2021 Carryall 300 Maintenance and Service Manual



Gasoline Vehicle with Kohler ECH440 Engine
Electric Vehicle with ERIC Charging System

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FOREWORD

Club Car vehicles are designed and built to provide the ultimate in performance efficiency; however, proper maintenance and repair are essential for achieving maximum service life and continued safe and reliable operation.

This manual provides detailed information for the maintenance and repair of the 2019 Carryall 300 vehicle, and should be thoroughly reviewed prior to servicing the vehicle. The procedures provided must be properly implemented, and the DANGER, WARNING, and CAUTION statements must be heeded.

This manual was written for the trained technician who already possesses knowledge and skills in electrical and mechanical repair. *If the technician does not have such knowledge and skills, attempted service or repairs to the vehicle may render the vehicle unsafe.* For this reason, Club Car advises that all repairs and/or service be performed by an authorized Club Car distributor/dealer representative or by a Club Car factory-trained technician.

It is the policy of Club Car to assist its distributors and dealers in continually updating their service knowledge and facilities so they can provide prompt and efficient service for vehicle owners. Regional technical representatives, vehicle service seminars, periodic service bulletins, maintenance and service manuals, and other service publications also represent Club Car's continuing commitment to customer support.

Club Car offers a full line of training and continuing education classes for technicians who want to learn more about our products. For more information, contact your local dealer or Club Car's Technical Services department for a list of upcoming classes.

This manual covers all aspects of typical vehicle service; however, unique situations sometimes occur when servicing a vehicle. If it appears that a service question is not answered in this manual, please contact your nearest authorized Club Car dealer or distributor for assistance.

To find your local authorized Club Car dealer, visit www.clubcardealer.com, call 1-800-ClubCar (258–2227), or scan this Quick Response (QR) code to be taken to the Club Car dealer locator. Refer to Figure 1. Download a QR code reader such as RedLaser or Barcode Scanner to your cell phone or tablet.

If you would prefer to write to us, direct your letter to: Club Car LLC, Attention: Marketing Services, P.O. Box 204658, Augusta, Georgia 30917-4658 USA.

Dealer Locator QR Code



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FOREWORD

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The online survey can be found at *http://bit.ly/1w9uFMh* or using the QR Code below.

Online Survey QR Code



⚠ WARNING

- **Read Safety on page 1-1 before attempting any service on the vehicle.**
- **Before servicing vehicle, read complete section(s) and any referenced information that may be relevant to the service or repair to be performed.**

NOTE: *This manual represents the most current information at the time of publication. Club Car is continually working to further improve its vehicles and other products. These improvements may affect servicing procedures. Any modification and/or significant change in specifications or procedures will be forwarded to all Club Car dealers and will, when applicable, appear in future editions of this manual.*

Club Car reserves the right to change specifications and designs at any time without notice and without the obligation of making changes to units previously sold.

There are no warranties expressed or implied in this manual. See the limited warranty found in the vehicle Owner's Manual.

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SECTION 1 — SAFETY

1

SAFETY DETAILS

To ensure the safety of those servicing Club Car vehicles, and to protect the vehicles from possible damage resulting from improper service or maintenance, the procedures in this manual must be followed.

It is important to note that throughout this manual there are statements labeled DANGER, WARNING, or CAUTION. These special statements relate to specific safety issues, and must be read, understood, and heeded before proceeding with procedures. There are statements labeled NOTE, which provide other essential service or maintenance information.

PERSONAL SAFETY

⚠ DANGER

- **A DANGER indicates an immediate hazard that will result in severe personal injury or death. The color associated with Danger is RED.**

⚠ WARNING

- **A WARNING indicates an immediate hazard that could result in severe personal injury or death. The color associated with Warning is ORANGE.**

⚠ CAUTION

- **A CAUTION with the safety alert symbol indicates a hazard or unsafe practice that could result in minor personal injury. The color associated with Caution is YELLOW.**

MACHINE SAFETY

CAUTION

- **A CAUTION without the safety alert symbol indicates a potentially hazardous situation that could result in property damage.**

A CAUTION, without the safety alert symbol, is intended for machine and property safety. It is used throughout this manual followed by specific instructions to prevent machine or property damage. Failure to follow these CAUTION messages could result in machine or property damage.

INFORMATION

NOTE: *Instructions that clarify steps, procedures, or other information in this manual.*

GENERAL WARNINGS

The following safety statements must be heeded whenever the vehicle is being operated, repaired, or serviced. Other specific safety statements appear throughout this manual and on the vehicle.

⚠ DANGER

- **Battery – Explosive gases! Do not smoke. Keep sparks and flames away from the vehicle and service area. Ventilate when charging or operating vehicle in an enclosed area. Wear a full face shield and rubber gloves when working on or near batteries.**
- **Gasoline – Flammable! Explosive! Do not smoke. Keep sparks and flames away from the vehicle and service area. Service only in a well-ventilated area.**
- **Do not operate engine in an enclosed area without proper ventilation. The engine produces carbon monoxide, which is an odorless, deadly poison.**
- **The vehicle will not provide protection from lightning, flying objects, or other storm-related hazards. If caught in a storm while driving a Club Car vehicle, exit the vehicle and seek shelter in accordance with applicable safety guidelines for your location.**

⚠ WARNING

- **Follow the procedures exactly as stated in this manual, and heed all DANGER, WARNING, and CAUTION statements in this manual as well as those on the vehicle and battery charger.**
- **Do not leave children unattended in vehicle at any time.**
- **Prior to leaving the vehicle unattended or servicing the vehicle, set the park brake, place the Forward/Neutral/Reverse control (FNR) or switch in the NEUTRAL position, turn the key switch to the OFF position, and remove the key. Chock the wheels when servicing the vehicle.**
- **Improper use of the vehicle or failure to properly maintain it can result in decreased vehicle performance, severe personal injury, or death.**
- **Any modification or change to the vehicle that affects the electrical system, stability or handling of the vehicle, or increases maximum vehicle speed beyond factory specifications, can result in severe personal injury or death.**
- **Check the vehicle for proper location of all vehicle safety and operation decals and make sure they are in place and are easy to read.**
- **For vehicles with cargo beds, remove all cargo (including accessories) before raising the bed or servicing the vehicle. If the vehicle is equipped with a prop rod, ensure that it is securely engaged while bed is raised. Do not close bed until all persons are clear of cargo bed area. Keep hands clear of all crush areas. Do not drop cargo bed; lower gently and keep entire body clear. Failure to heed this warning can result in severe personal injury or death.**
- **Only trained technicians should service or repair the vehicle or battery charger. Anyone doing even simple repairs or service should have knowledge and experience in electrical and mechanical repair. The appropriate instructions must be used when performing maintenance, service, or accessory installation.**

Electric vehicles only:

- **Ensure battery connections are clean and properly tightened.**
- **Place Run/Tow switch in the TOW position before disconnecting or connecting the batteries. Failure to heed this warning can result in a battery explosion or severe personal injury.**
- **To avoid unintentionally starting an electric vehicle, disconnect the batteries and discharge the controller.**

WARNING CONTINUED ON NEXT PAGE

⚠ WARNING

Gasoline vehicles only:

- **To avoid unintentionally starting a gasoline vehicle, disconnect the battery and spark plug wire.**
- **Frame ground – Do not allow tools or other metal objects to contact frame when disconnecting battery cables or other electrical wiring. Do not allow a positive wire to touch the vehicle frame, engine, or any other metal component.**

All vehicles:

- **Wear safety glasses or approved eye protection when servicing the vehicle or battery charger. Wear a full face shield and rubber gloves when working on or near batteries.**
- **Do not wear loose clothing or jewelry such as rings, watches, chains, etc., when servicing the vehicle or battery charger.**
- **Use insulated tools when working near batteries or electrical connections. Use extreme caution to avoid shorting of components or wiring.**

DISABLE THE VEHICLE

1. Park the vehicle on a solid level surface.
2. Engage the park brake to lock the wheels..
3. Turn the key to OFF.

NOTE: *Key OFF for 15 seconds lets the ECU do a permanent memory write.*

4. Remove the key.
5. Set the Forward / Neutral / Reverse control (FNR) to N.
6. Put the chocks against the wheels.

DISCONNECT THE BATTERY- GASOLINE VEHICLES

1. Disable the vehicle.
2. Remove positive terminal cover.
3. Disconnect the negative (-) cable (1) **(Figure 1-1, Page 1-4)**.

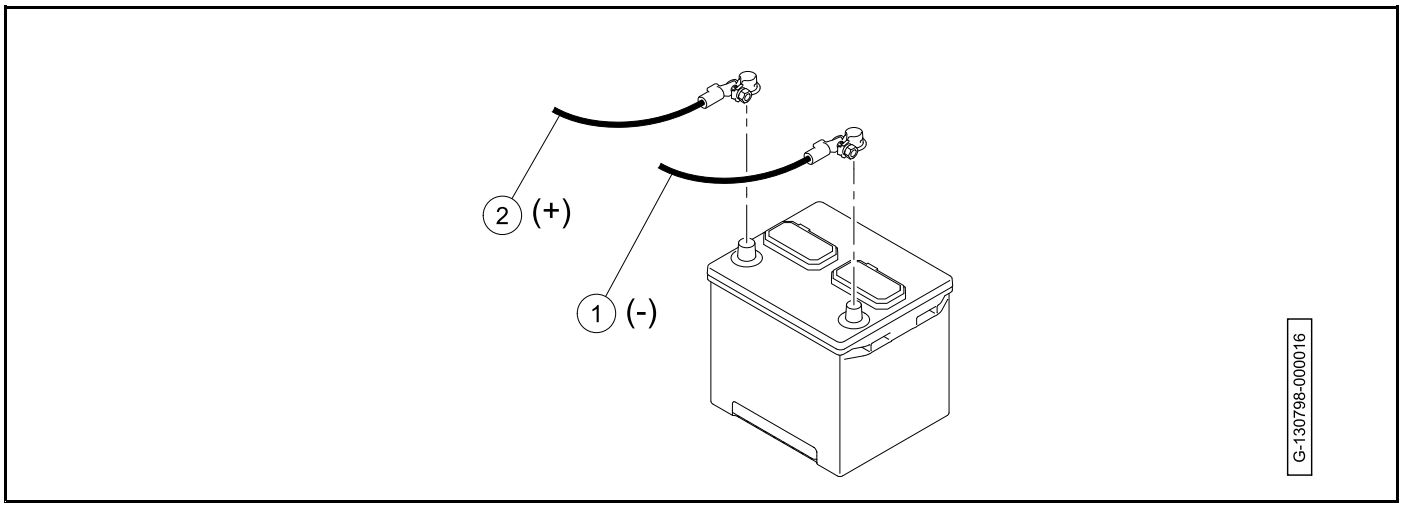


Figure 1-1 Battery - Gasoline Vehicles

4. Disconnect the positive (+) cable (2).

CONNECT THE BATTERY- GASOLINE VEHICLES

1. Connect the positive (+) cable (2) **(Figure 1-1, Page 1-4)**.
2. Connect the negative (-) cable (1).
3. Tighten the battery terminals to 41 in·lb (4.3 N·m).
4. Coat terminals with Battery Terminal Protector Spray to minimize corrosion.
5. Attach the positive terminal cover.

DISCONNECT THE BATTERIES – ELECTRIC VEHICLES

⚠ WARNING

- **Place Run/Tow switch in the TOW position before disconnecting or connecting the batteries. Failure to heed this warning can result in a battery explosion or severe personal injury.**

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the negative (-) cable (1) **(Figure 1-2, Page 1-5)**.

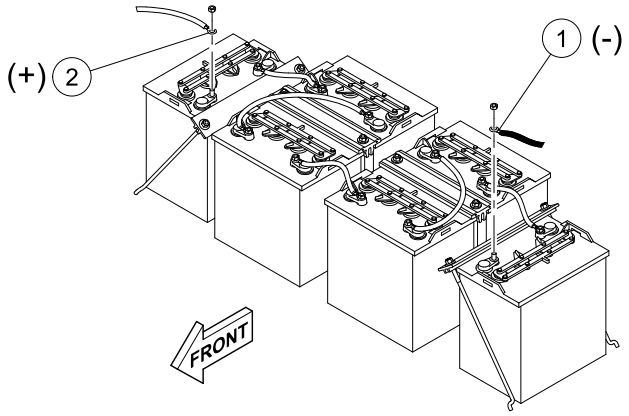


Figure 1-2 Batteries - Electric Vehicle

4. Disconnect the positive (+) cable (2).
5. Wait 90 seconds for the controller capacitors to discharge.

CONNECT THE BATTERIES – ELECTRIC VEHICLES

⚠ WARNING

- **Place Run/Tow switch in the TOW position before disconnecting or connecting the batteries. Failure to heed this warning can result in a battery explosion or severe personal injury.**

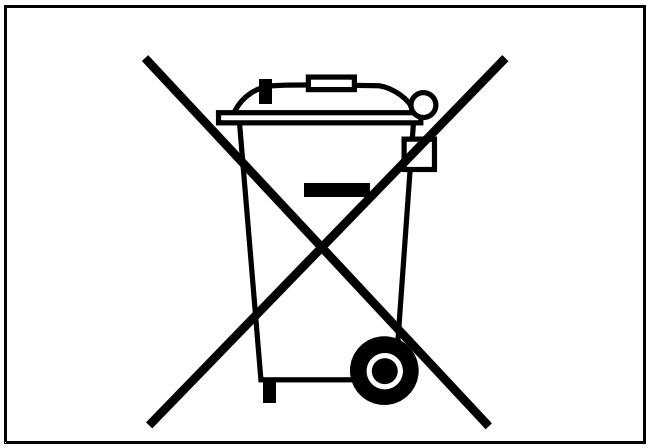
1. Set the Run/Tow switch to TOW.
2. Connect the positive (+) cable (2) **(Figure 1-2, Page 1-5)**.
3. Connect the negative (-) cable (1).
4. Tighten the battery terminals to 110 in·lb (12.4 N·m).
5. Coat terminals with Battery Terminal Protector Spray to minimize corrosion.

RECYCLING LEAD-ACID BATTERIES

⚠ WARNING

- **Lead-acid batteries contain lead (Pb), other metals, acids and other compounds. If improperly handled, they can contaminate both water and soil, causing environmental damage and personal injury.**

Lead-acid batteries are identified by the symbol shown below and should be properly recycled **(Figure 1-3)**. They cannot be disposed as municipal waste and must be collected separately. Responsibility for environmental protection must be shared, not only by the manufacturers of the batteries, but by people who use the batteries as well. Please contact your nearest Club Car dealer or distributor for information on how to properly recycle your batteries.



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Figure 1-3 Dispose of Lead-acid Batteries Properly

INTERNATIONAL SAFETY SYMBOLS ON BATTERIES

Anyone using, repairing, or servicing the vehicle must understand and heed the safety symbols on the vehicle battery or batteries.



1. Shield eyes.	3. No smoking, no open flames, no sparks.	5. Battery acid hazard.
2. Read and follow operating instructions.	4. Keep away from children.	6. Explosive gas hazard.
Refer to General Warnings for more information.		

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Figure 1-4 International Safety Symbols on Batteries

VEHICLE SPECIFICATIONS

VEHICLE SPECIFICATIONS – ELECTRIC VEHICLES

SPECIFICATIONS	CARRYALL 300
POWER SOURCE	**ELECTRIC**
Drive motor: Direct drive, 48 volts DC, shunt wound, 3.3 hp	•
Transaxle: Double reduction helical gear with 12.3:1 direct drive axle	•
Electrical system: 48 volts DC, reduced speed reverse	•
Batteries: High capacity, deep cycle, 8-volt	•
Charger: E.R.I.C. Automatic, 48-volt; UL and CSA listed **See E.R.I.C. Battery Charger Specifications on page 2-3.**	•
STEERING/SUSPENSION/BRAKES	
Steering: Self-adjusting rack and pinion	•
Suspension: Independent leaf spring with dual hydraulic shocks	•
Brakes: Mechanical brake cable system to self-adjusting drum brakes on each rear wheel. Park brake is automatically released. Multi-latch ratchet and pawl	•
BODY/CHASSIS	
Frame/chassis: Twin I-Beam welded aluminum	•
Side and rear body: Aluminum	•
Front body: ArmorFlex®	•
Front body finish: Automotive-grade paint with clear-coat finish	•
Tires: 20 x 10 – 10 tubeless, 6-ply rated load range front and rear	•
DIMENSIONS/WEIGHT	
Overall length: With standard boxbed Add for Heavy-Duty Bumper:	110.1 in (279.6 cm) 1.8 in (4.5 cm)
Overall width with mirrors:	50.3 in (127.7 cm) 62.6 in (159.0 cm)
Overall height: At steering wheel	47.1 in (119.6 cm)
Overall height: With canopy	70.7 in (179.5 cm)
Overall height: With cab	74.3 in (188.7 cm)
Wheelbase	65.5 in (166.37 cm)
Ground clearance	5.6 in (14.2 cm)
Front wheel tread	36.6 in (92.9 cm)
Rear wheel tread	39.5 in (100.3 cm)
Weight: Standard electric vehicle	1105 lb (501.2 kg)
Maximum forward speed	15 to 17 mph (24 to 27 km/h)
Curb clearance circle (diameter)	230.5 in (585.4 cm)
Turning radius per SAE J 695	108.7 in (276.2 cm)

SPECIFICATIONS	CARRYALL 300
POWER SOURCE	**ELECTRIC**
Intersecting aisle clearance	87 in (221 cm)
Floorboard height	12.5 in (31.7 cm)
Load bed height	29.5 in (74.93 cm)
Load bed size: Box bed inside dimensions	36.2 x 47.5 x 10.5 in (91.9 x 120.6 x 26.6 cm)
Load bed size: Flat bed inside dimensions	36.5 x 48.8 in (92.7 x 123.9 cm)
Vehicle rated capacity: Level surface only	800 lb (363 kg)
Standard seating capacity	2
LIQUID CAPACITIES	
Transaxle	22 fl-oz (0.67 L)
TIRE PRESSURE	
Front and rear	28 to 32 psig (193 to 221 kPa)
NOISE AND VIBRATION	
Drive-by noise level to operator Test method: EN 12053:2001	66.6 dBa Uncertainty: 2 dBa
Vibration at driver's seat Test method: EN 13059:2002	0.5 $(m/s^2)^2$ Uncertainty: 0.16 $(m/s^2)^2$

E.R.I.C. BATTERY CHARGER SPECIFICATIONS

E.R.I.C. BATTERY CHARGER SPECIFICATIONS	
MODEL NUMBER	IC650-048-CC
AC INPUT	
AC voltage	100 to 240 VAC
Frequency	50 / 60 Hz
POWER CONSUMPTION	
Maximum AC input current (amps)	7.5
DC OUTPUT	
Rated DC voltage (VDC)	48
Maximum DC voltage (VDC)	72
Maximum DC output current (amps)	13.5
DIMENSIONS/WEIGHT	
Case – overall length	9.9 in (25.2 cm)
Case – overall width	7.3 in (18.6 cm)
Case – overall height	3.1 in (8 cm)
AC cord length (standard length)	6 ft (183 cm)
DC cord length (standard length)	9 ft (274 cm)
Weight	6.5 lb (3 kg)
MOUNTING CONFIGURATION	
Mounting: Set on shelf; mount under shelf, on wall or ceiling; or hang securely from ceiling: any orientation.	•

VEHICLE SPECIFICATIONS – GASOLINE VEHICLES

NOTE: *Engine horsepower and torque specifications are provided by the engine manufacturer. Actual horsepower and torque in use may differ and are dependent on environmental conditions as well as maintenance condition of the engine.*

SPECIFICATIONS	CARRYALL 300
POWER SOURCE	**GASOLINE**
Engine: 4 cycle, OHV, 429 cc, 14 Horsepower (10.4 kW) rated engine @ 3600 RPM (per SAE J 1940), single cylinder, air cooled, with splash lubrication system	•
Fuel system: Electronic fuel injection (EFI), closed loop	•
Battery: 12-volt Top-Post Battery	•
Governor: Automatic ground speed sensing, internally geared in transaxle	•
Ignition: Battery ignition, ECU controlled	•
Transaxle: Precision helical gears, forward/reverse with neutral position (11.47:1 forward; 15.63:1 reverse), with optional limited slip differential	•
Electrical system: 12 volt, 525 cca, 85 minute reserve capacity	•
Gasoline Vehicle Electrical Charging System: 23 amps at max. RPM.	•
Torque converter: Automatic, variable speed, dry type	•
STEERING/SUSPENSION/BRAKES	
Steering: Self-adjusting rack and pinion	•
Suspension: Independent leaf spring with dual hydraulic shocks	•
Brakes: Mechanical brake cable system to self-adjusting drum brakes on each rear wheel. Park brake is automatically released. Multi-latch ratchet and pawl.	•
BODY/CHASSIS	
Frame/chassis: Twin I-Beam welded aluminum	•
Side and rear body: Aluminum	•
Front body: ArmorFlex®	•
Front body finish: Automotive-grade paint with clear-coat finish	•
Tires: 20 x 10 - 10 tubeless, 6-ply rated load range front and rear	•
DIMENSIONS/WEIGHT	
Overall length: With standard boxbed Add for Heavy-Duty Bumper:	110.1 in (279.6 cm) 1.8 in (4.5 cm)
Overall width with mirrors:	50.3 in (127.7 cm) 62.6 in (159.0 cm)
Overall height: at steering wheel	47.1 in (119.6 cm)
Overall height: with canopy	70.7 in (179.5 cm)
Overall height: with cab	74.3 in (188.7 cm)
Wheelbase	65.5 in (166.37 cm)
Ground clearance	5.2 in (13.2 cm)
Front wheel tread	36.6 in (92.9 cm)

SPECIFICATIONS	CARRYALL 300
POWER SOURCE	**GASOLINE**
Rear wheel tread	39.5 in (100.3 cm)
Weight: Standard gasoline vehicle (dry fuel tank) Curb weight	789 lb (357.8 kg) 817 lb (370. 5 kg)
Maximum forward speed	15 to 17 mph (24 to 27 km/h)
Curb clearance circle (diameter)	230.5 in (585.4 cm)
Turning radius (per SAE J 695)	108.7 in (276.2 cm)
Intersecting aisle clearance	87 in (221.0 cm)
Floorboard height	12.5 in (31.7 cm)
Load bed height	29.5 in (74.9 cm)
Load bed size: Box bed inside dimensions	36.2 x 47.5 x 10.5 in (91.9 x 120.6 x 26.6 cm)
Load bed size: Flat bed inside dimensions	36.5 x 48.8 in (92.7 x 123.9 cm)
Vehicle rated capacity: Level surface only	800 lb (363 kg)
Standard seating capacity: (persons)	2
LIQUID CAPACITIES	
Engine crankcase	44 fl-oz (1.3 L)
Transaxle	67.6 fl-oz (2 L)
Fuel tank	4.6 gallons (17.4 L)
TIRE PRESSURE	
Front and rear	28 to 32 psig (193 to 221 kPa)
NOISE AND VIBRATION	
Drive-by noise level to operator Test method: EN 12053:2001	79.1 dBa Uncertainty: 2 dBa
Vibration at driver's seat Test method: EN 13059:2002	1.0 $(m/s^2)^2$ Uncertainty: 0.31 $(m/s^2)^2$

Pagination Page

SECTION 3 — GENERAL INFORMATION

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

This manual features Carryall 300 vehicles. The electric Carryall 300 vehicle is equipped with the ERIC (Efficient, Reliable, Intelligent, Connected) battery charging system. The gasoline Carryall 300 vehicle is equipped with a Subaru engine and accompanying powertrain and is available with a pedal-start (standard) or key-start (optional) configuration.

Throughout this manual, important features unique to each model are highlighted. We urge the owner/operator to read and understand this manual, and to pay special attention to the features specific to their vehicle(s).

Refer to the owner's manual provided with the vehicle for information on the following topics:

- Controls and Indicators
- Pre-Operation and Daily Safety Checklist
- Driving Instructions
- Bed Latch
- Prop Rod
- Loading and Unloading
- Towing with a Vehicle
- Transporting on a Trailer
- Subsequent Owner Registration
- Warranties

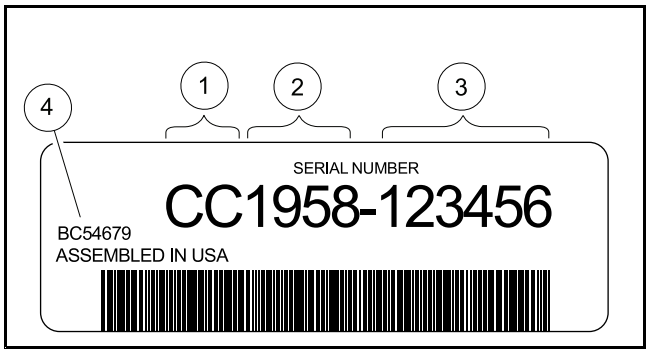
MODEL IDENTIFICATION

The serial number of each vehicle is printed on a bar code decal mounted below the center dash panel (Example: CC5819-123456) **(Figure 3-1)**.

The two letters (1) at the beginning of the serial number indicate the vehicle model. The following four digits (2) indicate the model year and production week during which the vehicle was built. The six digits (3) following the hyphen represent the unique sequential number assigned to each vehicle built within a given model year. **See following NOTE.**

NOTE: *Have the vehicle serial number available when ordering parts or making inquiries.*

Build Code: The build code (4) is a five-digit number that appears on the vehicle serial number decal. The build code exists to enable the user to identify the correct owner's manual for a vehicle. This owner's manual is valid for the build code range indicated on the back cover of this owner's manual.



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Figure 3-1 Serial Number Decal

STORAGE – ELECTRIC VEHICLES

See General Warnings on page 1-1.

⚠ WARNING

- **Turn the key switch to the OFF position, remove the key, and leave the Forward/Neutral/Reverse control (FNR) or switch in the NEUTRAL position during storage. This is to prevent unintentionally starting the vehicle or a fire hazard. Place Run/Tow switch in the TOW position.**
- **Do not attempt to charge frozen batteries or batteries with bulged cases. Discard the battery. Frozen batteries can explode.**

⚠ CAUTION

- **Batteries in a low state of charge will freeze at low temperatures.**
- **To avoid exposing electrical components to moisture and subsequent damage, do not use any type or pressure washing or steam cleaning equipment to wash the vehicle.**

PREPARING THE ELECTRIC VEHICLE FOR EXTENDED STORAGE

Check Battery Water Levels Two Weeks Prior to Storage

Check water levels at least two weeks prior to winter storage to ensure proper mixing of water and electrolyte. Note that it takes approximately five charge cycles with a minimum of 10 amp hours removed after each charge to properly mix the water with electrolyte. Do NOT water batteries immediately prior to storage because this will not provide sufficient charge time to mix the water with the electrolyte. Freezing can occur when batteries are stored in this condition.

1. Check the water levels in each battery cell. If water is required, fill the cells to cover the plates, charge the batteries, and then use distilled water to fill each cell to the correct level. Electrolyte level should be from 0.5 inch (13 mm) above plates to 0.25 inch (6 mm) below the level indicator **(Figure 14-3)**.

Immediately Prior to Storage, Perform the Following Steps

1. Unload the vehicle so that tires are supporting only the weight of the vehicle.

2. Turn the key switch to the OFF position, remove the key, and leave the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position during storage.
3. If so installed, turn off all accessories, including GPS units, fans, etc.
4. Place the Run/Tow switch in the TOW position.

NOTE: *All functions of the dash-mounted charge indicator light are disabled when the Run/Tow switch is in the TOW position.*

If Visage or Guardian units are installed on vehicles and remote monitoring will be used during the storage period, make sure the Run/Tow switch remains in the RUN position rather than in the TOW position required for all other vehicles during storage.

5. Batteries should be clean and free of corrosion. Wash tops and terminals of batteries with a solution of baking soda and water; use 1 cup (237 mL) baking soda per 1 gallon (3.8 L) of water. Rinse solution off batteries. Do not allow this solution to enter the batteries. Let the terminals dry and then coat them with Battery Terminal Protector Spray.
6. Tighten all battery cable connections to 110 in·lb (12.4 N·m).
7. Store vehicle in a cool, dry place. This will minimize battery self-discharge.
8. Adjust tires to recommended tire pressure. **See Vehicle Specifications – Electric Vehicles on page 2-1.**
9. Perform semiannual periodic lubrication. **See Periodic Lubrication Schedules on page 10-7.**
10. Thoroughly clean front body, rear body, seats, battery compartment, and underside of vehicle.
11. Do not engage the park brake. Chock the wheels to prevent the vehicle from rolling.

NOTE: *It is recommended that the vehicles be plugged in and the electrolyte level maintained throughout the storage period. If any of the following conditions exist, however, then disconnect the batteries for storage: 1) The charger cannot remain plugged in, 2) AC power will not be available during extended storage, or 3) Electrolyte levels will not be maintained. To disconnect batteries for storage, go to step 13.*

12. To keep batteries fully charged during storage:

12.1. Plug the battery charger into the car. Leave battery chargers plugged in during storage. The charger will automatically activate when necessary.

12.2. Check the electrolyte level and charger function monthly to ensure that proper operation is maintained. The charger is functioning properly if the blue light is ON and the triangular light is OFF.

CAUTION

- **Be sure to check the batteries and charger monthly to maintain correct battery water level and to ensure the charger is operating correctly during storage.**

13. If disconnecting the batteries for storage, disconnect B negative (-) battery cable and secure it in a way that ensures the cable will not come into contact with battery terminal.

RETURNING THE STORED ELECTRIC VEHICLE TO SERVICE

1. If necessary, connect batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**
2. Fully charge batteries.

⚠ WARNING

- **Do not attempt to charge frozen batteries or batteries with bulged cases. Discard the battery. Frozen batteries can explode.**

3. Adjust tires to recommended tire pressure. **See Vehicle Specifications – Electric Vehicles on page 2-1.**

4. Perform the Pre-Operation and Daily Safety Checklist on page 10-1 and the Performance Inspection on page 10-1.

STORAGE – GASOLINE VEHICLES

See General Warnings on page 1-1.

⚠ DANGER

- **Do not attempt to drain fuel when the engine is hot or while it is running.**
- **Be sure to clean up any spilled gasoline before operating the vehicle.**
- **Store fuel in an approved fuel container only. Store in a well-ventilated area away from sparks, open flames, heaters, or heat sources.**
- **Keep fuel out of the reach of children.**
- **Do not siphon fuel from the vehicle.**

⚠ WARNING

- **Only trained technicians should service or repair the vehicle or battery charger. Anyone doing even simple repairs or service should have knowledge and experience in electrical and mechanical repair. The appropriate instructions must be used when performing maintenance, service, or accessory installation.**
- **Turn the key switch to the OFF position, remove the key, and leave the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position during storage. This is to prevent unintentionally starting the vehicle or a fire hazard.**
- **Do not attempt to charge frozen batteries or batteries with bulged cases. Discard the battery. Frozen batteries can explode.**

⚠ CAUTION

- **Batteries in a low state of charge will freeze at low temperatures.**

PREPARING THE GASOLINE VEHICLE FOR EXTENDED STORAGE

1. Unload the vehicle so that tires are supporting only the weight of the vehicle.
2. Store vehicle in a cool, dry place. This will minimize battery self-discharge. If the battery appears to be weak, have it charged by a trained technician. Use an automotive-type 12-volt battery charger rated at 10 amps or less.
3. Seal the fuel tank.

3.1. Fill fuel tank, and, following manufacturer's directions, add a commercially available fuel stabilizer (such as Sta-Bil®).

3.2. Disconnect fuel vent line from fuel tank vent nipple.

3.3. Plug the fuel tank vent nipple so that it is air tight. We recommend using a slip-on vinyl cap (1) **(Figure 3-2)**.

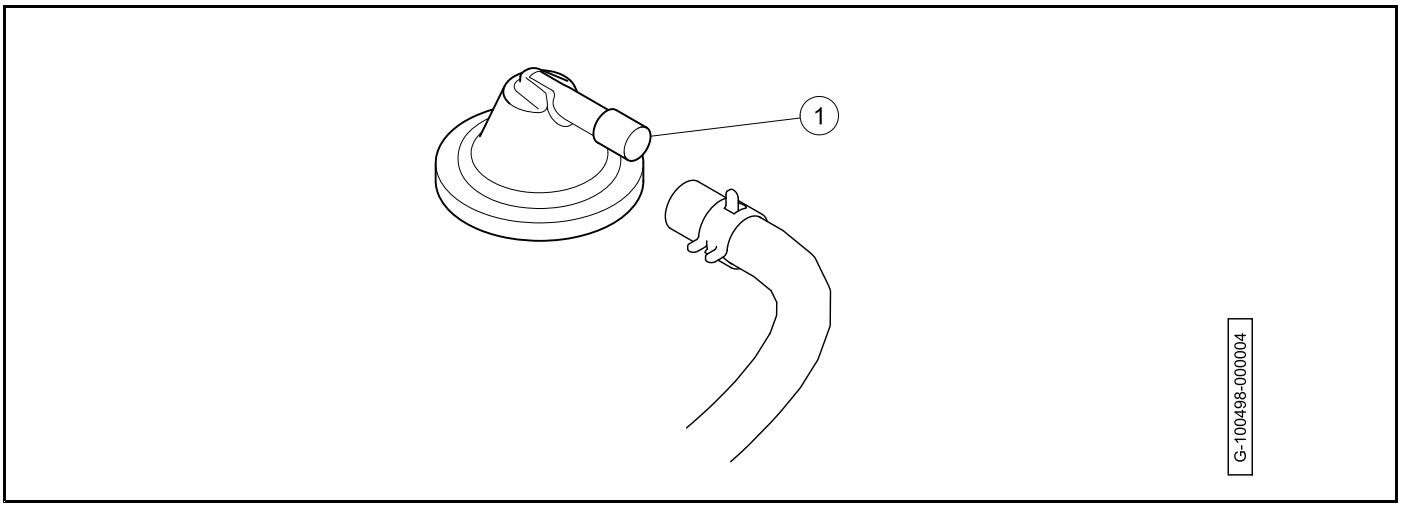


Figure 3-2 Plug Vent

NOTE: *It is not necessary to drain the fuel line.*

4. Disconnect the battery and the spark plug wire.
5. Batteries should be clean and free of corrosion. Wash tops and terminals of batteries with a solution of baking soda and water: use 1 cup (237 mL) baking soda per 1 gallon (3.8 L) of water. Rinse solution off batteries. Do not allow this solution to enter the batteries. Let the terminals dry and then coat them with Battery Terminal Protector Spray.
6. To protect the engine, remove spark plug and pour 0.5 fl-oz (14.2 mL) of SAE 10 weight oil into the engine through the spark plug hole. Rotate engine crankshaft by hand several times and then install the spark plug and tighten it to 20 ft·lb (27 N·m).
7. Adjust tires to recommended tire pressure.
8. Perform semiannual periodic lubrication.
9. Thoroughly clean front body, rear body, seats, cargo bed, engine compartment, and underside of vehicle.
10. Do not engage the park brake. Chock the wheels to prevent the vehicle from rolling.

RETURNING THE STORED GASOLINE VEHICLE TO SERVICE

1. Restore fuel system to operation.

1.1. Remove the plug (1) from the fuel tank vent **(Figure 3-3)**.

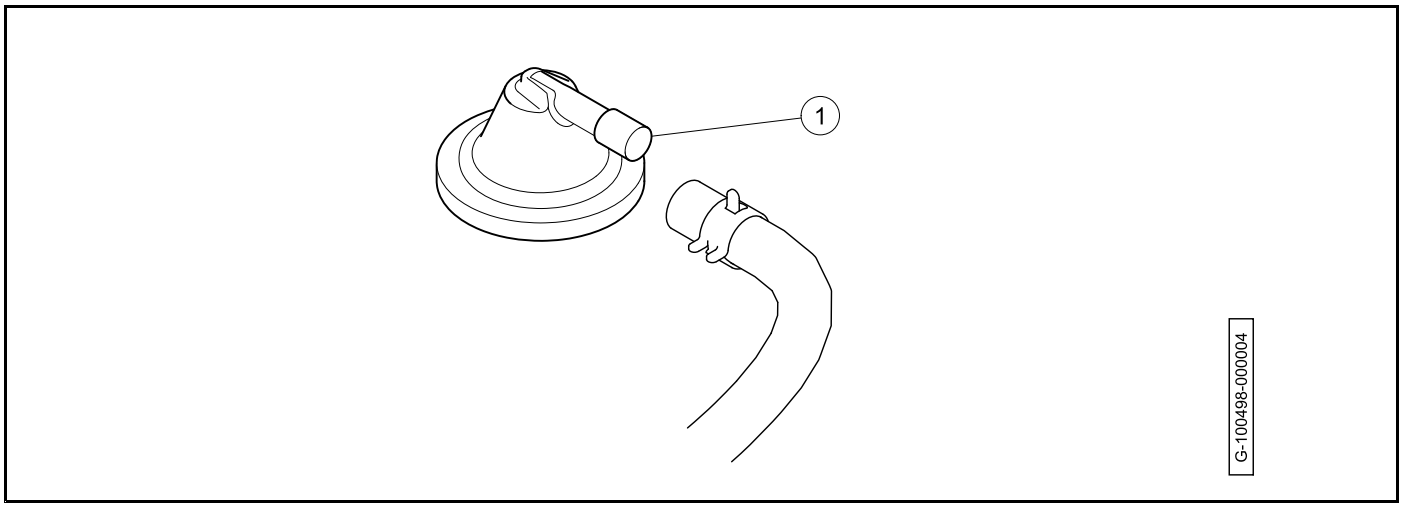


Figure 3-3 Plug Vent

1.2. Connect vent tube to fuel tank vent.

2. Connect battery and spark plug wire.

3. Place the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position and the Maintenance/Operate switch in the MAINTENANCE position. Crank the engine until the engine starts. Turn the engine off and return the Maintenance/Operate switch to the OPERATE position. **See following NOTE.**

NOTE: *Due to the oil added to the engine in preparation for storage, engine may smoke excessively for a short time when it is run for the first time after storage.*

4. Adjust tires to recommended tire pressure.

5. Perform the Pre-Operation and Daily Safety Checklist and the Performance Inspection.

SECTION 4 — BODY AND TRIM

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

CLEANING THE VEHICLE

See General Warnings on page 1-1.

CAUTION

- **Do not use detergents or cleaning solvents that contain ammonia, aromatic solvents, or alkali materials on body panels or seats.**
- **Do not allow battery acid to drip on body panels. Battery acid will cause permanent damage. Wash spilled battery acid from body panels immediately.**

These vehicles are equipped with painted TPO front bodies and aluminum only rear bodies with black polypropylene rear fender and tailskirt. The cargo beds are steel with aluminum sheet and Rhino Lining®.

The manufacturer does not recommend any type of pressure washing or steam cleaning. Such a process will expose electrical components to moisture. Moisture entering electrical components can result in water damage and subsequent component failure. Normal residential water pressure is adequate for exterior cleaning.

For regular cleaning, use commercially available automotive cleaning solutions with a sponge or soft cloth. The painted finish is the same paint used in automotive applications. Automotive cleaning/polishing products are available at automotive specialty and hardware stores.

Use non-abrasive wax products. Battery acid, fertilizers, tars, asphalt, creosote, paint, or chewing gum should be removed immediately to prevent possible stains.

SEAT CLEANING

Clean seats regularly using the following guidelines:

Light Soiling – A solution of 10% liquid dish soap and warm water applied with a soft, damp cloth is recommended. A soft bristle brush may be used if necessary. Wipe off any residue with a water dampened cloth. **See following NOTE.**

NOTE: *Dispose of waste water properly.*

Difficult Stains – Dampen a soft, white cloth with a solution of 10% household bleach (sodium hypochlorite) and 90% water. Rub gently to remove stain, then rinse with a water dampened cloth to remove bleach concentration.

More Difficult Stains – Perform previous procedure using full-strength bleach, or allow bleach to puddle on affected area for approximately 30 minutes. Rinse with a water dampened cloth to remove any remaining bleach concentration. **See following CAUTION.**

CAUTION

- **To prevent damage to the vehicle when removing difficult stains or heavy soiling, remove the seat from the vehicle first.**

FRONT BODY REPAIR

See General Warnings on page 1-1.

LIGHT SCRATCHES

1. Clean entire area to be repaired with clean, clear water.
2. Using 1200 grit sandpaper, water-sand entire area of scratch until original scratch is no longer visible, either with finishing sander or wet sanding block. Be sure that sandpaper is centered on sanding pad. Continue to flush with water while sanding, to increase sandpaper life and keep the sanded surface cool. Wipe repaired area dry and visually inspect to be sure that the originial scratch has completely disappeared.
3. Repeat step 2 using 1500 grit sandpaper until all 1200 grit scratches are removed paying close attention to edges.
4. Install a wool cutting pad (3M #5711 or equivalent) on buffer and spread approx 1/2 tsp. (2mL) of compound (3M #05955 or equivalent). Buff slowly and steadily over small area so as not to heat surface as this may cause warping or melting of plastic. Buff sanded area until all sanding scratches have disappeared. Use as much buffing compound as necessary to achieve this step. If at any time original scratches can be seen, repeat steps 2 and 3 as needed. When all 1500 grit scratches have disappeared, there will be a dull luster over entire area.
5. Install a foam polishing pad (3M #5725 or equivalent) on buffer and repeat step 4 using approx 1/2 tsp. (2 mL) buffing compound (3M #5933 or equivalent). Buff compound off until scratches have disappeared. It may be necessary to apply additional compound to achieve this. The result will be an almost-finished product with a very high luster and very few buffer swirls.
6. Using a clean foam polishing pad (3M #5725 or equivalent) and finish glaze (3M #05937 or equivalent), apply a slightly smaller amount of material than in steps 4 and 5 and buff to desired gloss.
7. Wipe clean with soft, clean cloth. Any dirt on cloth can mar surface.

ABRASIONS AND HAZE

Abrasions and haze can be greatly minimized by performing steps 5 through 7 above.

LARGE SCRATCHES AND ABRASIONS

Touch-up is not recommended. Replace the entire body part or have it repaired by a professional paint and body repair shop with experience repairing bodies.

FRONT BODY

See General Warnings on page 1-1.

BRUSHGUARD REMOVAL

1. Disconnect the batteries. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Disconnect the Battery- Gasoline Vehicles on page 1-4.**
2. Remove the bolts (1) **(Figure 4-1, Page 4-3)**.
3. Remove the screws (2) and washers (3).
4. Remove the brushguard (4).

BRUSHGUARD INSTALLATION

1. Position the brushguard (4) onto the vehicle **(Figure 4-1, Page 4-3)**.
2. Install the washers (3), screws (2), and bolts (1). Tighten the bolts to 36 ft·lb (49 N·m). Tighten the screws to 25 ft·lb (34 N·m).
3. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Connect the Battery- Gasoline Vehicles on page 1-4.**

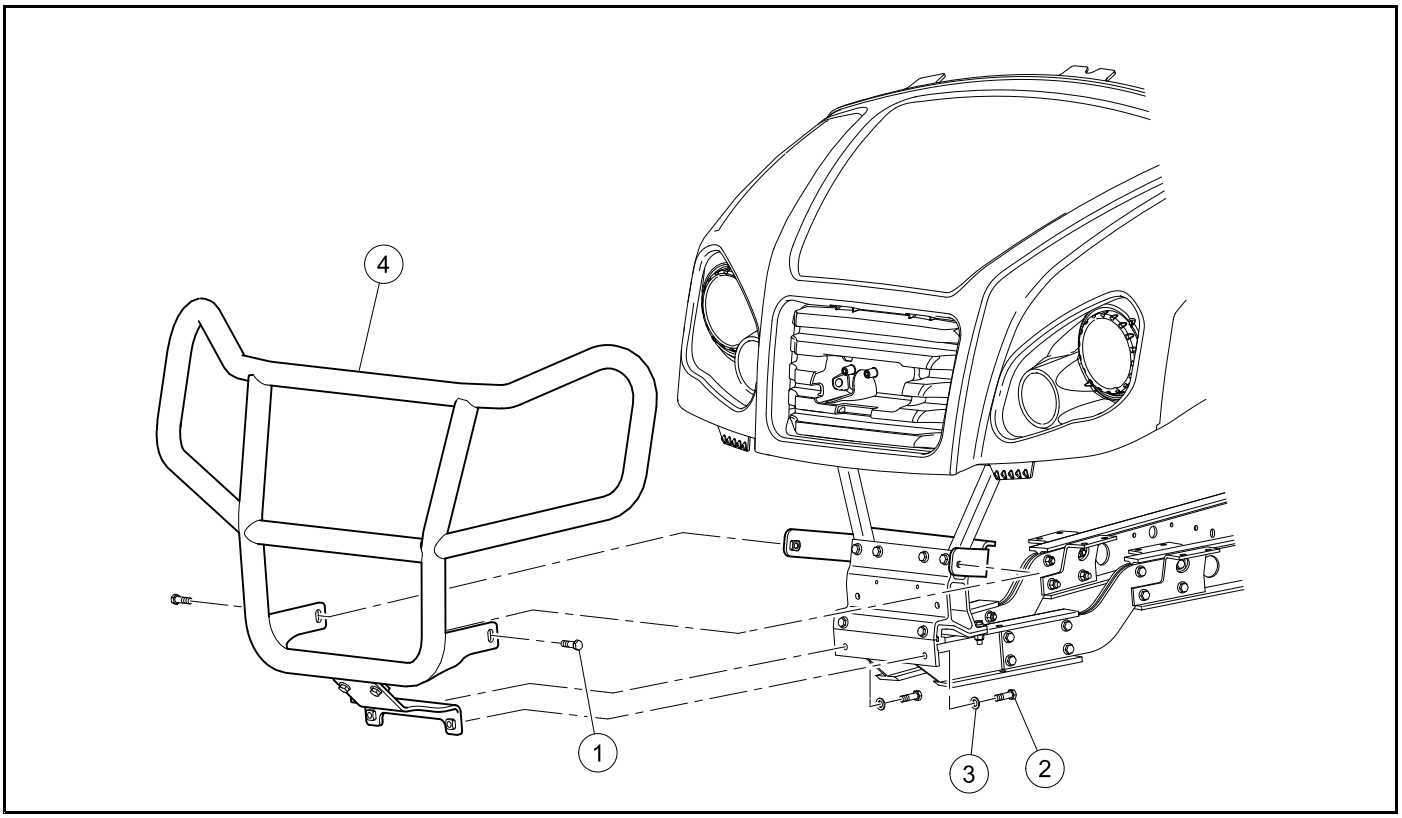


Figure 4-1 Brushguard

COWL REMOVAL

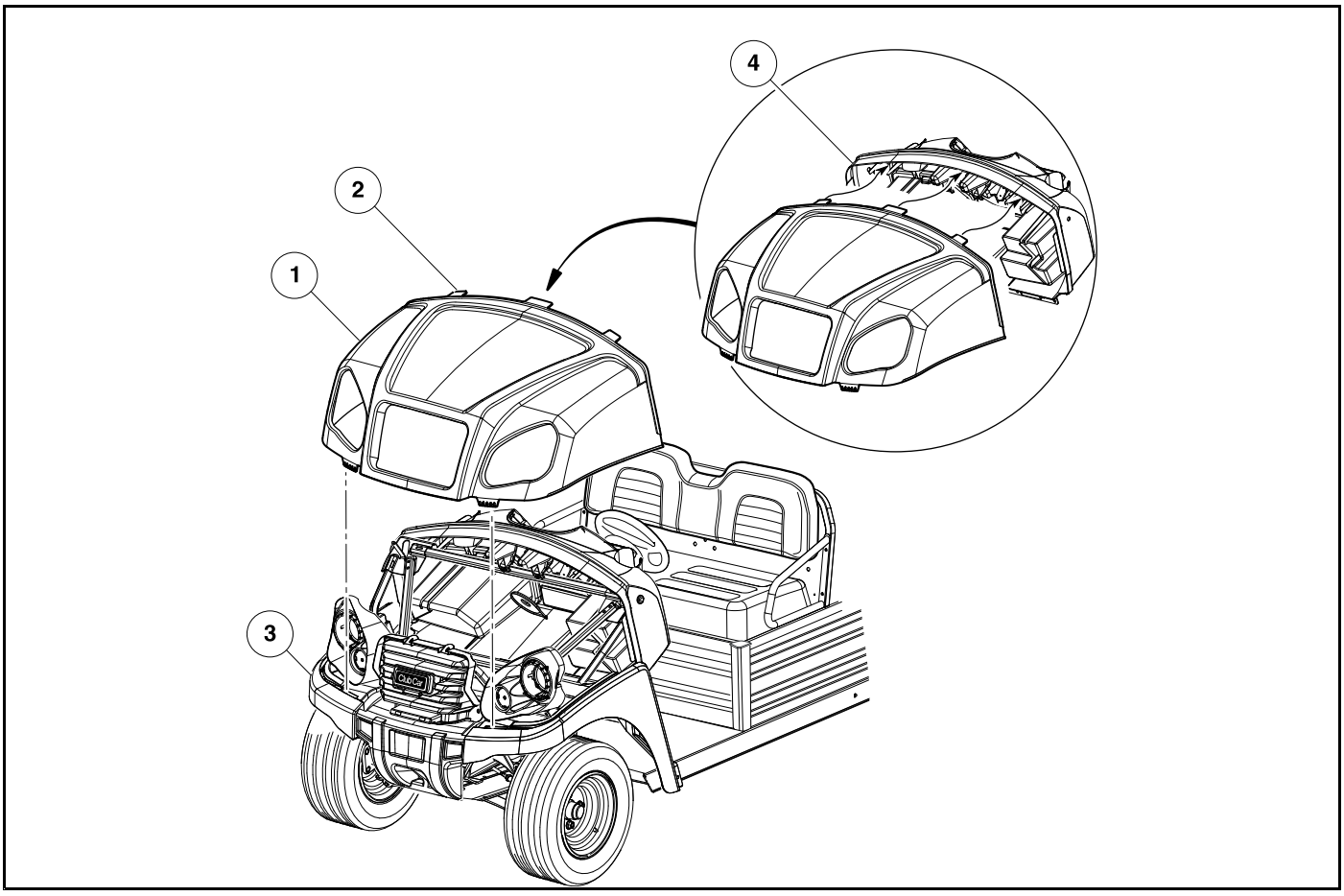
1. Disable the vehicle.
2. Disconnect the batteries. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Disconnect the Battery- Gasoline Vehicles on page 1-4.**
3. The cowl (1) is secured by tabs (2) located behind the front fenders (3), and under the lip of the dash (4) **(Figure 4-2, Page 4-5)**.
4. Push down and rearward on front fenders to unsnap cowl in two locations.
5. Slide cowl forward until free, then lift out cowl.

COWL INSTALLATION

1. Slide bottom edges of cowl into grooves in front fenders.
2. Ensure the three tabs (2) on cowl install under lip of dash (4). **(Figure 4-2, Page 4-5)**.
3. Ensure sides of cowl (1) assemble between the two ribs on side of dash.
4. Ensure center tab on cowl assembles beneath the rib in the grille.
5. With fenders disengaged from the front bumper, press down on front fenders, line up cowl tabs and fully engage snap tabs.
6. Ensure front corners of cowl are engaged with front fender (3).
7. Engage the front fenders to the body clips under the front bumper.

NOTE: *Ensure that cowl is fully engaged to prevent dislodging during use.*

8. Connect the batteries.**See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Connect the Battery- Gasoline Vehicles on page 1-4.**
9. Remove tire chocks.



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Figure 4-2 Front Cowl

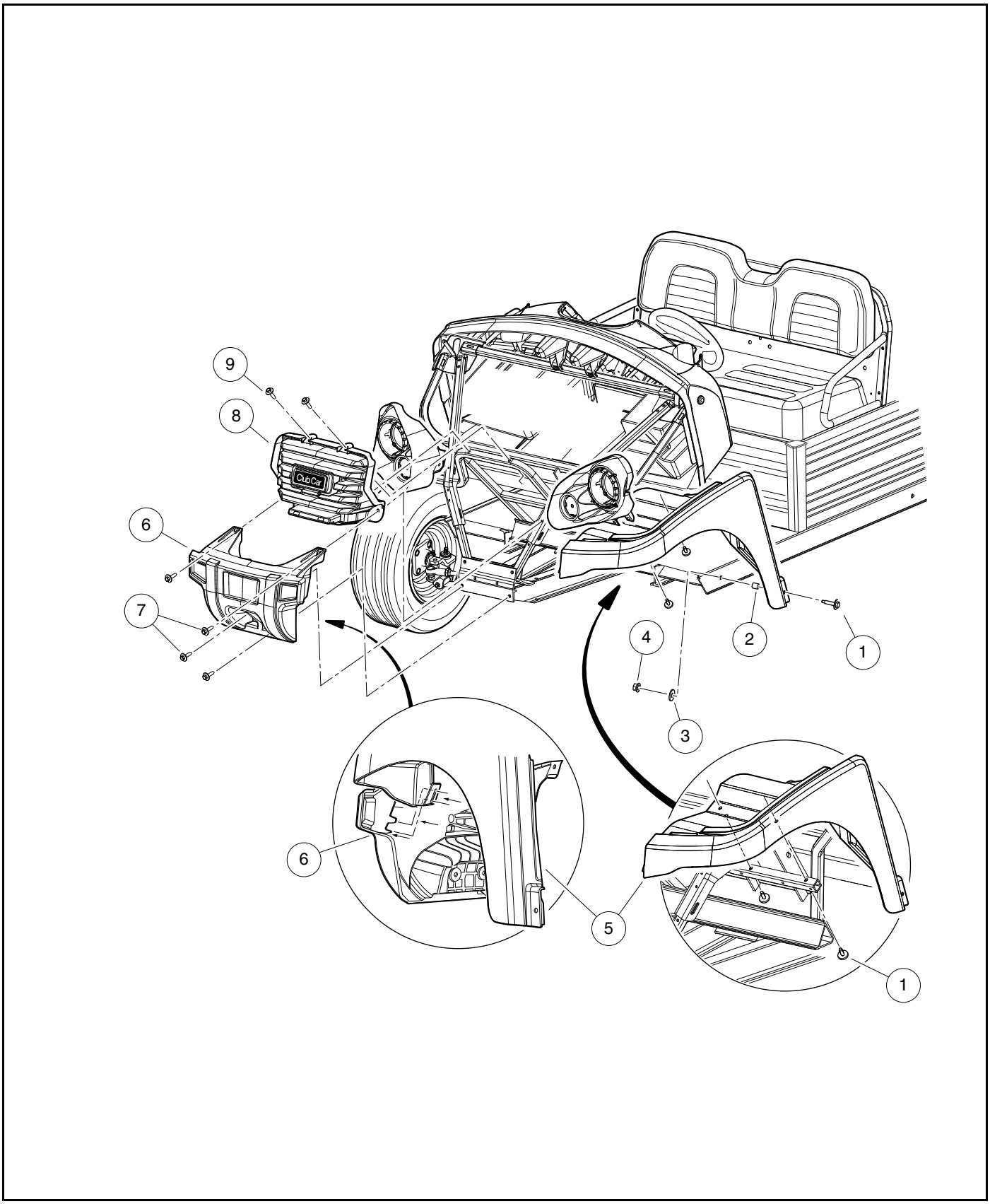
GRILLE REMOVAL

1. Park vehicle and chock the tires.
2. Disconnect the batteries. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Disconnect the Battery- Gasoline Vehicles on page 1-4.**
3. Remove HD bumper (if equipped). **See Brushguard Removal, Section 4, Page 4-3.**
4. Remove cowl. **See Cowl Removal on page 4-4.**
5. Loosen and remove the two M6 self-tapping fasteners (1) at the top of grille (7). **(Figure 4-3, Page 4-7)**.
6. Loosen and remove the two lower left and right side bolts (1 and 7) that attach the grille and plastic bumper (6).
7. Remove charger receptacle (if equipped) by removing the three screws that attach the receptacle or disconnect connector (quick connect)

GRILLE INSTALLATION

1. Connect the charger receptacle or connector (quick connect).
2. Install, but do not tighten upper M6 screws. (Do not tighten screws until plastic bumper is installed).
3. Lower grille holes are shared with the front bumper, ensure lower bumper screws are attached first then install grille.
4. Line up upper and lower bolt holes.

5. Install and tighten upper bolts, then lower right and left side bolts. Tighten to 44 in·lb (5 N·m).
6. Connect the batteries.**See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Connect the Battery- Gasoline Vehicles on page 1-4.**



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Figure 4-3 Front Grille, Bumper, and Side Fenders

FRONT BUMPER AND SIDE FENDER REMOVAL

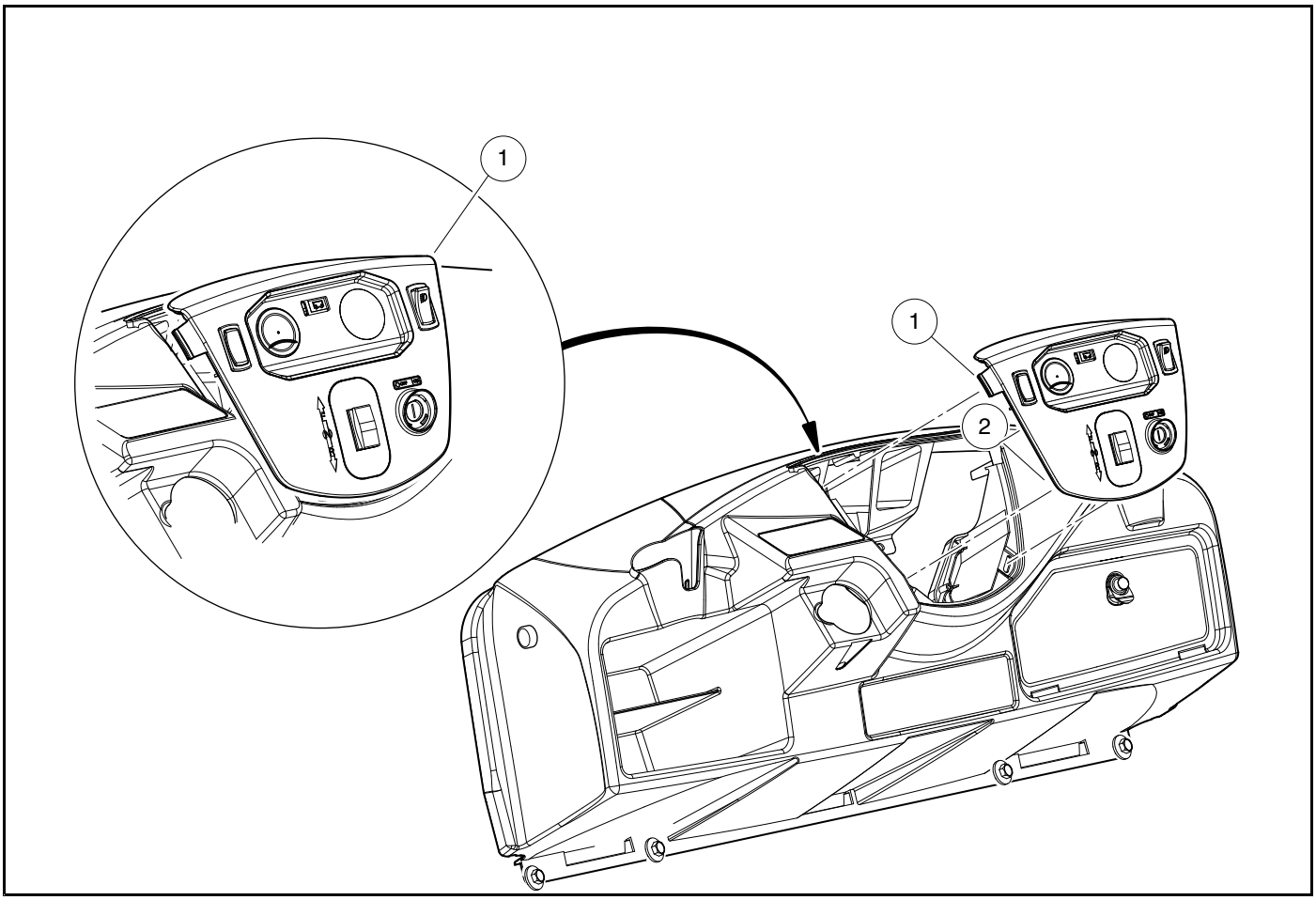
1. Park the vehicle, chock tires.
2. Disconnect the batteries. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Disconnect the Battery- Gasoline Vehicles on page 1-4.**
3. Remove HD bumper, (if equipped). **See Brushguard Removal on page 4-3.**
4. Remove the front cowl. **See Front Cowl on page 4-5.**
5. Remove the grille. **See Grille Removal on page 4-5.**
6. Loosen and remove the two upper and lower bolts (7) that attach the bumper to the vehicle frame. Push down and rearward on front fenders near the bumper **(Figure 4-3, Page 4-7)**.
7. Remove front bumper (6).
8. Loosen and remove the inner screws, nuts, and spacers (1, 2, 3, and 4) that attach the side fender to the frame (repeat procedure on opposite side).
9. Unsnap body clips and remove side fenders (5).

FRONT BUMPER AND SIDE FENDER INSTALLATION

1. Install side fenders (5) by snapping in body clips.
2. Install inner screws, nuts, and spacers (1, 2, 3, and 4) that attach the side fender to the frame.
3. Install front bumper (6).
4. Install the two upper and lower bolts (7) that attach the bumper to the vehicle frame. Push down and rearward on front fenders near the bumper to install.
5. Install the grille. **See Grille Installation, Section 4, Page 4-5.**
6. Install the front cowl. **See Cowl Installation, Section 4, Page 4-4.**
7. Install HD bumper (if equipped). **See Brushguard Installation, Section 4, Page 4-3.**
8. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Connect the Battery- Gasoline Vehicles on page 1-4.**
9. Remove tire chocks.

INSTRUMENT PANEL REMOVAL

1. Disconnect the batteries. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Disconnect the Battery- Gasoline Vehicles on page 1-4.**
2. Remove front cowl. **See Cowl Removal, Section 4, Page 4-4.**
3. From the inside of the dash, press upper snap tabs (1) of the instrument panel inward to release from dash.
4. Then push the instrument panel near the bottom (2) to pop out the lower body clips (be careful not to pry the lower clips off).
5. Pull instrument panel out from the dash panel (2).



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Figure 4-4 Instrument Panel

INSTRUMENT PANEL INSTALLATION

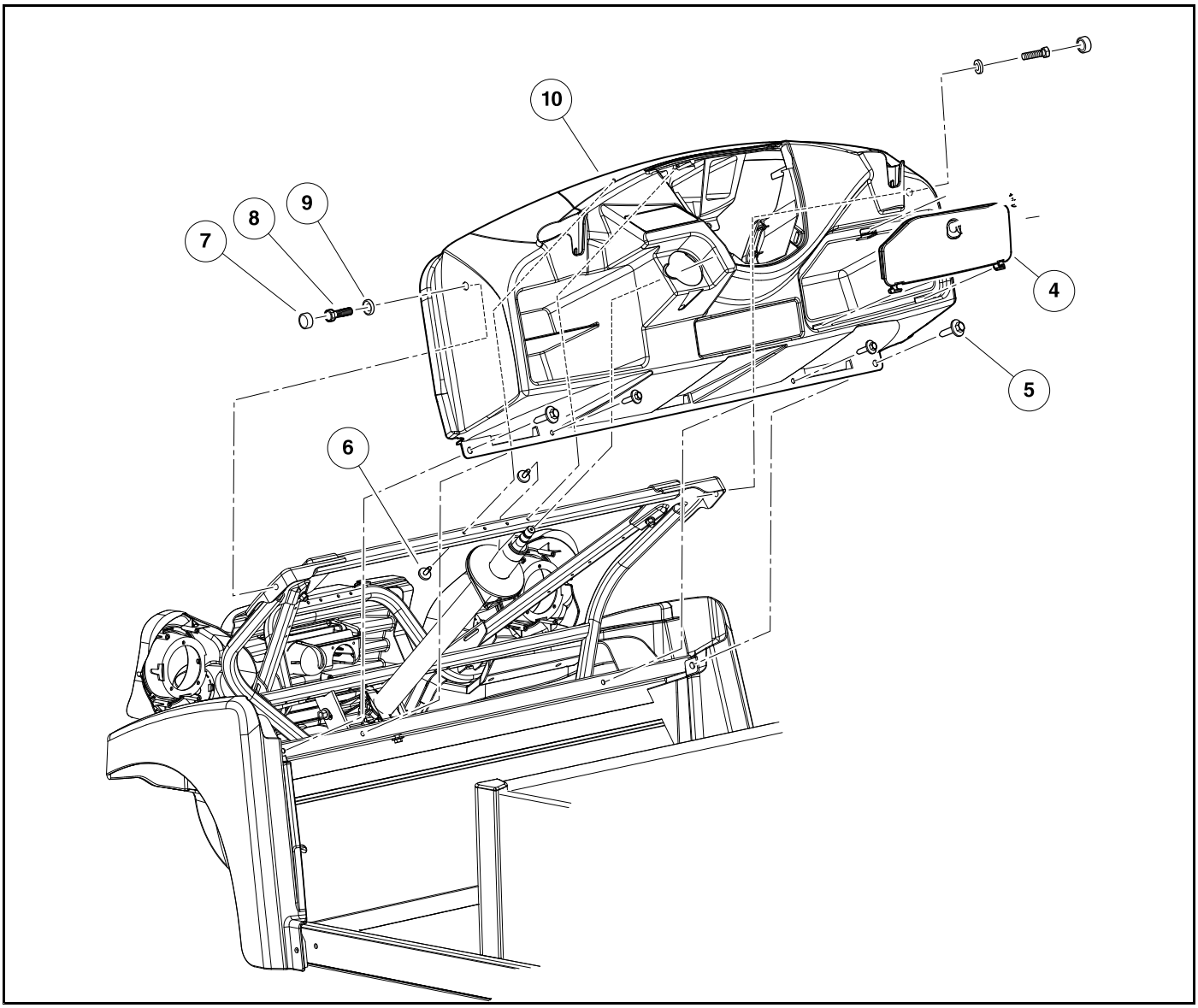
1. Place upper tab of instrument panel into slot (1).
2. Snap panel into dash while pushing in on the driver and passenger side tabs and sliding the top portion of the panel into place.
3. Snap lower body clips in at each lower corner.
4. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Connect the Battery- Gasoline Vehicles on page 1-4.**

DASH REMOVAL

1. Disconnect the batteries. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
   See Disconnect the Battery- Gasoline Vehicles on page 1-4.
2. Remove cowl. **See Cowl Removal on page 4-4.**
3. Remove steering wheel. **See Steering Wheel Removal, Section 7, Page 7-1.**
4. Disconnect instrument panel wiring.
5. Remove the bolts, and washers (5, 6, 7, 8, and 9) from the top, sides and bottom of the dash (10). **(Figure 4-5, Page 4-11)**.
6. Remove dash assembly.

DASH INSTALLATION

1. Install dash assembly.
2. Install the bolts, and washers (5, 6, 7, 8, and 9) to the top, sides and bottom of dash (10). **(Figure 4-5, Page 4-11)**
3. Connect instrument panel wiring.
4. Install steering wheel. **See Steering Wheel Installation, Section 7, Page 7-2.**
5. Install cowl. **See Cowl Installation, Section 4, Page 4-4.**
6. Connect the batteries.
   See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.
   See Connect the Battery- Gasoline Vehicles on page 1-4.

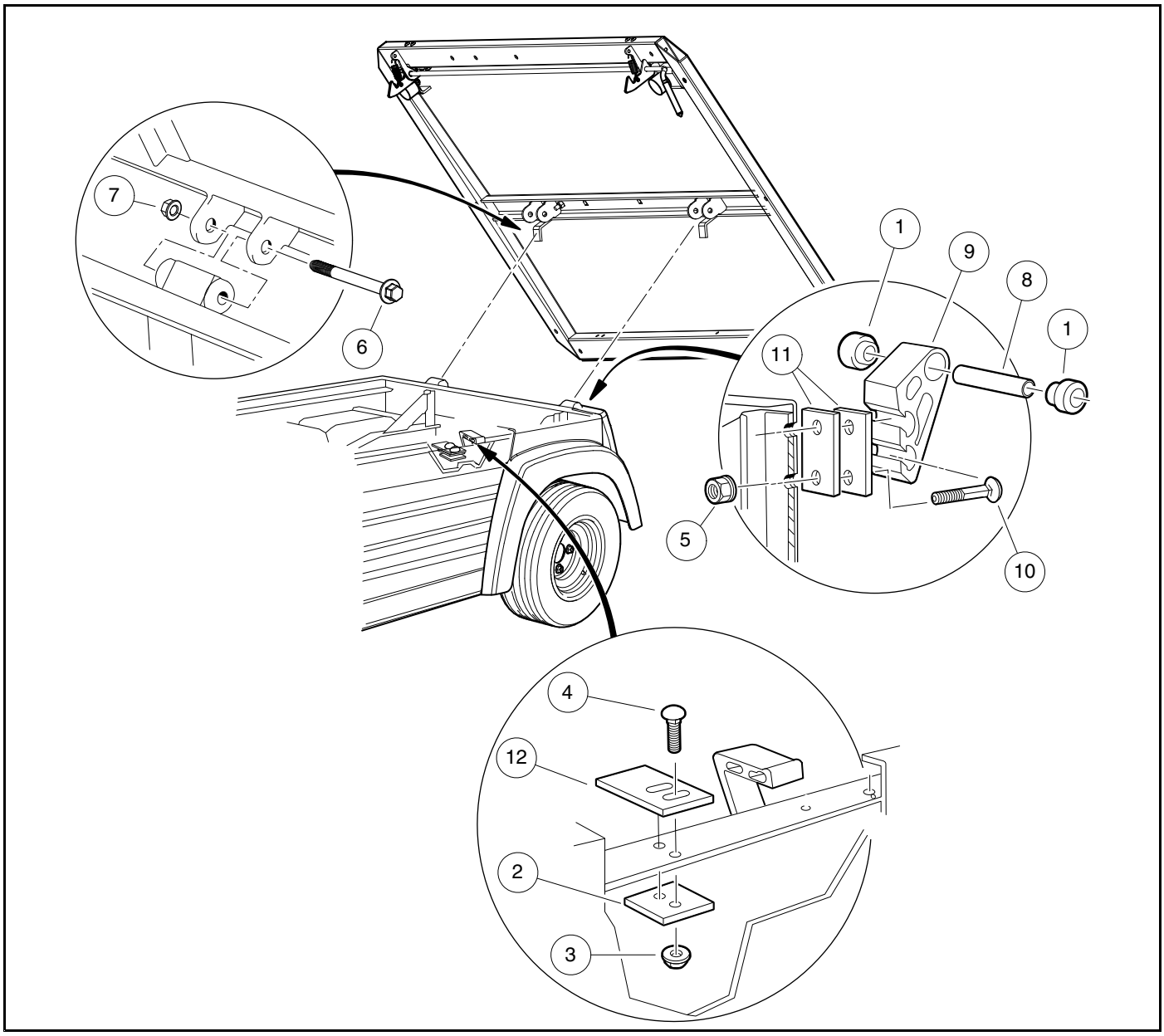


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Figure 4-5 Dash Assembly

TILT BED

See General Warnings on page 1-1.



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Figure 4-6 Tilt Bed Mounting

TILT BED REMOVAL

NOTE: *This procedure requires two people.*

⚠ WARNING

- **Remove all cargo before raising the bed or servicing the vehicle. If the vehicle is equipped with a prop rod, ensure that it is securely engaged while bed is raised. Do not close bed until all persons are clear of cargo bed area. Keep hands clear of all crush areas. Do not drop cargo bed; lower gently and keep entire body clear. Failure to heed this warning could result in severe personal injury or death.**

1. Disconnect the batteries. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Disconnect the Battery- Gasoline Vehicles on page 1-4.**
2. Raise bed. Hold bed securely in an upright position **(Figure 4-6, Page 4-12)**.
3. Remove locknut (7) from each hinge assembly. Lower bed onto vehicle frame.
4. Apply slight upward pressure (by hand) on the rear of the bed to relieve pressure on the hinges, and remove the hinge bolts (6) from the hinge assemblies. **See following WARNING and CAUTION.**

⚠ WARNING

- **Keep hands and arms from between the bed and vehicle frame and do not allow the bed to drop.**

CAUTION

- **Support bed as pins are removed.**
- **Keep bed and hinges aligned to avoid binding the pins during removal.**

5. Raise rear edge of bed approximately 6 inches (15.2 cm) and pull bed assembly toward rear of vehicle approximately 3 inches (7.6 cm) to release bed latch assembly from latch plate (12).
6. Lift bed from vehicle.

TILT BED INSTALLATION

NOTE: *This procedure requires two people.*

Lubricate the hinge bolts (6) with light motor oil prior to assembly.

1. Hold bed at a slight angle (front of bed lower than rear of bed) to vehicle and place front edge of bed onto vehicle frame. Bed latches should engage with latch plates (12) **(Figure 4-6, Page 4-12)**.
2. Lower edge of bed onto vehicle and align hinge brackets (9) with bed hinge. **See following WARNING and CAUTION.**

⚠ WARNING

- **Keep hands and arms from between the bed and vehicle frame and do not allow the bed to drop.**

CAUTION

- **Keep bed and hinges aligned to avoid binding the pins during installation.**

3. Start the bolts (6) into left and right hinge assemblies. It may be necessary to use an alignment tool to align holes in hinge bracket with steel bushing in hinge assembly.

4. Use a small hammer to lightly tap bolts through hinge assembly **(Figure 4-6, Page 4-12)**. Adjust the striker plates (12), if necessary.
5. Install a locknut (7) on each bolt (6) and tighten to 15 ft·lb (21 N·m).
6. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Connect the Battery- Gasoline Vehicles on page 1-4.**

BED LATCH ASSEMBLY REMOVAL

NOTE: *This procedure requires the aid of an assistant.*

1. Park the vehicle and chock the tires.
2. Disconnect the batteries. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Disconnect the Battery- Gasoline Vehicles on page 1-4.**
3. Raise bed and secure prop rod (9) in prop rod track (2) **(Figure 4-6, Page 4-12)**. **See following WARNING.**

⚠ WARNING

- **Remove all cargo before raising the bed or servicing the vehicle. If the vehicle is equipped with a prop rod, ensure that it is securely engaged while bed is raised. Do not close bed until all persons are clear of cargo bed area. Keep hands clear of all crush areas. Do not drop cargo bed; lower gently and keep entire body clear. Failure to heed this warning could result in severe personal injury or death.**

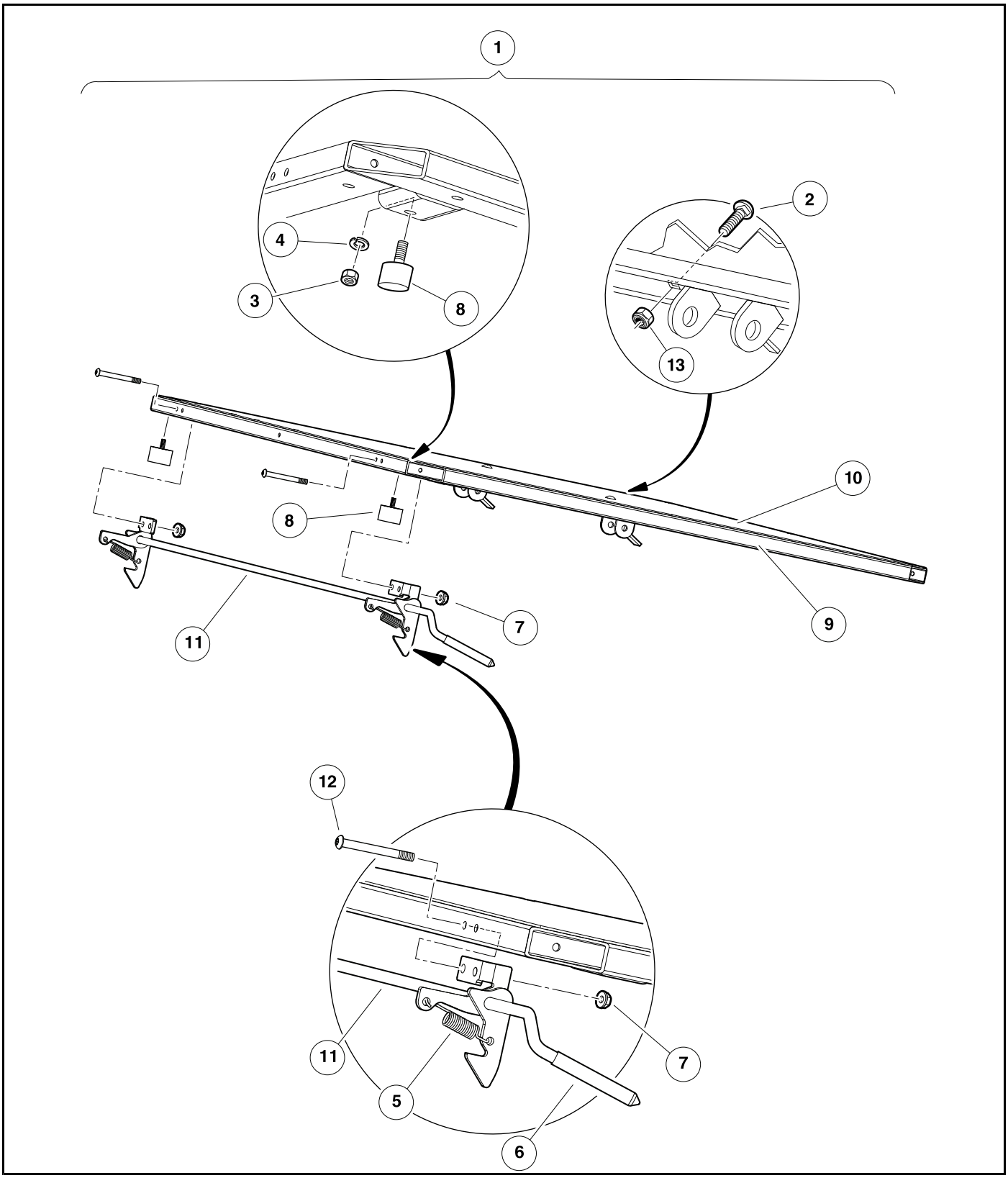
4. Remove the four bolts (12) and lock nuts (7) that secure the bed latch (6) to the underside of the bed **(Figure 4-7, Page 4-15)**.
5. Remove the bed latch (6) and springs (5).

BED LATCH ASSEMBLY INSTALLATION

1. Install bed latch (6) and springs (5).

NOTE: *Latch assembly needs to sit open exactly as shown* ***(Figure 4-7, Page 4-15)****.*

2. Install the four bolts (12) and lock nuts (7) that secure the bed latch (6) to the underside of the bed. Tighten to 70 to 80 in·lb (8 to 9 N·m).
3. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Connect the Battery- Gasoline Vehicles on page 1-4.**
4. Remove tire chocks.

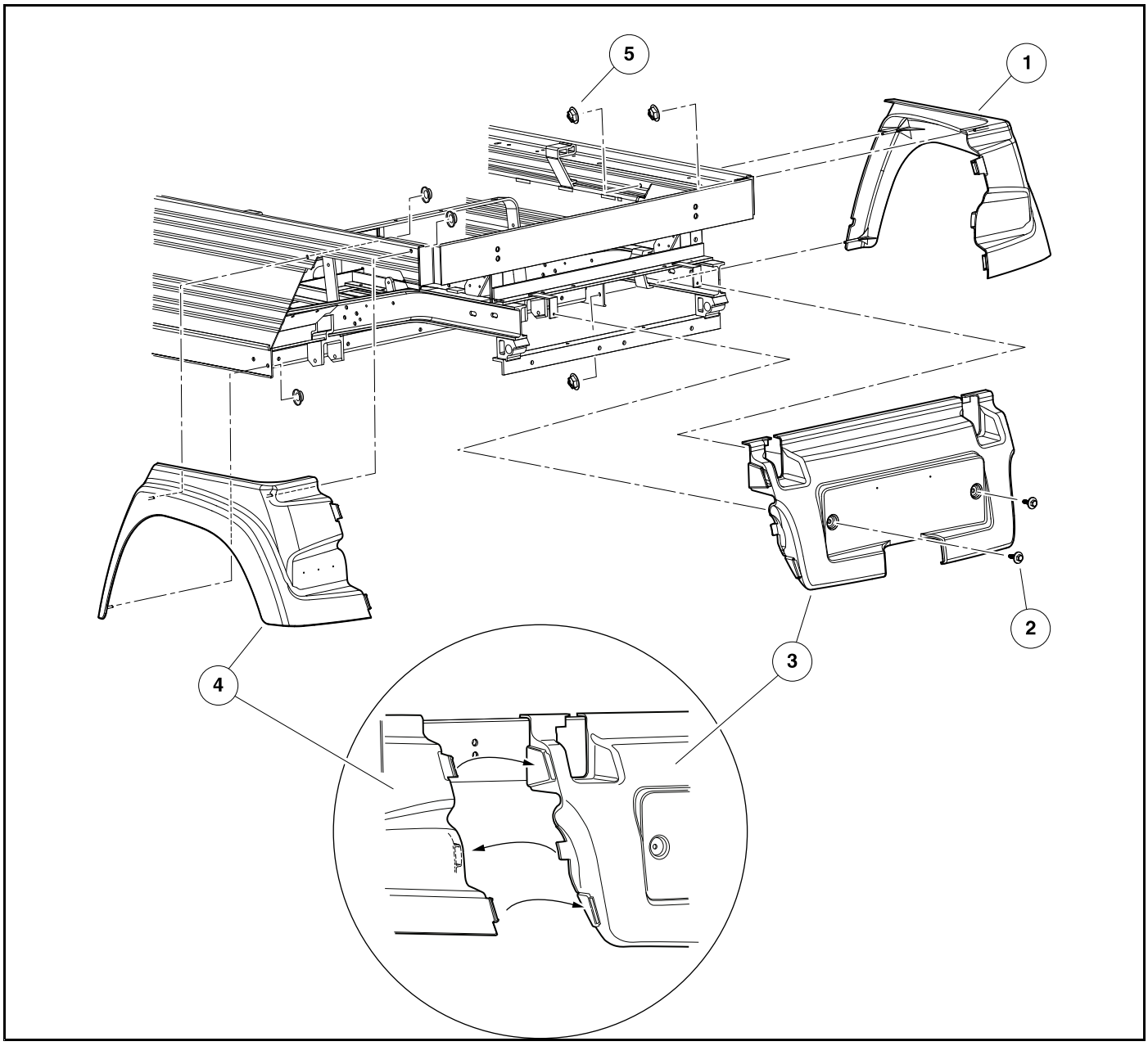


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Figure 4-7 Bed Latch Assembly

REAR FENDERS AND TAILSKIRT

See General Warnings on page 1-1.



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Figure 4-8 Rear Fender and Tailskirt

REAR FENDER AND TAILSKIRT REMOVAL

1. Turn the key switch OFF and remove the key. Place the Forward/Neutral/Reverse control (FNR) in NEUTRAL and set the park brake. Chock the wheels.

2. Disconnect the battery cables and either discharge the controller or disconnect the spark plug wire. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
   See Disconnect the Battery- Gasoline Vehicles on page 1-4.
3. Remove the tilt bed. **See Tilt Bed Removal on page 4-13.**
4. Disconnect the three taillight wires.
5. Using a 10 mm socket, remove the three fasteners (5) that attach the rear fender (4) to vehicle frame **(Figure 4-8, Page 4-16)**.
6. Using a 10 mm socket, remove the two M6 screws (2) that attach the tailskirt (3) to the vehicle frame.
7. Remove fenders and tailskirt.

REAR FENDER AND TAILSKIRT INSTALLATION

1. Using a 10 mm socket, install the two screws (2) that attach the tailskirt (3) to the vehicle frame **(Figure 4-8, Page 4-16)**. Tighten to 44 in·lb (5 N·m).
2. Using a 10 mm socket, install the three fasteners (5) that attach the rear fender (4) to the vehicle frame. Tighten to 5 in·lb (0.56 N·m). Do not over torque.
3. Connect the taillight wires.
4. Install the two bolts and nuts that secure taillight to the rear fender.
5. Connect the three taillight wires.
6. Install the tilt bed. **See Tilt Bed Installation on page 4-13.**
7. Connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**
   See Connect the Battery- Gasoline Vehicles on page 1-4.

REAR TRIANGLE REFLECTOR

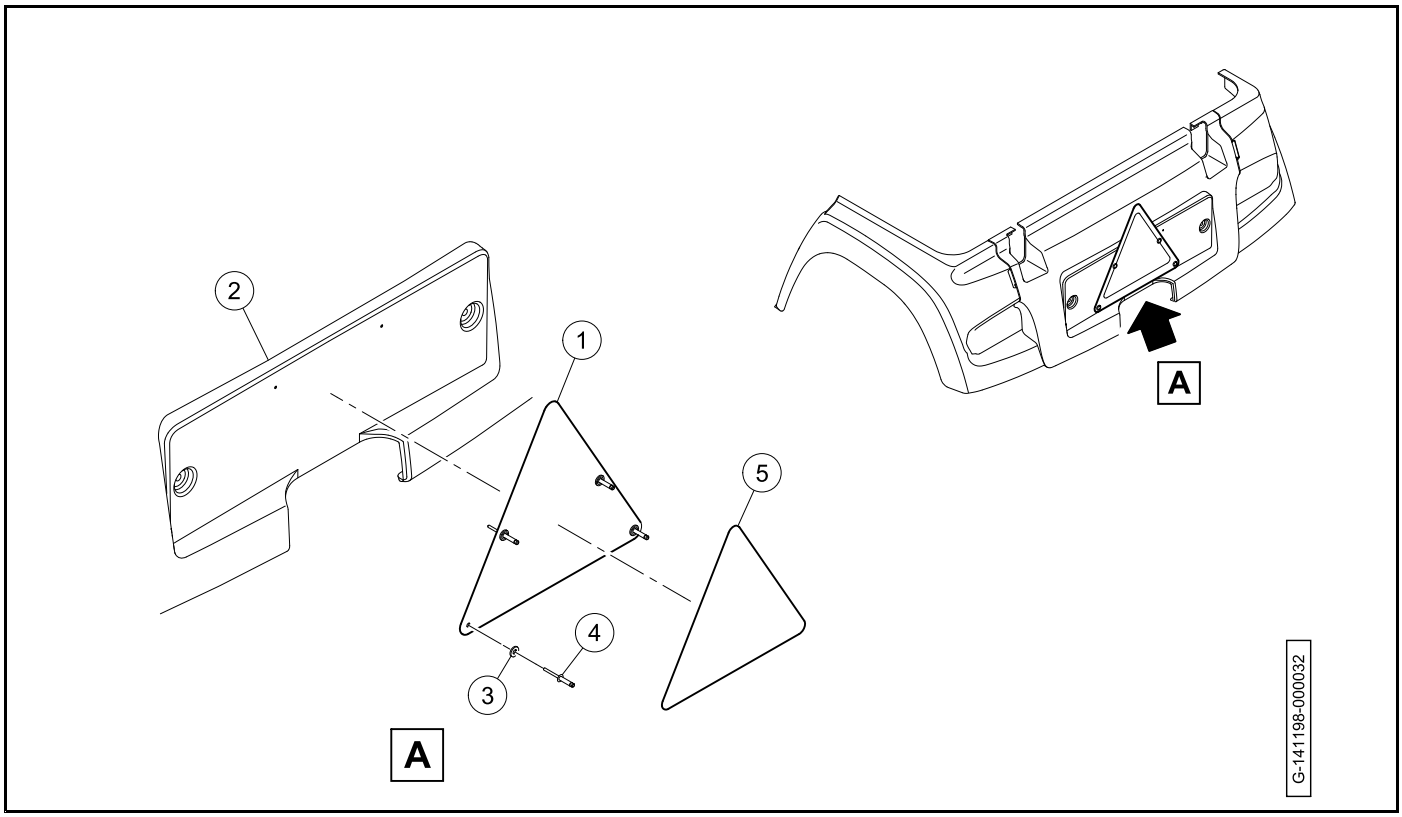


Figure 4-9

REAR TRIANGLE REFLECTOR REMOVAL

1. Disable the vehicle.
2. Remove the four rivets (1) and washers (2) **(Figure 4-9)**. Discard the rivets.
3. Remove the rear triangle reflector (3).

REAR TRIANGLE REFLECTOR INSTALLATION

1. If the rear triangle reflector has never been installed:

1.1. Put the triangle plate (1) on the tail skirt (2) **(Figure 4-9)**.

NOTE: *Make sure to laterally align the triangle plate on the center-line of the tail skirt.*

Make sure to vertically align the lower edge of the triangle plate with the lower part of the flat vertical surface.

1.2. Use the four holes in the triangle plate as a template. Match drill four 0.20 inch (5.08 mm) holes through the tail skirt. Deburr all holes drilled and remove unwanted material.

2. Attach the triangle plate to the tail skirt with four washers (3) and four new rivets (4).
3. Make sure that the air and surface temperatures are above 60° F (16° C). Temperatures above 60° F (16° C) result in a good bond.
4. Clean the triangle plate surface area with soap and water. Make sure to remove all debris (dirt, grease, and oils).
5. Dry the area fully with a lint free cloth.

6. Clean the triangle plate surface area with an Isopropyl Alcohol prep pad (70 percent Isopropyl Alcohol and 30 percent water). Wipe dry before the Isopropyl Alcohol dries.
7. Install the reflective triangle decal (5) on the triangle plate. Make sure to keep proper alignment and remove any air bubbles.

FLOOR MAT

See General Warnings on page 1-1.

FLOOR MAT REMOVAL

1. Remove the brake and accelerator pedals. **See Accelerator and Brake Pedal Group, Section 5, Page 5-1.**
2. Remove the top edge of the floor mat from the overlapping flange under the dash.
3. Lift the mat from the vehicle.

FLOOR MAT INSTALLATION

1. Install mat into vehicle. Ensure mat is laying flat.
2. Install top edge of the floor mat into the overlapping flange under the dash.
3. Install the brake and accelerator pedals. **See Accelerator and Brake Pedal Group, Section 5, Page 5-1.**

Pagination Page

SECTION 5 — ACCELERATOR AND BRAKE PEDAL GROUP 5

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

BRAKE PEDAL AND PARK BRAKE (GAS AND ELECTRIC VEHICLES)

See General Warnings on page 1-1.

BRAKE PEDAL REMOVAL (GAS AND ELECTRIC VEHICLES)

1. Disconnect the battery cables and either discharge the controller or disconnect the spark plug wire. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
   See Disconnect the Battery- Gasoline Vehicles on page 1-4.
2. Place chocks under the rear wheels and lift the front end of the vehicle with a chain hoist or floor jack. Place jack stands under the front cross tube of the vehicle frame and lower the vehicle onto the jack stands. **See following WARNING.**

⚠ WARNING

- **Lift only one end of the vehicle at a time. Use a suitable lifting device (chain hoist or hydraulic floor jack) with 1000 lb (454 kg) minimum lifting capacity. Do not use lifting device to hold vehicle in raised position. Use approved jack stands of proper weight capacity to support the vehicle and chock the wheels that remain on the floor. When not performing a test or service procedure that requires movement of the wheels, lock the brakes.**

3. Remove the brake pedal assembly.

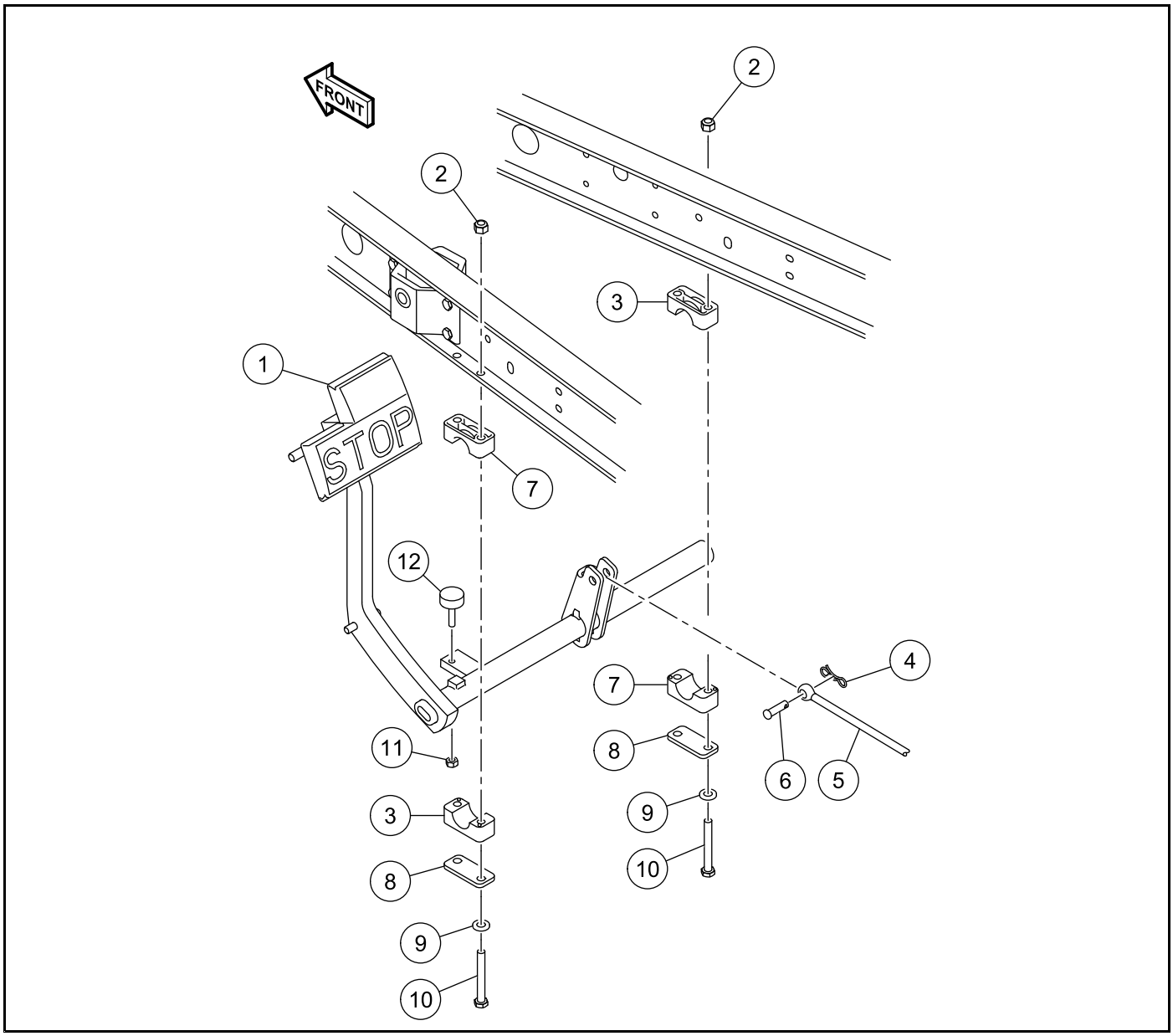
3.1. Disconnect the equalizer rod (5) from the pedal shaft by removing the clevis pin (6) and bow-tie pin (4) **(Figure 5-1, Page 5-2)**.

3.2. Remove the nuts (2), flat washers (9), bolts (10), and mounting blocks (3 and 7). If the mounting blocks (3 and 7) show signs of excessive wear or are damaged, they must be replaced with new ones before installing pedal assembly.

3.3. Remove the nut (2) and brake stop bumper (12) and lift pedal assembly (1) through the floorboard **(Figure 5-2, Page 5-3)**.

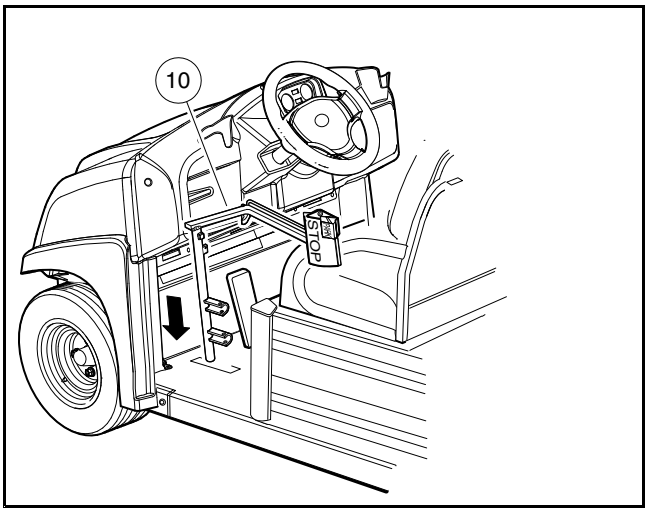
BRAKE PEDAL INSTALLATION (GAS AND ELECTRIC VEHICLES)

1. From the top side of the floorboard, insert the brake pedal assembly (1) through the opening in the floor as shown **(Figure 5-2, Page 5-3)** and install the brake pedal stop bumper (12) **(Figure 5-1, Page 5-2)** on the brake pedal assembly, but do not tighten the jam nut (11) at this time.
2. Secure the equalizer rod (5) to the brake pedal assembly (1) with clevis pin (6) and bow-tie pin (4) as shown.



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Figure 5-1 Brake and Park Brake Pedal Assembly and Mounting



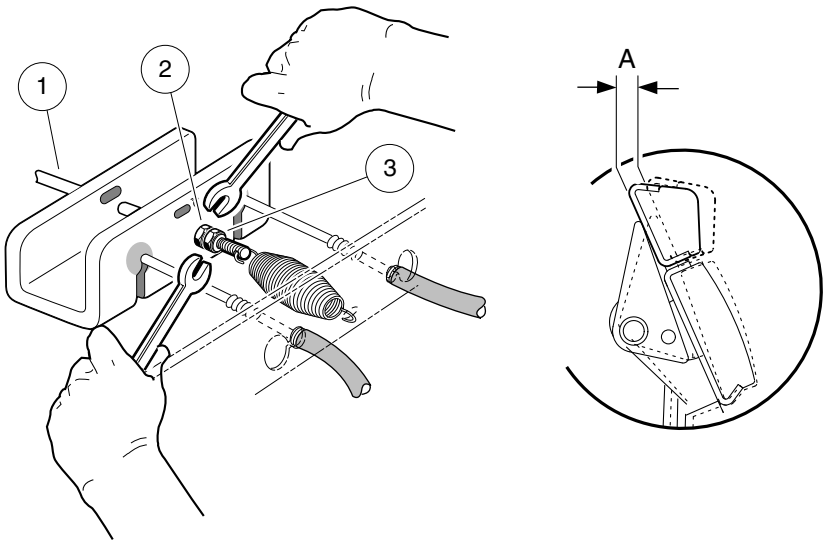
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Figure 5-2 Brake Pedal Weldment Through Floor

3. Position and attach brake pedal assembly, mounting blocks (3 and 7), and washers (9) to vehicle frame as shown. Tighten the bolts (10) and nuts to 95 in·lb (10.7 N·m). Figure 5-1, Page 5-2
4. Tighten the nut (2) on the equalizer rod (1) so that brake pedal free-play is from 1/4 inch to 1/2 inch (6 mm to 13 mm) **(Figure 5-3, Page 5-3)**. **See following NOTE.**

NOTE: *Brake pedal free-play is the distance the brake pedal can be pressed before the brake actuator arm moves.*

5. Tighten the jam nut (3) while holding the adjustment nut (2) in the correct position.
6. Adjust the pedal group. Refer to the appropriate adjustment procedure:
   – **For gasoline vehicles, see Pedal Group Adjustment – Gasoline Vehicles on page 5-10.**
   – **For electric vehicles, see Pedal Group Adjustment – Electric Vehicles on page 5-15.**



Dimension A: 1/4 inch to 1/2 inch (6 mm to 13 mm)
Note: Equalizer bracket may be inverted on some vehicles.

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Figure 5-3 Brake Pedal Free-Play Adjustment

PARK BRAKE REMOVAL (GAS AND ELECTRIC VEHICLES)

1. Disconnect the battery cables and either discharge the controller or disconnect the spark plug wire. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
See Disconnect the Battery- Gasoline Vehicles on page 1-4.
2. Place chocks under the rear wheels and lift the front end of the vehicle with a chain hoist or floor jack. Place jack stands under the front cross tube of the vehicle frame and lower the vehicle onto the jack stands. **See following WARNING.**

⚠ WARNING

- **Lift only one end of the vehicle at a time. Use a suitable lifting device (chain hoist or hydraulic floor jack) with 1000 lb (454 kg) minimum lifting capacity. Do not use lifting device to hold vehicle in raised position. Use approved jack stands of proper weight capacity to support the vehicle and chock the wheels that remain on the floor. When not performing a test or service procedure that requires movement of the wheels, lock the brakes.**

3. Remove the park brake assembly.

3.1. To remove the park brake rod and pawl assembly (17 through 20), remove the push nut (19) and disconnect the ball joint sleeve (21) from the park brake pedal (1) **(Figure 5-4, Page 5-4)**. **See following NOTE.**

NOTE: *New push nuts (19) and (32) must be used when reassembling the park brake.*

3.2. To remove the park brake pedal (1), remove the push retainer nut (32), disconnect the torsion spring (22), and slide the pedal off of the shaft. **See preceding NOTE.**

3.3. Inspect all parts for wear and damage and replace as necessary.

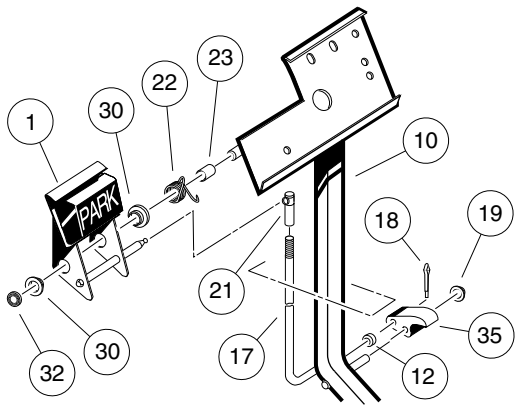
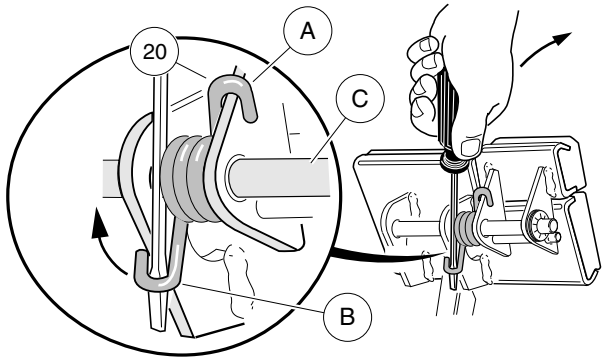


Figure 5-4 Park Brake Assembly



A. Hook one end of spring (20) on park brake weldment.
B. Lift other end of spring (20) up and over brake weldment by prying down on shaft with small screwdriver.
C. Shaft

Figure 5-5 Torsion Spring Installation

PARK BRAKE INSTALLATION (GAS AND ELECTRIC VEHICLES)

1. From the bottom side of the floorboard, insert the park brake rod (17) through the brake pedal assembly opening. Then install the park brake pawl (35) onto the shaft on the brake pedal assembly (10) and also insert the park brake rod (17) into the park brake pawl **(Figure 5-4, Page 5-4)**.
2. Install the push nut (19) on to the park brake pawl shaft.
3. Install the spacer (23) and torsion spring (22) on the park brake pedal shaft on the brake pedal assembly.

4. Install the two bushings (30) in the park brake pedal and position the park brake pedal on the shaft on the brake pedal assembly weldment (10). Then attach the ends of the torsion spring to the park brake pedal and to the brake pedal weldment as shown **(Figure 5-5, Page 5-4)**.
5. Install the push nut (32) on the park brake pedal shaft **(Figure 5-4, Page 5-4)**.
6. Connect park brake rod (17) with ball joint (21) to the ball stud on the park brake pedal assembly.
7. Adjust park brake ratchet/pawl gap and pawl engagement. Refer to the appropriate adjustment procedure:
   – **For gasoline vehicles, see Pedal Group Adjustment – Gasoline Vehicles on page 5-10.**
   – **For electric vehicles, see Pedal Group Adjustment – Electric Vehicles on page 5-15.**

ACCELERATOR PEDAL – GASOLINE VEHICLES

See General Warnings on page 1-1.

ACCELERATOR PEDAL REMOVAL – GASOLINE VEHICLES

1. Disconnect battery and spark plug wire. **See Disconnect the Battery- Gasoline Vehicles on page 1-4.**
2. Place chocks under the rear wheels and lift the front end of the vehicle with a chain hoist or floor jack. Place jack stands under the front cross tube of the vehicle frame and lower the vehicle onto the jack stands. **See following WARNING.**

⚠ WARNING

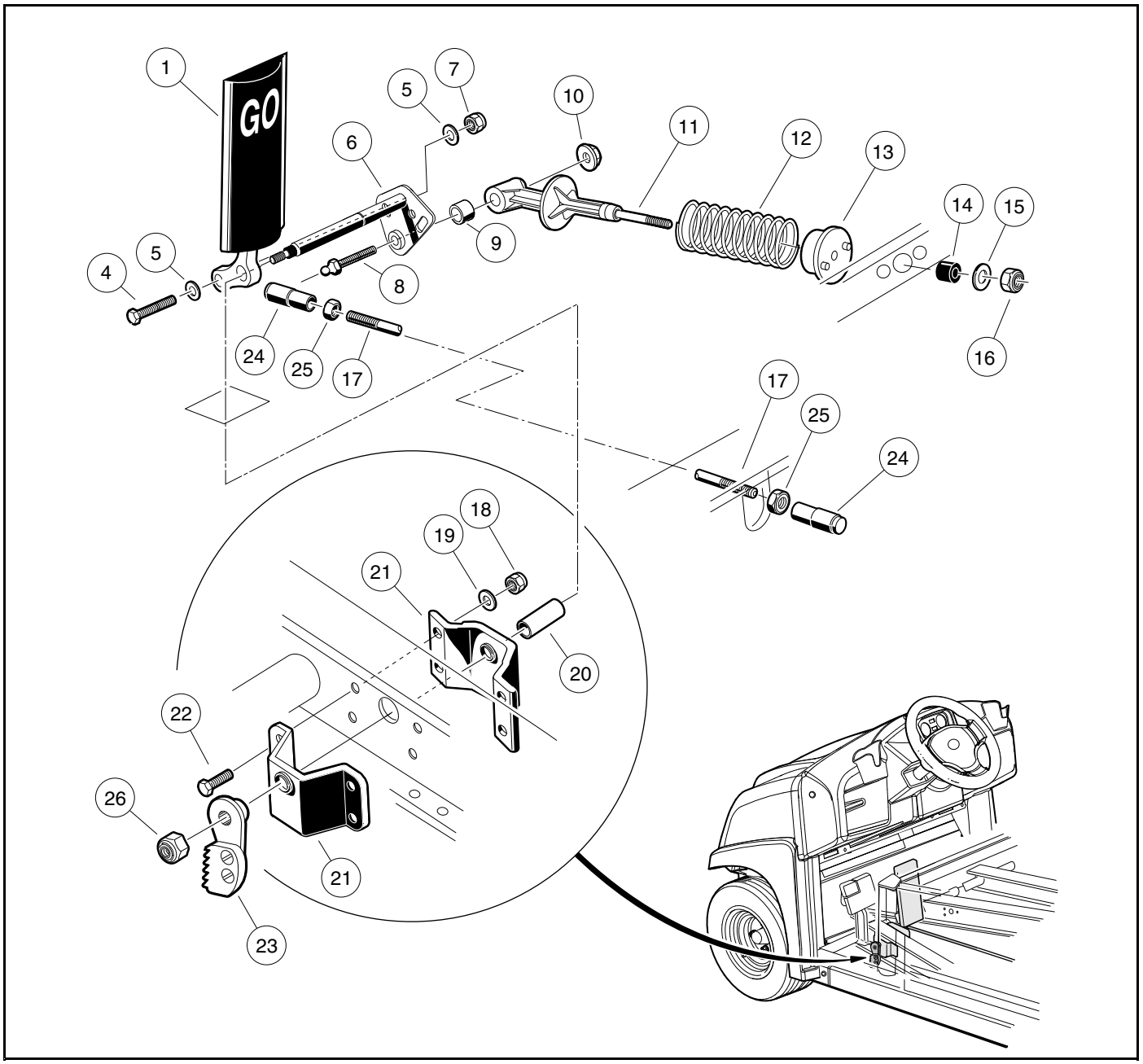
- **Lift only one end of the vehicle at a time. Use a suitable lifting device (chain hoist or hydraulic floor jack) with 1000 lb (454 kg) minimum lifting capacity. Do not use lifting device to hold vehicle in raised position. Use approved jack stands of proper weight capacity to support the vehicle and chock the wheels that remain on the floor. When not performing a test or service procedure that requires movement of the wheels, lock the brakes.**

3. Disconnect the accelerator rod assembly (17, 24, and 25) **(Figure 5-6, Page 5-6)** at the front and rear ball studs and remove it from the vehicle.
4. Use a 9/16-inch (14 mm) socket and 9/16-inch (14 mm) wrench to remove the nut (7), two washers (5), and bolt (4) securing the accelerator pedal (1) to the pivot rod (6).
5. Remove the nut (10) and ball stud (8) from the accelerator pivot rod assembly (6).
6. Slide the spring retainer (11) off of the accelerator pivot rod.
7. Inspect the pivot support bearing (9) for wear and replace if necessary.
8. Use a marker to mark the position of the park brake ratchet (23) on the accelerator pivot rod (6). **See following NOTE.**

NOTE: *Failure to mark position of the ratchet could cause it to be reinstalled improperly, resulting in improper adjustment and possible failure of the park brake.*

9. Remove the lock nut (26) from the accelerator pivot rod **(Figure 5-6, Page 5-6)**.
10. Press the brake pedal slightly and slide the park brake ratchet (23) toward the end of the accelerator pivot rod. Rotate the ratchet and remove it from the pivot rod.
11. Remove the pivot rod (6) and spacer (20) from the accelerator pivot rod supports (21).
12. Inspect the accelerator pivot rod supports (21) for wear and damage and replace if necessary. If the pivot rod supports do not require replacement, loosen, but do not remove, the four bolts (22) and lock nuts (18) to make installation of the pivot rod easier.

13. Remove the accelerator pedal (1) from the vehicle.
14. Inspect all parts for wear and damage. Replace as necessary.



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Figure 5-6 Accelerator Pedal – Gasoline Vehicles

ACCELERATOR PEDAL INSTALLATION – GASOLINE VEHICLES

1. If the accelerator pivot rod supports were replaced, position the supports (21) on the vehicle frame and install the four bolts (22), flat washers (19), and lock nuts (18). Finger-tighten nuts at this time **(Figure 5-6, Page 5-6)**.
2. Insert the lower end of the accelerator pedal (1) through the floorboard and install the accelerator pivot rod (6) through the uppermost hole in the pedal.
3. Install the plastic spacer (20) on the pivot rod (6).
4. Insert the pivot rod through the pivot rod supports on the vehicle frame.
5. Tighten the four bolts (22) attaching the pivot rod supports to the frame to 75 in·lb (8.5 N·m).
6. Install the bolt (4), two washers (5), and a new lock nut (7) through the lower hole in the pedal and through the pivot rod. Finger-tighten nut at this time.
7. Install the ball stud (8) through the pivot rod. Install the bearing (9) and spring retainer (11) onto the ball stud. Secure these parts with the nut (10). Tighten the nut to 50 in·lb (5.7 N·m).
8. Press the brake pedal slightly, and with the park brake ratchet oriented so that the tip of the ratchet is pointed toward the rear of vehicle, slide the ratchet onto the pivot rod (do not slide the ratchet onto the pivot rod splines). Release the brake pedal and allow the ratchet to rotate until its tip is pointed downward **(Figure 5-7, Page 5-7)**. The ratchet should now rotate freely on the rod.

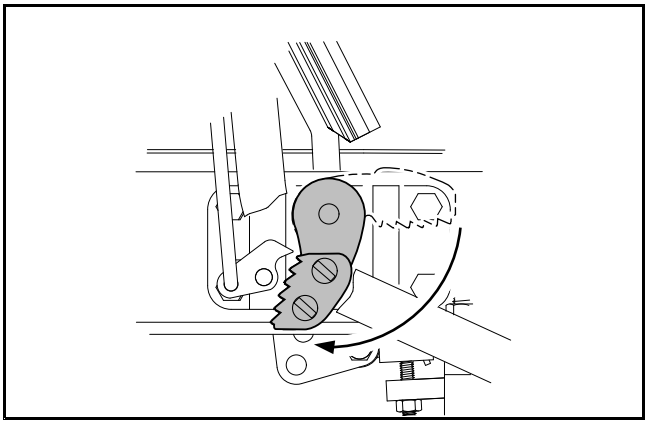


Figure 5-7 Ratchet Installation

9. Rotate the ratchet clockwise until it touches the park brake pawl, then slide the ratchet onto the splines of the pivot rod (it may be necessary to push the pivot rod toward the driver side of the vehicle to make the splines accessible). The ratchet may have to be rotated counterclockwise slightly to align the splines.
10. Install the nylon lock nut (26) on the pivot rod and tighten the nut to 18 ft·lb (24 N·m) **(Figure 5-6, Page 5-6)**.
11. Install the accelerator rod assembly (17, 24, and 25).
12. Adjust the accelerator pedal height and accelerator rod. **See Pedal Group Adjustment – Gasoline Vehicles on page 5-10.**

ACCELERATOR PEDAL – ELECTRIC VEHICLES

See General Warnings on page 1-1.

ACCELERATOR PEDAL REMOVAL – ELECTRIC VEHICLES

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Place chocks under the rear wheels and lift the front end of the vehicle with a chain hoist or floor jack. Place jack stands under the front cross tube of the vehicle frame and lower the vehicle onto the jack stands. **See following WARNING.**

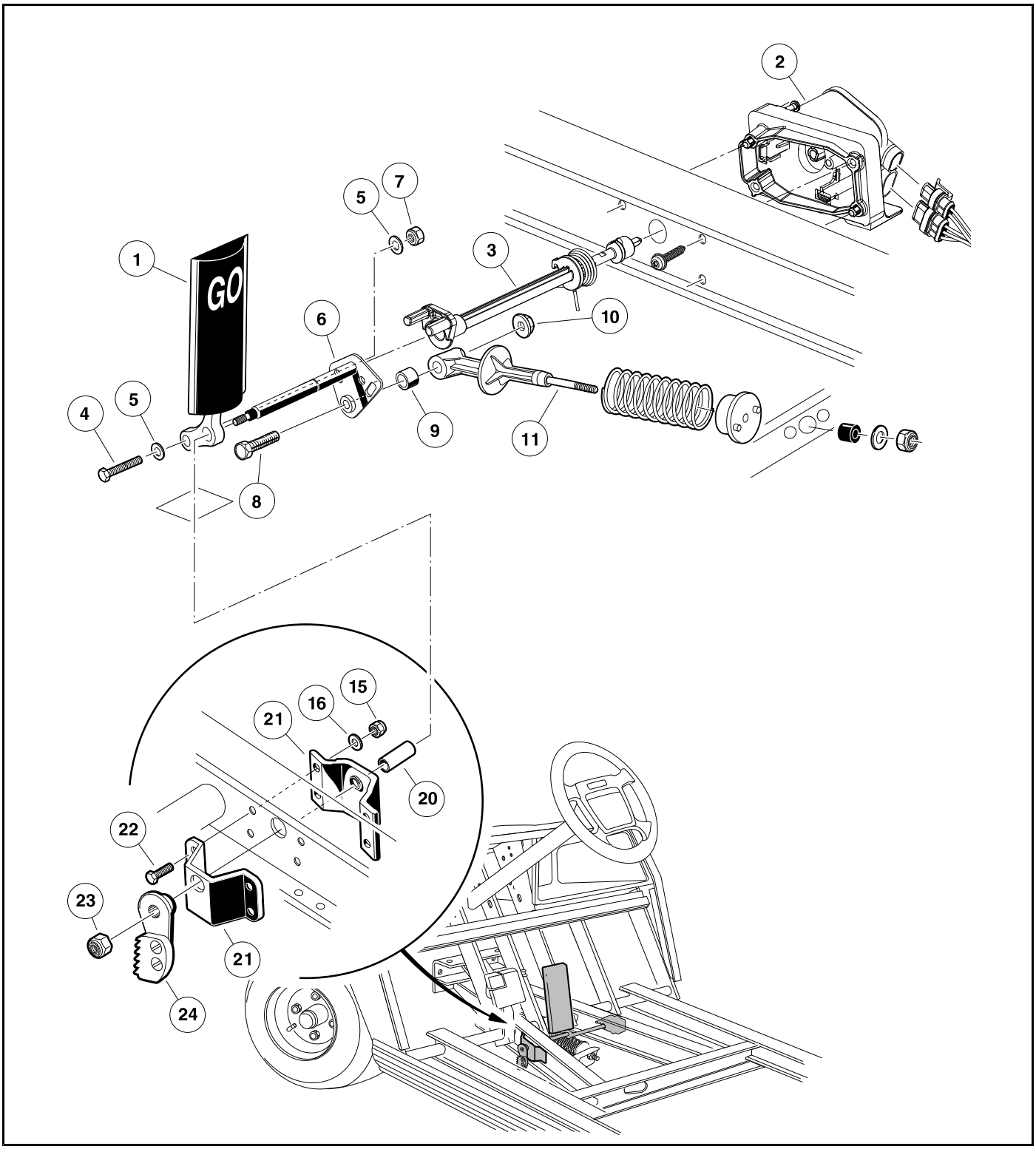
⚠ WARNING

- **Lift only one end of the vehicle at a time. Use a suitable lifting device (chain hoist or hydraulic floor jack) with 1000 lb (454 kg) minimum lifting capacity. Do not use lifting device to hold vehicle in raised position. Use approved jack stands of proper weight capacity to support the vehicle and chock the wheels that remain on the floor. When not performing a test or service procedure that requires movement of the wheels, lock the brakes.**

3. Remove the MCOR (2) and drive bar (3) as instructed **(Figure 5-8, Page 5-9)**. **See MCOR Removal, Section 13, Page 13-4.**
4. Use a 9/16-inch (14 mm) socket and 9/16-inch (14 mm) wrench to remove the nut (7), two washers (5), and bolt (4) securing the accelerator pedal (1) to the pivot rod (6) **(Figure 5-8, Page 5-9)**.
5. Remove the nut (10) and bolt (8) from the accelerator pivot rod assembly (6).
6. Slide the spring retainer (11) off of the accelerator pivot rod.
7. Inspect the pivot support bearing (9) for wear and replace if necessary.
8. Use a marker to mark the position of the park brake ratchet (24) on the accelerator pivot rod (6). **See following NOTE.**

NOTE: *Failure to mark position of the ratchet could cause it to be installed improperly, resulting in improper adjustment and possible failure of the park brake.*

9. Remove the lock nut (23) from the accelerator pivot rod.
10. Press the brake pedal slightly and slide the park brake ratchet (24) toward the end of the accelerator pivot rod. Rotate the ratchet and remove it from the pivot rod.
11. Remove the pivot rod (6) and spacer (20) from the accelerator pivot rod supports (21) **(Figure 5-8, Page 5-9)**.
12. Inspect the accelerator pivot rod supports (21) for wear and damage and replace as necessary. If the pivot rod supports do not require replacement, loosen, but do not remove, the four bolts (22) and lock nuts (15) to make installation of the pivot rod easier.
13. Remove the accelerator pedal (1) from the vehicle.
14. Inspect all parts for wear and damage. Replace as necessary.



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Figure 5-8 Accelerator Pedal – Electric Vehicle with MCOR

ACCELERATOR PEDAL INSTALLATION – ELECTRIC VEHICLES

1. If the accelerator pivot rod supports were replaced, position the supports (21) on the vehicle frame and install the four bolts (22), flat washers (16), and lock nuts (15) **(Figure 5-8, Page 5-9)**. Finger-tighten nuts at this time.
2. Insert the lower end of the accelerator pedal (1) through the floorboard and install the accelerator pivot rod (6) through the uppermost hole in the pedal.
3. Install plastic spacer (20) on pivot rod (6).
4. Insert the pivot rod through the pivot rod supports (21) on the vehicle frame.
5. Tighten the four bolts (22) attaching the pivot rod supports to the frame to 75 in·lb (8.5 N·m).
6. Insert the bolt (4), two washers (5), and a new lock nut (7) through the lower hole in the pedal and through the pivot rod. Finger-tighten lock nut at this time.
7. Install the bolt (8) through the pivot rod (6) bearing (9) and spring retainer (11). Secure these parts with the nut (10). Tighten the nut to 50 in·lb (5.5 N·m).
8. Press the brake pedal slightly, and with the park brake ratchet oriented so that the tip of the ratchet is pointed toward the rear of the vehicle, slide the ratchet onto the pivot rod (do not slide the ratchet onto the pivot rod splines). Release the brake pedal and allow the ratchet to rotate until its tip is pointed downward **(Figure 5-7, Page 5-7)**. The ratchet should now rotate freely on the rod.
9. Rotate the ratchet clockwise until it touches the park brake pawl, then slide the ratchet onto the splines of the pivot rod (it may be necessary to push the pivot rod toward the driver side of the vehicle to make the splines accessible). The ratchet may have to be rotated counterclockwise slightly to align the splines.
10. Install lock nut (23) on pivot rod **(Figure 5-8, Page 5-9)**. Tighten to 18 ft·lb (24.5 N·m).
11. Install the MCOR (2) and drive bar (3) as instructed. **See MCOR Installation, Section 13, Page 13-4.**
12. Adjust the accelerator pedal height. **See Pedal Group Adjustment – Electric Vehicles on page 5-15.**

PEDAL GROUP ADJUSTMENT – GASOLINE VEHICLES

See General Warnings on page 1-1.

1. Disconnect battery and spark plug wire. **See Disconnect the Battery- Gasoline Vehicles on page 1-4.**
2. Adjust brake pedal height.

2.1. Chock wheels and release park brake. Lift rear of vehicle and place jack stands under the axle tubes to support the vehicle.

2.2. To provide slack in the brake cables, loosen the equalizer retaining nuts (1) on the equalizer rod (2) **(Figure 5-9, Page 5-11)**.

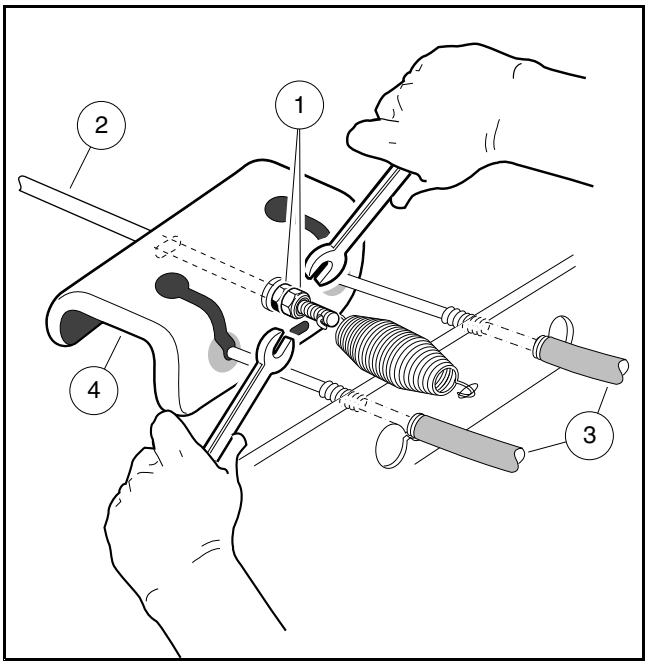


Figure 5-9 Loosen Rear Brake Equalizer Rod Nuts

2.3. Loosen the brake stop jam nut (31), then relieve pedal pressure on the stop by pushing down slightly on the pedal. Next, adjust the brake stop bumper (22) up or down **(Figure 5-10, Page 5-11)**. Adjusting the bumper upward decreases distance between pedal and floorboard. Adjusting the bumper downward increases distance between pedal and floorboard. Proper brake pedal height is 6 inches (15.2 cm) **(Figure 5-11, Page 5-11)**.

2.4. Tighten the jam nut (31) to 8 ft·lb (9.5 N·m) **(Figure 5-10, Page 5-11)**.

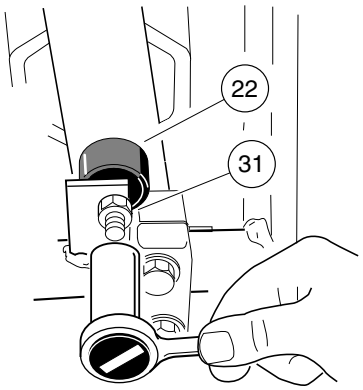
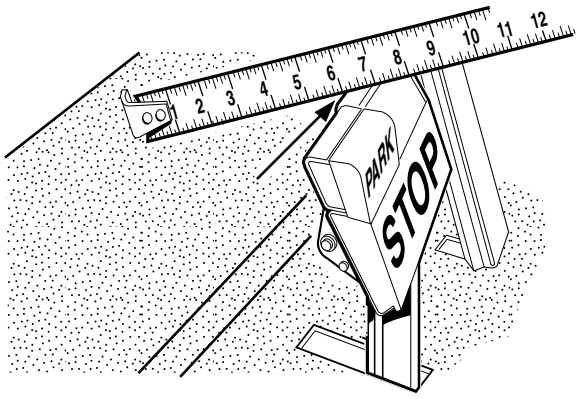


Figure 5-10 Brake Pedal Height Adjustment



Correct pedal position is 6 inches (15.2 cm) from floormat to back of brake pedal.

Figure 5-11 Brake Pedal Height Measurement

3. Adjust brake pedal free play. **See following NOTE.**

NOTE: *Brake pedal free play is the distance the brake pedal can be pressed before the brake actuator arm (at the brake cluster) moves.*

3.1. Measure perpendicularly from the floorboard to the back of the brake pedal, then press the brake pedal and measure the distance that the pedal moves before all of the slack is taken out of the brake cables **(Figure 5-11, Page 5-11)**.

3.2. Tighten the nut (2) on the equalizer rod (1) so that the brake pedal free play is 1/4 to 1/2 inch (6 mm to 13 mm) **(Figure 5-3, Page 5-3)**.

3.3. Tighten the jam nut (3) while holding the adjustment nut (2) in the correct position.

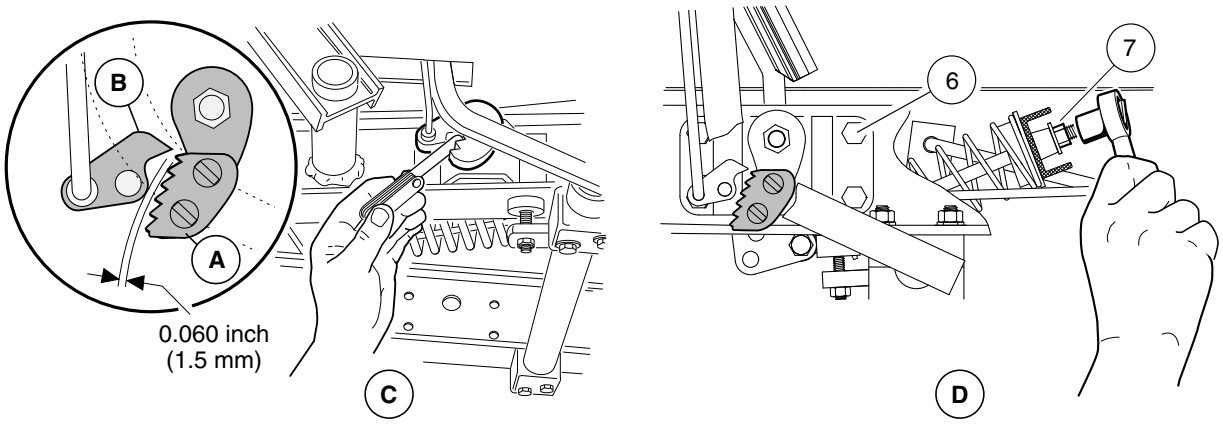
4. Adjust park brake ratchet/pawl gap and pawl engagement.

4.1. Inspect the park brake pawl and ratchet for excessive wear, grooves, cracks, or chips. If either the pawl or ratchet is damaged, both must be replaced.

4.2. Adjust retaining nut (7) on spring support rod until there is a 0.060 inch (1.5 mm) gap between the pawl and the tips of the ratchet teeth. Use a feeler gauge to verify the gap **(Figure 5-12, Page 5-12)**. The gap should be consistent through range of pawl movement. If the gap is not consistent, loosen the four bolts (6) securing the accelerator pivot rod supports and adjust the supports. If the gap becomes smaller as the park brake pedal is pressed, move the pivot rod supports slightly rearward until the gap is consistent. If the gap becomes larger as the park brake pedal is pressed, move the pivot rod supports slightly forward until gap is consistent. **See following NOTE.**

NOTE: *The accelerator rod must also be checked if the ratchet/pawl gap is adjusted.* ***See step 6.***

The accelerator rod must be disconnected before proceeding to the next step.



C. Bottom View
D. Cutaway Side View

Figure 5-12 Park Brake Ratchet/Pawl Gap Adjustment

4.3. With the park brake unlocked, measure and note the distance from the top of the accelerator pedal to the floorboard, then lock the park brake **(Figure 5-13, Page 5-13)**.

4.4. With the park brake locked, make sure at least 75% of ratchet tooth length engages the pawl **(Figure 5-14, Page 5-13)**. Tooth engagement should be between the two lines marked on the pawl.

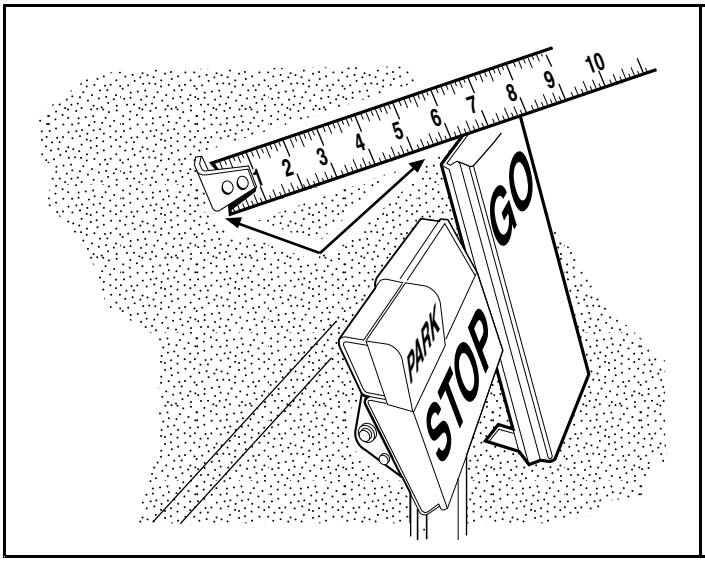
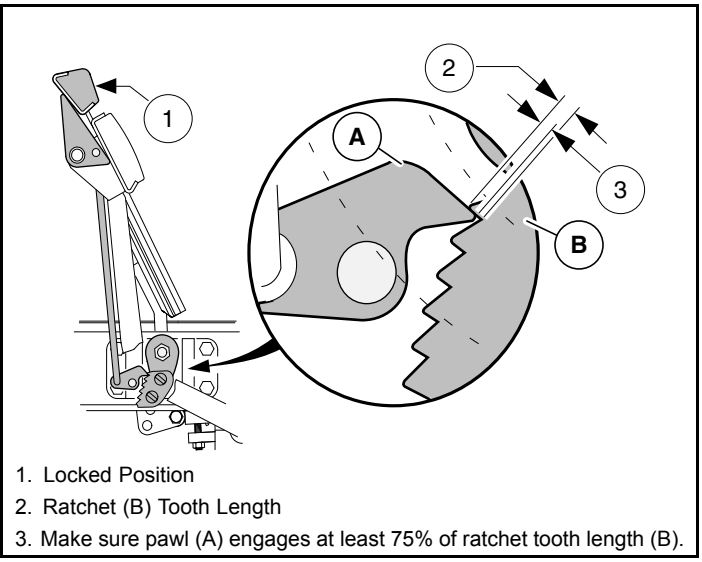


Figure 5-13 Accelerator Pedal Height Measurement



1. Locked Position
2. Ratchet (B) Tooth Length
3. Make sure pawl (A) engages at least 75% of ratchet tooth length (B).

Figure 5-14 Ratchet/Pawl Tooth Engagement

4.5. With park brake still locked, measure the distance from the top of accelerator pedal to floorboard. If the measurement has changed, ratchet tooth engagement is too deep and must be adjusted.

4.6. If ratchet/pawl engagement must be adjusted, disconnect the ball joint at the top of the brake rod and rotate the ball joint sleeve clockwise to increase engagement or counterclockwise to decrease engagement. Reconnect ball joint **(Figure 5-15, Page 5-13)**.

4.7. If the accelerator push rod was disconnected from the accelerator pedal, reconnect it.

4.8. Check for proper brake operation prior to driving the vehicle.

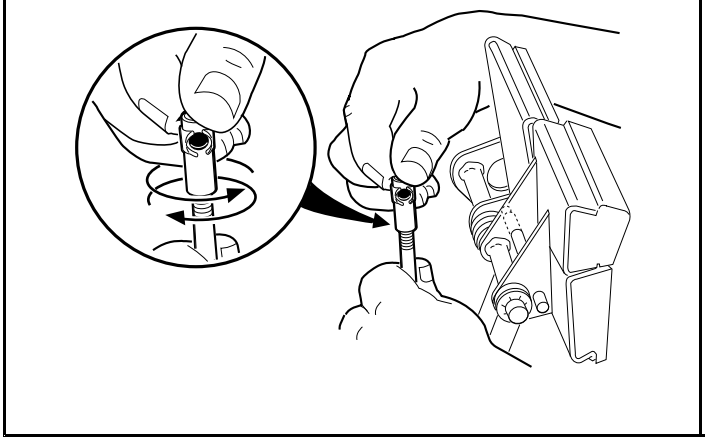
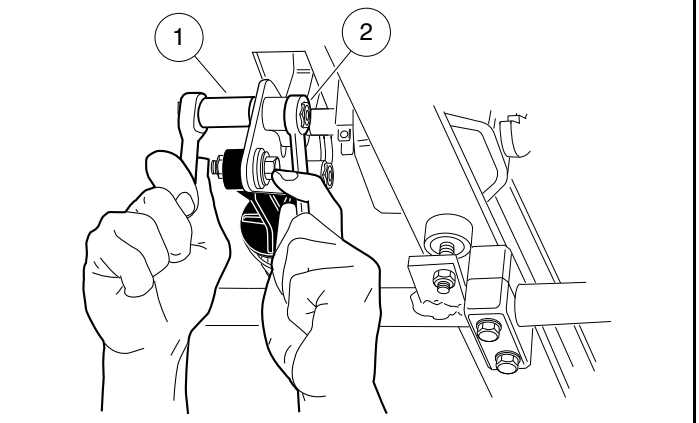


Figure 5-15 Brake Rod Adjustment

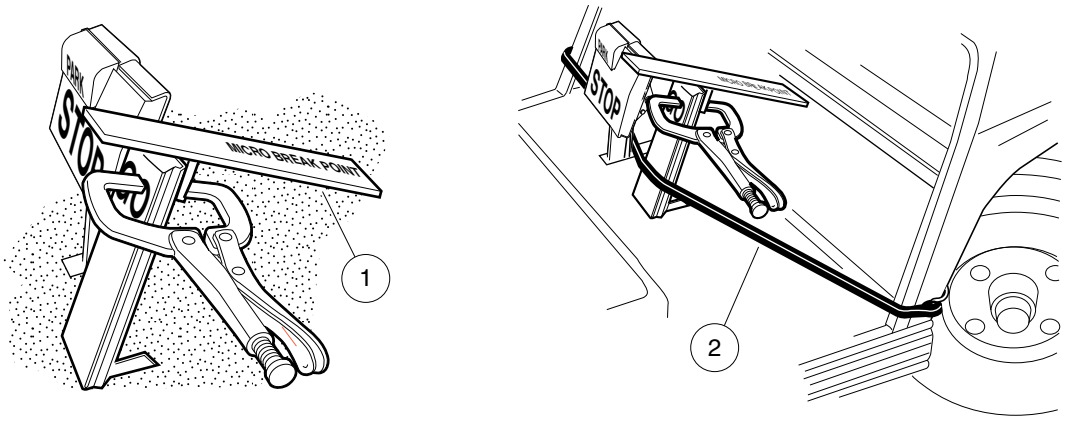


1. 1/2-Inch Socket
2. 1/2-Inch Wrench

Figure 5-16 Accelerator Pedal Height Adjustment

5. Adjust accelerator pedal height.

5.1. Loosen the nut and bolt **(Figure 5-16, Page 5-13)** securing the accelerator pedal to the pivot plate. Clamp the accelerator pedal adjustment tool to the accelerator pedal, with the end marked *accelerator pedal height* closest to the floorboard. Press the accelerator pedal until the end of the tool rests against the floorboard; pedal height should be 5-5/8 inches (14.3 cm). Use a rubber strap to hold pedal in position against the floorboard and then tighten nut to 26 ft·lb (35.3 N·m) **(Figure 5-17, Page 5-14)**.



1. Accelerator Pedal Adjustment Tool
2. Rubber Strap

Figure 5-17 Accelerator Pedal Height Adjustment

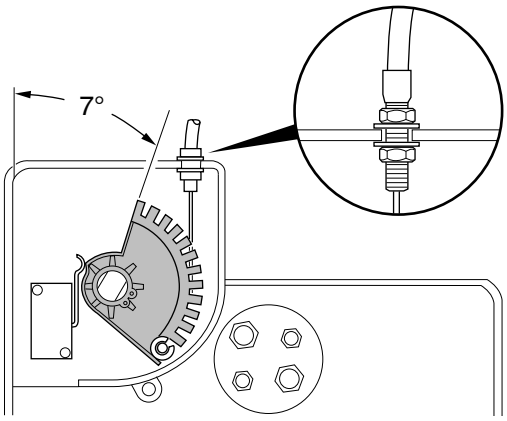
6. Adjust the accelerator rod. **See following DANGER.**

⚠ DANGER

- **Before servicing, turn the key switch to the OFF position and place the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position.**
- **To prevent accidentally starting the vehicle, disconnect the battery cables as instructed. See Disconnect the Battery- Gasoline Vehicles, Section 1, Page 1-4.This will prevent the possibility of the vehicle running over you when you are adjusting the accelerator rod.**

6.1. Remove the electrical box screw and cover. **See preceding DANGER.**

6.2. Loosen the jam nuts (25) and disconnect the accelerator rod (17) at the accelerator pedal **(Figure 5-6, Page 5-6)**. Adjust the length of the rod to obtain an accelerator cable cam position of 7° as shown **(Figure 5-18, Page 5-14)**. **See following CAUTION.**



Top View of the Electrical Component Box

3113

Figure 5-18 Accelerator Cable

⚠ CAUTION

- **After accelerator rod adjustment, make sure that approximately the same number of threads are exposed at each end of the accelerator rod.**
- **If the lever on the limit switch in the electrical box is bent, replace the limit switch.**
- **When loosening jam nuts on the accelerator rod with one end disconnected, hold the disconnected accelerator rod with locking pliers.**
- **When tightening jam nuts on the accelerator rod, hold the disconnected ball joint with locking pliers.**

6.3. Reconnect the accelerator rod at the accelerator pedal.

6.4. Before tightening jam nuts on accelerator rod, set park brake to first ratchet and pawl position. Press accelerator pedal and make sure the following events occur in the exact order shown:

EVENT	APPROXIMATE PEDAL TRAVEL
Park brake release	0° to 4°
Solenoid activation and engine start	4° to 15°
Throttle body actuation	15° and greater

6.5. If the events above occur as they should, hold the ball joint at each end of the accelerator rod with pliers and tighten the accelerator rod jam nut against it.

6.6. Ensure that the events occur as described in the table above. **See following NOTE.**

NOTE: *After the pedal group and accelerator rod are adjusted, the final governed engine RPM should be set.* ***See Engine RPM Adjustment, Section 21, Page 21-10.***

6.7. Install the electrical box cover and screw.

7. Adjust the brakes. **See Brake Adjustment, Section 6, Page 6-9.**

8. Connect the battery cables. **See Connect the Battery- Gasoline Vehicles on page 1-4. See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

PEDAL GROUP ADJUSTMENT – ELECTRIC VEHICLES

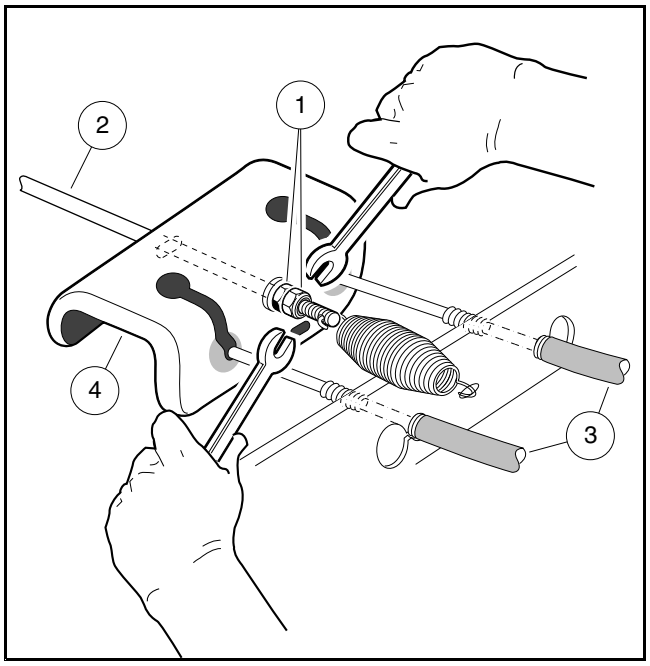
See General Warnings on page 1-1.

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

2. Adjust brake pedal height.

2.1. Chock wheels and release park brake. Lift rear of vehicle and place jack stands under the axle tubes to support the vehicle.

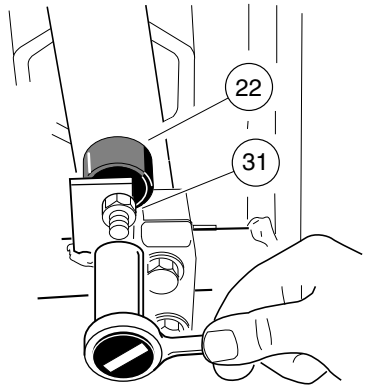
2.2. To provide slack in the brake cables, loosen the equalizer retaining nuts (1) on the equalizer rod (2) **(Figure 5-19, Page 5-16)**.



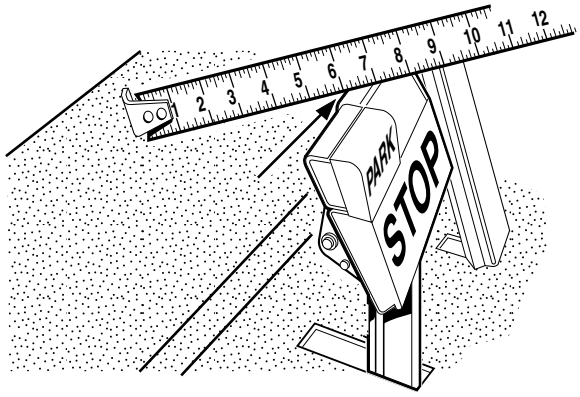
1400-18100-10209
Figure 5-19 Loosen Rear Brake Equalizer Rod Nuts

2.3. Loosen the brake stop jam nut (31), then relieve pedal pressure on the stop by pushing down slightly on the pedal. Next, adjust the brake stop bumper (22) up or down **(Figure 5-20, Page 5-16)**. Adjusting the bumper upward decreases distance between pedal and floorboard. Adjusting the bumper downward increases distance between pedal and floorboard. Proper brake pedal height is 6 inches (15.2 cm) **(Figure 5-21, Page 5-16)**.

2.4. Tighten the jam nut (31) to 8 ft·lb (9.5 N·m) **(Figure 5-20, Page 5-16)**.



1400-18000-10211
Figure 5-20 Brake Pedal Height Adjustment



Correct pedal position is 6 inches (15.2 cm) from floormat to back of brake pedal.

1400-18000-10212
Figure 5-21 Brake Pedal Height Measurement

3. Adjust brake pedal free play. **See following NOTE.**

NOTE: *Brake pedal free play is the distance the brake pedal can be pressed before the brake actuator arm (at the brake cluster) moves.*

3.1. Measure perpendicularly from the floorboard to the back of the brake pedal, then press the brake pedal and measure the distance that the pedal moves before all of the slack is taken out of the brake cables **(Figure 5-21, Page 5-16)**.

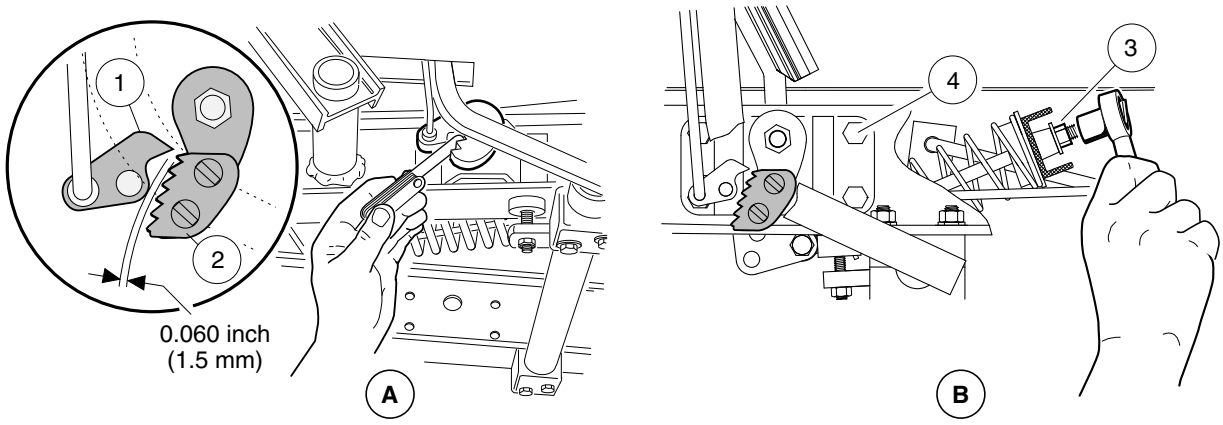
3.2. Tighten the nut (2) on the equalizer rod (1) so that the brake pedal free play is 1/4 to 1/2 inch (6.3 to 12.7 mm) **(Figure 5-3, Page 5-3)**.

3.3. Tighten the jam nut (3) while holding the adjustment nut (2) in the correct position.

4. Adjust park brake ratchet/pawl gap and pawl engagement.

4.1. Inspect the park brake pawl (1) and ratchet (2) for excessive wear, grooves, cracks, or chips **(Figure 5-22, Page 5-17)**. If either the pawl or ratchet is damaged, both must be replaced.

4.2. Adjust retaining nut (3) on spring support rod until there is a 0.060 inch (1.5 mm) gap between the pawl and the tips of the ratchet teeth. Use a feeler gauge to verify the gap **(Figure 5-22, Page 5-17)**. The gap should be consistent through range of pawl movement. If the gap is not consistent, loosen the four bolts (4) securing the accelerator pivot rod supports and adjust the supports. If the gap becomes smaller as the park brake pedal is pressed, move the pivot rod supports slightly rearward until the gap is consistent. If the gap becomes larger as the park brake pedal is pressed, move the pivot rod supports slightly forward until gap is consistent.



A. Bottom View
B. Cutaway Side View

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Figure 5-22 Park Brake Ratchet/Pawl Gap Adjustment

4.3. With the park brake unlocked, measure and note the distance from the top of the accelerator pedal to the floorboard, then lock the park brake **(Figure 5-23, Page 5-18)**.

4.4. With the park brake locked, make sure at least 75% of ratchet tooth length engages the pawl **(Figure 5-24, Page 5-18)**. Tooth engagement should be between the two lines marked on the pawl.

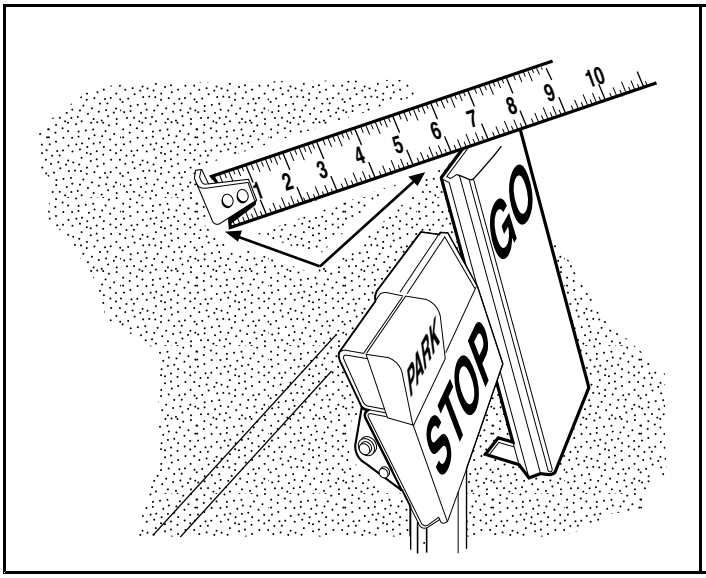
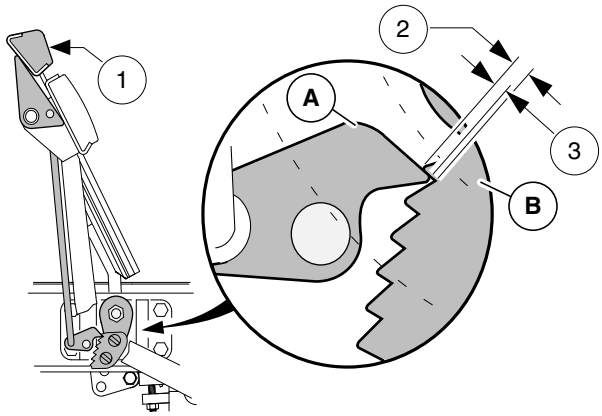


Figure 5-23 Accelerator Pedal Height Measurement



1. Locked Position
2. Ratchet (B) Tooth Length
3. Make sure pawl (A) engages at least 75% of ratchet tooth length (B).

Figure 5-24 Ratchet/Pawl Tooth Engagement

4.5. With park brake still locked, measure the distance from the top of accelerator pedal to floorboard. If the measurement has changed, ratchet tooth engagement is too deep and must be adjusted.

4.6. If ratchet/pawl engagement must be adjusted, disconnect the ball joint at the top of the brake rod and rotate the ball joint sleeve clockwise to increase engagement or counterclockwise to decrease engagement. Reconnect ball joint **(Figure 5-25, Page 5-18)**.

4.7. Check for proper brake operation prior to driving the vehicle.

5. Adjust accelerator pedal height.

5.1. Loosen the nut and bolt **(Figure 5-26, Page 5-18)** securing the accelerator pedal to the pivot plate. Clamp the accelerator pedal adjustment tool to the accelerator pedal, with the end marked *accelerator pedal height* closest to the floorboard. Press the accelerator pedal until the end of the tool rests against the floorboard; pedal height should be 5-5/8 inches (14.3 cm). Use a rubber strap to hold pedal in position against the floorboard and then tighten nut to 26 ft·lb (35.3 N·m) **(Figure 5-27, Page 5-19)**.

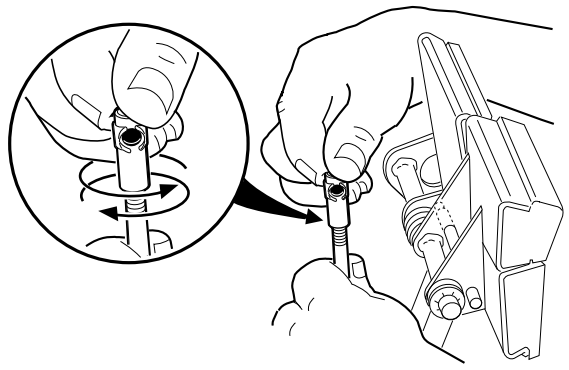
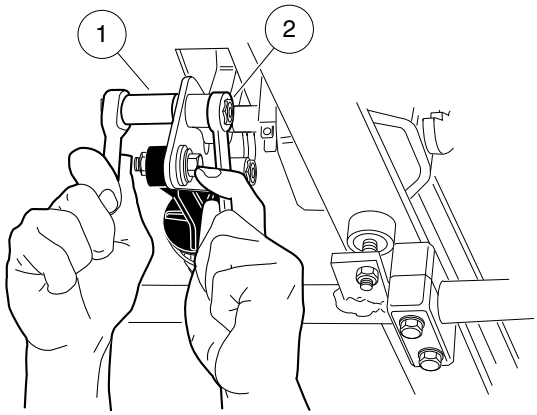
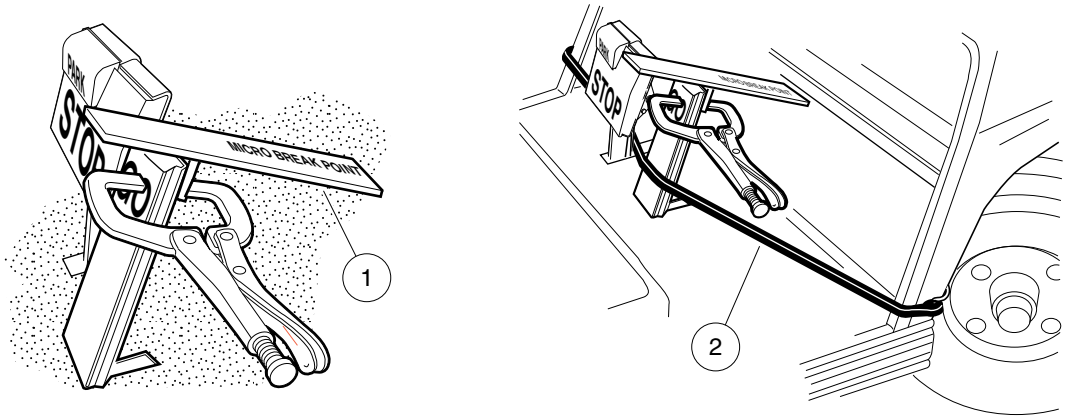


Figure 5-25 Brake Rod Adjustment



1. 1/2-Inch Socket
2. 1/2-Inch Wrench

Figure 5-26 Accelerator Pedal Height Adjustment



1. Accelerator Pedal Adjustment Tool
2. Rubber Strap

Figure 5-27 Accelerator Pedal Height Adjustment

6. Adjust the brakes. **See Brake Adjustment, Section 6, Page 6-9.**
7. Connect the battery cables. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

Pagination Page

SECTION 6 — WHEEL BRAKE ASSEMBLIES

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

Asbestos Dust Warning

- **Some aftermarket brake shoes contain asbestos dust. Asbestos dust is created when these brake mechanisms are handled. Wear approved eye and respiratory protection when disassembling and cleaning brake mechanisms. Inhalation of asbestos could result in severe personal injury or death. Do not use compressed air or aerosol sprays to clean the brake mechanism. Clean brake mechanism using the negative pressure enclosure/hepa vacuum system or low pressure/wet cleaning method per OSHA/29 CFR - 1910.1001.**

GENERAL INFORMATION

This vehicle is equipped with self-adjusting mechanically-expanding shoe drum brakes on each rear wheel.

BRAKE SHOE REMOVAL

See General Warnings on page 1-1. See also Asbestos Dust Warning on page 6-1.

1. Disconnect the battery cables and either discharge the controller or disconnect the spark plug wire. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
   See Disconnect the Battery- Gasoline Vehicles on page 1-4.
2. Place chocks at the front wheels. Loosen, but do not remove, lug nuts on rear wheels and lift the rear of the vehicle with a chain hoist or floor jack. Place jack stands under the axle tubes to support the vehicle. **See WARNING "Lift only one end..." in General Warnings on page 1-1.**
3. Loosen the equalizer retaining nuts (1) on the equalizer rod (2) to loosen the brake cable **(Figure 6-1, Page 6-2)**.
4. Remove the rear wheels and brake drums. If the brake drums were easily removed, go to step 6. **See following CAUTION and NOTE.**

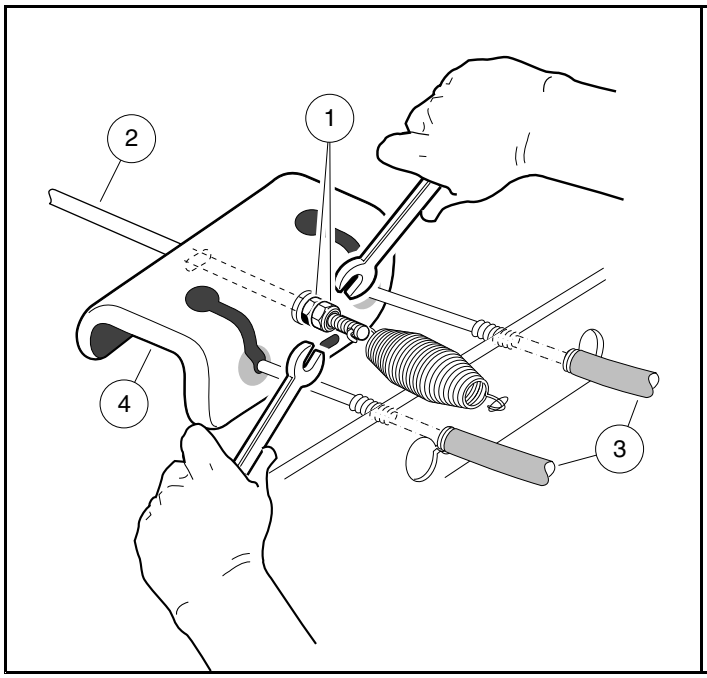
⚠ CAUTION

- **Worn or damaged brake drums cannot be machined to refinish them. Replace as necessary.**

NOTE: *When servicing vehicles with severely worn brake shoes and when the drums cannot be removed by normal methods, proceed to step 5 to minimize damage to the brake assemblycomponents.*

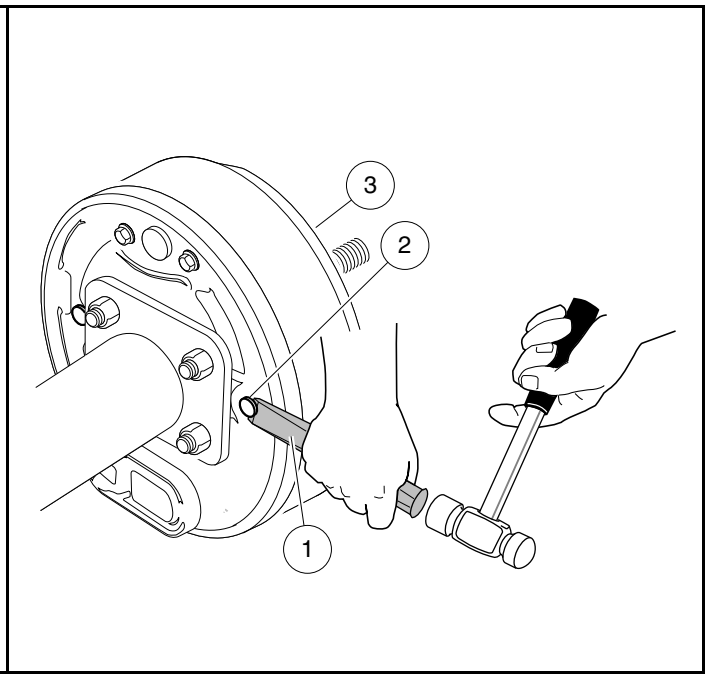
5. Remove brake drums and badly worn brake shoes.

5.1. On the back of each brake cluster assembly, locate the heads of two brake shoe retainer pins. It may be necessary to remove sealant material around the head of each pin.



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Figure 6-1 Loosen Brake Cables



1400-18100-10220

Figure 6-2 Shoe Retainer Pins

5.2. Insert a 1/2 inch x 5/8 inch (1.27 x 1.58 cm) cold chisel (1) under the head of each pin (2) and shear them off as illustrated **(Figure 6-2, Page 6-2)**. This will release the brake shoes from the backing plate, allowing them to pivot away from the inside of the brake drum (3), and allow the brake drum to be pulled free. After completing step 6, skip step 7. **See following NOTE.**

NOTE: *Although step 6 allows easier access to the brake shoes, it is not imperative to do so in order to remove the brake shoes.*

6. **For electric vehicles:** Remove the axle shaft. **See Axle Shaft and Oil Seal Removal, Section 17, Page 17-1.**

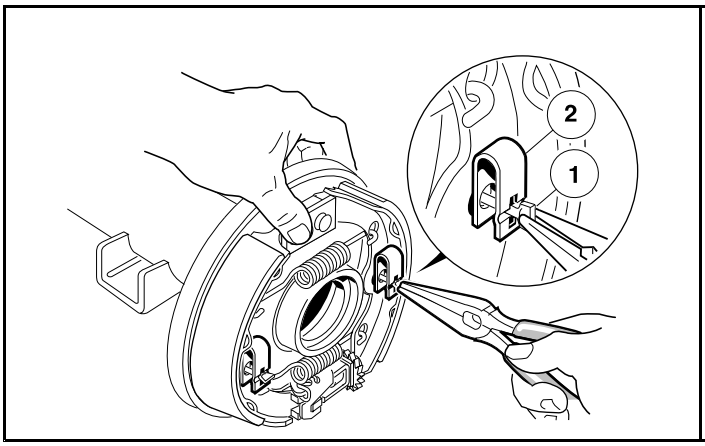
   For gasoline vehicles: Remove the wheel hub assembly. **See Rear Hub Removal, Section 24, Page 24-4.**

7. Using needle nose pliers, rotate the clip retainer pin (1) 90° to remove the shoe retainer clip (2) **(Figure 6-3, Page 6-3)**. **See following CAUTION.**

⚠ CAUTION

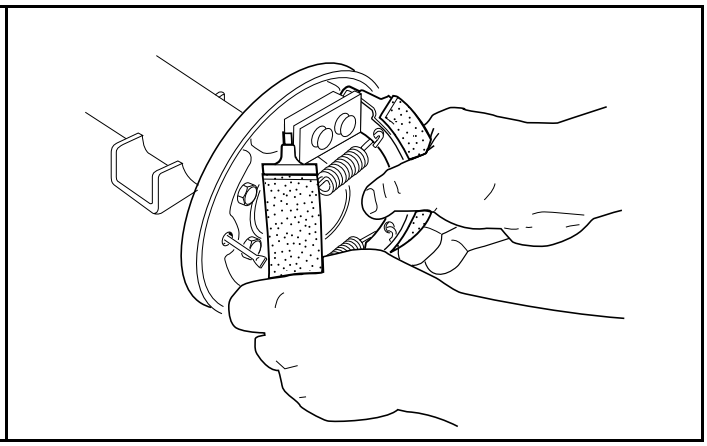
- **The brake shoes are under pressure and can release suddenly when brake shoe retainers are removed.**

8. Grasp both brake shoes and pull them, together with the springs, out of the brake assembly as shown **(Figure 6-4, Page 6-3)**.
9. Remove the adjuster wheel (1) and two washers (2 and 3) from the backing plate **(Figure 6-5, Page 6-3)**.



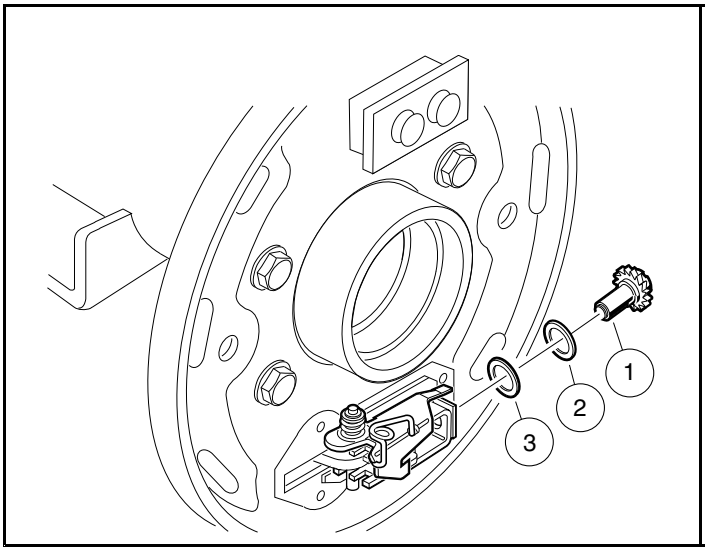
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Figure 6-3 Remove Shoe Retainer Clip



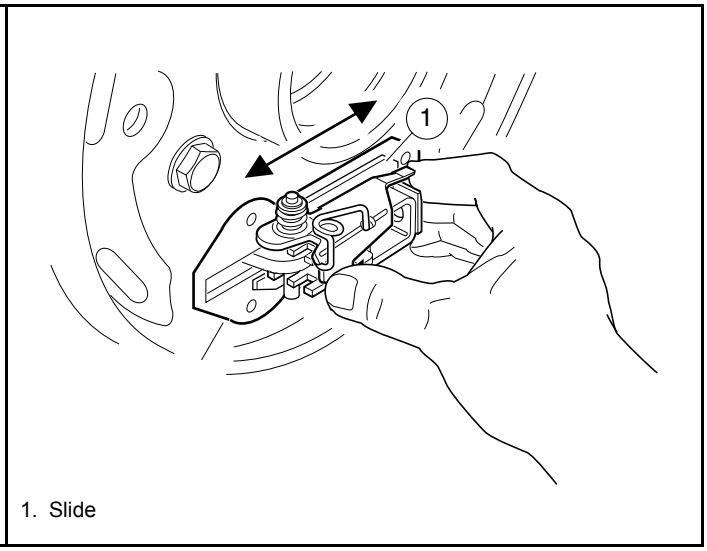
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Figure 6-4 Remove Brake Shoes



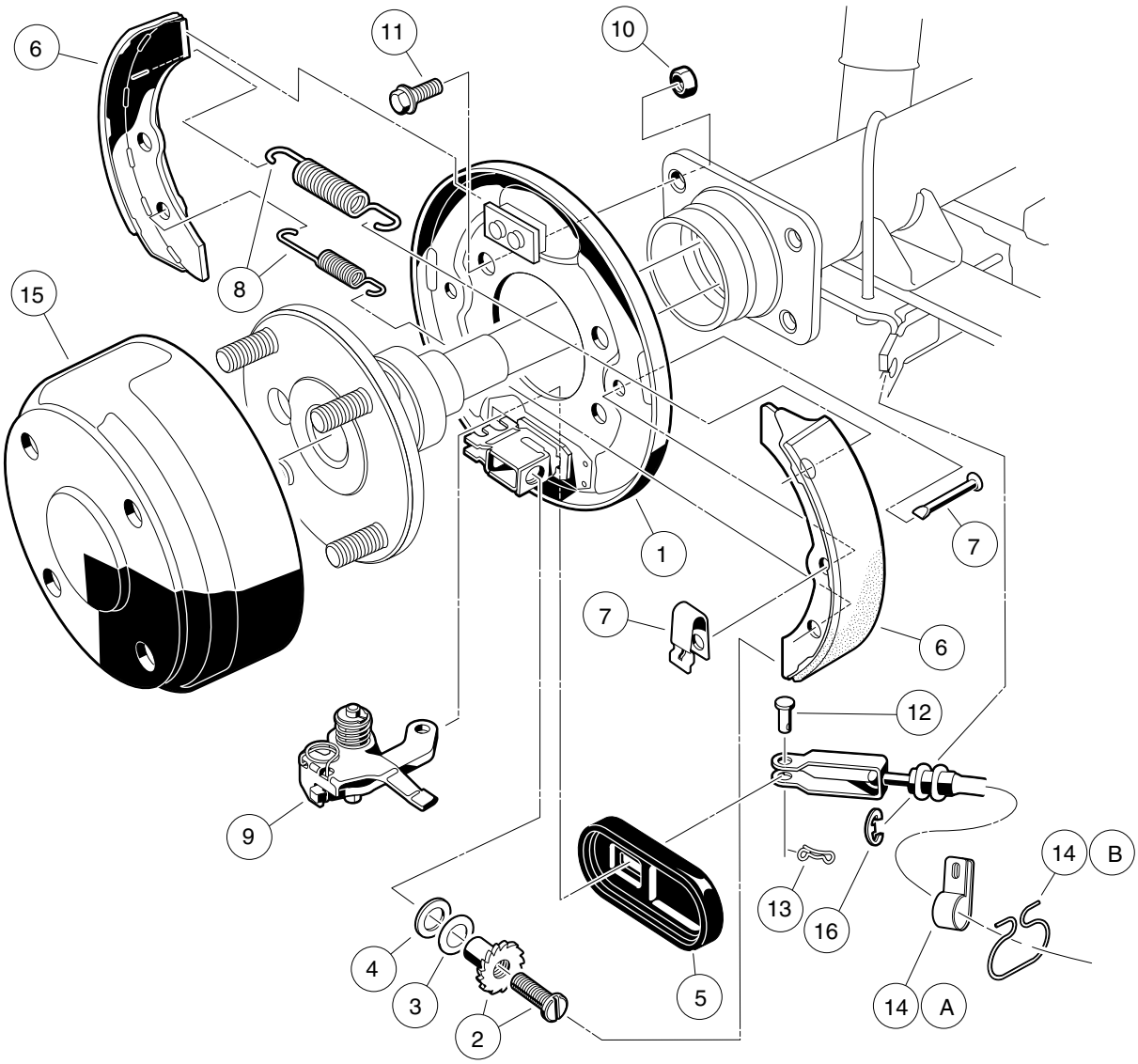
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Figure 6-5 Remove Adjuster Wheel



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Figure 6-6 Lubricate Slide and Slide Plate



A. Electric Vehicle
B. Gasoline Vehicle

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Figure 6-7 Self-adjusting Wheel Brake Assembly

BRAKE ASSEMBLY CLEANING

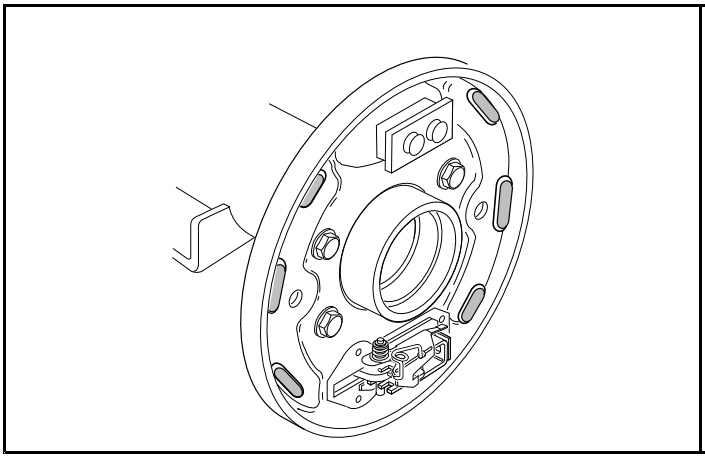
See General Warnings on page 1-1. See also Asbestos Dust Warning on page 6-1.

1. Carefully clean the brake backing plate and all of its mechanical components.
2. Remove the rubber boot from backing plate and wipe with a clean damp cloth.
3. For vehicles equipped **without** a slide plate (2), lubricate the backing plate, where the slide operates, with dry moly lubricant.
4. Lubricate the slide (1) with dry moly lubricant. After lubricating, work slide back and forth against backing plate to ensure that it slides smoothly and easily. Install rubber boot onto backing plate.

⚠ WARNING

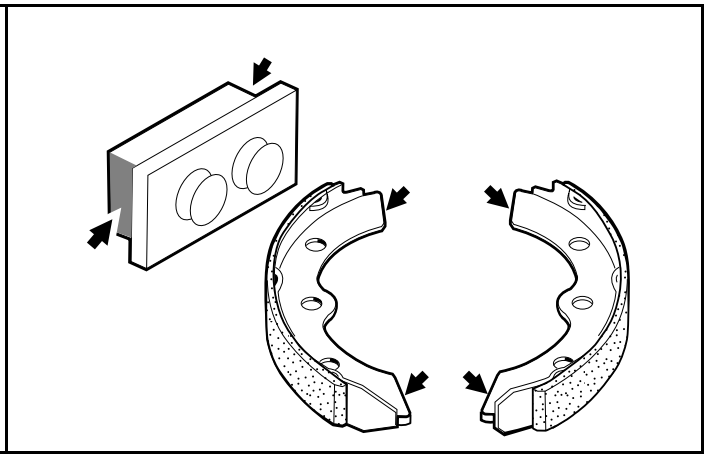
- **Apply grease carefully when performing the following steps. Do not allow any grease to get onto the friction surfaces of the brake shoe pads or the brake drum. Failure to adhere may could cause diminished brake performance, possibly resulting in property damage or severe personal injury.**

5. Use a small brush to carefully apply a light coat of white lithium NLGI #2 grease (Dow Corning® BR2-Plus or equivalent) on each of the six raised bosses on the brake backing plate **(Figure 6-8, Page 6-5)**. **See preceding WARNING.**
6. Use a small brush to carefully apply a light coat of white lithium NLGI #2 grease (Dow Corning BR2-Plus or equivalent) to each end of both brake shoes and into the slots in the brake shoe mounting block as shown **(Figure 6-9, Page 6-5)**. **See preceding WARNING.**



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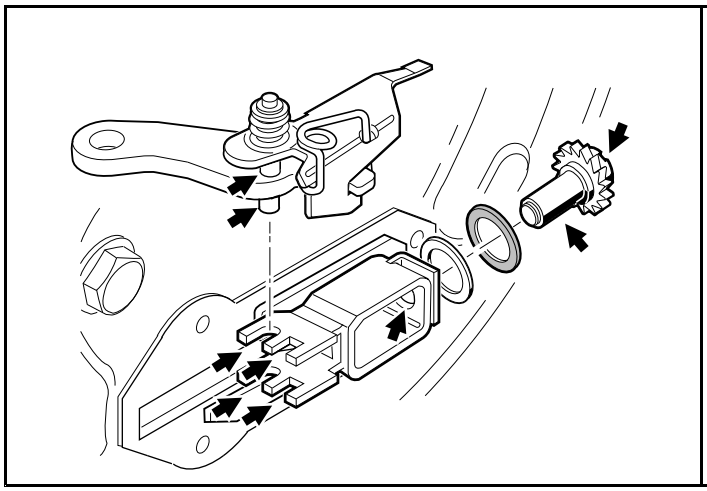
Figure 6-8 Apply Grease On Bosses



641

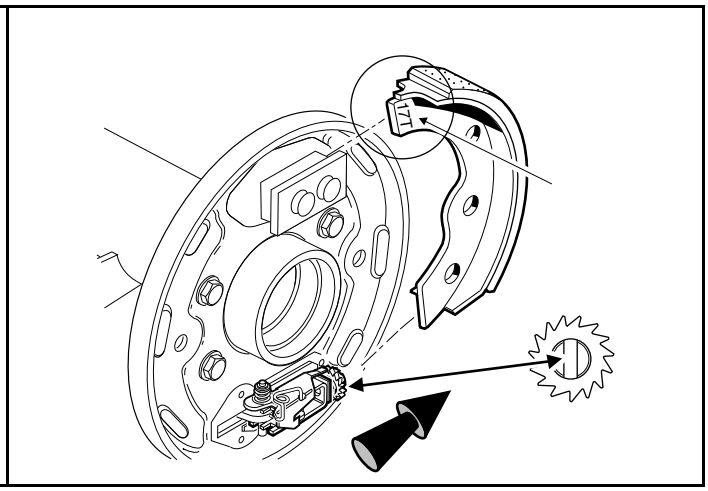
Figure 6-9 Apply Grease To Brake Shoes and Slots

7. Use a small brush to carefully apply a light coat of white lithium NLGI #2 grease (Dow Corning BR2-Plus or equivalent) to the brake adjuster assembly, adjuster wheel shoe slots, and the shaft of the adjuster wheel as shown **(Figure 6-10, Page 6-6)**. **See preceding WARNING.**
8. Install the adjuster wheel (1) and two washers (2 and 3) into the adjuster assembly **(Figure 6-5, Page 6-3)**.



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Figure 6-10 Apply Grease To Brake Adjuster



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Figure 6-11 Install Adjuster Wheel, Trailing Shoe

BRAKE SHOE INSTALLATION

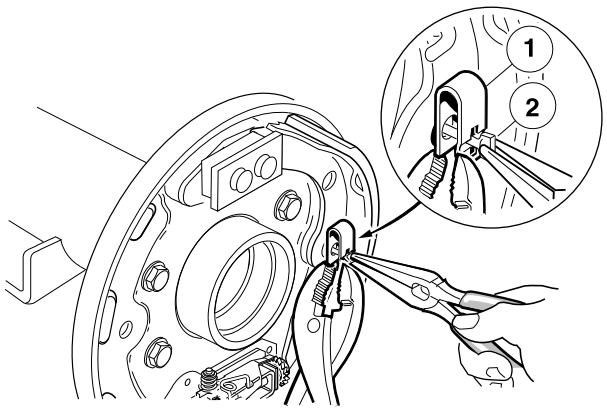
See General Warnings on page 1-1. See also Asbestos Dust Warning on page 6-1.

1. Turn the adjusting wheel screw so that the shoe slot is vertical, then position the trailing shoe in the slots in the shoe mounting block and adjuster assembly **(Figure 6-11, Page 6-6)**. **See following NOTE.**

NOTE: *The trailing shoe has 17T stamped into the tip of the shoe flange **(Figure 6-11, Page 6-6)**. The leading shoe is stamped 17L. When installing the shoes, the stamping on both shoes should be oriented to the top of the brake assembly. When installing the shoes on the passenger side of the vehicle, the side of the trailing shoe flange marked 17T should be facing out and be visible. On the driver side, the 17L on the leading shoe should be facing out and be visible.*

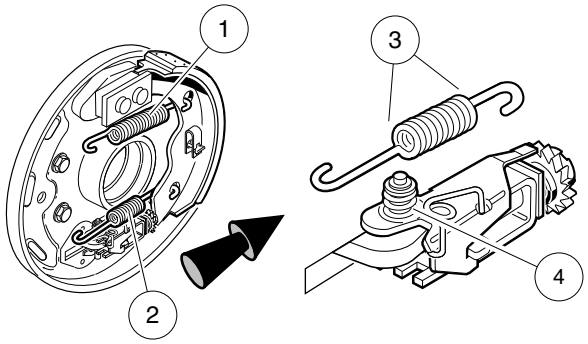
*When installed on the backing plate, the **leading** shoe (stamped 17L) is **always** oriented toward the **rear** of the vehicle.*

2. Install the shoe retainer clip, using pliers to compress the clip (1) while turning the retainer pin (2) into a horizontal position **(Figure 6-12, Page 6-7)**.
3. Attach the springs onto the trailing shoe already installed. Then, hold the leading shoe next to the trailing shoe, correctly oriented, and attach the springs to it **(Figure 6-13, Page 6-7)**.



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Figure 6-12 Install Trailing Shoe Retainer Clip

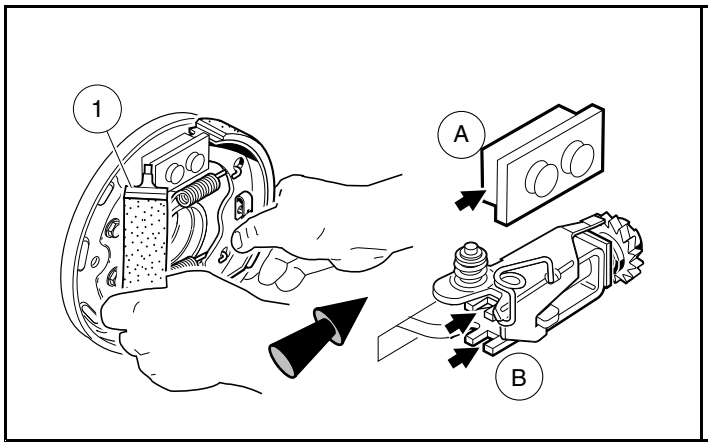


1. Bronze Spring 2. Silver Spring 3. Spring Coils 4. Note that the silver spring is mounted with the coils to the side of the adjustment lever spring (A).

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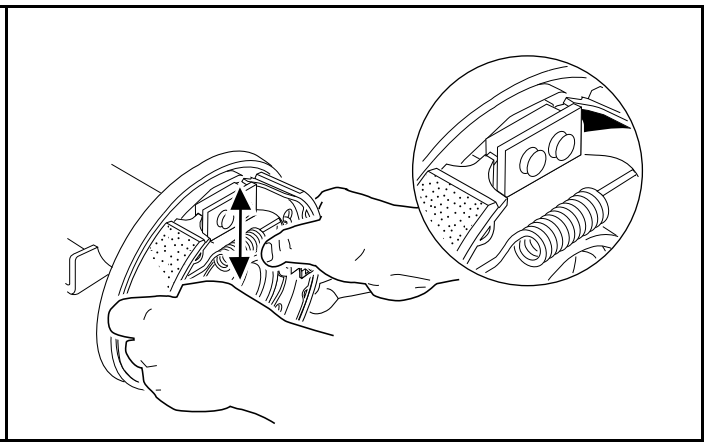
Figure 6-13 Attach Springs

4. While maintaining spring attachment on both shoes, position tips of leading shoe (1) in the mounting slots and then push shoe into place. Hold shoe in position and install retaining clip **(Figure 6-14, Page 6-8)**.
5. After the shoes are installed, move them together up and down and side to side to make sure that they will easily slide approximately from 1/4 to 3/8 inch (6.3 mm to 9.5 mm) without binding **(Figure 6-15, Page 6-8)**.



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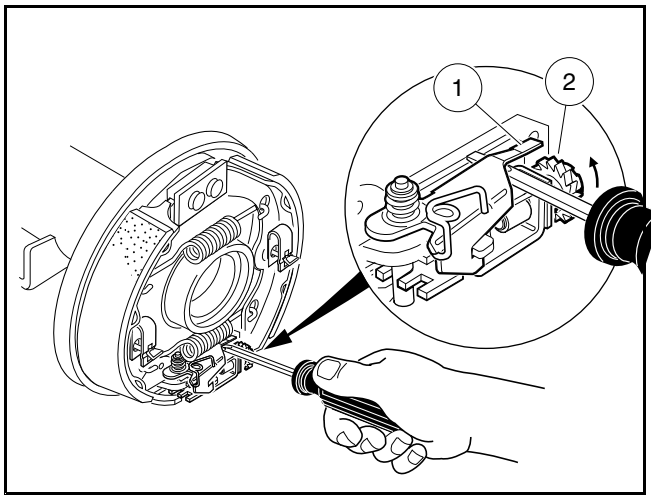
Figure 6-14 Install Leading Shoe



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Figure 6-15 Check Shoe Positions

6. Place a flatblade screwdriver under the adjusting arm (1) and raise the arm off of the adjusting wheel (2). While holding the arm (1) up, turn the wheel (2) upward until it stops **(Figure 6-16, Page 6-8)**. Arm must engage teeth of the wheel. Remove the screwdriver.



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Figure 6-16 Set Adjusting Wheel

7. **For electric vehicles:** Install the axle shaft. **See Axle Shaft and Oil Seal Installation, Section 17, Page 17-4.**

   For gasoline vehicles: Install the wheel hub assembly. **See Rear Hub Installation, Section 24, Page 24-4.**

8. Install the brake drum, and make sure that it is properly seated. **See following NOTE.**

NOTE: *If drum installation is difficult, the brake shoes may need to be adjusted vertically in the mounting slots.*

9. After the drum is installed, make sure the axle and drum turn freely and then install the wheel. **See Wheel Installation on page 8-1.**
10. Connect the battery cables. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Connect the Battery- Gasoline Vehicles on page 1-4.**

BRAKE ADJUSTMENT

See General Warnings on page 1-1. See also Asbestos Dust Warning on page 6-1.

1. When cleaning or repair on both wheels is complete, and with the brake cable still loose, lower the vehicle to the floor.
2. Make the brake shoe and drum adjustment by pressing and releasing the brake pedal repeatedly until an audible clicking can no longer be heard.
3. Adjust brake pedal free play.

3.1. **For gasoline vehicles: See Pedal Group Adjustment – Gasoline Vehicles on page 5-10.**

3.2. **For electric vehicles: See Pedal Group Adjustment – Electric Vehicles on page 5-15.**

BRAKE ASSEMBLY REMOVAL AND INSTALLATION

See General Warnings on page 1-1. See also Asbestos Dust Warning on page 6-1.

BRAKE ASSEMBLY REMOVAL

1. Disconnect the battery cables and either discharge the controller or disconnect the spark plug wire. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
   See Disconnect the Battery- Gasoline Vehicles on page 1-4.
2. Place chocks at the front wheels and loosen the lug nuts on the rear wheels. Lift the rear of the vehicle with a chain hoist or floor jack. Place jack stands under the axle tubes to support the vehicle. **See WARNING "Lift only one end..." in General Warnings on page 1-1.**
3. Loosen the brake cables, remove the rear wheel, remove the brake drum. **See Brake Shoe Removal on page 6-1.**
4. **For electric vehicles:** Remove the axle shaft. **See Axle Shaft and Oil Seal Removal, Section 17, Page 17-1.**

   For gasoline vehicles: Remove the wheel hub assembly. **See Rear Hub Removal, Section 24, Page 24-4.**
5. Remove bow tie locking pin (13) and clevis pin (12) from brake cable **(Figure 6-7, Page 6-4)**.
6. Remove four bolts (11) and lock nuts (10) that mount the brake assembly to the transaxle **(Figure 6-7, Page 6-4)**.
7. Remove brake assembly from transaxle.

BRAKE ASSEMBLY INSTALLATION

1. Install in reverse order of disassembly. Use new bow tie locking pins when installing brake cables. **See following CAUTION.**

⚠ CAUTION

- **Before installing axle shaft, clean any residual oil from the exposed end of the axle tube and from the oil seal area.**

2. Be sure new bolts (11) and new lock nuts (10) are used to mount the brake assembly **(Figure 6-7, Page 6-4)**.
3. Tighten nuts to 17 ft·lb (23.0 N·m). If torquing the bolt heads, torque to 30 ft·lb (40.6 N·m).
4. **For electric vehicles:** Install the axle shaft. **See Axle Shaft and Oil Seal Installation, Section 17, Page 17-4.**

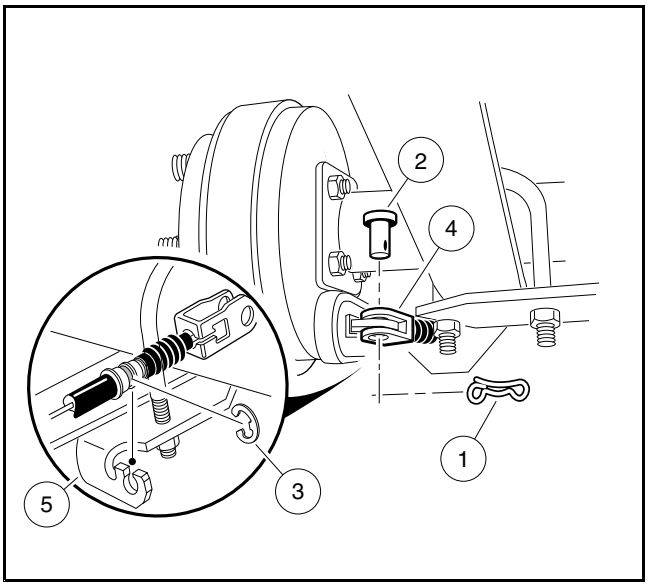
   For gasoline vehicles: Install the wheel hub assembly. **See Rear Hub Installation, Section 24, Page 24-4.**
5. Install the brake drum and rear wheel. **See Brake Shoe Installation on page 6-7.**
6. Tighten lug nuts on rear wheels, using a star pattern, to 65 ft·lb (88 N·m). **See Wheel Installation on page 8-1.**
7. Adjust the brakes. **See Brake Adjustment on page 6-9.**

BRAKE CABLE REMOVAL AND INSTALLATION

See General Warnings on page 1-1. See also Asbestos Dust Warning on page 6-1.

BRAKE CABLE REMOVAL

1. Disconnect the battery cables and either discharge the controller or disconnect the spark plug wire. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
   See Disconnect the Battery- Gasoline Vehicles on page 1-4.
2. Place chocks at the front wheels.
3. Release the park brake if engaged and loosen equalizer retaining nuts (1) on equalizer rod (2) to slightly loosen the brake cables (3) **(Figure 6-1, Page 6-2)**.
4. Rotate the brake cable upward and pull cable end through hole in top of equalizer (4).
5. Remove E-clip securing front end of cable to frame crossmember and pull cable from crossmember.
6. Remove bow-tie pin (1) and the clevis pin (2) from the brake lever on each wheel and pull the clevis (4) away from the lever **(Figure 6-17, Page 6-11)**.
7. Remove E-clip (3) from cable at the cable support bracket (5). Remove cable from bracket.
8. Note routing of cable through hanger for installation of new cable. Pull cable from vehicle.



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Figure 6-17 Disconnect Cables at Rear Brakes

BRAKE CABLE INSTALLATION

1. Place the end of the new cable into the equalizer (4) **(Figure 6-1, Page 6-2)**. Secure the cable to the vehicle frame with new E-clip. Route cable through hanger in the same manner as before.
2. At the rear wheel brake, connect the cable to the brake actuator arm using new clevis pin (2) and new bow-tie pin (1) **(Figure 6-17, Page 6-11)**.
3. Place the cable in the cable support bracket (5) and secure with new E-clip (3).
4. Adjust the brakes. **See Brake Adjustment on page 6-9.**

Pagination Page

SECTION 7 — STEERING AND FRONT SUSPENSION

7

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

GENERAL INFORMATION

Steering is controlled through a rack and pinion steering assembly that is connected by a steering column to a steering wheel. No manual adjustment to the rack and pinion gear assembly is required. A spring loaded self-adjusting mechanism is incorporated into the assembly.

STEERING WHEEL

See General Warnings on page 1-1.

STEERING WHEEL REMOVAL

1. Disconnect the battery cables and either discharge the controller or disconnect the spark plug wire. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
   See Disconnect the Battery- Gasoline Vehicles on page 1-4.
2. Remove the two mounting screws (1) and plate (2) **(Figure 7-1, Page 7-2)**.
3. Match mark the steering wheel (3) and steering column shaft (4) so when the steering wheel is removed it can be placed back in exactly the same position on steering column shaft.
4. Loosen the steering wheel nut (5) and back it off approximately 1/4 inch (6 mm). Do not remove the nut.
5. Use the steering wheel puller to remove steering wheel.

5.1. Place the puller anvil (6) through the top opening of the steering wheel **(Figure 7-2, Page 7-2)**.

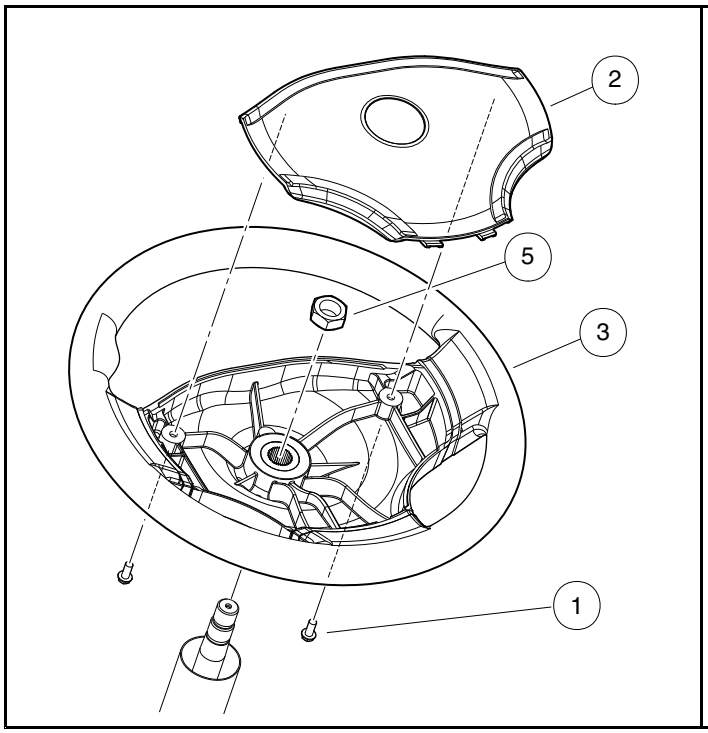
5.2. Insert the anvil feet through the two slots in the base plate (marked “B”) (7) as shown.

5.3. Rotate the anvil screw (8) clockwise until the base plate contacts the bottom of the steering wheel where it attaches to the steering column.

5.4. Use a 1/2-inch drive air impact wrench to tighten the anvil screw (8) until the steering wheel breaks free from the steering shaft.

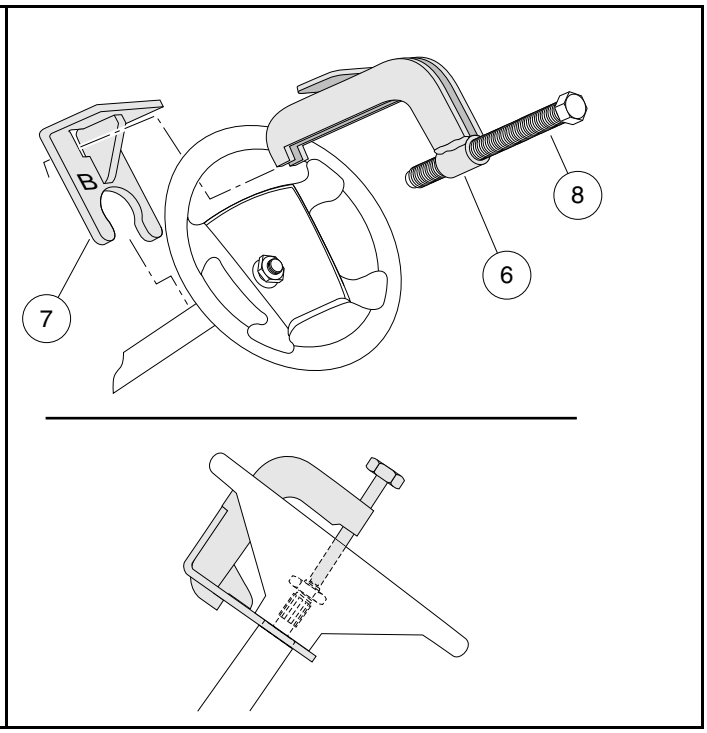
5.5. Remove the steering wheel puller.

5.6. Remove the steering wheel nut (5) and the steering wheel (3) from the steering column (9) **(Figure 7-1, Page 7-2)**.



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Figure 7-1 Steering Wheel



1500-18300-10253

Figure 7-2 Steering Wheel Puller

STEERING WHEEL INSTALLATION

NOTE: *To minimize corrosion and to make future removal of the steering wheel easier, apply a small amount of oil or anti-seize compound to steering shaft splines and taper before installing the steering wheel.*

1. Install the steering wheel (3) on the splines of the steering shaft (4). Be sure to align the match marks placed on the wheel and steering column shaft in step 3 above **(Figure 7-1, Page 7-2)**.
2. Install the steering wheel nut (5) and tighten to 156 in·lb (17.6 N·m).
3. Install the plate (2) and screws (1) **(Figure 7-1, Page 7-2)**. Tighten screws to 16 in·lb (1.8 N·m).
4. Connect the battery cables. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5. See Connect the Battery- Gasoline Vehicles on page 1-4.**

STEERING COLUMN

See General Warnings on page 1-1.

STEERING COLUMN REMOVAL

1. Remove the steering wheel as previously instructed.
2. Remove the front cowl. **See Front Body, Section 4, Page 4-3.**
3. Remove the grille and bumper.
4. Remove steering column sleeve.
5. Remove the dash panel.**See Key Switch Removal, Section 13, Page 13-1.**
6. Remove the steering column from the vehicle.

STEERING COLUMN DISASSEMBLY

1. Remove bolts (6) and mounts (4 and 5) from steering column. Remove boot (12) **(Figure 7-3, Page 7-4)**.
2. While supporting steering column (20) on a workbench, remove snap ring (13) from shaft. **See following NOTE.**

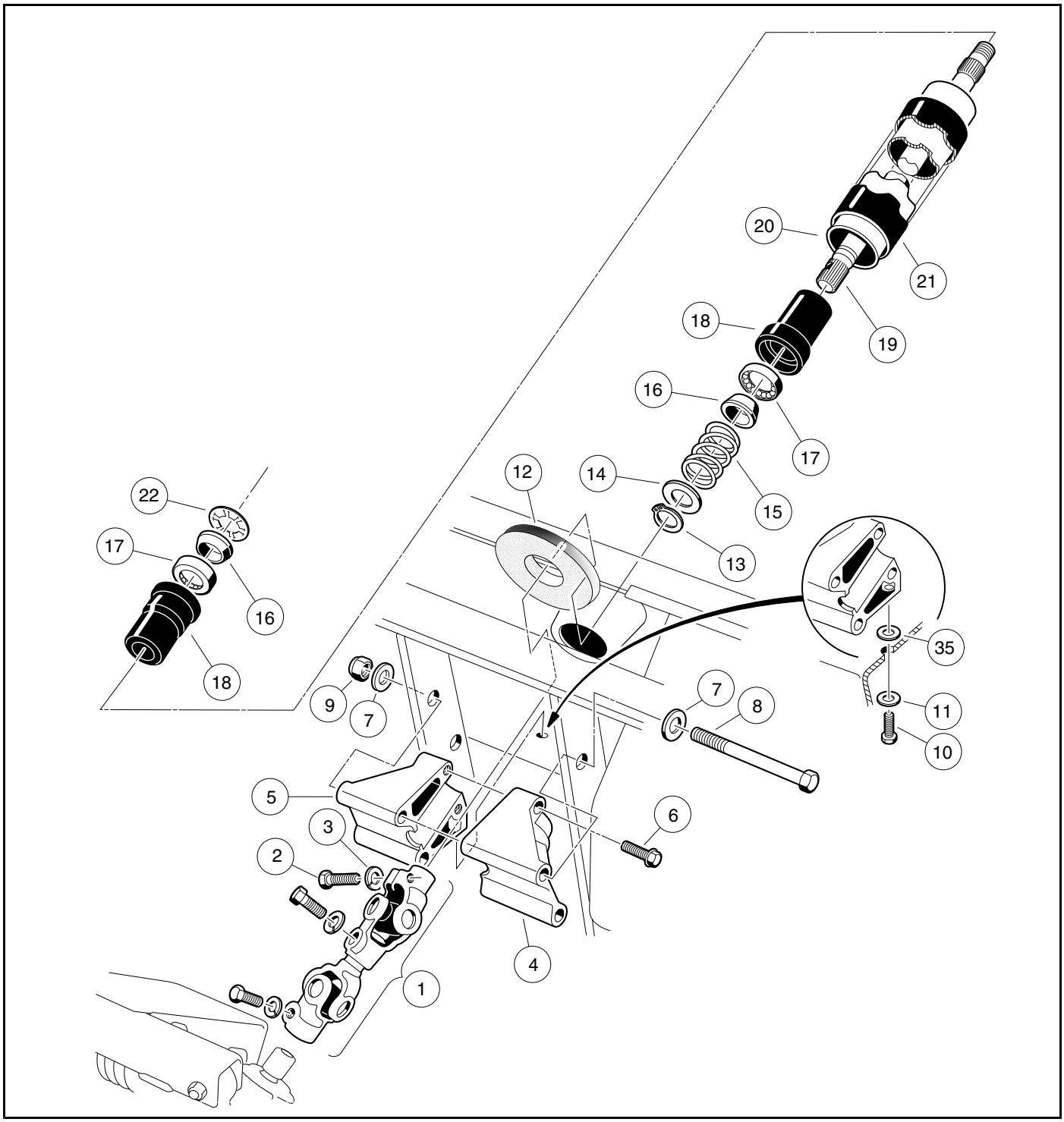
NOTE: *Do not allow the steering shaft to slide out of the steering tube when removing the snap ring.*

3. Remove the washer (14), spring (15), and wedge (16).
4. Turn the steering column over and slide the shaft out of the tube to expose the retaining ring (22). Use pliers to twist the retaining ring (22) until it breaks off, then remove the wedge (16).
5. Remove the shaft (19) from the bottom of the tube (20).
6. Use steering shaft (19) to push bearing seat (18) out from the opposite end of the steering tube (20).
7. Insert a flat blade screwdriver between the bottom of the outer race of the bearing (17) and the bottom lip of the bearing seat (18) and remove the bearing (17). **See following NOTE.**

NOTE: *Use new retaining rings and bearings for reassembly.*

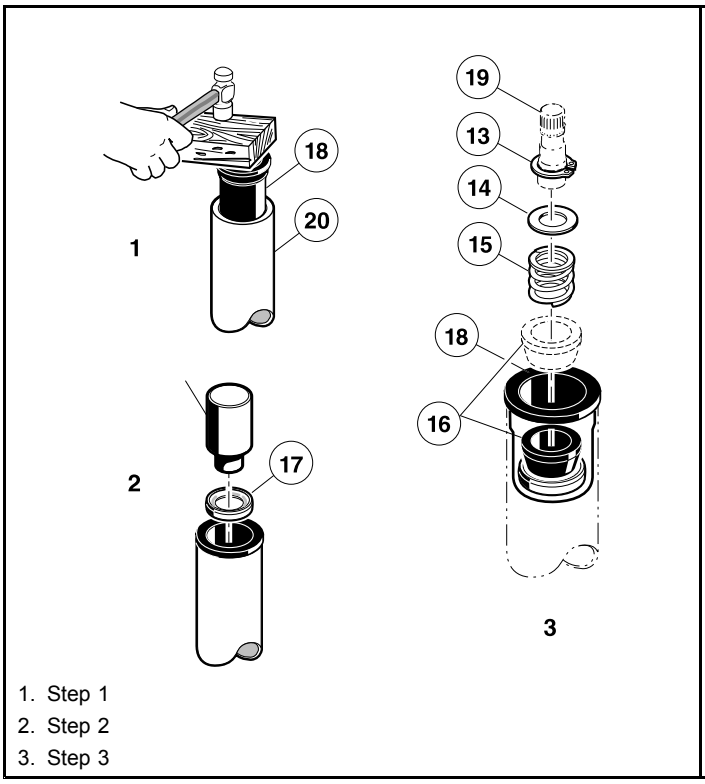
STEERING COLUMN ASSEMBLY

1. Insert bearing seat (18) into both ends of steering tube (20). Place a block of wood on bearing seat and tap lightly on block until bearing seat (18) is fully seated in steering tube (20) **(Figure 7-4, Page 7-5)**.
2. Press the bearing (17) all the way into the bearing seat (18) using a steering column bearing press tool or a metal tube approximately 6 inches (15.2 cm) long with a maximum outer diameter of 1-3/16 inches (3.3 cm) and a minimum inside diameter of 7/8 inch (2.2 cm). Be sure the bearing is installed in the bearing seat as shown **(Figure 7-4, Page 7-5)** so the wedge (16) will ride against the inner race of the bearing.
3. Install the wedge (16), spring (15), washer (14), and snap ring (13) onto the bottom end of the steering shaft (19) **(Figure 7-4, Page 7-5)**.
4. Insert the shaft (19) from the bottom of the steering tube (20) **(Figure 7-3, Page 7-4)**.
5. Turn the assembly over and place the shaft (19) on a bench. Install the wedge (16) and retaining ring (22) onto the top of the shaft. Be sure the prongs on the retaining ring face up and away from the wedge. Use a steering column retaining ring tool to seat the retaining ring to the proper depth. Support end of tube while pressing. If you do not have the recommended tool, use the same tube as was used in step 2 to press the retaining ring onto the top of the shaft. The retaining ring should be pressed onto the shaft until 2 to 2-1/8 inches (5.1-5.4 cm) of the shaft extends from the top of the bearing seat in the steering tube **(Figure 7-5, Page 7-5)**.



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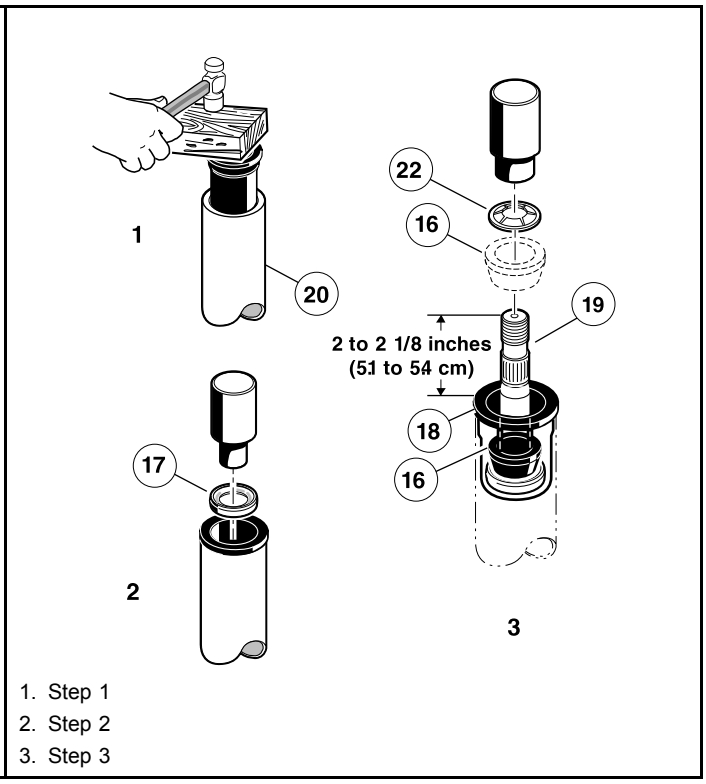
Figure 7-3 Steering Column



1. Step 1
2. Step 2
3. Step 3

1500-18200-10255

Figure 7-4 Steering Shaft – Bottom End



1. Step 1
2. Step 2
3. Step 3

1500-18200-10256

Figure 7-5 Steering Shaft – Top End

STEERING COLUMN INSTALLATION

1. Install boot (12). Reinstall mount (4 and 5) onto the end of the steering column. Tighten bolts (6) to 20 ft·lb (27 N·m) **(Figure 7-3, Page 7-4)**.
2. For ease of assembly and to prevent corrosion, apply a light coat of anti-seize or lubricating compound to both splined ends of the steering shaft.
3. Position the steering column assembly in the vehicle while inserting the steering column shaft into the upper universal joint (1). The flat portion of the steering shaft spline (19) must be aligned with the bolt hole in the universal joint (1) before sliding the spline into the universal joint. While holding the steering column in place, attach it to the frame using bolts (8), washers (7), and nuts (9) **(Figure 7-3, Page 7-4)**. Thread the nuts onto the bolts but do not tighten them.
4. Install wide washer (35), washer (11) and screw (10). Tighten to 20 ft·lb (27 N·m) **(Figure 7-3, Page 7-4)**.
5. Install the bolt (2) and lock washer (3) on the upper universal joint and finger-tighten.
6. Tighten the two nuts (9) and bolts (8) to 18 ft·lb (24.4 N·m) **(Figure 7-3, Page 7-4)**.
7. Tighten the bolt (2) on the upper universal joint to 15 ft·lb (20 N·m) **(Figure 7-3, Page 7-4)**.
8. Check the other two bolts of the universal joint (1) to ensure that they are properly tightened to 15 ft·lb (20 N·m) **(Figure 7-3, Page 7-4)**.
9. Reinstall dash panel and related hardware.
10. Make sure the key switch terminals do not touch the frame and the dash panel is properly seated and snapped into place.
11. Install front cowl, grille and bumper. **See Front Body, Section 4, Page 4-3.**
12. Install the steering wheel. **See Steering Wheel Installation on page 7-2.**

STEERING ADJUSTMENT

See General Warnings on page 1-1.

1. Turn the steering wheel all the way to the right. Note the distance between the passenger side spindle stop (2) and passenger side A-plate (3) **(Figure 7-6, Page 7-8)**. The internal stop on the rack must reach its limit of travel against rack and pinion housing at exactly the same time the spindle stops against the passenger side A-plate (with vehicle wheels turned to the right). If simultaneous contact occurs, steering is in correct adjustment; go to step 4. If simultaneous contact does not occur, go to step 2.
2. Loosen the nuts (27 and 29) and turn the drag link (28) **(Figure 7-10, Page 7-10)** to adjust the drag link rod. Adjust the link rod with the steering wheel turned all the way to the right, so the passenger side spindle stop lightly touches the passenger side A-plate. The internal stop on the rack must reach its limit of travel at the same time the spindle stops against the passenger side A-plate (with vehicle wheels turned to the right). **See following CAUTION.**

CAUTION

- **The drag link has both left and right-hand threads. The end of the drag link toward the spindle has left-hand threads, and the end toward the rack has right-hand threads. To prevent damage to threaded parts, care should be taken when servicing the drag link.**

3. When all adjustments have been completed, tighten the nuts (27 and 29) on the drag link assembly with an open end wrench. Tighten nuts to 21 ft·lb (28.4 N·m) **(Figure 7-10, Page 7-10)**. **See following CAUTION.**

CAUTION

- **When tightening the nuts (27 and 29), make sure the drag link (28) does not turn (Figure 7-10, Page 7-10).**

4. Straighten wheels and turn steering wheel from lock to lock. Wheels should turn smoothly and easily. If steering wheel does not turn smoothly and easily, inspect steering assemblies as follows:
   – ball joints (23) **(Figure 7-10, Page 7-10)** and (6 and 13) **(Figure 7-18, Page 7-18)**
   – spindle bushings (3 and 4) **(Figure 7-19, Page 7-19)**
   – wave washers (20) **(Figure 7-19, Page 7-19)**
   – rack assembly (17) **(Figure 7-10, Page 7-10)**
5. Also inspect front suspension assemblies as follows:
   – A-plates (1) **(Figure 7-18, Page 7-18)**
   – urethane bushings (2) **(Figure 7-18, Page 7-18)**
   – leaf springs (6) **(Figure 7-19, Page 7-19)**
6. Replace components as necessary.

RACK AND PINION

See General Warnings on page 1-1.

CAUTION

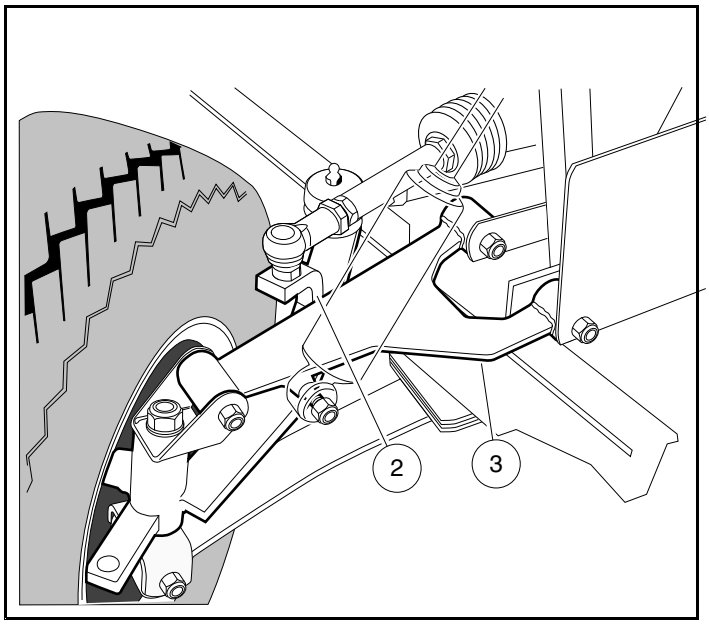
- **Front impacts that bend tie rods and/or drag links can possibly damage internal steering gear components. See Rack and Pinion Inspection on page 7-7. The manufacturer recommends inspecting the rack and pinion and replacing if damaged.**

RACK AND PINION INSPECTION

1. Look for obvious damage to the chassis, where the rack and pinion is mounted, and the rack and pinion housing. Particularly check the housing for broken mounting points.
2. Compare the toe-in against the specification. **See Toe-in Adjustment on page 7-16.**
3. If obvious visible damage is found, such as a bent tie rod, check the steering gear for abnormal free-play, noise, binding or clunking while it is under a load. With the steering system fully assembled and all four tires on the ground/floor, turn the steering wheel from stop to stop. While turning, feel for any binding, clunking or tight/loose spots. Listen for unusual noises. Replace the rack and pinion as an assembly if any is found.
4. In the event of an known impact and obvious visible damage is not found in the method described above, disconnect the tie rods and/or drag links from the spindles. Turn the steering wheel from stop to stop. While turning, feel for any binding or tight/loose spots. Listen for unusual noises. Replace the rack and pinion as an assembly if any is found.

RACK AND PINION REMOVAL – MAINTENANCE-FREE BALL JOINTS

1. Remove the front body. **See Front Body, Section 4, Page 4-3.**
2. Remove the drag link ball joint retaining nut (25) **(Figure 7-10, Page 7-10)**.
3. Remove the outer drag link ball joint (23) from the spindle assembly (33) and inspect for excessive wear and seal damage.
4. Remove the bolts (30), washers (31), and lock nuts (32) from the steering rack assembly mounting bracket **(Figure 7-10, Page 7-10)**.
5. Remove the bolt (2) and flat washer (3) on the upper universal joint, then remove the rack assembly and universal joint from the vehicle **(Figure 7-3, Page 7-4)**.



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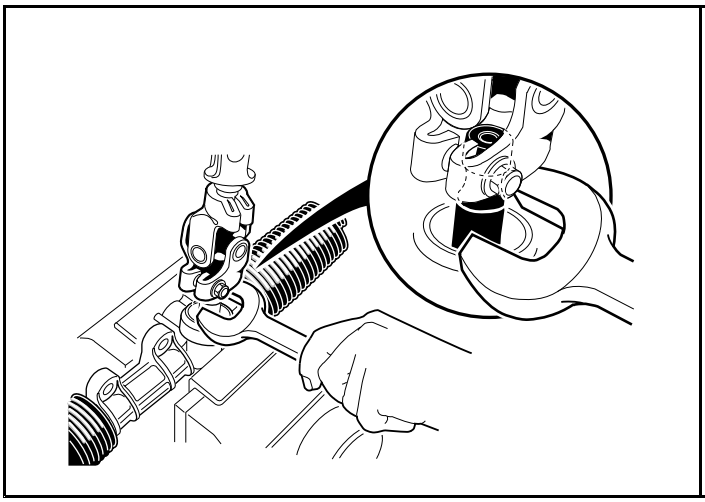
Figure 7-6 Adjust Steering Alignment

RACK AND PINION DISASSEMBLY

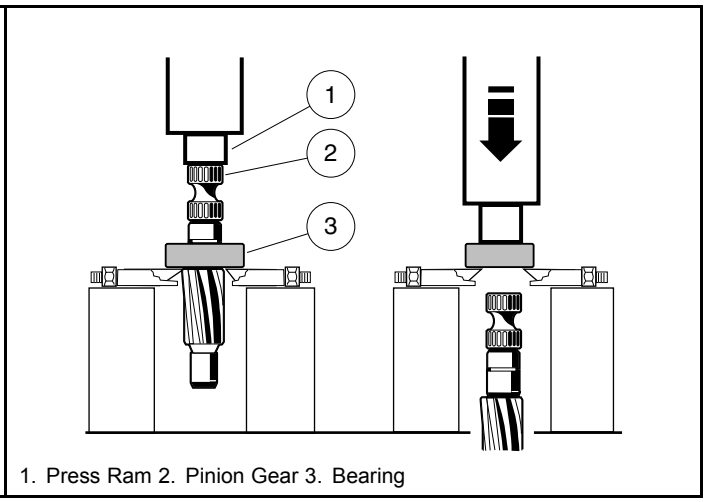
CAUTION

- **The ball joint (23) (Figure 7-10, Page 7-10) has left-hand threads.**

1. Remove ball joint from the spindle and inspect it for excessive wear.
2. Remove the drag link (28) **(Figure 7-10, Page 7-10)**.
3. Remove both bellows clamps (2) (plastic wire ties).
4. Remove the hex nut (29) and slide off the dust seal bellows (1).
5. Remove the retaining ring (21), then slide off dust seal bellows (20).
6. Remove the rack screw lock nut (15), rack guide screw (16), rack guide pressure spring (14), and the rack guide (13) **(Figure 7-10, Page 7-10)**.
7. Remove the universal joint assembly from the pinion (8) by fully removing the bolt and then sliding off the universal joint.



1500-18400-10259
Figure 7-7 Remove Pinion from Housing



1. Press Ram 2. Pinion Gear 3. Bearing

1500-18400-10260
Figure 7-8 Remove Bearing from Pinion

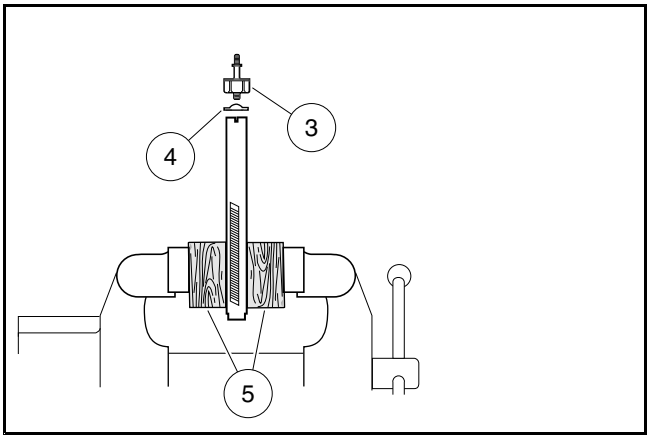
8. If necessary, remove the dust seal (12). **See following NOTE.**

NOTE: *If the dust seal (12) is removed, replace with a new one.*

9. Use snap ring pliers to remove the internal snap ring (11) **(Figure 7-10, Page 7-10)**.
10. Install the universal joint onto the pinion and place a large open end wrench under the universal joint **(Figure 7-7, Page 7-9)**. Use the wrench as a lever to pull the pinion from the housing.
11. If the ball bearing (9) has been damaged, remove the external snap ring (10) **(Figure 7-10, Page 7-10)** and press the bearing off **(Figure 7-8, Page 7-9)**.
12. Remove retaining ring (19) and stop washer (18), then remove rack (17) from housing (6) **(Figure 7-10, Page 7-10)**.
13. If the inner ball joint (3) is excessively worn, remove the ball joint and tab washer (4) from the rack **(Figure 7-9, Page 7-9)**.

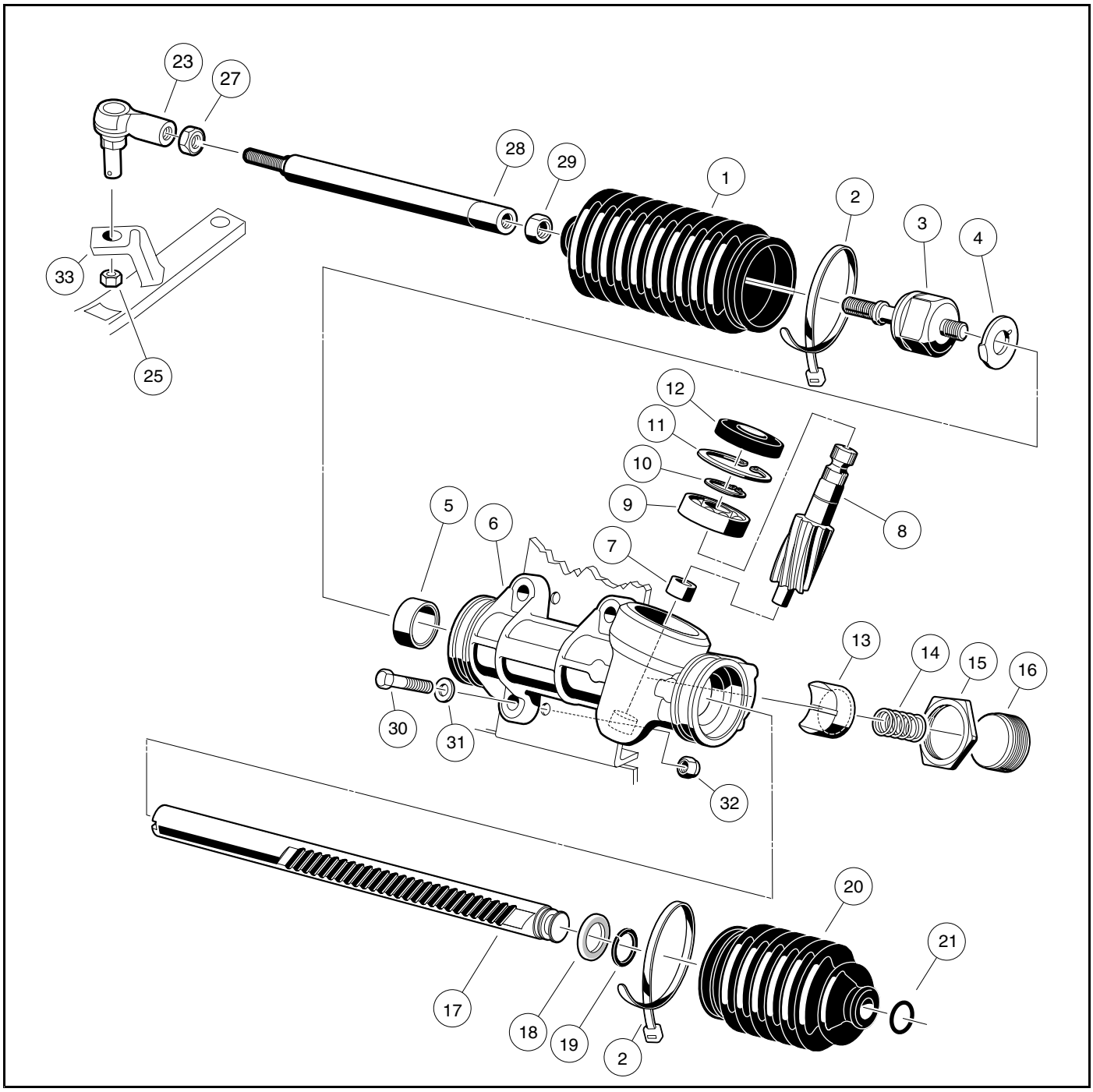
13.1. Secure the rack in a vise using wood blocks (5) between the rack and the jaws of the vise to protect the rack from damage **(Figure 7-9, Page 7-9)**.

13.2. Loosen and remove the inner ball joint with a wrench.



1500-18400-10261
Figure 7-9 Secure Rack in Vise

14. Inspect the bushing (5) for excessive wear. If wear is excessive, replace the steering box assembly **(Figure 7-10, Page 7-10)**.



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Figure 7-10 Steering Gear – Maintenance-Free Ball Joints

RACK AND PINION ASSEMBLY

1. Install a new tab washer (4) and an inner ball joint (3) **(Figure 7-9, Page 7-9)**. Install the ball joint onto the rack by securing the rack in a vise using wood blocks between the rack and the jaws of the vise to protect the rack from damage. Tighten the ball joint to 60 ft·lb (81 N·m).
2. Bend the edges of the tab washer (4) up against the ball joint (3) **(Figure 7-9, Page 7-9)**.

3. Apply a light coating of EP grease to the teeth of the rack (17), then slide the rack through the bushing (5) and housing (6). Install the stop washer (18) and retaining ring (19) to the end of the rack **(Figure 7-10, Page 7-10)**.

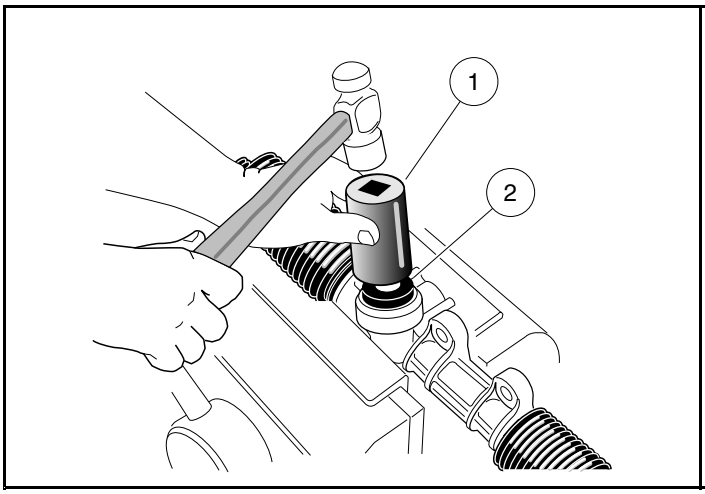
CAUTION

- **In step 4, do not press against the outer race of the bearing.**

4. If the bearing (9) was removed, press on a new bearing, exerting all pressure on the inner race (grease the bearing before installing it). Then install the external snap ring (10) **(Figure 7-10, Page 7-10)**. **See preceding CAUTION.**
5. If the needle bearing (7) is damaged, the steering box assembly must be replaced **(Figure 7-10, Page 7-10)**.
6. Install pinion (8) and bearing (9) assembly into the housing (6) **(Figure 7-10, Page 7-10)**. Make sure the rack gear teeth will mesh with the gear teeth on the pinion. The rack may need to be rotated slightly while lightly tapping on the pinion-bearing assembly with a rubber mallet. **See following CAUTION.**

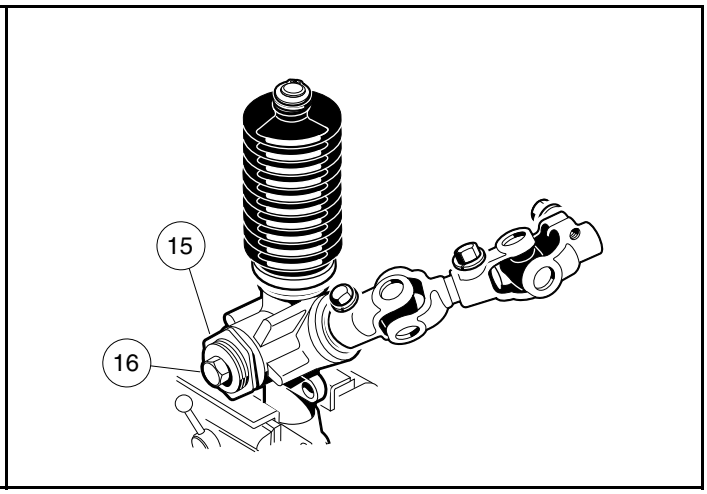
CAUTION

- **Do not force the pinion-bearing assembly into the housing. The gear teeth or the small bearing could be damaged.**



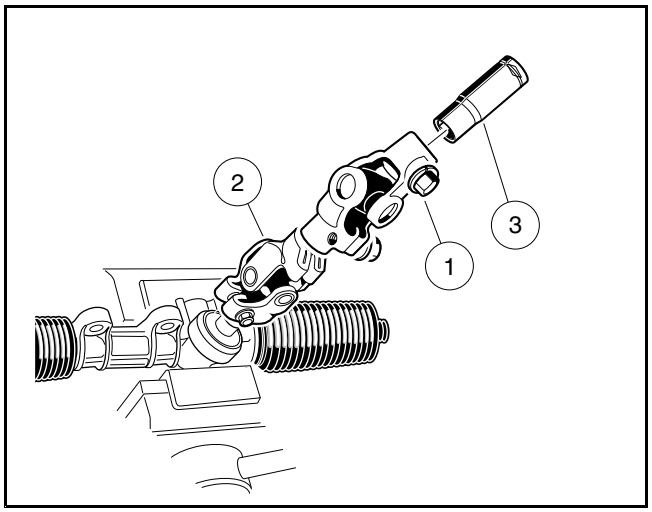
1500-18400-10263

Figure 7-11 Press In Dust Seal



1500-18400-10264

Figure 7-12 Rack and Pinion Adjustment



1500-18400-10265
Figure 7-13 Rack and Pinion Resistance

7. Install the internal snap ring (11) **(Figure 7-10, Page 7-10)**.
8. Using an appropriate size deep well socket (1) to apply pressure evenly, press in a new dust seal (2) **(Figure 7-11, Page 7-11)**.
9. Apply a small amount of grease to the rack guide (13) where it comes into contact with the rack (17) **(Figure 7-10, Page 7-10)**.
10. Place a few drops of Loctite® 222 to the threads of the screw (16) **(Figure 7-10, Page 7-10)**.
11. Install the rack guide (13), pressure spring (14), and screw (16). The screw should be threaded in until a rotational torque of 10 in·lb (1.13 N·m) is achieved **(Figure 7-10, Page 7-10)**.

11.1. Reposition the rack and pinion in a vise.

11.2. Insert a 3/8-inch deep well socket (3) into the steering column end of the universal joint (2) and tighten the bolt (1) to 15 ft·lb (20.3 N·m) **(Figure 7-13, Page 7-12)**.

11.3. Use a torque wrench connected to the 3/8-inch deep well socket (3) to measure the resistance of the rack and pinion. Rotational resistance should measure 7 to 15 in·lb (0.8 to 1.7 N·m).

11.4. If measured resistance does not equal 7 to 15 in·lb, loosen the lock nut (15) and tighten the screw (16) until it bottoms out, then back the screw off one quarter turn. Tighten the lock nut to 28 ft·lb (38 N·m) **(Figure 7-12, Page 7-11)**. **See following NOTE.**

NOTE: *When tightening the lock nut (15) make sure the screw (16) does not change adjustment* ***(Figure 7-12, Page 7-11)****.*

12. Install the dust seal bellows (20) and retaining ring (21) **(Figure 7-10, Page 7-10)**.
13. Install the dust seal bellows (1) and hex nut (29) **(Figure 7-10, Page 7-10)**.
14. Install the universal joint on the pinion. Tighten the bolt to 15 ft·lb (20 N·m).
15. Install new bellows clamps (wire ties) (2) **(Figure 7-10, Page 7-10)**.
16. Install the drag link (28) by fully threading the ground end into the inner ball joint (3). **See following CAUTION.**

CAUTION

- **The ball joint (23) (Figure 7-10, Page 7-10) has left-hand threads.**
- **The tie rod and drag link have right-hand threads on one end and left-hand threads on the other end. Right-hand threads are identified by a groove in the tie rod or drag link.**

17. Install the ball joint (23) **(Figure 7-10, Page 7-10)**. **See preceding CAUTION.**

RACK AND PINION INSTALLATION – MAINTENANCE-FREE BALL JOINTS

1. Position the steering gear box assembly on the shock and gear support and install the bolts (30), washers (31), and nuts (32). Do not tighten the mounting bolts **(Figure 7-10, Page 7-10)**.
2. For ease of assembly and to prevent corrosion, apply a light coat of anti-seize and lubricating compound to the splined end of the steering column shaft.
3. Align the flat portion of the steering shaft spline with the bolt hole in the universal joint and then slide the shaft into the upper universal joint. Install the bolt and lock washer on the upper universal joint and tighten it to 15 ft·lb (20 N·m).
4. Tighten the steering rack mounting bolts (30) to 22 ft·lb (29.8 N·m) **(Figure 7-10, Page 7-10)**.
5. Install the drag link ball joint (23) on the spindle arm riser (33) and secure with retaining nut (25). Tighten nut to 40 ft·lb (54 N·m).
6. Adjust the steering. **See Steering Adjustment on page 7-6.**

TIE ROD AND DRAG LINK

See General Warnings on page 1-1.

TIE ROD AND DRAG LINK REMOVAL – MAINTENANCE-FREE BALL JOINTS

1. Using locking pliers to hold tie rod and drag link, loosen jam nuts (7 and 12) on tie rod ball joints **(Figure 7-18, Page 7-18)** and loosen jam nuts (27 and 29) on the drag link **(Figure 7-10, Page 7-10)**.
2. Remove the ball joint retaining nuts (20) **(Figure 7-18, Page 7-18)**.
3. Remove ball joints (6 and 13) **(Figure 7-18, Page 7-18)** and (23) **(Figure 7-10, Page 7-10)** from the spindles.
4. Remove the ball joints from the tie rod (11) **(Figure 7-18, Page 7-18)**.
5. Remove drag link (28) from inner ball joint assembly (3) and drag link ball joint (23) **(Figure 7-10, Page 7-10)**.

TIE ROD AND DRAG LINK INSTALLATION – MAINTENANCE-FREE BALL JOINTS

1. Thread ball joints (6 and 13) into tie rod (11) to a depth of 1/2-inch (12.5 mm) **(Figure 7-18, Page 7-18)**. **See following WARNING and CAUTION.**

⚠ WARNING

- **The ball joints must be threaded into the rod at least 5/16 of an inch (8 mm). Failure to thread ball joints in deep enough may cause a ball joint to separate from the rod during adjustment or while being operated, possibly resulting in loss of vehicle control and severe personal injury.**

CAUTION

- **The tie rod and drag link have right-hand threads on one end and left-hand threads on the other end. Right-hand threads are identified by a groove in the tie rod or drag link.**

2. Attach the tie rod ball joints (6 and 13) to the spindle tabs (23), then install and tighten the nuts (20) to 40 ft·lb (54 N·m) **(Figure 7-18, Page 7-18)**.
3. Thread the drag link rod (28) all the way onto the threaded stud of the inner ball joint assembly (3) (right-hand threads) **(Figure 7-10, Page 7-10)**.
4. Thread the ball joint (23) into the drag link rod (28) (left-hand threads) to full thread depth **(Figure 7-10, Page 7-10)**.
5. Install the drag link ball joint (23) on the spindle arm riser (33) and secure with retaining nut (25) **(Figure 7-10, Page 7-10)**. Tighten nut to 40 ft·lb (54 N·m).
6. Adjust camber and toe-in. **See Camber Adjustment on page 7-15 and Toe-in Adjustment on page 7-16.**
7. Adjust steering. **See Steering Adjustment on page 7-6.**

FRONT SUSPENSION

See General Warnings on page 1-1.

LUBRICATION

Two grease fittings (one in each spindle housing) are provided. Lubricate these fittings at the recommended interval with the proper lubricant. **See Periodic Lubrication Schedules, Section 10, Page 10-7.**

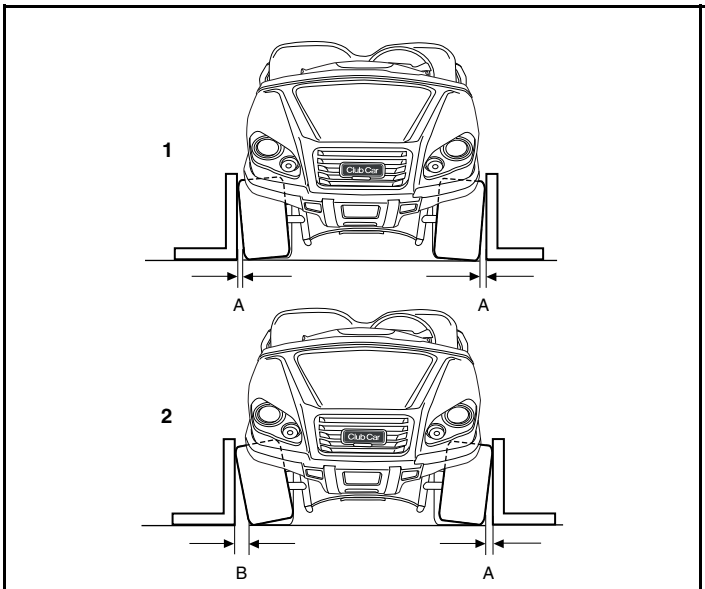
WHEEL ALIGNMENT

Wheel alignment is limited to equalizing the camber angle of each front wheel and adjusting toe-in of the front wheels. There is also a drag link adjustment to equalize the turning radius in both directions. **See Steering Adjustment on page 7-6. See following NOTE.**

NOTE: *Prior to making any front suspension adjustments, inspect components for wear and damage and repair or replace as necessary.*

Camber Adjustment

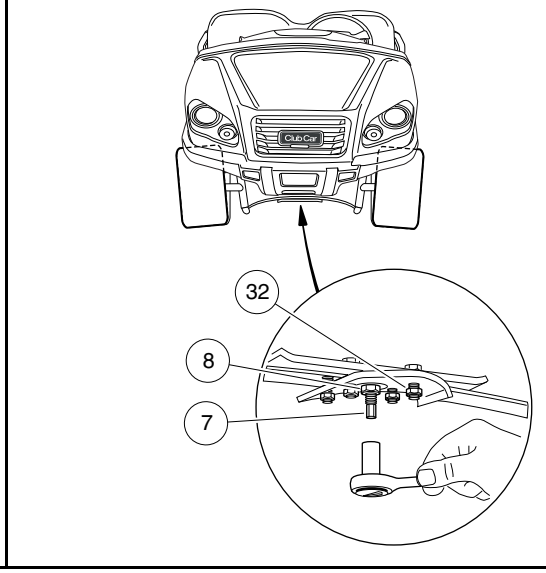
1. Check each front wheel with a framing square. At the floor (or ground), there should be an equal amount of space between each tire and the framing square **(Figure 7-14, Page 7-15)**.
2. Loosen, but do not remove, the four nuts (32) that secure the leaf spring (6) to the bottom spring plate (29) **(Figure 7-19, Page 7-19)**. **See also Figure 7-15, Page 7-15.**



1. Proper Camber Adjustment 2. Improper Camber Adjustment

2868

Figure 7-14 Check Camber



2869

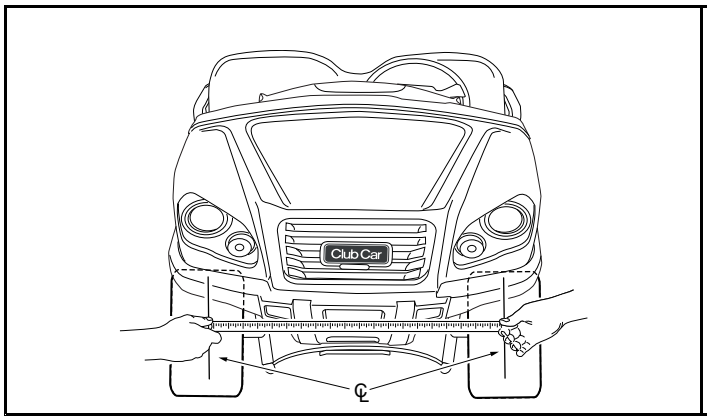
Figure 7-15 Adjust Camber

3. Loosen, but do not remove, the hex nut (8) on the adjustment eccentric (7) **(Figure 7-19, Page 7-19)** in the center of the spring. **See also Figure 7-15, Page 7-15.**
4. Use a 7 mm deep well socket to rotate the eccentric **(Figure 7-15, Page 7-15)**.
5. After adjusting camber, tighten the four spring retaining nuts (32) **(Figure 7-19, Page 7-19)** to 23 ft·lb (31 N·m). Then roll the vehicle forward one full tire revolution and recheck the camber. Adjust as required. **See also Figure 7-14, Page 7-15.**

6. Tighten the hex nut (8) on the adjustment eccentric (7) to 23 ft·lb (31 N·m) **(Figure 7-19, Page 7-19)**. **See also Figure 7-15, Page 7-15.**

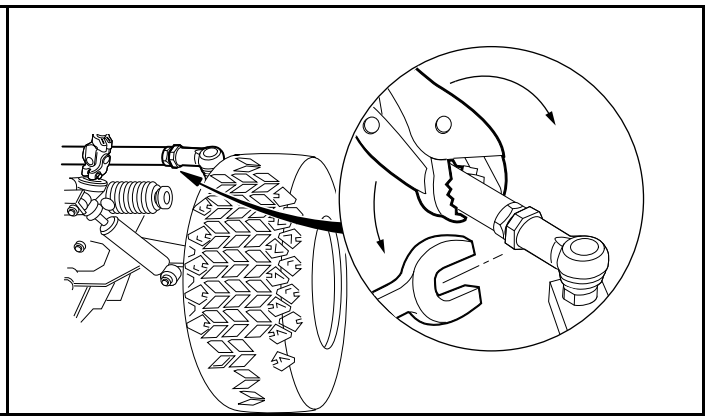
Toe-in Adjustment

1. On a level surface, roll the vehicle forward, then stop. Make sure the front wheels are pointed straight ahead. Do not turn the steering wheel again during this procedure.
2. On each front tire, mark (as closely as possible) the center of the tread face that is oriented toward the rear of the vehicle. The marks should be even with the bottom surfaces of the vehicle frame I-beams.
3. Measure the distance between the marks on the rear-facing surfaces of the tires, and then roll the vehicle **forward** one and a half wheel revolutions until the marks appear on the forward facing surfaces of the tires at about the same height from the floor **(Figure 7-16, Page 7-16)**.



2870

Figure 7-16 Check Toe-In



2620

Figure 7-17 Adjust Toe-In

4. Measure the distance between the marks on the forward-facing surfaces of the tires. **See following NOTE.**

NOTE: *The front measurement must be less than the rear measurement.*

5. Subtract the measurement on the front of the tires from the measurement on the rear of the tires. The difference is the toe-in. Proper toe-in is 1/8 to 3/8 of an inch (3.2 to 9.5 mm).
6. If adjustment is necessary, loosen the jam nut on each tie rod ball joint and rotate the tie rod to increase or decrease toe-in **(Figure 7-17, Page 7-16)**. **See following CAUTION.**

CAUTION

- **The tie rod has right-hand threads on one end and left-hand threads on the other end. Right-hand threads are identified by a groove in the tie rod.**

7. Tighten nuts (loosened in step 6) to 21 ft·lb (28 N·m) and recheck toe-in.
8. After toe-in adjustment is made and with wheels in the straight ahead position, the steering wheel should be at the center of its travel. There should be equal travel to the left and right. **See following NOTE.**

NOTE: *If the minimum turning radius is not the same for both left and right turns, adjust the steering.* ***See Steering Adjustment on page 7-6.***

FRONT SUSPENSION COMPONENTS

See General Warnings on page 1-1.

LEAF SPRING REMOVAL

1. Disconnect the battery cables and either discharge the controller or disconnect the spark plug wire. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
   See Disconnect the Battery- Gasoline Vehicles on page 1-4.
2. Remove both front wheels. **See Wheel Removal, Section 8, Page 8-1.**
3. Remove the nuts (14) and bolts (25) from the bottom of each king pin (26) **(Figure 7-19, Page 7-19)**.
4. Remove the four bolts (30), four nuts (32), four lock washers (31), and bottom spring plate (29).
5. Remove leaf spring (6).
6. Check the condition of the urethane bushings (27) and steel sleeves (28). Replace any that are worn or damaged.

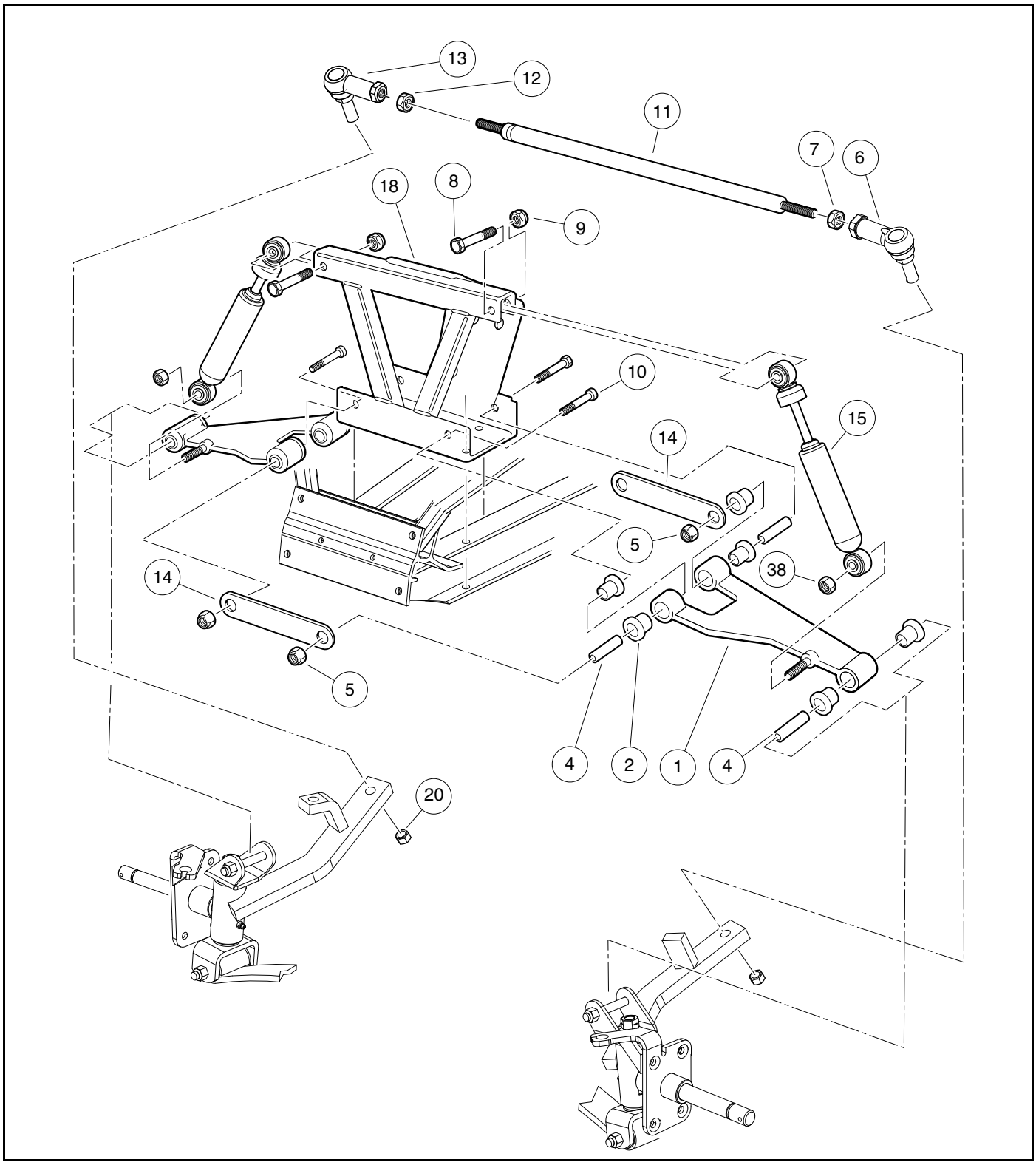
LEAF SPRING INSTALLATION

1. Install urethane bushings (27) and steel sleeves (28) into leaf spring eyes **(Figure 7-19, Page 7-19)**.
2. Install tapered leaf spring (6), bottom spring plate (29), four bolts (30), four lock washers (31), and four nuts (32). Using a crisscross pattern sequence, tighten bolts to 23 ft·lb (31 N·m).
3. Install spring in king pins (26) with bolts (25) and nuts (14). Tighten to 17 ft·lb (23 N·m).
4. Install the wheels and lower the vehicle. **See Wheel Installation, Section 8, Page 8-1.**
5. Adjust camber and toe-in. **See Camber Adjustment on page 7-15 and Toe-in Adjustment on page 7-16.**

KINGPIN AND STEERING SPINDLE REMOVAL – MAINTENANCE-FREE BALL JOINTS

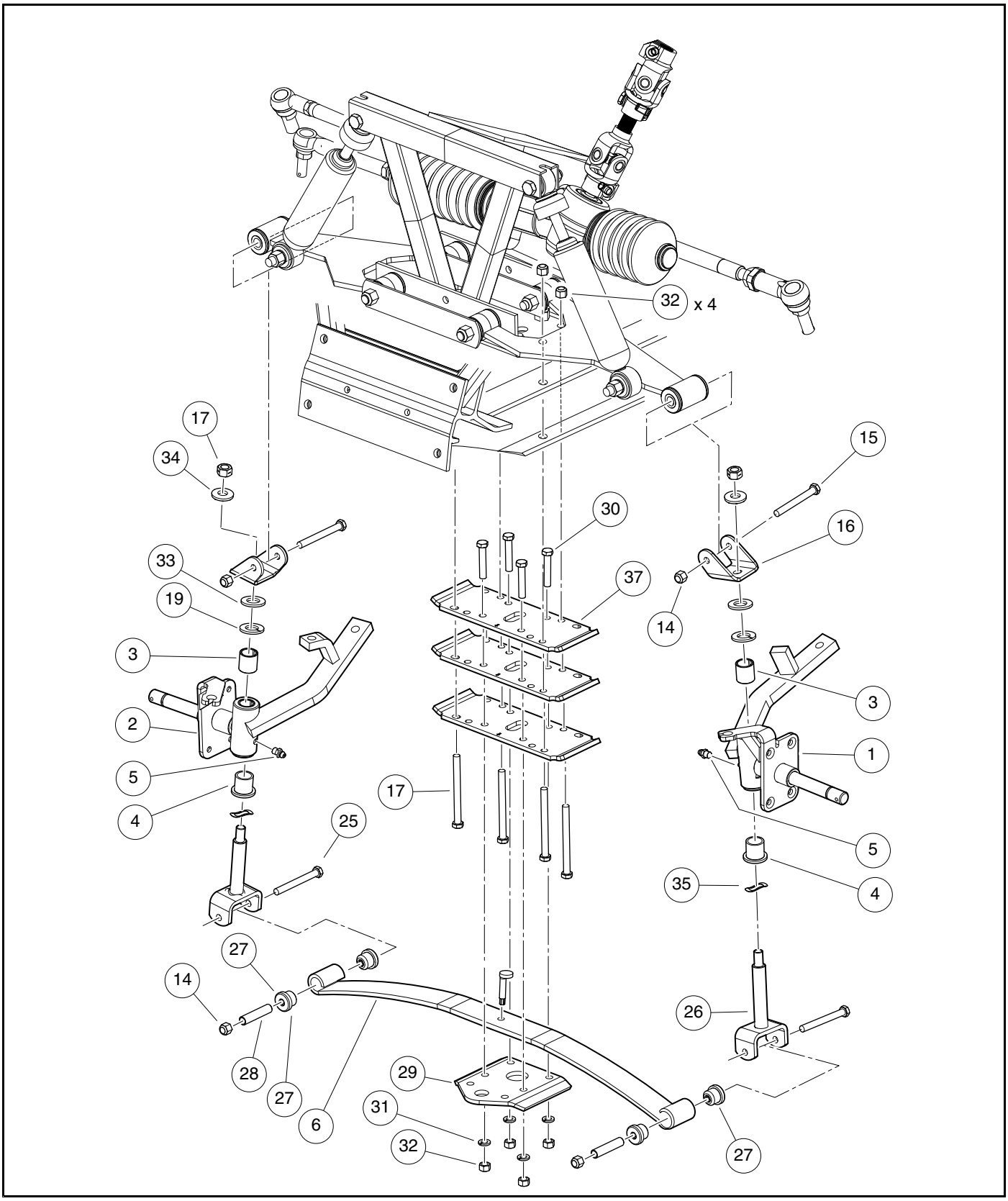
1. Remove the front hub. **See Front Hub Removal on page 7-21.**
2. Remove nuts (20) and remove ball joints from spindles **(Figure 7-18, Page 7-18)**. Remove drag link ball joint. **See also Tie Rod and Drag Link Removal – Maintenance-Free Ball Joints on page 7-14.**
3. Remove the lock nut (17) and conical washer (34) from the top of the kingpin (26) **(Figure 7-19, Page 7-19)**.
4. Raise the upper clevis (16) from the kingpin.
5. Remove the flat washer (33) and thrust washer (19).
6. Slide the spindle (1 or 2) off the kingpin (26).
7. Remove the wave washer (35) and inspect it. If the washer is broken or has a wave bottom to wave crest height dimension of less than 0.040 inch (0.10 cm), it must be replaced.
8. Remove bolt (25) and nut (14) from bottom of kingpin (26) and remove kingpin.
9. Inspect the kingpin and spindle. If either is worn or damaged, it must be replaced.
10. Inspect the bushings (3 and 4). If the bushings are worn or damaged, remove them and press in new ones. **See following NOTE.**

NOTE: *If the bushings are replaced, ream new bushings from 0.750 to 0.752 (19.05 to 19.10 mm) in diameter. The reamer should be long enough to ream both bushings from one direction.*



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Figure 7-18 Front Suspension – Upper Portion



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Figure 7-19 Front Suspension – Lower Portion

KINGPIN AND STEERING SPINDLE INSTALLATION – MAINTENANCE-FREE BALL JOINTS

1. Inspect all parts and replace them as necessary.
2. Install the kingpin (26) over the leaf spring eye. Insert the bolt (25) and install the nut (14) **(Figure 7-19, Page 7-19)**. Tighten the bolt to 17 ft·lb (23 N·m).
3. Install the wave washer (35).
4. Install the steering spindle on the kingpin. Then install the thrust washer (19), flat washer (33), upper plate clevis (16), conical washer (34), and nut (17). Tighten the nut to 65 ft·lb (88 N·m).
5. Attach the tie rod ball joints (6 and 13) to the spindle tabs, then install and tighten the nuts (20) to 40 ft·lb (54 N·m) **(Figure 7-18, Page 7-18)**.
6. Install the drag link ball joint. **See Tie Rod and Drag Link Installation – Maintenance-Free Ball Joints on page 7-14.**
7. Install front hub and wheel. **See Front Hub Installation on page 7-21.**

DELTA A-PLATE REMOVAL

1. Remove front wheel(s). **See Wheel Removal, Section 8, Page 8-1.**
2. Remove bolts (10 and 24), A-Plate straps (14), and nuts (5) **(Figure 7-18, Page 7-18)**.
3. Remove the lower shock absorber mounting nut (38), then slide the shock absorber (15) free of the Delta A-Plate (1).
4. Remove the Delta A-Plate (1).
5. Inspect the bushings (2) and sleeves (3 and 4) in the Delta A-Plate and replace them if necessary.

DELTA A-PLATE INSTALLATION

1. Install the A-Plate (1) in reverse order of removal. Tighten the A-Plate suspension bolts (10 and 24) to 20 ft·lb (27 N·m) **(Figure 7-18, Page 7-18)**.
2. Tighten shock absorber mounting nut (38) to 20 ft·lb (27.1 N·m).
3. Install the wheel(s). **See Wheel Installation, Section 8, Page 8-1.**
4. Adjust the wheel alignment. **See Wheel Alignment on page 7-15.**

SHOCK ABSORBER REMOVAL

1. Inspect the shock absorbers (15) for fluid leakage at the point where the shaft enters the shock absorber body. Leaking shock absorbers should be replaced.
2. Remove the nut (38) attaching the shock absorber to the A-Plate (1) **(Figure 7-18, Page 7-18)**.
3. Remove the nut (9) and bolt (8) attaching the shock absorber to the shock and gear support (18).
4. Remove the shock absorber (15).

SHOCK ABSORBER INSTALLATION

NOTE: *When installing shock absorbers, make sure front shocks have identical part numbers and rear shocks have identical part numbers.*

1. Install the shock absorber by reversing the removal procedure.
2. Tighten the nuts (9 and 38) to 20 ft·lb (27 N·m).

FRONT WHEEL BEARINGS AND HUBS

See General Warnings on page 1-1.

NOTE: *The front wheel bearings are pressed into the spindle and are not serviceable. If excessive free-play is detected the entire hub should be replaced.*

FRONT WHEEL FREE PLAY INSPECTION

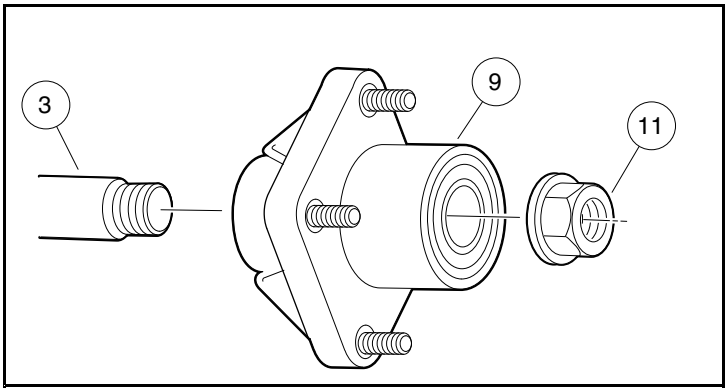
1. Raise the front of the vehicle.
2. Use your hands to attempt to rock the wheel and hub assembly back and forth on the spindle. Movement of the wheel and hub on the spindle indicates that the hub bearing is worn; therefore, the hub assembly must be replaced. **See Front Hub Removal on page 7-21.**

FRONT HUB REMOVAL

1. Remove the front wheels. **See Wheel Removal on page 8-1.**
2. Remove dust cap (12) and lock nut (11) **(Figure 7-20, Page 7-21)**.
3. Slide the hub assembly (9) off of the spindle shaft (3).
4. Lightly sand spindle shaft to clean away any light rust.
5. Inspect the surface of the spindle shaft for surface damage. It should be clean and smooth. If severe pitting from rust or corrosion has occurred, replace the spindle assembly. **See Kingpin and Steering Spindle Removal – Maintenance-Free Ball Joints on page 7-17.**

FRONT HUB INSTALLATION

1. Clean and apply a light coat of anti-seize lubricant to the spindle shaft (3).
2. Slide the hub assembly (9) onto the spindle shaft **(Figure 7-20, Page 7-21)**.
3. Install a new flanged lock nut (11) and tighten to 50 ft·lb (68 N·m).
4. Rotate the hub. The hub should rotate smoothly without binding, side play, or any indication of rough spots.
5. Repeat the procedure for the opposite wheel.
6. Install wheels and finger-tighten lug nuts.
7. Lower the vehicle and finish tightening lug nuts, using a crisscross pattern. **See Wheel Installation, Section 8, Page 8-1.**



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Figure 7-20 Front Wheel Hub

Pagination Page

SECTION 8 — WHEELS AND TIRES

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

GENERAL INFORMATION

NOTE: *Use only Club Car approved tires when replacing tires.*

Maximum tire life and good vehicle handling qualities are directly related to proper wheel and tire care.

- Keep tires properly inflated. **See Vehicle Specifications on page 2-1.**
- Keep lug nuts properly tightened.
- Keep the front end properly aligned and adjusted.

WHEELS

See General Warnings on page 1-1.

WHEEL REMOVAL

1. Slightly loosen the lug nuts on the wheel to be removed.
2. Raise the end of the vehicle from which the wheel is to be removed. Make sure the wheels are off the ground. **See WARNING "Lift only one end of the vehicle..." in General Warnings on page 1-1.**
3. Remove the lug nuts and remove the wheel.

WHEEL INSTALLATION

1. Install wheel(s), and tighten the lug nuts, using a crisscross pattern, until they are snug.
2. Lower the vehicle and finish tightening the lug nuts, using a crisscross pattern, to 65 ft·lb (88 N·m).

TIRES

See General Warnings on page 1-1.

TIRE REMOVAL

NOTE: *Tire must be removed or installed from the valve stem side of the rim.*

1. Remove the tire and wheel assembly from the vehicle as instructed above. **See Wheel Removal on page 8-1.**
2. Remove the valve cap and valve core and allow air to escape from the tire.
3. If possible, use a tire machine to remove the tire from the rim.

3.1. If a tire machine is not available, loosen both tire beads by applying pressure to the tire side walls and pushing the tire bead away from the rim flange and into the rim well **(Figure 8-1, Page 8-2, Detail A)**.

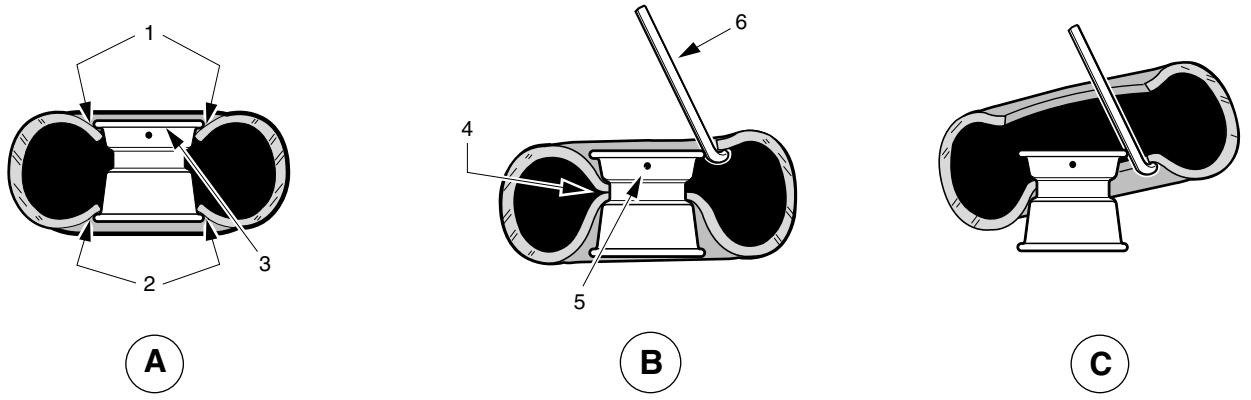
3.2. With the valve stem side of the wheel up, use a tire tool to carefully start the upper bead over the edge of the rim **(Figure 8-1, Page 8-2, Detail B)**. **See following CAUTION.**

CAUTION

- **To avoid damage to the tire, do not use excessive force when starting the bead over the edge of the rim.**

3.3. When top bead is free of the rim, pull the bead from the bottom side of the rim up into the upper part of the rim well. Insert the tire tool under the lower bead as shown **(Figure 8-1, Page 8-2, Detail C)** and carefully pry the lower bead over the rim flange.

3.4. Once the lower bead is started over the rim flange, the tire can be removed from the rim by hand.



1. Upper Tire Beads 2. Lower Tire Beads 3. Rim Flange 4. Tire Beads Positioned In Rim Well 5. Valve Stem Side Up 6. Tire Tool

Figure 8-1 Tire Removal

TIRE REPAIR

1. Determine the location and cause of the air leak.

1.1. Remove the wheel. **See Wheel Removal on page 8-1.** Inflate the tire to no more than 20 psig (138 kPa).

1.2. Immerse the tire in water and then mark the point where bubbles are formed by escaping air.

1.3. Determine the cause of the air leak. **See following NOTE.**

NOTE: *An air leak could be due to a punctured casing, faulty valve core, improperly seated valve stem, or improperly seated tire bead.*

Small holes in the casing can be plugged using a standard automotive tubeless tire repair kit available at auto supply stores.

2. When the cause of the air leak has been determined, remove tire from the rim and repair as required. **See Tire Removal on page 8-2.**

TIRE INSTALLATION

⚠ WARNING

- **While mounting or inflating tire, keep hands, fingers, etc. from exposed areas between the tire bead and rim.**

1. Clean both tire beads to remove dirt or other foreign matter.
2. Where the tire beads seat, clean the rim with a wire brush. Wipe away any debris with a clean cloth. **See following NOTE.**

NOTE: *Because tubeless tires require a perfect seal in order to seat, keeping the tire and rim clean is very important.*

3. Apply a liberal amount of tire-mounting lubricant (soap and water solution) to both tire beads and rim flanges.
4. Install the tire on the rim from the valve stem side. If there is no tire machine available, use a rubber mallet and tire iron.
5. Remove the valve core, and position the tire so that both beads are on the rim flange narrow bead seats.
6. Place the tire and wheel assembly against a wall in an upright position and push it against the wall while inflating the tire to the recommended pressure. **See Vehicle Specifications on page 2-1.** The three-point contact (wall, floor, and hand) will help ensure that beads snap into place and form a proper seal as the tire is inflated **(Figure 8-2, Page 8-4)**. **See following WARNING.**

⚠ WARNING

- **Do not use a compressed air source with pressure over 100 psig (689 kPa). Due to the low pressure requirements of a small tire, over-inflation could be reached almost instantly when using a high pressure air supply. Over-inflation could cause the tire to explode, possibly resulting in personal injury.**

7. Quickly remove the air nozzle and install the valve core.
8. Adjust air pressure in the tire to recommended pressure. **See Vehicle Specifications on page 2-1.**
9. Immerse the wheel and tire assembly in water to make sure there are no leaks.



Figure 8-2 Inflate Tire

SECTION 9 — REAR SUSPENSION

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

GENERAL INFORMATION

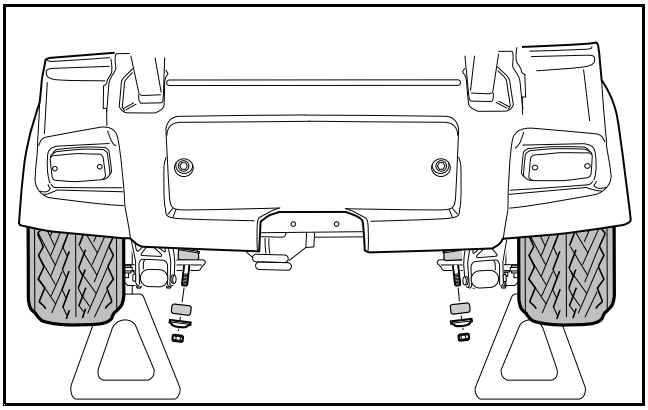
The rear suspension and powertrain of the vehicle move independently from the vehicle frame. The suspension includes three multi-leaf springs controlled by two hydraulic shock absorbers mounted between the spring mounting plate and the frame. On the gasoline vehicle, the engine is mounted on an engine mounting plate that moves with the suspension. At the front of the mounting plate, a snubber limits the mounting plate motion.

SHOCK ABSORBERS

See General Warnings on page 1-1.

SHOCK ABSORBER INSPECTION AND REMOVAL

1. Check shock absorbers (10) for damage or fluid leakage at the point where the shaft enters the shock absorber body. Replace damaged or leaking shock absorbers **(Figure 9-1, Page 9-1)** and **(Figure 9-5, Page 9-4)**.
2. To remove a shock absorber (10), remove the nut (1), cup washer (4), and rubber bushing (3) from the upper shock absorber stem.
3. Remove lower mounting hardware (1, 8, and 9) on shock absorber lower mount.
4. Compress the shock absorber to remove it.



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Figure 9-1 Shock Absorber Removal

SHOCK ABSORBER INSTALLATION

NOTE: *When installing shock absorbers, make sure front shocks have identical part numbers and rear shocks have identical part numbers.*

NOTE: *Tighten 3/8 hex nut at shock absorber until shock absorber cushions are approximately the same diameter as the retainers. Do not over tighten.*

1. On the upper shock absorber mount, tighten nut (1) until rubber bushing (3) expands to size of cup washer (4) **(Figure 9-5, Page 9-4)**.
2. On the lower shock absorber mount, install mounting hardware. Tighten the nut (1) until the rubber bushing (8) expands to the same diameter as the cup washer (9).

MULTI-LEAF SPRINGS

See General Warnings on page 1-1.

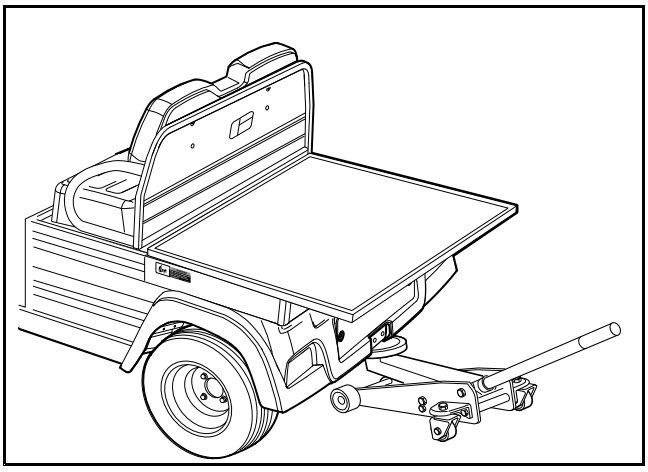
NOTE: *Carryall 300 vehicles are equipped with jounce bumpers (17).* ***(Figure 9-5, Page 9-4)****.*

MULTI- LEAF SPRING REMOVAL

1. Disconnect the battery cables and either discharge the controller or disconnect the spark plug wire. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
   See Disconnect the Battery- Gasoline Vehicles on page 1-4.
2. Loosen, but do not remove, lug nuts on tire and wheel assembly on the side from which the spring is to be removed.
3. Place chocks at the front wheels and lift rear of vehicle with a chain hoist or floor jack **(Figure 9-2, Page 9-3)**. Position jack stands under the frame crossmember between the rear leaf spring front frame mount and the side stringer, just forward of each rear wheel **(Figure 9-3, Page 9-3)**. Lower the vehicle to let the jack stands support the vehicle. **See following WARNING.**

⚠ WARNING

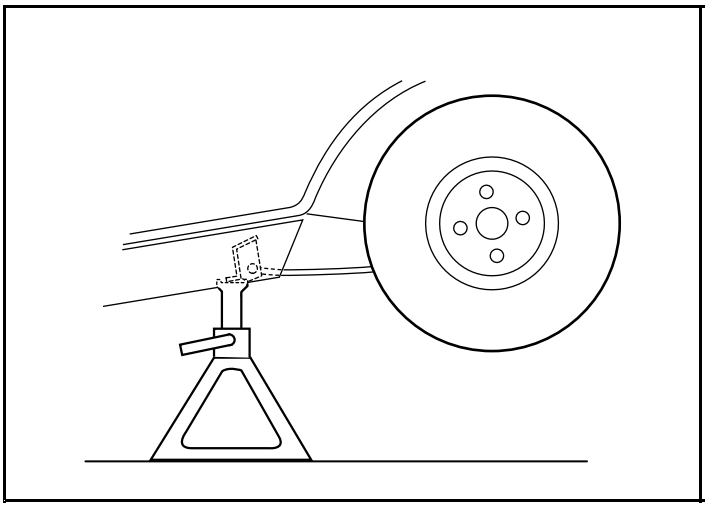
- **Lift only one end of the vehicle at a time. Use a suitable lifting device (chain hoist or hydraulic floor jack) with 1000 lb (454 kg) minimum lifting capacity. Do not use lifting device to hold vehicle in raised position. Use approved jack stands of proper weight capacity to support the vehicle and chock the wheels that remain on the floor. When not performing a test or service procedure that requires movement of the wheels, lock the brakes.**



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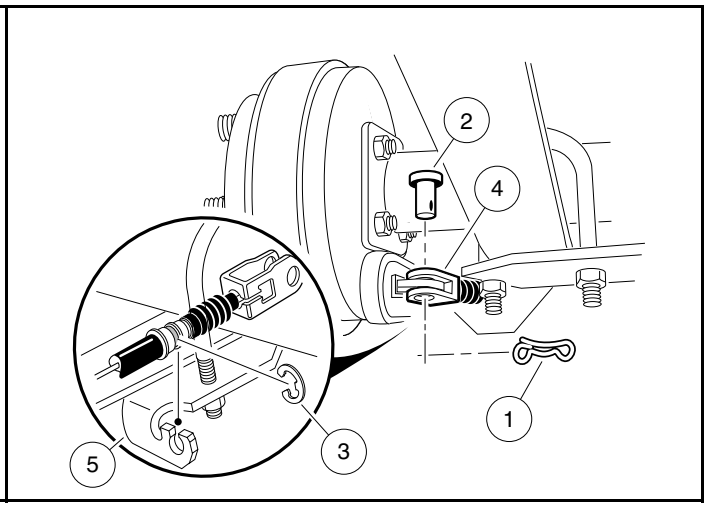
Figure 9-2 Lifting Position

4. Place a floor jack under the transaxle differential casing to support (but not lift) the drivetrain. Raise it just enough to relieve tension on the shock absorbers without compressing them.
5. Remove the tire and wheel assembly on the side from which the spring is to be removed. Thread one lug nut onto a stud on the rear hub. This will keep the brake drum on the hub.
6. Remove lower nut (1), cup washer (9), and rubber bushing (8) from shock absorber (10) **(Figure 9-5, Page 9-4)**.
7. Remove the lock nuts (12) and flat washers (if present) attaching the U-bolt (15) to the shock mount bracket (6). Remove jounce bumper mount (17) and spacer (11).
8. Allow shock mount bracket (6) to rotate downward and remove spring retainer (13). Do not disconnect brake cable from bracket **(Figure 9-5, Page 9-4)**.
9. Raise axle with floor jack until axle tube saddle is 1 inch (2.5 cm) above spring.
10. Remove bolt (22) and lock nut (18) attaching the leaf spring (20) to the rear shackles (23) **(Figure 9-5, Page 9-4)**.
11. Allow rear of leaf spring (20) to rest on the ground and remove the bolt (22) and lock nut (18) attaching the front of the spring to the vehicle frame **(Figure 9-5, Page 9-4)**. Remove spring from vehicle.
12. Inspect the rubber bushings and steel sleeves in the spring eyes and replace if worn or damaged **(Figure 9-5, Page 9-4)**.



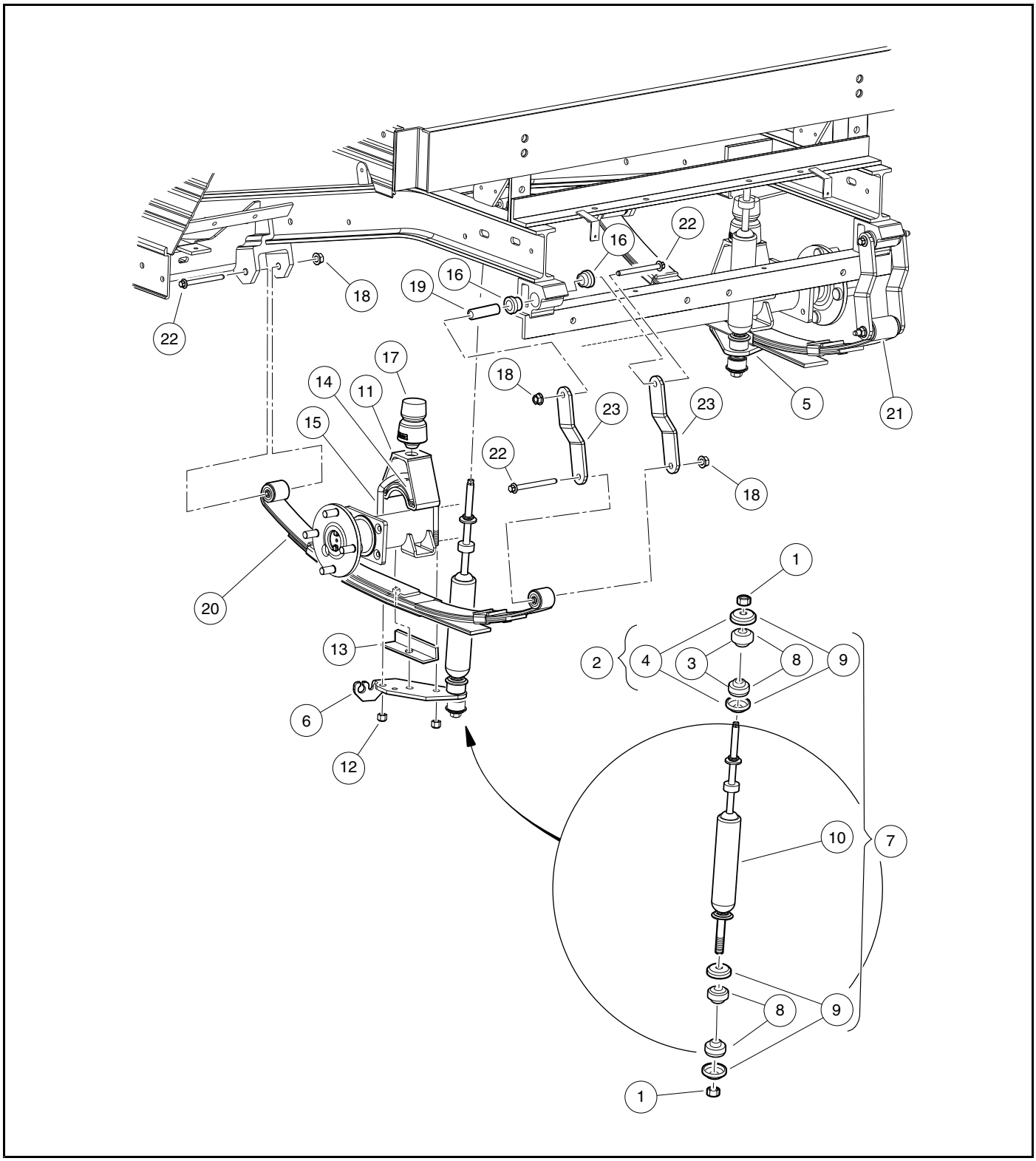
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Figure 9-3 Support Vehicle on Jack Stands



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Figure 9-4 Disconnect Brake Cable



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Figure 9-5 Rear Suspension Assembly and Mounting

MULTI-LEAF SPRING INSTALLATION

NOTE: *When installing rear leaf springs, make sure that both springs have identical part numbers.*

Tighten flange bolt (19) after clamp from brake cable has been positioned between nut and frame component.

1. Place front of leaf spring (20) into vehicle frame and insert bolt (22) through frame and leaf spring eye **(Figure 9-5, Page 9-4)**. Install lock nut (18) and tighten to 17 to 20 ft·lb (24 to 28 N·m).
2. Align the other end of leaf spring with the holes in the spring shackles (23). Insert bolt (22) through leaf spring eye and shackles. Install lock nut (18) and tighten to 17 to 20 ft·lb (24 to 28 N·m). Lower transaxle onto leaf spring (20). **See following CAUTION**.

CAUTION

- **When placing transaxle on spring, be sure to position locating bolt on the spring in the locating hole in the transaxle saddle.**

3. Tighten the nuts (1) until the rubber bushing (8) expands to the size of the cup washer (9).
4. Install spring retainer (13) and shock mount bracket (6) onto locating bolt at bottom center of leafspring **(Figure 9-5, Page 9-4)**. **See preceding CAUTION.**
5. Position jounce bumper mount (17) with spacer (11) onto axle tube. Install U-bolt (15), flat washers (if present), and lock nuts (12). Tighten U-bolt to 22 to 27 ft·lb (30 to 37 N·m). **(Figure 9-5, Page 9-4)**.
6. Install shock absorber. **See Shock Absorber Installation on page 9-2.**

JOUNCE BUMPERS

See General Warnings on page 1-1.

JOUNCE BUMPER REMOVAL

1. Grip jounce bumper (18) and pull from bumper mount (12). **(Figure 9-5, Page 9-4)**.

JOUNCE BUMPER INSTALLATION

1. Insert jounce bumper (18) into bumper mount (12).
   Make sure the entire circumference of bumper is seated firmly in mounting hole.

Pagination Page

SECTION 10 — PERIODIC MAINTENANCE

10

GENERAL INFORMATION

To ensure trouble-free vehicle performance, it is very important to follow an established preventive maintenance program. Regular and consistent vehicle maintenance can prevent vehicle downtime and expensive repairs that can result from neglect. Use the Pre-Operation and Daily Safety Checklist and the following Periodic Service Schedules and Periodic Lubrication Schedules to keep the vehicle in proper working condition.

Any vehicle not functioning correctly should be removed from use until it is properly repaired. This will prevent further damage to the vehicle and avoid the possibility of injury due to unsafe conditions.

Contact your local Club Car distributor/dealer to perform all repairs and semiannual and annual periodic service.

PRE-OPERATION AND DAILY SAFETY CHECKLIST

Each Club Car vehicle has been thoroughly inspected and adjusted at the factory; however, upon receiving your new vehicle(s), you should become familiar with its controls, indicators, and operation. Carefully inspect each vehicle to ensure that it is in proper working condition before accepting delivery.

Use the following checklist as a guide to inspect the vehicle. This checklist should be used daily to ensure that the vehicle is in proper working condition and in conjunction with the Performance Inspection and the Periodic Service Schedules. Any problems should be corrected by a Club Car distributor/dealer or a trained technician.

- **General:** All the parts should be in place and properly installed. Be sure that all nuts, bolts, and screws are tight. On gasoline vehicles, check all hose clamps for tight fit as well as the starter belt for tightness.
- **Safety and information decals:** Check to ensure that all safety and information decals are in place.
- **Tires:** Visually inspect for wear, damage, and proper inflation on a daily basis.
- **Battery(ies):** Check electrolyte to ensure that it is at its proper level. Check battery posts. Wires should be tight and free of corrosion. On electric vehicles, charge batteries fully before first use of vehicle.
- **Charger cord, plug, and receptacle (electric vehicles):** Visually inspect for cracks, loose connections, and frayed wiring.
- **Battery (gasoline vehicles):** Check battery posts. Wires should be tight and free of corrosion and battery should be fully charged.
- **Engine (gasoline vehicles):** Check for proper engine oil level. Inspect air intake for blockage.
- **Fuel (gasoline vehicles):** Check fuel level. Check fuel tank, fuel injector, lines, cap, and pump for fuel leakage on a daily basis.
- **Performance Inspection:** Inspect as instructed.

⚠ WARNING

- **Be sure the plastic has been removed from the seat bottom before operating the vehicle. Failure to do so can result in a fire, property damage, personal injury, or death.**

PERFORMANCE INSPECTION

After you have familiarized yourself with the vehicle controls and have read and understood the driving instructions, take the vehicle for a test drive.

Use the following checklist, in conjunction with the Pre-Operation and Daily Safety Checklist, as a guide to inspect the vehicle and check daily for proper operation. Any problems should be corrected by a Club Car distributor/dealer or a trained technician.

All Vehicles

- **Forward/Reverse control:** Check for proper operation.
- **Brakes:** Be sure the brakes function properly. When brake pedal is fully pressed under moderate pressure, it should not go more than halfway to the floor, and vehicle should come to a smooth, straight stop. If the brake pedal goes more than halfway to the floor, or if the vehicle swerves or fails to stop, have the brake system checked and adjusted as required. Brake adjustment must be maintained so that the brake pedal cannot be pressed to the floor under any circumstance.
- **Park brake:** When latched, the park brake should lock the wheels and hold the vehicle stationary (on an incline of 20% or less). It should release when either the accelerator or brake pedal is pressed.
- **Reverse buzzer:** The reverse buzzer should sound as a warning when the Forward/Reverse handle or switch is in the REVERSE position.
- **Steering:** The vehicle should be easy to steer and should not have any play in the steering wheel.
- **General:** Listen for any unusual noises such as squeaks or rattles. Check the vehicle ride and performance. Have a Club Car distributor/dealer or a trained technician investigate anything unusual.

Electric Vehicles

- **Accelerator:** With the key switch in the ON position and the Forward/Neutral/Reverse control (FNR) in the F position, as the accelerator pedal is pressed, the motor should start and the vehicle should accelerate smoothly to full speed. Club Car vehicles operate at reduced speed in reverse. When the pedal is released, it should return to the original position and the motor should rotate freely or go into motor braking mode. **See Pedal Up Motor Braking below.**
- **Walk Away Braking:** With the vehicle parked on level ground and the park brake disengaged, place the Run/Tow switch in the RUN position and attempt to push the vehicle. Motor braking should engage and limit rolling to no more than 1 to 3 mph (1.6 to 4.8 km/h) with the Forward/Neutral/Reverse control (FNR) in any position. When walk away motor braking is engaged, the reverse buzzer should emit a distinct pattern of beeps.
- **Motor Braking:** Accelerate down an incline with the accelerator pedal fully pressed. When the vehicle reaches maximum programmed speed, motor braking should engage and limit the vehicle to its maximum programmed speed. On very steep grades, the vehicle may slightly exceed its maximum programmed speed, requiring the use of the brake pedal. Also, travel downhill with the accelerator pedal partially pressed. Motor braking should limit speed to less than top speed and maintain speeds proportional to the accelerator pedal position. On a level surface, accelerate the vehicle to full speed and then release the accelerator pedal. Motor braking should smoothly slow the vehicle to a complete stop or else allow the vehicle to coast freely, depending on the selected controller setting.

Gasoline Vehicles

- **Accelerator for pedal-start vehicles:** With the key switch in the ON position and the Forward/Neutral/Reverse control (FNR) in the F position, as the accelerator pedal is pressed, the engine should start and the vehicle should accelerate smoothly to full speed. When the pedal is released, it should return to the original position and the engine should stop.
- **Accelerator for key-start vehicles:** After starting the engine with the key switch and placing the Forward/Neutral/Reverse control (FNR) in the F position, the vehicle should accelerate smoothly to full speed as the accelerator pedal is pressed. When the accelerator pedal is released, it should return to the original position and the engine should idle.
- **Governor:** Check maximum speed of the vehicle on a level surface. Refer to Vehicle Specifications beginning on page 2-4 for the rated speed of the vehicle.

MAINTENANCE

⚠ WARNING

- **If any problems are found during scheduled inspection or service, do not operate the vehicle until repairs are made. Failure to make necessary repairs can result in fire, property damage, severe personal injury, or death.**
- **Only trained technicians should service or repair the vehicle or battery charger. Anyone doing even simple repairs or service should have knowledge and experience in electrical and mechanical repair. The appropriate instructions must be used when performing maintenance, service, or accessory installation.**
- **Do not work on vehicle powertrain or under the cargo bed when it is loaded.**
- **Do not wear loose clothing or jewelry, such as rings, watches, chains, etc., when servicing the vehicle.**
- **Turn the key switch to OFF, remove the key, place the Forward/Reverse handle or switch in the NEUTRAL position, and chock tires prior to servicing.**
- **Do not close bed until all persons are clear of the bed area. Lower the bed gently, keeping entire body clear. Do not drop the bed. Failure to follow these instructions can result in severe personal injury.**

Electric vehicles:

- **Hot! Do not attempt to service hot motor. Attempting to do so can cause severe burns.**
- **To avoid unintentionally starting the vehicle, disconnect the batteries and discharge the controller.**

Gasoline vehicles only:

- **Moving parts: Do not attempt to service gasoline vehicle while the engine is running.**
- **Hot! Do not attempt to service hot engine or exhaust system. Failure to heed this warning can result in severe burns.**
- **To avoid unintentionally starting the vehicle, disconnect battery and spark plug wire.**
- **Frame ground – Do not allow tools or other metal objects to contact frame when disconnecting batteries or other electrical wiring. Never allow a positive wire to touch the vehicle frame, engine, or other metal component.**

PERIODIC SERVICE SCHEDULES

See General Warnings on page 1-1.

⚠ WARNING

- **Service, repairs, and adjustments must be made per instructions in the maintenance and service manual.**
- **If any problems are found during scheduled inspection or service, do not operate the vehicle until repairs are made. Failure to make necessary repairs can result in fire, property damage, severe personal injury, or death.**

NOTE: *If the vehicle is constantly hauling heavy loads or hauling a trailer, these preventive maintenance procedures should be performed more often than recommended in the Periodic Service Schedule.*

Both the Periodic Service Schedules and the Periodic Lubrication Schedules must be followed to keep vehicle in optimum operating condition.

PERIODIC SERVICE SCHEDULE – ELECTRIC VEHICLES		
REGULAR INTERVAL	**SERVICE**	
Daily service by owner	Pre-Operation and Daily Safety Checklist	See Pre-Operation and Daily Safety Checklist.
	Performance Inspection	See Performance Inspection.
	Batteries	Charge batteries (after each daily use only).
Weekly service by owner	Batteries (For vehicles NOT equipped with the Single-Point Watering System)	Check electrolyte level. Add water if necessary. See Battery Care.
Monthly service by owner or trained technician	Batteries (For vehicles equipped with the Single-Point Watering System). Water monthly or according to the established watering interval.	Water the batteries. Observe that water flow occurs and no water overflows from any cell. See Battery Care.
	Batteries	Wash battery tops and clean terminals with baking soda/water solution.
	Tires	Check air pressure and adjust if necessary. See Vehicle Specifications.
	General vehicle	Wash battery compartment and underside of vehicle.
Initial (one-time) inspection by owner or trained technician after six weeks of use	Batteries (For vehicles newly equipped with the SPWS)	For vehicles newly equipped with the SPWS, manually check battery electrolyte levels of all cells to verify correct valve operation.
Semiannual service by trained technician only (or every 50 hours of operation, whichever comes first)	Brake system	Check brake shoes; replace if necessary or adjust as required.
		Check brake cables for damage; replace if necessary.
		Check brake cable equalizer adjustment; adjust if necessary.
	Electrical wiring and connections	Check for tightness and damage.
	Front wheel alignment and camber	Check and adjust as required. **See Steering and Front Suspension section in the maintenance and service manual.**
	Motor Controller Output Regulator (MCOR)	Check for loose hardware, cracks, or other damage.
Annual service by trained technician only (or every 100 hours of operation, whichever comes first)	Batteries (For vehicles equipped with the SPWS)	Manually check battery electrolyte levels of all cells to verify correct valve operation.
	Batteries	If batteries are not performing as expected, see the Batteries section in the maintenance and service manual.
	Safety decals	Check safety decals. Replace if damaged or illegible.

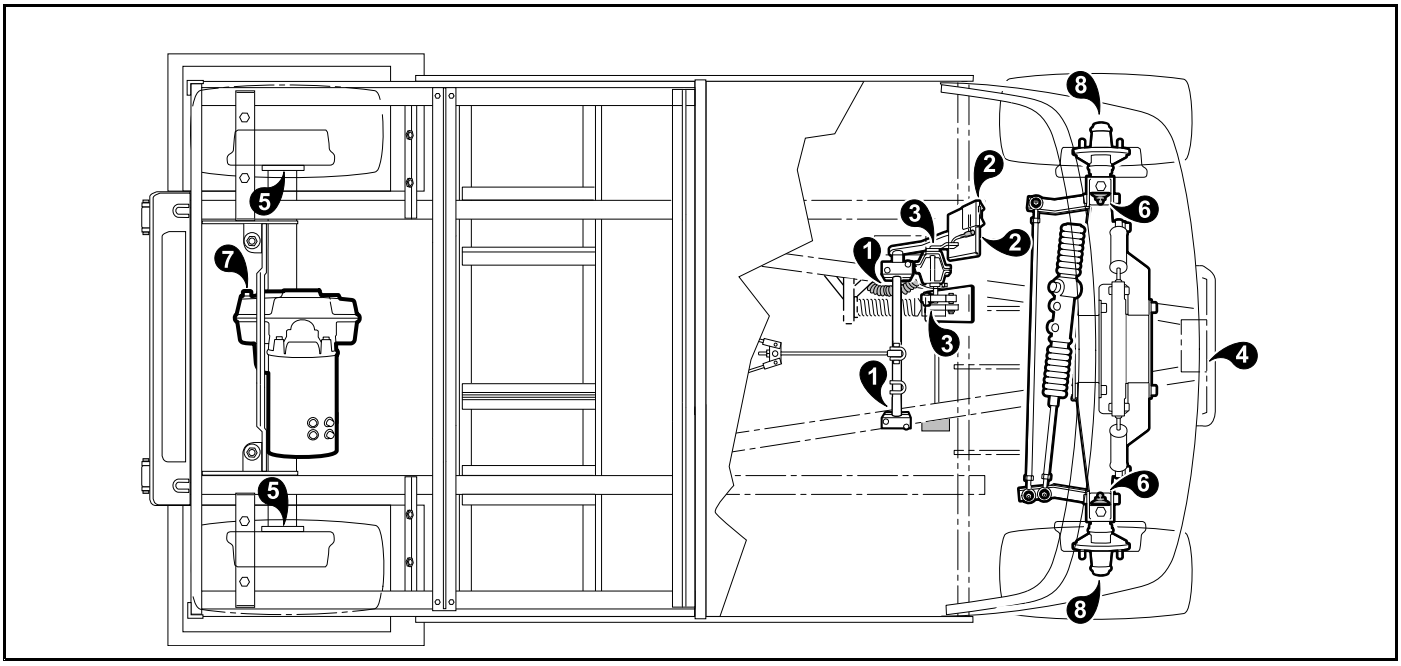
PERIODIC SERVICE SCHEDULE – GASOLINE VEHICLES		
REGULAR INTERVAL	**SERVICE**	
Daily service by owner	Pre-Operation and Daily Safety Checklist	See Pre-Operation and Daily Safety Checklist.
	Performance Inspection	See Performance Inspection.
Monthly service by owner or trained technician	Engine	Check engine oil level; change if necessary. Dispose of used oil properly.
		Check engine cooling air intake; visually inspect unshrouded area around engine exhaust for grass and debris, and clean if necessary.
	Tires	Check air pressure and adjust if necessary.
	General vehicle	Wash engine compartment and underside of vehicle. Do not wash engine when hot.
Semiannual service by trained technician only (or every 50 hours of operation, whichever comes first)	Battery	Clean terminals and wash dirt from casing.
	Front wheel alignment and camber	Check and adjust if necessary. **See Steering and Front Suspension section in the maintenance and service manual.**
	Electrical wiring and connections	Check for tightness and damage.
	Brake system	Check brake shoes; replace if necessary or adjust as required.
		Check brake cables for damage; replace as required.
		Check brake cable equalizer adjustment; adjust if necessary.

TABLE CONTINUED ON NEXT PAGE

PERIODIC SERVICE SCHEDULE – GASOLINE VEHICLES		
REGULAR INTERVAL	**SERVICE**	
Annual service by trained technician only (or every 100 hours of operation, whichever comes first)	Belts	Inspect the drive belt and starter/generator belt. Replace and adjust as necessary.
	Engine	Check for leaks around gaskets, fill plugs, etc.
		Inspect, clean and gap spark plug; replace if necessary.
	Engine air intake system	Check air filter element; clean or replace if necessary.
		Check clamps for tightness; check hose for cracks.
	General vehicle	Check for loose hardware and tighten if necessary. Check the vehicle top speed. Adjust as necessary.
	Safety decals	Check safety decals. Replace if damaged or illegible.
Two-year service by trained technician only.	Engine	Check and adjust valve clearance as needed.

PERIODIC LUBRICATION SCHEDULES

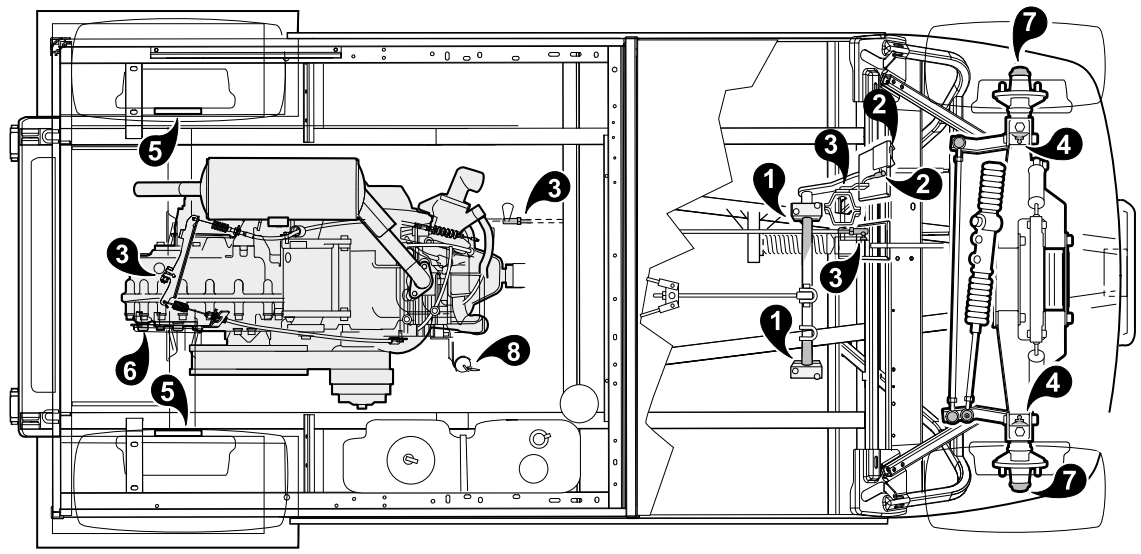
PERIODIC LUBRICATION SCHEDULE – ELECTRIC VEHICLES			
REGULAR INTERVAL	**SERVICE**	**LUBRICATION POINTS**	**RECOMMENDED LUBRICANT**
Semiannually by owner or trained technician (or every 50 hours of operation, whichever comes first)	Brake pedal shaft bearings	1	Dry Moly Lube
	Brake linkage and pivots	2	Dry Moly Lube
	Accelerator pivot rod supports	3	Dry Moly Lube
	Charger Receptacle	4	WD-40®
	Brake slides	5	Dry Moly Lube
	Front suspension	6	Chassis Lube – EP NLGI Grade 2
Annually by trained technician only (or every 100 hours of operation, whichever comes first)	Transaxle: Check/fill to plug level.	7	22 fl-oz (0.67 L) SAE 30 WT. API Class SE, SF, SG Oil (or higher)
	Inspect front wheel bearings (Repack as necessary)	8	Chassis Lube – EP NLGI Grade 2



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Figure 10-1 Lubrication Points – Electric Vehicles

PERIODIC LUBRICATION SCHEDULE – GASOLINE VEHICLES			
REGULAR INTERVAL	**SERVICE**	**LUBRICATION POINTS**	**RECOMMENDED LUBRICANT**
Semiannually by owner or trained technician (or every 50 hours of operation, whichever comes first)	Brake pedal shaft bearings	1	Dry Moly Lube
	Brake linkage and pivots	2	Dry Moly Lube
	Accelerator pivot rod supports and shifter cable pivots	3	Dry Moly Lube
	Front suspension	4	Chassis Lube (EP NLGI Grade 2)
	Brake slides	5	Dry Moly Lube
Annually by trained technician only (or every 100 hours of operation, whichever comes first)	**Transaxle:** Check/fill to plug level	6	67.6 fl-oz (2 L) SAE 80W-90 API Class GL-5
	Inspect front wheel bearings (Repack as necessary)	7	Chassis Lube – EP NLGI Grade 2
First change 100 hours – additional change every 200 hours of operation or annually, whichever comes first	Change engine oil	8	44 fl-oz (1.3 L) **See Engine Oil Viscosity**



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Figure 10-2 Lubrication Points – Gasoline Vehicles

AIR FILTER

⚠ CAUTION

- **Engine damage will occur if the air cleaner cap is not properly secured.**
- **If air cleaner is extremely dirty, remove air cleaner from vehicle and clean thoroughly.**
- **Use only Club Car replacement air filters. The use of other air filters could result in engine damage and void the warranty.**

The air filter should be inspected periodically and replaced when necessary. Filter changes should not exceed the recommended interval. More frequent service may be required in extremely dirty operating environments. In the event of a loss of power, sluggish acceleration, or a roughly running engine, service the air filter immediately.

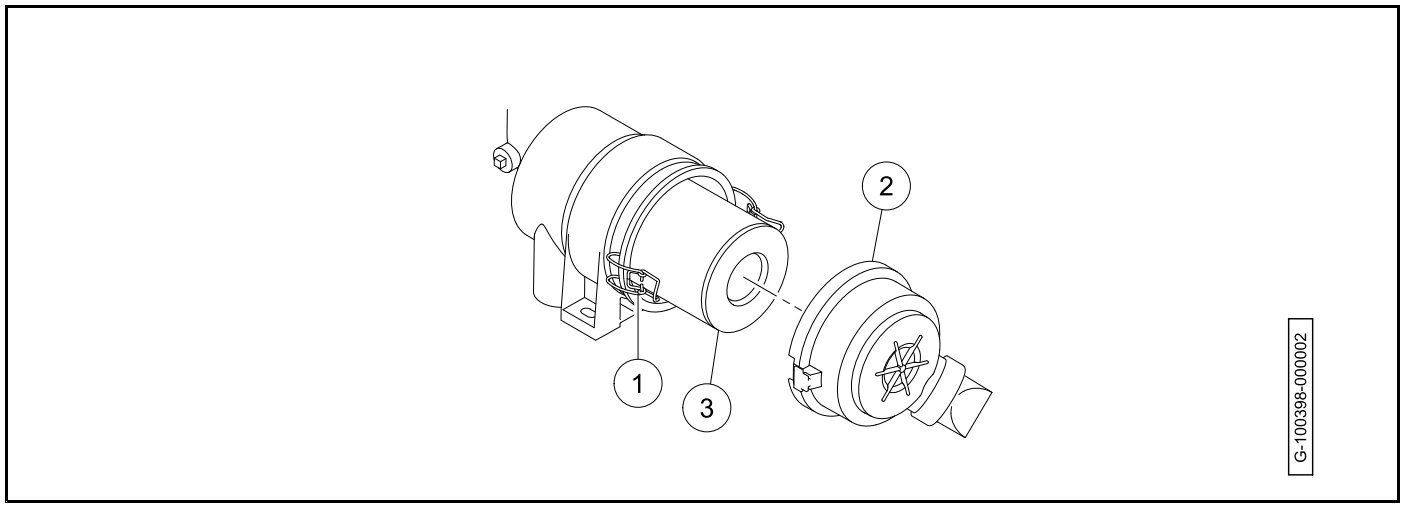


Figure 10-3 Air Filter

AIR FILTER REMOVAL

Before the air filter is removed:

- Disable the vehicle.

To remove the air filter:

1. Release the latches (1).
2. Remove the air cleaner cover (2).
3. Remove the air filter (3).

AIR FILTER INSTALLATION

1. Use a wet lint-free cloth to clean the inside of the air filter container.
2. Install the air filter (3).

NOTE: *The filter is specifically designed for this engine. It fits into the canister only one way. Use only direct replacement part.*

3. Install the air cleaner cover (2).
4. Engage the latches (1).

ENGINE OIL

ENGINE OIL VISCOSITY

Select the engine oil viscosity for your environmental conditions.

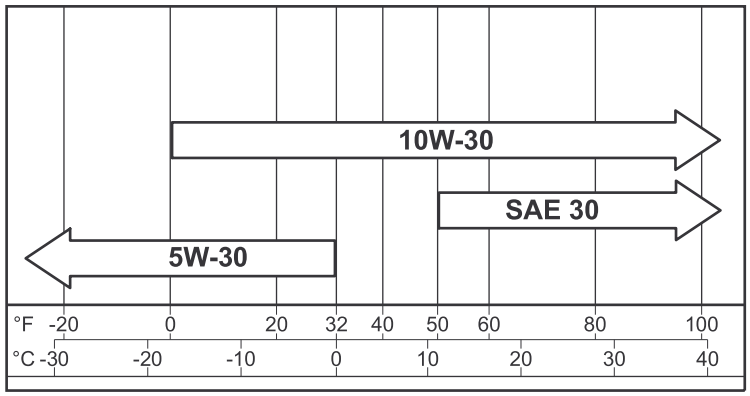


Figure 10-4 Engine Oil Viscosity

ENGINE OIL LEVEL INSPECTION

Before the engine oil is examined:

- Disable the vehicle.

To examine the engine oil:

1. Remove the dipstick (1) **(Figure 10-5, Page 10-11)**.

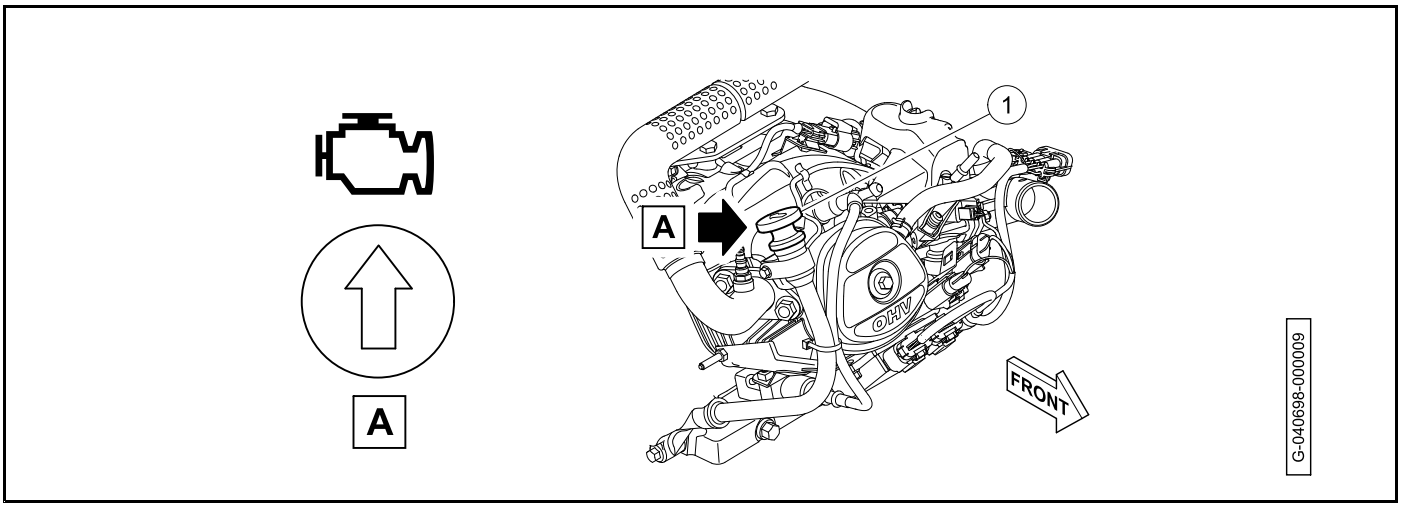


Figure 10-5 Dipstick Location

2. Make sure that the oil level is between the maximum (1) and minimum (2) indicators **(Figure 10-6, Page 10-11)**.

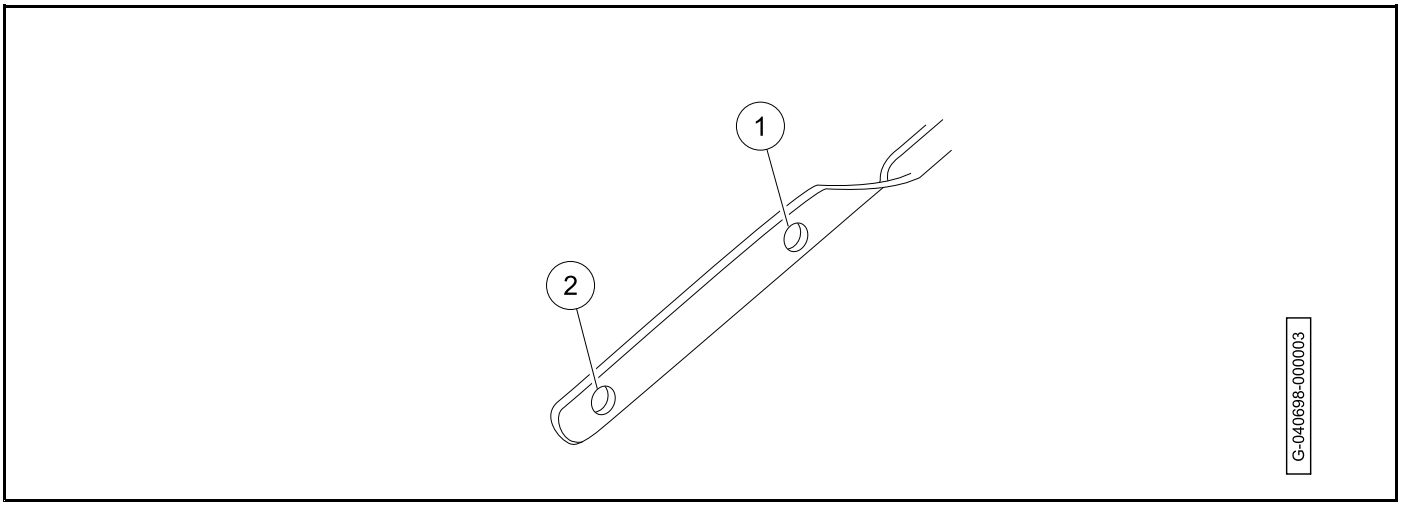


Figure 10-6 Dipstick Indicators

3. If the oil level is below the minimum indicator, add engine oil.
4. Install the dipstick.

NOTE: *Make sure that the arrow points towards the engine.*

ENGINE OIL REPLACEMENT

⚠ CAUTION

- **Hot engine oil will cause skin burns. Do not change the engine oil when the engine is hot. Let the engine temperature decrease before the oil is changed.**

CAUTION

- **Too much engine oil can decrease engine performance and damage the engine. Do not exceed the recommended engine oil capacity.**

Before the engine oil is replaced:

- Disable the vehicle.
- Disconnect the battery.

To replace the engine oil:

1. Remove the dipstick (1) **(Figure 10-7, Page 10-12)**.

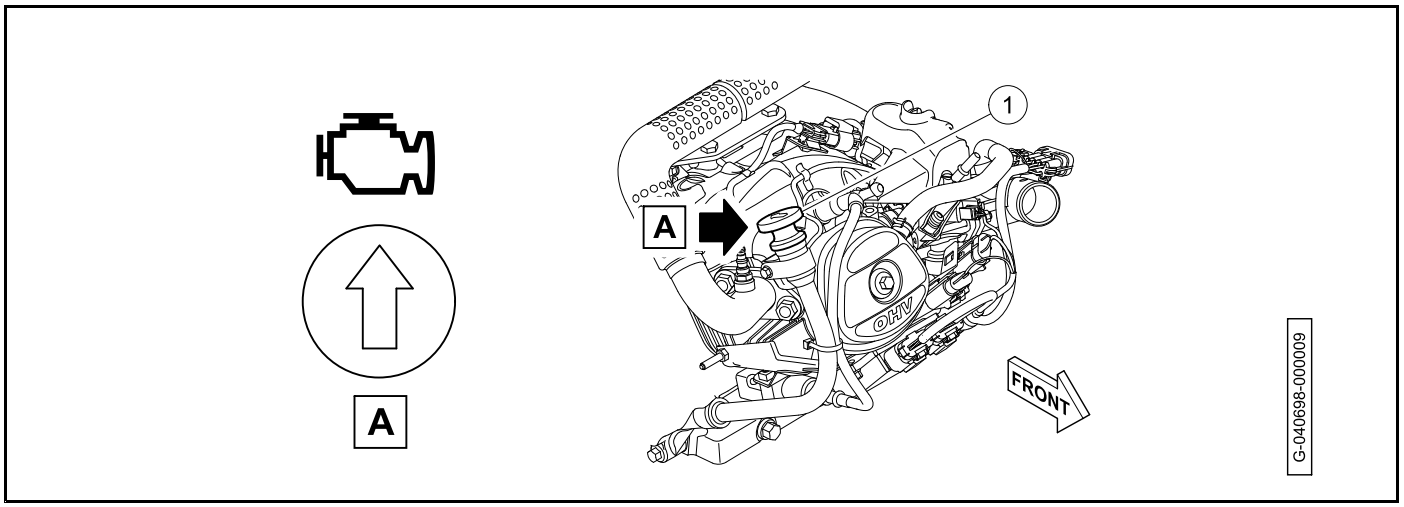


Figure 10-7 Dipstick Location

2. Clean the area around the oil drain plug (2) **(Figure 10-8, Page 10-13)**.

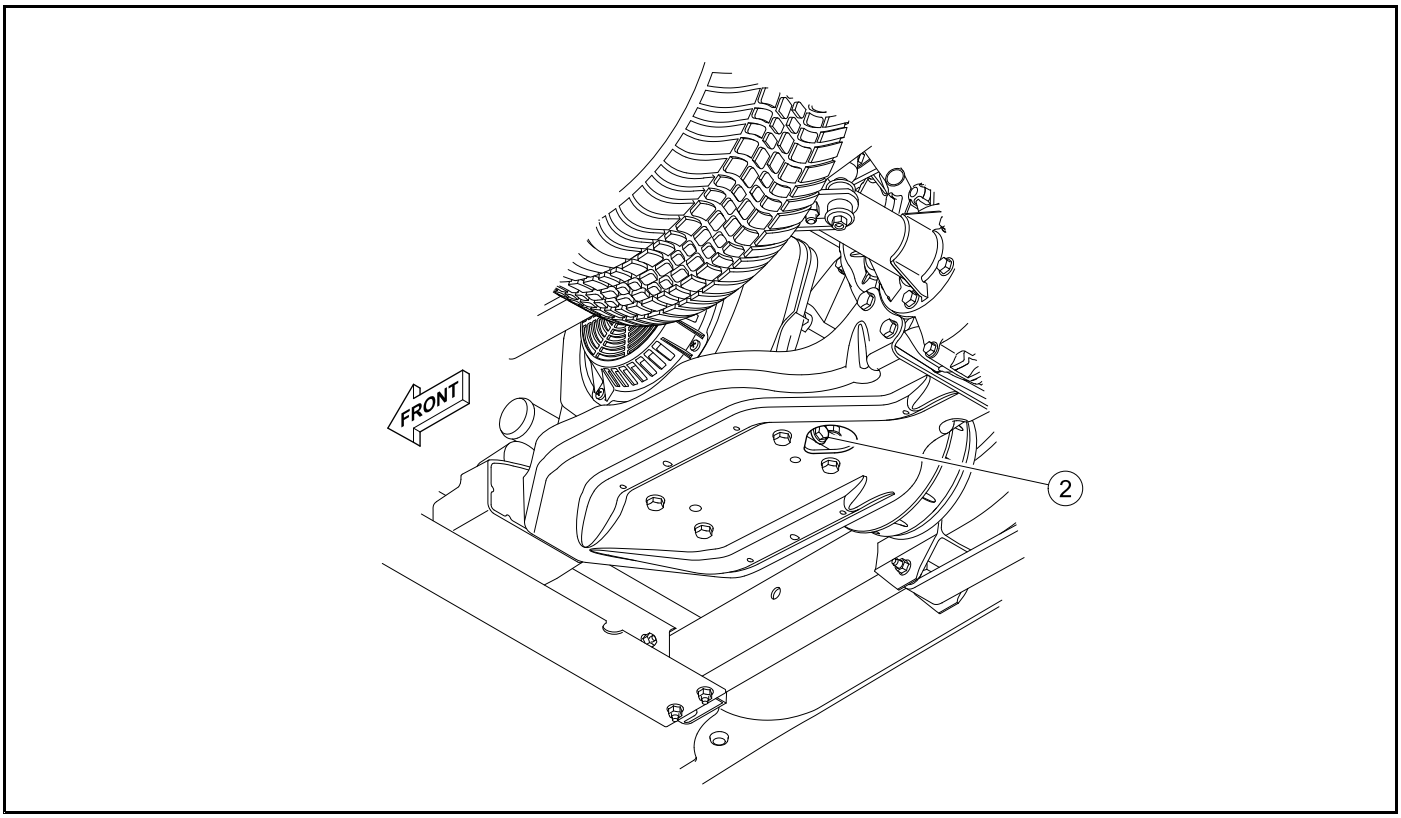


Figure 10-8 Oil Drain Plug

3. Put a drain pan below the oil drain plug.
4. Remove the oil drain plug.
5. Drain the oil fully.
6. Clean the oil drain plug.
7. Examine the gasket on the oil drain plug for damage. Replace if necessary.
8. Install the oil drain plug and tighten to 13 lb·ft (18 N·m).
9. Add 44 fl-oz (1.3 l) of recommended engine oil **(Figure 10-9, Page 10-14)**.

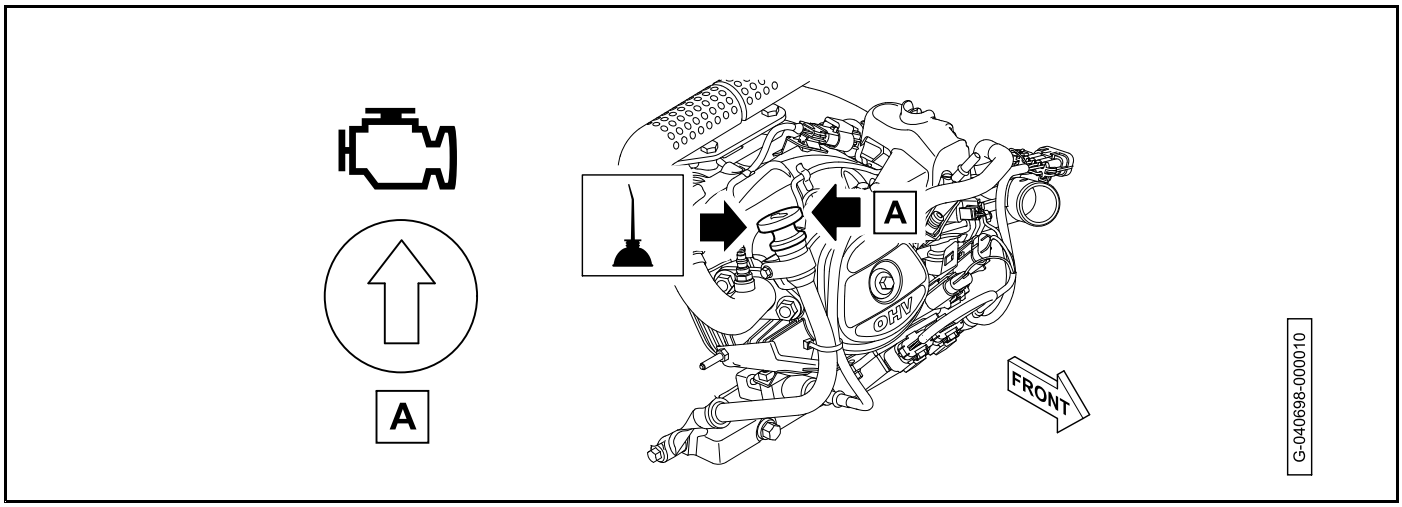


Figure 10-9 Oil Fill Location

10. Install the dipstick.
11. Connect the battery.
12. Correctly discard the used engine oil.

ADD ENGINE OIL

⚠ CAUTION

- **Hot engine oil will cause skin burns. Do not change the engine oil when the engine is hot. Let the engine temperature decrease before the oil is changed.**

CAUTION

- **Too much engine oil can decrease engine performance and damage the engine. Do not exceed the recommended engine oil capacity.**

Before the engine oil is added:

- Disable the vehicle.

To add engine oil:

1. Remove the dipstick (1) **(Figure 10-10, Page 10-15)**.

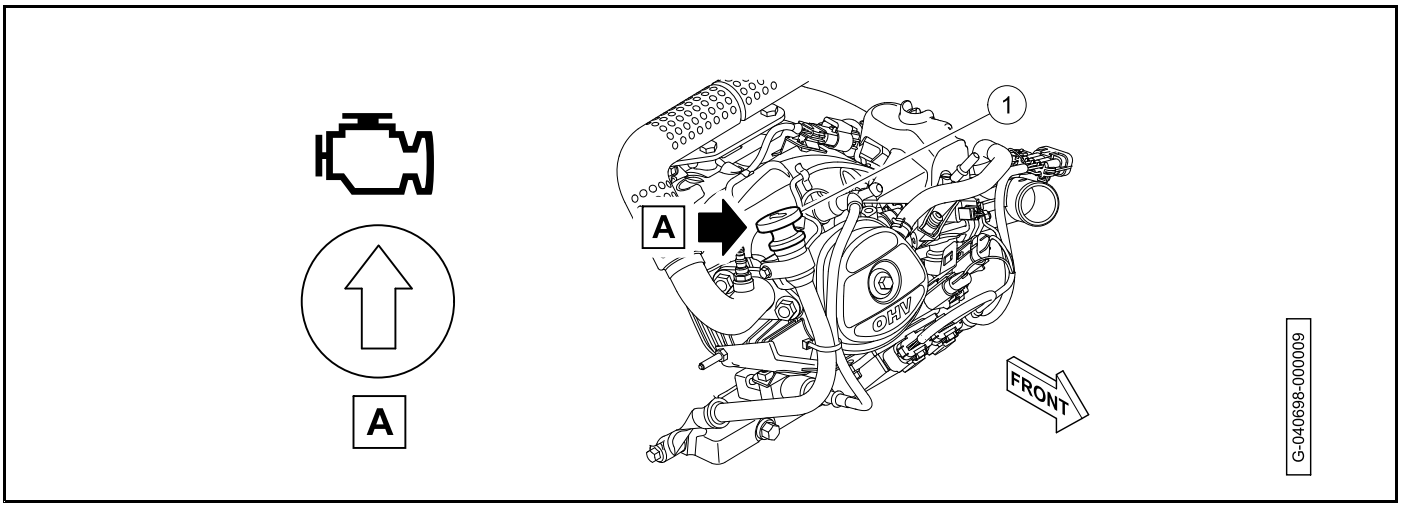


Figure 10-10 Dipstick Location

2. Add engine oil until the oil level is between the maximum (1) and minimum (2) indicators **(Figure 10-11, Page 10-15)**.

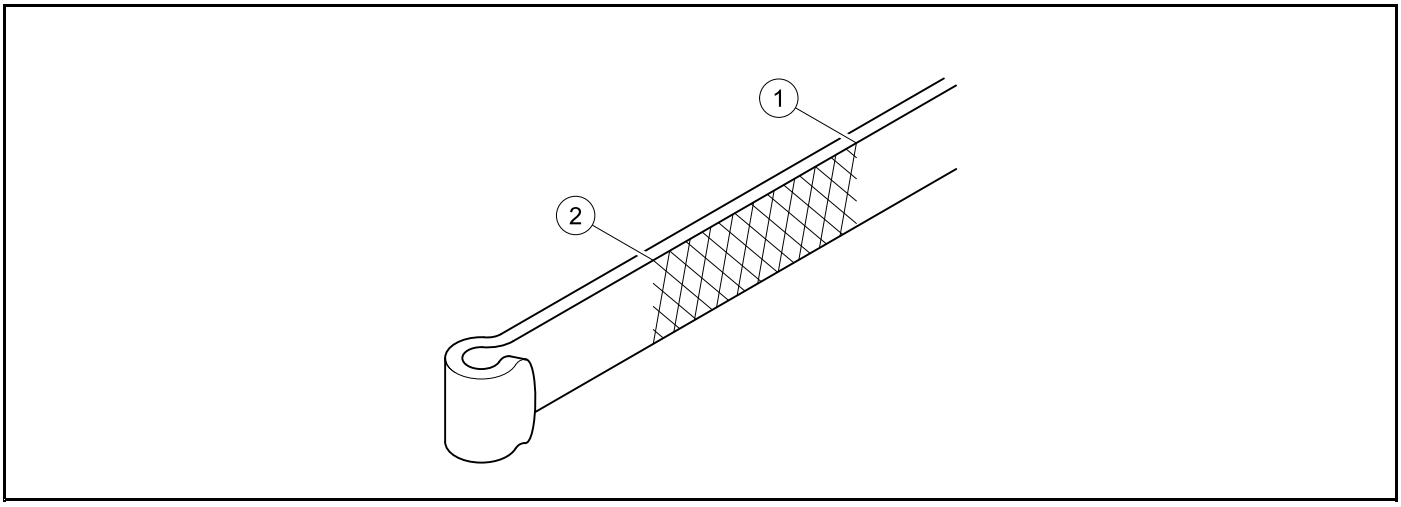


Figure 10-11 Dipstick Indicators

3. Install the dipstick.

REFUEL

⚠ DANGER

- **Fuel is flammable and explosive. Do not add fuel with the key switch set to ON. Before fuel is added, turn the key switch to OFF.**

DANGER CONTINUED ON NEXT PAGE

⚠ DANGER

- **Fuel is flammable and explosive. Do not fill the fuel tank when the engine is on or hot. Wait for the engine temperature to decrease before fuel is added.**
- **Fuel is flammable and explosive. Do not operate the vehicle when fuel is spilled. Correctly clean the spilled fuel.**
- **Fuel is toxic. Do not siphon fuel from the vehicle.**
- **Fuel is toxic. Keep fuel out of reach of children.**
- **Fuel is flammable and explosive. Keep the fuel in an approved fuel container. Keep the fuel container in a ventilated area away from sparks and heat sources.**
- **Fuel is flammable and explosive. To avoid electric arc caused by static electricity, the fuel storage/pumping device must be grounded. If the pump is not grounded, the vehicle must be grounded to the pump before and during the fueling operation.**

CAUTION

- **A fuel with an alcohol content that exceeds 10% by volume (like E15 and E85) will cause vehicle damage and void the warranty. Only use the recommended fuel type.**

Before the fuel is added:

- Disable the vehicle.

To remove the air filter:

1. Turn the key to OFF.
2. Let the engine cool.
3. Remove the fuel fill cap.
4. Fill the fuel tank with the recommended fuel.
5. Install and tighten the fuel fill cap.

LIFT THE VEHICLE

LIFT THE FRONT OF THE VEHICLE

⚠ WARNING

- **Lifting the vehicle with cargo can cause property damage, serious personal injury, or death. Remove all cargo from the cargo bed before the vehicle is lifted.**

Before the vehicle is lifted:

- Disable the vehicle.
- Disconnect the battery.

- Use a jack and jack stands rated for the vehicle.

To lift the front of the vehicle:

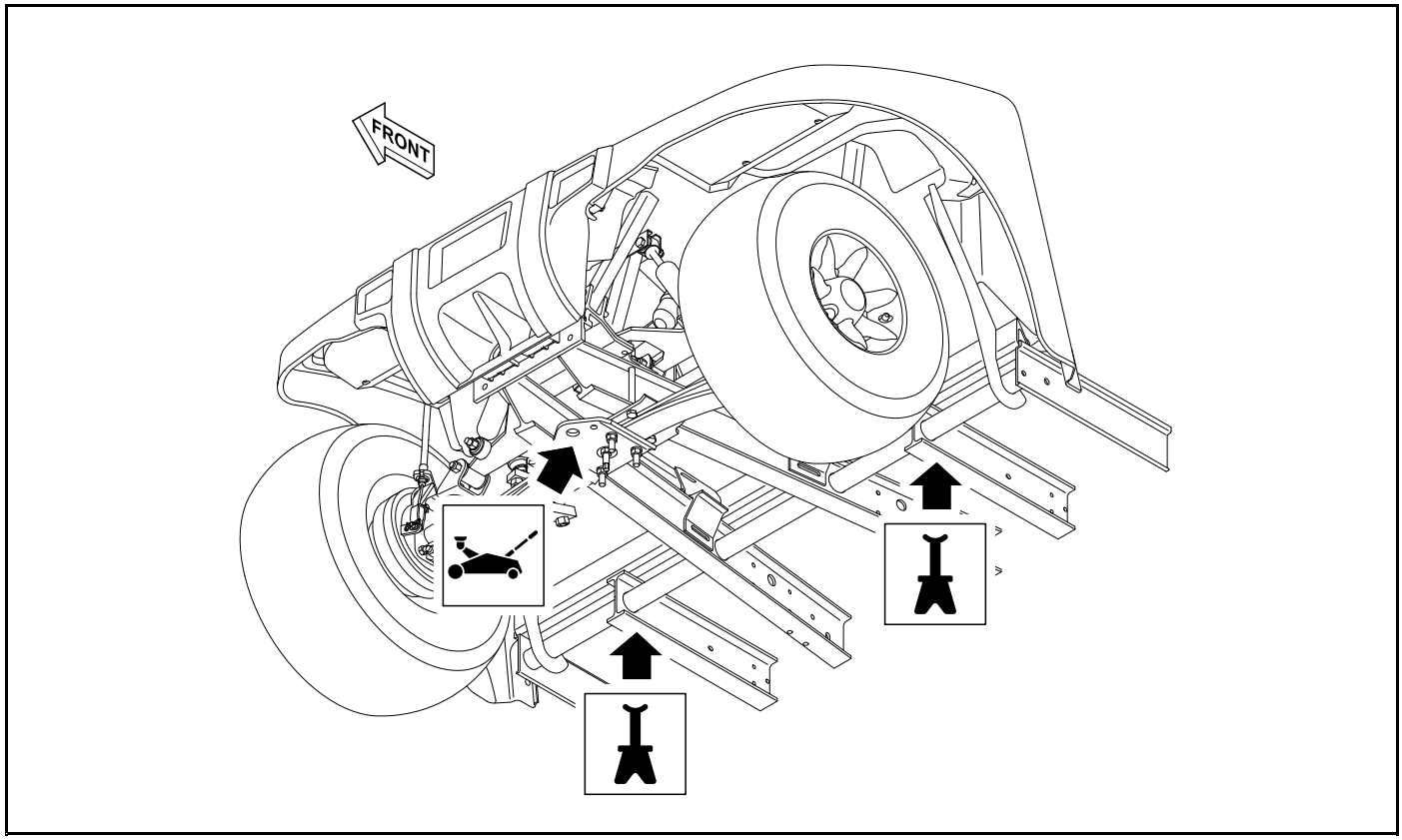


Figure 10-12 Lift The Front

1. Place the jack in the center of the lift point.
2. Lift the front of the vehicle.
3. Put jack stands under the frame rails.
4. Lower the vehicle onto the jack stands.

LIFT THE REAR OF THE VEHICLE

⚠ WARNING

- **Lifting the vehicle with cargo can cause property damage, serious personal injury, or death. Remove all cargo from the cargo bed before the vehicle is lifted.**

Before the vehicle is lifted:

- Disable the vehicle.
- Disconnect the battery.
- Use a jack and jack stands rated for the vehicle.

To lift the rear of the vehicle:

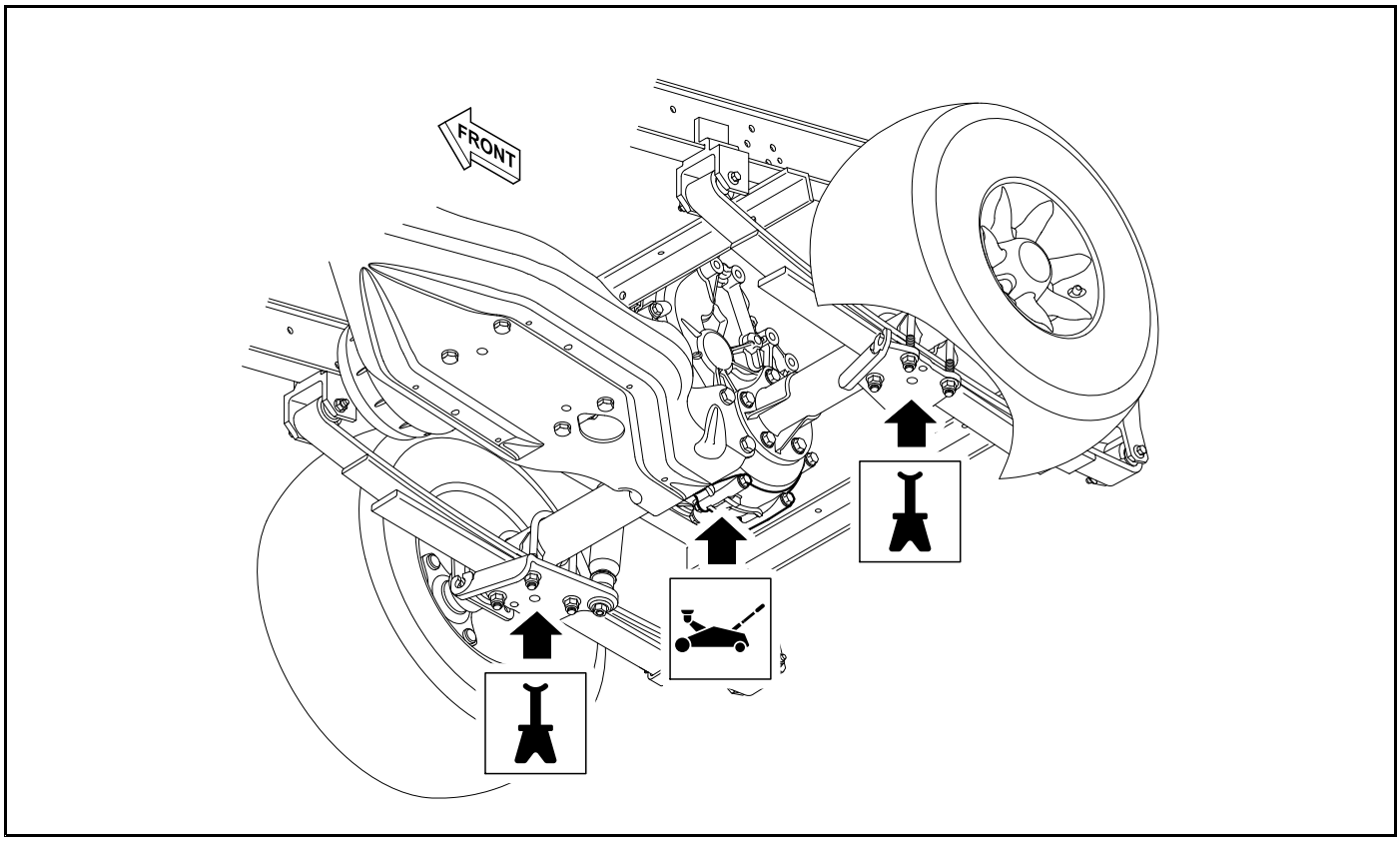


Figure 10-13 Lift The Rear

1. Place the jack in the center of the lift point.
2. Lift the rear of the vehicle.
3. Put jack stands under the frame rails.
4. Lower the vehicle onto the jack stands.

LOWER THE FRONT OF THE VEHICLE

Before the vehicle is lowered:

- Use a jack rated for the vehicle.

To lower the front of the vehicle:

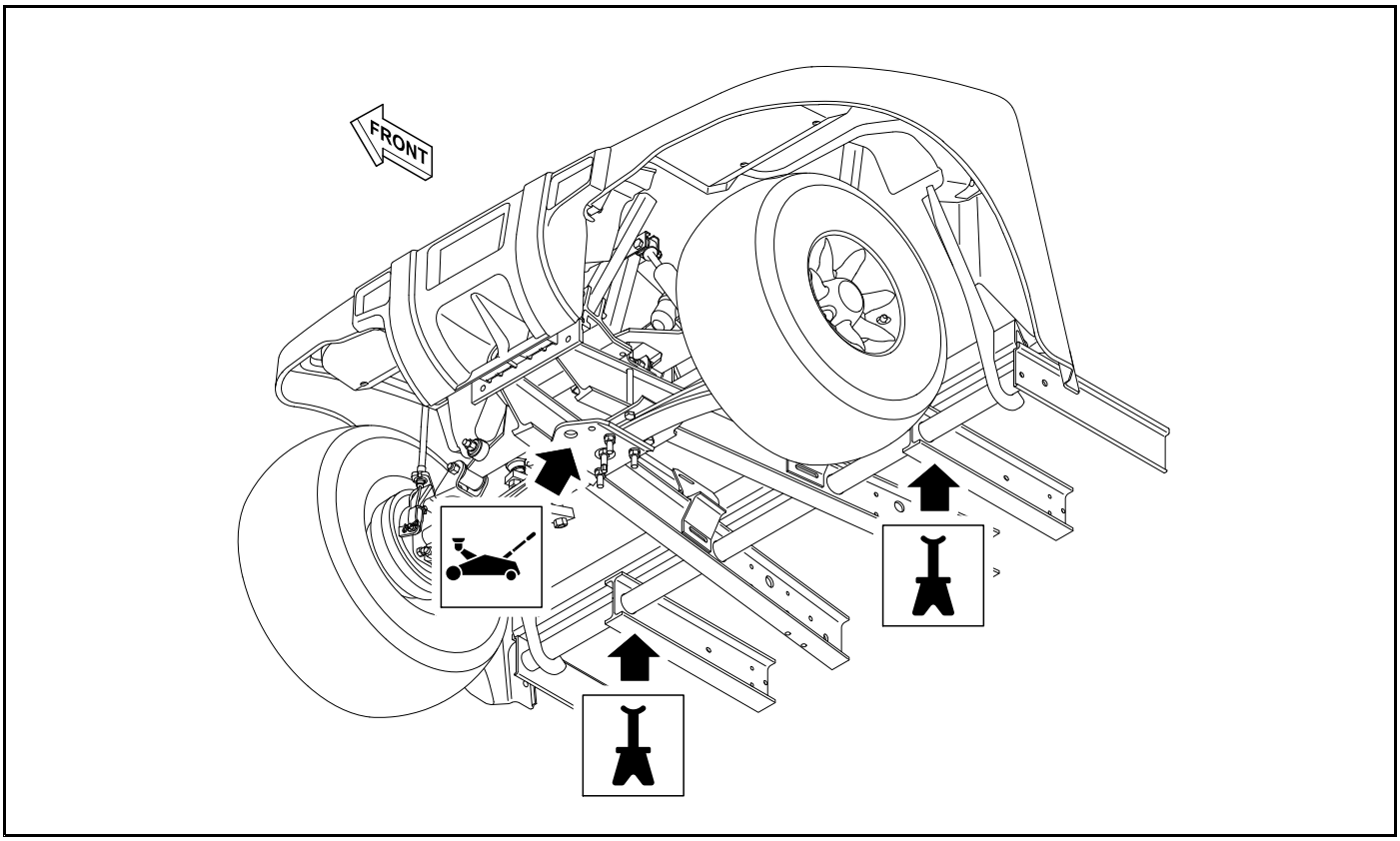


Figure 10-14 Lower The Front

1. Place the jack in the center of the lift point.
2. Lift the vehicle off of the jack stands.
3. Remove the jack stands.
4. Lower the vehicle.

LOWER THE REAR OF THE VEHICLE

Before the vehicle is lowered:

- Use a jack rated for the vehicle.

To lower the rear of the vehicle:

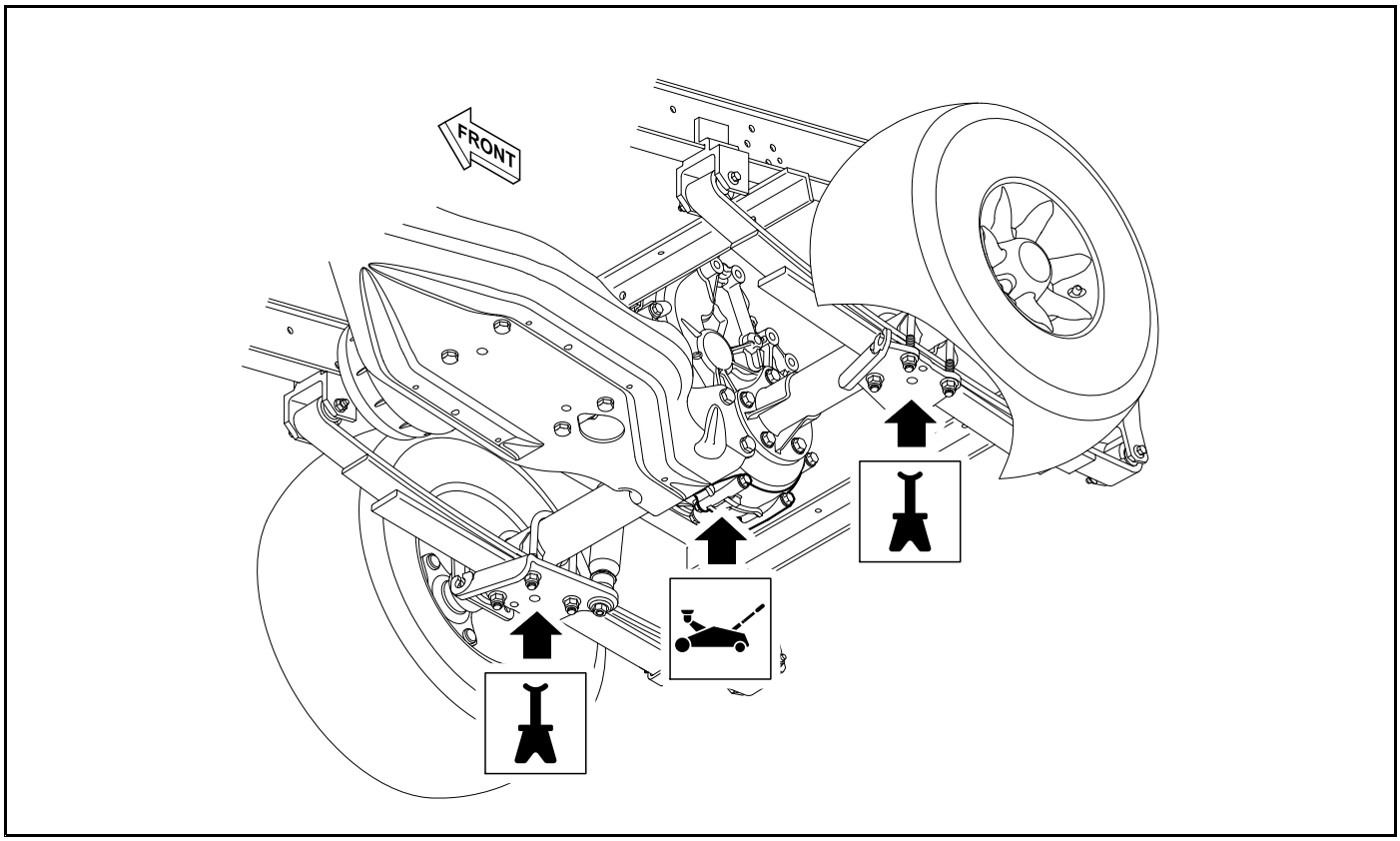


Figure 10-15 Lower The Rear

1. Place the jack in the center of the lift point.
2. Lift the vehicle off of the jack stands.
3. Remove the jack stands.
4. Lower the vehicle.

SPARK PLUG

SPARK PLUG REMOVAL

Before the spark plug is removed:

- Disable the vehicle.
- Disconnect the battery.

To remove the spark plug:

1. Clean the spark plug area.
2. Disconnect the spark plug wire (1) **(Figure 10-16, Page 10-21)**.

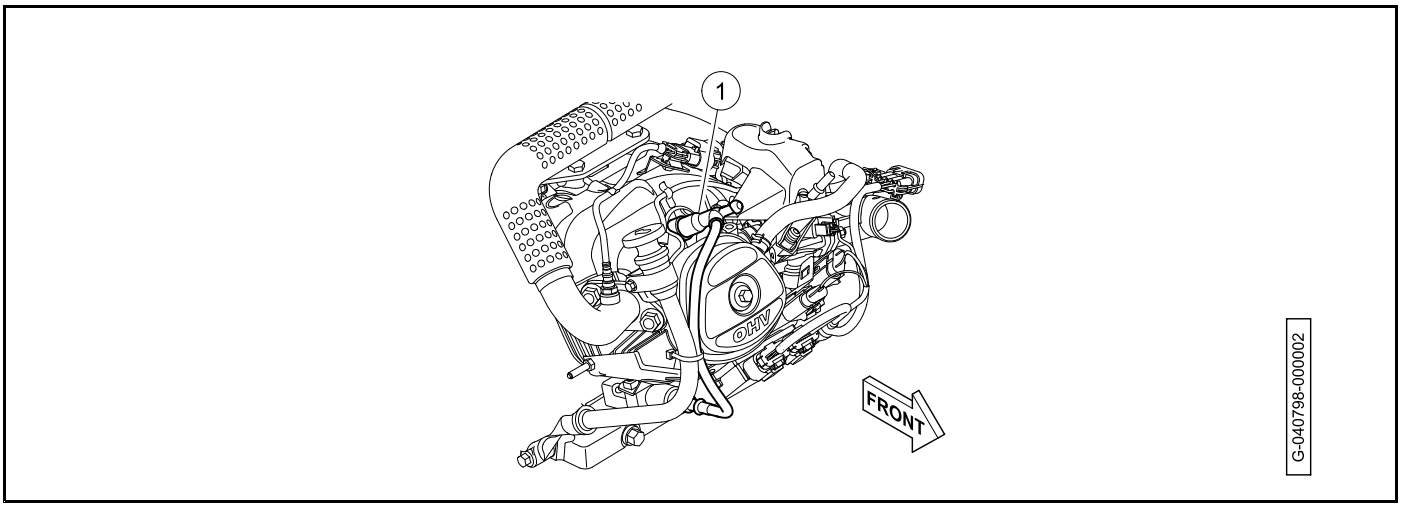


Figure 10-16 Spark Plug Wire Disconnect

3. Use a spark plug socket to remove the spark plug.

SPARK PLUG INSPECTION

1. Use a wire brush to clean the electrodes (1).

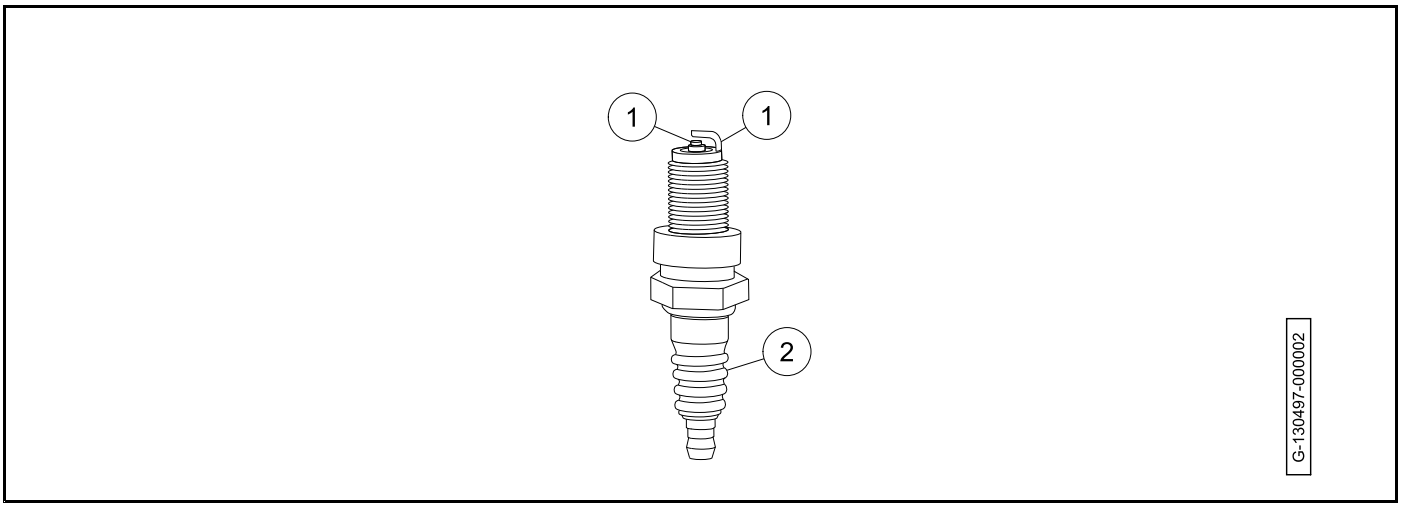


Figure 10-17 Spark Plug Inspection

2. Examine the spark plug electrodes for corrosion and damage.
3. Examine the spark plug insulator (2) for cracks.
4. Replace the spark plug if corrosion, damage, or cracks are found.

SPARK PLUG GAP

1. Use a spark plug gap tool to measure the spark plug gap.
2. Adjust the ground electrode (1) and set the spark plug gap to 0.044 in (1.11 mm).

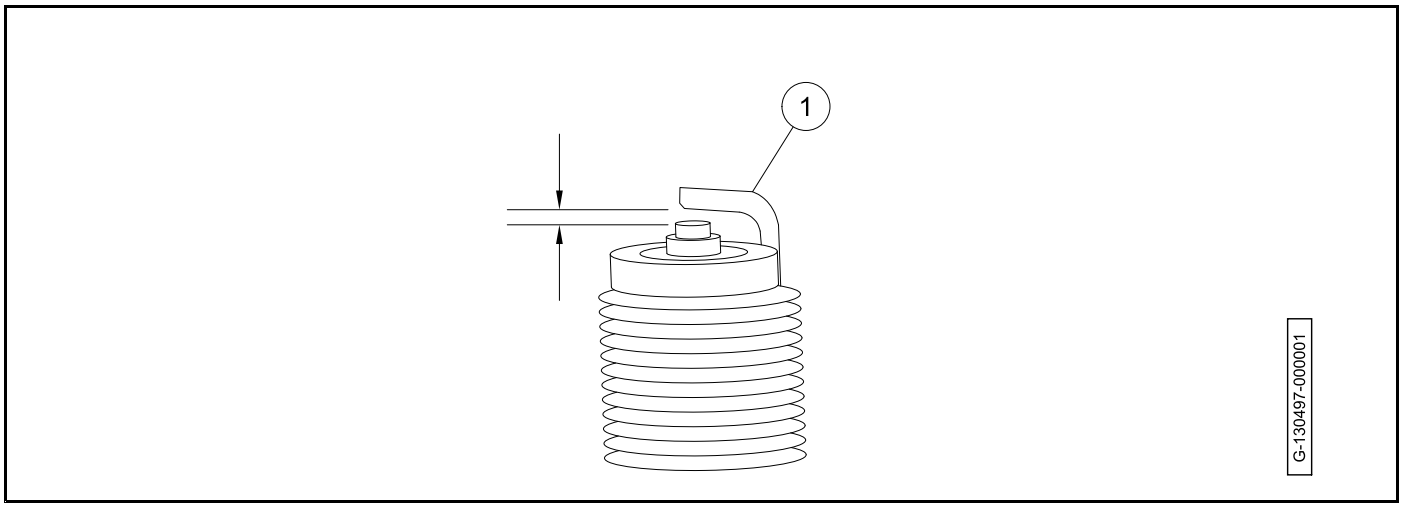


Figure 10-18 Spark Plug Gap

SPARK PLUG INSTALLATION

1. Apply a thin layer of high temperature anti-seize lubricant to the spark plug threads.
2. Use a spark plug socket to install and tighten the spark plug to 20 lb·ft (27 N·m).
3. Connect the spark plug wire (1) **(Figure 10-19, Page 10-22)**.

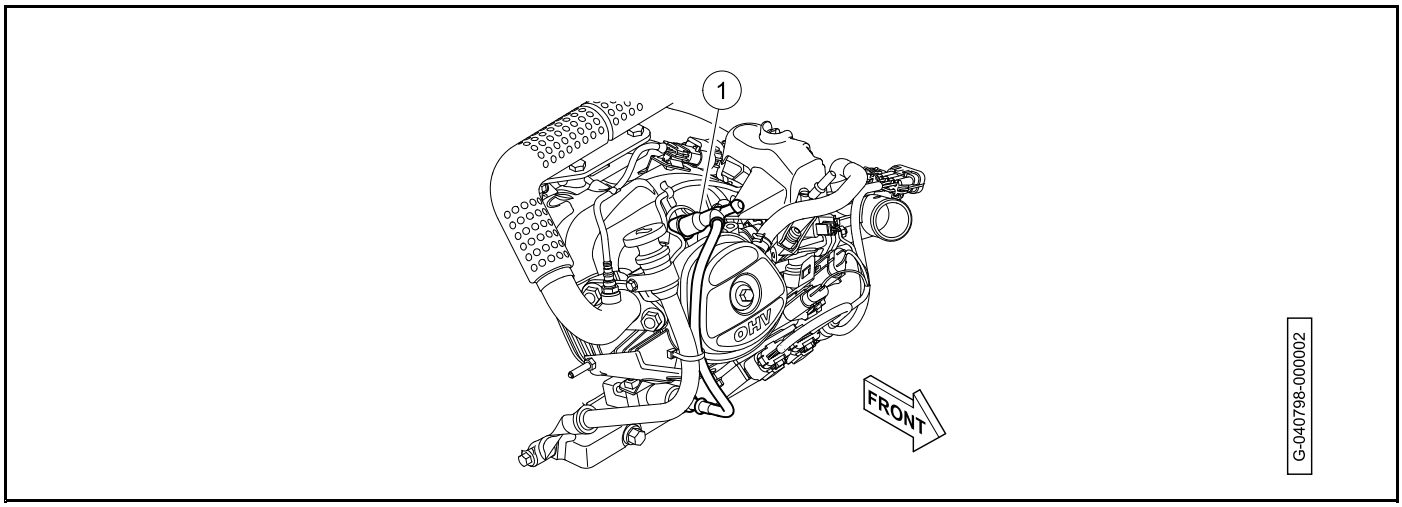


Figure 10-19 Spark Plug Wire Connect

4. Connect the battery.

VALVE CLEARANCE CHECK AND ADJUSTMENT

See Kohler Engine Service Manual.

SECTION 11 — CONTROLLER DIAGNOSTIC TOOL (CDT)

⚠ DANGER

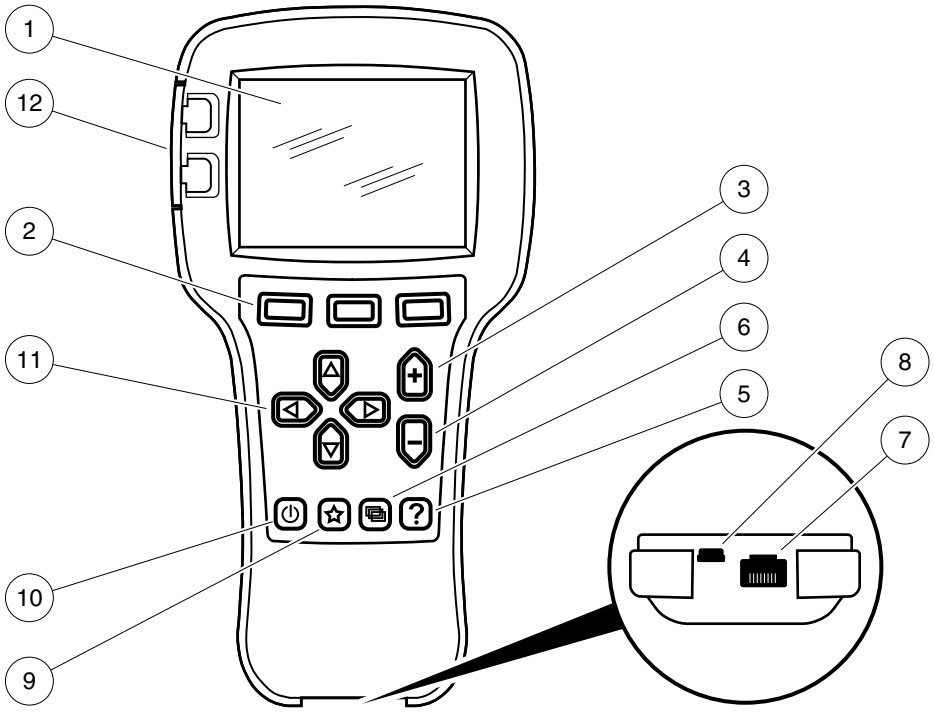
- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

NOTE: *The information presented in this section addresses the following:*

- *The Controller Diagnostic Tool (CDT) handheld programmer which replaced the IQDM series 2 handset.*
- *How to use the CDT to troubleshoot the vehicle and to adjust controller parameters that affect vehicle behavior.*
- *The Excel controller with OS version 34 or version 35. The OS version can be viewed in the System Info menu of the CDT.* ***See System Info on page 11-5.***



1. Display Screen	5. Help Button	9. Favorites Button
2. Softkeys	6. Main Menu Button	10. Power Button
3. “+” Key	7. System Port	11. Arrow Keys
4. “–” Key	8. USB Port	12. SD-card Slot

3115

Figure 11-1 CDT Overview

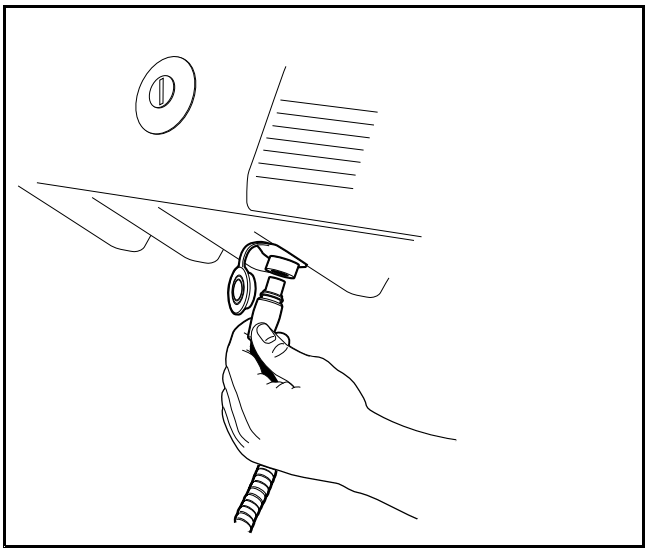
GENERAL INFORMATION

The CDT is used to adjust and save parameter settings of the controller, monitor real-time data, and perform diagnostics and troubleshooting of the electric vehicle.

FEATURES

- **Batteries:** Two AA batteries provide power for the CDT's real-time clock and they allow for use of the CDT when not connected to a vehicle.
- **Convenient parameter adjustment:** You can easily adjust a wide range of parameters to customize vehicle performance. These settings can then be saved as a unique .cpf (Cab Provisioning Format) file and stored. Multiple .cpf files can be stored and restored as needed.
- **Diagnostics and troubleshooting:** Existing faults as well as all the accumulated faults in the system's fault history file are listed in clear language. Suggestions for clearing each fault are also provided.
- **Help function:** Help screens give descriptions of adjustable parameters, monitored variables, and faults.
- **PC interface:** Files can be downloaded from a PC (onto an Secure Digital (SD) card or into the programmer directly through its USB connector) for installation into the controller.
- **Plot and Log:** The plot and log programs allow you to look at variables over time, either in graphical format or as data files you can upload in a spreadsheet program, such as Microsoft Excel.
- **Real-time monitoring:** Values of monitored data variables are displayed in easy-to-read formats.
- **SD-card support:** An SD card provides additional memory capacity. This is where any screenshots you take will be stored. SD cards can be used to deliver software upgrades, and can be used in multiple programmers to install identical software.
- **Softkeys:** Three versatile softkeys provide multiple functions, depending on context.
- **Update:** The handheld programmer can update its own software.

PLUGGING THE CDT INTO THE VEHICLE



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Figure 11-2 Communication Port Under Instrument Panel

1. Connect one end of the cable to the port located on the bottom of the CDT.
2. Connect the cable adaptor to the CDT cable.
3. Find the communication port on the vehicle **(Figure 11-2, Page 11-3)**.
4. Remove the dust cap from the communication port.
5. Align the keyed portion of the plug with the communication port and insert plug into port.

INTRODUCTORY DISPLAY

Immediately after the CDT is connected to the vehicle, it begins loading controller information. During this time, the loading status is shown as a percentage, the CDT's software version is given, and status/information icons appear in the upper right corner. Once loading is complete, the screen displays the Main Menu.

NOTE: *If the Power button is used to turn ON the handset and the handset is not connected to a vehicle, the message "No System Detected" will be displayed.*

In the event that the handset does not display any information, or the screen is difficult to read, refer to the CDT troubleshooting procedures. **See CDT Troubleshooting on page 11-26.**

QUICK REFERENCE GUIDE – EXCEL WITH ERIC CHARGING SYSTEM

OPERATION:	
Change screen contrast for better viewing by selecting the following: HPP Settings, Backlight	
Preset Favorites: Select a frequently viewed screen, press “Add to” softkey, highlight “Favorites”, press “Select” softkey.	
CONTROLLER FAULTS:	
Anti Tamper: If car is not equipped with Visage, make sure Control Mode is set to zero (0).	**Main Driver Off:** Replace controller.
Current Sense Fault: Clear the Fault History in CDT. If fault does not return and car operates normally, do not replace controller. If fault remains in System Faults, or Fault History after clearing, and car will not operate, replace controller.	**Main Driver On:** Replace controller.
FLD Missing: Check in order: orange or blue wire broke or disconnected at motor/controller, short in motor. If good, replace controller.	**Main Driver Overcurrent:** Replace controller.
High Speed WalkAway: This is a symptom, not a cause. Most likely due to driver error. If not, check speed sensor on motor and key switch for proper operation.	**Main Dropout:** Solenoid or any component before it in circuit could be at fault. Check components from key switch to solenoid and connections.
HPD: Check throttle %. If at zero (0), is a driver issue.	**Main Dropout 2:** Symptom more than the cause; see other faults that accompany Main Dropout 2.
HW Failsafe: Replace controller.	**Main Weld:** Replace solenoid. If it doesn’t correct fault of car running at half speed, check accessory wiring.
Incorrect Password: Incorrect code being entered into controller, check code A,B,C.	**Motor Stall:** If car moves freely, issue not with vehicle, operator error.
Lockout Fault: This is a symptom, not a cause. Inspect and test the charger interlock circuit. If no problems are found in the charger interlock circuit, replace the controller.	**Overvoltage:** Controller reads 72 volts or more; it’s a symptom, not a cause. See other faults that accompany OV.
Low Battery Voltage: Check Battery Voltage Under a Load less than 34 volts; could be a symptom, not a cause.	**Speed Sensor:** Check connection; replace speed sensor.
Low SOC (State of Charge): This is a symptom, not a cause. Controller only acknowledges it happened and counts the number of occurrences. Charge batteries.	**Thermal Cutback:** Controller heatsink rises above 185° F (85° C); increased resistance causes issue.
M (Main) Coil Open: Broken or disconnected coil wire (B+ or B-), a defective solenoid coil. Replace solenoid.	**Throttle Fault:** Possible MCOR failure; perform additional diagnostic if car is running.
M– Shorted: Replace controller.	
WHEN CDT IS NOT COMMUNICATING WITH CONTROLLER, CHECK THE FOLLOWING COMPONENTS:	
The main connection port is corroded. Plug directly into the controller. See Figure 11-3 on page 11-29.	The battery pack voltage is below 32 volts. Check pack voltage to see if it is above 32 volts.
The DC cord is plugged into the car for more than 10 minutes. Unplug DC Cord.	Grey wire (pin # 9) to controller (16-pin connector) is loose or broken.
The charger interlock circuit has failed. Check for voltage on Light Blue wire in pin 5 of 16-pin connector. **See Test Procedure 10 – Charger Interlock on page 12-24.**	15 Amp fuse in the harness has failed (Precedent Car only).
Run/Tow switch is in “Tow” position. Switch to “Run” position.	Sonic weld(s) in Tow switch circuit failed (wire harnesses vary; see wiring schematic for that model car)
The Tow circuit has failed. Check Tow switch, 16-pin connector, and wire harness.	The controller has failed.

SYSTEM INFO

The *System Info* menu is accessed by using the arrow keys to highlight *System Info* and pressing the *Select* softkey to activate the menu.

The *System Info* selection displays information pertaining to the controller. The information provided from this menu selection includes:

MODEL NUMBER

Displays the model number of the controller.

SERIAL NUMBER

Displays the serial number of the controller.

HARDWARE VERSION

Displays the controller hardware version. **See following NOTE.**

NOTE: *This manual covers hardware version 5.*

PROTOCOL VERSION

Displays the controller protocol version.

PARAM BLOCK VERSION

Displays a number that represents the default parameter settings at time of manufacture.

MFG DATE CODE

Displays the date the controller was manufactured.

OS VERSION

Displays the controller operating system software version. **See following NOTE.**

NOTE: *This manual spans OS version 34 and version 35.*

SM VERSION

Displays the version number of the Start Manager software in the controller.

VCL APP VERSION

Displays the version number of the Vehicle Control Language application software in the controller.

PARAMETERS

The *Parameters* menu is accessed by using the arrow keys to highlight *Parameters* and pressing the *Select* softkey to activate the menu.

The Parameters menu is where you can view and modify the settings of the controller's adjustable parameters. Navigate through this complex menu using the arrow keys, +/- keys, and softkeys. **The parameters displayed will depend on the access level of the handset.**

Be aware when changing parameter settings, the new values replace the earlier values. If you make adjustments that you don't like, and wish you could return to the earlier values, you cannot do this unless you have written down those earlier settings (which is unlikely) or unless you have saved them. To save your parameter settings, use the "Save .cpf File" function in the Programming menu; see Plot & Log on page 11-25. Your parameter settings will then be saved in a .cpf file. You can save as many .cpf files as you desire, and you can create unique names for them. If you prefer, each .cpf can automatically be given a name consisting of the date and time when it was created; see the "Text for save as" item in the HHP (Handheld Programmer) Settings menu; see Plot & Log on page 11-25. For information on creating names, see **Using the Keyboard** in the CDT Owner's Manual.

SETTINGS

Speed Setting

The vehicle's top speed can be changed by selecting values 1 through 3. If a value of 4 is displayed for the speed setting, a special access code has been entered to place the vehicle in "private speed mode." A speed setting of 4 cannot be selected with the *speed setting* menu item. For additional information on speed setting 4, refer to *Code A, Code B, and Code C*. **See Code A, Code B, and Code C on page 11-8.**

SPEED SETTING	DESCRIPTION	VEHICLE SPEED
1	Commercial speed	8.0 mph (12.9 km/h)
2	Slow golf speed	11.4 mph (18.3 km/h)
3	Normal golf speed	Typical 14.8 mph (23.8 km/h). **See S3 FWD Speed on page 11-7.**
4	Private speed mode	19.2 mph (30.9 km/h)

NOTE: *Present speed values for each speed setting may be observed in the Monitor menu.* ***See Vehicle Speeds on page 11-13.***

Fast Accel

Fast accel (fast acceleration) is an option that can be enabled or disabled. With *fast accel* turned on, the vehicle will accelerate at a noticeably faster rate. With this feature turned off, the vehicle speed will gradually increase, even if the accelerator is quickly pressed to the floor. Turn the feature on or off by pressing "+" or "–" on the change value button.

Pedal Up Mode

Three options exist for *pedal up mode* (motor braking). When the accelerator pedal is released, motor braking will slow the vehicle to "near zero speed" when pedal up motor braking is enabled (option 1 or 2). If pedal up motor braking is disabled (option 0), the vehicle will coast to a stop when the accelerator pedal is released. **See following NOTE.**

Change the settings of the Pedal Up Mode by pressing "+" or "–" on the change value button.

NOTE: *Pedal Up Mode does not affect top vehicle speed. When the vehicle is going down an incline, the motor braking function will activate to prevent the vehicle from exceeding the speed setting defined in the Program menu, regardless of Pedal Up Mode setting (0,1, or 2).* ***See Speed Setting on page 11-6.***

When going down an incline with the accelerator pedal partially pressed, the motor braking function will activate to assist the operator in maintaining a speed less than the top speed setting. For example, if the vehicle is going down an incline with the accelerator pedal pressed half way, the motor braking function will activate to assist the operator in maintaining a speed approximately half of the speed setting defined in the Program Menu.

PEDAL UP MODE SETTING	MODE	OPERATION DESCRIPTION
0	Off	Pedal up motor braking is disabled
1	Mild pedal up	Mild pedal up motor braking
2	Aggressive pedal up	Aggressive pedal up motor braking

Speed Cal

The *speed cal* (speed calibration) menu item allows the user to fine tune the vehicle speed. This feature cannot be used to increase the vehicle speed. The range for speed calibration is 0 to 30. Each time the number is increased, the top speed will be decreased by 0.1 mph (0.16 km/h). The top vehicle speed will be determined by the *speed setting* menu item and the speed calibration setting. For example, if the speed setting is set for a value of 2 (11.4 mph (18.3 km/h)), and the speed calibration is set for 5, the total top speed of the vehicle should be approximately 10.9 mph (17.5 km/h).

NOTE: *The SPEED CAL function will not be necessary in most golf applications since the speed setting 3 is finely adjustable with S3 FWD SPEED.* ***See S3 FWD Speed on page 11-7.***

S3 FWD Speed

The *s3 fwd speed* option allows for adjustability of the SPEED 3 speed setting. From the factory, *s3 fwd speed* will be set to one of 4 options: 12.4, 13.2, 14.0 and 14.8 mph (20.0, 21.3, 22.6 and 23.8 km/h, respectively). The default *s3 fwd speed* is 14.8 mph (23.8 km/h). The *s3 fwd speed* may be adjusted with the handset from 11.4 to 14.8 mph (18.3 to 23.8 km/h) in 0.1 mph (0.16 km/h) increments. The speed value chosen for *s3 fwd speed* may also be observed in the monitor menu. **See Vehicle Speeds on page 11-13.**

To fine tune vehicle top speed in normal golf speed range (12.4 to 14.8 mph (20.0 to 23.8 km/h)):

1. Access the *program* menu, then the *speed setting* menu with the navigation keys.
2. Select Speed Setting 3 with the change value buttons.
3. Access the *program* menu and the *s3 fwd speed* menu with the navigation keys.
4. Use the change value buttons to select desired speed.

Control Mode

The *control mode* option is used to configure the 1515 controller for different modes of speed control operation. Four modes are avaiable:

- 0 = Standard: Uses maximum speeds defined by the *S1* through *S4 Fwd Speed*, *Rev Speed*, and *Speed Cal* parameters.
- 1 = LIN (Local Interconnect bus) (i.e. Guardian or Visage): Uses maximum speeds assigned to a particular location or area as defined by the fleet operator; however, these defined speeds can not override maximums set in the *S1* through *S4 Fwd Speed*, *Rev Speed*, and *Speed Cal* parameters.
- 2 = ES-Protocol (UpLink): Uses maximum speeds assigned to a particular location or area as defined by the fleet operator; however, these defined speeds can not override previously set values from other *control mode* options. To avoid this, after changing the *control mode* to 2, cycle power to the controller by placing the Run/Tow Switch in the TOW position for 30 seconds. Then return it to RUN.
- 3 = Deterrent Demo Mode: Uses maximum speeds defined by the *deterrent demo* setting to demonstrate the automatic speed control features of Guardian and UpLink. **See Deterrent Demo on page 11-8.**

Anti-Tamper

The *anti-tamper* setting defines maximum speed if the Anti-Tamper fault is triggered (e.g. controller is disconnected from the Guardian or Visage system). These speeds can only be activated if the Control Mode option is set to 1 (Guardian/Visage) and are intended to be a deterrent. Factory default setting is 1.

- 0 = OFF; uses controller configured speed (*S1* through *S4 Fwd Speed*, *Rev Speed*, and *Speed Cal* parameters) even if the Anti-Tamper fault is triggered

- 1 = 2 mph
- 2 = 0 mph
- 3 = 7 mph

Deterrent Demo

The *deterrent demo* setting defines maximum speed of Control Mode 3.

- 0 = Controller configured speed (*S1* through *S4 Fwd Speed*, *Rev Speed*, and *Speed Cal* parameters)
- 1 = 10 mph
- 2 = 7 mph
- 3 = 2 mph

Excel Braking

The *excel braking* menu item allows the user to turn this function ON or OFF. With it ON, the vehicle maintains the regen motor braking “feel” of the Excel system. With it OFF, regen motor braking is less aggressive and the vehicle mimics the “feel” of the IQ system.

For example: A *Pedal Up Mode* setting of 2 = 150 amps of regen motor braking. Setting *Excel Braking* to ON increases regen by 30 amps for a total of 180 amps and a more aggressive braking action.

WalkAway Deterrent

The *walkaway deterrent* menu item allows the user to turn this function ON or OFF. *Walkaway deterrent* is triggered by the High Speed WalkAway fault. With it ON, the reverse buzzer will sound immediately upon the key switch being turned OFF at speeds above 2 mph. With it OFF, the buzzer will cycle on and off at a higher frequency (7.5 Hz vs. 2.5 Hz).

Battery Type

The *battery type* menu item is intended to be used with Guardian/Visage so that the type of battery could be determined and displayed when remotely monitoring vehicles.

Charger Control

Beep Option

The *Beep Option* controls use of the reverse buzzer to sound a confirmation that charging has started: 0 = OFF, 1 = 1 beep, 2 = 3 beeps. From the factory, the *Beep Option* will be set to 2.

AMP HOURS

Reset Trip Amp Hours

The *reset trip amp hours* menu item allows the user to reset counter to zero (0). To reset, set to ON and then immediately back to OFF. To review or validate, go to Amp Hours Display on page 11-13 under the Monitor Menu.

ACCESS CODES

Code A, Code B, and Code C

The code entries are used to place the vehicle in “private speed mode”, speed setting code 4. Each vehicle has a unique code for placing the vehicle in this mode. A vehicle programmed for “private speed mode”, speed setting 4, does not conform to ANSI Z130.1 – American National Standard for Golf Cars – Safety and Performance Specifications because it is capable of speeds in excess of 15 mph (24.1 km/h). For more information on this feature, contact your local Club Car distributor or dealer.

NOTE: *If controller is replaced, the information below must be entered into the new controller.* ***See Speed Controller Installation, Section 13, Page 13-8.***

VEHICLE ID

S/N ASCII Letter 1

S/N ASCII Letter 2

The two-letter serial number prefix is coded as two separate ASCII characters per the following table. For example, serial number JE1401-000001 would have 74 for *S/N ASCII Letter 1* and 69 for *S/N ASCII Letter 2*.

ASCII NUMBER	ASCII CHARACTER		ASCII NUMBER	ASCII CHARACTER
65	A		78	N
66	B		79	O
67	C		80	P
68	D		81	Q
69	E		82	R
70	F		83	S
71	G		84	T
72	H		85	U
73	I		86	V
74	J		87	W
75	K		88	X
76	L		89	Y
77	M		90	Z

Vehicle Date of Manufacture

Four digit number programmed by vehicle manufacturer. **Example:** 1401 represents Model Year 2014, week 1.

Vehicle S/N

Six digit number programmed by vehicle manufacturer.

Vehicle Decal

Decal number ranging from 0 to 999 and programmed by vehicle manufacturer.

MONITOR MENU

The *Monitor* menu is accessed by using the arrow keys to highlight *Monitor* and pressing the *Select* softkey to activate the menu.

All information in the *Monitor* menu is updated in real time, allowing the trained technician to troubleshoot the vehicle by monitoring the handset as the key switch is cycled, Forward/Neutral/Reverse control (FNR) is activated, etc. **See following NOTE.**

NOTE: *Values appearing in these menus represent approximate measurements made by the controller and may differ from measurements made by external instruments.*

Since the *Monitor* menu is updated while the vehicle is in operation, the trained technician has the ability to monitor the status of several components in conditions or locations where a problem with vehicle performance has been reported. **See following WARNING.**

⚠ WARNING

- **The vehicle operator should not monitor the handset while the vehicle is in motion. A technician can monitor the handset while traveling as a passenger in the vehicle. Failure to heed this warning could result in severe personal injury or death.**

The following parameters can be monitored in real time with the handset from the *Monitor* menu:

BATT VOLTAGE

Displays the current battery voltage at the speed controller.

V_{MIN} I

Displays volts (minimum) at a certain amperage. This is a setting parameter used with the Low SOC (State of Charge) detection fault.

SIGNED BATTERY CURRENT

While driving the vehicle, this displays either the current being pulled out of the batteries or the current being returned to the batteries during regenerative motor braking. It has a range from negative (–) 300 amps to positive (+) 300 amps.

BDI PERCENT

Battery Discharge Indicator (BDI) Percent displays the current battery state of charge as a percent. It is based on several parameters monitored by the controller.

SPEED

Vehicle speed in mph.

THROTTLE

Indicates the position of the accelerator pedal from 0% (pedal not pressed) to between 95 and 100% (pedal fully pressed). This item can be monitored when the key switch is in the ON or OFF position.

TEMPERATURE

Displays the temperature (in degrees Celsius) of the speed controller heatsink. During normal operating conditions, the heatsink temperature should be below 185 °F (±9) (85 °C (±5)). **See following NOTE.**

NOTE: *Anything that adds resistance (i.e. improper brake adjustment, low air pressure in tires, low battery voltage, etc.) can cause the operating current to be higher than normal. This higher current increases the temperature of the speed controller heatsink.*

ARM CURRENT

Displays the motor armature current (in amperes).

FIELD CURRENT

Displays the motor field current (in amperes).

ARMATURE PWM

Displays motor armature PWM (pulse width modulation). The range of pulse width modulation is 0% to 100%. When the vehicle is operating at full speed, the pulse width modulation should be at 100%.

FIELD PWM

Displays motor field PWM (pulse width modulation). The range of pulse width modulation is 0% to 100%. When the vehicle is in operation, the pulse width modulation will fluctuate in response to the terrain and throttle input.

SPEED PULSES

The *speed pulses* menu item displays the activity of the motor speed sensor. With the key switch in the OFF position, the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position, and the vehicle at rest, the handset should indicate that speed pulses are off. When the vehicle is gently pushed a short distance, the handset should indicate that speed pulses are on.

FOOT INPUT

Indicates the status of the MCOR (Motor Controller Output Regulator) internal limit switch: on or off. When the accelerator pedal is unpressed, the handset should indicate that the limit switch is off. When the accelerator pedal is pressed and the key switch is in the ON position, the display should indicate that the limit switch is on.

KEY INPUT

Displays the position of the key switch: OFF or ON.

FORWARD INPUT

With the Forward/Neutral/Reverse control (FNR) in the NEUTRAL or REVERSE position, the handset should indicate that the forward input is off. When the Forward/Neutral/Reverse control (FNR) is placed in the F position, the handset should indicate that the forward input is on.

REVERSE INPUT

With the Forward/Neutral/Reverse control (FNR) in the NEUTRAL or F position, the handset should indicate that the reverse input is off. When the Forward/Neutral/Reverse control (FNR) is placed in the REVERSE position, the handset should indicate that the reverse input is on.

MODE SWITCH INPUT

This menu is reserved for possible future use and has no application at this time.

CHARGER INHIBIT

Displays charger connection. When the charger is connected and the controller does not drive (inhibited), the handset indicates ON. When the charger is not connected and the controller is allowed to drive, the handset indicates OFF.

MAIN CONT DRIVER

Displays the present solenoid (main contactor) state. When the controller energizes the solenoid coil, the handset indicates ON. When the controller de-energizes the solenoid coil, the handset indicates OFF.

LED DRIVER

Displays the present state of pin 11 in the controller 16-pin connector that operates the charge indicator light on the dash. When pin 11 is activated, power is provided to the light and the handset indicates that the LED Driver is ON. When pin 11 is not activated, the handset indicates that the LED Driver is OFF.

PASSWORD TRIES (OEM ACCESS LEVEL ONLY)

A password is required to place the vehicle in “private speed mode” (speed setting 4). The speed controller will log unsuccessful and unauthorized attempts to place the speed controller in “private speed mode”. If repeated attempts

are unsuccessful, the speed controller will permanently lock out access to “private speed mode”. In the event that “private speed mode” is locked out, the controller must be removed and shipped to Club Car before it can ever be placed in “private speed mode”. **See Code A, Code B, and Code C on page 11-8.**

ODOMETER

Displays approximate distance travelled in miles.

BDI INFO

Load Line SOC

Load Line SOC is the state of charge estimation based upon battery voltage during a defined discharge current (between 50 and 60 amps).

Load Line Valid

Load Line Valid is an indication (Load Line Valid = 1) that the discharge current is between 50 and 60 amps.

BDI Int Factor

BDI Int Factor is an auto-adjusting correction factor for estimating state of charge based upon the difference between the currently estimated state of charge and the Load Line SOC.

Open Circuit Voltage Start

Open Circuit Voltage Start is the voltage, as determined by the controller, following a cycle of the Run/Tow switch or coming out of sleep mode.

Open Circuit SOC Start

Open Circuit SOC Start is the estimated state of charge following a cycle of the Run/Tow switch or coming out of sleep mode.

BATTERY MONITOR

These menu items reset every time the vehicle is charged.

Lowest Battery Voltage

Displays the lowest battery pack voltage reached since the last charge.

I Batt at Lowest Volts

Displays the current through the controller at the lowest battery pack voltage.

Highest Battery Voltage

Displays the highest battery pack voltage after being charged.

CHARGING TOTALS

These menu items accumulate totals for the life of the vehicle.

Completed Charges

Displays the number of completed charge cycles.

Interrupted Charges

Displays the number of interrupted charge cycles.

Storage Charges

Displays the number of storage charge cycles.

AMP HOURS DISPLAY

Signed Battery Current

While driving the vehicle, this displays either the current being pulled out of the batteries or the current being returned to the batteries during regenerative motor braking. It has a range from negative (–) 300 amps to positive (+) 300 amps.

Amp Hours

Displays total accumulated amp hours removed from batteries since initial vehicle start-up.

Regen Amp Hours

Displays total accumulated amp hours returned to the batteries from regenerative braking since initial vehicle start-up.

Charge Amp Hours

Displays amp hours removed from batteries since the last charge.

Charge Regen Amp Hours

Displays amp hours returned to the batteries from regenerative braking since the last charge.

Trip Amp Hours

Displays amp hours removed from batteries since *trip amp hours* was reset. **See Reset Trip Amp Hours on page 11-8.**

Trip Regen Amp Hours

Displays amp hours returned to the batteries from regenerative braking since *trip amp hours* was reset.

LIN

Relates to communication between the controller and the Guardian/Visage device (if equipped).

Charger

Additional

VEHICLE SPEEDS

Press right arrow to display programmed speeds for each speed setting. **See Code A, Code B, and Code C on page 11-8.**

PEDAL COUNTERS

Accumulates accelerator pedal usage.

FAULT COUNTERS

The Fault Counters indicate how many times each fault type has been recorded since the last clearing of fault history. **See following Faults Menu section.**

FAULT COUNT ODOMETERS

The Fault Count Odometers indicate the odometer reading associated with the last occurrence of each fault type. Will indicate 0.0 (miles) if the fault occurred before the last clearing of fault history.

DIAGNOSTICS MENU

CAUTION

- **A failed motor will damage the controller. Always inspect the motor before replacing the controller. See External Motor Testing, Section 16, Page 16-1.**

NOTE: *The software is subject to frequent updates, and this manual may span many versions. Be aware that some faults listed in this manual may not display in the CDT, indicating older software.*

Sometimes the fault circuits catch a temporary event that is not a true fault in the system. It is good practice to turn the control system OFF and back ON again to see if the fault clears by itself.

The *Diagnostics* menu is accessed by using the arrow keys to highlight *Diagnostics* and pressing the *Select* softkey to activate the menu. Under the Diagnostics menu are two folders: *Present Errors* and *Fault History*.

Faults displayed in the *Diagnostics* menu will aid the trained technician in troubleshooting the vehicle. Faults displayed often indicate which components in the electrical system need to be tested.

Since the *Diagnostics* menu is updated while the vehicle is in operation, the trained technician has the ability to monitor the occurrence of faults in conditions or locations where a problem with vehicle performance has been reported. **See following WARNING.**

⚠ WARNING

- **The vehicle operator should not monitor the handset while the vehicle is in motion. A technician can monitor the handset while traveling as a passenger in the vehicle. Failure to heed this warning could result in severe personal injury or death.**

PRESENT ERRORS FOLDER

The *Fault History* folder displays all existing faults in chronological order. An item in this folder can only be removed by remedying the fault. As long as the fault exists, it will be included in the Present Errors folder. The “number / number” in the upper right corner of the screen indicates the number of present faults and which fault is highlighted. *Example: “1/3” means the first of three total faults is highlighted.*

FAULT HISTORY FOLDER

The *Fault History* folder displays all of the faults detected by the controller since the last time the fault history has been cleared. The faults displayed in this folder may or may not be currently active. Once a fault has been detected, it is stored in the memory of the controller for display on the *Fault History* folder. Each detected fault is listed only once, even if the fault has occurred multiple times. You can clear the entire contents of this folder to allow a fresh Fault History to be started.

CAUSES OF FAULTS

Some common causes of faults are:

- Loose, broken, or disconnected wires or connectors
- Failed components
- Improper adjustment or installation of electrical or mechanical components (examples: brake adjustment, improper MCOR installation)
- Improper wiring of electrical components

As shown above, there are many possible causes for faults to occur, and the controller has a programmed reaction to each fault that is based on the fault currently detected. The technician should be familiar with the detected faults and the controller's reactions to faults to ensure a proper diagnosis.

An example of a possible mis-diagnosis of a vehicle due to a fault: If the three-pin speed sensor wire has been disconnected, the controller will detect a *speed sensor* fault. When a *speed sensor* fault is detected, the controller responds to the fault by limiting the vehicle speed to 1/2 of its normal top speed. If the technician reaches the conclusion that the vehicle is running slowly because batteries are heavily discharged, he has made an improper diagnosis of the problem.

The controller should be checked for fault codes before any service is performed.

After detecting a fault, the controller will respond in one or more of the following ways:

- A. Reduce vehicle speed to zero by reducing armature current
- B. Reduce vehicle speed to zero by reducing field current to zero
- C. Turn off the solenoid
- D. Cause the vehicle to run at slow speed
- E. Gradually reduce the armature current limit
- F. Quickly reduce the armature current until speed sensor pulses occur
- G. Reduce field current and beep reverse buzzer at a fast rate
- H. Limits vehicle speed per Anti-Tamper setting
- J. Adds the occurrence to the fault counter
- K. Activates a warning device
- L. Locks out Private Speed Mode

CONTROLLER FAULT	CONTROLLER RESPONSE	VEHICLE RESPONSE
HW FAILSAFE	A, B, C	Vehicle comes to a stop
THROTTLE FAULT	A, C	Vehicle comes to a stop
SPEED SENSOR	D	Vehicle runs at slow speed
MAIN WELDED	D	Vehicle runs at slow speed
MAIN DRIVER ON	A, B	Vehicle comes to a stop
MAIN DRIVER OFF	A, C	Vehicle comes to a stop
MAIN COIL OPEN	A	Vehicle comes to a stop
FIELD MISSING	A, B, C	Vehicle comes to a stop
HPD	A	Vehicle comes to a stop
OVERVOLTAGE	A, B, G	Vehicle slows and beeps
LOW BATTERY VOLTAGE	E	Top speed is reduced
THERMAL CUTBACK	E	Top speed is reduced
MOTOR STALL	J	None
MAIN DROPOUT (1 and 2)	A, C	Vehicle comes to a stop
MAX PASSWORD TRIES	L	Vehicle continues to only reach a top speed determined by the Speed Setting
INCORRECT PASSWORD	J	None
MAIN DRIVER OVERCURRENT	A, B	Vehicle comes to a stop
CURRENT SENSE FAULT	A, B, C	Vehicle comes to a stop
M– SHORTED	A, B, C	Vehicle comes to a stop
ANTI-TAMPER	H	Top speed is reduced
HIGH SPEED WALKAWAY	J, K	Vehicle beeps
LOCKOUT FAULT	J	None
LOW SOC	J, K	Charge indicator light ON

FAULT RECOVERY

When a fault is detected by the controller, the controller will attempt to recover from the fault and resume normal operation. In the case of an intermittent problem, such as a loose wiring connection, the controller **may** be able to recover and operate normally for a while, but the problem should be repaired before placing the vehicle in service.

Depending on the type of fault, the controller will attempt to recover either immediately after the condition clears or after the accelerator pedal has been cycled (released and pressed again).

CONTROLLER FAULT	CONTROLLER ATTEMPTS TO RECOVER...
HW FAILSAFE	When key switch is cycled
THROTTLE FAULT	When condition clears
SPEED SENSOR	When condition clears
MAIN WELDED	When condition clears
MAIN DRIVER ON	When condition clears
MAIN DRIVER OFF	When accel. pedal is cycled
MAIN COIL OPEN	When accel. pedal is cycled
FIELD MISSING	When accel. pedal is cycled
HPD	When accel. pedal is cycled
OVERVOLTAGE	When condition clears
LOW BATTERY VOLTAGE	When condition clears
THERMAL CUTBACK	When condition clears
MOTOR STALL	When condition clears
MAIN DROPOUT (1 and 2)	When accel. pedal is cycled
MAX PASSWORD TRIES	When Run/Tow switch is cycled
INCORRECT PASSWORD	When Run/Tow switch is cycled
MAIN DRIVER OVERCURRENT	When condition clears
CURRENT SENSE FAULT	Within controller
M– SHORTED	When key switch is cycled
ANTI-TAMPER	When condition clears
HIGH SPEED WALKAWAY	When condition clears
LOCKOUT FAULT	When condition clears
LOW SOC	When condition clears

FAULT DESCRIPTIONS

The following faults can be detected by the Excel System controller and seen under both the *Monitor Menu* and *Diagnostics Menu*:

INCORRECT PASSWORD (OEM ACCESS LEVEL ONLY)

Each vehicle has a password in the form of a unique set of codes used to place the vehicle in “private speed mode”. If a set of codes has been entered incorrectly, the *incorrect password* fault is declared. For additional information on codes, refer to Code A, Code B, and Code C. **See Code A, Code B, and Code C on page 11-8. See also Password Tries (OEM Access Level Only) on page 11-11.**

MAX PASSWORD TRIES (OEM ACCESS LEVEL ONLY)

The *max password tries* fault is declared when the incorrect password fault has been declared several times. In the event that the *max password tries* fault is indicated, the speed controller must be removed and shipped to Club Car before it can ever be placed in “private speed mode”. **See Code A, Code B, and Code C on page 11-8. See also Password Tries (OEM Access Level Only) on page 11-11.**

THROTTLE FAULT

If the MCOR (Motor Controller Output Regulator) voltage is less than 0.20 volts or greater than 4.80 volts, the controller detects a *throttle fault*.

What it means: If the voltage seen by the controller coming out of the MCOR is not within specified limits, this fault occurs and the controller de-energizes the solenoid coil. Perform additional diagnostic if vehicle is running.

What to do: Replace MCOR. **See following NOTE.**

NOTE: *Newer controllers may, infrequently, read voltages above or below limits and give a false fault.*

LOW BATTERY VOLTAGE (UNDERVOLTAGE)

If the battery voltage falls below 34 volts ±5%, the *low battery voltage* fault is detected by the speed controller.

What it means: Could be a symptom, not a cause. Voltage coming into the controller is at, or less than, 34 volts.

What to do: Check battery voltage under a load.

OVERVOLTAGE

If the speed controller detects that the battery voltage is too high (68.4 to 75.6 volts DC), the *overvoltage* fault is detected.

What it means: This is a symptom that occurs when the controller sees 72 or more volts. Reverse Buzzer beeps when fault occurs and the car will freewheel.

What to do: Check to see if car has been towed without being put into “Tow” mode. Check charger relay because, in Excel vehicles, bypassing the relay in the charger could cause the controller to read an overvoltage fault. Note too that Excel vehicles, on hilly courses, may see this fault if the driver turns the key switch off while the vehicle is in motor braking mode.

THERMAL CUTBACK

If the controller heatsink temperature is found to be in excess of 185 °F (±9) (85 °C (±5)) or below –13 °F (±9) (–25 °C (±5)), the *thermal cutback* fault is detected.

What it means: Heatsink temperature rises above 185 °F (85 °C).

What to do: Monitor Heatsink Temp, battery voltage, brakes dragging, car under extreme loads, low or no air pressure in tire(s).

ANTI-TAMPER FAULT

If communication with the Visage or Guardian unit is interrupted, the controller registers an *anti-tamper fault*.

What it means: This is a symptom, not a cause. The controller is set to communicate with a Visage or Guardian unit and it is unable to.

What to do: Clear the Fault History in the CDT. Ensure wiring is connected and inspect for damaged wires. If the vehicle is not or no longer going to be equipped with these services, change Control Mode setting to zero (0).

HPD

The *HPD* (High Pedal Detect) fault is detected if the accelerator pedal is already depressed when the key switch is turned to the ON position. This fault is also detected if the accelerator pedal is pressed when the selected direction is changed by pressing the Forward/Neutral/Reverse control (FNR). This fault, when not caused by the operator, can indicate that the pedal limit switch has failed closed.

What it means: The pedal is depressed before the key switch and/or the FNR is switched on. This is a safety control and the controller must see the pedal engaged last in the following sequence: key switch first, FNR second, and then pedal last.

What to do: Check throttle percentage and, if at 0, issue is driver error.

MAIN DRVR OVERCURRENT

If the current on the relay driver exceeds 120 mA, or the current on the solenoid driver exceeds 6 A, a *main driver overcurrent* fault is detected.

LOCKOUT FAULT

If the controller receives a signal that the charger interlock is activated while the vehicle is being driven, the controller registers a *lockout fault* and may prevent the vehicle from operating.

What it means: This is a symptom, not a cause. The controller should only see charger interlock activated when the charger's DC cord (external charger) is connected to the vehicle or AC cord (onboard charger) is connected to an AC outlet. One possible cause is failure of the 10k ohm resistor in the charger interlock circuit.

What to do: Clear the Fault History in the CDT. If the fault does not return and the car operates normally, do not replace the controller. If the fault continues to occur, inspect and test the charger interlock circuit. **See Test Procedure 10 – Charger Interlock on page 12-24.** If the 10k ohm resistor has failed, replace resistor. If no problems are found in the charger interlock circuit, replace the controller.

LOW SOC

If the controller sees that the battery pack has reached a low state of charge (SOC), the controller registers a *low SOC fault*.

What it means: This is a symptom, not a cause. The controller records the number of times this occurs.

What to do: Charge batteries. If fault occurs more frequently than normal, test battery pack. Section 14 — Electric Vehicle - Batteries

MAIN WELDED

If the speed controller detects that the solenoid contacts are welded closed, a *main welded* fault is detected.

What it means: The solenoid contact is welded closed and will not dropout when pedal is released, or key switch is turned to OFF, or FNR is switched to N.

What to do: Replace solenoid. If vehicle continues to operate at half speed, check accessory wiring.

HIGH SPEED WALKAWAY

If the controller receives a signal to activate walk away braking while the vehicle is moving at a speed greater than 2 mph (3.2 km/h), the controller registers a *high speed walkaway fault*.

What it means: This is a symptom, not a cause. The key switch was turned to OFF while the vehicle was coasting faster than 2 mph (3.2 km/h).

What to do: Most likely, this is due to driver error. If not, check speed sensor on motor and key switch for proper operation.

SPEED SENSOR

If the speed controller does not detect pulses from the speed sensor while the controller outputs power (greater than 75% armature PWM) to the motor, a *speed sensor* fault is detected.

What it means: Speed sensor is not working. Check connection.

What to do: Replace speed sensor.

MAIN DRIVER ON

If the field-effect transistor (FET) that controls the closing of the solenoid contacts is found to be energized when it should not be, a *main driver on* fault is detected by the speed controller.

What it means: The controller FET controlling the energizing of the solenoid is on (or energized) when it should not be. This causes main contactors to stay engaged. Pin 12 provides ground for the solenoid coil when FORWARD, REVERSE, KEY, or FOOT INPUT is present at the controller. If the ground continues to be present once either KEY, FOOT, FORWARD or REVERSE INPUT is removed, *main driver on* is detected.

What to do: Replace controller.

MAIN COIL OPEN

If the speed controller determines that the solenoid is not closing as a result of a solenoid coil failure, a *main coil open fault* is detected.

What it means: An open circuit in the solenoid coil. It could be in either the ground side or B+ side of the circuit.

What to do: Check for a broken or disconnected blue wire on the B+ side of the solenoid coil, a broken or disconnected blue/white wire on the B- side of the solenoid coil, a broken coil wire inside the solenoid which would result in zero ohms resistance reading, a defective coil which could result in very low coil resistance (usually less than 40 ohms;

large solenoids should read 180 to 190 ohms; small solenoids 200 to 250 ohms), a broken blue/white wire at the 16-pin controller plug or its terminal is loose in the 16-pin plug.

MAIN DROPOUT (1 OR 2)

If the controller detects that the solenoid contacts have opened while the vehicle is in operation, a *main dropout* fault is detected.

What it means: Occurs when the solenoid coil losses ground causing the main contact to lose connection. With Main Dropout 2, the solenoid drops out while the vehicle is in regen/motor braking. Main Dropout 2 is usually a symptom more than a cause.

What to do: Check the following components: key switch, MCOR, batteries, battery cables, FNR, solenoid coil, solenoid contacts, and controller 16-pin connector.

MOTOR STALL

If the motor current is high and there is no movement of the vehicle wheels for a short period of time, a *motor stall* is detected by the speed controller. This fault can be caused by an operator holding the vehicle on a hill by depressing the accelerator pedal instead of the brake pedal.

What it means: This fault appears anytime current is running to the motor and no movement of the armature is registered.

What to do: In most cases this is an operator issue holding the vehicle on an incline with the accelerator pedal, not the brake pedal. **See following NOTE.**

NOTE: *In rare cases, it could be a controller or drivetrain issue. If the vehicle rolls, the drivetrain is okay. Check to see if Armature Current spikes to 250 amps when accelerator pedal is pressed. If so, replace controller.*

MAIN DRIVER OFF

If the FET that controls the closing of the solenoid is **not** energized when it should be, a *main driver off* fault is detected by the speed controller.

What it means: This is the exact opposite of *main driver on*. The controller FET controlling the energizing of the solenoid is off (or not energized) when it should be.

What to do: Replace controller.

CURRENT SENSE FAULT

What it means: If there are problems with the armature current sensor circuitry, a *current sense* fault is detected and the controller de-energizes the solenoid coil.

What to do: Clear the Fault History in the CDT. If the fault does not return and the car operates normally, do not replace the controller. If the fault remains in System Faults or Fault History after clearing and the car will not operate, replace the controller.

M– SHORTED

If an uncontrolled current path is detected from the motor to B- (bypassing the MOSFETs), an M- shorted fault is detected.

FLD (FIELD) MISSING

If the speed controller is operating at a duty cycle of greater than 90% (almost full speed) and the field current is less than 3 amps, a *field missing* fault is detected by the speed controller.

CAUTION

- **A failed motor will ruin a controller. If a new controller is installed in a vehicle with a bad motor, the bad motor will blow the field FET in the new controller. Always check the motor before replacing a controller when a FLD Missing fault is shown.**

What it means: Not necessarily a controller issue.

What to do: Check in this order: connections and continuity of orange and blue motor field wires, short in motor, and then controller. **See External Motor Testing, Section 16, Page 16-1.**

HW FAILSAFE

The armature drive FETs (field effect transistors) regulate the armature current. If the speed controller detects a failure of the armature drive FETs or circuitry, a *hardware failsafe* fault is detected.

What it means: A catastrophic failure internal to the controller on either the power board or the logic board.

What to do: Check motor before replacing controller.

FAULT HISTORY

The *fault history* menu can be useful in determining the cause of a vehicle problem; however, the fault history alone should not be the factor that determines when a component is replaced. Some faults detected by the speed controller are not the result of a failed component, and are instead the result of vehicle operator error. If a fault appears in the *fault history* menu, the trained technician should attempt to determine when and where the fault has occurred. For example, if the *motor stall* fault is present in the fault history, the trained technician may be able to determine the location on the course where an operator has held the vehicle on a hill by using the accelerator pedal.

CLEAR FAULT HISTORY

After a repair has been made, the fault history should be cleared. This will enable the trained technician to properly troubleshoot the vehicle in the future, in the event that another problem occurs. It is recommended that the fault history be cleared in order to avoid the replacement of a component that caused a fault in the past, but has been replaced and is now functioning correctly. For example, if the MCOR (Motor Controller Output Regulator) was disconnected and the speed controller detected a fault code associated with the throttle, the fault history should be cleared so that any future problem is not diagnosed incorrectly as a throttle problem. **See Fault History Folder on page 11-14.**

PROGRAMMING

The *Programming* menu is accessed by using the arrow keys to highlight *Programming* and pressing the *Select* softkey to activate the menu.

The *Programming* menu selection allows the user to save and restore parameter settings files (.cpf files). These files contain controller information and are saved to the internal memory or SD card. Once saved, they can be used for future reference or emailed when the CDT or SD card is connected to a PC. For information on how to save and restore these files, refer to the manual supplied with the CDT.

CLONING

Use the “Restore .cpf File” function to clone a controller with a saved .cpf file stored in the CDT.

If using an OEM-level CDT, after you highlight a stored .cpf file and choose “Restore,” a pop-up window will ask whether you want to enable Advanced Cloning (“Yes”/“No”) using the softkeys. This choice is not offered in the User-level CDT. Without Advanced Cloning (if you select “No”), an OEM-level CDT will restore only those parameters up to and including OEM level. Advanced Cloning (“Yes”) restores all parameters, including those at a higher level. This makes a true clone by copying parameters that cannot be seen at the OEM level. It is recommended to enable Advanced Cloning.

FAVORITES

The *Favorites* menu is accessed by pressing the Favorites key (9) **(Figure 11-1, Page 11-1)**. This menu can also be accessed by using the arrow keys to highlight *Favorites* and pressing the *Select* softkey to activate the menu. Return to the Main Menu at any time by pressing the Main Menu key (6).

The *Favorites* menu selection consists of the custom set of items you have created. Typically, you will want to include the parameters you most frequently adjust, along with the monitor items you most frequently check. This way you can go directly to these items more easily than by navigating through the entire Parameters and Monitor menus.

Any item or folder in the Parameters or Monitor menu can be added to Favorites. Once added, it can be renamed if desired. When you add a ready-made folder from the Parameters or Monitor menu, the folder icon will appear in the Favorites menu with a star on it. Although you can rename a ready-made folder, you are not allowed to rename any of the items within that folder. You can also create folders of your own to hold specific sets of items; these folders will be indicated with the usual folder icon. You may want to create a folder for each type of vehicle or application, or for each customer.

HHP SETTINGS

The *HHP Settings* menu is accessed by using the arrow keys to highlight *HHP Settings* and pressing the *Select* softkey to activate the menu.

The *HHP Settings* menu selection allows the user to adjust the appearance of the screen displays, adjust several aspects of the handheld programmer’s functionality, and displays information pertaining to the handset.

MENU ITEM	DESCRIPTIONS
Access Level	The Access Level of the programmer can be set to its own level or to any lower level: OEM, Dealer, Service, User. Setting the Access Level to a lower level allows you to see what a person with that level programmer would see. For example, a dealer could set the Access Level to User, to see what a person with a User-level programmer would see.
Language	You can select English, Deutsch, Français, Italiano, or Español for the screen text.
Left Handed Soft Keys	Selecting “Yes” for Left Handed Soft Keys reverses the position of items in the softkey text line, to make the keys more convenient for left-handed people.

TABLE CONTINUED ON NEXT PAGE

MENU ITEM	DESCRIPTIONS
Backlight	Here you can set the brightness of the programmer's LCD display—from 100% to 20%, in 5% increments.
Keytone	You can choose between several tones to sound each time you press a key, or you can turn the keytone Off for silent programmer operation.
Auto Poweroff (battery)	You can set the idle time before the programmer will automatically power off when it is powered by its own batteries (i.e., when the control system is not running, or when the programmer is not connected to the control system).
Auto Poweroff (ext)	You can set the idle time before the programmer will automatically power off when it is being powered by the controller.
Exit menus with left arrow	The left-arrow key ( ) is used to navigate backwards within menus. When set to Yes, you can use the left-arrow key to leave the presently displayed screen and return to the next higher (i.e., previous) screen; using the left-arrow key will eventually return you to the Main Menu. When set to No, you must use the appropriate softkeys (Exit, Cancel) and the Main Menu key ( ) to leave the present screen and reach the Main Menu. You may find this setting preferable if you use the table screens frequently, as it eliminates any possible confusion caused by the left-arrow key having two functions: moving one cell to the left, and exiting the table altogether.
Enable Screenshot	The Yes/No setting of this item determines whether the programmer will allow screenshots to be taken; see Section 14 for a description of this function. When set to "No," if you attempt to take a screenshot—by pressing the Power key ( ) followed by the Favorites key ( )—the power command is ignored and the screen jumps to the Favorites menu in response to the Favorites key command.
Show only empty battery	A battery icon showing the state-of-charge of the programmer's battery can be displayed in the upper right corner of the screen. If you do not want the icon to be displayed except as a warning when the battery is empty, set this to "Yes."
Text for save as	When you create a new .cpf file, the field at the top of the keyboard screen is either blank ("No text") or is automatically filled with the date and time in this format: YYYY_MM_DD_HHMM ("Date/Time").
Keyboard help text	When set to On, every time you enter the keyboard screen a pop-up explains how to use the keyboard. When set to Off, no pop-up appears as you enter the keyboard screen, but you can still use the Help key (?) at any time.
Remember Last View	When set to On, when you select a menu from the Main Menu screen, you will be returned to the screen you were on before you last exited that menu. When set to Off, each time you select a menu from the Main Menu screen, you will go to the selected root menu. It does not matter what you did the last time you used that menu.
Delete Cache File	This item is different from the other HHP items, because it is a procedure instead of an adjustable setting. The first time you connect the programmer to a system, menu cache files are created. If you encounter problems when connecting, you can delete the cache files and retry connecting. To delete the cache files, select this item and press the right-arrow key ( ).
Date & Time	This folder contains eight items. Show Date/Time in header. The date and time are typically displayed at the top of the Main Menu screen. However, if you do not use batteries in the handheld programmer and there is no real-time clock in the connected control system, you can set this item to "Off," since it would not provide accurate information. 12h/24h. Here you can select the format used to display the time. Date Format. Several options are available: the year appearing first or last, and the month appearing before the day or the day appearing before the month. Year, Month, Day, Hour, and Minute allow you to set the date and the time for your time zone.
About	This folder contains information about the programmer similar to what is shown in the System Info menu for each of the modules in the control system: model number, software version, hardware version, serial number, etc.

PLOT & LOG

The *Plot & Log* menu selection allows the user, with the Plot program, to plot real-time variables on the CDT display screen; or, with the Log program, to create a log file of variable values to view later in a spreadsheet program on a PC.

The first step is to add the desired items to the Plot Variable List or the Log Variable List. While in the *Monitor* menu or *Parameters* menu, highlight an item and press the “Add to” softkey. In the next screen, highlight Plot or Log and press the “Select” softkey to view the list. To add the item to the list, press the “Add” softkey followed by the “Finish” softkey; you can include up to five items. To remove an item from a Variable List, select it and press the “Delete” softkey.

PLOT

In the Plot Variables list, a colored circle beside each variable shows the color that will be used to represent that variable in the plot. The colors are in a fixed order. If you want to use specific colors for specific variables, use the “Move Down” and “Move Up” softkeys to achieve the desired combinations. Use the left-arrow key to return to the Plot & Log menu.

To open the plotting program, highlight Plot and press the right-arrow key. The vertical axis is always used for the variables being plotted, and the horizontal axis is always used for time. For On/Off items, On = 1 and Off = 0 on the plot. Press the “Start” softkey to begin plotting data. Press the “Stop” softkey to stop plotting data and freeze the plot. You have the option of pressing the “Start” softkey to resume the plot.

LOG

To create a log of the items in your Log Variable List, highlight Log and press the right-arrow key. Then, in the “Start Logging” window, press the “OK” softkey. Select the location where you want to save the .xls file, and after pressing the “Save As” softkey and naming the .xls file, press the “OK” softkey. The display will now show the Plot & Log menu with a flashing red dot next to Log, indicating that logging is in progress. To stop logging, press the right-arrow key, and then in the “Stop Logging” screen, press the “OK” softkey.

CDT TROUBLESHOOTING

In the event that the handset does not function as described in this manual, the following troubleshooting guide should be studied and the referenced test procedures should be performed to troubleshoot the handset.

TROUBLESHOOTING GUIDE		
SYMPTOM	**POSSIBLE CAUSES**	**CORRECTIVE ACTION**
Handset display screen is blank	Handset cord and/or adaptor is disconnected	**See Plugging the CDT into the Vehicle on page 11-3.**
	Vehicle batteries – loose terminals or corrosion	Section 14 — Electric Vehicle - Batteries
	Vehicle batteries – improperly wired	Section 14 — Electric Vehicle - Batteries
	Vehicle batteries – batteries failed	Section 14 — Electric Vehicle - Batteries
	Vehicle batteries – batteries not fully charged	Section 14 — Electric Vehicle - Batteries
	Handset cord has failed	Test Procedure 1 – Handset Cord on page 11-27
	Handset cord adaptor has failed	Test Procedure 2 – Handset Cord Adaptor on page 11-27
	CDT port (mounted under instrument panel assembly) has failed	Test Procedure 3 – CDT Ports on page 11-28
	Contrast Setting is too light	See Backlight under *HHP Settings* menu
	Controller is in power-down mode (vehicle unused and not charged for 72 hours)	Connect charger or drive the vehicle a short distance and reconnect the handset to the vehicle
	Charger has been connected and charging for more than 10 minutes	Disconnect charger, wait 30 seconds and reconnect charger
	Loose vehicle wire harness connections	Test Procedure 3 – CDT Ports on page 11-28
	Speed controller malfunction	Section 12 — Electric Vehicle - Electrical System Troubleshooting
	Handset has failed	Replace handset
Display screen shows jumbled or undecipherable characters	Speed controller malfunction	Section 12 — Electric Vehicle - Electrical System Troubleshooting
	Handset malfunction	Disconnect the CDT cord from the vehicle. Wait a few seconds and reconnect the handset to the vehicle
	Loose connection at CDT port	Test Procedure 3 – CDT Ports on page 11-28
	Intermittent handset cord failure	Test Procedure 1 – Handset Cord on page 11-27
	Intermittent handset cord adaptor failure	Test Procedure 2 – Handset Cord Adaptor on page 11-27
	Loose vehicle wire harness connections	Test Procedure 3 – CDT Ports on page 11-28

TABLE CONTINUED ON NEXT PAGE

TROUBLESHOOTING GUIDE		
SYMPTOM	**POSSIBLE CAUSES**	**CORRECTIVE ACTION**
Handset is “locked-up” – buttons do not respond	Handset malfunction	Disconnect the CDT cord from the vehicle. Wait a few seconds and reconnect the handset to the vehicle
	Vehicle batteries – loose terminals or corrosion	Section 14 — Electric Vehicle - Batteries
	Vehicle batteries – improperly wired	Section 14 — Electric Vehicle - Batteries
	Vehicle batteries – batteries failed	Section 14 — Electric Vehicle - Batteries
	Vehicle batteries – batteries not fully charged	Section 14 — Electric Vehicle - Batteries
	Speed controller malfunction	Section 12 — Electric Vehicle - Electrical System Troubleshooting

CONNECTION TESTS

⚠ WARNING

- **If wires are removed or replaced, make sure wiring and wire harness is properly routed and secured. Failure to properly route and secure wiring could result in vehicle malfunction, property damage, personal injury, or death.**

Index of Test Procedures

1 – Handset Cord
2 – Handset Cord Adaptor
3 – CDT Ports

TEST PROCEDURE 1 – Handset Cord

See General Warnings on page 1-1.

1. Using a multimeter set for 200 ohms, place the red (+) probe into one of the terminals on the end of the cord with the square plug.
2. Place the black (–) probe on each of the pins, one at a time, on the plug on the other end of the cord.
3. The multimeter should indicate continuity on only one pin. If any other reading is obtained, the cord must be replaced.
4. Repeat the procedure three more times, each time with the red (+) probe inserted into a different terminal on the end of the cord with the square plug.

TEST PROCEDURE 2 – Handset Cord Adaptor

See General Warnings on page 1-1.

The procedure for testing the handset cord adaptor is similar to the cord test.

1. Using a multimeter set for 200 ohms, place the red (+) probe into one of the terminals on the end of the adapter with the square plug.

2. Place the black (–) probe on each of the pins, one at a time, on the other plug of the adaptor.
3. The multimeter should indicate continuity on only one pin. If any other reading is obtained, the adaptor must be replaced.
4. Repeat the procedure three more times, each time with the red (+) probe inserted into a different terminal on the end of the adaptor with the square plug.

TEST PROCEDURE 3 – CDT Ports

Inspect the CDT ports for damage or corrosion.

3A – CDT PORT (LOCATED UNDER INSTRUMENT PANEL)

See General Warnings on page 1-1.

1. Turn the key switch to the OFF position, place the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position, and lock the park brake.
2. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
3. Check the CDT port mounted under the steering wheel.

3.1. Remove the instrument panel. **See Instrument Panel Removal, Section 4, Page 4-9.**

3.2. Disconnect the CDT port four-pin connector from the main wire harness and visually inspect the contacts for damage and corrosion. Inspect the CDT port mounted to the bottom of the dash panel. Repair and replace parts as necessary.

3.3. If no problem is found, connect the four-pin connector and install the center dash panel.

3.4. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

3.5. Align the keyed portion of the CDT plug with the CDT port and connect. If the handset fails to function, **see CDT Troubleshooting on page 11-26**.

3B – CDT PORT (LOCATED ON CONTROLLER)

See General Warnings on page 1-1.

1. Check the CDT port on the speed controller.

1.1. Remove the controller access panel.

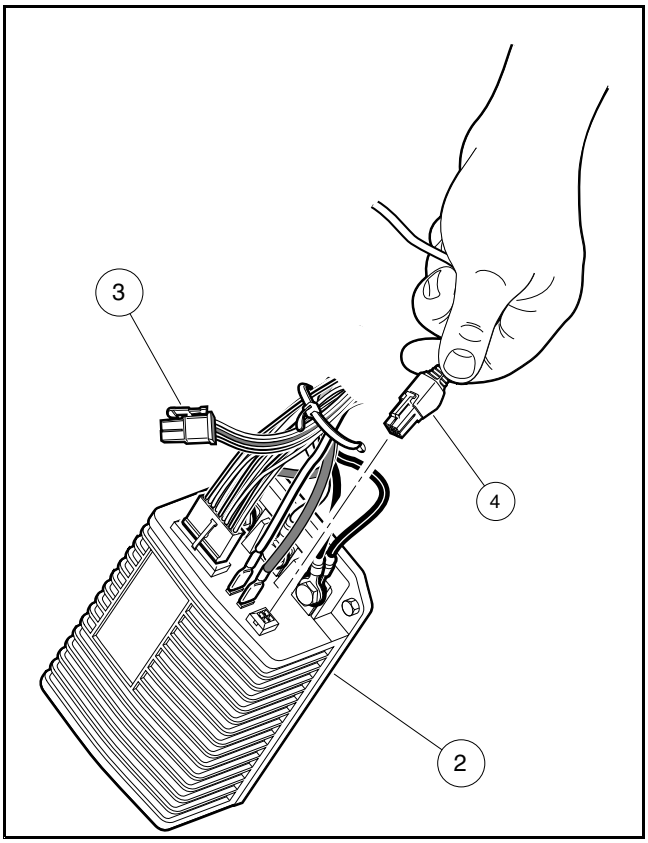
1.2. Disconnect the square four-pin connector (1) from the speed controller.

1.3. Connect the handset cord to the handset.

1.4. Connect the other end of the handset cord (without the adapter) to the four-pin connector of the speed controller.

1.5. Connect the vehicle batteries, positive (+) cable first.

If the handset does not function during Test Procedure 3A, but does function when connected directly to the speed controller, the handset cord adapter and vehicle wire harness should be thoroughly tested. **See Test Procedure 2 – Handset Cord Adaptor on page 11-27.** The CDT ports and connections should also be thoroughly checked.



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Figure 11-3 Disconnect Four-pin Connector.

Pagination Page

SECTION 12 — ELECTRIC VEHICLE - ELECTRICAL SYSTEM TROUBLESHOOTING

12

⚠ DANGER

- ***General Warnings***

⚠ WARNING

- ***General Warnings***
- **Shorting of battery terminals can cause personal injury or death.**
  - **Do not place component mounting plate directly on top of batteries when removing or installing plate.**
  - **Remove plate from vehicle completely.**

GENERAL INFORMATION

The Excel vehicle with ERIC Charging system uses a 48-volt electrical system with a shunt-wound, 3.1 hp motor that is powered by six 8-volt lead-acid batteries and charged by a high-frequency charger. The Excel vehicle with ERIC Charging system includes several additional features.

ACCESSORIES

For powered accessories that need to be controlled by the key switch, use the 12-volt power strip located under the cowl.

CHARGE INDICATOR LIGHT

Excel vehicles with ERIC Charging system feature a dash mounted charge indicator light (below the steering column) that serves two functions: 1) Battery low state of charge warning, and 2) Charging confirmation. The charge indicator light is controlled by pin 11 of the controller.

Battery Low State of Charge Warning

- The light comes on and remains solid when the battery state of charge falls below 20%.
- The light begins flashing when the battery state of charge falls below 10%.

Charging Confirmation

- The light will flash three times and the reverse buzzer simultaneously will sound three times to indicate a battery charging session has begun. **See following NOTE.**

NOTE: *The number of flashes and beeps can vary depending on the Beep Option setting.* ***See Beep Option, Section 11, Page 11-8.***

ATTRIBUTES OF THE EXCEL SYSTEM

- Excel utilizes the 1515 controller instead of the 1510A.
- The Excel 1515 controller uses half-bridge technology allowing cooler operating temperatures and increased motor braking.

- The Excel minimum motor braking speed has been lowered to almost zero.
- Excel has higher energy output during regenerative braking due to the lowered minimum motor braking speed.
- The Excel accelerator pedal has more control of downhill speed.
- The programmed speed of the Excel vehicle can now range from 5 to 19.2 mph (8 to 30.8 km/h) with fine adjustments in 0.1 mph (0.16 km/h) increments.
- Excel provides mileage readings.
- Excel has more diagnostics available.
- Excel offers the ability to change software. Section 11 — Controller Diagnostic Tool (CDT)

KEY DIFFERENCES: EXCEL WITH ERIC CHARGING SYSTEM VS. POWERDRIVE CHARGERS

- Utilizes the 1515-5206 controller (white in color) instead of the 1515-5201 (gray in color).
- New main wire harness (which is not compatible with PowerDrive chargers) that uses a 10k ohm pull-up resistor for the charger interlock circuit (charger plug lockout pin pulls Lo to lockout the vehicle, and the 10k resistor pulls Hi once charger plug is removed to enable the vehicle). In addition, the three throttle circuit resistors are now internal to the controller.
- New B- wire assembly, which replaces the one integral to the onboard computer (OBC). With the OBC gone, the New B- wire assembly is needed to connect the B- terminal of the controller to the negative (-) post of battery no. 6 (6 x 8-Volt battery set).
- New battery charge indicator light in the instrument panel. This light is an LED and is used to confirm when a charge cycle begins and when the battery pack has reached a low state of charge.
- New instrument panel wire harness (not compatible with vehicles using PowerDrive chargers)
- A new controller is used that has data collecting functions previously performed by the OBC. Pin 11 in the 16-pin connector is now utilized to operate the charge indicator light in the instrument panel. In addition, the controller has mounting slots instead of holes for easier replacement.
- An expanded Monitor menu for CDT: Charge Cycle, Amp-Hours, Faults, and Diagnostics.
- The controller tracks amp-hour usage for fleet management and warranty administration.
- No Communication Display Module (CDM) required. Use only the IQ Display Module (CDT).
- The CDT will remain ON for approximately 10 minutes when the charger is connected.
- Improved charger and battery state of charge (SOC) status indication.
- Battery charger algorithm is programmable in the field via a USB flash drive or laptop computer instead of changing onboard computer (OBC).
- B+ red wire of charger wire harness now connects directly to the solenoid to reduce potential corrosion.

FEATURES

- **Shunt-Wound Motor:** The shunt-wound motor, unlike a series motor, is designed so that the speed controller is able to vary the amount of current passing through the field coils independently from the current passing through the armature.
- **Motor Braking:** Under certain conditions a shunt-wound motor also has the ability to act as an electrical brake to slow the vehicle. There are two features of the Excel electrical system that will activate the motor braking function: Walk Away Braking and Motor Braking (adjustable with the CDT-P handset).
- **Walk Away Braking:** This feature prevents the vehicle from rolling away uncontrolled should the driver park on a slope and leave the vehicle without locking the park brake. The vehicle will roll at about 1 to 3 mph (1.5 to 4.8

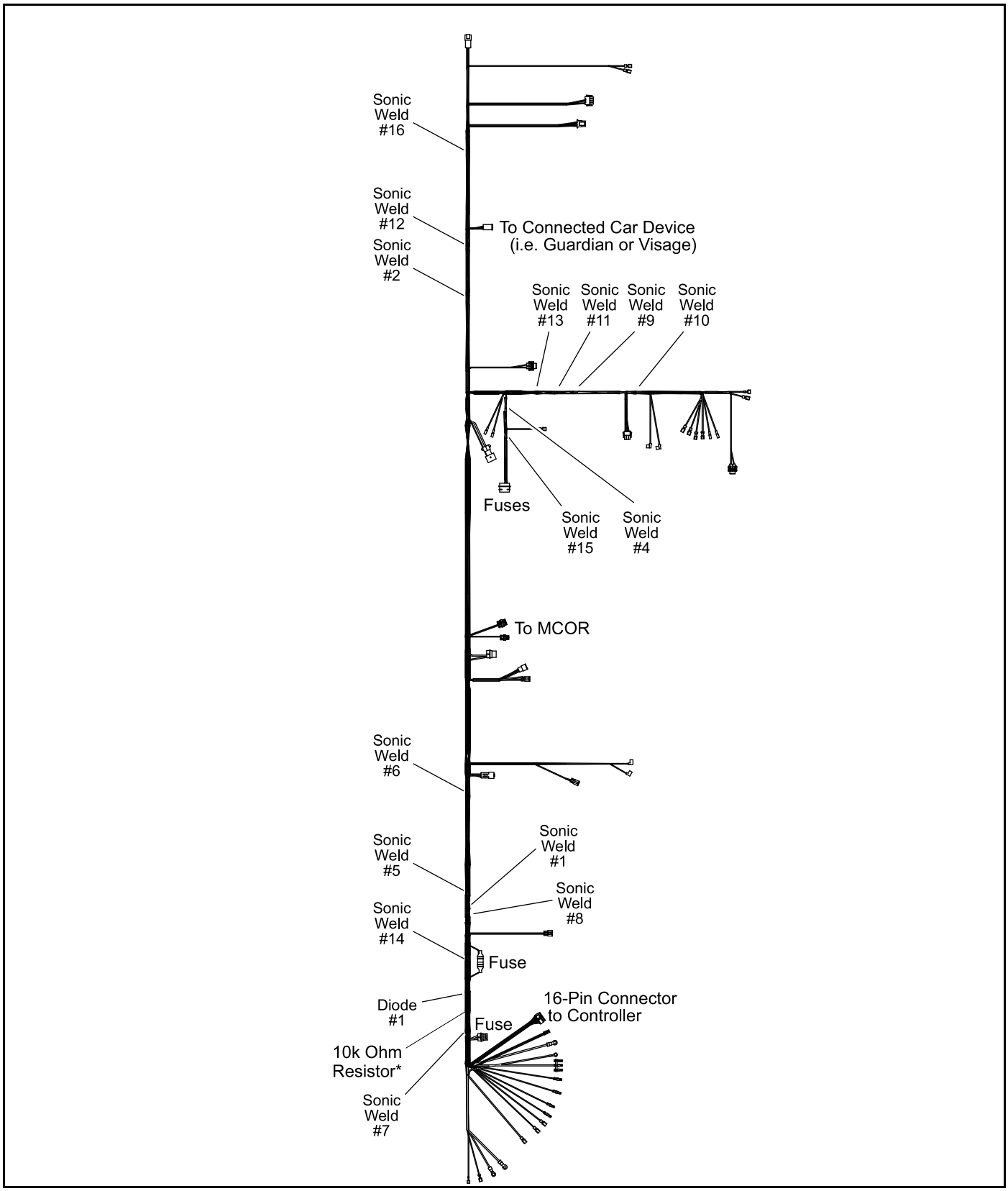
km/h). If the walk away braking function remains engaged for two seconds or more, a warning buzzer will sound to alert the driver that motor braking has been activated.

⚠ WARNING

- **Walk Away Braking will not limit vehicle speed to 3 mph (4.8 km/h) on very steep grades. Do not operate vehicle on slopes exceeding 20% grades.**

- **Motor Braking:** When going down an incline with the accelerator pedal partially pressed, the motor braking function will activate to assist the operator in maintaining a speed less than the speed setting. For example, if the vehicle is going down an incline with the accelerator pedal pressed half way, the motor braking function will activate to assist the operator in maintaining a speed approximately half of the speed setting defined in the Program Menu.
- **Regenerative Braking**: When motor braking is activated, the vehicle motor acts as a generator, slowing the vehicle as it creates energy that is used to charge the batteries.
- **Run/Tow Switch:** When the Run/Tow switch is in the RUN position, the vehicle will function normally. When the switch is in the TOW position, power to the controller is shut off, disabling the vehicle operating circuit and walk away braking, allowing the vehicle to be towed.
- **Motor Protection Circuit:** The operator should never attempt to hold the vehicle on an incline by pressing the accelerator pedal instead of the brake pedal, as motor overheating could result. By reducing the current to the motor during such an occurrence, the motor protection circuit reduces the possibility of motor damage. When this situation arises, a *motor stall fault* is recorded by the speed controller and will be displayed on a CDT handset in the Diagnostic History menu. *Motor Stall*.
- **High Pedal Detect:** This function prevents unexpected vehicle movement if the key switch is turned ON after the accelerator is pressed. The vehicle will not move until the accelerator is released and pressed again. When this situation arises, a *HPD fault* is recorded by the speed controller and will be displayed on a CDT handset in the Diagnostic History menu. *HPD*.

SONIC WELD, DIODE, AND 10K OHM RESISTOR LOCATIONS



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Figure 12-1 Sonic Weld, Diode and 10k Ohm Resistor Locations (Approximate) – CA300 with ERIC Charging

TROUBLESHOOTING

The following troubleshooting guides will be helpful in identifying operating difficulties should they occur. The guides include the symptom, probable cause(s) and suggested checks. The procedures used for making these checks can be found in the referenced sections of this maintenance and service manual.

TROUBLESHOOTING THE VEHICLE WITH THE CDT

Club Car recommends the use of the CDT handheld programmer for troubleshooting vehicles equipped with the Excel electrical system. Troubleshooting Guide 1 is to be used in conjunction with the CDT handheld programmer. **See** 11 *Controller Diagnostic Tool (CDT)*for operating instructions. **See following WARNING.**

⚠ WARNING

- **The vehicle operator should not monitor the CDT while the vehicle is in motion. A technician can monitor the CDT while traveling as a passenger in the vehicle. Failure to heed this warning could result in severe personal injury or death.**

In the event that the vehicle is not functioning properly after completing Troubleshooting Guide 1, the technician should go to Troubleshooting Guide 2.

If a CDT handheld programmer is unavailable, the technician should go to Troubleshooting Guide 2.

TROUBLESHOOTING GUIDE 1

The following troubleshooting guide is intended for use with a CDT handheld programmer. **See following NOTE.**

NOTE: *Before troubleshooting the vehicle, check the diagnostic history from the Special Diagnostics Menu. Note any fault codes.*

TROUBLESHOOTING GUIDE 1		
SYMPTOM	**POSSIBLE CAUSES**	**CORRECTIVE ACTION**
Monitor Menu – THROTTLE % value does not increase as the accelerator pedal is pressed or Diagnostic Menu – THROTTLE FAULT fault code	Loose or disconnected three-pin connector at the MCOR or broken wire	Repair and/or connect the three-pin connector to the MCOR
	Loose or disconnected 16-pin connector at speed controller or broken wire	Repair and/or connect the 16-pin connector to the speed controller
	Failed MCOR	Test Procedure 11 – MCOR Voltage on page 12-25
Monitor Menu – TEMPERATURE °C indicates that temperature is above 85 °C (145 °F) or Diagnostic Menu – THERMAL CUTBACK fault code	Over-adjusted brakes	Section 6 – Wheel Brake Assemblies
	Vehicle is overloaded	Ensure that vehicle is not overloaded before returning to operation
Monitor Menu – ARM PWM value does not reach 100% when vehicle is at full speed	Failed MCOR	Test Procedure 11 – MCOR Voltage on page 12-25

TABLE CONTINUED ON NEXT PAGE

TROUBLESHOOTING GUIDE 1		
SYMPTOM	**POSSIBLE CAUSES**	**CORRECTIVE ACTION**
Monitor Menu – SPEED PULSES menu item indicates that speed pulses are OFF when the vehicle is in motion or Diagnostic Menu – SPEED SENSOR fault code	Loose or disconnected motor speed sensor or broken wire	Repair and/or connect the three-pin connector to the motor speed sensor
	Loose or disconnected 16-pin connector at speed controller or broken wire	Repair and/or connect the 16-pin connector to the speed controller
	Failed motor speed sensor	Test Procedure 12 – Motor Speed Sensor on page 12-27
Monitor Menu – FOOT INPUT menu item indicates that the MCOR internal limit switch is always ON or always OFF.	Loose or disconnected two-pin connector at the MCOR or broken wire	Repair and/or connect the two-pin connector to the MCOR
	Loose or disconnected 16-pin connector at speed controller or broken wire	Repair and/or connect the 16-pin connector to the speed controller
	Failed MCOR	Test Procedure 5 – Key Switch and MCOR Limit Switch Circuit on page 12-19
Monitor Menu – FORWARD INPUT and/or REVERSE INPUT does not indicate the correct reading	Loose or disconnected Forward/Reverse rocker switch (quick disconnect terminals) or broken wire	Repair and/or connect the quick disconnect terminals to the Forward/Neutral/Reverse control (FNR)
	Loose or disconnected Forward/Reverse rocker switch (three-pin connector) or broken wire	Repair and/or connect the three-pin connector from the Forward/Neutral/Reverse control (FNR) to the wire harness
	Loose or disconnected 16-pin connector at speed controller or broken wire	Repair and/or connect the 16-pin connector to the speed controller
	Failed Forward/Neutral/Reverse control (FNR)	Test Procedure 6 – Forward/Neutral/Reverse control (FNR) on page 12-20
Monitor Menu – MAIN CONT DRIVER (solenoid) does not indicate ON when the solenoid should be activated. or Diagnostic Menu – MAIN CONT DNC (main contactor in solenoid did not close) fault code	Speed controller logic malfunction	Disconnect the batteries and allow the speed controller capacitors to discharge. **See WARNING "To avoid unintentionally starting..." in *General Warnings*.** Reconnect the batteries and see if the symptom returns.
	Loose, broken, or disconnected wire at solenoid or B+ speed controller terminal	Repair and/or connect the loose or disconnected wire
	Loose or disconnected 16-pin connector at speed controller or broken wire	Repair and/or connect the 16-pin connector to the speed controller
	Failed solenoid	Replace solenoid. **See Solenoid Removal on page 13-6.**
Monitor Menu – KEY INPUT does not indicate ON when key switch is in the ON position	Loose or disconnected wires at key switch terminals or broken wire	Repair and/or connect the quick disconnect terminals to the Forward/Neutral/Reverse control (FNR)
	Loose or disconnected 16-pin connector at speed controller or broken wire	Repair and/or connect the 16-pin connector to the speed controller
	Failed key switch	Test Procedure 5 – Key Switch and MCOR Limit Switch Circuit on page 12-19

TABLE CONTINUED ON NEXT PAGE

TROUBLESHOOTING GUIDE 1		
SYMPTOM	**POSSIBLE CAUSES**	**CORRECTIVE ACTION**
Diagnostic Menu – THROTTLE FAULT fault code	Loose or disconnected three-pin connector at the MCOR or broken wire	Repair and/or connect the three-pin connector to the MCOR
	Loose or disconnected 16-pin connector at speed controller or broken wire	Repair and/or connect the 16-pin connector to the speed controller
	Failed MCOR	Test Procedure 11 – MCOR Voltage on page 12-25
Diagnostic Menu – HW FAILSAFE (Hardware Failsafe) fault code	Armature drive FETs (field-effect transistors) inside speed controller have failed	Replace the speed controller. **See Speed Controller Removal on page 13-7.**
	Speed controller logic malfunction	Disconnect the batteries and allow the speed controller capacitors to discharge. **See WARNING "To avoid unintentionally starting..." in *General Warnings*.** Reconnect the batteries and see if the symptom returns.
Diagnostic Menu – MAIN WELDED (main solenoid contacts welded) fault code	Solenoid contacts have failed closed	Replace solenoid. **See Solenoid Removal on page 13-6.**
Diagnostic Menu – MAIN DRIVER ON or MAIN DRIVER OFF fault code	Speed controller logic malfunction	Disconnect the batteries and allow the speed controller capacitors to discharge. **See WARNING "To avoid unintentionally starting..." in *General Warnings*.** Reconnect the batteries and see if the symptom returns.
	Failure of the FET that controls the solenoid coil	Replace the speed controller. **See Speed Controller Removal on page 13-7.**
Diagnostic Menu – MAIN COIL FAULT fault code or Diagnostic Menu – MAIN DROPOUT (1 or 2) fault code	Solenoid coil has failed in an open condition	Replace solenoid. **See Solenoid Removal on page 13-6.**
Diagnostic Menu – FIELD MISSING fault code	Loose or disconnected motor field coil wires at motor or speed controller or broken wire	Repair and/or connect the field coil wires
	Failure of the motor field windings	Section 16 — Electric Vehicle - Motor
	Failure of the FETs that control field current	Replace the speed controller. **See Speed Controller Removal on page 13-7.**
Diagnostic Menu – HPD (high pedal detect) fault code	Operator error	Train operators to fully remove foot from accelerator pedal before turning key switch to the ON position or changing the selected direction with the Forward/Neutral/Reverse control (FNR)
Diagnostic Menu – LOW BATTERY fault code	Batteries require charging	Place batteries on battery charger and allow them to fully charge
	Improperly maintained or failed batteries	Section 14 — Electric Vehicle - Batteries
Diagnostic Menu – MOTOR STALL fault code	Operator error	Train operators to use the brake to hold the vehicle on a hill, rather than holding the vehicle on a hill using the accelerator pedal

TROUBLESHOOTING GUIDE 2

In the event that the vehicle is not functioning properly after completing Troubleshooting Guide 1, use Troubleshooting Guide 2.

If a CDT handheld programmer is unavailable, use Troubleshooting Guide 2.

TROUBLESHOOTING GUIDE 2		
SYMPTOM	**POSSIBLE CAUSES**	**CORRECTIVE ACTION**
Vehicle does not operate	Batteries – batteries discharged	Charge batteries
	Batteries – battery connections	Check vehicle wiring. **See Sonic Weld, Diode, and 10k Ohm Resistor Locations on page 12-4.**
	Battery charger is connected to the vehicle – charger interlock feature has disabled the vehicle	Disconnect the battery charger from the vehicle
	Charger interlock failure	Test Procedure 10 – Charger Interlock on page 12-24
	Key switch and MCOR limit switch circuit	Check for loose or disconnected wires at key switch and MCOR
	Failed key switch	Test Procedure 5 – Key Switch and MCOR Limit Switch Circuit on page 12-19
	Failed MCOR	Test Procedure 5 – Key Switch and MCOR Limit Switch Circuit on page 12-19. See also Test Procedure 11 – MCOR Voltage on page 12-25.
	Forward/Neutral/Reverse control (FNR)	Test Procedure 6 – Forward/Neutral/Reverse control (FNR) on page 12-20
	Solenoid – loose wires	Test Procedure 7 – Solenoid Activating Coil on page 12-22
	Solenoid – failed coil	Test Procedure 7 – Solenoid Activating Coil on page 12-22
	Speed controller thermal cutback	Allow controller to cool and ensure that vehicle is not over-loaded before returning to operation
	16-pin connector at speed controller	Check for loose or disconnected wires at the 16-pin connector. **See also Test Procedure 15 – 16-Pin Connector on page 12-30.**
	High pedal detect	Cycle accelerator pedal
	Motor stall	Cycle accelerator pedal
	Motor Failure	Section 16 — Electric Vehicle - Motor
	Speed controller failure	Replace speed controller. **See Speed Controller Removal on page 13-7.**
	Motor – motor connections	Check for loose or disconnected wires
	Speed controller – Motor and power connections	Check for loose or disconnected wires

TABLE CONTINUED ON NEXT PAGE

TROUBLESHOOTING GUIDE 2		
SYMPTOM	**POSSIBLE CAUSES**	**CORRECTIVE ACTION**
Vehicle runs slowly	Speed sensor disconnected or failed	Test Procedure 12 – Motor Speed Sensor on page 12-27
	Incorrect speed setting	To change the programmed top speed of the vehicle, an OEM-level CDT handheld programmer must be used
	Wiring – improperly wired	Check vehicle wiring. **See Sonic Weld, Diode, and 10k Ohm Resistor Locations on page 12-4.**
	Batteries – batteries discharged	Charge batteries
	MCOR malfunction	Test Procedure 11 – MCOR Voltage on page 12-25
	Motor – loose wires	Inspect and tighten all wire connections at the motor.
	Failed motor	Replace motor. **See Motor Removal on page 16-4.**
	Vehicle is over-loaded	Ensure that vehicle is not over-loaded before returning to operation.
	Speed controller failure	Replace speed controller. **See Speed Controller Removal on page 13-7.**
	Brakes – improperly adjusted	Section 6 — Wheel Brake Assemblies
	Tires – under-inflated or flat tires	Section 8 — Wheels and Tires
Vehicle operates but has points in pedal travel where it does not maintain speed nor accelerate	MCOR malfunction	Test Procedure 11 – MCOR Voltage on page 12-25
Vehicle reaches top speed before 100% pedal travel is reached	Speed controller – failed throttle resistor(s)	Replace speed controller. **See Speed Controller Removal on page 13-7.**
Vehicle operates, but motor braking function does not	Wiring – improperly wired	Check vehicle wiring. **See Sonic Weld, Diode, and 10k Ohm Resistor Locations on page 12-4.**
	Speed sensor disconnected or failed	Test Procedure 12 – Motor Speed Sensor on page 12-27
Vehicle will run in forward, but not in reverse or will run in reverse but not forward	Forward/Neutral/Reverse control (FNR) – improperly wired	Test Procedure 6 – Forward/Neutral/Reverse control (FNR) on page 12-20
	Motor – improperly wired	Check motor wiring. **See Sonic Weld, Diode, and 10k Ohm Resistor Locations on page 12-4.**
	Speed controller – improperly wired or failed speed controller FET	Check vehicle wiring. **See Sonic Weld, Diode, and 10k Ohm Resistor Locations on page 12-4.**

TABLE CONTINUED ON NEXT PAGE

TROUBLESHOOTING GUIDE 2		
SYMPTOM	**POSSIBLE CAUSES**	**CORRECTIVE ACTION**
Vehicle operates, but battery charger does not charge batteries	Charger interlock failure	Test Procedure 10 – Charger Interlock on page 12-24
	Battery charger connections – loose plug or wires at charger, receptacle or batteries	Check wire connections and tighten if necessary.
	Battery charger	15 *Electric Vehicle - Battery Charger*

TEST PROCEDURES

Using the following procedures, the entire electrical system can be tested without major disassembly of the vehicle.

⚠ WARNING

- **If wires are removed or replaced, make sure wiring and wire harness is properly routed and secured. Failure to properly route and secure wiring could result in vehicle malfunction, property damage, personal injury, or death.**

For many tests, the electronics module cover must be removed to gain access to the various components that are mounted on the component mounting plate. **See following WARNING.**

⚠ WARNING

- **Shorting of battery terminals can cause personal injury or death.**
  - **Do not place component mounting plate directly on top of batteries when removing or installing plate.**
  - **Remove plate from vehicle completely.**

After test procedures are completed, be sure to replace the cover. **See Electric Vehicle - Electrical Components on page 13-1. See following CAUTION.**

CAUTION

- **Exposure to water may damage electronic components.**
  - **Do not operate vehicle without the cover properly installed.**
  - **Do not direct a water stream in area of the cover.**

TESTING BASICS

- To use the CDT handheld programmer, the Run/Tow switch must be in the RUN position. The Run/Tow switch provides power to the logic board and power board inside the controller.
- Battery Pack Voltage (BPV) will be referenced throughout the test procedures. BPV is accessed in **Test Procedure 1 – Batteries / Voltage Check (BPV) on page 12-14**.
- The Run/Tow switch powers the key switch, controller, Forward/Neutral/Reverse control (FNR), 15-amp fuse, and reverse buzzer.
- The key switch powers the MCOR 2-pin circuit, Forward/Reverse switch, solenoid, and the female bullet connector (W34 shown on .
- The MCOR 3-pin circuit, motor speed sensor circuit, the communication point for the car device (white/black wire in position 13 of the 16 pin connector), and charge indicator light is powered by the controller (with Run/Tow switch in RUN).
- The 2-amp fuse is powered directly by the batteries via the solenoid and carries BPV to the connected car device. No switch is involved.
- The term “back-probe” refers to probing the side of a connector that the wire enters. This is usually done when the connector must remain connected to a device. **See following CAUTION.**

CAUTION

- **Be careful not to damage the wire or terminal when back-probing.**

- When testing voltage, the batteries must remain connected.
- When testing voltage, unless specifically directed to do otherwise in a procedure, connect the black (–) probe of the multimeter to the negative post of battery no. 6 (6 x 8-Volt battery set) or the B- terminal of the controller, whichever is easier to access.
- When testing controller functions, the Run/Tow switch must be in the RUN position. The TOW position removes power to the controller.

Index of Test Procedures

1 – Batteries / Voltage Check (BPV)
2 – 48-Volt Battery Pack Voltage Under Load
3 – Run/Tow Switch
4 – Fuses
5 – Key Switch and MCOR Limit Switch Circuit
6 – Forward/Neutral/Reverse control (FNR)
7 – Solenoid Activating Coil
8 – Pre-Charge Resistor
9 – Solenoid Continuity
10 – Charger Interlock
11 – MCOR Voltage
12 – Motor Speed Sensor
13 – A1 and A2 Motor Voltage
14 – Voltage at Charger Receptacle
15 – 16-Pin Connector
16 – Reverse Buzzer
17 – Charge Indicator Light
18 – 4-Pin Connector (for Connected Car Device)

TEST PROCEDURE 1 – Batteries / Voltage Check (BPV)

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

The batteries must be properly maintained and fully charged in order to perform the following test procedures. Battery maintenance procedures, including watering information and allowable mineral content, can be found in the Battery section of this manual. ***See Battery Care on page 14-6.***

The battery voltage can be displayed with the CDT handheld programmer. If a CDT is not available, go to **Batteries / Voltage Check without the CDT Handheld Programmer**.

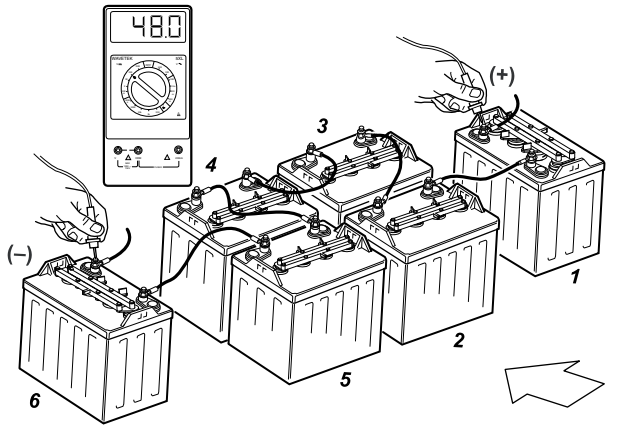
Batteries / Voltage Check with the CDT Handset

1. Connect the CDT to the vehicle.
2. Access the Monitor menu and select BATT VOLTAGE by using the SCROLL DISPLAY buttons. The CDT should indicate at least 48 volts. **See following NOTE.** If not, check for loose battery connections or a battery installed in reverse polarity. **Refer to 14 *Electric Vehicle - Batteries* for further details on battery testing.**

NOTE: *The voltage displayed through the CDT shows what the controller thinks it sees. If the controller is not operating properly, it may display a different voltage from what the battery pack voltage (BPV) really is. Always compare and confirm with readings obtained using a multimeter in the following procedure.*

Batteries / Voltage Check without the CDT Handset

1. If necessary, see Testing Basics on page 12-12.
2. With batteries connected and using a multimeter set to 200 volts DC, place red (+) probe on the positive (+) post of battery no. 1 and the black (–) probe on the negative (–) post of battery no.6 **(Figure 12-2, Page 12-14)**.
3. The multimeter should indicate at least 48 volts. If not, check for loose battery connections or a battery installed in reverse polarity. **Refer to Electric Vehicle - Batteries on page 14-1 for further details on battery testing.**



(Viewed from driver side of vehicle)
1. RED probe to battery no. 1 (+).
2. BLACK probe to battery no. 6 (-).

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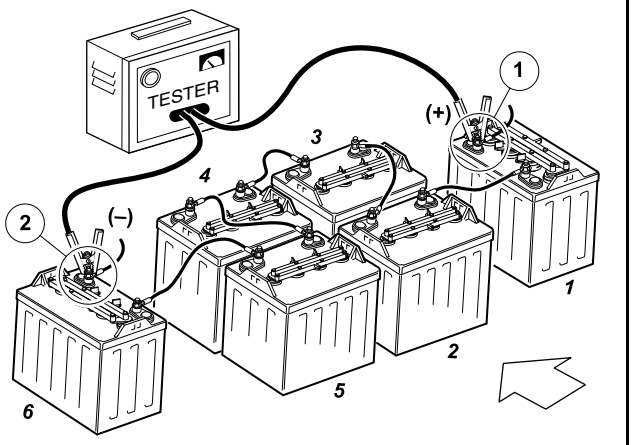
Figure 12-2 Battery Voltage Test

TEST PROCEDURE 2 – 48-Volt Battery Pack Voltage Under Load

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

1. If necessary, see Testing Basics on page 12-12.
2. Be sure the batteries are fully charged and that the electrolyte level is correct in all cells.
3. Connect the tester leads to the positive (+) post of battery no.1 and negative (–) post of battery no.6 **(Figure 12-3, Page 12-15)**.



(Viewed from driver side of vehicle)
1. RED probe to battery no. 1 (+).
2. BLACK probe to battery no. 6 (-).

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Figure 12-3 Battery Discharge Test

4. Turn the discharge machine on and record the voltage reading of battery pack while under load.
5. A fully charged set of batteries in good condition should read between 46 and 49 volts while under load.
6. A reading of 32 to 46 volts indicates discharged or failed batteries. Each battery should be checked with a multimeter while under load. **See following NOTE.**

NOTE: *If a 48-volt set of batteries is down in the 32 to 38 volt range, the discharge machine will activate but it will think it is testing a 36-volt battery set.*

7. A reading of 31.5 volts or less will not activate discharge machine. If the voltage of the batteries is below 32– volts, the batteries are deeply discharged or have failed.
8. Recording the battery pack voltage reading while under load provides a more accurate diagnosis of the condition of the batteries. When the discharge machine is ON, it places the battery pack under load and many times can help determine if one or more batteries in the set have failed. Testing battery voltage while the batteries are not under load will not always indicate the true condition of the batteries. For more information about the batteries, refer to 14 *Electric Vehicle - Batteries*.

TEST PROCEDURE 3 – Run/Tow Switch

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

If no voltage is coming to the Run/Tow Switch, inspect the red-to-pink wire spade connection at the solenoid.

Run/Tow Switch Test with the CDT Handset

1. With the Run/Tow switch in the RUN position, connect the CDT to the vehicle.
2. Immediately after the CDT is connected to the vehicle, the screen should display a copyright notice and the CDT model number.
3. If the CDT display screen remains blank, the CDT port has failed. In this case, disconnect the CDT from the port and connect it directly to the controller **(Figure 11-3, Page 11-29)**.
4. If the CDT display screen begins to work, go to step 5; otherwise, perform the following procedure, **Run/Tow Switch Test without the CDT Handset**.
5. With the CDT still connected to vehicle, place Run/Tow Switch in TOW position.
6. If the CDT display screen goes blank, the Run/Tow switch and connecting wires are operating correctly.
7. If the CDT display screen is still active, the switch has failed closed. Replace the Run/Tow switch. **See Run/Tow Switch Removal on page 13-3.**

Run/Tow Switch Test without the CDT Handset

⚠ WARNING

- **The key switch should be placed in the OFF position and left in the OFF position for the duration of this test.**

1. If necessary, see Testing Basics on page 12-12.
2. Access the Run/Tow switch but do not disconnect wires.
3. With the Run/Tow switch in the RUN position:

3.1. The pink wire should show BPV coming to the switch.

3.2. The light green wire should also show BPV. If it shows less than 5 volts, the switch has failed OPEN and must be replaced.

4. With the Run/Tow switch in the TOW position:

4.1. The light green wire should show less than 5 volts. If it still shows BPV, the switch has failed CLOSED and must be replaced.

TEST PROCEDURE 4 – Fuses

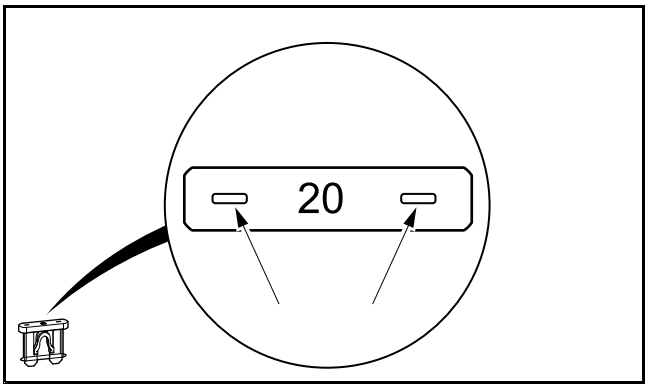
See General Warnings on page 1-1.

⚠ WARNING

- **Failure to use properly rated fuse can result in a fire hazard.**

NOTE: *These vehicles predominately use a combination of ATC-style and ATM-style blade fuses. A single AGC-style glass fuse is used for the charger interlock circuit.*

This is a voltage test. It can be performed relatively easily on ATC-style and ATM-style fuses. A voltage test can be performed on the AGC-style glass fuse if insulation-piercing probes are used. Otherwise, the AGC-style will have to be removed to visually inspect or check using a continuity test.



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Figure 12-4 Testing the Fuse

1. If necessary, see Testing Basics on page 12-12.
2. Access the fuses but do not remove them. Fuses are found at the following locations:
   – **On Controller Mounting Plate:** 15-amp fuse to DC/DC converter, 2-amp fuse to connected car device (Guardian/Visage V3 Circuit), and 15-amp fuse to electric powertrain
   – **Under Floorboard Near MCOR:** 20-amp fuse from DC/DC converter to accessories
   – **Under Front Cowl:** 15-amp fuse to cab, 10-amp fuse to brake lights, horn and turn signals, 7.5-amp fuse to headlights and taillights, 10-amp fuse to 12-volt power strip and power point
   – **On Main Harness Near Controller Mounting Plate:** 30-amp fuse for charger receptacle harness
   – **On Main Harness Forward of the 30-Amp Fuse:** 1-amp fuse for charger interlock circuit
3. **2-Amp and 15-Amp ATC Fuses On Controller Mounting Plate and 30-Amp ATC Charger Receptacle Fuse:** With the batteries connected and the Run/Tow switch in the RUN position:

3.1. Probe the two, small metal contacts on the top of the fuse **(Figure 12-4, Page 12-17)**.

3.2. Each contact should show BPV.

3.3. If only one side shows BPV, replace fuse.

3.4. If neither side of fuse shows BPV, do the following:
   – Check BPV.
   – Check condition and connection of large red wires at solenoid.
   – Check sonic weld_8 in main wire harness.
   – For one of the 15-amp ATC fuses, check Run/Tow switch to make sure it is in RUN position.
   – Check if 12 gauge red wire is coming off large post on solenoid.

4. **1-amp AGC Glass Fuse Only:** With the Run/Tow switch in the RUN position:

4.1. Probe the wire on each side of the fuse with insulation-piercing probes.

4.2. Each probe should show 42 to 46 volts.

4.3. If only one side shows voltage, replace fuse.

4.4. If neither side of fuse shows voltage, do the following:
   – Check Run/Tow switch to make sure it is in RUN position.
   – Check diode_1 in main wire harness.
   – Check 10k ohm in main wire harness.
   – Check 15-amp ATC fuse on controller mounting plate.

5. **20-Amp ATC Fuse Near MCOR and ATM Fuses Under Front Cowl:** With the batteries connected, key switch ON and DC/DC converter operating:

NOTE: *For these fuses only, connect the black probe of the meter to the 12 volt ground terminal block located under the front cowl.*

5.1. Probe the two, small metal contacts on the top of the fuse **(Figure 12-4, Page 12-17)**.

5.2. Each contact should show approximately 12.5 to 13.5 volts.

5.3. If only one side shows 12.5 to 13.5 volts, replace fuse.

5.4. If neither side of fuse shows 12.5 to 13.5 volts, do the following:

- Check 15-amp ATC fuse on controller mounting plate that supplies power to DC/DC converter. If fuse is good, check converter.
- **For ATM Fuses Under Front Cowl:** Check sonic weld_4 in main wire harness.
- Check key switch.
- Check lockout relay.
- **For All Fuses Powered by the DC/DC Converter:** Check sonic weld_16 in main wire harness.

TEST PROCEDURE 5 – Key Switch and MCOR Limit Switch Circuit

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

The MCOR provides FOOT INPUT to the controller.

The key switch provides KEY INPUT to the controller.

Key Switch and MCOR Limit Switch Circuit Test with the CDT Handset

1. Place chocks at the front wheels and lift the rear of the vehicle with a chain hoist or floor jack. Position jack stands under the frame rails just forward of each spring mount. **See General Warnings, Section 1, Page 1-1.**
2. Turn the key switch to the OFF position and place the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position.
3. Connect the CDT to the vehicle.
4. Test the key switch.

4.1. Access the Monitor menu and select KEY INPUT by using the SCROLL DISPLAY buttons. The CDT should indicate OFF when the key switch is in the OFF position.

4.2. While monitoring the CDT display screen, turn the key switch to the ON position. The CDT should indicate ON.

4.3. If the CDT does not indicate that KEY INPUT is ON when the key switch is in the ON position, go to the following procedure, **Key Switch and MCOR Limit Switch Circuit Test without the CDT Handset**. If the key switch functions as described, go to the following step. **See following NOTE.**

NOTE: *The key switch MUST function properly in order to test the MCOR limit switch with the CDT handset.*

5. Test the MCOR limit switch.

5.1. Select FOOT INPUT on the Monitor menu by using the SCROLL DISPLAY buttons on the CDT.

5.2. The CDT should indicate that FOOT INPUT is OFF when the accelerator pedal is not pressed, regardless of the key switch position.

5.3. With the key switch in the ON position, press the accelerator pedal. The CDT should indicate that FOOT INPUT is ON when the accelerator pedal is pressed.

6. If any reading is obtained that is not described in steps 4 and 5, perform the following steps:

6.1. Check the wiring of the key switch and MCOR. **See Sonic Weld, Diode, and 10k Ohm Resistor Locations, Section 12, Page 12-4.**

6.2. Check the continuity of the key switch wires and the MCOR limit switch wires.

7. If the problem was not found, go to the following procedure, **Key Switch and MCOR Limit Switch Circuit Test without the CDT Handset**.

Key Switch and MCOR Limit Switch Circuit Test without the CDT Handset

1. If necessary, see Testing Basics on page 12-12.
2. Place chocks at the front wheels and lift the rear of the vehicle with a chain hoist or floor jack. Position jack stands under the frame rails just forward of each spring mount. **See WARNING "Lift only one end..." in *General Warnings*.**
3. Place the Run/Tow switch in the RUN position and the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position.
4. **Pin 6 Tan/Green Wire:** Lift bed, remove access cover, access the controller. **See following NOTE.**

NOTE: *The easiest way to test the key switch and MCOR Limit Switch is to check the pin 6 green wire in the 16-pin connector. Pin 6 is the end of this circuit.*

4.1. Locate and connect an insulation-piercing probe to the pin 6 green wire in the 16-pin connector.

4.2. With the key switch in the OFF position and the accelerator pedal at rest, the green wire should show zero (0) volts.

4.3. With the key switch in the ON position and the accelerator pedal pressed, the green wire should show BPV which is FOOT INPUT to controller.
– If it shows BPV, then the key switch, MCOR and related wiring is functioning properly.
– If not, first check the key switch and then the MCOR limit switch.

5. **Key Switch:** Remove instrument panel to access the back of the key switch but do not disconnect wires. **See Instrument Panel Removal, Section 4, Page 4-9.**

5.1. With the key switch in the OFF position:
– The green wire should show BPV coming to the switch.
– The blue wire should show zero (0) volts. If it shows BPV, the switch has failed CLOSED and must be replaced.

5.2. With the key switch in the ON position:
– The blue wire should show BPV passing through the key switch to the MCOR. If it does not show BPV, the switch has failed OPEN and must be replaced.

6. **MCOR Limit Switch (FOOT INPUT):** Access the MCOR from under the vehicle passenger side.

6.1. With the key switch in the ON position:
– With an insulation-piercing probe, check voltage of the blue wire in the MCOR 2-pin connector. It should show BPV coming to the MCOR. If not, check wiring.
– With an insulation-piercing probe, check voltage of the green wire in the MCOR 2-pin connector. It should show zero (0) volts with the accelerator pedal at rest. Press the accelerator pedal and the green wire should show BPV passing through the MCOR to the controller for FOOT INPUT. If not, replace MCOR. **See MCOR Removal on page 13-4.**

TEST PROCEDURE 6 – Forward/Neutral/Reverse control (FNR)

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

The Forward/Neutral/Reverse control (FNR) provides FORWARD INPUT and REVERSE INPUT to the controller.

If the controller sees both FORWARD INPUT and REVERSE INPUT at the same time, the reverse buzzer will sound in all FNR positions and the vehicle will not operate in either direction. Common causes of this include corrosion across the contacts inside the switch, water inside the switch, or a switch that has failed CLOSED.

Forward/Neutral/Reverse control (FNR) Test with the CDT Handset

1. Turn the key switch to the OFF position and place the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position.
2. Connect the CDT to the vehicle.
3. Test FORWARD INPUT.

3.1. Access the Monitor menu and select FORWARD INPUT by using the SCROLL DISPLAY buttons. The CDT should indicate OFF when the Forward/Neutral/Reverse control (FNR) is in the NEUTRAL or REVERSE position.

3.2. Place the Forward/Neutral/Reverse control (FNR) in the F position. The CDT should indicate that FORWARD INPUT is ON. If the CDT indicates any other reading, check vehicle wiring. **See Sonic Weld, Diode, and 10k Ohm Resistor Locations on page 12-4.** Also check the 16-pin connector at the speed controller. **See Test Procedure 15 – 16-Pin Connector on page 12-30.**

4. Test REVERSE INPUT.

4.1. Access the Monitor menu and select REVERSE INPUT by using the SCROLL DISPLAY buttons. The CDT should indicate OFF when the Forward/Neutral/Reverse control (FNR) is in the NEUTRAL or F position.

4.2. Place the Forward/Neutral/Reverse control (FNR) in the REVERSE position. The CDT should indicate that REVERSE INPUT is ON. If the CDT indicates any other reading, check vehicle wiring. **See Sonic Weld, Diode, and 10k Ohm Resistor Locations on page 12-4.** Also check the 16-pin connector at the speed controller. **See Test Procedure 15 – 16-Pin Connector on page 12-30.**

5. If the CDT displays readings other than those described above and the wiring is found to be correct, go to the following procedure, **Forward/Neutral/Reverse control (FNR) Test without the CDT Handset**.

Forward/Neutral/Reverse control (FNR) Test without the CDT Handset

1. If necessary, see Testing Basics on page 12-12.
2. Place the Run/Tow switch in the RUN position and the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position.
3. Remove Forward/Neutral/Reverse control (FNR) from its housing by carefully prying up each side with a small, flat-tip screwdriver.
4. Back-probe the following three wires connected to the Forward/Neutral/Reverse control (FNR) in each position:

4.1. **Orange Wire**
– The orange wire provides power to the switch and should show BPV coming to the switch in all three positions.

If the orange wire does not show BPV, check the 20–amp fuse, Run/Tow switch, red-to-pink wire spade terminal connection and related wiring.

4.2. **Brown Wire**
– The brown wire should show BPV in F.

– The brown wire should show zero (0) volts in NEUTRAL and REVERSE

If the brown wire shows voltage in NEUTRAL, the switch may have corrosion across the contacts or the switch has failed CLOSED and must be replaced. *Forward/Neutral/Reverse control (FNR) Removal*.

If the brown wire does not show BPV in F, the switch may have corrosion on the contact or the switch has failed OPEN and must be replaced. *Forward/Neutral/Reverse control (FNR) Removal*.

4.3. **Red/Green Wire**
– The red/green wire should show BPV in REVERSE.

– The red/green wire should show zero (0) volts in NEUTRAL and F.

If the red/green wire shows voltage in NEUTRAL, the switch may have corrosion across the contacts or the switch has failed CLOSED and must be replaced. *Forward/Neutral/Reverse control (FNR) Removal*.

If the red/green wire does not show BPV in REVERSE, the switch may have corrosion on the contact or the switch has failed OPEN and must be replaced. *Forward/Neutral/Reverse control (FNR) Removal*.

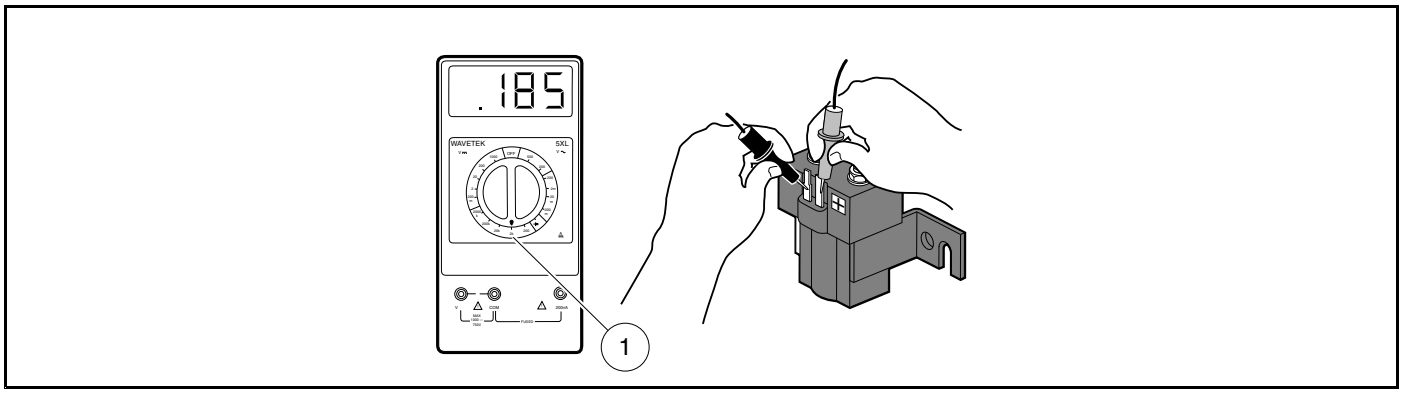
TEST PROCEDURE 7 – Solenoid Activating Coil

See General Warnings on page 1-1.

NOTE: *This is a resistance test.*

Be aware that one of two different solenoids may be found on the vehicle. Visually, the production solenoid is smaller than the service replacement. On the labels, the larger service replacement solenoid has SOL0605 and the smaller production solenoid has SOL5006. Internally, specifications and test results differ between the two.

1. If necessary, see Testing Basics on page 12-12.
2. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-5.**
3. Access the solenoid by removing the electronics module cover. **See Electric Vehicle - Electrical Components on page 13-1.**
4. Remove the two small wire terminals from the solenoid.
5. Place red (+) probe of the multimeter on the positive (+) solenoid terminal. Place the black (–) probe on the other small solenoid terminal.
   – A reading of 180 to 190 ohms should be obtained for service replacement solenoids **(Figure 12-5, Page 12-22)**. If not, replace the solenoid.



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Figure 12-5

TEST PROCEDURE 8 – Pre-Charge Resistor

See General Warnings on page 1-1.

NOTE: *This is a resistance test.*

1. If necessary, see Testing Basics on page 12-12.
2. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-5.**
3. Access the solenoid by lifting the bed.
4. Remove wires between 2 large posts of solenoid.
5. Measure resistance between the two large posts of the solenoid. The reading should be approximately 250 ohms. If not, remove pre-charge resistor, with pre-charge resistor removed, if it does not read approximately 250 ohms and is not discolored, replace.**Solenoid Removal on page 13-6**.

5.1. If it reads less than 250 ohms and is discolored replace and check pre-charge resistor. Go to Motor Test Procedure 1.

5.2. If pre-charge resistor test is good reinstall.

6. Place the Run/Tow switch in the TOW position and connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**

TEST PROCEDURE 9 – Solenoid Continuity

See General Warnings on page 1-1.

Solenoid Continuity Test with the CDT Handset

1. If necessary, see Testing Basics on page 12-12.
2. Place chocks at the front wheels and lift the rear of the vehicle with a chain hoist or floor jack. Position jack stands under the frame rails just forward of each spring mount. **See WARNING "Lift only one end..." in *General Warnings*.**
3. Connect the CDT to the vehicle.
4. Access the Monitor menu and select MAIN CONT DRIVER by using the SCROLL DISPLAY buttons. The CDT should indicate OFF.
5. Turn the key switch to the ON position and place the Forward/Neutral/Reverse control (FNR) in the F position.
6. Press the accelerator pedal. When the controller energizes the solenoid coil, the CDT should indicate ON. If not, check the KEY, FORWARD, REVERSE and FOOT INPUTS to the controller. **See Sonic Weld, Diode, and 10k Ohm Resistor Locations on page 12-4.** Also check the 16-pin connector at the speed controller. **See Test Procedure 15 – 16-Pin Connector on page 12-30.**
7. If the CDT displays readings other than those described above and the wiring is found to be correct, go to the following procedure, **Solenoid Continuity Test without the CDT Handset**.

Solenoid Continuity Test without the CDT Handset

1. If necessary, see Testing Basics on page 12-12.
2. Place chocks at the front wheels and lift the rear of the vehicle with a chain hoist or floor jack. Position jack stands under the frame rails just forward of each spring mount. **See WARNING "Lift only one end..." in *General Warnings*.**
3. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-5.**
4. Disconnect the 6-gauge yellow wire and pre-charge resistor from large post of solenoid. **See following NOTE.**

NOTE: *When disconnecting heavy gauge wires from solenoid, use a second wrench on the lower nut of the terminal post to hold post steady, preventing damage to the solenoid.*

If the pre-charge resistor is not disconnected, the meter will read approximately 250 ohms.

5. Check for continuity between the two large posts of the solenoid. The reading should be no continuity. If continuity is found, the solenoid has failed CLOSED and must be replace. **See Solenoid Removal on page 13-6.**
6. Reconnect the 6-gauge yellow wire and pre-charge resistor to the solenoid and secure with washer and nut. Tighten nut to 77 in·lb (8.7 N·m).
7. Place the Run/Tow switch in the TOW position and connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**

⚠ WARNING

- **Keep people and equipment clear from rotating rear wheels. Do not allow persons under the car. Contact with rotating rear wheels could result in serious personal injury.**

8. Change the multimeter to measure resistance.

9. Place the Run/Tow switch in the RUN position, turn the key switch to the ON position, place the Forward/Reverse rocker switch in the F position, and press the accelerator pedal. The rear tire should rotate and the multimeter should show a change in resistance. If not, replace the solenoid. **See Solenoid Removal on page 13-6.**

TEST PROCEDURE 10 – Charger Interlock

See General Warnings on page 1-1.

Controller Interlock Function Test with the CDT Handset

1. If necessary, see Testing Basics on page 12-12.
2. Connect the CDT to the vehicle.
3. Access the Monitor menu and select CHARGER INHIBIT by using the SCROLL DISPLAY buttons. The CDT should indicate OFF.
4. **For external charger:** Insert the charger DC cord into the vehicle's charger receptacle.

   For onboard charger: Insert the onboard charger AC plug into an AC outlet.
5. In a few seconds, the CDT should indicate ON and the vehicle can no longer be driven. If not, check the KEY, FORWARD, REVERSE and FOOT INPUTS to the controller.
   – If the CDT does not indicate ON, check circuit wiring and DC plug connection. See the following procedure **Testing the Interlock Circuit**.
   – If the CDT does indicate ON, but the vehicle can still be driven, replace the controller. **See Speed Controller Removal, Section 13, Page 13-7.**

Testing the Interlock Circuit

The charger interlock circuit consists of a 48 V power source through the RUN/TOW switch, a diode, a 10k ohm resistor, the charger receptacle blue wire and DC plug. **See following NOTE.** Use the following procedure to test the charger interlock circuit:

NOTE: *The following steps involve testing voltage and resistance.*

At the charger end of the DC cord, the black wire and blue wire are crimped together in the same fork terminal. This closes the circuit once the DC cord plug is inserted into the charger receptacle.

1. With batteries connected, place the Run/Tow switch in the RUN position.
2. Remove electronics module cover. **See Electric Vehicle - Electrical Components, Section 13, Page 13-1.**
3. **Check 15-amp fuse: See Test Procedure 4 – Fuses on page 12-16.**
4. **Check power:** Using a multimeter set to 200- volts DC, place red (+) probe (with insulation-piercing probe) on the light blue wire (pin 5 of the 16-pin connector) and black (–) probe on B- terminal of controller. The reading should be approximately 42 to 46 volts. If the reading is not approximately 42 to 46- volts, go to check the 10k ohm resistor. If the reading is approximately 42 to 46 volts, check continuity of circuit wires.
5. **Check 10k ohm resistor:** Set multimeter to 20k ohms. Remove the 15-amp fuse. With the red (+) probe (with insulation-piercing probe) still on the light blue wire (pin 5 of the 16-pin connector), place the black (–) probe to the red wire terminal in the 15-amp fuse holder. The reading should be approximately 10.0k ohms. If the reading is not approximately 10.0k ohms, replace the resistor or main wire harness **(Figure 12-1, Page 12-4)**.
6. **Check continuity:** Set multimeter to Continuity test. With the red (+) probe (with insulation-piercing probe) still on the light blue wire (pin 5 of the 16-pin connector), place the black (–) probe in the blue wire terminal of the charger receptacle. The meter should beep to indicate continuity. If not, check bullet connector of blue wires.

   Next, probe from the pink wire terminal in the 15-amp fuse holder to the large solenoid post with the red wires attached. The meter should beep to indicate continuity. If not, verify Run/Tow switch is in RUN and check the red-to-pink wire spade connector near the solenoid.

If the meter does not indicate continuity, check and repair related connections, Run/Tow switch and wiring. If necessary, replace affected wire harness, charger receptacle or Run/Tow switch.

7. When finished, install 15-amp fuse and fuse cover.

TEST PROCEDURE 11 – MCOR Voltage

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

The accelerator position, which is proportional to the MCOR voltage, can be displayed with the CDT handset. If a CDT handset is not available, go to **MCOR Voltage Test without the CDT Handset**.

The following are potential MCOR symptoms:

- Vehicle will not drive due to no FOOT INPUT to the controller.
- Vehicle will not reach top speed because MCOR does not reach 100% throttle position.
- Vehicle does not maintain speed nor will it accelerate due to MCOR having a “dead-spot” in its pedal travel.
- The voltage signal from the MCOR randomly or sporadically fluctuates with pedal at rest, during pedal travel and with pedal fully pressed.

MCOR Voltage Test with the CDT Handset

1. Place chocks at the front wheels and lift the rear of the vehicle with a chain hoist or floor jack. Position jack stands under the frame rails just forward of each spring mount. **See WARNING “Lift only one end...” in *General Warnings*. See also following WARNING.**

⚠ WARNING

- **The key switch should be placed in the OFF position and left in the OFF position for the duration of this test.**

2. Connect the CDT to the vehicle.
3. Access the Monitor menu and select THROTTLE % by using the SCROLL DISPLAY buttons.
4. The CDT should indicate 0% with the pedal not pressed. While monitoring the CDT display screen, slowly press the accelerator pedal. As the pedal is pressed, the CDT should indicate a steady, incremental rise from 0% (pedal not pressed) to 100% (pedal fully pressed). **See following NOTE.**

NOTE: *Observe closely to see if throttle input percentage randomly or sporadically fluctuates with pedal at rest, during pedal travel and with pedal fully pressed. If it fluctuates, the MCOR is defective and must be replaced.*

5. If the MCOR passes the previous test, press and hold the accelerator pedal to the floor. By hand, gently move the pedal from side to side and see if the throttle input percentage fluctuates from 100%. If it fluctuates, the MCOR is defective and must be replaced.
6. If throttle input percentage does not reach 100% in the previous steps, go to **MCOR Voltage Test without the CDT Handset.**

MCOR Voltage Test without the CDT Handset

1. Place chocks at the front wheels and lift the rear of the vehicle with a chain hoist or floor jack. Position jack stands under the frame rails just forward of each spring mount. **See WARNING “Lift only one end...” in *General Warnings*. See also following WARNING.**

⚠ WARNING

- **The key switch should be placed in the OFF position and left in the OFF position for the duration of this test.**

2. With the batteries connected, place Run/Tow switch in RUN. Using a multimeter set to 200 volts DC, place red (+) probe on battery no. 1 positive post and place black (–) probe (with insulation-piercing probe) on the purple/white wire at a point close to the three-pin connector at the MCOR. The reading should be approximately 48 to 50 volts (full battery voltage).
3. If reading is zero volts, check the purple/white wire continuity from the three-pin connector at the MCOR to the 16-pin connector at the speed controller. Check terminal positions in three-pin connector at the MCOR and the 16-pin connector. If all of the continuity readings are correct and the connectors are wired correctly, replace the speed controller.
4. With multimeter set to 20 volts DC, place the black (–) probe on battery no. 6 (6 x 8-Volt battery set) negative post and the red (+) probe (with insulation-piercing probe) on the white wire at a point close to the three-pin connector at the MCOR. The reading should be approximately 4.65 volts.
5. If reading is zero volts, check the white wire continuity from the three-pin connector at the MCOR to the 16-pin connector at the speed controller. Check terminal positions in three-pin connector at the MCOR and the 16-pin connector. If all of the continuity readings are correct and the connectors are wired correctly, replace the speed controller.
6. With multimeter set to 20 volts DC, place the black (–) probe on battery no. 6 (6 x 8-Volt battery set) negative post and the red (+) probe (with insulation-piercing probe) on the yellow wire at a point close to three-pin connector at the MCOR. The reading should be zero (0) volts with the pedal up. Slowly press the accelerator pedal and note the readings on the multimeter. As the pedal is pressed, the reading should increase until it reaches approximately 4.65 volts when the pedal is fully pressed.
7. If reading does not increase as the pedal is pressed, replace the MCOR. **See following NOTE.**

NOTE: *Observe closely to see if voltage randomly or sporadically fluctuates with pedal at rest, during pedal travel and with pedal fully pressed. If it fluctuates, the MCOR is defective and must be replaced.*

TEST PROCEDURE 12 – Motor Speed Sensor

See General Warnings on page 1-1.

Motor Speed Sensor Test without any Tool

⚠ CAUTION

- **Perform the following procedure only on a level surface. To avoid injury or property damage, ensure that the path of the vehicle is clear before pushing vehicle.**

1. Place the Forward/Neutral/Reverse control (FNR) in the REVERSE position to verify reverse buzzer is functioning properly. If not, repair or replace the buzzer.
2. With Run/Tow switch in the RUN position, turn the key switch to the OFF position and place the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position.
3. Slowly push the vehicle a short distance (about 3 feet (1 meter)). The reverse buzzer should sound and motor braking should engage while the vehicle is rolling.
4. If the reverse buzzer does not sound and motor braking does not engage while the vehicle is rolling, replace the Motor Speed Sensor.

Motor Speed Sensor Test with the CDT Handset

⚠ CAUTION

- **Perform the following procedure only on a level surface. To avoid injury or property damage, ensure that the path of the vehicle is clear before pushing vehicle.**

1. Turn the key switch to the OFF position and place the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position.
2. Connect the CDT to the vehicle.
3. Access the Monitor menu and select SPEED PULSES by using the SCROLL DISPLAY buttons. The CDT should indicate OFF when the vehicle is at rest.
4. While monitoring the CDT display screen, slowly push the vehicle a short distance (about 3 feet (1 meter)). The CDT should indicate ON for speed sensor pulses while the wheels are in motion.
5. If the CDT does not indicate ON while the wheels are in motion, go to the following procedure.

Motor Speed Sensor Test without the CDT Handset

NOTE: *This is a voltage test.*

1. Turn the key switch to the OFF position and place the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position.
2. With batteries connected, disconnect the three-pin connector at the motor speed sensor.
3. Check voltage at purple/white wire:

3.1. Using a multimeter set to 200 volts DC, place the red (+) probe on the battery no. 1 positive post and place the black (–) probe on the purple/white wire terminal socket in the three-pin connector. The voltage reading should be 48 to 50 volts (full battery voltage).

3.2. If the reading is zero volts, check the continuity of the purple/white wire from the 16-pin connector at the speed controller to the three-pin connector at the motor speed sensor. If the continuity is correct, replace the speed controller.

4. Check voltage at the red motor speed sensor wire:

4.1. With Run/Tow switch in the RUN position and using a multimeter set to 20 volts DC, place the black (–) probe on the battery no. 6 (6 x 8-Volt battery set) negative post and place red (+) probe on red wire terminal socket in three-pin connector. The voltage reading should be approximately 15 to 16 volts.

4.2. If the voltage reading is zero volts, check the continuity of the red wire from the 16-pin connector at the speed controller to the three-pin connector at the motor speed sensor. If the wire continuity is correct, replace the speed controller.

4.3. If the reading is below 14 volts, replace the speed controller.

4.4. If the voltage reading is correct, go to the following step.

5. Check voltage at the light green wire:

5.1. Using a multimeter set to 20 volts DC, place the black (–) probe on the battery no. 6 (6 x 8-Volt battery set) negative post and place the red (+) probe on the light green wire female terminal in the three-pin connector at the motor speed sensor. The voltage reading should be from 4.60 to 4.90 volts.

5.2. If the voltage is zero volts, check the continuity of the light green wire from the 16-pin connector at the speed controller to the three-pin connector at the motor speed sensor. If the continuity is correct, replace the speed controller.

5.3. If reading is below 3.50 volts, check the continuity of the wires and plug and replace the speed controller if necessary.

6. Reconnect the three-pin connector at the motor speed sensor. Using a multimeter set to 20 volts DC, place the black (–) probe on the battery no. 6 (6 x 8-Volt battery set) negative post and place the red (+) probe (with insulation-piercing probe) on the green wire between the three-pin connector and the motor speed sensor.

6.1. Raise one rear wheel off ground. Slowly turn the rear wheel to rotate the motor armature. As the armature rotates, the voltage reading should alternate from zero to approximately 4.85 volts. The voltage reading will fluctuate from zero to 4.85 volts and back to zero four times for each revolution of the motor armature.

NOTE: *The voltage reading of 4.85 is an approximate reading. The actual reading may vary from 4.50 to 5.00 volts.*

6.2. Replace the speed sensor if any of the following results occur:
- There is no voltage reading.
- The voltage reading is not above 3.50.
- The voltage reading does not fluctuate as the motor is turned.

TEST PROCEDURE 13 – A1 and A2 Motor Voltage

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

1. Place chocks at the front wheels and lift the rear of the vehicle with a chain hoist or floor jack. Position jack stands under the frame rails just forward of each spring mount. **See WARNING "Lift only one end..." in *General Warnings*. See also following WARNING.**

⚠ WARNING

- **Keep people and equipment clear from rotating rear wheels. Do not allow persons under the car. Contact with rotating rear wheels could result in serious personal injury.**

2. With the batteries connected and using a multimeter set to 200 volts DC, place the black (–) probe on the A2 motor terminal (white wire) and connect the red (+) probe to the A1 (green wire) motor terminal.
3. With Run/Tow switch in the RUN position, place the Forward/Neutral/Reverse control (FNR) in the F position, turn key switch to the ON position and slowly press accelerator pedal.

4. As the accelerator pedal is pressed, the voltage reading should increase from approximately 5 volts RMS when the MCOR limit switch closes, to approximately 48 volts RMS with the accelerator pedal fully pressed. **See following NOTE.**

NOTE: *Voltage can vary depending on controller speed setting as well as which zone a Visage equipped vehicle is located.*

Example: *Speed setting 1 may only read 30 volts.*

4.1. If there is no voltage reading, check the MCOR. **See MCOR Voltage on page 12-25.** Also check the continuity of the large posts of the solenoid. **See Solenoid Continuity on page 12-23.**

4.2. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-5.**

4.3. Check continuity on A1 and A2 motor terminal posts and continuity of the F1 and F2 motor terminal posts. Also, check continuity of all motor wires. Section 16 — Electric Vehicle - Motor

TEST PROCEDURE 14 – Voltage at Charger Receptacle

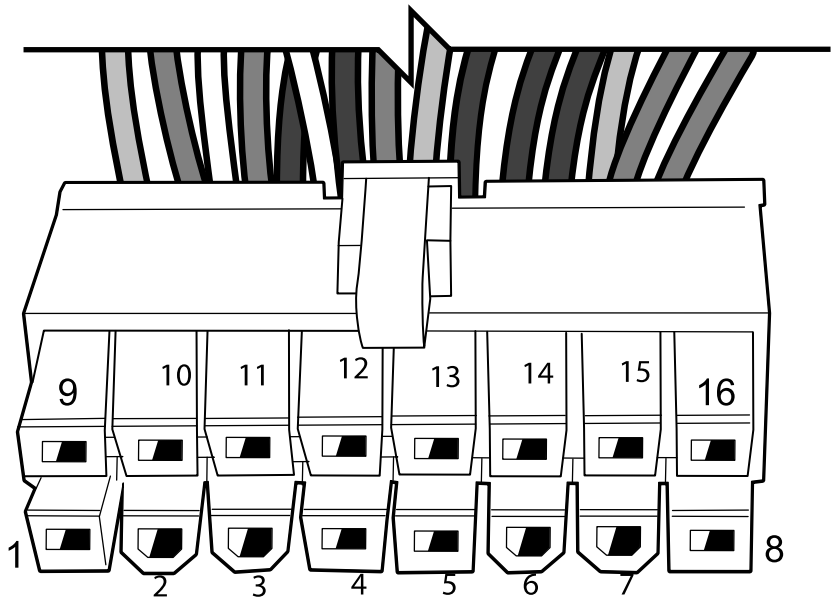
See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

1. If necessary, see Testing Basics on page 12-12.
2. Place red probe in red wire socket of charger receptacle and black probe on named negative battery #6. The reading should be BPV
3. If the reading is zero volts, check the following items:
   – The 30-amp fuse (located near solenoid) in the 10-gauge red wire of the charger receptacle harness.
   – Continuity of the 10-gauge red wire from the solenoid to the receptacle socket.
   – Continuity of the 6-gauge red wire from the positive post of battery no.1 to the solenoid.
4. If the reading is less than BPV, inspect related wiring and connections for tightness, damage and corrosion.

TEST PROCEDURE 15 – 16-Pin Connector

See General Warnings on page 1-1.



Pin 1 – White	Pin 5 – Light Blue	Pin 9 – Gray	Pin 13 – White/Black
Pin 2 – Yellow	Pin 6 – Green	Pin 10 – Tan	Pin 14 – Light Green
Pin 3 – Purple/White	Pin 7 – Orange/White	Pin 11 – Blue/Yellow	Pin 15 – Red
Pin 4 – Open (No wire)	Pin 8 – Brown	Pin 12 – Blue/White	Pin 16 – Blue

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Figure 12-6 Pin And Wire Color

Inspection and General Information

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-5.**
2. Disconnect the 16-pin connector from the speed controller. Inspect terminal ends inside plug to ensure they are in position and seated in plug housing. If any terminals look like they are not pushed all the way into the connector, gently push the terminals until they are firmly seated in the 16-pin connector. After each terminal has been pushed into the housing, gently pull on the wire to ensure it is locked into place.
3. Check wires in the plug to make sure none are broken at the terminal pin crimp. Repair or replace as required.
4. Check the wire colors of each wire and make sure that the colors for each pin position match the wire colors as shown in **Figure 12-6, Page 12-30**.
5. When connecting the 16-pin connector to the controller, push plug into controller receptacle with enough force to lock plug into place. An audible click will be heard when plug is properly seated to the controller.

A procedure is provided for testing each of the wires in the 16-pin connector. For testing, wires have been grouped together based on purpose as either controller input or controller output. Tests vary whether the 16-pin must be connected or disconnected from the controller to get the appropriate result.

If 16-pin must be disconnected:

1. Keep the 16-pin connector disconnected from the controller.
2. With Run/Tow switch in the TOW position, reconnect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**
3. Place the Run/Tow switch in the RUN position and then check the appropriate wires.

If 16-pin must be connected:

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-5.**
2. Connect the 16-pin connector to the controller. **See following NOTE.**

NOTE: *When connecting the 16-pin connector to the controller, push plug into controller receptacle with enough force to lock plug into place. An audible click will be heard when plug is properly seated to the controller.*

3. With Run/Tow switch in the TOW position, reconnect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**
4. Place the Run/Tow switch in the RUN position and then check the appropriate wires.

Refer to the following tables. Each table contains the following information:

- What function the wire performs.
- Whether or not the 16-pin connector must remain connected during the test.
- The appropriate test result for each pin.

If results differ from those described in the procedure, check the continuity of the wires in the wire harness and test the connected components with the appropriate test procedures. **See Index of Test Procedures.**

Testing Controller Inputs

CONTROLLER INPUTS	PERFORM TEST WITH 16-PIN CONNECTED TO CONTROLLER? (IF YES, BACK-PROBE TO TEST)	TEST PROCEDURE
THROTTLE INPUT Pin 2 – Yellow	Yes	Range of zero (0) volts (with accelerator pedal at rest) to 4.65 volts (with accelerator pedal fully pressed) from MCOR 3-pin circuit
GROUND FOR PINS 1 AND 15 Pin 3 – Purple/White	Yes	BPV measured between solenoid post with red wires and pin 3
CHARGER INTERLOCK INPUT Pin 5 – Light Blue	Yes	Approx. 42 to 46 volts (can vary depending on BPV) with charger disconnected. **See Test Procedure 10 – Charger Interlock on page 12-24.**
FOOT INPUT Pin 6 – Green	No	BPV from MCOR limit switch (Key switch must be ON)
REVERSE BUZZER INPUT Pin 7 – Orange/White	No	BPV from Reverse Buzzer with Run/Tow switch in RUN (Key switch either ON or OFF)

TABLE CONTINUED ON NEXT PAGE

CONTROLLER INPUTS	PERFORM TEST WITH 16-PIN CONNECTED TO CONTROLLER? (IF YES, BACK-PROBE TO TEST)	TEST PROCEDURE
FORWARD INPUT Pin 8 – Brown	No	BPV from Forward/Neutral/Reverse control (FNR) in FWD (Key switch either ON or OFF)
B+ INPUT Pin 9 – Gray Powers the controller logic and power boards.	No	BPV from Run/Tow switch in RUN
KEY SWITCH INPUT Pin 10 – Tan	No	BPV from Key switch in ON
SOLENOID INPUT Pin 12 – Blue/White	No	BPV from Solenoid Activating Coil (result of Key switch in ON)
SPEED SENSOR INPUT Pin 14 – Light Green	Yes	Alternates from zero (0) to approx. 4.85 volts depending on speed sensor position. Rotate rear wheel to see voltage switch (Key switch either ON or OFF)
REVERSE INPUT Pin 16 – Blue	No	BPV from Forward/Neutral/Reverse control (FNR) in REV (Key switch either ON or OFF)

Testing Controller Outputs

CONTROLLER OUTPUTS	PERFORM TEST WITH 16-PIN CONNECTED TO CONTROLLER? (IF YES, BACK-PROBE TO TEST*)	TEST PROCEDURE
THROTTLE OUTPUT Pin 1 – White Supplies approximately 5 volts in MCOR 3-pin circuit.	Yes	4 to 5 volts measured between pin 1 and B- terminal on controller (Key switch either ON or OFF)
CHARGE INDICATOR LIGHT OUTPUT Pin 11 – Blue/Yellow Supplies a positive (+), controlled current source to power the charge indicator light on the instrument panel.	Yes* Do not back-probe for this test.	Start a charging session. After a few seconds, light should flash. Can also be seen under LED Driver in the Monitor menu of the CDT.
CONNECTED CAR OUTPUT Pin 13 – White/Black Supplies approximately 13 volts to the Guardian/Visage unit.	Yes	Approximately 13 volts measured between pin 1 and B- terminal on controller (Key switch either ON or OFF)
SPEED SENSOR OUTPUT Pin 15 – Red Supplies approximately 15 to 16 volts to the motor speed sensor.	Yes	Approximately 15 to 16 volts measured between pin 1 and B- terminal on controller (Key switch either ON or OFF)

TEST PROCEDURE 16 – Reverse Buzzer

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

1. If necessary, see Testing Basics on page 12-12.
2. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-5.**
3. Remove the instrument panel. **See Instrument Panel Removal, Section 4, Page 4-9.**
4. Disconnect the orange/white and pink wires from the reverse buzzer.
5. Place the Run/Tow switch in the TOW position and connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**
6. Place the key switch in the OFF position and the Run/Tow switch in the RUN position.
7. Using a multimeter set to 200 volts DC, place the black (–) probe on battery no. 6 (6 x 8-Volt battery set) negative post and place the red (+) probe on the pink wire terminal end that was disconnected from the reverse buzzer. The reading should be approximately 48 volts (full battery voltage).

7.1. If the voltage reading is correct, go to step 7.

7.2. If reading is zero volts, check wire continuity, 9-pin connector, 15-amp fuse and Run/Tow switch. **See Test Procedure 3 – Run/Tow Switch on page 12-15.**

7.3. If the continuity readings are not correct, repair or replace the pink wire.

7.4. If the continuity readings are correct, go to step 7.

8. Place the Forward/Neutral/Reverse control (FNR) in REVERSE. Using a multimeter set to 200 volts DC, place the black (–) probe on the orange/white wire terminal end (that was disconnected from the reverse buzzer) and place the red (+) probe on battery no. 1 positive post. The reading should be approximately 48 volts (full battery voltage).

8.1. If the voltage reading is correct, replace the reverse buzzer.

8.2. If reading is zero volts, check orange/white wire continuity and connection at Pin 7 in 16-Pin connector.

8.3. If there is no continuity in the orange/white wire, or the pin 7 terminal in the 16-pin connector is not properly seated, repair or replace as required.

8.4. If the orange/white wire continuity and 16-Pin connector are correct and there is no voltage at the orange wire, replace the controller.

TEST PROCEDURE 17 – Charge Indicator Light

See General Warnings on page 1-1.

1. With batteries connected, Run/Tow switch in the RUN position and the key switch in the OFF position, connect charger DC cord to vehicle.
2. In a few seconds, the light will flash three times and the reverse buzzer simultaneously will sound three times to indicate charging has begun. **See following NOTE.**

NOTE: *The number of flashes and beeps can vary depending on the Beep Option setting.* ***See Beep Option, Section 11, Page 11-8.***

3. If charge indicator light does not flash three times, disconnect charger DC cord from vehicle and connect a CDT to the vehicle.
4. Access the Monitor menu and select LED Driver by using the SCROLL DISPLAY buttons. The CDT should indicate OFF.
5. Reconnect charger DC cord to vehicle.
6. In a few seconds, the CDT should quickly display ON just once while the dash-mounted charge indicator light flashes three times. **See following NOTE.**

NOTE: *The CDT will still flash ON even with a failed or missing charge indicator light.*

7. If the CDT quickly displays ON but the charge indicator light still does not flash, check the following items:
   – Condition of the blue/yellow wire terminal in the 16-pin connector.

– Condition of the 9-pin connector behind instrument panel.

– Condition of the yellow/green wire terminal in the instrument panel wire harness.

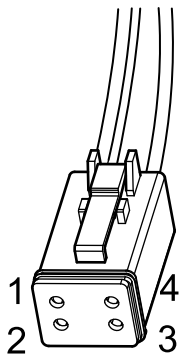
– Continuity of the wires in the wire harnesses.

8. If no problems exist in the above items, replace the charge indicator light.

TEST PROCEDURE 18 – 4-Pin Connector (for Connected Car Device)

See General Warnings on page 1-1.

NOTE: *This is a voltage and continuity test.*



Pin 1 – Yellow/Black	Pin 4 – White/Black
Pin 2 – Red/White	Pin 3 – Open (No wire)

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Figure 12-7 4-Pin Connector

1. If necessary, see Testing Basics on page 12-12.
2. Check for continuity between pin 1 (yellow/black wire) **(Figure 12-7, Page 12-34)** and pin 3 (purple/white wire) of the 16-pin connector. It should indicate continuity. If not, check sonic welds no. 1 and no. 2.
3. Probe pin 2 (red/white wire). It should show BPV. If not, check 2-amp fuse. **See following NOTE.**

NOTE: *The red/white wire has BPV with the Run/Tow switch in either position.*

4. Probe pin 4 (white/black wire). It should show approximately 13 volts supplied by the controller. If not, check wiring and then controller. **See following NOTE.**

NOTE: *The white/black wire only has voltage with the Run/Tow switch in the RUN position.*

If pin 4 has no voltage, the controllers LIN (Local Interconnect bus) may have failed. The vehicle can be driven if it is not used with Guardian or Visage and will not show any symptoms. Otherwise, Guardian or Visage will disable the vehicle until communication is restored.

SECTION 13 — ELECTRIC VEHICLE - ELECTRICAL COMPONENTS

13

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

KEY SWITCH

See General Warnings on page 1-1.

TESTING THE KEY SWITCH

See Test Procedure 5 – Key Switch and MCOR Limit Switch Circuit on page 12-19.

KEY SWITCH REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Remove instrument panel. Refer to **See Instrument Panel Removal on page 4-9.**.

NOTE: *Take care to prevent key switch terminals and wires from touching the metal frame around the dash.*

3. Disconnect the wires from the key switch. Do not allow wires to touch.
4. From the back of the instrument panel, push down on the retaining tabs surrounding the key switch (4) and remove the key switch cap (8). Using a 1-inch socket, hold the key switch and remove the switch retaining nut (6) from the outside of the instrument panel **(Figure 13-1, Page 13-2)**.

KEY SWITCH INSTALLATION

1. Position the key switch (3) and key switch washer (1) in the instrument panel, then install and tighten the key switch nut (5) to 35 to 45 in·lb (4 to 5 N·m). Install key switch cap (6) into instrument panel, align the bent washer tab with the slot in the plastic.**(Figure 13-1, Page 13-2)**.
2. Refer to the wiring diagram to connect the wires to the key switch terminals. **See Sonic Weld, Diode, and 10k Ohm Resistor Locations, Section 12, Page 12-4.**
3. Install instrument panel. Refer to **See Instrument Panel Installation on page 4-9.**
4. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

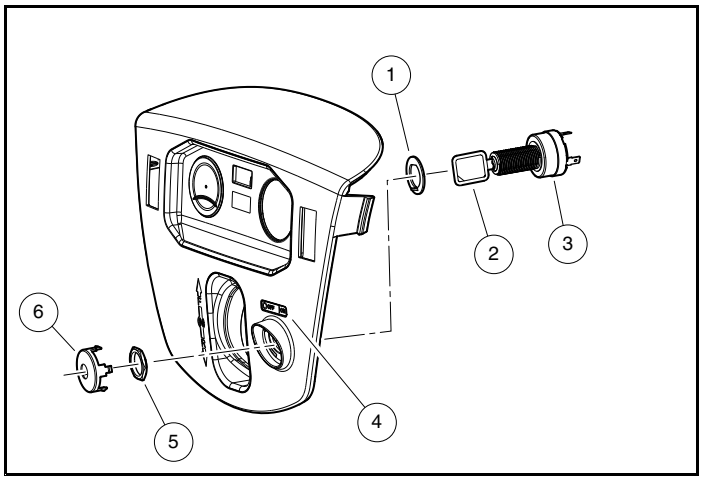


Figure 13-1 Key Switch

FORWARD/NEUTRAL/REVERSE CONTROL (FNR)

See General Warnings on page 1-1.

TESTING THE FORWARD/NEUTRAL/REVERSE CONTROL (FNR)

See Test Procedure 6 – Forward/Neutral/Reverse control (FNR) on page 12-20.

FORWARD/NEUTRAL/REVERSE CONTROL (FNR) REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Remove instrument panel. Refer to **See Instrument Panel Removal, Section 4, Page 4-9.**
3. Disconnect the three wires from the rocker switch.
4. Press in on the locking tabs on each side of switch (11) and push switch out of instrument panel.

FORWARD/NEUTRAL/REVERSE CONTROL (FNR) INSTALLATION

1. Press the locking tabs (11) on each end of the rocker switch and push switch into instrument panel.
2. Connect the 18-gauge brown, orange, and red/green wires to the rocker switch exactly as shown in the wiring diagram. **See Sonic Weld, Diode, and 10k Ohm Resistor Locations, Section 12, Page 12-4.**
3. Install instrument panel. **See Instrument Panel Installation on page 4-9.**
4. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
5. Place the Run/Tow switch in the RUN position.
6. Inspect the vehicle for proper operation. **See following WARNINGS.**

⚠ WARNING

- **Make sure that the vehicle operates in the forward direction when the Forward/Neutral/Reverse control (FNR) is in the F position.**
- **Make sure that the vehicle operates in the reverse direction when the Forward/Neutral/Reverse control (FNR) is in the REVERSE position. The reverse buzzer will sound as a warning when the Forward/Neutral/Reverse control (FNR) is in REVERSE.**
- **Make sure that the vehicle does not operate when the Forward/Reverse switch is in the NEUTRAL position.**

RUN/TOW SWITCH

See General Warnings on page 1-1.

TESTING THE RUN/TOW SWITCH

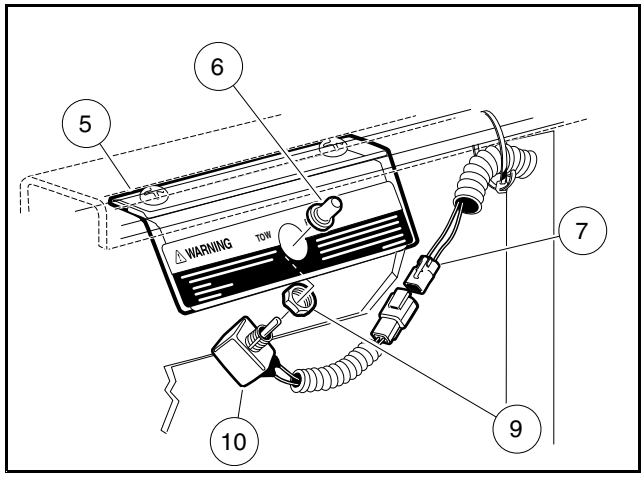
See Test Procedure 3 – Run/Tow Switch on page 12-15.

RUN/TOW SWITCH REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Using a 5/8 in (16 mm) socket, remove Run/Tow switch boot/hex nut (6).
3. Remove Run/Tow switch (10) and nut (9) from bracket (5).
4. Disconnect the two-pin connector (7) and remove switch.

RUN/TOW SWITCH INSTALLATION

1. Make sure groove on switch is aligned with tang on bracket. Tighten Run/Tow switch boot/hex nut (6) to 16 in·lb (1.8 N·m).
2. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**



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Figure 13-2 Run/Tow Switch

MOTOR CONTROLLER OUTPUT REGULATOR (MCOR)

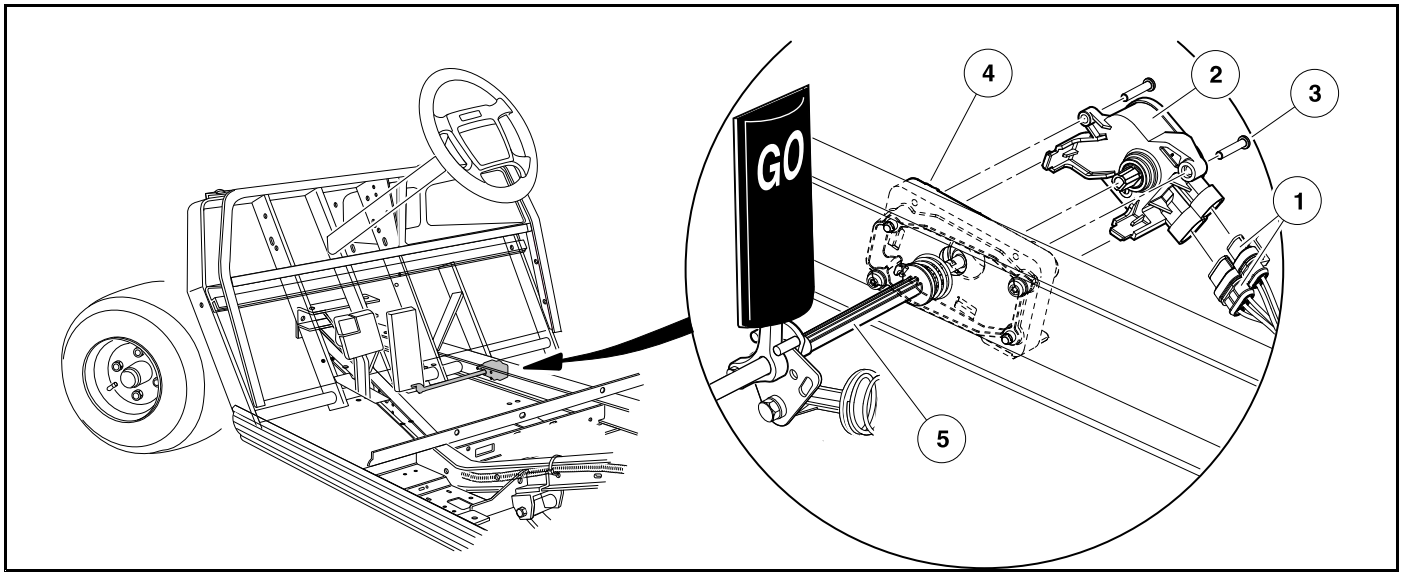
See General Warnings on page 1-1.

TESTING THE MCOR

11 – *MCOR Voltage*

MCOR REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Place chocks at rear wheels and lift the front of the vehicle with a chain hoist or floor jack. Place jack stands under the round tube crossmember of the frame to support vehicle.
3. Disconnect the two-pin and three-pin connectors (1) from the MCOR (2) **(Figure 13-3, Page 13-4)**.
4. Remove the two torx screws (3) securing the MCOR (2) to the plastic housing (4) on the chassis.
5. Detach the two tabs from the plastic housing (4) and remove the MCOR (2) from vehicle.



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Figure 13-3 MCOR Mounting

MCOR INSTALLATION

1. Align the two tabs of the MCOR (2) with the slots in the plastic housing (4) on the chassis **(Figure 13-3, Page 13-4)**. Insert the MCOR into the plastic housing (4) until the tabs engage. **See following NOTE.**

NOTE: *Rotate the drive bar (5) back and forth if necessary to align the D-shaped end with the MCOR.*

2. Secure the MCOR (2) to the plastic housing (4) with two torx screws (3). Tighten screws to 12 in·lb (1.4 N·m).
3. Connect the two-pin and three-pin connectors (1) from the wire harness to the MCOR (2).
4. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

REVERSE BUZZER

See General Warnings on page 1-1.

TESTING THE REVERSE BUZZER

16 – *Reverse Buzzer*

REVERSE BUZZER REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Remove instrument panel. **See Instrument Panel Removal on page 4-9.**
3. Disconnect the 18-gauge pink wire and orange/white wires from reverse buzzer.
4. Remove the two screws from the reverse buzzer. Remove the reverse buzzer from the center dash panel.

REVERSE BUZZER INSTALLATION

1. Install the reverse buzzer in the reverse order of removal. Tighten screws to 4 in·lb (0.45 N·m).
2. Reconnect wires. Pink on positive, orange/white on negative.
3. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

SOLENOID

See General Warnings on page 1-1.

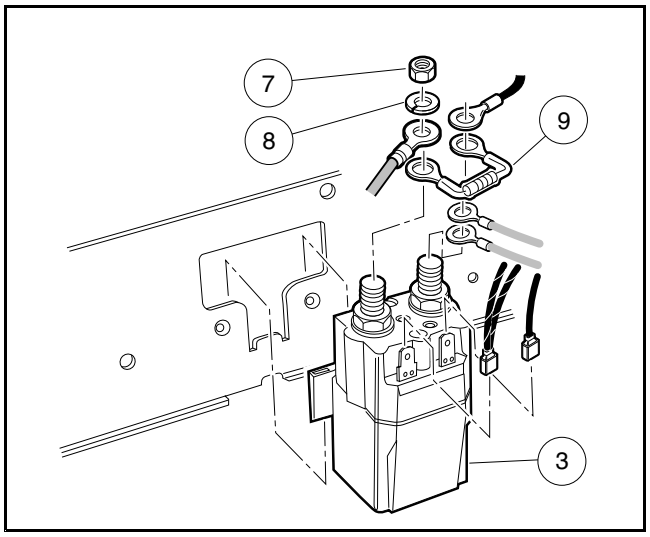
The solenoid is located on the driver side of the electrical component mounting plate.

TESTING THE SOLENOID

7 – *Solenoid Activating Coil*

SOLENOID REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Lift cargo bed.
3. Disconnect all wires from the solenoid (3) **(Figure 13-4, Page 13-6)**.
4. Slide solenoid (3) up to disengage the mounting tabs and remove from component mounting plate.



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Figure 13-4 Solenoid

SOLENOID INSTALLATION

1. Mount solenoid (3) onto component mounting plate by engaging slot **(Figure 13-4, Page 13-6)**.
2. Using the wiring diagram, install the wires, pre-charge resistor (9), washers (8), and nuts (7) onto the large mounting posts. Tighten nuts to 77 in·lb (8.7 N·m). .
3. Install the blue/white and light blue wires onto the small terminals of the solenoid.
4. Lower cargo bed.
5. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

SPEED CONTROLLER

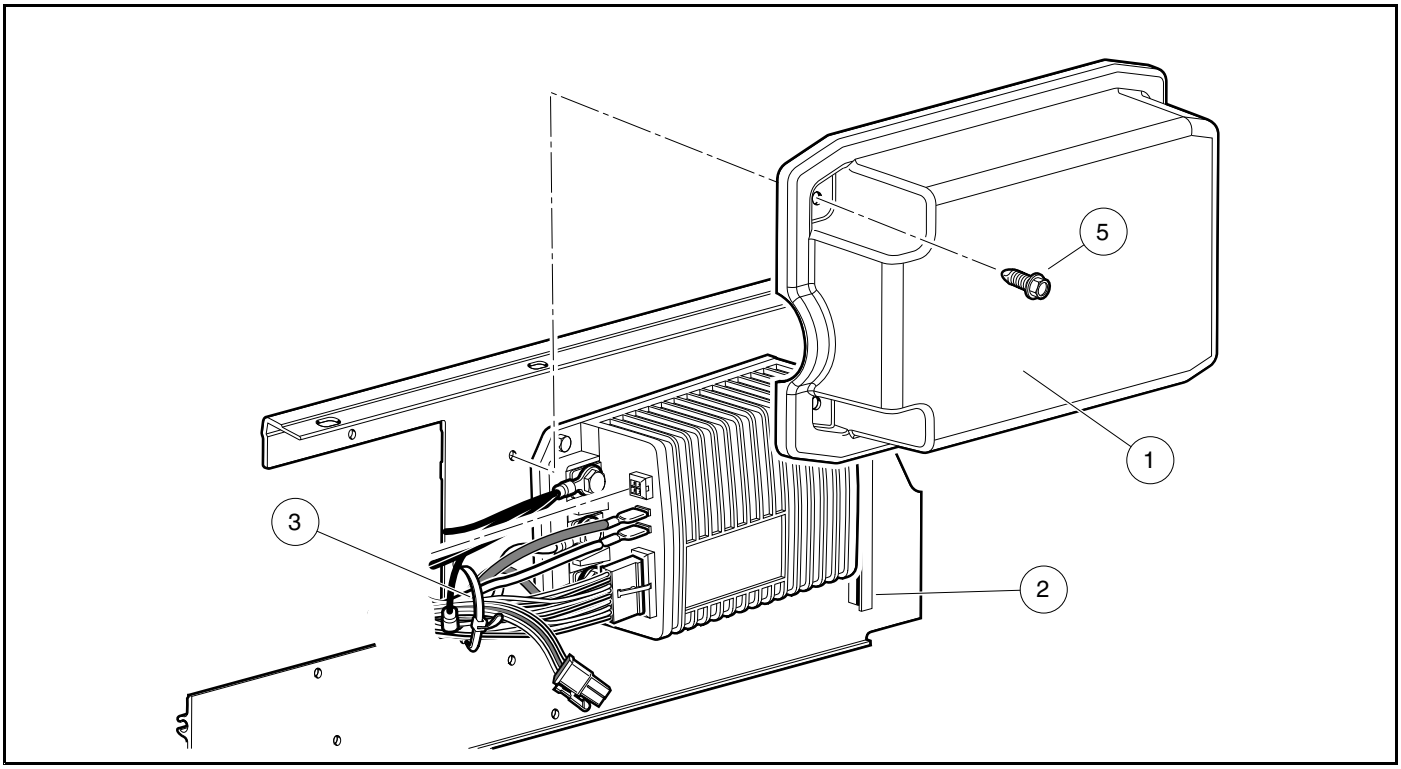
See General Warnings on page 1-1.

TESTING THE SOLID STATE SPEED CONTROLLER

See Test Procedure 13 – A1 and A2 Motor Voltage on page 12-28.

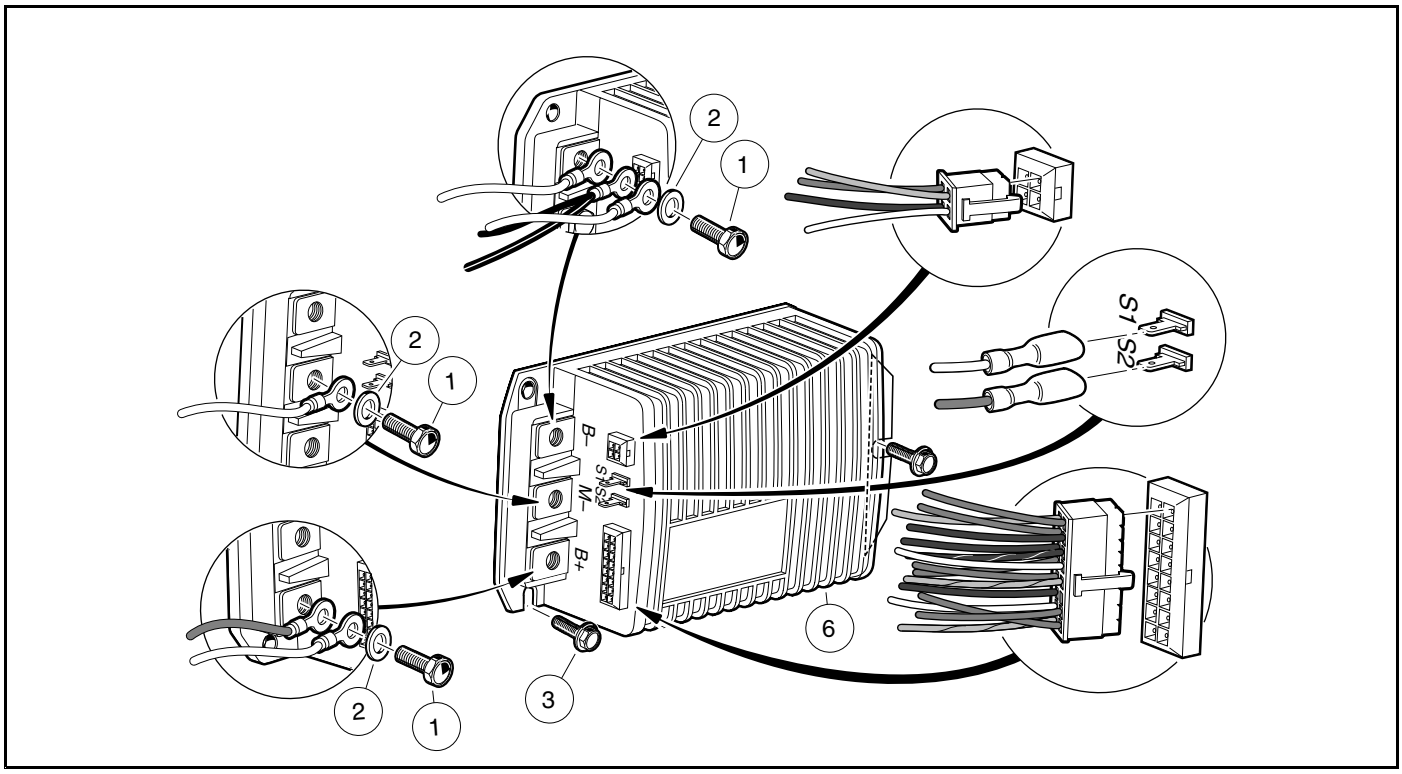
SPEED CONTROLLER REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-5.**
2. Remove the two screws (5) from controller cover (1) and remove cover. **(Figure 13-6, Page 13-8)**.
3. Disconnect the heavy gauge wires from the controller by removing the three screws (1). **(Figure 13-6, Page 13-8)**.
4. Disconnect the 16-pin connector, 4-pin connector, and spade connectors from the controller (6).
5. Remove the one self-tapping screw (3) nearest the B- terminal of the controller. Loosen the remaining two self-tapping screws (3) that secure the controller and remove controller from vehicle.



1325

Figure 13-5 Speed Controller Cover



2901

Figure 13-6 Speed Controller

SPEED CONTROLLER INSTALLATION

1. Install controller (6) on the two self-tapping screws (3). Install third self-tapping screw (3) and tighten to 5.5 ft·lb (7.5 N·m) **(Figure 13-6, Page 13-8)**.
2. Connect the the heavy gauge wires to the controller (6) per the electrical schematics. **See Sonic Weld, Diode, and 10k Ohm Resistor Locations on page 12-4.** Tighten terminal screws (1) on the controller to 108 in·lb (12.2 N·m).
3. Connect the 16-pin connector, 4-pin connector, and spade connectors to the controller (6).
4. Place the Run/Tow switch in the TOW position and connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**
5. Place the Run/Tow switch in the RUN position.
6. If vehicle is equipped with the Guardian SVC system, perform the following additional steps for proper setup.

6.1. Connect a CDT to the CDT port on the vehicle.

6.2. Select *Program, Settings, Control Mode* and set the value to 1.

6.3. Select *Program, Settings, Anti Tamper* and set the value to 0.

6.4. Select *Program, Vehicle ID, Vehicle S/N* and enter the last six digits of the vehicle serial number.

NOTE: *The speed for scrolling values may be increased by utilizing the bookmark keys (yellow buttons) in combination with the data inc/dec key (+/-).*

6.5. Select *Program, Vehicle ID, Vehicle Decal* and enter the number on the Vehicle Number Decal.

6.6. Select *Program, Vehicle ID, Vehicle Date of Manufacture* and enter the number on the model year and week from the vehicle serial number.

6.7. Select *Information, Software Version* and verify the value is 13 or higher. If not, contact a Club Car Technical Representative.

6.8. Place the Run/Tow switch in the TOW position for 30 seconds. Then return it to RUN.

7. Inspect the vehicle for proper operation.

⚠ WARNING

- **Make sure that the vehicle operates in the forward direction when the Forward/Neutral/Reverse control (FNR) is in the F position.**
- **Make sure that the vehicle operates in the reverse direction when the Forward/Neutral/Reverse control (FNR) is in the REVERSE position. The reverse buzzer will sound as a warning when the Forward/Neutral/Reverse control (FNR) is in REVERSE.**
- **Make sure that the vehicle does not operate when the Forward/Reverse switch is in the NEUTRAL position.**

CHARGER RECEPTACLE

See General Warnings on page 1-1.

The charger cord, plug, and receptacle are wear items and should be inspected daily. Visually inspect them for cracks, loose connections, and frayed wiring; they must be replaced when worn or damaged. If charger plug or receptacle show signs of corrosion or the plug is difficult to insert or remove, the receptacle contacts and plug terminals should be cleaned with a good electrical contact cleaner or lightly sprayed with WD-40® brand spray lubricant. The plug should then be inserted and removed several times to ensure ease of insertion, ease of removal, and good electrical contact.

TESTING THE CHARGER RECEPTACLE

14 – *Voltage at Charger Receptacle*

See also the appropriate battery charger maintenance and service manual.

CHARGER RECEPTACLE INSPECTION

Inspect the receptacle for cracks, loose connections and frayed wiring. **See following Note.**

NOTE: *Disassembly of the charger receptacle, for the purpose of removal or installation, is not recommended.*

CHARGER RECEPTACLE REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Remove the cowl. **See Cowl Removal on page 4-4.**
3. Disconnect 3-pin connector.
4. Cut tie wrap.
5. Using a 5/16–inch socket with extension, remove the three screws (1 inside and 2 front outer) that attaches the charger receptacle to the grille.
6. Remove charger receptacle.

CHARGER RECEPTACLE INSTALLATION

1. Insert receptacle assembly into grille.

2. Install the three screws (1) that secure the receptacle to the grille. Tighten screws to 16 in·lb (1.8 N·m).
3. Connect three-pin connector.
4. Install cowl. **See Cowl Installation on page 4-4.**
5. Place the Run/Tow switch in the TOW position and connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**

CHARGE INDICATOR LIGHT

See General Warnings on page 1-1.

TESTING THE CHARGE INDICATOR LIGHT

17 – *Charge Indicator Light*

CHARGE INDICATOR LIGHT REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Remove instrument panel. **See Instrument Panel Removal on page 4-9.**
3. Disconnect the wires at the warning light.
4. Press the two retaining tabs and remove the light from the instrument panel.

CHARGE INDICATOR LIGHT INSTALLATION

1. Install light into instrument panel.
2. Connect wires to the warning light.
3. Install the instrument panel. **See Instrument Panel Installation on page 4-9.**
4. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

DC/DC CONVERTER

DC/DC CONVERTER REMOVAL

The DC/DC Converter is mounted to the chassis under the passenger-side floorboard.

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-5.**
2. Disconnect the DC/DC converter three pin (1) and two pin (2) plugs from the wire harness (3).
3. Remove the two locknuts (4) securing the DC/DC converter (5) to the frame and remove converter.

DC/DC CONVERTER INSTALLATION

1. Install the DC/DC converter (5) to the frame and secure with new locknuts (4). Tighten locknuts (4) to 75 in·lb (8.5 N·m).
2. Connect the three pin (1) and the two pin plugs (2) of the wire harness (3) to the DC/DC converter (5) leads.
3. Connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**

FUSE BLOCK

FUSE BLOCK REMOVAL

1. Lift bed.
2. Disconnect the batteries and discharge the controller. Disconnect the Batteries – Electric Vehicles on page 1-5.
3. Using a 3/8 inch socket remove the upper and lower bolts that attach the fuse block cover.
4. Remove fuse block cover.
5. Remove nut and washers.
6. Using a 3/8 inch socket and flat blade screwdriver remove two bolts and fuse block.
7. Using a small flathead screwdriver, disconnect wires.

FUSE BLOCK INSTALLATION

1. Connect wires to fuse block.
2. Install two bolts to fuse block.
3. Using a 3/8 inch socket install nuts and washers that attach fuse block cover.
4. Install fuse block cover.
5. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
6. Lower bed.

HEADLIGHT SWITCH

See General Warnings on page 1-1.

TESTING THE LIGHT SWITCH

See Test Procedure 23 – Headlight Switch on page 18-38.

HEADLIGHT SWITCH REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Remove the instrument panel. **See Instrument Panel Removal, Section 4, Page 4-9.**
3. Disconnect the wires from the light switch (4 and 9) .
4. Collapse the tabs and un-snap the light switch (4) from instrument panel.

HEADLIGHT SWITCH INSTALLATION

1. Connect the wires to the light switch (4 and 9) .
2. Reinsert light switch (4) to instrument panel.
3. Install the instrument panel. **See Instrument Panel Installation on page 4-9.**
   Be sure that key switch terminals cannot touch the frame and the instrument panel is properly seated and snapped in place.
4. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

HEADLIGHTS

HEADLIGHT BEZEL REMOVAL

1. Disconnect the batteries and discharge the controller. Disconnect the Batteries – Electric Vehicles on page 1-5.
2. Remove the cowl. **See Cowl Removal, Section 4, Page 4-4.**
3. Remove the front fenders. **See Front Bumper and Side Fender Removal, Section 4, Page 4-8.**
4. Loosen and remove the M6 self-tapping bolts (3) that attach the bezel (1) to the vehicle frame. **(Figure 13-7, Page 13-14)**.

HEADLIGHT BEZEL INSTALLATION

1. Install bezel (1) to vehicle frame.
2. Install the three M6 self-tapping bolts (3) that attach the bezel onto frame. Tighten to 44 in·lb (5 N·m).
3. Install the front fenders. **See Front Bumper and Side Fender Installation, Section 4, Page 4-8.**
4. Install the cowl. **See Cowl Installation, Section 4, Page 4-4.**
5. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

HEADLIGHT BULB REMOVAL (HALOGEN)

1. Disconnect the batteries. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Remove cowl. **See Cowl Removal, Section 4, Page 4-4.**
3. Remove front fenders. **See Front Bumper and Side Fender Removal, Section 4, Page 4-8.**
4. Rotate (but do not touch) bulb (4) in a 90° angle and pull out of lens assembly (5). **(Figure 13-7, Page 13-14)**.

HEADLIGHT BULB INSTALLATION (HALOGEN)

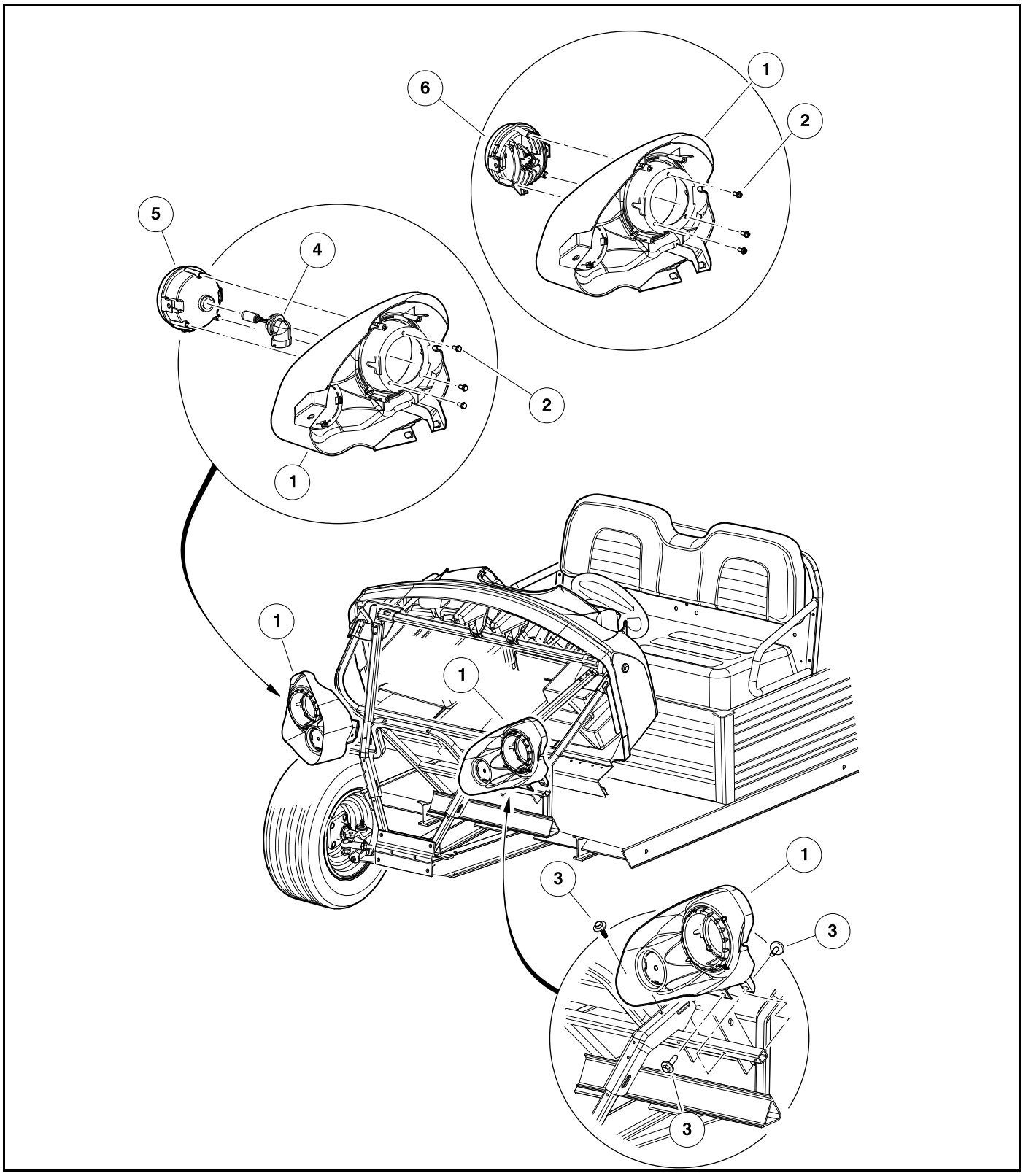
1. Install (but do not touch) bulb into socket, install into lens assembly (5). **(Figure 13-7, Page 13-14)**.
2. Connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**
3. Install front fenders. **See Front Bumper and Side Fender Installation, Section 4, Page 4-8.**
4. Install cowl. **See Cowl Installation, Section 4, Page 4-4.**

HEADLIGHT BULB REMOVAL (LED)

1. Disconnect the batteries.
2. Remove cowl. **See Cowl Removal, Section 4, Page 4-4.**
3. Remove front fenders. **See Front Bumper and Side Fender Removal, Section 4, Page 4-8.**
4. Remove the three screws (2) and pull headlight housing assembly (6) from bezel (1). **(Figure 13-7, Page 13-14)**

HEADLIGHT BULB INSTALLATION (LED)

1. Install headlight housing assembly (6) into bezel (1) and secure with screws (2). **(Figure 13-7, Page 13-14)**
2. Connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**
3. Install front fenders. **See Front Bumper and Side Fender Installation, Section 4, Page 4-8.**
4. Install cowl. **See Cowl Installation, Section 4, Page 4-4.**



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Figure 13-7 Headlight Assembly

USB RECEPTACLE

The 5-volt, 2.1 amp USB receptacle supplies electricity to power and charge portable devices. The USB receptacle is not for movement of data.

The USB receptacle will only operate when a shielded USB cord is connected. When the USB receptacle is not in use, remove the shielded USB cord to prevent battery drain.

USB RECEPTACLE REMOVAL

1. Disable the vehicle.
2. Disconnect the batteries and discharge the controller.
3. Remove the cowl.
4. Disconnect the USB red wire from the 12V power point (1) and the main harness red wire (2) **(Figure 13-8)**.

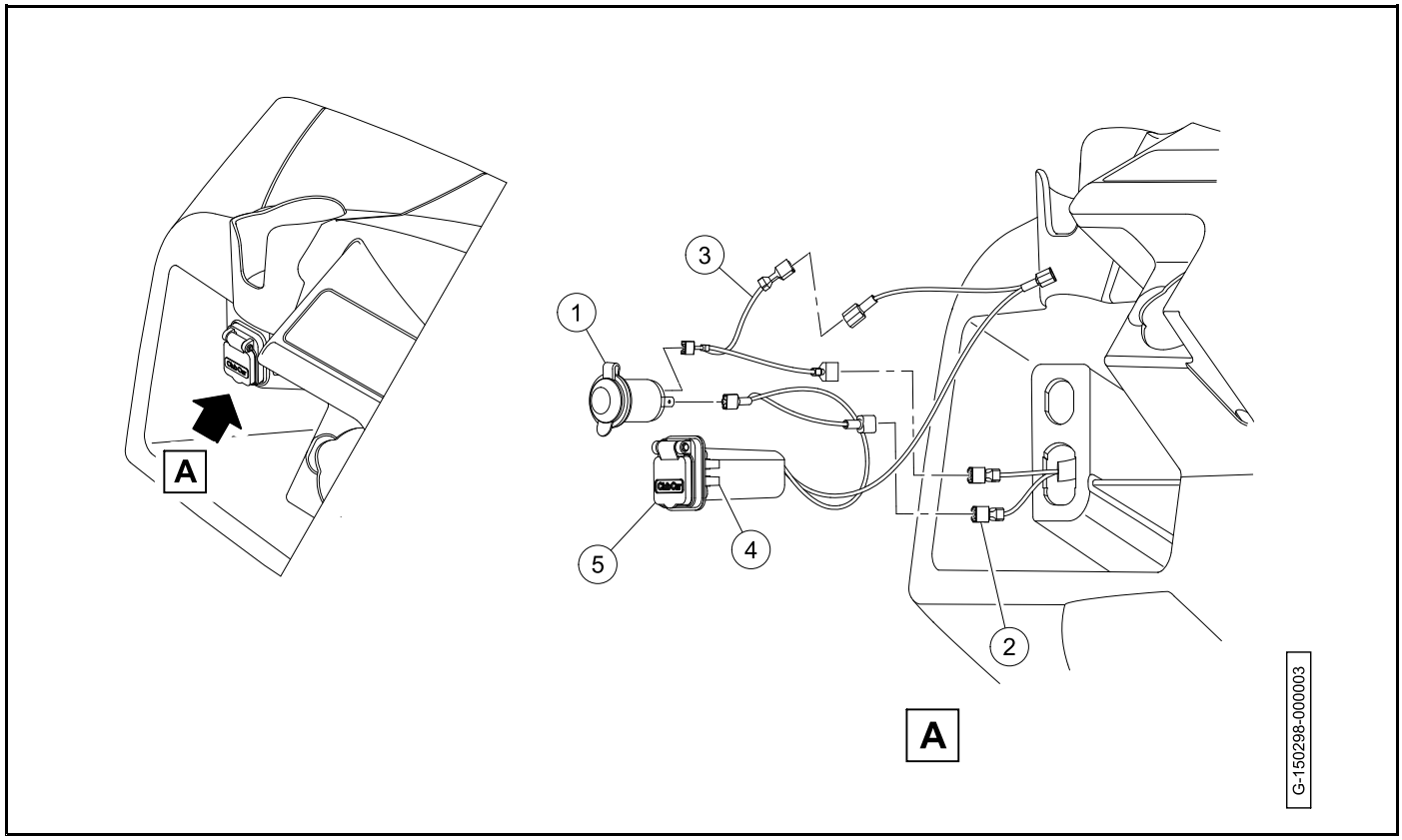


Figure 13-8

5. Disconnect the USB black wire from the jumper wire (3).
6. Push the lock tabs (4) on both sides and remove the USB receptacle (5).

USB RECEPTACLE INSTALLATION

1. Put the USB receptacle wires into the dash.
2. Push the USB receptacle (5) into the dash **(Figure 13-8)**.
3. Make sure that the locking tabs (4) engage.

4. Connect the USB black wire to the jumper wire (3).
5. Connect the USB red wire to the main harness red wire (2) and the 12V power point (1).
6. Install the cowl.
7. Connect the batteries.

SECTION 14 — ELECTRIC VEHICLE - BATTERIES

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

⚠ DANGER

- **Battery – Explosive gases! Do not smoke. Keep sparks and flames away from the vehicle and service area. Ventilate when charging or operating vehicle in an enclosed area. Wear a full face shield and rubber gloves when working on or near batteries.**
- **Charge batteries in a well-ventilated area only. Batteries emit hydrogen while being charged. Hydrogen is an explosive gas and must never exceed a level of 2% of the air.**
- **Battery – Poison! Contains acid! Causes severe burns. Avoid contact with skin, eyes, or clothing. Antidotes:**
  - **External: Flush with water. Call a physician immediately.**
  - **Internal: Drink large quantities of milk or water. Follow with milk of magnesia or vegetable oil. Call a physician immediately.**
  - **Eyes: Flush with water for 15 minutes. Call a physician immediately.**

⚠ WARNING

- **Wear safety glasses or approved eye protection when servicing the vehicle or battery charger. Wear a full face shield and rubber gloves when working on or near batteries.**
- **Use insulated tools when working near batteries or electrical connections. Use extreme caution to avoid shorting of components or wiring.**
- **Ensure battery connections are clean and properly tightened. See Battery Care on page 14-6.**

CAUTION

- **On all vehicles, turn off all accessories before charging batteries.**

NOTE: *Recycle or dispose of discarded batteries in accordance with local, state, and federal regulations.*

GENERAL INFORMATION

The batteries supplied with an electric vehicle are different from those supplied with an automobile. The outward appearance of these two batteries is similar, but the operating characteristics are very different. The electric vehicle battery is a deep-cycle battery, and the automotive battery is a “starting, lighting, and ignition” (SLI) battery. They should never be substituted for one another.

BATTERY TESTING BASICS – 8 VOLT

See General Warnings on page 1-1.

OBSERVATION

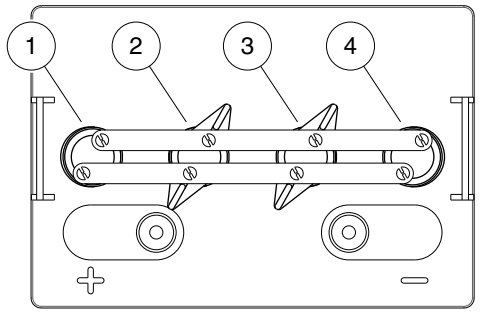
Inspect the battery compartment for the following items:

- Rusted, corroded, or broken battery posts
- Rusted, corroded, loose or broken wires
- Low or overfilled electrolyte levels
- Cracked, punctured, or bulging battery cases
- Loose, over-tightened, missing, or improperly placed battery hold-downs
- Incorrect orientation of batteries (i.e. terminal posts)
- Poor, fair, or proper cleanliness of batteries
- Added electric accessories
- Use of a single-point watering system (SPWS)

MEASURING VOLTAGE OF BATTERY SET

Set the multimeter to 200 volts DC. Place the red (+) probe on the positive (+) post of battery no. 1 and the black (–) probe on the negative (–) post of battery no. 6. Record the reading.

BATTERY CELL NUMBERING



1. Cell 1 (Cell with Positive Post)
2. Cell 2 (Cell adjacent to Positive Post)
3. Cell 3 (Cell adjacent to Negative Post)
4. Cell 4 (Cell with Negative Post)

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Figure 14-1 Battery Cell Numbering – 8 Volt

BATTERY TESTING – 8 VOLT

See General Warnings on page 1-1.

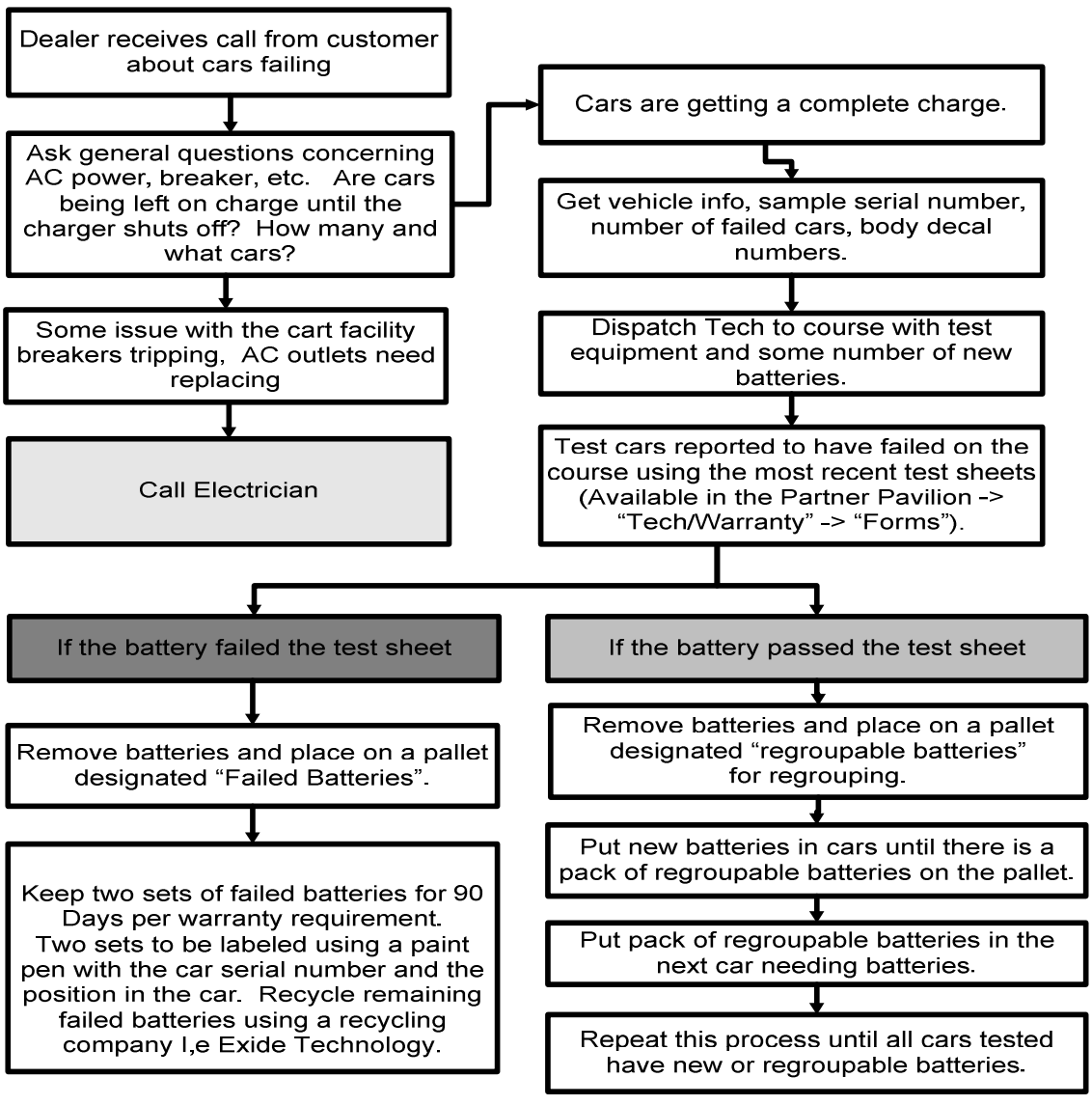
Test procedures not available at time of publication. Refer to any Bulletin that is released concerning testing for Model Year 2015.

BATTERY REGROUPING

CAUTION

- **To prevent degradation of battery performance and life, never mix batteries of different part numbers or brands/model numbers. Anytime a different model of battery is used, the charging algorithm must be changed to match it. For vehicles with PowerDrive charger, the vehicles' onboard computer must be changed to one that is specific to the battery installed. For vehicles with high-frequency charger (e.g. ERIC or QuiQ), the charger must be reprogrammed with the appropriate algorithm specific to the battery installed.**

Regrouping is now Club Car's standard battery replacement method. *Regrouping* is the practice of placing batteries of similar condition together in one vehicle. For example, if there was an issue with the batteries in two cars and the battery test indicated three failed batteries in each car, after removing the failed batteries, there will be six good batteries remaining. Install the six remaining good batteries together in one car and install NEW batteries in the other car. We recommend regrouping batteries in as many cars as possible at a given opportunity to minimize mixing old and new batteries together in one battery pack. A training video for regrouping is available to view in the Partner Pavilion under "Tech/Warranty" and then "Training Videos". Contact your regional Tech Support person to assist you in the regrouping process if needed.



CAUTION: To prevent degradation of battery performance and life, never mix batteries of different part numbers or brands/model numbers. Charging algorithms are specific to a particular battery model.

1. **Install all new batteries or all regroupable batteries of the same brand and model or part number; do not mix new with regroupable except for the last car regrouped.**
2. **Accurate and accumulative Amp Hours are required for Warranty claims. Make sure to have battery lights on hand to replace ones that may be defective so you can capture every car's Amp Hour reading.**

3104

Figure 14-2 Battery Regrouping Process Flow

BATTERY REPLACEMENT

See General Warnings on page 1-1.

⚠ WARNING

- **Wear steel-toe shoes when replacing batteries.**
- **To prevent electrolyte leakage from the battery vents, batteries must be kept in an upright position. Tipping a battery beyond a 45° angle in any direction can allow a small amount of electrolyte to leak out the vent hole. Do not exceed this 45° angle when lifting, carrying, or installing batteries. Battery acid can cause severe personal injury to skin or eyes, and can damage clothing.**
- **When replacing batteries in the Single Point Watering System, place the battery cap from the new replacement battery onto the used battery being removed from the car. Important safety warnings on the battery cap must remain with the battery after it has been removed from the car.**

CAUTION

- **To prevent degradation of battery performance and life, never mix batteries of different part numbers or brands/model numbers. Anytime a different model of battery is used, the charging algorithm must be changed to match it. For vehicles with PowerDrive charger, the vehicles' onboard computer must be changed to one that is specific to the battery installed. For vehicles with high-frequency charger (e.g. ERIC or QuiQ), the charger must be reprogrammed with the appropriate algorithm specific to the battery installed.**

1. Before removing batteries, note the orientation of the batteries and the connecting wires. Disconnect the battery cables and discharge the controller as instructed. **See Disconnect the Batteries – Electric Vehicles on page 1-5.** Remove remaining wires and batteries.
2. Visually inspect the new batteries for any damage that may have occurred in transit. New batteries will not deliver their full capabilities until they have been discharged and recharged 50 to 70 times. To obtain the maximum service life from new batteries, restrict vehicles with new batteries to one hour of operation between charges for the first two months vehicle is in service. Batteries should be fully charged before first use of new vehicle, before first use of a vehicle after storage, and before use each day.
3. If the battery cables are to be reused, inspect them for broken or frayed wires, damaged terminals, or worn insulation. Remove any corrosion on the connectors. A solution of baking soda and water (1 cup (237 mL) baking soda per 1 gallon (3.8 L) of water) does an excellent job of neutralizing and removing the corrosion. Be careful not to allow the baking soda solution to enter the battery.
4. Check and clean the battery rack and hold-downs. The nuts and bolts on the hold-downs may corrode. It is therefore advised they be cleaned periodically and replaced as necessary.
5. Regroup batteries as required. **See Battery Regrouping on page 14-3.**
6. Install regrouped or new batteries in the proper orientation **(Figure 1-2, Page 1-5)**. Install battery hold-downs. The hold-downs should be tight enough so batteries do not move while vehicle is in motion, but not so tight as to crack or buckle battery case. Tighten hold-down retaining nuts to 72 in·lb (8.1 N·m), alternating between hold-down bolts.
7. Install wires in proper sequence. Install black wire to negative post of battery no. 6 (6 x 8-Volt battery set) last. **See Connect the Batteries – Electric Vehicles on page 1-5.**
8. If replacement batteries have a different part number than the batteries removed, either replace the vehicles' onboard computer or reprogram the high-frequency charger. **See preceding CAUTION.**
9. Give the batteries a full charge prior to operation. This ensures all the batteries are fully charged and the cells are equalized prior to use.

BATTERY CARE

See General Warnings on page 1-1.

WATER QUALITY

Water purity is the most important factor in the performance and life span of the vehicle batteries. Club Car is, therefore, placing increased importance on battery water quality.

Outlined below are four battery watering procedures, grouped into two categories: Preferred and Alternate methods. Club Car recommends the use of a deionizer or distilled water. Alternate methods of reverse osmosis or tap water are allowable but should be avoided since water quality can change from day to day depending on additives, water main leaks, etc.

Preferred Methods

- **Distilled Water:** Distilled water is the most common type of water used in batteries. Distilled water is created by boiling water, collecting the steam, and allowing the steam to condense back into water. The distilling process results in water that is free of minerals that can lead to the degradation of battery performance and life.
- **Deionized Water:** Deionized water is created by inducing electrically charged resins that attract and bind to sodium, calcium, iron, copper, chloride, and bromide ions. The result of this electrical filtering is purified water, which contains little to no mineral ions. To make sure the deionized water remains at a high quality, replace the filter in the deionizer per the manufacturer's recommendations.
- **Deionized Systems:** The Service Parts Department at Club Car offers two deionizer system: one for vehicles equipped with the Single Point Watering System (SPWS) and one for vehicles without SPWS (used in combination with the Battery Watering Nozzle Gun).

Alternate Methods

- **Reverse Osmosis:** Reverse osmosis involves forcing water through a membrane that allows water to pass while trapping solids. The choice of membrane used determines the amount of solids or impurities that get trapped and hence the purity quality of the filtered water. In addition, the usage frequency of the membrane can also contribute to the filtered water quality. Due to the variance in water quality consistency, Club Car recommends the use of the deionizer or distilled water.
- **Tap Water:** While the use of tap water without filtering is an alternate method of battery watering, its use should be limited due to the levels of dissolved minerals and chemicals that can degrade battery performance and life. If unfiltered tap water is used, regular water analyses must be conducted to check for impurities. The following chart lists the maximum allowable minerals, solids, and contaminates in parts per million and their impact on battery performance. Water testing, however, is expensive, and water quality can change from day to day depending on additives, water main leaks, etc. Due to the cost and labor of performing water quality tests, Club Car recommends the use of distilled water or a deionizer.

IMPURITY	ALLOWABLE CONTENT (PARTS PER MILLION)	EFFECTS OF IMPURITY
Suspended matter	Trace	N/A
Total solids	100.0	N/A
Organic and volatile matter	50.0	Corrosion of positive plates
Ammonia	8.0	Slight self-discharge of both plates

TABLE CONTINUED ON NEXT PAGE

IMPURITY	ALLOWABLE CONTENT (PARTS PER MILLION)	EFFECTS OF IMPURITY
Antimony	5.0	Self-discharge, reduces life, lower on-charge voltage
Arsenic	0.5	Self-discharge, can form poisonous gas
Calcium	40.0	Increase of positive plate shedding
Chloride	5.0	Loss of capacity in plates, greater loss in positive plates
Copper	5.0	Increased self-discharge, lower on-charge voltage
Iron	3.0	Increased self-discharge, lower on-charge voltage
Magnesium	40.0	Reduced life
Nickel	None allowed	Intense lowering of on-charge voltage
Nitrates	10.0	Increased sulfation of negative plate
Nitrites	5.0	Plate corrosion, loss of capacity, reduced life
Platinum	None allowed	Violent self-discharge, lower on-charge voltage
Selenium	2.0	Positive plate shedding
Zinc	4.0	Slight self-discharge of negative plates

DEIONIZER

Deionizer systems for SPWS configured fleets became standard with Model Year 2014 fleet golf orders.

Regular Maintenance

This system requires regular preventative maintenance on at least a quarterly basis.

- Check all screens and/or filters on water supplies. Clean or replace all filters / line strainers as necessary. Failure to do so can cause a reduction in the water pressure and flow rates needed to operate the system properly. A filter screen can be found on the inlet of all regulators, and a line strainer on all supply hoses. Be sure to replace the deionizer filter cartridge as indicated by the water quality light. The Deionizer system has a battery-powered, water quality light. Deionizer filters have a limited life cycle and are disposable. Life cycle of the filter will vary based on incoming water quality and water usage. If the deionizer system is equipped with a water quality light, press the button to check. Replace filter immediately if the red light comes ON indicating service is required.

  Replacement filters are available from Club Car Service Parts.

- Inspect the condition of all tubing, connections, and couplers. Make sure that all parts are in good working condition, secure, leak free, and properly connected. The coupler must have an O-ring and the dust cover properly attached.

- Clean optical indicator of the water quality light. If the optical indicator is dirty, clean it by wiping with a cloth.

Decals

Starting December 2013, new decals were installed on the deionizer wall bracket and the deionizer filter. The blue, deionizer wall bracket decal is a Filter Replacement Record Log. The yellow filter decal is a Fleet Inspection Record Log. Use these decals to record filter replacement activity and fleet inspection activity. For convenience, both decals have a QR code for ordering replacement filters.

Seasonal Maintenance

Water supplies must be drained and stored in an empty state if they will be exposed to freezing temperatures. Failure to do so can cause permanent damage.

Single point watering systems will require seasonal maintenance if vehicles are taken out of service or put into storage for a period of 6 weeks or longer. To prepare the SPWS, ensure the feed tube and coupler are on top of battery. Then, use the following steps to bring vehicle back into service:

1. After the batteries have been fully charged/equalized, connect the system to its water supply for 3 to 5 seconds, then disconnect regardless of whether or not the batteries are completely full.
2. Return the vehicle to normal operation.
3. Place the vehicle back into its regular watering schedule, waiting at least one week until next watering.

BATTERY CARE – VEHICLES EQUIPPED WITH THE SINGLE-POINT WATERING SYSTEM (SPWS)

To keep batteries in good working condition, follow this maintenance program on a regular basis:

1. Keep the batteries clean and free of corrosion. Wash tops and terminals of batteries with a solution of baking soda and water; use 1 cup (237 mL) baking soda per 1 gallon (3.8 L) of water. Rinse solution off of the batteries. Do not allow this solution to enter the battery. Be sure terminals are tight. Let the terminals dry and then coat with Battery Terminal Protector Spray. **See following NOTE.**

NOTE: *Dispose of waste water properly.*

2. The battery hold-downs should be tight enough so that the batteries do not move while the vehicle is in motion, but not so tight as to crack or buckle the battery case. Tighten retaining nuts on the two inner hold-downs to 110 in·lb (12.4 N·m), and tighten the retaining nuts on the two outer hold-downs to 55 in·lb (6.2 N·m). The terminal connections should be clean and tight, and any worn insulation or frayed wires should be replaced. Tighten battery terminals to proper torque. **See Connect the Batteries – Electric Vehicles on page 1-5. See following WARNING.**

⚠ WARNING

- **If battery wire terminals are damaged or corroded, replace or clean them as necessary. Failure to do so may cause them to overheat during operation and can result in fire, property damage, or personal injury.**

3. After use, charge the batteries. The batteries should never be left discharged any longer than absolutely necessary (do not leave discharged overnight).
4. Water the batteries monthly or according to the watering interval. **See Establishing the Watering Interval for New Vehicles on page 14-8. See Watering Batteries with the SPWS on page 14-12.**

CAUTION

- **The watering interval must adequately maintain the electrolyte level above the top of the plates (Figure 14-3, Page 14-10).**
- **Water the batteries only AFTER charging.**

NOTE: *Bottled distilled water, with the hand pump is recommended for private consumer SPWS applications.*

Establishing the Watering Interval for New Vehicles

If you do not already have a battery watering interval for your vehicles, manually check the battery water level weekly to establish the correct watering interval. Thereafter, water batteries according to the established interval. During periods of heavy use, add additional watering as required.

Single-Point Watering System (SPWS) Maintenance

1. For vehicles newly equipped with the Single-Point Watering System, the initial electrolyte level check on all battery cells verifies that all the valves in the SPWS are functioning correctly. **See Periodic Service Schedules**

on page 10-3. If a valve fails to open, the cell will eventually dry out. The initial one-time inspection of all cells will identify any occurrence of a valve that fails to open. If a valve fails to close, it will become evident due to the cell overflowing during routine watering. Either failure scenario is rare, but should be monitored in the initial inspection and during routine watering sessions. Replace malfunctioning valves to ensure maximum battery life. **See following CAUTION.**

CAUTION

- **After checking the electrolyte, fully tighten the battery caps to prevent electrolyte leakage.**

2. After the initial six-week inspection, manually check the electrolyte level at least once per year, particularly after long-term storage or any other period of vehicle inactivity. **See preceding CAUTION.**

BATTERY CARE – VEHICLES WITHOUT THE SINGLE-POINT WATERING SYSTEM (SPWS)

To keep batteries in good working condition, follow this maintenance program on a regular basis:

1. Keep the batteries clean and free of corrosion. Wash tops and terminals of batteries with a solution of baking soda and water; use 1 cup (237 mL) baking soda per 1 gallon (3.8 L) of water. Rinse solution off of the batteries. Do not allow this solution to enter the battery. Be sure terminals are tight. Let the terminals dry and then coat with Battery Terminal Protector Spray. **See following NOTE.**

NOTE: *Dispose of waste water properly.*

2. Check the electrolyte level weekly **(Figure 14-3)**. Add water only **after** charging unless the electrolyte level is below the top of the plates. In this case, add just enough water to cover the plates, charge, and then check the level again. Never charge batteries if plates are exposed above electrolyte level. For best battery life, add only distilled water. **See following CAUTION and NOTE.**

⚠ CAUTION

- **Do not overfill the batteries.**

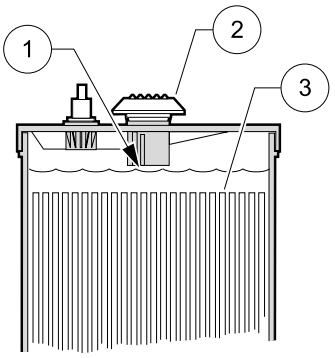
NOTE: *A battery watering gun or bottle is available from your authorized Club Car dealer.*

3. The battery hold-downs should be tight enough so that the batteries do not move while the vehicle is in motion, but not so tight as to crack or buckle the battery case. Tighten retaining nuts on the two inner hold-downs to 110 in·lb (12.4 N·m), and tighten the retaining nuts on the two outer hold-downs to 55 in·lb (6.2 N·m). The terminal connections should be clean and tight, and any worn insulation or frayed wires should be replaced. Tighten battery terminals to proper torque. **See Connect the Batteries – Electric Vehicles on page 1-5. See following WARNING.**

⚠ WARNING

- **If battery wire terminals are damaged or corroded, replace or clean them as necessary. Failure to do so may cause them to overheat during operation and can result in fire, property damage, or personal injury.**

4. After use, charge the batteries. The batteries should never be left discharged any longer than absolutely necessary (do not leave discharged overnight).



1. Level Indicator 2. Cap 3. Plates
Maintain electrolyte level from at least 1/2 inch (13 mm) above plates to 1/4 inch (6 mm) below level indicator.

17

Figure 14-3 Electric Battery Electrolyte Level

SELF-DISCHARGE

Contaminants on dirty batteries can provide a path for a small current draw that can slowly discharge batteries, thus wasting valuable energy. To prevent self-discharge, batteries should always be kept clean.

Hot weather also has an effect on a battery's self-discharge rate. The higher the temperature, the quicker a set of batteries will discharge. In hotter climates, batteries should be checked more often. When storing batteries, keep in a cool place. **See Battery Storage on page 14-14.**

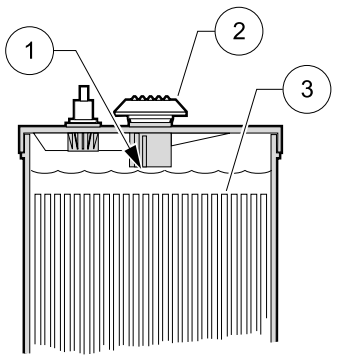
ELECTROLYTE LEVEL

⚠ CAUTION

- **Do not allow battery acid from battery caps or hydrometer to drip onto the front or rear body of the vehicle. Battery acid will cause permanent damage. Wash immediately.**

CAUTION CONTINUED ON NEXT PAGE

⚠ CAUTION



1. Level Indicator 2. Cap 3. Plates
Maintain electrolyte level from at least 1/2 inch (13 mm) above plates to 1/4 inch (6 mm) below level indicator.

17

Figure 14-4 Electric Battery Electrolyte Level

Add water only after charging unless the electrolyte is below the level of the plates. If the electrolyte level is below the level of the plates, add just enough water to cover the plates and then charge the batteries. After charging, fill with water to the level indicator. Filling a battery to the level indicator before charging will result in overfilling because the electrolyte level will rise during charging and some of the electrolyte may bubble out of the cap. This reduces the battery's capacity and corrodes the metal parts around it.

The electrolyte level should be checked weekly to be sure electrolyte is at its proper level **(Figure 14-3, Page 14-10)**. Never allow the electrolyte level to fall below the tops of the plates because this will cause the exposed part of the plate to become permanently inactive. For best results, use a battery watering gun to add water to batteries. Check the electrolyte level more frequently in hot weather or when batteries are old.

VIBRATION DAMAGE

The battery hold-downs should always be tight enough to keep the battery from bouncing. Battery life may be severely shortened if the battery hold-downs are too loose. **See step 6. of Battery Replacement on page 14-5.** Excessive vibration causes the plates to shed prematurely and shortens the life of the battery. It may also cause acid to leak out of the vent caps and corrosion to build up on surrounding metal parts. The acid which is lost reduces the capacity of the battery and cannot be replaced. Battery hold-downs should NOT be so tight as to crack or buckle the battery case. This may cause leaks which would dry out a cell or cause internal short circuits. **See Battery Replacement on page 14-5.**

SINGLE POINT WATERING SYSTEM (SPWS)

⚠ WARNING

- **When replacing batteries in the Single Point Watering System, place the battery cap from the new replacement battery onto the used battery being removed from the car. Important safety warnings on the battery cap must remain with the battery after it has been removed from the car**

CAUTION

- **Water the batteries only AFTER charging.**
- **Use water that meets the quality standards shown on page 14-6. Maximize battery life by removing ions and heavy metals from water with the use of a single point watering system deionizer. A deionizer for vehicles with SPWS, Club Car Part Number 105166801 is available from Service Parts (DC powered water quality indicator light). Replacement cartridge: 104005901. Bottled distilled water, with hand pump, Club Car Part Number 104006101, is recommended for private consumer applications.**

INITIAL MAINTENANCE OF THE SPWS

After six weeks of operation, remove the valves from the batteries and manually check the battery water level to ensure that the SPWS is not leaving any cells dry. This initial electrolyte level check on all the battery cells verifies that all the valves in the SPWS are functioning correctly. If a valve fails to open, the cell will eventually dry out. The initial one-time inspection of all cells will identify any occurrence of a valve that fails to open. If a valve fails to close, it will become evident due to the cell overflowing during routine watering. Either failure scenario is rare, but should be monitored in the initial inspection and during routine watering sessions. Replace malfunctioning valves to ensure maximum battery life.

After the initial six-week inspection, manually check the battery water levels at least once per year, particularly after winter storage or any other period of vehicle inactivity. **See following NOTE.**

NOTE: *For the longest battery life, be sure the mineral contents of the water meet the minimum requirements as stated in the vehicle's appropriate maintenance and service manual.* ***See Battery Care on page 14-6.***

WATERING BATTERIES WITH THE SPWS

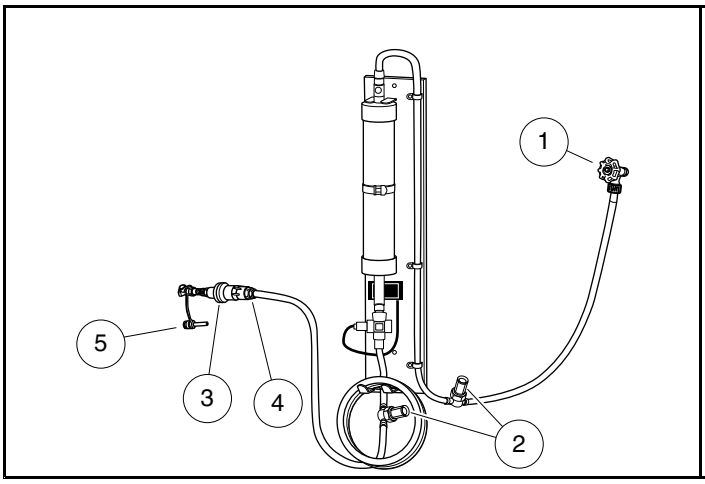
Checking the Water Flow Rate

1. Connect the water hose with the built-in screen filter (2) to the water faucet (1) **(Figure 14-5)**. **See following CAUTION.**

CAUTION

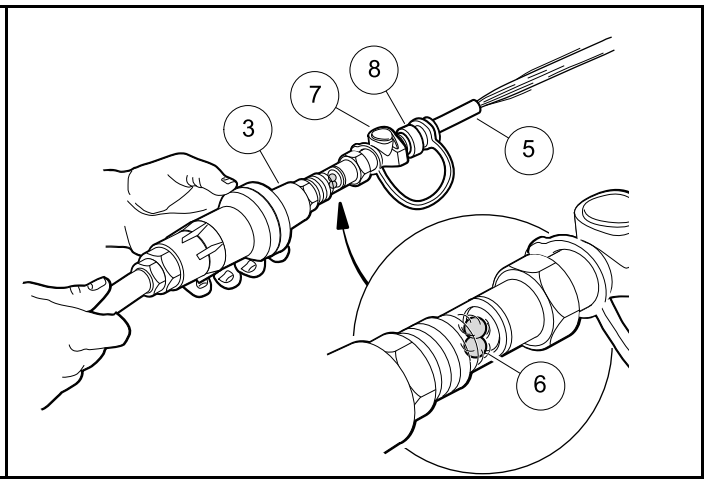
- **Make sure the screen filter is clean.**
- **Do not use a longer garden hose than provided with the System (20 feet or 6 meters), as a decrease in water pressure can overfill the batteries and damage the refill system.**

2. Before screwing the hose-end assembly (3) onto the opposite end of the water hose, check the screen filter (4) inside the end of the assembly to make sure it is clean **(Figure 14-5)**.
3. Connect the purger (5) to the female coupler (8) on the end of the hose-end assembly **(Figure 14-6)**.



3083

Figure 14-5 Connecting Hose with Filter to Water Source



69

Figure 14-6 Checking the Water Flow Rate

4. Completely open the water faucet until the water flows out of the hose-end assembly (3), and note the movement of the red flow indicator balls (6). **See following NOTE.**

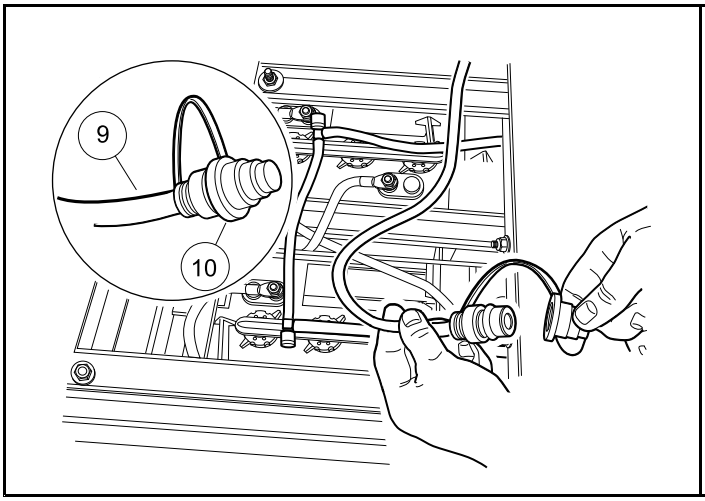
NOTE: *This step also eliminates any trapped air from the water hose.*

The water flow rate must be at least 2 gallons per minute (7.6 L per minute) and the water pressure must be no more than 100 psig (689.5 kPa) when static (no flow) for the SPWS to function properly.

5. Check the water quality light on the deionizer to make sure the light is green in color, indicating acceptable water quality. If the light indicates unacceptable water quality, the cartridge must be replaced.
6. After ensuring adequate water flow rate and water quality, press the grey button (7) on the end of the female coupler (8) to disconnect the purger from the pressure regulator.

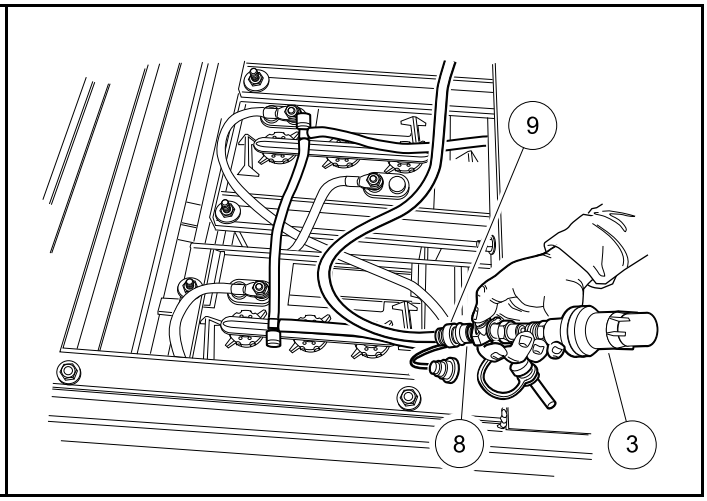
Refilling the Batteries

1. Locate the battery fill coupling (9) on the driver side of the battery compartment, remove the dust cover (10) from the male connector **(Figure 14-7)**, and connect the hose-end assembly (3) **(Figure 14-8)**. The water flow will begin immediately.



2829

Figure 14-7 Dust Cap



2830

Figure 14-8 Connecting Hose-end Assembly to Battery Fill Connector

2. The red flow indicator balls should swirl, indicating that the batteries are being filled. **See following CAUTION.**

CAUTION

- **If at any time water overflows from the batteries, immediately stop the refill process, disconnect the pressure regulator from the battery fill coupling, and call for service.**

3. When the red flow indicator balls stop moving, immediately press the grey button to disconnect the hose-end assembly from the battery fill coupling (9), and squeeze the dust cover (10) to lightly secure it to the male connector of the battery fill coupling **(Figure 14-7)**.
4. Place the battery fill coupling into the space between the batteries and the car body. Leaving the fill coupling on top of the battery bank or tucked between the batteries can result in coupling damage.
5. Turn the water faucet off when finished filling the vehicle(s).

BATTERY STORAGE

See Storage – Electric Vehicles, Section 3, Page 3-2.

FLEET ROTATION

Rotate vehicle usage. It is very hard on batteries if the last vehicles in at night are the first ones out in the morning. Spread the workload evenly, giving all vehicles the same amount of use. This will keep your fleet in balance and will not overwork certain sets of batteries. **See following NOTE.**

NOTE: *When vehicles are being rotated, the CDT (Controller Diagnostic Tool) can be a very helpful service tool. Monitoring the value of the Odometer or Amp-Hours with the CDT simplifies vehicle usage scheduling.* ***See Monitor Menu, Section 11, Page 11-9.***

DEEP-DISCHARGE

Never discharge batteries to the point the vehicle will no longer operate. This will considerably shorten the cycle life of the batteries, and may permanently damage the batteries. It is possible the batteries will not accept a charge if they are completely discharged. The deeper the discharge, the harder it is on the batteries. For this reason, it is recommended that electric vehicle batteries be charged after each use (provided the charge cycle will not be interrupted and the charger will be allowed to shut off automatically). Placing the batteries on charge after each use reduces the depth of discharge and prolongs battery life.

EARLY EXCESSIVE DISCHARGING

When vehicle batteries are new, they do not reach their full capacity until they have been discharged and recharged 50 to 70 times. If they are excessively discharged early in their life, their effective service life will be shortened. It is advisable to limit the use of any vehicle with new batteries for at least the first four weeks and then gradually increase their range.

SECTION 15 — ELECTRIC VEHICLE - BATTERY CHARGER

15

See General Warnings on page 1-1.

⚠ DANGER

- **The charging area must be ventilated. Hydrogen level in the air must never exceed 2%. The total volume of air in the charging area must be changed at least five times per hour. Exhaust fans should be located at the highest point of the roof. Contact a local HVAC engineer.**
- **Do not charge the vehicle batteries with the vehicle covered or enclosed. Any enclosure or cover should be removed or unzipped and pulled back when batteries are being charged. An accumulation of hydrogen gas could result in an explosion.**

⚠ WARNING

- **Only trained technicians should repair or service the charger. Contact your nearest Club Car distributor/dealer.**
- **This appliance is not intended for use by persons (including children) with reduced physical, sensory or mental capabilities, or lack of experience and knowledge, unless they have been given supervision or instruction concerning use of the appliance by a person responsible for their safety. Children should be supervised to ensure that they do not play with the appliance.**
- **Do not operate the charger if it has received a sharp blow, was dropped, or otherwise damaged in any way.**
- **Have worn, cut, or damaged power cords or wires replaced immediately.**
- **Do not connect a stationary charger to the receptacle if the charger cord, plug, or the vehicle receptacle is broken, damaged, or does not make a good electrical connection. Fire or personal injury can result. Have a qualified technician replace the damaged parts.**
- **Do not use near fuels, grain dust, solvents, thinners, or other flammables. Chargers can ignite flammable materials and vapors.**
- **Do not expose to rain or any liquid. Keep the charger dry.**
- **When the charger is on, the charger DC cord may be disconnected from the vehicle receptacle slowly. Jerking or pulling the DC cord out quickly could cause arcing and burning that could damage the plug and receptacle and could cause batteries to explode.**
- **Do not cover the charger cooling fins. Do not allow clothing, blankets, or other material to cover the charger. The fins dissipate heat and protect the charger from overheating.**
- **Cooling fins will become hot during charging. Do not touch. Use the handle.**

CAUTION

- **The high-frequency battery charger was specifically designed for use with the high-frequency charging system. Do not use the high-frequency battery charger with other operating systems, and do not use other charger models with high-frequency charging system vehicles.**
- **The battery charger provided with this vehicle is approved for use only with the battery type originally shipped with the vehicle. Using a different battery type (different brand, different capacity, etc.) can cause under or overcharging and subsequent battery damage unless the charger is first reprogrammed with a new charging algorithm. Club Car only recommends OEM replacement batteries. Contact your authorized Club Car dealer/distributor with any questions about battery and charger compatibility or algorithm updates.**

GENERAL INFORMATION

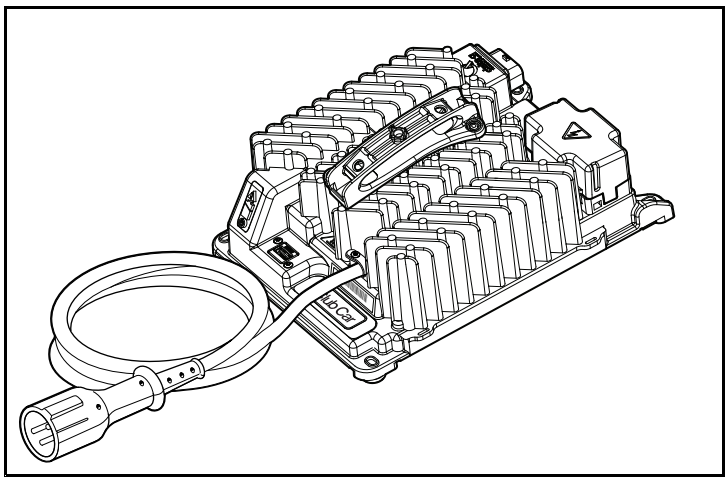
NOTE: *This charger has no internals to service or repair. It only has a few external repairs that can be performed. If an internal component needs repair, the charger must be replaced.*

Because the charger has a storage charge feature that automatically checks and recharges the batteries as necessary, the charger can remain plugged to the vehicle throughout the storage period.

Key Differences between ERIC Chargers and PowerDrive Chargers

- Programmable in the field instead of changing onboard computer (OBC).
- Ability to fully update software via USB flash drive or laptop computer instead of changing OBC.
- DV/DT charge termination instead of Amp-Hour Returned charge termination.
- Communication Display Module (CDM) is not used. Only a CDT is needed for data.
- The CDT will remain ON when the charger is connected.
- Only PD+ 8-volt batteries are approved for use with this high-frequency charging system at this time. Other batteries have not been approved. When other batteries are approved, the charger can be updated with the appropriate algorithm using the USB port.

This section includes information, troubleshooting and service procedures pertaining to the external high-frequency battery charger (model number IC0650-048-CC). Do not attempt to service a battery charger that has not been properly identified. If a charger cannot be properly identified, contact your local Club Car dealer or distributor.



COV-1481

Figure 15-1 High-Frequency Battery Charger – External

The high-frequency battery charger is automatic and has no external controls. It functions as an integral part of the vehicles' electrical system and will not work with other electric vehicles. The charger is programmed with a specific charge algorithm that is appropriate to the specific battery type used in the vehicle. When the charger is connected, there is a 2 to 5 second delay before charging begins. When the AC cord is connected, the charger performs a start-up self-test (all three charger status indicators on the front of the charger flash ON at the same time).

The charger supplied with the electric vehicle resolves the most common problems associated with battery charging. The charger utilizes sophisticated charge termination criterion to shut off automatically, preventing the possibility of either undercharging or overcharging. The charger accomplishes this by monitoring battery voltage, charge current, charge time and using strict dV/dt termination criterion.

Batteries should never be left in a discharged state, as this too affects the internal components and can reduce the capacity of the battery. The batteries should be charged every day they are used. However, the batteries should not be charged if they have not been used.

USB SERVICE PORT

The ERIC charger has a USB port for use by Club Car authorized technicians for data transfer, reconfiguration, and updates. Keep the USB port cover in place when the port is not in use. **See USB Service Port Cleaning and Care on page 15-22.**

UL AND CSA LISTING

High-frequency charging system battery chargers have been listed by UL and by the Canadian Underwriters and meet the criteria of the Canadian Standards Association.

CE COMPLIANCE

This battery charger is compliant with the EU EMC Directive 2004/108/EC.

PLUG AND RECEPTACLE

The charger cord, plug, and receptacle are wear items and should be inspected daily. Visually inspect for cracks, loose connections, frayed wiring or bent pins; they must be immediately replaced when worn or damaged. Do not attempt to straighten a bent pin. If charger plug or receptacle show signs of corrosion or the plug is difficult to insert or remove, check for bent pins, then clean the receptacle contacts and plug terminals with a good electrical contact cleaner or light coating of WD-40® brand spray lubricant. The plug should then be inserted and removed several times to ensure ease of insertion, ease of removal, and good electrical contact.

⚠ DANGER

- **To prevent fire, immediately replace battery charger DC cord plug and receptacle if the following conditions exist:**
  - **Plug pins have worn nickel plating and copper is exposed.**
  - **Plug requires an inordinate amount of force to insert into receptacle, especially if accompanied by a “grinding” feel.**

⚠ WARNING

- **If pins are bent, the plug must be replaced immediately. The plug is not serviceable. Do not attempt to repair the plug or straighten bent pins.**
- **Disconnect the AC cord prior to lubricating the plug and receptacle.**

NOTE: *If the warning tag has been damaged or removed from the DC cord, have it replaced immediately.*

CHARGER POWER CONNECTION FUSE

The charger receptacle harness has an in-line, 30-amp fuse located near the solenoid.

CHARGER INTERLOCK

External Charger: While the charger DC cord is plugged into the vehicle, the vehicle control circuit is locked out, preventing operation of the vehicle, as well as the possibility of consequent damage to the charger and the vehicle.

Onboard Charger: While the charger AC cord is plugged into an electrical outlet, the vehicle control circuit is locked out, preventing operation of the vehicle, as well as the possibility of consequent damage to the charger and the vehicle.

AC INPUT VOLTAGE DETECTION

The high-frequency charger automatically detects the AC input voltage and will operate at full power if the voltage is within the 100 to 240 VAC range. The charger also will function outside of that range down to 85 VAC and up to 270 VAC although charging times will be longer. Outside of the 85 to 270 VAC range, the charger will not operate.

THERMAL CUTBACK

The charger operates at full power in ambient temperatures between -40 °F (-40 °C) and 104 °F (40 °C). The charger also will function outside of that range although charging times will be longer.

CHARGE INDICATOR LIGHT

Excel System vehicles with ERIC Charging system feature a dash mounted charge indicator light (below the steering column) that serves two functions: 1) Battery low state of charge warning, and 2) Charging confirmation. The charge indicator light is controlled by pin 11 of the controller.

Battery Low State of Charge Warning

- The light comes on and remains solid when the battery state of charge falls below 20%.
- The light begins flashing when the battery state of charge falls below 10%.

Charging Confirmation

- The light will flash three times and the reverse buzzer simultaneously will sound three times to indicate a battery charging session has begun. **See following NOTE.**

NOTE: *The number of flashes and beeps can vary depending on the Beep Option setting.* ***See Beep Option, Section 11, Page 11-8.***

EXTERNAL CHARGER STATUS INDICATORS

The indicator lights on the external charger provides information concerning charger status.

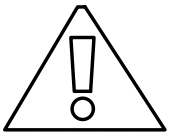
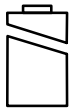
LIGHT	STATUS	STATUS EXPLANATION
 G-130892-000001	Solid red	Charger fault condition. Reset charger power.
	Flashing orange	Charger cannot complete charge.

TABLE CONTINUED ON NEXT PAGE

		Solid green Solid green	Charging is complete. Battery pack is fully charged.
		Flashing green Solid green	Charging is in progress. Battery pack has reached a high state of charge.
		Off Flashing green	Charging is in progress. Battery pack has NOT reached a high state of charge.
	Solid blue		AC power to charger is present.

ONBOARD CHARGER STATUS INDICATORS

The indicator lights on the onboard charger provides information concerning charger status.

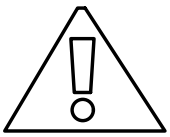
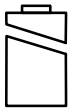
LIGHT	STATUS	STATUS EXPLANATION
 G-130892-000001	Solid red	Charger fault. See the display panel for details.
	Flashing orange	External error condition - caution. See the display panel for details.
	Flashing green	USB port is active.
	Solid green	Safe to remove the USB flash drive.

TABLE CONTINUED ON NEXT PAGE

		Solid green Solid green	Charging is complete. Battery pack is fully charged.
		Flashing green Solid green	Charging is in progress. Battery pack has reached a high state of charge.
		Off Flashing green	Charging is in progress. Battery pack has NOT reached a high state of charge.
	Solid blue		AC power to charger is present.
	Solid yellow		The charger output is active. There is a potential risk of electric shock.
	F code		Internal fault condition has caused the charging to stop. See the charger fault codes for more information.
	E code		External error condition has caused the charging to stop. See the charger fault codes for more information.
	P code		The charger programming mode is active.
	USB code		The USB interface is active. Do not remove the USB flash drive.

LONG-TERM STORAGE

High-frequency chargers are designed to be left connected with AC power to the charger during off-season or long-term storage. **See Storage – Electric Vehicles on page 3-2.**

EXTERNAL CHARGER MOUNTING

⚠ WARNING

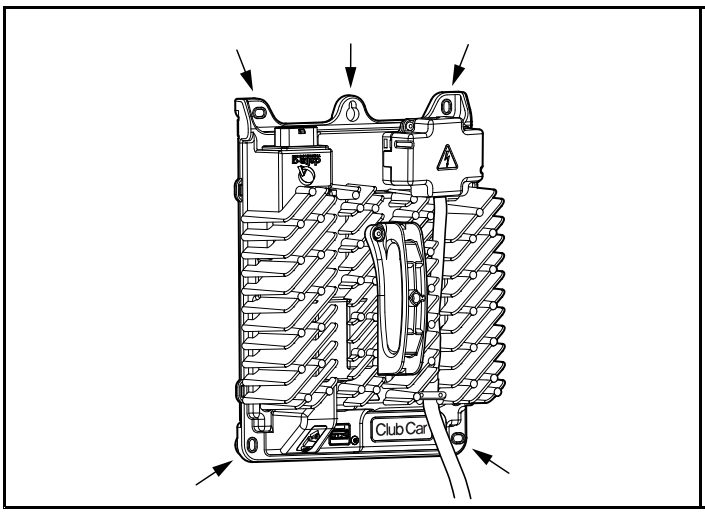
- **Make sure the charger is securely mounted. Do not hang the charger by its handle.**
- **Place all cords so they will not be stepped on, tripped over, or otherwise subjected to damage or stress.**

CAUTION

- **Do not mount the charger in exceptionally hot locations, such as on a tin exterior wall with southern or western exposure, with chargers stacked together and especially with heatsinks next to each other, etc.**
- **Charger must not be subjected to water spray.**

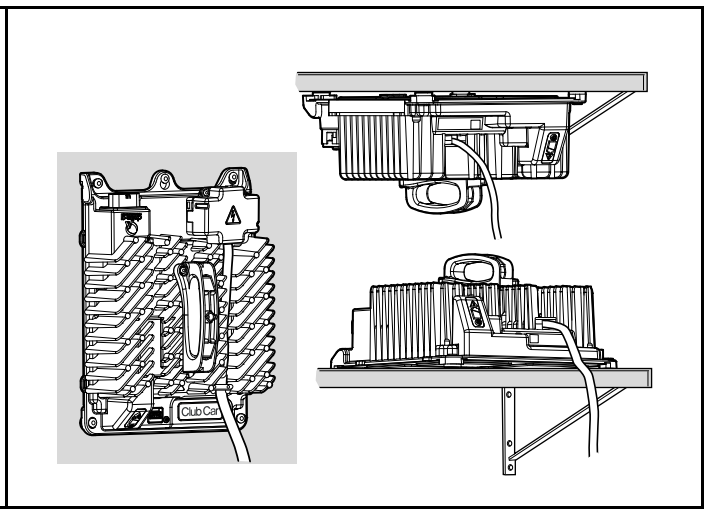
Use the mounting holes to secure the charger **(Figure 15-2)**. Position the charger so that is has adequate ventilation and the charger status indicator panel is visible. The charger can be mounted in any orientation (right-side up, upside down, etc.) provided the cooling fins are unobstructed it has adequate ventilation **(Figure 15-3)**.

To help ensure optimal charge times, mount the charger in an area where ambient temperatures during charging remain below 104 °F (40 °C). **See Thermal Cutback on page 15-4.**



2674

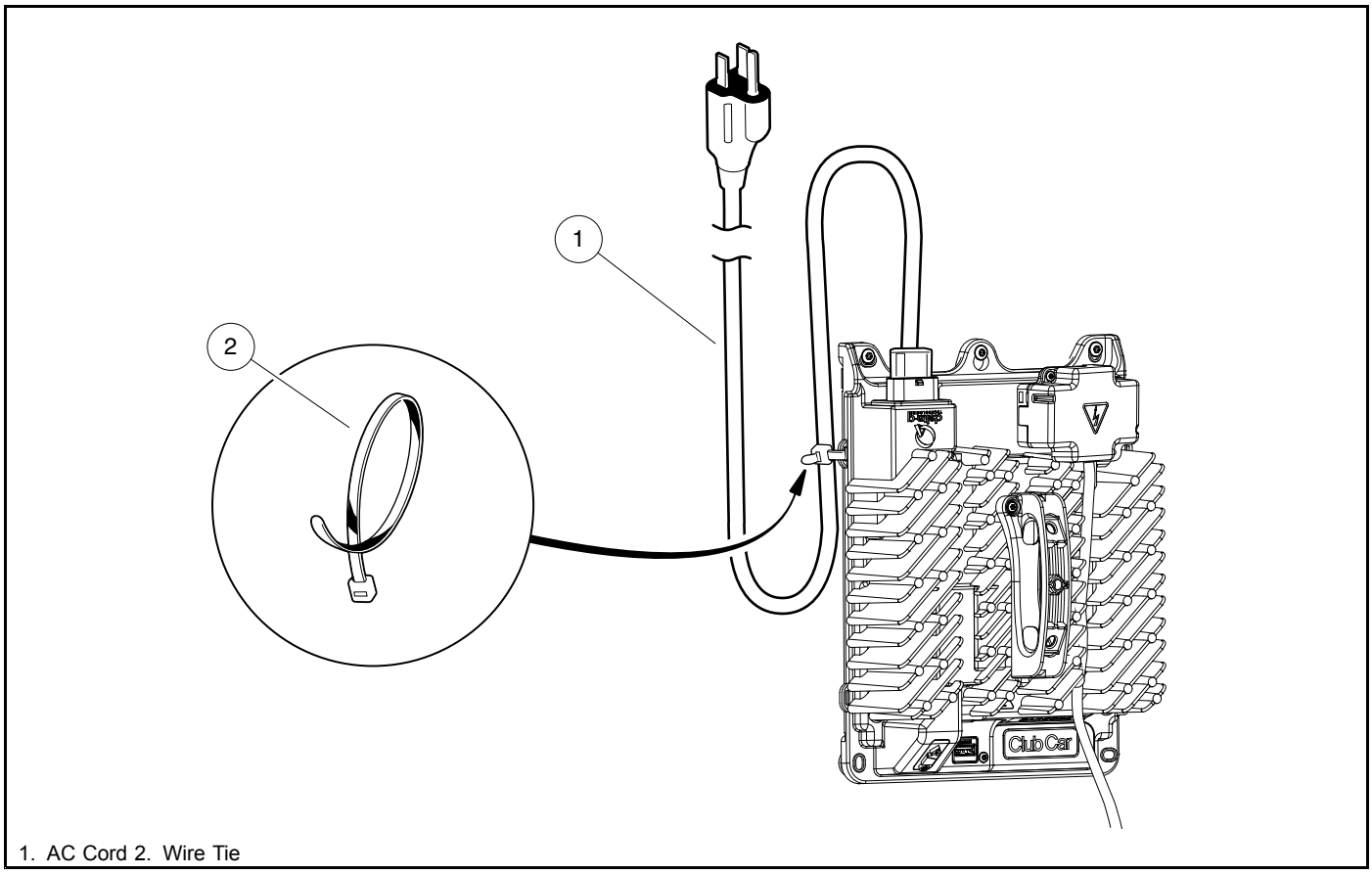
Figure 15-2 Charger Mounting Holes



2675

Figure 15-3 Examples of Charger Mounting Orientation

When installing charger, incorporate a "drip loop" in the AC cord to prevent water from running down the cord and into the AC cord receptacle on the charger **(Figure 15-4, Page 15-8)**.



1. AC Cord 2. Wire Tie

2758

Figure 15-4 AC Cord Drip-Loop Example

AC POWER CONNECTION

⚠ WARNING

- **Install surge arrestors on incoming AC power lines. Surge arrestors will help protect electrical components in the charger and on the vehicle from all but direct or close lightning strikes.**
- **Two high-frequency chargers can share a circuit, which should be a dedicated 15 or 20 ampere separately protected (circuit breaker or fuse) single-phase branch circuit that complies with all applicable electrical codes for the location.**
- **Connect the charger AC supply cord to a properly grounded, three-wire outlet within the voltage and frequency range shown on the charger.**
- **Do not use an adapter to plug the charger with a three-prong plug into a two-prong outlet. Improper connection of the equipment-grounding conductor can result in a fire or an electrical shock.**

WARNING CONTINUED ON NEXT PAGE

⚠ WARNING

- **Place all cords so they will not be stepped on, tripped over, or otherwise subjected to damage or stress.**

NOTE: *Make sure that the AC cord provided with your charger has the proper AC plug for your location. If it does not, contact your Club Car representative to obtain the proper cord or plug.*

Two of these high-frequency chargers can be used on a dedicated 15 or 20 ampere, single-phase branch circuit. This high-frequency charger caps current draw at 6 amps and will operate at full power if the voltage is within the 100 to 240 VAC and 50 to 60 Hz ranges. The charger also will function outside of those ranges (down to 85 VAC and 40 Hz, up to 270 VAC and 70 Hz) although charging times will be longer. Outside of the 85 to 270 VAC and 40 to 70 Hz ranges, the charger will not operate.

To reduce the risk of electric shock, the battery charger must be grounded. The charger is equipped with an AC electric cord having an equipment-grounding conductor and a grounding type plug. The AC plug must be connected to an appropriate receptacle that is properly installed and grounded in accordance with the National Electrical Code and all local codes and ordinances.

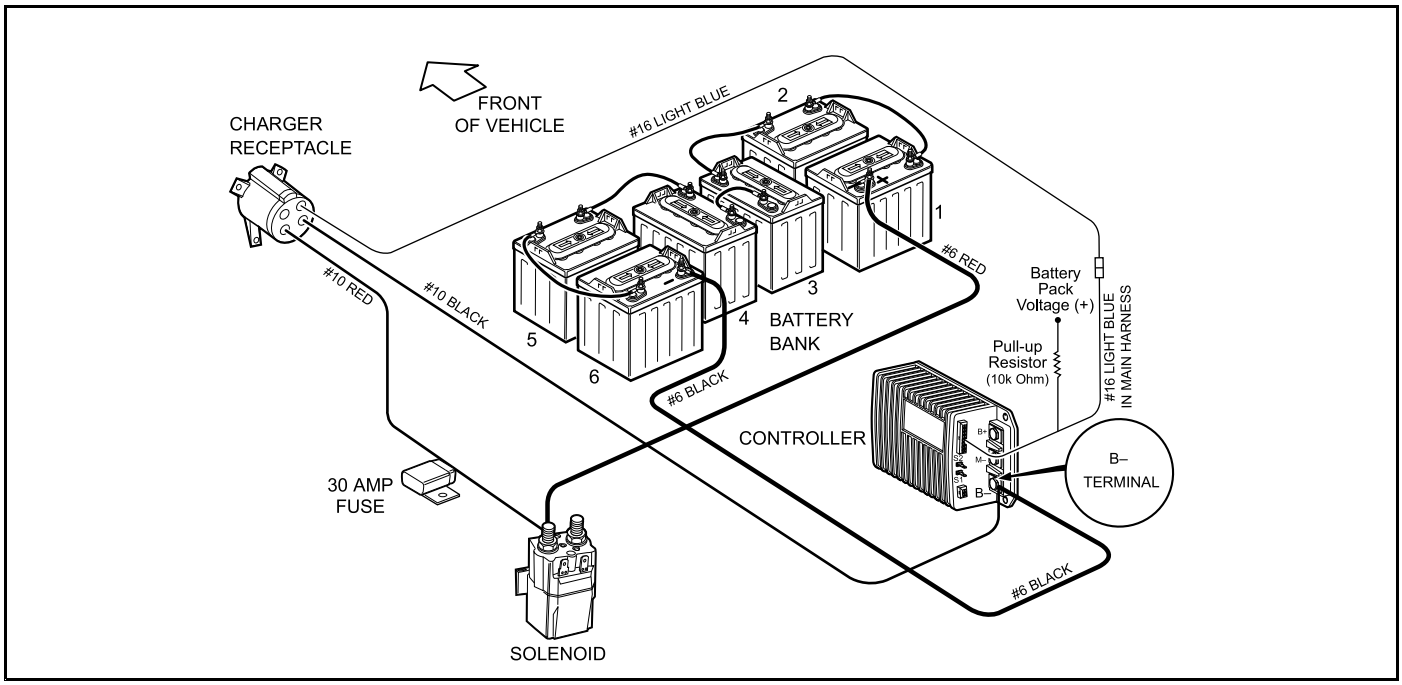
The use of an extension cord with the charger should be avoided. If one must be used, heed the following WARNING.

⚠ WARNING

- **An extension cord or electrical outlet must accept a three-prong plug. The extension cord should be a three-wire No. 12 AWG (American Wire Gauge) or no. 14 (British Standard Wire Gauge), and be as short as possible (no more than 12 feet (3.7 m). The use of an improper extension cord could result in fire or an electrical shock.**

THE CHARGE CIRCUIT

External Charger: The charge circuit consists of the charger receptacle, interlock wire, controller, solenoid and battery pack **(Figure 15-5, Page 15-10)**.



2788

Figure 15-5 Charge Circuit – External High-Frequency Charger

BATTERY CHARGING

See Dangers and Warnings beginning on page 15-1.

⚠ DANGER

- **Charging batteries emit hydrogen gas, that is explosive above 2% air concentration. Charge the batteries in a ventilated area without covers or enclosures.**
- **Charging batteries emit hydrogen gas, that is explosive above 2% air concentration. Keep batteries away from sparks and open flames.**
- **Charging batteries emit hydrogen gas, that is explosive above 2% air concentration. Individual vehicles require one air exchange per hour. Fleet 5 times per hour. The total volume of air in the charging area must be changed at least five times per hour. Exhaust fans must be located at the highest point of the roof. Speak with a local HVAC engineer.**
- **Charging the batteries with accessories on can cause a fire and serious personal injury. Turn off all accessories before charging the batteries.**

⚠ WARNING

- **The battery charger becomes hot when it is on and can cause a fire, property damage, or serious personal injury. Do not cover the battery charger. Do not touch. Make sure that the battery charger has adequate airflow. Use the handle. Keep the battery charger away from clothing and flammable material.**
- **Loose cord connections can cause a fire. Make sure that all cord connections at the receptacle are clean and tight.**
- **Do not connect a charger to the receptacle if the charger cord, plug, or the vehicle receptacle is broken, damaged in any manner, or does not make a good electrical connection. Fire or personal injury can result. Have it replaced by a qualified service person immediately. Failure to follow these instructions could result in damage to the charger cord, the plug, and (or) the vehicle receptacle.**
- **Do not attempt to charge frozen batteries or batteries with bulged cases. Discard the battery in accordance with all environmental laws or return to an authorized Club Car dealer. Frozen batteries can explode.**
- **Do not use a charger if any of the following conditions exist:**
  - **The plug is too loose or does not make a good connection.**
  - **The plug and receptacle feel hotter than normal during charge.**
  - **The plug pins or receptacle contacts are bent or corroded.**
  - **The plug, receptacle, or cords are cut, worn, have any exposed wires or are damaged in any way.**
- **Using the charger with any of the above symptoms could result in a fire, property damage, personal injury, or death.**

CAUTION

- **On all vehicles, turn off all accessories before charging batteries.**
- **The battery charger provided with this vehicle is approved for use only with the battery type originally shipped with the vehicle. Using a different battery type (different brand, different capacity, etc.) can cause under or overcharging and subsequent battery damage unless the charger is first reprogrammed with a new charging algorithm. Club Car only recommends OEM replacement batteries. Contact your authorized Club Car dealer/distributor with any questions about battery and charger compatibility or algorithm updates.**

NOTE: *When temperatures fall below 65 °F (18.3 °C), batteries charged in unheated areas should be placed on charge as soon as possible after use. Batteries are warmest immediately after use, and cold batteries require more time to fully charge.*

Batteries should be put on charge even if they have been used for only a short period.

Because the charger has a storage charge feature that automatically checks and recharges the batteries as necessary, the charger can remain plugged to the vehicle throughout the storage period. ***See Storage – Electric Vehicles, Section 3, Page 3-2.***

Vehicles should be restricted to 40 to 50 amp hours of discharge between charges until the batteries have been properly seasoned (50 to 70 charge cycles). For maximum battery life, Club Car recommends that electric vehicles always be recharged after 40 to 50 amp hours of discharge or each night in order to avoid deeply discharging the batteries. To detect amp-hour discharge, use the CDT diagnostic tool.

CHARGING WITH EXTERNAL CHARGER

1. Turn the key to OFF.

2. Turn off all accessories.
3. Connect the AC cord to the charger.
4. Connect the AC cord to the power source.

CAUTION

- **Incorrect removal and installation of the DC cord can cause DC cord damage and vehicle charger receptacle damage. Do not twist, bend, or move the DC cord plug side to side. Do not pull on the DC cord. Hold the plug handle and push the plug straight into the vehicle charger receptacle.**

5. Connect the DC cord to the vehicle charger receptacle (1).

NOTE: *The vehicle will start to charge in 2 to 10 seconds.*

The charge indicator light will flash and the multi-purpose buzzer will operate when the vehicle starts to charge.

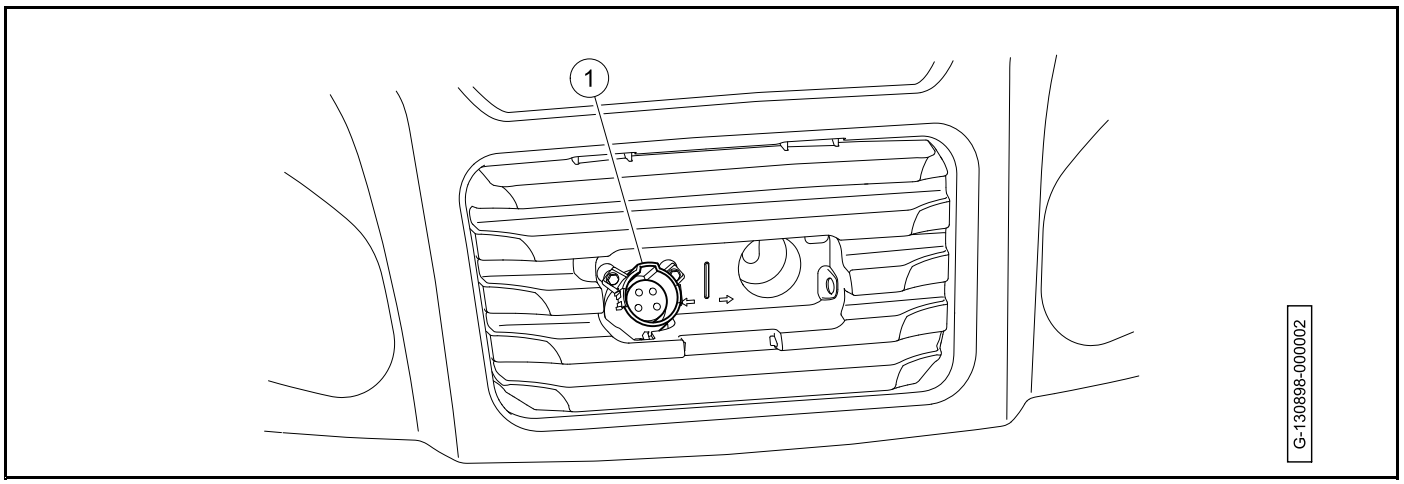


Figure 15-6 Vehicle Charger Receptacle

⚠ DANGER

- **If the DC cord is removed too fast, arcing and burning can cause damage to the plug, receptacle, and cause the batteries to explode. Remove the DC cord slow.**

6. Before vehicle operation, disconnect the DC cord from the vehicle charger receptacle.

CHARGING WITH ONBOARD CHARGER

1. Turn the key to OFF.
2. Turn off all accessories.
3. Connect the AC cord (1) to the power source.

NOTE: *The vehicle will start to charge in 2 to 10 seconds.*

The charge indicator light will flash and the multi-purpose buzzer will operate when the vehicle starts to charge.

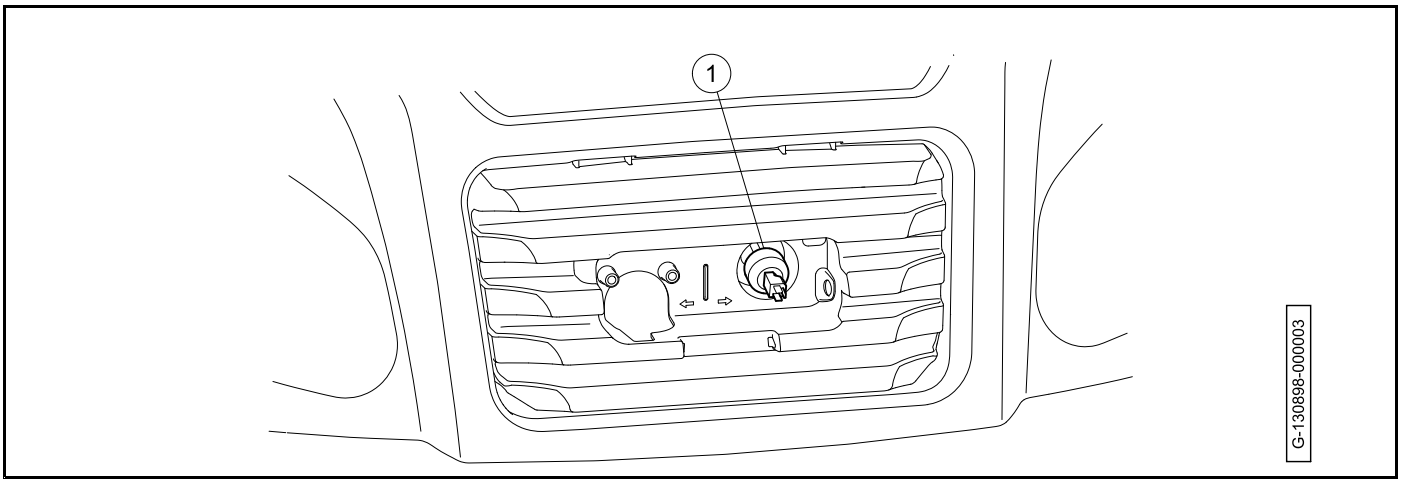


Figure 15-7 AC Cord

4. Before vehicle operation:

4.1. Disconnect the AC cord from the power source.

4.2. Retract the AC cord.

ALGORITHM

CAUTION

- **The battery charger provided with this vehicle is approved for use only with the battery type originally shipped with the vehicle. Using a different battery type (different brand, different capacity, etc.) can cause under or overcharging and subsequent battery damage unless the charger is first reprogrammed with a new charging algorithm. Club Car only recommends OEM replacement batteries. Contact your authorized Club Car dealer/distributor with any questions about battery and charger compatibility or algorithm updates.**

EXTERNAL BATTERY CHARGER

How To View Algorithm - External Battery Charger

1. Format a USB 2.0 flash drive as FAT16 or FAT32. Make sure the USB is blank.
2. Connect the AC cord to the battery charger.
3. Connect the AC cord to the power source.
4. Disconnect the DC cord from the vehicle.
5. Wait until only the blue light (1) is on **(Figure 15-8)**.

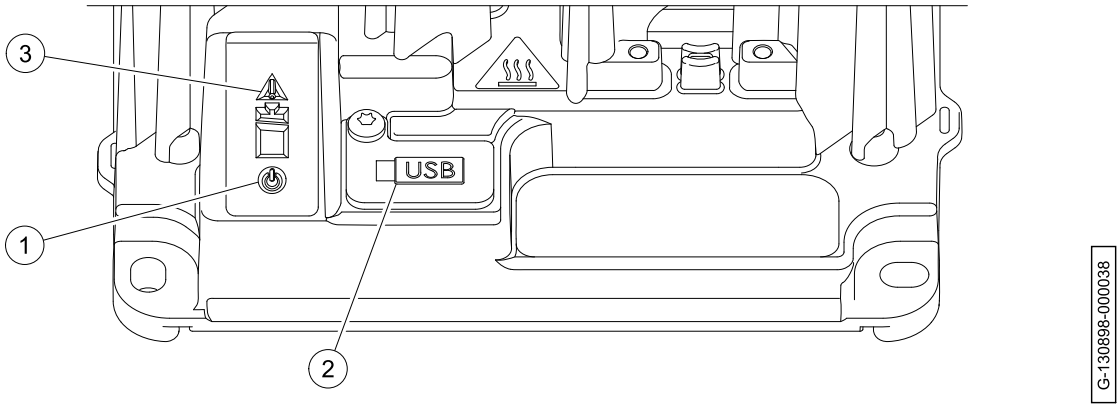
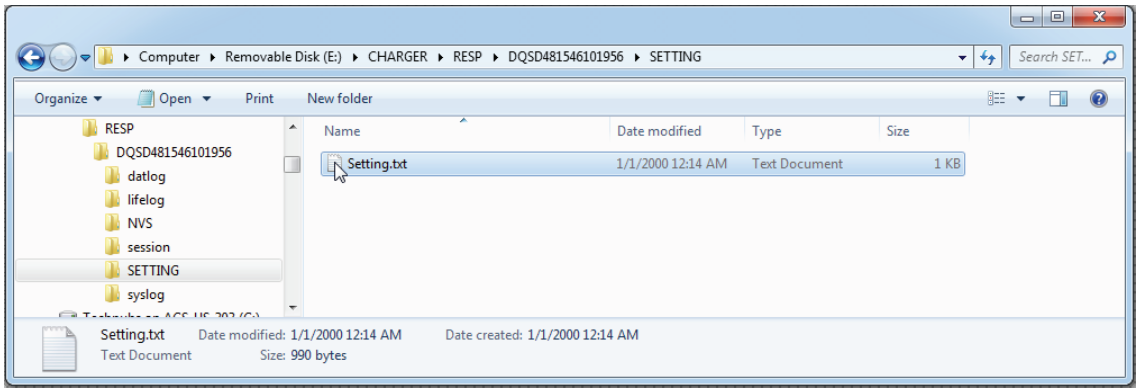


Figure 15-8 USB Dust Cover

6. Remove the USB dust cover (2).
7. Connect the USB flash drive to the battery charger. The green triangle light (3) will flash for approximately 10 seconds.
8. When the green triangle light is constant, remove the USB flash drive.
9. Install the USB dust cover.
10. Connect the USB flash drive to a PC.
11. Open the USB flash drive.

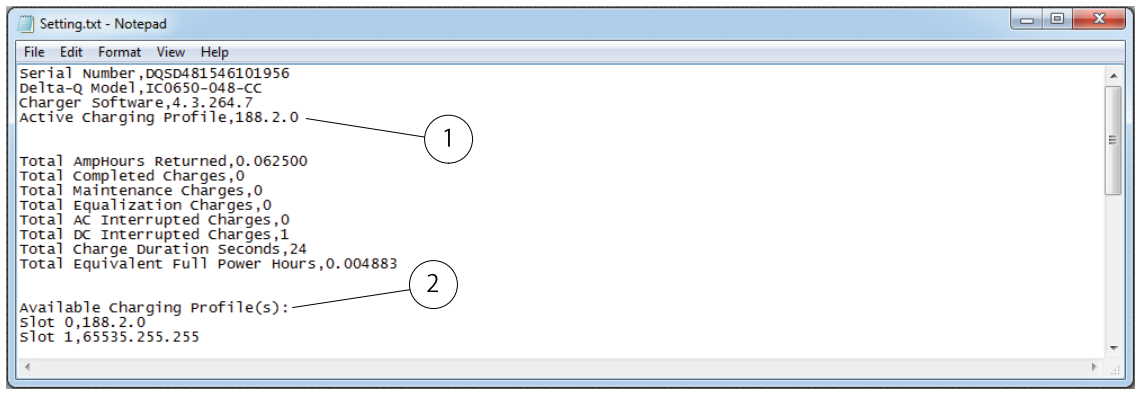
12. Go to CHARGER/RESP/Battery charger serial number/SETTING **(Figure 15-9)**.



G-130898-000051

Figure 15-9 Setting.txt File Location

13. Open the Setting.txt file **(Figure 15-10)**.



G-130898-000052

Figure 15-10 Setting.txt File

The Active Charging Profile (1) displays the active algorithm.

The Available Charging Profile(s) (2) displays the algorithms that are loaded on the battery charger.

- JCI battery algorithm - 31.2.0
- Trojan battery algorithm - 188.2.0

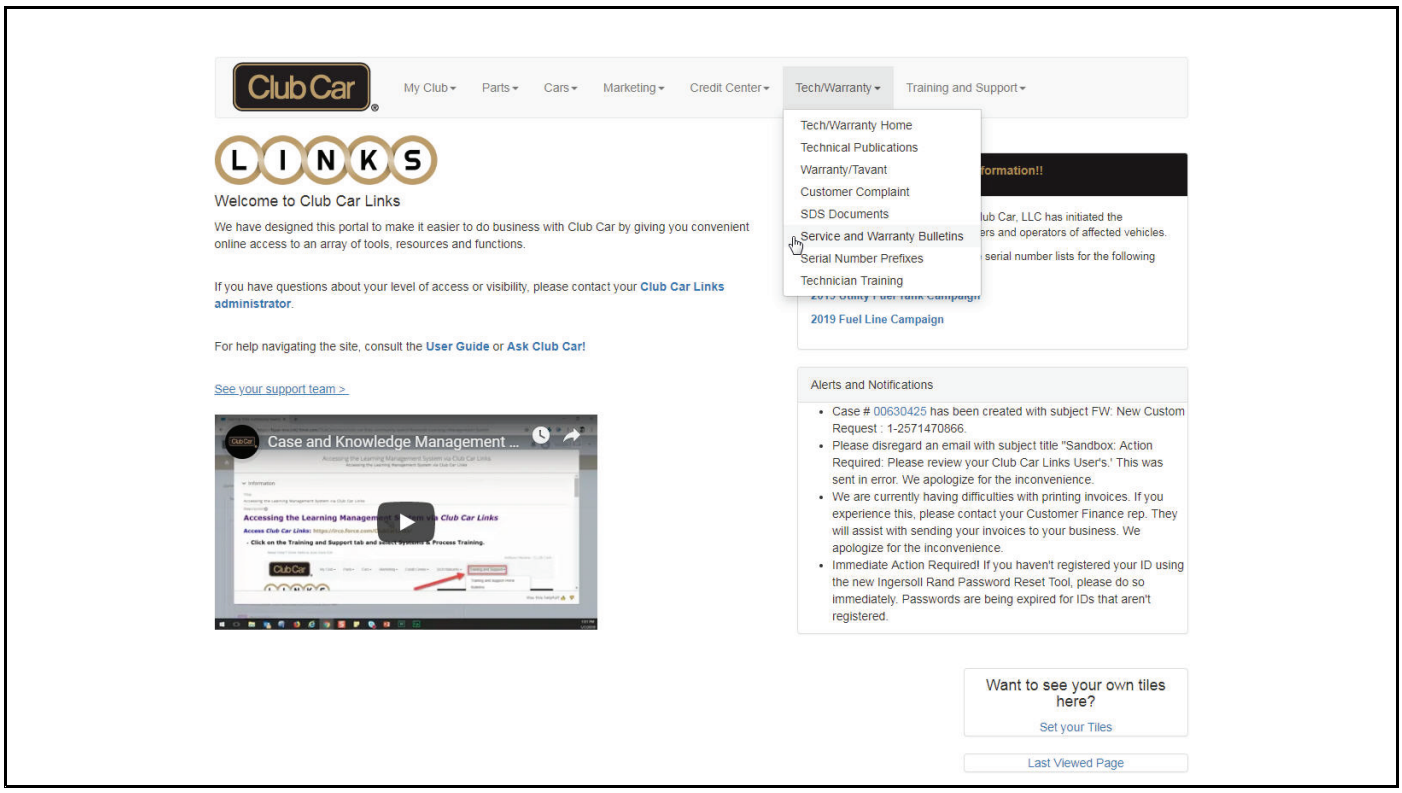
How To Install Trojan Algorithm - External Battery Charger

CAUTION

- **This procedure is for external chargers only. Do not use this procedure on an onboard charger.**

The Trojan battery algorithm is for Trojan T875 and T890 8-Volt batteries. For all other battery algorithms, see Update Battery Charger With USB.

1. Format a USB 2.0 flash drive as FAT16 or FAT32. Make sure the USB is blank.
2. Login to Club Car Links via https://www.clubcar.com.
3. Click on the Tech/Warranty drop-down menu and select Service and Warranty Bulletins **(Figure 15-11)**.

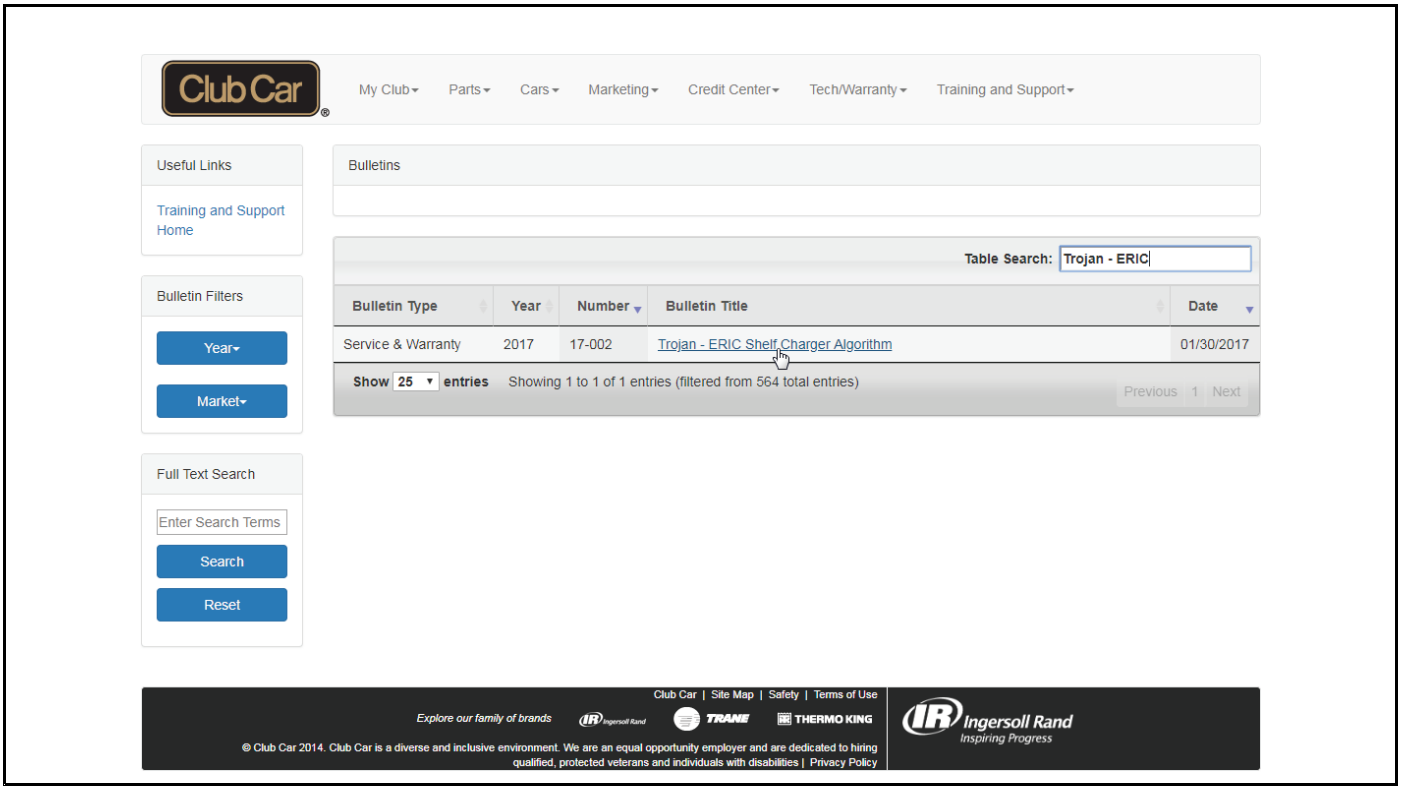


G-130898-000050

Figure 15-11 Service and Warranty Bulletins

4. Find the Trojan - ERIC Shelf Charger Algorithm.

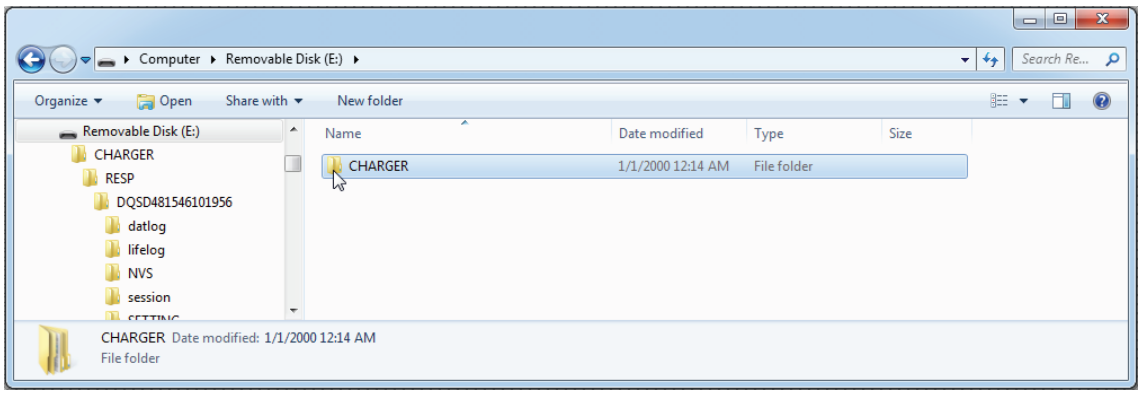
5. Click on the Trojan - ERIC Shelf Charger Algorithm link **(Figure 15-12)**.



G-130898-000053

Figure 15-12 Trojan - ERIC Shelf Charger Algorithm

6. Open the Trojan - ERIC Shelf Charger Algorithm.zip file.
7. Copy the CHARGER folder to the USB flash drive **(Figure 15-13)**.



G-130898-000049

Figure 15-13 CHARGER Folder

8. Safely eject the USB flash drive from the computer.
9. Connect the AC cord to the battery charger.
10. Connect the AC cord to the power source.
11. Disconnect the DC cord from the vehicle.

12. Wait until only the blue light (1) is on **(Figure 15-14)**.

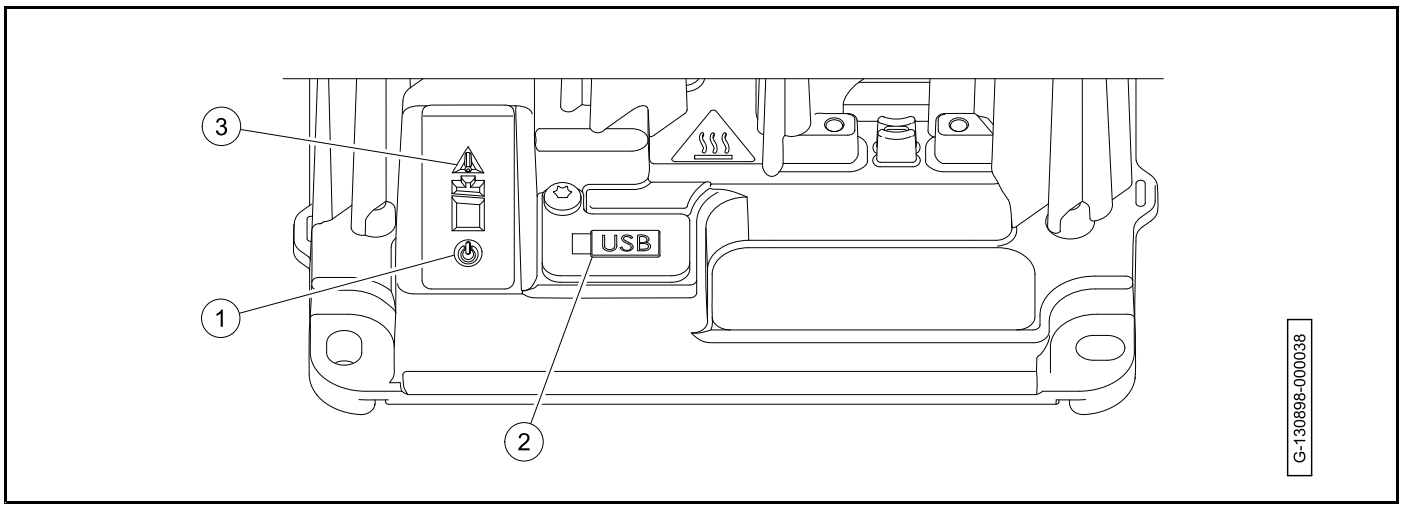


Figure 15-14 USB Dust Cover

13. Remove the USB dust cover (2).
14. Connect the USB flash drive to the battery charger. The blue light and green triangle light (3) will turn off and on for approximately three minutes.
15. When the blue light and green triangle light are constant, remove the USB flash drive.
16. Install the USB dust cover.

ONBOARD BATTERY CHARGER

How To View Algorithm - Onboard Battery Charger

1. Disconnect the AC cord from the battery charger. Wait 30 seconds.
2. Push and hold the Select Charge Profile button (1) **(Figure 15-15, Page 15-19)**.

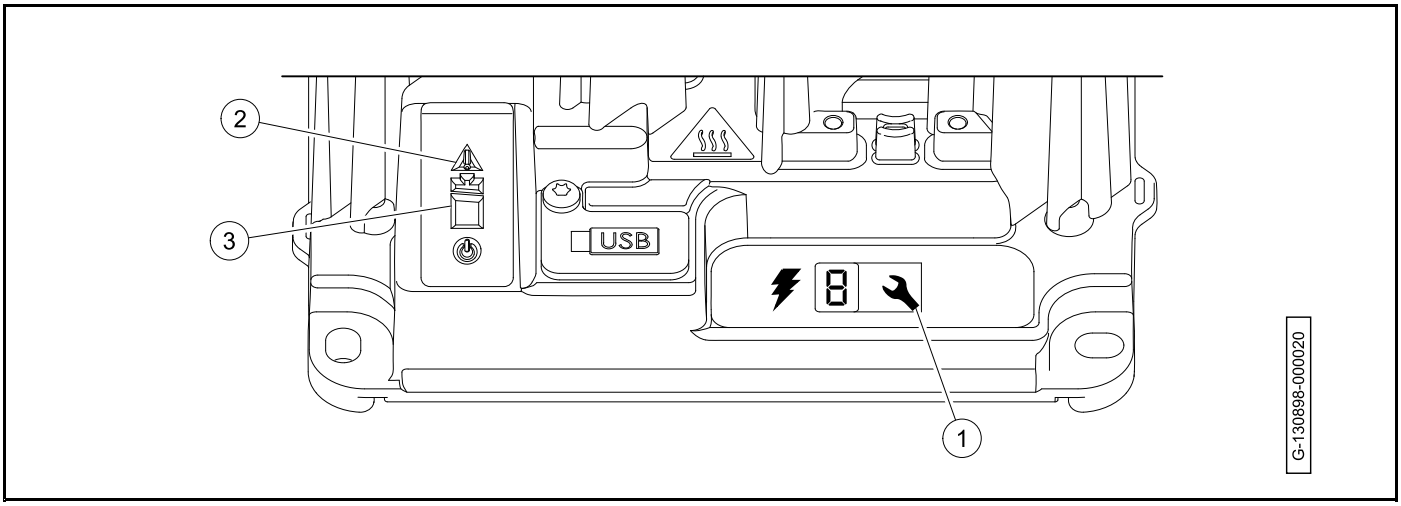


Figure 15-15 Algorithm Change

3. While pushing the Select Charge Profile button, connect the AC cord to the battery charger.
4. Continue to push the Select Charge Profile button until the Error/Fault Indicator (2) illuminates amber and the Battery Charging Indicator (3) is flashing green.

NOTE: *Wait approximately 25 seconds.*

5. Release the Select Charge Profile button.
6. Push and release the Select Charge Profile button to advance through the charging algorithms.

NOTE: *The selected charging profile will be displayed up to three times (P-0-3-1 for Profile 31).*

BATTERIES	ALGORITHM NUMBER
JCI	31
Trojan	188

How To Change Algorithm - Onboard Battery Charger

1. Disconnect the AC cord from the battery charger. Wait 30 seconds.
2. Push and hold the Select Charge Profile button (1) **(Figure 15-15, Page 15-19)**.

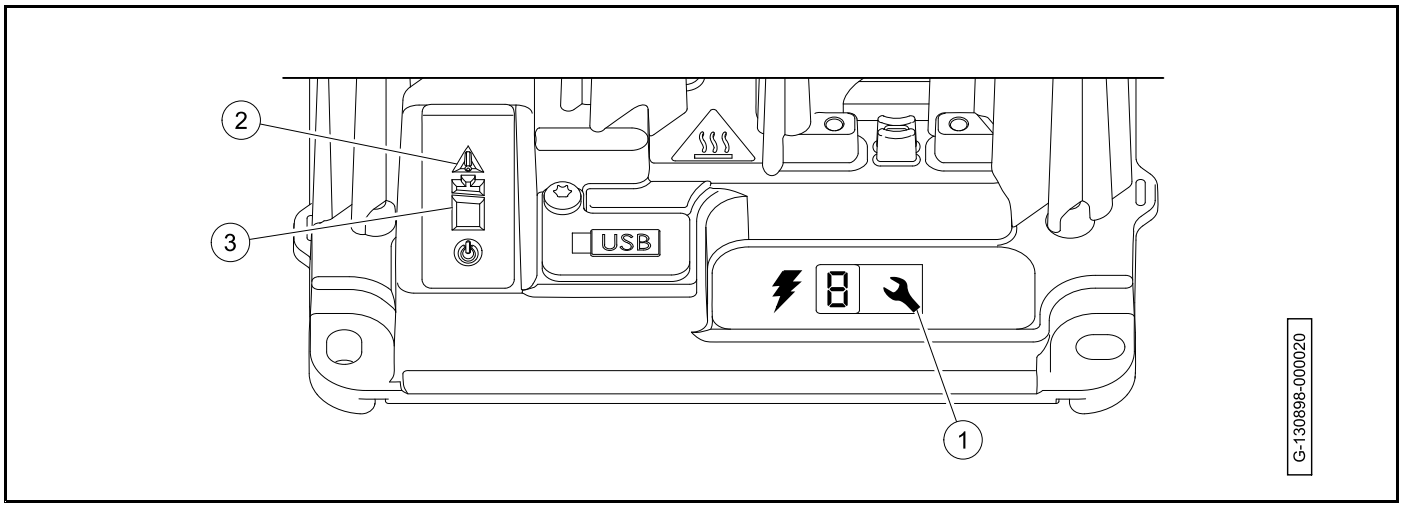


Figure 15-16 Algorithm Change

3. While pushing the Select Charge Profile button, connect the AC cord to the battery charger.
4. Continue to push the Select Charge Profile button until the Error/Fault Indicator (2) illuminates amber and the Battery Charging Indicator (3) is flashing green.

NOTE: *Wait approximately 25 seconds.*

5. Release the Select Charge Profile button.
6. Push and release the Select Charge Profile button to advance through the charging algorithms.

NOTE: *The selected charging profile will be displayed up to three times (P-0-3-1 for Profile 31).*

BATTERIES	ALGORITHM NUMBER
JCI	31
Trojan	188

7. When the desired charging algorithm is displayed, push and hold the Select Charge Profile until the Error/Fault Indicator and Battery Charging Indicator turns off and the AC Power Indicator remains on (approximately 10 seconds).
8. Push and release the Select Charge Profile button to view the selected algorithm.

UPDATE BATTERY CHARGER WITH USB

1. Contact Club Car to obtain the required algorithm, software, and settings files for the correct battery charger and vehicle model.
2. Format a USB 2.0 flash drive as FAT16 or FAT32. Make sure that the USB flash drive is blank.
3. Connect the AC cord to the battery charger.
4. Connect the AC cord to the power source.
5. Disconnect the DC cord from the vehicle.
6. Wait until only the blue light (1) is on **(Figure 15-14)**.

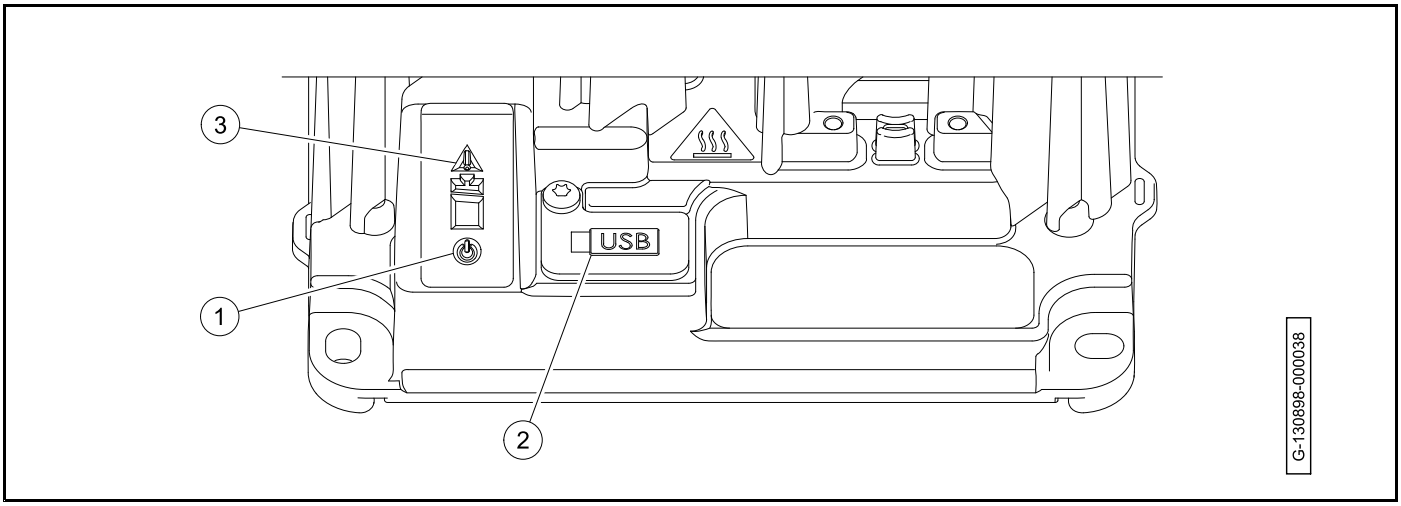


Figure 15-17 USB Dust Cover

7. Remove the USB dust cover (2).
8. Connect the USB flash drive to the battery charger. The blue light and green triangle light (3) will turn off and on for approximately three minutes.
9. When the blue light and green triangle light are constant, remove the USB flash drive.
10. Install the USB dust cover.

CHARGER MAINTENANCE

See General Warnings on page 1-1.

To ensure trouble-free performance, it is very important to follow an established preventive maintenance program. Regular and consistent maintenance can prevent vehicle downtime and expensive repairs that can result from neglect.

Any charger not functioning correctly should be removed from use until it is properly repaired. This will prevent further damage to the vehicle and avoid the possibility of injury due to unsafe conditions.

To perform all periodic service, see Periodic Maintenance on page 10-1.

To perform all troubleshooting, see Charger Troubleshooting on page 15-23.

To perform all repairs, see External Charger Repairs on page 15-32.

⚠ WARNING

- **If any problems are found during scheduled inspection or service, do not operate the vehicle until repairs are made. Failure to make necessary repairs could result in fire, property damage, severe personal injury, or death.**
- **Do not wear loose clothing or jewelry, such as rings, watches, chains, etc., when servicing the charger.**

- Do not expose charger to oil, dirt, mud or direct heavy water spray when cleaning vehicle.
- Keep all AC connections and the USB port clean and dry.
- Keep all cooling fins clean.
- If the detachable input power supply cord set is damaged, replace with a cord that meets the following criteria:

For North America:	UL or CSA listed/approved detachable cord, 3 conductor, 16AWG minimum, and rated SJT; terminating in a grounding type IEC 60320 C14 plug rated 250V, 13A minimum.
For all other countries:	Safety approved detachable cord, 3 conductor, 1.5mm²; minimum, rated appropriately for industrial use. The cord set must be terminated on one end with a grounding type input connector appropriate for use in the country of destination and, on the other end, an output grounding type IEC 60320 C14 plug.

USB SERVICE PORT CLEANING AND CARE

Depending on environmental conditions, such as coastal locations, open-air storage facilities, possible contamination in the USB port could result, preventing connectivity. If a poor connection is experienced, cleaning the USB port located in the front of the charger with an approved electrical contact cleaner will restore the connection.

Always reinstall the USB port dust cover after cleaning and use.

After cleaning, preventative maintenance of the USB port should include applying dielectric grease into the port cavity or applying Corrosion Block ® Corrosion Preventative to help prevent any reoccurance of contamination.

CHARGER TROUBLESHOOTING

See General Warnings on page 1-1.

⚠ DANGER

- **Do not touch any wire or component in the battery charger while AC power is present. Failure to heed this warning will result in an electric shock.**

⚠ WARNING

- **Knowledge of battery charger wiring and component terminology is required before attempting any repair. See The Charge Circuit on page 15-9.**
- **Prior to servicing the external charger, disconnect the DC plug from the vehicle charger receptacle and the AC power supply cord from the wall outlet.**

NUMBERING VEHICLES AND CHARGERS

Return the vehicles to the same charger each night if possible. If the vehicles are put in a storage facility at random and a vehicle dies while in use and testing shows the batteries are sound, then the problem is most likely with the charger. However, finding the problem charger may prove to be quite time consuming. Numbering the vehicles and the chargers and returning each vehicle to its designated charger each night can significantly reduce the amount of time spent troubleshooting a problem.

USB SERVICE PORT

NOTE: *The triangular charge status light doubles as the USB light. Flashing green means data transfer from the USB is occurring. Solid green means data transfer is complete.*

Use the USB service port for charging algorithm updates, software updates and troubleshooting.

To use the port, pull the cover from the port and insert a USB flash drive.

To update charger: With update file already on flash drive, insert drive into charger and let charger find file and update itself.

To download from charger: Insert an empty flash drive into charger and let charger write charge history file to it.

When finished, reinstall the cover.

INCOMING AC SERVICE

Make sure the incoming AC line service is sufficient. If circuit breakers are tripping, fuses blow during the night or the charger does not give the required starting rate when sound batteries are put on charge, an AC line problem exists. The electrical service to the vehicle storage facility should be sufficient to deliver adequate voltage and current to each charger with all the chargers turned on. If not, consult your local power company or electrical contractor.

TERMINAL BLOCK COVER

The terminal block cover prevents water exposure and prevents a short across the terminals, which will blow the 30-amp fuse in the charger receptacle wire harness.

RESETTING POWER – EXTERNAL CHARGER

The triangular status indicator light on the charger comes on in a solid red state to communicate a significant charger hardware or software failure. **See External Charger Status Indicators on page 15-4.** Before replacing the charger, however, reset the charger in case the failure was caused by a temporary situation. To reset charger power, take the following steps:

1. Unplug the DC cord from the vehicle.
2. Unplug the AC cord from the AC power source.
3. Wait for the red light to go off, wait 30 seconds, then plug the AC cord into the AC power source.
4. When the blue AC status indicator light comes on, connect the DC cord to the vehicle.
5. If the triangular status indicator light comes on, contact your Club Car dealer. If the light does not come back on, attempt to charge the car as usual.

RESETTING POWER – ONBOARD CHARGER

The triangular status indicator light on the charger comes on in a solid red state to communicate a significant charger hardware or software failure. **See External Charger Status Indicators on page 15-4.** Before replacing the charger, however, reset the charger in case the failure was caused by a temporary situation. To reset charger power, take the following steps:

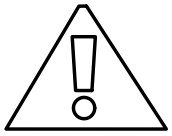
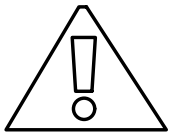
1. Unplug the AC cord from the AC power source.
2. Disconnect the DC cord under the rear-facing seat.
3. Wait for the red light to go off, wait 30 seconds, then plug the AC cord into the AC power source.
4. When the blue AC status indicator light comes on, reconnect the DC cord under the rear-facing seat.
5. If the triangular status indicator light comes on, contact your Club Car dealer. If the light does not come back on, attempt to charge the vehicle as usual.

EXTERNAL CHARGER TROUBLESHOOTING INDICATORS

If a fault occurs, count the number of red flashes (on the charger or dash) between pauses and refer to the table below:

EXTERNAL CHARGER TROUBLESHOOTING GUIDE				
CHECK STATUS INDICATOR LIGHT	**STATUS**	**STATUS EXPLANATION**	**POSSIBLE CAUSES** (check in order shown)	**SOLUTIONS**
	OFF	AC power to charger is NOT present.	1. AC cord connection	Unplug and inspect AC cord. Reconnect and attempt to charge again.
			2. AC power supply was shut off	Verify AC power is present and charge again. **See AC Power and Continuity Test of AC Circuit on page 15-30.**
			3. AC circuit breaker is tripped	Reset AC circuit breaker and charge again.
			4. Improper AC outlet voltage	Test AC outlet voltage and correct if necessary. **See AC Power and Continuity Test of AC Circuit on page 15-30.**
			5. Failed AC plug or cord	Replace cord. **See AC Power and Continuity Test of AC Circuit on page 15-30.**

TABLE CONTINUED ON NEXT PAGE

EXTERNAL CHARGER TROUBLESHOOTING GUIDE				
 G-130892-000001	Flashing orange	Charger unable to complete charge. (Usually not related to charger itself. Something occurred to prevent the charger from completing the charge. Check external factors first.)	1. Erroneous event (an unknown variable; something occurred to the charger or vehicle that was not the fault of either)	Reset charger power. **See Resetting Power – External Charger on page 15-24.** Reconnect DC cord to vehicle. If status goes away, continue using charger.
			2. Battery high voltage	Ensure battery set is rated 48 volts and composed of 24 cells. **See Battery Voltage Using Multimeter on page 15-29.** If not, replace with correct battery set. Reset charger power. **See Resetting Power – External Charger on page 15-24.**
			3. Battery low voltage	Ensure battery set is rated 48 volts and composed of 24 cells. Also, check the voltage of each individual battery. **See Battery Voltage Using Multimeter on page 15-29.** If not, replace with correct battery set. Reset charger power. **See Resetting Power – External Charger on page 15-24.**
			4. Charge timeout caused by battery pack not reaching required voltage.	Check for loose or corroded connections. Check for old or defective batteries. **See Test Procedures on page 15-29.**
			5. Bad battery pack	Test battery pack health. Look for shorted or damaged cells. **See Battery Condition Using Charger on page 15-30. See also Electric Vehicle - Batteries on page 14-1.**
			6. AC voltage out-of-range	Test and inspect incoming AC power. **See AC Power and Continuity Test of AC Circuit on page 15-30.**
			7. Ambient temperature too hot (above 104 °F (40 °C))	Check for dirty, obstructed, or damaged cooling fins. Clean if necessary and ensure sufficient cooling air flow. Chargers stacked on top of or located too close to each other. Move chargers farther apart. If issue continues, wait for ambient temperature to cool or relocate charger to a cooler environment.
			8. Ambient temperature too cold (below -40 °F (-40 °C))	Wait for ambient temperature to warm or relocate charger to a warmer environment.
			9. Bad DC connection	Inspect charger receptacle, receptacle harness connections and DC cord connection to charger. **See DC Plug and Receptacle on page 15-29. See Charger DC Circuit Continuity Test on page 15-31.**
			10. Corroded or loose connections	Clean or tighten connections.
 G-130892-000001	Solid red	Charger error	1. Charger abnormality	Reset charger power. **See Resetting Power – External Charger on page 15-24.** Reconnect DC cord to vehicle. If status goes away, proceed to charge again. **See Charger Output Test on page 15-31.** If status occurs again during the next charge cycle, attempt to charge with another identical charger. If charge is successful, proceed to step 2. If status occurs again, troubleshoot the AC power supply, vehicle and battery pack.
			2. Charger internal fault	Replace charger.

ONBOARD CHARGER FAULT CODES

The “E” and “F” codes will appear in the display panel followed by three numbers and a period to indicate the different conditions.

ONBOARD CHARGER FAULT CODES		
FAULT CODE	**DESCRIPTION**	**SOLUTIONS**
F-0-0-1 F-0-0-2 F-0-0-3 F-0-0-4 F-0-0-5 F-0-0-6	Internal charger fault	• Remove the AC power supply and the battery for a minimum of 30 seconds.
E-0-0-1 E-0-2-1	Battery high voltage	• Check the battery voltage and cable connections. • Check the battery size and condition. • This error will automatically clear once the condition has been corrected.
E-0-0-2 E-0-2-2	Battery low voltage	• Check the battery voltage and cable connections. • Check the battery size and condition. • This error will automatically clear once the condition has been corrected.
E-0-0-3	Charge timeout caused by battery pack not reaching required voltage within safe time limit	**Possible causes:** Charger output reduced due to high temperatures, poor battery health, discharged battery, and/or the battery is not connected correctly. • Operate at lower ambient temperature. • Replace the battery pack. • Check the DC connections. • This error will automatically clear once the charger is reset by cycling DC.
E-0-0-4	Battery could not meet minimum voltage	• Check for shorted or damaged cells. • Replace the battery pack. • This error will automatically clear once the charger is reset by cycling DC.
E-0-0-5	Charger temperature limit exceeded	• Ensure sufficient cooling air flow and reset the charger by disconnecting the AC cord for 10 minutes. Reconnect the AC cord. • This error will automatically clear once the condition has been corrected.
E-0-0-6	Low AC voltage error	• Connect the charger to an AC source that provides stable AC between 85 - 270 VAC / 45 - 65 Hz. • This error will automatically clear once the condition has been corrected.

TABLE CONTINUED ON NEXT PAGE

ONBOARD CHARGER FAULT CODES		
E-0-0-7	Battery amp hour limit reached	**Possible causes:** Poor battery health, discharged battery, battery not connected correctly, and/or high parasitic loads on the battery while it is charging. • Replace the battery pack. • Check the DC connections. • Disconnect the parasitic loads. • This error will automatically clear once the charger is reset by cycling DC.
E-0-0-8	Battery temperature is out of range	Possible battery temperature sensor error. • Check the temperature sensor and connections. • Reset the charger. • This error will automatically clear once the condition has been corrected.
E-0-1-2	Reverse polarity error	The battery is not connected to the charger correctly. • Check the battery connections. • This error will automatically clear once the condition has been corrected.
E-0-1-3	Battery does not take current	Battery voltage is detected but the charger is unable to charge the battery. This can be due to an electrical device connected between the charger and the battery, which passes through voltage but not current. Make sure that the vehicle has original factory set up.
E-0-2-3 E-0-2-5	AC voltage out of range	AC voltage is out of range. • Connect the charger to an AC source that provides stable AC between 85 - 270 VAC / 45 - 65 Hz. • This error will automatically clear once the condition has been corrected.
E-0-2-4	Charger failed to initialize	The charger has failed to turn on correctly. • Disconnect the AC input and battery for 30 seconds. Connect the AC input and battery.
E-0-1-1 E-0-2-9 E-0-3-0 E-0-3-2 E-0-3-8	Charger is disabled by external comman (CANbus)	Charger has been disabled by an external controller over the CANbus network. Contact OEM for instruction.
E-0-1-6 E-0-1-8 E-0-1-9 E-0-2-6	Software error	Software upgrade failure or script operation failure. • Make sure the USB flash drive is properly formatted. Reconnect the USB flash drive to the charger.
E-0-2-0 E-0-2-8	Algorithm error	The selected charging profile is incompatible with the charger software. • Update the charger software or select a different charging profile. • Make sure that the default algorithm is selected.

TABLE CONTINUED ON NEXT PAGE

ONBOARD CHARGER FAULT CODES		
E-0-1-7 E-0-2-7	USB error	There has been a problem connecting or disconnecting the USB flash drive. • Disconnect and reconnect the USB flash drive. • If the problem persists, remove AC and battery for minimum 30 seconds and retry charger. • If the problem persists, contact Delta-Q for further help.
E-0-1-4 E-0-1-5 E-0-2-4 E-0-3-1 E-0-3-3 E-0-3-4 E-0-3-5 E-0-3-6 E-0-3-7	Configurations error	There is an error with the chargers internal configuration. • Contact Delta-Q. USB flash drive update may be provided to clear error.

TEST PROCEDURES

See General Warnings on page 1-1.

When the upper green light is flashing, indicating the charger is in finish charge, it is okay to begin a battery discharge test if so desired.

Index of Test Procedures

1 – Battery Voltage Using Multimeter
2 – DC Plug and Receptacle
3 – Battery Condition Using Charger
4 – On-Charge Battery Voltage Using Charger And Multimeter
5 – AC Power and Continuity Test of AC Circuit
6 – Charger DC Circuit Continuity Test
7 – Charger Output Test

TEST PROCEDURE 1 – Battery Voltage Using Multimeter

1. Check battery pack voltage. **See Measuring Voltage of Battery Set, Section 14, Page 14-2.**
2. Normal no-load voltage should be between 50 and 52 volts for a fully charged battery set. Normal no-load voltage of an individual battery should not be less than 0.7 volts of the other 5 batteries (for 6 x 8-volt battery set).

TEST PROCEDURE 2 – DC Plug and Receptacle

1. Check the DC plug and the vehicle charger receptacle for damage, dirt, corrosion, bent pins or any condition that might prevent a sound electrical connection. **See Plug and Receptacle on page 15-3.**
2. Inspect the receptacle contacts to ensure that they are not damaged and they are firmly seated within the receptacle. **See Plug and Receptacle on page 15-3.**
3. Check the wire connections from the charger receptacle.

3.1. Verify that the 10-gauge red wire from the charger receptacle is connected to the large post of solenoid with 6-gauge red wire **(Figure 15-5, Page 15-10)**.

3.2. Verify that the 10-gauge black wire from the charger receptacle is connected to the B- terminal of controller.

3.3. Verify that the 16-gauge light blue wire from the charger receptacle is connected to the light blue wire bullet connector from the main wire harness.

4. With batteries connected, DC cord disconnected, and using a multimeter set to 200 volts DC, place the black (–) probe in the charger receptacle socket connected to the black 10-gauge wire and place the red (+) probe in the charger receptacle socket connected to the red 10-gauge wire. The reading should be 48 to 50 volts (full battery voltage).

5. If the reading is not 48 to 50 volts, check the following items:
   – The 30-amp fuse (located near solenoid) in the 10-gauge red wire of the charger receptacle harness.
   – Continuity of the 10-gauge red wire from the solenoid to the receptacle socket.
   – Continuity of the 6-gauge red wire from the positive post of battery no. 1 to the solenoid.

TEST PROCEDURE 3 – Battery Condition Using Charger

The easiest way to monitor the condition of a vehicle's batteries is simply to observe the Charger Status Indicators on the charger at the end of the charge cycle. After a full charge, disconnect the charger DC plug, wait 30 seconds and reconnect the charger DC plug. The battery-shaped status indicator will be green with the upper half flashing at first and then stay on continuously within 10 to 20 minutes, indicating sound, fully charged batteries. **See External Charger Status Indicators on page 15-4.**

NOTE: *Batteries near the end of their useful lives may not allow the battery charge current to taper and the upper half of the battery-shaped status indicator will continue to flash.* ***Section 14 — Electric Vehicle - Batteries***

Continued poor performance may indicate a problem in the vehicle electrical system, brakes or battery charger. If the problem is not found in the vehicle or charging system, proceed to the on-charge voltage test. If the upper half of the battery-shaped status indicator does not stop flashing, the batteries should be tested further using the on-charge voltage test.

TEST PROCEDURE 4 – On-Charge Battery Voltage Using Charger And Multimeter

When the batteries are fully charged, disconnect the charger DC plug. Wait 20 to 30 seconds and reconnect the DC plug to restart the charger. After 5 minutes, use a multimeter to check and record the voltage of the battery set as well as the individual batteries. Set the multimeter to 200 volts DC. Place the red (+) probe on the positive (+) post of battery no. 1 and the black (–) probe on the negative (–) post of battery no. 6 (for 6 x 8-volt battery set). Record reading. Then set multimeter to 20 volts DC and place the red (+) probe on the positive (+) post and the black (–) probe at the negative (–) post of each battery. Record the readings.

The on-charge voltage for the set should be between 56.0 and 63.0 volts depending on the age and state of charge of the batteries being tested.

Old batteries may have enough capacity left to last several more months.

TEST PROCEDURE 5 – AC Power and Continuity Test of AC Circuit

1. Disconnect AC cord from the wall outlet and DC plug from the vehicle receptacle.
2. Check the AC line fuse or circuit breaker in the storage facility.

3. With a multimeter set to 500 volts AC, check incoming AC voltage. Insert multimeter test probes into AC wall outlet; voltage should be between 85 and 270 volts. **See AC Input Voltage Detection on page 15-4.** If proper voltage is not present, have building wiring checked by a licensed electrical contractor.
4. If the charger will not power ON, check AC cord connections.
5. If the charger is connected correctly, check continuity of the AC cord wires.

TEST PROCEDURE 6 – Charger DC Circuit Continuity Test

1. Disconnect the AC cord from the wall outlet and the DC cord from the vehicle charger receptacle.
2. Remove DC terminal block cover. **See Terminal Block Cover Removal on page 15-32.**
3. Note polarity and loosen screws securing DC cord wires. Pull wires from DC terminals on charger.
4. Check continuity of the DC cord wires from plug pin to fork terminal.
5. When finished, attach DC cord white wire to positive terminal (+) and black wire to negative terminal (–) with torx screws. **See following NOTE.** Tighten torx screws to 39.8 in·lb (4.5 N·m).

NOTE: *The positive symbol (+) and negative symbol (–) are molded into the terminal block for easy identification.*

6. Install terminal block cover. **See Terminal Block Cover Installation on page 15-33.**

TEST PROCEDURE 7 – Charger Output Test

Without a Meter: Connect DC cord and start a charge cycle. If buzzer sounds three times, then charger is functioning. Both a confirmed connection with the charger and a rise in battery pack voltage are required for buzzer to sound three times. **See following NOTE.**

NOTE: *The number of flashes and beeps can vary depending on the Beep Option setting.* ***See Beep Option, Section 11, Page 11-8.***

With a Meter: A clamp meter can be used to measure current in the red battery cable (connected to the positive (+) post of battery no. 1) while charging. Current can reach just over 13-amps at the beginning of a charge session and taper down to approximately 5-amps near the end.

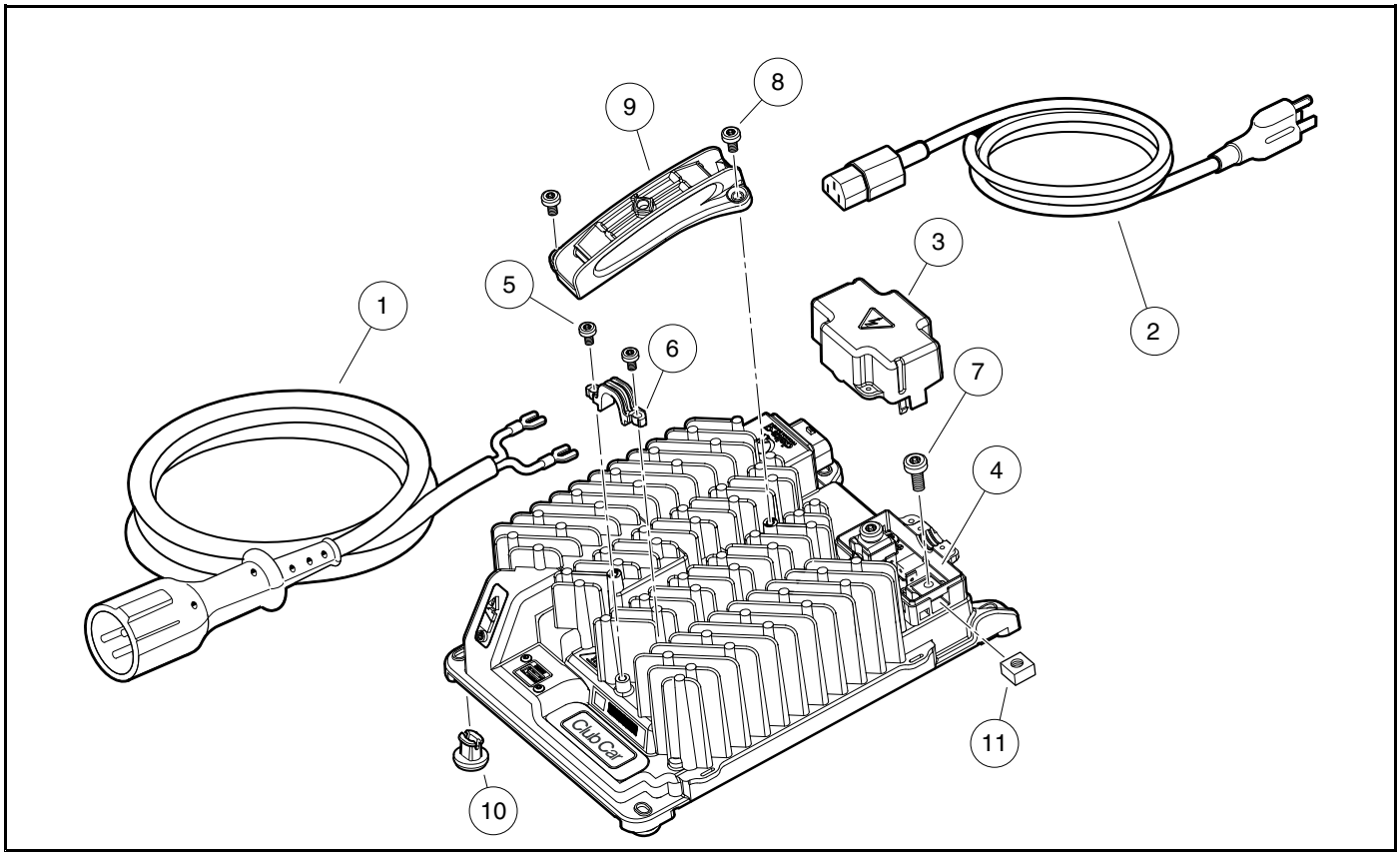
EXTERNAL CHARGER REPAIRS

See General Warnings on page 1-1.

⚠ WARNING

- **Knowledge of battery charger wiring and component terminology is required before attempting any repair (Figure 15-5, Page 15-10).**
- **Prior to servicing the charger, disconnect the DC plug from the vehicle charger receptacle and the AC cord from the AC outlet.**

NOTE: *This charger has no internals to service or repair. It only has a few external repairs that can be performed. If an internal component needs repair, the charger must be replaced.*

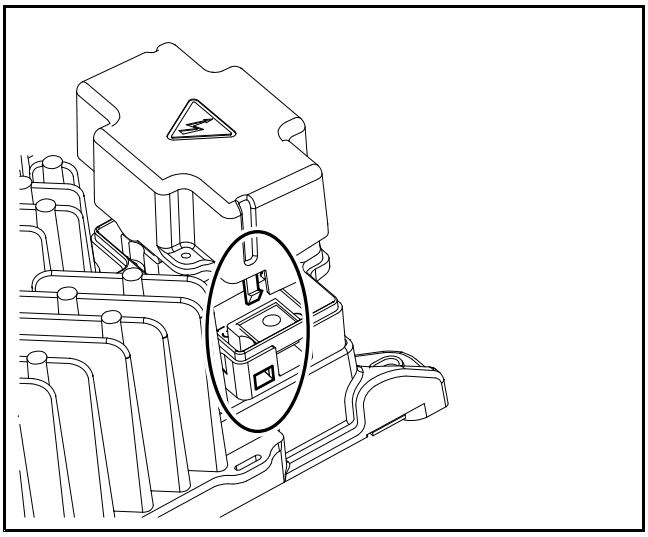


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Figure 15-18 External High-Frequency Charger Components

TERMINAL BLOCK COVER REMOVAL

1. Disconnect DC cord (1) from vehicle.
2. Disconnect AC cord (2) from AC outlet.
3. Push in mounting tabs **(Figure 15-19, Page 15-33)** to release cover (3) from terminal block (4).



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Figure 15-19 Terminal Block Cover Mounting Tabs

TERMINAL BLOCK COVER INSTALLATION

⚠ WARNING

- **The terminal block cover (3) on the DC terminal block (4) must be installed properly to comply with UL code. This cover prevents water exposure and prevents a short across the DC terminals.**

1. Align cover (3) with terminal block (4) and push onto block until tabs lock into place.

DC CORD AND STRAIN RELIEF REMOVAL

1. Disconnect DC cord (1) from vehicle.
2. Disconnect AC cord (2) from AC outlet.
3. Remove two torx screws (5) securing strain relief (6) to charger.
4. Remove terminal block cover (3). **See Terminal Block Cover Removal on page 15-32.**
5. Remove torx screw (7) securing each DC cord wire to terminal block (4).

DC CORD AND STRAIN RELIEF INSTALLATION

1. Attach DC cord white wire to positive terminal (+) and black wire to negative terminal (–) with torx screws (7). **See following NOTE.** Tighten screws (7) to 39.8 in·lb (4.5 N·m).

NOTE: *The positive symbol (+) and negative symbol (–) are molded into the terminal block for easy identification.*

2. Install terminal block cover (3). **See Terminal Block Cover Installation on page 15-33.**
3. Secure strain relief (6) to charger with torx screws (5). Tighten screws (5) to 27 in·lb (3.1 N·m).

HANDLE REMOVAL

Remove torx screws (8) securing handle (9) to charger.

HANDLE INSTALLATION

Place handle (9) onto charger and seat it onto mounting bosses of charger. **See following NOTE.**

NOTE: *The handle (9) features locating tabs to aid installation.*

Secure handle (9) to charger with two torx screws (8). Tighten screws (8) to 39.8 in·lb (4.5 N·m).

FOOT REMOVAL

1. Disconnect DC cord (1) from vehicle.
2. Disconnect AC cord (2) from AC outlet.
3. If mounted, detach charger from shelf or wall.
4. Squeeze barbs on back side of foot (10) and push foot out of charger mounting tab. Repeat for other feet if necessary.

FOOT INSTALLATION

1. Push foot (10) into hole in charger mounting tab until the barbs come through and secure foot in place.
2. If required, mount charger to shelf or wall. **See External Charger Mounting on page 15-7.**

SECTION 16 — ELECTRIC VEHICLE - MOTOR

16

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

GENERAL INFORMATION

The vehicle is equipped with a 48-volt DC, shunt-wound, reversible traction motor. The shunt-wound motor is designed for use in Excel System vehicles. Club Car recommends that motors requiring major repair be sent to a qualified motor repair shop; however, there are many relatively simple tasks that can be performed by a technician with general knowledge and experience in electric motor repair.

EXTERNAL MOTOR TESTING

The following tests can be performed without disassembling the motor using a multimeter or continuity tester.

NOTE: *Observe the following before testing the motor:*

- *This is only testing continuity.*
- *Tag the motor wires for identification before disconnecting.*
- *Remove motor wire from one of the "A" terminals and one of the "F" terminals if testing while motor is in vehicle.*
- *When disconnecting wires from motor terminals, use a second wrench on the lower nut of the terminal post to hold post steady.*
- *Scrape a small amount of paint from motor housing (ground) and use this location when testing motor terminals to electrical ground.*

Index of Test Procedures

1 – Motor Continuity Test
2 – Internal Short Circuits
3 – Armature Circuit Open
4 – Field Circuit Open

TEST PROCEDURE 1 – Motor Continuity Test

1. Disable the vehicle.
2. Disconnect the batteries and discharge the controller.
3. Disconnect the wires from the motor.
4. Set a multimeter to check for continuity.
5. Check the continuity readings between the motor terminals below:

MOTOR TERMINALS	CONTINUITY TEST RESULT
A1 to A2 F1 to F2	Continuity
A1 to F1 A1 to F2	No Continuity
A2 to F1 A2 to F2	No Continuity
A1 to Ground A2 to Ground	No Continuity
F1 to Ground F2 to Ground	No Continuity

6. If readings are correct, reconnect the motor wires. **See Motor Installation on page 16-15.**
7. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

TEST PROCEDURE 2 – Internal Short Circuits

See General Warnings on page 1-1.

1. Place vehicle on a level surface.
2. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
3. Disconnect wires from terminals on motor using two wrenches to prevent posts from turning.
4. With a multimeter set to 200 ohms, place black (–) probe on motor housing. Scratch through paint to ensure a good connection. Place red (+) probe on A1, A2, F1, and F2 terminals respectively while rolling the vehicle slowly to rotate the armature. Multimeter should indicate no continuity between the motor housing and all individual terminals. If readings indicate continuity, motor will need to be removed from the vehicle and repaired by a qualified technician. **See Motor Removal on page 16-4.**

4.1. An incorrect reading from the A1 or A2 terminal indicates three possible problems: a grounded A1 or A2 terminal, a grounded wire in the brush area, or a grounded armature/commutator. An incorrect reading for the F1 or F2 terminal indicates a possible grounded F1 or F2 terminal or field coil.

5. If readings are correct, reconnect the motor wires. **See Motor Installation on page 16-15.**
6. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

TEST PROCEDURE 3 – Armature Circuit Open

See General Warnings on page 1-1.

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Disconnect wires from the A1 and A2 terminals on the motor using two wrenches to prevent posts from turning. Set a multimeter to 200 ohms and place the red (+) probe on the A1 terminal and black (–) probe on the A2 terminal. The multimeter should indicate continuity. If the reading is incorrect, a possible open or poor contact in a brush assembly and/or open armature windings may be the cause. The motor will need to be removed from the vehicle and repaired by a qualified technician. **See Motor Removal on page 16-4.**
3. If reading is correct, reconnect the motor wires. **See Motor Installation on page 16-15.**
4. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

TEST PROCEDURE 4 – Field Circuit Open

See General Warnings on page 1-1.

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Disconnect wires from the F1 and F2 terminals on the motor using two wrenches to prevent posts from turning. Set a multimeter to 200 ohms and place the red (+) probe on the F1 terminal and the black (–) probe on the F2 terminal. The multimeter should indicate continuity. If the reading is incorrect, a possible open field coil or bad connections at the terminals may be the cause. The motor will need to be removed from the vehicle and repaired by a qualified technician. **See Motor Removal on page 16-4.**
3. If reading is correct, reconnect the motor wires. **See Motor Installation on page 16-15.**
4. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

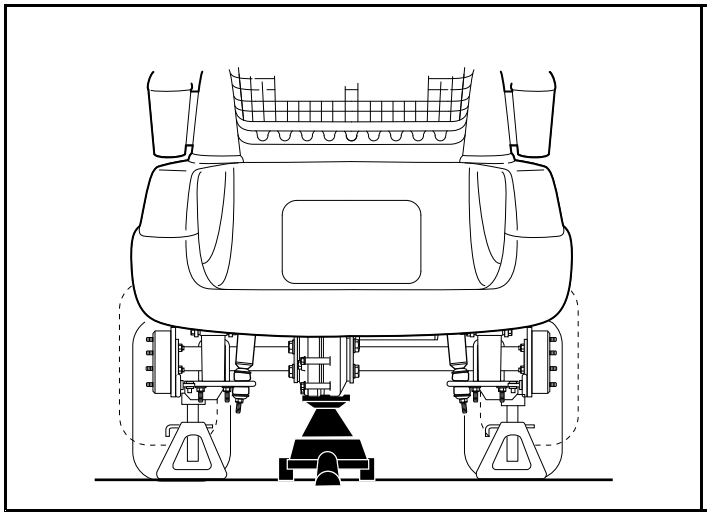
MOTOR REMOVAL

See General Warnings on page 1-1.

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Disconnect wires from the terminals on the motor using two wrenches to prevent posts from turning. Label the wires to ensure proper reconnection.
3. Slightly loosen all the lug nuts on both rear wheels.
4. Place floor jack under transaxle and raise rear of vehicle **(Figure 16-1, Page 16-4)** then place jack stands under frame crossmember between the spring mount and the side stringer, just forward of each rear wheel. Lower the vehicle to let the jack stands support the vehicle **(Figure 16-2, Page 16-4)**. **See following WARNING.**

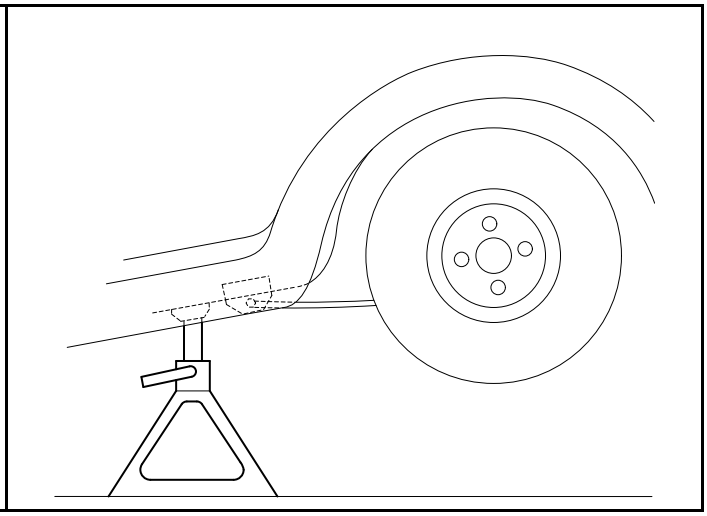
⚠ WARNING

- **Lift only one end of the vehicle at a time. Use a suitable lifting device (chain hoist or hydraulic floor jack) with 1000 lb. (454 kg) minimum lifting capacity. Do not use lifting device to hold vehicle in raised position. Use approved jack stands of proper weight capacity to support the vehicle and chock the wheels that remain on the floor. When not performing a test or service procedure that requires movement of the wheels, lock the brakes.**



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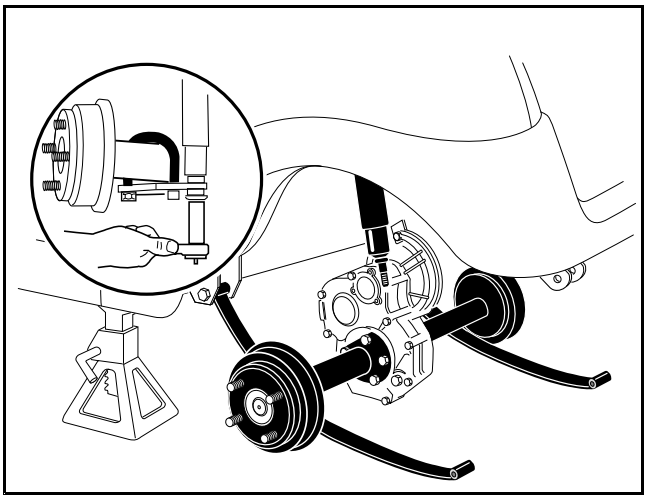
Figure 16-1 Lift Vehicle with Floor Jack



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Figure 16-2 Vehicle Supported on Jack Stands

5. Remove both rear wheels.
6. Remove the nut, cup washer, and bushing from the bottom side of the shock absorber. Compress the shock absorber (pushing upwards) to move it out of the way **(Figure 16-3, Page 16-5)**.
7. Remove the nuts and bolts mounting the rear leaf springs to the shackles.
8. To gain easier access to the motor, lower the transaxle as low as it will go. If more room is needed, remove the jack from beneath the transaxle and allow the springs to rest on the floor **(Figure 16-3, Page 16-5)**.



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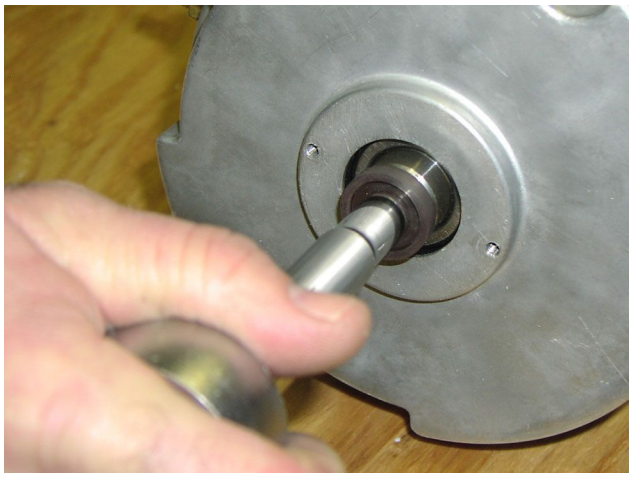
Figure 16-3 Lower Axle

9. Remove the bolts and lock washers that secure the motor to the transaxle **(Figure 16-25, Page 16-18)**. **See following CAUTION.**

⚠ CAUTION

- **Do not position fingers under motor when sliding motor off of the input shaft in step 9. Fingers may get pinched when motor disengages.**

10. Carefully slide the motor away from the transaxle until the motor spline disengages the input shaft and remove the motor from the vehicle.



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Figure 16-4 Speed Sensor Magnet



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Figure 16-5 End Cap

MOTOR DISASSEMBLY

1. Before beginning disassembly, place match marks on the motor end cap and motor frame.
2. Remove speed sensor and magnet.

2.1. Remove the two screws (25) and clamp that secure the speed sensor (10) to the end cap (11) **(Figure 16-15, Page 16-12)**.

2.2. Remove the screw securing the magnet to the armature shaft **(Figure 16-4, Page 16-5)**.

2.3. Inspect the speed sensor magnet. **See Speed Sensor Magnet Inspection on page 16-11.**

3. Loosen, but do not remove, the two screws securing the end cap to the motor frame **(Figure 16-5, Page 16-5)**.



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Figure 16-6 End Cap Disengagement



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Figure 16-7 End Cap Removal

4. Orient the motor so that the splined end of the armature is facing down.
5. Inspect the area where the end cap mates with the motor frame. If the end cap appears to be loose where it connects to the motor frame, go to step 6; otherwise, disengage the end cap from the motor frame using the following procedure:

5.1. With the end cap bolts loose (about 1/4 inch (6.3 mm) between the end cap and the head of the bolt), place a socket on the head of the bolt. **See following CAUTION.**

CAUTION

- **Ensure that there is sufficient thread engagement of the end cap bolts before proceeding. Performing the procedure without having adequate thread engagement could damage the motor frame, end cap, or end cap bolts.**

5.2. Gently tap each bolt, alternating between blows, until the end cap and motor frame become disengaged **(Figure 16-6, Page 16-6)**.

6. Remove the two end cap bolts.
7. Remove the end cap and armature from the motor frame **(Figure 16-7, Page 16-6)**.
8. Inspect the brush springs for proper tension. **See Motor Brush, Spring, and Terminal Insulator Inspection on page 16-10.**
9. Remove the armature from the end cap bearing. **See following CAUTION and NOTE.**

⚠ CAUTION

- **Removing the armature from the end cap requires two people: one to operate the press, and another to hold the armature. Failure to heed this CAUTION could result in personal injury and/or damage to the armature resulting from an unsupported armature falling after it becomes disengaged from the end cap bearing.**

NOTE: *Replacement of the end cap bearing is recommended if the armature is removed.*

9.1. Place the end cap in a press with the armature facing down.

9.2. Place a bearing press tool with an outer diameter smaller than that of the armature shaft between the press ram and the armature shaft **(Figure 16-8, Page 16-7)**.

9.3. Have an assistant support the armature while the press is activated.

10. Inspect the armature for wear and damage. **See Armature Inspection and Testing on page 16-8.**

11. Inspect the motor frame and field windings. **See Motor Frame and Field Windings Inspection on page 16-10.**

12. Remove the brush rigging.

12.1. Mark the brush terminal posts (A1 and A2).

12.2. Remove the two nuts securing the brush terminals (A1 and A2) to the end cap **(Figure 16-9, Page 16-7)**.

12.3. Remove the two screws and the brush rigging to the end cap **(Figure 16-10, Page 16-8)**.

13. Inspect the terminal insulators. **See Terminal Insulator Inspection on page 16-10.**

14. Remove the bearing from the end cap.

14.1. Remove the retaining ring that secures the bearing in the end cap **(Figure 16-11, Page 16-8)**.

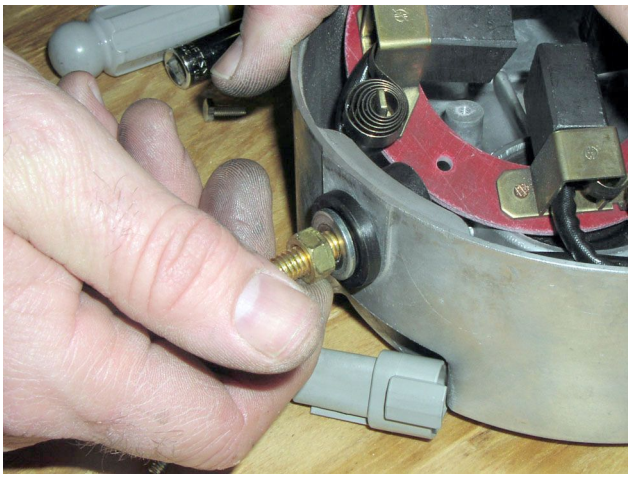
14.2. Use an arbor press to remove the bearing from the end cap.

15. Inspect the bearing for wear and damage. **See Bearing Inspection on page 16-11.**



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Figure 16-8 Armature Removal



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Figure 16-9 A1 and A2 Terminals



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Figure 16-10 Brush Rigging



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Figure 16-11 Bearing Retaining Ring

MOTOR COMPONENT TESTING AND INSPECTION

See General Warnings on page 1-1.

ARMATURE INSPECTION AND TESTING

1. Remove the motor from the vehicle. **See Motor Removal on page 16-4.**
2. Remove the end cap and armature by performing steps 1 through 7 of Motor Disassembly on page 16-6.

Visual Inspection

- Burned, charred or cracked insulation
- Improperly cured varnish
- Thrown solder
- Flared armature windings
- Damaged armature core laminations
- Worn, burned or glazed commutators
- Dirty or oily commutators
- Raised commutator bars
- Worn armature bearing or shaft

A dirty or oily commutator should be cleaned and wiped dry. Abnormalities identified during the inspection can help determine original cause of failure. Slight roughness of the commutator can be polished smooth with 400 grit or finer sandpaper. **See following CAUTION and NOTE.**

CAUTION

- **Do not use emery cloth to polish the commutator. Particles of emery are conductive and may short-circuit the commutator bars. Do not use oil or lubricants on the commutator or brushes.**

NOTE: *Oil on the commutator may indicate a faulty transaxle input shaft oil seal.*

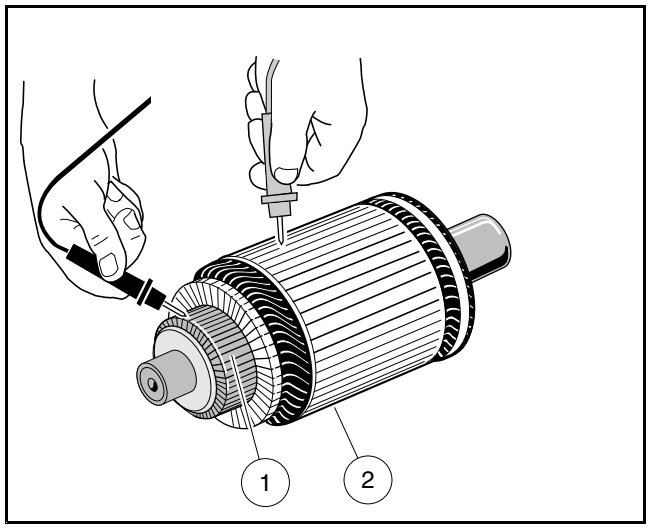
Armature Ground Test

CAUTION

- **Do not submerge the armature in solvent.**

NOTE: *Before testing the armature, wipe it clean with a clean cloth. Remove any carbon dust and metal particles from between the commutator bars.*

1. With a multimeter set to 200 ohms, place one probe on the commutator (1) and the other on the armature core (2). The multimeter should indicate no continuity **(Figure 16-12, Page 16-9)**. If the reading is incorrect, replace the armature.



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Figure 16-12 Armature Test

MOTOR FRAME AND FIELD WINDINGS INSPECTION

1. Remove the motor from the vehicle. **See Motor Removal on page 16-4.**
2. Remove the and cap and armature by performing steps 1 through 7 of Motor Disassembly on page 16-6.
3. Burned or scorched insulation on the field windings indicates the motor has overheated due to overloads or grounded or shorted coil windings. If the insulation on the field windings is scorched, replace the motor or the stator shell assembly.

MOTOR BRUSH, SPRING, AND TERMINAL INSULATOR INSPECTION

Brush Spring Tension Test

1. Remove the motor from the vehicle. **See Motor Removal on page 16-4.**
2. Remove the end cap and armature by performing steps 1 through 7 of Motor Disassembly on page 16-6.
3. Inspect the brush springs (14) **(Figure 16-15, Page 16-12)**. Replace springs that are discolored from heat (light gold or blue tinted).
4. Test the brush springs for proper tension.

4.1. Place a C-shaped steel plate on a scale.

4.2. Place the end of the C-shaped plate so that it is between the spring and the brush as shown **(Figure 16-13, Page 16-11)**.

4.3. Gently pull the scale to obtain the spring tension reading. **See following CAUTION.**

CAUTION

- **When checking brush spring tension, do not over-extend the spring. Using excessive force will damage the spring.**

4.4. Replace springs which require a force of less than 35 ozf (0.99 kgf) **(Figure 16-13, Page 16-11)**. **See following NOTE.**

NOTE: *When installing new brushes, remove and replace brushes one at a time. This method ensures the terminals and brushes will be properly positioned in the rigging. Refer to* ***Motor Assembly on page 16-13*** *for brush installation.*

When replacing brushes, replace all four brushes. Never replace only two.

Install the brushes in the same rigging 180° apart from each other.

Brush Inspection

1. Remove the motor from the vehicle. **See Motor Removal on page 16-4.**
2. Remove the end cap and armature by performing steps 1 through 7 of Motor Disassembly on page 16-6.
3. Inspect the brushes (13) for damage or excessive wear **(Figure 16-15, Page 16-12)**. Replace brushes if required. **See preceding NOTE.**
4. Use dial calipers or a micrometer to measure the brush length. The minimum-allowable brush length is 0.62 inches (16 mm). Replace the set of brushes as required. **See preceding NOTE.**

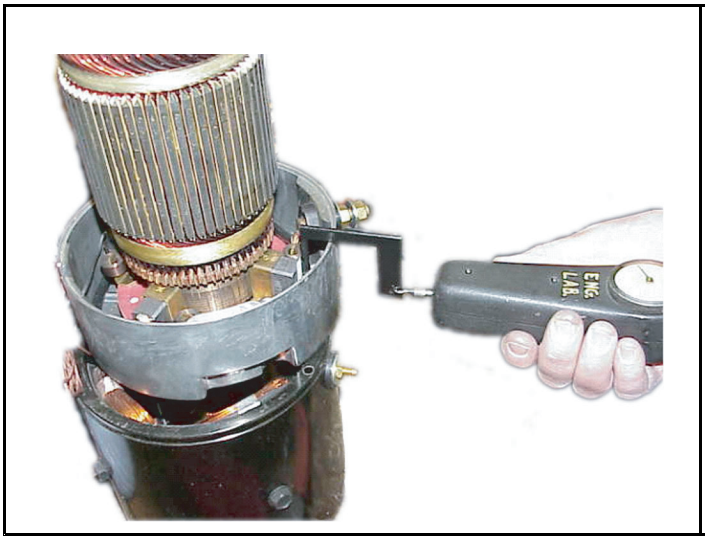
Terminal Insulator Inspection

1. Remove the motor from the vehicle. **See Motor Removal on page 16-4.**
2. Remove the terminal insulators by performing steps 1 through 12 of Motor Disassembly on page 16-6.
3. Inspect the insulators (4 and 6) for cracks or other damage **(Figure 16-15, Page 16-12)**. Replace insulators as required.

Bearing Inspection

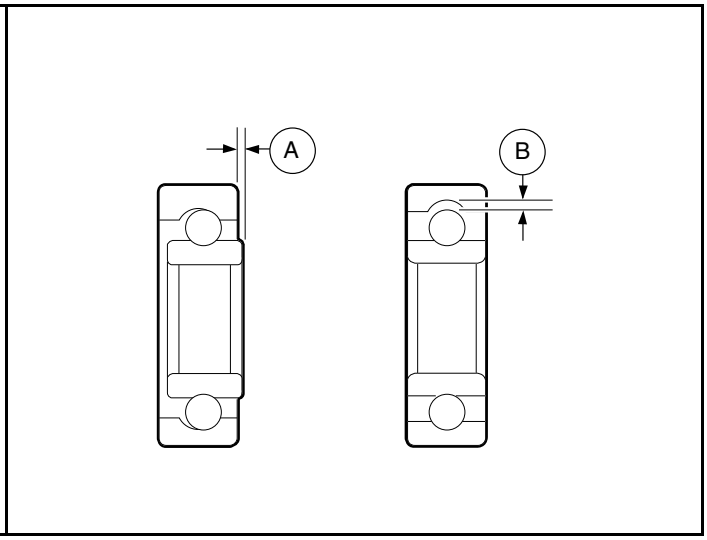
NOTE: *Replacement of the end cap bearing is highly-recommended if the end cap is removed from the motor. The following procedure is provided as a guideline for determining general bearing failure.*

1. Remove the motor from the vehicle. **See Motor Removal on page 16-4.**
2. Remove the bearing by performing steps 1 through 14 of Motor Disassembly on page 16-6.
3. Use a clean cloth to wipe the carbon dust off of the bearing. Inspect the bearing by spinning it by hand and checking for both axial (A) and radial (B) play **(Figure 16-14, Page 16-11)**.
4. Replace the bearing if it is noisy, does not spin smoothly, or has excessive play. Check the bearing and replace if rusted, worn, cracked, or if there is an abnormal color change in the metal of the bearing.



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Figure 16-13 Brush Spring Tension Test

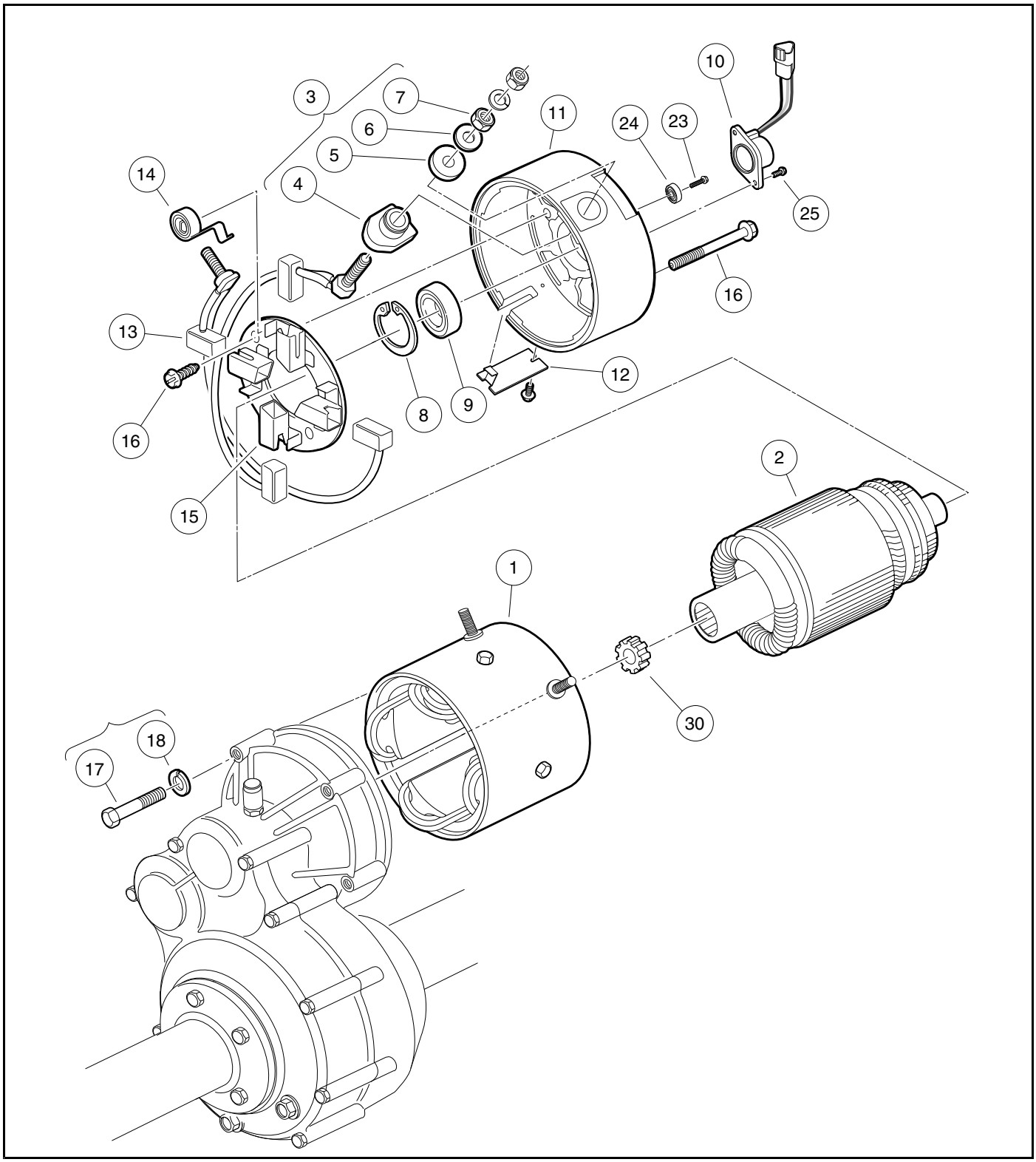


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Figure 16-14 Bearing Inspection

Speed Sensor Magnet Inspection

Inspect the speed sensor magnet (24) for rust, wear, and cracks **(Figure 16-15, Page 16-12)**. Replace the magnet if necessary.



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Figure 16-15 Electric Motor (EJ8-4001A)

RECONDITIONING THE MOTOR

See General Warnings on page 1-1.

Motor reconditioning must be performed by a qualified motor repair technician. The use of proper tools and procedures is absolutely essential for successful motor reconditioning.

MOTOR SPECIFICATIONS

Any rework must be performed by a qualified technician. Motor service specifications are listed in the following table.

ITEM	SERVICE LIMIT
Commutator diameter (minimum)	2.80 in. (71.10 mm)
Commutator concentric with armature shaft within	0.003 in. (0.08 mm)
Bar to bar runout should not exceed	0.005 in. (0.013 mm)
Undercut of segment insulator after machining commutator	0.040 in. (1.0 mm)
Armature resistance at 75 °F (24 °C)	0.012 ohms between bar 1 and bar 15
Field coil resistance at 75 °F (24 °C)	1.75 ohms

MOTOR ASSEMBLY

See General Warnings on page 1-1.

1. Replace the bearing.

1.1. Use an arbor press to install a new bearing into the end cap. To help avoid damaging the bearing, apply pressure only to the outer race when installing the bearing.

1.2. Install the retaining ring to secure the bearing **(Figure 16-11, Page 16-8)**.

2. Install the brushes and brush rigging. **See following NOTE.**

NOTE: *When installing new brushes, remove and replace brushes one at a time. This method ensures the terminals and brushes will be properly positioned in the rigging.*

When replacing brushes, replace all four brushes. Never replace only two.

Install the brushes in the same rigging 180° apart from each other.

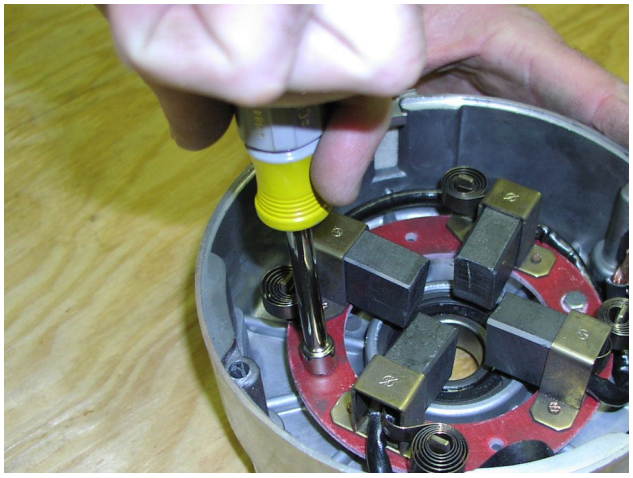
2.1. Insert the brushes into the brush rigging as shown **(Figure 16-16, Page 16-14)**.

2.2. Insert the two terminal posts through insulators (4) in the end cap (11) wall at the A1 and A2 positions **(Figure 16-15, Page 16-12)**.

2.3. Place external insulators (5) and washers (6) on each terminal post, and secure terminal with nuts (7). Tighten nuts (7) to 100 in·lb (11.3 N·m). Ensure that the terminal posts do not rotate when tightening the nuts **(Figure 16-15, Page 16-12)**.

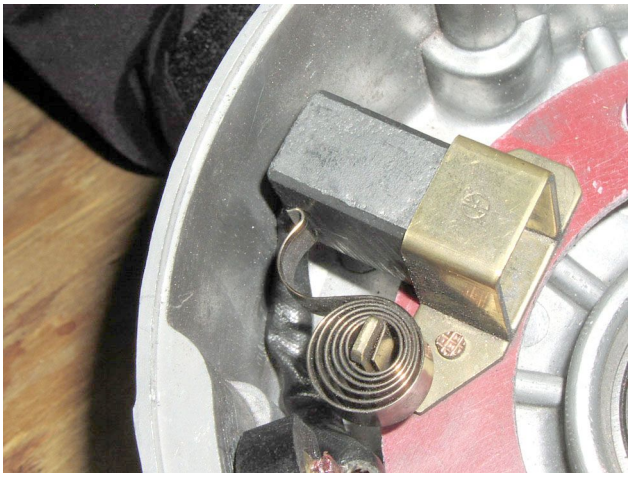
2.4. Secure the brush rigging to the end cap with two screws. Tighten the screws to 25 in·lb (2.8 N·m) **(Figure 16-10, Page 16-8)**.

2.5. One at a time, push the brushes back until they are completely retracted into their mounting slots and the spring pressure holds them in the retracted position as shown **(Figure 16-17, Page 16-14)**.



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Figure 16-16 Brush Rigging



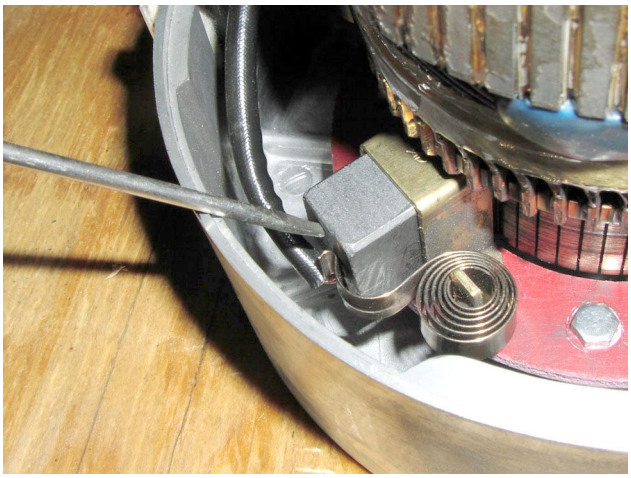
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Figure 16-17 Retracted Brushes



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Figure 16-18 Armature Installation



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Figure 16-19 Brush Setting

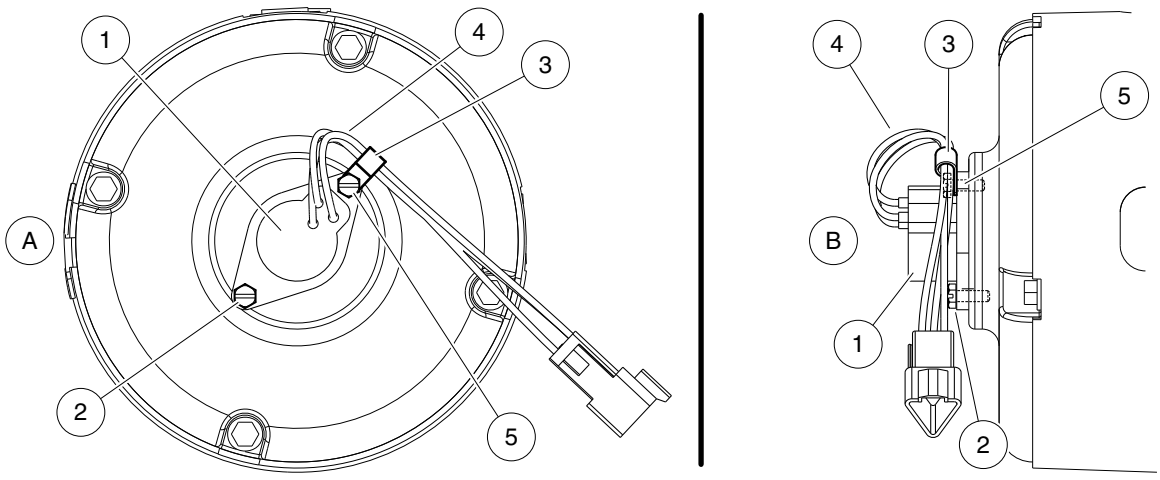
3. With the brushes retracted, use an arbor press to press the armature shaft into the end cap bearing **(Figure 16-18, Page 16-14)**. **See following CAUTION.**

CAUTION

- **Make sure the brushes are held back. Do not allow the brushes to support the weight of the commutator. The brushes can be easily damaged by this weight.**

4. Gently press each brush with a small screwdriver until the spring rests on the end of each brush as shown **(Figure 16-19, Page 16-14)**.
5. Align the match marks on the end cap and the motor frame (1) and secure with two bolts (16) **(Figure 16-15, Page 16-12)**. Tighten bolts to 130 in·lb (14.7 N·m).
6. Install the speed sensor magnet (24) with screw (23). Tighten to 65 in·lb (7.3 N·m).
7. Install the speed sensor (1) with one screw (2) finger-tight **(Figure 16-20, Page 16-15)**.

8. Install clamp (3) onto sensor wires (4) and secure with other screw (5) finger-tight. Ensure clamp (3) and wires (4) are oriented as shown **(Figure 16-20, Page 16-15)**. Tighten both screws (2 and 5) to 20 in·lb (2.2 N·m).
9. Make sure the armature turns freely. If it does not turn freely, disassemble the motor to find the problem.



A. End View B. Side View

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Figure 16-20 Speed Sensor Clamp

MOTOR INSTALLATION

See General Warnings on page 1-1.

1. Clean the transaxle input shaft.

1.1. Spray the input shaft thoroughly with CRC® Brakleen™ or equivalent brake cleaner degreaser.

1.2. Wipe input shaft with a clean cloth.

1.3. Inspect the grooves of the input shaft and remove any remaining debris.

1.4. Repeat steps 1.1 through 1.3 until input shaft is clean.

2. Lubricate the transaxle input shaft.

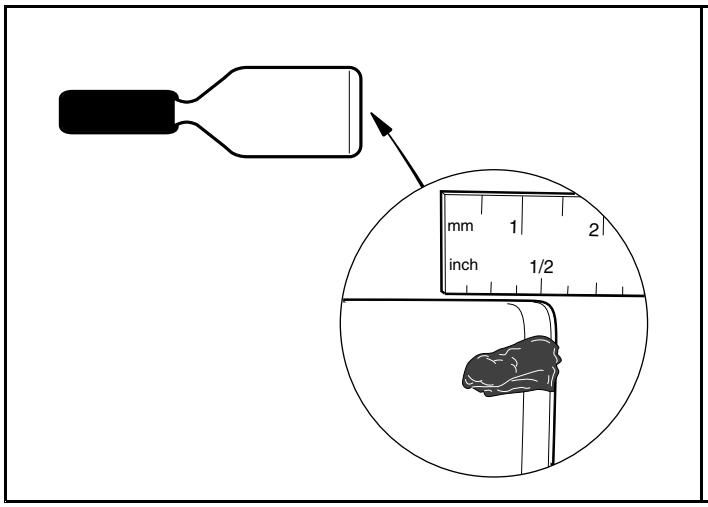
2.1. Squeeze approximately 1/2 inch (1.3 cm) of moly-teflon lubricant from tube onto a putty knife as shown **(Figure 16-21, Page 16-16)**.

2.2. Rotate wheels to rotate input shaft.

2.3. Apply motor coupling grease evenly to the rotating input shaft starting at approximately 1/8 inch (3.1 mm) from the end of the shaft and working back toward the transaxle (away from the end of the shaft) **(Figure 16-22, Page 16-16)**.

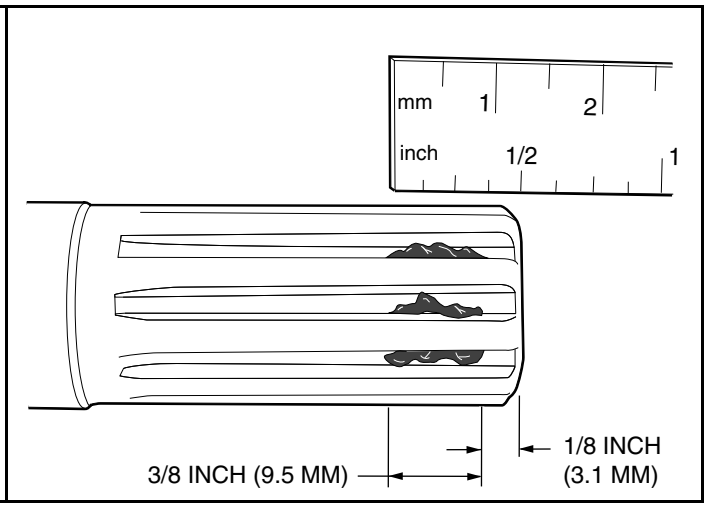
2.4. The grease should be evenly distributed in the grooves to a width of approximately 3/8 inch (9.5 mm).

2.5. Use a flat screwdriver to clean the grease out of one of the grooves and allow air to escape when the motor is pushed onto the input shaft.



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Figure 16-21 Grease on Putty Knife



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Figure 16-22 Application of grease to Input Shaft Grooves

2.6. Check the chamfer (1) and end (2) of the input shaft to ensure these areas are completely clean of grease as shown **(Figure 16-23, Page 16-17)**.

3. Install the molded bumper.

3.1. With the flat side toward the bottom of the coupling and the cupped side toward the transaxle input shaft, install the molded bumper (30) into the motor coupling **(Figure 16-15, Page 16-12)**. **See following NOTE.**

NOTE: *The motor coupling and the new molded bumper must be free of grease and debris.*

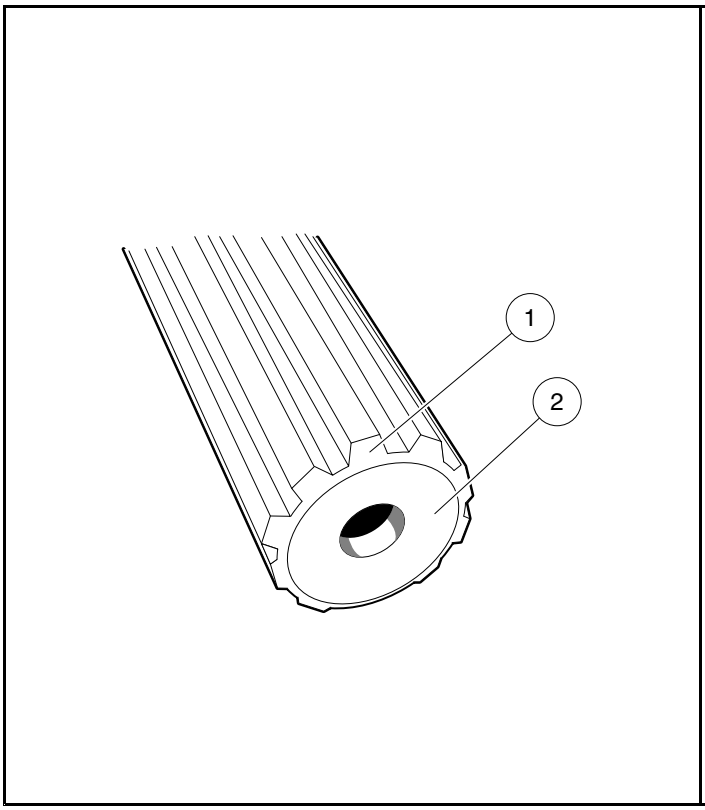
3.2. Ensure that the installed bumper is seated at the bottom of the coupling.

4. Install motor on transaxle.

4.1. Slide the motor coupling onto the transaxle input shaft. **See following NOTE.**

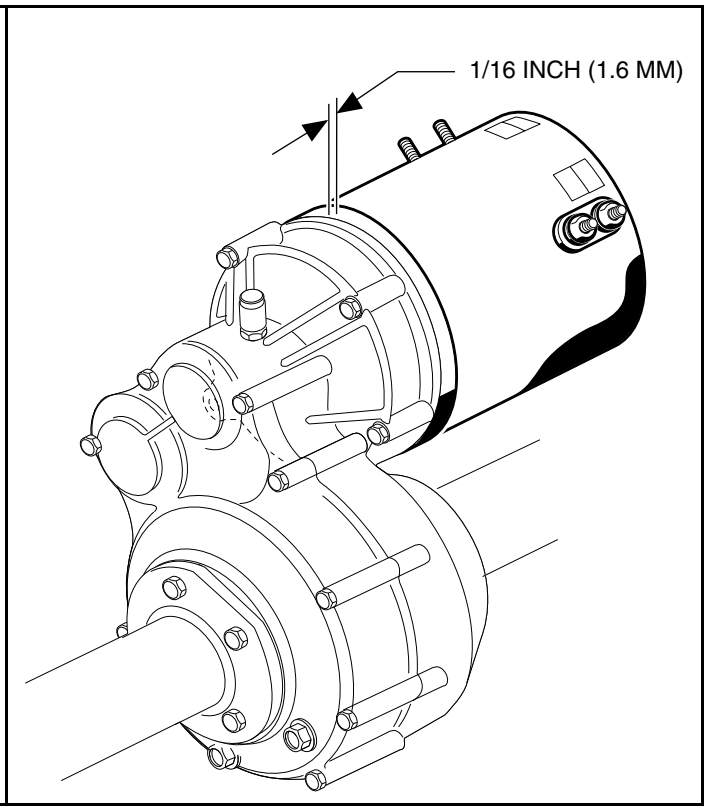
NOTE: *The coupling will push any excess grease on the input shaft along the shaft toward the transaxle.*

*When the motor is pushed onto the input shaft, the motor housing will not bottom out against the transaxle housing **(Figure 16-15, Page 16-12)**. There will be approximately 1/16 inch (1.6 mm) gap between the motor adapter ring and transaxle housing as shown **(Figure 16-24, Page 16-17)**.*



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Figure 16-23 Clean Chamfer and Input Shaft End



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Figure 16-24 Gap at Motor and Transaxle

4.2. Loosely install the three bolts and lock washers that secure the motor to the transaxle **(Figure 16-25, Page 16-18)**. Do not tighten.

4.3. Begin finger-tightening the bolts (1, 2, and 3) in the sequence indicated. Continue tightening by hand until the motor is seated in the transaxle housing. **See following CAUTION and NOTE.**

CAUTION

- **Make sure the motor is properly seated in the transaxle housing.**

NOTE: *Failure to install and tighten the motor mounting bolts in the proper sequence and to the proper tightness may result in motor noise during operation.*

4.4. Tighten the center bolt (3) to 100 in·lb (11.3 N·m).

4.5. Tighten the left and right bolts (1 and 2) to 100 in·lb (11.3 N·m).

4.6. Retighten all three bolts (1, 2, and 3) to 100 in·lb (11.3 N·m).

4.7. Install the motor wires, making sure they are connected to the correct motor terminals and that the terminal orientation is correct. **See page 12-4.** Hold the bottom nut of stud with wrench and tighten the terminal retaining nuts. For 5/16 inch (8mm) diameter studs, tighten the nuts to 100 in·lb (11 N·m). For 1/4 inch (6.3mm) diameter studs, tighten the nuts to 45 in·lb (5.0 N·m).

4.8. Secure the white, orange, green, and blue wires with a wire tie so that none of the motor wires will scrub the motor or transaxle when the vehicle is in operation.

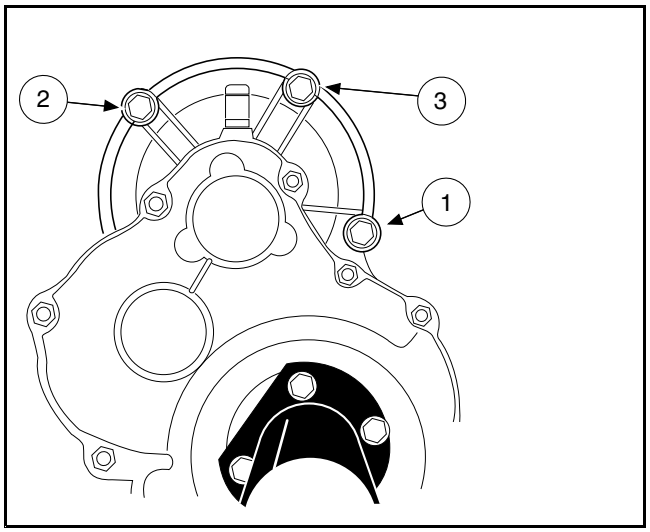
4.9. Connect the three-pin speed sensor wire to the vehicle wire harness.

5. If using a chain hoist, lower the vehicle and guide the leaf springs into the shackles. If using a floor jack, raise the transaxle until the leaf springs can be guided into the shackles.

6. Insert the mounting bolts through the spring shackles and the bushings in the leaf spring eyes and install lock nuts. Tighten the bolts to 23 ft·lb (31 N·m). **See Multi-Leaf Spring Installation, Section 9, Page 9-5.**
7. Install the shock absorbers. Tighten nut until rubber bushing expands to the diameter of the cup washer.
8. If removed, install wheels and finger tighten the lug nuts.
9. Lift vehicle and remove jack stands. Lower vehicle to the floor and tighten lug nuts, using a crisscross pattern, to 65 ft·lb (88 N·m).
10. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
11. Place the Run/Tow switch in the RUN position.
12. Inspect the vehicle for proper operation. **See following WARNING.**

⚠ WARNING

- **Make sure that the vehicle operates in the forward direction when the Forward/Neutral/Reverse control (FNR) is in the F position.**
- **Make sure that the vehicle operates in the reverse direction when the Forward/Neutral/Reverse control (FNR) is in the REVERSE position. The reverse buzzer will sound as a warning when the Forward/Neutral/Reverse control (FNR) is in REVERSE.**
- **Make sure that the vehicle does not operate when the Forward/Reverse switch is in the NEUTRAL position.**



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Figure 16-25 EJ8–4001A Motor Mounting Bolts and Tightening Sequence

SECTION 17 — ELECTRIC VEHICLE - TRANSAXLE

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

LUBRICATION

See General Warnings on page 1-1.

There are two plugs located on the lower half of the transaxle housing. The upper plug (21) (as viewed when the vehicle is on a level surface) is used as a lubricant level indicator **(Figure 17-5, Page 17-3)**. When the vehicle is parked on a level surface, the lubricant level should be even with the bottom of the hole. The lower plug (22) is for draining the lubricant. When draining the lubricant, the upper plug should be removed so the lubricant will drain faster. Be sure the drain plug is installed before filling. **See following NOTE.**

NOTE: *Recycle or dispose of used oil or lubricant in accordance with local, state, and federal regulations.*

AXLE BEARING AND SHAFT

See General Warnings on page 1-1.

AXLE SHAFT

Axle Shaft and Oil Seal Removal

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Place chocks at the front wheels. Loosen lug nuts on rear wheels and lift the rear of the vehicle with a chain hoist or floor jack. Place jack stands under the axle tubes to support the vehicle. **See WARNING "Lift only one end..." in General Warnings on page 1-1.**
3. Remove the rear wheel and brake drum. **See Wheel Brake Assemblies Section and Wheels and Tires Section.**
4. Use 90° internal snap ring pliers to remove the internal retaining ring (1) from the axle tube **(Figure 17-1, Page 17-2)**.
5. Remove the axle (2), retaining ring, and bearing assembly by pulling the axle straight out of the housing.
6. If necessary, remove the axle oil seal and adapter ring.

6.1. Use a bearing puller to remove the axle seal and adapter ring from the axle tube **(Figure 17-2, Page 17-2)**. **See following CAUTION and NOTE.**

CAUTION

- **Do not scar or damage the inside surfaces of the tube when removing the oil seal and adapter ring. A damaged tube might have to be replaced.**

NOTE: *Do not discard the adapter ring. If the adapter ring is lost or damaged, the axle tube will have to be replaced.*

6.2. Use a press to separate the axle oil seal (15) from the adapter ring (39) **(Figure 17-3, Page 17-2)**. Retain the adapter ring and discard the oil seal.

7. Inspect the axle shaft assembly to be sure the bearing and collar have not slipped and are still seated against the shoulder on the axle shaft.

8. Inspect bearing (5) **(Figure 17-5, Page 17-3)**. If the bearing in a Type G transaxle is worn or damaged, the entire axle shaft assembly (1 or 2) must be replaced.

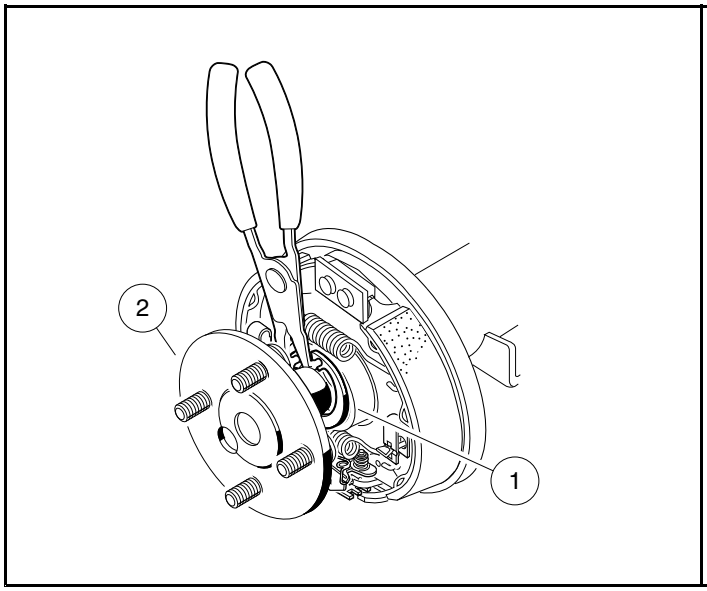


Figure 17-1 Remove Internal Retaining Ring

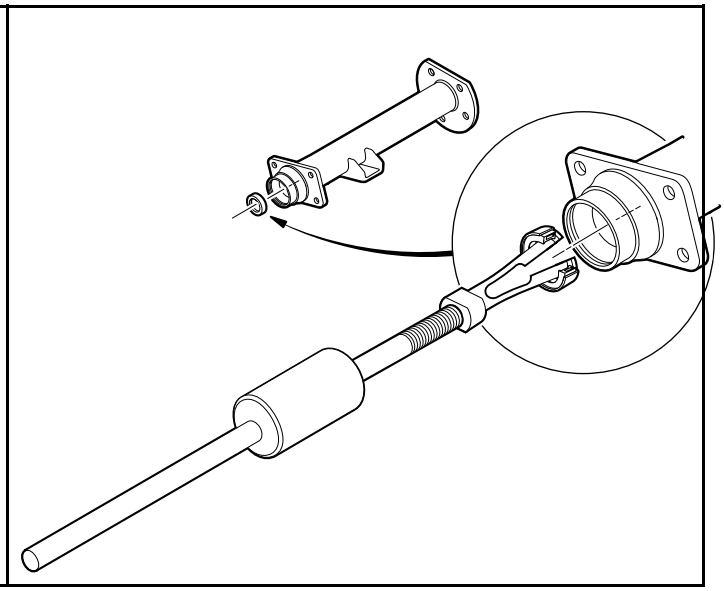
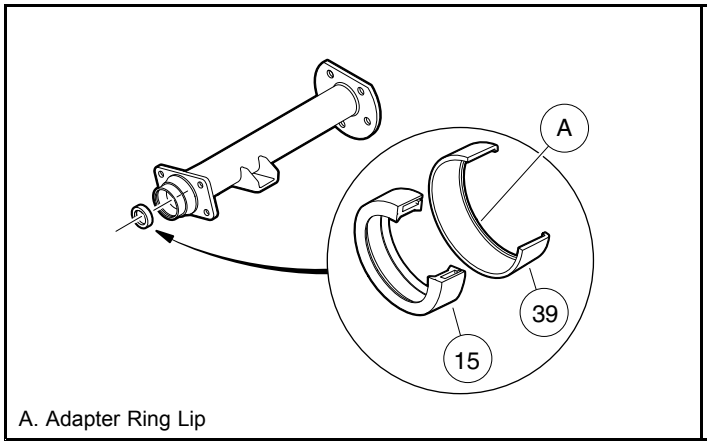


Figure 17-2 Axle Seal and Adapter Ring Removal



A. Adapter Ring Lip

Figure 17-3 Axle Seal and Adapter Ring

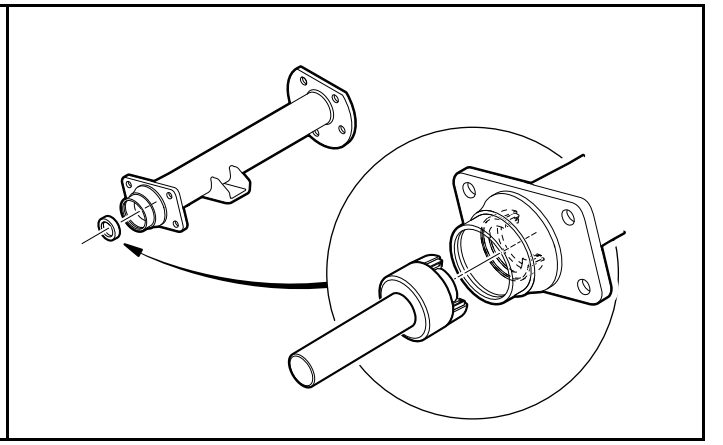


Figure 17-4 Axle Seal and Adapter Ring Installation

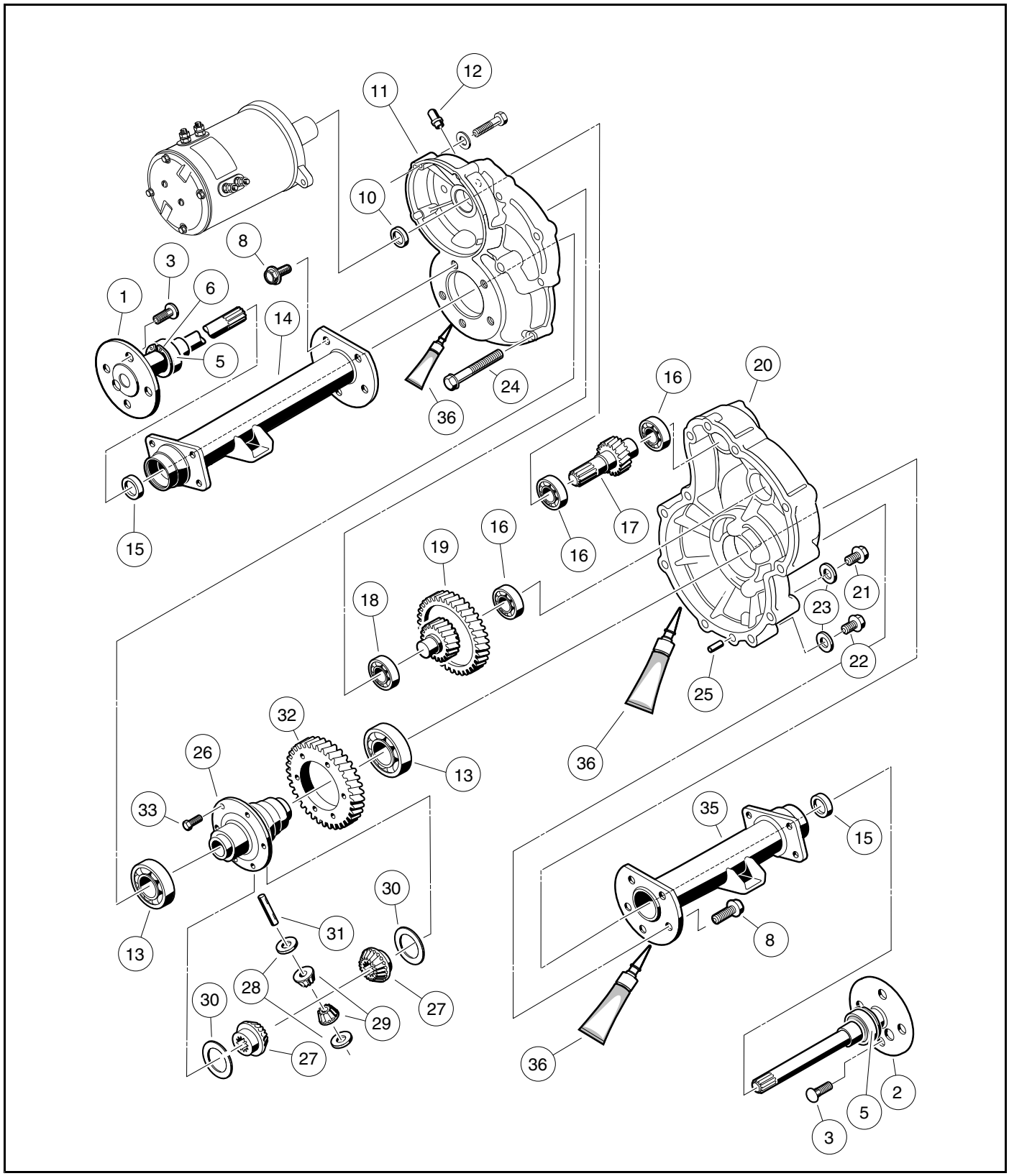


Figure 17-5 Transaxle – Type G

Axle Shaft and Oil Seal Installation

1. If previously removed, install a new oil seal.

1.1. Clean seal seat in the adapter ring (39) **(Figure 17-3, Page 17-2)**.

1.2. Place a new seal (15) in the adapter ring with the seal lip facing toward the adapter ring lip **(Figure 17-3, Page 17-2)**. Use an axle seal tool and mallet to tap it in until it seats firmly in position **(Figure 17-3, Page 17-2)**. A hydraulic press may also be used with the axle seal tool.

1.3. Clean adapter ring seat(s) in the axle tube (14 or 35) **(Figure 17-5, Page 17-3)**.

1.4. Apply Loctite® 603 to the outer diameter of the adapter ring.

1.5. Place the oil seal and adapter ring assembly into the axle tube with the seal lip facing away from the bearing **(Figure 17-4, Page 17-2)**. Use an axle seal tool and mallet to tap it in until it seats firmly in position. **See following CAUTION.**

CAUTION

- **Clean any residual oil from the exposed end of the axle shaft and from the oil seal area prior to installing the axle shaft to prevent oil from coming in contact with brakes.**

2. Install the rear axle into the transaxle. **See following NOTE.**

2.1. Insert the shaft, splined end first, through the seal and into the axle tube. Be careful not to damage the seal on the inside of the axle tube hub. Advance the shaft through to the bearing on the shaft, then rotate it to align the shaft splines with the splined bore of the differential side gear (27) **(Figure 17-5, Page 17-3)**. Continue advancing the shaft until the bearing on the axle is firmly seated within the axle tube hub seat.

2.2. Use a pair of snap ring pliers to install the retaining ring (6) inside axle tube hub so that it seats against the axle bearing assembly and into the machined slot in the inside wall of the axle tube hub **(Figure 17-5, Page 17-3)**. **See following NOTE.**

NOTE: *If the retaining ring (6), axle bearing (5), or sleeve (4) must be replaced, the entire axle shaft assembly (1 or 2) must be replaced **(Figure 17-5, Page 17-3)**.*

2.3. Place a 1/4 to 3/8-inch (6 to 10 mm) diameter rod against the retaining ring and tap lightly at four to five locations around the retaining ring to ensure it is properly seated. **See following WARNING.**

⚠ WARNING

- **Be sure the retaining ring is properly seated in its groove. If the ring is not properly installed, the axle assembly will separate from the transaxle and damage the axle assembly and other components. Loss of vehicle control could result, causing severe personal injury or death.**

3. If a new oil seal was installed, allow 24 hours before operating the vehicle to allow the Loctite 603 to fully cure.
4. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

AXLE BEARING

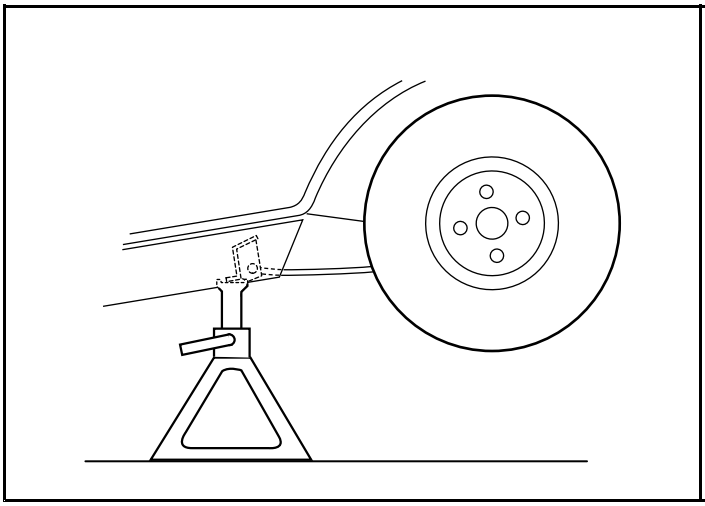
Do not remove the axle bearing (5) from a Type G transaxle. If bearing is worn or damaged, the entire axle assembly (1 or 2) must be replaced **(Figure 17-5, Page 17-3)**.

TRANSAXLE

See General Warnings on page 1-1.

TRANSAXLE REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
2. Place chocks at the front wheels and slightly loosen lug nuts on both rear wheels.
3. Place a floor jack under the transaxle and raise the rear of the vehicle. Position jack stands under the frame crossmember between the spring mount and the side stringer, just forward of each rear wheel. Lower the vehicle to let the jack stands support the vehicle **(Figure 17-6, Page 17-5)**. **See WARNING "Lift only one end of the vehicle..." in General Warnings on page 1-1.**
4. Remove the rear wheels, then thread one lug nut onto a stud on each rear hub. This will keep the brake drums on the hubs.
5. Remove the bow tie pins (1), brake cable clevis pins (2), and cable retaining E-clips (3). Disconnect the brake cables (4) **(Figure 17-7, Page 17-5)**.



2600-30000-10369

Figure 17-6 Vehicle Supported on Jack Stands

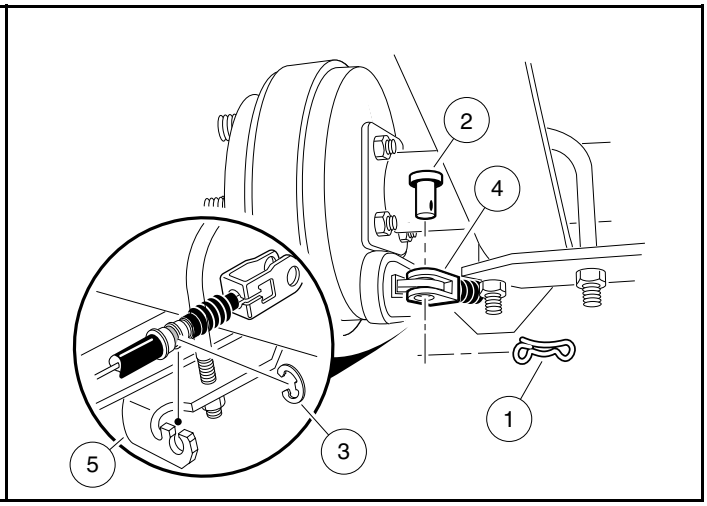
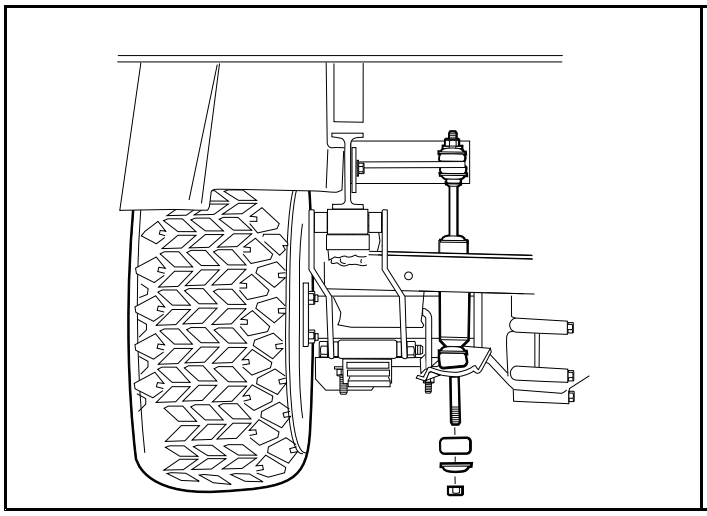
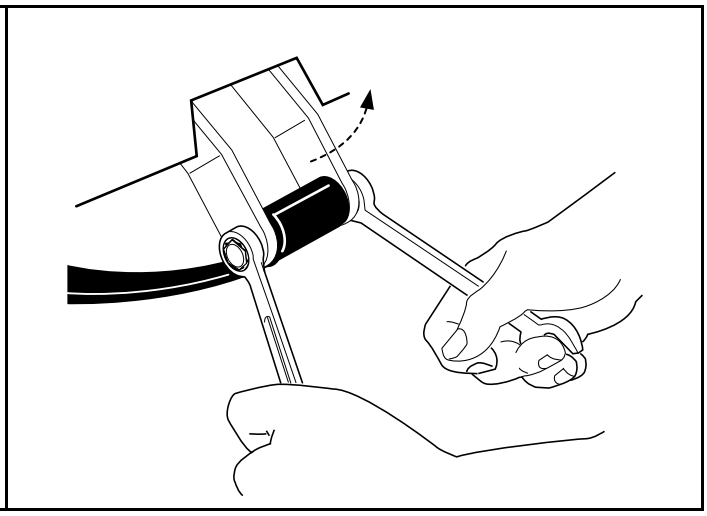


Figure 17-7 Brake Cables



2629

Figure 17-8 Disconnect Shocks



2631

Figure 17-9 Detach Spring From Shackles

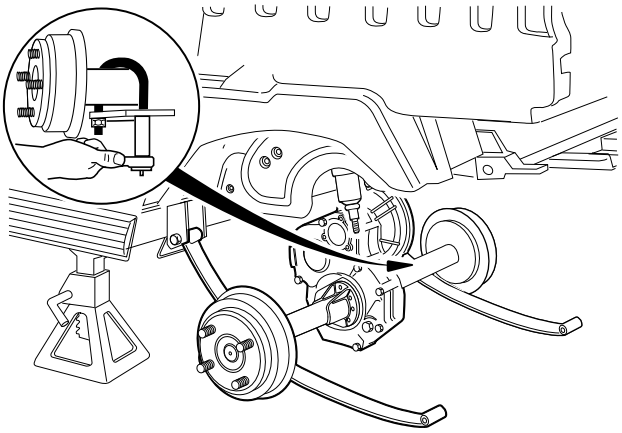
6. Disconnect the shock absorbers from their lower mounts **(Figure 17-8, Page 17-6)**.
7. Disconnect the four motor wires. Use two wrenches to prevent the post from turning.
8. With a floor jack supporting the transaxle, remove lower spring shackle nuts and bolts. Rotate shackles up and away from springs **(Figure 17-9, Page 17-6)**.
9. If a chain hoist was used to raise the vehicle, lift the vehicle high enough to permit easy access and clearance for removal of the motor. If a floor jack was used to raise the vehicle, lower the transaxle enough to permit easy access and clearance for removal of the motor.
10. Remove the three motor mounting bolts **(Figure 17-11, Page 17-7)** and the motor positioning bolt **(Figure 17-12, Page 17-7)** mounting the motor to the transaxle. **See following CAUTION.**

⚠ CAUTION

- **Do not position fingers under motor when sliding motor off of the input shaft. Fingers may get pinched when motor disengages.**

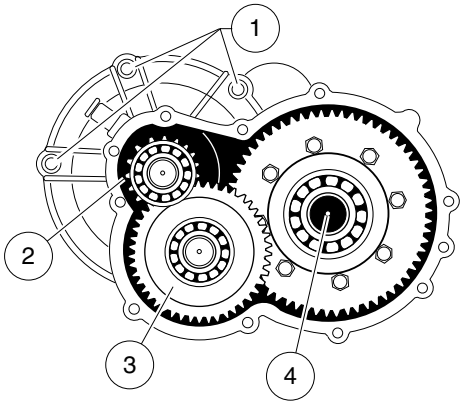
CAUTION CONTINUED ON NEXT PAGE

⚠ CAUTION



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Figure 17-10 Detach Axle From Leaf Springs



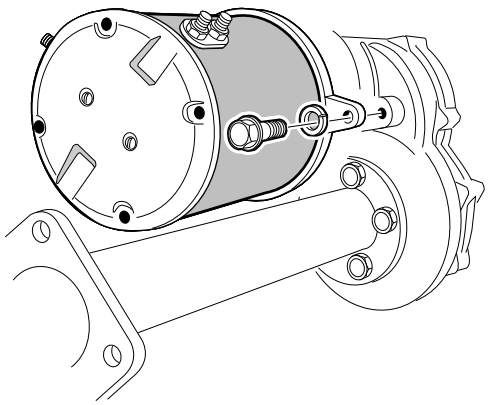
1. **Motor Mounting Bolts**
2. **Input Pinion Gear**
3. **Intermediate Gear Assembly**
4. **Differential Gear Case**

Figure 17-11 Motor Mounting Bolts and Gear Assembly

11. Carefully remove the motor from the transaxle. Slide the motor away from the transaxle until the motor spline becomes disengaged from the input shaft, then lift motor out. **See preceding WARNING.**
12. If a floor jack was used, pull floor jack from beneath the transaxle and allow the springs to rest on the floor.
13. Remove the U-bolts attaching the transaxle to the leaf springs **(Figure 17-10, Page 17-7)**.
14. Carefully lift each end of the transaxle off its positioning pin (on the leaf spring) and slide the transaxle to the rear and out of the vehicle.
15. Drain the lubricant from the transaxle and remove the axle shafts. **See Axle Shaft and Oil Seal Removal on page 17-1. See following NOTE.**

NOTE: *Recycle or dispose of used oil or lubricant in accordance with local, state, and federal regulations.*

16. Remove the brake assemblies if required. **See Wheel Brake Assemblies Section.**



Appearance of motor may be different from the motor shown above.

Figure 17-12 Motor Positioning Bolt

TRANSAXLE DISASSEMBLY, INSPECTION, AND ASSEMBLY

See General Warnings on page 1-1.

TRANSAXLE DISASSEMBLY AND INSPECTION

1. To detach axle tubes (14 and 35) from the transaxle housing, remove the bolts (8) **(Figure 17-5, Page 17-3)**.
2. Remove 11 bolts (24) that hold housing together.
3. Pull the halves of the housing (11 and 20) apart. If necessary, tap lightly on the spline of the input pinion (17). **See following CAUTION.**

CAUTION

- **To prevent damage to the housing mating seal surfaces, use caution when separating halves.**

4. Remove input pinion gear (17) by pulling gear out while rocking intermediate gear assembly (19). Lift intermediate gear assembly and differential gear case unit out simultaneously **(Figure 17-5, Page 17-3)**. **See following CAUTION.**

CAUTION

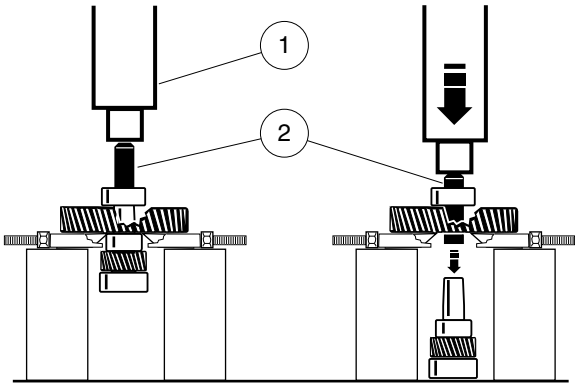
- **Do not damage gears. Use extreme care when handling them.**

5. Use a bearing puller or arbor press to remove bearings (16) from the input pinion gear. If the oil seal (10) is damaged, replace it **(Figure 17-5, Page 17-3)**. **See also Figure 17-13, Page 17-8. See following CAUTION.**

CAUTION

- **Do not reuse bearings after removing them. Replace bearings with new ones.**

6. To disassemble the intermediate gear assembly, press off together the bearing (16) and the gear (19) **(Figure 17-5, Page 17-3)**. **See also Figure 17-13, Page 17-8.**
7. Press the bearing (18) off the intermediate gear assembly **(Figure 17-5, Page 17-3)**.



1. Press Ram
2. Arbor

Figure 17-13 Intermediate Gear Assembly

8. Disassemble the differential gear case:

8.1. Remove the hex bolts (33) and the ring gear (32) from the differential case **(Figure 17-5, Page 17-3)**.

8.2. Remove the ring gear.

8.3. Separate the differential gear case housing. If necessary, install two of the hex bolts (removed previously in step 8.1) into the differential gear unit and, while holding the unit slightly above the work area, lightly tap the bolt heads **(Figure 17-14, Page 17-9)**. Remove the two bolts.

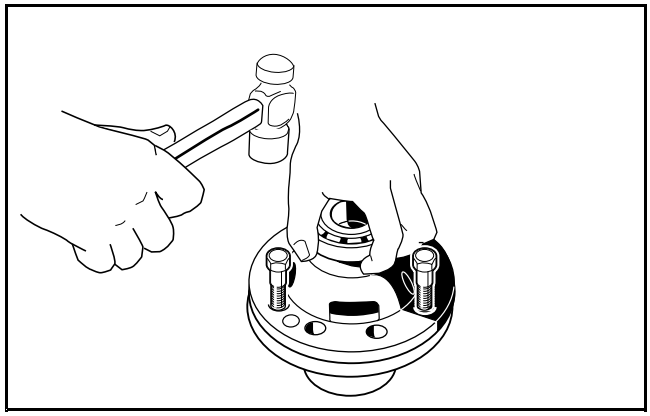


Figure 17-14 Separate Housing

8.4. Remove the differential pin (31) by pushing pin through differential gear case from one side **(Figure 17-5, Page 17-3)**. **See also Figure 17-15, Page 17-9.**

8.5. Remove the idler gears (1 and 2) and thrust plates (3 and 4) **(Figure 17-16, Page 17-9)**.

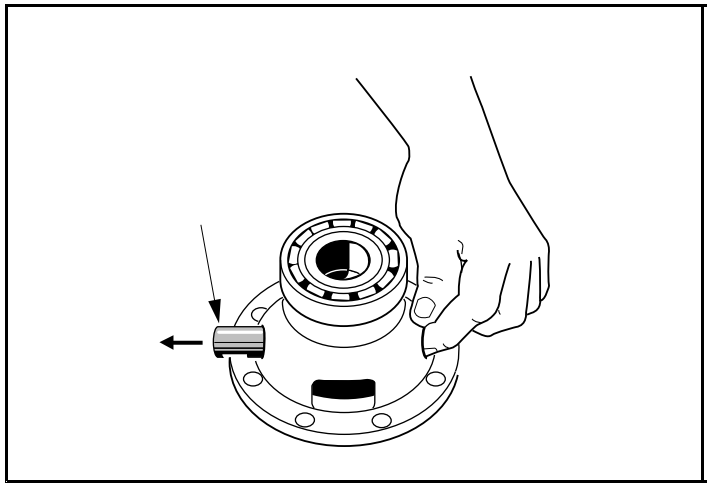


Figure 17-15 Differential Pin

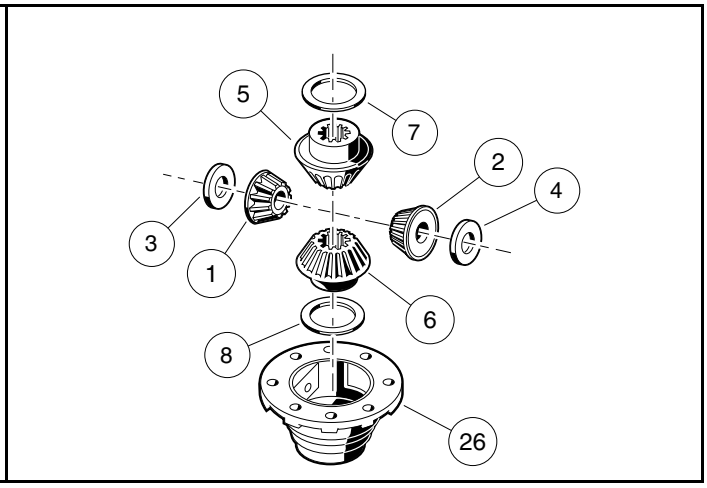


Figure 17-16 Left Differential

8.6. Remove the differential gears (5 and 6) and thrust plates (7 and 8).

8.7. Inspect the bearings (13) of the differential case (26) and replace them if they are damaged **(Figure 17-5, Page 17-3)**. To remove them, press them off. **See following CAUTION.**

CAUTION

- **Do not reuse bearings after removing them. Replace bearings with new ones.**

9. Inspect parts for wear or damage. Any worn or damaged parts should be replaced. **See following NOTE.**

NOTE: *Damaged or worn gears should be replaced as sets.*

TRANSAXLE ASSEMBLY

CAUTION

- **Do not press against the bearing outer race.**
- **The housing and all parts must be wiped clean and dry before reassembly.**

1. If bearings (13) were removed during disassembly, install new bearings using an arbor press **(Figure 17-5, Page 17-3)**.
2. Assemble the differential gear case.

2.1. Install the pin (31) **(Figure 17-5, Page 17-3)**. Apply a small amount of oil to all thrust plates and to both ends of the pin.

2.2. Install the hex bolts (33) and output gear (32). Tighten bolts to 58 ft·lb (78.6 N·m).

3. Press a new bearing (18) onto the intermediate gear assembly **(Figure 17-5, Page 17-3)**.
4. Press new bearing (16) onto input pinion gear (17).
5. Apply grease to the lip of the new oil seal (10) and install the seal using a transaxle pinion seal tool. The lip of the oil seal should face the inside of the transaxle housing. Make sure the seal is firmly seated.
6. Install the differential assembly, the intermediate gear assembly, and the input pinion gear simultaneously. Be sure all bearings are seated properly in the housing. Rotate the input shaft to check for smooth gear operation **(Figure 17-11, Page 17-7)**.
7. Install both dowel pins (25) in the transaxle housing (20) **(Figure 17-5, Page 17-3)**.
8. Install left half of transaxle housing:

8.1. Place a 1/8-inch (3 mm) bead of Three Bond liquid gasket on mating surface of housing.

8.2. Install left half of transaxle housing (20) **(Figure 17-5, Page 17-3)**.

8.3. Install eleven bolts (24) in the case housing and tighten to 19 ft·lb (25.7 N·m). Type G transaxles have no shims or gasket.

8.4. Install axle tube (14 and 35) with bolts (8) **(Figure 17-5, Page 17-3)**. Tighten the bolts to 37 ft·lb (50.2 N·m).

9. Install the brake assemblies as instructed. **See Wheel Brake Assemblies Section.**
10. Apply a small amount of grease to the lip of the oil seal (15) **(Figure 17-5, Page 17-3)**. **See following CAUTION.**

⚠ CAUTION

- **Clean any residual oil from the exposed end of the axle shaft and from the oil seal area prior to installing the axle shaft to prevent oil from coming in contact with brakes.**

11. Install the rear axle onto the transaxle.

11.1. Insert the splined end of the axle shaft into the axle tube. Be careful not to damage the seal on the inside of the axle tube hub. Advance the shaft through to the bearing on the shaft, and rotate it to align the shaft splines with the splined bore of the differential gear. Continue advancing the shaft until the bearing on the axle is firmly seated within the axle tube hub seat.

11.2. Using 90° internal snap ring pliers (0.090 tip), attach the internal retaining ring into the axle tube hub so that it seats against the axle bearing assembly and into the machined slot in the inside wall of the axle tube hub **(Figure 17-5, Page 17-3)**.

11.3. Place a 1/4 to 3/8-inch (6 to 10 mm) diameter rod against the retaining ring and tap lightly at four or five locations to ensure it is properly seated. **See following WARNING**.

⚠ WARNING

- **Be sure retaining ring is properly seated in its groove. If ring is not properly installed, the axle assembly will separate from the transaxle and damage the axle assembly and other components. Loss of vehicle control could result in severe personal injury or death.**

12. Make sure the drain plug (22) is installed in the transaxle and tightened to 23 ft·lb (31 N·m). Fill the transaxle, through the level indicator hole, with 22 fl-oz of SAE 30 API Class SE, SF, or SG oil (a higher grade may also be used). Install and tighten the level indicator plug (21) to 23 ft·lb (31 N·m).

TRANSAXLE INSTALLATION

See General Warnings on page 1-1.

1. If using a chain hoist, raise the vehicle and place transaxle in position on the jack stands. If using a floor jack, lower the jack stands to their lowest settings and place the transaxle in position on the jack stands.
2. Align the center hole in the saddle of the transaxle with the pilot bolt in the leaf spring assembly.
3. Install the two U-bolts, jounce bumper mount (if required), and spacers, lockwashers, and nuts. Tighten the nuts to 25 ft·lb (34 N·m). Tighten the U-bolt nuts so an equal amount of thread is visible on each leg of the bolt.
4. Install the motor. **See Motor Installation on page 16-15.**
5. If using a chain hoist, lower the vehicle while guiding the leaf springs into the rear spring shackles. If using a floor jack, raise the differential while guiding the leaf springs into the rear spring shackles. Then raise the jack stands to support the transaxle.
6. Connect the four motor wires. Tighten the retaining nuts to 65 in·lb (7.3 N·m). Use two wrenches to prevent the posts from turning. **See following NOTE.**

NOTE: *If the motor wires were not tagged when disconnected, refer to the wiring diagram for proper connection.* ***See Sonic Weld, Diode, and 10k Ohm Resistor Locations, Section 12, Page 12-4.***

7. Insert bolts through the spring shackles and bushings in the leaf spring eyes. Secure bolts with locknuts. Tighten to 15 ft·lb (20.3 N·m).
8. Connect the brake cables using new bow tie pins (1) **(Figure 17-7, Page 17-5)**.
9. Install the shock absorbers. Tighten shock absorber retaining nuts until the rubber bushings expand to the same size as the cup washers.
10. Install the rear wheels and finger-tighten the lug nuts.
11. Lift the vehicle and remove the jack stands.
12. Lower vehicle and tighten the lug nuts using a crisscross pattern. **See Wheel Installation, Section 8, Page 8-1.**
13. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
14. Inspect the vehicle to check for proper operation. **See following WARNING.**

⚠ WARNING

- **Make sure that the vehicle operates in the forward direction when the Forward/Neutral/Reverse control (FNR) is in the F position.**
- **Make sure that the vehicle operates in the reverse direction when the Forward/Neutral/Reverse control (FNR) is in the REVERSE position. The reverse buzzer will sound as a warning when the Forward/Neutral/Reverse control (FNR) is in REVERSE.**
- **Make sure that the vehicle does not operate when the Forward/Reverse switch is in the NEUTRAL position.**

SECTION 18 — GASOLINE VEHICLE - TROUBLESHOOTING AND ELECTRICAL SYSTEM

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

GENERAL INFORMATION

⚠ WARNING

- **To prevent damage to the ECU, never mix the black and gray connectors that attach to it. The black connector is tethered to the ECU mounting plate to help avoid installing it in the gray port.**

This section contains the information required to correctly troubleshoot the EFI gas vehicle. In addition to troubleshooting, this section contains general information on the electrical system and the circuits of the electrical system.

Most components are shared between pedal-start and key-start systems except for the following items unique to the key-start vehicle:

- **Key Switch:** Only way to start and shut off the engine.
- **Accelerator Pedal:** Is not linked to the accelerator pedal limit switch and kill limit switch in the electrical component box because these switches are omitted for key-start applications.
- **Charging Diode:** Is connected to the solenoid in the electrical component box.
- **Forward/Neutral/Reverse control (FNR):** Is not linked to the neutral lockout limit switch on the transaxle because this switch is omitted for key-start applications.

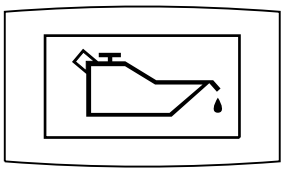
ACCESSORIES

For powered accessories that do not need to be controlled by the key switch, use the red/white and black/yellow wires with female, quick-disconnect terminals located behind the instrument panel.

LOW OIL WARNING LIGHT

CAUTION

- **Failure to add oil immediately when the low oil warning light stays on may result in permanent engine damage.**
- **A high engine temperature for too long can cause engine damage. When the low oil warning light flashes, open the louver arm immediately.**



The low oil warning light gives a visual indication of an oil level problem.
If equipped with Kit Instruction TPCC040401EN019 Edition B ECH440 Engine Oil Dilution Prevention, the engine temperature is too high

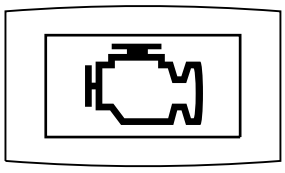
Figure 18-1 Low Oil Warning Light

STATUS	CONDITION
OFF	Normal Operation
FLASHING	The engine temperature is at or above 283.1°F (139.5°C). When possible: 1. Stop the vehicle. 2. Turn the key to OFF. 3. Open the louver arm. 4. Turn the key to ON. 5. Wait for 15 minutes or until the low oil warning light is off.
ON	When possible: 1. Stop the vehicle. 2. Turn the key to OFF. 3. Examine the engine oil level. 4. Add engine oil as necessary. 5. If the low oil level warning light stays on, have a trained technician examine the vehicle.

MALFUNCTION INDICATOR LIGHT

CAUTION

- **A high engine temperature for too long can cause engine damage. When the malfunction indicator light (MIL) flashes, open the louver arm immediately.**



The malfunction indicator light (MIL) gives a visual indication when:

- Key switch is set to ON
- Engine fault code is active
- If equipped with Kit Instruction TPCC040401EN019 Edition C ECH440 Engine Oil Dilution Prevention, the engine temperature is too high

STATUS	CONDITION
OFF	Normal Operation
ON (for three seconds)	Normal Operation when the key switch is set to ON.
FLASHING	The engine temperature is at or above 283.1°F (139.5°C). When possible: 1. Stop the vehicle. 2. Turn the key to OFF. 3. Open the louver arm. 4. Turn the key to ON. 5. Wait for 15 minutes or until the MIL is off.
ON	The engine has sensed a fault. See the Kohler Engine Service Manual for more information.

GROUND LOCATIONS

Electrical grounds are located at the following areas:

- **Below the Battery:** The battery, starter/generator, voltage regulator and main wire harness are all grounded to the chassis on the frame rail below the battery.
- **In Front of Engine:** The engine is grounded to the chassis cross-member with an un-insulated, braided wire.
- **Top of Fuel Tank:** The fuel tank is grounded to the chassis through the main wire harness.

FEATURES OF THE ELECTRONIC FUEL INJECTION (EFI) SYSTEM

- Closed-loop system, oxygen (O2) sensor included
- Controls fuel pump, fuel injector, malfunction indicator light (MIL)
- Inputs: Temperature/Manifold Absolute Pressure (TMAP), Throttle Position Sensor (TPS), oxygen (O2) sensor, crank sensor, ignition timing, cylinder head temp
- Separate EFI wire harness

TROUBLESHOOTING GUIDE

The following troubleshooting guides will be helpful in identifying operating difficulties should they occur. The guides include the symptom, probable cause(s) and suggested checks. The procedures used in making these checks can be found in the referenced sections of the maintenance and service manual.

GASOLINE POWERTRAIN

TROUBLESHOOTING GUIDE		
SYMPTOM	**POSSIBLE CAUSES**	**CORRECTIVE ACTION**
Engine starts to run rough and continuously gets worse	The engine temperature is too high. The ECU is derating the engine. The louver arm is closed.	If a engine oil dilution prevention kit has been installed, open the engine fan louver. See Louver Arm, Low Oil Warning Light, and Malfunction Indicator Light for more information.
Starter fails to operate.	Maintenance/Operate switch is in the MAINTENANCE position	Set the Maintenance/Operate switch to OPERATE
	Fuse is blown	See the Fuses Test Procedure
	Battery is dead	See the Battery Test Procedure
	Starter control circuit is not operating	**Pedal-Start:** See the Key Switch (Start Circuit) Test Procedure **Key-Start:** See the Key Switch Test Procedures
	Starter/generator failed	See the Starter/Generator (Starter Function) Test Procedure
	Starter solenoid failed	See the Solenoid Test Procedure
	Accelerator pedal limit switch failed	See the Accelerator Pedal Limit Switch (Pedal-Start) Test Procedure
	Key switch failed	**Pedal-Start:** See the Key Switch (Start Circuit) Test Procedure **Key-Start:** See the Key Switch Test Procedures
	Neutral lockout limit switch failed	See the Neutral Lockout Limit Switch (Pedal-Start) Test Procedure
	Loose or broken wire in starter/generator circuit	See Starter/Generator in the Electrical Components Section
	Cylinder and/or crankcase flooded with fuel	See the Fuel System Section
Starter/generator does not charge battery.	Loose or broken wire in the starter/ generator circuit	See the Starter/Generator (Generator Function) Test Procedure
	Generator field coil is shorted	See the Starter/Generator (Generator Function) Test Procedure
	Brushes are worn or commutator is dirty	See Starter/Generator in the Electrical Components Section
	Starter/generator belt is loose or slipping	See Belt Tension Adjustment For EFI Engines in the Electrical Components Section
	Voltage regulator failed	See the Voltage Regulator Test Procedure
	Battery failed	See the Battery Test Procedure

TABLE CONTINUED ON NEXT PAGE

TROUBLESHOOTING GUIDE		
SYMPTOM	**POSSIBLE CAUSES**	**CORRECTIVE ACTION**
Transmission does not engage or disengage smoothly.	Transmission shifter linkage is binding or is out of adjustment	See the Transaxle (ED65) Section
	Insufficient (low) level of lubricant or wrong type of lubricant in transmission	See the Transaxle (ED65) Section
	Internal gears are damaged or worn	See the Transaxle (ED65) Section
	Dog clutch jammed or broken	See the Transaxle (ED65) Section
Excessive vehicle vibration.	Engine mounting nuts or bolts are loose	See the Engine (Kohler ECH440) Section
	Snubber on frame is worn or damaged	See the Engine (Kohler ECH440) Section
	Loose muffler mounting hardware	See the Exhaust System: Gasoline Vehicles Section
	Damaged drive belt or starter belt	See the Clutches: Gasoline Vehicles Section
	Damaged drive clutch	See the Clutches: Gasoline Vehicles Section
	Damaged starter/generator pulley	See Starter/Generator in the Electrical Components Section
	RPM setting is incorrect	See Engine RPM Adjustment in the Fuel System Section
Clutches do not shift smoothly.	Drive belt is worn, cracked, glazed, or frayed	See the Clutches: Gasoline Vehicles Section
	Drive clutch malfunction	See the Clutches: Gasoline Vehicles Section
	Governor is sticking	See the Transaxle (ED65) Section
Engine won't stop running.	Kill circuit wire is disconnected from the ignition coil	See the Kill Limit Switch (Pedal-Start) Test Procedure
	Accelerator pedal linkage out of adjustment causing engine kill limit switch not to activate	See the Fuel System: Gasoline Vehicles Section
	Fuel mixture is too lean; check EFI	See the Fuel System: Gasoline Vehicles Section
	Throttle stop screw out of adjustment at governor arm	See the Fuel System: Gasoline Vehicles Section

ELECTRICAL SYSTEM

The electrical system on the gasoline vehicle is 12 volts DC with negative (–) ground to frame, and consists of the following circuits that are easily identified:

- Starter Circuit
- Generator Circuit
- Electronic Fuel Injection Circuit
- Engine Ignition Circuit
- Engine Kill Circuit
- Reverse Buzzer Circuit
- Low Oil Warning Light Circuit
- Neutral Lockout Circuit
- Fuel Pump Circuit
- Fuel Gauge and Sending Unit Circuit
- Hour Meter Circuit
- Lighting Circuit

Recognizing and understanding the function of each of these circuits will help to quickly isolate the source of an electrical problem. Use the appropriate test procedure to correct the electrical problem. See Test Procedures.

For a complete wiring diagram, see the Wiring Diagrams for Pedal-Start or Key-Start vehicles.

TEST PROCEDURES

Using the following procedures, the entire electrical system can be tested without major disassembly of the vehicle.

⚠ WARNING

- **If wires are removed or replaced, make sure wiring and wire harness is properly routed and secured. Failure to properly route and secure wiring could result in vehicle malfunction, property damage, personal injury, or death.**

For some tests, the electrical component box cover must be removed to gain access to the various components that are mounted inside the component box. **See following WARNING.**

⚠ WARNING

- **Shorting of battery terminals can cause personal injury or death.**

After test procedures are completed, be sure to replace the cover. **See following CAUTION.**

CAUTION

- **Exposure to water and the elements may damage electrical components. Do not operate vehicle without the cover properly installed.**

TESTING BASICS

- Battery voltage will be referenced throughout the test procedures. Battery voltage is accessed in the Battery test procedure.
- The Maintenace/Operate switch, in the MAINTENANCE position, grounds and kills the ignition if the Forward/Neutral/Reverse control (FNR) is placed in F or R.
- The key switch powers the ECU, fuel pump, solenoid, lights, and the connected car device.
- The 2-amp fuse is powered by the key switch via the 10-amp ATM fuse and carries battery voltage to the connected car device.
- The term “back-probe” refers to probing the side of a connector that the wire enters. This is usually done when the connector must remain connected to a device. An alternative method is to use an insulation-piercing probe. **See following CAUTION.**

CAUTION

- **Be careful not to damage the wire or terminal when back-probing.**

- When testing voltage, the battery must remain connected.
- When testing voltage, unless specifically directed to do otherwise in a procedure, connect the black (–) probe of the multimeter to chassis ground.
- When testing resistance or continuity, turn off power to the circuit being measured and discharge any capacitor(s). The presence of voltage can cause inaccurate readings.

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7 – Solenoid - Pedal-Start Vehicles Only
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TEST PROCEDURE 1 – Battery

See General Warnings on page 1-1.

⚠ DANGER

- **Due to the danger of an exploding battery, wear a full face shield and rubber gloves when working near a battery.**
- **Battery – Explosive gases! Do not smoke. Keep sparks and flames away from the vehicle and service area. Ventilate when charging or operating vehicle in an enclosed area. Wear a full face shield and rubber gloves when working on or near batteries.**
- **Battery – Poison! Contains acid! Causes severe burns. Avoid contact with skin, eyes, or clothing. Antidotes:**
  - **External: Flush with water. Call a physician immediately.**
  - **Internal: Drink large quantities of milk or water. Follow with milk of magnesia or vegetable oil. Call a physician immediately.**
  - **Eyes: Flush with water for 15 minutes. Call a physician immediately.**

NOTE: *The battery must be properly maintained and fully charged in order to perform the following test procedures. Battery maintenance procedures can be found in the Electrical Components: Pedal-Start Gas Vehicle section.*

1. Disable the vehicle.
2. Set the Maintenance/Operate switch to MAINTENANCE.
3. Check for loose or corroded battery terminal connections.
4. Disconnect the battery.
5. Clean the battery terminals and connections. Replace the connections and wires as necessary.
6. Connect the battery.

Voltage Test

1. Set the multimeter to 20 VDC.
2. Put the red (+) probe on the positive (+) battery post.
3. Put the black (-) probe on the black (-) battery post.

3.1. If the voltage is more than 12.4 volts, the battery is good.

3.2. If the voltage is less than 12.4 volts, charge the battery. Go to the next step.

3.2.1. If the voltage does not reach 12.4 volts after charging, replace the battery.

Load Test

1. Make a note of the ambient temperature.
2. Connect a 160-ampere load tester to the battery posts.
3. Turn the switch on the load tester to the ON position.
4. Wait for 15 seconds. Read the battery voltage. Compare the battery's voltage reading with the following table.

IF TEMPERATURE IS	MINIMUM CRANKING VOLTAGE
70 °F (20 °C and above)	9.6 V
60 °F (16 °C)	9.5 V
50 °F (10 °C)	9.4 V
40 °F (4 °C)	9.3 V
30 °F (-1 °C)	9.1 V
20 °F (-7 °C)	8.9 V
10 °F (-12 °C)	8.7 V
0 °F (-18 °C)	8.5 V

5. If the battery voltage is less than the minimum cranking voltage, replace the battery. Go to next step.

5.1. If the electrical problem continues, test the electrical circuits.

6. If the battery voltage is the minimum cranking voltage or higher, test the electrical circuits.

TEST PROCEDURE 2 – Fuses

See General Warnings on page 1-1.

⚠ WARNING

- **Failure to use properly rated fuse can result in a fire hazard.**

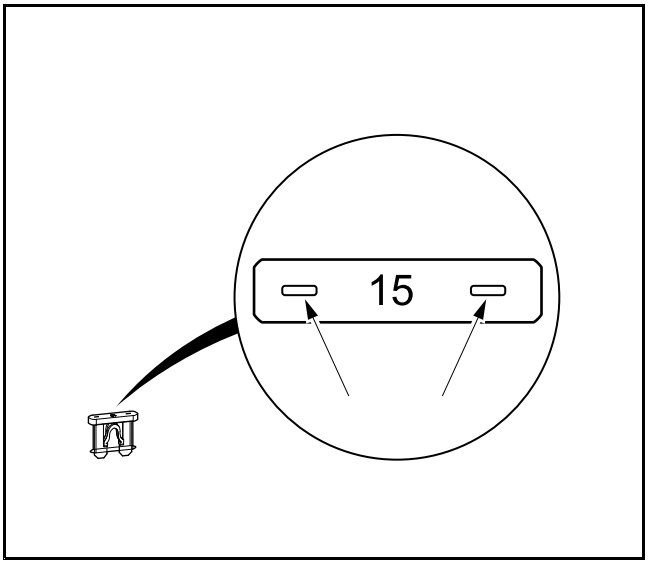
NOTE: *These vehicles predominately use a combination of ATC-style and ATM-style blade fuses. A single ABC-style glass fuse is used for the Guardian/Visage 4-pin connector that is labeled "V3 circuit" on the harness.*

This is a voltage test. It can be performed relatively easily on ATC-style and ATM-style fuses. A voltage test can be performed on the ABC-style glass fuse if insulation-piercing probes are used. Otherwise, the ABC-style will have to be removed to visually inspect or check using a continuity test.

ATC-style blade fuses are located inside the electrical component box near the battery.

ATM-style blade fuses are located on the main wire harness in front of the engine.

The ABC-style glass fuse is located on the main wire harness underneath the front cowl.



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Figure 18-2 Testing the ATC and ATM-style Blade Fuse

1. If necessary, see Testing Basics.
2. Access the fuse but do not remove it.
3. **10-amp ATC and ATM Fuses Only:** With the battery and solenoid connected:

3.1. Probe the two, small metal contacts on the top of the fuse **(Figure 18-2, Page 18-11)**.

3.2. Each contact should show battery voltage.

3.3. If only one side shows battery voltage, replace fuse.

3.4. If neither side of a fuse shows battery voltage, inspect the following locations:
– Wire connections at the solenoid.

4. **5-amp ATM Fuse Only:** With the key switch in the ON position:

4.1. Probe the two, small metal contacts on the top of the fuse **(Figure 18-2, Page 18-11)**.

4.2. Each contact should show battery voltage.

4.3. If only one side shows battery voltage, replace fuse.

4.4. If neither side of a fuse shows battery voltage, inspect the following locations:
– 12-pin dash wire harness connector, key switch and sonic weld 3.

5. **2-amp ABC Glass Fuse Only:** With the key switch in the ON position:

5.1. Probe the wire on each side of the fuse with insulation-piercing probes.

5.2. Each probe should show battery voltage.

5.3. If only one side shows battery voltage, replace fuse.

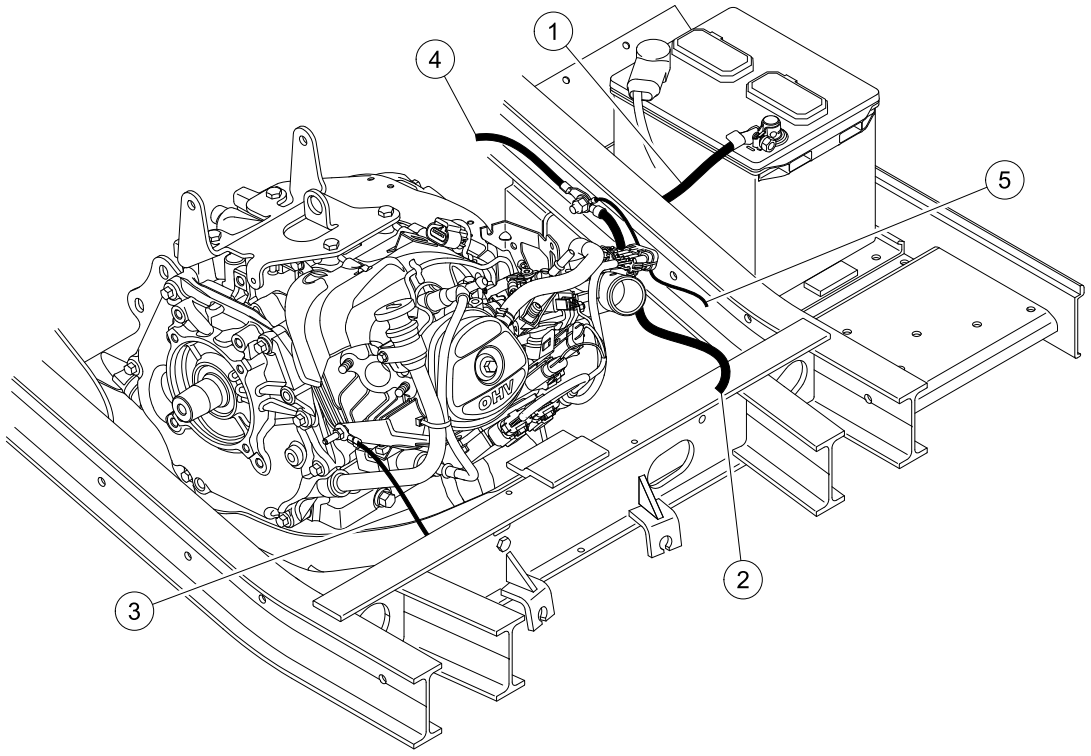
5.4. If neither side of a fuse shows battery voltage, inspect the following locations:
– 5-amp ATM fuse, 12-pin dash wire harness connector, key switch and sonic weld 3.

TEST PROCEDURE 3 – Ground Cables

See General Warnings on page 1-1.

NOTE: *This is a continuity test for the main ground wire of the vehicle. An additional ground wire is located on top of the fuel tank.*

1. If necessary, see Testing Basics.
2. Disconnect battery and spark plug wire.
3. Check the following wires and cables for clean, tight connections and continuity **(Figure 18-3, Page 18-13)**:
   – Check the starter/generator ground cable (black wire) from A1 terminal to chassis.
   – Check the battery ground cable from the disconnected terminal to chassis.
   – Check the engine ground cable from engine block to chassis.
4. The reading should be continuity. If the reading is incorrect, clean and tighten cable connections. If the connections are good and the reading is incorrect, repair or replace the wire or cable.



1. Battery Ground 2. Main Wire Harness Ground 3. Engine Ground Cable 4. Starter/Generator Ground (from A1 Terminal) 5. Voltage Regulator Ground Wire (from electrical component box)
Side-Post Battery Shown

Figure 18-3 Ground Wires and Cables

TEST PROCEDURE 4 – Key Switch (Start Circuit) - Pedal-Start Vehicles Only

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

The key switch provides power and KEY INPUT to the ECU.

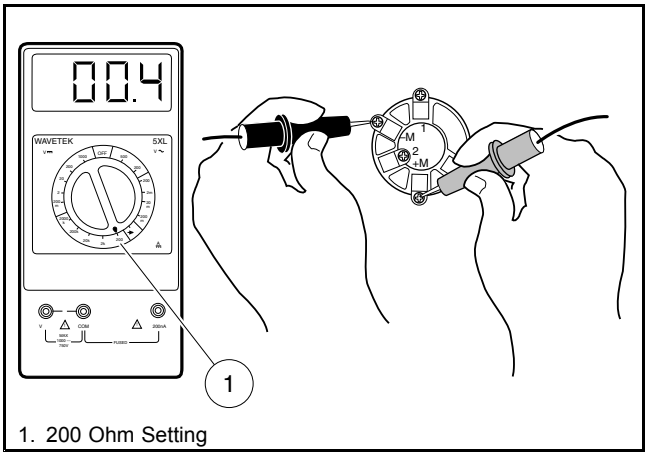
1. If necessary, see Testing Basics.
2. Remove the instrument panel. Do not disconnect the wires.
3. With the key switch in the OFF position:
   – The green wire should show battery voltage coming to the switch.
   – The brown/white wire should show zero (0) volts. If it shows battery voltage, the switch has failed CLOSED and must be replaced.
4. With the key switch in the ON position:
   – The brown/white wire should show battery voltage. If it does not show battery voltage, the switch has failed OPEN and must be replaced.

TEST PROCEDURE 5 – Key Switch (Engine Kill Circuit) - Pedal-Start Vehicles Only

See General Warnings on page 1-1.

NOTE: *This is a continuity test.*

1. If necessary, see Testing Basics.
2. Disconnect battery and spark plug wire.
3. Remove the instrument panel. See Instrument Panel Removal.
4. Disconnect the wires from the (+M) and (–M) terminals of the key switch.
5. Set the multimeter to 200 Ohm (1) **(Figure 18-4, Page 18-15)**.
6. Put the red (+) probe on the (+M) terminal.



1. 200 Ohm Setting

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Figure 18-4 Key Switch Test – Engine Kill Circuit

7. Put the black (–) probe on the (–M) terminal.
8. With the key switch OFF, the reading should be continuity.

8.1. If there is no continuity, replace the key switch.

9. With the key switch ON, the reading should be no continuity.

9.1. If there is continuity, replace the key switch.

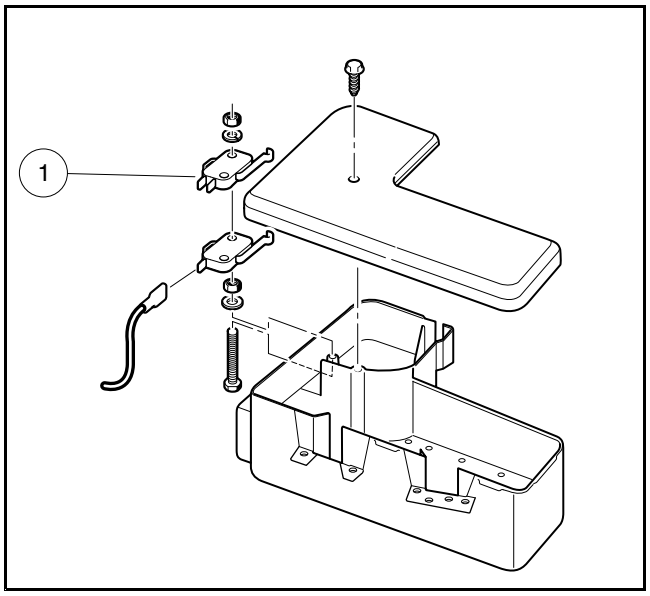
10. Connect the wires to the key switch. Make sure wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
11. Install the instrument panel. See Instrument Panel Installation.

TEST PROCEDURE 6 – Accelerator Pedal Limit Switch – Pedal-Start Vehicles Only

See General Warnings on page 1-1.

NOTE: *This is a continuity test.*

The accelerator pedal limit switch (1) is the top switch located in the electrical component box **(Figure 18-5)**. There is a green wire and a pink wire connected to this limit switch.



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Figure 18-5 Accelerator Pedal Limit Switch

1. If necessary, see Testing Basics.
2. Check for proper wiring and tight connections. See Wiring Diagrams.
3. Disconnect the battery.
4. Set the key switch to OFF.
5. Set the Forward/Neutral/Reverse control (FNR) to N.
6. Make sure the accelerator pedal is in the up position.
7. Set the multimeter to 200 ohms.
8. Put the red (+) probe on the common (COM) terminal (green wire) of the accelerator pedal limit switch.
9. Put the black (–) probe on the normally closed (NC) terminal (pink wire) of the accelerator pedal limit switch.

9.1. If there is continuity, replace the accelerator pedal limit switch.

10. Push the accelerator pedal.

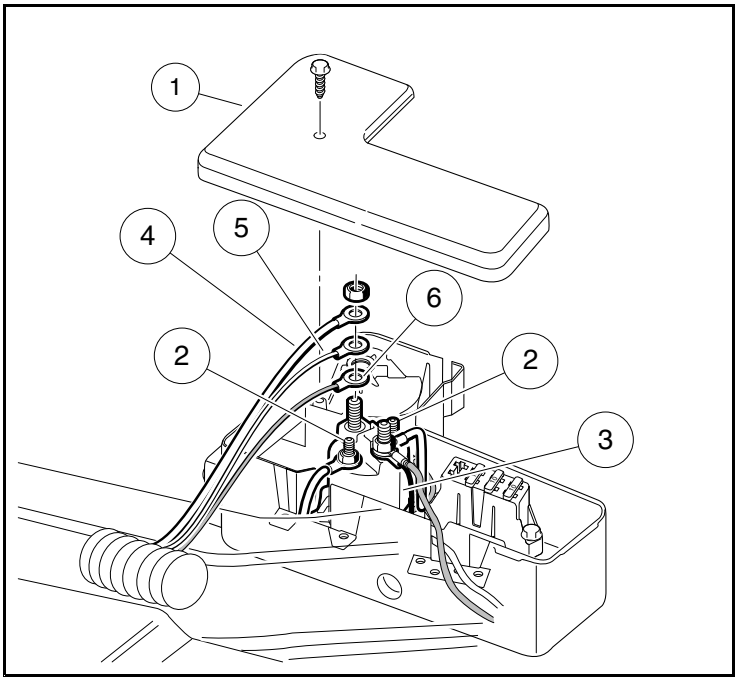
10.1. If there is no continuity, replace the accelerator pedal limit switch.

TEST PROCEDURE 7 – Solenoid - Pedal-Start Vehicles Only

See General Warnings on page 1-1.

NOTE: *This is a resistance and voltage test.*

1. If necessary, see Testing Basics.
2. Remove the electrical component box cover (1) **(Figure 18-6)**.

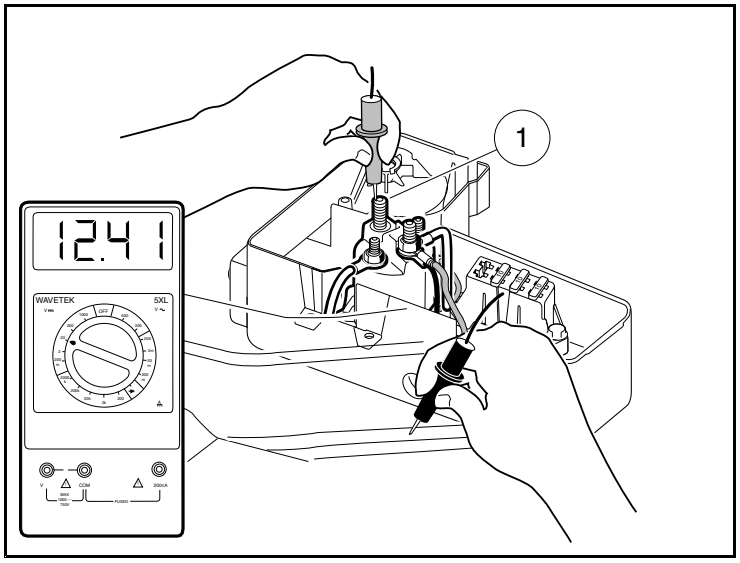


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Figure 18-6 Solenoid Wires

3. Make sure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
4. **Coil Side:** Check the resistance across the small posts (2) of the solenoid (3). The reading should be 14 to 16 ohms. If the reading is not within limits, replace the solenoid.
5. **Contact Side:** Remove the wires (4,5,6) from the large post of the solenoid. Do not allow the wires to touch the frame or other components of the vehicle. Cover the other large post.
6. Set the Forward/Neutral/Reverse control (FNR) to N.
7. Set the Maintenance/Operate switch to MAINTENANCE.
8. Set the key switch to ON.

9. Check the voltage between the empty large post (1) and ground **(Figure 18-7, Page 18-18)**.



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Figure 18-7 Solenoid Voltage Test

10. **With accelerator pedal in the UP position:** The meter should read no voltage.

10.1. If there is voltage, replace the solenoid.

11. **With accelerator pedal pressed:** The solenoid should click and the meter should read battery voltage.

11.1. If there is no voltage, replace the solenoid.

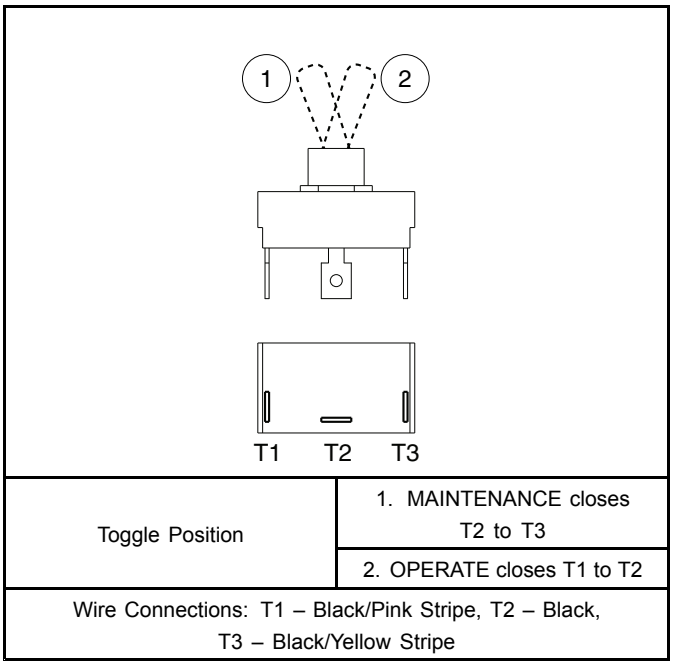
TEST PROCEDURE 8 – Maintenance/Operate Switch – Pedal-Start Vehicles

See General Warnings on page 1-1.

NOTE: *This is a continuity test.*

The Maintenance/Operate Switch is also known as the Neutral Lockout Switch.

1. If necessary, see Testing Basics.
2. Remove the wires from switch.



Toggle Position	1. MAINTENANCE closes T2 to T3
	2. OPERATE closes T1 to T2
Wire Connections: T1 – Black/Pink Stripe, T2 – Black, T3 – Black/Yellow Stripe	

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Figure 18-8 Maintenance/Operate Switch Test – for Pedal-Start Vehicles

3. Set the switch to MAINTENANCE (1) **(Figure 18-8)**:

3.1. Check for no continuity between terminals T1 and T2. If there is continuity, replace the switch.

3.2. Check for continuity between terminals T2 and T3. If there is no continuity, replace the switch.

4. Set the switch to OPERATE (2):

4.1. Check for no continuity between terminals T2 and T3. If there is continuity, replace the switch.

4.2. Check for continuity between terminals T1 and T2. If there is no continuity, replace the switch.

5. If the switch works as stated and the MAINTENANCE/OPERATE modes still do not work:

5.1. Check the limit switches.

5.2. Check continuity of the wires involved.

TEST PROCEDURE 9 – Neutral Lockout Limit Switch – Pedal-Start Vehicles Only

See General Warnings on page 1-1.

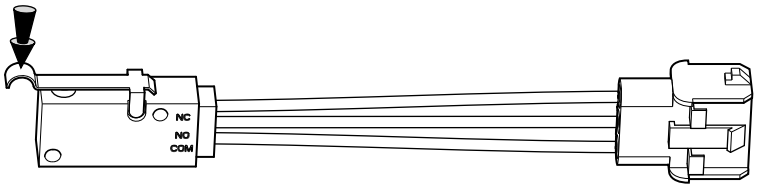
NOTE: *This is a continuity test.*

This switch is located on the transaxle. A black/white wire, a gray wire, and a red wire are connected to this limit switch with a 3-pin connector.

1. If necessary, see Testing Basics.
2. Disconnect the battery and spark plug wire.
3. At the transaxle, disconnect the neutral lockout limit switch three-wire lead from main wire harness.
4. Make sure that the cam lobe on the shift lever is pressing the neutral lockout limit switch as the Forward/Neutral/Reverse control (FNR) is being shifted.

4.1. If the neutral lockout switch does not make an audible click as it is pressed, check for wear on the cam lobe and replace shift lever if necessary.

5. Check the following terminals for no continuity with the shift lever released and continuity with the lever engaged **(Figure 18-9, Page 18-20)**:



PROBE BETWEEN LOCATIONS	TEST RESULT
Between terminal 1 “COM” (black/white wire) and terminal 2 “NO” (gray wire)	**With lever released:** No continuity
	With lever pressed: Continuity
Between terminal 1 “COM” (black/white wire) and terminal 3 “NC” (red wire)	**With lever released:** Continuity
	With lever pressed: No continuity

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Figure 18-9 Neutral Lockout Limit Switch Test

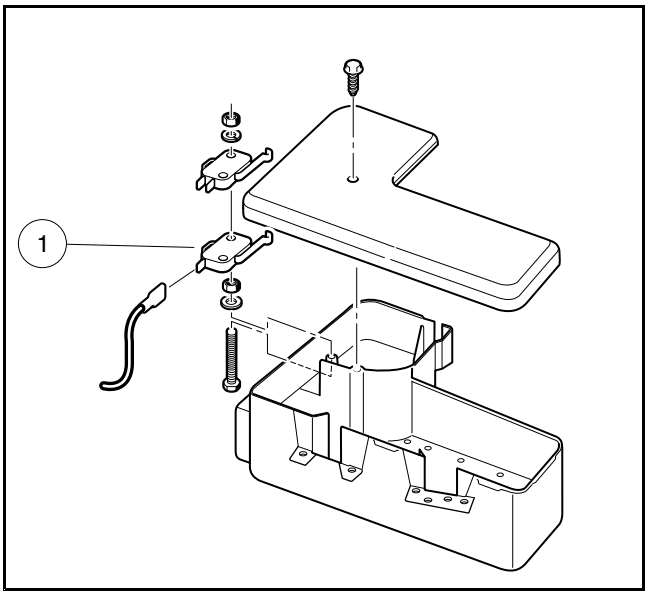
6. If switch does not work as stated in previous step, replace the neutral lockout limit switch.

TEST PROCEDURE 10 – Kill Limit Switch – Pedal-Start Vehicles Only

See General Warnings on page 1-1.

NOTE: *This is a continuity test.*

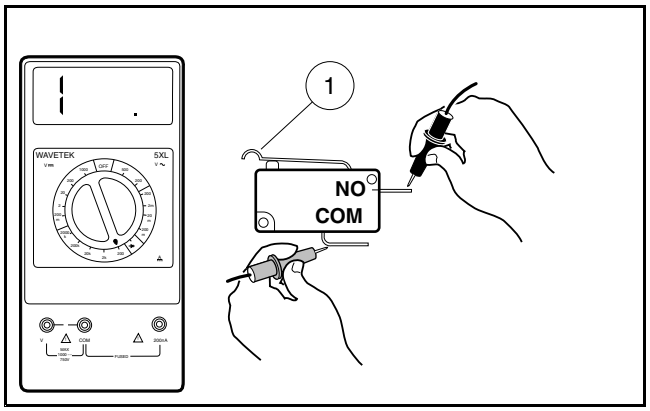
The kill limit switch (1) is the lower of the two limit switches located in the electrical component box **(Figure 18-10)**. There is a white/black wire and a blue wire connected to this limit switch.



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Figure 18-10 Kill Limit Switch

1. If necessary, see Testing Basics.
2. Disconnect the battery and spark plug wire.
3. Remove the electrical component box cover.
4. Check for proper wiring and tight connections. See Wiring Diagrams.
5. Disconnect the wires from the kill limit switch.
6. Put the red (+) probe of the multimeter on the common (COM) terminal (white/black wire) of the kill limit switch.
7. Put the black (–) probe on the normally open (NO) terminal (blue wire) of the kill limit switch.
8. Without the lever (1) pressed, check for continuity **(Figure 18-11)**.



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Figure 18-11 Kill Limit Switch Test

8.1. If there is continuity, replace the kill limit switch.

8.2. If there is no continuity, go to the next step.

9. Press the lever and check for continuity.

9.1. If there is continuity, the kill limit switch is good.

9.2. If there is no continuity, replace the kill limit switch.

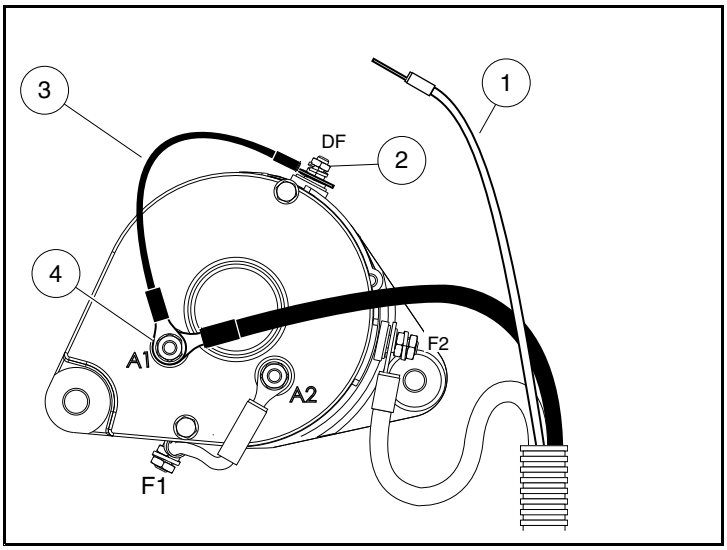
10. Connect the wires to kill limit switch.

TEST PROCEDURE 11 – Starter/Generator (Generator Function)

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

1. If necessary, see Testing Basics.
2. Disable the vehicle.
3. Set the Maintenance/Operate switch to MAINTENANCE.
4. Make sure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
5. Disconnect the yellow wire (1) from the DF terminal (2) on starter/generator **(Figure 18-12)**.



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Figure 18-12 Jumper Wire Ground – DF to A1

6. Cover terminal on yellow wire to make sure it will not short to ground.
7. Use a jumper wire (3) to ground DF terminal to A1 terminal (4).
8. Set the multimeter 20 VDC.
9. Put the red (+) probe on the positive (+) post of the battery.
10. Put the black (–) probe on the negative (–) post.
11. Start the engine and run it at full governed speed. The reading should show the voltage rising on the meter.

11.1. If the voltage rises above 15.3 volts DC, test the voltage regulator.

11.2. If the voltage does not rise, do a tear-down inspection of the starter/generator.

12. Remove the jumper wire.
13. Reconnect the yellow wire to the DF terminal on starter/generator.

TEST PROCEDURE 12 – Starter/Generator (Starter Function)

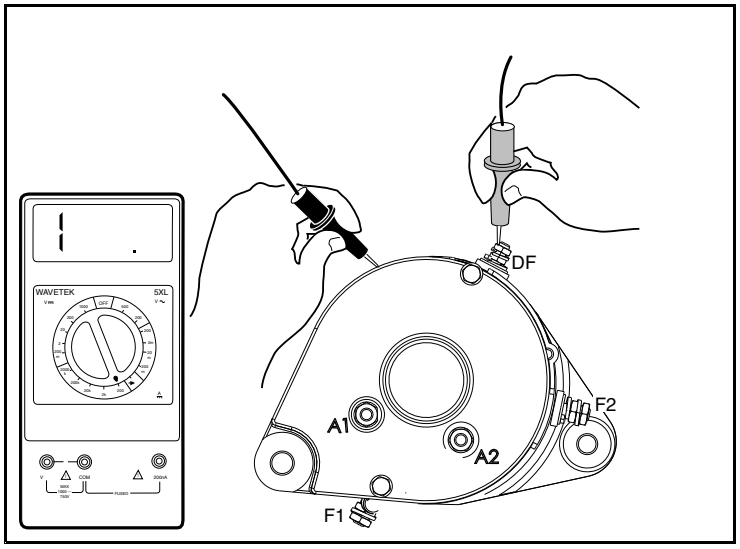
See General Warnings on page 1-1.

NOTE: *Observe the following before testing the starter/generator:*

- *This is only testing continuity.*
- *Tag the starter/generator wires for identification before disconnecting.*
- *Remove starter/generator wire from one of the "A" terminals and one of the "F" terminals if testing while starter/generator is in vehicle.*
- *When disconnecting wires from starter/generator terminals, use a second wrench on the lower nut of the terminal post to hold post steady.*
- *Scrape a small amount of paint from starter/generator housing (ground) and use this location when testing motor terminals to electrical ground.*

MOTOR TERMINALS	CONTINUITY TEST RESULT
A1 to A2 F1 to F2	Continuity
A1 to F1 A1 to F2	No Continuity
A2 to F1 A2 to F2	No Continuity
A1 to Ground A2 to Ground	No Continuity
F1 to Ground F2 to Ground	No Continuity

1. If necessary, see Testing Basics.
2. Disconnect the battery and spark plug wire.
3. Disconnect the wires from all the terminals on the starter/generator.
4. Set the multimeter to 200 Ohms.
5. Put the black (–) probe on the starter/generator housing. Scratch through the finish to ensure a good ground.



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Figure 18-13 Check Starter Terminal Continuity

6. Put the red (+) probe (one at a time) on the A1, A2, F1, F2 and DF terminals. The readings should be no continuity.

6.1. If there is continuity, the starter/generator will need to be removed from the vehicle and disassembled by a qualified technician.

7. Put the red (+) probe on the A1 terminal and the black (–) probe on the A2 terminal. The reading should be continuity.

7.1. If there is no continuity, the starter/generator will need to be removed from the vehicle and disassembled by a qualified technician.

Possible causes:

– A grounded wire in the brush area.

– A grounded armature/commutator.

– A grounded A1 or A2 terminal.

8. Put the red (+) probe on the F1 terminal and the black (–) probe on the F2 terminal. The reading should be between approximately 0.1 and 0.3 ohms.

8.1. If the reading is incorrect, the starter/generator will need to be removed from the vehicle and disassembled by a qualified technician.

Possible causes:

– A grounded F1 or F2 terminal or a grounded field coil.

9. Put the red (+) probe on the DF terminal and the black (–) probe on the F1 terminal. The reading should be between 4.5 and 5.5 ohms.

9.1. If the reading is incorrect, the starter/generator will need to be removed from the vehicle and disassembled by a qualified technician.

Possible causes:

– A grounded DF terminal or a grounded field coil.

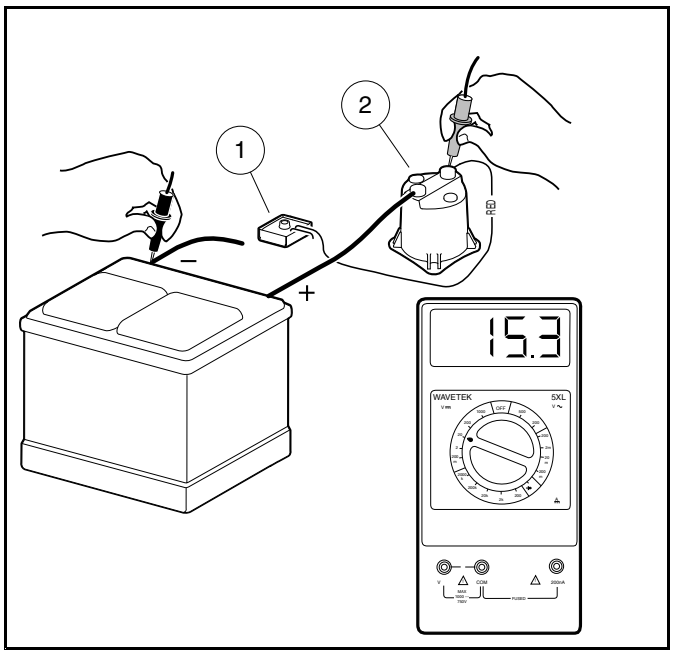
10. Make sure that wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.

TEST PROCEDURE 13 – Voltage Regulator

See General Warnings on page 1-1.

NOTE: *This is a voltage test. Keep the battery connected while performing this test procedure.*

1. If necessary, see Testing Basics.
2. Disable the vehicle.
3. Set the Maintenance/Operate switch to MAINTENANCE.
4. Make sure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
5. Check the engine RPM setting to make sure that it is adjusted correctly.
6. Make sure that the battery is good and fully charged.
7. Turn the key switch to ON.
8. Operate the engine for several minutes to bring the voltage regulator to operating temperature.
9. Turn the key switch to OFF position.
10. Make sure that the red wire from the voltage regulator (1) is connected to the solenoid (2).



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Figure 18-14 Voltage Regulator Test

11. Set the multimeter to 20 VDC.
12. Put the red (+) probe on the large post of the solenoid.
13. Put the black (–) probe on the negative (–) battery post.
14. Turn the key switch to the ON position.
15. Press the accelerator to start the engine and run it at full governed speed.

15.1. If the reading is between 14.7 and 15.3 volts, the voltage regulator is good.

15.2. If the reading is over 15.3 volts and continues to rise, replace the voltage regulator.

15.3. If the reading is lower than 14.7 volts but rising steadily, check the battery condition.

15.4. If the reading is lower than 14.7 volts and not rising, check the starter/generator. Go to the next step.

15.4.1. If the starter/generator is good, replace the voltage regulator.

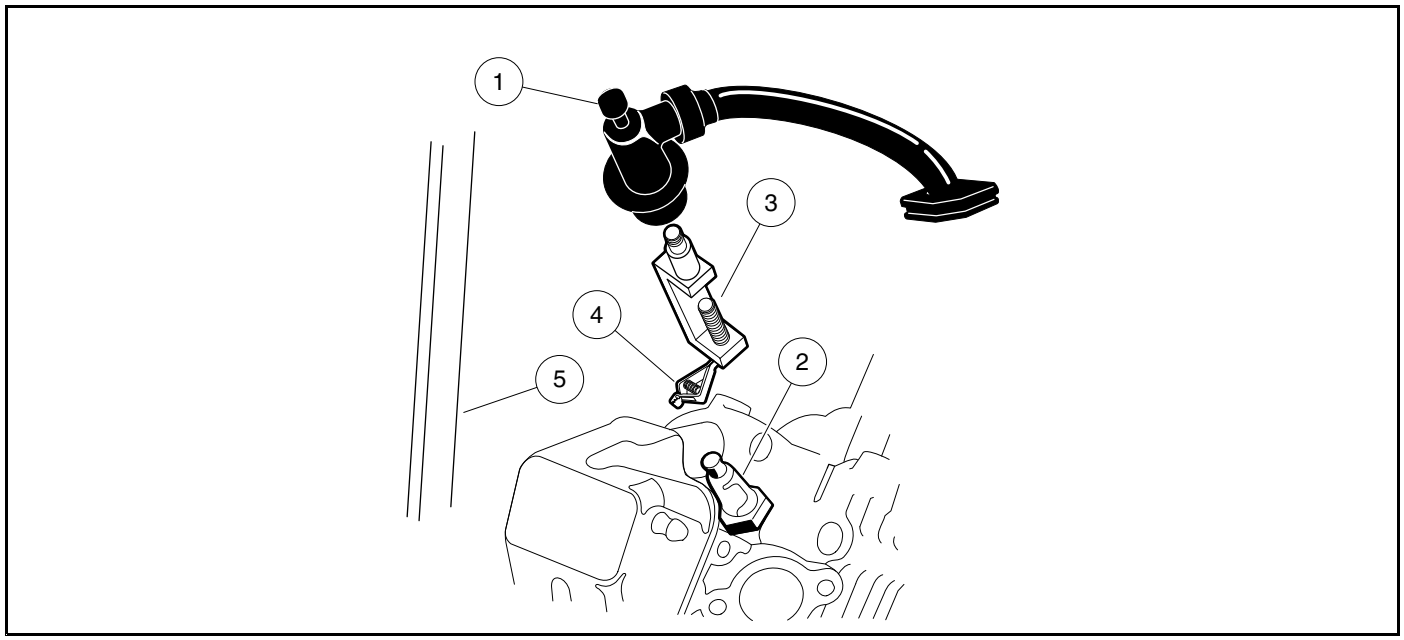
TEST PROCEDURE 14 – Ignition Spark

See General Warnings on page 1-1.

NOTE: *Keep the battery connected while performing this test procedure.*

Use an spark gap test tool (Thexton 404® or equivalent)

1. If necessary, see Testing Basics.
2. Disable the vehicle.
3. Set the Maintenance/Operate switch to MAINTENANCE.
4. Remove the spark plug wire (1) from the spark plug (2) **(Figure 18-15, Page 18-27)**.



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Figure 18-15 Ignition Spark Test

5. Adjust the spark gap test tool (3) probes to approximately 18,000 volts (18 kV) setting (SE – *Small Engine Setting* on the Thexton 404® tool).
6. Connect the ignition spark gap test tool to the spark plug wire.
7. Connect the alligator clip (4) to a solid engine ground (5).
8. Start the engine.

8.1. If the spark gap test tool has no spark, test the ignition circuit.

8.2. If the spark gap test tool has a faint yellow or red color, test the ignition circuit.

8.3. If the spark gap test tool has a strong blue spark, check the spark plug gap.

8.3.1. If the spark plug gap is correct, replace the spark plug.

TEST PROCEDURE 15 – Reverse Buzzer and Reverse Buzzer Limit Switch

See General Warnings on page 1-1.

NOTE: Reverse Buzzer: *This is a voltage test.*

A reverse buzzer is mounted on the back side of the instrument panel. On some models, another reverse buzzer is also mounted on a bracket at the left rear of the vehicle. The reverse buzzer is powered by the 10-amp ATM fuse.

1. If necessary, see Testing Basics.
2. Remove the instrument panel.
3. Check for proper wiring and tight connections.
4. Turn the key switch to ON.
5. Check that battery voltage is present in the orange/white wire at reverse buzzer.

5.1. If there is no battery voltage, check the 10-amp ATM fuse.

6. Set the Forward/Neutral/Reverse control (FNR) to R.

6.1. If the reverse buzzer does not sound, check the reverse buzzer limit switch.

7. Turn the key switch to OFF.

NOTE: Reverse Buzzer Limit Switch: *This is a continuity test.*

The reverse buzzer limit switch is located on the FNR. Purple/white and orange wires are connected to it.

1. Disconnect the black/orange wire from the reverse buzzer.
2. Set the FNR to R.
3. Check for continuity between the black/orange wire and ground.

3.1. If there is no continuity, replace the reverse buzzer limit switch.

3.2. If there is continuity, go to the next step.

4. Set the FNR to F.
5. Check for continuity between the black wire and ground.

5.1. If there is continuity, replace the reverse buzzer limit switch.

5.2. If there is no continuity, replace the reverse buzzer..

TEST PROCEDURE 16 – Malfunction Indicator Light (MIL)

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

1. If necessary, see Testing Basics.
2. Remove the instrument panel.
3. Make sure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
4. Turn the key switch to ON.
5. Check for battery voltage at red/green wire to malfunction indicator light (MIL).

5.1. If there is no voltage, check the key switch.

5.2. If there is battery voltage, use a test lead to ground the tan wire terminal of the MIL.

5.2.1. If the light illuminates, the MIL is good.

5.2.2. If the light does not illuminate, replace the MIL.

TEST PROCEDURE 17 – Low Oil Warning Light (LED)

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

1. If necessary, see Testing Basics.
2. Remove the instrument panel.
3. Make sure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
4. Turn the key switch to ON.
5. Check for battery voltage at yellow wire to low oil warning light.

5.1. If there is no voltage, check the key switch.

5.2. If there is battery voltage, use a test lead to ground the black wire terminal of the low oil warning light.

5.2.1. If the light illuminates, the low oil warning light is good.

5.2.2. If the light does not illuminate, replace the low oil warning light.

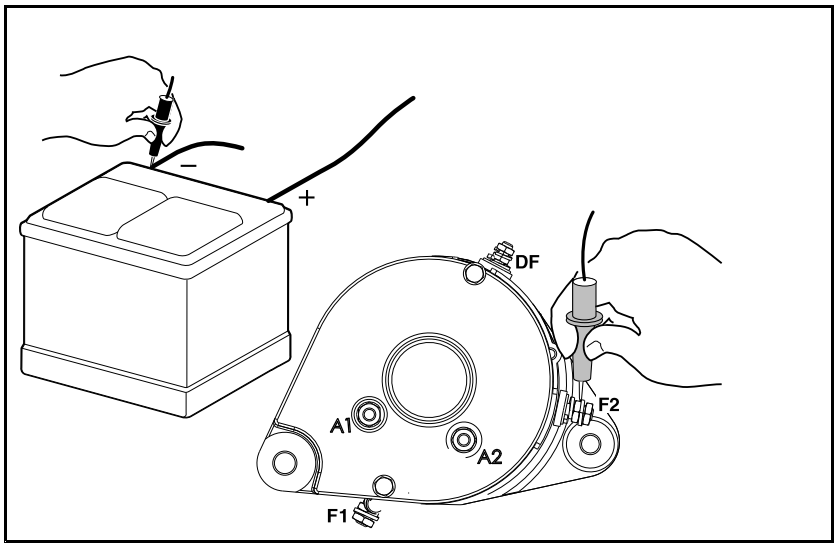
TEST PROCEDURE 18 – Battery Test (Under Load)

See General Warnings on page 1-1.

NOTE: *Keep the battery connected while performing this test procedure.*

The voltage reading listed is for electrolyte at 70 °F (21 °C). At lower electrolyte temperatures the voltage reading will be lower.

1. If necessary, see Testing Basics.
2. Set the Forward/Neutral/Reverse control (FNR) to N.
3. Set the Maintenance/Operate switch to MAINTENANCE.
4. Put chocks against the wheels.
5. Set a multimeter to 20 VDC.
6. Put the red (+) probe on the F2 (white wire) terminal on the starter/generator **(Figure 18-16)**.



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Figure 18-16 Battery Test (Under Load)

7. Put the black (–) probe on the negative (–) battery post.
8. Turn the key switch to ON.
9. Make sure that the FNR is in N, and push the accelerator pedal.

NOTE: *With the accelerator pedal pushed, the battery is under load.*

9.1. If the voltage reading is over 9.6 volts, with an electrolyte temperature of 70 °F (21 °C), check the starter/generator.

9.2. If the reading is below 9.6 volts, with an electrolyte temperature of 70 °F (21 °C), check the battery.

9.3. If the reading is zero, there may be no continuity across the large posts of the solenoid. Check the solenoid.

9.4. If all of the test results are good and the voltage reading is zero, there may be a broken or damaged 6-gauge white wire from the solenoid to the starter/generator.

10. If all of the test results are good and the voltage reading is zero, there may be a broken or damaged 6-gauge white wire from the solenoid to the starter/generator.

TEST PROCEDURE 19 – Fuel Pump

See General Warnings on page 1-1.

⚠ WARNING

- **To avoid the possibility of fire or explosion, make sure the fuel tank cap is securely in place while performing this test procedure.**

NOTE: *This is a voltage and resistance test.*

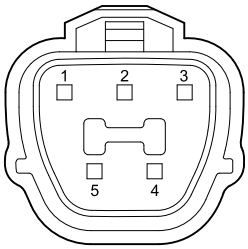
Voltage to Fuel Pump

1. If necessary, see Testing Basics.
2. Check the 10 amp fuse in the fuel pump circuit.

2.1. If the 10 amp fuse is bad, replace the fuse.

2.2. If the 10 amp fuse is good, go to the next step.

3. Disconnect the fuel pump connector from the top of the fuel pump module.
4. Set the Maintenance/Operate switch to MAINTENANCE.
5. Put chocks against the wheels.
6. While the engine is running, check for battery voltage between ground and the pin 5 of the fuel pump connector.



Pin	Wire Color	Description
1	Open	Open
2	Orange/Black	Sending Unit Positive (+)
3	Black	Sending Unit Negative (-)
4	Black/White	Fuel Pump Negative (-)
5	Red/White	Fuel Pump Positive (+)

Figure 18-17 Fuel Pump Connector

6.1. If there is no voltage, check for battery voltage at the red wire of the fuel pump relay while the engine is running.

6.1.1. If there is battery voltage, replace the fuel pump relay.

6.1.2. If there is no battery voltage, check the key switch.

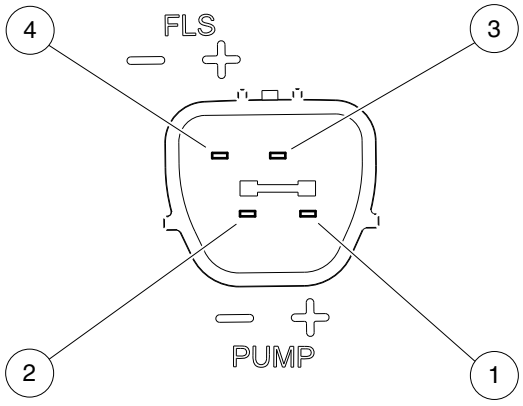
6.2. If there is voltage, check for battery voltage at the black/white wire of the fuel pump relay while the engine is running.

6.2.1. If there is no voltage, replace the fuel pump relay.

6.2.2. If there is voltage, check the fuel pump resistance.

Fuel Pump Resistance Procedure

1. If necessary, see Testing Basics.
2. Disconnect the battery.
3. Disconnect the fuel pump connector from the top of the fuel pump module.
4. Set the multimeter to 200 Ohms.
5. Check for approximately 2 to 5 ohms between pin (1) and pin (2) terminals in fuel pump module.



Description	WIRE COLOR
1. Fuel Pump Positive (+)	Red/White
2. Fuel Pump Negative (–)	Black/White
3. Sending Unit Positive (+)	Orange/Black
4. Sending Unit Negative (–) Black Wire	Black

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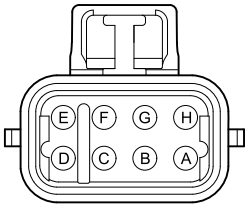
Figure 18-18 Fuel Pump Module Terminals

5.1. If the reading indicates no resistance, the fuel pump has failed and the fuel pump module must be replaced.

5.2. If the reading is correct and the fuel pump does not function correctly, go to the next steps. Leave the battery disconnected while checking continuity.

5.2.1. Check the continuity from the black/white wire of the fuel pump relay to pin (G) of the ECU connector.

ECU Connector



Pin	Wire Color	Description
A	Red	Switched 12V Power
B	Red	Constant 12V Power
C	Open	NA
D	Tan	Malfunction Indicator Light (MIL)
E	White	Ground Kill Wire
F	Green	Low Oil Light
G	Black / White	Fuel Pump
H	Open	NA

Figure 18-19 ECU Connector

TEST PROCEDURE 20 – Fuel Level Sending Unit

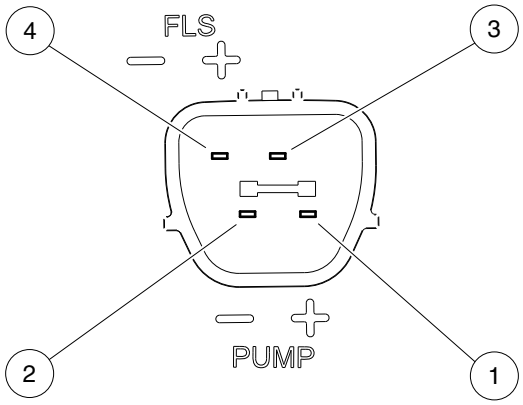
See General Warnings on page 1-1.

⚠ WARNING

- **To avoid the possibility of fire or explosion, make sure the fuel tank cap is securely in place while performing this test procedure.**

NOTE: *This is a resistance test.*

1. If necessary, see Testing Basics.
2. Disconnect the battery.
3. Disconnect the fuel pump connector from the top of the fuel pump module.
4. Check the resistance between pin (3) and pin (4) terminals in module.



Description	Wire Color
1. Fuel Pump Positive (+)	Red/White
2. Fuel Pump Negative (–)	Black/White
3. Sending Unit Positive (+)	Orange/Black
4. Sending Unit Negative (–) Black Wire	Black

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Figure 18-20 Fuel Pump Module Terminals

5. The following resistance readings (in ohms) should be obtained depending on the position of the float inside the fuel tank. The resistance reading will vary according to the exact position of the float. The chart below may be used as a guideline to determine if the fuel level sending unit is operating correctly. Make sure the float is at the surface of the fuel in the tank.

FLOAT POSITION	RESISTANCE READING	FUEL GAUGE READINGS
Lower position (tank empty)	250 ohms (±10)	Empty
Center position (tank half full)	141 ohms (±8)	Half full
Upper position (tank full)	33.3 ohms (±6)	Full

5.1. If the readings are within the specifications listed above, the fuel level sending unit is working properly.

5.2. If the readings are incorrect, the fuel level sending unit has failed and the fuel pump module must be replaced.

5.3. If the readings are correct and the fuel gauge does not function correctly, go to the next steps. Leave the battery disconnected while checking continuity.

5.3.1. Check the continuity of the orange/black wire from the fuel level sending unit to the purple wire on the fuel gauge/hour meter.

5.3.2. Check the continuity of the red/white wire from the fuel gauge/hour meter to the brown/white wire on the key switch.

5.3.3. Check the continuity of the black ground wire at the fuel level sending unit.

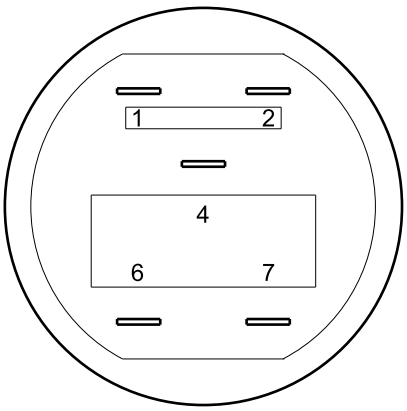
5.3.4. Check the continuity of the black ground wires at the fuel gauge/hour meter.

6. If the readings are correct according to the position of the float, but give an incorrect reading on the fuel gauge/hour meter, test the fuel gauge/hour meter.

TEST PROCEDURE 21 – Fuel Gauge

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

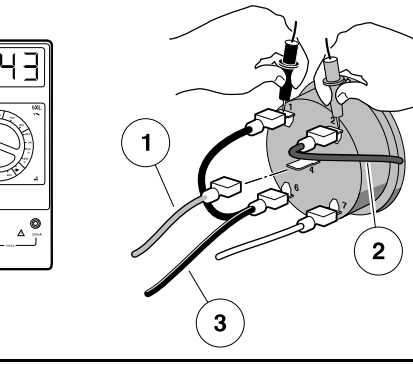


1. Black 2. Red/White 4. Purple 6. Black 7. White

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Figure 18-21 Fuel Gauge/Hour Meter

1. If necessary, see Testing Basics.
2. Disable the vehicle.
3. Remove the instrument panel to gain access to the back of the fuel gauge/hour meter.
4. Place a sheet of insulating material between the front frame and the electrical connections on the rear of the instrument panel to prevent contact between the two.
5. Disconnect the purple wire (1) from the fuel gauge/hour meter **(Figure 18-22, Page 18-36)**.



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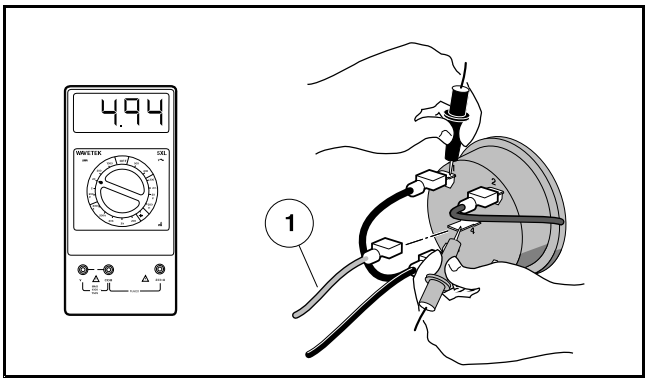
Figure 18-22 Fuel Gauge Voltage Test - Terminal 2

6. Set a multimeter to 20 VDC.
7. Put the red (+) probe of the multimeter on the positive post of the battery.
8. Put the black (–) probe on the negative post of the battery. Record the voltage reading.
9. Put the red (+) probe on terminal 2 of the fuel gauge/hour meter with the red/white wire (2) connected.

10. Put the black (–) probe on terminal 1 of the fuel gauge/hour meter with the black wire (3) connected.
11. Turn the key switch ON. The voltage reading should be the same as the battery voltage reading recorded earlier.

11.1. If not, check the continuity of the red/white and black wires.

12. Make sure that the purple wire (1) is disconnected **(Figure 18-23, Page 18-37)**.



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Figure 18-23 Fuel Gauge Voltage Test - Terminal 4

13. Put the black (-) probe on terminal 1 of the fuel gauge/hour meter.
14. Put the red (+) probe on terminal 4 of the fuel gauge/hour meter. The voltage reading should be approximately 4.94 volts.

14.1. If the reading is incorrect, replace the fuel gauge/hour meter.

TEST PROCEDURE 22 – Hour Meter

See General Warnings on page 1-1.

⚠ DANGER

- **Do not operate vehicle in an enclosed area without proper ventilation. The engine produces carbon monoxide, which is an odorless, deadly poison.**

NOTE: *Keep the battery connected while performing this test procedure.*

1. If necessary, see Testing Basics.
2. Disable the vehicle.
3. Make sure that the key switch OFF.
4. Check the hour meter display. It is powered by an internal battery and should always be on, even with the engine off and the key removed.
5. Start the engine and let it idle.
6. With engine idling, the "hour glass" icon should flash.

6.1. If not, check the low oil warning light and the oil pressure switch. **See following NOTE.**

NOTE: *The hour meter is designed to record actual engine running time and will not start adding increments until the engine is running and the oil pressure switch has opened.*

7. If the hour meter still does not function after the low oil warning light, oil pressure switch, and all of the appropriate wires have been checked for continuity, replace the fuel gauge/hour meter.

TEST PROCEDURE 23 – Headlight Switch

See General Warnings on page 1-1.

NOTE: *The headlight circuit is protected by the 20-amp fuse. Check the fuse before this procedure is performed.* ***See Test Procedure 2 – Fuses on page 18-11.***

This is a voltage test.

1. If necessary, see Testing Basics.
2. Check the 20 amp fuse that protects the headlight circuit.

2.1. If the fuse is bad, replace the fuse.

2.2. If the fuse is good, go to the next step.

3. Remove the instrument panel.
4. Set the multimeter set to 20 VDC.
5. Put alligator clips on the multimeter probes.
6. Connect the red (+) probe to terminal of the headlight switch where the green/white wire is connected..
7. Connect the black (–) probe of the multimeter to ground.
8. Set the headlight switch to OFF.

8.1. If there is voltage, replace the headlight switch.

8.2. If there is no voltage, go to the next step.

9. Set the headlight switch to ON.

9.1. If there is battery voltage, the headlight switch is good.

9.2. If there is no voltage, check the associated wiring and 10 amp fuse.

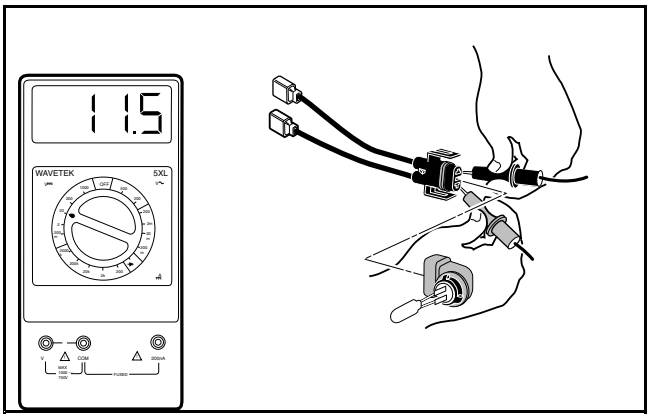
9.2.1. If the wires and fuse show continuity and the readings are still incorrect, replace the headlight switch.

TEST PROCEDURE 24 – Voltage at Headlight Socket

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

1. If necessary, see Test Basics.
2. Inspect the wires at the light bulb socket. Make sure the wires are securely fastened to the contacts inside the socket and that wires are installed correctly.
3. Remove the wire harness connector from the headlight bulb.
4. Set the headlight switch to ON.
5. Check for voltage across the two terminals in the connector.



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Figure 18-24 Voltage Measurement at Headlight Socket

5.1. If there is battery voltage, check and replace the headlight bulb as necessary..

5.2. If there is no voltage, check the associated wiring, light switch, and 10-amp fuse.

TEST PROCEDURE 25 – Voltage Limiter

See General Warnings on page 1-1.

NOTE: *This is a diode test.*

The voltage limiter is a diode. Diodes are designed to conduct current in one direction only. **See following NOTE.**

NOTE: *If the voltage limiter conducts current in both directions, the diode has failed closed. If the voltage limiter will not conduct current in either direction, the diode has failed open.*

1. If necessary, see Testing Basics.
2. Disable the vehicle.
3. Remove the cowl.
4. Disconnect the black wire from positive (+) terminal of voltage limiter.
5. Disconnect the green wire from negative (-) terminal of the voltage limiter.
6. Set the multimeter to the diode setting.

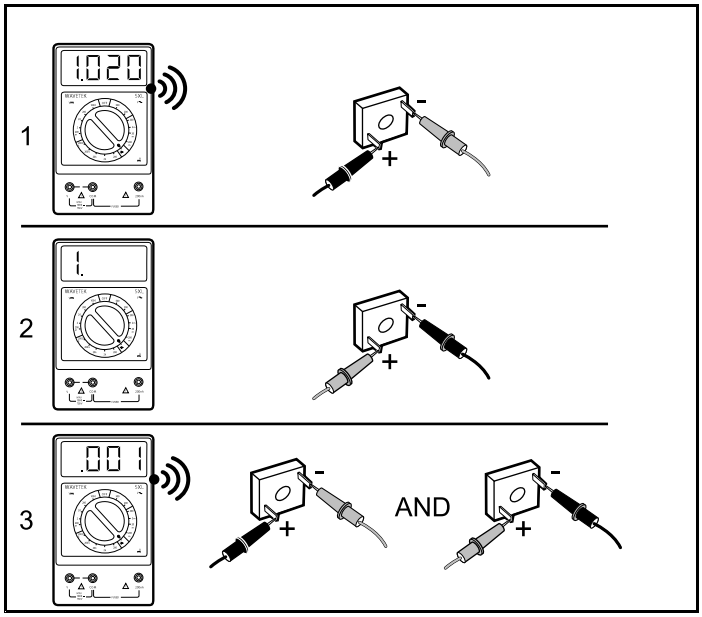


Figure 18-25 Voltage Limiter Test

7. Put the red (+) probe on the negative (-) diode terminal.
8. Put the black (-) probe on the positive (+) diode terminal.

8.1. Check for continuity (1). Go to the next step.

9. Put the red (+) probe on the positive (+) diode terminal.
10. Put the black (-) probe on the negative (-) diode terminal.

10.1. If there is no continuity (2), the diode is good.

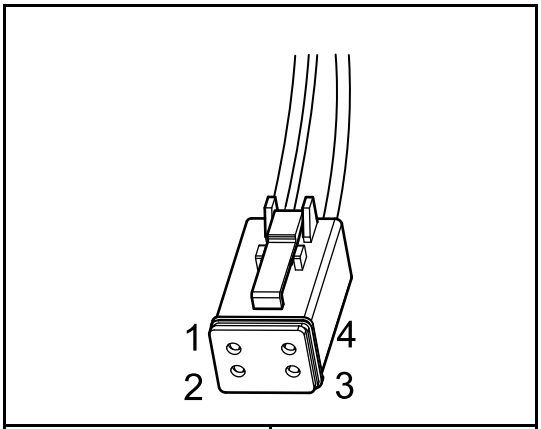
10.2. If there is continuity (3), replace the diode.

TEST PROCEDURE 26 – 4-Pin Connector (for Connected Car Device)

See General Warnings on page 1-1.

NOTE: *This is a voltage and continuity test.*

The Connected Car Device 4-pin connector is used for Guardian/Visage and is labeled "V3 circuit" on the main wire harness.



Pin 1 – Black	Pin 4 – Open
Pin 2 – Red	Pin 3 – Open

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Figure 18-26 4-Pin Connector

1. If necessary, see Testing Basics.
2. Set the multimeter to 200 Ohms.
3. Check for continuity between pin 1 (black wire) of the 4-pin connector **(Figure 18-26, Page 18-41)** and pin 18 (black wire) of the black 18-pin connector on the ECU.

3.1. If there is continuity, go to the next step.

3.2. If there is no coninuity, check sonic welds 4, 10, and 14. Proceed to the next step.

4. Set the key switch to ON.
5. Set the multimeter to 20 VDC.
6. Check for battery voltage at pin 2 (red wire) of the 4-pin connector.

6.1. If there is battery voltage, go to the next step.

6.2. If there is no voltage, check the 2-amp fuse located near the 4-pin connector. **See following NOTE.**

NOTE: *The red wire only has battery voltage with the key switch in the ON position.*

6.3. If the 2-amp fuse is good, check the 5-amp fuse located near the electrical box.

7. Set the key switch to ON.
8. Set the multimeter to 20 VDC.
9. Check the voltage at pin 4 (blue wire) of the 4-pin connector. **See following NOTE.**

NOTE: *The blue wire only has voltage with the key switch in the ON position.*

9.1. If the voltage is approximately 11.8 volts, the 4-pin connector circuit is good.

9.2. If the voltage is incorrect, check the wiring and then the ECU. **See following NOTE.**

NOTE: *If pin 4 has no voltage, the ECU LIN (Local Interconnect bus) may have failed. If the vehicle does not use Guardian or Visage, the vehicle can be driven and will not show any symptoms. If a vehicle uses Guardian or Visage, Guardian or Visage will disable the vehicle until communication is restored.*

TEST PROCEDURE 27 – Key Switch (ON Position) - Key-Start Vehicles Only

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

The key switch ON position provides power and KEY INPUT to the ECU.

1. If necessary, see Testing Basics.
2. Remove the instrument panel.
3. Set the key switch to OFF.
   – The green wire should show battery voltage coming to the switch.
   – The brown/white wire should show zero (0) volts. If it shows battery voltage, the switch has failed CLOSED and must be replaced.
4. Set the key switch to ON.
   – The brown/white wire should show battery voltage. If it does not show battery voltage, the switch has failed OPEN and must be replaced.

TEST PROCEDURE 28 – Key Switch (START Position) - Key-Start Vehicles Only

See General Warnings on page 1-1.

NOTE: *This is a voltage test.*

The key switch START position provides power to the starter/generator.

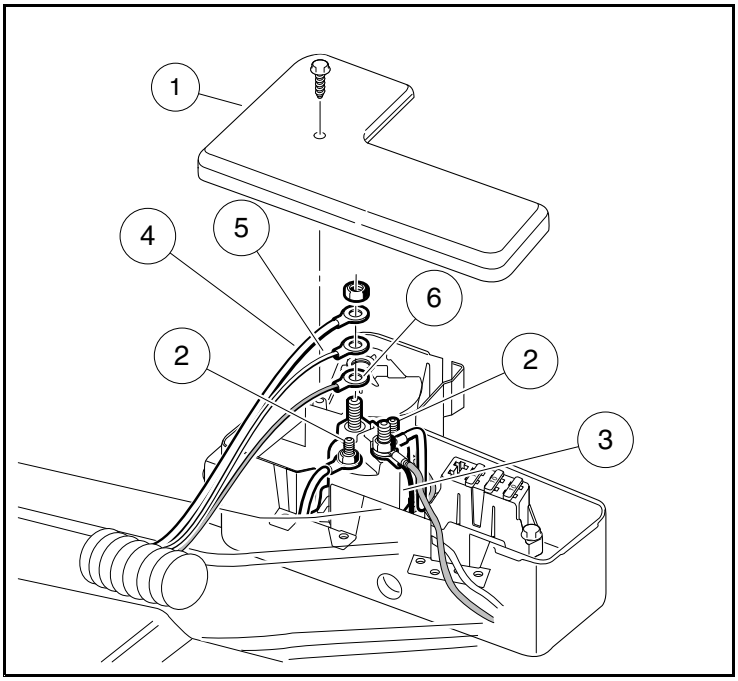
1. If necessary, see Testing Basics.
2. Remove the instrument panel.
3. Set the key switch to OFF.
   – The green wire should show battery voltage coming to the switch.
   – The gray wire should show zero (0) volts. If it shows battery voltage, the switch has failed CLOSED and must be replaced.
4. Set the key switch to START.
   – The gray wire should show battery voltage. If it does not show battery voltage, the switch has failed OPEN and must be replaced.

TEST PROCEDURE 29 – Solenoid - Key-Start Vehicles Only

See General Warnings on page 1-1.

NOTE: *This is a resistance and voltage test.*

1. If necessary, see Testing Basics.
2. Remove the electrical component box cover (1) **(Figure 18-27)**.



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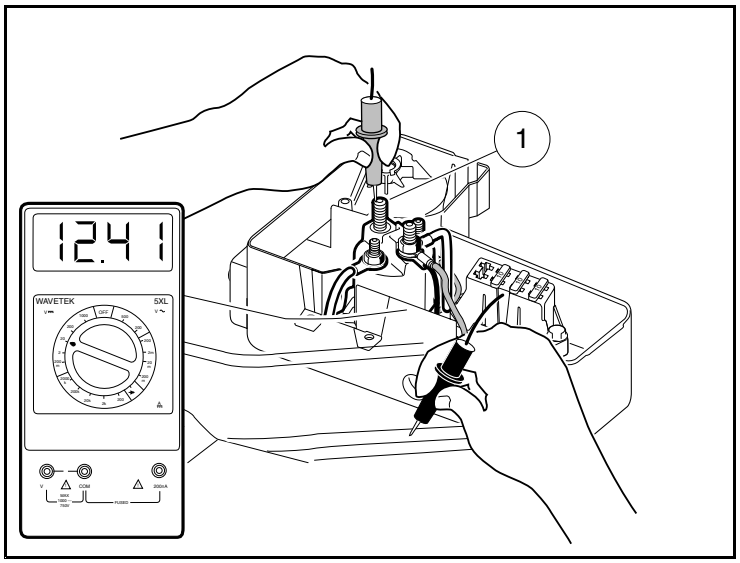
Figure 18-27 Solenoid Wires

3. Make sure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
4. **Coil Side:** Check the resistance across the small posts (2) of the solenoid (3). The reading should be 14 to 16 ohms. If the reading is not within limits, replace the solenoid.
5. **Contact Side:** Remove the wires (4,5,6) from the large post of the solenoid. Do not allow the wires to touch the frame or other components of the vehicle. Cover the other large post.
6.

6.1. Set the Forward/Neutral/Reverse control (FNR) to N.

6.2. Set the Maintenance/Operate switch to MAINTENANCE.

6.3. Check the voltage between the empty large post (1) and ground **(Figure 18-7, Page 18-18)**.



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Figure 18-28 Solenoid Voltage Test

6.4. **With key switch in the OFF and ON positions:** The multimeter should read no voltage.

6.4.1. If there is voltage, replace the solenoid.

6.5. **With key switch in the START position:** The solenoid should click and the multimeter should read battery voltage.

6.5.1. If there is no voltage, replace the solenoid.

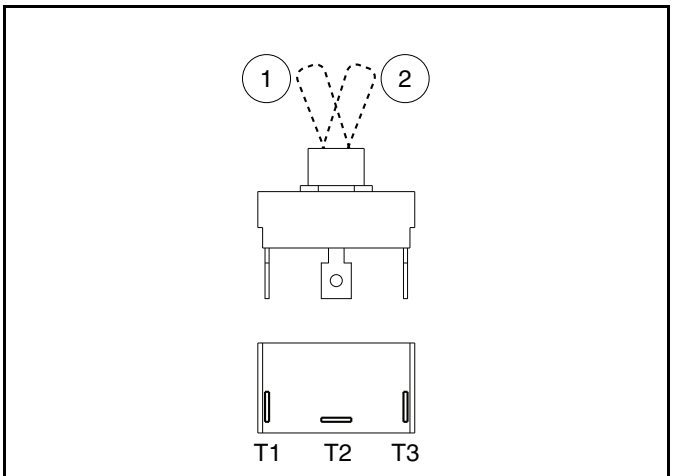
TEST PROCEDURE 30 – Maintenance/Operate Switch – Key-Start Vehicles

See General Warnings on page 1-1.

NOTE: *This is a continuity test.*

The Maintenance/Operate Switch is also known as the Neutral Lockout Switch.

1. If necessary, see Testing Basics.
2. Remove the wires from switch.



Toggle Position Operates:	1. Position 1 (MAINT.) closes T2 to T3
	2. Position 2 (OP.) closes T1 to T2
3. T1 – Blue/White Stripe; T2 – Black	

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Figure 18-29 Maintenance/Operate Switch Test – for Key-Start Vehicles

3. Set the switch to MAINTENANCE (1) **(Figure 18-8, Page 18-19)**:

3.1. Check for no continuity between terminals T1 and T2. If there is continuity, replace the switch.

3.2. Check for continuity between terminals T2 and T3. If there is no continuity, replace the switch.

4. Set the switch to OPERATE (2):

4.1. Check for no continuity between terminals T2 and T3. If there is continuity, replace the switch.

4.2. Check for continuity between terminals T1 and T2. If there is no continuity, replace the switch.

5. If the switch works as stated and the MAINTENANCE/OPERATE modes still do not work:

5.1. Check the limit switches.

5.2. Check continuity of the wires involved.

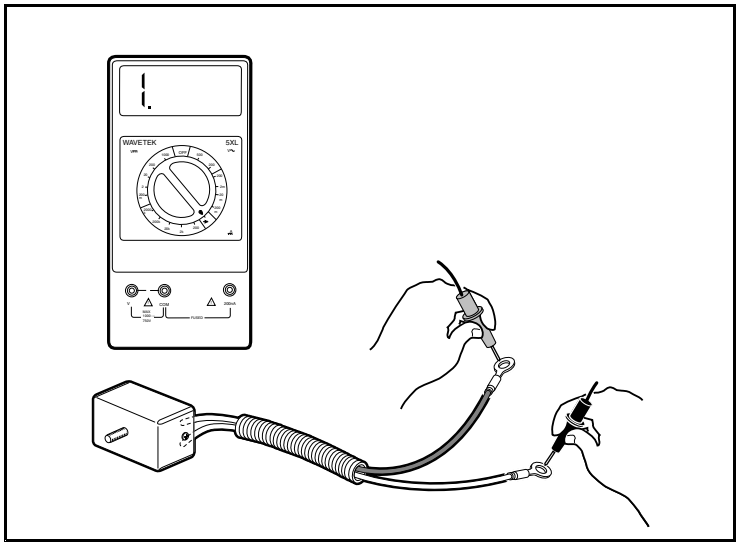
TEST PROCEDURE 31 – Charging Diode (Generator Circuit) – Key-Start Vehicles Only

See General Warnings on page 1-1.

⚠ WARNING

- **Incorrect wiring could result in severe injury or death.**
- **Diode and solenoid connections must have correct polarity.**
- **Keep all persons clear of engine belts when making final connections.**

1.
2. Disable the vehicle.
3. Disconnect the battery and spark plug wire.
4. Disconnect the red wire and white wire of the charging diode assembly from the solenoid.
5. Set the multimeter to the diode test function.
6. Connect the black (–) multimeter probe to the white lead of the charging diode.



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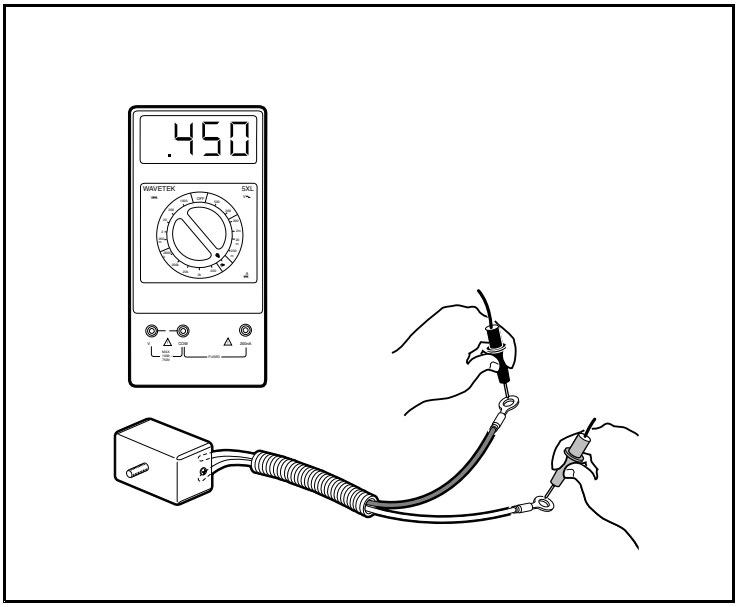
Figure 18-30 Diode Test

7. Connect the red (+) multimeter probe to the red lead of the charging diode.

7.1. If there is continuity, replace the charging diode.

7.2. If there is no continuity, go to the next step.

8. Connect the black (–) multimeter probe to the red lead of the charging diode.



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Figure 18-31 Diode Test – Probes Reversed

9. Connect the red (+) multimeter probe to the white lead of the charging diode.

9.1. The multimeter should read 400 to 500 mV.

10. Connect the red (+) multimeter probe to the diode body.

11. Connect the black (-) multimeter probe to the red charging diode lead.

11.1. If there is continuity, replace the charging diode.

11.2. If there is no continuity, go to the next step.

12. Connect the black (-) multimeter probe to the white charging diode lead.

12.1. If there is continuity, replace the charging diode.

12.2. If there is no continuity, the charging diode is good.

Pagination Page

SECTION 19 — GASOLINE VEHICLE - ELECTRICAL COMPONENTS

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

GENERAL INFORMATION

⚠ WARNING

- **To prevent damage to the ECU, never mix the black and gray connectors that attach to it. The black connector is tethered to the ECU mounting plate to help prevent accidentally installing it in the gray port.**

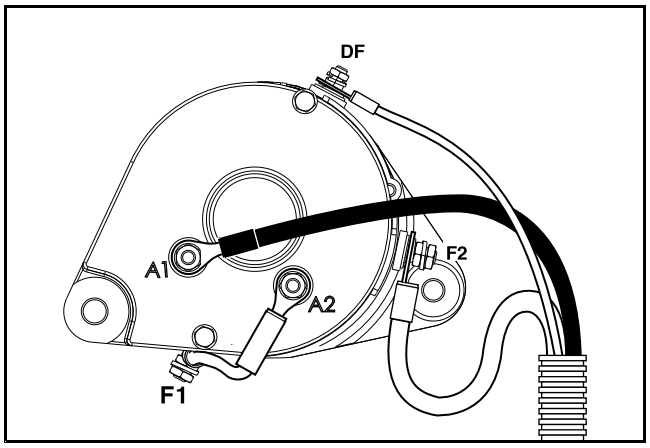
This section covers the electrical components for the key-start gasoline vehicle and pedal-start gasoline vehicle. Most components are shared between the two systems except for the following items unique to the key-start vehicle:

- **Key Switch:** Only way to start and shut off the engine.
- **Accelerator Pedal:** Is not linked to the accelerator pedal limit switch and kill limit switch in the electrical component box because these switches are omitted for key-start applications.
- **Charging Diode:** Is connected to the solenoid in the electrical component box.
- **Forward/Neutral/Reverse control (FNR):** Is not linked to the neutral lockout limit switch on the transaxle because this switch is omitted for key-start applications.

STARTER/GENERATOR

STARTER/GENERATOR REMOVAL

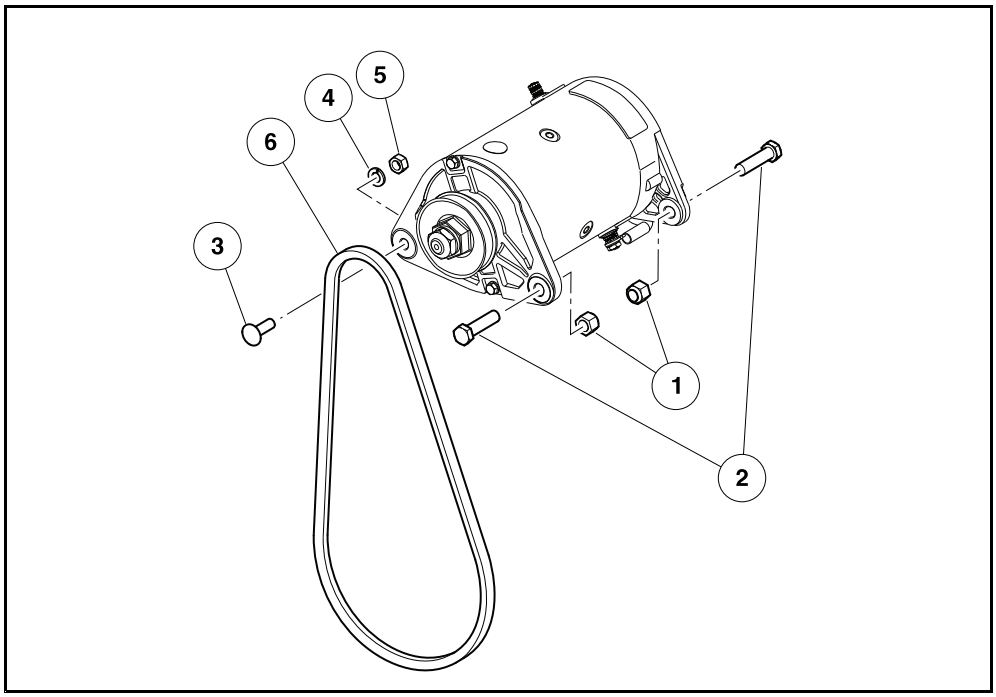
1. Disconnect the battery and spark plug wire.
2. Set the Maintenance/Operate switch to MAINTENANCE.
3. Disconnect the wires from the starter/generator **(Figure 19-1)**.



3033C

Figure 19-1 Starter/Generator Wiring

4. Loosen the pivot nuts (1) and pivot bolts (2) **(Figure 19-2, Page 19-2)**.



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Figure 19-2 Starter/Generator Removal

5. Remove the adjustment nut (3), washer (4) and adjustment bolt (5).
6. Lower the starter/generator and remove the belt (6) from the pulley.
7. Support the starter/generator so that when the pivot bolts are removed the starter/generator will not fall.
8. Remove the pivot nuts and bolts from the mounting bracket.
9. Remove the starter/generator.

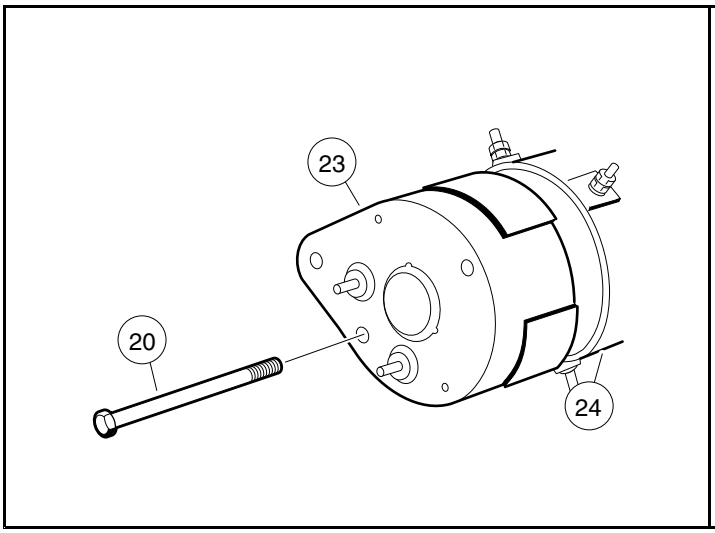
DISASSEMBLY OF THE STARTER/GENERATOR TO SERVICE THE BRUSHES

1. Remove the two bolts (20) and pull commutator end cover (23) free of starter/generator housing (24) **(Figure 19-3, Page 19-3)**. **See following NOTE.**

NOTE: *If the brushes are not removed, contact between the brushes and commutator as the commutator end cover is being removed or installed could damage the brushes. Lift the brush springs out of the notches in the brushes and pull the brushes back from the center of the commutator end cover. The springs will rest on the sides of the brushes and help prevent them from sliding towards the center of the cover* ***(Figure 19-7, Page 19-5)****.*

2. Remove brush covers (29 and 30), terminal hardware (25), brush springs (28), and brushes (27) **(Figure 19-4, Page 19-3)**. **See following NOTE.**

NOTE: *To clean and inspect the armature/commutator and the bearings, see* ***Disassembly of the Starter/Generator to Service the Armature/Commutator on page 19-5****.*



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Figure 19-3 Commutator End Cover

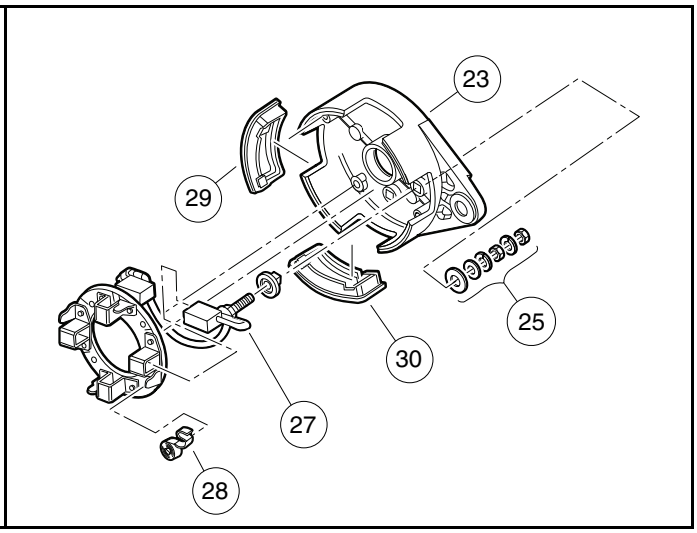


Figure 19-4 Brush Covers and Brushes

BRUSH INSPECTION AND REPLACEMENT

1. Visually inspect brushes. Replace brushes that are cracked or severely chipped.
2. Measure the length of each brush. Replace the brush set if a brush is less than 0.375 inch (9.5 mm) **(Figure 19-5, Page 19-3)**.

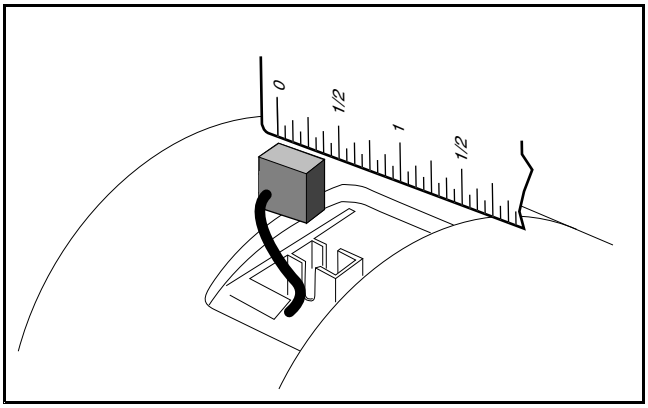


Figure 19-5 Inspect Brushes and Measure Length

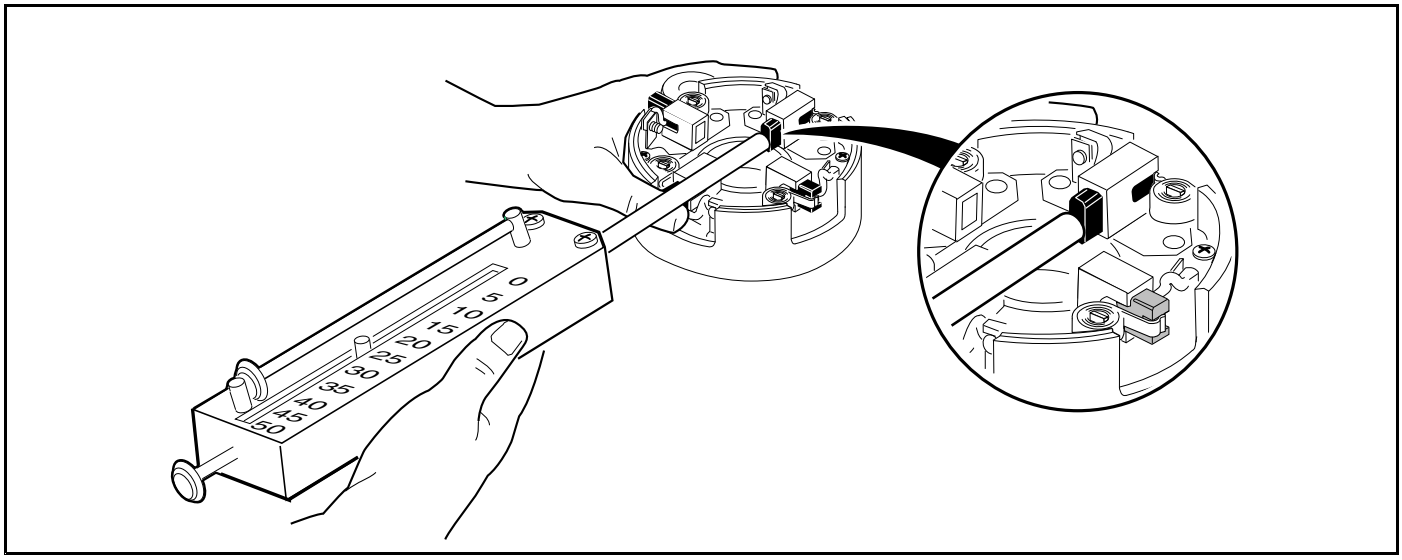
BRUSH SPRING INSPECTION AND REPLACEMENT

1. Visually inspect springs. Replace all four springs if any spring is discolored from heat (straw or bluish in color).

2. Install the four brushes (27) into their holders and insert the four brush springs (28) **(Figure 19-4, Page 19-3)**. Using a spring scale, test brush spring tension. If any spring has a tension less than 24 ozf (0.68 kgf), replace all four springs **(Figure 19-6, Page 19-4)**. **See following CAUTION.**

⚠ CAUTION

- **When checking brush spring tension, do not push springs beyond the point they would normally be if there were new brushes installed. Exerting excessive force or pushing brush springs beyond their normal maximum extension point will damage springs.**



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Figure 19-6 Brush Spring Tension Test

STARTER/GENERATOR ASSEMBLY

1. Install the brushes (27) into the holders. Install the terminal hardware (25) **(Figure 19-4, Page 19-3)**.
2. To prevent contact between the brushes and commutator as the commutator is installed, and possible damage to the brushes, lift the brush springs and pull the brushes back from the center of the commutator end cover. The springs will rest on the sides of the brushes and help prevent them from sliding towards the center of the cover **(Figure 19-7, Page 19-5)**.
3. Install the commutator end cover (23) onto the armature shaft. Align the locating pin with the pin hole in the cover. Install two M6 x 180 mm bolts (20) and tighten to 100 in·lb (11.3 N·m) **(Figure 19-3, Page 19-3)**.
4. Push the brushes down into the holders. Position springs on the end of the brushes. Install the brush cover (30) that has the drain hole in it next to the A2 terminal. Install the remaining three brush covers (29) in the openings in the commutator end cover (23) **(Figure 19-4, Page 19-3)**.

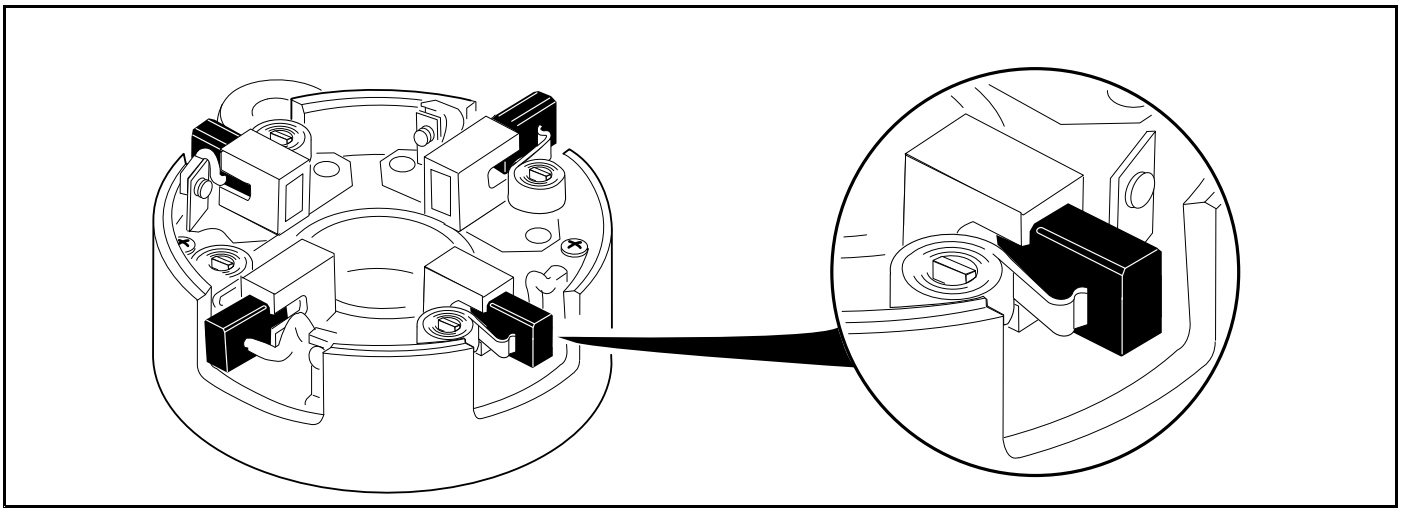
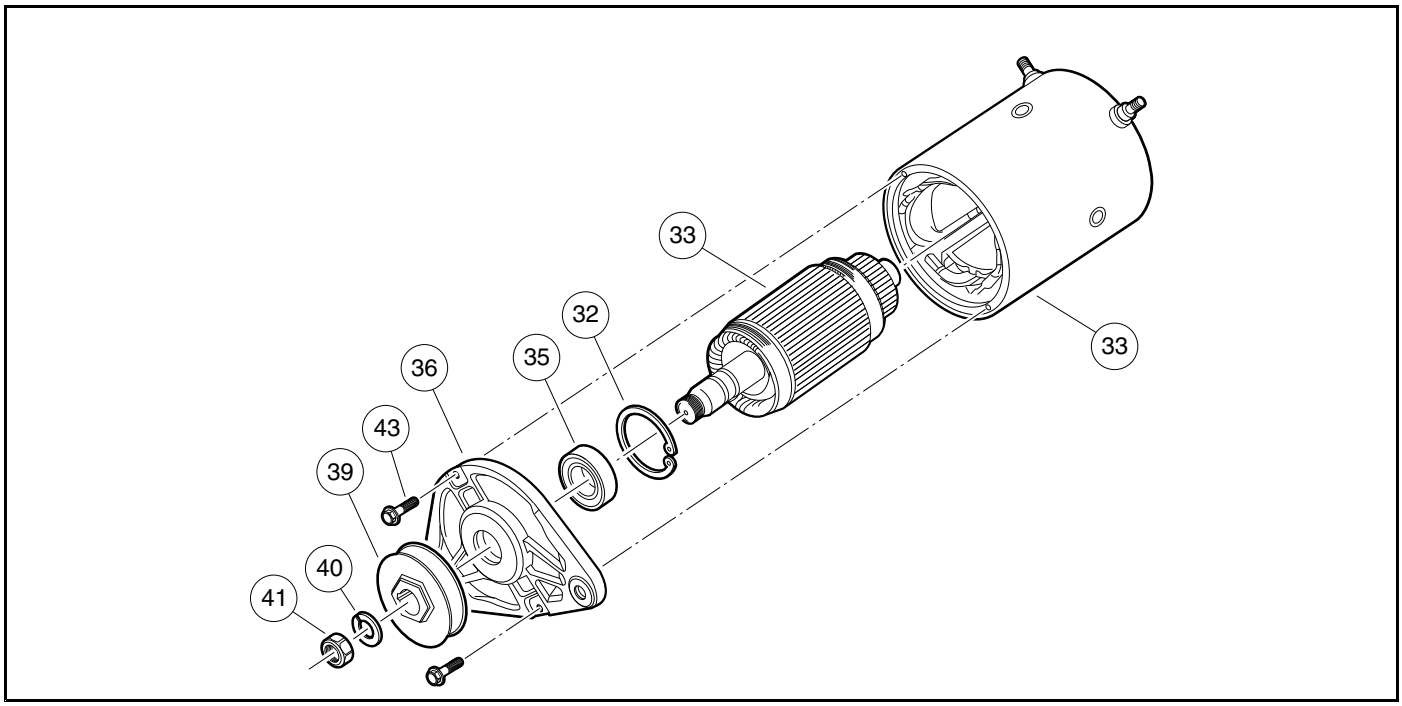


Figure 19-7 Pull Brushes Away From Center of the Commutator End Cover

DISASSEMBLY OF THE STARTER/GENERATOR TO SERVICE THE ARMATURE/COMMUTATOR

1. Remove the commutator end cover to prevent damage to the brushes and armature.
2. To separate armature and output end cover assembly from the field coil housing, first remove the two securing bolts (43). Carefully remove armature and output end cover assembly from the field coil housing so components are not damaged.
3. To separate armature (33) from output end cover (36), remove nut (41), lock washer (40), pulley (39). It may be necessary to use the wedge attachment tool to remove the pulley from the shaft.
4. Remove the internal retaining ring (32) to release the bearing (35) and armature (33) from the output end cover (36). **(Figure 19-8, Page 19-6)**.

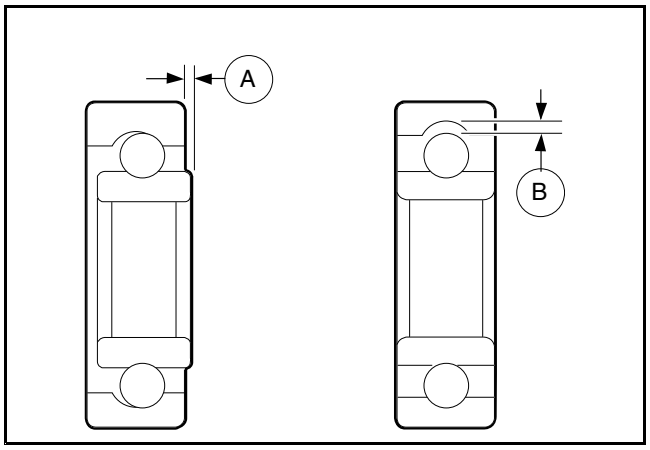


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Figure 19-8 Output End Cover Assembly, Armature and Housing

BEARING CLEANING AND INSPECTION

1. Using a clean cloth, wipe the carbon dust from the two bearings. Inspect bearings by spinning them by hand and checking for both axial (A) and radial (B) play **(Figure 19-9, Page 19-6)**.
2. Replace the bearing if it is noisy, does not spin smoothly, or has excessive play. Check the bearings and replace if rusted, worn, cracked, or if there is an abnormal color change in the metal of the bearing. Bearings should be replaced if there is extensive wear or pitting on the balls or on the rolling surfaces. Do not remove the bearings unless they are to be replaced.

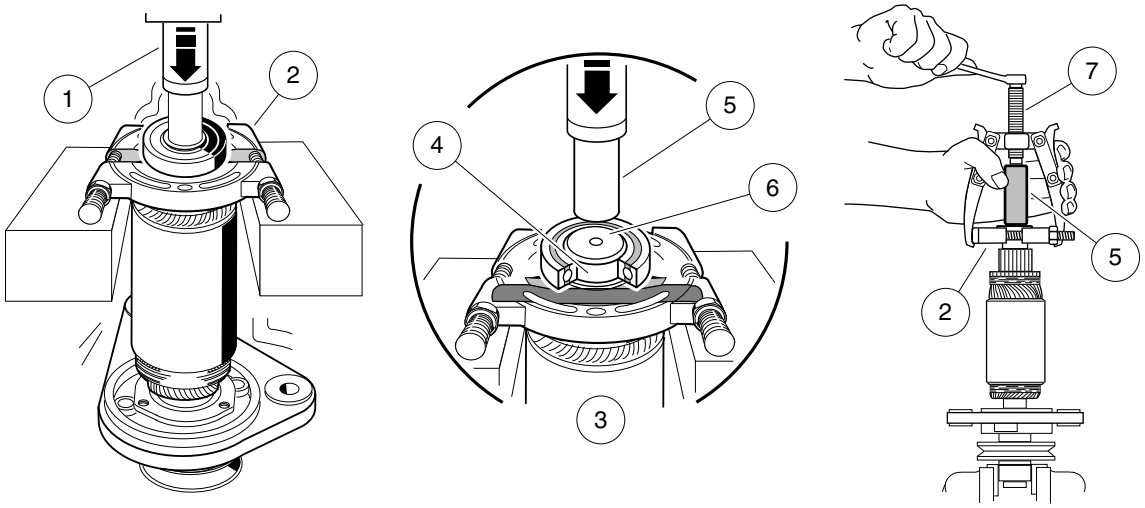


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Figure 19-9 Bearing Play Inspection

BEARING REMOVAL

1. Place the wedge attachment tool between the bearing and the armature. Make sure the wedge attachment tool is supporting the inner race of the bearing. If a press is not available, secure a bearing puller to the wedge attachment tool and pull the bearing off of the end of the armature shaft. Support the armature so that it will not drop when the bearing is removed **(Figure 19-10, Page 19-7)**.
2. Slide the bearing retainer ring (32) off of the output end of the shaft **(Figure 19-8, Page 19-6)**.



1. Press Ram 2. Wedge Attachment Tool 3. Bearing sectioned for clarity 4. Support inner race of bearing 5. Use a 1/2 inch socket or pipe 6. Press against armature shaft 7. Use bearing puller if a press is not available

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Figure 19-10 Bearing Removal

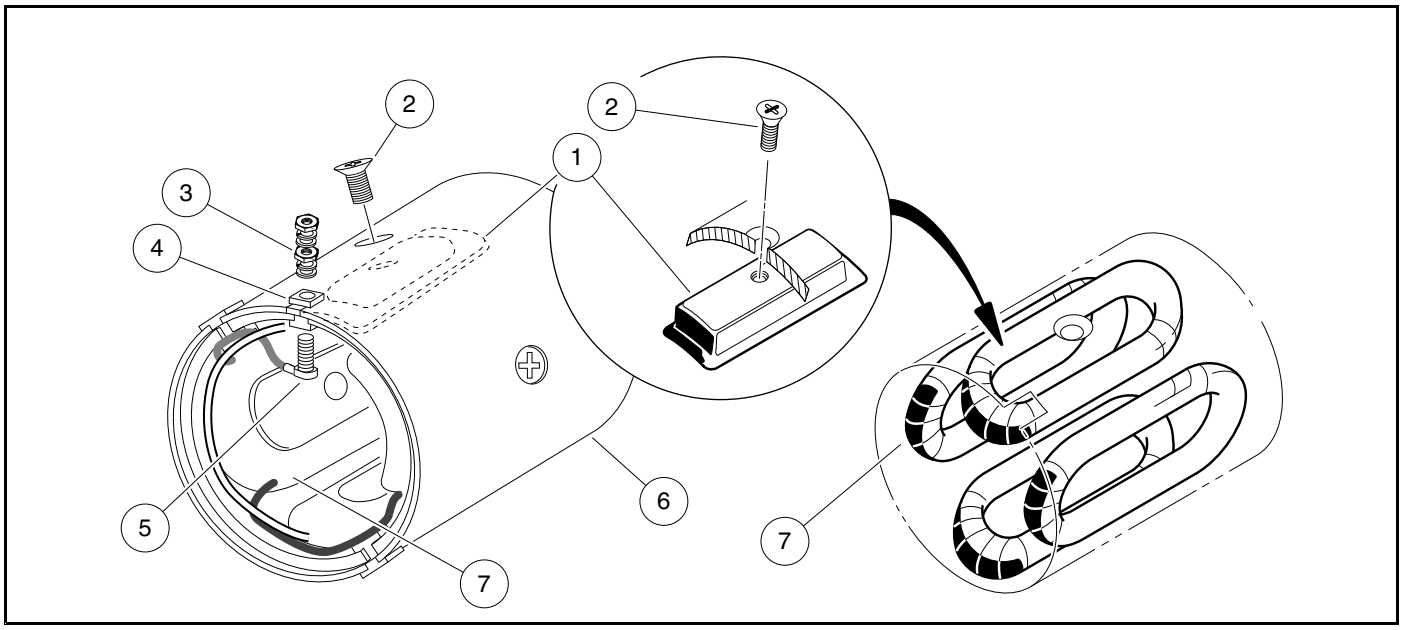
FIELD COIL ASSEMBLY

Replace entire field coil housing assembly if coils, pole shoes or terminals are damaged. **(Figure 19-11, Page 19-8)**.

VISUAL INSPECTION OF ARMATURE

Obvious defects can be seen by examining the armature. If an armature has frayed or charred insulation, broken wires or thrown solder, it is obvious without testing that it should be replaced. Faults seen during the visual inspection can aid in diagnosing the original cause of the failure. Items to look for are listed below.

- Burned, charred, or cracked insulation
- Improperly cured varnish
- Thrown solder
- Flared armature windings
- Worn, burned, or glazed commutator
- Loose or raised commutator bars
- Bruised or damaged armature core laminations
- Worn armature bearing or shaft
- Dirty or oily commutator



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Figure 19-11 Field Coil Assembly

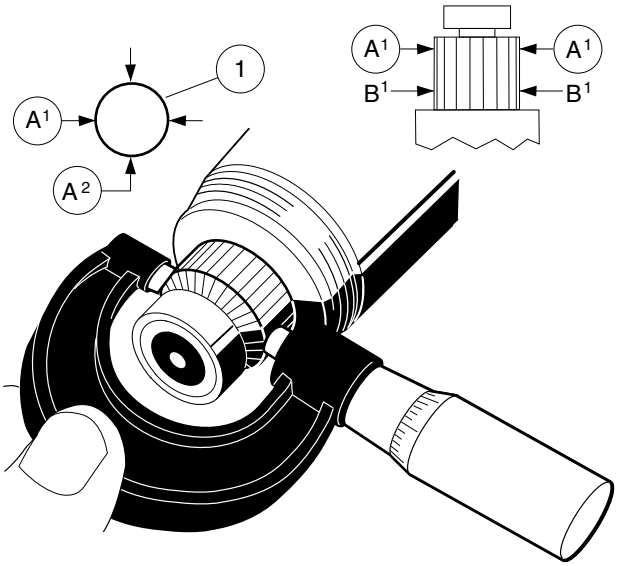
COMMUTATOR CLEANING AND INSPECTION

1. Clean the carbon dust, dirt and oil from the commutator. Visually inspect the commutator for worn, burned or glazed areas. Check for loose or raised commutator bars. Slight roughness of the commutator can be polished away with 400 grit (or finer) sandpaper. **See following CAUTION.**

⚠ CAUTION

- **Do not use emery cloth on the commutator. Particles of emery are conductive and may short-circuit the commutator bars. Do not use oil or lubricants on the commutator or brushes.**

2. Using a micrometer, measure the outside diameter at two points along the commutator. If the commutator outside diameter is less than 1.535 inches (39 mm), replace the armature and bearings **(Figure 19-12, Page 19-9)**.



1. Measure each position in two places, 90 degrees apart

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Figure 19-12 Inspect Commutator

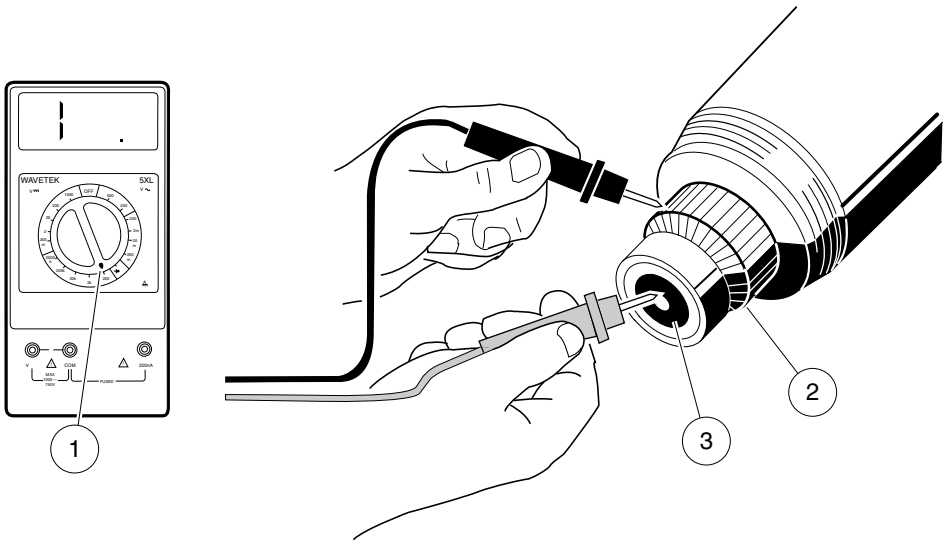
ARMATURE GROUND TEST

⚠ CAUTION

- **Do not submerge armature in solvent.**

NOTE: *Before testing, wipe the armature with a clean cloth and remove carbon dust and metal particles from between commutator bars.*

Using a multimeter set on 200 ohms, place the positive (+) probe on the commutator bars and the negative (–) probe on the armature core. The reading should be no continuity. If the reading is incorrect, replace the armature and the two bearings **(Figure 19-13, Page 19-10)**.



1. 200 Ohms Setting 2. Commutator 3. Armature Shaft

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Figure 19-13 Armature Ground Test

VISUAL INSPECTION OF FIELD COILS

If the insulation on the field coils appears blackened or charred, the serviceability of the coils is questionable. Burned or scorched coil insulation indicates the starter/generator has overheated due to overloads or grounded or shorted coil windings. Be sure the insulators are tight in the housing.

STARTER/GENERATOR REWORK

Any rework must be performed by a qualified technician. Starter/generator service specifications are listed in the following table.

ITEM	SERVICE LIMIT
Commutator diameter (minimum)	1.60 in. (41 mm)
Concentric with armature shaft within	0.002 in. (0.051 mm)
Minimum commutator diameter for reslotting	1.65 in. (42 mm)
Undercut (Commutator must have a minimum diameter of 1.65 in (42 mm) for reslotting):	0.050 in. (1.3 mm)
Dielectric strength	500 VAC for one minute
Armature insulation resistance	0.2M (ohms) at 500 VDC
Starter field coil resistance	0.006 to 0.01 ohms
Generator field coil resistance	4.5 to 5.5 ohms

STARTER/GENERATOR ASSEMBLY

1. Slide the bearing retainer (32) onto the output end of the armature shaft (33) **(Figure 19-8, Page 19-6)**.

2. Press a new ball bearing (35) onto the output end of the armature **(Figure 19-8, Page 19-6)**. Press a new ball bearing onto the commutator end of the armature shaft. **See following CAUTION.**

⚠ CAUTION

- **To prevent damage to the retainer, use care while pressing new bearing onto the output end of the shaft.**
- **Press against the inner race of the new bearing until it is fully seated.**

3. Install the drive end cover (36) onto the armature. Secure the bearing retainer ring (32) **(Figure 19-8, Page 19-6)**.
4. Slide the housing with field coils over the armature. Use the tapped mounting holes to align housing to the cover, rotate and orient as shown.

NOTE: *The terminal insulators should be on the commutator end of the housing.*

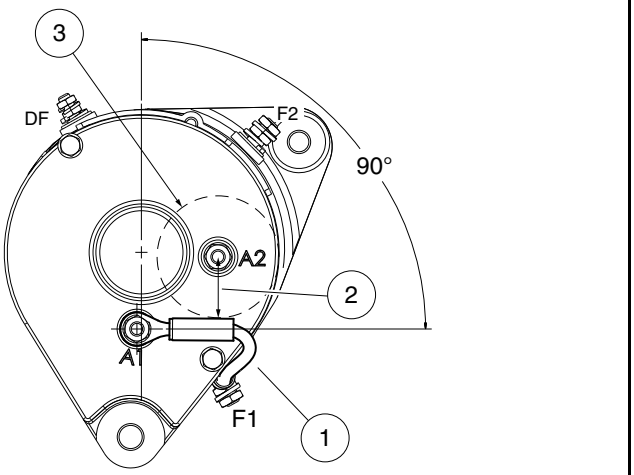
5. To prevent contact between the brushes and commutator as the commutator cover is installed, and possible damage to the brushes, lift the brush springs out of the notches in the brushes and pull the brushes back from the center of the commutator end cover. The springs will rest on the sides of the brushes and help prevent them from sliding towards the center of the cover **(Figure 19-7, Page 19-5)**.
6. Install the commutator end cover (23) onto the armature shaft. Use the tapped mounting holes to align housing to the cover, rotate and orient as shown. Install the two M6 x 180 mm bolts (20), and tighten to 60 in·lb (6.8 N·m) **(Figure 19-3, Page 19-3)**.
7. Push the brushes down into the holders. Place springs into the notches in the brushes. Install the brush cover (30) that has the drain hole in it next to the A2 terminal. Install the remaining three brush covers (29) in the openings in the commutator end cover (23) **(Figure 19-4, Page 19-3)**.
8. Install the belt pulley (39) onto the shaft, and install the lock washer (40) and M14 nut (41). Tighten the nut to 30 ft·lb (40.7 N·m) **(Figure 19-8, Page 19-6)**.
9. Install the A1 to F1 terminal jumper wire on the starter/generator.

9.1. Loosely attach wire, flat washers, lock washers and nuts onto each terminal.

9.2. Orient wire at A1 to be 1 inch (25.4 mm) away from A2 terminal as shown and tighten nut to 44 in·lb (5 N·m) **(Figure 19-14, Page 19-12)**. **See following NOTE.**

NOTE: *Secure bottom nut of terminal with wrench before tightening top nut.*

9.3. Form wire against starter housing as shown and allow terminal at F1 to self-orient. Tighten nut to 44 in·lb (5 N·m). **See preceding NOTE.**



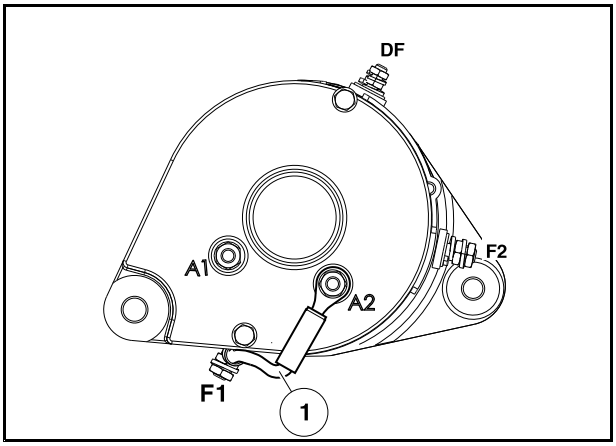
1. Jumper Wire
2. 1 inch (25.4 mm) Minimum Radius
3. Jumper Wire Not Allowed in this Area.

2687

Figure 19-14 A1 to F1 Terminal Jumper Wire Routing

STARTER/GENERATOR INSTALLATION

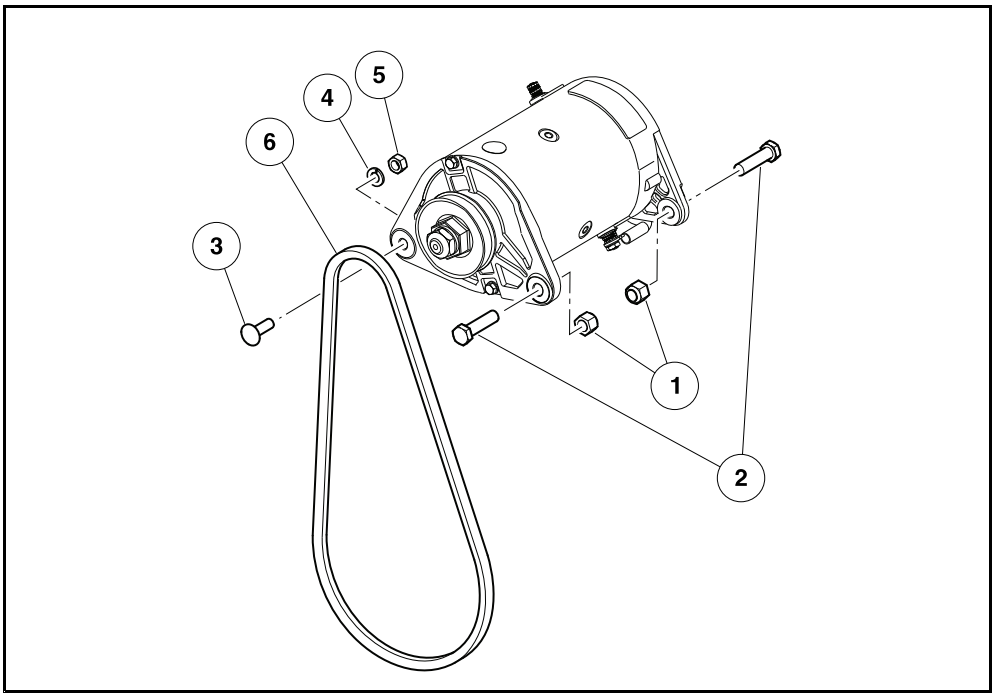
1. Disable the vehicle.
2. Disconnect the battery and spark plug wire.
3. Install the green wire (1) from the F1 terminal to the A2 terminal on the starter/generator **(Figure 19-15)**.



3033B

Figure 19-15 Starter/Generator Green Wire

4. Install a flat washer, lock washer, and nut onto each terminal and tighten to 48 in·lb (5.4 N·m).
5. Position the starter/generator over the mounting bracket.
6. Install the pivot bolts (2) and pivot nuts (1) **(Figure 19-16, Page 19-13)**. Tighten the pivot nuts with your hand.

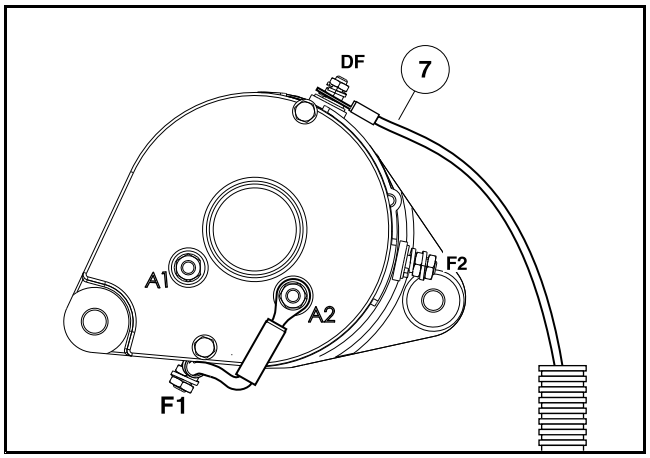


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Figure 19-16 Starter/Generator Installation

7. Install the adjustment bolt (3), lock washer (4), and nut (5). Tighten the hardware with your hand.
8. Install starter/generator belt (6).

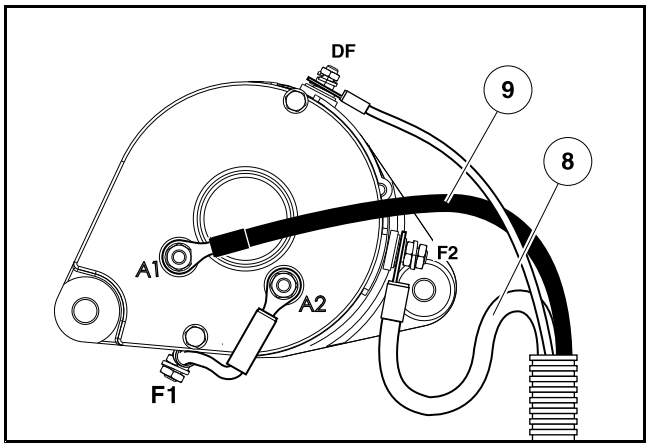
9. Adjust the belt tension. See Belt Tension Adjustment For EFI Engines.
10. Connect the yellow wire (7) from the voltage regulator to the DF terminal on the starter/generator **(Figure 19-17)**.



3033D

Figure 19-17 Starter/Generator Yellow Wire

11. Install a flat washer, lock washer, and nut onto the terminal. Tighten the nut to 31 in·lb (3.5 N·m).
12. Install the white wire (8) from the solenoid to the F2 terminal on the starter/generator **(Figure 19-18)**.



3033E

Figure 19-18 Starter/Generator White and Black Wires

13. Install the black wire (9) from the frame to the A1 terminal on the starter/generator.
14. Install a flat washer, lock washer and nut onto each terminal, and tighten the nut to 48 in·lb (5.4 N·m).
15. Connect the battery and spark plug wire.

BELT TENSION INSPECTION FOR EFI ENGINES

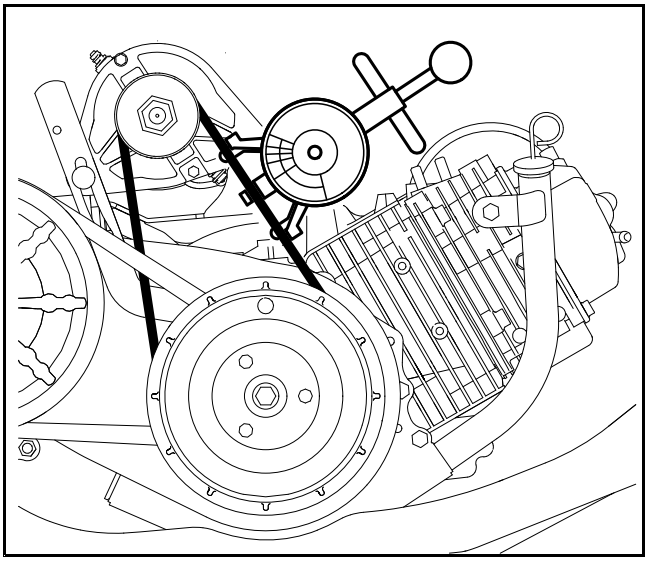
NOTE: *To prevent belt slipping while starting an EFI engine, follow procedure outlined below which is best performed by two people to expedite the process, but can be performed by a single individual if required.*

The amount a starter/generator belt is tensioned varies between a used and new belt.

EFI engines have higher starting torque demands that require consistent belt tension to prevent slipping. Belt tension should be checked periodically.

Existing Belts Only

1. Disconnect the battery and spark plug wire.
2. Mark a location on belt to repeat tension measurement each time. Use paint pen or permanent marker of light color.
3. Install a Universal Belt Tension Gauge (OTC® 6673 recommended) midway between the pulleys.



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Figure 19-19 Belt Tension Gauge

4. Measure the belt tension. Correct belt tension for a used starter/generator belt is 75 to 85 lbf (334 to 378 N).

4.1. If the belt tension is within the accepted range, no further action is needed. Connect the battery and spark plug wire.

4.2. If the belt tension is not within the accepted range, adjust the belt tension. See Belt Tension Adjustment For EFI Engines.

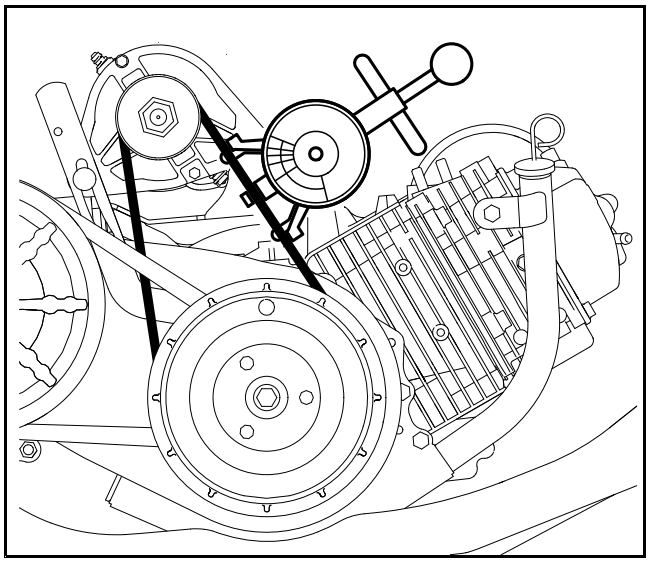
BELT TENSION ADJUSTMENT FOR EFI ENGINES

NOTE: *To prevent belt slipping while starting an EFI engine, follow procedure outlined below which is best performed by two people to expedite the process, but can be performed by a single individual if required.*

The amount a starter/generator belt is tensioned varies between a used and new belt.

EFI engines have higher starting torque demands that require consistent belt tension to prevent slipping. Belt tension should be checked periodically.

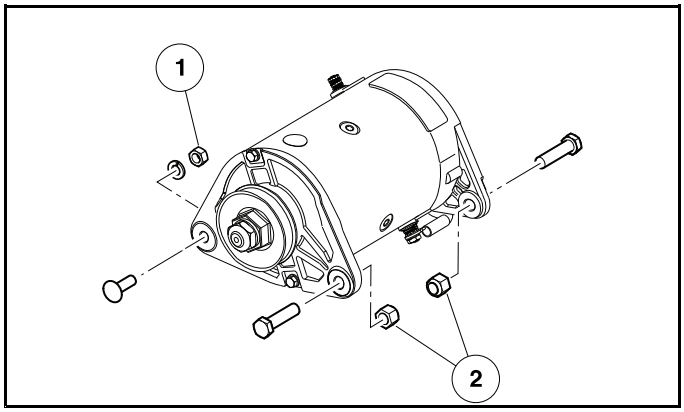
1. Disconnect the battery and spark plug wire.
2. Mark a location on belt to repeat tension measurement each time. Use paint pen or permanent marker of light color.
3. Install a Universal Belt Tension Gauge (OTC® 6673 recommended) midway between the pulleys.



2724

Figure 19-20 Belt Tension Gauge

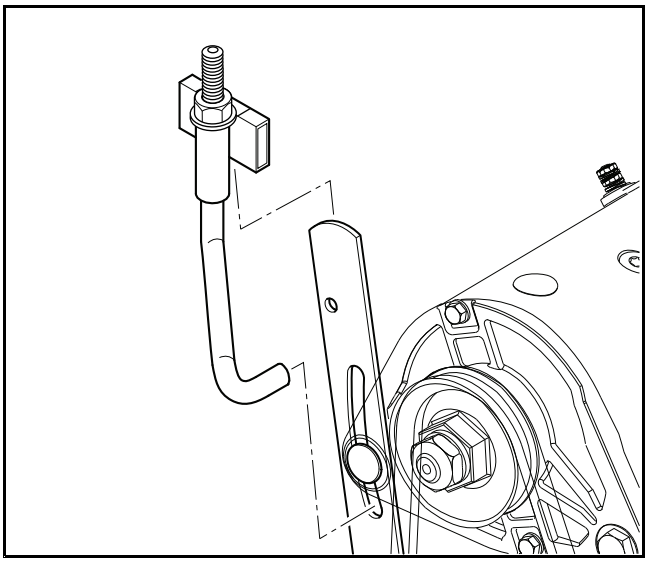
4. Tighten the adjustment nut (1) and pivot nut (2) with your hand **(Figure 19-21, Page 19-16)** .



2997C

Figure 19-21 Starter/Generator Mounting Hardware

5. Install the belt tension tool.



2725

Figure 19-22 Belt Tensioning Tool Installation

5.1. Carefully insert pry bar between starter/generator and bracket.

NOTE: *In some cases, the threaded J-bolt of the belt tension tool does not have enough length to consistently fit under the starter/generator mounting ear. Fit can be greatly improved by modifying the tension tool. See Belt Tension Tool Modification.*

5.2. Carefully lift the starter/generator up until tension tool can be installed as shown over the slotted adjustment bracket **(Figure 19-22, Page 19-17)**. Note orientation of tension tool on the slotted adjustment bracket and how the threaded J-bolt is inserted into the slot under the starter/generator mounting ear.

5.3. Remove the pry bar.

6. Tension the belt.

6.1. Tighten the nut on belt tension tool 1/2 turn and check belt tension with the gauge.

NOTE: *To prevent errors in measurement caused by residual tension, ensure to loosen, then reapply, the Universal Belt Tension gauge between measurements.*

6.2. Continue to tighten in 1/2 turn increments until proper belt tension is achieved.
- Proper tension for a **used** starter/generator belt is 75 to 85 lbf (334 to 378 N).
- Proper tension for a **new** starter/generator belt is 120 to 130 lbf (534 to 578 N).

7. Seat the belt.

7.1. Remove all other tools.

7.2. The belt tension tool can be temporarily left in place.

7.3. Only connect the battery. DO NOT CONNECT SPARK PLUG WIRE. **See following WARNING.**

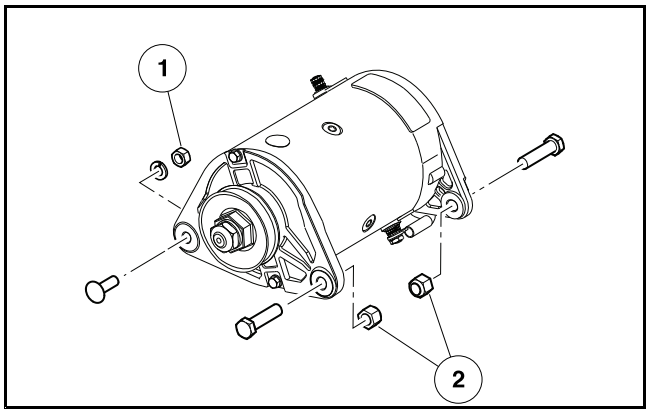
⚠ WARNING

- **Remove pry bar before starting engine.**
- **Ensure clearance between F2 terminal and starter/generator bracket before starting engine.**

7.4. Operate the engine a minimum of 5 seconds and a maximum of 15 seconds to fully seat the belt into pulleys and help eliminate any slack.

8. Repeat step 6..

9. Maintain tension and tighten the adjustment nut (1) to 15 to 18 ft·lb (20 to 24.5 N·m). Tighten the pivot nuts (2) to 20 to 25 ft·lb (27 to 34 N·m) **(Figure 19-23, Page 19-18)**.

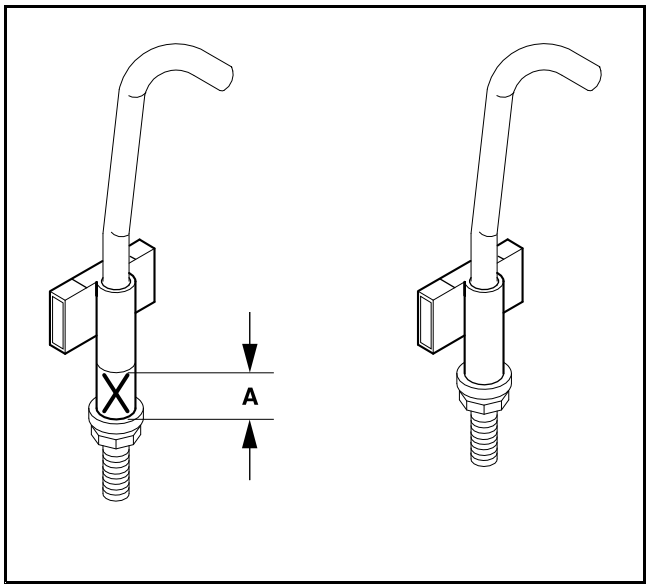


2997C
Figure 19-23 Starter/Generator Mounting Hardware Installation

10. Remove the belt tension tool.
11. Confirm proper belt tension with a final measurement.
12. Connect the spark plug wire.

BELT TENSION TOOL MODIFICATION

1. Remove the nut and J-bolt from the bracket.
2. Grind or cut 3/8 to 1/2 inch (9.5 to 12.7 mm) (A) from bracket as shown to increase the effective length of the J-bolt **(Figure 19-24, Page 19-18)**.



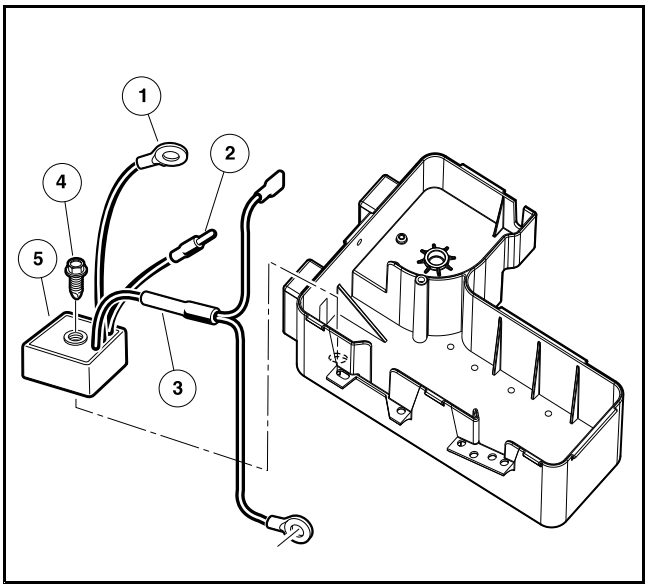
2726B
Figure 19-24 Belt Tension Tool Modification (If Necessary)

3. Install the J-bolt and nut into the bracket.

VOLTAGE REGULATOR

VOLTAGE REGULATOR REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the electrical component box cover.
3. Disconnect the voltage regulator red wire (1) at the large post on the solenoid **(Figure 19-25)**.



2973B

Figure 19-25 Voltage Regulator

4. Disconnect the yellow wire (2) at the bullet connector.
5. Disconnect the black wire (3) from the (NO) terminal of the kill limit switch and at the battery frame ground.
6. Remove the screw (4).
7. Remove the voltage regulator (5).

VOLTAGE REGULATOR INSTALLATION

1. Position the voltage regulator (5) in the electrical component box **(Figure 19-25)**.
2. Install the screw (4). Tighten the screw to 23 in·lb (2.6 N·m).
3. Connect the voltage regulator red wire (1) at the large post on the solenoid.
4. Connect the yellow wire (2) at the bullet connector.
5. Connect the black wire (3) at the battery frame ground.
6. Install the electrical component box cover. Be sure to firmly press down all corners.
7. Install the box cover screw and tighten to 18 in·lb (2 N·m).
8. Connect the battery and spark plug wire.
9. Set the Forward/Neutral/Reverse control (FNR) to N.
10. Set the Maintenance/Operate switch to MAINTENANCE.
11. Start the engine.
12. Make sure that the voltage regulator operates correctly. See the test procedure for voltage regulator.

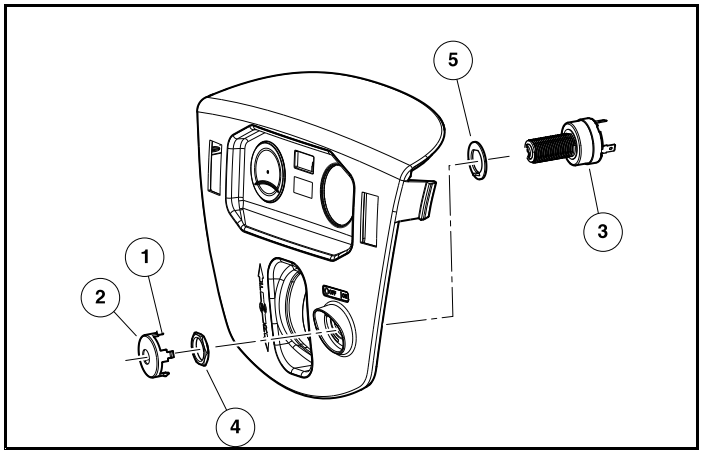
KEY SWITCH

KEY SWITCH REMOVAL

1. Disconnect the battery and spark plug.
2. Remove the instrument panel.

NOTE: *Take care to prevent key switch terminals and wires from touching the metal frame around the dash.*

3. Disconnect the wires from the key switch. Do not allow wires to touch.
4. From the back of the instrument panel, push down on the retaining tabs (1) and remove the key switch cap (2) **(Figure 19-26, Page 19-20)**.



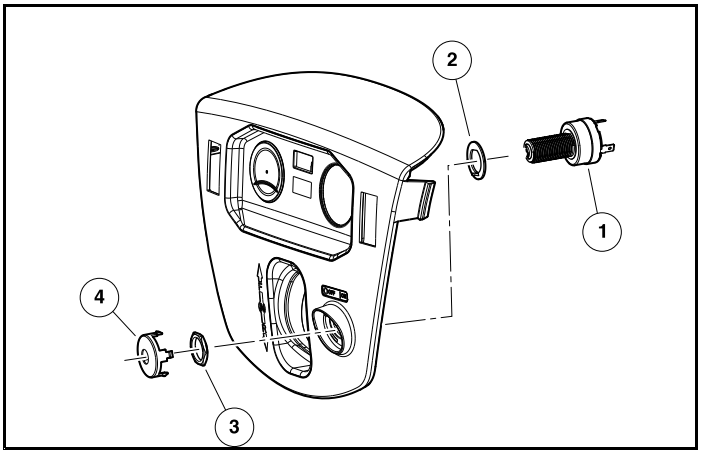
2931B

Figure 19-26 Key Switch Removal

5. Hold the key switch (3) and remove the switch retaining nut (4).
6. Remove the key switch and washer (5).

KEY SWITCH INSTALLATION

1. Install the key switch (1) and washer (2) into the instrument panel **(Figure 19-27, Page 19-21)**.



2931C

Figure 19-27 Key Switch Installation

2. Install the key switch nut (3). Tighten the nut to 35 to 45 in·lb (4 to 5 N·m).
3. Install key switch cap (4) into instrument panel.
4. Connect the wires to the key switch terminals. See the following table.

Pedal-Start

Terminal	Wire Color
1	Brown / White
2	Green
-M	Black
+M	Red / Yellow

Key-Start

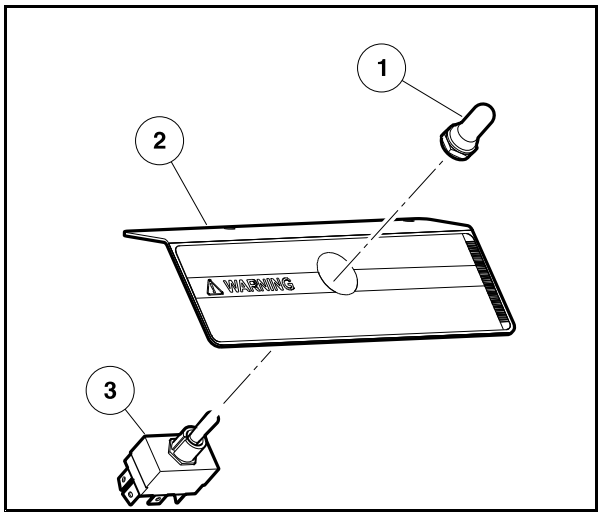
Terminal	Wire Color
1	Brown / White
2	Green
-M	Black
+M	Red / Yellow
S	Gray

5. Install the instrument panel.
6. Connect the battery and spark plug.

MAINTENANCE/OPERATE SWITCH

MAINTENANCE/OPERATE SWITCH REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the boot/hex nut (1) **(Figure 19-28)**.



000755-004

Figure 19-28 Maintenance/Operate Switch

3. Remove the Maintenance/Operate switch (2) from bracket (3).
4. Disconnect the wires and remove Maintenance/Operate switch.

MAINTENANCE/OPERATE SWITCH INSTALLATION

1. Connect the wires to the Maintenance/Operate switch.

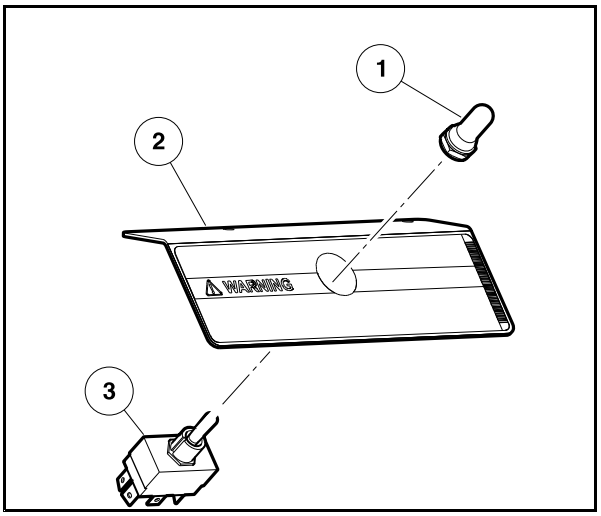
Pedal-Start

Terminal	Wire Color
T1	Black / Pink
T2	Black
T3	Black / Yellow

Key-Start

Terminal	Wire Color
T1	Blue/White
T2	Black
T3	Open

2. Make sure that the groove switch is aligned with tang on bracket (3) and install the Maintenance/Operate switch (2) **(Figure 19-29, Page 19-23)**.



000755-004
Figure 19-29 Maintenance/Operate Switch

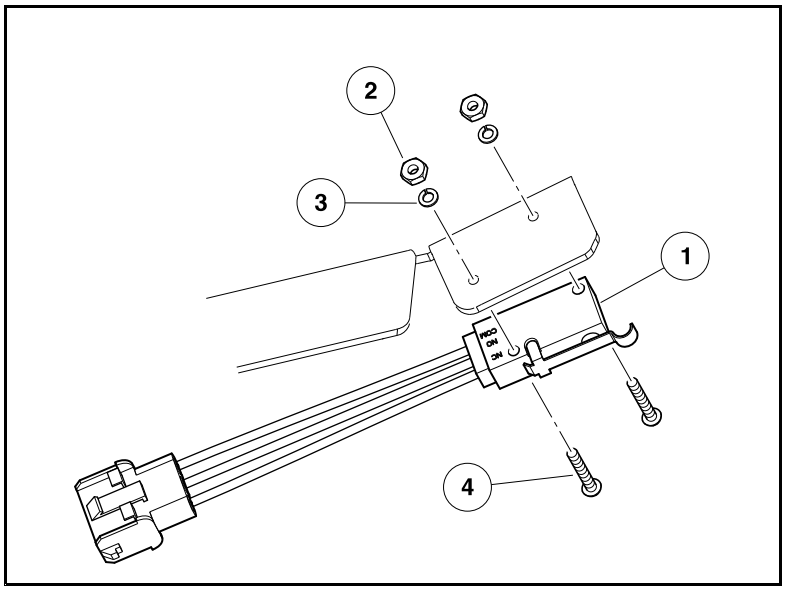
3. Install the boot/hex nut (1). Tighten the boot/hex nut to 16 in·lb (1.8 N·m).
4. Connect the battery.

NEUTRAL LOCKOUT LIMIT SWITCH

NEUTRAL LOCKOUT LIMIT SWITCH REMOVAL

On Transaxle

1. Disable the vehicle.
2. Disconnect the battery and spark plug wire.
3. Disconnect the 3-wire connector from the neutral lockout limit switch (1) **(Figure 19-30)**.

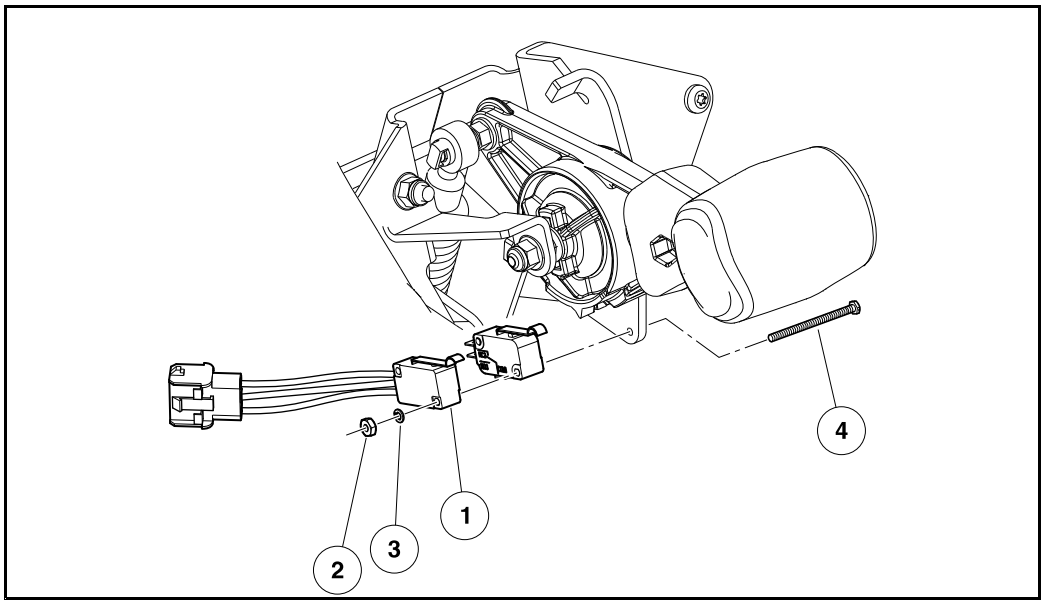


000999-003
Figure 19-30 Transaxle - Neutral Lockout Limit Switch

4. Remove the nuts (2),washers (3), and bolts (4).
5. Remove the neutral lockout limit switch.

On FNR

1. Disable the vehicle.
2. Disconnect the battery and spark plug wire.
3. Remove the instrument panel.
4. Disconnect the 3-wire connector from the neutral lockout limit switch (1) **(Figure 19-31)**.



000999-004
Figure 19-31 FNR - Neutral Lockout Limit Switch

5. Remove the nut (2), washer (3), and bolt (4).
6. Remove the neutral lockout limit switch.

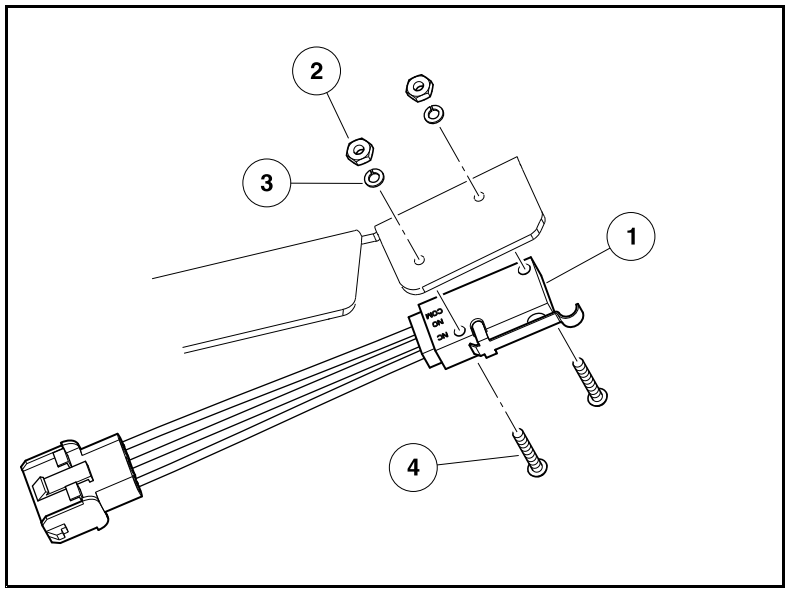
NEUTRAL LOCKOUT LIMIT SWITCH INSTALLATION

⚠ CAUTION

- **Do not overtighten the retaining nuts. If the nuts are overtightened, limit switches could be damaged.**

On Transaxle

1. Install the limit switch (1) with the screws (4), washers (3), and nuts (2). Tighten the hardware to 5 in·lb (0.6 N·m) **(Figure 19-32)**.

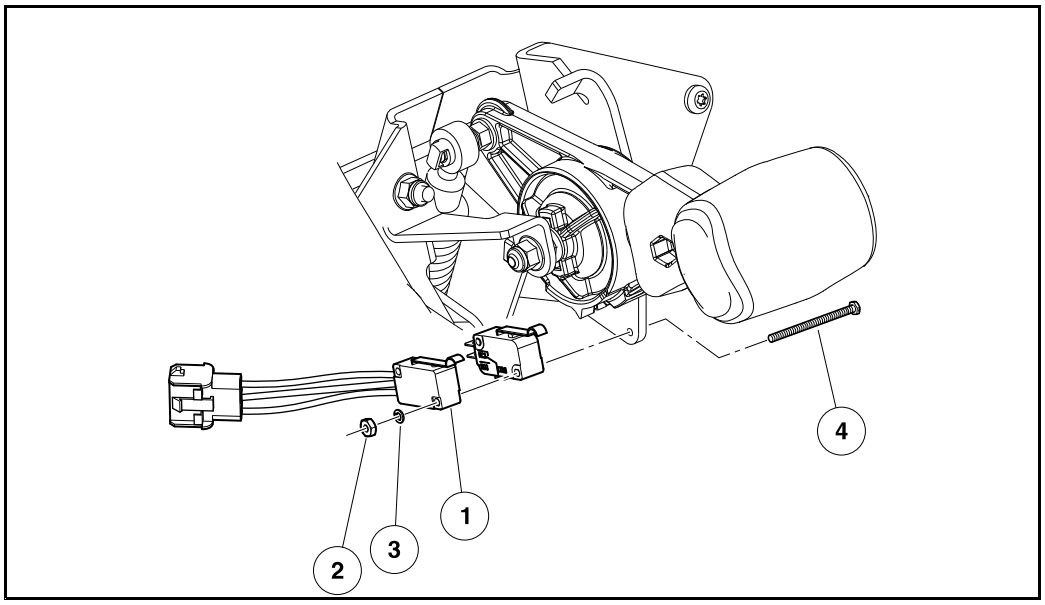


000999-003
Figure 19-32 Transaxle - Neutral Lockout Limit Switch

2. Move the Forward/Neutral/Reverse control (FNR) to make sure that the switch actuates.
3. Connect the 3-wire connector to the neutral lockout limit switch lead.
4. Connect the battery and spark plug wire.
5. Test drive the vehicle in both forward and reverse for proper operation.

On FNR

1. Install the limit switch (1) with the bolt, (4), washer (3), and nut (2). Tighten the hardware to 5 in·lb (0.6 N·m) **(Figure 19-33)**.



000999-004

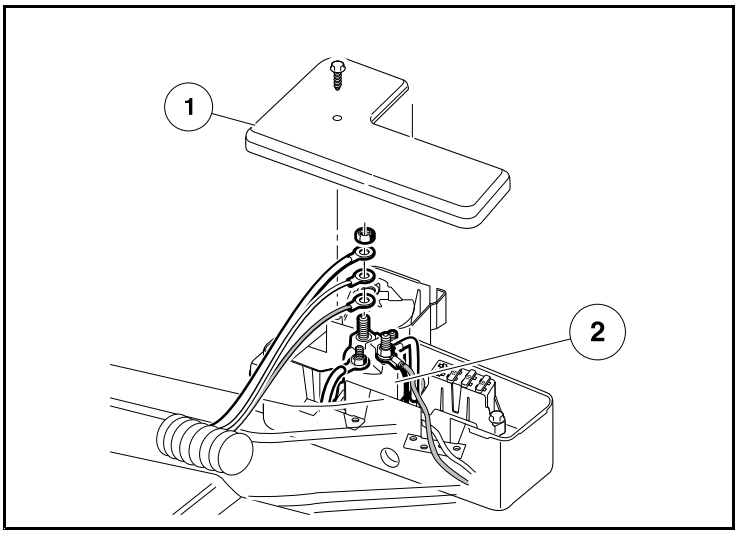
Figure 19-33 FNR - Neutral Lockout Limit Switch

2. Move the Forward/Neutral/Reverse control (FNR) to make sure the switch actuates
3. Connect the 3-wire connector to the neutral lockout limit switch lead.
4. Connect the battery and spark plug wire.
5. Test drive the vehicle in both forward and reverse for proper operation.

SOLENOID

SOLENOID REMOVAL

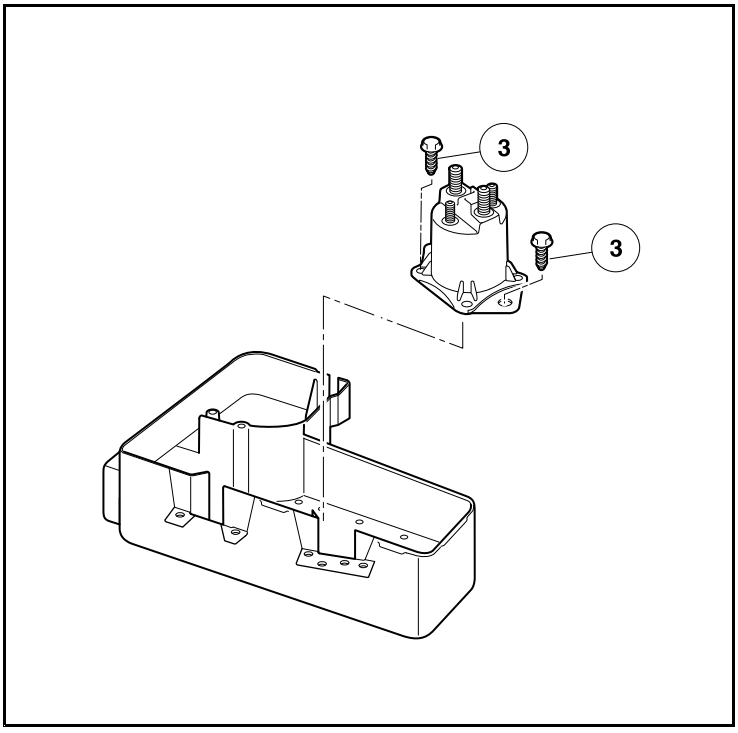
1. Disconnect the battery and spark plug wire.
2. Remove the electrical component box cover (1) **(Figure 19-34)**.



3025C

Figure 19-34 Solenoid Wires

3. Disconnect the wires from the solenoid (2).
4. Remove the screws (3) from the solenoid **(Figure 19-35)**.



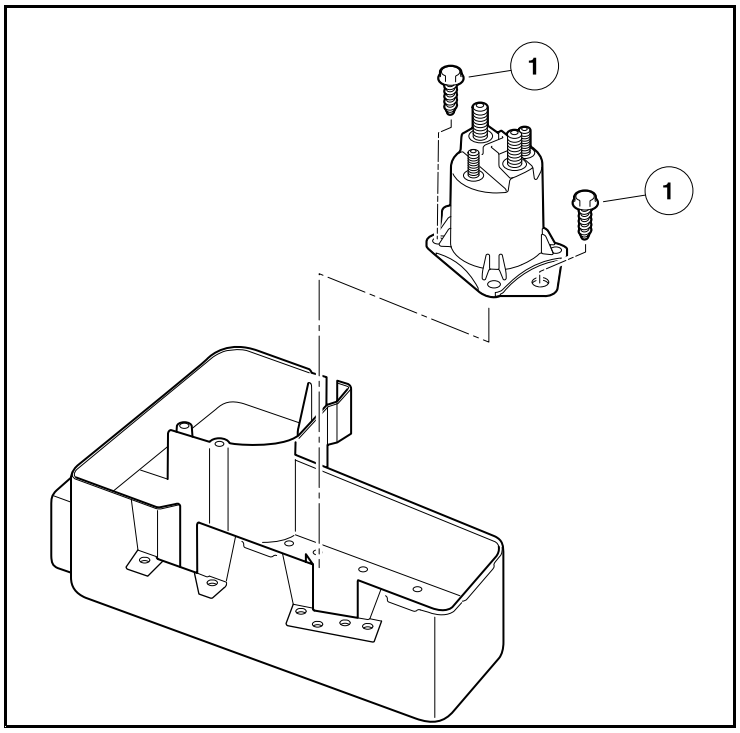
001014-003

Figure 19-35 Solenoid Screws

5. Remove the solenoid.

SOLENOID INSTALLATION

1. Install the solenoid in the electrical component box.
2. Install the screws (1) **(Figure 19-36)**. Tighten the screws to 14 in·lb (1.6 N·m) .



001014-004

Figure 19-36 Solenoid Screws

3. **Pedal-Start Vehicle:**

3.1. Connect the 4 gauge white wire, 18 gauge white wire, and the 18 gauge red wire to the large post.

3.2. Connect the 4-gauge red wire, 10-gauge red wire, and 16-gauge orange wire to the other large post on the solenoid.

4. **Key-Start Vehicle:**

4.1. Connect the 4 gauge white wire, 18 gauge white wire, 10 gauge white wire, and the 18 gauge red wire to the large post.

4.2. Connect the 4-gauge red wire, 10-gauge red wire, 10 gauge red wire, and 16-gauge orange wire to the other large post on the solenoid.

5. Connect the 18 gauge orange wire to the small post on the solenoid.
6. Connect the 18 gauge blue wire to the other small post on the solenoid.
7. Install the nuts on the large solenoid posts. Tighten the nuts to 60 in·lb (6.8 N·m).
8. Install the nuts on the small solenoid posts. Tighten the nuts to 22 in·lb (2.5 N·m).
9. Install the electrical box cover.
10. Connect the battery and spark plug wire.

FUSE

ATC-style fuses are located inside the electrical component box near the battery.

ATM-style fuses are located on the main wire harness in front of the engine.

FUSE REMOVAL

1. Disconnect the battery.
2. **ATC Fuse Only:** Remove electrical component box cover cover.

   ATM Fuse Only: Remove fuse holder cover.
3. Remove the fuse from the fuse block.

FUSE INSTALLATION

1. Install the fuse. **See following WARNING.**

⚠ WARNING

- **If a fuse is blown, determine the cause of the failure and make necessary repairs before installing a new fuse. Use the appropriately rated fuse; if a fuse with a higher amp rating is used, damage to the vehicle electrical system may occur.**

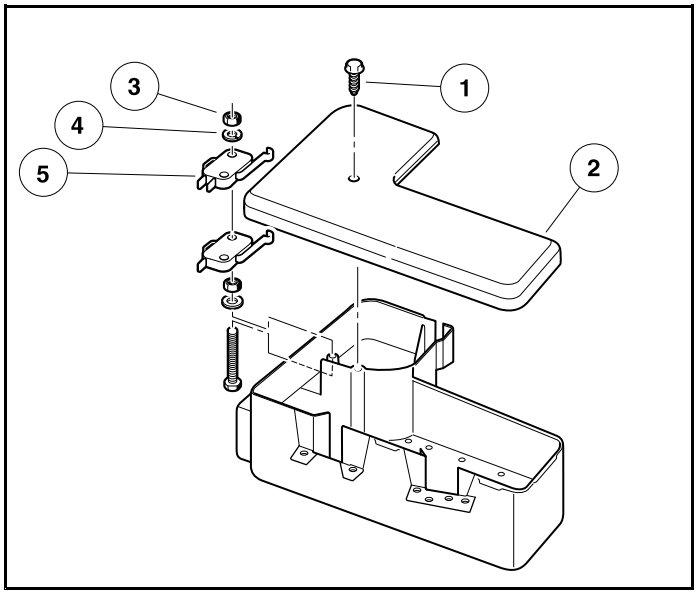
2. **ATC Fuse Only:** Install the snap-on electrical box cover by pressing down firmly on all corners and install the screw, tightening to 18 in·lb (2 N·m).

   ATM Fuse Only: Install the fuse holder cover.
3. Connect the battery.

ACCELERATOR PEDAL LIMIT SWITCH

ACCELERATOR PEDAL LIMIT SWITCH REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the screw (1) **(Figure 19-37)**.



2948D

Figure 19-37 Accelerator Pedal Limit Switch

3. Remove the electrical component box cover (2).
4. Remove the two nuts (3) and washers (4).
5. Disconnect the wires from the accelerator pedal limit switch (5).
6. Remove the accelerator pedal limit switch.

ACCELERATOR PEDAL LIMIT SWITCH INSTALLATION

1. Connect the green wire to the common (COM) terminal.
2. Connect the pink wire to the normally closed (NC) terminal.
3. Install the two washers (4) and two nuts (3) **(Figure 19-37, Page 19-30)**. Tighten the nuts to 5 in·lb (0.6 N·m). **See following CAUTION.**

⚠ CAUTION

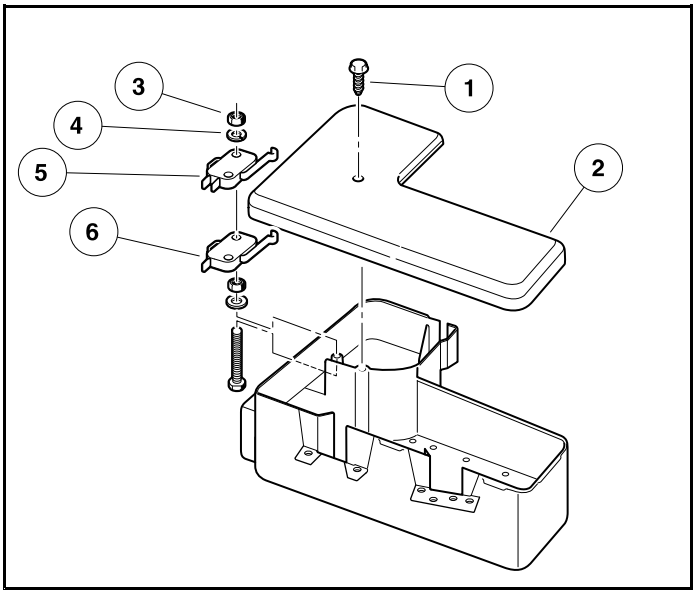
- **Do not overtighten the retaining nuts. If the nuts are overtightened, limit switches could be damaged.**

4. Press and release the accelerator pedal to make sure that both switches are being activated when the pedal is released.
5. Install the electrical component box cover (2). Be sure to press down firmly all corners. Install the screw (1). Tighten the screw to 18 in·lb (2 N·m).
6. Connect the battery and spark plug wire.

KILL LIMIT SWITCH

KILL LIMIT SWITCH REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the screw (1) **(Figure 19-38)**.



2948E

Figure 19-38 Kill Limit Switch

3. Remove the electrical component box cover (2).
4. Remove the two nuts (3) and washers (4).
5. Remove the accelerator pedal limit switch (5). Do not disconnect the wires attached to accelerator pedal limit switch.
6. Disconnect the wires from the kill limit switch (6).
7. Remove the kill limit switch.

KILL LIMIT SWITCH INSTALLATION

1. Connect the white/black wire to the common (COM) terminal.
2. Connect the blue wire to the normally open (NO) terminal.
3. Install the kill limit switch (6) on the mounting screws **(Figure 19-38, Page 19-31)**.
4. Install the accelerator limit switch (5) on the mounting screws.
5. Install the two washers (4) and two nuts (3). Tighten the nuts to 5 in·lb (0.6 N·m). **See following CAUTION.**

⚠ CAUTION

- **Do not overtighten the retaining nuts. If the nuts are overtightened, limit switches could be damaged.**

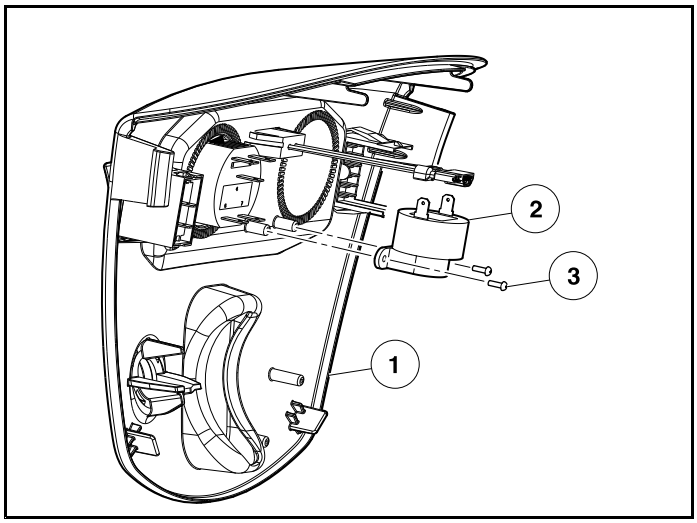
6. Press and release the accelerator pedal to make sure that both switches are being activated when the pedal is released.

7. Install the electrical component box cover (2). Be sure to press down firmly all corners.
8. Install the screw (1). Tighten the screw to 18 in·lb (2 N·m).
9. Connect the battery and spark plug wire.

REVERSE WARNING BUZZER

REVERSE WARNING BUZZER REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel (1) **(Figure 19-39, Page 19-32)**.



3003B

Figure 19-39 Reverse Warning Buzzer

3. Disconnect the wires from the reverse warning buzzer (2). Do not let the wires touch.
4. Remove the mounting screws (3).
5. Remove the reverse buzzer.

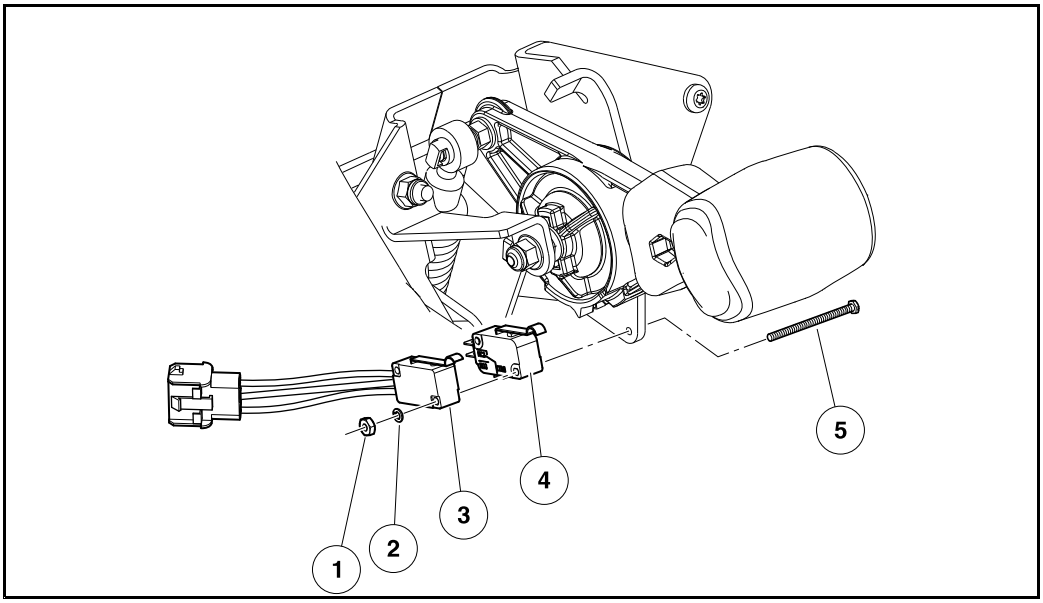
REVERSE WARNING BUZZER INSTALLATION

1. Install the reverse buzzer (2) on the instrument panel (1) **(Figure 19-39, Page 19-32)**.
2. Install the screws (3). Tighten the screws to 3.5 in·lb (0.40 N·m).
3. Connect the black wire from the key switch to the negative (–) terminal.
4. Connect the orange/white wire from the wire harness to the positive (+) terminal.
5. Install the instrument panel. Make sure that the key switch terminals cannot touch the frame. Make sure that the panel is properly seated and snapped in place.
6. Connect the battery and spark plug wire.

REVERSE BUZZER LIMIT SWITCH

REVERSE BUZZER LIMIT SWITCH REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Cut the wire tie that retains the limit switch leads to the instrument panel harness.
4. Remove the nuts (1) and washers (2) **(Figure 19-40, Page 19-33)**.



000999-005
Figure 19-40 Reverse Buzzer Limit Switch

5. Disconnect the neutral lockout limit switch (3).
6. Remove the neutral lockout limit switch.
7. Disconnect the wires from the reverse buzzer limit switch (4).
8. Remove the screws (5) and reverse buzzer limit switch.

REVERSE BUZZER LIMIT SWITCH INSTALLATION

1. Install the reverse buzzer switch (4) with two screws (5) **(Figure 19-40, Page 19-33)**.
2. Install the neutral lockout limit switch (3).
3. Install the washers (2) and nuts (1). Tighten the nuts to 5 in·lb (0.6 N·m). **See following CAUTION.**

⚠ CAUTION

- **Do not overtighten the retaining nuts. If the nuts are over tightened, limit switches could be damaged.**

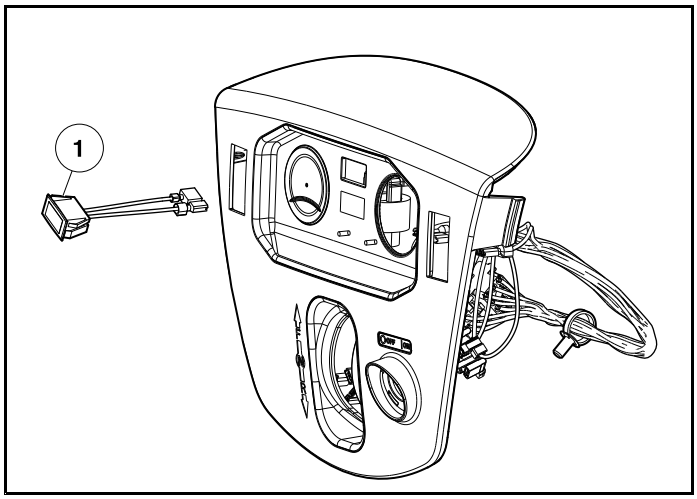
4. Connect the wires to the reverse buzzer limit switch.
5. Connect the neutral lockout limit switch.
6. Set the Forward/Neutral/Reverse control (FNR) to R. Make sure that both switches actuate.

7. Connect the battery and spark plug wire.
8. Turn the key switch to the ON position.
9. Set the FNR to R. Make sure that the buzzer sounds.

LOW OIL WARNING LIGHT

LOW OIL WARNING LIGHT REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the low oil warning light (1) wires **(Figure 19-41, Page 19-34)**. Do not allow wires to touch.



3003C

Figure 19-41 Low Oil Warning Light

4. Push the retaining tabs and remove the low oil warning light from the instrument panel.

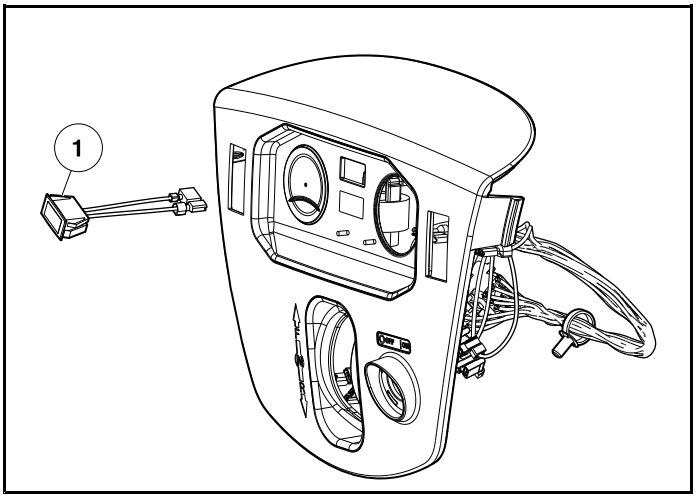
LOW OIL WARNING LIGHT INSTALLATION

1. Install the low oil warning light (1) in the instrument panel until plastic tabs engage instrument panel **(Figure 19-41, Page 19-34)**.
2. Connect the low oil warning light (1) wires.
3. Install the instrument panel. Make sure that the key switch terminals cannot touch the frame. Make sure that the instrument panel is correctly seated and snapped in place.
4. Connect the battery and spark plug wire.

MALFUNCTION INDICATOR LIGHT

MALFUNCTION INDICATOR LIGHT REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the malfunction indicator light (1) wires **(Figure 19-42, Page 19-35)**. Do not allow wires to touch.



3003C

Figure 19-42 Malfunction Indicator Light

4. Push the retaining tabs and remove the malfunction indicator light from the instrument panel.

MALFUNCTION INDICATOR LIGHT INSTALLATION

1. Install the malfunction indicator light (1) in the instrument panel until plastic tabs engage instrument panel **(Figure 19-42, Page 19-35)**.
2. Connect the malfunction indicator light (1) wires.
3. Install the instrument panel. Make sure that the key switch terminals cannot touch the frame. Make sure that the instrument panel is correctly seated and snapped in place.
4. Connect the battery and spark plug wire.

FUEL GAUGE/HOUR METER

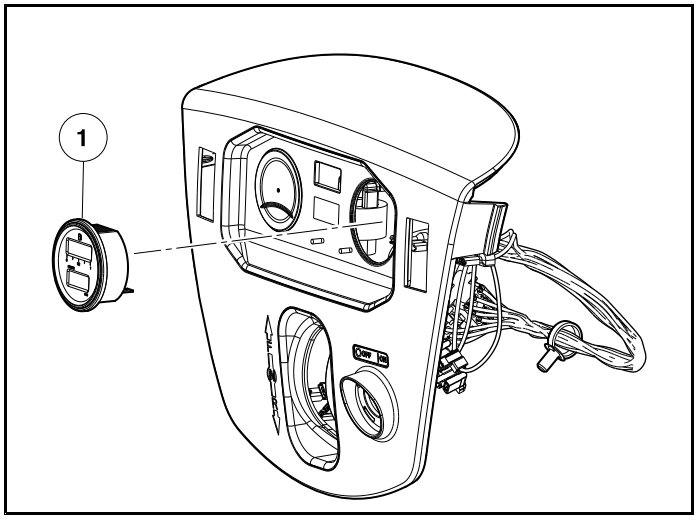
GENERAL INFORMATION

With the key switch in the OFF position, the fuel gauge field is blank; however, the hour meter field is always ON. When the key switch is turned to ON, the fuel gauge field activates. The fuel gauge initially registers full before indicating the actual fuel level.

The hour meter displays the number of hours of use in increments of 0.1 (one tenth) hour, but does not record additional time unless the key switch is in the ON position and the engine is on. When recording, the hourglass icon on the left blinks.

FUEL GAUGE/HOUR METER REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the fuel gauge/hour meter (1) wires **(Figure 19-43, Page 19-36)**. Do not allow wires to touch.



3003D

Figure 19-43 Fuel Gauge/Hour Meter

4. Alternate pulling the lower and upper tabs away from the gauge housing to remove clip.
5. Remove gauge/meter from the instrument panel.

FUEL GAUGE/HOUR METER INSTALLATION

1. Install the fuel gauge/hour meter (1) into the hole in the instrument panel until the flange seats against the instrument panel **(Figure 19-43, Page 19-36)**.
2. Connect the wires to the fuel gauge/hour meter.
3. Install the instrument panel. Make sure that the key switch terminals cannot touch the frame. Make sure that the instrument panel is properly seated and snapped in place.
4. Connect the battery and spark plug wire.

FUEL LEVEL SENDING UNIT

The fuel level sending unit is an integral part of the fuel pump module and is not replaceable. Thoroughly test the fuel level sending unit before replacing the fuel pump module.

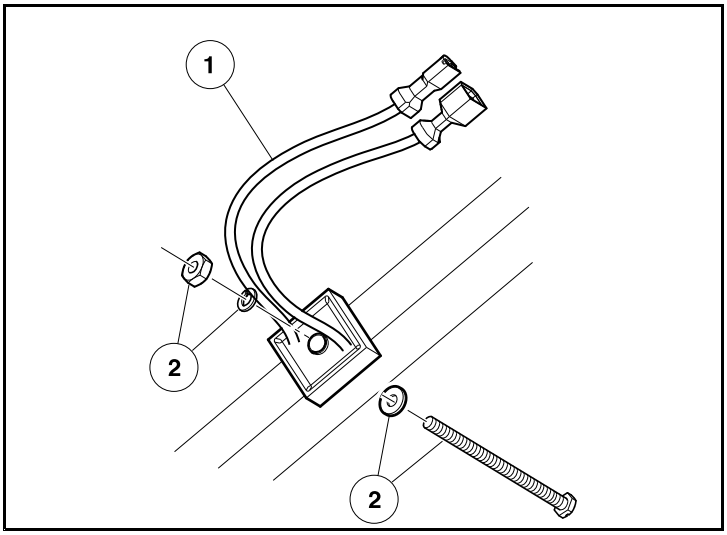
VOLTAGE LIMITER

VOLTAGE LIMITER REMOVAL

NOTE: *Battery will charge reducing the voltage going to accessories.*

The voltage limiter is located on the driver side cowl frame.

1. Disable the vehicle.
2. Disconnect the battery and spark plug wire.
3. Remove the cowl.
4. Disconnect the voltage limiter wires (1) **(Figure 19-44, Page 19-37)**. Do not allow wires to touch.



3002B

Figure 19-44 Voltage Limiter

5. Remove the hardware (2).
6. Remove the voltage limiter.

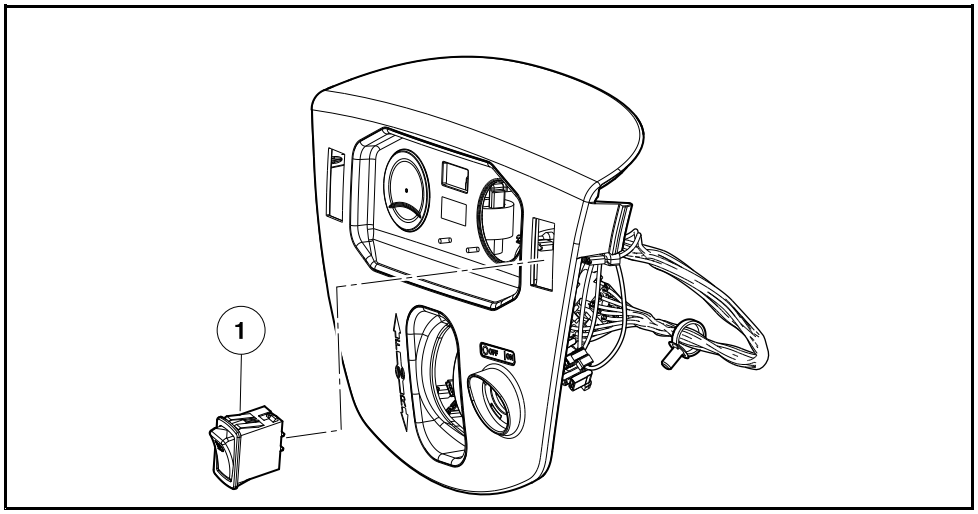
VOLTAGE LIMITER INSTALLATION

1. Install the voltage limiter to the driver side cowl frame.
2. Install the hardware (2). Tighten the hardware to 25 in·lb (2.8 N·m) **(Figure 19-44, Page 19-37)**.
3. Connect the voltage limiter green wire to the harness green wire.
4. Connect the voltage limiter black wire to the harness black wire.
5. Install the cowl.
6. Connect the battery and spark plug wire.

HEADLIGHT SWITCH

HEADLIGHT SWITCH REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the wires from the headlight switch (1) **(Figure 19-45)**.



3003E

Figure 19-45 Headlight Switch

4. Push the tabs and remove the headlight switch from the instrument panel.

HEADLIGHT SWITCH INSTALLATION

1. Connect the wires to the headlight switch (1) **(Figure 19-45)**.
2. Install the headlight switch into instrument panel.
3. Install the instrument panel. Make sure that the key switch terminals cannot touch the frame. Make sure that the instrument panel is properly seated and snapped in place.
4. Connect the battery and spark plug wire.

HEADLIGHTS

HEADLIGHT BEZEL REMOVAL

1. Disconnect the battery
2. Remove the cowl.
3. Remove the front fender.
4. Disconnect the headlight and turn signal electrical connectors.
5. Remove the bolts (1) **(Figure 19-46, Page 19-39)**.

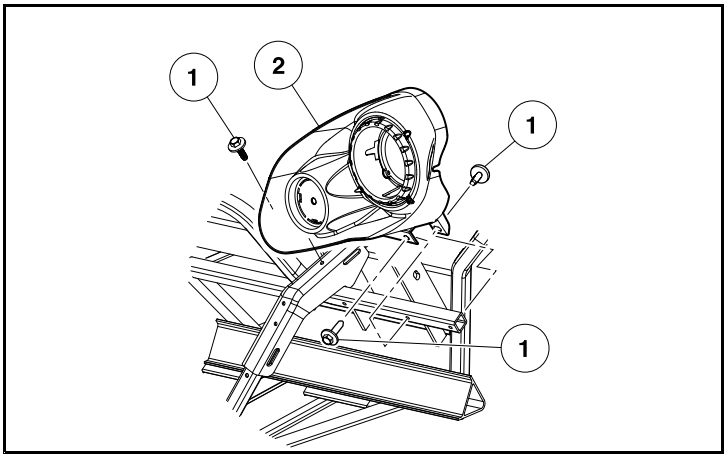


Figure 19-46 Headlight Bezel

6. Remove the headlight bezel (2).

HEADLIGHT BEZEL INSTALLATION

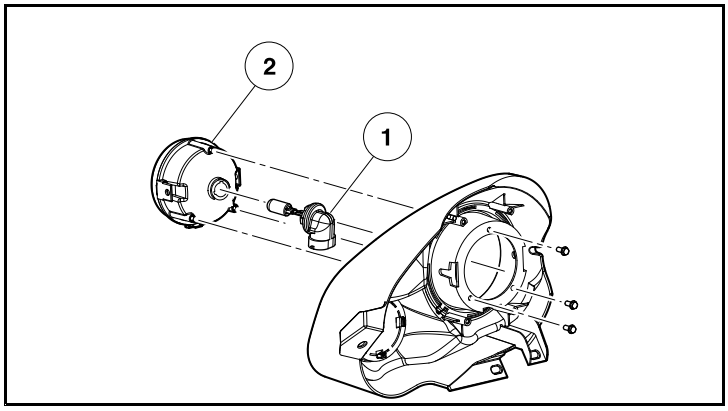
1. Install the headlight bezel (2) to vehicle frame **(Figure 19-46, Page 19-39)**.
2. Install the bolts (1). Tighten the bolts to 44 in·lb (5 N·m).
3. Connect the headlight bulb and turn signal electrical connectors.
4. Install the front fenders.
5. Install the cowl.
6. Connect the battery.

HALOGEN HEADLIGHT BULB REMOVAL

CAUTION

- **Do not touch the glass part of the headlight bulb. Oil from fingertips can decrease the life of the headlight bulb.**

1. Disconnect the battery
2. Remove the cowl.
3. Lift the tabs on the connector harness to release the electrical connector from the headlight bulb (1) **(Figure 19-47, Page 19-40)**.



2993C

Figure 19-47 Halogen Headlight Bulb

4. Turn the headlight bulb clockwise 1/4 (one-quarter) turn. Remove the headlight bulb from the headlight assembly (2).

HALOGEN HEADLIGHT BULB INSTALLATION

CAUTION

- **Do not touch the glass part of the headlight bulb. Oil from fingertips can decrease the life of the headlight bulb.**

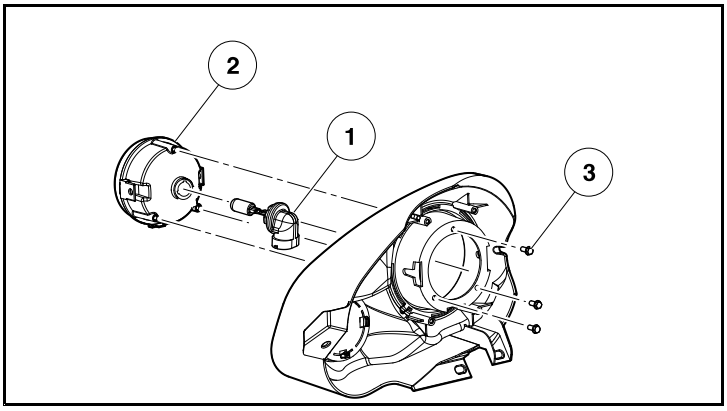
1. Install the headlight bulb (1) into the headlight lens (2) **(Figure 19-47, Page 19-40)**.
2. Install the electrical connector onto the headlight bulb.
3. Connect the battery.
4. Install the cowl.

HALOGEN HEADLIGHT LENS REMOVAL

CAUTION

- **Do not touch the glass part of the headlight bulb. Oil from fingertips can decrease the life of the headlight bulb.**

1. Disconnect the battery
2. Remove the cowl.
3. Lift the tabs on the connector harness to release the electrical connector from the headlight bulb (1) **(Figure 19-48, Page 19-41)**.



2993D

Figure 19-48 Halogen Headlight Lens

4. Turn the headlight bulb clockwise 1/4 (one-quarter) turn. Remove the headlight bulb from the headlight lens (2).
5. Remove the screws (3).
6. Remove the headlight lens.

HALOGEN HEADLIGHT LENS INSTALLATION

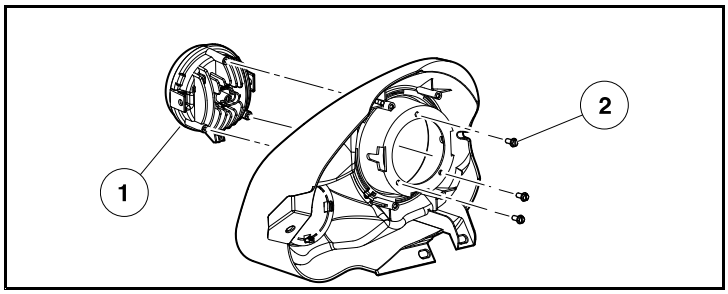
CAUTION

- **Do not touch the glass part of the headlight bulb. Oil from fingertips can decrease the life of the headlight bulb.**

1. Install the headlight lens (2) into the headlight bezel **(Figure 19-48, Page 19-41)**.
2. Install the screws (3). Tighten the screws to 22 in·lb (2.5 N·m).
3. Install the headlight bulb (1) into the headlight lens.
4. Install the electrical connector onto the headlight bulb.
5. Connect the battery.
6. Install the cowl.

LED HEADLIGHT REMOVAL

1. Disconnect the battery.
2. Remove the cowl.
3. Lift the tabs on the connector harness to release the electrical connector from the LED headlight (1) **(Figure 19-49, Page 19-42)**.



2993E

Figure 19-49 LED Headlight

4. Remove the screws (2).
5. Remove the LED headlight.

LED HEADLIGHT INSTALLATION

1. Install the LED headlight (1) into the headlight bezel **(Figure 19-49, Page 19-42)**.
2. Install the screws (2). Tighten the screws to 22 in·lb (2.5 N·m).
3. Install the electrical connector onto the LED headlight.
4. Connect the battery.
5. Install the cowl.

BATTERY

⚠ DANGER

- **Due to the danger of an exploding battery, wear a full face shield and rubber gloves when working on or near batteries.**
- **Battery – Explosive gases! Do not smoke. Keep sparks and flames away from the vehicle and service area. Ventilate when charging or operating vehicle in an enclosed area. Wear a full face shield and rubber gloves when working on or near batteries.**
- **Tools, wires, and metal objects can cause sparks when shorted across a battery.**
- **Follow all instructions carefully when working with batteries.**
- **Charge battery in a well-ventilated area only.**

DANGER CONTINUED ON NEXT PAGE

⚠ DANGER

- **Battery – Poison! Contains acid! Causes severe burns. Avoid contact with skin, eyes, or clothing. Antidotes:**
  - **External: Flush with water. Call a physician immediately.**
  - **Internal: Drink large quantities of milk or water followed with milk of magnesia or vegetable oil. Call a physician immediately.**
  - **Eyes: Flush with water for 15 minutes. Call a physician immediately.**

⚠ WARNING

- **Do not jump start a dead battery using another battery and jumper cables.**

GENERAL INFORMATION

See preceding DANGER and WARNING statements.

Gasoline vehicles are equipped with a 12-volt battery. When changing a 12-volt battery in any gasoline-powered vehicle, the same size battery with adequate amperage ratings should be used as a replacement.

A group 26, top-post battery, with a 525 cold cranking amp rating and a reserve capacity of at least 85 minutes is recommended. The group 26 classification indicates battery size: 8 inches W x 6-3/4 inches D x 7 inches H (20.3 cm W x 17.2 cm D x 17.8 cm H). It is important to use the proper size to ensure that the battery clamp will fit correctly.

PREVENTIVE MAINTENANCE

1. To keep the battery in good operating condition, remove any corrosion immediately. Post connections should be clean and tight. Any frayed or worn wires should be replaced. After all cables have been connected and properly tightened to 41 in·lb (4.3 N·m), coat terminals with Battery Terminal Protector Spray to prevent future corrosion. **See preceding WARNINGS and following CAUTION.**

⚠ CAUTION

- **If battery wire terminals are damaged or corroded, replace or clean them as necessary. Failure to do so may cause them to overheat during operation and could result in a fire, property damage, or personal injury.**

2. The battery should be kept clean and dry to prevent self-discharge. Any dirt, grime or acid spillage should be removed. Wash the battery with a bristle brush using water and bicarbonate of soda (1 cup (237 mL) baking soda per 1 gallon (3.8 L) of water). Rinse with water. Do not allow solution to enter battery through the vent cap holes.
3. Check battery periodically to see that it is in a full state of charge.
4. Keep battery hold-down clamp tight.

SELF-DISCHARGE

Dirt and battery acid can provide a path for a small current draw that slowly discharges the battery. To prevent self-discharge, the battery should always be kept clean.

Hot weather also has an effect on a battery's self-discharge rate. The higher the temperature, the quicker a battery will discharge. In hotter climates, therefore, the battery should be checked more often. When storing the battery, keep in a cool place.

VIBRATION DAMAGE

The battery hold-down clamp should always be tight enough to keep the battery from bouncing. Battery life may be severely shortened if the clamp is too loose. Excessive vibration shortens the life of the battery. It may also cause acid to leak out of the vent caps and corrosion to build up on surrounding metal parts. The acid that is lost reduces the capacity of the battery and cannot be replaced.

BATTERY REMOVAL

See General Warnings on page 1-1. Also see DANGER at beginning of Battery topic.

1. Turn the key switch OFF and remove the key. Place the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position. Chock the wheels.
2. Disconnect the battery and spark plug wire.
3. Remove the battery hold-down clamp from the battery.
4. Lift the battery from the vehicle. **See following WARNING.**

⚠ WARNING

- **Keep the battery in an upright position to prevent electrolyte leakage. Tipping the battery beyond a 45° angle in any direction can allow a small amount of electrolyte to leak out of the vent hole. Do not exceed this 45° angle when lifting, carrying or installing battery. The battery acid could cause severe personal injury when accidentally coming in contact with the skin or eyes, and could damage clothing.**

CHARGING THE BATTERY

See General Warnings on page 1-1. Also see DANGER at beginning of Battery topic.

1. Charge the battery using an automotive type 12-volt battery charger. Follow all warnings and procedures supplied by the battery charger manufacturer.
2. Attach the positive (+) charger cable to the positive (+) battery post.
3. Attach the negative (–) charger cable to the negative (–) battery post.
4. The battery may be charged with a slow charge (3 to 10 amps) or a fast charge (20 to 30 amps). Charge until the battery voltage is greater than 12.4 volts. **See following WARNING.**

⚠ WARNING

- **If the battery case feels hot (approximately 125 °F (52 °C) or more), emits gases, or fluid boils from vents, stop charging immediately. Failure to stop charging battery when any of these conditions are present could result in an explosion, personal injury and/or damage to the battery.**
- **Do not disconnect the charger DC leads from the battery when the charger is on. The resulting arcing between the DC leads and battery post could cause an explosion.**
- **If the charger must be stopped, disconnect the AC supply cord from the wall outlet before disconnecting the DC leads from the battery. Allow the battery to cool to room temperature and resume charging battery at a lower amp rate.**

BATTERY INSTALLATION

See General Warnings on page 1-1. Also see DANGER at beginning of Battery topic.

1. Place the battery into the vehicle with the battery posts facing the engine.
2. Secure the battery to the vehicle with the clamp and install bolt, washer and locknut and tighten to 144 in·lb (16.3 N·m). A loose battery clamp may allow the battery to become damaged from vibration or jarring.

3. Connect the battery and spark plug wire.

BATTERY STORAGE

See General Warnings on page 1-1. Also see DANGER at beginning of Battery topic.

1. Keep the battery clean and free of corrosion.
2. The battery cables should be disconnected from the battery so the battery can be connected to the charger. The battery can be left in the vehicle. Disconnect the negative (–) cable first.
3. Fully charge the battery prior to storage.
4. Store in a cool, dry area. The colder the area in which the battery is stored, the less the battery will self-discharge. A battery stored at 0 °F (-17.8 °C) will discharge very little over a four-month period. A battery stored at 80 °F (27 °C) will have to be recharged every few weeks.
5. Check the state of charge periodically. A battery that is discharged and left in a cold environment can freeze and crack. If the voltage drops below 12.4 volts, the battery should be recharged. **See following WARNING.**

⚠ WARNING

- **If the battery is frozen or the container is bulged, discard battery. A frozen battery can explode.**

6. The frequency of recharging required depends on the temperature of the storage area, but it is recommended that the battery be monitored for state of charge every month. Also, if the storage area is unheated in a cold climate and recharging is required, it is recommended that the area be heated to at least 60 °F (16 °C) prior to charging. The battery will not charge effectively in cold temperatures for the same reasons that it does not discharge as rapidly in cold temperatures.

CHARGING A DEAD BATTERY

See General Warnings on page 1-1. Also see DANGER at beginning of Battery topic.

The vehicle is equipped with a starter/generator. The generator is not designed to charge a dead battery. If the vehicle battery has become discharged, it must be charged using a properly rated automotive type charger. **See following WARNING.**

⚠ WARNING

- **Do not jump-start a dead battery using another battery and jumper cables.**

OXYGEN SENSOR

OXYGEN SENSOR REMOVAL

1. Disconnect the battery.
2. Disconnect the oxygen sensor connector from the engine wire harness (1) **(Figure 19-50, Page 19-46)**.

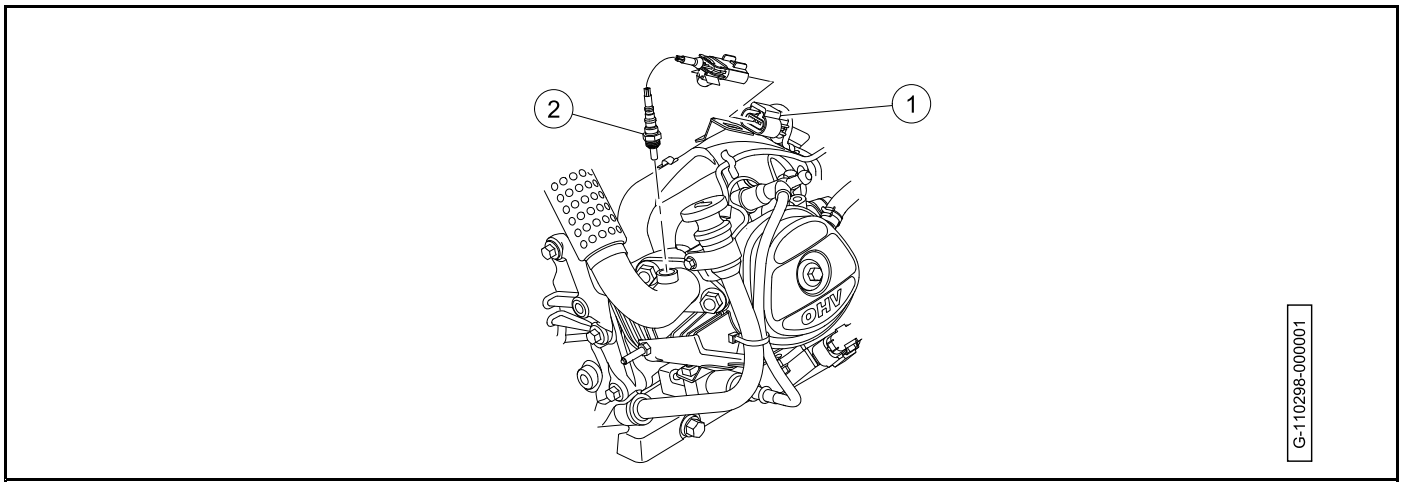


Figure 19-50 Oxygen Sensor

3. Remove the oxygen sensor (2).

OXYGEN SENSOR INSTALLATION

1. Install the oxygen sensor (2) into the muffler tube **(Figure 19-50, Page 19-46)**. Tighten the oxygen sensor to 13.25 ft·lb (18 N·m).
2. Connect the oxygen sensor connector to the engine wire harness (1).
3. Connect the battery.

GROUND CABLES

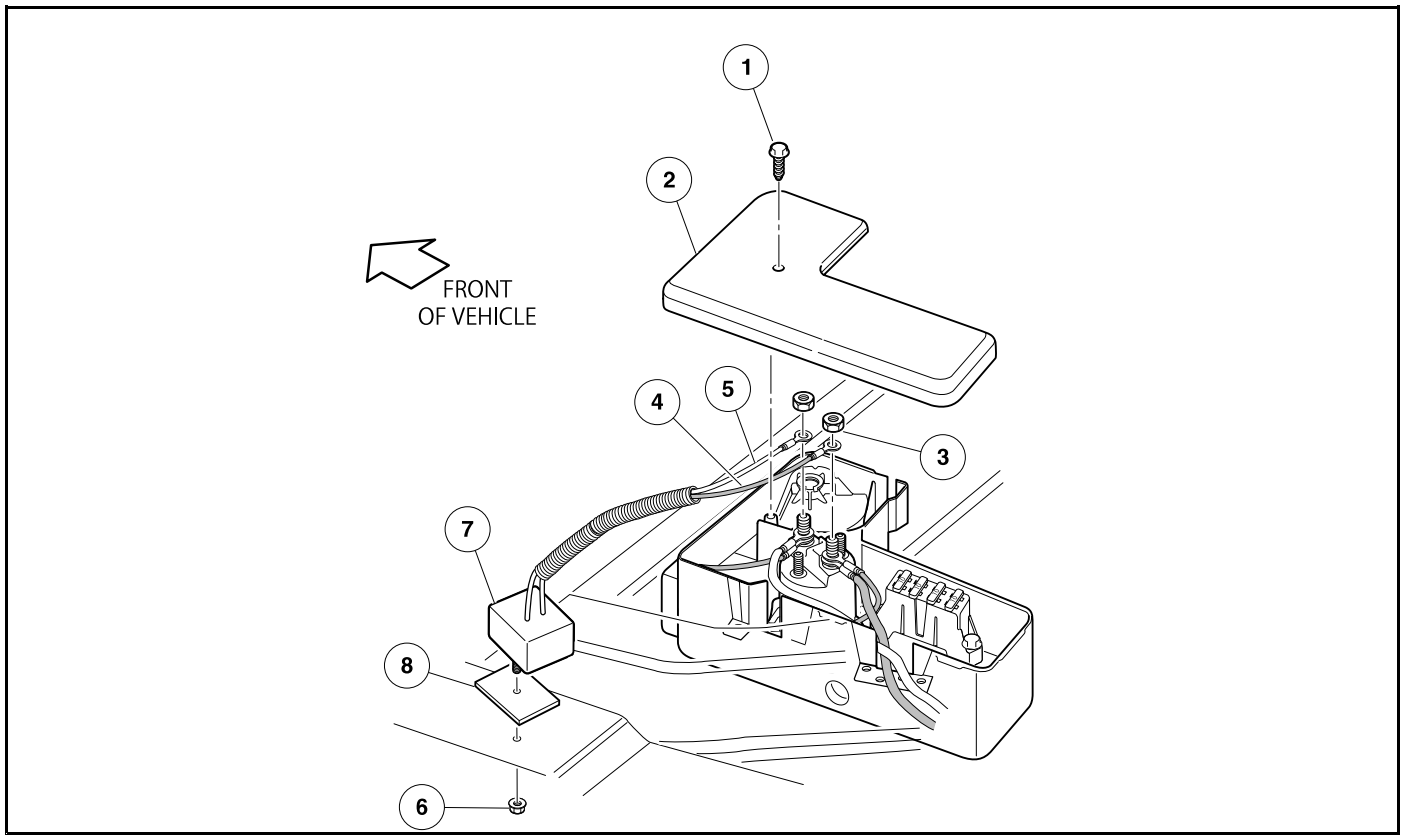
NOTE: *Verify that all cables (fuel tank, engine, battery, starter/generator and voltage regulator) are connected securely.*

CHARGING DIODED (KEY-START ONLY)

See General Warnings on page 1-1.

CHARGING DIODE REMOVAL

1. Disable the vehicle.
2. Disconnect the battery and spark plug wire.
3. Remove the screw (1) **(Figure 19-51, Page 19-47)**



2978Beps

Figure 19-51 Charging Diode

4. Remove the electrical component box cover (2).
5. Remove the nuts (3) from the two large solenoid posts.
6. Disconnect the charging diode red wire (4) and white wire (5) from the solenoid.
7. Remove the nut (6), charging diode (7), and thermal transfer pad (8) from the chassis.
8. Discard the transfer pad.

CHARGING DIODE INSTALLATION

CAUTION

- **Be sure to remove and discard the protective film from both sides of the thermal pad before installing it. If not removed, the film will reduce the thermal heat transfer and therefore reduce the power handling capability of the diode, causing it to overheat and damage the electrical system.**

1. Thoroughly clean and dry the area of the chassis where the new charging diode (7) is to be attached **(Figure 19-51, Page 19-47)**.
2. Peel the protective film from both sides of the new thermal pad (8).
3. Install the new thermal pad onto the charging diode.
4. Install the charging diode onto the chassis.
5. Install the nut (6). Tighten the nut to 25 in·lb (2.8 N·m).
6. Route and connect the charging diode wires to the solenoid posts in the electrical component box. **See following WARNING.**

⚠ WARNING

- **Incorrect wiring could result in severe injury or death.**
- **Charging diode and solenoid connections must have correct polarity.**
- **Keep all persons clear of engine belts when making final connections.**

6.1. Connect the charging diode red wire (4) to the solenoid post with the 4 gauge red wire, 10 gauge red wire, and 16 gauge orange wire.

6.2. Connect the charging diode white wire (5) to the other large solenoid post with the 4 gauge white wire, 18 gauge white wire, and 18 gauge red wire.

7. Install the nuts (3). Tighten the nuts to 55 in·lb (6.2 N·m).
8. Install the electrical component box cover (2).
9. Install the screw (1). Tighten the screw to 18 in·lb (2.0 N·m).
10. Connect the battery and spark plug wire.

USB RECEPTACLE

The 5-volt, 2.1 amp USB receptacle supplies electricity to power and charge portable devices. The USB receptacle is not for movement of data.

The USB receptacle will only operate when a shielded USB cord is connected. When the USB receptacle is not in use, remove the shielded USB cord to prevent battery drain.

USB RECEPTACLE REMOVAL

1. Disable the vehicle.
2. Disconnect the battery.
3. Remove the cowl.
4. Disconnect the USB red wire from the 12V power point (1) and the main harness red wire (2) **(Figure 13-8)**.

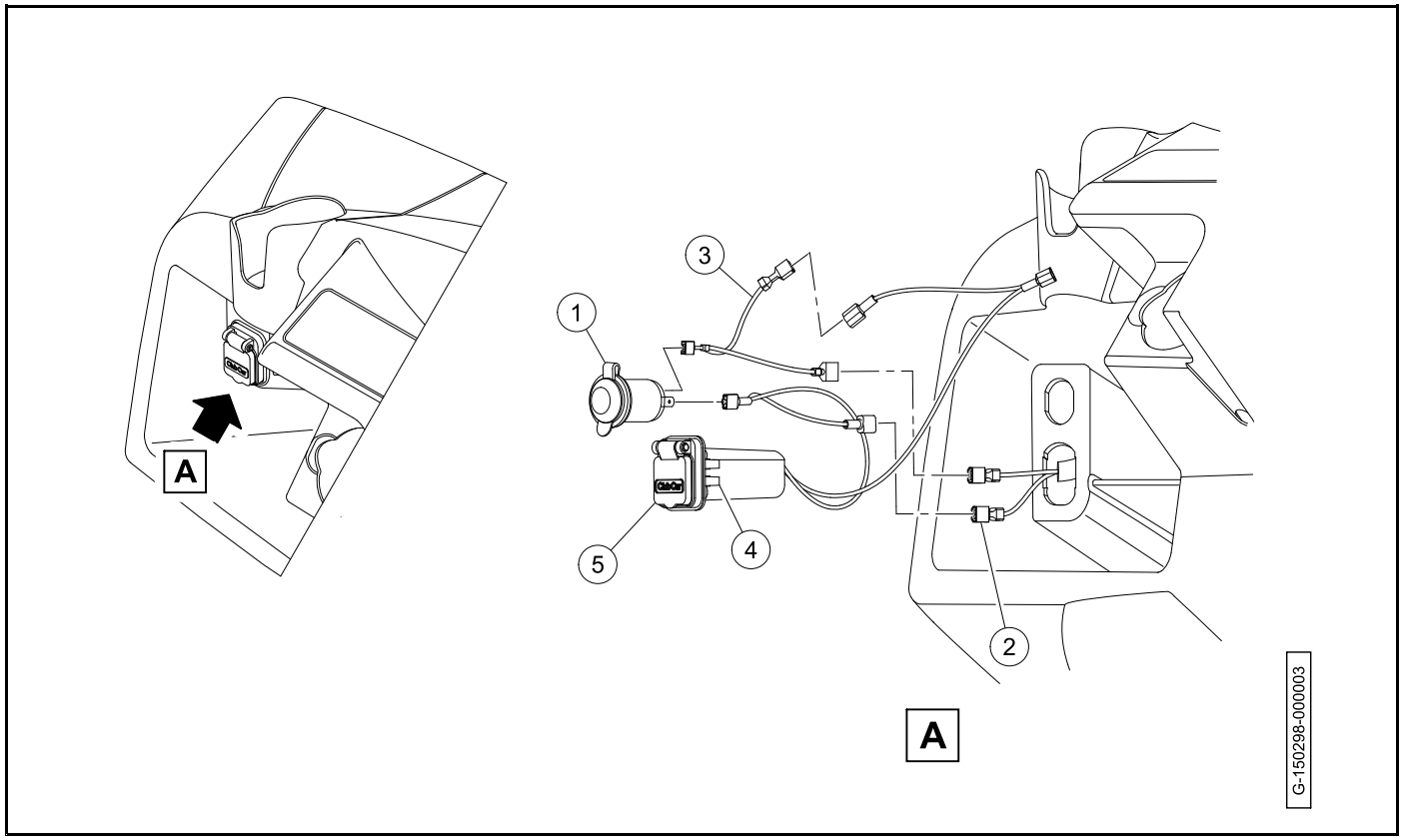


Figure 19-52

5. Disconnect the USB black wire from the jumper wire (3).
6. Push the lock tabs (4) on both sides and remove the USB receptacle (5).

USB RECEPTACLE INSTALLATION

1. Put the USB receptacle wires into the dash.
2. Push the USB receptacle (5) into the dash **(Figure 13-8)**.
3. Make sure that the locking tabs (4) engage.

4. Connect the USB black wire to the jumper wire (3).
5. Connect the USB red wire to the main harness red wire (2) and the 12V power point (1).
6. Install the cowl.
7. Connect the battery.

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

GENERAL INFORMATION

See General Warnings on page 1-1.

This vehicle is powered by a Kohler, high-compression, chain driven, overhead valve engine (OHV). **See following NOTE.**

NOTE: *Engine rotation is counterclockwise as viewed from the clutch side of the engine.*

This section contains information for removing and replacing the engine and snubber.

See Kohler Engine Service Manual for complete disassembly, rebuild, and repair information.

BEFORE SERVICING

Carefully read the applicable information and instructions before beginning engine service. Diagrams, DANGER, WARNING, CAUTION and NOTE statements and detailed descriptions have been included wherever necessary. Anyone attempting engine service should have knowledge and experience in small engine service and repair.

LOUVER ARM

The louver assembly is installed with the Kit Instruction TPCC040401EB019 ECH440 Engine Oil Dilution Prevention.

Move the louver arm (1) up or down to open or close the louver assembly.

The close position will increase the engine temperature faster.

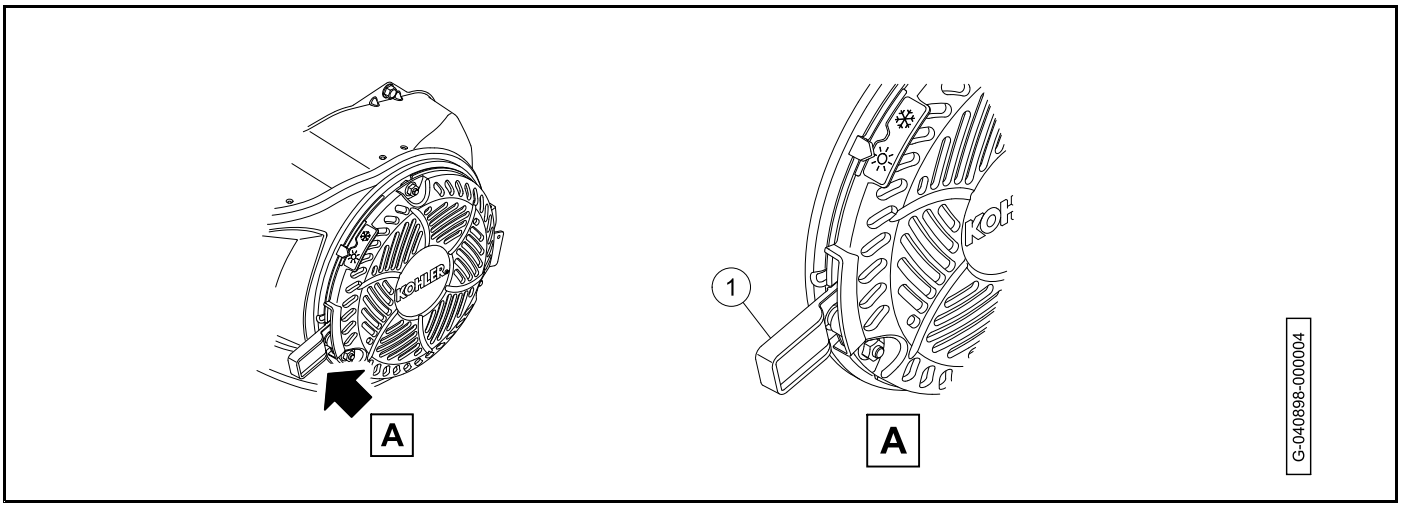
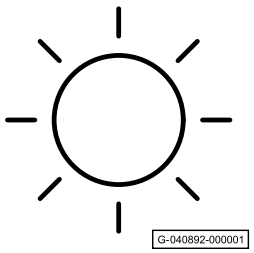
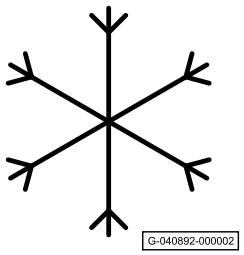


Figure 20-1

Set the louver arm to close for short trip operation. Set the louver arm to open when: • The vehicle continuously operates for 15 minutes or more. • The vehicle is regularly operated multiple times a day. • The vehicle has a heavy load. • The vehicle is towing. • The temperature is above 70°F (21°C).	**POSITION**	**FUNCTION**
		Open
		Close (Normal Operation)

ENGINE REMOVAL

See General Warnings on page 1-1.

⚠ CAUTION

- **Before removal and disassembly, clean the engine.**

1. Disconnect the battery.
2. Disconnect the spark plug wire.
3. For some vehicles, the engine can be removed by lifting it up and out of the chassis. For other vehicles, it is easier to remove the entire powertrain assembly first. If removing the powertrain, see Transaxle Removal.
4. Loosen the clamp and disconnect the air intake hose from the engine.
5. Disconnect the fuel line. See Fuel Line Removal.
6. Remove the screw (1) **(Figure 20-2, Page 20-3)**

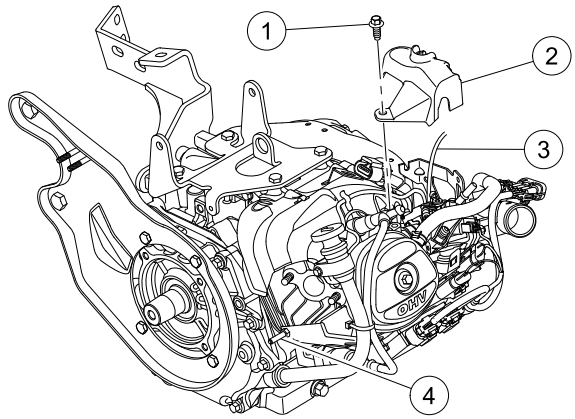


Figure 20-2 Governor Cover and Ground Cable Removal

7. Remove the governor cover (2).
8. Loosen the clamp and disconnect the vent line (3).
9. Disconnect the engine wire harness from the main harness.
10. Remove the governor cable. See Governor Cable Removal.
11. Remove the accelerator cable. See Accelerator Cable Removal.
12. Disconnect the ground cable from the engine (4).
13. Remove the starter/generator and belt. See Starter/Generator Removal.
14. Remove the drive clutch. See Drive Clutch Removal.
15. Remove the muffler. See Muffler Removal.

16. Remove the bolts (5 and 6) **(Figure 20-3, Page 20-4)**.

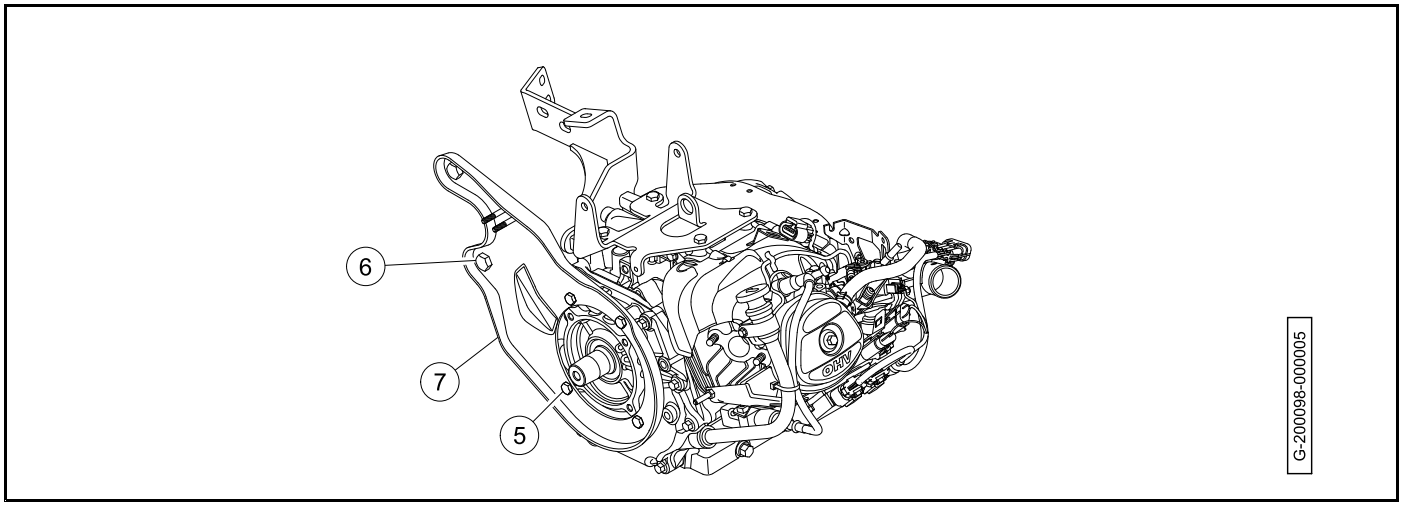


Figure 20-3 Clutch Plate Removal

17. Remove the clutch plate (7).
18. Remove the bolts (8) **(Figure 20-4, Page 20-4)**.

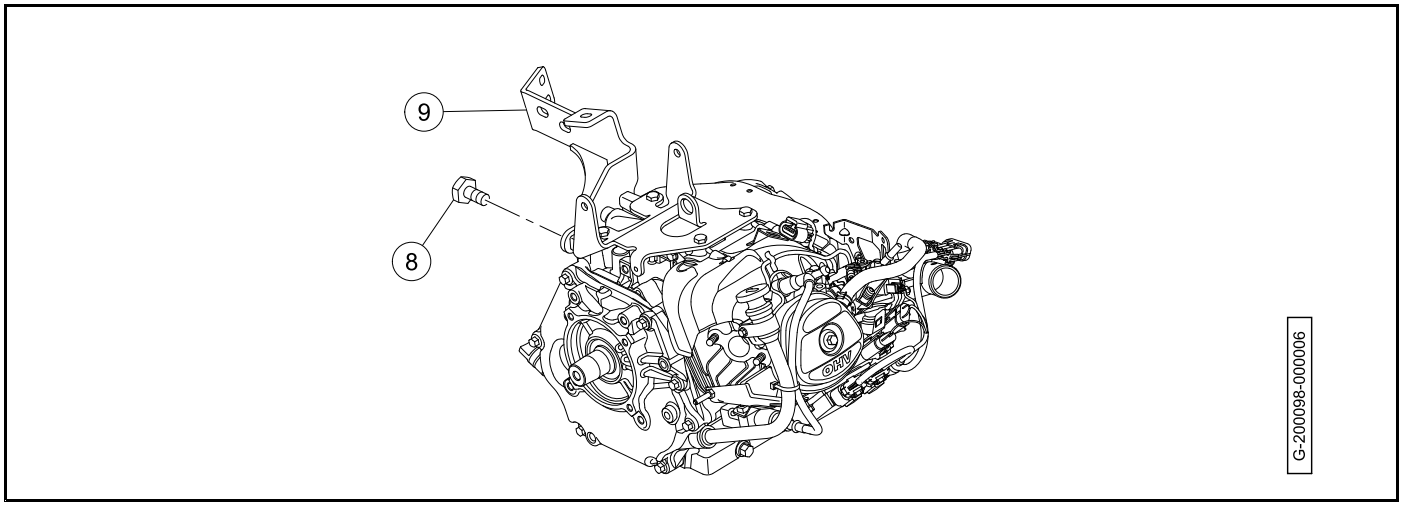


Figure 20-4 Exhaust Weldment Removal

19. Remove the exhaust weldment (9).

20. Remove the bolts (10), washers (11), and nuts (12) **(Figure 20-5, Page 20-5)**.

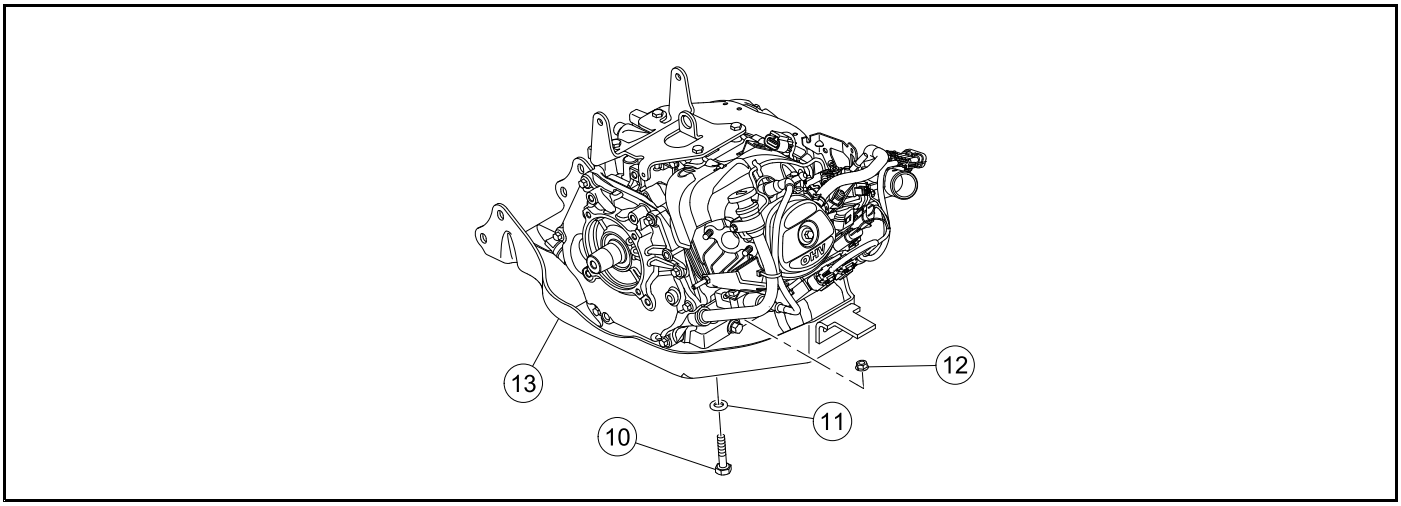


Figure 20-5 Engine Pan Removal

21. Lift the engine from engine pan (13). **See following NOTE.**

NOTE: *The engine weighs approximately 54 lb (24.5 kg).*

22. Remove the oil drain plug and drain all oil from crankcase. Dispose of engine oil properly.
23. If replacing the engine, remove the starter/generator mounting weldment and retain for installation on new engine. **See following NOTE.**

ENGINE INSTALLATION

See General Warnings on page 1-1.

1. If replacing engine, install starter/generator mounting weldment on engine with the screws. Tighten the screws to 17 ft·lb (23 N·m).
2. Install oil drain plug and tighten to 13 ft·lb (18 N·m).
3. Place the engine onto the engine pan (13) and secure with mounting hardware (10, 11, and 12) **(Figure 20-6, Page 20-6)**. Tighten the nuts to 33 ft·lb (40.6 N·m).

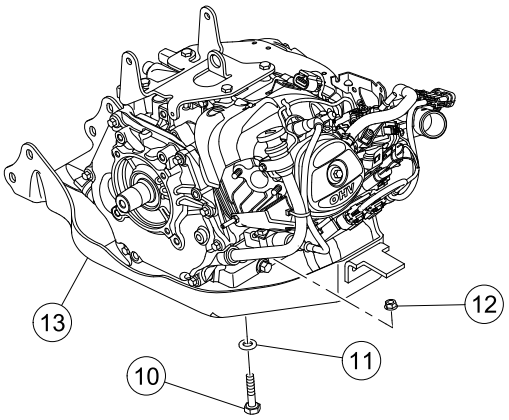


Figure 20-6 Engine Pan Installation

4. Install the muffler weldment (9) with the bolts (8) **(Figure 20-7, Page 20-6)**. Tighten the bolts to 18 ft·lb (24 N·m).

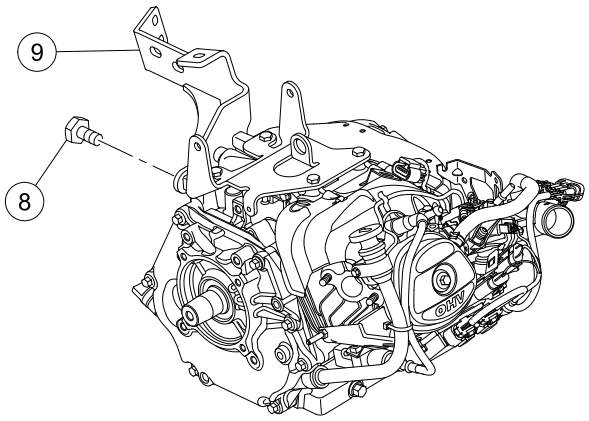


Figure 20-7 Exhaust Weldment Installation

5. Install the clutch plate (7) with bolts (5 and 6) **(Figure 20-8, Page 20-7)**. Tighten the bolts (5) to 27 ft·lb (36 N·m). Tighten the bolts (6) to 50 ft·lb (68 N·m).

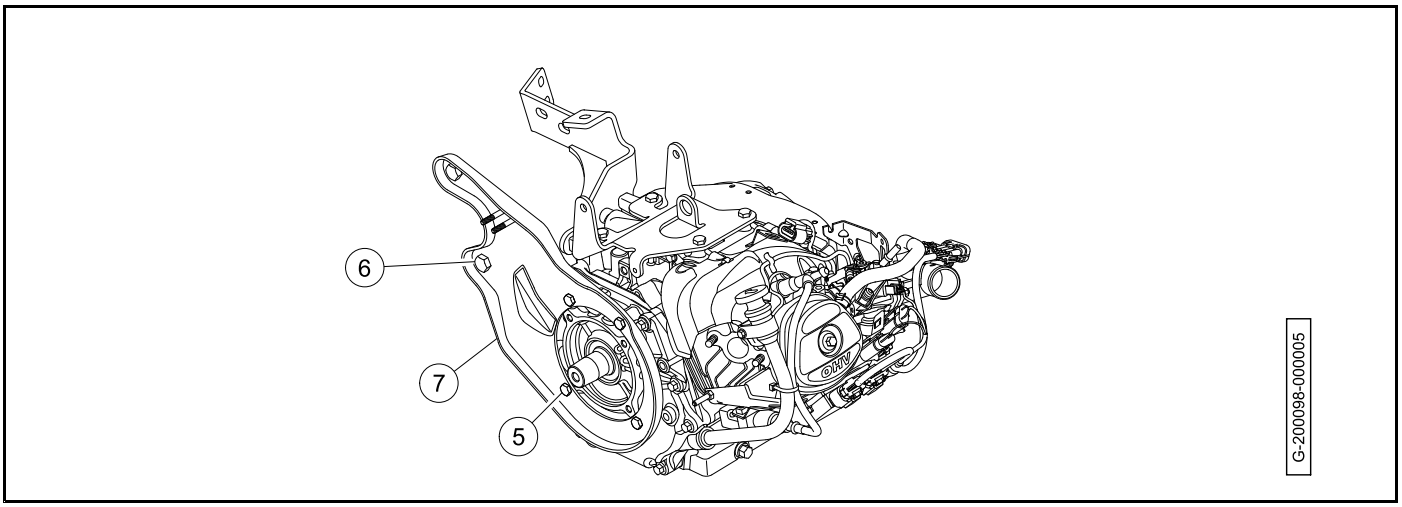


Figure 20-8 Clutch Plate Installation

6. Install the drive clutch. See Drive Clutch Installation.
7. Install the muffler. See Muffler Installation.
8. Install the starter/generator and belt. See Starter/Generator Installation.
9. If necessary, install the powertrain. See Transaxle Installation.
10. Install the governor cable. See Governor Cable Installation and Adjustment.
11. Install the accelerator cable. See Accelerator Cable Installation and Adjustment.
12. Secure the accelerator cable and governor cable P-clamps to engine. Tighten the P-clamp bolts to 36 in·lb (4.0 N·m).
13. Connect the air intake hose. See Air Cleaner Installation.
14. Install the fuel line. See Fuel Line Installation.
15. Connect the engine wire harness to the main wire harness.

16. Connect the ground cable to the engine (4) **(Figure 20-9, Page 20-8)**.

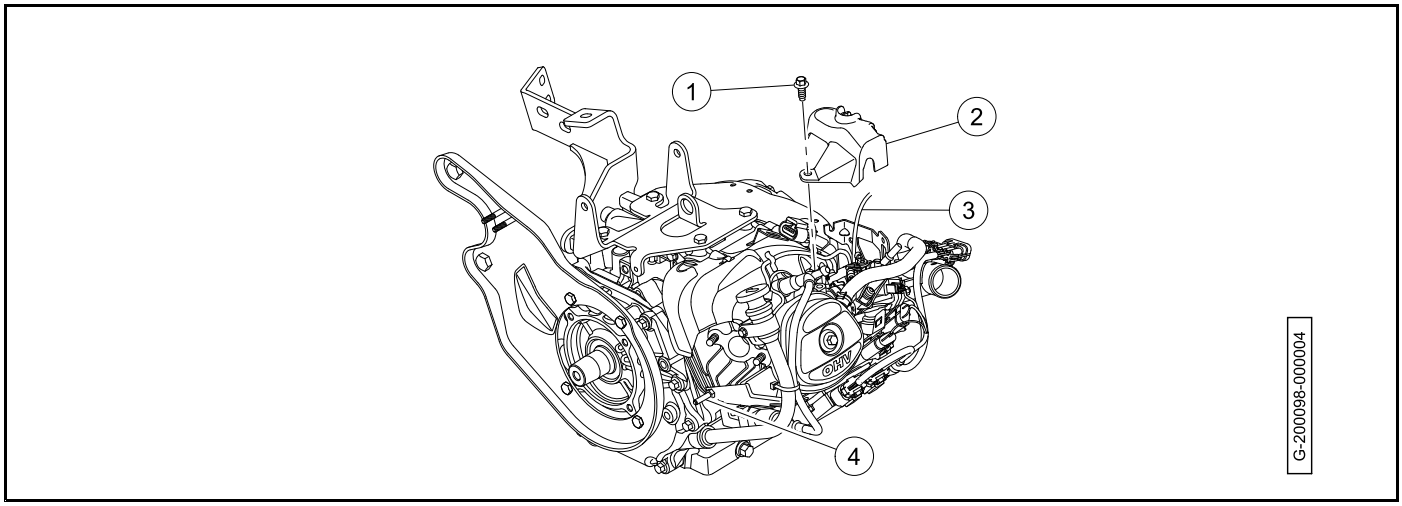


Figure 20-9 Governor Cover and Ground Cable Installation

17. Route the vent line (3) through the governor cover (2).
18. Connect the vent line.
19. Install the governor cover with the screw (1). **Torx Head:** Tighten the screw to 36 in·lb (4.0 N·m). **Hex Head:** Tighten the screw between 75 to 85 in·lb (8.48 to 9.6 N·m).
20. Check all hardware for proper torque/tightness.
21. Fill engine to proper level with correct type of oil. See Vehicle Specifications.

⚠ CAUTION

- **Do not overfill with oil.**

22. Connect the battery and spark plug wire.
23. Adjust the idle. See **ECU Reset Procedure** and **TPS Learn Procedure for Pedal Start Applications** in the Kohler Service Manual.
24. Adjust the engine RPM setting. See Engine RPM Adjustment.
25. Test-drive vehicle to ensure all systems are functional and correctly adjusted.

SNUBBER

See General Warnings on page 1-1.

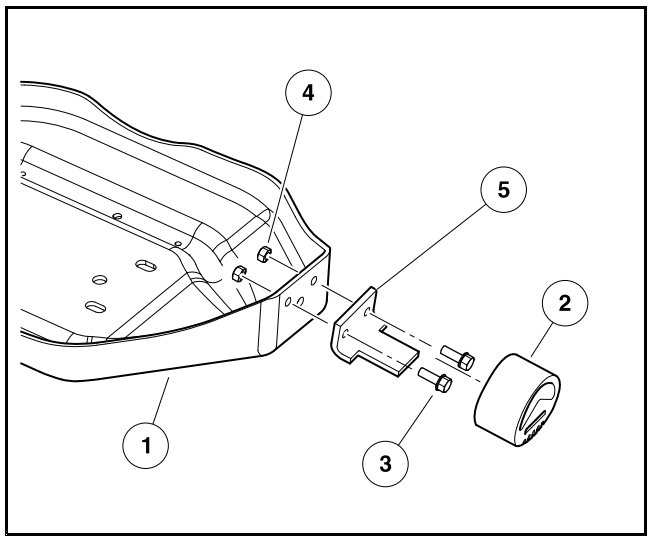
NOTE: *The snubber is installed on the gasoline vehicle only.*

SNUBBER REMOVAL

1. Support the powertrain with a floor jack under the engine pan (1) so that the snubber (2) is raised slightly and does not rest on the vehicle frame **(Figure 20-10, Page 20-9)**.
2. Remove the two bolts (3) and two lock nuts (4) securing the snubber bracket (5) to the engine pan.
3. Slide the snubber and snubber bracket assembly toward the battery to remove it from vehicle.
4. Slide the snubber off the snubber bracket.

SNUBBER INSTALLATION

1. Slide the snubber (2) onto the snubber bracket (5) **(Figure 20-10, Page 20-9)**.
2. Install the snubber bracket and snubber assembly onto engine pan (1).
3. Install the bolts (3) and lock nuts (4). Tighten the lock nuts (4) from 20 to 25 ft·lb (27.1 to 33.9 N·m).



3039C

Figure 20-10 Snubber

Pagination Page

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**
- **Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure.**

GENERAL INFORMATION

The engine is equipped with a throttle body/fuel injector assembly that is controlled by an ECU and requires no adjustment. The ECU monitors engine conditions through inputs from a Manifold Absolute Pressure (MAP) sensor, engine block temperature sensor and ignition timing.

EFI SYSTEM FEATURES/SPECIFICATIONS

- The fuel pump operating pressure is 50 psi +/- 3. The Kohler fuel pressure gauge has a psi variance of +/- 3.
- Fuel pump operates for a few seconds when key switch is turned to the ON position; it stops if no engine RPM is detected by the ECU
- The ECU indicates a fault code through the malfunction indicator light (MIL)
- In-tank fuel pump
- Return-less system
- High fuel pressure system
- Controls fuel pump, fuel injector, and oil lamp
- Automatic altitude compensation
- Closed-loop system (includes oxygen sensor)
- Separate EFI wire harness
- Fail-safe function

ENGINE CONTROL LINKAGES

See General Warnings on page 1-1.

⚠ DANGER

- **To ensure the vehicle does not run over you while you disconnect or adjust the accelerator push rod, do the following:**
  - **– Turn key switch OFF and remove key, place Forward/Reverse handle in the NEUTRAL position, and chock the wheels prior to servicing the vehicle.**
  - **– Disconnect battery cables, negative (–) cable first.**
  - **– Disconnect the spark plug wire from the spark plug.**
  - **– See Disconnect the Battery- Gasoline Vehicles on page 1-4.**

GENERAL INFORMATION

For proper vehicle operation, it is important the accelerator pedal, governor linkage, and throttle adjustments are done correctly and in the proper sequence. **See following CAUTION.**

⚠ CAUTION

- **Improper adjustment can result in poor vehicle performance and/or damage to the engine components.**

GROUND SPEED

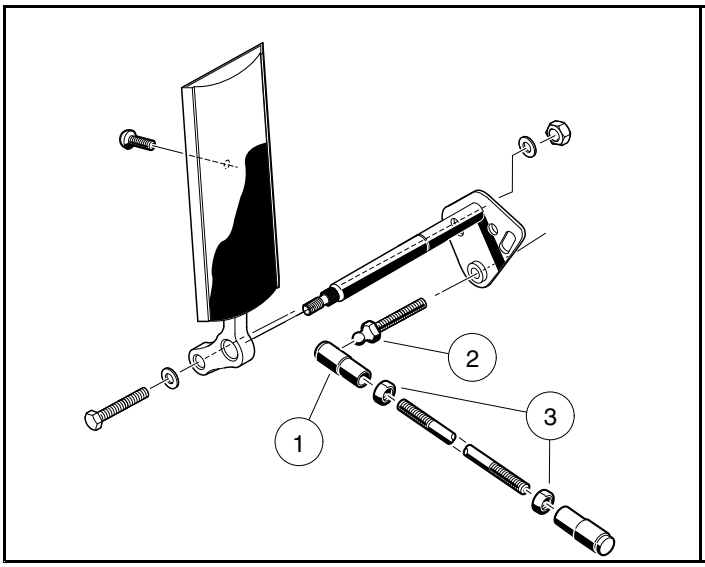
NOTE: *If possible, the manufacturer recommends measuring ground speed when setting engine RPM.*

This vehicle should reach the forward ground speed specified in the Vehicle Specifications Section.

ACCELERATOR ROD

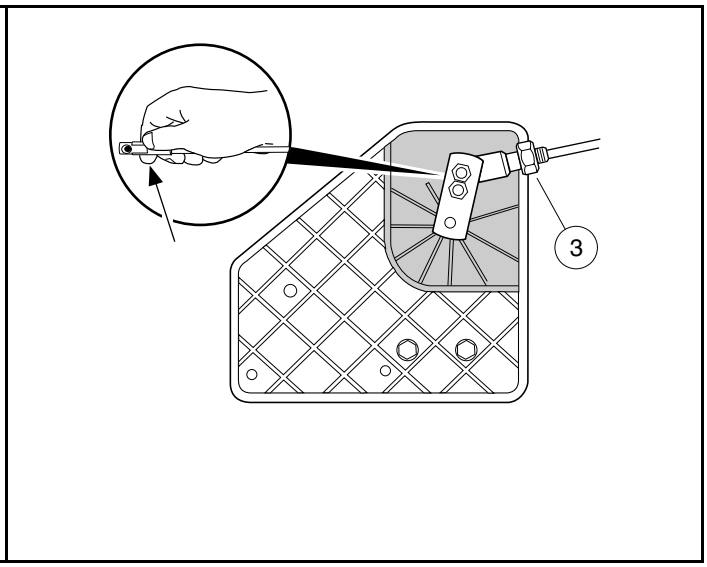
Accelerator Rod Removal

1. Raise the front of the vehicle. Place chocks at the rear wheels and lift the front of the vehicle with a chain hoist or floor jack. Place jack stands under the round frame cross tube to support the vehicle. **See preceding DANGER. See also WARNING "Lift only one end of the vehicle..." in General Warnings on page 1-1.**
2. Remove the accelerator rod by disconnecting the ball joint (1) from the ball stud (2) on the accelerator pedal **(Figure 21-1, Page 21-3)** and from the bell crank at the electrical box **(Figure 21-2, Page 21-3)**.



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Figure 21-1 Accelerator Rod



1345

Figure 21-2 Accelerator Rod – Pull Spring Release to Attach (Bottom View)

Accelerator Rod Installation and Adjustment

1. Before installing the accelerator rod, adjust accelerator pedal position. **See Pedal Group Adjustment – Gasoline Vehicles in the Accelerator and Brake Pedal Group Section.**
2. Install the ball joint (1) on the ball stud (2) at the accelerator pedal **(Figure 21-1, Page 21-3)**.
3. Access the engine compartment.
4. Remove the electrical component box screw and cover **(Figure 21-3, Page 21-4)**.
5. Adjust length of accelerator rod. With the ball joint jam nuts (3) loose **(Figure 21-1, Page 21-3)**, adjust the length of the rod to obtain an accelerator cable cam position of 7° as shown **(Figure 21-3, Page 21-4)**. **See following CAUTION.**

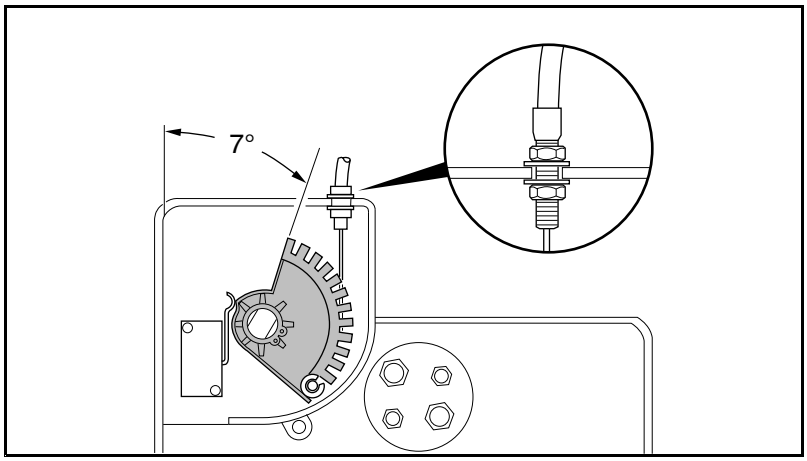
⚠ CAUTION

- **Be sure that approximately an equal number of threads are exposed at each end of the accelerator rod.**

6. Install the accelerator rod on the bell crank ball joint on the electrical component box **(Figure 21-2, Page 21-3)**. **See following CAUTION.**

⚠ CAUTION

- **Inspect the limit switches inside the electrical component box. If a limit switch lever is bent, replace the switch.**



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Figure 21-3 Accelerator Cable Cam Position – 7° (Top View)

7. Before tightening the jam nuts (3), set the park brake to the first latch and pawl position and check for proper activation of switches.
8. While pressing the accelerator pedal, the following events should occur in exactly the order shown:

NOTE: *Always perform a visual check to ensure the starter motor begins rotating the engine prior to the throttle body lever moving.*

EVENT	APPROXIMATE PEDAL TRAVEL
Park brake release	0° to 4°
Solenoid activation and engine start	4° to 15°
Throttle body actuation	15° and greater

9. While holding the accelerator ball joint with pliers, tighten the jam nuts against the ball joints, accelerator ball joint first, at each end of the accelerator rod.
10. Check rod adjustment for proper switch activation.
11. After the pedal group and accelerator rod are properly adjusted, adjust the engine RPM setting. **See Engine RPM Adjustment on page 21-10.**
12. Install the electrical component box cover and tighten retaining screw to 18 in·lb (2.0 N·m).
13. Connect battery and spark plug wire. **See Connect the Battery- Gasoline Vehicles on page 1-4.**

GOVERNOR CABLE

Governor Cable Removal

1. Turn the key switch to the OFF position and remove the key, place the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position, and chock the wheels.
2. Disconnect battery and spark plug wire.
3. At engine:

3.1. If equipped, remove air deflector from top of engine.

3.2. Remove the governor cable fitting (1) from the linkage retainer (2) **(Figure 21-4, Page 21-5)**.

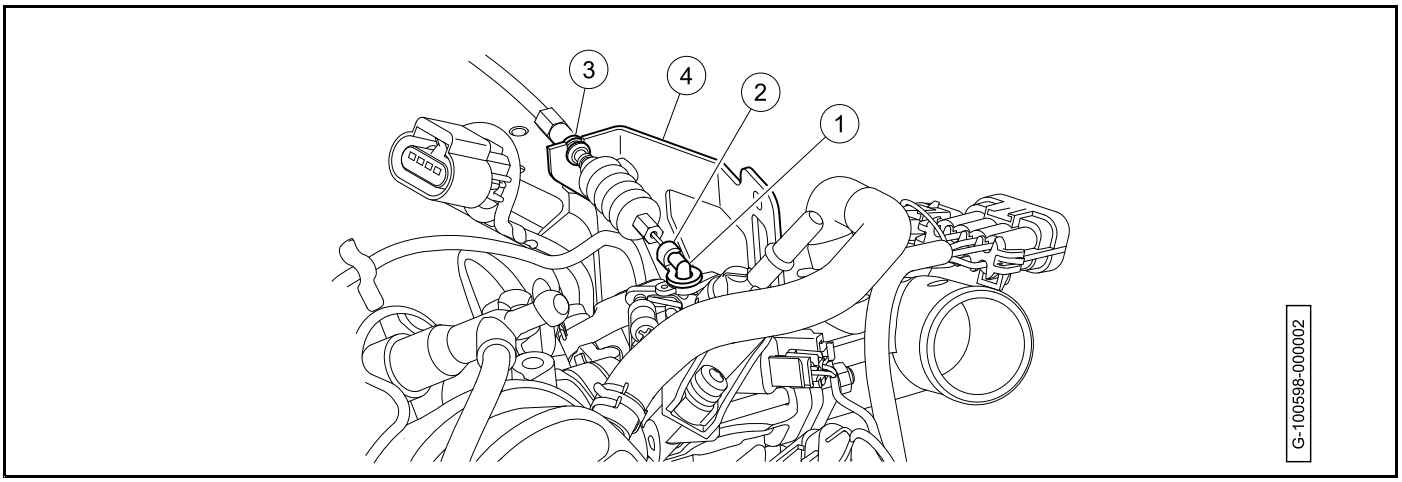


Figure 21-4 Governor Cable Removal - Throttle Body

3.3. Disconnect the governor cable fitting from throttle lever (3).

3.4. Unsnap governor cable from throttle body bracket (4).

4. At transaxle:

4.1. Disconnect “Z” fitting of governor cable (1) from governor arm (2) **(Figure 21-5, Page 21-5)**.

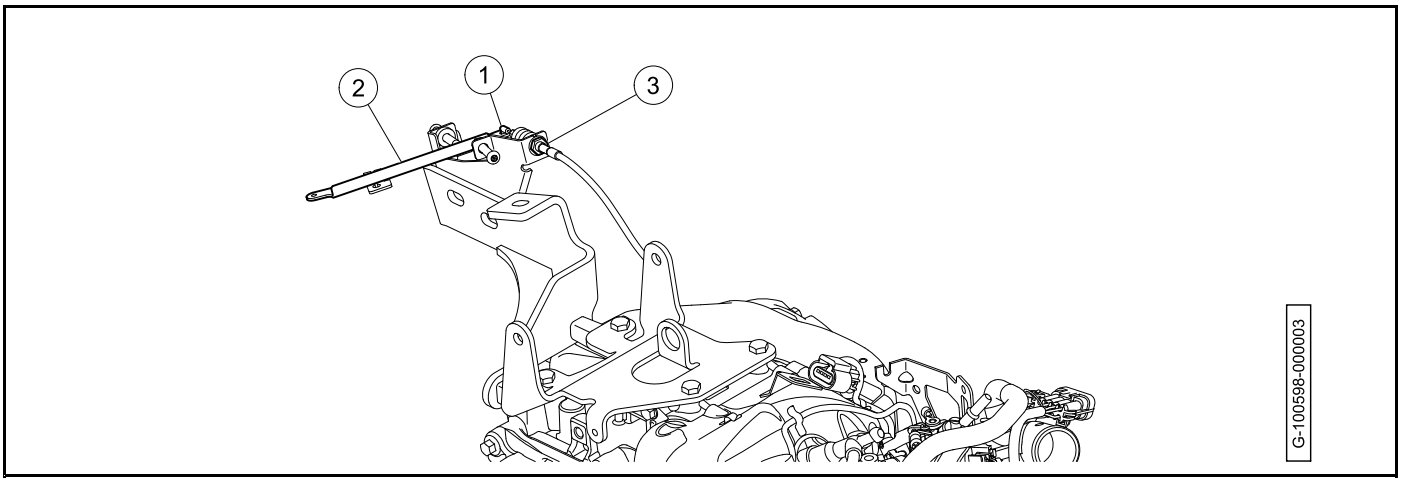


Figure 21-5 Governor Cable Removal - Governor Arm

4.2. Loosen jam nuts at governor bracket (3) and remove the governor cable from vehicle.

Governor Cable Installation and Adjustment

1. At engine:

1.1. Snap governor cable into throttle body bracket (4) **(Figure 21-6, Page 21-6)**.

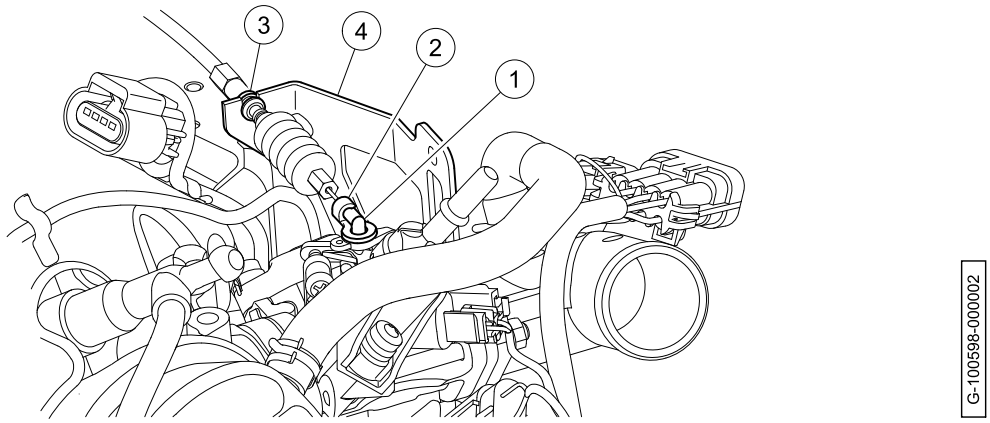


Figure 21-6 Governor Cable Installation - Throttle Body

1.2. Connect the governor cable fitting (1) to throttle lever (2).

1.3. Install the governor cable fitting into the linkage retainer (3).

2. At transaxle:

2.1. Slide bellows off threaded end of cable housing, separate jam nuts and place threaded end into governor bracket (3) **(Figure 21-7, Page 21-6)**.

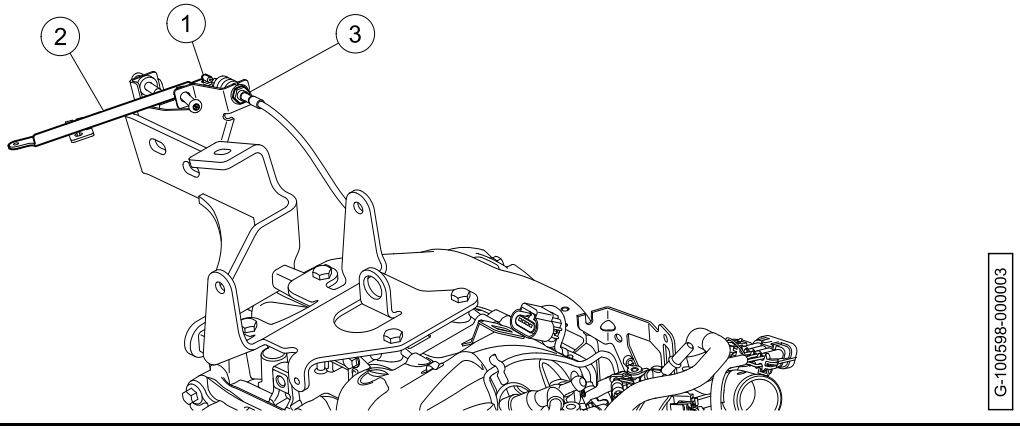


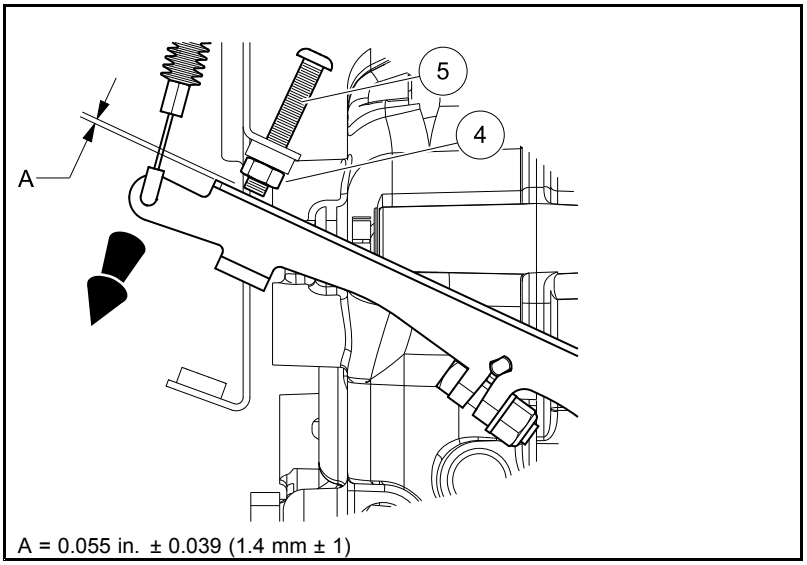
Figure 21-7 Governor Cable Installation - Governor Arm

2.2. Finger-tighten the jam nuts.

2.3. Push bellows back onto threaded end of cable housing.

2.4. Connect “Z” fitting of governor cable (1) to governor arm (2).

3. Loosen adjustment screw jam nut (4) and back off throttle stop screw (5) several turns **(Figure 21-8, Page 21-7)**.



3111B

Figure 21-8 Throttle Stop Screw Gap

4. Rotate governor arm counterclockwise until it stops and hold in this position.
5. Adjust governor cable jam nuts until throttle lever is at “wide open throttle” (WOT) and tighten the governor cable jam nuts to 36 in·lb (4.0 N·m).
6. Release governor arm to return to “idle” position.
7. Adjust gap (A) between governor arm and throttle stop screw to 0.055 in. (±0.039) (1.4 mm (±1)) as shown **(Figure 21-8, Page 21-7)**. Tighten stop screw jam nut to 36 in·lb (4.0 N·m).
8. Check engine RPM adjustment. See Engine RPM Adjustment.

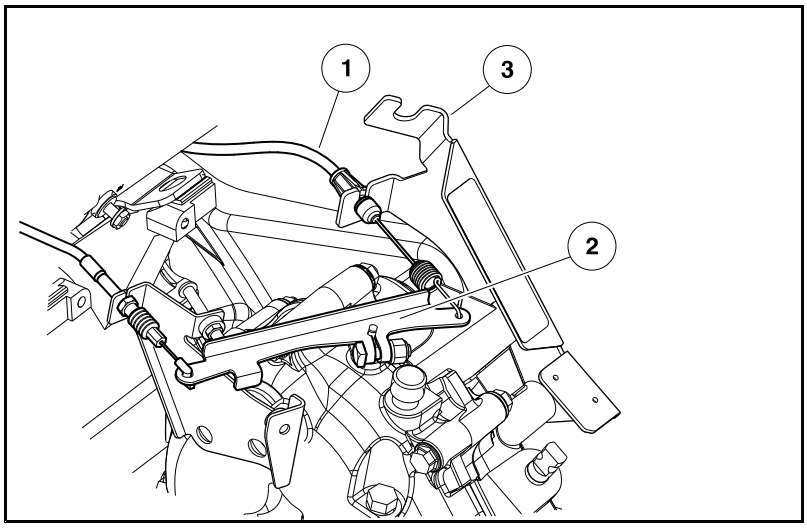
ACCELERATOR CABLE

Accelerator Cable Removal

1. Disable the vehicle.
2. Disconnect the battery and spark plug wire.

3. At transaxle:

3.1. Unhook spring fitting of accelerator cable (1) from governor arm (2) **(Figure 21-9, Page 21-8)**.

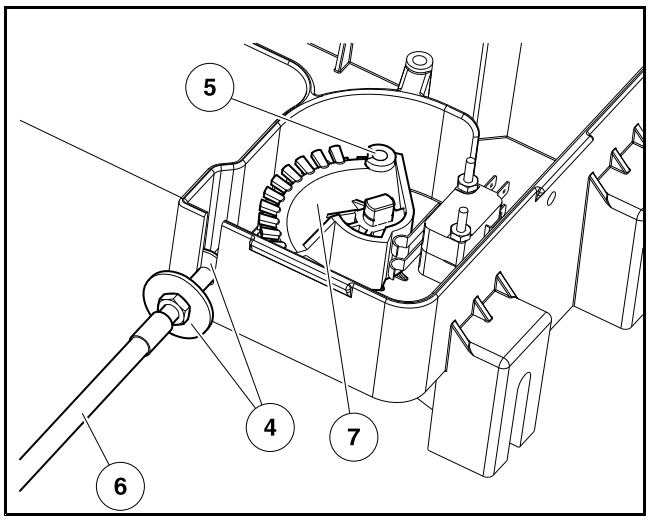


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Figure 21-9 Accelerator Cable Removal - Governor Arm

3.2. Unsnap accelerator cable from FNR/accelerator cable bracket (3).

4. At electrical component box:

4.1. Remove electrical component box cover and loosen jam nuts (4) on side of electrical component box **(Figure 21-10, Page 21-8)**.



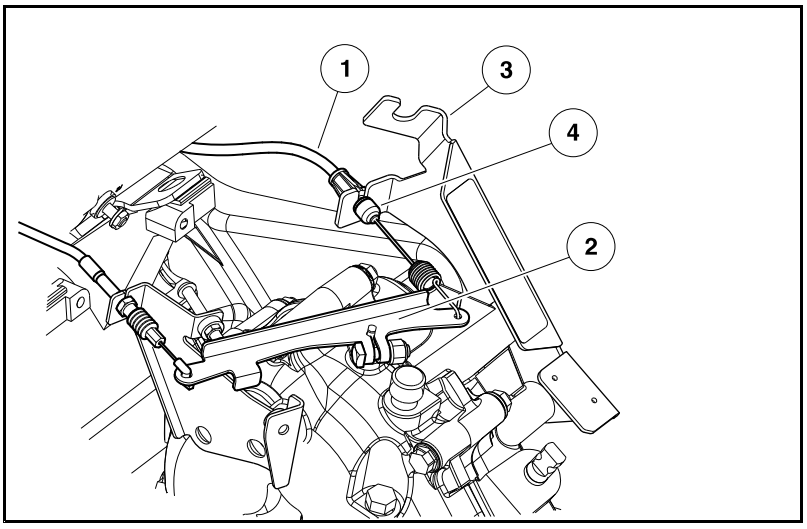
3046B
Figure 21-10 Accelerator Cable Removal - Electrical Component Box

4.2. Disconnect barrel fitting (5) of accelerator cable (6) from cam (7) in electrical component box and remove accelerator cable from vehicle.

Accelerator Cable Installation

1. At transaxle:

1.1. Hook spring fitting of accelerator cable (1) to governor arm (2) **(Figure 21-11, Page 21-9)**.



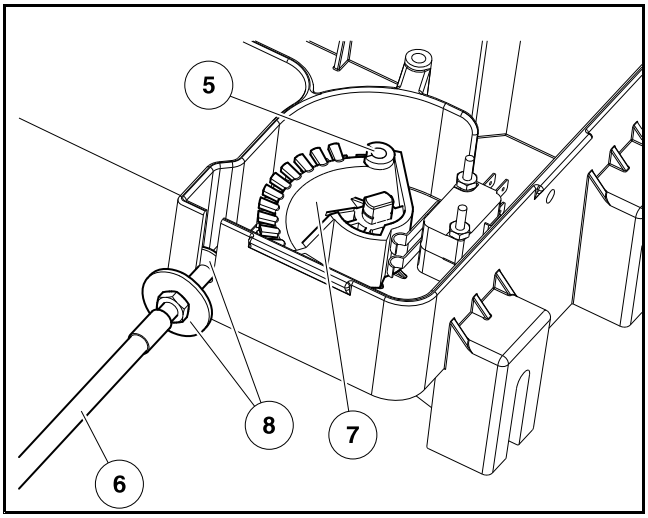
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Figure 21-11 Accelerator Cable Installation - Governor Arm

1.2. Snap accelerator cable into FNR/accelerator cable bracket (3).

1.3. Push dust shield (4) onto end of cable housing.

2. At electrical component box:

2.1. Insert barrel fitting (5) of accelerator cable (6) into cam (7) in electrical component box **(Figure 21-12, Page 21-9)**.



3046C
Figure 21-12 Accelerator Cable Installation - Electrical Component Box

2.2. Separate jam nuts (8) on cable and place threaded end into slot of electrical component box. Tighten the jam nuts finger-tight.

2.3. Before tightening the jam nuts, make sure the engine RPM adjustment is correct. See Engine RPM Adjustment.

2.4. Install electrical component box cover and tighten screw to 18 in·lb (2.0 N·m).

3. Connect the battery and spark plug wire.

CLOSED THROTTLE OR IDLE ADJUSTMENT – PEDAL-START VEHICLES

To adjust the idle, see **ECU Reset Procedure** and **TPS Learn Procedure for Pedal Start Applications** in the Kohler Service Manual.

CLOSED THROTTLE OR IDLE ADJUSTMENT – KEY-START VEHICLES

To adjust the idle, see **ECU Reset Procedure** and **TPS Learn Procedure for Key Start Applications** in the Kohler Service Manual.

HOW TO MEASURE GROUND SPEED

Best Method

An easy way to check ground speed is by using a GPS device or smartphone application (app). If these are not available, use the alternate method below.

Alternate Method (Calculated)

Ground speed is easily determined by a known distance travelled, divided by the amount of time it took to travel that known distance (*Rate = Distance/Time*).

1. Establish a known distance to travel (example: 100 ft. (30.5 m) in a safe location using cones or other type of marker.
2. Drive vehicle and bring to maximum speed before reaching the first cone.
3. Using a stopwatch, record the amount of time it takes to travel from the first cone to the second cone at maximum speed.
4. With distance and time determined, calculate ground speed:

4.1. **Rate in seconds:** Divide distance (100 ft (30.5 m)) by time (5 seconds) = 20 ft/sec (6.1 m/sec).

4.2. **Convert seconds to hour:** Multiply 20 ft/sec (6.1 m/sec) by 3600 (the number of seconds in an hour) = 72000 ft/hour (21960 m/hour)

4.3. **Convert to MPH:** Divide 72000 ft/hour by 5280 (number of ft in 1 mile) = 13.64 miles/hour

Convert to KPH: Move the decimal point over three places; 21960 m/hour = 21.96 km/hour

ENGINE RPM ADJUSTMENT

⚠ DANGER

- **Do not operate gasoline vehicle in an enclosed area without proper ventilation. The engine produces carbon monoxide, which is an odorless, deadly poison.**

1. If governor is adjusted, go to step 2; otherwise, adjust governor. See Governor Cable Installation and Adjustment.
2. Connect the battery and spark plug wire.
3. Measure vehicle ground speed. See How to Measure Ground Speed.
4. Compare measured ground speed with forward ground speed specified in Vehicle Specifications..
5. If adjustment is necessary, use the following procedures:

5.1. To **reduce** RPM, loosen the accelerator cable jam nut on the outside of the electrical component box and tighten the jam nut on the inside of the box until specified ground speed is reached. See Vehicle Specifications.

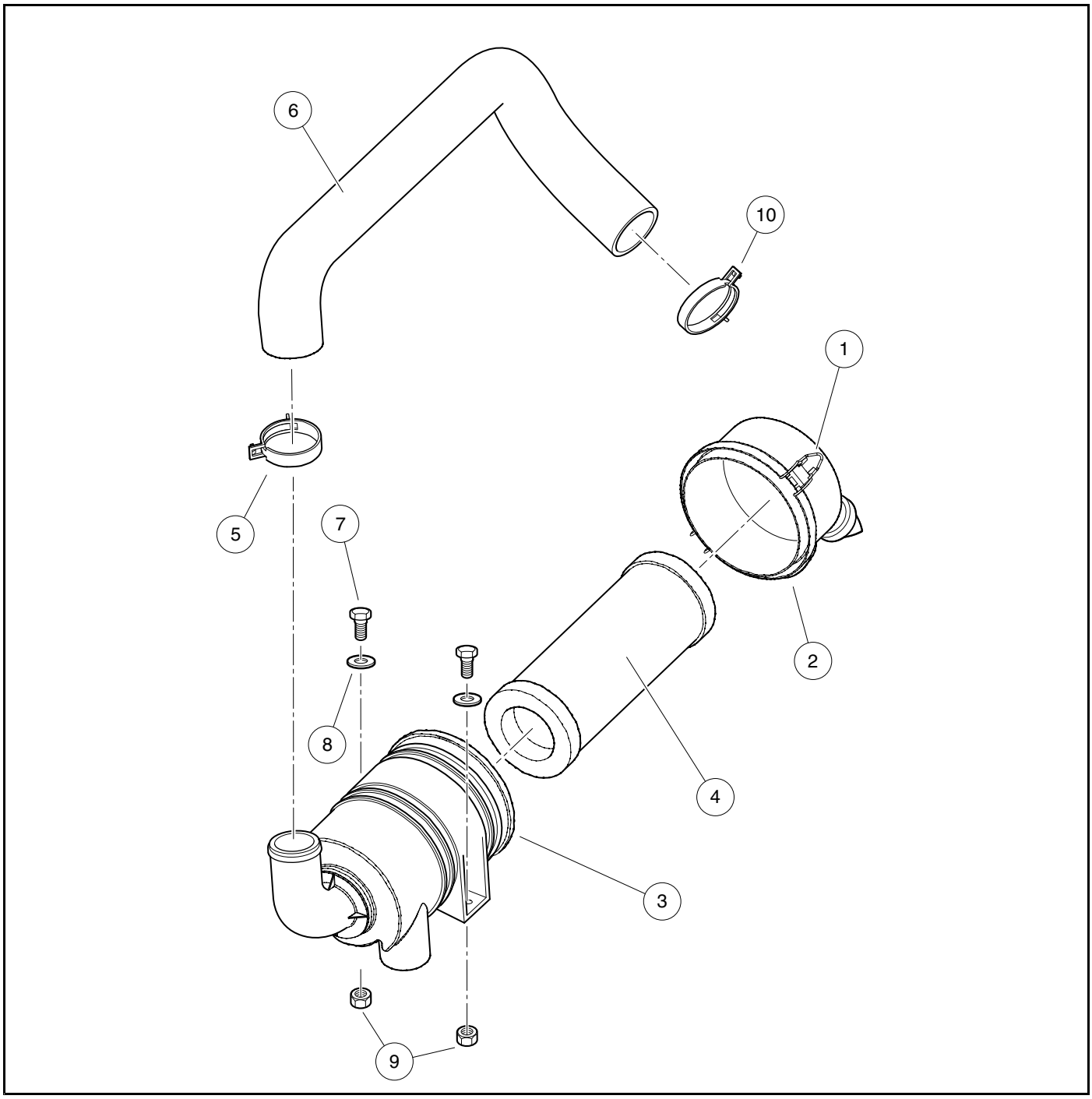
5.2. To **increase** RPM, loosen the jam nut inside the electrical component box and tighten the jam nut outside the box until specified ground speed is reached.

5.3. Be sure both jam nuts are locked against the electrical component box and check ground speed again. If ground speed needs to be adjusted, repeat previous step. **See following NOTE.**

NOTE: *If more adjustment is required than the cable housing will allow, make sure the spring fitting on the other end of the accelerator cable is properly installed. Excessive drive belt and clutch wear can also prevent proper ground speed adjustment. Check them for excessive wear.* ***Section 23 — Gasoline Vehicle - Clutches***

AIR INTAKE SYSTEM

See General Warnings on page 1-1.



3048

Figure 21-13 Air Intake System – CA 300

AIR CLEANER REMOVAL

1. Turn key switch to the OFF position and remove key, place Forward/Neutral/Reverse control (FNR) in the NEUTRAL position, and chock the wheels.
2. Disconnect battery and spark plug wire. **See Disconnect the Battery- Gasoline Vehicles on page 1-4.**
3. Remove clamp (5) and disconnect air intake hose (6) from air cleaner (3) **(Figure 21-13, Page 21-12)**.
4. Remove hardware (7, 8, and 9) securing air cleaner (3) to vehicle.

AIR CLEANER INSTALLATION

1. Place air cleaner (3) into vehicle and secure with hardware (7, 8, and 9) **(Figure 21-13, Page 21-12)**. Tighten locknuts (9) to 85 in·lb (9.5 N·m).
2. Connect air intake hose (6) to air cleaner (3) and secure with clamp (5).
3. Connect battery and spark plug wire. **See Connect the Battery- Gasoline Vehicles on page 1-4.**

RELIEVING FUEL PRESSURE

In the event that servicing the EFI fuel system necessitates removal of the fuel delivery hose, extreme caution must be exercised. The fuel system is under high pressure even with the engine not running. Disconnecting any part of the fuel delivery system, without first depressurizing the system, will result in a sudden release of pressurized gasoline at the connection. To prevent possible serious injury or death, fuel pressure must be relieved before disconnecting or removing the pump, hose and throttle body.

Either of these suggested procedures MUST be followed before attempting ANY service work on the EFI fuel system. Following these will relieve any pressure in the fuel hose prior to opening the fuel system.

TO RELIEVE FUEL PRESSURE

Option 1:

1. Turn the key switch to OFF.
2. Disconnect the battery.
3. Wait 15 minutes or more to let the fuel pressure dissipate.

Option 2:

1. Turn the key switch to OFF.
2. Disconnect the fuel pump module at the fuel tank.
3. Crank the engine for 5 seconds to start reducing the fuel pressure.
4. Wait for 2-5 seconds.
5. Crank the engine for 5 seconds to let the fuel pressure dissipate.

NOTE: *To absorb any residual fuel the may be present in the fuel hose, place a rag or towel around the hose at the end being disconnected.*

FUEL LINE

See General Warnings on page 1-1.

⚠ WARNING

- **Make sure fuel line is the correct length and properly routed. Failure to heed this warning could result in damage to fuel line and fire.**
- **Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure.**

CAUTION

- **This EFI gasoline vehicle is equipped with fuel hose rated for high-pressure systems. Always replace the fuel line on this vehicle with approved Club Car replacement part. Do not attempt to repair, patch or splice the fuel line.**

The fuel line must be properly routed from the fuel tank to the throttle body. The fuel line has dual-locking connectors at both ends.

FUEL LINE REMOVAL

⚠ WARNING

- **Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure.**
- **Carefully drain any fuel into an approved container. Add drained fuel back into fuel tank or dispose of properly.**

1. Disable the vehicle.

⚠ WARNING

- **Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure.**

2. Relieve the fuel pressure.
3. Disconnect the battery.
4. Clean the top of the fuel tank and fuel pump module.
5. At engine:

5.1. Remove the bolt (1) and P-clamp (2) from the fuel line support bracket (3) **(Figure 21-14, Page 21-15)**.

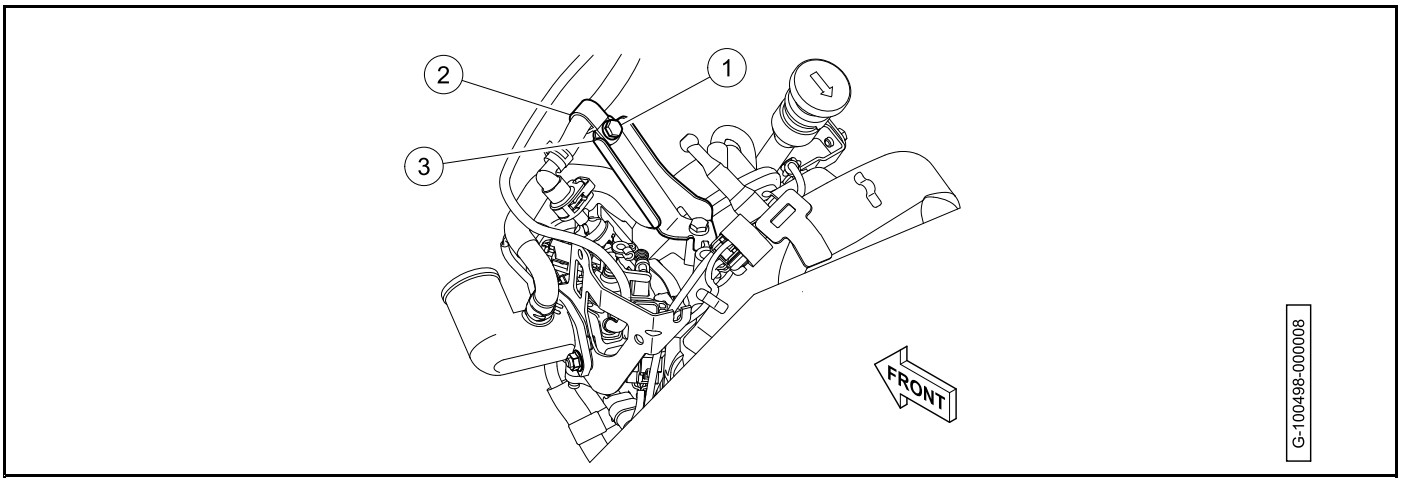


Figure 21-14 Fuel Line Support Bracket - Disconnect

5.2. Pull out the locking clip (4) **(Figure 21-15, Page 21-16)**.

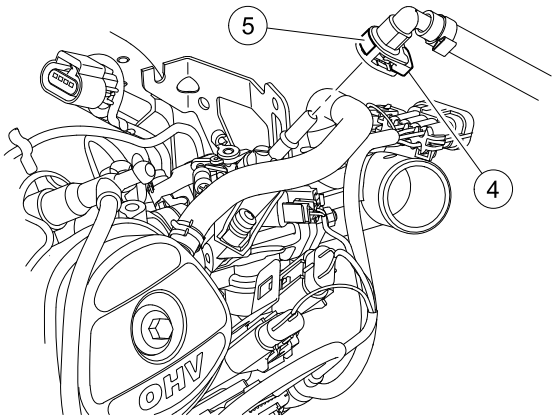


Figure 21-15 Fuel Line Connector – Disconnect

5.3. Push in and hold the release tab (5).

5.4. Remove the fuel line from the throttle body.

5.5. Drain the fuel line into an appropriate container.

6. At fuel tank:

6.1. Pull out the locking clip.

6.2. Push in and hold the release tab.

6.3. Remove the fuel line from fuel tank.

FUEL LINE INSTALLATION

1. At fuel tank and engine

1.1. Route the fuel line and vent line through the carbon canister bracket **(Figure 21-16, Page 21-17)**.

⚠ WARNING

- **Fuel is flammable. Do not let the fuel line contact the engine or exhaust. Make sure that the fuel line is routed through the fuel line bracket.**

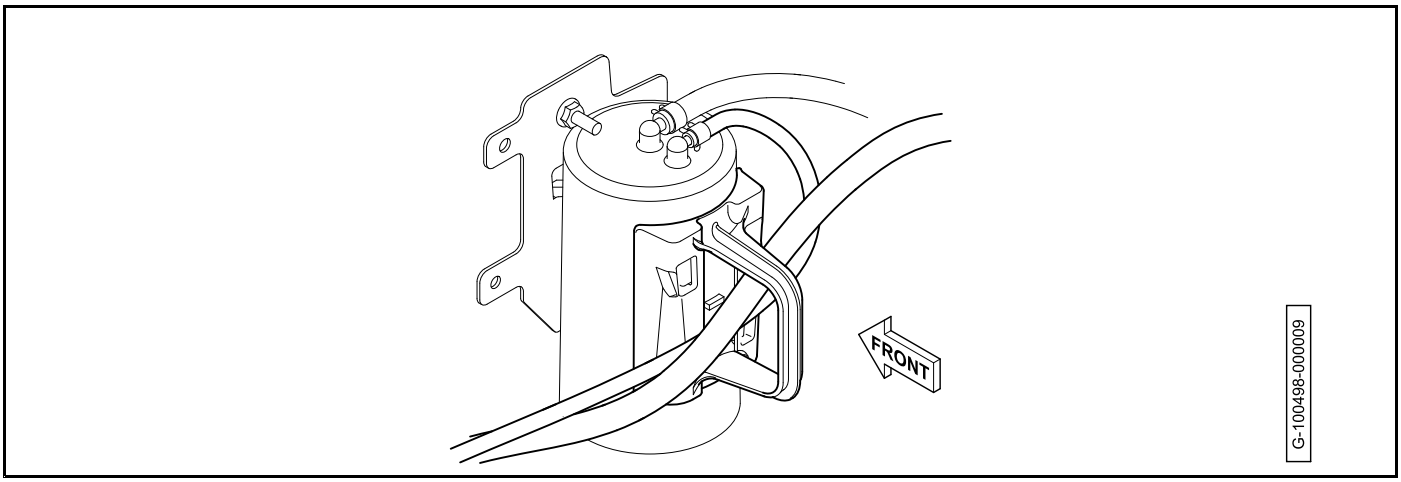


Figure 21-16 Carbon Canister Bracket

1.2. Install the P-clamp (2) and bolt onto the fuel line support bracket (3) **(Figure 21-17, Page 21-17)**. Tighten the bolt to 93 to 111 in·lb (10.5 to 12.5 N·m).

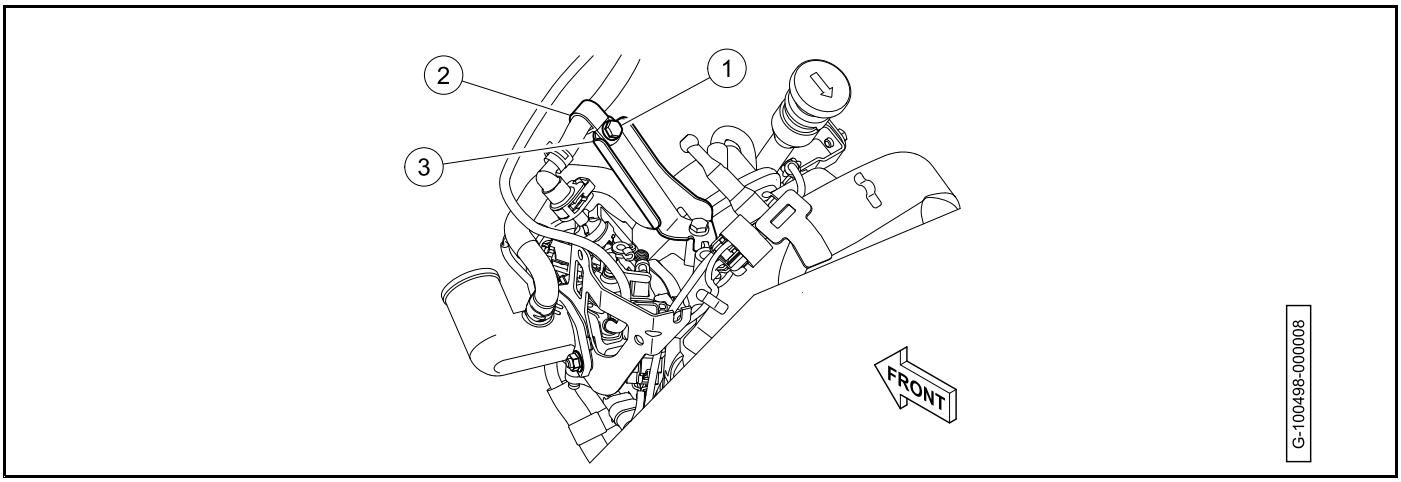


Figure 21-17 Fuel Line Support Bracket - Connect

1.3. Clean the nipple on top of fuel pump module.

1.4. Push the fuel line (5) onto the nipple until it locks into place **(Figure 21-18, Page 21-18)**.

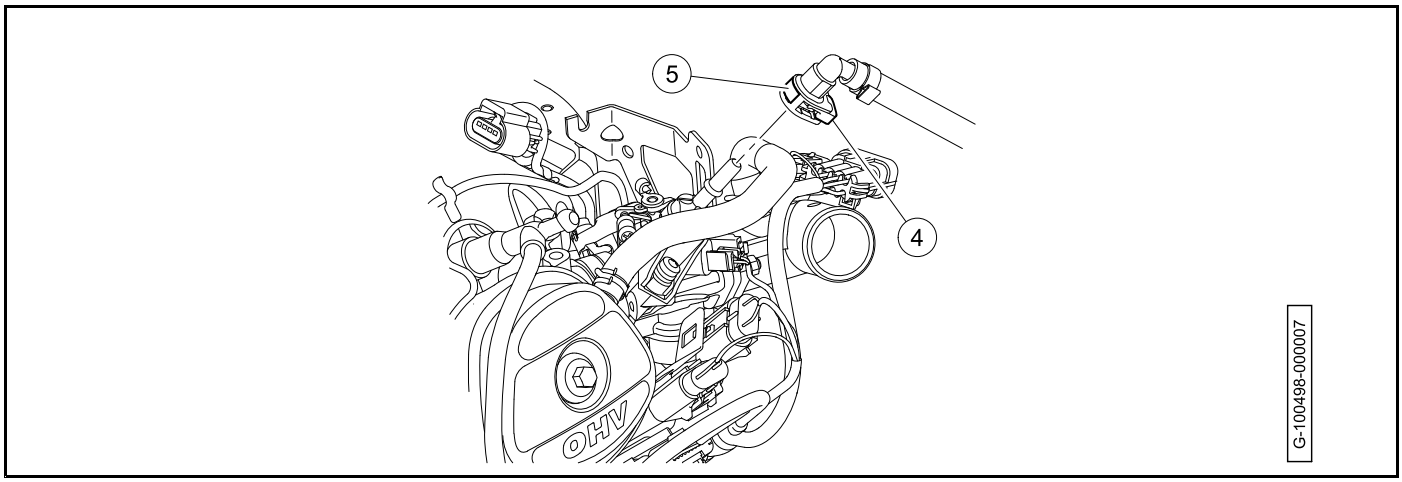


Figure 21-18 Fuel Line Connector – Connect

1.5. Push in the locking clip (4) until it is fully seated.

⚠ DANGER

- **Ensure line is connected properly to avoid a leak that can cause a fire.**

2. Clean spilled and remove any drained gasoline from the area.
3. Connect the battery.
4. Disable the vehicle.
5. Set the Maintenance/Operate switch to MAINTENANCE.
6. Turn the key switch to the ON position and check for fuel leaks. Repeat as necessary to build fuel pressure. Any leaks found must be fixed.

⚠ DANGER

- **Repair all fuel leaks before returning the vehicle to service.**

7. If no leaks are found, set the Maintenance/Operate switch in the OPERATE.

FUEL PUMP MODULE

See General Warnings on page 1-1.

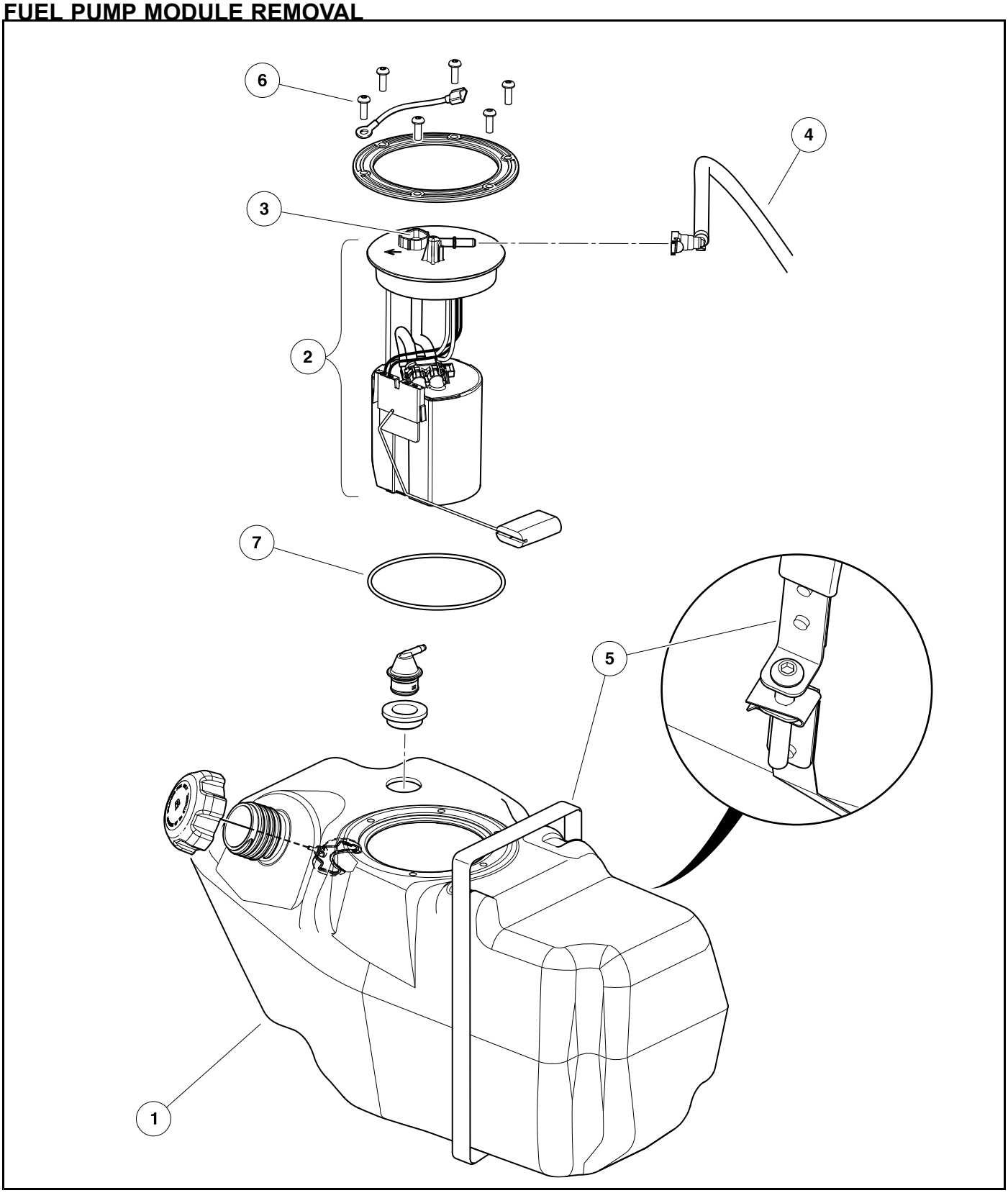
GENERAL INFORMATION

NOTE: *The fuel pump and fuel level sending unit themselves are not replaceable. If necessary, the fuel pump module must be replaced as an assembly.*

The fuel pump module can be disassembled to replace the fuel filter.

The EFI gasoline vehicle is equipped with an electric fuel pump. The fuel pump is protected by a filter and pickup screen.

FUEL PUMP MODULE REMOVAL



3052B

Figure 21-19 Fuel Pump Module Removal

1. Disable the vehicle.
2. Disconnect the battery.
3. Clean the top of the fuel tank (1) and fuel pump module (2) **(Figure 21-19, Page 21-19)**.
4. With a marker pen, make a mark across the top of the fuel pump module and onto the tank to note orientation before removal.
5. Disconnect the wire harness plug (3).

⚠ WARNING

- **Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure.**
- **Carefully drain any fuel remaining in the hose or pump module into an approved container. Add drained fuel back into fuel tank or dispose of properly.**

6. Disconnect the fuel line (4) and drain into an appropriate container. See Fuel Line Removal.
7. Loosen the fuel tank retaining strap (5) to allow tank to move and provide access to all of the fuel pump module hardware (6).
8. Remove the fuel pump module hardware.
9. Lift the fuel pump module out of fuel tank and drain into an appropriate container. Discard the fuel module o-ring (7).

NOTE: *If equipped with a fuel level sending unit, carefully maneuver module so as to avoid damaging the float arm mechanism.*

FUEL PUMP MODULE INSTALLATION

1. Clean the groove on top of fuel tank.
2. Place new fuel module o-ring (8) into groove on top of fuel tank .
3. Lower fuel pump module (1) into fuel tank noting correct orientation marked before removal. **See following NOTE and CAUTION.**

NOTE: *If equipped with a fuel level sending unit, carefully maneuver module so as to avoid damaging the float arm mechanism.*

⚠ CAUTION

- **Ensure o-ring stays seated in place during fuel pump module installation.**

4. Install hold down ring (6) and ground wire (7) with hardware (5) and tighten in a crisscross pattern to 66 in·lb (7.5 N·m). **See following WARNING.**

⚠ WARNING

- **Always install ground wires during reassembly.**

5. Tighten the fuel tank retaining strap screw to 26.5 in·lb (3 N·m).
6. Connect the fuel line (3) to fuel pump module (1). See Fuel Line Installation. **See following DANGER.**

⚠ DANGER

- **Ensure line is connected properly to avoid a leak that can cause a fire.**

7. Connect the wire harness plug (2) to the fuel pump module (1).
8. Clean spilled fuel. Remove any drained fuel from the area.
9. Connect the battery.
10. Disable the vehicle.
11. Set the Maintenance/Operate switch to MAINTENANCE.
12. Turn the key switch to ON and check for fuel leaks. Repeat as necessary to build fuel pressure. Any leaks found must be fixed.

⚠ DANGER

- **Repair all fuel leaks before returning the vehicle to service.**

13. If no leaks are found, set the Maintenance/Operate switch to OPERATE.

FUEL TANK

See General Warnings on page 1-1.

GENERAL INFORMATION

The vehicle is equipped with a high impact, plastic fuel tank.

⚠ WARNING

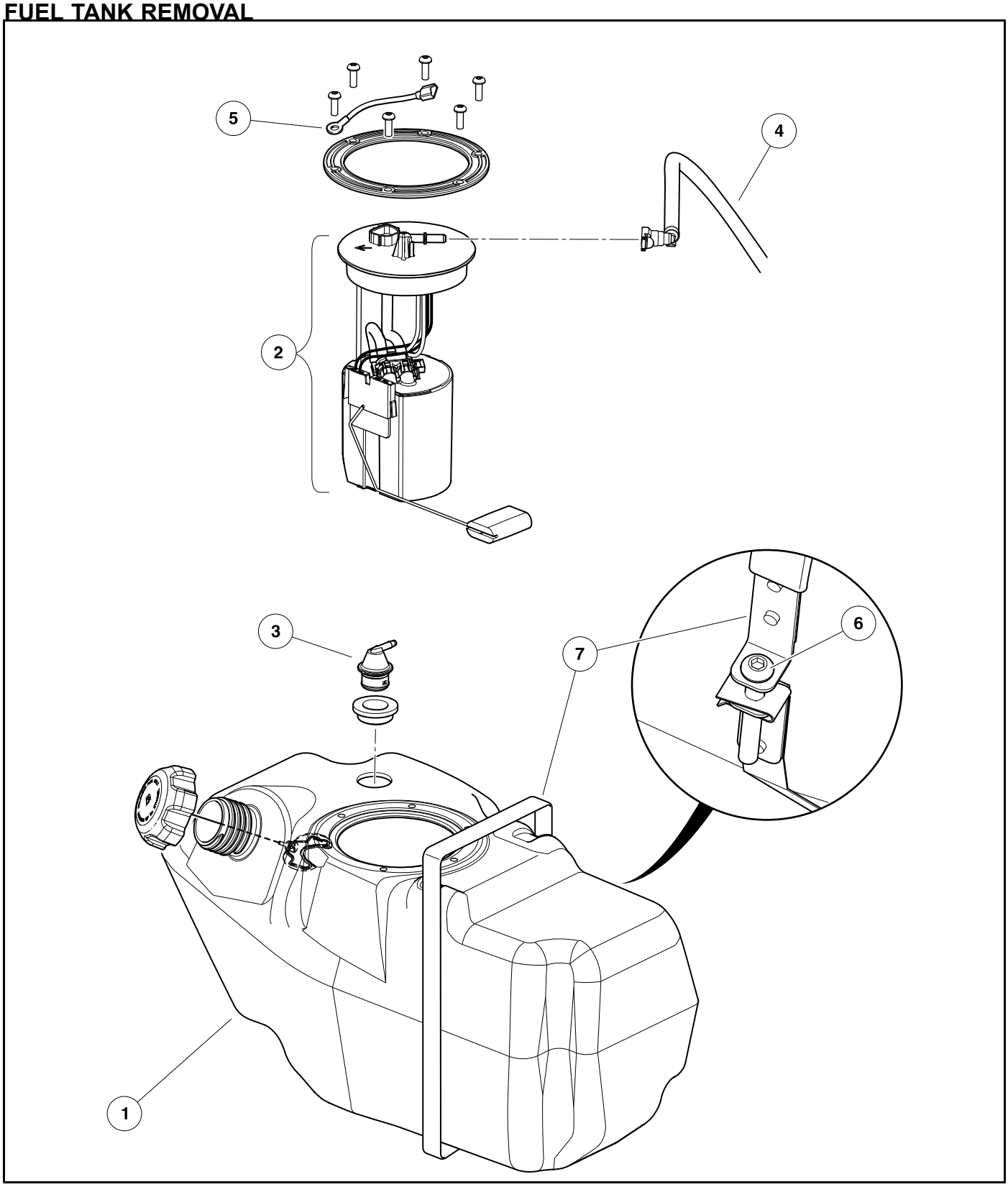
- **If the fuel tank is damaged, replace it. Do not attempt to repair it. See the following tank removal and disposal procedure.**

⚠ CAUTION

- **Add only unleaded fuel to the tank. Do not put oil in the fuel tank.**

NOTE: *This gasoline vehicle complies with the California Air Resources Board (CARB) and EPA evaporative emissions regulations when equipped with SAEJ30R9 1/4 in (6.3 mm) fuel vent hose and 3/16 in (4.78 mm) fuel vent hose. To remain in compliance with California and EPA regulations, replace any fuel vent hose on this vehicle with Club Car fuel vent hoses or equivalent.*

FUEL TANK REMOVAL



3052D

Figure 21-20 Fuel Tank Removal

1. Disable the vehicle.
2. Set the Maintenance/Operate switch to MAINTENANCE.
3. Disconnect the battery.
4. Clean the top of the fuel tank (1) and fuel pump module (2) **(Figure 21-20, Page 21-22)**.
5. Remove gas cap and siphon all fuel from tank into an approved container. **See following DANGER and WARNING.**

⚠ DANGER

- **Gasoline – Flammable! Explosive! Do not smoke. Keep sparks and flames away from the vehicle and service area. Service only in a well-ventilated area.**

⚠ WARNING

- **Do not attempt to siphon fuel using a hose that does not have a built-in suction device.**
- **Do not attempt to siphon fuel using your mouth.**

6. Disconnect the wire harness plug from fuel pump module.
7. Disconnect the vent hose from fuel tank vent (3).
8. Disconnect the fuel line (4) from the fuel pump module and drain into an appropriate container. See Fuel Line Removal. **See following WARNING.**

⚠ WARNING

- **Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure.**
- **Carefully drain any fuel remaining in the hose or pump module into an approved container. Add drained fuel back into fuel tank or dispose of properly.**

9. Disconnect fuel pump module ground wire (5).
10. Loosen screw (6) securing fuel tank retaining strap (7) and remove fuel tank.

FUEL TANK DISPOSAL

1. Remove gas cap and fuel pump module from tank. See Fuel Pump Module Removal. The cap may be discarded or kept as a spare.
2. In a well-ventilated area, flush the fuel tank with water to remove any remaining fuel.
3. In a well-ventilated area, set the tank upside down so that the water can drain out of it. To make sure that the tank dries completely, allow the tank to sit for 24 hours. **See following CAUTION.**

⚠ CAUTION

- **Dispose of wastewater and fuel tank in accordance with local, state, and federal laws and ordinances.**

FUEL TANK STORAGE

1. Remove gas cap and fuel pump module from tank. See Fuel Pump Module Removal.
2. In a well-ventilated area, flush the fuel tank with water to remove any remaining fuel.

3. In a well-ventilated area, set the tank upside down so that the water can drain out of it. To make sure that the tank dries completely, allow the tank to sit for 24 hours.
4. Completely drain gas from fuel pump module and allow to module to dry.
5. After the module is completely dry, install it in fuel tank. See Fuel Pump Module Installation.
6. Store the tank upside down, with the cap installed, in a well-ventilated area.

FUEL TANK INSTALLATION

NOTE: *This gasoline vehicle complies with the California Air Resources Board (CARB) and EPA evaporative emissions regulations when equipped with SAEJ30R9 1/4 in (6.3 mm) fuel vent hose and 3/16 in (4.78 mm) fuel vent hose. To remain in compliance with California and EPA regulations, replace any fuel vent hose on this vehicle with Club Car fuel vent hoses or equivalent.*

1. Place fuel tank (1) in vehicle **(Figure 21-20, Page 21-22)**.
2. Secure tank with retaining strap (7).

2.1. Position the retaining strap in the indention of the tank.

2.2. Install the screw (6) into retaining strap and tighten to 26.5 in·lb (3 N·m).

3. Connect fuel pump module ground wire (5) to main wire harness. **See following WARNING.**

⚠ WARNING

- **Always install ground wires during reassembly.**

4. Connect fuel line (4) to fuel pump module (2). **See Fuel Line Installation on page 21-16. See following DANGER.**

⚠ DANGER

- **Ensure line is connected properly to avoid a leak that can cause a fire.**

5. Install the vent line onto the fuel tank vent (3).
6. Connect the wire harness plug to fuel pump module.
7. Clean spilled fuel and remove any drained fuel from the area.
8. Connect the battery.
9. Add fuel to the fuel tank.
10. Disable the vehicle.
11. Set the Maintenance/Operate switch to MAINTENANCE.
12. Turn key switch to the ON position and check for fuel leaks. Repeat as necessary to build fuel pressure. Any leaks found must be fixed.

⚠ DANGER

- **Repair all fuel leaks before returning the vehicle to service.**

13. If no leaks are found, set the Maintenance/Operate switch to OPERATE.

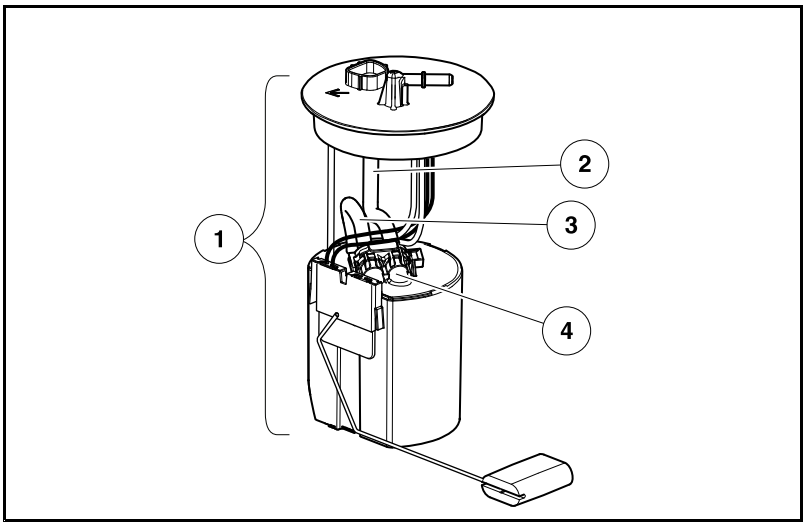
FUEL FILTER

See General Warnings on page 1-1.

GENERAL INFORMATION

The fuel filter is located in the fuel tank. It is part of the fuel pump module assembly and should last the life of the vehicle; however, it is replaceable if the need should arise. In addition, the module assembly features a fuel pickup screen to catch larger particles before entering the fuel filter.

FUEL FILTER REMOVAL



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Figure 21-21 Fuel Filter Removal

1. Disable the vehicle.
2. Disconnect the battery.
3. Remove fuel pump module (1) **(Figure 21-21, Page 21-25)**. See Fuel Pump Module Removal.
4. Disconnect the flex hoses (2 and 3) from filter (4).

4.1. Pull the hose retainer clip straight up and out of the filter. Do not discard clip.

4.2. Pull the flex hoses straight out of the filter inlet and outlet.

5. Remove filter from fuel pump module and dispose of properly.

FUEL FILTER INSTALLATION

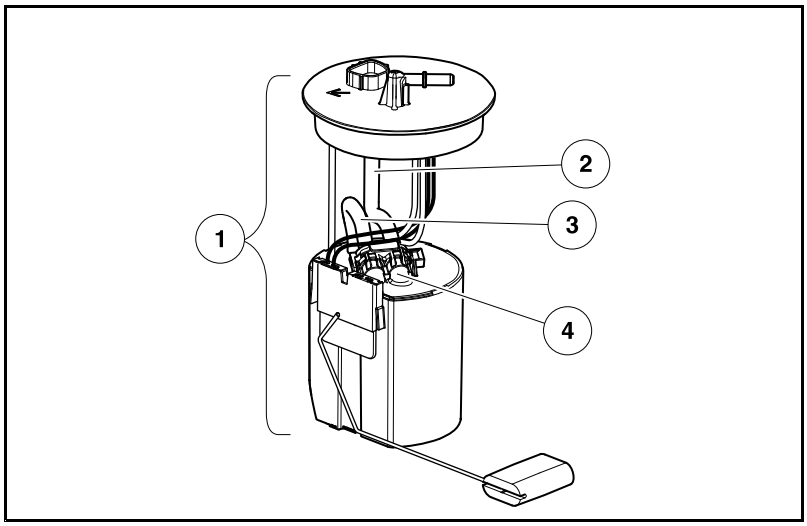
⚠ CAUTION

- **Fuel filter flex hoses are keyed to aid proper installation into fuel pump module.**

NOTE: *The fuel filter is keyed to the fuel pump module to prevent incorrect assembly.*

The inlet and outlet flex hoses are keyed to the fuel filter ports to prevent incorrect assembly.

1. Orient fuel filter (4) and insert into fuel pump module (1) until fully seated **(Figure 21-22, Page 21-26)**.



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Figure 21-22 Fuel Filter Installation

2. Connect flex hoses (2 and 3) to the fuel filter.

2.1. Orient flex hoses with matching port in filter and push each hose end straight into filter until fully seated.

2.2. Push hose retainer clip straight into filter until fully seated.

3. Install fuel pump module. See Fuel Pump Module Installation.
4. Connect the battery and spark plug wire.
5. Set the Forward/Neutral/Reverse control (FNR) to N.
6. Chock the wheels.
7. Set the Maintenance/Operate switch to MAINTENANCE.
8. Start the engine and check for fuel leaks. **See following DANGER.**

⚠ DANGER

- **Repair all fuel leaks before operating the vehicle.**

9. If no leaks are found, set the Maintenance/Operate switch to OPERATE.

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

MUFFLER

MUFFLER REMOVAL

1. Disconnect the battery and spark plug wire.
2. If necessary, remove the oxygen sensor (1) from the muffler (2) **(Figure 22-1, Page 22-1)**. See Oxygen Sensor Removal.

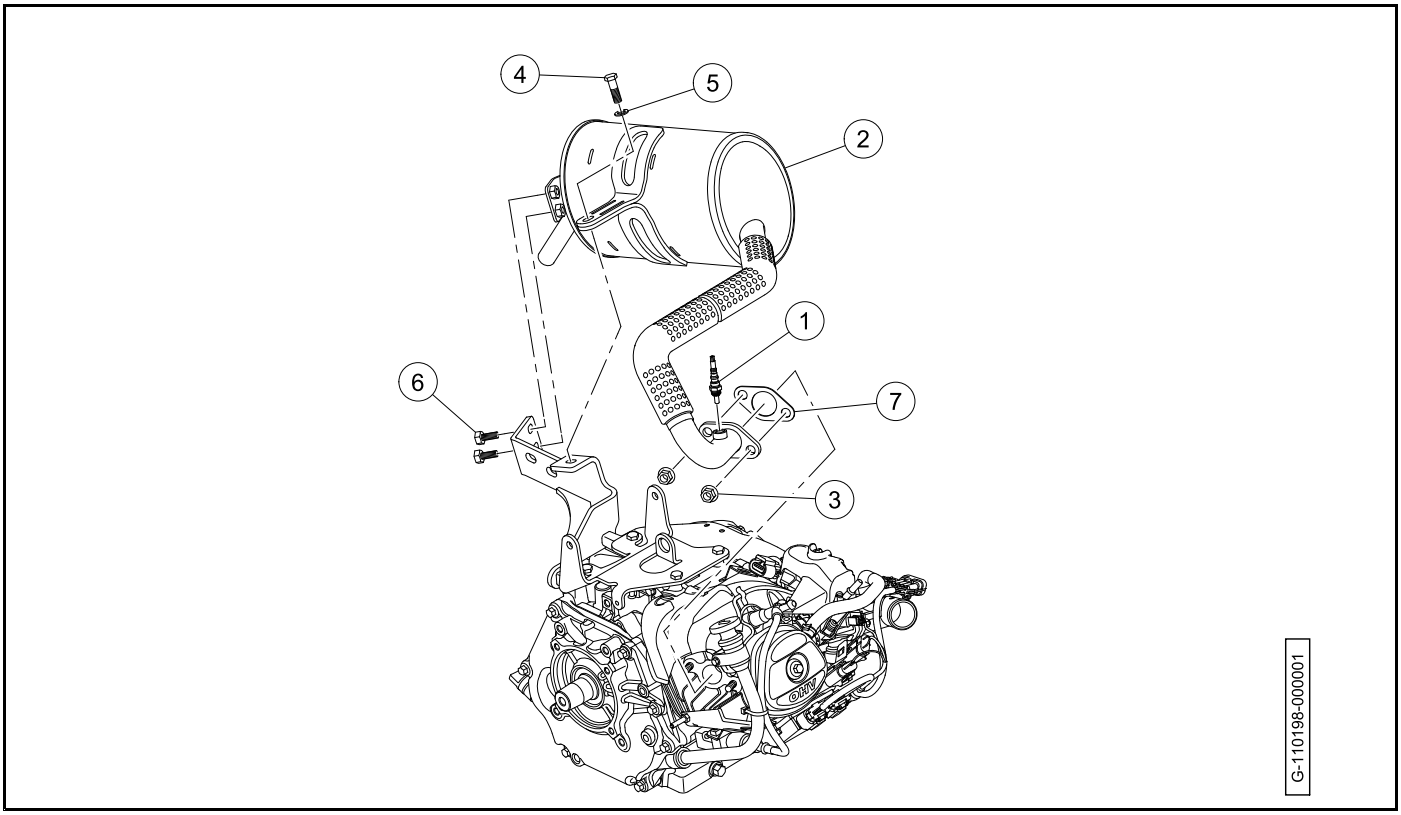


Figure 22-1 Muffler Removal

3. Remove the nuts (3).
4. Remove the bolt (4) and washer (5).
5. Remove the bolts (6).
6. Remove the muffler.
7. Remove the exhaust gasket (7).

MUFFLER INSTALLATION

1. Install the new exhaust gasket (7) on the exhaust port studs **(Figure 22-2, Page 22-2)**.

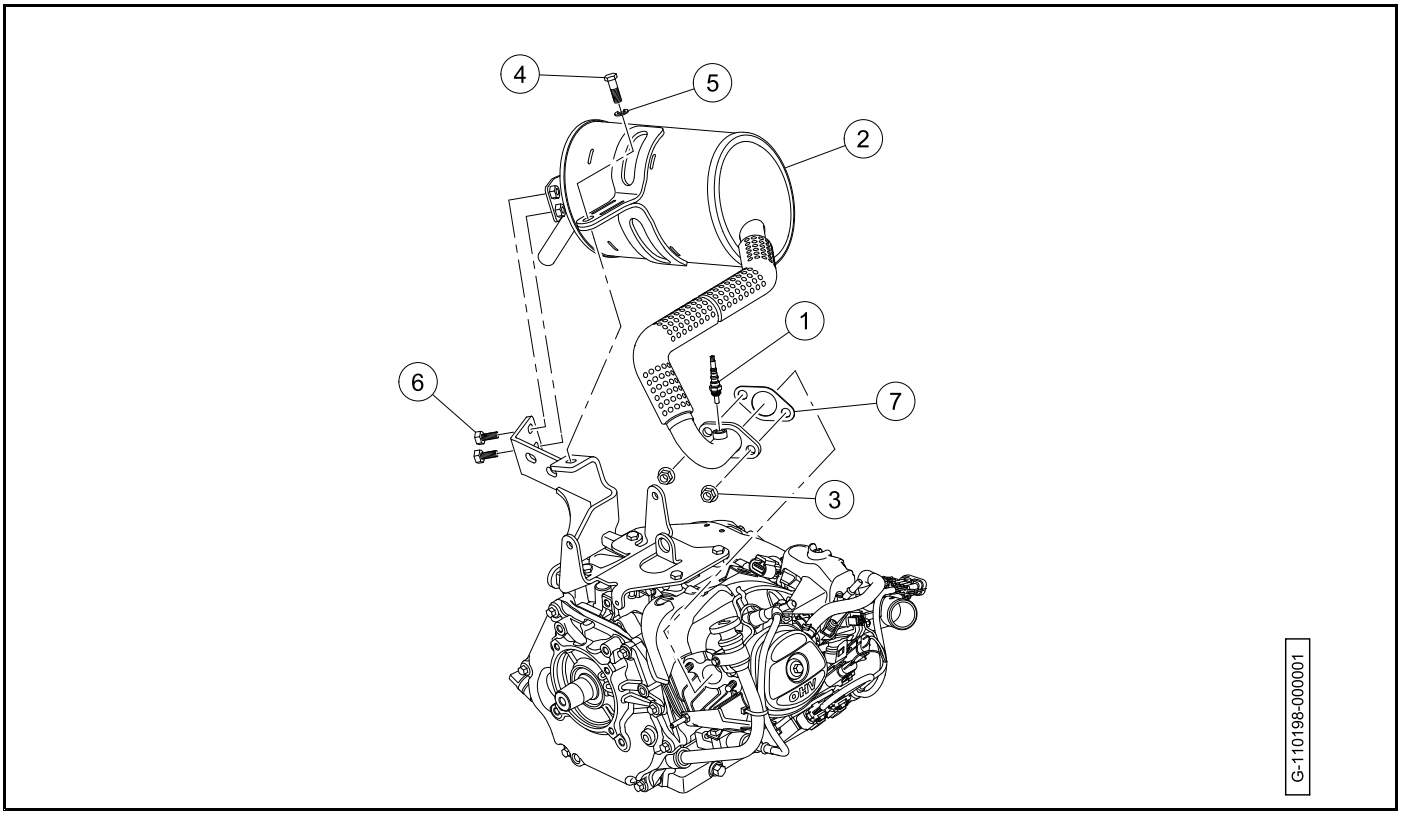


Figure 22-2 Muffler Installation

2. Put the muffler (2) into position on the engine.
3. Install the nuts (3), bolt (4), washer (5), and bolts (6). Tighten the hardware by hand.
4. Tighten the hardware in the following order:

4.1. Tighten the nuts (3) to 19 ft·lb (26 N·m).

4.2. Tighten the bolt (4) to 17 ft·lb (23 N·m).

4.3. Tighten the bolts (6) to 17 ft·lb (23 N·m).

5. If the oxygen sensor (1) was removed, install the oxygen sensor. See Oxygen Sensor Installation.
6. Connect the battery and spark plug wire.
7. Set the Forward/Neutral/Reverse control (FNR) to N.
8. Set the Maintenance/Operate switch to MAINTENANCE.
9. Put the chocks against the wheels.

⚠ DANGER

- **Do not operate gasoline vehicle in an enclosed area without proper ventilation. The engine produces carbon monoxide, which is an odorless, deadly poison.**

10. Start the engine.
11. Check for exhaust leaks and correct engine operation. **See following DANGER.**

SECTION 23 — GASOLINE VEHICLE - CLUTCHES

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

GENERAL INFORMATION

The torque converter consists of a drive clutch, a driven clutch, and a drive belt. The drive clutch, which is mounted to the engine, is in the open position when the engine is at idle. At this point, the belt is riding at a low position (smaller diameter) on the drive clutch. The driven clutch is mounted on the transaxle. It is in the closed position, and the drive belt is riding at a high position (large diameter) on it when the engine is at idle.

At the point of clutch engagement, the speed ratio of the drive clutch to the driven clutch provides excellent starting and low-speed torque.

As engine speed increases, centrifugal force on internal weights close the drive clutch, pushing the belt up to a higher position on the clutch (increasing the diameter of the belt loop). As the diameter of the belt loop increases at the drive clutch, the driven clutch is forced open as the diameter of its belt loop decreases.

On steep grades, or when the vehicle is heavily loaded, higher torques are achieved through the use of a torque-sensing ramp device on the driven clutch. This device overcomes the force of the centrifugal weights to close the driven clutch and open the drive clutch, thus increasing axle torque with little or no change in engine RPM.

The engine and torque converter rotate counter-clockwise as viewed from the clutch side of the engine.

To provide optimum performance for the engine and powertrain, the vehicle uses a pair of tuned clutches.

To properly assemble and disassemble the torque converter, the following tools should be used:

- Drive Clutch Hub Puller
- Drive Clutch Puller
- Drive Clutch Holder Tool
- Driven Clutch Cam Puller
- Driven Clutch Puller Plug
- Driven Clutch Cam Press
- Scribe or small pick (not included with clutch tools).

TROUBLESHOOTING

See General Warnings on page 1-1.

Maintaining proper adjustment of the engine and governor, as well as the torque converter, is essential to the troubleshooting process. If these adjustments are within specifications and, when climbing a steep hill, the engine begins to lose RPM before the drive belt reaches the top of the driven clutch, there is a torque converter problem.

If the torque converter is not operating properly, perform the following steps:

1. Check the governor and throttle settings. See Engine Control Linkages.
2. Inspect the driven clutch for dirt and dust buildup on its component parts. Clean the driven clutch with water to remove any dust or dirt, then drive the vehicle and check for proper operation.
3. If cleaning the driven clutch does not solve the problem, disassemble and thoroughly clean all parts of the drive clutch. Be sure to clean the plastic drive buttons (7) **(Figure 23-2, Page 23-4)**.

DRIVE BELT

See General Warnings on page 1-1.

The drive belt should be inspected semiannually for wear and (or) glazing. If it is excessively worn, frayed, or glazed, replace the belt.

As the drive belt wears, the engine RPM will increase to compensate for the change in torque converter ratio. This will keep the vehicle's maximum ground speed correct. **See Vehicle Specifications.**

DRIVE BELT REMOVAL

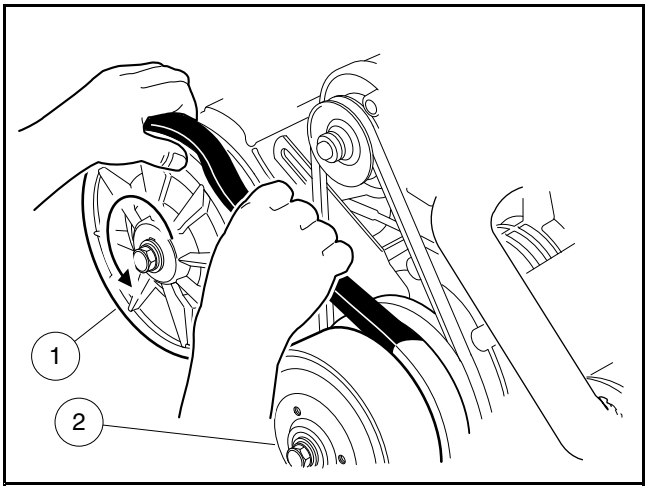
1. Disconnect battery and spark plug wire. **See Disconnect the Battery- Gasoline Vehicles on page 1-4.**
2. Grasp the belt midway between the drive (2) and driven (1) clutches. Lift upward on the belt to force the sheaves of the driven clutch (1) apart, then roll the belt off the driven clutch by rotating the clutch counterclockwise **(Figure 23-1, Page 23-3)**. **See following CAUTION.**

⚠ CAUTION

- **Make sure fingers are not underneath the belt when rolling the belt off the driven clutch.**

NOTE: *Roll away from compression to make removal easier.*

3. Remove the belt from the drive clutch (2).



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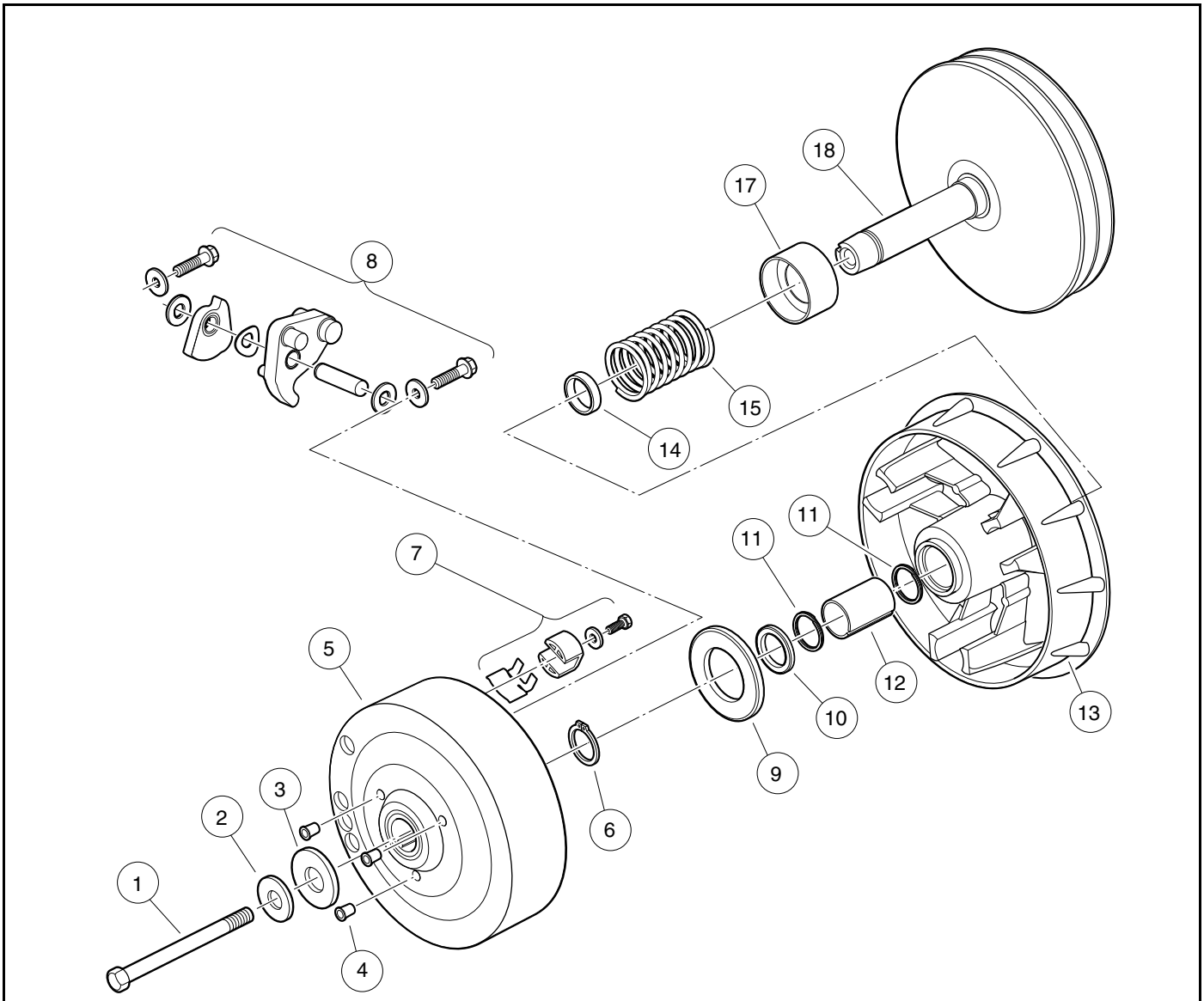
Figure 23-1 Drive Belt Removal

DRIVE BELT INSTALLATION

1. Position the new belt on the drive clutch (2), then start the belt over the top of the driven clutch (1).
2. With the belt started onto the driven clutch (1), rotate the driven clutch counterclockwise and roll the belt over the outer, moveable sheave.
3. Connect battery and spark plug wire. **See Connect the Battery- Gasoline Vehicles on page 1-4.**

DRIVE CLUTCH

See General Warnings on page 1-1.



1. Screw, 3/8-24 x 5.75, Patch	10. Retainer
2. Washer, Hard, M10	11. Ring, Spiral Backup
3. Washer, 3/8, Type A, Flat	12. Bushing, Split, Drive Clutch
4. Cap Plug	13. Sheave, Moveable, Drive
5. Drive Hub Assy, Drive Clutch	14. Spacer, Fixed Face Shaft
6. Ring, 0.810 in. (20.5 mm) Internal Retaining	15. Spring, Drive Clutch
7. Drive Clutch Button	16. No Item to Show

8. Drive Clutch Weight	17. Spacer, Idler, Drive
9. Thrust Washer	18. Sheave, Fixed, Drive

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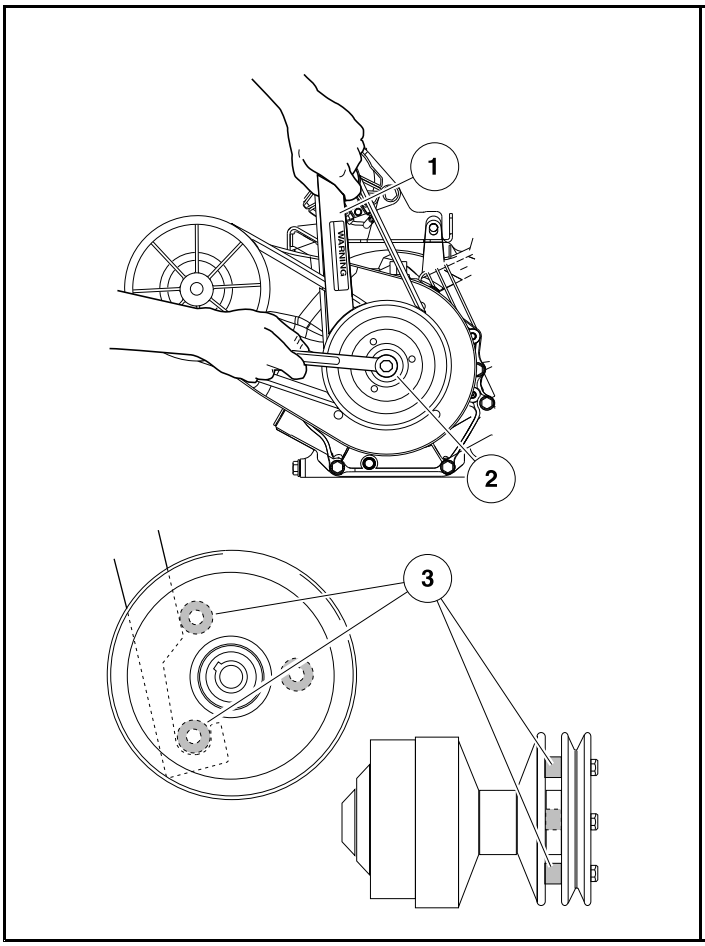
Figure 23-2 Drive Clutch – Exploded View

⚠ CAUTION

- **Be very careful when handling the clutches. A clutch that has been dropped will not be properly balanced. If either clutch is dropped, assume that it is damaged and replace it.**

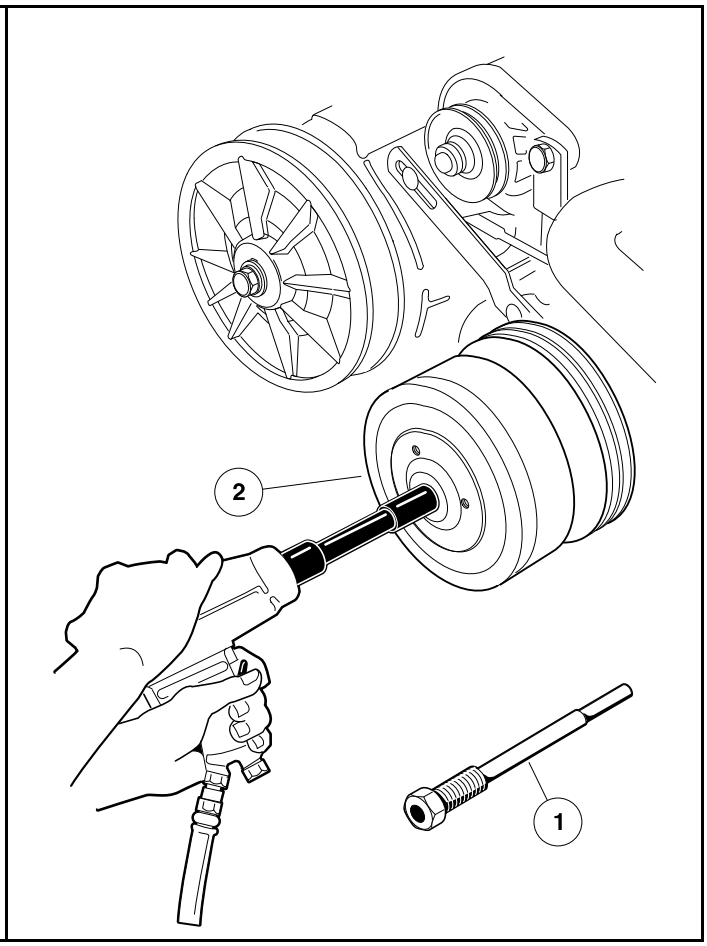
DRIVE CLUTCH REMOVAL

1. Remove the drive belt as instructed. **See Drive Belt Removal on page 23-3.**
2. Loosen starter/generator mounting and adjusting hardware and remove starter belt. **See WARNING "Moving parts! Do not..." in General Warnings on page 1-1.**



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Figure 23-3 Loosen Retaining Bolt



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Figure 23-4 Drive Clutch Removal

3. Place chocks at the front wheels and lift the rear of the vehicle with a chain hoist or floor jack. Place jack stands under the chassis to support the vehicle. The weight of the powertrain will allow the centerline of the drive clutch to drop below the frame I-beam for access to the bolt securing the drive clutch. **See following WARNING.**

⚠ WARNING

- **Lift only one end of the vehicle at a time. Use a suitable lifting device (chain hoist or hydraulic floor jack) with 1000 lb. (454 kg) minimum lifting capacity. Do not use lifting device to hold vehicle in raised position. Use approved jack stands of proper weight capacity to support the vehicle and chock the wheels that remain on the floor. When not performing a test or service procedure that requires movement of the wheels, lock the brakes.**

4. Remove the drive clutch retaining bolt (1) and mounting washers (2 and 3) **(Figure 23-2, Page 23-4)**. **See also Figure 23-3, Page 23-5. See following NOTE.**

NOTE: *The drive clutch mounting bolt has right-hand threads.*

The crankshaft has right-hand threads at the clutch mounting hole.

4.1. Use the drive clutch holder tool (1) while tightening or loosening the drive clutch retaining bolt (2) **(Figure 23-3, Page 23-5)**.

4.2. Hook clutch holder on boss (3) of pulley located behind drive clutch and push against the adjacent boss with holder.

5. Lubricate the threaded portion of the clutch puller tool (1) with a light oil and thread the clutch puller tool into the clutch retaining bolt hole **(Figure 23-4, Page 23-5)**.
6. Use a 1/2-in. drive air wrench to tighten the clutch puller tool. The drive clutch (2) will pull free of the crankshaft.
7. Support the drive clutch assembly in your hand and back the clutch puller tool out of the crankshaft.

⚠ CAUTION

- **Do not hit or tap the clutch with a hammer. Do not pry the clutch. These actions will damage the clutch.**

DRIVE CLUTCH CLEANING AND INSPECTION

1. Use a dry, lint-free cloth to clean clutch parts.

⚠ CAUTION

- **Do not lubricate the drive clutch. Lubricants attract dirt and dust, which interfere with proper clutch operation.**
- **Use only a dry cloth to lightly wipe the shaft of the fixed sheave (18) (Figure 23-2, Page 23-4). Do not use a brush or steel wool. These will damage the surface of the shaft.**
- **Do not use solvents. Solvents will damage the lubricating characteristics of the bushings.**

2. Inspect the belt contact surfaces of the clutch sheaves for wear. If any area of a sheave contact surface has wear of 0.060 in. (1.52 mm) or more, the clutch should be replaced.

DRIVE CLUTCH DISASSEMBLY

⚠ CAUTION

- **The drive clutch is balanced as an assembly. Before disassembly, make match marks on the drive clutch hub and on the moveable sheave so they can be reassembled in the same positions (Figure 23-5, Page 23-7).**

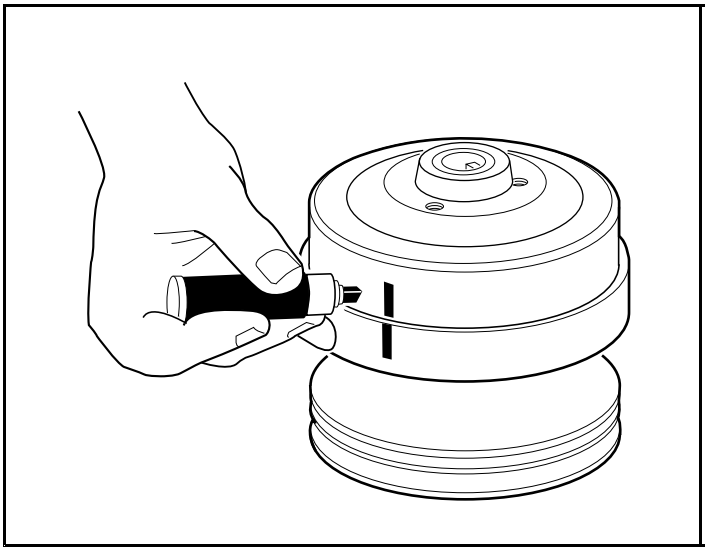
1. Make match marks on the drive clutch hub and on the moveable face **(Figure 23-5, Page 23-7)**.
2. Remove the drive clutch hub (5) **(Figure 23-2, Page 23-4)**:

2.1. Remove the three plugs (4) from the clutch puller attachment holes.

2.2. Thread the center bolt of the Drive Clutch Hub Puller (1) into clutch until the stop nut touches the clutch, then back the bolt out one-half turn **(Figure 23-6, Page 23-7)**.

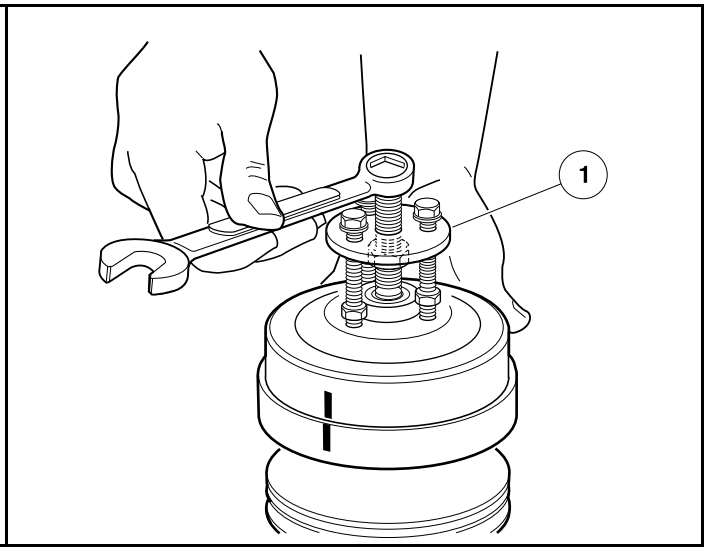
2.3. Thread the three small bolts of the puller into corresponding holes in the clutch. Tighten bolts evenly, making sure the face of the puller plate is parallel to the face of the clutch **(Figure 23-6, Page 23-7)**.

2.4. Unscrew the puller center bolt out of the clutch to pull drive clutch hub off.



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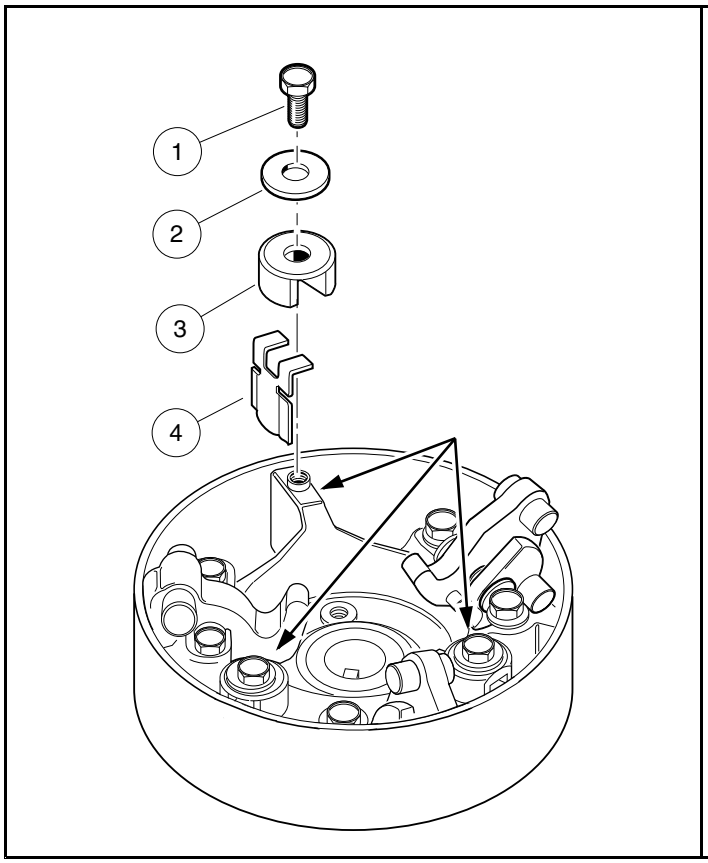
Figure 23-5 Mark Drive Clutch Hub



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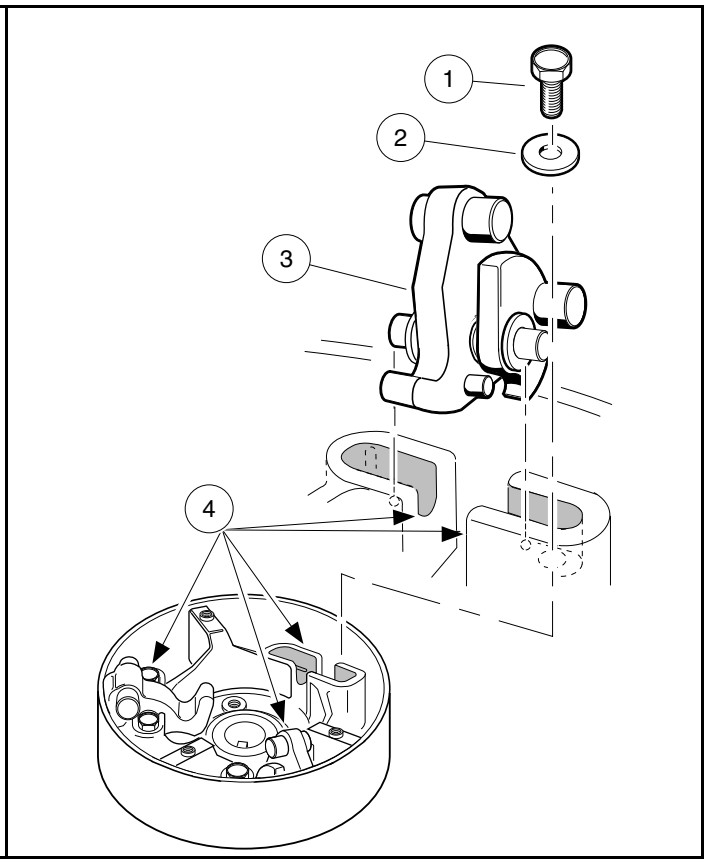
Figure 23-6 Remove Drive Clutch Hub

3. Remove the thrust washer (9) from the moveable sheave (13) **(Figure 23-2, Page 23-4)**.
4. Remove the drive buttons (3) by removing the screws (1), flat washers (2), and drive button take-up springs (4) as shown **(Figure 23-7, Page 23-8)**.



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Figure 23-7 Drive Button Mounting



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Figure 23-8 Weight Position

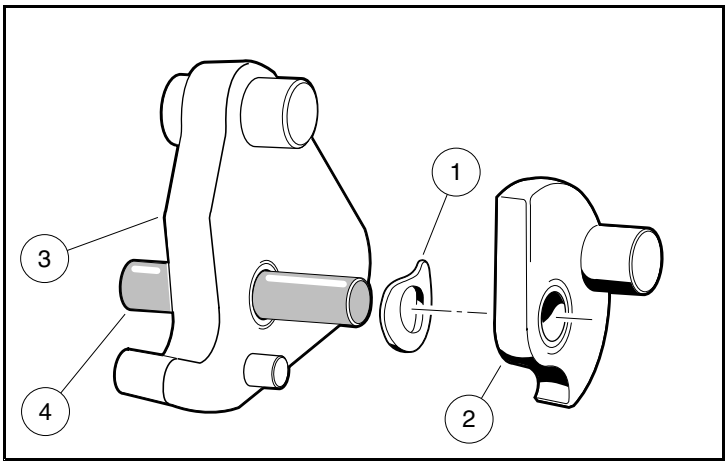
5. Remove the clutch weights:

5.1. Remove the screws (1) and flat washers (2) attaching the weights (3) as shown **(Figure 23-8, Page 23-8)**.

5.2. Pull the weight assemblies (3), with pins, from slots (4) in the clutch. **See following NOTE.**

NOTE: *Before removing, note the orientation of the wave washer (1) and secondary weight (2) on the primary weight (3)* ***(Figure 23-9, Page 23-9)****.*

5.3. Remove the plastic washers, weights (2 and 3) and wave washer (1) from the pin (4). Retain all parts.



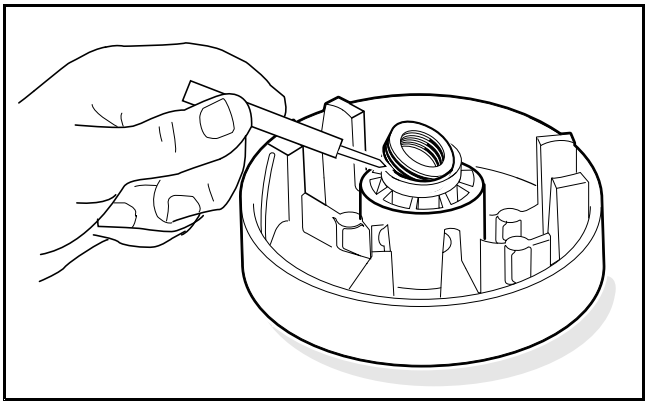
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Figure 23-9 Primary and Secondary Weights, Wave Washer and Pin

6. Remove the retaining ring (6) from the shaft of the fixed sheave (18) and slide the moveable sheave (13) off the shaft **(Figure 23-2, Page 23-4)**. **See following NOTE.**

NOTE: *If the moveable sheave is removed from the hub of the fixed sheave, the spiral back-up rings (11) must be replaced with new rings **(Figure 23-2, Page 23-4)**.*

7. Remove the spacer (14) and spring (15) **(Figure 23-2, Page 23-4)**.
8. Use a scribe or small pick to remove the spiral backup rings (11) from each end of the bore in the fixed sheave **(Figure 23-2, Page 23-4)**. **See also Figure 23-10, Page 23-9.** Discard the rings.



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Figure 23-10 Spiral Back-up Rings

INSPECTION OF DRIVE CLUTCH PARTS

1. Inspect the idler spacer (17) for smoothness **(Figure 23-2, Page 23-4)**.
2. Inspect the bore of the moveable sheave (13) for scarring or wear. The moveable sheave must be replaced if the bore is worn to a diameter of 0.883 in. (22.4 mm) or larger **(Figure 23-2, Page 23-4)**.
3. Inspect the steel shaft on the fixed sheave (18). There should be no measurable wear anywhere on the shaft. Replace the shaft if it is worn, scratched, or damaged.
4. Inspect the thrust washer (9) for wear. If it is worn more than 0.030 in. (0.76 mm), turn it over or replace it with a new one.

5. Inspect the primary weights (8) and the hub casting for wear. If the primary weights show signs they are touching the casting, the tips of the weights have worn beyond specification and they must be replaced.
6. Inspect the pins on the primary weights (8). There should be no measurable wear. Replace them if they are worn, scratched, or damaged**.**
7. Inspect the drive belt pulley sheaves for excessive wear or damage. If the sheaves are excessively worn or damaged, replace the entire fixed sheave.

DRIVE CLUTCH ASSEMBLY

1. Install the spring (15) into the cup of the idler spacer (17).
2. Install the spacer (14) onto the shaft of the fixed sheave.
3. Install a new spiral backup ring (11) in each end of the bore of the moveable sheave (13).
4. Install the moveable sheave (13) onto the shaft of the fixed sheave (18).

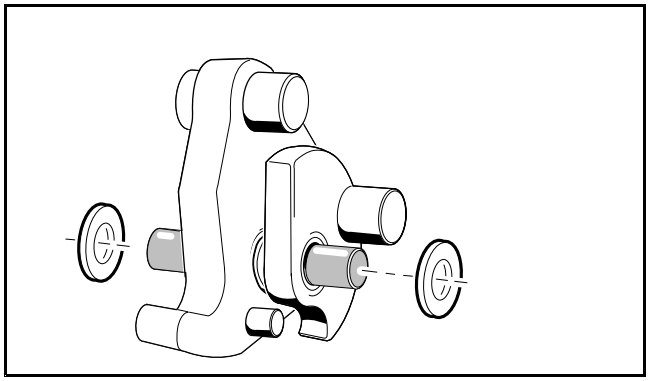
⚠ CAUTION

- **To avoid damaging the spiral back-up rings, be very careful when installing the moveable sheave.**

4.1. Rotate the moveable sheave clockwise while installing it onto the shaft.

4.2. Install the retaining ring (6) **(Figure 23-2, Page 23-4)**.

5. Install the primary weights (3) on the mounting pins (4) **(Figure 23-9, Page 23-9)**.
6. Install a wave washer (1) on each mounting pin (4). Make sure that the concave side of the washer faces the side of the primary weight (3) with the small guide pin protruding from it **(Figure 23-9, Page 23-9)**.
7. Install the secondary weights (2) onto the mounting pins (4) with the weight pins on the secondary weights pointing away from the primary weights (3). The wave washers should be between the primary and secondary weights **(Figure 23-9, Page 23-9)**.
8. Install white plastic flat washers on each end of the mounting pin and push them against the outside surfaces of the weights. Center the weights and washers on the mounting pin **(Figure 23-11, Page 23-10)**.
9. Install the weight assemblies into the slots (4) in the hub casting **(Figure 23-8, Page 23-8)**. Make sure the mounting pin protrudes an equal amount on each side of the weights when the assemblies are in position **(Figure 23-11, Page 23-10)**.



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Figure 23-11 Install White Washers

10. Install the 1/4-20 bolts (1) and washers (2) and tighten them to 10 ft·lb (13 N·m) **(Figure 23-8, Page 23-8)**. **See following NOTE.**

NOTE: *Make sure there is at least a (minimum) gap of 0.020 in. (0.51 mm) between each end of the mounting pin and the mounting bolt.*

11. Install three drive button take-up springs.

11.1. Install each spring on right-hand side of the three button mounting posts (when looking into the interior of the clutch drive hub, and with the rib at a twelve o'clock position) as shown **(Figure 23-12, Page 23-11)**.

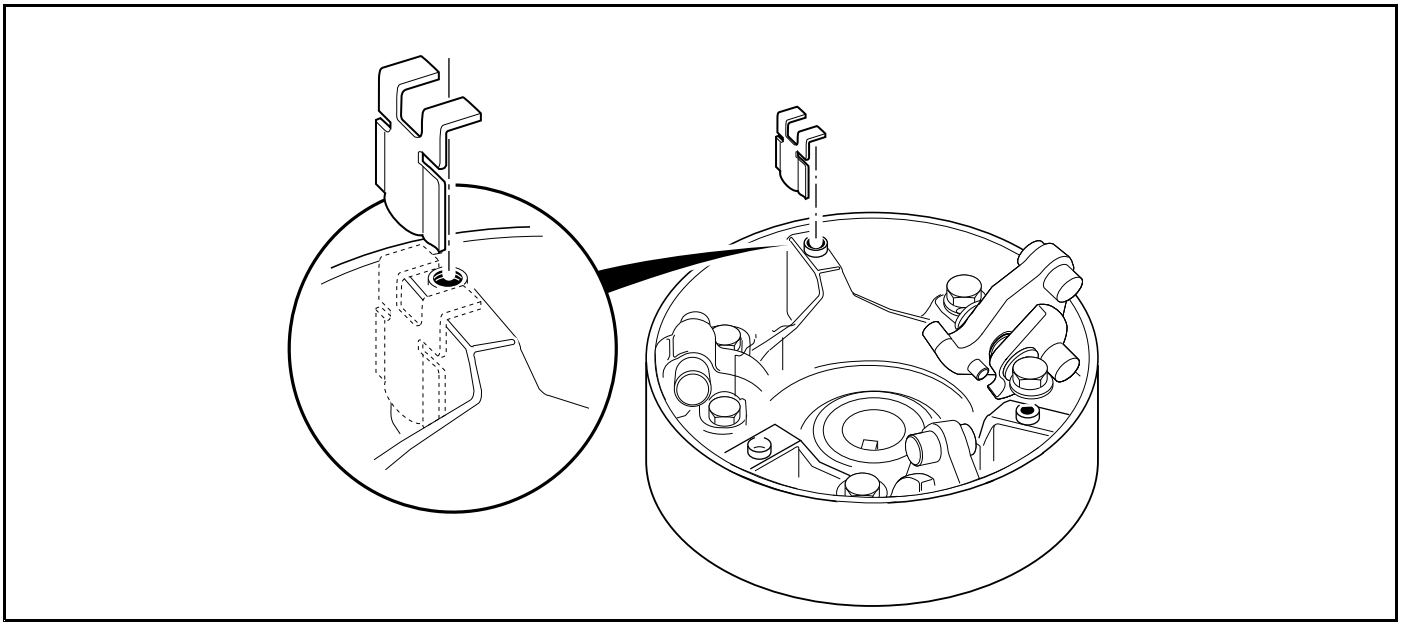
12. Compress each take-up spring and install the drive button over the rib and take-up spring **(Figure 23-7, Page 23-8)**.

13. Install a drive button retaining bolt (1) with flat washer (2) through each button (3) and into the rib. Tighten the bolts to 34 in·lb (3.8 N·m) **(Figure 23-7, Page 23-8)**.

14. Install the thrust washer (9) onto the moveable sheave (13) **(Figure 23-2, Page 23-4)**.

15. Install the hub assembly (5) on the moveable sheave (13) and align the match marks made before disassembling the clutch. Press the hub assembly on by hand.

16. Replace the three plastic plugs (4) into the holes **(Figure 23-2, Page 23-4)**.



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Figure 23-12 Correct Orientation of Drive Button Take-up Springs

DRIVE CLUTCH INSTALLATION

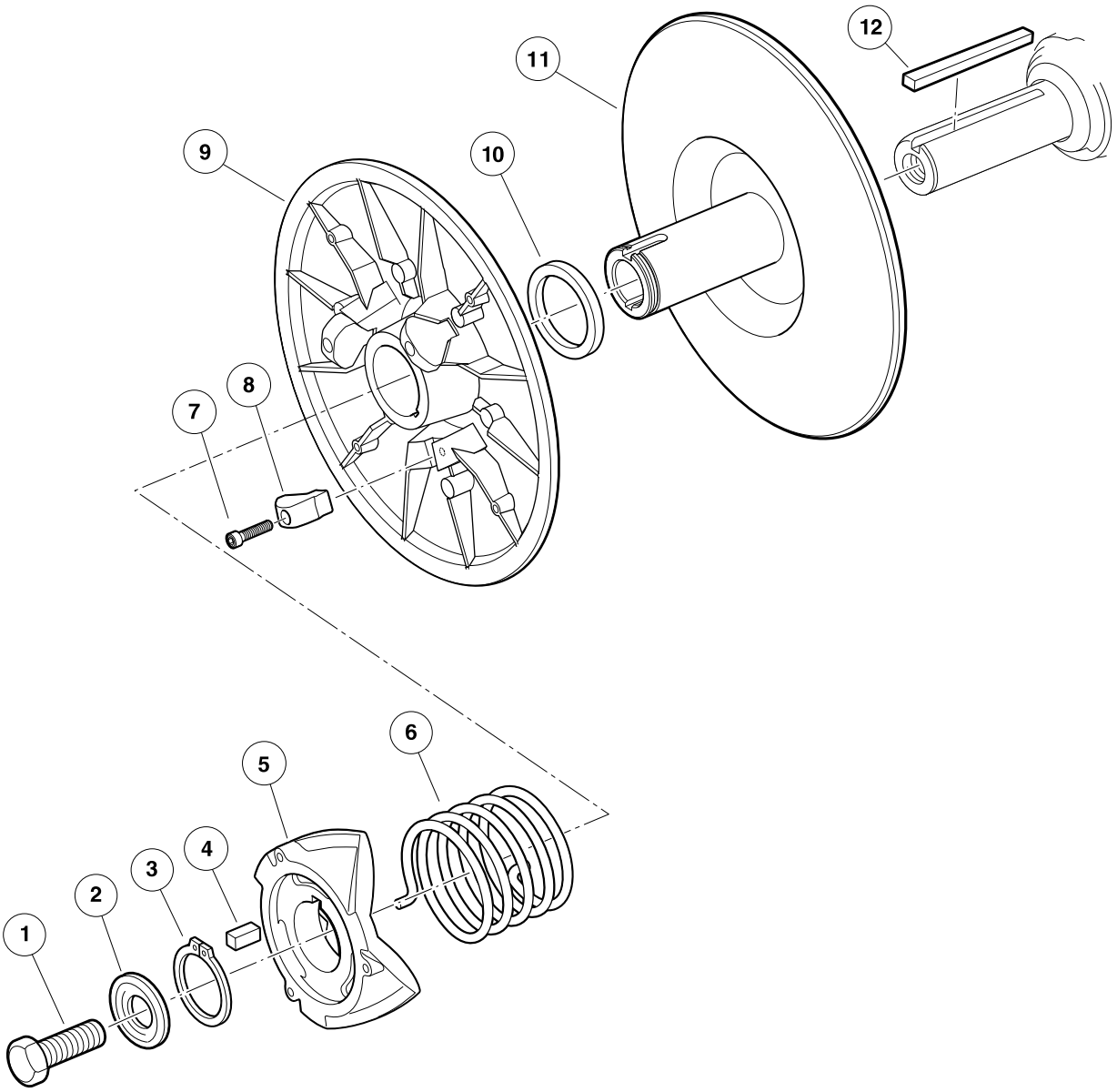
1. Place the drive clutch assembly on the crankshaft taper. Position the mounting washers (2 and 3) on the bolt (1) and start the bolt into the crankshaft **(Figure 23-2, Page 23-4)**. **See following NOTE.**

NOTE: *The drive clutch retaining bolt has right-hand threads. The manufacturer recommends replacing the drive clutch retaining bolt when installing the drive clutch. If a new bolt is not available, clean the threads of the original bolt and apply Loctite® 242 to the threaded end prior to installation.*

2. Tighten the drive clutch retaining bolt (1) to 35 ft·lb (47.5 N·m) **(Figure 23-2, Page 23-4)**.
3. Install the starter/generator belt and adjust belt tension as instructed. **See Belt Tension Adjustment for EFI Engines, Section 19, Page 19-15.**
4. Install the drive belt as instructed. **See Drive Belt Installation on page 23-3.**
5. Connect battery and spark plug wire. **See Connect the Battery- Gasoline Vehicles on page 1-4.**
6. Drive the vehicle and check for proper operation.

DRIVEN CLUTCH

See General Warnings on page 1-1.



1. Screw, 5/16-18 X 3/4 Hex-Head with Patch	7. Screw, #8-32 X 3/4, Socket-Head Cap
2. Washer, Driven Clutch	8. Button, Drive
3. Ring, Retaining	9. Sheave, Movable, Driven
4. Key, Driven Clutch	10. Washer, Acetal, Driven Clutch

5. Cam, Driven Clutch	11. Sheave, Fixed, Driven
6. Spring, Driven Clutch, CCW, Red	12. Key, 3/16 in. (4.7 mm) Square X 1.50 in. (38 mm) Long

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Figure 23-13 Driven Clutch – Exploded View

DRIVEN CLUTCH REMOVAL

1. Remove the drive belt as instructed. **See Drive Belt Removal on page 23-3.**
2. Remove the bolt (1) and mounting washer (2) from the transaxle input shaft **(Figure 23-13, Page 23-12)**. Discard the bolt.

NOTE: *The bolt (1) must be replaced with a new bolt containing a locking patch that will prevent the bolt from loosening.*

3. Grasp the driven clutch assembly and slide it off the shaft.
4. Leave the key (12) in the keyway **(Figure 23-13, Page 23-12)**.
5. Inspect the key for damage. Replace as necessary.

DRIVEN CLUTCH DISASSEMBLY

⚠ CAUTION

- **The driven clutch is balanced as an assembly. Before disassembly, make match marks on the driven clutch fixed sheave and moveable sheave so they can be reassembled in the same positions.**

1. Make match marks on the driven clutch fixed sheave and on the moveable sheave to maintain balance upon reassembly.
2. Set the edge of the clutch body (1) on a clean, flat surface **(Figure 23-14, Page 23-13)**.

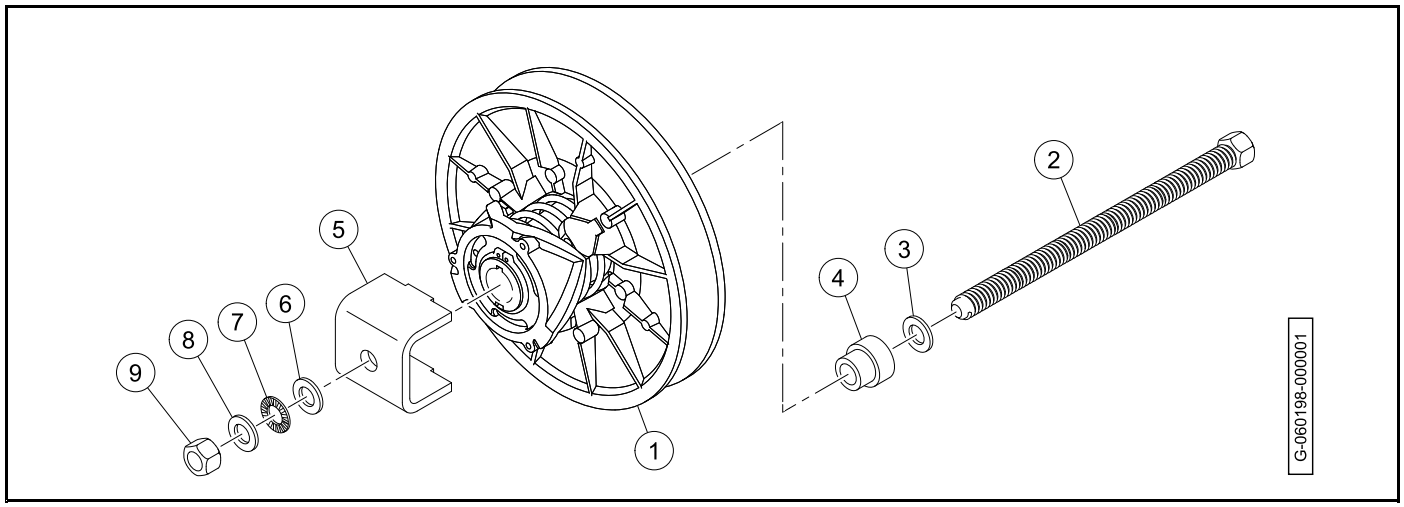


Figure 23-14 Driven Clutch Tool - Disassembly

3. Assemble the threaded bolt (2) through the washer (3) and thrust collar (4).

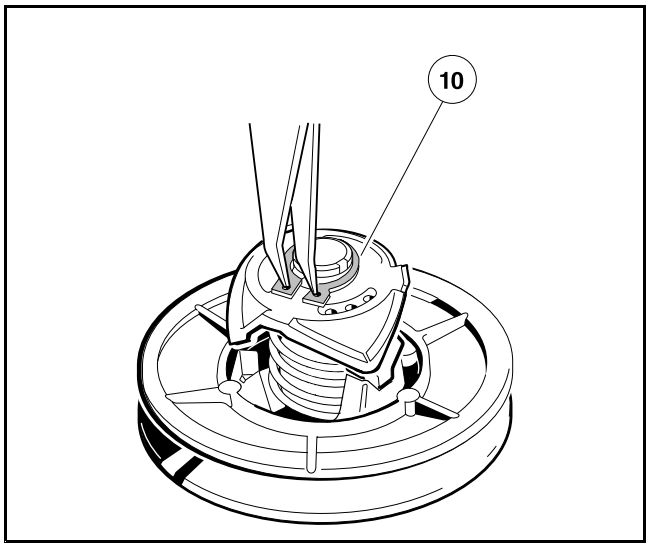
NOTE: *It is very important that the bolt, washers, and thrust bearing assembly be assembled in the order described and shown.*

4. Slide the threaded bolt assembly through the clutch body until the threaded bolt and thrust collar are against the fixed sheave.
5. Install the cam press plate (5), thrust washer (6), thrust bearing (7), thrust washer (8), and nut (9) onto the threaded bolt.
6. Thread the nut down onto the cam hub, centering the press hub onto the cam hub.
7. Use two wrenches and hold the threaded bolt head while tightening the cam press plate to press the cam onto the keyed shaft. Advance the cam press plate until it is firm against the shaft end.

⚠ WARNING

- **Do not place fingers under the cam when removing the cam. The moveable face may spin when the cam buttons release from the cam ramps, resulting in severe personal injury.**

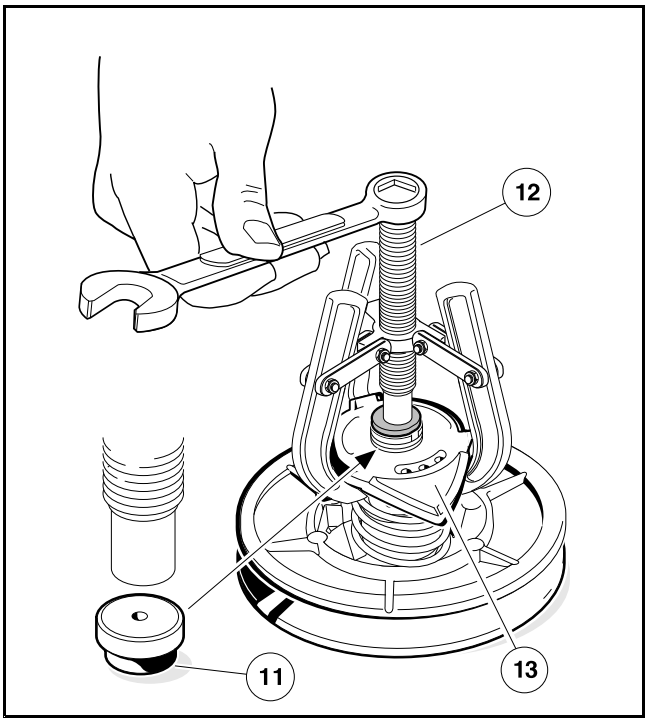
8. Remove the retaining ring (10) **(Figure 23-15, Page 23-14)**.



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Figure 23-15 Remove Retaining Ring

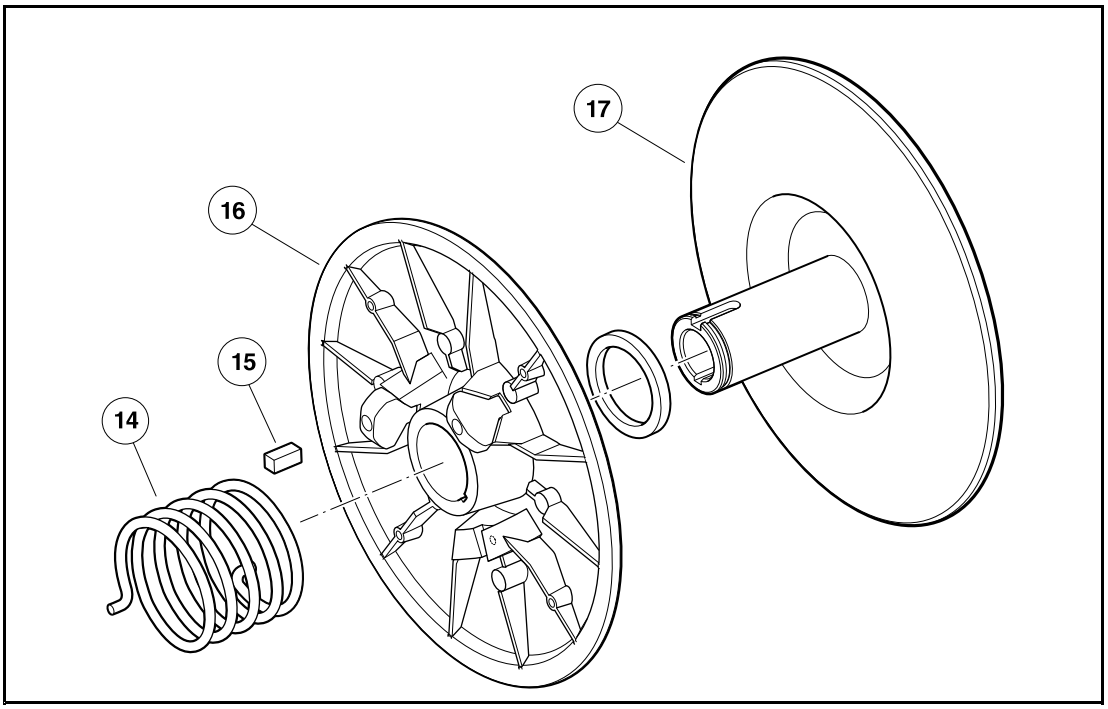
9. Insert a puller plug (11) into the shaft bore **(Figure 23-16, Page 23-15)**.



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Figure 23-16 Cam Removal

10. Use a driven clutch cam puller (12) to remove the cam (13) from the fixed sheave.
11. Remove the spring (14) **(Figure 23-17, Page 23-15)**.



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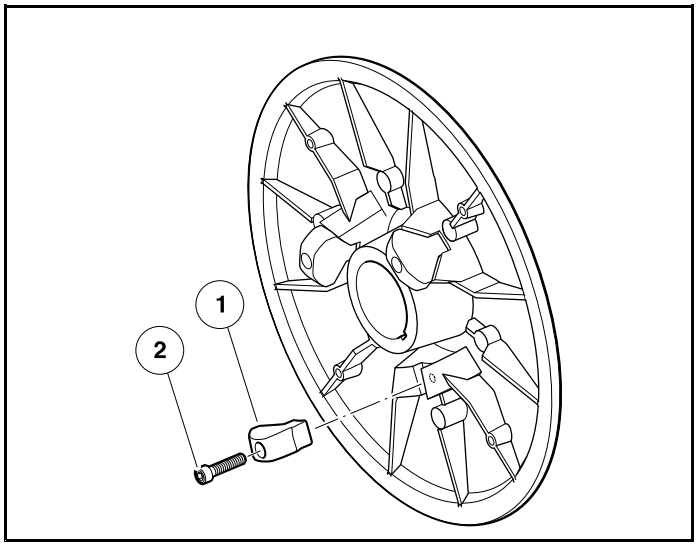
Figure 23-17 Driven Clutch Disassembly

12. Inspect the key (15) for damage. Replace as necessary.

13. Slide the moveable sheave (16) off the fixed sheave (17).

DRIVEN CLUTCH INSPECTION

1. Inspect the cam for excessive wear. Replace it if necessary.
2. Inspect the drive buttons (2) for excessive wear **(Figure 23-18, Page 23-16)**. Replace if necessary. To remove the drive buttons, remove the socket-head cap screws (1) and then the buttons.



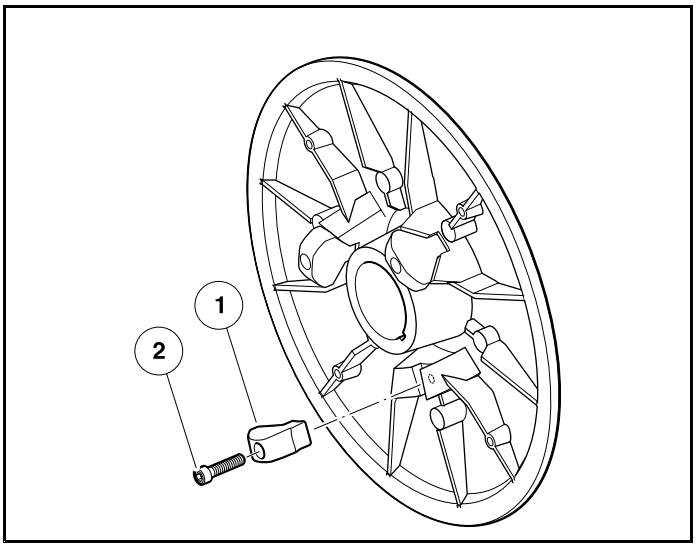
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Figure 23-18 Drive Button Inspection

3. Inspect the smooth surface on the fixed and moveable sheaves. Sheaves must be replaced if surfaces are worn more than 0.060 in. (1.5 mm).
4. Inspect the bronze bearing in the moveable sheave. If the bearing bore diameter is more than 1.384 in. (35.15 mm), the entire moveable sheave must be replaced.
5. Inspect the shaft of the fixed sheave. There should be no noticeable wear. Replace the fixed sheave if it is worn, scratched or damaged.
6. Inspect the retaining ring. If the outside diameter is more than 1.607 in. (40.82 mm), replace the retaining ring.

DRIVEN CLUTCH ASSEMBLY

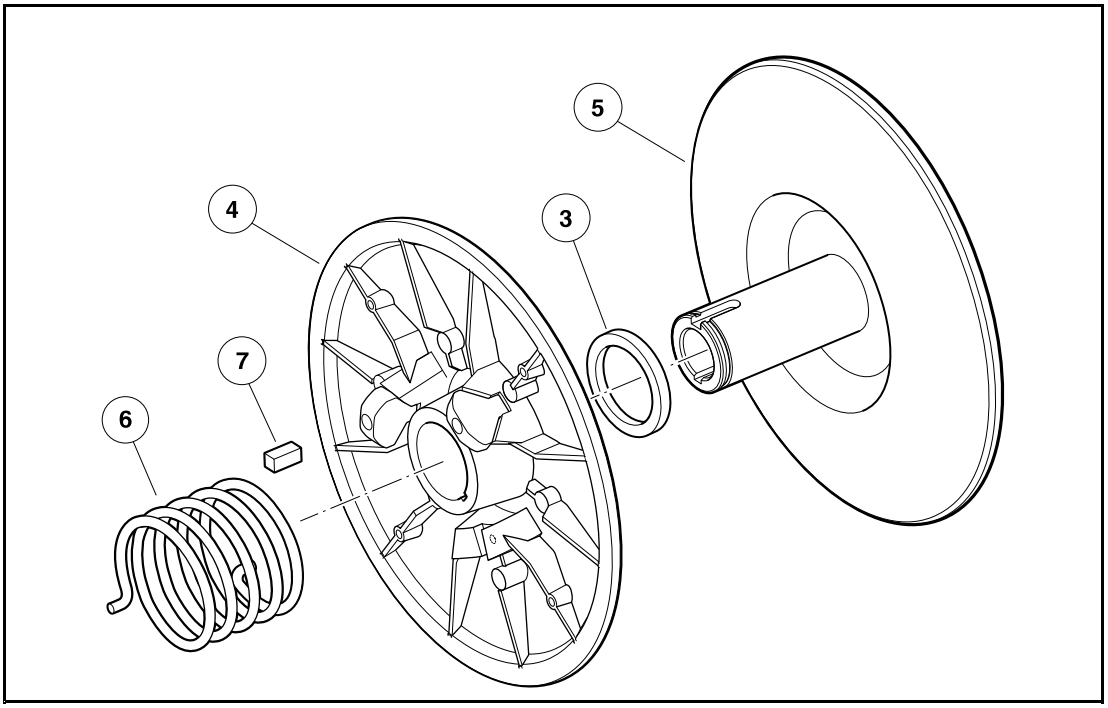
1. Place the three drive buttons (2) in position. Apply one drop of Loctite® 222 to each of the socket-head cap screws (1) and then install and tighten them to 8 in·lb (0.9 N·m) **(Figure 23-19, Page 23-17)**.



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Figure 23-19 Drive Button Installation

2. Slide the acetal washer (3) and moveable sheave (4) onto the fixed sheave (5) **(Figure 23-20, Page 23-17)**.



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Figure 23-20 Driven Clutch Assembly

3. Place the end of the spring (6) into the hole in the moveable sheave (9).
4. Install the key (7) into the keyway of the fixed sheave shaft.
5. Holding the cam (8) in position for assembly on the shaft, install the other end of the spring into the center spring hole of the cam. Rotate the cam until the keyway is aligned with the key on the fixed sheave, and then start the cam onto the shaft approximately 1/4 to 3/8 in. (6.3 to 9.5 mm).
6. With the clutch loosely assembled, set the edge of the clutch body (9) on a clean, flat surface **(Figure 23-21, Page 23-18)**.

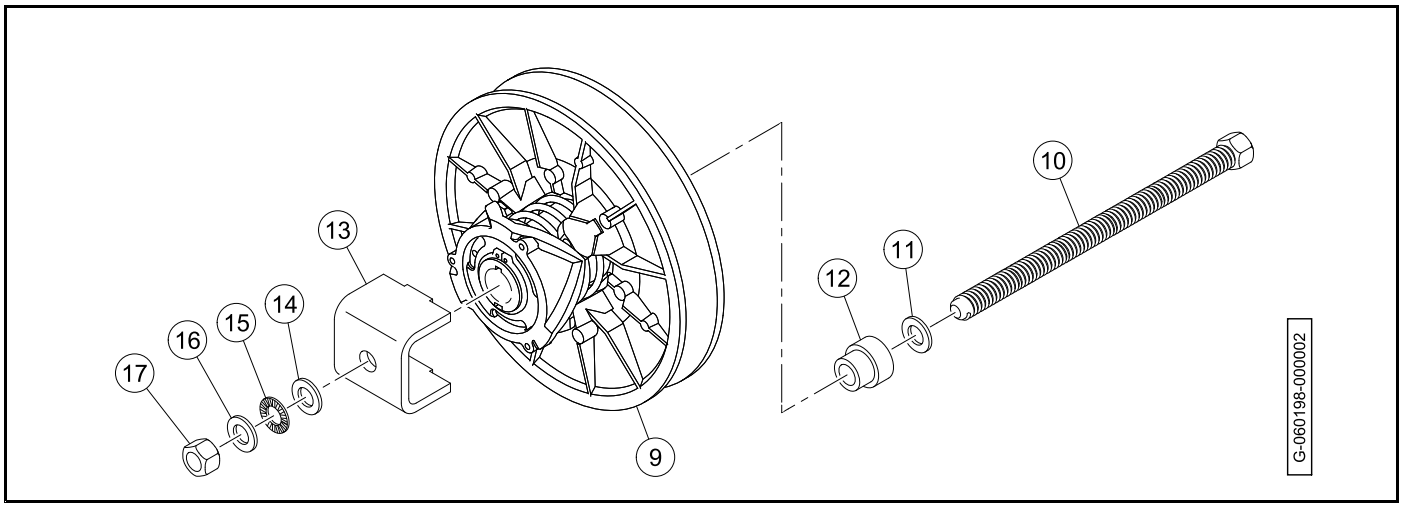


Figure 23-21 Driven Clutch Tool - Assembly

7. Assemble the threaded bolt (10) through the washer (11) and thrust collar (12).

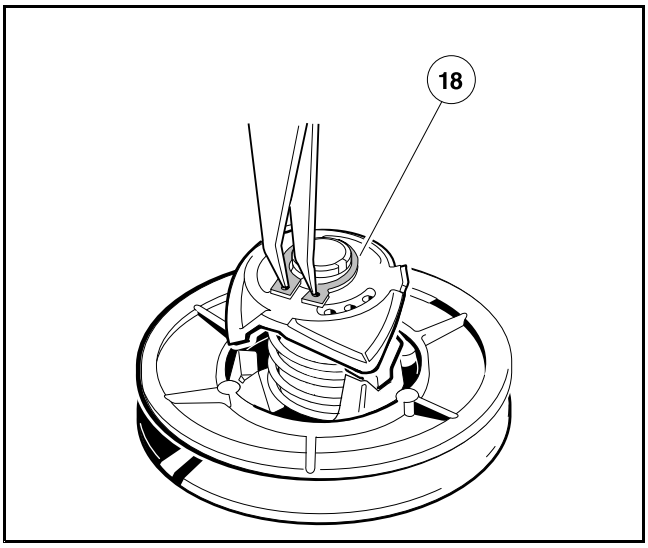
NOTE: *It is very important that the bolt, washers, and thrust bearing assembly be assembled in the order described and shown.*

8. Slide the threaded bolt assembly through the clutch body until the threaded bolt and thrust collar are against the fixed sheave.
9. Hold the clutch assembly and cam installation tool together and place the fixed sheave down on spaced blocks.
10. Install the cam press plate (13), thrust washer (14), thrust bearing (15), thrust washer (16), and nut (17) onto the threaded bolt.
11. Thread the nut down onto the cam hub, centering the press hub onto the cam hub.
12. Hold the fixed sheave of the clutch and rotate the moveable sheave of the clutch one-third turn counterclockwise. The match marks made before disassembly should now align.
13. Use two wrenches and hold the threaded bolt head while tightening the cam press plate to press the cam onto the keyed shaft. Advance the cam press plate until it is firm against the shaft end.

⚠ WARNING

- **Do not place fingers under the cam when removing the cam. The moveable face may spin when the cam buttons release from the cam ramps, resulting in severe personal injury.**

14. Install the retaining ring (18) **(Figure 23-22, Page 23-19)**.



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Figure 23-22 Install Retaining Ring

15. Remove the driven clutch tool.

DRIVEN CLUTCH INSTALLATION

1. To install the driven clutch, reverse the removal procedure.
2. Make sure that the washer (2) is mounted with the flat portion of the washer against the driven clutch **(Figure 23-13, Page 23-12)**.
3. Tighten the new bolt (1) to 18 ft·lb (24.4 N·m). **See following NOTE.**

NOTE: *The bolt (1) must be replaced with a new bolt containing a locking patch that will prevent the bolt from loosening.*

4. Connect the battery and spark plug wire.

Pagination Page

⚠ DANGER

- **See General Warnings on page 1-1.**

⚠ WARNING

- **See General Warnings on page 1-1.**

GENERAL INFORMATION

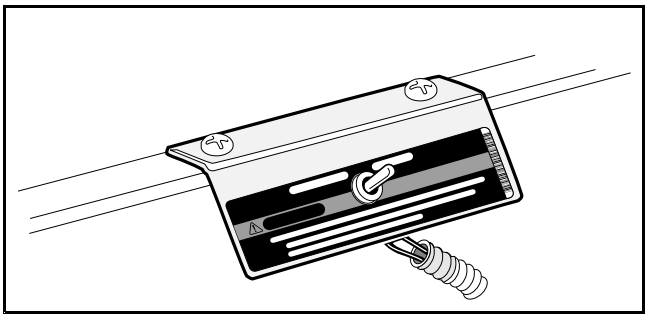
The vehicles addressed in this manual are equipped with heavy-duty transaxles. The transaxle utilizes internal gearing to change vehicle direction. Because the transaxle is used to reverse vehicle direction, the engine, drive clutch, belt, and driven clutch rotate in the same direction; therefore, the engine and clutches are not subjected to reversing loads. This reduces maintenance requirements on the engine and clutches. With the transaxle, power is transferred from the engine through the drive clutch, the drive belt, the driven clutch, and then through the transaxle to the wheels.

FORWARD/NEUTRAL/REVERSE CONTROL (FNR)

A shifter lever, connected to a shifter arm, is used to change the gears to one of three shift positions: F (Forward), N (Neutral), or R (Reverse). Bring the vehicle to a complete stop before changing F or R direction.

MAINTENANCE/OPERATE SWITCH

For the convenience of the trained technician, there is a Maintenance/Operate switch located on the seat support panel under the seat **(Figure 24-1, Page 24-1)**. The Maintenance/Operate switch has two positions, MAINTENANCE and OPERATE, which are clearly marked.



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Figure 24-1 MAINTENANCE/OPERATE Switch

Pedal-Start Vehicles

During normal vehicle operation, the Maintenance/Operate switch in the OPERATE position prevents the engine from running when the Forward/Neutral/Reverse control (FNR) is in the NEUTRAL position. If a vehicle is started in F or REVERSE and then shifted to NEUTRAL, the engine will stop running.

When the switch is in the MAINTENANCE position, it will allow the technician to run the engine in the NEUTRAL position to perform certain maintenance and/or repair functions. With the switch in this position, the vehicle will not operate if the Forward/Neutral/Reverse control (FNR) is placed in either the F or REVERSE position. **See following WARNING and NOTE.**

⚠ WARNING

- **With the switch in the MAINTENANCE position and the engine running, the vehicle may move suddenly if the Forward/Neutral/Reverse control (FNR) is shifted or accidentally bumped. To prevent this, chock the front and rear wheels and firmly set the park brake before servicing or leaving the vehicle.**

NOTE: *Be sure to return the switch to the OPERATE position after servicing the vehicle, or it will not run with the Forward/Reverse handle in either the F or REVERSE position.*

Key-Start Vehicles

During normal vehicle operation, the Maintenance/Operate switch in the OPERATE position allows the engine to start only when the Forward/Reverse handle is in the NEUTRAL position. In addition, it allows the engine to run and increase RPM's with the Forward/Neutral/Reverse control (FNR) in any position.

With the switch in the MAINTENANCE position, it allows the technician to start, run, and increase the engine RPM's only in the NEUTRAL position to perform certain maintenance and/or repair functions. With the switch in this position, the engine will shut off if the Forward/Reverse handle is placed in either the F or REVERSE position. **See preceding WARNING and NOTE.**

GOVERNOR SYSTEM

The governor system regulates vehicle ground speed. It is mounted inside the transaxle and is driven by transaxle gears. If any of the governor linkages are removed in order to service other components, readjustment of the governor linkage is required. **See Governor Cable Installation and Adjustment on page 21-6.**

TRANSAXLE SERVICE

The transaxle is extremely durable and should require very little service under normal operating conditions. The only service required is to maintain proper lubricant level. **See Lubrication on page 24-2.** Under normal operating conditions, adjustment to the system should not be required.

LUBRICATION

There are two oil port plugs located on the right (driven clutch) side of the transaxle **(Figure 24-2, Page 24-3)**. When the vehicle is on a level surface, use the upper plug as a lubricant level indicator. Lubricant level should be even with the bottom of level indicator hole. Use the lower plug for draining. **See following NOTE.**

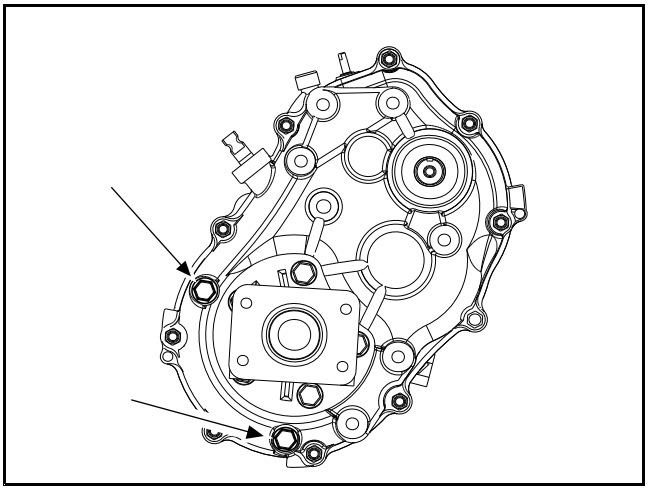
NOTE: *Observe the following for transaxles equipped with a limited-slip differential:*

- *Uses a magnetic drain plug.*
- *Unlike most limited-slip differentials, this unit **does not** use a friction modifier added to the gear oil.*

Oil Change – Transaxle

1. When draining transaxle oil, remove both plugs to allow the oil to drain faster.
2. Clean and reinstall the drain plug and gasket before filling the transaxle with new lubricant. Tighten drain plug to 17 ft·lb (23 N·m).

3. Use a funnel when filling the transaxle through the lubricant level indicator hole. Fill with 67.6 fl-oz (2 L) 80-90 WT. API class GL or 80-90 WT. AGMA class 5 EP gear lubricant (or until lubricant begins to run out of the level indicator hole).
4. Install upper plug and gasket and tighten to 17 ft·lb (23 N·m).



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Figure 24-2 Lubricant Level Plug and Drain Plug

TOOLS REQUIRED FOR THIS SECTION

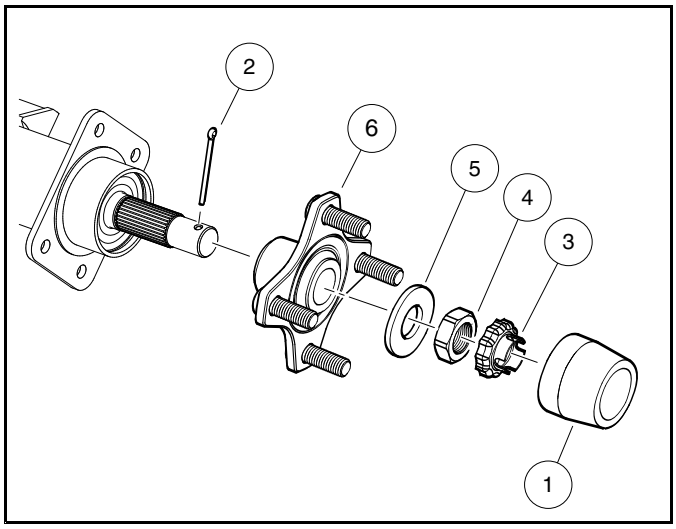
Hydraulic floor jack (or chain hoist)	Torque wrench, 3/8-in. drive	1/2-in. combination wrench
Jack stands (2) (one ton capacity)	3/8-in. socket, 3/8-in. drive	9/16-in. combination wrench
Standard slip joint pliers	7/16-in. socket, 3/8-in. drive	Small flat blade screwdriver
External snap ring pliers (.0.047- in. tip)	1/2-in. socket, 3/8-in. drive	Medium flat blade screwdrivers (2)
90° Internal snap ring pliers (0.090-in. tip)	9/16-in. socket, 3/8-in. drive	No. 2 phillips-head screwdriver
16-in. rolling head prybar	5/8-in. socket, 3/8- in. drive	1/4-in. nut driver
Plastic or rubber mallet	Axle seal tool	5/16-in. nut driver
Ratchet wrench, 3/8-in. drive	7/16-in. combination wrench	

REAR HUBS

REAR HUB REMOVAL

1. Turn the key switch to the OFF position and remove the key, and place the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position.
2. Disconnect battery and spark plug wire. **See Disconnect the Battery- Gasoline Vehicles on page 1-4.**
3. Place chocks at the front wheels and loosen lug nuts on both rear wheels.
4. Remove the rubber dust cap (1).
5. Remove and discard the cotter pin (2) **(Figure 24-3, Page 24-4)**.
6. Remove nut locking cap (3) and loosen the hub nut (4) on the axle shaft.
7. Lift and support the rear of vehicle.
8. Remove the lug nuts and wheel.
9. Slide brake drum off hub.
10. Remove hub nut (4) and large flat washer (5) and pull hub (6) off axle shaft. **See following NOTE.**

NOTE: *If the hub (6) does not slide easily off the axle shaft, use a two or four-jaw wheel puller to remove the hub.*



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Figure 24-3 Rear Hub Exploded View

REAR HUB INSTALLATION

1. Inspect brake shoes for wear and replace if necessary. **See Wheel Brake Assemblies section.**

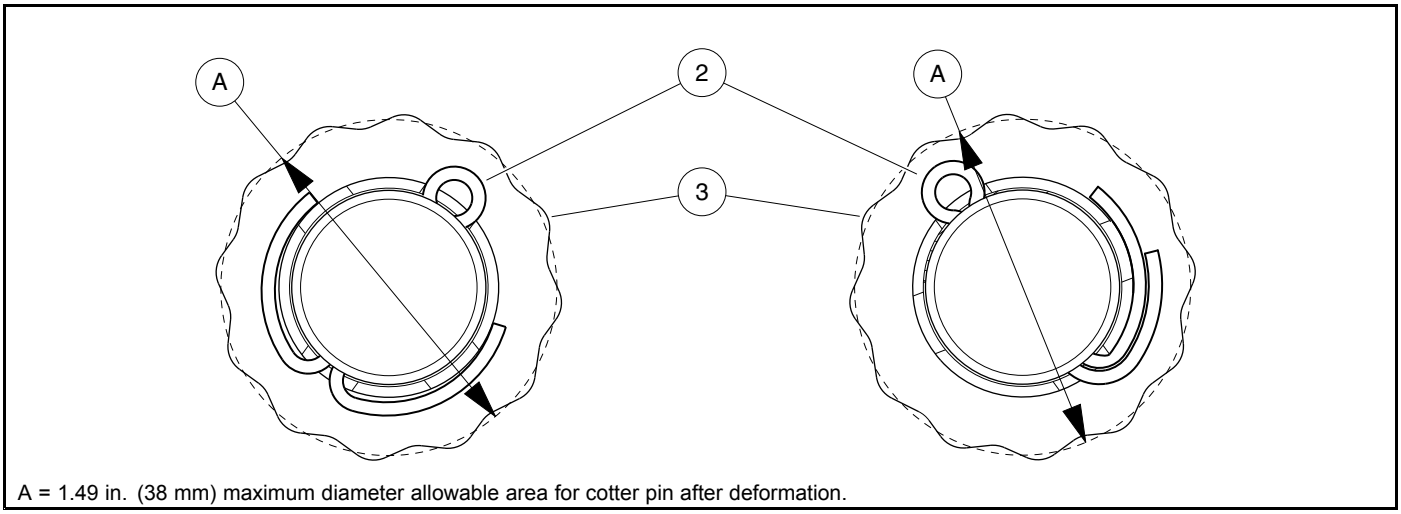
NOTE: *If brake shoes are replaced on one side, replace the opposite side also.*

2. Clean the splines and threaded portion of the axle shaft.
3. Apply anti-seize compound to both the axle shaft splines and hub (6) splines. **See following CAUTION.**

CAUTION

- **Do not allow anti-seize compound to contact the brake drum or shoes.**

4. Slide hub (6) onto axle shaft **(Figure 24-3, Page 24-4)**.
5. Install the large flat washer (5) onto the threaded portion of the axle.
6. Install hub nut (4) and advance the nut to the large flat washer.
7. Install brake drum onto hub.
8. Install the tire and wheel and finger-tighten the lug nuts.
9. Lower the rear of the vehicle.
10. Tighten the hub nut (4) to 147 ft·lb (200 N·m) initially. If possible, position the locking cap (3) on hub nut (4) and install new cotter pin (2). If necessary, tighten hub nut (4) further (177 ft·lb (240 N·m) max.) until the locking cap (3) and new cotter pin (2) can be installed.
11. Deform cotter pin (2) as shown **(Figure 24-4, Page 24-5)**. Either way is acceptable. No part of the cotter pin (2) should protrude beyond the perimeter of the locking cap (3).
12. Install rubber dust cap (1).
13. Tighten lug nuts to 65 ft·lb (88 N·m) using a crisscross pattern.
14. Connect battery and spark plug wire.



A = 1.49 in. (38 mm) maximum diameter allowable area for cotter pin after deformation.

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Figure 24-4 Cotter Pin Deformation

AXLE TUBES, AXLE SHAFTS, DIFFERENTIAL GUARD, AND WHEEL BEARINGS

Removal of the transaxle is not required for servicing or replacing axle shafts, axle bearings, or axle shaft oil seals. If the transaxle is to be removed from the vehicle, do not remove the wheels, axle shafts, or axle tubes first. Instructions for removing the transaxle from the vehicle begin on page 24-10.

NOTE: *The axle shaft oil seals (7) are located in the transaxle gearcase (4), not the axle tubes (2)* ***(Figure 24-7, Page 24-8)****. The axle tubes must be removed in order to replace these oil seals.*

DIFFERENTIAL GUARD REMOVAL

Differential guard is installed on some vehicles to protect the transaxle, remove it before working on the axle tube.

1. Clean debris from the differential guard and mounting bolts.
2. Remove the four bolts (1) securing the differential guard (2) to the transaxle (3) **(Figure 24-5, Page 24-6)**.
3. Remove the differential guard from the transaxle.

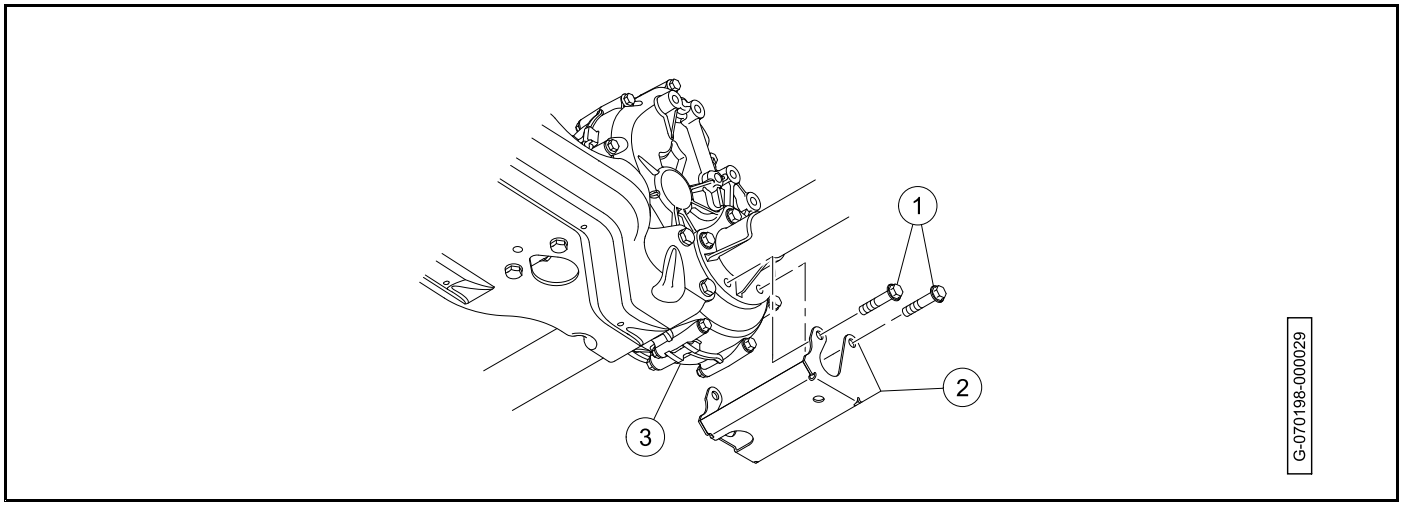


Figure 24-5 Differential Guard Removal

DIFFERENTIAL GUARD INSTALLATION

1. Clean the threads of the four axle tube mounting holes for the differential guard.
2. Secure the differential guard (2) to the transaxle (3) with the 4 bolts (1). Tighten the four bolts from 25 ft·lb to 31 ft·lb (34.3 N·m to 42.2 N·m) **(Figure 24-6, Page 24-7)**.

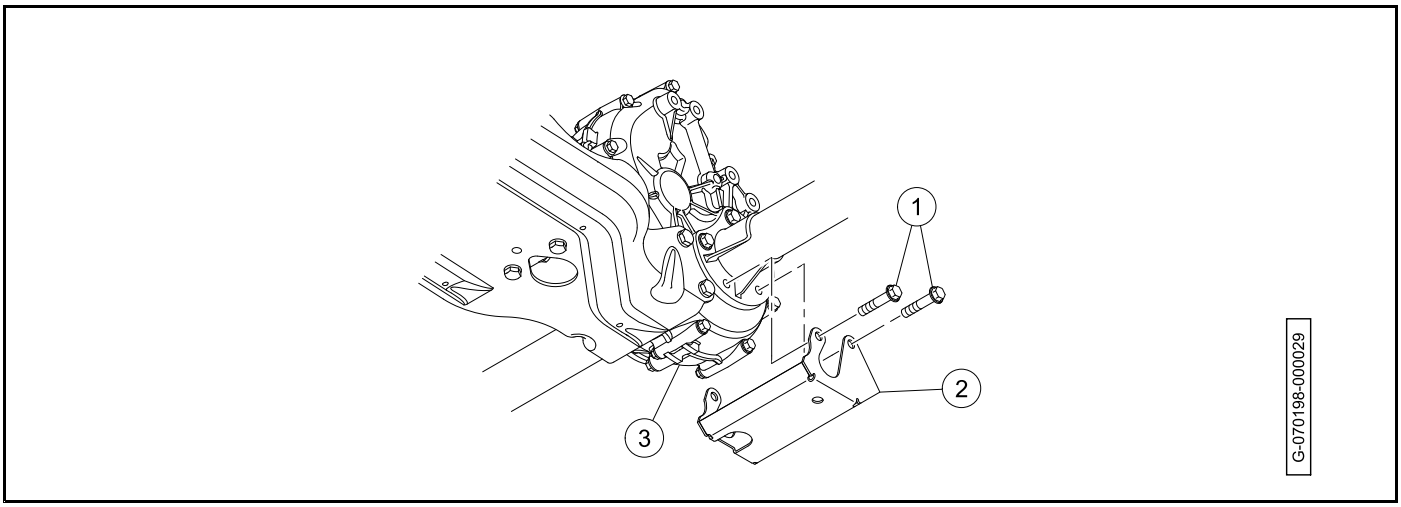


Figure 24-6 Differential Guard Installation

AXLE TUBE AND AXLE SHAFT REMOVAL

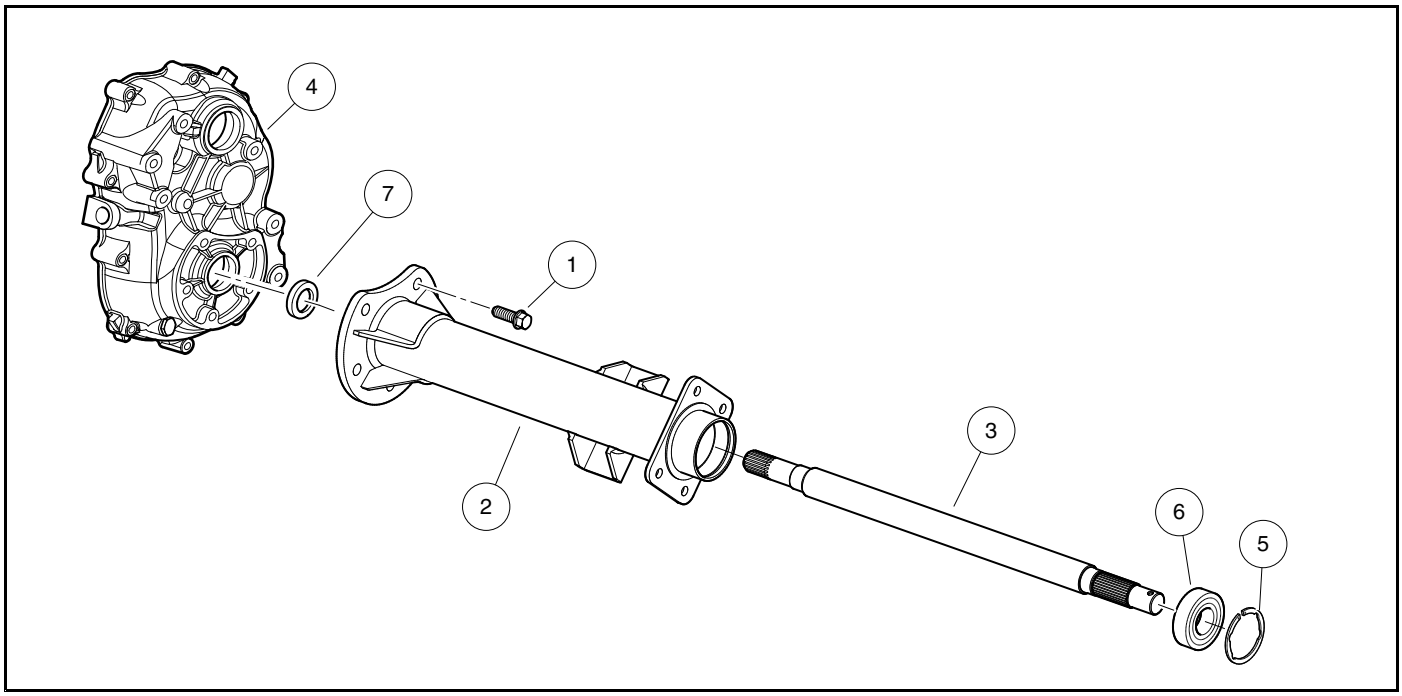
See General Warnings, Section 1, Page 1-1.

The transaxle has two axle shafts. If only a tube or shaft is to be serviced, it can be done one side at a time without removing the transaxle.

1. Clean debris from drain plug and area around it at the bottom of the transaxle. Drain oil. Install plug after draining.
2. If removing entire transaxle from vehicle, remove the transaxle and clean it in preparation for disassembly. **See Transaxle Removal on page 24-10. See following NOTE.**

NOTE: *After cleaning, move transaxle to a clean location before disassembly.*

3. If removing only one axle tube or shaft from vehicle, clean that tube and hub in preparation for disassembly.
4. Remove hub. **See Rear Hub Removal on page 24-4.**
5. Remove the five flange-head bolts (1) securing axle tube (2) to transaxle **(Figure 24-7, Page 24-8)**.
6. Avoiding damage caused by dragging splines across lip of oil seal (7) in transaxle gearcase, carefully pull axle tube (2) and shaft (3) from transaxle.



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Figure 24-7 Axle Tube, Shaft, Bearing and Oil Seal

AXLE TUBE AND AXLE SHAFT INSTALLATION

1. Clean mating surfaces of axle tube (2) flange and transaxle gearcase (4). Also clean the threads of the five axle tube mounting holes in the gearcase. **See following CAUTION.**

CAUTION

- **If necessary. clean each mounting hole with a thread tap (M10 x 1.25 pitch) before installing flange bolts.**

2. Clean and lubricate the oil seal (7) in the transaxle gearcase (4) with oil **(Figure 24-7, Page 24-8)**.
3. Clean inner end of axle shaft (3). Avoiding damage caused by dragging splines across lip of oil seal (7) in transaxle gearcase (4), carefully install axle shaft (3) and tube (2). **See following NOTE.**

NOTE: *It may be necessary to rotate each shaft (3) slightly to engage the splines in the differential.*

4. Secure axle tube (2) to gearcase (4) with flange bolts (1). Use a crisscross pattern to tighten flange bolts to 28 ft·lb (38 N·m).
5. Install hub. **See Rear Hub Installation on page 24-4.**
6. If entire transaxle was removed from vehicle, install transaxle. **See Transaxle Installation on page 24-14.**
7. Refill transaxle with appropriate type and volume of oil. **See Oil Change – Transaxle on page 24-2.**

REAR WHEEL BEARING REMOVAL

1. Remove hub. **See Rear Hub Removal on page 24-4.**
2. Remove axle tube (2) from transaxle. **See Axle Tube and Axle Shaft Removal on page 24-7.**
3. Remove the snap ring (5) that is in front of the bearing (6) and discard **(Figure 24-7, Page 24-8)**.

4. Drive axle shaft (3) and bearing (6) from outer end of axle tube (2) as an assembly.
5. Use a puller to remove bearing (6) from axle shaft (3). **See following CAUTION.**

CAUTION

- **To prevent damaging the threads on end of axle shaft (3), install hub nut to cover initial threads prior to using puller.**

REAR WHEEL BEARING INSTALLATION

1. Press new bearing (6) onto axle shaft (3) until fully seated.
2. Clean inside axle tube (2) where new bearing (6) will sit and lightly lubricate the bore **(Figure 24-7, Page 24-8)**.
3. Using an appropriate sized bearing driver that fits the outer race, drive in bearing/shaft assembly (3 and 6) until fully seated in tube (2).
4. Install new snap ring (5).
5. Install axle tube (2). **See Axle Tube and Axle Shaft Installation on page 24-8.**
6. Install hub. **See Rear Hub Installation on page 24-4.**

AXLE SHAFT OIL SEAL REMOVAL

The rear axle tubes (2) must be unbolted from the transaxle to replace oil seals (7) **(Figure 24-7, Page 24-8)**.

1. Clean debris from drain plug and area around it at the bottom of the transaxle. Drain oil. Install plug after draining.
2. Remove axle tube (2) from gearcase (4) **(Figure 24-7, Page 24-8)**. **See Axle Tube and Axle Shaft Removal on page 24-7.**
3. Pull oil seal (7) from gearcase (4).

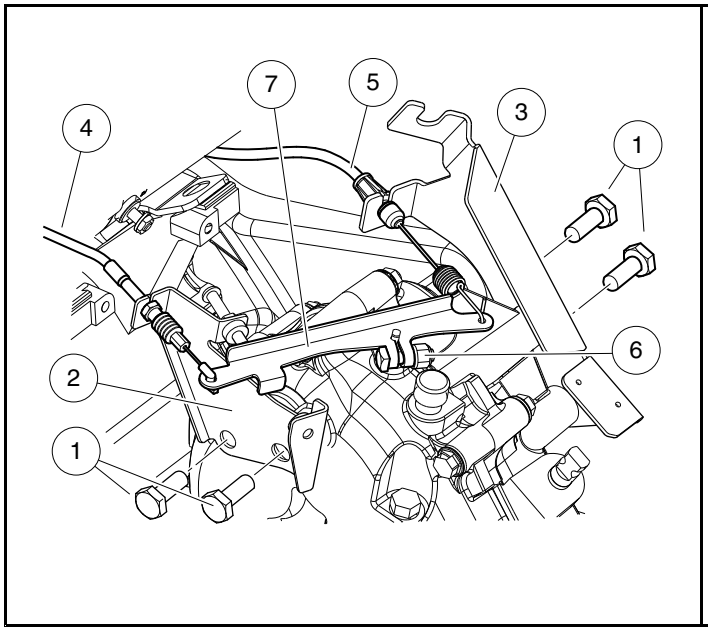
AXLE SHAFT OIL SEAL INSTALLATION

1. Clean bore in gearcase (4) where new oil seal (7) will sit **(Figure 24-7, Page 24-8)**.
2. Using an appropriate sized seal driver, drive in new oil seal (7) until 0.0393 in. (1 mm) below surface, not fully seated.
3. Clean end of axle shaft (3) and carefully install axle tube (2) to avoid damaging new oil seal (7) with splines of axle shaft. **See Axle Tube and Axle Shaft Installation on page 24-8.**
4. Refill transaxle with appropriate type and volume of oil. **See Oil Change – Transaxle on page 24-2.**

TRANSAXLE REMOVAL

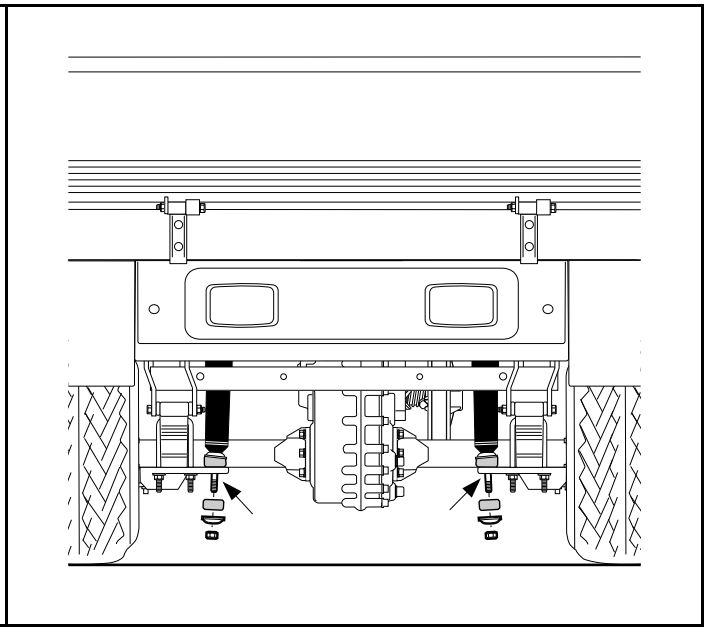
See General Warnings on page 1-1.

1. Turn the key switch to the OFF position and remove the key, and place the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position.
2. Disconnect battery and spark plug wire. **See Disconnect the Battery- Gasoline Vehicles on page 1-4.**
3. Place chocks at the front wheels and loosen lug nuts on both rear wheels.
4. Disconnect air intake hose, vent hose, and fuel line from throttle body and accelerator cable from electrical component box. **See Gasoline Vehicle - Fuel System, Section 21, Page 21-1.**
5. Disconnect gray 18-pin connector from ECU.
6. Disconnect braided ground cable from engine **(Figure 18-3, Page 18-13)**.
7. **Pedal-Start Vehicles Only:** Disconnect 3-wire plug from limit switch on transaxle.
8. Disconnect three wires of main wire harness from starter/generator .
9. Loosen jam nuts (1) securing shifter cable (2) to FNR/accelerator cable mounting bracket. Then, remove bowtie clip (3) to disconnect shifter cable end (4) from transaxle shift lever (5) and set shifter cable (2) aside **(Figure 24-16, Page 24-15)**.
10. Remove bolts (1) securing governor cable bracket (2) and FNR/accelerator cable bracket (3) to transaxle **(Figure 24-8, Page 24-10)**. Do not disconnect cables (4 and 5).
11. Unhook governor cable (4) and accelerator cable (5) from the governor arm (7).



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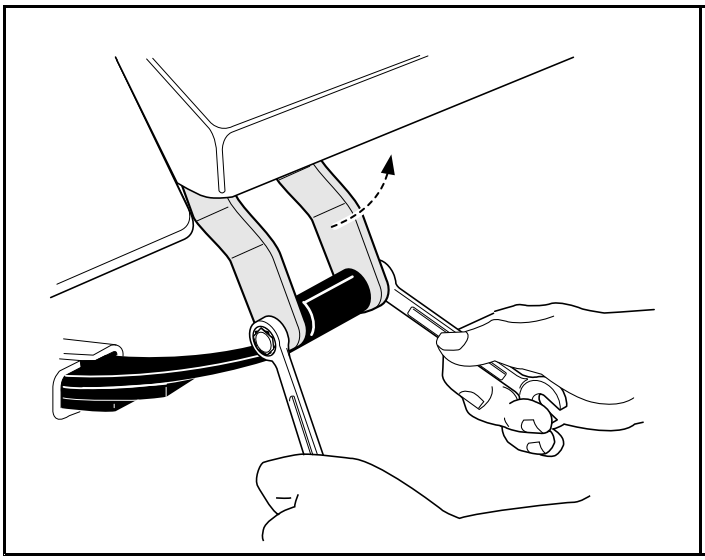
Figure 24-8 Governor Arm, Cable and Brackets



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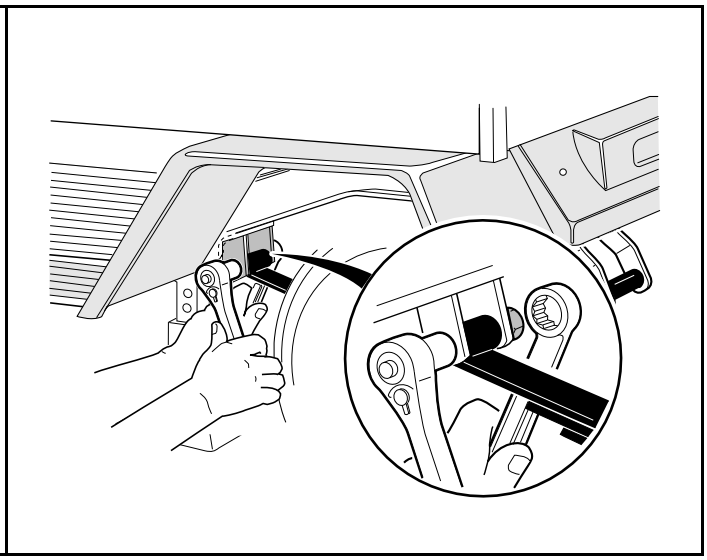
Figure 24-9 Disconnect Shock Absorbers

12. Disconnect brake cables from brake assemblies. **See Wheel Brake Assemblies section.**
13. Remove lower shock mounting hardware from both rear shocks **(Figure 24-9, Page 24-10)**.



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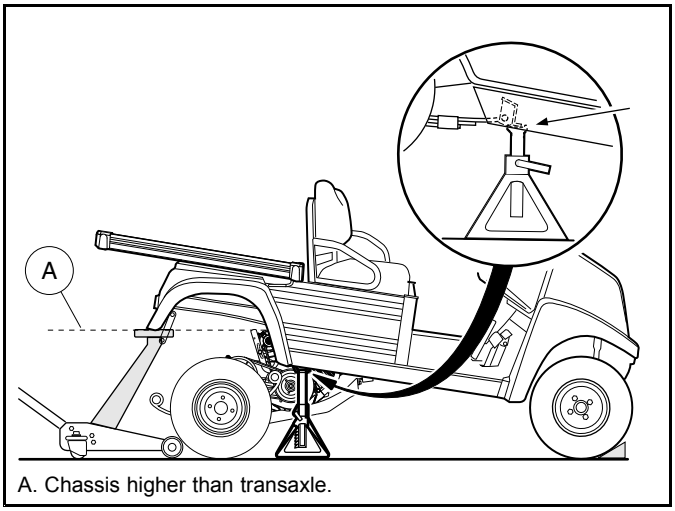
Figure 24-10 Disconnect Rear Shackles



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Figure 24-11 Disconnect Front of Leaf Spring

14. Position floor jack under rear crossmember of chassis or trailer hitch mount (if equipped) **(Figure 24-12, Page 24-11)**. **See WARNING "Lift only one end of the vehicle..." in General Warnings on page 1-1.**
15. Raise vehicle just enough to relieve weight on leaf springs, then remove bolts securing leaf springs to shackles **(Figure 24-10, Page 24-11)**.
16. Remove bolts securing front of leaf springs **(Figure 24-11, Page 24-11)**.



A. Chassis higher than transaxle.

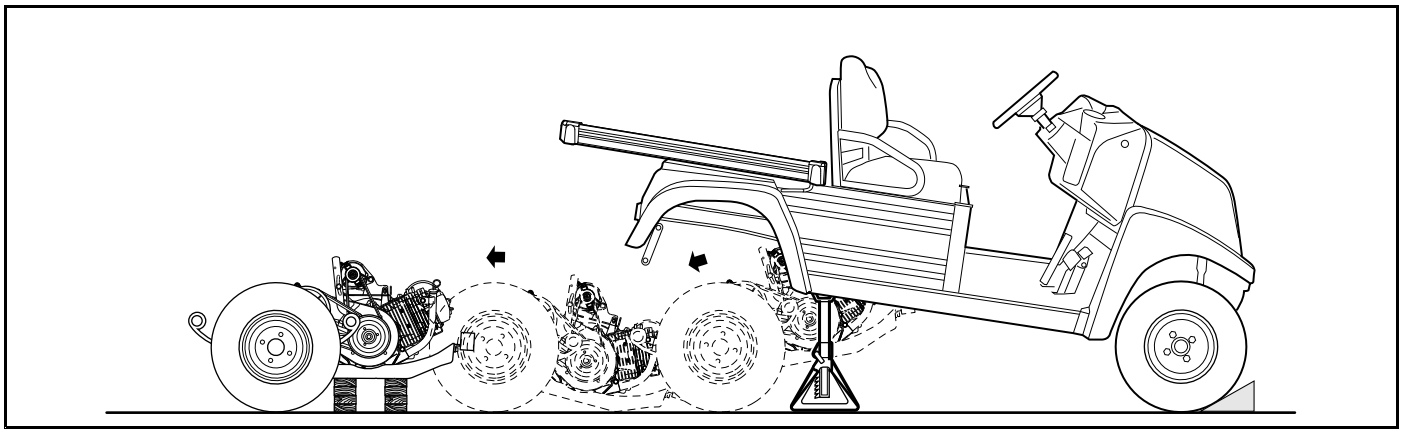
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Figure 24-12 Raise Vehicle and Support On Jack Stands

17. Continue raising vehicle until chassis is higher than the top of the transaxle (i.e. enough to allow powertrain to be rolled out from under vehicle) **(Figure 24-12, Page 24-11)**. Position jack stands, adjusted to support the vehicle at this height, under the frame crossmember between the leaf spring mounts and side stringers, just forward of each rear wheel. Lower the floor jack to allow the jack stands to support the vehicle.
18. Remove floor jack from beneath vehicle.
19. Grasp ends of leaf springs at rear of vehicle and carefully pull the powertrain until snubber at front of engine pan is free of the chassis. Gently lower front of powertrain to the floor **(Figure 24-13, Page 24-12)**. The powertrain should be completely disconnected from vehicle and resting on floor.

20. Roll powertrain out from under vehicle.
21. Place blocks under the engine pan so they will completely support the engine and keep it **level to the floor (Figure 24-13, Page 24-12)**. **See following NOTE.**

NOTE: *Place the blocks so they will support the engine when the transaxle is detached and moved away from the powertrain.*



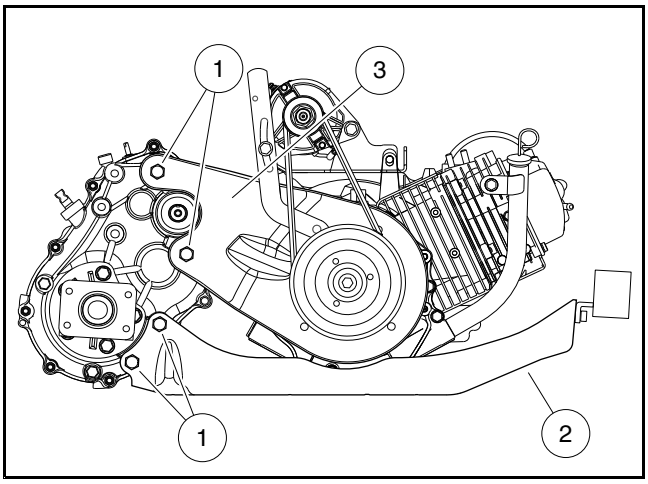
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Figure 24-13 Remove Powertrain and Place Wood Blocks Under Engine Pan

22. Remove oil drain plug and drain all oil from transaxle. Dispose of gear oil properly.
23. Remove driven clutch. **See Driven Clutch Removal, Section 23, Page 23-13.**
24. Remove eight bolts (1) total that secure transaxle to powertrain **(Figure 24-14, Page 24-13)** at the following locations:
    – Four bolts (1) at engine pan (2).
    – Two bolts (1) at clutch plate (3).
    – Two bolts (1) at muffler bracket.
25. Roll transaxle from engine pan (2). **See following NOTE.**

NOTE: *The transaxle weighs approximately 58 lb (26.2 kg).*

26. If replacing transaxle, remove leaf springs, wheels, hubs and brake assemblies and retain for installation on new transaxle. **See Rear Suspension section. See Wheel Brake Assemblies section.**



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Figure 24-14 Transaxle Mounting Bolts

TRANSAXLE INSTALLATION

See General Warnings on page 1-1.

1. Installation is reverse of removal procedure. When attaching transaxle to powertrain, initially install the eight bolts (1) finger-tight **(Figure 24-14, Page 24-13)**. Then, tighten fasteners in the following order:

1.1. Tighten the two bolts (1) at clutch plate (3) to 50 ft·lb (68 N·m).

1.2. Tighten the four bolts (1) at engine pan (2) to 50 ft·lb (68 N·m).

1.3. Tighten the two bolts (1) at muffler bracket to 50 ft·lb (68 N·m).

1.4. Tighten the governor cable bracket (2) and FNR/accelerator cable bracket (2) bolts to 50 ft·lb (68 N·m) **(Figure 24-8, Page 24-10)**.

1.5. Tighten leaf spring hardware to 19 ft·lb (26 N·m) at chassis and shackle. **See Rear Suspension section.**

1.6. Tighten lower nuts of shock absorbers until cushions expand to be the same diameter as the mounting washers.

1.7. Tighten transaxle drain plug to 17 ft·lb (23.5 N·m).

2. Fill transaxle with appropriate type and volume of oil. **See Oil Change – Transaxle on page 24-2.**
3. Ensure that all wires and cables are secured properly with wire ties. **See following WARNING.**

⚠ WARNING

- **If wires and cables are removed or replaced make sure they are properly routed and secured to vehicle frame. Failure to properly route and secure wires and cables could result in vehicle malfunction, property damage or personal injury.**

4. Connect battery and spark plug wire. **See Connect the Battery- Gasoline Vehicles on page 1-4.**
5. Check governor adjustment and correct if necessary. **See Governor Cable Installation and Adjustment, Section 21, Page 21-6.**
6. Check engine RPM setting. Adjust if necessary. **See Engine RPM Adjustment, Section 21, Page 21-10.**

SHIFTER CABLE

See General Warnings on page 1-1.

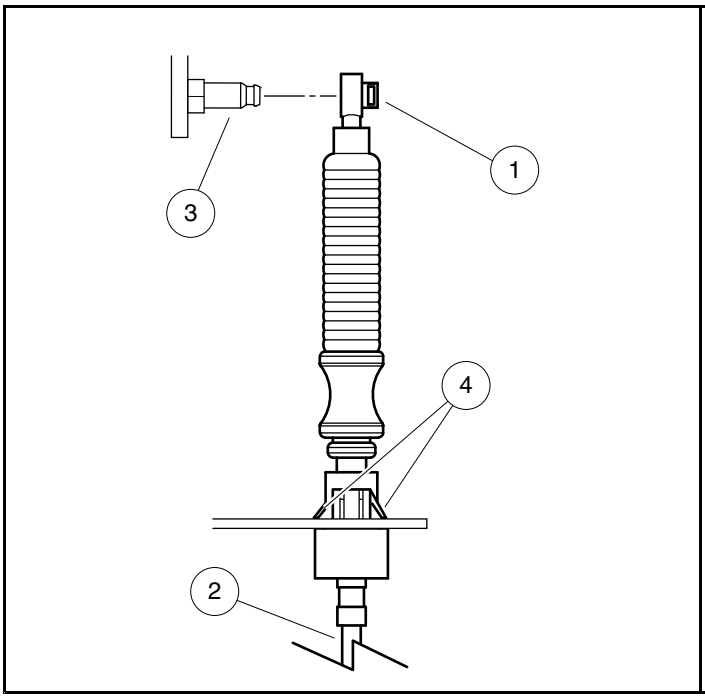
If the Forward/Neutral/Reverse control (FNR) cable is damaged in any way, it must be replaced.

SHIFTER CABLE REMOVAL

NOTE: *Before removing cable, note cable routing and positions of wire ties or other devices securing the cable to the vehicle. When installed, cable must be routed and secured as it was originally.*

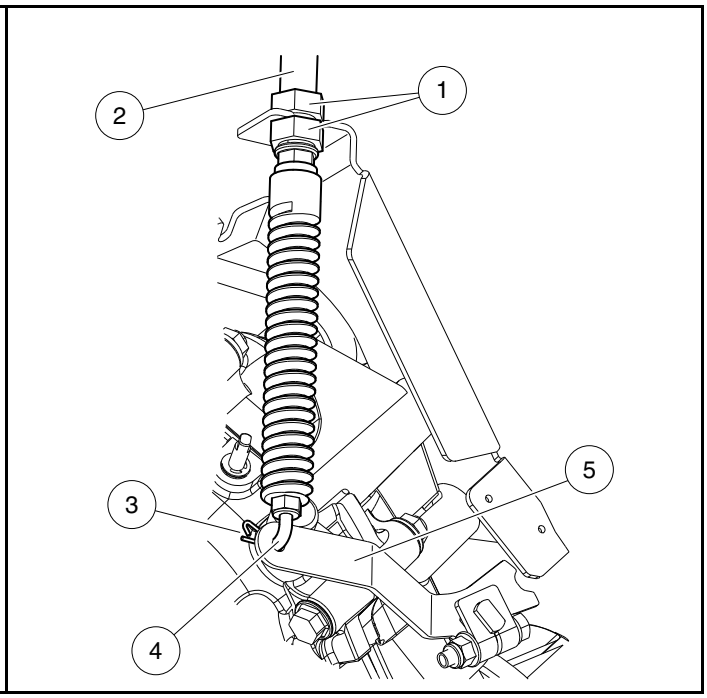
1. Turn the key switch to the OFF position and remove the key. Place the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position and chock the wheels.
2. Disconnect battery and spark plug wire. **See Disconnect the Battery- Gasoline Vehicles on page 1-4.**
3. Push the cable end socket (1) off the stud (3) on the Forward/Neutral/Reverse control (FNR) handle **(Figure 24-15, Page 24-15)**.
4. Press in tangs (4) anchoring shifter cable (2) to chassis and push out of mounting hole.

5. Loosen jam nuts (1) securing shifter cable (2) to FNR/accelerator cable bracket (3) **(Figure 24-16, Page 24-15)**. Then, remove bowtie clip (3) to disconnect shifter cable end (4) from transaxle shift lever (5).
6. Cut wire ties securing shifter cable to chassis.
7. Make note of cable routing, then remove shifter cable from vehicle.



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Figure 24-15 Shifter Cable at FNR Handle



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Figure 24-16 Shifter Cable at Transaxle

SHIFTER CABLE INSTALLATION

1. Install shifter cable (2), routing it exactly as it was originally, from instrument panel to transaxle.
2. Place rear of cable (2) in FNR/accelerator cable bracket with a jam nut (1) on each side of bracket **(Figure 24-16, Page 24-15)**. Tighten jam nuts (1) to 22 ft·lb (29.8 N·m).
3. Hook shifter cable end (4) into transaxle shift lever (5) and secure with bowtie clip (3).
4. Feed front of cable (2) through its mounting hole and push the plastic anchor into hole until tangs (4) snap into place **(Figure 24-15, Page 24-15)**.
5. Snap cable end socket (1) onto stud (3) of Forward/Reverse shifter handle.
6. Secure shifter cable along chassis with wire ties.
7. Connect battery and spark plug wire. **See Connect the Battery- Gasoline Vehicles on page 1-4.**

SHIFTER CABLE ADJUSTMENT

Cable is properly adjusted when both the Forward/Neutral/Reverse control (FNR) at instrument panel and shift lever on transaxle are in the NEUTRAL position at the same time.

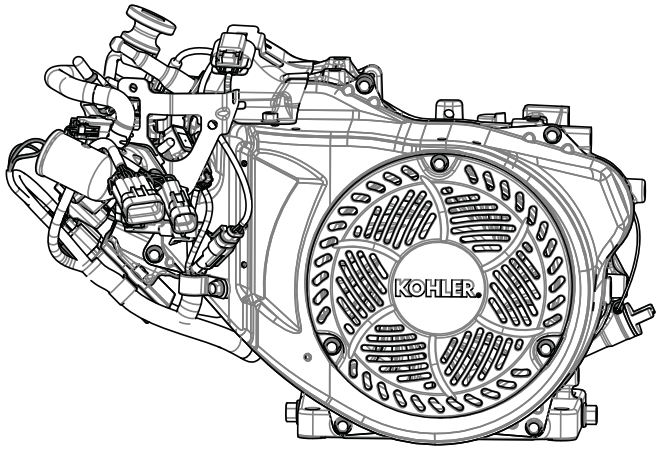
To adjust, the jam nuts (6) at the FNR/accelerator cable bracket must be loosened and moved forward or backward as required **(Figure 24-16, Page 24-15)**. Tighten jam nuts (6) to 22 ft·lb (29.8 N·m).

Pagination Page

KOHLER® Command PRO

ECH440 for CLUB CAR

Service Manual



IMPORTANT: Read all safety precautions and instructions carefully before operating equipment. Refer to operating instruction of equipment that this engine powers.

Ensure engine is stopped and level before performing any maintenance or service.

2 Safety
3 Maintenance
5 Specifications
16 Tools and Aids
19 Troubleshooting
23 Air Cleaner/Intake (OEM Supplied)
24 Electronic Fuel Injection (EFI) System
51 Governor System (OEM Supplied)
52 Lubrication System
54 Electrical System
57 Starter System (OEM Supplied)
58 Disassembly/Inspection and Service
70 Reassembly

SAFETY PRECAUTIONS

⚠ **WARNING:** A hazard that could result in death, serious injury, or substantial property damage.

⚠ **CAUTION:** A hazard that could result in minor personal injury or property damage.

NOTE: is used to notify people of important installation, operation, or maintenance information.



⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Do not fill fuel tank while engine is hot or running.

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.



⚠ WARNING

Rotating Parts can cause severe injury.

Stay away while engine is in operation.

Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate engine with covers, shrouds, or guards removed.



⚠ WARNING

Carbon Monoxide can cause severe nausea, fainting or death.

Avoid inhaling exhaust fumes.

Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled.



⚠ WARNING

Accidental Starts can cause severe injury or death.

Disconnect and ground spark plug lead(s) before servicing.

Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug lead(s). 2) Disconnect negative (–) battery cable from battery.



⚠ WARNING

Hot Parts can cause severe burns.

Do not touch engine while operating or just after stopping.

Never operate engine with heat shields or guards removed.



⚠ WARNING

Cleaning Solvents can cause severe injury or death.

Use only in well ventilated areas away from ignition sources.

Carburetor cleaners and solvents are extremely flammable. Follow cleaner manufacturer's warnings and instructions on its proper and safe use. Never use gasoline as a cleaning agent.



⚠ WARNING

High Pressure Fluids can puncture skin and cause severe injury or death.

Do not work on fuel system without proper training or safety equipment.

Fluid puncture injuries are highly toxic and hazardous. If an injury occurs, seek immediate medical attention.



⚠ CAUTION

Electrical Shock can cause injury.

Do not touch wires while engine is running.



⚠ CAUTION

Damaging Crankshaft and Flywheel can cause personal injury.

Using improper procedures can lead to broken fragments. Broken fragments could be thrown from engine. Always observe and use precautions and procedures when installing flywheel.



⚠ CAUTION

Failure to utilize or reassemble debris screen as designed could result in debris screen failure and serious personal injury.

MAINTENANCE INSTRUCTIONS

	**⚠ WARNING** Accidental Starts can cause severe injury or death. Disconnect and ground spark plug lead(s) before servicing.	Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug lead(s). 2) Disconnect negative (–) battery cable from battery.

Normal maintenance, replacement or repair of emission control devices and systems may be performed by any repair establishment or individual; however, warranty repairs must be performed by a Kohler authorized dealer.

MAINTENANCE SCHEDULE

After first 100 Hours[3]

● Change oil.	Lubrication System

Every 100 Hours[1]

● Check air cleaner element; replace as necessary (OEM supplied air cleaner).	Refer to equipment manual

Every 100 Hours or Annually[1]

● Clean cooling areas.	Air Cleaner/Intake

Every 200 Hours[3]

● Change oil.	Lubrication System

Every 300 Hours

● Check fuel filters (tank outlet filter and in-line filter) clean or replace if needed (OEM supplied if equipped).	Refer to equipment manual

Every 300 Hours[1]

● Replace unique Electronic Fuel Injection (EFI) fuel filter (OEM supplied if equipped).	Refer to equipment manual

Every 300 Hours[2]

● Check and adjust valve clearance when engine is cold.	Reassembly

Every 500 Hours or Annually[1]

● Replace spark plug and set gap.	Electrical System

[1] Perform these procedures more frequently under severe, dusty, dirty conditions.
[2] Have a Kohler authorized dealer perform this service.
[3] If engine is frequently used for short periods of time in ambient temperatures below 4°C (40°F), reduce oil change intervals to every 25 hours. Refer to Winter Lubrication details in Lubrication System.

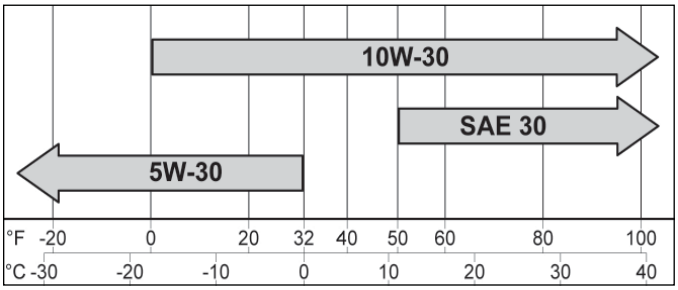
REPAIRS/SERVICE PARTS

Kohler genuine service parts can be purchased from Kohler authorized dealers. To find a local Kohler authorized dealer visit KohlerEngines.com or call 1-800-544-2444 (U.S. and Canada).

Maintenance

OIL RECOMMENDATIONS

We recommend use of Kohler oils for best performance. Other high-quality detergent oils (including synthetic) of API (American Petroleum Institute) service class SJ or higher are acceptable. Select viscosity based on air temperature at time of operation as shown in table below.



FUEL RECOMMENDATIONS



⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Do not fill fuel tank while engine is hot or running.

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

NOTE: E15, E20 and E85 are NOT approved and should NOT be used; effects of old, stale or contaminated fuel are not warrantable.

Fuel must meet these requirements:

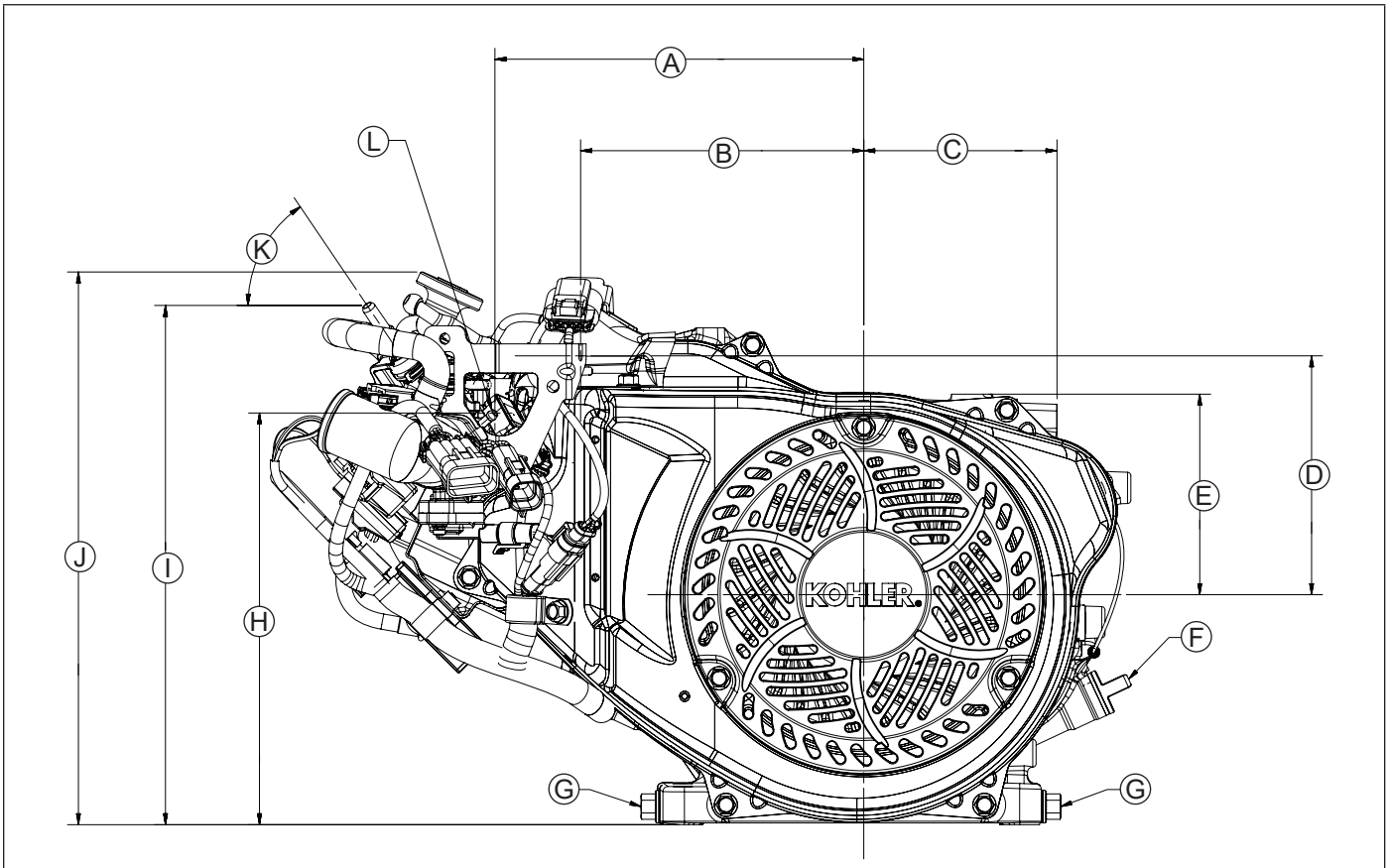
- Clean, fresh, unleaded gasoline.
- Octane rating of 87 (R+M)/2 or higher.
- Research Octane Number (RON) 90 octane minimum.
- Gasoline up to 10% ethyl alcohol, 90% unleaded is acceptable.
- Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blend (max 15% MTBE by volume) are approved.
- Do not add oil to gasoline.
- Do not overfill fuel tank.
- Do not use gasoline older than 30 days.

STORAGE

If engine will be out of service for 2 months or more follow procedure below.

1. Add Kohler PRO Series fuel treatment or equivalent to fuel tank. Run engine 2-3 minutes to get stabilized fuel into fuel system (failures due to untreated fuel are not warrantable).
2. Change oil while engine is still warm from operation. Remove spark plug(s) and pour about 1 oz. of engine oil into cylinder(s). Replace spark plug(s) and crank engine slowly to distribute oil.
3. Disconnect negative (-) battery cable.
4. Store engine in a clean, dry place.

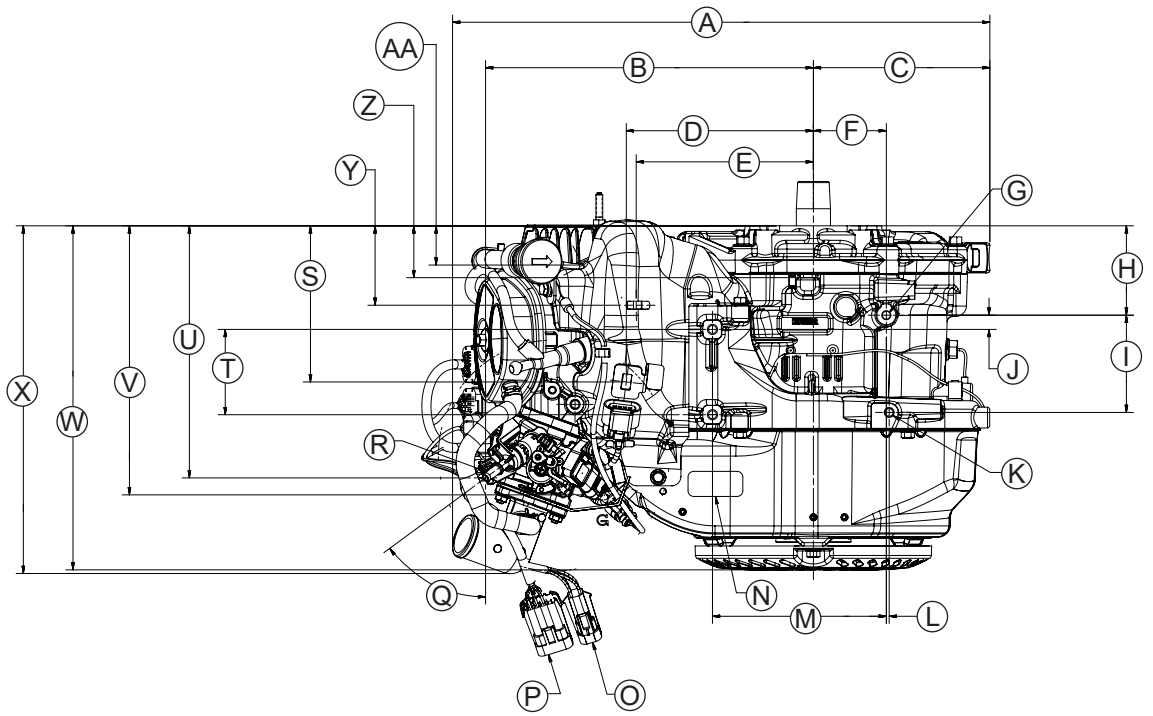
Engine Dimensions-Flywheel Side



A	214.1 mm (8.43 in.) Throttle Body Evap Fitting	**B**	164.3 mm (6.47 in.) Throttle Cable Mount Face	**C**	2 X 112.1 mm (4.42 in.)	**D**	138.6 mm (5.46 in.) Throttle Cable Center Line
E	116.4 mm (4.58 in.)	**F**	Oil Fill Plug	**G**	Oil Drain Plug	**H**	239.0 mm (9.41 in.) Throttle Body Evap Fitting
I	301.4 mm (11.87 in.) Fuel Injector Cap	**J**	320.8 mm (12.63 in.)	**K**	55.9°	**L**	Throttle Body Evap Fitting

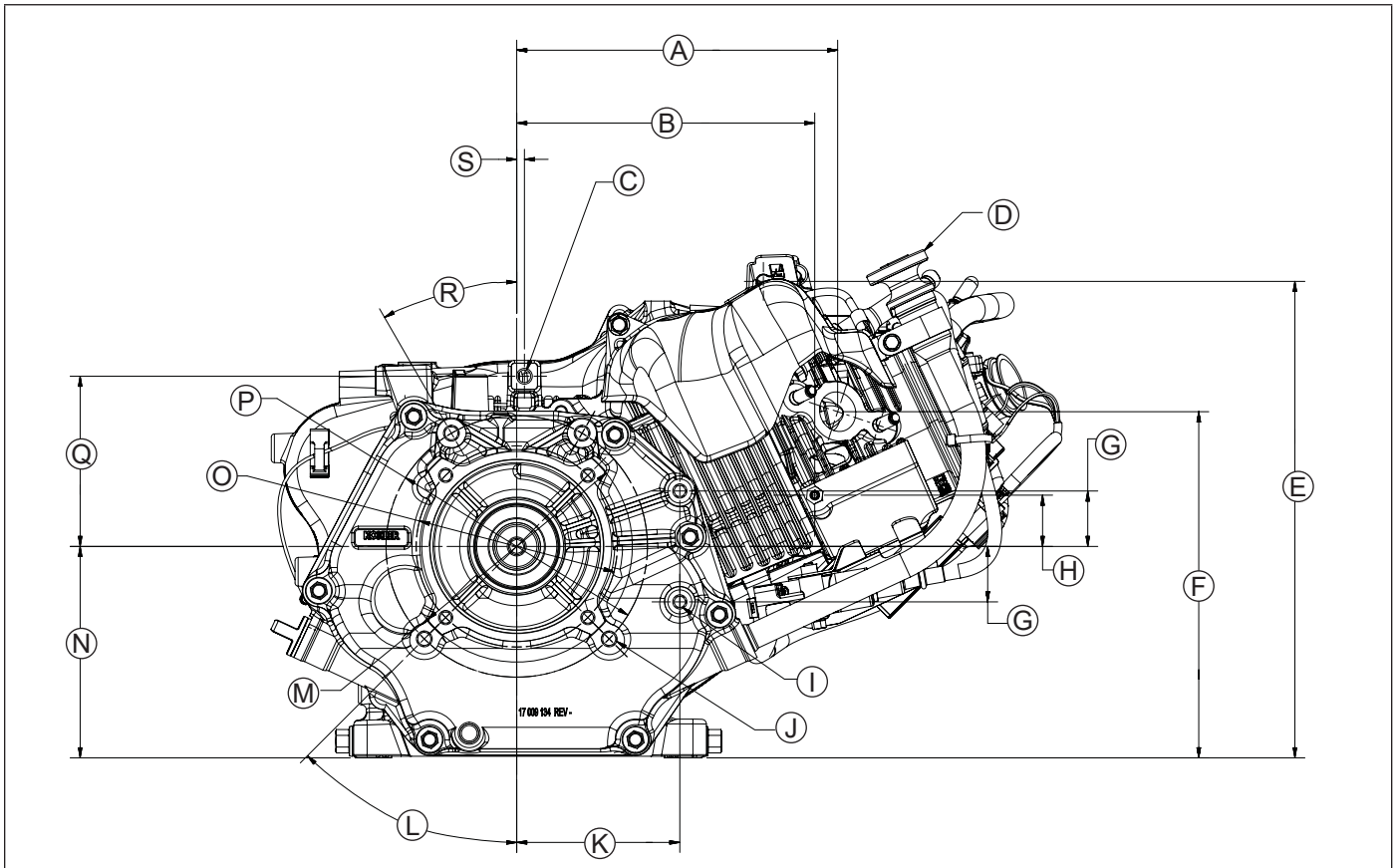
Specifications

Engine Dimensions-Top Side



A	472.4 mm (18.60 in.)	**B**	288.2 mm (11.35 in.) Fuel Injector Cap	**C**	155.1 mm (6.11 in.)	**D**	164.5 mm (6.48 in.) Oxygen Sensor Bracket
E	155.8 mm (6.13 in.) Oxygen Sensor Harness Clip	**F**	64.1 mm (2.53 in.)	**G**	M8 X 1.25-6H Tap 19.0 mm (0.75 in.) Deep	**H**	78.6 mm (3.09) in.)
I	85.5 mm ± 0.36 mm (3.37 in. ± 0.01 in.)	**J**	12.5 mm ± 0.43 mm (0.49 in. ± 0.02 in.)	**K**	3 X M8 X 1.25-6H Tap Thru	**L**	2.5 mm ± 0.36 mm (0.10 in. ± 0.01 in.)
M	152.9 mm ± 0.43 mm (6.02 in. ± 0.02 in.)	**N**	Emission Label	**O**	Diagnostic Connector	**P**	8-Terminal Customer Connector
Q	53.7°	**R**	Fuel Injector Cap	**S**	137.3 mm (5.41 in.) Oxygen Sensor Bracket	**T**	75.0 mm ± 0.50 mm (3.0 in. ± 0.02 in.)
U	221.6 mm (8.73 in.) Fuel Injector Cap	**V**	236.5 mm (9.31 in.) Throttle Body Evap Fitting	**W**	302.5 mm (11.91 in.)	**X**	305.7 mm (12.04 in.)
Y	69.8 mm (2.75 in.) Oxygen Sensor Harness Clip	**Z**	45.6 mm (1.80 in.) Engine Lifting Hole Surface	**AA**	34.5 mm (1.36 in.) Exhaust Port		

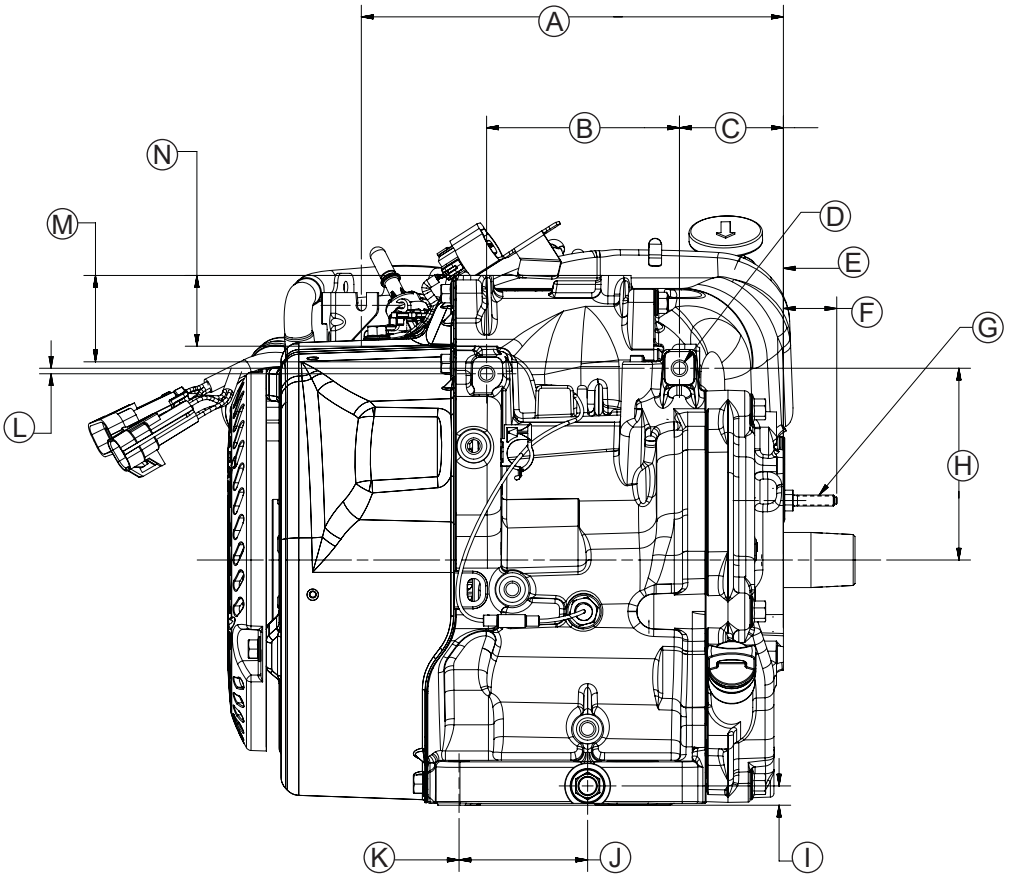
Engine Dimensions-PTO Side



A	202.7 mm (7.98 in.) Exhaust Port	**B**	188.2 mm (7.41 in.)	**C**	6 X M8 X 1.25-6H 18.00 mm (0.71 in.) Deep	**D**	Dipstick and Oil Fill Tube
E	300.9 mm (11.85 in.) Oxygen Sensor Harness Clip	**F**	218.6 mm (8.61 in.) Exhaust Port	**G**	35.0 mm (1.38 in.)	**H**	32.4 mm (1.28 in.)
I	6 X 5/16-24 UNF TAP 18.0 mm (0.71 in.) Deep	**J**	4 X 3/8-16 UNC 2B TAP 20.0 mm (0.79 in.) Deep	**K**	2 X 103 mm (4.06 in.)	**L**	2 X 45°
M	Ø 146.0 mm (5.75 in.) Pilot	**N**	133.5 mm (5.26 in.)	**O**	Ø 127.0 mm (5.00 in.)	**P**	Ø 165.1 mm (6.50 in.)
Q	107.49 mm (4.23 in.)	**R**	2 X 30°	**S**	4.9 mm (0.19 in.)		

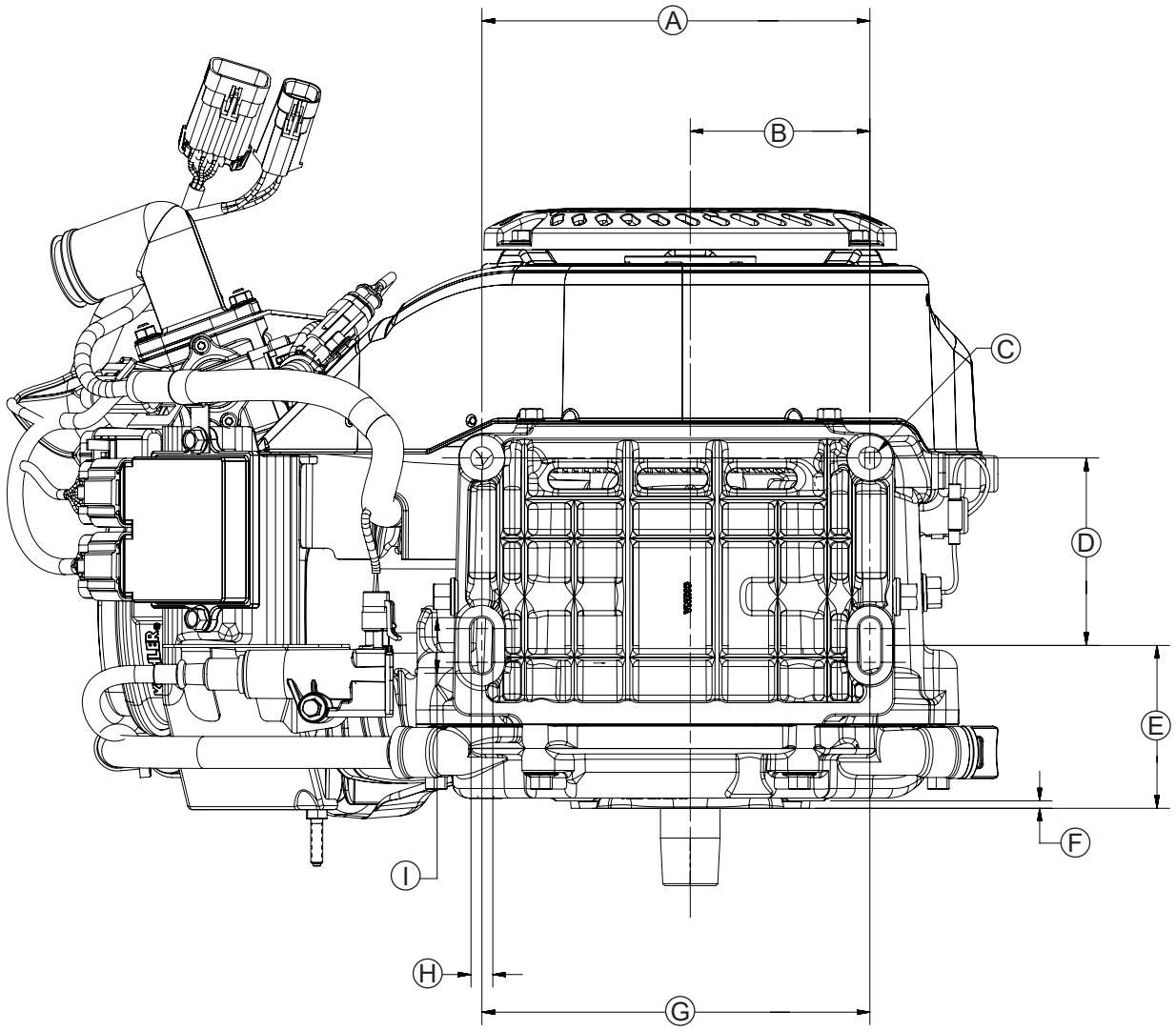
Specifications

Engine Dimensions-Opposite Cylinder Head Side



A	229.8 mm (9.05 in.) Throttle Cable Mount Face	**B**	105.0 mm (4.13 in.)	**C**	56.6 mm (2.23 in.)	**D**	2 X M8 X 1.25-6H Tap 22.0 mm (0.87 in.) Deep
E	Primary Mounting Face	**F**	29.1 mm (1.14 in.)	**G**	M6 X 1.0-6H 14.5 mm Min. Full Thread (Ground Location)	**H**	104.4 mm (4.11 in.)
I	2 X 10.5 mm (0.41 in.)	**J**	2 X 70.0 mm (2.76 in.)	**K**	Engine Mounting Hole Center Line	**L**	3.0 mm (0.12 in.)
M	47.0 mm (1.85 in.)	**N**	38.5 mm (1.52 in.)				

Engine Dimensions-Bottom Side

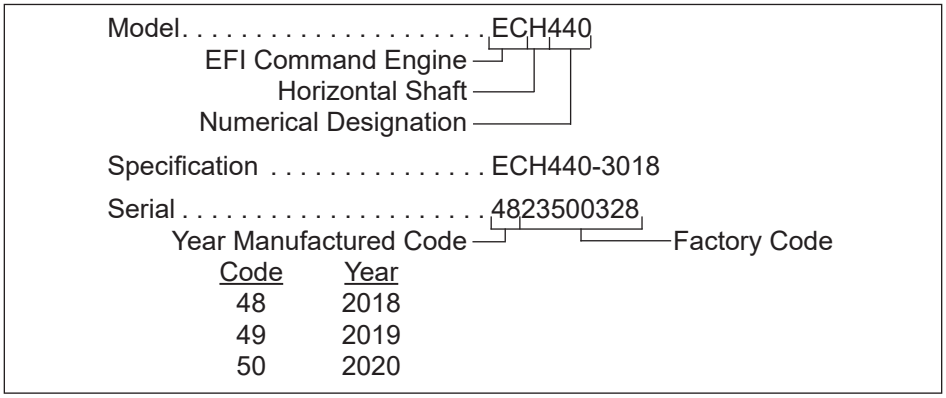


A	195.5 mm ± 0.50 mm (7.70 in. ± 0.02 in.) Machined Holes Distance	**B**	90.5 mm (3.56 in.)	**C**	2 X Ø 11.25 mm ± 0.25 mm (0.44 in. ± 0.01 in.)	**D**	2 X 94.5 mm ± 0.75 mm (3.72 in. ± 0.03 in.)
E	82.1 mm (3.23 in.)	**F**	3.75 mm (0.15 in.) Pilot	**G**	195.5 mm ± 1.0 mm (7.70 in. ± 0.04 in.) Cast Holes Distance	**H**	2 X 11.0 mm ± 0.25 mm (0.43 in. ± 0.01 in.) As Cast
I	2 X 28.0 mm ± 0.25 mm (1.10 in. ± 0.01 in.) As Cast						

Specifications

ENGINE IDENTIFICATION NUMBERS

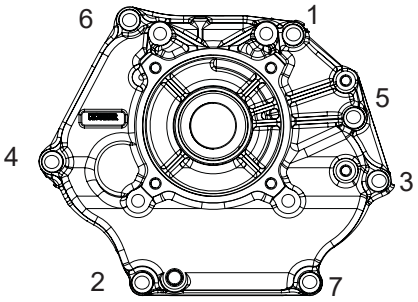
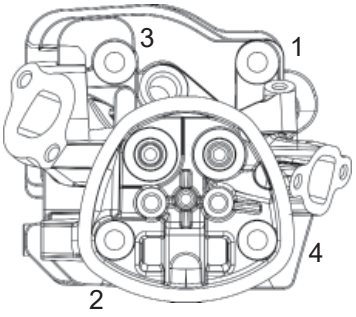
Kohler engine identification numbers (model, specification and serial) should be referenced for efficient repair, ordering correct parts, and engine replacement.



GENERAL SPECIFICATIONS[4,5]	ECH440 for Club Car
Bore	89 mm (3.5 in.)
Stroke	69 mm (2.7 in.)
Displacement	429 cc (26.2 cu. in.)
Oil Capacity (refill)	1.1 L (1.16 U.S. qt.)
Maximum Angle of Operation (@ full oil level)[6]	25°

TORQUE SEQUENCES — **ECH440 for Club Car**

(Refer to Torque Specifications for torque values).

Closure Plate	
Cylinder Head	

[4] Values are in Metric units. Values in parentheses are English equivalents.

[5] Any and all horsepower (hp) references by Kohler are Certified Power Ratings and per SAE J1940 & J1995 hp standards. Details on Certified Power Ratings can be found at KohlerEngines.com.

[6] Exceeding maximum angle of operation may cause engine damage from insufficient lubrication.

TORQUE SPECIFICATIONS[4,7]	ECH440 for Club Car
Air Cleaner (OEM Supplied)	
Air Inlet Elbow Mounting Nuts	8.0 N·m (71 in. lb.)
Blower Housing and Sheet Metal	
M6 Screw	10 N·m (89 in. lb.)
Cylinder Shield to Cylinder Head Ground Stud and Screw	8.0 N·m (71 in. lb.)
Upper Heat Shield to Crankcase	6.2 N·m (55 in. lb.) into new holes 4.0 N·m (35 in. lb.) into used holes
Blower Housing Screen Fastener	7.3 N·m (65 in. lb.)
Connecting Rod	
Cap Fastener (torque in increments)	20 N·m (177 in. lb.)
Crankcase	
Engine Temperature Sensor Fastener	11.9 N·m (105 in. lb.)
Oil Fill Tube Bracket Screw	5.4 N·m (48 in. lb.)
Oil Drain Plug	18 N·m (13 ft. lb.)
Oil Sentry™ Level Switch Screw	8 N·m (71 in. lb.)
Oil Sentry™ Wire Lead Nut	10 N·m (89 in. lb.)
Closure Plate Screw (torque sequence on page 10)	
Fastener	24 N·m (212 in. lb.)
Cylinder Head (torque sequence on page 10)	
Fastener (torque in 2 increments)	First to 25 N·m (221 in. lb.) Finally to 57.5 N·m (509 in. lb.)
Rocker Arm Stud	13.6 N·m (120 in. lb.)
Rocker Arm Pivot Jam Nut	10 N·m (89 in. lb.)
Flywheel	
Retaining Nut	113 N·m (1000 in. lb.)
Ignition	
Electronic Control Unit (ECU) to Cylinder Shield Fastener	8.0 N·m (71 in. lb.)
Spark Plug	27 N·m (20 ft. lb.)
Ignition Coil Fastener	10.2 N·m (90 in. lb.)
Crankshaft Position Sensor to Bracket Screw	4.2 N·m (37 in. lb.)
Crankshaft Position Sensor Bracket to Crankcase Screw	7.3 N·m (65 in. lb.)
Ground Wire Fastener	7.3 N·m (65 in. lb.)
Muffler (OEM Supplied)	
Oxygen Sensor 14 mm (9/16 in.) wrench size	18 N·m (159 in. lb.)

[4] Values are in Metric units. Values in parentheses are English equivalents.

[7] Lubricate threads with engine oil prior to assembly.

Specifications

TORQUE SPECIFICATIONS[4,7]	ECH440 for Club Car
Throttle Body	
Studs	10 N·m (89 in. lb.)
Primary Mounting Nuts	8.0 N·m (71 in. lb.)
Temperature/Manifold Absolute Pressure (TMAP) Sensor Fastener	7.3 N·m (65 in. lb.)
Throttle Position Sensor (TPS) Fastener	1.3 N·m (11.5 in. lb.)
Throttle Lever Fastener	1.3 N·m (11.5 in. lb.)
Fuel Injector Cap Fastener	7.3 N·m (65 in. lb.)
Valve Cover	
Fastener	10 N·m (89 in. lb.)

CLEARANCE SPECIFICATIONS[4]	ECH440 for Club Car
Camshaft	
Running Clearance	0.016/0.052 mm (0.0006/0.0020 in.)
Bore I.D. New	16.000/16.018 mm (0.6299/0.6306 in.)
Max. Wear Limit	16.068 mm (0.6326 in.)
Camshaft Bearing Surface O.D. New	15.975 mm (0.6289 in.)
Max. Wear Limit	15.90 mm (0.626 in.)
Cam Lobe Profile (minimum dimension, measured from base circle to top of lobe) Intake - New	32.286 mm (1.271 in.)
Max. Wear Limit	32.032 mm (1.261 in.)
Exhaust - New	32.506 mm (1.280 in.)
Max. Wear Limit	32.252 mm (1.270 in.)
Connecting Rod	
Crankpin End I.D. @ 21°C (70°F) New	37.020/37.030 mm (1.4575/1.4579 in.)
Max. Wear Limit	37.08 mm (1.460 in.)
Connecting Rod-to-Crankpin Side Clearance	
New	0.56 mm (0.022 in.)
Max. Wear Limit	1.06 mm (0.042 in.)
Connecting Rod-to-Piston Pin Running Clearance	0.008/0.025 mm (0.0003/0.0010 in.)
Piston Pin End I.D. @ 21°C (70°F) New	20.006/20.017 mm (0.7876/0.7881 in.)
Max. Wear Limit	20.03 mm (0.789 in.)

[4] Values are in Metric units. Values in parentheses are English equivalents.

[7] Lubricate threads with engine oil prior to assembly.

CLEARANCE SPECIFICATIONS[4]	ECH440 for Club Car
Crankshaft	
End Play (free)	0.0508/0.254 mm (0.002/0.010 in.)
Ball Bearing Internal Clearance	0.006/0.020 mm (0.0002/0.0008 in.)
Crankshaft O.D. (new) PTO end	34.975/34.989 mm (1.3770/1.3775 in.) 35.009/35.027 mm (1.3783/1.3790 in.)
Flywheel end	
Connecting Rod Journal O.D. New	36.975/36.985 mm (1.4557/1.4561 in.)
Max. Wear Limit	36.92 mm (1.4535 in.)
Max. Taper Max. Out-of-Round	2.5 microns (0.0001 in.) 12.7 microns (0.0005 in.)
Width	28.30/28.36 mm (1.1142/1.1165 in.)
Runout (either end)	0.025 mm (0.001 in.)
Main Bearing I.D. (Crankcase/Closure Plate) New (installed)	34.988/35.000 mm (1.3775/1.3779 in.)
Cylinder Bore	
Bore I.D. New	89.000/89.015 mm (3.5039/3.5045 in.)
Max. Wear Limit	89.185 mm (3.5112 in.)
Max. Out-of-Round Max. Taper	12.7 microns (0.0005 in.) 12.7 microns (0.0005 in.)
Cylinder Head	
Max. Out-of-Flatness	0.1 mm (0.0039 in.)
Ignition	
Spark Plug Gap	1.11 mm (0.044 in.)

[4] Values are in Metric units. Values in parentheses are English equivalents.

Specifications

CLEARANCE SPECIFICATIONS[4]	ECH440 for Club Car
Piston, Piston Rings, and Piston Pin	
Piston-to-Piston Pin Running Clearance	0.002/0.016 mm (0.0001/0.0006 in.)
Piston Pin Bore I.D. New	20.000/20.008 mm (0.7874/0.7877 in.)
Max. Wear Limit	20.05 mm (0.7894 in.)
Piston Pin O.D. New	19.992/19.998 mm (0.7871/0.7873 in.)
Max. Wear Limit	19.95 mm (0.7854 in.)
Top and Center Compression Ring Side Clearance New Bore	0.045 mm (0.0018 in.)
Used Bore (Max.)	0.10 mm (0.004 in.)
Top Compression Ring End Gap New Bore	0.250/0.400 mm (0.010/0.016 in.)
Used Bore (Max.)	1.00 mm (0.039 in.)
Center Compression Ring End Gap New Bore	0.640/0.800 mm (0.025/0.032 in.)
Used Bore (Max.)	1.50 mm (0.059 in.)
Oil Control Ring-to-Groove Side Clearance	0.09/0.15 mm (0.0035/0.0059 in.)
Piston Thrust Face O.D. New	88.955/88.975 mm (3.502/3.503 in.)[8]
Max. Wear Limit	88.82 mm (3.497 in.)
Piston Thrust Face-to-Cylinder Bore Running Clearance	0.025/0.060 mm (0.001/0.002 in.)[8]
Valves and Valve Lifters	
Valve Lash	0.0762/0.127 mm (0.003/0.005 in.)
Intake Valve Stem-to-Valve Guide Running Clearance	0.025/0.055 mm (0.0010/0.0022 in.)
Exhaust Valve Stem-to-Valve Guide Running Clearance	0.040/0.07 mm (0.0016/0.0028 in.)
Intake Valve Stem O.D. New	6.57 mm (0.259 in.)
Max. Wear Limit	6.40 mm (0.252 in.)
Exhaust Valve Stem O.D. New	6.55 mm (0.258 in.)
Max. Wear Limit	6.41 mm (0.252 in.)
Intake Valve Stem to Guide New	0.025/0.055 mm (0.0010/0.0022 in.)
Max. Wear Limit	0.14 mm (0.0055 in.)
Exhaust Valve Stem to Guide New	0.040/0.070 mm (0.0016/0.0028 in.)
Max. Wear Limit	0.11 mm (0.0043 in.)
Valve Guide Reamer Size Standard Intake	6.608 mm (0.2602 in.)
Standard Exhaust	6.608 mm (0.2602 in.)
Valve Seat Width	1.20 mm (0.0472 in.)
Nominal Valve Face Angle	45°

[4] Values are in Metric units. Values in parentheses are English equivalents.

[8] Measure 29.8-30.2 mm (1.1732-1.1890 in.) above bottom of piston skirt at right angles to piston pin.

GENERAL TORQUE VALUES

English Fastener Torque Recommendations for Standard Applications				
	Bolts, Screws, Nuts and Fasteners Assembled Into Cast Iron or Steel			Grade 2 or 5 Fasteners Into Aluminum
Size	Grade 2	Grade 5	Grade 8	
Tightening Torque: N·m (in. lb.) ± 20%				
8-32	2.3 (20)	2.8 (25)	—	2.3 (20)
10-24	3.6 (32)	4.5 (40)	—	3.6 (32)
10-32	3.6 (32)	4.5 (40)	—	—
1/4-20	7.9 (70)	13.0 (115)	18.7 (165)	7.9 (70)
1/4-28	9.6 (85)	15.8 (140)	22.6 (200)	—
5/16-18	17.0 (150)	28.3 (250)	39.6 (350)	17.0 (150)
5/16-24	18.7 (165)	30.5 (270)	—	—
3/8-16	29.4 (260)	—	—	—
3/8-24	33.9 (300)	—	—	—
Tightening Torque: N·m (ft. lb.) ± 20%				
5/16-24	—	—	40.7 (30)	—
3/8-16	—	47.5 (35)	67.8 (50)	—
3/8-24	—	54.2 (40)	81.4 (60)	—
7/16-14	47.5 (35)	74.6 (55)	108.5 (80)	—
7/16-20	61.0 (45)	101.7 (75)	142.5 (105)	—
1/2-13	67.8 (50)	108.5 (80)	155.9 (115)	—
1/2-20	94.9 (70)	142.4 (105)	223.7 (165)	—
9/16-12	101.7 (75)	169.5 (125)	237.3 (175)	—
9/16-18	135.6 (100)	223.7 (165)	311.9 (230)	—
5/8-11	149.5 (110)	244.1 (180)	352.6 (260)	—
5/8-18	189.8 (140)	311.9 (230)	447.5 (330)	—
3/4-10	199.3 (147)	332.2 (245)	474.6 (350)	—
3/4-16	271.2 (200)	440.7 (325)	637.3 (470)	—

Metric Fastener Torque Recommendations for Standard Applications						
	Property Class					Noncritical Fasteners Into Aluminum
Size	4.8	5.8	8.8	10.9	12.9	
Tightening Torque: N·m (in. lb.) ± 10%						
M4	1.2 (11)	1.7 (15)	2.9 (26)	4.1 (36)	5.0 (44)	2.0 (18)
M5	2.5 (22)	3.2 (28)	5.8 (51)	8.1 (72)	9.7 (86)	4.0 (35)
M6	4.3 (38)	5.7 (50)	9.9 (88)	14.0 (124)	16.5 (146)	6.8 (60)
M8	10.5 (93)	13.6 (120)	24.4 (216)	33.9 (300)	40.7 (360)	17.0 (150)
Tightening Torque: N·m (ft. lb.) ± 10%						
M10	21.7 (16)	27.1 (20)	47.5 (35)	66.4 (49)	81.4 (60)	33.9 (25)
M12	36.6 (27)	47.5 (35)	82.7 (61)	116.6 (86)	139.7 (103)	61.0 (45)
M14	58.3 (43)	76.4 (56)	131.5 (97)	184.4 (136)	219.7 (162)	94.9 (70)

Torque Conversions	
N·m = in. lb. x 0.113	in. lb. = N·m x 8.85
N·m = ft. lb. x 1.356	ft. lb. = N·m x 0.737

Tools and Aids

Certain quality tools are designed to help you perform specific disassembly, repair, and reassembly procedures. By using these tools, you can properly service engines easier, faster, and safer! In addition, you'll increase your service capabilities and customer satisfaction by decreasing engine downtime.

Here is a list of tools and their source.

NOTE: Not all tools listed are required to service this engine.

SEPARATE TOOL SUPPLIERS

Kohler Tools
Contact your local Kohler source of supply.

SE Tools
415 Howard St.
Lapeer, MI 48446
Phone 810-664-2981
Toll Free 800-664-2981
Fax 810-664-8181

Design Technology Inc.
768 Burr Oak Drive
Westmont, IL 60559
Phone 630-920-1300
Fax 630-920-0011

TOOLS

Description	Source/Part No.
Alcohol Content Tester For testing alcohol content (%) in reformulated/oxygenated fuels.	Kohler 25 455 11-S
Camshaft Endplay Plate For checking camshaft endplay.	SE Tools KLR-82405
Camshaft Seal Protector (Aegis) For protecting seal during camshaft installation.	SE Tools KLR-82417
Cylinder Leakdown Tester For checking combustion retention and if cylinder, piston, rings, or valves are worn. Individual component available: Adapter 12 mm x 14 mm (Required for leakdown test on XT-6 engines)	Kohler 25 761 05-S Design Technology Inc. DTI-731-03
Dealer Tool Kit (Domestic) Complete kit of Kohler required tools. Components of 25 761 39-S Ignition System Tester Cylinder Leakdown Tester Oil Pressure Test Kit Rectifier-Regulator Tester (120 V AC/60Hz)	Kohler 25 761 39-S Kohler 25 455 01-S Kohler 25 761 05-S Kohler 25 761 06-S Kohler 25 761 20-S
Dealer Tool Kit (International) Complete kit of Kohler required tools. Components of 25 761 42-S Ignition System Tester Cylinder Leakdown Tester Oil Pressure Test Kit Rectifier-Regulator Tester (240 V AC/50Hz)	Kohler 25 761 42-S Kohler 25 455 01-S Kohler 25 761 05-S Kohler 25 761 06-S Kohler 25 761 41-S
Digital Vacuum/Pressure Tester For checking crankcase vacuum. Individual component available: Rubber Adapter Plug	Design Technology Inc. DTI-721-01 Design Technology Inc. DTI-721-10
Electronic Fuel Injection (EFI) Diagnostic Software For Laptop or Desktop PC.	Kohler 25 761 23-S
EFI Service Kit For troubleshooting and setting up an EFI engine. Components of 24 761 01-S Fuel Pressure Tester Noid Light 90° Adapter Code Plug, Red Wire Code Plug, Blue Wire Shrader Valve Adapter Hose Wire Probe Set (2 pieces regular wire with clip; 1 piece fused wire) Hose Removal Tool, Dual Size/End (also sold as individual Kohler tool) K-Line Adapter Jumper Lead Wiring Harness	Kohler 24 761 01-S Design Technology Inc. DTI-019 DTI-021 DTI-023 DTI-027 DTI-029 DTI-037 DTI-031 DTI-033 Kohler 25 176 23-S
Kohler Wireless Diagnostic System Module (Bluetooth®) For wireless Android EFI diagnostics. Individual component available: Wireless Diagnostic System Interface Cable	Kohler 25 761 45-S Kohler 25 761 44-S

TOOLS

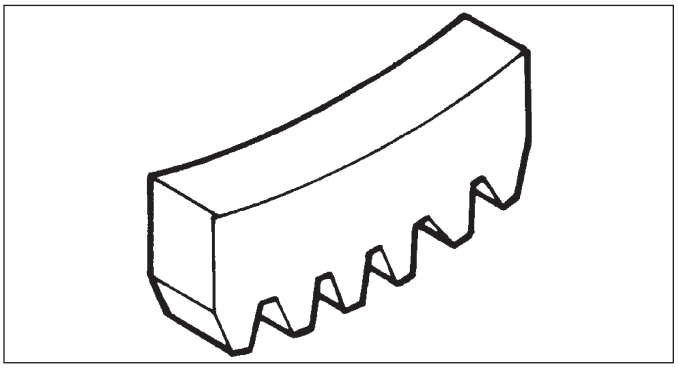
Description	Source/Part No.
Flywheel Puller For properly removing flywheel from engine.	SE Tools KLR-82408
Hose Removal Tool, Dual Size/End (also available in EFI Service Kit) Used to properly remove fuel hose from engine components.	Kohler 25 455 20-S
Hydraulic Valve Lifter Tool For removing and installing hydraulic lifters.	Kohler 25 761 38-S
Ignition System Tester For testing output on all systems, including CD.	Kohler 25 455 01-S
Inductive Tachometer (Digital) For checking operating speed (RPM) of an engine.	Design Technology Inc. DTI-110
Offset Wrench (K and M Series) For removing and reinstalling cylinder barrel retaining nuts.	Kohler 52 455 04-S
Oil Pressure Test Kit For testing/verifying oil pressure on pressure lubricated engines.	Kohler 25 761 06-S
Rectifier-Regulator Tester (120 volt current) **Rectifier-Regulator Tester (240 volt current)** For testing rectifier-regulators. Components of 25 761 20-S and 25 761 41-S CS-PRO Regulator Test Harness Special Regulator Test Harness with Diode	Kohler 25 761 20-S Kohler 25 761 41-S Design Technology Inc. DTI-031R DTI-033R
Spark Advance Module (SAM) Tester For testing SAM (ASAM and DSAM) on engines with SMART-SPARK™.	Kohler 25 761 40-S
Starter Servicing Kit (All Starters) For removing and reinstalling drive retaining rings and brushes. Individual component available: Starter Brush Holding Tool (Solenoid Shift)	SE Tools KLR-82411 SE Tools KLR-82416
Stepper Motor Controller Tool For testing operation of stepper motor/Digital Linear Actuator (DLA).	Kohler 25 455 21-S
Jumper Lead Tool For use with Stepper Motor Controller Tool to test rotary stepper motor.	Kohler 25 518 43-S
Triad/OHC Timing Tool Set For holding cam gears and crankshaft in timed position while installing timing belt.	Kohler 28 761 01-S
Valve Guide Reamer (K and M Series) For properly sizing valve guides after installation.	Design Technology Inc. DTI-K828
Valve Guide Reamer O.S. (Command Series) For reaming worn valve guides to accept replacement oversize valves. Can be used in low-speed drill press or with handle below for hand reaming.	Kohler 25 455 12-S
Reamer Handle For hand reaming using Kohler 25 455 12-S reamer.	Design Technology Inc. DTI-K830

AIDS

Description	Source/Part No.
Camshaft Lubricant (Valspar ZZ613)	Kohler 25 357 14-S
Dielectric Grease (GE/Novaguard G661)	Kohler 25 357 11-S
Dielectric Grease	Loctite® 51360
Kohler Electric Starter Drive Lubricant (Inertia Drive)	Kohler 52 357 01-S
Kohler Electric Starter Drive Lubricant (Solenoid Shift)	Kohler 52 357 02-S
RTV Silicone Sealant Loctite® 5900® Heavy Body in 4 oz. aerosol dispenser. Only oxime-based, oil resistant RTV sealants, such as those listed, are approved for use. Permatex® the Right Stuff® 1 Minute Gasket™ or Loctite® Nos. 5900® or 5910® are recommended for best sealing characteristics.	Kohler 25 597 07-S Loctite® 5910® Loctite® Ultra Black 598™ Loctite® Ultra Blue 587™ Loctite® Ultra Copper 5920™ Permatex® the Right Stuff® 1 Minute Gasket™
Spline Drive Lubricant	Kohler 25 357 12-S

Tools and Aids

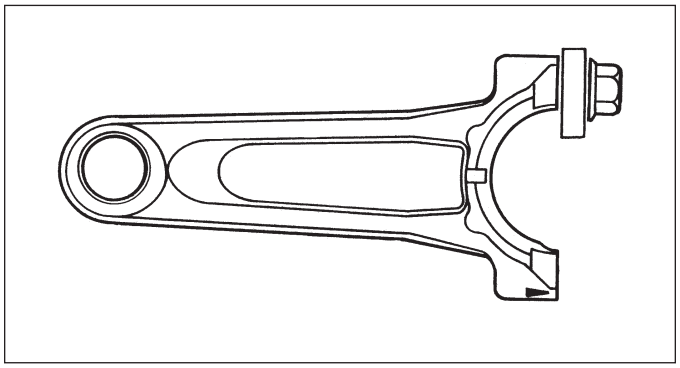
FLYWHEEL HOLDING TOOL



A flywheel holding tool can be made out of an old junk flywheel ring gear and used in place of a strap wrench.

1. Using an abrasive cut-off wheel, cut out a six tooth segment of ring gear as shown.
2. Grind off any burrs or sharp edges.
3. Invert segment and place it between ignition bosses on crankcase so tool teeth engage flywheel ring gear teeth. Bosses will lock tool and flywheel in position for loosening, tightening, or removing with a puller.

ROCKER ARM/CRANKSHAFT TOOL



A spanner wrench to lift rocker arms or turn crankshaft may be made out of an old junk connecting rod.

1. Find a used connecting rod from a 10 HP or larger engine. Remove and discard rod cap.
2. Remove studs of a Posi-Lock rod or grind off aligning steps of a Command rod, so joint surface is flat.
3. Find a 1 in. long capscrew with correct thread size to match threads in connecting rod.
4. Use a flat washer with correct I.D. to slip on capscrew and approximately 1 in. O.D**.** Assemble capscrew and washer to joint surface of rod.

TROUBLESHOOTING GUIDE

When troubles occur, be sure to check simple causes which, at first, may seem too obvious to be considered. For example, a starting problem could be caused by an empty fuel tank.

NOTE: An EFI engine will not operate without a battery connected to system.

Some general common causes of EFI engine troubles are listed below and vary by engine specification. Use these to locate causing factors.

Engine Cranks But Will Not Start

- Battery connected backwards.
- Blown fuses.
- Clogged fuel line or fuel filter.
- Empty fuel tank.
- Faulty ignition coil.
- Faulty spark plug.
- Fuel pump malfunction.
- Insufficient voltage to electronic control unit.
- Interlock circuit is engaged or faulty.
- Key switch or kill switch in OFF position.
- Quality of fuel (dirt, water, stale, mixture).
- Spark plug lead disconnected.

Engine Starts But Does Not Keep Running

- Faulty cylinder head gasket.
- Faulty or misadjusted throttle controls.
- Fuel pump malfunction.
- Intake leak.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Quality of fuel (dirt, water, stale, mixture).
- Restricted fuel tank cap vent.

Engine Starts Hard

- Clogged fuel line or fuel filter.
- Engine overheated.
- Faulty ACR mechanism.
- Faulty spark plug.
- Flywheel key sheared.
- Fuel pump malfunction.
- Interlock circuit is engaged or faulty.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Low compression.
- Quality of fuel (dirt, water, stale, mixture).
- Weak spark.

Engine Will Not Crank

- Battery is discharged.
- Faulty starter circuit.
- Faulty key switch or ignition switch.
- Interlock circuit is engaged or faulty.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Seized internal engine components.

Engine Runs But Misses

- Fuel system issue (Fuel Injector).
- Engine overheated.
- Faulty spark plug.
- Ignition coil faulty.
- Interlock circuit is engaged or faulty.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Quality of fuel (dirt, water, stale, mixture).
- Spark plug lead disconnected.
- Spark plug lead boot loose on plug.
- Spark plug lead loose.

Engine Will Not Idle

- Engine overheated.
- Faulty spark plug.
- Idle speed adjusting screw improperly set.
- Inadequate fuel supply.
- Low compression.
- Quality of fuel (dirt, water, stale, mixture).
- Restricted fuel tank cap vent.

Engine Overheats

- Cooling fan broken.
- Excessive engine load.
- Lean fuel mixture.
- Low crankcase oil level.
- Cooling system components clogged or restricted.

Engine Knocks

- Excessive engine load.
- Incorrect valve lash adjustment.
- Incorrect oil viscosity/type.
- Internal wear or damage.
- Low crankcase oil level.
- Quality of fuel (dirt, water, stale, mixture).
- Loose/worn pulley/clutch on crankshaft PTO.

Engine Loses Power

- Dirty air cleaner element (OEM supplied).
- Engine overheated.
- Excessive engine load.
- Restricted exhaust (OEM supplied).
- Faulty spark plug.
- High crankcase oil level.
- Incorrect governor setting (OEM supplied).
- Low battery.
- Low compression.
- Low crankcase oil level.
- Quality of fuel (dirt, water, stale, mixture).

Engine Uses Excessive Amount of Oil

- Loose or improperly torqued fasteners.
- Blown head gasket/overheated.
- Breather reed broken.
- Clogged, broken, or inoperative crankcase breather.
- Crankcase overfilled.
- Incorrect oil viscosity/type.
- Worn cylinder bore.
- Worn or broken piston rings.
- Worn valve stems/valve guides.

Oil Leaks from Oil Seals, Gaskets

- Breather reed broken.
- Clogged, broken, or inoperative crankcase breather.
- Loose or improperly torqued fasteners.
- Piston blow by, or leaky valves.
- Restricted exhaust (OEM supplied).

EXTERNAL ENGINE INSPECTION

NOTE: It is good practice to drain oil at a location away from workbench. Be sure to allow ample time for complete drainage.

Before cleaning or disassembling engine, make a thorough inspection of its external appearance and condition. This inspection can give clues to what might be found inside engines (and cause) when it is disassembled.

- Check for buildup of dirt and debris on crankcase, cooling fins, screen, and other external surfaces. Dirt or debris on these areas can cause overheating.
- Check for obvious fuel and oil leaks, and damaged components. Excessive oil leakage can indicate a clogged or inoperative breather, worn or damaged seals or gaskets, or loose fasteners.
- Check air cleaner system (OEM supplied) for damage or indications of improper fit and seal.
- Check air cleaner element (OEM supplied). Look for holes, tears, cracked or damaged sealing surfaces, or other damage that could allow unfiltered air into engine. A dirty or clogged element could indicate insufficient or improper maintenance.
- Check throttle body throat for dirt. Dirt in throat is further indication that air cleaner was not functioning properly.
- Check if oil level is within operating range on dipstick. If it is above, sniff for gasoline odor.
- Check condition of oil. Drain oil into a container; it should flow freely. Check for metal chips and other foreign particles.

  Sludge is a natural by-product of combustion; a small accumulation is normal. Excessive sludge formation could indicate over rich fuel settings, weak ignition, overextended oil change interval or wrong weight or type of oil was used.

CLEANING ENGINE



⚠ WARNING

Cleaning Solvents can cause severe injury or death.

Use only in well ventilated areas away from ignition sources.

Carburetor cleaners and solvents are extremely flammable. Follow cleaner manufacturer's warnings and instructions on its proper and safe use. Never use gasoline as a cleaning agent.

After inspecting external condition of engine, clean engine thoroughly before disassembly. Clean individual components as engine is disassembled. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil, and grime from engine parts. When such a cleaner is used, follow manufacturer's instructions and safety precautions carefully.

Make sure all traces of cleaner are removed before engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down lubricating properties of engine oil.

CRANKCASE VACUUM TEST



⚠ WARNING

Carbon Monoxide can cause severe nausea, fainting or death.

Avoid inhaling exhaust fumes.

Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled.



⚠ WARNING

Rotating Parts can cause severe injury.

Stay away while engine is in operation.

Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate engine with covers, shrouds, or guards removed.

A partial vacuum should be present in crankcase when engine is operating. Pressure in crankcase (normally caused by a clogged or improperly assembled breather) can cause oil to be forced out at oil seals, gaskets, or other available spots.

Crankcase vacuum is best measured with either a water manometer or a vacuum gauge. Complete instructions are provided in kits.

To test crankcase vacuum with manometer:

1. Insert rubber stopper into oil fill hole. Be sure pinch clamp is installed on hose and use tapered adapters to connect hose between stopper and one manometer tube. Leave other tube open to atmosphere. Check that water level in manometer is at 0 line. Make sure pinch clamp is closed.
2. Start engine and run no-load high speed.
3. Open clamp and note water level in tube.

   Level in engine side should be a minimum of 10.2 cm (4 in.) above level in open side.

   If level in engine side is less than specified (low/no vacuum), or level in engine side is lower than level in open side (pressure), check for conditions in table below.
4. Close pinch clamp before stopping engine.

To test crankcase vacuum with vacuum/pressure gauge:

1. Remove dipstick or oil fill plug/cap.
2. Install adapter into oil fill//dipstick tube opening, upside down over end of a small diameter dipstick tube, or directly into engine if a tube is not used. Insert barbed gauge fitting into hole in stopper.
3. Run engine and observe gauge reading.

   Analog tester–needle movement to left of 0 is a vacuum, and movement to right indicates a pressure.

   Digital tester–depress test button on top of tester.

   Crankcase vacuum should be a minimum of 10.2 cm (4 in.) of water. If reading is below specification, or if pressure is present, check table below for possible causes and conclusions.

Condition	Conclusion
Crankcase breather clogged or inoperative.	NOTE: If breather is integral part of valve cover and cannot be serviced separately, replace valve cover and recheck pressure. Disassemble breather, clean parts thoroughly, check sealing surfaces for flatness, reassemble, and recheck pressure.
Seals and/or gaskets leaking. Loose or improperly torque fasteners.	Replace all worn or damaged seals and gaskets. Make sure all fasteners are tightened securely. Use appropriate torque valves and sequences when necessary.
Piston blow by or leaky valves (confirm by inspecting components).	Recondition piston, rings, cylinder bore, valves and valves guides.
Restricted exhaust (OEM supplied).	Refer to equipment manufacturer's manual for information on exhaust system.

COMPRESSION TEST

This engine is equipped with an automatic compression release (ACR) mechanism. It is difficult to obtain an accurate compression reading because of ACR mechanism. As an alternative, use cylinder leakdown test described below.

CYLINDER LEAKDOWN TEST

A cylinder leakdown test can be a valuable alternative to a compression test. By pressurizing combustion chamber from an external air source you can determine if valves or rings are leaking, and how badly.

Cylinder leakdown tester is a relatively simple, inexpensive leakdown tester for small engines. This tester includes a quick-connect for attaching adapter hose and a holding tool.

1. Run engine for 3-5 minutes to warm it up.
2. Remove spark plug and air filter from engine.
3. Rotate crankshaft until piston (of cylinder being tested) is at top dead center (TDC) of compression stroke. Hold engine in this position while testing. Holding tool supplied with tester can be used if PTO end of crankshaft is accessible. Lock holding tool onto crankshaft. Install a 3/8 in. breaker bar into hole/slot of holding tool, so it is perpendicular to both holding tool and crankshaft PTO.

   If flywheel end is more accessible, use a breaker bar and socket on flywheel nut/screw to hold it in position. An assistant may be needed to hold breaker bar during testing. If engine is mounted in a piece of equipment, it may be possible to hold it by clamping or wedging a driven component. Just be certain that engine cannot rotate off of TDC in either direction.
4. Install adapter into spark plug hole, but do not attach it to tester at this time.
5. Turn regulator knob completely counterclockwise.
6. Connect an air source of at least 50 psi to tester.
7. Turn regulator knob clockwise (increase direction) until gauge needle is in yellow set area at low end of scale.
8. Connect tester quick-connect to adapter hose. While firmly holding engine at TDC, gradually open tester valve. Note gauge reading and listen for escaping air at combustion air intake, exhaust outlet, and crankcase breather.

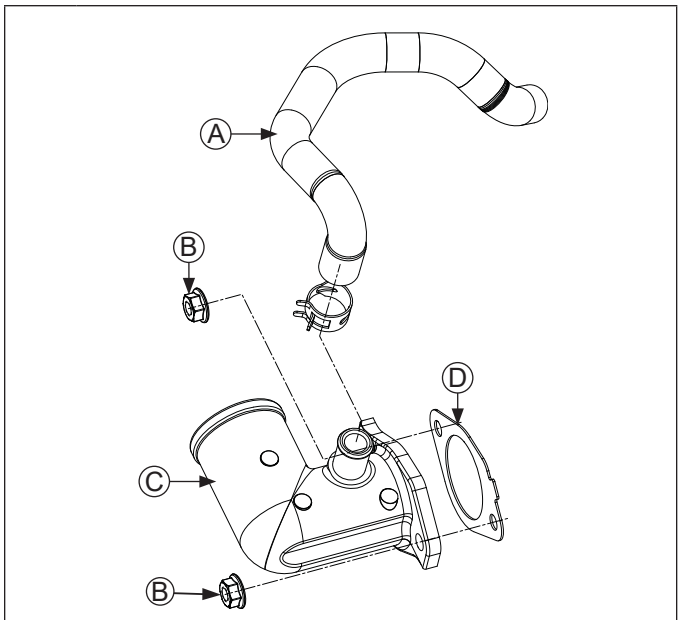
Condition	Conclusion
Air escaping from crankcase breather.	Ring or cylinder worn.
Air escaping from exhaust system.	Defective exhaust valve/improper seating.
Air escaping from intake.	Defective intake valve/improper seating.
Gauge reading in low (green) zone.	Piston rings and cylinder in good condition.
Gauge reading in moderate (yellow) zone.	Engine is still usable, but there is some wear present. Customer should start planning for overhaul or replacement.
Gauge reading in high (red) zone.	Rings and/or cylinder have considerable wear. Engine should be reconditioned or replaced.

AIR CLEANER (OEM Supplied)

These systems are CARB/EPA certified and components should not be altered or modified in any way.

Refer to operating instructions of equipment this engine powers for specific air cleaner instructions.

Air Inlet Elbow Components



A	Breather Hose	**B**	Nut
C	Air Inlet Elbow	**D**	Throttle Body Gasket

NOTE: Operating engine with loose or damaged air cleaner components could cause premature wear and failure. Replace all bent or damaged components.

Air Inlet Elbow

NOTE: Refer to equipment manufacturer's manual for air cleaner they supply.

1. Disconnect one end of breather hose from valve cover or air inlet elbow.
2. Remove nuts securing air inlet elbow to throttle body.
3. Remove air inlet elbow and gasket from mounting studs.

BREATHER TUBE

Ensure both ends of breather tube are properly connected.

AIR COOLING



⚠ WARNING

Hot Parts can cause severe burns.

Do not touch engine while operating or just after stopping.

Never operate engine with heat shields or guards removed.

Proper cooling is essential. To prevent over heating, clean screens, cooling fins, and other external surfaces of engine. Avoid spraying water at wiring harness or any electrical components. Refer to Maintenance Schedule.

EFI SYSTEM



⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Do not fill fuel tank while engine is hot or running.

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

NOTE: Engines in this application have in-tank fuel pump, EFI fuel filter, and all fuel lines supplied and installed by OEM. Refer to equipment manufacturer's manual for information on these components and before working on fuel system.

Typical electronic fuel injection (EFI) system and related components include:

- In-tank fuel pump (OEM supplied and installed).
- Fuel filter (OEM supplied and installed).
- High pressure fuel line (OEM supplied and installed).
- Fuel injector.
- Throttle body.
- Electronic control unit (ECU).
- Ignition coil.
- Engine temperature sensor.
- Throttle position sensor (TPS).
- Crankshaft position sensor.
- Oxygen sensor.
- Temperature/Manifold Absolute Pressure (TMAP) sensor.
- Wire harness assembly & affiliated wiring.
- 10 Amp fuse (ignition switch).
- 10 Amp fuse (battery power).
- Malfunction indicator light (MIL) - OEM supplied and installed).

FUEL RECOMMENDATIONS
Refer to Maintenance.

FUEL LINE (OEM Supplied)
Low permeation fuel line must be installed on all Kohler Co. engines to maintain EPA and CARB regulatory compliance.

OPERATION

NOTE: When performing voltage or continuity tests, avoid putting excessive pressure on or against connector pins. Pin probes (maximum diameter 0.81 mm (0.032 in.) approximately) are recommended for testing to avoid spreading or bending terminals.

EFI system is designed to provide peak engine performance with optimum fuel efficiency and lowest possible emissions. Ignition and injection functions are electronically controlled, monitored and continually corrected during operation to maintain ideal air/fuel ratio.

Central component of system is Electronic Control Unit (ECU) which manages system operation, determining best combination of fuel mixture and ignition timing for current operating conditions.

An in-tank fuel pump is used to move fuel from tank through a fuel filter and fuel line. Fuel pump regulates fuel pressure to a system operating pressure of 50 psi. Fuel is delivered through high pressure fuel line into injector, which injects fuel into intake port. ECU controls amount of fuel by varying length of time that injector is on. This can range from 2 to over 12 milliseconds depending on fuel requirements. Controlled injection of fuel occurs every other crankshaft revolution, or once for each 4-stroke cycle. When intake valve opens, air/fuel mixture is drawn into combustion chamber, where it is compressed, ignited, and burned.

ECU controls amount of fuel being injected and ignition timing by monitoring primary sensor signals for engine temperature, speed (RPM), and throttle position (load). These primary signals are compared to preprogrammed maps in ECU computer chip, and ECU adjusts fuel delivery to match mapped values. After engine reaches operating temperature, an exhaust gas oxygen sensor provides feedback to ECU based upon amount of unused oxygen in exhaust, indicating whether fuel mixture being delivered is rich or lean. Based upon this feedback, ECU further adjusts fuel input to re-establish ideal air/fuel ratio. This operating mode is referred to as closed loop operation. EFI system operates closed loop when all three of following conditions are met:

- Engine temperature is greater than 40°C (104°F).
- Oxygen sensor has warmed sufficiently to provide a signal (minimum 400°C, 752°F).
- Engine operation is at a steady state (not starting, warming up, accelerating, etc.).

During closed loop operation ECU has ability to readjust temporary and learned adaptive controls, providing compensation for changes in overall engine condition and operating environment, so it will be able to maintain ideal air/fuel ratio. This system requires a minimum engine temperature of 40°C (104°F) to properly adapt. These adaptive values are maintained as long as ECU is not reset.

During certain operating periods such as cold starts, warm up, acceleration, high load, etc., a richer air/fuel ratio is required and system operates in an open loop mode. In open loop operation oxygen sensor output is used to ensure engine is running rich, and controlling adjustments are based on primary sensor signals and programmed maps only. This system operates open loop whenever three conditions for closed loop operation (above) are not being met.

ECU is brain or central processing computer of entire EFI system. During operation, sensors continuously gather data which is relayed through wiring harness to input circuits within ECU. Signals to ECU include: ignition (on/off), crankshaft position and speed (RPM), throttle position, engine temperature, intake air temperature, exhaust oxygen levels, manifold absolute pressure, and battery voltage.

ECU compares input signals to programmed maps in its memory to determine appropriate fuel and spark requirements for immediate operating conditions. ECU then sends output signals to set injector duration and ignition timing.

ECU continually performs a diagnostic check of itself, each sensor, and system performance. If a fault is detected, ECU can turn on a Malfunction Indicator Light (MIL) on equipment control panel, store fault code in its fault memory, and go into a default operating mode. Depending on significance or severity of fault, normal operation may continue. A technician can access stored fault code using a fault code diagnosis flashed out through MIL. An optional computer software diagnostic program is also available, refer to Tools and Aids.

ECU requires a minimum of 6.0 volts to operate.

To prevent engine over-speed and possible failure, a rev-limiting feature is programmed into ECU. If maximum RPM limit (4400) is exceeded, ECU suppresses injection signals, cutting off fuel flow. This process repeats itself in rapid succession, limiting operation to preset maximum.

Wiring harness used in EFI system connects electrical components, providing current and ground paths for system to operate. All input and output signaling occurs through two special all weather connectors that attach and lock to ECU. Connectors are Black and Grey and keyed differently to prevent being attached to ECU incorrectly.

Condition of wiring, connectors, and terminal connections is essential to system function and performance. Corrosion, moisture, and poor connections are as likely a cause of operating problems and system errors as an actual component. Refer to Electrical System for additional information.

EFI system is a 12 VDC negative ground system, designed to operate down to a minimum of 6.0 volts. If system voltage drops below this level, operation of voltage sensitive components such as ECU, fuel pump relay, ignition coil, and injector will be intermittent or disrupted, causing erratic operation or hard starting. A fully charged, 12 volt battery with a minimum of 350 cold cranking amps is important in maintaining steady and reliable system operation. Battery condition and state of charge should always be checked first when troubleshooting an operational problem.

Keep in mind that EFI-related problems are often caused by wiring harness or connections. Even small amounts of corrosion or oxidation on terminals can interfere with milliamp currents used in system operation.

Cleaning connectors and grounds will solve problems in many cases. In an emergency situation, simply disconnecting and reconnecting connectors may clean up contacts enough to restore operation, at least temporarily.

If a fault code indicates a problem with an electrical component, disconnect ECU connector and test for continuity between component connector terminals and corresponding terminals in ECU connector using an ohmmeter. Little or no resistance should be measured, indicating that wiring of that particular circuit is OK.

Crankshaft position sensor is essential to engine operation; constantly monitoring rotation and speed (RPM) of crankshaft. There are 23 consecutive teeth cast into flywheel. One tooth is missing and is used to reference crankshaft position for ECU.

When ignition is turned ON, ECU captures and records battery voltage. During engine start (cranking) voltage drops 2+ volts. When ECU receives voltage drop input, it then looks for a signal from crankshaft position sensor. During rotation, an AC voltage pulse is created within sensor for each passing tooth. ECU calculates engine speed from time interval between consecutive pulses. Gap from missing tooth creates an interrupted input signal, corresponding to specific crankshaft position near BDC for cylinder. This signal serves as a reference for control of ignition timing by ECU. Synchronization of inductive speed pickup and crankshaft position takes place during first two revolutions each time engine is started. Sensor must be properly connected at all times. If sensor becomes disconnected for any reason, engine will quit running.

Throttle position sensor (TPS) is used to indicate throttle plate angle to ECU. Since throttle (by way of governor) reacts to engine load, angle of throttle plate is directly related to load on engine.

Mounted on throttle body and operated directly off end of throttle shaft, TPS works by varying voltage signal to ECU in direct correlation to angle of throttle plate. This signal, along with other sensor signals, is processed by ECU and compared to internal preprogrammed maps to determine required fuel and ignition settings for amount of load.

Correct position of TPS is established and set at factory. Do not loosen TPS or alter mounting position unless absolutely required by fault code diagnosis. If TPS is loosened or repositioned, appropriate TPS Learn Procedure must be performed to re-establish baseline relationship between ECU and TPS.

Engine temperature sensor is used by system to help determine fuel requirements for starting (a cold engine needs more fuel than one at or near operating temperature).

Mounted on cylinder head, it has a temperature-sensitive resistor. Resistance changes with engine temperature, altering voltage sent to ECU. Using a table stored in its memory, ECU correlates voltage drop to a specific temperature. Using fuel delivery maps, ECU then knows how much fuel is required for starting at that temperature.

Temperature/Manifold Absolute Pressure (TMAP) sensor is an integrated sensor that checks both intake air temperature and manifold absolute pressure.

Intake Air Temperature control is a thermally sensitive resistor that exhibits a change in electrical resistance with a change in its temperature. When sensor is cold, resistance of sensor is high. As sensor warms up, resistance drops and voltage signal increases. From voltage signal, ECU can determine temperature of intake air.

Purpose of sensing air temperature is to help ECU calculate air density. Higher air temperature less dense air becomes. As air becomes less dense ECU knows that it needs to lessen fuel flow to achieve correct air/fuel ratio. If fuel flow was not changed engine would become rich, possibly losing power and consuming more fuel.

Manifold Absolute Pressure check provides immediate manifold pressure information to ECU. TMAP sensor measures difference in pressure between outside atmosphere and vacuum level inside intake passage and monitors pressure in passage as primary means of detecting load. Data is used to calculate air density and determine engine's mass air flow rate, which in turn determines required ideal fueling. TMAP also stores instant barometric pressure reading when key is turned ON.

Oxygen sensor functions like a small battery, generating a voltage signal to ECU based upon difference in oxygen content between exhaust gas and an air reference signal.

Tip of sensor, protruding into exhaust gas, is hollow. Outer portion of tip is surrounded by exhaust gas, using a pumping current to maintain nominal air reference of approximately 21% oxygen in air reference chamber of sensor, differences between exhaust and air reference are sent using a generated voltage signal of up to 1.0 volt to ECU. Voltage signal tells ECU if engine is straying from ideal fuel mixture, and ECU then adjusts injector pulse accordingly.

Oxygen sensor functions after being heated to a minimum of 400°C (752°F). A heater inside sensor heats electrode to optimum temperature in about 10 seconds. Oxygen sensor receives ground through wire, eliminating need for proper grounding through muffler. If problems indicate a bad oxygen sensor, check all connections and wire harness. Oxygen sensor can also be contaminated by leaded fuel, certain RTV and/or other silicone compounds, fuel injector cleaners, etc. Use only those products indicated as O2 Sensor Safe.

Fuel injector mounts on throttle body and high pressure fuel line attaches to cap on fuel injector. Replaceable O-rings on both ends of injector prevent external fuel leakage and also insulate it from heat and vibration. A special clip connects injector and fuel injector cap. O-rings and retaining clip must be replaced any time fuel injector is separated from its normal mounting position.

When key switch is on, fuel pump will pressurize high pressure fuel line to 50 psi, and voltage is present at injector. At proper instant, ECU completes ground circuit, energizing injector. Valve needle in injector is opened electromagnetically, and pressure in high pressure fuel line forces fuel down through injector. Director plate at tip of injector contains a series of calibrated openings which directs fuel into intake passage in a cone-shaped spray pattern.

Injector has sequential fueling that opens and closes once every other crankshaft revolution. Amount of fuel injected is controlled by ECU and determined by length of time valve needle is held open, also referred to as injection duration or pulse width. Time injector is open (milliseconds) may vary in duration depending on speed and load requirements of engine.

A high-voltage, solid-state, battery ignition system is used with EFI system. ECU controls ignition output and timing through transistorized control of primary current delivered to coil. Based on input from crankshaft position sensor, ECU determines correct firing point for speed at which engine is running. At proper instant, it interrupts flow of primary current in coil, causing electromagnetic flux field to collapse. Flux collapse induces an instantaneous high voltage in coil secondary which is strong enough to bridge gap on spark plug. Coil fires every other revolution.

Equipment this engine powers has a starter generator, refer to equipment manufacturer's manual for charging system troubleshooting information.

An electric in-tank fuel pump (OEM supplied) is used to transfer fuel in EFI system. Fuel pump is regulated at 350 kilopascals (50 psi).

When key switch is turned ON and all safety switch requirements are met, ECU activates fuel pump for up to six seconds (prime process), which pressurizes system for start-up. If key switch is not promptly turned to start position, engine fails to start, or engine is stopped with key switch ON (as in case of an accident), ECU switches off pump preventing continued delivery of fuel. Once engine is running, fuel pump remains on.

A special EFI 10-micron filter (OEM supplied) is in fuel tank. Be sure to use an approved 10-micron filter for replacement. Refer to equipment manufacturer's manual for information.

High pressure fuel line assembly (OEM supplied) attaches to injector cap and fuel pump using connectors. High pressure fuel line feeds fuel to top of injector through injector cap.

Vent hose assembly (OEM supplied) is intended to vent fuel vapor out of fuel tank, through an OEM supplied carbon canister and then directs all fuel vapor into purge port located on throttle body.

EFI engines have no carburetor, so throttle function (regulate incoming combustion airflow) is achieved with a throttle valve in a separate throttle body attached to cylinder head/intake port/air inlet elbow. Throttle body provides mounting for fuel injector, throttle position sensor, TMAP sensor, high pressure fuel line, idle speed screw, and air inlet elbow.

Idle speed is only adjustment that may be performed on throttle body. Standard idle speed setting is 1050 RPM for pedal start applications or 1250 RPM for key start applications.

For starting and warm up, ECU will adjust fuel and ignition timing, based upon ambient temperature, engine temperature, and loads present. In cold conditions, idle speed will probably be different than normal for a few moments. Under other conditions, idle speed may actually start lower than normal, but gradually increase to established setting as operation continues. Do not attempt to circumvent this warm up period, or readjust idle speed during this time. Engine must be completely warmed up, in closed loop operating mode for accurate idle adjustment.

IMPORTANT NOTES!

- Cleanliness is essential and must be maintained at all times when servicing or working on EFI system. Dirt, even in small quantities, can cause significant problems.
- Clean any joint or fitting with parts cleaning solvent before opening to prevent dirt from entering system.
- Always depressurize fuel system through fuel connector on fuel pump before disconnecting or servicing any fuel system components. Refer to equipment manufacturer's manual for information.
- Never attempt to service any fuel system component while engine is running or ignition switch is ON.
- Do not use compressed air if system is open. Cover any parts removed and wrap any open joints with plastic if they will remain open for any length of time. New parts should be removed from their protective packaging just prior to installation.
- Avoid direct water or spray contact with system components.
- Do not disconnect or reconnect ECU wiring harness connector or any individual components with ignition on. This can send a damaging voltage spike through ECU.
- Do not allow battery cables to touch opposing terminals. When connecting battery cables attach positive (+) cable to positive (+) battery terminal first, followed by negative (-) cable to negative (-) battery terminal.
- Never start engine when cables are loose or poorly connected to battery terminals.
- Never disconnect battery while engine is running.
- Never use a quick battery charger to start engine.
- Do not charge battery with key switch ON.
- Always disconnect negative (-) battery cable before charging battery, and also unplug harness from ECU before performing any welding on equipment.

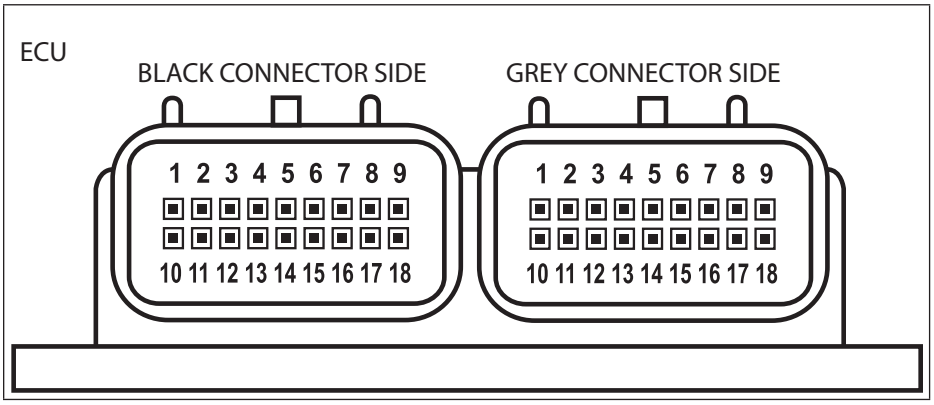
ELECTRICAL COMPONENTS

Electronic Control Unit (ECU)

Pinout of ECU

Black Connector Side	
Pin #	**Function**
1	Ignition Coil Ground
2	Battery Ground
3	Diagnostic Communication Line
4	Speed Sensor input
5	Fuel Injector Output Ground
6	Not Used
7	Oxygen Sensor Heater
8	Intake Air Temperature (TMAP) sensor input
9	Fuel Pump Ground
10	Ground for TPS, TMAP, O2 and Oil Sensors
11	Manifold Absolute Pressure (TMAP) sensor input
12	Throttle Position Sensor (TPS) input
13	Speed Sensor Ground
14	Engine Temperature Sensor input
15	Ignition Switch (Switched +12V)
16	Power for TPS and TMAP Sensors (+5V)
17	Oxygen Sensor (O2) input
18	Battery Power (Permanent +12V)

Grey Connector Side	
Pin #	**Description**
1	Not Used
2	Not Used
3	Malfunction Indicator Light (MIL) Ground
4	Not Used
5	Not Used
6	Not Used
7	Not Used
8	Not Used
9	Battery Ground
10	Not Used
11	Not Used
12	Not Used
13	Not Used
14	Safety Switch Ground
15	Not Used
16	ECU
17	Fuel Pump Control (+12V)
18	Not Used



Pinout of ECU

Never attempt to disassemble ECU. It is sealed to prevent damage to internal components. Warranty is void if case is opened or tampered with in any way.

All operating and control functions within ECU are preset. No internal servicing or readjustment may be performed. If a problem is encountered, and you determine ECU to be faulty, contact your source of supply.

ECU pins are coated at factory with a thin layer of electrical grease to prevent fretting and corrosion. Do not attempt to remove grease from ECU pins.

Relationship between ECU and throttle position sensor (TPS) is very critical to proper system operation. If TPS or ECU is changed, or mounting position of TPS is altered, appropriate TPS Learn Procedure must be performed to restore synchronization.

Any service to ECU, TPS/Throttle Body (including idle speed increase over 300 RPM), or fuel pump replacement should include ECU Reset.

This will clear all trouble codes, all closed loop learned offsets, all max values, and all timers besides permanent hour meter.

This system will NOT reset when battery is disconnected!

ECU Reset Procedure

1. Turn key/ignition OFF.
2. Install Red wire jumper from Kohler EFI service kit on to service port (connect white wire to black wire in 4 way diagnostic port).
3. Turn key/ignition ON, then OFF and count 15 seconds.
4. Turn key/ignition ON, then OFF and count to 15 seconds a second time.
5. Remove Red wire jumper. Turn key/ignition ON, then OFF and count to 15 seconds a third time. ECU is reset.

A TPS Learn Procedure **must** be performed after ECU Reset. Follow TPS Learn Procedure for appropriate specific application being serviced.

TPS Learn Procedure for Pedal Start Applications

NOTE: Refer to equipment manufacturer's manual for details on throttle body cover and throttle cable removal/reinstallation.

1. Remove throttle body cover.
2. Disconnect throttle cable from throttle lever.
3. Turn idle screw clockwise one full turn prior to key/ignition ON after ECU Reset.
4. Start engine, run at low idle until engine is warm.
5. Idle speed must be above 1100 RPM. If below 1100 RPM, turn idle screw up to 1200 RPM and then shut down engine and perform ECU Reset again.
6. Restart engine, adjust idle speed down to 1050 RPM. Allow engine to dwell at 1050 RPM for about 3 seconds.
7. Turn key/ignition OFF and count to 15 seconds.
8. Reinstall throttle cable.
9. Reinstall throttle body cover.

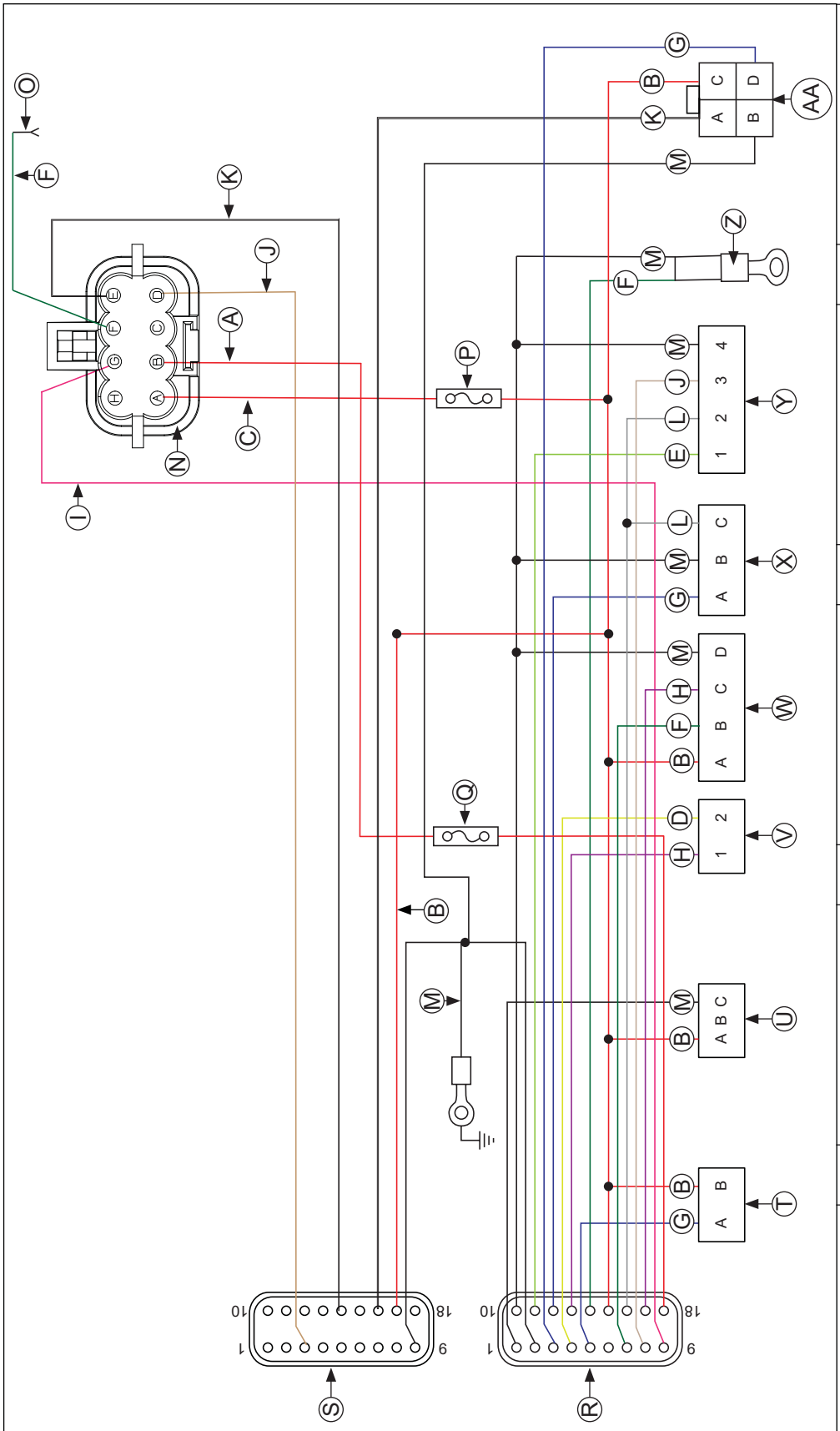
Learn procedure for pedal start application is complete.

TPS Learn Procedure for Key Start Applications

1. Turn idle screw clockwise one full turn prior to key/ignition ON after ECU Reset.
2. Start engine, run at low idle until engine is warm.
3. Idle speed must be above 1200 RPM. If below 1200 RPM, turn idle screw up to 1300 RPM and then shut down engine and perform ECU Reset again.
4. Restart engine, adjust idle speed down to 1250 RPM. Allow engine to dwell at 1250 RPM for about 3 seconds.
5. Turn key/ignition OFF and count to 15 seconds.

Learn procedure for key start application is complete.

Wiring Diagram



A	Red	B	Red/Black	C	Red/White	D	Yellow	E	Light Green		
F	Dark Green	G	Dark Blue	H	Purple	I	Pink (OEM Fuel Pump Relay)	J	Tan		
K	White	L	Grey	M	Black	N	8-Terminal Customer Connector	O	Oil Level Switch		
P	10A Fuse (Ignition Switch)	Q	10A Fuse (Battery Power)	R	Black Connector	S	Grey Connector	T	Fuel Injector		
U	Ignition Coil	V	Crankshaft Position Sensor	W	Oxygen Sensor	X	Throttle Position Sensor	Y	TMAP Sensor		
Z	Engine Temperature Sensor	AA	Diagnostic Connector								

Crankshaft Position Sensor

A sealed, non-serviceable assembly. If fault code P0337 is present and engine does not start/run, proceed to step 1. If P0337 is present and engine operates, clear codes and retest. If Fault Code diagnosis indicates a problem within this area, test and correct as follows.

1. Inspect wiring and connections for damage or problems.
2. Make sure engine has resistor type spark plug.
3. Disconnect Black connector from ECU.
4. Connect an ohmmeter between #4 and #13 pin terminals. A resistance value of 325-395 Ω at room temperature (20°C, 68°F) should be obtained. If resistance is correct, remove blower housing to check sensor mounting, flywheel teeth (damage, run-out, etc.), and flywheel key. Follow procedures in Disassembly to remove blower housing.
5. Disconnect crankshaft position sensor connector from wiring harness. Test resistance between terminals. A reading of 325-395 Ω should again be obtained.
   a. If resistance is incorrect, remove screw securing sensor to bracket and replace sensor.
   b. If resistance in step 4 was incorrect, but resistance of sensor alone was correct, test wire harness circuits between sensor connector terminals and corresponding pin terminals (#4 and #13) in main connector. Correct any observed problem, reconnect sensor, and perform step 4 again.
6. When fault is corrected and engine starts, clear fault codes following ECU Reset procedure.

Throttle Position Sensor (TPS)

TPS is a sealed, non-serviceable assembly. If diagnosis indicates a bad sensor, complete replacement is necessary. If a fault code indicates a problem with TPS, it can be tested as follows:

Diagnostics of sensor: ECU will have electrical faults captured in fault codes P0122 and P0123. Fault code P0122 detecting low voltage, open circuit, and P0123 for high voltage conditions between ECU, wire harness, and sensor. Tip: when working with any electrical connection, remember to keep connections clean & dry. This is best accomplished by cleaning connection thoroughly prior to disassembly. Contaminated sensor connections can cause premature engine faults. Functionally testing sensor cannot be done with simple resistance checks. If either of these two faults is present or a TPS fault is suspected, recommended diagnostic test is as follows:

If a computer with diagnostic software is available

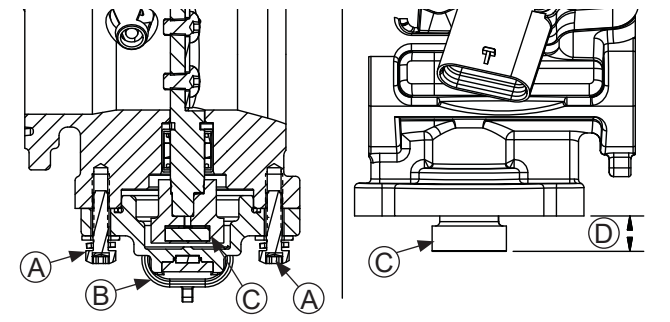
Observe throttle percent and raw TPS values through diagnostic software. With diagnostic software communicating to ECU and key ON engine not running, these values can be observed while throttle is moved from closed to full open position. There should be a smooth and repeatable throttle percent value starting at closed position reading between 0 and 3% to WOT position reading of 93 to 100%. If one of these values is outside of specified range and output transitions in a smooth manner, reset ECU and run test again.

Since there is no longer any wear elements inside sensor, most likely faults will be in electrical connections between sensor and wire harness and wire harness to ECU. With service software communicating to ECU and engine not running, a small load or gentle back and forth motion can be applied to connectors or wires just outside connectors to detect a faulty connection.

If only a volt meter is available

Measure voltage supply to sensor from ECU. This voltage should be 5.00 +/- 0.20 volts. This can be measured by gently probing terminals B & C on harness side with TPS connector removed from TPS and key ON. This will generate a P0122 fault that can be cleared with an ECU reset. If voltage is low, battery, harness and ECU should be investigated. If supply voltage is good, plug sensor back into harness. Probe sensor signal wire with volt meter, terminal A at TPS or pin Black 12 at ECU. This signal should start between 0.6-1.2 volts at low idle and grow smoothly as throttle is opened to 4.3-4.8 volts at full open (WOT). Since there is no longer any wear elements inside sensor, most likely faults will be in electrical connections between sensor and wire harness and wire harness to ECU.

Replace TPS



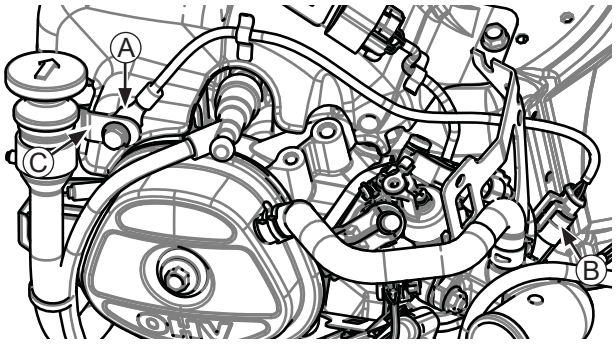
A	TPS Screws	**B**	TPS
C	Magnet Assembly	**D**	Magnet Installation Depth

Magnet assembly is captured in a small plastic housing that is press fit to end of throttle shaft. If replacement is required, it can be replaced as follows:

1. Remove screws securing TPS to throttle body. Remove sensor from throttle body, exposing round magnet assembly.
2. A pair of flat blade screw drivers or a spanner tool can be used to pry this off shaft. Caution should be used to avoid damage to machined flat surface that sensor seals against. Also, make sure throttle blade is in full open position to avoid driving throttle blade into throttle bore causing damage to blade and/or bore.
3. When replacing magnet assembly, alignment is critical. There is a D-shaped drive feature on end of shaft and a matching pocket in magnet assembly. On outer diameter of magnet assembly is a notch that aligns with center of flat feature of D. Align this notch and flat of D feature in shaft and preassemble parts.

4. With throttle blade in full open position (WOT), press magnet assembly fully on to throttle shaft. Full insertion can be checked by measuring height from throttle body sensor mounting face to end of magnet assembly. This should be no more than 8.6 mm (0.34 in.). Installation process requires significant force, so take care that all parts are aligned. Tapping magnet assembly on can fracture/damage brittle magnet within assembly and throttle body assembly and is NOT RECOMMENDED.
5. Install sensor and secure with screws. Torque screws to 1.3 N·m (11.5 in. lb.).

Engine Temperature Sensor



A	Engine Temperature Sensor
B	Unplug Sensor to Replace
C	Dipstick Tube Bracket

NOTE: Engine temperature sensor resembles a ground wire.

A sealed, serviceable assembly. A faulty sensor requires replacement. If a fault code indicates a problem with temperature sensor, it can be tested as follows:

1. Shut off engine and allow it to return to room temperature (25°C, 77°F).
2. With sensor still connected, check temperature sensor circuit resistance between Black pin 10 and 14 terminals. Value should be 9000-11000 Ω.
3. If resistance is out of specifications, unplug sensor from wiring harness and replace. Note that sensor is installed under dipstick tube bracket.

Temperature/Manifold Absolute Pressure (TMAP) Sensor

A sealed non-serviceable integrated sensor that checks both intake air temperature and manifold absolute pressure. Complete replacement is required if it is faulty. Sensor and wiring harness can be checked as follows.

If a fault code indicates a problem with Intake Air Temperature (TMAP) Sensor Circuit (P0112 or P0113), it can be tested as follows:

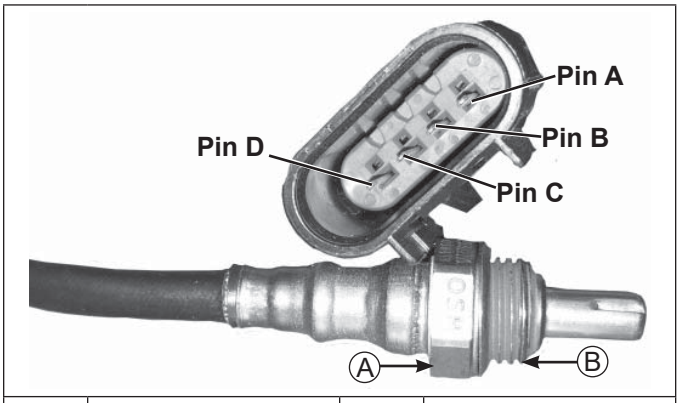
1. Remove TMAP sensor from throttle body.
2. Allow it to reach room temperature (20°C, 68°F).
3. Unplug Black connector from ECU.
4. With sensor still connected, check temperature sensor circuit resistance between Black pin 10 and 8 pin terminals. Value should be 1850-2450 Ω.
5. Unplug sensor from wire harness and check sensor resistance separately across pin. Resistance value should again be 1850-2450 Ω.
   a. If resistance is out of specifications, check local temperature. Sensor resistance will go down as temperature is higher. Replace TMAP sensor if determined to be faulty.
   b. If it is within specifications, proceed to Step 6.
6. Check circuits (input, ground), from main harness connector to sensor plug for continuity, damage, etc. Connect one ohmmeter lead to Black pin 8 in main harness connector (as in step 4). Connect other lead to terminal #3 in sensor plug. Continuity should be indicated. Repeat test between Black pin 10 and terminal #4 in sensor plug.
7. Reinstall sensor.

If a fault code indicates a problem with Manifold Absolute Pressure (TMAP) Sensor Circuit (P0107 or P0108), it can be tested as follows:

1. Make sure all connections are making proper contact and are free of dirt and debris. Slide locking tab out and pull off TMAP connector. Turn key switch to ON and check with a volt meter by contacting red lead to pin 1 and black lead to pin 2. There should be 5 volts present, indicating ECU and wiring harness are functioning.
2. Check continuity in wire harness. Ohms between Pin 3 at sensor connector and Black pin 11 connector at ECU should be near zero ohms. If no continuity is measured or very high resistance, replace wire harness.
3. Check to make sure throttle body is not loose and TMAP sensor is not loose. Loose parts would allow a vacuum leak, making TMAP sensor report misleading information to ECU.
   a. Tighten all hardware and perform an ECU Reset and a TPS Learn Procedure to see if MIL will display a fault with sensor again. If MIL finds a fault with TMAP sensor, replace it.

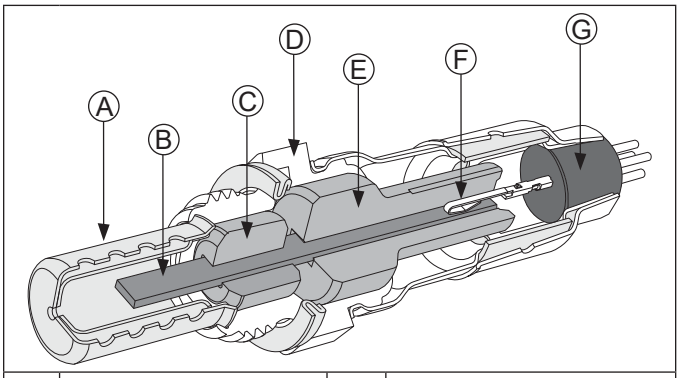
Oxygen Sensor (O2)

Detail



Pin A	Purple Wire, Heater +	**Pin B**	White Wire, Heater -
Pin C	Grey Wire, Sensor Output	**Pin D**	Black Wire, Sensor Ground
A	14 mm or 9/16 in. Wrench Size	**B**	12 mm x 1.25 Thread Size
Installation Torque 18 N·m (159 in. lb.)			

Cutaway Oxygen Sensor (O2) Components



A	Protection Shield	**B**	Planar Element and Heater
C	Lower Insulator	**D**	Stainless Steel Housing
E	Upper Insulator	**F**	Terminal Connection to Element
G	High Temp Water Seal		

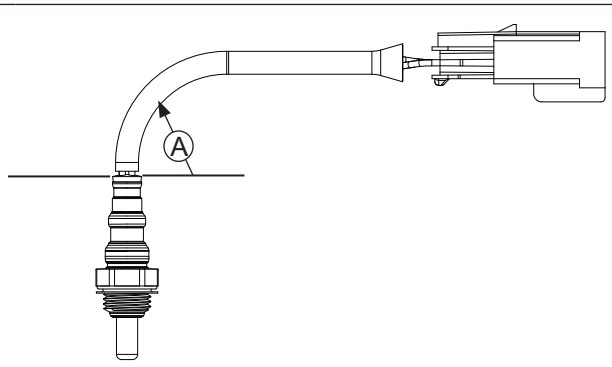
Temperature must be controlled very accurately and gas constituents measured to a high degree of accuracy for absolute sensor measurements. This requires laboratory equipment to determine a good or bad sensor in field. Furthermore, as with most devices, intermittent problems are difficult to diagnose. Still, with a good understanding of system and sensor, it is possible to diagnose many sensor problems in field.

Using diagnostic software connected to ECU is a useful technique for observing sensor performance. However, user must understand that such software reads a signal generated by ECU. If there is an ECU or wiring problem, readings could be misinterpreted as a sensor problem. Digital nature of signal to software means that it is not reading continuous output of sensor. A voltmeter can also be used as an effective tool in diagnosing sensors.

It is advisable to use an electronic meter such as a digital voltmeter. Simple mechanical meters may place a heavy electrical load on sensor and cause inaccurate readings. Since resistance of sensor is highest at low temperatures, such meters will cause largest inaccuracies when sensor is in a cool exhaust.

Visual Inspection

Sensor Wire Detail



A	Keep a minimum of 25 mm (1.0 in.) radius at grommet.

NOTE: Always route harness away from hot exhaust and away from moving parts.

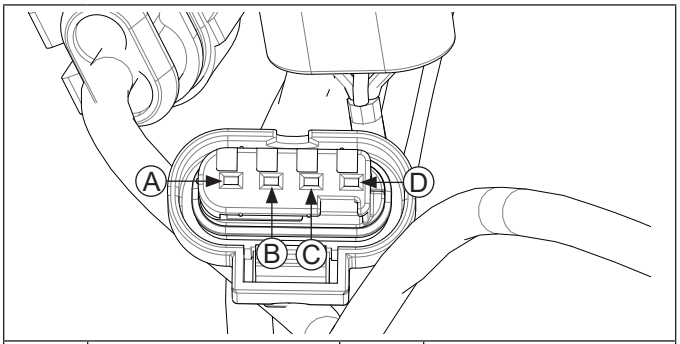
NOTE: **Do not attempt to clean sensor.** Replace as needed.

1. Look for a damaged or disconnected sensor-to-engine harness connection.
2. Look for damage to sensor lead wire or associated engine wiring due to cutting, chaffing or melting on a hot surface.
3. Disconnect sensor connector and look for corrosion in connector.
4. Try reconnecting sensor and observe if problem has cleared.
5. Correct any problems found during visual check.
6. Inspect for any exhaust system leaks upstream or downstream of oxygen sensor. Confirm oxygen sensor is secured to 18 N·m (159 in. lb.).

   All leaks must be repaired and an ECU/TPS reset must be performed before proceeding with sensor testing.
7. Using diagnostic software, document any trouble codes. Determine if historic trouble codes are logically related to current fault experienced. If uncertain, clear codes and retest.

Sensor Signal Observation

Engine Harness O2 Sensor Connector Plug Detail



A	Red w/Black Stripe	**B**	Dark Green
C	Purple	**D**	Black

NOTE: **Do not cut into or pierce sensor or engine wiring to make this connection.** Sensor produces a very small signal. Corrosion or damage to wiring could lead to an incorrect signal because of repairs or contamination to sensor.

1. With sensor connected and using diagnostic software, start engine to observe O2 sensor activity. Run engine at sufficient speed to bring sensor and engine up to operating temperature (engine temperature of 150°F (66°C) or more displayed by diagnostic software).

   Maintained throttle openings of less than 37% typically display closed loop operation where sensor output voltage should cycle between 0.05 to 0.95 Volts.

   Maintained throttle openings of 38-50% and above typically display open loop operation where sensor should have above 0.500 Volt. Occasional spikes outside these values is normal. Lack of continuous fluctuation is not an indication of a defective sensor.
2. With key ON and engine OFF, sensor connected, using diagnostic software, O2 volts displayed should be more than 1.0 volt. This voltage is generated by ECU. If not present, there may be a power and/or ground supply fault to engine harness or ECU, a fault of engine harness itself (refer to Visual Inspection), or a fault of ECU.

   With key ON and sensor unplugged, using a digital voltmeter, observe voltage between Pin socket C and Pin socket D of engine wiring harness (refer to engine harness connector plug detail at top of page). Voltage should read approximately 5.0 volts.
3. Using a digital voltmeter, observe system sensor voltage between Pin socket A and negative (-) battery ground. Battery voltage should be seen. If battery voltage is not seen, inspect engine wiring, fuses, and/or electrical connections.

Removal Inspection

NOTE: Apply anti-seize compound only to threads. **Anti-seize compound will affect sensor performance if it gets into lower shield of sensor.**

1. If sensor has heavy deposits on lower shield, engine, oil, or fuel may be source.
2. If heavy carbon deposits are observed, incorrect engine fuel control may be occurring.
3. With sensor at room temperature, measure heater circuit resistance, purple wire (Pin A) and white wire (Pin B).

   Resistance should be 16.5-19.5 Ω.
4. If a damaged sensor is found, identify root cause, which may be elsewhere in application. Refer to Troubleshooting-Oxygen (O2) Sensor table.
5. A special "dry to touch" anti-seize compound is applied to all new oxygen sensors at factory. If recommended mounting thread sizes are used, this material provides excellent anti-seize capabilities and no additional anti-seize is needed. If sensor is removed from engine and reinstalled, anti-seize compound should be reapplied. Use an oxygen sensor safe type anti-seize compound. It should be applied according to directions on label. Torque sensor to 18 N·m (159 in. lb.).

Troubleshooting-Oxygen (O2) Sensor

Condition	Possible Cause	Conclusion
Continuous low voltage output (less than 400mV) observed with throttle openings of 38-50% or more. Fault codes P0131, P0171, or P0174 may set.	Shorted sensor or sensor circuit. Shorted lead wire. Wiring shorted to ground.	Replace sensor or replace and properly route wiring.
	Upstream or downstream exhaust leaks observed. Air leak at sensor.	Repair all exhaust leaks and torque sensor to 18 N·m (159 in. lb.).
	Restricted fuel supply.	Resolve fuel supply issues from tank to engine. Test fuel pressure. Perform repairs necessary.
	Misfire	A misfire causing incomplete combustion will result in lean (low voltage) values.
	Sensor failure-stuck lean.	Replace sensor.
Continuous high voltage output (600mV or more) observed with throttle openings of 37% or less. Fault codes P0172 or P0132 may set.	Silica poisoning.	Replace sensor. Identify and resolve root cause.
	Contaminated gasoline.	Purge fuel system and retest.
	Wiring shorted to voltage.	Replace damaged harness.
	Overly rich condition due to unmetered fuel entering combustion chamber.	Test fuel pressure. Inspect fuel pump vent and evaporative emissions hoses for raw fuel flow. Inspect engine oil for fuel contamination; drain and refill if suspect. Perform repairs as necessary.
	Cold engine. Engine temperature below 150°F (66°C) as displayed by diagnostic software.	Normal operation, or engine operated in an excessively cold environment.
	Sensor failure-stuck rich.	Replace sensor.
No activity from sensor. Diagnostic software displays 1.015 Volts continuously. Fault codes P0031 or P0032 may set.	Heater circuit open or shorted.	Replace sensor.
	Engine keyed ON with sensor disconnected. Historic codes.	Secure and/or confirm sensor connection and clear codes.
	Contaminated gasoline.	Purge fuel system and retest.
	Broken wire. Damaged sensor.	Replace sensor.

Fuel Injector

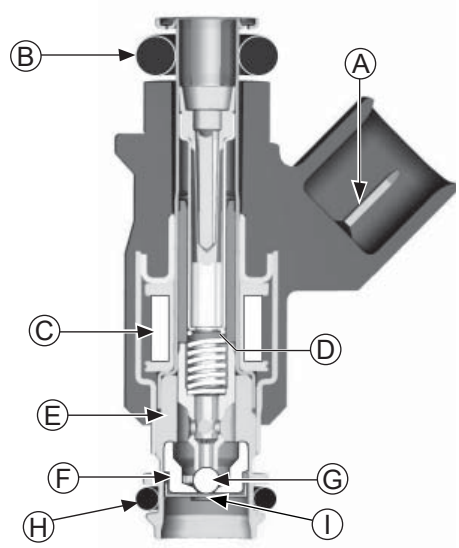
⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Do not fill fuel tank while engine is hot or running.

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

Details



A	Electrical Connection	**B**	Upper O-ring
C	Solenoid Winding	**D**	Armature
E	Valve Housing	**F**	Valve Seat
G	Valve End	**H**	Lower O-ring
I	Director Plate		

NOTE: Do not apply voltage to fuel injector. Excessive voltage will burn out injector. Do not ground injector with ignition ON. Injector will open/turn on if relay is energized.

NOTE: When cranking engine with injector disconnected, fault codes will be registered in ECU and will need to be cleared using software fault clear or an ECU Reset and TPS Learn Procedure.

Injector problems typically fall into three general categories: electrical, dirty/clogged, or leakage. Injector problems due to dirt or clogging are generally unlikely due to design of injector, high fuel pressure, and detergent additives in gasoline. Symptoms that could be caused by dirty/clogged injector include rough idle, hesitation/stumbling during acceleration, or triggering of fault codes related to fuel delivery.

Injector clogging is usually caused by a buildup of deposits on director plate, restricting flow of fuel, resulting in a poor spray pattern. Some contributing factors to injector clogging include higher than normal operating temperatures, short operating intervals, and dirty, incorrect, or poor quality fuel.

Cleaning of clogged injector is not recommended; it should be replaced. Additives and higher grades of fuel can be used as a preventative measure if clogging has been a problem.

An electrical problem usually will cause injector to stop functioning. Several methods may be used to check if injector is operating.

1. With engine running at idle, listen for a buzzing or clicking sound.
2. Disconnect electrical connector from injector and engine should stop running. If engine continues to run, disconnect vent line at air cleaner base. If engine continues to run, injector is suspect.

If an injector is not operating, it can indicate either a bad injector, or a wiring/electrical connection problem. Check as follows:

1. Disconnect electrical connector from injector. Plug a 12 volt noid light into connector.
2. Make sure all safety switch requirements are met. Crank engine and check for flashing of noid light.
   a. If flashing occurs, use an ohmmeter (Rx1 scale) and check resistance of injector across two terminals. Proper resistance is 11-13 Ω. If injector resistance is correct, check whether connector and injector terminals are making a good connection. If resistance is not correct, replace injector.

Check all electrical connections, connectors, and wiring harness leads if resistance is incorrect.

Injector leakage is very unlikely, but in those rare instances it can be internal (past tip of valve needle), or external (weeping around injector O-ring). Loss of system pressure from leakage can cause hot restart problems and longer cranking times. Refer to Disassembly for removal of injector.

1. Remove throttle body from engine leaving TPS, high pressure fuel line, injector and fuel line connections intact. Discard old gaskets.
2. Position throttle body over an appropriate container to capture fuel and turn key switch ON to activate fuel pump and pressurize system. Do not turn switch to START position.
3. If injector exhibits leakage of more than two to four drops per minute from tip, or shows any sign of leakage around outer shell, turn ignition switch OFF and replace injector as follows.
4. Depressurize fuel system and disconnect high pressure fuel line from fuel injector cap.
5. Clean any dirt accumulation from sealing/mounting area of faulty injector and disconnect electrical connector.

6. Pull retaining clip to separate fuel injector cap/bracket assembly from injector. Remove screw holding fuel injector cap/bracket assembly to throttle body. Lift injector from throttle body.
7. Reverse appropriate procedures to install new injector and reassemble engine. Use new O-ring and retaining clip any time an injector is removed (new replacement injector includes new O-rings and retaining clip). Lubricate O-rings lightly with clean engine oil. Use installation tool provided with O-rings to install new upper O-ring. Place tool into fuel injector inlet. Place one side of O-ring into O-ring groove and roll O-ring over tool onto fuel injector. Torque screw securing fuel injector cap to 7.3 N·m (65 in. lb.). An ECU Reset and TPS Learn Procedure will need to be completed.

Ignition Coil

If coil is determined to be faulty, replacement is necessary. An ohmmeter may be used to test wiring and coil windings.

NOTE: Do not ground coil with ignition ON as it may overheat or spark.

NOTE: Always disconnect spark plug lead from spark plug before performing following tests.

NOTE: **If ignition coil is disabled and an ignition fault is registered, system will automatically disable corresponding fuel injector drive signal.** Fault must be corrected to ignition coil and ECU power (switch) must be turned OFF for 15 seconds for injector signal to return. This is a safety measure to prevent bore washing and oil dilution.

Testing

Using an ohmmeter set on Rx1 scale, check resistance in circuit as follows:

1. To check ignition coil, disconnect Black connector from ECU and test between Black pins 1 and 15. Wiring and coil primary circuit is OK if reading is 0.85-1.15 Ω.
2. If reading is not within specified range, check and clean connections and retest.
3. If reading is still not within specified range, test coil separately from main harness as follows:
   a. Remove mounting screw retaining coil and disconnect primary lead connector.
   b. Connect an ohmmeter set on Rx1 scale to primary terminal of coil. Primary resistance should be 0.5-0.8 Ω.
   c. Connect an ohmmeter set on Rx10K scale between spark plug boot terminal and B+ primary terminal. Secondary resistance should be 6400-7800 Ω.
   d. If either primary or secondary resistance is not within specified range, coil is faulty and needs to be replaced.

FUEL COMPONENTS



⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Do not fill fuel tank while engine is hot or running.

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

NOTE: Engines in this application have in-tank fuel pump, EFI fuel filter, and all fuel lines supplied and installed by OEM. Refer to equipment manufacturer's manual for information on these components and before working on fuel system.

In-Tank Fuel Pump (OEM Supplied and Installed)

Refer to equipment manufacturer's manual for information. Use only original equipment replacement parts.

High Pressure Fuel Line (OEM Supplied and Installed)

No specific servicing is required unless operating conditions indicate that it needs replacement. Thoroughly clean area around all joints and relieve any pressure before starting any disassembly. Refer to equipment manufacturer's manual for information. Use only original equipment replacement parts.

Vent Hose Assembly (OEM Supplied and Installed)

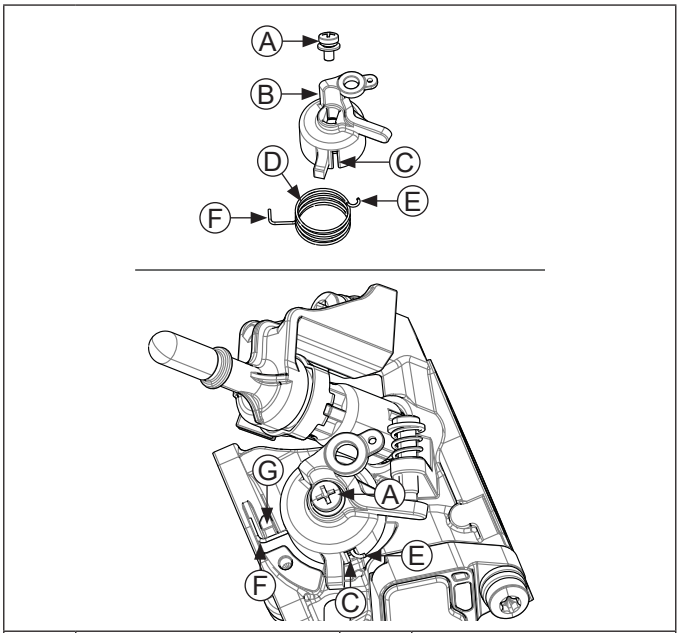
Purge port is located on throttle body by TMAP sensor and no specific servicing is required. No specific servicing is required for vent hose assembly (OEM supplied) unless operating conditions indicate replacement is required. Use only original equipment replacement parts. Visit KohlerEngines.com for recommended Kohler replacement parts; refer to equipment manufacturer's manual for replacement part information.

Throttle Body Assembly

NOTE: ECU Reset is required if throttle body is replaced.

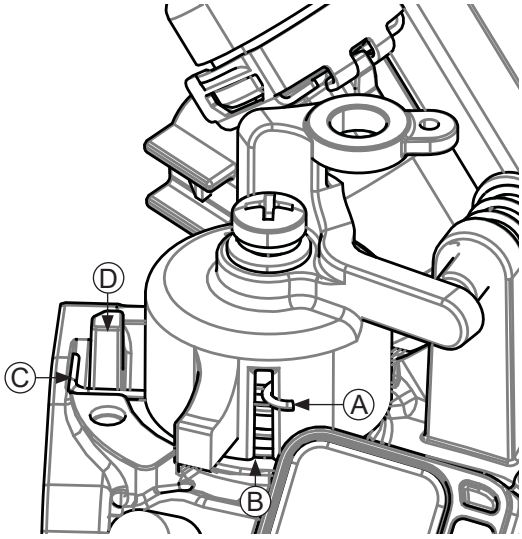
Throttle body is serviced as an assembly, with throttle shaft, TPS, throttle plate, TMAP sensor, fuel injector/cap/bracket assembly, return spring, and idle speed adjusting screw installed. Throttle shaft rotates on needle bearings (non-serviceable), capped with seals to prevent air leaks.

NOTE: If return spring is replaced, proper placement of each hook end is required. Take note of each hook end before removing screw securing throttle lever.



A	Screw	**B**	Throttle Lever
C	Window	**D**	Return Spring
E	Hook End	**F**	L-Shaped Hook End
G	Post		

1. Remove screw, throttle lever, and return spring.
2. Insert hook end of return spring in window of throttle lever and hold in place.
3. Hold throttle plate closed while positioning L-shaped hook end of return spring on post; holding throttle lever at slight angle, install throttle lever/spring assembly onto throttle shaft. A slight clockwise spring load rotation is required to align lever onto shaft.
4. Check that hook is in upper 1/3 to 1/2 of window in throttle lever. If hook is further down in window, wire is bound and steps 2 and 3 should be repeated.



A	Hook End	**B**	Window
C	L-Shaped Hook End	**D**	Post

5. When hook end is in proper position, install screw to secure throttle lever to shaft. Torque screw to 1.3 N·m (11.5 in. lb.).

TROUBLESHOOTING

Troubleshooting Guide

Condition	Possible Cause
Engine Starts Hard or Fails to Start When Cold.	Fuel pump not running.
	Empty fuel tank.
	Faulty spark plug.
	Old/stale fuel.
	Incorrect fuel pressure.
	Crankshaft position sensor loose or faulty.
	TPS set incorrect (ECU Reset and TPS Learn).
	TPS faulty.
	Engine temperature sensor faulty.
	Faulty coil.
	Low system voltage.
	Faulty injector.
	Faulty battery.
	Loose or corroded connections.
Engine Starts Hard or Fails to Start When Hot.	Faulty spark plug.
	Fuel pump not running.
	Fuel pressure low.
	Insufficient fuel delivery.
	TPS set incorrect (ECU Reset and TPS Initialization).
	Crankshaft position sensor loose or faulty.
	TPS faulty.
	Engine temperature sensor faulty.
	Faulty injector.
Engine Stalls or Idles Roughly (cold or warm).	Faulty spark plug.
	Insufficient/excessive fuel delivery.
	TPS set incorrect.
	TPS faulty.
	Faulty engine temperature sensor.
	Faulty injector.
Engine Misses, Hesitates, or Stalls Under Load.	Fuel injector, fuel filter, fuel line, or fuel pick-up dirty/restricted.
	Dirty air cleaner.
	Insufficient fuel pressure or fuel delivery.
	Vacuum (intake air) leak.
	Improper governor setting, adjustment or operation.
	TPS/TMAP faulty, mounting problem or TPS Initialization Procedure incorrect.
	Bad coil, spark plug, or wires.

Troubleshooting Guide

Condition	Possible Cause
Low Power	Faulty/malfunctioning ignition system.
	Dirty air filter.
	Insufficient fuel delivery.
	Improper governor adjustment.
	Plugged/restricted exhaust.
	Basic engine problem exists.
	TPS faulty or mounting exists.
	Throttle plate in throttle body not fully opening to WOT stop (if equipped).

Function Test



⚠ WARNING

High Pressure Fluids can puncture skin and cause severe injury or death.

Do not work on fuel system without proper training or safety equipment.

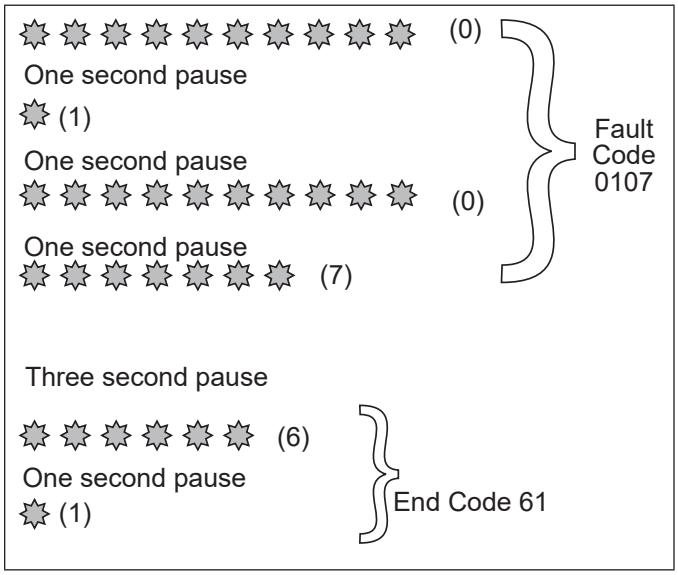
Fluid puncture injuries are highly toxic and hazardous. If an injury occurs, seek immediate medical attention.

Function of fuel system is to provide sufficient delivery of fuel at system operating pressure of 50 psi ± 3. If an engine starts hard, or turns over but will not start, it may indicate a problem with EFI fuel system. A quick test will verify if system is operating.

1. Disconnect and ground spark plug lead.
2. Complete all safety interlock requirements and crank engine for approximately 3 seconds.
3. Remove spark plug and check for fuel at tip.
   a. If there is fuel at tip of spark plug fuel pump and injector are operating.
   b. If there is no fuel at tip of spark plug, check following:
      1. Make sure fuel tank contains clean, fresh, proper fuel.
      2. Make sure that vent in fuel tank is open.
      3. Make sure fuel tank valve (if equipped) is fully opened.
      4. Make sure battery is supplying proper voltage.
      5. Check that fuses and fuel pump relay are good, and that no electrical or fuel line connections are damaged or broken.
      6. Test fuel pump operation as described in original equipment manufacturer's manual.

Fault Codes

Example of Diagnostic Display



Diagnostic Fault Code Summary

Fault Code	Connection or Failure Description
0031	Oxygen Sensor Heater Circuit Low Voltage
0032	Oxygen Sensor Heater Circuit High Voltage
0107	Manifold Absolute Pressure (TMAP) Circuit Low Voltage or Open
0108	Manifold Absolute Pressure (TMAP) Circuit High Voltage
0112	Intake Air Temperature (TMAP) Circuit Low Voltage
0113	Intake Air Temperature (TMAP) Circuit High Voltage or Open
0117	Engine Temperature Sensor Circuit Low Voltage
0118	Engine Temperature Sensor Circuit High Voltage or Open
0122	Throttle Position Sensor Circuit Low Voltage or Open
0123	Throttle Position Sensor Circuit High Voltage
0131	Oxygen Sensor 1 Circuit Low Voltage, or Open
0132	Oxygen Sensor 1 Circuit High Voltage
0171	Maximum Adaptation Limit Exceeded
0172	Minimum Adaptation Limit Exceeded
0174	Lean Fuel Condition at High Load (Open Loop)
0201	Injector Circuit Malfunction
0230	Fuel Pump Relay Circuit Low Voltage or Open
0232	Fuel Pump Relay Circuit High Voltage
0336	Crankshaft Position Sensor Noisy Signal
0337	Crankshaft Position Sensor No Signal
0351	Ignition Coil Malfunction
0562	System Voltage Low
0563	System Voltage High
0650	MIL Circuit Malfunction
61	End of Code Transmission

MIL Operation for Pedal Start Applications
Key ON/MIL on for 3 seconds then turns off. MIL will remain off during normal operation or until a trouble code/fault is detected or until key switch is cycled power OFF for 15 seconds and returned to key ON position.

If code/fault is detected and is a current code, light will remain on for duration of operating cycle (key ON). If code/fault is temporarily detected and fault is recorded and then returns to normal, MIL will go out, but code is stored in ECU as a historic code.

MIL Operation for Key Start Applications
ECU continuously monitors engine operation against preset performance limits. If operation is outside limits, ECU activates MIL, if equipped, and stores a diagnostic code in its fault memory. If component or system returns to proper function, ECU will turn off MIL. If MIL stays illuminated, it warns customer a fault is currently happening, and dealer service is required. Upon receipt, dealer technician can access fault code(s) to help determine what portion of system is malfunctioning.

Codes are accessed through key switch and displayed as blinks or flashes of MIL. Access codes as follows:

1. Check that battery voltage is above 11 volts.
2. Start with key switch OFF.
3. Turn key switch to ON and OFF, then ON and OFF, then ON, leaving it on in third sequence. Do not start engine. Time between sequences must be less than 2.5 seconds.
4. MIL will blink a series of times. Number of times MIL blinks represents a number in fault code.
5. A sequence of four digits make up a fault code. There is a one (1) second pause between blinks of a fault code. There is a three (3) second pause between separate fault codes. After fault code(s) are blinked a two digit 61 is blinked to indicate program has completed. Zero (0) = ten (10) blinks.
   a. It's a good idea to write down codes as they appear, as they may not be in numerical sequence.
   b. Code 61 will always be last code displayed, indicating end of code transmission. If code 61 appears immediately, no other fault codes are present.

After problem has been corrected, fault codes may be cleared by following ECU Reset and TPS Learn Procedures.

Diagnostic Fault Code Summary lists fault codes, and what they correspond to. Diagnostic Code Summary is a list of individual codes with an explanation of what triggers them, what symptoms might be expected, and probable causes.

Diagnostic Code Summary

Code 0031

NOTE: Codes 0031 and 0032 may have been mistakenly activated by turning key ON with oxygen sensor disconnected. If either code status is historic, that code may have set during assembly or a previous repair and may not be related to current event. Clear codes and retest to confirm. If code status is current, refer to Oxygen Sensor (O2) earlier in this section, to test and troubleshoot.

Component:	Oxygen Sensor Heater
Fault:	O2S Heater Circuit Low Voltage
Condition:	System voltage too low, open connection or faulty sensor.
Conclusion:	Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU black pin 7 or broken wire. Oxygen Sensor Related ● Sensor connector or wiring problem. Poor system ground from ECU to engine or battery to engine.

Code 0032

NOTE: Codes 0031 and 0032 may have been mistakenly activated by turning key ON with oxygen sensor disconnected. If either code status is historic, that code may have set during assembly or a previous repair and may not be related to current event. Clear codes and retest to confirm. If code status is current, refer to Oxygen Sensor (O2) earlier in this section, to test and troubleshoot.

Component:	Oxygen Sensor Heater
Fault:	O2S Heater Circuit High Voltage
Condition:	System voltage too high, shorted connection or faulty sensor.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor damaged. ● Pin circuit wiring or connectors at Black 7. ECU Related ● ECU-to-harness connection problem.

Code 0107

Component:	Manifold Absolute Pressure (TMAP)
Fault:	MAP Circuit Low Voltage or Open
Condition:	Throttle body leak, open connection or faulty sensor.
Conclusion:	TMAP Sensor Related ● Sensor malfunction. ● Vacuum leaks from loose throttle body or sensor. Wire Harness Related ● Poor grounding or open circuit. ● Wire harness and connectors loose, damaged or corroded. ● Pin circuit wiring or connectors at Black 10, 11 and 16. Bad TPS Learn.

Code 0108

Component:	Manifold Absolute Pressure (TMAP)
Fault:	MAP Circuit High Voltage
Condition:	Throttle body leak, shorted connection or faulty sensor.
Conclusion:	TMAP Sensor Related ● Sensor malfunction. ● Vacuum leaks from loose throttle body or sensor. Wire Harness Related ● Poor grounding. ● Pin circuit wiring or connectors at Black 11. Bad TPS Learn.

Code 0112

Component:	Intake Air Temperature (TMAP)
Fault:	Intake Air Temperature Sensor Circuit Low Voltage
Condition:	Shorted connection, faulty sensor or shorted wire.
Conclusion:	TMAP Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits Black 10 and Black 8 may be damaged or routed near noisy signal (coil, alternator, etc.). ● ECU-to-harness connection problem.

Code 0113

Component:	Intake Air Temperature (TMAP)
Fault:	Intake Air Temperature Sensor Circuit High Voltage or Open
Condition:	Shorted connection, faulty sensor, broken wire or connection.
Conclusion:	TMAP Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits ECU Black pin 10 and 8 may be damaged. ● ECU-to-harness connection problem or broken wire.

Code 0117

Component:	Engine Temperature Sensor
Fault:	Engine Temperature Sensor Circuit Low Voltage
Condition:	Shorted connection, faulty sensor or shorted wire.
Conclusion:	Temperature Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits Black 10 and Black 14 maybe damaged or routed near noisy signal (coils, stator, etc.). ● ECU-to-harness connection problem.

Code 0118

Component:	Engine Temperature Sensor
Fault:	Engine Temperature Sensor Circuit High Voltage or Open
Condition:	Shorted connection, faulty sensor, open connection or broken wire.
Conclusion:	Temperature Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits ECU Black pin 10 and 14 may be damaged. ● ECU-to-harness connection problem or broken wire. System Related ● Engine is operating above 176°C (350°F) temperature sensor limit.

Code 0122

Component:	Throttle Position Sensor (TPS)
Fault:	TPS Circuit Low Voltage or Open
Condition:	Open connection, broken wire or faulty sensor.
Conclusion:	TPS Related ● TPS bad or worn internally. Engine Wiring Harness Related ● Broken or shorted wire in harness. ECU Black pin 10 to TPS pin B. ECU Black pin 12 to TPS pin A. ECU Black pin 16 to TPS pin C. Throttle Body Related ● Throttle shaft inside TPS worn, broken, or damaged. ● Throttle plate loose or misaligned. ● Throttle plate bent or damaged allowing extra airflow past, or restricting movement. ECU Related ● Circuit providing voltage or ground to TPS damaged. ● TPS signal input circuit damaged.

Code 0123

Component:	Throttle Position Sensor (TPS)
Fault:	TPS Circuit High Voltage
Condition:	Shorted connection or faulty sensor.
Conclusion:	TPS Sensor Related ● Sensor connector or wiring. ● Sensor output affected or disrupted by dirt, grease, oil, wear. ● Sensor loose on throttle body. Throttle Body Related ● Throttle shaft or bearings worn/ damaged. Engine Wiring Harness Related ● ECU pins Black 10, 12 and 16 damaged (wiring, connectors). ● ECU pins Black 10, 12 and 16 routed near noisy electrical signal (coil, alternator). ● Intermittent 5 volt source from ECU (pin Black 16). ● ECU-to-harness connection problem.

Code 0131

Component:	Oxygen Sensor
Fault:	O2S 1 Circuit Low Voltage
Condition:	Open connection, broken wire or faulty sensor.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor contaminated, corroded or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or 17. TPS Learn Procedure Incorrect ● Lean condition (check oxygen sensor signal with VOA and refer to Oxygen Sensor section). Engine wiring harness related such as a cut wire, broken or pinched.

Code 0132

Component:	Oxygen Sensor
Fault:	O2S 1 Circuit High Voltage
Condition:	Shorted connection or faulty sensor.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor contaminated or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or Black pin 17. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Short in wire harness.

Code 0171

Component:	Fuel System
Fault:	Maximum adaptation limit exceeded
Condition:	Fuel inlet screen/filter plugged, low pressure at high pressure fuel line, TPS malfunction, shorted connection, faulty sensor, low fuel or wrong fuel type.
Conclusion:	Oxygen Sensor Related ● Corrosion or poor connection. ● Sensor contaminated or damaged. ● Air leak into exhaust. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or Black pin 17. TPS Sensor Related ● Throttle plate position incorrect during Learn procedure. ● TPS problem or malfunction. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Problem in wiring harness. ● ECU-to-harness connection problem. Systems Related ● Ignition (spark plug, plug wire, ignition coil). ● Fuel (fuel type/quality, injector, fuel pressure too low, fuel pump). ● Combustion air (air cleaner dirty/ restricted, intake leak, throttle bore). ● Base engine problem (rings, valves). ● Exhaust system leak (muffler, flange, oxygen sensor mounting boss, etc.). ● Fuel in crankcase oil.

Code 0172

Component:	Fuel System
Fault:	Minimum adaptation limit exceeded
Condition:	Too high pressure at high pressure fuel line, TPS malfunction, shorted connection, faulty sensor or fuel pump failure.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring. ● Sensor contaminated or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or 17. TPS Sensor Related ● Throttle plate position incorrect during Learn procedure. ● TPS problem or malfunction. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Problem in wiring harness. ● ECU-to-harness connection problem. Systems Related ● Ignition (spark plug, plug wire, ignition coil). ● Fuel (fuel type/quality, injector, fuel pressure too high, fuel pump). ● Combustion air (air cleaner dirty/ restricted). ● Base engine problem (rings, valves). ● Fuel in crankcase oil.

Code 0174

Component:	Fuel System
Fault:	Lean fuel condition
Condition:	Fuel inlet screen/filter plugged, low pressure at high pressure fuel line, TPS malfunction, shorted connection or faulty sensor.
Conclusion:	TPS Learn Incorrect ● Lean condition (check oxygen sensor signal with VOA and refer to Oxygen Sensor). Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 10, 12, 16 and 17. Low Fuel Pressure ● Plugged filters. Oxygen Sensor Related ● Sensor connector or wiring problem. ● Exhaust leak. ● Poor ground. Poor system ground from ECU to engine, causing rich running while indicating lean. Fuel pump connection. Refer to equipment manufacturer's manual for information.

Code 0201

Component:	Fuel Injector
Fault:	Injector Circuit Malfunction
Condition:	Injector damaged or faulty, shorted or open connection.
Conclusion:	Injector Related ● Injector coil shorted or opened. Engine Wiring Harness Related ● Broken or shorted wire in harness. ECU pin Black 5. ● Wiring from Ignition. ECU Related ● Circuit controlling injector damaged.

Code 0230

Component:	Fuel Pump Relay
Fault:	Circuit Low Voltage or Open
Condition:	Shorted or open connection.
Conclusion:	Fuel Pump Relay Related ● Fuel pump relay open or shorted internally. Engine Wiring Harness related ● Broken or shorted wire in harness. ECU pin Black 9 or Grey 17. ECU Related ● ECU is damaged.

Code 0232

Component:	Fuel Pump Relay
Fault:	Circuit High Voltage
Condition:	Shorted connection.
Conclusion:	Fuel Pump Relay Related ● Fuel pump damaged internally. Charging Output System Too High.

Code 0336

Component:	Crankshaft Position Sensor
Fault:	Crankshaft Position Sensor Noisy Signal
Condition:	Loose sensor, faulty/bad battery, shorted or faulty connection, faulty sensor or faulty sensor grounding.
Conclusion:	Crankshaft Position Sensor Related ● Sensor connector or wiring. ● Sensor loose. Crankshaft Position Sensor Wheel Related ● Damaged teeth. ● Gap section not registering. Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 4 and Black 13. ● ECU-to-harness connection problem. Ignition System Related ● Non-resistor spark plug used. ● Faulty or disconnected ignition coil or secondary lead.

Code 0337

NOTE: If fault code P0337 is present and engine does not start/run, proceed to step 1 of Crankshaft Position Sensor earlier in this section. If P0337 is present and engine operates, clear codes and retest.

Component:	Crankshaft Position Sensor
Fault:	Crankshaft Position Sensor No Signal
Condition:	Loose sensor, open or shorted connection (sensor connector or battery connections) or faulty sensor.
Conclusion:	Crankshaft Position Sensor Related ● A false fault code P0337 is triggered by a voltage drop with key ON and engine off. Voltage drop may be caused by a poor/inadequate battery connection, battery charger connected or disconnected, or any event that may interrupt voltage signal to ECU like a power interruption or heavy load from equipment that results in a recordable voltage drop. ● Sensor connector or wiring. ● Sensor loose. Crankshaft Position Sensor Wheel Related ● Damaged teeth. Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 4 or Black 13. ● ECU-to-harness connection problem. If code is stored in fault history and starts normally. Clear code, no other service required.

Code 0351

Component:	Ignition Coil
Fault:	Ignition Coil Malfunction
Condition:	Broken wire in harness (may not be visible), shorted connection or faulty sensor.
Conclusion:	Engine Wiring Harness Related ● Connection to ignition or fuse. ● Pin circuit wiring or connectors. ● ECU pin Black 1. ● ECU-to-harness connection problem. Ignition System Related ● Incorrect spark plug used. ● Poor connection to spark plug.

Code 0562

Component:	System Voltage
Fault:	System Voltage Low
Condition:	Bad fuse or shorted connection.
Conclusion:	Corroded Connections Bad Battery* ● Low output charging system.* ● Bad or missing fuse.* *Refer to equipment manufacturer's manual for information.

Code 0563

Component:	System Voltage
Fault:	System Voltage High
Condition:	Shorted connection.
Conclusion:	Bad Battery.* ● Low output charging system.* *Refer to equipment manufacturer's manual for information.

Code 0650

Component:	MIL Circuit
Fault:	MIL Circuit Malfunction
Condition:	Failure in MIL circuit detected.
Conclusion:	Bad Connection. Broken Wire. Bad ECU.

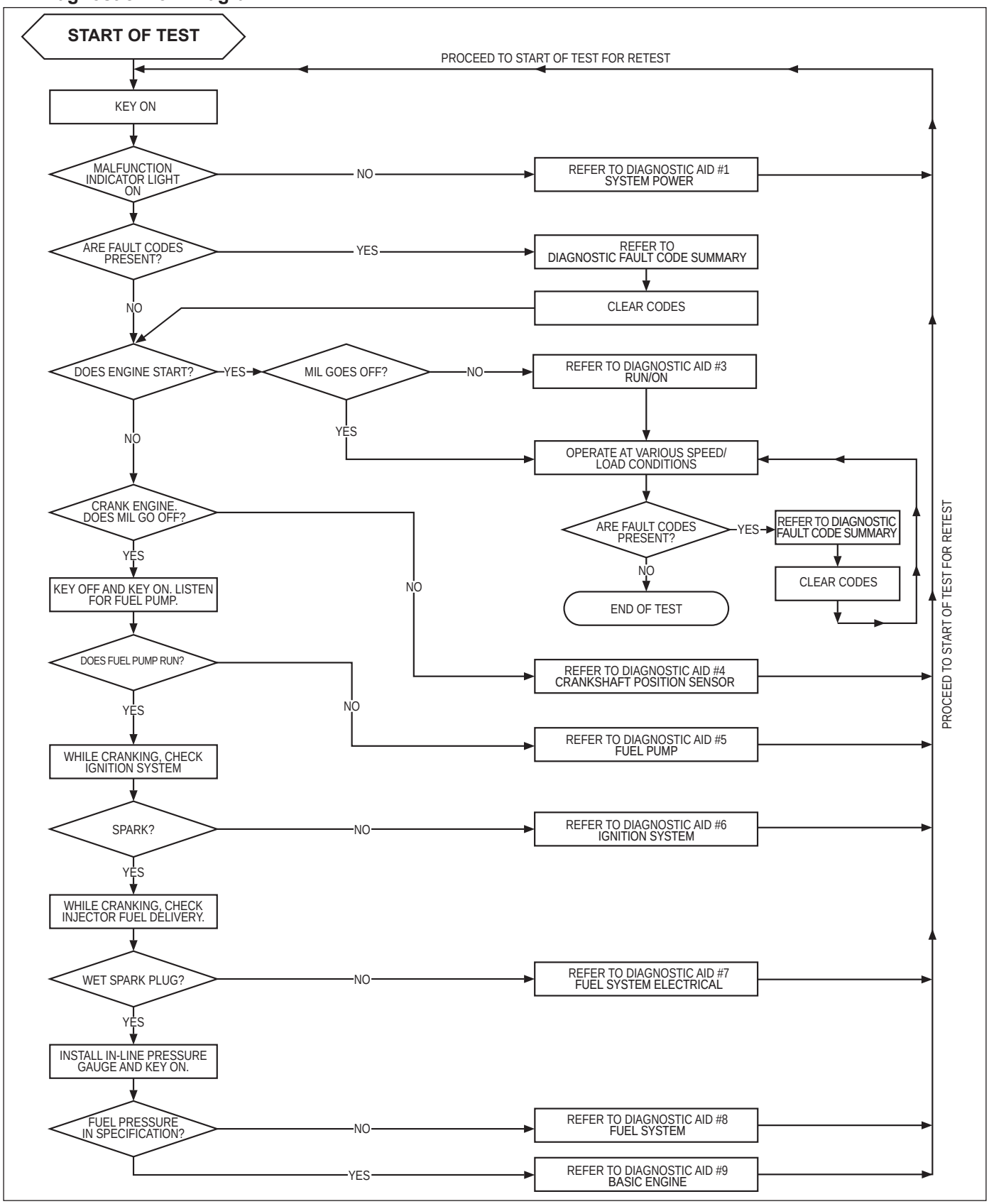
Code 61

Component:	End of Code Transmission

Troubleshooting Flow Chart

Following a flow chart provides an alternative method of troubleshooting EFI system. Chart will enable you to review entire system in about 10-15 minutes. Using chart, accompanying diagnostic aids (listed chart), and any signaled fault codes, you should be able to quickly locate any problems within system.

EFI Diagnostic Flow Diagram



Flow Chart Diagnostic Aids

Diagnostic Aid #1 SYSTEM POWER
(MIL does not illuminate for 3 seconds when key is first turned ON)

NOTE: MIL is installed by vehicle OEM. Twelve volt supply to bulb will be part of vehicle wire harness. Review **MIL Operation for Pedal Start Applications** or **MIL Operation for Key Start Applications** earlier in this section.

Conclusion
- Battery
- Main system fuse
- MIL light bulb burned out
- MIL electrical circuit problem
  Pin circuits Grey 3.
- Ignition switch
- Permanent ECU power circuit problem
  Pin circuit Black 18.
- Switched ECU power circuit problem
  Pin circuit Black 15.
- ECU grounds
- ECU

Diagnostic Aid #2 FAULT CODES
Refer to Diagnostic Fault Code Summary.

NOTE: If fault code P0337 is present and engine does not start/run, proceed to step 1 of Crankshaft Position Sensor earlier in this section. If P0337 is present and engine operates, clear codes and retest.

Diagnostic Aid #3 RUN/ON
(MIL remains ON while engine is running)

Conclusion
- All current fault codes will turn on MIL when key is ON or engine is running.
- If MIL is on and no fault codes are active, check MIL wiring between ECU and bulb.

Diagnostic Aid #4 CRANKSHAFT POSITION SENSOR
(MIL does not turn off during cranking)

Condition
- Crankshaft position sensor
- Crankshaft position sensor circuit problem, pin circuits Black 4 and Black 13.
- Crankshaft position sensor/toothed wheel air gap
- Toothed wheel
- Flywheel key sheared
- ECU

Diagnostic Aid #5 FUEL PUMP
(fuel pump not turning on)

Condition
- Inspect fuse(s)
- Fuel pump relay circuit problem, pin circuits Black 9 and Grey 17.
- Fuel pump

Diagnostic Aid #6 IGNITION SYSTEM
(no spark)

Condition
- Spark plug
- Plug wire
- Coil
- Coil circuit, pin circuits Grey 10 and Black 1.
- ECU grounds
- ECU
- Vehicle safety interlocks, refer to equipment manufacturer's manual

Diagnostic Aid #7 FUEL SYSTEM ELECTRICAL
(no fuel delivery)

Condition
- No fuel
- Air in high pressure fuel line
- Fuel filter/line plugged
- Injector circuit, pin circuits Black 5 and Black 6
- Injector
- ECU grounds
- ECU

Diagnostic Aid #8 FUEL SYSTEM
(fuel pressure)

Low Fuel Pressure-Condition
- No fuel
- Fuel filter(s) plugged
- Fuel supply line plugged
- Fuel pump - internally plugged
- Pressure regulator not functioning properly inside fuel pump.

Diagnostic Aid #9 BASIC ENGINE
(cranks but will not run)

Condition
- Refer to basic engine troubleshooting charts within Troubleshooting and/or refer to equipment manufacturer's manual.

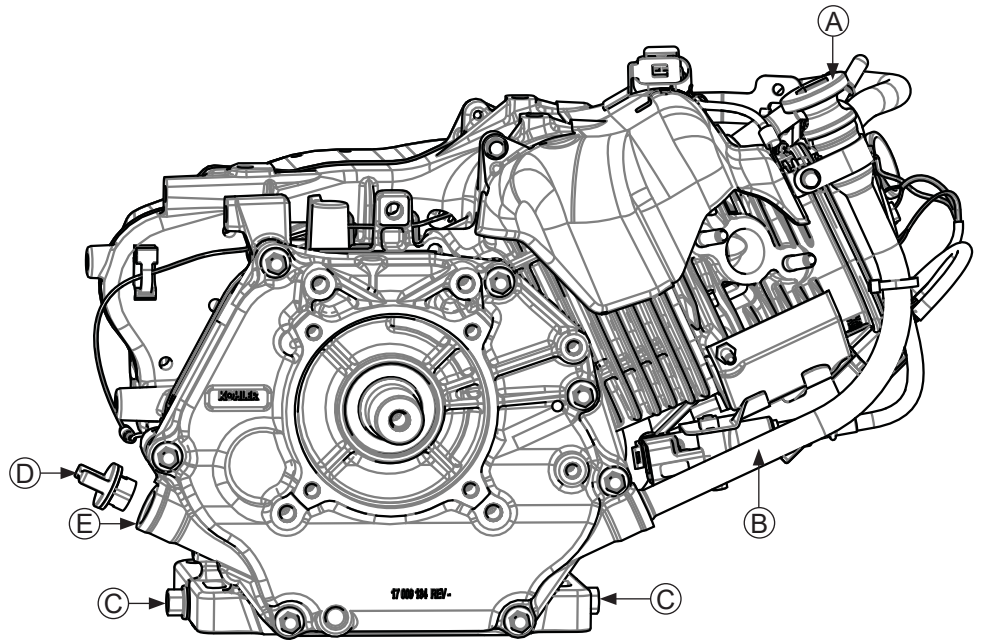
GOVERNOR (OEM Supplied)

Refer to operating instructions of equipment this engine powers for specific governor instructions.

Lubrication System

These engines use a splash lubrication system, supplying necessary lubrication to crankshaft, camshaft, connecting rod and valve train components.

Lubrication Components



A	Dipstick	**B**	Tube	**C**	Oil Drain Plug
D	Oil Fill Plug	**E**	Filler Neck		

WINTER LUBRICATION

If engine is frequently used for short periods of time in ambient temperatures below 4°C (40°F), reduce oil change intervals to every 25 hours.

A rise in oil level during cold weather operation can indicate contaminants collecting in crankcase. If oil level begins to rise:

1. Run vehicle longer to bring engine up to operating temperature before shutting it off. Continuous running for a period of 30 minutes will stabilize engine temperatures.
2. Change oil if oil level begins to rise over full mark on dipstick.
3. Monitor oil level and if it continues to rise, discontinue use and contact your dealer.

NOTE: As ambient weather temperatures decrease below 4°C (40°F), more frequent oil changes may be required. Water vapor is a normal by-product of combustion in any engine. During cold weather operation, some water vapor condenses into liquid form on cool metal surfaces inside engine. In cold weather, this water will accumulate and become mixed with engine oil. In addition to water vapor in cold conditions, liquid fuel can pass by piston rings and accumulate in engine oil. Emulsified fluids in oil can give the oil a cloudy or milky appearance.

If engine is run at normal operating temperatures, most of this water and fuel will become vapor and will be passed through breather.

OIL RECOMMENDATIONS

Refer to Maintenance.

CHECK OIL LEVEL

NOTE: To prevent extensive engine wear or damage, never run engine with oil level below or above operating range indicator on dipstick.

Ensure engine is cool and level. Clean oil fill/dipstick areas of any debris.

1. Check oil level using dipstick or oil fill plug.
   a. Push-on cap dipstick: Remove dipstick; wipe oil off. Reinsert dipstick into tube; press down completely. Remove dipstick; check oil level. Level should be at top of indicator on dipstick.

      or

   b. Remove oil fill plug. Level should be up to point of overflowing filler neck.
2. If oil is low, add oil up to top of indicator mark on dipstick or to point of overflowing filler neck.
3. Reinstall and secure dipstick or oil fill plug.

CHANGE OIL

Change oil while engine is warm.

1. Clean area around oil fill plug/dipstick and drain plug.
2. Remove drain plug and oil fill plug/dipstick. Drain oil completely.
3. Reinstall drain plug. Torque to 18 N·m (13 ft. lb.).

4. Fill crankcase with new oil, up to point of overflowing filler neck.
5. Reinstall oil fill plug/dipstick and tighten securely.
6. Dispose of used oil in accordance with local ordinances.

OIL SENTRY™ (if equipped)

This switch is designed to prevent engine from starting in a low oil or no oil condition. Oil Sentry™ may not shut down a running engine before damage occurs. In some applications this switch may activate a warning signal. Read your equipment manuals for more information.

Oil Sentry™ Oil Level Sensor Switch Testing (if equipped)

Some engines are equipped with an oil level sensor switch. This switch is connected to equipment through 8-pin customer connector. It provides a switching mechanism using continuity to indicate a safe operating oil level.

No continuity from switch indicates a safe (full) operating oil level.

Continuity from switch indicates a unsafe (low) operating oil level.

Review these troubleshooting guidelines.

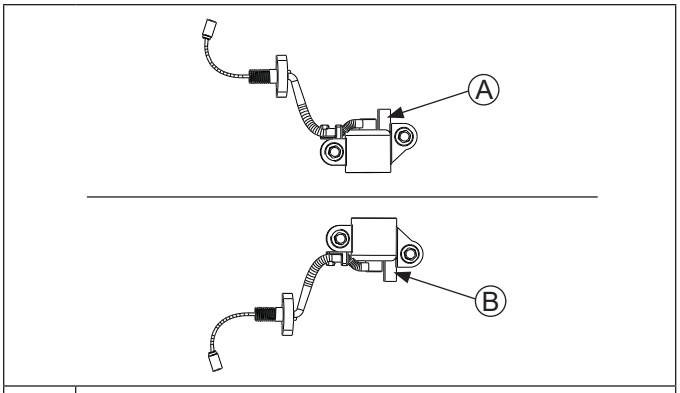
1. Set an ohmmeter to Rx1 scale and zero meter. Connect one ohmmeter lead to Oil Sentry™ oil level switch lead (yellow with green sleeve) and touch other lead to a bare spot on crankcase (ground). Drain oil from crankcase and repeat test.

   With oil at proper level, no continuity should have been indicated. After oil was drained, continuity should have been indicated.

Condition	Conclusion
No continuity indicated.	Remove closure plate from engine and remove oil level switch for further testing (steps 1a and 1b).

   a. If continuity was indicated with and without oil above, check if insulation has been scraped off oil level switch lead.

Condition	Conclusion
Lead wire is bare.	Allowing it to short, repair with electrical tape or replace oil level switch.



A	Upright = Continuity
B	Upside down = No Continuity

   b. With oil level switch removed, connect one ohmmeter lead to oil level switch lead terminal and connect other lead to mounting bracket. Test resistance with switch in normal position and inverted. Repeat test 2 or 3 times in each direction.

Condition	Conclusion
Switch continuity should be as indicated.	If not, replace it.

BATTERY CHARGING SYSTEM (OEM Supplied)

⚠ CAUTION

Electrical Shock can cause injury.

Do not touch wires while engine is running.

Engines in this application have an original equipment manufacturer (OEM) supplied starter generator. Refer to OEM manual for starter generator charging system troubleshooting information.

Battery

A 12-volt battery with 400 cold cranking amps (cca) is generally recommended for starting in all conditions. A smaller capacity battery is often sufficient if an application is started only in warmer temperatures. Refer to following table for minimum capacities based on anticipated ambient temperatures. Actual cold cranking requirement depends on engine size, application, and starting temperatures. Cranking requirements increase as temperatures decrease and battery capacity shrinks. Refer to operating instructions of equipment for specific battery requirements.

Battery Size Recommendations

Temperature	Battery Required
Above 32°F (0°C)	300 cca minimum
0°F to 32°F (-18°C to 0°C)	300 cca minimum
-5°F to 0°F (-21°C to -18°C)	300 cca minimum
-10°F (-23°C) or below	400 cca minimum

If battery charge is insufficient to turn over engine, recharge battery.

Battery Maintenance

Regular maintenance is necessary to prolong battery life.

Battery Test

To test battery, follow manufacturer's instructions.

FUSES

This engine has 2 blade type automotive fuses. Replacement fuses must have same rating as blown fuse. Use fuse chart below to determine correct fuse.

Wire Color	Fuse Rating
1 Red Wire w/Black Stripe 1 Red Wire w/White Stripe	10-amp Fuse
2 Red Wires	10-amp Fuse

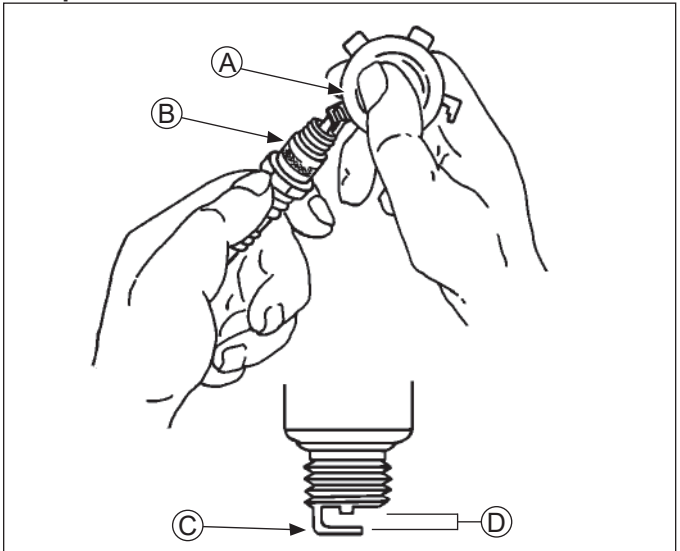
Fuse Replacement

1. Shut engine off and remove key.
2. Locate fuse holders.
3. Remove fuse cover and pull out fuse holder. Inspect condition of fuse holder.
4. Inspect fuse for a solid fusible link or a broken fusible link. Replace fuse if fusible link is broken. If you are not sure if fusible link is broken, replace fuse.
5. Insert fuse into fuse holder until it is seated properly. Install fuse cover.
6. If replacement fuse fails, there is a problem within circuit. Diagnostics are required. Identify which circuit is affected (see EFI System for electrical schematic) by identifying failed fuse/circuit. Perform troubleshooting procedures appropriate for circuit fuse that failed.
7. Install fuse holder into fuse cover.

IGNITION SYSTEM

Spark Plug

Component and Details



A	Wire Gauge	**B**	Spark Plug
C	Ground Electrode	**D**	Gap

NOTE: Do not clean spark plug in a machine using abrasive grit. Some grit could remain in spark plug and enter engine causing extensive wear and damage.

Engine misfire or starting problems are often caused by a spark plug that has improper gap or is in poor condition.

Engine is equipped with following spark plug:

Gap	1.11 mm (0.044 in.)
Thread Size	14 mm
Reach	19.1 mm (3/4 in.)
Hex Size	15.9 mm (5/8 in.)

Refer to Maintenance for Repairs/Service Parts.

Service

Clean out spark plug recess. Remove plug and replace.

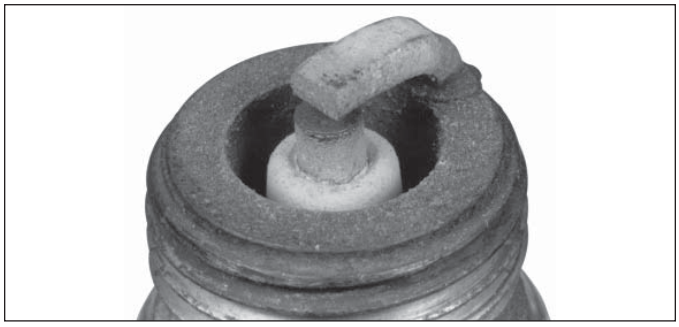
1. Check gap using wire feeler gauge. Adjust gap to 1.11 mm (0.044 in.).
2. Install plug into cylinder head.
3. Torque plug to 27 N·m (20 ft. lb.).

Inspection

Inspect spark plug as it is removed from cylinder head. Deposits on tip are an indication of general condition of piston rings, valves, and fuel mixture.

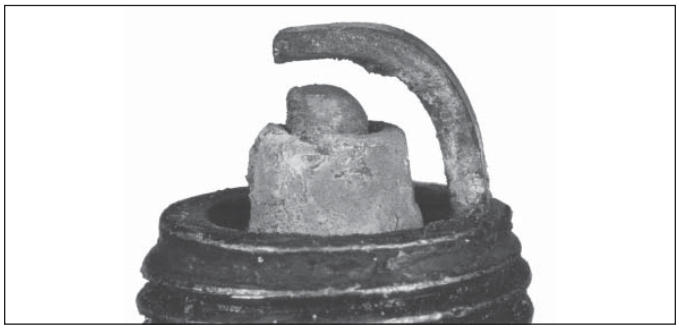
Normal and fouled plugs are shown in following photos:

Normal



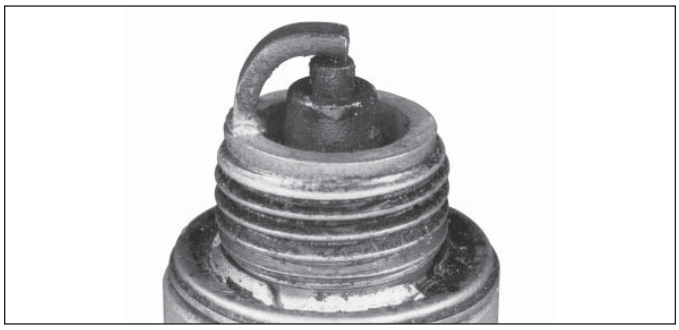
Plug taken from an engine operating under normal conditions will have light tan or gray colored deposits. If center electrode is not worn, plug can be set to proper gap and reused.

Worn



On a worn plug, center electrode will be rounded and gap will be greater than specified gap. Replace a worn spark plug immediately.

Wet Fouled



A wet plug is caused by excess fuel or oil in combustion chamber. Excess fuel could be caused by a restricted air cleaner, a fuel mixture problem. Oil in combustion chamber is usually caused by a restricted air cleaner, a breather problem, worn piston rings, or valve guides.

Carbon Fouled



Soft, sooty, black deposits indicate incomplete combustion caused by a restricted air cleaner, over rich fuel mixture, weak ignition, or poor compression.

Overheated



Chalky, white deposits indicate very high combustion temperatures. This condition is usually accompanied by excessive gap erosion. Lean fuel mixture settings, an intake air leak, or incorrect spark timing are normal causes for high combustion temperatures.

Troubleshooting Guide

Test Ignition System

Isolate and verify trouble is within engine.

1. If Kohler diagnostic software is available, review "Safety System Active" status in Data Display screen. If yes is displayed, equipment safety circuit is active (Refer to equipment manufacturer's manual for safety system information). This must be corrected prior to continuing testing.

Condition	Possible Cause	Conclusion
Problem goes away.	Electrical System	Check key switch, wires, connections, safety interlocks, etc.
Problem persists.	Ignition or Electrical System	Inspect wiring harness (primary and secondary) for any obvious issues. Testing of ignition coil is required. Refer to EFI System, Ignition Coil Testing for details.

Test for Spark

NOTE: Do not crank engine or perform tests with spark plug lead disconnected and not grounded, or permanent coil damage may occur.

1. With engine stopped, disconnect spark plug lead. Connect spark plug lead to post terminal of spark tester and attach tester clip to a good engine ground.
2. Crank engine over, establishing a minimum of 550-600 RPM, and observe tester for spark.

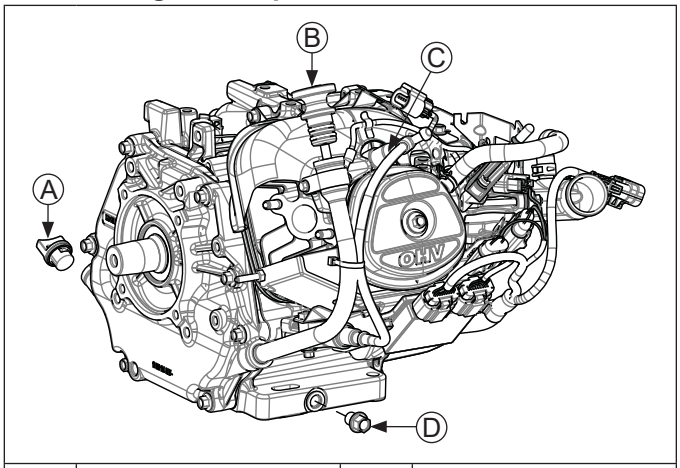
Condition	Possible Cause	Conclusion
Cylinder is not firing or has intermittent spark.	Wiring, Connections, or System Power	Using a DVOM, attach black (-) lead of meter to battery ground, remove primary plug from coil, test voltage at red wire with black tracer at coil primary connector with ignition key ON. Battery voltage should be seen. If no voltage, check all fuses. Key OFF, perform continuity test between black primary wire connector and corresponding pin terminal 1 on black ECU connector (refer to EFI System Wiring Diagram). If no continuity is found, repair or replace electrical wiring harness. If continuity is found, refer to EFI System, Ignition Coil Testing, test circuit (power and ground). Repair/replace as needed. Test ignition coil and connection. Refer to **Test Ignition System** (above).
Tester shows spark but engine misses or won't run.	Spark Plug	Try new spark plug.
	Flywheel Key	Remove flywheel, inspect key, replace key if damaged.
No spark.	Ignition Switch, EFI System, Kill Lead	Test for "Safety System Active" as described in step 1 of **Test Ignition System** (above). Inspect red 10 amp fuses. Replace fuse if found blown. If fuse is OK, using a DVOM, attach black (-) lead of meter to battery ground, key ON, test for voltage at 2 red 10 amp fuses. Battery voltage should be seen on both sides of fuses. If voltage is found on 1 side of fuse only, inspect for blown fuse or inspect fuse holder/ terminals for arching or corrosion. If no voltage is seen at any fuse, further electrical testing inspection is required (application, key switch, ground connections, etc.) Recheck position of ignition switch and check for shorted kill lead.
Good spark but engine runs poorly or existing plug condition is questionable.	Spark Plug	Install new spark plug and retest engine performance.
	Flywheel Key	Remove flywheel, inspect key, replace key if damaged.

Starter (OEM Supplied)

Refer to operating instructions of equipment this engine powers for specific starter system instructions.

	⚠ WARNING	Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug lead(s). 2) Disconnect negative (–) battery cable from battery.
	Accidental Starts can cause severe injury or death. Disconnect and ground spark plug lead(s) before servicing.	

External Engine Components



A	Oil Fill Plug	**B**	Dipstick
C	Spark Plug Lead	**D**	Oil Drain Plug

Clean all parts thoroughly as engine is disassembled. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil, and grime from engine parts. When such a cleaner is used, follow manufacturer's instructions and safety precautions carefully.

Make sure all traces of cleaner are removed before engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down lubricating properties of engine oil.

NOTE: Engines in this application have air cleaner, starter generator, in-tank fuel pump, EFI fuel filter, and all fuel lines supplied and installed by OEM. Refer to equipment manufacturer's manual for information on these components and before working on fuel system. Use only original equipment replacement parts.

Disconnect Spark Plug Lead

NOTE: Pull on boot only, to prevent damage to spark plug lead.

1. Disconnect lead from spark plug.
2. Turn off fuel at fuel supply.

Drain Oil From Crankcase

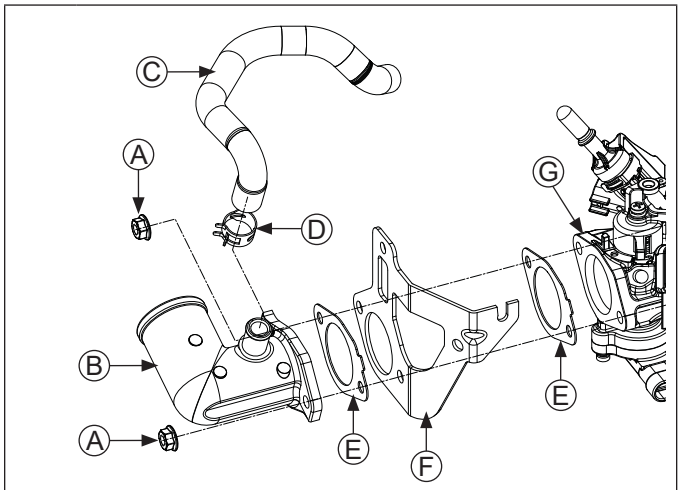
1. Remove 1 oil drain plug and oil fill plug or dipstick.
2. Allow ample time for oil to drain from crankcase.

Disconnect Oxygen Sensor

NOTE: Unless oxygen sensor is damaged or malfunctioning, disassembly from OEM supplied muffler is unnecessary.

Disconnect oxygen sensor connector from wire harness.

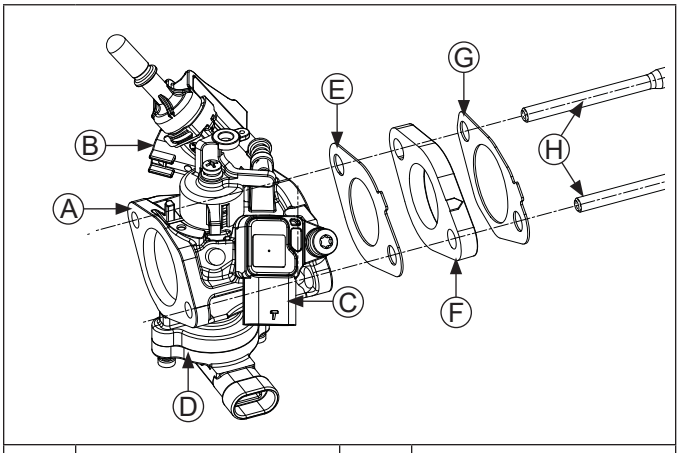
Remove Air Inlet Elbow



A	Nut	**B**	Air Inlet Elbow
C	Breather Hose with Sleeve	**D**	Clamp
E	Throttle Body Gasket	**F**	Governor Bracket
G	Throttle Body		

1. Remove nuts securing air inlet elbow.
2. Disconnect breather hose from valve cover.
3. Remove air inlet elbow and throttle body gasket from mounting studs.
4. Remove governor bracket and throttle body gasket from mounting studs.

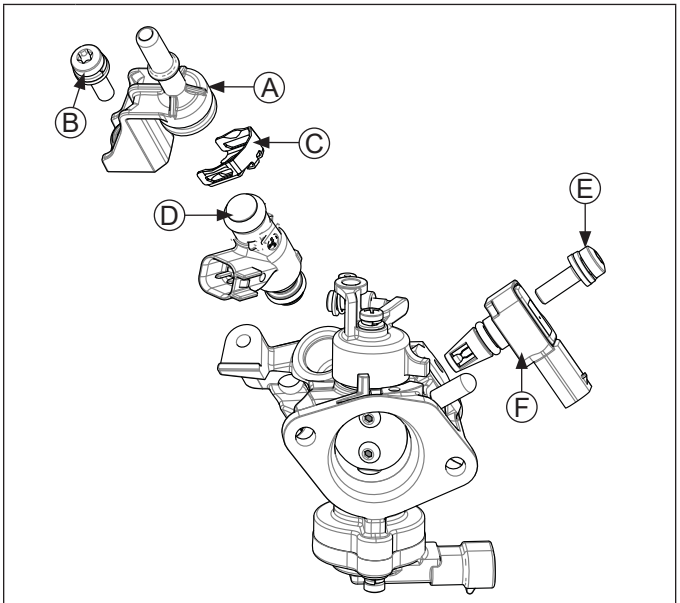
Remove Throttle Body Assembly



A	Throttle Body	**B**	Fuel Injector
C	TMAP	**D**	Throttle Position Sensor (TPS)
E	Insulator to Throttle Body Gasket	**F**	Insulator
G	Insulator to Cylinder Head Gasket	**H**	Intake Studs

1. With a screwdriver, slide locking tab on electrical connector of TMAP. Detach connector.
2. Disconnect fuel injector electrical connector.
3. Disconnect throttle position sensor (TPS) connector.
4. Slide throttle body off intake studs and remove insulator to throttle body gasket, insulator, and insulator to cylinder head gasket.

Remove Fuel Injector and TMAP



A	Fuel Injector Cap	**B**	Screw
C	Metal Retaining Clip	**D**	Fuel Injector
E	Screw	**F**	TMAP

Remove Fuel Injector

NOTE: Unless fuel injector is damaged or malfunctioning, disassembly from throttle body is unnecessary.

NOTE: Make note of fuel injector position before removing.

NOTE: Unless fuel injector cap is damaged, removing retainer securing cap to injector is unnecessary.

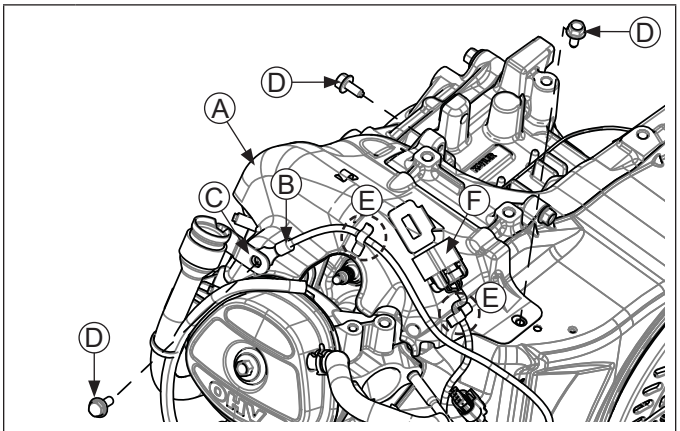
1. Disconnect fuel injector electrical connector.
2. Remove screw and pull injector out of throttle body.
3. When removed, pull metal retaining clip connecting fuel injector to fuel injector cap/fuel cap bracket. There may be some fuel left in line. Any spilled fuel must be cleaned up immediately.

Remove Temperature/Manifold Absolute Pressure (TMAP) Sensor

NOTE: Unless TMAP sensor is damaged or malfunctioning, disassembly from throttle body is unnecessary.

1. With a screwdriver, slide locking tab on electrical connector.
2. Detach connector.
3. Remove screw and pull TMAP sensor out of throttle body.

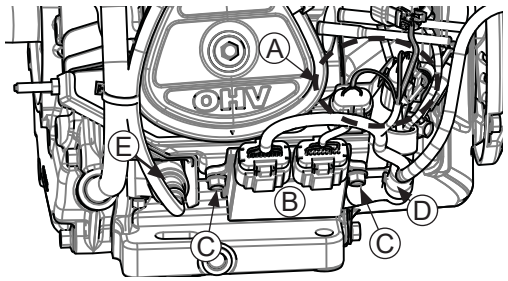
Remove Upper Heat Shield and Engine Temperature Sensor



A	Upper Heat Shield	**B**	Engine Temperature Sensor
C	Dipstick Tube Bracket	**D**	Screw
E	Clip	**F**	Oxygen Sensor Connector

1. Note position of engine temperature sensor. Sensor is located between oil fill tube bracket and upper heat shield. Remove screw securing oil fill tube bracket and sensor to upper heat shield.
2. Remove engine temperature wire from upper heat shield clip. Remove oxygen sensor wire from upper heat shield clip.
3. Remove screws and lift off upper heat shield.

Fuses and ECU Components



A	Fuses/Fuse Holders	**B**	ECU
C	Screw	**D**	Cable Clip
E	Ignition Coil		

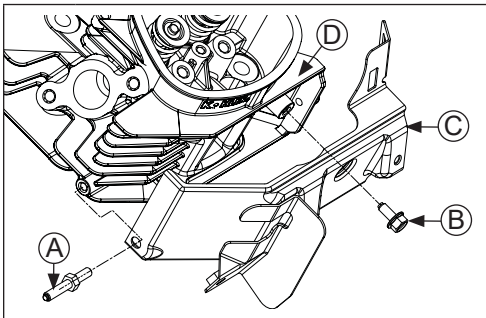
Remove Fuses

Remove fuses from holders located on lower shield.

Remove Electronic Control Unit (ECU)

1. Remove screws and remove ECU and cable clip with wiring harness from lower shield.
2. Disconnect Black and Grey electrical connectors from ECU.

Remove Cylinder Shield

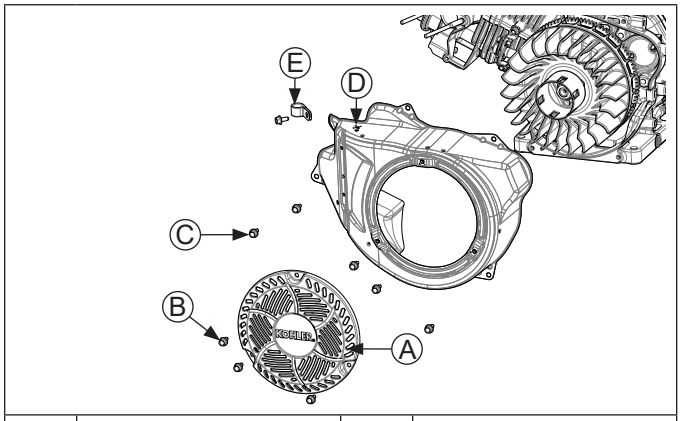


A	Ground Stud	**B**	Screw
C	Cylinder Shield	**D**	Cylinder Head

NOTE: Unless ignition coil is damaged or malfunctioning, disassembly from lower shield is unnecessary.

1. Disconnect ignition coil electrical connector.
2. Remove screw and ground stud securing lower shield to cylinder head; remove lower shield.

Blower Housing Components



A	Blower Housing Screen	**B**	Screw
C	Screw	**D**	Blower Housing
E	Clamp		

Remove Blower Housing Screen

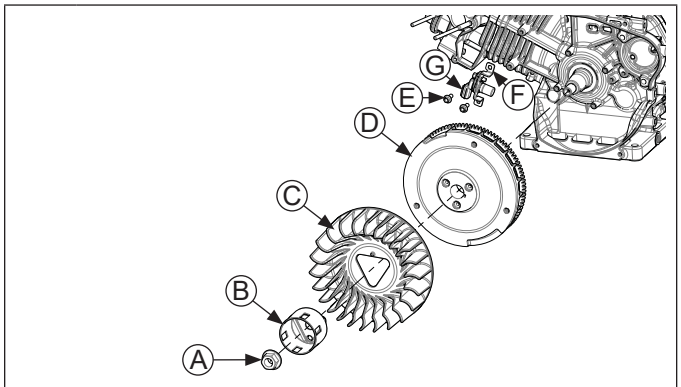
NOTE: Unless blower housing screen is damaged, disassembly from blower housing is unnecessary.

Remove screws securing blower housing screen to blower housing and remove screen.

Remove Blower Housing

1. A clamp secures part of wiring harness to blower housing. Note which wires are secured, remove screw and clamp from blower housing.
2. Remove screws securing blower housing to engine and remove blower housing.

Flywheel Components



A	Flywheel Retaining Nut	**B**	Drive Cup
C	Flywheel Fan	**D**	Flywheel
E	Crankshaft Position Sensor Bracket Screw	**F**	Crankshaft Position Sensor Bracket
G	Crankshaft Position Sensor		

Remove Crankshaft Position Sensor

NOTE: Do not remove sensor from bracket unless sensor is being replaced.

1. Unplug crankshaft position sensor electrical connector.
2. Remove upper screw securing crankshaft position sensor bracket to crankcase post.
3. Remove lower screw securing crankshaft position sensor bracket to crankcase post and also securing ground wire.
4. Remove crankshaft position sensor assembly.

Remove Flywheel

NOTE: Whenever possible, an impact wrench should be used to loosen flywheel retaining nut. A flywheel strap wrench may be used to hold flywheel when loosening or tightening flywheel retaining nut.

NOTE: Always use a puller to remove flywheel from crankshaft. Do not strike flywheel or crankshaft as these parts could become cracked or damaged.

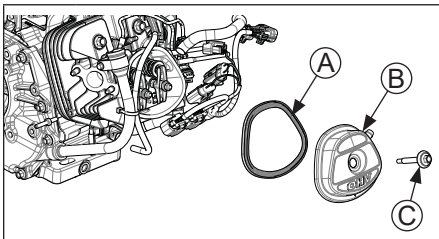
1. Remove flywheel retaining nut.
2. Remove drive cup and fan from flywheel.
3. Remove flywheel from crankshaft using a suitable puller.
4. Remove flywheel key from crankshaft keyway.

Inspection
Inspect flywheel for cracks and flywheel keyway for damage. Replace flywheel if it is cracked. Replace flywheel, crankshaft, and key if flywheel key is sheared or keyway is damaged.

Remove Wiring Harness

Disconnect oil level switch green wire from wiring harness; pull wiring harness through clip secured to crankcase. Pick up wiring harness from on top of crankcase, thread through hole and remove.

Remove Valve Cover



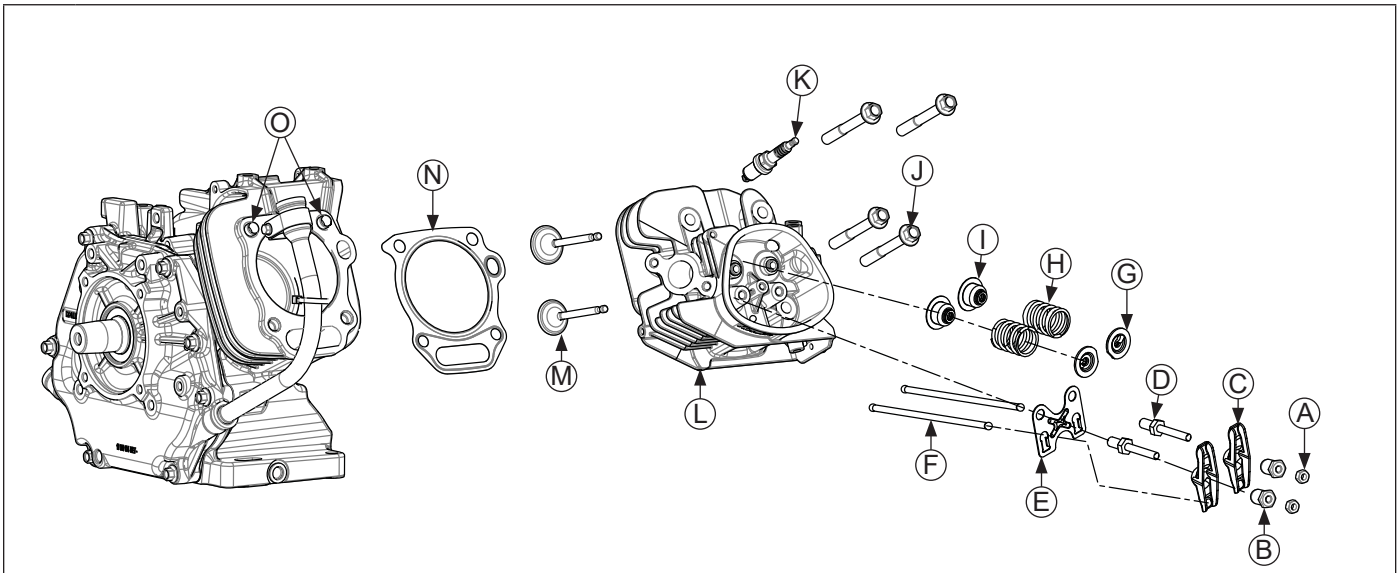
A	Valve Cover Gasket	**B**	Valve Cover
C	Valve Cover Seal Screw Assembly		

Remove valve cover seal screw assembly and remove valve cover and gasket from engine. Breather assembly is inside valve cover.

Breather System
Breather system is designed to control amount of oil in head area and still maintain necessary vacuum in crankcase.

When piston moves downward, crankcase gases are pushed past reed through mesh filter into intake system. Upward travel of piston closes reed and creates a low vacuum in lower crankcase. Any oil separated out through filter drains back into crankcase.

Cylinder Head Components



A	Hex Jam Nut	**B**	Rocker Arm Pivot Adjuster	**C**	Rocker Arm	**D**	Rocker Arm Stud
E	Push Rod Guide	**F**	Push Rod	**G**	Valve Spring Retainer	**H**	Valve Spring
I	Valve Stem Seal	**J**	Cylinder Head Screw	**K**	Spark Plug	**L**	Cylinder Head
M	Valve	**N**	Cylinder Head Gasket	**O**	Dowel Pin		

Remove Rocker Arms, Push Rods, and Cylinder Head Assembly

NOTE: Mark location of push rods and any other part removed being reused.

1. Loosen and remove rocker arm pivot adjuster and hex jam nuts. Remove rocker arms and push rods.
2. Remove spark plug.
3. Remove screws securing cylinder head.
4. Remove cylinder head, dowel pins, and cylinder head gasket.

Remove Valves

NOTE: Mark locations of any part removed being reused.

1. Supporting head of valve from below, depress valve spring retainer and valve spring until retainer can be released from valve stem. Remove valve spring and valve from head. Repeat this procedure for remaining valve.
2. Remove and replace valve stem seals whenever cylinder head is serviced or disassembled.

Inspection and Service

After cleaning, check flatness of cylinder head and corresponding top surface of crankcase, using a surface plate or precision straight edge and feeler gauge. Maximum allowable out of flatness is 0.1 mm (0.0039 in.).

Carefully inspect valve mechanism parts. Inspect valve springs and related hardware for excessive wear or distortion. Check valves and valve seat area or inserts for evidence of deep pitting, cracks, or distortion.

Check clearance of valve stems in guides. See valve details and specifications.

Hard starting, or loss of power accompanied by high fuel consumption may be symptoms of faulty valves. Although these symptoms could also be attributed to worn rings, remove and check valves first. After removal, clean valve heads, faces, and stems with a power wire brush.

Then, carefully inspect each valve for defects such as warped head, excessive corrosion, or worn stem end. Replace valves found to be in bad condition.

Valve Guides
If a valve guide is worn beyond specifications, it will not guide valve in a straight line. This may result in burnt valve faces or seats, loss of compression, and excessive oil consumption.

To check valve guide-to-valve stem clearance, thoroughly clean valve guide and, using a split-ball gauge, measure inside diameter of guide. Then, using an outside micrometer, measure diameter of valve stem at several points on stem where it moves in valve guide. Use largest stem diameter to calculate clearance by subtracting stem diameter from guide diameter. If intake or exhaust clearance exceeds specifications in Valve Specification table, determine whether valve stem or guide is responsible for excessive clearance.

If guides are within limits but valve stems are worn beyond limits, install new valves.

Valve Seat Inserts
Hardened steel alloy intake and exhaust valve seat inserts are press-fitted into cylinder head. Inserts are not replaceable but can be reconditioned if not too badly pitted or distorted. If cracked or badly warped, cylinder head should be replaced.

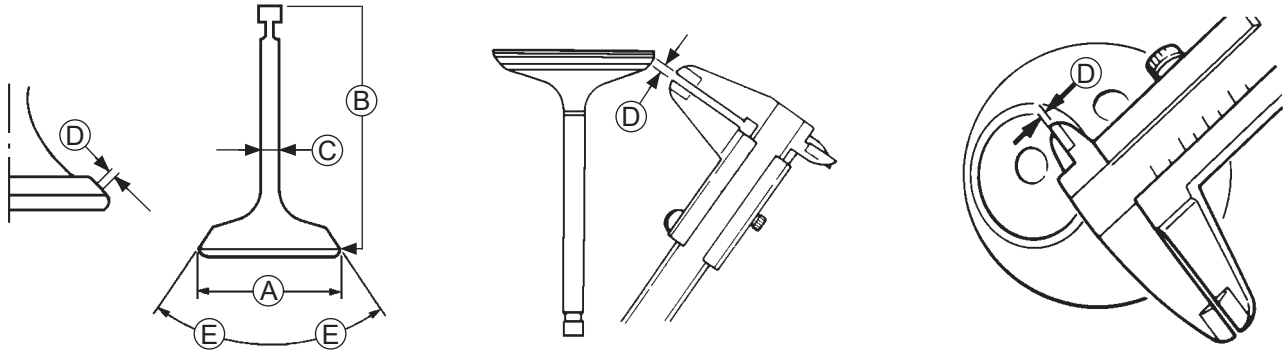
Recondition valve seat inserts following instructions provided with valve seat cutter being used. Final cut should be made with a 44.5° cutter as specified for valve seat angle. Cutting proper 45° valve face angle, as specified, and proper valve seat angle (44.5°) will achieve desired 0.5° (1.0° full cut) interference angle where maximum pressure occurs on outside diameters of valve face and seat.

Lapping Valves
Reground or new valves must be lapped in, to provide proper fit. Use a hand valve lapping tool with suction cup for final lapping. Lightly coat valve face with fine grade of grinding compound, then rotate valve on seat with tool. Continue lapping until smooth surface is obtained on seat and on valve face. Thoroughly clean cylinder head in soap and hot water to remove all traces of grinding compound. After drying cylinder head, apply a light coating of SAE 10 oil to prevent rusting.

Valve Stem Seals
These engines use valve stem seals on intake and exhaust valves.

Always use new seals when valves are removed from cylinder head. Seals should also be replaced if deteriorated or damaged in any way. Never reuse old seals.

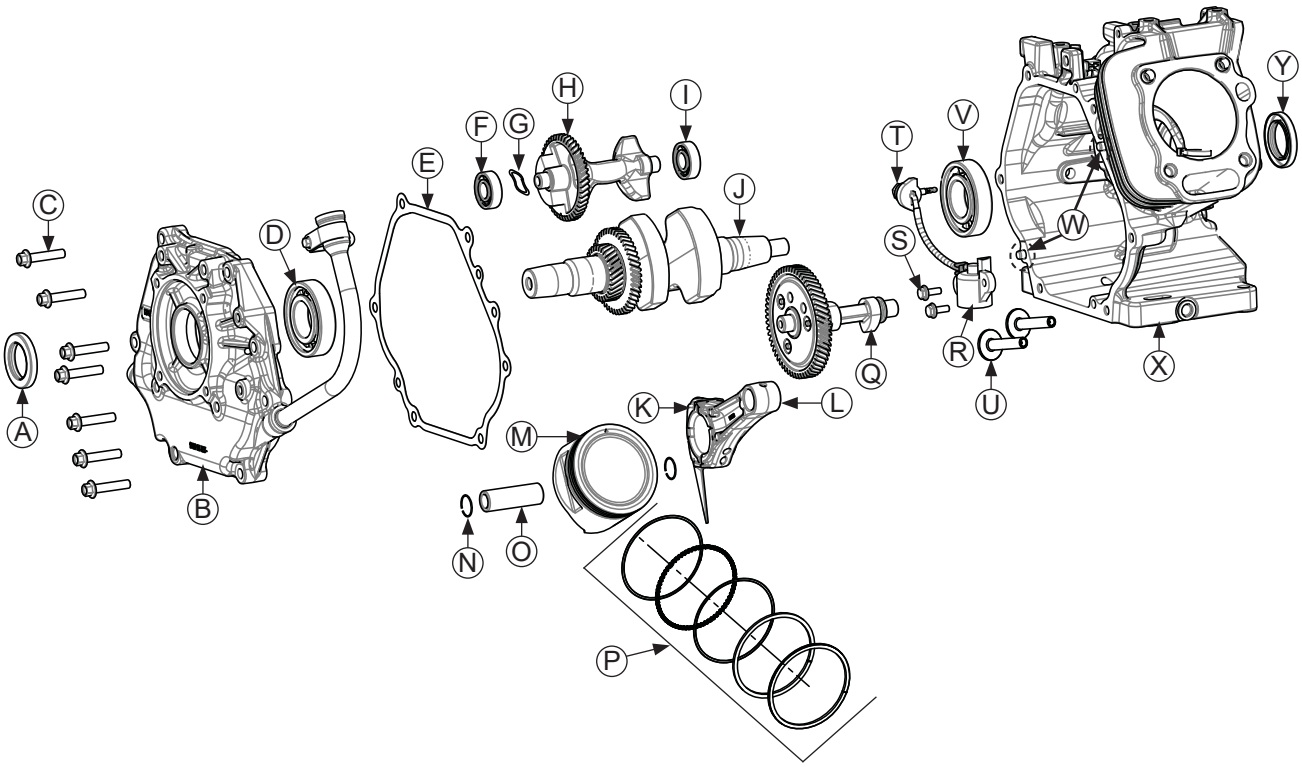
Valve Details



Valve Specifications

Item	Dimension	Intake	Exhaust
A	Head Diameter	35.875-36.125 mm (1.4124-1.4222 in.)	32.875-33.125 mm (1.2943-1.3041 in.)
B	Valve Length	86.175-86.375 mm (3.3927-3.4006 in.)	86.341-86.541 mm (3.3993-3.4071 in.)
C	Stem Diameter	6.560-6.575 mm (0.2583-0.2589 in.)	6.545-6.560 mm (0.2577-0.2583 in.)
D	Face/Seat Width - Maximum	1.5 mm (0.059 in.)	1.5 mm (0.059 in.)
E	Face/Seat Angle	45°-44.5°	45°-44.5°

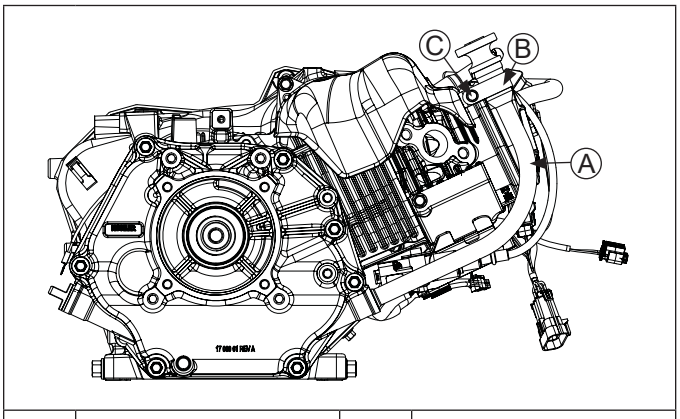
Crankcase/Crankshaft/Camshaft/Closure Plate Components



A	Closure Plate Oil Seal	**B**	Closure Plate	**C**	Screw	**D**	Closure Plate Bearing
E	Closure Plate Gasket	**F**	Closure Plate Balance Shaft Bearing	**G**	Wave Spring	**H**	Balance Shaft
I	Crankcase Balance Shaft Bearing	**J**	Crankshaft	**K**	Connector Rod End Cap	**L**	Connector Rod
M	Piston	**N**	Piston Pin Retainer	**O**	Piston Pin	**P**	Piston Ring Set
Q	Camshaft	**R**	Oil Sentry™ Level Switch	**S**	Screw	**T**	Oil Sentry™ Wire
U	Tappet	**V**	Crankcase Bearing	**W**	Dowel Pin	**X**	Crankcase
Y	Crankcase Oil Seal						

Remove Oil Fill Tube

Details



A	Oil Fill Tube	**B**	Oil Fill Tube Bracket
C	Bracket Screw		

NOTE: Unless oil fill tube is damaged, disassembly from closure plate is unnecessary.

1. Remove bracket screw and oil fill tube bracket.
2. If necessary, remove tube from closure plate. If not, allow oil fill tube to remain in closure plate. Tube will be removed with closure plate as an assembly.

Remove Closure Plate

NOTE: Do not pry on gasket surface of crankcase or closure plate, as this can cause damage and leakage.

1. Remove screws securing closure plate to crankcase.
2. Remove closure plate, gasket, and dowel pins (if required) from crankcase.
3. Remove closure plate and oil fill tube as an assembly.
4. Remove shims from crankshaft.

Inspection
Inspect main bearing surface for wear or damage (refer to Specifications). Replace closure plate if required.

Remove Balance Shaft

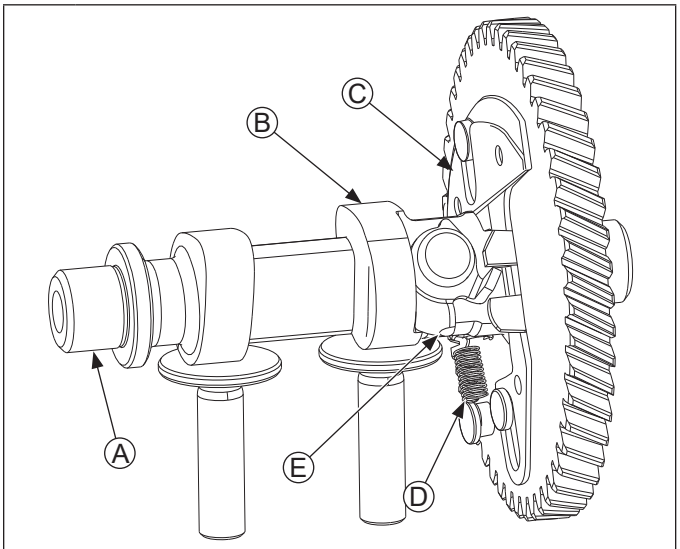
Remove balance shaft (with wave spring) by pulling it straight out of crankcase.

Remove Camshaft and Valve Tappets

1. Remove camshaft by pulling it straight out of crankcase.
2. Remove valve tappets by pulling them straight out of crankcase. Mark their positions.

Automatic Compression Release (ACR)

ACR Operation Details



A	Camshaft	**B**	Exhaust Cam Lobe
C	Decompression Weight	**D**	Return Spring
E	Arm		

ACR mechanism consists of a spring-loaded arm and sliding pin mounted to camshaft. When engine is rotating at low cranking speeds, arm holds pin so it protrudes above heel of exhaust cam. This holds exhaust valve off of its seat during first part of compression stroke.

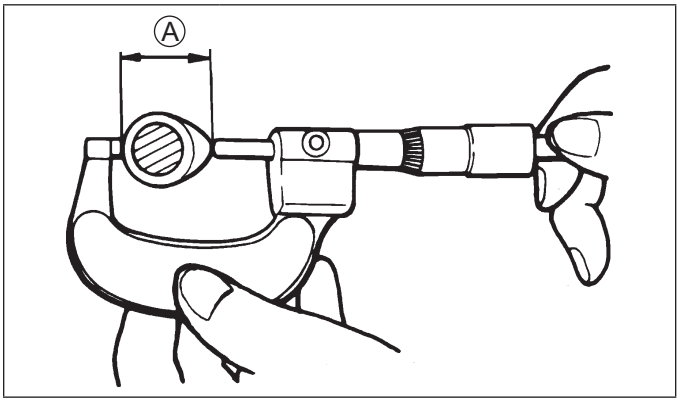
After engine speed increases centrifugal force causes spring-loaded arm to move outward causing pin to retract. When in this position pin has no effect on exhaust valve and engine operates at full compression and power.

Benefits
As a result of reduced compression at cranking speeds, several important benefits are obtained:

1. Electric start models can use a smaller starter and battery more practical for application.
2. ACR eliminates need for a spark retard/advance mechanism. ACR eliminates this kickback making manual starting safer.
3. Engines with ACR start much faster in cold weather than engines without ACR.
4. Engines with ACR can be started with worn or fouled spark plug. Engines without ACR are more difficult to start with those same spark plug.

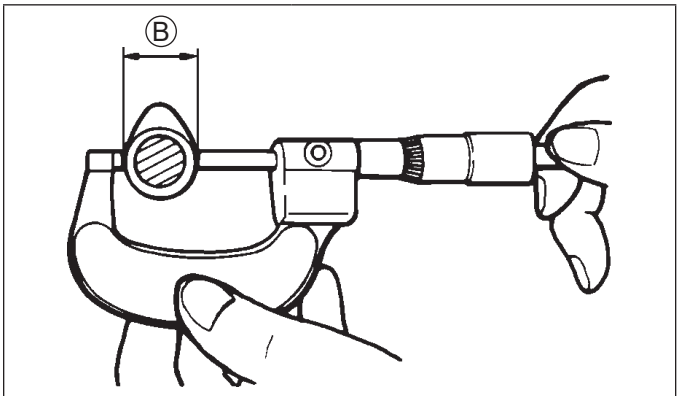
Inspection and Service

Dimension A



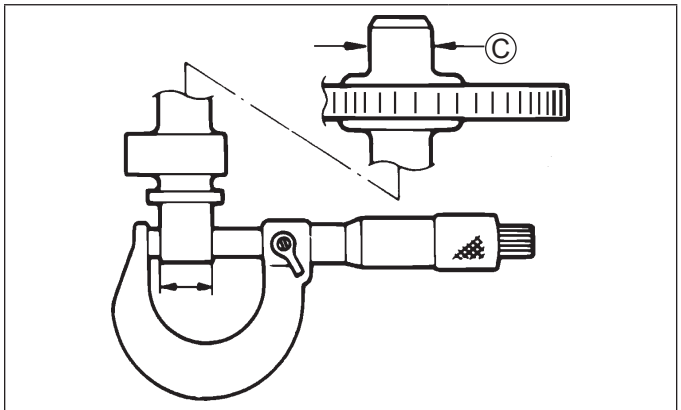
Cam Lobe		
INTAKE	32.286 mm (1.271 in.)	32.032 mm (1.261 in.)
EXHAUST	32.506 mm (1.280 in.)	32.252 mm (1.270 in.)

Dimension B



Cam Lobe Specifications		
Valve	**Dimension B**	**Service Limit**
INTAKE	25.94 mm (1.021 in.)	25.68 mm (1.011 in.)
EXHAUST	25.94 mm (1.021 in.)	25.68 mm (1.011 in.)

Dimension C



Camshaft Journal Specifications	
Dimension C	**Limit**
15.975 mm (0.6289 in.)	15.900 mm (0.6260 in.)

Inspect gear teeth of camshaft. If teeth are badly worn, chipped, or some are missing, replacement of camshaft will be necessary. If unusual wear or damage is evident on either lobe or mating tappet, camshaft and both tappets must be replaced. Check condition and operation of ACR mechanism.

Measure cam lobe profile, A and B, using an outside micrometer and compare with specifications listed.

Measure camshaft journals, C, which fit in ball bearings, for wear using a micrometer. Compare with specifications listed.

Remove Piston, Connecting Rod and Crankshaft

NOTE: If a carbon ridge is present at top of cylinder bore, use a ridge reamer to remove it before attempting to remove piston.

1. Remove screws securing end cap to connecting rod. Remove end cap. Carefully guiding connecting rod, slide piston and connecting rod from cylinder bore.
2. Remove crankshaft from crankcase.

Connecting Rod Inspection and Service

Check bearing area (big end) for excessive wear, score marks, running and side clearances (see Specifications and Tolerances). Replace rod and cap if scored or excessively worn.

Service replacement connecting rods are available in STD size and 0.25 mm (0.010 in.) undersize. 0.25 mm (0.010 in.) undersized rods have an identification marking on lower end of rod shank. Always refer to appropriate parts information to ensure correct replacements are used.

Piston and Rings Inspection

Scuffing and scoring of piston and cylinder wall occurs when internal engine temperatures approach welding point of piston. Temperatures high enough to do this are created by friction, which is usually attributed to improper lubrication and/or overheating of engine.

Normally, very little wear takes place in piston boss-piston pin area. If original piston and connecting rod can be reused after new rings are installed, original pin can also be reused but new piston pin retainers are required. Piston pin is included as part of piston assembly – if pin boss in piston or pin are worn or damaged, a new piston assembly is required.

Ring failure is usually indicated by excessive oil consumption and blue exhaust smoke. When rings fail, oil is allowed to enter combustion chamber where it is burned along with fuel. High oil consumption can also occur when piston ring end gap is incorrect because ring cannot properly conform to cylinder wall under this condition. Oil control is also lost when ring gaps are not staggered during installation.

When cylinder temperatures get too high, lacquer and varnish collect on pistons causing rings to stick, which results in rapid wear. A worn ring usually takes on a shiny or bright appearance.

Scratches on rings and piston are caused by abrasive material such as carbon, dirt, or pieces of hard metal. Detonation damage occurs when a portion of fuel charge ignites spontaneously from heat and pressure shortly after ignition. This creates 2 flame fronts, which meet and explode to create extreme hammering pressures on a specific area of piston. Detonation generally occurs from using low octane fuels.

Preignition, or ignition of fuel charge before timed spark can cause damage similar to detonation. Preignition damage is often more severe than detonation damage. Preignition is caused by a hot spot in combustion chamber such as glowing carbon deposits, blocked cooling fins, an improperly seated valve, or wrong spark plug.

Replacement pistons are available in STD bore size, and 0.25 mm (0.010 in.) oversize. Replacement pistons include new piston ring sets and new piston pins.

Replacement ring sets are also available separately for STD, and 0.25 mm (0.010 in.) oversize pistons. Always use new piston rings when installing pistons. Never use old rings.

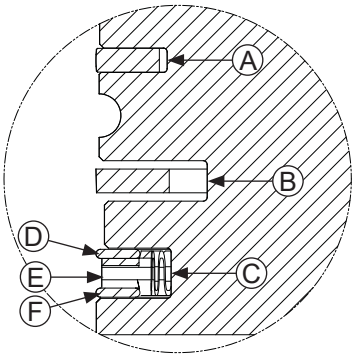
Some important points to remember when servicing piston rings:

1. Cylinder bore must be deglazed before service ring sets are used.
2. If cylinder bore does not need reboring and if old piston is within wear limits and free of score or scuff marks, old piston may be reused.
3. Remove old rings and clean up grooves. Never reuse old rings.
4. Before installing new rings on piston, place top 2 rings, each in turn, in its running area in cylinder bore and check end gap. Refer to Specifications.
5. After installing new compression (top and middle) rings on piston, check piston-to-ring side clearance. Refer to Specifications. If side clearance is greater than specified, a new piston must be used.

Piston and Rings

Inspection

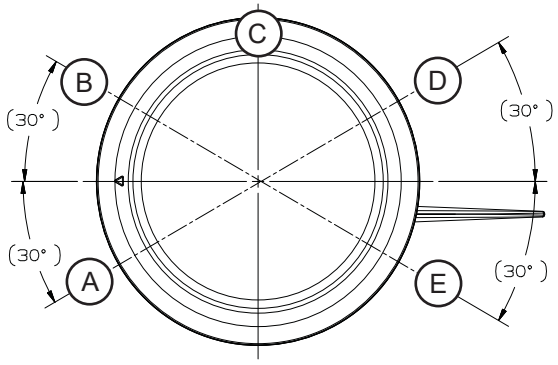
Piston and Rings Components and Details



A	Top Compression Ring	**B**	Middle Compression Ring
C	Oil Control Ring	**D**	Top Rail
E	Expander Ring	**F**	Bottom Rail

Install New Piston Rings

Piston Ring Orientation



A	Top Oil Rail Gap	**B**	Bottom Oil Rail Gap
C	Middle Ring Gap	**D**	Oil Ring Expander Gap
E	Top Ring Gap		

NOTE: Rings must be installed correctly. Use a piston ring expander to install rings. Install bottom (oil control) ring first and top compression ring last.

To install new piston rings, proceed as follows:

1. Oil control ring (bottom groove): Install expander and then rails. Make sure ends of expander are not overlapped.
2. Middle compression ring (center groove): Install center ring using a piston ring installation tool. Make sure identification mark is up or colored dye stripe (if contained), is to left of end gap.
3. Top compression ring (top groove): Install top ring using a piston ring expander. Make sure identification mark is up or colored dye stripe (if contained), is to left of end gap.

Crankshaft Inspection and Service

Inspect gear teeth of crankshaft. If teeth are badly worn, chipped, or some are missing, replacement of crankshaft will be necessary.

Inspect crankshaft bearing surfaces for scoring, grooving, etc. Measure running clearance between crankshaft journals and their respective bearing bores. Use an inside micrometer or telescoping gauge to measure inside diameter of both bearing bores in vertical and horizontal planes. Use an outside micrometer to measure outside diameter of crankshaft main bearing journals. Subtract journal diameters from their respective bore diameters to get running clearances. Check results against values in Specifications and Tolerances. If running clearances are within specification, and there is no evidence of scoring, grooving, etc., no further reconditioning is necessary. If bearing surfaces are worn or damaged, crankcase and/or closure plate will need to be replaced.

Inspect crankshaft keyways. If worn or chipped, replacement of crankshaft will be necessary. Inspect crankpin for score marks or metallic pickup. Slight score marks can be cleaned with crocus cloth soaked in oil. If wear limits are exceeded, as stated in Specifications, it will be necessary to replace crankshaft.

Remove Oil Sentry™ System

1. Remove nut securing Oil Sentry™ lead wire grommet assembly in crankcase.
2. Pull grommet assembly from inside of crankcase.
3. Remove screws securing Oil Sentry™ level switch to crankcase. Remove switch assembly.

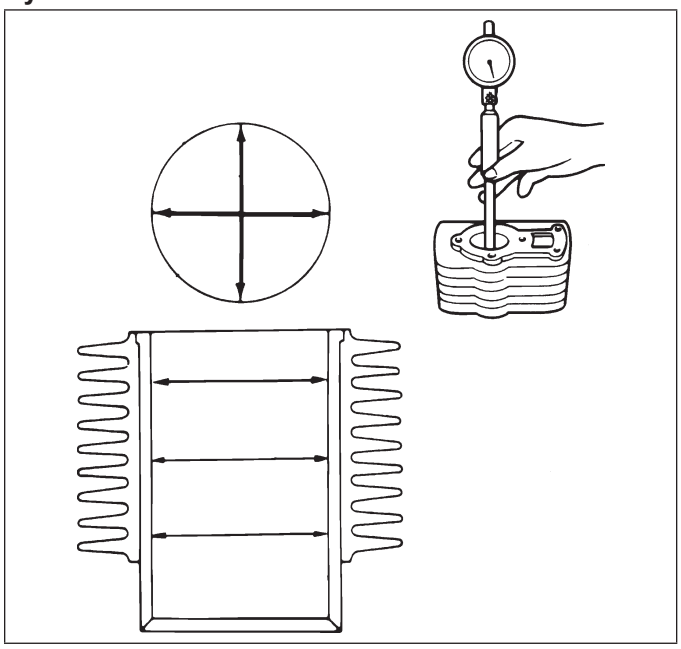
Remove Crankcase and Closure Plate Seals and Bearings

NOTE: Inspect bearings for signs of wear by rotating inner race and examine for marring or cracks. Check to make sure race moves easily and is not sloppy. If bearing is tight and rotates smoothly, removal is not necessary. If you feel any roughness or chattering or bearing is sloppy, it should be replaced.

1. Remove oil seal from crankcase.
2. Using a suitable press, push crankshaft bearing from crankcase.
3. Remove oil seal from closure plate.
4. Using a suitable press, push crankshaft bearing from closure plate.

Crankcase Inspection and Service

Cylinder Bore Detail



NOTE: A 0.25 mm (0.010 in.) oversize piston is available if resizing is selected. Initially, resize using a boring bar, then follow procedures for honing cylinder.

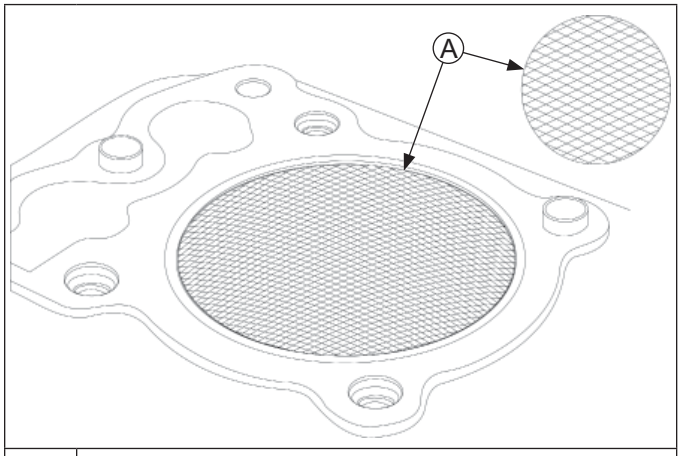
Check all gasket surfaces to make sure they are free of gasket fragments. Gasket surfaces must also be free of deep scratches or nicks.

Check cylinder bore for scoring. In severe cases, unburned fuel can cause scuffing and scoring of cylinder wall. It washes necessary lubricating oils off piston and cylinder wall. As raw fuel seeps down cylinder wall, piston rings make metal to metal contact with wall. Scoring of cylinder wall can also be caused by localized hot spots resulting from blocked cooling fins or from inadequate or contaminated lubrication.

If cylinder bore is badly scored, excessively worn, tapered, or out-of-round, resizing is necessary. Use an inside micrometer to determine amount of wear (refer to Specifications).

Honing

Crosshatch Detail



A	23°-33° Crosshatch

NOTE: Kohler pistons are custom-machined to exacting tolerances. When over-sizing a cylinder, it should be machined exactly 0.25 mm (0.010 in.) over new diameter (Specifications and Tolerances). Oversize Kohler replacement piston will then fit correctly.

While most commercially available cylinder hones can be used with either portable drills or drill presses, use of a low speed drill press is preferred as it facilitates more accurate alignment of bore in relation to crankshaft crossbore. Honing is best accomplished at a drill speed of about 250 RPM and 60 strokes per minute. After installing coarse stones in hone, proceed as follows:

1. Lower hone into bore and after centering, adjust stones so they are in contact with cylinder wall. Use of a commercial cutting-cooling agent is recommended.
2. With lower edge of each stone positioned even with lowest edge of bore, start drill and honing process. Move hone up and down while resizing to prevent formation of cutting ridges. Check size frequently.
3. When bore is within 0.064 mm (0.0025 in.) of desired size, remove coarse stones and replace them with burnishing stones. Continue with burnishing stones until bore is within 0.013 mm (0.0005 in.) of desired size and then use finish stones (220-280 grit) and polish bore to its final size. A crosshatch should be observed if honing is done correctly. Crosshatch should intersect at approximately 23°-33° off horizontal. Too flat an angle could cause rings to skip and wear excessively, and too steep an angle will result in high oil consumption.
4. After resizing, check bore for roundness, taper, and size. Use an inside micrometer, telescoping gauge, or bore gauge to take measurements. These measurements should be taken at 3 locations in cylinder – at top, middle, and bottom. Two measurements should be taken (perpendicular to each other) at each location.

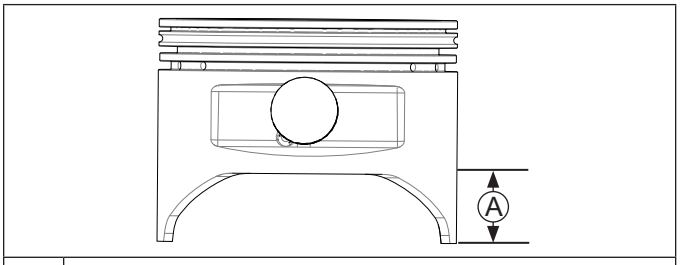
Clean Cylinder Bore After Honing

Proper cleaning of cylinder walls following boring and/or honing is very critical to a successful overhaul. Machining grit left in cylinder bore can destroy an engine in less than one hour of operation after a rebuild.

Final cleaning operation should always be a thorough scrubbing with a brush and hot, soapy water. Use a strong detergent capable of breaking down machining oil while maintaining a good level of suds. If suds break down during cleaning, discard dirty water and start again with more hot water and detergent. After scrubbing, rinse cylinder with very hot, clear water, dry it completely, and apply a light coating of engine oil to prevent rusting.

Measuring Piston-to-Bore Clearance

Piston Details



A	29.8-30.2 mm (1.1732-1.1890 in.)

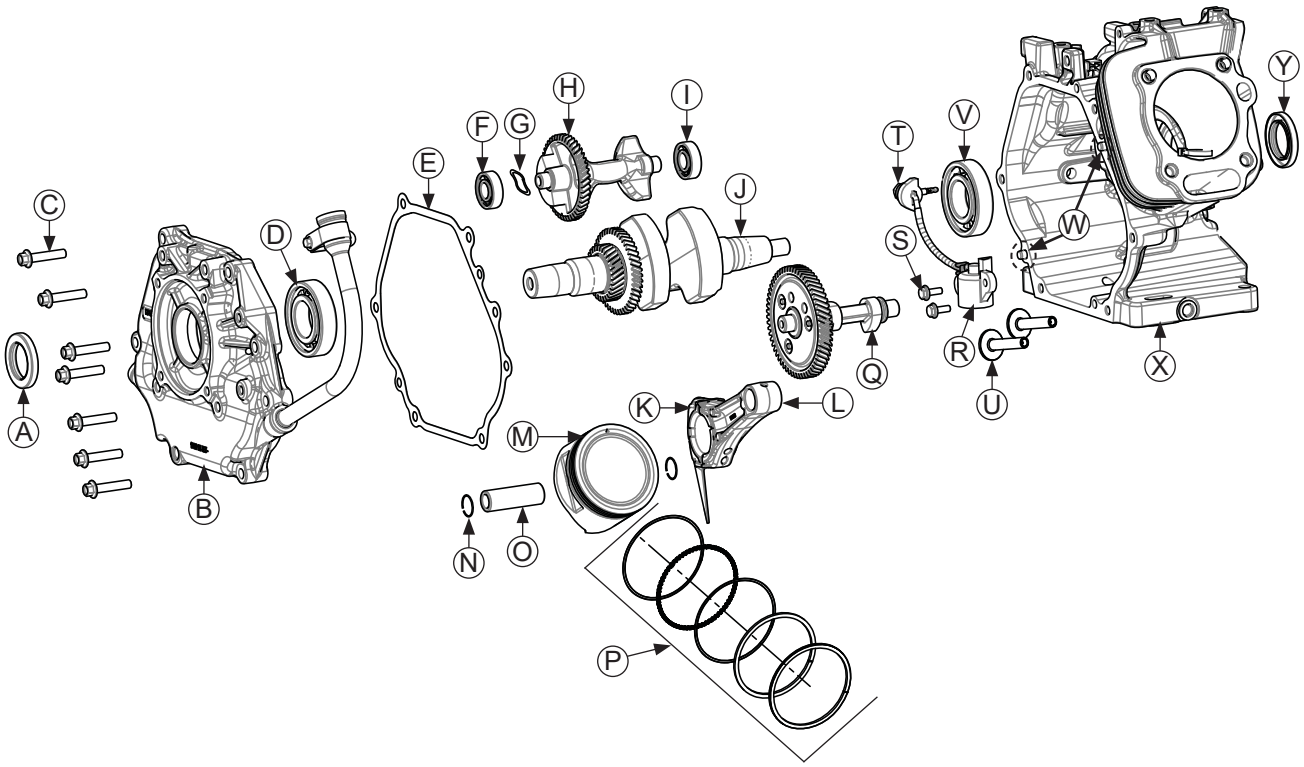
NOTE: Do not use a feeler gauge to measure piston-to-bore clearance, it will yield inaccurate measurements. Always use a micrometer.

Before installing piston into cylinder bore, it is necessary that clearance be accurately checked. This step is often overlooked, and if clearances are not within specifications, engine failure will usually result.

Use following procedure to accurately measure piston-to-bore clearance:

1. Use a micrometer and measure diameter of piston above bottom of piston skirt and perpendicular to piston pin.
2. Use an inside micrometer, telescoping gauge, or bore gauge and measure cylinder bore. Take measurement approximately 7.0 mm (0.2760 in.) below top of bore and perpendicular to piston pin.
3. Piston-to-bore clearance is difference between bore diameter and piston diameter (step 2 minus step 1).

Crankcase/Crankshaft/Camshaft/Closure Plate Components



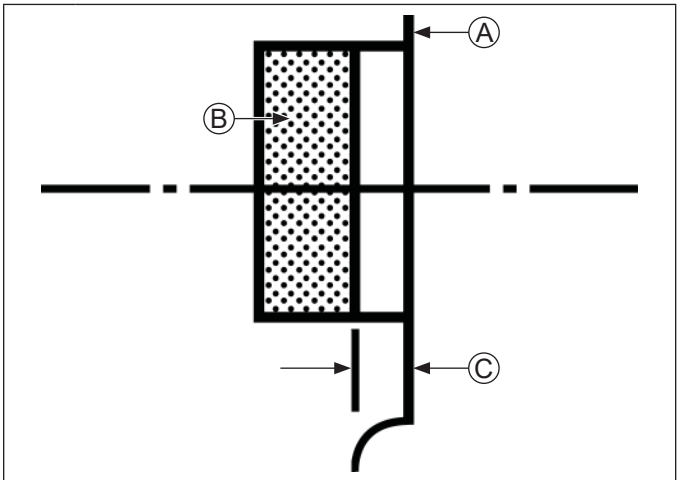
A	Closure Plate Oil Seal	**B**	Closure Plate	**C**	Screw	**D**	Closure Plate Bearing
E	Closure Plate Gasket	**F**	Closure Plate Balance Shaft Bearing	**G**	Wave Spring	**H**	Balance Shaft
I	Crankcase Balance Shaft Bearing	**J**	Crankshaft	**K**	Connector Rod End Cap	**L**	Connector Rod
M	Piston	**N**	Piston Pin Retainer	**O**	Piston Pin	**P**	Piston Ring Set
Q	Camshaft	**R**	Oil Sentry™ Level Switch	**S**	Screw	**T**	Oil Sentry™ Wire
U	Tappet	**V**	Crankcase Bearing	**W**	Dowel Pin	**X**	Crankcase
Y	Crankcase Oil Seal						

NOTE: Engines in this application have air cleaner, starter generator, in-tank fuel pump, EFI fuel filter, and all fuel lines supplied and installed by OEM. Refer to equipment manufacturer's manual for information on these components and before working on fuel system. Use only original equipment replacement parts.

NOTE: Make sure engine is assembled using all specified torque values, tightening sequences, and clearances. Failure to observe specifications could cause severe engine wear or damage. Always use new gaskets.

Install Crankcase Bearings and Oil Seals

Details



A	Outer Surface	**B**	Seal
C	Depth		

NOTE: Oil bearings liberally with engine oil when installing.

NOTE: In steps 3 and 4, position oil seals with manufacturer's identification marks visible and facing you.

1. Make sure there are no nicks, burrs, or damage in bores for bearings. Crankcase and closure plate must be clean.
2. Use an arbor press to make sure bearings are installed straight into their respective bores, until fully seated.
3. Using an appropriate seal driver, install oil seal into closure plate to depth of 8.2 mm (0.323 in.) from outer surface.
4. Using an appropriate seal driver, install oil seal into crankcase to depth of 0.0-1.0 mm (0.0-0.039 in.) from outer surface.
5. Apply a light coating of lithium grease to seal lips after installing.

Install Oil Sentry™ System

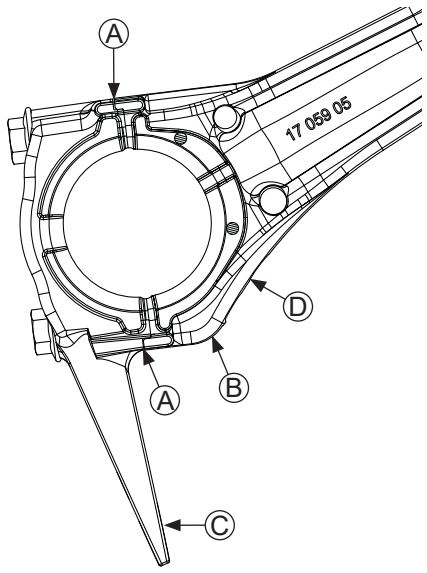
1. Mount Oil Sentry™ switch into crankcase housing using two M6x18 screws and torque to 8 N·m (71 in. lb.).
2. Route wire lead grommet assembly through crankshaft housing.
3. Install nut on grommet assembly external stud and torque to 10 N·m (89 in. lb.).

Install Crankshaft

Carefully slide flywheel end of crankshaft through main ball bearing and seal.

Install Connecting Rod with Piston and Rings

Connecting Rod Details

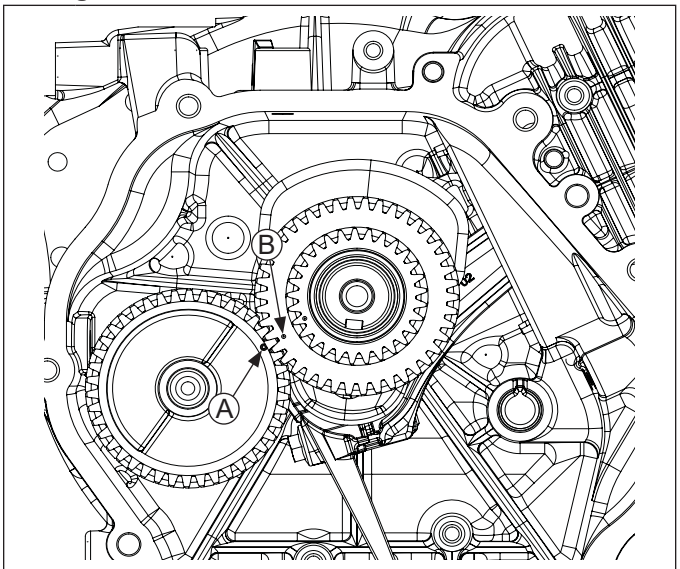


A	Match Marks	**B**	Offset
C	Dipper	**D**	Oil Hole

1. Make sure these are correct before installing.
   a. Locating mark on piston is down.
   b. Connecting rod offset is down and oil hole is in 4 o'clock position shown. Match marks should align as shown with dipper down.
2. If piston rings were removed, see Disassembly/ Inspection and Service procedure to install rings.
3. Lubricate cylinder bore, piston, piston pin, and piston rings with engine oil. Compress rings using a piston ring compressor.
4. Lubricate crankshaft journal and connecting rod bearing surfaces with engine oil.
5. Ensure ▼ stamping on piston is facing down toward base of engine. Use a hammer handle or rounded wood dowel and gently tap piston into cylinder. Be careful oil ring rails do not spring free between bottom of ring compressor and top of cylinder.
6. Install connecting rod cap to connecting rod so dipper is down and match marks are aligned.
7. Torque both screws in increments to 20 N·m (177 in. lb.).

Install Balance Shaft

Timing Mark Detail

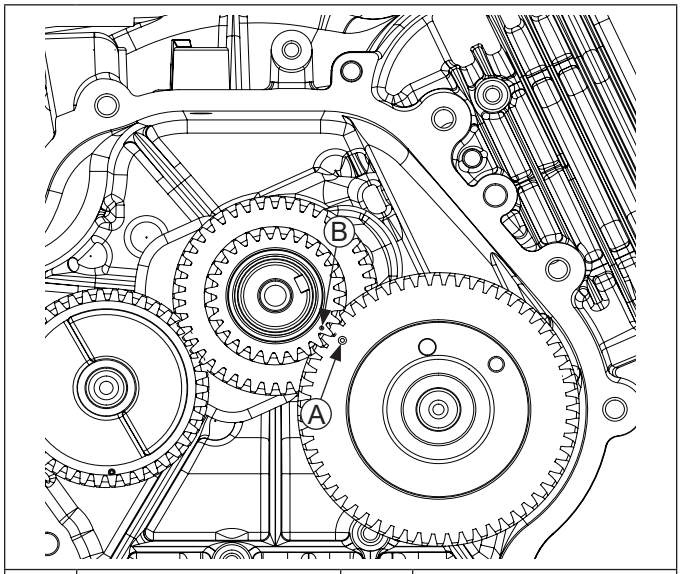


A	Balance Shaft Timing Mark	**B**	Balance Shaft Drive Gear on Crankshaft Timing Mark

1. Position crankshaft so timing mark on larger crankgear is in 8 o'clock position.
2. Install balance shaft (with wave spring), aligning timing mark with timing mark on larger crankgear.

Install Valve Tappets and Camshaft

Timing Mark Detail

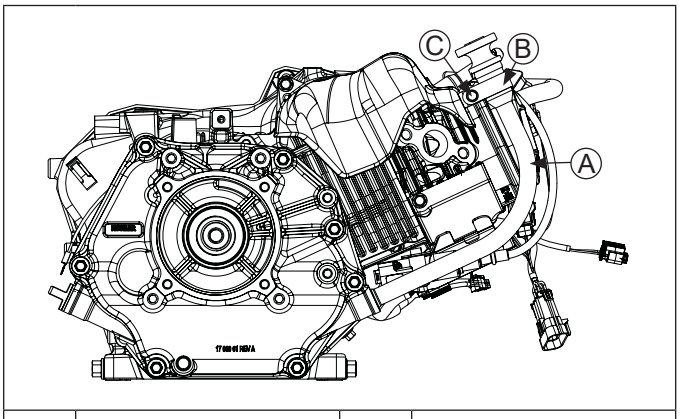


A	Camshaft Gear Timing Mark	**B**	Camshaft Drive Gear on Crankshaft Timing Mark

1. Lubricate face and stem of each tappet with engine oil. Install each into their respective bores.
2. Lubricate camshaft bearing surfaces and cam lobes as well as camshaft bore in crankcase with engine oil.
3. Rotate crankshaft to TDC so timing mark (dimple) on smaller crankgear is in 4 o’clock position. Install camshaft into crankcase, aligning timing marks on two gears.
4. Install original shims on crankshaft.

Install Oil Fill Tube

Details

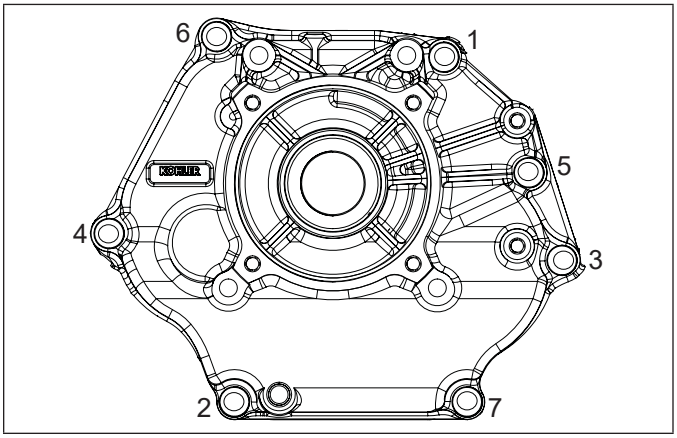


A	Oil Fill Tube	**B**	Oil Fill Tube Bracket
C	Bracket Screw		

1. If oil fill tube was removed from closure plate, apply a small amount of Loctite® 620™ (or equivalent) to end of tube, then press into closure plate until tube bead seats in closure plate. Tube should be parallel to closure plate PTO face.
2. Place bracket over tube and secure with bracket screw. Tighten screw until bracket is tight all around tube; then torque to 5.4 N·m (48 in. lb.).

Install Closure Plate

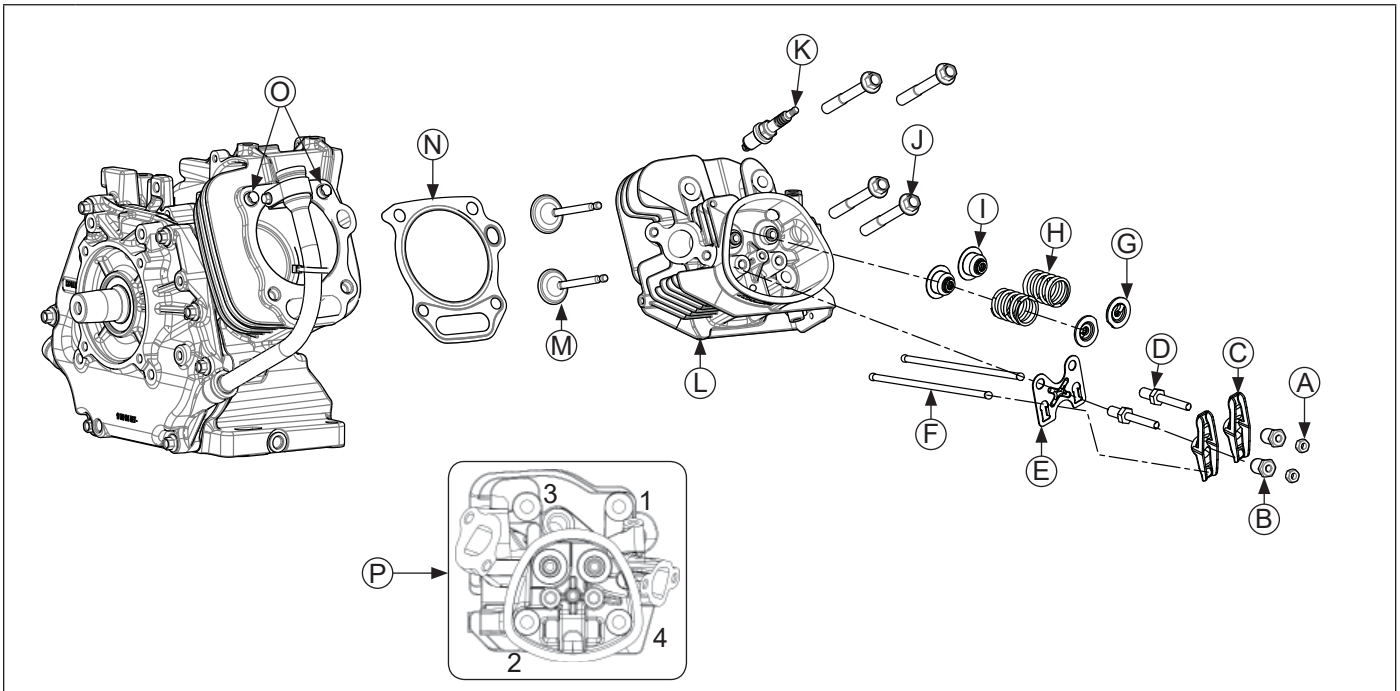
Torque Sequence



1. Check to make sure sealing surfaces of crankcase and closure plate are clean and free of nicks/burrs.
2. Install two dowel pins into locations shown in crankcase. Install new closure plate gasket (dry) onto dowel pins.
3. Install closure plate to crankcase. Carefully seat ends of camshaft and balance shaft into their mating bearings.
4. Install screws securing closure plate to crankcase. Torque screws in sequence shown to 24 N·m (212 in. lb.).

Reassembly

Cylinder Head Components



A	Hex Jam Nut	**B**	Rocker Arm Pivot Adjuster	**C**	Rocker Arm	**D**	Rocker Arm Stud
E	Push Rod Guide	**F**	Push Rod	**G**	Valve Spring Retainer	**H**	Valve Spring
I	Valve Stem Seal	**J**	Cylinder Head Screw	**K**	Spark Plug	**L**	Cylinder Head
M	Valve	**N**	Cylinder Head Gasket	**O**	Dowel Pin	**P**	Torque Sequence

Assemble Cylinder Head

NOTE: Engine utilizes valve stem seals on valves. Always use a new seal when valves are installed in cylinder head. Never reuse old seals.

1. Install valves into their respective positions.
2. Install new valve seals on stem of valves.
3. Install valve springs and retainers into their respective locations in cylinder head. Support valve heads from underneath. Using hand pressure, compress each valve spring and slide each retainer onto valve stem to lock in place.

Install Cylinder Head

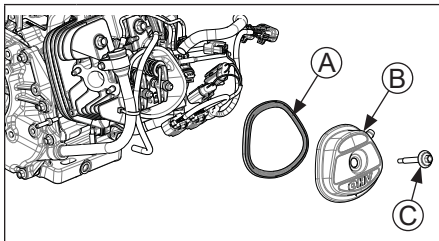
1. Check to make sure there are no nicks or burrs on sealing surfaces of cylinder head or crankcase.
2. Rotate crankshaft to position piston at TDC on compression stroke.
3. Install dowel pins into recesses around upper cylinder head bolt holes.
4. Install a new cylinder head gasket.
5. Apply clean engine oil under head of each cylinder head screw.
6. Install cylinder head and start screws. Finger tighten screws, then torque screws in increments using sequence shown. Torque screws first to 25 N·m (221 in. lb.), then finally to 57.5 N·m (509 in. lb.).

Install Push Rods and Rocker Arms

NOTE: Push rods should always be installed in original location.

1. Identify proper position of each push rod. Dip ends of push rods in engine oil and install them in their respective locations, seating each into tappet socket.
2. Install push rod guide plate, aligning holes for rocker arm studs. Screw in rocker arm studs and torque to 13.6 N·m (120 in. lb.).
3. Assemble rocker arms, rocker arm pivot adjusters, and hex jam nuts onto studs and push rods. Finger tighten rocker arm pivot jam locknuts.
4. Adjust valve tappet clearance as follows:
   a. Make sure piston is still at top of compression stroke.
   b. Insert a flat feeler gauge between rocker arm and valve stem. Recommended valve to rocker arm clearance for both intake and exhaust is 0.076-0.127 mm (0.003-0.005 in.)(Cold).
   c. Adjust clearance as required by loosening hex jam nut and turning rocker arm pivot adjuster.
      Turn clockwise to decrease clearance.
      Turn counterclockwise to increase clearance.
   d. Hold rocker arm pivot adjuster from turning and tighten hex jam nut. Torque hex jam nut to 10 N·m (89 in. lb.).
   e. Recheck clearance is correct.
5. Set gap of a new spark plug to 1.11 mm (0.044 in.).
6. Install spark plug in cylinder head and torque to 27 N·m (20 ft. lb.).

Install Valve Cover



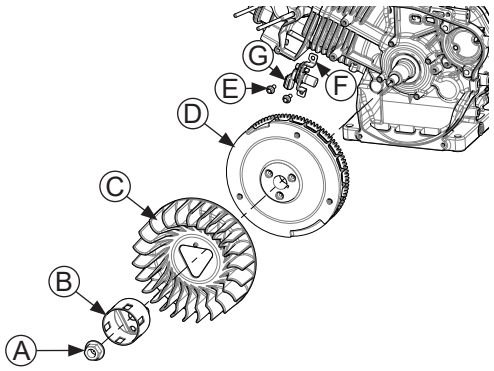
A	Valve Cover Gasket	**B**	Valve Cover
C	Valve Cover Seal Screw Assembly		

1. Install a new valve cover gasket onto valve cover.
2. Position valve cover/gasket assembly on head. Install screw and washer; torque screw to 10 N·m (89 in. lb.).

Install Wiring Harness

Route wiring harness through castings on crankcase. Direct green wire toward oil level switch. Feed this wire through clip secured to crankcase. Connect oil level switch green wire to wiring harness.

Flywheel Components



A	Flywheel Retaining Nut	**B**	Drive Cup
C	Flywheel Fan	**D**	Flywheel
E	Crankshaft Position Sensor Bracket Screw	**F**	Crankshaft Position Sensor Bracket
G	Crankshaft Position Sensor		

Install Flywheel



⚠ CAUTION

Damaging Crankshaft and Flywheel can cause personal injury.

Using improper procedures can lead to broken fragments. Broken fragments could be thrown from engine. Always observe and use precautions and procedures when installing flywheel.

NOTE: Before installing flywheel make sure crankshaft taper and flywheel hub bore are clean, dry, and completely free of lubricants. Presence of lubricants can cause flywheel to be over stressed and damaged when nut is torqued to specification.

NOTE: Make sure flywheel key is installed properly in keyway. Flywheel can become cracked or damaged if key is not installed properly.

1. Install woodruff key into keyway of crankshaft. Make sure key is properly seated and parallel with taper of shaft.
2. Install flywheel onto crankshaft, being careful not to shift position of woodruff key.
3. Install fan bosses into matching holes in flywheel.
4. Position drive cup on flywheel, engaging boss on its base with corresponding hole in fan. Hold in position and install nut. Finger tighten to keep cup indexed.
5. Use a flywheel holding tool and torque wrench to tighten flywheel nut. Torque nut to 113 N·m (1000 in. lb.).

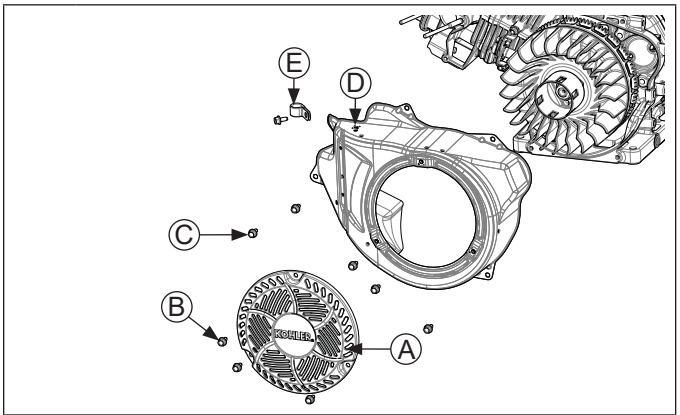
Install Crankshaft Position Sensor

NOTE: Ensure all parts are clean, undamaged and free of debris and make sure electrical connectors have seal in place.

NOTE: When mounting ground wire on bottom screw of bracket, ensure ground wire is routed outside and away from flywheel.

1. Install crankshaft position sensor to bracket. Torque screw to 4.2 N·m (37 in. lb.).
2. Install crankshaft position sensor and bracket assembly to crankcase posts.
3. Secure bracket assembly to crankcase posts. Torque bracket screws to 7.3 N·m (65 in. lb.).
4. Push electrical connector on crankshaft position sensor making sure a good connection is made.

Blower Housing Components



A	Blower Housing Screen	**B**	Screw
C	Screw	**D**	Blower Housing
E	Clamp		

Install Blower Housing

Install blower housing on crankcase with screws. Torque screws to 10 N·m (89 in. lb.).

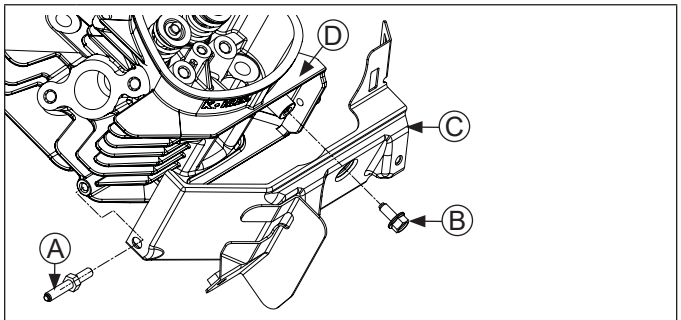
Install Blower Housing Screen

Install blower housing screen on blower housing using screws. Torque screws to 7.3 N·m (65 in. lb.).

Install Wiring Harness Clamp

Insert wiring harness into clamp and install clamp with wiring harness to blower housing. Tighten screw securely.

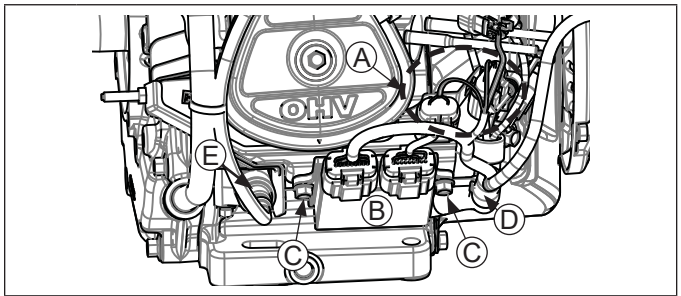
Install Cylinder Shield



A	Ground Stud	**B**	Screw
C	Cylinder Shield	**D**	Cylinder Head

1. Install cylinder shield on cylinder head; secure with ground stud and screw as shown. Torque stud and screw to 8 N·m (71 in. lb.).
2. If removed, install ignition coil onto cylinder shield. Torque screw to 10.2 N·m (90 in. lb.).
3. Plug connector into ignition coil.

Fuses and ECU Components



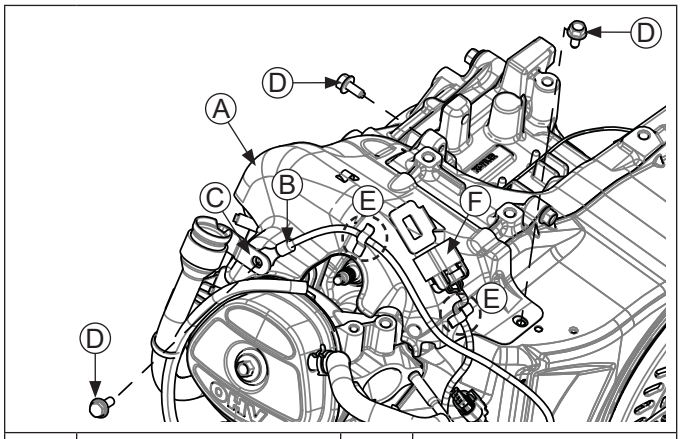
A	Fuses/Fuse Holders	**B**	ECU
C	Screw	**D**	Cable Clip
E	Ignition Coil		

Install Electronic Control Unit (ECU)

NOTE: ECU pins should be coated with a thin layer of electrical grease to prevent fretting and corrosion and may need to be reapplied if ECU is being reused.

1. Connect Black and Grey electrical connectors. Connectors and ECU are keyed in such a way so they cannot be installed incorrectly.
2. Install ECU to cylinder shield using screws. Wire harness clip secures with screw closest to flywheel. Torque screws to 8 N·m (71 in. lb.).
3. Install fuses into holders on cylinder shield.

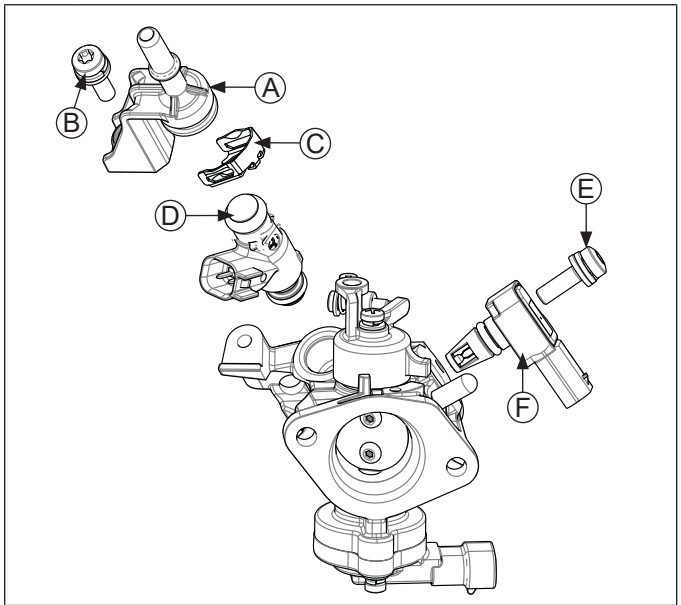
Install Upper Heat Shield and Engine Temperature Sensor



A	Upper Heat Shield	**B**	Engine Temperature Sensor
C	Dipstick Tube Bracket	**D**	Screw
E	Clip	**F**	Oxygen Sensor Connector

1. Position upper heat shield on crankcase and start 2 screws securing to crankcase. Do not tighten screws at this time.
2. Position engine temperature sensor between dipstick tube bracket and upper heat shield; start screw to secure. Torque this screw to 11.9 N·m (105 in. lb.).
3. Fully tighten and torque 2 screws securing shield to crankcase to 6.2 N·m (55 in. lb.) into new holes or 4.0 N·m (35 in. lb.) into used holes.
4. Install engine temperature wire under upper heat shield clip. Install oxygen sensor wire under upper heat shield clip.

Install Fuel Injector and TMAP



A	Fuel Injector Cap	**B**	Screw
C	Metal Retaining Clip	**D**	Fuel Injector
E	Screw	**F**	TMAP

Install Temperature/Manifold Absolute Pressure (TMAP) Sensor

NOTE: Ensure all parts are clean, undamaged, and free of debris and make sure electrical connector has seal in place.

1. Lightly oil TMAP sensor O-ring and push sensor into bore in throttle body.
2. Torque screw to 7.3 N·m (65 in. lb.).
3. Push electrical connector on TMAP sensor making sure a good connection is made. Slide down lock tab.

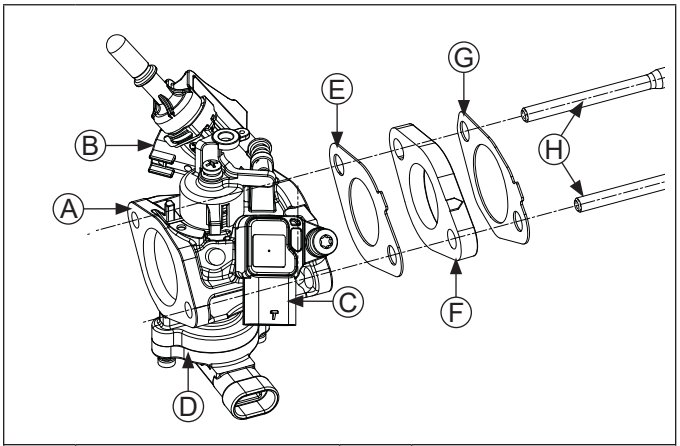
Install Fuel Injector

NOTE: Ensure all parts are clean, undamaged, and free of debris and make sure electrical connectors have seal in place.

NOTE: O-rings and retaining clip should be replaced any time fuel injector is separated from its normal mounting position.

1. Lightly lubricate fuel injector O-rings with clean engine oil.
2. Push retaining clip onto fuel injector, aligning clip.
3. Press fuel injector cap onto fuel injector until retaining clip snaps into place.
4. Press fuel injector into bore in throttle body and rotate to original position, as noted in Disassembly/ Inspection and Service.
5. Install fuel injector cap screw into throttle body and torque to 7.3 N·m (65 in. lb.).
6. Push electrical connector on fuel injector making sure a good connection is made.

Install Throttle Body Assembly



A	Throttle Body	**B**	Fuel Injector
C	TMAP	**D**	Throttle Position Sensor (TPS)
E	Insulator to Throttle Body Gasket	**F**	Insulator
G	Insulator to Cylinder Head Gasket	**H**	Intake Studs

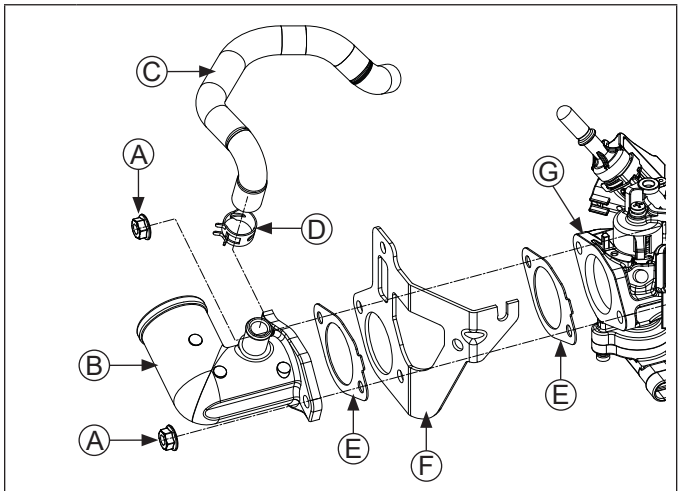
NOTE: Ensure all parts are clean, undamaged, and free of debris and make sure electrical connector has seal in place.

1. Install new insulator to cylinder head gasket, insulator, and insulator to throttle body gasket as shown.

   Ensure notched section of each gasket is outward and points to flywheel side.

   Ensure arrow on insulator points toward cylinder head.
2. Install throttle body on studs.
3. Push electrical connector onto throttle position sensor (TPS) making sure a good connection is made.

Install Air Inlet Elbow



A	Nut	**B**	Air Inlet Elbow
C	Breather Hose with Sleeve	**D**	Clamp
E	Throttle Body Gasket	**F**	Governor Bracket
G	Throttle Body		

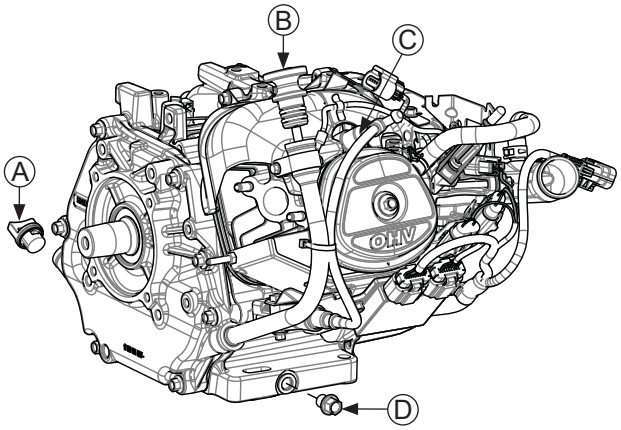
1. Install a new throttle body gasket onto mounting studs followed by air inlet elbow.
2. Install governor bracket onto mounting studs followed by a new throttle body gasket.

   Ensure notched section of each gasket is outward and points to flywheel side.
3. Install air inlet elbow onto mounting studs and secure with nuts. Torque nuts to 8 N·m (71 in. lb.).
4. Attach breather hose onto air inlet elbow connection port; position hose clamp to secure. Connect opposite end of breather hose to valve cover.

Oxygen Sensor

Install oxygen sensor, torque to 18 N·m (159 in. lb.), and connect to wire harness.

External Engine Components



A	Oil Fill Plug	**B**	Dipstick
C	Spark Plug Lead	**D**	Oil Drain Plug

Connect Spark Plug Lead

Connect lead to spark plug. Secure lead to dipstick tube with a new wire tie.

Prepare Engine for Operation

NOTE: If ECU, throttle body, TPS, or fuel pump were replaced, an ECU Reset and TPS Learn is required. Refer to EFI System, ECU Reset and TPS Learn procedure.

Engine is now reassembled. Before starting or operating engine be sure to do following:

1. Make sure all hardware is properly torqued.
2. Make sure oil drain plugs, oil fill plugs and Oil Sentry$_{TM}$ wire lead bushing are tightened securely.
3. Fill crankcase with correct oil. Refer to Maintenance and Lubrication System for oil recommendations and procedures.
4. Ensure all electrical connectors are installed and secure.
5. Make sure all fuel and vent lines are connected. Refer to equipment manufacturer's manual for Reassembly information.
6. Reinstall engine into application and test operation. Refer to equipment manufacturer's manual for details.



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Pagination Page

SECTION 26 — WIRING DIAGRAMS

26

GENERAL INFORMATION

Wire Description

EXAMPLE: 18_GRN_RED

- 18 = 18 gauge wire
- GRN_RED = Green wire with red stripe

Wire Colors

NOTE: *The following colors will represented as a black wire in the wiring diagrams:*

- *Black*
- *White*
- *Yellow*
- *White with Black Stripe*

Abbreviation	Wire Color
BLK	Black
BLU	Blue
LT BLU	Light Blue
BRN	Brown
GRAY	Gray
GRN	Green
ORG	Orange
PINK	Pink
PUR	Purple
RED	Red
TAN	Tan
WHT	White
YEL	Yellow
BLK_LT_BLUE	Black with Light Blue Stripe
BLK_ORG	Black with Orange Stripe
BLK_PINK	Black with Pink Stripe
BLK_WHT	Black with White Stripe
BLK_YEL	Black with Yellow Stripe
BLU_WHT	Blue with White Stripe
BRN_WHT	Brown with White Stripe
GRN_RED	Green with Red Stripe

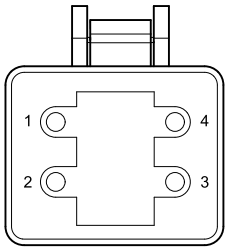
TABLE CONTINUED ON NEXT PAGE

GRN_WHT	Green with White Stripe
ORG_BLK	Orange with Black Stripe
ORG_WHT	Orange with White Stripe
PUR_WHT	Purple with White Stripe
RED_GRN	Red with Green Stripe
RED_WHT	Red with White Stripe
RED_YEL	Red with Yellow Stripe
WHT_BLK	White with Black Stripe

PEDAL-START CONNECTOR PINOUTS

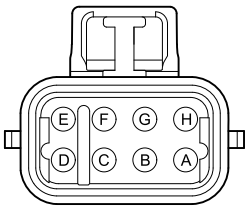
PEDAL-START MAIN HARNESS CONNECTOR PINOUTS

To Connected Car



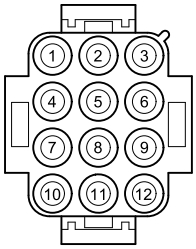
Pin	Wire Color	Description
1	Red	Power
2	Black	Ground
3	OPEN	OPEN
4	OPEN	OPEN

To Engine Harness



Pin	Wire Color	Description
A	Red	Switched 12V Power
B	Red	Constant 12V Power
C	OPEN	OPEN
D	Tan	Malfunction Indicator Light (MIL)
E	White	Ground Kill Wire
F	Green	Low Oil Light
G	Black / White	Fuel Pump
H	OPEN	OPEN

To Instrument Panel (IP) Harness

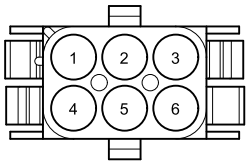


Pin	Wire Color	Description
1	Green / White	Headlights / Taillights
2	Green / Red	Headlight Switch Power
3	Red / Yellow	To Key Switch (M+)
4	OPEN	OPEN
5	Orange / White	Reverse Buzzer Power
6	Blue / White	Power
7	Black / White	Ground
8	Tan	Malfunction Indicator Light (MIL)
9	Purple / White	To FNR Harness Pin 3

TABLE CONTINUED ON NEXT PAGE

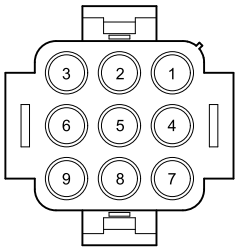
10	Orange / Black	Fuel Sending Unit Input
11	White	Hour Meter Input
12	Green	Low Oil Light

To FNR Harness



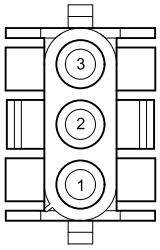
Pin	Wire Color
1	Black / Yellow
2	Orange
3	Purple / White
4	Black / Light Blue
5	Blue / White
6	Yellow

To Accessories



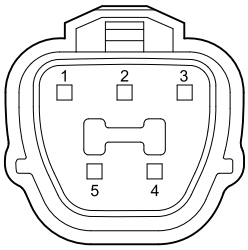
Pin	Wire Color	Description
1	Blue	Horn Power
2	Gray	To Rear Lights
3	Gray / Black	Brake Light Relay
4	White	To Rear Lights
5	OPEN	OPEN
6	Black	Ground
7	Brown	Power
8	Red	Right Turn Signal Power
9	Green	Left Turn Signal Power

To Brake Light Relay



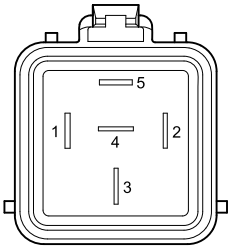
Pin	Wire Color	Description
1	Black	Ground
2	White / Black	Power
3	Gray / Black	To Accessories Pin 3

To Fuel Pump



Pin	Wire Color	Description
1	Open	Open
2	Orange/Black	Sending Unit Positive (+)
3	Black	Sending Unit Negative (-)
4	Black/White	Fuel Pump Negative (-)
5	Red/White	Fuel Pump Positive (+)

Fuel Pump Relay

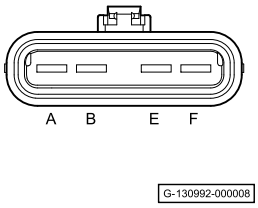


Pin	Wire Color
1	Green

TABLE CONTINUED ON NEXT PAGE

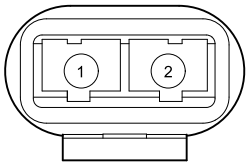
2	Black/White
3	Red/White
4	Open
5	Red

Fuse Holder



Pin	Wire Color
A	Red
B	Red/Black
E	Orange/White
F	Orange

Fuse Connector

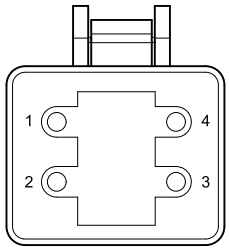


Pin	Wire Color
1	Red
2	Pink

KEY-START CONNECTOR PINOUTS

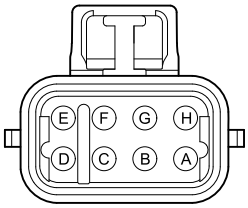
KEY-START MAIN HARNESS CONNECTOR PINOUTS

To Connected Car



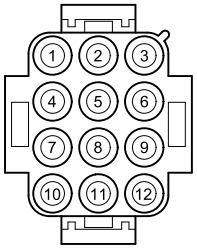
Pin	Wire Color	Description
1	Red	Power
2	Black	Ground
3	OPEN	OPEN
4	OPEN	OPEN

To Engine Harness



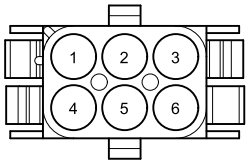
Pin	Wire Color	Description
A	Red	Switched 12V Power
B	Red	Constant 12V Power
C	OPEN	OPEN
D	Tan	Malfunction Indicator Light (MIL)
E	White	Ground Kill Wire
F	Green	Low Oil Light
G	Black / White	Fuel Pump
H	OPEN	OPEN

To Instrument Panel (IP) Harness



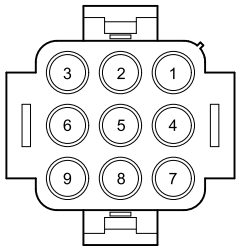
Pin	Wire Color	Description
1	Green / White	Headlights / Taillights
2	Green / Red	Headlight Switch Power
3	Red / Yellow	To Key Switch (M+)
4	OPEN	OPEN
5	Orange / White	Reverse Buzzer Power
6	Blue / White	Power
7	Black / White	Ground
8	Tan	Malfunction Indicator Light (MIL)
9	Purple / White	To FNR Harness Pin 3
10	Orange / Black	Fuel Sending Unit Input
11	White	Hour Meter Input
12	Green	Low Oil Light

To FNR Harness



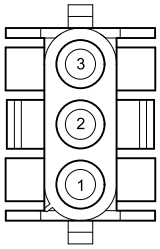
Pin	Wire Color
1	Black / Yellow
2	Orange
3	Purple / White
4	Black / Light Blue
5	Blue / White
6	Yellow

To Accessories



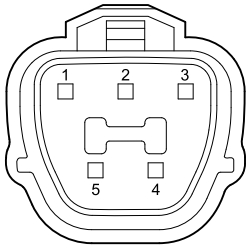
Pin	Wire Color	Description
1	Blue	Horn Power
2	Gray	To Rear Lights
3	Gray / Black	Brake Light Relay
4	White	To Rear Lights
5	OPEN	OPEN
6	Black	Ground
7	Brown	Power
8	Red	Right Turn Signal Power
9	Green	Left Turn Signal Power

To Brake Light Relay



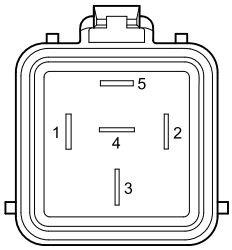
Pin	Wire Color	Description
1	Black	Ground
2	White / Black	Power
3	Gray / Black	To Accessories Pin 3

To Fuel Pump



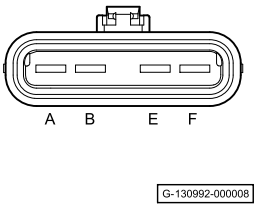
Pin	Wire Color	Description
1	Open	Open
2	Orange/Black	Sending Unit Positive (+)
3	Black	Sending Unit Negative (-)
4	Black/White	Fuel Pump Negative (-)
5	Red/White	Fuel Pump Positive (+)

Fuel Pump Relay



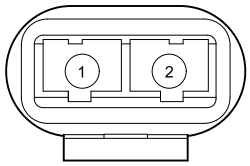
Pin	Wire Color
1	Green
2	Black/White
3	Red/White
4	Open
5	Red

Fuse Holder



Pin	Wire Color
A	Red
B	Red/Black
E	Orange/White
F	Orange

Fuse Connector

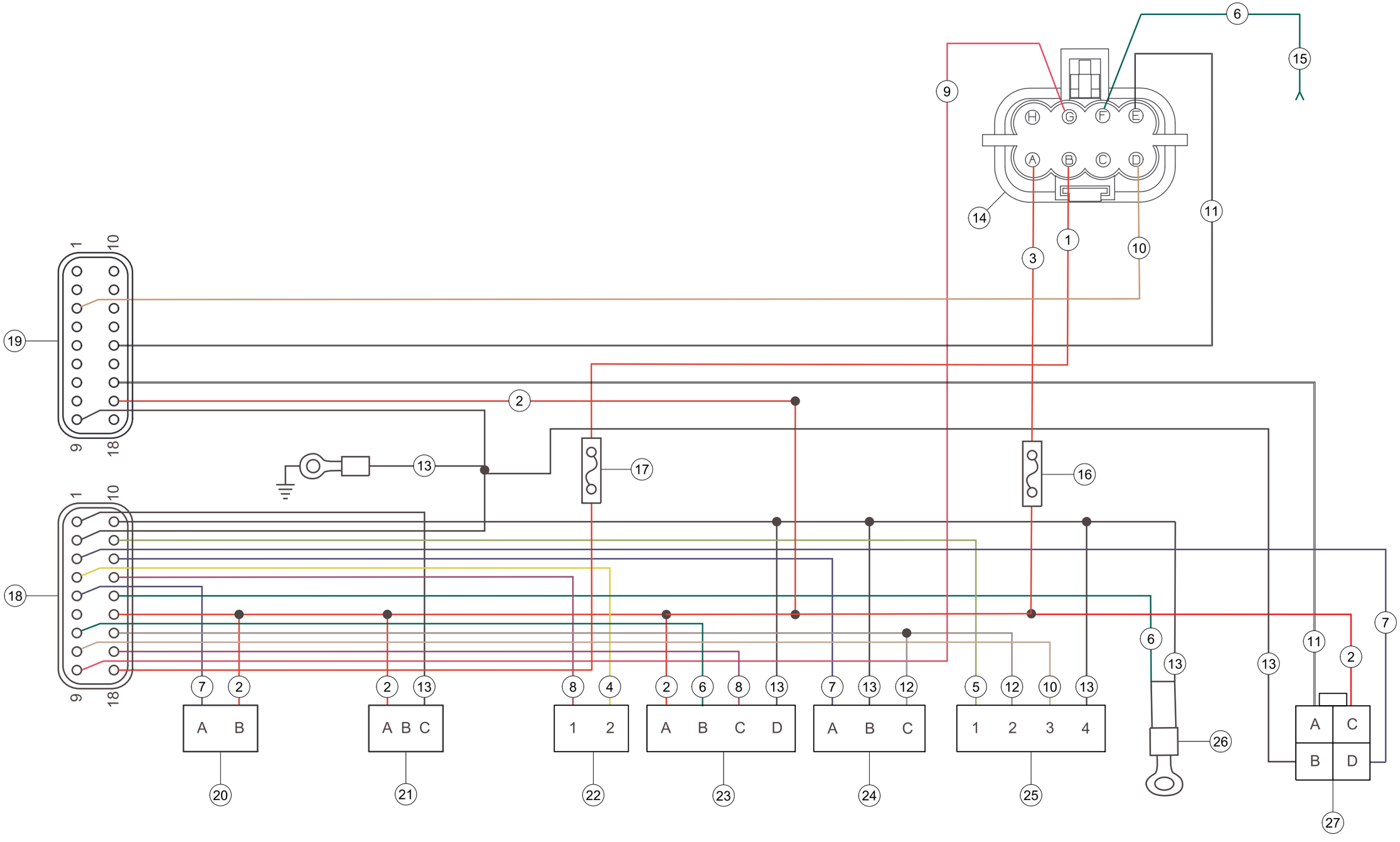


Pin	Wire Color
1	Red
2	Pink

ENGINE HARNESS WIRING DIAGRAM TABLE

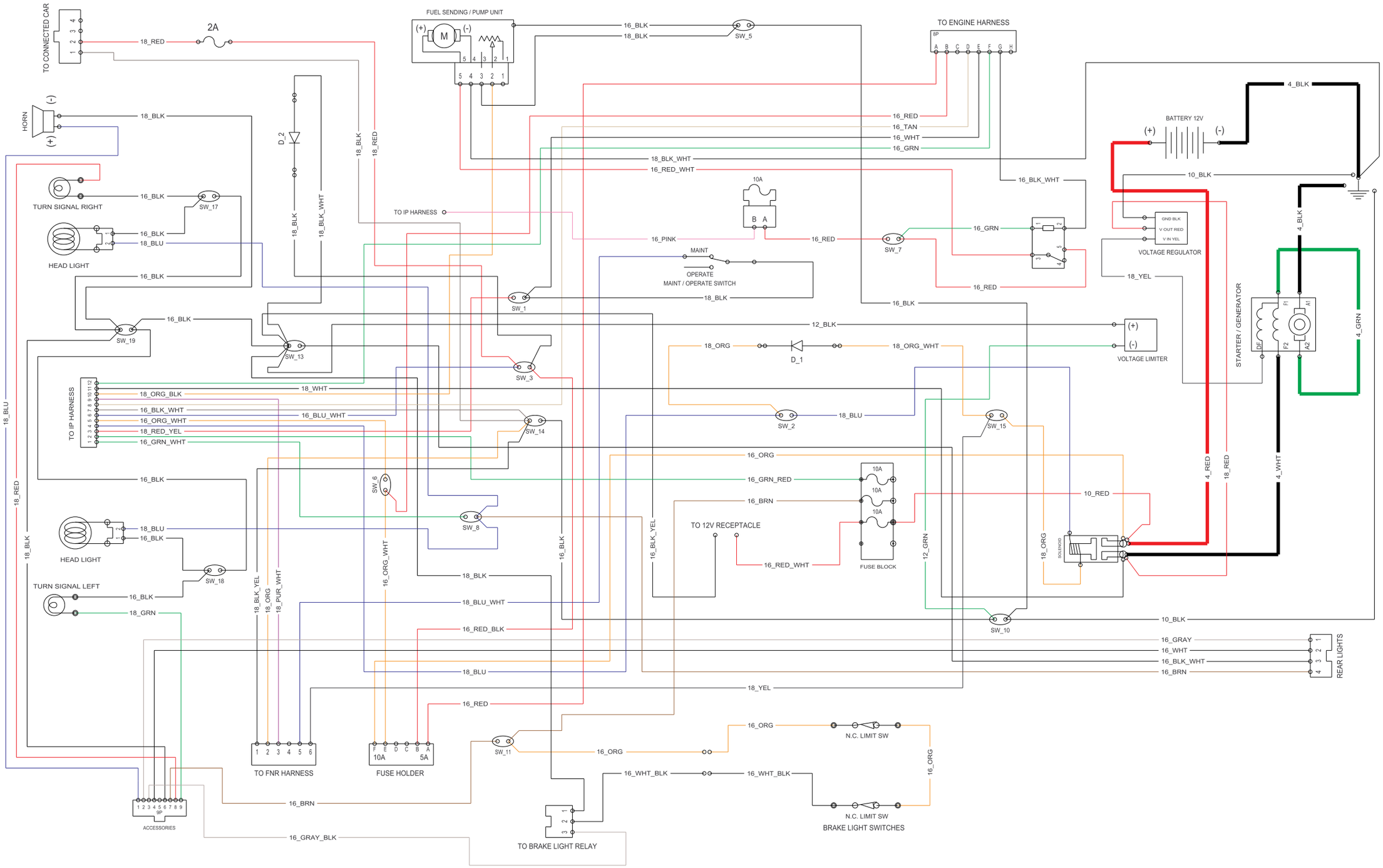
Callout	Description
1	Red
2	Red/Black
3	Red/White
4	Yellow
5	Light Green
6	Dark Green
7	Dark Blue
8	Purple
9	Pink
10	Tan
11	White
12	Grey
13	Black
14	To Main Harness
15	Oil Level Switch
16	10-amp Fuse (Ignition Switch)
17	10-amp Fuse (Battery Power)
18	Black Connector
19	Grey Connector
20	Fuel Injector
21	Ignition Coil
22	Crankshaft Position Sensor
23	Oxygen Sensor
24	Throttle Position Sensor
25	TMAP Sensor
26	Engine Temperature Sensor
27	Diagnostic Connector

GASOLINE: ENGINE HARNESS



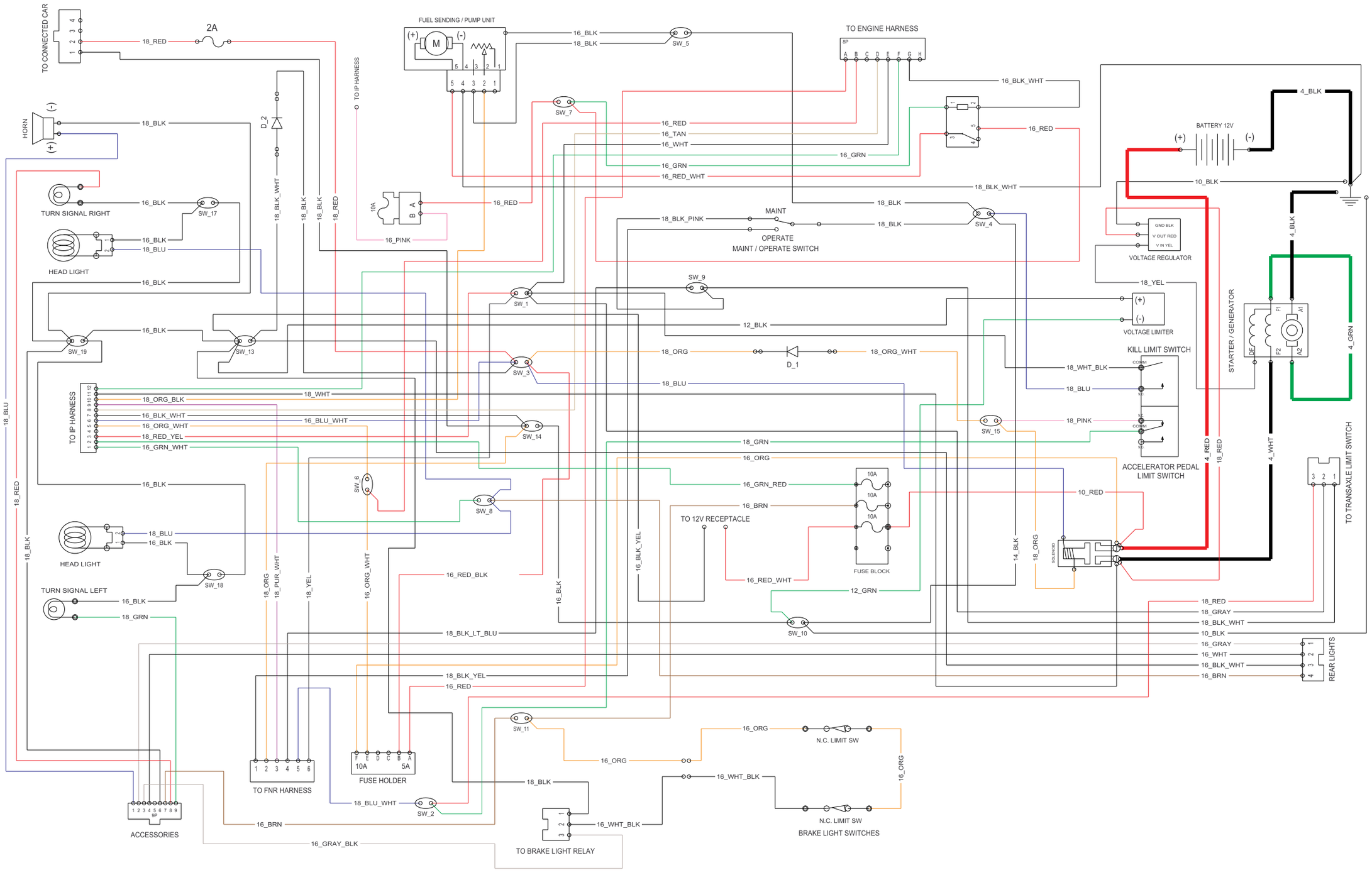
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GASOLINE: KEY-START MAIN HARNESS



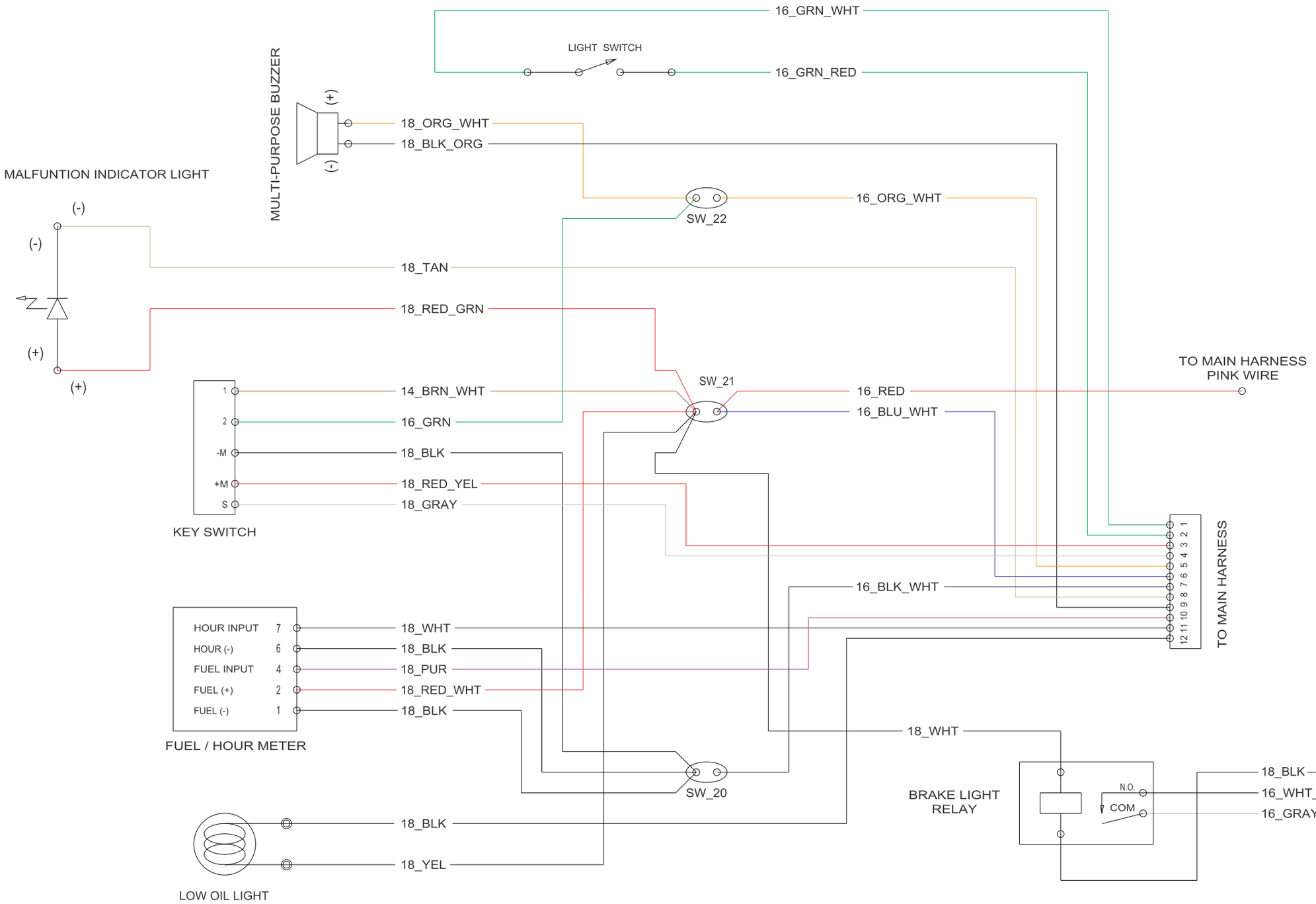
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GASOLINE: PEDAL-START MAIN HARNESS



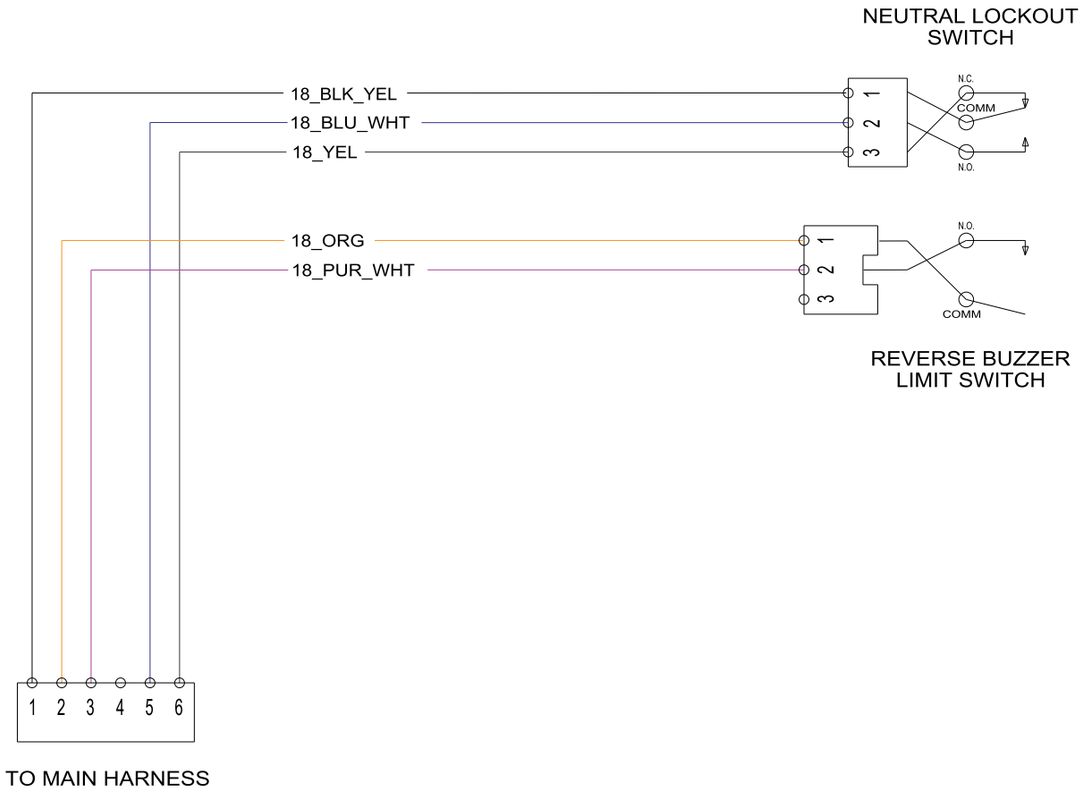
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GASOLINE: INSTRUMENT PANEL HARNESS



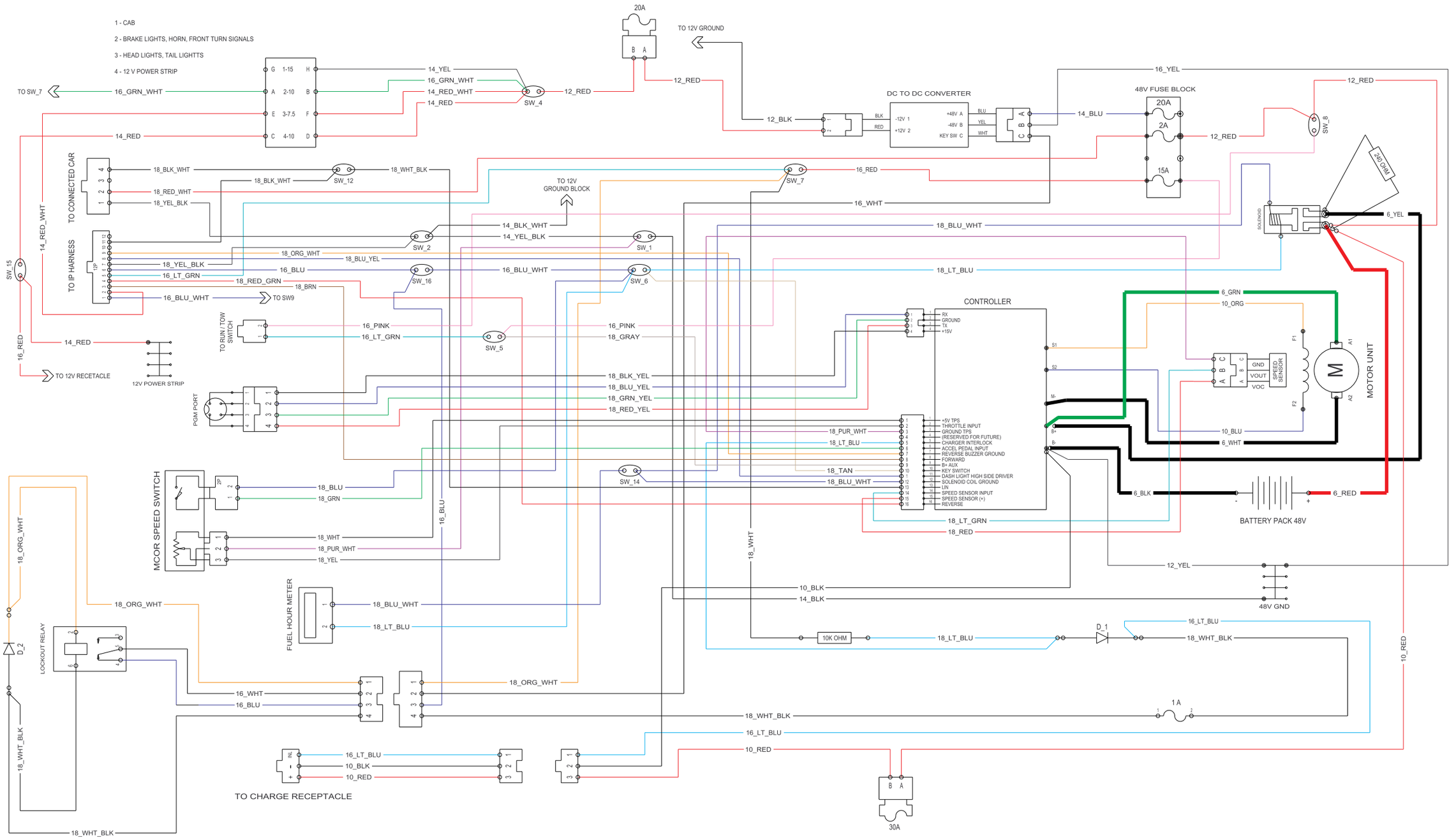
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GASOLINE: FNR HARNESS



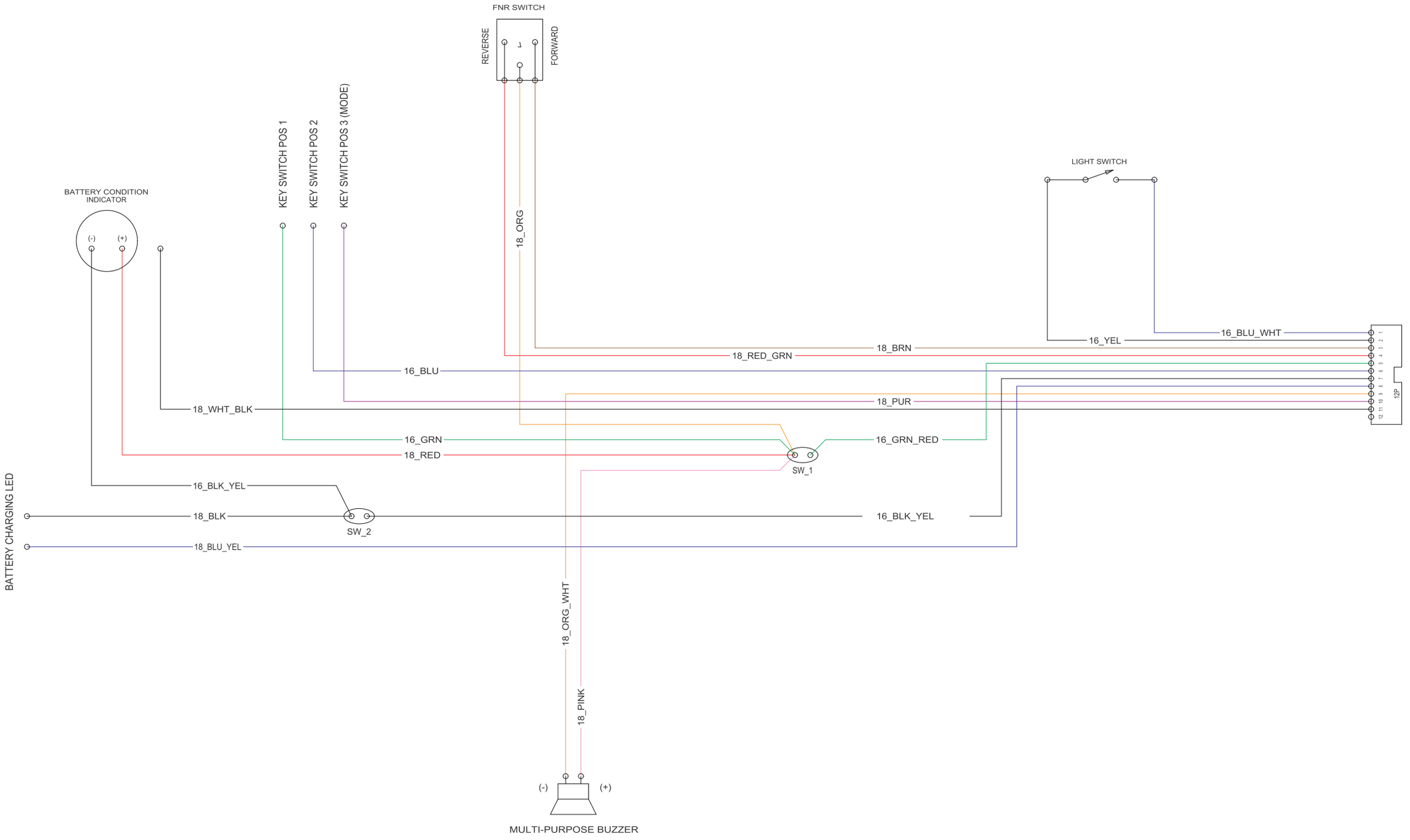
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ELECTRIC: MAIN HARNESS



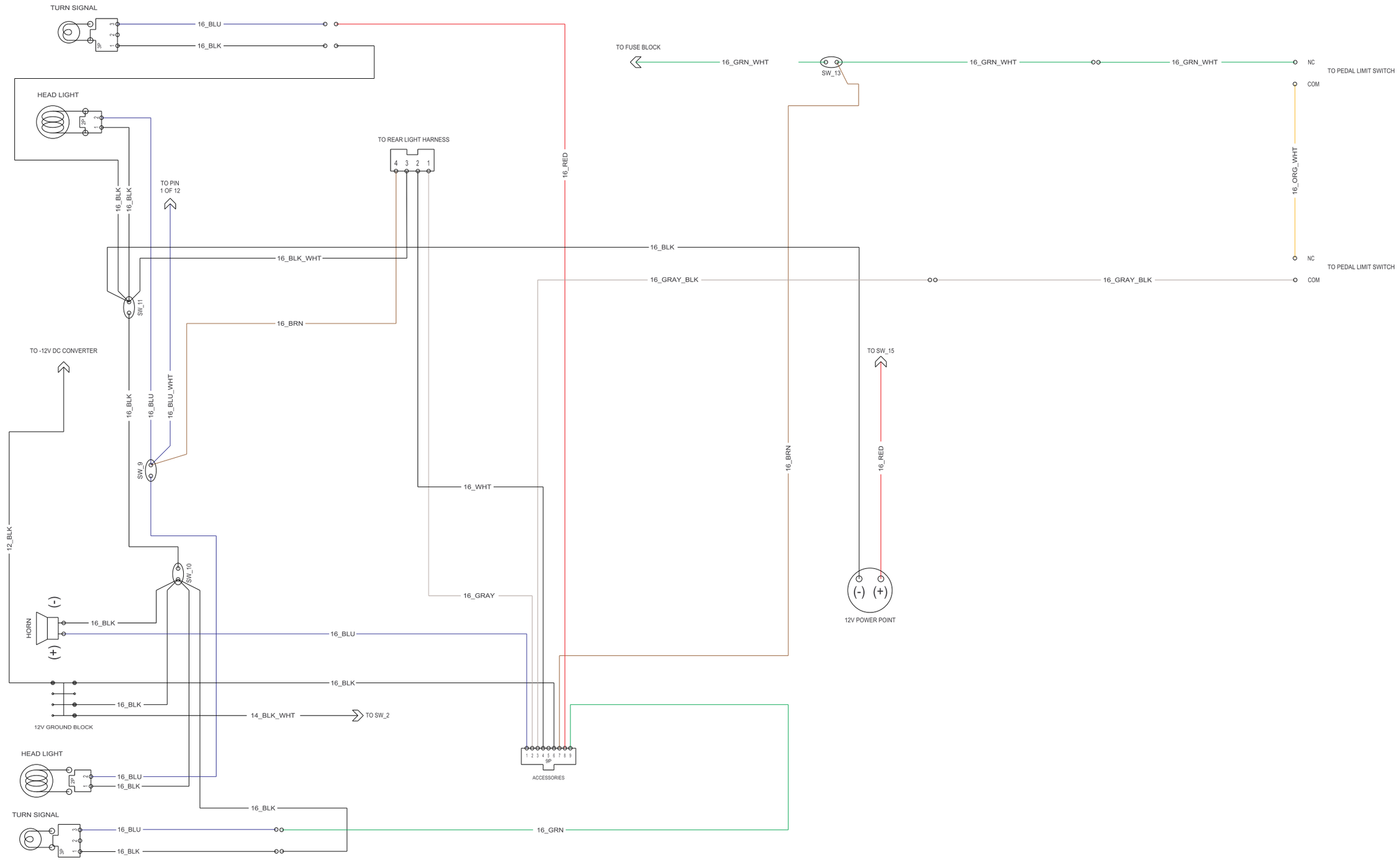
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ELECTRIC: INSTRUMENT PANEL HARNESS



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ELECTRIC: ACCESSORIES HARNESS



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