

**JOHN DEERE**  
**WORLDWIDE COMMERCIAL & CONSUMER**  
**EQUIPMENT DIVISION**

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**Gator™ Utility Vehicle**  
**TE**

TM2339 OCTOBER 2005

**TECHNICAL MANUAL**



**JOHN DEERE**

North American Version  
Litho In U.s.a.

# INTRODUCTION

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## 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.

**Safety**

**Specifications and Information**

**Batteries**

**Battery Charger**

**Electric Motor**

**Electrical**

**Power Train**

**Steering**

**Brakes**

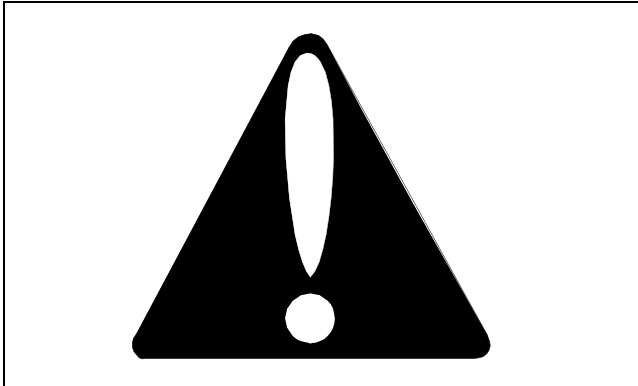
**Miscellaneous**

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# SAFETY

## Be Prepared For Emergencies

### Recognize Safety Information



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.

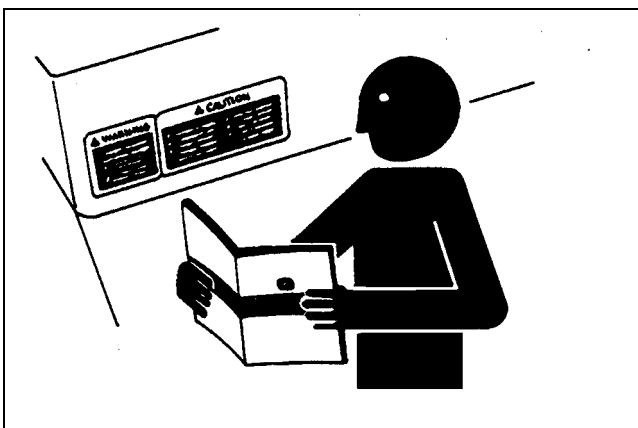
Follow recommended precautions and safe servicing practices.

### Understand Signal Words

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

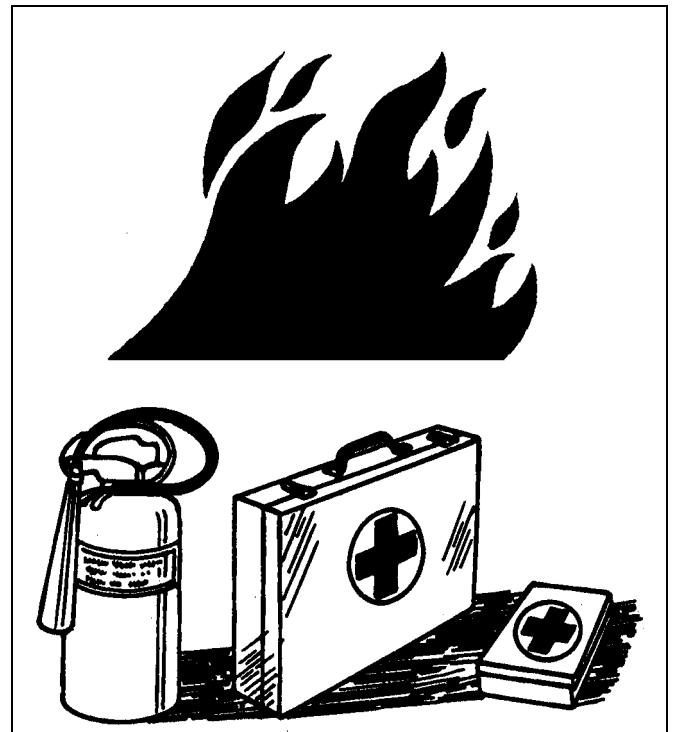
DANGER or WARNING safety signs are located near specific hazards. General precautions are listed on CAUTION safety signs. CAUTION also calls attention to safety messages in this manual.

### Replace Safety Signs



TS201

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



TS227 and TS291

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

Charge batteries in a well ventilated area.

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

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

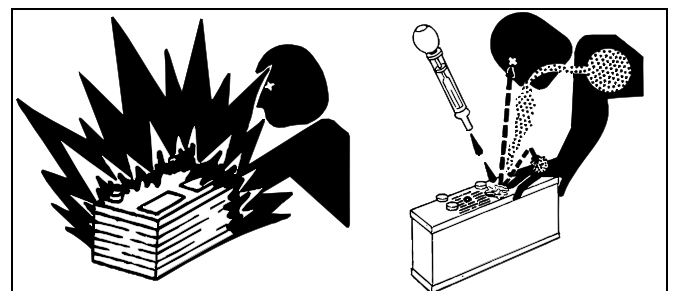
Do not store oily rags; they can ignite and burn spontaneously.

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



# SAFETY

## Prevent Battery Explosions

Batteries contain sulfuric acid and produce explosive mixtures of hydrogen and oxygen. Because self-discharge action generates hydrogen gas even when the battery is not in operation, make sure batteries are stored and serviced in a well ventilated area.

- Always wear proper eye, face and hand protection.
- Keep sparks, lighted matches, and open flame away from the top of battery.
- Remove all jewelry (watches, rings, bracelets, etc.) before servicing the electrical system or batteries.
- Make sure work area is well ventilated.
- Never lean over battery while testing or charging.
- Keep removable vents tight and level except when servicing electrolyte.
- Exercise caution while working with metallic tools or conductors to prevent short circuits and sparks.
- Never check battery charge by placing a metal object across the posts. Use a battery tester, volt-meter or hydrometer.
- Do not charge a frozen battery; it may explode. Warm battery to 16°C (60°F).

## Safe Charging

- Never attempt to charge a battery without first reviewing the instructions for the charger being used.
- Use only the battery charger provided with the utility vehicle. DO NOT use substitutes.
- Always wear proper eye, face and hand protection.
- Keep sparks, lighted matches, and open flame away from the top of battery.
- Make sure work area is well ventilated.
- Never lean over battery while testing or charging.
- Keep removable vents tight and level except when servicing electrolyte.
- To avoid dangerous sparks, Do not disconnect the DC output cord from the battery receptacle when the charger is on. Disconnect the AC power supply cord to turn the charger off before disconnecting the DC output plug.
- Never try to charge a visibly damaged or frozen battery.
- Be sure that the key switch and all electrical accessories are turned off.
- Make sure that the charger leads are not broken, frayed or loose.
- If the battery becomes hot, or if violent gassing or spewing of electrolyte occurs, unplug the charger AC

source first before removing the DC plug

- If battery set is on charge, unplug the charger AC plug before disconnecting the charger DC cable plug to avoid dangerous sparks.

## 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.

Use extreme caution when handling electrolyte and keep an acid neutralizing solution - such as baking soda or household ammonia mixed with water - readily available.

### Avoid acid burns by:

1. Filling batteries in a well-ventilated area.
2. Wearing eye and face protection a rubber apron and rubber gloves.
3. Avoiding breathing fumes when electrolyte is added.
4. Avoiding spilling or dripping electrolyte.

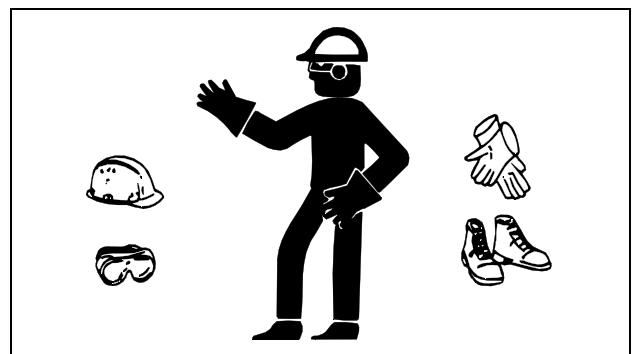
### If you spill acid on yourself:

1. Flush area of body that has been exposed with clean water for at least 20 minutes.
2. Remove contaminated clothing.
3. Flush your eyes with clean, cool water for at least 20 minutes.
4. Get medical attention immediately.

### If acid is swallowed:

1. Drink large amounts of water or milk. Do not induce vomiting.
2. Then drink milk of magnesia, beaten eggs, or vegetable oil.
3. Get medical attention immediately.

## Wear Protective Clothing



# SAFETY

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

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 Caution When Servicing Electrical System

Always use extreme caution when servicing this utility vehicle. This utility vehicle is equipped with a 48 volt electrical system capable of passing a high voltage electrical current.

Only persons trained in electrical maintenance should repair or service this utility vehicle.

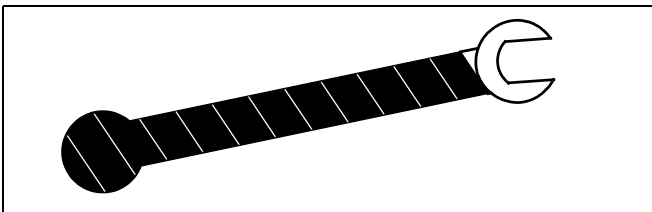
Always move the service/drive switch to the SERVICE position before servicing any part of the electrical system.

Always refer to the battery position/connection diagram when making battery connections to avoid battery explosion. Disconnect the battery set positive (B+) cable before servicing the electrical system.

## Use Proper Tools

Use tools appropriate to the work.

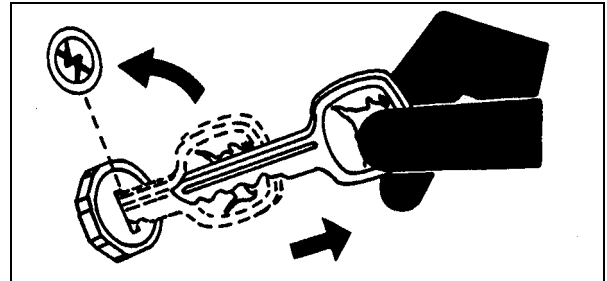
Use extreme caution when using tools, wires, or metal objects near batteries! A short circuit and/or spark could cause an electrical shock or an explosion. Wrap tools with vinyl tape to prevent shorting out battery(s).



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

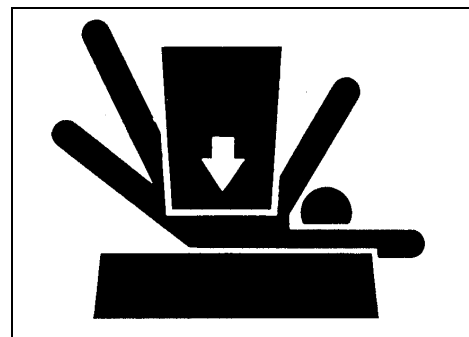


TS230

### Before working on the machine:

1. Turn key switch to the OFF position and remove the key.
2. Place the Forward/Neutral/Reverse switch in the NEUTRAL position.
3. Lock the park brake.
4. Raise and tilt operator seat forward. Move the service/drive switch to the SERVICE position.
5. Hang a "DO NOT OPERATE" tag in operator station.

## Support Machine Properly And Use Proper Lifting Equipment



TS229

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.

# SAFETY

## 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.

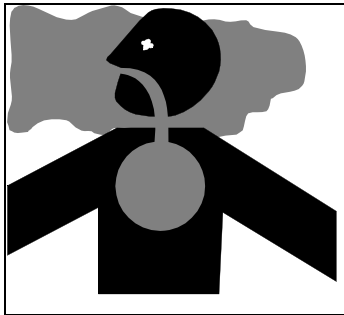
## Using High Pressure Washers

Directing pressurized water at electronic/electrical components or connectors, bearings, 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

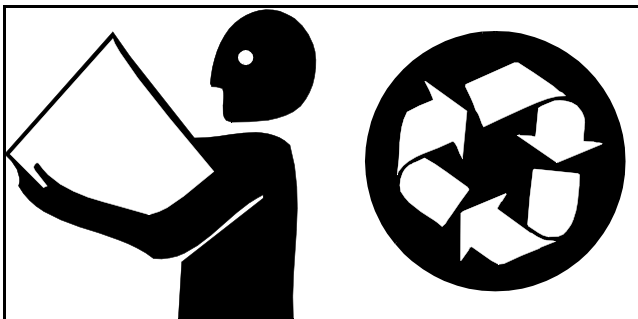
Illuminate your work area adequately but safely. Use a portable safety light for working inside or under the machine. Make sure the bulb is enclosed by a wire cage. The hot filament of an accidentally broken bulb can ignite hydrogen gases or spilled fuel or oil.

## Work In Ventilated Area



Battery fumes can cause sickness or death. Make sure the work area is well ventilated if it is necessary to charge the batteries in an enclosed area.

## Handle Chemical Products Safely



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

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

## 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, greases and batteries. Use leakproof containers when draining fluids.

- Waste products such as batteries, can harm the environment and people.
- 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.
- A Material Safety Data Sheet (MSDS) provides specific details on chemical products: physical and health hazards, safety procedures, and emergency response techniques. The seller of the chemical products used with your vehicle is responsible for providing the MSDS for that product.

## Live With Safety



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

# SPECIFICATIONS & INFORMATION TABLE OF CONTENTS

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# SPECIFICATIONS & INFORMATION GENERAL SPECIFICATIONS

## General Specifications

### Metric Fastener Torque Values

<b>Property Class and Head Markings</b>				
<b>Property Class and Nut Markings</b>				

TS1163

SIZE	Class 4.8		Class 8.8 or 9.8				Class 10.9				Class 12.9					
	Lubricated <sup>a</sup>		Dry <sup>a</sup>		Lubricated <sup>a</sup>		Dry <sup>a</sup>		Lubricated <sup>a</sup>		Dry <sup>a</sup>		Lubricated <sup>a</sup>		Dry <sup>a</sup>	
	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	190
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  $\pm 10\%$  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 class. 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 lock nuts to the full torque value.

<sup>a</sup> “**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-200



# SPECIFICATIONS & INFORMATION GENERAL SPECIFICATIONS









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## Metric Fastener Torque Values—Grade 7

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)

# SPECIFICATIONS & INFORMATION GENERAL SPECIFICATIONS

## Inch Fastener Torque Values

<b>SAE Grade and Head Markings</b>	1 or 2 <sup>b</sup> No Marks 	5    5.1    5.2 	8    8.2 
<b>SAE Grade and Nut Markings</b>	2 No Marks 	5  	8  

TS1162

SIZE	Grade 1		Grade 2 <sup>b</sup>				Grade 5, 5.1 or 5.2				Grade 8 or 8.2					
	Lubricated <sup>a</sup>		Dry <sup>a</sup>		Lubricated <sup>a</sup>		Dry <sup>a</sup>		Lubricated <sup>a</sup>		Dry <sup>a</sup>		Lubricated <sup>a</sup>		Dry <sup>a</sup>	
	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 class. 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 lock nuts to the full torque value.

<sup>a</sup> “**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.

<sup>b</sup> “**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

## Gasket Sealant Application

### Cleaning:

Clean both surfaces that will be joined using 100% isopropyl alcohol. Wipe excess off with a clean cloth. Cleaner/degreaser can be substituted for isopropyl alcohol.

### How to Dispense/Apply/Assemble Gasket Sealants:

Dispense approximately 1 to 2 ounces of flexible form-in-place gasket on a clean sheet or table top. Avoid using excess amounts that may be exposed for long periods of time. This will help prevent contamination from surrounding atmosphere such as dust with metal content.

Using an ink roller or similar device, apply to one surface of the joint by loading the roller from a plastic sheet and transferring the material in a thin film to the joint. The application should be the thinnest film possible, but providing complete coverage. This can be judged by the appearance of the joint once it is put together. Excessive amounts of will cause incorrect bearing end play, extend cure time, and will cause runoff of the material. A small bead or buildup at the joint is permissible and indicates good dispersion through the joint. Excess can be wiped from the joint. Joining should take place within three minutes after sealant application.

Apply proper cap screw torque and sequence as applicable. Allow a minimum of 30 minutes before air test or adding oil for test stand usage.

### Disassembly:

Cured material can be removed with a wire brush or scraper. Chemical cleaners are available for customer use, should they be deemed necessary.

## Lubricants

### Alternative Lubricants

Conditions in certain geographical areas outside the United States and Canada may require different lubricant recommendations than the ones printed in this technical manual or the operator's manual. Consult with your John Deere Dealer, or Sales Branch, to obtain the alternative lubricant recommendations.

**Important: Avoid Damage! 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.

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.

# SPECIFICATIONS & INFORMATION LUBRICANTS

## Anti-Corrosion Grease

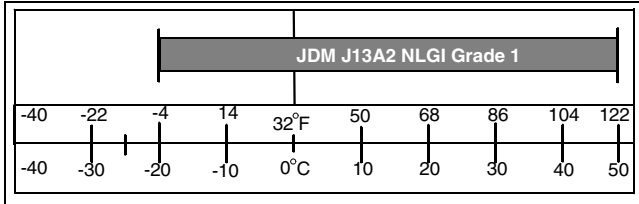
This anti-corrosion grease is formulated to provide the best protection against absorbing moisture, which is one of the major causes of corrosion. This grease is superior in resistance to separation and migration.

The following anti-corrosion grease is preferred:

- **DuBois MPG-2 Multi-Purpose Polymer Grease**

Other greases may be used if they meet or exceed the following specification:

- **John Deere Standard JDM J13A2, NLGI Grade 1**



## Chassis Grease

Use the following grease based on the air temperature range. Operating outside of the recommended grease air temperature range may cause premature failures.

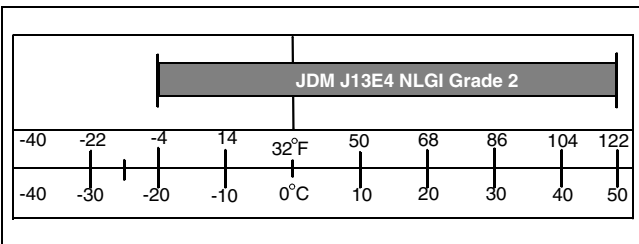
The following John Deere grease is preferred:

- **Non-Clay High-Temperature EP Grease®—JDM J13E4, NLGI Grade 2**

- Multi-Purpose SD Polyurea Grease
- Multi-Purpose HD Lithium Complex Grease

Other greases may be used if above preferred John Deere grease is not available, provided they meet the following specification:

- **John Deere Standard JDM J13E4, NLGI Grade 2**



## Transaxle Oil

**Important: Avoid Damage! Transaxle is filled with John Deere HY-Gard™ (J20C) transmission oil at the factory. DO NOT mix oils.**

Do not use type "F" automatic transmission fluid.

Use Hy-Gard™ (J20C) or Low Viscosity Hy-Gard (J20D) transmission oil.

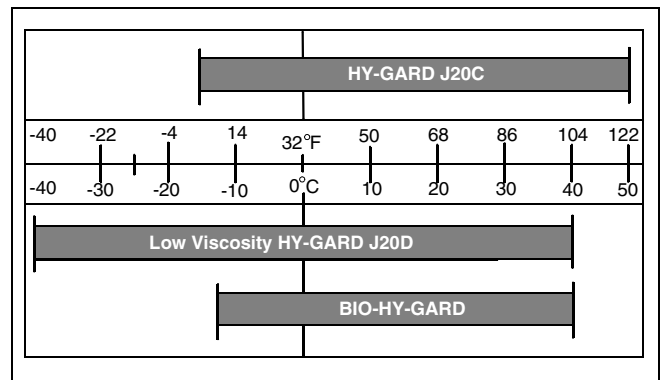
John Deere Low Viscosity Hy-Gard transmission oil is specially formulated for operation below -18°C (0°F) to provide maximum protection for the hydraulic system.

The following John Deere oil is **preferred**:

- **Hy-Gard J20C Oil**

The following oil is also recommended if above preferred oil is not available:

- **Low Viscosity Hy-Gard J20D Oil**
- **BIO-Hy-Gard when a biodegradable transmission/hydraulic oil is required**



**Important: Avoid Damage! If operating temperatures are below -18°C (0°F), you must use Low Viscosity HY-GARD™ or transmission damage will occur.**

Use the appropriate oil viscosity based on the air temperature ranges. Operating outside of these recommended oil air temperature ranges may cause premature gear case failure.

# SPECIFICATIONS & INFORMATION SERIAL NUMBER LOCATIONS

## Serial Number Locations

### Machine Product Identification Number

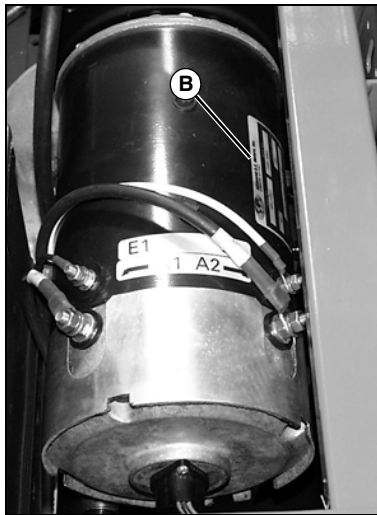
When ordering parts or submitting a warranty claim, it is **IMPORTANT** that the machine product identification number (PIN) and component serial numbers are included. The location of the PIN and component serial numbers are shown.



M99930

Vehicle identification number plate (A) is located on the frame under the passenger seat.

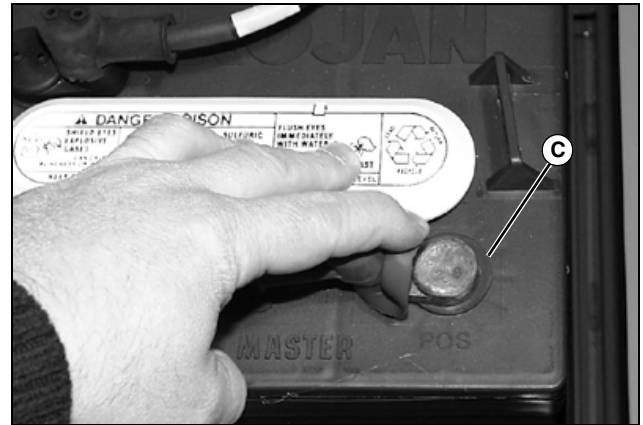
### Electric Motor Identification Number



M99933

The electric motor serial number sticker (B) is located on the motor at the rear of the vehicle.

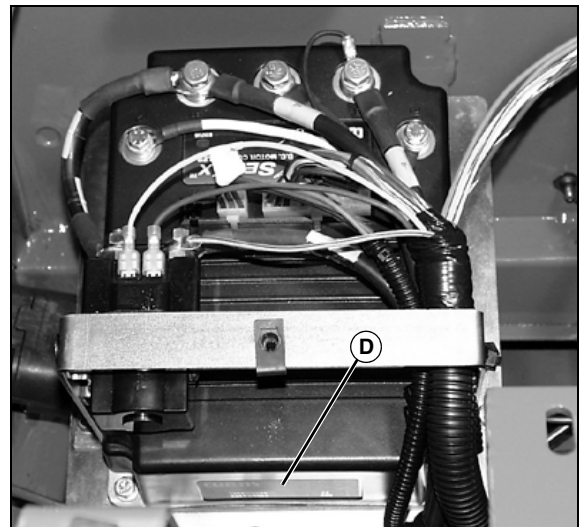
## Battery Identification Date Code



M99932

The battery date codes (C) are stamped into the top surface of both the positive and negative terminal of each battery.

## Motor Controller Identification Number



M99931

The motor controller serial number (D) is located on a label located on the lower surface of the controller.

# SPECIFICATIONS & INFORMATION SERIAL NUMBER LOCATIONS

## Battery Charger Identification Number



M99934

The battery charger serial number (E) is located on the front control panel of the charger.

# BATTERIES TABLE OF CONTENTS

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## Table of Contents

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# BATTERIES SPECIFICATIONS

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## Specifications

### Battery Specifications

#### Standard Batteries:

Type .....	Trojan T-105
Voltage (Each Battery) .....	6 VDC
Total Voltage (8 Batteries) .....	48 VDC
Rating (Minutes @ 56 amps) .....	165
Approximate Weight .....	28.1 kg (62 lbs)

#### Optional Batteries:

Type .....	Trojan T-145
Voltage (Each Battery) .....	6 VDC
Total Voltage (8 Batteries) .....	48 VDC
Rating (Minutes @ 56 amps) .....	205
Approximate Weight .....	32.2 kg (71 lbs)

### Torque Specifications

#### Torque Specifications:

Battery Hold Downs .....	7 - 9 N•m (62 - 80 lb-in.)
Battery Post Connectors .....	14 - 16 N•m (124 - 142 lb-in.)
Battery Support Tray .....	95 N•m (70 lb-ft)

# BATTERIES DIAGNOSTICS

## Diagnostics

### Troubleshooting:

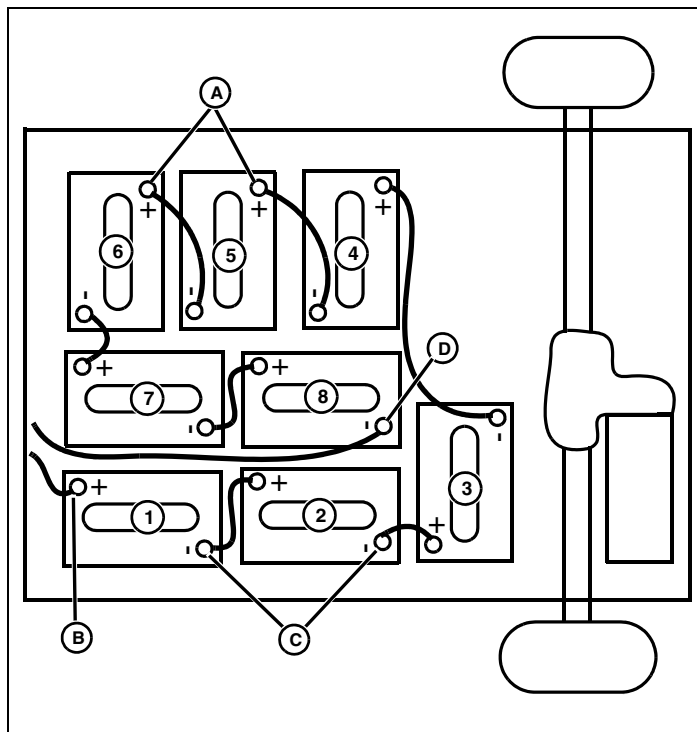
**Symptom: Poor Vehicle Performance or Run Time Not To Expectation**

#### Problem

#### Cause - Solution

- |   |   |
|---|---|
| <p>1. Battery not charged, or not holding a charge.</p>   | <p>a. Using a battery charger that is known to be operational, place batteries on charge until charger shuts off or sixteen hours, whichever comes first.</p> <p>b. Perform hydrometer test. See "Hydrometer Test" on page 18. Go to next step.</p> |
| <p>2. Extremely low or no reading in any cell.</p>  | <p>a. Battery has dead cell(s). Replace battery.</p>  |
| <p>3. Any battery has a variation of more than 30 points (0.030) between cells.</p>   | <p>a. Mark the cell(s) that vary and confirm readings with load test. See "Battery Discharge Test" on page 21. If battery(s) with low cells does not pass load test, replace battery(s).</p>  |
| <p>4. All readings appear to be satisfactory.</p>   | <p>a. Perform load test. See "Battery Discharge Test" on page 21.</p>   |
| <p>5. Voltage of each battery within 0.3V of each other, but discharge time is less than 86 minutes (standard batteries).</p> | <p>a. End of battery set useful life. Replace battery set.</p>  |
| <p>6. Discharge time is low and the batteries show more than 0.3V per battery at the end of the discharge cycle.</p>          | <p>a. Replace the battery(s) with the low voltage with batteries of the same approximate age and usage as the remaining batteries. Repeat load test.</p>  |
| <p>7. Discharge time is greater than 86 minutes (standard batteries) or 83 minutes (optional batteries).</p>                  | <p>a. Problem is not with batteries. Check motor controller, machine electrical wiring, or electric motor.</p>  |
| <p>8. Throttle Position Potentiometer misadjusted or defective.</p>   | <p>a. Test and adjust the throttle position potentiometer. See "Throttle Position Potentiometer Test" on page 148 and See "Throttle Linkage and Stop Adjustment" on page 152</p>  |

## Battery Position/Connection Diagram



mif

- A- Positive (+) Terminal - Must use Red Boot
- B- Battery Pack Positive (B+) - 1 cable and 1 wire
- C- Negative (-) Terminal - Must use Black Boot
- D- Battery Pack Negative (B-) - 1 cable and 2 wires

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# BATTERIES BATTERY THEORY AND OPERATION

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## Battery Theory and Operation

### Deep Cycle Batteries

#### Description:

A cycling battery has a service requirement which is quite different from that of an automotive battery. The automotive battery must deliver high cranking currents at a satisfactory voltage for a few seconds and a portion of the accessory load (10-25 amperes) for a minute or two at a time in city or heavy traffic. Therefore, the automotive battery is designed with maximum plate area and low internal resistance to provide high cranking performance. Power taken from this battery is immediately replaced by the alternator or generator. Therefore, the battery is subjected to shallow discharge cycles (2-3% of the battery capacity). These batteries operate in the 90-100% state of charge.

Cycling batteries supply all the motive power and power for the accessories for the vehicles in which they are used. The rate of discharge varies with the type of service. In electric vehicle service, the battery normally provides a nominal intermittent discharge of 75 amperes, with a typical range of 40-350 amperes. The depth of discharge varies with the length of time it is used before being recharged. Once the battery is discharged, it must be recharged to continue operating the vehicle since it is not maintained by a vehicle generator or alternator. These batteries usually receive "deep" discharge (60-70% or more of their capacity).

**Note: New cycling batteries do not have their full capacity until they have been cycled several times (usually between 20 and 50 cycles). Therefore, they can be excessively discharged early in their vehicular life, thereby shortening their service life.**

Cycling batteries are designed to have good life performance in "deep" cycle service. The major cause of battery failure in "deep" cycle service is poor maintenance:

- Dirt and corrosion on battery tops or terminals
- Water too much or too little
- Excessive discharge (lack of charging)

A battery is a perishable item that requires periodic maintenance. With a reasonable amount of care, the life of a battery can be significantly extended.

The life of a cycling battery is determined not only by the number of cycles (a discharge and a recharge) it receives, but also by the depth of each cycle. Assume a set of batteries is used 4 hours per day; let's call that one life cycle. If they are used for 8 hours, this is a much deeper discharge and is equivalent to approximately three life cycles. A battery pack used 8 hours per day has a life span approximately one-third that of one used for 4 hours per

day.

#### Electrolyte And Specific Gravity

The electrolyte in a lead-acid storage battery is a dilute sulfuric acid solution. A battery with a fully charged specific gravity of 1.250 corrected to 26.7°C (80°F) contains an electrolyte with approximately 33.9% sulfuric acid by weight or 23.5% by volume. The remainder of the electrolyte is water. Pure (concentrated) sulfuric acid has a specific gravity of 1.835.

The sulfuric acid in the electrolyte is one of the necessary ingredients for the chemical reactions taking place inside the battery. It supplies the sulfate ions (SO<sub>4</sub>) which combine with the active material in the plates. It is also the carrier for the electric current as it passes from plate to plate. When the battery terminals are connected to an external load, the sulfate combines with the active materials of the positive and negative plates forming lead sulfate (PbSO<sub>4</sub>) on both and releasing electrical energy.

Specific gravity is a unit of measurement for determining the sulfuric acid content of the electrolyte. The recommended fully charged specific gravity of most batteries today is in the range of 1.250 – 1.280 corrected to 26.7°C (80°F). The charts in this service manual assume a fully charged specific gravity of 1.250 or higher.

On the specific gravity scale, water by definition is 1.000. Therefore, electrolyte with a specific gravity of 1.250 means it is 1.250 times heavier per unit volume than pure water.