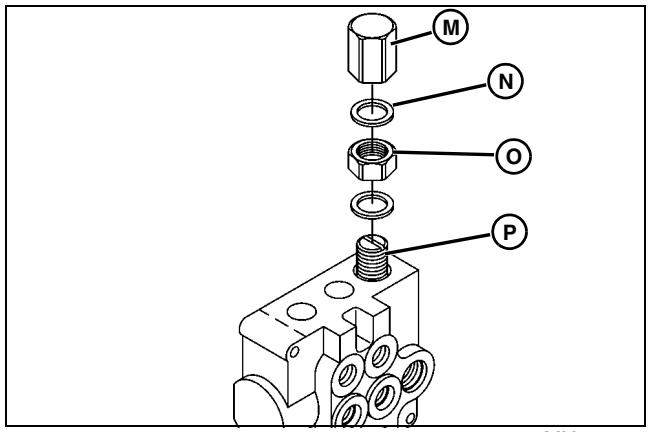
S.N. (-020000)



MX0718

- Hold top of relief valve (J) to keep it from turning and loosen seal locknut (K) one-half turn.
- Adjust pressure by rotating adjusting screw (L) clockwise to increase pressure or counterclockwise to decrease pressure.

S.N. (020001-)



MX18125

- Remove cap (M). Use care not to lose seal ring (N).
- Loosen jam nut (O).
- Adjust pressure by turning adjusting screw (P) clockwise to increase pressure or counterclockwise to decrease pressure.

3. Retest system pressure, and repeat adjustment as required until pressure is set to specification.

4. Once system pressure is set correctly, tighten locknut.

Specifications

Relief Pressure
Control Valve . . . . . 16 553-17 926 kPa (2400-2500 psi)

Hydraulic Cycle Time Test

Reason

To determine if hydraulic system is working efficiently.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Stopwatch	NA	Measure cycle time.

Procedure

IMPORTANT: Avoid damage! To obtain accurate readings, oil in system should be at normal operating temperature and machine should be equipped with a cargo box.

1. Park machine on flat level surface.

2. Warm up hydraulic oil to normal operating temperature.

3. Shift machine into neutral position and apply park brake. Lower cargo box.

4. Run engine at fast idle.

5. Raise the cargo box and start the stopwatch at the same time. Note the time required to raise the box to fully raised position.

Results

Cycle times should be to specification.

If not:

- Check that oil is proper level and at normal operating temperature.
- Replace hydraulic system filter cartridge or check for screen filter for obstruction. (See “Remove and Replace Transaxle Oil Strainer” on page 405.)
- Check system relief pressure. (See “Adjust System Pressure Relief” on page 396.)
- Perform pump flow test. (See “Test Auxiliary Pump Flow - S.N. (-030000) and S.N. (030001-) with Auxiliary Hydraulic Kit Installed” on page 398.)
- Repair or replace pump or lift cylinder as required. (See “Remove and Install Hydraulic Pump” on page 402.)

Specifications

Gas Engine Hydraulic Cycle Time . . . . . 2.5 seconds
Diesel Engine Hydraulic Cycle Time. . . . . 2.5 seconds

Test Auxiliary Pump Flow - S.N. (-030000) and S.N. (030001-) with Auxiliary Hydraulic Kit Installed

Reason

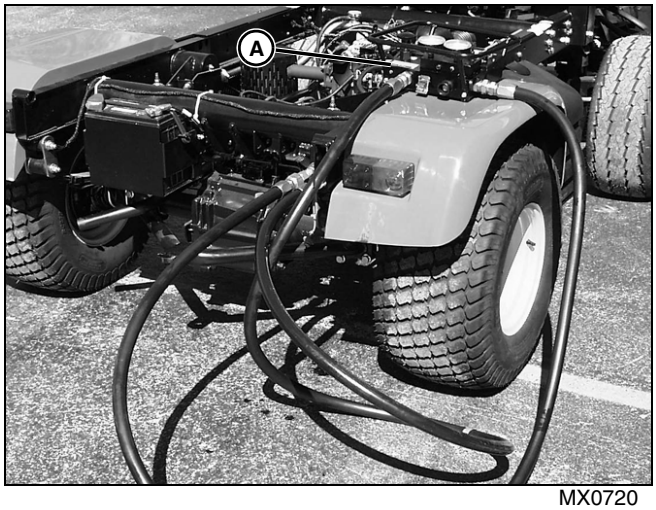
To determine if auxiliary hydraulic pump is providing adequate flow under pressure.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Male Quick Coupler (2 used)	AM105467	Test system flow.
Adapter Fittings (2 used)	JT03082	Test system flow.
Flowmeter	D01169AA	Test system flow.

Procedure

IMPORTANT: Avoid damage! Oil in system should be at normal operating temperature.



MX0720

1. Install D01169AA Flowmeter (A) and hoses between PTO ports on rear of vehicle.
2. Open valve on flowmeter all the way.
3. Start engine and run at fast idle.
4. Hold the lift cylinder lever in the up position.
5. Observe flow.

Results

Pump flow should be to specification.

NOTE: Pump output is based on pump volume per revolution x engine rpm x gear reduction of 0.815 (example: 9 cm^3 x 3530 x 0.815 = 25 893 cm^3).

If not:

- Check intake filter for obstruction. Clean and/or replace as required. See “Remove and Replace Transaxle Oil Strainer” on page 405.
- Repair/replace pump as required. See “Remove and Install Hydraulic Pump” on page 402.

Specifications

Gas Engine (3570 RPM) . . . . . 28.0 liters/min (7.4 gpm)
Diesel Engine (3450 RPM) . . . . 27.1 liters/min (7.2 gpm)

Test Auxiliary Pump Flow - S.N. (030001-) without Auxiliary Hydraulic Kit Installed

Reason

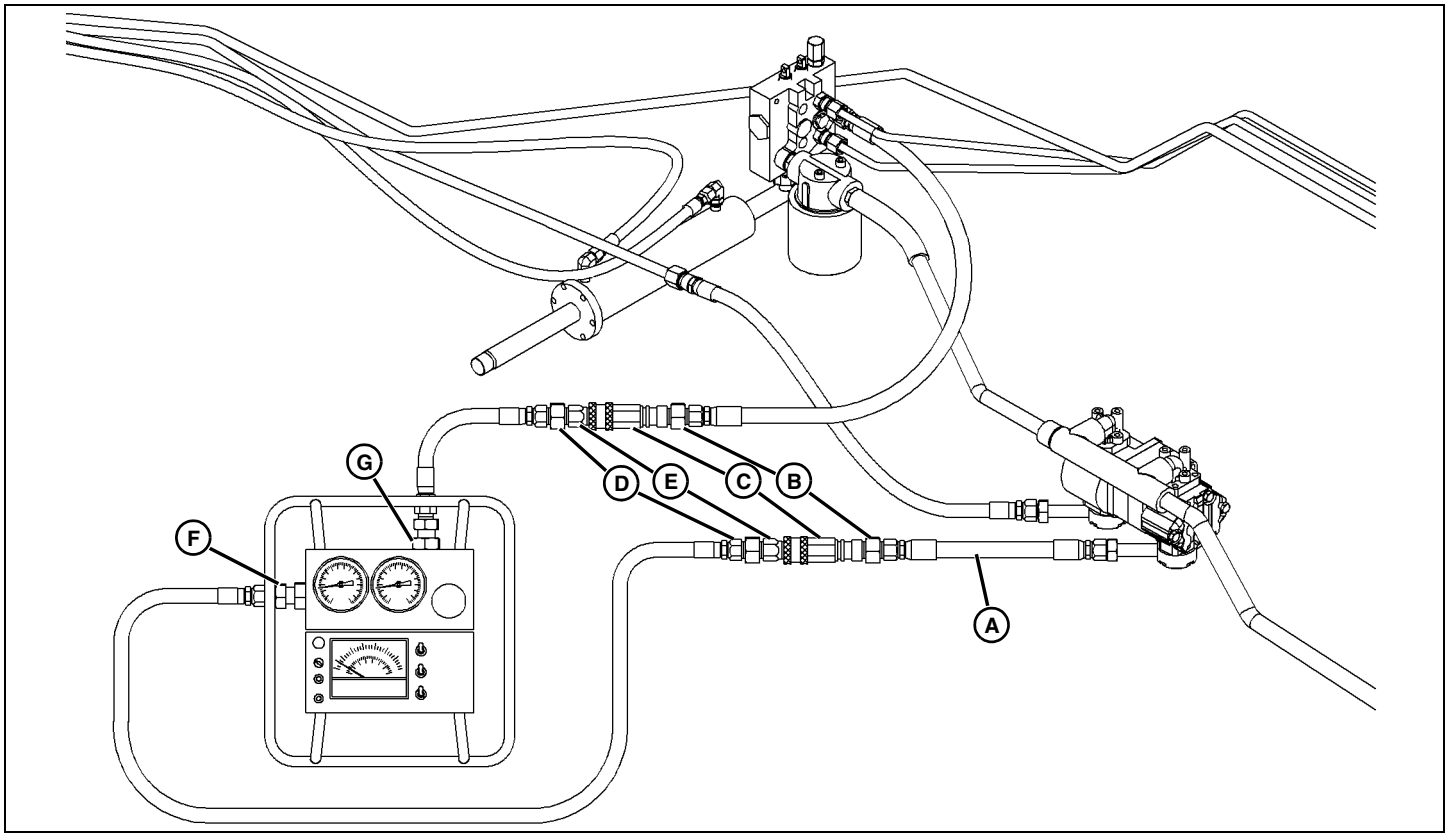
To determine if auxiliary hydraulic pump is providing adequate flow under pressure.

Special or Required Tools

Tool Name	Tool No.	Tool Use
Hose	AM126653	Test system flow.
Adapter Fittings (2 used)	61H1161	Test system flow.
Female Quick Coupler (2 used)	AM105466	Test system flow.
Male Quick Coupler (2 used)	AM105467	Test system flow.
Adapter Fittings (2 used)	JT03082	Test system flow.
Flowmeter	D01169AA	Test system flow.

Procedure

IMPORTANT: Avoid damage! Oil in system should be at normal operating temperature.



MX18121

1. Place a drain pan under auxiliary pump.

2. Assemble AM126653 Hose (A), 61H1161 Adapters (B), AM105466 Female Quick Couplers (C), AMJT03082 Adapters (D), AM105467 Male Quick Couplers (E), and D01169AA Flowmeter as shown.

3. Disconnect output hose from pump at pump fitting.

4. Connect AM126653 Hose to auxiliary pump fitting. This hose must lead to the “IN” port (F) of the flowmeter.

5. Connect the auxiliary pump hose (disconnected earlier) to the “OUT” port (G) of the flowmeter.

6. Check the level of hydraulic fluid in the reservoir. Add fluid as required.

7. Open valve on flowmeter all the way.

8. Start engine and run at fast idle.

9. Hold the lift cylinder lever in the UP position.

10.Observe flow.

Results

Pump flow should be to specification.

NOTE: Pump output is based on pump volume per revolution x engine rpm x gear reduction of 0.815 (Example: 9 cm^3 x 3530 x 0.815 = 25 893 $cm.^3$)

If not:

- Check intake filter for obstruction. Clean and/or replace as required. See “Remove and Replace Transaxle Oil Strainer” on page 405.
- Repair/replace pump as required. See “Remove and Install Hydraulic Pump” on page 402.

Specifications

Pump Flow (Gasoline Engine @ 3520 RPM) . . . . . 25.9 liters/min (6.84 gpm)

Pump Flow (Diesel Engine @ 3450 RPM) . . . . . 25.3 liters/min (6.68 gpm)

Test Steering System

Reason

To check steering control unit (SCU) and steering cylinder operation and check for internal leakage.

Special or Required Tools

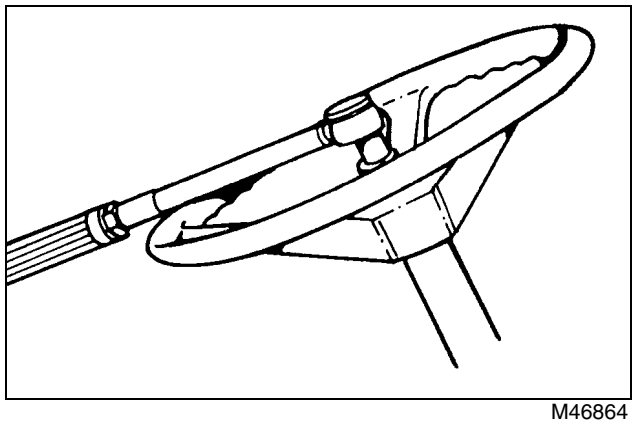
Tool Name	Tool No.	Tool Use
Torque Wrench	NA	Used to turn steering wheel at a constant torque.
Caps for Hydraulic Lines	NA	Used to cap ends of hoses to prevent leakage.

Procedure

1. Park vehicle safely.

2. Run the engine until the hydraulic fluid is at operating temperature.

3. Turn the steering wheel to the full right position.



M46864

4. Remove steering wheel cap.

5. Place a torque wrench on steering wheel nut. Turn steering shaft to the right at a constant torque of 6.8 N•m (60 lb-in.) and count the number of turns in one minute.

6. Repeat the procedure, turning the steering wheel to the full left position.

7. Stop engine.

Results

If the rotation in left or right direction exceeded 5 rpm, the steering system has internal leakage. To determine whether it is the SCU or cylinder that is leaking, proceed as directed below.

Procedure

CAUTION: Avoid injury! Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury may call Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.

1. Label and remove both left and right hydraulic hoses at the steering cylinder.
2. Cap the ends of both hoses.
3. Repeat the SCU test.

Results

- If the rotation speed is now below 5 rpm, replace the steering cylinder.
- If the rotation speed remains above 5 rpm, replace the SCU.

Test Steering Cylinder Leakage

Reason

To check steering cylinder for internal leakage.

Procedure

1. Park machine safely.
2. With machine at room temperature, start and run engine at FAST idle for five minutes, to warm up hydraulic oil.
3. Turn key switch to OFF position.
4. Turn steering wheel to full right to fully retract cylinder end.
5. Disconnect hydraulic hose from steering cylinder. Cap hydraulic line with O-ring seal plug.
6. Start engine and run at fast idle.
7. Continue turning steering wheel to the right.
8. Watch for any flow of oil out of the cylinder at hose.
9. Repeat steps 5 through 8 for left turn and opposite end of cylinder.

Results

- If any flow of oil out of the cylinder occurred, replace cylinder.
- If no oil flow:
  - Shut off engine.
  - Connect hydraulic hose. Tighten hose connection to specification.

Specifications

Hose Connection Torque. . . . . 30 N•m (22 lb-ft)

Repair

Remove and Install Hydraulic Pump

Removal

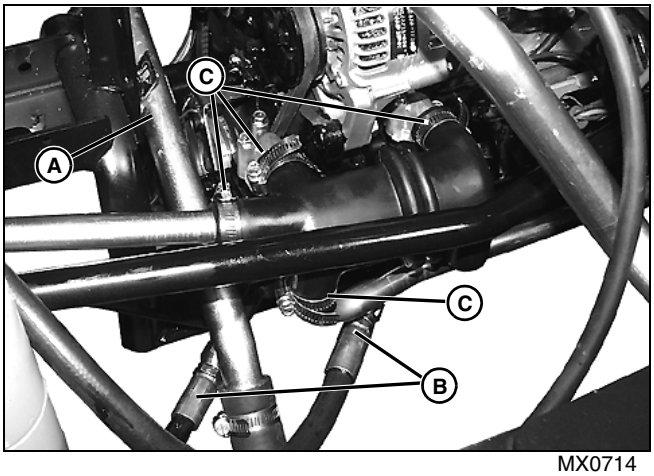
1. Drain oil from sump.
2. Disconnect battery cables from battery.

IMPORTANT: Avoid damage! Disconnect battery cables. The long cap screws being removed from the hydraulic pumps pull out to the starting motor.

3. Disconnect the bracket securing the coolant hose between the engine and radiator.

NOTE: It is not necessary to drain the radiator or remove the alternator belt for removal of pumps.

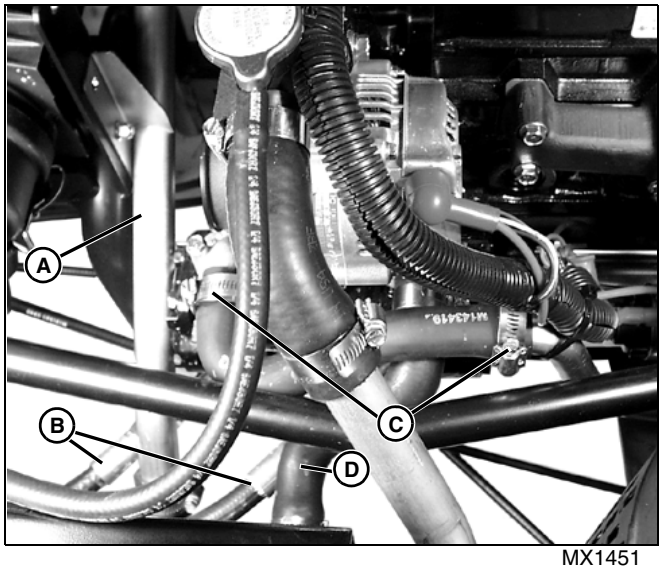
4. Place a suitable container under hydraulic pumps to catch oil from lines, filter and pumps.



MX0714

Picture Note: Old Style Manifold Shown

5. Drain radiator. Disconnect and remove coolant line (A) to access front of hydraulic pumps.



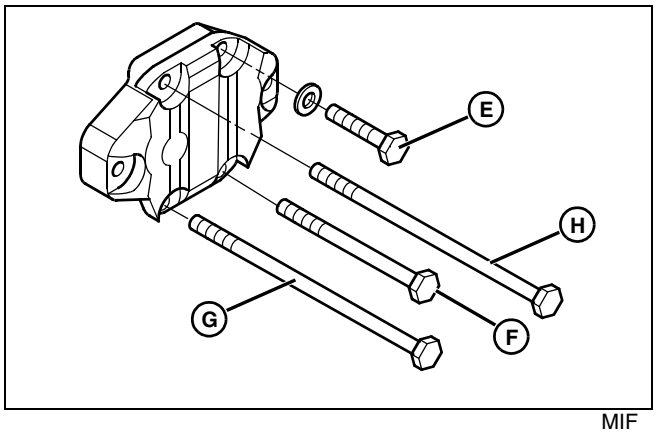
MX1451

Picture Note: New Style Shown with Auxiliary Hydraulic Kit Installed

6. Remove the two pressure lines (B) from the bottom of the pumps.

7. Loosen hose clamps (C) securing rubber intake manifold to pumps. Remove manifold.

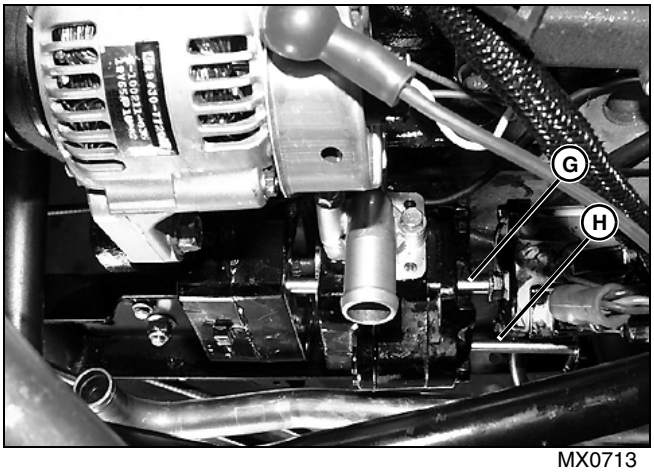
8. Disconnect auxiliary tank hose (D) (if installed).



MIF

9. Remove the top inside cap screws (E) from the pumps.

10. Remove the lower inside cap screw (F) and flange washer.



MX0713

Picture Note: Old Model Suction Tube Shown

11.Remove the flange nut from the two long outside cap screws (G and H).

12.Loosen the front and rear hydraulic pumps.

13.Slide the two long cap screws toward the rear until they clear the front pump. Loosen and remove the front pump.

14.Slide the two long cap screws toward the rear until they clear the engine drive housing. Slide the rear pump back until it is possible to remove the lower cap screw.

15.Remove remaining cap screw and rear pump.

Installation

1. Align splines on rear pump input shaft with splines on engine drive.

2. Remove the rear pump and loosely install the two long cap screws.

3. Install new rear pump gasket.

4. Slide the cap screws into the engine drive housing and slide the rear pump forward until the splined shaft engages.

5. Install the lower inside cap screw through the pump and engine housing.

6. Install inside upper cap screw finger tight.

7. Install a new front gasket and the front pump.

8. Secure hydraulic pumps to engine with cap screws and flange nuts. Tighten to specification.

9. Install new O-ring on pressure fittings as required and secure to pump body. Tighten to specification.

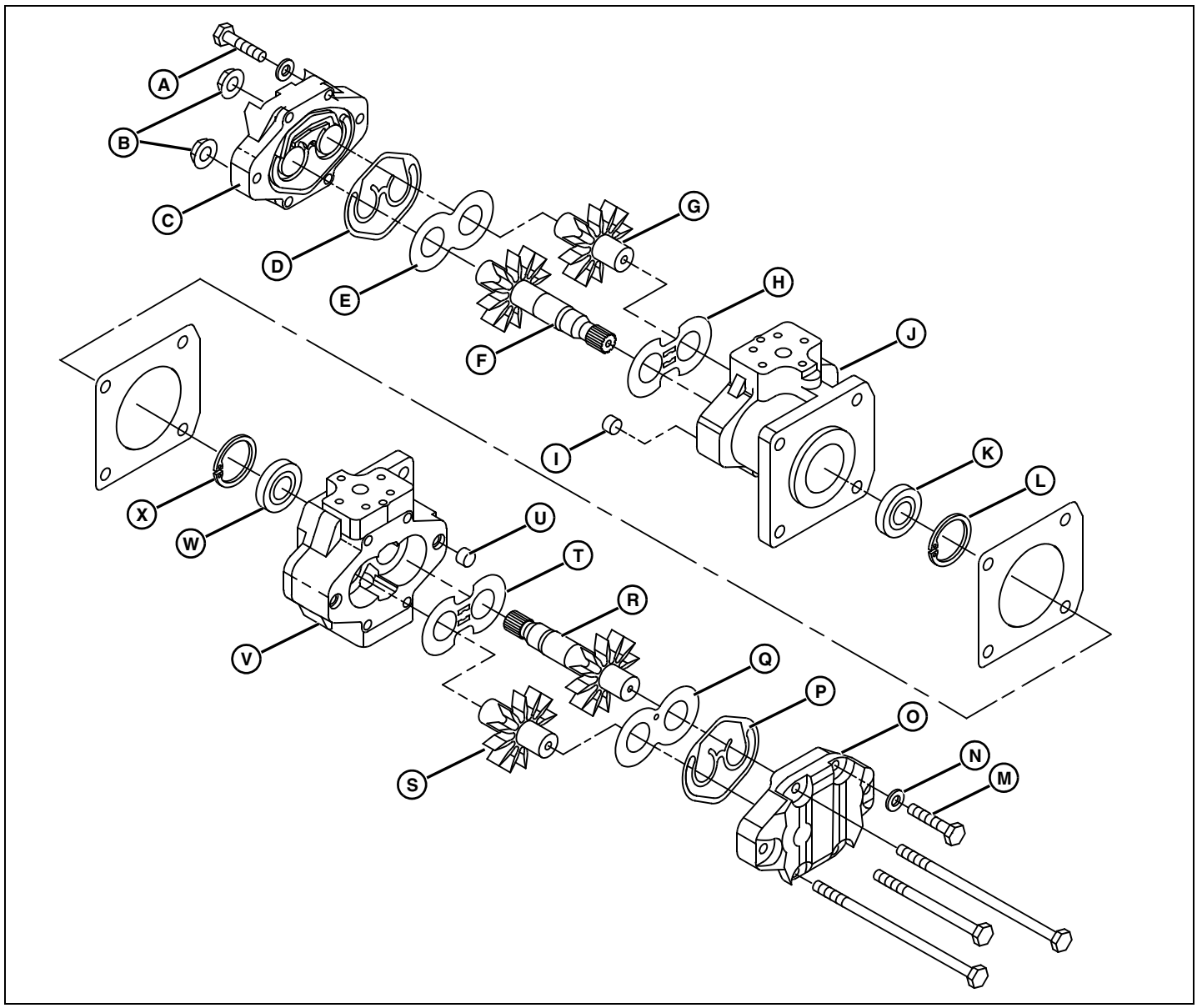
10.Install intake manifold and secure with hose clamps.

11.Secure coolant hose bracket to frame.

Specifications

Cap Screw Torque . . . . . 26 N•m (22 lb-ft)
Pressure Fitting Screw Torque . . . . . 6 N•m (53 lb-in.)

Disassemble and Assemble Hydraulic Pump



MIF

Picture Note: Letters A-L Refer to Steering Pump (Front), Letters M-X Refer to Auxiliary Pump (Rear)

A - Cap Screw and Washer
B - Flange Nut
C - Pump Cover
D - Formed O-Ring
E - Thrust Plate (Thick)
F - Drive Gear
G - Idler Gear
H - Thrust Plate (Thin)
I - Alignment Pin
J - Pump Body
K - Seal
L - Snap Ring
M - Cap Screw and Washer
N - Lock Washer
O - Pump Cover
P - Formed O-Ring
Q - Thrust Plate (Thick)
R - Drive Gear
S - Idler Gear
T - Thrust Plate (Thin)
U - Alignment Pin
V - Pump Body
W - Seal
X - Snap Ring

Disassembly and Inspection

1. Remove pump(s) from engine. (See “Remove and Install Hydraulic Pump” on page 402.)

2. Remove remaining cap screws (A) securing pump cover to pump body.

3. Remove pump cover.

4. Remove formed O-ring gasket (D).

5. Inspect bushings in cover. If not to specifications, replace.

6. Remove thick thrust plate (E).

7. Remove pump gears.

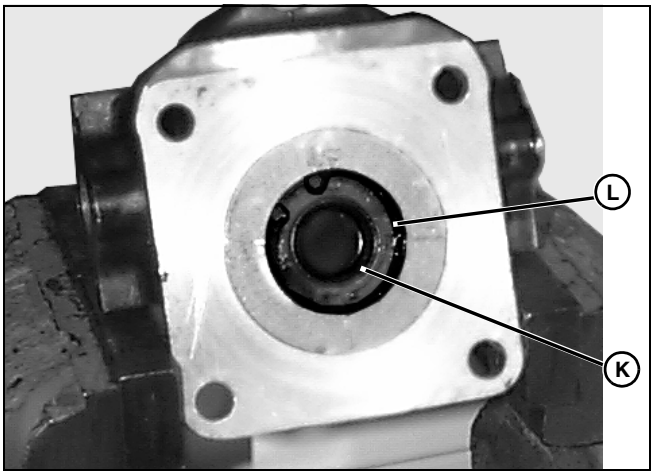
8. Inspect gear faces for wear. Replace as required.

9. Inspect input gear shaft splines. Replace if damaged.

10.Measure gear shaft bearing surfaces. Replace if not within specifications.

11.Remove thin thrust plate (H) from pump body.

12.Inspect pump body internal surfaces for scoring or excessive scratching. Replace pump if damaged.



M87861

13.Remove internal snap ring (L) retaining seal (K) in pump body.

14.Remove seal.

Assembly

1. Install new seal in pump body. Secure with internal snap ring.

2. If needed, replace bushings in pump body using suitable bearing driver.

3. Place thin thrust plate in pump body with “brass” colored side facing to gears and groove in thrust plate toward intake side of pump.

4. Place pump gears in pump body.

NOTE: Idler gear is symmetrical and can be placed in the body either end first.

5. Place thick thrust plate, with “brass” colored surface towards gears, on gear shafts. Pump thrust plate should be flush with pump body gasket surface when correctly installed.

6. Install new formed O-ring.

7. Place pump cover on pump body. Secure with cap screws. Tighten to specification.

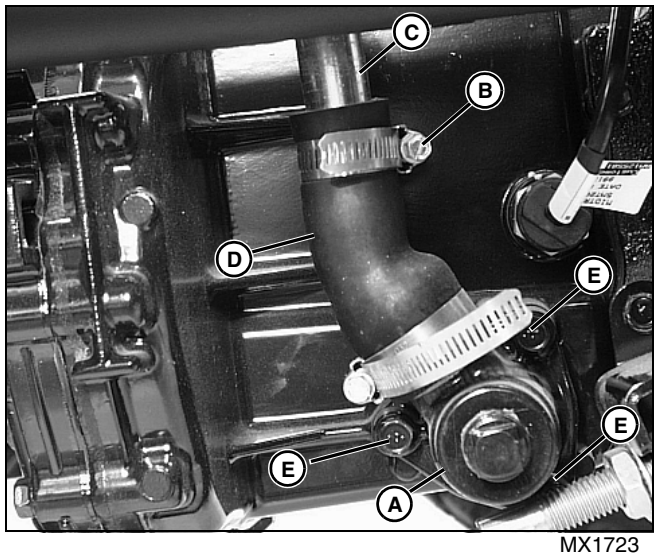
Specifications

Input Shaft
Bearing OD . . . . . 17.93-18.06 mm (0.7059-0.7110 in.)
Idler Gear Shaft
Bearing OD . . . . . 17.93-18.06 mm (0.7059-0.7110 in.)
Bushing ID . . . . . 18.00-18.06 mm (0.7087-0.7110 in.)
Thrust Plate (Thick) . . 1.98-2.00 mm (0.0780-0.0787 in.)
Thrust Plate (Thin) . . . 1.18-1.20 mm (0.0465-0.0472 in.)
Pump Body Cap Screw Torque . . . . . 15 N•m (133 lb-in.)

Remove and Replace Transaxle Oil Strainer

NOTE: System capacity is approximately 11.4 L (3.0 gal).

1. Drain oil from transaxle through drain plug.



MX1723

2. Locate strainer housing (A) on the left side of vehicle.

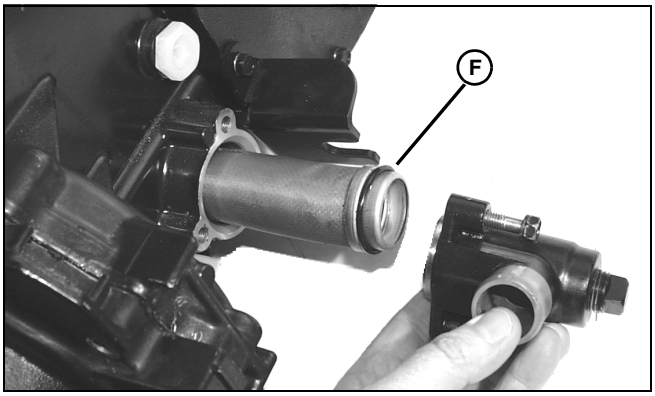
NOTE: Second strainer (with auxiliary hydraulic system) is located at end of suction hose within hydraulic fluid tank.

3. Loosen hose clamp (B).

4. Remove hydraulic line (C) from rubber hose (D).

5. Loosen and remove three hex bolts (E).

6. Remove strainer housing and strainer.



MX0946

7. Clean strainer (F) with solvent or mineral spirits.
8. If strainer is damaged, torn or bent, replace it.

Installation

Installation done in the reverse order of removal.

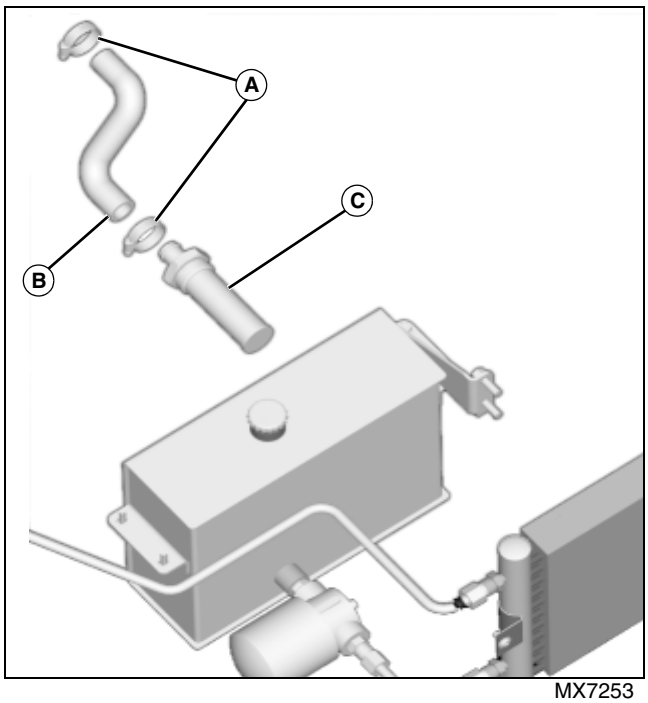
- Refill transaxle with correct oil.

Remove and Replace Hydraulic Tank Oil Strainer (Auxiliary Hydraulic Kit)

NOTE: This procedure only applies to vehicles equipped with the auxiliary hydraulic kit.

Tank capacity is approximately 13.2 L (3.5 gal).

1. Drain oil from hydraulic tank through drain plug.



MX7253

2. Loosen adjustable hose clamp (A).
3. Remove rubber hose (B) from strainer (C).
4. Remove strainer from the hydraulic oil tank.
5. Clean strainer with solvent or mineral spirits and allow to dry.
6. If strainer is damaged, torn or bent, replace it.

Installation

Installation done in the reverse order of removal.

- Fill hydraulic tank with correct oil.

Service Hydraulic/PTO Control Valve

Removal

1. Remove control plate. (See “Remove and Install Control Plate” on page 456.)
2. Remove seat base cover. (See “Remove and Install Seat Base Cover” on page 457.)

NOTE: Hydraulic/PTO controls can be adjusted without removing seat base cover.

3. Disconnect hydraulic lines from control valve.
4. Remove two hex head cap screws and nuts securing hydraulic/PTO valve to frame.

NOTE: These steps reference the explode view below. (See “Remove and Install Hydraulic-PTO Control Valve” on page 407.)

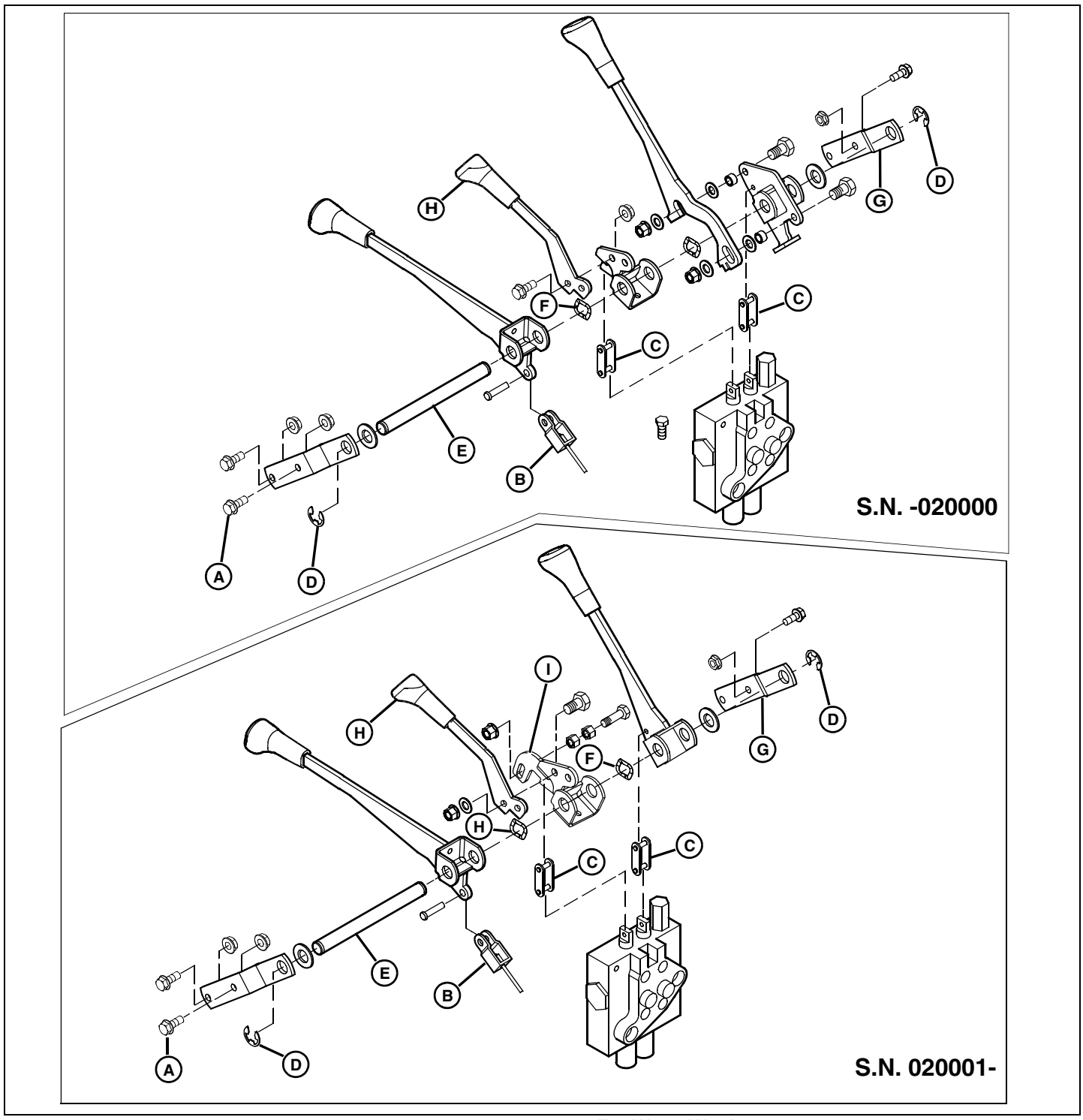
5. Remove four cap screws (A) and lock washers securing pivot brackets to frame.
6. Disconnect differential lock cable (B).
7. Remove hydraulic/PTO valve assembly (valve block and control lever[s]).
8. Remove chain master links (C) securing lever assembly to hydraulic/PTO valve. Remove lever(s).

Shift Assembly Disassembly

1. Remove either E-clip (D) from lever shaft (E).
2. Slowly slide shaft out of bracket and control levers.

NOTE: Washers and wave washers are loose on the shaft and will fall out when the shaft is removed.

Remove and Install Hydraulic-PTO Control Valve



MIF

A - Cap Screw and Locknut (4 used)
B - Differential Lock Cable
C - Master Links
D - E-Clip
E - Shaft
F - Wave Washers
G - Bracket
H - Hydraulic Control Valve Handle (PTO) (If equipped with auxiliary kit)
I - Units provide for adjustable contact of PTO switch

Removal

1. Remove control plate. (See “Remove and Install Control Plate” on page 456.)

2. Remove seat base cover. (See “Remove and Install Seat Base Cover” on page 457.)

NOTE: Hydraulic/PTO controls can be adjusted without removing seat base cover.

3. Disconnect hydraulic lines from control valve.

4. Remove two hex head cap screws and nuts securing hydraulic/PTO valve to frame.

5. Remove four cap screws (A) and lock washers securing pivot brackets to frame.

6. Disconnect differential lock cable (B).

7. Remove hydraulic/PTO valve assembly (valve block and control lever[s]).

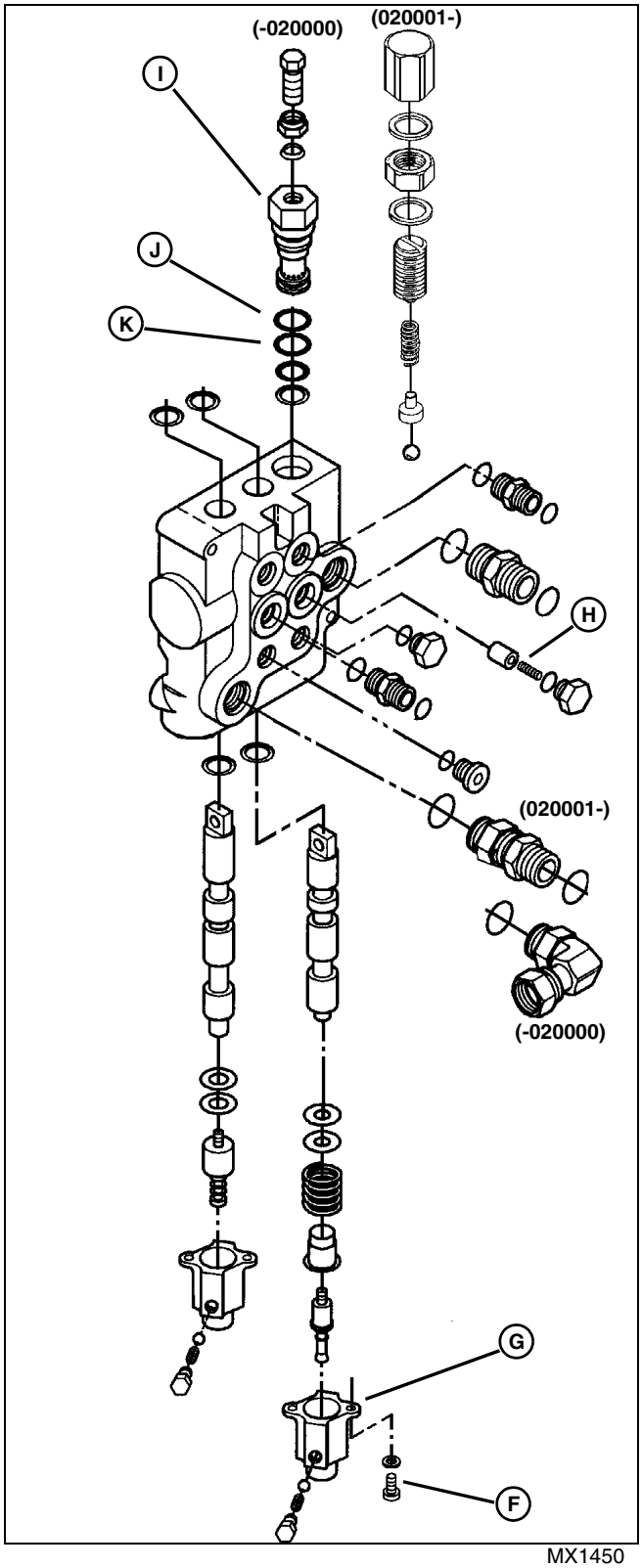
8. Remove chain master links (C) securing lever assembly to hydraulic/PTO valve. Remove lever(s).

Shift Assembly Disassembly

1. Remove either E-clip (D) from lever shaft (E).

2. Slowly slide shaft out of bracket and control levers.

NOTE: Washers and wave washers are loose on the shaft and will fall out when the shaft is removed.



MX1450

Control Valve Disassembly

1. Remove two (2) cap screws (F), with lock washers, securing end cap (G) to hydraulic/PTO valve. Remove end cap.

NOTE: When removing spools from hydraulic/PTO valve body be sure to note or mark which spool is removed from which bore. Spools MUST be returned to their original locations.

2. Carefully remove spools from body. Clean and inspect spools. Replace spool O-ring seal in hydraulic/PTO valve body.

3. Remove check valve (H) from port in hydraulic/PTO valve.

4. Clean cap, spring and plunger in suitable solvent.

5. Remove relief valve assembly (I). Clean all parts in suitable solvent.

6. Remove relief valve assembly.

7. Inspect O-rings (J) and seals (K). Replace as necessary. Note that the O-rings are placed to the outside of the seals.

8. Inspect all components for wear or damage. Replace as required.

Installation

Installation is done in the reverse order of removal.

- Lubricate spools, relief valve and all O-rings in clean hydraulic oil before assembly.
- Tighten cap screws securing hydraulic/PTO valve to frame to specification.
- Tighten hydraulic lines to specification. (See “O-Ring Face Seal Fittings” on page 18.)
- Adjust system relief pressure. (See “Adjust System Pressure Relief” on page 396.)

Specifications

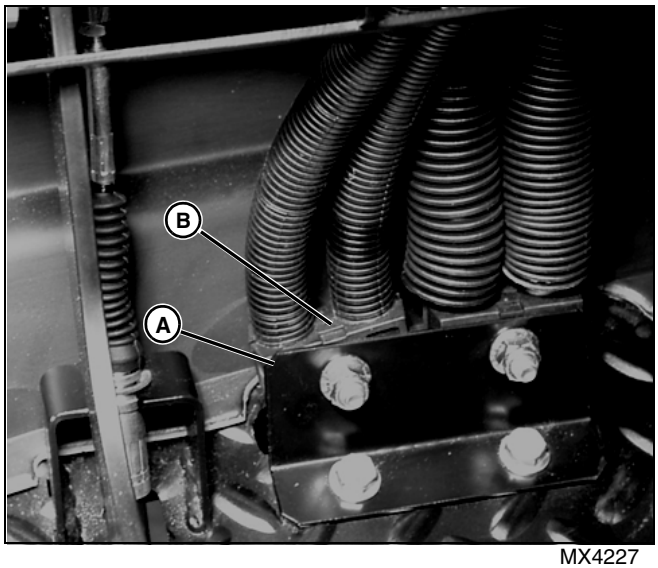
Hydraulic/PTO Valve-to-Frame Cap Screw Torque . . . . . 16.7 N•m (147 lb-in.)

Steering Control Unit (SCU)

Removal - Method 1

1. Remove steering wheel and rubber boot.

2. Remove four cap screws securing steering control unit to dash.



MX4227

3. Disconnect pressure and return hydraulic hoses from floorboard bulkhead fittings (earlier models) or bracket (A) and clamp (B) assembly shown.

4. Slide SCU down and out from behind dash, being careful to avoid kinking hydraulic hoses.

5. Mark hydraulic lines to ensure proper placement during installation.

NOTE: Adapter fitting torques are lower than hose fittings. Hold adapter fittings with a wrench while disconnecting hoses.

6. Disconnect and remove pressure hoses and steering hoses.

7. Disconnect and remove steering cylinder hoses.

8. Remove SCU.

Removal - Method 2

1. Remove front hood. (See “Remove and Install Hood” on page 456.)

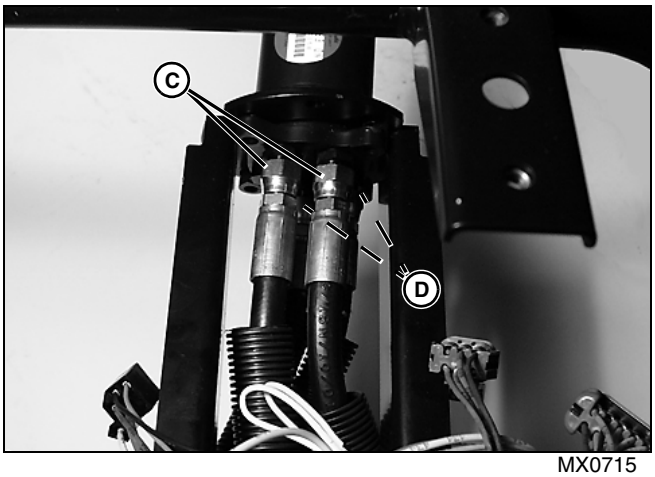
2. Remove steering wheel and rubber boot.

3. Remove four cap screws securing steering control unit to dash.

4. Remove dash panel. (See “Remove Dash” on page 456.)

5. Mark hydraulic lines to ensure proper placement during installation.

NOTE: Adapter fitting torques are lower than hose fittings. Hold adapter fittings with a wrench while disconnecting hoses.



MX0715

6. Disconnect and remove pressure hoses (C) and steering hoses.

7. Disconnect and remove steering cylinder hoses (D).

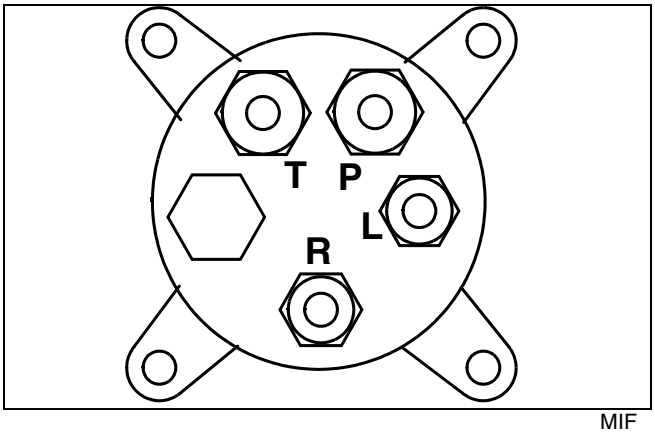
NOTE: It may be necessary to cut and remove tie wraps securing hydraulic lines to frame. Replace tie wraps during installation.

8. Remove SCU.

Installation

Installation is done in the reverse order of removal.

- If adapter fittings were removed, inspect O-rings in adapter fittings for cracks or damage. Replace if required.
- Secure SCU to frame.
- Tighten hydraulic fittings to specification.
- Install four cap screws securing SCU to frame.
- Install dash (if removed) and steering wheel.



MIF

Picture Note: Viewed from Bottom

Port	Hydraulic Lines
P	Pressure input from pump
T	Return line to suction manifold
L	Left side of steering cylinder
R	Right side of steering cylinder

Specifications

SCU-to-Frame Cap
Screw Torque . . . . . 30-38 N•m (22-28 lb-ft)
Pressure and Return Hose
Fitting-to-SCU Torque . . . . . 40-57 N•m (30-42 lb-ft)
Steering Hose
Fitting-to-SCU Torque . . . . . 17-24 N•m (150-212 lb-in.)
Adapter Fitting-to-SCU . . . . 14-19 N•m (124-168 lb-in.)

Table of Contents

STEERING TABLE OF CONTENTS

Specifications

Test and Adjustment Specifications

Steering System Leakage Test at Fast Idle

Torque Applied to Steering Shaft	6.8 N•m (60 lb-in.)
Maximum Right Turn RPM	5 rpm
Toe-in	3 ± 1.5 mm (1/8 ± 1/16 in.)
Brake Drum Diameter (Maximum)	221.21 mm (8.71 in.)

Slip Clutch Thickness (Minimum)

Plate A	0.945 mm (0.037 in.)
Plate B	0.345 mm (0.014 in.)

Input Shaft

#1 Bearing (#6009) Shaft OD	45.002-45.018 mm (1.7717-1.7724 in.)
#1 Bearing Case Bore ID	75.000-75.030 mm (2.9528-2.9539 in.)
#2 Bearing (#6305R) Shaft OD	25.002-25.015 mm (0.9843-0.9848 in.)
#2 Bearing Case Bore ID	62.000-62.030 mm (2.4409-2.4421 in.)
#3 Bearing (#NJ306EG) Shaft OD	30.002-30.015 mm (1.1812-1.1817 in.)
#3 Bearing Case Bore ID	72.000-72.030 mm (2.8346-2.8358 in.)

Differential

#1 Bearing (#6207) Shaft OD	34.9875-35.0125 mm (1.3775-1.3785 in.)
#1 Bearing Case Bore ID	75.000-75.030 mm (2.9528-2.9539 in.)

Axle Shaft

#1 Bearing (#6005) Shaft OD	24.977-24.990 mm (0.9833-0.9839 in.)
#1 Bearing Case Bore ID	46.9875-47.0125 mm (1.8499-1.8509 in.)

Wheel Hub

#1 Bearing (#32008) Shaft OD	40.002-40.018 mm (1.5749-1.5755 in.)
#1 Bearing Case Bore ID	68.000-68.030 mm (2.6772-2.6783 in.)

Torque Specifications

Steering Control Unit (SCU)

Steering Wheel Nut Torque	54 N•m (40 lb-ft)
SCU Mounting Screw	54 N•m (40 lb-ft)
SCU (-4) Small Hose Connection	24 N•m (18 lb-ft)
SCU (-6) Large Hose Connection	27 N•m (20 lb-ft)

Steering Cylinder

Cylinder Mount Flange Screw	54 N•m (40 lb-ft)
Connections (Hose-to-Elbow)	24 N•m (18 lb-ft)
Connections (Hose-to-Elbow)	24 N•m (18 lb-ft)
2WD Cylinder Rod to Tie Rod	170 N•m (125 lb-ft)
MFWD Cylinder Rod to Bridge Locknut	142 N•m (105 lb-ft)
MFWD Cylinder Bridge to Tie Rod	170 N•m (125 lb-ft)

STEERING SPECIFICATIONS

Hydraulic Pump

Pressure Outlet Fitting Screw	**6.8 N•m (60 lb-in.)**

Leaf Spring Mounting Hardware

Rear Shackle Plate Cap Screw	**102 N•m (75 lb-ft)**
Leaf Spring-to-Axle Cap Screw	**129 N•m (95 lb-ft)**
Front Chassis Bracket Hardware	**80 N•m (60 lb-ft)**

Shock Absorber

Upper Shock Nut	**45 N•m (33 lb-ft)**
Lower Shock Nut	**70 N•m (52 lb-ft)**

Tie Rod

Tie Rod to Bridge Plate (MFWD)	**170 N•m (125 lb-ft)**
Tie Rod to Cylinder Rod (2WD)	**170 N•m (125 lb-ft)**
Tie Rod to Steering Knuckle	**95 N•m (70 lb-ft)**

Bearing Housing-to-Steering Knuckle Bolt (M10)	**44-59 N•m (33-43 lb-ft)**
Front Axle Case-to-Bracket Bolt (M10)	**44-59 N•m (33-43 lb-ft)**
Steering Ball Joint Nut	**167-206 N•m (123-152 lb-ft)**
Steering Knuckle Stop Bolt Nut	**44-59 N•m (33-43 lb-ft)**
Wheel Hub Nut (M20)	**157-196 N•m (118-144 lb-ft)**
Adapter Plate-to-Axle Cap Screw	**102 N•m (75 lb-ft)**
Ring Gear Cap Screw (M8)	**30-39 N•m (22-29 lb-ft)**
Input Coupling Bolt (M10)	**61-80 N•m (45-59 lb-ft)**
Input Shaft Nut (M14)	**61-80 N•m (45-59 lb-ft)**
Drain Plug (M14)	**49 N•m (36 lb-ft)**
Slip Clutch Breakaway Torque	**570-625 N•m (420-460 lb-ft)**

Capacities

MFWD Gear Lube (J20C)	**3.4-4.0 L (0.90-1.06 gal)**

Tools and Materials

Special Tools

Special or Required Tools

Tool Name	Tool No.	Tool Use
MFWD Clutch Retaining Nut Spanner	JDG1336	Used to remove and install the MFWD clutch nut.

Other Materials

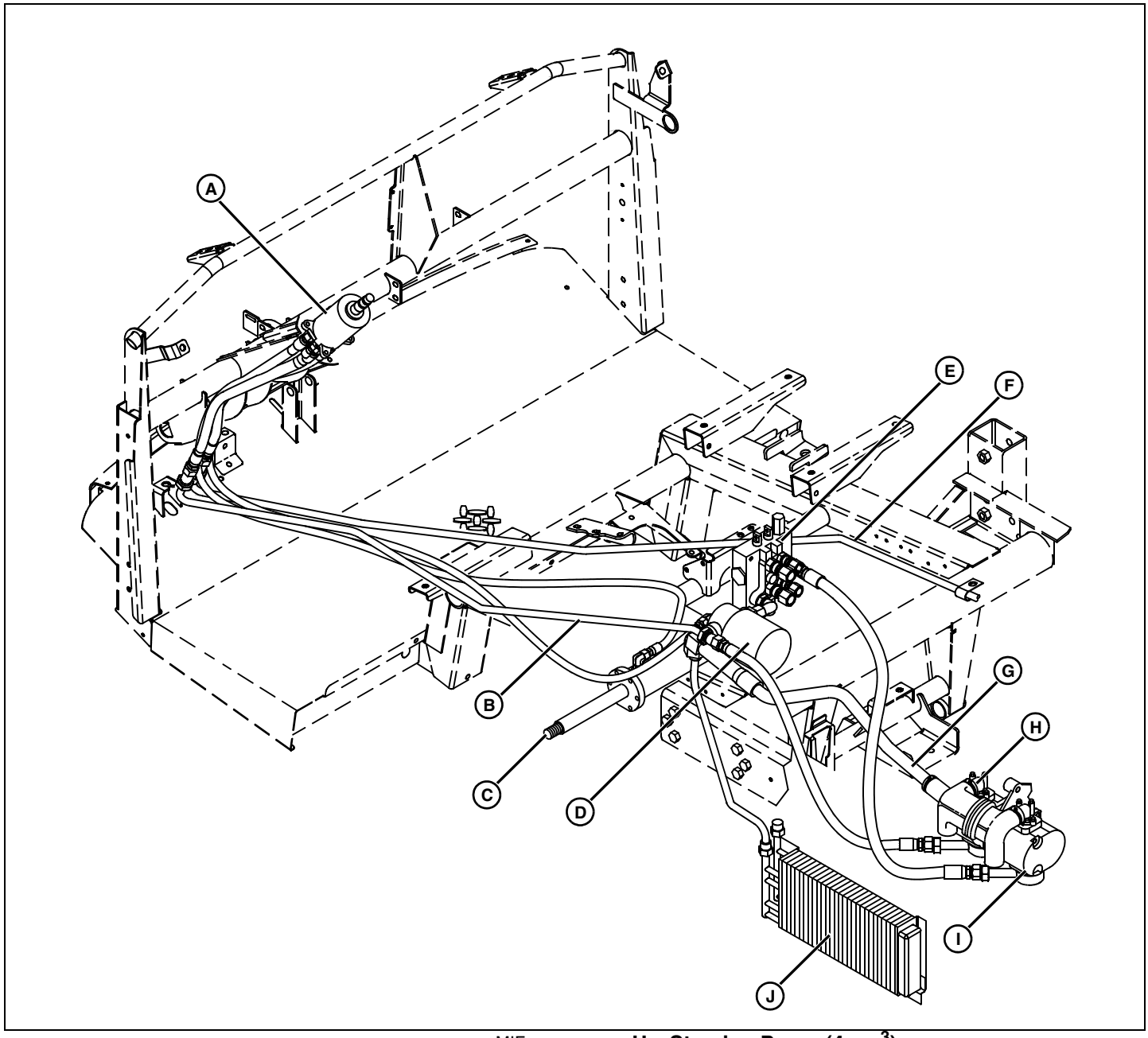
Other Material

Part No.	Part Name	Part Use
TY24416	Special-Purpose HD Lithium Complex Grease	Grease wheel bearings and hubs.
TY6333	Moly High Temperature EP Grease	Apply to splines of transaxle input shaft and MFWD drive shaft.

STEERING COMPONENT LOCATION

Component Location

Hydraulic Components

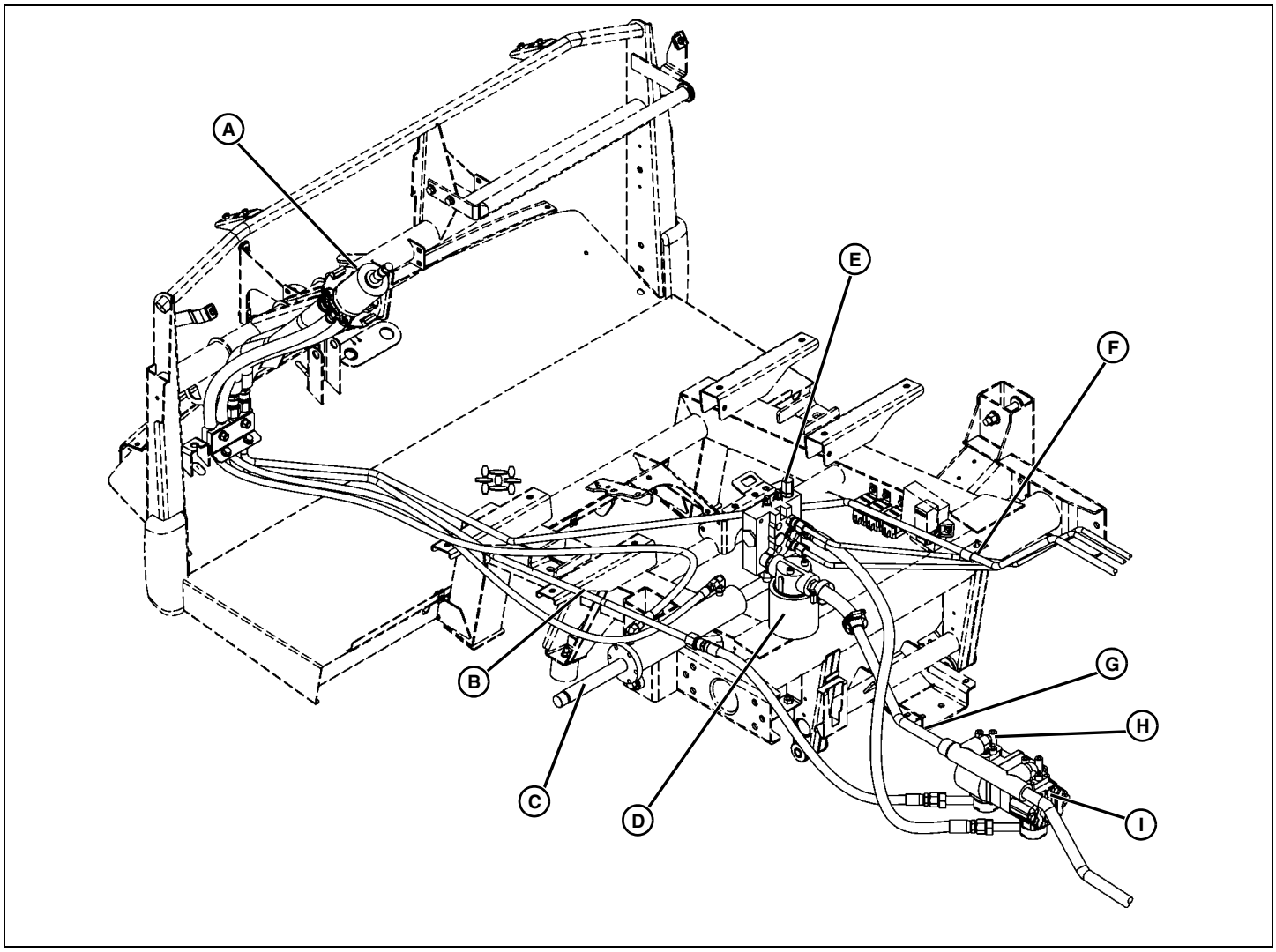


MIF

Picture Note: S.N. (-020000)

A - Steering Control Unit
B - Pressure Line
C - Steering Cylinder
D - Filter
E - Control Valve
F - Return Line to Sump (Steering)
G - Return Line to Pump (Auxiliary)
H - Steering Pump (4 cm^3)
I - Auxiliary Pump (9 cm^3)
J - Oil Cooler

STEERING COMPONENT LOCATION

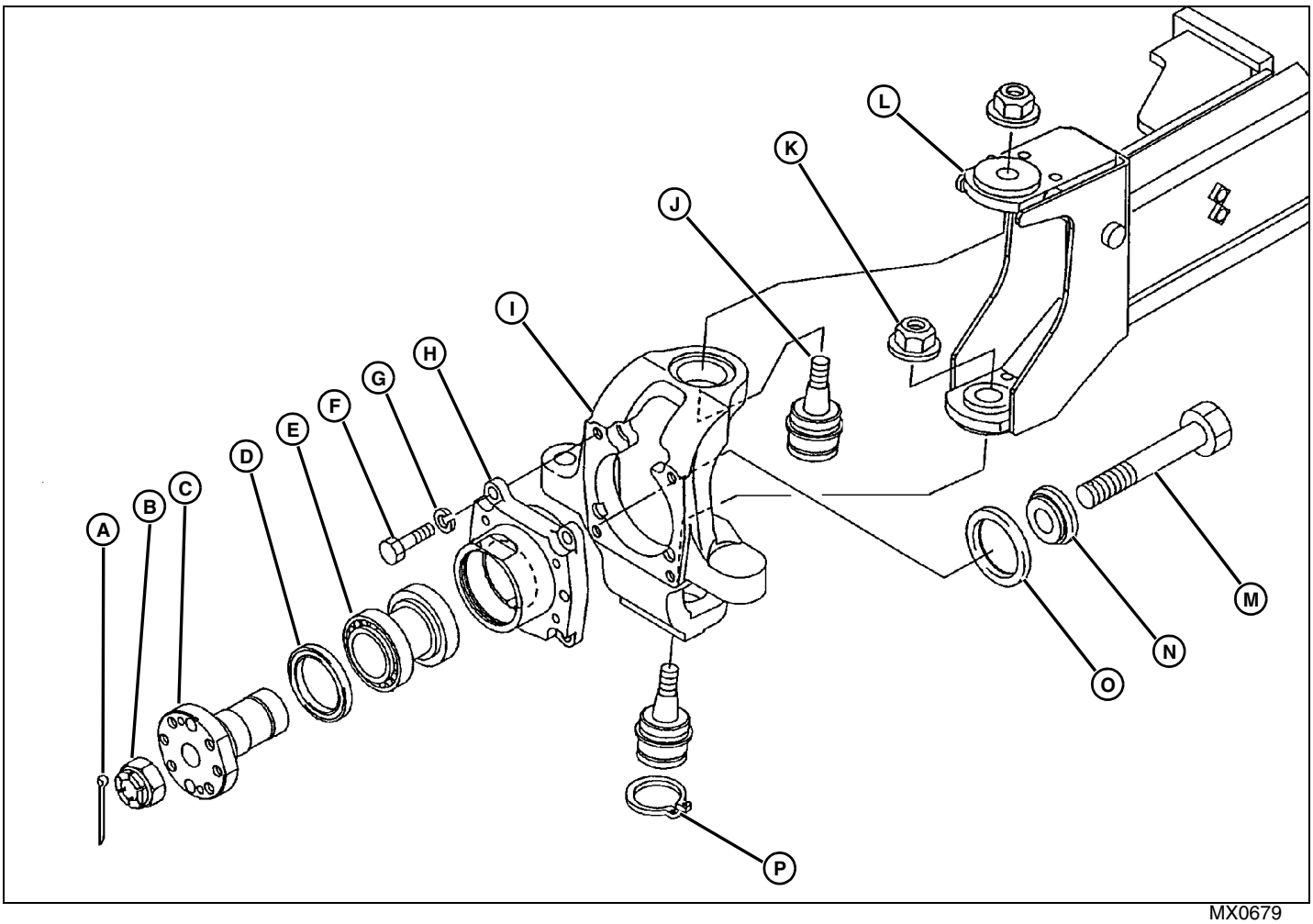


MIF

Picture Note: S.N. (020001-)

A - Steering Control Unit
B - Pressure Line
C - Steering Cylinder
D - Filter
E - Control Valve
F - Return Line to Sump (Steering)
G - Return Line to Pump (Aux)
H - Steering Pump (4 cm^3)
I - Auxiliary Pump (9 cm^3)

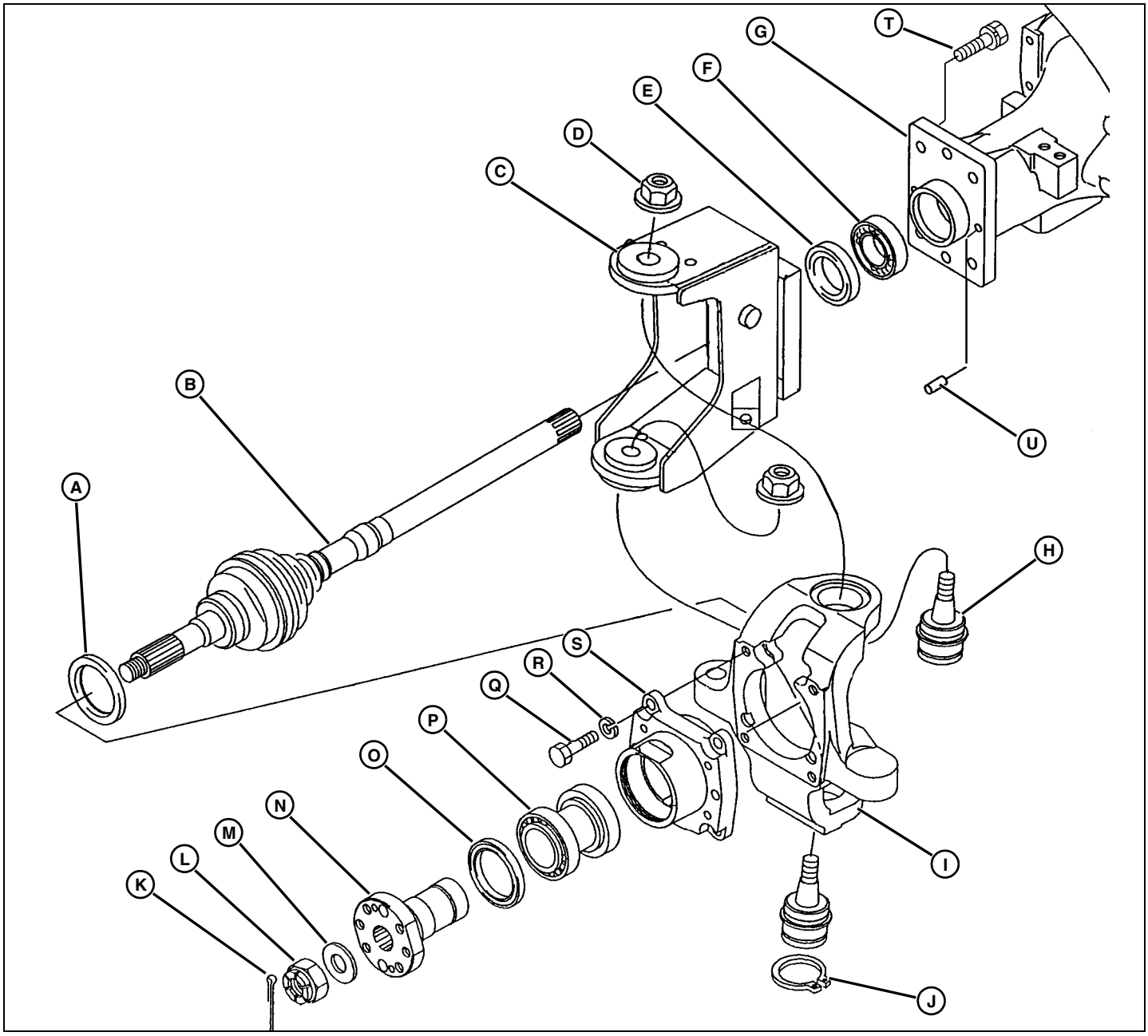
2-WD Axle Component Location



MX0679

A - Cotter Pin
B - Nut
C - Hub
D - Seal
E - Bearing
F - Cap Screw (4 used)
G - Lock Washer (4 used)
H - Bearing Housing
I - Steering Knuckle
J - Ball Joint (2 used)
K - Nut (2 used)
L - Steering Bracket
M - Axle
N - Washer
O - Seal
P - Snap Ring

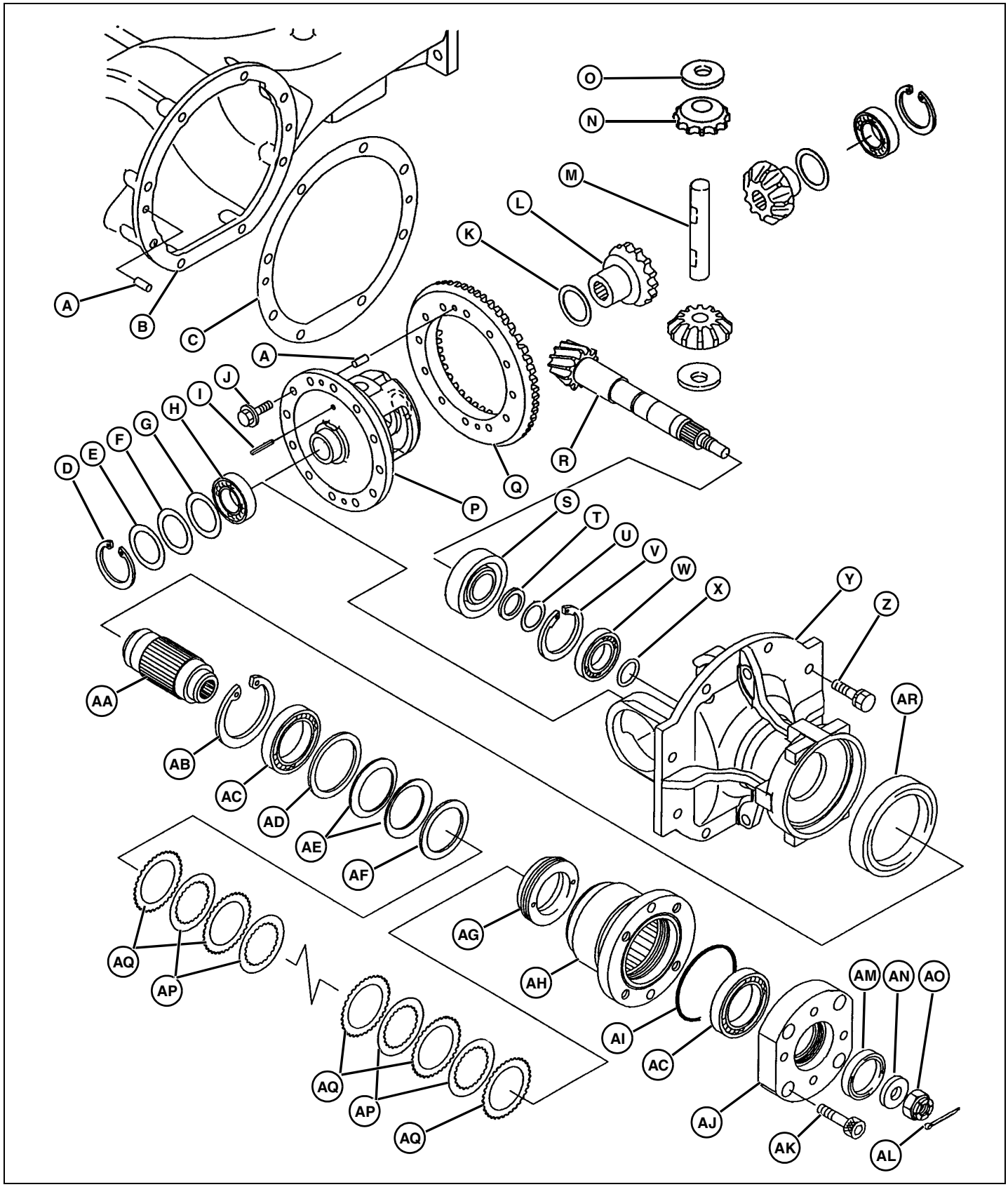
MFWD Axle Component Location



MX0680

A - Seal
B - CV Joint
C - Steering Bracket
D - Locknut
E - Seal
F - Bearing
G - Differential Housing
H - Ball Joint (2 used)
I - Steering Knuckle
J - Snap Ring (2 used)
K - Cotter Pin
L - Nut
M - Washer
N - Hub
O - Seal
P - Bearing Assembly
Q - Cap Screw
R - Lock Washer
S - Bearing Housing
T - Cap Screw (6 used)
U - Pin (2 used)

MFWD Differential Component Location



MX0681

A - Pin
B - Differential Housing
C - Gasket
D - Snap Ring (2 used)
E - Washer
F - Shim (as required)
G - Shim (as required)
H - Ball Bearing (2 used)
I - Spring Pin
J - Cap Screw (12 used)
K - Thrust Washer (2 used)
L - Bevel Gear (2 used)
M - Pinion Shaft
N - Pinion Bevel Gear (2 used)
O - Washer (2 used)
P - Case
Q - Ring Gear
R - Pinion
S - Bearing
T - Bushing
U - Shim (as required)
V - Snap Ring
W - Ball Bearing
X - Seal
Y - Differential Carrier
Z - Cap Screw (8 used)
AA- Shaft
AB- Snap Ring
AC- Ball Bearing
AD- Bushing
AE- Spring Plate (2 used)
AF- Plate
AG- Nut
AH- Clutch Housing
AI - Seal
AJ- Coupling
AK- Cap Screw (4 used)
AL- Cotter Pin
AM- Seal
AN- Washer
AO- Nut
AP- Slip Clutch Plate (Internally splined, 16 used)
AQ- Slip Clutch Plate (Externally splined, 17 used)
AR- Seal

Theory of Operation

SCU and System Operation

Function

Supply pressurized oil to the proper side of the steering cylinder to turn the wheels when the engine is running.

Theory of Operation

NOTE: Right-hand turn shown.

All external oil flow from the steering pump is routed through the steering control unit (SCU). The SCU is an open center type valve.

The SCU consists of a self-centering fluid control valve section and a fluid metering section. These are hydraulically and mechanically interconnected inside the unit.

Neutral

Whenever the steering wheel is released, the SCU returns to the neutral position. In this position, charge pressure oil entering the SCU through port “P” is allowed to flow through the control valve and out through port “T”. In this position the control valve prevents charge pressure oil from entering the fluid metering section.

Power Turn

As the steering wheel is turned to the right, the SCU section is shifted by the drive link assembly. This shifting opens the steering cylinder ports “R” and “L”.

Oil flows from port “P” directly to the inlet of the control valve section. As the steering wheel is turned to the right, metered oil is routed to port “R” at the front of the steering cylinder (B). Return oil from the rear of the steering cylinder is routed back to port “L”, through the control valve and out port “T”. As oil exits port “T” of the SCU it returns to the transaxle, and is considered to be “charge make-up oil”.

When the rotation of the steering wheel stops, the centering springs move the control valve section back to the center (neutral) position, and will remain there until the steering wheel is moved again.

Manual Turn

If hydraulic pressure is lost, the machine can still be steered without hydraulic assistance. All components still function the same with the exception of the fluid metering section. The fluid metering section now acts as a pump, moving oil from one side of the metering section to the other as the steering wheel is turned. Metered oil is routed through port “R” to the front of the steering cylinder. Return oil from the rear of the steering cylinder is routed back to port “L”, through the control valve, check valve, and is drawn back into the control valve section.

When the rotation of the steering wheel stops, the centering springs move the valve back to the center (neutral) position, and will remain there until the steering wheel is moved again.

Steering Cylinder Operation

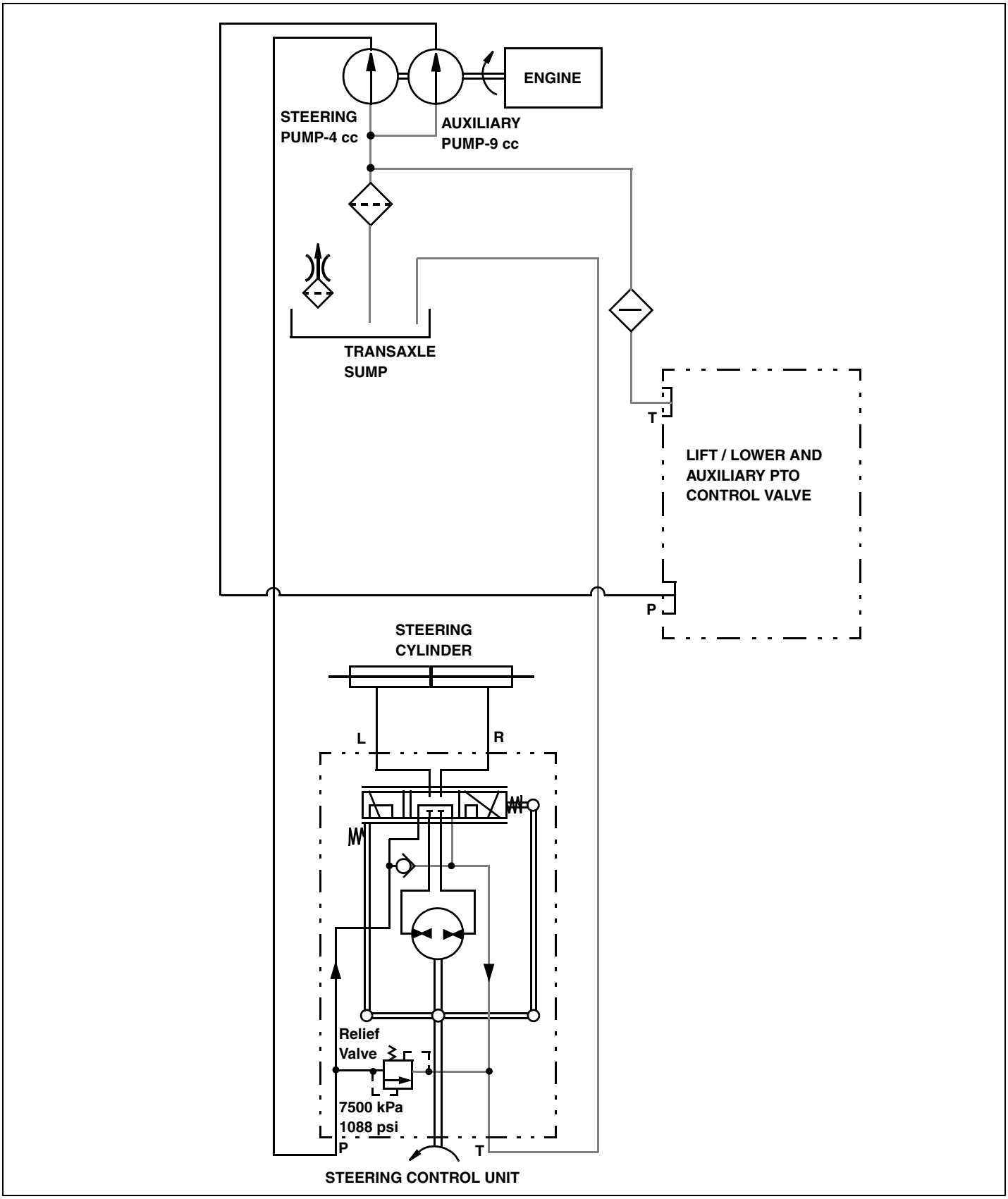
The steering cylinder is a double-acting design.

One end of the cylinder is attached to the axle housing which prevents the cylinder from moving. The rod ends are attached to the steering knuckles.

As pressurized oil enters the cylinder, the piston and rods move, which in turn causes the steering knuckles to move, causing the machine to turn.

To turn in the other direction, pressurized oil is applied to the other port, moving the cylinders in the opposite direction.

Steering Hydraulic Schematic



MIF

Diagnostics

Steering Troubleshooting

Symptom: Steers Hard or No Steering in Both Directions

(1) Is the air pressure in both front tires at specification?

Yes - Go to step (2).

No - Increase or decrease air pressure as necessary.

(2) Is the transaxle oil strainer clean and free of debris and fungus?

Yes - Go to step (3).

No - Clean transaxle oil strainer.

(3) Are both front tires the correct size and same circumference?

Yes - Go to step (4).

No - Install the correct size tires.

(4) Are the steering lines and hoses in good condition (not leaking or restricted)?

Yes - Go to step (5).

No - Replace lines and hoses as necessary. (See “Steering Hydraulic Schematic” on page 423.)

(5) Is the steering cylinder in good condition (no internal or external leaks)?

Yes - Go to step (6).

No - Replace cylinder as necessary. (See “Remove and Install Steering Cylinder” on page 429.)

(6) Is the steering control unit (SCU) in good condition (no internal or external leaks)?

Yes - Go to step (7).

No - Perform “Check Steering System” on page 427. Replace SCU as necessary. (See “Steering Control Unit” on page 429.)

(7) Is the steering column in good condition (not binding)?

Yes - Go to step (8).

No - Replace parts as necessary.

(8) Are the tie rods and steering cylinder end sockets in good condition and properly lubricated?

Yes - Go to step (9).

No - Replace tie rods and/or lubricate as necessary. (See “Remove and Install Tie Rod” on page 433.)

Symptom: Steers Hard or No Steering in Both Directions

(9) Are the steering knuckle ball joints in good condition and properly lubricated?

Yes - Go to step (10).

No - Replace steering knuckle ball joints and/or lubricate as necessary.

(10) Are the wheel bearings and hubs in good condition and properly lubricated?

Yes - Go to step (11).

No - Replace wheels bearings and hub as necessary. Repack wheel bearings. (See “Remove and Install Front Hub” on page 434.)

(11) Is toe-in within specification?

Yes - Go to step (12).

No - Perform toe-in procedure. (See “Adjust Toe-In (2-WD)” on page 427 and “Adjust Toe-In (4-WD)” on page 428.)

(12) 4-WD Only: Are the drag link and the drag link slide bearings in good condition and properly lubricated?

No - Replace and/or lubricate drag link and slide bearings as necessary.

Symptom: Steers Hard or No Steering in One Direction

(1) Is the steering cylinder in good condition (no internal or external leaks)?

Yes - Go to step (2).

No - Replace cylinder as necessary. (See “Remove and Install Steering Cylinder” on page 429.)

(2) Is the steering control unit (SCU) in good condition (no internal or external leaks)?

Yes - Go to step (3).

No - Perform “Check Steering System” on page 427. Replace SCU as necessary. (See “Steering Control Unit” on page 429.)

(3) Are the steering knuckle ball joints in good condition and properly lubricated?

No - Replace steering knuckle ball joints and/or lubricate as necessary.

Symptom: Steering Pulls in One Direction

(1) Is the air pressure in both front tires at specification?

Yes - Go to step (2).

No - Increase or decrease air pressure as necessary.

(2) Are both front tires the correct size and same circumference?

Yes - Go to step (3).

No - Install the correct size tires.

(3) Is the steering cylinder in good condition (no internal or external leaks)?

Yes - Go to step (4).

No - Replace cylinder as necessary. (See “Remove and Install Steering Cylinder” on page 429.)

(4) Is the steering control unit (SCU) in good condition (no internal or external leaks)?

Yes - Go to step (5).

No - Perform “Check Steering System” on page 427. Replace SCU as necessary. (See “Steering Control Unit” on page 429.)

(5) Are the steering knuckle ball joints in good condition and properly lubricated?

Yes - Go to step (6).

No - Replace steering knuckle ball joints and/or lubricate as necessary.

(6) Are the wheel bearings and hubs in good condition and properly lubricated?

No - Replace wheels bearings and hub as necessary. Repack wheel bearings. (See “Remove and Install Front Hub” on page 434.)

Symptom: Steering Wheel Creeps

(1) Are the steering lines and hoses in good condition (not leaking or restricted)?

Yes - Go to step (2).

No - Replace lines and hoses as necessary. (See “Steering Hydraulic Schematic” on page 423)

(2) Is the steering cylinder in good condition (no internal or external leaks)?

Yes - Go to step (3).

No - Replace cylinder as necessary. (See “Remove and Install Steering Cylinder” on page 429.)

Symptom: Steering Wheel Creeps

(3) Is the steering control unit (SCU) in good condition (no internal or external leaks)?

No - Perform “Check Steering System” on page 427. Replace SCU as necessary. (See “Steering Control Unit” on page 429.)

Symptom: Steering Shimmy or Vibration

(1) Is the air pressure in both front tires at specification?

Yes - Go to step (2).

No - Increase or decrease air pressure as necessary.

(2) Are both front tires the correct size and same circumference?

Yes - Go to step (3).

No - Install the correct size tires.

(3) Are the front tire rims in good condition (not bent)?

Yes - Go to step (4).

No - Replace tire rim(s).

(4) Are the tie rods and steering cylinder end sockets in good condition and properly lubricated?

Yes - Go to step (5).

No - Replace tie rods and/or lubricate as necessary. (See “Remove and Install Tie Rod” on page 433.)

(5) Are the steering knuckle ball joints in good condition and properly lubricated?

Yes - Go to step (6).

No - Replace steering knuckle ball joints and/or lubricate as necessary.

(6) Are the wheel bearings and hubs in good condition and properly lubricated?

Yes - Go to step (7).

No - Replace wheels bearings and hub as necessary. Repack wheel bearings. (See “Remove and Install Front Hub” on page 434.)

(7) Is toe-in within specification?

No - Perform toe-in procedure. (See “Adjust Toe-In (2-WD)” on page 427 and “Adjust Toe-In (4-WD)” on page 428.)

Symptom: Noise During Turn

(1) Are the steering lines and hoses in good condition (not leaking or restricted)?

Yes - Go to step (2).

No - Replace lines and hoses as necessary. (See "Steering Hydraulic Schematic" on page 423)

(2) Is the transaxle oil strainer clean and free of debris and fungus?

Yes - Go to step (3).

No - Clean transaxle oil strainer.

(3) Is the steering cylinder in good condition (no internal or external leaks)?

Yes - Go to step (4).

No - Perform "Check Steering System" on page 427. Replace steering cylinder as necessary. (See "Remove and Install Steering Cylinder" on page 429.)

(4) Is the steering control unit (SCU) in good condition (no internal or external leaks)?

Yes - Go to step (5).

No - Perform "Check Steering System" on page 427. Replace SCU as necessary. (See "Steering Control Unit" on page 429.)

(5) Is the steering column in good condition (not binding or loose?)?

Yes - Go to step (6).

No - Replace parts as necessary.

(6) Are the tie rods and steering cylinder end sockets in good condition and properly lubricated?

Yes - Go to step (7).

No - Replace tie rods and/or lubricate as necessary. (See "Remove and Install Tie Rod" on page 433.)

(7) Are the steering knuckle ball joints in good condition and properly lubricated?

Yes - Go to step (8).

No - Replace steering knuckle ball joints and/or lubricate as necessary.

(8) Are the wheel bearings and hubs in good condition and properly lubricated?

Yes - Go to step (9).

No - Replace wheels bearings and hub as necessary. Repack wheel bearings. (See "Remove and Install Front Hub" on page 434.)

Symptom: Noise During Turn

(9) Is toe-in within specification?

Yes - Go to step (10).

No - Perform toe-in procedure. (See "Adjust Toe-In (2-WD)" on page 427 and "Adjust Toe-In (4-WD)" on page 428.)

(10) 4-WD Only: Are the drag link and the drag link slide bearings in good condition and properly lubricated?

No - Replace and/or lubricate drag link and slide bearings as necessary.

Symptom: Slow Steering Response

(1) Are the steering lines and hoses in good condition (not leaking or restricted)?

Yes - Go to step (2).

No - Replace lines and hoses as necessary. (See "Steering Hydraulic Schematic" on page 423.)

(2) Is the steering cylinder in good condition (no internal or external leaks)?

Yes - Go to step (3).

No - Replace cylinder as necessary. (See "Remove and Install Steering Cylinder" on page 429.)

(3) Is the steering control unit (SCU) in good condition (no internal or external leaks)?

No - Perform "Check Steering System" on page 427. Replace SCU as necessary. (See "Steering Control Unit" on page 429.)

Tests and Adjustments

Check Steering System

Procedure

1. Lock the park brake.

2. With machine at room temperature, start and run engine at FAST idle for five minutes to warm up hydraulic oil.

3. Run engine at high rpm.

4. Turn steering wheel, at a very fast rate, for a full right turn then a full left turn.

Results

- Should have power steering at all times (low effort).
- If not: Check hydraulic lines for sharp bends or restrictions. Replace damaged lines as necessary.

Check steering cylinder for external or internal leakage. Replace cylinder if necessary. (See “Test Steering Cylinder Leakage” on page 401.)

Check SCU for external or internal leakage. Repair or replace as necessary. (See “Test Steering System” on page 400.)

Adjust Toe-In (2-WD)

Reason

Correct toe-in adjustment prevents premature tire wear and steering wander.

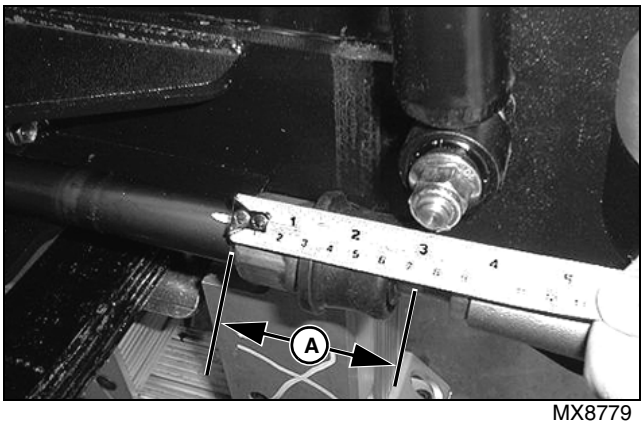
Initial Adjustment Procedure

1. Park machine safely. (See Operator’s Manual.)

NOTE: Toe-in cannot be adjusted with wheels off the ground or on an uneven surface.

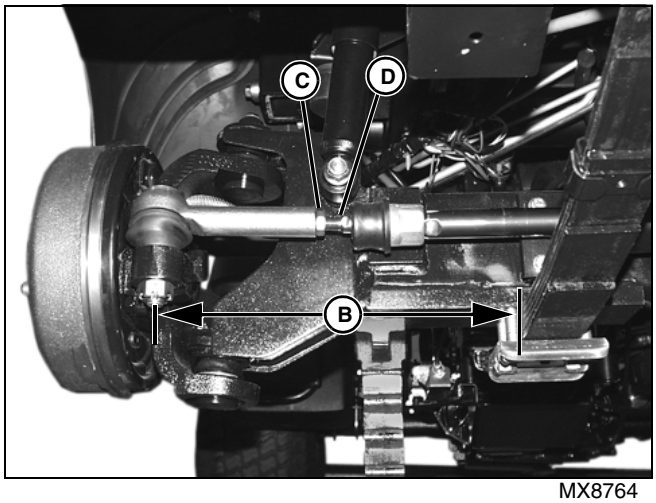
2. Turn key switch to the OFF position.

3. Lock the park brake.



MX8779

4. Place wheels in straight-ahead position. Measure the distance (A) from the inside edge of the ball socket nut to the center of the lower shock mounting stud on each side of the vehicle.Turn the steering wheel left or right until this measurement is equal on both sides.



MX8764

Picture Note: Tires Removed for Photo Only; Perform Adjustment with Tires on Vehicle.

5. Measure the distance (B) from the outside edge of the front leaf spring to the center of the tie rod bolt on each side of the vehicle. This dimension should be equal.

Results

If the dimension from the center of the wheel to the edge of the leaf spring is not equal, loosen tie rod locknut (C) and turn link (D) until the measurement is equal. Tighten locknuts.

Final Adjustment Procedure

1. Measure the distance between the center of the tire beads (center of tire) at front of tire, hub height. Record measurement.

2. Measure the distance between the center of the tire beads (center of tire) at rear of tire, hub height. Record measurement.

Results

If not according to specifications, loosen both tie rod locknuts and turn left and right links equal amounts until toe-in is to specification. Tighten nuts. Check toe-in dimension again after tightening nuts and readjust if necessary.

Specifications

2WD Toe-In (Less in Front than Rear) . . . . 3 mm ± 1.5 mm (0.125 ± 0.062 in.)

Adjust Toe-In (4-WD)

Reason

Correct toe-in adjustment prevents premature tire wear and steering wander.

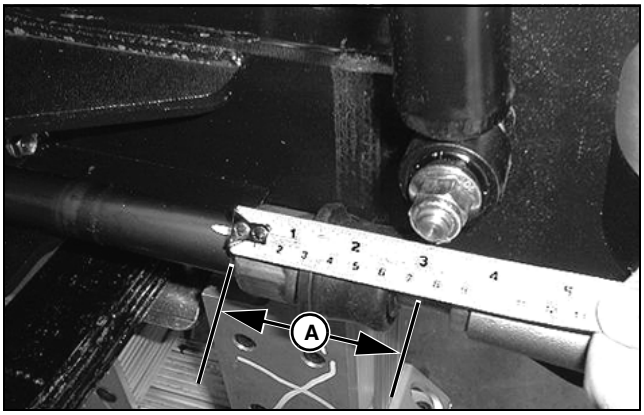
Initial Adjustment Procedure

1. Park machine safely. (See Operator's Manual.)

NOTE: Toe-in cannot be adjusted with wheels off the ground or on an uneven surface.

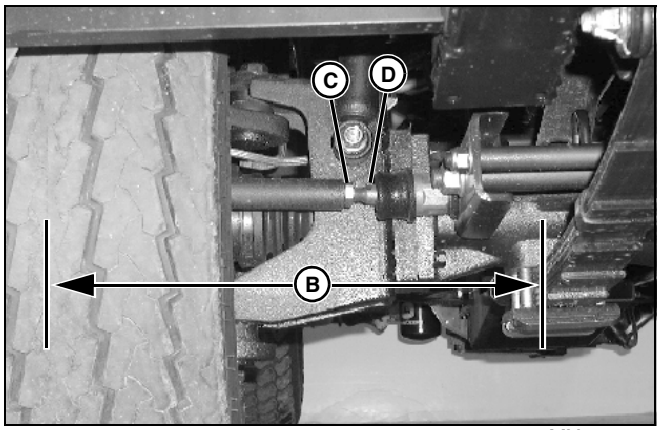
2. Turn key switch to the OFF position.

3. Lock the park brake.



MX8779

4. Place wheels in straight-ahead position. Measure the distance (A) from the inside edge of the ball socket nut to the center of the lower shock mounting stud on each side of the vehicle.Turn the steering wheel left or right until this measurement is equal on both sides.



MX23946

5. Measure the distance (B) from the outside edge of the front leaf spring to the center of the tire beads (center of tire) on each side of the vehicle. This dimension should be equal.

Results

If the dimension from the center of the wheel to the edge of the leaf spring is not equal, loosen tie rod locknut (C) and turn link (D) until the wheel spread is equal. Tighten locknuts.

Final Adjustment Procedure

1. Measure the distance between the center of the tire beads (center of tire) at front of tire, hub height. Record measurement.

2. Measure the distance between the center of the tire beads (center of tire) at rear of tire, hub height. Record measurement.

Results

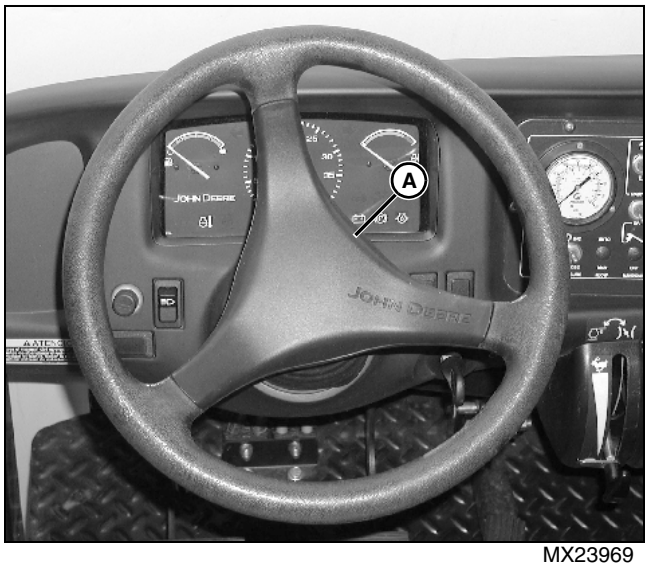
If not according to specifications, loosen tie rod locknuts and turn each link equal amounts until toe-in is to specification. Tighten nuts. Check toe-in dimension again after tightening nuts and readjust if necessary.

Specifications

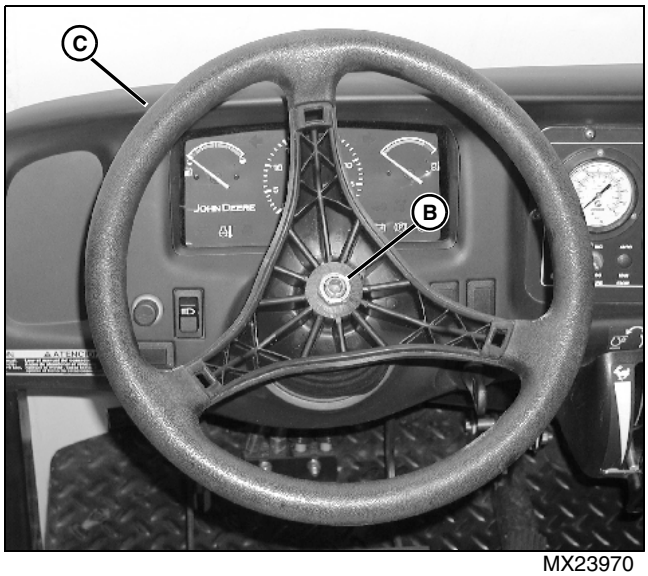
4WD Toe-In (Less in Front than Rear) . . . . 3 mm ± 1.5 mm (0.125 ± 0.062 in.)

Repair

Remove and Install Steering Wheel



MX23969



MX23970

1. Remove steering wheel cap (A).

IMPORTANT: Avoid damage! DO NOT use a hammer on the end of steering shaft. Damage can occur to steering valve or shaft.

NOTE: If steering wheel cannot be pulled off shaft easily, use a knife-edge puller to remove.

2. Remove nut (B) and steering wheel (C).

Installation

- Installation is done in the reverse order of removal.
- Tighten nut to specification.

Specifications

Steering Wheel Retaining Nut Torque . . . . . 38 N•m (28 lb-ft)

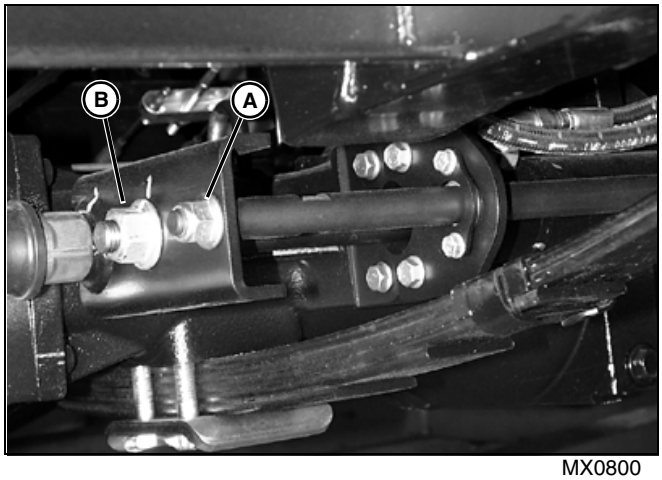
Steering Control Unit

See “Steering Control Unit (SCU)” on page 409 in the Hydraulics section.

Remove and Install Steering Cylinder

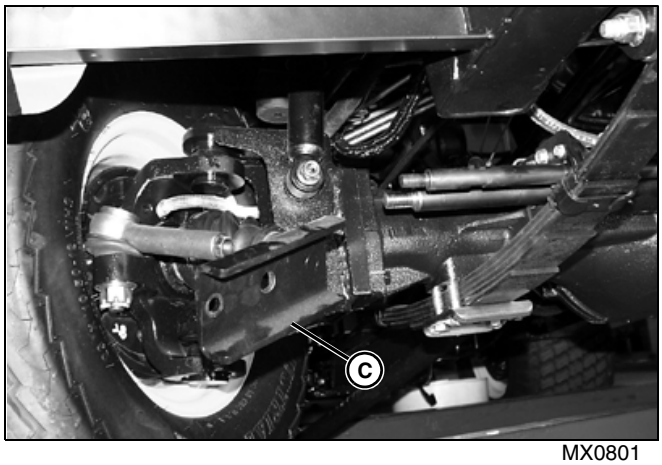
Removal

1. Park machine safely. (See Operator’s Manual.)
2. Lock the park brake.
3. Place wheels in straight-ahead position.



MX0800

4. Remove the front nut (A) and the rear nut (B) securing the drag link and the steering cylinder rod to the connecting plate on each side of the vehicle.
5. Carefully raise the front of the vehicle until the front wheels are off the ground.

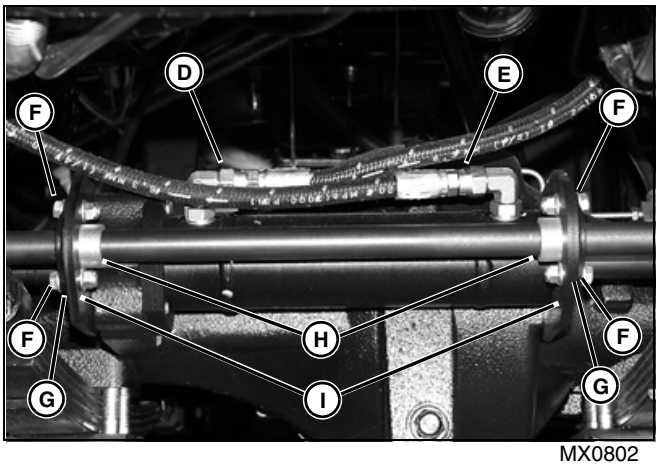


MX0801

6. Remove the connector plate assembly (C) by pivoting each wheel fully outward.

7. Lower the vehicle back to the ground.

CAUTION: Avoid injury! Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury may call Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.

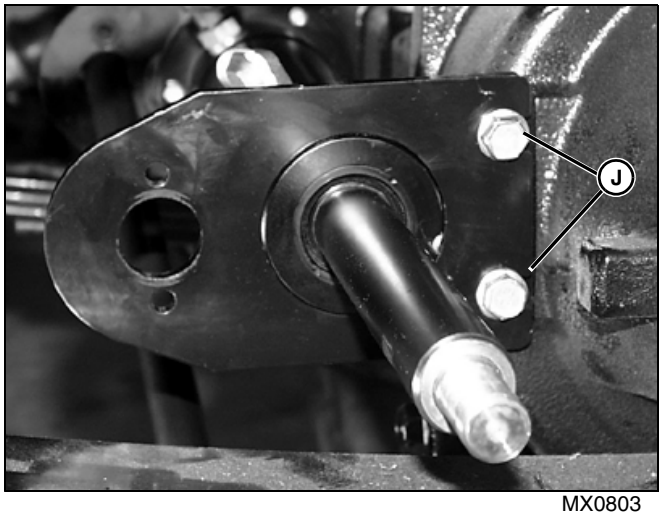


MX0802

8. Remove and cap the steering hoses (D and E).

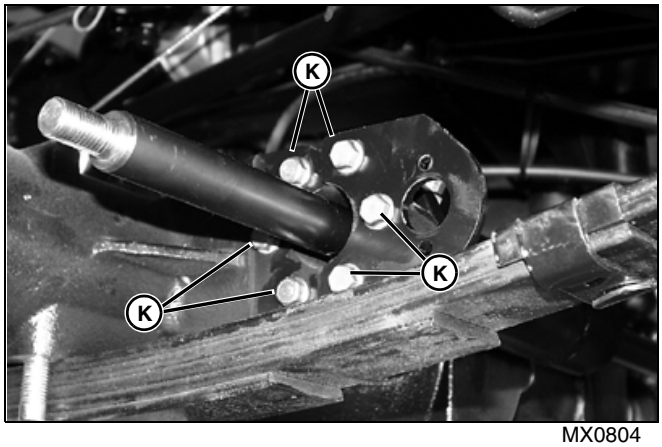
9. Remove the cap screws (F) and retainer plate (G) from the drag link slide bearings (H) and remove the slide bearings.

10.Slide the drag link out of the bridge brackets (I).



MX0803

11.Remove the two cap screws (J) securing the steering cylinder to the left side of the front axle and remove the bridge bracket.



MX0804

12.Remove the six cap screws (K) securing the bridge bracket and the steering cylinder to the axle on the right side of the vehicle and remove the steering cylinder. Note the position of the three longer cap screws.

Installation

Installation is done in the reverse order of removal.

- Tighten steering cylinder mounting cap screws to specification.
- Tighten drag link slide bearing retainer cap screws to specification.
- Tighten hose connections to specification.
- Tighten rear locknut to specification.
- Tighten front locknut to specification.
- Fill transaxle to proper level with low viscosity HY-GARD oil. (See “Transaxle Oil” on page 22.)
- Check the toe-in adjustment.
(See “Adjust Toe-In (4-WD)” on page 428.)

Specifications

Steering Cylinder Mounting Cap Screw Torque . . . . . 54 N•m (40 lb-ft)

Drag Link Slide Bearing Retainer Cap Screw Torque . . . . . 13.7 N•m (60 lb-ft)

Steering Cylinder Hose Connection Torque. . . . . 24.4 N•m (18 lb-ft)

Steering Cylinder Rear Locknut Torque. . . . . 142 N•m (105 lb-ft)

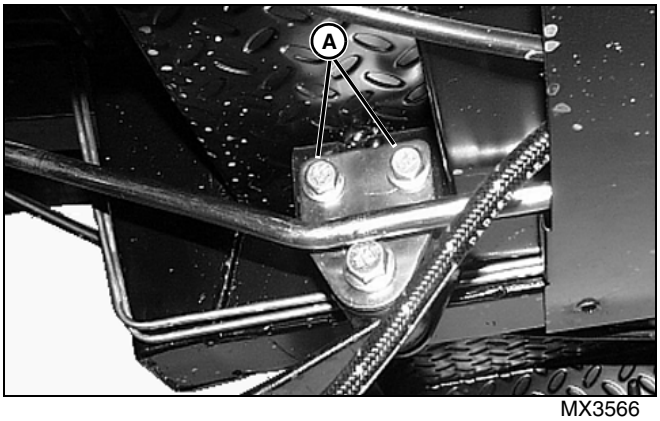
Steering Cylinder Front Locknut Torque. . . . . 95 N•m (70 lb-ft)

Remove and Install Front Leaf Spring

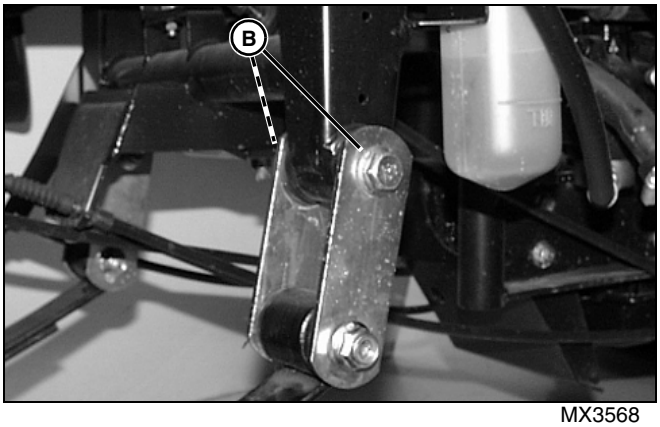
Removal

1. Park machine safely. (See Operator's Manual.)
2. Turn key switch to the OFF position.
3. Place shift lever in the neutral position.
4. Lock the park brake.
5. Raise the front of the vehicle and place on jack stands so that the front tires are at least 25 mm (1 in.) off the ground.

NOTE: Remove and replace one leaf spring at a time to hold the front axle in place during installation.

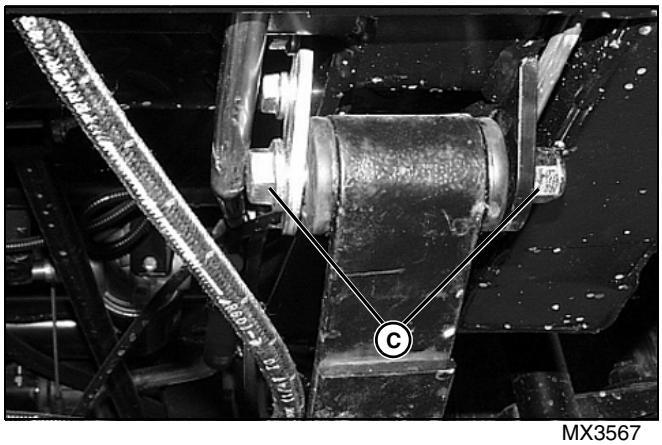


MX3566

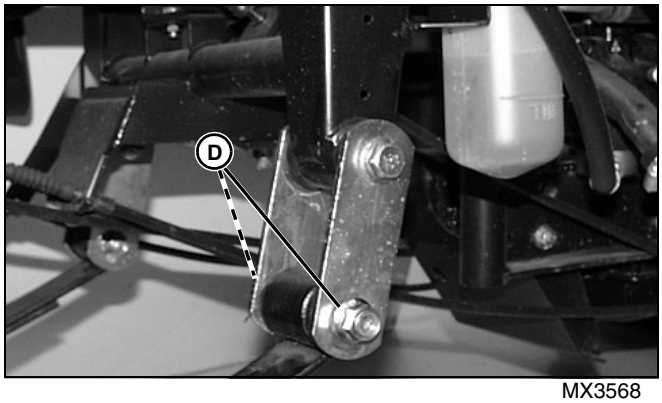


MX3568

6. Loosen, but do not remove, the hardware securing the front chassis bracket (A) and rear shackle plates (B) to vehicle frame.



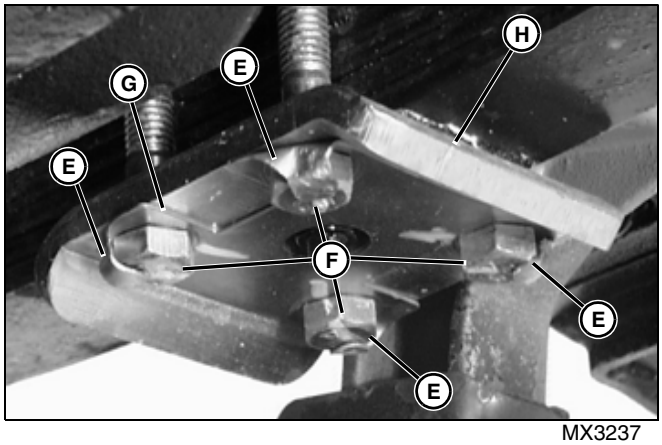
MX3567



MX3568

7. Remove cap screw and nut (C) from the front and cap screw and nut (D) from the rear of the leaf spring. Retain hardware for installation.

CAUTION: Avoid injury! The leaf spring is heavy, use care while removing bolts to avoid injury.

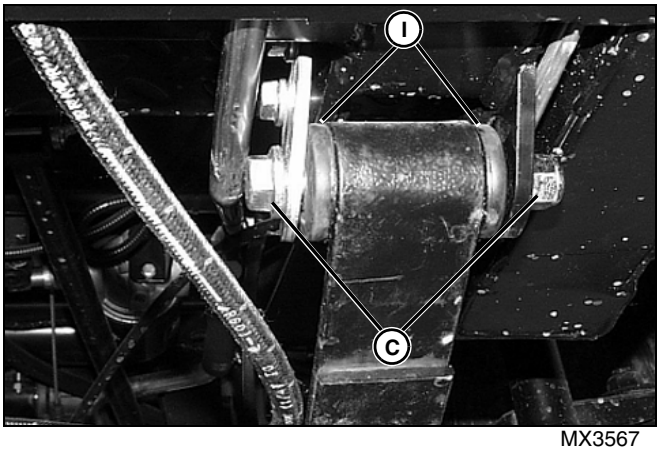


MX3237

8. Bend the lock plate tabs (E) away from the mounting cap screws (F).

9. Hold the leaf spring assembly and remove the four cap screws, lock plate (G), spring plate (H), and leaf spring.

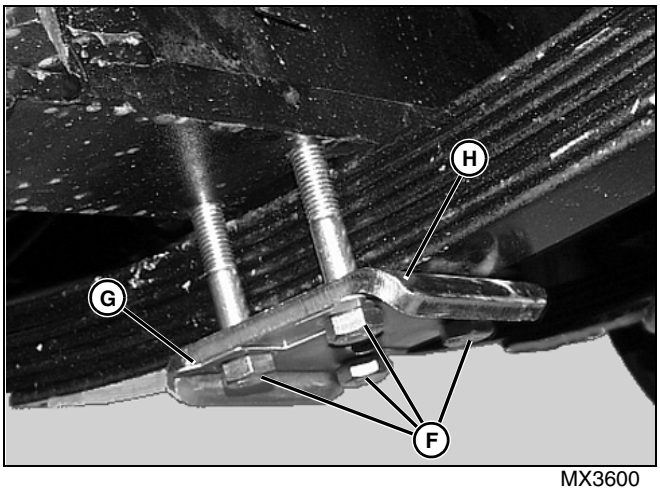
Installation



MX3567

1. Lubricate the rubber bushings (I) with liquid soap and install bushings into the new leaf spring.

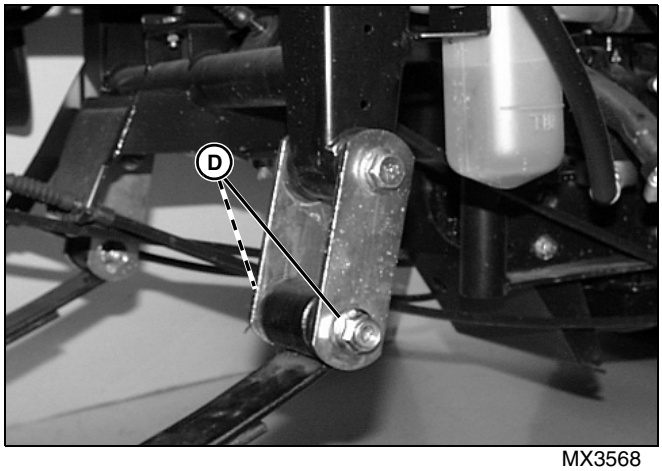
2. Install front of new leaf spring between chassis brackets. Install cap screw (C) and nut but do not tighten.



MX3600

3. Install four cap screws (F) through the holes of the lock plate (G) and the spring plate (H).

4. Place the bolts around the leaf spring and install the cap screws until snug.



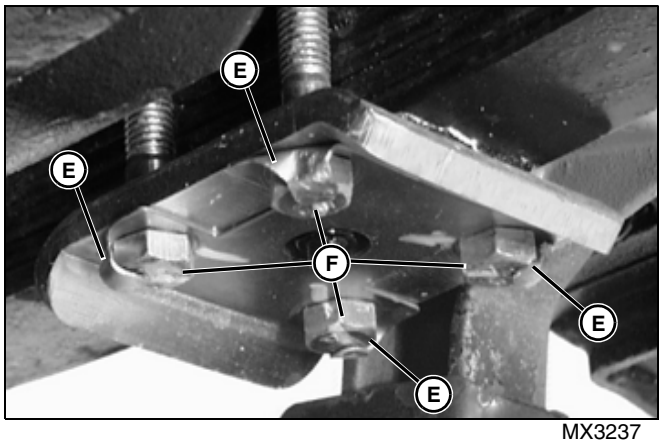
MX3568

5. Place a floor jack under the front axle and raise the axle until the leaf spring aligns with the rear shackle plates. Install cap screw and nut (D) but do not tighten.

6. Tighten all the hardware securing the front chassis brackets and rear shackle plates to vehicle frame and the leaf spring to specification.

7. Raise the front axle and remove the jack stands.

8. Lower the vehicle to the floor.



MX3237

9. Tighten the four cap screws (F) securing the leaf spring to the axle to specification.

10.Crimp the tabs (E) of the lock plate over each cap screw head.

Specifications

Rear Shackle Plate Cap Screw Torque . . . . . 102 N•m (75 lb-ft)

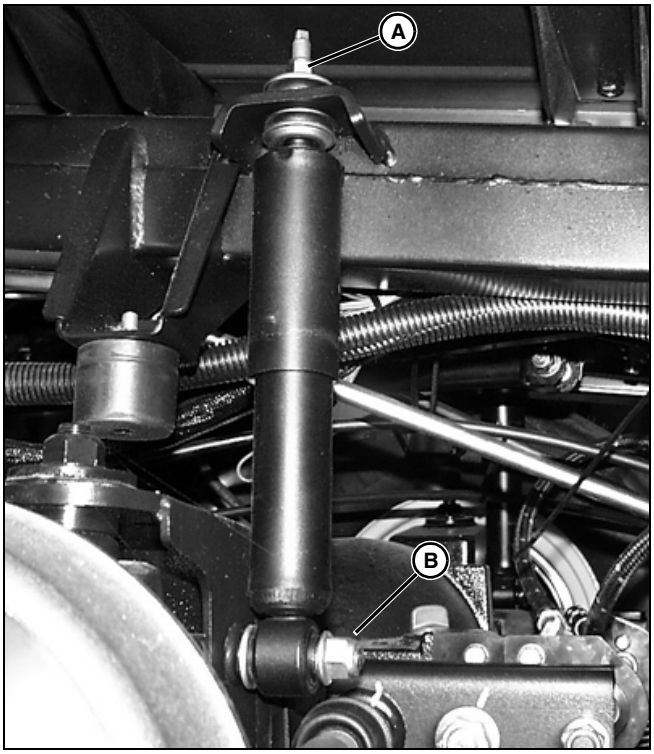
Leaf Spring-to-Axle Cap Screw Torque . . . . . 129 N•m (95 lb-ft)

Front Chassis Bracket Hardware Torque . . . . . 80 N•m (60 lb-ft)

Remove and Install Front Shock

Removal

1. Park machine safely. (See Operator's Manual.)
2. Turn key switch to the OFF position.
3. Place shift lever in the neutral position.
4. Lock the park brake.
5. Loosen lug nuts on wheel(s) being removed.
6. Raise and support machine so that the wheel(s) being removed is just off the ground.
7. Remove lug nuts and remove wheel(s).



MX0809

8. Remove the upper locknut, washer and rubber bushing (A).
9. Remove the lower locknut (B) and slide the shock off of the mounting pin.

Installation

Installation is done in the reverse order of removal.

- Tighten shock mounting nuts to specification.
- Install wheel(s) with stems toward outside of machine and tighten lug nuts to specification.

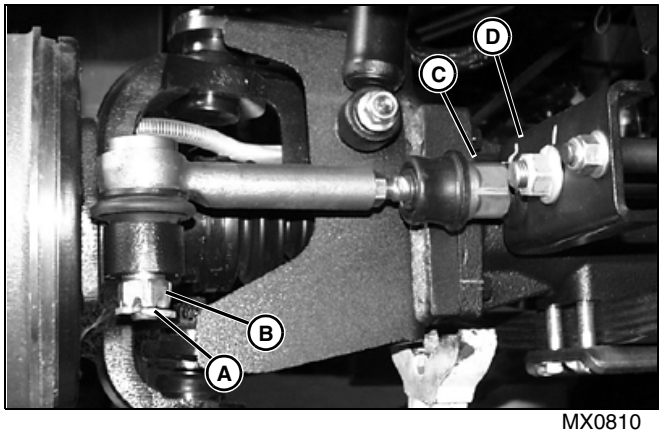
Specifications

Upper Shock Nut Torque . . . . . 45 N•m (33 lb-ft)
Lower Shock Nut Torque . . . . . 70 N•m (52 lb-ft)
Wheel Lug Nut Torque . . . . . 115 N•m (85 lb-ft)

Remove and Install Tie Rod

Removal

1. Park machine safely. (See Operator's Manual.)
2. Turn key switch to the OFF position.
3. Place shift lever in the neutral position.
4. Lock the park brake.
5. Loosen lug nuts on wheel(s) being removed.
6. Raise and support machine so that the wheel(s) being removed is just off the ground.
7. Remove lug nuts and remove wheel(s).



MX0810

8. Remove cotter pin (A) and castle nut (B) securing tie rod to steering knuckle.
9. Remove socket (C) from bridge plate (D) (MFWD), (cylinder rod 2-WD), and remove tie rod.

Installation

Installation is done in the reverse order of removal.

- Tighten mounting hardware to specification.
- Install cotter pin.
- Install wheel(s) with stems toward outside of machine and tighten lug nuts to specification.
- Check the toe-in adjustment. (See "Adjust Toe-In (2-WD)" on page 427 and "Adjust Toe-In (4-WD)" on page 428.)

Specifications

Tie Rod-to-Bridge Plate
Torque (MFWD). . . . . 170 N•m (125 lb-ft)
Tie Rod-to-Cylinder Rod
Torque (2-WD) . . . . . 170 N•m (125 lb-ft)
Tie Rod-to-Spindle
Knuckle Torque . . . . . 95 N•m (70 lb-ft)
Wheel Lug Nut Torque . . . . . 115 N•m (85 lb-ft)

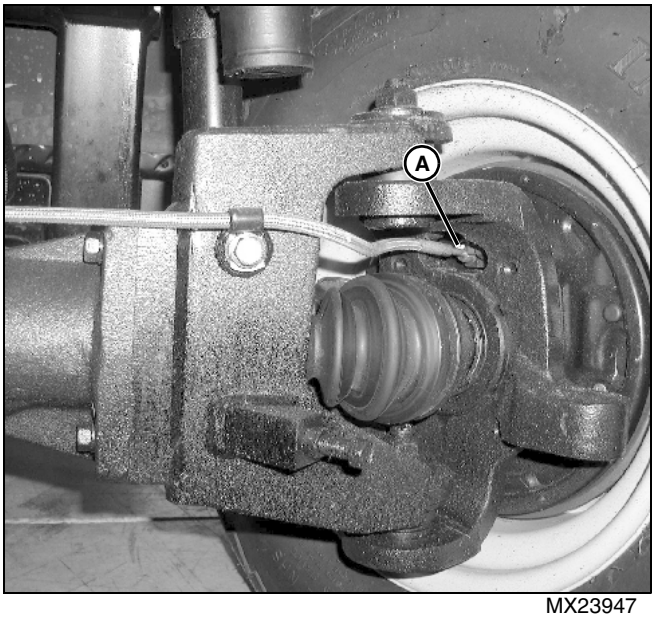
Remove and Install Front Axle

Removal

NOTE: The hubs of the 2-WD front axle and the hubs, CV joints and differential of the MFWD are serviceable with the axle in the machine.

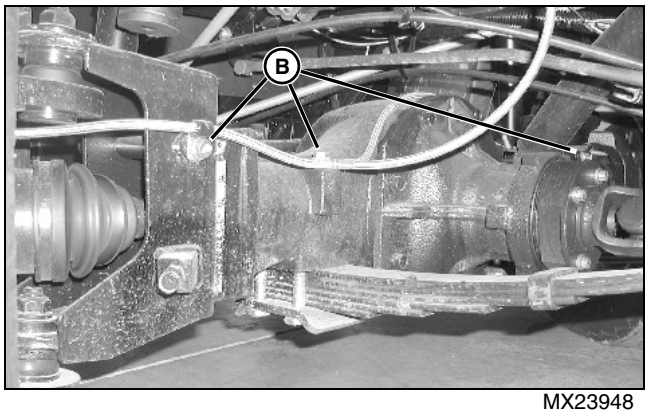
1. Safely raise and support the front of the unit. Remove the tires.

2. Disconnect the steering cylinder and shock absorbers. (See “Remove and Install Steering Cylinder” on page 429 and “Remove and Install Front Shock” on page 433.)



MX23947

3. Disconnect the front brake hose at the brake (A) on each side.



MX23948

4. Disconnect three hose clamps (B).

5. Disconnect the drive shaft to the MFWD (if equipped).

6. Remove the leaf springs and front axle from the machine. (See “Remove and Install Front Leaf Spring” on page 431.)

Installation

1. Install the leaf springs and front axle to the machine.

2. Connect the drive shaft to the MFWD (if equipped).

3. Connect the front brake hose and bleed the brakes. (See “Bleed Brakes” on page 448.)

4. Connect the steering cylinder and shock absorbers.

5. Install the tires and lower the unit.

Remove and Install Front Hub

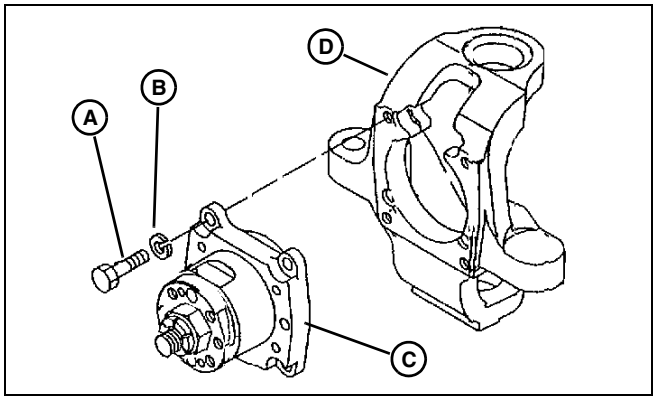
Other Material

Part No.	Part Name	Part Use
TY24416	Special-Purpose HD Lithium Complex Grease	Grease wheel bearings and hubs.

Removal

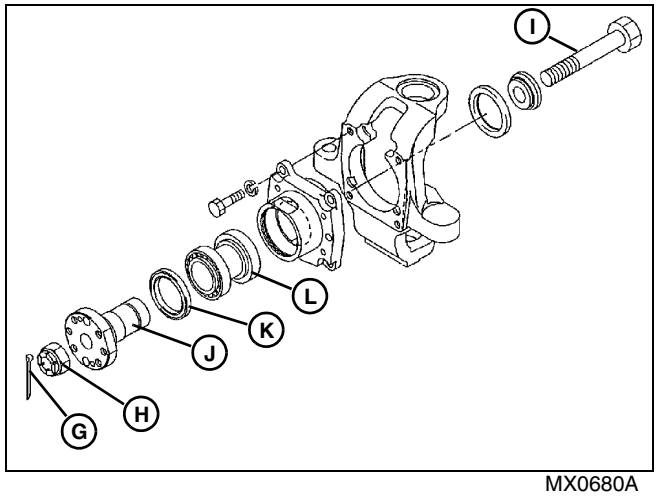
1. Raise and safely support the hub being serviced.

2. Remove the wheel and tire from the hub.



MX0680B

3. Remove four cap screws (A) and washers (B). Pull the bearing housing and hub (C) from the steering knuckle (D).



MX0680A

4. Remove the cotter pin (G), and hub nut (H) from the axle (I). Slide out the axle.

5. Remove the hub (J), seal (K), and bearing (L) from the bearing housing. Replace the seal.

6. Clean and inspect all parts. Replace any unserviceable components.

Installation

Installation is done in the reverse order of removal.

- Pack the bearings with TY24416 Special-Purpose HD Lithium Complex Grease and fill the bearing housing 1/3 with wheel bearing grease.
- Tighten the hub nut to specification.

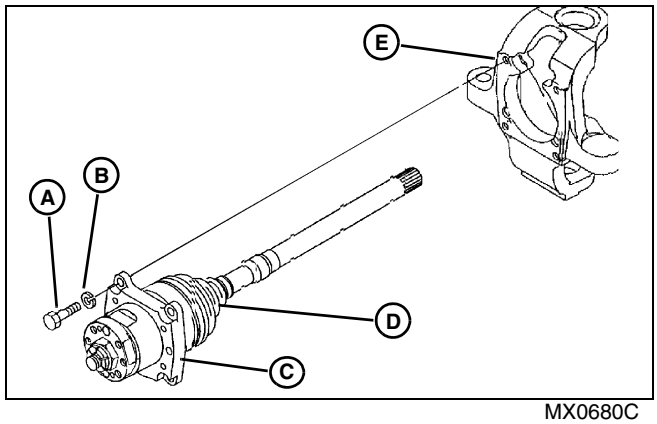
Specifications

Hub Nut Torque. . . . . 157-196 N•m (116-144 lb-ft)

Remove and Install CV Joint

Removal

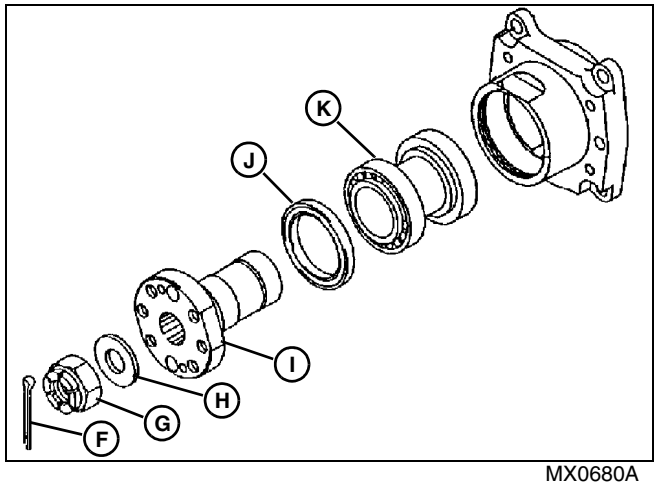
1. Raise and safely support the hub being serviced.
2. Remove the wheel and tire from the hub.



MX0680C

3. Remove four cap screws (A) and washers (B). Pull the bearing housing and hub (C), with the CV joint assembly (D) from the steering knuckle (E).

NOTE: The CV joint assembly has no serviceable components. If the CV joint makes noise, has bent or damaged parts, or does not operate smoothly, replace the assembly.



MX0680A

4. Remove the cotter pin (F), nut (G), and washer (H) from the axle (2-WD) or CV joint (MFWD). Slide out the axle or CV joint.

5. Remove the hub (I), seal (J), and bearing (K) from the bearing housing. Replace the seal.

6. Clean and inspect all parts. Replace any unserviceable components.

Installation

Installation is the reverse of removal.

- On MFWD units the splines on the shaft of the CV joint must lock the differential unit inside the differential housing.
- Tighten the hub nut to specification.

Specifications

Hub Nut Torque. . . . . 157-196 N•m (116-144 lb-ft)7

Table of Contents

BRAKES TABLE OF CONTENTS

Specifications

General Specifications

Brake Lining Thickness (Nominal) . . . . . 4.1 mm (0.16 in.)
Brake Fluid Quantity . . . . . 0.7 L (24 oz)
Brake Drum Diameter (Maximum) . . . . . 221.21 mm (8.709 in.)

Torque Specifications

Axle-to-Frame and Hitch Carriage Bolt . . . . . 90 N•m (70 lb-ft)
Drum Brake Assembly-to-Axle Case . . . . . 23 N•m (17 lb-ft)
Backing Plate-to-Axle Housing . . . . . 102 N•m (75 lb-ft)
Adapter Plate-to-Axle Cap Screw . . . . . 102 N•m (75 lb-ft)
Drum to Axle Hub Bolts . . . . . 102 N•m (75 lb-ft)
Lug Nut . . . . . 115 N•m (85 lb-ft)
Brake Line/Hose-to-Wheel Cylinder . . . . . 24 N•m (18 lb-ft)
Brake Line-to-Master Cylinder . . . . . 19.5 N•m (14.5 lb-ft)

Tools and Materials

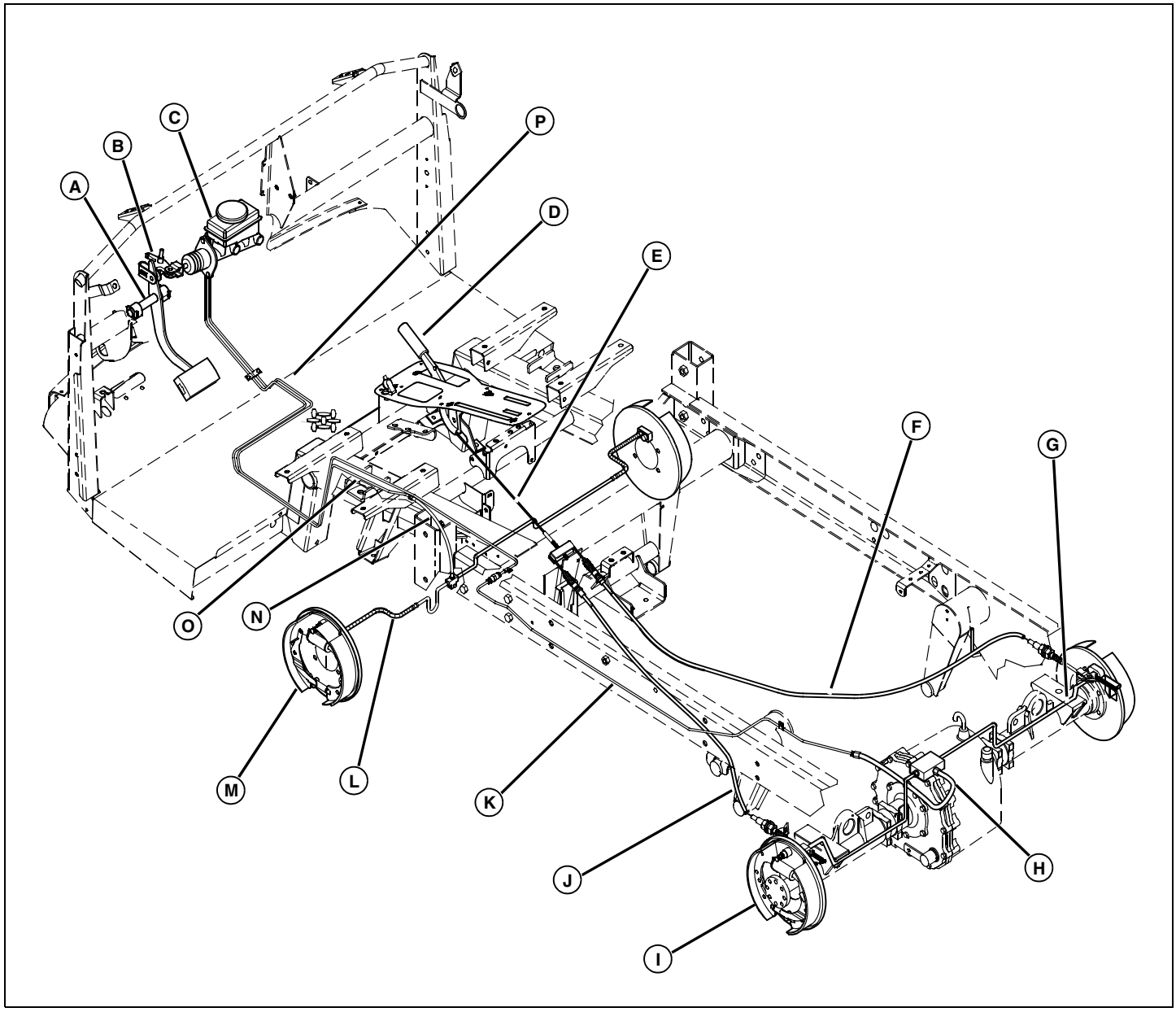
Other Materials

Other Material

Part No.	Part Name	Part Use
TY15975	Brake Fluid - DOT 3	Wheel brake hydraulic system.

Component Location

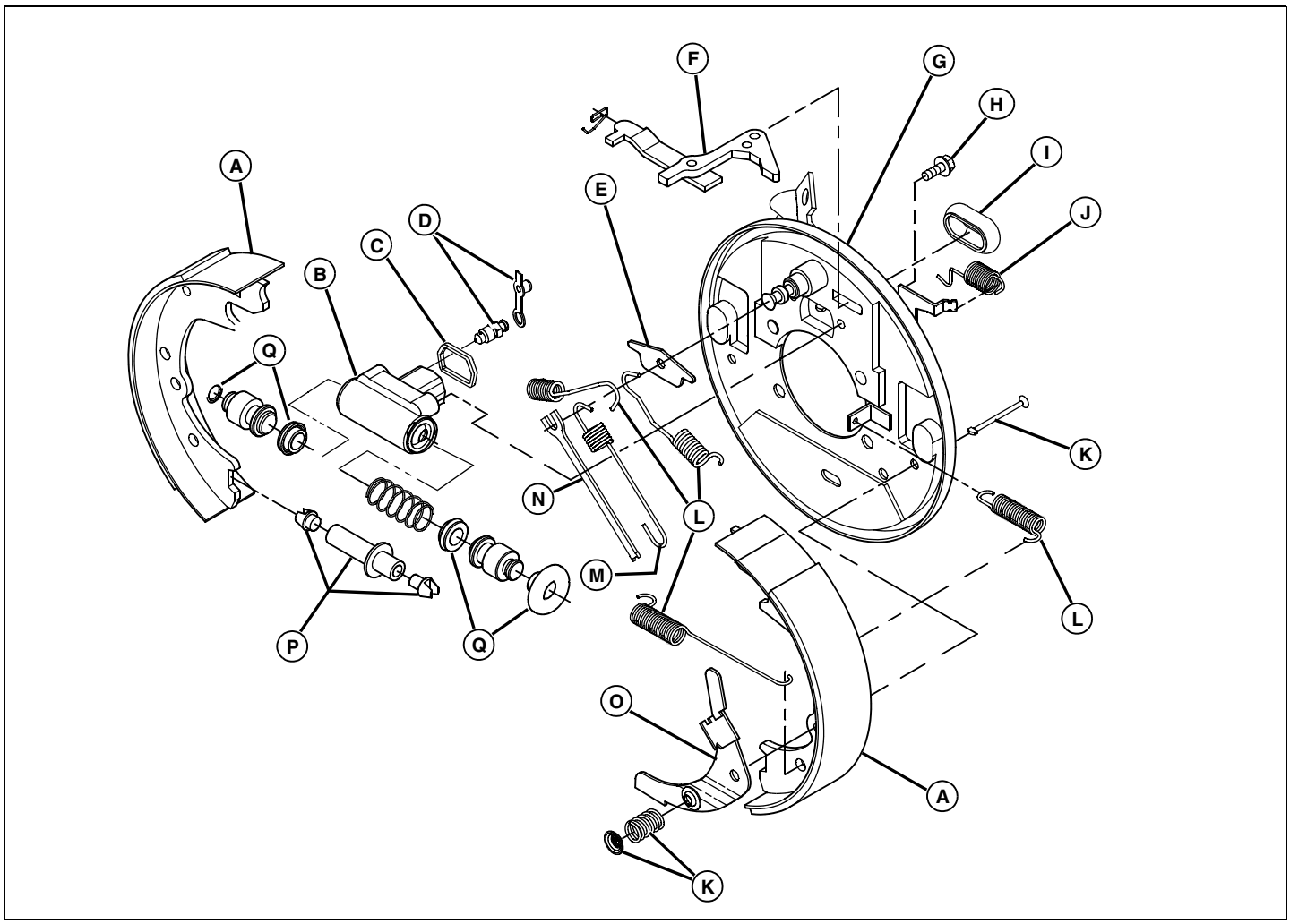
Brake System



MIF

A - Brake Pedal
B - Pivot
C - Master Cylinder
D - Park Brake Lever
E - Front Park Brake Cable
F - Right Rear Park Brake Cable
G - Park Brake Assembly
H - Rear Brake Hose
I - Rear Brake and Axle
J - Left Rear Park Brake Cable
K - Rear Brake Line (Rear section)
L - Front Wheel Brake Hose (2 used)
M - Front Brake Assembly
N - Front Brake Hose
O - Front Brake Line
P - Rear Brake Line (Front section)

Wheel Brake



MIF

A - Brake Shoe Set
B - Wheel Cylinder
C - Gasket
D - Bleeder Screw and Cap (Kit)
E - Brake Shoe Guide Plate
F - Park Brake Lever and Strut (Rear only)
G - Back Plate
H - Cap Screw (2 used)
I - Lever Boot (Rear only)
J - Lever Return Spring (Rear only)
K - Brake Shoe Hold-Down Kit
L - Return Spring Kit
M - Overload Spring (Kit)
N - Stopper
O - Brake Pawl Lever
P - Brake Adjuster (Kit)
Q - Wheel Cylinder (Kit)

Theory of Operation

Theory of Operation

Function

The brakes provide a means of stopping or slowing the unit when in motion. The park brakes prevent movement when the unit is not in use.

Theory of Operation

The ProGator uses an automotive style, self-adjusting, dual hydraulic, four-wheel drum brake system. The front piston of the master cylinder supplies the front brakes; the rear piston of the master cylinder supplies the rear brakes.

When the brake pedal is depressed, the top of the pedal pulls a pivot plate through a clevis, which pivots on a bolt pushing the rod into the brake master cylinder. As the rod is pushed into the master cylinder it pressurizes the brake fluid inside the master cylinder. The pressure is transferred through the brake lines and hoses to the wheel cylinders, where it presses outward on the wheel cylinder pistons. The wheel cylinder pistons press outward on the brake shoes causing them to contact the brake drums.

The friction between the brake shoes and brake drums slows or stops wheel rotation.

The park brake system is cable operated. When the park brake lever is raised into its locked position, the front park brake cable pulls the rear park brake cables through an equalizer, which pulls on the park brake lever of each rear brake assembly. The levers press outward on the brake shoes causing them to contact the brake drums. To release the park brake lever, raise the lever slightly, then depress the release button and lower the lever all the way.

The brakes self-adjust by means of an adjustment lever and star wheel-type adjusting screw. When the ProGator is backed up, or the park brake is activated, the trailing brake shoe is pushed outward. The adjustment lever is attached to the center of the brake shoe, and pivots slightly upward when the shoe moves outward. Through wear and outward pressure, the lever obtains enough travel to advance the star wheel to the next ratchet click stop, adjusting the brake shoes outward.

Diagnostics

Brakes Troubleshooting

Symptom: Brakes Will Not Engage or Have Poor Response

(1) Does master cylinder reservoir contain correct amount of brake fluid?

Yes - Go to step (2).

No - Add brake fluid as necessary.

(2) Is the hydraulic brake system free of air?

Yes - Go to step (3).

No - Bleed brake system. (See “Bleed Brakes” on page 448.)

(3) Are the brake lines and hoses in good condition (not leaking or restricted)?

Yes - Go to step (4).

No - Replace lines and hoses as necessary.

(4) Are the brakes adjusted correctly?

Yes - Go to step (5).

No - Perform “Adjust Brake” on page 447.

(5) Are the wheel cylinders in good condition (no leakage)?

Yes - Go to step (6).

No - Repair or replace wheel cylinders as necessary. (See “Replace Wheel Cylinder” on page 451 and “Service Wheel Cylinder” on page 451.)

(6) Is the master cylinder in good condition (no leakage)?

Yes - Go to step (7).

No - Repair or replace master cylinder. (See “Remove and Install Master Cylinder” on page 448 and “Service Master Cylinder” on page 452.)

(7) Is the master cylinder push rod adjusted correctly?

Yes - Go to step (8).

No - Perform “Adjust Master Cylinder Rod” on page 447.

(8) Are the brake pedal and pivot in good condition (not bent, binding, or worn)?

No - Repair or replace as necessary.

Symptom: Excessive Brake Effort Required to Engage Brakes

(1) Does master cylinder reservoir contain correct amount of brake fluid?

Yes - Go to step (2).

No - Add brake fluid as necessary.

(2) Are the brakes adjusted correctly?

Yes - Go to step (3).

No - Perform “Adjust Brake” on page 447.

(3) Are the wheel cylinders in good condition (no leakage)?

Yes - Go to step (4).

No - Repair or replace wheel cylinders as necessary. (See “Replace Wheel Cylinder” on page 451 and “Service Wheel Cylinder” on page 451.)

(4) Is the master cylinder in good condition (no leakage)?

Yes - Go to step (5).

No - Repair or replace master cylinder. (See “Remove and Install Master Cylinder” on page 448 and “Service Master Cylinder” on page 452.)

(5) Is the master cylinder push rod adjusted correctly?

Yes - Go to step (6).

No - Perform “Adjust Master Cylinder Rod” on page 447.

(6) Are the brake pedal and pivot in good condition (not bent, binding, or worn)?

No - Repair or replace as necessary.

Symptom: Brake Engagement Too Aggressive

(1) Is the park brake cable adjusted correctly?

No - Perform “Adjust Park Brake Cable” on page 447.

Symptom: Brakes Will Not Release

(1) Is the park brake cable adjusted correctly?

Yes - Go to step (2).

No - Perform “Adjust Park Brake Cable” on page 447.

(2) Are the brakes adjusted correctly?

Yes - Go to step (3).

No - Perform “Adjust Brake” on page 447.

Symptom: Brakes Will Not Release

(3) Are the brake shoe return springs in good condition (not stretched or broken)?

Yes - Go to step (4).

No - Replace parts as necessary.

(4) Is the master cylinder push rod adjusted correctly?

Yes - Go to step (5).

No - Perform “Adjust Master Cylinder Rod” on page 447.

(5) Are the brake pedal and pivot in good condition (not bent, binding, or worn)?

No - Repair or replace as necessary.

Symptom: Brakes Chatter or Are Noisy

(1) Are the wheel cylinders in good condition (no leakage)?

Yes - Go to step (2).

No - Repair or replace wheel cylinders as necessary. (See “Replace Wheel Cylinder” on page 451 and “Service Wheel Cylinder” on page 451.)

(2) Are the brake shoe return springs in good condition (not stretched or broken)?

No - Replace parts as necessary.

Symptom: Brakes Pull Left or Right

(1) Are the brakes adjusted correctly?

Yes - Go to step (2).

No - Perform “Adjust Park Brake Cable” on page 447.

(2) Are the brake lines and hoses in good condition (not leaking or restricted)?

Yes - Go to step (3).

No - Replace lines and hoses as necessary.

(3) Are the wheel cylinders in good condition (no leakage)?

Yes - Go to step (4).

No - Repair or replace wheel cylinders as necessary. (See “Replace Wheel Cylinder” on page 451 and “Service Wheel Cylinder” on page 451.)

Symptom: Brakes Pull Left or Right

(4) Are the brake shoe return springs in good condition (not stretched or broken)?

Yes - Go to step (5).

No - Replace parts as necessary.

(5) Are the park brake lever and locking pawl in good condition (not bent, broken, binding, or worn)?

No - Replace parts as necessary.

Symptom: Excessive Brake Pedal Travel

(1) Does the master cylinder reservoir contain the correct amount of brake fluid?

Yes - Go to step (2).

No - Add brake fluid as necessary.

(2) Is the hydraulic brake system free of air?

Yes - Go to step (3).

No - Bleed brake system. (See “Bleed Brakes” on page 448.)

(3) Are the brake lines and hoses in good condition (not leaking or restricted)?

Yes - Go to step (4).

No - Replace parts as necessary.

(4) Are the brakes adjusted correctly?

Yes - Go to step (5).

No - Perform “Adjust Brake” on page 447.

(5) Are the wheel cylinders in good condition (no leakage)?

Yes - Go to step (6).

No - Repair or replace wheel cylinders as necessary. (See “Replace Wheel Cylinder” on page 451 and “Service Wheel Cylinder” on page 451.)

(6) Is the master cylinder in good condition (no leakage)?

No - Repair or replace master cylinder. (See “Remove and Install Master Cylinder” on page 448 and “Service Master Cylinder” on page 452.)

Symptom: Excessive Brake Wear

(1) Is the park brake cable in good condition (not binding) and adjusted correctly?

Yes - Go to step (2).

No - Perform “Adjust Park Brake Cable” on page 447.

(2) Are the park brake lever and locking pawl in good condition (not bent, broken, binding, or worn)?

Yes - Go to step (3).

No - Replace parts as necessary.

(3) Are the brake shoe return springs in good condition (not stretched or broken)?

Yes - Go to step (4).

No - Replace parts as necessary.

(4) Is the master cylinder push rod adjusted correctly?

Yes - Go to step (5).

No - Perform “Adjust Master Cylinder Rod” on page 447.

(5) Is the brake pedal return spring in good condition (not stretched or broken)?

Yes - Go to step (6).

No - Replace spring.

(6) Is the brake pedal and pivot in good condition (not bent, binding, or worn)?

No - Repair or replace as necessary.

Symptom: Brake Pedal Feels Hard with Very Little Travel

(1) Is the park brake cable in good condition (not binding) and adjusted correctly?

Yes - Go to step (2).

No - Perform “Adjust Park Brake Cable” on page 447.

(2) Are the brake pedal and pivot in good condition (not bent, binding, or worn)?

Yes - Go to step (3).

No - Replace parts as necessary.

(3) Are the brake shoe return springs in good condition (not stretched or broken)?

No - Replace part as necessary.

Symptom: Park Brake Will Not Engage

(1) Is the park brake cable in good condition (not binding) and adjusted correctly?

Yes - Go to step (2).

No - Perform “Adjust Park Brake Cable” on page 447.

(2) Are the park brake lever and locking pawl in good condition (not bent, broken, binding, or worn)?

Yes - Go to step (3).

No - Replace parts as necessary.

(3) Are the brake adjusters in good condition (not worn, binding, or disconnected) and adjusted correctly?

No - Perform “Adjust Brake” on page 447.

Symptom: Park Brake Will Not Release

(1) Is the park brake cable in good condition (not binding) and adjusted correctly?

Yes - Go to step (2).

No - Perform “Adjust Park Brake Cable” on page 447.

(2) Is the park brake lever and locking pawl in good condition (not bent, broken, binding, or worn)?

Yes - Go to step (3).

No - Replace parts as necessary.

(3) Are the brake shoe return springs in good condition (not stretched or broken)?

No - Replace parts as necessary.

Symptom: Park Brake Will Not Hold

(1) Is the park brake cable in good condition (not binding) and adjusted correctly?

Yes - Go to step (2).

No - Perform “Adjust Park Brake Cable” on page 447.

(2) Are the park brake lever and locking pawl in good condition (not bent, broken, binding, or worn)?

Yes - Go to step (3).

No - Replace parts as necessary.

Symptom: Park Brake Will Not Hold

(3) Are the brake adjusters in good condition (not worn, binding, or disconnected) and adjusted correctly?

Yes - Go to step (4).

No - Perform “Adjust Brake” on page 447.

(4) Are the wheel cylinders in good condition (no leakage)?

No - Repair or replace wheel cylinders as necessary. (See “Replace Wheel Cylinder” on page 451 and “Service Wheel Cylinder” on page 451.)

Tests and Adjustments

Adjust Park Brake Cable

Procedure

NOTE: The rear brakes must be adjusted correctly before adjusting the park brake cable.

1. The park brake cable is adjusted by removing the slack from the cable between the park brake lever and the rear park brake cables.

2. Adjust the nut on the front brake cable at the equalizer until the slack in the control cable slide rod and clevis has been removed.

Do not overtighten the cable or the brakes will be preloaded.

Adjust Master Cylinder Rod

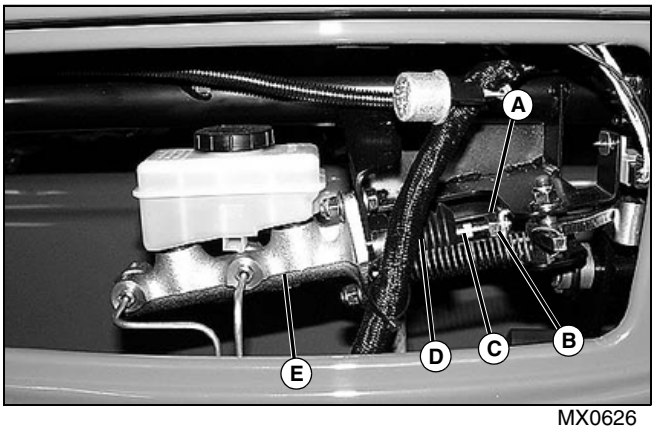
Reason

Master cylinder must be fully destroked when the pedal is against the backstop or pressure will be maintained in the brake system.

Procedure

1. Park machine safely. (See Operator's Manual.)

2. Remove the front access panel.



MX0626

3. Loosen the jam nut (A) on the master cylinder rod (B) adjacent to the clevis (C).

4. Pull the rubber boot (D) off of the shoulder on the master cylinder (E).

5. Turn the master cylinder rod in the clevis to adjust brake pedal.

Adjustment is correct when the return spring has pulled the back of the brake arm against the stop bar, and the master cylinder primary piston is fully destroked and resting against the retaining washer.

6. Push boot back onto the master cylinder.

7. Tighten the jam nut, and verify brake pedal operation.

8. Install the front access cover.

Adjust Brake

Procedure

1. Park machine safely. (See Operator's Manual.)

2. Raise and safely support the wheels at least 25 mm (1.0 in.) off ground. Release the park brake, and do not apply the foot brake.

3. Remove the rubber dust cover from the brake being adjusted.

4. Rotate the wheel by hand. Use a brake adjusting tool through adjustment hole in the back plate to adjust the brakes.

Adjustment is correct when the brake shoes just touch the brake drum as the wheel turns.

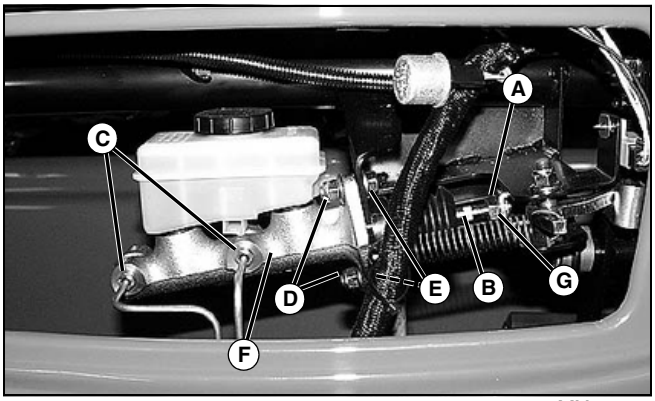
5. Replace the rubber dust cover and lower the vehicle.

Repair

Remove and Install Master Cylinder

Removal

1. Park machine safely. (See Operator's Manual.)
2. Remove the front access panel.



MX0626

3. Loosen the jam nut (A) on the master cylinder rod (B).
4. Disconnect both brake lines (C) from the master cylinder.
5. Remove nuts (D), from cap screws (E) and remove the master cylinder (F).
6. Turn the master cylinder rod counter-clockwise to remove it from the clevis (G).

Installation

1. Hold the master cylinder in position and thread the master cylinder rod into the clevis.
2. Install the master cylinder, and secure with cap screws and nuts.
3. Connect brake lines to the master cylinder. Tighten to specification.
4. Adjust the master cylinder rod length. (See "Adjust Master Cylinder Rod" on page 447.)
5. Install the front access panel.

Specifications

Brake Line-to-Master Cylinder Torque . . . . . 19.5 N•m (14.5 lb-ft)

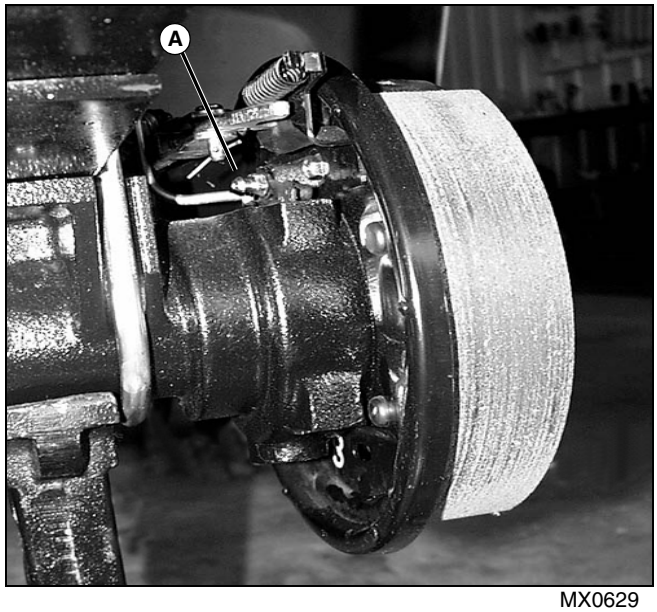
Bleed Brakes

Other Material

Part No.	Part Name	Part Use
TY15975	Brake Fluid - DOT 3	Wheel brake hydraulic system.

NOTE: The brake hydraulic system must be bled any time a new component is installed, or any time the system has been breached. If only one component has been repaired or replaced it may only be necessary to bleed that component.

1. Remove the front access panel.



MX0629

Picture Note: Rear Brake Shown; Front Brakes Are Similar

2. Remove the wheel to access the bleeder screw (A).
3. Remove the rubber covers on the bleeder screws (front wheels only).
4. Attach one end of a clear piece of tubing to the bleeder screw. Put the other end into a clear container with approximately 13 mm (1/2 in.) of fresh brake fluid.
5. With the bleeder screw closed, have an assistant slowly pump the brake pedal to build pressure in the system.
6. After several pumps have the assistant stop pumping, but keep pressure on the brake pedal.
7. Open the brake bleeder screw, allowing brake fluid and air to escape. Watch the fluid entering the container through the tube. The fluid should be clear, without any air bubbles.
8. Close the bleeder screw. The assistant can now release the pedal.

9. Check the fluid level in the master cylinder, topping off with TY15975 DOT 3 Brake Fluid as required.

10.Repeat as required until the fluid running into the container is clear, and there is no evidence of air or bubbles. The pedal should have a firm feel and should not “sink” toward the floor with constant pressure.

11.Make sure all bleeder screws are closed securely and the master cylinder has the correct amount of brake fluid.

12.Install the wheel(s) and front access cover.

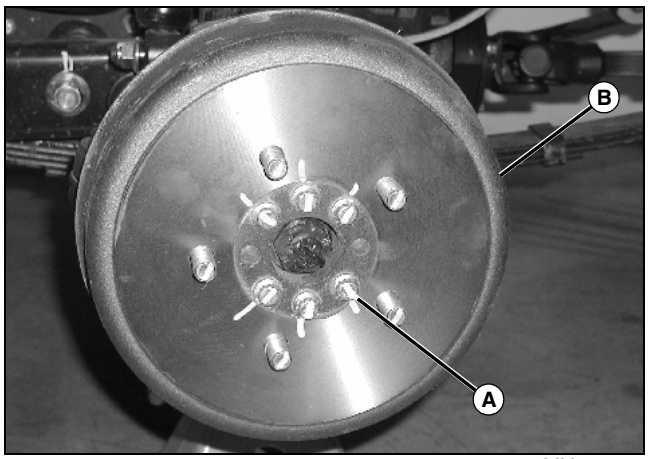
Replace Brake Shoe

Removal

NOTE: The front wheel and rear wheel brakes are similar, with the exception that the rear brakes have the park brake feature.

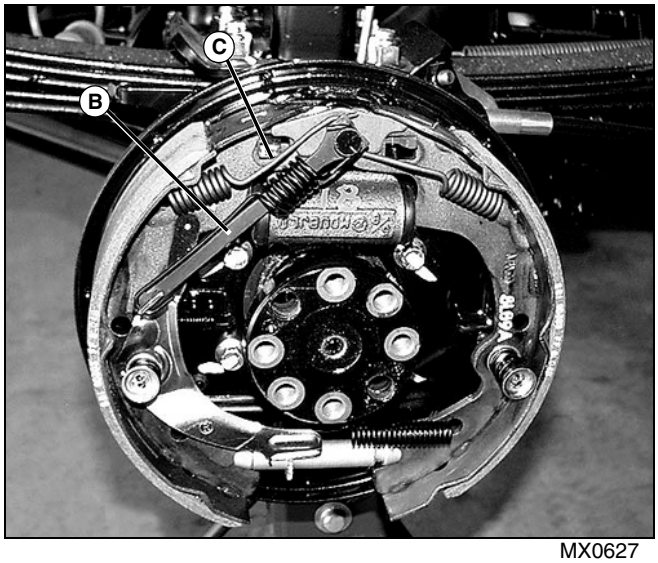
1. Raise and safely support the wheels at least 25 mm (1.0 in.) off ground.

2. Remove five lug nuts and wheel.



MX23955

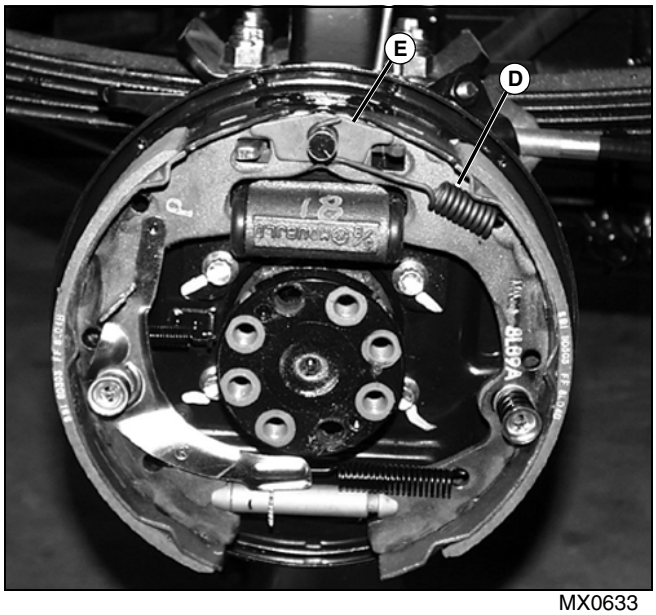
3. Remove six cap screws (A) and brake drum (B).



MX0627

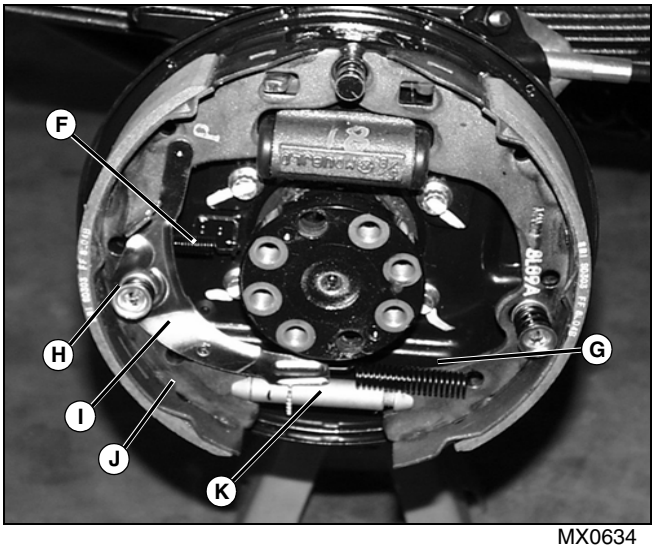
4. Remove the stopper with spring (B).

5. Remove the trailing shoe return spring (C).



MX0633

6. Remove the leading shoe return spring (D), and the brake shoe guide plate (E).



MX0634

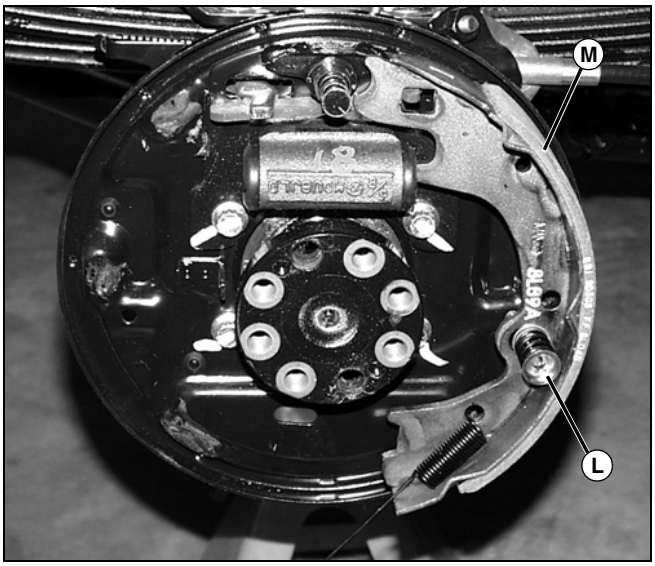
7. Disconnect the adjuster lever return spring (F) and spring (G).

NOTE: It may be necessary to press in on the back side of the hold-down pin to remove the spring and caps.

8. Press in and twist the spring cap for the brake shoe hold down (H) a quarter turn (90°), aligning the slot in the cap with the flat of the hold down pin. Remove the spring and caps.

9. Remove the brake adjusting pawl lever (I) and brake shoe (J).

10. Remove the brake adjuster (K).



MX0635

11. Remove the spring cap for the brake shoe hold-down (L) and spring. Remove leading brake shoe (M) and spring if still attached.

12. Service and inspect adjuster. The threaded end of the adjuster should turn freely.

Installation

NOTE: The brake shoe with the short lining should always be toward the front of the vehicle.

1. Install leading brake shoe (short lining), hold-down spring and caps. Depress spring cap and rotate 90° during installation. Ensure that the flat of the hold-down pin is fully seated into the spring cap.

2. Insert lower brake shoe retaining spring into leading brake shoe as shown, and connect the opposite end to the trailing brake shoe.

3. Place trailing brake shoe in position.

4. Position the adjuster lever on the trailing brake shoe, and install the hold-down spring and caps. Ensure that the flat of the hold-down pin is fully seated into the spring cap.

5. Install the adjuster. The brake shoes should be seated in the slots of the adjuster screw.

6. Connect both ends of lower brake shoe spring.

7. Install top brake shoe guide plate and leading shoe return spring.

8. Install trailing shoe return spring and adjuster link and spring.

9. Check brake shoes for correct positioning, freedom of movement and seating against adjuster.

10. Early models only: Install adapter flange. Tighten the cap screws to specification.

11. Install brake drum. Tighten cap screws to specification.

12. Adjust the brakes. (See “Adjust Brake” on page 447.)

13. Lower the vehicle to the ground and tighten the lug nuts to specification.

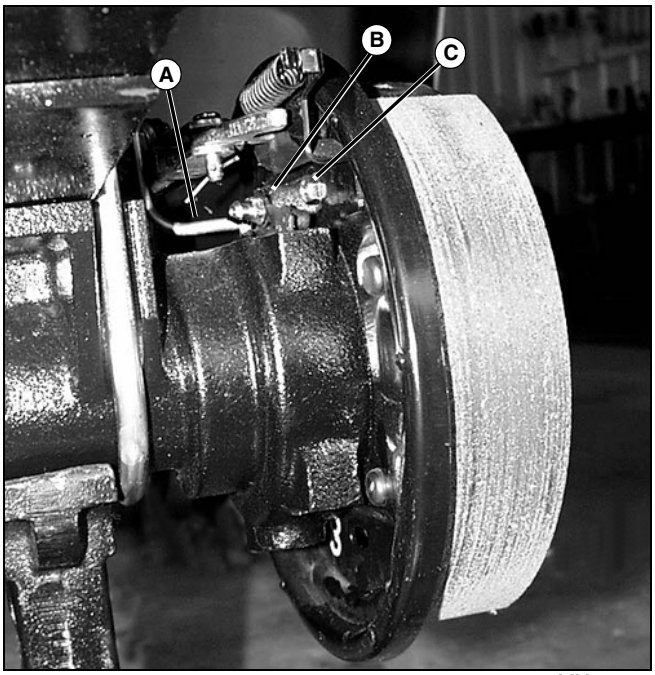
Torque Specifications

Backing Plate-to-Axle Housing . . . . . 102 N•m (75 lb-ft)
Adapter Plate-to-Axle Cap Screw . . . . 102 N•m (75 lb-ft)
Drum to Axle Cap Screws . . . . . 102 N•m (75 lb-ft)
Lug Nut . . . . . 115 N•m (85 lb-ft)

Replace Wheel Cylinder

Removal

1. Remove the brake shoes. (See “Replace Brake Shoe” on page 449.)



MX0629

2. Disconnect the brake line (A) from the wheel cylinder (B).
3. Remove two cap screws (C) from the wheel cylinder.
4. Pull the wheel cylinder from the backing plate.

Installation

Installation is done in the reverse order of removal.

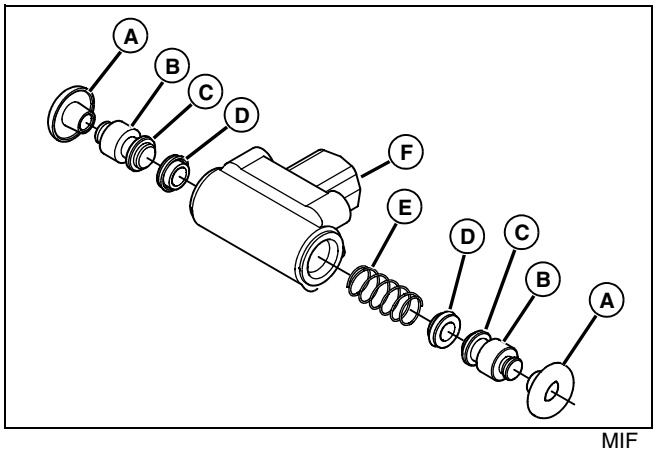
- Bleed the brakes. (See “Bleed Brakes” on page 448.)

Specifications

Brake Line/Hose-to-Wheel Cylinder Torque . . . . . 24 N•m (18 lb-ft)

Service Wheel Cylinder

1. Remove the wheel cylinder requiring service. (See “Replace Wheel Cylinder” on page 451.)



MIF

2. Disassemble the wheel cylinder by removing the dust covers (A), pistons (B), cups (C), locators (D) and spring (E), from the wheel cylinder (F).
3. Inspect the components for wear or damage. Replace the complete cylinder if required.
4. Closely inspect the bore of the wheel cylinder for scratches, nicks, pitting, or corrosion.
5. Use a brake cylinder hone to remove small imperfections from the bore of the wheel cylinder. The bore should be smooth and free of all imperfections before reassembling the wheel cylinder.

NOTE: If the bore of the wheel cylinder has imperfections that cannot be removed by honing, replace the wheel cylinder.

6. Clean the wheel cylinder, making sure that the bore and fluid passages are free of any material left over from honing.
7. Coat the wheel cylinder bore and new cups with fresh, clean brake fluid.
8. Install the locators to the spring, and install to the wheel cylinder.
9. Insert the cups, pistons, and dust covers to the wheel cylinder.
10. Install the wheel cylinder to the backing plate. (See “Replace Wheel Cylinder” on page 451.)

NOTE: All wheel cylinders are different. Always match the wheel cylinders to the brakes when working on more than one cylinder.

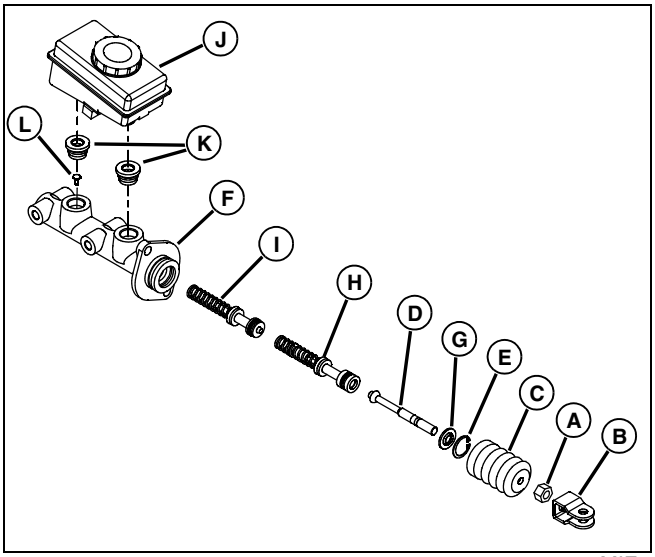
11. Assemble the remaining brake components.
12. Bleed the brakes. (See “Bleed Brakes” on page 448.)

NOTE: Carefully inspect the wheel cylinder and brake connections for leaks or seepage. If there is any evidence of brake fluid escaping from the wheel cylinder or connections, repeat the previous steps or replace the cylinder.

13.Adjust the brakes if required. (See “Adjust Brake” on page 447.)

Service Master Cylinder

1. Remove the master cylinder. (See “Remove and Install Master Cylinder” on page 448.)



MIF

2. Remove the nut (A), clevis (B), and dust cover (C) from the master cylinder push rod (D).

CAUTION: Avoid injury! The springs on the pistons in the master cylinder exert outward pressure on the rod, washer, and snap ring. Use caution when removing and installing the snap ring and related components. Wear eye protection during removal and installation of these components.

3. Remove the snap ring (E) from the master cylinder (F).

4. Remove the retainer washer (G), push rod, primary piston (H) and secondary piston (I) from the master cylinder.

5. Inspect all components for wear or damage. Replace as required.

6. Closely inspect the bore of the master cylinder for scratches, nicks, pitting or corrosion.

7. If the master cylinder requires honing, remove the reservoir assembly (J), reservoir seals (K), and stop pin (L) from the master cylinder.

8. Use a brake cylinder hone to remove small imperfections from the bore of the master cylinder. The bore should be smooth and free of all imperfections before reassembling the master cylinder.

NOTE: If the bore of the master cylinder has imperfections that cannot be removed by honing, replace the cylinder.

9. Clean the master cylinder, making sure that the bore and fluid passages are free of any material left over from honing.

10.Coat the cylinder bore and piston seals with fresh, clean brake fluid.

11.Install the pistons and rod to the master cylinder.

12.Push the pistons and rod far enough into the master cylinder to install the retaining washer and snap ring. Install the snap ring to the master cylinder.

13.Assemble the dust cover, clevis and nut to the push rod.

NOTE: Carefully inspect the master cylinder and brake line connections for leaks or seepage. If there is any evidence of brake fluid escaping from the master cylinder repeat the previous steps or replace the cylinder.

14.Install and bleed the master cylinder. (See “Bleed Brakes” on page 448.)

NOTE: If air entered the brake lines the brake system will have to be bled. Be certain that no air remains in the brake hydraulic system.

Table of Contents

MISCELLANEOUS SPECIFICATIONS

Specifications

General Specifications

Tire Pressure	**69-97 kPa (10-14 psi)**
Tire Pressure with HD200 Sprayer (minimum)	**83 kPa (12 psi)**
Tire Pressure with HD300 Sprayer (minimum)	**110 kPa (16 psi)**

Torque Specifications

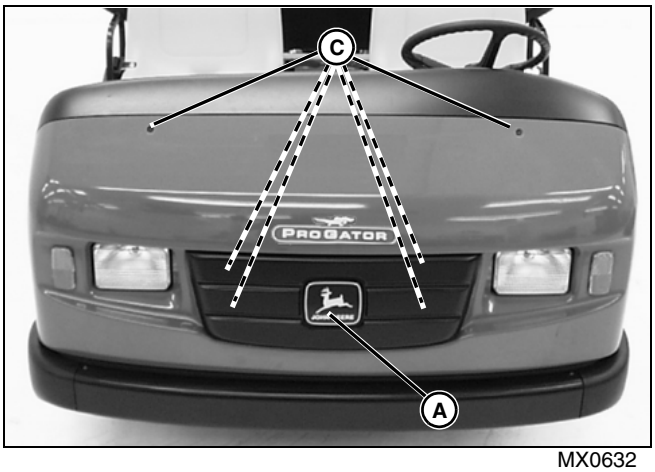
ROPS Mounting Bolt	**69 N•m (51 lb-ft)**
Seat Mounting Cap Screw	**17 N•m (150 lb-in.)**
Control Plate Mounting Screw	**6 N•m (52 lb-in.)**
Wheel Lug Nut	**115 N•m (85 lb-ft)**

Repair

Remove and Install Hood

Removal

1. Park machine safely. (See Operator's Manual.)



MX0632

MX1708

2. Remove service panel (A) from hood.

3. Remove four nuts and bolts and four screws securing the corner fenders (B).

4. Remove eight screws and nuts (C) securing hood.

5. Disconnect wiring harness connectors to the left and right headlights and turn signals.

6. Remove hood.

Installation

Installation is done in the reverse order of removal.

Remove Dash

1. Remove hood. (See "Remove and Install Hood" on page 456.)

2. Remove steering wheel. (See "Remove and Install Steering Wheel" on page 429.)

3. Remove four cap screws securing steering control unit to dash.

4. Remove flange cap screws securing dash grab bar to frame. Slide grab bar out of frame.

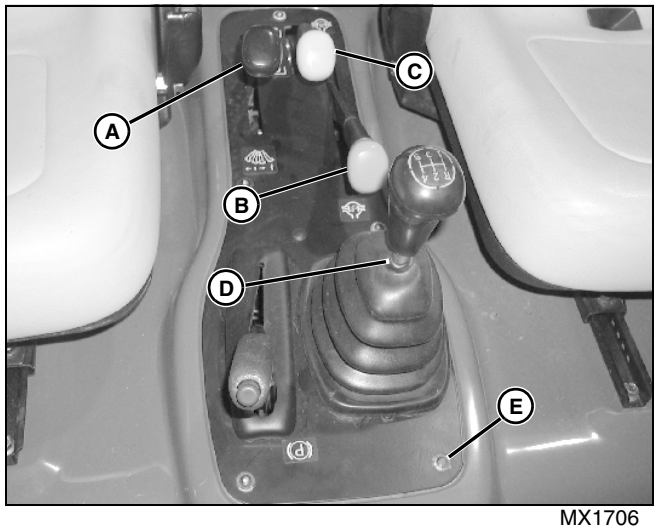
5. Remove two screws securing dash to frame and remove dash.

6. Disconnect electrical connections to control panel.

Remove and Install Control Plate

Removal

1. Park machine safely. (See Operator's Manual.)



MX1706

Picture Note: S.N. (-035000) shown. Gas model engine will require the removal of the choke cable.

2. Remove lever caps from hydraulic control lever (A), differential lock lever (B), and optional PTO lever. Remove nuts securing lever knobs and pull knobs off levers.

3. Loosen jam nut (D) securing shift knob and unscrew knob from shift lever. Remove jam nut from shift lever.

4. Remove five screws (E) securing control plate and remove plate from machine.

Installation

- Installation is done in the reverse order of removal.
- Tighten control plate mounting screws to specifications.

Specifications

Control Plate Mounting Screw . . . . . 6 N•m (53 lb-in.)

Remove and Install Roll Over Protective Structure (ROPS)

Removal

1. Park machine safely. (See Operator's Manual.)
2. Disconnect wiring harness electrical connector from wiring inside ROPS (light connector if option is installed).
3. Remove two bolts securing each side of ROPS to frame.

CAUTION: Avoid injury! The approximate weight of the ROPS is 57 kg (125 lb). Do not attempt to remove ROPS without an assistant or overhead crane.

NOTE: For removal, more working room is provided if the front wheels are turned to the right or left.

4. Using a hoist or assistance, lift the ROPS straight up and remove from machine.

Installation

Installation is done in the reverse order of removal.

- Tighten mounting bolts to specification.

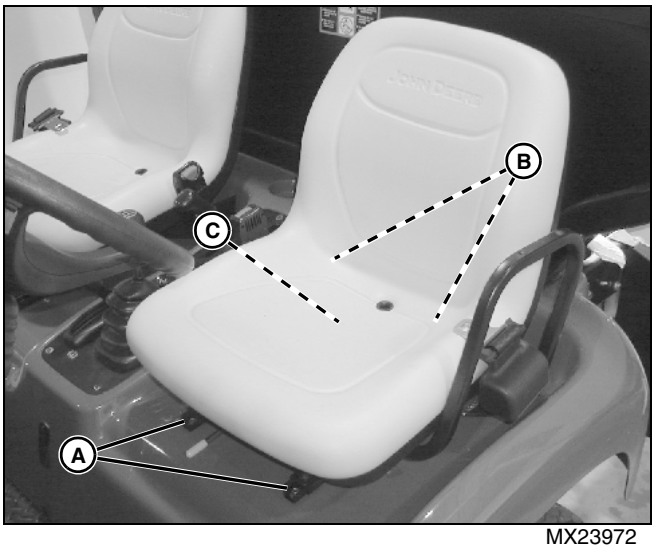
Specifications

ROPS Mounting Bolt Torque . . . . . 69 N•m (51 lb-ft)

Remove and Install Seat

Removal

1. Park machine safely. (See Operator's Manual.)



MX23972

2. Slide seat(s) rearward and remove two cap screws (A) securing seat brackets to machine.
3. Slide seat(s) forward and remove two cap screws (B) securing seat brackets to machine.
4. Disconnect wiring harness from driver side seat switch (C) (under seat).
5. Remove seat(s).

Installation

1. Position seat(s) on machine and install four cap screws securing seat brackets.
2. Tighten cap screws to specification.
3. Connect wiring harness to driver side seat switch.

Specifications

Seat Mounting Cap Screw Torque . . 17 N•m (150 lb-in.)

Remove and Install Seat Base Cover

Removal

1. Park machine safely. (See Operator's Manual.)
2. Remove control plate. (See "Remove and Install Control Plate" on page 456.)
3. Remove ROPS. (See "Remove and Install Roll Over Protective Structure (ROPS)" on page 457.)
4. Remove seats. (See "Remove and Install Seat" on page 457.)
5. Remove seat base cover.

Installation

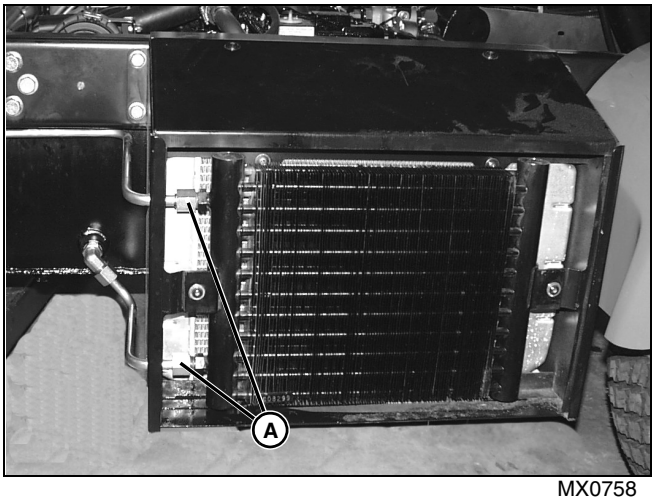
Installation is done in the reverse order of removal.

Remove and Install Radiator

CAUTION: Avoid injury! Hot coolant under pressure can spray and burn unprotected skin and eyes. Allow the unit to cool down before performing this procedure. Dress appropriately and wear eye protection.

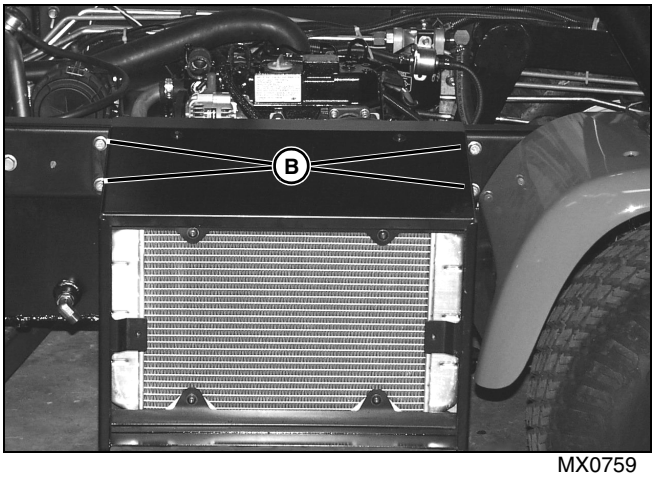
Removal

1. Park machine safely. (See Operator's Manual.)
2. Drain coolant.
3. Remove screen from front of radiator support.



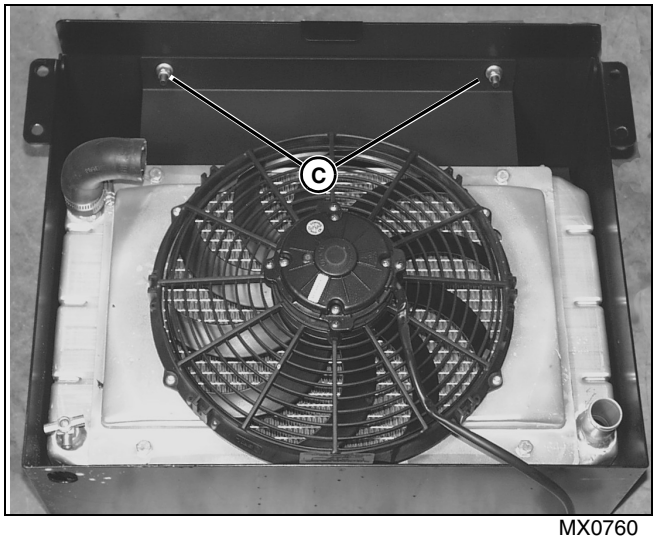
MX0758

4. If machine is equipped with hydraulic tank and cooler, drain oil from tank and remove lines (A) to oil cooler.
5. Disconnect wires to electric fan.
6. Remove the upper and lower radiator hoses from the radiator.



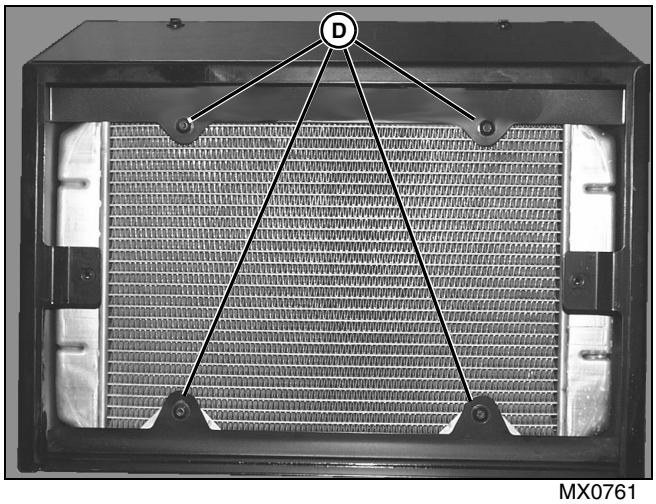
MX0759

7. Remove cap screws (B) from radiator frame and remove unit from machine frame.



MX0760

8. Remove cap screws (C) from radiator support.



MX0761

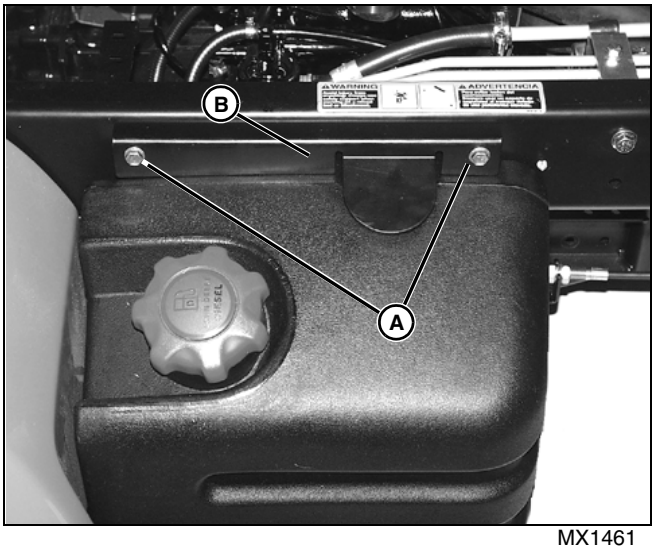
9. Remove four cap screws (D) securing radiator to frame.
10. Lift and remove radiator from radiator frame.

Installation

1. Install radiator to radiator frame.
2. Install radiator frame to machine frame.
3. Connect radiator hoses and fan wiring.
4. If machine is equipped with hydraulic oil cooler, install cooler and lines. Fill hydraulic reservoir.
5. Close drain valve. Fill cooling system and recovery tank with approved coolant.
6. Install radiator cap.
7. Run machine. Check cooling system for leaks.

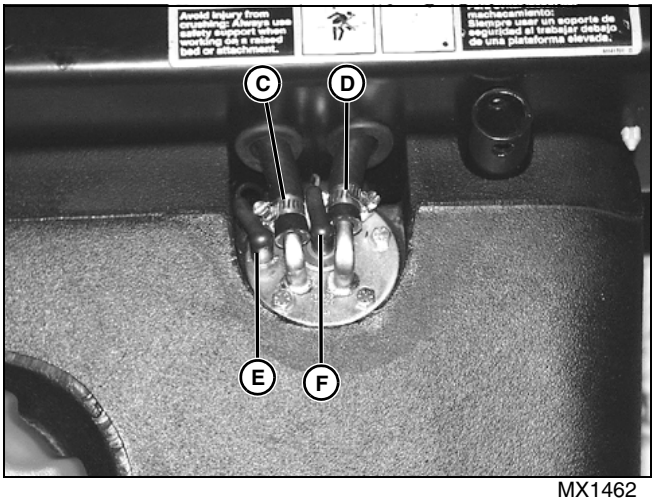
Remove and Install Fuel Tank

Removal



MX1461

1. Hold nuts behind frame rail and remove cap screws (A) and bracket (B).



MX1462

2. Loosen hose clamps and disconnect fuel return line (C) (diesel models) and fuel suction hose (D).

3. Disconnect black wire (E) and pink wire (F) from fuel level sensor.

4. Tip top of fuel tank away from frame and lift tank out of support bracket.

Installation

1. Set tank into lower bracket.

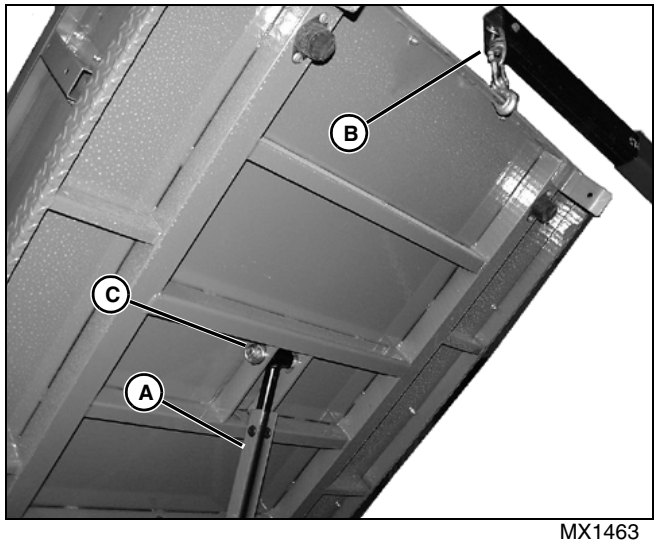
2. Connect hoses and wires to fuel level sensor.

3. Install bracket.

Remove and Install Cargo Box

Removal

CAUTION: Avoid injury! The approximate weight of the cargo box is 137 kg (300 lb). Do not attempt to remove cargo box without several assistants or overhead crane.



MX1463

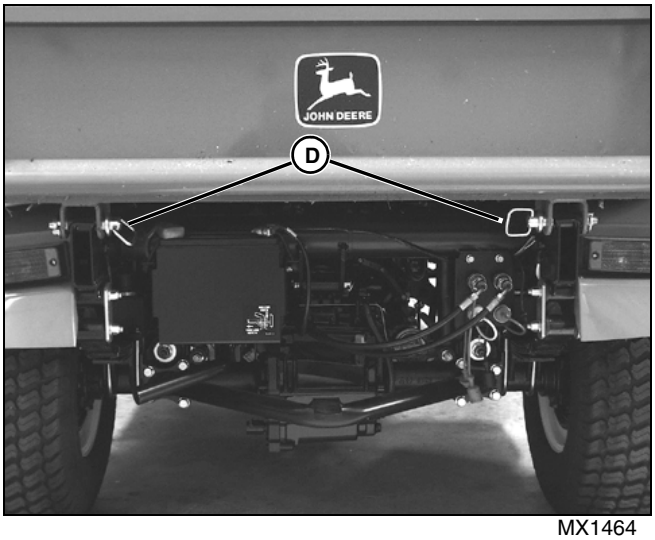
Picture Note: S.N. (-035000) shown.

1. Safely park machine and raise cargo box. Install safety lock bar (A) on lift cylinder.

2. Support front of box with engine hoist or similar lifting device (B). Make sure engine hoist is supporting enough weight so that pin (C) is loose.

3. Hold lift cylinder and remove pin. Disconnect lift cylinder hoses and remove lift cylinder from machine.

4. Lower cargo box with engine hoist.



MX1464

5. Remove hinge pins (D).

6. Use an appropriate lifting device and lift box from machine.

Installation

Installation is done in the reverse order of removal.

Remove and Install Wheel

Removal

1. Park machine safely. (See Operator's Manual.)

2. Loosen lug nuts on wheel(s) being removed.

3. Raise and support machine so that the wheel being removed is just off the ground.

4. Remove lug nuts and remove wheel.

Installation

Installation is done in the reverse order of removal.

- Install wheel(s) with stems toward outside of machine.
- Tighten mounting cap screw to specification.
- Check that tire pressure is to specification.

Specifications

Wheel Lug Nut Torque . . . . . 115 N•m (85 lb-ft)
Tire Pressure. . . . . 69-97 kPa (10-14 psi)

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