Onward Maintenance and Service Manual



AC Electric Vehicle
DC Electric Vehicle
Gasoline Vehicle with Kohler ECH440 Engine
Gasoline Vehicle with Subaru EX-40 Engine

Manual Number 86753090006
Edition Code E

INTRODUCTION

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 electric and gasoline-powered vehicles, and should be thoroughly reviewed prior to servicing the vehicle. The procedures provided herein 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 (1-800-258-2227), 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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INTRODUCTION

TECHNICAL PUBLICATION CUSTOMER SATISFACTION ONLINE SURVEY

Let your voice be heard!

Please participate in the Technical Publication customer satisfaction online survey.
This survey takes less than five minutes to complete and your responses will help examine current performance and identify areas for future improvement.

Our top priority is to provide timely, accurate, and user friendly manuals.

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 the 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.

NOTICES

Important features unique to the different models covered in this manual are highlighted. Club Car, LLC recommends the owner/operator read and understand this manual and pay special attention to features specific to their vehicle(s).

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

- Pre-Operation and Daily Safety Checklist
- Controls and Indicators
- Driving Instructions

SERIAL NUMBER DECAL

- Towing
- Transporting on a Trailer
- Subsequent Owner Registration
- Warranties

MODEL IDENTIFICATION

The serial number of each vehicle is printed on a bar code decal mounted either below the passenger side cup holder or above the accelerator or brake pedal (Example: CC5819–123456) .

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.*

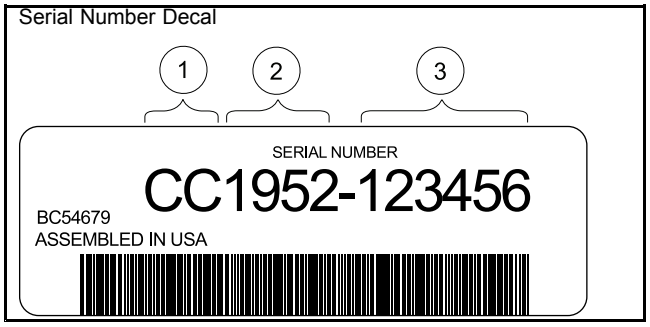


Figure -1 Serial Number Decal

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SECTION 1 — SAFETY

SAFETY DETAILS

⚠ WARNING

- **This owner's manual should be read completely before attempting to drive or service the vehicle. Failure to follow the instructions in this manual could result in property damage, severe personal injury, or death.**

It is important to note that some vital statements throughout this manual and on the decals affixed to the vehicle are preceded by the words DANGER, WARNING, or CAUTION. For your protection, we recommend that you take special notice of these safety precautions. Safety precautions are essential and must be followed.

If any of the operation or safety decals on the vehicle become damaged, have been removed or cannot be easily read, they should be replaced immediately to avoid possible property damage, personal injury, or death. Contact your distributor/dealer.

⚠ DANGER

- **A DANGER indicates an immediate hazard that will result in severe personal injury or death.**

⚠ WARNING

- **A WARNING indicates an immediate hazard that could result in severe personal injury or death.**

⚠ CAUTION

- **A CAUTION with the safety alert symbol indicates a hazard or unsafe practice that could result in minor personal injury.**

CAUTION

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

GENERAL WARNINGS

The following safety statements must be heeded whenever the vehicle is being operated, repaired, or serviced. Vehicle feature identification information is also included. 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.**
- **Children requiring a child safety seat must not ride in vehicle.**
- **Do not leave children unattended on vehicle.**
- **Prior to leaving the vehicle unattended or servicing the vehicle, set the park brake, place the Forward/Neutral/Reverse handle 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 could 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, could 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.**
- **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.**
- **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.**

WARNING CONTINUED ON NEXT PAGE

⚠ WARNING

- **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.**

Electric vehicles only:

- **Place Run/Tow switch in the TOW position before disconnecting or connecting the batteries. Failure to heed this warning could result in a battery explosion or severe personal injury.**
- **To avoid unintentionally starting an electric vehicle, disconnect the batteries and discharge the controller. See Disconnect the Batteries – Electric Vehicles on page 1-4.**

Gasoline vehicles only:

- **To avoid unintentionally starting a gasoline vehicle, disconnect the battery and spark plug wire. See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
- **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.**

DISABLING THE VEHICLE

1. Park the vehicle on a solid level surface.
2. Engage the park brake to prevent vehicle movement.
3. Turn the key to OFF.
4. Remove the key.
5. Set the Forward/Neutral/Reverse control (FNR) to N.
6. Put chocks against the wheels.

DISCONNECT THE BATTERY - GASOLINE VEHICLES

1. Disable the vehicle.
2. Disconnect the negative (-) cable (1) **(Figure 1-1, Page 1-3)**.

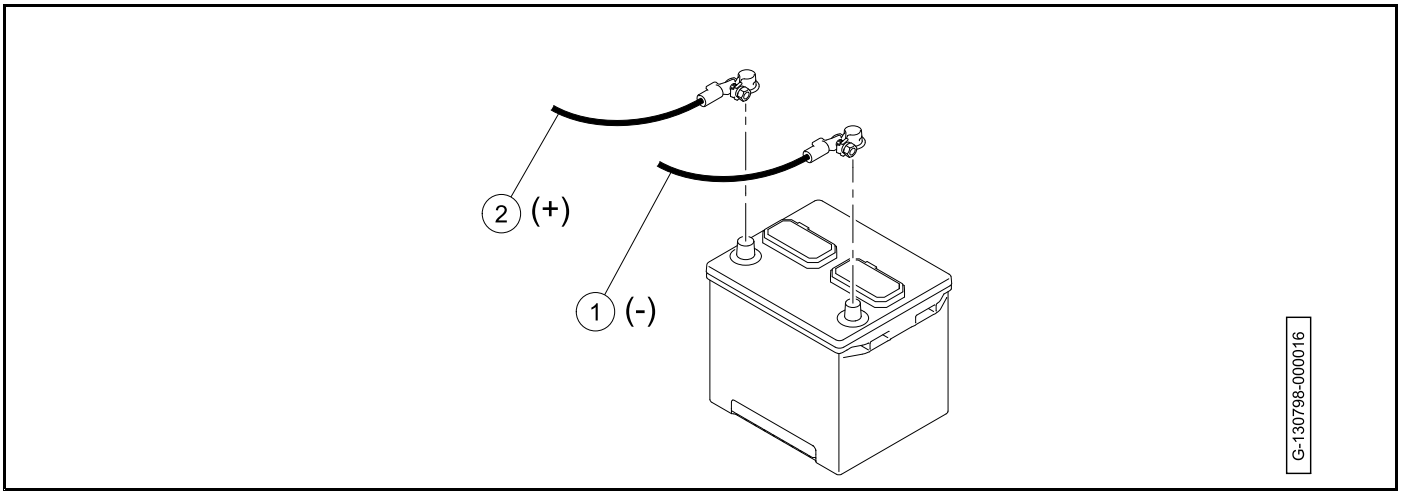


Figure 1-1 Gasoline Vehicle Battery

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

CONNECT THE BATTERY - GASOLINE VEHICLES

1. Connect the positive (+) cable (2) **(Figure 1-1, Page 1-3)**.
2. Connect the negative (-) cable (1).
3. Tighten the hardware to 41 lb·in (4.3 N·m).
4. Apply battery terminal protector spray to the battery terminals.

DISCONNECT THE BATTERIES – ELECTRIC VEHICLES

1. Disable the vehicle.

⚠ DANGER

- **Batteries disconnected or connected with the Run/Tow switch set to RUN can cause a battery explosion and serious personal injury. Set the Run/Tow switch to TOW before the batteries are disconnected or connected.**

2. Set the Run/Tow switch to TOW.
3. Disconnect the negative (-) cable (1) **(Figure 1-2, Page 1-4)**.

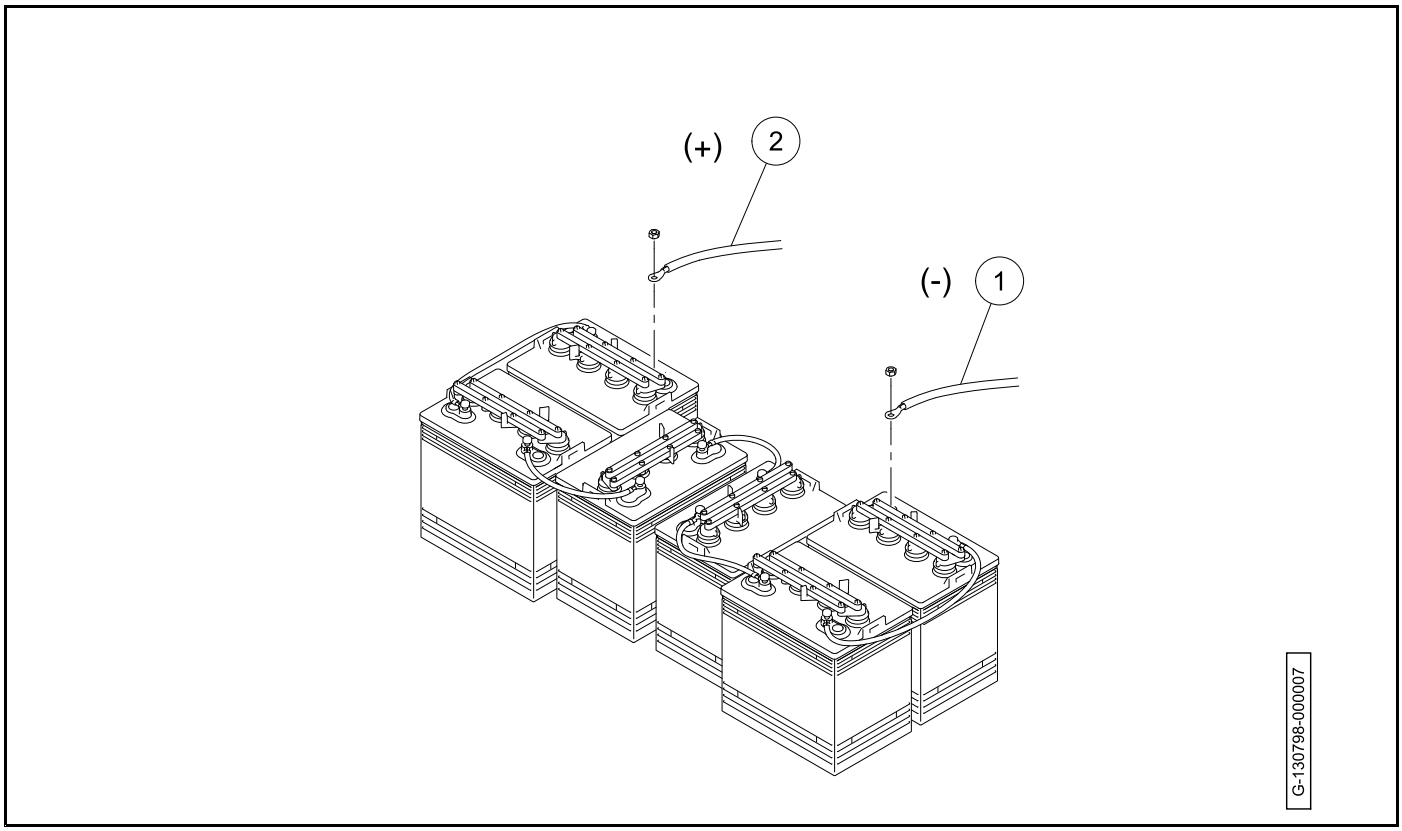


Figure 1-2 Disconnect Electric Vehicle Batteries

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

CONNECT THE BATTERIES – ELECTRIC VEHICLES

⚠ DANGER

- **Batteries disconnected or connected with the Run/Tow switch set to RUN can cause a battery explosion and serious personal injury. Set the Run/Tow switch to TOW before the batteries are disconnected or connected.**

1. Set the Run/Tow switch to TOW.
2. Connect the positive (+) cable (2) **(Figure 1-3, Page 1-5)**.

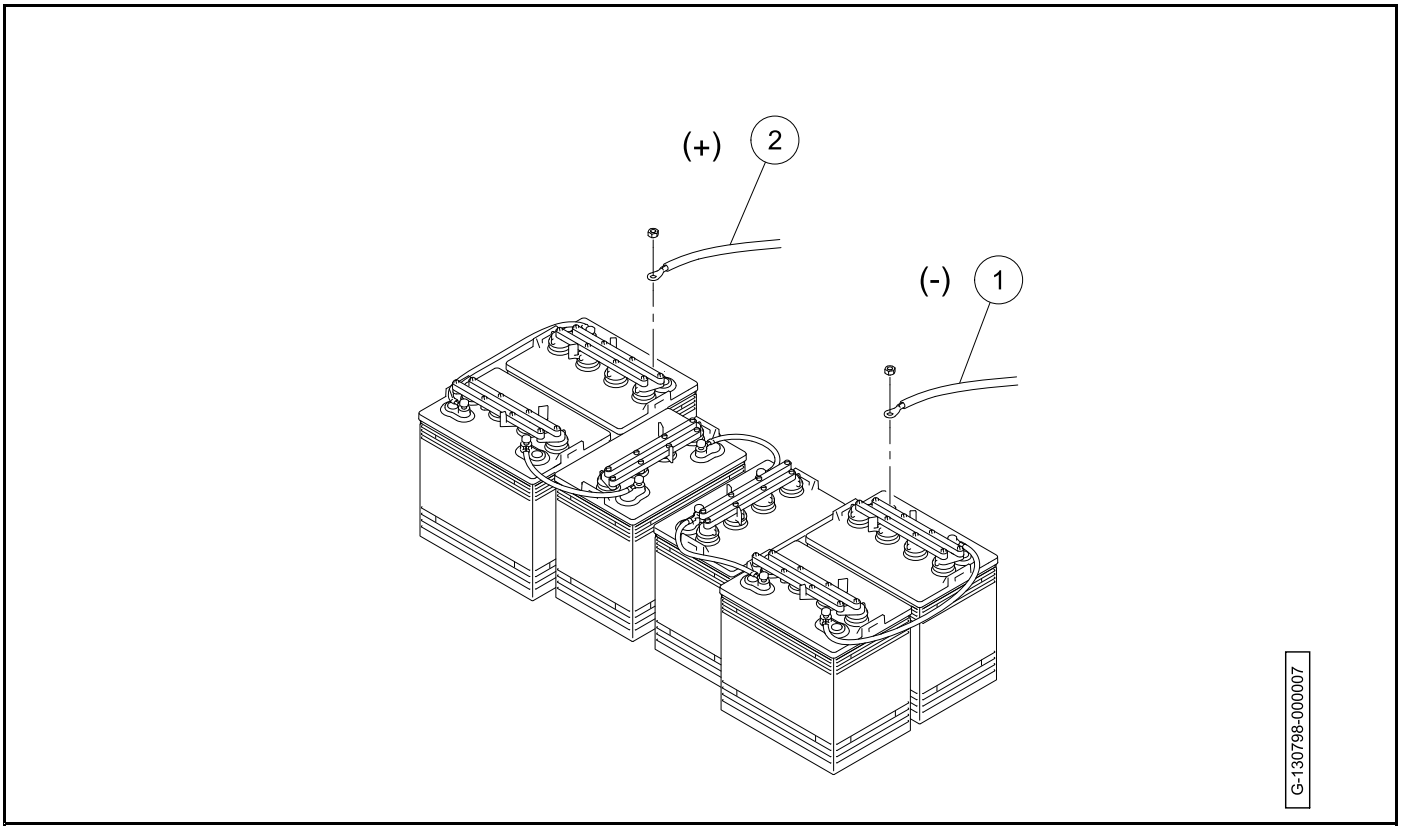


Figure 1-3 Connect Electric Vehicle Batteries

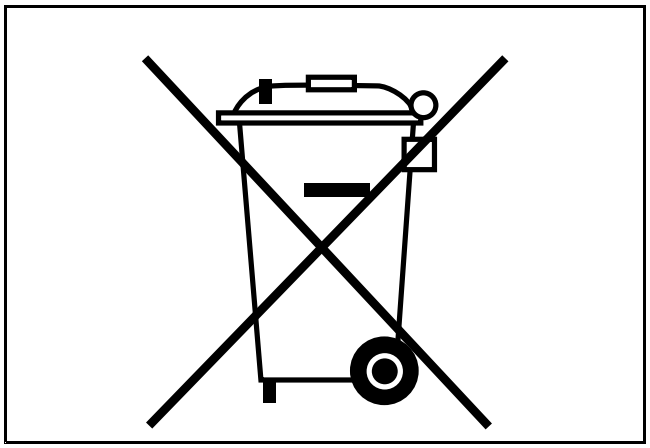
3. Connect the negative (-) cable (1).
4. Tighten the hardware to 110 lb·in (12.4 N·m).
5. Apply battery terminal protector spray to the battery terminals.

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 1-4)**. 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.

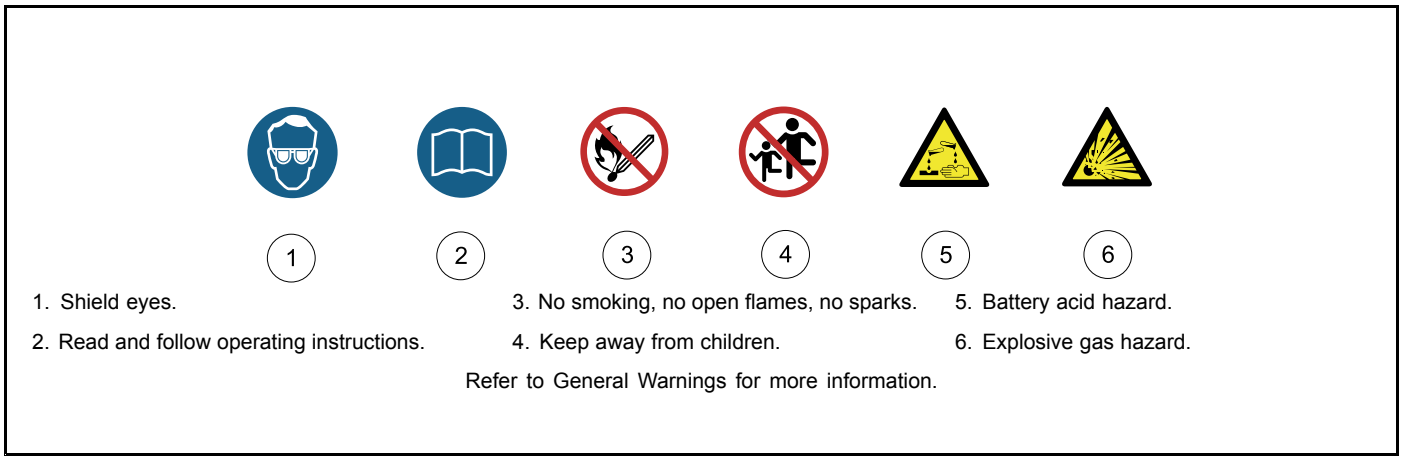


1403

Figure 1-4 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.



1642

Figure 1-5 International Safety Symbols on Batteries

AC ELECTRIC - VEHICLE SPECIFICATIONS

DIMENSIONS

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Length	92 in (233.7 cm)	108 in. (274.3 cm)	114 in (289.5 cm)
Width	48.75 in (13.8 cm)	48.75 in (13.8 cm)	49.5 in (125.7 cm)
Height - at steering wheel	48.75 in (123.8 cm)	48.75 in (123.8 cm)	54.5 in (138.4 cm)
Height - with canopy	71 in (180 cm)	71 in (180 cm)	80.5 in (204.4 cm)
Ground clearance	4.5 in (11 cm)	4.5 in (11 cm)	6.4 in (16.2 cm)
Front wheel tread	36 in (91.4 cm)	36 in (91.4 cm)	40.75 in (103.5 cm)
Rear wheel tread	40 in. (101.6 cm)	40 in. (101.6 cm)	39.5 in (100.3 cm)
Wheelbase	65.5 in. (166 cm)	65.5 in. (166 cm)	67.5 in (171.4 cm)

PERFORMANCE

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Forward speed (On Level Ground)	19 mph (30.6 km/h)		
Curb-To-Curb	210 in (533 cm)	210 in (533 cm)	236 in (599.4 cm)

TIRES

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Go to the approved wheel and tire assemblies matrix on http://www.clubcar.com for information regarding tire type, inflation pressure, and lugnut torque.	•	•	•

ELECTRIC MOTOR

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Motor Type: 30V AC motor	•	•	•
Motor Horsepower: 4.7 hp (3.5 kW)	•	•	•

BATTERIES

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Battery Type: 8V high capacity deep cycle flooded lead acid	•	•	•
Battery Quantity: 6	•	•	•

TRANSAXLE

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Fluid Capacity: 22 fl-oz (0.67 l)	•	•	•

VEHICLE WEIGHTS AND LOAD CAPACITIES

⚠ WARNING

- **If the rated capacities of the vehicle are exceeded, property damage, serious personal injury, or death can occur. Do not exceed the rated capacity of the vehicle. Rated capacity is for level surfaces only.**
- **Too much weight in the vehicle can affect the vehicles handling, or cause component failure, resulting in loss of control of the vehicle and serious personal injury. Do not exceed the vehicle load capacities.**
- **Do not tow when the cargo capacity is exceeded.**

VEHICLE WEIGHTS AND LOAD CAPACITIES	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Vehicle Dry Weight	585 lb (265.5 kg)	685 lb (310.8 kg)	804 lb (364.8 kg)
Vehicle Curb Weight	980 lb (444.5 kg)	1080 lb (489.9 kg)	1199 lb (543.9 kg)
Occupant Capacity	400 lb (181 kg)	800 lb (363 kg)	800 lb (363 kg)
Cargo Capacity	100 lb (45.4 kg)	150 lb (68 kg)	150 lb (68 kg)
Trailer Tongue Weight	Not Applicable	150 lbf (667 N)	150 lbf (667 N)
Gross Trailer Weight	Not Applicable	600 lb (272 kg)	600 lb (272 kg)
Vehicle Rated Capacity	500 lb (226.8 kg)	800 lb (363 kg)	800 lb (363 kg)
Vehicle Combination Rated Capacity	Not Applicable	800 lb (363 kg)	800 lb (363 kg)
Maximum Gross Vehicle Weight	1480 lb (671.3 kg)	1880 lb (852.8 kg)	1999 lb (906.7 kg)
Maximum Gross Vehicle Combination Weight	1480 lb (671.3 kg)	1880 lb (852.8 kg)	1999 lb (906.7 kg)

TERM	DEFINITION
Vehicle Dry Weight	The vehicle dry weight is the weight of the vehicle with no batteries.
Vehicle Curb Weight	The vehicle curb weight is the weight of the vehicle with the batteries installed.
Occupant Capacity	The occupant capacity is the maximum permitted weight for occupants to operate the vehicle safely.
Cargo Capacity	The cargo capacity is the maximum weight of a load that the vehicle can have in the cargo area. The cargo capacity includes the weight of optional equipment.

TABLE CONTINUED ON NEXT PAGE

TERM	DEFINITION
Trailer Tongue Weight	The trailer tongue weight is the maximum permitted weight applied by the trailer tongue onto the trailer hitch.
Gross Trailer Weight	The gross trailer weight is the trailer weight plus the weight of the load on the trailer.
Vehicle Rated Capacity	The vehicle rated capacity is the maximum weight on the vehicle. This capacity includes the weight of: bed load, cargo, occupants, and optional equipment.
Vehicle Combination Rated Capacity	The vehicle combination rated capacity is the maximum weight on the vehicle with a trailer. This capacity includes: vehicle rated capacity and the gross trailer weight.
Maximum Gross Vehicle Weight	The maximum gross vehicle weight is the vehicle weight plus the vehicle rated capacity.
Maximum Gross Vehicle Combination Weight	The maximum gross vehicle combination weight is the maximum gross vehicle weight plus the gross trailer weight.

DC ELECTRIC - VEHICLE SPECIFICATIONS

DIMENSIONS

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Length	92 in (233.7 cm)	108 in. (274.3 cm)	114 in (289.5 cm)
Width	48.75 in (13.8 cm)	48.75 in (13.8 cm)	49.5 in (125.7 cm)
Height - at steering wheel	48.75 in (123.8 cm)	48.75 in (123.8 cm)	54.5 in (138.4 cm)
Height - with canopy	71 in (180 cm)	71 in (180 cm)	80.5 in (204.4 cm)
Ground clearance	4.5 in (11 cm)	4.5 in (11 cm)	6.4 in (16.2 cm)
Front wheel tread	36 in (91.4 cm)	36 in (91.4 cm)	40.75 in (103.5 cm)
Rear wheel tread	40 in. (101.6 cm)	40 in. (101.6 cm)	39.5 in (100.3 cm)
Wheelbase	65.5 in. (166 cm)	65.5 in. (166 cm)	67.5 in (171.4 cm)

PERFORMANCE

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Forward speed (On Level Ground)	19 mph (30.6 km/h)		
Curb-To-Curb	210 in (533 cm)	210 in (533 cm)	236 in (599.4 cm)

TIRES

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Go to the approved wheel and tire assemblies matrix on http://www.clubcar.com for information regarding tire type, inflation pressure, and lugnut torque.	•	•	•

ELECTRIC MOTOR

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Motor Type: 48V DC motor	•	•	•
Motor Horsepower: 3.1 hp (2.3 kW)	•	•	•

BATTERIES

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Battery Type: 8V high capacity deep cycle flooded lead acid	•	•	•
Battery Quantity: 6	•	•	•

TRANSAXLE

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Fluid Capacity: 22 fl-oz (0.67 l)	•	•	•

VEHICLE WEIGHTS AND LOAD CAPACITIES

⚠ WARNING

- **If the rated capacities of the vehicle are exceeded, property damage, serious personal injury, or death can occur. Do not exceed the rated capacity of the vehicle. Rated capacity is for level surfaces only.**
- **Too much weight in the vehicle can affect the vehicles handling, or cause component failure, resulting in loss of control of the vehicle and serious personal injury. Do not exceed the vehicle load capacities.**
- **Do not tow when the cargo capacity is exceeded.**

VEHICLE WEIGHTS AND LOAD CAPACITIES	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Vehicle Dry Weight	580 lb (263 kg)	675 lb (306.1 kg)	730 lb (331.1 kg)
Vehicle Curb Weight	975 lb (442 kg)	1070 lb (485.3 kg)	1125 lb (510.3 kg)
Occupant Capacity	400 lb (181 kg)	800 lb (363 kg)	800 lb (363 kg)
Cargo Capacity	100 lb (45.4 kg)	150 lb (68 kg)	150 lb (68 kg)
Trailer Tongue Weight	Not Applicable	150 lbf (667 N)	150 lbf (667 N)

TABLE CONTINUED ON NEXT PAGE

VEHICLE WEIGHTS AND LOAD CAPACITIES	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Gross Trailer Weight	Not Applicable	600 lb (272 kg)	600 lb (272 kg)
Vehicle Rated Capacity	500 lb (226.8 kg)	800 lb (363 kg)	800 lb (363 kg)
Vehicle Combination Rated Capacity	500 lb (226.8 kg)	800 lb (363 kg)	800 lb (363 kg)
Maximum Gross Vehicle Weight	1775 lb (805.1 kg)	1870 lb (848.2 kg)	1925 lb (873.2 kg)
Maximum Gross Vehicle Combination Weight	1775 lb (805.1 kg)	1870 lb (848.2 kg)	1925 lb (873.2 kg)

TERM	DEFINITION
Vehicle Dry Weight	The vehicle dry weight is the weight of the vehicle with no batteries.
Vehicle Curb Weight	The vehicle curb weight is the weight of the vehicle with the batteries installed.
Occupant Capacity	The occupant capacity is the maximum permitted weight for occupants to operate the vehicle safely.
Cargo Capacity	The cargo capacity is the maximum weight of a load that the vehicle can have in the cargo area. The cargo capacity includes the weight of optional equipment.
Trailer Tongue Weight	The trailer tongue weight is the maximum permitted weight applied by the trailer tongue onto the trailer hitch.
Gross Trailer Weight	The gross trailer weight is the trailer weight plus the weight of the load on the trailer.
Vehicle Rated Capacity	The vehicle rated capacity is the maximum weight on the vehicle. This capacity includes the weight of: bed load, cargo, occupants, and optional equipment.
Vehicle Combination Rated Capacity	The vehicle combination rated capacity is the maximum weight on the vehicle with a trailer. This capacity includes: vehicle rated capacity and the gross trailer weight.
Maximum Gross Vehicle Weight	The maximum gross vehicle weight is the vehicle weight plus the vehicle rated capacity.
Maximum Gross Vehicle Combination Weight	The maximum gross vehicle combination weight is the maximum gross vehicle weight plus the gross trailer weight.

KOHLER ECH440 - VEHICLE SPECIFICATIONS

DIMENSIONS

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Length	92 in (233.7 cm)	108 in. (274.3 cm)	114 in (289.5 cm)
Width	48.75 in (13.8 cm)	48.75 in (13.8 cm)	49.5 in (125.7 cm)
Height - at steering wheel	48.75 in (123.8 cm)	48.75 in (123.8 cm)	54.5 in (138.4 cm)
Height - with canopy	71 in (180 cm)	71 in (180 cm)	80.5 in (204.4 cm)
Ground clearance	4.5 in (11 cm)	4.5 in (11 cm)	6.4 in (16.2 cm)
Front wheel tread	36 in (91.4 cm)	36 in (91.4 cm)	40.75 in (103.5 cm)

TABLE CONTINUED ON NEXT PAGE

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Rear wheel tread	40 in. (101.6 cm)	40 in. (101.6 cm)	39.5 in (100.3 cm)
Wheelbase	65.5 in. (166 cm)	65.5 in. (166 cm)	67.5 in (171.4 cm)

PERFORMANCE

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Forward speed (On Level Ground)	19 mph (30.6 km/h)		
Curb-To-Curb	210 in (533 cm)	210 in (533 cm)	236 in (599.4 cm)

TIRES

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Go to the approved wheel and tire assemblies matrix on http://www.clubcar.com for information regarding tire type, inflation pressure, and lugnut torque.	•	•	•

GASOLINE ENGINE

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Horsepower 14 hp (10.4 kw) at 3600 rpm (per SAE J1940)	•	•	•
Fuel Type Gasoline with less than 10% ethanol rating	•	•	•
Fuel Capacity 5.6 gal (21.2 l)	•	•	•
Engine Oil Capacity	39 fl-oz (1.1 l)	39 fl-oz (1.1 l)	40.5 fl-oz (1.2 l)

BATTERY

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Battery Type: 12V no-maintenance	•	•	•
Battery Quantity: 1	•	•	•

NOISE AND VIBRATION

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Drive-by Noise Level To Operator EN 12053:2001	77.6 dBA (± 2)	83.8 dBA (± 2)	84.9 dBA (± 2)
Vibration At Driver's Seat EN 13059:2002	0.8 $(m/s^2)^2$ (± 0.25)	0.8 $(m/s^2)^2$ (± 0.25)	0.9 $(m/s^2)^2$ (± 0.26)

TRANSAXLE

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Fluid Capacity: 67.6 fl-oz (2 l)	•	•	•

VEHICLE WEIGHTS AND LOAD CAPACITIES

⚠ WARNING

- **If the rated capacities of the vehicle are exceeded, property damage, serious personal injury, or death can occur. Do not exceed the rated capacity of the vehicle. Rated capacity is for level surfaces only.**
- **Too much weight in the vehicle can affect the vehicles handling, or cause component failure, resulting in loss of control of the vehicle and serious personal injury. Do not exceed the vehicle load capacities.**
- **Do not tow when the cargo capacity is exceeded.**

VEHICLE WEIGHTS AND LOAD CAPACITIES	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Vehicle Dry Weight	651 lb (295 kg)	768 lb (348 kg)	838 lb (380.1 kg)
Vehicle Curb Weight	675 lb (306.1 kg)	795 lb (361 kg)	875 lb (396.9 kg)
Occupant Capacity	400 lb (181.4 kg)	800 lb (363 kg)	800 lb (363 kg)
Cargo Capacity	100 lb (45.3 kg)	150 lb (68 kg)	150 lb (68 kg)
Trailer Tongue Weight	Not Applicable	150 lbf (667 N)	150 lbf (667 N)
Gross Trailer Weight	Not Applicable	600 lb (272 kg)	600 lb (272 kg)
Vehicle Rated Capacity	500 lb (226.8 kg)	800 lb (363 kg)	800 lb (363 kg)
Vehicle Combination Rated Capacity	500 lb (226.8 kg)	800 lb (363 kg)	800 lb (363 kg)
Maximum Gross Vehicle Weight	1475 lb (669.0 kg)	1595 lb (723.5 kg)	1675 lb (759.8 kg)
Maximum Gross Vehicle Combination Weight	1475 lb (669.0 kg)	1595 lb (723.5 kg)	1675 lb (759.8 kg)

TERM	DEFINITION
Vehicle Dry Weight	The vehicle dry weight is the weight of the vehicle with no fuel.
Vehicle Curb Weight	The vehicle curb weight is the weight of the vehicle with the fuel tank filled.
Occupant Capacity	The occupant capacity is the maximum permitted weight for occupants to operate the vehicle safely.
Cargo Capacity	The cargo capacity is the maximum weight of a load that the vehicle can have in the cargo area. The cargo capacity includes the weight of optional equipment.
Trailer Tongue Weight	The trailer tongue weight is the maximum permitted weight applied by the trailer tongue onto the trailer hitch.
Gross Trailer Weight	The gross trailer weight is the trailer weight plus the weight of the load on the trailer.
Vehicle Rated Capacity	The vehicle rated capacity is the maximum weight on the vehicle. This capacity includes the weight of: bed load, cargo, occupants, and optional equipment.
Vehicle Combination Rated Capacity	The vehicle combination rated capacity is the maximum weight on the vehicle with a trailer. This capacity includes: vehicle rated capacity and the gross trailer weight.

TABLE CONTINUED ON NEXT PAGE

TERM	DEFINITION
Maximum Gross Vehicle Weight	The maximum gross vehicle weight is the vehicle weight plus the vehicle rated capacity.
Maximum Gross Vehicle Combination Weight	The maximum gross vehicle combination weight is the maximum gross vehicle weight plus the gross trailer weight.

SUBARU EX-40 - VEHICLE SPECIFICATIONS

DIMENSIONS

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Length	92 in (233.7 cm)	108 in. (274.3 cm)	114 in (289.5 cm)
Width	48.75 in (13.8 cm)	48.75 in (13.8 cm)	49.5 in (125.7 cm)
Height - at steering wheel	48.75 in (123.8 cm)	48.75 in (123.8 cm)	54.5 in (138.4 cm)
Height - with canopy	71 in (180 cm)	71 in (180 cm)	80.5 in (204.4 cm)
Ground clearance	4.5 in (11 cm)	4.5 in (11 cm)	6.4 in (16.2 cm)
Front wheel tread	36 in (91.4 cm)	36 in (91.4 cm)	40.75 in (103.5 cm)
Rear wheel tread	40 in. (101.6 cm)	40 in. (101.6 cm)	39.5 in (100.3 cm)
Wheelbase	65.5 in. (166 cm)	65.5 in. (166 cm)	67.5 in (171.4 cm)

PERFORMANCE

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Forward speed (On Level Ground)	19 mph (30.6 km/h)		
Curb-To-Curb	210 in (533 cm)	210 in (533 cm)	236 in (599.4 cm)

TIRES

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Go to the approved wheel and tire assemblies matrix on http://www.clubcar.com for information regarding tire type, inflation pressure, and lugnut torque.	•	•	•

GASOLINE ENGINE

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Horsepower 14 hp (10.4 kw) at 3600 rpm (per SAE J1940)	•	•	•
Fuel Type Gasoline with less than 10% ethanol rating	•	•	•
Fuel Capacity 5.9 gal (23 l)	•	•	•
Engine Oil Capacity	40 fl-oz (1.2 l)	40 fl-oz (1.2 l)	40 fl-oz (1.2 l)

BATTERY

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Battery Type: 12V no-maintenance	•	•	•
Battery Quantity: 1	•	•	•

NOISE AND VIBRATION

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Drive-by Noise Level To Operator EN 12053:2001	Not Applicable		
Vibration At Driver's Seat EN 13059:2002	Not Applicable		

TRANSAXLE

DESCRIPTION	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Fluid Capacity: 67.6 fl-oz (2 l)	•	•	•

VEHICLE WEIGHTS AND LOAD CAPACITIES

⚠ WARNING

- **If the rated capacities of the vehicle are exceeded, property damage, serious personal injury, or death can occur. Do not exceed the rated capacity of the vehicle. Rated capacity is for level surfaces only.**
- **Too much weight in the vehicle can affect the vehicles handling, or cause component failure, resulting in loss of control of the vehicle and serious personal injury. Do not exceed the vehicle load capacities.**
- **Do not tow when the cargo capacity is exceeded.**

VEHICLE WEIGHTS AND LOAD CAPACITIES	2 PASSENGER	4 PASSENGER	4 PASSENGER LIFTED
Vehicle Dry Weight	651 lb (295 kg)	768 lb (348 kg)	838 lb (380.1 kg)
Vehicle Curb Weight	675 lb (306.1 kg)	795 lb (361 kg)	875 lb (396.9 kg)
Occupant Capacity	400 lb (181.4 kg)	800 lb (363 kg)	800 lb (363 kg)
Cargo Capacity	100 lb (45.3 kg)	150 lb (68 kg)	150 lb (68 kg)
Trailer Tongue Weight	Not Applicable	150 lbf (667 N)	150 lbf (667 N)
Gross Trailer Weight	Not Applicable	600 lb (272 kg)	600 lb (272 kg)
Vehicle Rated Capacity	500 lb (226.8 kg)	800 lb (363 kg)	800 lb (363 kg)
Vehicle Combination Rated Capacity	500 lb (226.8 kg)	800 lb (363 kg)	800 lb (363 kg)
Maximum Gross Vehicle Weight	1475 lb (669.0 kg)	1595 lb (723.5 kg)	1675 lb (759.8 kg)
Maximum Gross Vehicle Combination Weight	1475 lb (669.0 kg)	1595 lb (723.5 kg)	1675 lb (759.8 kg)

TERM	DEFINITION
Vehicle Dry Weight	The vehicle dry weight is the weight of the vehicle with no fuel.
Vehicle Curb Weight	The vehicle curb weight is the weight of the vehicle with the fuel tank filled.
Occupant Capacity	The occupant capacity is the maximum permitted weight for occupants to operate the vehicle safely.
Cargo Capacity	The cargo capacity is the maximum weight of a load that the vehicle can have in the cargo area. The cargo capacity includes the weight of optional equipment.
Trailer Tongue Weight	The trailer tongue weight is the maximum permitted weight applied by the trailer tongue onto the trailer hitch.
Gross Trailer Weight	The gross trailer weight is the trailer weight plus the weight of the load on the trailer.
Vehicle Rated Capacity	The vehicle rated capacity is the maximum weight on the vehicle. This capacity includes the weight of: bed load, cargo, occupants, and optional equipment.
Vehicle Combination Rated Capacity	The vehicle combination rated capacity is the maximum weight on the vehicle with a trailer. This capacity includes: vehicle rated capacity and the gross trailer weight.
Maximum Gross Vehicle Weight	The maximum gross vehicle weight is the vehicle weight plus the vehicle rated capacity.
Maximum Gross Vehicle Combination Weight	The maximum gross vehicle combination weight is the maximum gross vehicle weight plus the gross trailer weight.

SECTION 3 — EXTENDED STORAGE

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ DANGER

- **Fuel is flammable and explosive. Do not attempt to drain fuel when the engine is hot or while it is running.**
- **Fuel is flammable and explosive. Do not operate the vehicle when fuel is spilled. Correctly clean the spilled fuel.**
- **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 toxic. Keep fuel out of the reach of children.**
- **Fuel is toxic. Do not siphon fuel from the vehicle.**

⚠ WARNING

- **See General Warnings on page 1-2.**

⚠ WARNING

- **Unintended vehicle operation can cause serious personal injury or death. Before leaving the vehicle or during vehicle maintenance, disable the vehicle.**
- **Unintended vehicle operation can cause serious personal injury or death. Before leaving the vehicle or during vehicle maintenance, disable the vehicle. Set the Run/Tow switch to TOW.**
- **Frozen battery acid can cause damage including leaks and explosions. If the battery acid freezes, replace the battery before charging or use. Batteries in a low state of charge will freeze at low temperatures. Keep the batteries in a high state of charge.**

⚠ CAUTION

- **To avoid exposing electrical components to moisture and subsequent damages, do not use any type of pressure washing or steam cleaning equipment to wash the vehicle.**

ELECTRIC VEHICLE EXTENDED STORAGE

EXTENDED STORAGE PREPARATION - ELECTRIC

Keep sufficient water levels in each battery cell for a minimum of two weeks before extended storage to make sure proper mixing of water and battery acid. If necessary, add water as necessary then correctly charge batteries.

NOTE: *It takes approximately five charge cycles with a minimum of 10-amp hours of use after each charge to correctly mix the water with battery acid.*

1. Turn off all electronic accessories.

2. Set the Forward/Neutral/Reverse control (FNR) to N.
3. Turn the key to OFF.
4. Remove the key. Keep the key in a safe area.
5. Put chocks against the wheels.

NOTE: *Do not engage the park brake.*

6. Remove all cargo and personal items.
7. Run/Tow switch position:

NOTE: *The charge indicator light is disabled when the Run/Tow switch is set to TOW.*

7.1. **On vehicles equipped with Visage that will have remote monitoring,** set the Run/Tow switch to RUN.
7.2. **On vehicles equipped with Visage that will not have remote monitoring,** set the Run/Tow switch TOW.
7.3. **On all other vehicles,** set the Run/Tow switch to TOW.

8. Clean the batteries.
9. Tighten all battery cable connections to 110 lb·in (12.4 N·m).
10. Keep the vehicle in a cool and dry area to keep battery self-discharge to a minimum.
11. Adjust pressure in each tire to recommended tire pressure.
12. Clean the vehicle.
13. **If one or more conditions cannot be done while in storage,** disconnect the negative (-) battery cable. Make sure that the negative (-) battery cable does not touch the battery terminal.
    – The battery charger must stay connected to an electric outlet
    – AC electrical power will be available during storage
    – Battery acid levels will be kept at a sufficient level while in storage
14. **If all conditions can be done while in storage,** do as follows:
    – The battery charger must stay connected to an electric outlet
    – AC electrical power will be available during storage
    – Battery battery acid levels will be kept at a sufficient level while in storage

14.1. Connect the battery charger to the vehicle. Keep battery chargers connected during storage. The charger will automatically connect when necessary.
14.2. Examine the battery acid level and charger function monthly.

NOTE: *The charger is operating correctly when the blue light is ON and the triangular light is OFF.*

RETURN TO SERVICE FROM EXTENDED STORAGE - ELECTRIC

1. Clean the batteries.
2. If the batteries were disconnected, connect the batteries.
3. Fully charge the batteries.
4. Set the Run/Tow switch to RUN.
5. Set the Forward/Neutral/Reverse control (FNR) to N.
6. Adjust the pressure in each tire to the recommended tire pressure.

7. Have a trained technician lubricate the vehicle.
8. Do a daily pre-operation safety checklist.
9. Do a vehicle performance inspection.

GASOLINE VEHICLE EXTENDED STORAGE

See General Warnings on page 1-2.

EXTENDED STORAGE PREPARATION - GASOLINE

1. Examine the battery state of charge (SOC) condition. If the SOC is weak, charge the battery.

NOTE: *Use an automotive-type 12-volt battery charger rated at 10-amps or less.*

2. Turn off all accessories.
3. Set the Forward/Neutral/Reverse control (FNR) to N.
4. Turn the key to OFF.
5. Remove the key. Keep the key in a safe area.
6. Put chocks against the wheels.

NOTE: *Do not engage the park brake.*

7. Remove all cargo and personal items.
8. Fill the fuel tank.
9. Add a fuel stabilizer. Refer to the fuel stabilizer manufacturer's instructions.
10. Disconnect the fuel vent line from the fuel tank vent nipple.
11. Plug the fuel tank vent nipple with a slip-on vinyl cap (1) **(Figure 3-1, Page 3-4)**. Make sure that the connection is air tight.

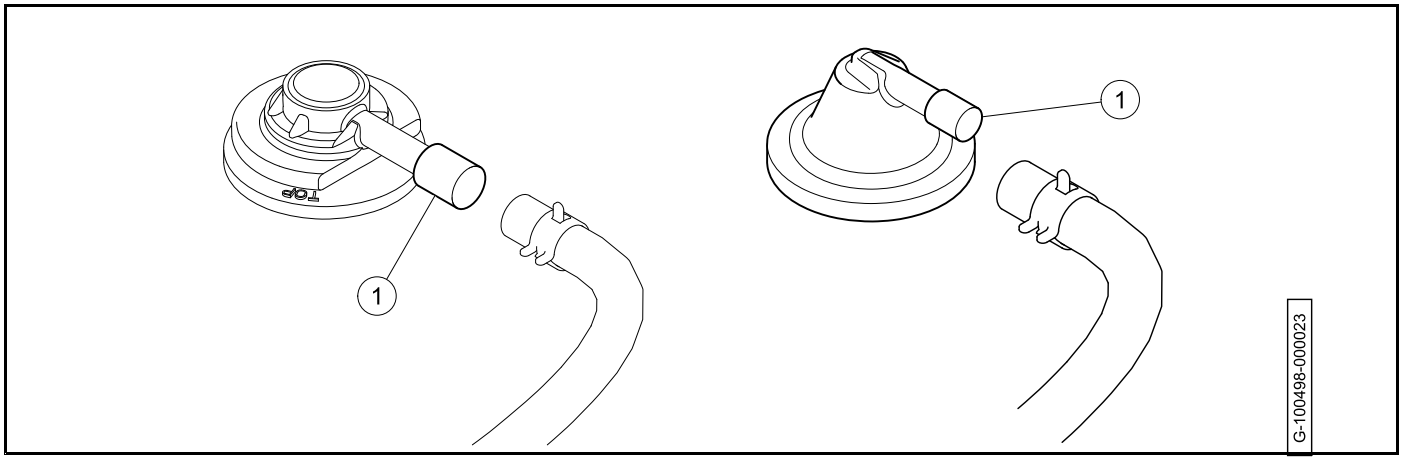


Figure 3-1 Left: Kohler / Right: Subaru

12. Disconnect the battery.
13. Clean the battery.

14. Prepare the engine for extended storage:

14.1. Disconnect the spark plug wire (1) **(Figure 3-2, Page 3-5)**.

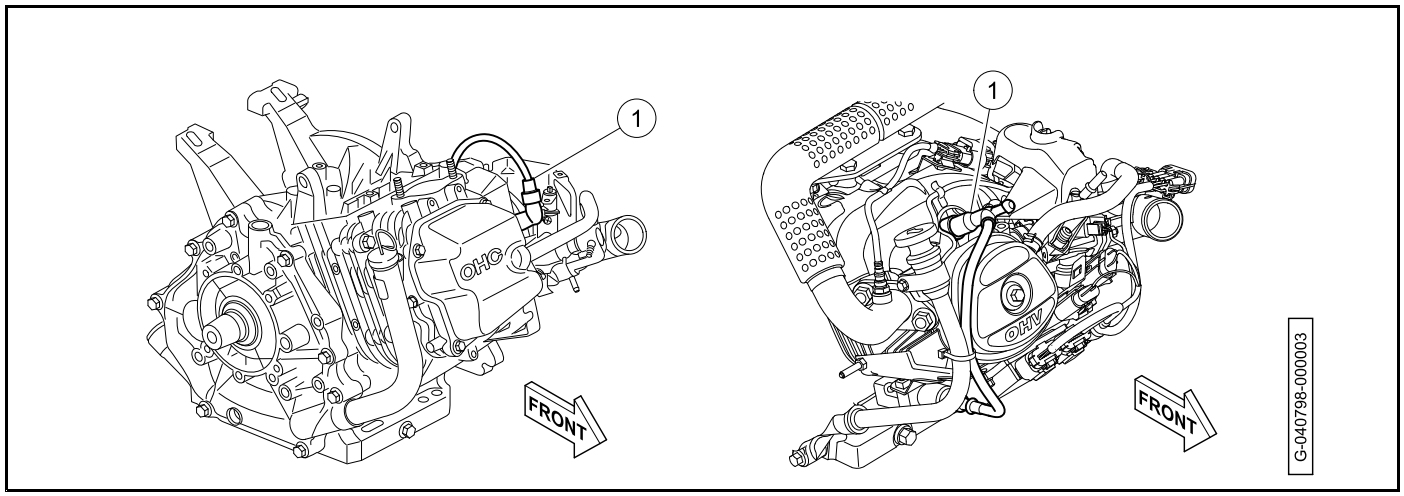


Figure 3-2 Left: Subaru / Right: Kohler

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

14.3. Put 0.5 fl-oz (14.2 ml) of SAE 10 weight oil into the spark plug hole.

14.4. Turn the engine crankshaft by hand several times.

14.5. Apply a thin layer of high temperature antiseize lubricant to the spark plug threads.

14.6. Use a spark plug socket to install and tighten the spark plug to 20 lb·ft (27 N·m).

14.7. Connect the spark plug wire.

15. Keep the vehicle in a cool and dry area to keep battery self-discharge to a minimum.

16. Adjust pressure in each tire to recommended tire pressure.

17. Clean the vehicle.

RETURN TO SERVICE FROM EXTENDED STORAGE - GASOLINE

1. Clean the battery.

2. Connect the fuel system:

2.1. Remove and discard the slip-on vinyl cap (1) from the fuel tank vent nipple **(Figure 3-3, Page 3-6)**.

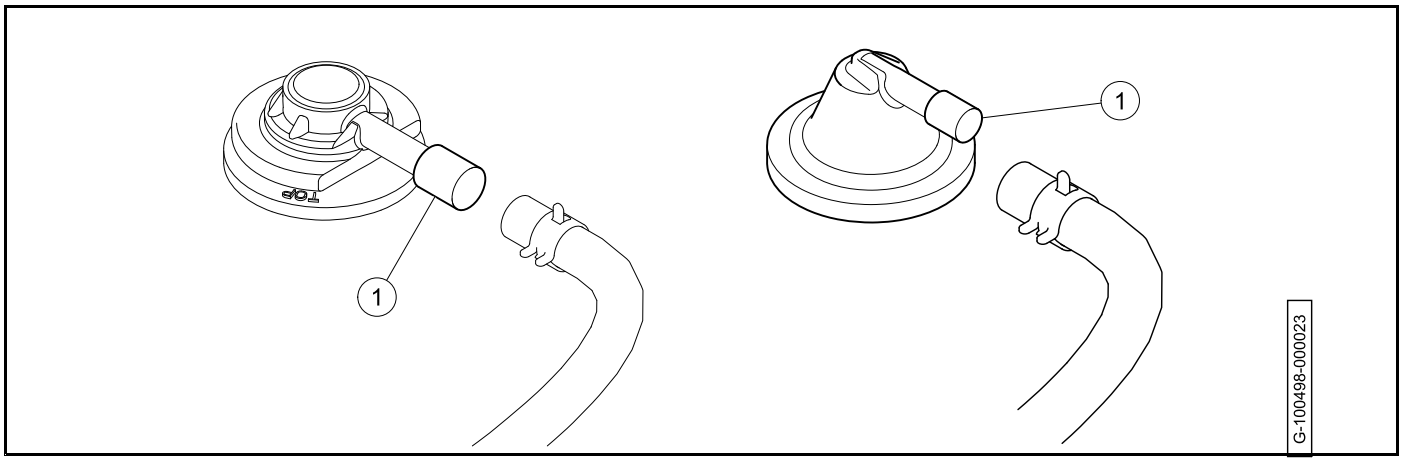


Figure 3-3 Left: Kohler / Right: Subaru

⚠ WARNING

- **Fuel is flammable and explosive. Make sure that the fuel tube is fully connected.**

2.2. Connect the vent tube to the fuel tank vent nipple.
3. Connect the battery.
4. Set the Forward / Neutral / Reverse control (FNR) to N.
5. Set the Maintenance/Operate switch to MAINTENANCE.
6. Start and run the engine.

NOTE: *The engine exhaust may smoke for a short time after returning to service.*

7. Turn the key to OFF.
8. Set the Maintenance/Operate switch to OPERATE.
9. Adjust the pressure in each tire to the recommended tire pressure.
10. Have a trained technician lubricate the vehicle.
11. Do a daily pre-operation safety checklist.
12. Do a vehicle performance inspection.

SECTION 4 — BODY AND TRIM

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

CLEANING THE WINDSHIELD

CAUTION

- **Do not use a household window cleaner.**

Use a soft towel and water to clean the windshield. Use mild soap as necessary.

CLEANING THE VEHICLE EXTERIOR

CAUTION

- **Do not use detergents or cleaning solvents that contain ammonia, aromatic solvents, or alkali materials on body panels or seats.**
- **Use of leveling or rubbing compounds will permanently dull finish of vehicle.**
- **Do not apply wax products to the black plastic material of the front and rear underbody, the front bumper, or the textured area of the rear beauty panel marked "NO STEP." Wax will cause these surfaces to become discolored.**
- **Moisture will cause electrical component damage. Do not use a pressure washer or steam cleaner to clean the vehicle.**

Use only commercially available automotive cleaners with a sponge or soft cloth for normal cleaning. A garden hose at normal residential water pressure is adequate.

Use a commercially available aluminum cleaner paste and fine grade (No. 00) steel wool to remove oxidation or discoloration from aluminum.

Use non-abrasive wax products. Do not use abrasive leveling or rubbing compounds; these will permanently dull the gloss. Fertilizers, tars, asphalt, creosote, paint, or chewing gum should be removed immediately to prevent possible stains.

NOTE: *Dispose of waste water properly.*

CLEANING THE VEHICLE INTERIOR

CAUTION

- **Moisture will cause electrical component damage. Do not use a pressure washer or steam cleaner to clean the vehicle.**
- **To prevent damage to the vehicle when removing difficult stains or heavy soiling, remove the seat bottom from the vehicle first.**

To preserve seat appearance, clean regularly with mild soap or detergent applied with a sponge or soft cloth. Use a soft bristle brush to clean areas that are especially soiled. Use 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.

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.

BODY REPAIR

STRESS LINES OR STREAKS

Repeatedly flexing the Surlyn® body can cause white stress lines or streaks in the finish. To remove them:

1. Hold a heat gun 12 inches (30 cm) away from the affected area, with the gun on its lowest heat setting.
2. Slowly wave the heat gun back and forth over the affected area until the streak fades.

CAUTION

- **Holding the heat gun too close to the body could melt the body or damage the finish. Do not hold the heat gun closer than 6 inches (15 cm) to the body.**

3. It may be necessary to move the gun closer to the body to fade the streak. Do not hold the gun closer than 6 inches (15 cm) to the body.

MINOR IMPACT DAMAGE/DEFORMATIONS

Minor impact damage to a Surlyn® body can be repaired using a procedure similar to the one used to remove stress lines. To remove deformations resulting from minor impact damage:

1. Hold a heat gun 12 inches (30 cm) away from the affected area, with the gun on its lowest heat setting.
2. Periodically remove the heat gun and bend the body, using a push block, in the opposite direction of the deformation.

CAUTION

- **Holding the heat gun too close to the body could melt the body or damage the finish. Do not hold the heat gun closer than 6 inches (15 cm) to the body.**

3. Continue heating and bending the body until the original shape returns. Do not hold the gun closer than 6 inches (15 cm) to the body.

MINOR SCRATCHES AND SURFACE BLEMISHES

For minor scratches or blemishes in the Surlyn® body that do not penetrate the finish:

1. Thoroughly clean the affected area using a strong, non-abrasive detergent and hot water, then clean with Ultra-Kleen® Solvent Cleaner to remove any oil-based contaminants.
2. Lightly buff imperfection with a clean soft cloth or buff pad. Do not use any kind of rubbing (abrasive) compound on body assemblies.
3. Wax the entire body part to restore luster and weather protection.

GOUGES, PUNCTURES, TEARS, 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 Surlyn® bodies.

SEAT HINGE

The seat bottom (1) is attached to the vehicle with two hinges (3) that hook into slots in the body.

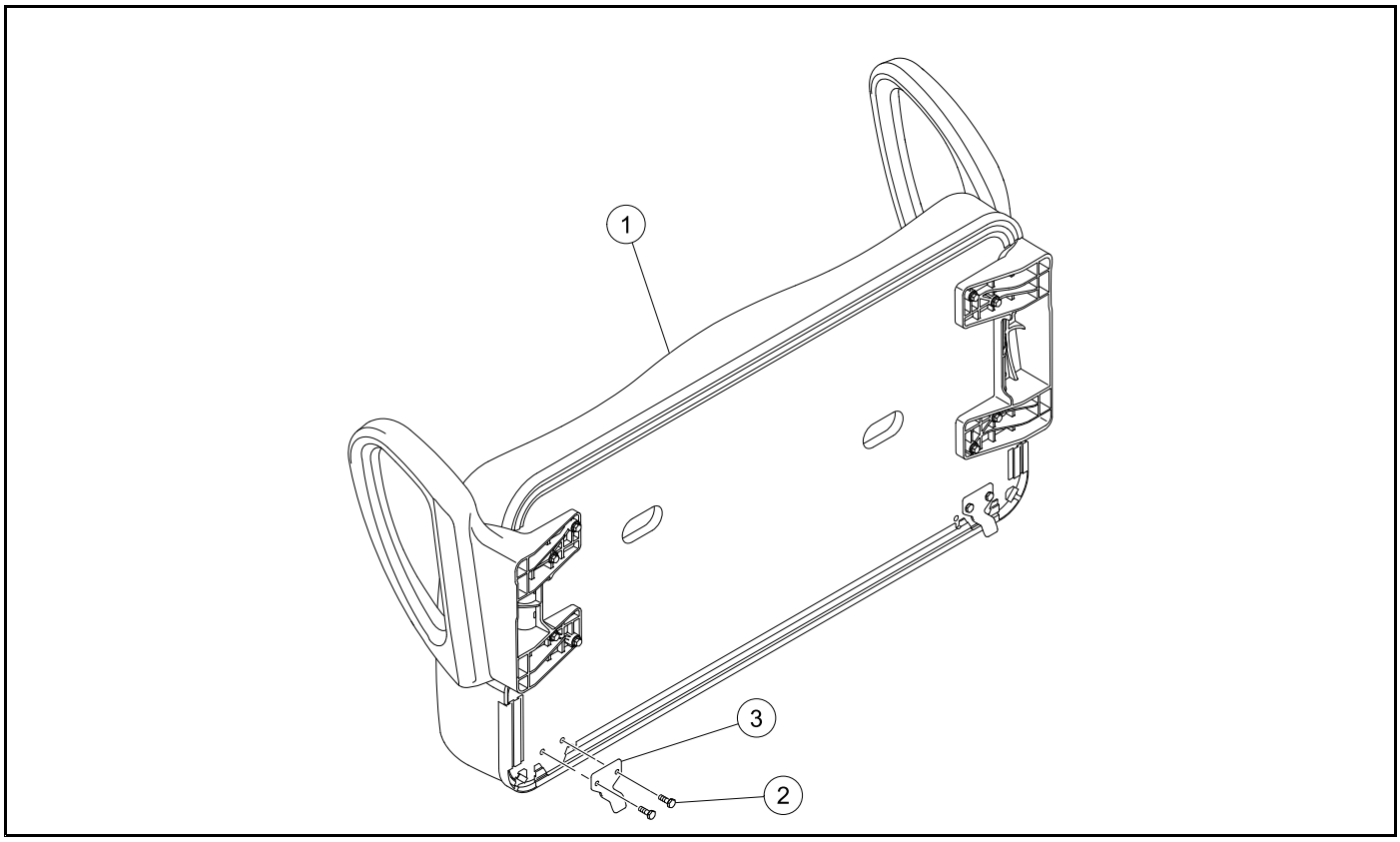


Figure 4-1 Seat Bottom Hinge

SEAT HINGE REMOVAL

1. Remove the seat bottom (1) from the vehicle **(Figure 4-1)**.
2. Remove the screws (2).
3. Remove the hinge (3).

SEAT HINGE INSTALLATION

1. Align the hinge (3) onto the seat bottom (1) **(Figure 4-1)**.
2. Install the screws (2). Tighten the screws to 75 lb·in (8.5 N·m).

HIP RESTRAINT

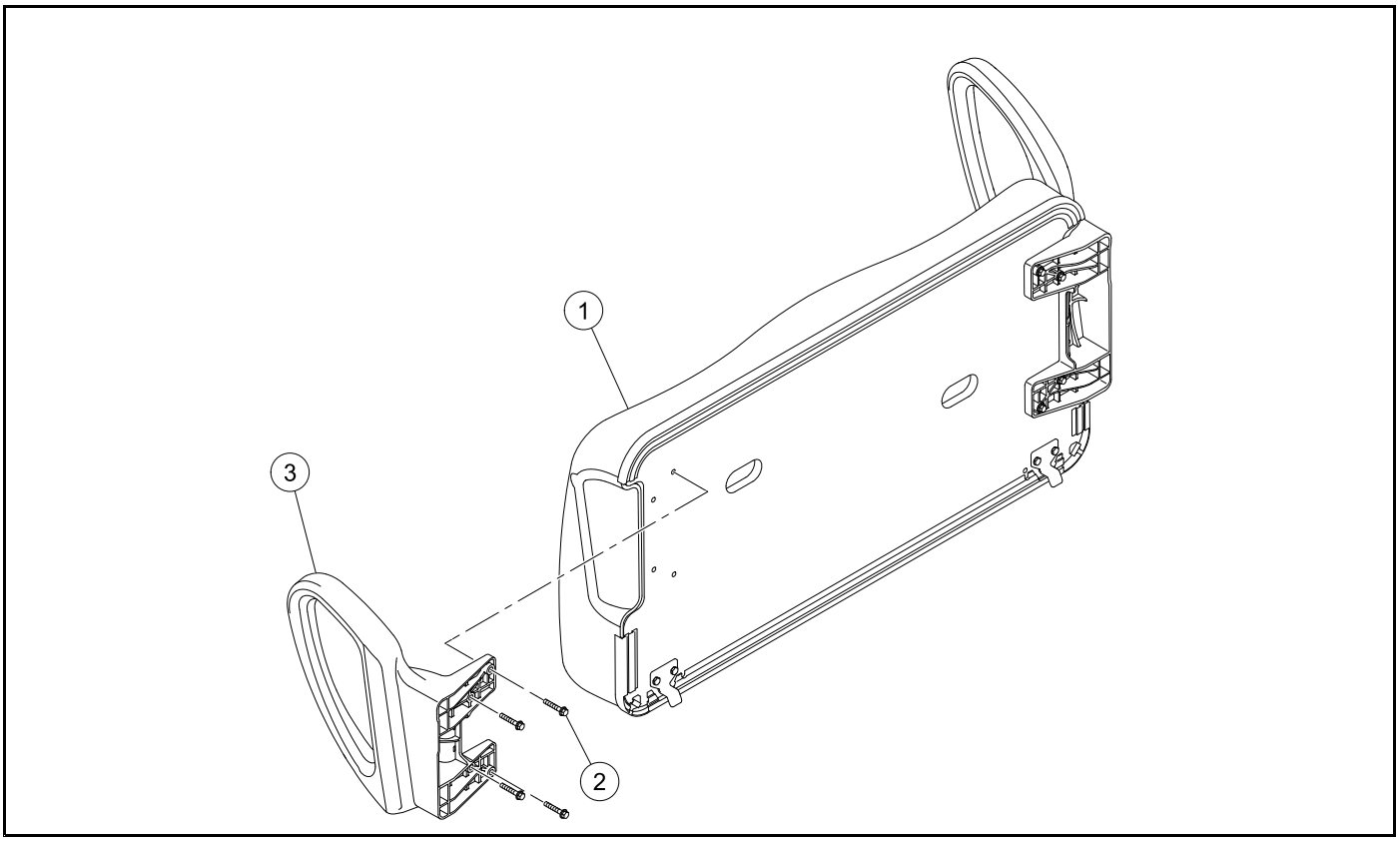


Figure 4-2 Hip Restraint

HIP RESTRAINT REMOVAL

1. Remove the seat bottom (1) from the vehicle **(Figure 4-2)**.
2. Remove the screws (2).
3. Remove the hip restraint (3).

HIP RESTRAINT INSTALLATION

1. Align the hip restraint (3) onto the seat bottom (1) **(Figure 4-2)**.
2. Install the screws (2). Tighten the screws to 65 lb·in (7.3 N·m).

FRONT BODY

FRONT BODY REMOVAL

1. Disconnect the two headlight harnesses (1) **(Figure 4-3, Page 4-7)**.
2. Remove the four screws (2) from the brow cap (3).
3. Remove the brow cap.
4. If equipped, remove the front fenders.
5. *Without brush guard:* Remove the screw (4) from the front bumper.
6. *With brush guard:*

6.1. Remove the bottom screw from the brush guard cowl bracket.

6.2. Remove the brush guard.

7. Remove the beauty panel (5).
8. Remove the five screws (6) from the brow (7).
9. Remove the brow.

FRONT BODY INSTALLATION

1. Put the brow (7) in position on the vehicle **(Figure 4-3, Page 4-7)**.
2. Install the five screws (6). Tighten the screws to 31 lb·in (3.5 N·m).
3. Put the beauty panel (5) in position on the brow.
4. *Without brush guard:* Install the screw (4) in the front bumper. Tighten the screw to 28 lb·in (3.0 N·m).
5. *With brush guard:*

5.1. Install the bottom screw to secure the beauty panel to the brush guard cowl bracket. Tighten the screw to 48.6 lb·in (5.5 N·m).

5.2. Remove the brush guard.

6. Put the brow cap (3) in position on the front beauty panel.
7. Install the four screws (2). Tighten the screws to 25 lb·in (2.8 N·m).
8. Connect the two headlight harnesses (1).

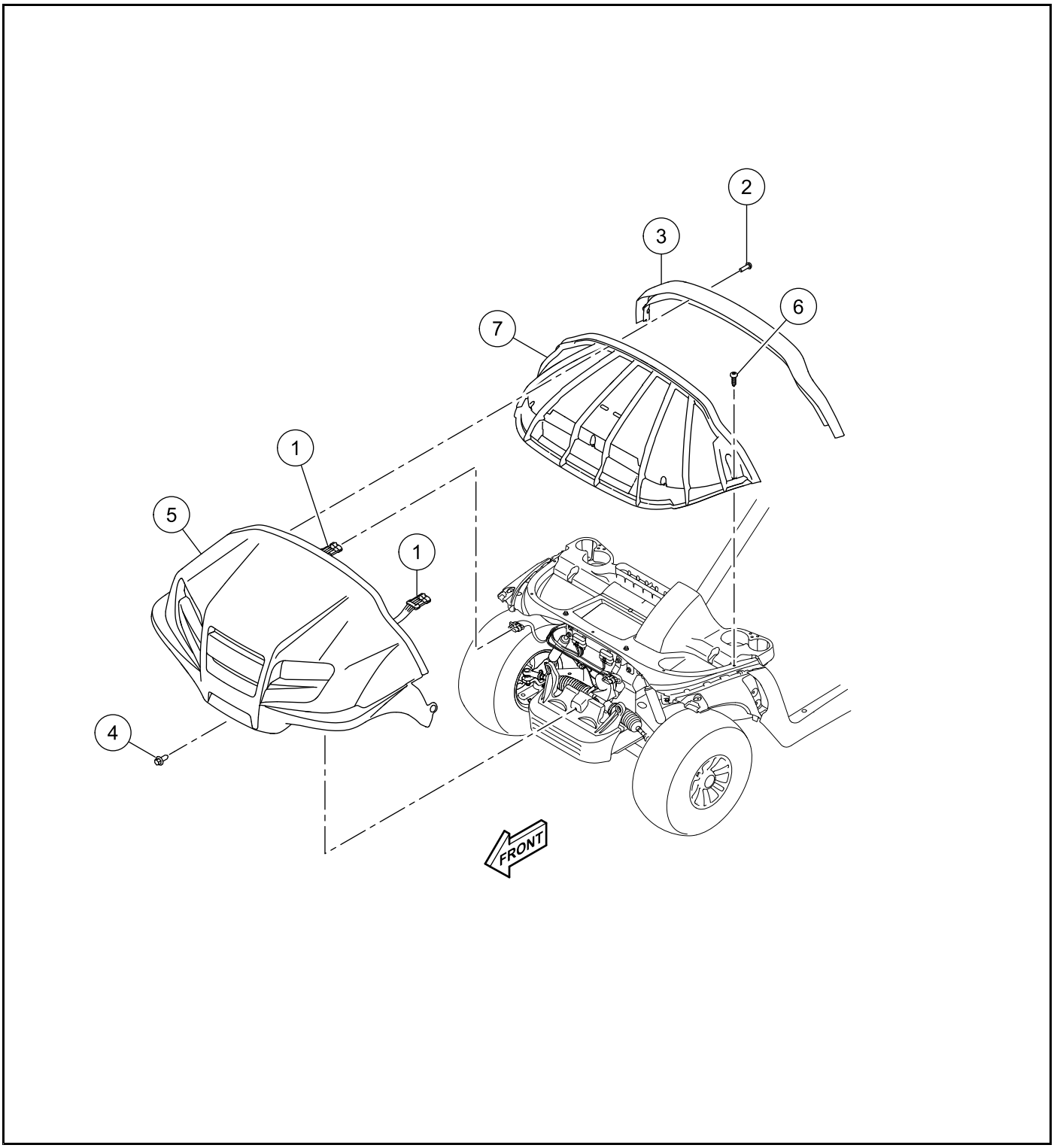


Figure 4-3 Front Body

BRUSH GUARD

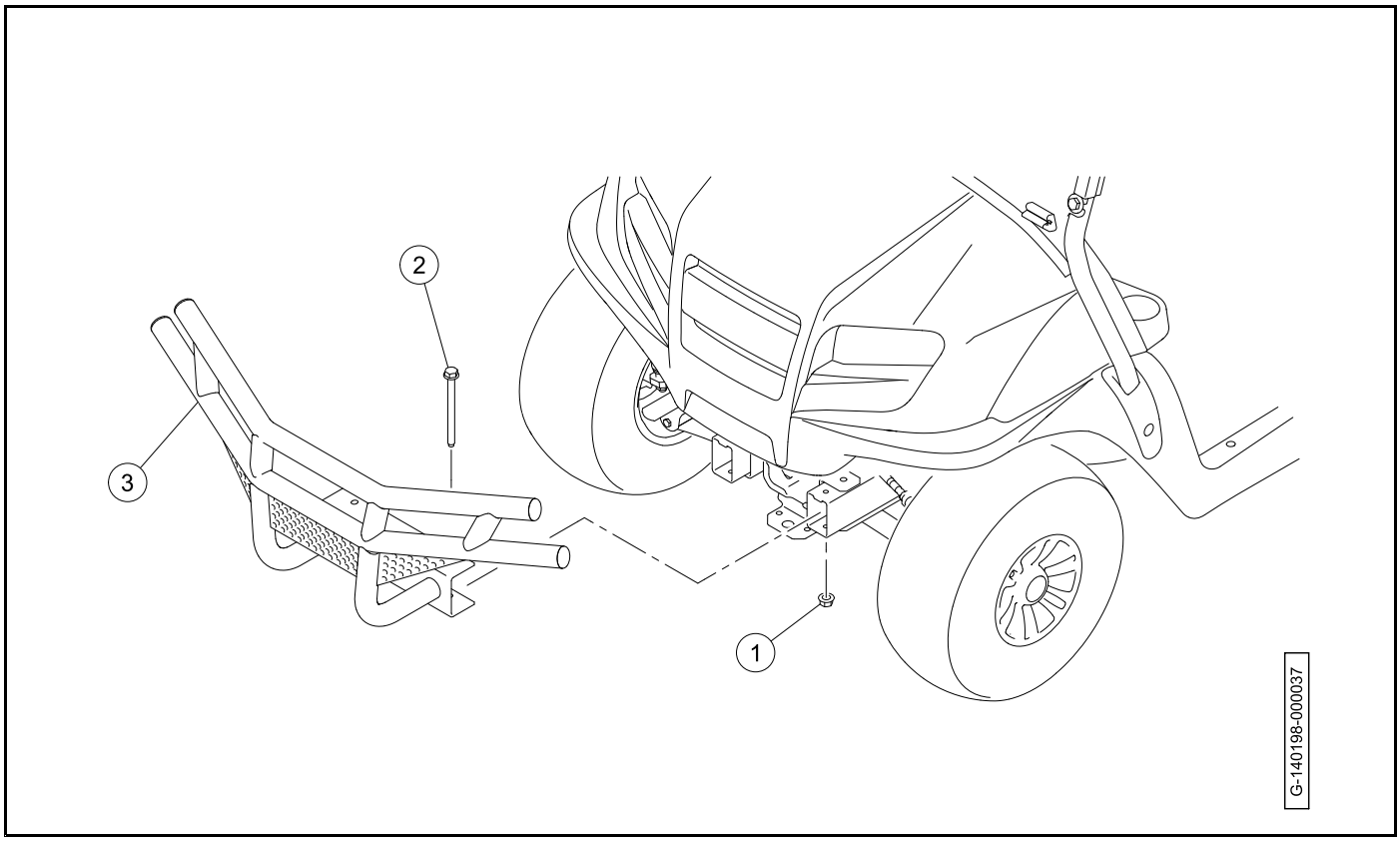


Figure 4-4 Brush Guard

BRUSH GUARD REMOVAL

1. Remove the nuts (1) and bolts (2) **(Figure 4-4, Page 4-8)**.
2. Remove the brush guard (3).

BRUSH GUARD INSTALLATION

1. Install the brush guard (3) onto the frame rails **(Figure 4-4, Page 4-8)**.
2. Install the bolts (2).
3. Install the nuts (1). Tighten the nuts to 18.7 lb·ft (25.5 N·m).

COWL BRACKET - LIFTED GASOLINE AND DC ELECTRIC

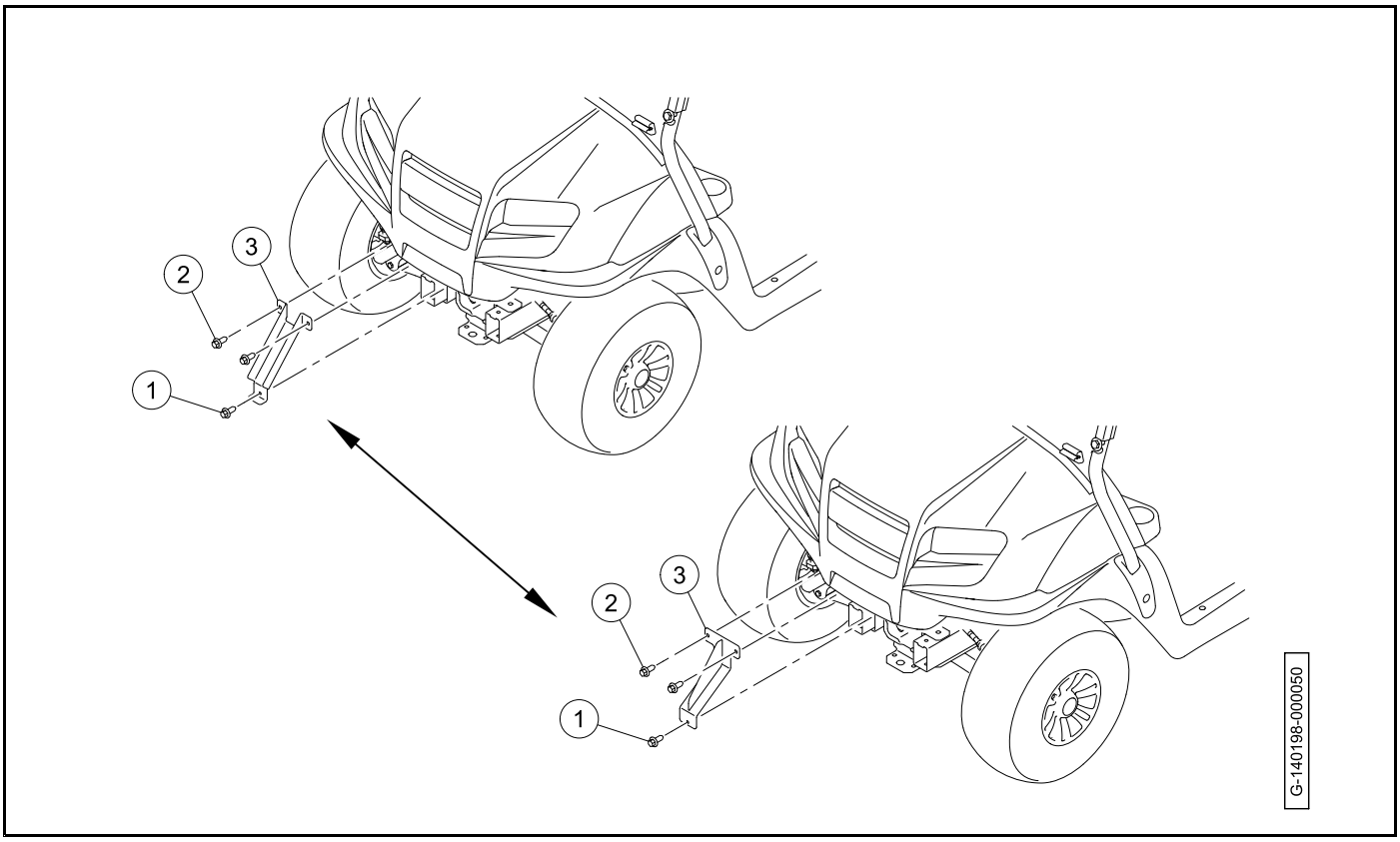


Figure 4-5

COWL BRACKET REMOVAL - LIFTED GASOLINE AND DC ELECTRIC

1. Remove the brush guard.
2. Remove the screw (1) **(Figure 4-5, Page 4-9)**.
3. Remove the screws (2).
4. Remove the cowl bracket (3).

COWL BRACKET INSTALLATION - LIFTED GASOLINE AND DC ELECTRIC

1. Install the cowl bracket (3) **(Figure 4-5, Page 4-9)**.
2. Install the screws (2). Tighten the screws to 12.9 lb·ft (17.5 N·m).
3. Install the screw (1). Tighten the screw to 48.6 lb·in (5.5 N·m).
4. Install the brush guard.

COWL BRACKET - LIFTED AC ELECTRIC

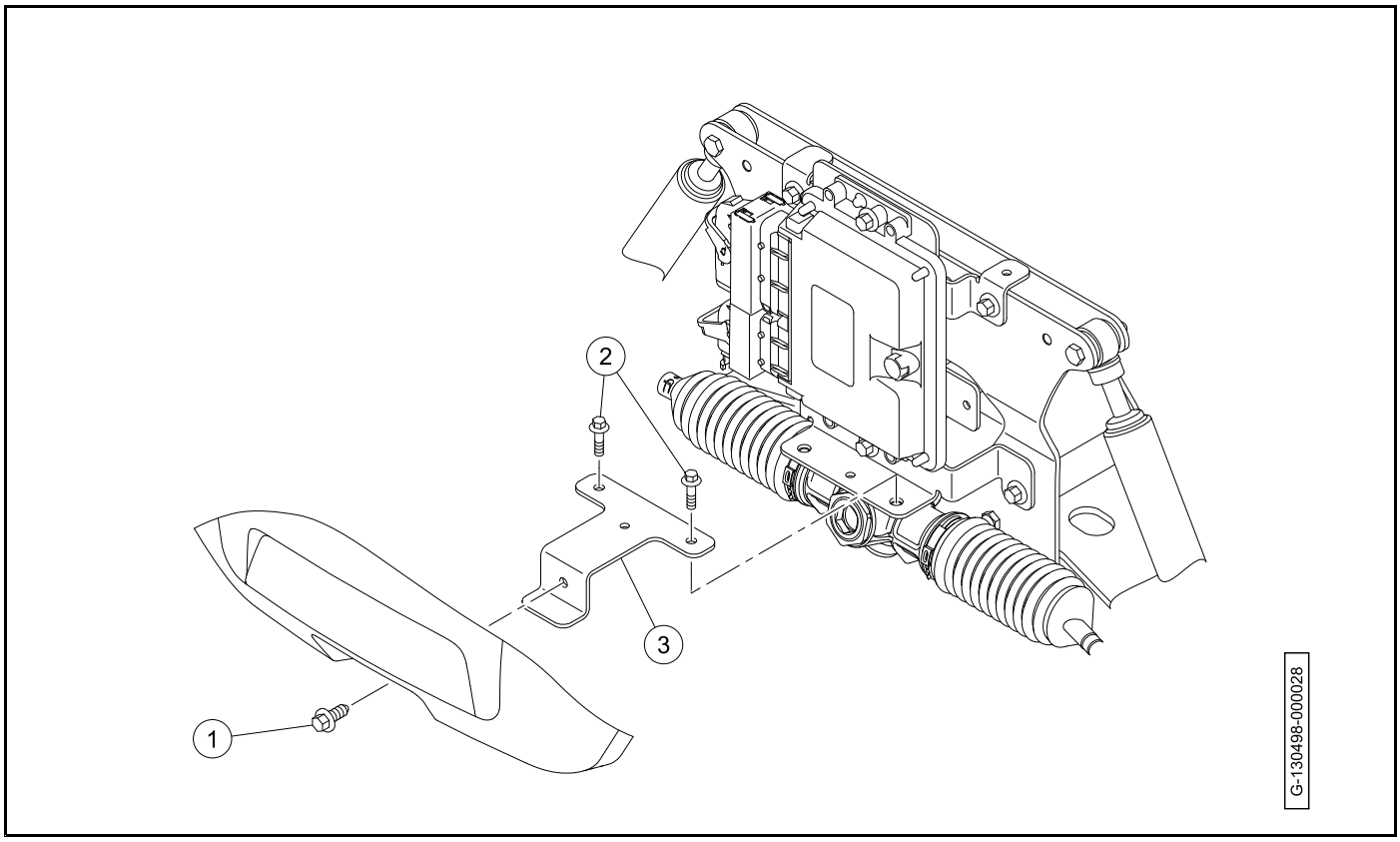


Figure 4-6

COWL BRACKET REMOVAL - LIFTED AC ELECTRIC

1. Remove the brush guard.
2. Remove the screw (1) **(Figure 4-6)**.
3. Remove the bolts (2).
4. Remove the cowl bracket (3).

COWL BRACKET INSTALLATION - LIFTED AC ELECTRIC

1. Install the cowl bracket (3) **(Figure 4-6)**.
2. Install the bolts (2). Tighten the bolts between 7.3 and 7.4 lb·ft (9 and 11 N·m).
3. Install the screw (1). Tighten the screw between 44.2 and 53 lb·in (10 N·m).
4. Install the brush guard.

COWL BRACKET - NON-LIFTED VEHICLES

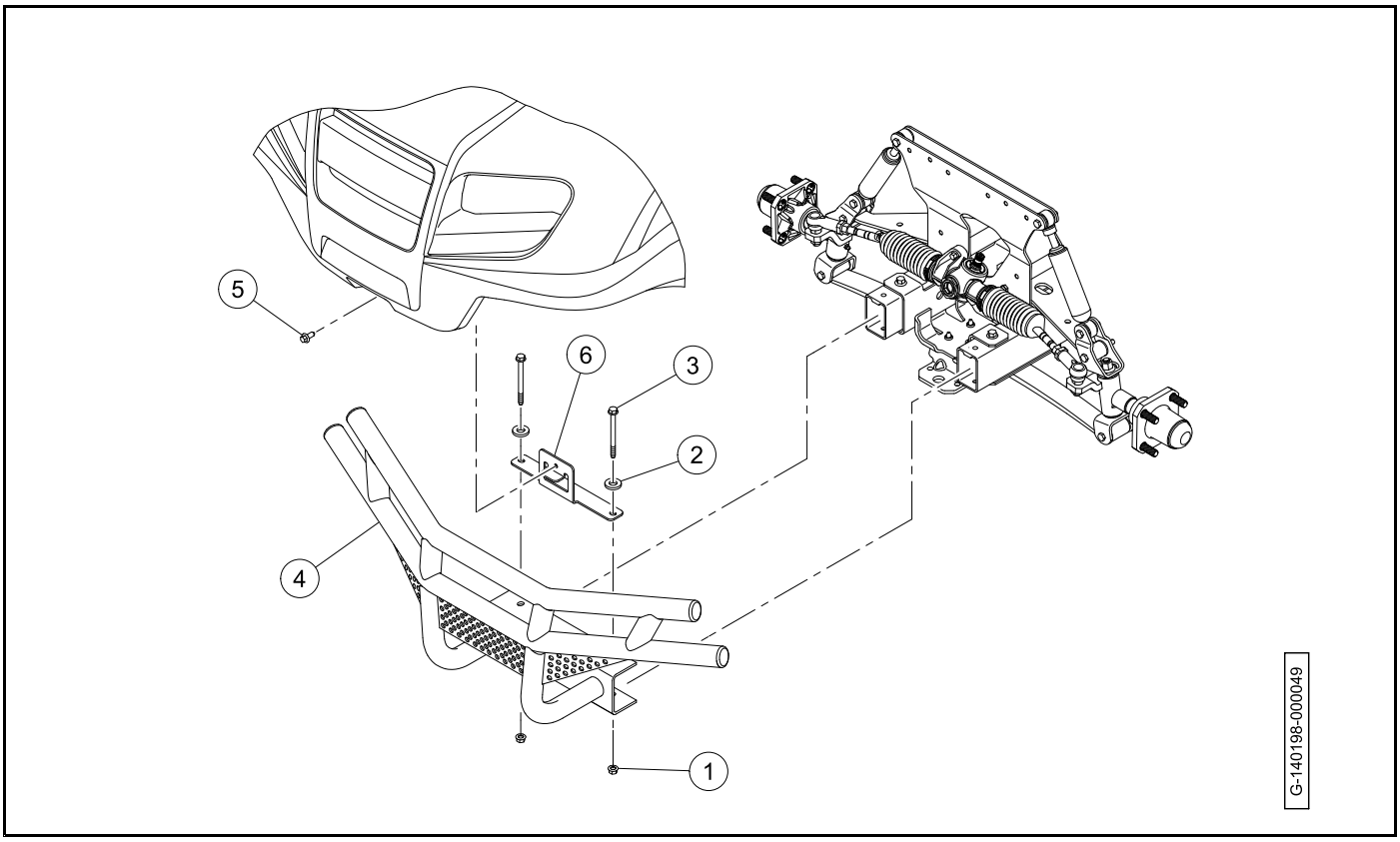


Figure 4-7

COWL BRACKET REMOVAL - NON-LIFTED VEHICLES

1. Disable the vehicle.
2. Remove the nuts (1) **(Figure 4-7)**.
3. Remove the washers (2) and bolts (3).
4. Remove the brush guard (4).
5. Remove the screw (5).
6. Remove the cowl bracket (6).

COWL BRACKET INSTALLATION - NON-LIFTED VEHICLES

1. Install the cowl bracket (6) on the frame **(Figure 4-7)**.
2. Install the screw (5). Tighten the screw between 44.2 and 53 lb·in (4.9 and 5.9 N·m).
3. Install the brush guard (4) on the frame.
4. Install the bolts (3), washers (2), and nuts (1). Tighten the nuts between 16.7 and 20.7 lb·ft (22.6 and 28 N·m).

FRONT BUMPER

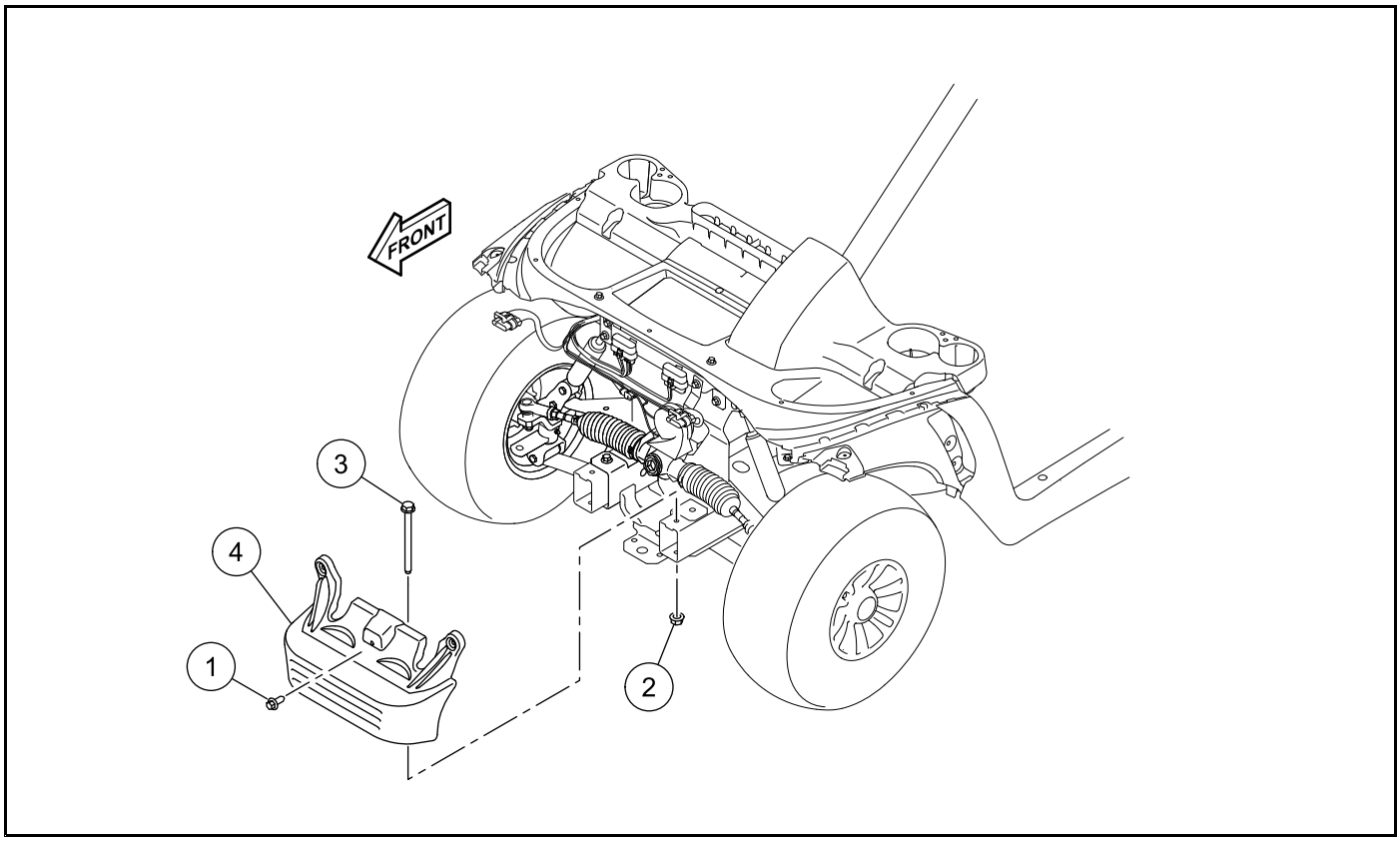


Figure 4-8 Front Bumper

FRONT BUMPER REMOVAL

1. Remove the screw (1) **(Figure 4-8, Page 4-12)**.
2. Remove the nuts (2) and bolts (3).
3. Remove the front bumper (4)

FRONT BUMPER INSTALLATION

1. Put the front bumper (4) on the frame rails **(Figure 4-8, Page 4-12)**.
2. Install the bolts (3) and nuts (2).
3. Tighten the nuts to 13.3 lb·ft (18 N·m).
4. Install the screw (1).
5. Tighten the screw to 28 lb·in (3.0 N·m).

FRONT FENDER

Driver-side shown. Passenger-side is typical.

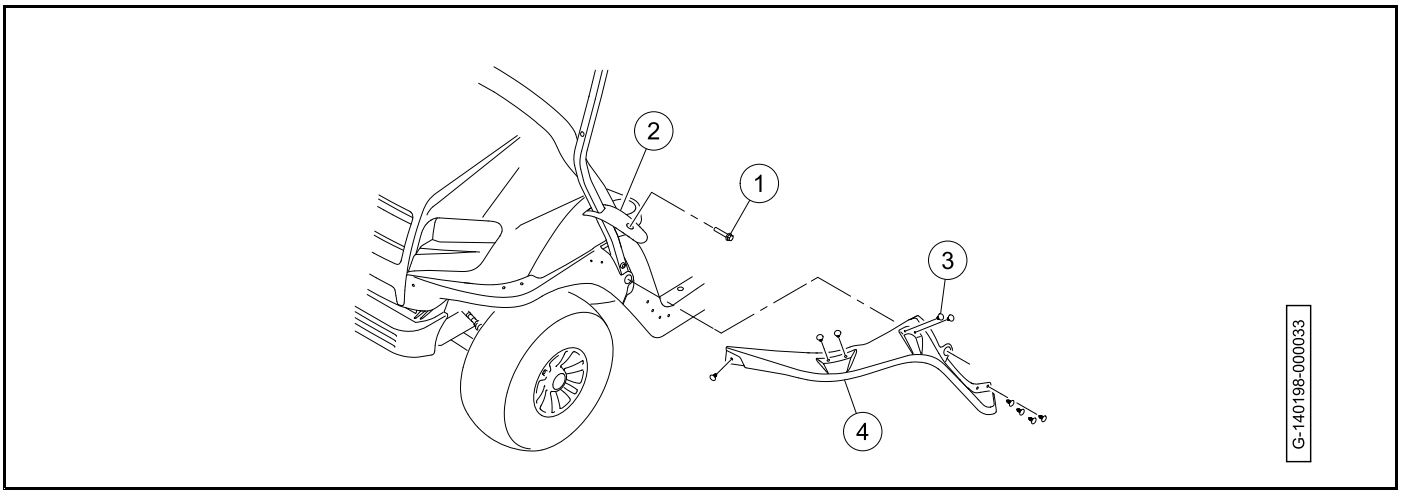


Figure 4-9 Front Fender

FRONT FENDER REMOVAL

1. Remove the screw (1) **(Figure 4-9, Page 4-13)**.
2. Slide the front canopy strut cover (2) up the front canopy strut.
3. Remove the push rivets (3).
4. Examine the push rivets. Replace as necessary.
5. Remove the front fender (4).

FRONT FENDER INSTALLATION

1. Install the front fender (4) on the beauty panel.
2. Install the push rivets (3).
3. Install the front canopy strut cover (2) onto the front canopy strut.
4. Install the screw (1). Tighten the screw to 31 lb·in (4.6 N·m).

REAR FENDER

Driver-side shown. Passenger-side is typical.

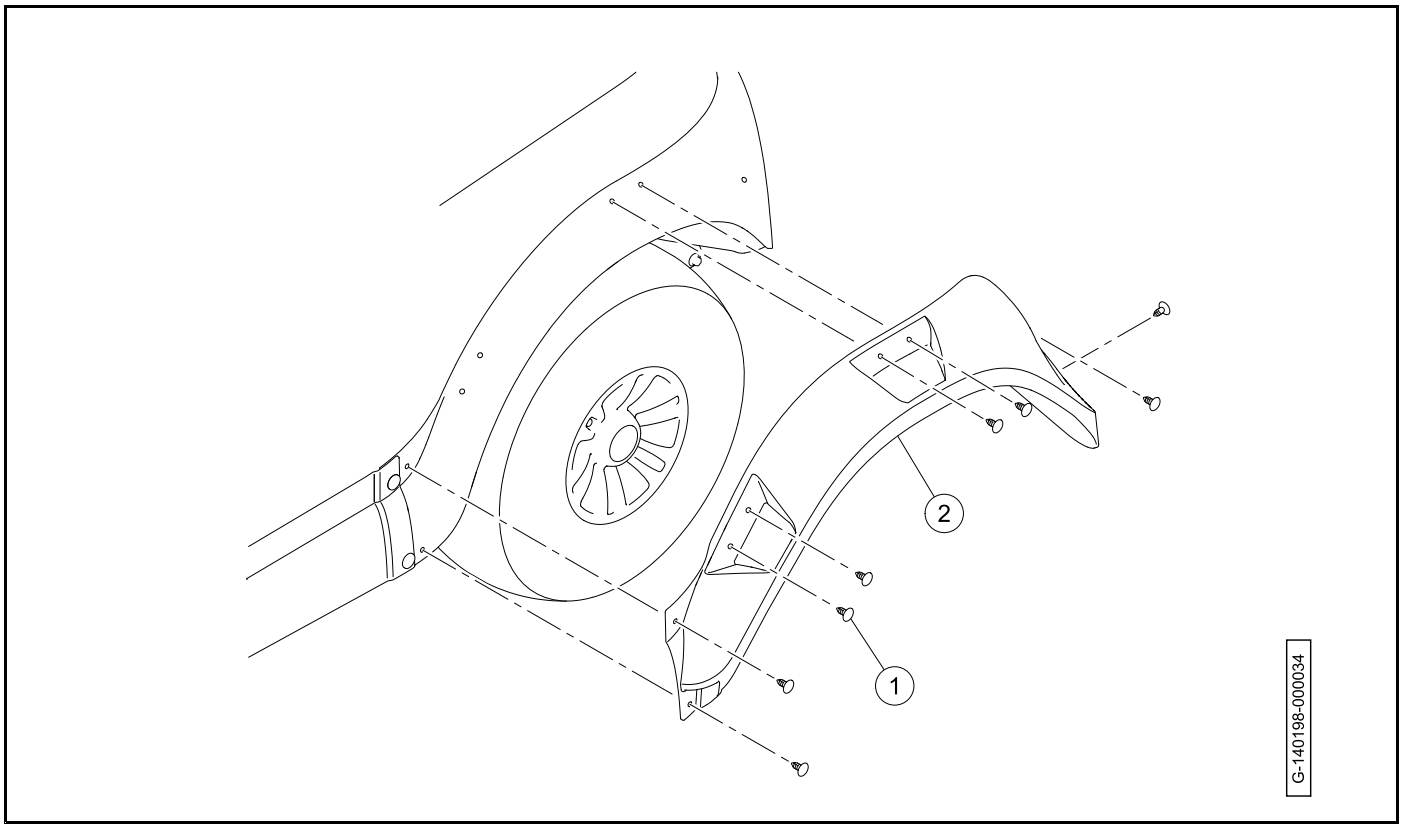


Figure 4-10 Rear Fender

REAR FENDER REMOVAL

1. Remove the push rivets (1) **(Figure 4-10, Page 4-14)**.
2. Examine the push rivets. Replace as necessary.
3. Remove the rear fender (2).

REAR FENDER INSTALLATION

1. Install the rear fender (2) onto the rear underbody.
2. Install the push rivets (1).

UNDERBODY BRACKET

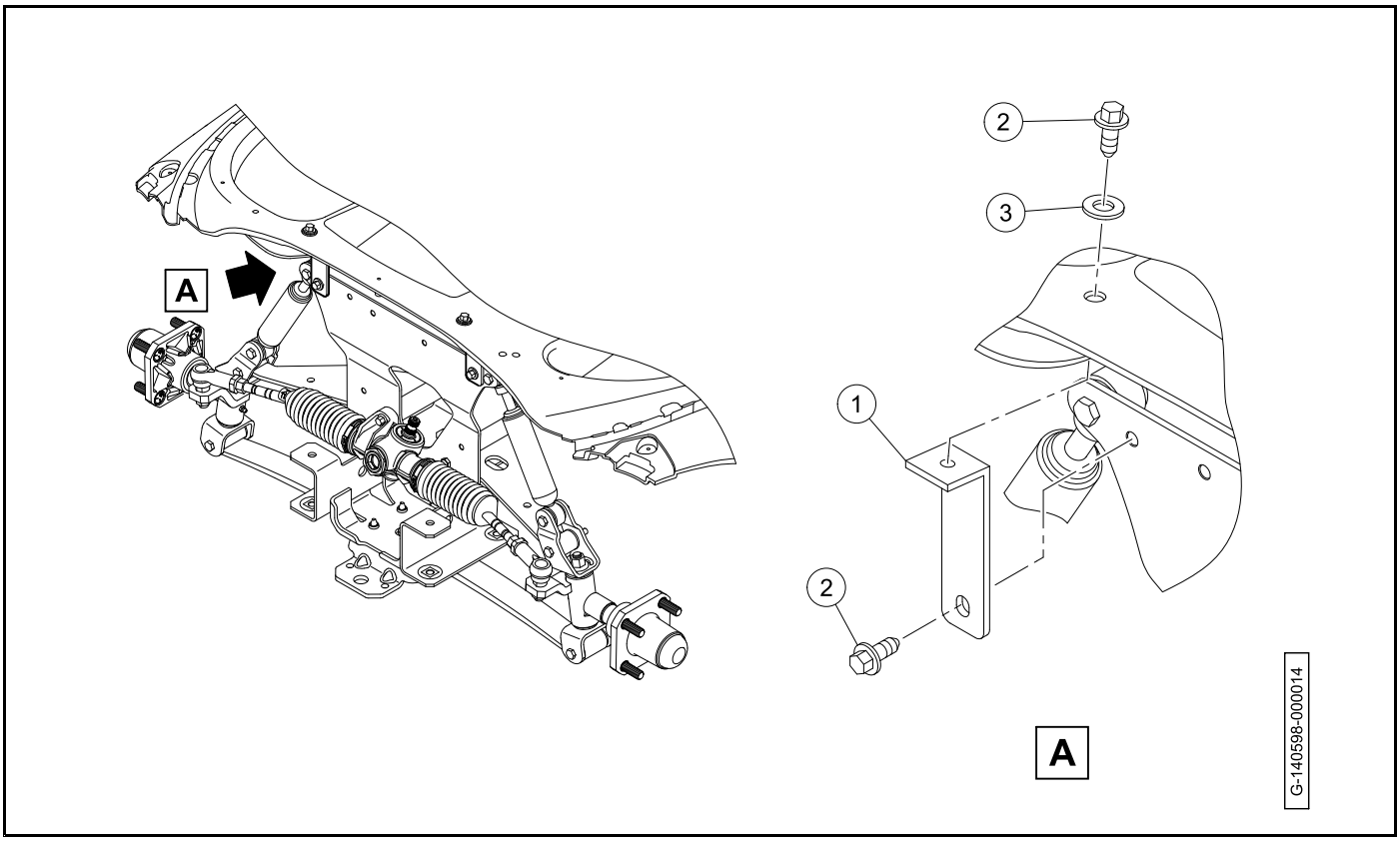


Figure 4-11 Underbody Bracket

UNDERBODY BRACKET REMOVAL

1. Remove the two screws (2) **(Figure 4-11, Page 4-15)**.
2. Remove the underbody bracket (1).

UNDERBODY BRACKET INSTALLATION

1. Put the underbody bracket (1) into position on the vehicle **(Figure 4-11, Page 4-15)**.
2. Install the two screws (2).
3. Tighten the screws to 13 lb·ft (17.6 N·m).

HEADLIGHTS

The headlights are not adjustable.

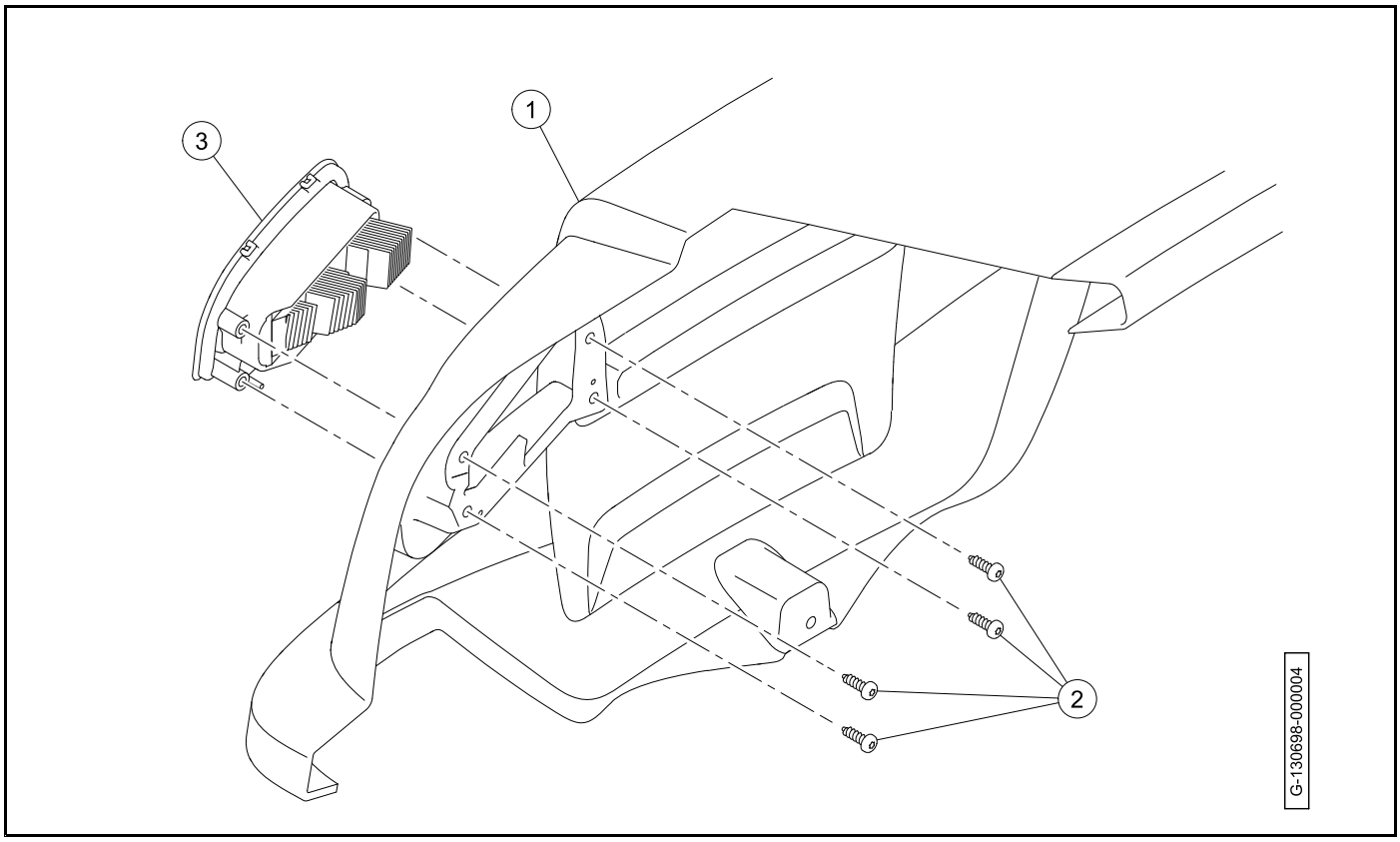


Figure 4-12 Headlights

HEADLIGHT REMOVAL

1. Disconnect the headlight harness.
2. Remove the front beauty panel (1) **(Figure 4-12)**.
3. Remove the screws (2).
4. Remove the headlight (3).

HEADLIGHT INSTALLATION

1. Install the headlight (3) **(Figure 4-12)**.
2. Install the screws (2).
3. Connect the headlight harness.
4. Install the front beauty panel (1).

INSTRUMENT PANEL

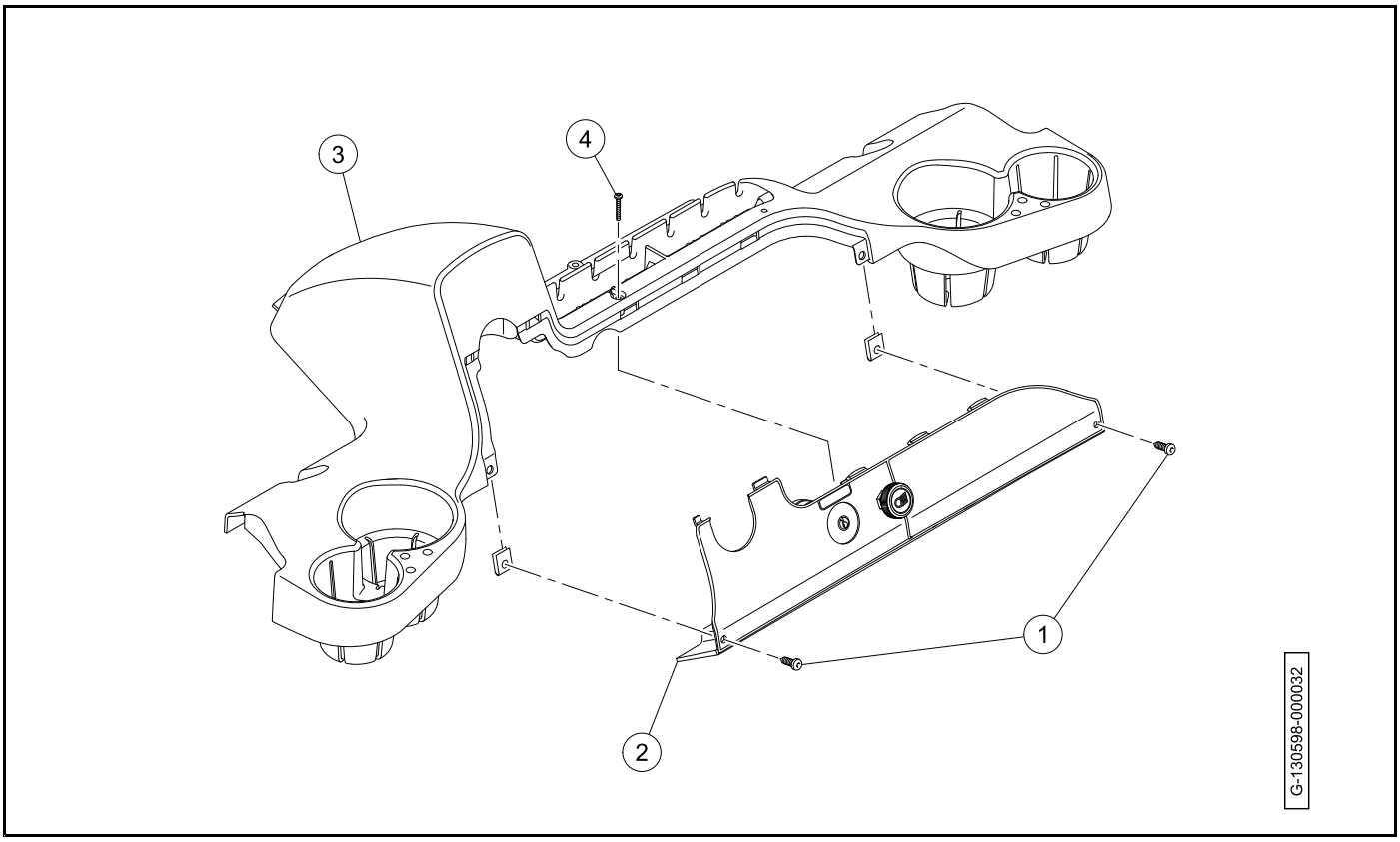


Figure 4-13 Instrument Panel

INSTRUMENT PANEL REMOVAL

1. Remove the screws (1 and 4) **(Figure 4-13)**.
2. Tilt instrument panel (2) up to release it from the dash assembly (3).
3. Disconnect the electrical connector on the passenger side.

INSTRUMENT PANEL INSTALLATION

1. Connect the electrical connector on the passenger side **(Figure 4-13)**.
2. Install the instrument panel (2) into the dash assembly (3). Make sure that the tabs on the instrument panel engage in the slots on the dash assembly.
3. Make sure that electrical wires are not exposed or pinched.
4. Install the screws (1 and 4). Tighten the screws to 22 lb·in (2.5 N·m).

DASH ASSEMBLY

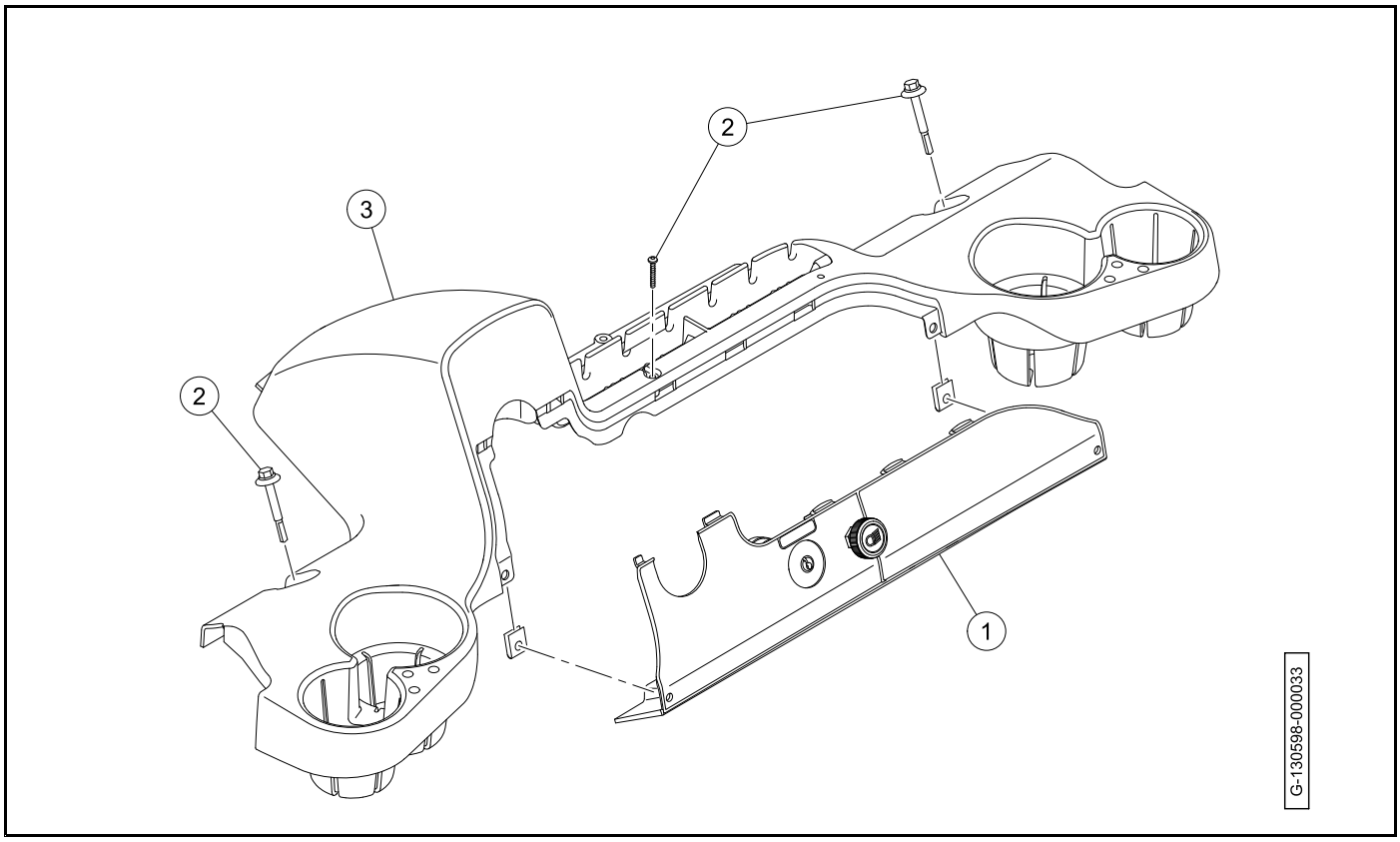


Figure 4-14 Dash Assembly

DASH ASSEMBLY REMOVAL

1. Remove the instrument panel (1) **(Figure 4-14)**.
2. Remove the screws (2).
3. Disconnect the USB receptacle.
4. Remove the dash assembly (3).

DASH ASSEMBLY INSTALLATION

1. Put the dash assembly (3) on vehicle **(Figure 4-14)**. Make sure tabs on the forward edge engage to front underbody.
2. Connect the USB receptacle.
3. Install the screws (2). Tighten the screws to 8.8 lb·ft (12 N·m).
4. Install the instrument panel (1).

FLOOR MAT AND RETAINERS

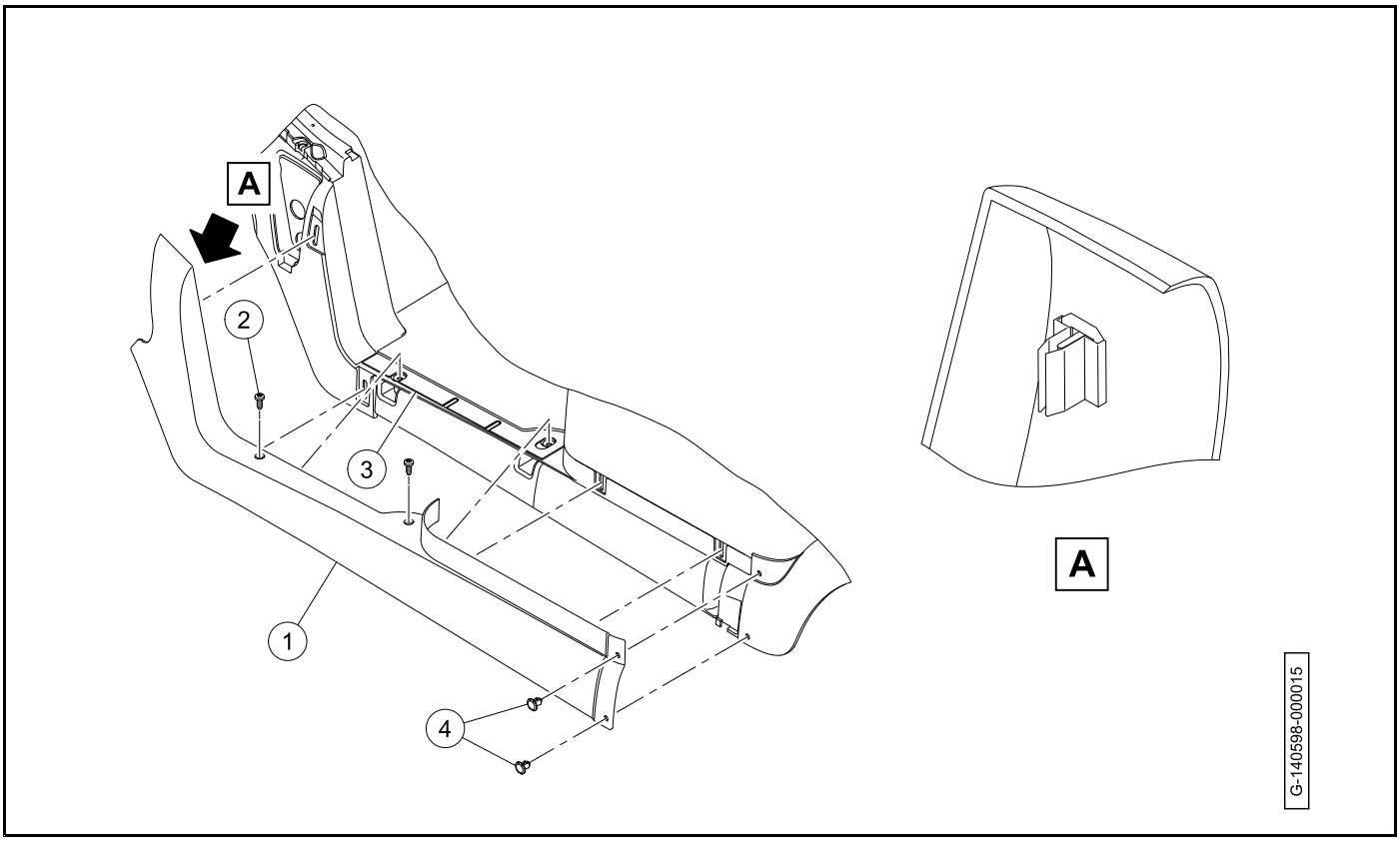


Figure 4-15 Floor Mat And Retainers

FLOOR MAT REMOVAL

1. Remove the screws (2) **(Figure 4-15)**.
2. Remove the floor mat (3) from under the floor mat retainers (1).

FLOOR MAT INSTALLATION

1. Install the floor mat (3) under the floor mat retainers **(Figure 4-15)**.
2. Install the screws (2). Tighten the screws to 4.4 lb·ft (6.0 N·m).

FLOOR MAT RETAINER REMOVAL

1. Remove the screws (2) **(Figure 4-15)**.
2. Remove the push rivets (4).
3. Carefully pull on floor mat retainer (1) to separate the trim clips from their respective slots. Trim clips do not normally need to be removed from the retainer.

FLOOR MAT RETAINER INSTALLATION

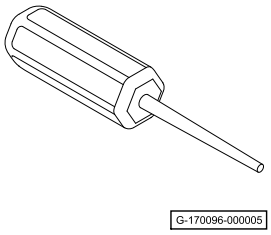
1. Position the floor mat retainer (1) on the vehicle and press firmly to engage the trim clips to the vehicle **(Figure 4-15)**.

2. Make sure that the floor mat (3) is correctly positioned beneath the top flange of the floor mat retainer.
3. Install the two screws (2). Do not tighten the screws.
4. Install the push rivets (4) **(Figure 4-15, Page 4-19)**.
5. Tighten the two screws (2) to 4.4 lb·ft (6.0 N·m).

KICK PLATE AND CHARGER RECEPTACLE BEZEL – ELECTRIC VEHICLES

KICK PLATE AND CHARGER RECEPTACLE BEZEL REMOVAL

Special Tools Needed

	Charger Bezel Tool

NOTE: *Refer to the Illustrated Parts Catalog for service tool part numbers.*

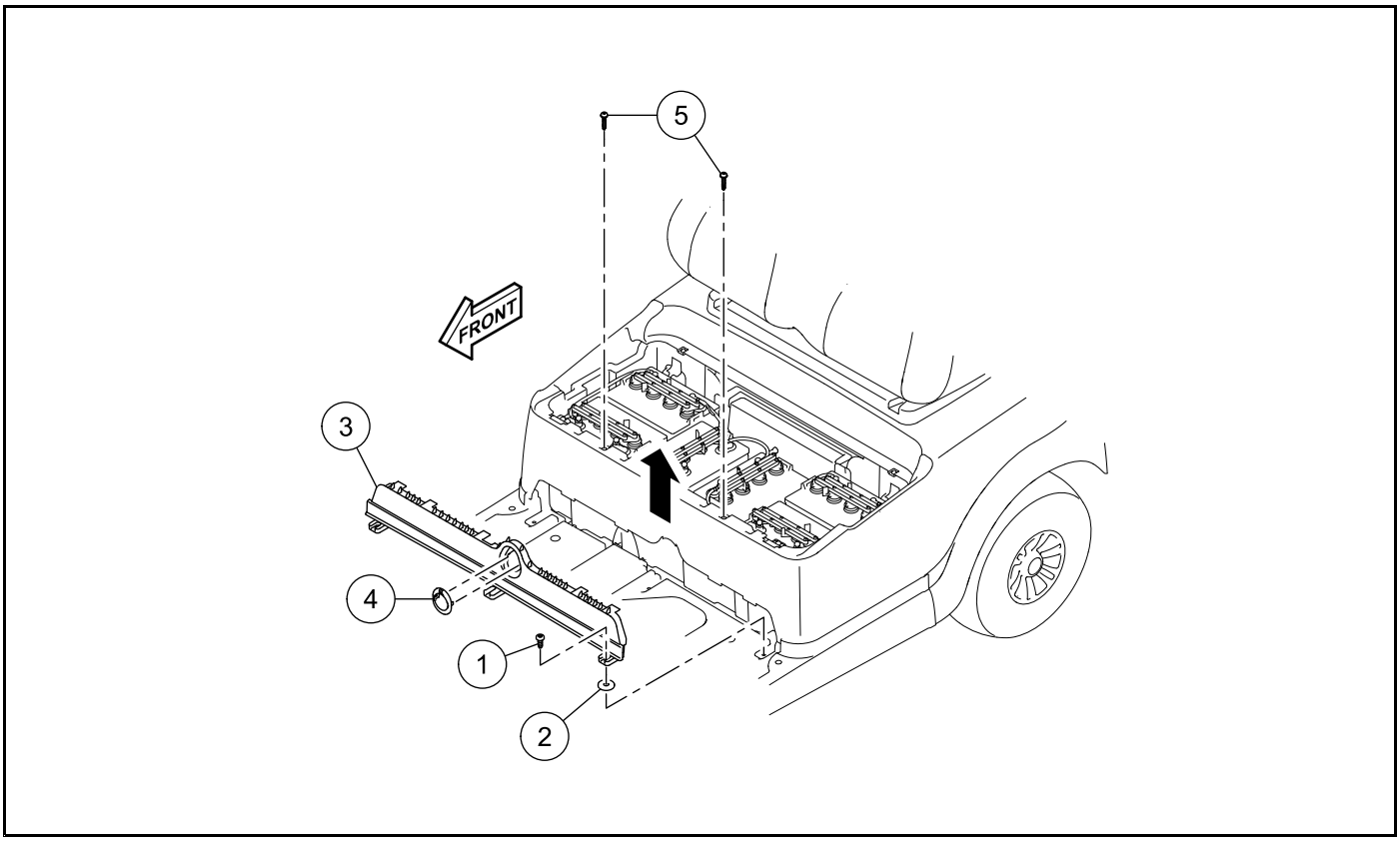


Figure 4-16 Kick Plate and Charger Receptacle Bezel Removal

1. Use the charger bezel tool to remove charger receptacle bezel (1) from the kick plate (2) **(Figure 4-16, Page 4-21)**.
2. Remove the floor mat.
3. Remove three screws (3) and washers (4).
4. Remove the two front screws (5).
5. Raise the forward portion of the rear beauty panel to disengage it from the tabs on the upper portion of the kick plate.
6. Remove the kick plate from vehicle.

KICK PLATE AND CHARGER RECEPTACLE BEZEL INSTALLATION

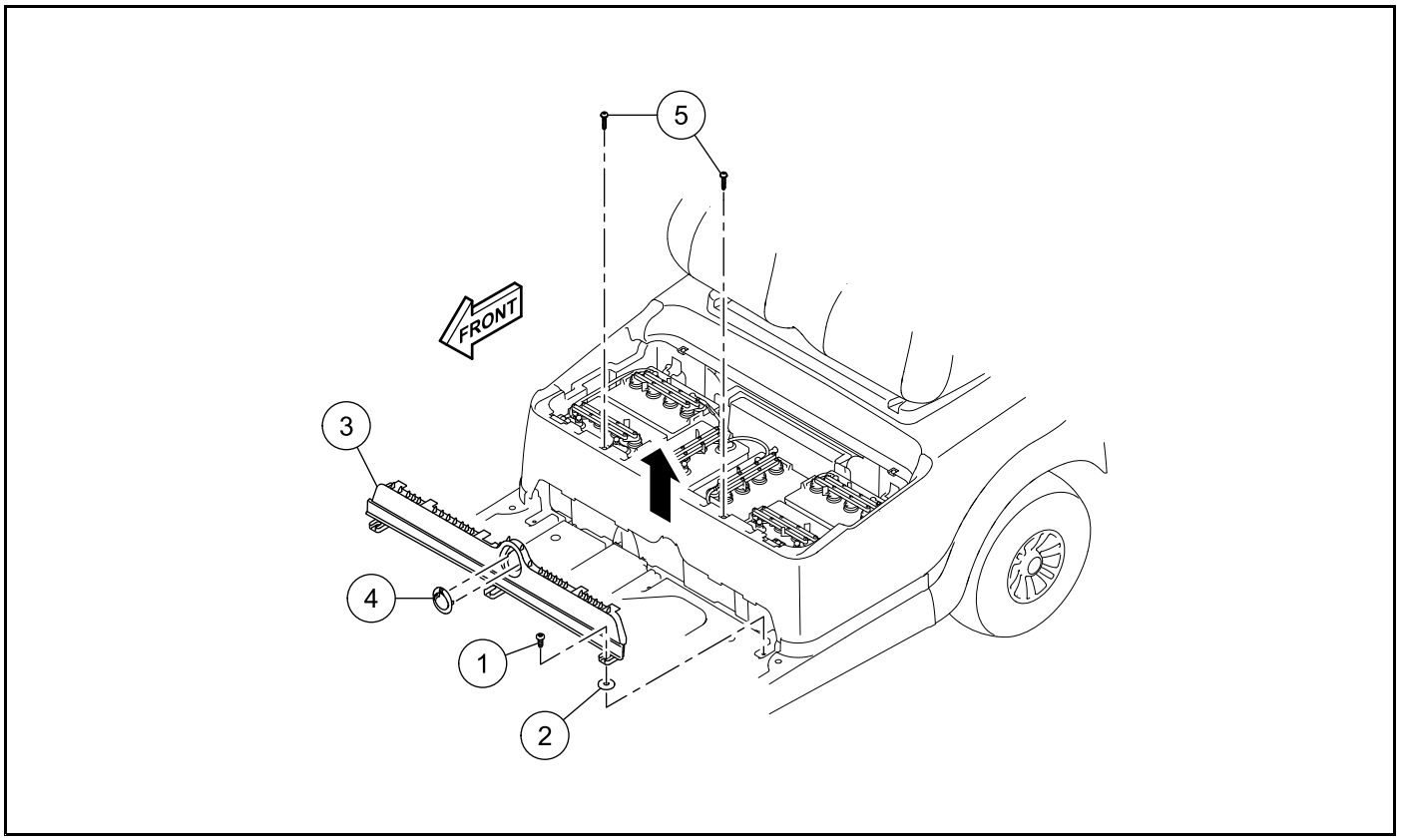


Figure 4-17 Kick Plate and Charger Receptacle Bezel Installation

1. Install the kick plate (3).
2. Make sure that the front lower edge of the rear beauty panel mates with the kick plate.
3. Install the three screws (1) and washers (2). Tighten the screws to 3.3 lb·ft (4.5 N·m).
4. Install the two front screws (5). Tighten screws to 3.7 lb·ft (5 N·m).
5. Install the floor mat.
6. Install the charger receptacle bezel (4).

KICK PLATE – GASOLINE VEHICLES

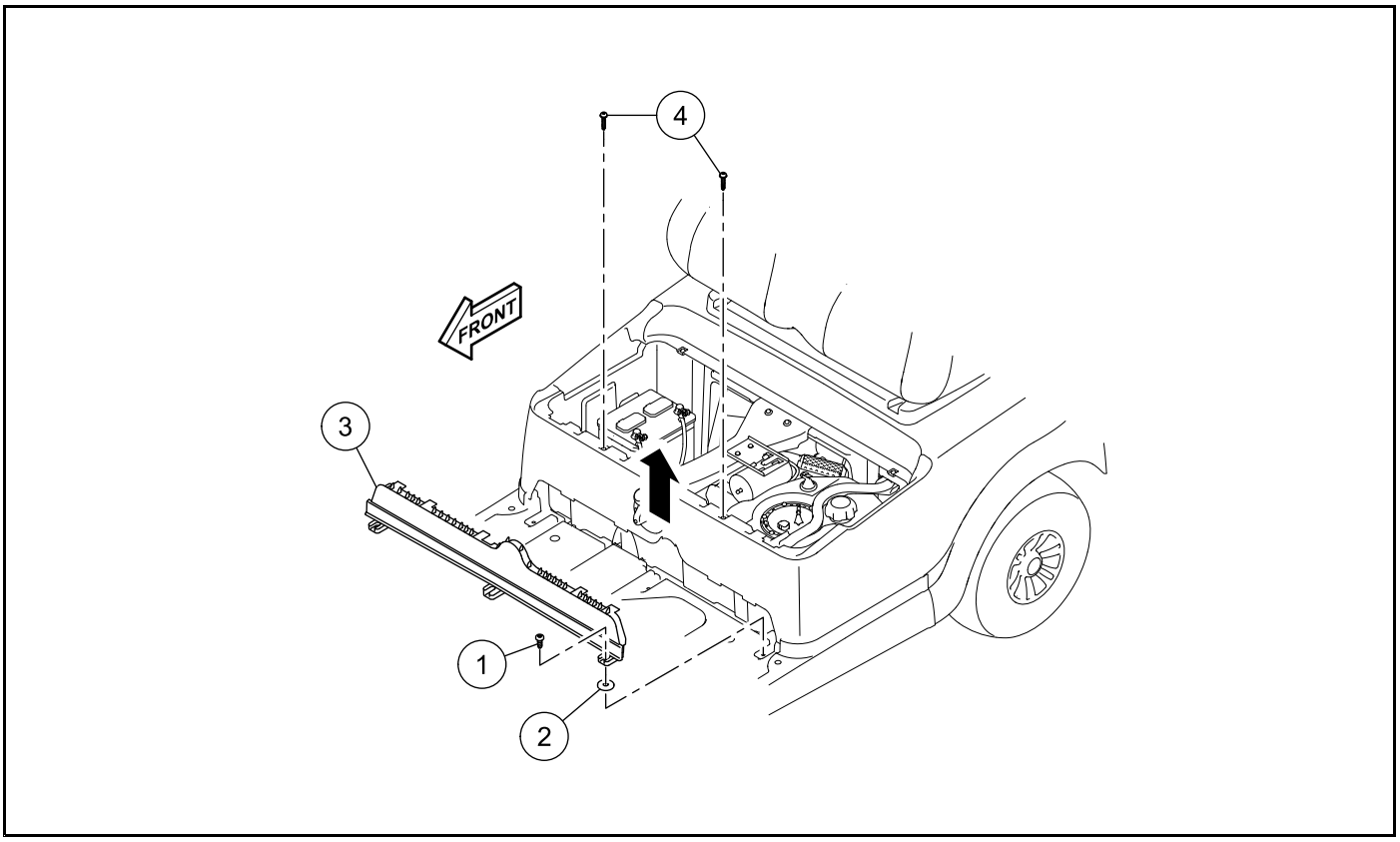


Figure 4-18 Kick Plate – Gasoline Vehicles

KICK PLATE REMOVAL

1. Remove the floor mat.
2. Remove the three screws (1) and washers (2).
3. Remove the two front screws (4).
4. Raise the forward portion of the rear beauty panel to disengage it from the tabs on the upper portion of the kick plate.
5. Remove the kick plate (3) from vehicle.

KICK PLATE INSTALLATION

1. Install the kick plate (3).
2. Install the three screws (1) and washers (2). Tighten the screws to 3.3 lb·ft (4.5 N·m).
3. Install two front screws (4). Tighten the screws to 3.7 lb·ft (5 N·m).
4. Install the floor mat.

ACCESS PANEL

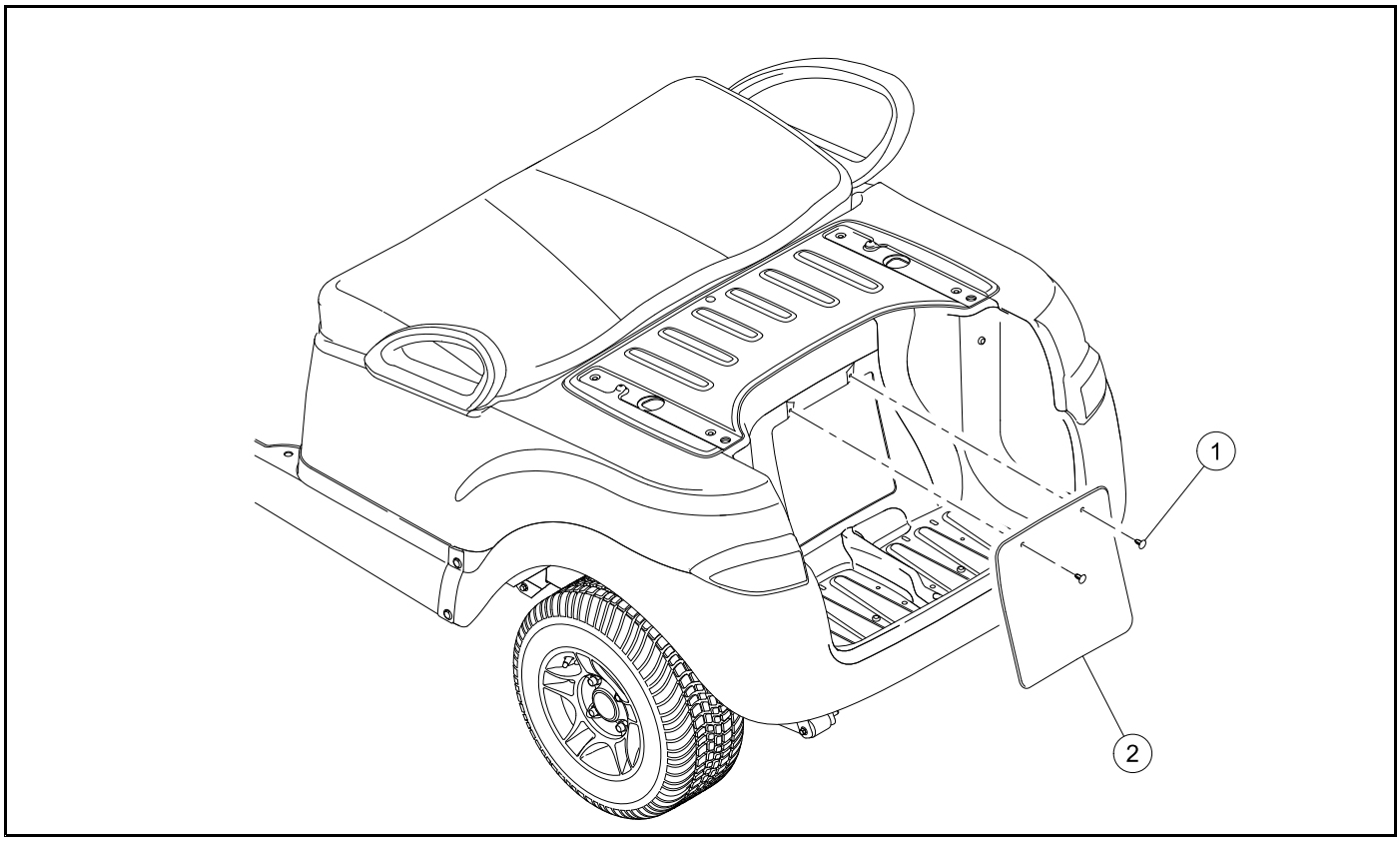


Figure 4-19 Access Panel

ACCESS PANEL REMOVAL

1. Remove the two push rivets (1) **(Figure 4-19)**.
2. Remove the access panel (2).

ACCESS PANEL INSTALLATION

1. Install the access panel (2) onto the rear underbody **(Figure 4-19)**.
2. Install the two push rivets (1).

TWO-PASSENGER - CANOPY

TWO-PASSENGER CANOPY REMOVAL

CAUTION

- **To prevent damage to the canopy, do not remove the canopy supports from the vehicle without first removing the canopy.**

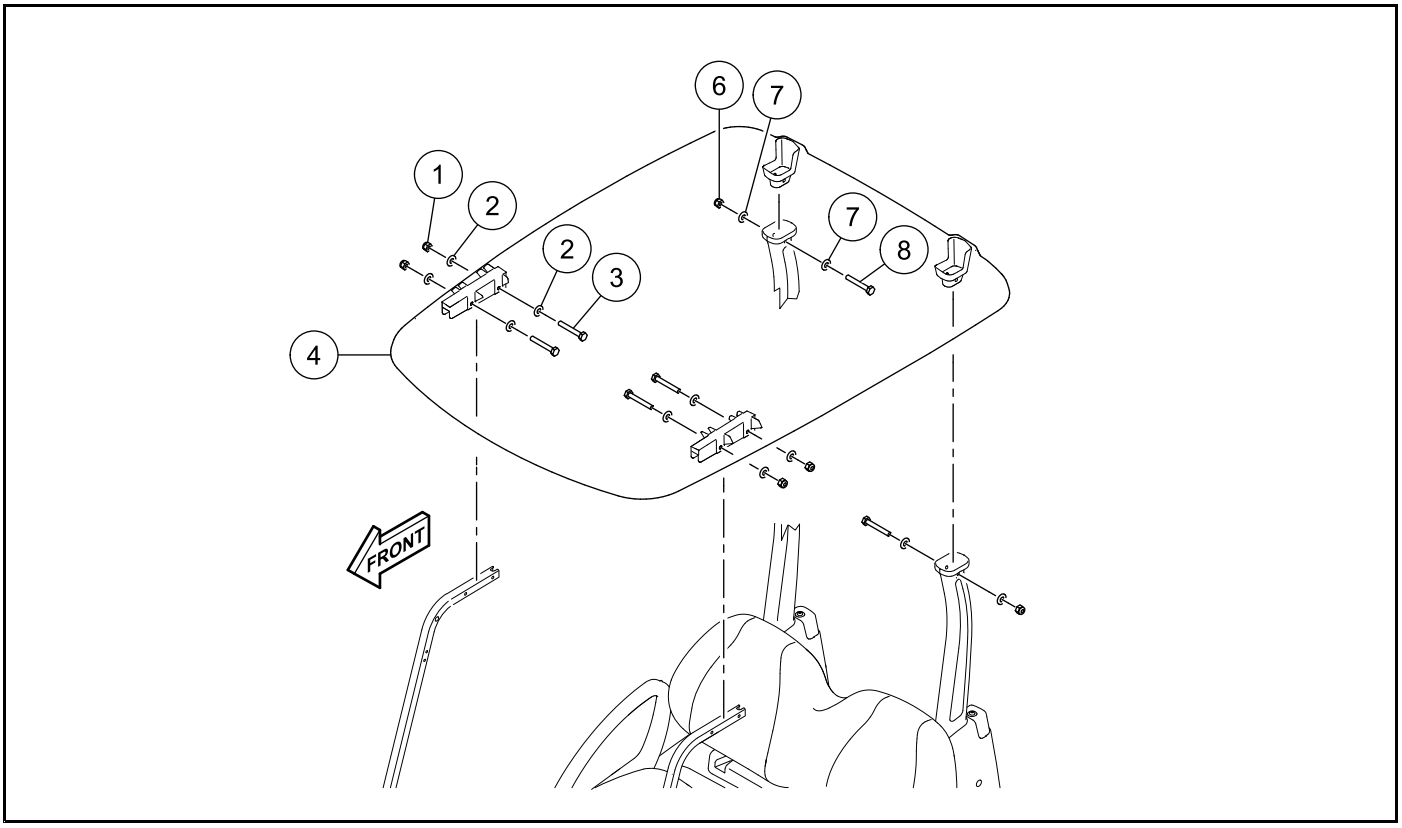


Figure 4-20 Two-Passenger Canopy Removal

1. Remove the nuts (1), washer (2), and bolts (3) from the canopy (4) and each front canopy strut **(Figure 4-20)**.
2. Remove the nuts (6), washer (7), and bolts (8) from the canopy and each rear canopy support.
3. Remove the canopy.

TWO-PASSENGER CANOPY INSTALLATION

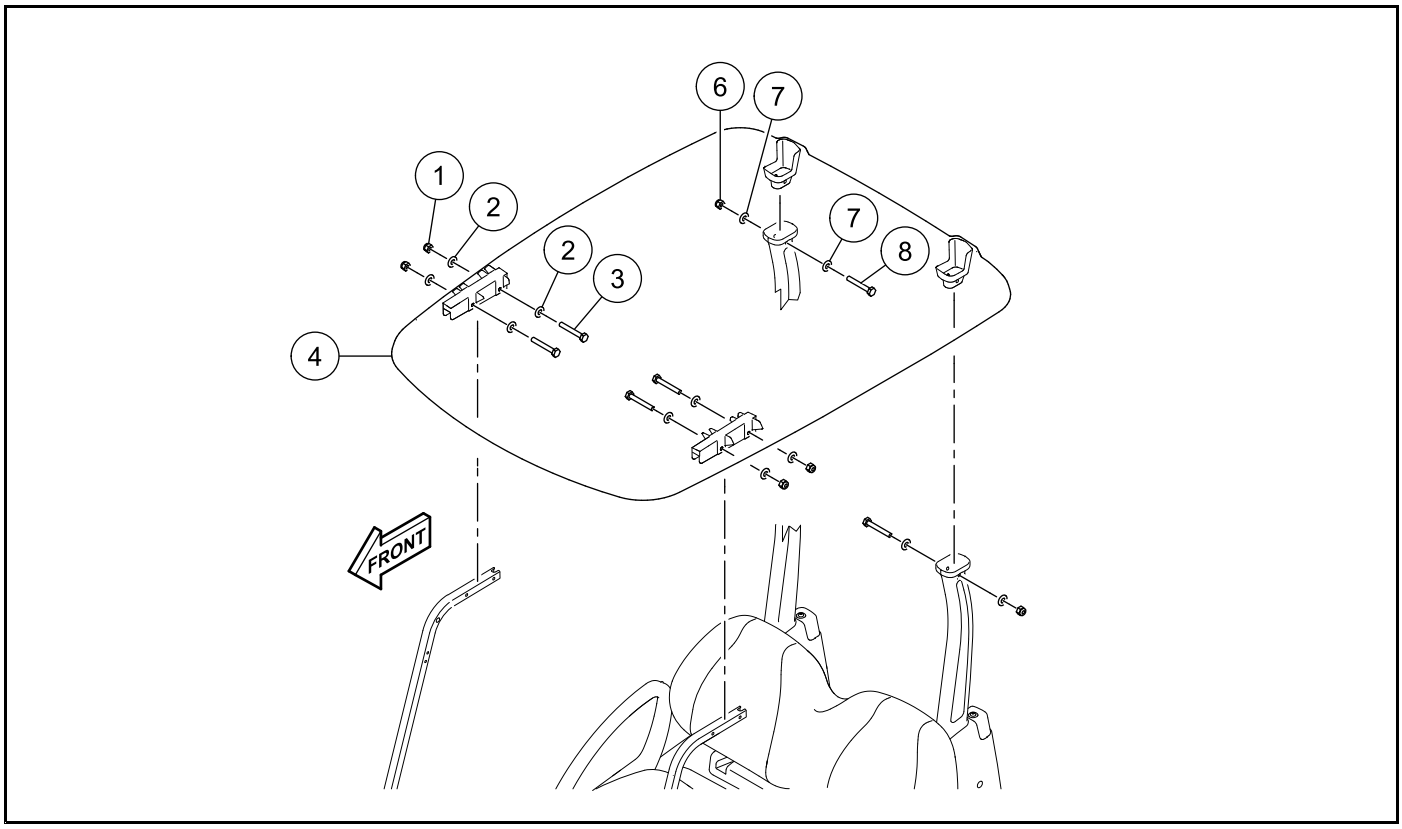


Figure 4-21 Two-Passenger Canopy Installation

1. Put the canopy (4) on top of the front and rear canopy supports **(Figure 4-21)**. Make sure that the front supports are correctly positioned between the molded tabs on the underside of the canopy. Make sure that the molded protrusions at the rear of the canopy extend into the top of the rear supports.
2. Install the bolts (3), washers (2), and nuts (1). Tighten the hardware to 50 lb·in (5.6 N·m).
3. Install the bolts (8), washers (7), and nuts (6). Tighten the hardware to 50 lb·in (5.6 N·m).

TWO-PASSENGER FRONT CANOPY STRUT REMOVAL

CAUTION

- **To prevent damage to the canopy, do not remove the canopy supports from the vehicle without first removing the canopy.**
- **Using tools to thread the bolts could prevent proper feel of the bolt as it captures the female threads in the support. This could result in damage to the components.**

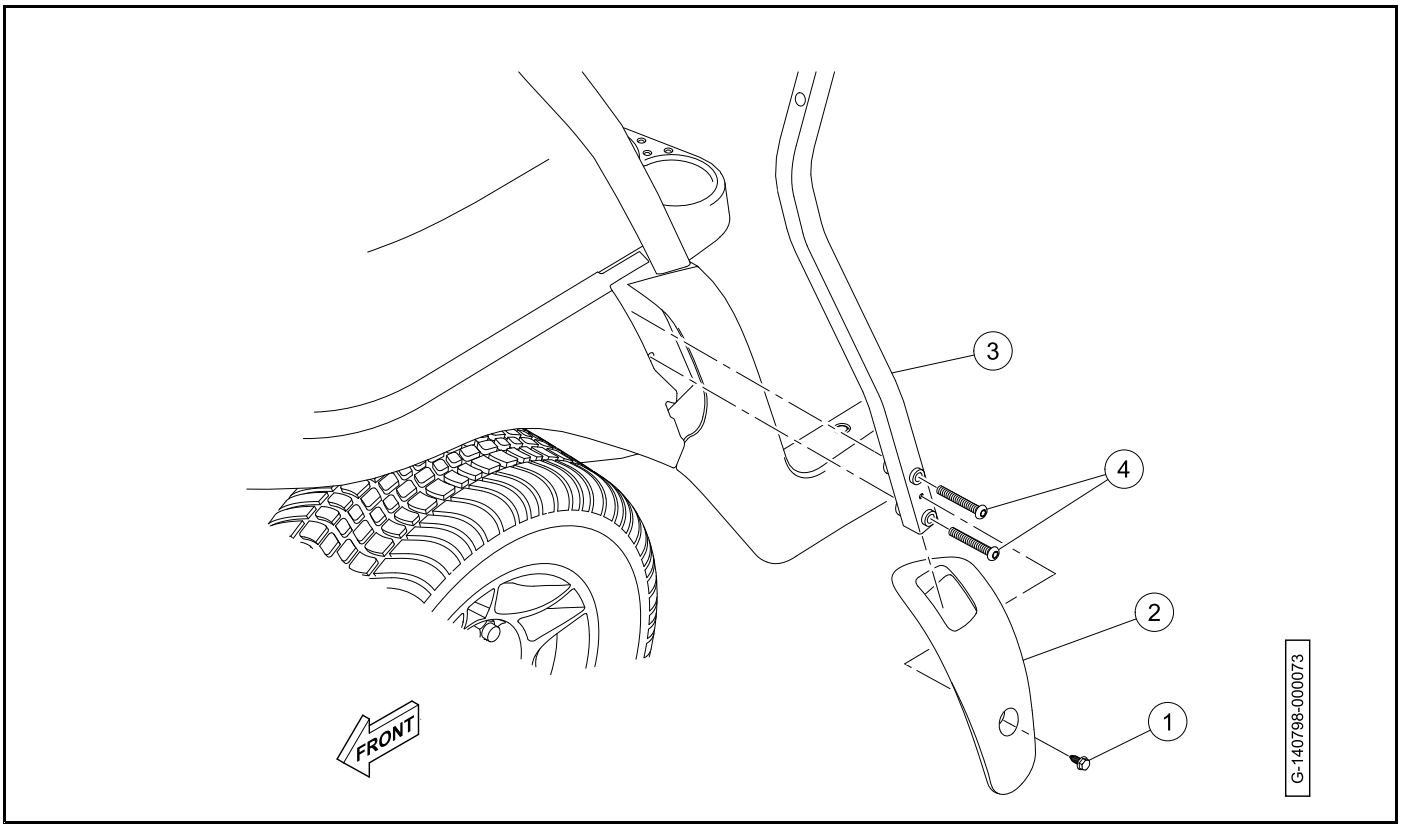


Figure 4-22 Front Canopy Strut Removal

1. Remove the canopy.
2. Remove the screw (1) **(Figure 4-22)**.
3. Slide the front canopy strut cover (2) up the front canopy strut (3).
4. Remove the screws (4) and the front canopy strut.

TWO-PASSENGER FRONT CANOPY STRUT INSTALLATION

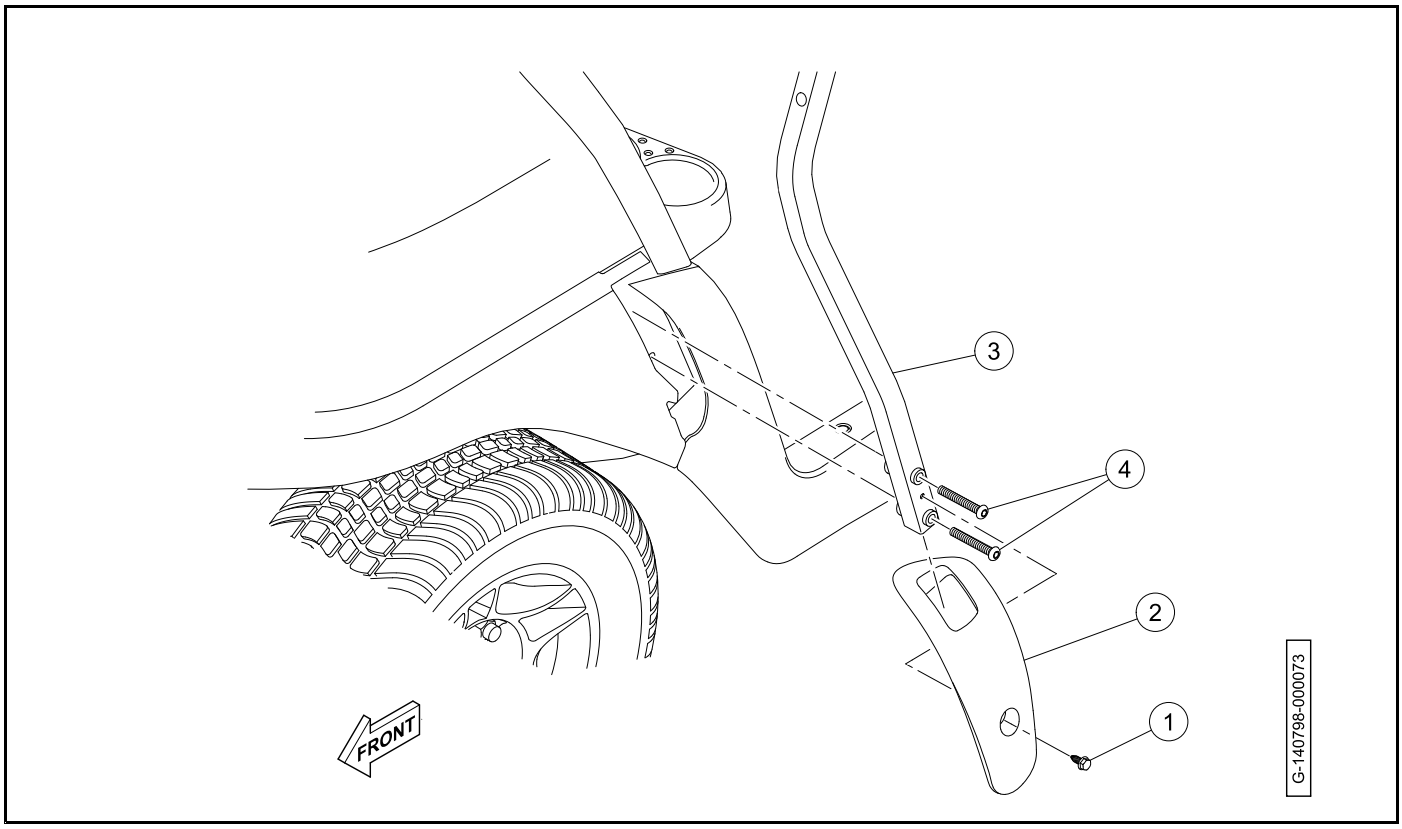


Figure 4-23 Front Canopy Strut Installation

1. Install the front canopy strut (3) onto the vehicle **(Figure 4-23)**.
2. Install the front canopy strut cover (2) onto the front canopy strut.
3. Install the screws (4). Tighten the screws to 18.4 lb·ft (25 N·m).
4. Install the screw (1). Tighten the screw to 31 lb·in (4.6 N·m).
5. Install the canopy.

TWO-PASSENGER REAR CANOPY SUPPORT REMOVAL

CAUTION

- **To prevent damage to the canopy, do not remove the canopy supports from the vehicle without first removing the canopy.**
- **Using tools to thread the bolts could prevent proper feel of the bolt as it captures the female threads in the support. This could result in damage to the components.**

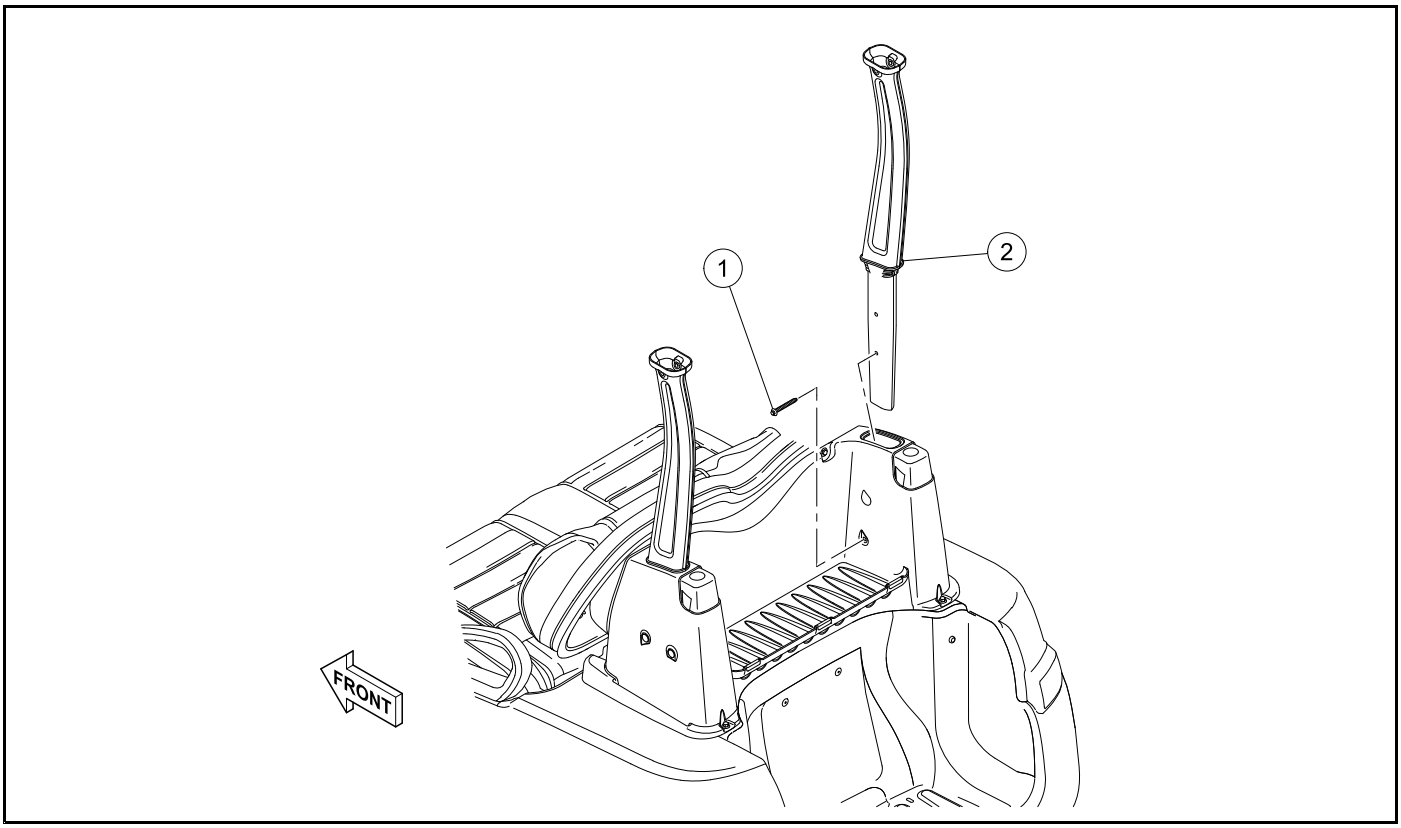


Figure 4-24 Rear Canopy Support Removal

1. Remove the canopy.
2. Remove the screw (1) **(Figure 4-24)**.
3. Remove the rear canopy support (2).

TWO-PASSENGER REAR CANOPY SUPPORT INSTALLATION

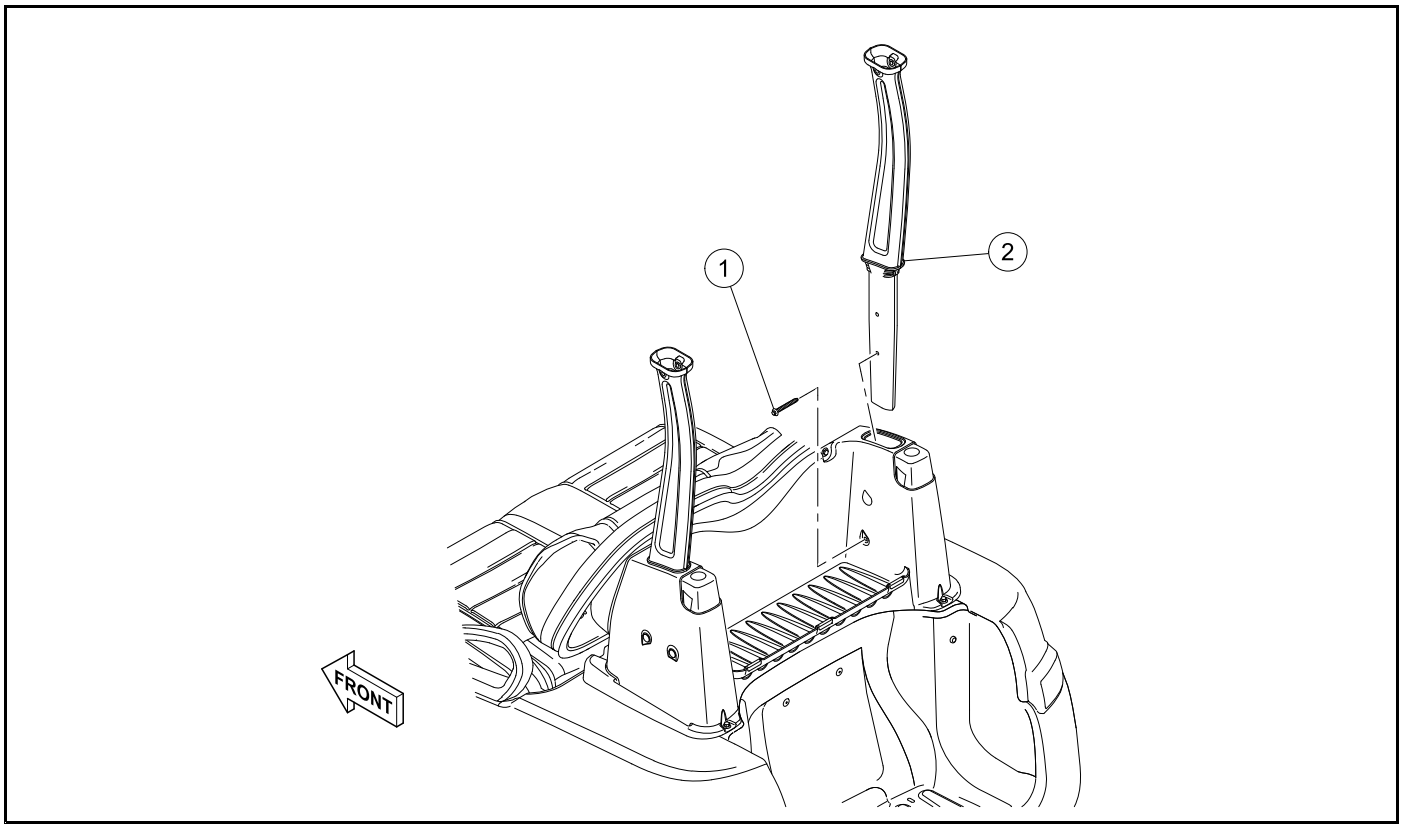


Figure 4-25 Rear Canopy Support Installation

1. Install the rear canopy support (2) into the structural accessory module (SAM) **(Figure 4-25)**.
2. Install the screw (1). Tighten the screw to 88 lb·in (10 N·m).
3. Install the canopy.

CANOPY DRAIN COVER

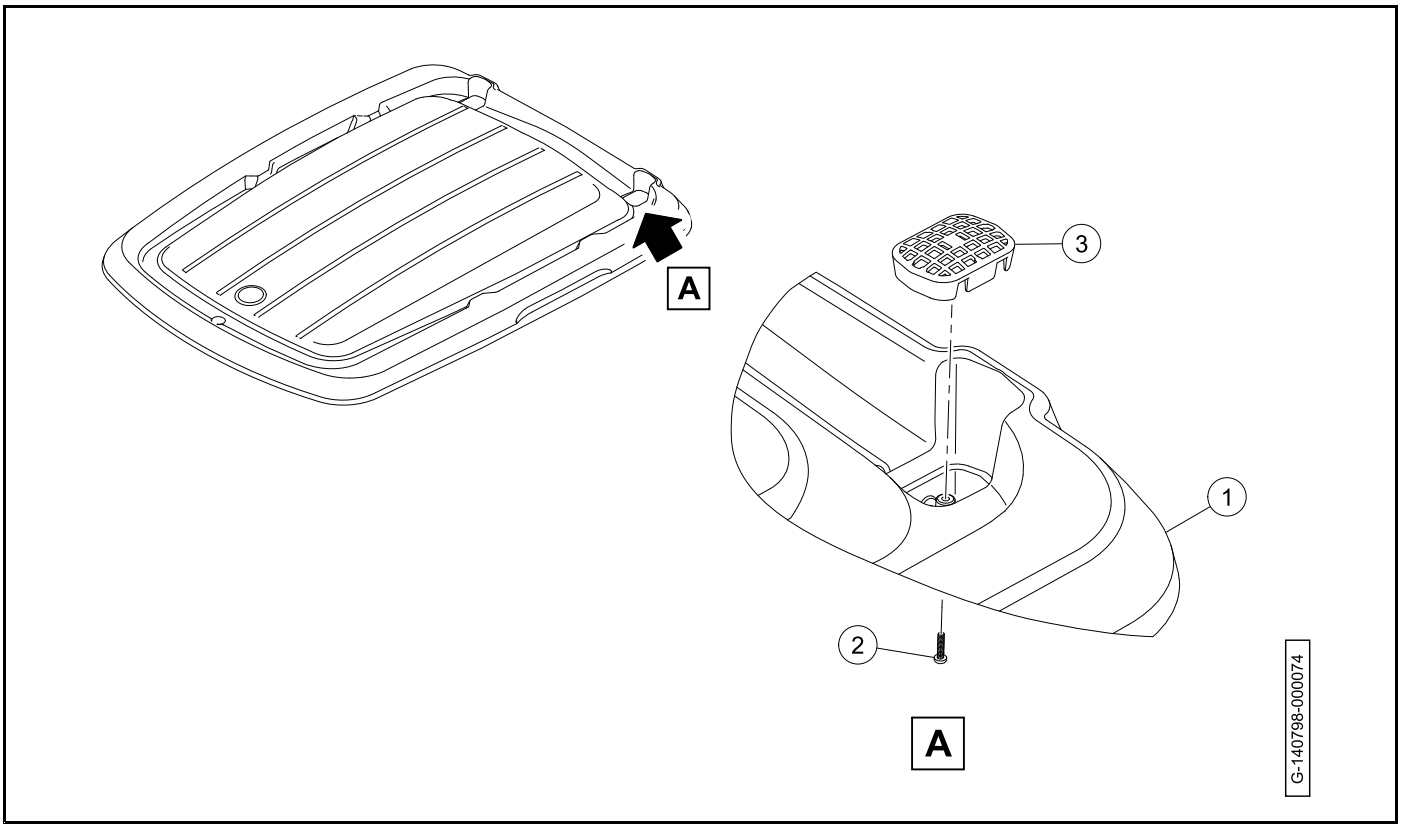


Figure 4-26 Canopy Drain Cover

Canopy Drain Cover Removal

1. Remove the canopy (1) **(Figure 4-26, Page 4-31)**.
2. Remove the screw (2).
3. Remove the canopy drain cover (3).

Canopy Drain Cover Installation

1. Install the canopy drain cover (3) **(Figure 4-26, Page 4-31)**.
2. Install the screw (2). Tighten the screw to 10 lb·in (1.2 N·m).
3. Install the canopy (1).

CANOPY HANDLE

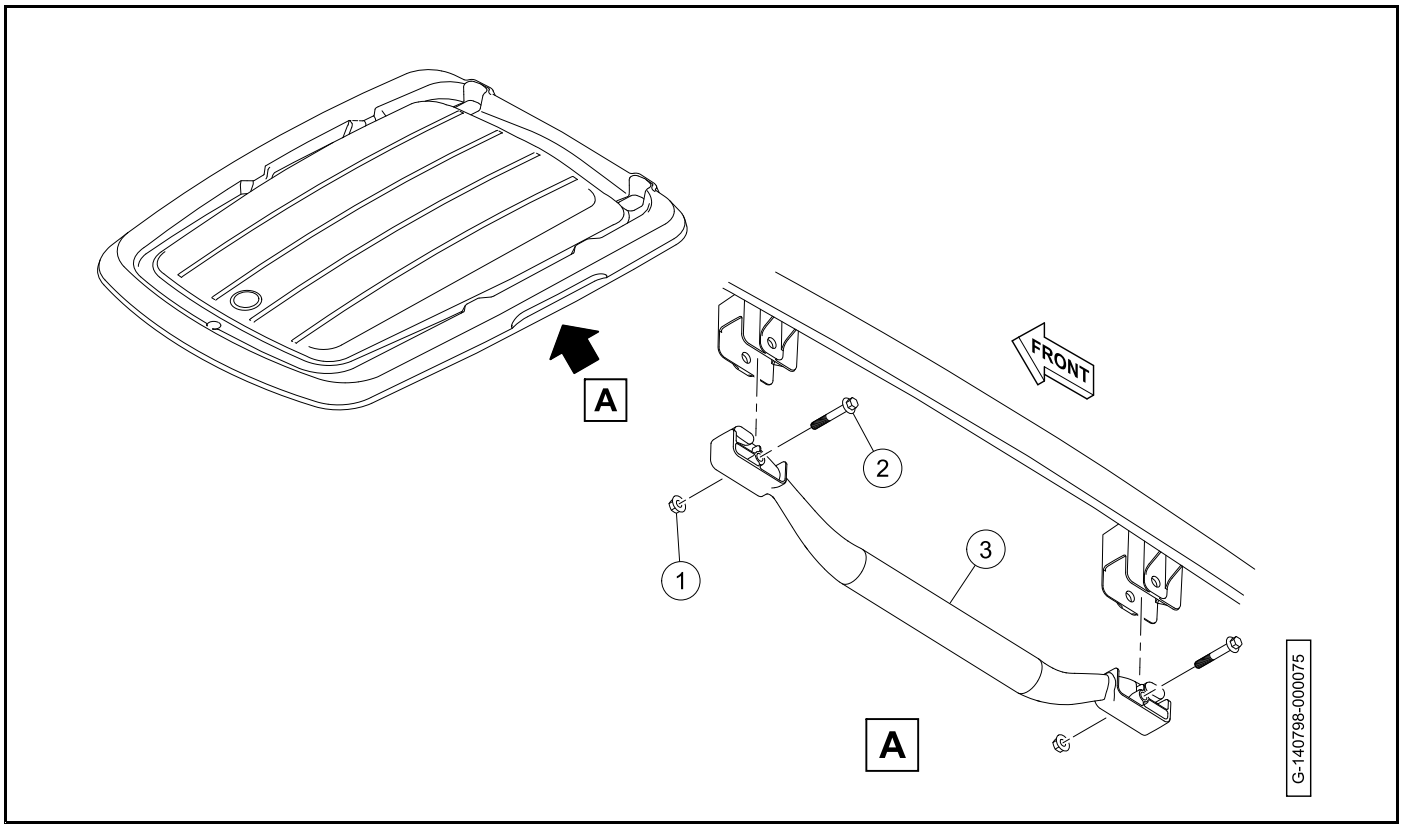


Figure 4-27 Canopy Handle

Canopy Handle Removal

1. Remove the nuts (1) **(Figure 4-27, Page 4-32)**.
2. Remove the bolts (2).
3. Remove the canopy handle (3).

Canopy Handle Installation

1. Install the canopy handle (3) on the canopy **(Figure 4-27, Page 4-32)**.
2. Install the bolts (2) and nuts (1). Tighten the bolts to 50 lb·in (5.6 N·m).

TWO-PASSENGER - REAR BODY

UNIVERSAL ACCESSORY MOUNTING

The Structural Accessory Module (SAM) includes two mounting locations on both the driver side and the passenger side. These serve as common attachment points for various accessories. Accessories that can be mounted on the SAM include single or dual sand bottles, sand bucket, and the club cleaner.

STRUCTURAL ACCESSORY MODULE (SAM)

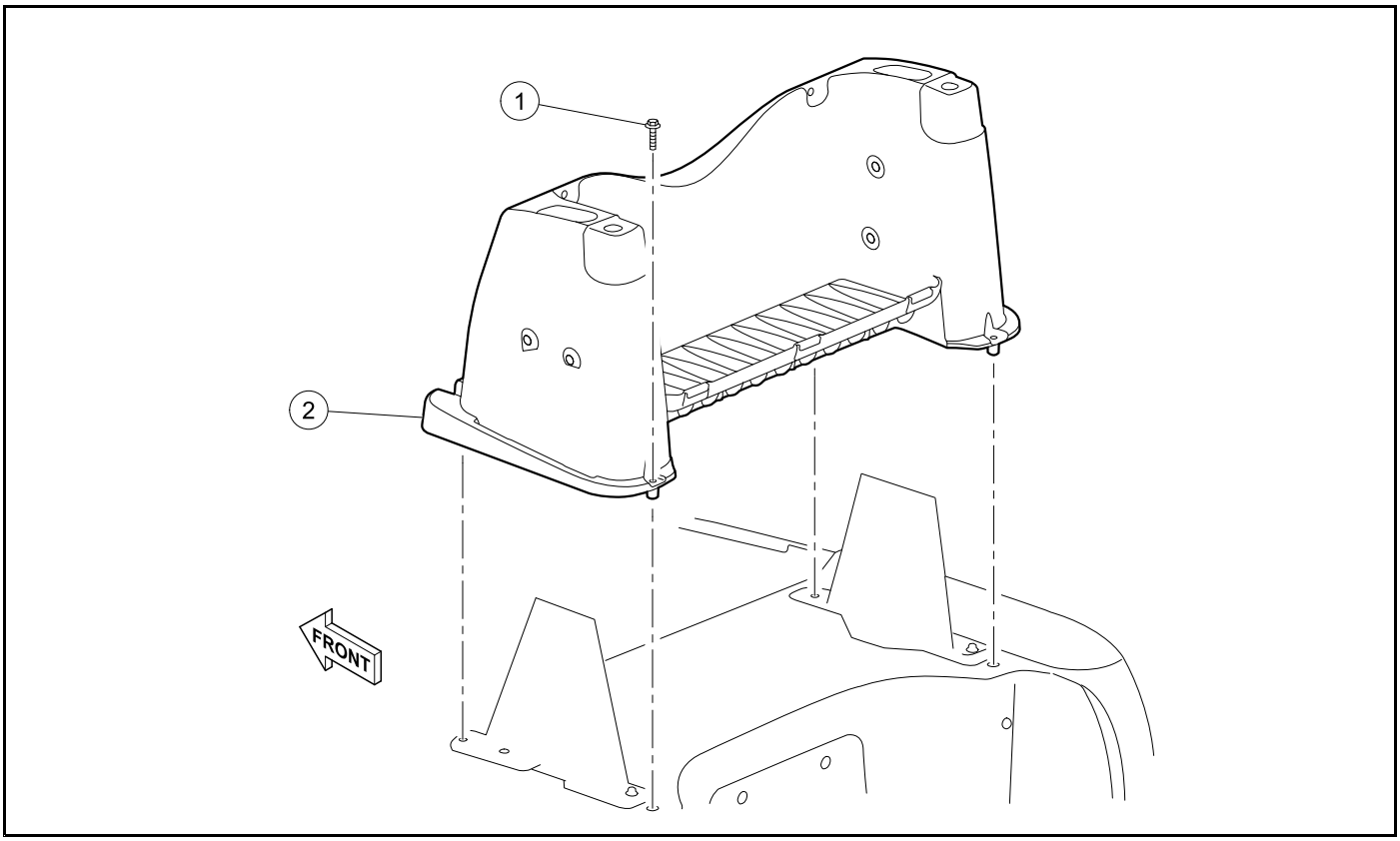


Figure 4-28 SAM

SAM Removal

1. If the vehicle has a canopy, remove the rear canopy supports from the SAM (2) **(Figure 4-28)**.
2. Remove the four bolts (1).

SAM Installation

1. Position the SAM (2) over its mounting holes **(Figure 4-28)**.
2. Install the four screws (1). Tighten the screws to 71 lb·in (8 N·m).

SEAT BACK

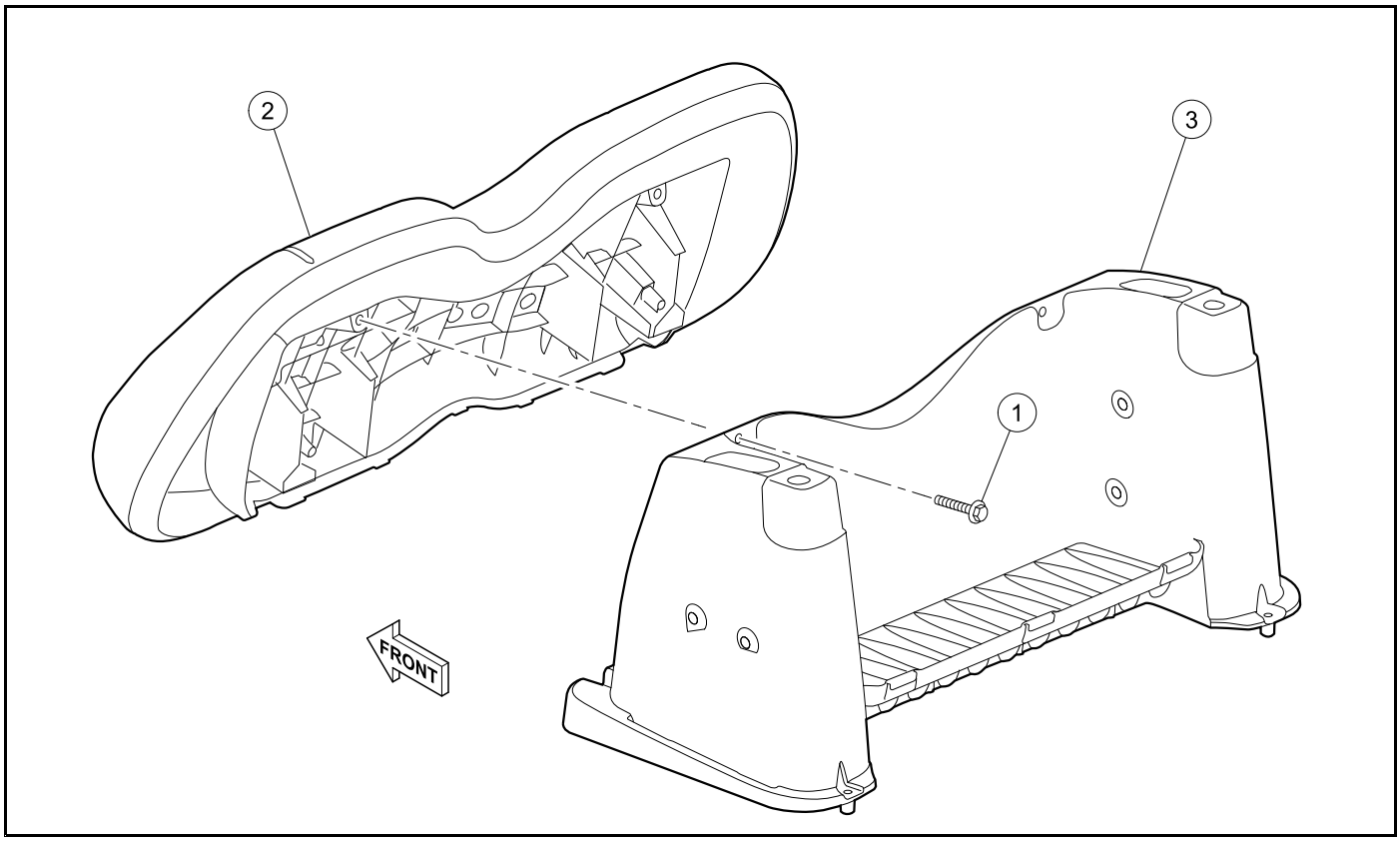


Figure 4-29 Seat Back

Seat Back Removal

1. Remove the two screws (1) **(Figure 4-29)**.
2. Remove the seat back (2) from the SAM (3).

Seat Back Installation

1. Put the seat back (2) on the SAM (3) **(Figure 4-29)**.
2. Install the two screws (1). Tighten the screws to 51 lb·in (5.8 N·m).

BAG RACK ASSEMBLY

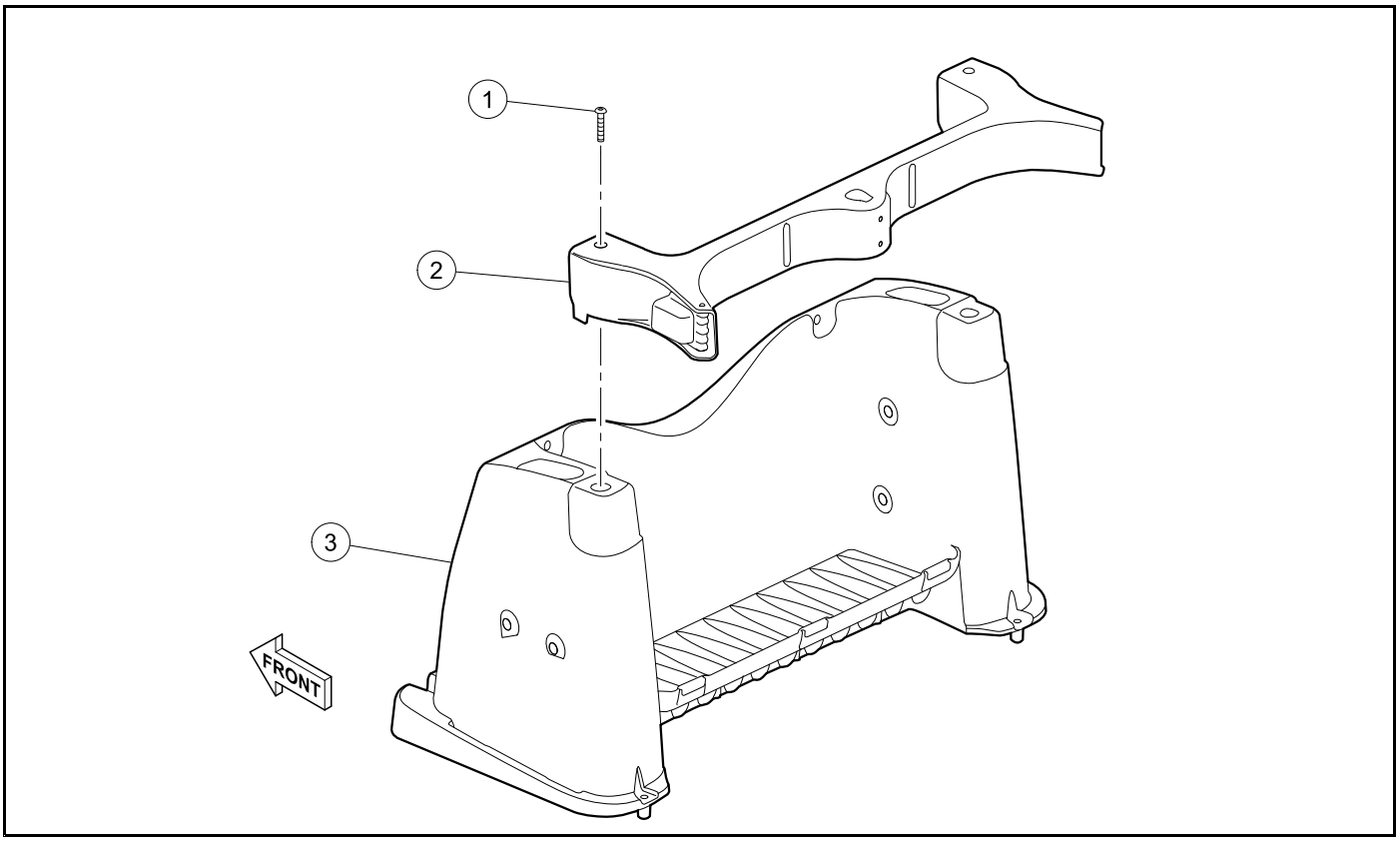


Figure 4-30 Bag Rack

Bag Rack Removal

1. Remove the two screws (1) **(Figure 4-30)**.
2. Remove the bag rack (2) from the SAM (3).

Bag Rack Installation

1. Install the bag rack (2) onto the SAM (3) **(Figure 4-30)**.
2. Install the two screws (1). Tighten the screws to 53 lb·in (6 N·m).

BAG STRAP

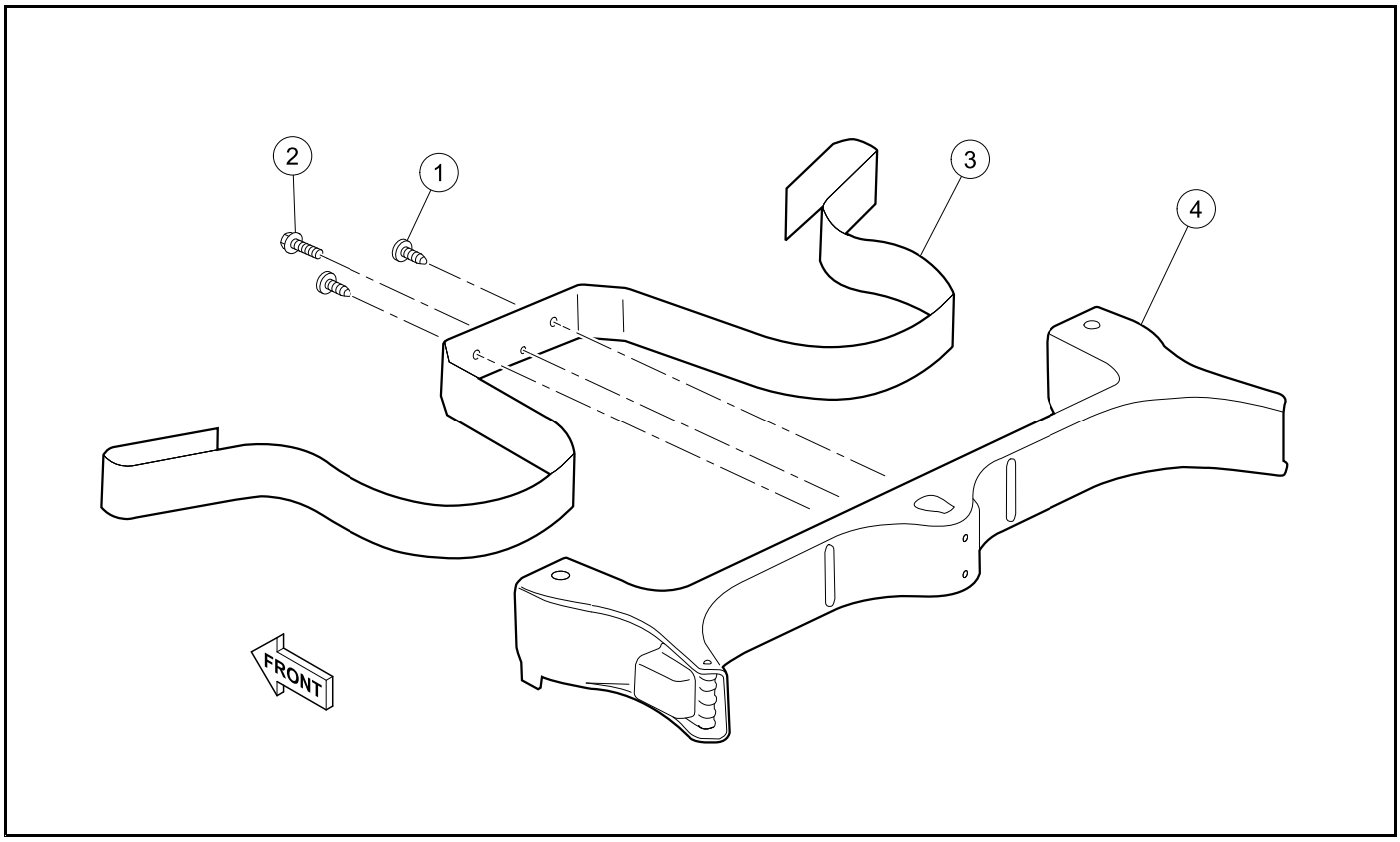


Figure 4-31 Bag Strap

Bag Strap Removal

1. Remove the push rivets (1) and screw (2) **(Figure 4-31)**.
2. Remove the bag strap (3) from the bag rack (4).

Bag Strap Installation

1. Install the bag strap (3) onto the bag rack (4) **(Figure 4-31)**.
2. Install the push rivets (1) and screw (2). Tighten the screw to 31 lb·in (3.5 N·m).

SWEATER BASKET

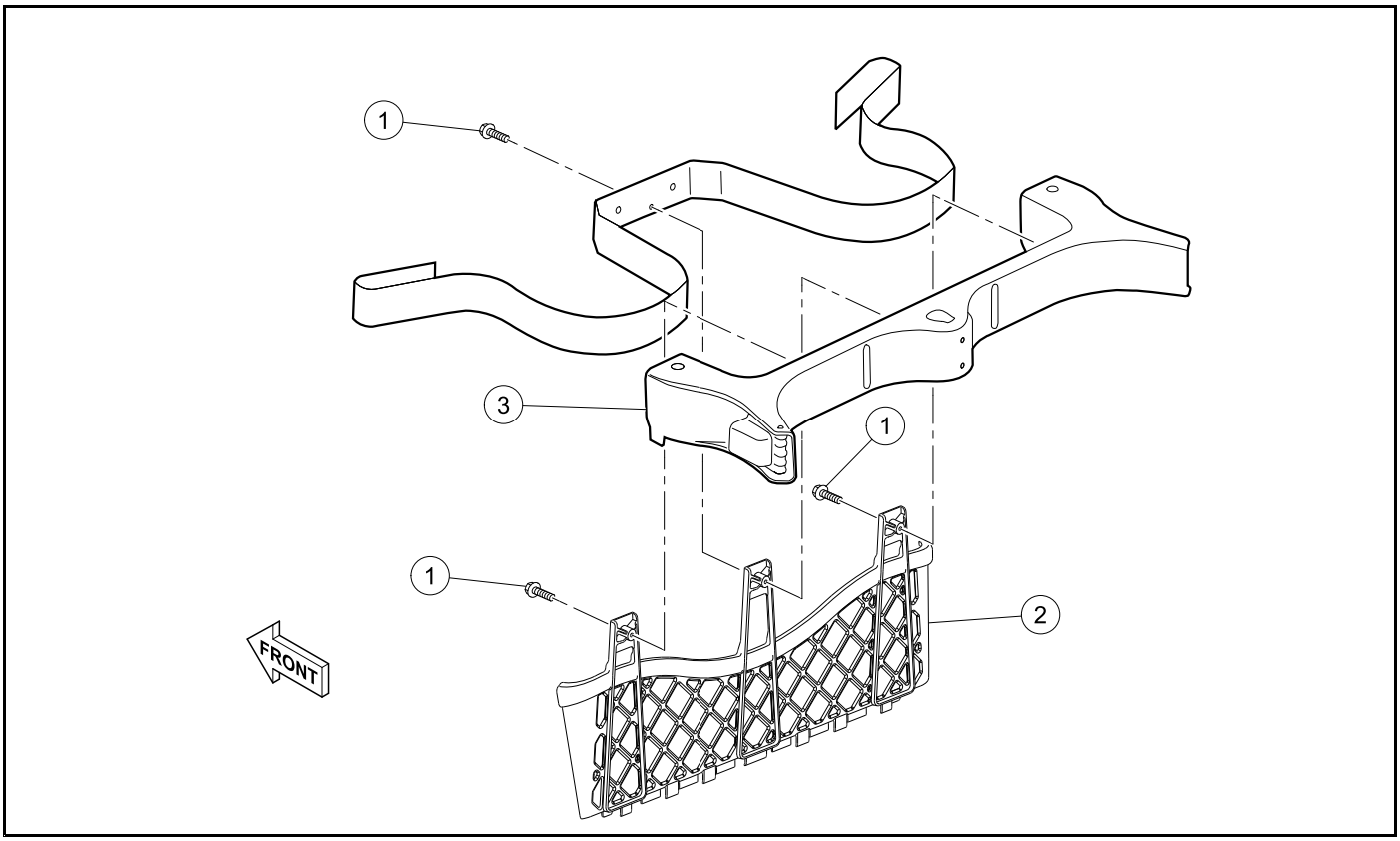


Figure 4-32 Sweater Basket

Sweater Basket Removal

1. Remove the three screws (1) **(Figure 4-32)**.
2. Remove the sweater basket (2) from the bag rack (3).

Sweater Basket Installation

1. Install the sweater basket (2) onto the bag rack (3) **(Figure 4-32)**.
2. Install the three screws (1). Tighten the screws to 31 lb·in (3.5 N·m).

REAR BEAUTY PANEL

Two-passenger rear beauty panel procedures.

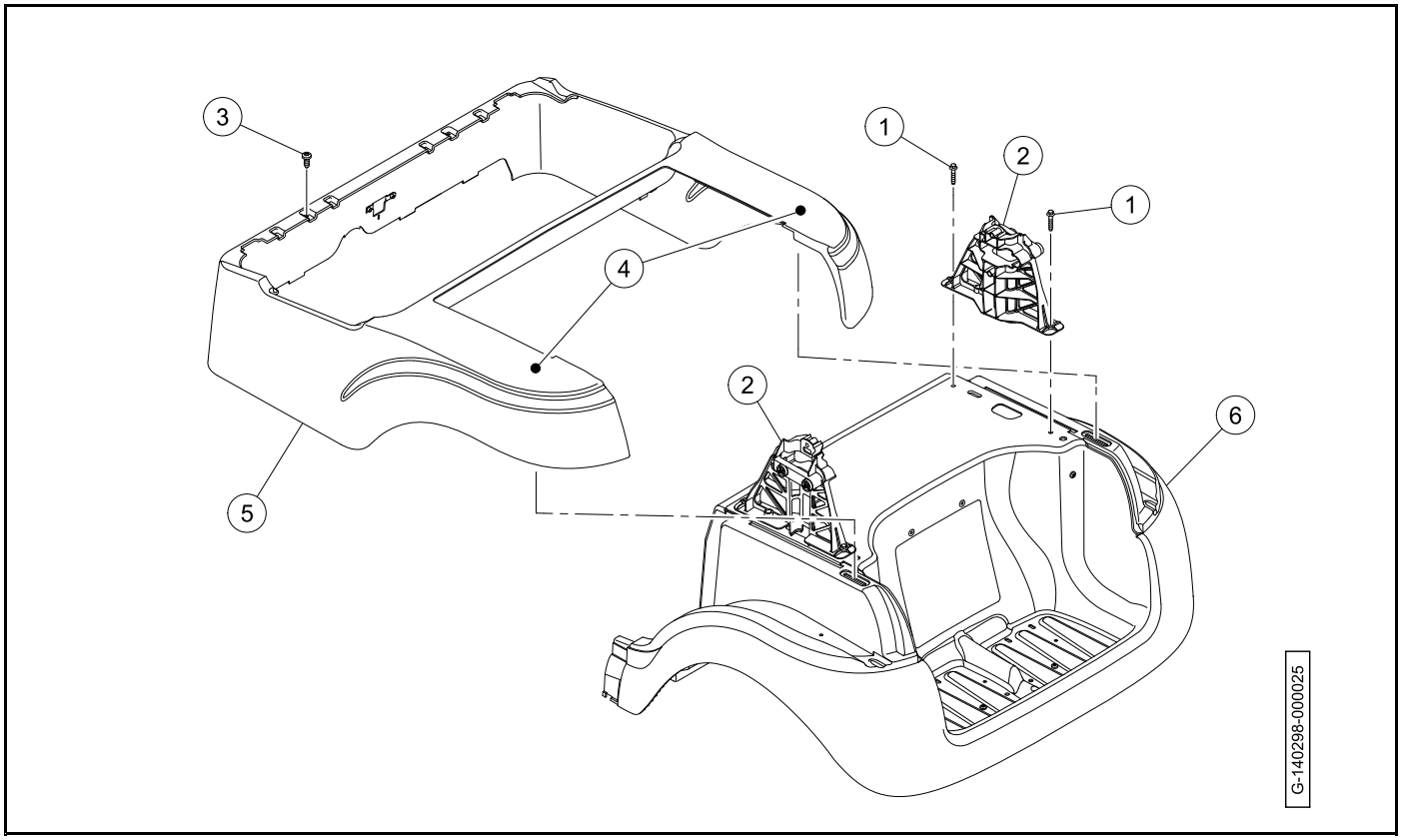


Figure 4-33 Rear Beauty Panel

Rear Beauty Panel Removal

1. Remove the structural accessory module (SAM).
2. Remove the screws (1) **(Figure 4-33)**.
3. Remove the canopy support brackets (2).
4. Remove the four screws (3).
5. Remove the Forward / Neutral / Reverse control (FNR).
6. Disengage the two body clips (4) of the rear beauty panel (5) from the slots in the rear underbody (6).
7. Remove the rear beauty panel from vehicle.

Rear Beauty Panel Installation

1. Install the rear beauty panel (5) onto vehicle **(Figure 4-33)**.
2. Make sure that the two body clips (4) engage the slots in the rear underbody (6).
3. Install the four screws (3). Tighten the screws to 44 lb·in (5 N·m).
4. Install the Forward / Neutral / Reverse control (FNR).
5. Put the canopy support brackets (2) on the vehicle.
6. Install the screw (1). Tighten the screw to 53 lb·in (6 N·m).

REAR UNDERBODY

Two-passenger rear underbody procedures.

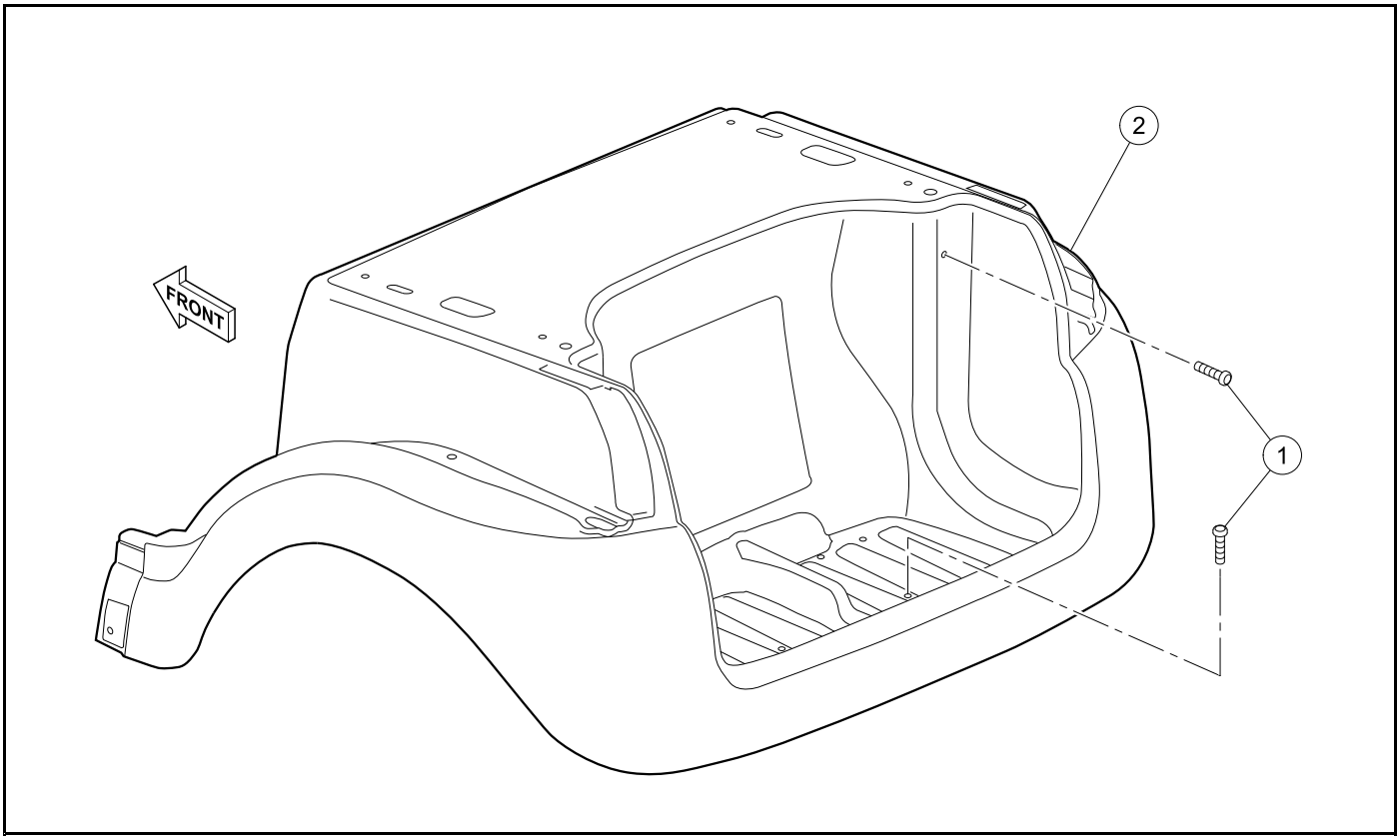


Figure 4-34 Rear Underbody

Rear Underbody Removal

1. Remove the structural accessory module (SAM).
2. Remove the rear beauty panel.
3. Remove remove the four screws (1) **(Figure 4-34)**.
4. Lift the rear edge of the rear underbody (2) until the front portion slides out from beneath the front underbody. Remove the rear underbody from the vehicle.

Rear Underbody Installation

1. Install the rear underbody (2) onto the vehicle **(Figure 4-34)**.
2. Install the four screws (1). Tighten the screws to 71 lb·in (8 N·m).

REAR CROSSMEMBER

Two-passenger rear crossmember procedures.

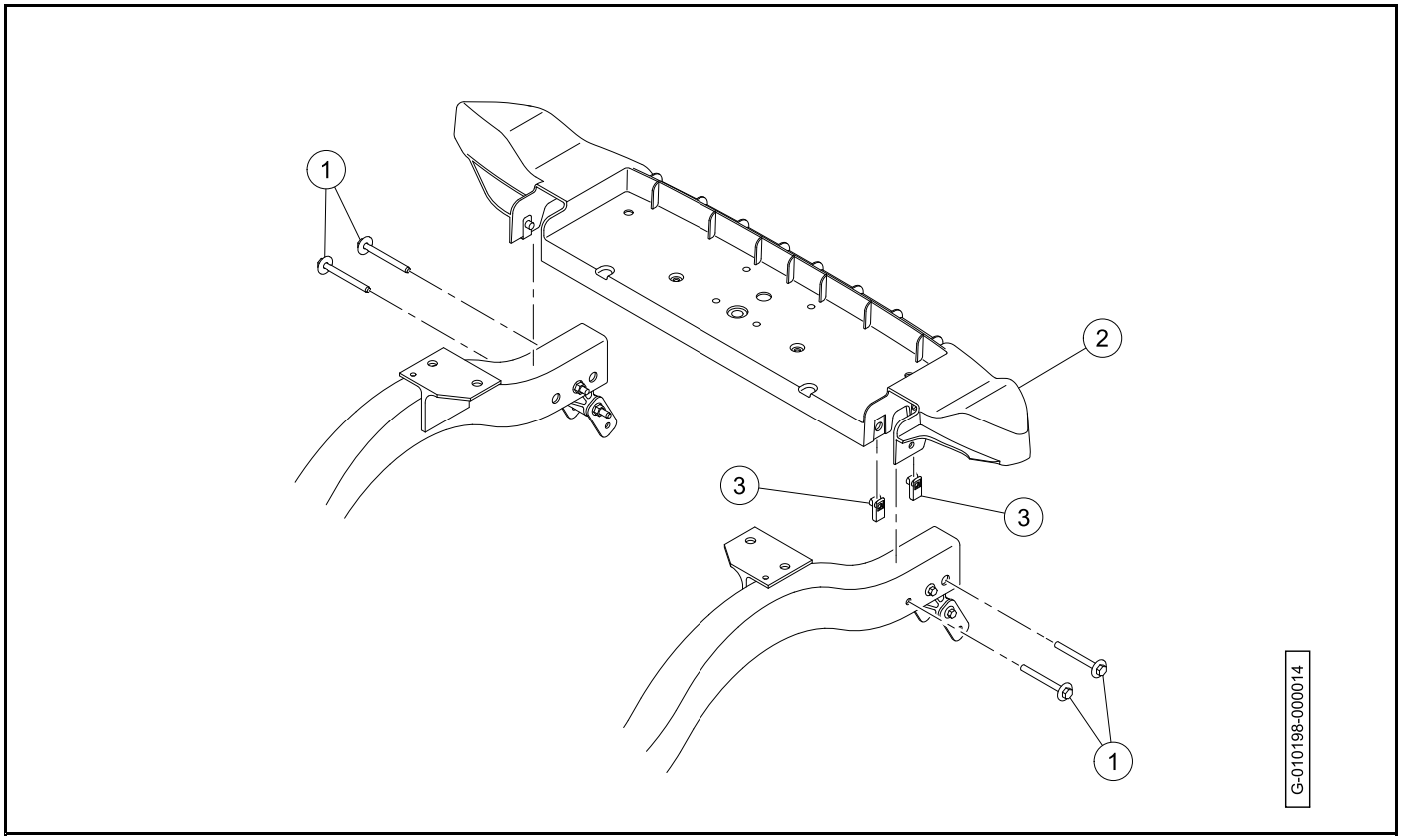


Figure 4-35 Rear Crossmember

Rear Crossmember Removal

1. Remove the four bolts (1) **(Figure 4-35)** .
2. Remove the rear crossmember (2).

Rear Crossmember Installation

1. Install the rear crossmember (2) onto the vehicle **(Figure 4-35)**.
2. Make sure that the J-clips (3) are installed on the inside of the frame rail.
3. Install the four bolts (1). Tighten the bolts to 56 lb·in (6.35 N·m).

FOUR-PASSENGER - CANOPY

CAUTION

- **To prevent damage to the canopy, do not remove the canopy supports from the vehicle without first removing the canopy.**

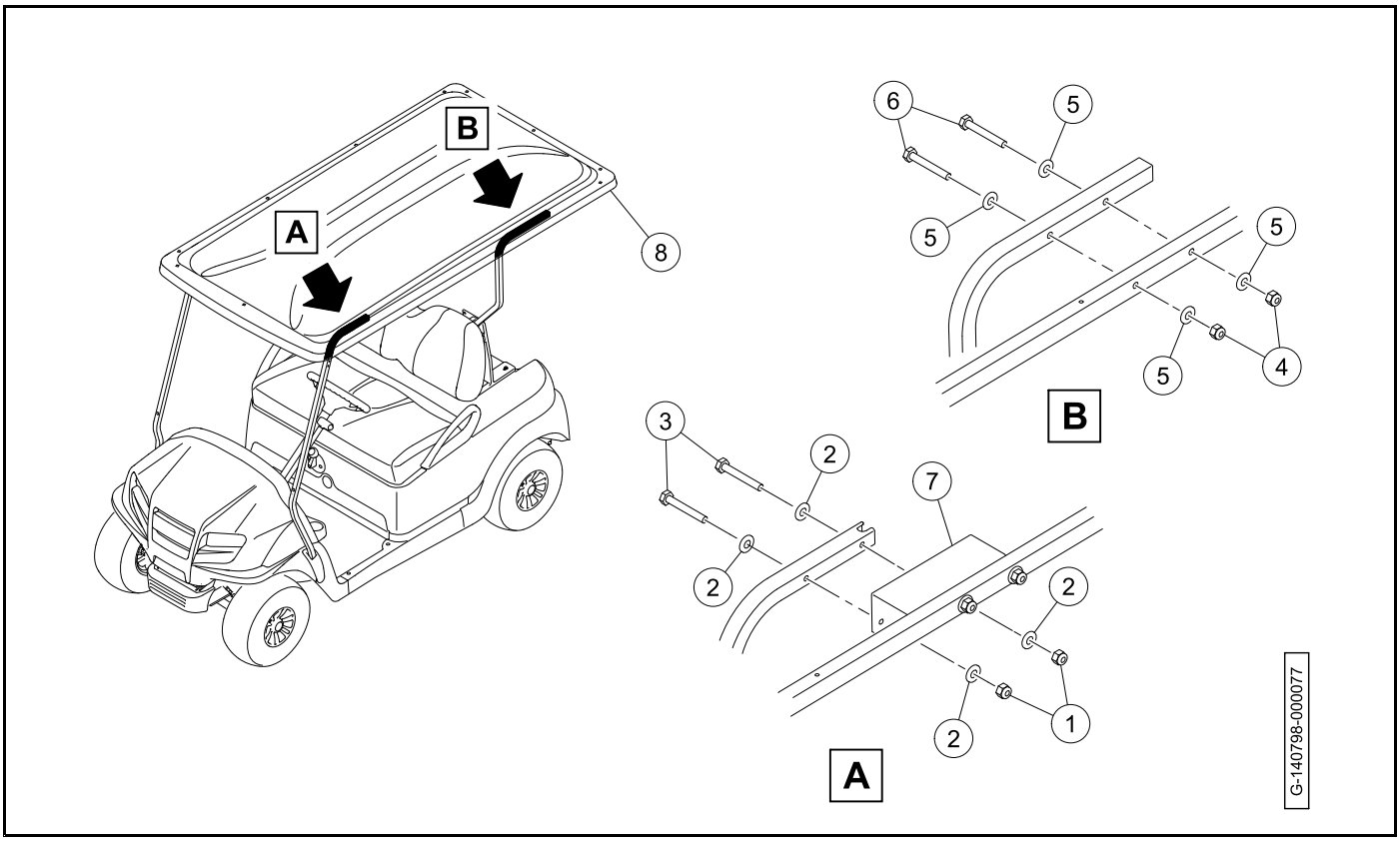


Figure 4-36 Four-Passenger Canopy

FOUR-PASSENGER CANOPY REMOVAL

1. Remove the nuts (1 and 4), washers (2 and 5), and bolts (3 and 6) from the front canopy supports **(Figure 4-36, Page 4-41)**.
2. Remove the front canopy brackets (7).
3. Remove the canopy (8) from the vehicle.

FOUR-PASSENGER CANOPY INSTALLATION

1. Install the front canopy brackets (7) onto the front canopy supports **(Figure 4-36, Page 4-41)**.
2. Position the canopy (8) on the front and rear supports.
3. Install the nuts (1), washers (2) and bolts (3) to secure the front canopy supports to the canopy. Tighten the hardware to 55 lb·in (6.2 N·m).
4. Install the nuts (4), washers (5), and bolts (6) to secure the rear canopy supports to the canopy. Tighten the hardware to 80 lb·in (9 N·m).

FOUR-PASSENGER FRONT CANOPY STRUT REMOVAL

CAUTION

- **To prevent damage to the canopy, do not remove the canopy supports from the vehicle without first removing the canopy.**
- **Using tools to thread the bolts could prevent proper feel of the bolt as it captures the female threads in the support. This could result in damage to the components.**

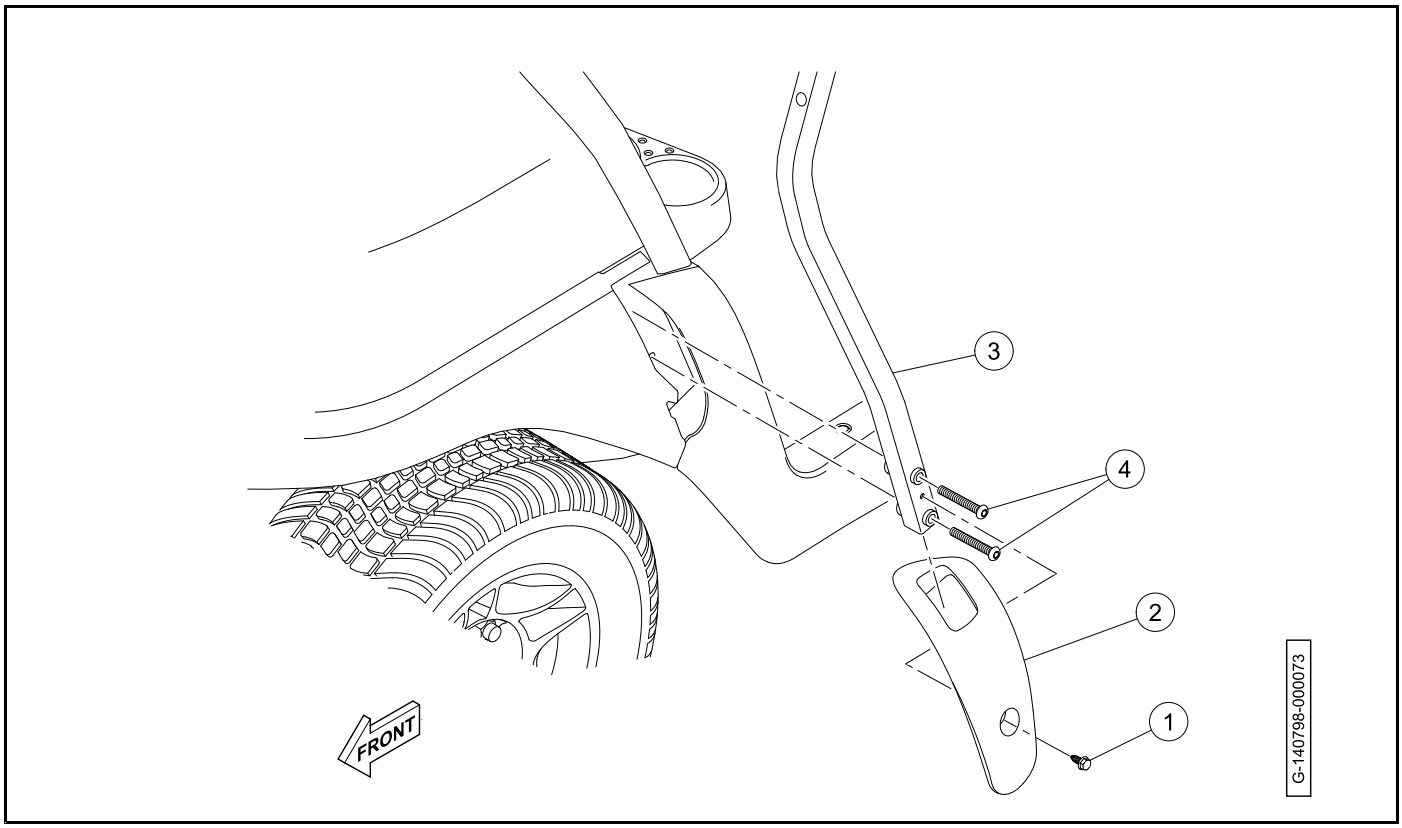


Figure 4-37 Front Canopy Strut Removal

1. Remove the canopy.
2. Remove the screw (1) **(Figure 4-37, Page 4-42)**.
3. Slide the front canopy strut cover (2) up the front canopy strut (3).
4. Remove the screws (4) and the front canopy strut.

FOUR-PASSENGER FRONT CANOPY STRUT INSTALLATION

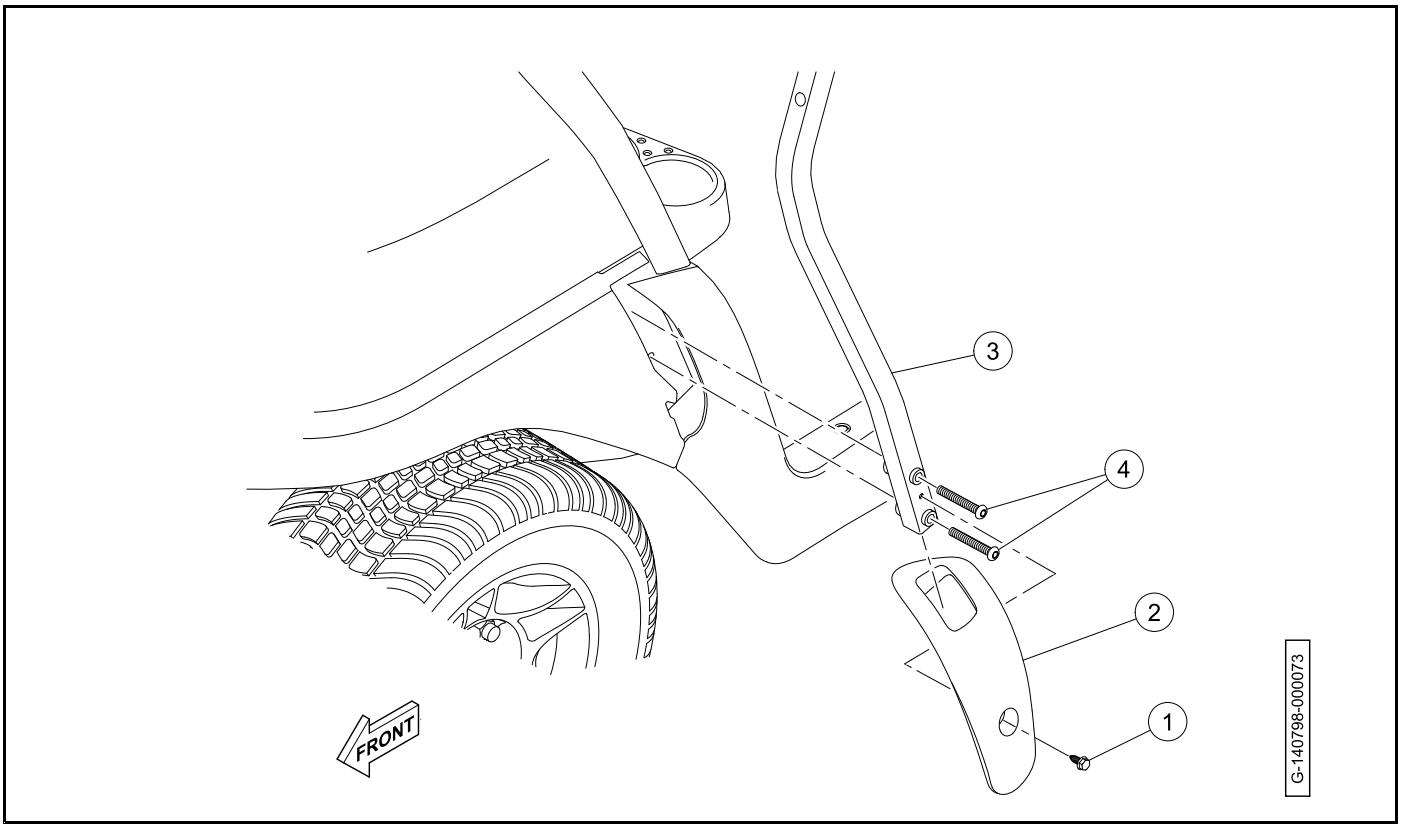


Figure 4-38 Front Canopy Strut Installation

1. Install the front canopy strut (3) onto the vehicle **(Figure 4-38, Page 4-43)**.
2. Install the front canopy strut cover (2) onto the front canopy strut.
3. Install the screws (4). Tighten the screws to 18.4 lb·ft (25 N·m).
4. Install the screw (1). Tighten the screw to 31 lb·in (4.6 N·m).
5. Install the canopy.

FOUR-PASSENGER REAR CANOPY SUPPORT REMOVAL

CAUTION

- **To prevent damage to the canopy, do not remove the canopy supports from the vehicle without first removing the canopy.**
- **Using tools to thread the bolts could prevent proper feel of the bolt as it captures the female threads in the support. This could result in damage to the components.**

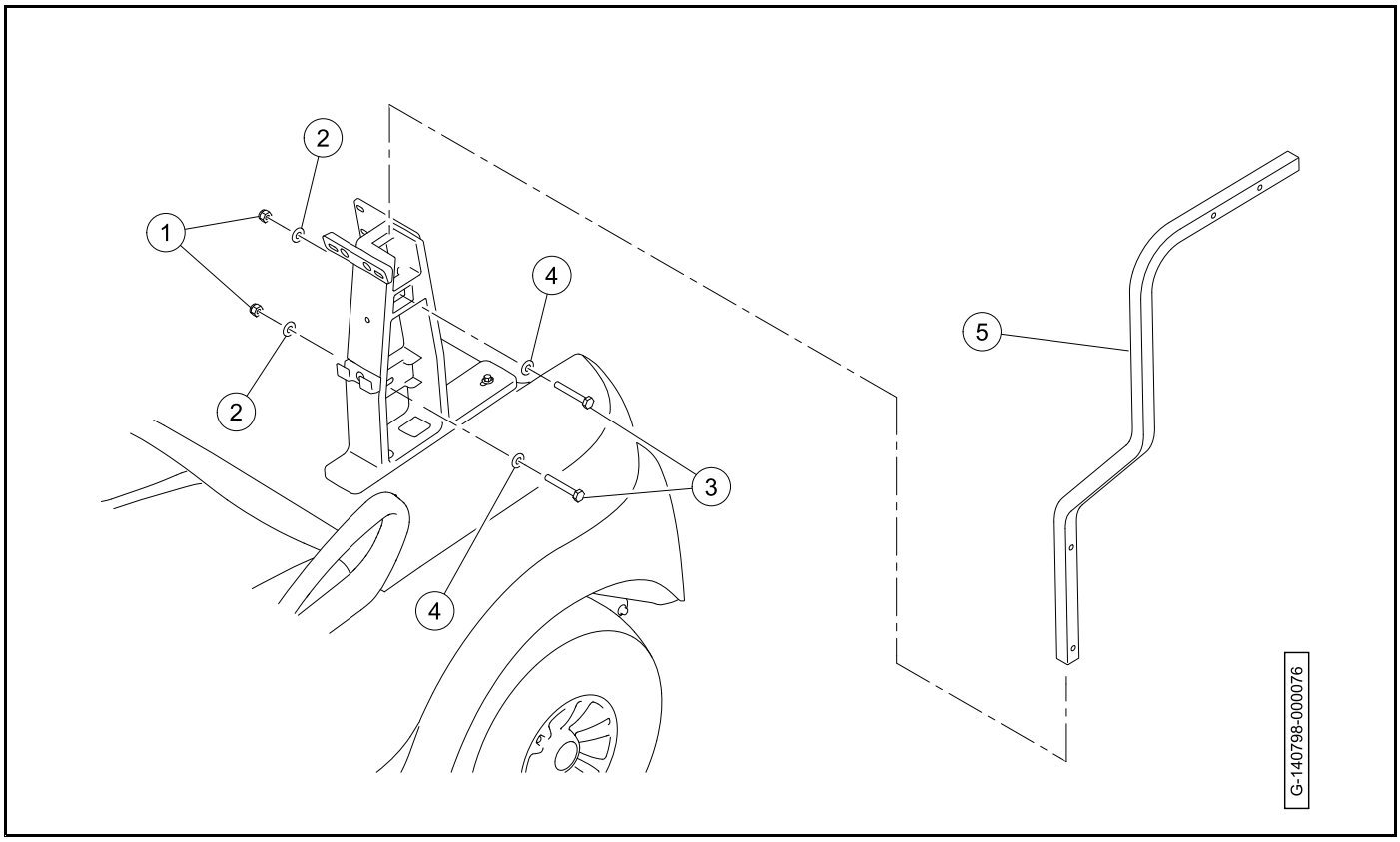


Figure 4-39 Four-Passenger Canopy

1. Remove the canopy.
2. Remove the screw (1) **(Figure 4-39, Page 4-44)**.
3. Remove the rear canopy support (2).

FOUR-PASSENGER REAR CANOPY SUPPORT INSTALLATION

1. Install the rear canopy support (2) into the structural accessory module (SAM) **(Figure 4-39, Page 4-44)**.
2. Install the screw (1). Tighten the screw to 88 lb·in (10 N·m).
3. Install the canopy.

FOUR-PASSENGER - REAR BODY

See General Warnings on page 1-2.

SEAT BACKS

Seat Back Removal

Remove screws (1 or 2) securing seat back (3 or 4) to seat support and remove the seat backs **(Figure 4-40, Page 4-45)**.

Seat Back Installation

Secure seat backs (3 or 4) to seat support with screws (1 or 2). Tighten screws to 51 lb·in (5.8 N·m) **(Figure 4-40, Page 4-45)**.

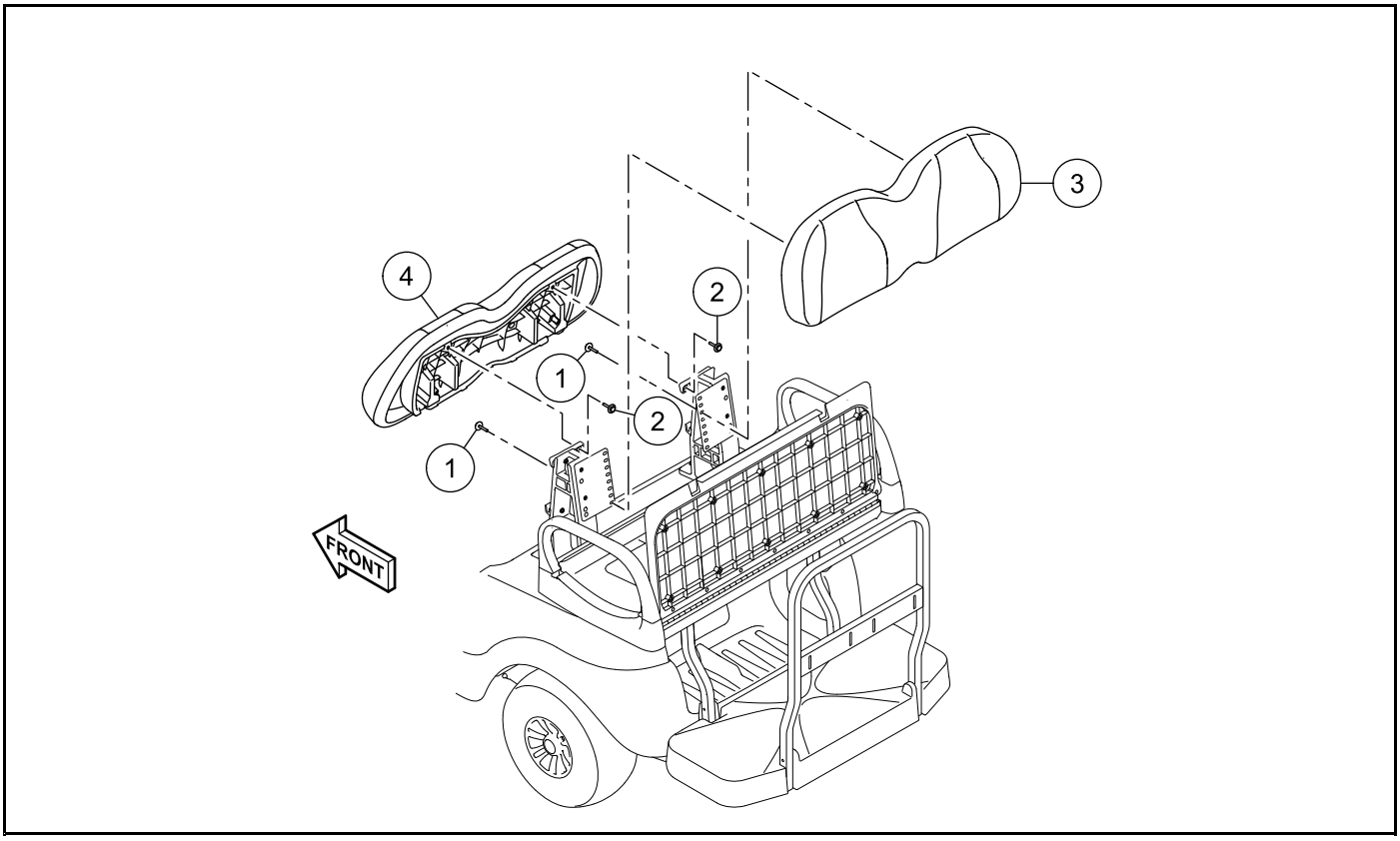


Figure 4-40 Seat Back (Four-Passenger Vehicles)

SEAT SUPPORT

Seat Support Removal

1. Remove the seat backs. **See Seat Back Removal on page 4-45.**
2. Remove the fold down seat. **See Fold Down Seat Removal on page 4-47.**
3. Remove the screws (1) **(Figure 4-41, Page 4-46)**.
4. Remove the seat supports (2) from the vehicle.

Seat Support Installation

1. Put the seat supports (2) into position on the vehicle.
2. Install the screws (1). Tighten the screws to 71 lb·in (8 N·m) **(Figure 4-41, Page 4-46)**.

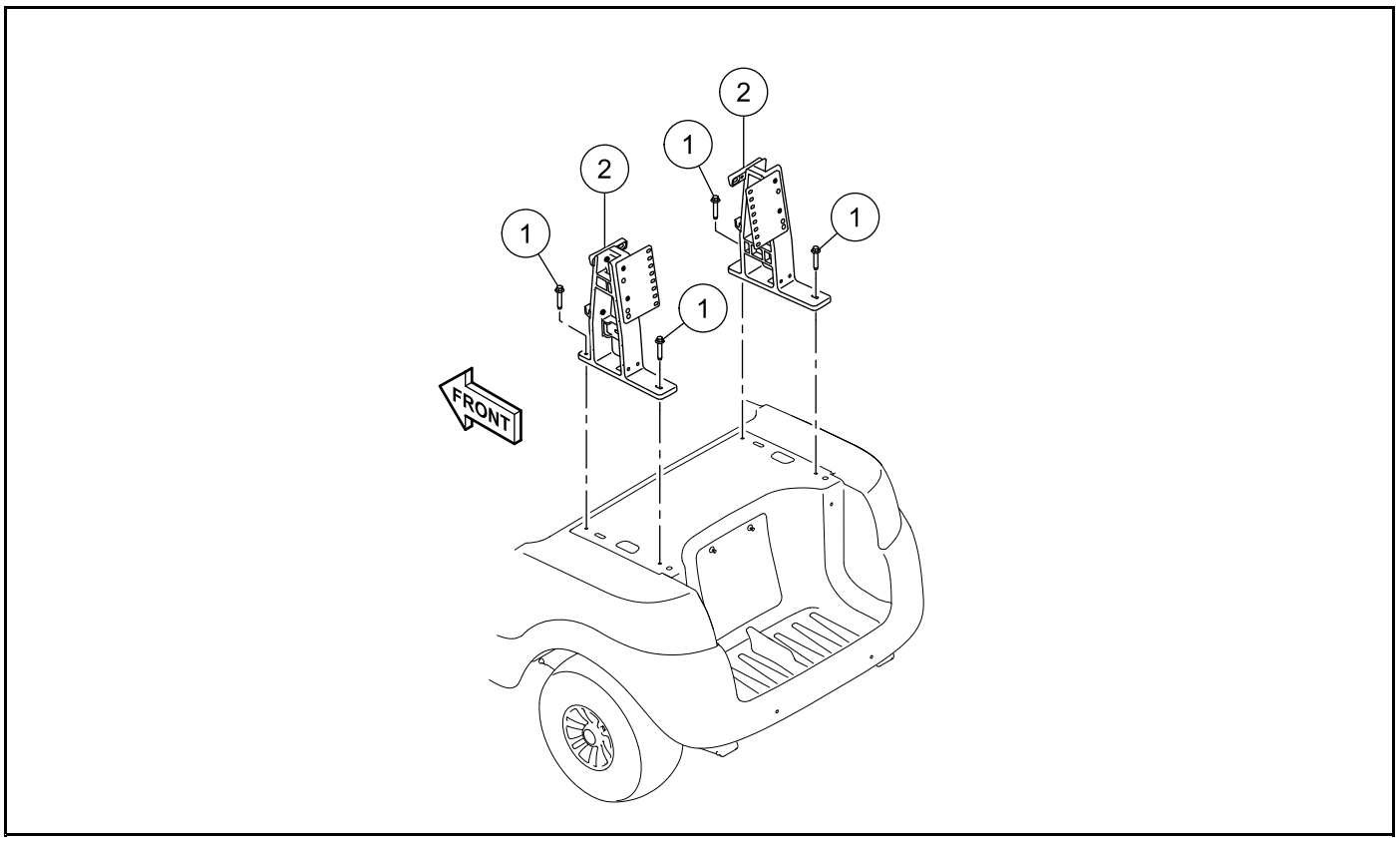


Figure 4-41 Seat Supports (Four-Passenger Vehicles)

FOLD DOWN SEAT

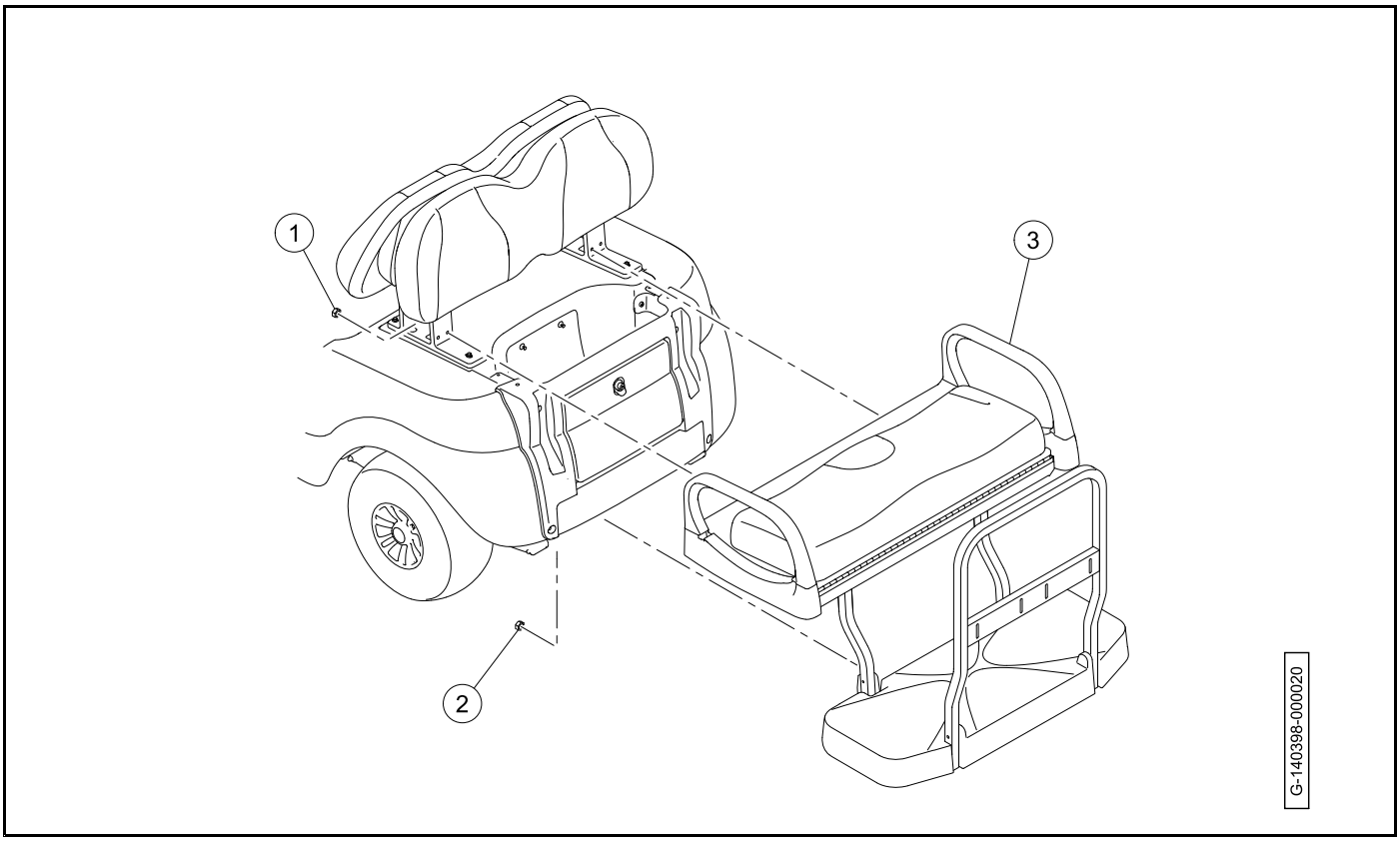


Figure 4-42 Fold Down Seat

Fold Down Seat Removal

1. Remove the nuts (1) **(Figure 4-42, Page 4-47)**.
2. Remove the nuts (2).
3. Remove the fold down seat (3).

Fold Down Seat Installation

1. Put the fold down seat (3) into position on the vehicle **(Figure 4-42, Page 4-47)**.
2. Install the nuts (2). Tighten the nuts to 40 lb·in (4.5 N·m).
3. Install the nuts (1). Tighten the nuts to 150 lb·in (17 N·m).

ARM REST

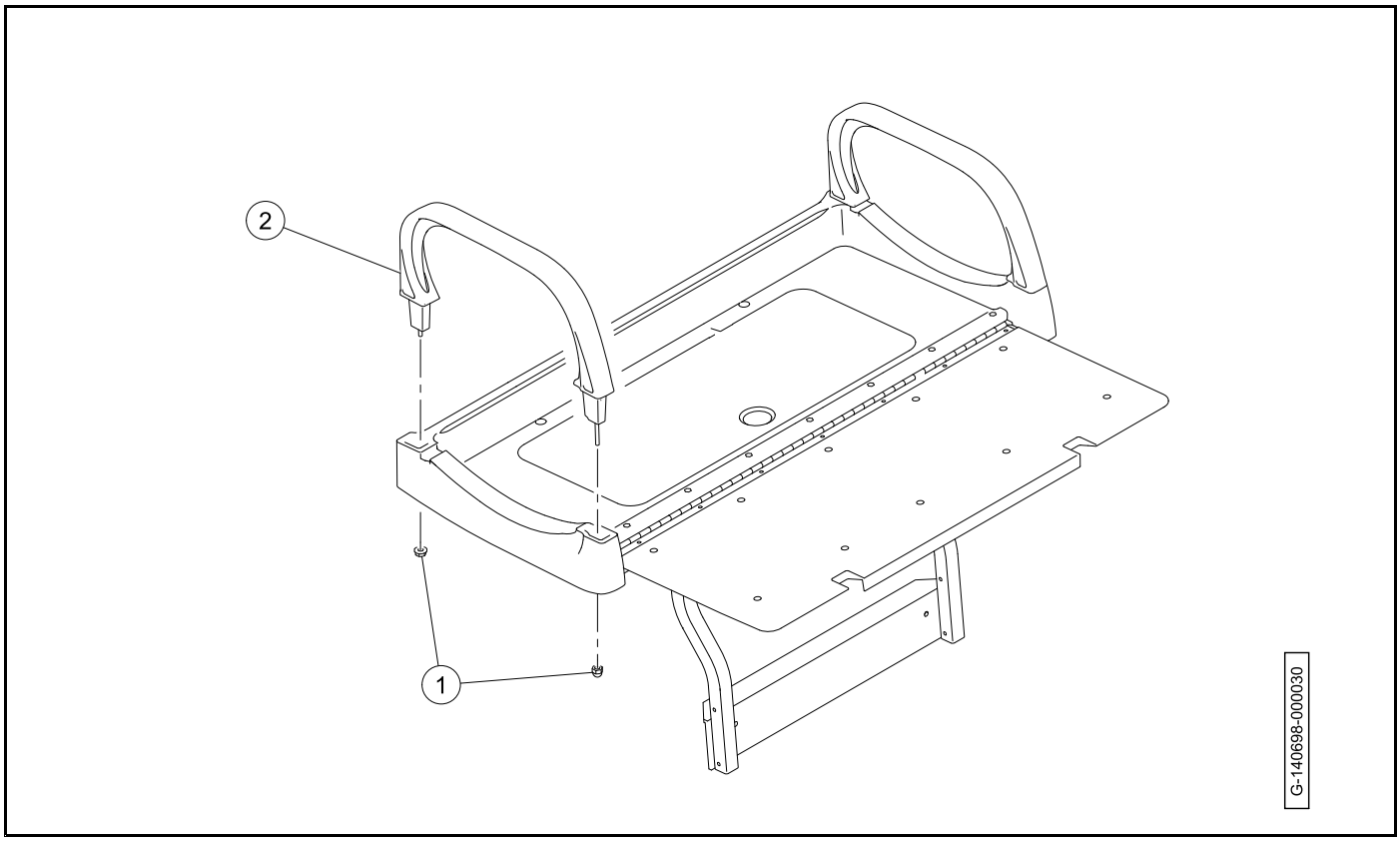


Figure 4-43 Arm Rests

Arm Rest Removal

1. Remove the nuts (1) **(Figure 4-43, Page 4-48)**.
2. Remove the arm rests (2).

Arm Rest Installation

1. Install the arm rests (2) **(Figure 4-43, Page 4-48)**.
2. Install the nuts (1). Tighten the nuts to 74 to 82 lb·in (8.4 to 9.3 N·m).

GRAB BAR

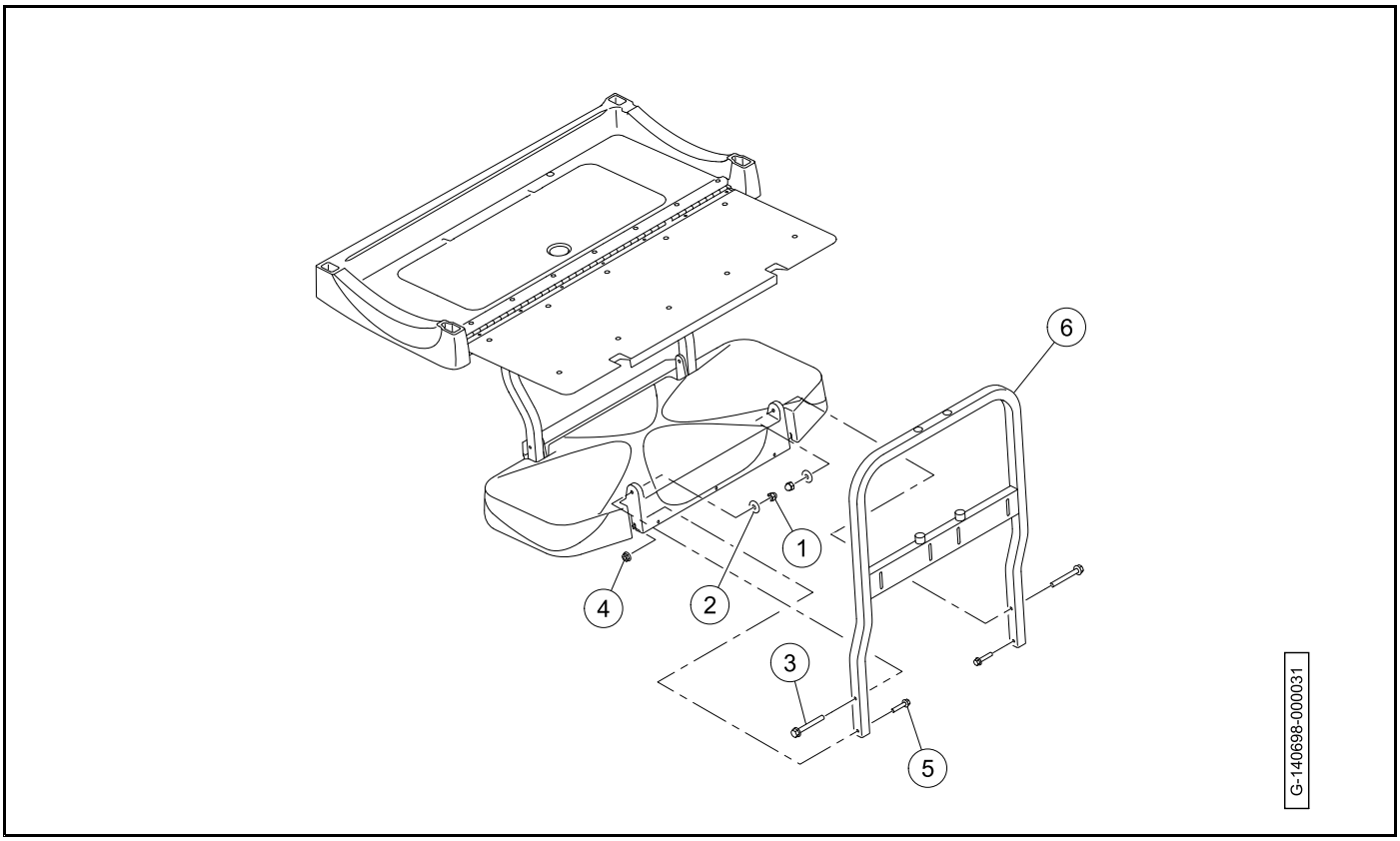


Figure 4-44 Grab Bar

Grab Bar Removal

1. Remove the cap nuts (1), washers (2), and bolts (3) **(Figure 4-44, Page 4-49)**.
2. Remove the nuts (4) and bolts (5).
3. Remove the grab bar (6).

Grab Bar Installation

1. Install the grab bar (6) on the foot deck **(Figure 4-44, Page 4-49)**.
2. Install the bolts (3), washers (2), and cap nuts (1). Tighten the bolts to 143 to 157 lb·in (16.1 to 17.8 N·m).
3. Install the bolts (5) and nuts (4). Tighten the bolts to 97 to 107 lb·in (10.9 to 12.1 N·m).

FOOT DECK

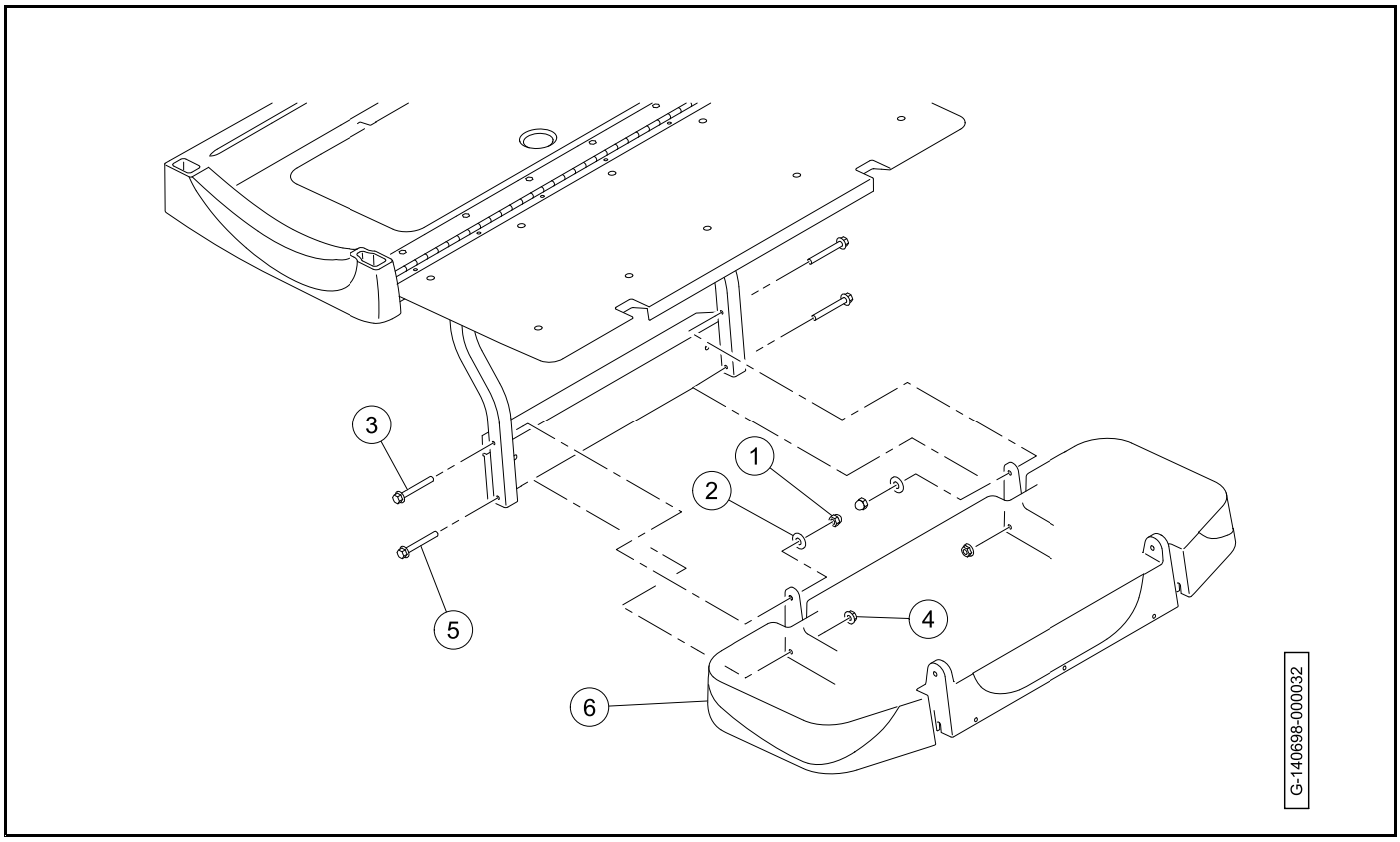


Figure 4-45 Foot Deck

Foot Deck Removal

1. Remove the cap nuts (1), washers (2), and bolts (3) **(Figure 4-45, Page 4-50)**.
2. Remove the nuts (4) and bolts (5).
3. Remove the foot deck (6).

Foot Deck Installation

1. Install the foot deck (6) **(Figure 4-45, Page 4-50)**.
2. Install the bolts (3), washers (2), and cap nuts (1). Tighten the cap nuts to 74 to 82 lb·in (8.4 to 9.3 N·m).
3. Install the bolts (5) and nuts (4). Tighten the nuts to 74 to 82 lb·in (8.4 to 9.3 N·m).

REAR BEAUTY PANEL

Four passenger rear body component procedures.

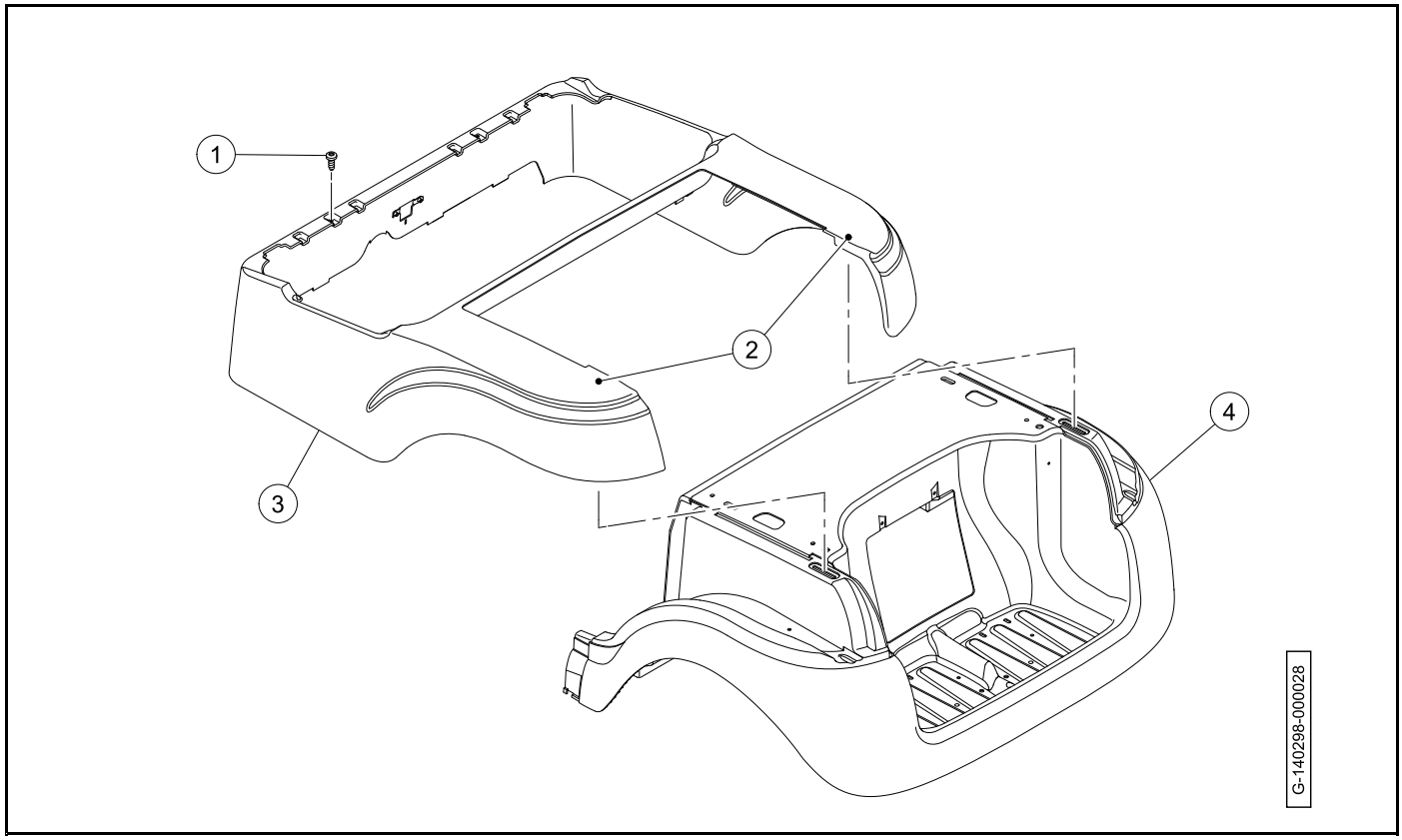


Figure 4-46 2+2 Rear Beauty Panel

Rear Beauty Panel Removal

1. Remove the front seat bottom.
2. Remove the rear seat assembly.
3. Remove the forward / neutral / reverse (FNR) control.
4. Remove the screws (1) **(Figure 4-46)**.
5. Disengage the two body clips (2) under the rear of the beauty panel (3) from the slots in the rear underbody (4).
6. Remove the rear beauty panel from the rear underbody.

Rear Beauty Panel Installation

1. Install the rear beauty panel (3) on the rear underbody (4). Make sure body clips (2) on the rear of the beauty panel engage the slots in the rear underbody**(Figure 4-46)**.
2. Install the screws (1). Tighten the screws to 44 lb·in (5 N·m).
3. Install the FNR control.
4. Install the rear seat assembly.
5. Install the front seat bottom.

REAR UNDERBODY

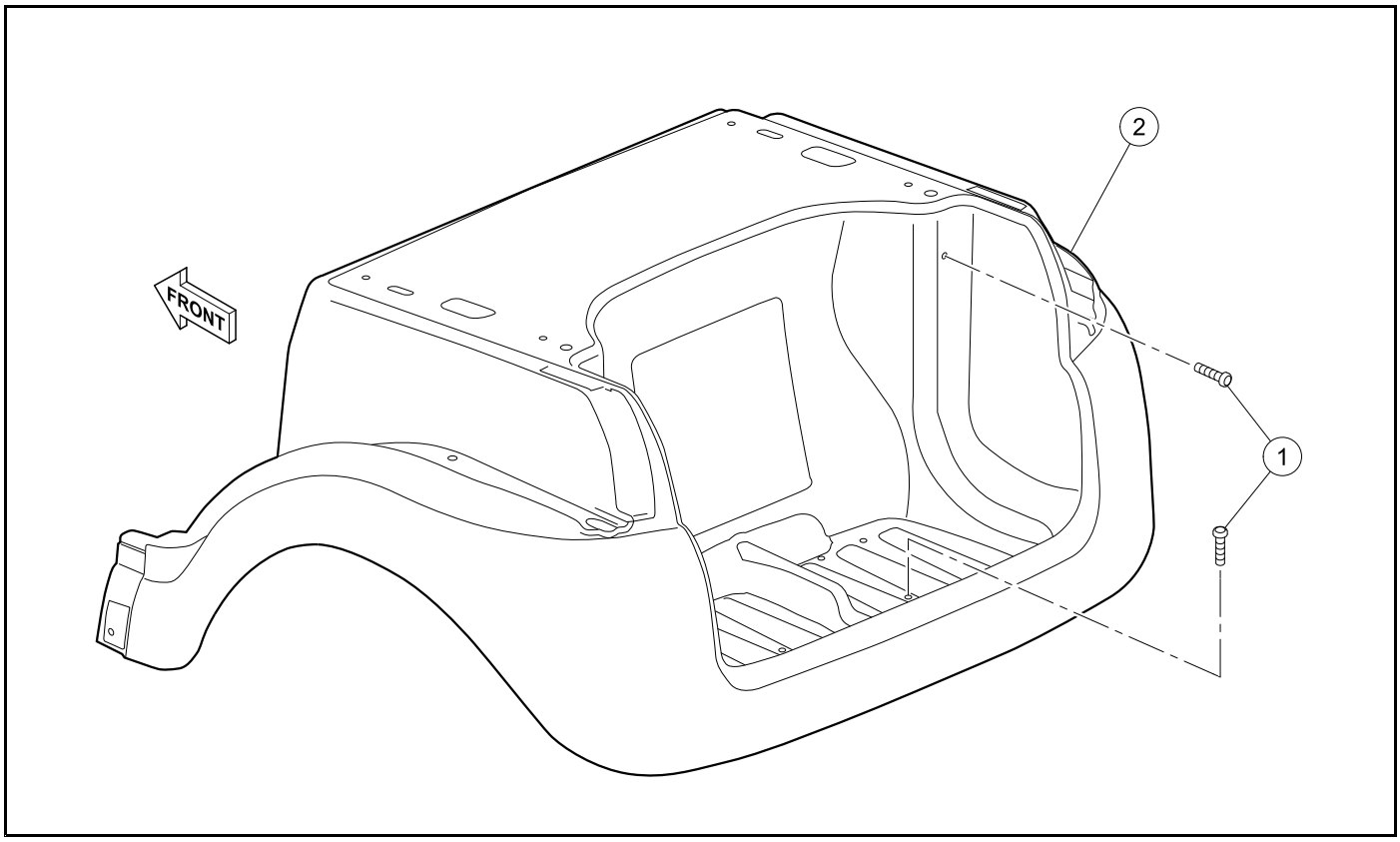


Figure 4-47 2+2 Rear Underbody

Rear Underbody Removal

1. Remove the rear beauty panel.
2. Remove the access panel.
3. Remove the screws (1) **(Figure 4-47)**.
4. Lift the rear edge of the rear underbody (2) until the front portion slides out from beneath the front underbody. Remove the rear underbody from the vehicle.

Rear Underbody Installation

1. Install the rear underbody (2) on the vehicle **(Figure 4-47)**.
2. Install the screws (1). Tighten the screws to 71 lb·in (8 N·m).
3. Install the access panel.
4. Install the rear beauty panel.

SECTION 5 — ACCELERATOR AND BRAKE PEDAL GROUP

5

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

PEDAL GROUP – ELECTRIC VEHICLE

PEDAL GROUP REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
2. Remove the floor mat retainer (1) **(Figure 5-1)**.

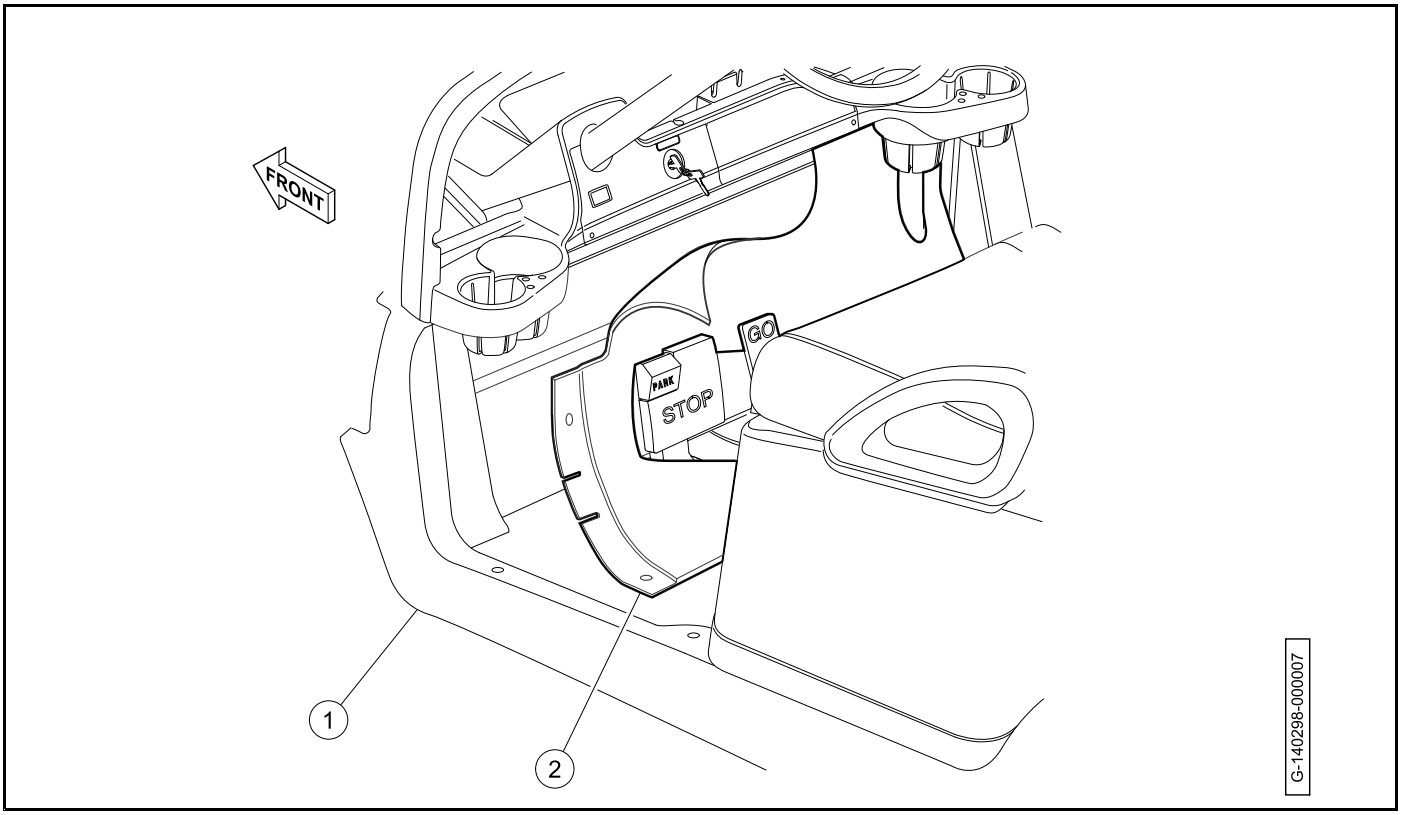


Figure 5-1

3. Pull the floor mat (2) over the pedal group.

4. Remove the fastener (3) **(Figure 5-2)**.

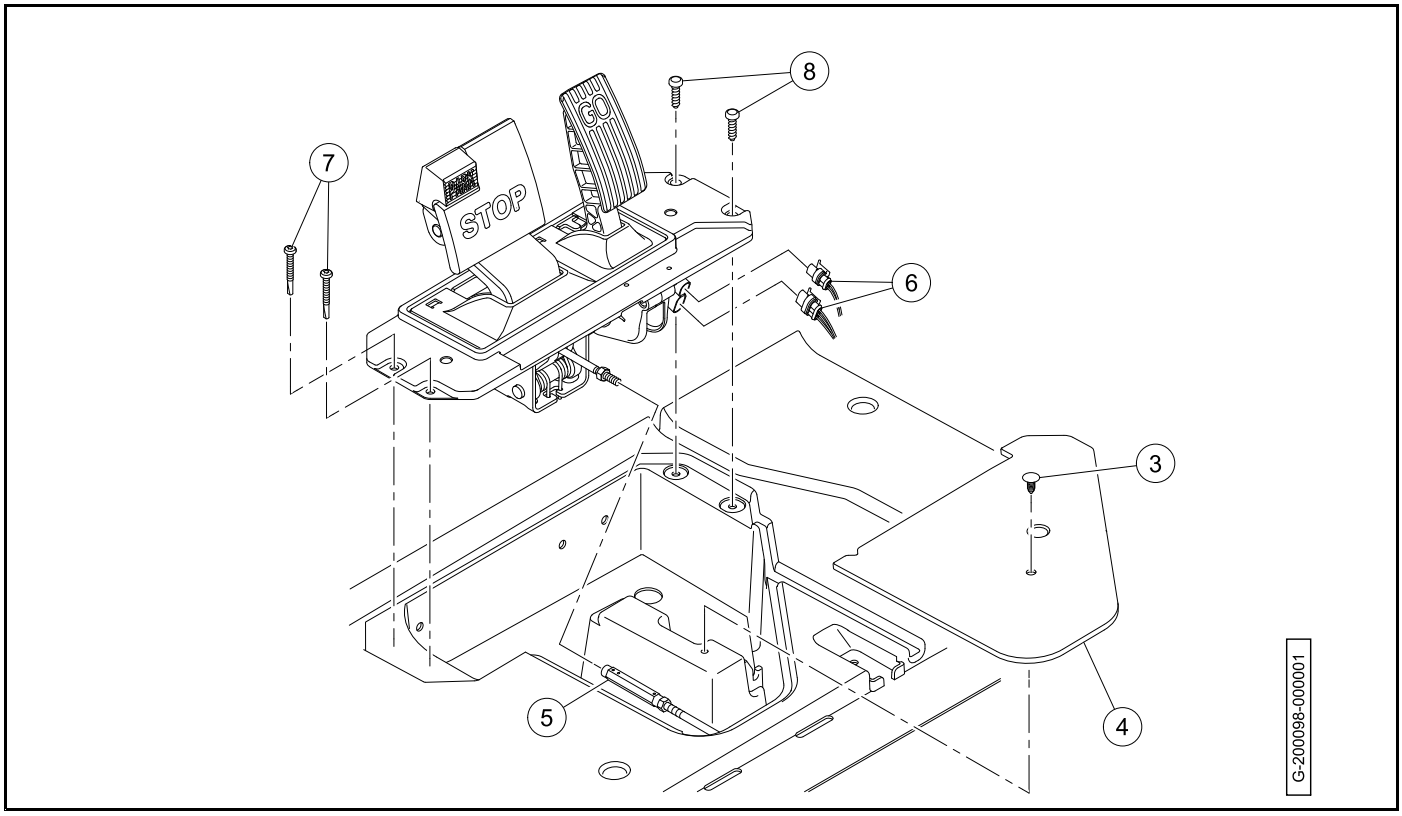


Figure 5-2 Pedal Group Removal

5. Remove the cover (4).
6. Loosen the jam nuts on each side of the turnbuckle (5).
7. Remove the turnbuckle from the pedal assembly.
8. Disconnect the wire harnesses (6).
9. Remove the screws (7 and 8).
10. Remove the pedal group.

PEDAL GROUP INSTALLATION

1. Connect the wire harnesses (1) **(Figure 5-3)**.

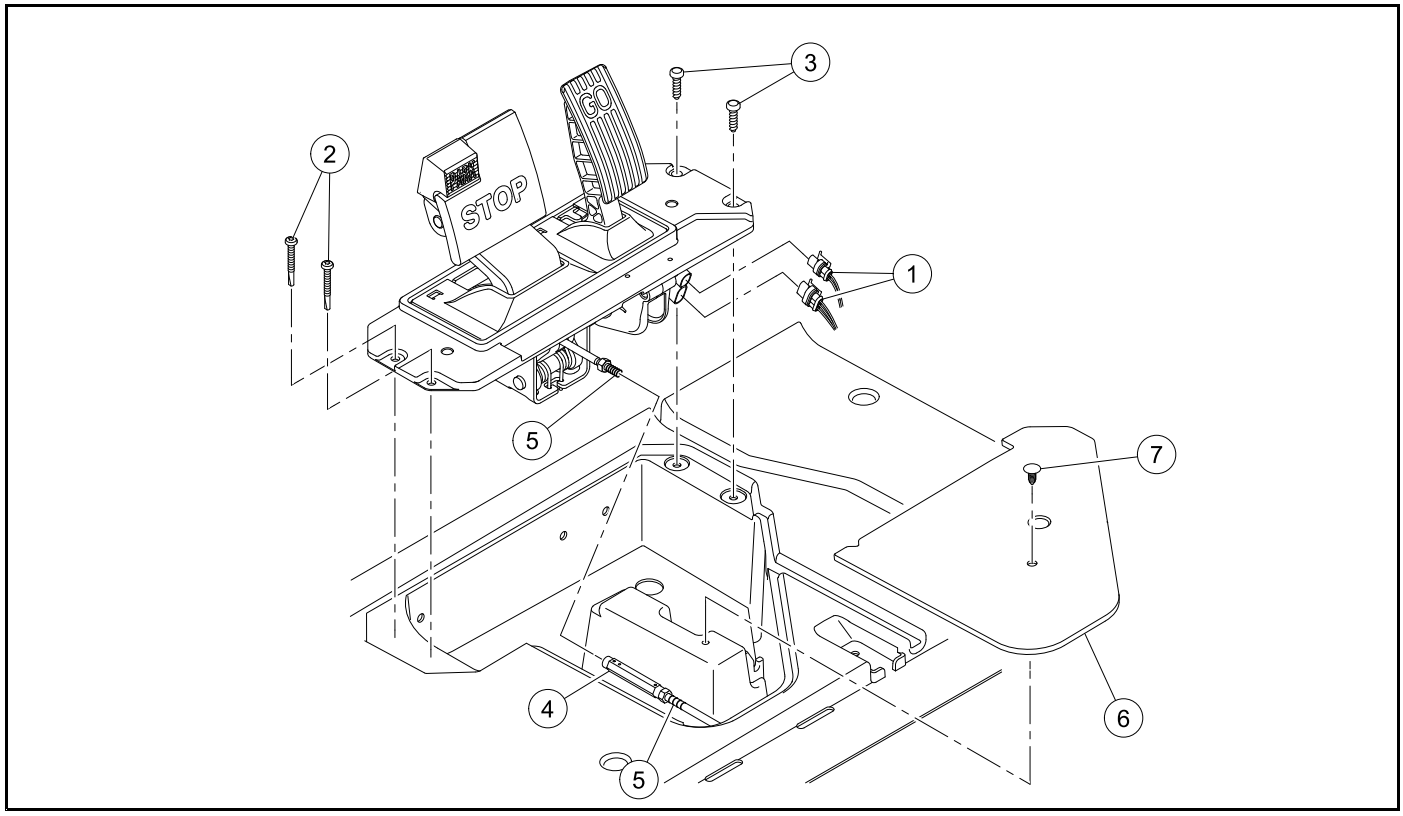


Figure 5-3 Pedal Group Installation

2. Install the driver side screws (2). Tighten the driver side screws to 97 lb·in (11 N·m).
3. Install the passenger side screws (3). Tighten the passenger side screws to 18 lb·in (2 N·m).
4. Remove the turnbuckle (4).
5. Apply Loctite® 242 to the threads (5) of both the rods.
6. Install the turnbuckle.
7. Adjust the brake cable equalizer tension.
8. Install the cover (6).
9. Install the fastener (7).

10. Install the floor mat (8) over the pedal group **(Figure 5-4)**.

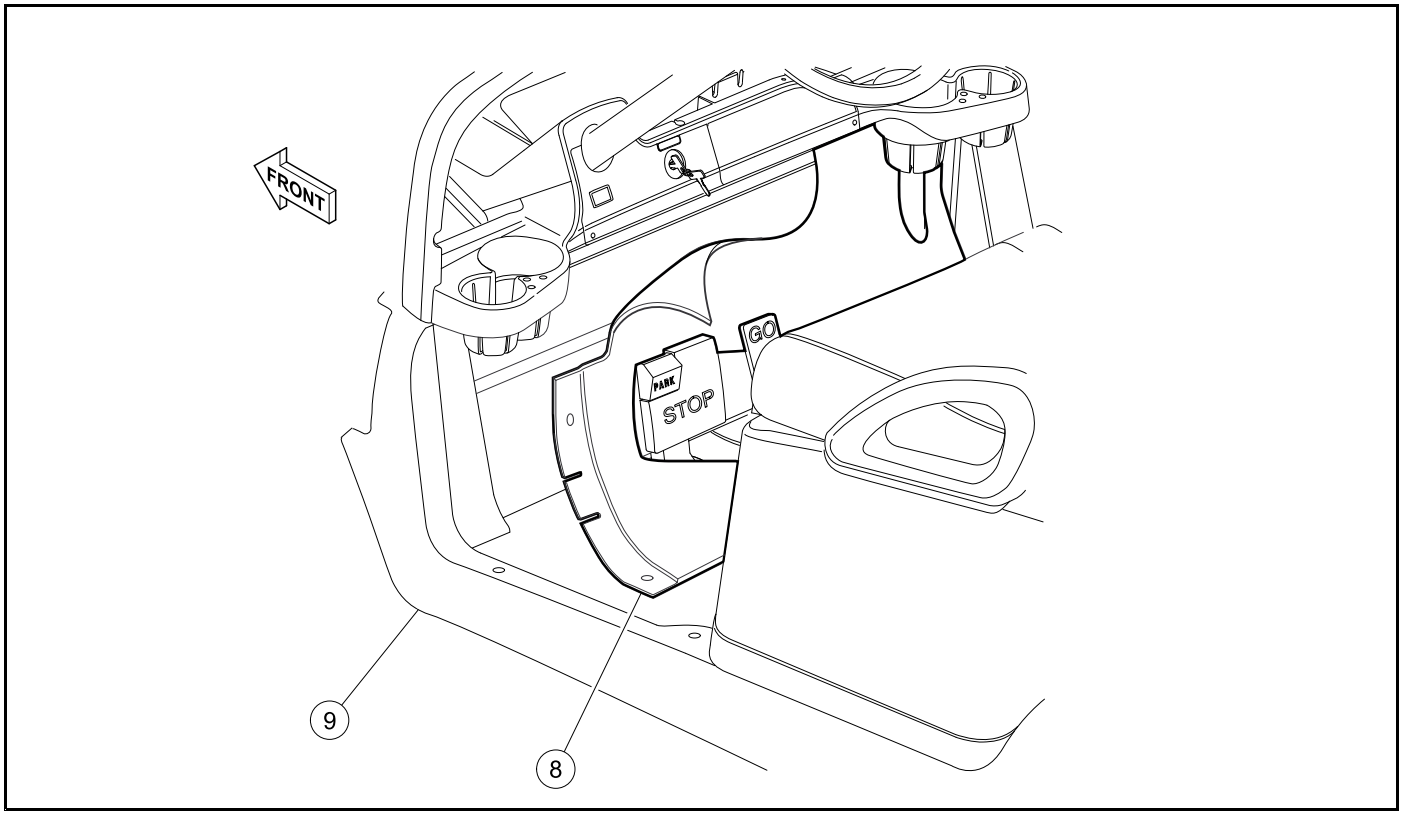


Figure 5-4 Floor Mat and Retainer Installation

11. Install the floor mat retainer (9).
12. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

PEDAL GROUP – GASOLINE VEHICLE

See General Warnings on page 1-2.

PEDAL GROUP REMOVAL

1. Disconnect battery and spark plug wire.
2. Remove the floor mat retainer (1) **(Figure 5-5)**.

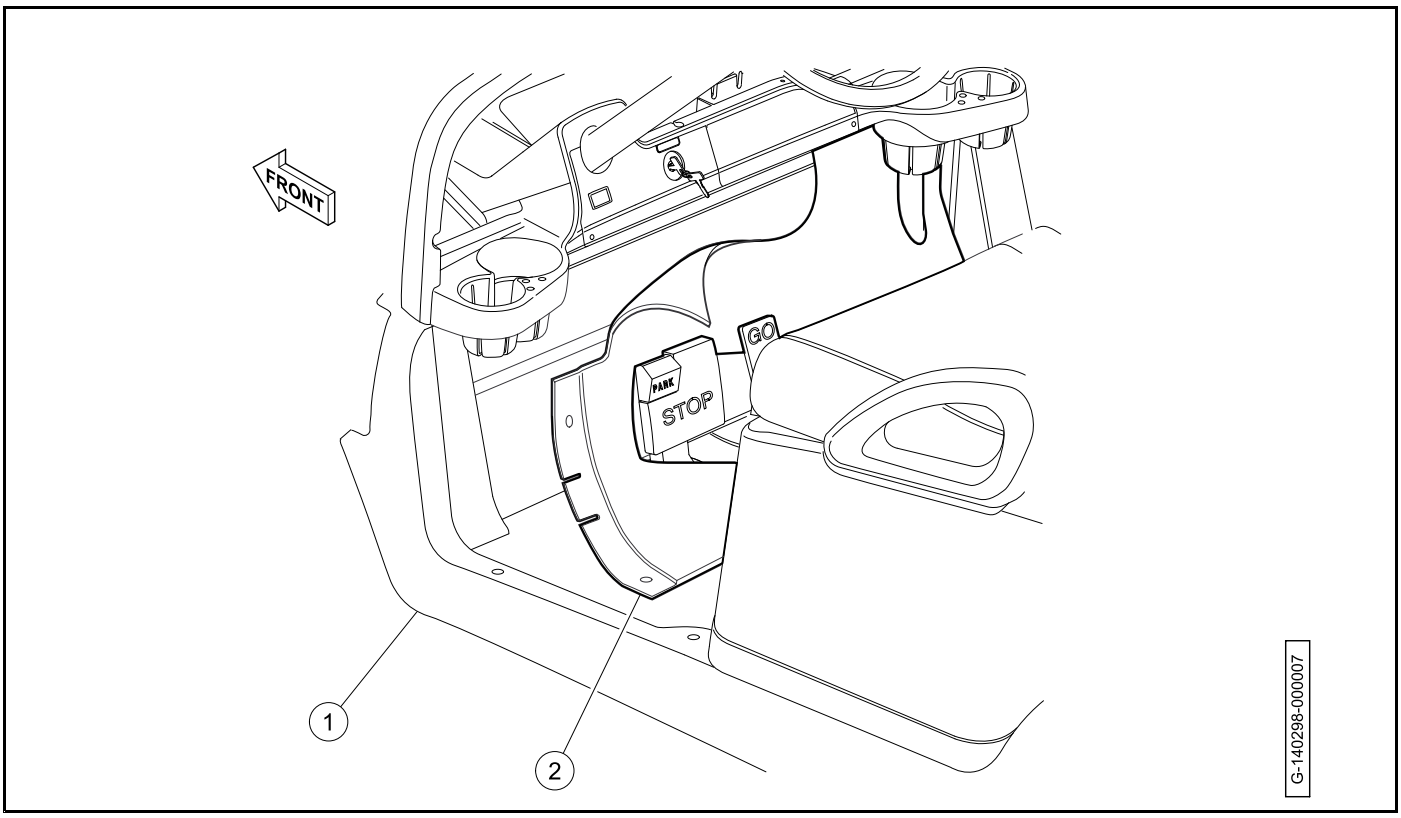


Figure 5-5

3. Pull the floor mat (2) over the pedal group.

4. Remove the fastener (3) **(Figure 5-6)**.

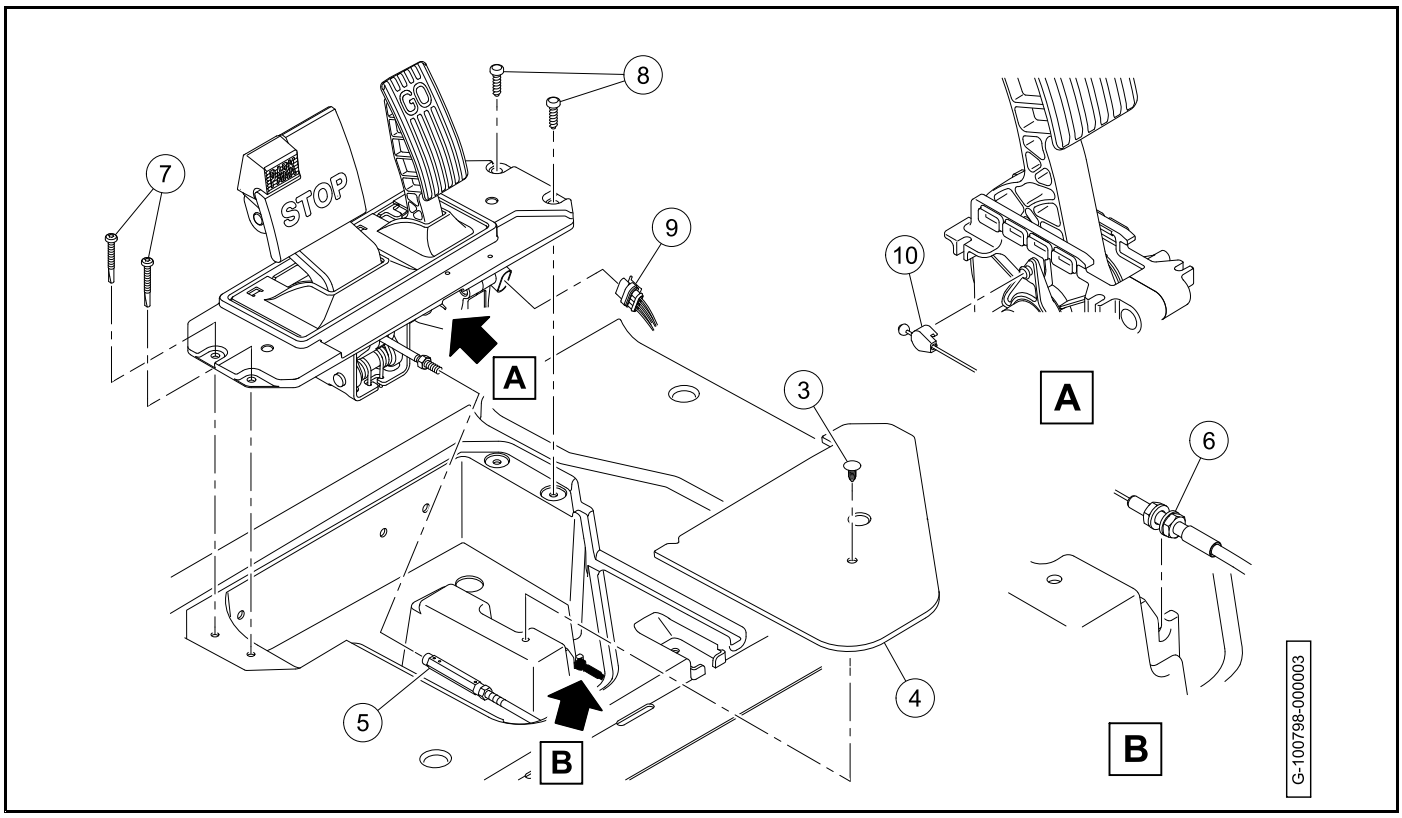


Figure 5-6

5. Remove the cover plate (4).
6. Loosen the jam nuts on each side of turnbuckle (5).
7. Remove the turnbuckle from the pedal assembly.
8. Loosen the two nuts (6) on the accelerator cable and lift the cable from its mounting bracket.
9. Remove the screws (7 and 8).
10. Disconnect the wire harness (9).
11. Disconnect the accelerator cable clip (10) from the accelerator pedal.
12. Remove the pedal group.

THROTTLE POSITION SENSOR

The pedal group for the vehicle includes a throttle position sensor mounted on the side of the accelerator pedal assembly. The throttle position sensor detects the position of the accelerator pedal and sends a voltage to the solenoid and forward/reverse limit switches. The throttle position sensor itself is not intended to be replaced. If sensor is determined to need replacing through test procedures found in this manual, the accelerator pedal assembly must be replaced. **See Accelerator Pedal on page 5-10.**

PEDAL GROUP INSTALLATION

1. Connect the accelerator cable clip (1) to the accelerator pedal **(Figure 5-7)**.

CAUTION

- **Make sure the accelerator cable is properly seated to the pedal group.**

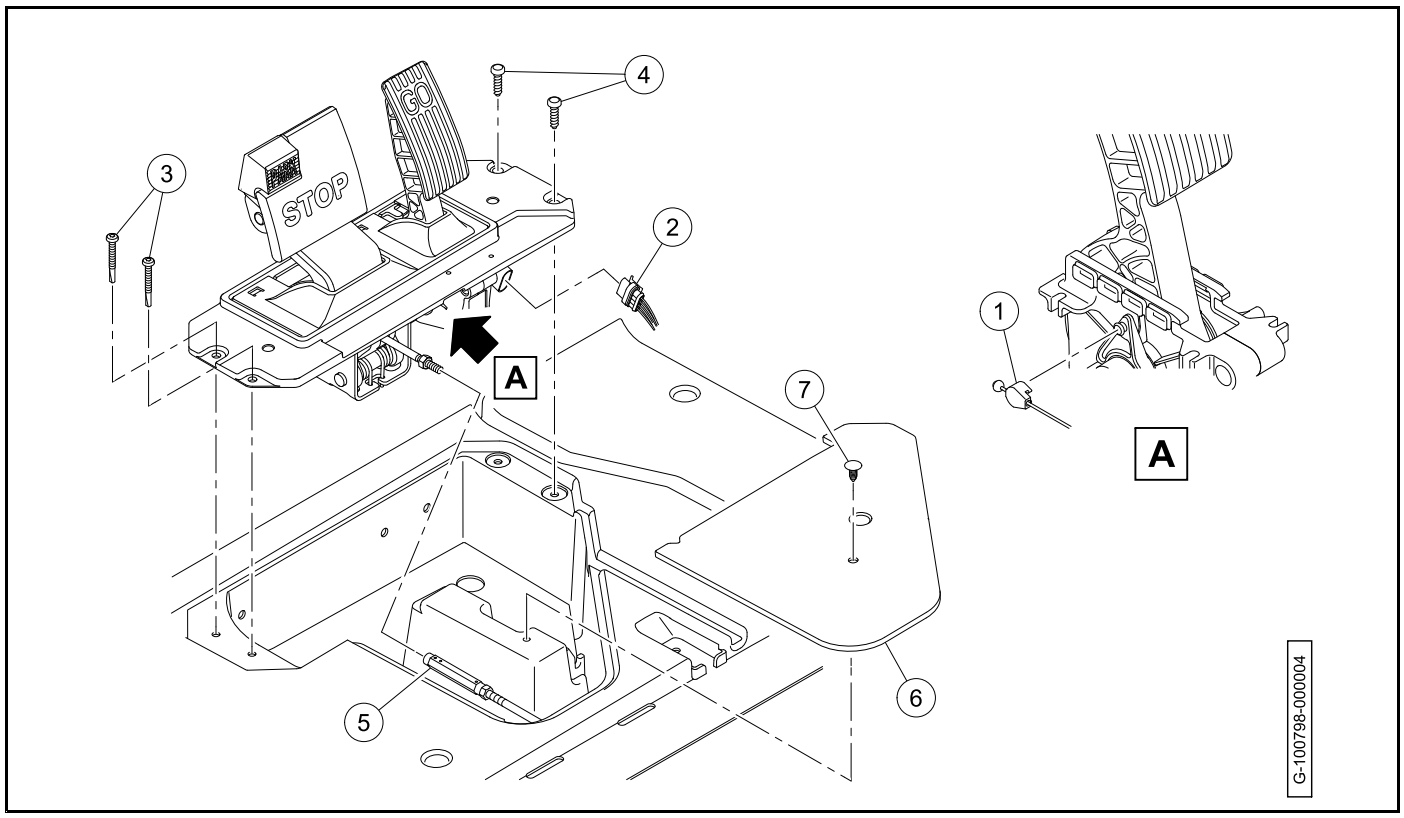


Figure 5-7

2. Connect the wire harness (2) to the throttle position sensor.
3. Install the pedal group in vehicle.
4. Install the screws (3). Tighten the screws to 97 lb·in (11 N·m).
5. Install the screws (4). Tighten the screws to 18 lb·in (2 N·m).
6. Adjust the engine rpm.
7. Install the cover (6).
8. Install the fastener (7).

9. Install the floor mat (8) over the pedal group **(Figure 5-8)**.

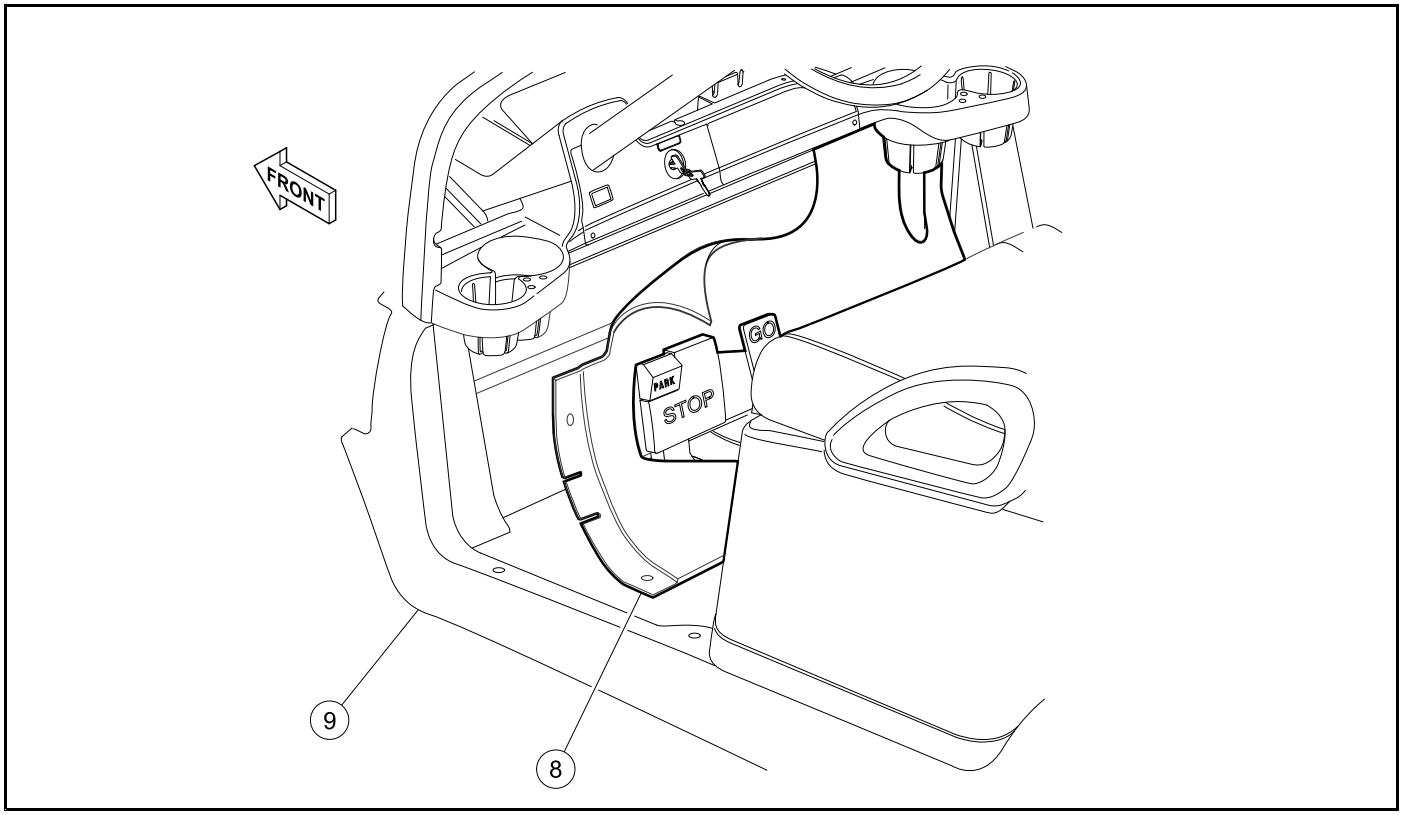


Figure 5-8

10. Install the floor mat retainer (9).
11. Connect battery and spark plug wire.

DEBRIS SHIELDS

Debris shields on the top face of the pedal group prevent excessive debris from contacting the moving parts of the pedal group.

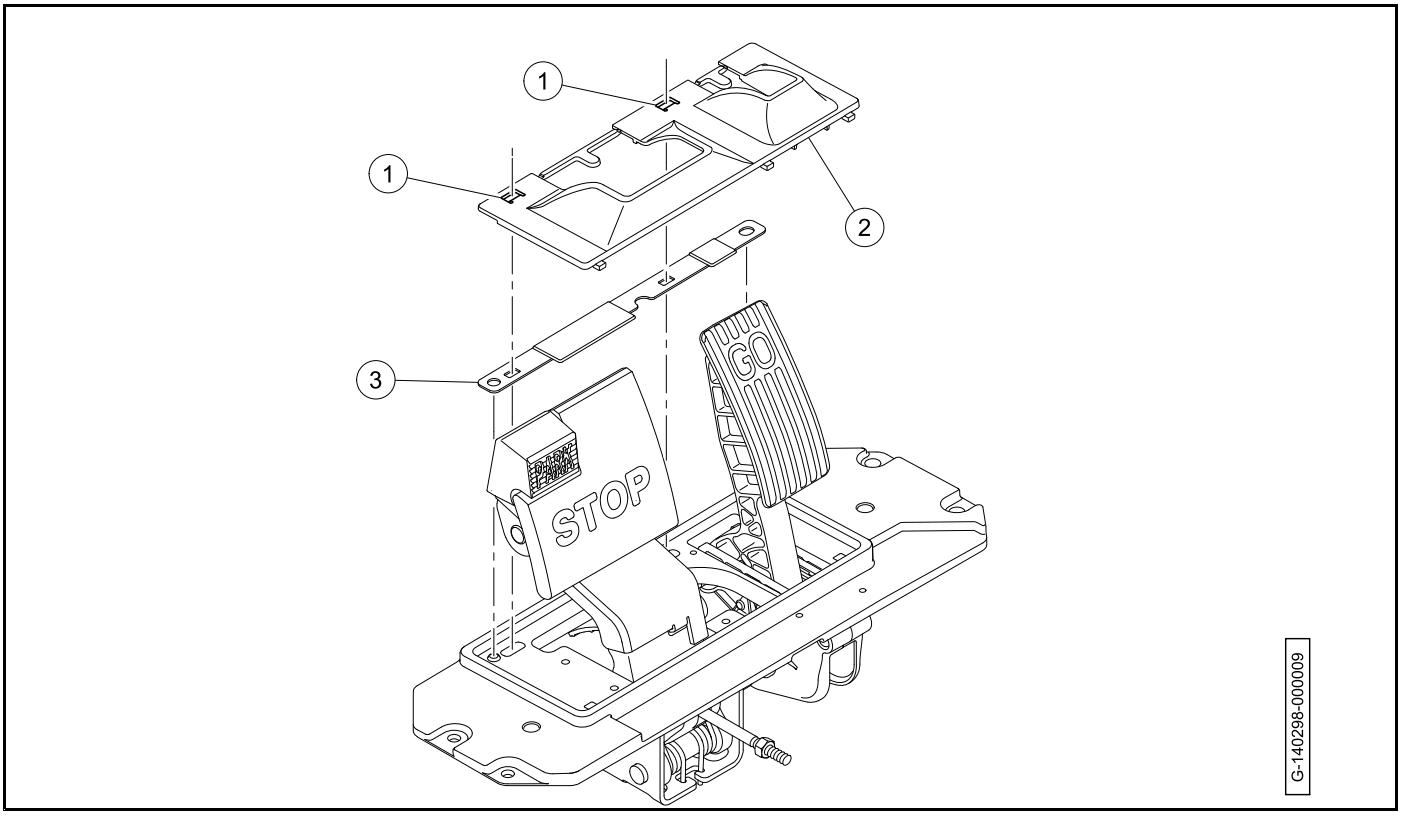


Figure 5-9 Debris Shields

DEBRIS SHIELDS REMOVAL

1. Use a flat blade screw driver to release the tabs (1) and remove the primary debris shield (2) **(Figure 5-9)**.
2. Remove the auxiliary debris shield (3).

DEBRIS SHIELDS INSTALLATION

1. Install the auxiliary debris shield (3) **(Figure 5-9)**.
2. Install the primary debris shield (2).
3. Make sure that the tabs (1) are locked in position.

ACCELERATOR PEDAL

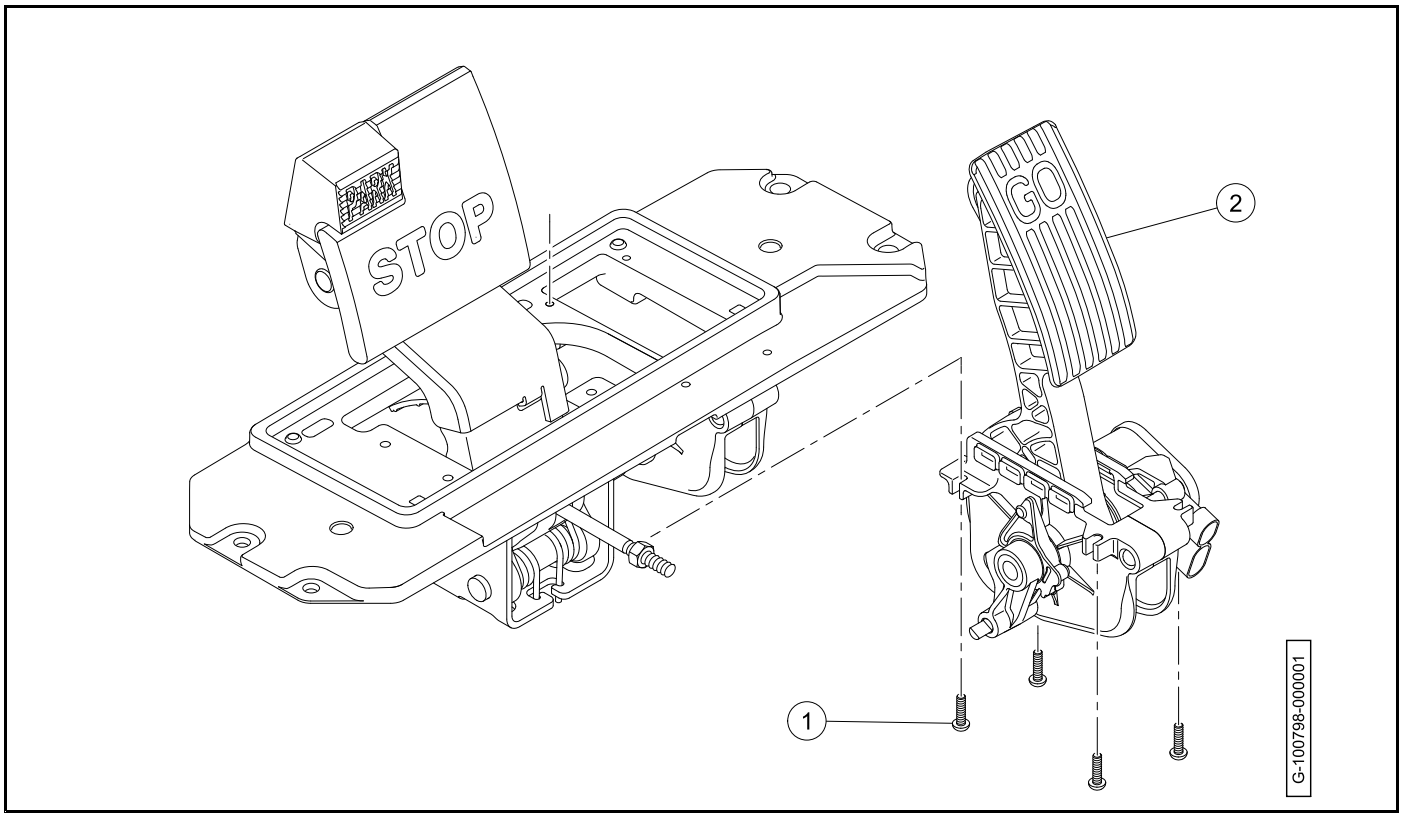


Figure 5-10 Electric vehicle shown. Gasoline vehicle is typical.

ACCELERATOR PEDAL REMOVAL

1. Remove the pedal group.
2. Remove the debris shields.
3. Remove the screws (1) **(Figure 5-10)**.
4. Turn the accelerator pedal assembly (2) and remove through bottom of pedal group mounting plate.

ACCELERATOR PEDAL INSTALLATION

1. Install the accelerator pedal assembly (2) through bottom of pedal group mounting plate **(Figure 5-10)**.
2. Make sure that the park brake release is installed in the brake pedal assembly.
3. Install the screws (1). Tighten the screws to 38 lb·in (4.3 N·m).
4. Install the debris shields.
5. Install the pedal group.

BRAKE PEDAL

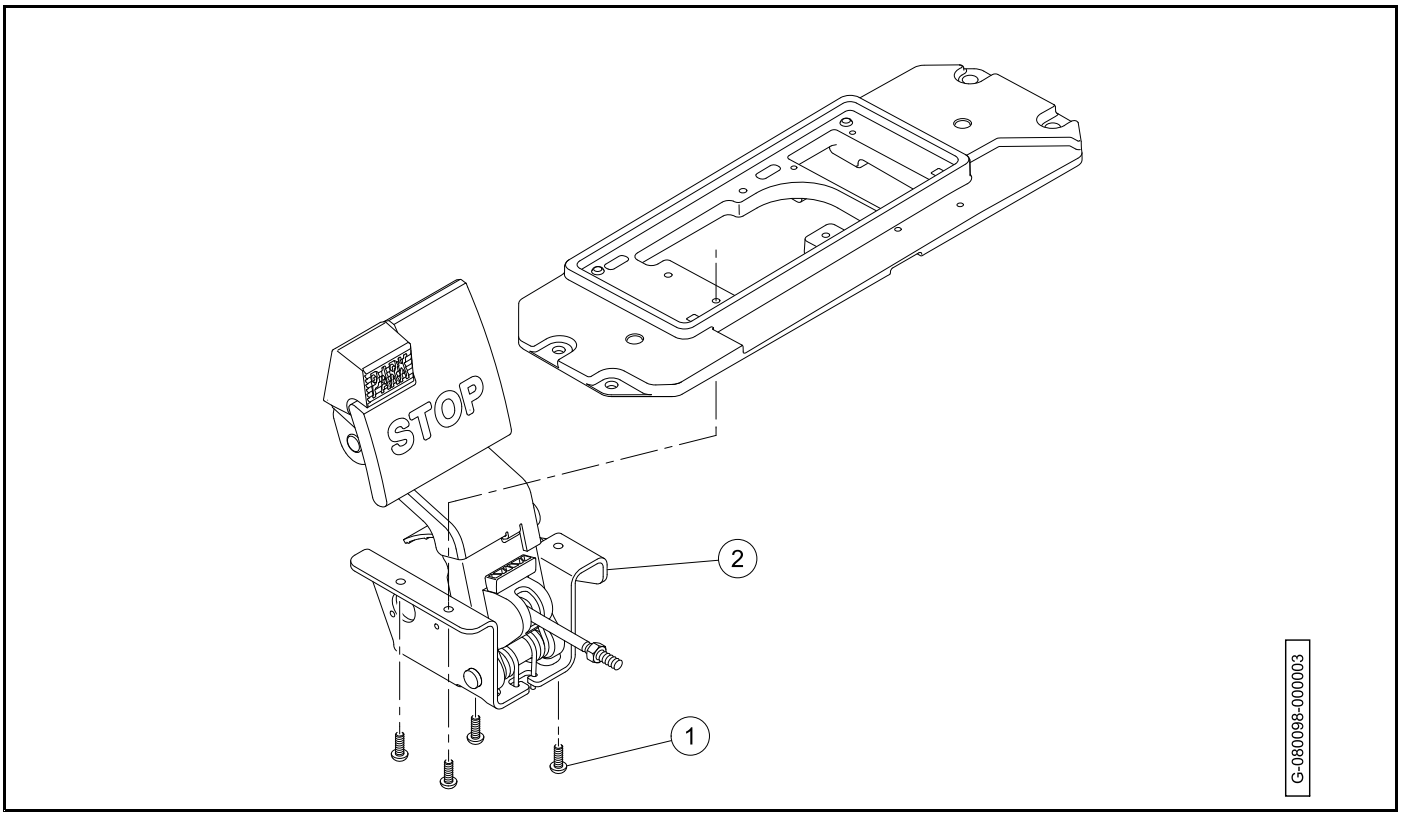


Figure 5-11

BRAKE PEDAL REMOVAL

1. Remove the pedal group.
2. Remove the debris shields.
3. Remove the screws (1) **(Figure 5-11)**.
4. Remove the brake pedal assembly (2) through bottom of pedal group mounting plate.

BRAKE PEDAL INSTALLATION

1. Install the brake pedal assembly (2) through bottom of pedal group mounting plate **(Figure 5-11)**.
2. Install the screws (1). Tighten the screws to 100 lb·in (11.3 N·m).
3. Install the debris shields.
4. Install the pedal group.

Pagination Page

SECTION 6 — WHEEL BRAKE ASSEMBLIES

⚠ WARNING

Asbestos Dust Warning

- **Some aftermarket brake shoes contain asbestos fiber, and 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

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

BRAKE SHOE REMOVAL

⚠ CAUTION

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

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect battery and spark plug wire.
3. Loosen the lug nuts on the rear wheels.
4. Lift the rear of the vehicle.

⚠ 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.**

5. Remove the rear wheels.
6. Remove the floor mat.
7. Remove the pedal access panel.

8. Loosen the left-hand thread jam nut (1) and right-hand thread jam nut (2) **(Figure 6-1)**.

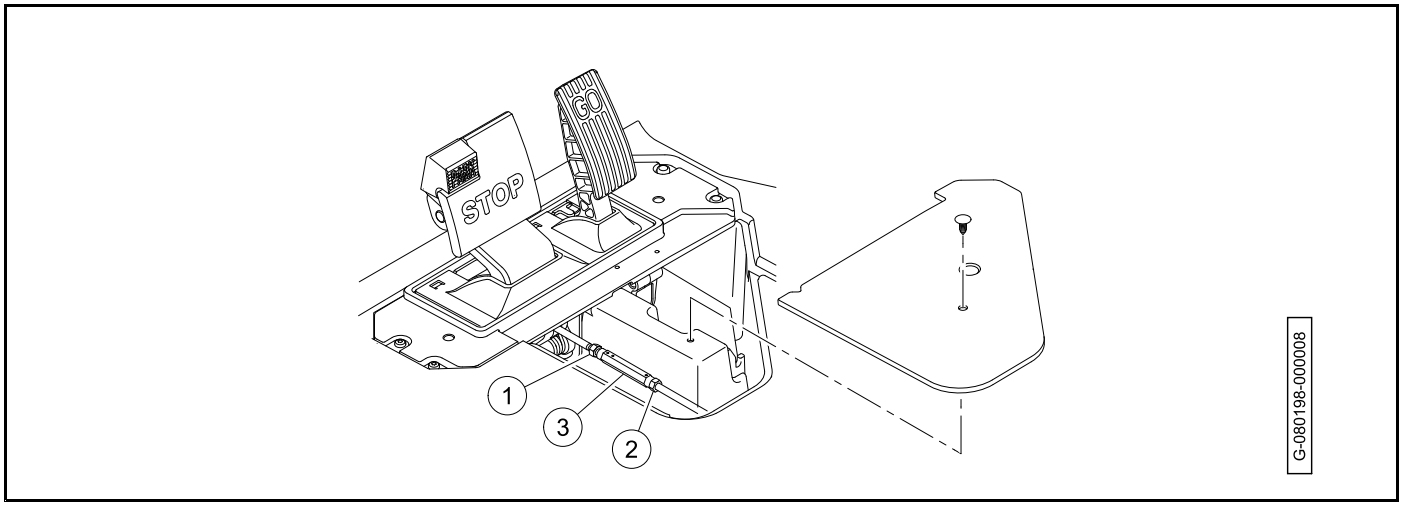


Figure 6-1

9. Loosen the turnbuckle (3) to release tension on the bell crank.
10. Remove the lugs nuts from the rear wheel.
11. Remove the rear wheel.
12. Remove the brake drum (1) **(Figure 6-2)**. If the brake drum cannot be easily removed:

NOTE: *When servicing vehicles with severely worn brake shoes and when the drums cannot be removed by normal methods, use the following steps to minimize damage to the brake cluster and brake components.*

12.1. Use a 1/2 inch x 5/8 inch cold chisel to shear off the head of each pin (2).

NOTE: *This will release the shoes from the backing plate, allowing them to pivot away from the inside of the brake drum, which should then allow the brake drum to be pulled free.*

NOTE: *It may be necessary to remove the sealant material around the head of each pin.*

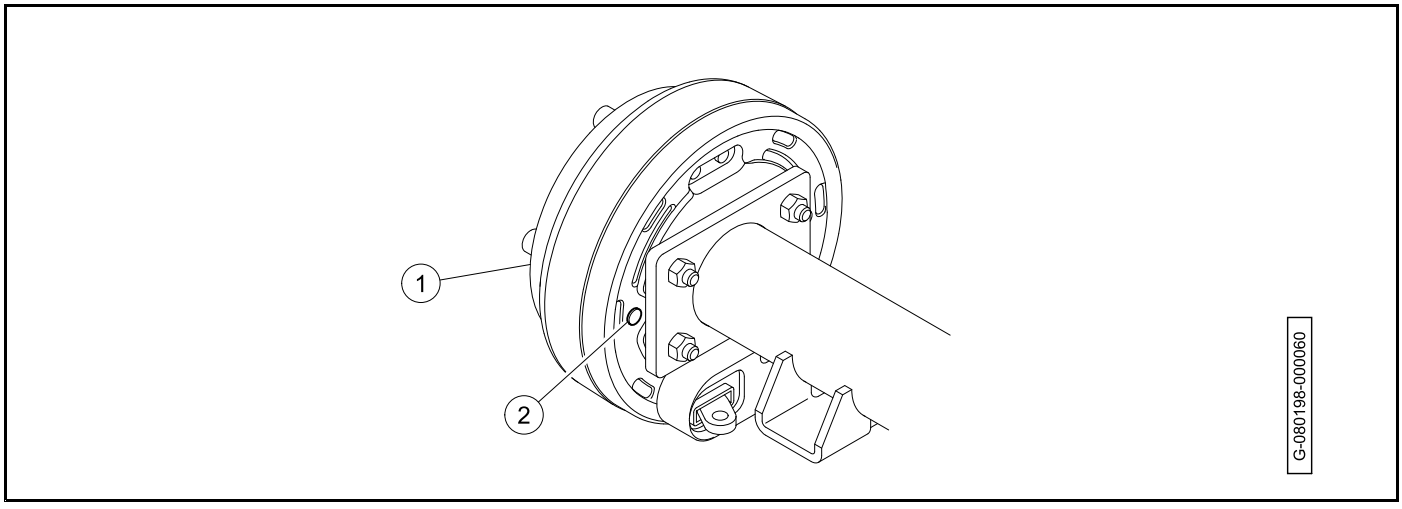


Figure 6-2

12.2. Remove the brake drum.

13. **Electric Vehicle:** Remove the axle shaft.
    Gasoline Vehicle: Remove the wheel hub assembly.
14. Using needle nose pliers, turn the retainer pin (1) 90° to remove the shoe retainer clip (2) **(Figure 6-3)**.

⚠ CAUTION

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

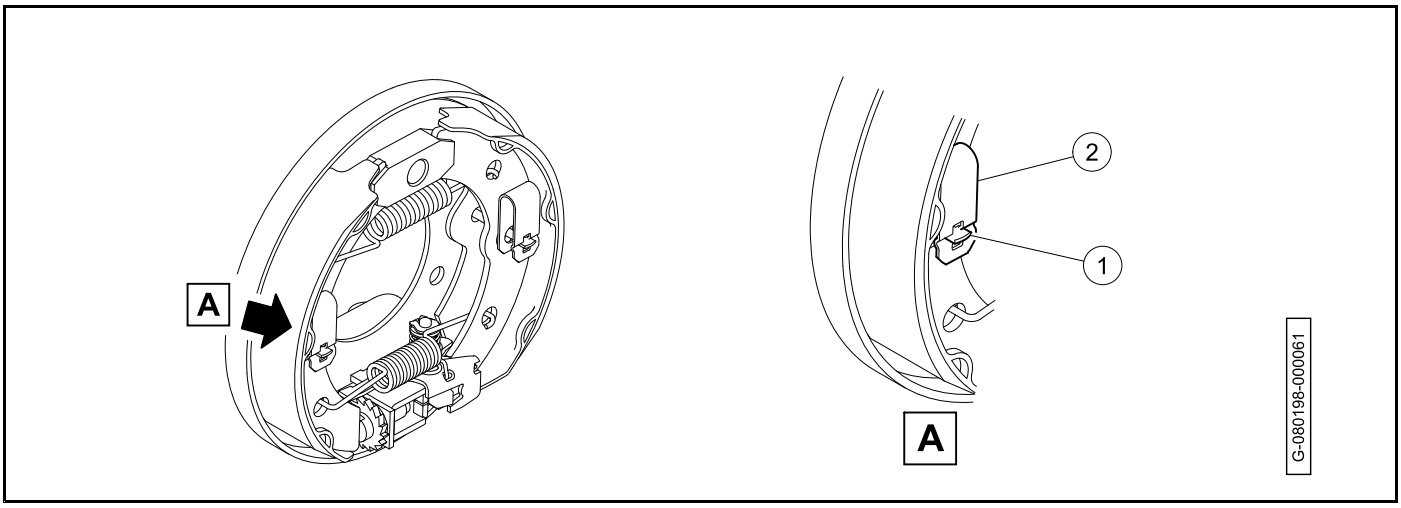


Figure 6-3

15. Hold both brake shoes and pull them, together with the springs, out of the brake assembly **(Figure 6-4)**.

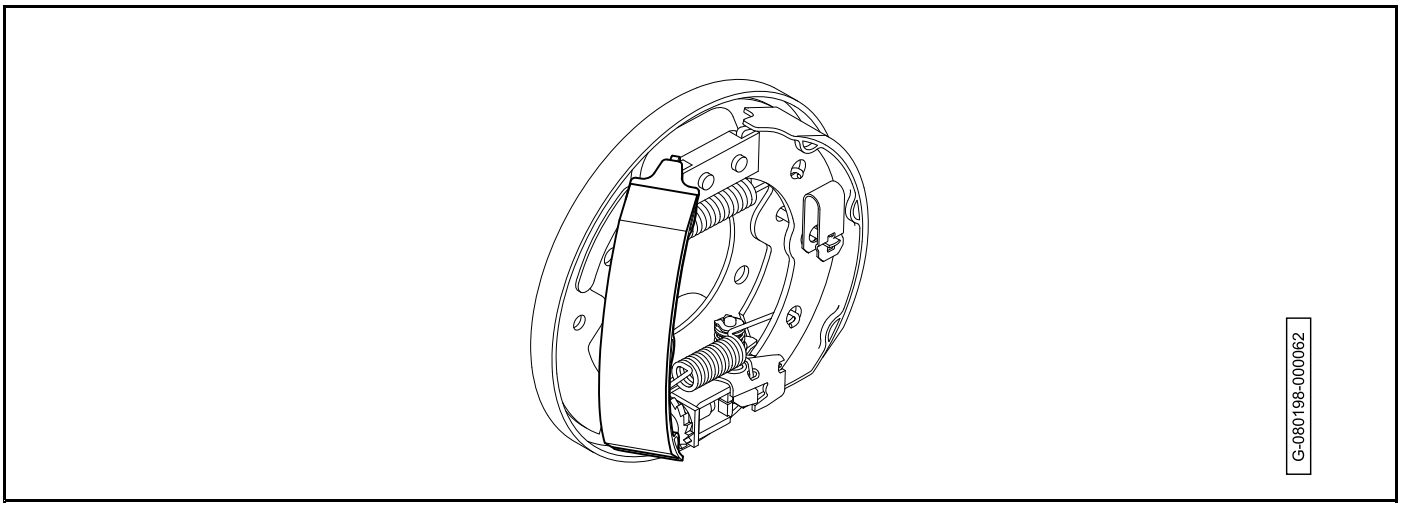


Figure 6-4

16. Remove adjuster wheel (1) with two washers (2 and 3) from the backing plate **(Figure 6-5)**.

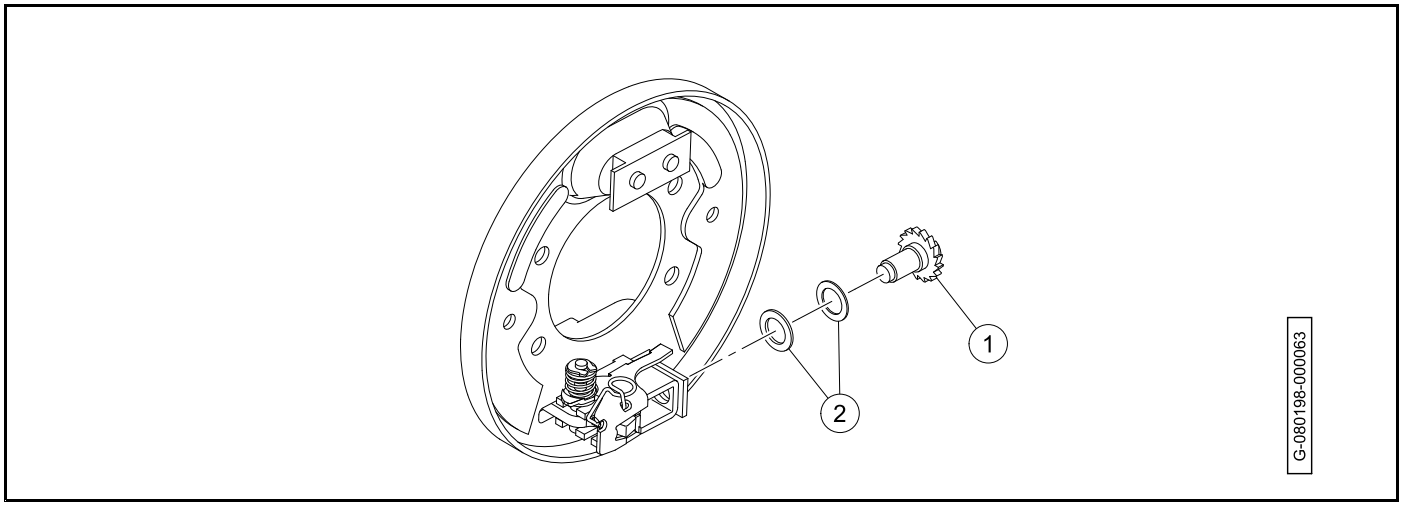


Figure 6-5

17. Clean the brake assembly.

BRAKE ASSEMBLY CLEANING

1. Carefully clean the brake backing plate (1) and all of its mechanical components **(Figure 6-6)**.

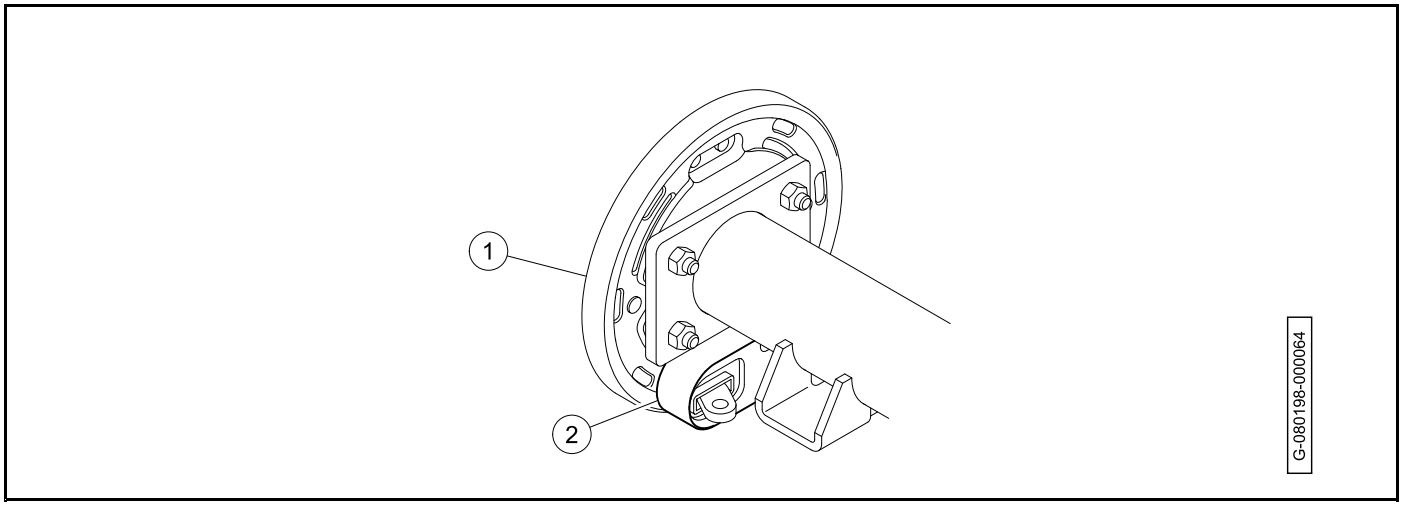


Figure 6-6

2. Remove the dust cover (2) from backing plate and wipe with a clean damp cloth.

3. Lubricate the slide (1) with dry moly lubricant **(Figure 6-7)**.

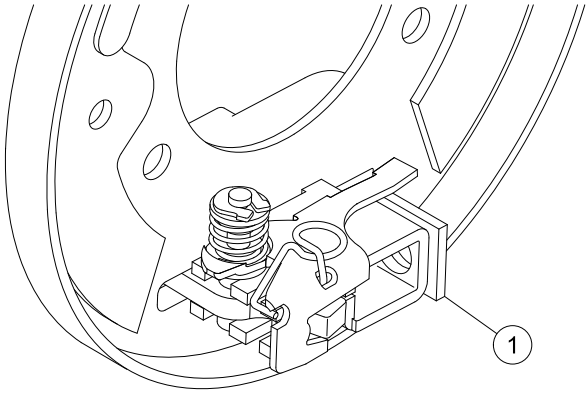


Figure 6-7

4. Make sure that the slide can easily move back and forth.
5. Install the dust cover onto the 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 heed this warning could cause diminished brake performance, possibly resulting in property damage or severe personal injury.**

6. Use a small brush to carefully apply a light coat of white lithium NLGI #2 grease (Dow Corning® BR2-Plus or equivalent) on the raised bosses (1) on the brake backing plate **(Figure 6-8)**.

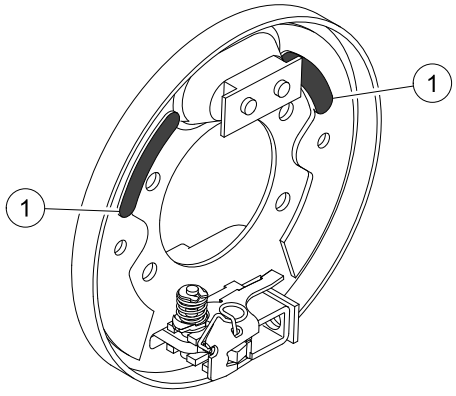


Figure 6-8

7. 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)**.

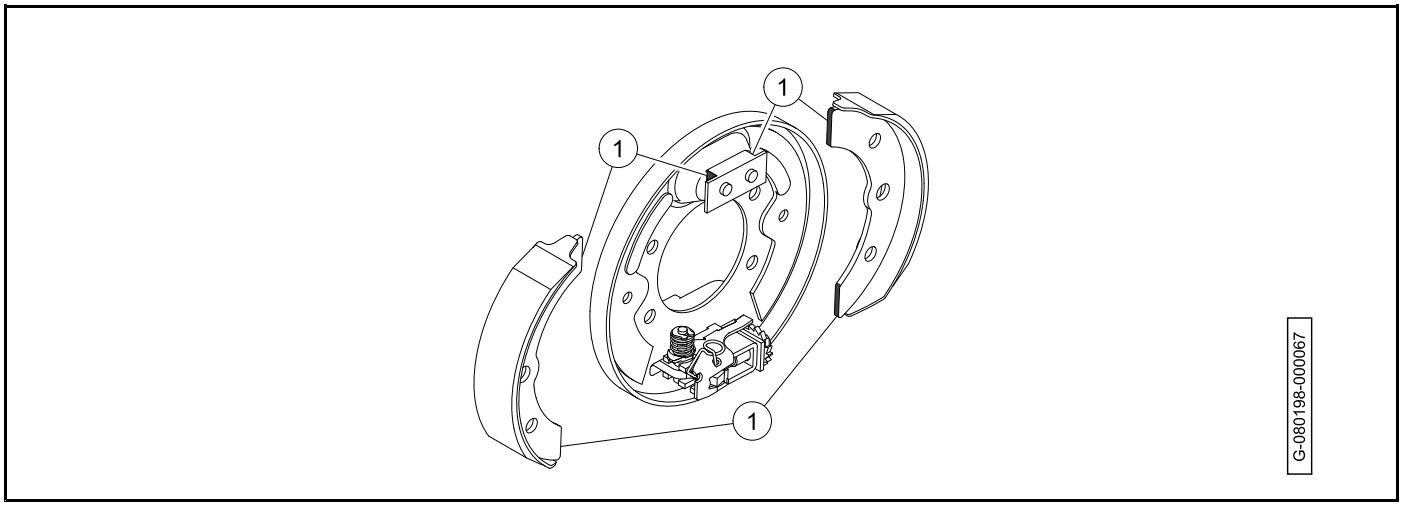


Figure 6-9

8. 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)**.

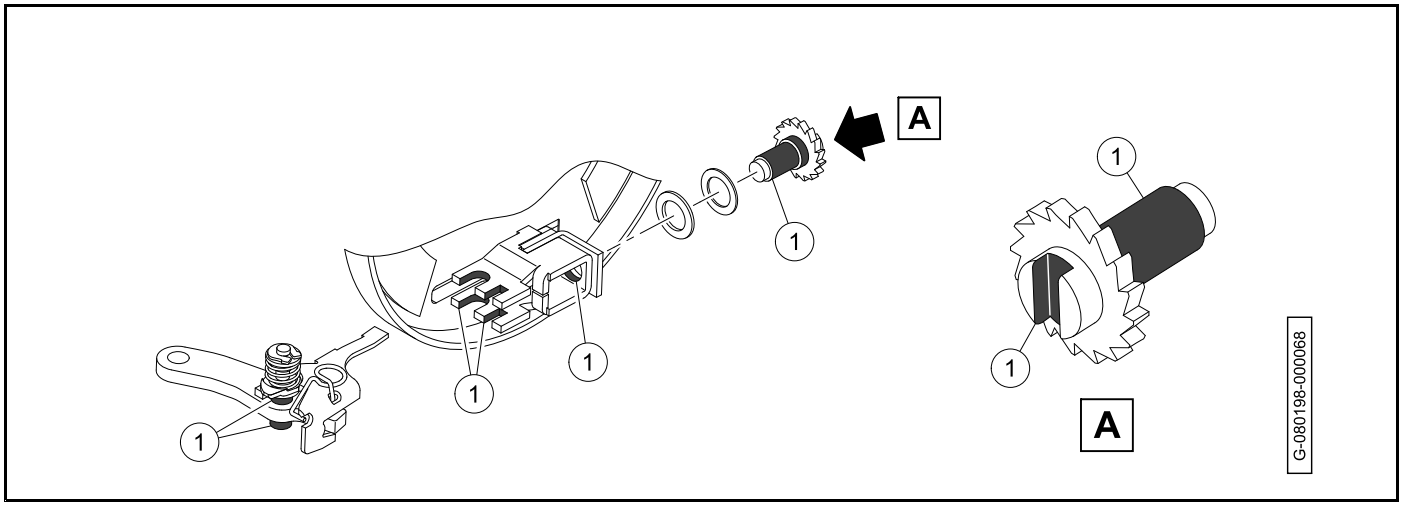


Figure 6-10

BRAKE SHOE INSTALLATION

⚠ WARNING

- **When installing brake shoes, the shoes must be oriented with tips stamped 10 inserted into the mounting block anchor piston slots rather than into the brake actuator slots. Incorrectly installed brake shoes will be too tight and make adjustment of the brake impossible.**

1. Install the adjuster wheel (1) and two washers (2) into the adjuster assembly **(Figure 6-11)**.

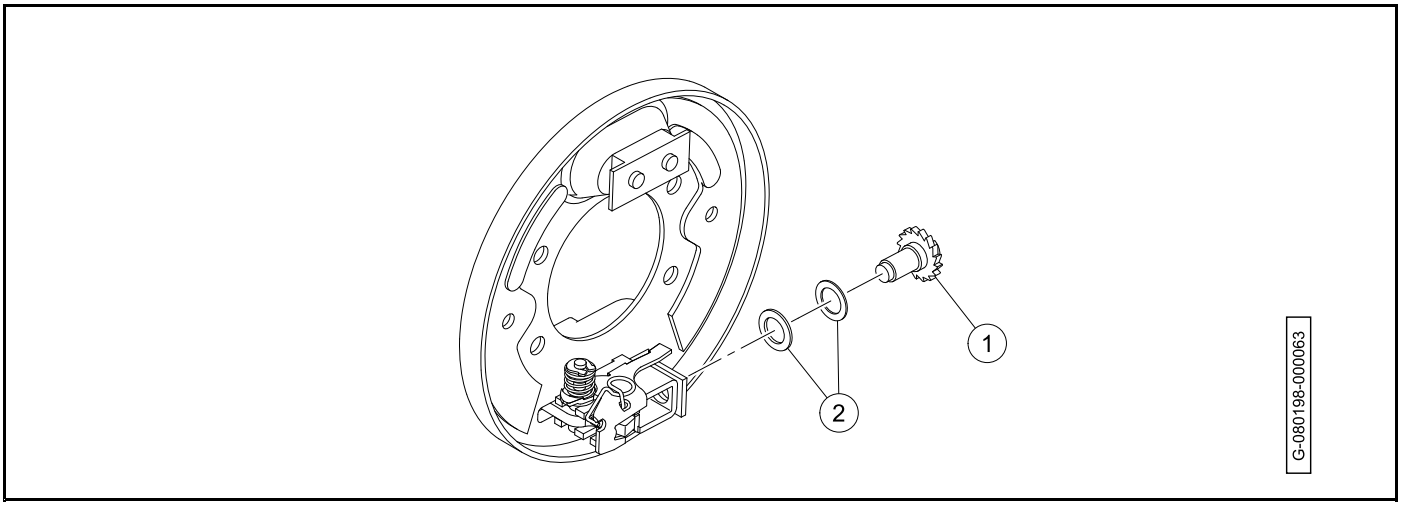


Figure 6-11

2. Turn the adjusting wheel screw so that the shoe slot is vertical (A) **(Figure 6-12)**.

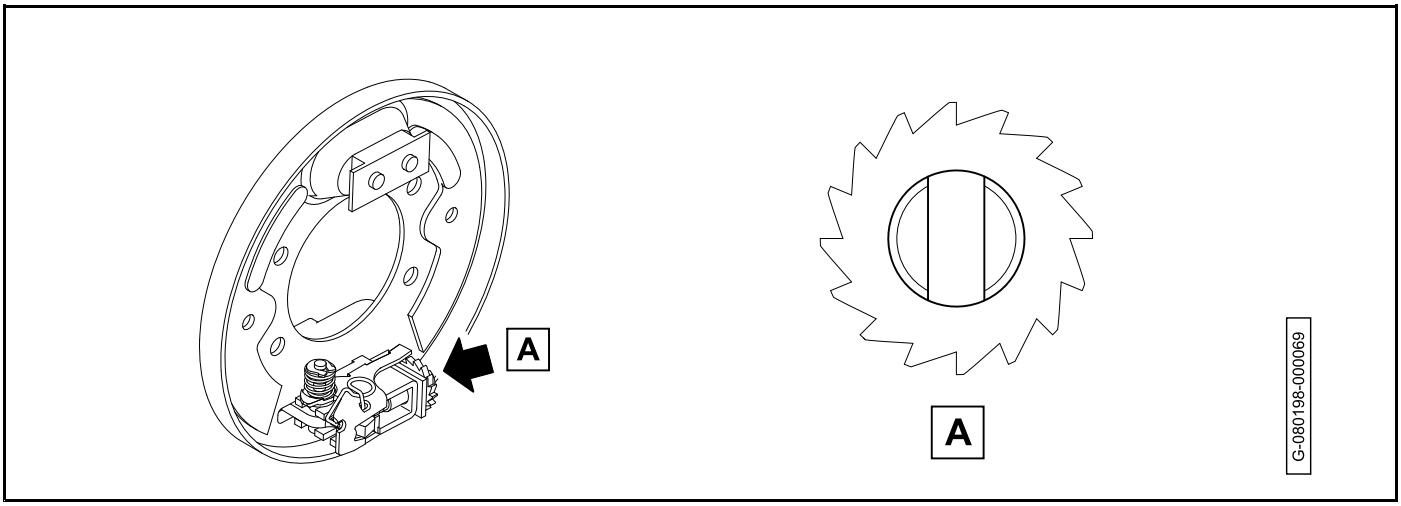


Figure 6-12

3. Install the first shoe (1) in the slots in the mounting block anchor piston (2) and the brake actuator (3) **(Figure 6-13)**. Make sure that the stamped end of the shoe in the mounting block anchor piston. **See detail A.**

NOTE: *10 is stamped into one of the shoe flanges.*

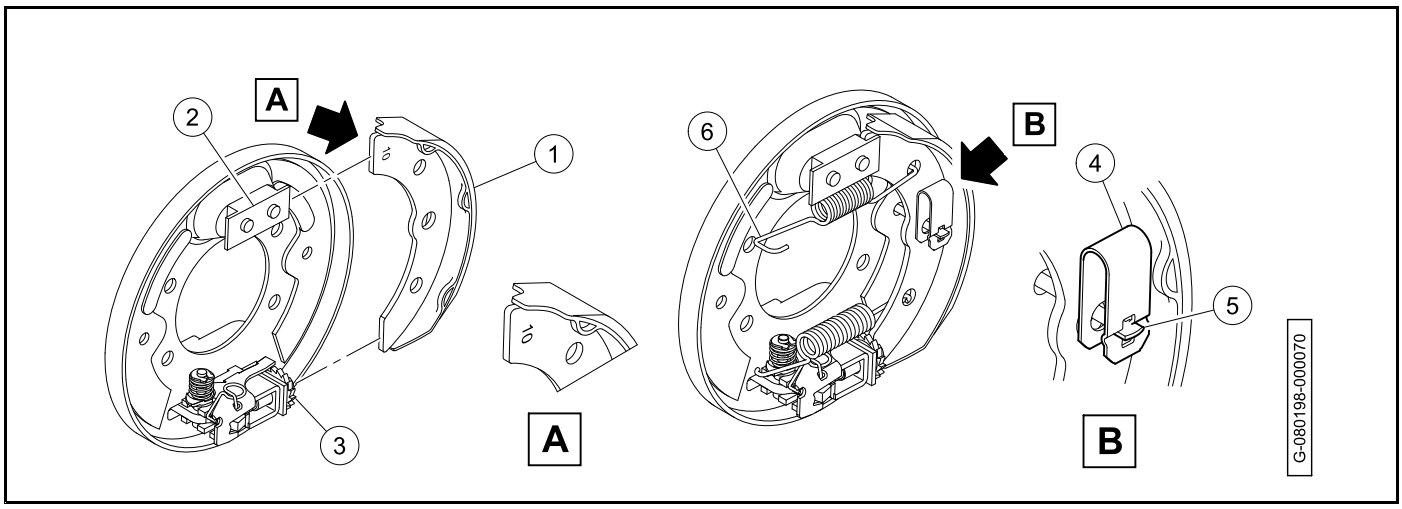


Figure 6-13

4. Use pliers to compress and install the shoe retainer clip (4), while turning the retainer pin (5) into position.
5. Attach the springs (6) onto the first shoe.
6. Hold the second brake shoe next to the first shoe and attach the springs to it. Make sure that the stamped end of the shoe will be in the mounting block anchor piston.
7. Install the second shoe (1) in the slots in the shoe mounting block (A) and the adjuster assembly (B) **(Figure 6-14)**.

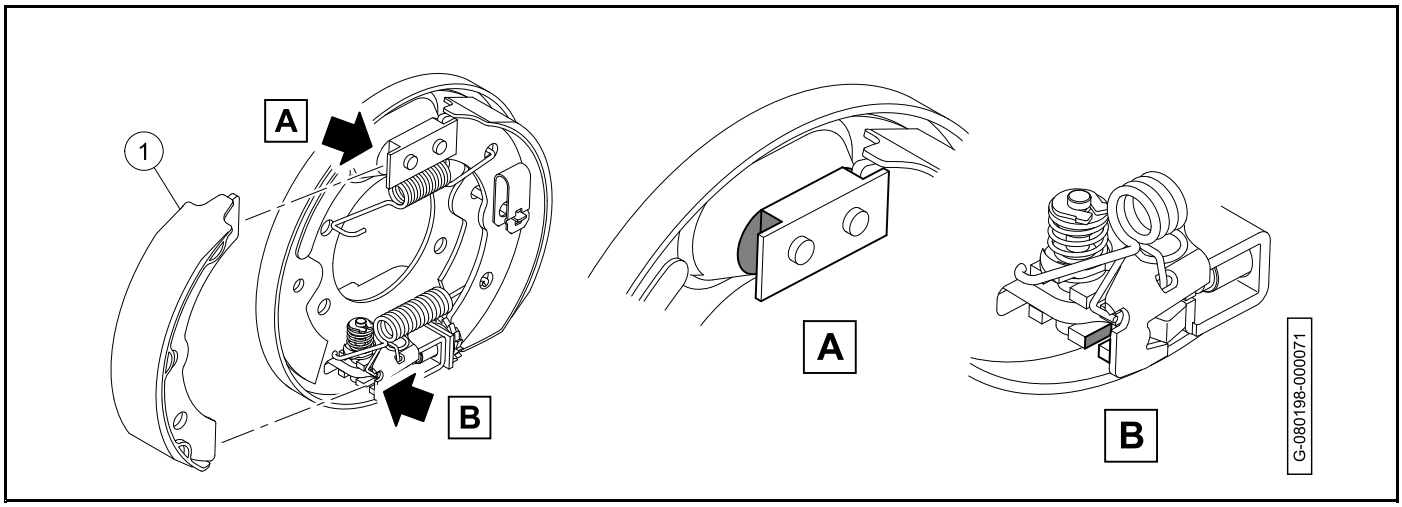


Figure 6-14

8. Hold the second brake shoe in position and install the shoe retainer clip, while turning the retainer pin into position.
9. Make sure that the brake shoes can move together up and down and side to side approximately 1/4 to 3/8 inch (6.3 to 9.5 mm) without binding.

10. Use a flatblade screwdriver to lift the adjusting arm (1) off of the adjusting wheel (2) **(Figure 6-15)**.

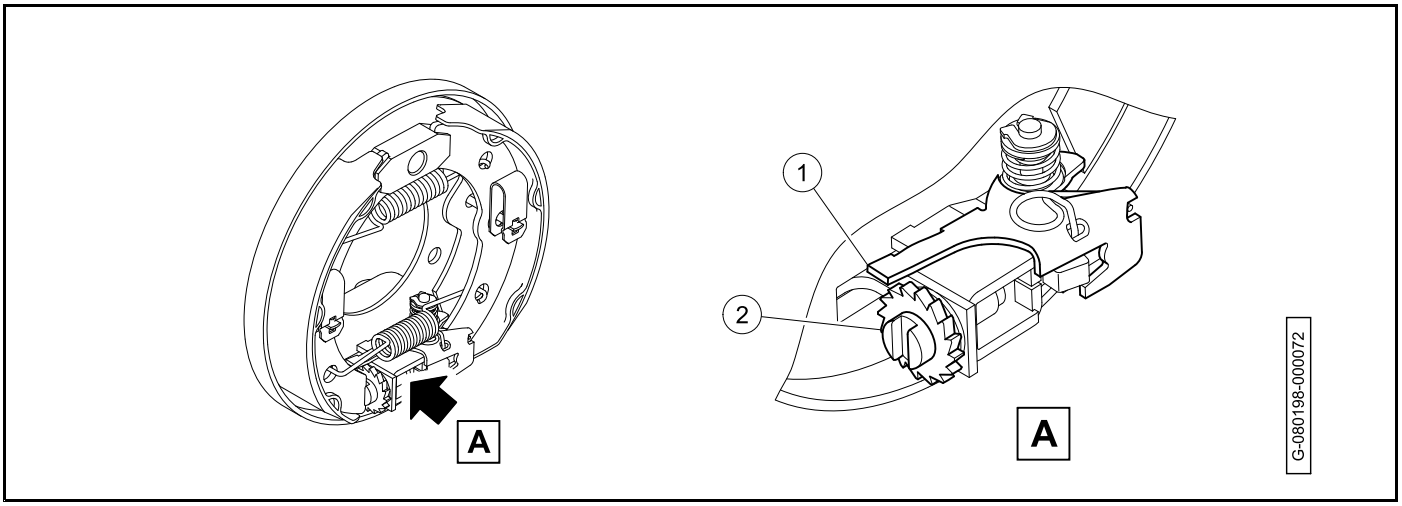


Figure 6-15

11. Turn the adjusting wheel upward until it stops.
12. Remove the screwdriver.
13. **Electric Vehicle:** Install the axle shaft.
    Gasoline Vehicle: Install the wheel hub assembly.
14. Install the brake drum. Make sure that the brake drum is properly seated.

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

15. Make sure that the axle and drum turn freely.
16. Install the wheels.
17. Lower the rear of the vehicle.
18. Remove the turnbuckle (1) **(Figure 6-16)**.

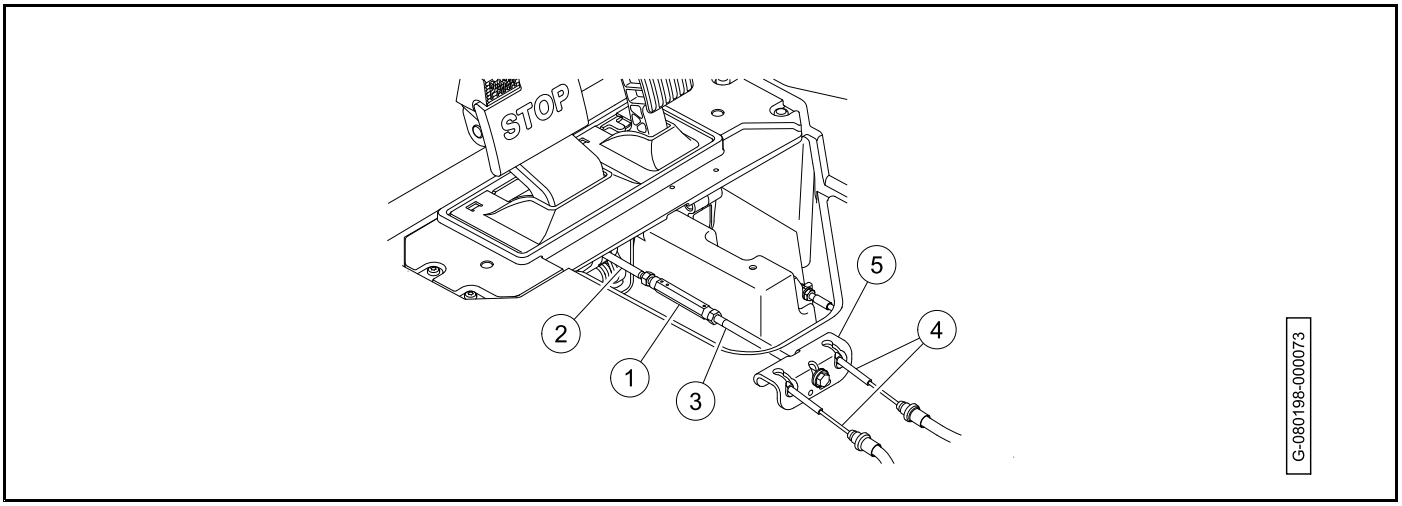


Figure 6-16

19. Apply Loctite® 242 to the threaded ends of the pedal group rod (2) and the brake actuator rod (3).
20. Install the turnbuckle. Make sure that the brake cables (4) are installed in the brake equalizer (5).

21. Adjust the brake cable equalizer.
22. **Electric Vehicle:** Connect the batteries.
    Gasoline Vehicle: Connect battery and spark plug wire.

BRAKE CABLE EQUALIZER ADJUSTMENT

1. Make sure that the brake pedal is in the fully up position.
2. Adjust the turnbuckle (1) until the distance (A) between the top of the brake cable equalizer (2) and the upper flange surface (3) is 2 inches (±1/16) (51 mm (±1.6) **(Figure 6-17)**.

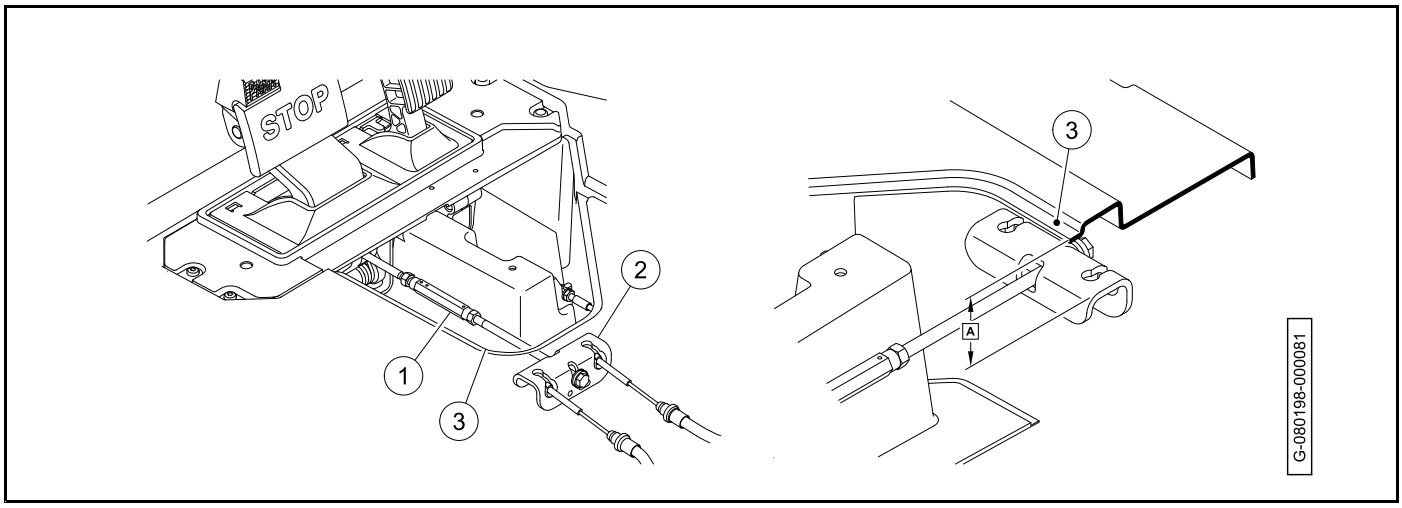


Figure 6-17

3. Make sure that the threaded rods are visible in the holes (1) of the turnbuckle (2) **(Figure 6-18, Page 6-10)**.

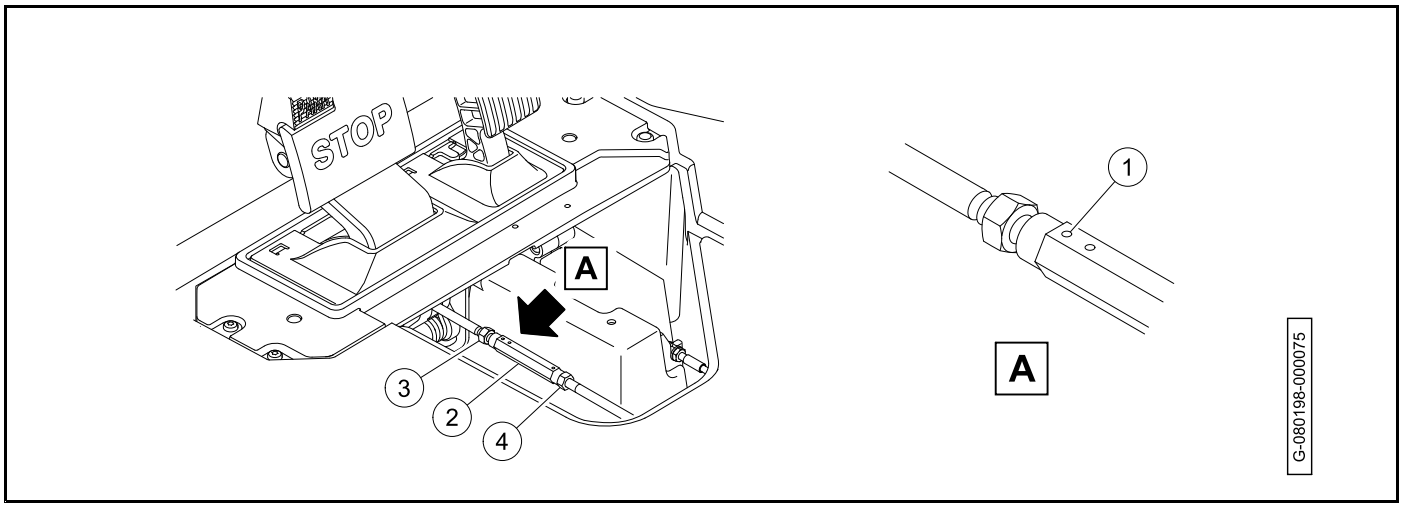


Figure 6-18

4. Snug the front (3) jam nut and rear jam nut (4) to their respective surfaces, then back the nuts off 1/4 to 3/8 inch (6.4 to 9.5 mm) and apply Loctite® 242 on the threads for both front and rear jam nuts.

⚠ WARNING

- **Reduced braking force could result if the jam nuts are not tightened in the proper sequence.**

5. Tighten the rear jam nut first to 208 lb·in (23.5 N·m), then tighten the front jam nut to 208 lb·in (23.5 N·m). For optimal performance, drive the vehicle and apply the brakes approximately 20 times to burnish the shoes, center the clusters, and adjust the brake mechanism.
6. Measure the distance between the top of the brake cable equalizer and the upper flange surface.
7. If the measurement is 2 inches (±1/16) (51 mm (±1.6), the adjustment is complete.
8. If the measurement is not 2 inches (±1/16) (51 mm (±1.6):

8.1. Repeat the adjustment procedure.

9. Install the access panel.
10. Install the floor mat.

BRAKE CLUSTER

BRAKE CLUSTER REMOVAL

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect battery and spark plug wire.
3. Loosen the lug nuts on the rear wheel.
4. Lift the rear of the vehicle.

⚠ 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.**

5. Release the park brake.
6. Remove the floor mat.
7. Remove the pedal access panel.
8. Loosen the left-hand thread jam nut (1) and right-hand thread jam nut (2) **(Figure 6-19)**.

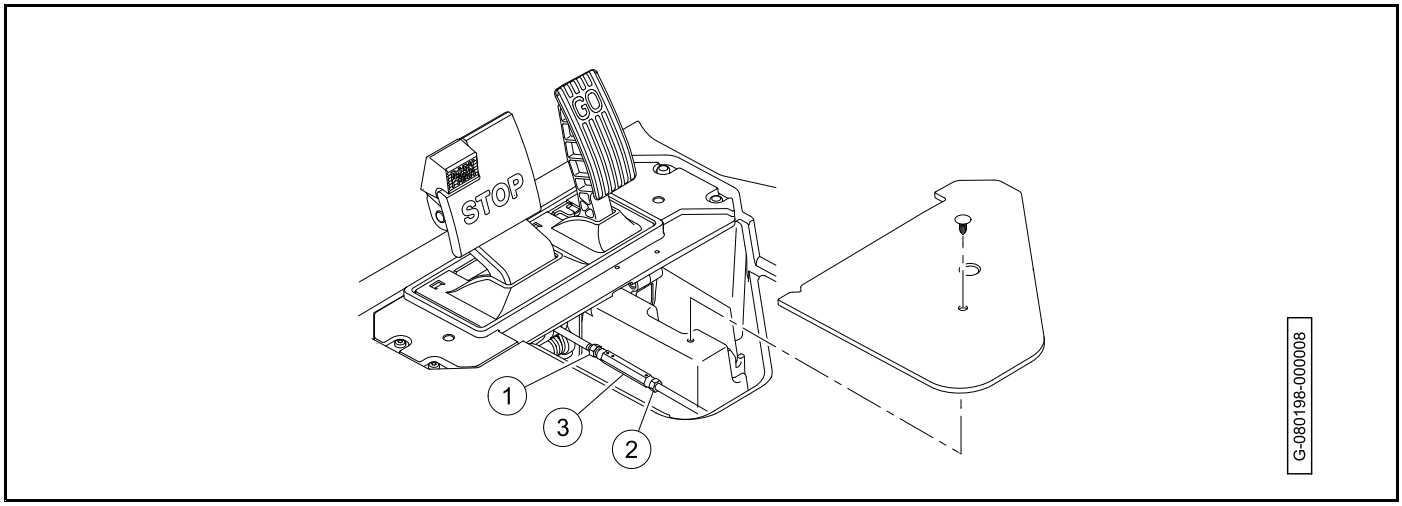


Figure 6-19

9. Loosen the turnbuckle (3) to release tension on the bell crank.
10. Remove the lugs nuts from the rear wheel.
11. Remove the rear wheel.

12. Remove and discard the bow tie pin (1) **(Figure 6-20)**.

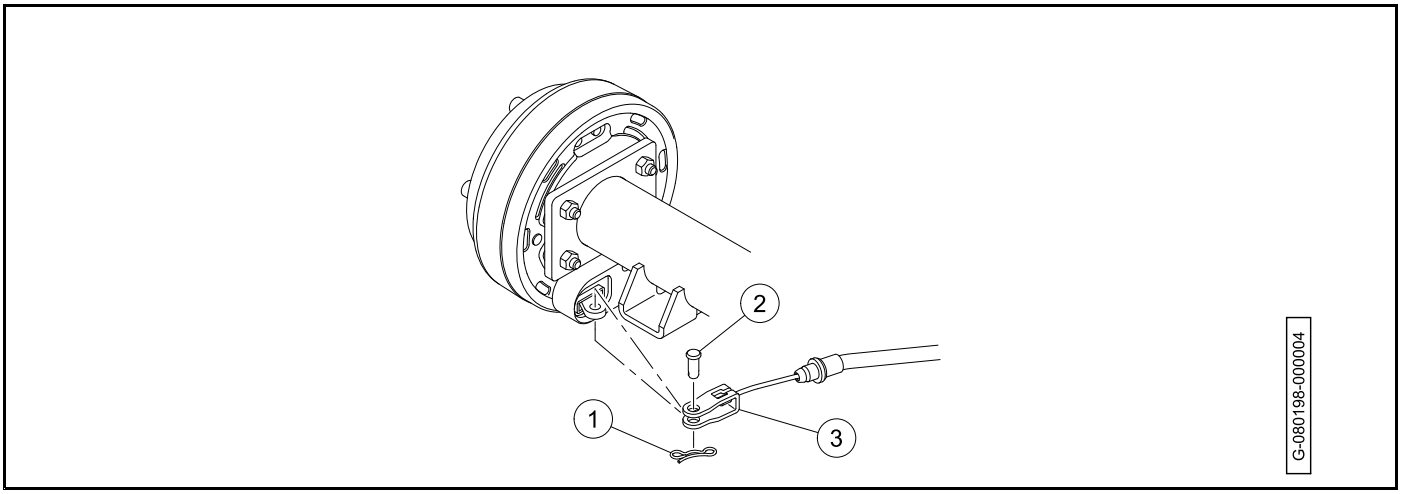


Figure 6-20

13. Remove the clevis pin (2).
14. Remove the brake cable (3) from the brake actuator arm.
15. Remove the brake drum (1) **(Figure 6-21)**. If the brake drum cannot be easily removed:

NOTE: *When servicing vehicles with severely worn brake shoes and when the drums cannot be removed by normal methods, use the following steps to minimize damage to the brake cluster and brake components.*

15.1. Use a 1/2 inch x 5/8 inch cold chisel to shear off the head of each pin (2).

NOTE: *This will release the shoes from the backing plate, allowing them to pivot away from the inside of the brake drum, which should then allow the brake drum to be pulled free.*

NOTE: *It may be necessary to remove the sealant material around the head of each pin.*

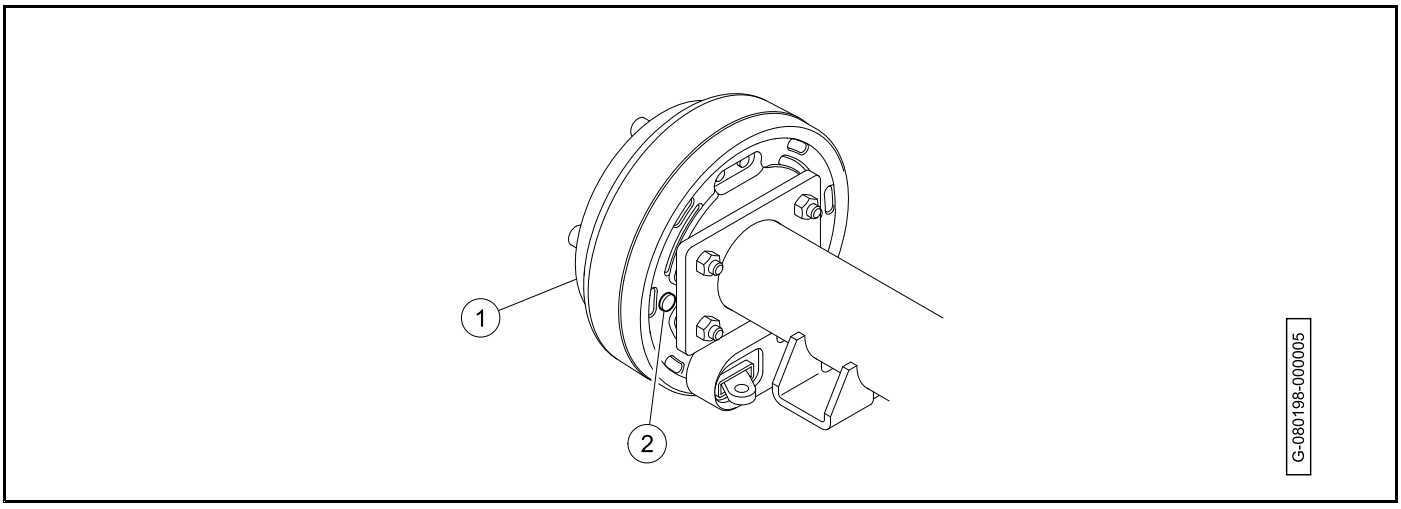


Figure 6-21

15.2. Remove the brake drum.
16. Remove the brake shoes.

17. **Electric Vehicle:** Remove the axle shaft.
    Gasoline Vehicle: Remove the wheel hub assembly.
18. Remove the bolts (1) and lock nuts (2) **(Figure 6-22)**. Discard the lock nuts.

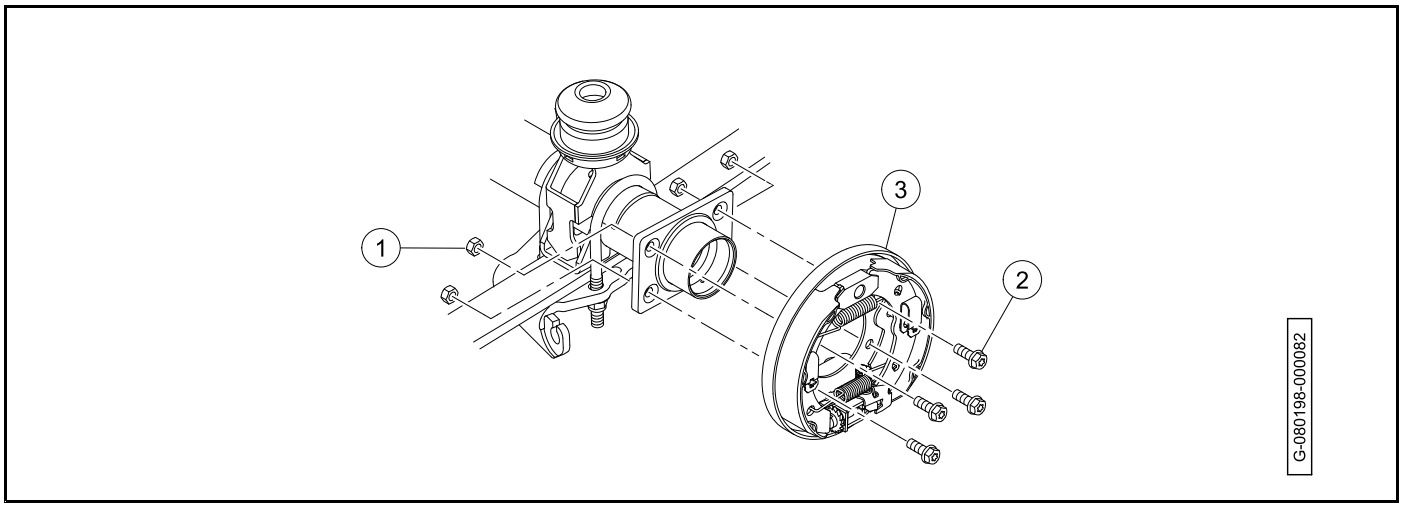


Figure 6-22

19. Remove the brake cluster (3).

BRAKE CLUSTER INSTALLATION

⚠ CAUTION

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

1. Install the brake cluster (1) on the spindle **(Figure 6-23)**.

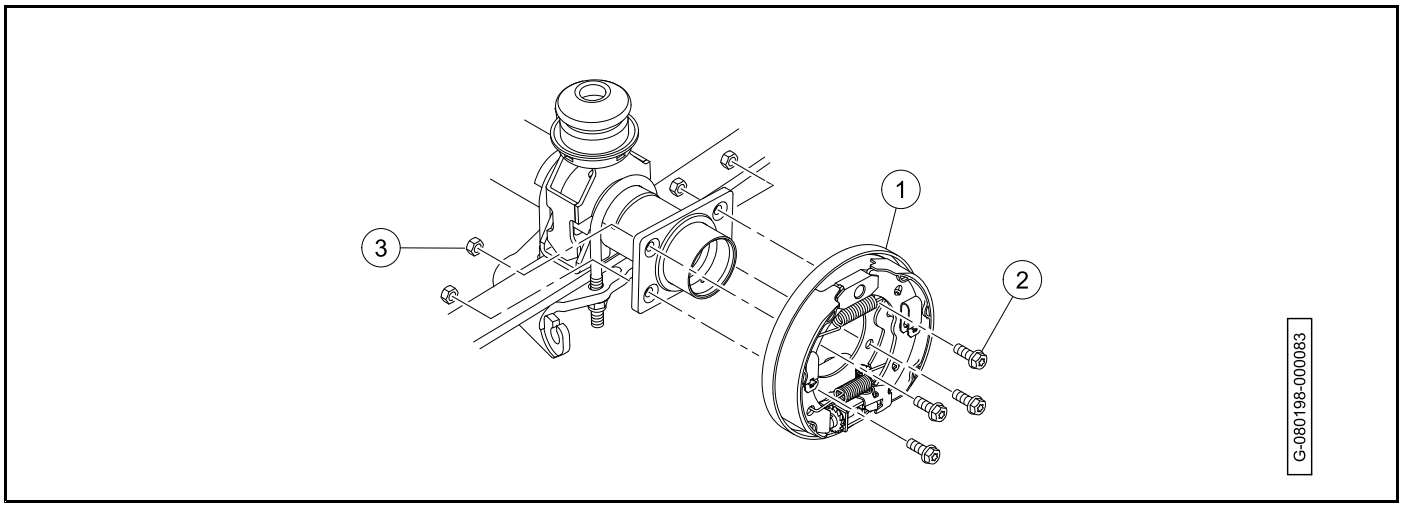


Figure 6-23

2. Install the bolts (2) and new lock nuts (3). Tighten the bolts to 30 lb·ft (40.6 N·m).
3. If the retainer pins were sheared during removal, install new retainer pins. Install the shoe retainer clips.

4. **Electric Vehicle:** Install the axle shaft.
   Gasoline Vehicle: Install the wheel hub assembly.
5. Install the brake drum.
6. Install the brake cable (1) on the brake actuator arm **(Figure 6-24)**.

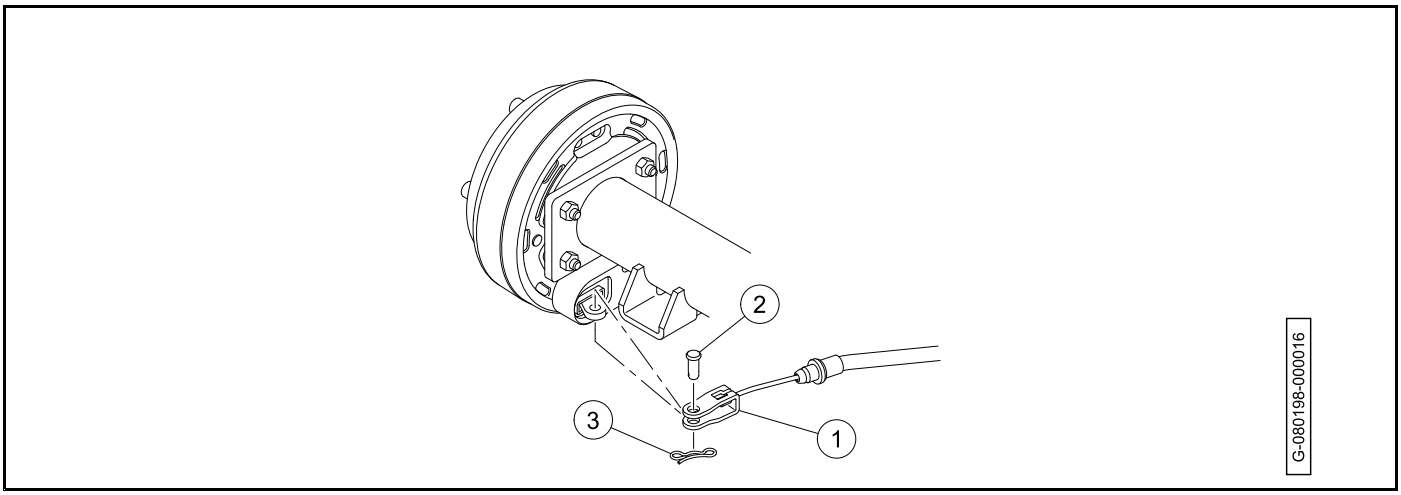


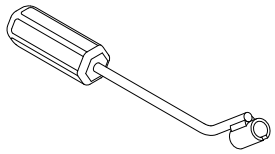
Figure 6-24

7. Install the brake cable clevis pin (2).
8. Install the new bow tie pin (3).
9. Install the rear wheels.
10. Lower the rear of the vehicle.
11. Adjust the brake cable equalizer.
12. Install the pedal access panel.
13. Install the floor mat.
14. **Electric Vehicle:** Connect the batteries.
    Gasoline Vehicle: Connect the battery and spark plug wire.

BRAKE CABLE

BRAKE CABLE REMOVAL

Special Tools Needed

 G-170096-000002	Brake Cable Release Tool

NOTE: *Refer to the Illustrated Parts Catalog for service tool part numbers.*

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect the battery and spark plug wire.
3. Remove the floor mat.
4. Remove the pedal access panel.
5. Loosen the left-hand thread jam nut (1) and right-hand thread jam nut (2) 1/2 inch (12.7 mm) away from the turnbuckle (3).

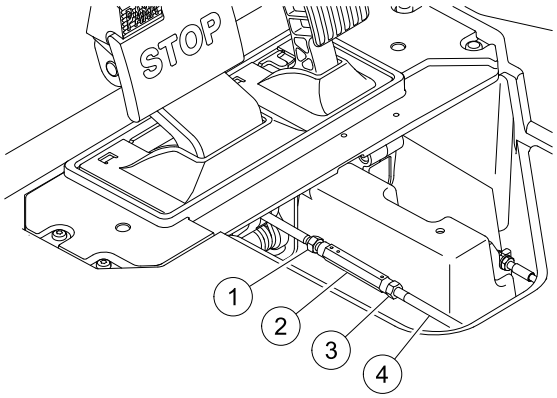


Figure 6-25

6. Remove the turnbuckle from the brake actuator rod (4).

7. Lift the brake actuator rod and equalizer bracket (1) **(Figure 6-26)**.

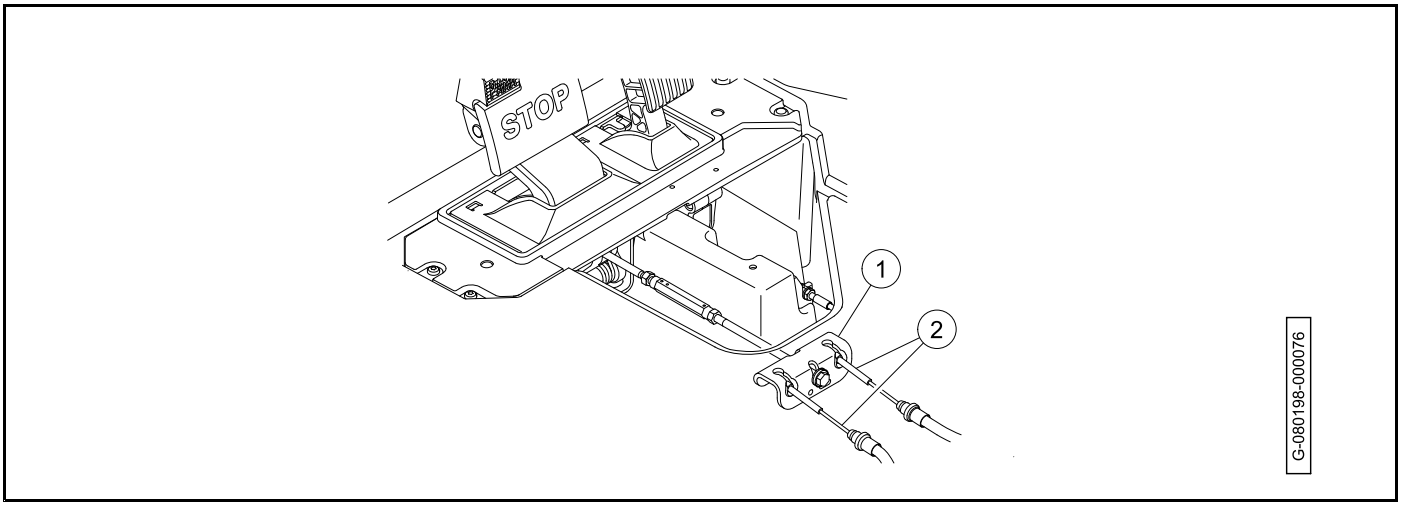


Figure 6-26

8. Remove the brake cables (2) from the equalizer bracket.
9. Remove the nut (1) **(Figure 6-27)**. Do not remove bolt (2).

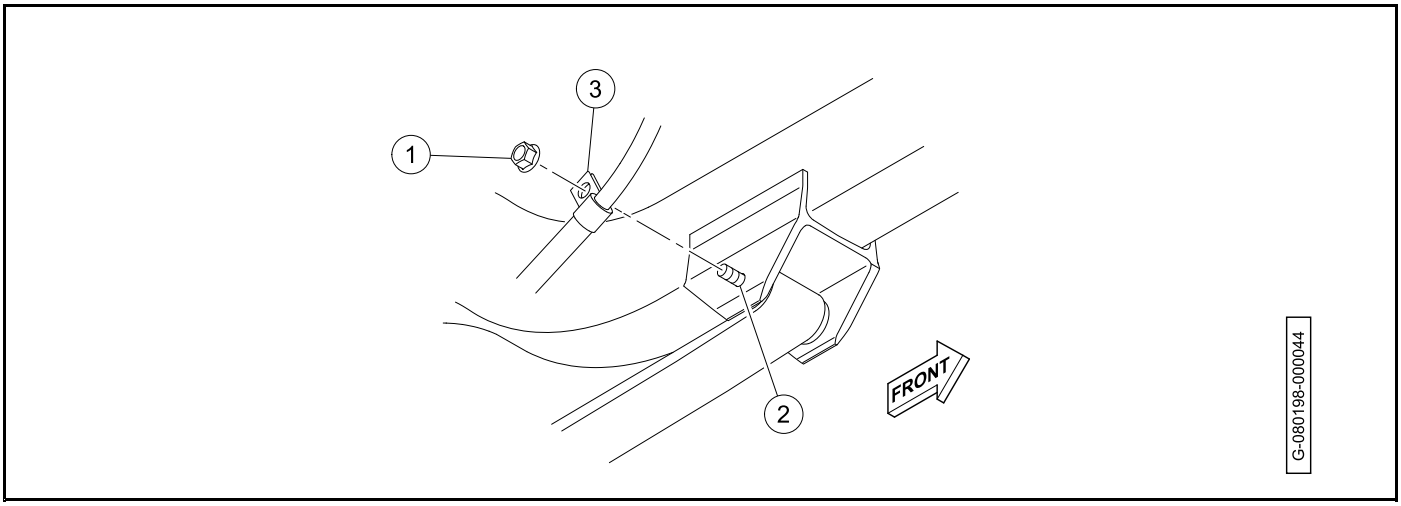


Figure 6-27

10. Remove the mounting tab (3) of the brake cable from the bolt.

11. Use a brake cable release tool to compress the retaining clips (1) on the end of the cable housing enough to slide the cable end out of the hole in the frame **(Figure 6-28)**.

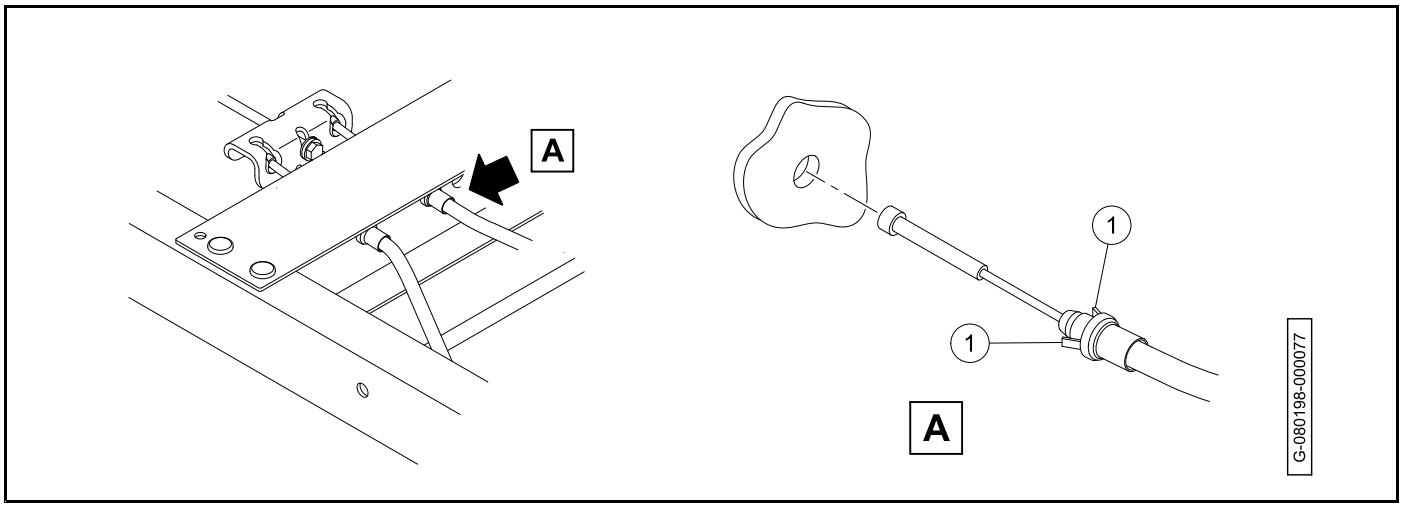


Figure 6-28

12. Remove and discard the bow tie locking pin (1) **(Figure 6-29)**.

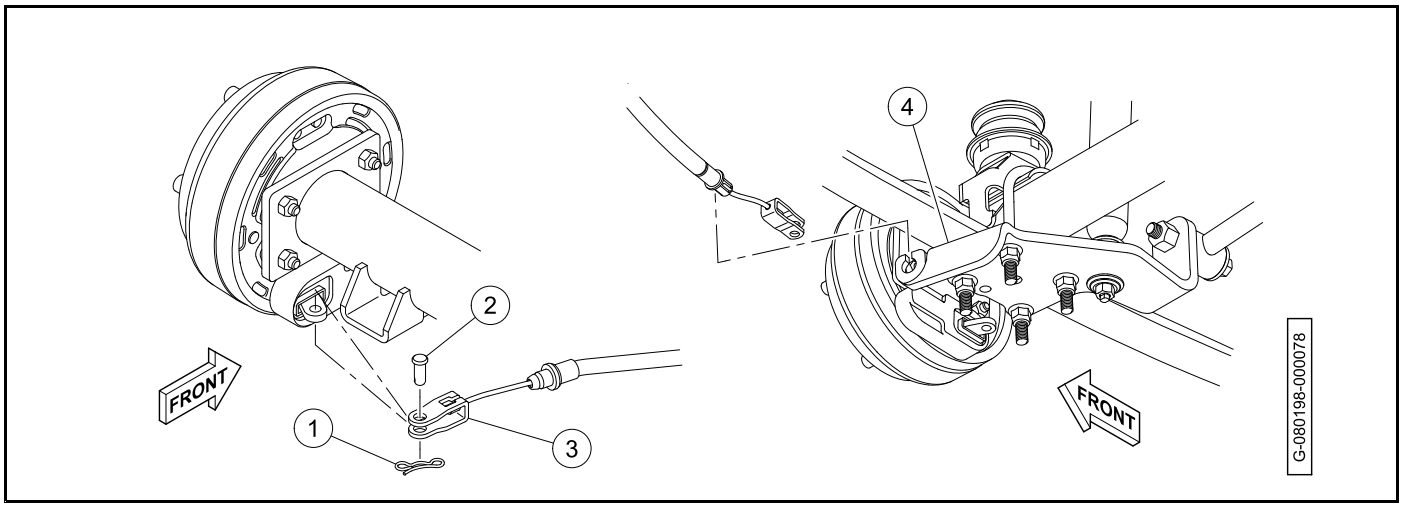


Figure 6-29

13. Remove the clevis pin (2).
14. Remove the brake cable (3) from the brake actuator arm.
15. Use a brake cable release tool to compress the retaining clips on the end of the cable housing enough to slip the cable end out of the bracket (4) and remove the brake cable from the vehicle.

BRAKE CABLE INSTALLATION

NOTE: *The driver-side and passenger-side brake cables are not interchangeable. The driver-side cable is shorter than the passenger-side cable. Make sure the correct cable is used on the correct side.*

Be sure to orient the cable so that the clevis end goes to the wheel rather than to the equalizer bracket.

1. Insert the end of the new brake cable through the hole in the frame **(Figure 6-30)**. Push on the cable housing so the clips on the housing ends secure the housing in the hole.

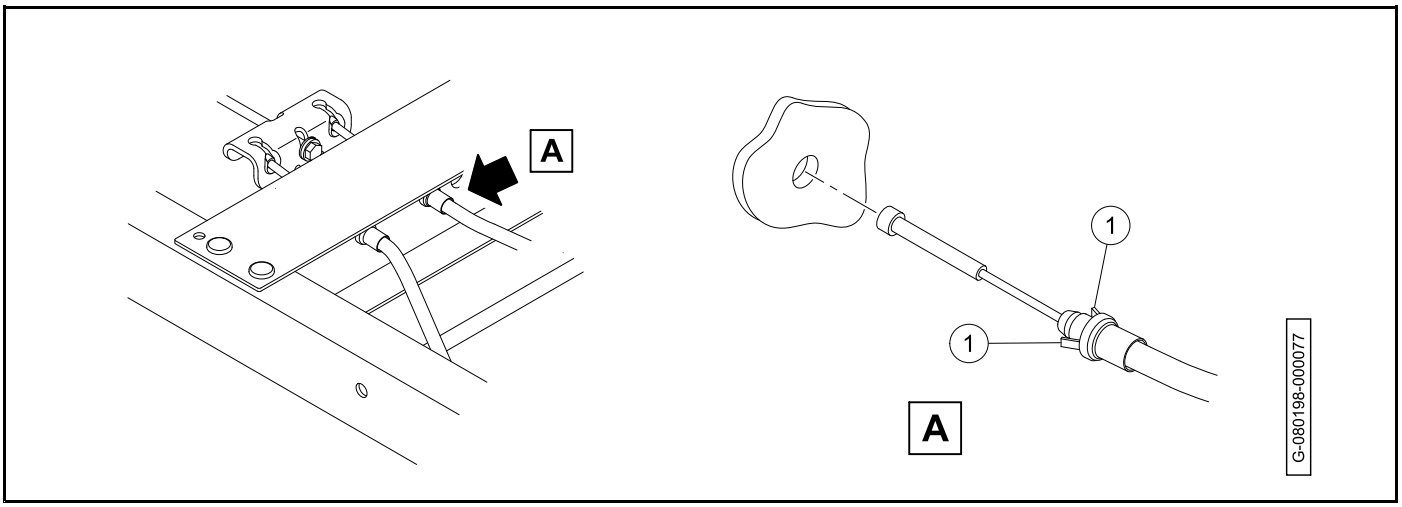


Figure 6-30

2. Hold the brake actuator rod (1) and the equalizer bracket (2) in the upright position and slip the cable head through the hole on top of the bracket. Pivot the equalizer to the horizontal position to capture the cable heads in the equalizer.

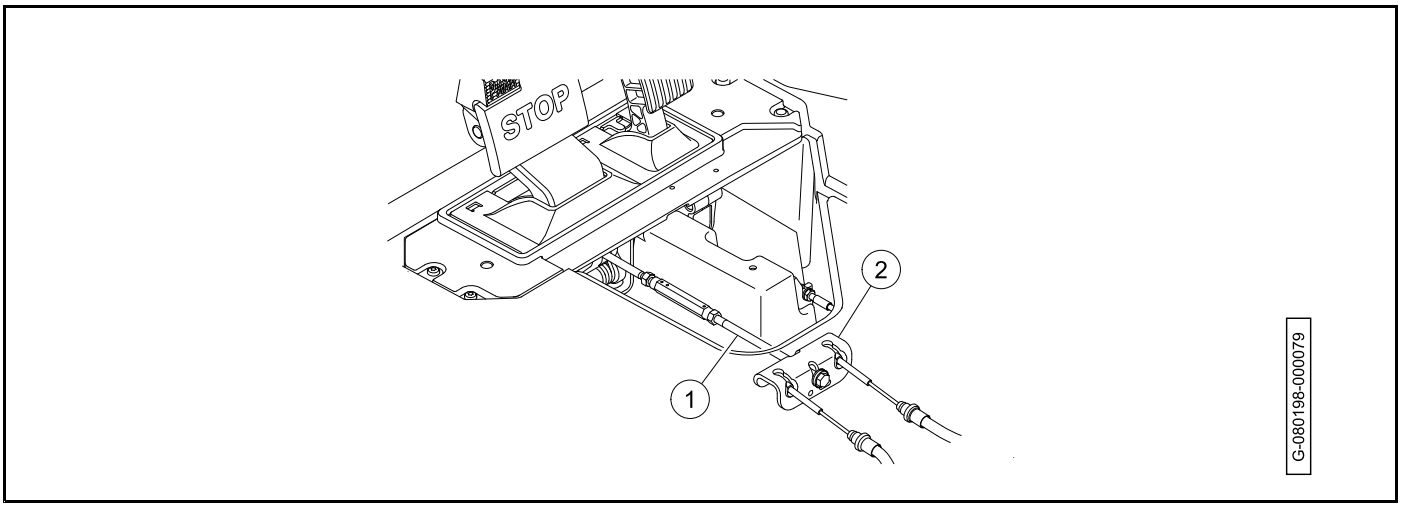


Figure 6-31

3. Insert the rear cable housing into the shock mount bracket (1) **(Figure 6-32)**.

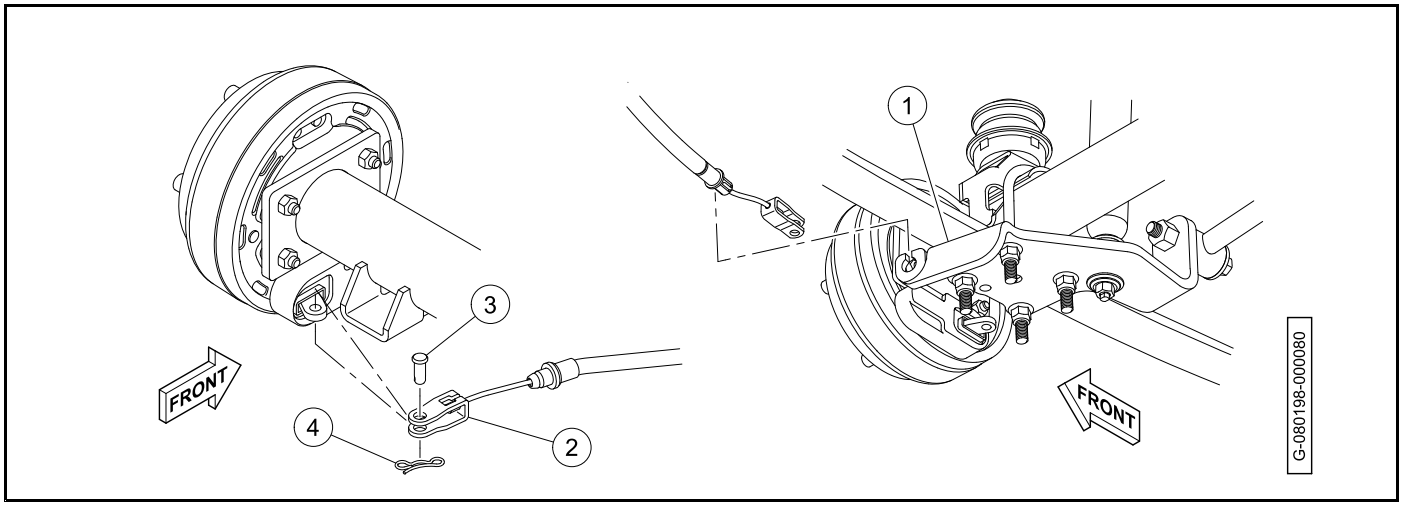


Figure 6-32

4. Make sure that the clips on the housing end secure the cable in position.
5. Install the brake cable (2) on the brake actuator arm.
6. Install the brake cable clevis pin (3).
7. Install the new bow tie pin (4).
8. Install the clamp (1) on the leaf spring bolt (2) **(Figure 6-33)**.

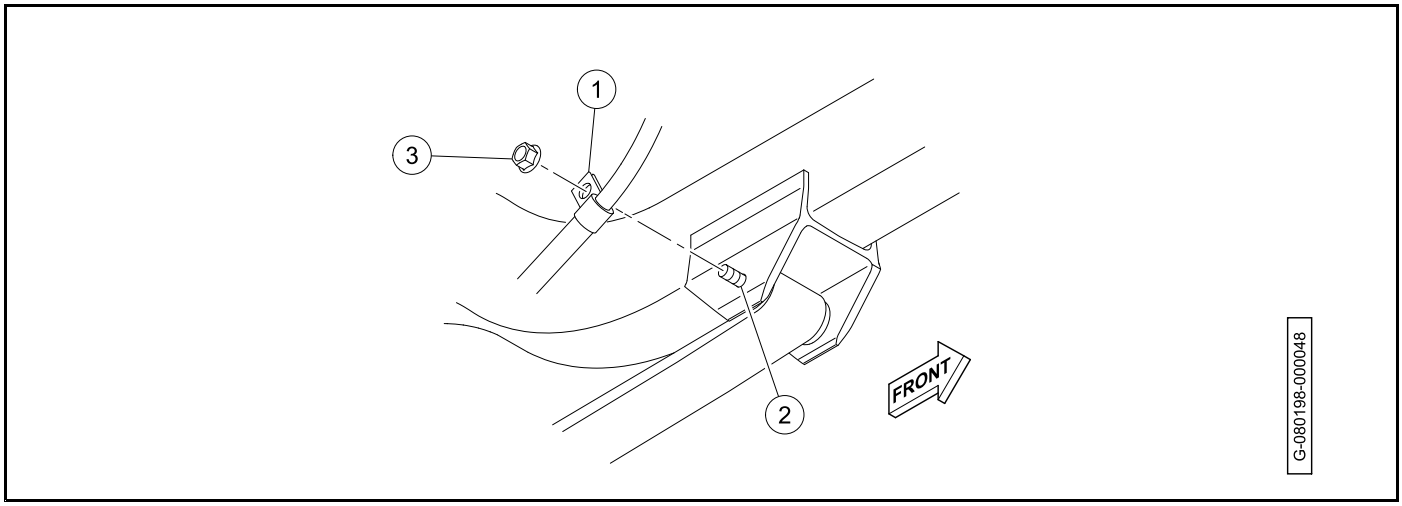


Figure 6-33

9. Install the nut (3). Tighten the nut to 18.4 lb·ft (25 N·m).
10. Adjust the brake cable equalizer.
11. **Electric Vehicle:** Connect the batteries.
    Gasoline Vehicle: Connect the battery and spark plug wire.

SECTION 7 — STEERING AND FRONT SUSPENSION

7

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

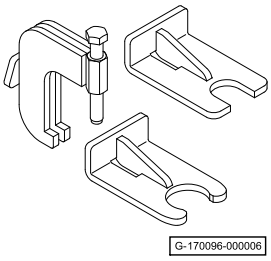
GENERAL INFORMATION

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

STEERING WHEEL REMOVAL

Special Tools Needed

 G-170096-000006	Steering Wheel Puller Tool

NOTE: *Refer to the Illustrated Parts Catalog for service tool part numbers.*

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect battery and spark plug wire.
3. Rotate steering wheel to a straight ahead position.

CAUTION

- **Do not turn the steering until the steering wheel has been installed.**

4. Remove the screws (1) **(Figure 7-1)**.

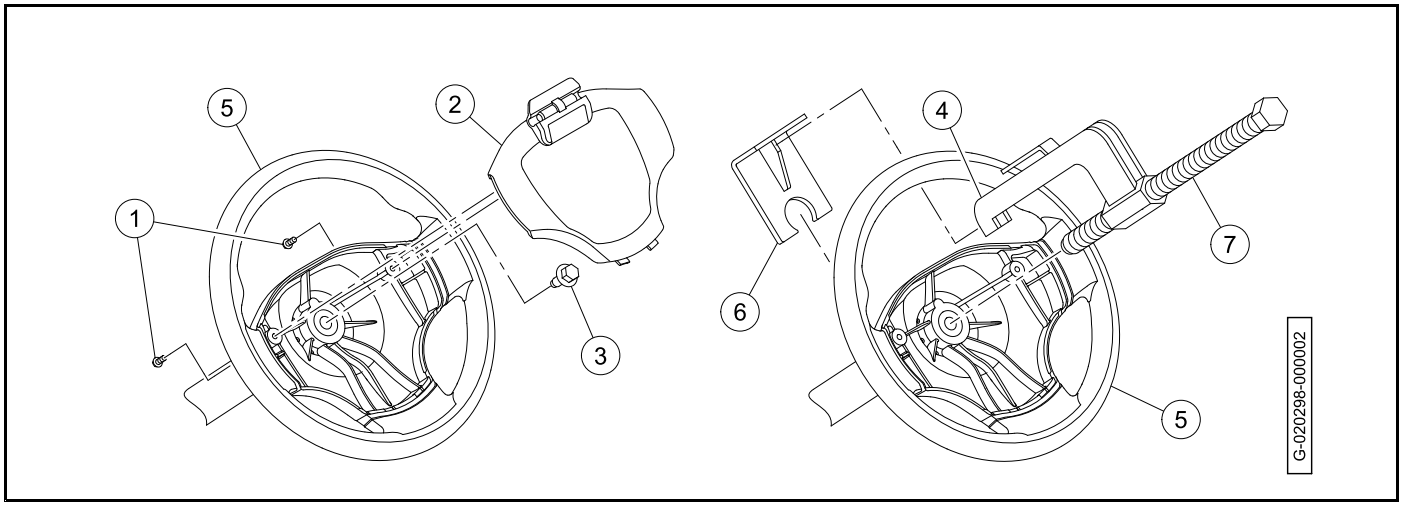


Figure 7-1

5. Remove the cover (2).
6. Remove the steering wheel retaining bolt (3).
7. Put the puller anvil (4) through the top opening of the steering wheel (5).
8. Insert the anvil feet through the two slots in the base plate (marked “B”) (6).
9. Turn the anvil screw (7) clockwise until the base plate contacts the bottom of the steering wheel at the steering column.
10. Use a 1/2-inch drive air impact wrench to tighten the anvil screw until the steering wheel releases from the steering shaft.
11. Remove the steering wheel from the steering column.

STEERING WHEEL INSTALLATION

1. Apply a small amount of oil or anti-seize compound to steering shaft (1) **(Figure 7-2)**.

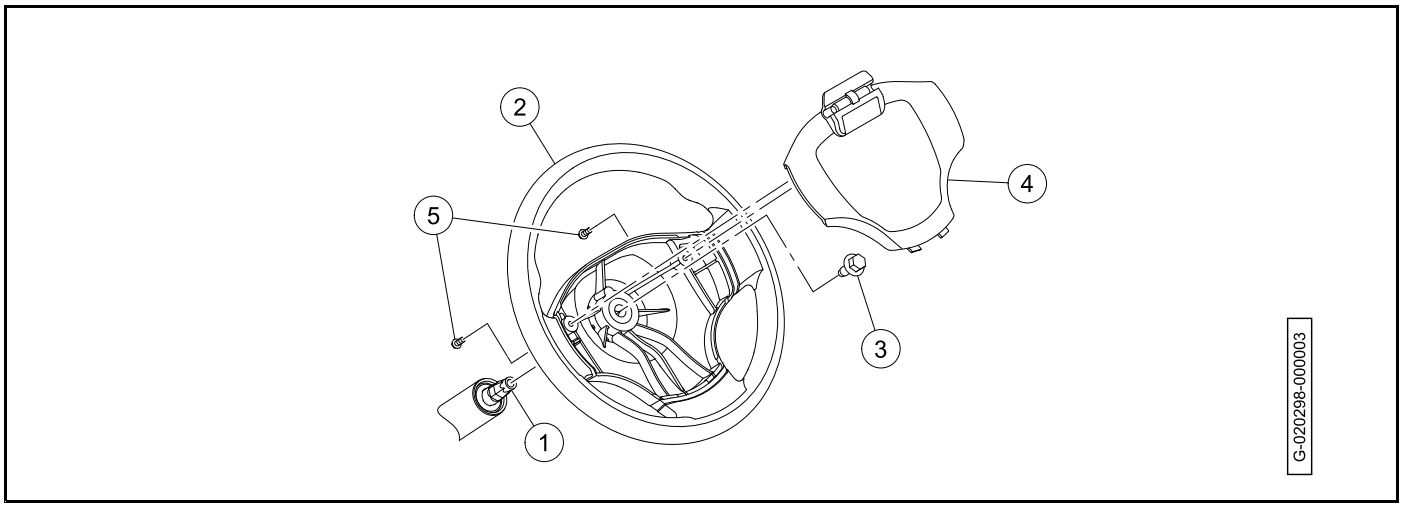


Figure 7-2

2. Install the steering wheel (2) on the steering shaft.

3. Install steering wheel retaining bolt (3). Tighten the bolt to 37 lb·ft (50 N·m).
4. Put the cover (4) on the steering wheel.
5. Install the screws (5). Tighten the screws to 15 lb·in (1.7 N·m).

STEERING COLUMN

STEERING COLUMN REMOVAL

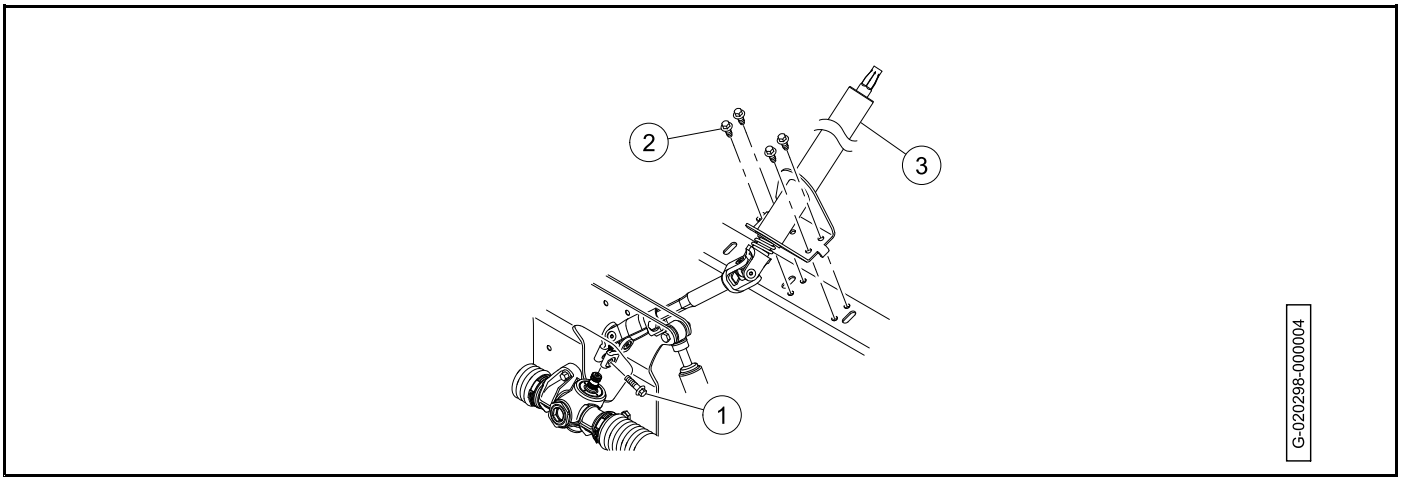


Figure 7-3 Steering Column Removal

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect battery and spark plug wire.
3. Remove the steering wheel.
4. Remove the dash insert, instrument panel, dash assembly, and front bumper.
5. Remove the bolt (1) **(Figure 7-3)**.
6. Remove the bolts (2).
7. Remove the steering column (3) from the vehicle.

STEERING COLUMN INSTALLATION

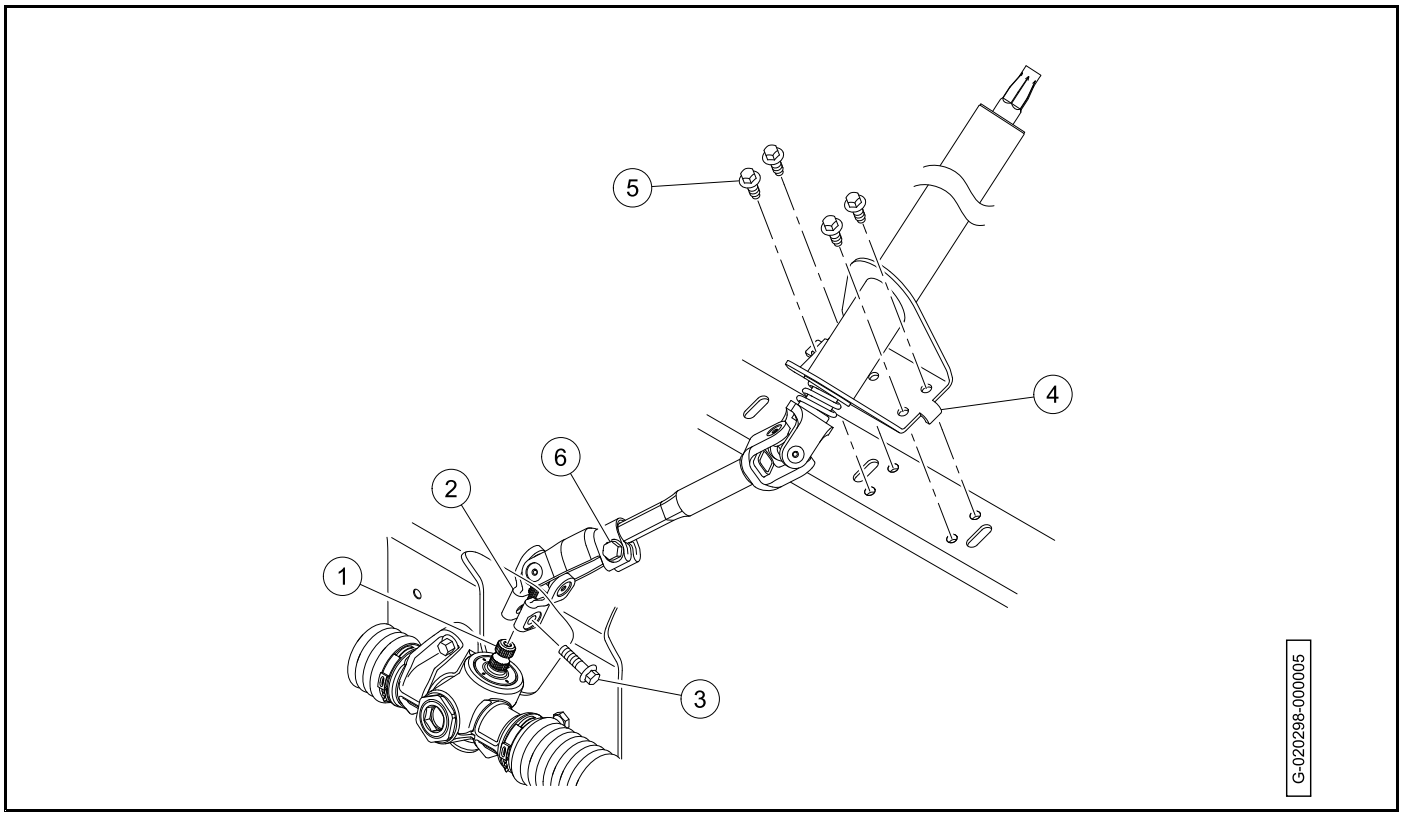


Figure 7-4 Steering Column Installation

1. Apply a light coat of anti-seize or lubricating compound to the pinion shaft (1) **(Figure 7-4)**.
2. Install the universal joint (2) onto pinion shaft.
3. Install the bolt (3) and tighten by hand. Do not fully tighten the bolt.
4. Install the steering column mounting bracket (4) on the vehicle frame.
5. Install the bolts (5). Tighten the bolts to 18.4 lb·ft (25 N·m).
6. Tighten the bolt (3) to 18.4 lb·ft (25 N·m).
7. Make sure that the upper universal joint bolt (6) is tighten to 18.4 lb·ft (25 N·m).
8. Install front bumper, dash assembly, dash insert, and instrument panel.
9. Install the steering wheel.
10. **Electric Vehicle:** Connect the batteries.
    Gasoline Vehicle: Connect the battery and spark plug wire.

RACK AND PINION

CAUTION

- **Front impacts that bend tie rods and/or drag links can possibly damage internal steering gear components. 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 Tow-in Adjustment.**
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.

NON-LIFTED RACK AND PINION REMOVAL

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect the battery and spark plug wire.
3. Remove the front bumper.
4. Remove the tie rod end retaining nuts (1) **(Figure 7-5, Page 7-5)**.

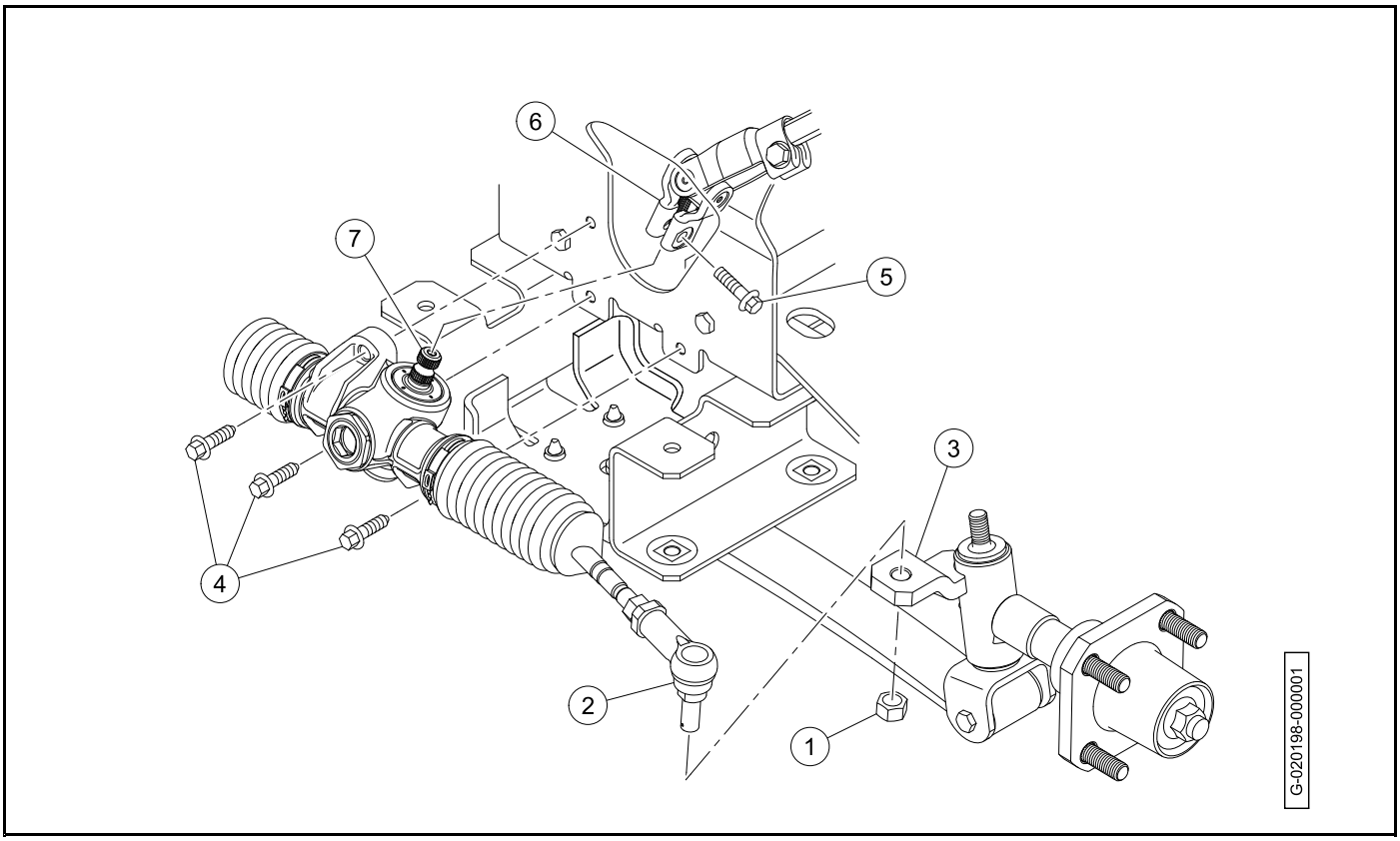


Figure 7-5

5. Remove the tie rod ends (2) from the spindle tabs (3).
6. Remove the bolts (4).
7. Remove the bolt (5) from the universal joint (6).

8. Remove the universal joint from the pinion shaft (7).
9. Remove the rack and pinion assembly.

NON-LIFTED RACK AND PINION INSTALLATION

1. Apply a light coat of anti-seize lubricating compound to the pinion shaft (1) **(Figure 7-6)**.

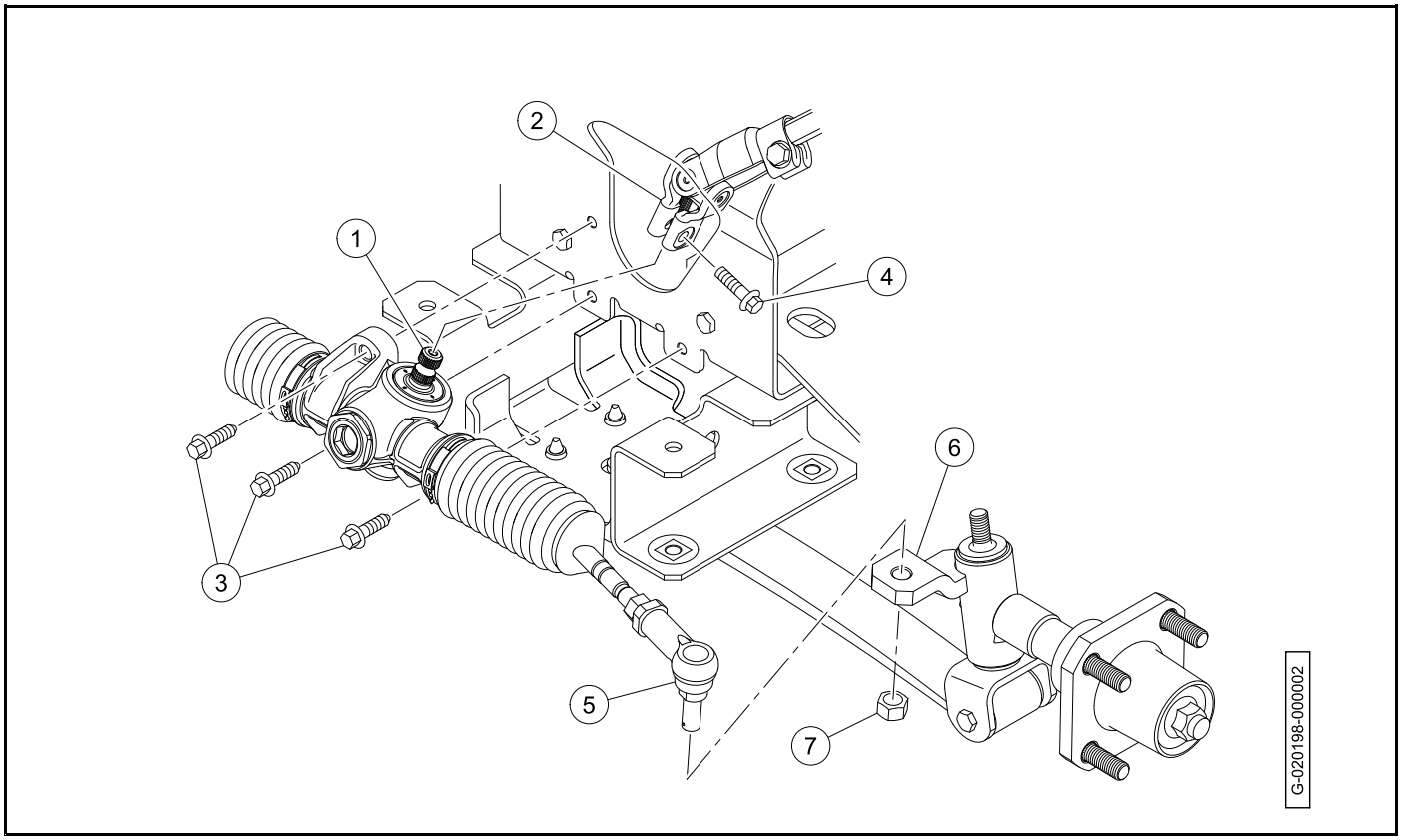


Figure 7-6 Rack and Pinion Installation

2. Install the universal joint (2) onto the pinion shaft.
3. Install the screws (3). Tighten the screws to 22 lb·ft (30 N·m).
4. Install the bolt (4). Tighten the bolt to 18.4 lb·ft (25 N·m).
5. Install the tie rod ends (5) into the spindle tabs (6)
6. Install the retaining nuts (7).

⚠ WARNING

- **Do not operate vehicle until toe-in is adjusted and ball joints are secured.**

7. Adjust the toe-in. **See Tow-in Adjustment.**
8. **Electric Vehicle:** Connect the batteries.
   Gasoline Vehicle: Connect the battery and spark plug wire.
9. Test drive the vehicle before returning it to service.

LIFTED RACK AND PINION REMOVAL

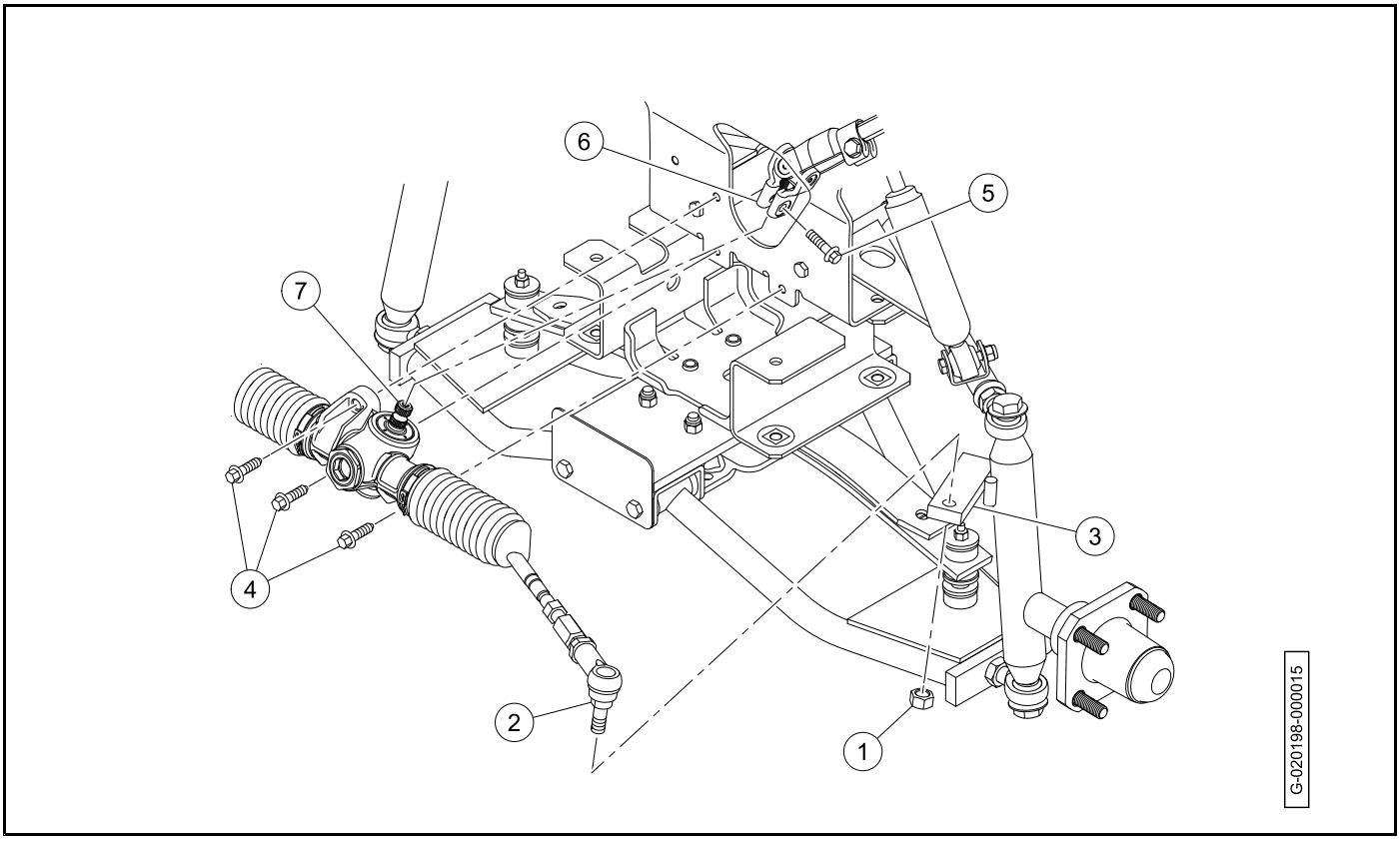


Figure 7-7

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect the battery and spark plug wire.
3. Remove the front bumper.
4. Remove the tie rod end retaining nuts (1) **(Figure 7-5, Page 7-5)**.
5. Remove the tie rod ends (2) from the spindle tabs (3).
6. Remove the bolts (4).
7. Remove the bolt (5) from the universal joint (6).
8. Remove the universal joint from the pinion shaft (7).
9. Remove the rack and pinion assembly.

LIFTED RACK AND PINION INSTALLATION

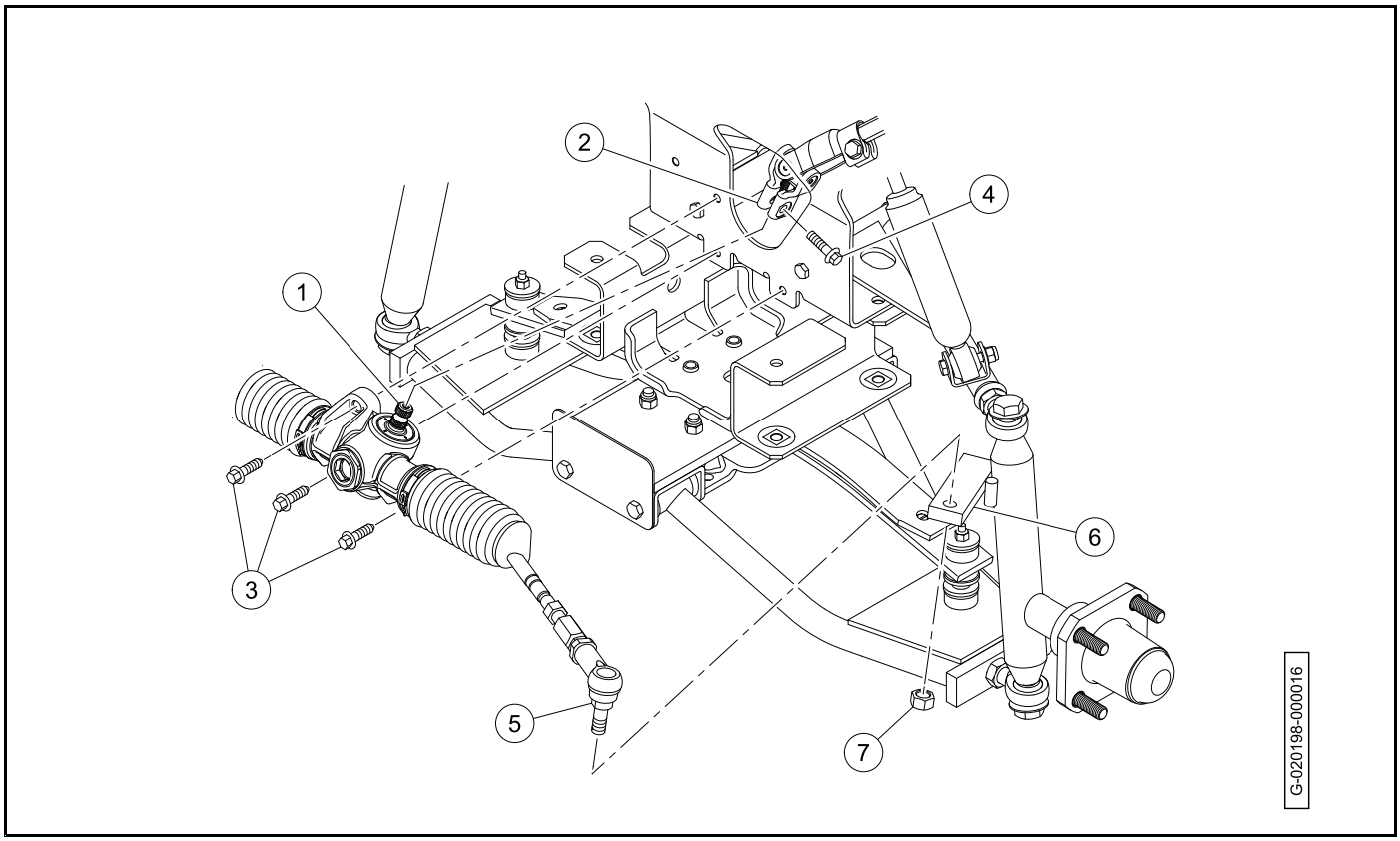


Figure 7-8 Rack and Pinion Installation

1. Apply a light coat of anti-seize lubricating compound to the pinion shaft (7) **(Figure 7-6)**.
2. Install the universal joint (6) onto the pinion shaft.
3. Install the screws (4). Tighten the screws to 22 lb·ft (30 N·m).
4. Install the bolt (5). Tighten the bolt to 18.4 lb·ft (25 N·m).
5. Install the tie rod ends (2) into the spindle tabs (3)
6. Install the retaining nuts (1).

⚠ WARNING

- **Do not operate vehicle until toe-in is adjusted and ball joints are secured.**

7. Adjust the toe-in. **See Tow-in Adjustment.**
8. **Electric Vehicle:** Connect the batteries.
   Gasoline Vehicle: Connect the battery and spark plug wire.
9. Test drive the vehicle before returning it to service.

FRONT SUSPENSION

See General Warnings on page 1-2.

LUBRICATION

Two grease fittings are provided (one in each spindle housing). Lubricate these fittings at the recommended interval with the proper lubricant. **See Periodic Lubrication Schedules on page 10-8.**

CAUTION

- **To ensure proper lubrication, raise front of vehicle to lubricate. See General Warnings on page 1-2.**

NON-LIFTED SUSPENSION WHEEL ALIGNMENT

Wheel alignment is limited to equalizing the camber angle of each front wheel and adjusting toe-in of the front wheels.

CAUTION

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

Camber Adjustment

1. Park the vehicle on a solid level surface.
2. Check each front wheel with a framing square. At the floor, there should be an equal amount of space (A) between each tire and the framing square **(Figure 7-9)**.

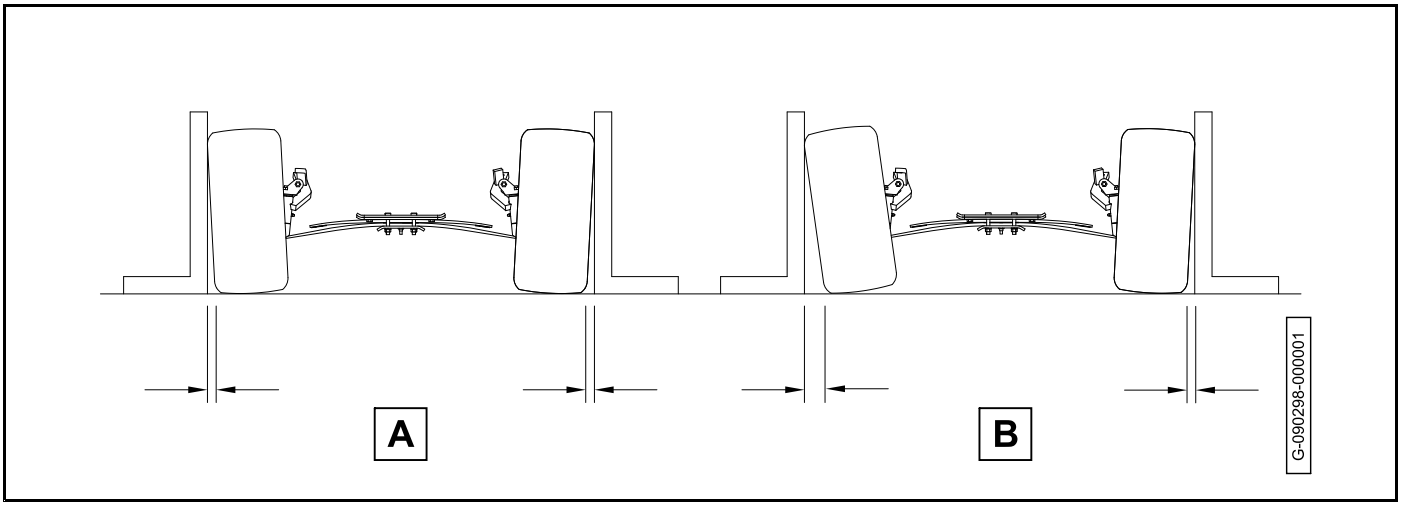


Figure 7-9 Check Camber

3. If there is not an equal amount of space (B) between each tire and the framing square **(Figure 7-9)**, go to step 4.
4. Loosen the four bolts (1). Do not remove the bolts **(Figure 7-10)**.

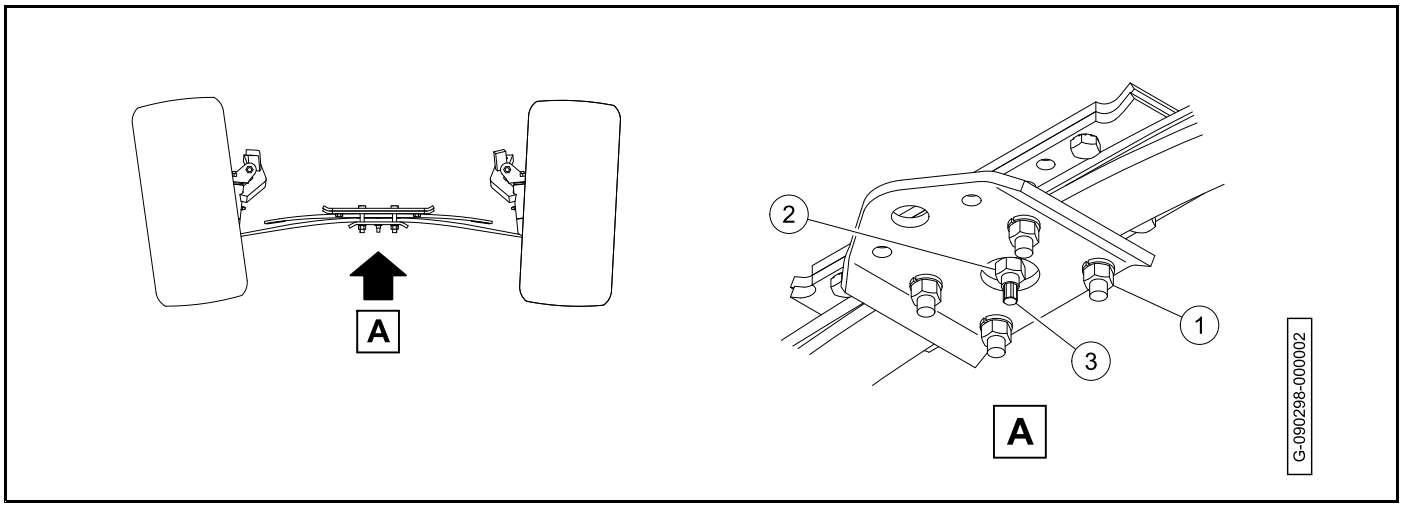


Figure 7-10 Adjust Camber

5. Loosen the nut (2) on the adjustment eccentric (3) in the center of the spring. Do not remove the nut.
6. Use a 7 mm deep well socket to rotate the adjustment eccentric and adjust the camber.
7. Tighten the four bolts in a crisscross pattern to 37 lb·ft (50 N·m).
8. Move the vehicle forward one full tire revolution.
9. Check the camber.
10. When the camber adjustment is complete, tighten the nut on the adjustment eccentric to 10 lb·ft (13.5 N·m).

Toe-in Adjustment

1. Park the vehicle on a solid level surface.
2. Roll the vehicle forward, then stop the vehicle.
3. Make sure the front wheels are pointed straight ahead.

CAUTION

- **Do not turn the steering wheel again during this procedure.**

4. On each front tire, mark (as closely as possible) the center of the tread face that is toward the rear of the vehicle. The marks should be even with the bottom surfaces of the vehicle frame.
5. Measure the distance between the marks on the rear-facing surfaces of the tires.
6. 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.

7. Measure the distance between the marks on the forward-facing surfaces of the tires **(Figure 7-11)**.

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

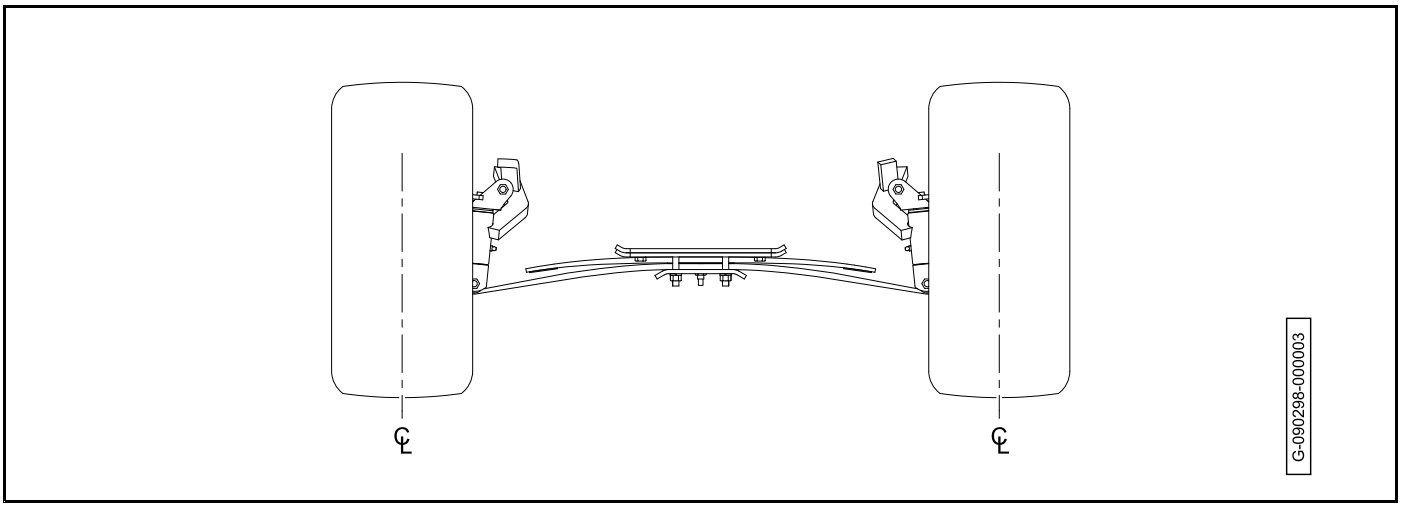


Figure 7-11

8. 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 3/8 inch (±1/8) (9.5 mm (±3.2)).
9. If toe-in adjustment is necessary:

9.1. Loosen the jam nuts (1) on both ends of each drag link (2) **(Figure 7-12)**.

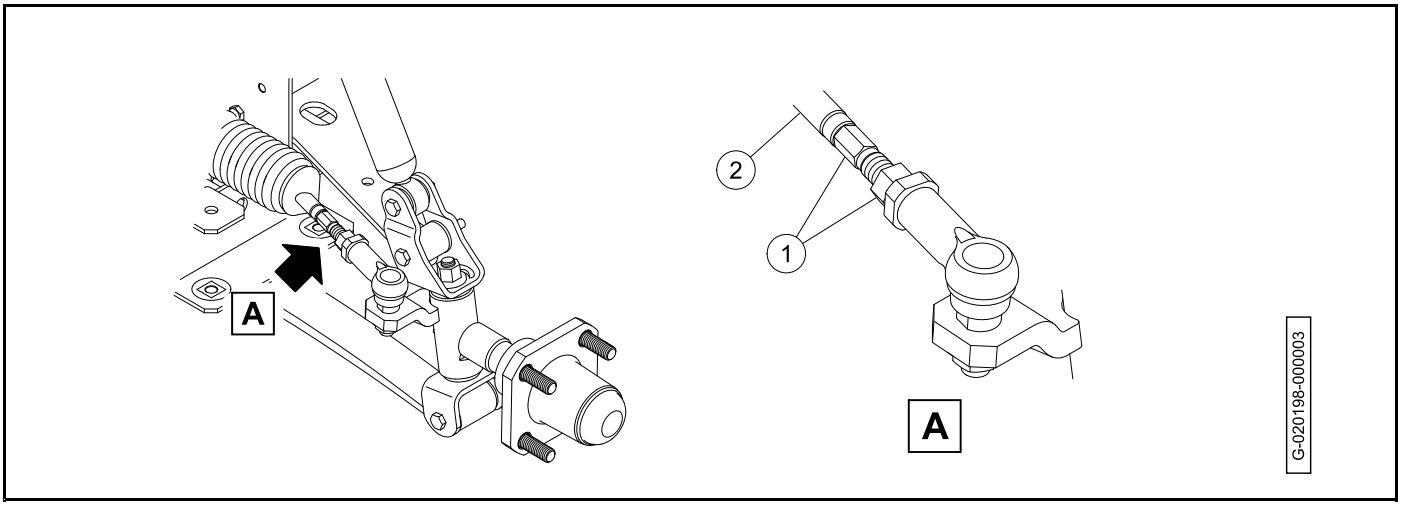


Figure 7-12

9.2. To increase the toe-in, rotate both drag links equally counterclockwise.

9.3. To decrease the toe-in, rotate both drag links equally clockwise.

9.4. Maintain an equal distance from the ball joint to the end of the threads on each drag link **(Figure 7-13)**.

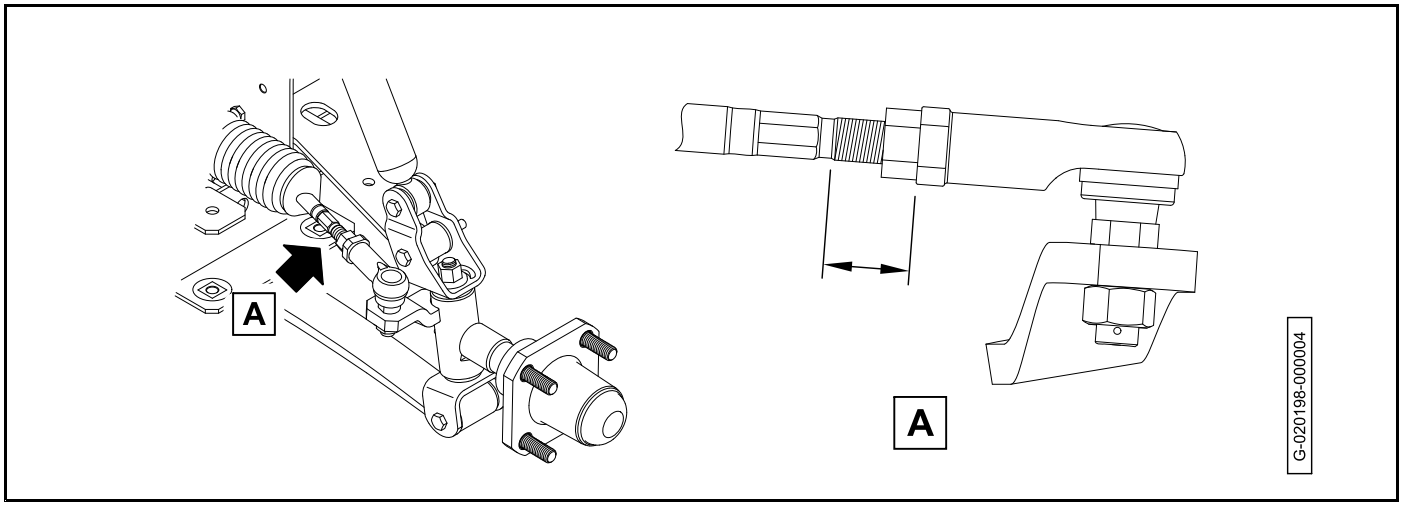


Figure 7-13

9.5. Tighten the jam nuts on both ends of each drag link to 26 lb·ft (35 N·m).

9.6. Check the toe-in.

9.7. Repeat the adjustment procedure if necessary.

9.8. After the 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.

LIFTED SUSPENSION WHEEL ALIGNMENT

The alignment specifications are zero camber and zero toe-in for this vehicle.

NOTE: *Roll vehicle forward and backwards (minimum 1 tire revolution) prior to measuring camber and toe-in and after each adjustment.*

Insure steering wheel remains straight during the entire alignment process.

Camber Adjustment

1. Center the steering wheel making sure the number of turns in a full right turn vs a full left turn is approximately equal.

2. Check each front wheel with a framing square **(Figure 7-14, Page 7-13)**.

NOTE: *Do not torque hardware until after all adjustments have been made.*

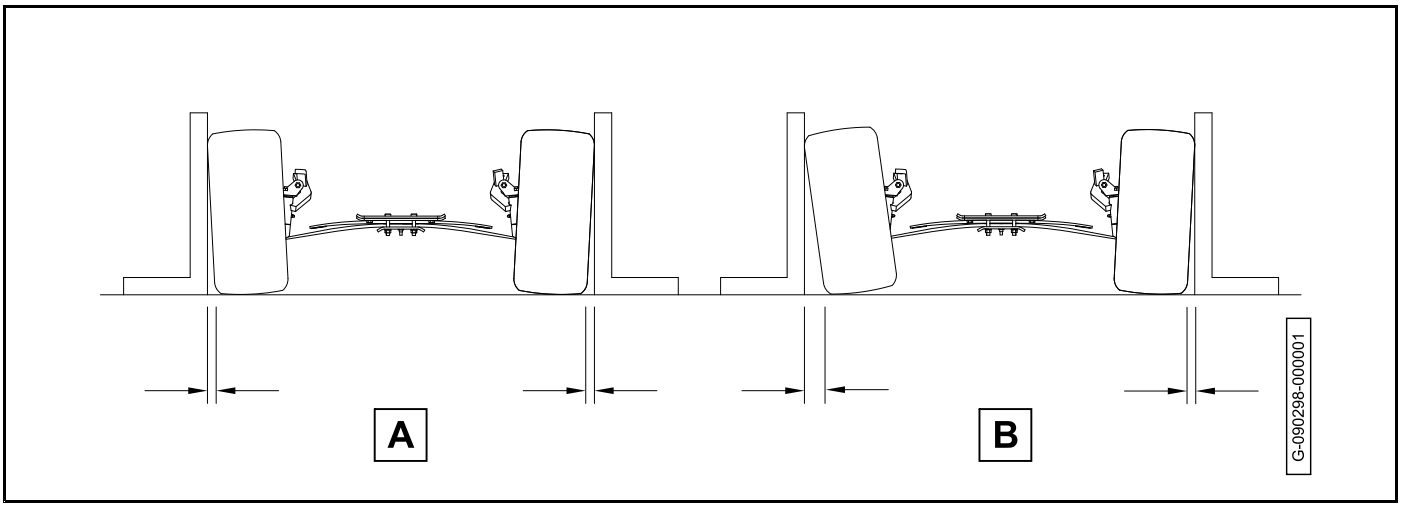


Figure 7-14

3. To adjust the camber, raise the front of the vehicle and place it on jack stands.
4. Remove the bottom hex-head bolt (1) that secures the lower a-arm (2) to the bottom of the spindle **(Figure 7-15, Page 7-13)**.

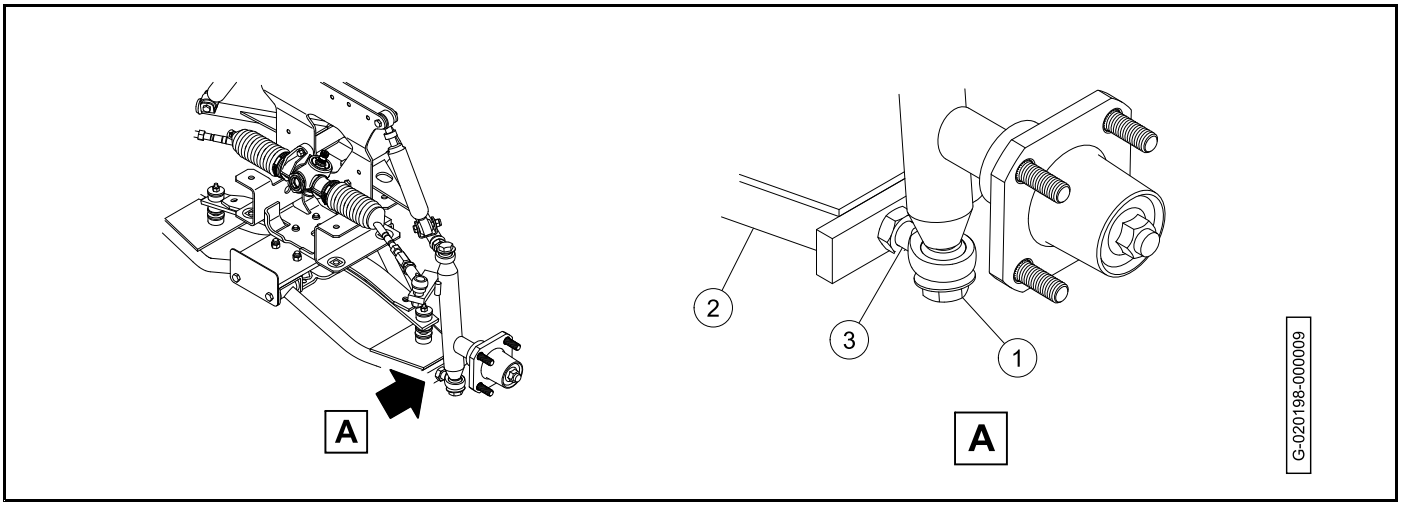


Figure 7-15

5. Adjust the bottom rod end (3) in the appropriate direction and secure with the jam nuts. Snug hardware but do not torque until alignment is complete .

6. Make sure both ends of the spindles are correctly centered on the swivel ball of the rod ends **(Figure 7-16, Page 7-14)**. Detail A is correct. Detail B is incorrect.

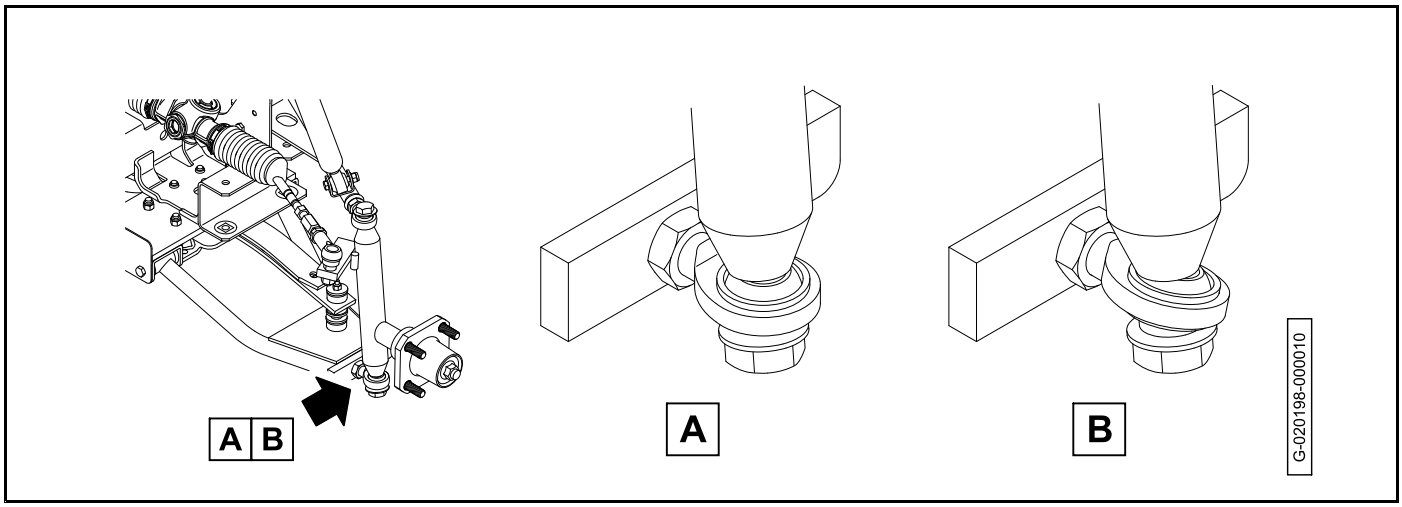


Figure 7-16

7. Add thread locker to the bottom hex-head bolt (1) that secures the lower a-arm to the bottom of the spindle and reinstall **(Figure 7-17, Page 7-14)**. Snug hardware but do not torque until alignment is complete.

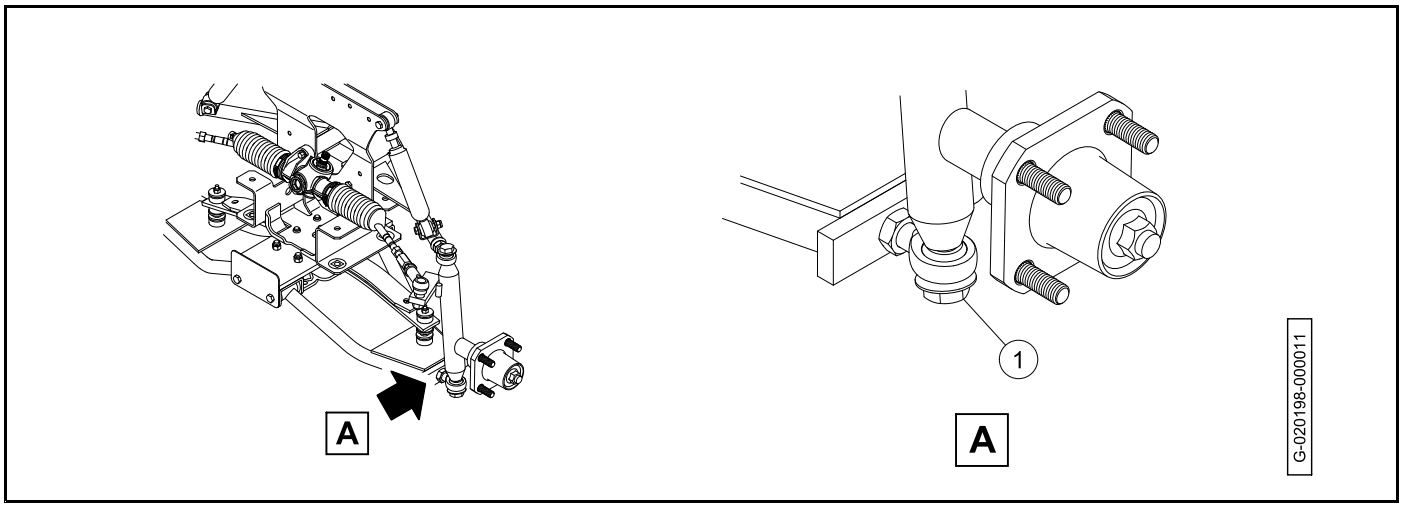


Figure 7-17

8. Lower the vehicle and check the camber.

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 **(Figure 7-18, Page 7-15)**.

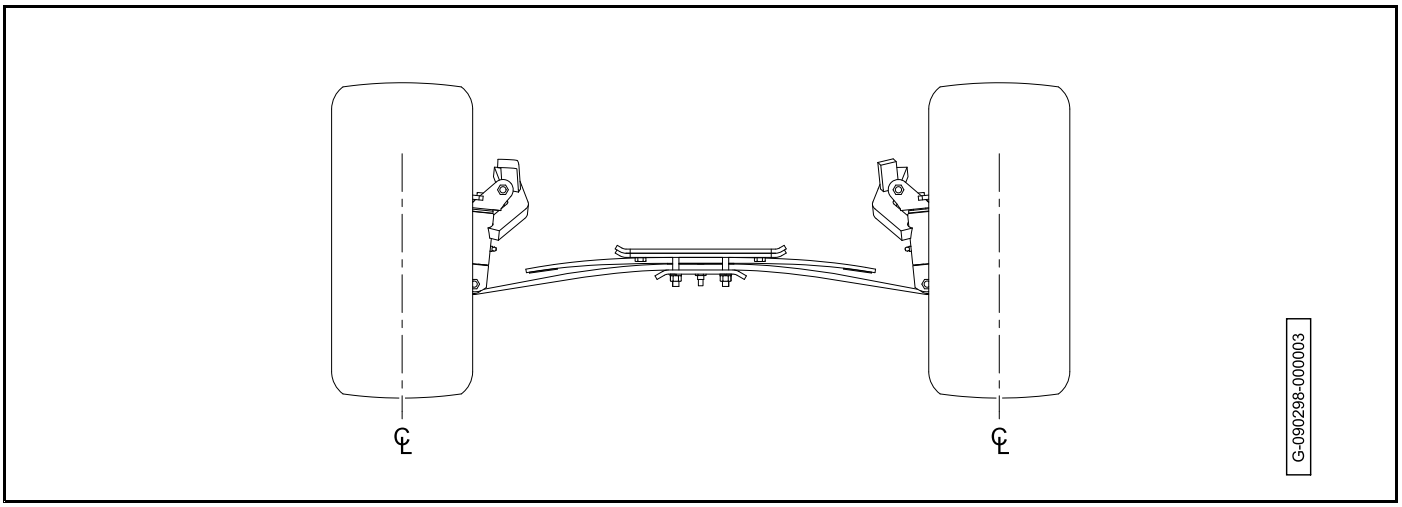


Figure 7-18

3. Measure the distance between the marks on the face of the front facing surfaces of the tires, and then roll the vehicle forward one and a half wheel revolutions until the marks appear on the rear facing surfaces of the tires at about the same height from the floor.
4. Measure the distance between the marks and compare measurements. **See following NOTE**.

NOTE: *The front face and rear face measurement should be equal, if not adjustment is required.*

5. If adjustment is necessary, proceed as follows:
6. Loosen the jam nuts on both ends of each tie rod end on the steering rack **(Figure 7-19, Page 7-15)**.

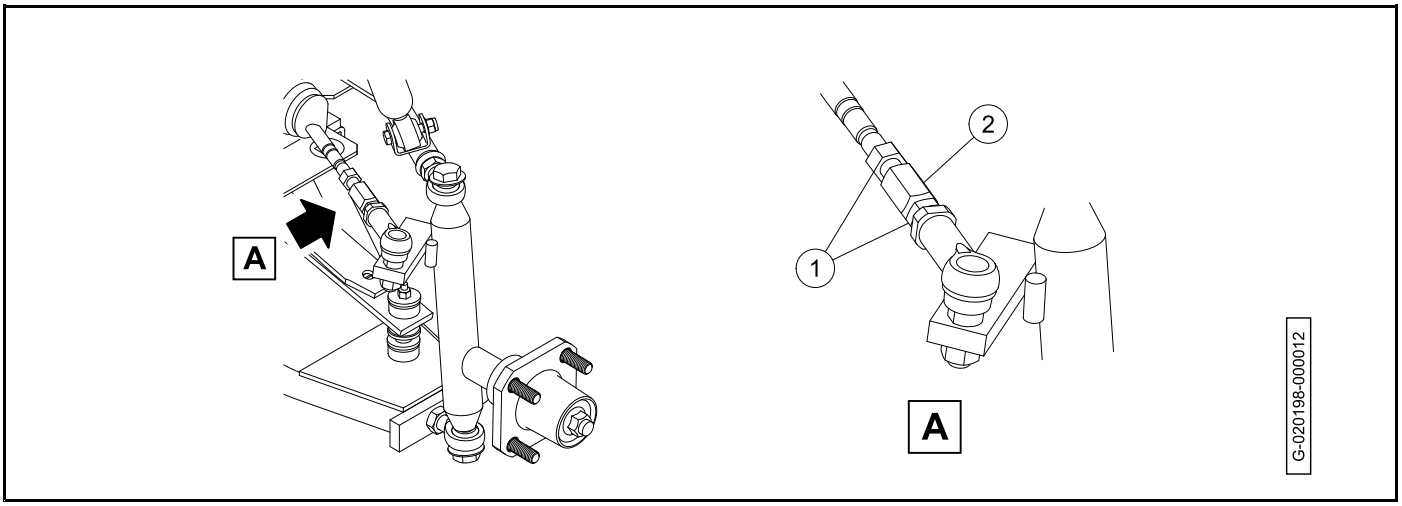


Figure 7-19

7. Rotate both of the tie rods equally. To increase the toe-in, rotate both tie rods clockwise. To decrease the toe-in, rotate both tie rods counterclockwise. Maintain an equal distance from the ball joint to the end of the threads on each tie rod **(Figure 7-20, Page 7-16)**. Snug hardware but do not torque until alignment is complete.

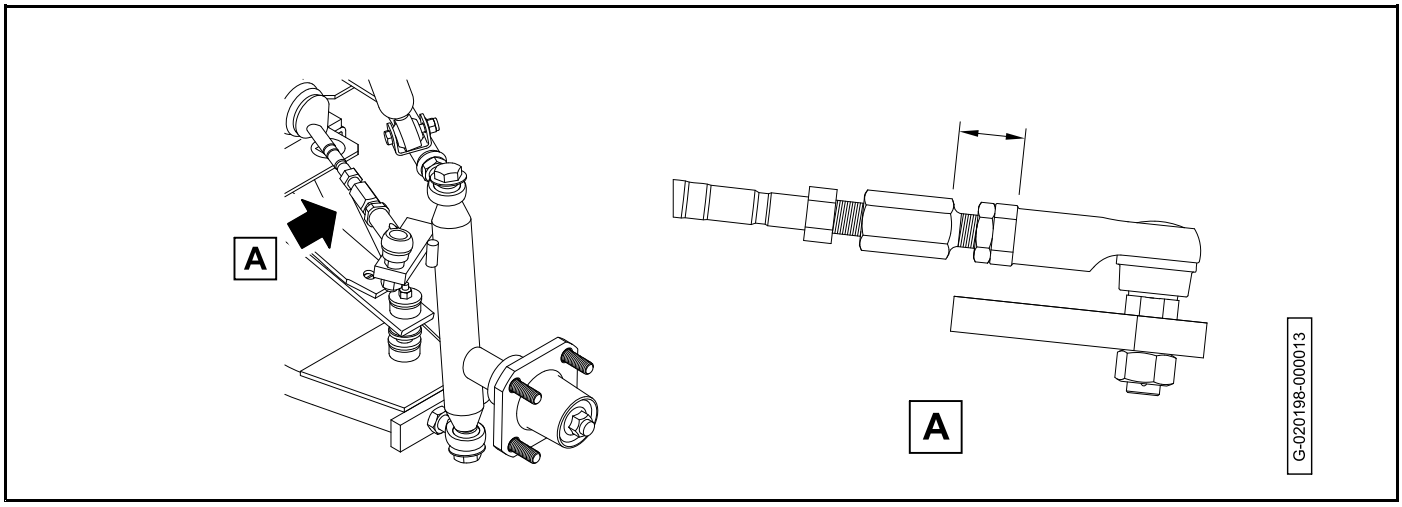


Figure 7-20

8. Check the toe-in, and repeat the adjustment procedure if necessary.
9. 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.
10. Verify the camber did not change. If adjustment is required, repeat the camber adjustment and toe-in adjustment until both camber and tow meet specifications.
11. Tighten the four jam nuts on the tie rods to 26 ft·lb (35 N·m).
12. Add thread locker to the bottom hex-head bolt (1) that secures the lower a-arm to the bottom of the spindle, reinstall, and tighten to 118 ft·lb (160 N·m) **(Figure 7-21, Page 7-16)**.

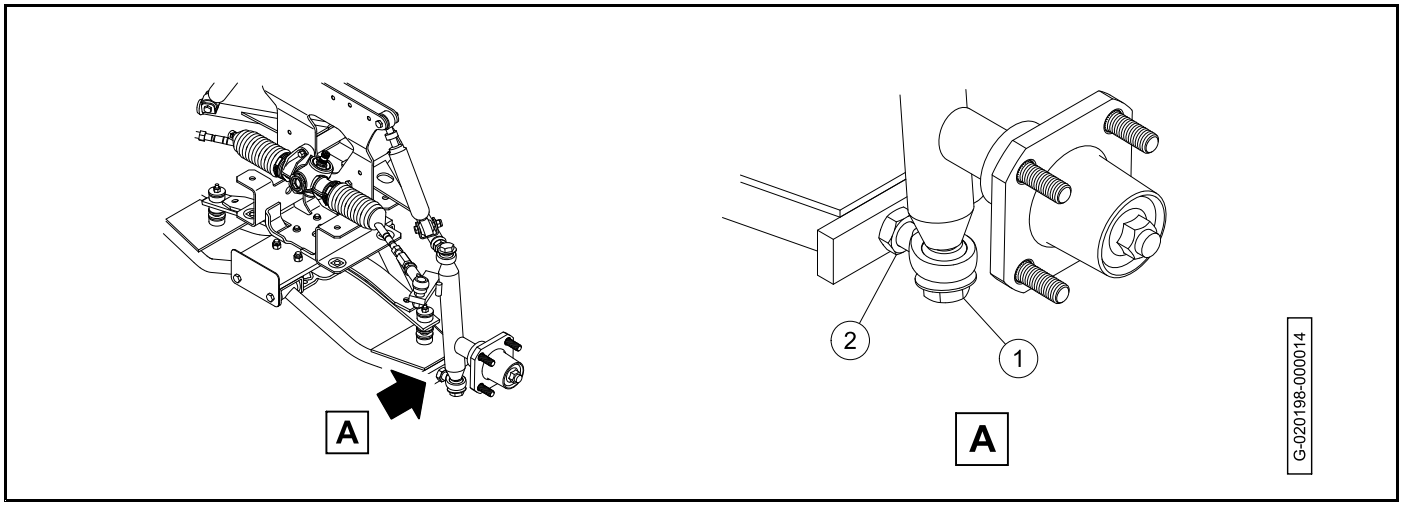


Figure 7-21

13. Tighten the jams nuts on the bottom rod ends (2) to 81 ft·lb (110 N·m).

NON-LIFTED FRONT SUSPENSION COMPONENTS

TIE ROD END REMOVAL

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect the battery and spark plug wire.
3. Loosen the jam nut (1) **(Figure 7-22)**.

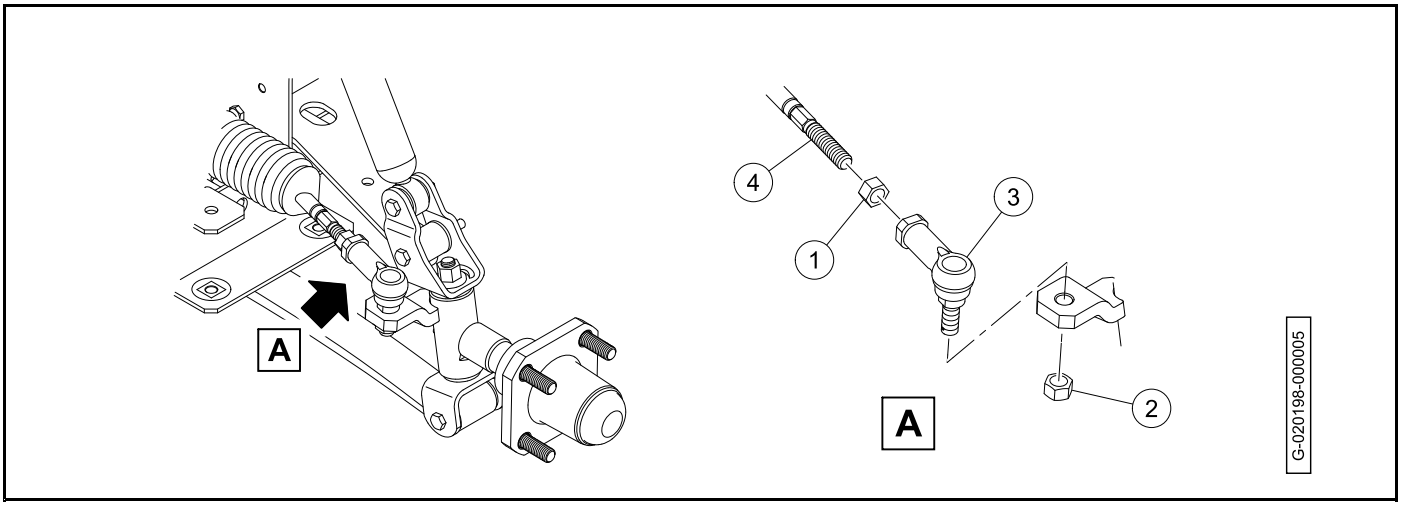


Figure 7-22

4. Remove the retaining nut (2).
5. Lift the tie rod (3) from the hole in the spindle tab.
6. Remove the tie rod end from the drag link.
7. Apply a light coat of anti-seize lubricating compound to the threads (4).

TIE ROD INSTALLATION

1. Install tie rod end (1) onto the drag link (2) to a depth of 1/2 inch (12.5 mm) **(Figure 7-23)**.

⚠ WARNING

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

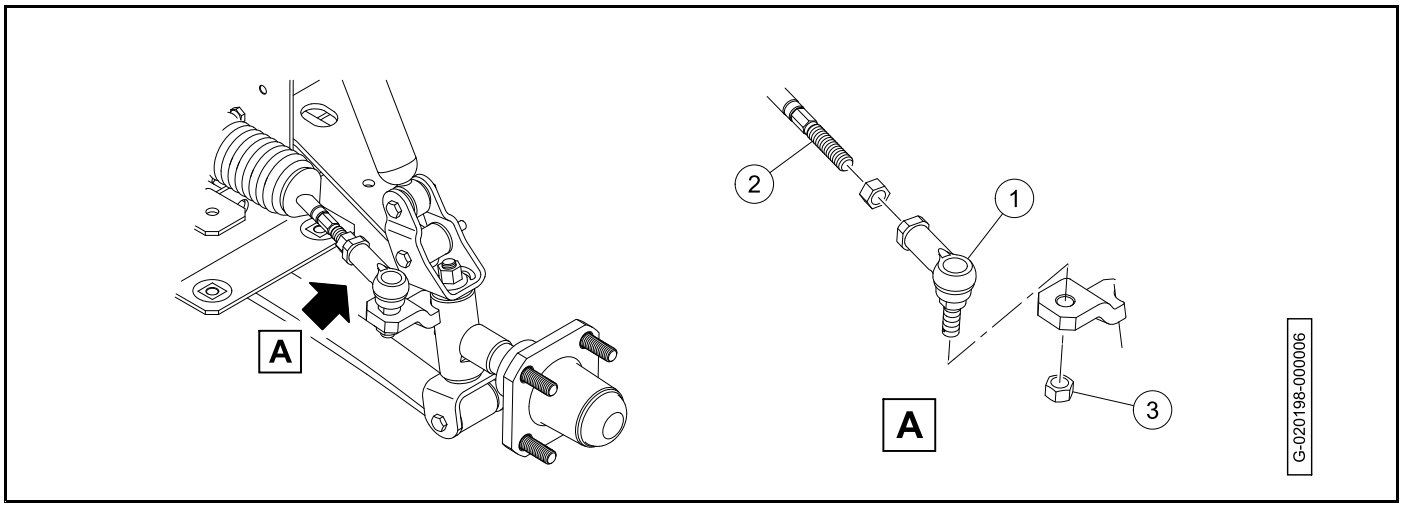


Figure 7-23

2. Install the tie rod end into the spindle tab.
3. Install the retaining nut (3).
4. Adjust the wheel toe-in.
5. **Electric Vehicle:** Connect the batteries.
   Gasoline Vehicle: Connect the battery and spark plug wire.

LEAF SPRING REMOVAL

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect the battery and spark plug wire.
3. Remove the front wheels.

4. Remove the bolts (1) from the bottom of each kingpin (2) **(Figure 7-24)**.

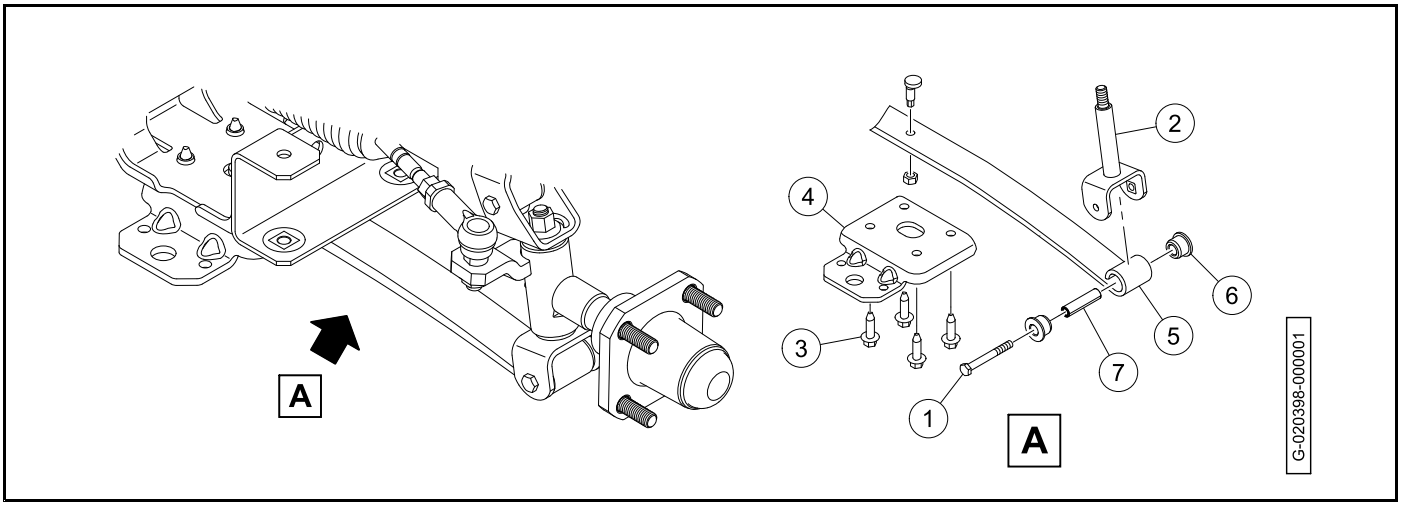


Figure 7-24

5. Remove the four bolts (3) and bottom spring plate (4).
6. Remove the leaf spring (5).
7. Check the condition of the urethane bushings (6) and steel sleeves (7). Replace any that are worn or damaged.

LEAF SPRING INSTALLATION

1. Install the urethane bushings (1) and steel sleeves (2) into leaf spring eyes **(Figure 7-25)**.

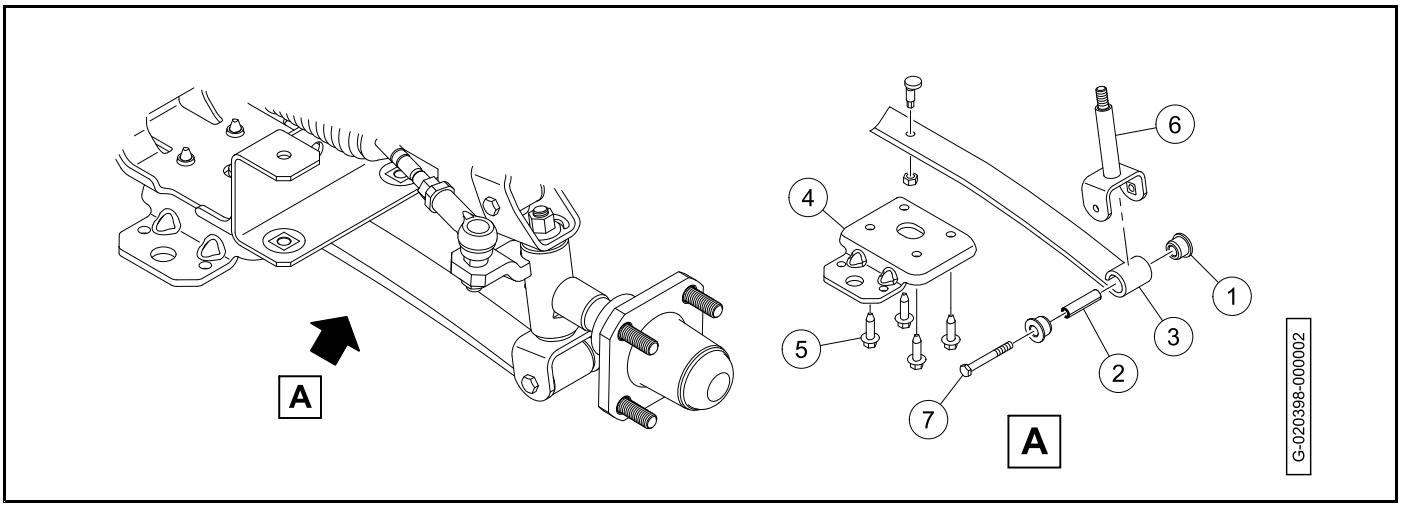


Figure 7-25

2. Install the leaf spring (3), bottom spring plate (4), and four bolts (5). Tighten the bolts in a crisscross pattern to 37 lb·ft (50 N·m).
3. Install the kingpins (6) on the leaf spring with the bolts (7). Tighten the bolts to 30 lb·ft (41 N·m).
4. Install the front wheels.
5. Adjust the camber and toe-in.
6. **Electric Vehicle:** Connect the batteries.
   Gasoline Vehicle: Connect the battery and spark plug wire.

KINGPIN AND STEERING SPINDLE REMOVAL

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect the battery and spark plug wire.
3. Remove the front wheels.
4. Remove and discard the lock nut (1) **(Figure 7-26)**.

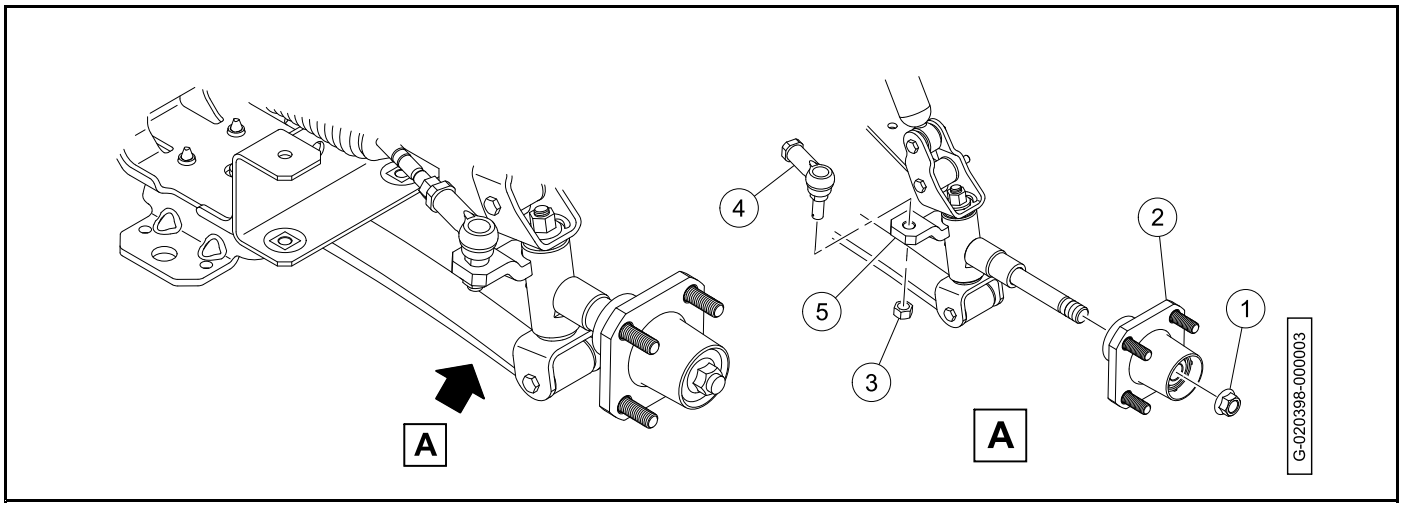


Figure 7-26

5. Remove the front hub (2).
6. Remove the retaining nut (3).
7. Remove tie rod end (4) from the tabs (5) on the spindles.
8. Remove the nut (1) **(Figure 7-27, Page 7-20)**.

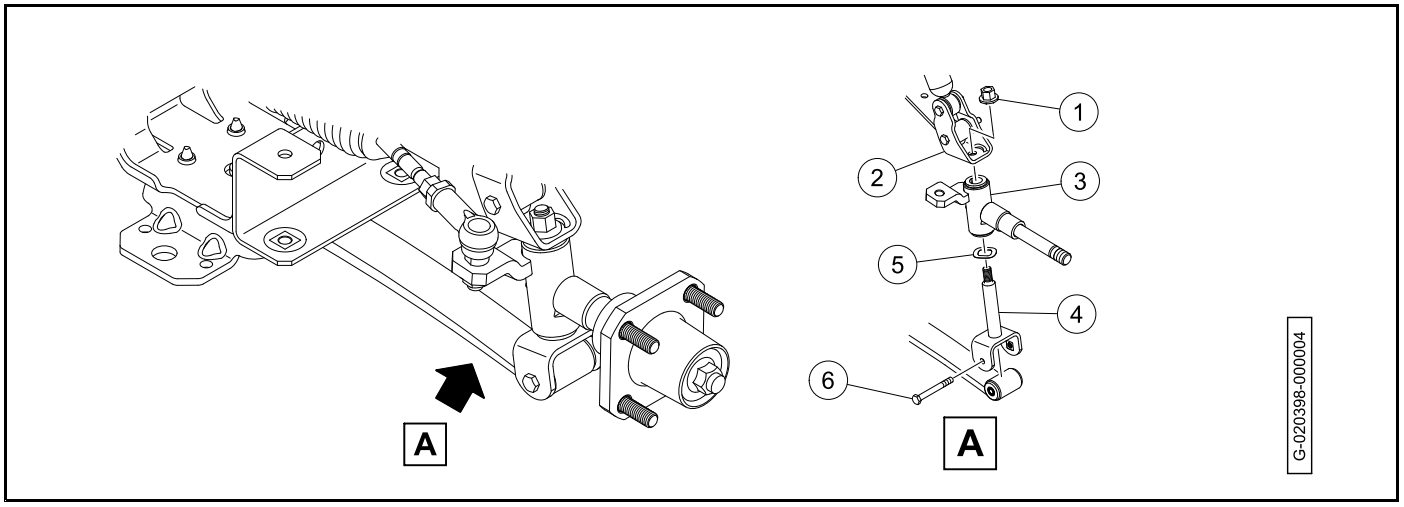


Figure 7-27

9. Raise the upper clevis (2) and slide the spindle (3) off of the kingpin (4).
10. Remove the wave washer (5).
11. Inspect the wave washer.

11.1. If the wave washer is broken, replace the washer.

11.2. If the wave washer bottom to crest height dimension is less than 0.040 inch (1 mm), replace the washer.

12. Remove the bolt (6) and the kingpin.
13. Inspect the kingpin and spindle. If either is worn or damaged, it must be replaced.
14. Inspect the spindle bushings. If the bushings are worn or damaged, remove them and press in new ones.

NOTE: *New bushings may not fit the kingpin after installing them into the spindle). Ream new bushings as required.*

14.1. After installing new bushings, ream bushings to 0.753 inch (±0.0005) (19.13 mm (±0.013)).

KINGPIN AND STEERING SPINDLE INSTALLATION

1. Inspect all parts and replace them as necessary.
2. Install the kingpin (1) over the leaf spring eyes **(Figure 7-28)**.

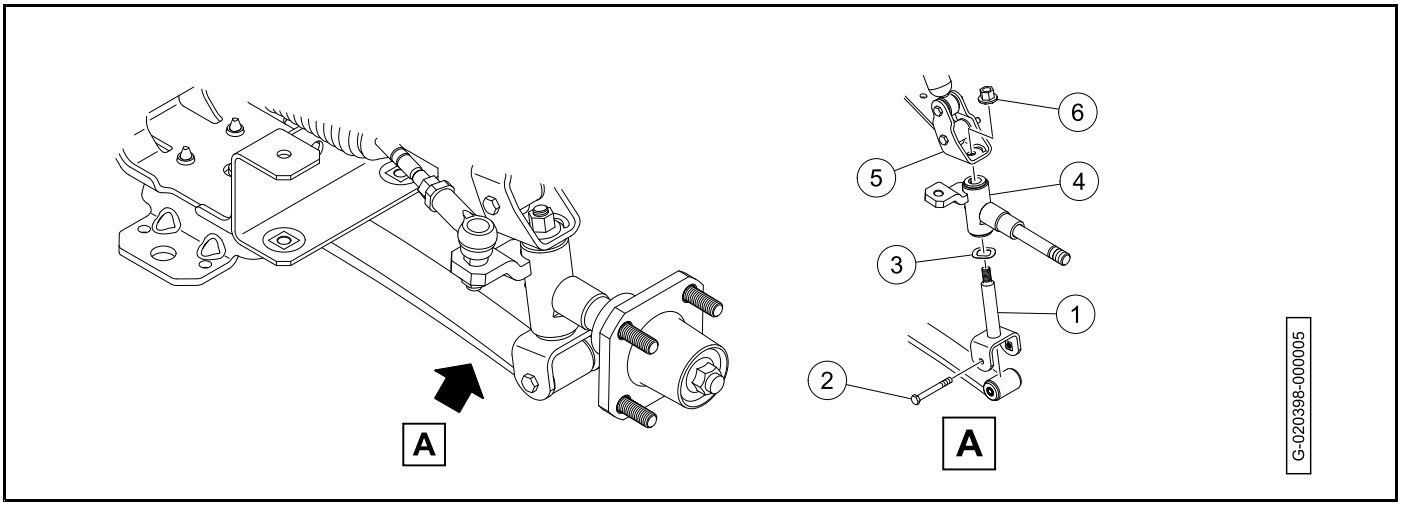


Figure 7-28

3. Install the bolt (2). Tighten the bolt to 30 lb·ft (41 N·m).
4. Install the wave washer (3) on the kingpin.
5. Install thespindle (4) on the kingpins.
6. Put the upper clevis (5) over the kingpin threads and install nuts (6). Tighten the nuts to 70 lb·ft (95 N·m).
7. Install the tie rod end (1) to the spindle tab (2) **(Figure 7-29, Page 7-22)**.

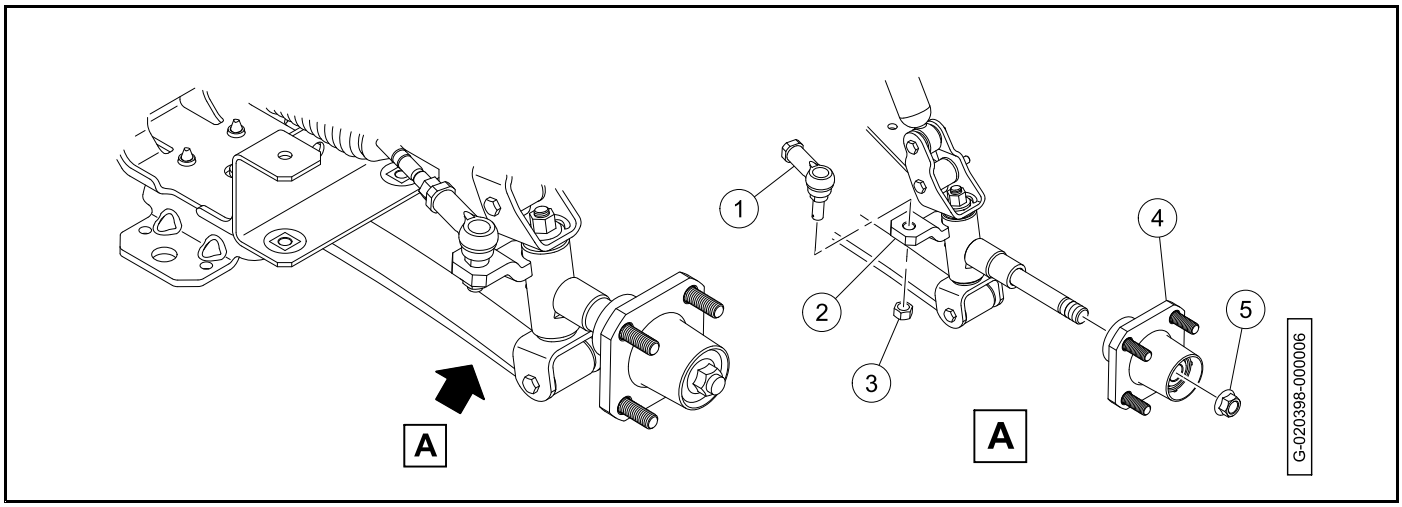


Figure 7-29

8. Install the nut (3). Tighten the nut to 70 lb·ft (95 N·m).
9. Install the front hubs (4).
10. Install the nut (5).
11. Install the front wheels.
12. Adjust the camber and toe-in.
13. **Electric Vehicle:** Connect the batteries.
    Gasoline Vehicle: Connect the battery and spark plug wire.

CONTROL ARM REMOVAL

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect the battery and spark plug wire.
3. Remove the front wheels.
4. Remove the bolts (1) **(Figure 7-30)**.

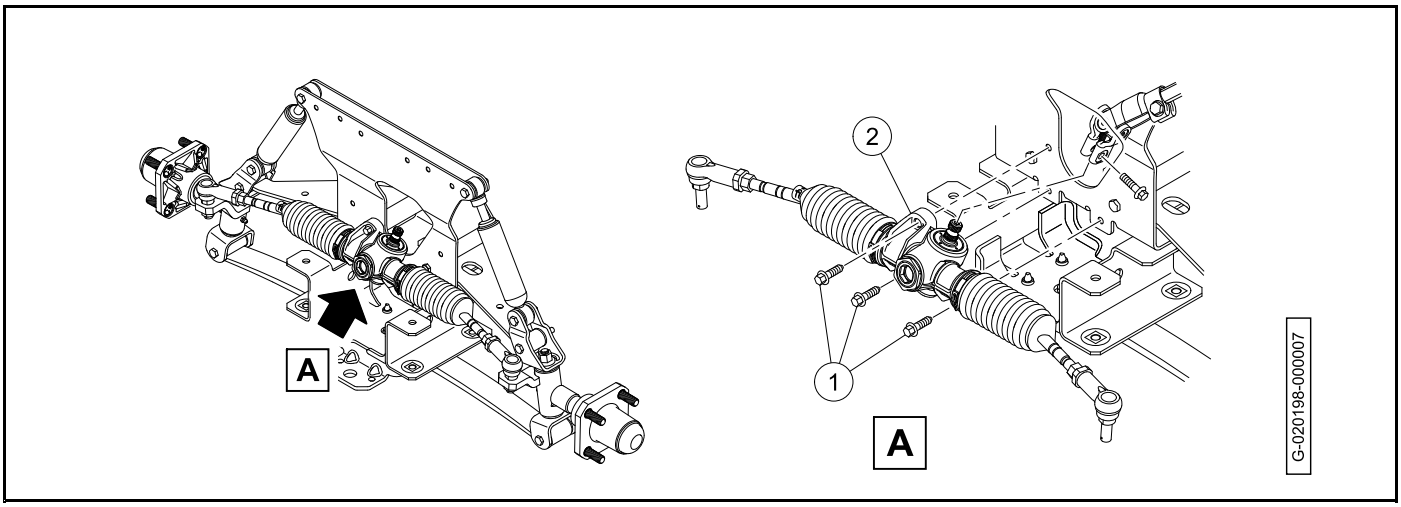


Figure 7-30

5. Move the rack and pinion (2) to allow clearance for the control arm bolts.
6. Remove the bolts (1 and 2) **(Figure 7-31)**.

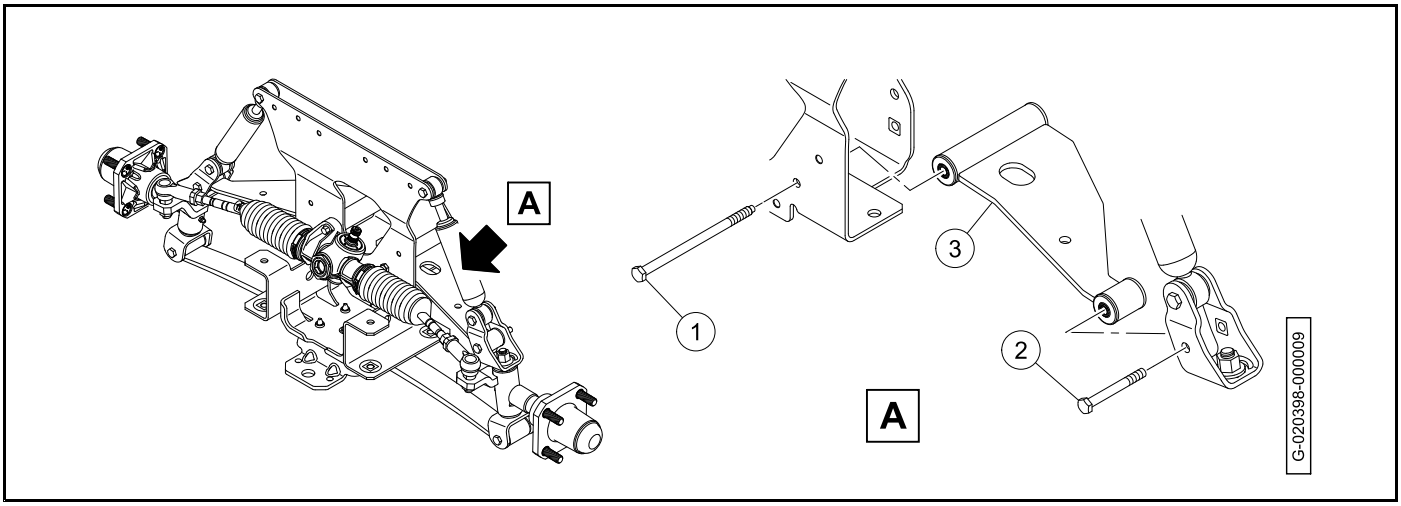


Figure 7-31

7. Remove the control arm (3).
8. Inspect the bushings and sleeves in the control arm. Replace as necessary.

CONTROL ARM INSTALLATION

1. Put the control arm (1) into position on the vehicle **(Figure 7-32)**.

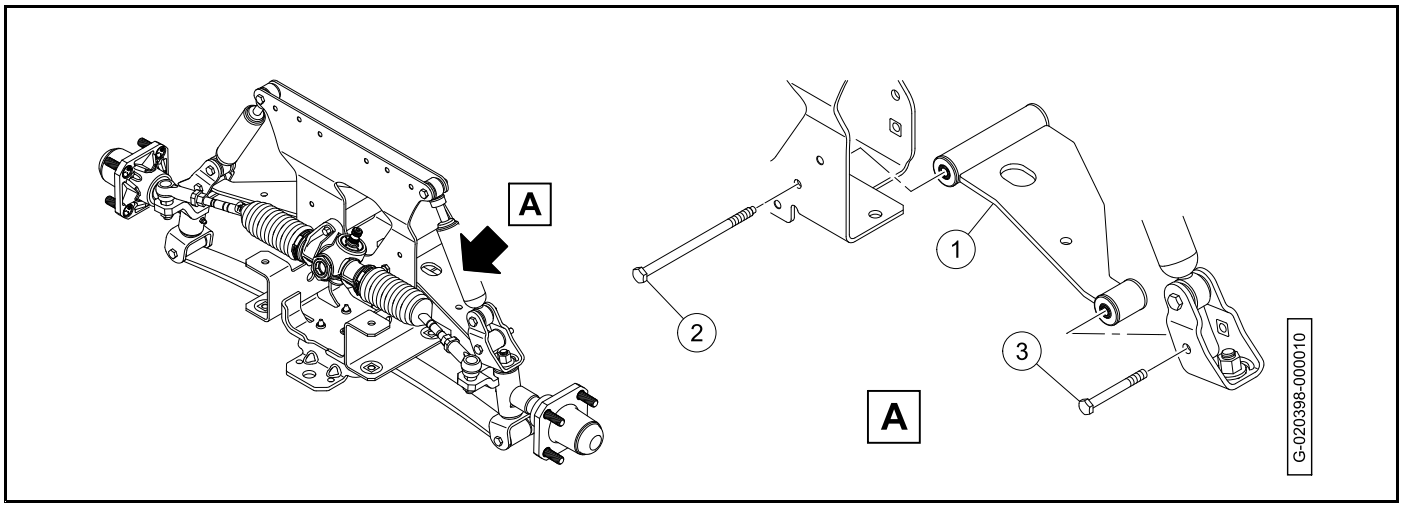


Figure 7-32

2. Install the bolts (2 and 3). Tighten the bolts to 30 lb·ft (41 N·m).
3. Move the rack and pinion (1) into position **(Figure 7-33)**.

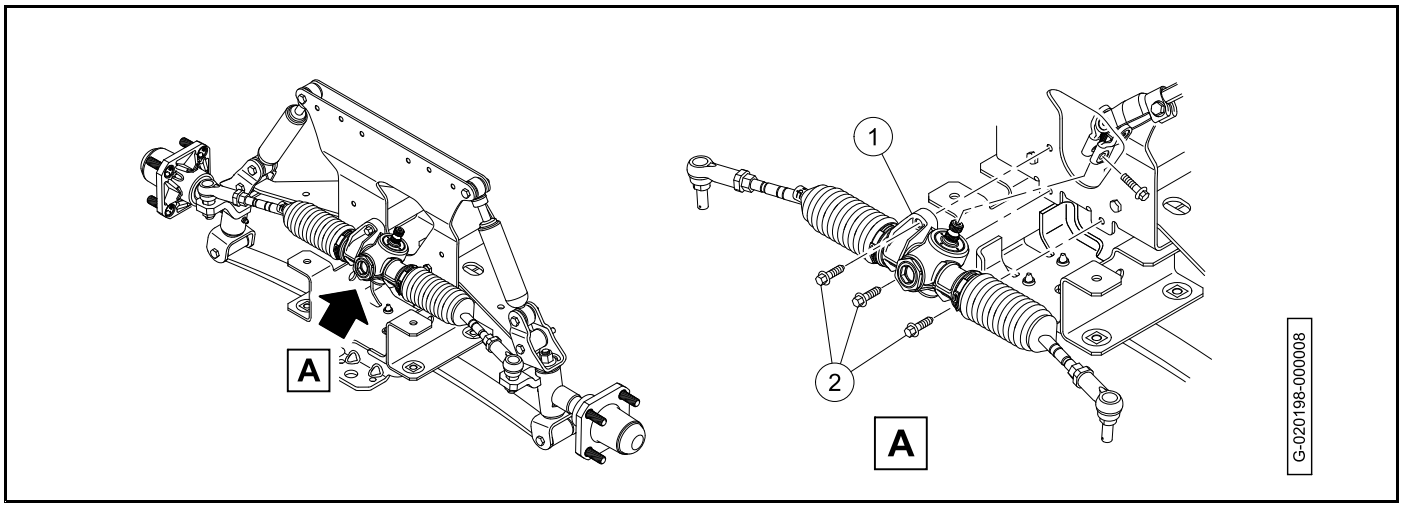


Figure 7-33

4. Install the bolts (2).Tighten the bolts to 22 lb·ft (30 N·m).
5. Install the front wheels.
6. Adjust the camber and toe-in.
7. **Electric Vehicle:** Connect the batteries.
   Gasoline Vehicle: Connect the battery and spark plug wire.

FRONT SHOCK ABSORBER INSPECTION

1. Examine the area (1) where the shaft enters the shock absorber body **(Figure 7-34, Page 7-25)**.

1.1. If there is fluid leakage, replace the shock absorber.

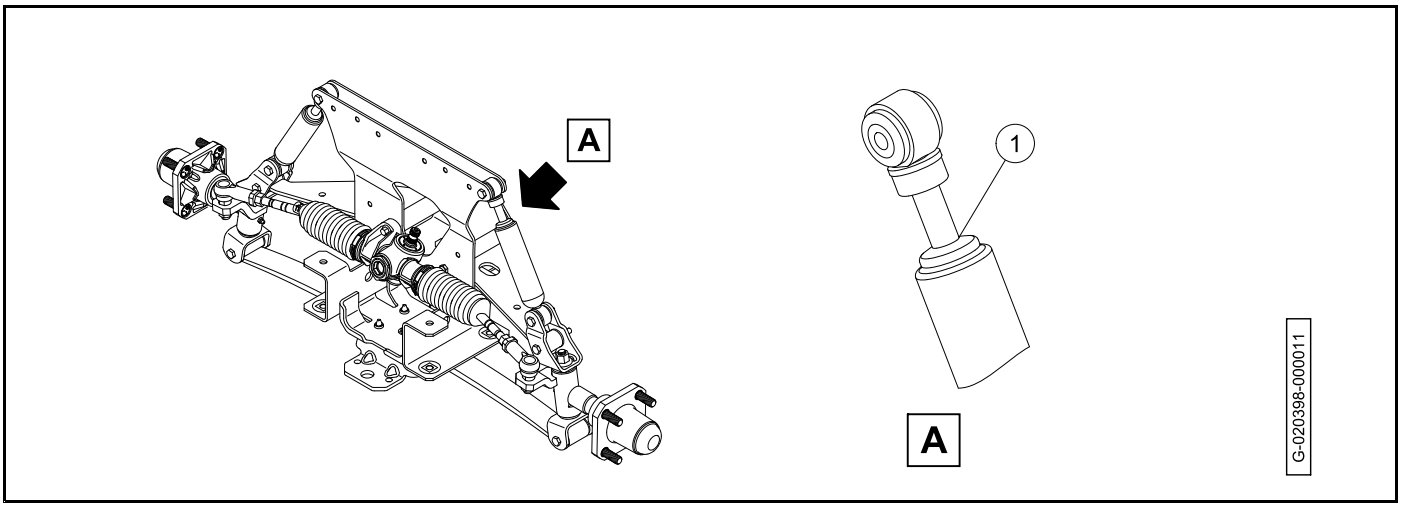


Figure 7-34

FRONT SHOCK ABSORBER REMOVAL

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect the battery and spark plug wire.
3. Remove the upper bolt (1) **(Figure 7-35)**.

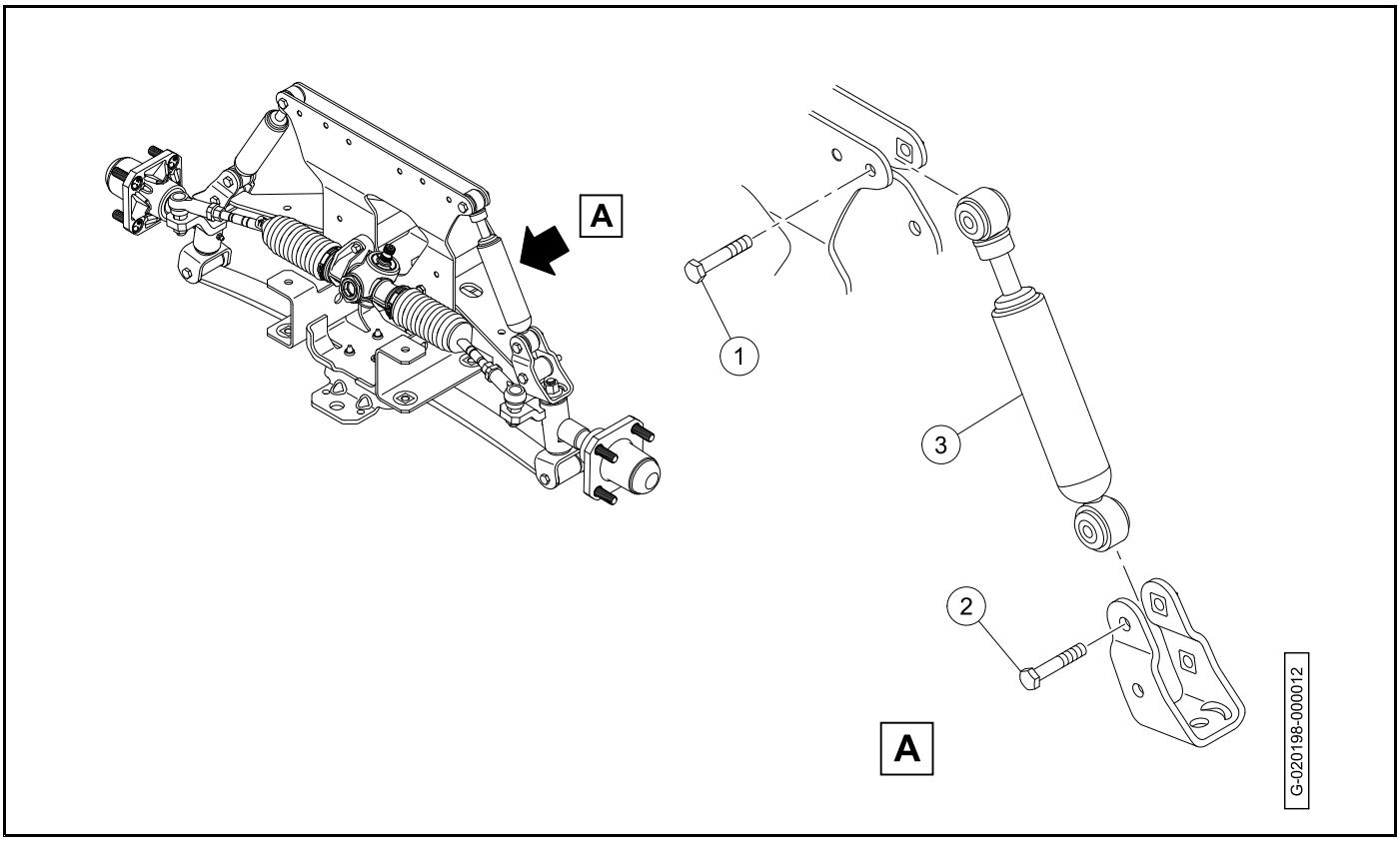


Figure 7-35

4. Remove the lower bolt (2).
5. Remove the shock absorber (3).

FRONT SHOCK ABSORBER INSTALLATION

1. Make sure that the front shock absorbers (3) have the same part number **(Figure 7-35)**.
2. Install the shock absorber.
3. Install the bolts (1 and 2). Tighten the bolts to 16 lb·ft (21 N·m).
4. **Electric Vehicle:** Connect the batteries.
   Gasoline Vehicle: Connect the battery and spark plug wire.

LIFTED FRONT SUSPENSION COMPONENTS

See General Warnings on page 1-2.

LIFTED TIE ROD END REMOVAL

1. **Electric Vehicle:** Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**

   Gasoline Vehicle: Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**

2. Loosen the jam nuts (1 and 2) **(Figure 7-36)**.

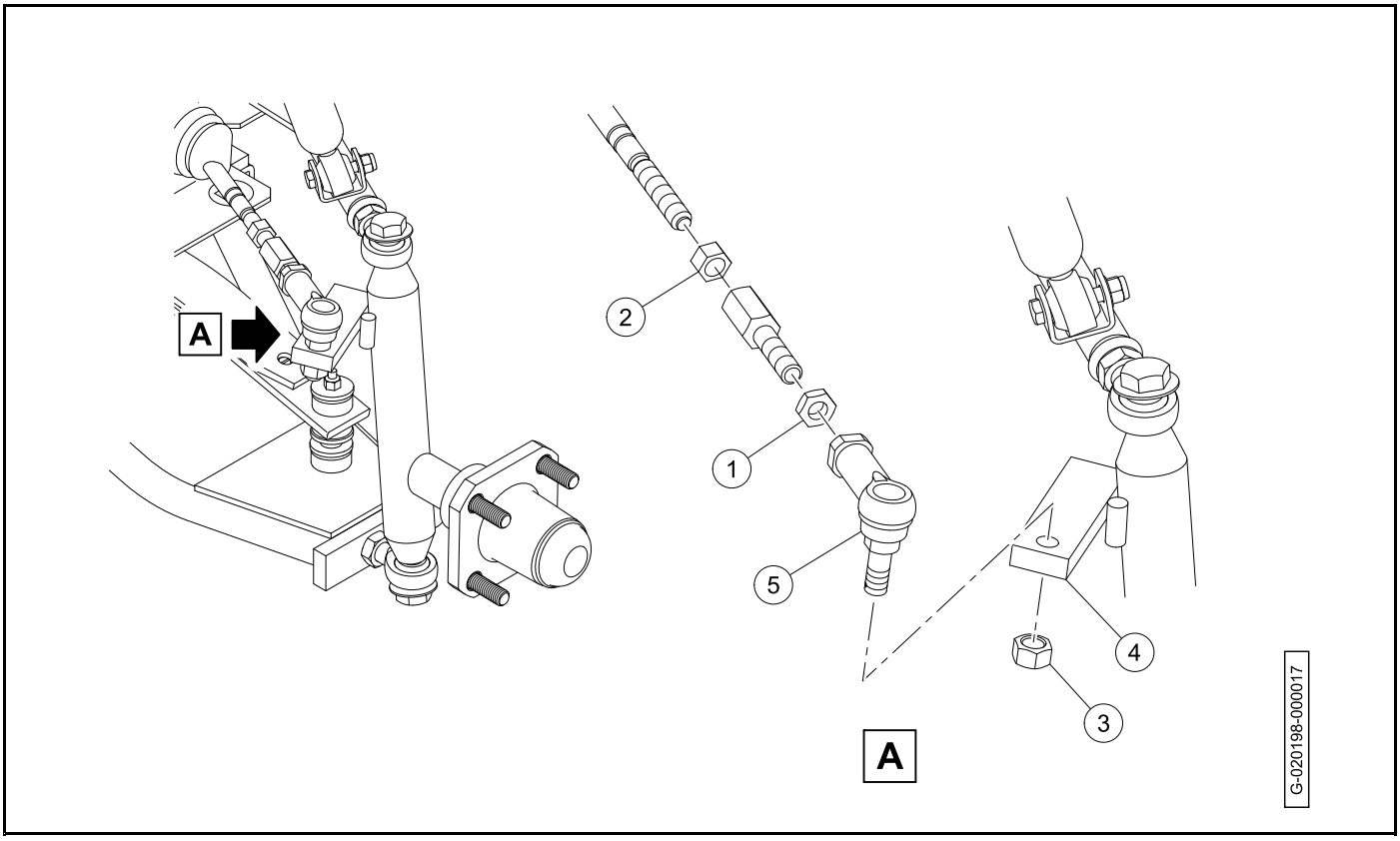


Figure 7-36

3. Remove the retaining nut (3).
4. Remove the tie rod from the spindle tab (4).
5. Remove the tie rod end (5).
6. To minimize corrosion, apply a light coat of anti-seize lubricating compound to the threads where the tie rod ends are installed.

LIFTED TIE ROD INSTALLATION

1. Thread the drag link extension (1) onto the drag link (2) to a depth of 1/2 inch (12.5 mm) and snug the jam nut (3) **(Figure 7-37)**. Do not tighten until the camber and tow-in are aligned .

⚠ WARNING

- **The tie rods and drag link extensions must be threaded into the rod at least 1/2 inch (12.5 mm). Failure to thread deep enough may cause tie rod ends to separate from the rod during adjustment or while being operated, possibly resulting in loss of vehicle control and severe personal injury.**

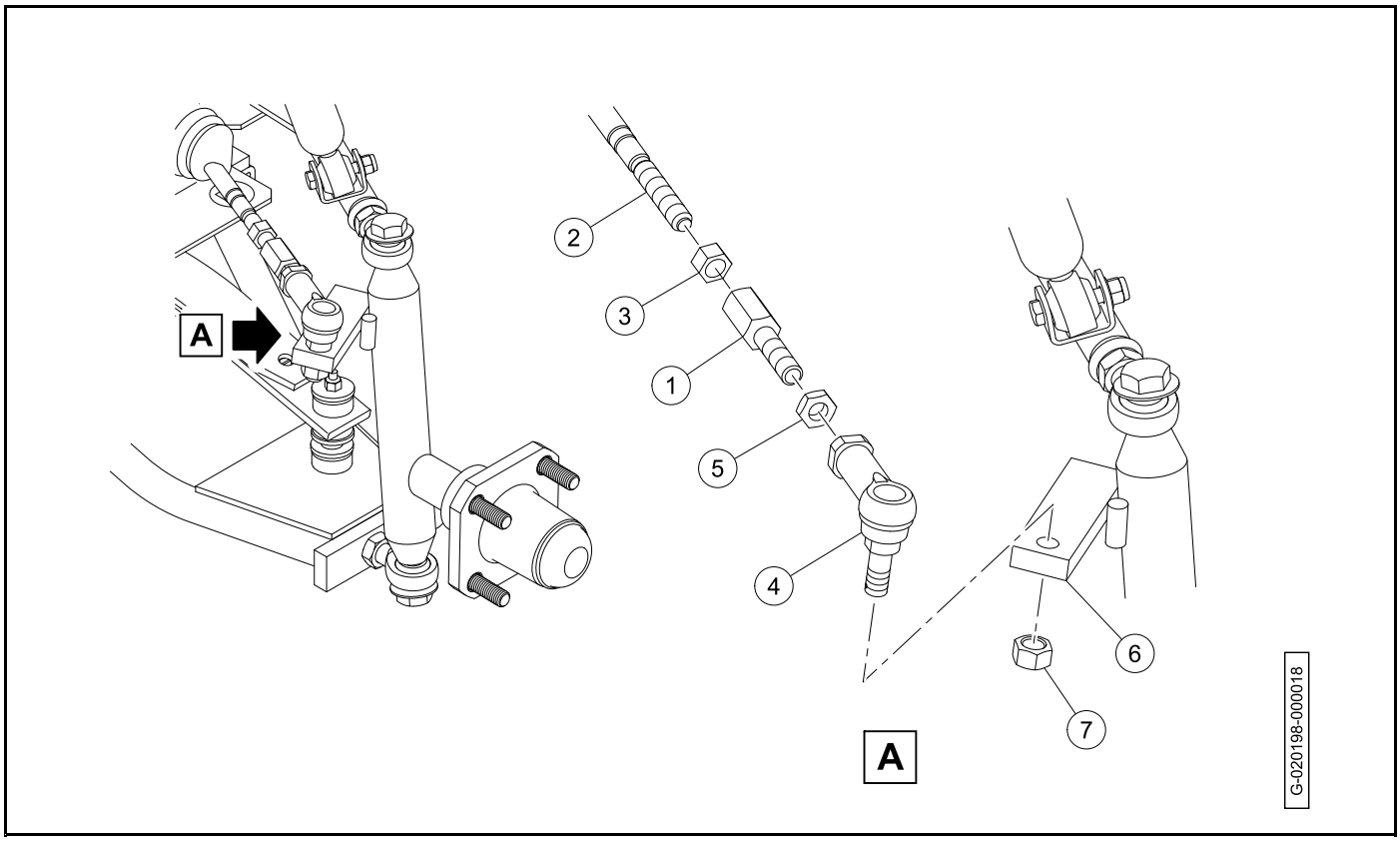


Figure 7-37

2. Thread the tie rod end (4) onto the drag link extension. Do not tighten the jam nuts (3 and 5) until the camber and tow-in are aligned.
3. Install the tie rod end into the spindle tab (6).
4. Install the retaining nut (7). Tighten the retaining nut to 70 lb·ft (95 N·m).

⚠ WARNING

- **Do not operate the vehicle until the wheels are aligned.**

5. Align the wheels.
6. **Electric Vehicle:** Connect batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

   Gasoline Vehicle: Connect battery and spark plug wire.
   See Connect the Battery - Gasoline Vehicles on page 1-4.

LIFTED LEAF SPRING ASSEMBLY REMOVAL

1. **Electric Vehicle:** Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**

   Gasoline Vehicle: Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Loosen lug nuts on both front wheels and raise front of vehicle with a chain hoist or floor jack. Place jack stands under the aluminum rails of the vehicle frame just aft of the front suspension. Lower the vehicle onto the jack stands. **See General Warnings on page 1-2.**
3. Remove both front wheels.
4. Support the leaf spring assembly (1) **(Figure 7-38)**.

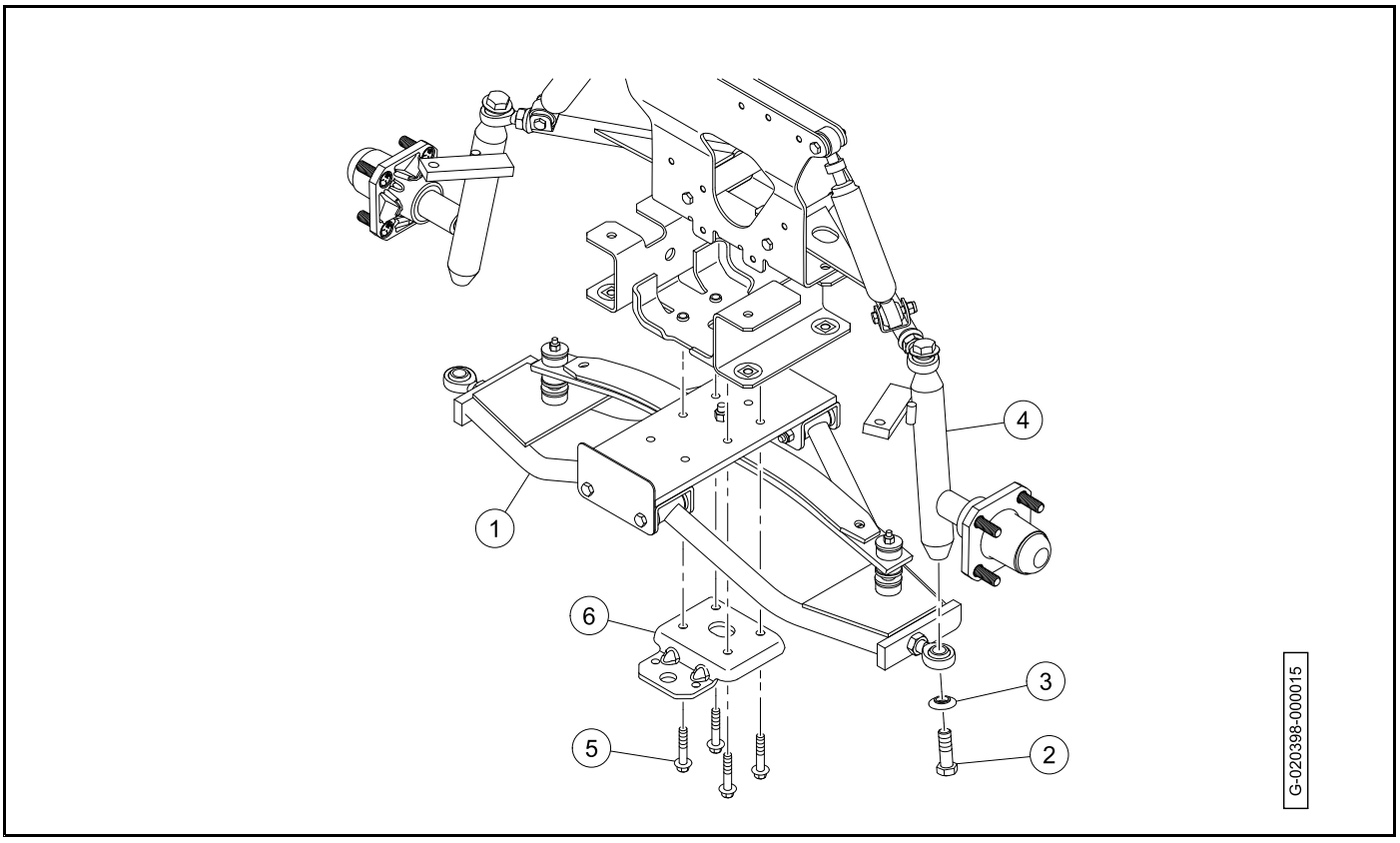


Figure 7-38

5. Remove the bolts (2) and tapered washers (3) from the bottom of each spindle (4) .
6. Remove the four bolts (5) and bottom spring plate (6).
7. Remove leaf spring assembly.

LIFTED LEAF SPRING ASSEMBLY INSTALLATION

1. Lift the leaf spring assembly (1) into position. Align the center bolt (2) with the center hole (3) in the frame mount **(Figure 7-39)**.

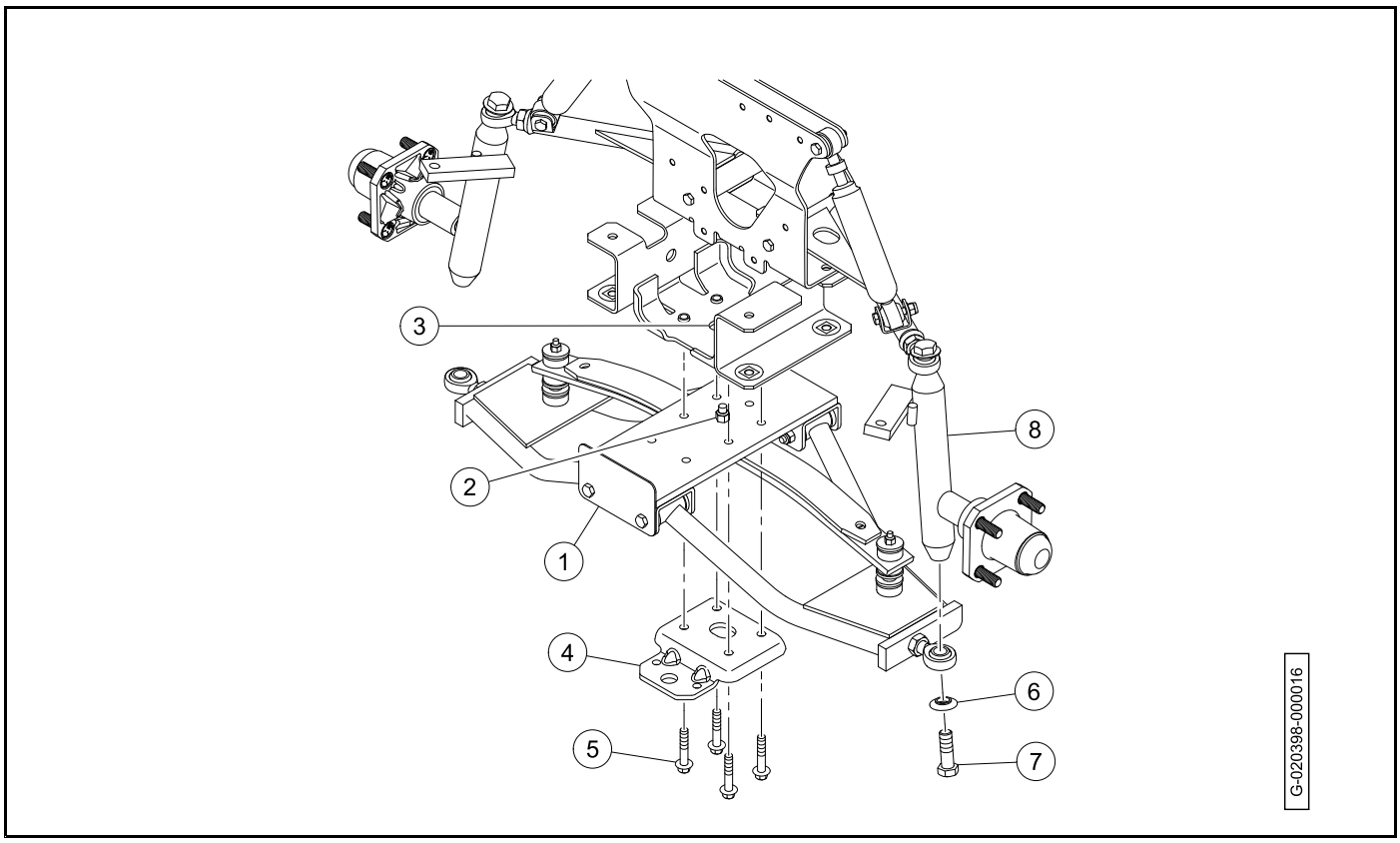


Figure 7-39

2. Install the spring retaining plate (4) with the four bolts (5). Tighten the bolts to 37 lb·ft (50 N·m).
3. Install the tapered washers (6) with the tapered end opposite of the bolts (7).
4. Apply thread locker to the bolts.
5. Install the bolts into the bottom of each spindle (8). Tighten the bolts to 118 lb·ft (160 N·m).
6. Install the wheels and finger tighten the lug nuts.
7. Lower the vehicle and finish tightening lug nuts (using a crisscross pattern) to 55 lb·ft (74.6 N·m).
8. Align the wheels.
9. **Electric Vehicle:** Connect batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

   Gasoline Vehicle: Connect battery and spark plug wire.
   See Connect the Battery - Gasoline Vehicles on page 1-4.

LIFTED SPINDLE REMOVAL

1. **Electric Vehicle:** Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**

   Gasoline Vehicle: Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Remove the front wheel.
3. Remove the front hub. **See Front Wheel Hub Removal on page 7-37.**
4. Remove the tie rod ends from the spindle (1) **(Figure 7-40)**.

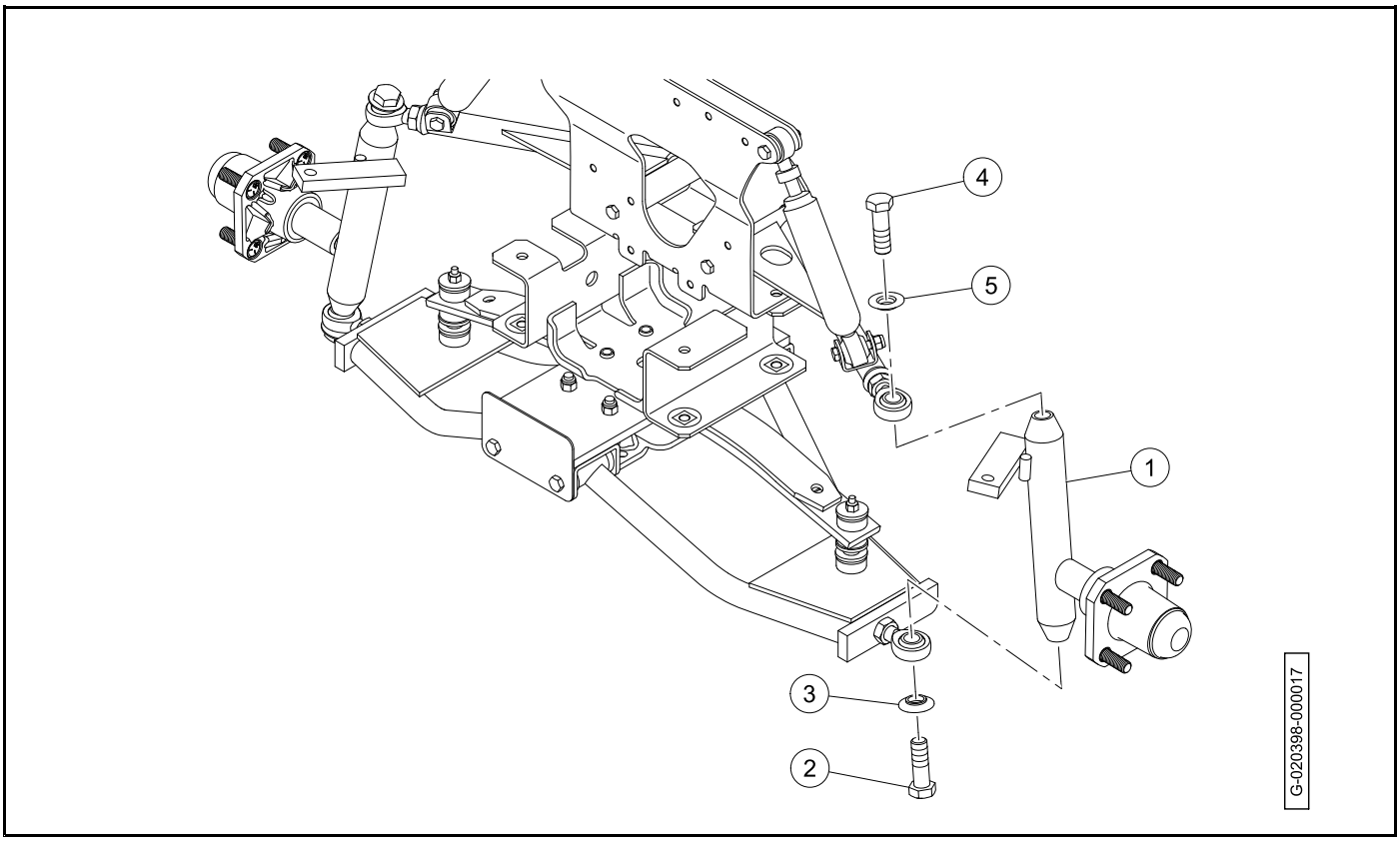


Figure 7-40

5. Remove the bolt (2) and the tapered washer (3) from the bottom of the spindle.
6. Remove the bolt (4) and the tapered washer (5) from the top of the spindle.
7. Remove the spindle.

LIFTED SPINDLE INSTALLATION

1. Inspect all parts and replace them as necessary.
2. Put the spindle (1) into position on the vehicle **(Figure 7-41)**.

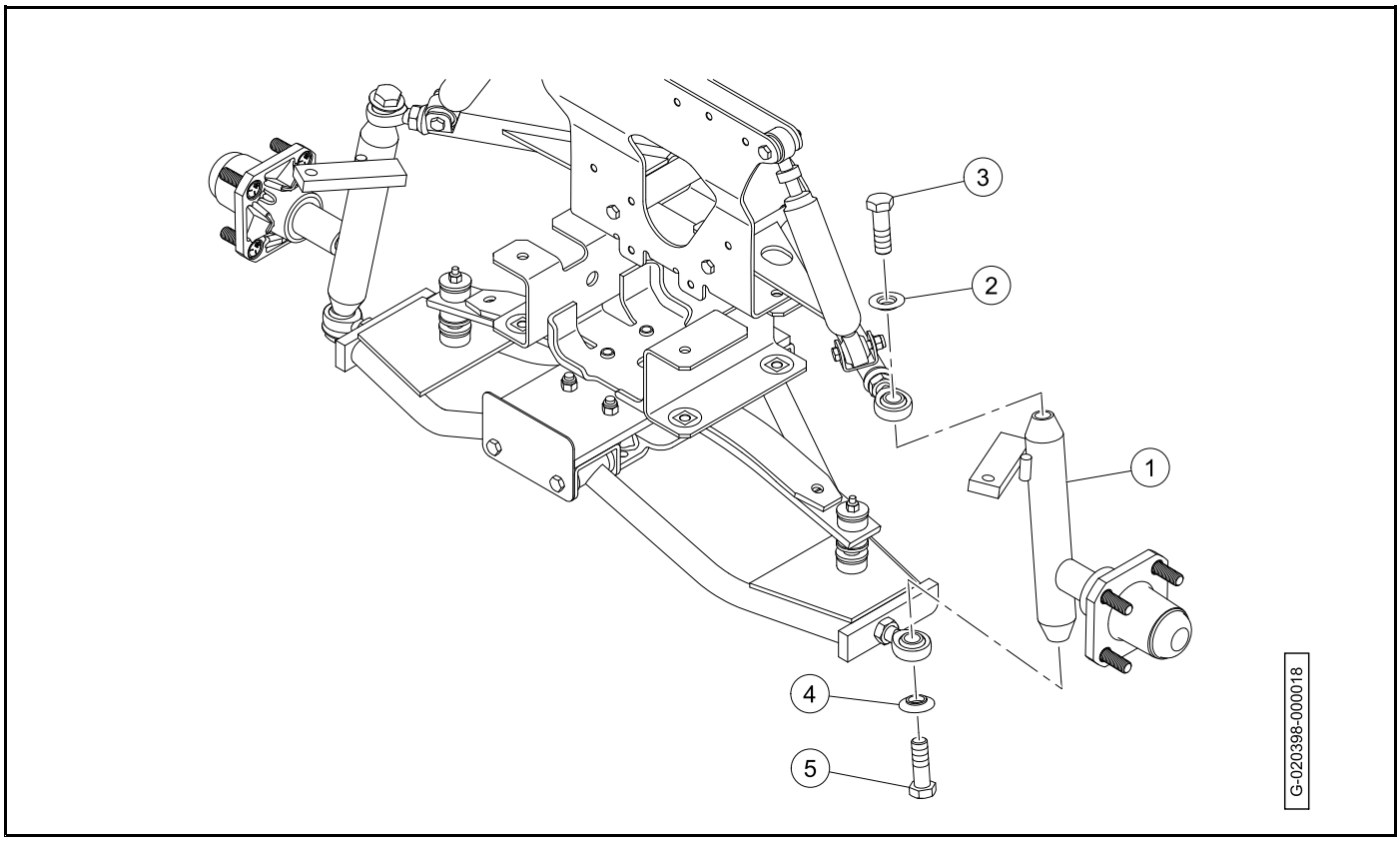


Figure 7-41

3. Install the tapered washer (2) with the tapered end opposite of the bolts (3).
4. Apply thread locker to the bolt.
5. Install the bolts into the top of the spindle.
6. Install the tapered washer (4) with the tapered end opposite of the bolts (5).
7. Apply thread locker to the bolt.
8. Install the bolt into the bottom of the spindle. Tighten the bolts to 118 lb·ft (160 N·m).
9. Attach the tie rod end to the spindle.
10. Install front hub and wheel. **See Front Wheel Hub Installation on page 7-38.**
11. **Electric Vehicle:** Connect batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

    Gasoline Vehicle: Connect battery and spark plug wire. **See Connect the Battery - Gasoline Vehicles on page 1-4.**

LIFTED CONTROL ARM REMOVAL

1. **Electric Vehicle:** Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**

   Gasoline Vehicle: Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Loosen lug nuts on both front wheels and raise front of the vehicle with a chain hoist or floor jack. Place jack stands under the front aluminum rails of the vehicle frame and lower the vehicle onto the jack stands.
3. Remove the wheel.
4. Remove bolts (1) and move rack and pinion (2) **(Figure 7-42)**.

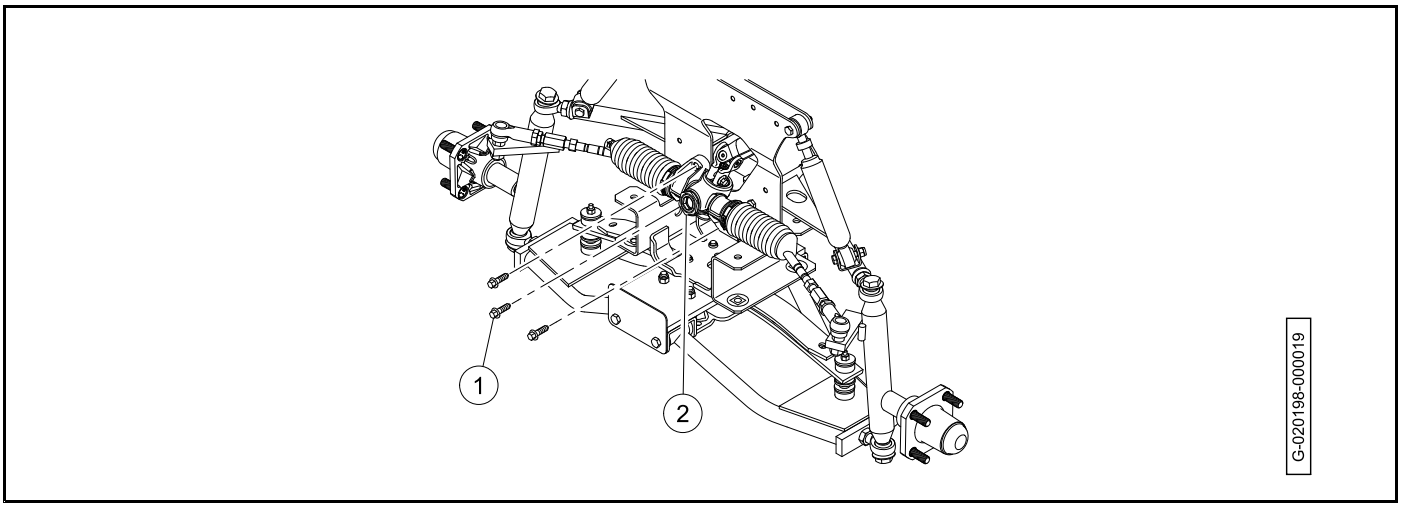


Figure 7-42

5. Remove the bolt (1) and tapered washer (2) from the top of the spindle (3) **(Figure 7-43)**. See detail A.

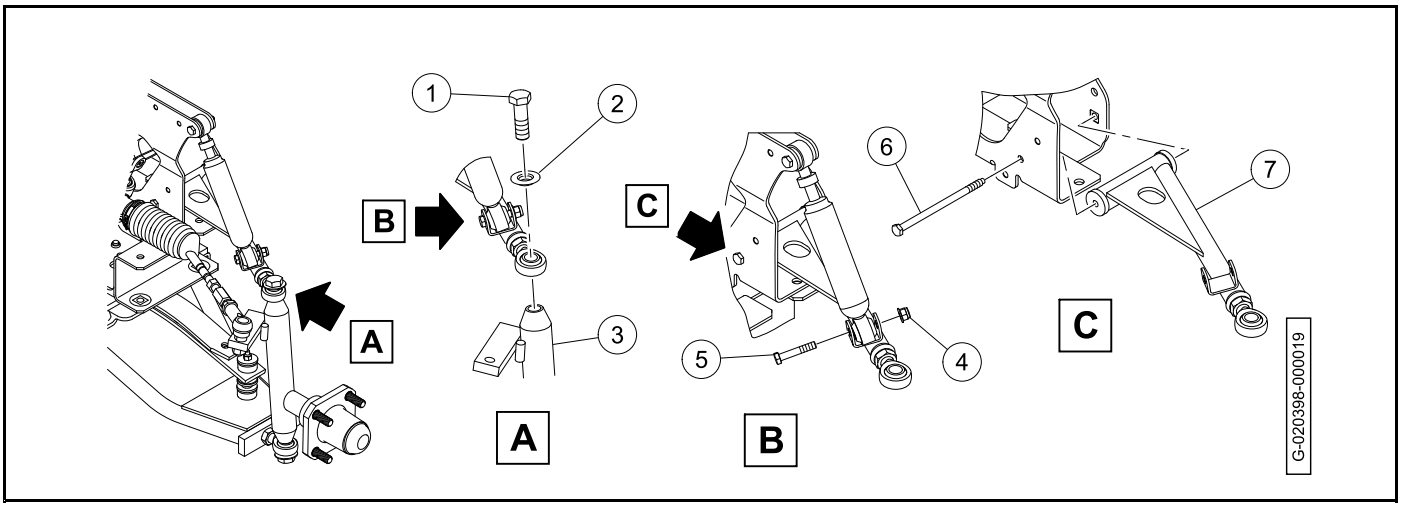


Figure 7-43

6. Remove the nut (4) and bolt (5). See detail B.
7. Remove the bolt (6). See detail C.
8. Remove the control arm (7).

LIFTED CONTROL ARM INSTALLATION

1. Put the control arm (1) into position on the vehicle **(Figure 7-44)**. See detail A.

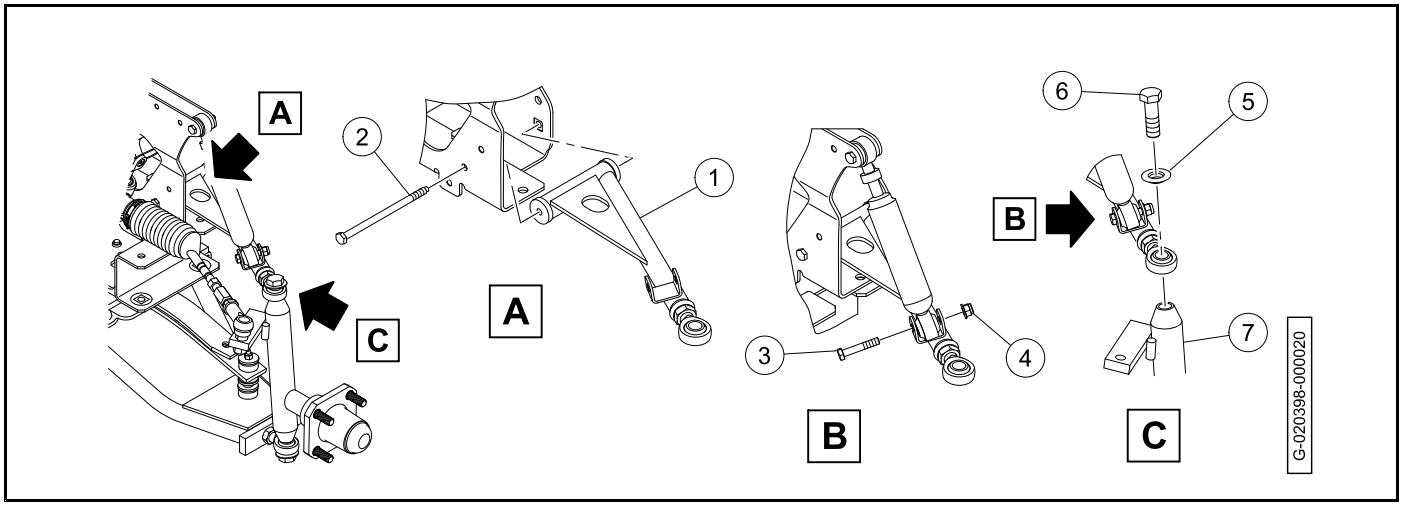


Figure 7-44

2. Install the control arm bolt (2). Tighten the bolt to 30 lb·ft (41 N·m).
3. Install the bolt (3) and nut (4). Tighten the bolt to 29 lb·ft (39 N·m). See detail B.
4. Install the tapered washer (5) with the tapered end opposite of the bolt (6). See detail C.
5. Apply thread locker to the bolt.
6. Install the bolt into the top of the spindle (7). Tighten the spindle bolt to 118 lb·ft (160 N·m).
7. Move the rack and pinion (1) into position **(Figure 7-45)**.

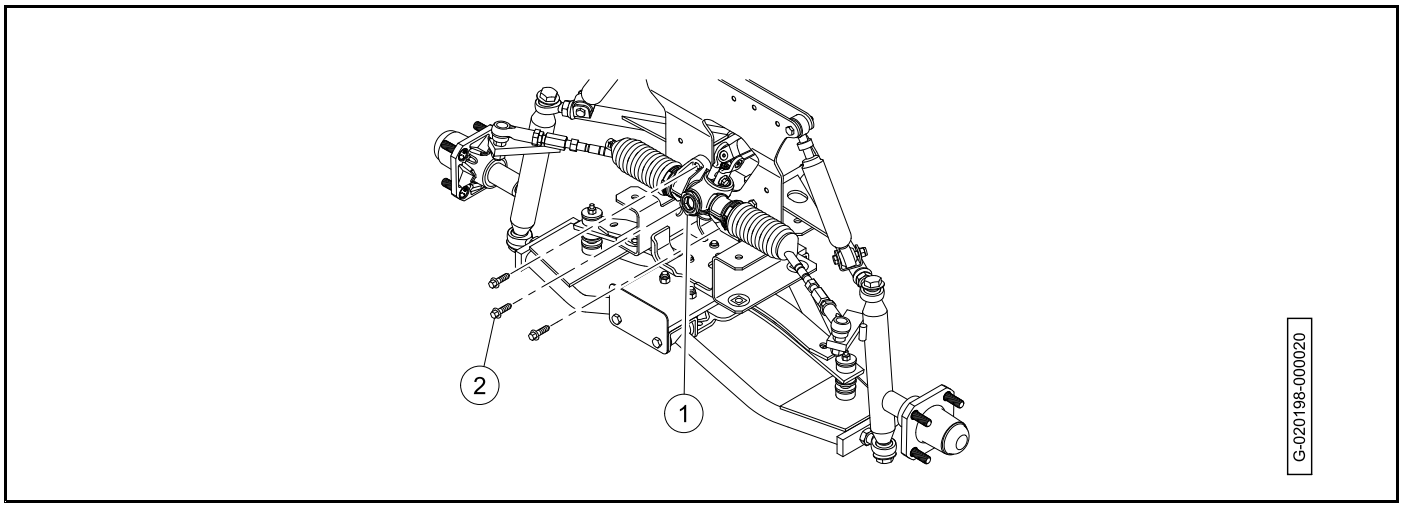


Figure 7-45

8. Install the bolts (2). Tighten the bolts to 22 lb·ft (30 N·m).
9. Install the wheels and adjust the wheel alignment as instructed on page 7-9.
10. **Electric Vehicle:** Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

    Gasoline Vehicle: Connect the battery and spark plug wire. **See Connect the Battery - Gasoline Vehicles on page 1-4.**

LIFTED SHOCK ABSORBER INSPECTION

1. Examine the area (1) where the shaft enters the shock absorber body **(Figure 7-46)**.

1.1. If there is fluid leakage, replace the shock absorber.

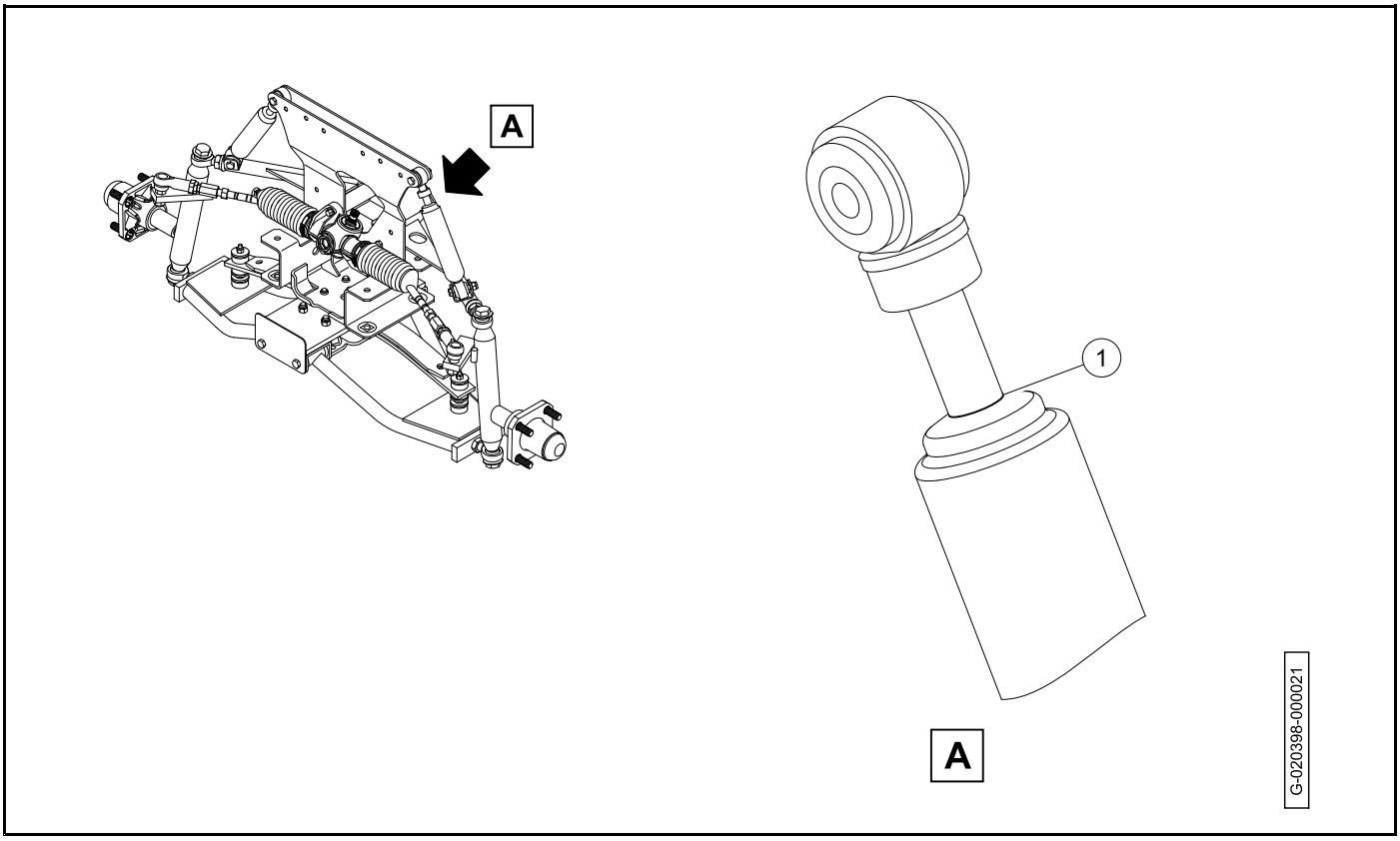


Figure 7-46

LIFTED SHOCK ABSORBER REMOVAL

1. Inspect the shock absorbers for fluid leakage at the point where the shaft enters the shock absorber body. Leaking shock absorbers should be replaced.
2. Remove the upper bolt (1) **(Figure 7-47, Page 7-36)**.

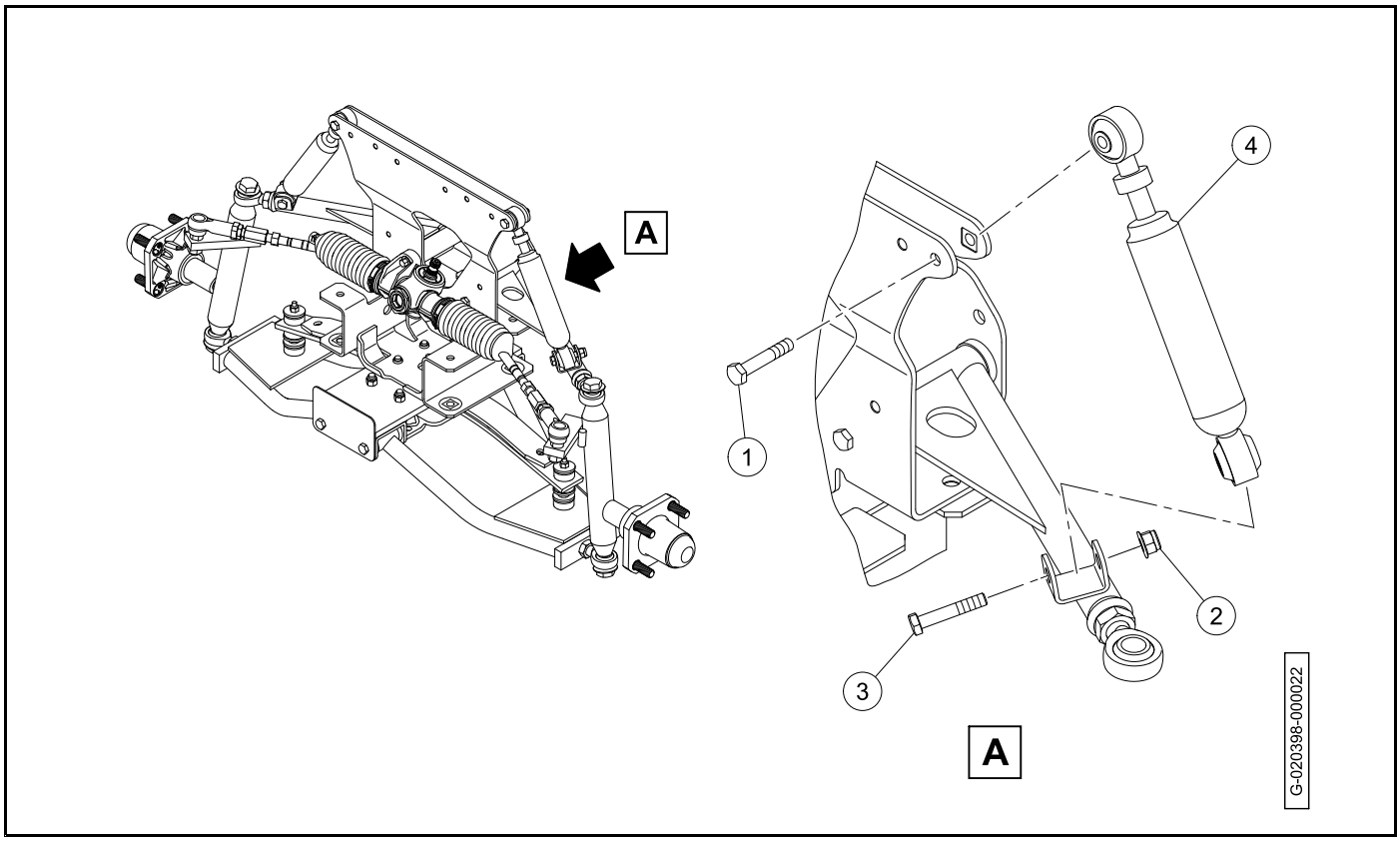


Figure 7-47

3. Remove the lower nut (2) and bolt (3).
4. Remove the shock absorber (4).

LIFTED SHOCK ABSORBER INSTALLATION

1. Make sure that the front shock absorbers (4) have the same part number **(Figure 7-47)**.
2. Install the shock absorber.
3. Install the upper bolt (1). Tighten the upper bolt to 29 lb·ft (39 N·m).
4. Install the lower bolt (3) and nut (2). Tighten the lower bolt to 29 lb·ft (39 N·m).

FRONT WHEEL HUBS

FRONT WHEEL FREE PLAY INSPECTION

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.*

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect the battery and spark plug wire.
3. Lift the front of the vehicle.
4. Try to move the wheel and hub assembly back and forth on the spindle.
5. If the wheel and hub move on the spindle, replace the hub assembly.

FRONT WHEEL HUB REMOVAL

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect the battery and spark plug wire.
3. Remove the front wheels.
4. Remove the dust cap (1) **(Figure 7-48)**.

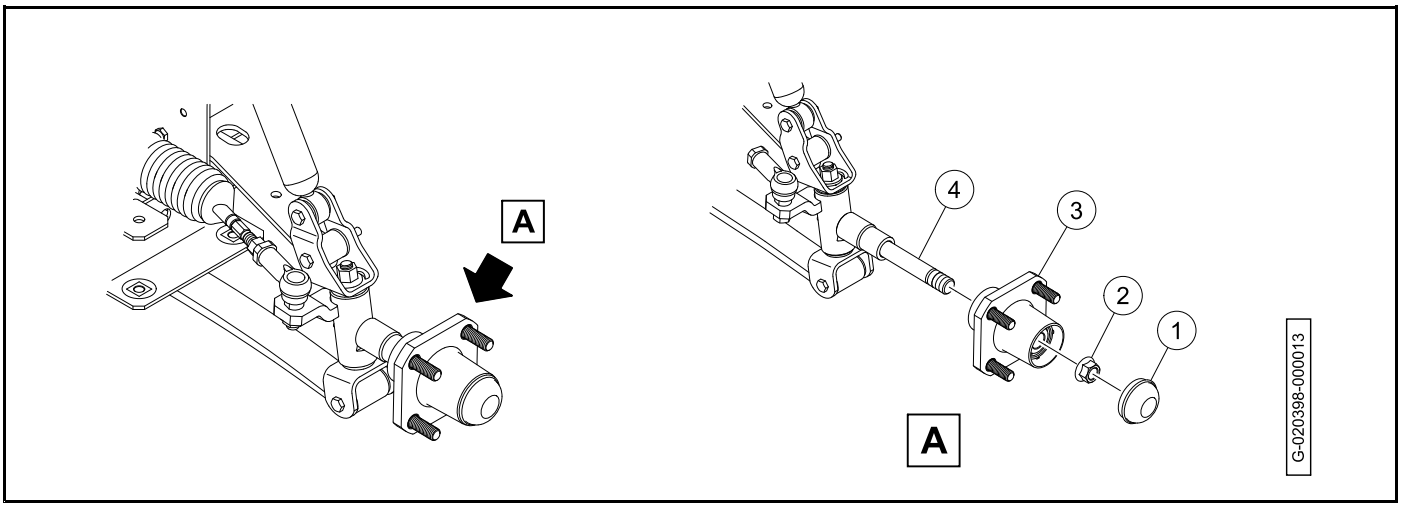


Figure 7-48 Non-Lifted Suspension Shown. Lifted Suspension Is Typical.

5. Remove and discard the lock nut (2).
6. Remove the hub assembly (3).
7. Inspect the surface of the spindle shaft (4) for surface damage. The spindle shaft must be clean and smooth.
8. If the spindle shaft has severe pitting from rust or corrosion, replace the spindle assembly.

FRONT WHEEL HUB INSTALLATION

1. Apply a light coat of anti-seize lubricant to the spindle shaft (1) **(Figure 7-49)**.

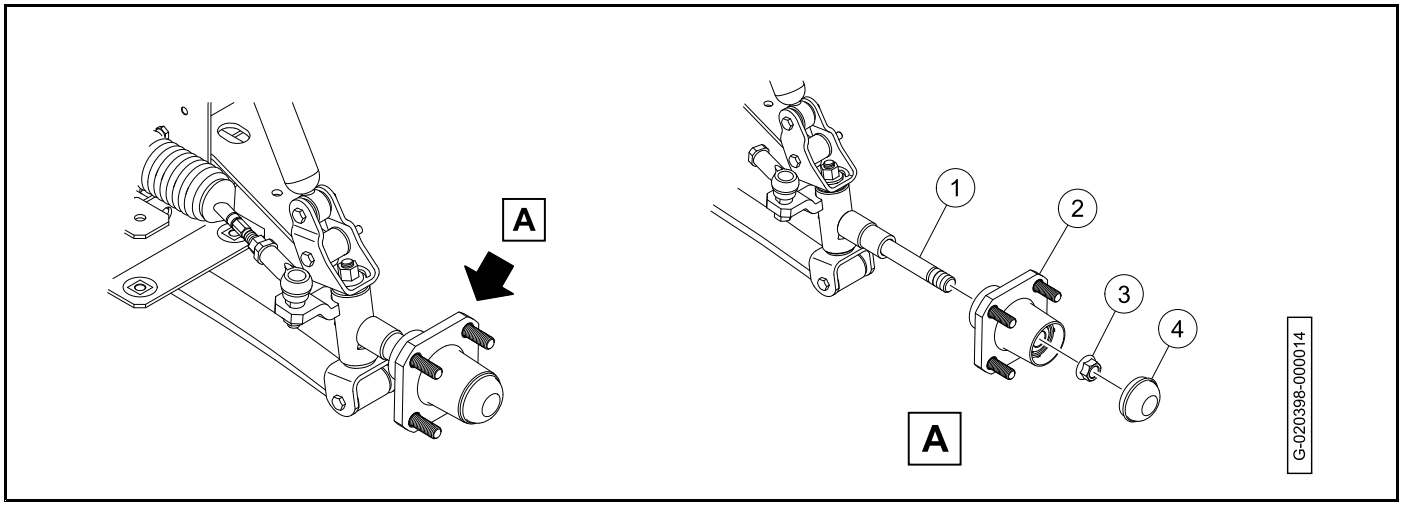


Figure 7-49 Non-Lifted Suspension Shown. Lifted Suspension Is Typical.

2. Install the hub assembly (2) onto the spindle shaft.
3. Install the new lock nut (3). Tighten the lock nut to 50 lb·ft (68 N·m).
4. Rotate the hub. The hub should rotate smoothly without binding, side play, or any indication of rough spots.
5. Install the dust cap (4).
6. Install the front wheels.
7. **Electric Vehicle:** Connect the batteries.
   Gasoline Vehicle: Connect the battery and spark plug wire.

SECTION 8 — WHEELS AND TIRES

8

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

GENERAL INFORMATION

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

- Keep tires properly inflated.
- Keep lug nuts properly tightened.
- Keep the front end aligned and adjusted.

⚠ WARNING

- **Tires affect vehicle handling. When selecting a replacement tire, use only original equipment or comparable tires.**

LIFT THE VEHICLE

⚠ 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.**

LIFT THE FRONT OF THE VEHICLE

Use a jack and jack stands rated for the vehicle.

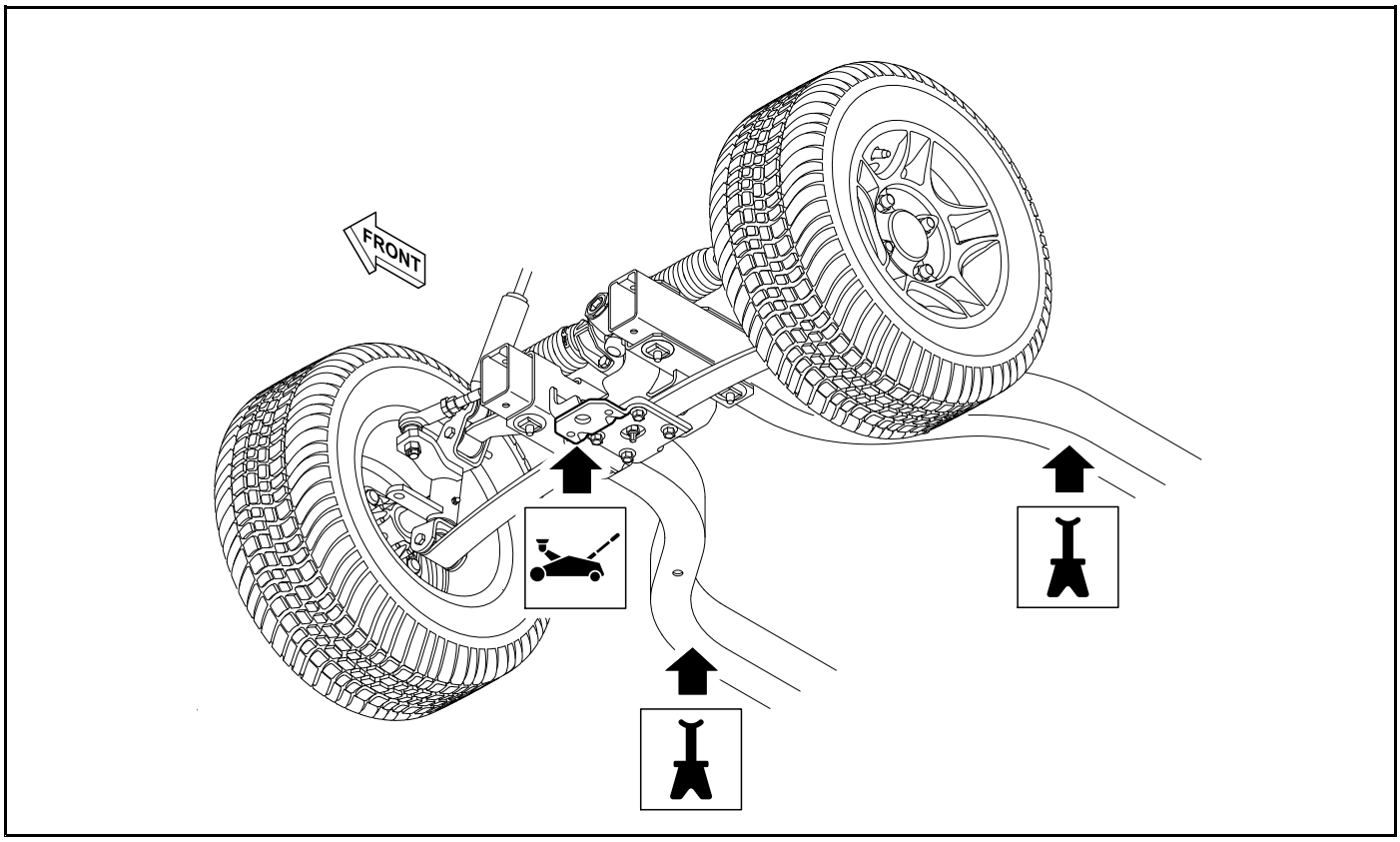


Figure 8-1

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect battery and spark plug wire.
3. Place the jack in the center of the lift point **(Figure 8-1, Page 8-2)**.
4. Lift the front of the vehicle.
5. Put jack stands under the frame rails.
6. Lower the vehicle onto the jack stands.

LOWER THE FRONT OF THE VEHICLE

Use a jack and jack stands rated for the vehicle.

1. Place the jack in the center of the lift point **(Figure 8-1, Page 8-2)**.
2. Lift the front of the vehicle.
3. Remove the jack stands.
4. Lower the vehicle.

LIFT THE REAR OF THE VEHICLE

Use a jack and jack stands rated for the vehicle **(Figure 8-2, Page 8-3)**.

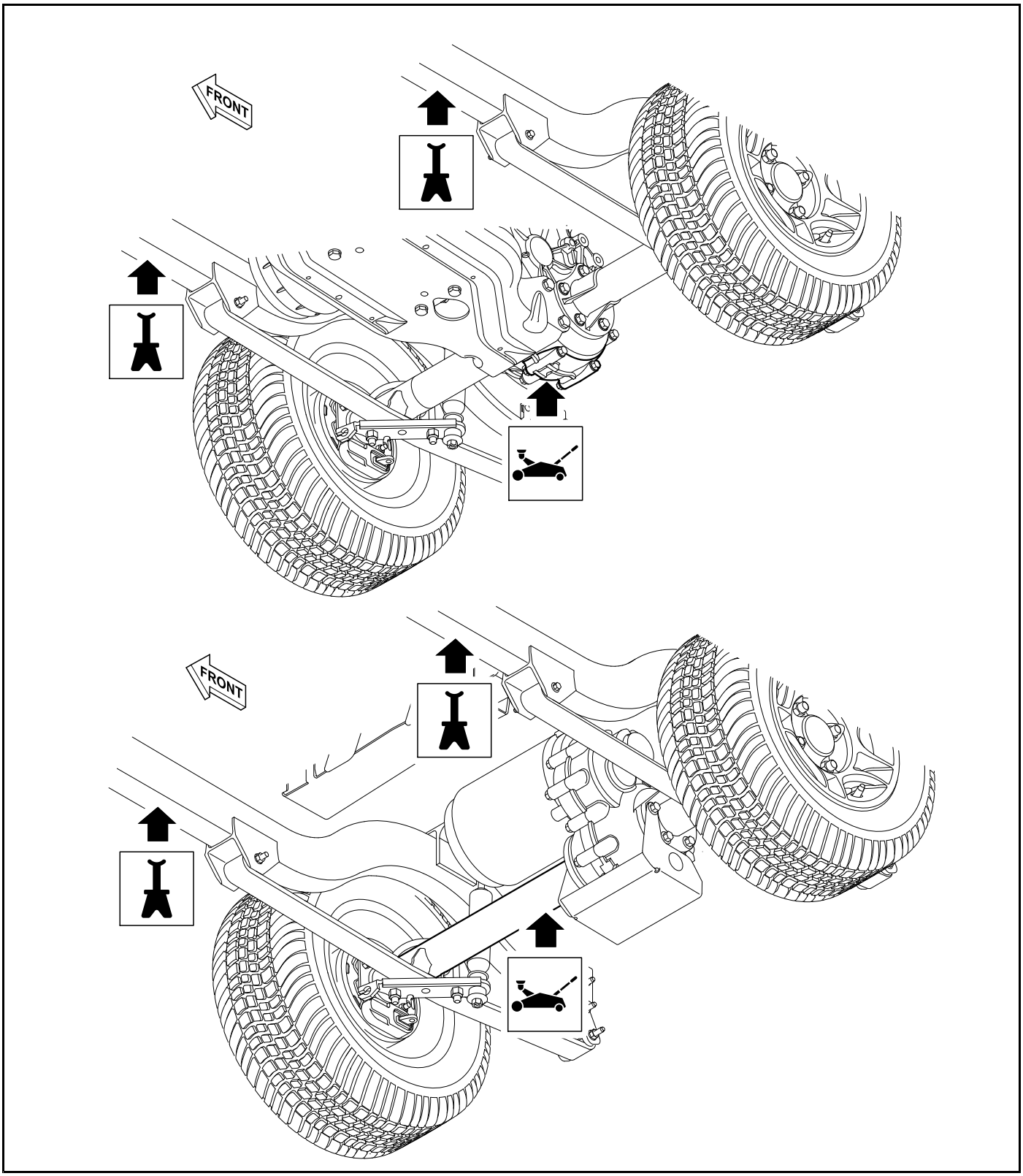


Figure 8-2 Top: Gasoline / Bottom: Electric

1. Disable the vehicle.

2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect battery and spark plug wire.
3. Place the jack in the center of the lift point **(Figure 8-2, Page 8-3)**.
4. Lift the rear of the vehicle.
5. Put jack stands under the frame rails.
6. Lower the vehicle onto the jack stands.

LOWER THE REAR OF THE VEHICLE

Use a jack and jack stands rated for the vehicle.

1. Place the jack in the center of the lift point **(Figure 8-2, Page 8-3)**.
2. Lift the front of the vehicle.
3. Remove the jack stands.
4. Lower the vehicle.

TIRES

See General Warnings on page 1-2.

TIRE PRESSURE MEASUREMENT

1. Disable the vehicle.
2. Remove the valve stem cap.
3. Use a pressure gauge to measure the tire pressure.
4. Adjust the tire pressure to meet the recommended tire pressure. Go to the approved wheel and tire assemblies matrix on *http://www.clubcar.com* for information regarding tire type, inflation pressure, and lug nut torque.
5. Install the valve stem cap.

TIRE REMOVAL

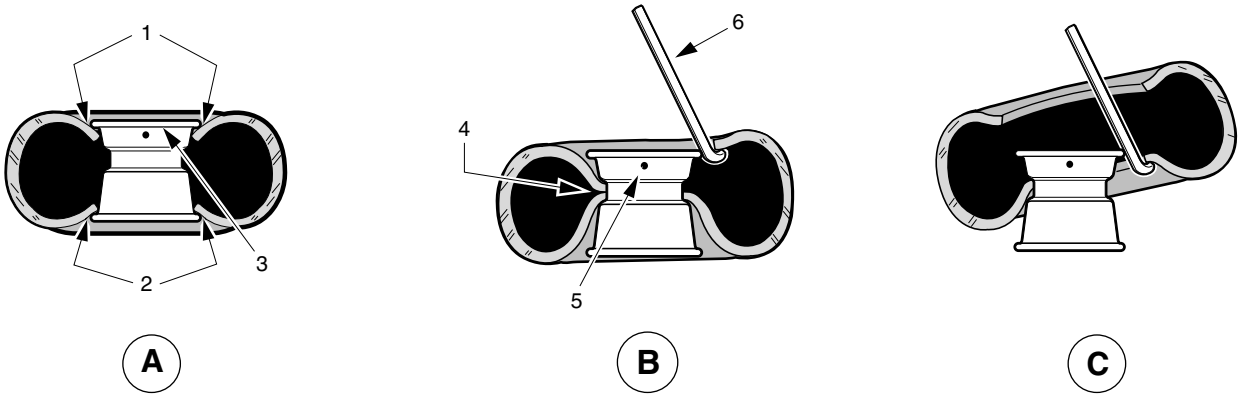
The tire must be removed from the valve stem side of the rim.

1. Remove the wheel assembly. See Wheel Assembly Removal.
2. Remove the valve cap and valve core.

NOTE: *This will allow air to escape from the tire.*

3. If possible, use a tire machine to remove the tire from the rim.

4. 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 8-3, Page 8-5, Detail A)**.



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

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Figure 8-3 Tire Removal

5. Position the wheel assembly with the valve stem up.

CAUTION

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

6. Use a tire tool to carefully start the upper bead over the edge of the wheel rim **(Figure 8-3, Page 8-5, Detail B)**.
7. 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 8-3, Page 8-5, Detail C)** and carefully pry the lower bead over the rim flange.
8. Once the lower bead is started over the rim flange, the tire can be removed from the rim by hand.

TIRE REPAIR

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

1.1. Remove the wheel. See Wheel Assembly Removal.

1.2. Inflate the tire to no more than 20 psig (138 kPa).

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

1.4. 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 your local Club Car dealer.

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

TIRE INSTALLATION

⚠ WARNING

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

The tire must be installed from the valve stem side of the rim.

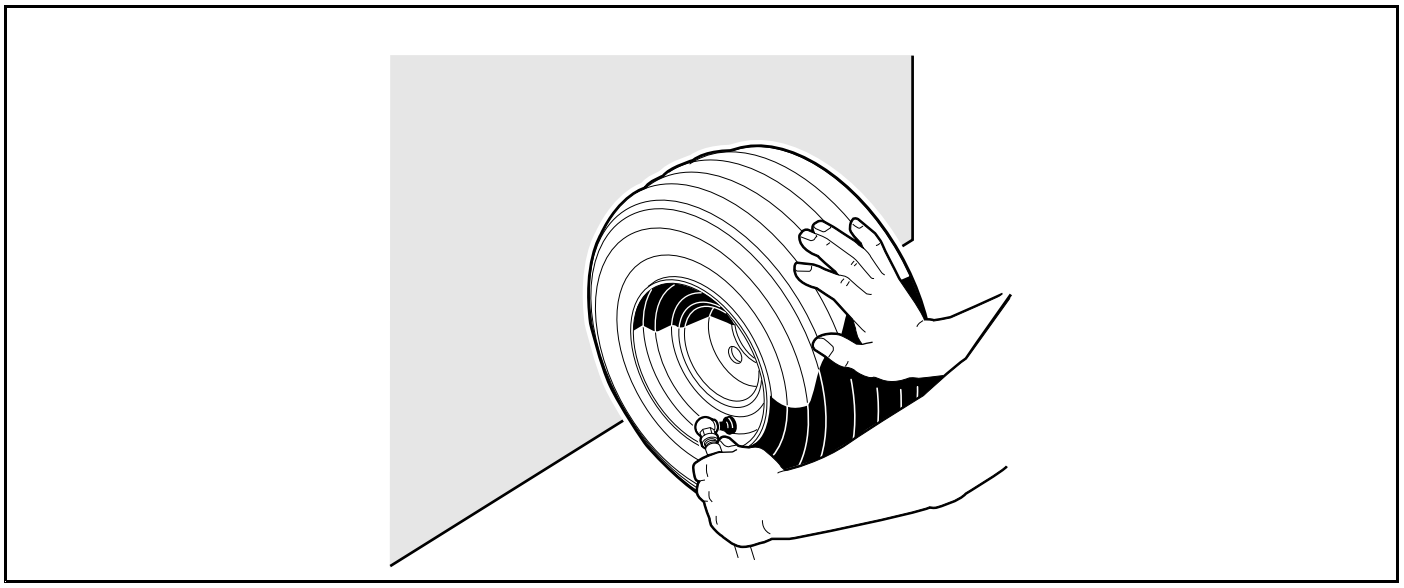
1. Clean both tire beads to remove dirt or other foreign matter.
2. Where the tire beads seat, clean the wheel rim with a wire brush. Wipe away any debris with a clean cloth.

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 tire so that both beads are on the rim flange narrow bead seats.
6. Place tire and wheel assembly against wall in upright position and push it against wall while inflating tire to 30 to 35 psig (207 to 242 kPa). The three-point contact (wall, floor, and hand) will help ensure that beads snap into place and form a proper seal as tire is inflated **(Figure 8-4, Page 8-6)**. **See following WARNING.**

⚠ WARNING

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



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Figure 8-4

7. Quickly remove the air nozzle and install the valve core.
8. Adjust air pressure in tire to recommended pressure.
9. Immerse the wheel and tire assembly in water to make sure there are no leaks.

WHEEL ASSEMBLY

See General Warnings on page 1-2.

WHEEL ASSEMBLY REMOVAL

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect battery and spark plug wire.
3. Remove the wheel cover.
4. Loosen the lug nuts.
5. Lift the front or rear of the vehicle. See Lift The Vehicle.
6. Remove the lug nuts.
7. Remove the wheel assembly.

WHEEL ASSEMBLY INSTALLATION

1. Disable the vehicle.
2. Align the wheel assembly onto the hub of the vehicle.

NOTE: *Make sure that the valve stem points to the outer side of the vehicle.*

NOTE: *Make sure that the tire tread is in the correct direction of travel.*

3. Install the lug nuts with the taper to the vehicle.
4. Tighten the lug nuts until they are hand-tight.
5. Lower the front or rear of the vehicle. See Lift The Vehicle section.
6. Tighten the lug nuts to the recommended torque specification in a crisscross pattern.
7. Install the wheel cover.
8. **Electric Vehicle:** Connect the batteries.

   Gasoline Vehicle: Connect the battery and spark plug wire.

Pagination Page

SECTION 9 — REAR SUSPENSION

See General Warnings Section.

GENERAL INFORMATION

The rear suspension and powertrain of the vehicle move independently from the vehicle frame. It consists of two leaf springs controlled by two shock absorbers mounted between the springs and the vehicle frame.

SHOCK ABSORBERS

The following procedures are the same for all vehicles.

REAR SHOCK ABSORBER INSPECTION

Examine the area (1) where the shaft enters the shock absorber body **(Figure 9-1, Page 9-1)**.

1. If there is fluid leakage, replace the shock absorber.

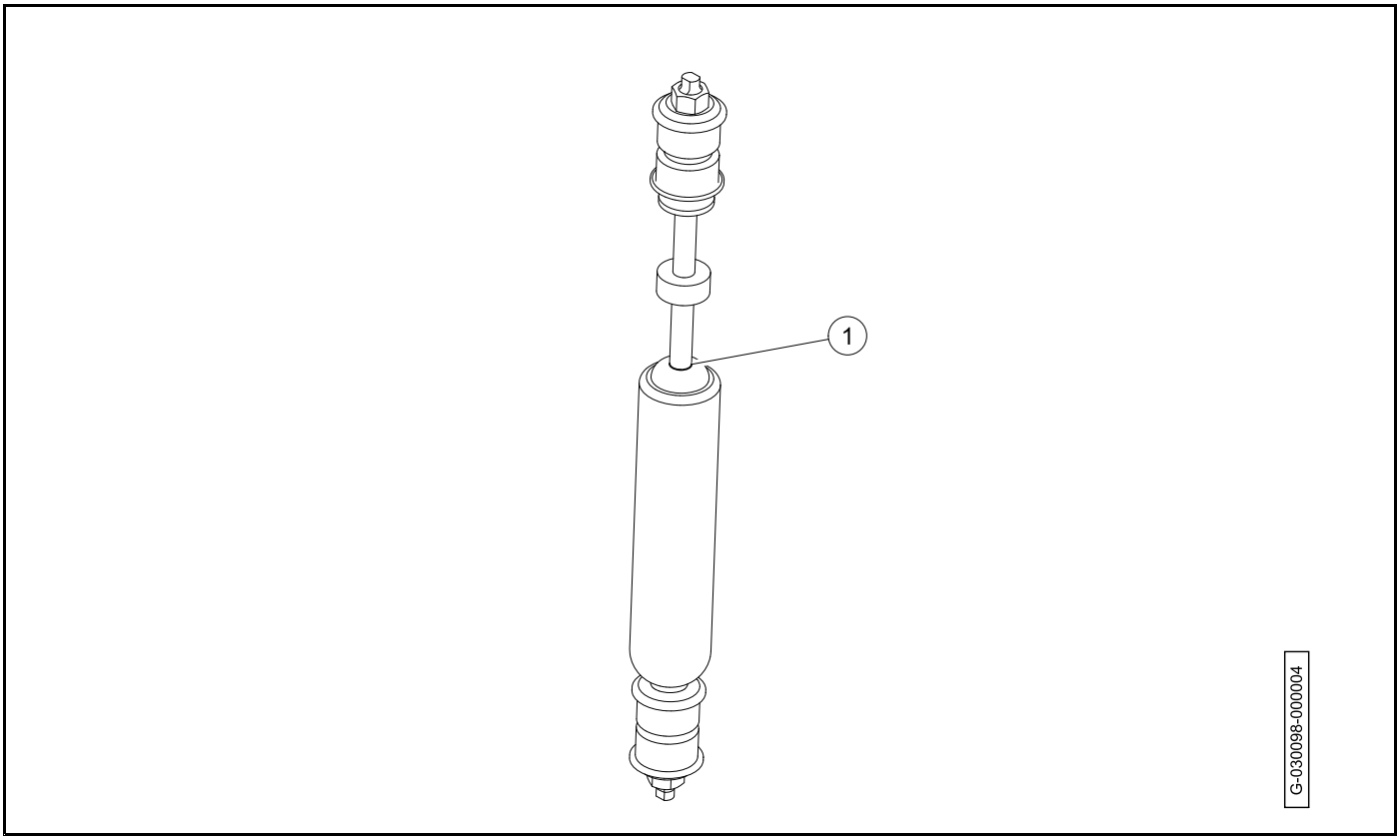


Figure 9-1 Rear Shock Absorber Inspection

REAR SHOCK ABSORBER REMOVAL

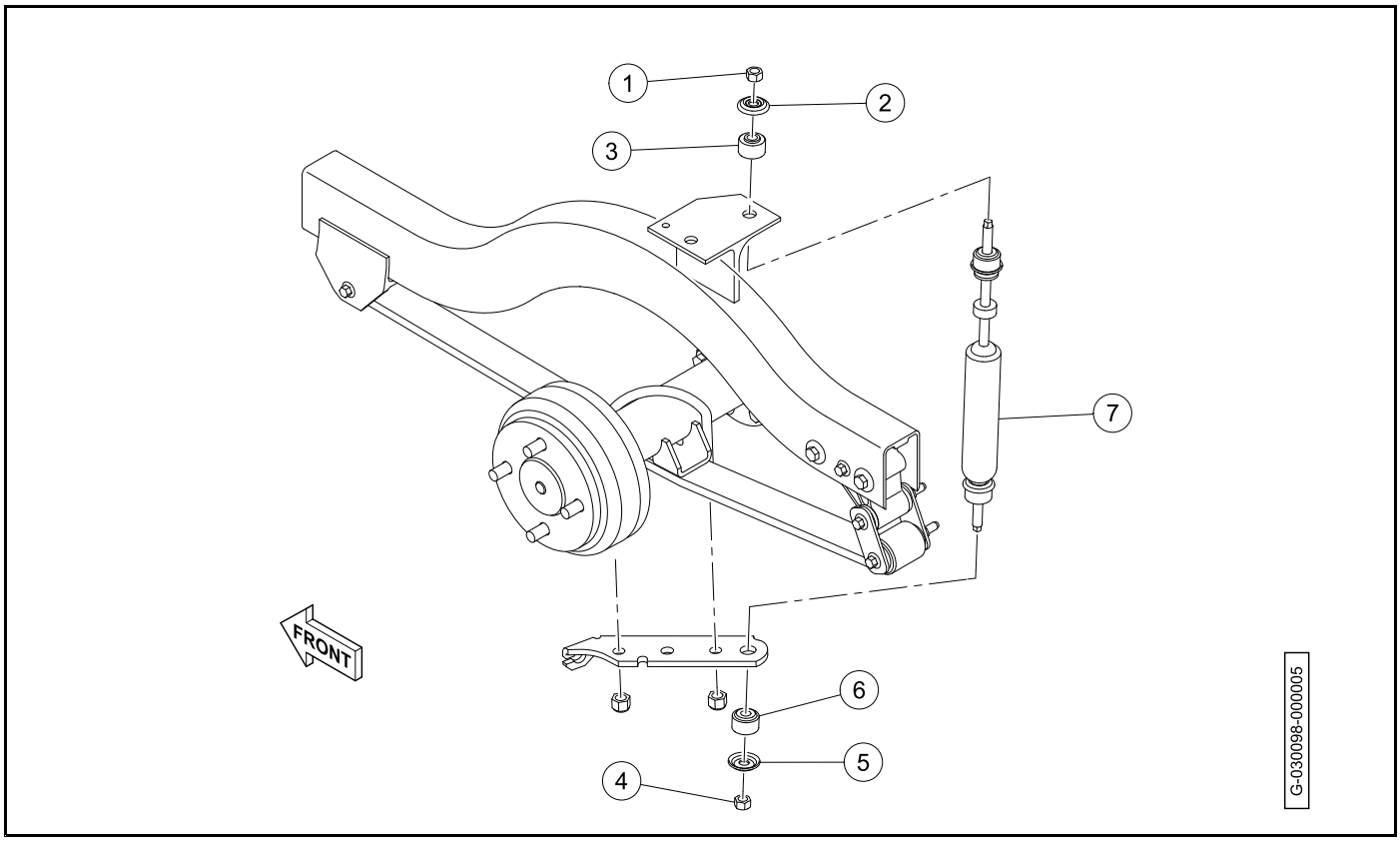


Figure 9-2 Rear Shock Absorber Removal

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect battery and spark plug wire.
3. Remove the nut (1), cup washer (2), and rubber bushing (3) from the top of the shock absorber **(Figure 9-2, Page 9-2)**.
4. Remove the nut (4), cup washer (5), and rubber bushing (6) from bottom of the shock absorber.
5. Compress and remove the shock absorber (7).

REAR SHOCK ABSORBER INSTALLATION

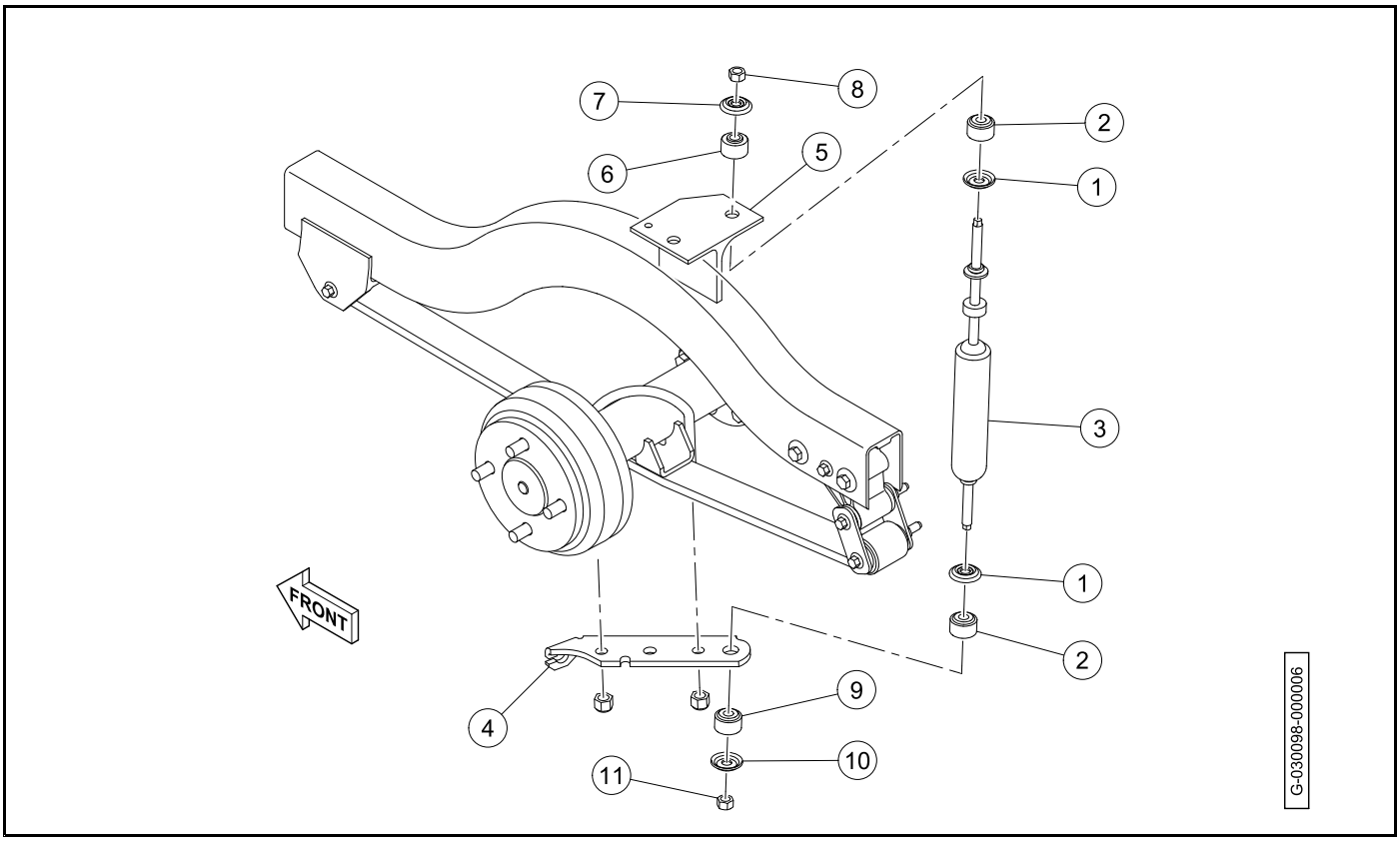


Figure 9-3 Rear Shock Absorber Installation

1. Install the cup washers (1) and rubber bushings (2) onto the shock absorber (3) **(Figure 9-3, Page 9-3)**.
2. Install the bottom stem of the shock absorber into the shock mount bracket (4).
3. Install the top stem of the shock absorber into the frame shock mount (5).
4. Install the rubber bushing (6), cup washer (7), and nut (8) onto the top of the shock absorber.
5. Install the rubber bushing (9), cup washer (10), and nut (11) onto the top of the shock absorber.
6. Tighten the nuts until the rubber bushings expand to the size of the cup washer.
7. **Electric Vehicle:** Connect the batteries.
   Gasoline Vehicle: Connect battery and spark plug wire.

PANHARD AND BRACKET

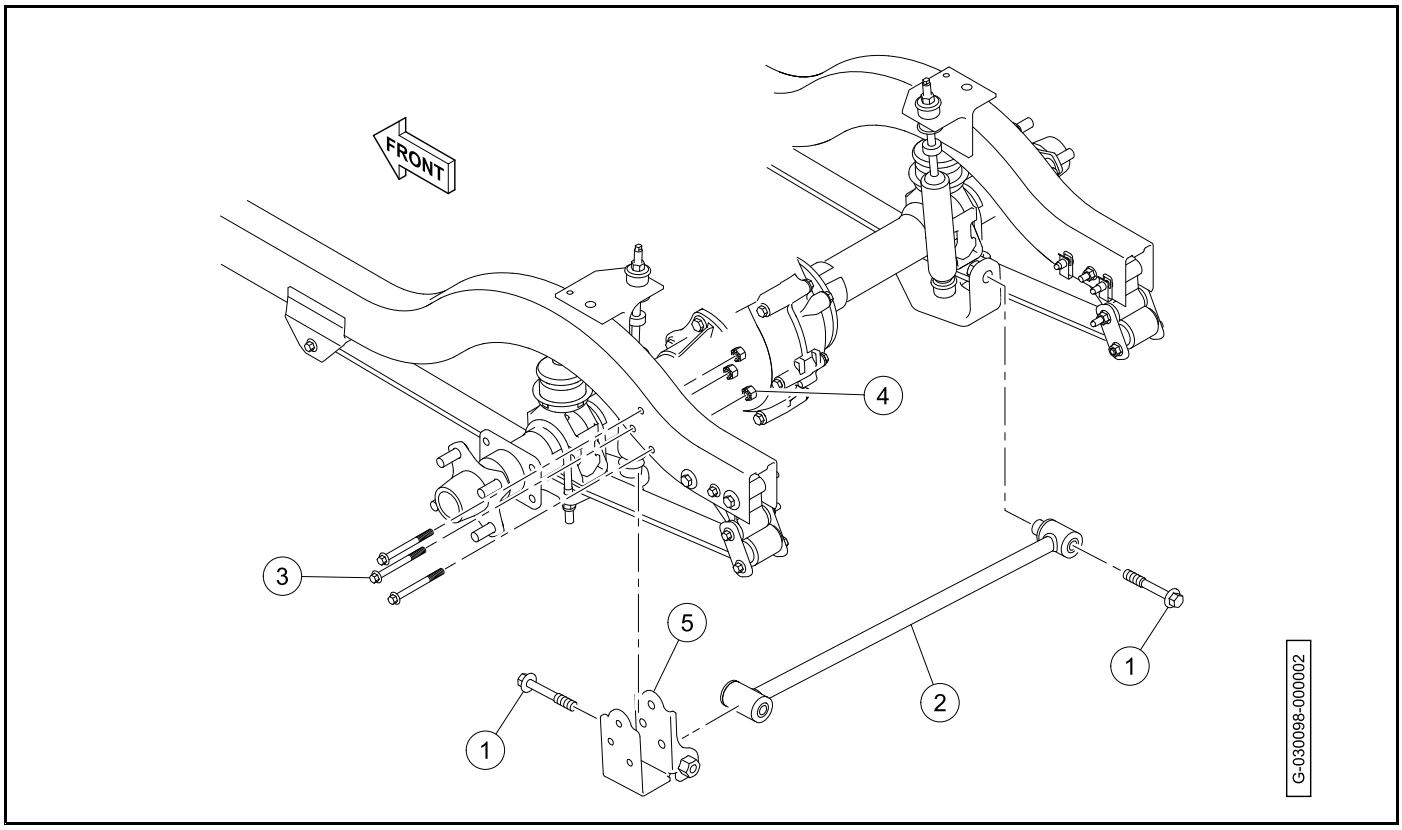


Figure 9-4 Panhard and Bracket

PANHARD AND BRACKET REMOVAL

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect battery and spark plug wire.
3. Remove the bolts (1) **(Figure 9-4, Page 9-4)**.
4. Remove the panhard (2).
5. Remove the bolts (3) and nuts (4).
6. Remove the bracket (5).

PANHARD AND BRACKET INSTALLATION

1. Put the bracket (5) into position on the frame **(Figure 9-4, Page 9-4)**.
2. Install the bolts (3) and nuts (4). Tighten the bolts to 18.5 lb·ft (25 N·m).
3. Put the panhard (2) into position on the vehicle.
4. Install the bolts (1). Tighten the bolts to 92 lb·ft (125 N·m).
5. **Electric Vehicle:** Connect the batteries.
   Gasoline Vehicle: Connect battery and spark plug wire.

LEAF SPRINGS (TWO-PASSENGER)

LEAF SPRING REMOVAL (TWO-PASSENGER)

⚠ 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.**

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect the battery and spark plug wire.
3. Lift the rear of the vehicle.
4. Put 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.
6. Remove the bow tie locking pin (1) and the clevis pin (2) **(Figure 9-5)**.

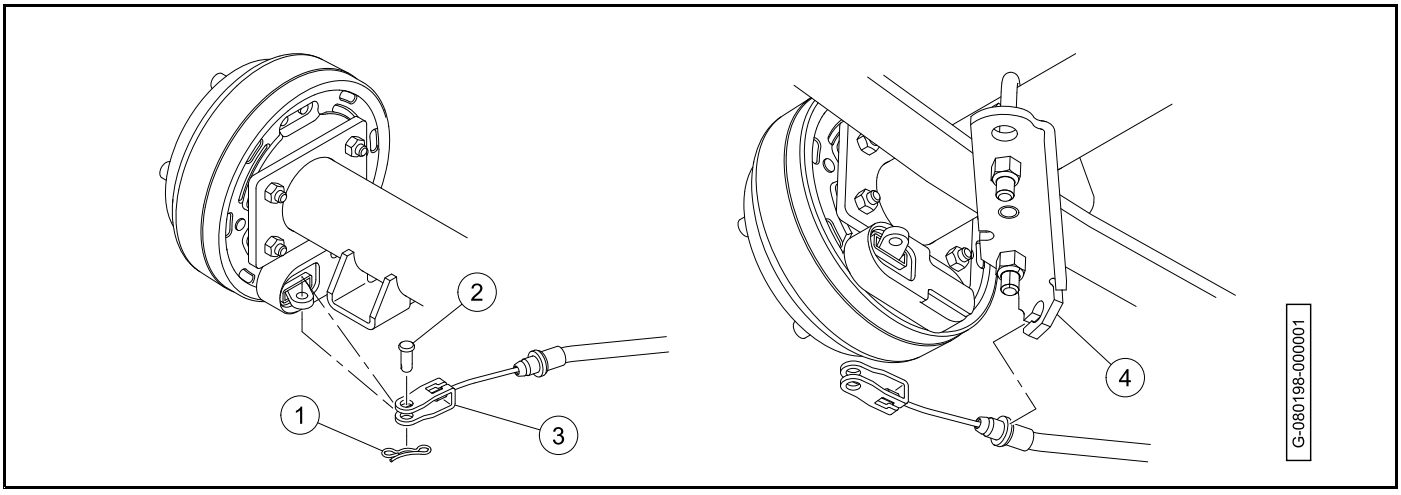


Figure 9-5

7. Remove the cable end (3) from the brake lever.
8. Remove the brake cable from the shock mount bracket (4).

9. Remove the nut (5), cup washer (6), and rubber bushing (7) from the bottom stem of the shock absorber **(Figure 9-6)**.

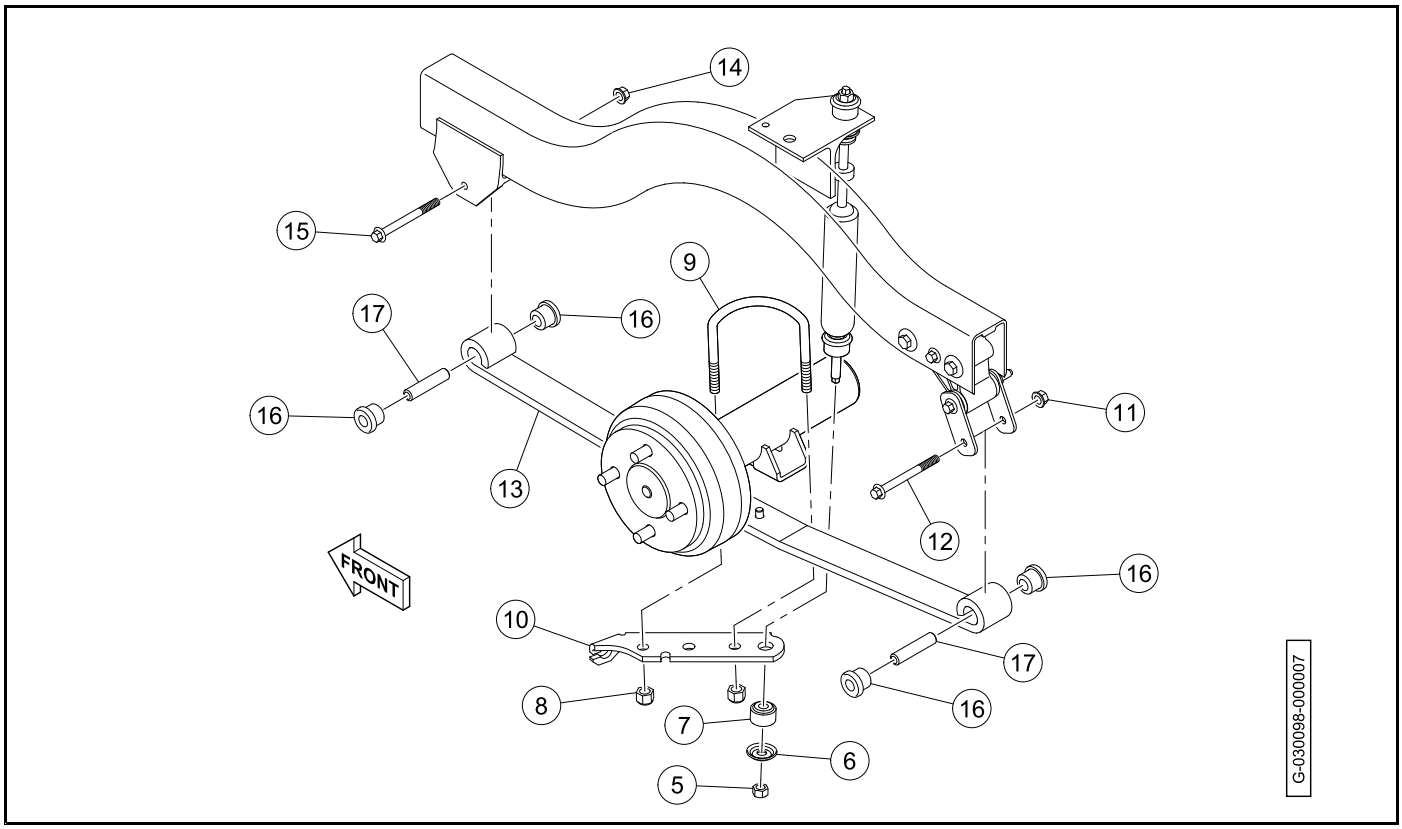


Figure 9-6 Leaf Spring Removal - Two-Passenger

10. Remove the nuts (8) and the U-bolt (9) securing the spring to the transaxle.
11. Remove the shock mount bracket (10) and the U-bolt.
12. Remove the nut (11) and bolt (12) from the rear of the leaf spring (13).
13. Remove the nut (14) and bolt (15) from the front of the leaf spring and remove the leaf spring.
14. Examine the bushings (16) and sleeves (17) in the spring eyes.

14.1. If the bushings or sleeves are worn or have damage, replace them.

LEAF SPRING INSTALLATION (TWO-PASSENGER)

⚠ CAUTION

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

1. Install the front of the leaf spring (1) onto the vehicle frame **(Figure 9-7)**.

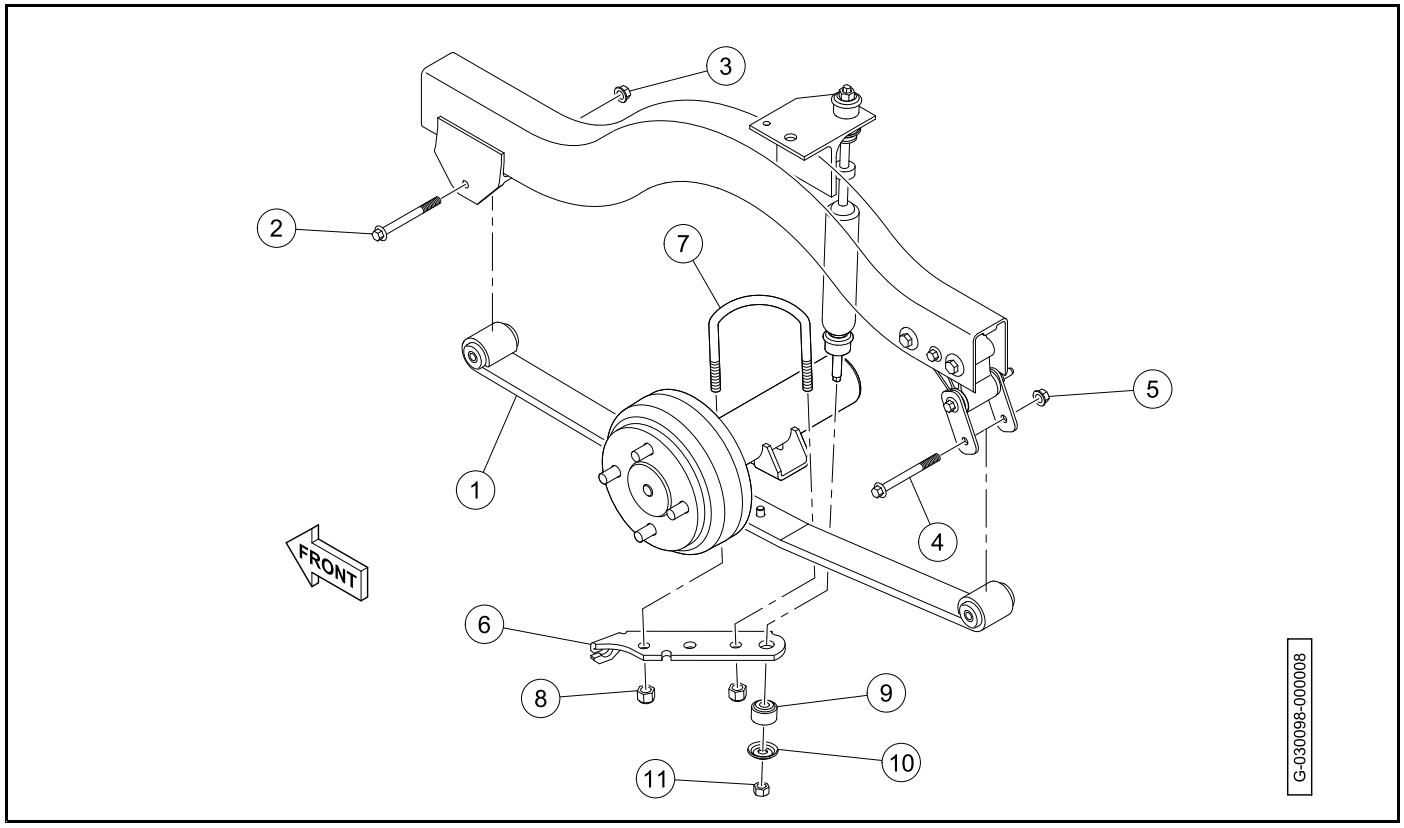


Figure 9-7 Leaf Spring Installation - Two-Passenger

2. Install the bolt (2) and nut (3). Tighten the nut to 18.5 lb·ft (25 N·m).
3. Install the rear of the leaf spring onto the shackle.
4. Install the bolt (4) and nut (5). Tighten the nut to 18.5 lb·ft (25 N·m).
5. Install the shock mount bracket (6), U-bolt (7), and nuts (8). Tighten the nuts to 25 lb·ft (34 N·m).
6. Install the bottom stem of the shock absorber into the shock mount bracket.
7. Install the rubber bushing (9), cup washer (10), and nut (11). Tighten the nut until the rubber bushing expands to the size of the cup washer.

8. Install the brake cable onto the shock mount bracket (1) **(Figure 9-8)**.

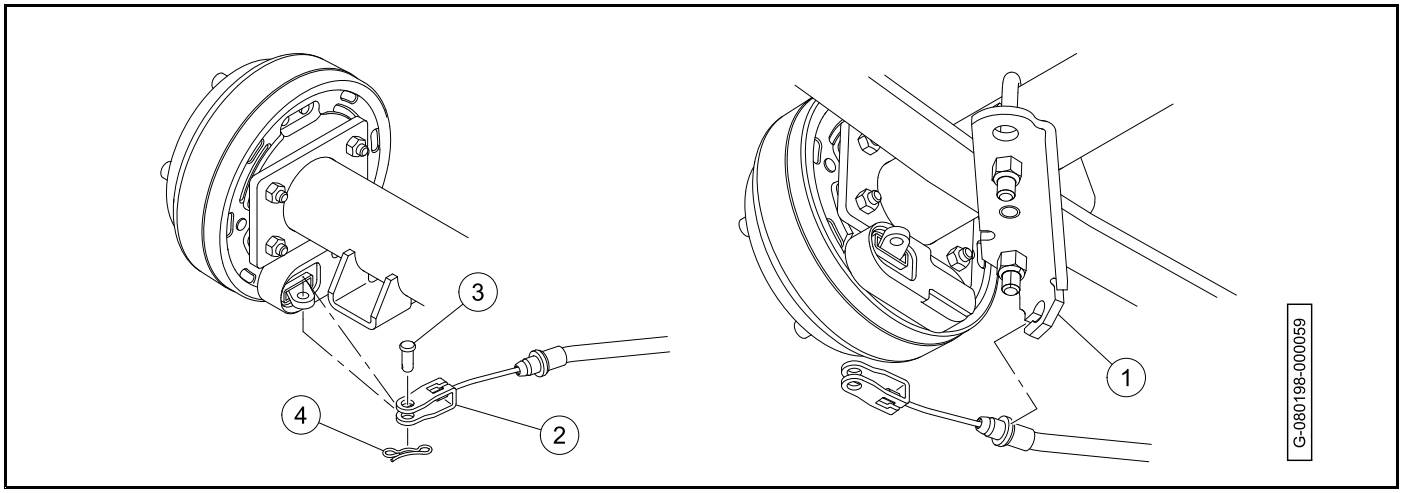


Figure 9-8

9. Install the cable end (2) onto the brake lever.
10. Install the clevis pin (3) and the bow tie locking pin (4).
11. Lower and remove the floor jack under the transaxle.
12. Install the tire and wheel assembly.
13. Lower the rear of the vehicle.
14. **Electric Vehicle:** Connect the batteries.
    Gasoline Vehicle: Connect the battery and spark plug wire.

LEAF SPRINGS (FOUR-PASSENGER)

See General Warnings on page 1-2.

LEAF SPRING REMOVAL (FOUR-PASSENGER)

⚠ 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.**

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect the battery and spark plug wire.
3. Lift the rear of the vehicle.
4. Put 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.
6. Remove the bow tie locking pin (1) and the clevis pin (2) **(Figure 9-9, Page 9-9)**.

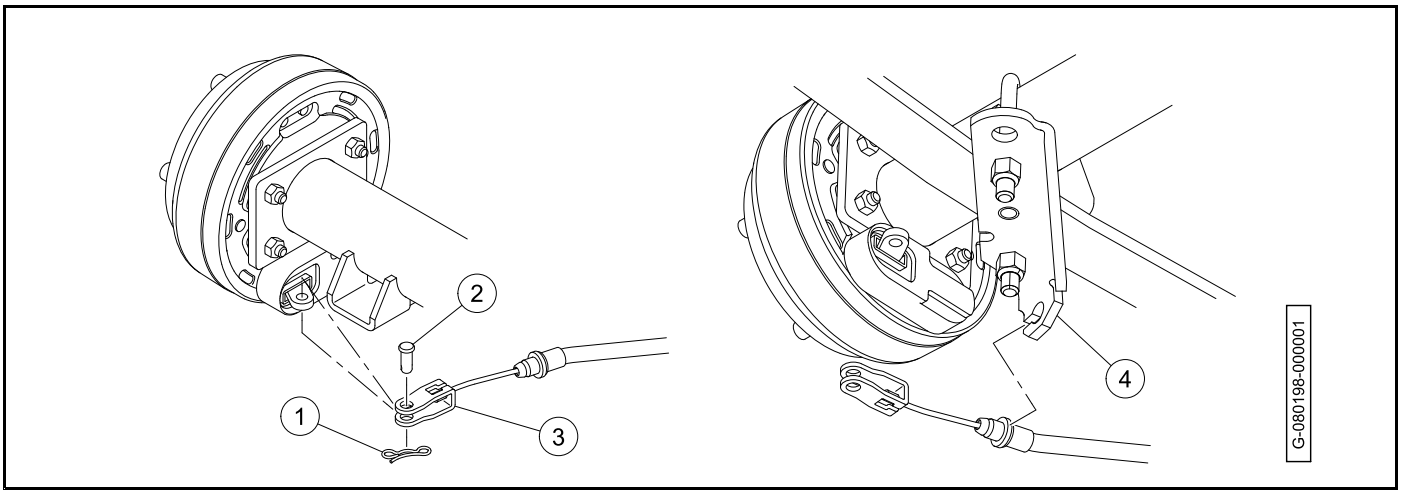


Figure 9-9

7. Remove the cable end (3) from the brake lever.
8. Remove the brake cable from the shock mount bracket (4).
9. Remove the nut (5), cup washer (6), and rubber bushing (7) from the bottom stem of the shock absorber **(Figure 9-10, Page 9-9)**.

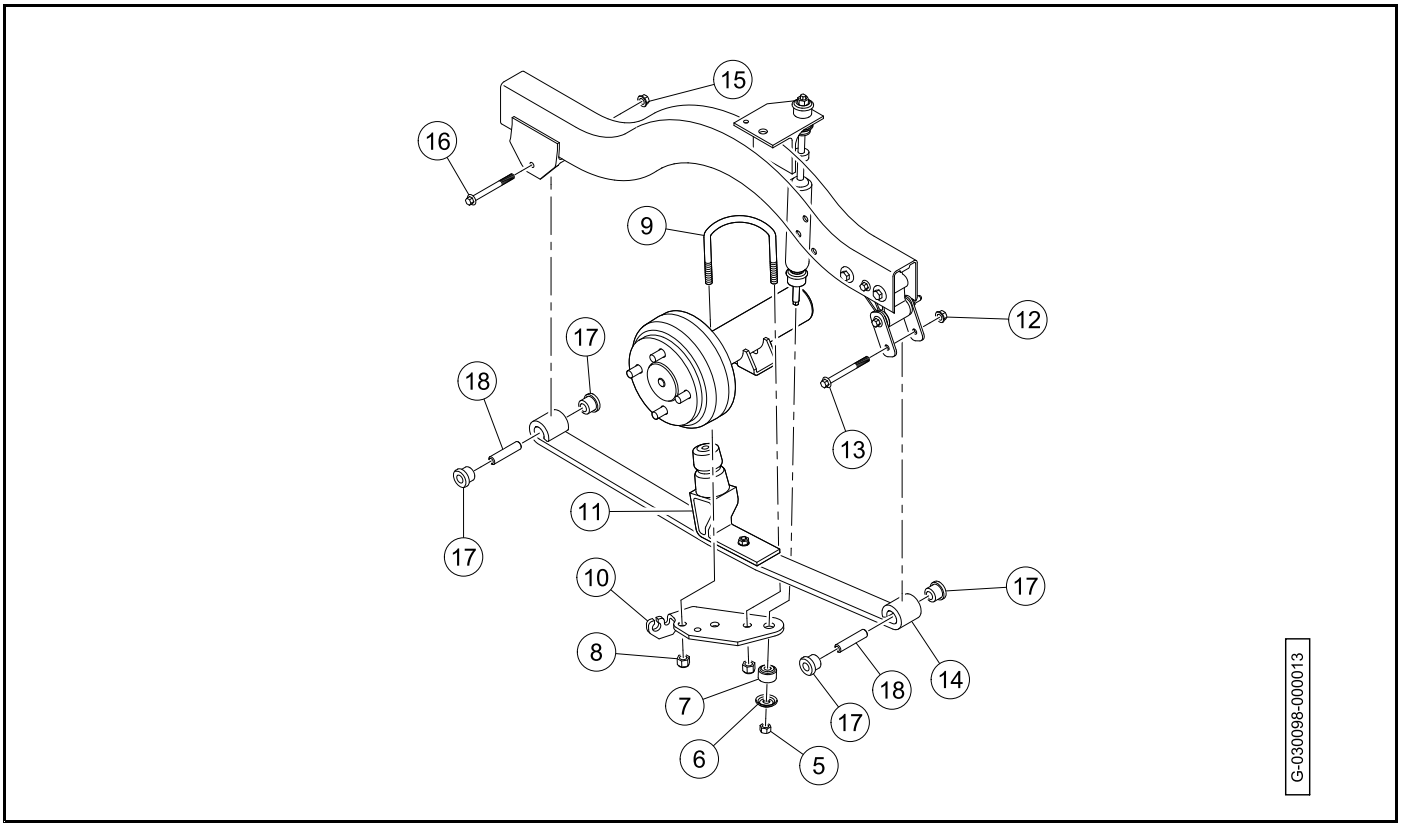


Figure 9-10 Leaf Spring Removal - Four-Passenger

10. Remove the nuts (8) and the U-bolt (9) securing the spring to the transaxle.
11. Remove the shock mount bracket (10), jounce bumper (11), and the U-bolt.
12. Remove the nut (12) and bolt (13) from the rear of the leaf spring (14).

13. Remove the nut (15) and bolt (16) from the front of the leaf spring and remove the leaf spring.
14. Examine the bushings (17) and sleeves (18) in the spring eyes.

14.1. If the bushings or sleeves are worn or have damage, replace them.

LEAF SPRING INSTALLATION (FOUR-PASSENGER)

⚠ CAUTION

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

1. Install the front of the leaf spring (1) onto the vehicle frame **(Figure 9-11, Page 9-10)**.

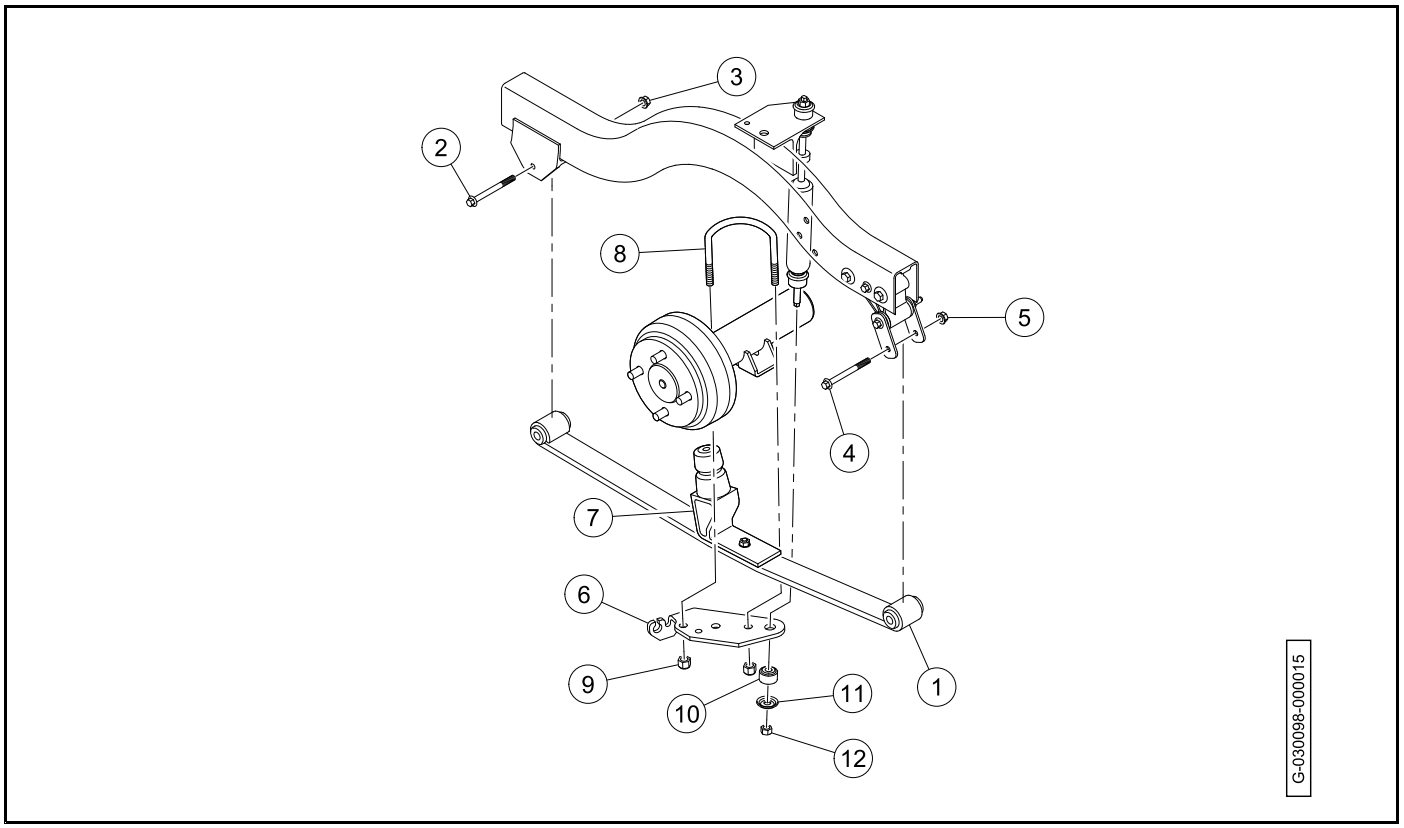


Figure 9-11 Leaf Spring Installation (Four-Passenger)

2. Install the bolts (2) and nut (3). Tighten the nut to 18.5 lb·ft (25 N·m).
3. Install the rear of the leaf spring onto the shackle.
4. Install the bolt (4) and nut (5). Tighten the nut to 18.5 lb·ft (25 N·m).
5. Install the shock mount bracket (6), jounce bumper (7), U-bolts (8), and nuts (9). Tighten the nuts to 45 lb·ft (60 N·m).
6. Install the bottom stem of the shock absorber into the shock mount bracket.
7. Install the rubber bushing (10), cup washer (11), and nut (12). Tighten the nut until the rubber bushing is the same size as the cup washer.
8. Install the brake cable onto the shock mount bracket (1) **(Figure 9-12, Page 9-11)**.

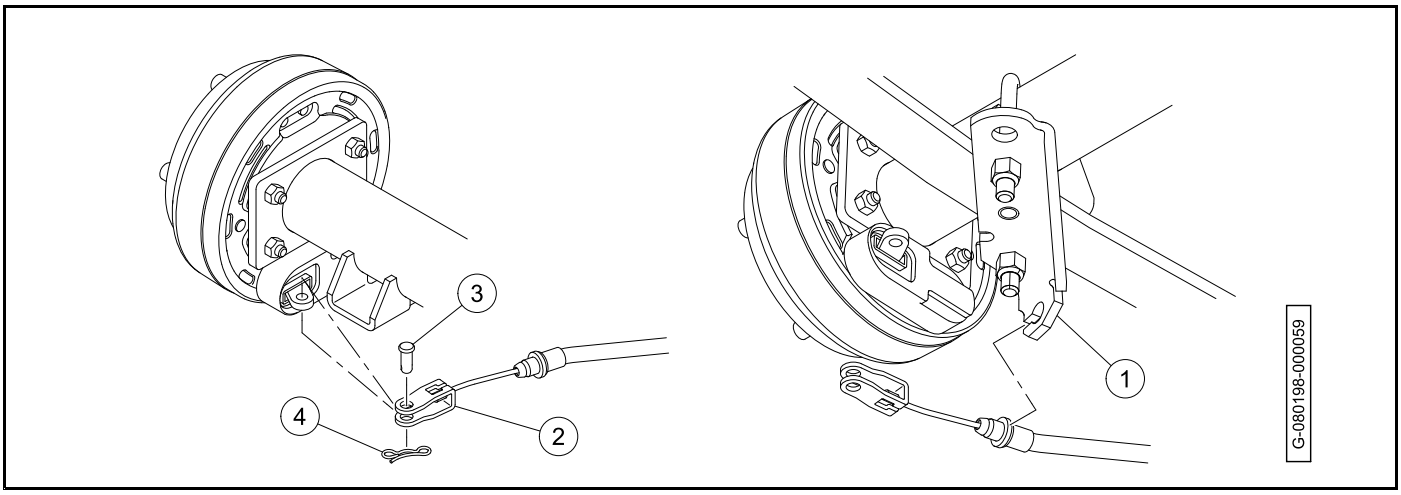


Figure 9-12

9. Install the cable end (2) onto the brake lever.
10. Install the clevis pin (3) and the bow tie locking pin (4).
11. Lower and remove the floor jack under the transaxle.
12. Install the tire and wheel assembly.
13. Lower the rear of the vehicle.
14. **Electric Vehicle:** Connect the batteries.
    Gasoline Vehicle: Connect the battery and spark plug wire.

LEAF SPRINGS (FOUR-PASSENGER - HEAVY DUTY WITH PANHARD)

LEAF SPRING REMOVAL (FOUR-PASSENGER - HEAVY DUTY WITH PANHARD)

⚠ 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.**

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect the battery and spark plug wire.
3. Lift the rear of the vehicle.
4. Put 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.
6. Remove the bow tie locking pin (1) and the clevis pin (2) **(Figure 9-13)**.

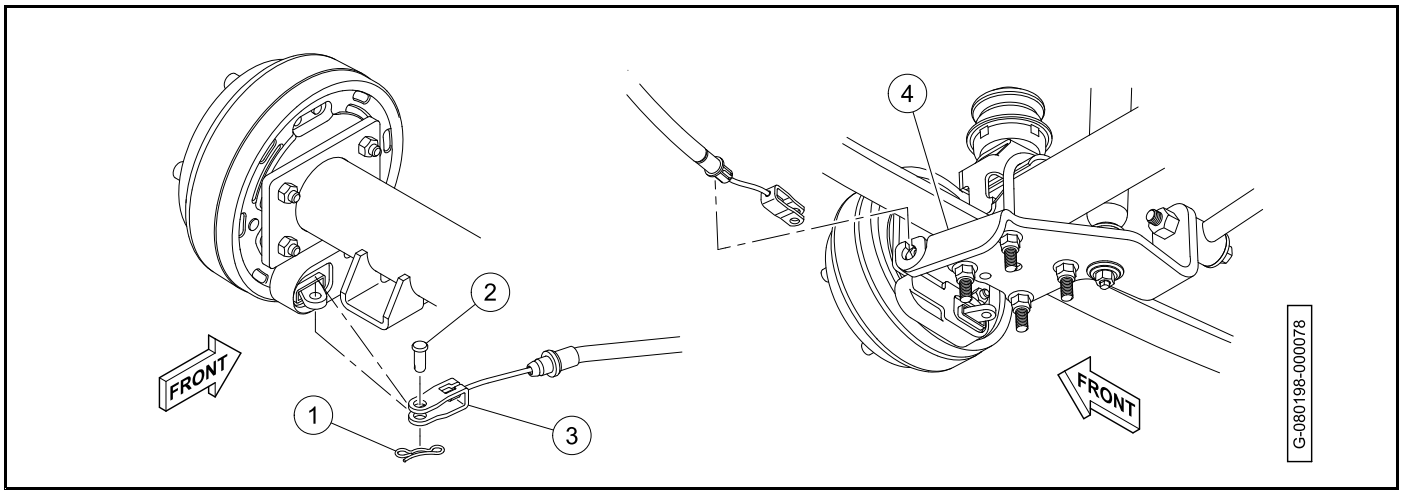


Figure 9-13

7. Remove the cable end (3) from the brake lever.
8. Remove the brake cable from the shock mount bracket (4).
9. Remove the nut (5), cup washer (6), and rubber bushings (7) from the lower mounting stem of the shock absorber **(Figure 9-14)**.

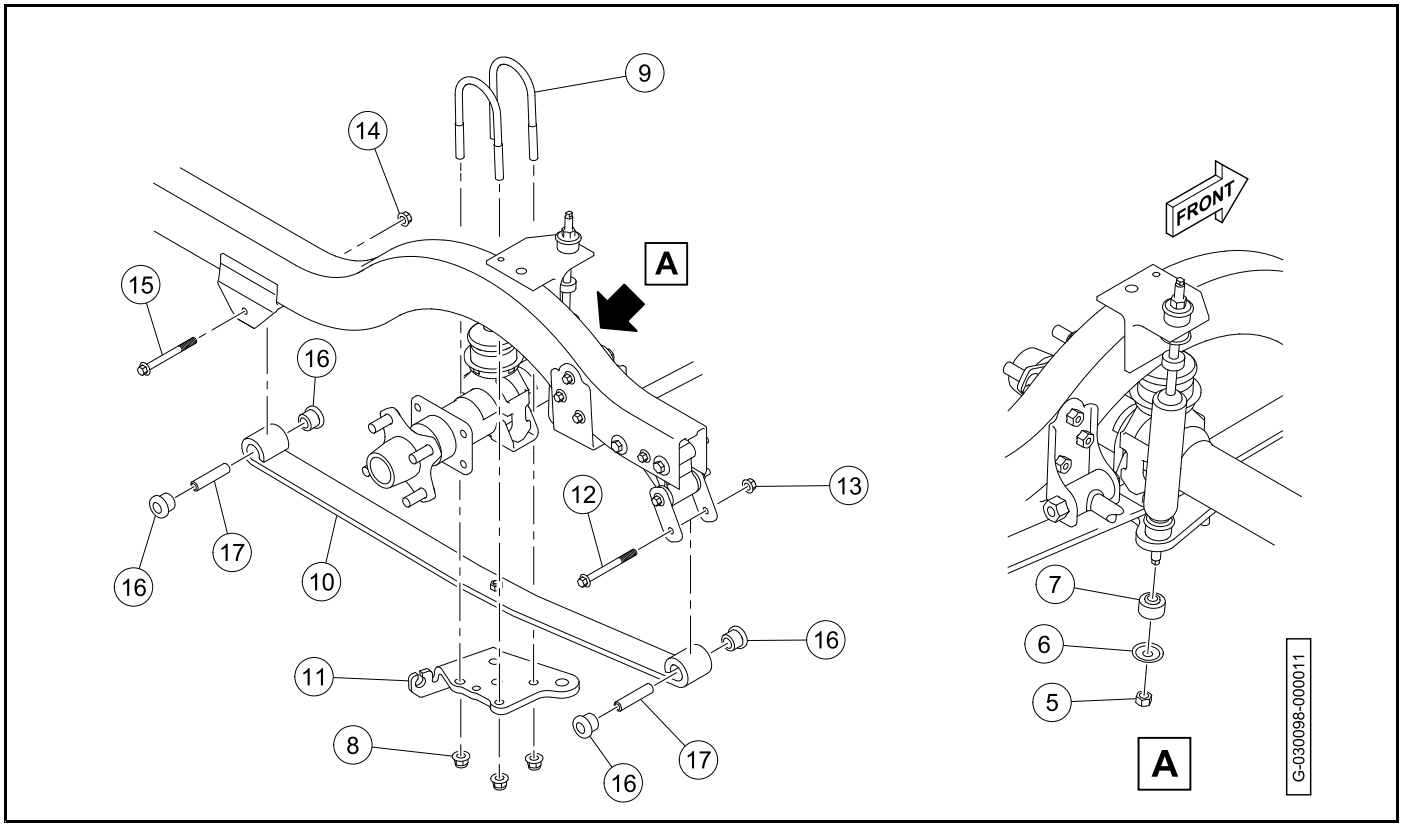


Figure 9-14 Leaf Spring Removal (Four-Passenger - Heavy Duty With Panhard)

10. Remove the nuts (8) U-bolts (9), and shock mount bracket (11).
11. Remove the bolt (12) and nut (13) attaching the rear of the (10) leaf spring to the shackle.
12. Remove the nut (14) and bolt (15) attaching the front of the leaf spring to the vehicle frame and remove the spring.

13. Inspect the bushings (16) and sleeves (17) in the spring eyes and replace them if they are worn or damaged.

LEAF SPRING INSTALLATION (FOUR-PASSENGER - HEAVY DUTY WITH PANHARD)

⚠ CAUTION

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

1. Install the front of the leaf spring (1) onto the vehicle frame **(Figure 9-15)**.

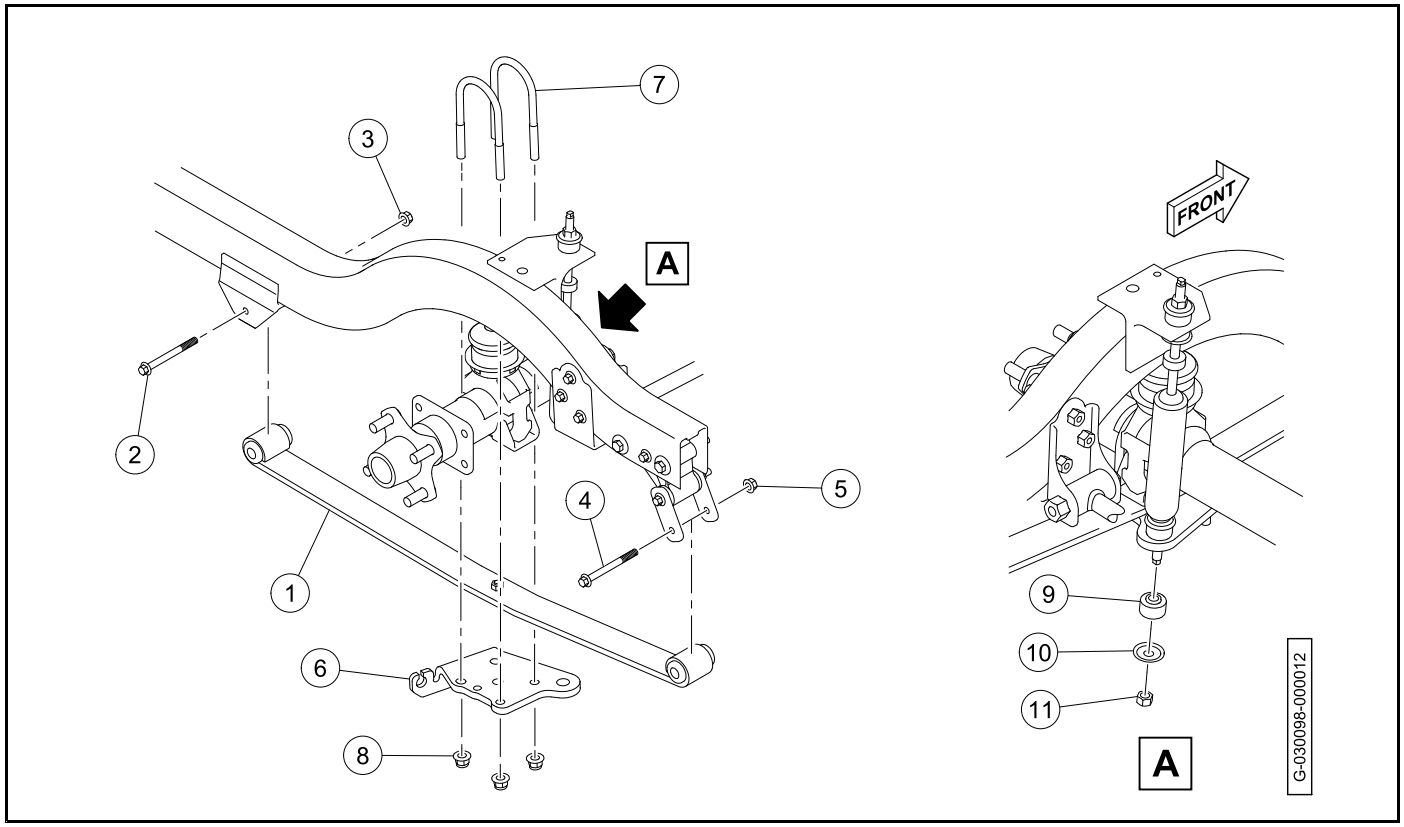


Figure 9-15 Leaf Spring Installation (Four-Passenger - Heavy Duty With Panhard)

2. Install the bolt (2) and nut (3). Tighten the nut to 18.5 lb·ft (25 N·m).
3. Install the rear of the leaf spring onto the shackle.
4. Install the bolt (4) and nut (5). Tighten the nut to 18.5 lb·ft (25 N·m).
5. Install the shock mount bracket (6), U-bolts (7), and nuts (8). Tighten the nuts to 45 lb·ft (60 N·m).
6. Install the bottom stem of the shock absorber into the shock mount bracket.
7. Install the rubber bushing (9), cup washer (10), and nut (11). Tighten the nut until the rubber bushing is the same size as the cup washer.

8. Install the brake cable onto the shock mount bracket (1) **(Figure 9-16)**.

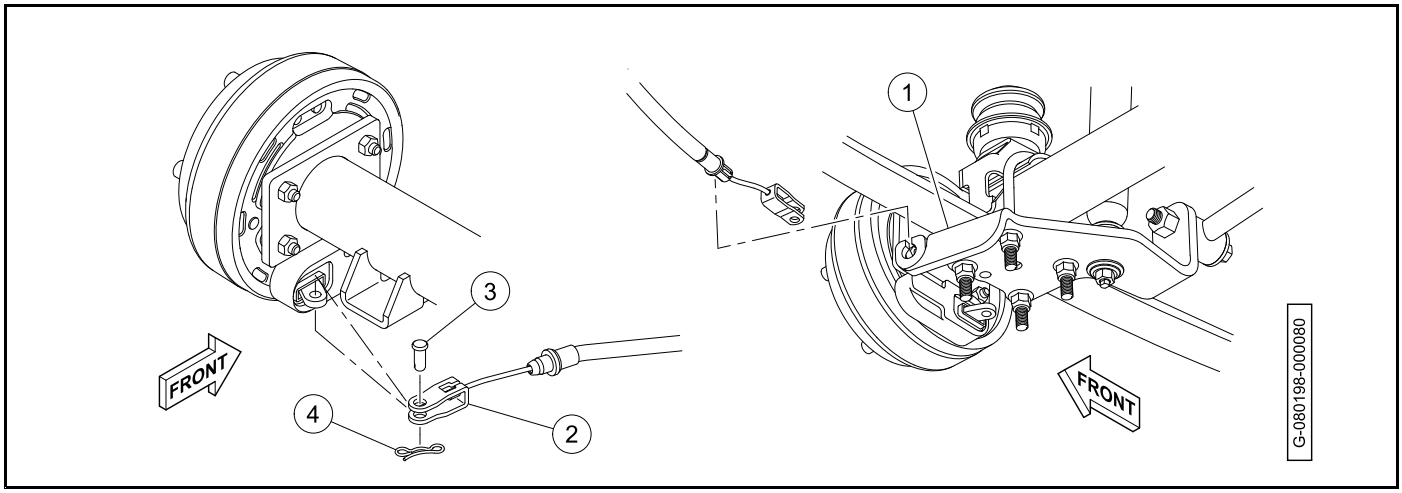


Figure 9-16

9. Install the cable end (2) onto the brake lever.
10. Install the clevis pin (3) and the bow tie locking pin (4).
11. Lower and remove the floor jack under the transaxle.
12. Install the tire and wheel assembly.
13. Lower the rear of the vehicle.
14. **Electric Vehicle:** Connect the batteries.
    Gasoline Vehicle: Connect the battery and spark plug wire.

LEAF SPRINGS (LIFTED FOUR-PASSENGER)

LEAF SPRING REMOVAL (LIFTED FOUR-PASSENGER)

1. Disable the vehicle.
2. **Electric Vehicle:** Disconnect the batteries and discharge the controller.
   Gasoline Vehicle: Disconnect the battery and spark plug wire.
3. Lift the rear of the vehicle.
4. Put 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.
6. Remove the bow tie locking pin (1) and the clevis pin (2) **(Figure 9-13, Page 9-12)**.

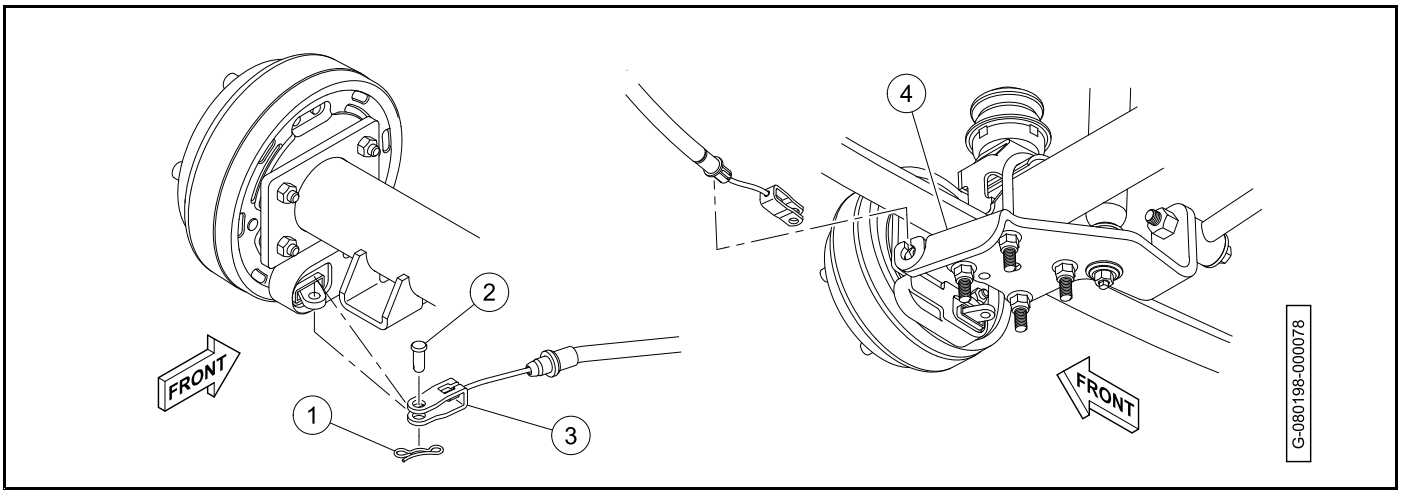


Figure 9-17

7. Remove the cable end (3) from the brake lever.
8. Remove the brake cable from the shock mount bracket (4).
9. Remove the nut (5), cup washer (6), and rubber bushings (7) from the lower mounting stem of the shock absorber **(Figure 9-18, Page 9-15)**.

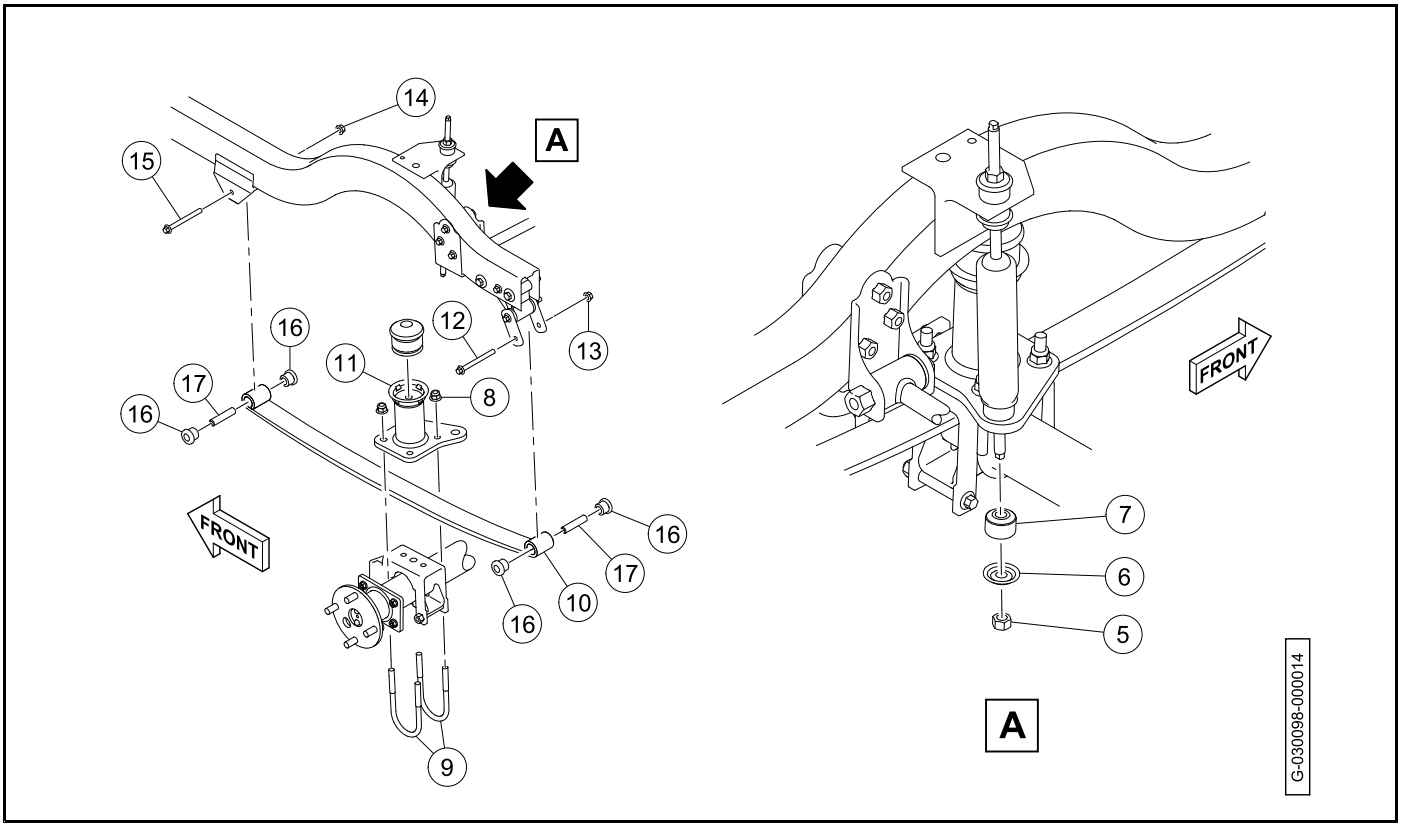


Figure 9-18 Leaf Spring Removal (Lifted Four Passenger)

10. Remove the nuts (8) and the U-bolts (9) securing the leaf spring (10) and jounce bumper bracket (11) to the transaxle.
11. Remove the jounce bumper bracket.
12. Remove the bolt (12) and nut (13) attaching the rear of the leaf spring to the shackle.

13. Remove the nut (14) and bolt (15) attaching the front of the leaf spring to the vehicle frame and remove the leaf spring.
14. Inspect the bushings (16) and sleeves (17) in the spring eyes and replace them if they are worn or damaged.

LEAF SPRING INSTALLATION (LIFTED FOUR-PASSENGER)

⚠ CAUTION

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

1. Install the front of the leaf spring (1) onto the vehicle frame **(Figure 9-19, Page 9-16)**.

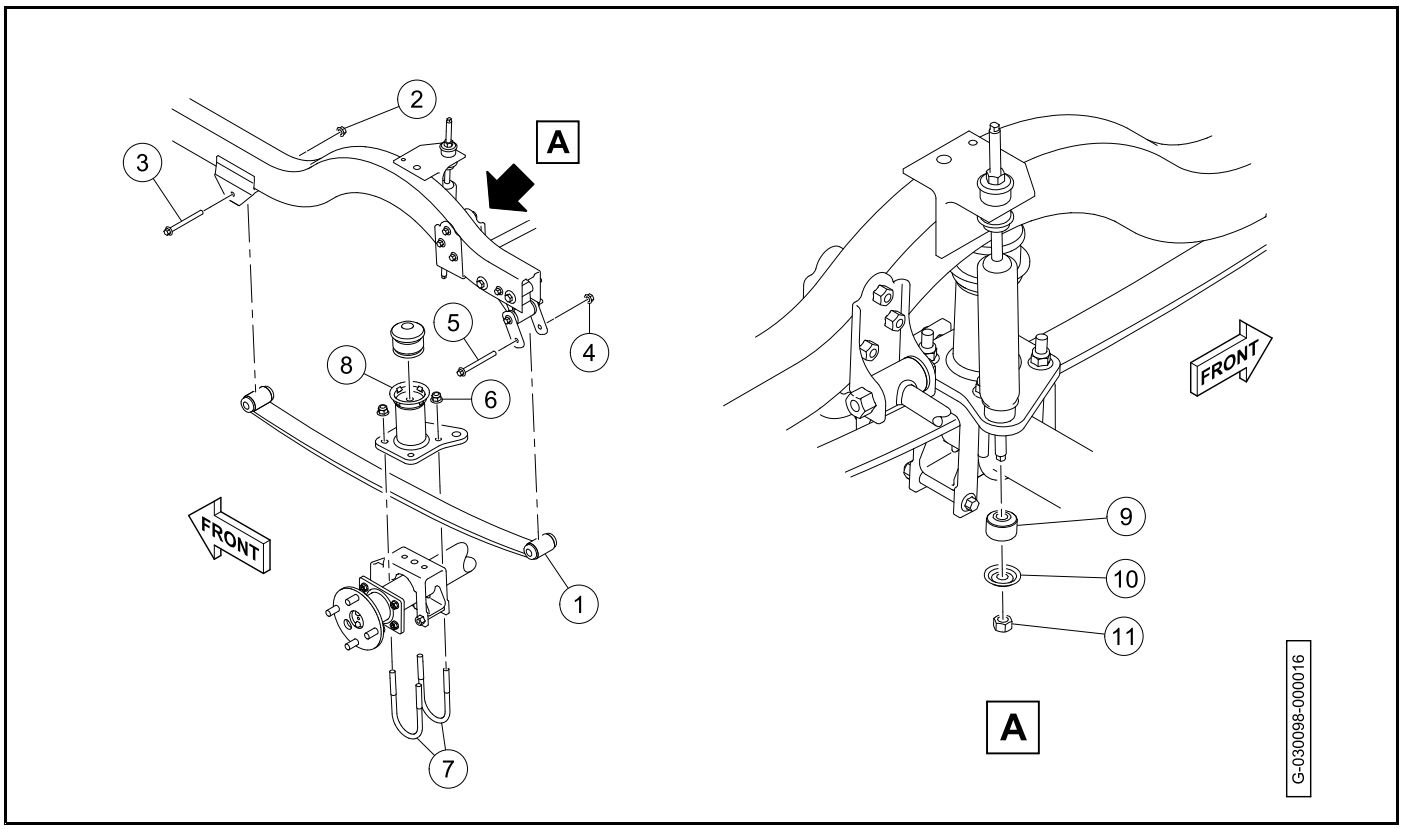


Figure 9-19 Leaf Spring Installation (Lifted Four Passenger)

2. Install the bolt (2) and nut (3). Tighten the nut to 18.5 lb·ft (25 N·m).
3. Install the rear of the leaf spring onto the shackle.
4. Install the bolt (4) and nut (5). Tighten the nut to 18.5 lb·ft (25 N·m).
5. Install the shock mount bracket (6), U-bolts (7), and nuts (8). Tighten the nuts to 45 lb·ft (60 N·m).
6. Install the bottom stem of the shock absorber into the shock mount bracket.
7. Install the rubber bushing (9), cup washer (10), and nut (11). Tighten the nut until the rubber bushing is the same size as the cup washer.
8. Install the brake cable onto the shock mount bracket (1) **(Figure 9-20, Page 9-17)**.

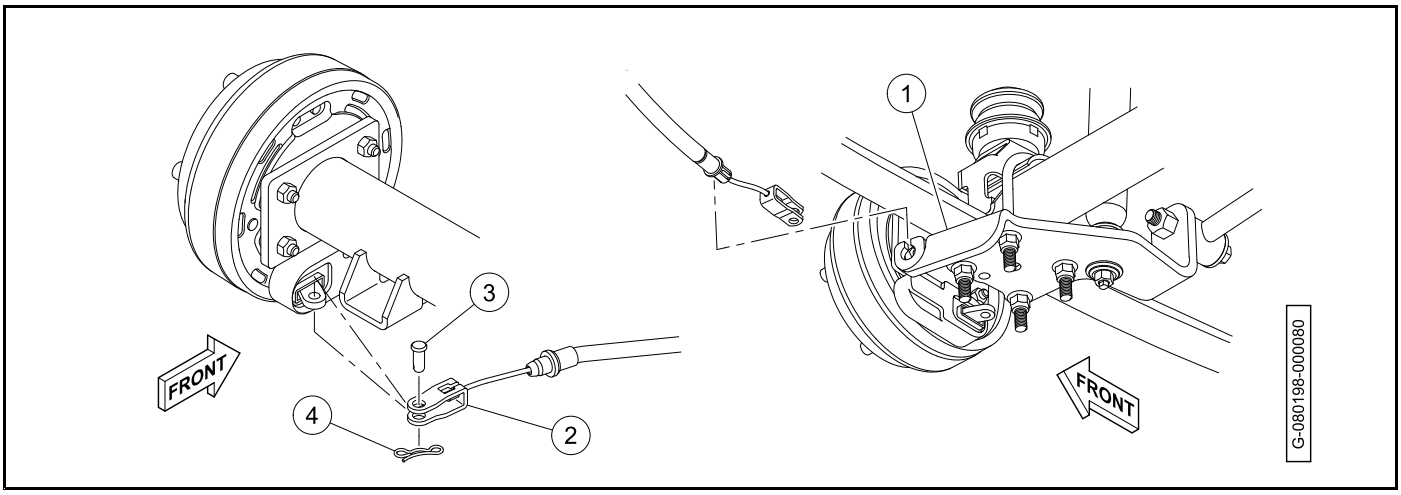


Figure 9-20

9. Install the cable end (2) onto the brake lever.
10. Install the clevis pin (3) and the bow tie locking pin (4).
11. Lower and remove the floor jack under the transaxle.
12. Install the tire and wheel assembly.
13. Lower the rear of the vehicle.
14. **Electric Vehicle:** Connect the batteries.
    Gasoline Vehicle: Connect the battery and spark plug wire.

Pagination Page

SECTION 10 — VEHICLE 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. 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, 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 on page 10-2, and the Periodic Service Schedules on page 10-4. Any problems should be corrected by a Club Car distributor/dealer or a trained technician.

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.

All Vehicles

- **General:** All the parts should be in place and properly installed. Be sure that all nuts, bolts, and screws are tight.
- **Safety and information decals:** Check to ensure that all safety and information decals are in place.
- **Tires:** Visually inspect tires for wear, damage, and proper inflation on a daily basis.
- **Performance Inspection:** Inspect as instructed. **See Performance Inspection on page 10-2.**

Electric Vehicles

- **Batteries:** Check electrolyte to ensure that it is at its proper level. Check battery posts. Wires should be tight and free of corrosion. Charge batteries fully before first use of vehicle.
- **Charger cord, plug, and receptacle:** Visually inspect for cracks, loose connections, and frayed wiring.

⚠ WARNING

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

Gasoline Vehicles

- **Battery:** Check battery posts. Wires should be tight and free of corrosion and battery should be fully charged.
- **Engine:** Check for proper engine oil level.
- **Fuel:** Check fuel level. Check fuel tank, lines, cap, pump, fuel filters, and fuel injector for fuel leakage.

⚠ WARNING

- **Be sure the plastic has been removed from the seat bottom before operating the vehicle. Failure to do so may 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 Daily Pre-Operation and 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/Neutral/Reverse switch:** Check for proper operation.
- **Brakes:** Be sure the brakes function properly. When brake pedal is pressed using moderate pressure, the vehicle should come to a smooth, straight stop. If the vehicle swerves or fails to stop, stops abruptly, or makes a grinding or squeaking noise, have the brake system checked and adjusted as required. Continued, moderate brake pedal pressure should be able to lock the wheels, but using lesser pressure should also permit a slow, gradual deceleration.
- **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.
- **Multi-purpose buzzer:** The multi-purpose buzzer will sound as a warning when the Forward/Neutral/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's 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 switch in the FORWARD position, as the accelerator pedal is pressed, the motor should start and the vehicle should accelerate smoothly to full speed. When the pedal is released it should return to the original position. All Club Car vehicles operate at reduced speed in reverse.
- **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 cause resistance to rolling ((moving at no more than 1 to 3 mph) (1.6 to 4.8 km/h)) with the Forward/Neutral/Reverse switch in any position. When walk away motor braking is engaged, the multi-purpose buzzer should emit a distinct pattern of beeps. **See following WARNING**.

⚠ 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.**

•

⚠ WARNING

- **If engine braking disengages, press the brake pedal as necessary to control the vehicle speed or to stop the vehicle. Partially press the accelerator to re-engage the motor. With the accelerator pedal partially pressed, the governor will cause the engine to assist the brakes in controlling downhill speed.**

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:** With the key switch in the ON position and the Forward/Neutral/Reverse switch in the FORWARD 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. All Club Car vehicles operate at reduced speed in reverse.
- **Governor:** Check maximum speed of the vehicle. The vehicle should operate at 19 mph (30.5 km/h) on a level surface.

MAINTENANCE

See General Warnings on page 1-2.

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 beginning on page 10-2, the Performance Inspection, 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.

⚠ 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.**
- **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:

- **Hot! Do not attempt to service hot motor. Attempting to do so could cause severe burns.**
- **To avoid unintentionally starting the vehicle, disconnect the batteries and discharge the controller. See Disconnect the Batteries – Electric Vehicles on page 1-4.**

Gasoline vehicles:

- **Moving parts: Do not attempt to service gasoline vehicle while the engine is running.**

WARNING CONTINUED ON NEXT PAGE

⚠ WARNING

- **Hot! Do not attempt to service hot engine or exhaust system. Failure to heed this warning could result in severe burns.**
- **To avoid unintentionally starting the vehicle, disconnect battery and spark plug wire. See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
- **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

⚠ 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 could result in fire, property damage, severe personal injury, or death.**

NOTE: *If the vehicle is constantly subjected to heavy use or severe operating conditions, the preventive maintenance procedure should be performed more often than recommended in the periodic service and lubrication schedules.*

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

ELECTRIC VEHICLE - PERIODIC SERVICE SCHEDULE

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 on page 10-1.**
	Performance Inspection	**See Performance Inspection on page 10-2.**
	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.

TABLE CONTINUED ON NEXT PAGE

PERIODIC SERVICE SCHEDULE – ELECTRIC VEHICLES		
REGULAR INTERVAL	**SERVICE**	
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.
	Batteries	Wash battery tops and clean terminals with baking soda/water solution. Apply Battery Terminal Protector Spray to battery terminals.
	Tires	Check air pressure and adjust if necessary.
	General vehicles	Thoroughly wash vehicle including the underside.
Initial (one-time) inspection by owner or trained technician after six weeks of use	Batteries (For vehicles newly equipped with the Single Point Watering System)	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 (every 50 hours of operation)	Brake system	Check brake shoes; replace if necessary.
		Lubricate brake system per Lubrication Schedule.
		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; replace if necessary.
	Front wheel alignment and camber	Check and adjust as required.
Annual service by owner or trained technician (every 100 hours of operation)	Batteries (For vehicles equipped with the Single Point Watering System)	Manually check battery electrolyte levels of all cells to verify correct valve operation.
	Safety decals	Check safety decals. Replace if damaged or illegible.
Annual service by trained technician only (every 100 hours of operation)	Batteries	If batteries are not performing as expected, see Batteries in the maintenance and service manual.
	Pedal group	Lubricate all rotating joints.
	General vehicle	Check for loose hardware; tighten if necessary. Refer to the appropriate maintenance and service manual.

GASOLINE VEHICLE - PERIODIC SERVICE SCHEDULE

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. Properly dispose of used oil.
		Check engine cooling air intake; clean if necessary. Visually inspect the unshrouded area around engine exhaust for grass and debris, and clean if necessary.
	Tires	Check air pressure and adjust as necessary.
	General vehicle	Wash engine compartment and underside of vehicle. Do not wash engine when hot.
Semiannual service by trained technician only (every 50 hours of operation)	Battery	Clean terminals and wash dirt from casing; Apply Battery Terminal Protector Spray to battery terminals.
	Front wheel alignment and camber	Check and adjust if necessary.
	Electrical wiring and connections	Check for tightness and damage; replace if necessary.
	Brake system	Check brake shoes; replace if necessary.
		Lubricate brake system per Lubrication Schedule.
		Check brake cables for damage; replace if necessary.
		Check brake cable equalizer adjustment; adjust if necessary.

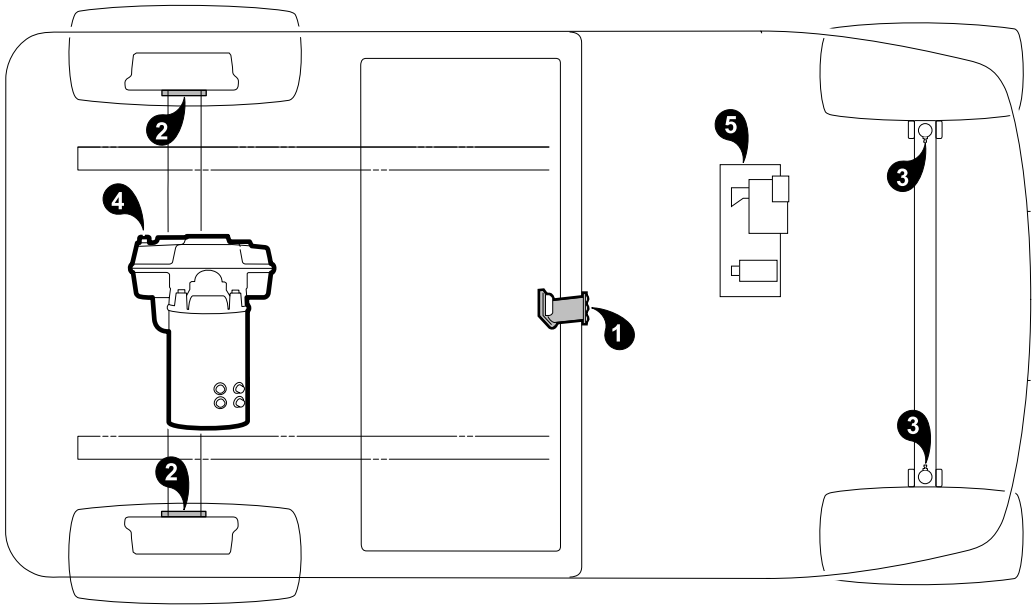
TABLE CONTINUED ON NEXT PAGE

PERIODIC SERVICE SCHEDULE – GASOLINE VEHICLES		
REGULAR INTERVAL	**SERVICE**	
Annual service by trained technician only (every 100 hours of operation)	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; replace if necessary.
		Check clamps for tightness; check hose for cracks.
	Pedal group	Lubricate all rotating joints.
	General vehicle	Check for loose hardware; 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 (every 200 hours of operation)	Engine	**Kohler ECH440:** Check and adjust valve clearance as needed. **Subaru EX-40:** Check and adjust valve lash as needed.

PERIODIC LUBRICATION SCHEDULES

NON-LIFTED ELECTRIC VEHICLE - PERIODIC LUBRICATION SCHEDULE

PERIODIC LUBRICATION SCHEDULE – NON-LIFTED ELECTRIC VEHICLES			
REGULAR INTERVAL	**SERVICE**	**LUBRICATION POINTS**	**RECOMMENDED LUBRICANT**
Semiannually by owner or trained technician (every 50 hours of operation)	Charger receptacle	1	WD-40®
	Brake system, per maintenance and service manual.	2	Dry Moly Lube, white lithium grease NLGI #2
	Front suspension (two fittings)	3	Chassis Lube - EP NLGI Grade 2
Annually by trained technician only (every 100 hours of operation)	Check/fill transaxle to plug level	4	22 fl-oz (0.67 L) SAE 30 WT. API Class SE, SF, or SG Oil (or higher)
	Pedal group (as required)	5	Dupont™ Performance Dry Multi-Use Lubricant



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Figure 10-1 Lubrication Points – Non-Lifted Electric Vehicles

LIFTED ELECTRIC VEHICLE - PERIODIC LUBRICATION SCHEDULE

PERIODIC LUBRICATION SCHEDULE – LIFTED ELECTRIC VEHICLES			
REGULAR INTERVAL	**SERVICE**	**LUBRICATION POINTS**	**RECOMMENDED LUBRICANT**
Semiannually by owner or trained technician (every 50 hours of operation)	Charger receptacle	1	WD-40®
	Brake system, per maintenance and service manual.	2	Dry Moly Lube, white lithium grease NLGI #2
Annually by trained technician only (every 100 hours of operation)	Check/fill transaxle to plug level	3	22 fl-oz (0.67 L) SAE 30 WT. API Class SE, SF, or SG Oil (or higher)
	Pedal group (as required)	4	Dupont™ Performance Dry Multi-Use Lubricant
Annually by owner or trained technician (every 100 hours of operation or as needed)	Control Arm Bushings	5	CRC Silicon Spray

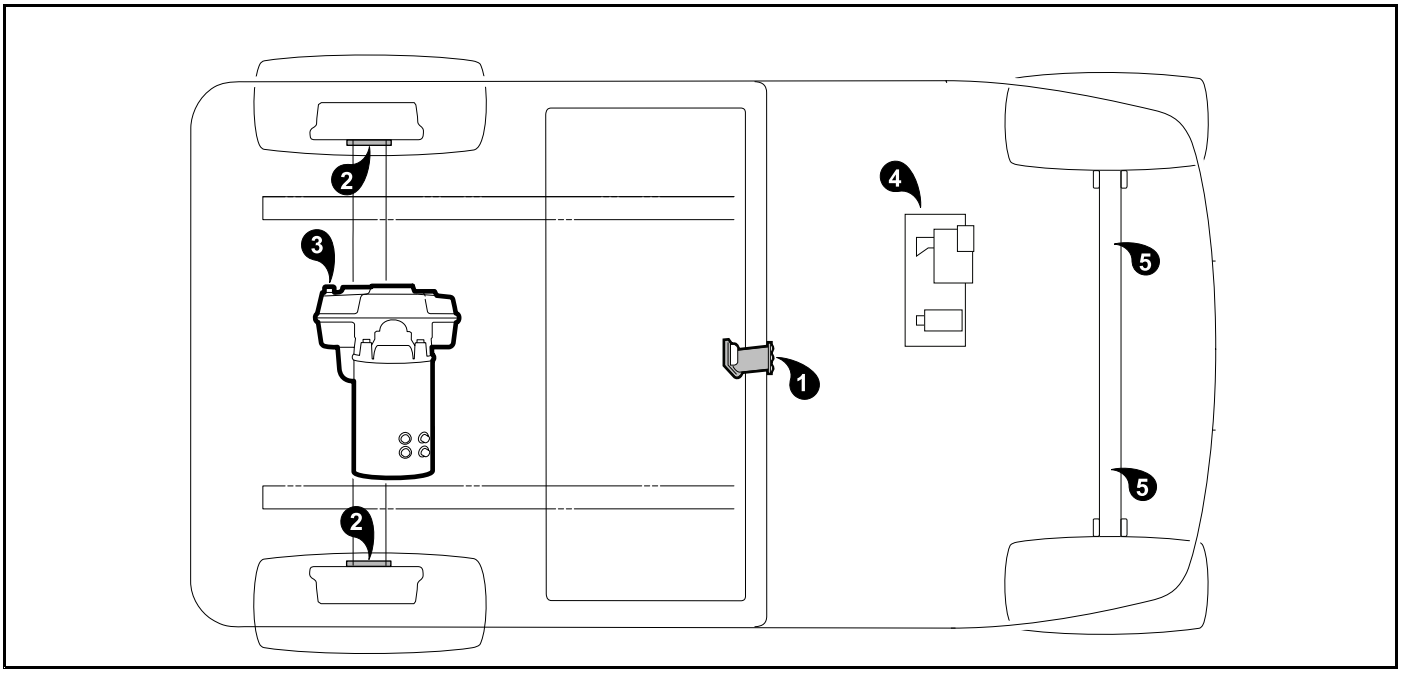
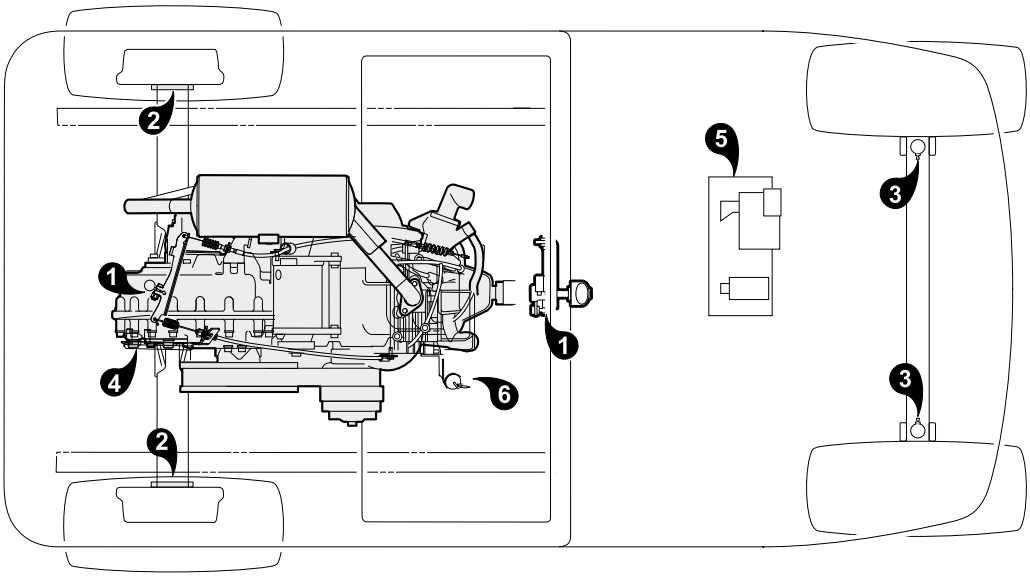


Figure 10-2 Lubrication Points – Lifted Electric Vehicles

NON-LIFTED GASOLINE VEHICLE - PERIODIC LUBRICATION SCHEDULE

PERIODIC LUBRICATION SCHEDULE – NON-LIFTED GASOLINE VEHICLES			
REGULAR INTERVAL	**SERVICE**	**LUBRICATION POINTS**	**RECOMMENDED LUBRICANT**
Semiannually by owner or trained technician (every 50 hours of operation)	Shifter cable pivots	1	Dry Moly Lube
	Brake system, per maintenance and service manual.	2	Dry Moly Lube, white lithium grease NLGI #2
	Front suspension (two fittings)	3	Chassis Lube - EP NLGI Grade 2
Annually by trained technician only (every 100 hours of operation)	**Transaxle:** Check/fill to plug level	4	67.6 fl-oz (2 L) SAE 80W-90 API Class GL-5
	Pedal group (as required)	5	Dupont™ Performance Dry Multi-Use Lubricant
First change 100 hours – additional change every 200 hours of operation or annually, whichever comes first	Change engine oil	6	40 fl-oz (1.2 L) 10W-30 or 5W-30 grade SE or higher. **See also Figure 35-3, Page 35-5.**



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Figure 10-3 Lubrication Points – Non-Lifted Gasoline Vehicles

LIFTED GASOLINE VEHICLE - PERIODIC LUBRICATION SCHEDULE

PERIODIC LUBRICATION SCHEDULE – LIFTED GASOLINE VEHICLES			
REGULAR INTERVAL	**SERVICE**	**LUBRICATION POINTS**	**RECOMMENDED LUBRICANT**
Semiannually by owner or trained technician (every 50 hours of operation)	Shifter cable pivots	1	Dry Moly Lube
	Brake system, per maintenance and service manual.	2	Dry Moly Lube, white lithium grease NLGI #2
Annually by trained technician only (every 100 hours of operation)	**Transaxle:** Check/fill to plug level	3	67.6 fl-oz (2 L) SAE 80W-90 API Class GL-5
	Pedal group (as required)	4	Dupont™ Performance Dry Multi-Use Lubricant
First change 100 hours – additional change every 200 hours of operation or annually, whichever comes first	Change engine oil	5	40 fl-oz (1.2 L) 10W-30 or 5W-30 grade SE or higher. **See also Figure 35-3, Page 35-5.**
Annually by owner or trained technician (every 100 hours of operation or as needed)	Control Arm Bushings	6	CRC Silicon Spray

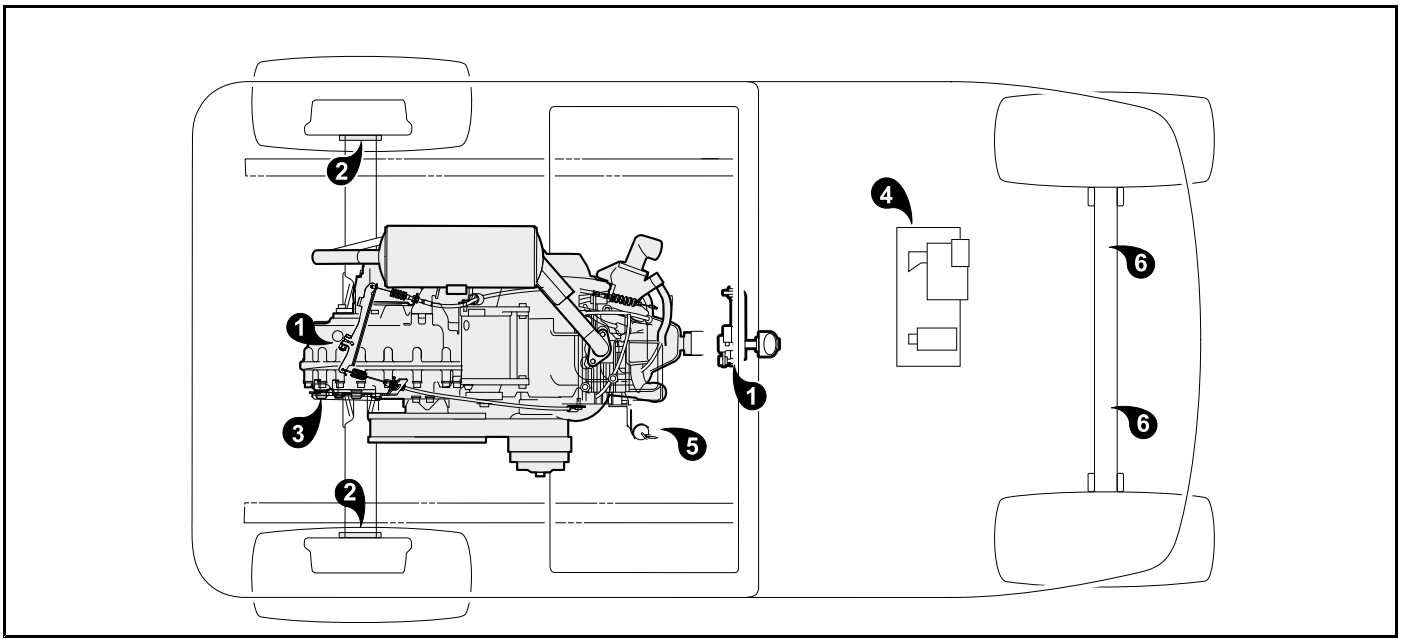


Figure 10-4 Lubrication Points – Lifted Gasoline Vehicles

AIR FILTER

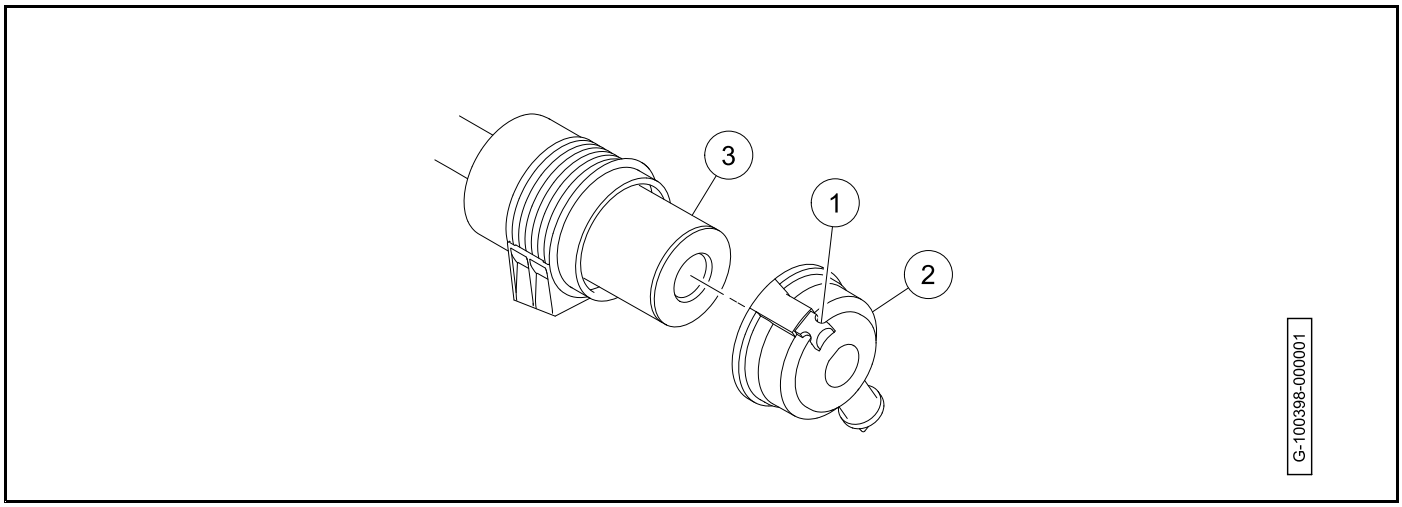


Figure 10-5 Air Filter

AIR FILTER REMOVAL

Before the air filter is removed:

- Disable the vehicle.

To remove the air filter:

1. Release the latch (1) **(Figure 10-5, Page 10-12)**.
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) **(Figure 10-5, Page 10-12)**.
3. Install the air cleaner cover (2).
4. Engage the latch (1).

KOHLER ECH440 - ENGINE OIL

Vehicles with Subaru EX-40, see Subaru EX-40 - Engine chapter.

KOHLER ECH440 - ENGINE OIL VISCOSITY

Select the engine oil viscosity for your environmental conditions.

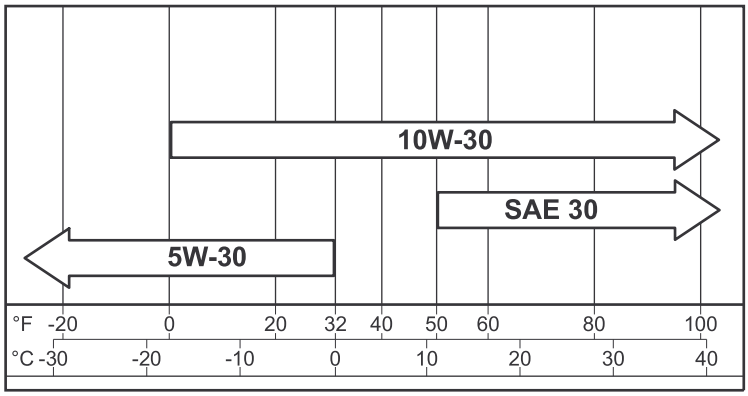


Figure 10-6 Engine Oil Viscosity

KOHLER ECH440 - ENGINE OIL LEVEL INSPECTION

Before the engine oil is examined:

- Disable the vehicle.

To examine the engine oil:

1. Remove the dipstick (1) **(Figure 10-7, Page 10-13)**.

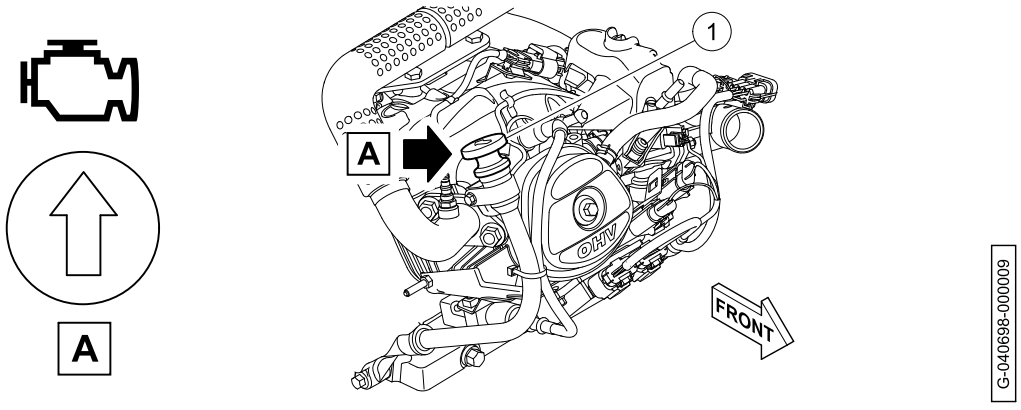


Figure 10-7 Dipstick

2. Make sure that there is oil on the dipstick.
3. Install the dipstick.
4. Start and operate the engine for three minutes. If the low oil warning light stays on, turn off the engine immediately.
5. Turn off the engine.
6. Wait two minutes.
7. Remove and clean the dipstick.
8. Install the dipstick.

9. Remove the dipstick.
10. Make sure that the oil level is between the maximum (1) and minimum (2) indicators **(Figure 10-8, Page 10-14)**.

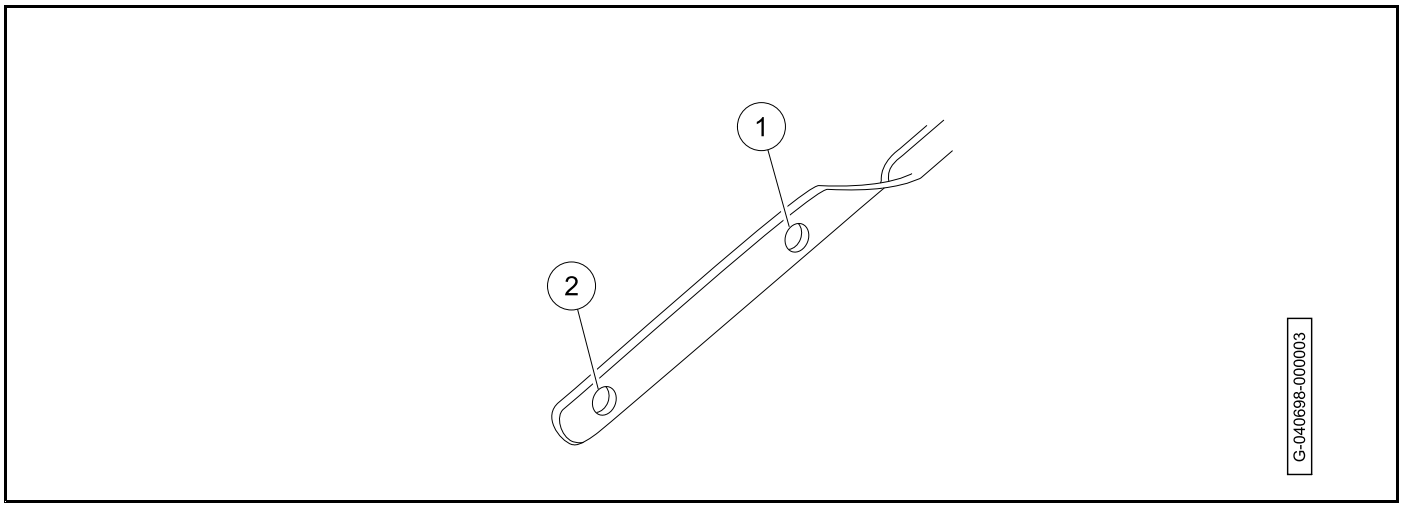


Figure 10-8 Dipstick Indicators

11. If the oil level is below the minimum indicator, add engine oil.
12. Install the dipstick.

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

KOHLER ECH440 - 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 10-9, Page 10-15)**.

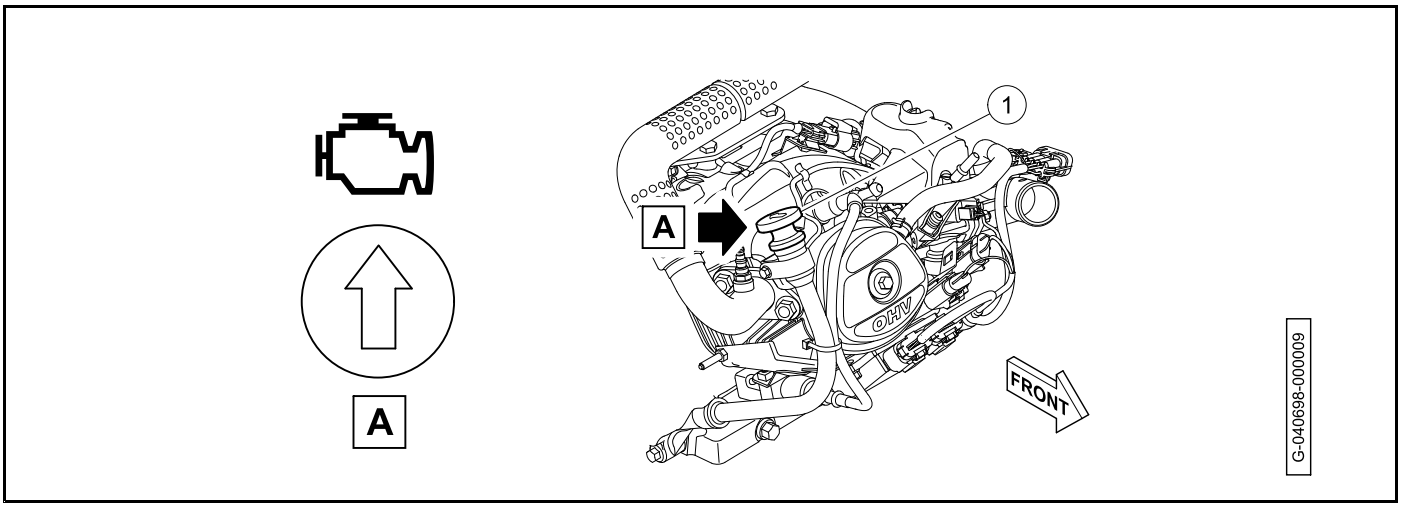


Figure 10-9 Dipstick

2. Clean the area around the oil drain plug (2) **(Figure 10-10, Page 10-15)**.

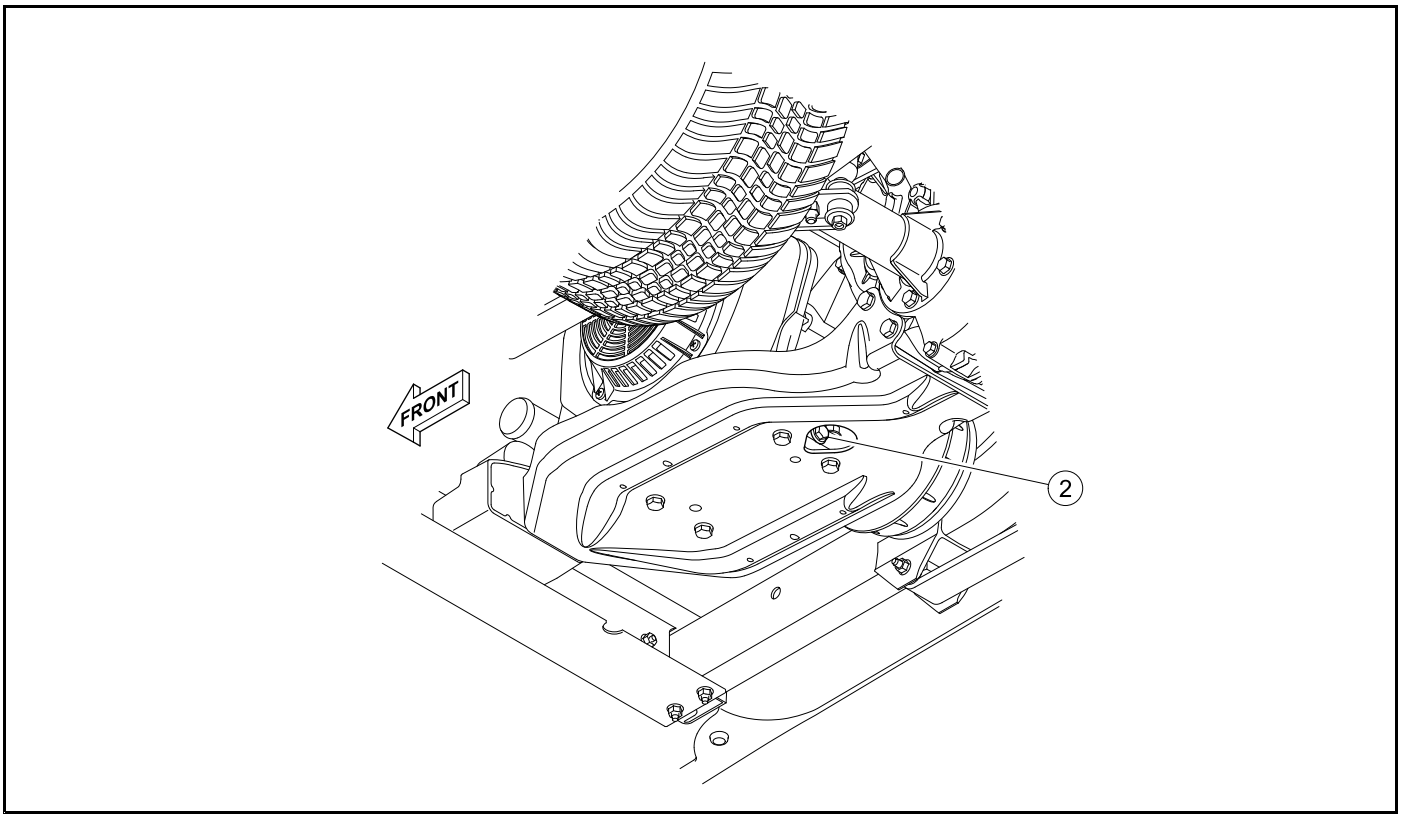


Figure 10-10 Oil Drain Plug

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. **Non-Lifted:** Add 39 fl-oz (1.1 l) of recommended engine oil.
   Lifted: Add 40.5 fl-oz (1.2 l) of recommended engine oil. **(Figure 10-11, Page 10-16)**

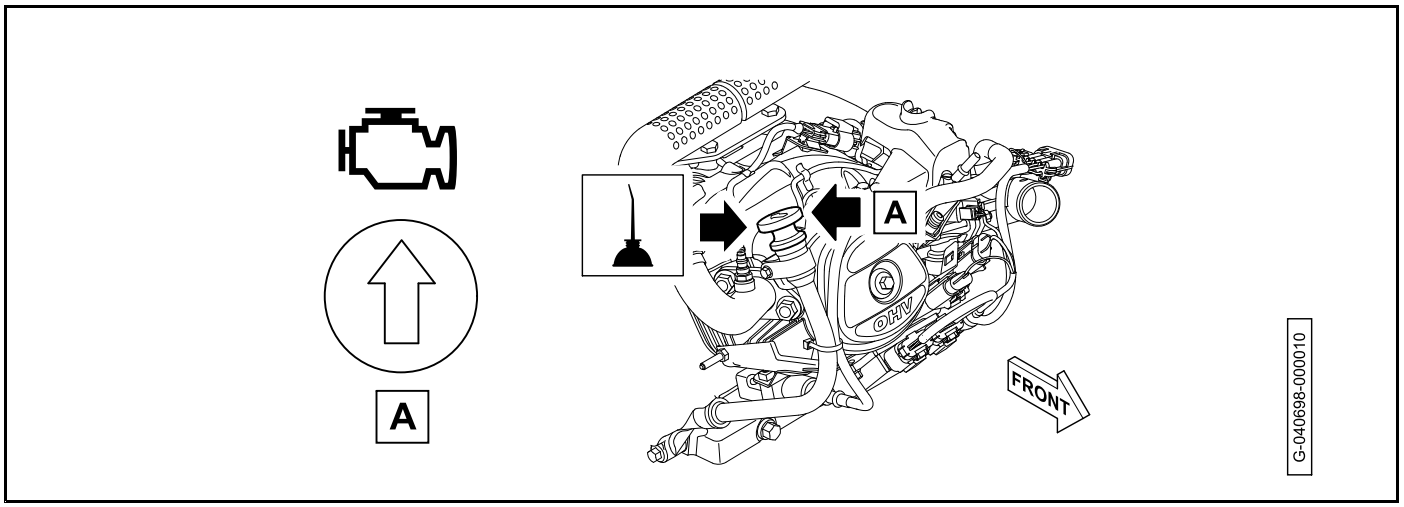


Figure 10-11 Engine Oil Fill Location

10. Install the dipstick.
11. Connect the battery.

KOHLER ECH440 - ADD ENGINE OIL

CAUTION

- **Do not remove the dipstick while the engine is on.**

⚠ CAUTION

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

Before engine oil is added:

- Disable the vehicle.

To add engine oil:

1. Remove the dipstick (1) **(Figure 10-9, Page 10-15)**.

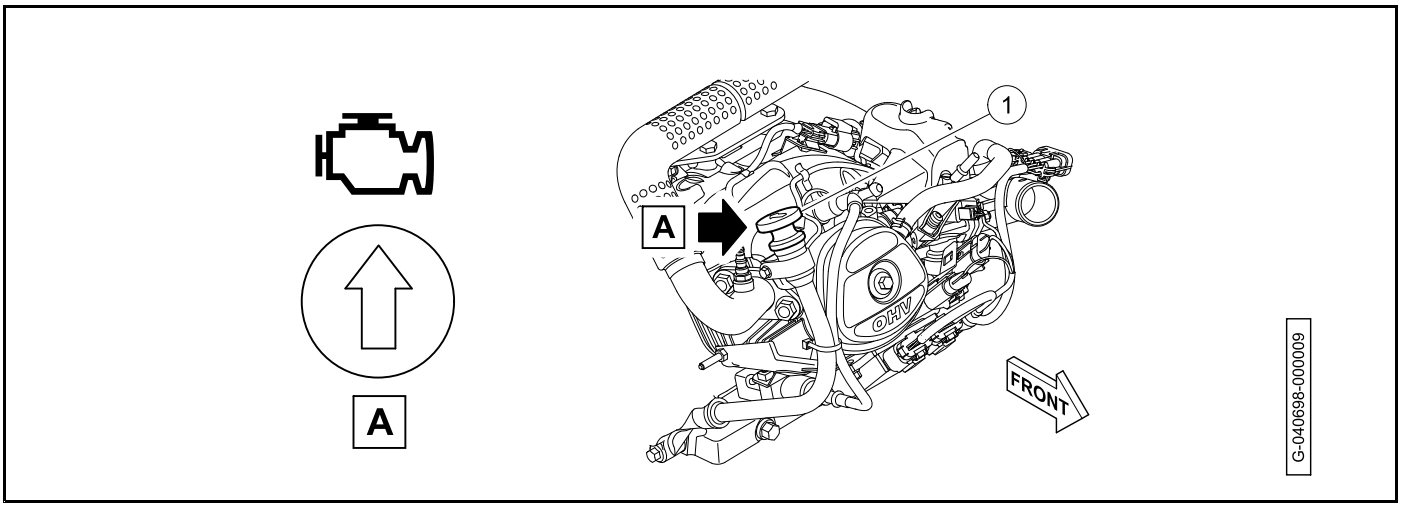


Figure 10-12 Dipstick

2. Add engine oil until the oil level is between the maximum (1) and minimum (2) indicators **(Figure 10-13, Page 10-17)**.

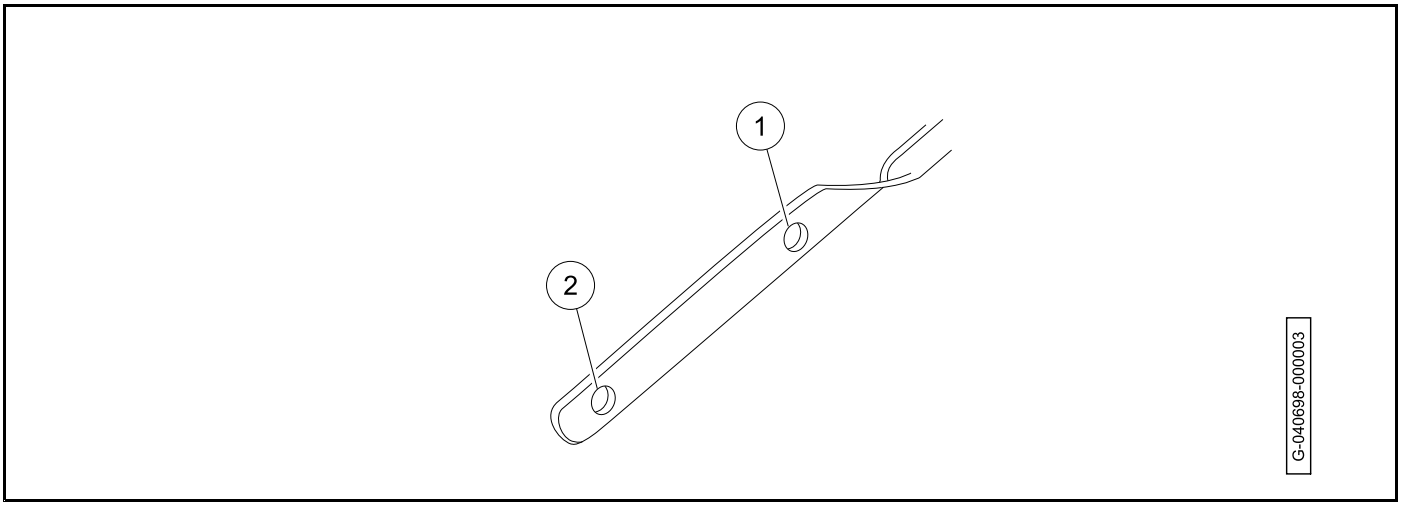


Figure 10-13 Dipstick Indicators

3. Install the dipstick.

REFUEL

⚠ DANGER

- **Fuel is flammable and explosive. Do not add fuel with the key set to ON. Before fuel is added, turn the key switch to OFF.**
- **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.**
- **Do not repeatedly attempt to start a vehicle when the fuel pump is dry (no gas in tank). Doing so can damage the fuel pump.**

1. Turn the key to OFF.
2. Let the engine cool.
3. Lift the seat bottom.

4. Remove the fill cap (1) **(Figure 10-14)**.

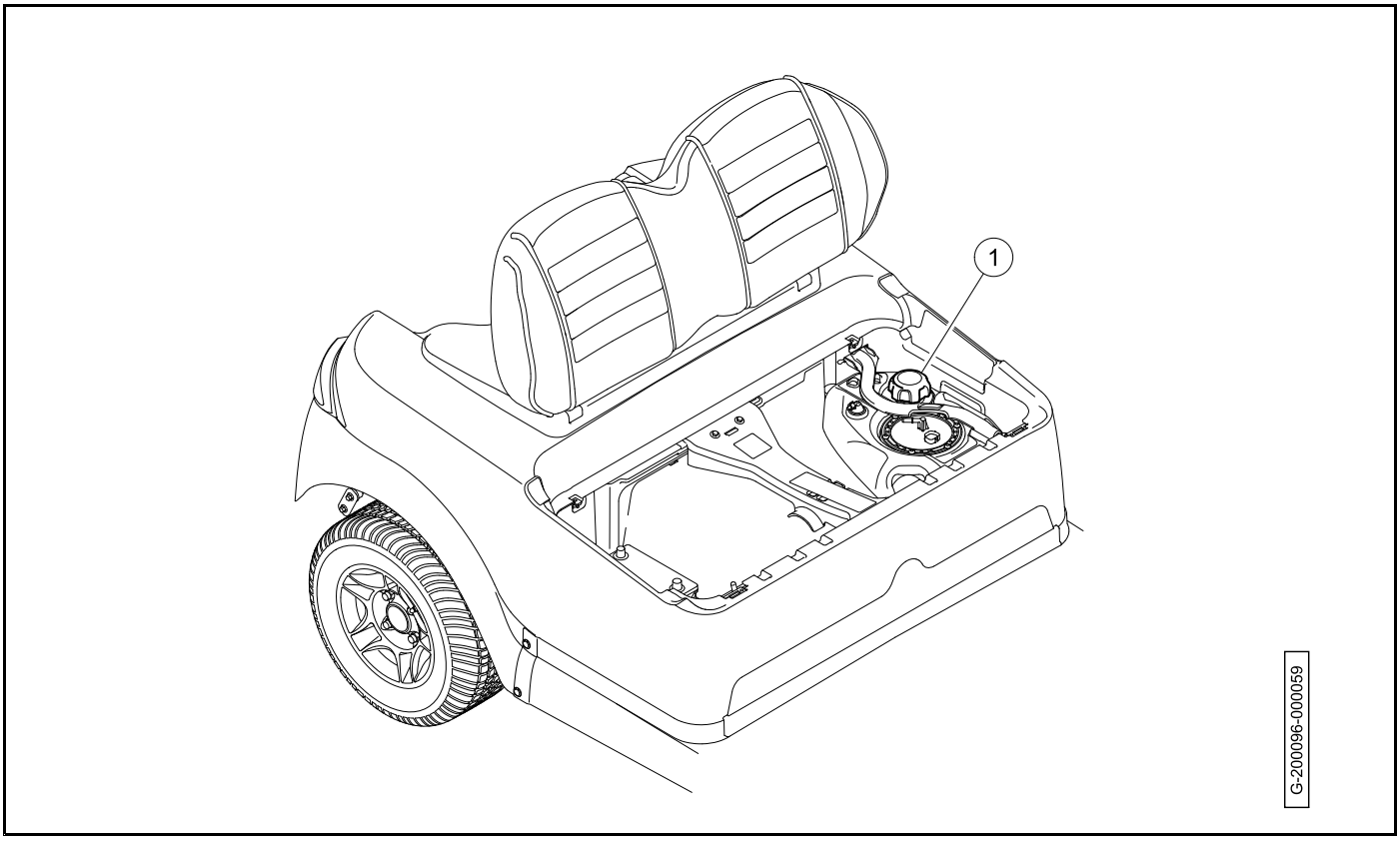


Figure 10-14

5. Fill the fuel tank with the recommended fuel.
6. Install the fuel cap.
7. Lower the seat bottom.

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SECTION 11 — CCDT

11

OVERVIEW

The CCDT is the diagnostic tool used for AC electric vehicles. The CCDT can be used for:

- Software updates for all electronic control units (ECUs)
- Read and clear diagnostic troubleshooting code (DTC)
- Diagnostics and troubleshooting
- Real time data monitoring
- Vehicle configuration and settings
- Finalize VCM's

For more information, see the latest version of the CCDT User Guide.

CONNECT THE DONGLE TO THE VEHICLE

1. Connect the diagnostic cable to the dongle.
2. Remove the dust cap on the diagnostic receptacle.

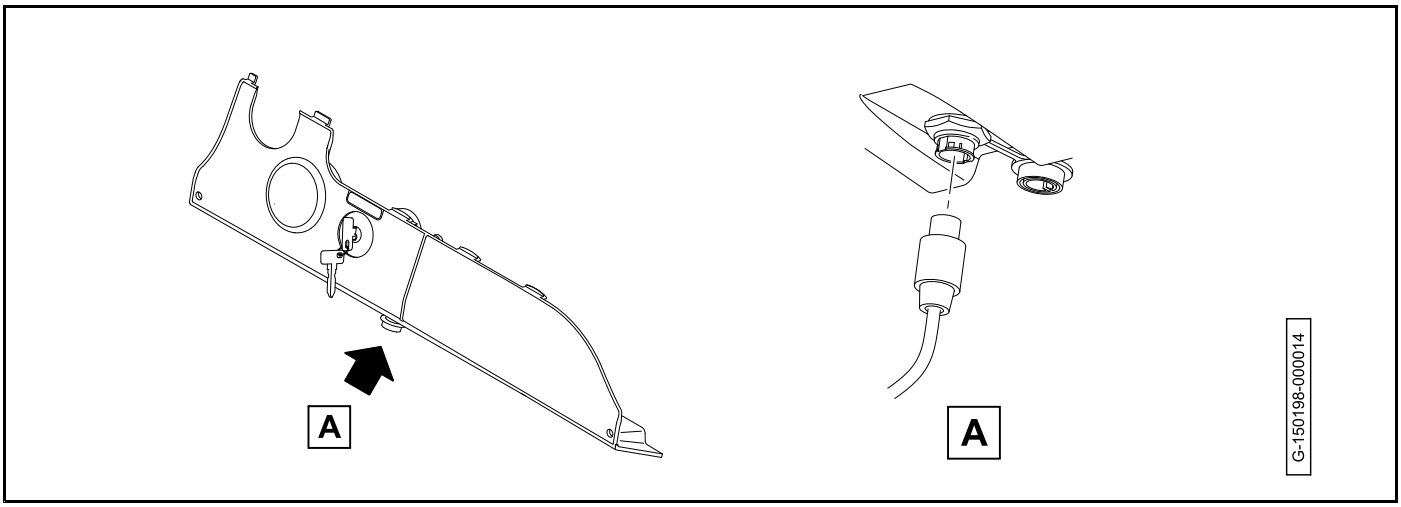


Figure 11-1 Diagnostic Receptacle

3. Align the diagnostic cable connector with the diagnostic receptacle.
4. Connect the diagnostic cable to the diagnostic receptacle.

NOTE: *A red LED will flash when the dongle is connected to the vehicle.*

ENABLE A HIGH SPEED CODE

The high speed option requires a high speed code. Contact Club Car for the high speed code.

To change the maximum speed to a higher setting, the high speed option must be enabled.

To enable the high speed option:

1. Go to the settings screen.
2. Go to the HIGH SPEED ENABLE tab.
3. Tap on the Unlock High Speed Code box **(Figure 11-2, Page 11-2)**

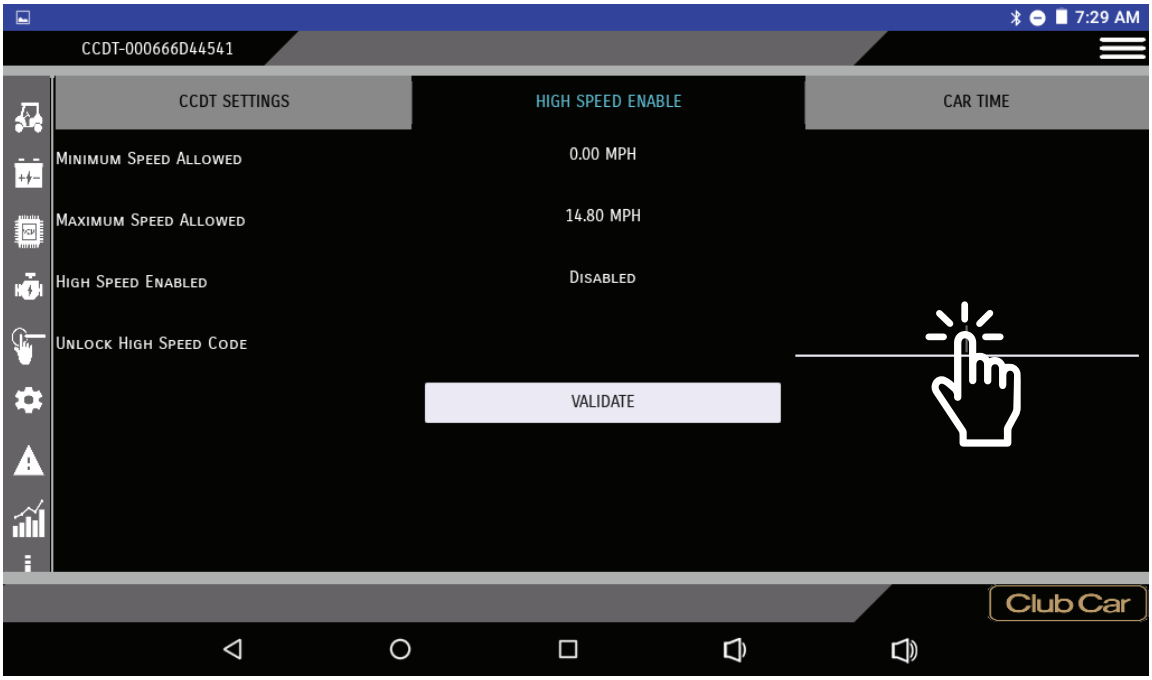


Figure 11-2

4. Enter the high speed code.
5. Tap the VALIDATE button.
6. Go to the WRITE screen.
7. Enter 19.2 in the Maximum Speed.
8. Tap WRITE.

NOTE: *WRITE SUCCESSFUL should appear.*

9. Operate the vehicle to validate the new configuration.

PROGRAM A NEW VEHICLE CONTROL MODULE (VCM)

CAUTION

- **Do not operate the vehicle between or during software updates.**

Before a new VCM is programmed:

- The user must have the latest or recommended version of diagnostic tool.
- The CAN bus must be fully functional.
- The VCM and diagnostics must have power.

CAUTION

- **Incorrect software versions can cause battery and vehicle damage. The CCDT app must be updated first.**

To program a new VCM:

1. Update the CCDT app.
2. Make sure that the CCDT dongle has the latest software version.
3. Connect the new VCM to the vehicle.
4. Connect the CCDT tool.
5. Go to the software update screen.

NOTE: *When connected to a new VCM, the CCDT-APP will display “no diagnostics”. This is normal as the VCM does not have functional software.*

CAUTION

- **If the incorrect software is installed, the vehicle will not operate correctly and can cause damage to the vehicle. The CCDT will display software updates for multiple vehicle types (AC-FLA and Lithium-ion). Select the correct software for the vehicle.**

6. Select the AC-FLA VCM software and update the VCM to the latest or recommended software version.

7. Select the correct AC-FLA VCM software and update the VCM to the latest or recommended software version **(Figure 11-3)**.

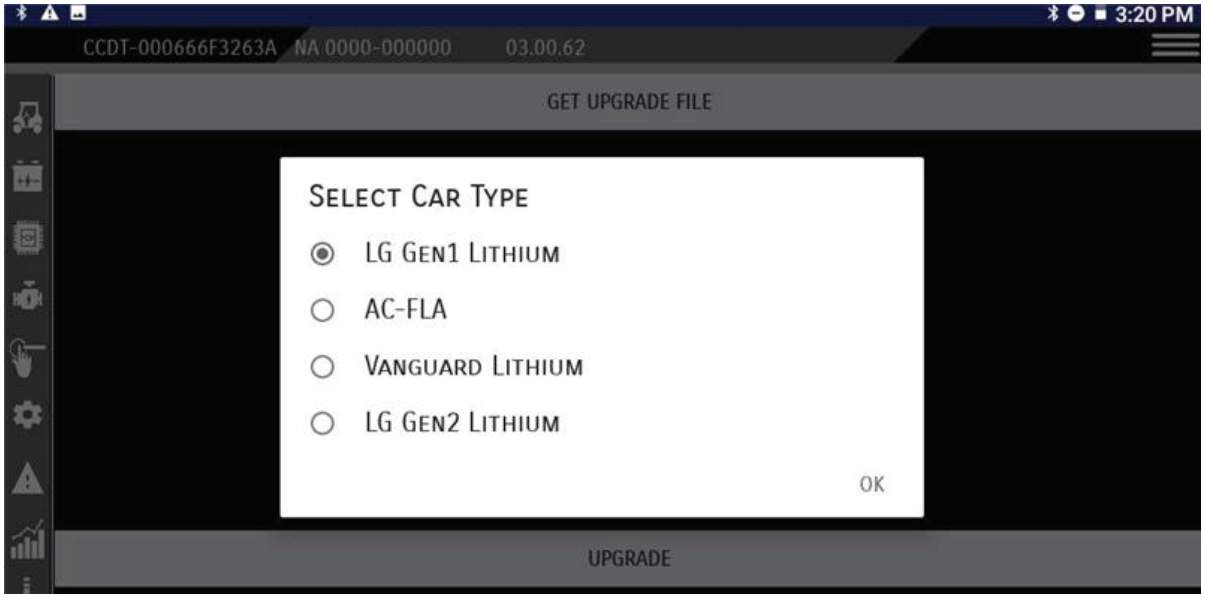


Figure 11-3

8. Go to the vehicle settings update / write screen.
9. Configure the vehicle to the factory or desired configuration.
10. Go to the settings screen.
11. Go to the FINALIZE SETTING tab.
12. Input the vehicle serial number.
13. Tap on the FINALIZE button.
14. Make sure that the motor control unit (MCU) has the latest software version.

SOFTWARE UPDATES

CAUTION

- **Do not operate the vehicle between or during software updates.**

Before updating software:

- The CAN bus must be fully functional.
- The components with software must have power.

When updating software, make sure that all components have the latest software version.

Update the software in the following order:

CAUTION

- **Incorrect software versions can cause battery and vehicle damage. The CCDT app must be updated first.**

1. CCDT app.

NOTE: *The latest software versions are loaded to the CCDT app.*

2. CCDT dongle software
3. Vehicle Control Module (VCM) software
4. Motor Control Unit (MCU) software

TROUBLESHOOTING

SYMPTOM	POSSIBLE CAUSES	CORRECTIVE ACTION
Dongle does not have power. Indication: • Green LED is off • Blue LED is off	• The diagnostic cable is not connected • The diagnostic fuse is blown • The vehicle will not power up	1. Make sure that the diagnostic cable is connected to the vehicle and dongle correctly. 2. Examine the diagnostic fuse. Replace as necessary. 3. Examine the wiring and connectors. 4. See Electrical System Troubleshooting.
No Bluetooth connectivity Indication: • Dongle is not listed in connectivity screen • During operation the app transitions to the connectivity screen	• The dongle is not powered • The dongle lost power • Mobile device is out of range	1. Connect the dongle. 2. Make sure the mobile device is close to the dongle. 3. Push the Bluetooth discovery button on the dongle and restart the CCDT-APP. 4. Restart the Bluetooth setting on the mobile device.
Dongle is not connected to the vehicle Indication: • Red LED is off	The Main CAN bus is not communicating	See Main CAN bus troubleshooting.

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SECTION 12 — AC ELECTRIC VEHICLE - ELECTRICAL SYSTEM TROUBLESHOOTING

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**
- **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.**

CAUTION

- **Do not operate the vehicle between or during software updates.**
- **If the incorrect VCM software is installed, the vehicle will not operate correctly and can cause damage to the vehicle. The CCDT will display software updates for multiple vehicle types (AC-FLA and Lithium-ion). Select the correct software for the vehicle.**

Before troubleshooting:

1. **Update the CCDT app. The latest software versions are loaded to the CCDT app.**

CAUTION

- **Incorrect software versions can cause battery and vehicle damage. The CCDT app must be updated first.**

2. **Update the CCDT dongle software.**
3. **Update the vehicle control module (VCM) software.**
4. **Update the motor control unit (MCU) software.**

GENERAL INFORMATION

The vehicle uses a 48-volt electrical system with a 30V AC motor, that is powered by six 8-volt lead-acid batteries and charged by a high-frequency charger. The vehicle includes several additional features.

CONTROLLER AREA NETWORK (CAN)

The vehicles use a Controller Area Network (CAN). Standard electrical vehicles use a conventional system that uses separate wires to control individual electrical components. The CAN system lets multiple electrical components communicate on the same data link wire. This lets multiple electronic components to communicate in real time.

CAN BUS

Data link is referred to as CAN bus in this manual. The CAN bus has a 120 Ohm terminating resistor at each end.

Main CAN bus - Provides a path for communication between the following electronic control units (ECU):

- A 120 ohm termination resistor installed on the strut connector.
- Vehicle control module (VCM)
- Auxiliary CAN Receptacle
- Diagnostic Receptacle
- Dash display
- Motor control unit (MCU)
- Optional Video Display Unit (VDU)

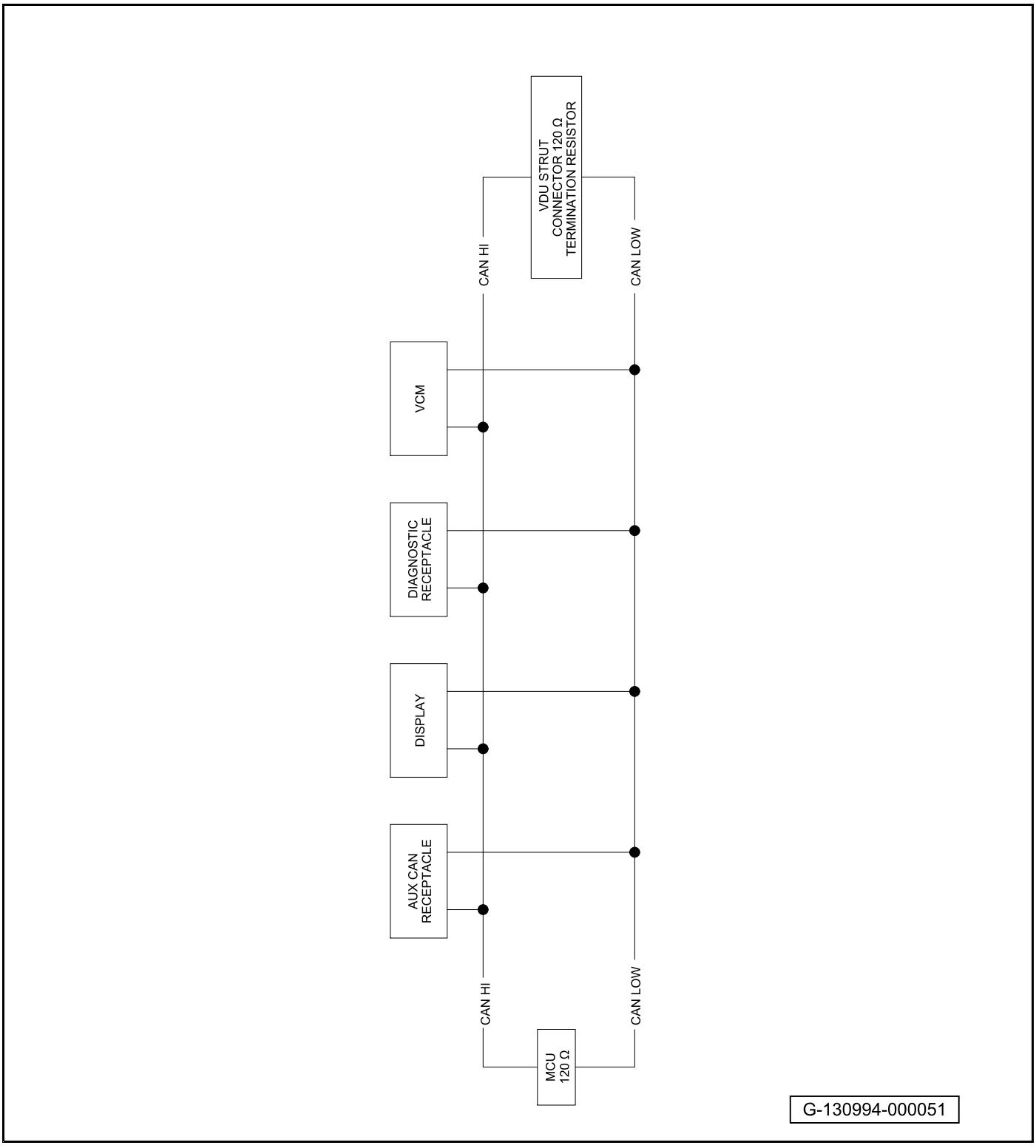


Figure 12-1 Main CAN bus

ACCESSORIES

For powered accessories, use the negative black wire and positive blue/white wire near the fuse block.

FEATURES

- **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 AC electrical system that will activate the motor braking function: Walk Away Braking and Motor Braking (adjustable with the CCDT).
- **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

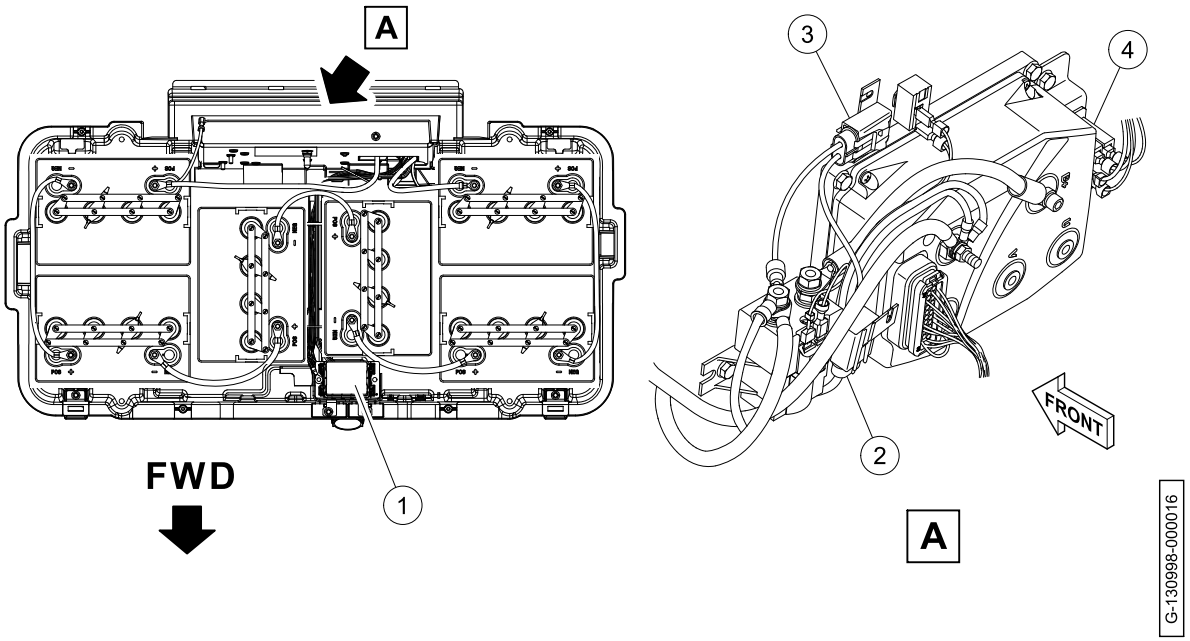
- **Walk Away Braking will not limit vehicle speed to 3 mph (4.8 km/h) on very steep grades. Do not operate vehicle on slopes exceeding 20% grades.**

- **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 DTC is recorded by the MCU and will be displayed on the CCDT handset.
- **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 DTC is recorded by the MCU and will be displayed on an CCDT handset in the Diagnostic History menu. **See HPD on page 18-20.**

SONIC WELD AND RESISTOR LOCATIONS

The sonic weld and resistor locator view is located in Section 39 — Wiring Diagrams .

FUSE AND RELAY LOCATIONS



Callout Number	Description
1	Fuse Block - See Fuse Block Table
2	30A Charger Fuse
3	10A DC to DC Converter Fuse
4	DC to DC Converter 48V Relay

Figure 12-2

FUSE BLOCK COVER

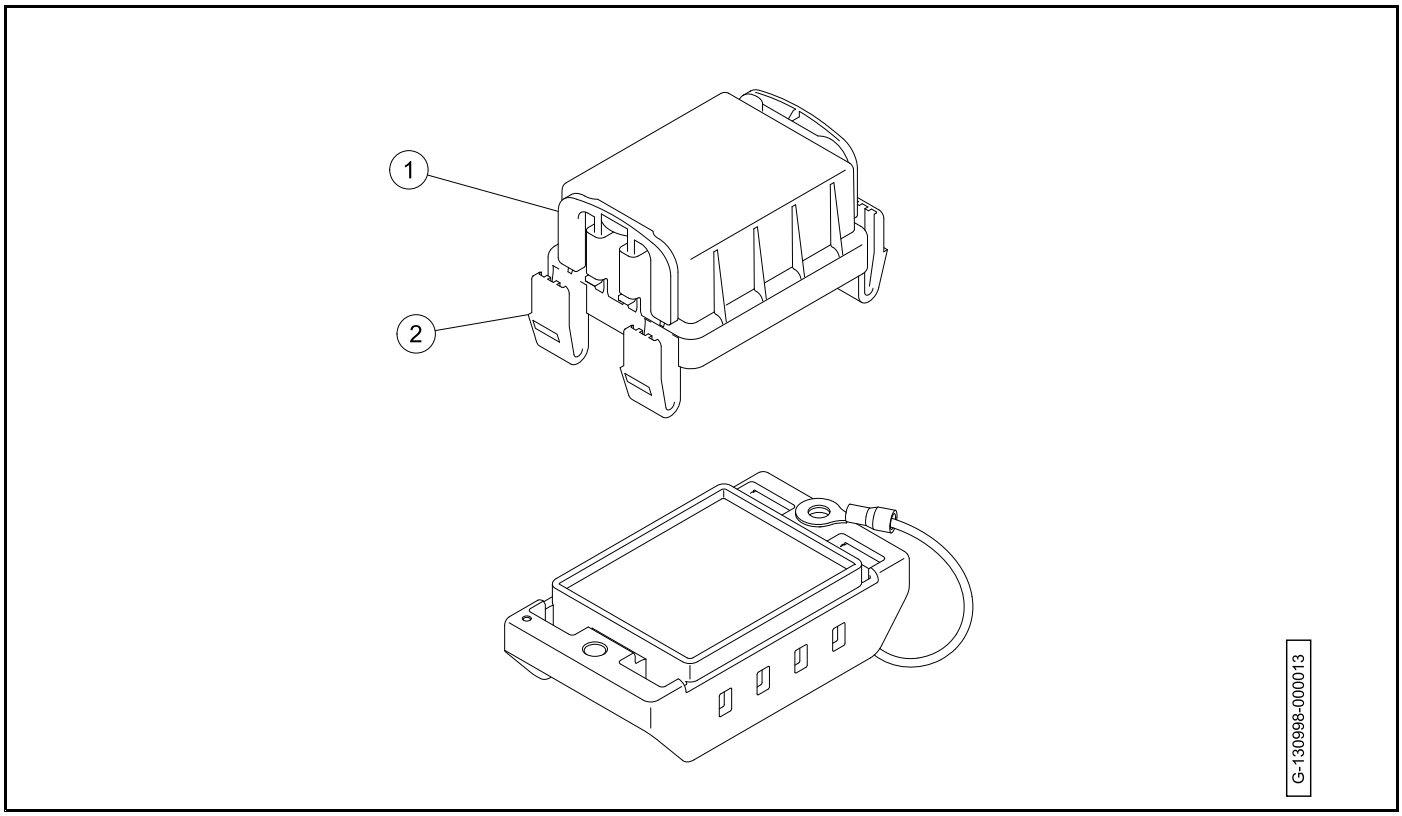


Figure 12-3 Fuse Block Cover

Fuse Block Cover Removal

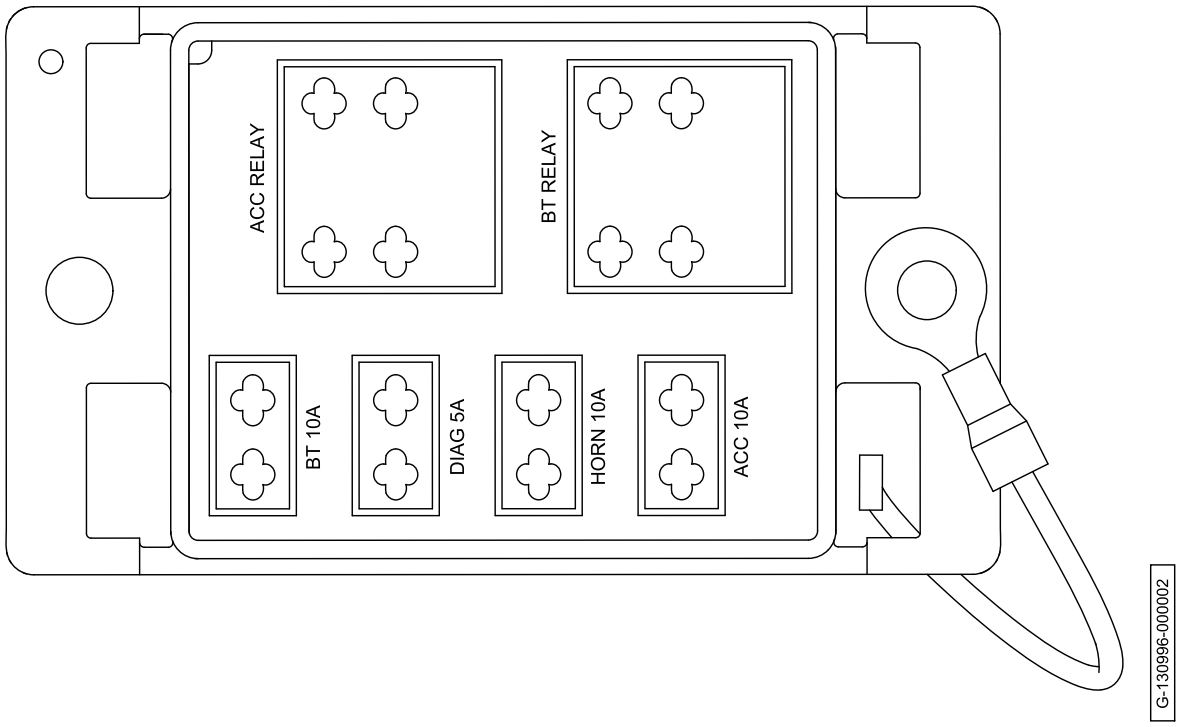
1. Pull up on the yellow tabs (1) **(Figure 12-3)**.
2. Push the four tabs (2) in.
3. Remove the fuse block cover.

Fuse Block Cover Installation

1. Install the fuse block cover.
2. Make sure that the four tabs (2) engage the fuse block **(Figure 12-3)**.
3. Push down the yellow tabs (1). Make sure that the yellow tabs engage.

FUSE BLOCK TABLE

The fuse block contains fuses and relays. The fuse block is located under the seat.



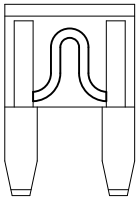
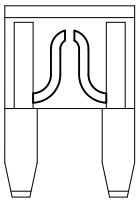
COMPONENT	DESCRIPTION
ACC RELAY	Accessory Relay
BT RELAY	Bluetooth Relay
BT 10A	10A Fuse - Bluetooth
DIAG 5A	5A Fuse - Diagnostic Receptacle
HORN 10A	10A Fuse - Horn
ACC 10A	10A Fuse - Accessories

Figure 12-4 Fuse Block

FUSES

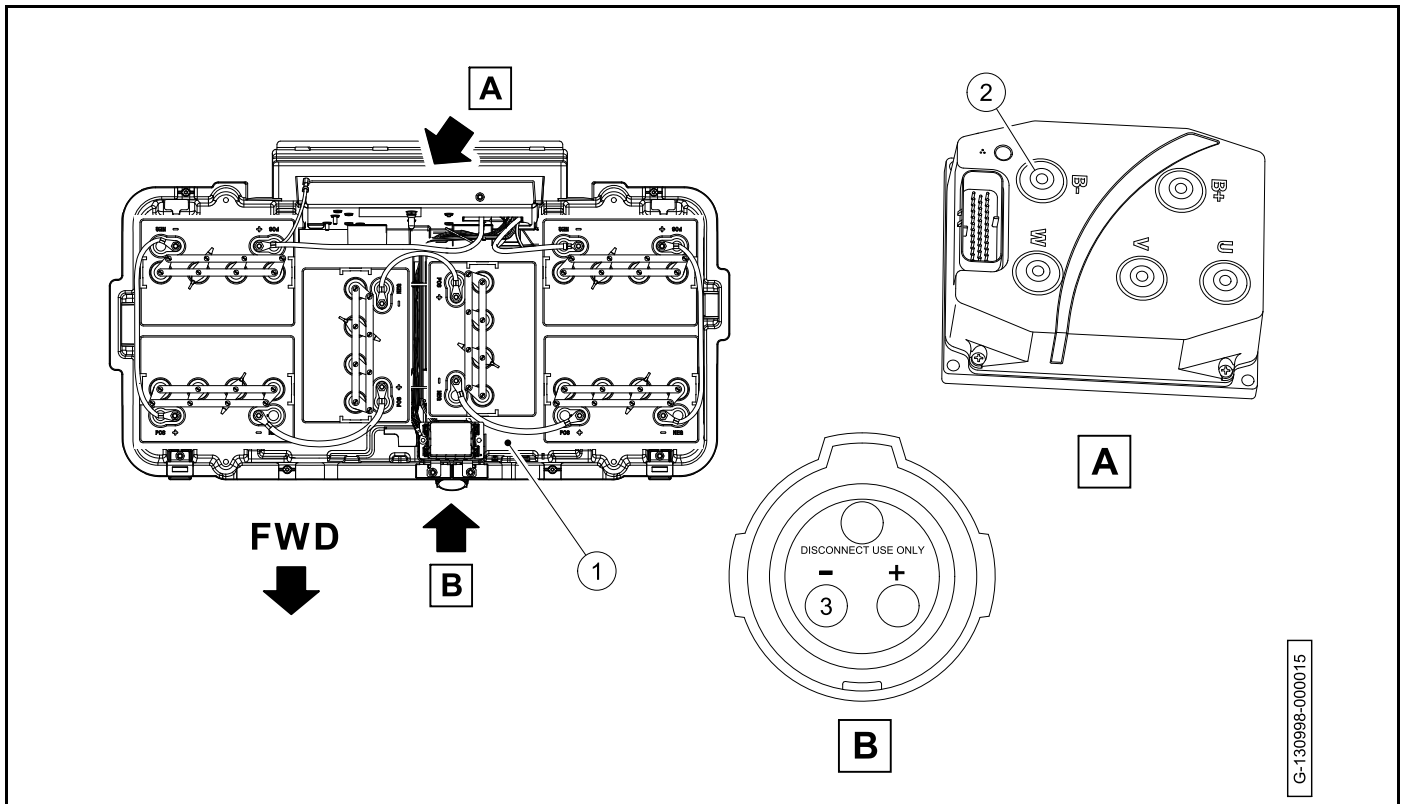
ATO AND MINI ATM FUSE INSPECTION

1. Disable the vehicle.
2. Remove the fuse.
3. Examine the fuse.

Good Fuse	 G-130998-000004
Blown Fuse	 G-130998-000005

GROUND LOCATIONS

Ground locations for test procedures.



Callout Number	Description
1	12V accessory ground connector
2	B- on motor control unit (MCU)
3	Pin (–) on vehicle charger receptacle

Figure 12-5

BASIC TROUBLESHOOTING GUIDE

SYMPTOM	POSSIBLE CAUSES	CORRECTIVE ACTION
Vehicle does not operate	Batteries are discharged	Charge the batteries as soon as possible.
	Battery connections	Check the battery connections and the vehicle wiring.
	Battery charger is connected to the vehicle and the charger interlock has disabled the vehicle	Disconnect the battery charger from the vehicle.
	Charger interlock failure	See the charger interlock test procedure.
	Key switch circuit	Check for loose or disconnected wires at key switch.
	Defective key switch	See the key switch test procedure.
	Defective Forward/Neutral/Reverse switch (FNR)	See the FNR switch test procedure.
	Defective MCOR	See the key switch and MCOR test procedures.
	Loose solenoid wires	See the solenoid activating coil test procedure.
	Solenoid coil has failed	See the solenoid activating coil test procedure.
	Motor control unit (MCU) thermal cutback	Let the MCU cool. Make sure that the vehicle is not over-loaded before returning to operation.
	35-pin connector at motor control unit (MCU).	Check for loose or disconnected wires at the 35-pin connector.
	High pedal detect	Cycle the accelerator pedal.
	Motor stall	Cycle the accelerator pedal.
	Defective motor	Check the fault codes.
	Defective motor control unit (MCU)	Check the fault codes.
	Motor connections	Check for loose or disconnected wires.
	Motor control unit (MCU) connections	Check for loose or disconnected wires.
Vehicle does not operate - No 12V	Main CAN bus is shorted	See Main CAN bus Test Procedure.
	Battery SOC is low	Charge the batteries as soon as possible.

TABLE CONTINUED ON NEXT PAGE

SYMPTOM	POSSIBLE CAUSES	CORRECTIVE ACTION
Vehicle runs slowly	Vehicle is over-loaded	Make sure that the vehicle is not over-loaded before returning to operation.
	Speed sensor is disconnected or defective	See the motor speed sensor test procedure.
	Incorrect speed setting	Use the CCDT to change the vehicles maximum speed.
	Incorrect wiring	Check the vehicle wiring.
	Batteries are discharged	Charge the batteries
	Defective MCOR	See the MCOR test procedures.
	Loose motor wires	Inspect and tighten all wire connections at the motor.
	Defective motor	See the motor test procedures.
	Defective motor control unit (MCU)	Check the fault codes.
	Brakes are not adjusted correctly	Adjust the brakes.
	Flat or under inflated tires	See the Wheels and Tires section.
Vehicle operates but has points in pedal travel where it does not maintain speed nor accelerate	Defective MCOR	See the MCOR test procedures.
Vehicle operates, but motor braking function does not	Incorrectly wired	Check the vehicle wiring.
	Motor speed sensor disconnected or failed	See the motor speed sensor test procedure.
Vehicle will run in forward, but not in reverse or will run in reverse but not forward	Forward/Neutral/Reverse switch (FNR) switch incorrectly wired	See the FNR switch test procedure.
	Motor incorrectly wired	Check the motor wiring.
	Motor control unit (MCU) incorrectly wired or defective MCU	Check the vehicle wiring.
Vehicle operates, but battery charger does not charge batteries	Charger interlock failure	See the charger interlock test procedure.
	Loose plug or wires at battery charger, vehicle charge receptacle, or the battery	Check wire connections and tighten if necessary.
	Battery charger	See the battery charger troubleshooting section.

DIAGNOSTIC TROUBLESHOOTING CODES (DTC)

⚠ WARNING

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

Use the CCDT to access the DTC's.

In the event of the DTC, the vehicle will log the DTC and store a snapshot of the vehicles state when the DTC occurred.

SYSTEM RESPONSE TO DTC

- Log - Log the event.
- Display - A message will display on the dash display. The vehicle will continue to operate normally.
- Limp - A message will display on the dash display. Vehicle speed will be reduced.
- Shutdown - A message will display on the dash display. The vehicle will shutdown.

HOW TO CLEAR DTC

- Auto - The DTC will clear automatically when the condition is corrected.
- Key Cycle - Turn the key switch to OFF, ON, then to OFF.
- Interlock - Disconnect the DC cord from the vehicle. Connect the DC cord to the vehicle.
- Technician - Use the diagnostic tool to clear the DTC.

DIAGNOSTIC TROUBLESHOOTING CODE (DTC) TABLE

CODE	RE-SPONSE	CLEAR	DESCRIPTION	CORRECTIVE ACTION
33	Shutdown	Key Cycle	MCU Contactor Opened Unexpectedly	1. Inspect the main solenoid wiring circuit for open/short. 2. See the solenoid activating coil test procedure.
39	Shutdown	Technician	Vehicle Overspeed With Positive Torque Possible Cause: • Motor control unit (MCU) internal malfunction	1. Refer to the other active MCU fault codes. 2. If there is no other MCU fault active, contact Club Car.
40	Limp	Auto	MCU Main Contactor In Fault State	1. Refer to the other active MCU fault codes. 2. If there is no other MCU fault active, contact Club Car.
41	Log	Auto	MCU Under Voltage - Derate Possible Cause: • Low SOC, then quickly accelerating going up a steep slope can cause a brief instance of MCU under voltage.	Notification Only. No action is needed.

TABLE CONTINUED ON NEXT PAGE

42	Shutdown	Key Cycle	MCU Severe Under Voltage - Power Off Possible Cause: • Vehicle has been operating at low state-of-charge (SOC) for long periods. • Loose MCU wires. • Defective battery or batteries.	1. Fully charge the batteries. If the fault occurs multiple times after a full charge: 1.1. Test batteries. 1.2. Check the MCU wiring.
43	Log	Auto	MCU Over Voltage - Derate Possible Cause: • Fully charged battery pack and vehicle goes down long incline.	Notification Only. No action is needed.
44	Shutdown	Key Cycle	MCU Severe Over Voltage - Power Off Possible Cause: • MCU voltage over maximum limit. • Main solenoid failed.	1. Check the motor and MCU wiring for possible shorts. 2. Replace main solenoid.
45	Log	Auto	MCU High Temperature - Derate Possible Cause: • Excessive load on the vehicle • High ambient temperature • Motor control unit (MCU) is operating in an extreme environment	Reduce the load on the vehicle.
46	Shutdown	Key Cycle	MCU High Temperature - Power Off Possible Cause: • Excessive load on the vehicle • High ambient temperature • Motor control unit (MCU) is operating in an extreme environment	Reduce the load on the vehicle.
47	Log	Auto	High Motor Temperature - Derate Possible Cause: • Excessive load on the vehicle • High ambient temperature • Motor control unit (MCU) is operating in an extreme environment	Reduce the load on the vehicle.
48	Shutdown	Auto	Throttle Out Of Range On Startup Possible Cause: • Software failure	Make sure that the MCU and VCM have the latest software version.
49	Shutdown	Auto	Fault Active Possible Cause: • An MCU fault has been detected	*If DTC 49 is the only code:* 1. Make sure that the latest software versions are installed. 2. Clear the DTC. 3. If the DTC activates again, contact Club Car.

TABLE CONTINUED ON NEXT PAGE

50	Shutdown	Key Cycle	Loss of CAN messages from VCM to MCU Possible Cause: • CAN bus circuit problem	1. Make sure there is power at pin 1 on the 35-pin MCU connector. 1.1. Cycle the key switch to wake the system. 1.2. If the LED on the MCU is flashing, the MCU has power. 1.3. If there is no power, inspect the MCU wiring. 2. See Main CAN bus troubleshooting.
51	Shutdown	Key Cycle	MCU Logic Severe Under Voltage Possible Cause: • Batteries discharged.	1. Fully charge the batteries. 2. Check the key switch wiring to the MCU.
53	Shutdown	Technician	MCU Logic Severe Over Voltage Possible Cause: • Fully charged battery pack and vehicle goes down long incline causing battery voltage to be 25% over nominal voltage	Check wiring harness connections for loose connections.
54	Shutdown	Key Cycle	MCU Phase Current Too High Possible Cause: • Motor phase wiring damaged • Internal motor damage • Internal motor control unit (MCU) damage	1. Inspect the motor phase wires (W, V, U). Replace as necessary. 2. See Stator Winding Test Procedure. 3. If the motor is good, replace the MCU.
55	Shutdown	Auto	5V Supply Fault Possible Cause: • 5V supply is open or short circuit • Disconnected speed sensor and/or motor temperature sensor	1. Inspect the wire harness for damage. 2. Make sure that the motor temperature sensor and speed sensor are connected to the main harness. 3. Test the motor temperature sensor and motor speed sensor. 4. Check for continuity between pin 26 on the MCU and pin 1 on the speed sensor. 5. Check for continuity between pin 8 on the MCU and pin 1 on the motor temperature sensor.
57	Display	Key Cycle	Motor Phase Open Circuit Possible Cause: • Motor phase wiring open circuit • Damaged motor • Internal motor control unit (MCU) damage	1. Examine the motor wires and connections. Repair or replace as necessary. 2. See Stator Winding Test Procedure. 3. If the stator winding test is good, replace the motor phase wire harness. 4. Test vehicle operation. 5. If DTC 57 activates again, replace the MCU. Test vehicle operation. 6. If DTC 57 continues to activate, contact Club Car.

TABLE CONTINUED ON NEXT PAGE

58	Shutdown	Key Cycle	No MCU To VCM CAN Communication Possible Cause: • CAN bus circuit problem	1. Make sure that the latest software versions are installed. 2. See Main CAN bus troubleshooting. 3. If the Main CAN bus is good, check the MCU 35-pin connection. 4. Make sure there is power at pin 1 on the 35-pin MCU connector. 4.1. Cycle the key switch to wake the system. 4.2. If the LED on the MCU is flashing, the MCU has power. 4.3. If there is no power, inspect the MCU wiring. 5. Check the main solenoid for loose or damaged wires. 6. Replace the MCU.
59	Shutdown	Auto	MCU Contactor Precharge Failure Possible Cause: • Internal motor control unit (MCU) damage	Replace the MCU.
60	Shutdown	Key Cycle	MCU Main Contactor Did Not Close	1. Inspect the main solenoid wiring circuit for open/short. 2. See the solenoid activating coil test procedure.
61	Shutdown	Key Cycle	MCU Main Contactor Did Not Open Possible Cause: • Main solenoid welded	See the solenoid activating coil test procedure.
62	Shutdown	Key Cycle	MCU Main Contactor Coil Open/Short Possible Cause: • Main solenoid wiring • Main solenoid coil open/shorted • Dirty connector pins at controller or contactor coil • Bad connector crimps or faulty wiring	1. Inspect the main solenoid wiring circuit for open/short. 2. See Solenoid Activating Coil Test Procedure.
66	Shutdown	Key Cycle	Motor Encoder Fault Possible Cause: • Defective speed sensor • Speed sensor wiring problem	1. Inspect the speed sensor wiring and connectors. 2. If the speed sensor wires and connectors are good, replace the speed sensor.
67	Shutdown	Key Cycle	Motor Stall Possible Cause: • Vehicle overloaded • Defective speed sensor • Damaged or defective drivetrain	1. Reduce the load on the vehicle. 2. Inspect the speed sensor wiring and connectors. 3. If the speed sensor wires and connectors are good, replace the speed sensor. 4. Inspect the drivetrain for damage/seized components
68	Shutdown	Key Cycle	FNR Validity Possible Cause: • Incorrect software version	Make sure that the MCU and VCM have the latest software version.

TABLE CONTINUED ON NEXT PAGE

69	Display	Key Cycle	Motor Temperature Sensor Possible Cause: • Motor temperature sensor wiring problem • Motor temperature sensor connector not connected • Defective motor temperature sensor	See the motor temperature sensor test procedure.
70	Shutdown	Key Cycle	MCU Current Sensor Possible Cause: • Internal motor control unit (MCU) damage	Replace the MCU.
71	Shutdown	Interlock	Charging Fault Possible Cause: • Voltage does not increase by 800mv after the battery charger is connected and 6 hours has elapsed. • Battery charger may not be operating correctly or is disconnected from AC power.	1. Check the battery charger. See battery charger test procedures. 2. Test the batteries.
87	Shutdown	Key Cycle	Charger Interlock Fault While Moving Possible Cause: • Vehicle moved while battery charger was connected • Interlock circuit shorting to ground while moving	1. See the charger interlock test procedure.
88	Limp	Auto	VDU Anti-Tamper Fault Possible Cause: • Visage Display Unit (VDU) console toggle switch turned off • CAN bus circuit problem	1. Use the console toggle switch to turn the VDU on. 2. See Main CAN bus Test Procedure.
89	Display	Key Cycle	Main DC/DC Failure Possible Cause: • DC/DC fuse blown • DC/DC Enabled but vehicle does not have lights • DC/DC internal malfunction • DC/DC enable signal not going high	1. If the vehicle does not have lights, make sure that the DC/DC is not enabled. 2. Inspect the vehicle and DC/DC wiring for a short circuit. 3. Inspect the DC/DC 10A fuse and internal 250V/30A fast acting fuse. Replace as necessary. 4. Inspect the wiring from the DC/DC connector to the 19-pin connector on the battery. 5. Replace the DC/DC converter.
90	Limp	Key Cycle	12V Bus Severe Under Voltage Possible Cause: • Supply is overloaded • Supply is short circuited	1. Check for non-approved loads/accesorries. 2. Check for wiring short circuits.
91	Display	Key Cycle	Main DC/DC Output Over Voltage Possible Cause: • DC/DC internal malfunction	Replace the DC/DC converter.
93	Log	Key Cycle	IVS Late Engagement (>25%) Possible Cause: • Limit switch engaging after 25% pedal travel • Sensor worn out	1. Test the Motor Controller Output Regulator (MCOR). 2. Replace the MCOR as necessary.

TABLE CONTINUED ON NEXT PAGE

99	Shutdown	Auto	FNR Switch Fault Possible Cause: • Defective Forward/Neutral/Reverse switch (FNR)	1. See Forward/Neutral/Reverse Switch (FNR) Test Procedure. 2. Inspect the FNR wiring.
100	Shutdown	Auto	Ignition Key Switch Fault Possible Cause: • Key is detected in RUN position without ACC signal	1. Inspect the key switch circuit wiring. 2. Test the key switch.
101	Display	Key Cycle	Body Builder/Accessory Relay Fault Possible Cause: • Low side driver short to 12 volt.	1. Inspect the accessory relay coil wiring circuit. Replace as necessary. 2. Test the relay.
103	Log	Auto	User Display CAN Communication Fault Possible Cause: • No power to the dash display • CAN bus circuit problem • Dash display internal problem	1. Inspect the dash display wiring and connections. 2. See the dash display test procedure.
104	Log	Auto	Vehicle Overspeed Above Set Speed By 2 MPH Possible Cause: • Vehicle overloaded while operating downhill • Vehicle operating down an excessive grade	Reduce the load on the vehicle.
109	Shutdown	Technician	IVS Severe Late Engagement (>50%) Possible Cause: • Failed Motor Controller Output Regulator (MCOR) • MCOR limit switch circuit open	1. Inspect the MCOR limit switch circuit wiring. 2. Test the MCOR.
111	Log	Auto	Battery SOC Zero (0% User) Possible Cause: • Battery State-Of-Charge (SOC) is low	Charge the batteries.
112	Log	Auto	Battery SOC Low (User SOC is 5%) Possible Cause: • Battery State-Of-Charge (SOC) is low	Charge the batteries.
113	Log	Auto	Stack Overflow Fault Possible Cause: • Incorrect software version	Make sure that the MCU and VCM have the latest software version.
114	Shutdown	Key Cycle	Motor Contactor Welded Possible Cause: • Main solenoid welded	1. Check the main solenoid for loose or damaged wires. 2. Test the main solenoid. Replace as necessary.
116	Limp	Auto	Vehicle Not Finalized Possible Cause: • Vehicle not configured	1. Use the diagnostic tool to configure and save the vehicle configuration. Make sure that all accessories are enabled. 2. Check the motor speed sensor wires and connectors. 3. Test the motor speed sensor. 4. Check the key switch wires and connectors. Repair or replace as necessary.

TABLE CONTINUED ON NEXT PAGE

117	Log	Key Cycle	Strut Relay Shorted To Battery Possible Cause: • Low side driver short to 12 volt	1. Inspect the relay wiring. 2. Test the relay.
118	Log	Interlock	Battery Over Discharged Possible Cause: • Charging circuit problem • Batteries are discharged	Charge the batteries.
123	Shutdown	Key Cycle	MCU Parameter Change ***NOTE:*** *MCU replacement will cause DTC 123.*	1. Clear the DTC. 2. Make sure that the MCU and VCM have the latest software version. 3. If the DTC activates again, contact Club Car.
124	Shutdown	Key Cycle	MCU Parameter Out Of Range	1. Make sure that the MCU and VCM have the latest software version. 2. If the DTC activates again, contact Club Car.

MAIN CAN BUS TEST PROCEDURE

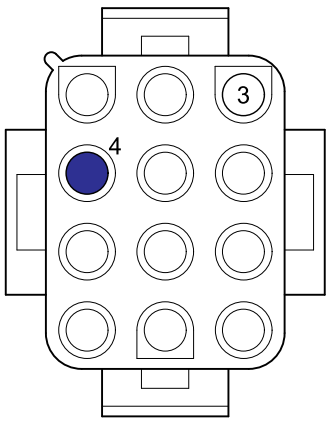
If the dash display shows asterisk (*) symbols, the main CAN bus has a short.

Before the procedure:

1. Disable the vehicle.
2. Disconnect the DC charger cord from the vehicle.

Test procedure:

1. Remove the instrument panel (IP).
2. Set a multimeter to measure resistance.
3. Disconnect the IP harness from the main harness.
4. Measure the resistance across pins 3 and 4 on the main harness IP connector **(Figure 12-6, Page 12-18)**.



G-130992-000059

Pin	Wire Color	Description

3	White	CAN Hi
4	Blue	CAN Low

Figure 12-6

4.1. If the resistance is approximately 60 ohms, the CAN bus is good.

4.1.1. Check the connector pins for damage and wire connection issues.

4.1.2. Check the continuity of the CAN bus wires between the two electronic control units (ECU) that have the communication fault.

4.2. If the resistance is less than 40 ohms, **See Low Resistance on page 12-19.**

4.3. If the resistance is approximately 120 ohms, **See 120 Ohm Resistor Test on page 12-23.**

4.4. If there is no resistance, **See Open Circuit on page 12-24.**

Index of Test Procedures

1 – Low Resistance
2 – 120 Ohm Resistor Test
3 – Open Circuit

TEST PROCEDURE 1 – Low Resistance

Possible causes:

- Damage to the harness at the 4-pin strut connector caused a components internal CAN circuit failure.
- Damage to the harness caused a components internal CAN circuit failure.

Before the procedure:

1. Disable the vehicle.
2. Disconnect the DC charger cord is from the vehicle.

Test procedure:

1. Set a multimeter to measure resistance.
2. Disconnect the dash display connector (1) from the dash display (2) **(Figure 12-7, Page 12-20)**.

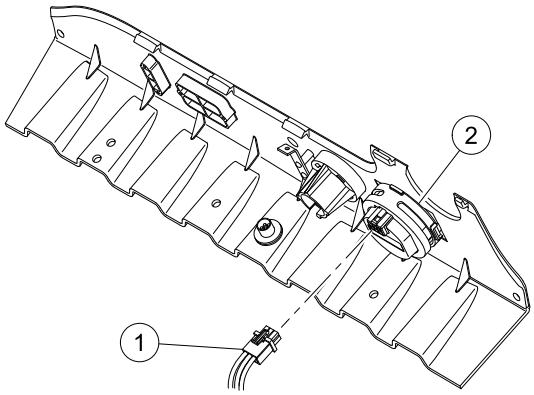
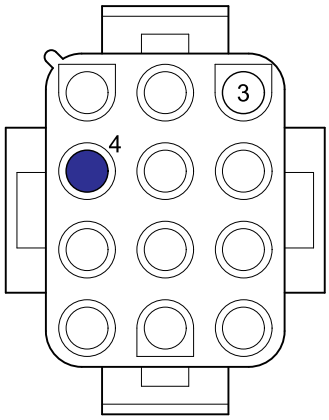


Figure 12-7 Dash Display Connector

3. Measure the resistance across pins 3 and 4 on the IP connector **(Figure 12-8, Page 12-20)**.



Pin	Wire Color	Description
3	White	CAN Hi
4	Blue	CAN Low

Figure 12-8

3.1. If the resistance is less than 40 ohms, connect the dash display. Go to step 4.

3.2. If the resistance is approximately 60 ohms:

3.2.1. Replace the dash display.

3.2.2. Check for continuity between the CAN bus and 12V. Replace the harness as necessary.

3.2.3. Check the main harness at the 4-pin strut connector for damage. Replace the main harness as necessary.

4. Remove the passengers-side strut cover.
5. Disconnect the 120k Ohm resistor from the 4-pin connector.
6. Measure the resistance across pins 3 and 4 on the main harness IP connector.

6.1. If the resistance is less 40 ohms:

6.1.1. Connect the 120k Ohm resistor to the 4-pin connector.

6.1.2. Install the passengers-side strut cover.

6.1.3. Go to step 7.

6.2. If the resistance is approximately 120 ohms:

6.2.1. The 120k Ohm resistor has failed. Before connecting the new 120k Ohm resistor to the vehicle, do the following steps.

6.2.2. Check for continuity between the CAN bus and 12V. Replace the harness as necessary.

6.2.3. Check the main harness at the 4-pin strut connector for damage. Replace the main harness as necessary.

6.2.4. Check the main harness near the battery for damage. Replace the main harness as necessary.

7. Disconnect the vehicle control module (VCM) 81-pin connector (1) from the VCM (2) **(Figure 12-9, Page 12-21)**.

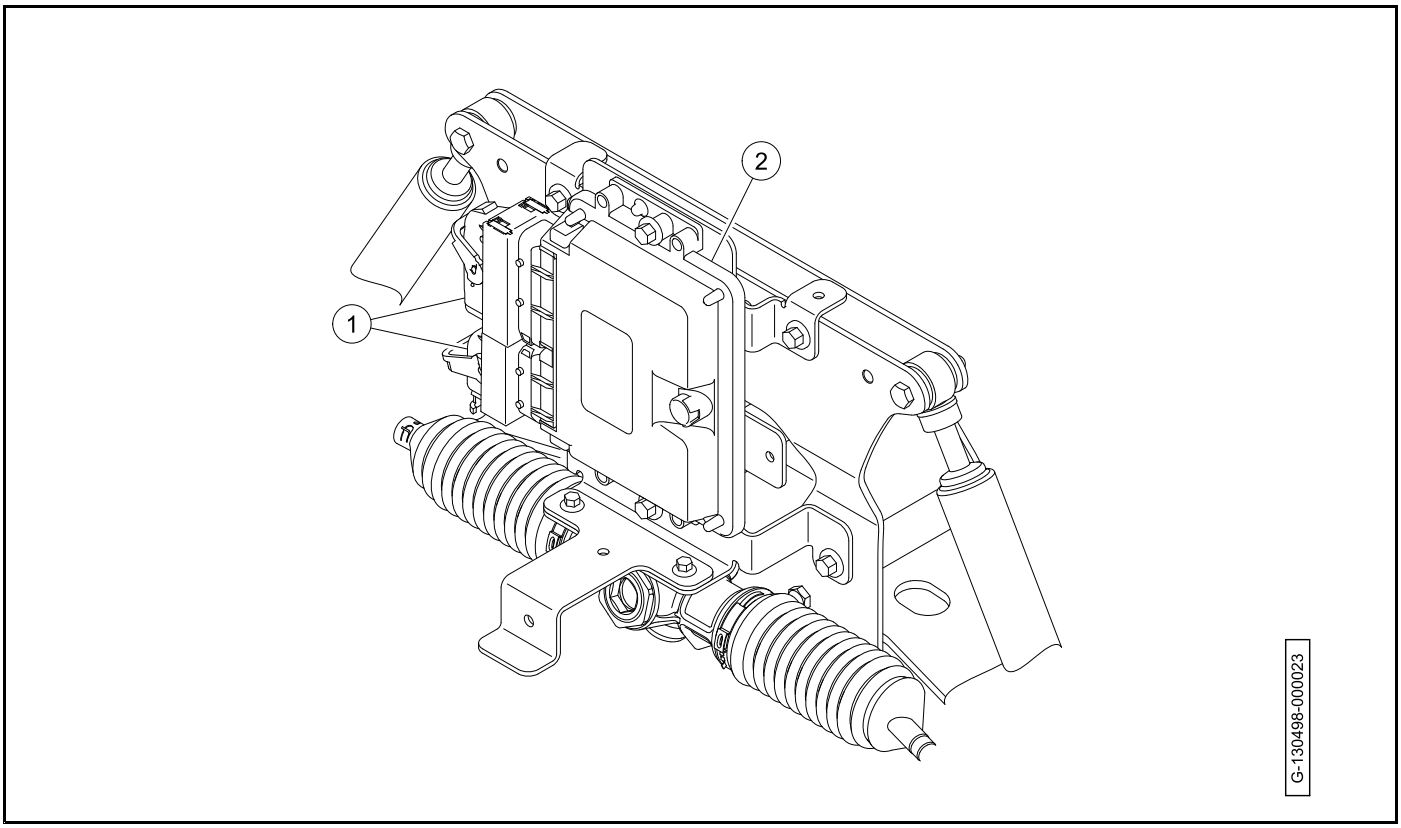


Figure 12-9 VCM 81–Pin Connector

8. Measure the resistance across pins 3 and 4 on the main harness IP connector.

8.1. If the resistance is less 40 ohms, connect the VCM 81-pin connector. Go to step 9.

8.2. If the resistance is approximately 60 ohms:

8.2.1. The VCM has failed. Before connecting the new VCM to the vehicle, do the following steps.

8.2.2. Check for continuity between the CAN bus and 12V. Replace the harness as necessary.

8.2.3. Check the main harness at the 4-pin strut connector for damage. Replace the main harness as necessary.

9. Disconnect the 35-pin connector (1) from the motor control unit (MCU) (2) **(Figure 12-10, Page 12-22)**.

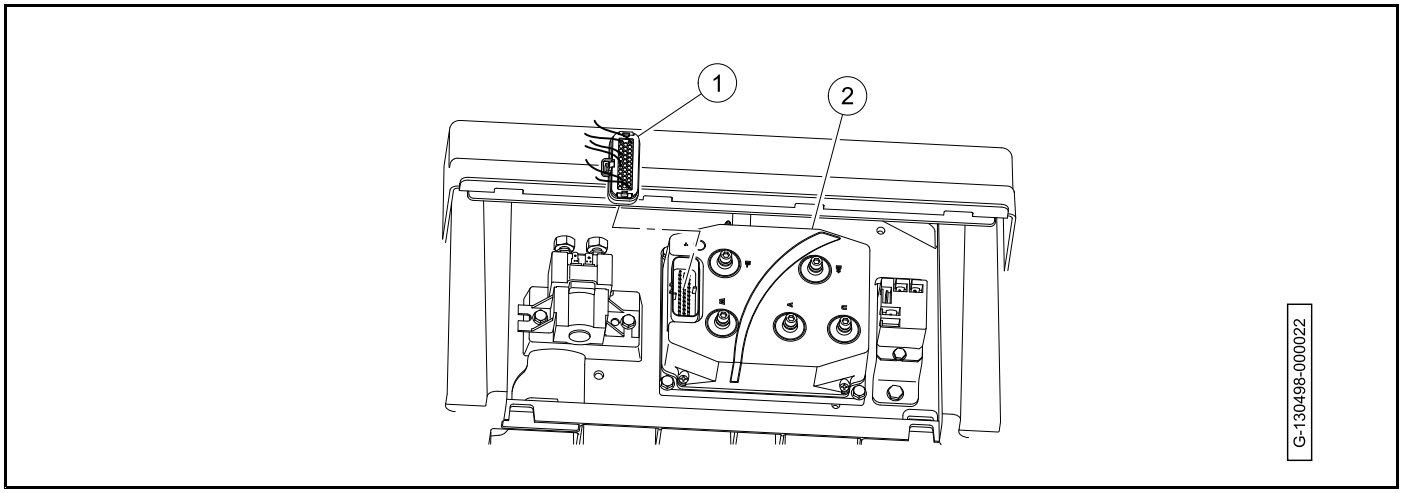


Figure 12-10 MCU 35–Pin Connector

10. Measure the resistance across pins 3 and 4 on the main harness IP connector.

10.1. If the resistance is approximately 120 ohms:

10.1.1. The MCU has failed. Before connecting the new MCU to the vehicle, do the following steps.

10.1.2. Check for continuity between the CAN bus and BPV. Replace the harness as necessary.

10.1.3. Check the main harness at the 4-pin strut connector for damage. Replace the main harness as necessary.

TEST PROCEDURE 2 – 120 Ohm Resistor Test

Before the procedure:

1. Disable the vehicle.
2. Disconnect the DC charger cord is from the vehicle.

Test Procedure:

1. **Without VDU:** Check for continuity between pin 3 of the main harness IP connector and pin 4 of the VDU strut connector.Check for continuity between pin 4 of the main harness IP connector and pin 3 of the VDU strut connector **(Figure 12-11, Page 12-23)**.

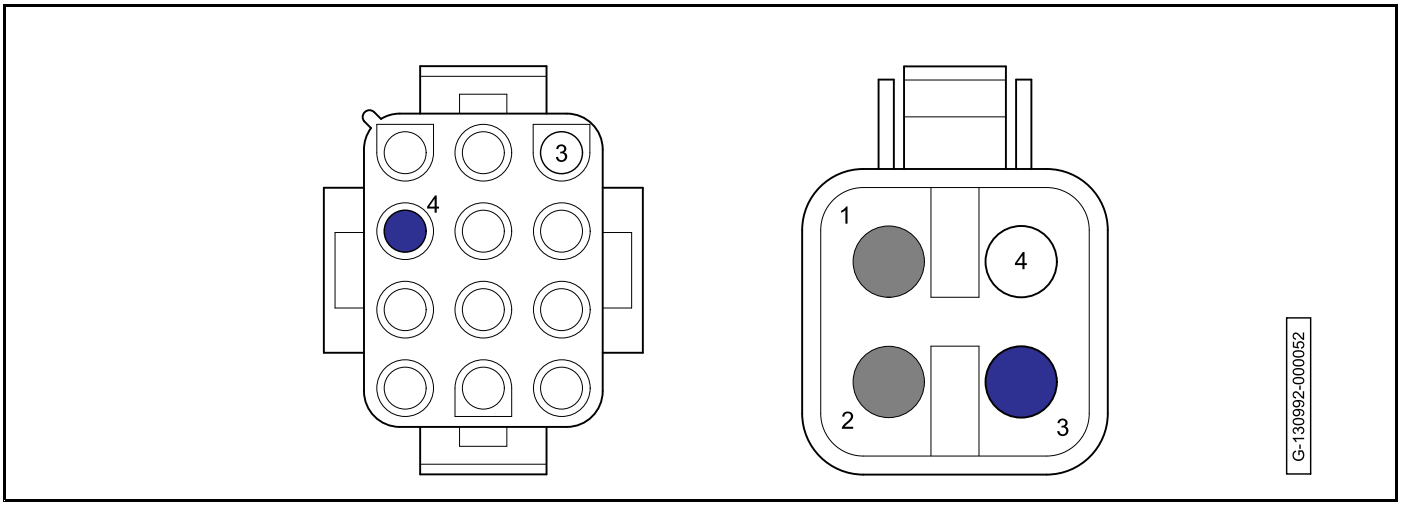


Figure 12-11

1.1. If there is continuity, go to step 4.

1.2. If there is no continuity, replace the wire harness.

2. **With VDU:** Check for continuity between pin 3 of the main harness IP connector and pin 1 of the VDU harness connector.Check for continuity between pin 4 of the main harness IP connector and pin 6 of the VDU harness connector **(Figure 12-12, Page 12-23)**.

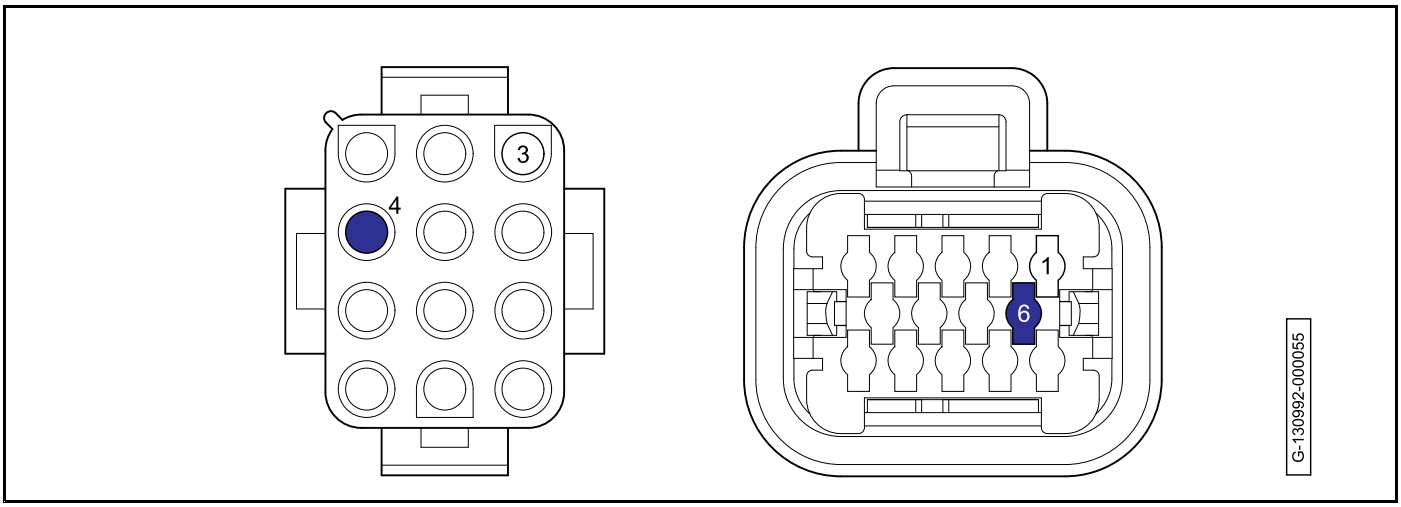


Figure 12-12

2.1. If there is continuity, go to step 3.

2.2. If there is no continuity, replace the wire harness.

3. Check for continuity between pin 3 of the main harness IP connector and pin 1 of the auxiliary can harness connector.Check for continuity between pin 4 of the main harness IP connector and pin 2 of the auxiliary can harness connector **(Figure 12-13, Page 12-24)**.

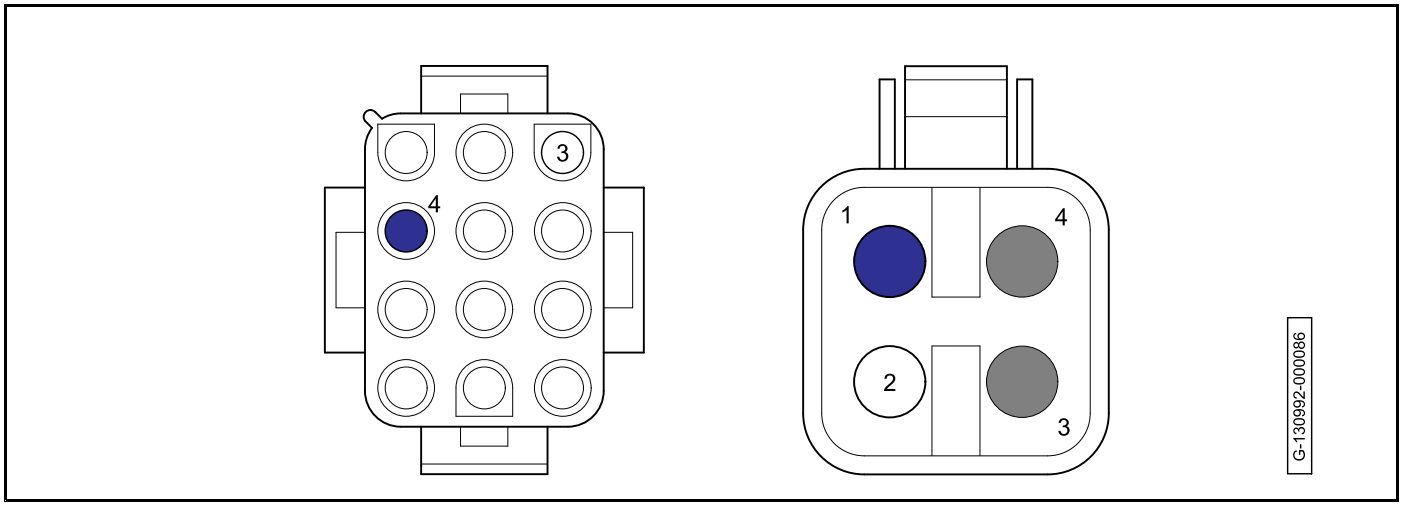


Figure 12-13

3.1. If there is continuity, got to step 4.

3.2. If there is no continuity, replace the wire harness.

4. Check for continuity between pin 3 of the main harness IP connector and pin 23 of the MCU 35-pin connector.Check for continuity between pin 4 of the main harness IP connector and pin 35 of the MCU 35-pin connector **(Figure 12-14, Page 12-24)**.

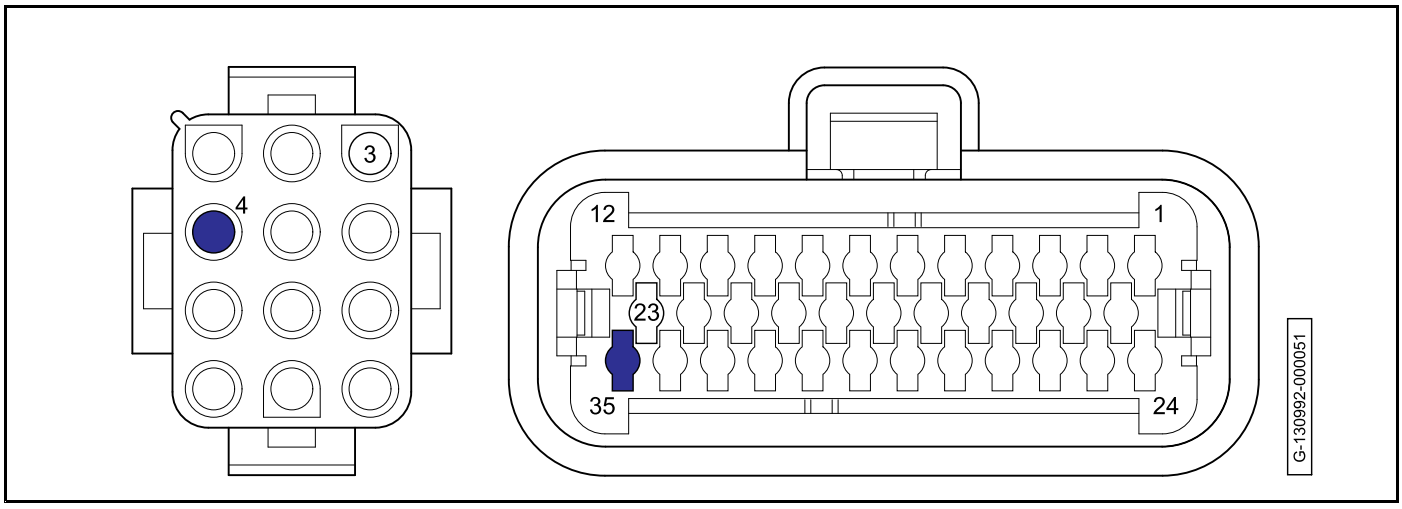


Figure 12-14

4.1. If there is no continuity, replace the wire harness.

4.2. Make sure that the wires at the 35-pin connector are fully seated.

TEST PROCEDURE 3 – Open Circuit

Check the continuity of the CAN bus wires between each component on the main CAN bus. Replace the harness.

AC 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 Controller Shield on page 13-4. 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 Controller Shield on page 13-4. 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 CCDT, the Main CAN bus and VCM must be operational.
- Battery Pack Voltage (BPV) will be referenced throughout the test procedures.
- When testing motor controller unit (MCU) functions, the Run/Tow-Stow switch must be in the RUN position. The TOW position removes power to the MCU.
- Several tests can be performed by accessing components through the access panel in the rear body.
- The Run/Tow switch powers the charger interlock, key switch, motor controller unit (MCU), 10-amp fuse, and USB port.
- 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.
- Several test can be performed by accessing components through the access panel in the rear body. If greater access is required, the two center batteries can be removed and the component mounting plate leaned forward; place the two center batteries on the floorboard and reconnect two of the existing battery cables. Use a third, “service only” cable that is long enough to connect the two batteries just for troubleshooting.

Index of Test Procedures

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2 – Battery Pack Voltage (BPV) Under Load
3 – Charger Interlock
4 – Dash Display
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7 – Headlights
8 – Horn Switch
9 – Horn
10 – Key Switch Circuit
11 – Light Switch
12 – MCOR Accelerator Position
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14 – Motor Speed Sensor
15 – Motor Stator Winding
16 – Motor Temperature Sensor
17 – Multi-Purpose Buzzer
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20 – Solenoid Activating Coil
21 – Solenoid Continuity
22 – Taillights
23 – Turn Signal
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25 – Voltage at Charger Receptacle Red Wire Socket
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27 – 4-Pin Connector (for Video Display Unit)

TEST PROCEDURE 1 – Batteries / Voltage Check (BPV)

See General Warnings on page 1-2.

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 14-11.***

The battery voltage can be displayed with the CCDT. If an CCDT handset is not available, proceed to **Batteries / Voltage Check without the CCDT**.

Batteries / Voltage Check with the CDT Handset

1. Connect the CCDT to the vehicle.

2. Access the MCU menu and select MCU logic voltage. The CCDT should indicate at least BPV. **See following NOTE.** If not, check for loose battery connections or a battery installed in reverse polarity. **Refer to AC Electric Vehicle - Batteries on page 14-1 for further details on battery testing.**

NOTE: *The voltage displayed through the CCDT 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 CCDT

1. If necessary, see Testing Basics on page 12-25.
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 12-15, Page 12-27)**.
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 AC Electric Vehicle - Batteries on page 14-1 for further details on battery testing.**

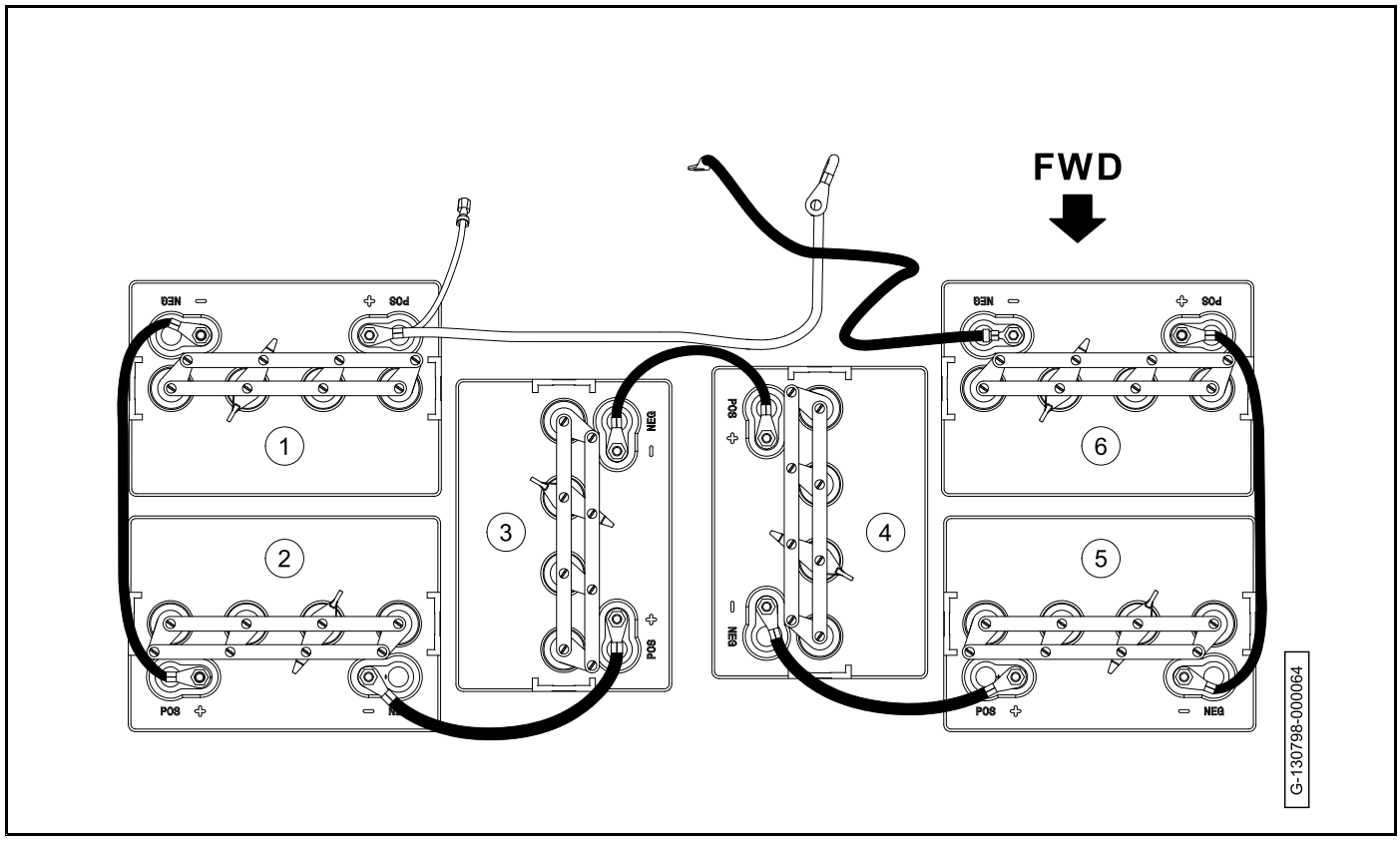


Figure 12-15 Battery Voltage Test

TEST PROCEDURE 2 – Battery Pack Voltage (BPV) Under Load

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

1. If necessary, see Testing Basics on page 12-25.
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 12-16, Page 12-28)**.

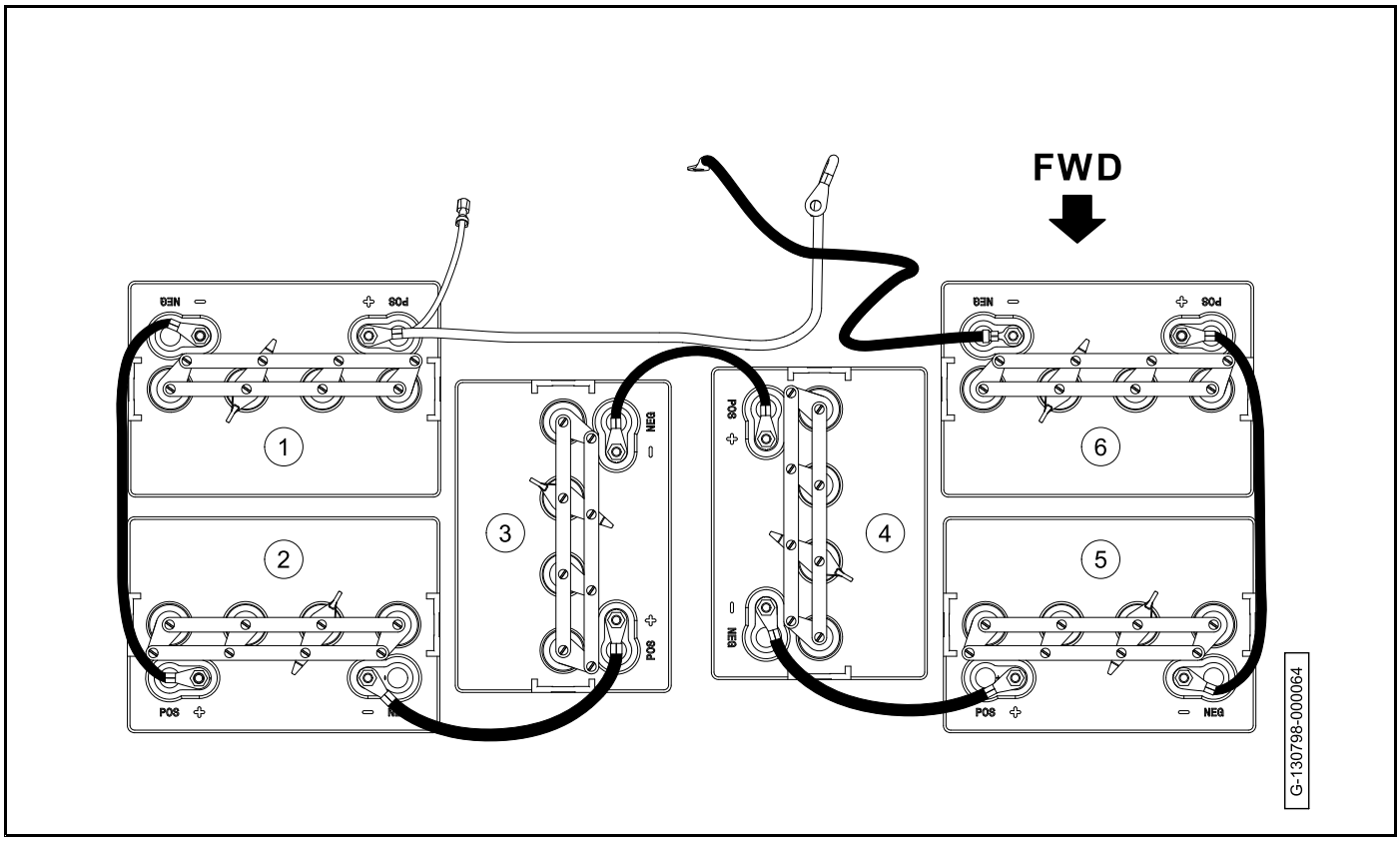


Figure 12-16 Battery Discharge Test

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 AC Electric Vehicle - Batteries on page 14-1.

TEST PROCEDURE 3 – Charger Interlock

See General Warnings on page 1-2.

NOTE: *This is a continuity and voltage test.*

1. Connect the CCDT to the vehicle.

2. Go to the VCM screen.
3. Go to the SIGNALSINPUT screen **(Figure 12-17, Page 12-29)**.



Figure 12-17

4. Connect the DC cord to the vehicle charge receptacle.
4.1. If the Input Charger Interlock displays On, go to step 5.
4.2. If the Input Charger Interlock displays Off, go to step 6.
5. Disconnect the DC cord from the vehicle charge receptacle.
5.1. If Battery Charger Input displays Off, the charger interlock is operating correctly.
5.2. If Battery Charger Input displays On, go to step 6.
6. Set the multimeter to measure DC voltage.
7. Disconnect the DC cord from the vehicle charge receptacle.
8. Measure the voltage of pin 1 **(Figure 12-18, Page 12-29)**.

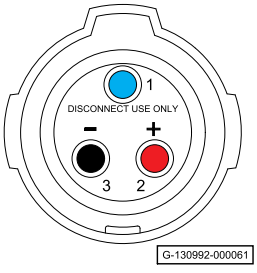


Figure 12-18

8.1. If the reading is BPV, go to step 9.

8.2. If the reading is not BPV, there is a wiring issue. Check the wiring circuit

9. Set the mulitmeter to measure continuity.
10. Check for continuity between the black wire and the nearest ground.
10.1. If there is continuity, the wiring circuit is good. Go to step 11.
10.2. If there is no continuity, check the wiring circuit.
11. Connect the DC cord to the vehicle charge receptacle.
12. Set the multimeter to measure DC voltage.
13. Measure the voltage on pin 1 **(Figure 12-19, Page 12-31)**.

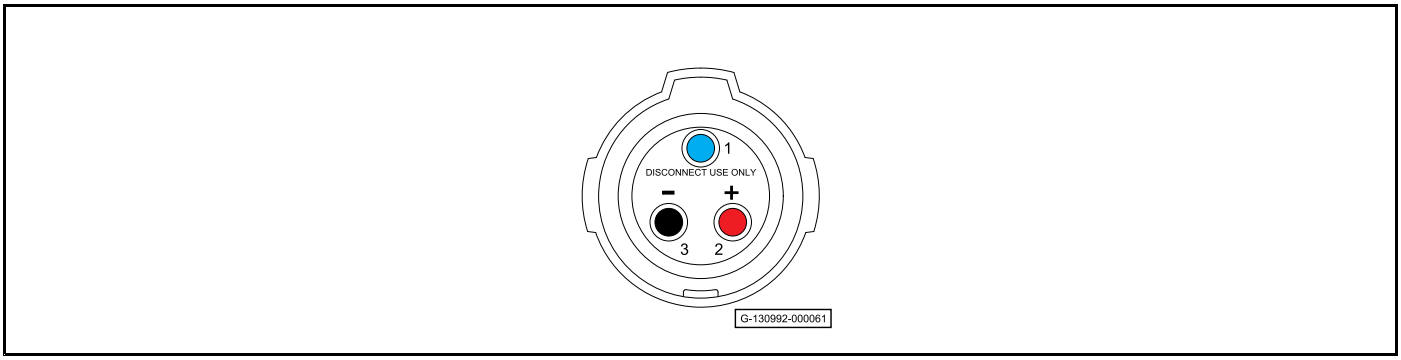


Figure 12-19

13.1. If the reading is BPV, the vehicle charge receptacle has failed. Replace the vehicle charge receptacle.
13.2. If the reading is not BPV, the vehicle charge receptacle is good. Test the battery charger.

TEST PROCEDURE 4 – Dash Display

If the dash display shows astrecks (*), there is a CAN communication error.

If the dash display shows nothing, there is a possible 12V supply issue or an issue with the dash display.

NOTE: *This is a continuity, resistance, and voltage test.*

1. Disable the vehicle.
2. Connect the CCDT.
2.1. If the CCDT does not work, see the Main CAN bus test procedure.
2.2. If the CCDT does work, go to step 3.
3. Check the continuity of the white and blue wires on the IP harness.
3.1. If there is no continuity, replace the IP harness.
3.2. If there is continuity, go to step 4.
4. Turn the key switch to ON.
5. Set a multimeter to measure voltage.
6. Disconnect dash display connector from dash display.

7. Measure the voltage of the green and white wire pin 2 at the dash display **(Figure 12-20, Page 12-32)**.

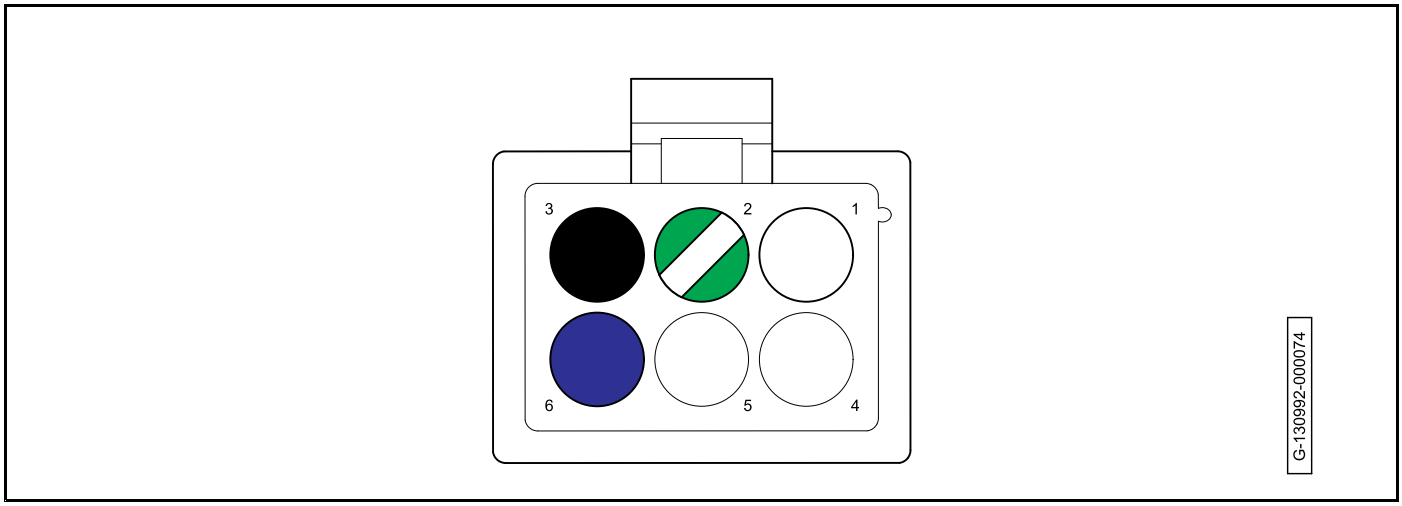


Figure 12-20

7.1. If there is 12.8V to 13.5V, reconnect dash display connector then go to step 8.

7.2. If there is not 12.8V to 13.5V, check wiring circuit or DC/DC converter output voltage.

8. Set a multimeter to measure resistance.

9. Disconnect 12-pin instrument panel (IP) harness from main harness.

10. Measure the resistance across pins 3 and 4 on the (IP) harness 12-pin connector **(Figure 12-21, Page 12-32)**.

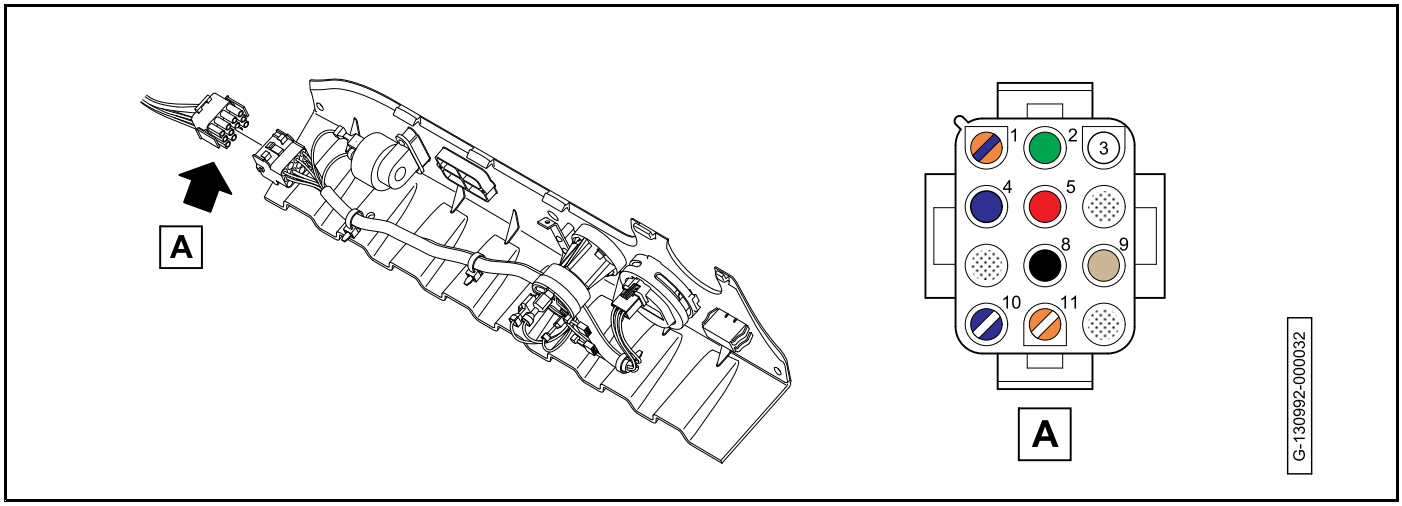


Figure 12-21

10.1. If there is resistance, replace the dash display.

TEST PROCEDURE 5 – DC/DC Converter

NOTE: *This is a voltage test.*

1. Disable the vehicle.
2. Connect the CCDT to the vehicle.

2.1. If the CCDT is unable to connect, go to step 3.

2.2. If the CCDT is able to connect the DC/DC converter is good.

3. Set the multimeter to measure DC voltage.

4. Measure the voltage of the red wire pin A on the 3 pin connector **(Figure 12-22, Page 12-33)**.

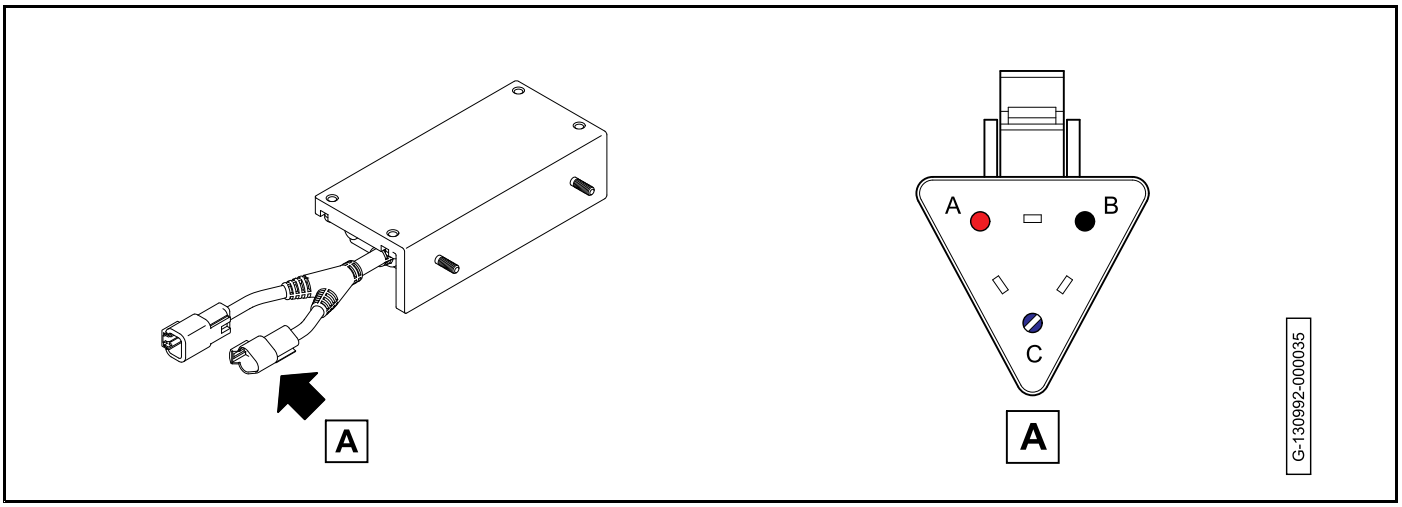


Figure 12-22 3-Pin DC/DC Connector

4.1. If the voltage is BPV, go to step 5.

4.2. If the voltage is not BPV, check the 10-amp fuse and wiring circuit.

5. Set the multimeter to measure DC voltage.

6. Measure the voltage of the blue and white wire pin C on the 3 pin connector **(Figure 12-23, Page 12-33)**.

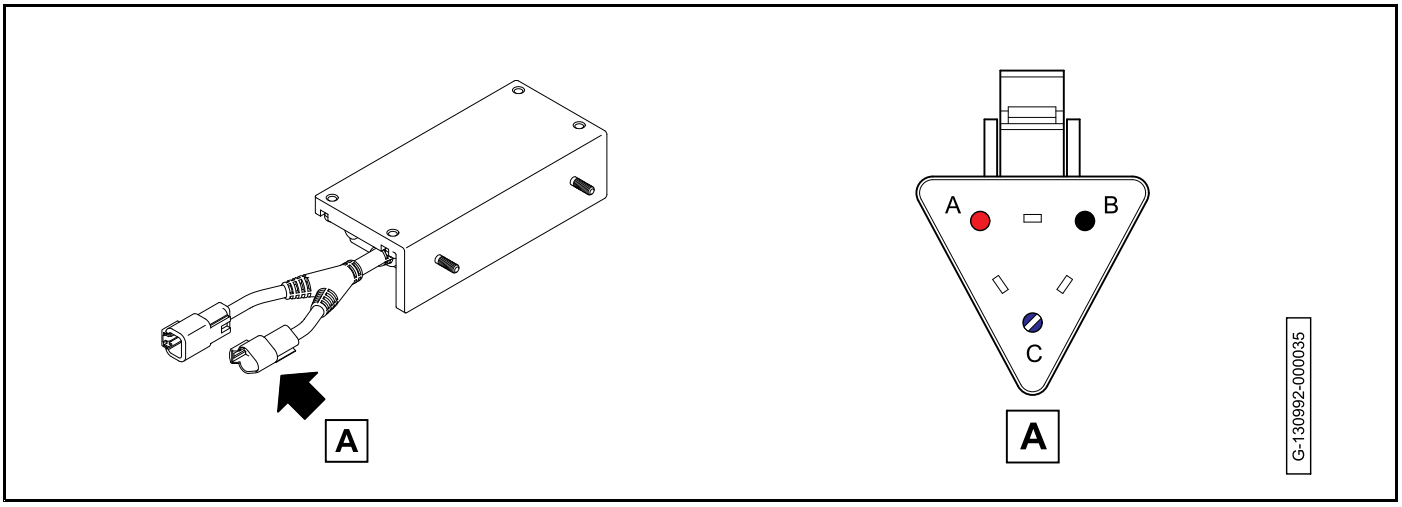


Figure 12-23 3-Pin DC/DC Connector

6.1. If the voltage is BPV the 48V relay is good, go to step 7.

6.2. If the voltage is not BPV, check the 48V relay.

7. Set the multimeter to measure DC voltage.

8. Measure the voltage of the red wire pin 2 on the 2 pin connector **(Figure 12-24, Page 12-34)**.

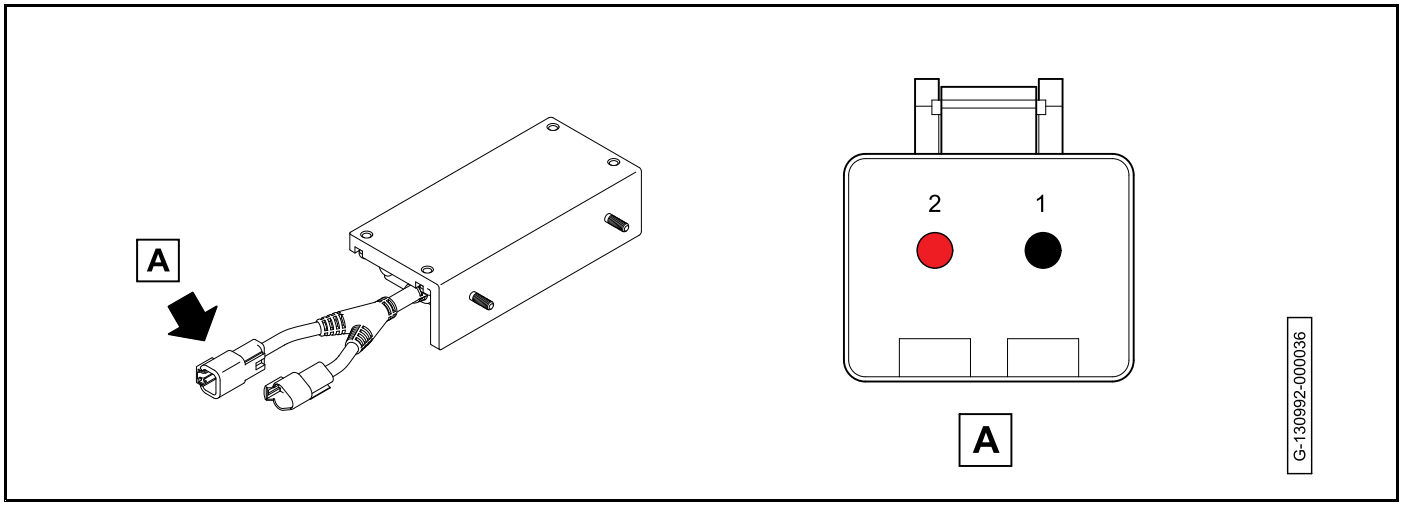


Figure 12-24 2-Pin DC/DC Connector

8.1. If the voltage is 12.8V to 13.5V, the DC/DC converter is good.

8.2. If the voltage is less than 12.8V or greater than 13.5V, replace the DC/DC converter.

TEST PROCEDURE 6 – Forward/Neutral/Reverse Switch (FNR)

NOTE: *This is a continuity and voltage test.*

1. Disable the vehicle.
2. Connect the CCDT to the vehicle.
3. Go to the VCM screen **(Figure 12-25, Page 12-35)**.

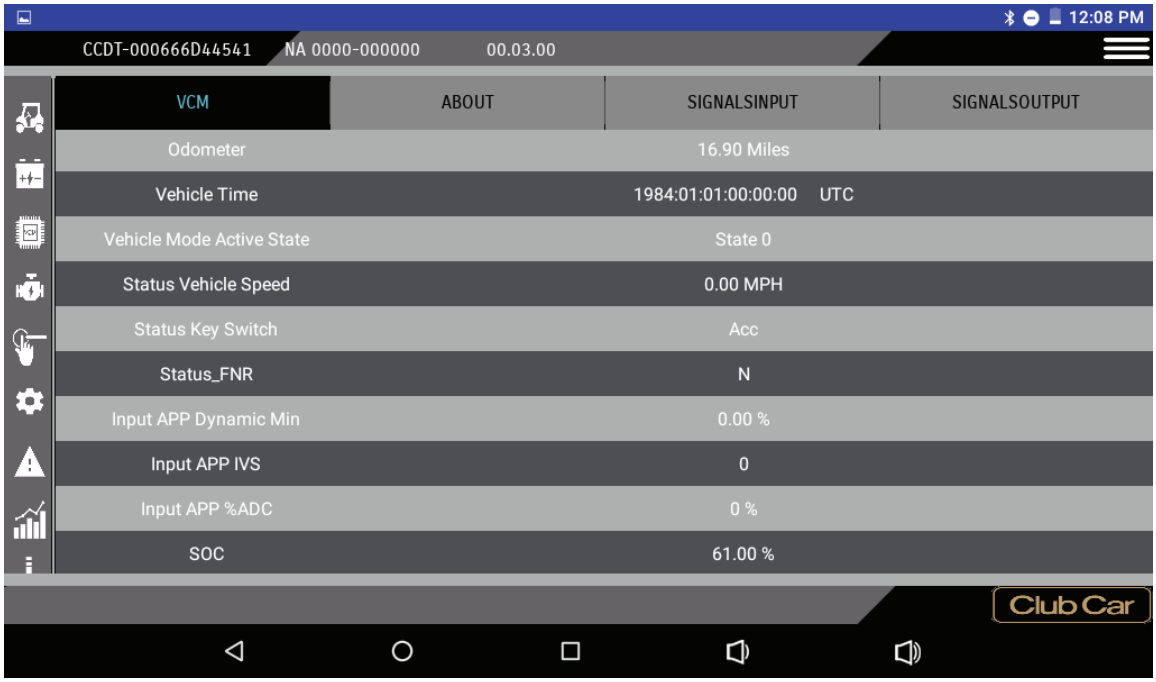


Figure 12-25

4. Set the Forward/Neutral/Reverse control (FNR) to F. Repeat this step for N and R positions.
4.1. If the Status FNR readings match the FNR positions, the switch and wiring are good.
4.2. If the Status FNR readings do not match the FNR positions, go to step 5.
5. Set the FNR to N.
6. Set the multimeter to measure DC voltage.
7. Measure the voltage of the blue and brown wires connected to the FNR.
7.1. If the voltage is greater than 3V, go to step 8.
7.2. If the voltage is less than 3V, check the FNR wiring circuit.
8. Set the multimeter to measure continuity.
9. Measure the continuity between the orange wire connected to the FNR and ground.
9.1. If there is continuity, the wiring is good. Go to step 10.
9.2. If there is no continuity, check the ground wiring circuit.
10. Set the multimeter to measure DC voltage.
11. Set the FNR to F.
12. Measure the voltage of the brown wire connected to the FNR.
12.1. If the voltage is greater than 3V, the switch is bad. Replace the FNR switch.
12.2. If the voltage 0, go to step 13.
13. Set the FNR to R.
14. Measure the voltage of the blue wire connected to the FNR.
14.1. If the voltage is greater than 3V, the switch is bad. Replace the FNR switch.
14.2. If the voltage 0, the switch is good.

TEST PROCEDURE 7 – Headlights

NOTE: *This is a voltage test.*

1. Disable the vehicle.
2. Connect the CCDT to the vehicle.
3. Go to the VCM screen.
4. Go to the SIGNALSOUTPUT tab **(Figure 12-26, Page 12-36)**.



Figure 12-26

5. Set the headlight switch to ON.

5.1. If the Output Headlight Left and Right go from OFF to ON, the switch and wiring are good.

5.2. If the Output Headlight Right/Left do not go from OFF to ON, see step 6. or step

6. Set the multimeter to measure DC voltage.
7. Disconnect instrument panel (IP) light harness headlight connectors from headlights.

8. Measure the voltage at pin A on the drivers-side headlight connector from the (IP) light harness **(Figure 12-27, Page 12-37)**.

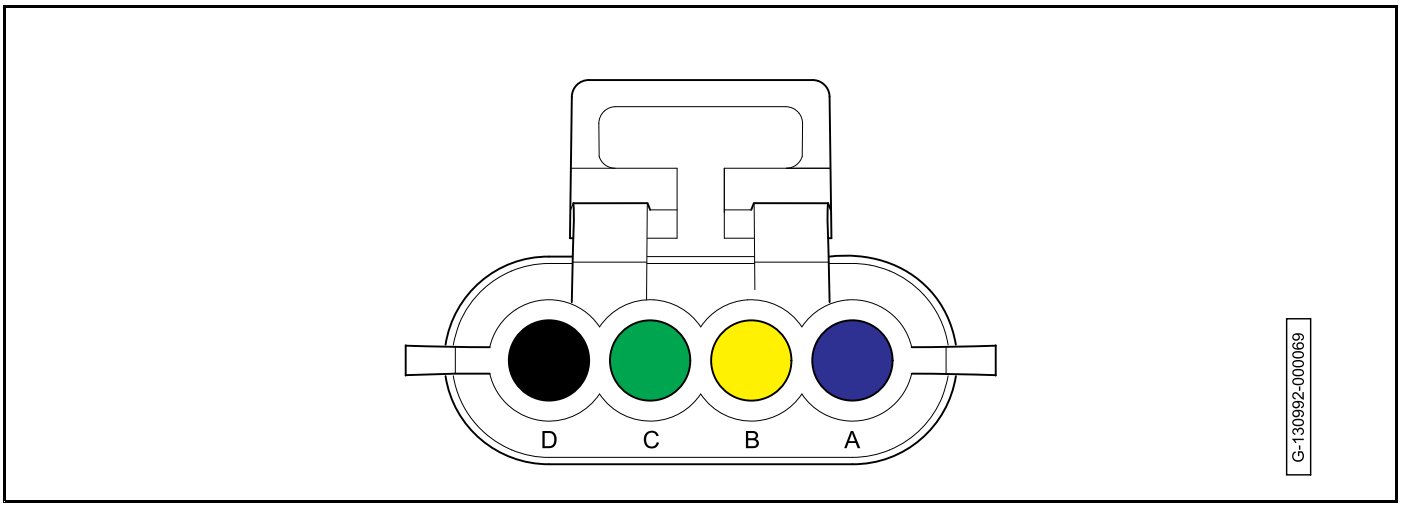


Figure 12-27 Drivers Headlight Connector

8.1. If the voltage is 12.8V to 13.5V, the wiring is good. Replace the headlight.

8.2. If the voltage is less than 12.8V or greater than 13.5V:

8.2.1. Check the headlight wiring circuit.

8.2.2. Test the DC/DC converter.

9. Measure the voltage at pin A on the passengers-side headlight connector from the IP light harness **(Figure 12-28, Page 12-37)**.

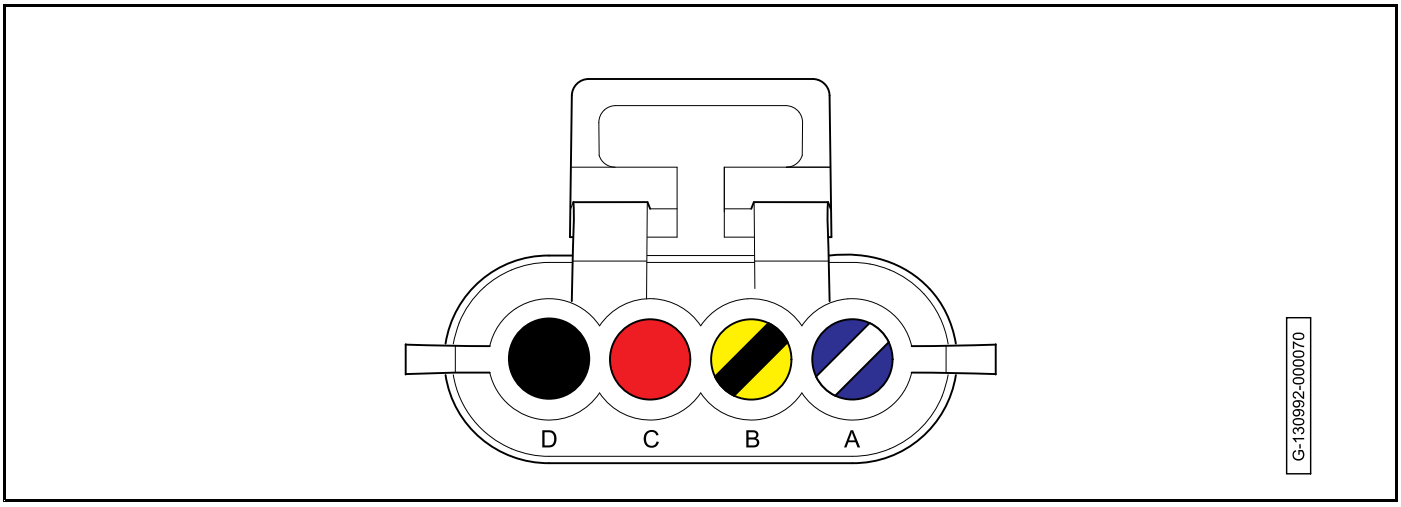


Figure 12-28 Passengers Headlight Connector

9.1. If the voltage is 12.8V to 13.5V, the wiring is good. Replace the headlight.

9.2. If the voltage is less than 12.8V or greater than 13.5V:, check wiring circuit or DC/DC converter output voltage.

9.2.1. Check the headlight wiring circuit.

9.2.2. Test the DC/DC converter.

TEST PROCEDURE 8 – Horn Switch

NOTE: *This is a continuity and voltage test.*

See General Warnings on page 1-2.

1. Disable the vehicle.
2. Connect the CCDT to the vehicle.
3. Go to the VCM screen.
4. Go to the SIGNALSINPUT screen **(Figure 12-29, Page 12-38)**.



Figure 12-29

5. Push and hold the horn button.

5.1. If the Inputs Switch Horn readings match the switch positions, the switch is good.

5.2. If the Inputs Switch Horn readings do not match the horn switch positions, go to step 6..

6. Set the multimeter to measure voltage.
7. Disconnect the 6-pin turn signal connector from the instrument panel (IP) light harness.
8. Measure the voltage at pin 1 **(Figure 12-30, Page 12-39)**.

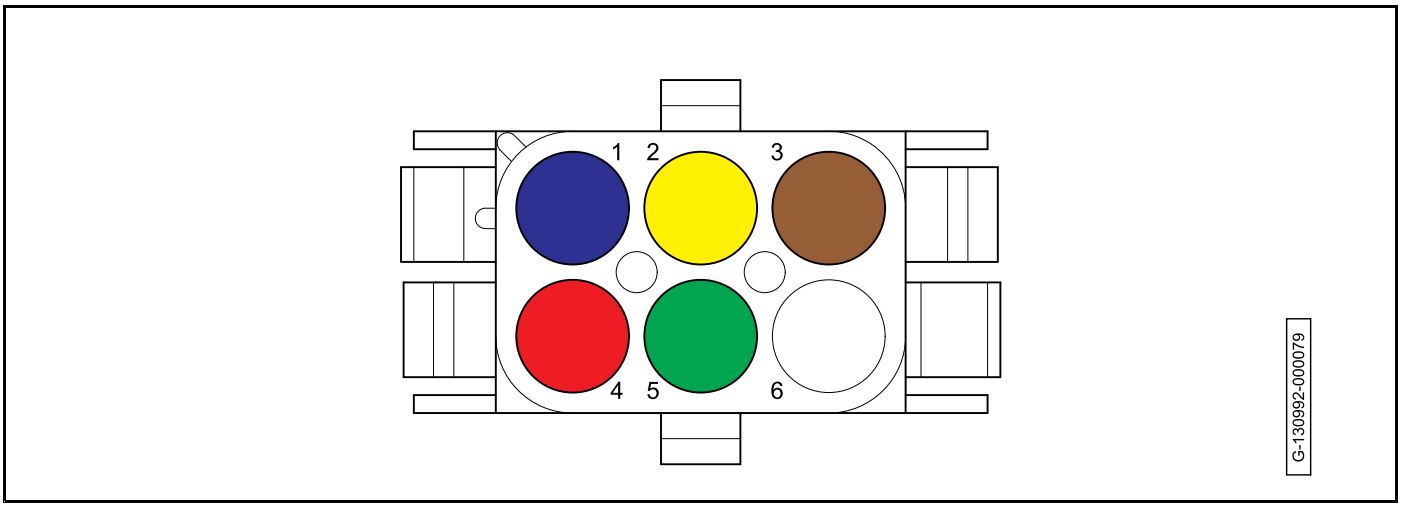


Figure 12-30

8.1. If voltage is greater than 3V, wiring is good.
8.2. If voltage is less than 3V, see step 9.
9. Set the multimeter to measure continuity.
10. Measure continuity of the brown wire pin 3 and the blue wire pin 1 **(Figure 12-30, Page 12-39)**.
11. With the horn switch OFF, switch should have no continuity.
11.1. With the horn switch ON switch should show continuity. If you have continuity the switch is good, see step 1.
11.2. If the horn switch does not show continuity when ON, replace the horn switch.

TEST PROCEDURE 9 – Horn

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

1. Set the multimeter to measure voltage.
2. Disconnect the 2-pin connector on the horn.
3. With the horn switch ON measure the voltage at pin B **(Figure 12-31, Page 12-40)**.

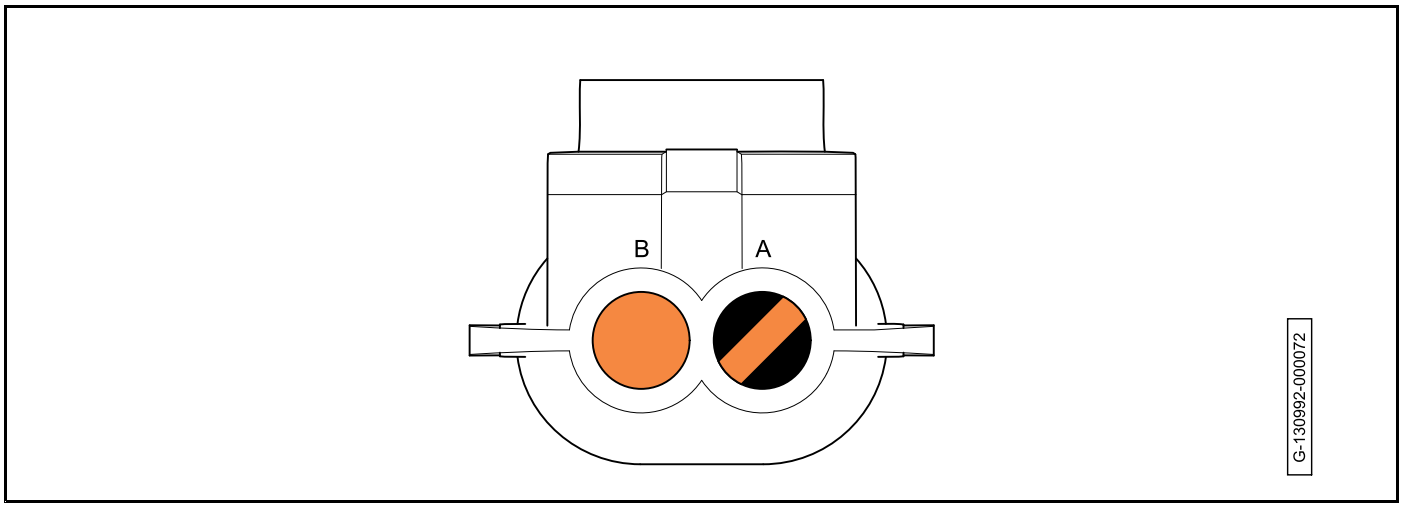


Figure 12-31

3.1. If voltage is 12.8V to 13.5V, the wiring is good. Replace the horn.

3.2. If voltage is less than 12.8V or greater than 13.5V:, check wiring circuit or DC/DC converter output voltage.

3.2.1. Check the horn wiring circuit.

3.2.2. Test the DC/DC converter.

TEST PROCEDURE 10 – Key Switch Circuit

See General Warnings on page 1-2.

NOTE: *This is a continuity and voltage test.*

The key switch provides KEY INPUT to the motor controller unit (MCU).

1. Disable the vehicle.
2. Connect the CCDT to the vehicle.
3. Go to the CAR screen.
4. Go to the CAR DETAILS tab **(Figure 12-32, Page 12-41)**.

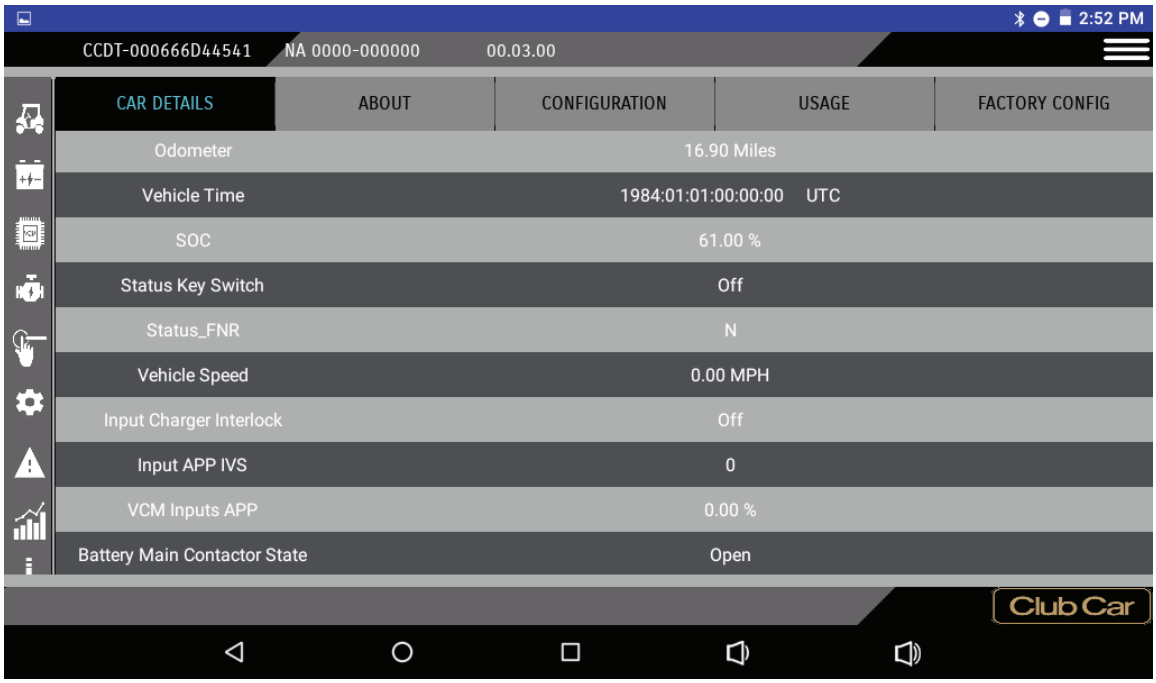


Figure 12-32

5. Set the key switch to OFF. Repeat this step for ACC and ON positions.

5.1. If the Status Key Switch readings match the key switch positions, the switch and wiring are good.

5.2. If the Status Key Switch readings do not match the key switch positions, go to step 5.3..

5.3. Turn the key switch to OFF.

5.4. Set a multimeter to measure DC voltage.

5.5. Disconnect the blue and white wire from the key switch.

5.6. Measure the voltage of the blue/white wire.

5.6.1. If the voltage is BPV, go to step 5.7.

5.6.2. If the voltage is less than BPV, go to step 5.6.3..

5.6.3. Set the multimeter to measure continuity.

5.6.4. Check for continuity between the blue/white wire and pin 12 of the MCU 35-pin connector **(Figure 12-33, Page 12-42)**.

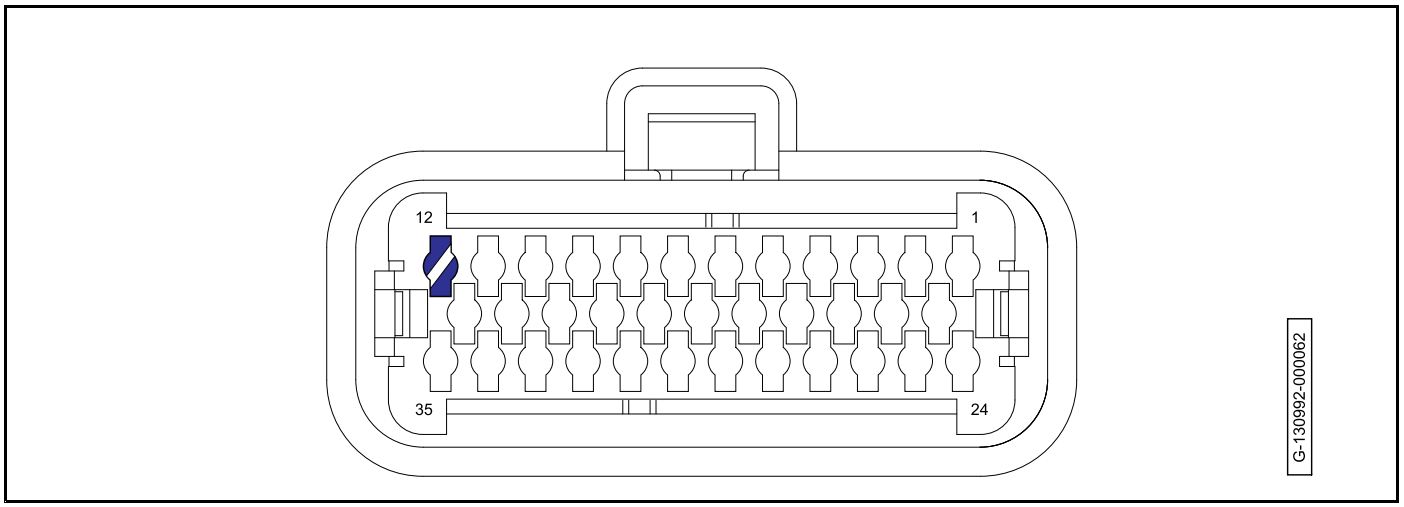


Figure 12-33 MCU 35–pin Connector

5.6.5. If there is no continuity, check the wire circuit for wiring short/open circuits.

5.6.6. If there is continuity, replace the MCU.

5.7. Set the multimeter to measure continuity.

5.8. Disconnect the black wire from the key switch.

5.9. Check for continuity between the black wire and the nearest ground.

5.9.1. If there is continuity, go to step 5.10.

5.9.2. If there is no continuity, check the ground wiring circuit.

5.10. Turn the key switch to ACC.

5.10.1. There should be continuity between the (I) terminal and the (B) terminal **(Figure 12-34, Page 12-42)**.

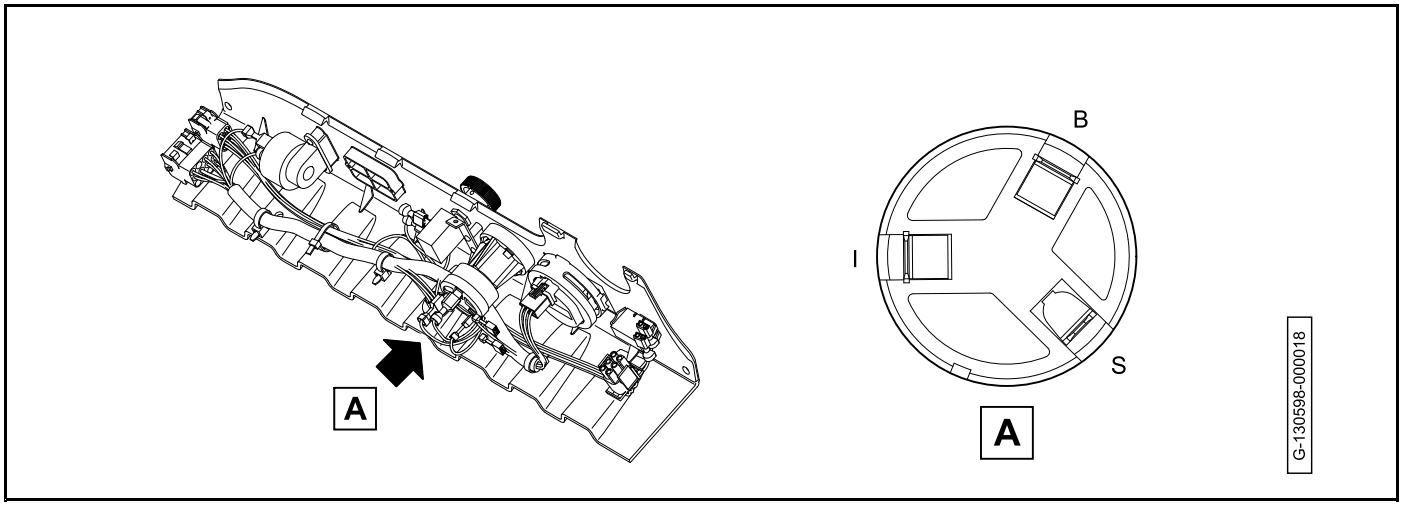


Figure 12-34 Key Switch

5.10.2. If there is continuity between the (I) and (S) terminals, replace the key switch.

5.10.3. If there is no continuity between the (I) and (S) terminals, go to step 5.11.

5.11. Turn the key switch to ON.

5.11.1. If there is continuity between all of the terminals. See step 5.12.

5.11.2. If there is no continuity between the terminals, replace the key switch.

5.12. Turn the key switch to OFF

5.12.1. If there is continuity between any of the terminals, replace the key switch.

5.12.2. If there is no continuity between the terminals, go to step 5.10.

TEST PROCEDURE 11 – Light Switch

See General Warnings on page 1-2.

NOTE: *This is a voltage and continuity test.*

1. Disable the vehicle.
2. Connect the CCDT to the vehicle.
3. Go to the VCM screen.
4. Go to the SIGNALSINPUT tab **(Figure 12-35, Page 12-43)**.



Figure 12-35

5. Turn the Light Switch from OFF to ON.

5.1. If the Inputs Switch Lights readings match the light switch positions, the switch and wiring are good.

5.2. If the Inputs Switch Lights readings do not match the light switch positions, go to step 6..

6. Set the multimeter to measure voltage.
7. Disconnect the white wire from the light switch.
8. Measure the voltage of the white wire.

8.1. If the voltage is greater than 3V, go to step 9.

8.2. If the voltage is less than 3V, check wiring for short/open circuit.

9. Set the multimeter to measure continuity.
10. Disconnect the white and black wires from the light switch.
11. With the light switch in the ON position measure continuity of the light switch terminals.

11.1. If the light switch has continuity, the switch is good.

11.2. If the light switch has no continuity, replace the light switch.

TEST PROCEDURE 12 – MCOR Accelerator Position

See General Warnings on page 1-2.

NOTE: *This is a continuity and voltage test.*

Failed MCOR symptoms:

- Vehicle does not operate. No input to the vehicle control module (VCM).
- Vehicle does not reach top speed. MCOR does not reach 100% throttle position.
- Vehicle does not maintain speed or accelerate. MCOR has a “dead-spot” in its pedal travel.
- Signal from the MCOR fluctuates with the pedal up, during pedal travel, and with the pedal fully pressed.

Procedure:

1. Disable the vehicle.
2. Connect the CCDT to the vehicle.
3. Go to the VCM screen **(Figure 12-36, Page 12-44)**.
4.

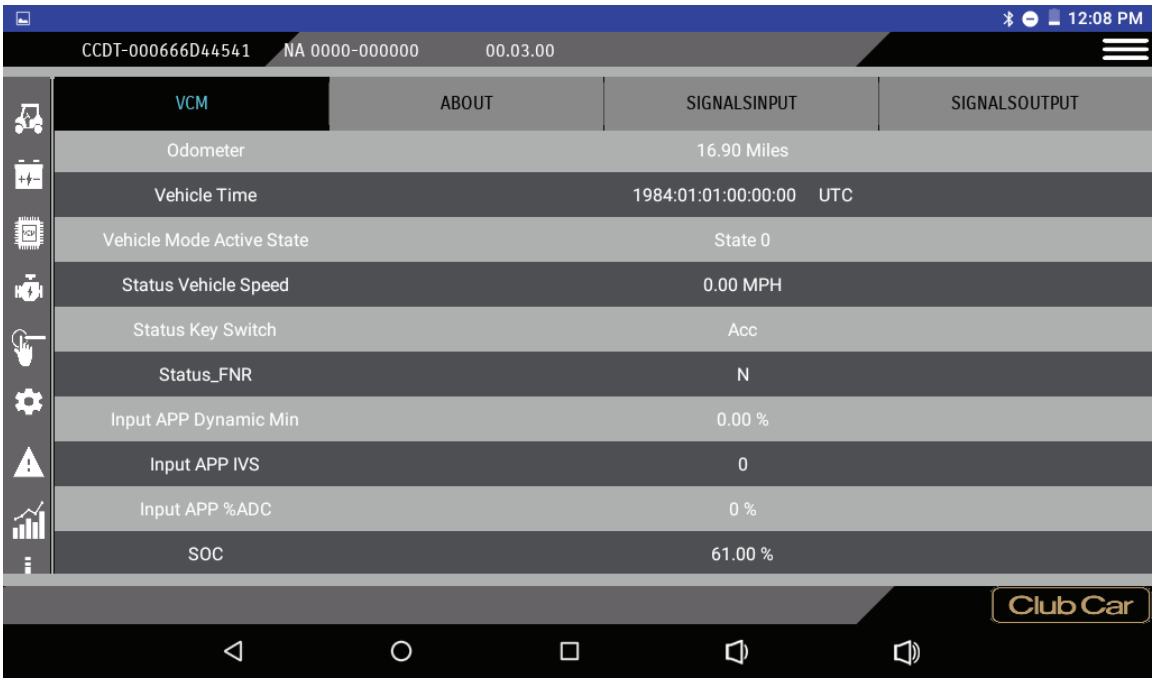


Figure 12-36

5. With the pedal in the up position, Input APP %ADC should be 0%.

5.1. If the pedal is in the up position and the Input APP %ADC is at 0%, go to step 6..

5.2. If the pedal is in the up position and the Input APP %ADC is not 0%, replace the mcor.

6. Slowly push the accelerator pedal. The Input APP %ADC should indicate a steady, slow increase from 0% to 100%.

6.1. If the Input APP %ADC indicates a steady, slow increase from 0% to 100%, go to step 7.

6.2. If the Input APP %ADC does not indicates a steady, slow increase from 0% to 100%, replace the MCOR.

7. Pull the floor mat over the pedal group.

8. Remove the pedal group cover.

9. Disconnect the MCOR 3-pin connector (1) **(Figure 12-37, Page 12-45)**.

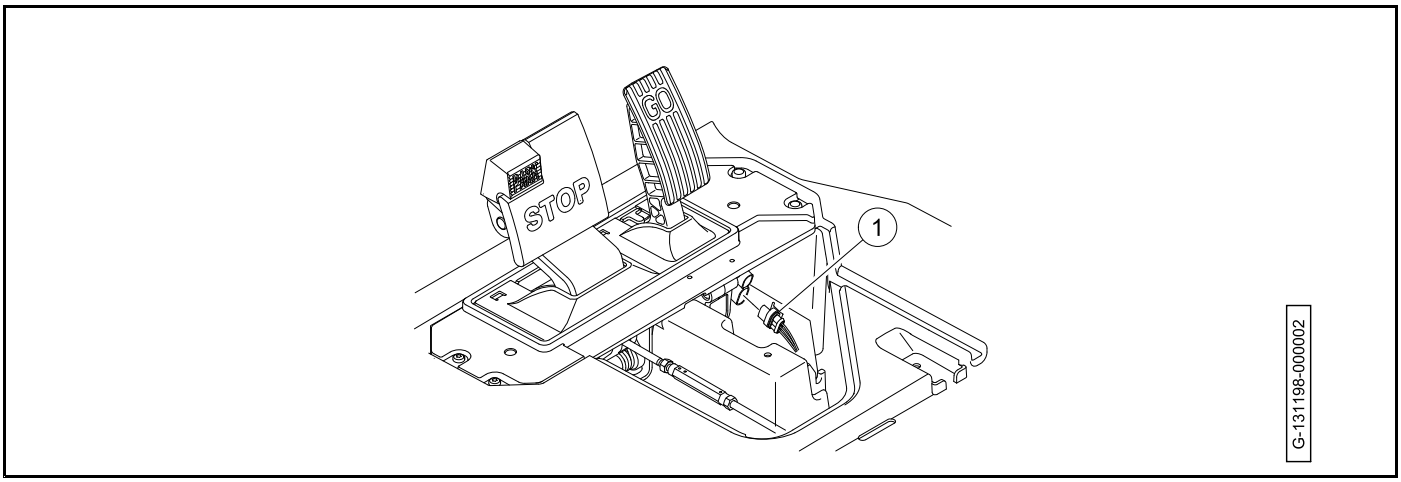


Figure 12-37 MCOR 3-Pin Connector

10. Set a multimeter to measure DC voltage.

11. Measure the voltage of pin 1 on the MCOR 3-pin connector **(Figure 12-38, Page 12-45)**.

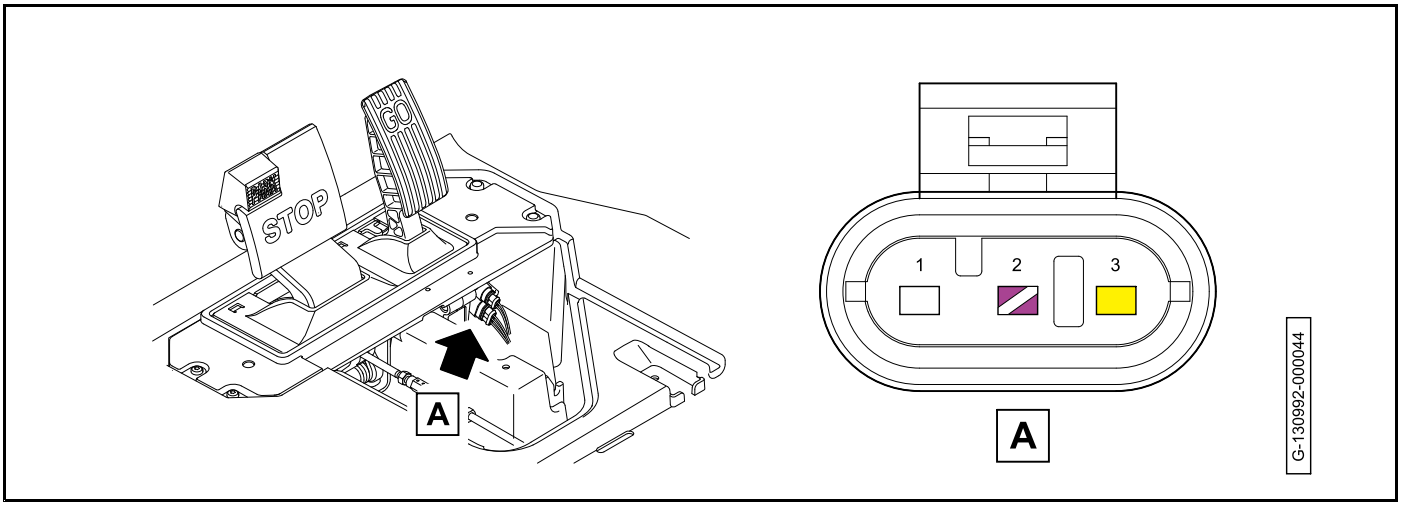


Figure 12-38 MCOR 3-Pin Connector

11.1. If the voltage is approximately 5V, go to step 12.

11.2. If the voltage is not approximately 5V, set the multimeter to measure continuity. Check the continuity between pin 1 of the MCOR 3-pin connector and pin 51 of the VCM 81-pin connector **(Figure 12-39, Page 12-46)**.

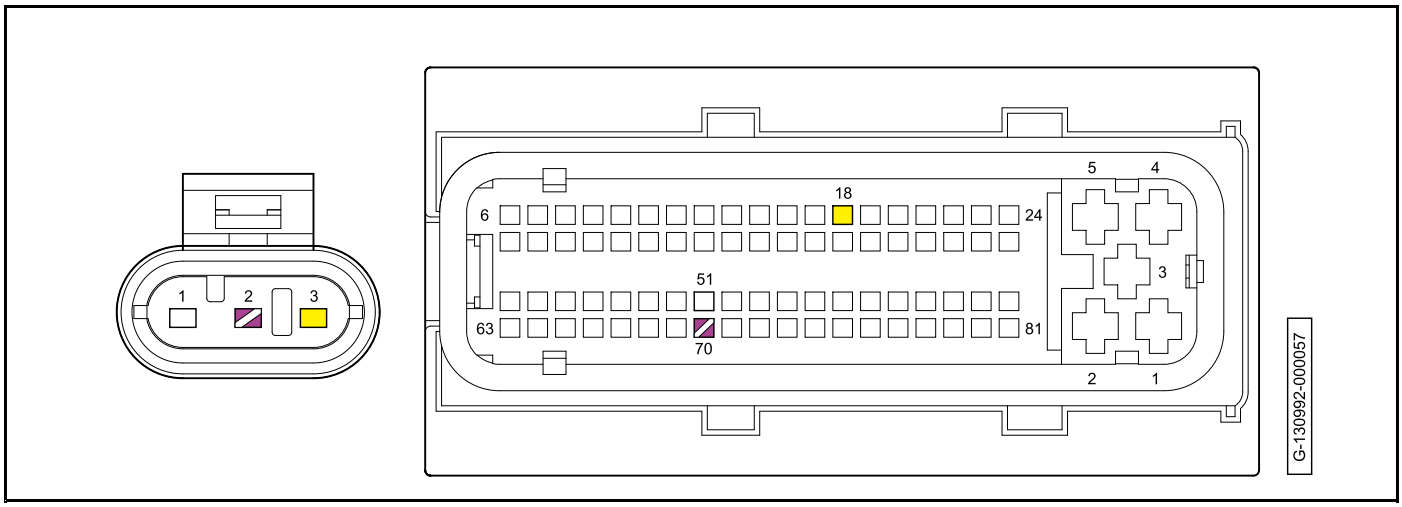


Figure 12-39 MCOR 3-Pin Connector and VCM 81-Pin Connector

11.2.1. If there is no continuity, check wiring circuit.

11.2.2. If there is continuity, replace the VCM.

12. Measure the continuity between pin 2 of the MCOR 3-pin connector and pin 70 of the VCM 81-pin connector **(Figure 12-39, Page 12-46)**.

12.1. If there is no continuity, replace or repair signal ground wiring circuit.

12.2. If there is continuity, go to step 13.

13. Connect the MCOR 3-pin connector to the MCOR.

14. Set the multimeter to measure DC voltage.

15. Measure the voltage with insulation-piercing probe on the yellow wire close to the MCOR 3-pin connector. The voltage should be 0.

16. Slowly push the accelerator pedal. The voltage should slowly increase from 0V to approximately 5V.

16.1. If the voltage does not increase to approximately 5V, replace the MCOR.

TEST PROCEDURE 13 – MCOR Limit Switch

See General Warnings on page 1-2.

NOTE: *This is a continuity and voltage test.*

1. Disable the vehicle.
2. Connect the CCDT to the vehicle.
3. Go to the VCM screen **(Figure 12-40, Page 12-47)**.

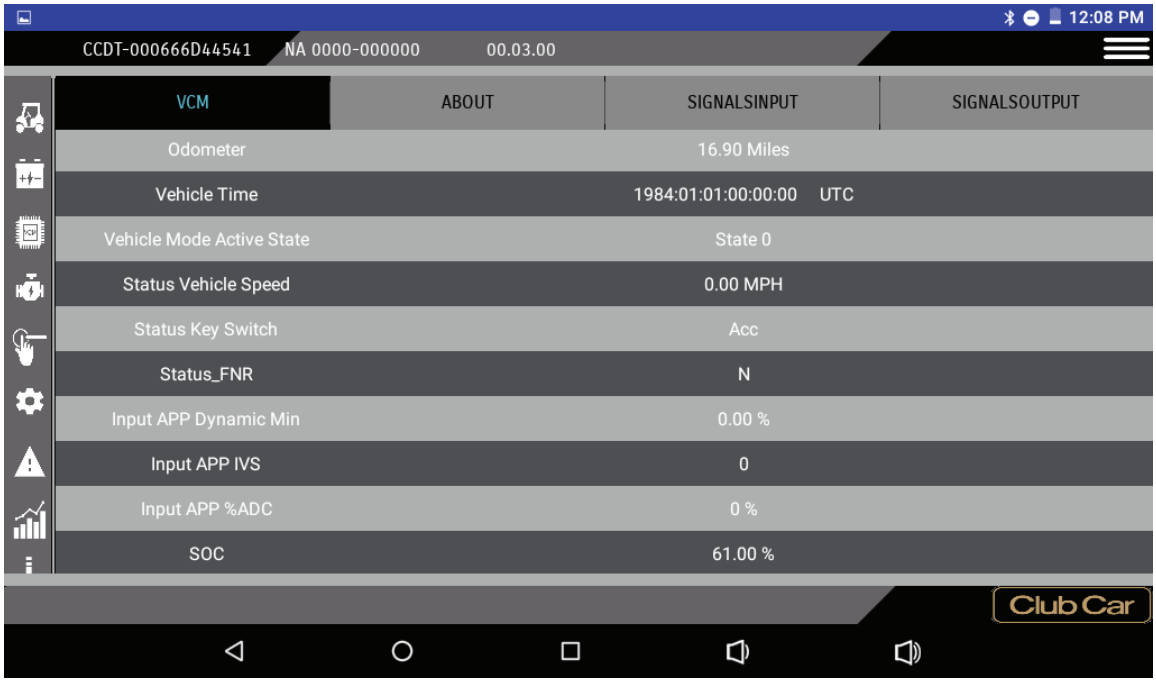


Figure 12-40

4. Input APP IVS should be 0 when the accelerator pedal is not pushed. Input APP IVS should be 1 when the accelerator pedal is pushed.

4.1. If the Input APP IVS readings are correct, the MCOR limit switch is good.

4.2. If the Input APP IVS readings are not correct, go to step 5.

5. Pull the floor mat over the pedal group.

6. Remove the pedal group cover.

7. Disconnect the MCOR 2-pin connector (1) **(Figure 12-41, Page 12-47)**.

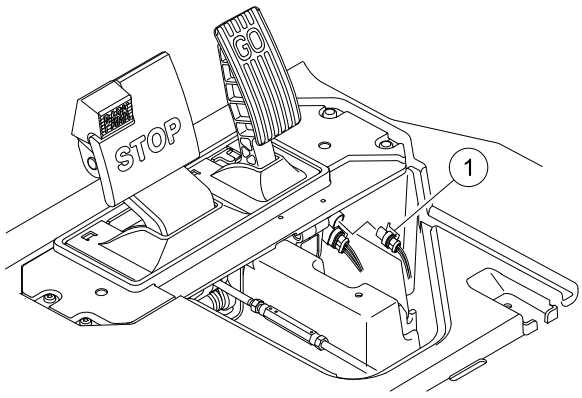


Figure 12-41 MCOR 2-Pin Connector

8. Set a multimeter to measure DC voltage.

9. Measure the voltage of the green wire pin 1 on the MCOR 2-pin connector **(Figure 12-42, Page 12-48)**.

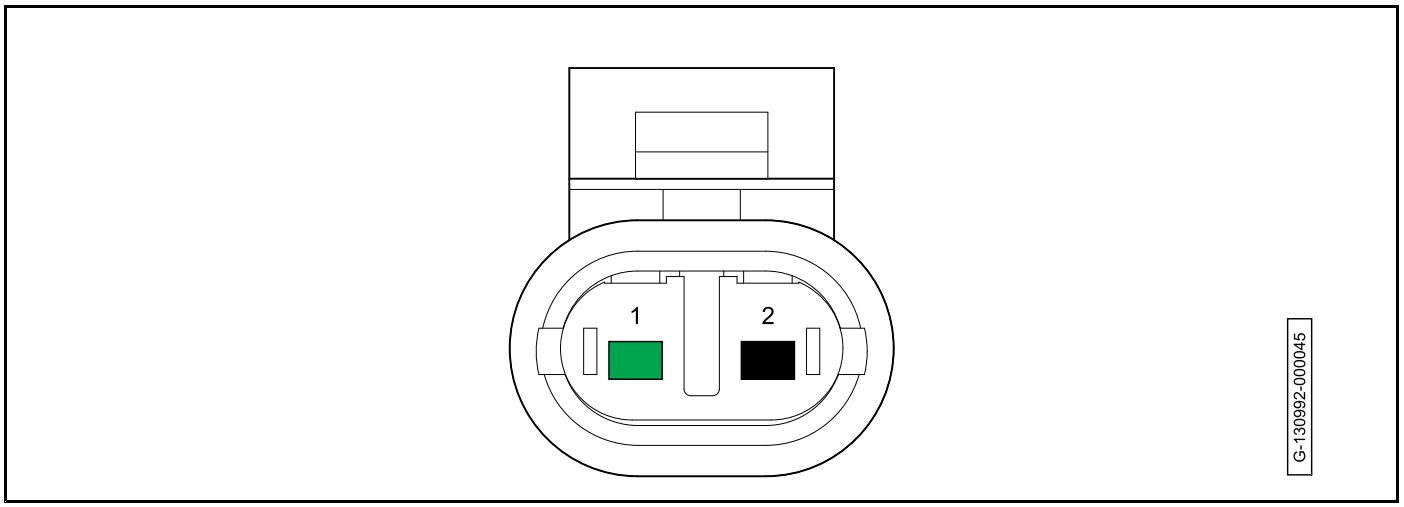


Figure 12-42 MCOR 2-Pin Connector

9.1. If the voltage is approximately 5V, go to step 10.

9.2. If the voltage is not approximately 5V, check the continuity between pin 1 of the MCOR 2-pin connector and pin 8 of the VCM 81-pin connector **(Figure 12-43, Page 12-48)**.

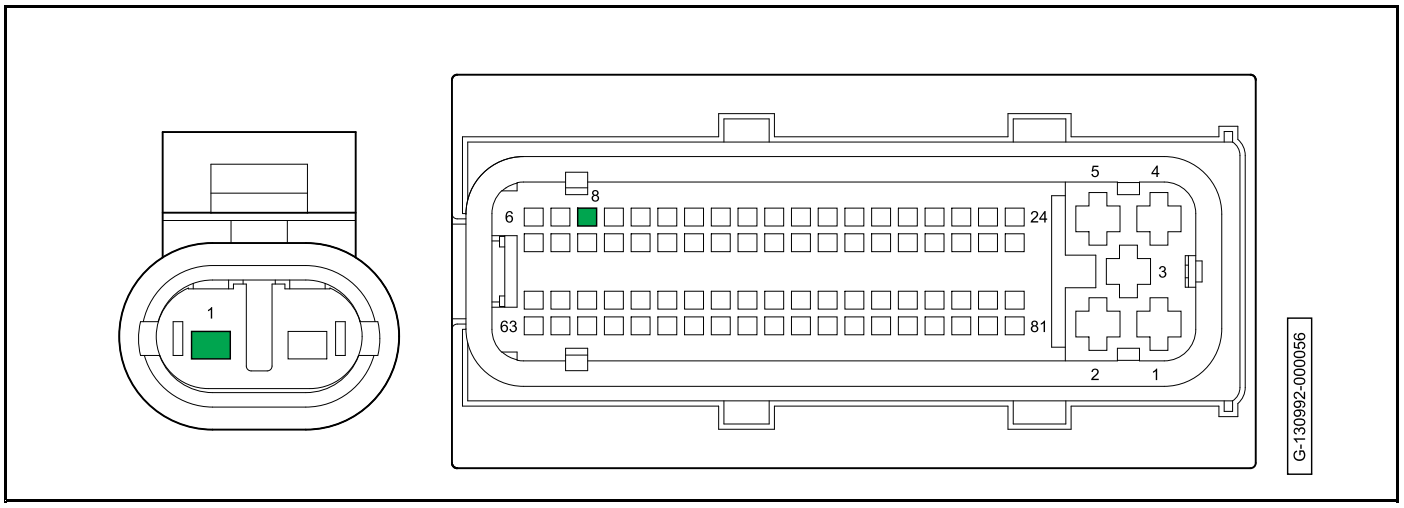


Figure 12-43 MCOR 2-Pin Connector and VCM 81-Pin Connector

9.2.1. If there is no continuity, replace or repair input wiring circuit.

9.2.2. If there is continuity, replace the VCM.

10. Measure the continuity between pin 2 of the MCOR 2-pin connector and the nearest ground point.

10.1. If there is no continuity, replace or repair ground wiring circuit.

10.2. If there is continuity, replace the MCOR.

TEST PROCEDURE 14 – Motor Speed Sensor

See General Warnings on page 1-2.

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.**

⚠ 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.
2. Set the Forward/Neutral/Reverse control (FNR) to N.
3. Connect the CCDT to the vehicle.
4. Go to the MCU tab **(Figure 12-44, Page 12-49)**.



Figure 12-44

5. MCU Motor RPM should indicate no RPM when the vehicle is at rest.
6. While monitoring the MCU screen, slowly push the vehicle a short distance (about 3 feet (1 meter)).

6.1. The CCDT should indicate RPM while vehicle is moving.

6.2. If the CCDT does not indicate RPM while in motion, see 7..

7.

NOTE: *This is a voltage and continuity test.*

With batteries connected, disconnect the motor speed sensor 4-pin connector.

8. Measure the voltage on pin 1 **(Figure 12-45, Page 12-50)**.

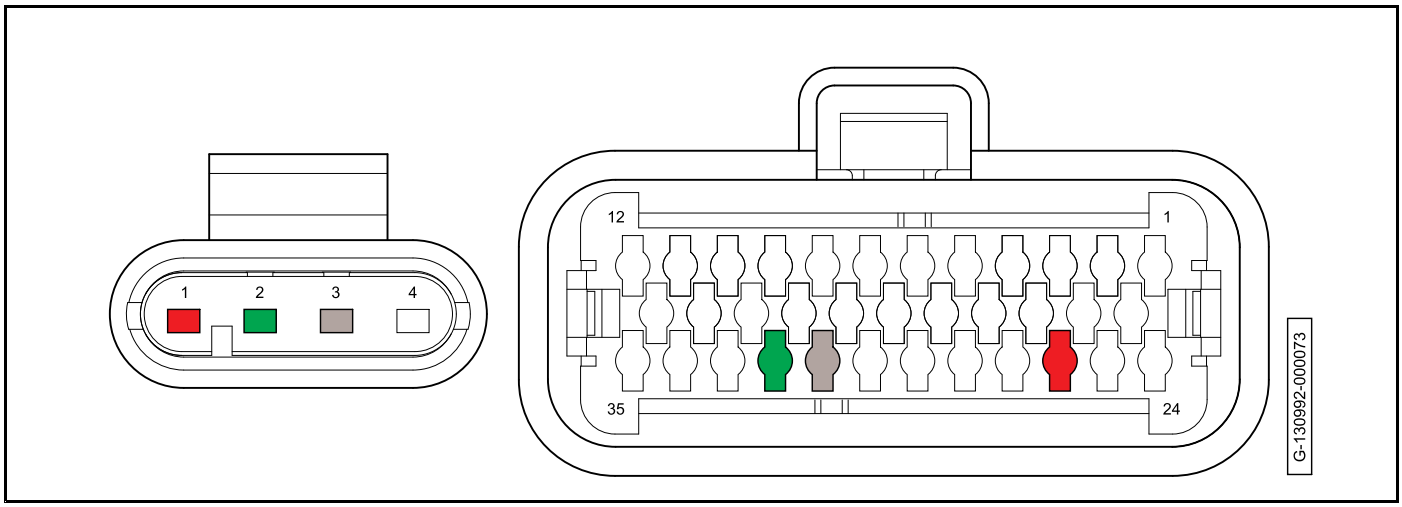


Figure 12-45

8.1. If the reading is greater than 3V wiring is good.

8.2. If the reading is less than 3V, see step 9.

9. Put the Run/Tow switch in the TOW position

10. Disconnect the batteries and wait for the controller to discharge capacitors.

11. Disconnect the 35-pin MCU connector.

12. Set a multimeter set to measure continuity.

13. Measure continuity between pin 26 on the MCU 35-pin connector and pin 1 on the 4-pin motor speed sensor connector **(Figure 12-45, Page 12-50)**.

13.1. If the reading is continuity, see step 13.3.

13.2. If the reading is not continuity, replace or repair the wiring harness.

13.3. Measure continuity between pin 32 of the 35-pin MCU connector and pin 2 of the 4-pin motor speed sensor connector **(Figure 12-45, Page 12-50)**.

13.3.1. If the reading is continuity, see step 13.4.

13.3.2. If the reading is not continuity, replace or repair the wiring harness.

13.4. Measure continuity between pin 31 of the MCU 35-pin connector and pin 3 of the 4-pin motor speed sensor connector **(Figure 12-45, Page 12-50)**.

13.4.1. If there is continuity, see step 13.5.

13.4.2. If the reading is not continuity, replace or repair the wiring harness.

13.5. Measure the continuity between pin 7 on the MCU 35-pin connector and pin 4 of the 4-pin motor speed sensor connector **(Figure 12-46, Page 12-51)**.

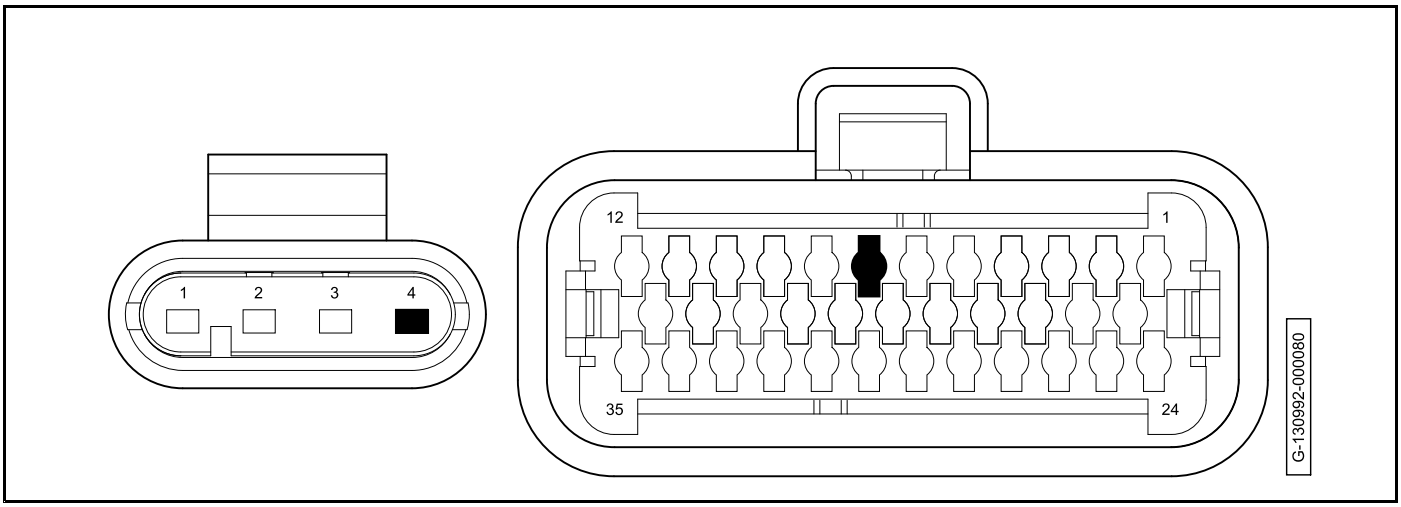


Figure 12-46

13.5.1. If the reading is not continuity, replace or repair the wiring harness.

13.5.2. If all wires show continuity, replace the speed sensor.

TEST PROCEDURE 15 – Motor Stator Winding

See General Warnings on page 1-2.

NOTE: *This is a continuity and resistance test.*

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the motor controller unit (MCU).
4. Remove the rubber boots (1) **(Figure 12-47, Page 12-51)**.

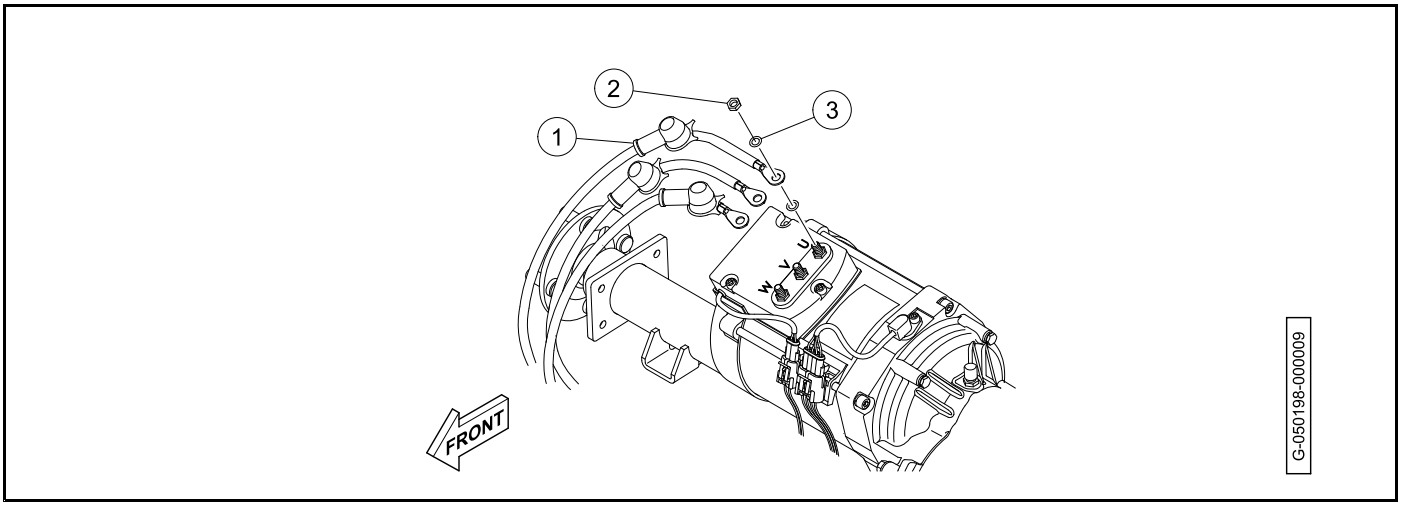


Figure 12-47 Motor Wire Connections

5. Remove the nuts (2) and lock washers (3).
6. Remove the motor wires from the terminal block.
7. Set a multimeter to measure resistance.

8. Measure the resistance between each phase on the motor.
   – The resistance should be the same for each combination, U-V, V-W, U-W.
   – If the resistance value is not the same between the motor phase posts, there is an internal motor failure. Replace the motor.
9. Measure the continuity between each post and the motor case. Scratch through the paint on the motor case for a good connection.
   – The resistance should indicate an open circuit (several Mega-ohms).
   – If the reading is incorrect, replace the motor.
10. Make sure that the washers (4) are installed.

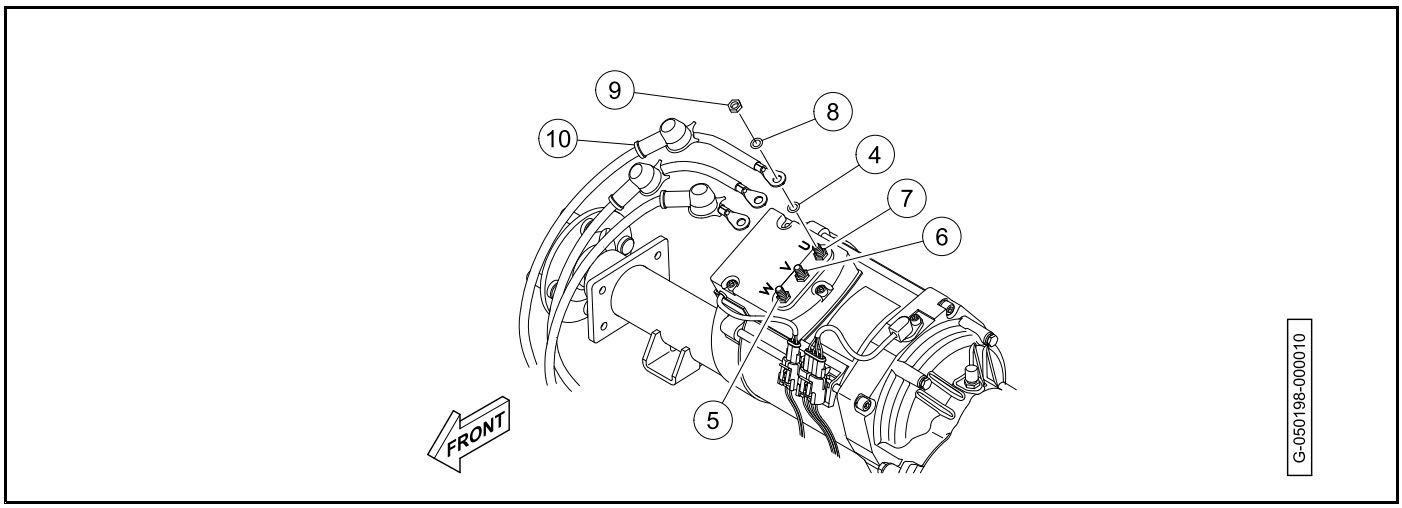


Figure 12-48 Motor Wire Connections

11. Connect the orange wire with the blue end to the W terminal (5).
12. Connect the orange wire with the yellow end to the V terminal (6).
13. Connect the orange wire with the white end to the U terminal (7).
14. Install the lock washers (8) and nuts (9). Hold the bottom nut of terminal with a wrench and tighten the nuts to 45 lb·in (5.0 N·m).
15. Install the rubber boots (10) over the terminals.

TEST PROCEDURE 16 – Motor Temperature Sensor

See General Warnings on page 1-2.

NOTE: *This is a continuity and resistance test.*

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the motor controller unit (MCU).
4. Disconnect the 35-pin connector (1) from the motor control unit (MCU) (2) **(Figure 12-49, Page 12-53)**.

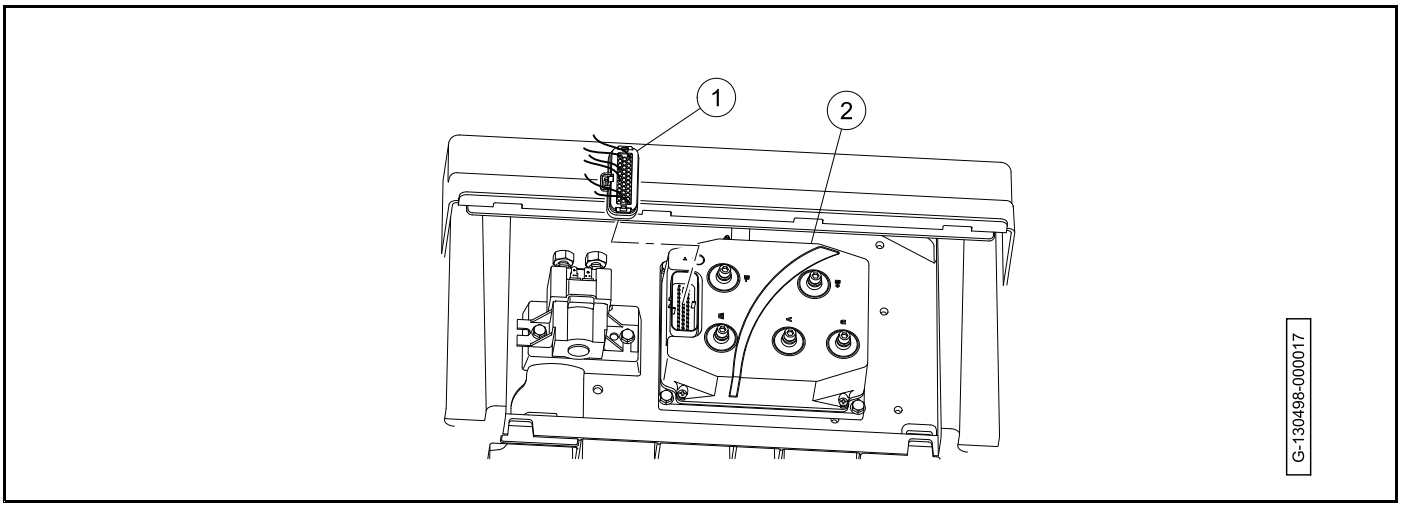


Figure 12-49 35-pin Connector

5. Set the multimeter to measure resistance (ohms).
6. Measure the resistance between pins 7 and 8 on the 35-pin connnector **(Figure 12-50, Page 12-53)**.

NOTE: *The temperature of the motor will affect the reading.*

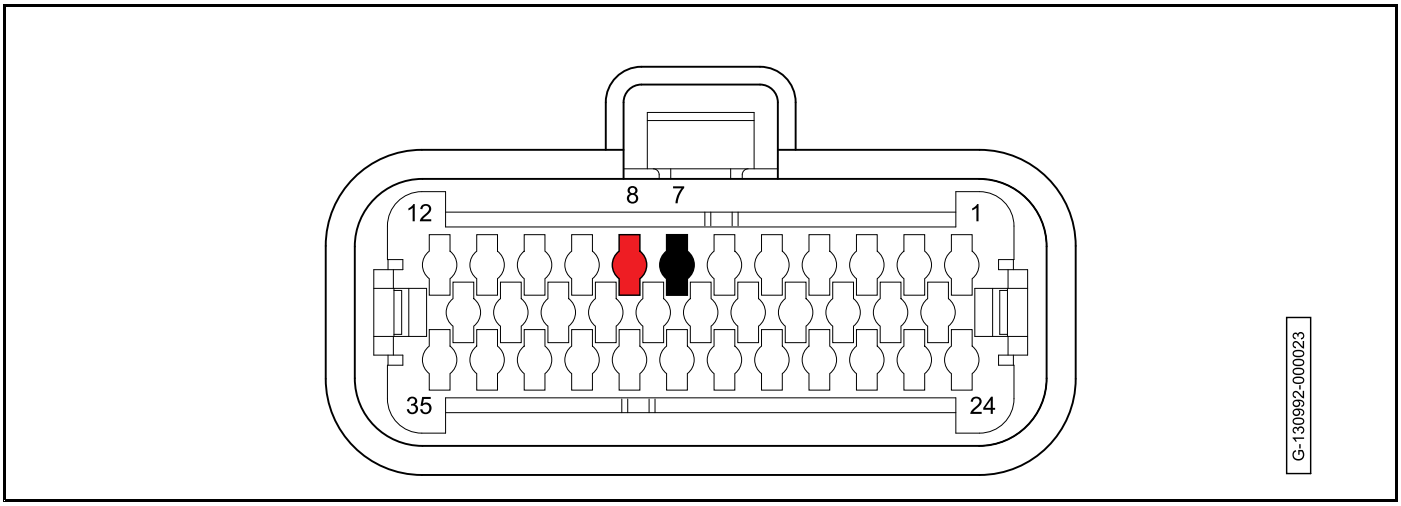


Figure 12-50 35-pin Connector

6.1. If the reading is approximately 1k to 1.7k ohms, the motor temperature sensor and wiring is good. Replace the MCU.

6.2. If the reading is not approximately 1k to 1.7k ohms, go to step 7.

7. Use snap ring pliers to separate the motor harness clip (3) and push the speed sensor connector (4) down **(Figure 12-51, Page 12-54)**.

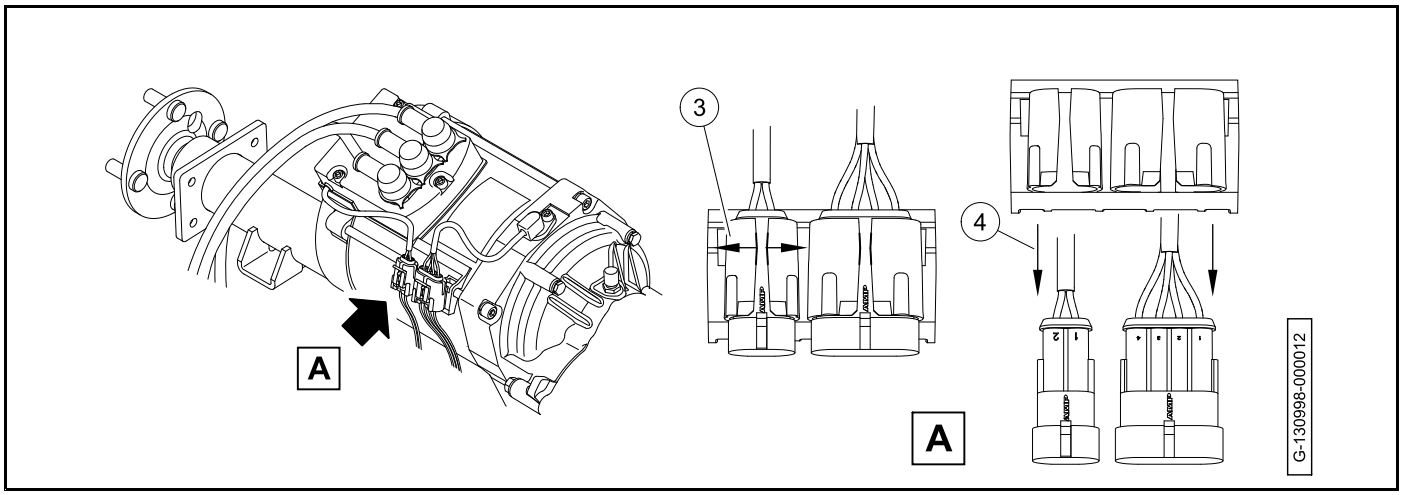


Figure 12-51 Motor Temperature Sensor Connector Removal

8. Disconnect the motor temperature sensor connector from the main harness.
9. Set the multimeter to measure continuity.
10. Check for continuity between pin 8 of the 35-pin connector and pin 1 of the main harness 2-pin connector. Check for continuity between pin 7 of the 35-pin connector and pin 2 of the main harness 2-pin connector **(Figure 12-52, Page 12-54)**.

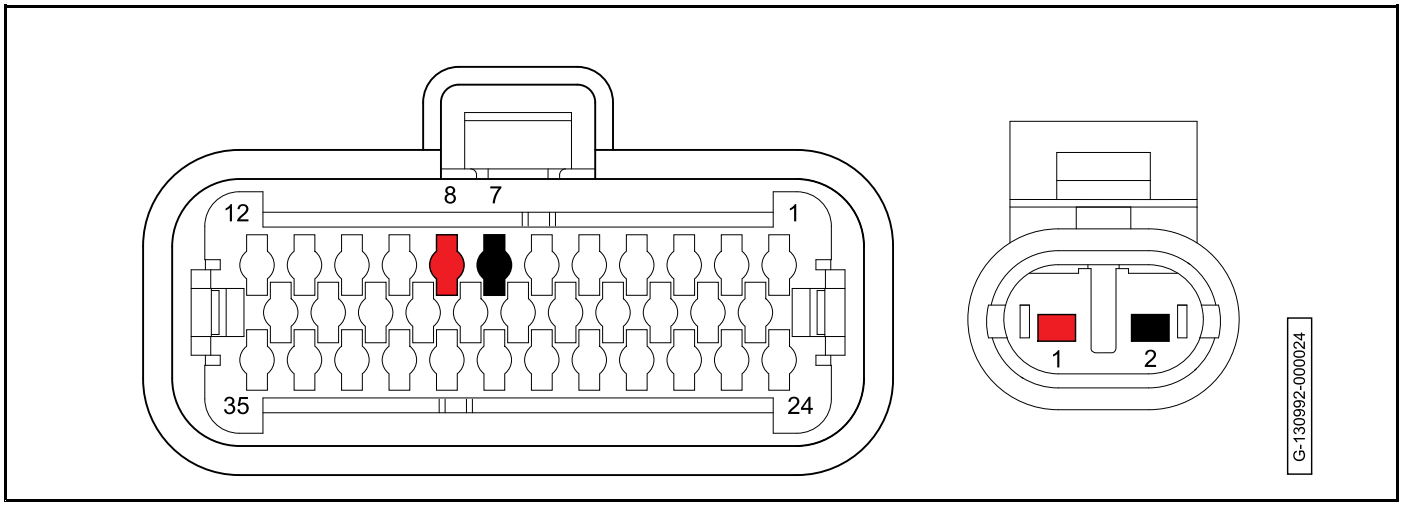


Figure 12-52 35-pin and 2-pin Connectors

10.1. If there is continuity, go to step 11.

10.2. If there is no continuity, repair or replace the wiring as necessary. After the wires are repaired or replaced, go to step 11.

11. Set the multimeter to measure resistance (ohms).
12. Measure the resistance between pin 1 and pin 2 of the motor temperature sensor connector (5) **(Figure 12-53, Page 12-55)**.

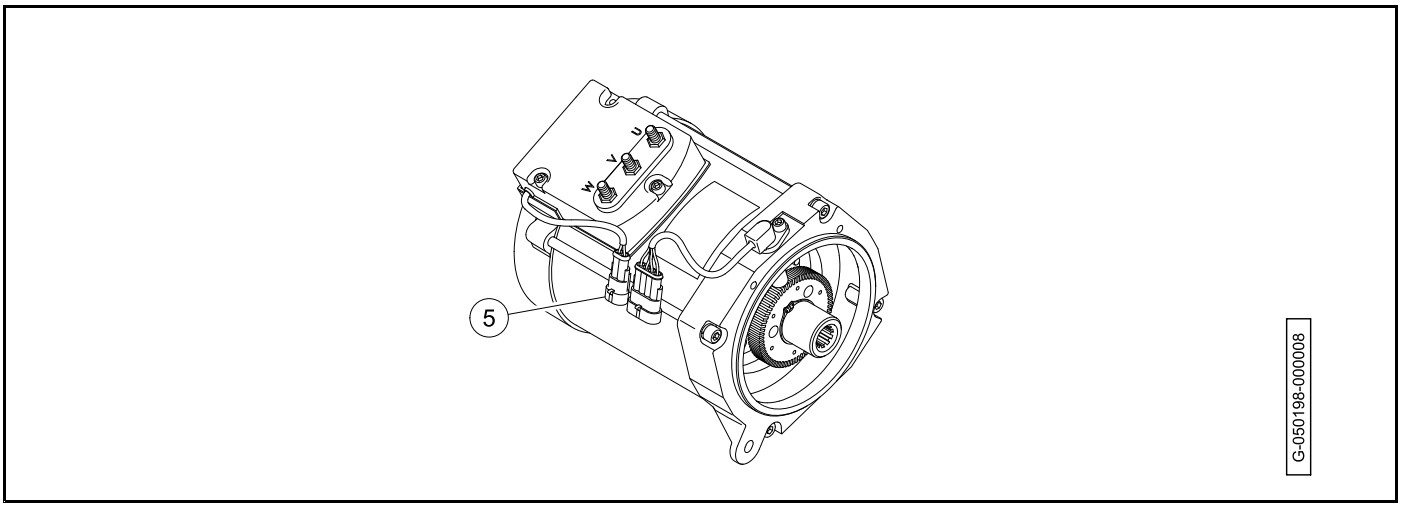


Figure 12-53 Motor Temperature Sensor Connector

12.1. If the reading is approximately 1k to 1.7k ohms, the motor temperature sensor is good. Replace the MCU.

12.2. If the reading is not approximately 1k to 1.7k ohms, the motor temperature sensor is bad. Replace the motor.

NOTE: *The motor temperature sensor is not a service part. If the motor temperature sensor is bad, the motor must be replaced.*

TEST PROCEDURE 17 – Multi-Purpose Buzzer

NOTE: *This is a voltage test.*

1. Disable the vehicle.
2. Turn the key switch OFF.
3. Remove the instrument panel.
4. Set the multimeter to measure DC voltage.
5. Disconnect the orange/white and black wires from the multi-purpose buzzer.
6. Set the FNR to R.
7. Measure the voltage on the orange/white wire.

7.1. If the voltage reading is 12.8V to 13.5V, replace the multi-purpose buzzer.

7.2. If the voltage reading is less than 12.8V or greater than 13.5V:

7.2.1. Check the multi-purpose buzzer wiring circuit.

7.2.2. Check the DC/DC converter.

TEST PROCEDURE 18 – Relay (12V and 48V)

See General Warnings on page 1-2.

12 Volt Relay Test (ACC and BT/VDU)

NOTE: *Check both 10 amp fuses on fuse block before testing 12V relays.*

This is a resistance and voltage test.

1. Disable the vehicle.

2. Make sure that the key switch is OFF.
3. Turn the key switch to ACC.

3.1. If the two 12V relays operate, the relays are good.

3.2. If one or both relays do not operate, go to step 4.

4. Set the mutimeter to measure resistance.
5. Remove 12V relay from the fuse block.
6. Measure the resistance on pins 85 and 86 on the 12V relay **(Figure 12-54, Page 12-56)**.

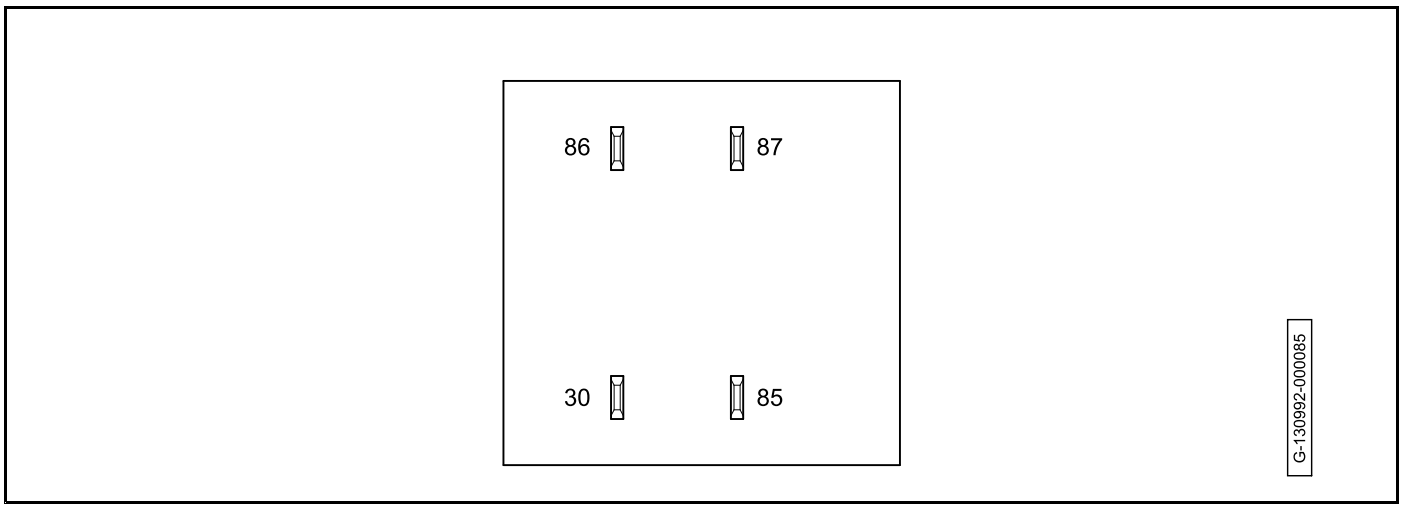


Figure 12-54

6.1. If the resistance is between 80 and 100 ohms, go to step 7.

6.2. If the resistance is above 100 or below 80 ohms, replace the 12V relay.

7. Set the multimeter to measure DC voltage.
8. Measure the voltage on pin 9 and pin 33 on the fuse block **(Figure 12-55, Page 12-57)**.

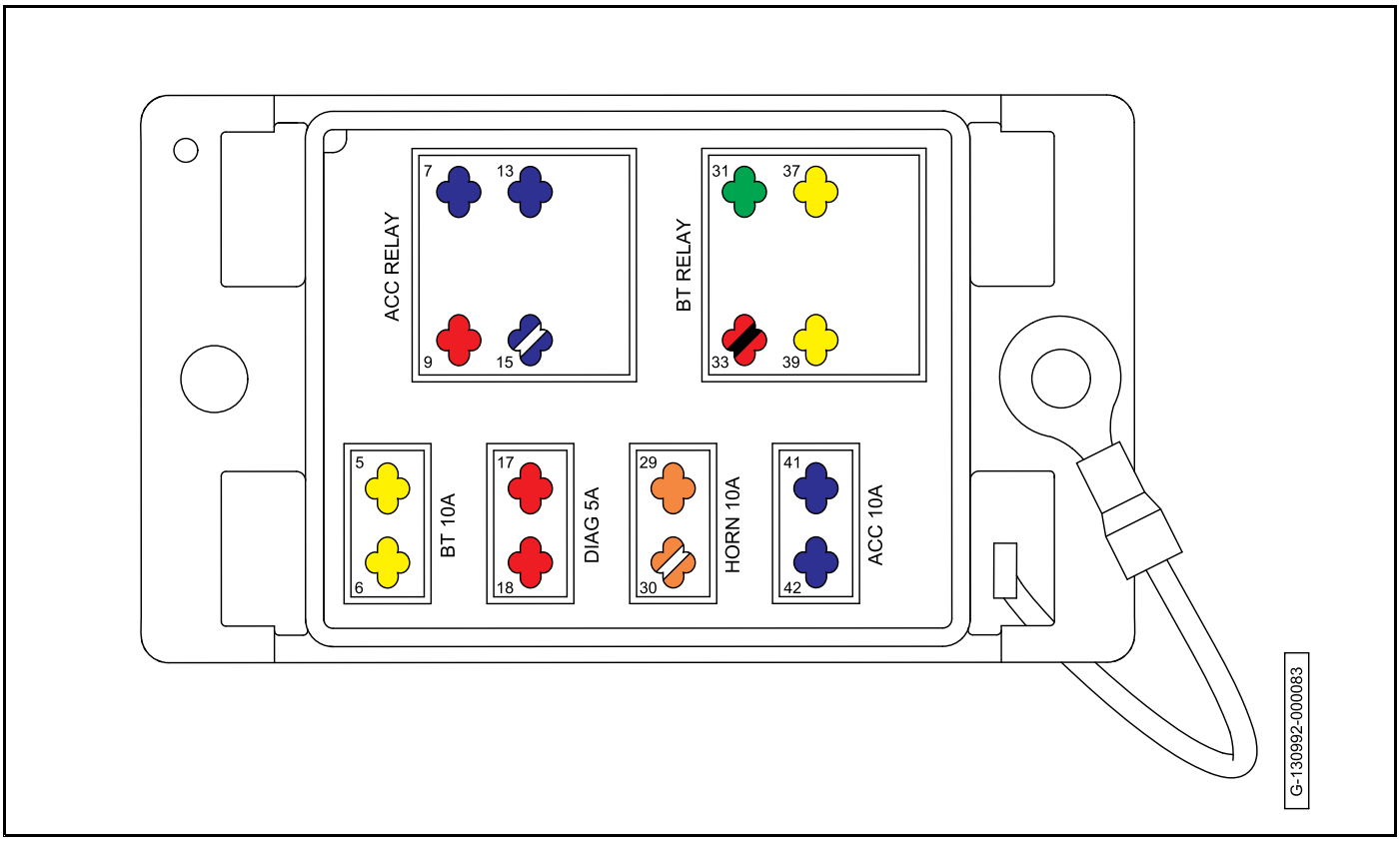


Figure 12-55

8.1. If the voltage is 12.8V to 13.5V, the wiring is good. Replace the relay.

8.2. If the voltage is less than 12.8V or greater than 13.5V:

8.2.1. Check the fuse block wiring circuit.

8.2.2. Check the DC/DC converter output voltage.

48 Volt Relay Test (DC/DC Converter)

NOTE: *This is a resistance and voltage test.*

1. Disable the vehicle.
2. Connect the CCDT.

2.1. If the CCDT connects and shows a display, the relay is good.

2.2. If no display shows on CCDT, got to step 3.

3. Set the mutimeter to measure resistance (20k ohms).
4. Disconnect the light blue wire and green wire on 48V the relay.
5. Measure the resistance between pin 1 and pin 2 on the relay **(Figure 12-56, Page 12-58)**.

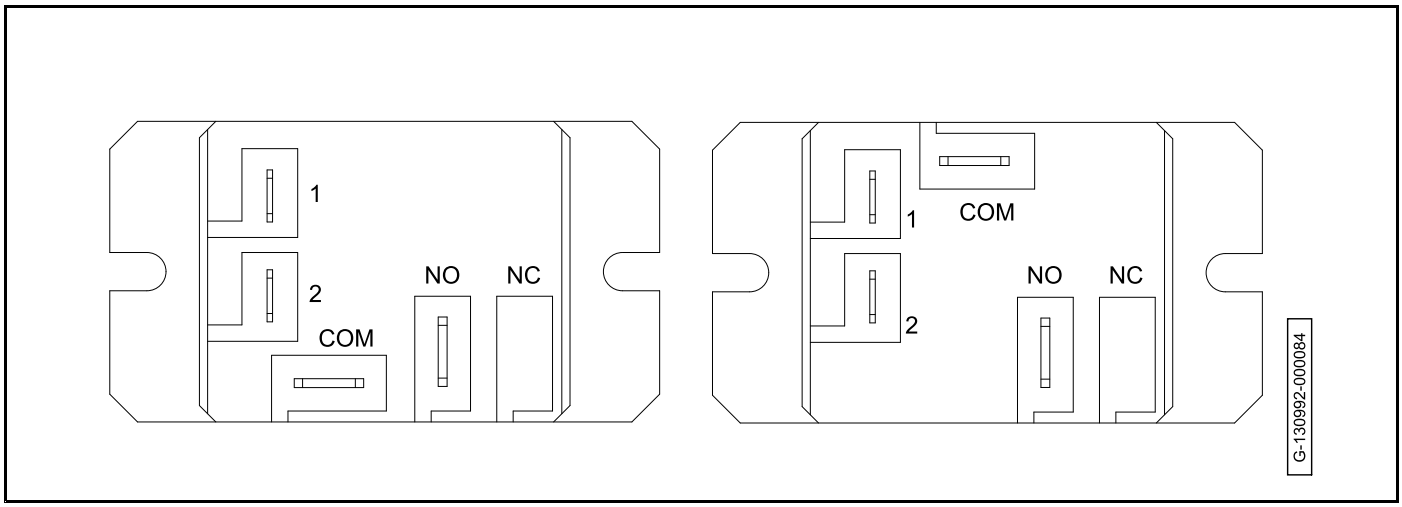


Figure 12-56

5.1. If the resistance is 1.5k to 4k ohms, the relay is good. Go to step 6.
5.2. If resistance is below 1.5k or above 4k ohms, replace the 48V relay.
6. Set mutimeter to measure DC voltage.
7. Measure voltage of the light blue wire on the relay.
7.1. If voltage reads BPV the wiring is good, see step 8.
7.2. If voltage is not BPV, check relay wiring circuit.
8. Set multimeter to measure DC voltage.
9. Disconnect the orange/blue wire from the relay.
10. Measure voltage of the orange/blue wire on the relay.
10.1. If reading is BPV, replace the relay.
10.2. If reading is not BPV, check the relay wiring circuit.

TEST PROCEDURE 19 – Run/Tow Switch

See General Warnings on page 1-2.

1. Disable the vehicle.
2. Connect the CCDT to the vehicle.
3. Set the Run/Tow switch to RUN, CCDT should come on.
4. Set the Run/Tow switch to TOW, CCDT should go off.,
4.1. If CCDT goes ON and OFF with the Run/Tow switch, switch is good.
4.2. If CCDT does not go ON and OFF with the Run/Tow switch, see step 5.
5. Set the multimeter to check DC voltage.
6. Access the Run/Tow switch. Do not disconnect the wires.
7. Set the Run/Tow switch to RUN.
8. Check the voltage at the white wire.
8.1. If the voltage is BPV, the wiring is good. Go to step 13.
8.2. If there is less than BPV, go to step 9.
9. Set a mutimeter to check continuity.
10. Check continuity of white wire on Run/Tow switch to 48V solenoid.

10.1. If there is continuity, the wiring is good.
10.2. If there is no continuity, go to step 11.
11. Check the 10 amp fuse for continuity.
11.1. If there is continuity, the fuse is good. Go to step 12.
11.2. If there is no continuity, replace the fuse.
12. Check the red wire from fuse holder to 48 volt solenoid.
12.1. If there is continuity, the wiring is good. Go to step 13.
12.2. If there is no continuity, repair or replace the wiring.
13. Set the Run/Tow switch to TOW.
14. Check the voltage at the orange and blue wire on the Run/Tow switch.
14.1. If there is no voltage, the switch and wiring is good.
14.2. If the voltage is BPV,. replace the Run/Tow switch.

TEST PROCEDURE 20 – Solenoid Activating Coil

See General Warnings on page 1-2.

NOTE: *This is a resistance test.*

1. Disable the vehicle.
2. Disconnect the batteries and discharge the controller.
3. Remove the controller shield.
4. Remove the two small wires from the solenoid.
5. Set a multimeter to measure resistance (ohms).
6. Measure resistance between the solenoid positive (+) terminal (1) and the other small solenoid terminal (2) **(Figure 12-57, Page 12-59)**.

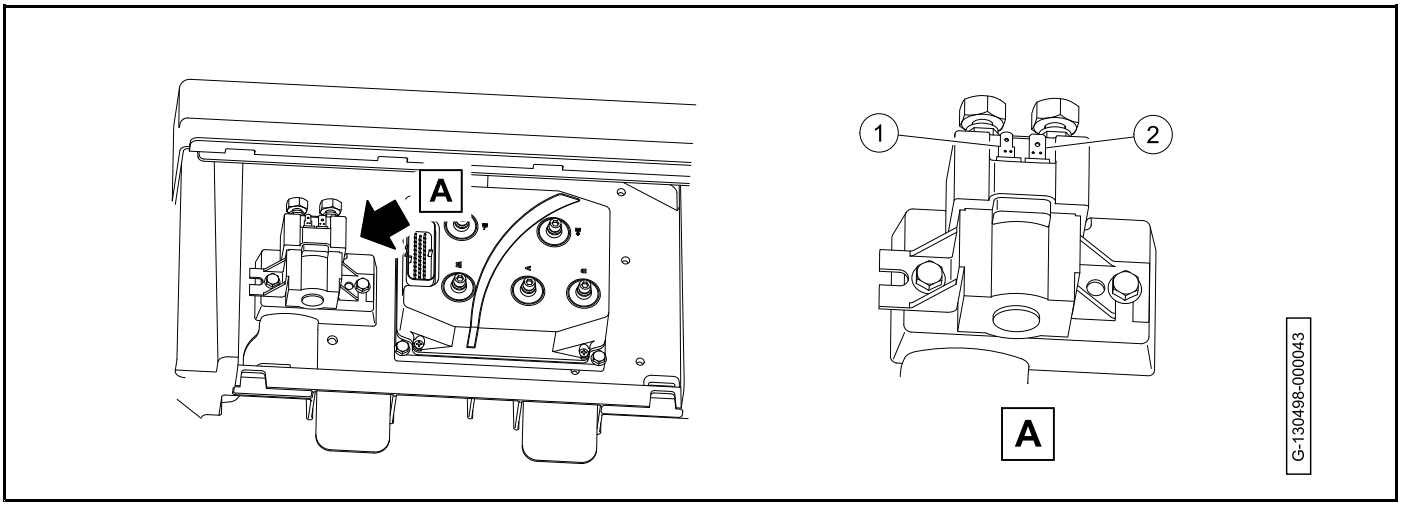


Figure 12-57 Solenoid Activating Coil Test

6.1. If the resistance is between 180 to 190 ohms, the solenoid activating coil is good.
6.2. If the resistance is not between 180 to 190 ohms, replace the solenoid.

TEST PROCEDURE 21 – Solenoid Continuity

See General Warnings on page 1-2.

Solenoid Continuity Test with the CCDT

1. Disable the vehicle.
2. Make sure the key is in the OFF position.
3. Connect the CCDT to the vehicle.
4. Go to the MCU screen **(Figure 12-58, Page 12-60)**.



G-008998-000034

Figure 12-58

5. Turn the key ON.
   – The MCU Main Contactor State should be Closed (Main Enable-ON).
   – The MCU Drive Enable should show Drive Enabled.
   – The MCU Main Power Voltage should increase to battery pack voltage.
   – If the MCU parameters above are good, go to step 6.
   – If the MCU parameters above do not match, check the wiring circuit and the key switch.
6. Turn the key switch to OFF.
   – The MCU Main Contactor State should be OPEN.
   – The MCU Main Power Voltage should slowly decrease to approximately 15V - 22V.
   – The MCU Drive Enable should show Drive Disabled.
   – If the MCU Main Power Voltage and MCU Logic Voltage match, the main solenoid is welded. Replace the main solenoid.

TEST PROCEDURE 22 – Taillights

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

1. Disable the vehicle.
2. Disconnect taillight connectors from taillights.
3. Turn the light switch to the ON position.
4. Set the multimeter to measure voltage.
5. Measure the voltage on the brown wire pin 3 on the drivers/passengers side taillight connectors **(Figure 12-59, Page 12-61)**.

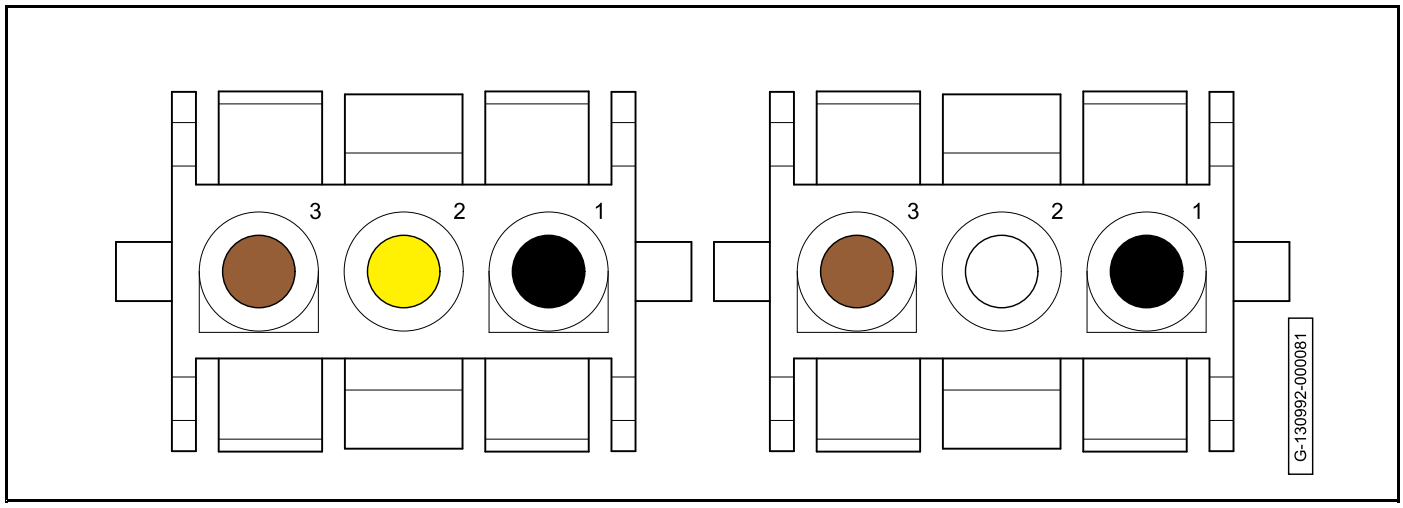


Figure 12-59

5.1. If voltage measures 12.8V to 13.5V the wiring is good, replace taillight.

5.2. If voltage measures less than 12.8V or greater than 13.5V, check wiring circuit or DC/DC converter output voltage.

TEST PROCEDURE 23 – Turn Signal

See General Warnings on page 1-2.

Turn Signal Test with the CCDT

NOTE: *This is a voltage test.*

1. Disable the vehicle.
2. Connect the CCDT to the vehicle.
3. Go to the VCM screen.
4. Go to the SIGNALSOUTPUT screen **(Figure 12-60, Page 12-62)**.



Figure 12-60

5. Turn the key switch to ACC.
6. Turn the left turn signal ON.

6.1. The Output Turn Front/Rear Left should indicate ON and OFF with the turn signal.

6.2. If CCDT does not indicate ON and OFF with turn signal, see step 7.

7. Turn the right turn signal ON.

7.1. The Output Turn Front/Rear Right should indicate ON and OFF with the turn signal.

7.2. If CCDT does not indicate ON and OFF with turn signal, see **Turn Signal Test without the CCDT (Taillights)** and **Turn Signal Test without the CCDT (Headlights)**.

Turn Signal Test without the CCDT (Taillights)

1. Disable the vehicle.
2. Turn the key switch to the ACC position.
3. Set the multimeter to measure DC voltage.
4. Disconnect the rear taillight connectors.
5. With the passengers-side turn signal switch ON measure the voltage on the yellow wire pin 2 for the passengers-side connector **(Figure 12-61, Page 12-63)**.

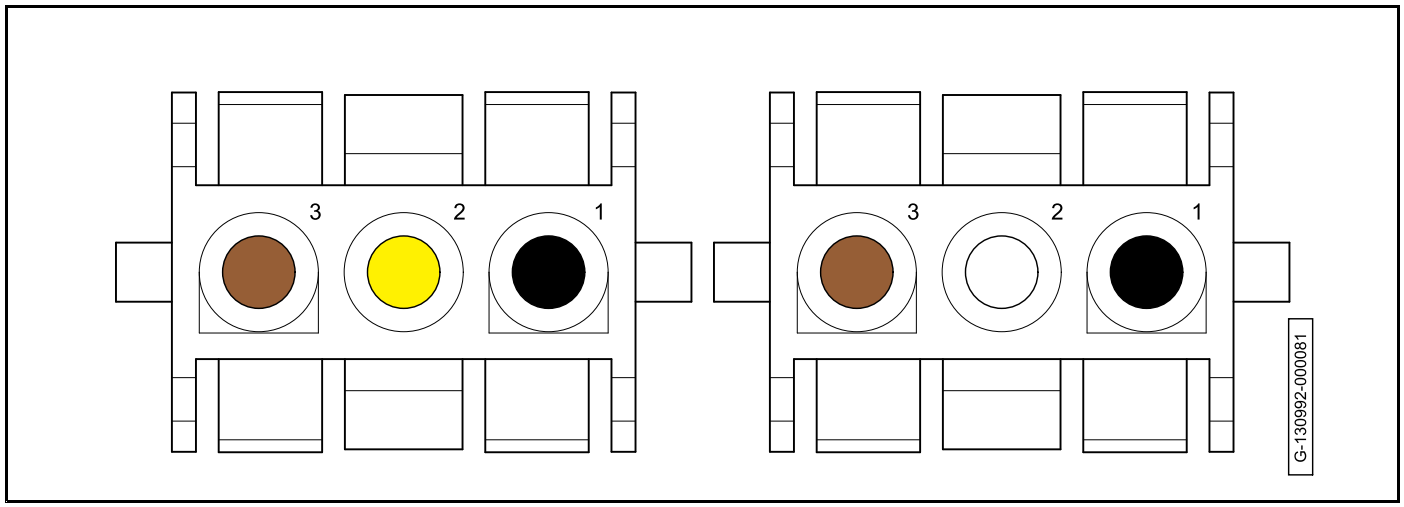


Figure 12-61

5.1. If voltage reads 12.8V to 13.5V with the turn signal ON then wiring is good, replace the taillight.

5.2. If voltage reads less than 12.8V or greater than 13.5V, check wiring circuit or DC/DC converter output voltage.

6. Set the multimeter to measure DC voltage.

7. With the drivers-side turn signal switch ON measure the voltage on the white wire pin 2 for the drivers-side connector **(Figure 12-61, Page 12-63)**.

7.1. If voltage reads 12.8V to 13.5V with the turn signal ON then wiring is good, replace the taillight.

7.2. If voltage reads less than 12.8V or greater than 13.5V, check wiring circuit or DC/DC converter output voltage.

Turn Signal Test without the CCDT (Headlights)

1. Disable the vehicle.
2. Disconnect the front headlight connectors.
3. Turn the key switch to ACC.
4. Set the multimeter to measure voltage.
5. With the drivers-side turn signal switch ON measure the voltage on the green wire pin C for the drivers-side headlight connector **(Figure 12-62, Page 12-64)**

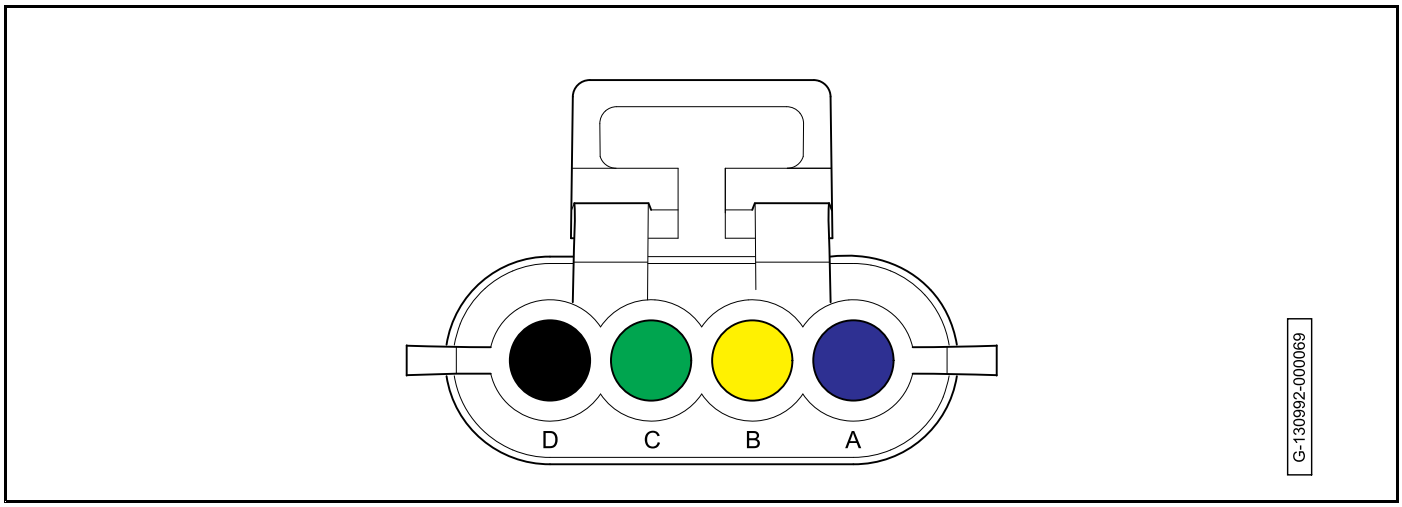


Figure 12-62

5.1. If voltage reads 12.8V to 13.5V with the turn signal ON then wiring is good, replace the headlight.

5.2. If voltage reads less than 12.8V or greater than 13.5V, check wiring circuit or DC/DC converter output voltage.

6. Set the multimeter to measure voltage.

7. With the passengers-side turn signal switch ON measure the voltage on the red wire pin C for the passengers-side headlight connector **(Figure 12-63, Page 12-64)**.

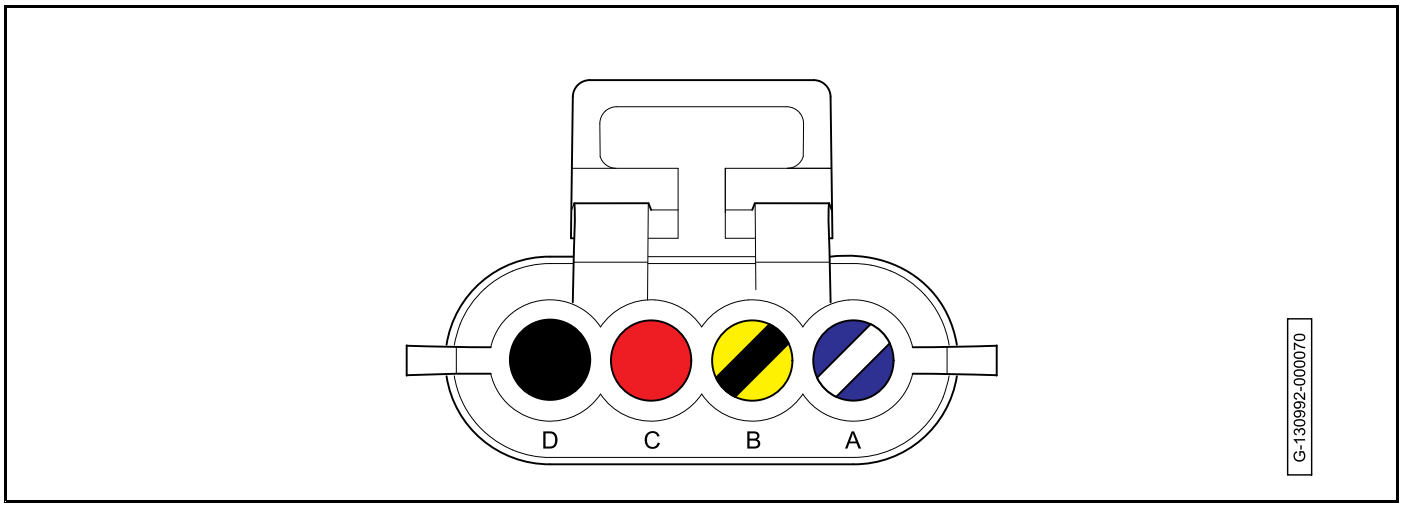


Figure 12-63

7.1. If voltage reads 12.8V to 13.5V with the turn signal ON then wiring is good, replace the headlight.

7.2. If voltage reads less than 12.8V or greater than 13.5V, check wiring circuit or DC/DC converter output voltage.

TEST PROCEDURE 24 – USB Receptacle

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

1. Remove the instrument panel (IP).
2. Set the multimeter to measure DC voltage.
3. Measure the voltage on the USB receptacle red wire (1) **(Figure 12-64, Page 12-65)**.

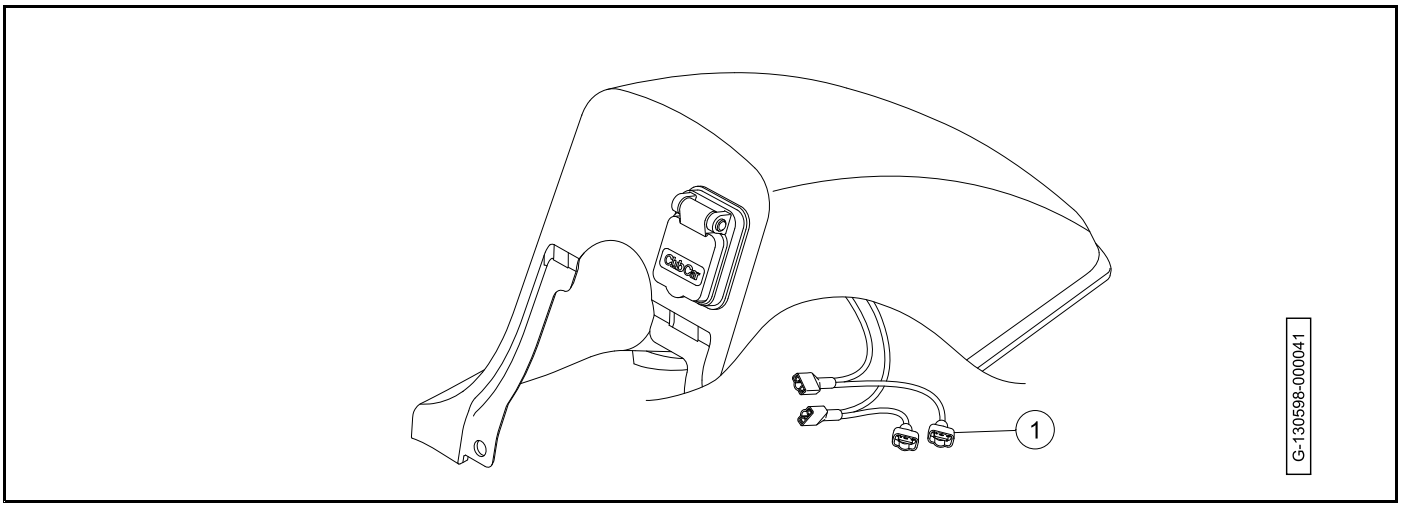


Figure 12-64 USB Receptacle

3.1. If the voltage is zero, check the wiring circuit.
3.2. If the voltage is BPV replace the USB receptacle.

TEST PROCEDURE 25 – Voltage at Charger Receptacle Red Wire Socket

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

1. Measure the voltage at the charger receptacle socket pin-2 on the red, 10-gauge wire. The reading should be BPV.

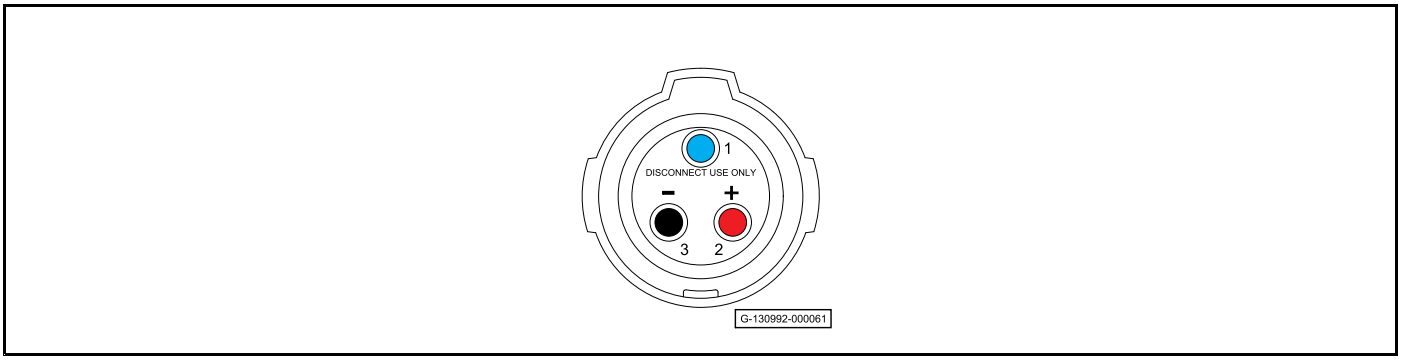


Figure 12-65

2. 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 4-gauge red wire from the positive post of battery no. 1 to the 48V solenoid.
3. If the reading is less than BPV, inspect related wiring and connections for tightness, damage and corrosion.

TEST PROCEDURE 26 – 3-Pin Connector (for Bluetooth Speakers)

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

1. Disable the vehicle.
2. Turn the key position to ACC.
3. Measure the voltage of the two red wires pin 2 and pin 3 **(Figure 12-66, Page 12-66)**.

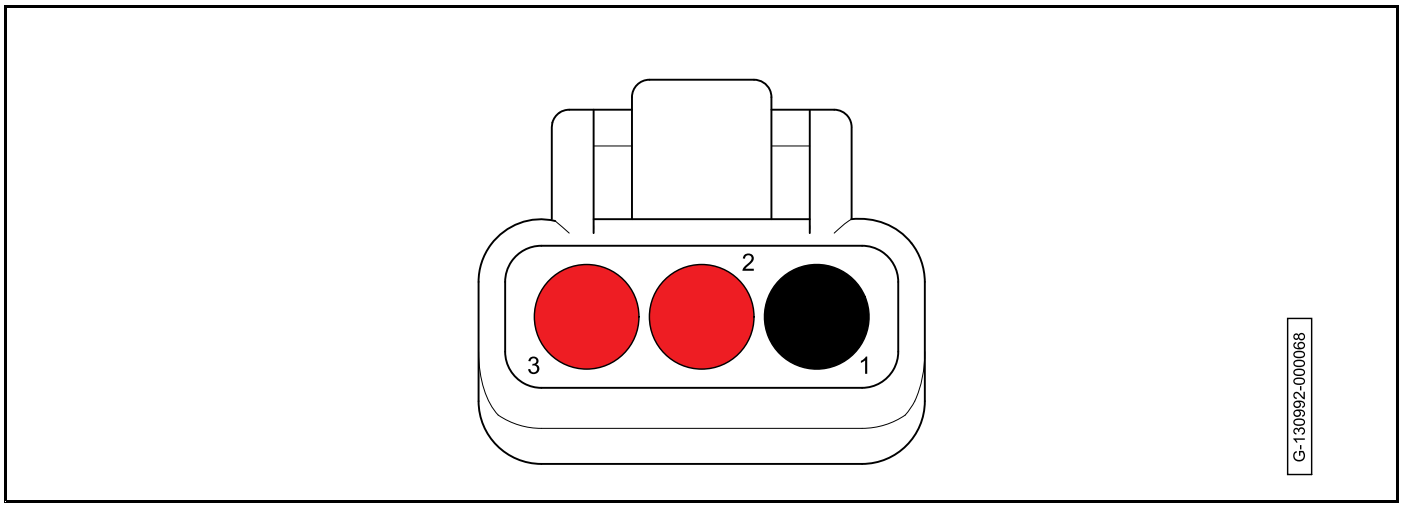


Figure 12-66

3.1. If voltage is 12.8V to 13.5V, wiring is good.

3.2. If voltage is lower than 12.8V or greater than 13.5V, check wiring circuit or DC/DC converter output voltage.

TEST PROCEDURE 27 – 4-Pin Connector (for Video Display Unit)

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

1. Inspect connector and make sure no damage is present, if damaged replace wiring harness.
2. Disable the vehicle.
3. Set the multimeter to measure DC voltage.
4. Turn the key position to ACC.
5. Measure the voltage of the red wire pin 2 of the 4 pin connector **(Figure 12-67, Page 12-67)**.

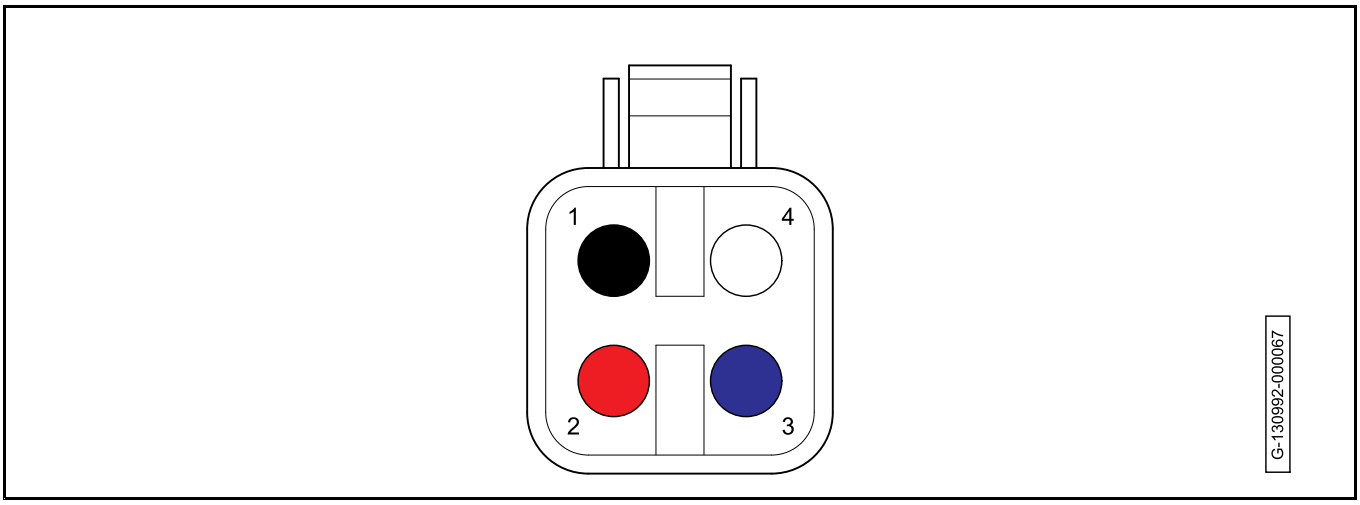


Figure 12-67 4-Pin Connector

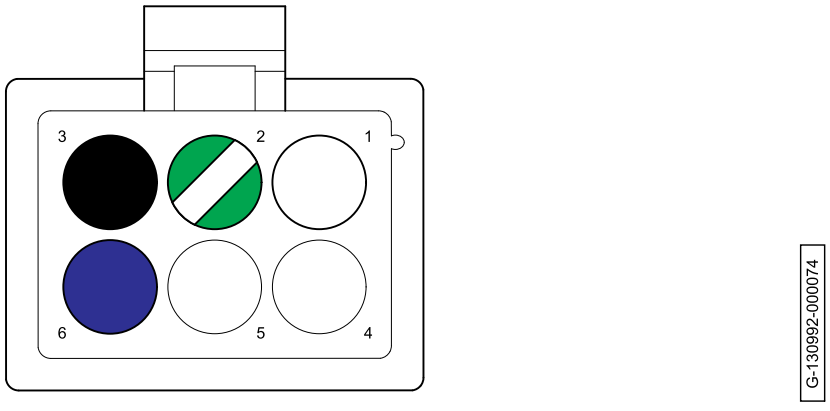
5.1. If the voltage is 12.8V to 13.5V, wiring is good.

5.2. If voltage is less than 12.8V or greater than 13.5V, check wiring circuit or DC/DC converter output voltage.

INSTRUMENT PANEL HARNESS CONNECTOR PINOUTS

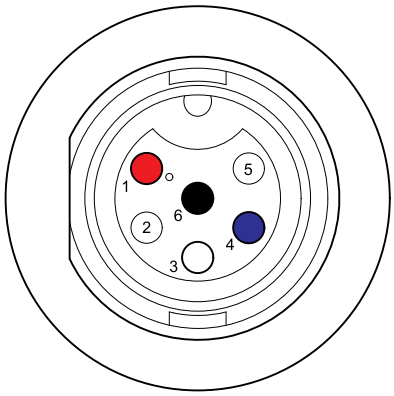
This section shows the pinouts for connectors on the main harness. Pins not in the table are not used.

DASH DISPLAY



Pin	Wire Color	Description
1	White	Main CAN bus High
2	Green/White	12V Power
3	Black	Ground
6	Blue	Main CAN bus Low

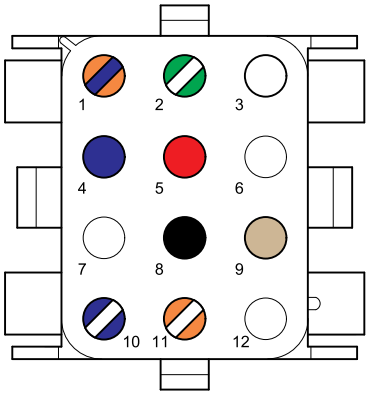
DIAGNOSTIC PORT



G-130992-000076

Pin	Wire Color	Description
1	Red	12V Power
3	White	Main CAN bus High
4	Blue	Main CAN bus Low
6	Black	Ground

12-PIN CONNECTOR (TO MAIN HARNESS)



G-130992-000075

Pin	Wire Color	Description
1	Orange/Blue	12V Power
2	Green	Dash Display On/Off
3	White	Main CAN bus High
4	Blue	Main CAN bus Low
5	Red	To 5A Diagnostic Receptacle Fuse
8	Black	Ground
9	Tan	Key Switch Wake

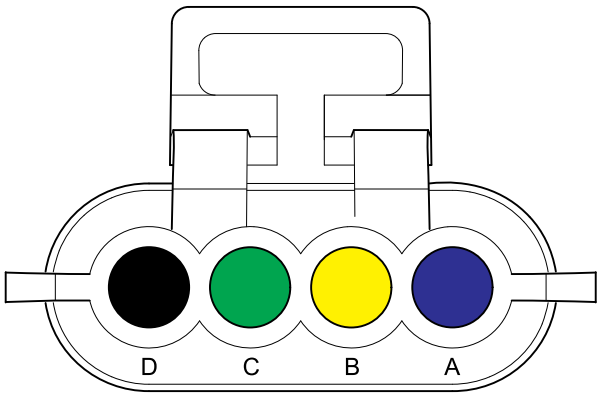
TABLE CONTINUED ON NEXT PAGE

10	Blue/White	Key Switch 48V MCU Input
11	Orange/White	Multi-purpose Buzzer from VCM

HORN, LIGHT, AND TURN SIGNAL HARNESS CONNECTOR PINOUTS

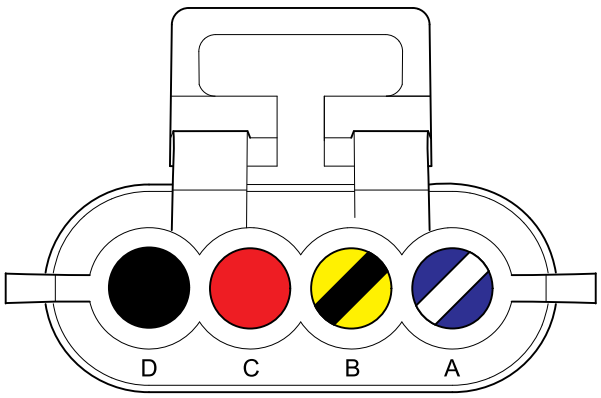
This section shows the pinouts for connectors on the main harness. Pins not in the table are not used.

HEADLIGHT CONNECTORS



Pin	Wire Color	Description
A	Blue	12V Power Headlight
B	Yellow	12V Power Daytime Running Light
C	Green	12V Power Turn Signal
D	Black	Ground

Figure 12-68 Drivers Side Headlight

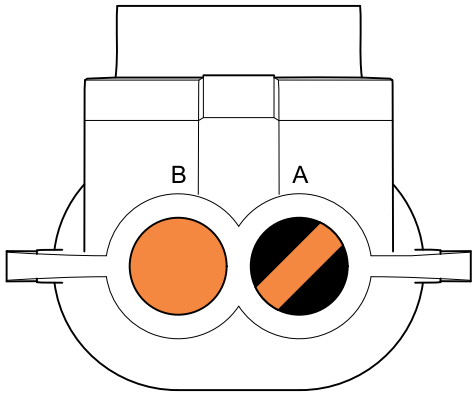


Pin	Wire Color	Description

1	Blue/White	12V Power Headlight
2	Yellow/Black	12V Power Daytime Running Light
3	Red	12V Power Turn Signal
4	Black	Ground

Figure 12-69 Passengers Side Headlight

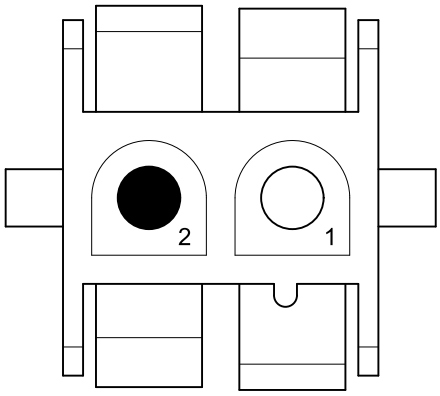
HORN CONNECTOR



G-130992-000072

Pin	Wire Color	Description
A	Black/Orange	Ground
B	Orange	12V Power

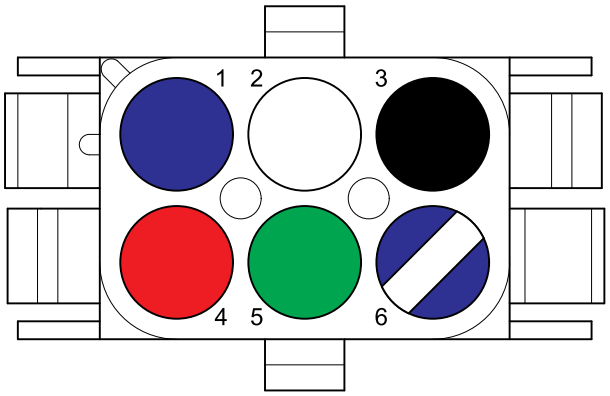
LIGHTED LOGO CONNECTOR



G-130992-000071

Pin	Wire Color	Description
1	White	12V Power
2	Black	Ground

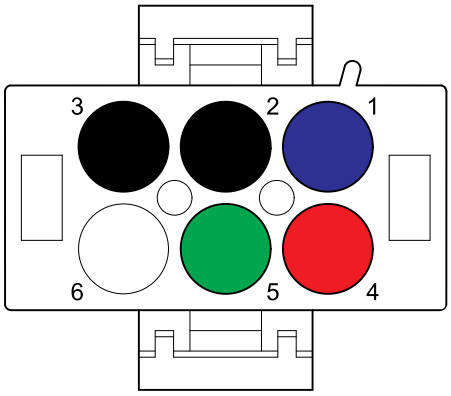
LIGHTING CONTROL (TO MAIN HARNESS)



G-130992-000078

Pin	Wire Color	Description
1	Blue	5V Power Horn Switch
2	White	5V Power Hazard Switch
3	Black	Ground
4	Red	5V Power Turn Signal Switch Right
5	Green	5V Power Turn Signal Switch Left
6	Blue/White	5V Power Light Switch

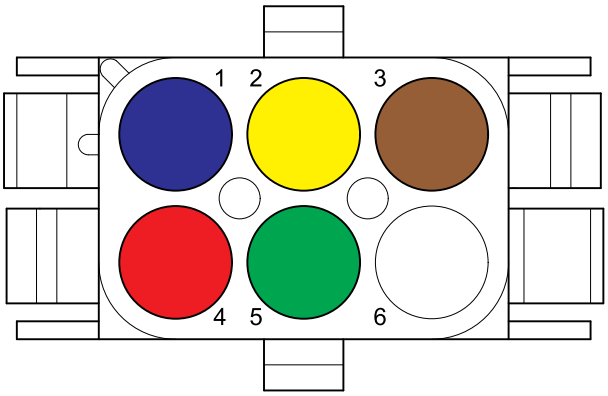
LIGHTING CONTROL (TO TURN SIGNAL)



G-130992-000077

Pin	Wire Color	Description
1	Blue	5V Power Horn Switch
2	Black	Ground
3	Black	Ground
4	Red	5V Power Turn Signal Switch Right
5	Green	5V Power Turn Signal Switch Left

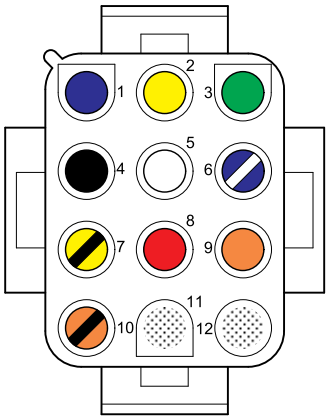
TURN SIGNAL CONNECTOR (TO LIGHTING CONTROL HARNESS)



G-130992-000079

Pin	Wire Color	Description
1	Blue	5V Power Horn
2	Yellow	Ground
3	Brown	Ground
4	Red	5V Power Turn Signal Right
5	Green	5V Power Turn Signal Left

IP LIGHT HARNESS (TO MAIN FORWARD LIGHTING)



G-130992-000082

Pin	Wire Color	Description
1	Blue	Left Headlight from VCM
2	Yellow	Left Daytime Run Light from VCM
3	Green	Front Left Turn Signal from VCM
4	Black	Ground
5	White	Logo Light from VCM
6	Blue/White	Right Headlight from VCM

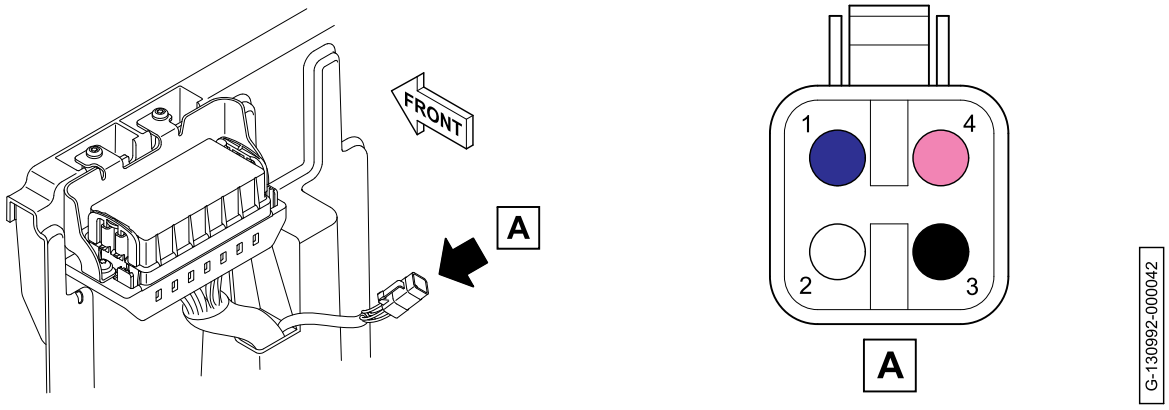
TABLE CONTINUED ON NEXT PAGE

7	Yellow/Black	Right Daytime Run Light from VCM
8	Red	Front Right Turn Signal from VCM
9	Orange	To 10A Horn Fuse
10	Orange/Black	Ground

MAIN HARNESS CONNECTOR PINOUTS

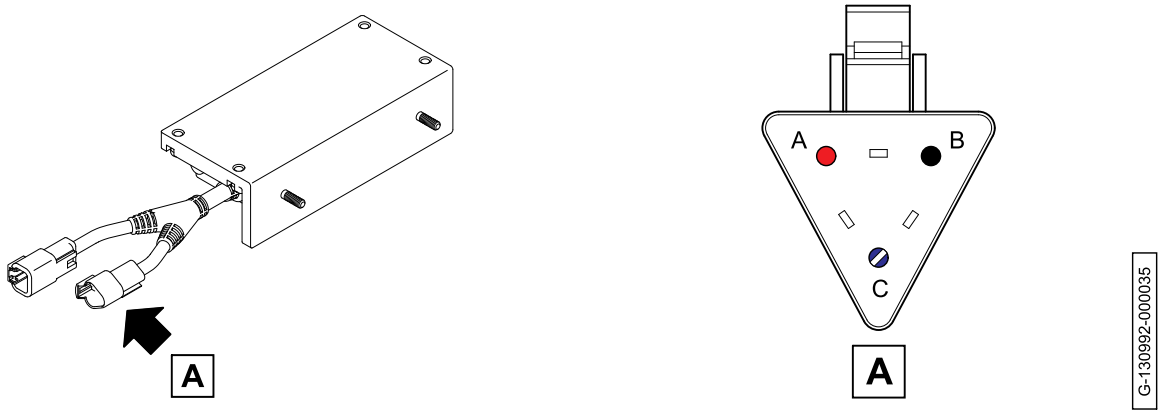
This section shows the pinouts for connectors on the main harness. Pins not in the table are not used.

AUXILIARY CAN CONNECTOR



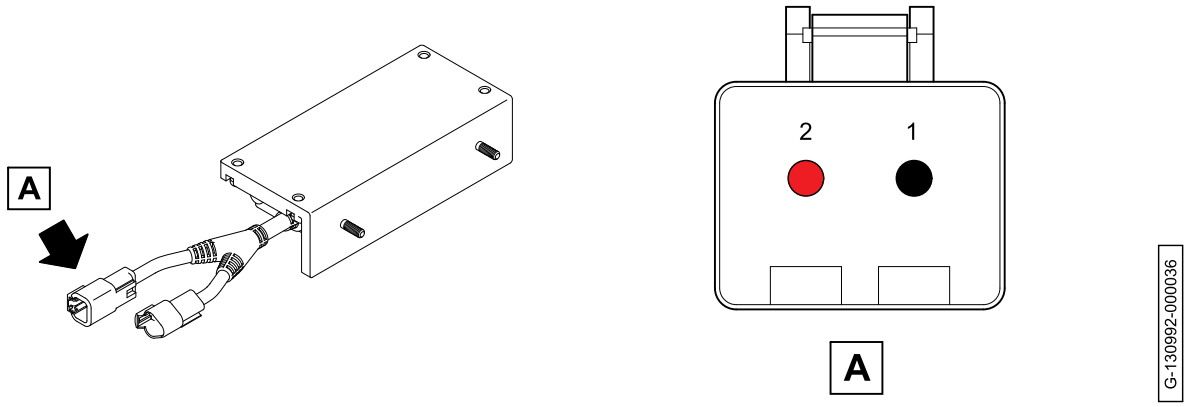
Pin	Wire Color	Description
1	Blue	Main CAN bus Low
2	White	Main CAN bus High
3	Black	Ground
4	Pink	5V Driver from VCM

DC/DC 3-PIN CONNECTOR



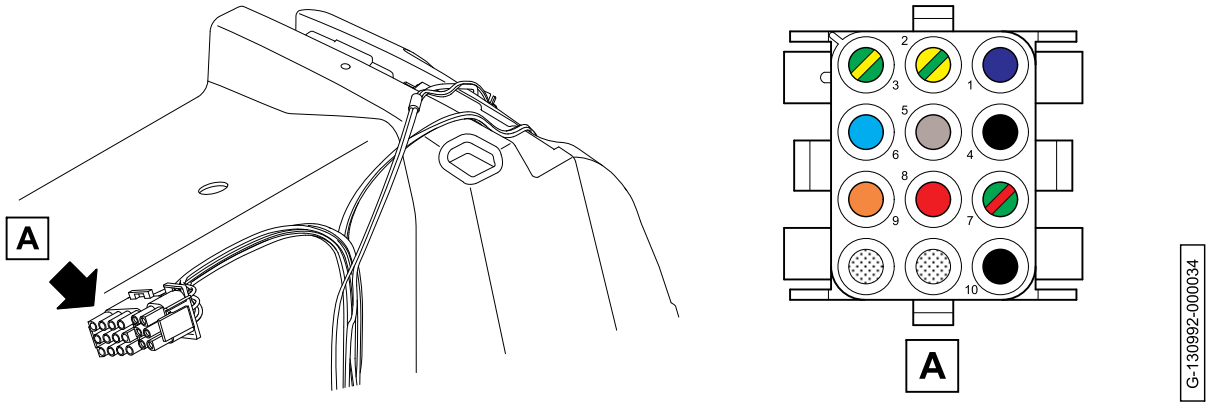
Pin	Wire Color	Description
A	Red	48V Input
B	Black	Ground
C	Blue/White	48V BMS Enable

DC/DC 2-PIN CONNECTOR



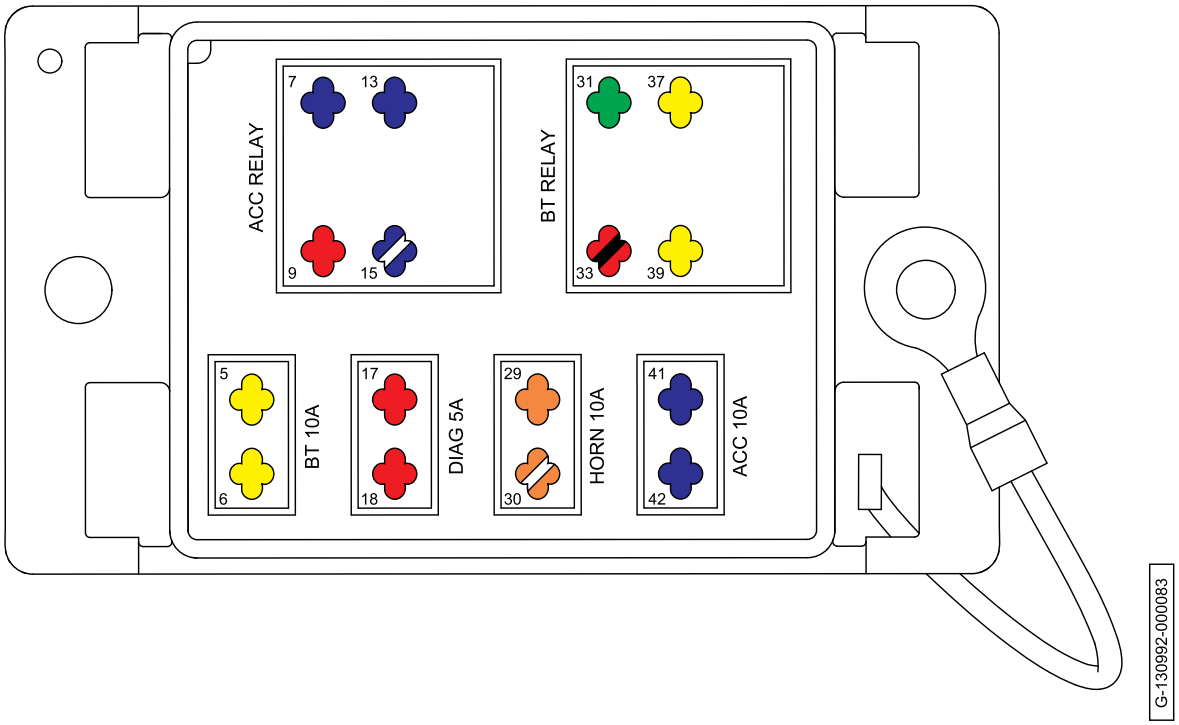
Pin	Wire Color	Description
1	Black	Ground
2	Red	12V (+) Output

FORWARD LIGHTING CONNECTOR



Pin	Wire Color	Description
1	Blue	Left Headlight from VCM
2	Yellow/Light Green	Left Daytime Run Light from VCM
3	Green/Yellow	Front Left Turn Signal from VCM
4	Black	Ground
5	Gray	Logo Light from VCM
6	Light Blue	Right Headlight from VCM
7	Light Green/Red	Right Daytime Run Light from VCM
8	Red	Front Right Turn Signal from VCM
9	Orange	To 10A Horn Fuse
10	Black	Ground

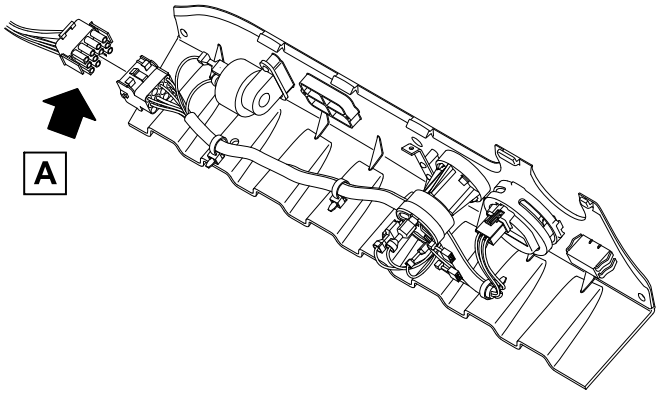
FUSE BLOCK

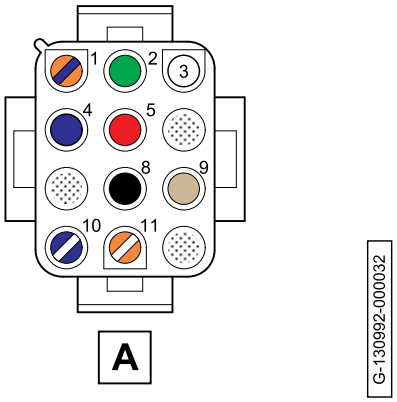


Pin	Wire Color	Description
5	Yellow	12V from DC/DC
6	Yellow	12V to BT Relay Coil and Contact
7	Blue	12V ACC Relay Contact
9	Red	ACC Relay Coil from VCM
13	Blue	12V ACC Relay Coil
15	Blue/White	12V ACC Output
17	Red	12V Diagnostic Port
18	Red	12V from DC/DC
29	Orange	12V from DC/DC
30	Orange/White	12V Horn
31	Green	12V Output to Visage and BT
33	Red/Black	BT Relay Coil from VCM
37	Yellow	12V BT Relay Coil
39	Yellow	12V BT Relay Contact
41	Blue	12V from DC/DC
42	Blue	12V to ACC Relay Coil and Contact

Figure 12-70

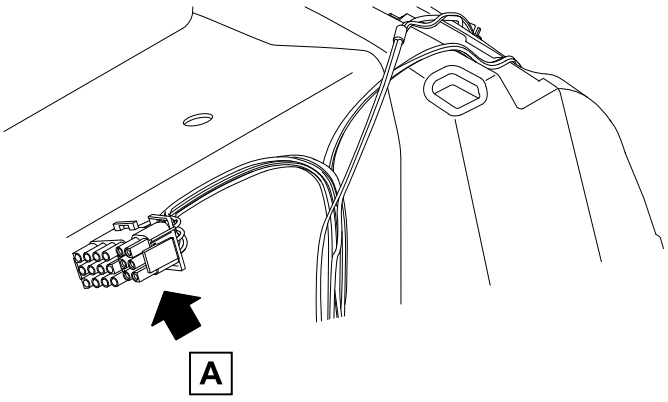
IP 12-PIN CONNECTOR

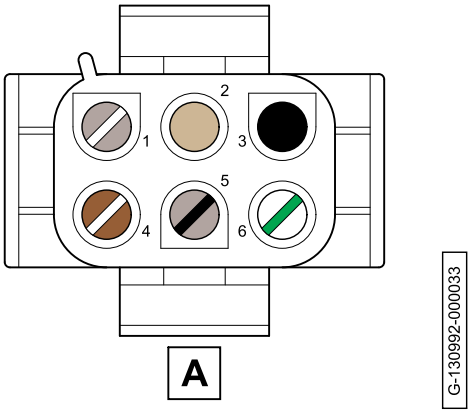




Pin	Wire Color	Description
1	Orange/Blue	12V Power
2	Green	Dash Display On/Off
3	White	Main CAN bus High
4	Blue	Main CAN bus Low
5	Red	To 5A Diagnostic Receptacle Fuse
8	Black	Ground
9	Tan	Key Switch Wake
10	Blue/White	Key Switch 48V MCU Input
11	Orange/White	Multi-purpose Buzzer from VCM

LIGHTING CONTROL CONNECTOR



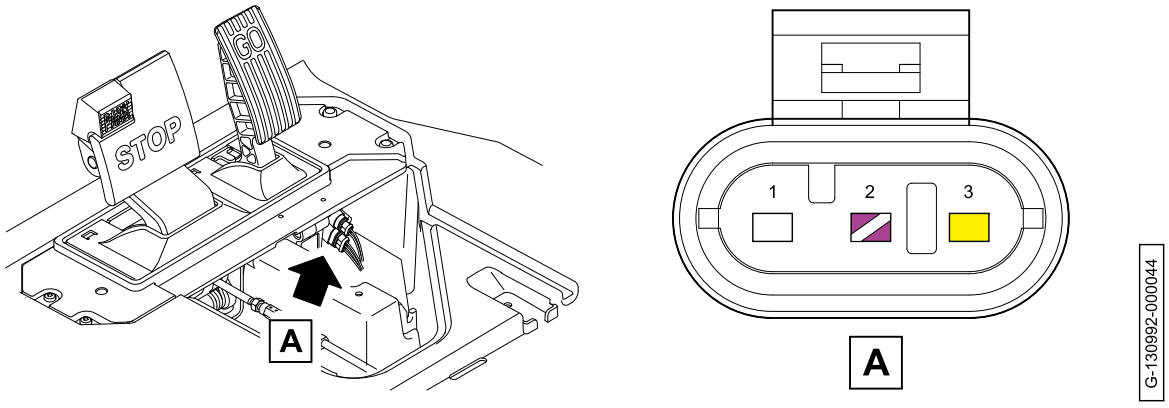


Pin	Wire Color	Description
1	Gray/White	5V Horn from VCM
2	Tan	5V Hazard Switch from VCM

TABLE CONTINUED ON NEXT PAGE

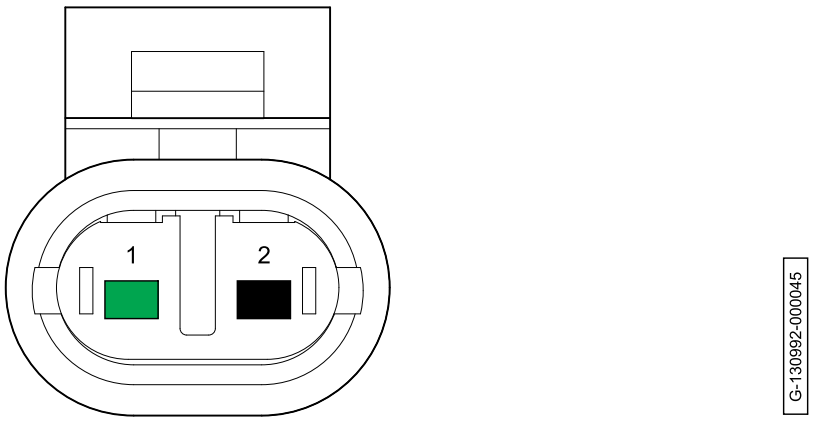
3	Black	Ground
4	Brown/White	5V Right Turn Signal from VCM
5	Gray/Black	5V Left Turn Signal from VCM
6	White/Light Green	5V Light Switch from VCM

MCOR 3-PIN CONNECTOR



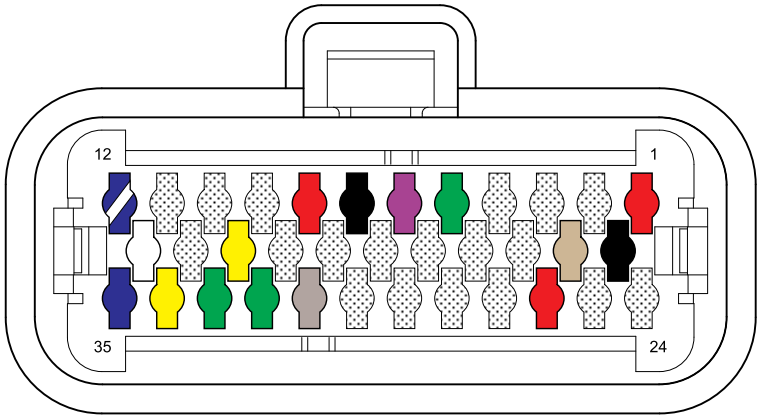
Pin	Wire Color	Description
1	White	5V VCM Input
2	Purple/White	Ground
3	Yellow	Input Signal to VCM

MCOR 2-PIN CONNECTOR



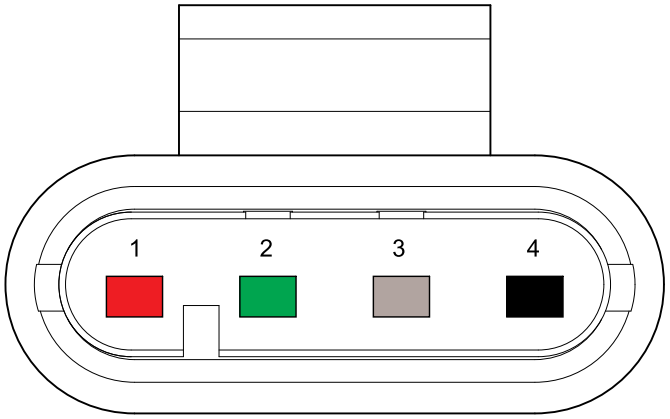
Pin	Wire Color	Description
1	Light Green	5V VCM Input
2	Black	Ground

MCU 35-PIN CONNECTOR



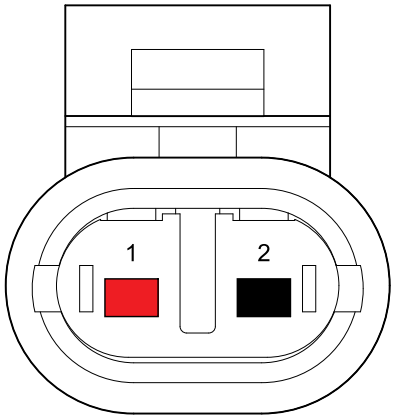
Pin	Wire Color	Description
1	Orange/Blue	48V Power
5	Green	48V Driver to Relay
6	Purple/White	5V Driver to Main Solenoid
7	Black	Ground
8	Red	5V Output to Motor Temperature Sensor
13	Light Blue	5V Coil Return
21	Yellow	Main CAN Terminal High
23	White	Main CAN bus High
26	Red	5V Ouput to Motor Speed Sensor
31	Tan	Position Feedback A
32	Green	Position Feedback B
34	Yellow	Main CAN Terminal Low
35	Blue	Main CAN bus Low

MOTOR SPEED SENSOR CONNECTOR



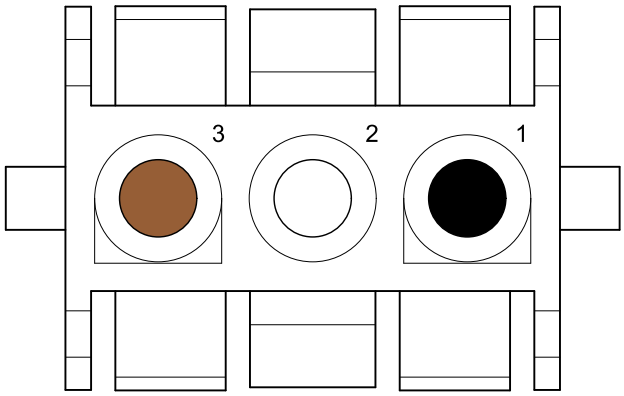
Pin	Wire Color	Description
1	Red	5V from MCU
2	Green	Position Feedback B
3	Grey	Position Feedback A
4	Black	Ground

MOTOR TEMPERATURE SENSOR CONNECTOR



Pin	Wire Color	Description
1	Red	5V from MCU
2	Black	Ground

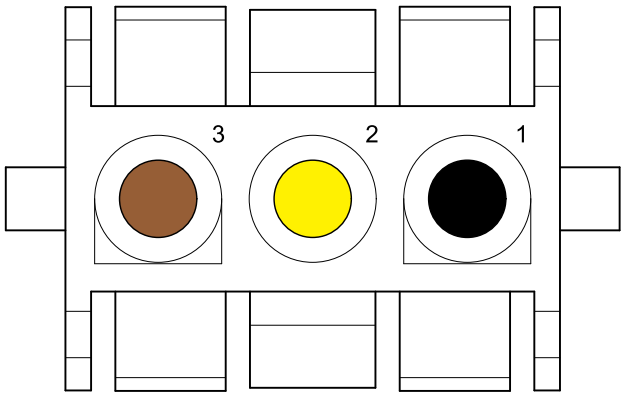
LEFT TAILLIGHT CONNECTOR



G-130992-000037

Pin	Wire Color	Description
1	Black	Ground
2	White	12V Turn Signal from VCM
3	Brown	12V Taillight from VCM

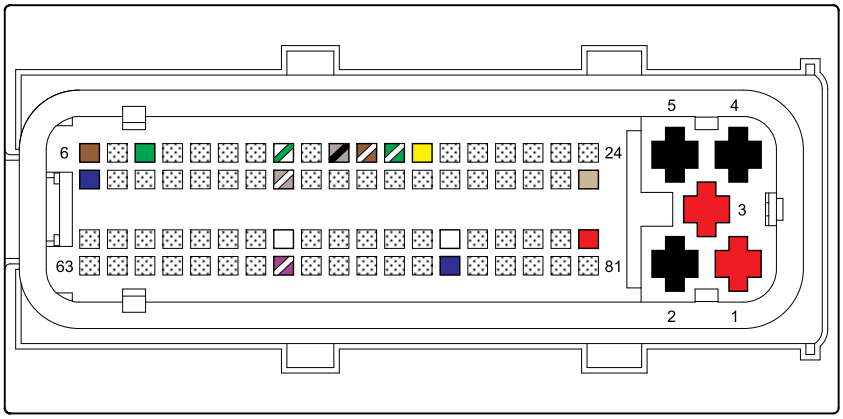
RIGHT TAILLIGHT CONNECTOR



G-130992-000038

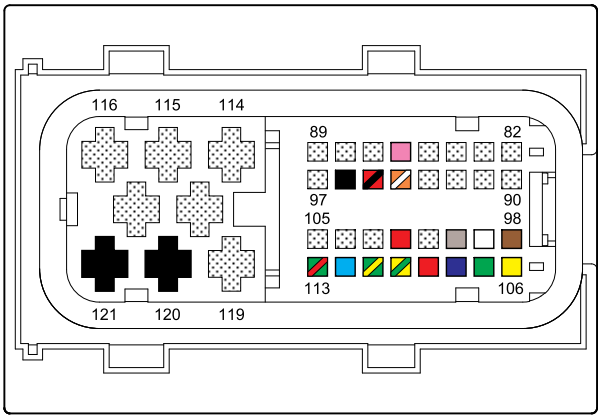
Pin	Wire Color	Description
1	Black	Ground
2	Yellow	12V Turn Signal from VCM
3	Brown	12V Taillight from VCM

VCM 81-PIN CONNECTOR



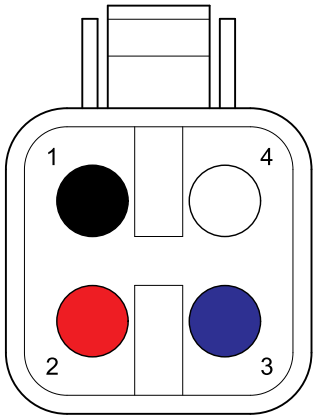
Pin	Wire Color	Description
1	Red	12V Battery (+)
2	Black	Ground
3	Red	12V Battery (+))
4	Black	Ground
5	Black	Ground
6	Brown	5V to Forward on FNR
8	Light Green	5V to MCOR 2-Pin Connector
13	White/Light Green	5V to Light Switch
15	Gray/Black	5V to Turn Signal Switch - Left
16	Brown/White	5V to Turn Signal Switch - Right
17	Green/White	5V to Brake Light Switch
18	Yellow	5V to MCOR 3-Pin Connector
25	Blue	5V to Reverse on FNR
32	Gray/White	5V to Horn
43	Tan	5V to Hazard Light Switch
51	White	5V to MCOR 3-Pin Connector
57	White	Main CAN bus High
62	Red	12V Key Switch ON to DC/DC 2-Pin Connector
70	Purple/White	Ground
76	Blue	Main CAN bus Low

VCM 40-PIN CONNECTOR



Pin	Wire Color	Description
86	Pink	5V Driver to Auxiliary CAN Connector
94	Orange/White	1A Multi-purpose buzzer
95	Red/Black	ACC Relay Coil on Fuse Block
96	Black	Ground to Front Lighting Connector
98	Brown	12V to Taillights
99	White	12V to Left Taillight
100	Gray	To Logo Light
102	Red	1A Front Right Turn Signal
106	Yellow	12V to Right Taillight
107	Green	Dash Display On/Off
108	Blue	1A Left Headlight
109	Red	ACC Relay Coil on Fuse Block
110	Yellow/Light Green	1A Left Daytime Run Light
111	Green/Yellow	1A Front Left Turn Signal
112	Light Blue	1A Right Headlight
113	Light Green/Red	1A Right Daytime Run Light
120	Black	Ground
121	Black	Ground

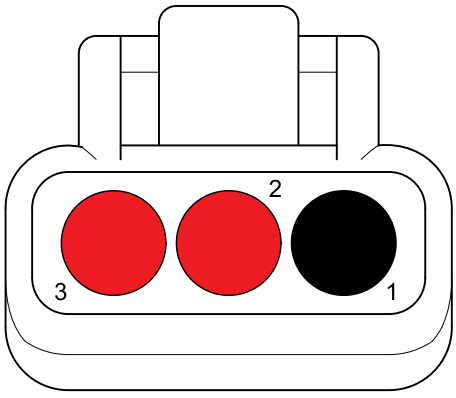
4–PIN VDU STRUT CONNECTOR



Pin	Wire Color	Description
1	Black	Ground
2	Red	48V Power
3	Blue	Main CAN bus Low
4	White	Main CAN bus High

Figure 12-71

3–PIN BLUETOOTH STRUT CONNECTOR



Pin	Wire Color	Description
1	Black	Ground
2	Red	12V Power
3	Red	12V Power

Figure 12-72

SECTION 13 — AC ELECTRIC VEHICLE - ELECTRICAL COMPONENTS

13

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

CHARGER RECEPTACLE

See General Warnings on page 1-2.

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.

CHARGER RECEPTACLE INSPECTION

Inspect the receptacle for cracks, loose connections and frayed wiring.

NOTE: *Disassembly of the charger receptacle, for the purpose of removal or installation, is not recommended.*

CHARGER RECEPTACLE REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the kick plate.
5. Disconnect the red wire (1) from the main solenoid **(Figure 13-1, Page 13-2)**.

NOTE: *Make a note of the wire routing.*

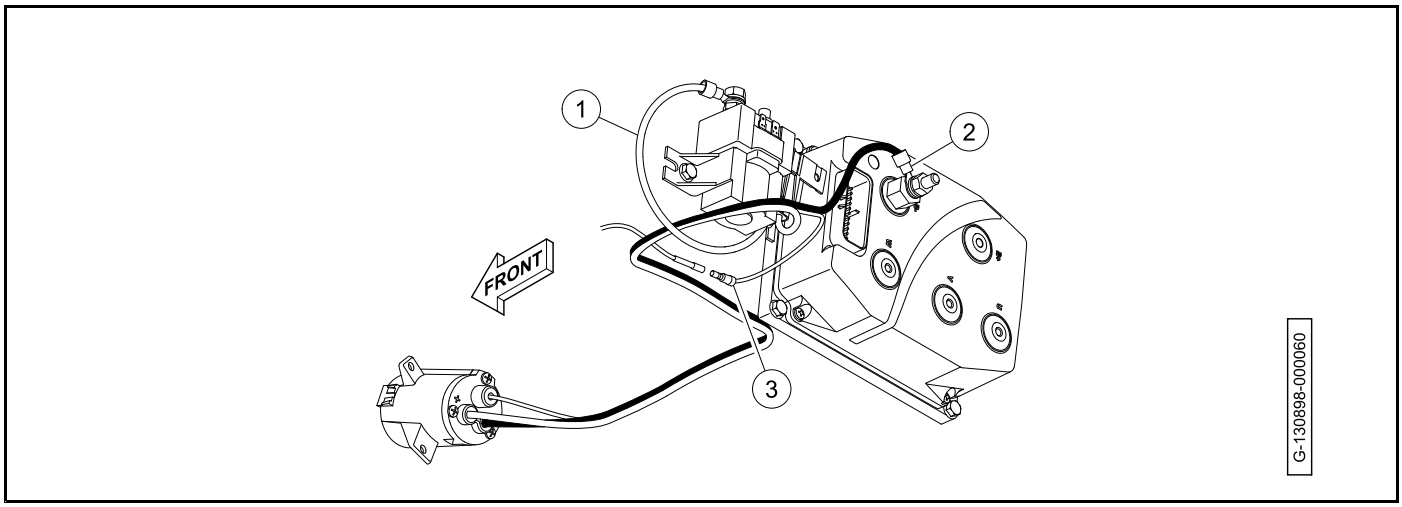


Figure 13-1

6. Remove the black wire (2) from the B- terminal on the Motor Control Unit (MCU).
7. Disconnect the light blue wire (3) from the green wire on the main harness.
8. Remove the screws (1) **(Figure 13-2)**.

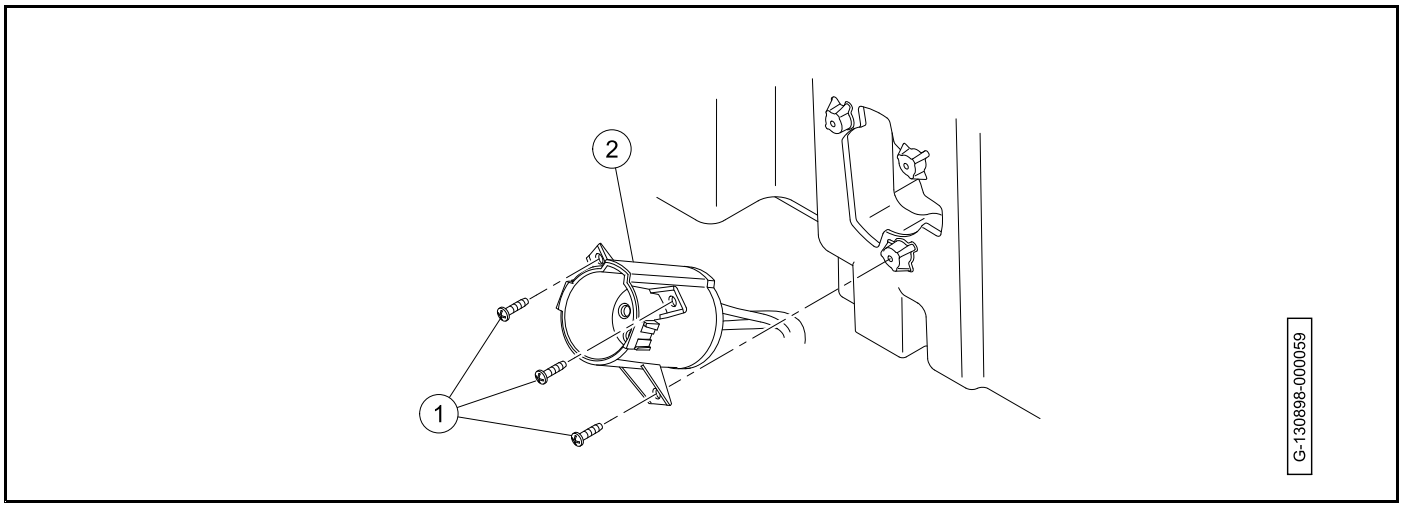


Figure 13-2

9. Remove the charger receptacle (2).

CHARGER RECEPTACLE INSTALLATION

1. Put the wires through the hole in the bucket.
2. Install the charger receptacle (2) in the bucket **(Figure 13-3)**.

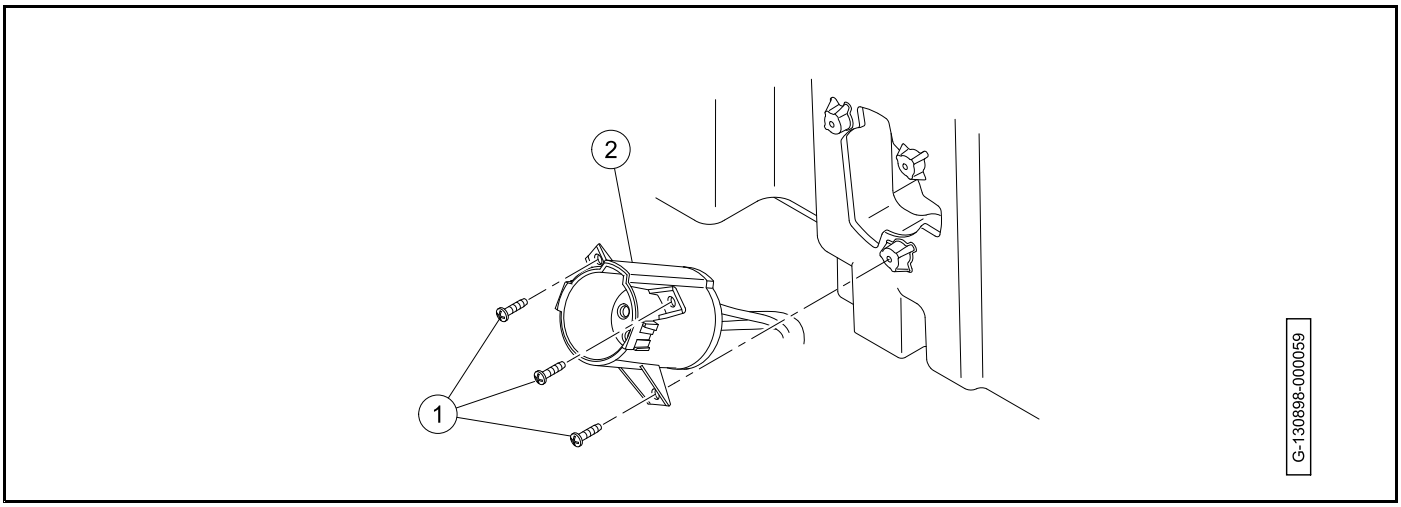


Figure 13-3

3. Install the screws (1). Tighten the screws to 16 lb·in (1.8 N·m).

CAUTION

- **Make sure that the routing of the wires is correct.**

4. Connect the red wire (1) to the main solenoid **(Figure 13-4)**. Tighten the nut between 72 to 84 lb·in (8 to 9.5 N·m).

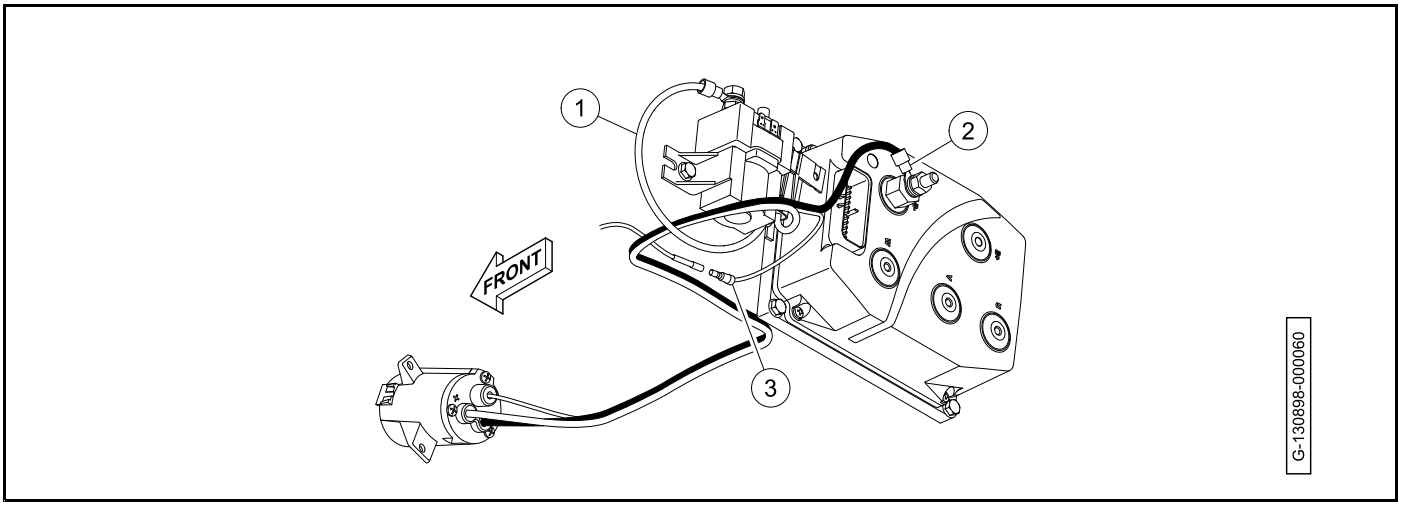


Figure 13-4

5. Connect the black wire (2) to the B- terminal on the Motor Control Unit (MCU). Tighten the screw to 35 lb·in (4 N·m).
6. Connect the light blue (3) to the green wire on the main harness.
7. Install the kick plate.
8. Connect the batteries
9. Set the Run/Tow switch to RUN.

CONTROLLER SHIELD

The electronics module cover needs to be removed to gain access to the 30A charger fuse, 10A DC/DC fuse, DC/DC relay, motor control unit (MCU), Run/Tow switch, and main solenoid.

CONTROLLER SHIELD REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the access panel.

CAUTION

- **Be careful not to break the two hooks on the bottom of the cover. Push the bottom of the cover up to release the hooks before pulling cover away from battery bucket.**

5. Lift the bottom of the controller shield (1) up and rearward to release the bottom two hooks (2) **(Figure 13-5, Page 13-4)**.

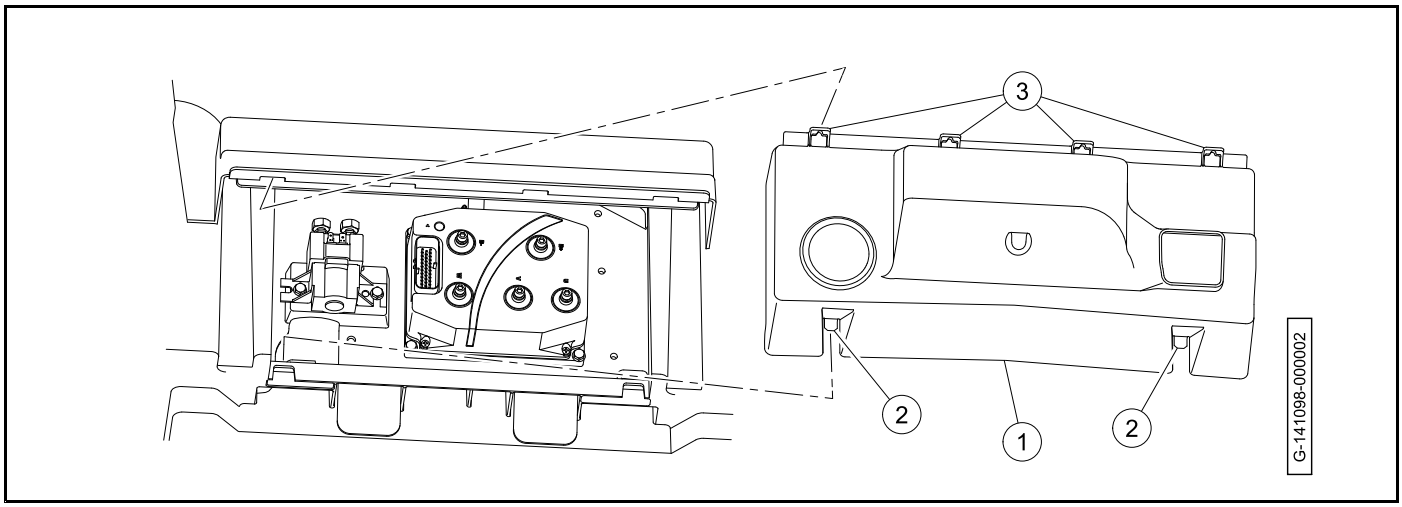


Figure 13-5 Controller Shield

6. Release the top four tabs (3) and remove the electronics module cover.

CONTROLLER SHIELD INSTALLATION

CAUTION

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

1. Install the top four tabs (3) of the controller shield (1) in the slots of the bucket.
2. Install the bottom two hooks (2)

3. Install the access panel.
4. Connect the batteries.
5. Set the Run/Tow switch to RUN.

DASH DISPLAY

The dash display operates when the key switch is set to ACC, ON, or when the battery is charging.

The backlight will dim when the headlight switch is on.

The dash display is on the main CAN bus system.

DASH DISPLAY REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the instrument panel.
5. Disconnect the electrical connector (1) **(Figure 13-6, Page 13-5)**.

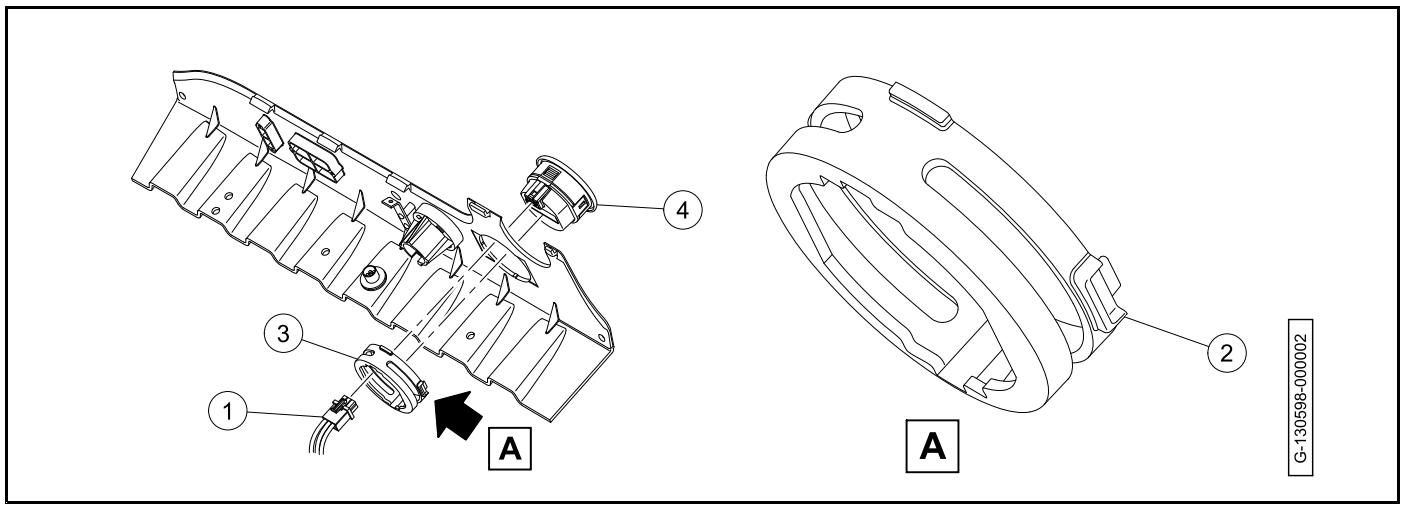


Figure 13-6 Dash Display

6. Push the tabs (2) on the retainer (3) in and remove from the dash display (4).
7. Remove the dash display.

DASH DISPLAY INSTALLATION

1. Install the dash display (4) into the instrument panel **(Figure 13-6, Page 13-5)**.
2. Install the retainer (3) onto the dash display.
3. Make sure that the tabs (2) fully engage.
4. Connect the electrical connector (1).
5. Install the instrument panel.

6. Connect the batteries.
7. Set the Run/Tow switch to RUN.

DC/DC CONVERTER

DC/DC CONVERTER REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Disconnect the electrical connectors (1) **(Figure 13-7, Page 13-6)**.

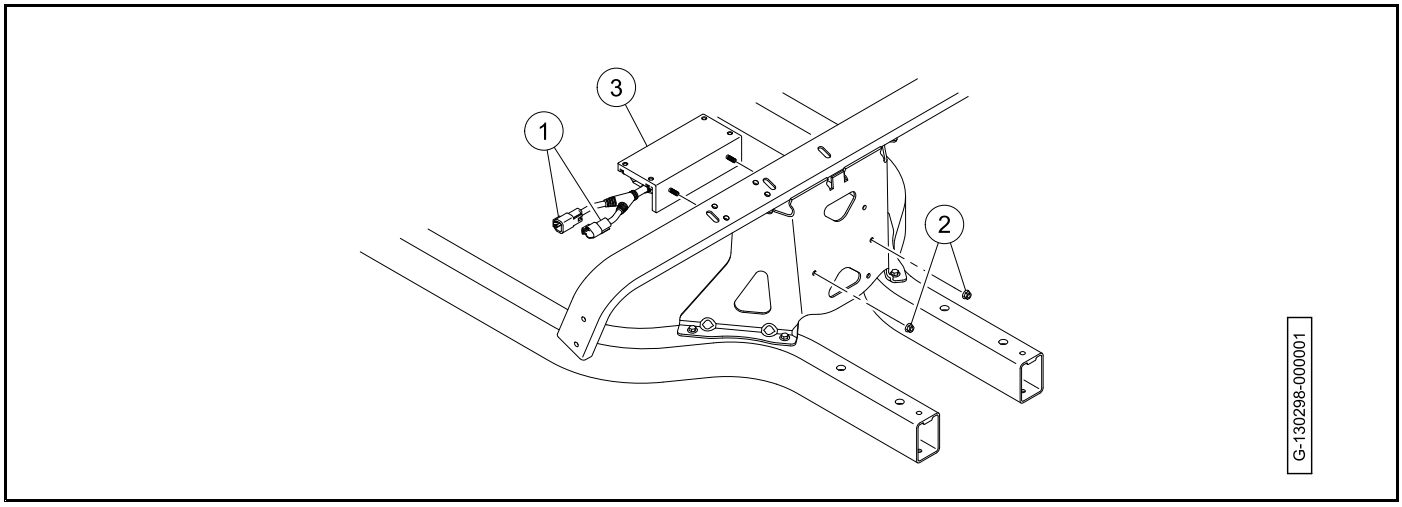


Figure 13-7 DC/DC Converter

5. Remove the nuts (2).
6. Remove the DC/DC converter (3).

DC/DC CONVERTER INSTALLATION

1. Install the DC/DC converter (3) on the vehicle **(Figure 13-7, Page 13-6)**.
2. Install the nuts (2). Tighten the nuts to 65 lb·in (7.3 N·m).
3. Connect the electrical connectors (1).
4. Connect the batteries
5. Set the Run/Tow switch to RUN.

DC/DC RELAY

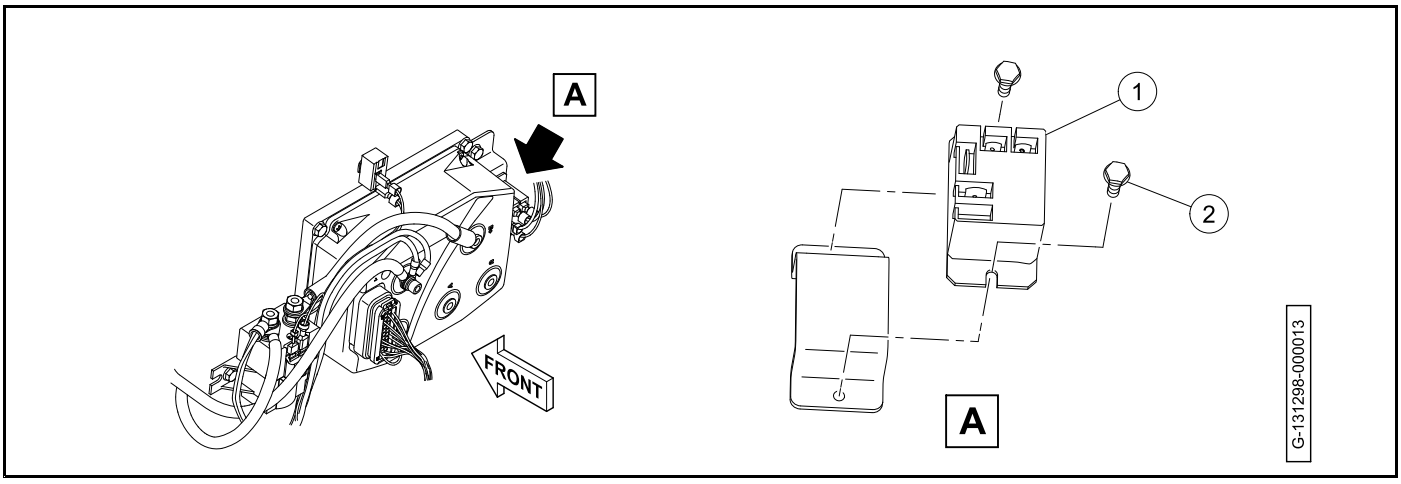


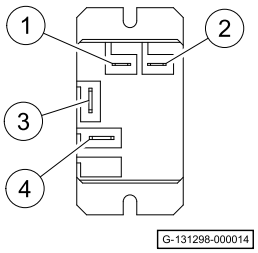
Figure 13-8

DC/DC RELAY REMOVAL

1. Disable the vehicle.
2. Disconnect the batteries and discharge the controller.
3. Remove the controller cover.
4. Disconnect the wires from the DC/DC relay (1) **(Figure 13-8)**.
5. Remove the screws (2) from the DC/DC relay.
6. Remove the DC/DC relay.

DC/DC RELAY INSTALLATION

1. Install the DC/DC relay (1) and screws (2) **(Figure 13-8)**. Tighten the screws from 8 to 10 in·lb (0.9 to 1.1 N·m).
2. Connect the wires to the DC/DC relay **(Figure 13-9)**.



Pin Description	Wire Color
1	Blue / White
2	Green

3	Light Blue
4	Orange / Blue

Figure 13-9

3. Install the controller cover.
4. Connect the batteries.

FORWARD/NEUTRAL/REVERSE SWITCH (FNR)

FORWARD/NEUTRAL/REVERSE SWITCH (FNR) REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the screws (1) **(Figure 13-10, Page 13-8)**.

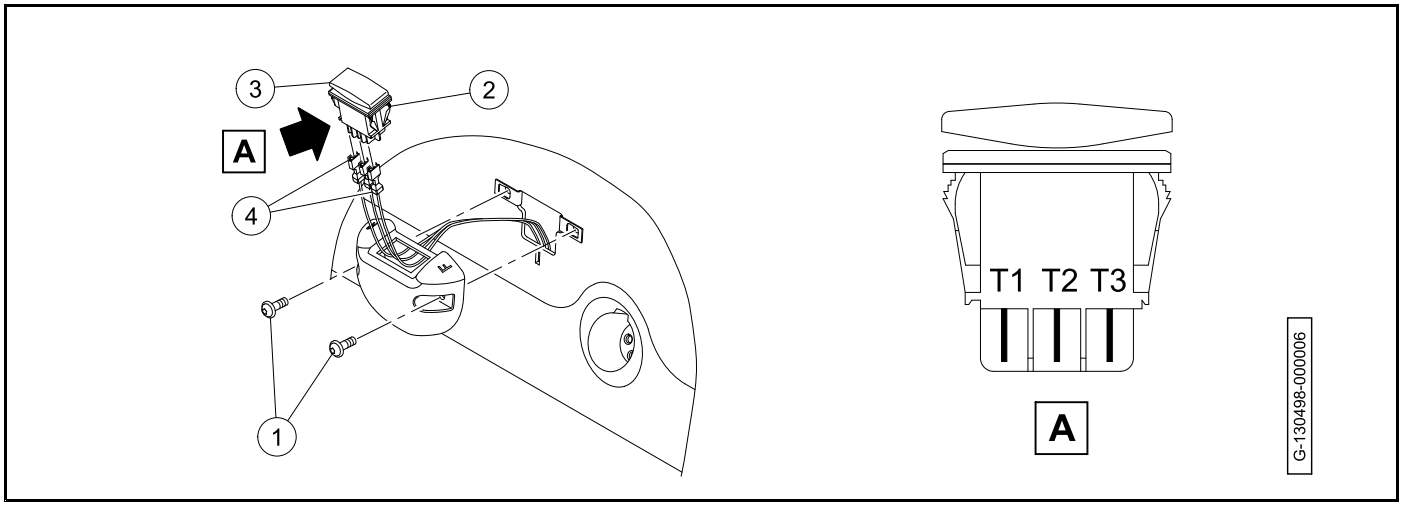


Figure 13-10 FNR Switch Removal

5. Push in on the locking tabs (2) and remove the rocker switch (3).
6. Disconnect the wires (4).

FORWARD/NEUTRAL/REVERSE SWITCH (FNR) INSTALLATION

1. Put the wires (4) through the housing **(Figure 13-11, Page 13-9)**.

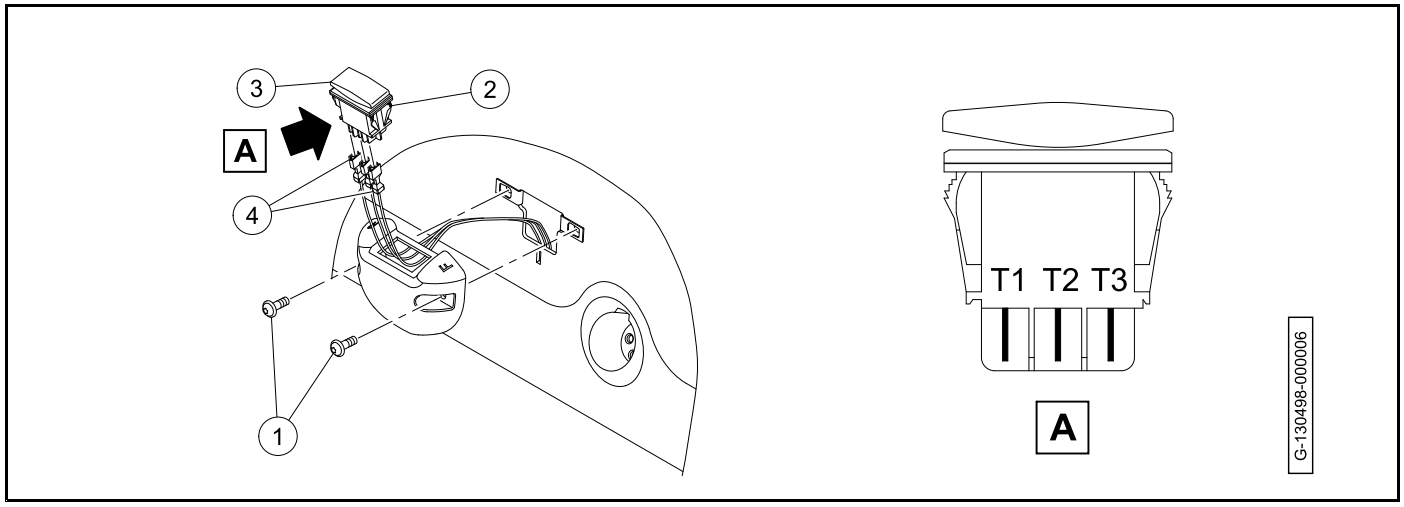


Figure 13-11 FNR Switch Installation

2. Make sure that the rocker switch terminals are towards the front of the vehicle.
3. Connect the blue wire to T1. **See graphic detail A.**
4. Connect the orange wire to T2.
5. Connect the brown wire to T3.
6. Push the rocker switch (3) into housing.
7. Make sure that the locking tabs (2) engage.
8. Install the housing with the screws (1). Tighten the screws to 20 lb·in (2.3 N·m).
9. Connect the batteries.
10. Set the Run/Tow switch to RUN.
11. Make sure that the vehicle operates correctly.

⚠ WARNING

- **Make sure that the vehicle operates in the forward direction when the Forward/Neutral/Reverse switch is in the FORWARD position.**
- **Make sure that the vehicle operates in the reverse direction when the Forward/Neutral/Reverse switch is in the REVERSE position. The multi-purpose buzzer will sound as a warning when the Forward/Neutral/Reverse switch is in REVERSE.**
- **Make sure that the vehicle does not operate when the Forward/Neutral/Reverse switch (FNR) is in the NEUTRAL position.**

HAZARD LIGHT SWITCH

HAZARD LIGHT SWITCH REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the instrument panel.
5. Disconnect the hazard switch wires (1) from the hazard light switch (2) **(Figure 13-12, Page 13-10)**.

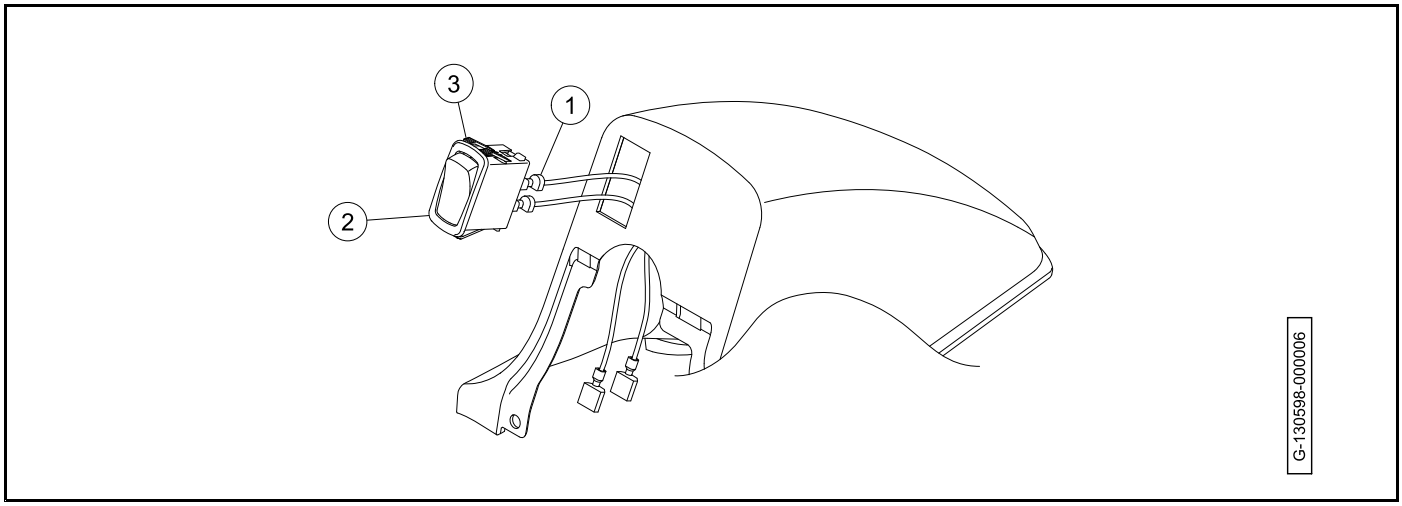


Figure 13-12 Hazard Light Switch

6. Push the lock tabs (3) on both sides and remove the hazard light switch.

HAZARD LIGHT SWITCH INSTALLATION

1. Connect the hazard switch wires (1) to the hazard light switch (2) **(Figure 13-12, Page 13-10)**.

NOTE: *Make sure that the hazard switch wires are connected to the lighting control harness.*

2. Push the hazard light switch into the dash.
3. Make sure that the locking tabs (3) engage.
4. Install the instrument panel.
5. Connect the batteries.
6. Set the Run/Tow switch to RUN.

HEADLIGHT SWITCH

HEADLIGHT SWITCH REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the instrument panel.
5. Disconnect the wires from the headlight switch.
6. Loosen the set screw (1) **(Figure 13-13, Page 13-11)**.

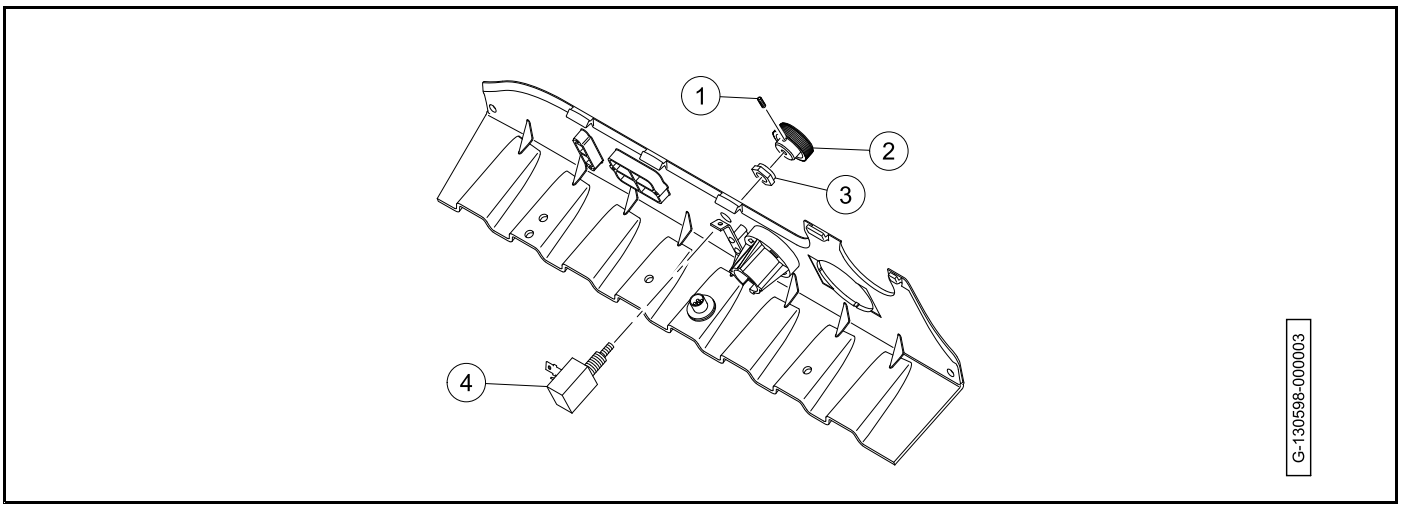


Figure 13-13 Headlight Switch

7. Remove the threaded knob (2).
8. Remove the nut (3).
9. Remove the headlight switch (4).

HEADLIGHT SWITCH INSTALLATION

1. Install the headlight switch (4) into the instrument panel **(Figure 13-13, Page 13-11)**.
2. Install the nut (3). Tighten the nut to 2.2 lb·in (0.25 N·m).
3. Install the threaded knob (2).
4. Tighten the set screw (1).
5. Install the blue/white and black wires onto the headlight switch terminals.
6. Install the instrument panel.
7. Connect the batteries
8. Set the Run/Tow switch to RUN.

KEY SWITCH

KEY SWITCH REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the instrument panel.
5. Make a note of the wire connections.
6. Disconnect the wires from the key switch.
7. Push on the retaining tabs and remove the key switch cap (1) **(Figure 13-14, Page 13-12)**.

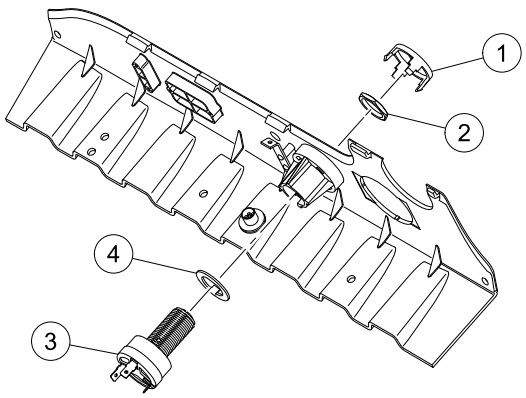


Figure 13-14 Key Switch

8. Remove the retaining nut (2).
9. Remove the key switch (3) and washer (4).

KEY SWITCH INSTALLATION

1. Install the washer (4) onto the key switch (3) **(Figure 13-14, Page 13-12)**.
2. Install the key switch into the instrument panel. Make sure that the key switch position is correct.
3. Install the retaining nut (2). Tighten the retaining nut to 40 lb·in (4.5 N·m).
4. Install the key switch cap (1). Make sure that the retaining tabs engage.
5. Connect the black wire to terminal B.
6. Connect the tan wire to terminal S.
7. Connect the blue/white wire to terminal I.
8. Install the instrument panel.
9. Connect the batteries.
10. Set the Run/Tow switch to RUN.

MAIN SOLENOID

MAIN SOLENOID REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the access panel.
5. Remove the controller shield.
6. Remove the nuts (1) and washers (2) **(Figure 13-15, Page 13-13)**.

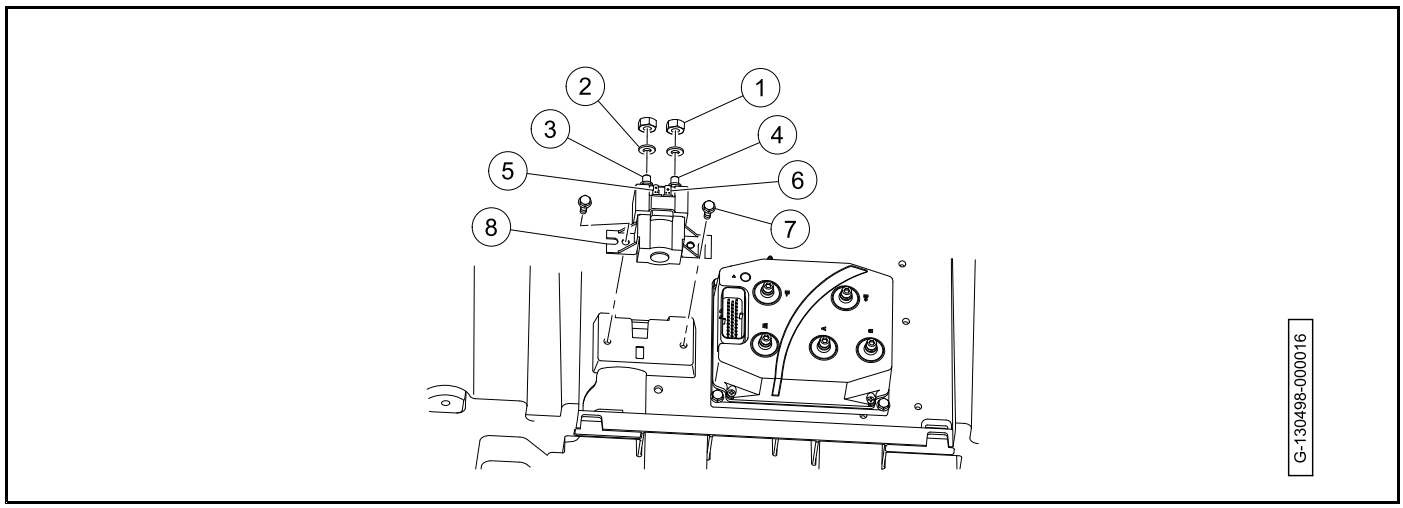


Figure 13-15 Main Solenoid Removal

7. Remove the wires from the main solenoid posts (3 and 4).
8. Disconnect the wires from the terminals (5 and 6).
9. Remove the screws (7).
10. Remove the main solenoid (8).

MAIN SOLENOID INSTALLATION

1. Install the main solenoid (8) with the screws (7) **(Figure 13-16, Page 13-14)**. Tighten the screws to 115 lb·in (13 N·m).

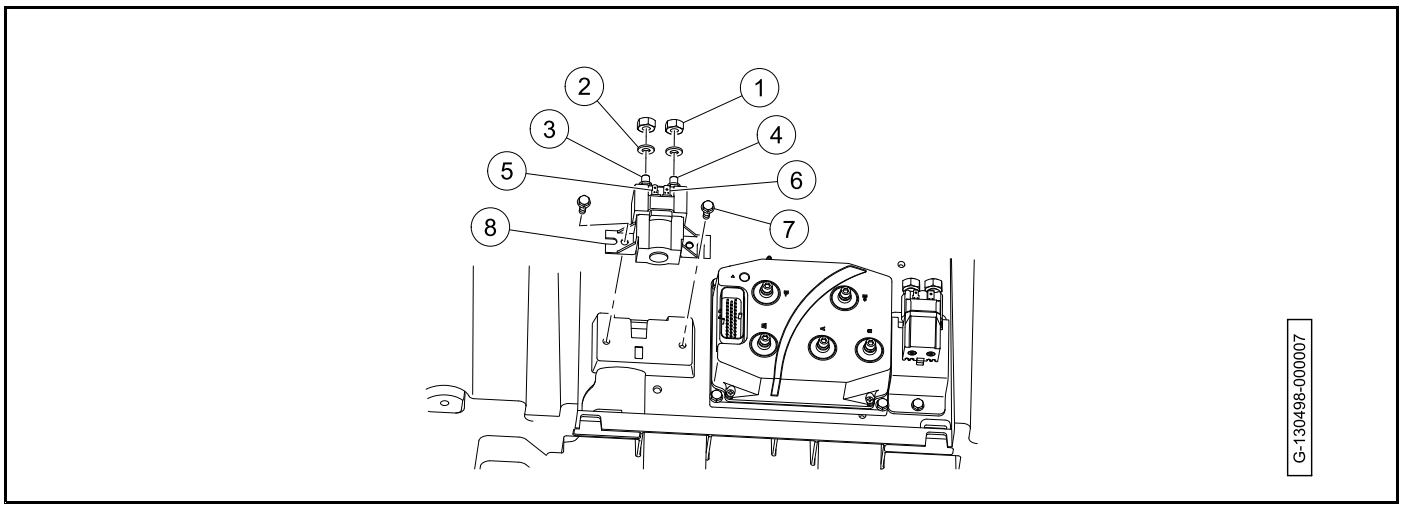


Figure 13-16 Main Solenoid Installation

2. Connect the 20 gauge light blue wire to the left terminal (5).
3. Connect the 20 gauge purple wire to the right terminal (6).
4. Install the 4 gauge orange wire from the motor control unit (MCU) on the right solenoid post (4).
5. Install the 4 gauge red wire, 4 gauge yellow wire, 10 gauge red wire, and 16 gauge red wire on the left solenoid post (3).

NOTE: *BATTERY POSITIVE is printed on the 4 gauge orange wire that connects to the left solenoid post.*

6. Install the washers (2) and nuts (1). Tighten the nuts to 84 lb·in (8 to 9.5 N·m).
7. Install the controller shield.
8. Install the access panel.
9. Connect the batteries
10. Set the Run/Tow switch to RUN.

MOTOR CONTROL UNIT (MCU)

MOTOR CONTROL UNIT (MCU) REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the access panel.
5. Remove the controller shield.
6. Make a note of the wire connections.
7. Remove the screws (1), nut (2), and washer (3) and wires from the motor control unit (MCU) (4) **(Figure 13-17, Page 13-15)**.

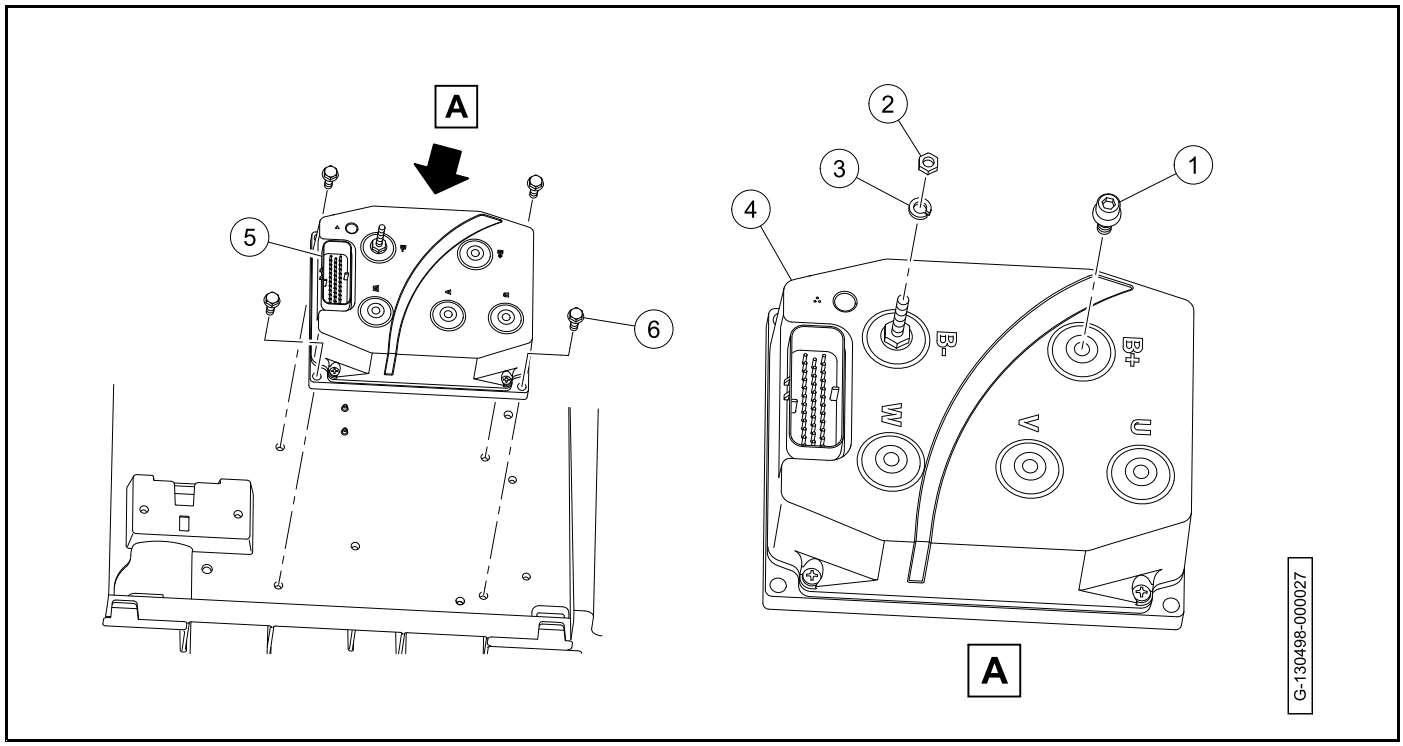


Figure 13-17 MCU Removal

8. Disconnect the CAN connector (5).
9. Remove the screws (6).
10. Remove the MCU (4).

MOTOR CONTROL UNIT (MCU) INSTALLATION

Before the motor control unit (MCU) is installed:

- The CAN bus must be fully functional.
- The components with software must have power.

CAUTION

- **Incorrect software versions can cause battery and vehicle damage. The CCDT app must be updated first.**

- Update the CCDT app.
- Make sure that the CCDT dongle has the latest software version.
- Make sure that the vehicle control module (VCM) has the latest software version.

To install the MCU:

1. Install the motor control unit (MCU) (4) with the screws (6). Tighten the screws to 115 lb·in (13 N·m) **(Figure 13-18, Page 13-16)**.

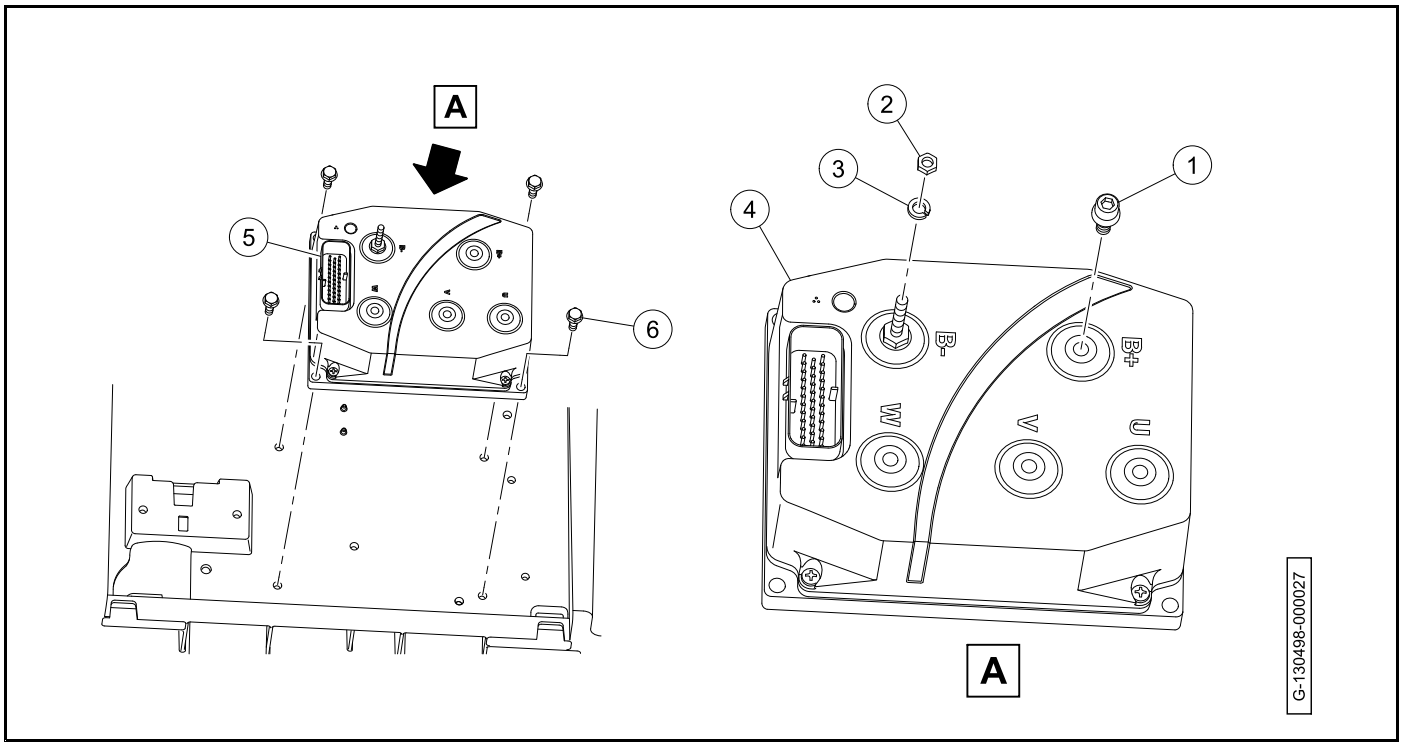


Figure 13-18 MCU Installation

2. Connect the CAN connector (5).
3. Install the wires with the screws (1).

3.1. Install the 4 gauge orange wire with the blue end to the W terminal. **See graphic detail A.**

3.2. Install the 4 gauge orange wire with the yellow end to the V terminal.

3.3. Install the 4 gauge orange wire with the white end to the U terminal.

3.4. Install the 4 gauge yellow wire from the main solenoid to the B+ terminal.

3.5. Tighten the screws (1) from 80.5 to 100 lb·in (9.1 to 11.3 N·m).

3.6. Install the two 10 gauge black wires and the 4 gauge black wire to the B- terminal with the nut (2) and washer (3). Tighten from 30.9 lb·in to 39.8 lb·in (3.5 N·m to 4.5 N·m).

NOTE: *If replacing the MCU it will be necessary to move the standoff on B- post over to new MCU. Tighten from 30.9 lb·in to 39.8 lb·in (3.5 N·m to 4.5 N·m).*

4. Install the controller shield.
5. Install the access panel.
6. Connect the batteries
7. Set the Run/Tow switch to RUN.
8. If a new MCU was installed, use the CCDT to update the MCU software.

MOTOR CONTROLLER OUTPUT REGULATOR (MCOR)

The pedal group includes a Motor Controller Output Regulator (MCOR) mounted on the side of the pedal group. The MCOR detects the position of the accelerator pedal and sends a corresponding voltage to the motor controller.

MCOR REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the pedal group.
5. Remove the screw (1) **(Figure 13-19, Page 13-18)**.

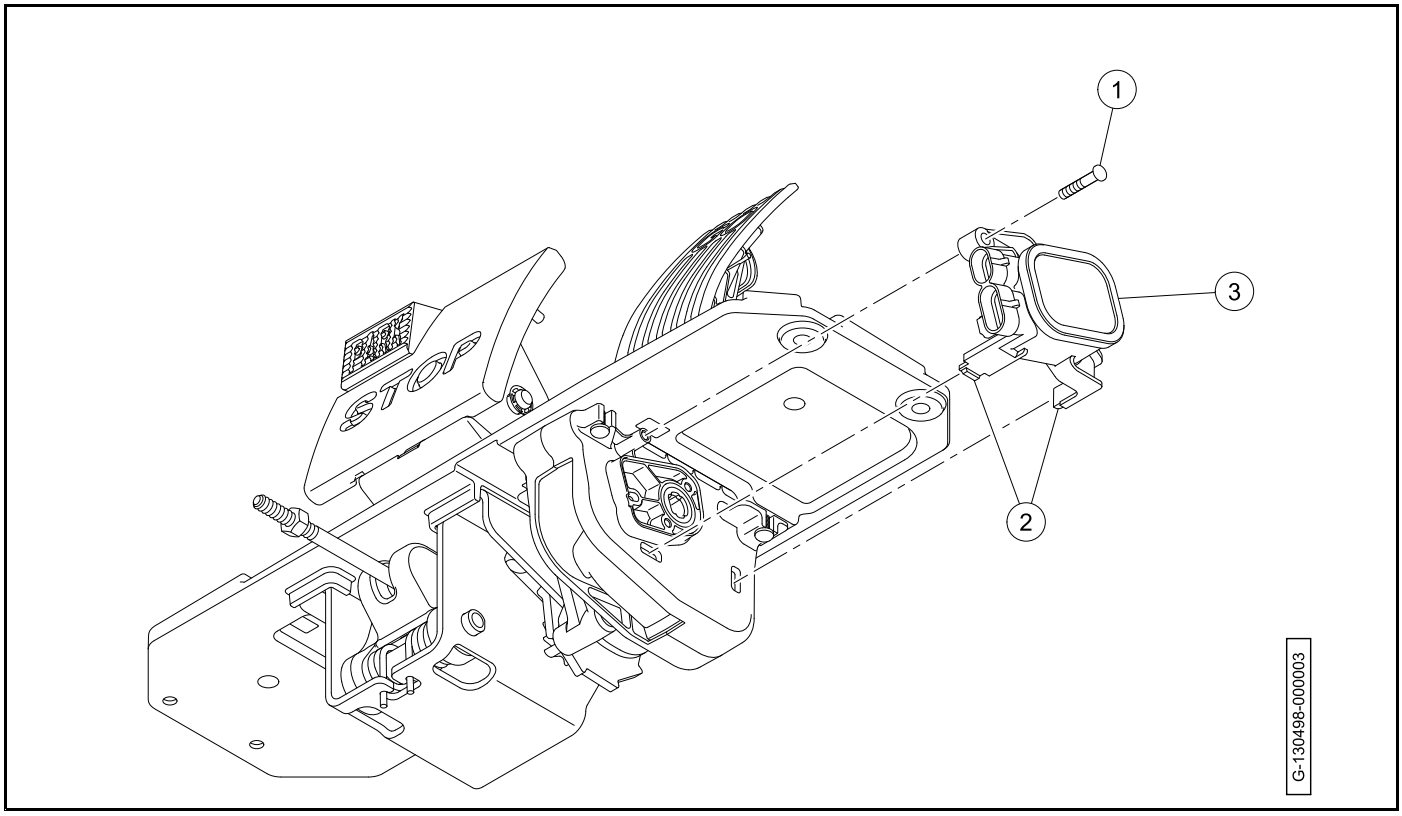


Figure 13-19 MCOR Removal

6. Disconnect the tabs (2) from the accelerator pedal and remove the motor controller output regulator (MCOR) (3).

MCOR INSTALLATION

1. Install the MCOR (3) onto the accelerator pedal **(Figure 13-20, Page 13-19)**.

NOTE: *Rotate the pedal back and forth if necessary to align the D-shaped end of shaft with the MCOR.*

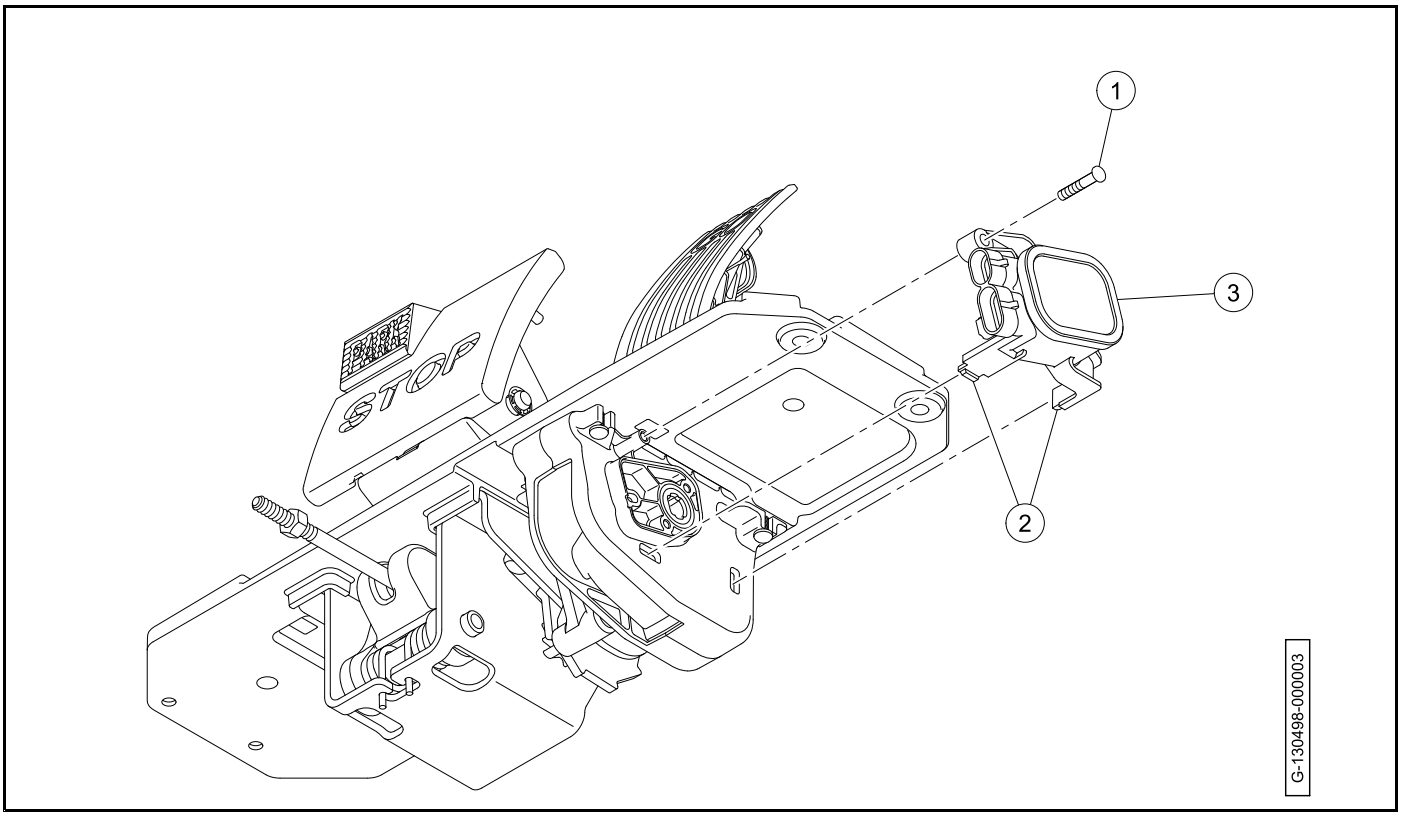


Figure 13-20 MCOR Installation

2. Make sure that the two tabs (2) engage.
3. Install the screw (1). Tighten the screw to 19 lb·in (2.1 N·m).
4. Install the pedal group.
5. Connect the batteries.
6. Set the Run/Tow switch to RUN.

MULTI-PURPOSE BUZZER

MULTI-PURPOSE BUZZER REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the instrument panel.
5. Disconnect the wires from the multi-purpose buzzer.
6. Remove the screws (1) **(Figure 13-21, Page 13-20)**.

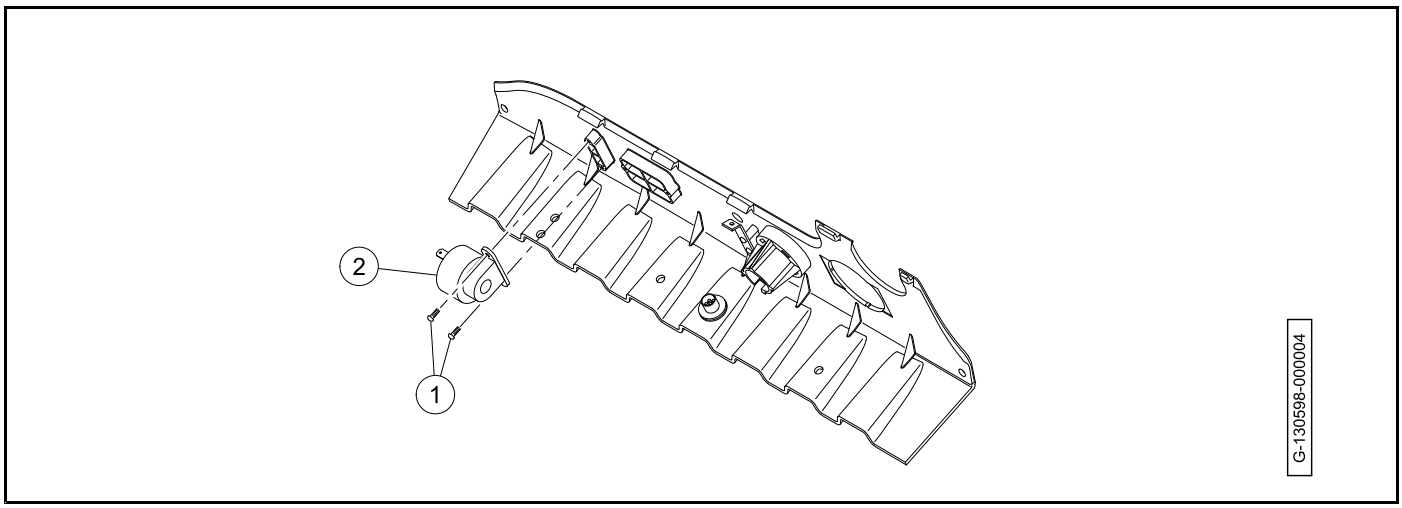


Figure 13-21 Multi-Purpose Buzzer

7. Remove the multi-purpose buzzer (2).

MULTI-PURPOSE BUZZER INSTALLATION

1. Install the multi-purpose buzzer (2) with the screws (1) **(Figure 13-21, Page 13-20)**. Tighten the screws to 4 lb·in (0.45 N·m).
2. Connect the orange/whtie wire to the positive (+) terminal.
3. Connect the black wire to the negative (-) terminal.
4. Install the instrument panel.
5. Connect the batteries.
6. Set the Run/Tow switch to RUN.

RUN/TOW SWITCH

RUN/TOWSWITCH REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the controller shield.
5. Disconnect the orange/blue wire (1) and white wire (2) **(Figure 13-22, Page 13-21)**.

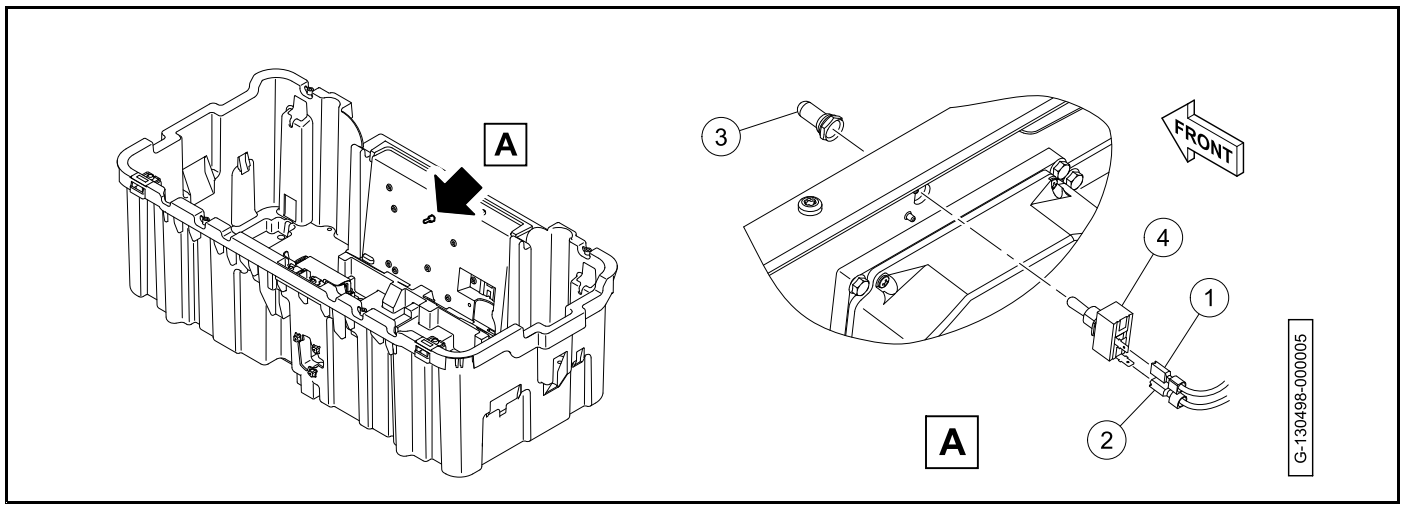


Figure 13-22 Run/Tow-Stow Switch

6. Remove the boot/nut (3).
7. Remove the Run/Tow switch (4).

RUN/TOW SWITCH INSTALLATION

1. Install the Run/Tow-Stow switch (4) **(Figure 13-22, Page 13-21)**.
2. Install the boot/nut (3). Tighten the boot/nut to 16 lb·in (1.8 N·m).
3. Connect the orange/blue wire (1).
4. Connect the white wire (2).
5. Connect the batteries
6. Set the Run/Tow switch to RUN.

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. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the instrument panel.
5. Disconnect the USB receptacle wires (1) **(Figure 13-23, Page 13-22)**.

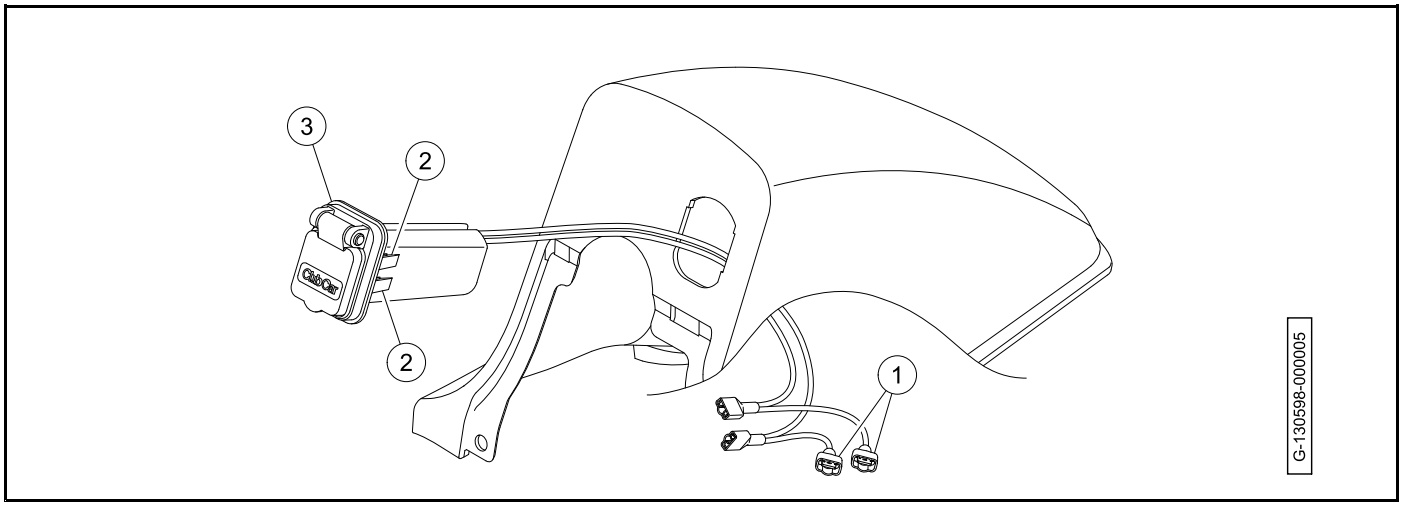


Figure 13-23 USB Receptacle

6. Push the lock tabs (2) on both sides and remove the USB receptacle (3).

USB RECEPTACLE INSTALLATION

1. Put the USB receptacle wires (1) into the dash **(Figure 13-23, Page 13-22)**.
2. Push the USB receptacle (3) into the dash.
3. Make sure that the locking tabs (2) engage.
4. Connect the orange/blue instrument panel wire to the red USB receptacle wire.
5. Connect the black instrument panel wire to the black USB receptacle wire.
6. Install the instrument panel.
7. Connect the batteries.
8. Set the Run/Tow switch to RUN.

VEHICLE CONTROL MODULE (VCM)

The VCM serves as the vehicle computer and the controller for all powered accessories.

VEHICLE CONTROL MODULE (VCM) REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Release the electrical connector levers (1) **(Figure 13-24, Page 13-23)**.

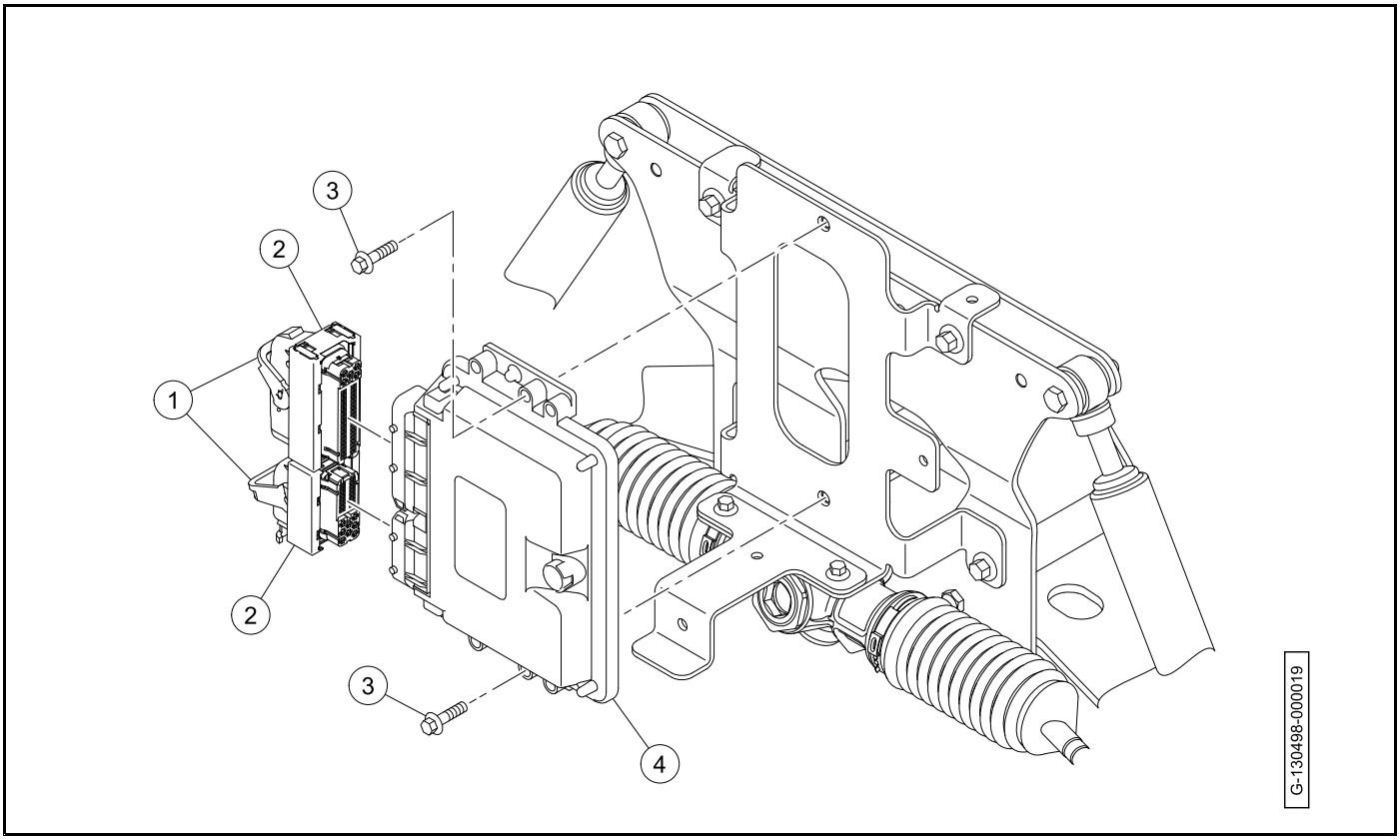


Figure 13-24 Vehicle Control Module (VCM) Removal

5. Disconnect the electrical connectors (2).
6. Remove the screws (3) from the VCM (4).
7. Remove the VCM (4) from the vehicle.

VEHICLE CONTROL MODULE (VCM) INSTALLATION

Before a VCM is installed:

1. Test the DC charger cord. Replace as necessary.

NOTE: *If the CAN bus is shorted to B+, it will cause the VCM to fail.*

2. Check for continuity between the CAN bus and BPV. Replace the harness as necessary.
3. Check the main harness at the 4-pin strut connector for damage. Replace the main harness as necessary.
4. Check the main harness near the battery for damage. Replace the main harness as necessary.
5. The CAN bus must be fully functional.
6. The components with software must have power.

CAUTION

- **Incorrect software versions can cause battery and vehicle damage. The CCDT app must be updated first.**

7. Update the CCDT app.
8. Make sure that the CCDT dongle has the latest software version.

To install the VCM:

1. Position the VCM (1) on the VCM mount **(Figure 13-25, Page 13-24)**.

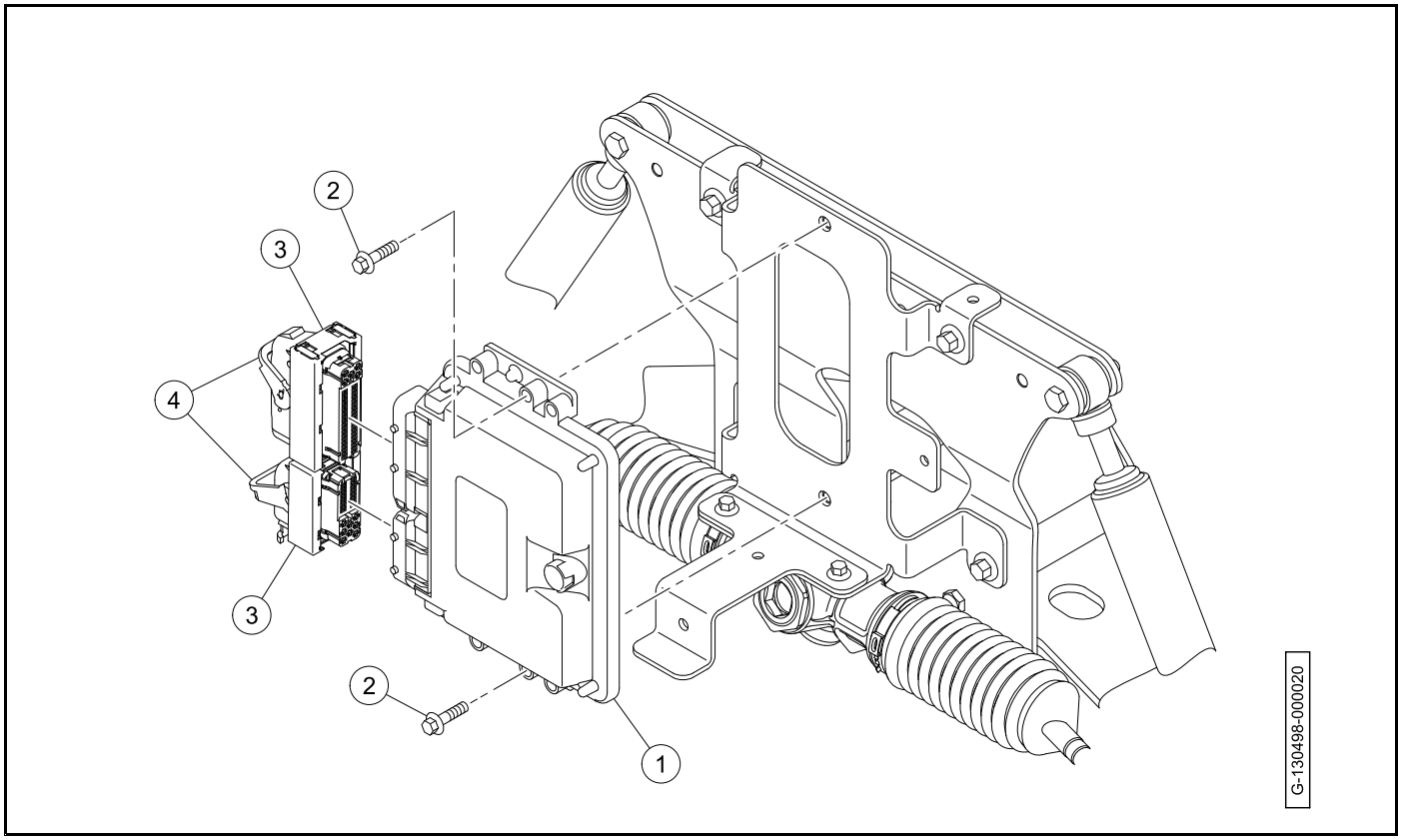


Figure 13-25 Vehicle Control Module (VCM) Installation

2. Install the screws (2). Tighten the screws between 6.6 to 8 lb·ft (9 to 11 N·m).
3. Connect the electrical connectors (3).
4. Engage the electrical connector levers (4).
5. Connect the batteries.
6. Set the Run/Tow switch to RUN.
7. If a new VCM was installed, use the CCDT to:

7.1. Update the VCM software.

VEHICLE CONTROL MODULE (VCM) MOUNT REMOVAL

1. Remove the VCM.
2. Remove the screws (1) and the VCM mount (2) **(Figure 13-26, Page 13-26)**.

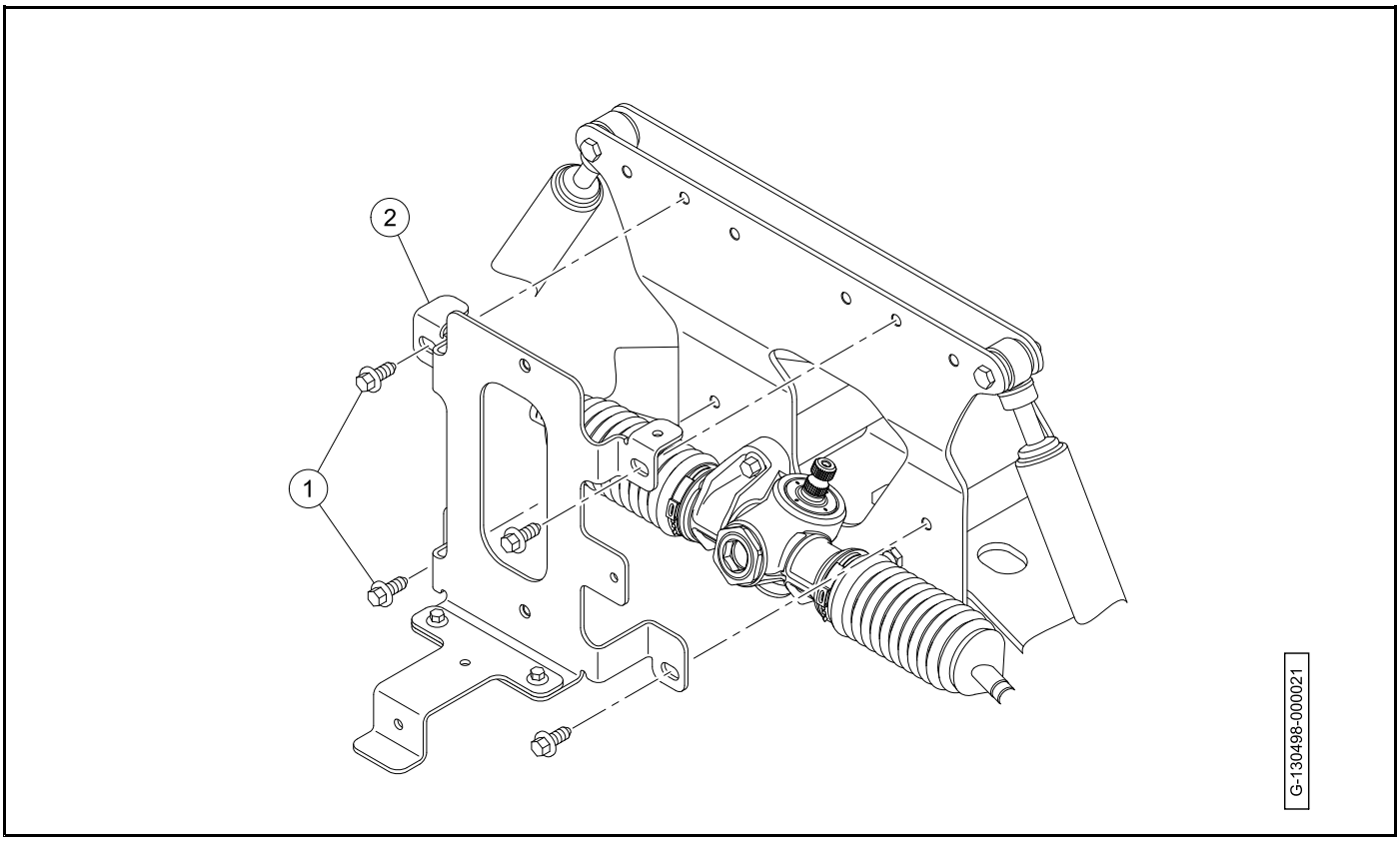


Figure 13-26 Vehicle Control Module (VCM) Mount

VEHICLE CONTROL MODULE (VCM) MOUNT INSTALLATION

1. Position the VCM mount (2) on the front shock bracket **(Figure 13-26, Page 13-26)**.
2. Install the screws (1). Tighten the screws between 11.7 to 14.2 lb·ft (15.8 to 19.2 N·m).

SECTION 14 — AC ELECTRIC VEHICLE - BATTERIES

14

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

⚠ 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 14-11.**

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 WIRING DIAGRAM

The battery cables are all 4-gauge.

- **(A)** - To the B- terminal on the motor control unit (MCU)
- **(B)** - To the main solenoid

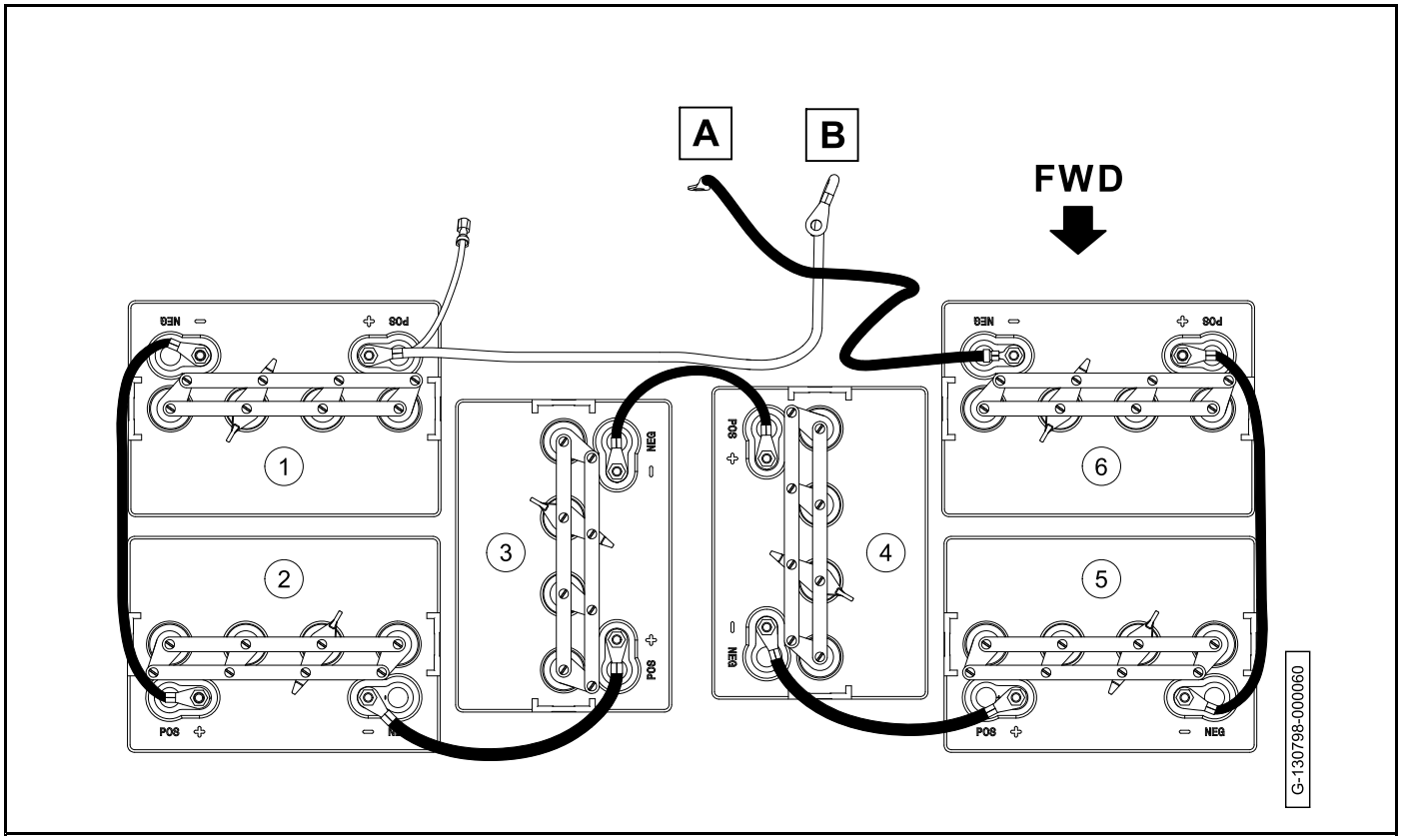


Figure 14-1 Battery Wiring Diagram

BATTERY TESTING BASICS – 8 VOLT

See General Warnings on page 1-2.

OBSERVATION

Inspect the battery compartment for the following items:

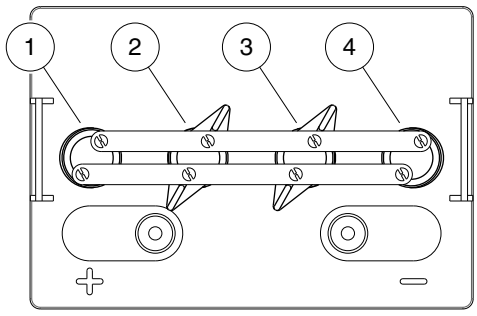
- Rusted, corroded, or broken battery posts
- Rusted, corroded, loose or broken wires
- Low or overfilled electrolyte levels
- Cracked, punctured, or bulging battery cases
- Loose, over-tightened, missing, or improperly placed battery hold-downs

- 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)

2739

Figure 14-2 Battery Cell Numbering – 8 Volt

BATTERY TESTING – 8 VOLT

See General Warnings on page 1-2.

Three tests have been developed to help diagnose problems with batteries that have not performed as expected. Because each test becomes progressively more detailed and time-consuming, begin with the first test and proceed with each additional test until the problem has been identified.

FULLY CHARGE BATTERIES TEST

NOTE: *Make sure the hardware securing battery cable terminals to battery posts is tightened to the specified torque.* ***See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.***

The easiest way to monitor the condition of a vehicle's batteries is simply to observe the reading at the end of the charge cycle and record the voltage of the battery set. After a full charge, disconnect the charger DC plug, wait 20 to 30 seconds and reconnect the charger DC plug. Wait approximately 10 to 20 minutes until battery set voltage rises above 56 volts and then record the battery set voltage readings (to the nearest 0.1 for volts).

- If the reading is above 56.0 volts, proceed to the Hydrometer Test.
- For all other readings, check the battery charger for proper output and operation. Recharge the batteries and repeat the Fully Charge Batteries Test.
- If after repeated attempts the charger does not go over 56.0 volts, record the test values as measured and proceed to the Hydrometer Test.

HYDROMETER TEST

NOTE: *Specific gravity is dependent on electrolyte temperature. Note and record electrolyte temperature of each cell before performing the Hydrometer Test. Use these temperature measurements to determine Corrected Specific Gravity.* ***See Hydrometer Calibration on page 14-5.***

A hydrometer or digital refractometer measures the specific gravity of the battery's electrolyte. The higher the specific gravity, the higher the state of charge of the batteries. A fully charged battery should read between 1.250 and 1.280 at 80 °F (26.7 °C). Never add acid to batteries to obtain a higher specific gravity. **See following CAUTION.**

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.**

IMPORTANT: Be sure batteries have sufficient electrolyte to cover plates by approximately 1/2 inch (13 mm) and are fully charged prior to beginning test. If electrolyte level is insufficient to obtain valid readings, add only enough distilled water to cover the plates, then recharge the batteries and proceed to the Discharge Test.

Performing the Hydrometer Test

1. Remove the vent caps.
2. If using the digital refractometer , follow manufacturer's directions. If using the hydrometer , proceed with the following steps.

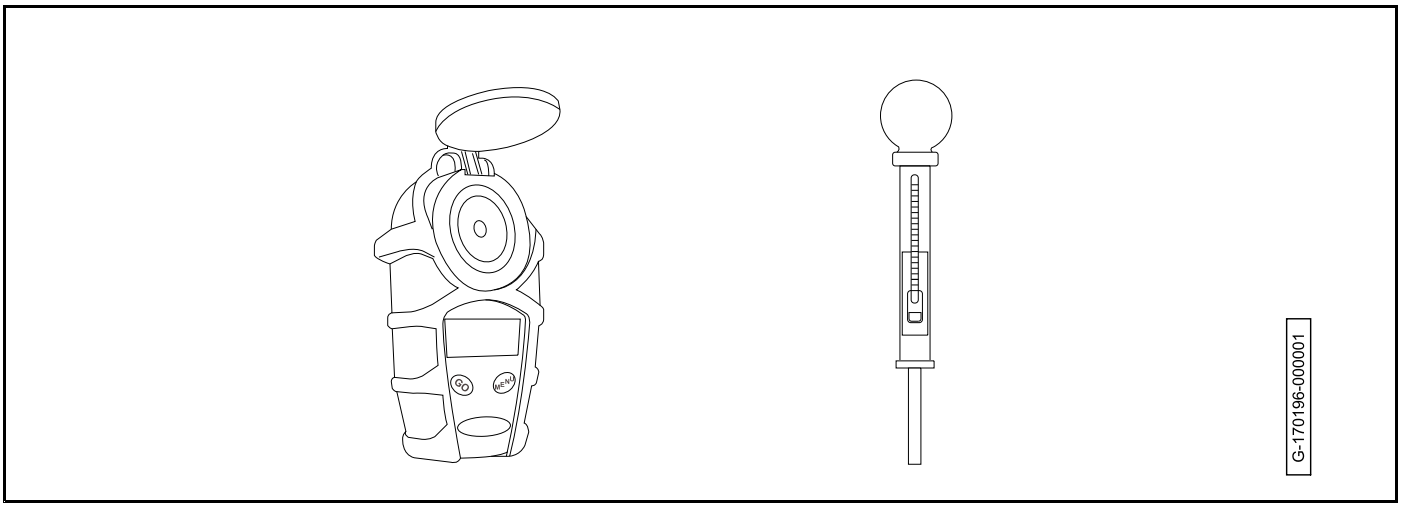


Figure 14-3 Hydrometer and Refractometer

3. Using a battery thermometer, record electrolyte temperature of each cell.
4. Squeeze the rubber bulb of the hydrometer and insert into the cell. Slowly release the bulb, drawing electrolyte up into the glass tube of the hydrometer.
5. When the float rises off the bottom, adjust the electrolyte level so that the float rides free of the bottom but does not strike the top of the glass tube. Remove the hydrometer from the cell and release the pressure from the bulb.
6. Hold the hydrometer vertically, ensuring that the float is not touching the sides of the barrel. Hold the hydrometer at eye level and read the scale at the level of electrolyte.
7. Record the specific gravity reading and return the electrolyte to the cell from which it was taken.
8. Repeat steps 3 through 7 on all remaining cells.
9. Replace vent caps.
10. Using the electrolyte temperature readings from step 3, correct the specific gravity readings for temperature Hydrometer Calibration .

Hydrometer Calibration

Most hydrometers are calibrated to read correctly at 80 °F (26.7 °C). The readings obtained as described above must be corrected for temperature. For each 10 °F (5.6 °C) above 80 °F (26.7 °C), add 0.004 to the reading. For each 10 °F (5.6 °C) below 80 °F (26.7 °C), subtract 0.004 from the reading.

Interpreting the Results of the Hydrometer Test

If an entire battery set has specific gravity readings below 1.250, the batteries are undercharged. Recharge batteries and repeat Hydrometer Test. If all specific gravity readings are still below 1.250 after recharge, the batteries are damaged.

If any single battery cell has specific gravity of 1.140 or less, replace the battery.

For all other specific gravity readings, proceed to the Discharge Test.

EXAMPLE OF A HYDROMETER TEST								
VEHICLE NO.	BATTERY NO.	ELECTROLYTE TEMPERATURE	CORRECTION FACTOR	CORRECTED SPECIFIC GRAVITY				REQUIRED ACTION
				CELL 1	CELL 2	CELL 3	CELL 4	
12	1	20 °F (-6.6 °C)	– 0.024	1.275 – 0.024 = 1.251	1.280 – 0.024 = 1.256	1.280 – 0.024 = 1.256	1.280 – 0.024 = 1.256	Strong Battery – Fully Charged
35	6	90 °F (32.2 °C)	+ 0.004	1.155 + 0.004 = 1.159	1.165 + 0.004 = 1.169	1.160 + 0.004 = 1.164	1.165 – 0.004 = 1.169	Discharged Battery – Recharge
69	5	80 °F (26.7 °C)	0.000	1.250 – 0 = 1.250	1.255 – 0 = 1.255	1.230 – 0 = 1.230	1.250 – 0 = 1.250	Weak no. 3 Cell – Catch-up Charge
38	2	100 °F (37.8 °C)	+ 0.008	1.200 + 0.008 = 1.208	1.180 + 0.008 = 1.188	1.170 + 0.008 = 1.178	1.180 + 0.008 = 1.188	Discharged Battery – Recharge and Recheck
22	4	80 °F (26.7 °C)	0.000	1.240 – 0 = 1.240	1.245 – 0 = 1.245	Float does not rise	1.250 – 0 = 1.250	no.3 Cell Dead – Replace Battery

DISCHARGE TEST

NOTE: *Discharge time is dependent on electrolyte temperature. Note and record electrolyte temperature before performing the Discharge Test. Calculate the Discharge Time to Shut-Off Point for the specific set of batteries being tested.* ***See Calculate the Discharge Time to Shut-Off Point Reference Table on page 14-7.***

The discharge test comes closest to simulating actual vehicle operating conditions by continuously drawing current from the batteries until voltage drops to 42.0 volts.

The discharge test is the hardest test on the batteries and the most time-consuming to perform. Use the battery discharge tester (CC P/N 101831901).

IMPORTANT: Be sure batteries have sufficient electrolyte to cover plates by approximately 1/2 inch (13 mm) and are fully charged prior to beginning test. If electrolyte level is insufficient to obtain valid readings, add only enough distilled water to cover the plates, then recharge the batteries before proceeding with the Discharge Test.

Performing the Discharge Test

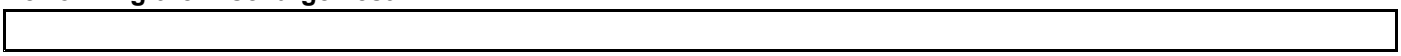


Figure 14-4 Discharge Test

1. Be sure the batteries are fully charged and that the electrolyte level is correct in all cells.
2. Using a battery thermometer (CC P/N 1011767), record electrolyte temperature of cell no. 2 (second cell from positive post) in each battery.
3. Connect the tester leads to the positive (+) post of battery no.1 and negative (–) post of battery no. 6 .
4. Reset discharge tester. Turn the tester ON and record the start time. Allow tester to run until the automatic shut-off time (based on electrolyte temperature reference table on page 14-7) is nearly reached.
5. Set the discharge tester to function 3 and check battery set voltage. Check battery set voltage every 10 minutes throughout the rest of the test. As soon as the battery set voltage reaches 0.5 volt above the automatic shut-off point (42.0 volts), use a multimeter to measure and record the voltage of each battery to the nearest 0.01 volt. **See following NOTE.**

NOTE: *Make certain that discharged battery voltages are taken with the battery discharge tester running. The tester will shut off at 42.0 volts. DO NOT record battery voltages with discharge tester OFF. This can easily be done by recording individual battery voltages once the discharge machine reaches 42.5 volts.*

Calculate the Discharge Time to Shut-Off Point Reference Table

ELECTROLYTE TEMPERATURE	DISCHARGE TIME TO SHUT-OFF POINT	ELECTROLYTE TEMPERATURE	DISCHARGE TIME TO SHUT-OFF POINT
40 to 49 °F (4 to 9 °C)	40 Minutes	85 to 89 °F (29 to 32 °C)	64 Minutes
50 to 59 °F (10 to 15 °C)	45 Minutes	89 to 99 °F (32 to 37 °C)	66 Minutes
60 to 64 °F (16 to 18 °C)	50 Minutes	100 to 109 °F (38 to 43 °C)	68 Minutes
65 to 69 °F (18 to 21 °C)	54 Minutes	110 to 119 °F (43 to 48 °C)	70 Minutes
70 to 74 °F (21 to 23 °C)	57 Minutes	120 to 129 °F (49 to 54 °C)	72 Minutes

continued on next page

ELECTROLYTE TEMPERATURE	DISCHARGE TIME TO SHUT-OFF POINT	ELECTROLYTE TEMPERATURE	DISCHARGE TIME TO SHUT-OFF POINT
75 to 79 °F (24 to 26 °C)	60 Minutes	130 to 150 °F (54 to 66 °C)	74 Minutes
80 to 84 °F (27 to 29 °C)	62 Minutes	Not Applicable	Not Applicable

Interpreting Discharge Test Results

1. If discharge time is 60 minutes** or higher, the batteries are performing properly.
2. If discharge time is less than 60 minutes**, replace batteries below 6.7 volts.

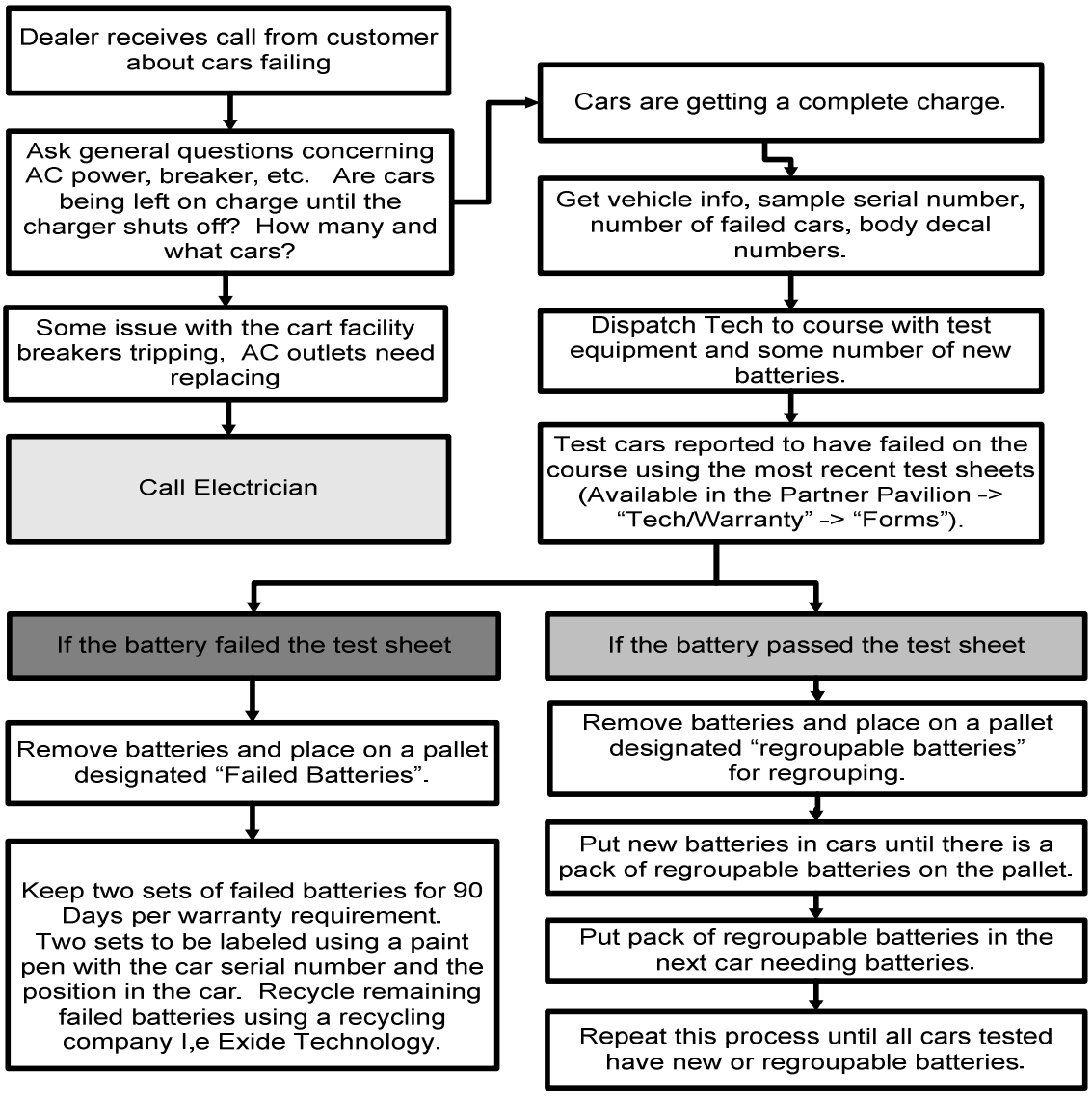
*** Refer to the Discharge Time to Shut-Off Point reference table for temperature-corrected discharge times.*

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.**

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Figure 14-5 Battery Regrouping Process Flow

BATTERY REPLACEMENT

See General Warnings on page 1-2.

⚠ 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 1-4.** 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 14-8.**
6. Install regrouped or new batteries in the proper orientation . 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 lb·in (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 1-2.

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 Method

- **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.

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
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

TABLE CONTINUED ON NEXT PAGE

IMPURITY	ALLOWABLE CONTENT (PARTS PER MILLION)	EFFECTS OF IMPURITY
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

BATTERY CARE – VEHICLES EQUIPPED WITH THE OPTIONAL 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. For 8-volt batteries, tighten hold-down retaining nuts to 106 lb·in (12 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 could 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 14-13. See Watering Batteries with the SPWS on page 14-15.**

CAUTION

- **The watering interval must adequately maintain the electrolyte level above the top of the plates. See (Figure 14-6, Page 14-14).**
- **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 equipped with the Single-Point Watering System (SPWS), 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 10-4.** 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. 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. For 8-volt batteries, tighten hold-down retaining nuts to 106 lb·in (12 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 could 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).

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 14-15.**

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.**

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.

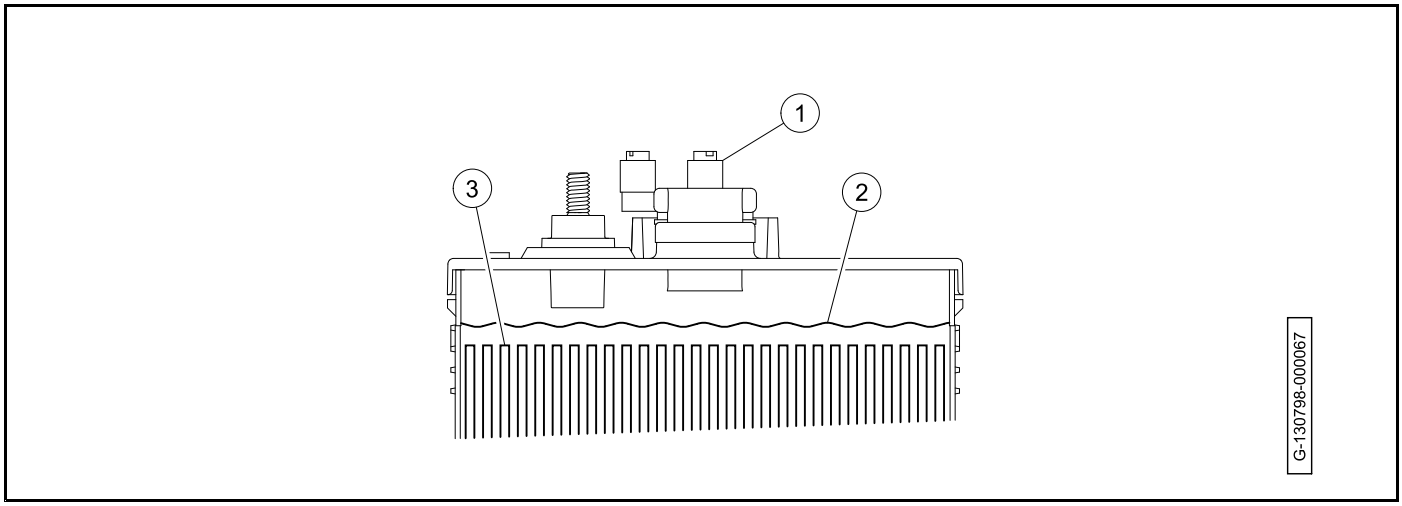


Figure 14-6 Electrolyte Level

The electrolyte level should be checked weekly to be sure electrolyte is at its proper level **(Figure 14-6, Page 14-14)**. 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 14-10.** 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 14-10.**

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 14-11. 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 14-11.***

WATERING BATTERIES WITH THE SPWS

Refer to the instructions included with the hand pump kit.

BATTERY STORAGE

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 — AC ELECTRIC VEHICLE - BATTERY CHARGER 15

See General Warnings on page 1-2.

⚠ 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.**
- **Modern Carbon Monoxide (CO) detectors come equipped with sensors that can detect and alert at gas levels below 2%. Make sure proper ventilation is used when charging batteries.**

⚠ 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.**
- **Each charger should have its own dedicated 15 or 20 ampere separately protected (circuit breaker or fuse) single phase branch circuit, in accordance with all applicable electrical codes for the location.**

CAUTION

- **Study all general information and DANGER, WARNING, CAUTION, and NOTE statements in the Battery Charger section.**
- **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.**
- **Before charging batteries, turn off all accessories on the vehicle.**
- **If using an onboard charger, be sure the AC plug is unplugged from the outlet before attempting to drive the vehicle.**
- **Be sure the AC cord is properly wound up on the reel before driving the vehicle.**

GENERAL INFORMATION

CAUTION

- **Study all general information and DANGER, WARNING, CAUTION, and NOTE statements in the Battery Charger section.**

This section includes information, troubleshooting, and service procedures pertaining to the external and onboard battery chargers. Do not attempt to service a battery charger that has not been properly identified. If a battery charger cannot be properly identified, contact your local Club Car dealer or distributor.

The battery charger has no internal parts or components to service or repair. It only has a few external repairs that can be performed. If an internal component needs repair, the battery charger must be replaced.

Because the battery charger has a storage charge feature that automatically checks and recharges the battery as necessary, the battery charger can remain plugged to the vehicle throughout the storage period.

The 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 battery charger is programmed with a specific charge algorithm that is appropriate to the specific battery type used in the vehicle. When the AC cord is connected, the battery 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 battery charger supplied with the vehicle resolves the most common problems associated with battery charging. The battery 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.

The battery should never be left in a discharged state, as this too affects the internal components and can reduce the capacity of the battery. The battery should be charged every day they are used. However, the battery should not be charged if they have not been used.

IC 650 BATTERY CHARGER SPECIFICATIONS

MANUFACTURER INFORMATION	
Manufacturer	Delta Q Technologies
Model Name	ERIC
Model Number	IC650-048-CC - without display IC650-048-COMM - with display
DIMENSIONS AND WEIGHT	
Length	9.9 in (25.1 cm)
Width	7.3 in (18.5 cm)
Height	3.1 in (7.9 cm)
Weight	5.3 lb (2.4 kg)
OPERATIONAL TEMPERATURE	
Temperature Range	-40° F to 104° F (-40° C to 40° C)
AC INPUT	
Voltage	85 to 270 VAC minimum/maximum 100 to 240 VAC maximum efficiency range
Current	7.5 A maximum
Frequency	50 to 60 Hz
DC OUTPUT	
Voltage	48 VDC nominal 72 VDC maximum
Current	13.5 A maximum

GOVERNMENTAL AND INDUSTRY CERTIFICATIONS

EUROPEAN CONFORMITY

The battery charger is European conformity (CE) certified per EU:

- 2014/30/EU Electromagnetic Compatibility Directive
- 2014/35/EU Low Voltage Equipment Directive
- 2014/65/EU Restriction of Hazardous Substances Directive
- LV Directives EN 60335-1:2012 and EN 60335-2-29:2004
- EMC Directives EN 61000-3-2: 2014, EN 61000-3-3: 2013, EN 61000-6-2: 2005, EN 61000-6-4: 2007

FEDERAL COMMUNICATIONS COMMISSION

The battery charger is Federal Communications Commission (FCC) certified.

NOTE: *This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in an industrial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at their own expense.*

INTERNATIONAL PROTECTION MARKING

The battery charger has an International Protection Marking (IP) certification of IP66.

The battery charger enclosure has an International Protection Marking (IP) certification of IP46.

The AC supply connector has an International Protection Marking (IP) certification of IP20.

The AC supply connector is applicable for indoor use only. Keep all AC connections clean and dry.

UNDERWRITERS LABORATORIES AND CANADIAN STANDARDS ASSOCIATION

Listed by Underwriters Laboratories (UL) and Canadian Underwriters. Meets the criteria of the Canadian Standards Association (CSA).

FEATURES

AC ELECTRICAL CORD AND PLUG

⚠ 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.**
- **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 AC electric cord has an equipment-grounding conductor and grounding type plug. The AC plug must be connected to a correctly rated ground fault circuit interrupter (GFCI) receptacle with arc flash protection. The receptacle must be installed and grounded in accordance with the National Electrical Code, local codes, and local ordinances.

Two IC650 battery chargers can be on a single phase branch circuit protected by a 15A circuit breaker or fuse.

⚠ WARNING

- **An extension cord is not recommended. Incorrect connection of the charger AC cord to an extension cord can cause a fire or an electrical shock.**

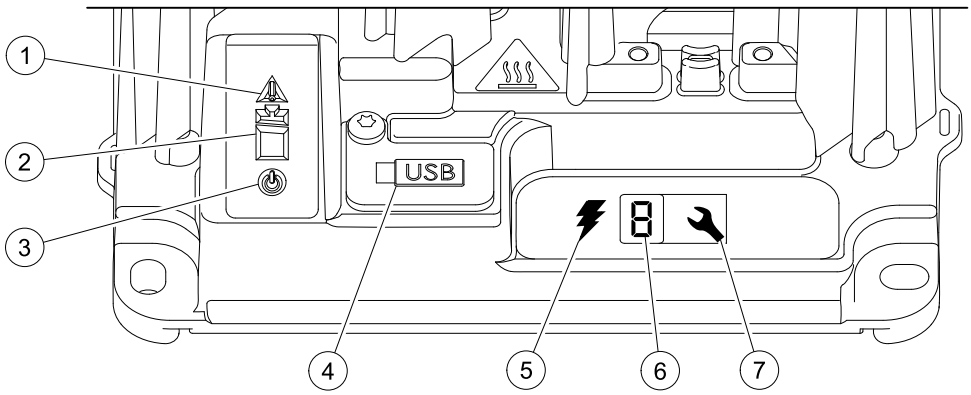
Use of an extension cord with the charger is not recommended. Precautions when the use of an extension cord is necessary:

- The extension cord must accept a three-prong plug.
- The extension cord must be as short as possible and not exceed 12 ft (3.7 m).
- The extension cord must be a three-wire No. 12-AWG (American Wire Gauge) or No. 14-SWG (British Standard Wire Gauge).
- Make sure that cords will not be stepped on, tripped over, or subject to damage or stress.

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.

BATTERY CHARGER INTERFACE



(1) Error/Fault Indicator
(2) Battery Charging Indicator
(3) AC Power Indicator
(4) USB Receptacle
(5) Charging Output Indicator
(6) Display Panel
(7) Select Charge Profile button

Figure 15-1 Battery Charger Interface

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.

EXTERNAL CHARGER STATUS INDICATORS

The indicator lights on the external charger provides information concerning charger status.

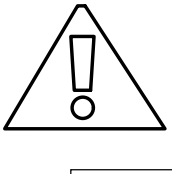
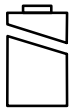
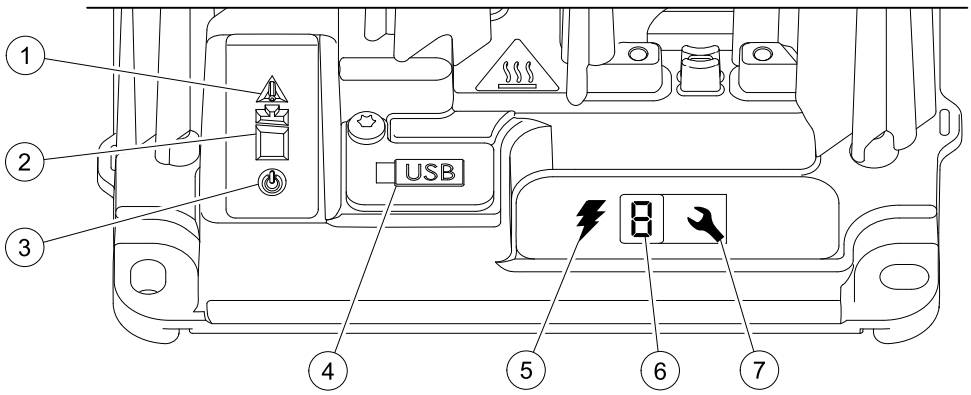
LIGHT	STATUS	STATUS EXPLANATION
 G-130892-000001	Solid red	Charger fault condition. Reset charger power.
	Flashing orange	Charger cannot complete charge.

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 BATTERY CHARGER INTERFACE



(1) Error/Fault Indicator
(2) Battery Charging Indicator
(3) AC Power Indicator
(4) USB Receptacle
(5) Charging Output Indicator
(6) Display Panel
(7) Select Charge Profile button

Figure 15-2 Battery Charger Interface

ONBOARD CHARGER STATUS INDICATORS

The indicator lights on the onboard charger provides information concerning charger status.

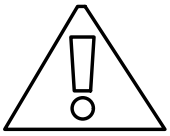
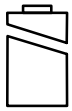
LIGHT	STATUS	STATUS EXPLANATION
 G-130892-000001	Solid red	Charger fault. See the display panel for details.
	Flashing orange	External error condition - caution. See the display panel for details.
	Flashing green	USB port is active.
	Solid green	Safe to remove the USB flash drive.

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.

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.

EXTERNAL BATTERY CHARGER MOUNTING

⚠ WARNING

- **Make sure the charger is securely mounted. Do not hang the charger by its handle.**

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.**

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.**

⚠ CAUTION

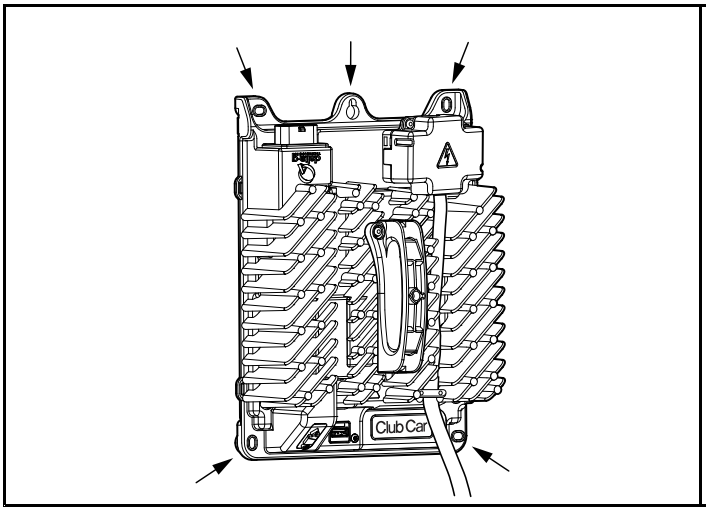
- **If the battery charger is not correctly attached, it can fall and cause damage and personal injury. Do not hang the battery charger by its handle or cord. Correctly attach the battery charger.**

NOTE: *This section is applicable to an external battery charger. The onboard battery chargers are installed on the vehicle.*

A strain relief and drip loop is necessary to prevent damage to the charger. The strain relief prevents tension on the AC plug. The drip loop prevents water damage to the AC plug.

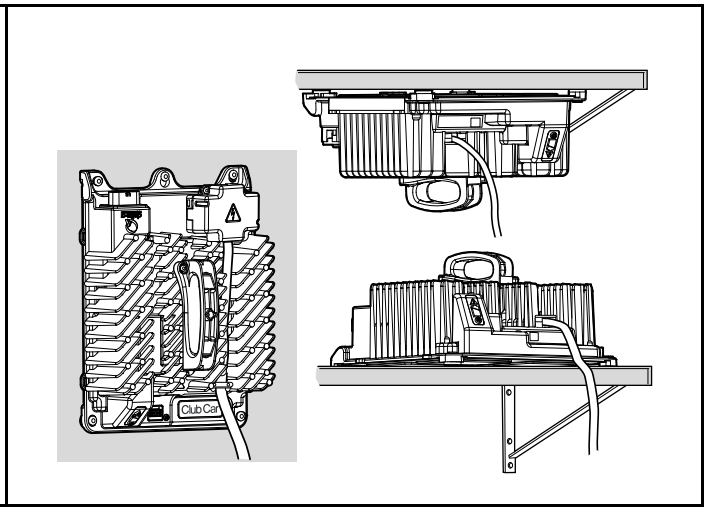
Use the mounting holes to secure the charger . Position the charger so that is has adequate ventilation and the charger status indicator panel is visible. The charger can be mounted in any orientation (right-side up, upside down, etc.) provided the cooling fins are unobstructed it has adequate ventilation .

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 15-9.**



2674

Figure 15-3 Charger Mounting Holes



2675

Figure 15-4 Examples of Charger Mounting Orientation

HOW TO MAKE A STRAIN RELIEF AND DRIP LOOP

A strain relief and drip loop is necessary to prevent damage to the charger. The strain relief prevents tension on the AC plug. The drip loop prevents water damage to the AC plug.

1. Connect the AC cord (1) into the AC plug **(Figure 15-5, Page 15-11)**.

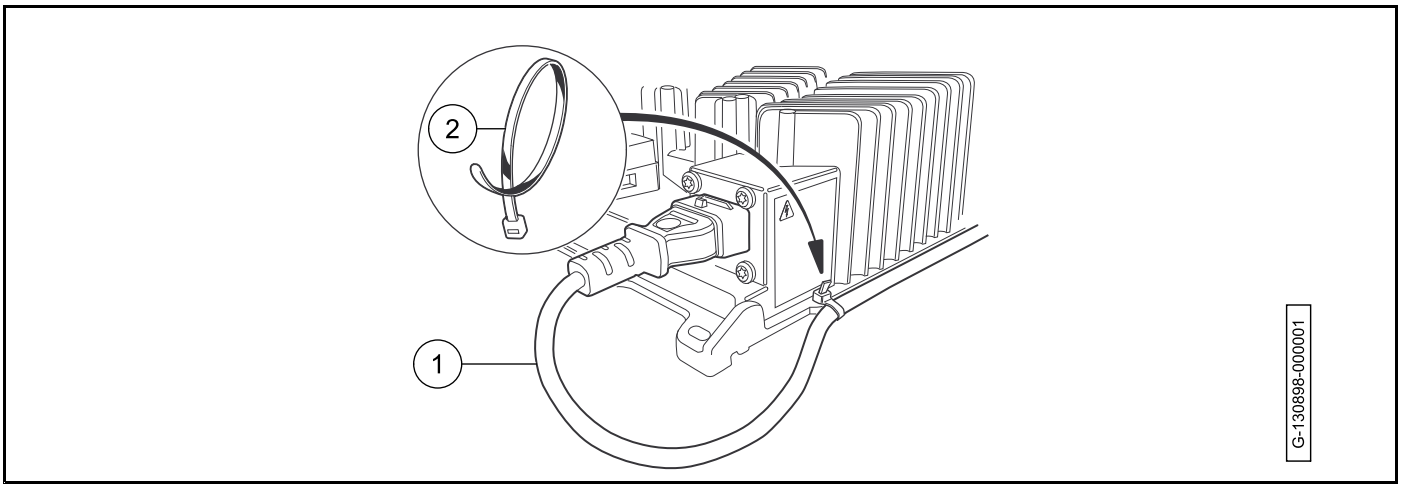


Figure 15-5 Strain Relief and Drip Loop

2. Supply sufficient AC cord to make a drip loop and strain relief.
3. Secure the AC cord to the battery charger with a plastic cable tie (2).

BATTERY CHARGER OPERATION

See Dangers and Warnings beginning on page 15-1.

⚠ WARNING

- **Be sure all wire connections at the receptacle are clean and tight.**
- **Do not rock or bend the plug. To connect the charger plug to the vehicle receptacle, grasp the plug handle and push the plug straight into the receptacle.**
- **Do not pull on the DC cord. Do not twist, rock or bend the plug. To disconnect the charger plug from the vehicle receptacle, grasp the plug by the handle and pull the plug straight out of the receptacle.**
- **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:**

WARNING CONTINUED ON NEXT PAGE

⚠ WARNING

- **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 (10 minutes of operation).

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.

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 CCDT.

CHARGING WITH EXTERNAL CHARGER

⚠ DANGER

- **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. Inadequate airflow 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.**

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 charge 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 charge receptacle.**

5. Connect the DC cord to the vehicle charge receptacle (1) **(Figure 15-6, Page 15-13)**.

NOTE: *The vehicle will start to charge in 10 seconds or less.*

When the vehicle starts to charge:
– ON CHG will show on the dash display.

– The multi-purpose buzzer will operate.

– The headlights will flash.

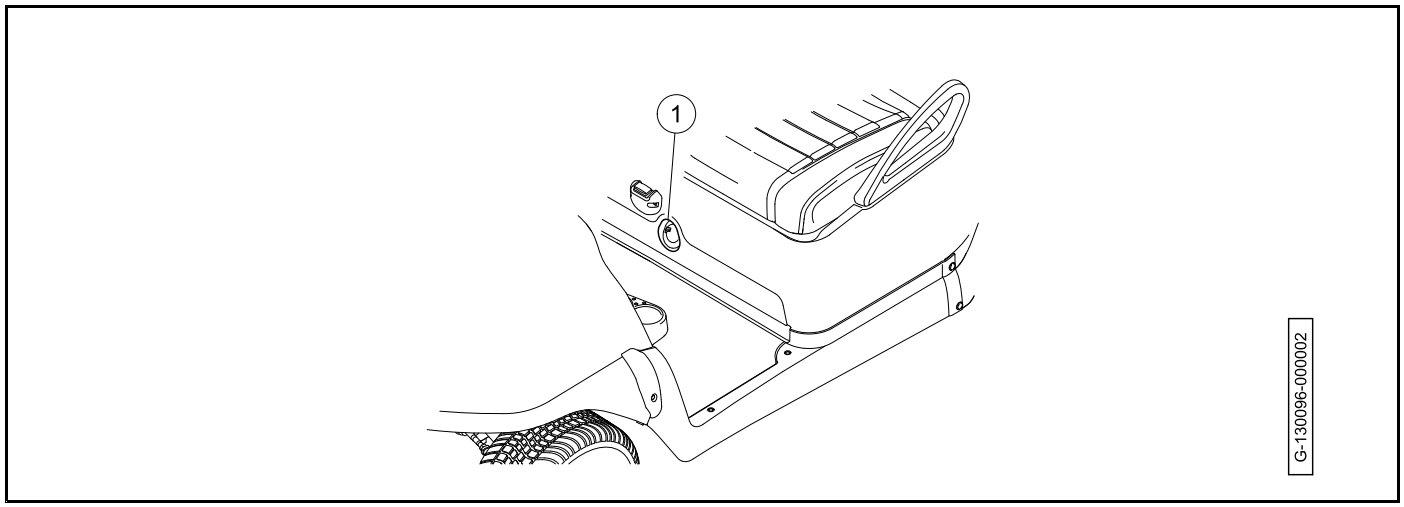


Figure 15-6 Vehicle Charge Receptacle

⚠ DANGER

- **If the DC cord is removed too fast, arcing and burning can cause damage to the plug, recetpacle, and cause the batteries to explode. Remove the DC cord slow.**

6. Before vehicle operation, disconnect the DC cord from the vehicle charge receptacle.

CHARGING WITH ONBOARD CHARGER

⚠ DANGER

- **Charging the batteries with accessories on can cause a fire and serious personal injury. Turn off all accessories before charging the batteries.**

1. Turn the key to OFF.
2. Turn off all accessories.
3. Connect the AC cord (1) to the power source **(Figure 15-7)**.

NOTE: *The vehicle will start to charge in 10 seconds or less.*

When the vehicle starts to charge:
– *ON CHG will show on the dash display.*

– *The multi-purpose buzzer will operate.*

– *The headlights will flash.*

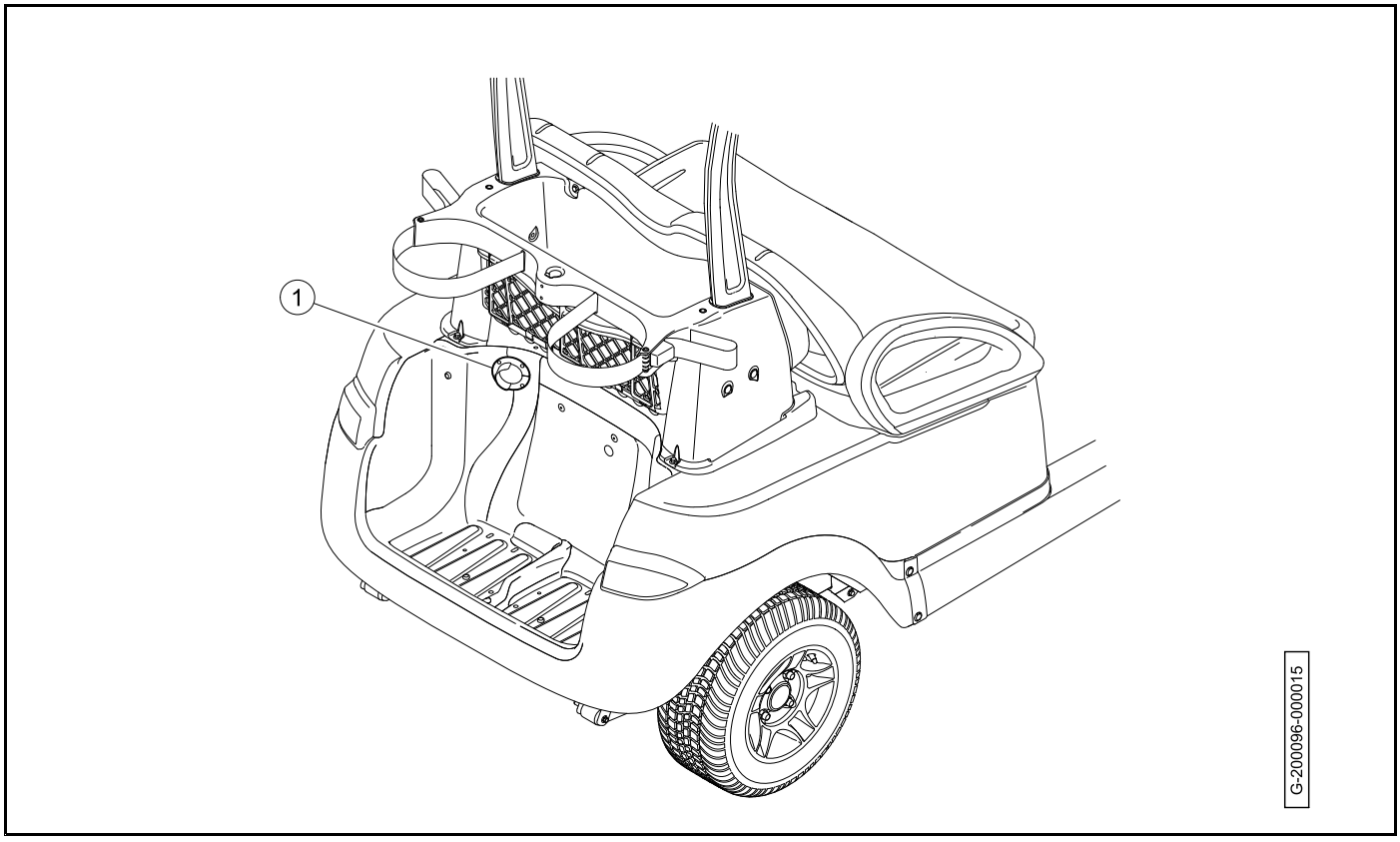


Figure 15-7 Two-Passenger Shown - 2+2 Is Typical

4. Before vehicle operation:

4.1. Disconnect the AC cord from the power source.

4.2. Retract the AC cord.

ONBOARD CHARGER - HOW TO CHANGE THE ALGORITHM

1. Disconnect the AC cord from the battery charger. Wait 30 seconds.
2. Push and hold the Select Charge Profile button (1) **(Figure 15-8, Page 15-15)**.

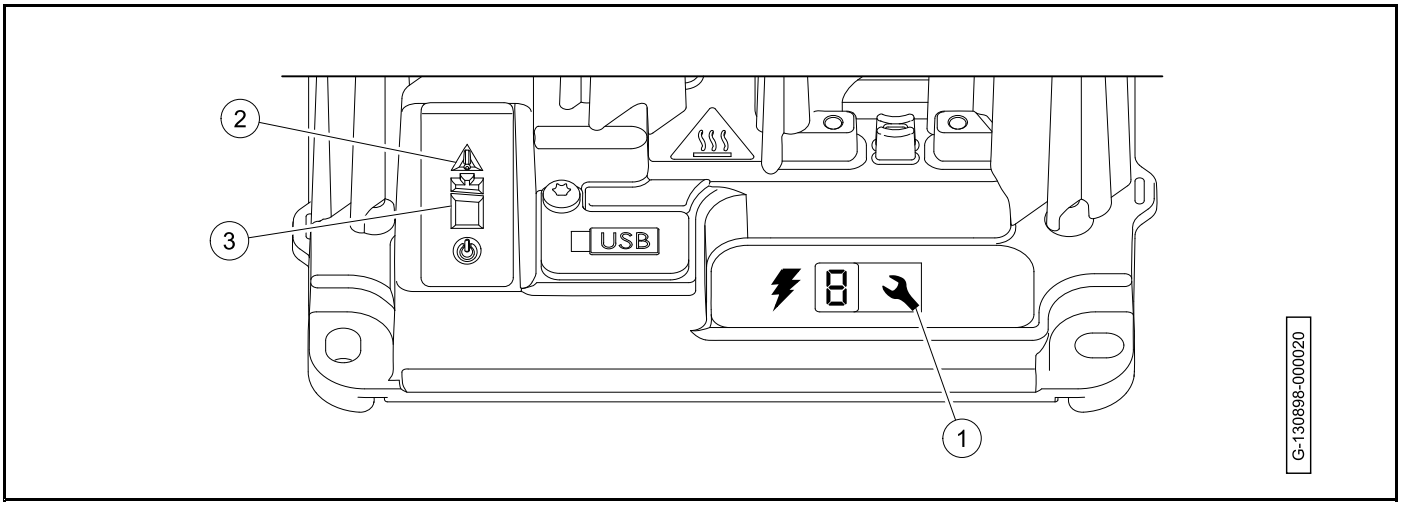


Figure 15-8 Algorithm Change

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 22 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-0-1-1 for Profile 11).*

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. Copy the files to a blank USB 2.0 flash drive formatted as FAT16 or FAT32. See the instructions that were included with the file.
3. Remove the USB dust cover (1). **(Figure 15-9, Page 15-16)**

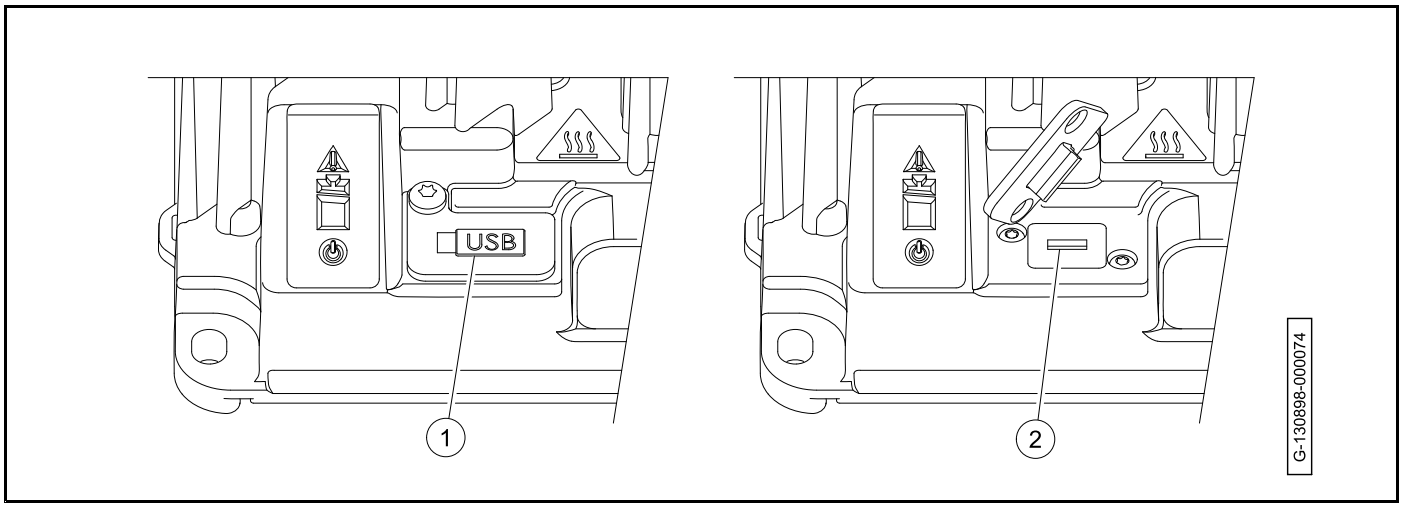


Figure 15-9 USB Receptacle and Dust Cover

4. With the update file on the USB flash drive, install the USB flash drive into the USB receptacle (2).

NOTE: *The triangle status indicator light will flash green.*

5. When the green triangle status indicator light is constant, it is safe to remove the USB flash drive.
6. Install the USB dust cover.

DOWNLOAD FROM BATTERY CHARGER WITH USB

1. Remove the USB dust cover (1). **(Figure 15-10, Page 15-16)**

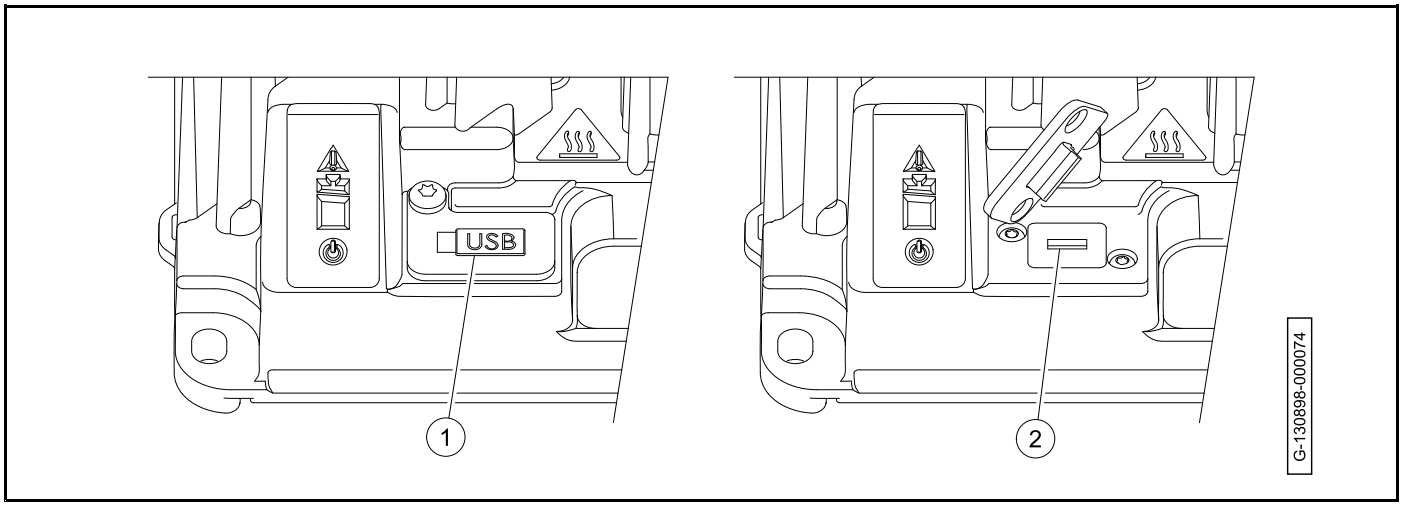


Figure 15-10 USB Receptacle and Dust Cover

2. Make sure that the USB flash drive is empty.
3. Install the USB flash drive into the USB receptacle (2).

NOTE: *The triangle status indicator light will flash green.*

4. When the green triangle status indicator light is constant, it is safe to remove the USB flash drive.
5. Install the USB dust cover.

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 15-11)**.

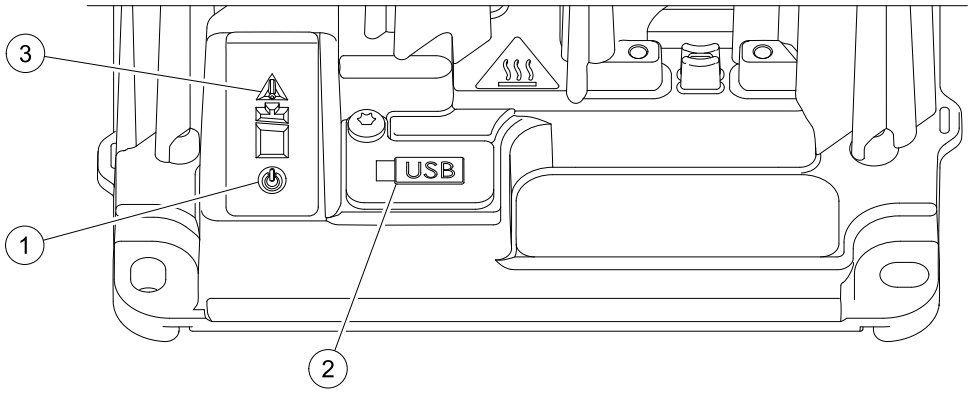
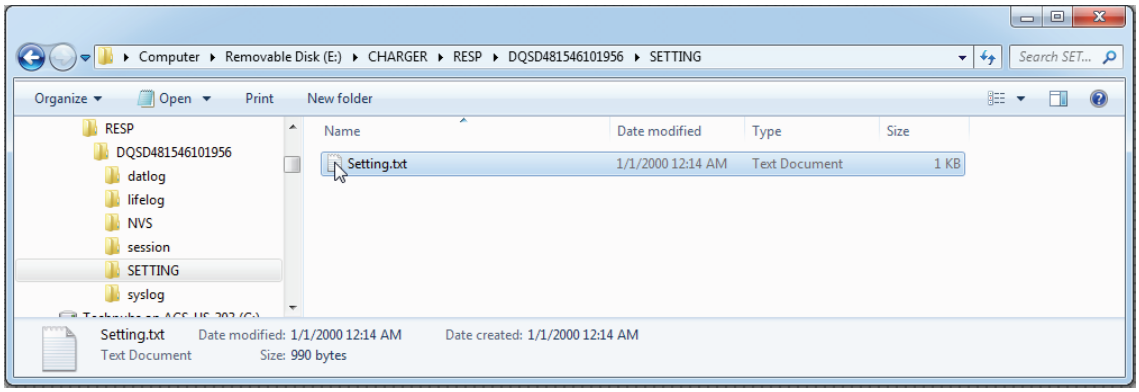


Figure 15-11 USB Dust Cover

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.

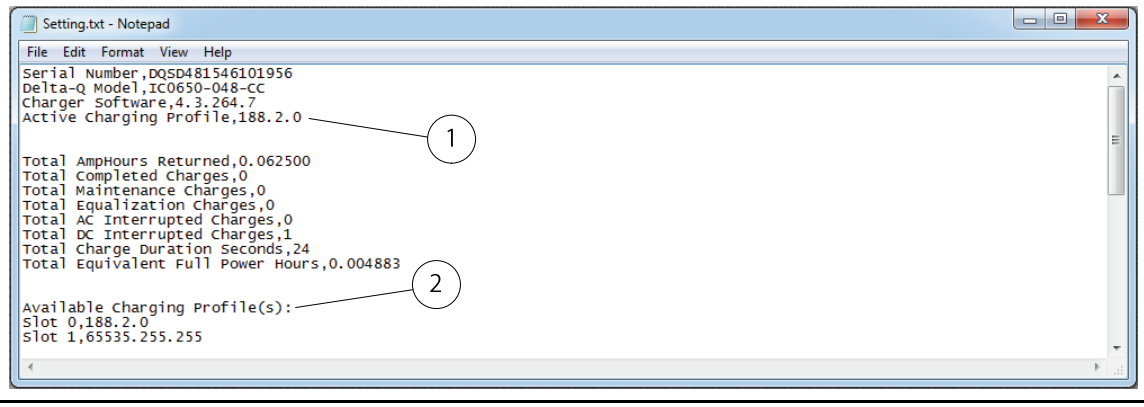
12. Go to CHARGER/RESP/Battery charger serial number/SETTING **(Figure 15-12)**.



G-130898-000051

Figure 15-12 Setting.txt File Location

13. Open the Setting.txt file **(Figure 15-13)**.



G-130898-000052

Figure 15-13 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

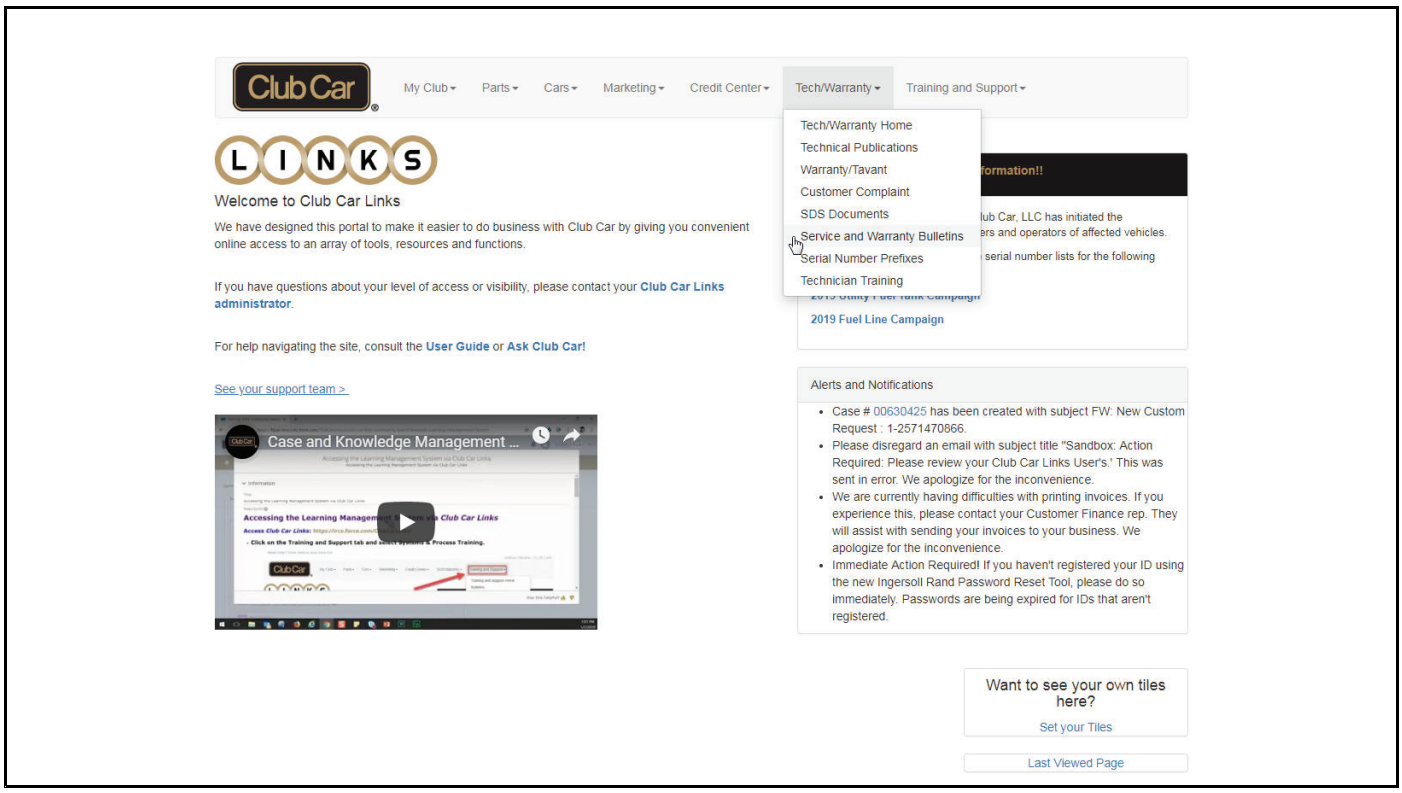
How To Install Trojan Algorithm - External Battery Charger

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 15-14)**.

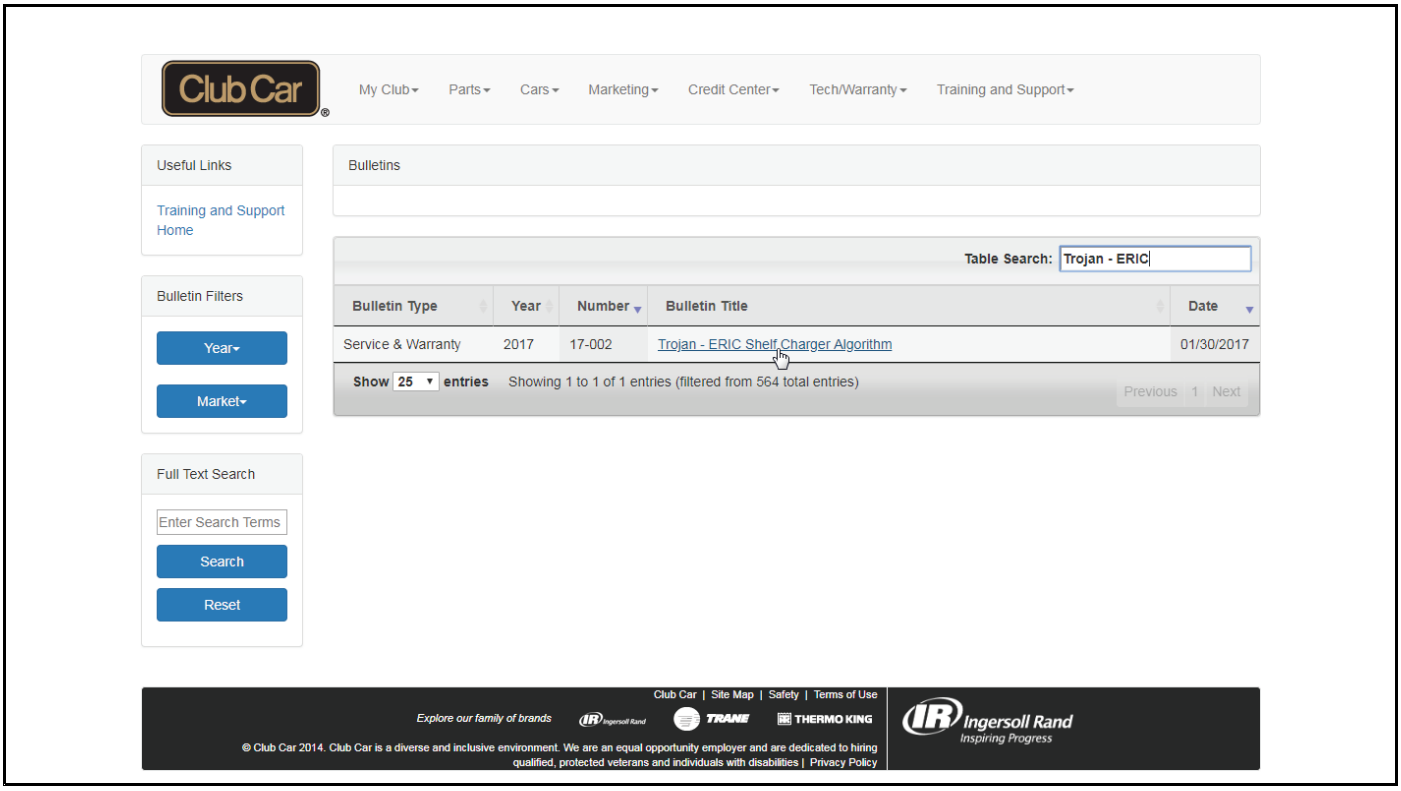


G-130898-000050

Figure 15-14 Service and Warranty Bulletins

4. Find the Trojan - ERIC Shelf Charger Algorithm.

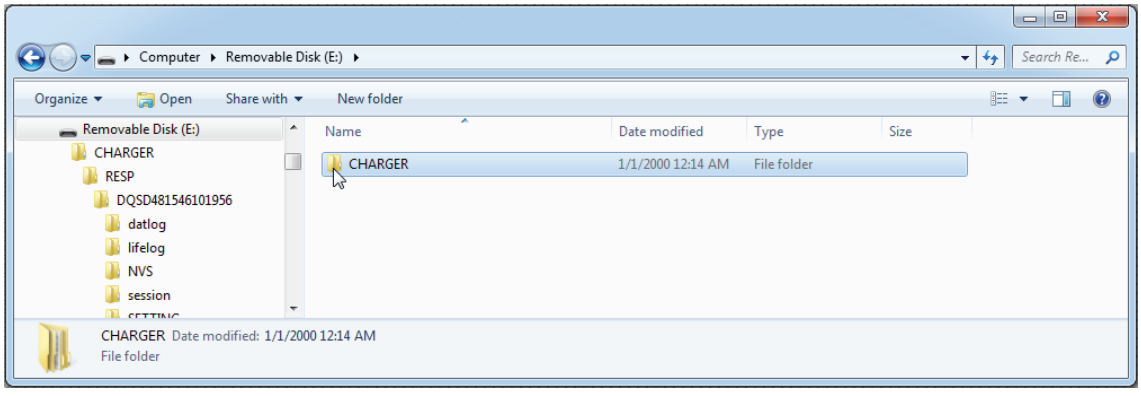
5. Click on the Trojan - ERIC Shelf Charger Algorithm link **(Figure 15-15)**.



G-130898-000053

Figure 15-15 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 15-16)**.



G-130898-000049

Figure 15-16 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 15-17)**.

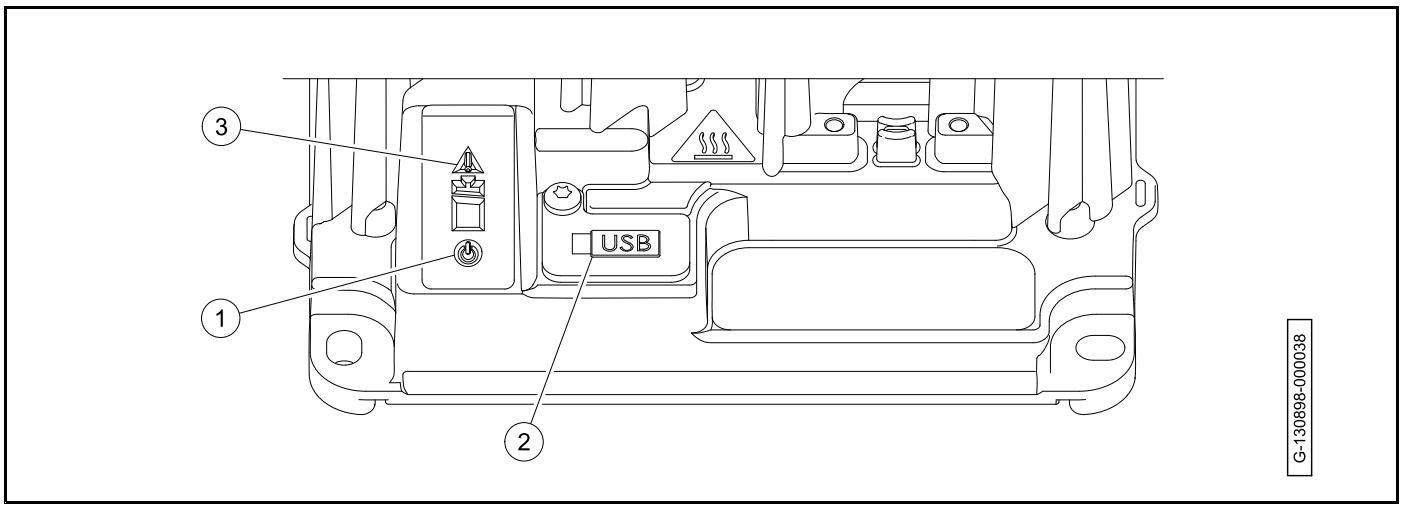


Figure 15-17 USB Dust Cover

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 15-8, Page 15-15)**.

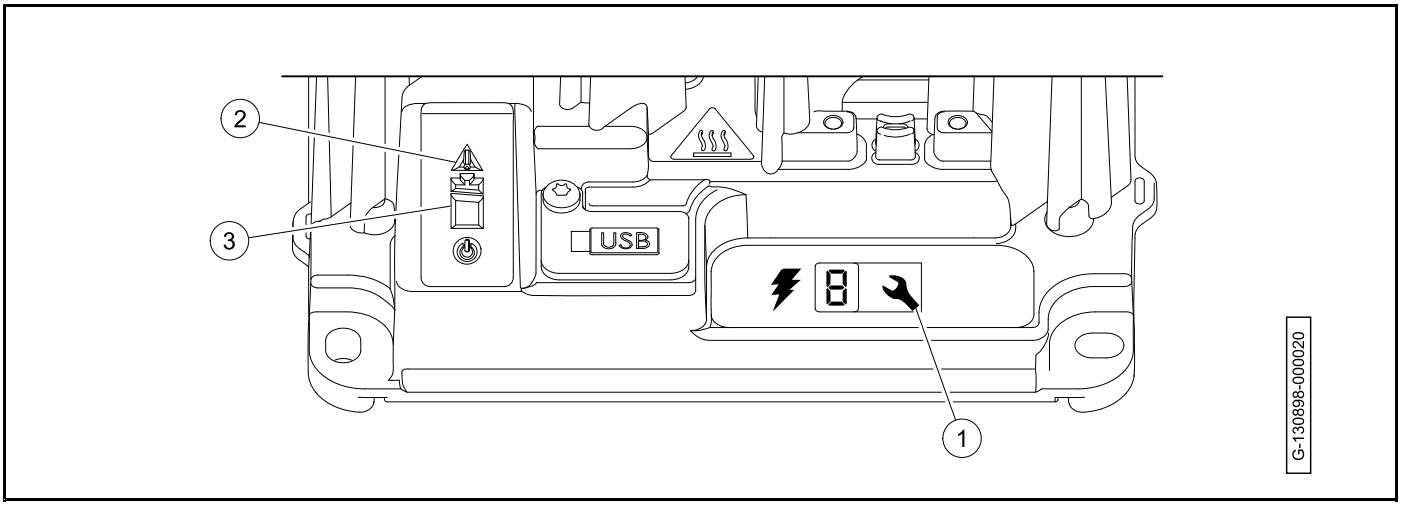


Figure 15-18 Algorithm Change

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 15-8, Page 15-15)**.

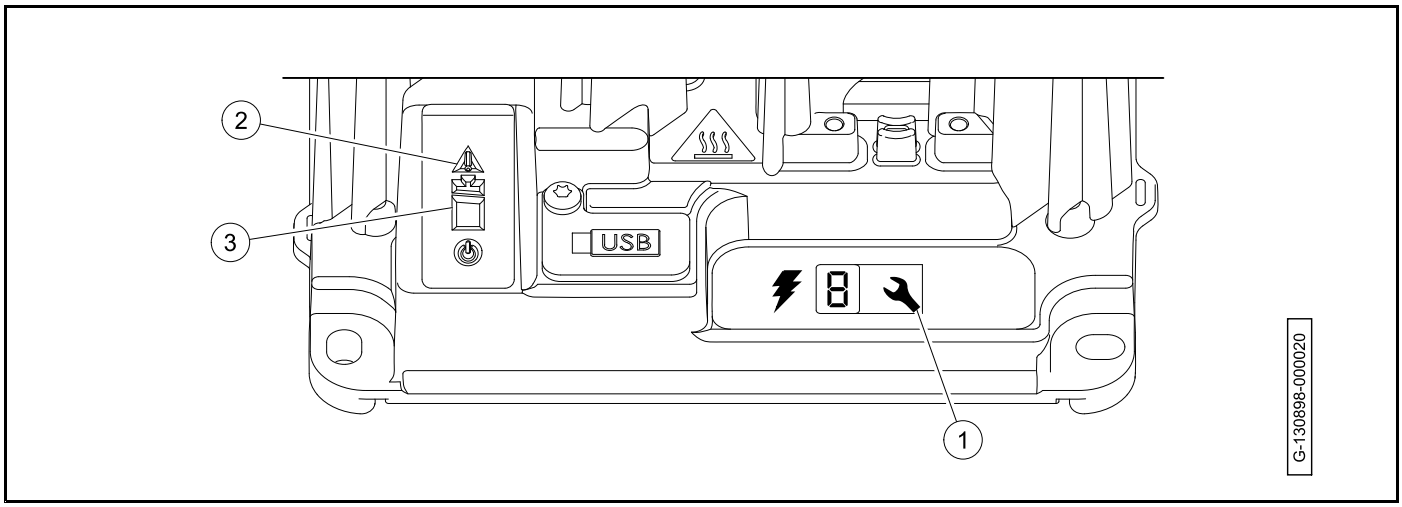


Figure 15-19 Algorithm Change

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 15-17)**.

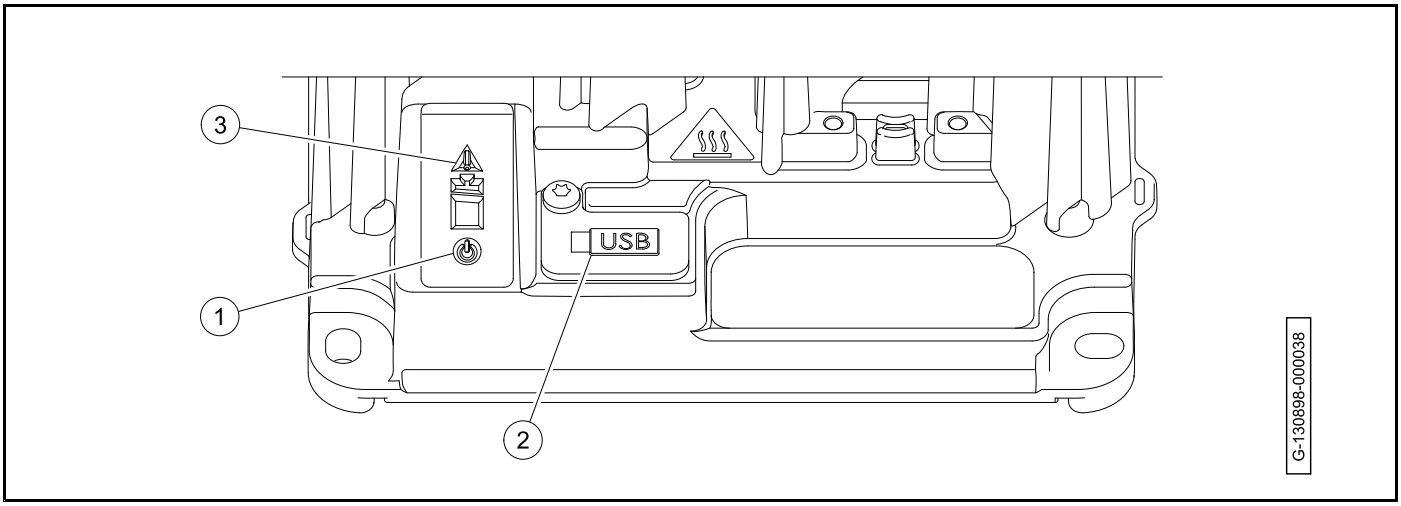


Figure 15-20 USB Dust Cover

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.

INSPECTION AND MAINTENANCE

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.

⚠ 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.**
- **Disconnect the AC cord prior to lubricating the plug and receptacle.**

⚠ 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.**

ELECTRICAL CORDS

CAUTION

- **An electrical short in the DC cord can cause the 30 amp fuse to blow. If there is damage to the DC cord, replace the DC cord.**

Examine electrical cords for wear and damage before use. Immediately replace electrical cords for:

- Cracks
- Cuts
- Frayed wiring
- Insulation damage
- Loose connections
- Splices

Make sure that the DC electrical cord has the warning tag attached and that the warning tag is readable. Replace a missing or damaged warning tag immediately.

ELECTRICAL PLUGS AND RECEPTACLES

Examine electrical plugs for wear and damage before use. Immediately replace electrical plugs for:

- Bent pins
- Corrosion
- Cracks
- Loose connections
- Missing pins
- Worn pins

CLEAN THE ELECTRICAL PLUGS AND RECEPTACLES

⚠ DANGER

- **Lubricating the plug and receptacle with the AC cord connected to a power source can cause property damage, electrical shock, serious injury, and death. Do not lubricate the plug and vehicle charge receptacle with the AC cord connected to a power source.**

1. Disconnect the AC cord from the power source.
2. Disconnect the AC cord from the battery charger.
3. Disconnect the DC cord from the vehicle charge receptacle.
4. Apply electrical contact cleaner to the electrical plugs and receptacles. Refer to the manufacturer instructions.
5. Clean the electrical plugs and receptacles.
6. Lubricate the electrical plugs and receptacles with WD-40®.

BATTERY CHARGER USB RECEPTACLE

The movement of charger data and download of the charge algorithm is done through the USB receptacle. Use of the USB receptacle is for approved persons and technicians.

The USB receptacle can have intermittent connectivity because of environmental contaminates. Always install the USB dust cover to protect the USB receptacle.

CLEAN THE USB RECEPTACLE

1. Disconnect the DC cord from the vehicle charge receptacle.
2. Disconnect the AC cord from the power source.
3. Carefully remove large contaminates.
4. Use compressed air in short intervals to remove dust and smaller contaminates.
5. Clean the USB receptacle with a cotton swab and rubbing alcohol or electronics cleaner solvent. Let sufficient time for the alcohol or solvent to dry.
6. If contamination continues, apply dielectric grease to the USB receptacle.
7. Install the USB dust cover.

BATTERY CHARGER TROUBLESHOOTING

⚠ 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 22-11.**
- **Prior to servicing the external charger, disconnect the DC plug from the vehicle charge receptacle and the AC power supply cord from the wall outlet.**
- **Prior to servicing the onboard charger, disconnect the AC power supply cord from the wall outlet and remove the battery charger from the vehicle.**

NUMBERING VEHICLES AND CHARGERS

Number the vehicle and battery charger. Use the same battery charger to charge the battery. If the vehicle dies while in use and testing shows the battery is good, then the problem is most likely with the battery charger.

AC POWER SOURCE

Make sure that the AC power source meets the AC Input specifications. The electrical service to the vehicle storage facility must supply adequate voltage, current, and frequency to each charger with all the chargers turned on. If not, consult your local power company or electrical contractor.

Symptoms of an AC power source problem include:

- Circuit breakers trip
- Fuses blow
- Battery does not fully charge during adequate time

TERMINAL BLOCK COVER

The terminal block cover prevents water exposure and prevents a short across the terminals, which will blow the 30-amp fuse.

RESET POWER – EXTERNAL CHARGER

Before replacing the charger, reset the charger in case the failure was caused by a temporary situation.

1. Disconnect the DC cord from the vehicle.
2. Disconnect the AC cord from the AC power source.
3. When the red triangle status indicator light turns off, wait 30 seconds.
4. Connect the AC cord to the AC power source.
5. When the blue status indicator light turns on, connect the DC cord to the vehicle.
6. If the triangular status indicator flashes orange, see Battery Charger Error Codes.
7. If the triangular status indicator is solid red, see Battery Charger Fault Codes.
8. If the light does not come back on, charge the vehicle as usual.

RESET POWER – ONBOARD CHARGER

Before replacing the charger, reset the charger in case the failure was caused by a temporary situation.

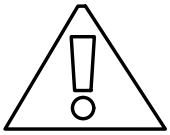
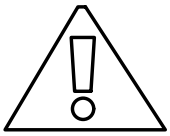
1. Disconnect the AC cord from the AC power source.
2. Disconnect the DC cord from the battery charger.
3. When the red triangle status indicator light turns off, wait 30 seconds.
4. Connect the AC cord to the AC power source.
5. When the blue AC status indicator light comes on, connect the DC cord to the battery charger.
6. If the triangular status indicator flashes orange, see Battery Charger Error Codes.
7. If the triangular status indicator is solid red, see Battery Charger Fault Codes.
8. If the light does not come back on, 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 Source on page 15-37.**
			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 Source on page 15-37.**
			5. Failed AC plug or cord	Replace cord. **See AC Power Source on page 15-37.**

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 Reset Power – External Charger on page 15-29.** 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 15-34.** If not, replace with correct battery set. Reset charger power. **See Reset Power – External Charger on page 15-29.**
			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 15-34.** If not, replace with correct battery set. Reset charger power. **See Reset Power – External Charger on page 15-29.**
			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 15-34.**
			5. Bad battery pack	Test battery pack health. Look for shorted or damaged cells. **See Battery Condition Using Charger on page 15-37. See also AC Electric Vehicle - Batteries on page 14-1.**
			6. AC voltage out-of-range	Test and inspect incoming AC power. **See AC Power Source on page 15-37.**
			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 15-35. See Charger DC Circuit Continuity Test on page 15-38.**
			10. Corroded or loose connections	Clean or tighten connections.
 G-130892-000001	Solid red	Charger error	1. Charger abnormality	Reset charger power. **See Reset Power – External Charger on page 15-29.** Reconnect DC cord to vehicle. If status goes away, proceed to charge again. **See Charger Output Test on page 15-38.** 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 1-2.

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 Source
6 – AC Circuit - Continuity Test
7 – Charger DC Circuit Continuity Test
8 – Charger Output Test

TEST PROCEDURE 1 – Battery Voltage Using Multimeter

1. Check the battery set voltage.

1.1. Put the red (+) probe on the positive (+) post of battery no. 1 **(Figure 15-21)**.

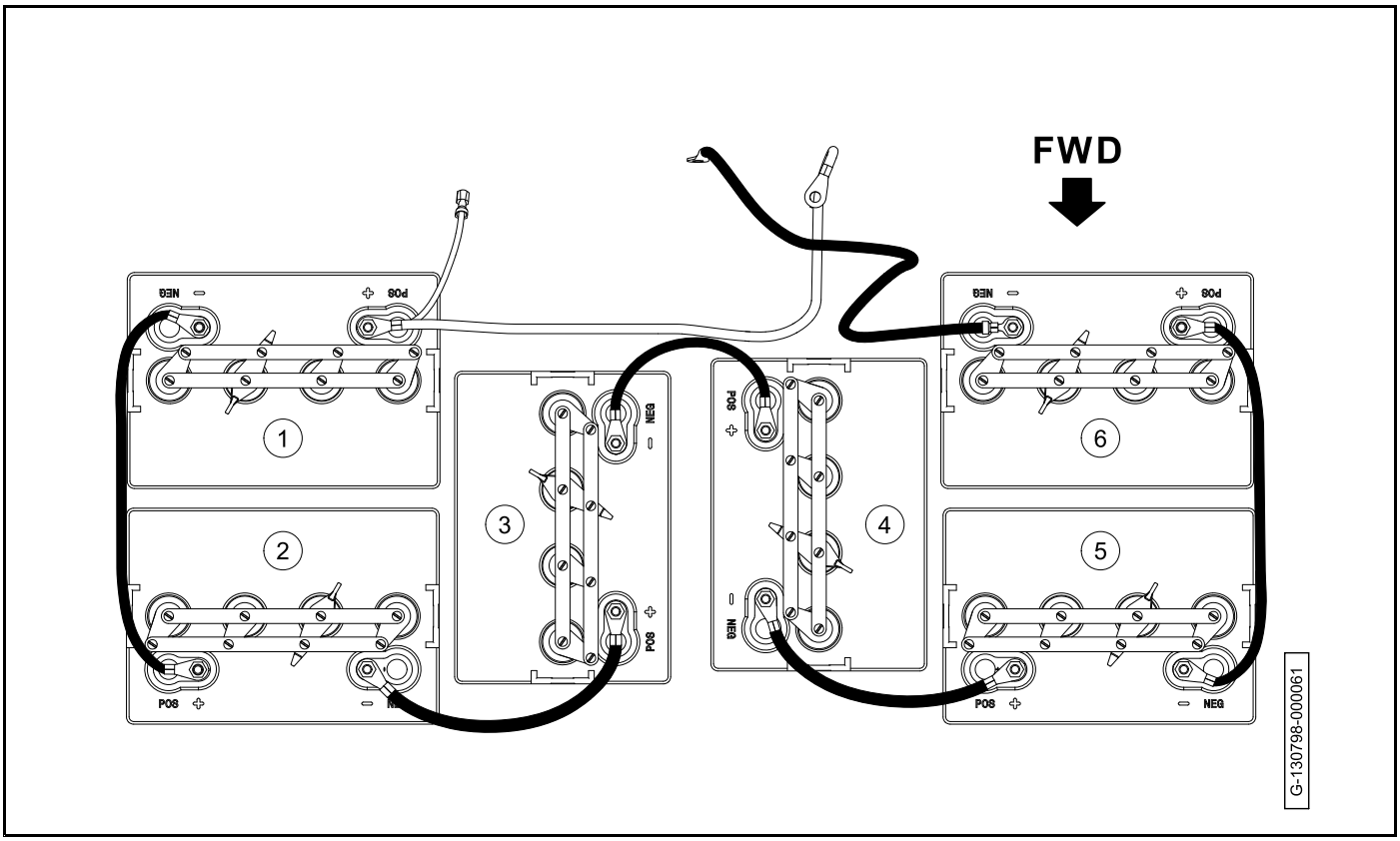


Figure 15-21

1.2. Put the black (–) probe on the negative (–) post of battery no. 6.

1.3. Record the measurement.

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 22-4.**

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 22-4.**

3. Check the wire connections from the charger receptacle.

3.1. Verify that the red wire (1) from the charger receptacle is connected to the large post of solenoid **(Figure 15-22)**.

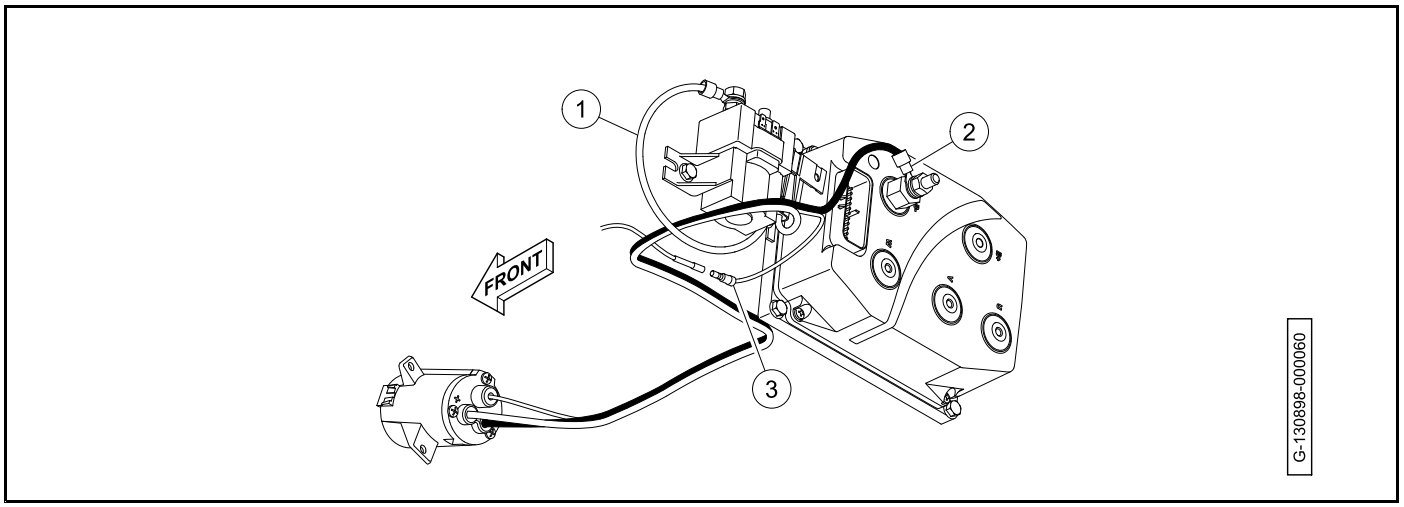


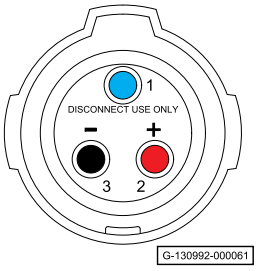
Figure 15-22

3.2. Verify that the black wire (2) from the charger receptacle is connected to the B- terminal of motor control unit (MCU).

3.3. Verify that the light blue wire (3) from the charger receptacle is connected to the green wire bullet connector from the main wire harness.

4. Make sure that the batteries are connected.
5. Disconnect the DC cord.
6. Set a multimeter set to 200 volts DC.
7. Put the black (–) probe in the socket (3) connected to the black wire.

Vehicle Charge Receptacle



Pin	Wire Color	Description
1	Light Blue	Interlock
2	Red	Positive (+)
3	Black	Negative (-)

8. Put the red (+) probe in the socket (2) connected to the red wire. The reading should be 48 to 50 volts (full battery voltage).
9. If the reading is not 48 to 50 volts, check the following items:
   – The 30-amp charger fuse.
   – Continuity of the red wire from the main solenoid to the receptacle socket.
   – Continuity of the 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 15-6.**

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 — AC 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 volts 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 Source

1. If the charger will not power ON, check AC cord connections.
2. Check the AC power source fuse or circuit breaker.
3. Disconnect the DC plug from the vehicle charge receptacle.
4. Disconnect the AC cord from the power source.
5. With a multimeter set to 500 volts AC, check incoming AC voltage.
6. Insert multimeter test probes into AC wall outlet; voltage should be between 85 and 270 volts.
7. If the voltage is between 85 and 270 volts, test the AC circuit. **See AC Circuit test procedure.**
8. If the voltage is not between 85 and 270 volts, have the building wiring checked by a licensed electrical contractor.

TEST PROCEDURE 6 – AC Circuit - Continuity Test

1. Test the AC power source. **See AC Power Source test procedure.**
2. Check the AC cord connections.
3. Check the continuity of the AC cord wires using a multimeter.
4. If you have continuity on all AC cord wires. **See Charger DC Circuit test procedure.**

TEST PROCEDURE 7 – Charger DC Circuit Continuity Test

1. Disconnect the DC cord from the vehicle charger receptacle.
2. Disconnect the AC cord from the wall outlet.
3. Remove DC terminal block cover. **See Terminal Block Cover Removal on page 15-49.**
4. Note polarity and loosen screws securing DC cord wires. Pull wires from DC terminals on charger.
5. Check continuity of the DC cord wires from plug pin to fork terminal.

NOTE: *The positive symbol (+) and negative symbol (–) are molded into the terminal block for easy identification.*

6. When finished, attach DC cord white wire to positive terminal (+) and black and green wire to negative terminal (–) with torx screws. **See following NOTE.** Tighten torx screws to 39.8 lb·in (4.5 N·m).
7. Install terminal block cover. **See Terminal Block Cover Installation on page 15-39.**

TEST PROCEDURE 8 – 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 18, Page 18-8.***

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

⚠ WARNING

- **Knowledge of battery charger wiring and component terminology is required before attempting any repair.**
- **Prior to servicing the charger, disconnect the DC cord from the vehicle charge receptacle and the AC cord from the AC outlet.**

NOTE: *This charger has no internal components 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.*

TERMINAL BLOCK COVER REMOVAL

1. Disconnect the DC cord from the vehicle charge receptacle.
2. Disconnect the AC cord from the AC power source.
3. Push in the mounting tabs (1) and remove the terminal block cover **(Figure 15-23, Page 15-39)**.

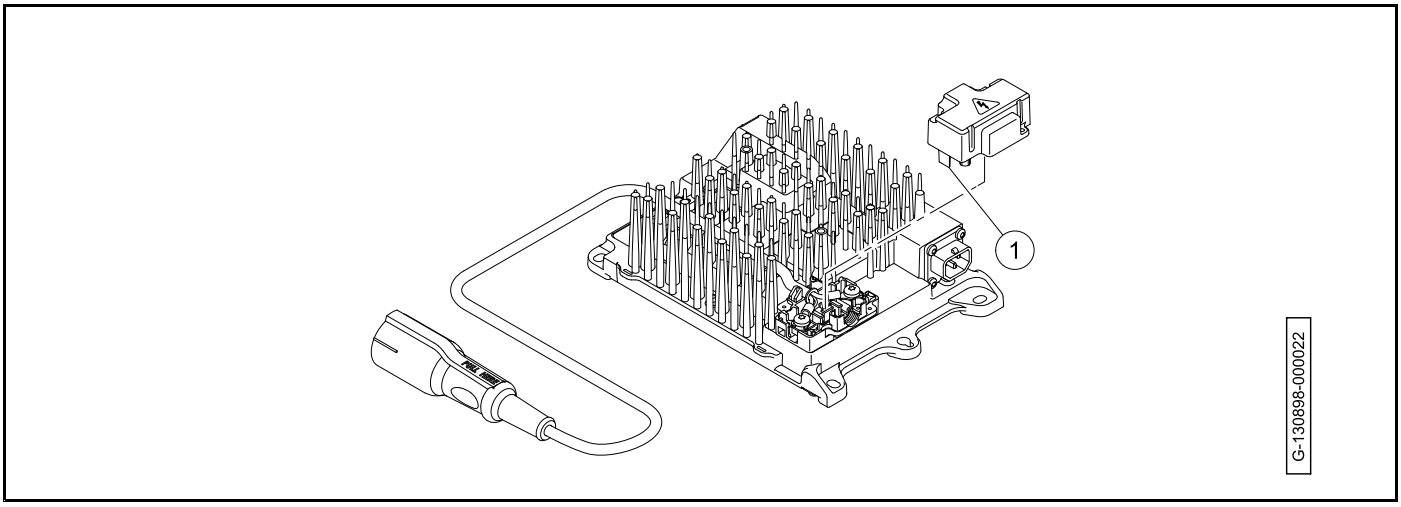


Figure 15-23 Terminal Block Cover

TERMINAL BLOCK COVER INSTALLATION

⚠ WARNING

- **The terminal block cover on the DC terminal block must be installed correctly to comply with UL code. This cover prevents water exposure and prevents a short across the DC terminals.**

1. Align the terminal block cover with the terminal block.
2. Push the terminal block cover until the mounting tabs (1) lock **(Figure 15-23, Page 15-39)**.

DC CORD REMOVAL

1. Disconnect the DC cord from the vehicle charge receptacle.
2. Disconnect the AC cord from the AC power source.
3. Remove the terminal block cover.
4. Remove the screws (1) **(Figure 15-24, Page 15-40)**.

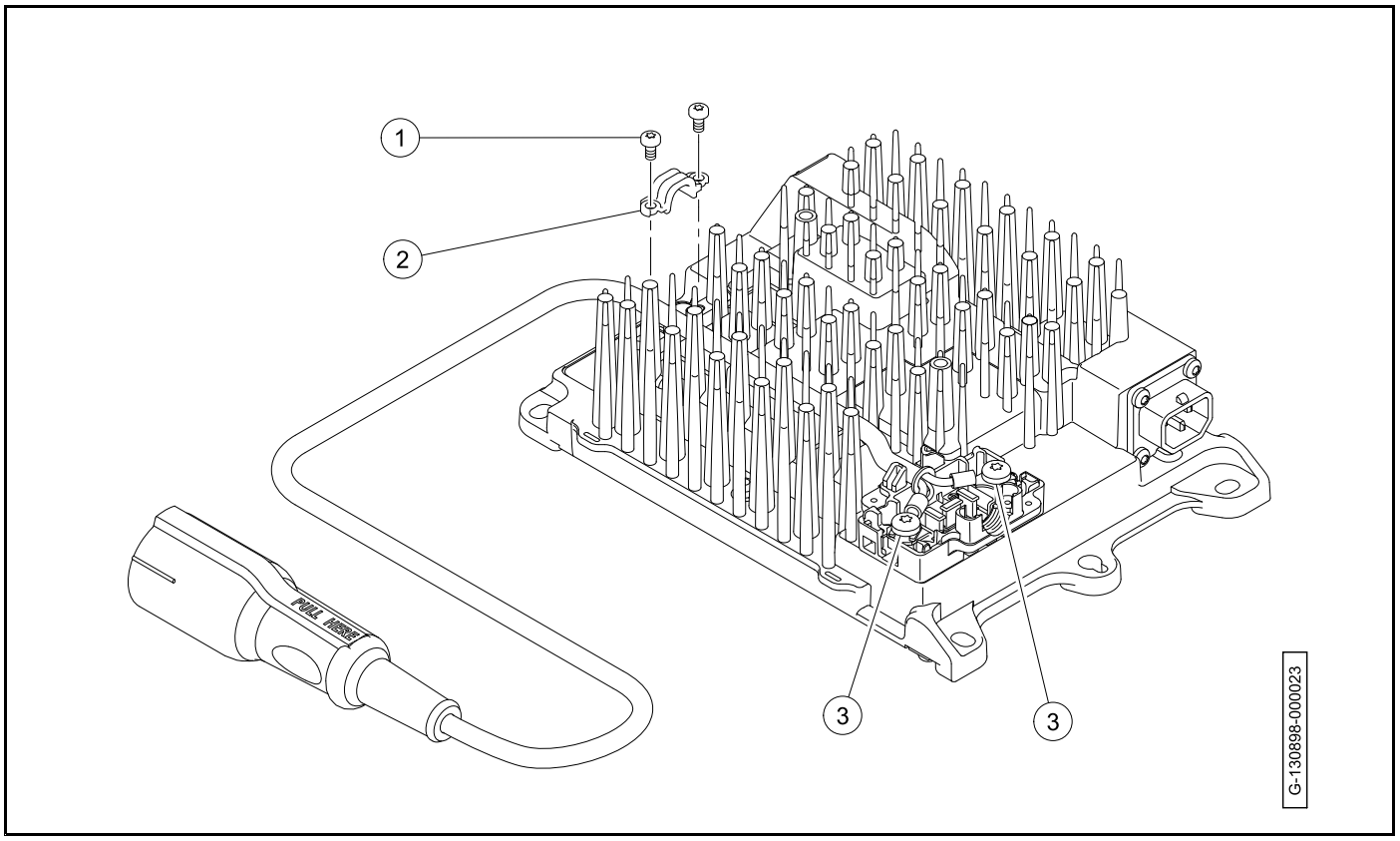


Figure 15-24 DC Cord

5. Remove the clamp (2).
6. Loosen the screws (3).
7. Pull the wires from DC terminals on battery charger.

DC CORD INSTALLATION

1. Attach the white DC cord wire to the positive (+) terminal (5) **(Figure 15-25, Page 15-41)**.

NOTE: *The positive symbol (+) and negative symbol (–) are molded into the terminal block.*

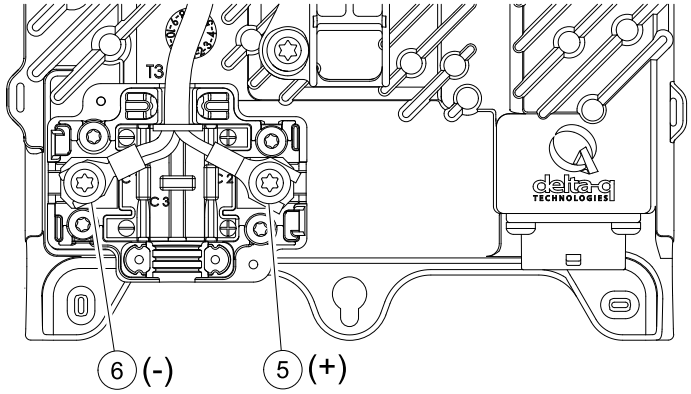


Figure 15-25 Wire Installation

2. Attach the black and green DC cord wires to the negative (-) terminal (6).
3. Tighten the screws (1) to 39.8 lb·in (4.5 N·m) **(Figure 15-26, Page 15-41)**.

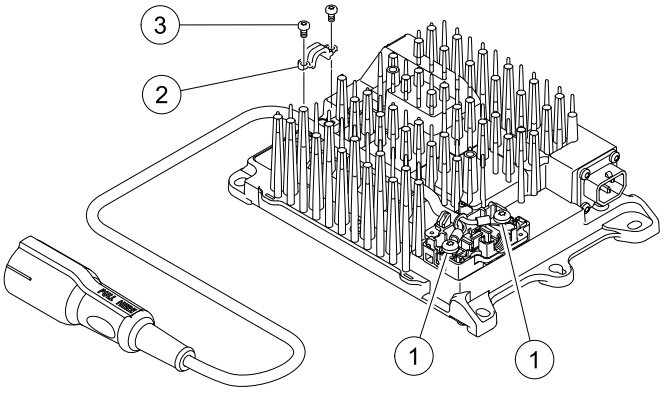


Figure 15-26 Clamp Installation

4. Install the terminal block cover.
5. Install the clamp (2).
6. Install the screws (3). Tighten the screws to 27.4 lb·in (3.1 N·m).

HANDLE REMOVAL

1. Remove the screws (1) **(Figure 15-27, Page 15-42)**.

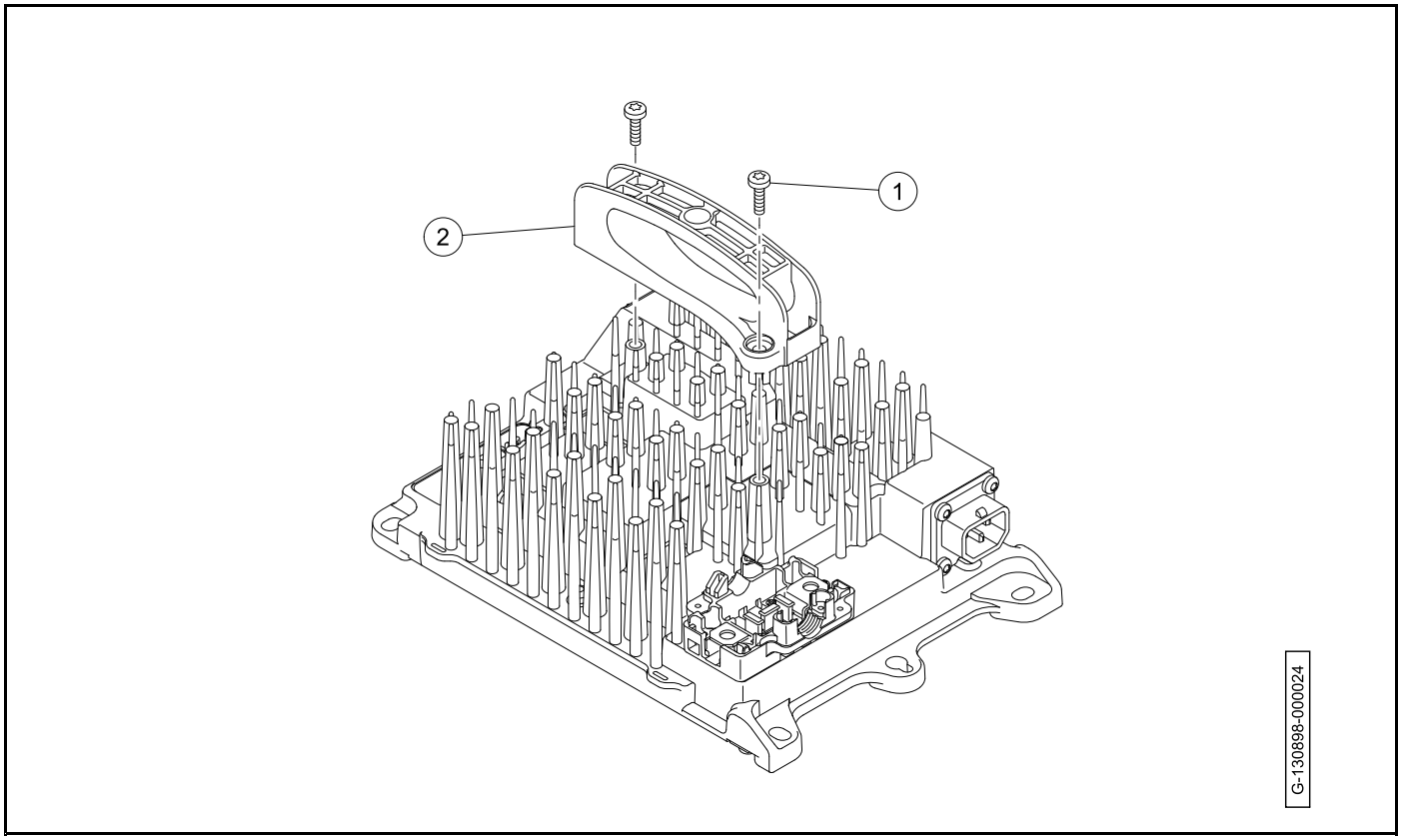


Figure 15-27 Handle

2. Remove the handle (2).

HANDLE INSTALLATION

1. Install the handle (2) on the battery charger **(Figure 15-27, Page 15-42)**.
2. Install the screws (1). Tighten the screws to 39.8 lb·in (4.5 N·m).

FOOT REMOVAL

1. Disconnect the DC cord from the vehicle charge receptacle.
2. Disconnect the AC cord from the AC power source.
3. If the battery charge is mounted, remove the battery charger.
4. Squeeze the barbs (1) on the foot (2) and push the foot out of charger mounting tab **(Figure 15-28, Page 15-43)**.

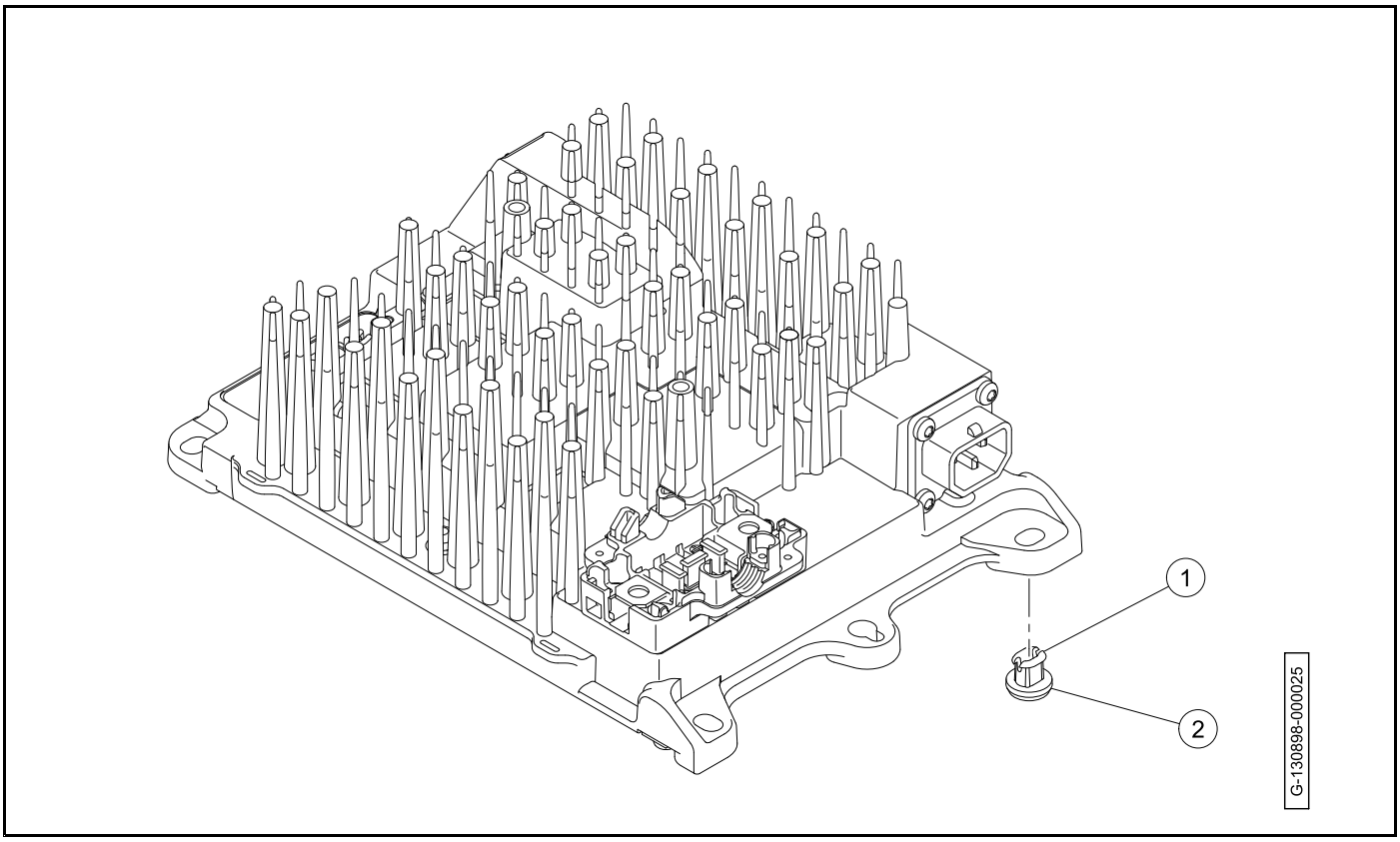


Figure 15-28 Foot

FOOT INSTALLATION

1. Push the foot (2) into hole in charger mounting tab until the barbs (1) come through and secure foot in place **(Figure 15-28, Page 15-43)**.
2. If required, mount the battery charger. **See External Battery Charger Mounting.**

ONBOARD CHARGER REPAIRS

⚠ WARNING

- **Knowledge of battery charger wiring and component terminology is required before attempting any repair.**
- **Prior to servicing the charger, disconnect the AC cord from the AC outlet.**

NOTE: *This charger has no internal components 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.*

ONBOARD CHARGER REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries.
4. Disconnect the AC cord from AC power source.
5. Disconnect the DC cord from the onboard charger harness (1) **(Figure 15-29, Page 15-44)**.

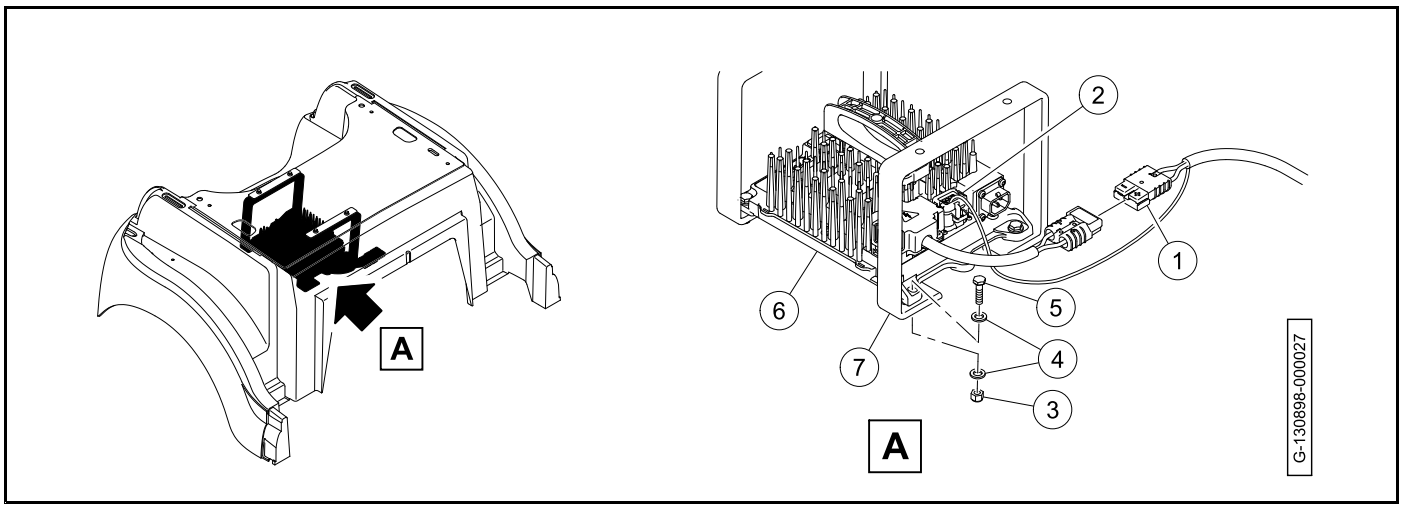


Figure 15-29 Onboard Charger

6. Disconnect the connector (2).
7. Remove the nuts (3), washers (4), and bolts (5).
8. Remove the onboard charger (6) from the bracket (7).

ONBOARD CHARGER INSTALLATION

1. Connect the DC cord to the onboard charger harness (1) **(Figure 15-30)**.

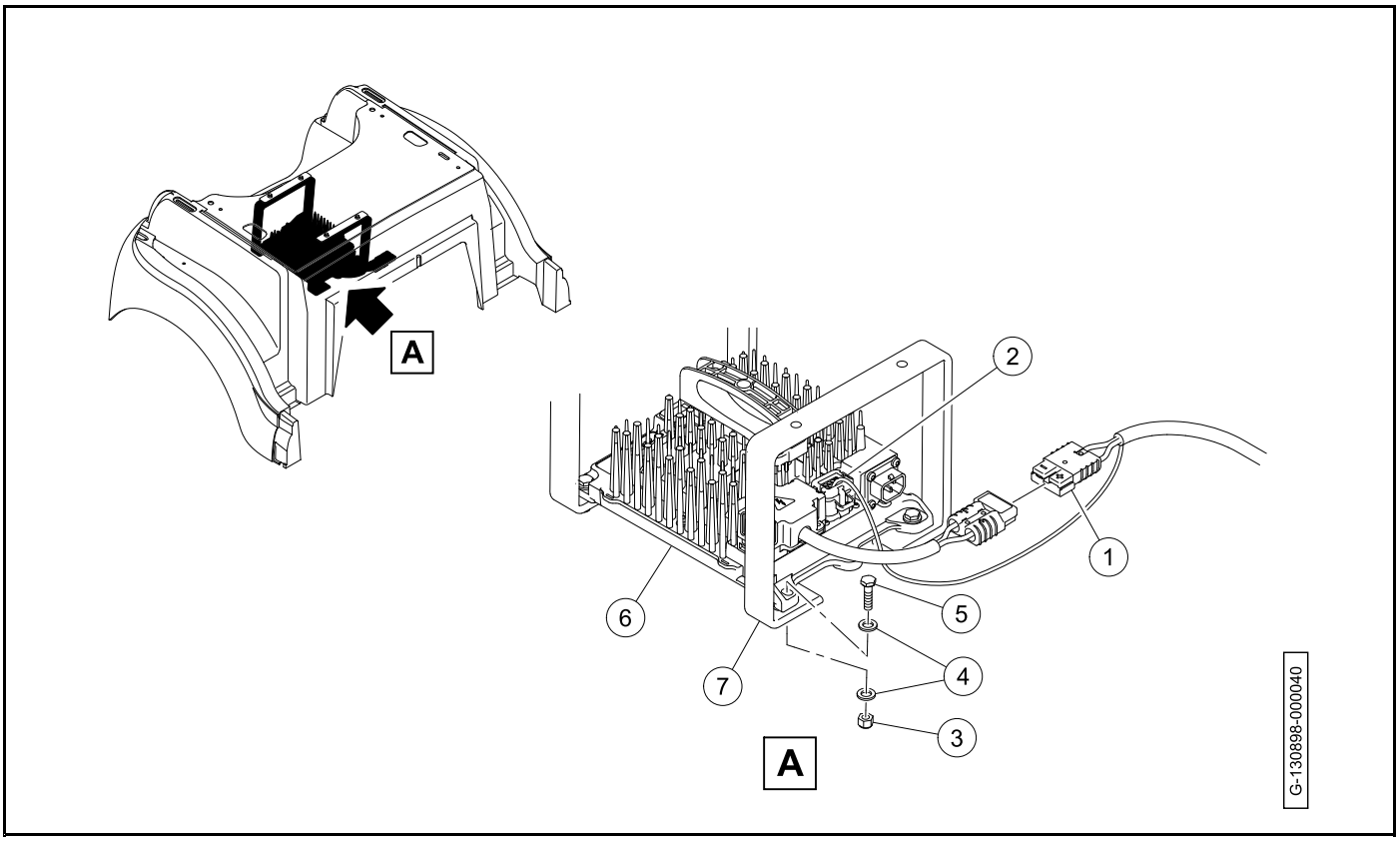


Figure 15-30 Onboard Charger

2. Connect the connector (2).
3. Put the onboard charger (5) on the bracket (6).
4. Install the bolts (5), washers (4), and nuts (3). Tighten the bolts to 13 lb·in (1.5 N·m).
5. Set the Run/Tow switch to TOW.
6. Connect the batteries.

AC CORD REEL REMOVAL

1. Disable the vehicle.
2. Disconnect the batteries.
3. Disconnect the AC cord from AC power source.
4. Disconnect the AC cord (1) from the battery charger **(Figure 15-31, Page 15-46)**.

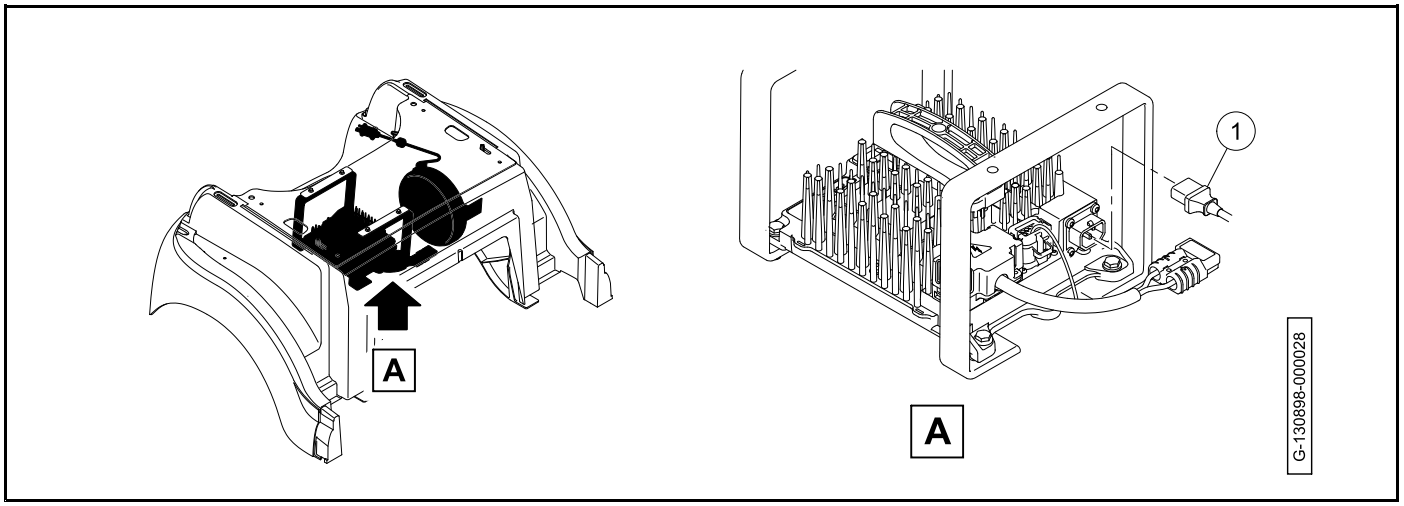


Figure 15-31 Disconnect From Battery Charger

5. Remove the screws (2) **(Figure 15-32, Page 15-46)**.

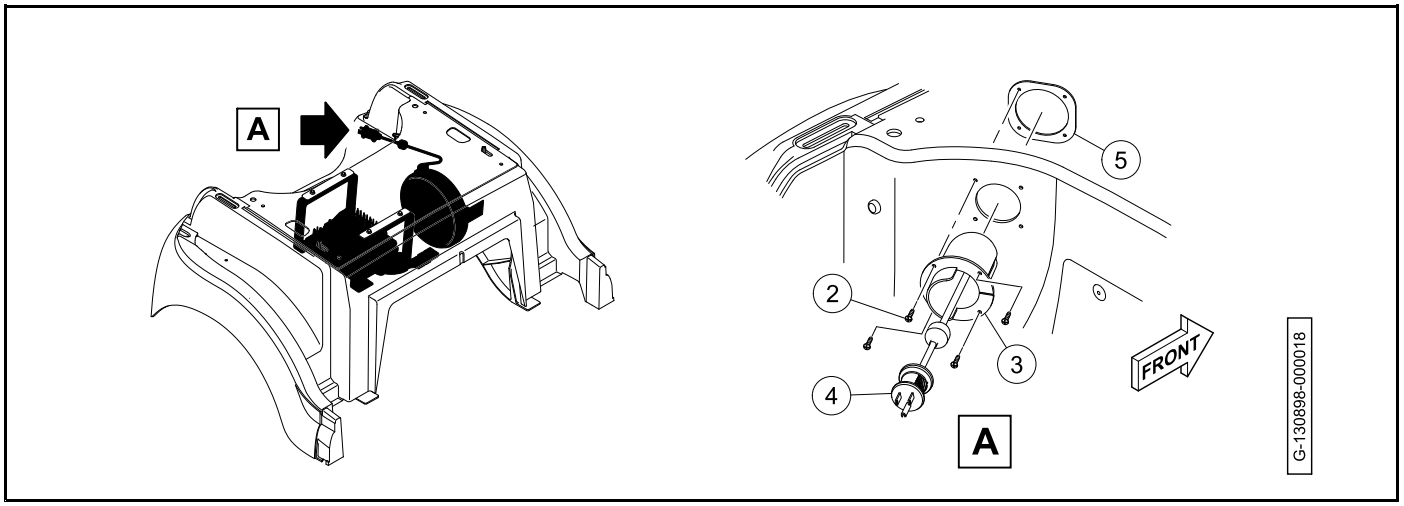


Figure 15-32 Cord Housing Removal

6. Remove the cord housing (3).
7. Remove the AC cord (4) from the cord housing.
8. Remove the backing plate (5).

9. Remove the nuts (6), washers (7), and bolts (8) **(Figure 15-33, Page 15-47)**.

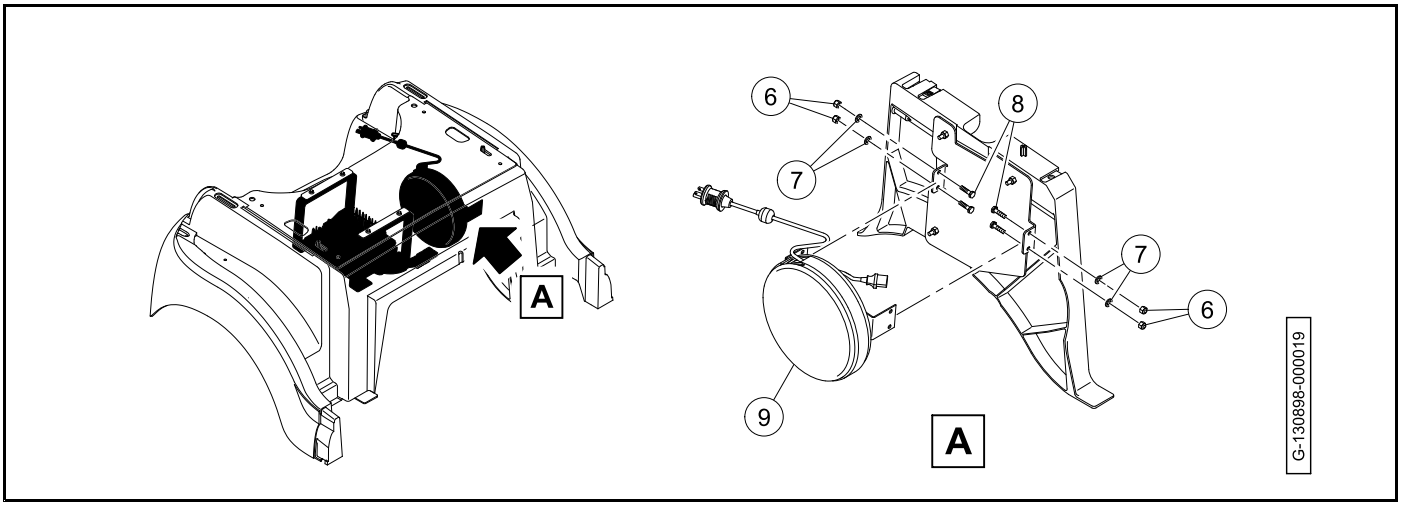


Figure 15-33 AC Cord Reel Removal

10. Remove the AC cord reel (9).

AC CORD REEL INSTALLATION

1. Install the AC cord reel (9) on the cord reel plate **(Figure 15-34, Page 15-47)**.

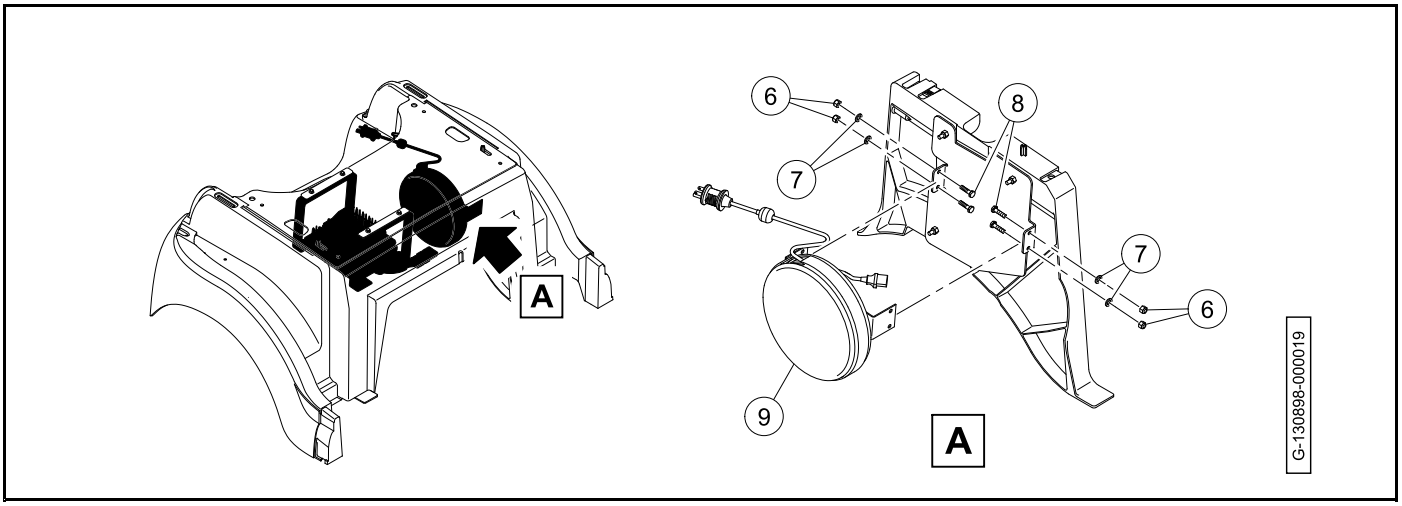


Figure 15-34 AC Cord Reel Installation

2. Install the bolts (8), washers (7), and nuts (6). Tighten the nuts to 88.5 lb·in (10 N·m).

3. Install the backing plate (5) on the AC cord (4) **(Figure 15-35, Page 15-48)**.

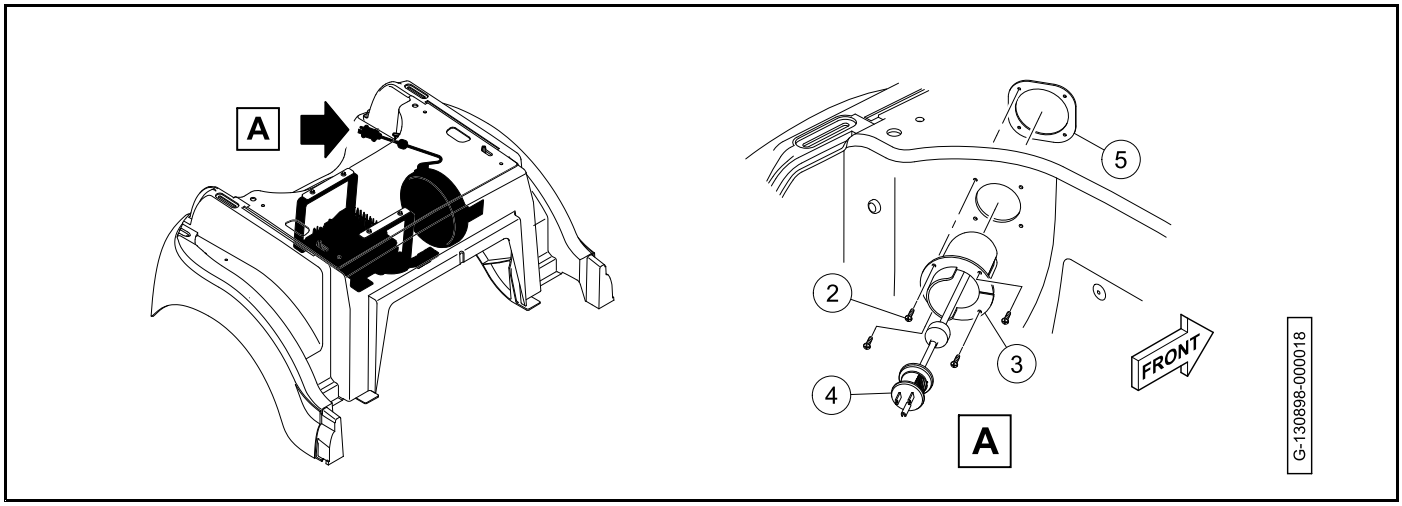


Figure 15-35 Cord Housing Installation

4. Put the AC cord through the cord housing (3).
5. Install the cord housing on the underbody.
6. Install the screws (2). Tighten the screws to 13 lb·in (1.5 N·m).
7. Connect the AC cord (1) to the battery charger **(Figure 15-36, Page 15-48)**.

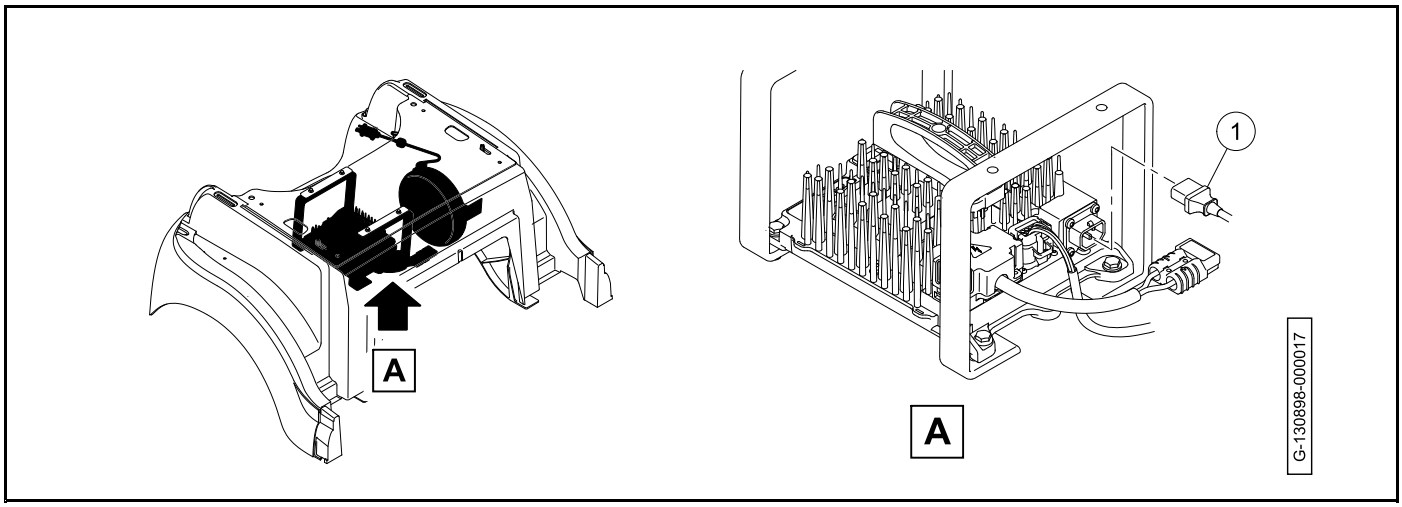


Figure 15-36 Connect To Battery Charger

8. Connect the batteries.

TERMINAL BLOCK COVER REMOVAL

1. Disconnect the AC cord from AC power source.
2. Disconnect the DC cord from the charger harness.
3. Push the tabs (1) in and remove the terminal block cover (2) **(Figure 15-37, Page 15-49)**.

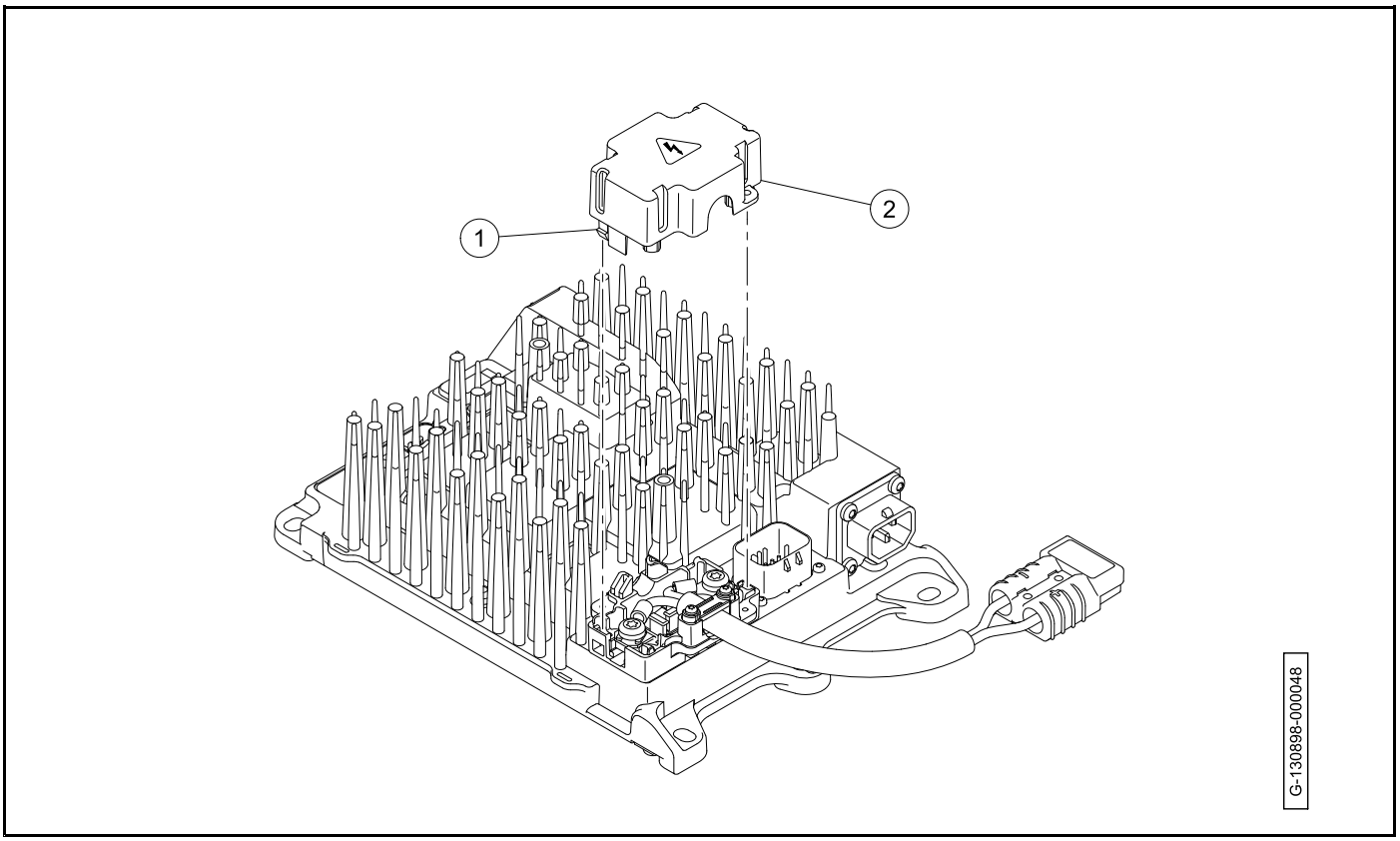


Figure 15-37 Onboard Charger Terminal Block Cover

TERMINAL BLOCK COVER INSTALLATION

⚠ WARNING

- **The terminal block cover on the DC terminal block must be installed properly to comply with UL code. This cover prevents water exposure and prevents a short across the DC terminals.**

1. Install the terminal block cover (2) onto the terminal block **(Figure 15-37, Page 15-49)**.
2. Push down until the tabs (1) lock into place.

DC CORD REMOVAL

1. Disable the vehicle.
2. Disconnect the batteries.
3. Disconnect the AC cord from AC power source.
4. Disconnect the DC cord from the onboard charger harness.
5. Remove the terminal block cover.
6. Remove the screws (1) **(Figure 15-38, Page 15-50)**.

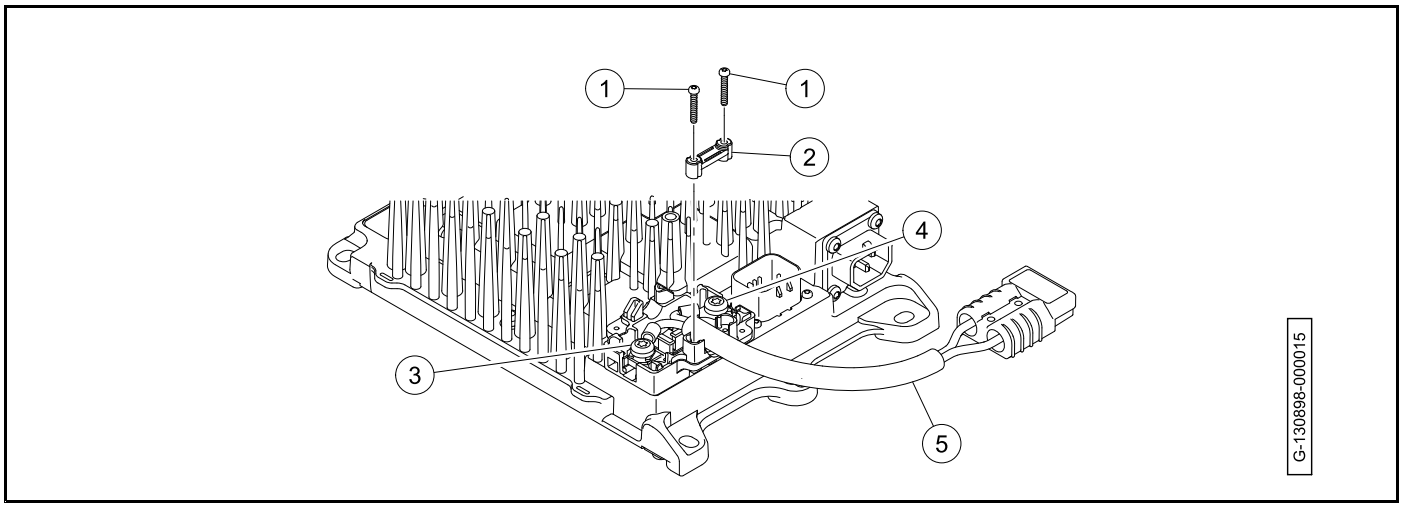


Figure 15-38 Onboard Charger DC Cord

7. Remove the clamp (2).
8. Loosen the terminal screws (3 and 4).
9. Remove the DC cord (5).

DC CORD INSTALLATION

1. Attach the red DC cord wire to positive (+) terminal (4) .

NOTE: *The positive symbol (+) and negative symbol (–) are molded into the terminal block.*

2. Attach the black DC cord wire to the negative (-) terminal (3).
3. Tighten the terminal screws to 39.8 lb·in (4.5 N·m).
4. Install the clamp (2).
5. Install the screws (1). Tighten the screws to 7.5 lb·in (0.85 N·m).
6. Install the terminal block cover.
7. Connect the DC cord (5) to the onboard charger harness.
8. Connect the batteries.

TEST PROCEDURES

See General Warnings on page 1-2.

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 – Charger DC Circuit Continuity Test
6 – Charger Output Test

TEST PROCEDURE 1 – Battery Voltage Using Multimeter

1. Check battery pack voltage. **See Measuring Voltage of Battery Set, Section 14, Page 14-3.**
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 22-4.**
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 22-4.**
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 22-7, Page 22-11)**.

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 15-6.**

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 — AC 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 volts 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 – 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 15-49.**
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 lb·in (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 15-39.**

TEST PROCEDURE 6 – 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 18, Page 18-8.***

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.

SECTION 16 — AC ELECTRIC VEHICLE - MOTOR

16

GENERAL INFORMATION

The vehicle is equipped with a 30-volt AC motor. 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.

MOTOR REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Lift the rear of the vehicle.
5. Remove the rear wheels.
6. Install one lug nut onto a stud on each rear hub.

NOTE: *This will keep the brake drums on the hubs.*

7. Remove the bow tie pins (1) **(Figure 16-1, Page 16-1)**.

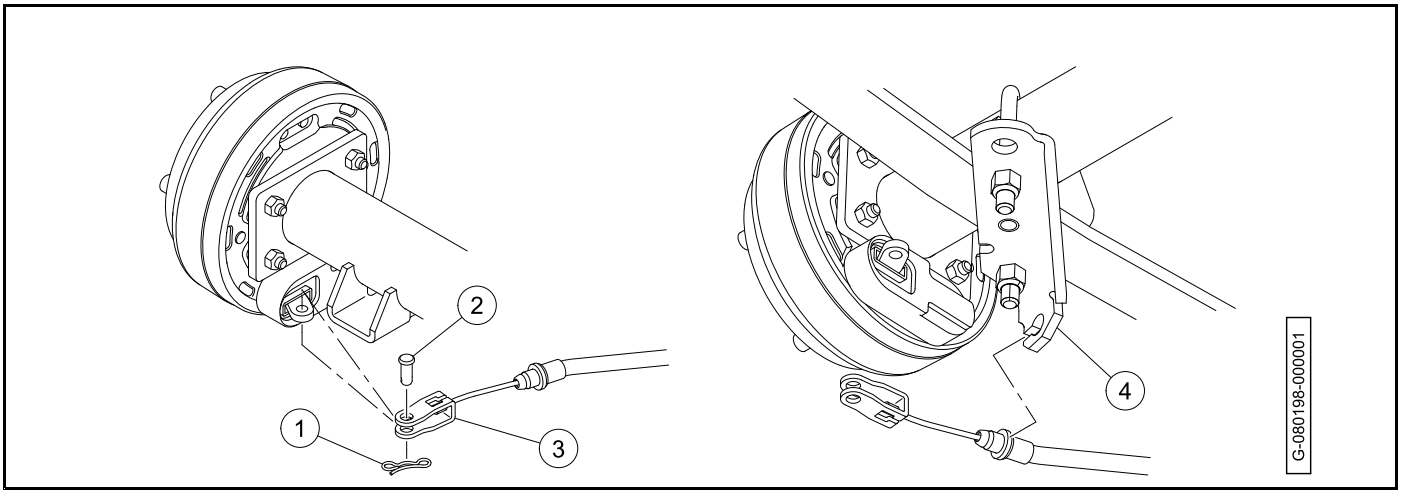


Figure 16-1 Brake Cable Removal

8. Remove the brake cable clevis pins (2).
9. Remove the brake cable (3) from the brake cluster.
10. Use the brake cable release tool to compress tangs on cable end and remove cable end from bracket (4).
11. Remove the nut (5), cup washer (6), and rubber bushings (7) from the lower mounting stem of the shock absorbers **(Figure 16-2, Page 16-2)**.

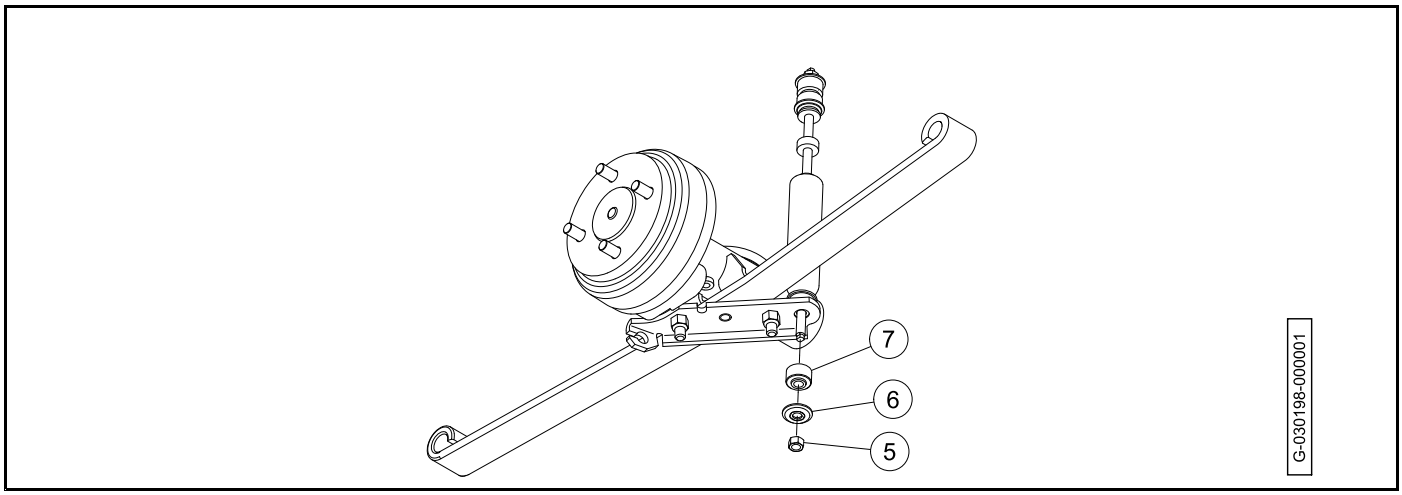


Figure 16-2 Disconnect Shocks

12. Remove the shock absorbers from the bracket.

CAUTION

- **If a motor wire has damage, the motor harness must be replaced. The motor harness has epoxy lined heat shrink. Do not try to cut the heat shrink.**

13. Label the motor wires.
14. Remove the rubber boots (8) **(Figure 12-47, Page 12-51)**.

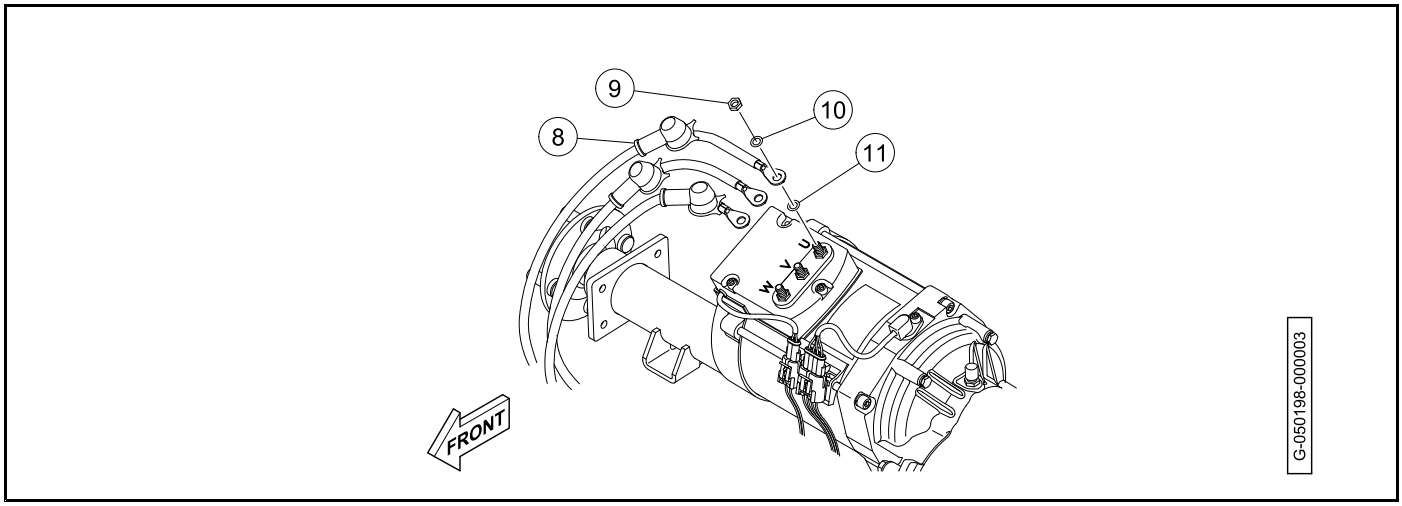


Figure 16-3 Motor Wire Connections

15. Remove the nuts (9) and lock washers (10).
16. Remove the motor wires from the terminal block.
17. Remove the washers (11).
18. Disconnect the speed sensor (12) and temperature sensor (13) **(Figure 16-4, Page 16-3)**.

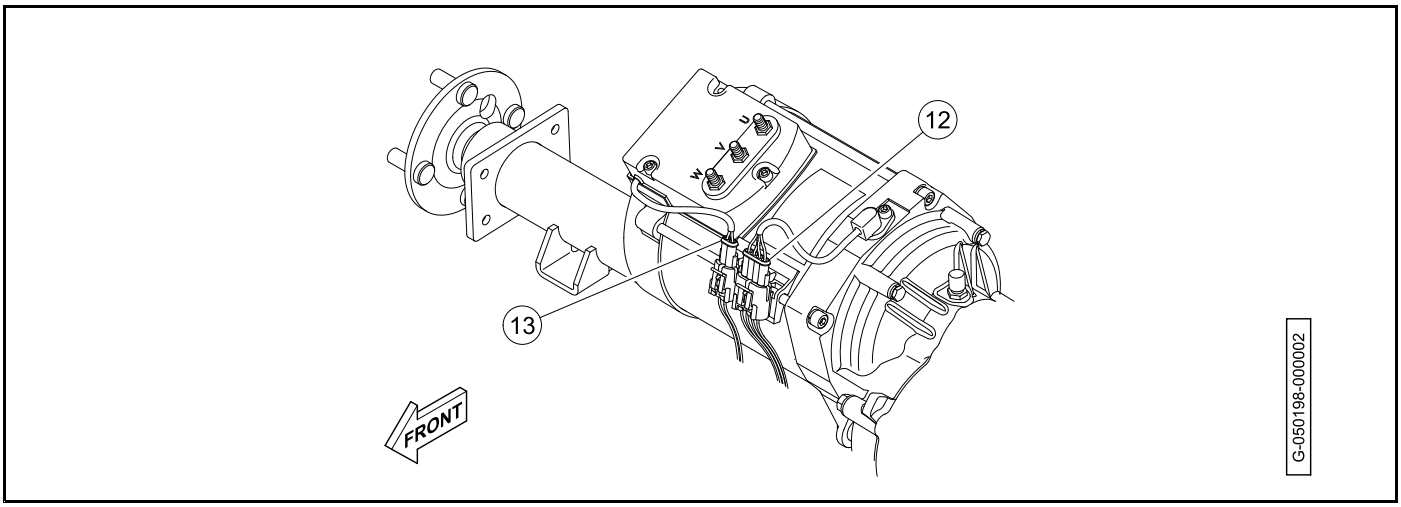


Figure 16-4 Temperature Sensor and Terminal Block Connections

19. Remove the rear lower shackle nuts (14) and bolts (15) **(Figure 16-5, Page 16-3)**.

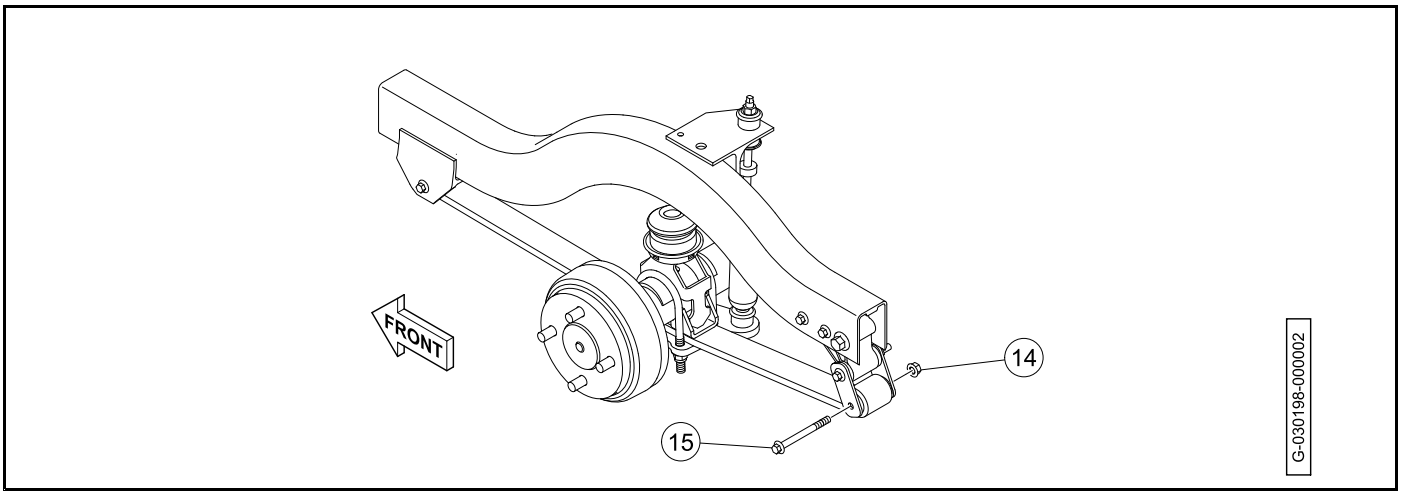


Figure 16-5 Rear Lower Shackle Hardware Removal

20. Position the shackles so they are clear of springs.
21. 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.
22. 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.
23. Remove the three motor mounting bolts (16) and lock washers (17) **(Figure 16-6, Page 16-4)**.

⚠ CAUTION

- **Do not position fingers under motor when sliding motor off of the input shaft. Fingers may get pinched when motor disengages.**

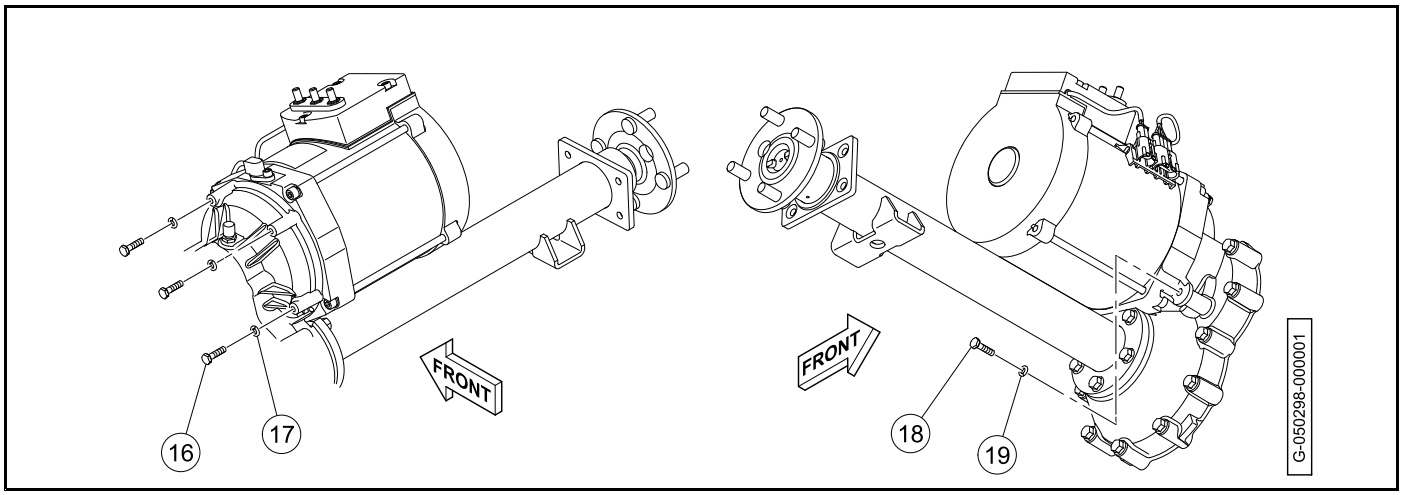


Figure 16-6 Motor Mounting Bolt Removal

24. Remove the motor mounting bolt (18) and lock washer (19).
25. Slide the motor away from the transaxle until the motor spline becomes disengaged from the input shaft, then lift motor out.

MOTOR INSTALLATION

See General Warnings on page 1-2.

1. Use a clean cloth and CRC® Brakleen™ or equivalent brake cleaner to clean the transaxle input shaft.
2. Make sure that the grooves of the transaxle input shaft are clean.
3. Apply approximately 1/2 inch (1.3 cm) of moly-teflon lubricant evenly on the input shaft approximately 1/8 inch (3.1 mm) (A) from the end of the shaft **(Figure 16-7, Page 16-4)**.

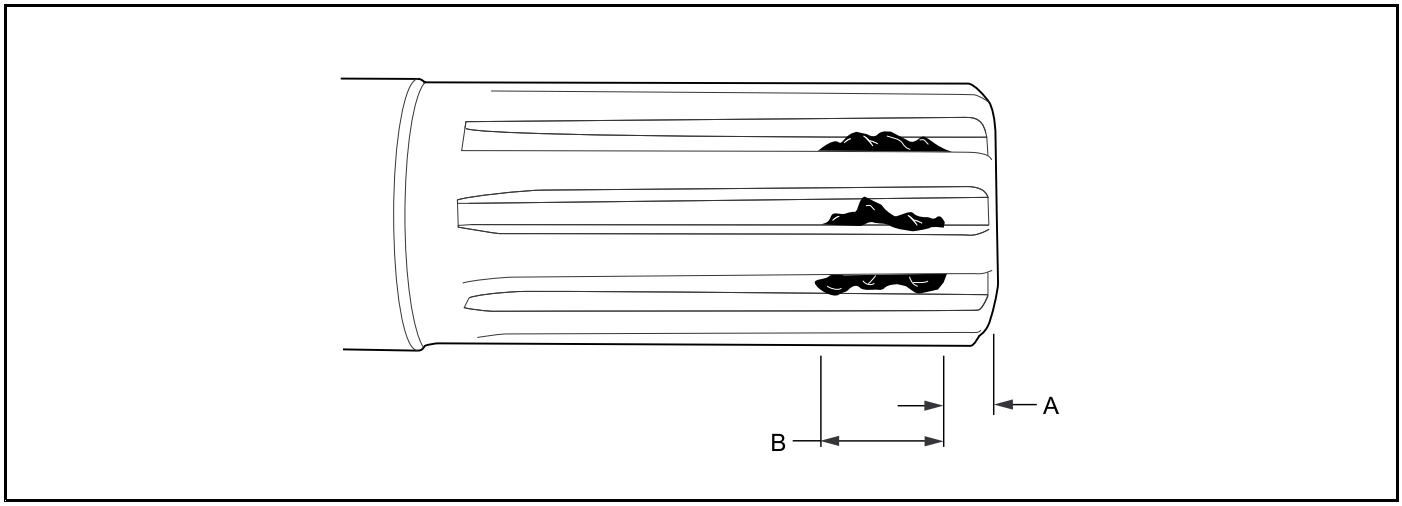


Figure 16-7 Moly-teflon Lubricant on Input Shaft Grooves

4. The moly-teflon lubricant should be evenly distributed in the grooves to a width of approximately 3/8 inch (9.5 mm) (B).
5. Clean the grease out of one groove.

NOTE: *This will let air escape when the motor is pushed onto the input shaft.*

6. Make sure that the chamfer (1) and end (2) are completely clean **(Figure 16-8, Page 16-5)**.

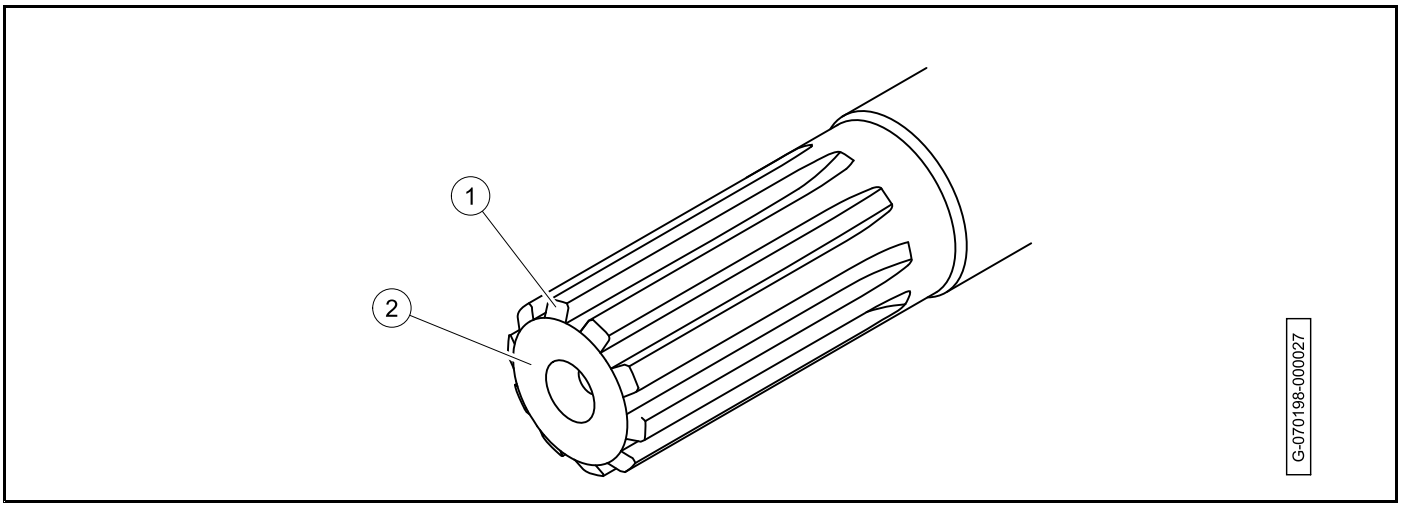


Figure 16-8 Clean Chamfer and Input Shaft End

7. Make sure that the motor coupling (3) and new molded bumper (4) are clean **(Figure 16-9, Page 16-5)**.

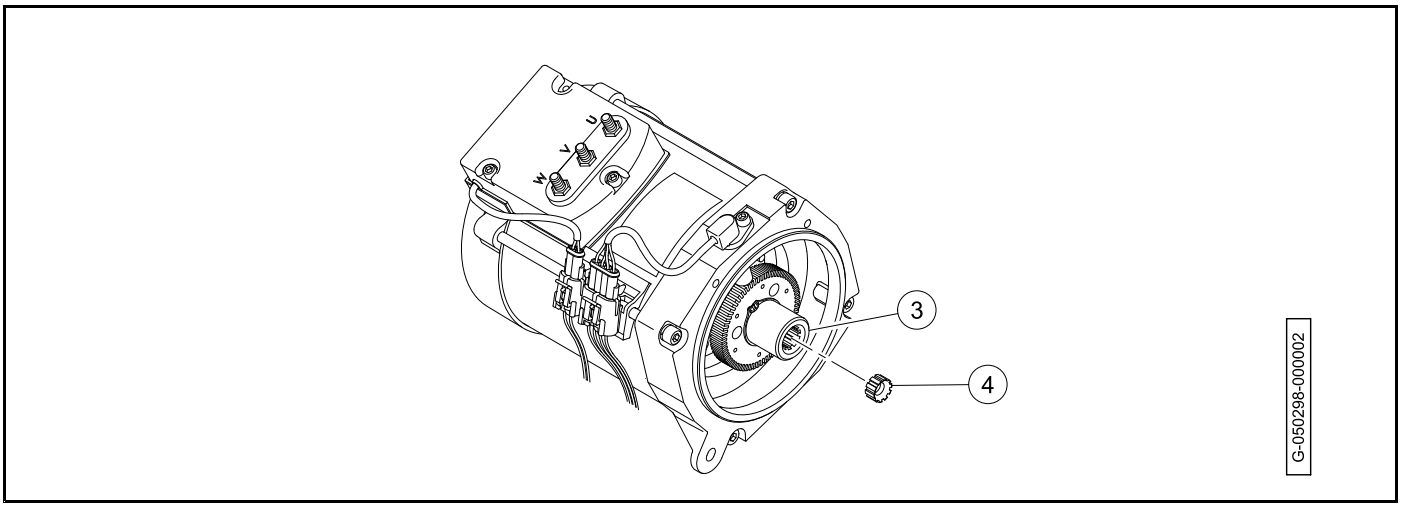


Figure 16-9 Motor Coupling and New Molded Bumper

8. Install the new molded bumper with the flat side toward the motor coupling.
9. Make sure that the new molded bumper is seated at the bottom of the motor coupling.
10. 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. There will be approximately 1/16 inch (1.6 mm) gap (A) between the motor adapter ring and transaxle housing **(Figure 16-10, Page 16-6)**.*

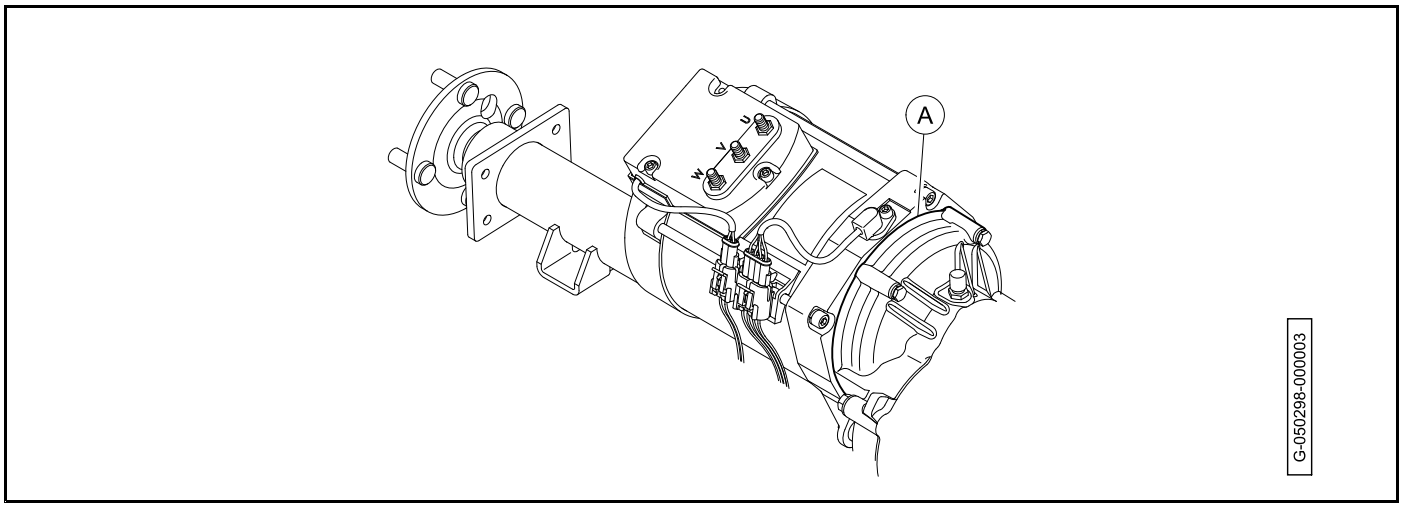


Figure 16-10 Gap at Motor and Transaxle

11. Loosely install the bolts (5) and lock washers (6). Do not tighten.

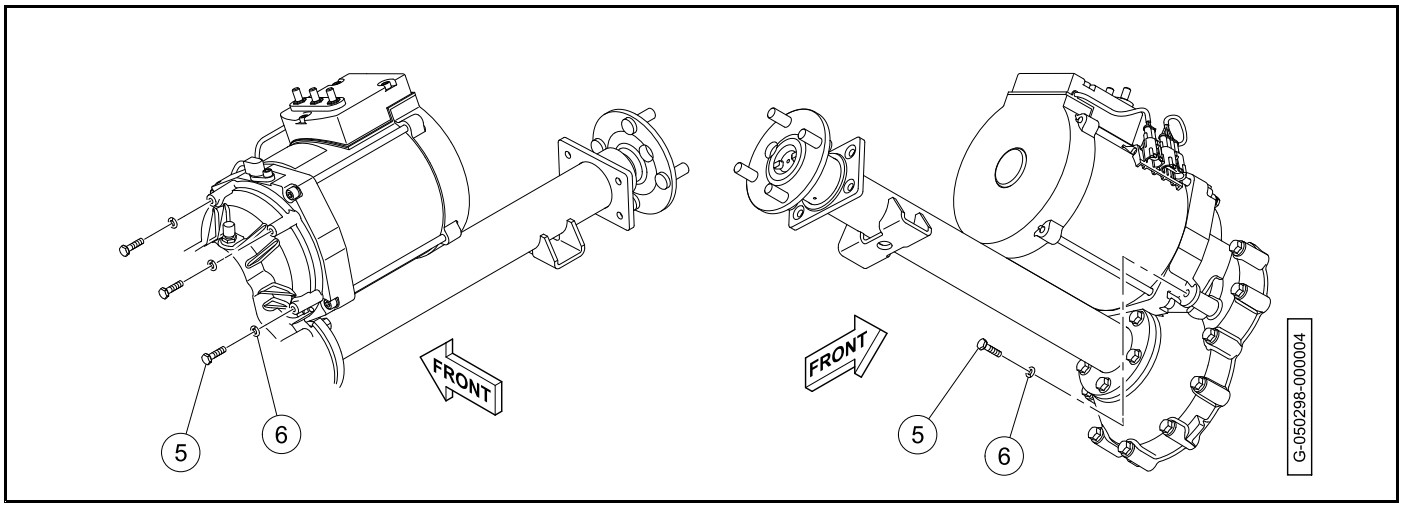


Figure 16-11 Motor Mounting Bolts

12. Tighten the bolts with your fingers in the sequence shown until the motor is seated on the transaxle housing **(Figure 16-12, Page 16-7)**.

CAUTION

- **Make sure the motor is properly seated in the transaxle housing.**
- **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.**

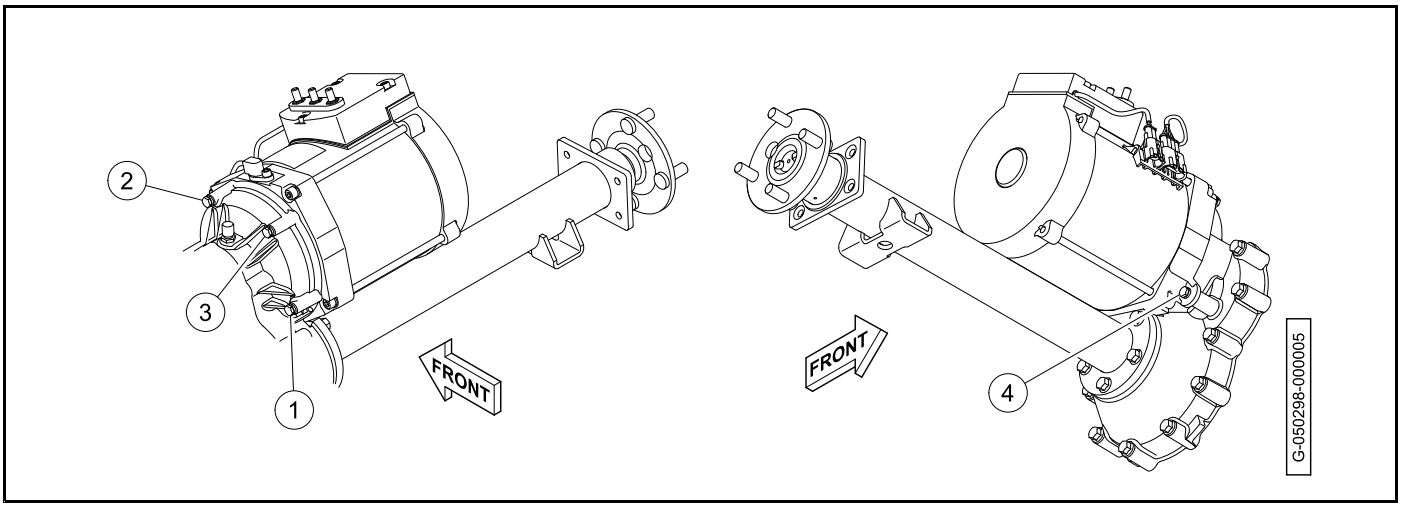


Figure 16-12 Tightening Sequence

13. Tighten the bolts in the sequence shown to 100 lb·in (11.3 N·m) **(Figure 16-11, Page 16-6)**.
14. Tighten the bolts again to 100 lb·in (11.3 N·m).
15. Connect the speed sensor (7) and temperature sensor (8) **(Figure 16-4, Page 16-3)**.

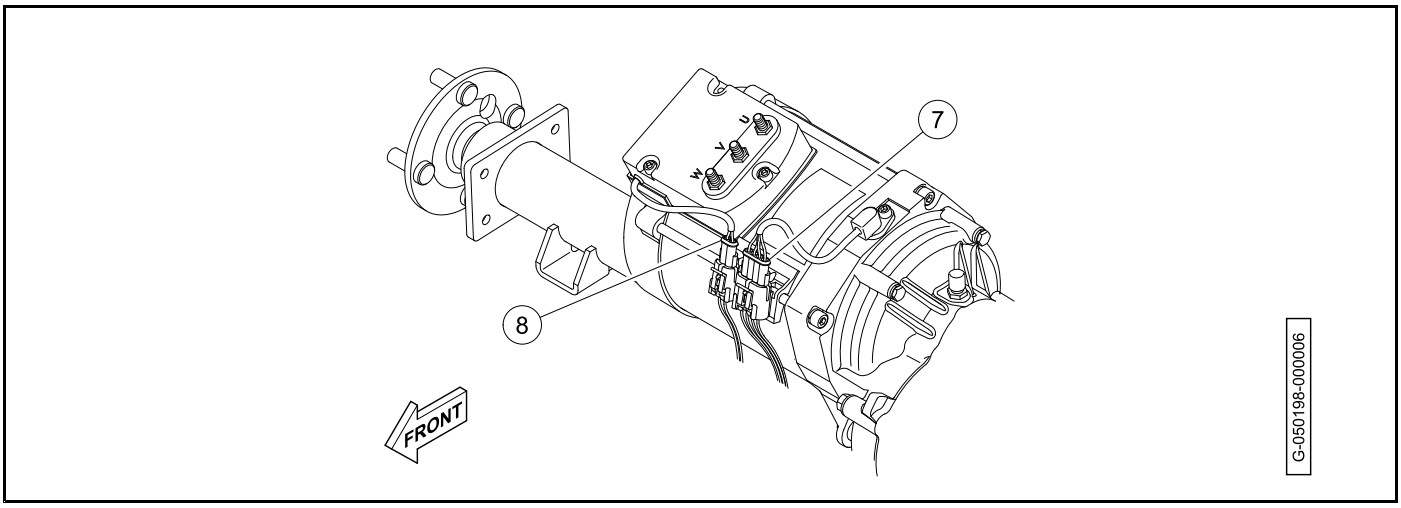


Figure 16-13 Temperature Sensor and Terminal Block Connections

16. Install the washers (9) **(Figure 16-14, Page 16-8)**.

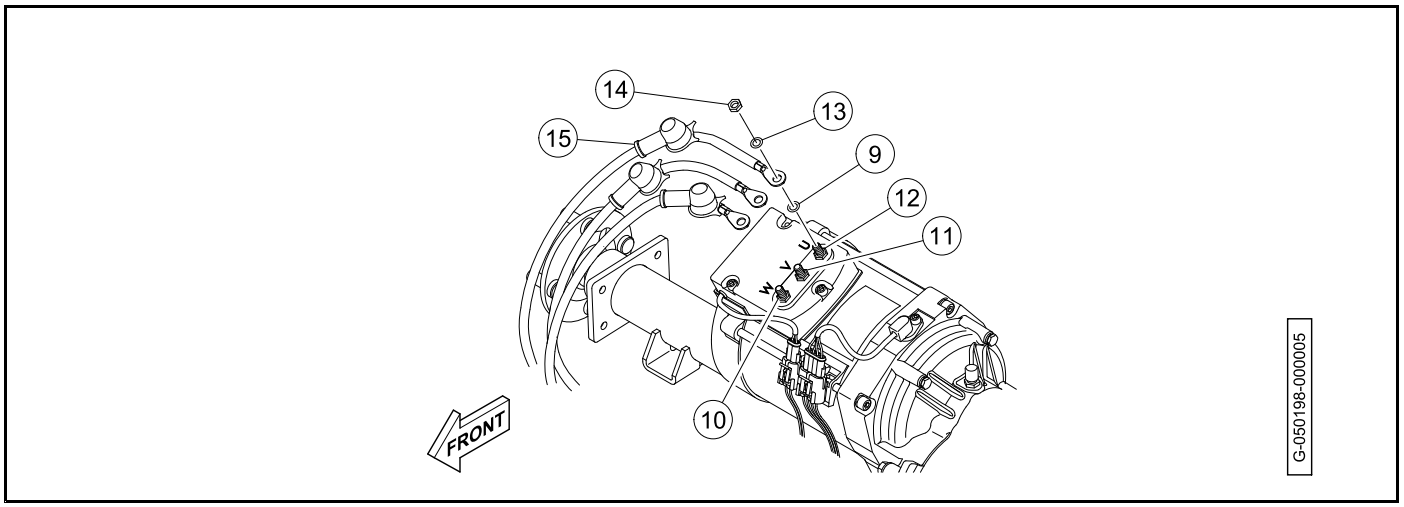


Figure 16-14 Motor Wire Connections

17. Connect the orange wire with the blue nd to the W terminal (10).
18. Connect the orange wire with the yellow end to the V terminal (11).
19. Connect the orange wire with the white end to the U terminal (12).
20. Install the lock washers (13) and nuts (14). Hold the bottom nut of terminal with a wrench and tighten the nuts to 45 lb·in (5.0 N·m).
21. Install the rubber boots (15) over the terminals.
22. If using a chain hoist, lower the vehicle while guiding the leaf springs into the rear spring shackles. Then lift the jack stands to support the transaxle.
23. If using a floor jack, lift the differential while guiding the leaf springs into the rear spring shackles. Then lift the jack stands to support the transaxle.
24. Install the bolts (16) and rear lower shackle nuts (17) **(Figure 16-15, Page 16-8)**. Tighten the nuts to 18.5 lb·ft (25 N·m).

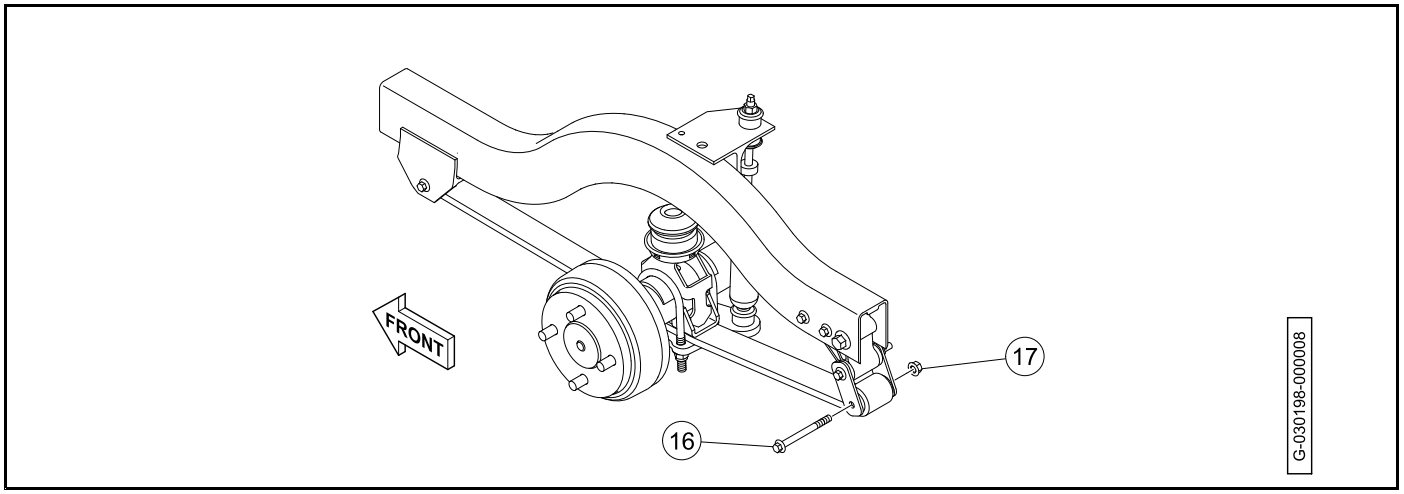


Figure 16-15 Rear Lower Shackle Hardware Installation

25. Install the cable housings into the shock mount brackets (18) **(Figure 16-16, Page 16-9)**. Make sure that the cable clips are secure.

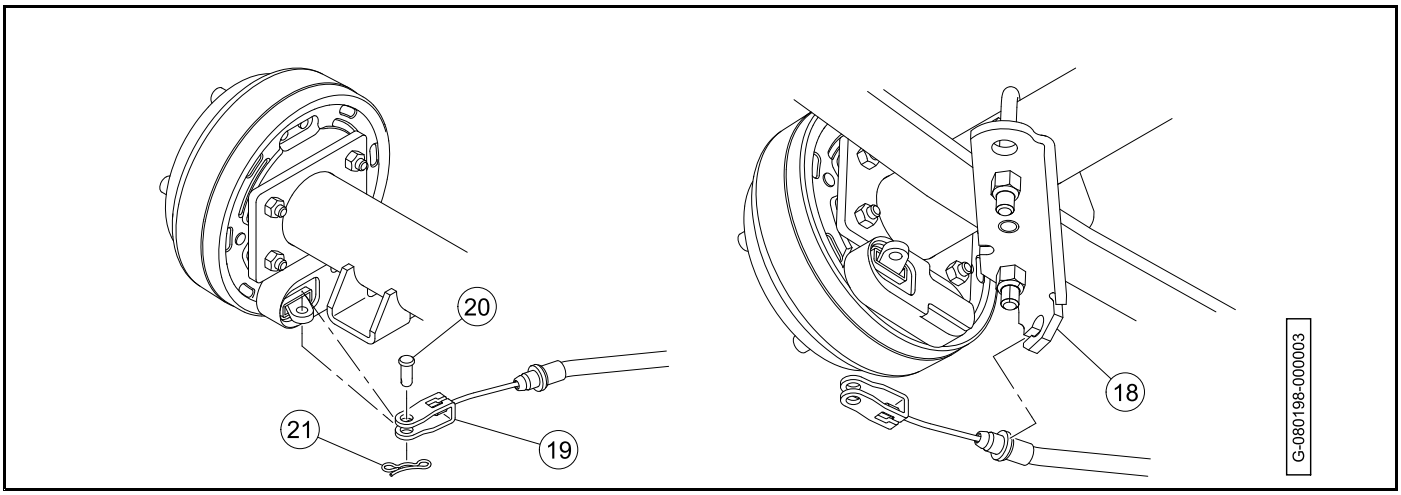


Figure 16-16 Brake Cable Installation

26. Install the cables (19) onto the brake actuator arms.
27. Install the brake cable clevis pins (20).
28. Install the bow tie pins (21).
29. Install the shock absorbers onto the shock mount brackets.
30. Install the rubber bushings (22), cup washers (22), and nuts (24) **(Figure 16-17, Page 16-9)**. Tighten the nuts until the rubber bushings expand to the same size as the cup washers.

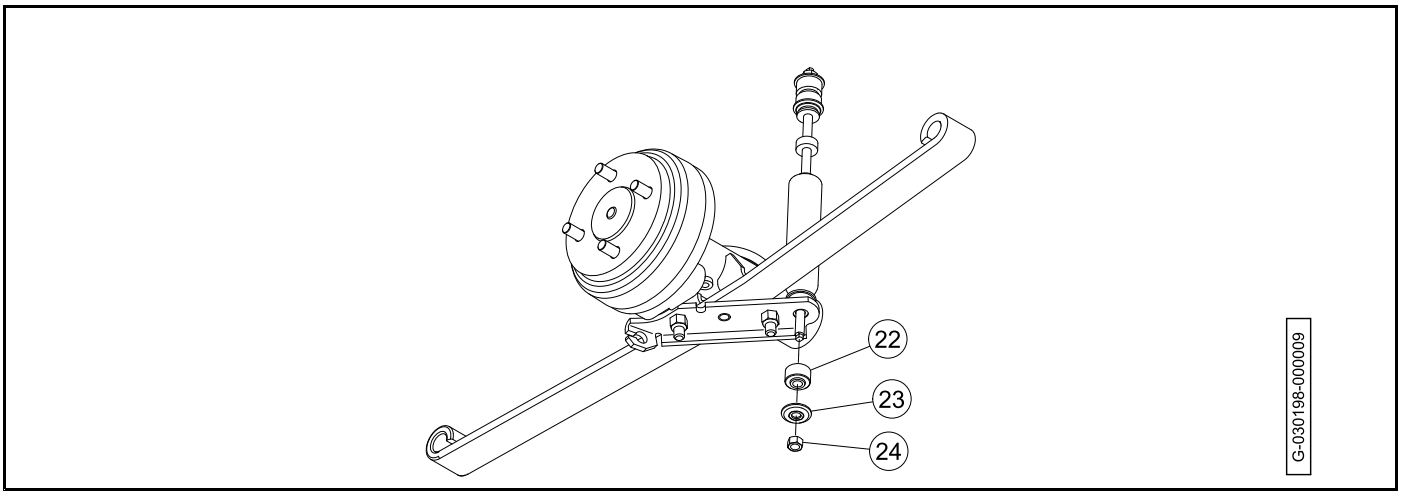


Figure 16-17 Connect Shocks

31. Install the rear wheels.
32. Lift the vehicle and remove the jack stands.
33. Lower the vehicle.
34. Connect the batteries.
35. Set the Run/Tow switch to RUN.
36. Inspect the vehicle to check for correct operation. **See following WARNING.**

⚠ WARNING

- **Make sure that the vehicle operates in the forward direction when the Forward/Reverse switch is in the FORWARD position.**
- **Make sure that the vehicle operates in the reverse direction when the Forward/Reverse switch is in the REVERSE position. The multi-purpose buzzer will sound as a warning when the Forward/Reverse switch is in REVERSE.**
- **Make sure that the vehicle does not operate when the Forward/Reverse switch is in the NEUTRAL position.**

TERMINAL BLOCK REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the motor.
5. Remove the screws (1) **(Figure 16-18, Page 16-10)**.

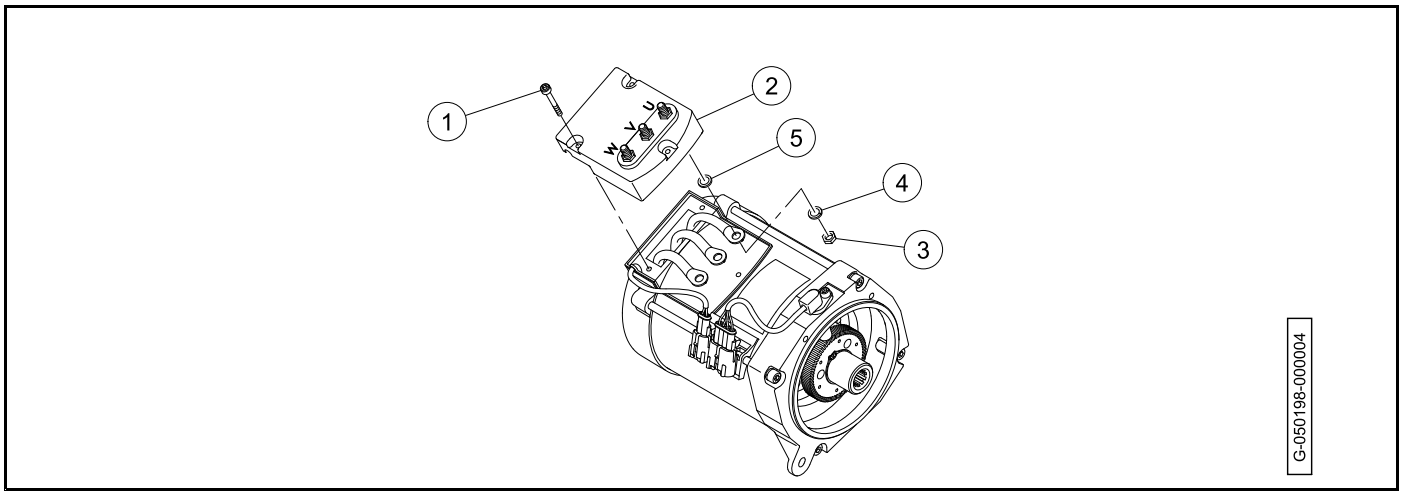


Figure 16-18 Terminal Block Removal

6. Pull the terminal block (2) away from the motor.
7. Remove the nuts (3).
8. Remove the wires and washers (4 and 5) from the terminal block.
9. Remove the terminal block.

TERMINAL BLOCK INSTALLATION

1. Install the washers (5) onto the terminal block (2) **(Figure 16-19, Page 16-11)**.

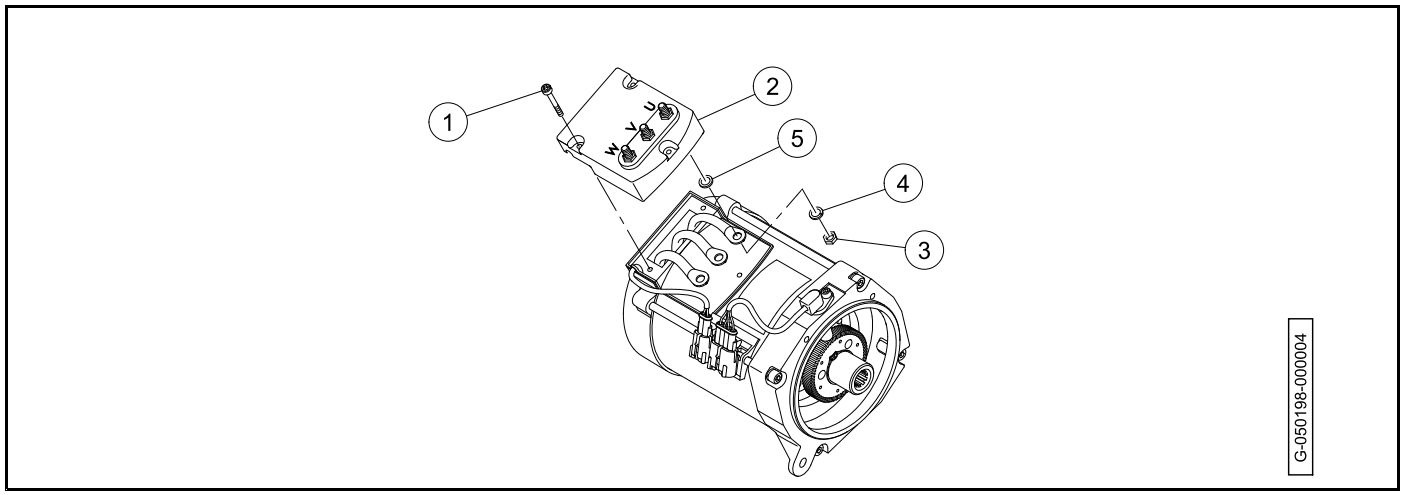


Figure 16-19 Terminal Block Installation

2. Install the wires, washers (4), and nuts (3). Tighten the nuts from 70 to 88.5 lb·in (8 to 10 N·m).
3. Install the terminal block onto the motor. Make sure that the gasket is installed correctly.
4. Apply Loctite® 222 or equivalent to the screws (1).
5. Install the screws (1) and tighten by hand.
6. Install the motor.
7. Connect the batteries.
8. Set the Run/Tow switch to RUN.
9. Inspect the vehicle to check for correct operation. **See following WARNING.**

⚠ WARNING

- **Make sure that the vehicle operates in the forward direction when the Forward/Reverse switch is in the FORWARD position.**
- **Make sure that the vehicle operates in the reverse direction when the Forward/Reverse switch is in the REVERSE position. The multi-purpose buzzer will sound as a warning when the Forward/Reverse switch is in REVERSE.**
- **Make sure that the vehicle does not operate when the Forward/Reverse switch is in the NEUTRAL position.**

SPEED SENSOR REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the access panel.
5. Use snap ring pliers to separate the motor harness clip (1) and push the speed sensor connector (2) down **(Figure 16-20, Page 16-12)**.

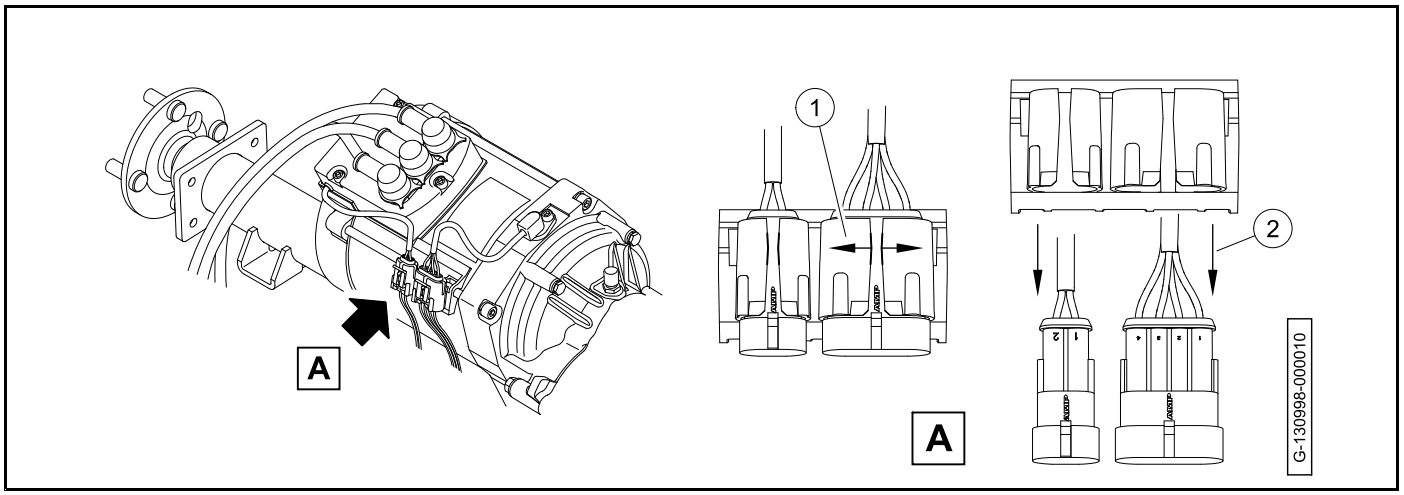


Figure 16-20 Speed Sensor Connector Removal

6. Remove the screw (3) **(Figure 16-21, Page 16-12)**.

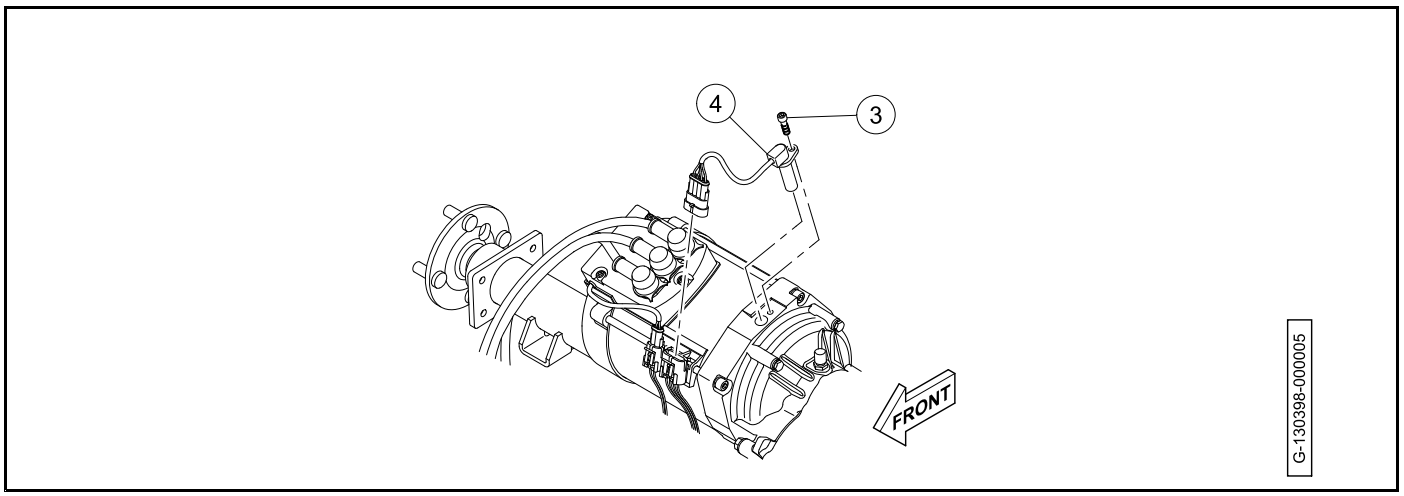


Figure 16-21 Speed Sensor Removal

7. Remove the speed sensor (4).

SPEED SENSOR INSTALLATION

1. Install the speed sensor (1) on the motor **(Figure 16-22, Page 16-13)**.

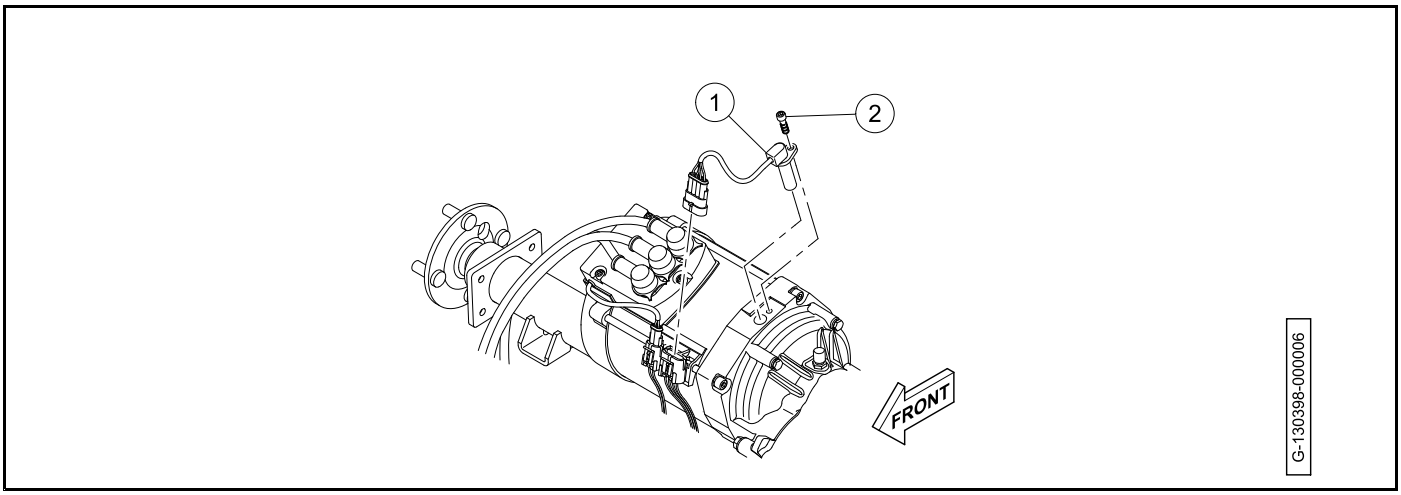


Figure 16-22 Speed Sensor Installation

2. Install the screw (2). Tighten the screw to 44 lb·in (5 N·m).
3. Route the speed sensor wire in the motor harness connector (3) **(Figure 16-23, Page 16-13)**.

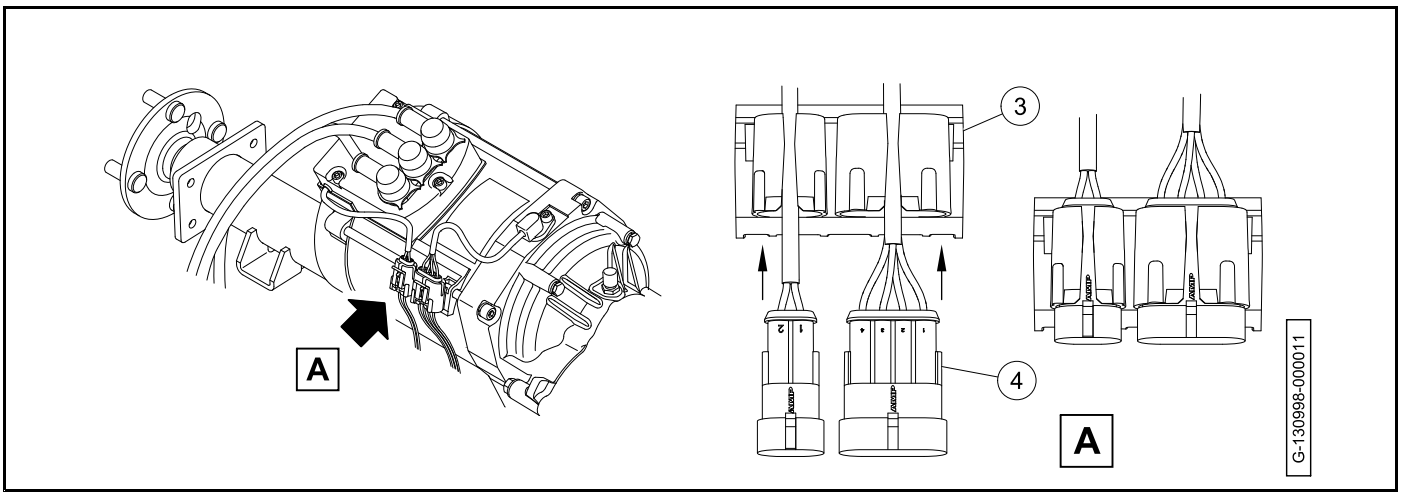


Figure 16-23 Speed Sensor Connector Installation

4. Install the speed sensor connector (4) in the motor harness connector.
5. Connect the speed sensor connector to the main harness.
6. Connect the batteries.
7. Set the Run/Tow switch to RUN.

Pagination Page

TRANSAXLE FLUID LEVEL CHECK

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the top plug (1) **(Figure 17-1, Page 17-1)**.

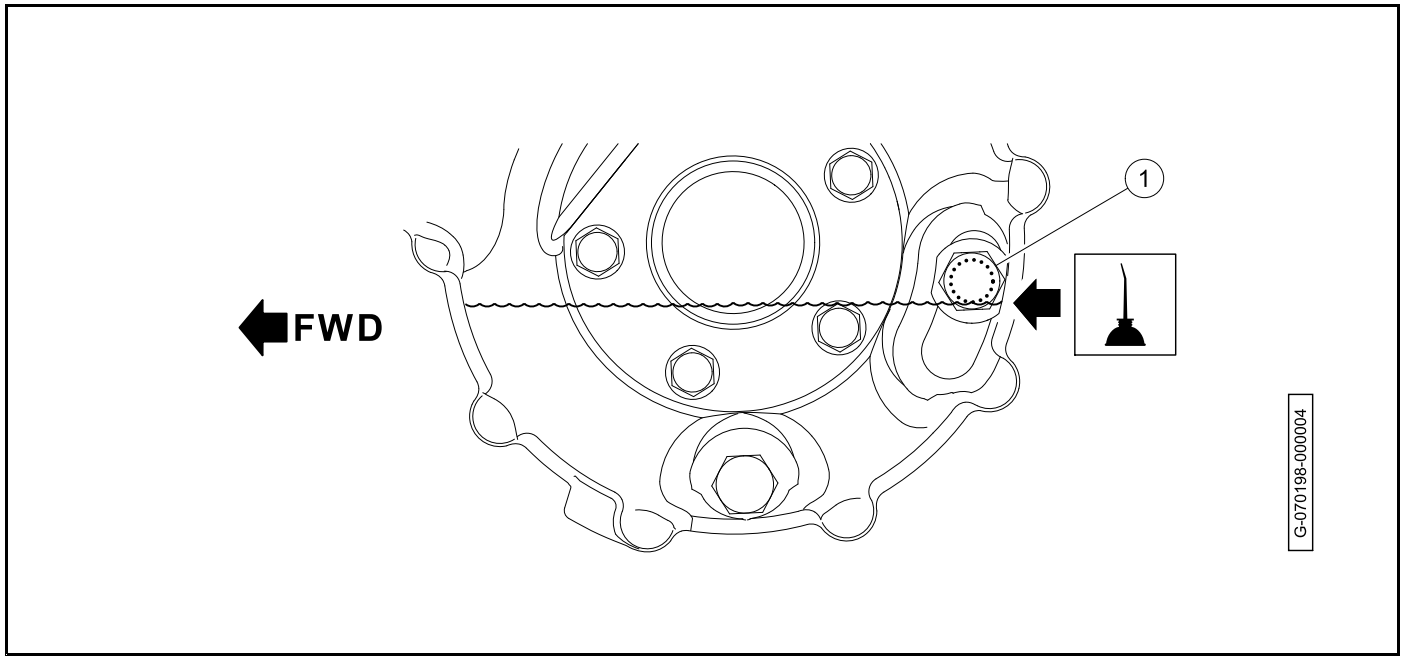


Figure 17-1 Transaxle Fluid Level Check

5. Make sure that the fluid level is at the bottom of the hole.
6. If the fluid level is low, add the recommended fluid until it is level with the bottom of the hole.
7. Install the top plug. Tighten the top plug to 23 lb·ft (31 N·m).
8. Connect the batteries.
9. Set the Run/Tow switch to RUN.

TRANSAXLE FLUID CHANGE

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Remove the top plug (1) **(Figure 17-2, Page 17-2)**.

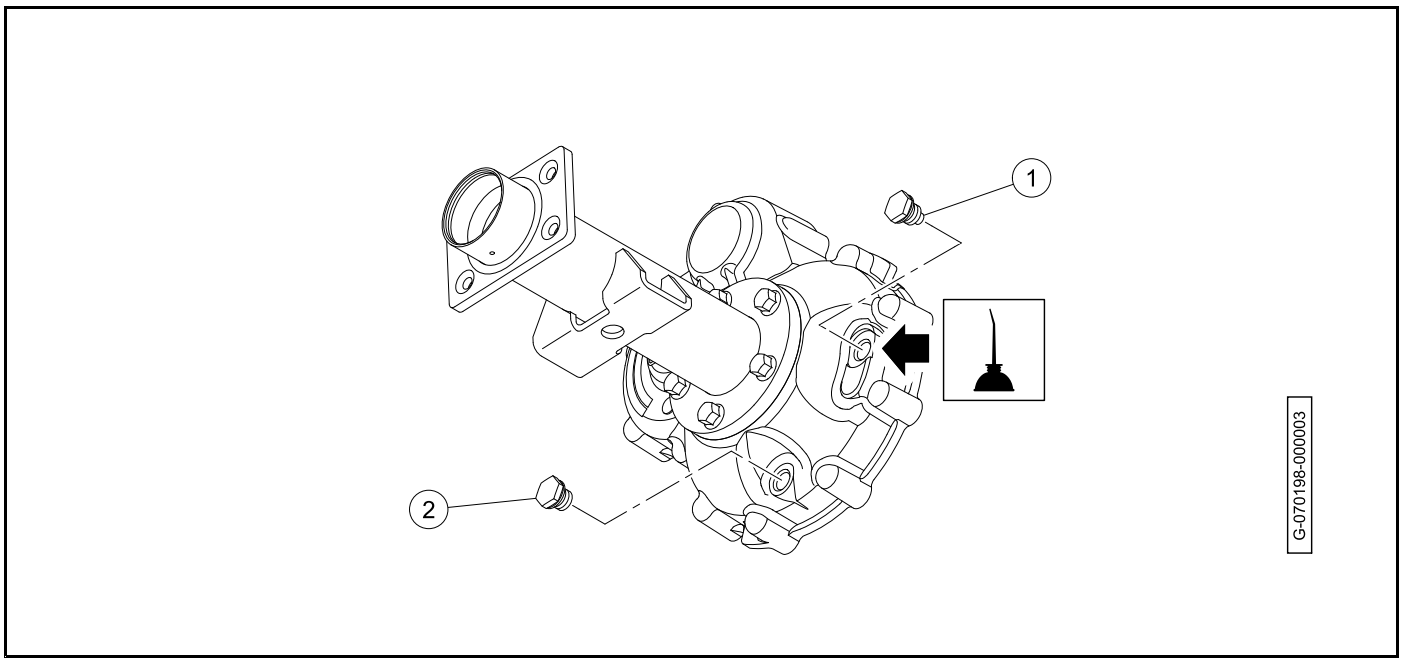


Figure 17-2 Transaxle Fluid Change

5. Put a drain pan below the bottom plug (2).
6. Remove the bottom plug.
7. Let the fluid drain fully.
8. Install the bottom plug. Tighten the bottom plug to 23 lb·ft (31 N·m).
9. Add recommended transaxle fluid until it is level with the bottom of the hole.
10. Install the top plug. Tighten the top plug to 23 lb·ft (31 N·m).
11. Connect the batteries.
12. Set the Run/Tow switch to RUN.

AXLE SHAFT AND OIL SEAL

AXLE SHAFT REMOVAL

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Lift the rear of the vehicle.

5. Remove the rear wheel.
6. Remove the brake drum.
7. Remove the internal retaining ring (1) **(Figure 17-3, Page 17-3)**.

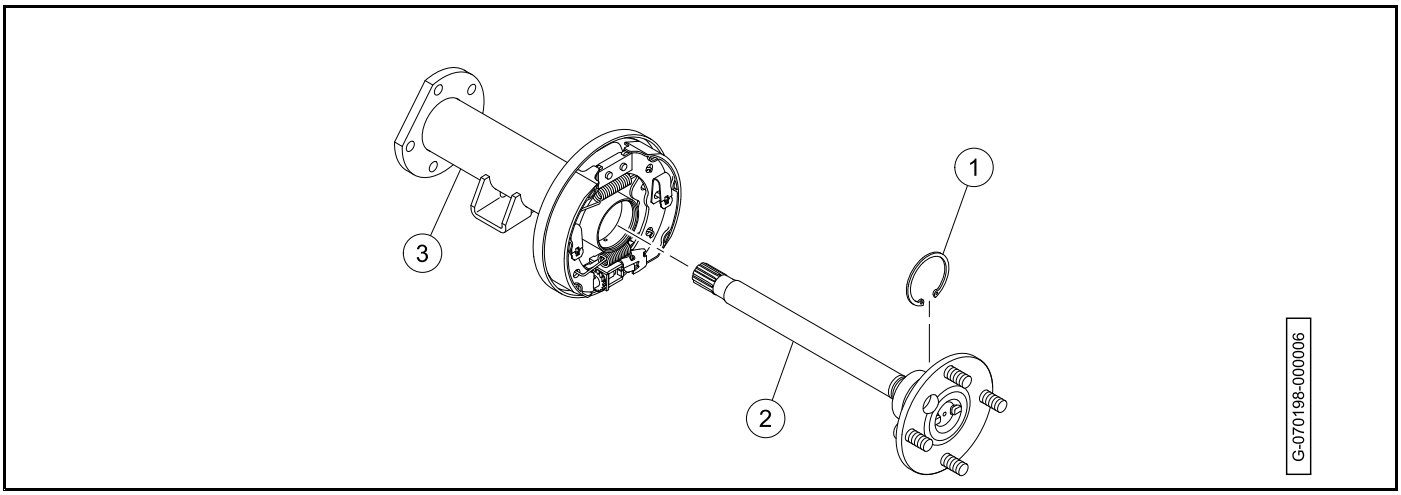


Figure 17-3 Axle Shaft Removal

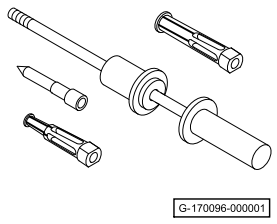
8. Pull the axle shaft assembly (2) straight out of the axle tube (3).

OIL SEAL REMOVAL

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.**
- **If the adapter ring is lost or damaged, the axle tube must be replaced. Do not discard the adapter ring.**

Special Tools Needed

	Bearing and Oil Seal Remover Assembly

NOTE: *Refer to the Illustrated Parts Catalog for service tool part numbers.*

1. Use the bearing and oil seal remover assembly to remove the oil seal (1) and adapter ring (2) from the axle tube (3) **(Figure 17-4, Page 17-4)**. Do not discard the adapter ring.

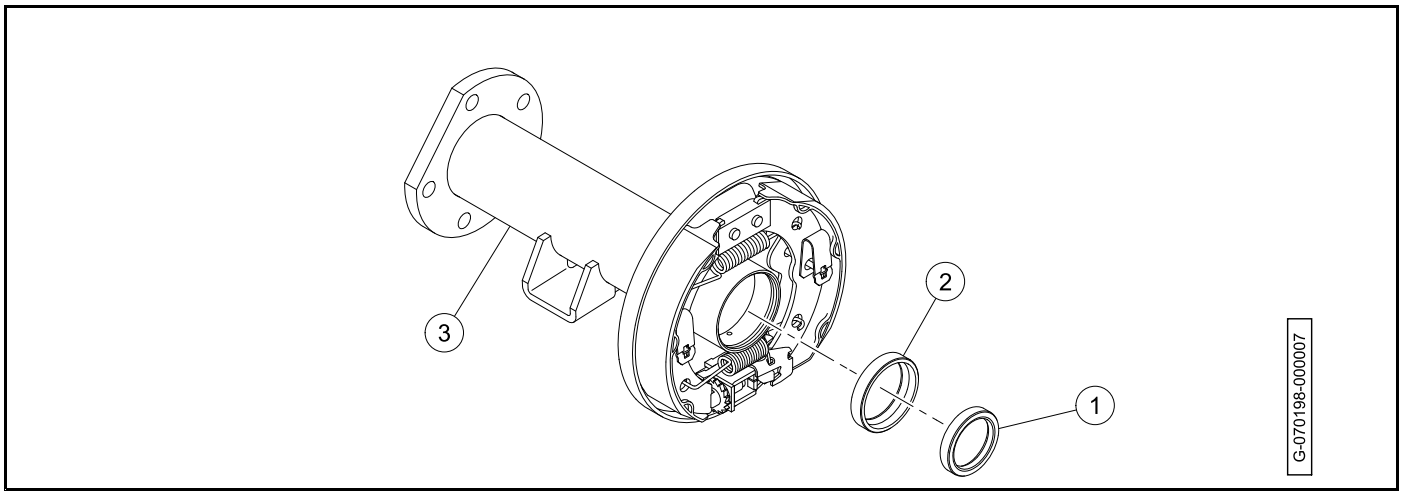


Figure 17-4 Oil Seal Removal

2. Use a press to separate the oil seal from the adapter ring.
3. Discard the oil seal.

AXLE SHAFT AND BEARING INSPECTION

1. Make sure that the bearing (1) and collar have not slipped and are still seated against the shoulder on the axle shaft **(Figure 17-5, Page 17-4)**. If the bearing and collar have slipped, the entire axle shaft assembly must be replaced.
2. Inspect the bearing. If the bearing is worn or damaged, the entire axle shaft assembly must be replaced. Do not remove the bearing from the axle shaft.

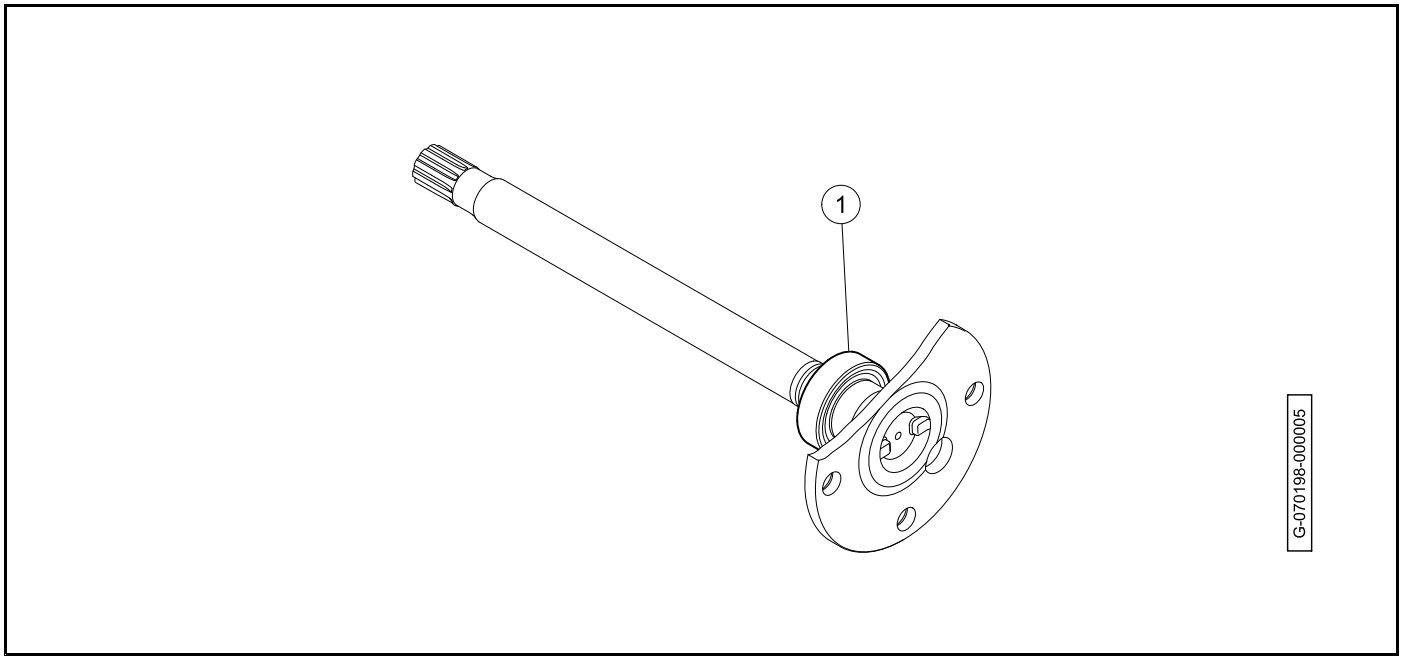
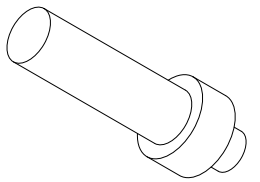


Figure 17-5 Axle Shaft And Bearing Inspection

OIL SEAL INSTALLATION

Special Tools Needed

 G-170096-000003	Transaxle Pinion Seal Tool

NOTE: *Refer to the Illustrated Parts Catalog for service tool part numbers.*

1. Clean seal seat in the adapter ring (2) **(Figure 17-6, Page 17-5)**.

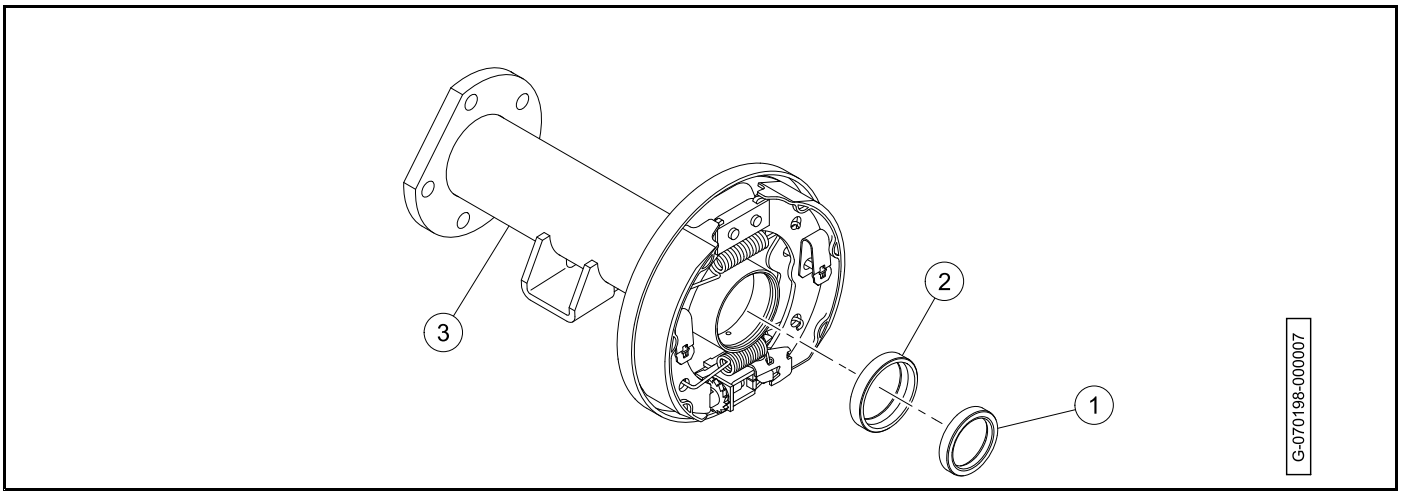


Figure 17-6 Oil Seal Installation

2. Use the transaxle pinion seal tool and a mallet to tap the new oil seal (1) into the adapter ring. Make sure that the oil seal seats firmly in position.

NOTE: *A hydraulic press may also be used with the axle seal tool.*

3. Clean the adapter ring seats in the axle tube.
4. Apply Loctite® 603 to the outer diameter of the adapter ring.
5. Put the oil seal and adapter ring assembly into the axle tube (3) with the seal lip away from the bearing.
6. Use the transaxle pinion seal tool and mallet to tap the oil seal and adapter ring assembly. Make sure that the oil seal and adapter ring assembly 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. Make sure that oil does not contact the brakes.**

7. Wait 24 hours before operating the vehicle to allow the Loctite® 603 to fully cure.

AXLE SHAFT INSTALLATION

1. Install the axle shaft (2) through the oil seal and into the axle tube (3) **(Figure 17-7, Page 17-6)**. Be careful not to damage the seal on the inside of the axle tube hub.

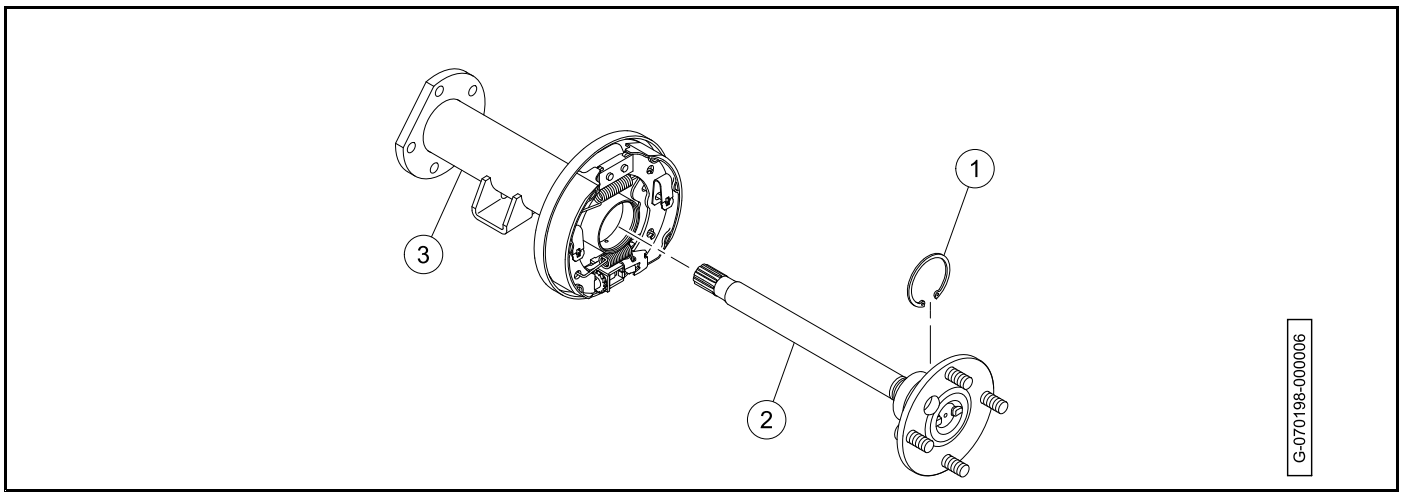


Figure 17-7 Axle Shaft Installation

2. Rotate the axle shaft to align the shaft splines with the differential side gear.
3. Continue to install the axle shaft until the bearing on the axle shaft is firmly seated within the axle tube hub seat.
4. Use 90 degree internal snap ring pliers to install the retaining ring (1) inside axle tube and into the slot in the axle tube hub.
5. Put 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.

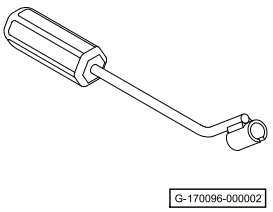
⚠ WARNING

- **Make sure that the retaining ring is correctly seated in its groove. If the ring is not correctly 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.**

6. If a new oil seal was installed, wait 24 hours before operating the vehicle to allow the Loctite® 603 to fully cure.

TRANSAXLE REMOVAL

Special Tools Needed

 G-170096-000002	Brake Cable Release Tool

NOTE: *Refer to the Illustrated Parts Catalog for service tool part numbers.*

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Lift the rear of the vehicle.
5. Remove the rear wheels.
6. Install one lug nut onto a stud on each rear hub.

NOTE: *This will keep the brake drums on the hubs.*

7. Remove the bow tie pins (1) **(Figure 17-8, Page 17-7)**.

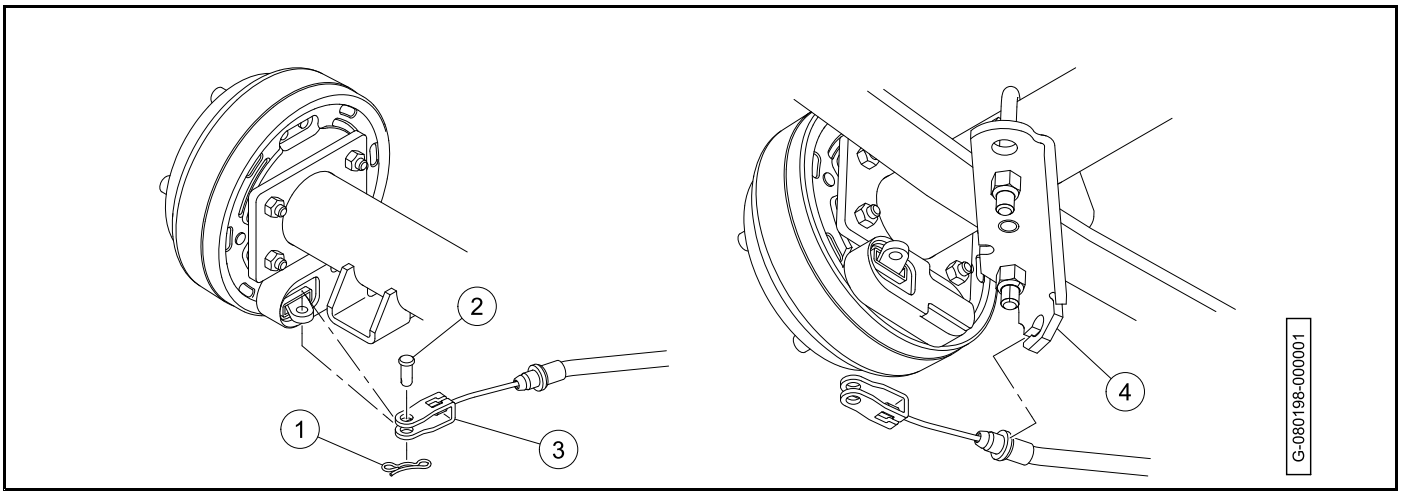


Figure 17-8 Brake Cable Removal

8. Remove the brake cable clevis pins (2).
9. Remove the brake cables (3) from the brake actuator arms.
10. Use the brake cable release tool to compress tangs on cable end and remove cable ends from shock mount brackets (4).

11. Remove the nut (5), cup washer (6), and rubber bushings (7) from the lower mounting stem of the shock absorbers **(Figure 17-9, Page 17-8)**.

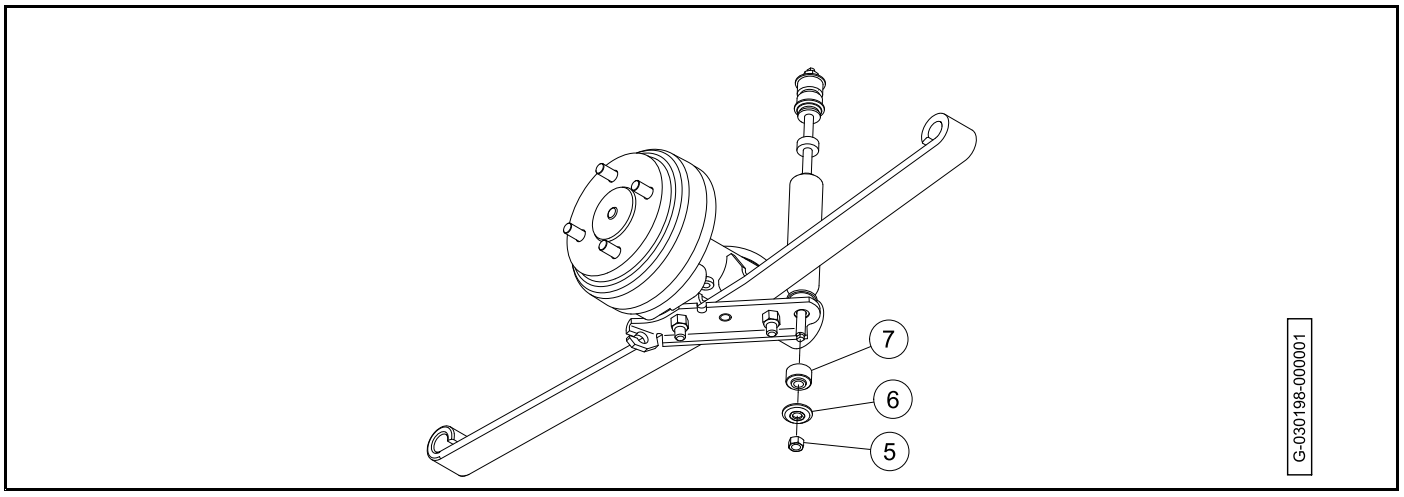


Figure 17-9 Disconnect Shocks

12. Remove the shock absorbers from the bracket.

CAUTION

- **If a motor wire has damage, the motor harness must be replaced. The motor harness has epoxy lined heat shrink. Do not try to cut the heat shrink.**

13. Label the motor wires.
14. Remove the rubber boots (8) **(Figure 17-10, Page 17-8)**.

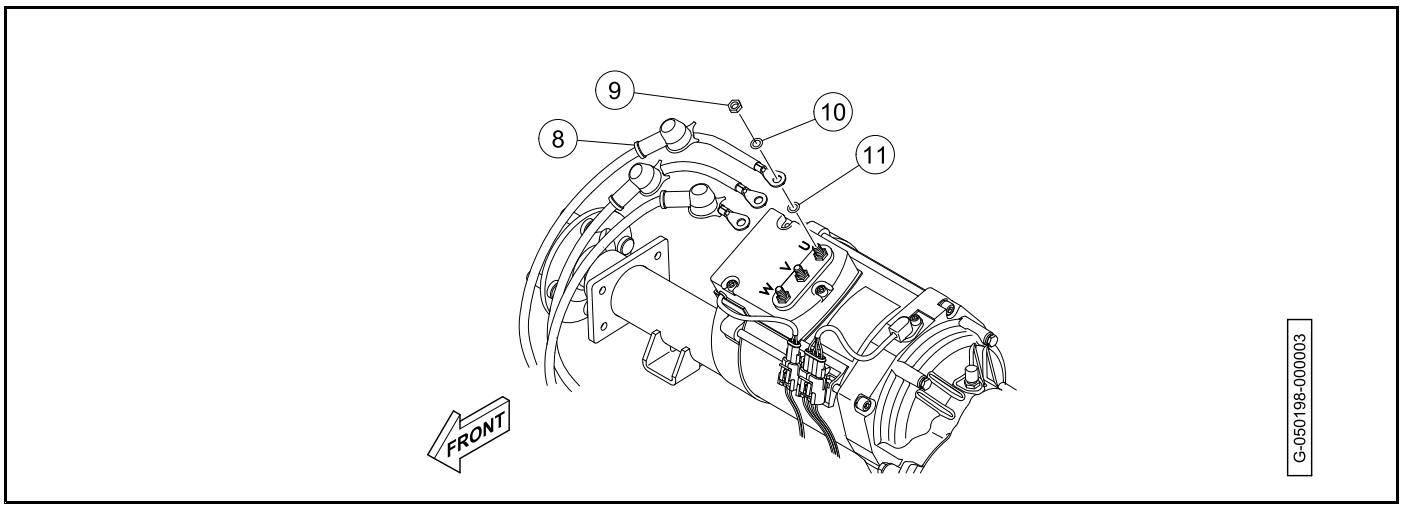


Figure 17-10 Motor Wire Connections

15. Remove the nuts (9) and lock washers (10).
16. Remove the motor wires from the terminal block.
17. Remove the washers (11).
18. Disconnect the speed sensor (12) and temperature sensor (13) **(Figure 17-11, Page 17-9)**.

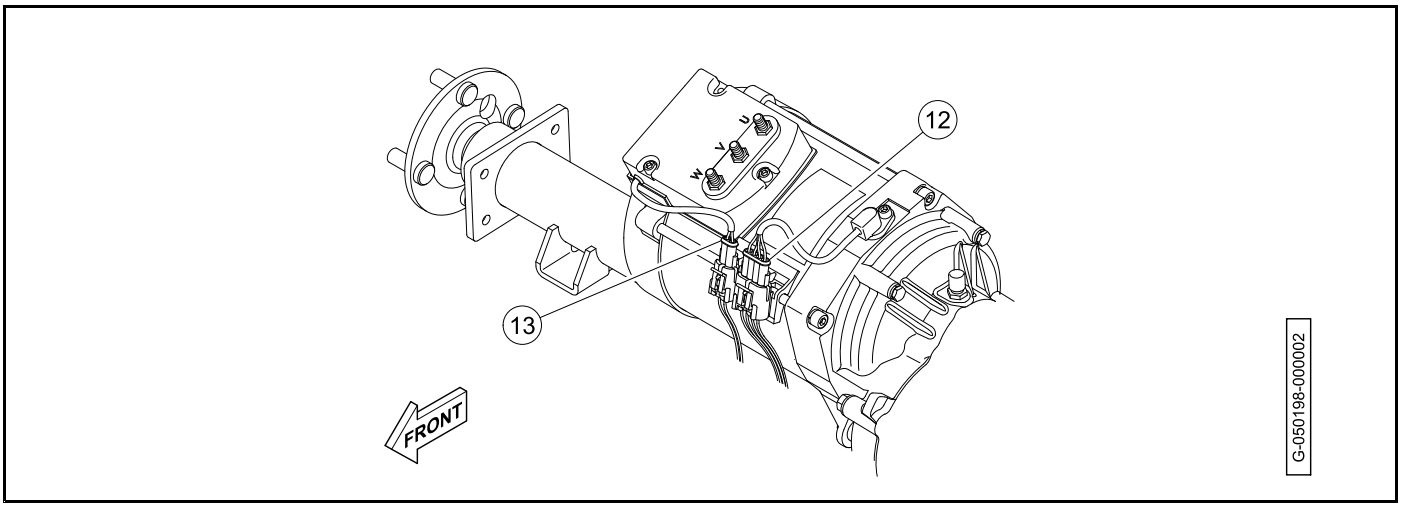


Figure 17-11 Temperature Sensor and Terminal Block Connections

19. Remove the rear lower shackle nuts (14) and bolts (15) **(Figure 17-12, Page 17-9)**.

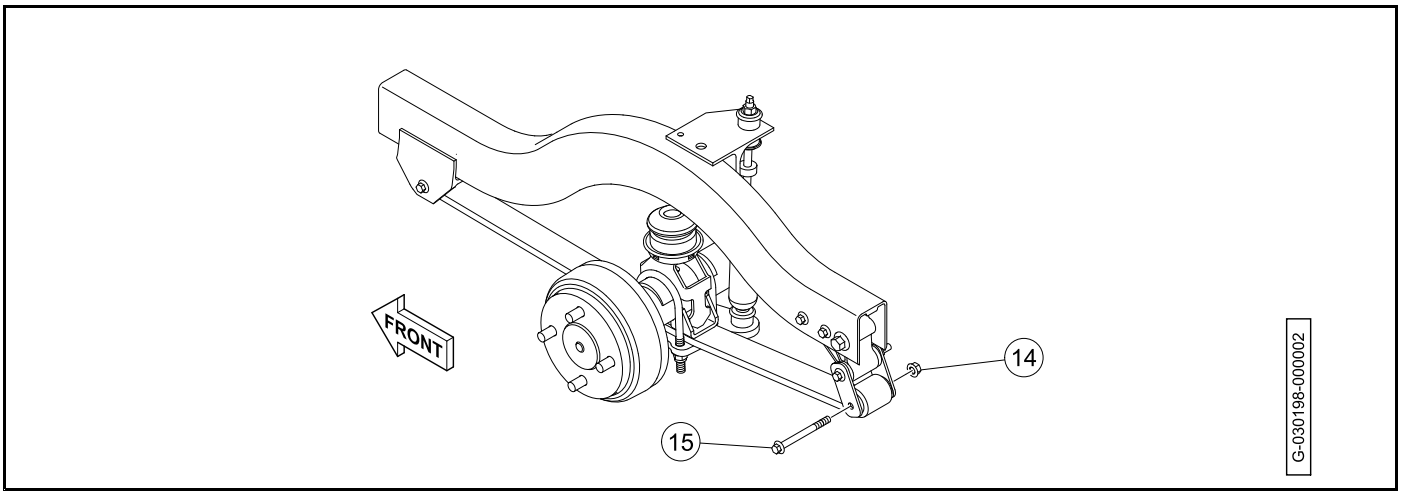


Figure 17-12 Rear Lower Shackle Hardware Removal

20. Position the shackles so they are clear of springs.
21. 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.
22. 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.
23. Remove the three motor mounting bolts (16) and lock washers (17) **(Figure 17-13, Page 17-10)**.

⚠ CAUTION

- **Do not position fingers under motor when sliding motor off of the input shaft. Fingers may get pinched when motor disengages.**

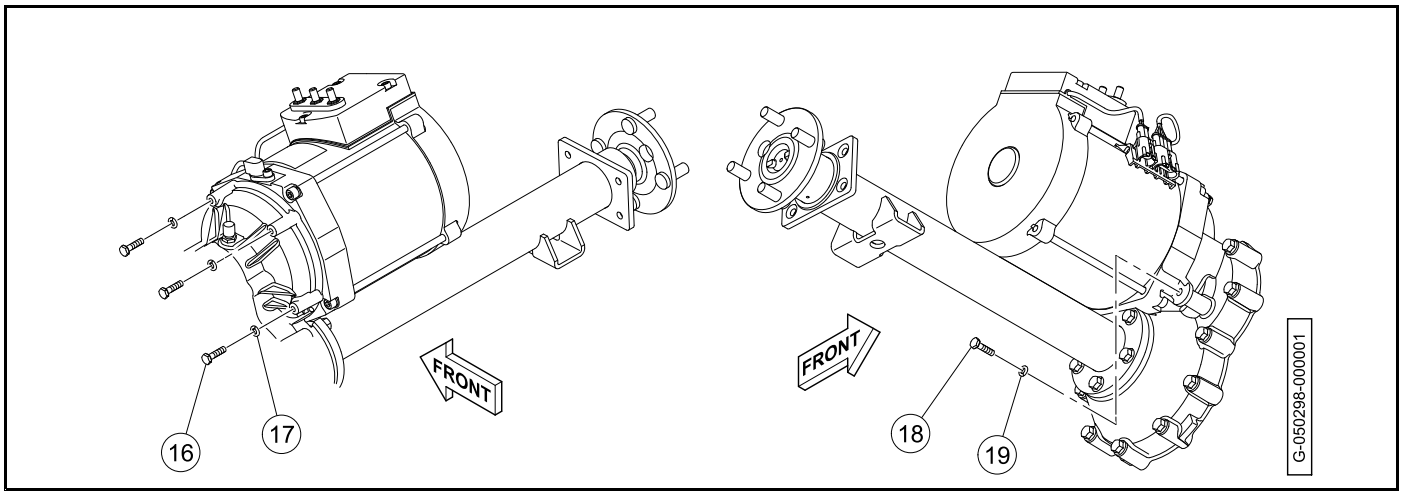


Figure 17-13 Motor Mounting Bolt Removal

24. Remove the motor mounting bolt (18) and lock washer (19).
25. Slide the motor away from the transaxle until the motor spline becomes disengaged from the input shaft, then lift motor out.

26. If a floor jack was used, pull floor jack from beneath the transaxle and lower the leaf springs to the floor **(Figure 17-14, Page 17-11)**.

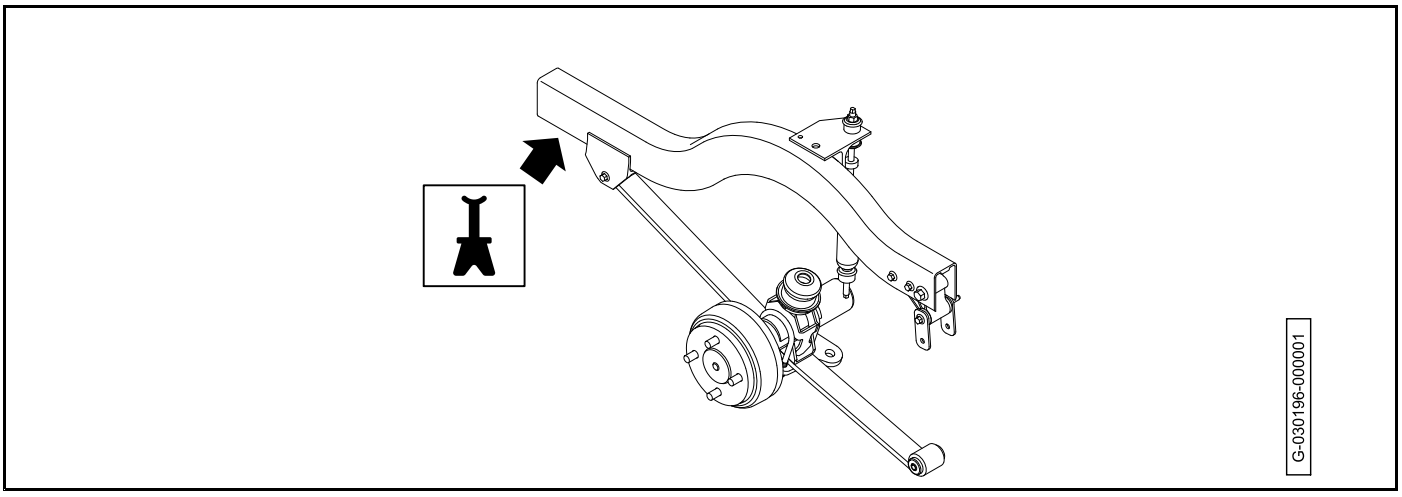


Figure 17-14 Lower Leaf Springs

27. Remove the nuts (20) and U-bolts (21) attaching the transaxle to the leaf springs **(Figure 17-15, Page 17-11)**.

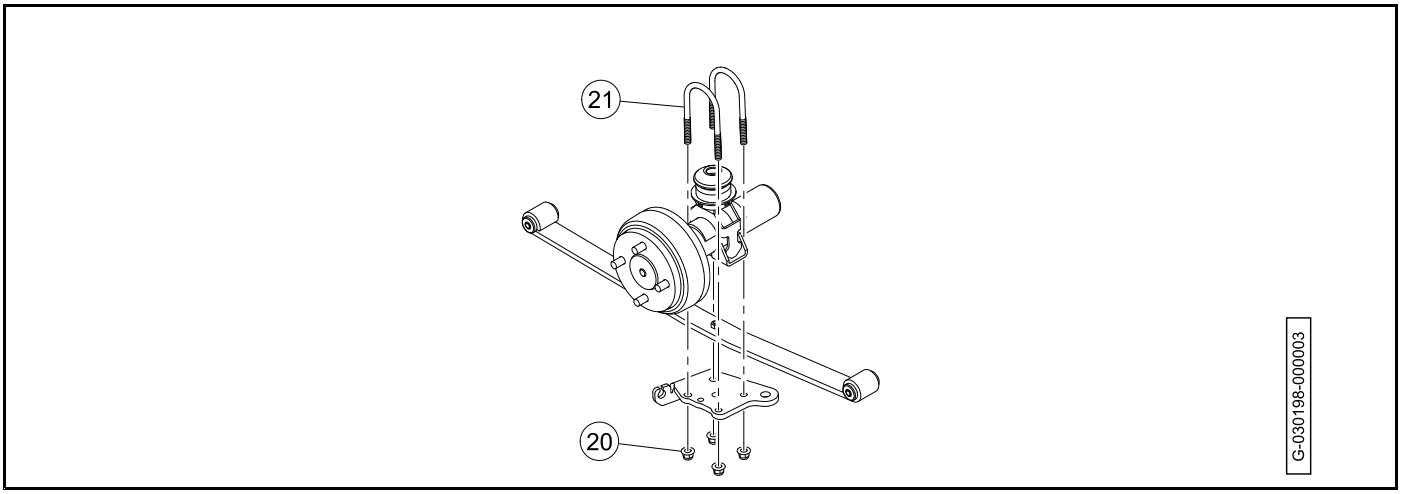


Figure 17-15 U-Bolt Removal

28. Lift each end of the transaxle off the leaf spring positioning pin and slide the transaxle to the rear and out of the vehicle.

TRANSAXLE DISASSEMBLY

1. Drain the transaxle fluid.

NOTE: *Recycle or dispose of used oil or lubricant in accordance with local, state, and federal regulations.*

2. Remove the axle shafts.
3. Remove the brake assemblies.
4. Remove the bolts (1) and the axle tubes (2) **(Figure 17-16, Page 17-12)**.

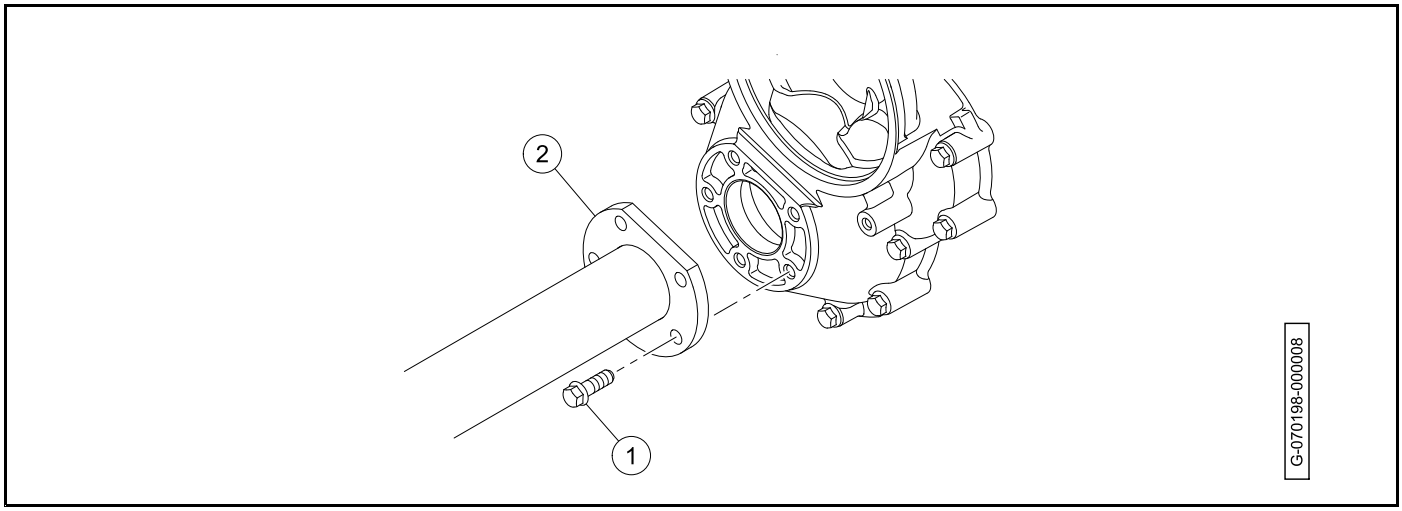


Figure 17-16 Axle Tube Removal

5. Remove the 11 bolts (3) **(Figure 17-17, Page 17-12)**.

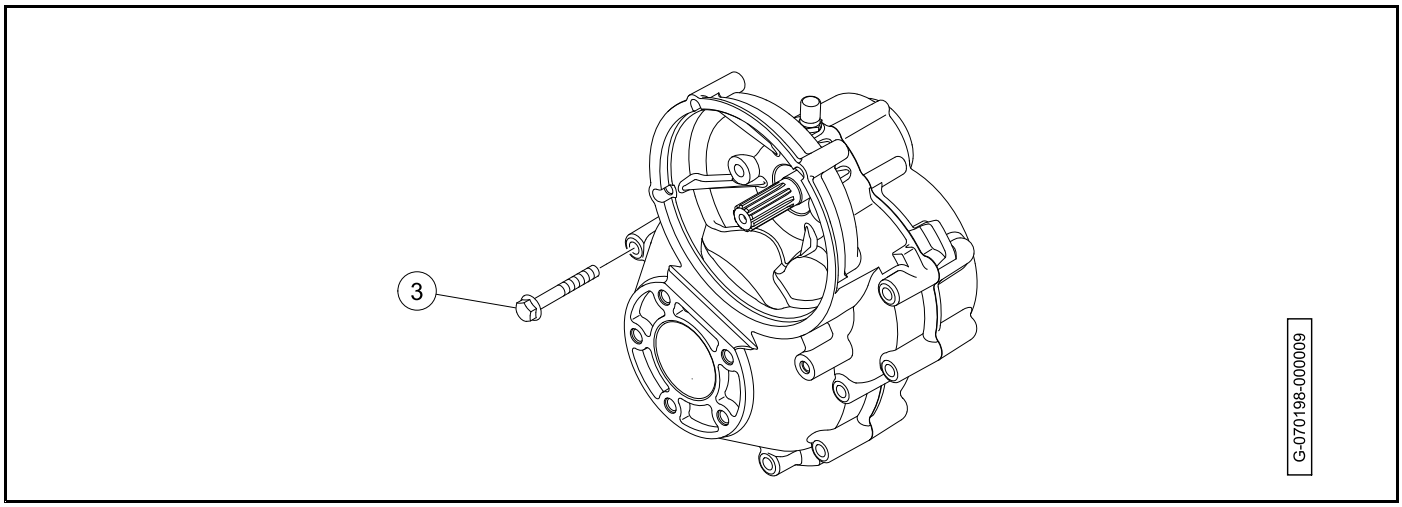


Figure 17-17 Gear Case Bolt Removal

CAUTION

- **To prevent damage to the gear case mating seal surfaces, use caution when separating the gear case.**

6. Pull the driver-side gear case (4) and passenger-side gear case (5) apart. If necessary, tap lightly on the spline of the input shaft (6) **(Figure 17-18, Page 17-13)**.

CAUTION

- **Do not damage gears. Use extreme care when handling them.**

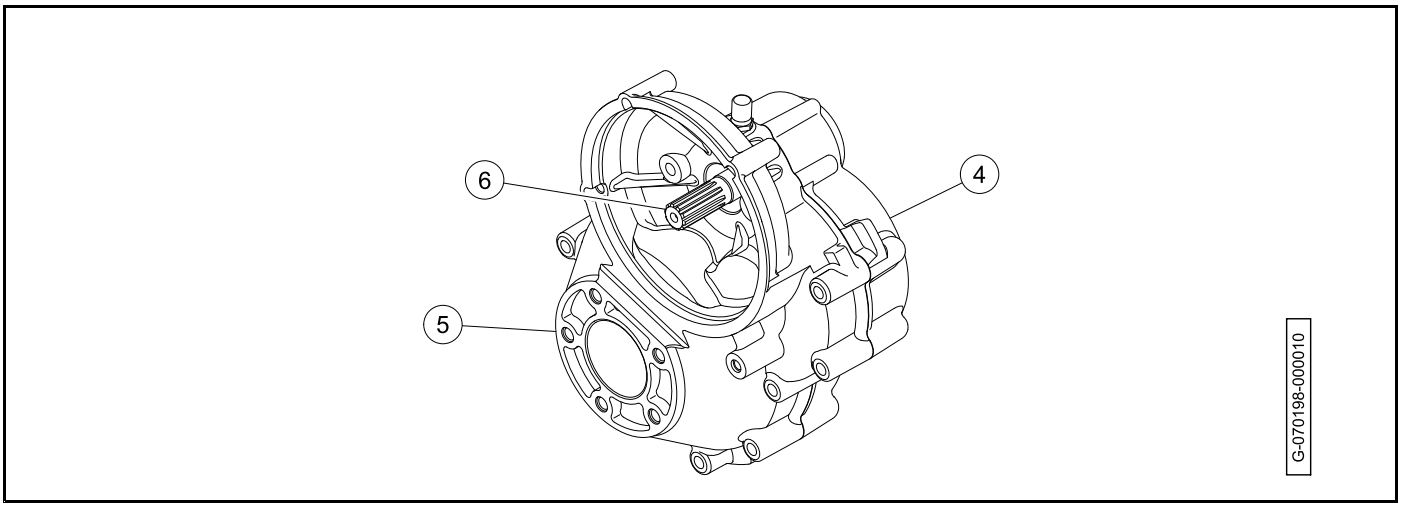


Figure 17-18 Gear Case Disassembly

7. Lift and remove the input pinion gear (7), intermediate gear (8), and differential assembly (9) at the same time **(Figure 17-19, Page 17-13)**.

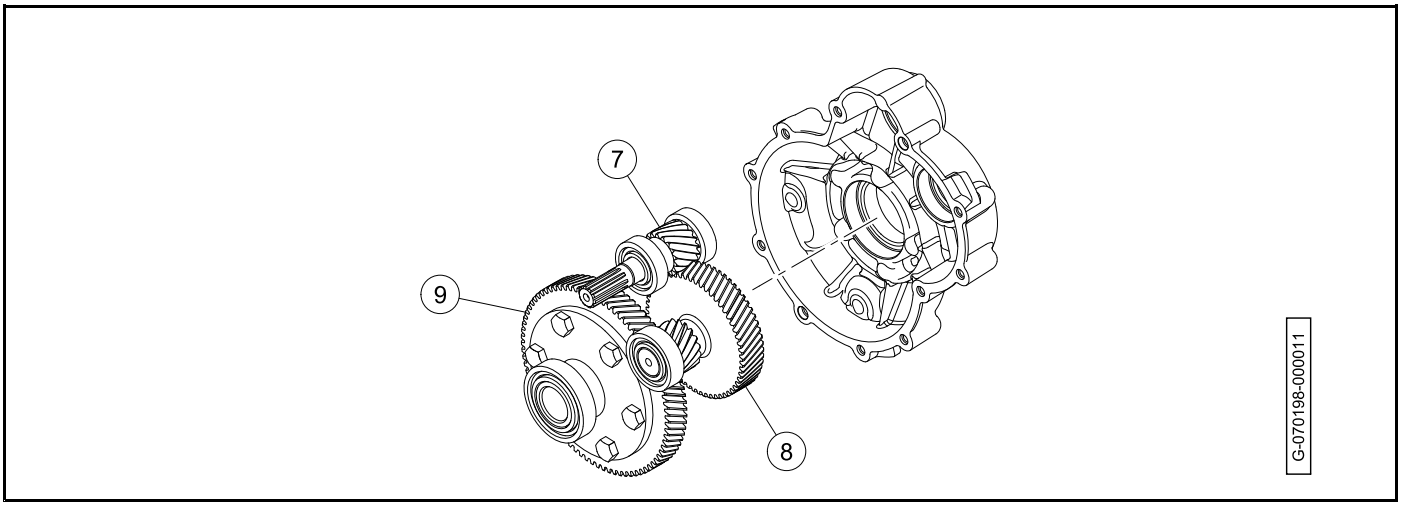


Figure 17-19 Remove Gear Assemblies

8. To disassemble the input pinion gear:

CAUTION

- **Do not reuse the bearings. Replace the bearings with new bearings.**

8.1. Use a bearing puller or arbor press to remove the bearings (10) from the input pinion gear **(Figure 17-20, Page 17-14)**.

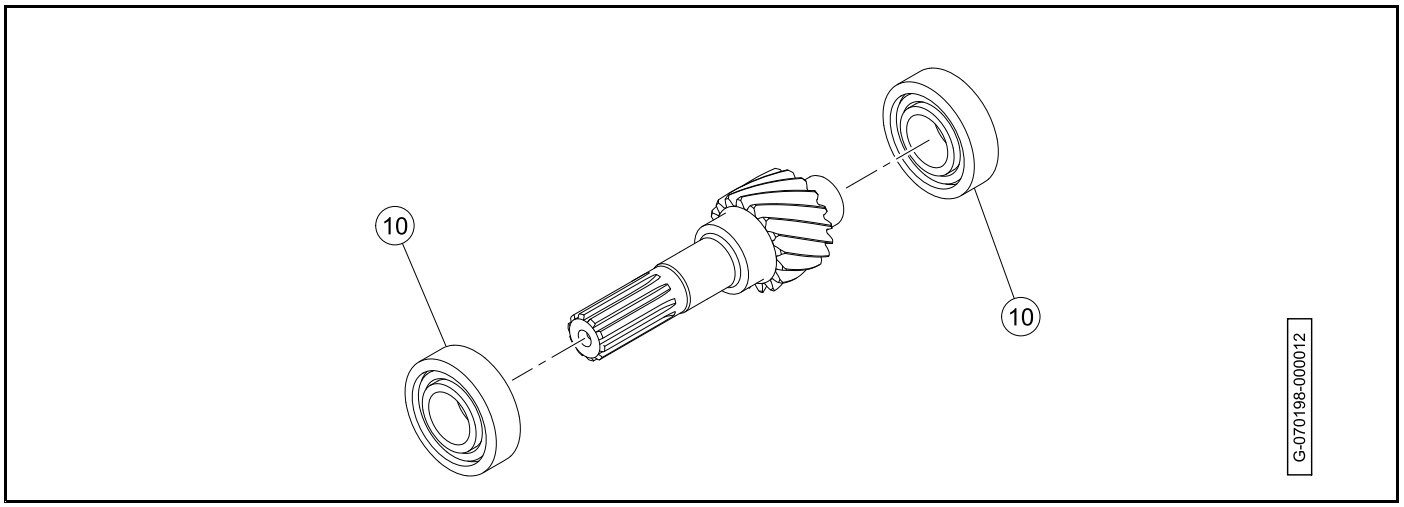


Figure 17-20 Input Pinion Gear Disassembly

9. To disassemble the intermediate gear:

CAUTION

- **Do not reuse the bearings. Replace the bearings with new bearings.**

9.1. Use a bearing puller or an arbor press to remove the bearings (11 and 12) from the intermediate gear **(Figure 17-21, Page 17-14)**.

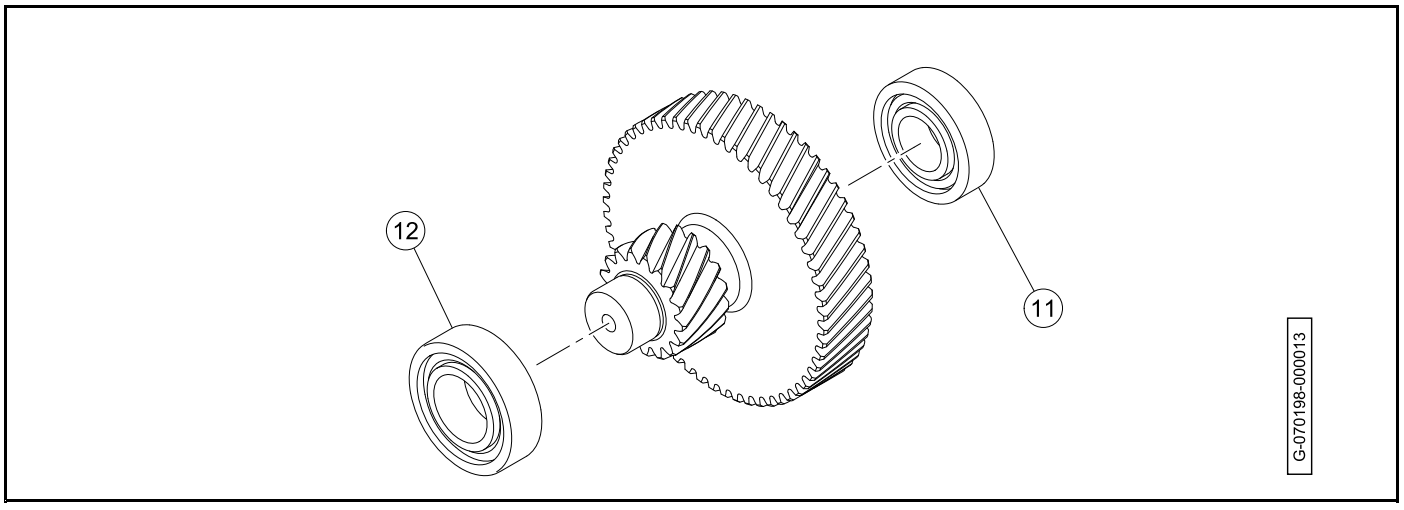


Figure 17-21 Intermediate Gear Disassembly

10. To disassemble the differential assembly:

CAUTION

- **Do not reuse the bearings. Replace the bearings with new bearings.**

10.1. Remove the bolts (13) and the output gear (14) **(Figure 17-22, Page 17-15)**.

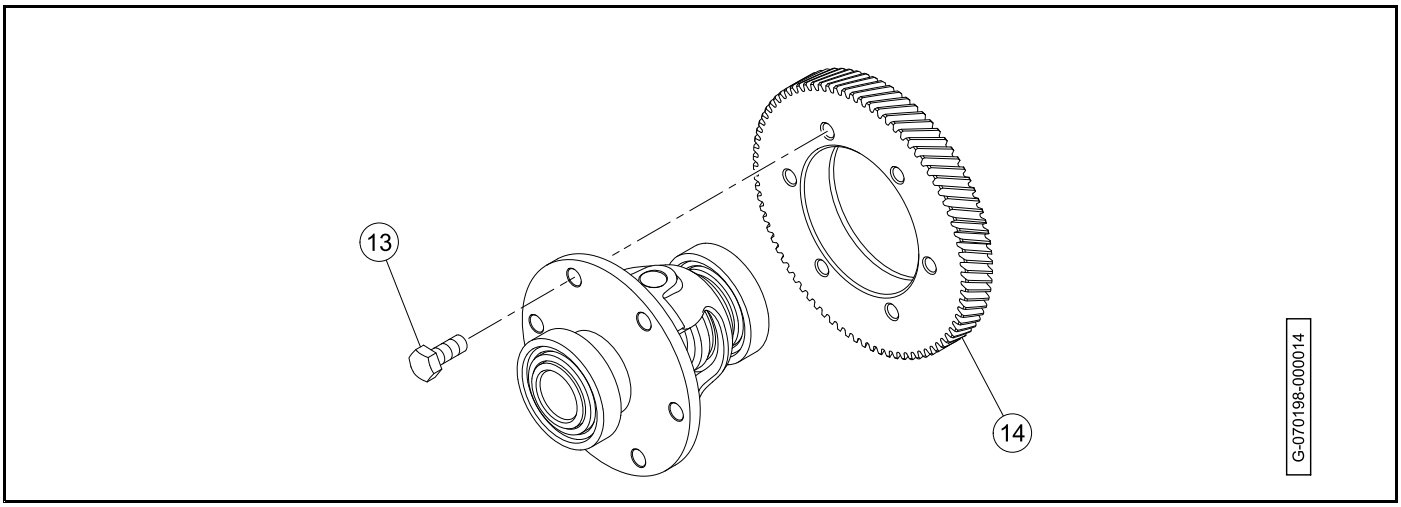


Figure 17-22 Ring Gear Removal

10.2. Use a press to remove the bearings (15) from the differential housing **(Figure 17-23, Page 17-15)**.

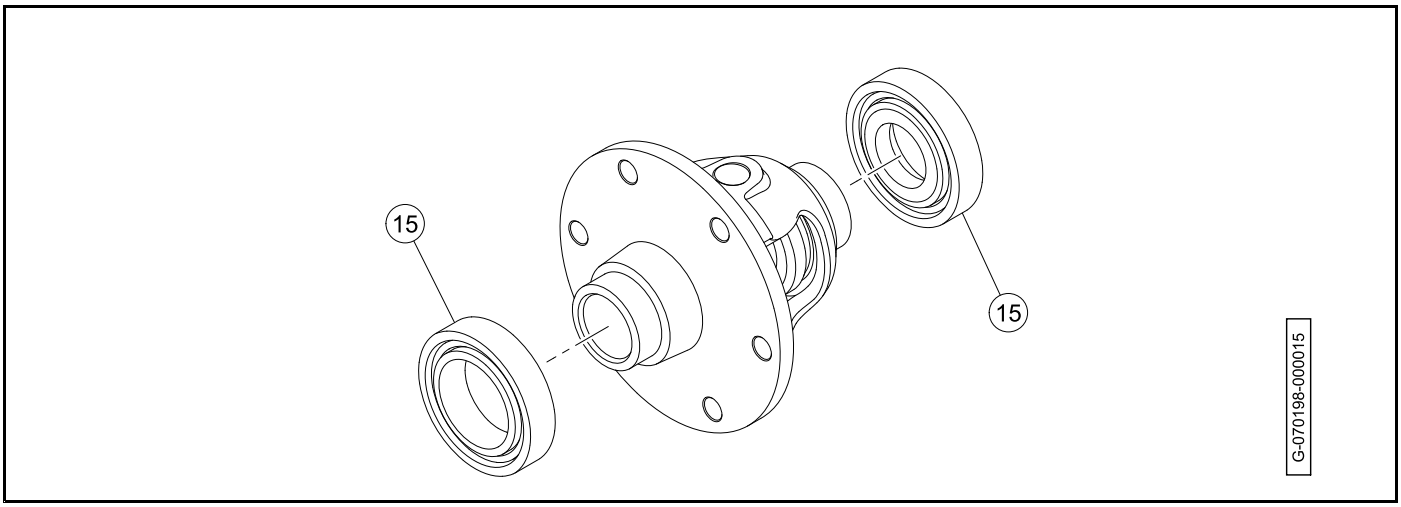


Figure 17-23 Differential Case Bearings

10.3. Remove the differential pin (16) **(Figure 17-24, Page 17-16)**.

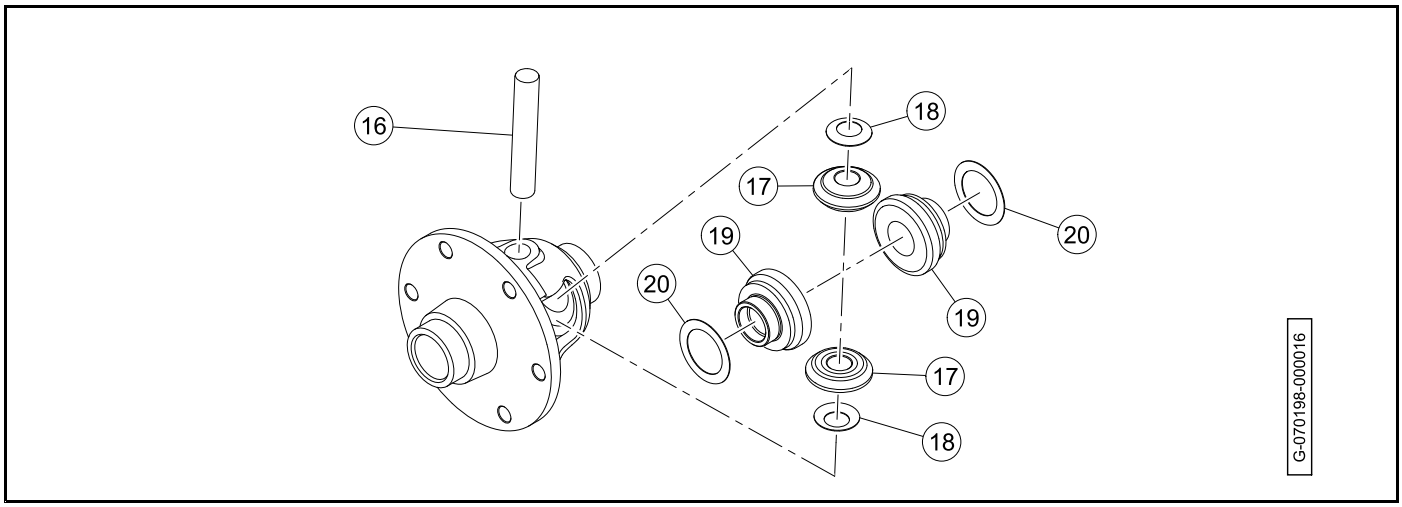


Figure 17-24 Differential Pin

10.4. Remove the idler gears (17), small thrust plates (18), differential gears (19), and large thrust plates (20).

TRANSAXLE INSPECTION

1. Inspect the oil seal (1) in the driver-side gear case (2) **(Figure 17-25, Page 17-16)**. Replace as necessary.

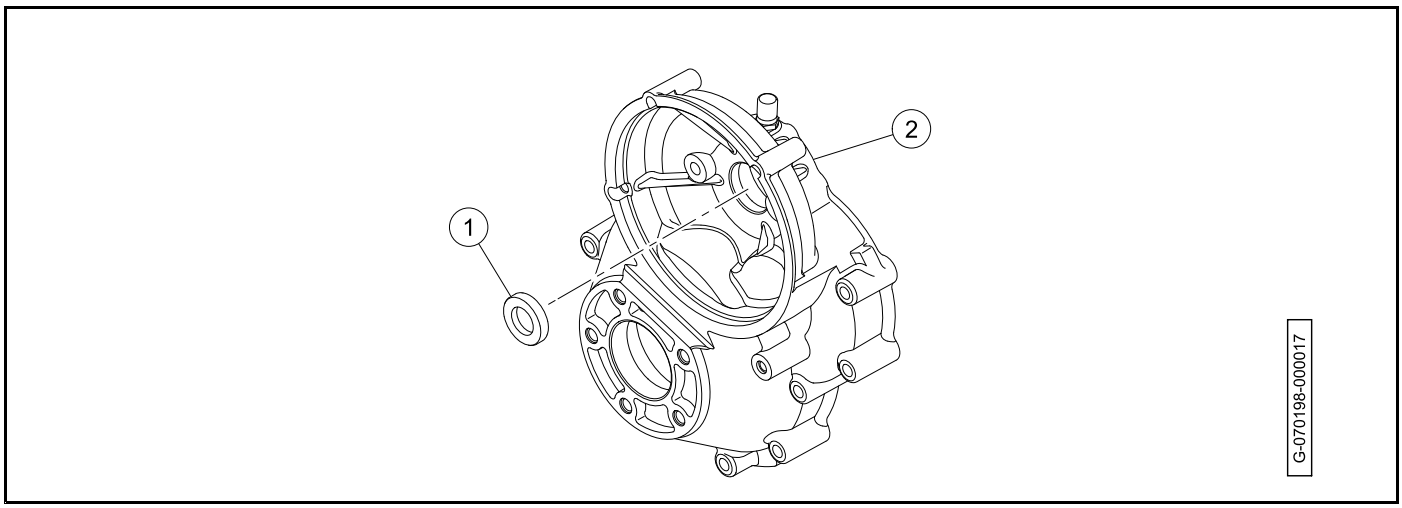


Figure 17-25 Oil Seal Inspection

2. Inspect all of the bearings. Replace as necessary.

CAUTION

- **Do not reuse bearings . Replace bearings with new ones.**

3. Inspect all parts for wear or damage. Replace any worn or damaged parts. **See following NOTE.**

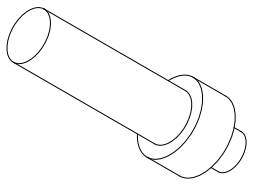
NOTE: *Damaged or worn gears should be replaced as sets.*

TRANSAXLE ASSEMBLY

CAUTION

- **Do not press against the bearing outer race.**
- **The housing and all parts must be wiped clean and dry before reassembly.**

Special Tools Needed

 G-170096-000003	Transaxle Pinion Seal Tool

NOTE: *Refer to the Illustrated Parts Catalog for service tool part numbers.*

1. To assemble the differential assembly (1):

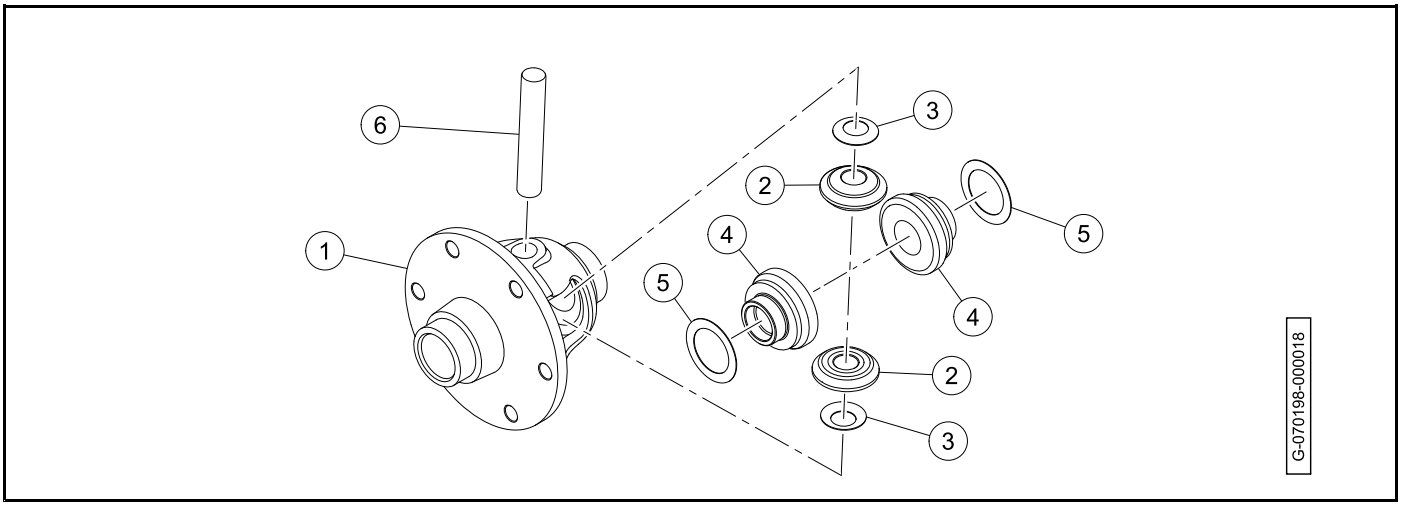


Figure 17-26 Differential Assembly

1.1. Install the idler gears (2), small thrust plates (3), differential gears (4), and large thrust plates (5).
1.2. Install the differential pin (6).
1.3. Apply a small amount of transaxle fluid to all the thrust plates and the ends of the differential pin.
1.4. Use a press to install the new bearings (7) **(Figure 17-27, Page 17-18)**.

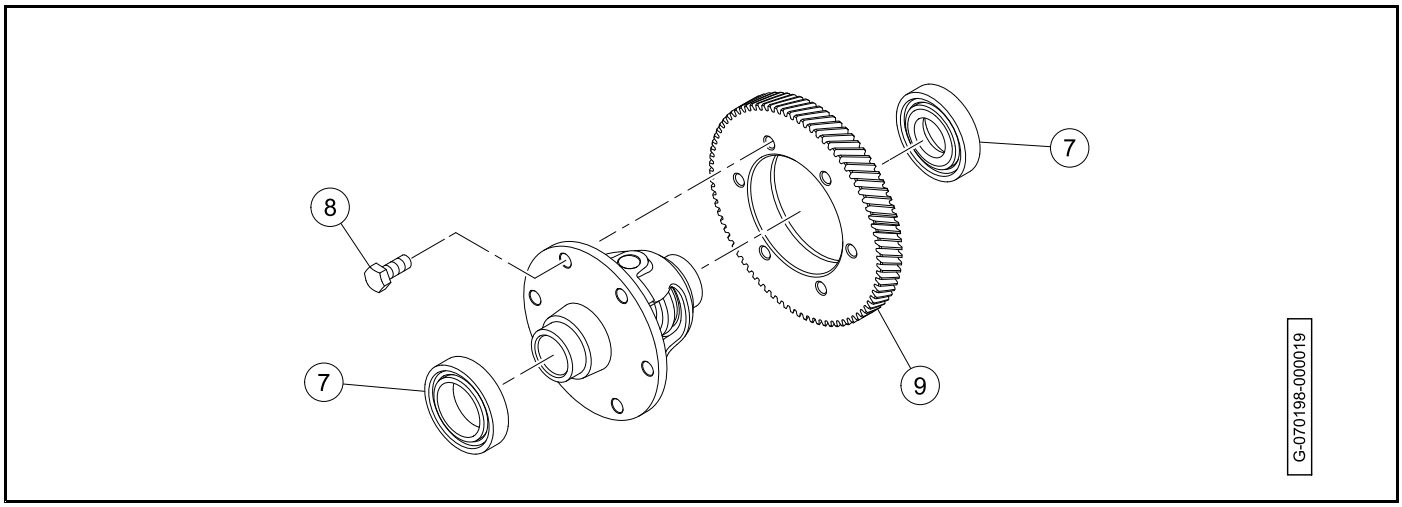


Figure 17-27 Differential Bearing and Output Gear Installation

1.5. Install the bolts (8) and output gear (9). Tighten the bolts to 58 lb·ft (78.6 N·m).

2. To assemble the intermediate gear (10):

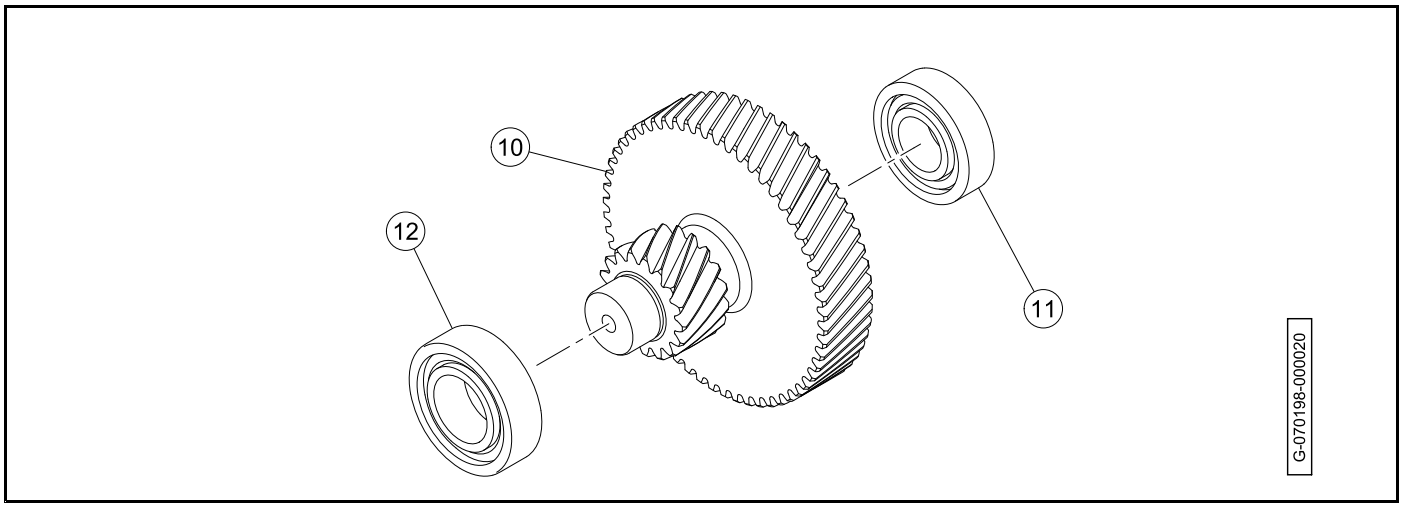


Figure 17-28 Intermediate Gear Assembly

2.1. Use a press to install new bearings (11 and 12).

NOTE: *Bearing (11) is smaller than bearing (12).*

3. To assemble the input pinion gear (13):

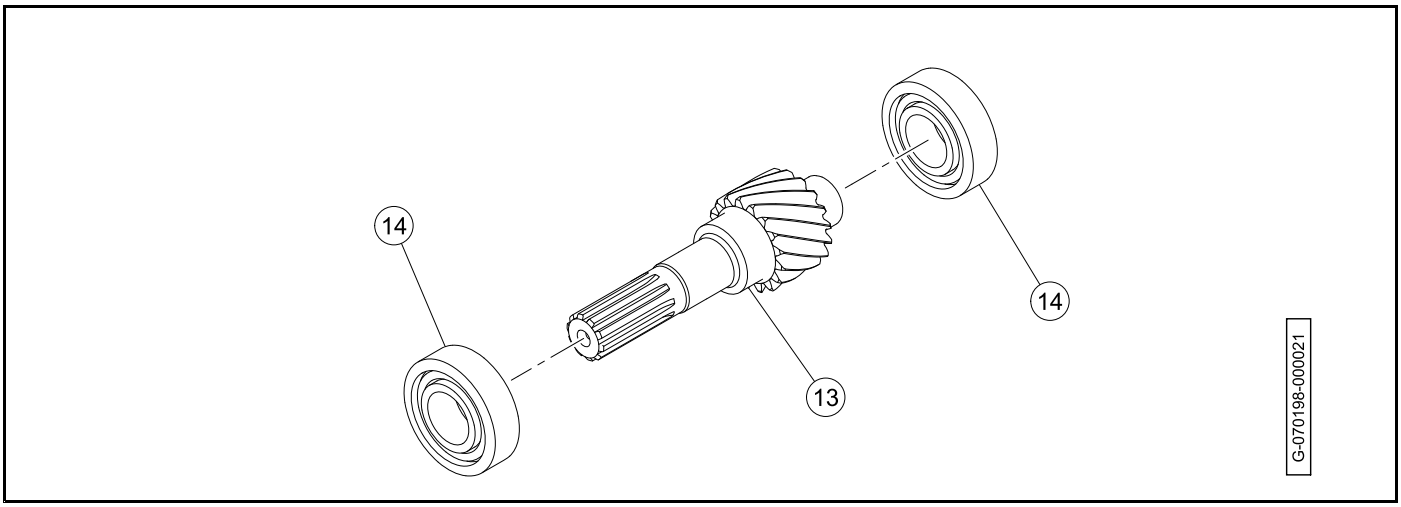


Figure 17-29 Input Pinion Gear Assembly

3.1. Use a press to install new bearings (14).

4. To install the oil seal (15):

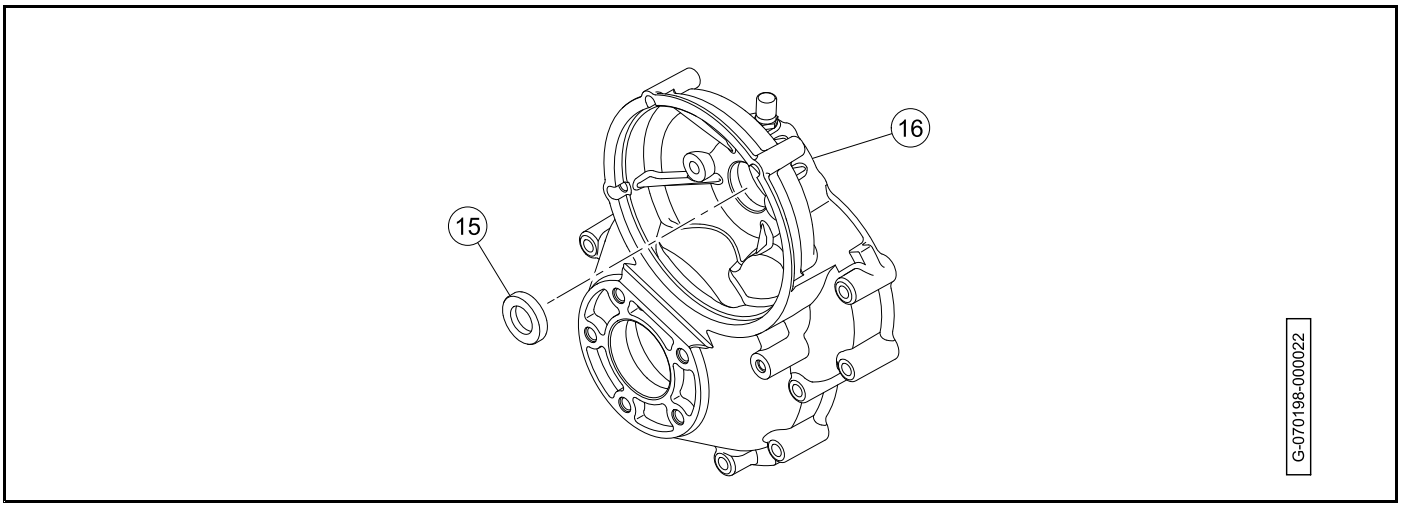


Figure 17-30 Oil Seal Installation

4.1. Apply grease to the lip of the new oil seal.

4.2. Use the transaxle pinion seal tool to install the new oil seal into the driver-side gear case (16). The lip of the new oil seal should face the inside of the gear case.

4.3. Make sure the new oil seal is firmly seated.

5. If removed, install the dowel pin (17) into the driver-side gear case **(Figure 17-31, Page 17-20)**.

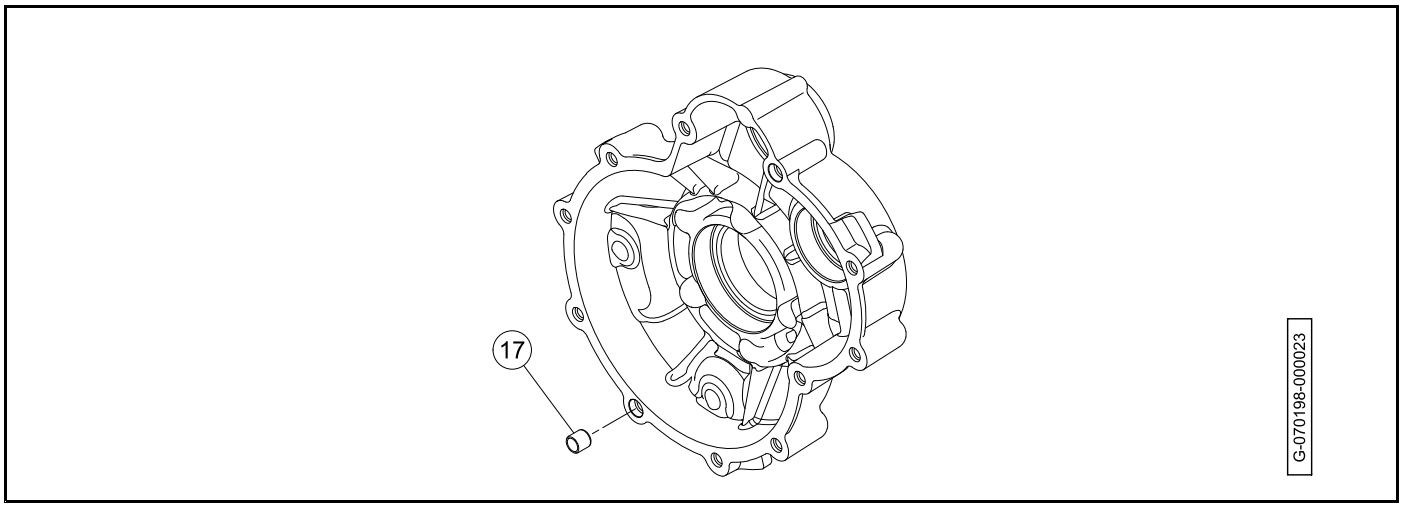


Figure 17-31 Dowel Pin Installation

6. Install the differential assembly, intermediate gear, and the input pinion gear into the driver-side gear case at the same time.
7. Make sure that all of the bearings are seated correctly in the gear case. Rotate the input shaft to check for smooth gear operation.
8. Apply a 1/8-inch (3 mm) bead of ThreeBond® 1215 liquid gasket on mating surface of the driver-side gear case (18)**(Figure 17-32, Page 17-20)**.

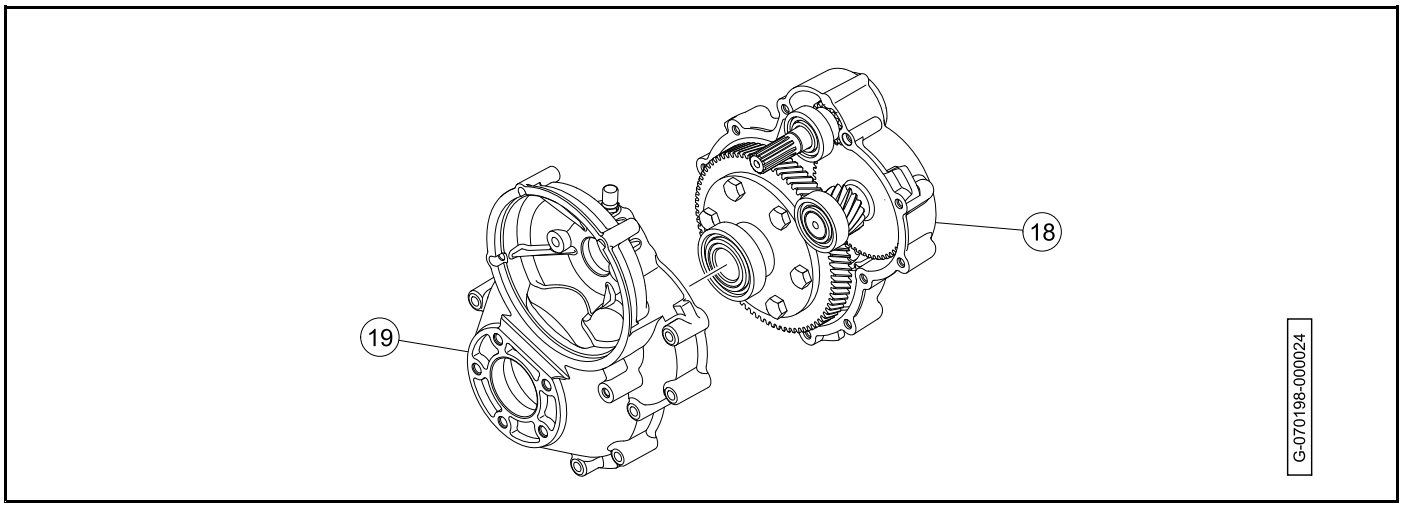


Figure 17-32 Gear Case Assembly

9. Install the passenger-side gear case (19).
10. Install the 11 bolts (20) **(Figure 17-33, Page 17-21)**. Tighten the bolts to 19 lb·ft (25.7 N·m).

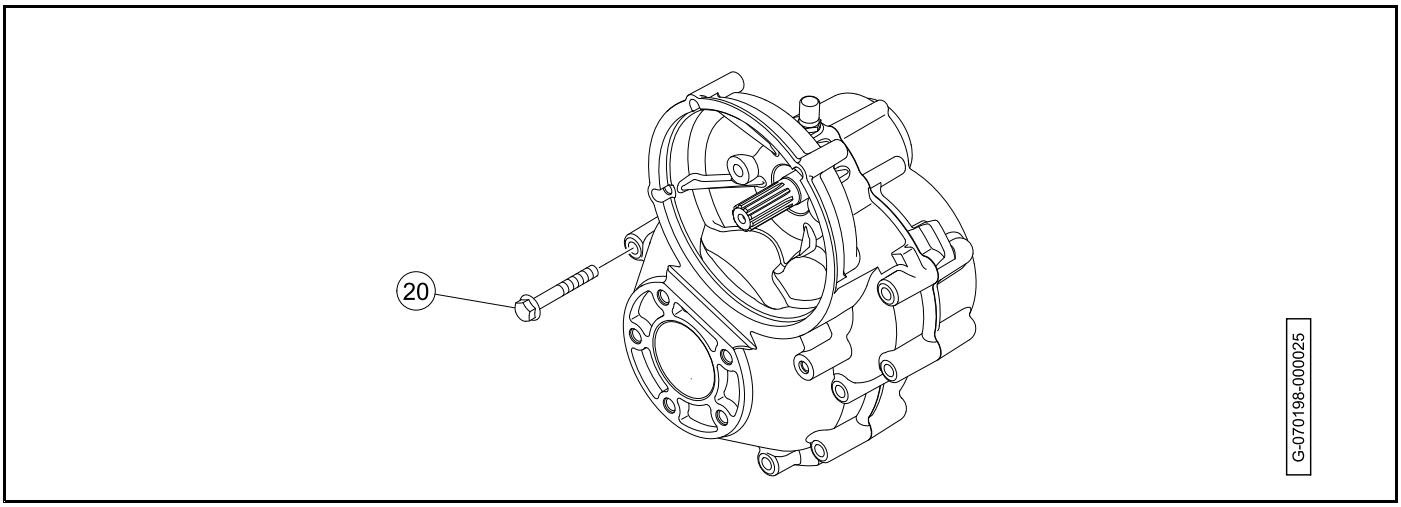


Figure 17-33 Gear Case Bolt Installation

11. Apply a thin bead of ThreeBond® 1215 liquid gasket on the gear case and axle tube mating points.
12. Install the axle tubes (21) and bolts (22) **(Figure 17-34, Page 17-21)**. Tighten the bolts to 37 lb·ft (50.2 N·m).

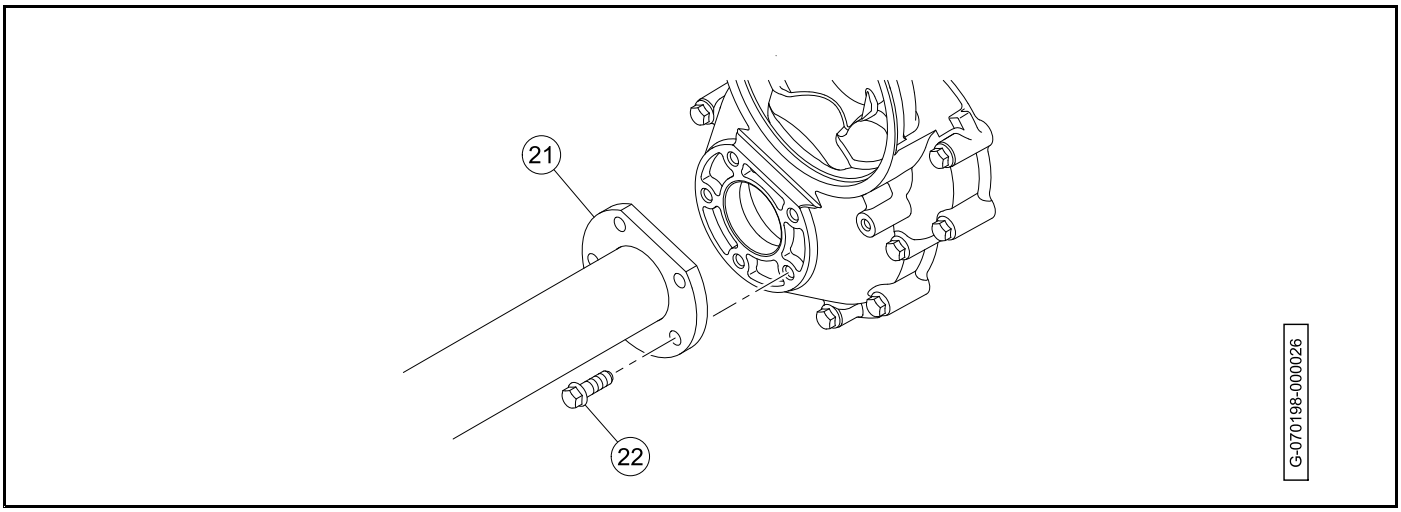


Figure 17-34 Axle Tube Installation

13. Install the brake clusters.
14. Apply a small amount of grease to the lip of the axle tube oil seal.

⚠ CAUTION

- **Clean any residual oil from the exposed end of the axle shaft and from the oil seal area. Make sure that oil does not contact the brakes.**

15. Install the axle shafts.
16. Fill the transaxle with recommended transaxle fluid.

TRANSAXLE INSTALLATION

See General Warnings on page 1-2.

1. If using a chain hoist, lift the vehicle and put the transaxle in position on the jack stands.
2. If using a floor jack, lower the jack stands to their lowest settings and place the transaxle in position on the jack stands.
3. Align the center hole (1) of the saddle on the transaxle with the pilot bolt (2) on the leaf spring **(Figure 17-35, Page 17-22)**.

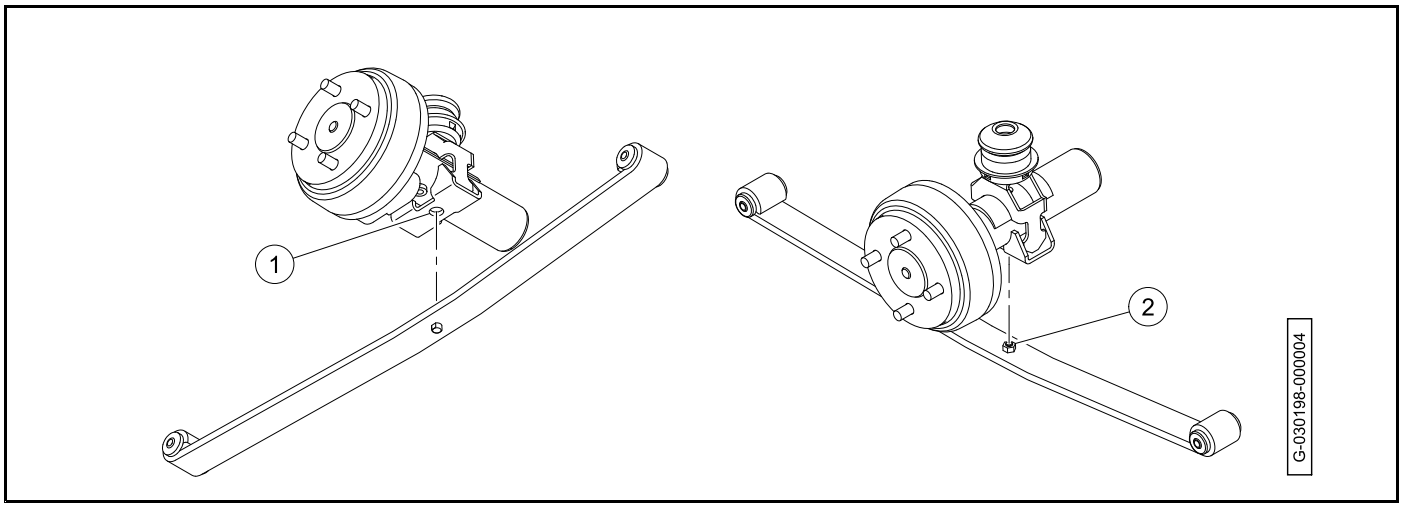


Figure 17-35 Install Transaxle On Leaf Spring

4. Install the two U-bolts (3), jounce bumper mount (if required), shock mount brackets (4), and nuts (5) **(Figure 17-36, Page 17-22)**. Install the nuts so that there is an equal amount of thread on each side. Tighten the nuts to 25 lb·ft (34 N·m).

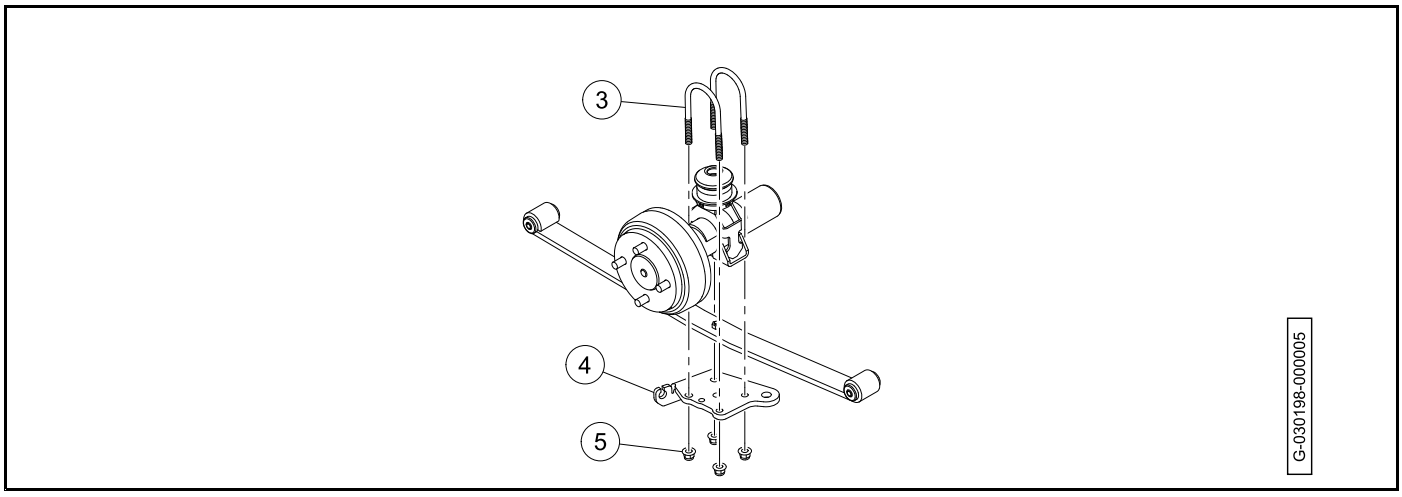


Figure 17-36 U-Bolt Installation

5. Install the motor.
6. If using a chain hoist, lower the vehicle while guiding the leaf springs into the rear spring shackles. Then lift the jack stands to support the transaxle.

7. If using a floor jack, lift the differential while guiding the leaf springs into the rear spring shackles. Then lift the jack stands to support the transaxle.
8. Install the bolts (6) and rear lower shackle nuts (7) **(Figure 16-15, Page 16-8)**. Tighten the nuts to 18.5 lb·ft (25 N·m).

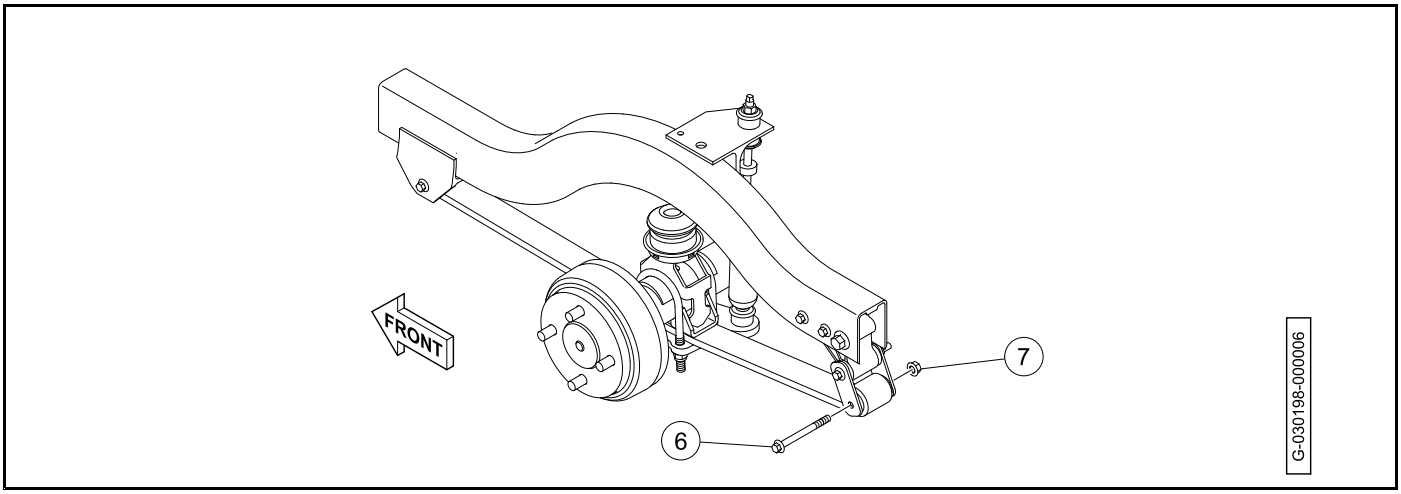


Figure 17-37 Rear Lower Shackle Hardware Installation

9. Install the cable housings into the shock mount brackets (8) **(Figure 16-16, Page 16-9)**. Make sure that the cable clips are secure.

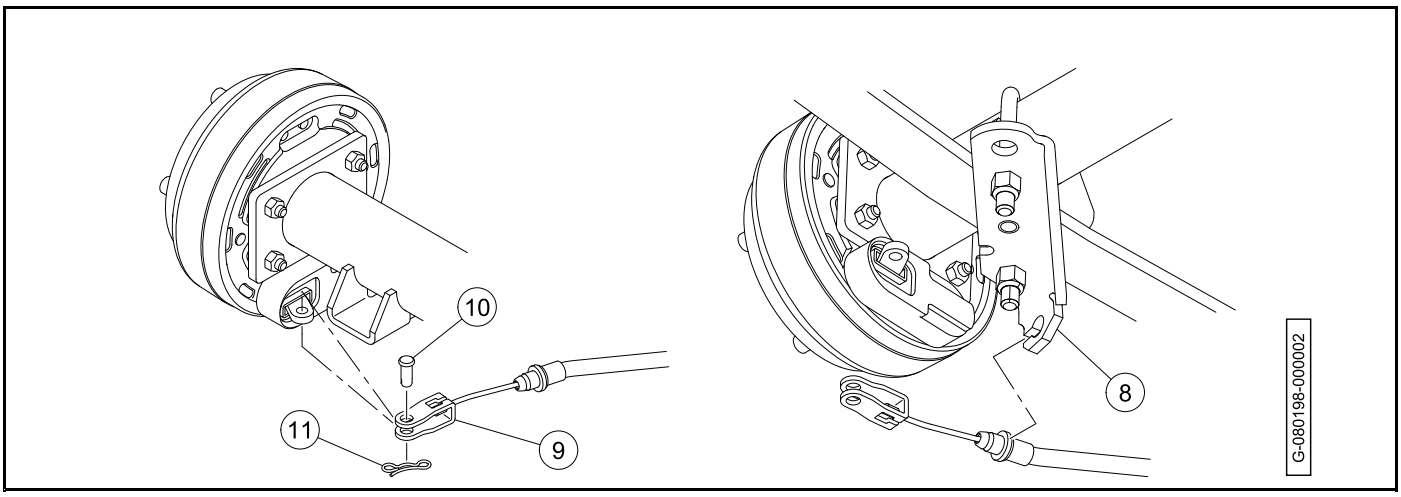


Figure 17-38 Brake Cable Installation

10. Install the cables (9) onto the brake actuator arms.
11. Install the brake cable clevis pins (10).
12. Install the bow tie pins (11).
13. Install the shock absorbers onto the shock mount brackets.
14. Install the rubber bushings (12), cup washers (13), and nuts (14) **(Figure 16-17, Page 16-9)**. Tighten the nuts until the rubber bushings expand to the same size as the cup washers.

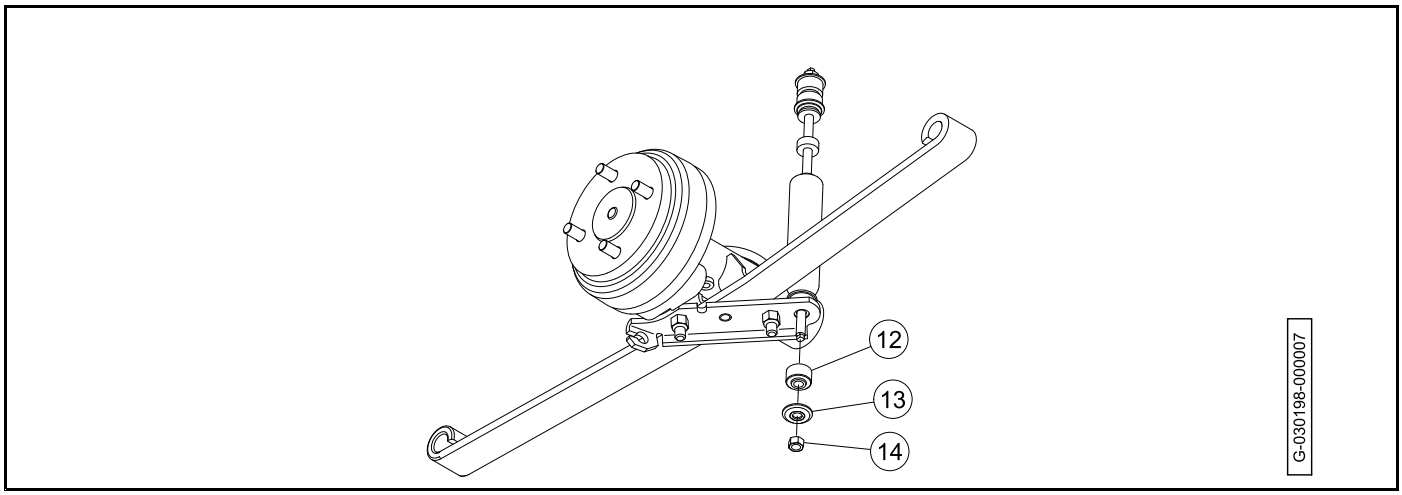


Figure 17-39 Connect Shocks

15. Install the rear wheels.
16. Lift the vehicle and remove the jack stands.
17. Lower the vehicle.
18. Set the Run/Tow switch to TOW.
19. Connect the batteries.
20. Set the Run/Tow switch to RUN.
21. Inspect the vehicle to check for correct operation. **See following WARNING.**

⚠ WARNING

- **Make sure that the vehicle operates in the forward direction when the Forward/Reverse switch is in the FORWARD position.**
- **Make sure that the vehicle operates in the reverse direction when the Forward/Reverse switch is in the REVERSE position. The multi-purpose buzzer will sound as a warning when the Forward/Reverse switch is in REVERSE.**
- **Make sure that the vehicle does not operate when the Forward/Reverse switch is in the NEUTRAL position.**

SECTION 18 — CONTROLLER DIAGNOSTIC TOOL (CDT)

⚠ DANGER

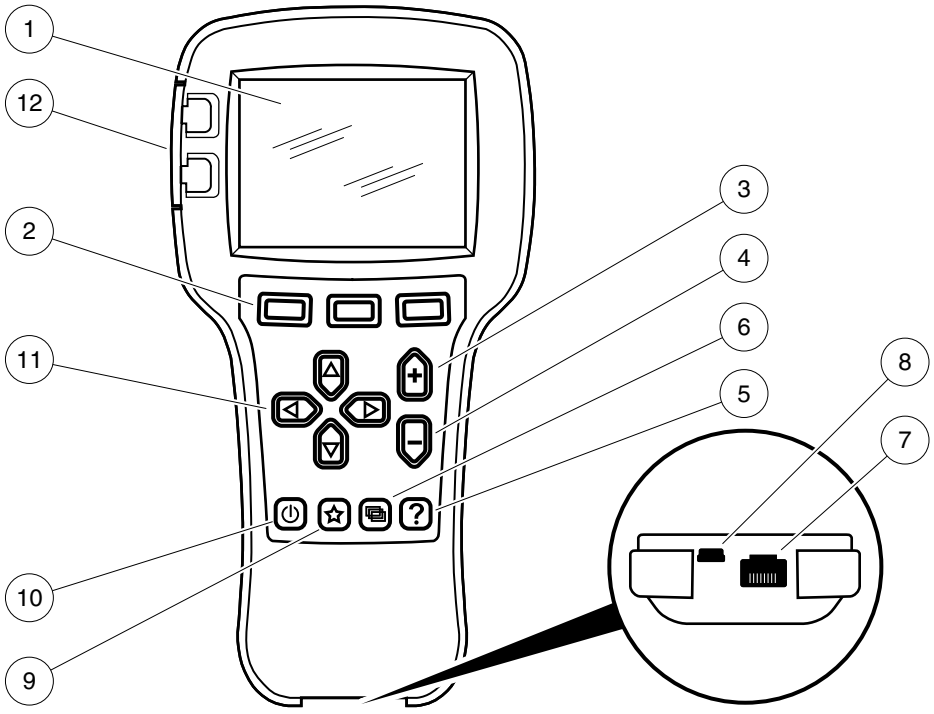
- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

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 18-5.***



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 18-1 CDT Overview

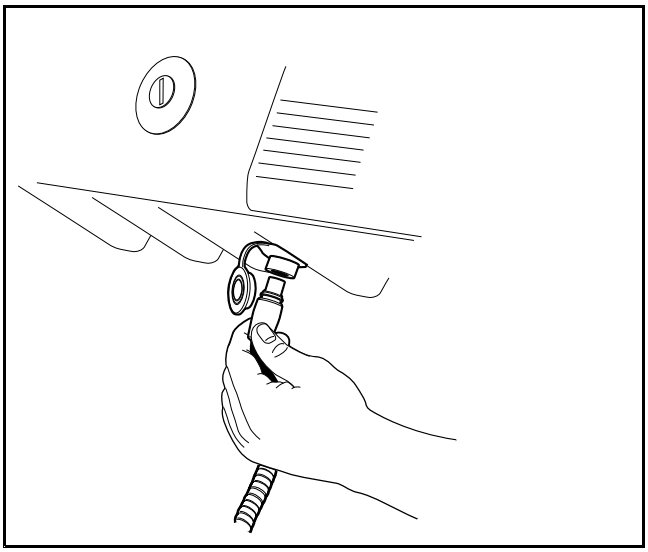
GENERAL INFORMATION

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 18-2 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 18-2, Page 18-3)**.
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 18-27.**

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 18-4 on page 18-30.	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 19-21.**	15 Amp fuse in the harness has failed.
Run/Tow switch is in “Tow” position. Switch to “Run” position.	Sonic weld 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 18-26. 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 menu; see Plot & Log on page 18-26. 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 18-9.**

SPEED SETTING	DESCRIPTION	VEHICLE SPEED
1	Commercial speed	8.0 mph (12.9 km/h)
2	Slow speed	11.4 mph (18.3 km/h)
3	Normal speed	Typical 14.8 mph (23.8 km/h). **See S3 FWD Speed on page 18-7.**
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 18-13.***

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 18-6.***

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 applications since the speed setting 3 is finely adjustable with S3 FWD SPEED.* ***See S3 FWD Speed on page 18-7.***

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 18-13.**

To fine tune vehicle top speed in normal 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 available:

- 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 18-8.**

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 multi-purpose 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 multi-purpose 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, proceed to Amp Hours Display on page 18-13 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 20, Page 20-12.***

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 switch 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) 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 switch 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 switch in the NEUTRAL or REVERSE position, the handset should indicate that the forward input is off. When the Forward/Neutral/Reverse switch is placed in the FORWARD position, the handset should indicate that the forward input is on.

REVERSE INPUT

With the Forward/Neutral/Reverse switch in the NEUTRAL or FORWARD position, the handset should indicate that the reverse input is off. When the Forward/Neutral/Reverse switch 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 18-9.**

ODOMETER

Displays approximate distance traveled 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 18-8.**

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 18-9.**

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 23, Page 23-1.**

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 multi-purpose 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 18-9. See also Password Tries (OEM Access Level Only) on page 18-12.**

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 18-9. See also Password Tries (OEM Access Level Only) on page 18-12.**

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. Multi-purpose 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.

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 switch. 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 19-21.** 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 — AC 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 23, Page 23-1.**

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 18-15.**

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 18-1, Page 18-1)**. 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.
Backlight	Here you can set the brightness of the programmer’s LCD display—from 100% to 20%, in 5% increments.

TABLE CONTINUED ON NEXT PAGE

MENU ITEM	DESCRIPTIONS
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 18-3.**
	Vehicle batteries – loose terminals or corrosion	Section 14 — AC Electric Vehicle - Batteries
	Vehicle batteries – improperly wired	Section 14 — AC Electric Vehicle - Batteries
	Vehicle batteries – batteries failed	Section 14 — AC Electric Vehicle - Batteries
	Vehicle batteries – batteries not fully charged	Section 14 — AC Electric Vehicle - Batteries
	Handset cord has failed	Test Procedure 1 – Handset Cord on page 18-28
	Handset cord adaptor has failed	Test Procedure 2 – Handset Cord Adaptor on page 18-28
	CDT port (mounted under instrument panel assembly) has failed	Test Procedure 3 – CDT Ports on page 18-29
	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 18-29
	Speed controller malfunction	Section 19 — DC Electric Vehicle - Troubleshooting and Electrical System
	Handset has failed	Replace handset
Display screen shows jumbled or undecipherable characters	Speed controller malfunction	Section 19 — DC Electric Vehicle - Troubleshooting and Electrical System
	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 18-29
	Intermittent handset cord failure	Test Procedure 1 – Handset Cord on page 18-28
	Intermittent handset cord adaptor failure	Test Procedure 2 – Handset Cord Adaptor on page 18-28
	Loose vehicle wire harness connections	Test Procedure 3 – CDT Ports on page 18-29

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 — AC Electric Vehicle - Batteries
	Vehicle batteries – improperly wired	Section 14 — AC Electric Vehicle - Batteries
	Vehicle batteries – batteries failed	Section 14 — AC Electric Vehicle - Batteries
	Vehicle batteries – batteries not fully charged	Section 14 — AC Electric Vehicle - Batteries
	Speed controller malfunction	Section 19 — DC Electric Vehicle - Troubleshooting and Electrical System

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 1-2.

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 1-2.

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.

CDT PORT (LOCATED UNDER INSTRUMENT PANEL)

See General Warnings on page 1-2.

1. Turn the key switch to the OFF position, place the Forward/Neutral/Reverse rocker switch in the NEUTRAL position, and lock the park brake.
2. Place the Run/Tow switch in the TOW position, disconnect the batteries, negative (–) cable first, and wait 90 seconds for the controller capacitors to discharge. **See General Warnings on page 1-2.**
3. Check the CDT port mounted under the instrument panel.

3.1. Remove the three screws (1) that secure the instrument panel assembly (2) to the dash assembly (3) **(Figure 18-3, Page 18-29)**.

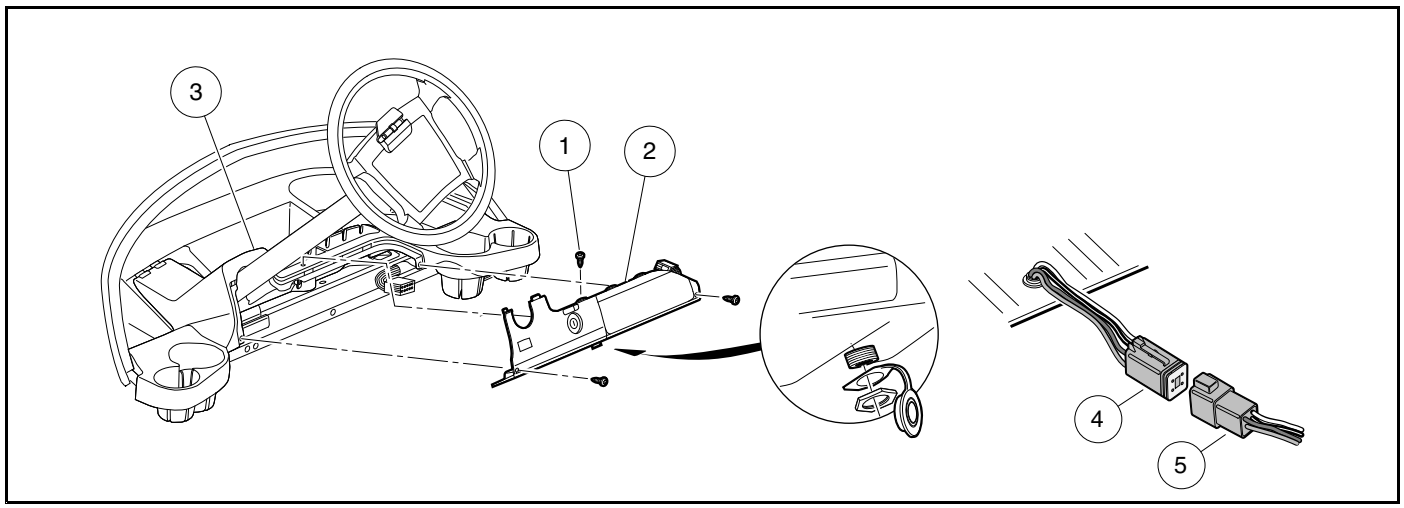


Figure 18-3 Instrument Panel Assembly Removal and CDT Port Connection

3.2. Disconnect the four-pin connectors (4 and 5) and visually inspect the contacts for damage and corrosion. Inspect the CDT port, mounted under the instrument panel assembly (2). Repair and replace parts as necessary.

3.3. If no problem is found, connect the four-pin connectors and install the instrument panel assembly.

3.4. Install the three screws (1) that secure the instrument panel assembly (2) to the dash assembly (3) **(Figure 18-3, Page 18-29)**.

4. Check the CDT port on the controller.

4.1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**

4.2. Remove electronics module cover. **See Speed Controller Removal, Section 20, Page 20-12.**

4.3. Connect CDT to controller.

4.3.1. Disconnect the square four-pin connector (3) from the controller.

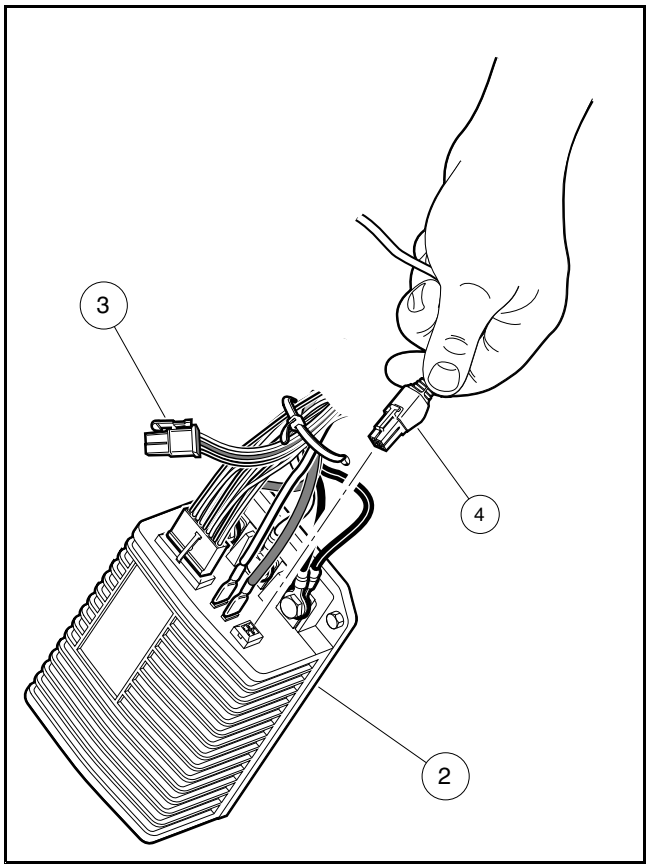
4.3.2. Connect the handset cord to the handset.

4.3.3. Connect the other end of the handset cord (without the adapter) (4) to the four-pin connector of the controller (2) **(Figure 18-4, Page 18-30)**.

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

4.3.5. If the handset functions when connected directly to the controller, the adapter plug or vehicle wire harness should be thoroughly tested. **See Test Procedure 2 – Handset Cord Adaptor on page 18-28.** Section 19 — DC Electric Vehicle - Troubleshooting and Electrical System

4.4. Replace electronics module cover. **See Speed Controller Installation, Section 20, Page 20-12.**



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Figure 18-4 CDT Connector On Controller

SECTION 19 — DC ELECTRIC VEHICLE - TROUBLESHOOTING AND ELECTRICAL SYSTEM

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**
- **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 vehicle 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 vehicle includes several additional features.

ACCESSORIES

For powered accessories that need to be controlled by the key switch, use the gray wire with a female bullet connector located behind the instrument panel.

CHARGE INDICATOR LIGHT

The dash mounted charge indicator light (below the steering column) 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 multi-purpose 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 18, Page 18-8.***

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 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 an CDT handset in the Diagnostic History menu. **See Motor Stall on page 18-22.**
- **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 an CDT handset in the Diagnostic History menu. **See HPD on page 18-20.**

BATTERY WIRING DIAGRAM

2-passenger vehicle battery cables are all 6-gauge.

4-passenger vehicle battery cables are all 4-gauge.

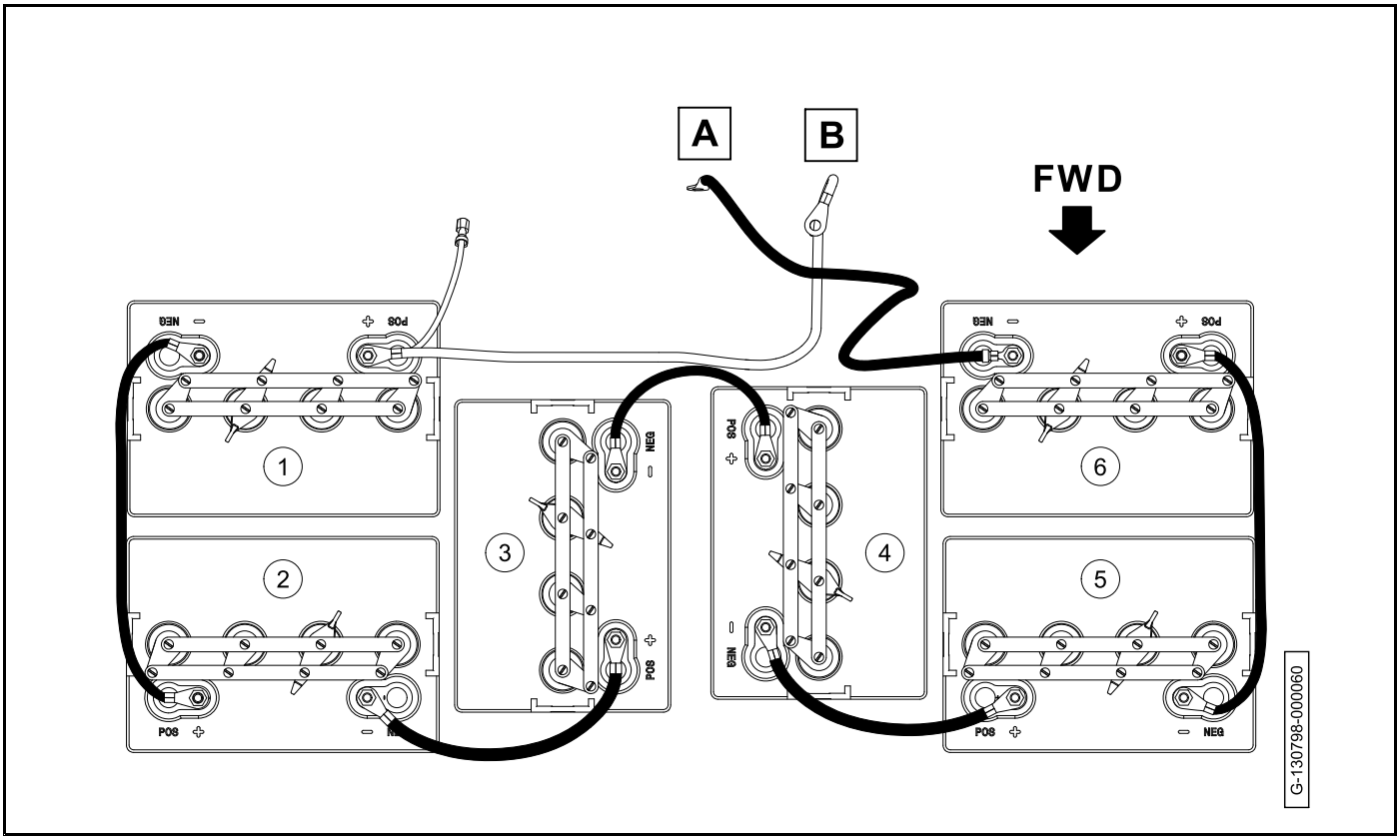
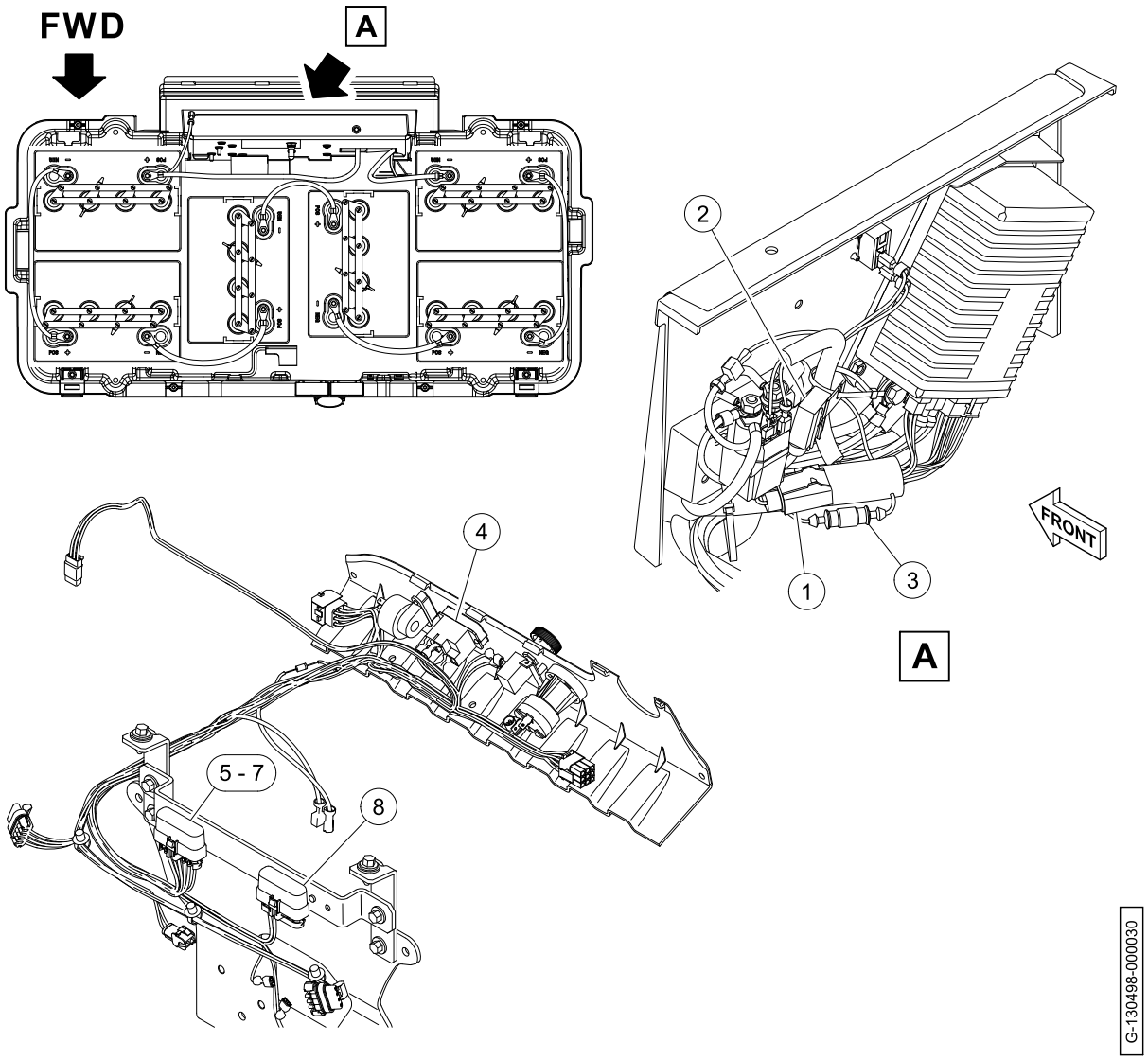


Figure 19-1 Battery Wiring Diagram

FUSE AND RELAY LOCATIONS



Callout Number	Description
1	15A Accessory Fuse
2	30A Charger Fuse
3	2A VDU Fuse
4	Brake Light Relay
5	7.5A Stereo Fuse
6	4A Logo Fuse
7	3A Headlight, Taillight Fuse
8	10A Horn, Turn Signal Fuse

Figure 19-2

MAIN HARNESS SONIC WELD AND 10K OHM LOCATIONS

The item numbers represent the sonic weld numbers. Example sonic weld 1 = item number (1).

The locations shown are approximate.

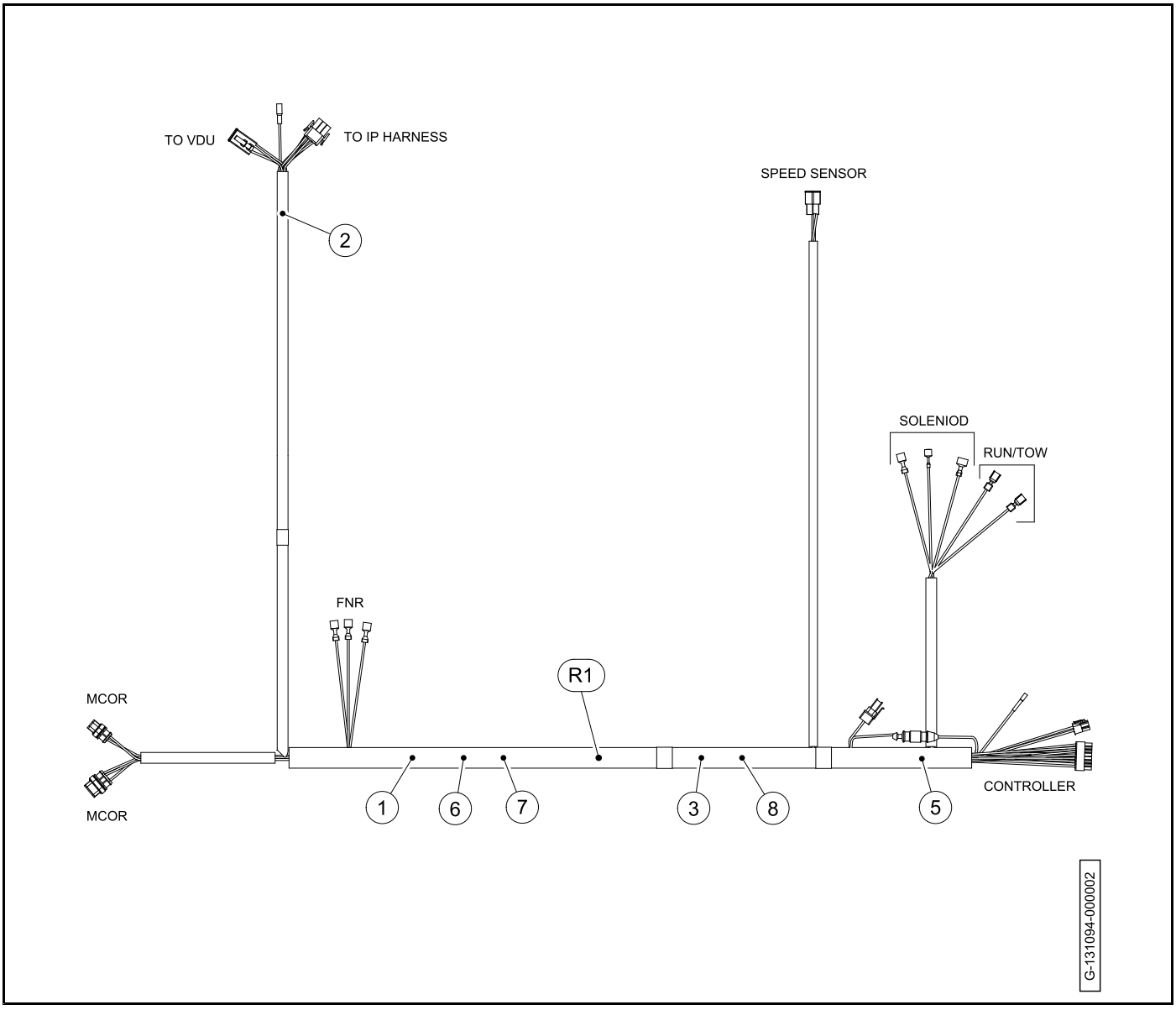


Figure 19-3

TROUBLESHOOTING

The following troubleshooting guides will be helpful in identifying operating difficulties should they occur. The guides include the symptom, probable cause 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 handset for troubleshooting vehicles equipped with the Excel electrical system. Troubleshooting Guide 1 is to be used in conjunction with the CDT handset. **See Controller Diagnostic Tool (CDT) on page 18-1** 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 proceed to Troubleshooting Guide 2.

If an CDT handset is unavailable, the technician should proceed to Troubleshooting Guide 2.

TROUBLESHOOTING GUIDE 1

The following troubleshooting guide is intended for use with an CDT handset. **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 19-22
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 19-22

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 14 – Motor Speed Sensor on page 12-48
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 9 – Horn on page 12-39
Monitor Menu – FORWARD INPUT and/or REVERSE INPUT does not indicate the correct reading	Loose or disconnected Forward/Neutral/Reverse rocker switch (quick disconnect terminals) or broken wire	Repair and/or connect the quick disconnect terminals to the Forward/Neutral/Reverse switch
	Loose or disconnected Forward/Neutral/Reverse rocker switch (three-pin connector) or broken wire	Repair and/or connect the three-pin connector from the Forward/Neutral/Reverse switch 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 rocker switch	Test Procedure 6 – Forward/Neutral/Reverse Switch (FNR) on page 12-34
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 on page 1-2.** 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 Main Solenoid Removal on page 13-13.**
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 switch
	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 9 – Horn on page 12-39

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 19-22
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 20-12.**
	Speed controller logic malfunction	Disconnect the batteries and allow the speed controller capacitors to discharge. **See WARNING "To avoid unintentionally starting..." in General Warnings on page 1-2.** 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 Main Solenoid Removal on page 13-13.**
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 on page 1-2.** 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 20-12.**
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 Main Solenoid Removal on page 13-13.**
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 23 — DC Electric Vehicle - Motor
	Failure of the FETs that control field current	Replace the speed controller. **See Speed Controller Removal on page 20-12.**
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 switch
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 — AC 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 an CDT handset 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 Fuse and Relay Locations on page 12-5.**
	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 19-21
	Key switch and MCOR limit switch circuit	Check for loose or disconnected wires at key switch and MCOR
	Failed key switch	Test Procedure 9 – Horn on page 12-39
	Failed MCOR	Test Procedure 9 – Horn on page 12-39. See also Test Procedure 11 – MCOR Voltage on page 19-22.
	Forward/Neutral/Reverse rocker switch	Test Procedure 6 – Forward/Neutral/Reverse Switch (FNR) on page 12-34
	Solenoid – loose wires	Test Procedure 20 – Solenoid Activating Coil on page 12-59
	Solenoid – failed coil	Test Procedure 20 – Solenoid Activating Coil on page 12-59
	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 19-27.**
	High pedal detect	Cycle accelerator pedal
	Motor stall	Cycle accelerator pedal
	Motor Failure	Section 23 — DC Electric Vehicle - Motor
	Speed controller failure	Replace speed controller. **See Speed Controller Removal on page 20-12.**
	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 14 – Motor Speed Sensor on page 12-48
	Incorrect speed setting	To change the programmed top speed of the vehicle, an CDT handset must be used
	Wiring – improperly wired	Check vehicle wiring. **See Fuse and Relay Locations on page 12-5.**
	Batteries – batteries discharged	Charge batteries
	MCOR malfunction	Test Procedure 11 – MCOR Voltage on page 19-22
	Motor – loose wires	Inspect and tighten all wire connections at the motor.
	Failed motor	Replace motor. **See Motor Removal on page 16-1.**
	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 20-12.**
	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 19-22
Vehicle reaches top speed before 100% pedal travel is reached	Speed controller – failed throttle resistor	Replace speed controller. **See Speed Controller Removal on page 20-12.**
Vehicle operates, but motor braking function does not	Wiring – improperly wired	Check vehicle wiring. **See Fuse and Relay Locations on page 12-5.**
	Speed sensor disconnected or failed	Test Procedure 14 – Motor Speed Sensor on page 12-48
Vehicle will run in forward, but not in reverse or will run in reverse but not forward	Forward/Neutral/Reverse rocker switch – improperly wired	Test Procedure 6 – Forward/Neutral/Reverse Switch (FNR) on page 12-34
	Motor – improperly wired	Check motor wiring. **See Fuse and Relay Locations on page 12-5.**
	Speed controller – improperly wired or failed speed controller FET	Check vehicle wiring. **See Fuse and Relay Locations on page 12-5.**
Vehicle operates, but battery charger does not charge batteries	Charger interlock failure	Test Procedure 10 – Charger Interlock on page 19-21
	Battery charger connections – loose plug or wires at charger, receptacle or batteries	Check wire connections and tighten if necessary.
	Battery charger	Section 15 — AC 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 Controller Shield on page 13-4. 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 Controller Shield on page 13-4. 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, 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 12-26**.
- The Run/Tow switch powers the key switch, controller, Forward/Neutral/Reverse switch, 15-amp fuse, and multi-purpose buzzer.
- The key switch powers the MCOR 2-pin circuit, Forward/Neutral/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.
- Several test can be performed by accessing components through the access panel in the rear body. If greater access is required, the two center batteries can be removed and the component mounting plate leaned forward; place the two center batteries on the floorboard and reconnect two of the existing battery cables. Use a third, "service only" cable that is long enough to connect the two batteries just for troubleshooting.

Index of Test Procedures

1 – Batteries / Voltage Check (BPV)
2 – 48-Volt Battery Pack Voltage Under Load
3 – Run/Tow Switch
4 – 15-Amp Fuse
5 – Key Switch and MCOR Limit Switch Circuit
6 – Forward/Neutral/Reverse Rocker Switch
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 Red Wire Socket
15 – 16-Pin Connector
16 – Multi-Purpose 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 1-2.

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 14-11.***

The battery voltage can be displayed with the CDT handset. If an CDT handset is not available, proceed to **Batteries / Voltage Check without the CDT Handset**.

Batteries / Voltage Check with the CDT Handset

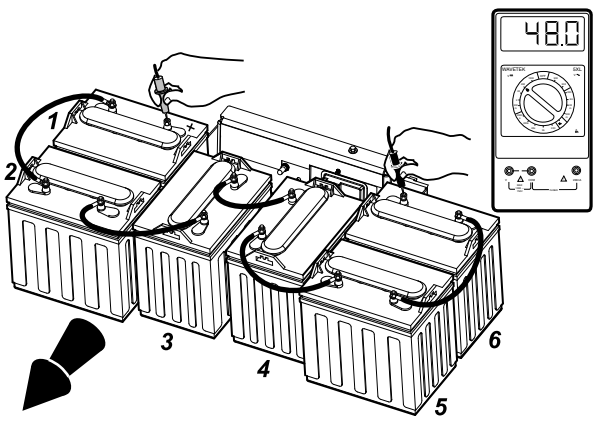
1. Connect the CDT to the vehicle.

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 AC Electric Vehicle - Batteries on page 14-1 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 12-25.
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 19-4, Page 19-13)**.
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 AC 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 (-).

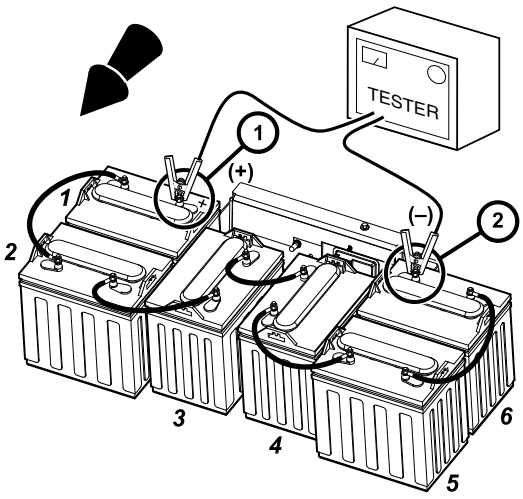
2500-30100-10413
Figure 19-4 Battery Voltage Test

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

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

1. If necessary, see Testing Basics on page 12-25.
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 19-5, Page 19-14)**.



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

2500-30100-10411

Figure 19-5 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 AC Electric Vehicle - Batteries on page 14-1.

TEST PROCEDURE 3 – Run/Tow Switch

See General Warnings on page 1-2.

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 18-4, Page 18-30)**.

4. If the CDT display screen begins to work, proceed 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/TowSwitch Removal on page 13-21.**

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 12-25.
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.

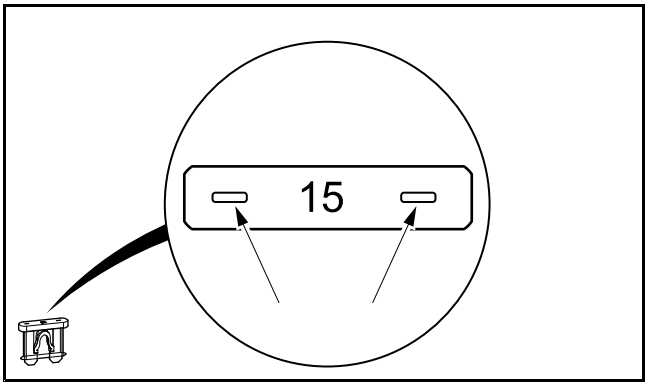
4. With the Run/Tow switch in the TOW position:

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 – 15-Amp Fuse

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*



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Figure 19-6 Testing the Fuse

1. If necessary, see Testing Basics on page 12-25.
2. Access the 15-amp fuse but do not remove it.
3. With the Run/Tow switch in the RUN position:

3.1. Probe the two, small metal contacts on the top of the fuse **(Figure 19-6, Page 19-15)**.

3.2. Each contact should show BPV.

3.3. If the red wire side does not show BPV, replace fuse.

3.4. If the pink wire side does not show BPV, make sure Run/Tow switch in the RUN position. If it is in RUN, inspect Run/Tow switch, red-to-pink wire spade connector near the solenoid, and sonic welds 5 and 8.

TEST PROCEDURE 5 – Key Switch and MCOR Limit Switch Circuit

See General Warnings on page 1-2.

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 WARNING "Lift only one end..." in General Warnings on page 1-2.**
2. Turn the key switch to the OFF position and place the Forward/Neutral/Reverse switch 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, proceed to the following procedure, **Key Switch and MCOR Limit Switch Circuit Test without the CDT Handset**. If the key switch functions as described, proceed 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 Fuse and Relay Locations, Section 12, Page 12-5.**

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

7. If the problem was not found, proceed 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 12-25.
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 on page 1-2.**
3. Place the Run/Tow switch in the RUN position and the Forward/Neutral/Reverse switch in the NEUTRAL position.

4. **Pin 6 Green Wire:** Access the controller by removing the access panel in the rear body. **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 Key Switch Removal, Section 13, Page 13-12.**

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):** Remove floormat and cover plate to access the MCOR. **See Pedal Group Removal on page 5-5.**

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 13-18.**

TEST PROCEDURE 6 – Forward/Neutral/Reverse Rocker Switch

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

The Forward/Neutral/Reverse Switch provides FORWARD INPUT and REVERSE INPUT to the controller.

If the controller sees both FORWARD INPUT and REVERSE INPUT at the same time, the multi-purpose 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 Rocker Switch Test with the CDT Handset

1. Turn the key switch to the OFF position and place the Forward/Neutral/Reverse switch 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 switch is in the NEUTRAL or REVERSE position.

3.2. Place the Forward/Neutral/Reverse switch in the FORWARD position. The CDT should indicate that FORWARD INPUT is ON. If the CDT indicates any other reading, check vehicle wiring. **See Fuse and Relay Locations on page 12-5.** Also check the 16-pin connector at the speed controller. **See Test Procedure 15 – 16-Pin Connector on page 19-27.**

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 switch is in the NEUTRAL or FORWARD position.

4.2. Place the Forward/Neutral/Reverse switch in the REVERSE position. The CDT should indicate that REVERSE INPUT is ON. If the CDT indicates any other reading, check vehicle wiring. **See Fuse and Relay Locations on page 12-5.** Also check the 16-pin connector at the speed controller. **See Test Procedure 15 – 16-Pin Connector on page 19-27.**

5. If the CDT displays readings other than those described above and the wiring is found to be correct, proceed to the following procedure, **Forward/Neutral/Reverse Rocker Switch Test without the CDT Handset**.

Forward/Neutral/Reverse Rocker Switch Test without the CDT Handset

1. If necessary, see Testing Basics on page 12-25.
2. Place the Run/Tow switch in the RUN position and the Forward/Neutral/Reverse switch in the NEUTRAL position.
3. Remove Forward/Neutral/Reverse switch 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 switch 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 15-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 FORWARD.

– 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. **See Forward/Neutral/Reverse Switch (FNR) Removal on page 13-8.**

If the brown wire does not show BPV in FORWARD, the switch may have corrosion on the contact or the switch has failed OPEN and must be replaced. **See Forward/Neutral/Reverse Switch (FNR) Removal on page 13-8.**

4.3. **Blue Wire**
– The blue wire should show BPV in REVERSE.

– The blue wire should show zero (0) volts in NEUTRAL and FORWARD.

If the blue wire shows voltage in NEUTRAL, the switch may have corrosion across the contacts or the switch has failed CLOSED and must be replaced. **See Forward/Neutral/Reverse Switch (FNR) Removal on page 13-8.**

If the blue 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. **See Forward/Neutral/Reverse Switch (FNR) Removal on page 13-8.**.

5. When installing the Forward/Neutral/Reverse switch into its housing, orient the three wire terminals towards the front of the vehicle (i.e. biased closer to the front of the switch housing and farther from the rear body).

TEST PROCEDURE 7 – Solenoid Activating Coil

See General Warnings on page 1-2.

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 12-25.
2. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
3. Access the solenoid by removing the electronics module cover. **See Controller Shield on page 13-4.**
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 200 to 250 ohms should be obtained for factory-installed solenoids **(Figure 19-7, Page 19-19)**. If not, replace the solenoid.
   – A reading of 180 to 190 ohms should be obtained for service replacement solenoids **(Figure 19-8, Page 19-19)**. If not, replace the solenoid.

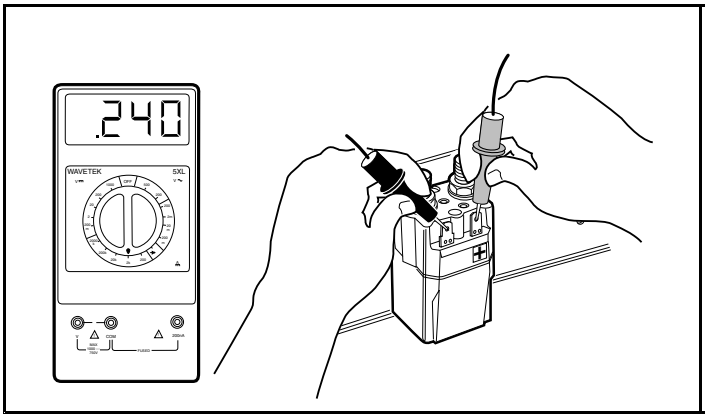
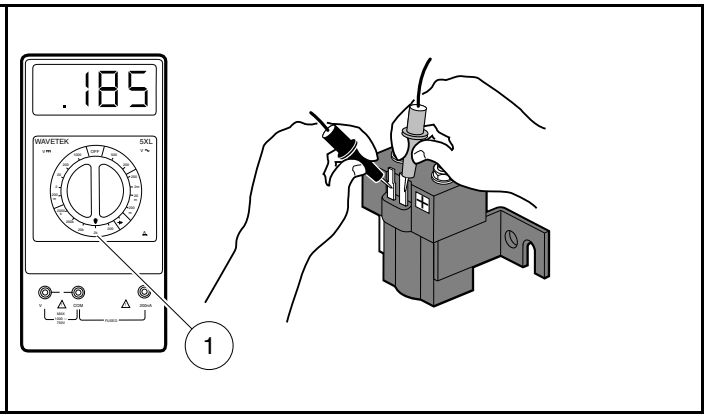


Figure 19-7 Activating Coil Test – Factory-installed Solenoid



2500-20000-10283
Figure 19-8 Activating Coil Test – Service Replacement Solenoid

TEST PROCEDURE 8 – Pre-Charge Resistor

See General Warnings on page 1-2.

NOTE: *This is a resistance test.*

1. If necessary, see Testing Basics on page 12-25.
2. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
3. Access the solenoid by removing the access panel in the rear body.
4. Measure resistance between the two large posts of the solenoid. The reading should be approx. 250 Ohms. If not, replace the pre-charge resistor using most of the steps found in **Main Solenoid Removal on page 13-13**.

5. 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 1-2.

Solenoid Continuity Test with the CDT Handset

1. If necessary, see Testing Basics on page 12-25.
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 on page 1-2.**
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 switch in the FORWARD 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 Fuse and Relay Locations on page 12-5.** Also check the 16-pin connector at the speed controller. **See Test Procedure 15 – 16-Pin Connector on page 19-27.**
7. If the CDT displays readings other than those described above and the wiring is found to be correct, proceed 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 12-25.
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 on page 1-2.**
3. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
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 approx. 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 Main Solenoid Removal on page 13-13.**
6. Reconnect the 6-gauge yellow wire and pre-charge resistor to the solenoid and secure with washer and nut. Tighten nut to 77 lb·in (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/Neutral/Reverse rocker switch in the FORWARD 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 Main Solenoid Removal on page 13-13.**

TEST PROCEDURE 10 – Charger Interlock

See General Warnings on page 1-2.

Controller Interlock Function Test with the CDT Handset

1. If necessary, see Testing Basics on page 12-25.
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 20, Page 20-12.**

Testing the Interlock Circuit

The charger interlock circuit consists of a 48V power source through the RUN/TOW switch, three sonic welds, a 15-amp fuse, a 10k Ohm resistor, a bullet connector, 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 Controller Shield Removal, Section 13, Page 13-4.**
3. **Check 15-amp fuse: See Test Procedure 4 – 15-Amp Fuse on page 19-15.**
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, proceed 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 19-3, Page 19-5)**.
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 1-2.

NOTE: *This is a voltage test.*

The accelerator position, which is proportional to the MCOR voltage, can be displayed with the CDT handset. If an CDT handset is not available, proceed 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 on page 1-2. 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, proceed 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 on page 1-2. 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 1-2.

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 switch in the REVERSE position to verify multi-purpose 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 switch in the NEUTRAL position.
3. Slowly push the vehicle a short distance (about 3 feet (1 meter)). The multi-purpose buzzer should sound and motor braking should engage while the vehicle is rolling.
4. If the multi-purpose 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 switch 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, proceed 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 switch 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, proceed 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 1-2.

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 on page 1-2. 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 switch in the FORWARD 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 Guardian 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 19-22.** Also check the continuity of the large posts of the solenoid. **See Horn Switch on page 12-38.**

4.2. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**

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 23 — DC Electric Vehicle - Motor

TEST PROCEDURE 14 – Voltage at Charger Receptacle Red Wire Socket

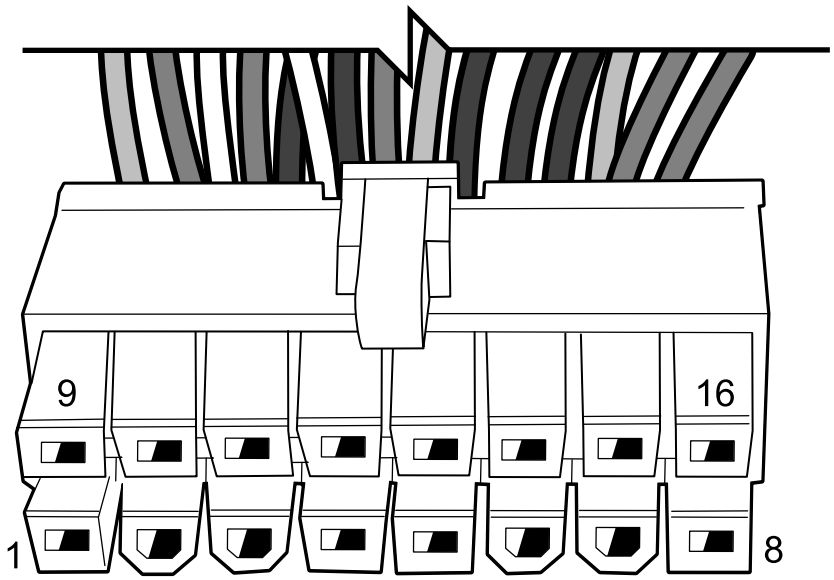
See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

1. If necessary, see Testing Basics on page 12-25.
2. Probe the charger receptacle socket connected to the red, 10-gauge wire. 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 1-2.



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 19-9 Pin And Wire Color

Inspection and General Information

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
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 19-9, Page 19-27**.
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 1-4.**
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 19-21.**
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 switch 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 switch 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 – Multi-Purpose Buzzer

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

1. If necessary, see Testing Basics on page 12-25.
2. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
3. Remove the instrument panel. **See Key Switch Removal, Section 13, Page 13-12.**
4. Disconnect the orange/white and pink wires from the multi-purpose 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 multi-purpose buzzer. The reading should be approximately 48 volts (full battery voltage).

7.1. If the voltage reading is correct, proceed 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 18 – Relay (12V and 48V) on page 12-55.**

7.3. If the continuity readings are not correct, repair or replace the pink wire.

7.4. If the continuity readings are correct, proceed to step 7.

8. Place the Forward/Neutral/Reverse switch 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 multi-purpose 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 multi-purpose 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 1-2.

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 multi-purpose 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 18, Page 18-8.***

3. If charge indicator light does not flash three times, disconnect charger DC cord from vehicle and connect an 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.

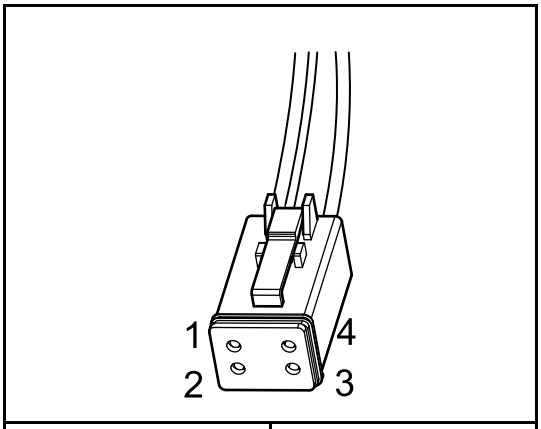
– Continuity of the wires in the wire harnesses.

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 1-2.

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 19-10 4-Pin Connector

1. If necessary, see Testing Basics on page 12-25.
2. Check for continuity between pin 1 (yellow/black wire) **(Figure 12-67, Page 12-67)** 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.

Pagination Page

SECTION 20 — DC ELECTRIC VEHICLE - ELECTRICAL COMPONENTS

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

KEY SWITCH

See General Warnings on page 1-2.

TESTING THE KEY SWITCH

See the appropriate troubleshooting section for the type of electrical system used in the vehicle.

See Test Procedure 9 – Horn on page 12-39.

KEY SWITCH REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
2. Remove the instrument panel **(Figure 20-1, Page 20-2)**.

2.1. Remove three screws (1) from the instrument panel (2).

2.2. Rotate the instrument panel up and away from the dash to disengage the tabs at the top of the panel.

2.3. Disconnect the electrical connector (3) to the instrument panel.

3. Disconnect the wires from the key switch.
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). Hold the key switch and remove the switch retaining nut (6) from the outside of the instrument panel **(Figure 20-2, Page 20-2)**.

KEY SWITCH INSTALLATION

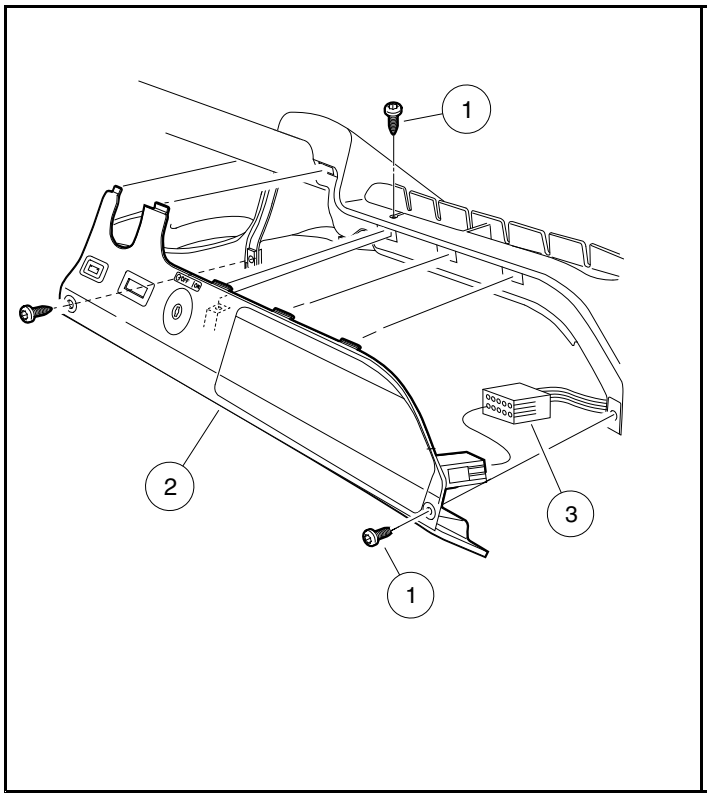
1. Position the key switch and flat washer (9) in the instrument panel, then install and tighten the switch retaining nut (6) to 40 lb·in (4.5 N·m). Install key switch cap (8) in center dash **(Figure 20-2, Page 20-2)**.
2. Connect the blue and green wires to the key switch terminals. Either orientation is correct. **See 12-5.**
3. Install the instrument panel.

3.1. Connect the electrical connector (3) **(Figure 20-1, Page 20-2)**.

3.2. Position the instrument panel (2) on the dash assembly. Make sure tabs on upper edge properly engage with the corresponding slots on the dash assembly. Ensure that there are no wires exposed or pinched during positioning.

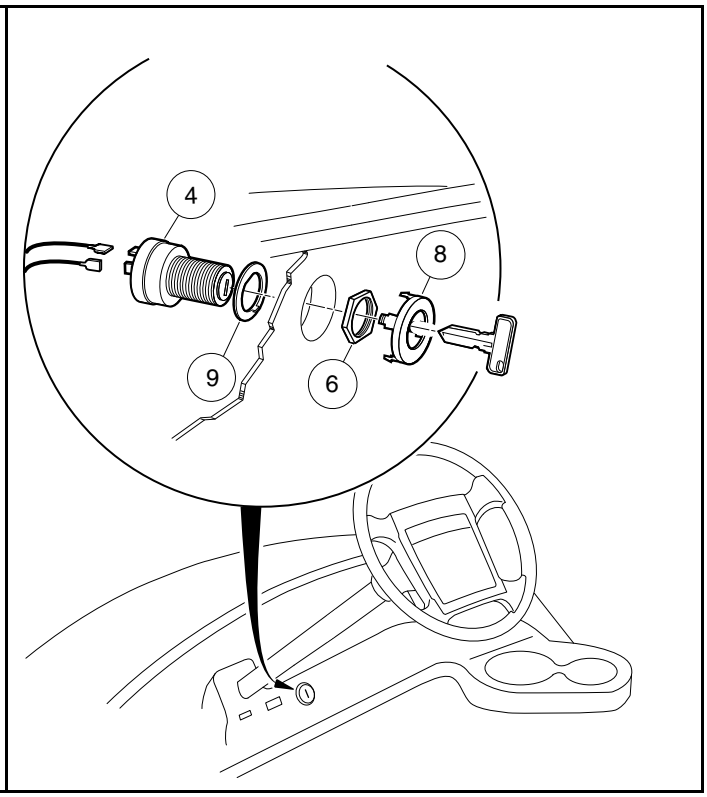
3.3. Secure instrument panel to the dash assembly with three screws (1). Tighten screws to 1.8 lb·ft (2.5 N·m).

4. Connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**



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Figure 20-1 Instrument Panel Removal



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Figure 20-2 Key Switch

CHARGE INDICATOR LIGHT

See General Warnings on page 1-2.

TESTING THE CHARGE INDICATOR LIGHT

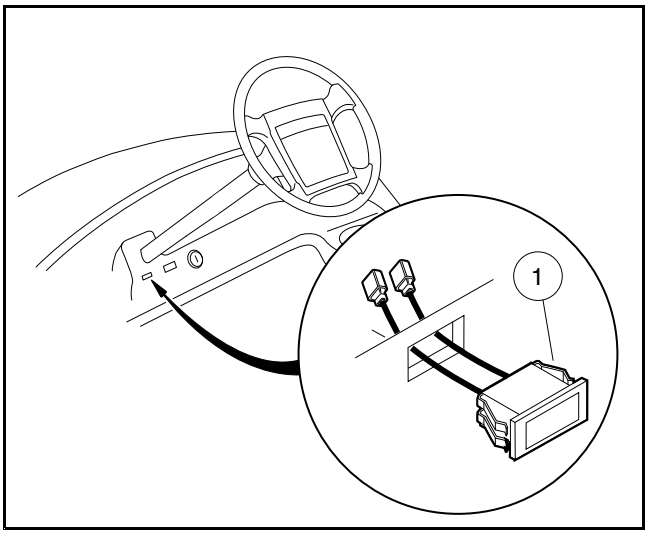
See Test Procedure 17 – Charge Indicator Light on page 19-30.

CHARGE INDICATOR LIGHT REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
2. Remove instrument panel. **See Key Switch Removal on page 13-12.**
3. Disconnect the wires at the warning light.
4. Press the two retaining tabs (1) and remove the light from the center dash **(Figure 20-3, Page 20-3)**.

CHARGE INDICATOR LIGHT INSTALLATION

1. Install in reverse order of removal.
2. Place the Run/Tow switch in the TOW position and connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**

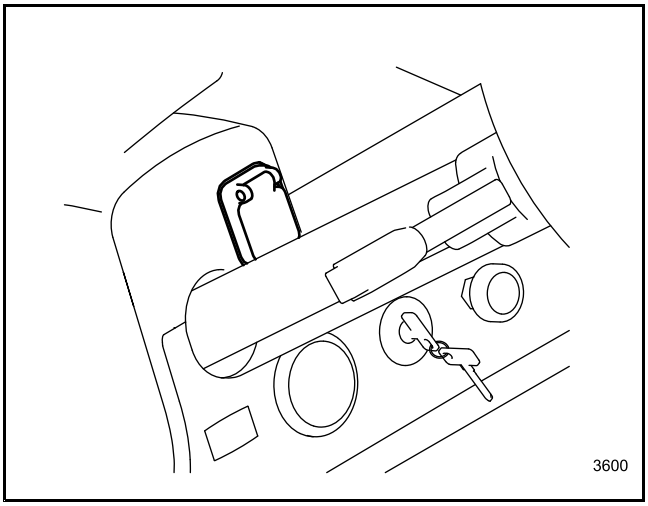


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Figure 20-3 Charge Indicator Light

USB RECEPTACLE

The 5–volt 3 amp USB receptacle **(Figure 20-4)** provides electricity to power and recharge portable devices. The USB receptacle is not designed for the transfer of data.



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Figure 20-4 USB Port

USB RECEPTACLE REMOVAL

1. Remove the instrument panel to access the USB receptacle wires and lock tabs **(Figure 20-5, Page 20-4)**.
2. Disconnect the USB receptacle wires.
3. Push the lock tabs on both sides and remove the USB receptacle.

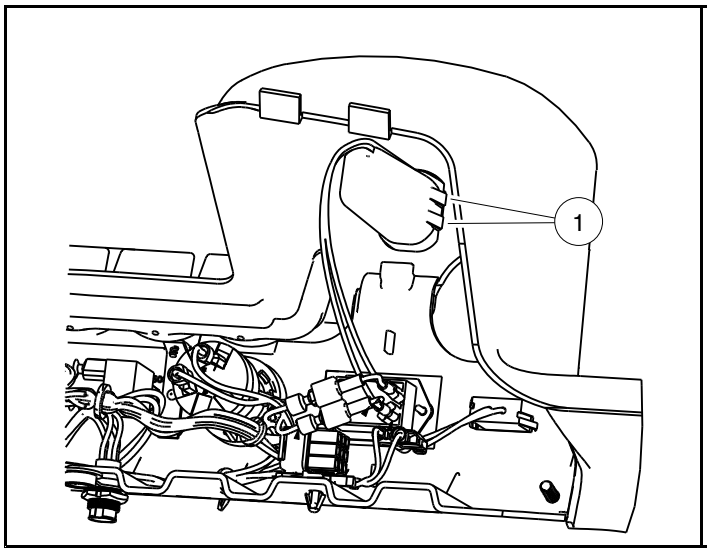


Figure 20-5 USB Port Removal (Electric)

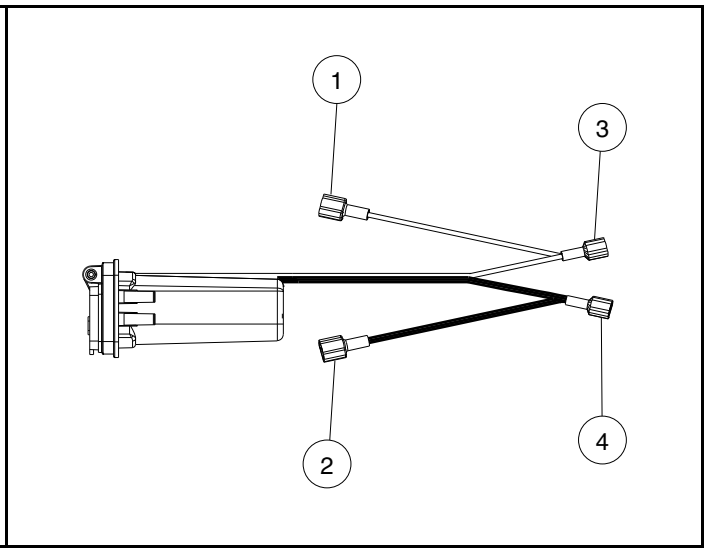


Figure 20-6 USB Port Installation (Electric)

USB RECEPTACLE INSTALLATION

1. Put the USB receptacle wires into the dash.
2. Push the USB receptacle into the dash.
3. Connect the red instrument panel wire to the red USB receptacle wire (1) **(Figure 20-6, Page 20-4)**.
4. Connect the black instrument panel wire to the black USB receptacle wire (2).
5. **Vehicles with a battery condition indicator:** Connect the red USB wire (3) to the battery condition indicator positive terminal. Connect the black USB wire (4) to the battery condition indicator negative terminal.
6. **Vehicles without a battery condition indicator:** Attach the extra wires (3 and 4) to the instrument panel harness with a plastic tie.
7. Install the instrument panel.

FORWARD/NEUTRAL/REVERSE ROCKER SWITCH

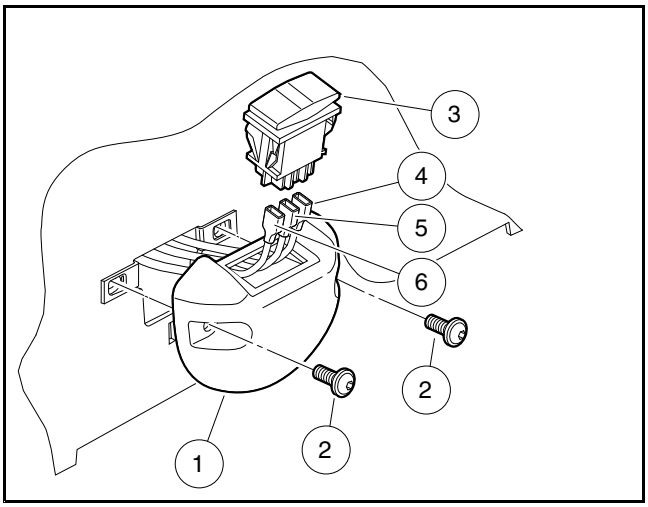
See General Warnings on page 1-2.

TESTING THE FORWARD/NEUTRAL/REVERSE ROCKER SWITCH

See Test Procedure 6 – Forward/Neutral/Reverse Switch (FNR) on page 12-34.

FORWARD/NEUTRAL/REVERSE ROCKER SWITCH REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
2. Remove two screws (2) that hold Forward/Neutral/Reverse rocker switch housing (1) to the vehicle **(Figure 20-7, Page 20-5)**.
3. Remove the three wires from the rocker switch.
4. Press in on the locking tabs on each side of switch (3), and push switch out of housing.



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Figure 20-7 Forward/Neutral/Reverse Rocker Switch

FORWARD/NEUTRAL/REVERSE ROCKER SWITCH INSTALLATION

1. Route the three wires through bezel. Connect the blue (4), orange (5) and brown (6) wires to the rocker switch (3), exactly as shown in **(Figure 20-7, Page 20-5)**.
2. Orient the rocker switch (3) so the terminals are towards the front of the housing (1). Push rocker switch (3) into housing (1).
3. Place the housing in position on the body and install the two screws (2). Tighten to 20 lb·in (2.3 N·m).
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. Inspect the vehicle for proper operation.

⚠ WARNING

- **Make sure that the vehicle operates in the forward direction when the Forward/Neutral/Reverse switch is in the FORWARD position.**
- **Make sure that the vehicle operates in the reverse direction when the Forward/Neutral/Reverse switch is in the REVERSE position. The multi-purpose buzzer will sound as a warning when the Forward/Neutral/Reverse switch is in REVERSE.**
- **Make sure that the vehicle does not operate when the Forward/Neutral/Reverse switch is in the NEUTRAL position.**

ELECTRONICS MODULE COVER

See General Warnings on page 1-2.

The electronics module cover needs to be removed to gain access to the speed controller, Run/Tow switch, and solenoid.

ELECTRONICS MODULE COVER REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
2. Remove the two plastic rivets (1) that secure the access panel (2) to the vehicle **(Figure 20-8, Page 20-7)**.
3. Remove cover (5) by first releasing the four tabs (3) from the matching holes in the hood of the battery bucket. Then, maneuver the cover to release the two hooks (4) that secure the cover to the battery bucket.

CAUTION

- **Be careful not to break the two hooks (4) on the bottom of the cover. Push the bottom of the cover up to release the hooks before pulling cover away from battery bucket.**

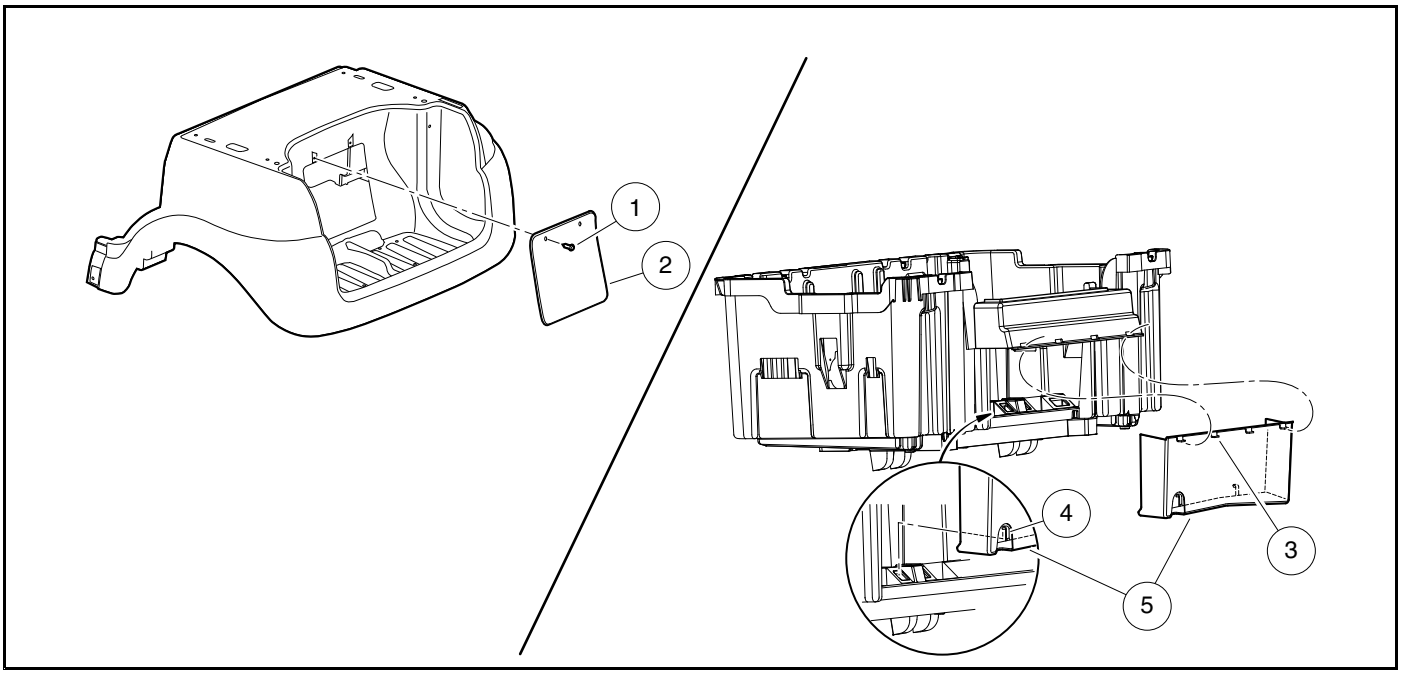
ELECTRONICS MODULE COVER INSTALLATION

1. Install cover (5) by first hooking the four tabs (3) into the matching holes in the hood of the battery bucket **(Figure 20-8, Page 20-7)**. Then, use the two hooks (4) to secure the cover to the battery bucket.
2. Place access panel (2) on vehicle and secure with the two plastic rivets (1). **See following CAUTION.**

CAUTION

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

3. Place the Run/Tow switch in the TOW position and connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**



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Figure 20-8 Access and Remove Electronics Module Cover

RUN/TOW SWITCH

See General Warnings on page 1-2.

TESTING THE RUN/TOW SWITCH

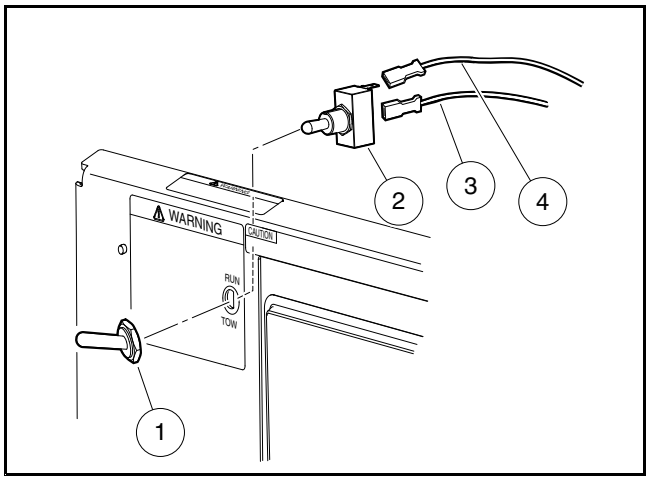
See Test Procedure 18 – Relay (12V and 48V) on page 12-55.

RUN/TOW SWITCH REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
2. Remove the electronics module cover to access back side of the Run/Tow switch (2). **See Controller Shield Removal on page 13-4.**
3. Remove Run/Tow switch boot/hex nut (1) **(Figure 20-9, Page 20-8)**.
4. Remove Run/Tow switch (2) from electronics module and disconnect the pink wire (3) and light green wire (4).

RUN/TOW SWITCH INSTALLATION

1. Installation is reverse of removal. Make sure flat on switch is aligned with flat part of D-shaped hole in electronics module **(Figure 20-9, Page 20-8)**. Tighten Run/Tow switch boot/hex nut (1) to 16 lb·in (1.8 N·m).
2. Place the Run/Tow switch in the TOW position and connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**



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Figure 20-9 Run/Tow Switch

MOTOR CONTROLLER OUTPUT REGULATOR (MCOR)

The MCOR is mounted on the side of the pedal group. The MCOR detects the position of the accelerator pedal and sends a corresponding voltage to the motor controller.

MCOR REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
2. Remove pedal group. **See Pedal Group Removal, Section 5, Page 5-1.**
3. Disconnect the two-pin and three-pin connectors from the MCOR.
4. Remove the T25 torx screw securing the MCOR to the pedal group.
5. Detach the two tabs from the accelerator pedal and remove the MCOR from vehicle.

MCOR INSTALLATION

1. Align the two tabs of the MCOR (2) with the slots in the accelerator pedal on the pedal group. Insert the MCOR into the accelerator pedal until the tabs engage. **See following NOTE.**

NOTE: *Rotate the pedal back and forth if necessary to align the D-shaped end of shaft with the MCOR.*

2. Secure MCOR to pedal group with T25 torx screw. Tighten screw to 19 lb·in (2.1 N·m).
3. Connect the two-pin and three-pin connectors from the wire harness to the MCOR.
4. Install the pedal group. **See Pedal Group Installation on page 5-3.**
5. Connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**

MULTI-PURPOSE BUZZER

See General Warnings on page 1-2.

TESTING THE MULTI-PURPOSE BUZZER

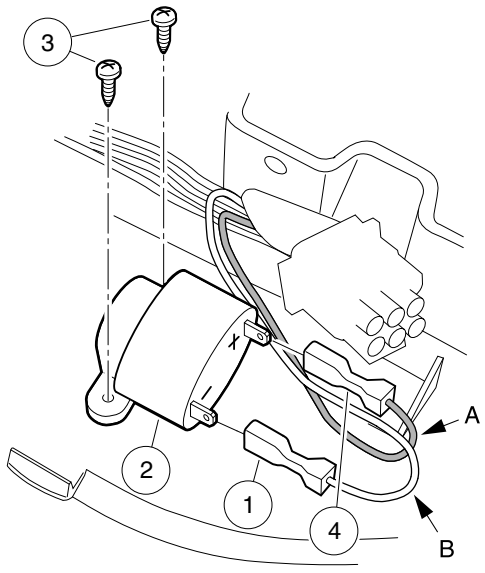
See 12-55.

MULTI-PURPOSE BUZZER REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
2. Remove instrument panel. **See Key Switch Removal on page 13-12.**
3. Disconnect the 18-gauge pink and orange/white wires from multi-purpose buzzer.
4. Remove the two screws from the multi-purpose buzzer. Remove the multi-purpose buzzer from the dash panel.

MULTI-PURPOSE BUZZER INSTALLATION

1. Install the multi-purpose buzzer in the reverse order of removal. Pink wire must be connected to the positive terminal. Tighten screws to 4 lb·in (0.45 N·m).
2. Place the Run/Tow switch in the TOW position and connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**



(Viewed from underside of instrument panel)
A. Pink B. Orange/White

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Figure 20-10 Multi-purpose Buzzer

ELECTRONICS MODULE

See General Warnings on page 1-2.

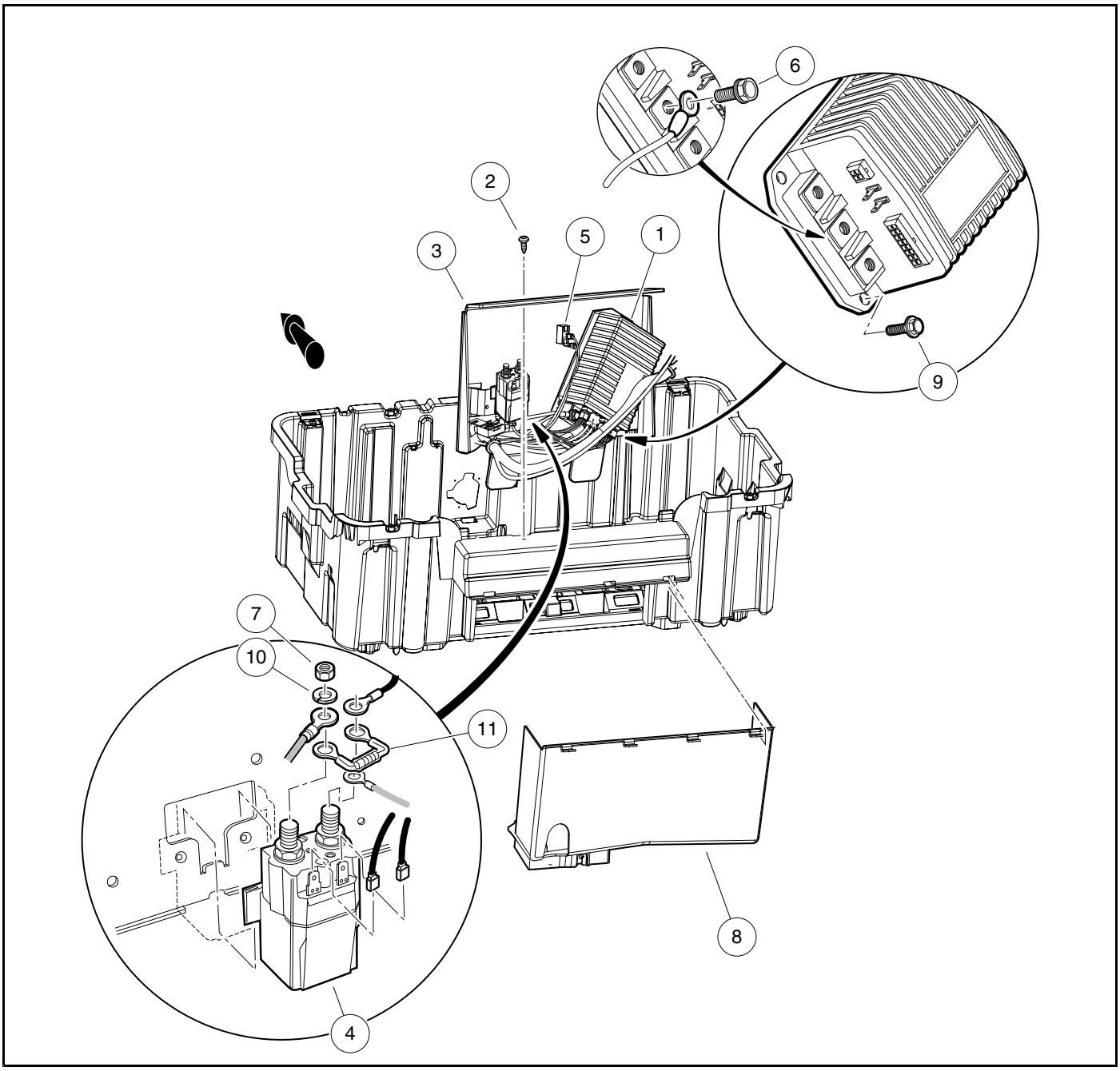
While it is not necessary to remove the electronics module from the vehicle, access to individual components may be easier with the module removed.

ELECTRONICS MODULE REMOVAL

1. Disconnect the batteries and discharge the controller (1). **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
2. Remove the batteries from the vehicle to provide enough room to access the controller (1) **(Figure 20-11, Page 20-11)**. **See Battery Replacement on page 14-10.**
3. Remove the bolt (2) that secures the electronics module (3) to the battery bucket.
4. Pull electronics module (3) forward and disconnect the heavy gauge wires from the controller (1) and solenoid (4).
5. Disconnect the 16-pin connector, 4-pin connector, and spade connectors from the controller (1).
6. Disconnect the spade connectors on the front of the solenoid (4).
7. Disconnect the two wires from Run/Tow switch (5).
8. Lift the electronics module (3) from the vehicle. **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.**



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Figure 20-11 Controller and Solenoid Removal

ELECTRONICS MODULE INSTALLATION

1. Return electronics module (3) to its location in vehicle but leave it tilted forward.
2. Complete connections to the controller (1), the Run/Tow switch (5) and the solenoid (4) per the electrical schematics. **See Fuse and Relay Locations on page 12-5.**
3. Tighten bolts (6) on the controller to 108 lb·in (12.2 N·m).
4. Tighten nuts (7) on the solenoid to 6.4 lb·ft (8.7 N·m).

5. Set electronics module in place and secure with bolt (2) **(Figure 20-11, Page 20-11)**. Tighten bolt to 40 lb·in (4.5 N·m).
6. Install the batteries and battery cables in their original locations. **See Battery Replacement on page 14-10.**
7. Place the Run/Tow switch (5) in the TOW position and connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**
8. Place the Run/Tow switch (5) in the RUN position.
9. 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 switch is in the FORWARD position.**
- **Make sure that the vehicle operates in the reverse direction when the Forward/Neutral/Reverse switch is in the REVERSE position. The multi-purpose buzzer will sound as a warning when the Forward/Neutral/Reverse switch is in REVERSE.**
- **Make sure that the vehicle does not operate when the Forward/Neutral/Reverse switch is in the NEUTRAL position.**

SPEED CONTROLLER

See General Warnings on page 1-2.

TESTING THE SOLID STATE SPEED CONTROLLER

See Test Procedure 13 – A1 and A2 Motor Voltage on page 19-25.

SPEED CONTROLLER REMOVAL

1. Disconnect the batteries and discharge the controller (1). **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
2. Remove the electronics module cover (8) to access the controller (1). **See Controller Shield Removal on page 13-4.**
3. Disconnect the heavy gauge wires from the controller by removing the three screws (6) **(Figure 20-11, Page 20-11)**.
4. Disconnect the 16-pin connector, 4-pin connector, and spade connectors from the controller (1).
5. Remove the one self-tapping screw (9) nearest the B- terminal of the controller. Loosen the remaining two self-tapping screws (9) that secure the controller and remove controller from vehicle.

SPEED CONTROLLER INSTALLATION

1. Install controller (1) on the two self-tapping screws (9). Install third self-tapping screw (9) and tighten to 5.5 lb·ft (7.5 N·m) **(Figure 20-11, Page 20-11)**.
2. Connect the 16-pin connector, 4-pin connector, and spade connectors to the controller (1).
3. Connect the the heavy gauge wires to the controller (1) per the electrical schematics. **See Fuse and Relay Locations on page 12-5.** Tighten terminal screws (6) on the controller to 108 lb·in (12.2 N·m).
4. Return electronics module cover (8) to its original location. **See Controller Shield Installation on page 13-4.**

5. Place the Run/Tow switch in the TOW position and connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**
6. Place the Run/Tow switch in the RUN position.
7. If vehicle is equipped with the Guardian SVC system, perform the following additional steps for proper setup.

7.1. Connect an CDT to the CDT port on the vehicle.

7.2. Select *Program, Settings, Control Mode* and set the value to 1.

7.3. Select *Program, Settings, Anti Tamper* and set the value to 0.

7.4. 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 (+/-).*

7.5. Select *Program, Vehicle ID, Vehicle Decal* and enter the number on the Vehicle Number Decal.

7.6. Select *Program, Vehicle ID, Vehicle Date of Manufacture* and enter the number on the model year and week from the vehicle serial number.

7.7. Select *Information, Software Version* and verify the value is 13 or higher. If not, contact a Club Car Technical Representative.

7.8. Place the Run/Tow switch in the TOW position for 30 seconds. Then return it to RUN.

8. Inspect the vehicle for proper operation.

⚠ WARNING

- **Make sure that the vehicle operates in the forward direction when the Forward/Neutral/Reverse switch is in the FORWARD position.**
- **Make sure that the vehicle operates in the reverse direction when the Forward/Neutral/Reverse switch is in the REVERSE position. The multi-purpose buzzer will sound as a warning when the Forward/Neutral/Reverse switch is in REVERSE.**
- **Make sure that the vehicle does not operate when the Forward/Neutral/Reverse switch is in the NEUTRAL position.**

SOLENOID

See General Warnings on page 1-2.

The solenoid is located on the rear side of the electronics module.

Lifted vehicles use a larger solenoid.

TESTING THE SOLENOID

See Test Procedure 20 – Solenoid Activating Coil on page 12-59 and Test Procedure 8 – Horn Switch on page 12-38.

SOLENOID REMOVAL

1. Disconnect the batteries and discharge the controller (1). **See Disconnect the Batteries – Electric Vehicles on page 1-4.**

2. Remove the electronics module cover (8) to access the solenoid (4). **See Controller Shield Removal on page 13-4.**
3. Disconnect the heavy gauge wires from the solenoid (4) by removing the nuts (7) and washers (10) **(Figure 20-11, Page 20-11)**.
4. Disconnect the spade connectors from the solenoid (4).
5. Slide solenoid (4) up to disengage the mounting tabs and remove from mounting plate.

SOLENOID INSTALLATION

1. Slide solenoid (4) into mounting plate **(Figure 20-11, Page 20-11)**.
2. With resistor (11) in place as shown, connect the four wires to the appropriate solenoid terminals. **See Fuse and Relay Locations on page 12-5.** Tighten the nuts (7) that secure the heavy-gauge yellow and red wires to 72 to 84 lb·in (8 to 9.5 N·m).
3. Return electronics module cover (8) to its original location. **See Controller Shield Installation on page 13-4.**
4. Place the Run/Tow switch in the TOW position and connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**

CHARGER RECEPTACLE

See General Warnings on page 1-2.

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

See Test Procedure 25 – Voltage at Charger Receptacle Red Wire Socket on page 12-65.

See also the appropriate battery charger maintenance and service manual.

CHARGER RECEPTACLE INSPECTION

Inspect the receptacle for cracks, loose connections and frayed wiring.

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 on page 1-4.**
2. Remove kick plate. **See Kick Plate and Charger Receptacle Bezel – Electric Vehicles on page 4-20.**
3. Remove the 10-gauge red wire from the solenoid.
4. Disconnect the 10-gauge black wire from the controller B- terminal.
5. Disconnect the light blue wire from main harness at the bullet connector.
6. Remove the three screws (1) that secure the charger receptacle (2) to the bucket.

CHARGER RECEPTACLE INSTALLATION

1. Insert the wires through the hole in the bucket.
2. Insert receptacle (2) into bucket.
3. Install the three screws (1) that secure the receptacle to the bucket. Tighten screws to 16 lb·in (1.8 N·m).
4. Connect 10-gauge red wire to solenoid. Tighten nut 72 to 84 lb·in (8 to 9.5 N·m).
5. Connect 10-gauge black wire to controller B- terminal. Tighten bolt to 108 lb·in (12.2 N·m).
6. Connect light blue wire to main harness at bullet connector with light blue wire.
7. Install kick plate. **See Kick Plate and Charger Receptacle Bezel – Electric Vehicles on page 4-20.**
8. Place the Run/Tow switch in the TOW position and connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**

Pagination Page

SECTION 21 — DC ELECTRIC VEHICLE - BATTERIES 21

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

⚠ 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 14-11.**

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.

Non-lifted vehicles have 6-gauge battery cables.

Lifted vehicles have 4-gauge battery cables.

BATTERY TESTING BASICS – 8 VOLT

See General Warnings on page 1-2.

OBSERVATION

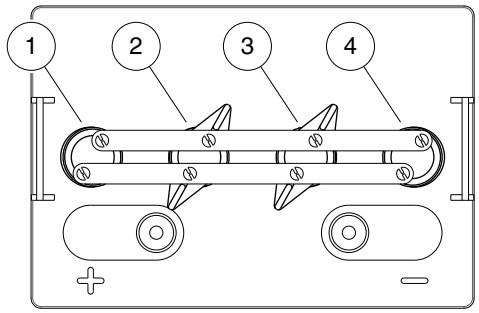
Inspect the battery compartment for the following items:

- 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 21-1 Battery Cell Numbering – 8 Volt

BATTERY TESTING – 8 VOLT

See General Warnings on page 1-2.

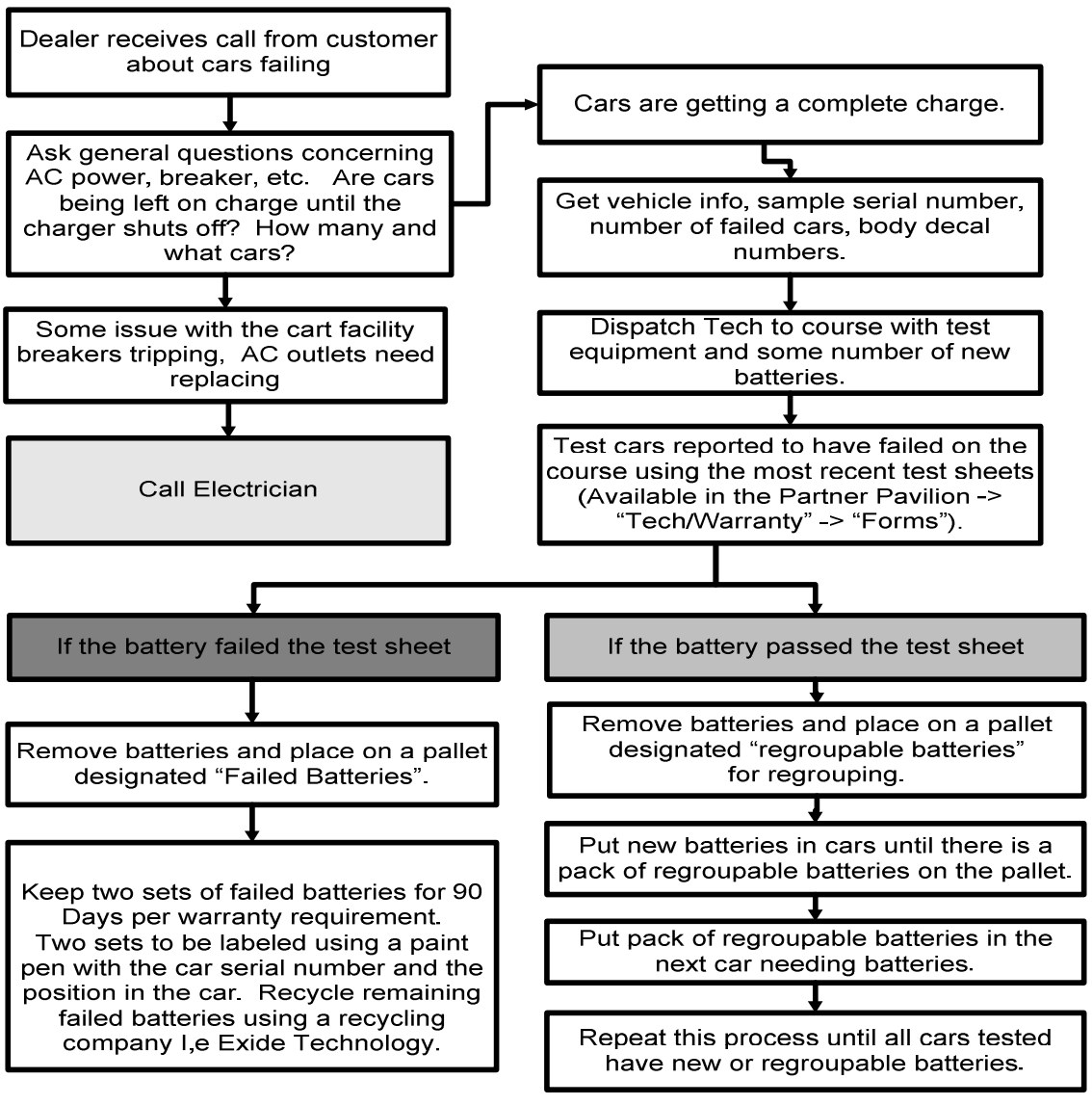
Test procedures not available at time of publication. Refer to any Bulletin that is released concerning testing for Model Year 2015.

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.**

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Figure 21-2 Battery Regrouping Process Flow

BATTERY REPLACEMENT

See General Warnings on page 1-2.

⚠ 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 1-4.** 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 14-8.**
6. Install regrouped or new batteries in the proper orientation . 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 lb·in (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 1-2.

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 Method

- **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.

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
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

TABLE CONTINUED ON NEXT PAGE

IMPURITY	ALLOWABLE CONTENT (PARTS PER MILLION)	EFFECTS OF IMPURITY
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

BATTERY CARE – VEHICLES EQUIPPED WITH THE OPTIONAL 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. For 8-volt batteries, tighten hold-down retaining nuts to 106 lb·in (12 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 could 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 14-13. See Watering Batteries with the SPWS on page 14-15.**

CAUTION

- **The watering interval must adequately maintain the electrolyte level above the top of the plates. See (Figure 21-3, Page 21-9).**

- **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 equipped with the Single-Point Watering System (SPWS), 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 10-4.** 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. 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. For 8-volt batteries, tighten hold-down retaining nuts to 106 lb·in (12 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 could 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).

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 14-15.**

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.**

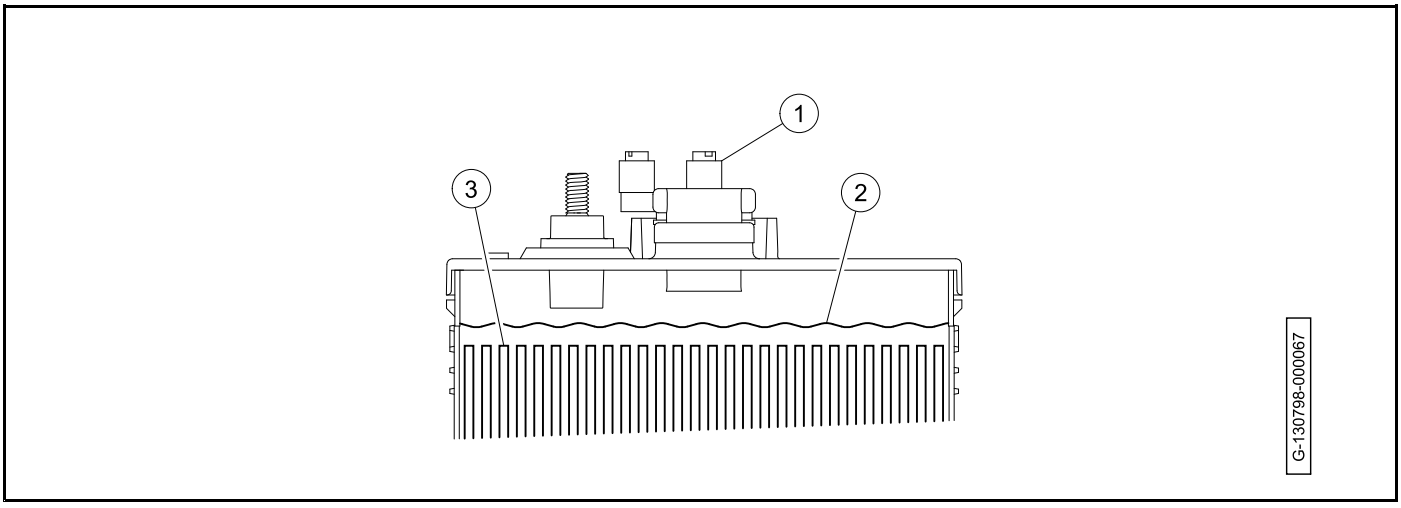


Figure 21-3 Electrolyte Level

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 21-3, Page 21-9)**. 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 14-10.** 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 14-10.**

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 14-11. 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 14-11.***

WATERING BATTERIES WITH THE SPWS

Refer to the instructions included with the hand pump kit.

BATTERY STORAGE

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.

Pagination Page

SECTION 22 — DC ELECTRIC VEHICLE - BATTERY CHARGER 22

See General Warnings on page 1-2.

⚠ 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.**
- **Modern Carbon Monoxide (CO) detectors come equipped with sensors that can detect and alert at gas levels below 2%. Make sure proper ventilation is used when charging batteries.**

⚠ 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.**
- **Each charger should have its own dedicated 15 or 20 ampere separately protected (circuit breaker or fuse) single phase branch circuit, in accordance with all applicable electrical codes for the location.**

CAUTION

- **Study all general information and DANGER, WARNING, CAUTION, and NOTE statements in the Battery Charger section.**
- **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.**
- **Before charging batteries, turn off all accessories on the vehicle.**
- **If using an onboard charger, be sure the AC plug is unplugged from the outlet before attempting to drive the vehicle.**
- **Be sure the AC cord is properly wound up on the reel before driving the vehicle.**

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.

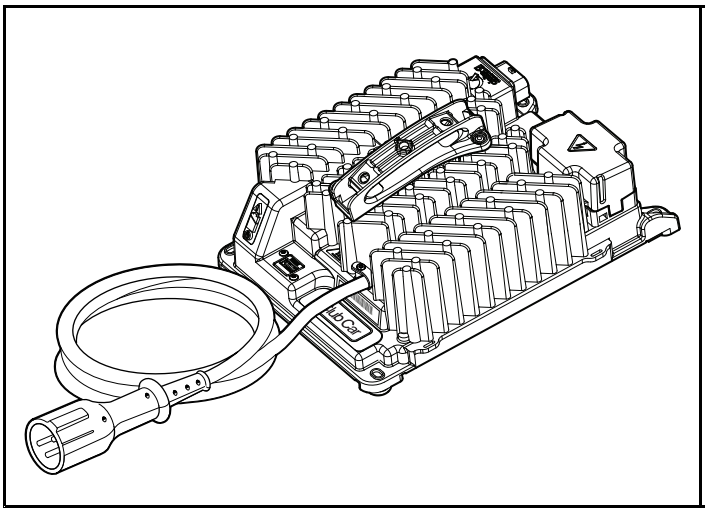
CAUTION

- **Study all general information and DANGER, WARNING, CAUTION, and NOTE statements in the Battery Charger section.**

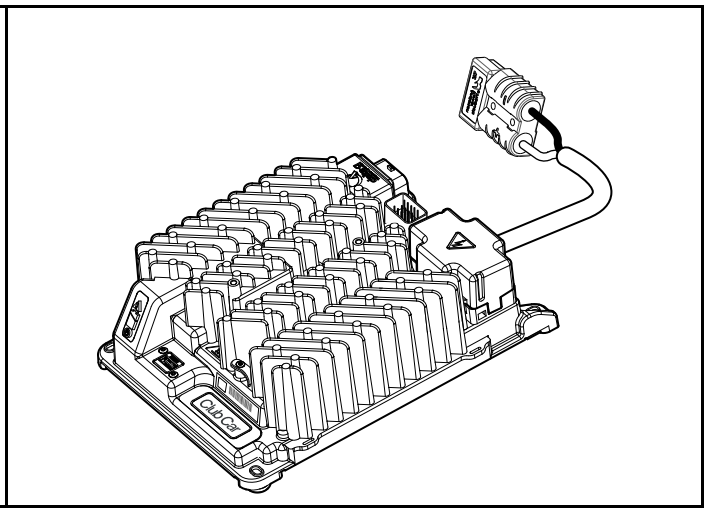
This section includes information, troubleshooting and service procedures pertaining to the external high-frequency battery charger (model number IC0650-048-CC) and onboard high-frequency battery charger (model number IC0650-048-COMM). Do not attempt to service a battery charger that has not been properly identified. If a charger cannot be properly identified, contact your local Club Car dealer or distributor.

How To Identify The Type Of High-Frequency Charger

- Vehicles that use the external (shelf), high-frequency battery charger can be easily identified by the charger DC cord receptacle in the kick plate.
- Vehicles that use the onboard, high-frequency battery charger can be easily identified by the battery charger and cord reel located on the underside of the rear-facing seat bottom and no charger DC cord receptacle in the kick plate.



COV-1481
Figure 22-1 High-Frequency Battery Charger – External



COV-1482
Figure 22-2 High-Frequency Battery Charger – Onboard

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.

ERIC IC650 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

TABLE CONTINUED ON NEXT PAGE

E.R.I.C. BATTERY CHARGER SPECIFICATIONS	
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) - Shelf Mount	6 ft (183 cm)
DC cord length (standard length) - Shelf Mount	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.	•

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 22-24.**

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%.

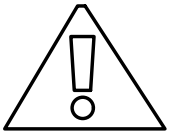
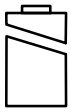
Charging Confirmation

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

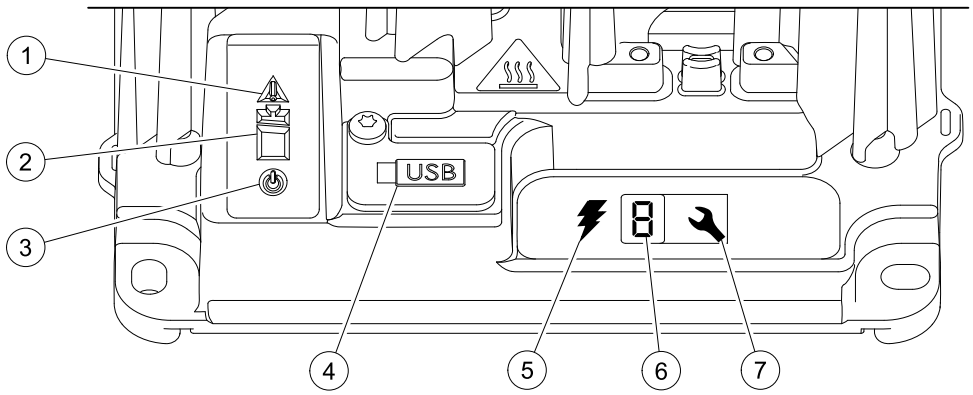
NOTE: *The number of flashes and beeps can vary depending on the Beep Option setting.* ***See Beep Option, Section 18, Page 18-8.***

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.
		Solid green	Charging is complete. Battery pack is fully charged.
		Solid green	
		Flashing green	Charging is in progress. Battery pack has reached a high state of charge.
		Solid green	
		Off	Charging is in progress. Battery pack has NOT reached a high state of charge.
		Flashing green	
	Solid blue		AC power to charger is present.

ONBOARD BATTERY CHARGER INTERFACE



(1) Error/Fault Indicator
(2) Battery Charging Indicator
(3) AC Power Indicator
(4) USB Receptacle
(5) Charging Output Indicator
(6) Display Panel
(7) Select Charge Profile button

Figure 22-3 Battery Charger Interface

ONBOARD CHARGER STATUS INDICATORS

The indicator lights on the onboard charger provides information concerning charger status.

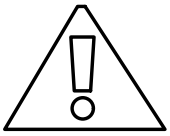
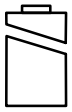
LIGHT	STATUS	STATUS EXPLANATION
 G-130892-000001	Solid red	Charger fault. See the display panel for details.
	Flashing orange	External error condition - caution. See the display panel for details.
	Flashing green	USB port is active.
	Solid green	Safe to remove the USB flash drive.

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.

EXTERNAL CHARGER MOUNTING

⚠ WARNING

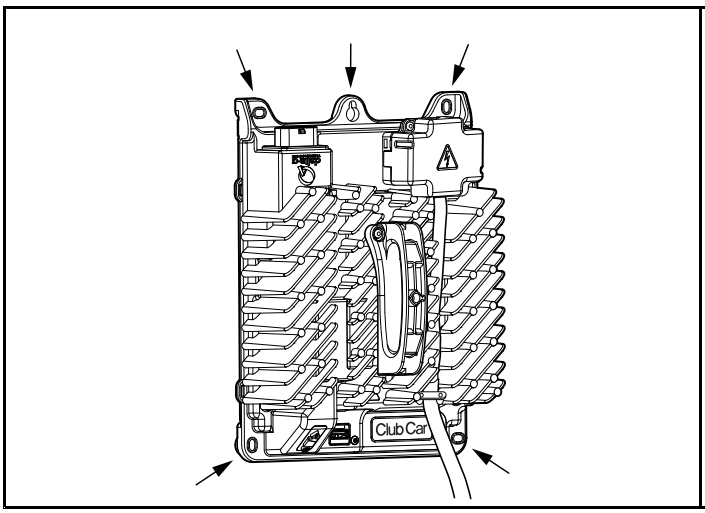
- **Make sure the charger is securely mounted. Do not hang the charger by its handle.**
- **Place all cords so they will not be stepped on, tripped over, or otherwise subjected to damage or stress.**

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.**

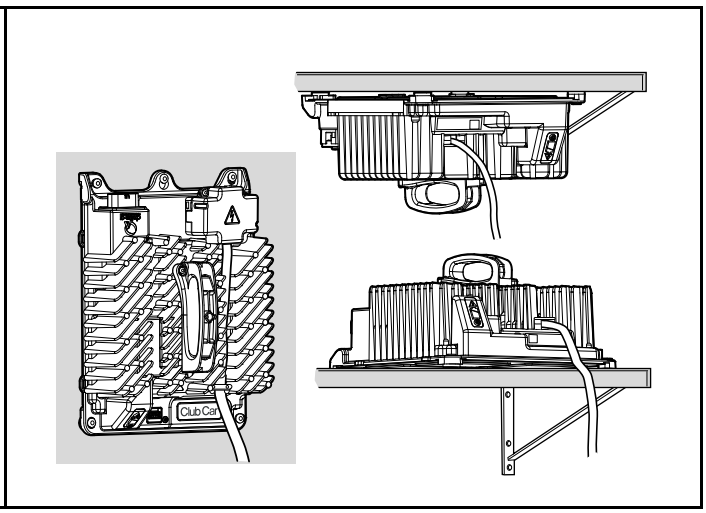
Use the mounting holes to secure the charger **(Figure 15-3)**. Position the charger so that is has adequate ventilation and the charger status indicator panel is visible. The charger can be mounted in any orientation (right-side up, upside down, etc.) provided the cooling fins are unobstructed it has adequate ventilation **(Figure 15-4)**.

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 15-9.**



2674

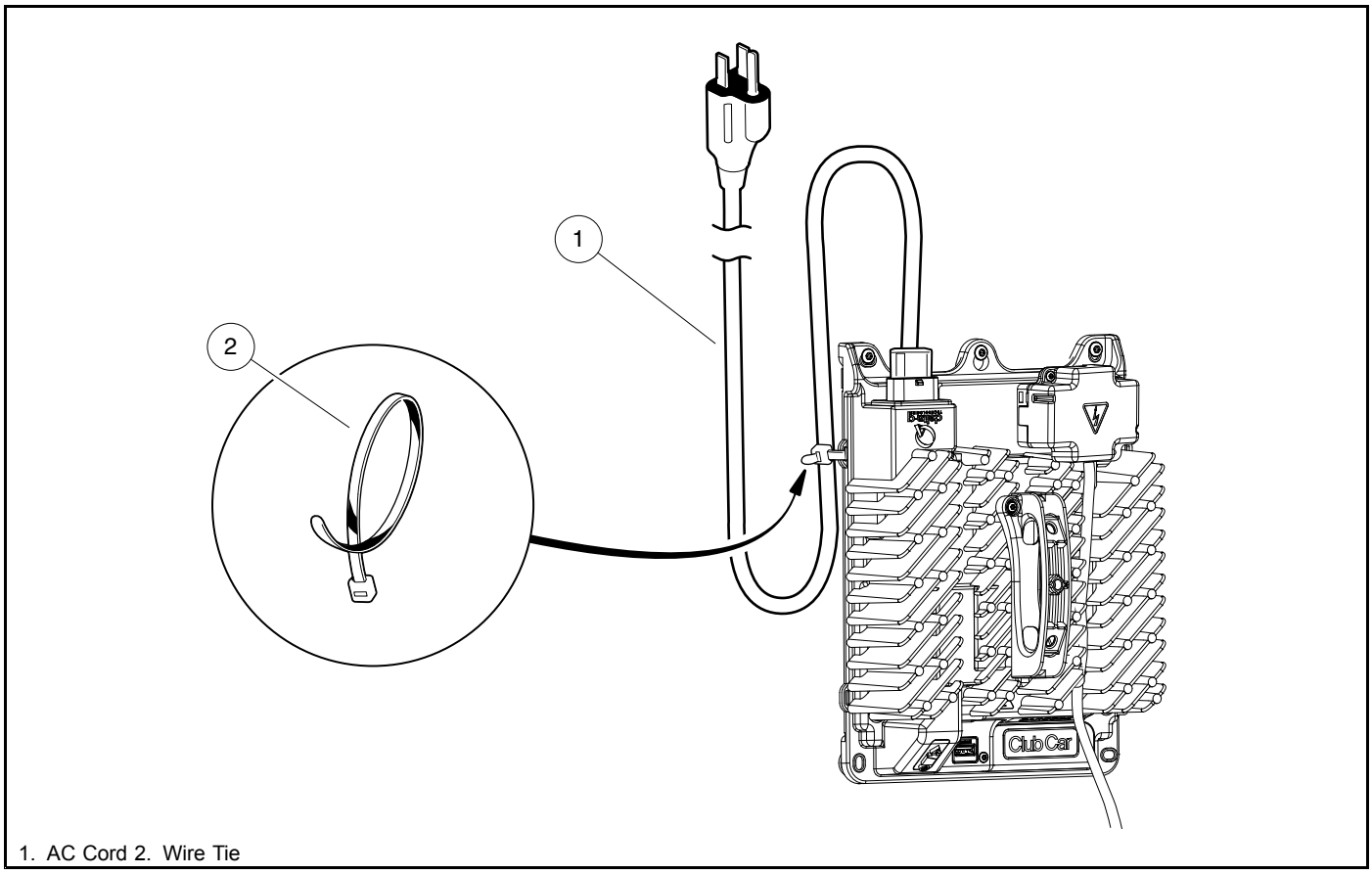
Figure 22-4 Charger Mounting Holes



2675

Figure 22-5 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 22-6, Page 22-10)**.



1. AC Cord 2. Wire Tie

2758

Figure 22-6 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.**
- **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.

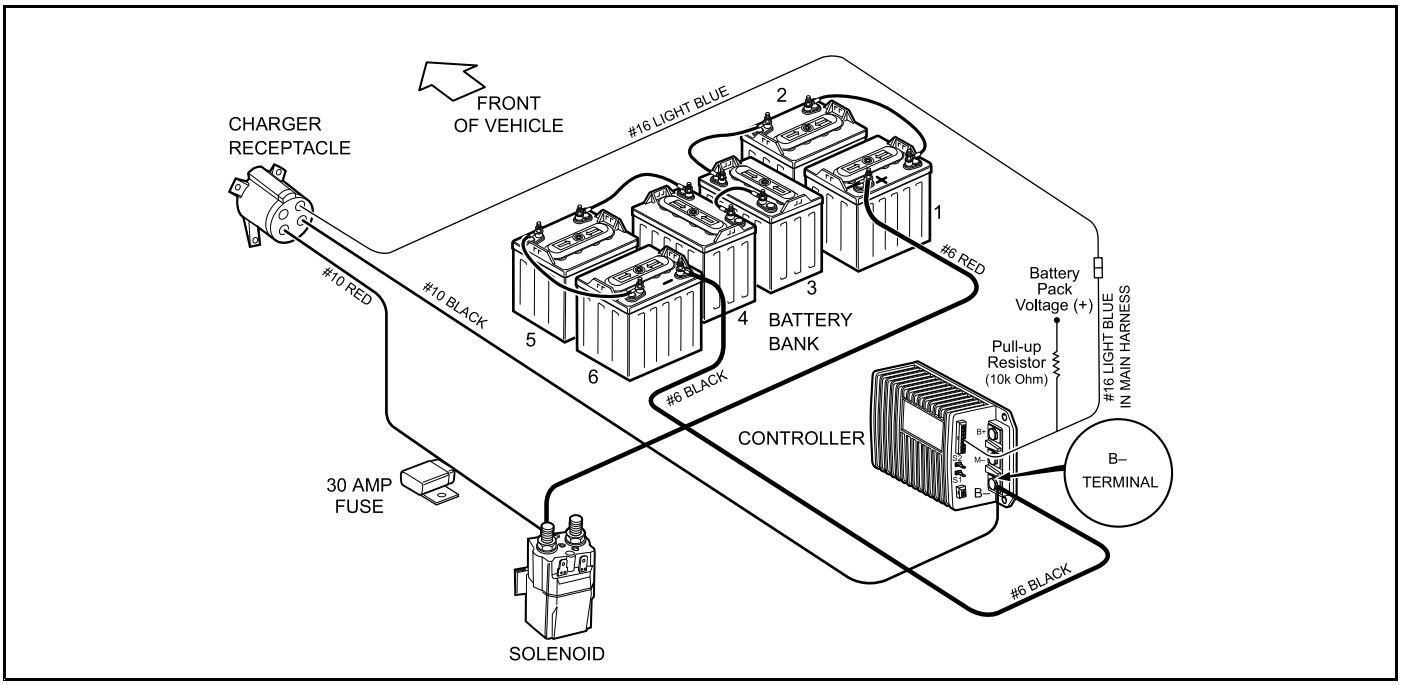
The use of an extension cord with the charger should be avoided. If one must be used, heed the following WARNING.

⚠ 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

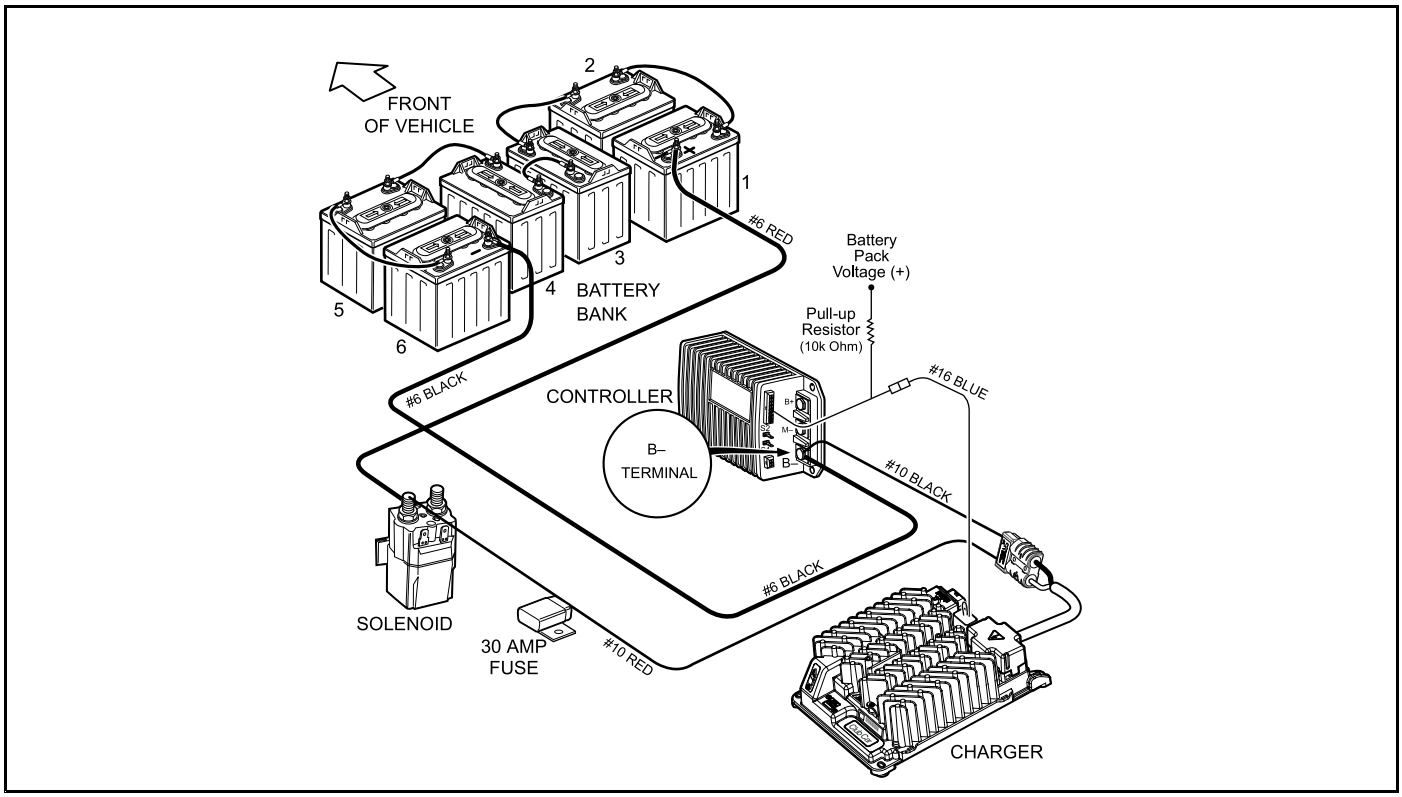
External Charger: The charge circuit consists of the charger receptacle, interlock wire, controller, solenoid and battery pack **(Figure 22-7, Page 22-11)**.



2788

Figure 22-7 Charge Circuit – External High-Frequency Charger

Onboard Charger: The charge circuit consists of the charger receptacle, interlock wire, controller, solenoid and battery pack **(Figure 22-8, Page 22-12)**.



2789

Figure 22-8 Charge Circuit – Onboard High-Frequency Charger

CHARGER OPERATION

CHARGING BATTERIES

See Dangers and Warnings beginning on page 15-1.

⚠ WARNING

- **Be sure all wire connections at the receptacle are clean and tight.**
- **Do not rock or bend the plug. To connect the charger plug to the vehicle receptacle, grasp the plug handle and push the plug straight into the receptacle (Figure 22-9, Page 22-14).**
- **Do not pull on the DC cord (Figure 22-10, Page 22-14). Do not twist, rock or bend the plug. To disconnect the charger plug from the vehicle receptacle, grasp the plug by the handle and pull the plug straight out of the receptacle.**

WARNING CONTINUED ON NEXT PAGE

⚠ WARNING

- **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: *Unlike the PowerDrive family of chargers, battery pack voltage does not have to be above 32 volts for charging to begin.*

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 (10 minutes of operation).

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.

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.

Battery Charging Procedure

1. **External Chargers:** With the charger DC cord disconnected from the vehicle charger receptacle, insert the charger AC plug into a dedicated and properly wired AC outlet. Connect a maximum of two chargers per dedicated circuit.

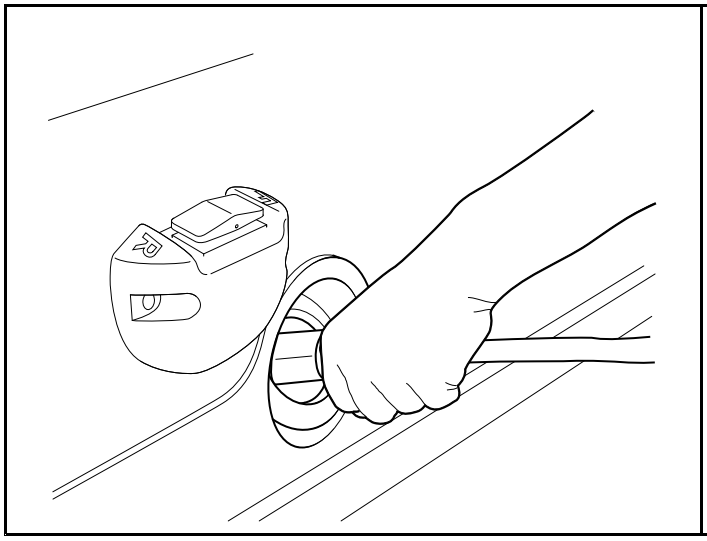
   Onboard Chargers: Insert the onboard charger AC plug into a dedicated and properly wired AC outlet to begin a charge cycle. Connect a maximum of two chargers per dedicated circuit.

2. **External Chargers:** Insert the charger DC cord plug into the vehicle receptacle to begin a charge cycle. When inserting the plug, align the raised guide on the plug with the guide slot in the receptacle and push straight in slowly **(Figure 22-9, Page 22-14)**.
3. **External Chargers:** The charger will turn on two to five seconds later, after the charger interlock function activates. The charger interlock remains activated and prevents operation of the vehicle until the DC cord is disconnected from the vehicle. **See following NOTE.**

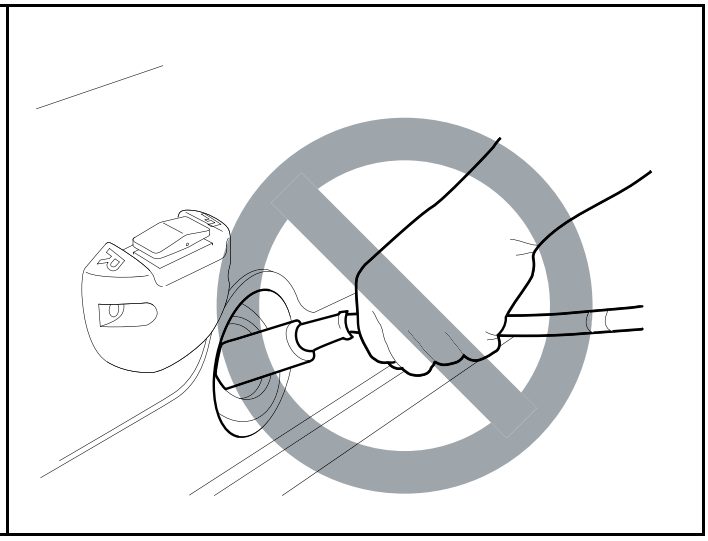
   Onboard Chargers: The charger will turn on two to five seconds later, after the charger interlock function activates. The charger interlock remains activated and prevents operation of the vehicle until the AC cord is disconnected from the AC outlet. **See following NOTE.**

NOTE: *The dash-mounted charge indicator light will flash three times and the multi-purpose buzzer simultaneously will sound three times to indicate charging has begun. The number of flashes and beeps can vary depending on the Beep Option setting.* ***See Beep Option, Section 18, Page 18-8.***

4. The charger monitors battery voltage, charge current and charge time to determine when the batteries are properly charged. The charger will shut off by itself and the entire battery-shaped green light will stop flashing and remain on. As long as the charger is allowed to shut off by itself, the batteries will be fully charged. Overcharging and undercharging will normally be prevented.
5. If the charger does not seem to be operating properly, or if the batteries seem weak, see Battery Charger Troubleshooting on page 15-28. If troubleshooting does not solve the issue, contact your local Club Car distributor/dealer.



66
Figure 22-9 Correct Insertion of External Charger DC Plug



67
Figure 22-10 Incorrect Removal of External Charger DC Plug

HOW TO CHANGE THE ALGORITHM

1. Disconnect the AC cord from the battery charger. Wait 30 seconds.
2. Push and hold the Select Charge Profile button (1) **(Figure 15-8, Page 15-15)**.

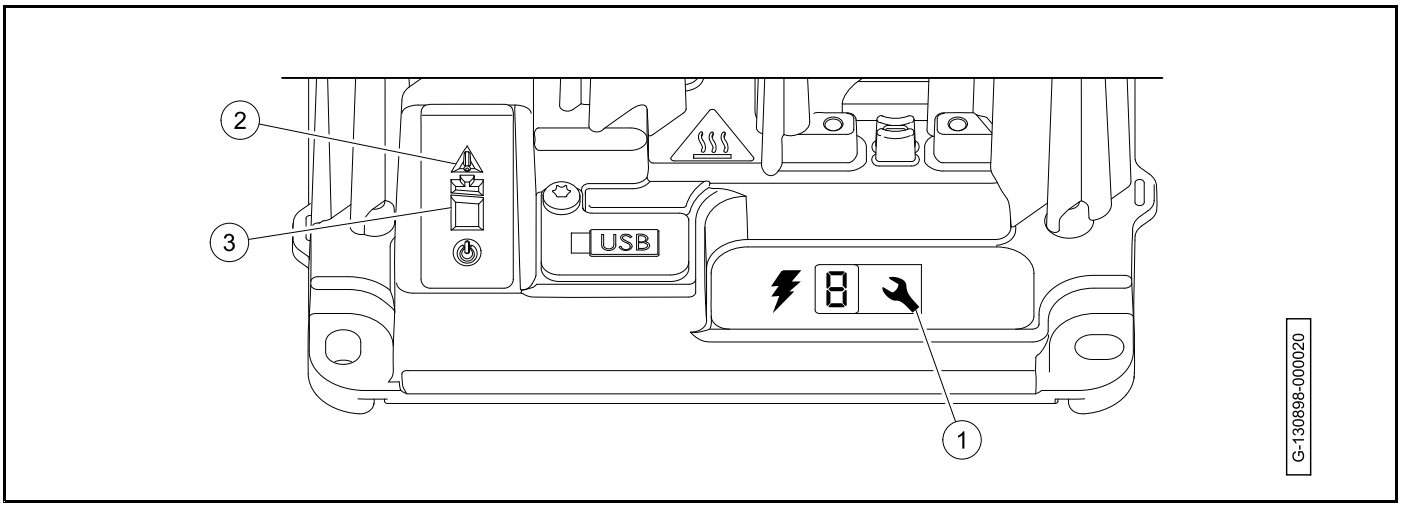


Figure 22-11 Algorithm Change

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 22 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-0-1-1 for Profile 11).*

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.

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 15-11)**.

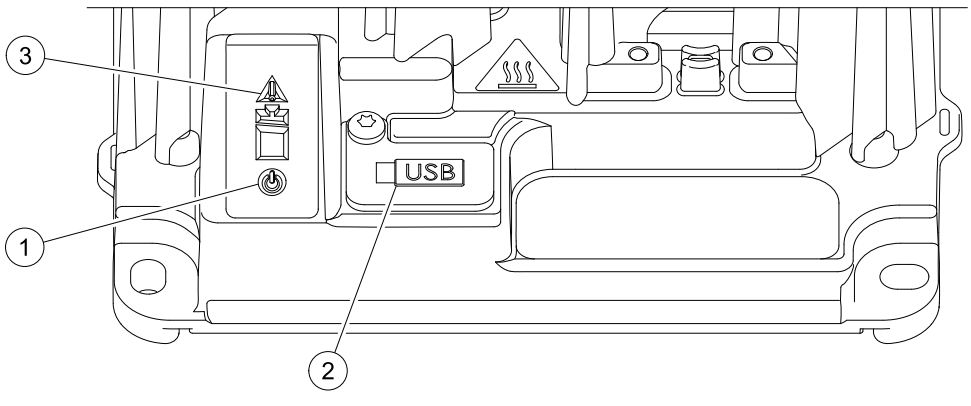
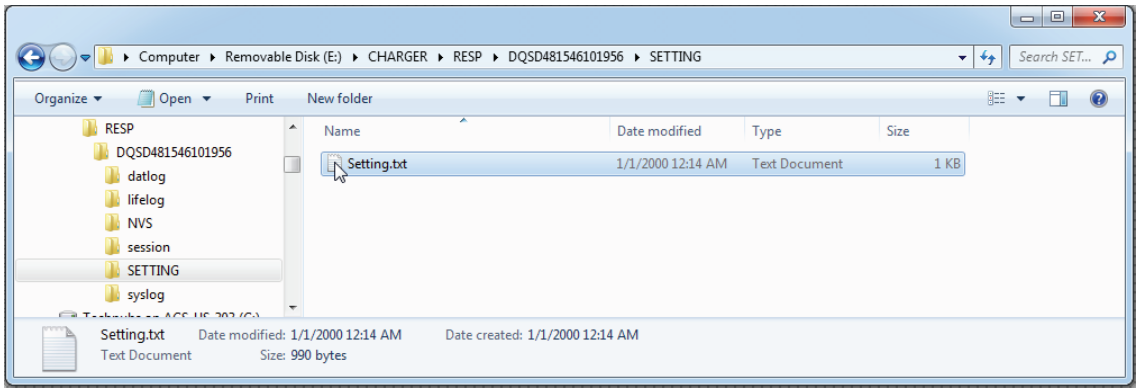


Figure 22-12 USB Dust Cover

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.

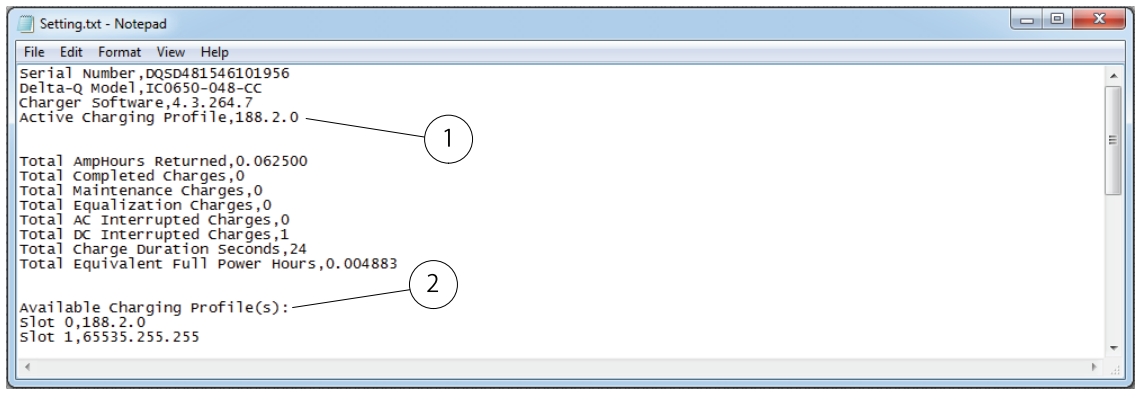
12. Go to CHARGER/RESP/Battery charger serial number/SETTING **(Figure 15-12)**.



G-130898-000051

Figure 22-13 Setting.txt File Location

13. Open the Setting.txt file **(Figure 15-13)**.



G-130898-000052

Figure 22-14 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

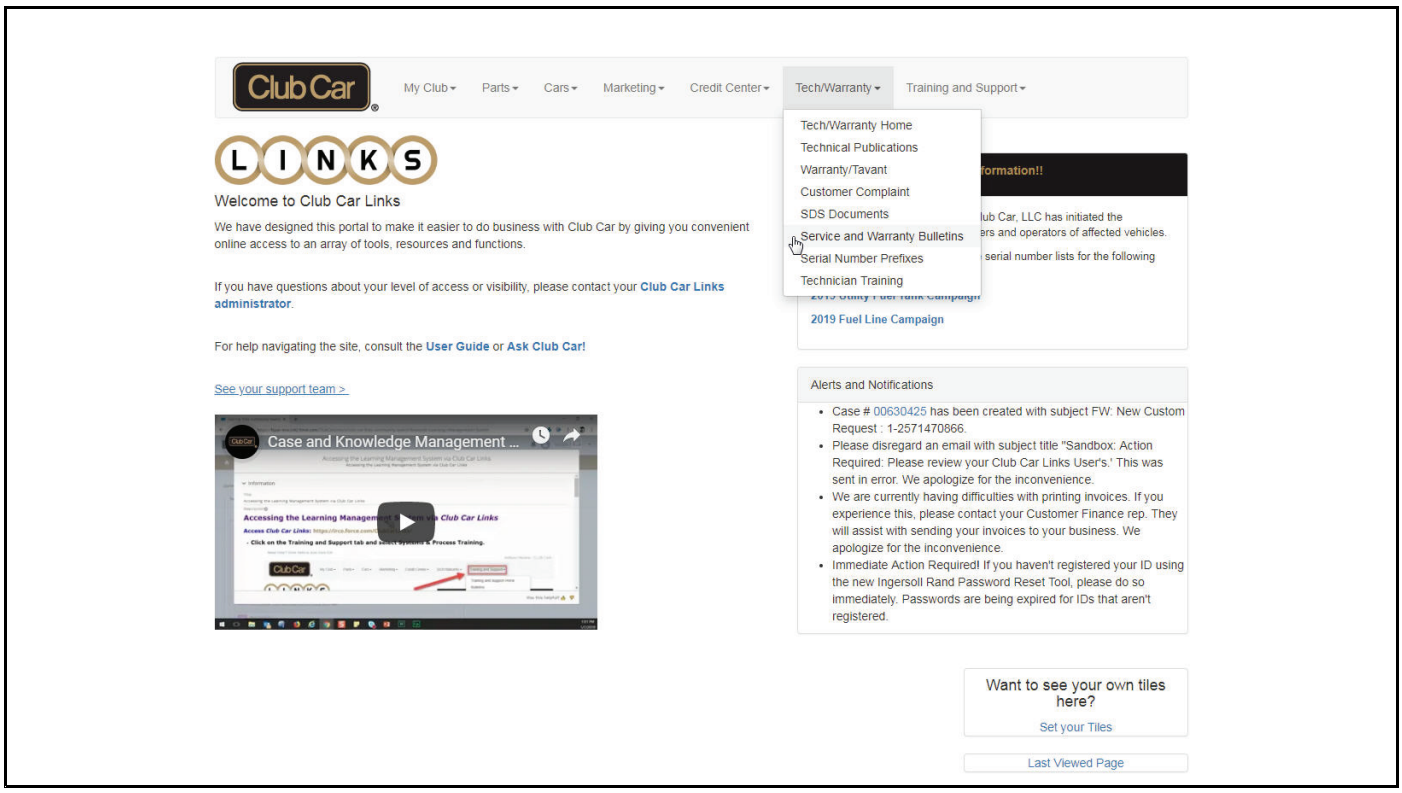
How To Install Trojan Algorithm - External Battery Charger

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 15-14)**.

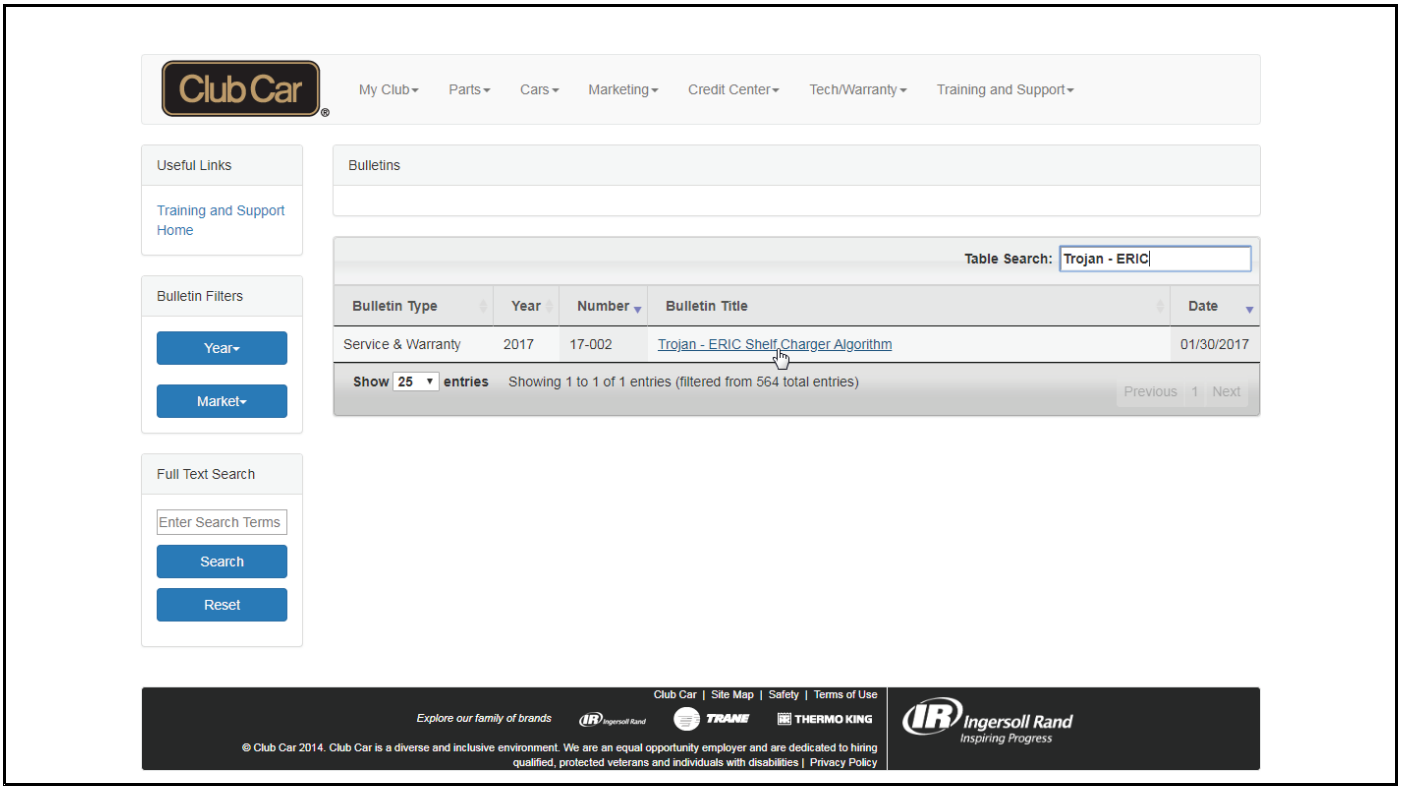


G-130898-000050

Figure 22-15 Service and Warranty Bulletins

4. Find the Trojan - ERIC Shelf Charger Algorithm.

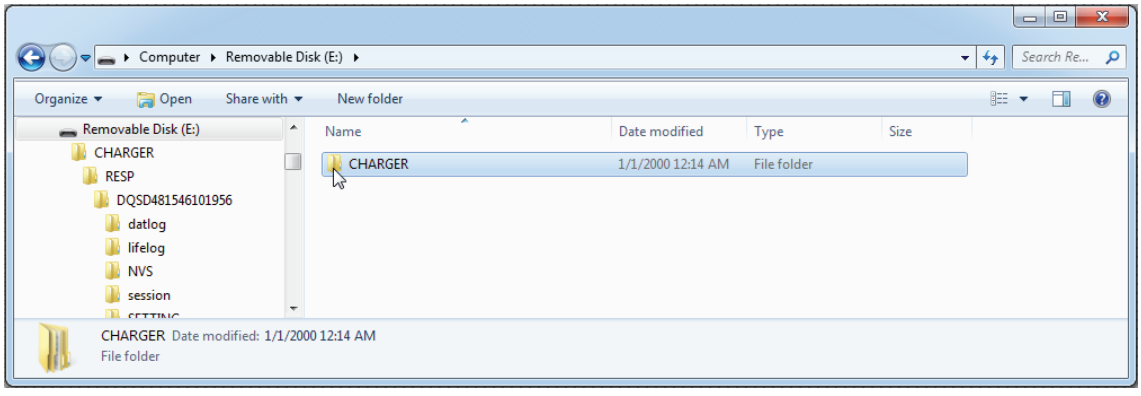
5. Click on the Trojan - ERIC Shelf Charger Algorithm link **(Figure 15-15)**.



G-130898-000053

Figure 22-16 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 15-16)**.



G-130898-000049

Figure 22-17 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 15-17)**.

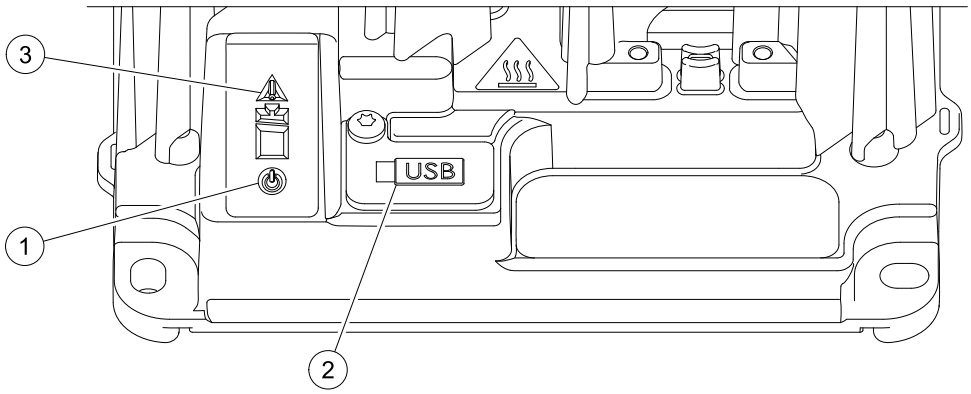


Figure 22-18 USB Dust Cover

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 15-8, Page 15-15)**.

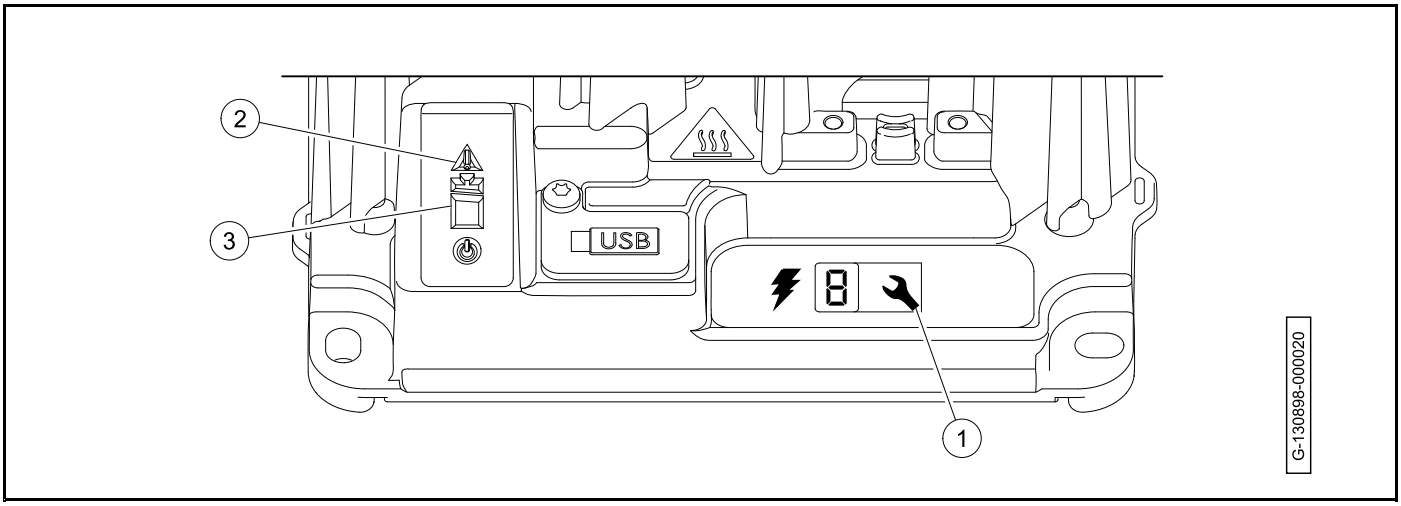


Figure 22-19 Algorithm Change

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 15-8, Page 15-15)**.

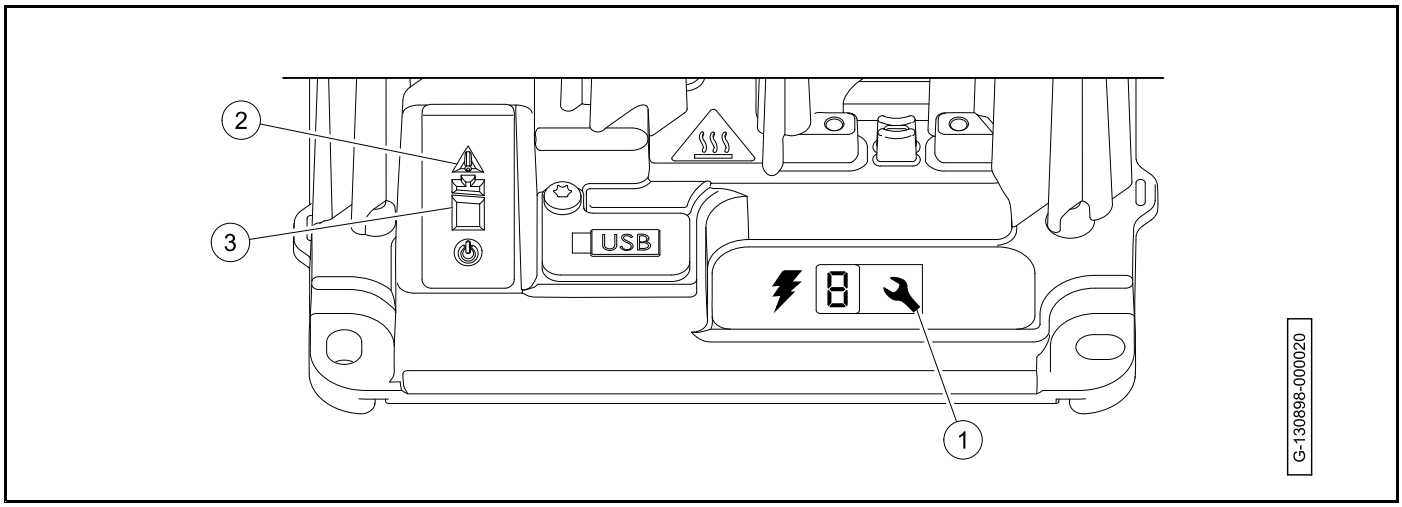


Figure 22-20 Algorithm Change

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 15-17)**.

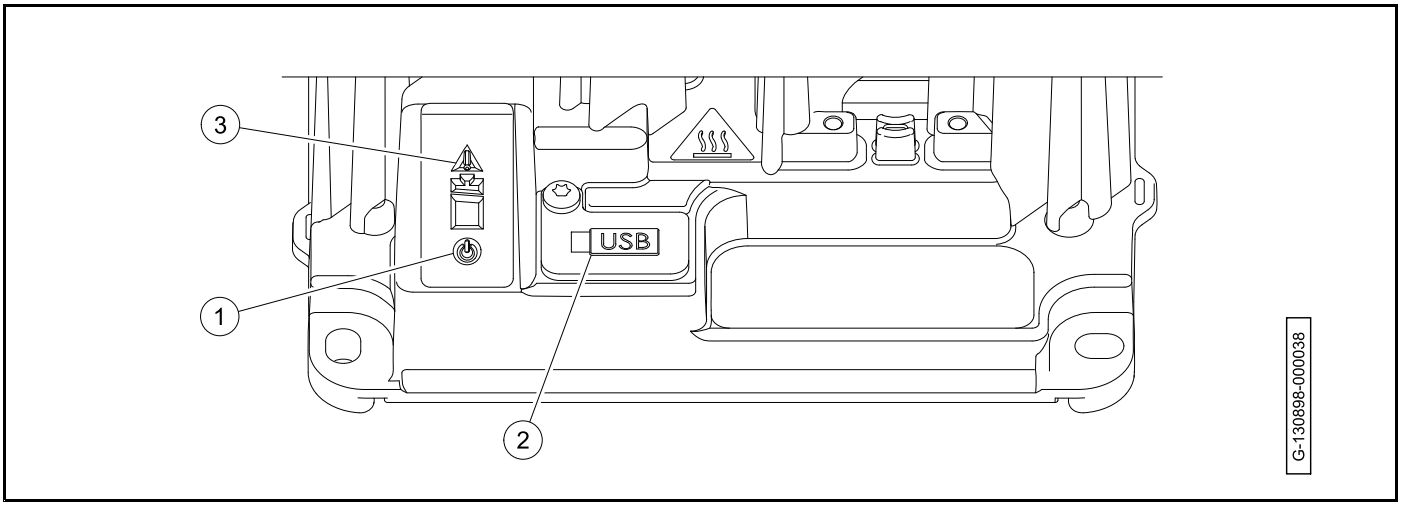


Figure 22-21 USB Dust Cover

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 1-2.

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 Vehicle Maintenance on page 10-1.

To perform all troubleshooting, see Battery Charger Troubleshooting on page 15-28.

To perform all repairs, see or .

⚠ 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 1-2.

⚠ 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 22-11.**
- **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.**
- **Prior to servicing the onboard charger, disconnect the AC power supply cord from the wall outlet and remove the battery charger from the vehicle.**

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 15-6.** 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 15-6.** 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:

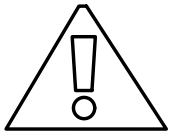
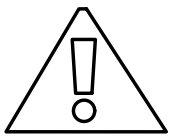
1. Unplug the AC cord from the AC power source.
2. Disconnect the DC cord under the rear-facing seat.
3. Wait for the red light to go off, wait 30 seconds, then plug the AC cord into the AC power source.
4. When the blue AC status indicator light comes on, reconnect the DC cord under the rear-facing 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 Source on page 15-37.**
			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 Source on page 15-37.**
			5. Failed AC plug or cord	Replace cord. **See AC Power Source on page 15-37.**

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 Reset Power – External Charger on page 15-29.** 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 15-34.** If not, replace with correct battery set. Reset charger power. **See Reset Power – External Charger on page 15-29.**
			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 15-34.** If not, replace with correct battery set. Reset charger power. **See Reset Power – External Charger on page 15-29.**
			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 15-34.**
			5. Bad battery pack	Test battery pack health. Look for shorted or damaged cells. **See Battery Condition Using Charger on page 15-37. See also AC Electric Vehicle - Batteries on page 14-1.**
			6. AC voltage out-of-range	Test and inspect incoming AC power. **See AC Power Source on page 15-37.**
			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 15-35. See Charger DC Circuit Continuity Test on page 15-38.**
			10. Corroded or loose connections	Clean or tighten connections.
 G-130892-000001	Solid red	Charger error	1. Charger abnormality	Reset charger power. **See Reset Power – External Charger on page 15-29.** Reconnect DC cord to vehicle. If status goes away, proceed to charge again. **See Charger Output Test on page 15-38.** 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 1-2.

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 14-3.**
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 22-4.**
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 22-4.**
3. Check the wire connections from the charger receptacle.

3.1. Verify that the red wire from the charger receptacle is connected to the large post of solenoid with red wire from the battery post **(Figure 22-7, Page 22-11)**.

3.2. Verify that the black wire from the charger receptacle is connected to the B- terminal of controller.

3.3. Verify that the 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 wire and place the red (+) probe in the charger receptacle socket connected to the red 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 red wire of the charger receptacle harness.
   – Continuity of the red wire from the solenoid to the receptacle socket.
   – Continuity of the 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 15-6.**

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 — AC 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 volts 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 15-5.** 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 15-49.**
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 lb·in (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 15-39.**

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 18, Page 18-8.***

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

⚠ WARNING

- **Knowledge of battery charger wiring and component terminology is required before attempting any repair.**
- **Prior to servicing the charger, disconnect the DC cord from the vehicle charge receptacle and the AC cord from the AC outlet.**

NOTE: *This charger has no internal components 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.*

TERMINAL BLOCK COVER REMOVAL

1. Disconnect the DC cord from the vehicle charge receptacle.
2. Disconnect the AC cord from the AC power source.
3. Push in the mounting tabs (1) and remove the terminal block cover **(Figure 15-23, Page 15-39)**.

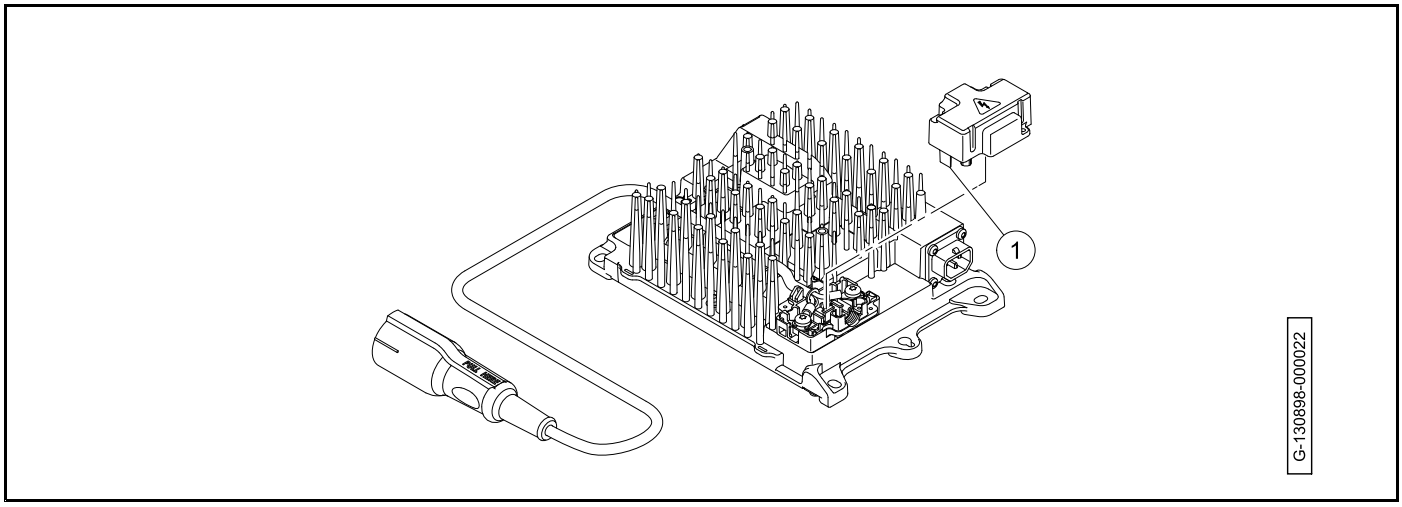


Figure 22-22 Terminal Block Cover

TERMINAL BLOCK COVER INSTALLATION

⚠ WARNING

- **The terminal block cover on the DC terminal block must be installed correctly to comply with UL code. This cover prevents water exposure and prevents a short across the DC terminals.**

1. Align the terminal block cover with the terminal block.
2. Push the terminal block cover until the mounting tabs (1) lock **(Figure 15-23, Page 15-39)**.

DC CORD REMOVAL

1. Disconnect the DC cord from the vehicle charge receptacle.
2. Disconnect the AC cord from the AC power source.
3. Remove the terminal block cover.
4. Remove the screws (1) **(Figure 15-24, Page 15-40)**.

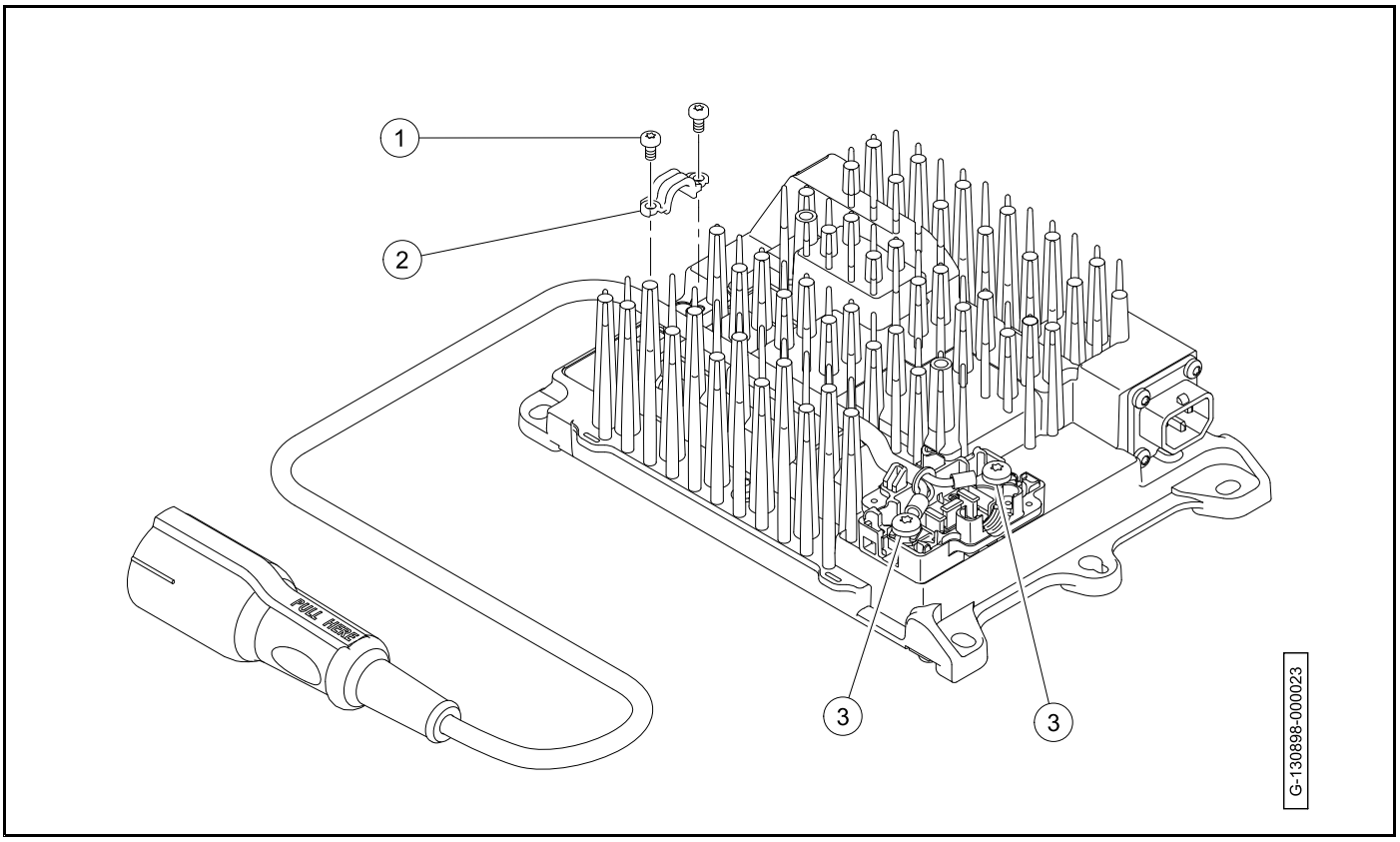


Figure 22-23 DC Cord

5. Remove the clamp (2).
6. Loosen the screws (3).
7. Pull the wires from DC terminals on battery charger.

DC CORD INSTALLATION

1. Attach the white DC cord wire to the positive (+) terminal (5) **(Figure 15-25, Page 15-41)**.

NOTE: *The positive symbol (+) and negative symbol (–) are molded into the terminal block.*

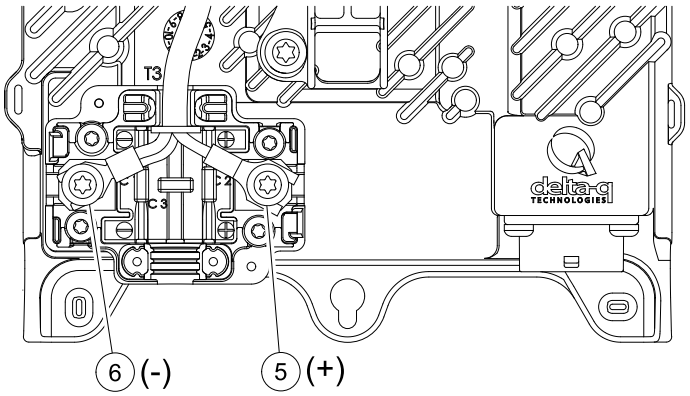


Figure 22-24 Wire Installation

2. Attach the black and green DC cord wires to the negative (-) terminal (6).
3. Tighten the screws (1) to 39.8 lb·in (4.5 N·m) **(Figure 15-26, Page 15-41)**.

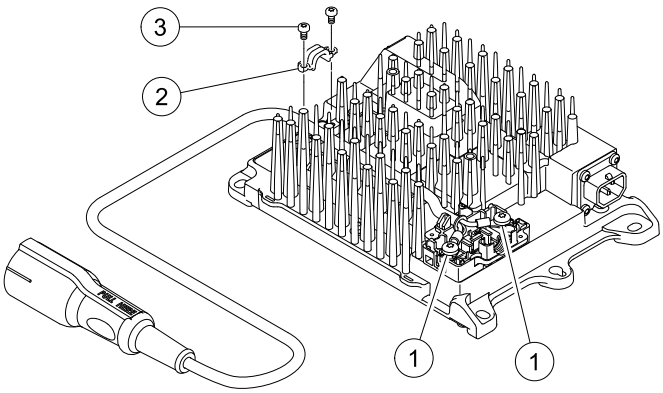


Figure 22-25 Clamp Installation

4. Install the terminal block cover.
5. Install the clamp (2).
6. Install the screws (3). Tighten the screws to 27.4 lb·in (3.1 N·m).

HANDLE REMOVAL

1. Remove the screws (1) **(Figure 15-27, Page 15-42)**.

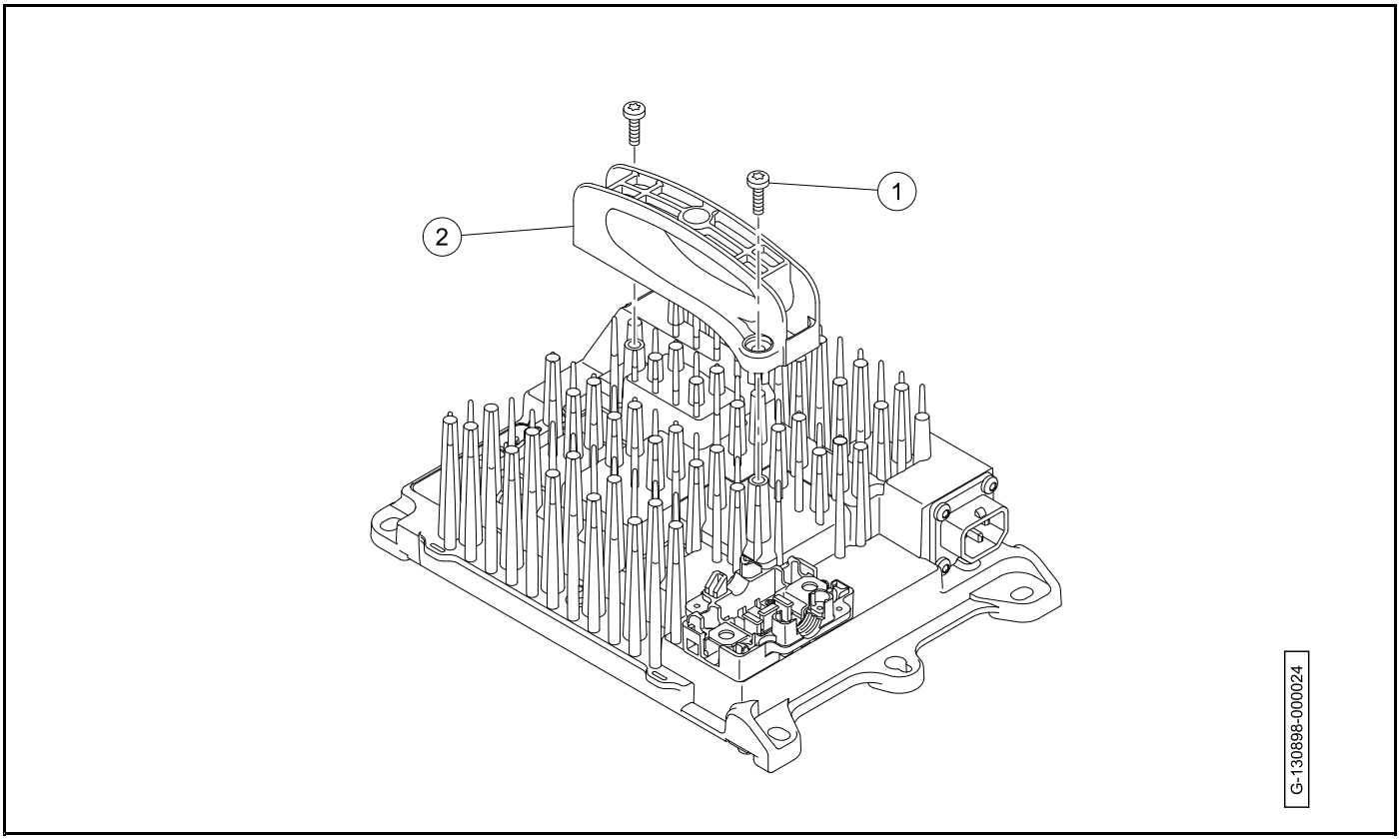


Figure 22-26 Handle

2. Remove the handle (2).

HANDLE INSTALLATION

1. Install the handle (2) on the battery charger **(Figure 15-27, Page 15-42)**.
2. Install the screws (1). Tighten the screws to 39.8 lb·in (4.5 N·m).

FOOT REMOVAL

1. Disconnect the DC cord from the vehicle charge receptacle.
2. Disconnect the AC cord from the AC power source.
3. If the battery charge is mounted, remove the battery charger.
4. Squeeze the barbs (1) on the foot (2) and push the foot out of charger mounting tab **(Figure 15-28, Page 15-43)**.

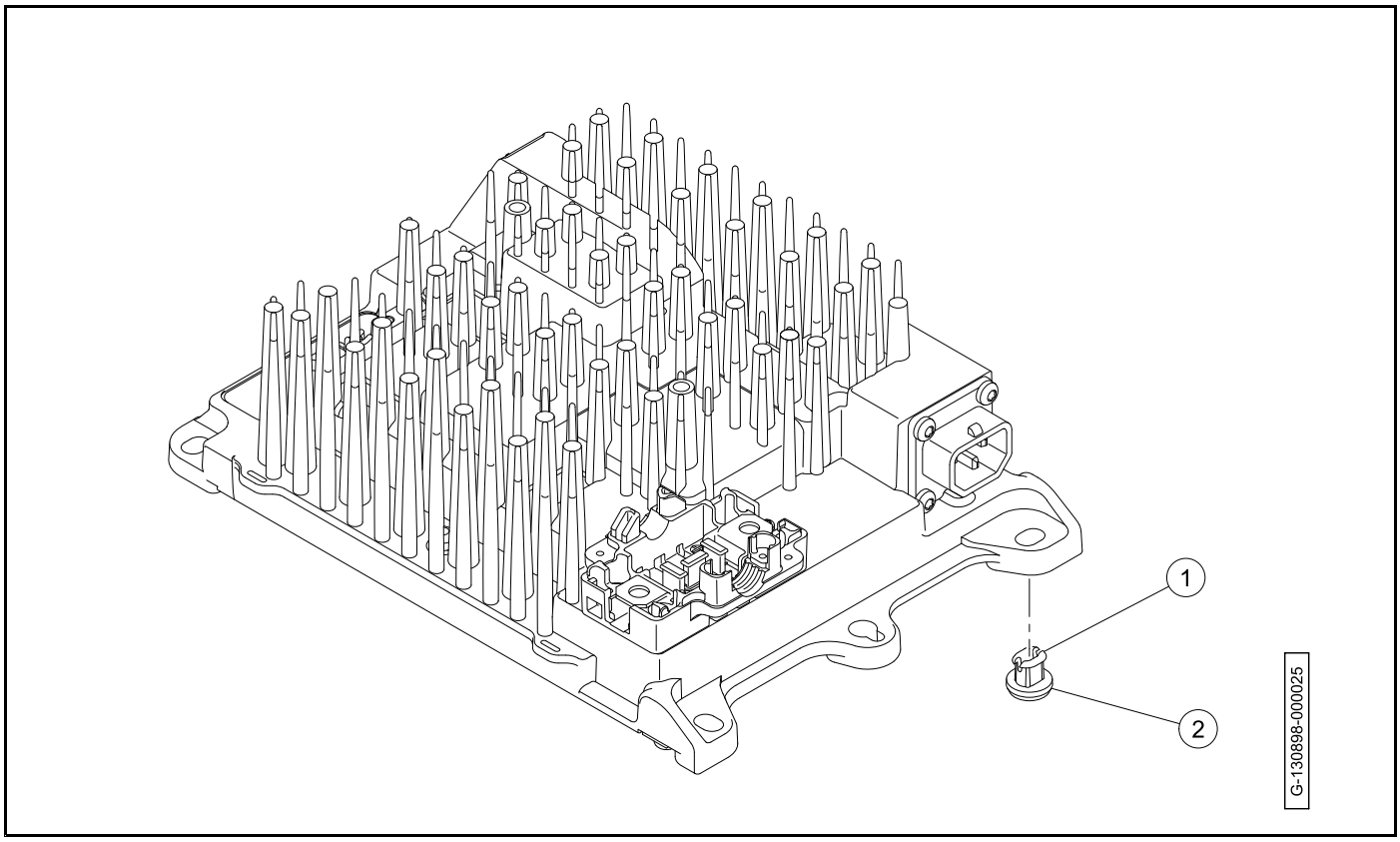


Figure 22-27 Foot

FOOT INSTALLATION

1. Push the foot (2) into hole in charger mounting tab until the barbs (1) come through and secure foot in place **(Figure 15-28, Page 15-43)**.
2. If required, mount the battery charger. **See External Battery Charger Mounting.**

ONBOARD CHARGER REPAIRS

⚠ WARNING

- **Knowledge of battery charger wiring and component terminology is required before attempting any repair.**
- **Prior to servicing the charger, disconnect the AC cord from the AC outlet.**

NOTE: *This charger has no internal components 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.*

TWO-PASSENGER ONBOARD CHARGER

Two-Passenger Onboard Charger Removal

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries.
4. Disconnect the AC cord from AC power source.
5. Disconnect the DC cord from the onboard charger harness (1) **(Figure 15-29, Page 15-44)**.

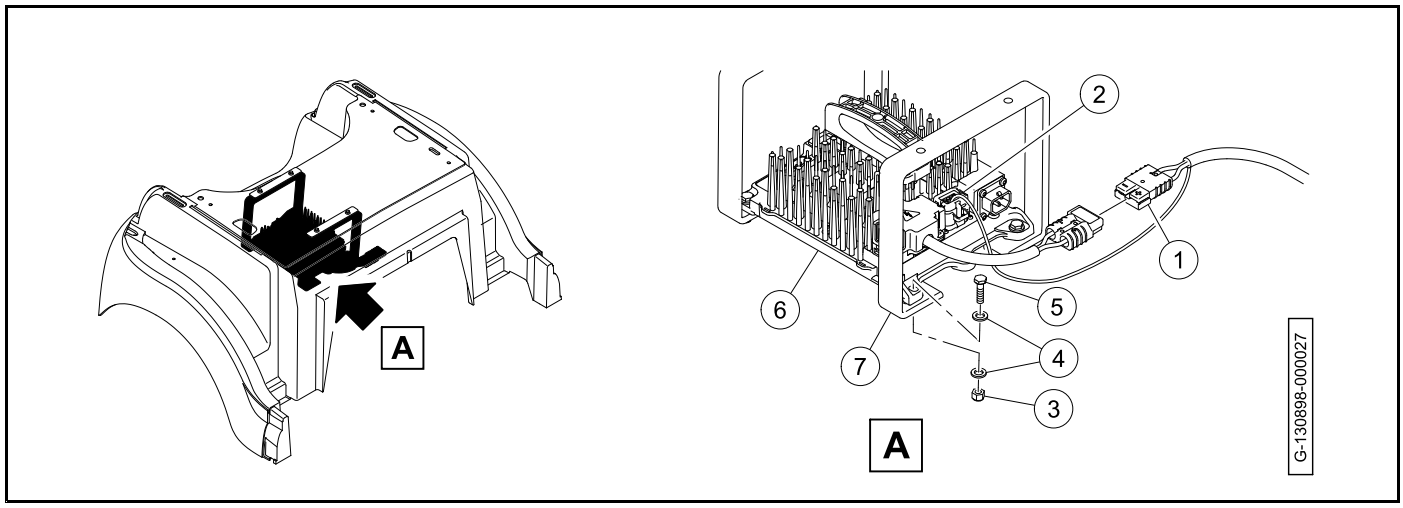


Figure 22-28 Onboard Charger

6. Disconnect the connector (2).
7. Remove the nuts (3), washers (4), and bolts (5).
8. Remove the onboard charger (6) from the bracket (7).

Two-Passenger Onboard Charger Installation

1. Connect the DC cord to the onboard charger harness (1) **(Figure 15-30)**.

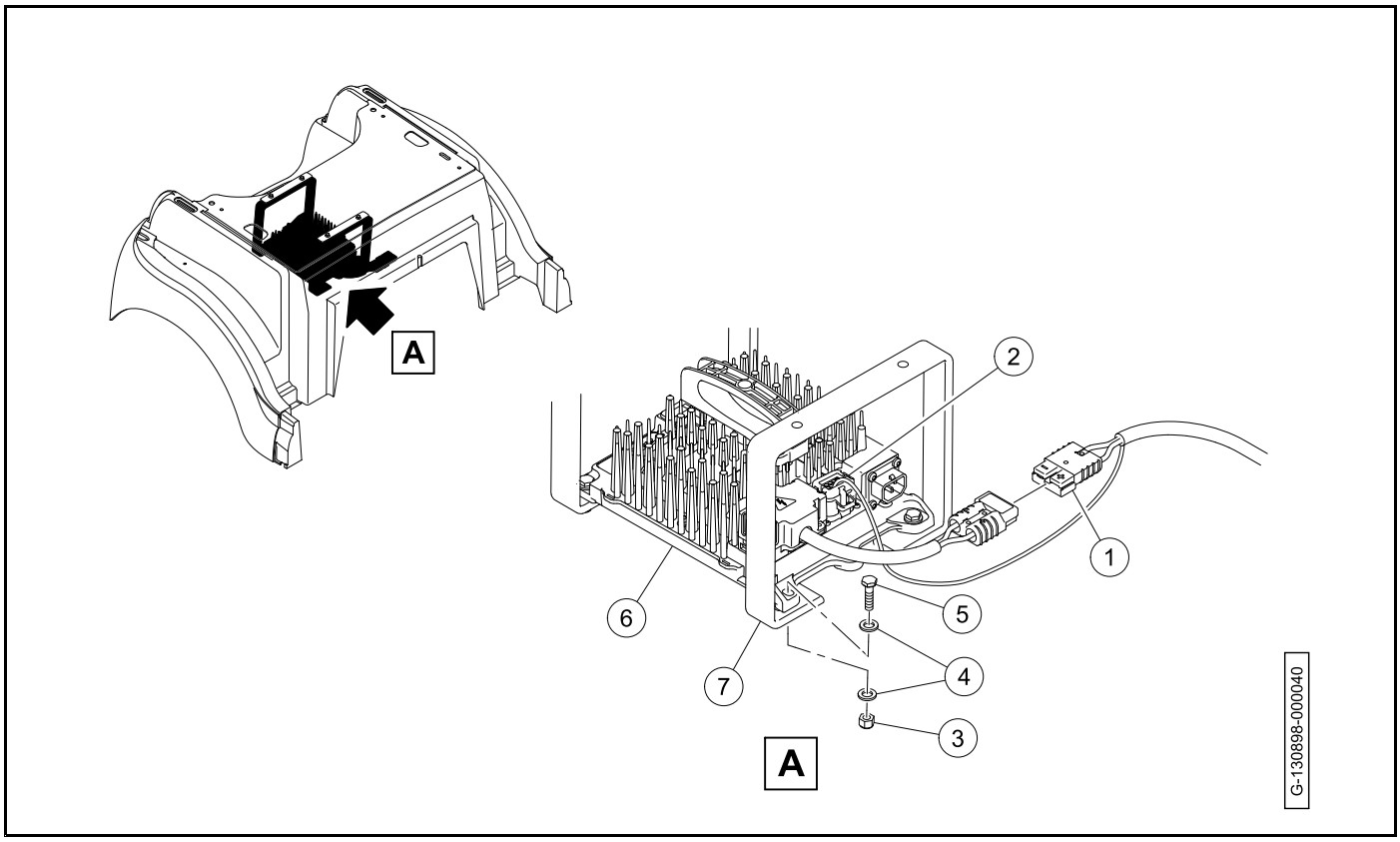


Figure 22-29 Onboard Charger

2. Connect the connector (2).
3. Put the onboard charger (5) on the bracket (6).
4. Install the bolts (5), washers (4), and nuts (3). Tighten the bolts to 13 lb·in (1.5 N·m).
5. Set the Run/Tow switch to TOW.
6. Connect the batteries.

Two-Passenger AC Cord Reel Removal

1. Disable the vehicle.
2. Disconnect the batteries.
3. Disconnect the AC cord from AC power source.
4. Disconnect the AC cord (1) from the battery charger **(Figure 15-31, Page 15-46)**.

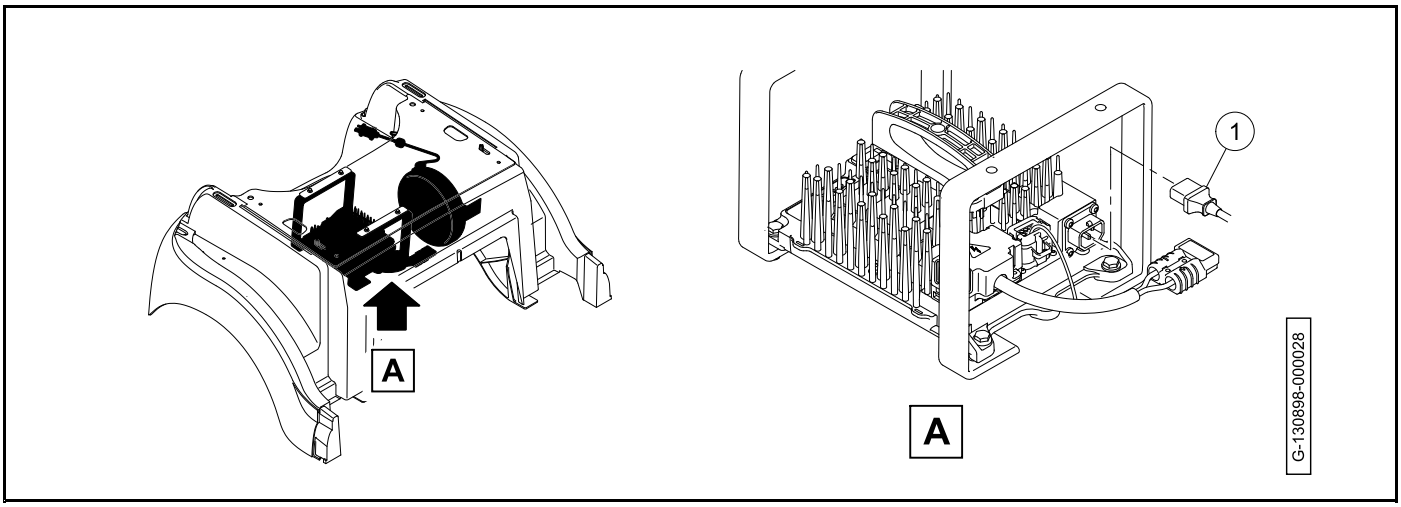


Figure 22-30 Disconnect From Battery Charger

5. Remove the screws (2) **(Figure 15-32, Page 15-46)**.

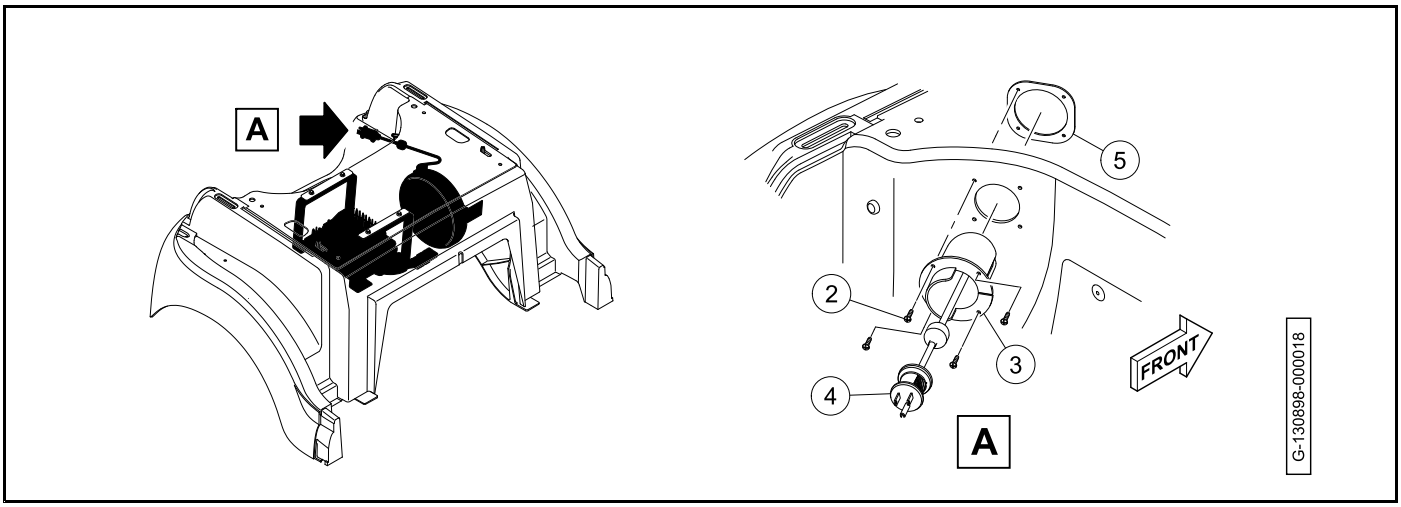


Figure 22-31 Cord Housing Removal

6. Remove the cord housing (3).
7. Remove the AC cord (4) from the cord housing.
8. Remove the backing plate (5).

9. Remove the nuts (6), washers (7), and bolts (8) **(Figure 15-33, Page 15-47)**.

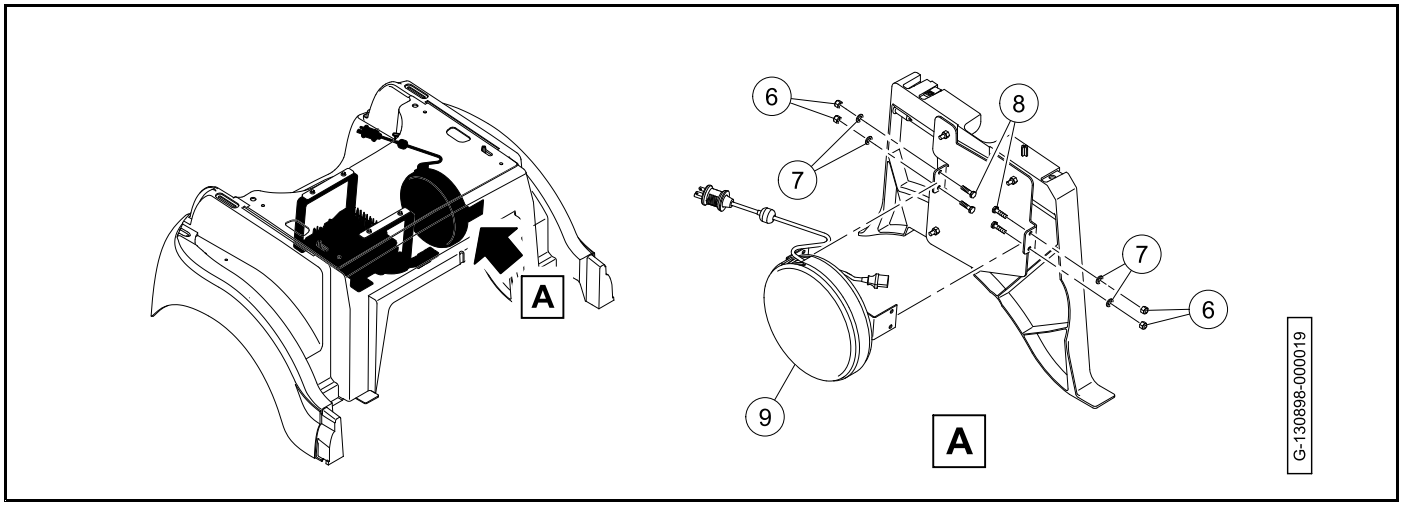


Figure 22-32 AC Cord Reel Removal

10. Remove the AC cord reel (9).

Two-Passenger AC Cord Reel Installation

1. Install the AC cord reel (9) on the cord reel plate **(Figure 15-34, Page 15-47)**.

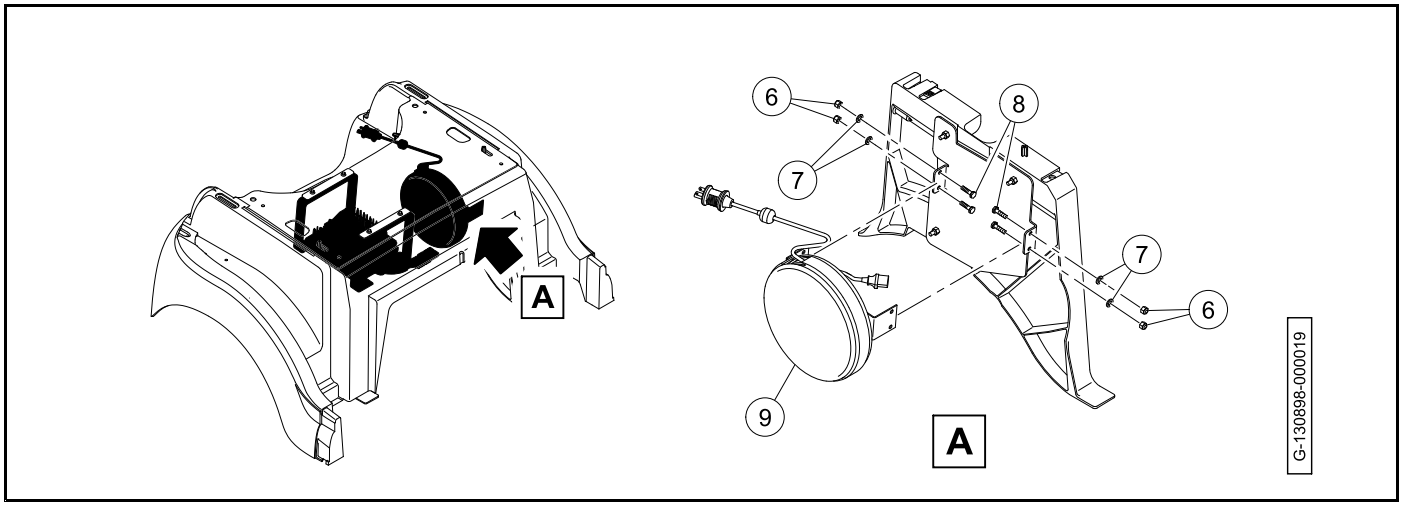


Figure 22-33 AC Cord Reel Installation

2. Install the bolts (8), washers (7), and nuts (6). Tighten the nuts to 88.5 lb·in (10 N·m).

3. Install the backing plate (5) on the AC cord (4) **(Figure 15-35, Page 15-48)**.

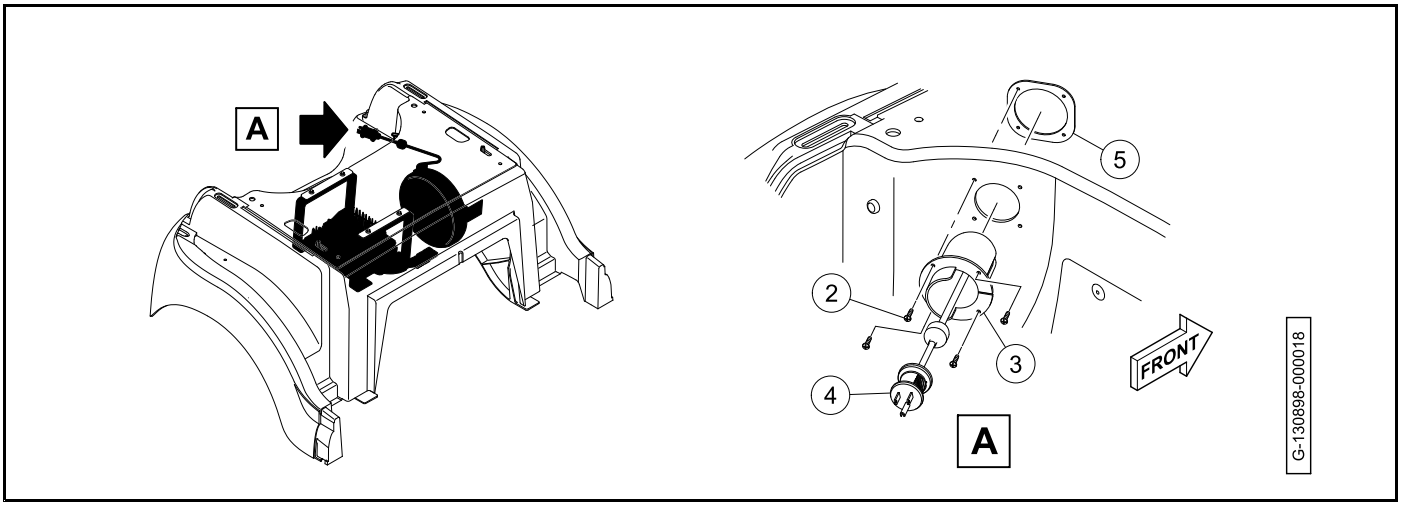


Figure 22-34 Cord Housing Installation

4. Put the AC cord through the cord housing (3).
5. Install the cord housing on the underbody.
6. Install the screws (2). Tighten the screws to 13 lb·in (1.5 N·m).
7. Connect the AC cord (1) to the battery charger **(Figure 15-36, Page 15-48)**.

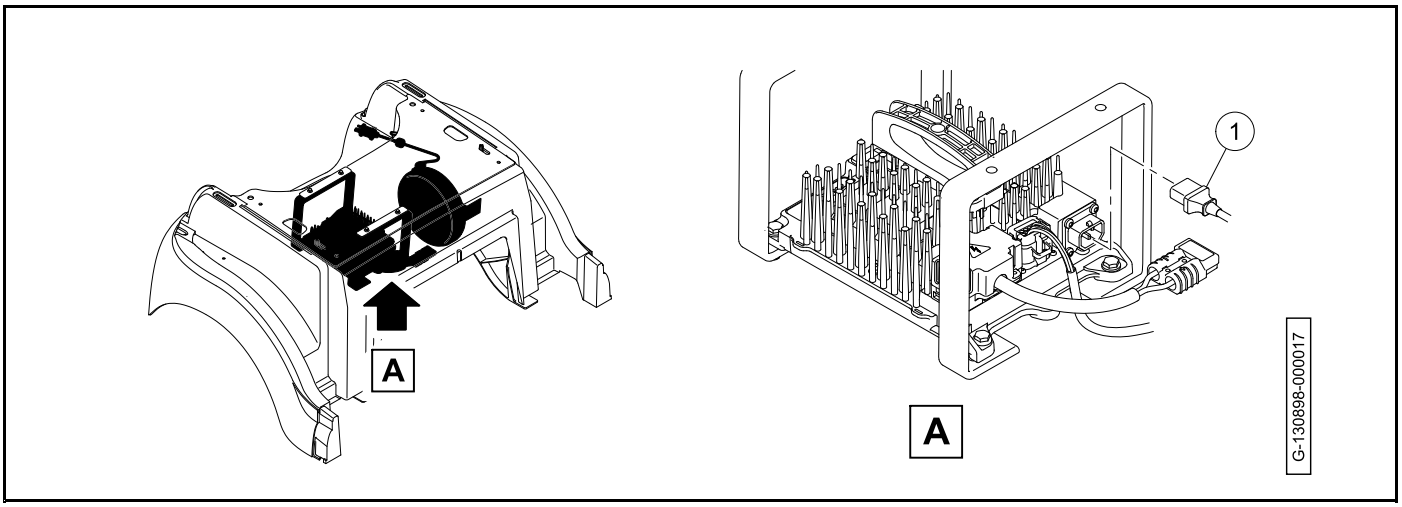


Figure 22-35 Connect To Battery Charger

8. Connect the batteries.

FIXED REAR SEAT ONBOARD CHARGER

Fixed Rear Seat Onboard Charger Removal

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Disconnect the AC cord from the AC power source.
5. Lift rear-facing seat bottom and support in the raised position.
6. Remove the screws (1) and the charger shield (2) **(Figure 22-36)**.

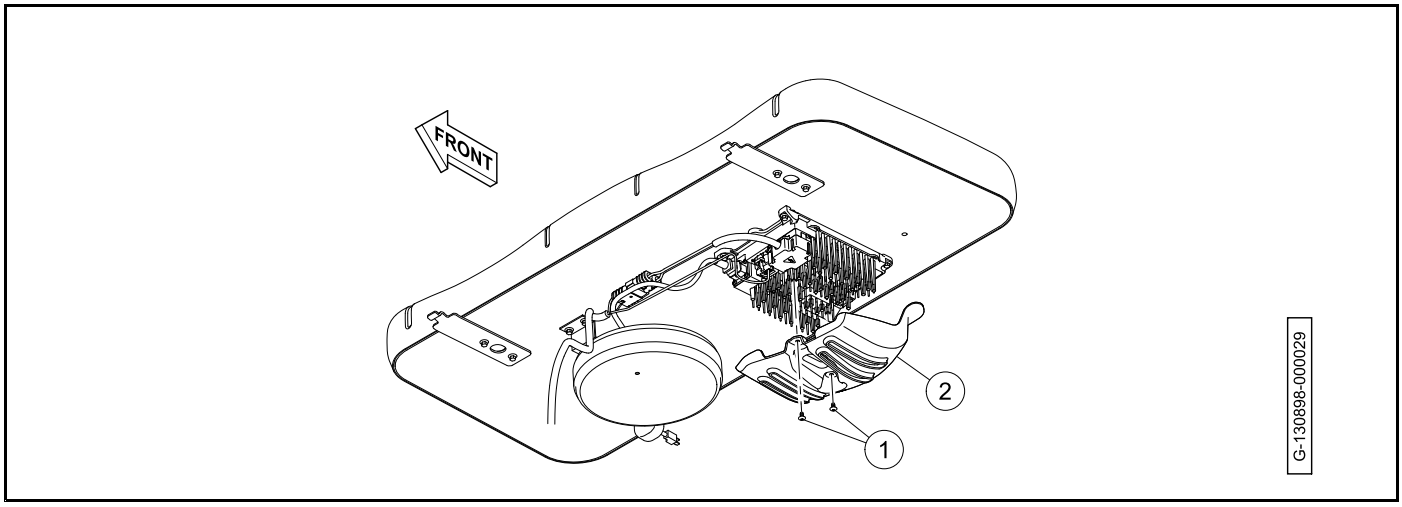


Figure 22-36 Charger Shield Removal

7. Disconnect the AC cord (3) from battery charger (4) **(Figure 22-37)**.

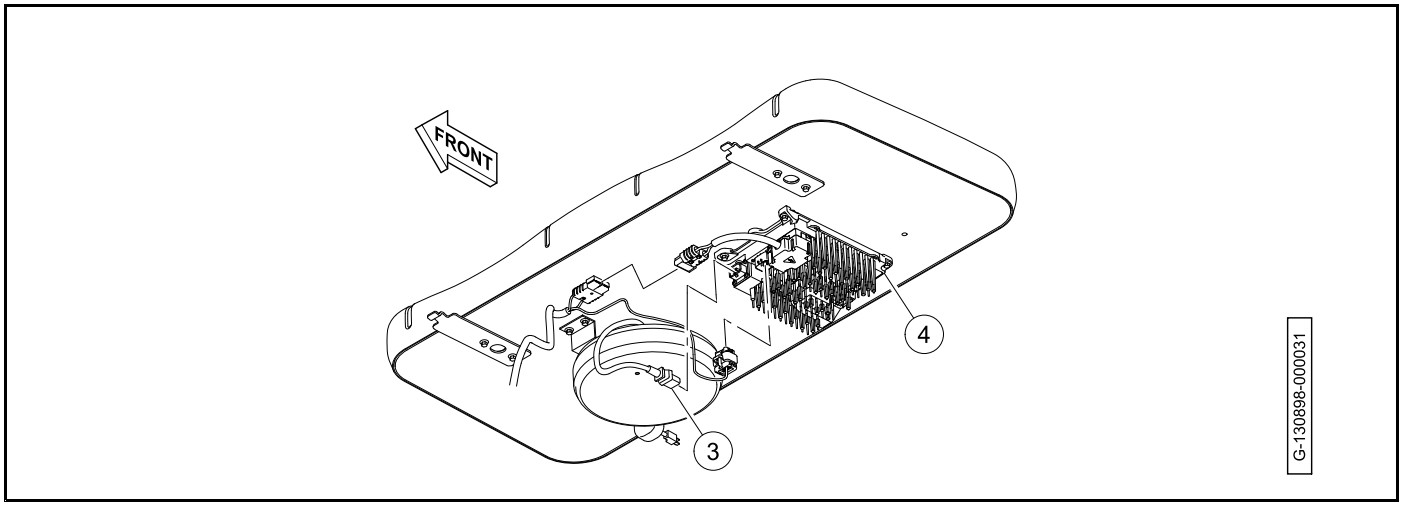


Figure 22-37 AC Cord Removal

8. Disconnect the charger harness (5) from the charger power harness (6) **(Figure 22-38)**.

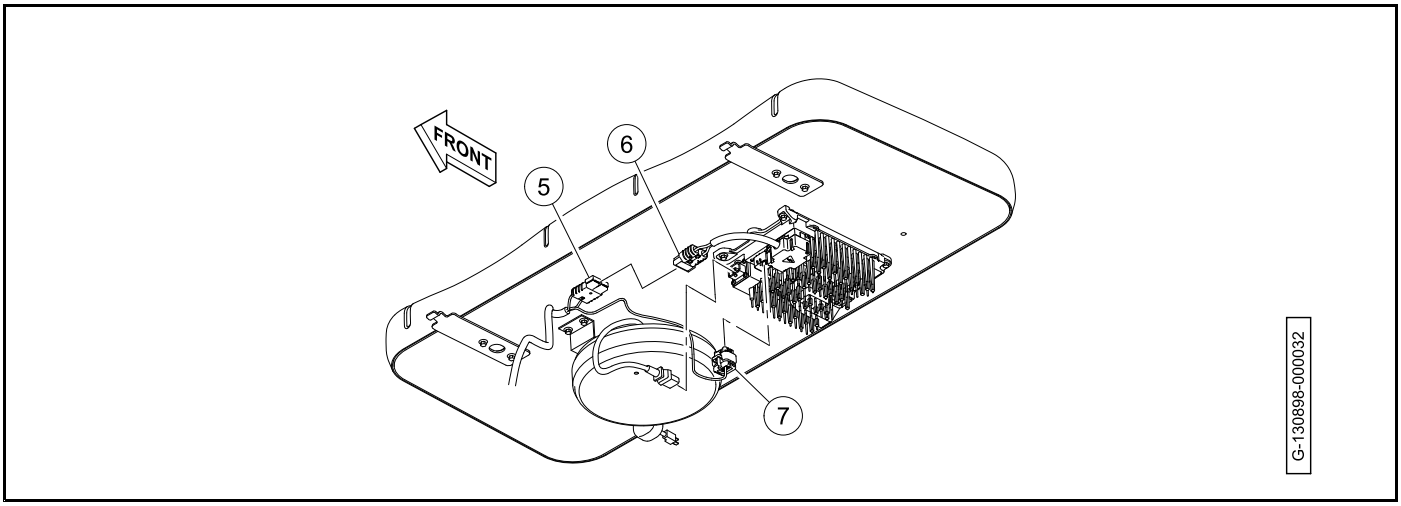


Figure 22-38 Charger Harness Connections

9. Disconnect the 14-pin connector (7) from battery charger.
10. Remove the screws (8). Retain the insulator (9) **(Figure 22-39)**.

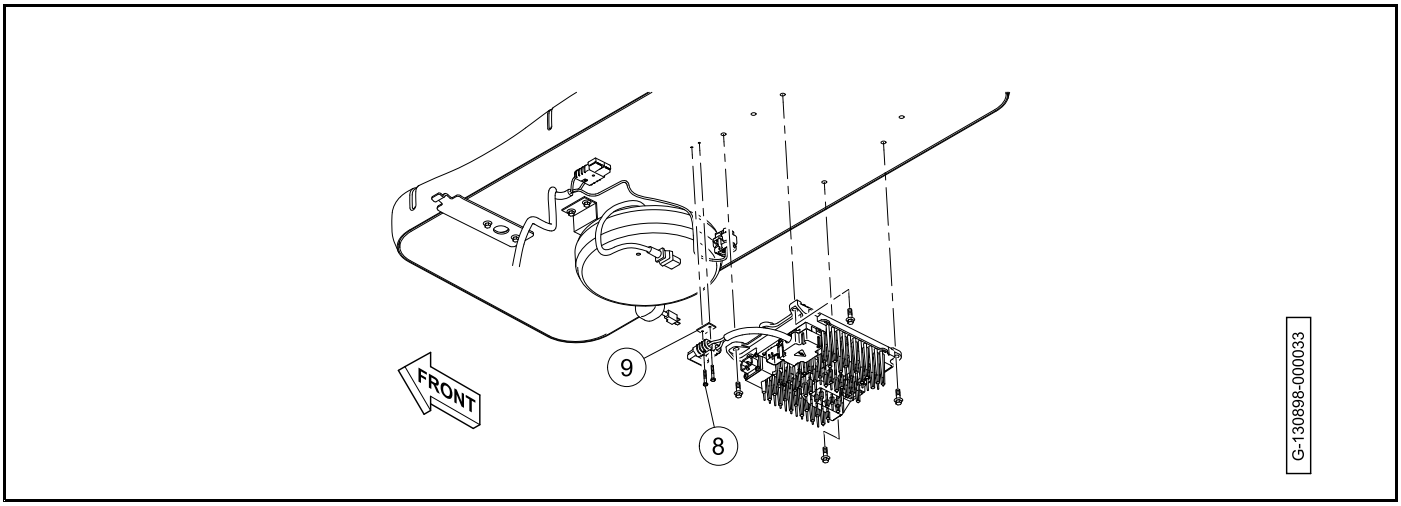


Figure 22-39 Charger Power Harness Connector Screws

11. Remove the bolts (10) and the battery charger **(Figure 22-40)**.

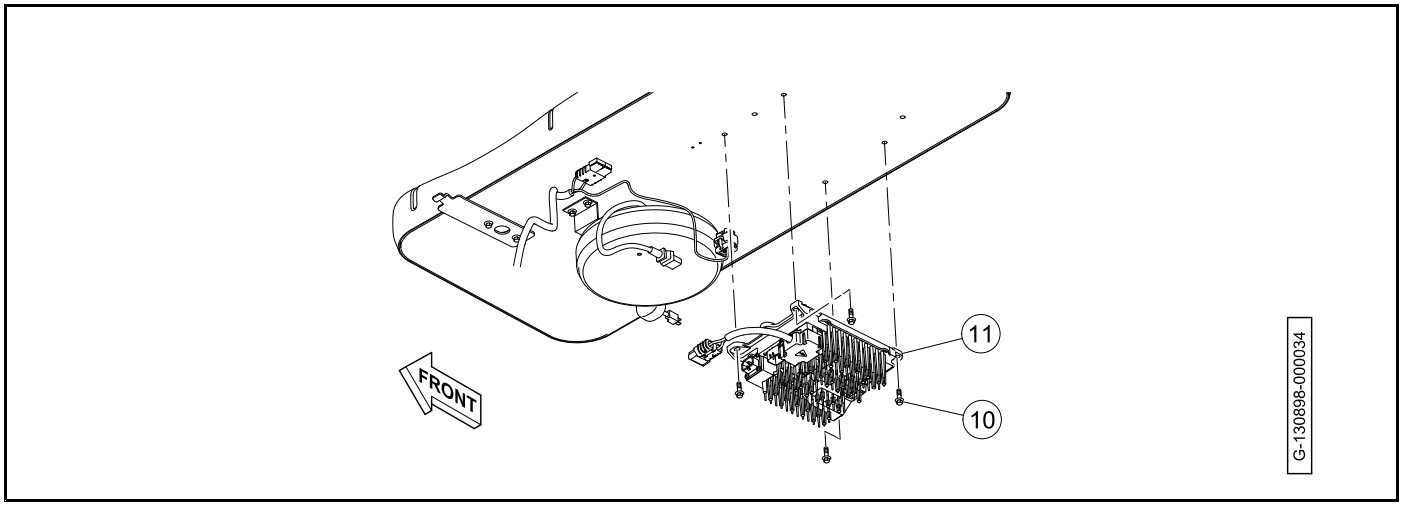


Figure 22-40 Battery Charger Removal

Fixed Rear Seat Onboard Charger Installation

1. Install the battery charger (1) and the bolts (2) **(Figure 22-41)**. Tighten the bolts to 53 in·lb (6 N·m).

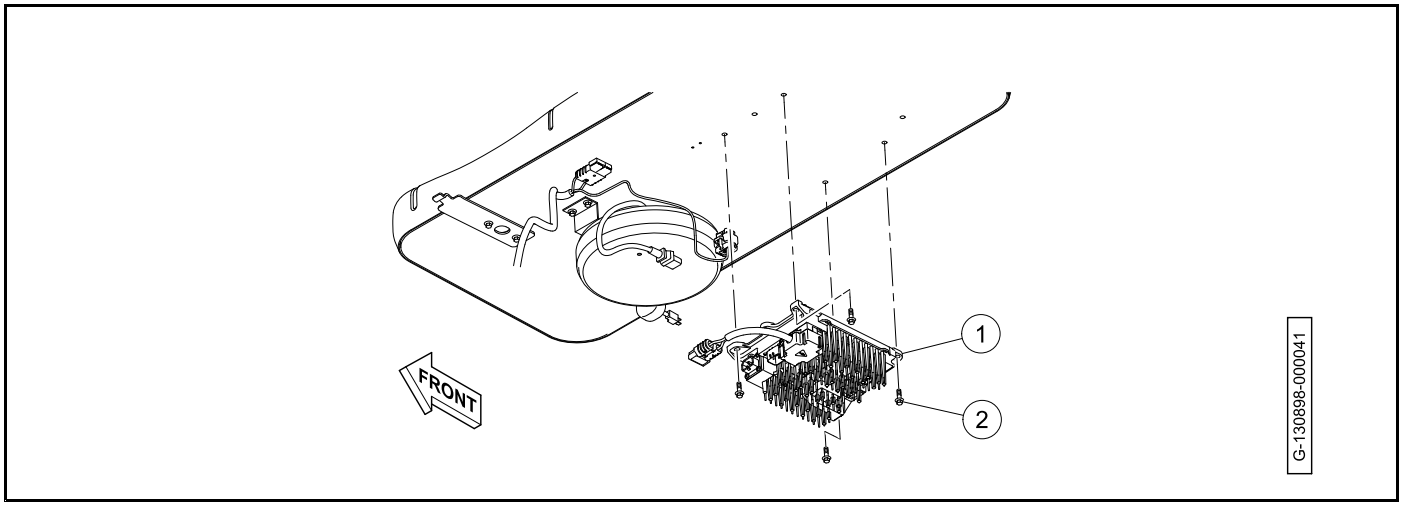


Figure 22-41 Battery Charger Installation

2. Install the insulator (3) and the screws (4) **(Figure 22-42)**. Tighten the screws to 11 in·lb (1.25 N·m).

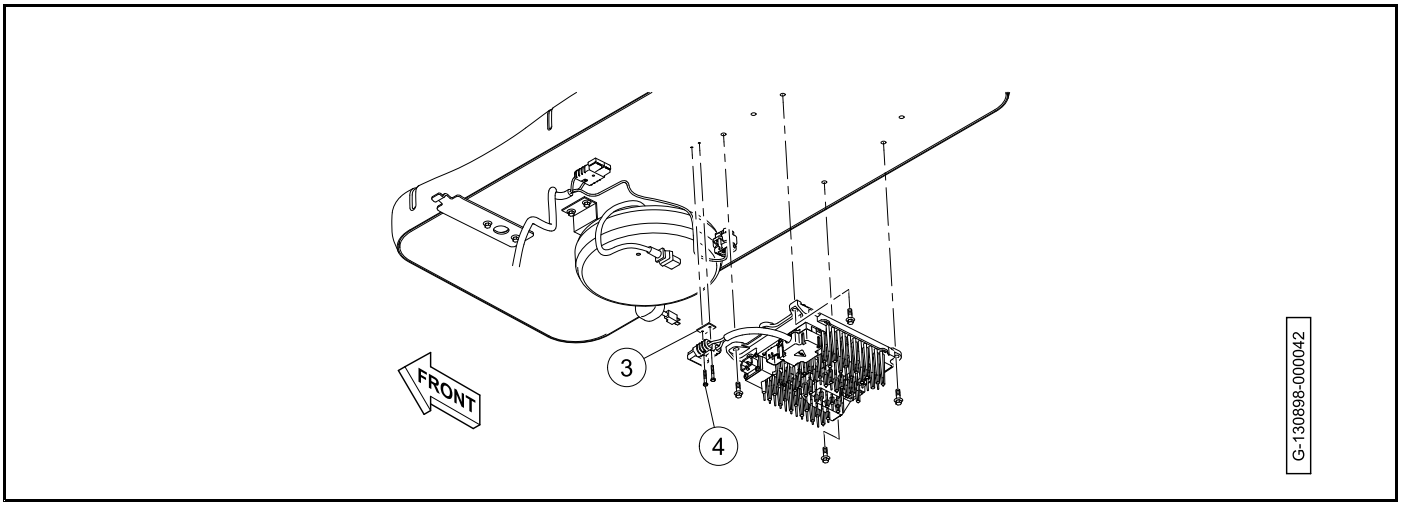


Figure 22-42 Charger Power Harness Connector Screws

3. Connect the charger harness (5) from the charger power harness (6) **(Figure 22-43)**.

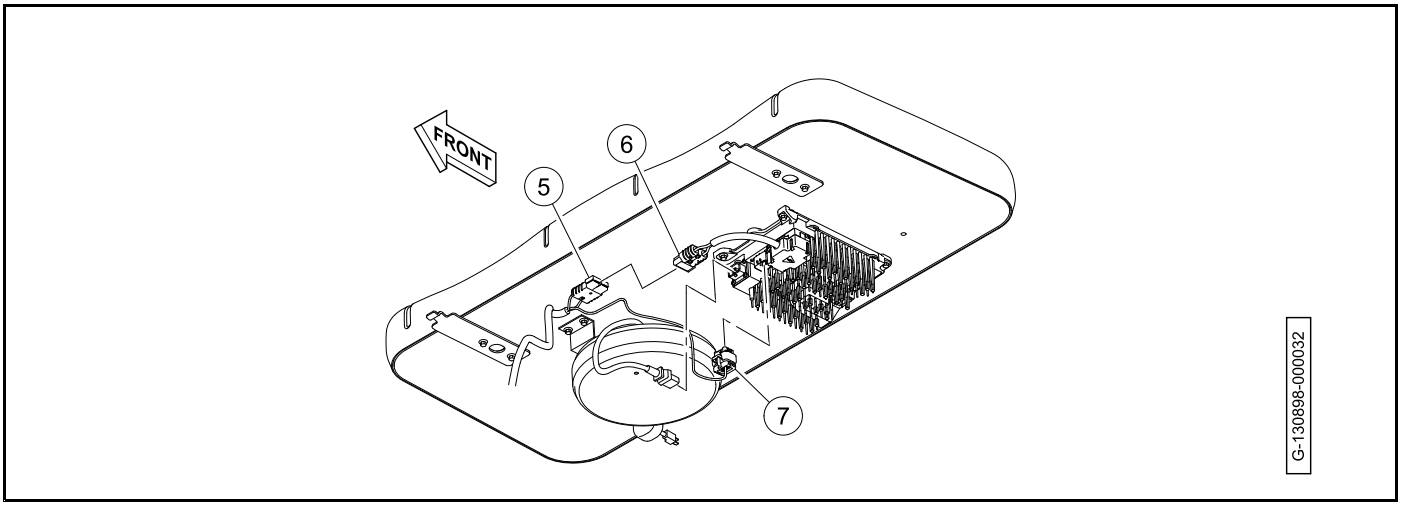


Figure 22-43 Charger Harness Connections

4. Connect the 14-pin connector (7) to the battery charger.

5. Connect the AC cord (8) to battery charger **(Figure 22-44)**.

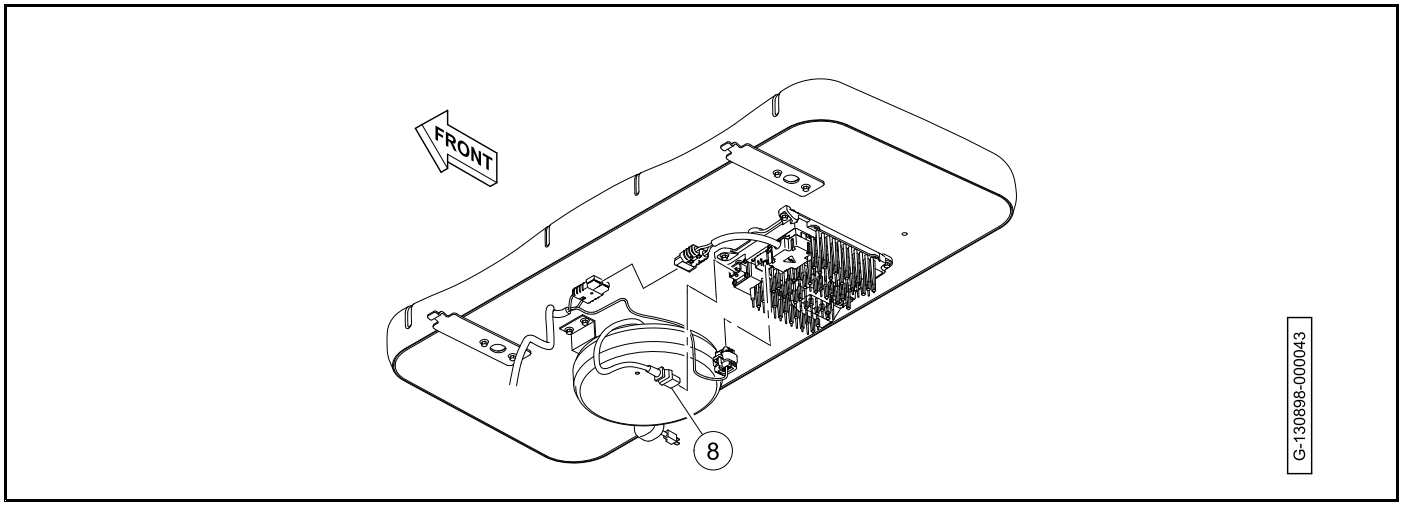


Figure 22-44 AC Cord Installation

6. Install the charger shield (9) and the screws (10) **(Figure 22-45)**. Tighten the screws to 17 in·lb (2 N·m).

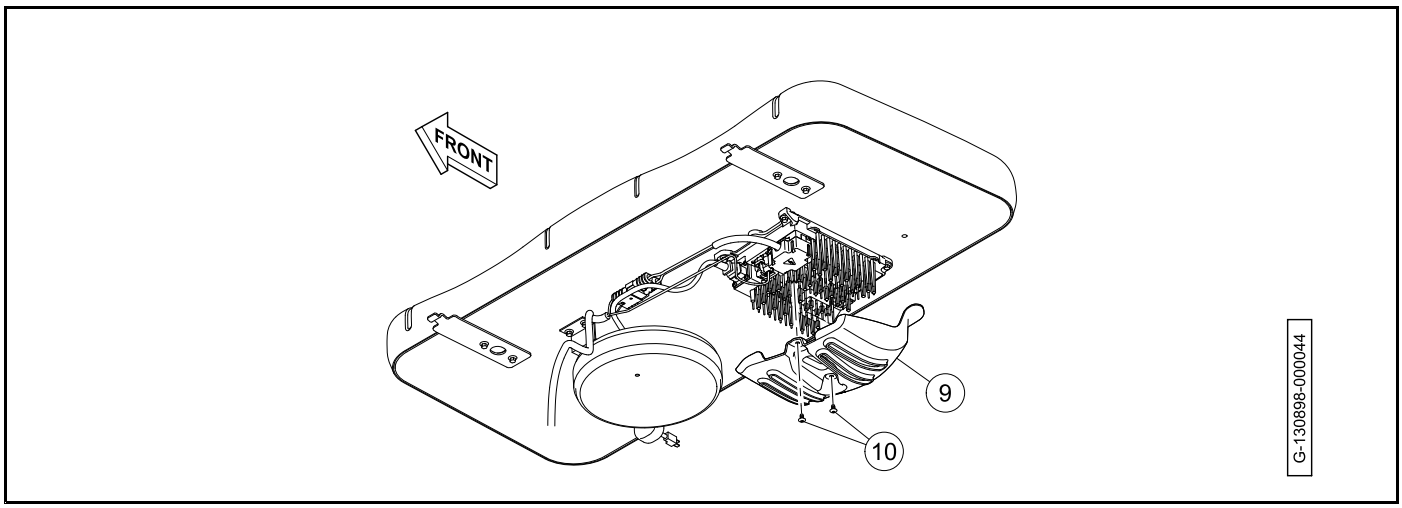


Figure 22-45 Charger Shield Installation

7. Lower rear-facing seat bottom.
8. Set the Run/Tow switch to TOW.
9. Connect the batteries.

Fixed Rear Seat AC Cord Reel Removal

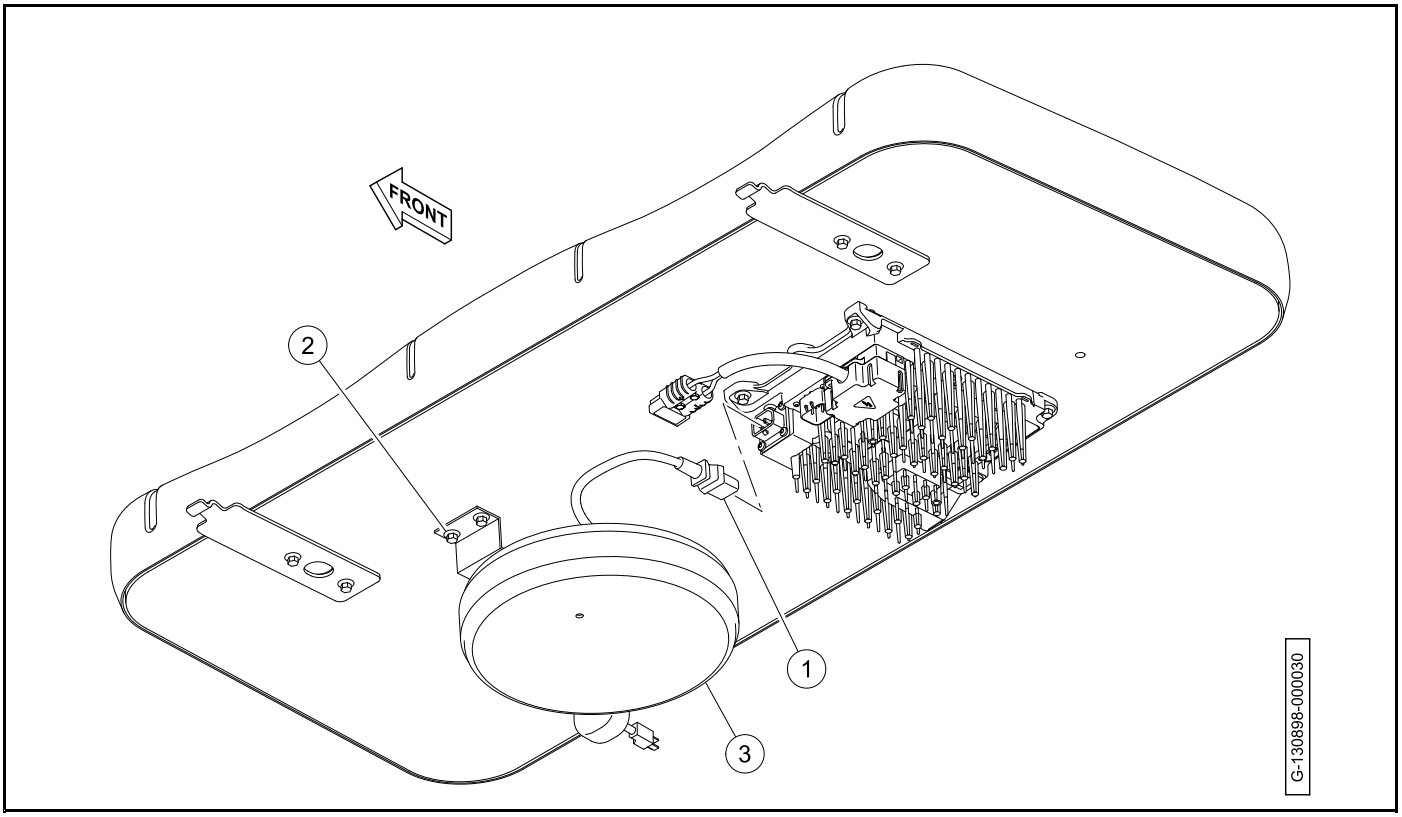


Figure 22-46 AC Cord

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Disconnect the AC cord from the AC power source.
5. Lift rear-facing seat bottom and support in the raised position.
6. Disconnect the AC cord (1) from the battery charger .
7. Remove the screws (2) and the AC cord reel (3).

Fixed Rear Seat AC Cord Reel Installation

1. Install the AC cord reel (3) and screws (2) . Tighten the screws to 53 in·lb (6 N·m).
2. Connect the AC cord (1) to the battery charger.
3. Lower rear-facing seat bottom.
4. Set the Run/Tow switch to TOW.
5. Connect the batteries.

FOLD-DOWN REAR SEAT ONBOARD CHARGER

Fold-Down Rear Seat Onboard Charger Removal

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Disconnect the AC cord from the AC power source.
5. Remove the screws (1) and the charger shield (2) **(Figure 22-36)**.

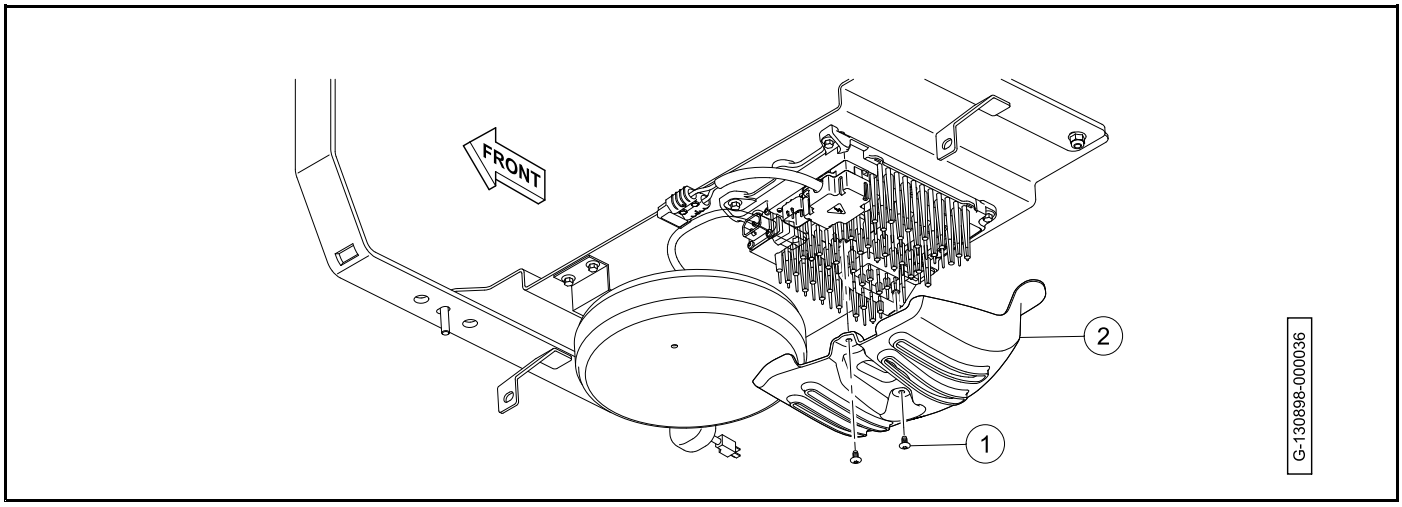


Figure 22-47 Charger Shield Removal

6. Disconnect the AC cord (3) from battery charger (4) **(Figure 22-37)**.

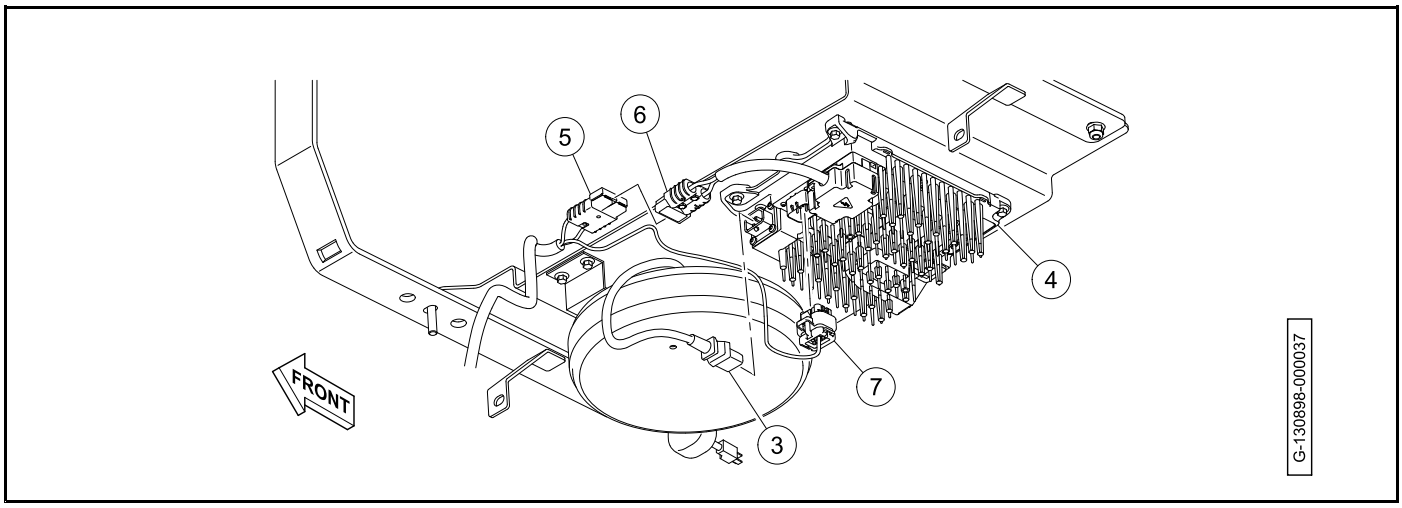


Figure 22-48 Harness Connections

7. Disconnect the charger harness (5) from the charger power harness (6).
8. Disconnect the 14-pin connector (7) from battery charger.

9. Remove the nuts (8), screws (9), and insulator (10) **(Figure 22-39)**. Retain the insulator.

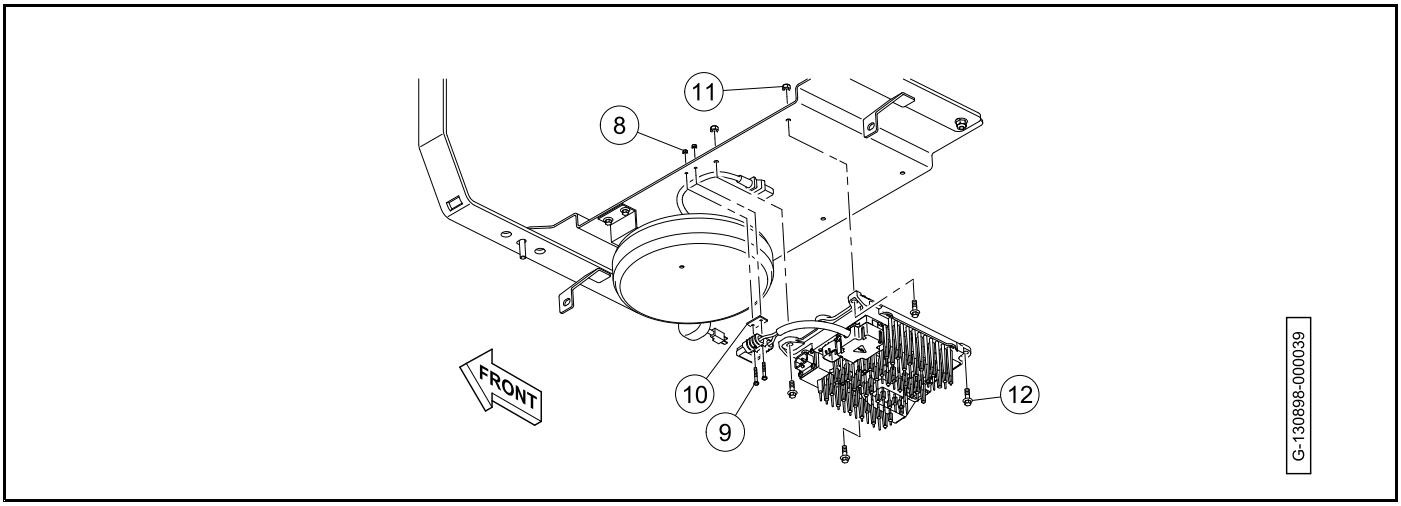


Figure 22-49 Battery Charger Removal

10. Remove the nuts (11), bolts (12), and the battery charger.

Fold-Down Rear Seat Onboard Charger Installation

1. Install the battery charger (1), bolts (2), and nuts (3) **(Figure 22-50)**. Tighten the nuts to 115 in·lb (13 N·m).

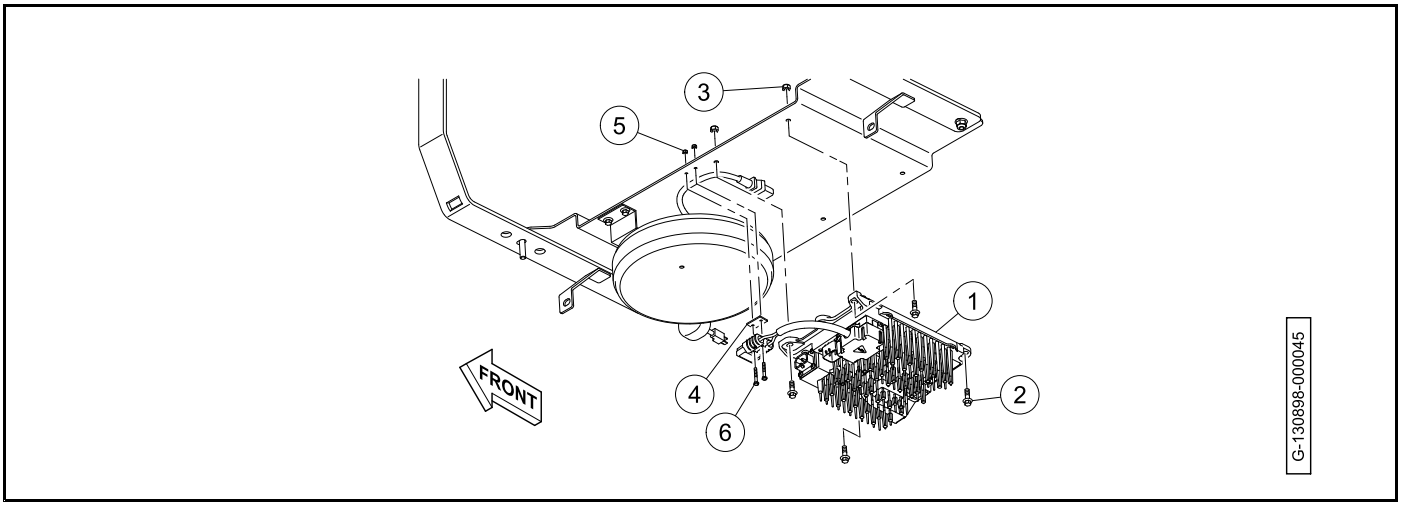


Figure 22-50 Battery Charger Installation

2. Install the insulator (4), nuts (5), and screws (6). Tighten the nuts to 17 in·lb (2 N·m).

3. Connect the charger harness (7) from the charger power harness (8) **(Figure 22-51)**.

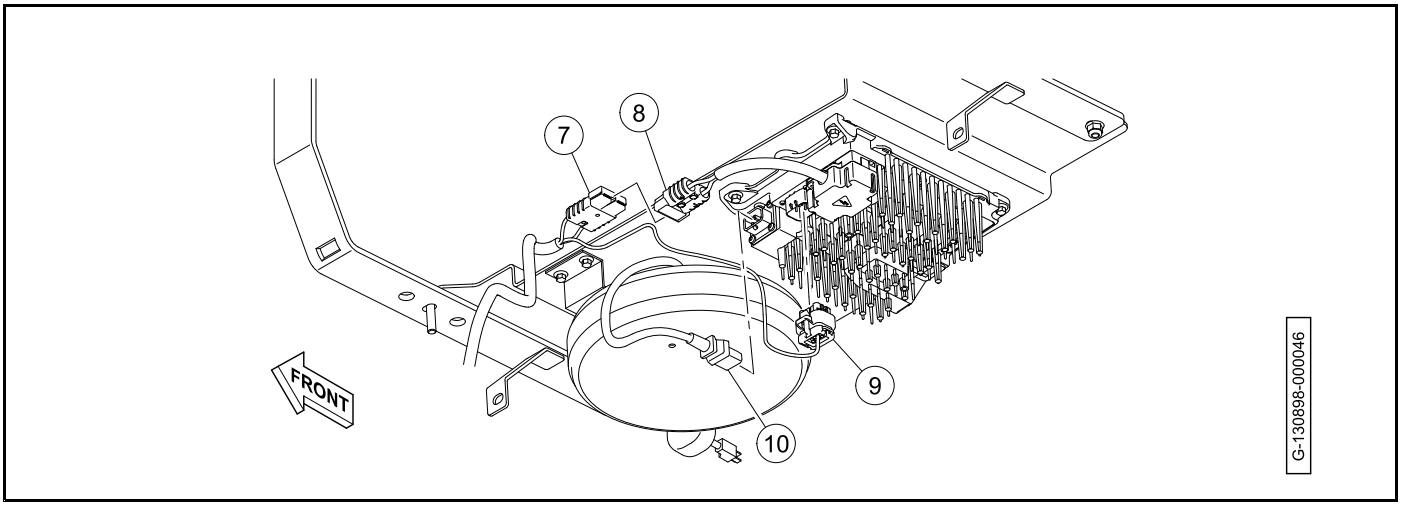


Figure 22-51 Harness Connections

4. Connect the 14-pin connector (9) to the battery charger.
5. Connect the AC cord (10) to battery charger.
6. Install the charger shield (11) and the screws (12) **(Figure 22-52)**. Tighten the screws to 17 in·lb (2 N·m).

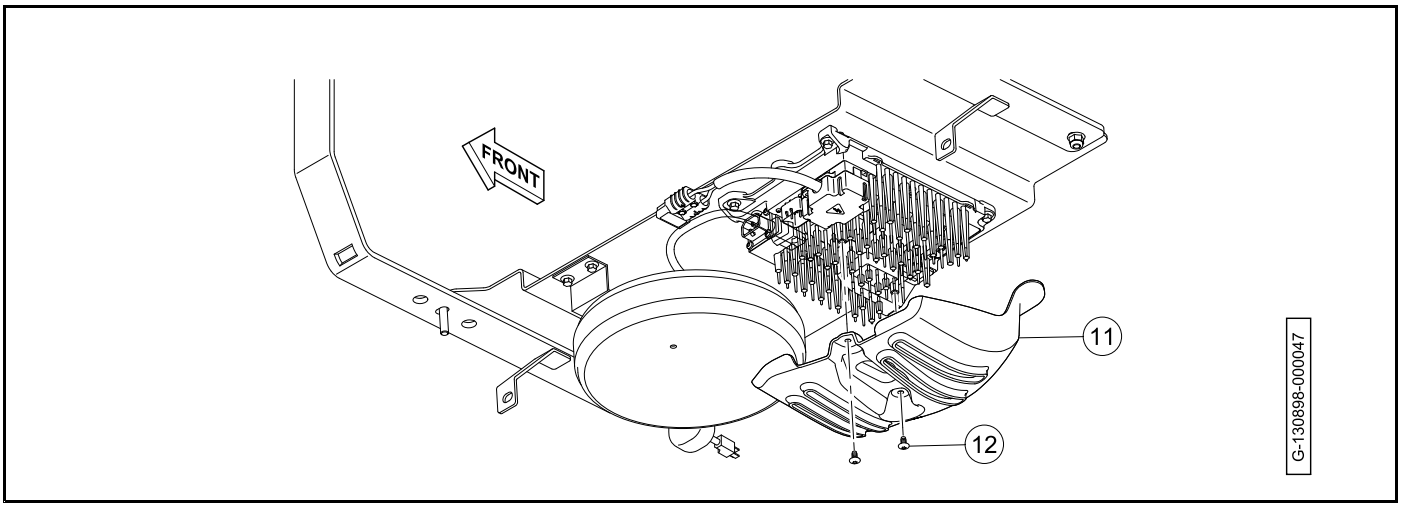


Figure 22-52 Charger Shield Installation

7. Set the Run/Tow switch to TOW.
8. Connect the batteries.

Fold-Down Rear Seat AC Cord Reel Removal

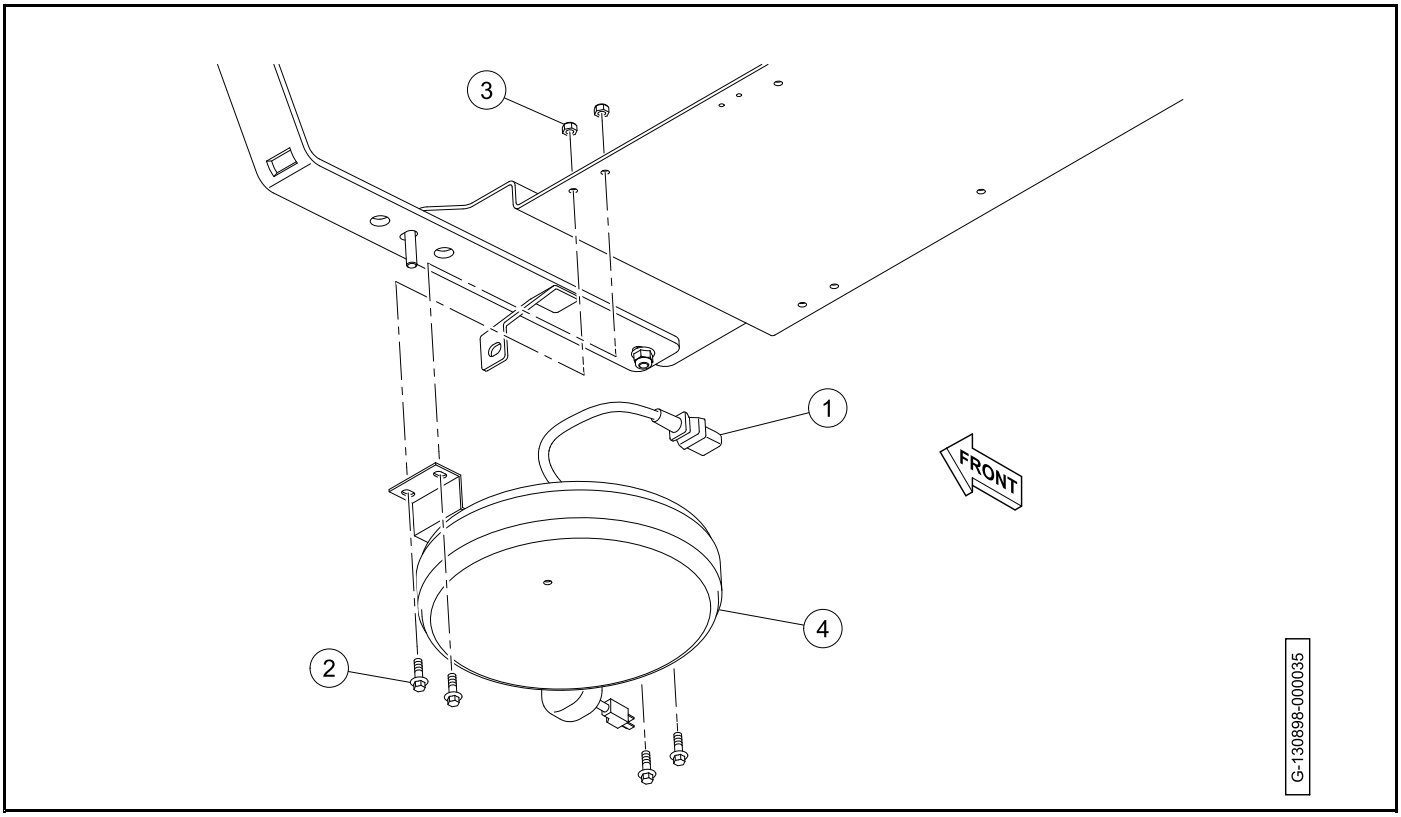


Figure 22-53 AC Cord

1. Disable the vehicle.
2. Set the Run/Tow switch to TOW.
3. Disconnect the batteries and discharge the controller.
4. Disconnect the AC cord from the AC power source.
5. Lift rear-facing seat bottom and support in the raised position.
6. Disconnect the AC cord (1) from the battery charger .
7. Remove the nuts (2), screws (3), and the AC cord reel (4).

Fold-Down Rear Seat AC Cord Reel Installation

1. Install the AC cord reel (4), screws (3), and nuts (2) . Tighten the nuts to 115 in·lb (13 N·m).
2. Connect the AC cord (1) to the battery charger.
3. Lower rear-facing seat bottom.
4. Set the Run/Tow switch to TOW.
5. Connect the batteries.

TERMINAL BLOCK COVER REMOVAL

1. Disconnect the AC cord from AC power source.
2. Disconnect the DC cord from the charger harness.
3. Push the tabs (1) in and remove the terminal block cover (2) **(Figure 15-37, Page 15-49)**.

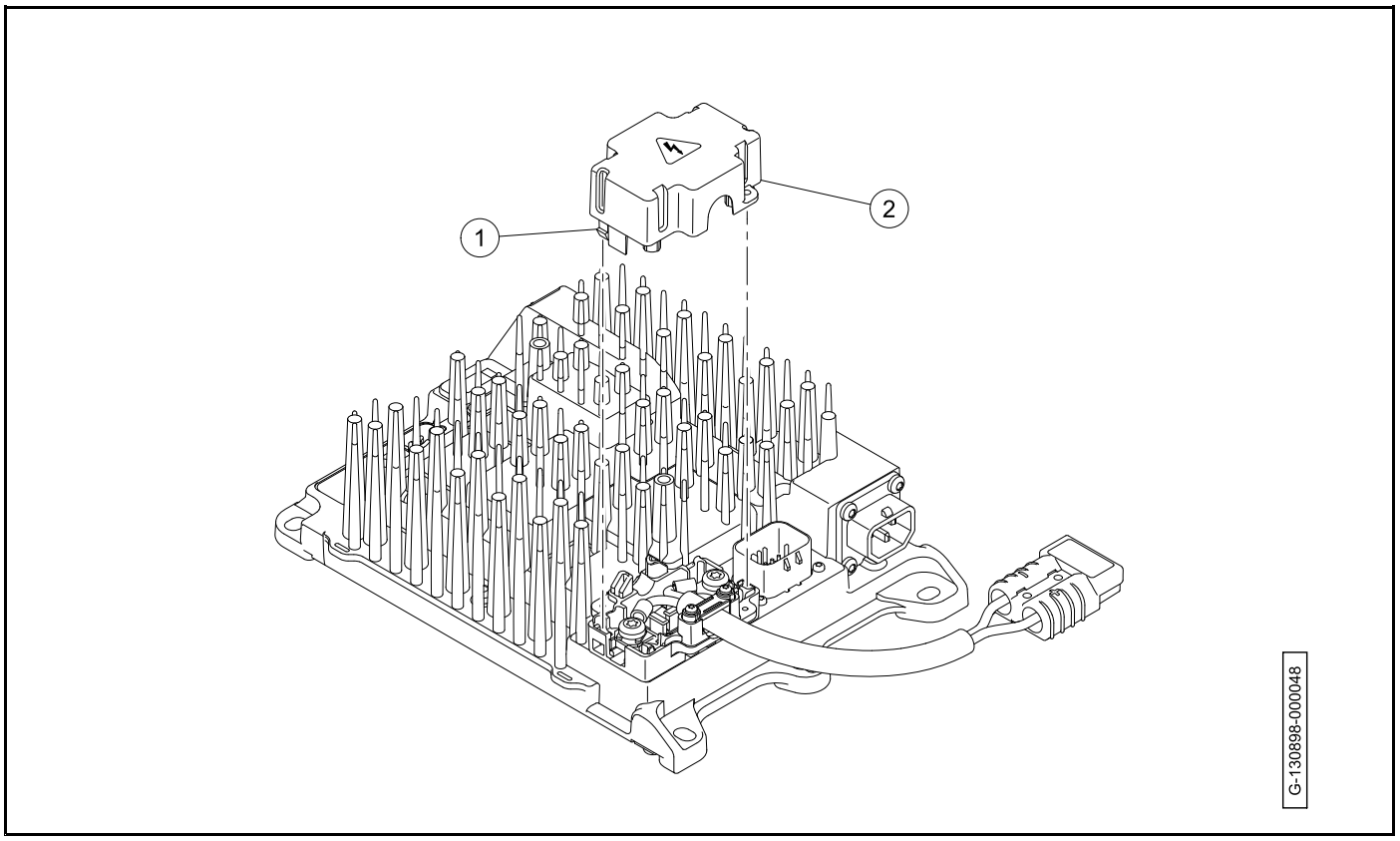


Figure 22-54 Onboard Charger Terminal Block Cover

TERMINAL BLOCK COVER INSTALLATION

⚠ WARNING

- **The terminal block cover on the DC terminal block must be installed properly to comply with UL code. This cover prevents water exposure and prevents a short across the DC terminals.**

1. Install the terminal block cover (2) onto the terminal block **(Figure 15-37, Page 15-49)**.
2. Push down until the tabs (1) lock into place.

DC CORD REMOVAL

1. Disable the vehicle.
2. Disconnect the batteries.
3. Disconnect the AC cord from AC power source.
4. Disconnect the DC cord from the onboard charger harness.
5. Remove the terminal block cover.
6. Remove the screws (1) **(Figure 15-38, Page 15-50)**.

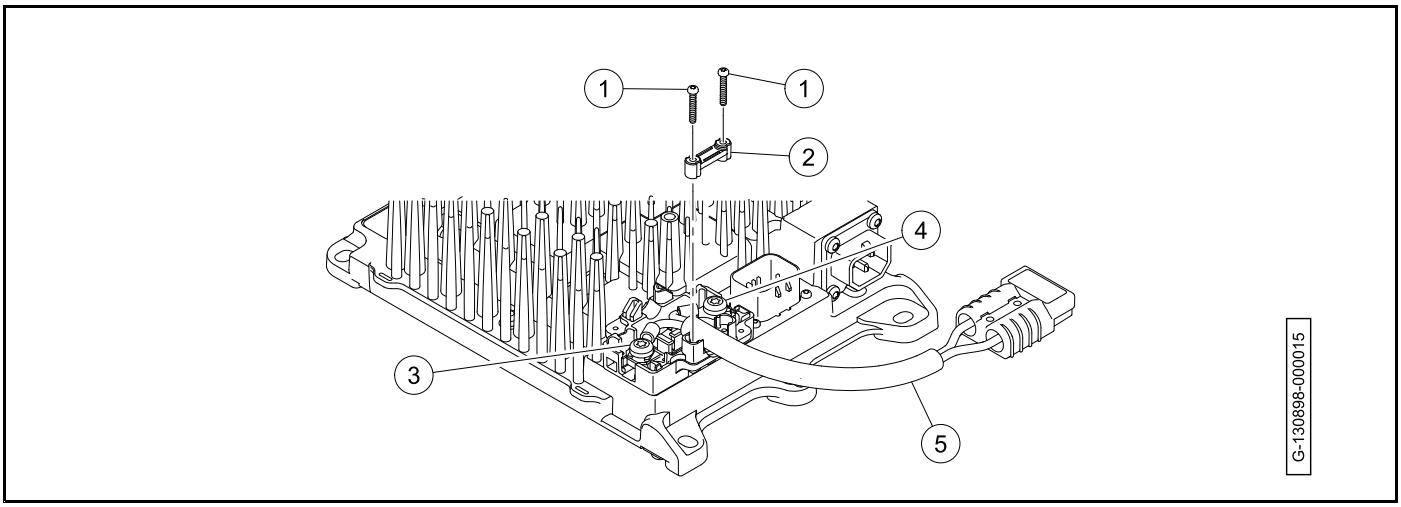


Figure 22-55 Onboard Charger DC Cord

7. Remove the clamp (2).
8. Loosen the terminal screws (3 and 4).
9. Remove the DC cord (5).

DC CORD INSTALLATION

1. Attach the red DC cord wire to positive (+) terminal (4) .

NOTE: *The positive symbol (+) and negative symbol (–) are molded into the terminal block.*

2. Attach the black DC cord wire to the negative (-) terminal (3).
3. Tighten the terminal screws to 39.8 lb·in (4.5 N·m).
4. Install the clamp (2).
5. Install the screws (1). Tighten the screws to 7.5 lb·in (0.85 N·m).
6. Install the terminal block cover.
7. Connect the DC cord (5) to the onboard charger harness.
8. Connect the batteries.

Pagination Page

SECTION 23 — DC ELECTRIC VEHICLE - MOTOR

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

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

See General Warnings on page 1-2.

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 16-4.**
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 1-2.

1. Place vehicle on a level surface.
2. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-4.**
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 16-1.**

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 16-4.**
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 1-2.

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-4.**
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 16-1.**
3. If reading is correct, reconnect the motor wires. **See Motor Installation on page 16-4.**
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 1-2.

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-4.**
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 16-1.**
3. If reading is correct, reconnect the motor wires. **See Motor Installation on page 16-4.**
4. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**

MOTOR

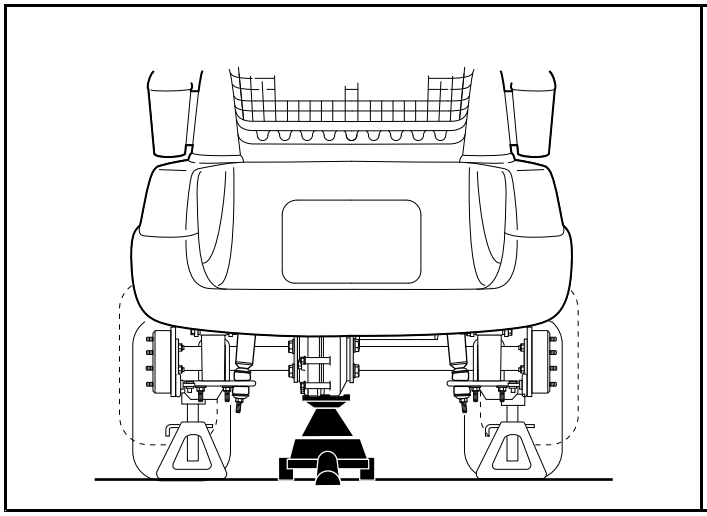
See General Warnings on page 1-2.

MOTOR REMOVAL

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles, Section 1, Page 1-4.**
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 23-1, Page 23-4)** 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 23-2, Page 23-4)**. **See following WARNING.**

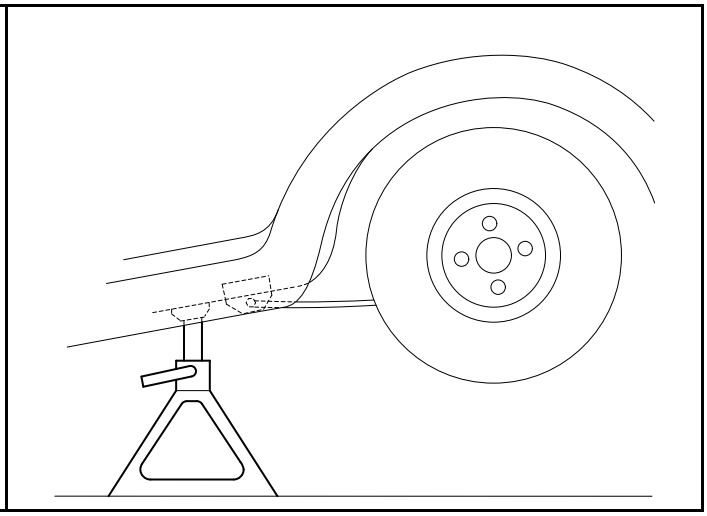
⚠ WARNING

- **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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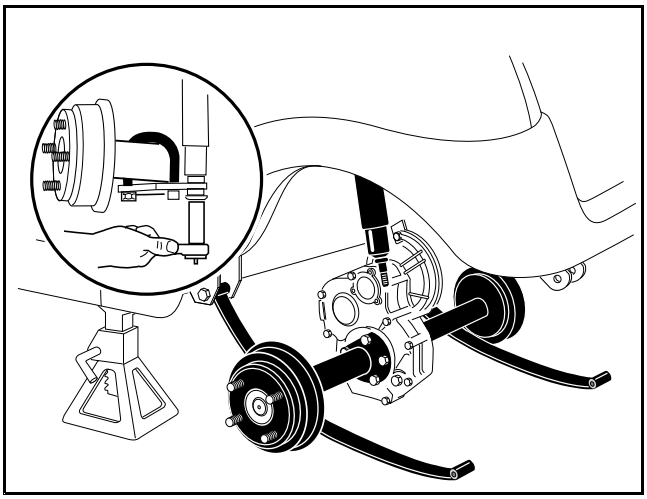
Figure 23-1 Lift Vehicle with Floor Jack



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Figure 23-2 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 23-3, Page 23-5)**.
7. ***Lifted Vehicles:*** Remove the panhard. **See Panhard and Bracket Removal on page 9-4.**
8. Remove the nuts and bolts mounting the rear leaf springs to the shackles.
9. 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 23-3, Page 23-5)**.



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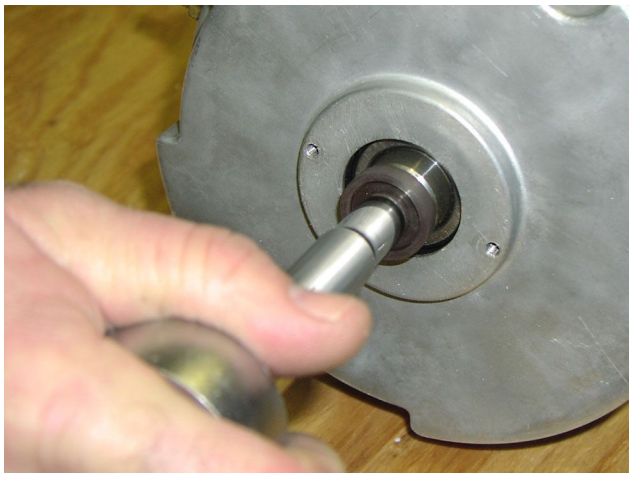
Figure 23-3 Lower Axle

10. Remove the bolts and lock washers that secure the motor to the transaxle **(Figure 23-24, Page 23-17)**. **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.**

11. Carefully slide the motor away from the transaxle until the motor spline disengages the input shaft and remove the motor from the vehicle.



748

Figure 23-4 Speed Sensor Magnet



749

Figure 23-5 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) that secure the speed sensor (10) to the end cap (11) **(Figure 23-15, Page 23-12)**.

2.2. Remove the screw securing the magnet to the armature shaft **(Figure 23-4, Page 23-5)**.

2.3. Inspect the speed sensor magnet. **See Speed Sensor Magnet Inspection on page 23-11.**

3. Loosen, but do not remove, the two screws securing the end cap to the motor frame **(Figure 23-5, Page 23-5)**.



750

Figure 23-6 End Cap Disengagement



751

Figure 23-7 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, proceed 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 23-6, Page 23-6)**.

6. Remove the two end cap bolts.

7. Remove the end cap and armature from the motor frame **(Figure 23-7, Page 23-6)**.

8. Inspect the brush springs for proper tension. **See Motor Brush, Spring, and Terminal Insulator Inspection on page 23-10.**

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 23-8, Page 23-7)**.

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 23-8.**

11. Inspect the motor frame and field windings. **See Motor Frame and Field Windings Inspection on page 23-10.**

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 23-9, Page 23-7)**.

12.3. Remove the two screws and the brush rigging to the end cap **(Figure 23-10, Page 23-8)**.

13. Inspect the terminal insulators. **See Terminal Insulator Inspection on page 23-10.**

14. Remove the bearing from the end cap.

14.1. Remove the retaining ring that secures the bearing in the end cap **(Figure 23-11, Page 23-8)**.

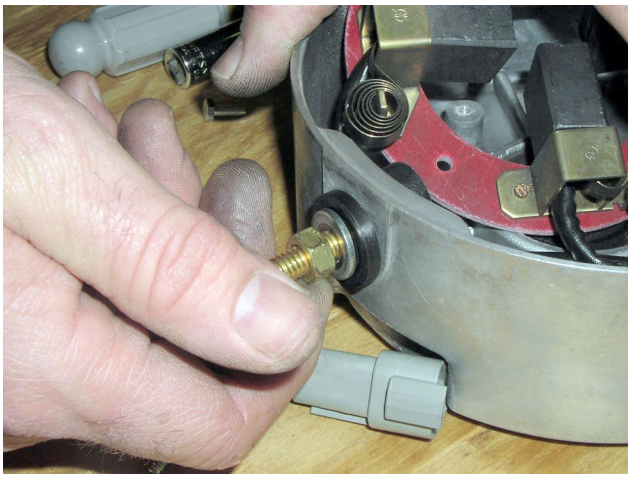
14.2. Use an arbor press to remove the bearing from the end cap.

15. Inspect the bearing for wear and damage. **See Bearing Inspection on page 23-11.**



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Figure 23-8 Armature Removal



753

Figure 23-9 A1 and A2 Terminals



754

Figure 23-10 Brush Rigging



755

Figure 23-11 Bearing Retaining Ring

MOTOR COMPONENT TESTING AND INSPECTION

See General Warnings on page 1-2.

ARMATURE INSPECTION AND TESTING

1. Remove the motor from the vehicle. **See Motor Removal on page 16-1.**
2. Remove the end cap and armature by performing steps 1 through 7 of Motor Disassembly on page 23-5.

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.*

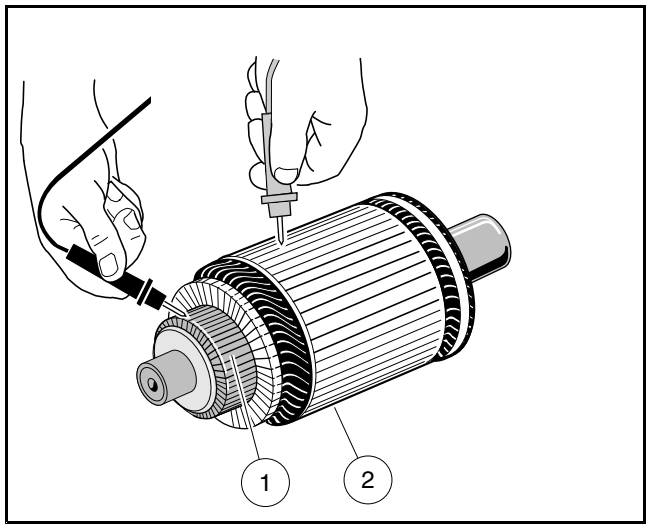
Armature Ground Test

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 23-12, Page 23-9)**. If the reading is incorrect, replace the armature.



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Figure 23-12 Armature Test

MOTOR FRAME AND FIELD WINDINGS INSPECTION

1. Remove the motor from the vehicle. **See Motor Removal on page 16-1.**
2. Remove the and cap and armature by performing steps 1 through 7 of Motor Disassembly on page 23-5.
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 16-1.**
2. Remove the end cap and armature by performing steps 1 through 7 of Motor Disassembly on page 23-5.
3. Inspect the brush springs (14) **(Figure 23-15, Page 23-12)**. 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 23-13, Page 23-11)**.

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 23-13, Page 23-11)**. **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 23-13*** *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 16-1.**
2. Remove the end cap and armature by performing steps 1 through 7 of Motor Disassembly on page 23-5.
3. Inspect the brushes (13) for damage or excessive wear **(Figure 23-15, Page 23-12)**. 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.**

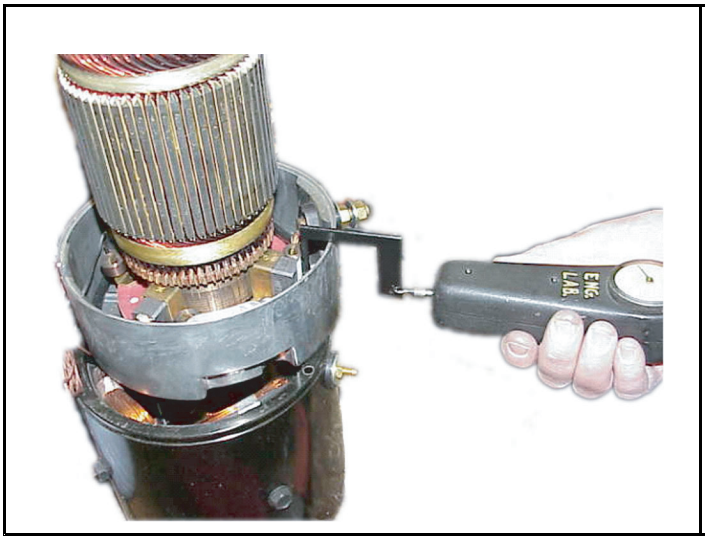
Terminal Insulator Inspection

1. Remove the motor from the vehicle. **See Motor Removal on page 16-1.**
2. Remove the terminal insulators by performing steps 1 through 12 of Motor Disassembly on page 23-5.
3. Inspect the insulators (4 and 6) for cracks or other damage **(Figure 23-15, Page 23-12)**. Replace insulators as required.

Bearing Inspection

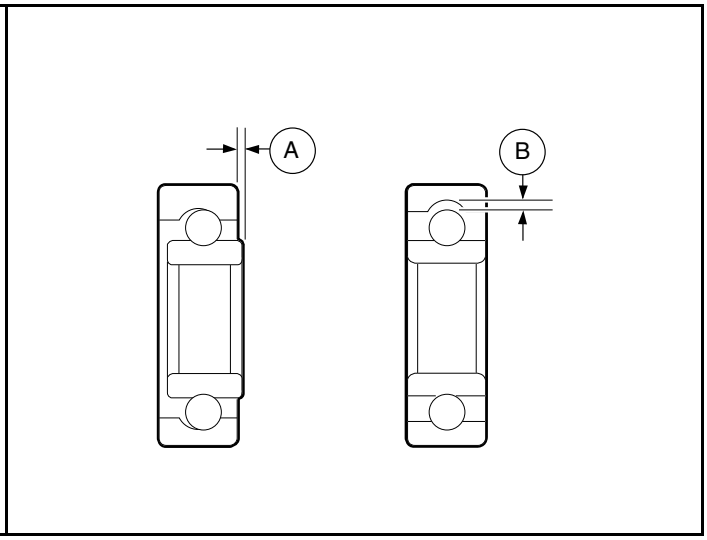
NOTE: *Replacement of the end cap bearing is highly-recommended if the end cap is removed from the motor. The following procedure is provided as a guideline for determining general bearing failure.*

1. Remove the motor from the vehicle. **See Motor Removal on page 16-1.**
2. Remove the bearing by performing steps 1 through 14 of Motor Disassembly on page 23-5.
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 23-14, Page 23-11)**.
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 23-13 Brush Spring Tension Test

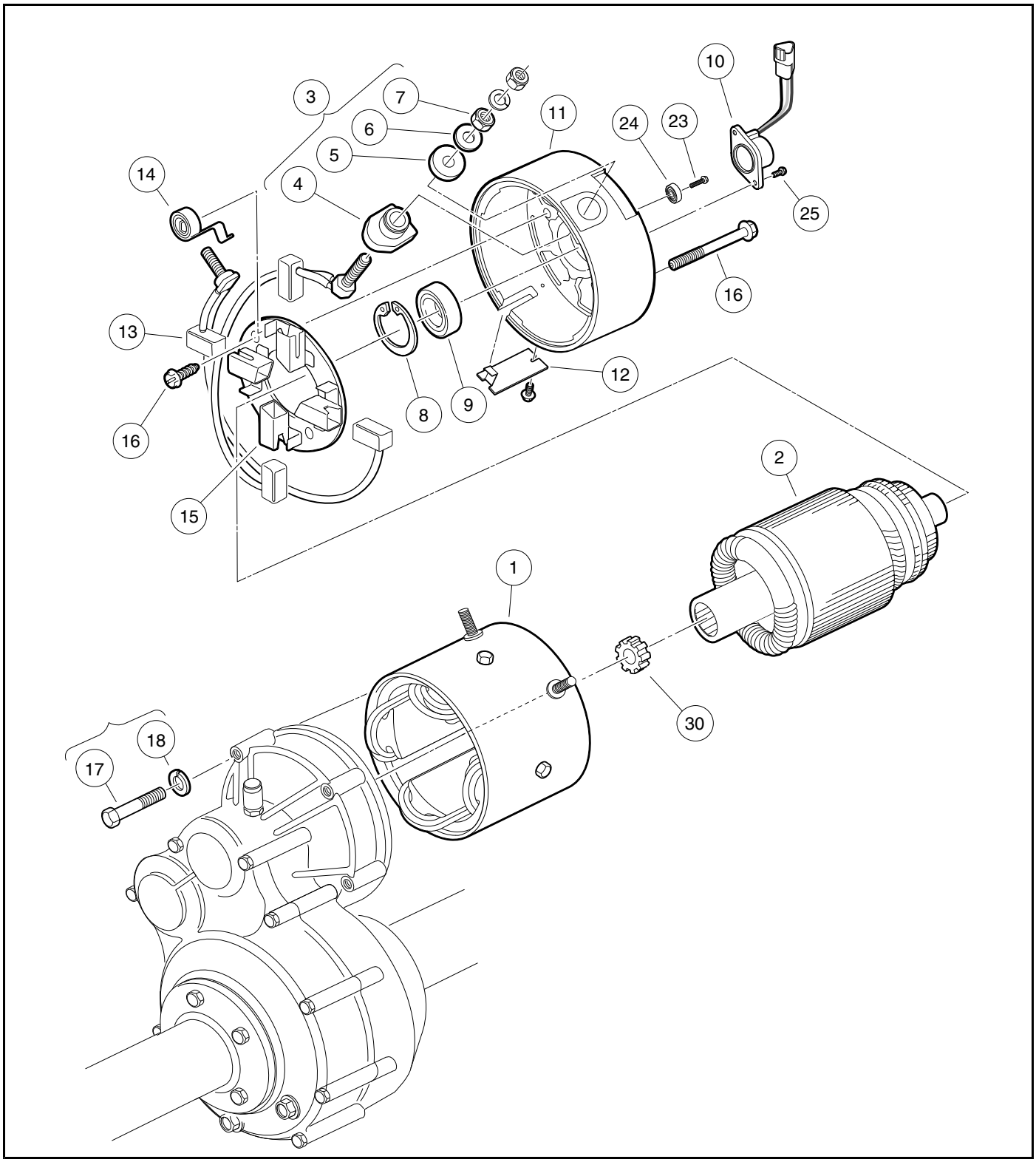


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Figure 23-14 Bearing Inspection

Speed Sensor Magnet Inspection

Inspect the speed sensor magnet (24) for rust, wear, and cracks **(Figure 23-15, Page 23-12)**. Replace the magnet if necessary.



2613

Figure 23-15 Electric Motor (EJ8-4001A)

RECONDITIONING THE MOTOR

See General Warnings on page 1-2.

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 1-2.

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 23-11, Page 23-8)**.

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.

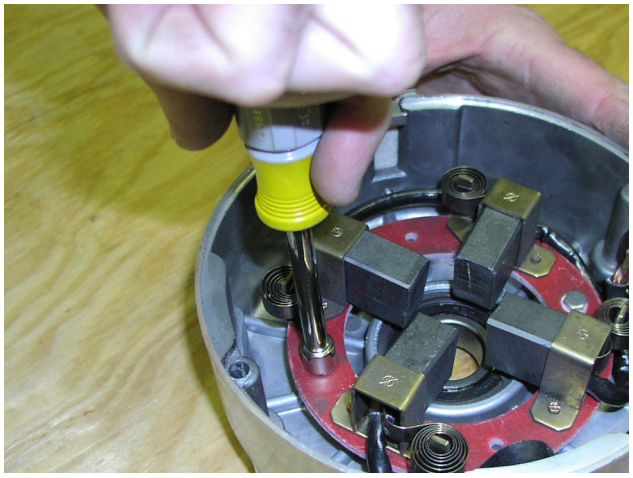
2.1. Insert the brushes into the brush rigging as shown **(Figure 23-16, Page 23-14)**.

2.2. Insert the two terminal posts through insulators (4) in the end cap (11) wall at the A1 and A2 positions **(Figure 23-15, Page 23-12)**.

2.3. Place external insulators (5) and washers (6) on each terminal post, and secure terminal with nuts (7). Tighten nuts (7) to 100 lb·in (11.3 N·m). Ensure that the terminal posts do not rotate when tightening the nuts **(Figure 23-15, Page 23-12)**.

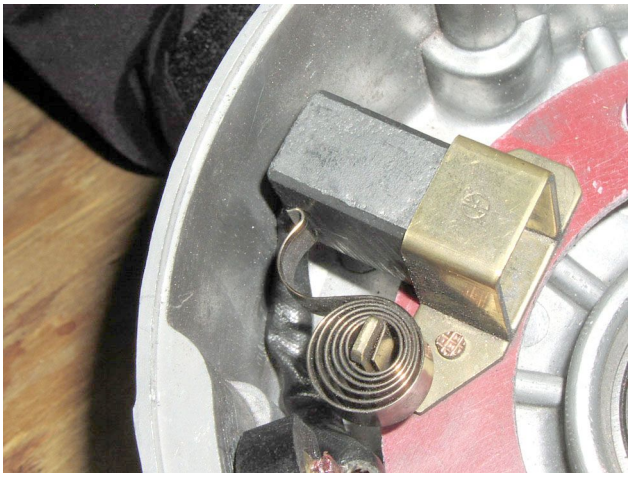
2.4. Secure the brush rigging to the end cap with two screws. Tighten the screws to 25 lb·in (2.8 N·m) **(Figure 23-10, Page 23-8)**.

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 23-17, Page 23-14)**.



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Figure 23-16 Brush Rigging



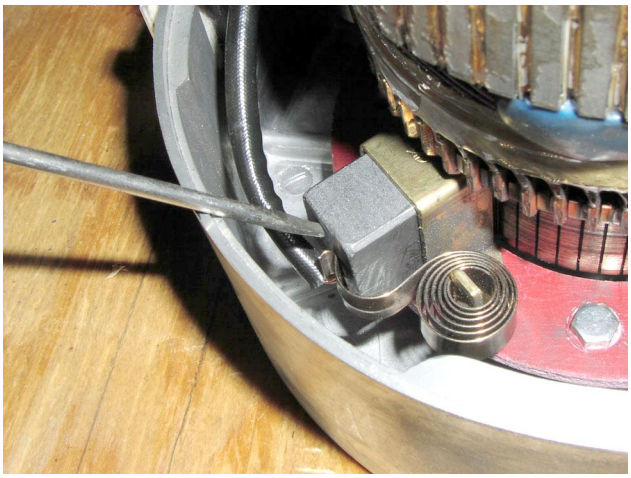
759

Figure 23-17 Retracted Brushes



760

Figure 23-18 Armature Installation



761

Figure 23-19 Brush Setting

3. With the brushes retracted, use an arbor press to press the armature shaft into the end cap bearing **(Figure 23-18, Page 23-14)**. **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 23-19, Page 23-14)**.
5. Align the match marks on the end cap and the motor frame (1) and secure with two bolts (16) **(Figure 23-15, Page 23-12)**. Tighten bolts to 130 lb·in (14.7 N·m).
6. Install the speed sensor magnet (24) with screw (23). Tighten to 65 lb·in (7.3 N·m).
7. Install the speed sensor (10) with screws (25). Tighten to 20 lb·in (2.2 N·m).

8. Make sure the armature turns freely. If it does not turn freely, disassemble the motor to find the problem.

MOTOR INSTALLATION

See General Warnings on page 1-2.

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.

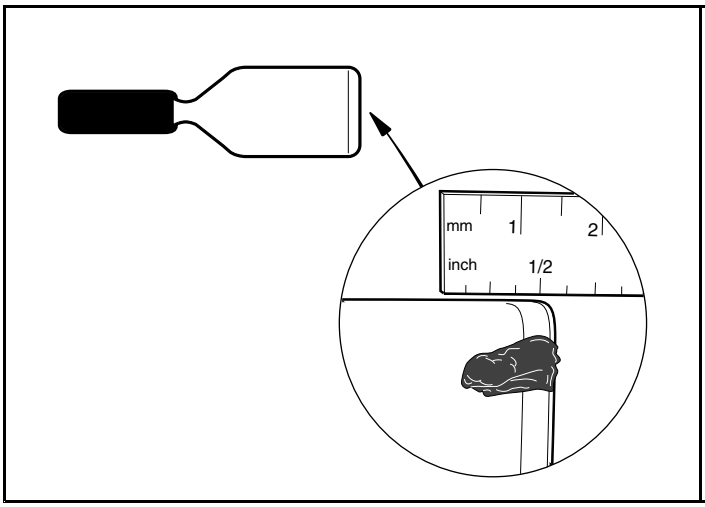
2.1. Squeeze approximately 1/2 inch (1.3 cm) of moly-teflon lubricant from tube onto a putty knife as shown **(Figure 23-20, Page 23-15)**.

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 23-21, Page 23-15)**.

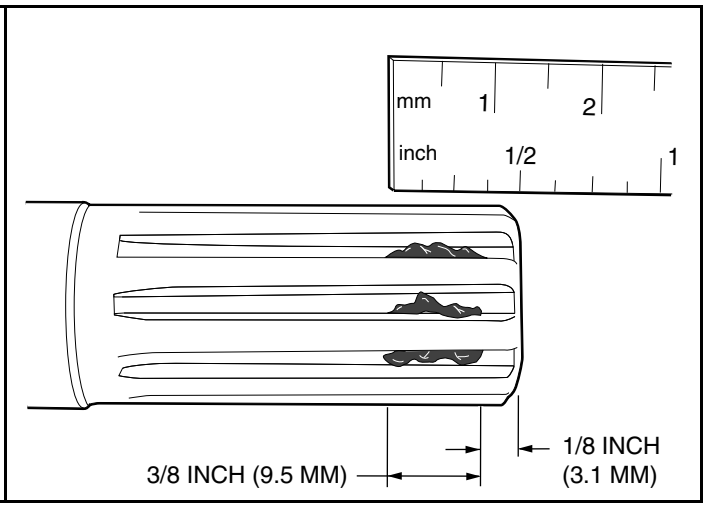
2.4. The grease should be evenly distributed in the grooves to a width of approximately 3/8 inch (9.5 mm).

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 23-20 Grease on Putty Knife



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Figure 23-21 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 23-22, Page 23-16)**.

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 23-15, Page 23-12)**. **See following NOTE.**

NOTE: *The motor coupling and the new molded bumper must be free of grease and debris.*

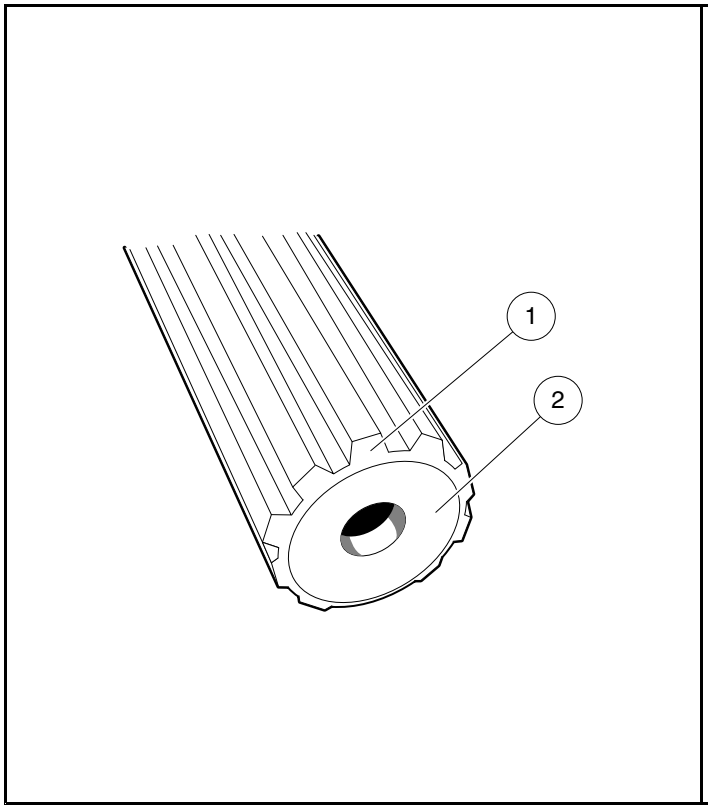
3.2. Ensure that the installed bumper is seated at the bottom of the coupling.

4. Install motor on transaxle.

4.1. Slide the motor coupling onto the transaxle input shaft. **See following NOTE.**

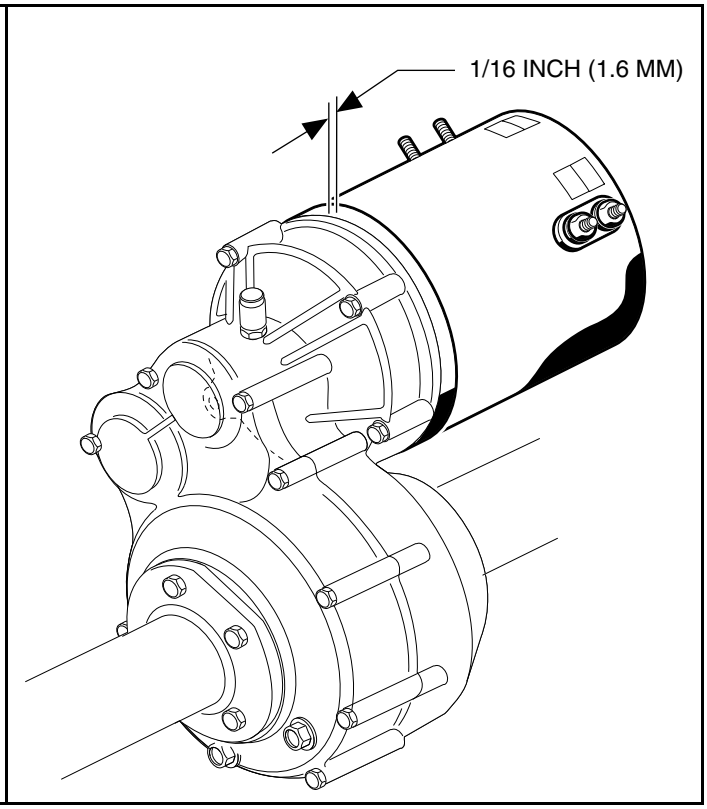
NOTE: *The coupling will push any excess grease on the input shaft along the shaft toward the transaxle.*

When the motor is pushed onto the input shaft, the motor housing will not bottom out against the transaxle housing ***(Figure 23-15, Page 23-12)****. There will be approximately 1/16 inch (1.6 mm) gap between the motor adapter ring and transaxle housing as shown* ***(Figure 23-23, Page 23-16)****.*



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Figure 23-22 Clean Chamfer and Input Shaft End



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Figure 23-23 Gap at Motor and Transaxle

4.2. Loosely install the three bolts and lock washers that secure the motor to the transaxle **(Figure 23-24, Page 23-17)**. 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 lb·in (11.3 N·m).

4.5. Tighten the left and right bolts (1 and 2) to 100 lb·in (11.3 N·m).

4.6. Retighten all three bolts (1, 2 and 3) to 100 lb·in (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 12-5.** 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 lb·in (11 N·m). For 1/4 inch (6.3mm) diameter studs, tighten the nuts to 45 lb·in (5.0 N·m).

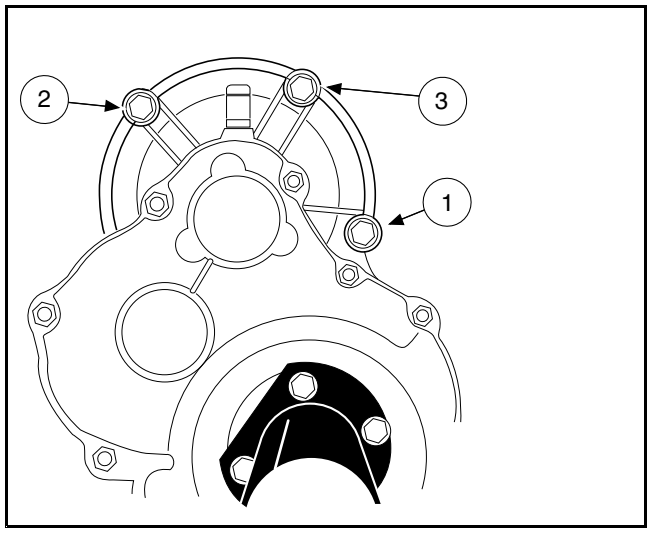
4.8. Secure the white, orange, green, and blue wires with a wire tie so that none of the motor wires will scrub the motor or transaxle when the vehicle is in operation.

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 lb·ft (31 N·m). **See Leaf Spring Installation (Two-Passenger) on page 9-7. See Leaf Spring Installation (Four-Passenger) on page 9-10.**
7. Install the shock absorbers. Tighten nut until rubber bushing expands to the diameter of the cup washer.
8. ***Lifted Vehicles:*** Install the panhard. **See Panhard and Bracket Installation on page 9-4.**
9. If removed, install wheels and finger tighten the lug nuts.
10. Lift vehicle and remove jack stands. Lower vehicle to the floor and tighten lug nuts, using a crisscross pattern, to 55 lb·ft (74.6 N·m).
11. Connect the batteries. **See Connect the Batteries – Electric Vehicles, Section 1, Page 1-5.**
12. Place the Run/Tow switch in the RUN position.
13. 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 switch is in the FORWARD position.**
- **Make sure that the vehicle operates in the reverse direction when the Forward/Neutral/Reverse switch is in the REVERSE position. The multi-purpose buzzer will sound as a warning when the Forward/Neutral/Reverse switch is in REVERSE.**
- **Make sure that the vehicle does not operate when the Forward/Neutral/Reverse switch is in the NEUTRAL position.**



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Figure 23-24 EJ8–4001A Motor Mounting Bolts and Tightening Sequence

Pagination Page

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

LUBRICATION

See General Warnings on page 1-2.

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 24-5, Page 24-3)**. 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 1-2.

AXLE SHAFT

Axle Shaft and Oil Seal Removal

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
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 1-2.**
3. Remove the rear wheel and brake drum. Section 6 — Wheel Brake Assemblies Section 8 — Wheels and Tires
4. Use 90° internal snap ring pliers to remove the internal retaining ring (6) from the axle tube **(Figure 24-5, Page 24-3)**. **See also Figure 24-1, Page 24-2.**
5. Remove the axle, 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 24-2, Page 24-2)**. **See following CAUTION and NOTE.**

CAUTION

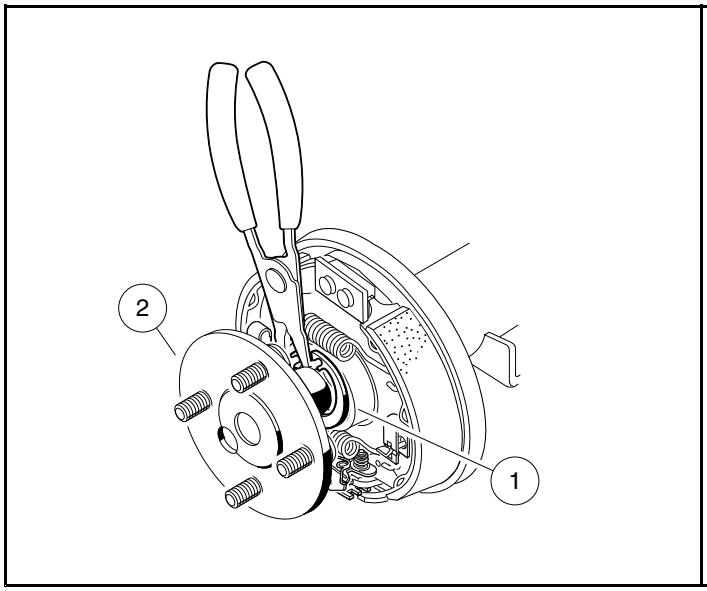
- **Do not scar or damage the inside surfaces of the tube when removing the oil seal and adapter ring. A damaged tube might have to be replaced.**

NOTE: *Do not discard the adapter ring. If the adapter ring is lost or damaged, the axle tube will have to be replaced. Varying rear axle configurations have been installed on vehicles. If replacing axle tubes, take note of individual axle tube lengths to ensure proper fit.*

6.2. Use a press to separate the axle oil seal (15) from the adapter ring (39) **(Figure 24-3, Page 24-2)**. Retain the adapter ring and discard the oil seal.

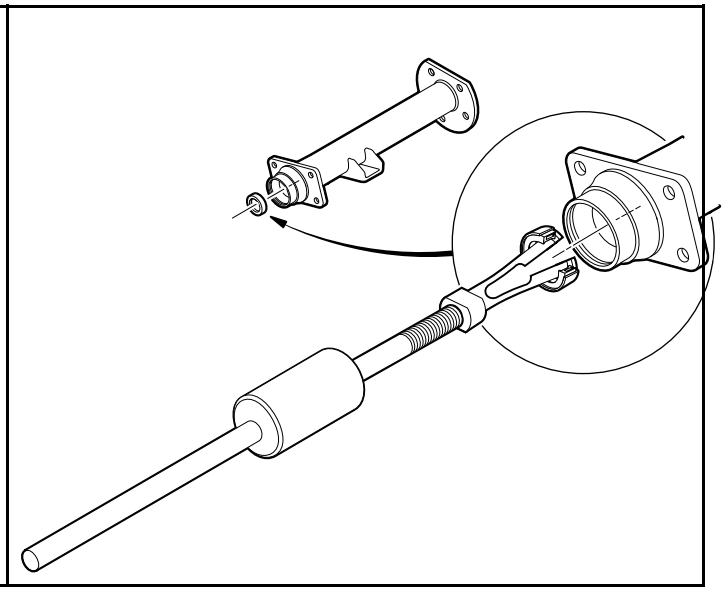
7. Inspect the axle shaft assembly to be sure the bearing and collar have not slipped and are still seated against the shoulder on the axle shaft.

8. Inspect bearing (5) **(Figure 24-5, Page 24-3)**. If the bearing in a Type G transaxle is worn or damaged, the entire axle shaft assembly (1 or 2) must be replaced.



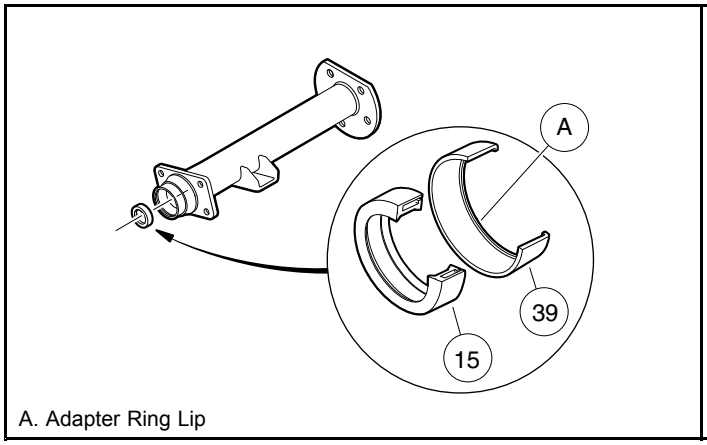
762

Figure 24-1 Remove Internal Retaining Ring



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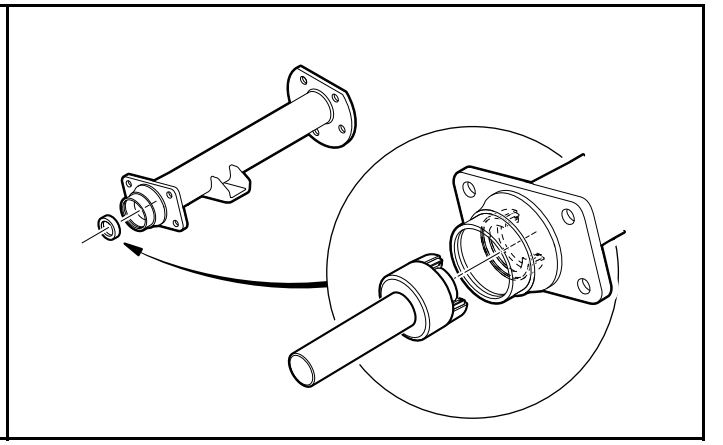
Figure 24-2 Axle Seal and Adapter Ring Removal



A. Adapter Ring Lip

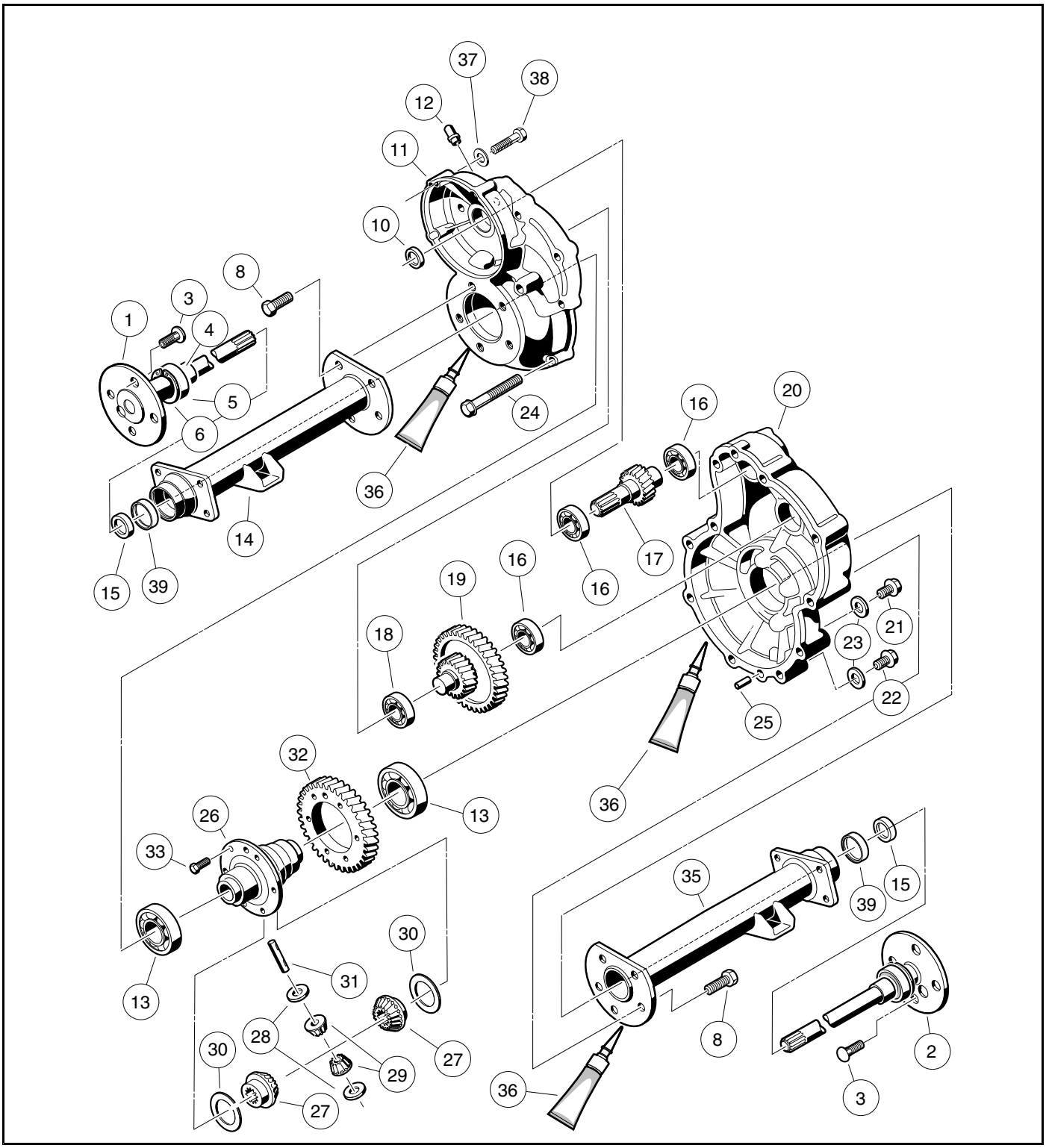
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Figure 24-3 Axle Seal and Adapter Ring



765

Figure 24-4 Axle Seal and Adapter Ring Installation



766

Figure 24-5 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 24-3, Page 24-2)**.

1.2. Place a new seal (15) in the adapter ring with the seal lip facing toward the adapter ring lip **(Figure 24-3, Page 24-2)**. Use an axle seal tool and mallet to tap it in until it seats firmly in position **(Figure 24-3, Page 24-2)**. A hydraulic press may also be used with the axle seal tool.

1.3. Clean adapter ring seat in the axle tube (14 or 35) **(Figure 24-5, Page 24-3)**.

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 24-4, Page 24-2)**. 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 24-5, Page 24-3)**. 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 24-5, Page 24-3)**.

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 24-5, Page 24-3)**.*

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.

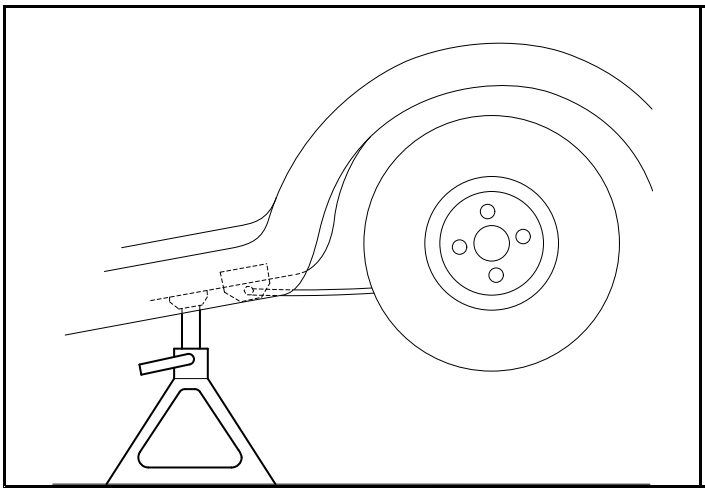
AXLE BEARING

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 24-5, Page 24-3)**.

TRANSAXLE REMOVAL

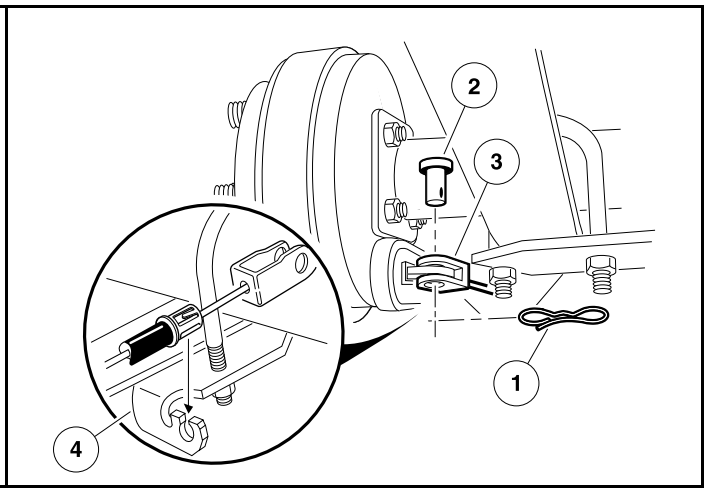
See General Warnings on page 1-2.

1. Disconnect the batteries and discharge the controller. **See Disconnect the Batteries – Electric Vehicles on page 1-4.**
2. Place chocks at the front wheels and slightly loosen lug nuts on both rear wheels. **See WARNING "Lift only one end..." in General Warnings on page 1-2.**
3. Place a floor jack under the transaxle and raise the rear of the vehicle. Position jack stands under the aluminum frame rails forward of the spring mount. Lower the vehicle to let the jack stands support the vehicle **(Figure 24-6, Page 24-5)**. **See WARNING "Lift only one end of the vehicle..." in General Warnings on page 1-2.**
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) and brake cable clevis pins (3). Use the brake cable release tool to compress tangs on cable end and remove cable end from bracket (4) **(Figure 24-7, Page 24-5)**.



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Figure 24-6 Vehicle Supported on Jack Stands



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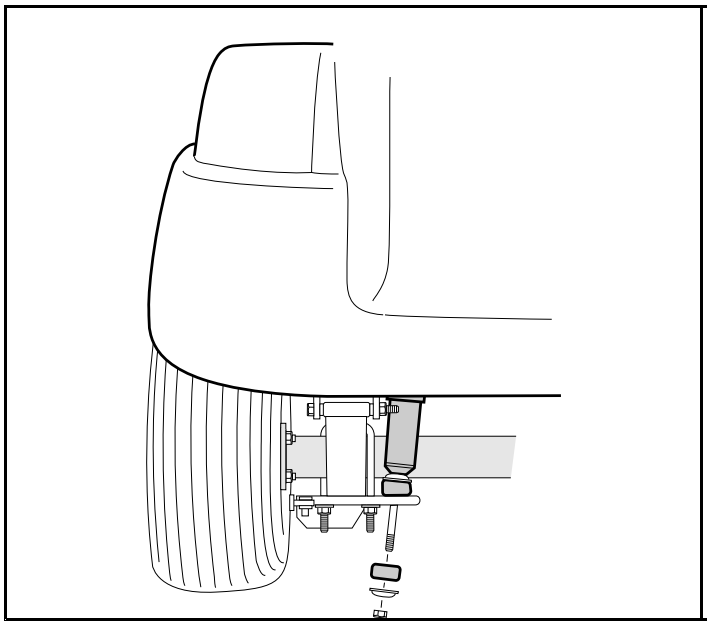
Figure 24-7 Brake Cable

6. Disconnect the shock absorbers from their lower mounts **(Figure 24-8, Page 24-6)**.
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. Position shackles so they are clear of springs **(Figure 24-9, Page 24-6)**.
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 (1) **(Figure 24-11, Page 24-6)** securing the motor to the transaxle. **See following CAUTION.**

⚠ CAUTION

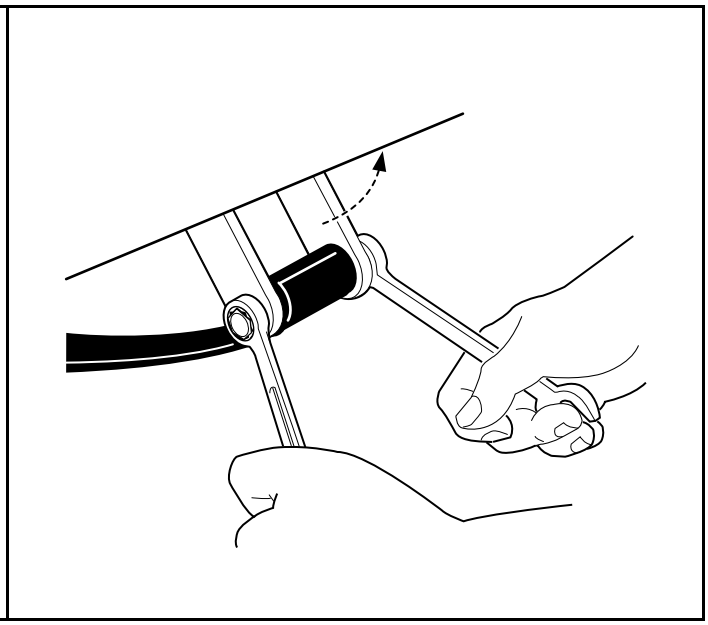
- **Do not position fingers under motor when sliding motor off of the input shaft. Fingers may get pinched when motor disengages.**

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.**



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Figure 24-8 Disconnect Shocks



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Figure 24-9 Shackles

12. If a floor jack was used, pull floor jack from beneath the transaxle and allow the springs to rest on the floor.
13. ***Lifted Vehicles:*** Remove the panhard. **See Panhard and Bracket Removal on page 9-4.**
14. Remove the U-bolts attaching the transaxle to the leaf springs **(Figure 24-10, Page 24-6)**.
15. 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.
16. Drain the lubricant from the transaxle and remove the axle shafts. **See Axle Shaft Removal on page 17-2. See following NOTE.**

NOTE: *Recycle or dispose of used oil or lubricant in accordance with local, state, and federal regulations.*

17. Remove the brake assemblies if required. **See Brake Cluster Removal on page 6-12.**

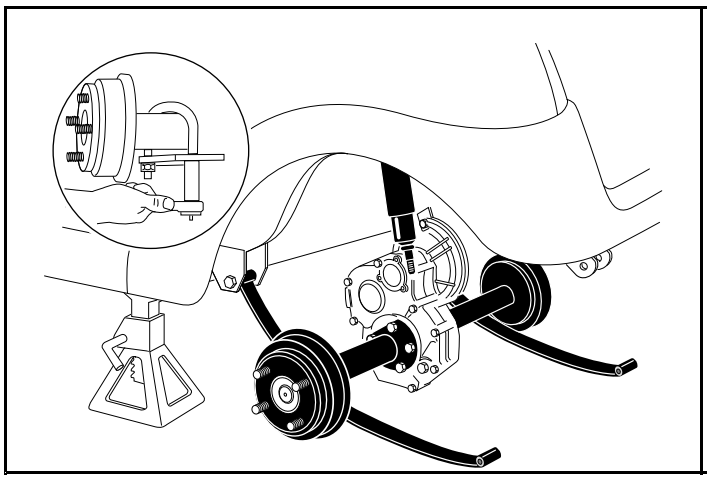
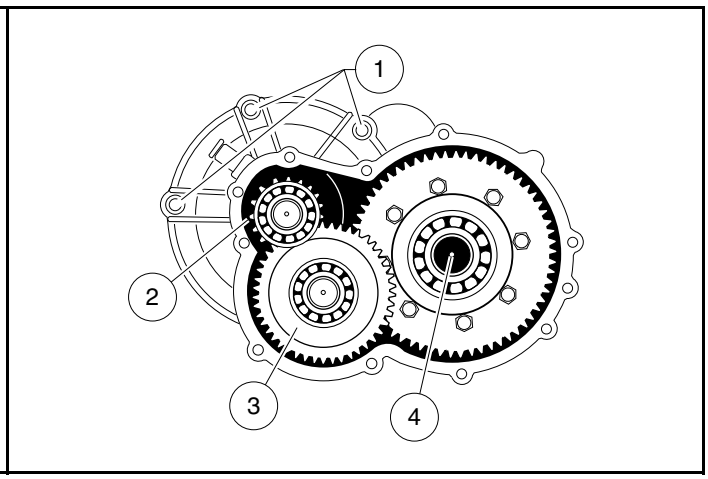


Figure 24-10 Leaf Springs



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Figure 24-11 Motor Mounting Bolts

TRANSAXLE DISASSEMBLY, INSPECTION, AND ASSEMBLY

See General Warnings on page 1-2.

TRANSAXLE DISASSEMBLY AND INSPECTION

1. To detach axle tubes (14 and 35) from the transaxle housing, remove the bolts (8) **(Figure 24-5, Page 24-3)**.
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 24-5, Page 24-3)**. **See following CAUTION.**

CAUTION

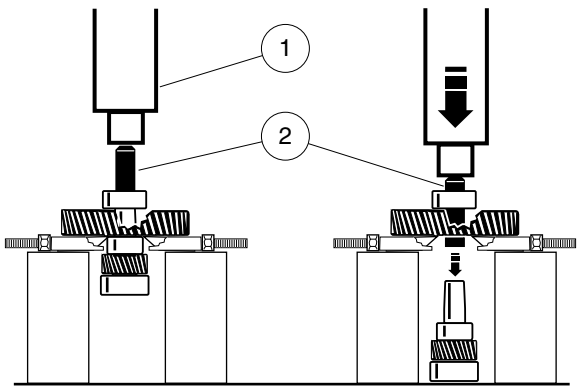
- **Do not damage gears. Use extreme care when handling them.**

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 24-5, Page 24-3)**. **See also Figure 24-12, Page 24-7. 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 24-5, Page 24-3)**. **See also Figure 24-12, Page 24-7.**
7. Press the bearing (18) off the intermediate gear assembly **(Figure 24-5, Page 24-3)**.



1. Press Ram 2. Arbor

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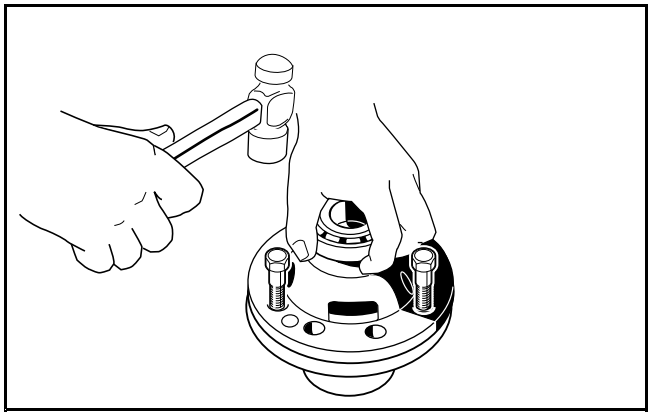
Figure 24-12 Intermediate Gear Assembly

8. Disassemble the differential gear case:

8.1. Remove the hex bolts (33) and the ring gear (32) from the differential case **(Figure 24-5, Page 24-3)**.

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 24-13, Page 24-8)**. Remove the two bolts.

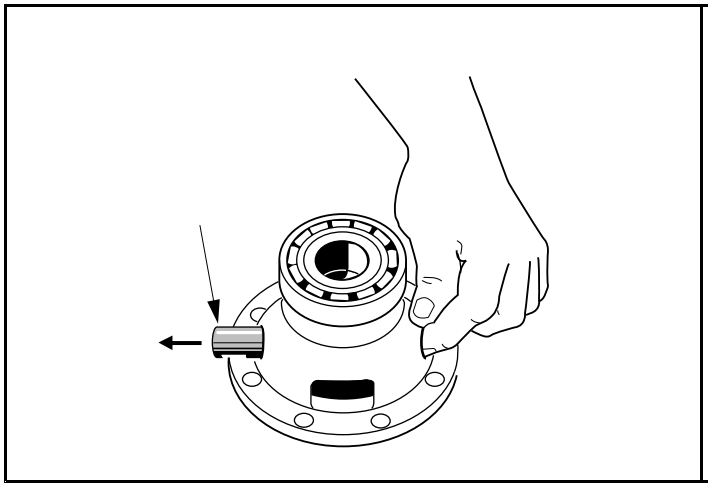


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Figure 24-13 Separate Housing

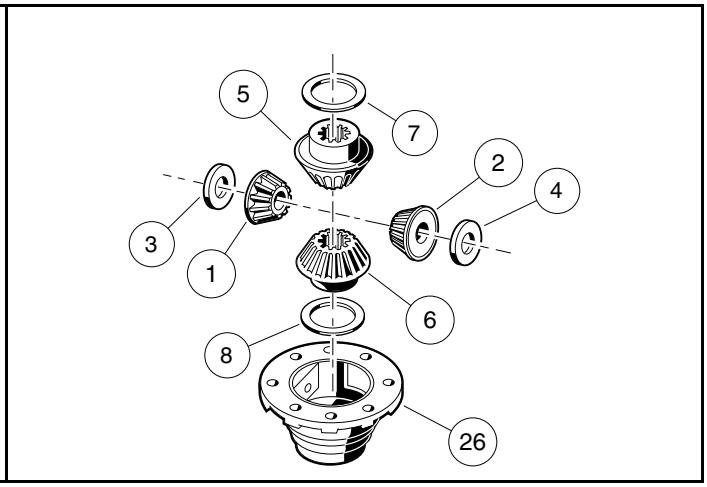
8.4. Remove the differential pin (31) by pushing pin through differential gear case from one side **(Figure 24-5, Page 24-3)**. **See also Figure 24-14, Page 24-8.**

8.5. Remove the idler gears (1 and 2) and thrust plates (3 and 4) **(Figure 24-15, Page 24-8)**.



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Figure 24-14 Differential Pin



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Figure 24-15 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 24-5, Page 24-3)**. 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 24-5, Page 24-3)**.
2. Assemble the differential gear case.

2.1. Install the pin (31) **(Figure 24-5, Page 24-3)**. 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 lb·ft (78.6 N·m).

3. Press a new bearing (18) onto the intermediate gear assembly **(Figure 24-5, Page 24-3)**.
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 (4), the intermediate gear assembly (3), and the input pinion gear (2) simultaneously. Be sure all bearings are seated properly in the housing. Rotate the input shaft to check for smooth gear operation **(Figure 24-11, Page 24-6)**.
7. Install dowel pin (25) (if originally installed) in the transaxle housing (20) **(Figure 24-5, Page 24-3)**.
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 24-5, Page 24-3)**.

8.3. Install bolts (24) in the case housing and tighten to 19 lb·ft (25.7 N·m). Type G transaxles have no shims or gasket.

8.4. Install axle tube (14 and 35) with bolts (8) **(Figure 24-5, Page 24-3)**. Tighten the bolts to 37 lb·ft (50.2 N·m).

9. Install the brake assemblies as instructed. **See Brake Cluster Installation on page 6-14.**
10. Apply a small amount of grease to the lip of the oil seal (15) **(Figure 24-5, Page 24-3)**. **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 24-5, Page 24-3)**.

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 lb·ft (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 lb·ft (31 N·m).

TRANSAXLE INSTALLATION

See General Warnings on page 1-2.

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, lock washers, and nuts. Tighten the nuts to 25 lb·ft (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 16-4.**
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 motor wires, making sure they are connected to the correct motor terminals and that the terminal orientation is correct. 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 lb·in (11 N·m). For 1/4 inch (6.3mm) diameter studs, tighten the nuts to 45 lb·in (5.0 N·m). **See following NOTE.**

NOTE: *If the motor wires were not tagged when disconnected, refer to the wiring diagram for proper connection.* ***See Fuse and Relay Locations on page 12-5.***

7. Insert bolts through the spring shackles and bushings in the leaf spring eyes. Secure bolts with lock nuts. Tighten to 18.5 lb·ft (25 N·m).
8. Connect the brake cables using new bow tie pins (1) **(Figure 24-7, Page 24-5)**.
9. Install the shock absorbers. Tighten shock absorber retaining nuts until the rubber bushings expand to the same size as the cup washers.
10. ***Lifted Vehicles:*** Install the panhard. **See Panhard and Bracket Installation on page 9-4.**
11. Install the rear wheels and finger-tighten the lug nuts.
12. Lift the vehicle and remove the jack stands.
13. Lower vehicle and tighten the lug nuts, using a crisscross pattern, to 55 lb·ft (74.6 N·m).
14. Place the Run/Tow switch in the TOW position and connect the batteries. **See Connect the Batteries – Electric Vehicles on page 1-5.**
15. 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 switch is in the FORWARD position.**
- **Make sure that the vehicle operates in the reverse direction when the Forward/Neutral/Reverse switch is in the REVERSE position. The multi-purpose buzzer will sound as a warning when the Forward/Neutral/Reverse switch is in REVERSE.**
- **Make sure that the vehicle does not operate when the Forward/Neutral/Reverse switch is in the NEUTRAL position.**

Pagination Page

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

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.

TRANSAXLE IDENTIFICATION

The transaxle serial number is located on a bar code decal installed on the axle tube (Example: ED65XX00FO1234567890). The ninth and tenth digits idenify the type of transaxle.

- FO - Open Differential
- FD - Limited Slip Differential

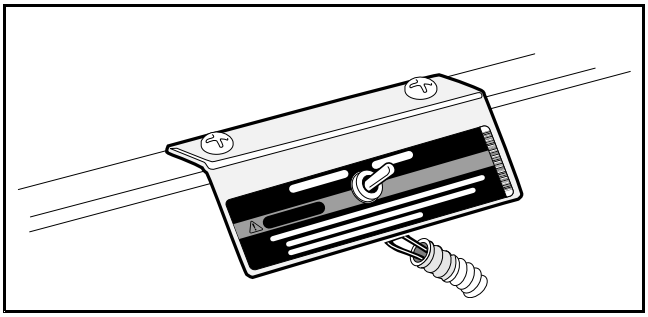
SHIFTER LEVER

A shifter lever, connected to a shifter arm, is used to change the gears to one of three shift positions: forward (F), neutral (N), or reverse (R). Bring the vehicle to a complete stop before changing F or R direction.

MAINTENANCE/OPERATE SWITCH

⚠ WARNING

- **With the switch in the MAINTENANCE position and the engine running, the vehicle may move suddenly if the Forward/Neutral/Reverse handle 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.**



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Figure 25-1 MAINTENANCE/OPERATE Switch

The maintenance/operate switch is used by a trained technician to do certain maintenance functions with the engine on.

NOTE: *Make sure that the Maintenance/Operate switch is set to OPERATE after the vehicle is serviced.*

POSITION	DESCRIPTION
OPERATE	Normal Operation The engine will not operate in neutral.
MAINTENANCE	The engine will operate in neutral (N). The vehicle will not operate in the forward (F) or reverse (R) position.

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 29-3.**

TRANSAXLE SERVICE

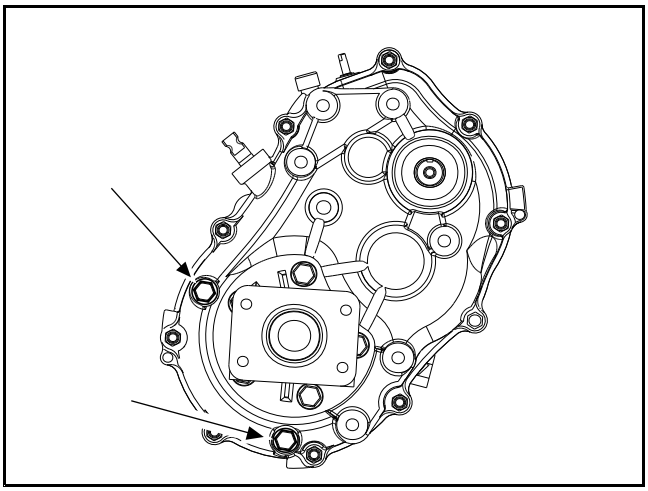
The transaxle is extremely durable and should require very little service under normal operating conditions. The only service required is to maintain proper lubricant level. **See Lubrication on page 25-2.** Under normal operating conditions, adjustment to the system should not be required.

LUBRICATION

There are two oil port plugs located on the right (driven clutch) side of the transaxle **(Figure 25-2, Page 25-3)**. 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.

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 lb·ft (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 lb·ft (23 N·m).



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Figure 25-2 Lubricant Level Plug and Drain Plug

TOOLS REQUIRED FOR THIS SECTION

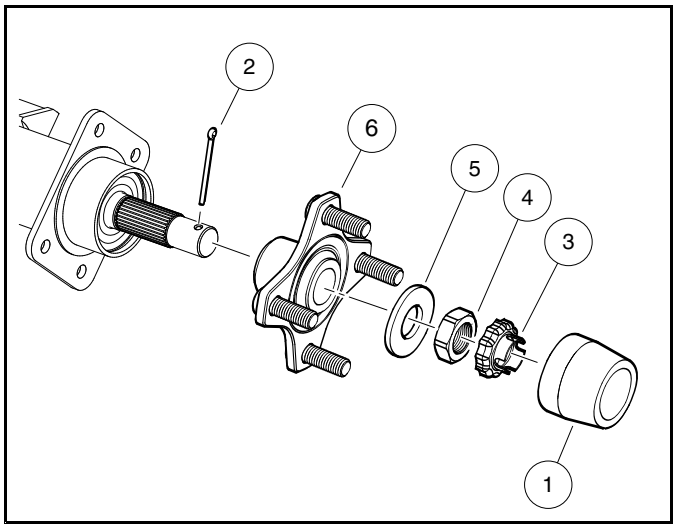
Hydraulic floor jack (or chain hoist)	Torque wrench, 3/8-in. drive	1/2-in. combination wrench
Jack stands (2) (one ton capacity)	3/8-in. socket, 3/8-in. drive	9/16-in. combination wrench
Standard slip joint pliers	7/16-in. socket, 3/8-in. drive	Small flat blade screwdriver
External snap ring pliers (.0.047- 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 handle in the NEUTRAL position.
2. Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
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 25-3, Page 25-4)**.
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 25-3 Rear Hub Exploded View

REAR HUB INSTALLATION

1. Inspect brake shoes for wear and replace if necessary. **See Wheel Brake Assemblies section.**

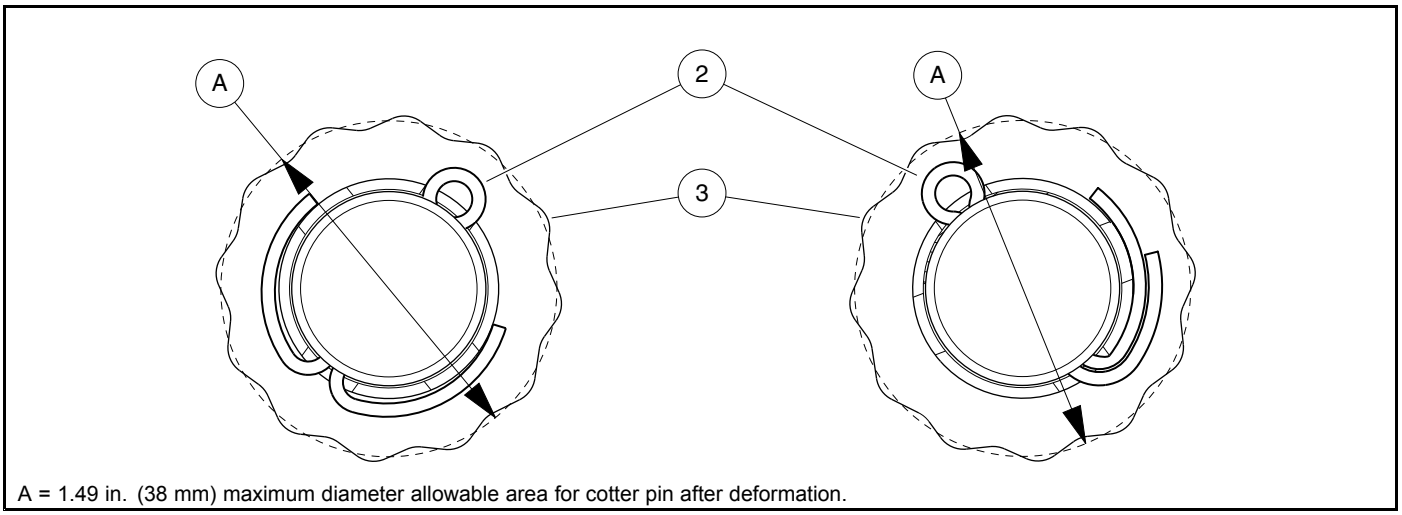
NOTE: *If brake shoes are replaced on one side, replace the opposite side also.*

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 25-3, Page 25-4)**.
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 lb·ft (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 lb·ft (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 25-4, Page 25-5)**. 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 lb·ft (88 N·m) using a crisscross pattern.
14. Connect battery and spark plug wire.
    See Connect the Battery - Gasoline Vehicles on page 1-4.



A = 1.49 in. (38 mm) maximum diameter allowable area for cotter pin after deformation.

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Figure 25-4 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 25-10.

NOTE: *The axle shaft oil seals (7) are located in the transaxle gearcase (4), not the axle tubes (2)* ***(Figure 25-7, Page 25-8)****. 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 25-5, Page 25-6)**.
3. Remove the differential guard from the transaxle.

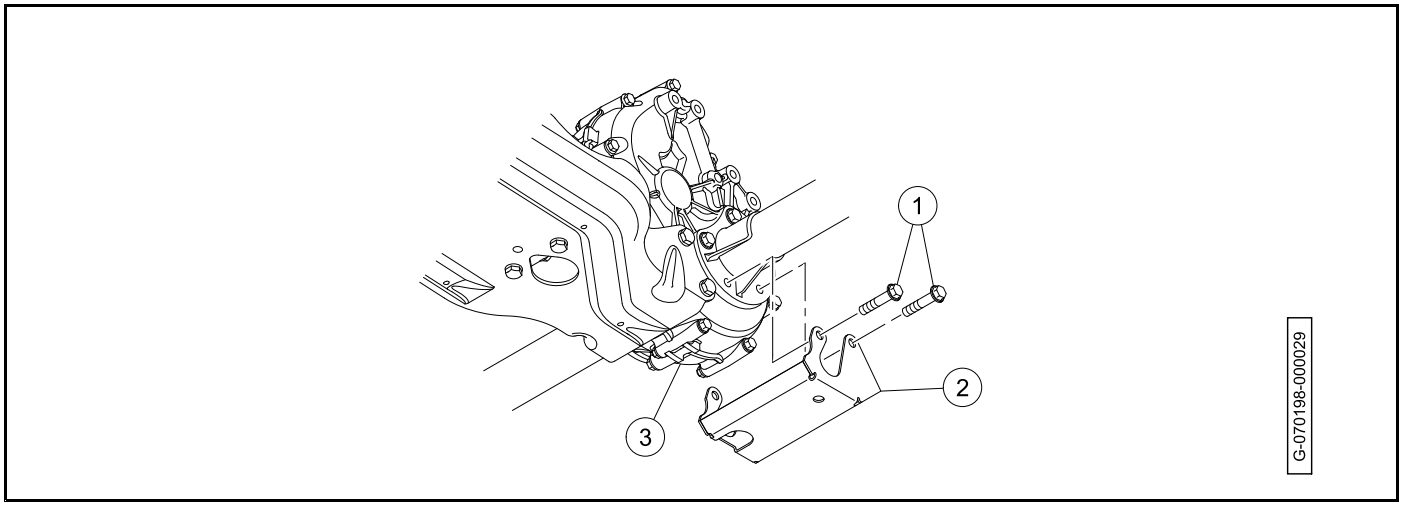


Figure 25-5 Differential Guard Removal

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 25-6, Page 25-7)**.

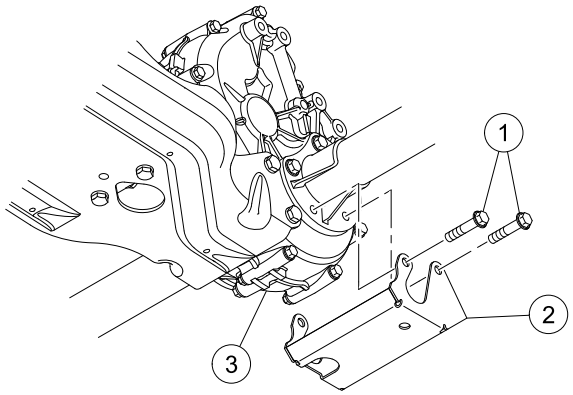


Figure 25-6 Differential Guard Installation

AXLE TUBE AND AXLE SHAFT REMOVAL

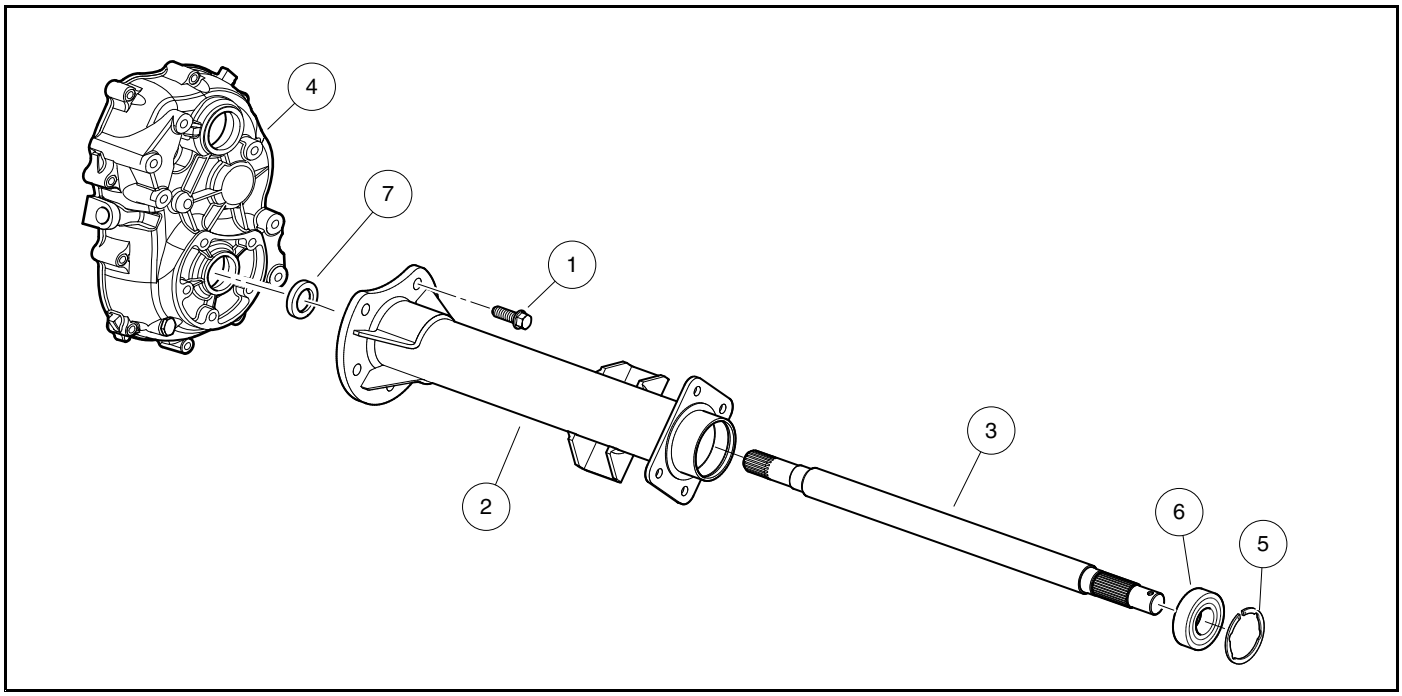
See General Warnings, Section 1, Page 1-2.

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 25-10. 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 25-4.**
5. Remove the five flange-head bolts (1) securing axle tube (2) to transaxle **(Figure 25-7, Page 25-8)**.
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 25-7 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 25-7, Page 25-8)**.
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 lb·ft (38 N·m).
5. Install hub. **See Rear Hub Installation on page 25-4.**
6. If entire transaxle was removed from vehicle, install transaxle. **See Transaxle Installation on page 25-13.**
7. Refill transaxle with appropriate type and volume of oil. **See Oil Change – Transaxle on page 25-2.**

REAR WHEEL BEARING REMOVAL

1. Remove hub. **See Rear Hub Removal on page 25-4.**
2. Remove axle tube (2) from transaxle. **See Axle Tube and Axle Shaft Removal on page 25-7.**
3. Remove the snap ring (5) that is in front of the bearing (6) and discard **(Figure 25-7, Page 25-8)**.

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 25-7, Page 25-8)**.
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 25-8.**
6. Install hub. **See Rear Hub Installation on page 25-4.**

AXLE SHAFT OIL SEAL REMOVAL

The rear axle tubes (2) must be unbolted from the transaxle to replace oil seals (7) **(Figure 25-7, Page 25-8)**.

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 25-7, Page 25-8)**. **See Axle Tube and Axle Shaft Removal on page 25-7.**
3. Pull oil seal (7) from gearcase (4).

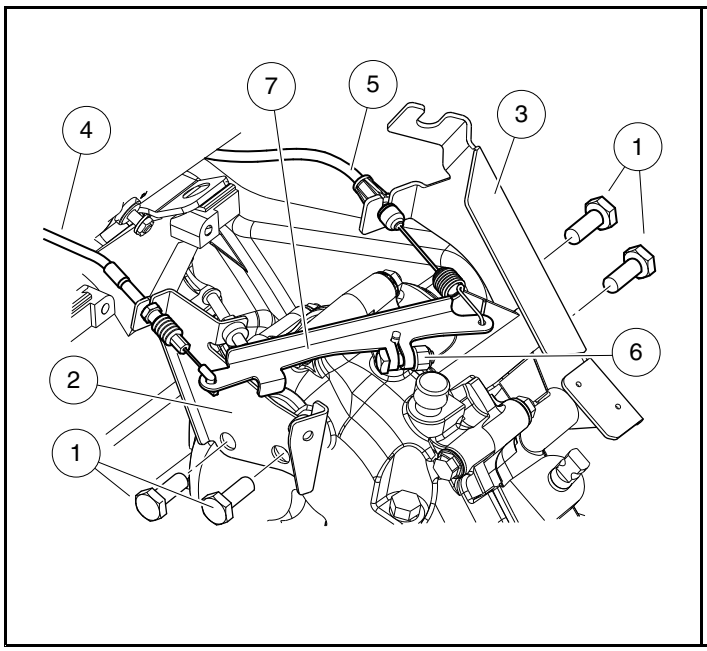
AXLE SHAFT OIL SEAL INSTALLATION

1. Clean bore in gearcase (4) where new oil seal (7) will sit **(Figure 25-7, Page 25-8)**.
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 25-8.**
4. Refill transaxle with appropriate type and volume of oil. **See Oil Change – Transaxle on page 25-2.**

TRANSAXLE REMOVAL

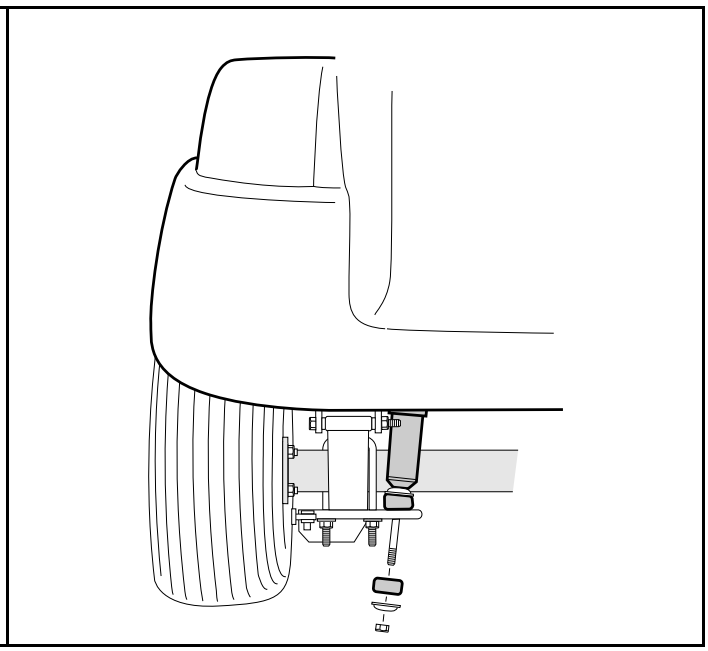
See General Warnings on page 1-2.

1. Turn the key switch to the OFF position and remove the key, and place the Forward/Neutral/Reverse handle in the NEUTRAL position.
2. Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
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 Kohler ECH440 - Fuel System, Section 29, Page 29-1.**
5. Disconnect gray 18-pin connector from ECU.
6. Disconnect engine ground cable lead from main wire harness.
7. 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 25-18, Page 25-15)**.
10. Remove bolts (1) securing governor cable bracket (2) and FNR/accelerator cable bracket (3) to transaxle **(Figure 25-8, Page 25-10)**. 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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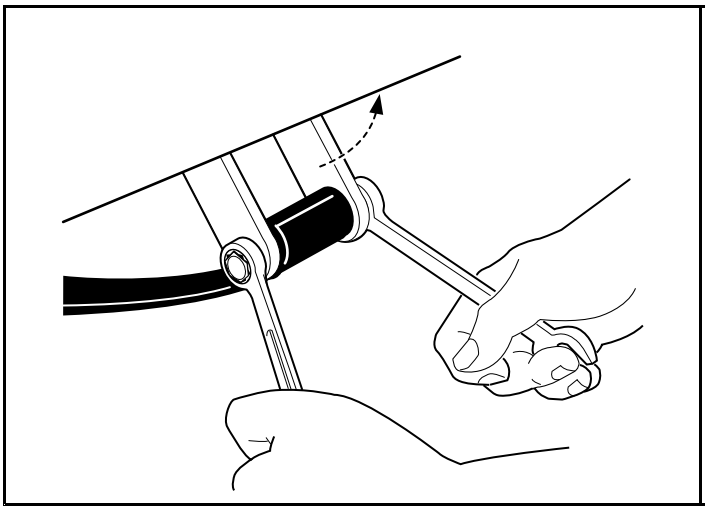
Figure 25-8 Governor Arm, Cable and Brackets



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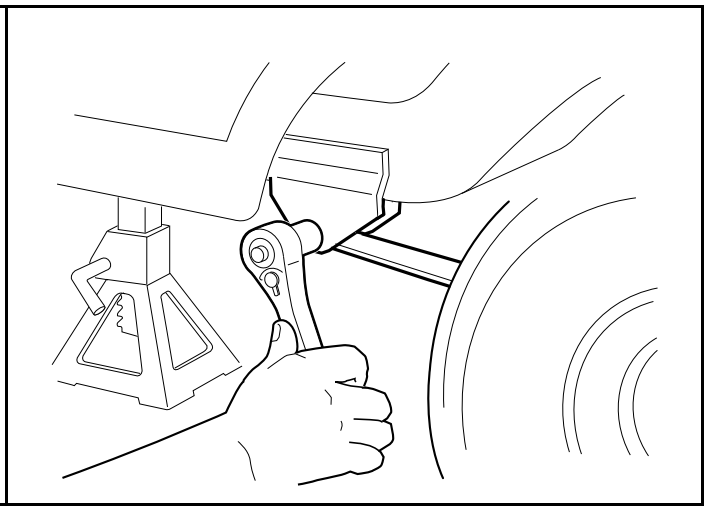
Figure 25-9 Disconnect Shock Absorbers

12. Disconnect brake cables from brake assemblies. **See Wheel Brake Assemblies section.**
13. Remove the panhard. **See Panhard and Bracket Removal on page 9-4.**
14. Remove lower shock mounting hardware from both rear shocks **(Figure 25-9, Page 25-10)**.



2700

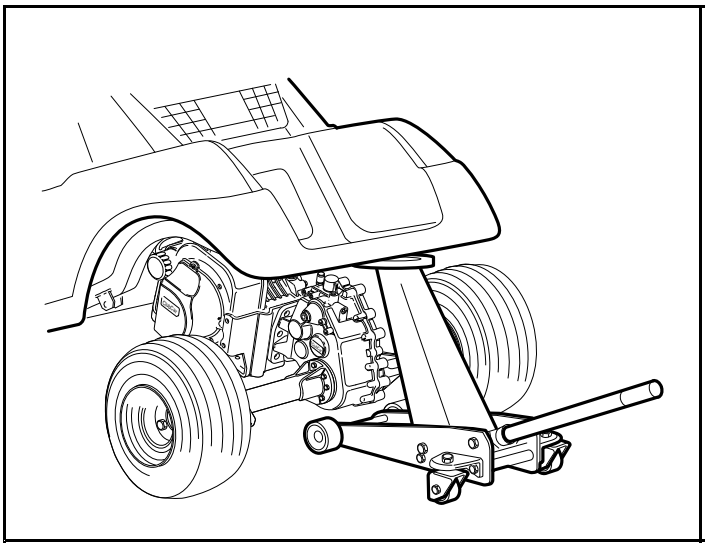
Figure 25-10 Disconnect Rear Shackles



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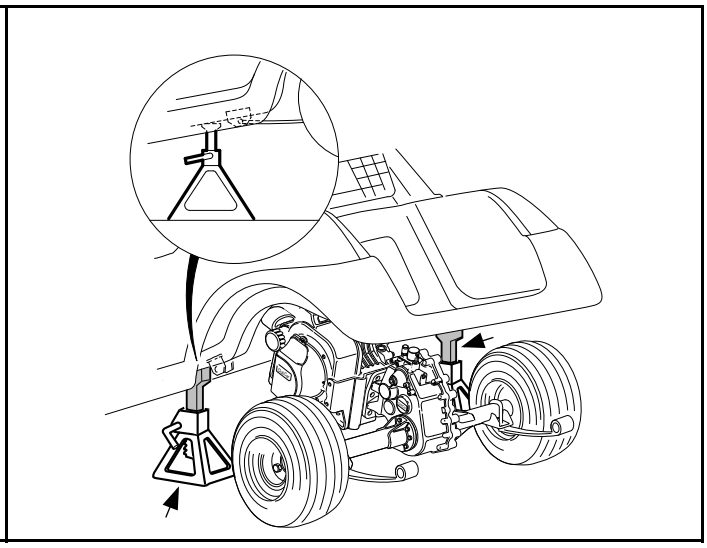
Figure 25-11 Disconnect Front of Leaf Spring

15. Position floor jack under rear crossmember of chassis or trailer hitch mount (if equipped) **(Figure 25-12, Page 25-11)**. **See WARNING "Lift only one end of the vehicle..." in General Warnings on page 1-2.**
16. Raise vehicle just enough to relieve weight on leaf springs, then remove bolts securing leaf springs to shackles **(Figure 25-10, Page 25-11)**.
17. Remove bolts securing front of leaf springs **(Figure 25-11, Page 25-11)**.



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Figure 25-12 Raise Vehicle



2403

Figure 25-13 Position Jack Stands On Both Sides of Frame

18. 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 25-12, Page 25-11)**. 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 **(Figure 25-13, Page 25-11)**. Lower the floor jack to allow the jack stands to support the vehicle.
19. Remove floor jack from beneath vehicle.
20. 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 . The powertrain should be completely disconnected from vehicle and resting on floor.

21. Roll powertrain out from under vehicle.
22. Place blocks under the engine pan so they will completely support the engine and keep it **level to the floor (Figure 25-14, Page 25-12)**. **See following NOTE.**

NOTE: *Place the blocks so they will support the engine when the transaxle is detached and moved away from the powertrain.*

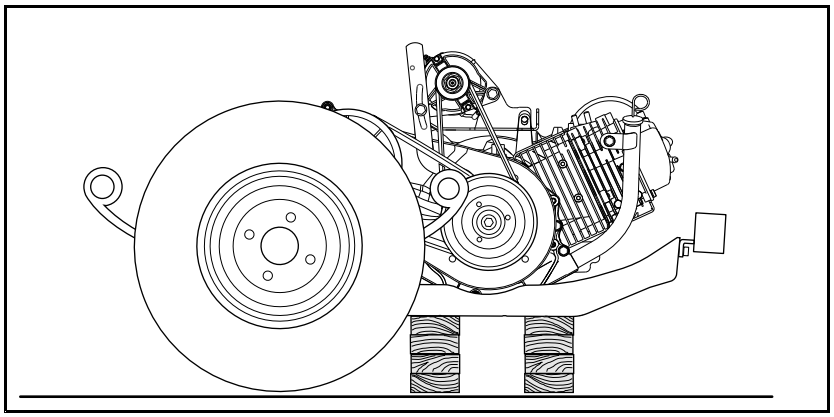
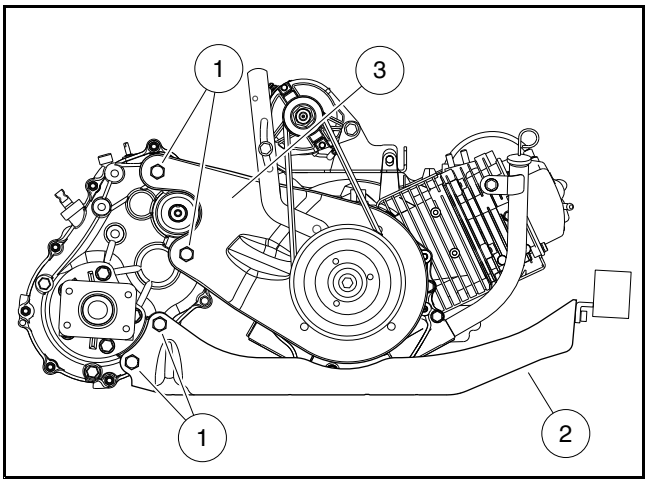


Figure 25-14 Remove Powertrain and Place Wood Blocks Under Engine Pan

23. Remove oil drain plug and drain all oil from transaxle. Dispose of gear oil properly.
24. Remove driven clutch. **See Driven Clutch Removal, Section 31, Page 31-13.**
25. Remove eight bolts (1) total that secure transaxle to powertrain **(Figure 25-15, Page 25-13)** at the following locations:
    – Four bolts (1) at engine pan (2).
    – Two bolts (1) at clutch plate (3).
    – Two bolts (1) at muffler bracket.
26. Roll transaxle from engine pan (2). **See following NOTE.**

NOTE: *The transaxle weighs approximately 58 lb (26.2 kg).*

27. 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 25-15 Transaxle Mounting Bolts

TRANSAXLE INSTALLATION

See General Warnings on page 1-2.

1. Installation is reverse of removal procedure. When attaching transaxle to powertrain, initially install the eight bolts (1) finger-tight **(Figure 25-15, Page 25-13)**. Then, tighten fasteners in the following order:

1.1. Tighten the two bolts (1) at clutch plate (3) to 50 lb·ft (68 N·m).

1.2. Tighten the four bolts (1) at engine pan (2) to 50 lb·ft (68 N·m).

1.3. Tighten the two bolts (1) at muffler bracket to 50 lb·ft (68 N·m).

1.4. Tighten the governor cable bracket (2) and FNR/accelerator cable bracket (2) bolts to 50 lb·ft (68 N·m) **(Figure 25-8, Page 25-10)**.

1.5. Tighten leaf spring hardware to 19 lb·ft (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 lb·ft (23.5 N·m).

2. Fill transaxle with appropriate type and volume of oil. **See Oil Change – Transaxle on page 25-2.**
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 29, Page 29-3.**
6. Check engine RPM setting. Adjust if necessary. **See Engine RPM Adjustment, Section 29, Page 29-9.**

FORWARD/NEUTRAL/REVERSE HANDLE

FORWARD/NEUTRAL/REVERSE HANDLE REMOVAL

1. Remove the bolt (1) from the Forward/Neutral/Reverse handle (2) **(Figure 25-16, Page 25-14)**.
2. Remove the bolts (3) from the bezel (4).
3. Remove the bezel.

FORWARD/NEUTRAL/REVERSE HANDLE INSTALLATION

1. Install the bezel (4) and the bolts (3). Tighten the bolts to 22 lb·in (2.5 N·m) **(Figure 25-16, Page 25-14)**.
2. Install the Forward/Neutral/Reverse handle (2).
3. Install the bolt (1). Tighten the bolt to 15 lb·in (1.5 N·m).

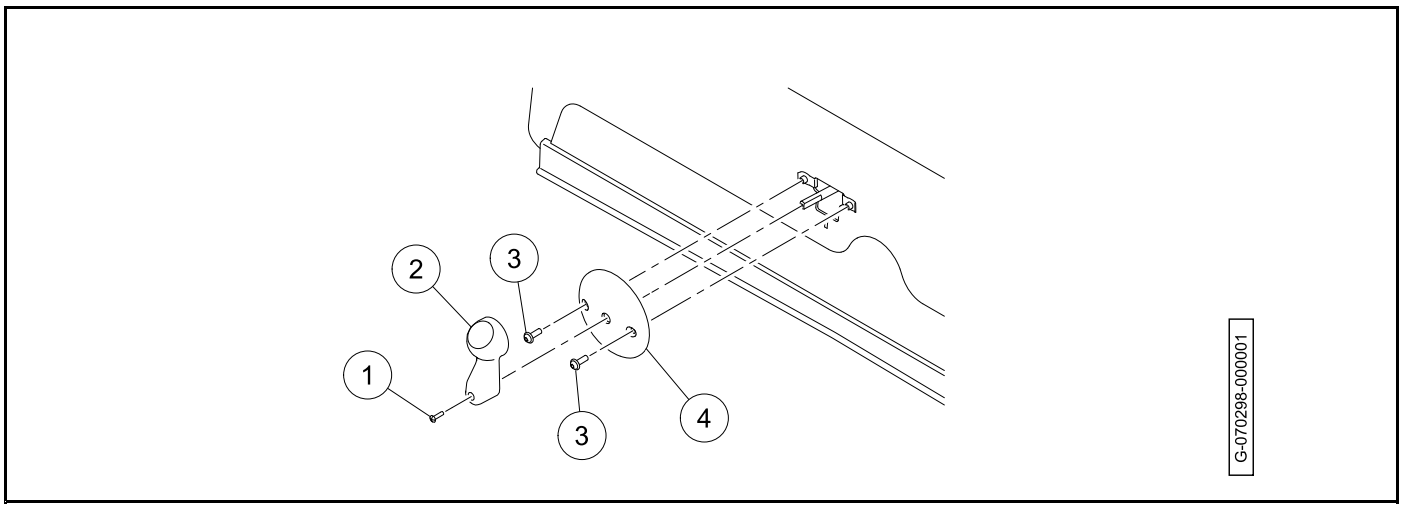


Figure 25-16 Forward/Neutral/Reverse Handle

SHIFTER CABLE

See General Warnings on page 1-2.

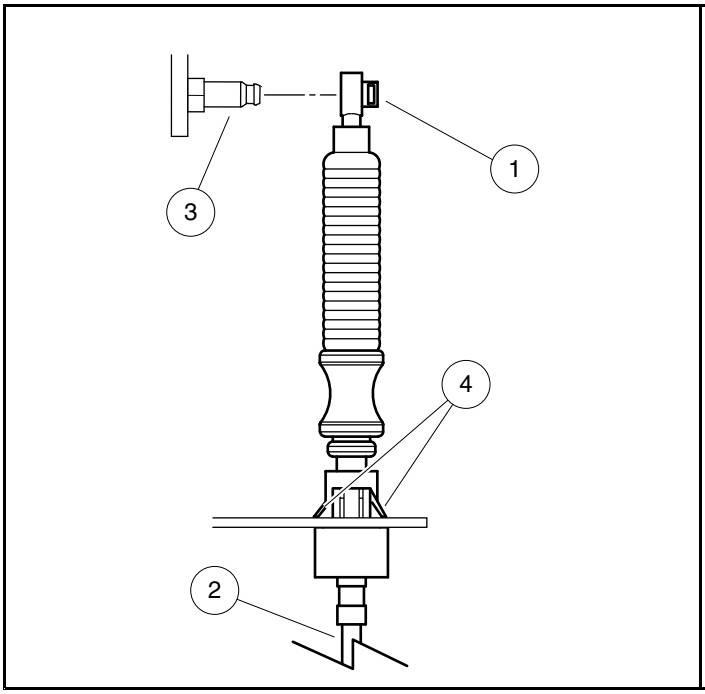
If the Forward/Neutral/Reverse shifter cable is damaged in any way, it must be replaced.

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.*

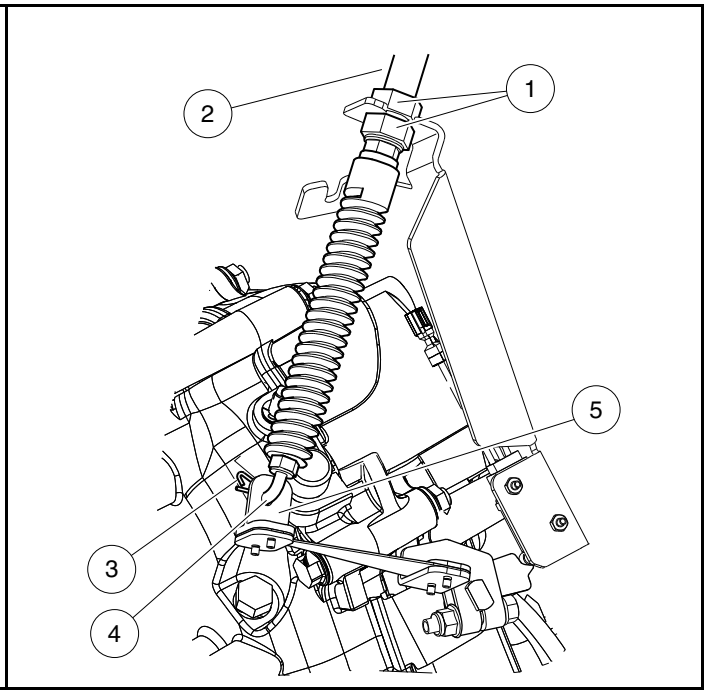
1. Turn the key switch to the OFF position and remove the key. Place the Forward/Neutral/Reverse handle in the NEUTRAL position and chock the wheels.
2. Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**

3. Push the cable end socket (1) off the stud (3) on the Forward/Neutral/Reverse shifter handle **(Figure 25-17, Page 25-15)**.
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 25-18, Page 25-15)**. 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 25-17 Shifter Cable at FNR Handle



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Figure 25-18 Shifter Cable at Transaxle

SHIFTER CABLE INSTALLATION

1. Install shifter cable (2), routing it exactly as it was originally, from Forward/Neutral/Reverse shifter handle to transaxle.
2. Place rear of cable (2) in FNR/accelerator cable bracket with a jam nut (1) on each side of bracket **(Figure 25-18, Page 25-15)**. Tighten jam nuts (1) to 22 lb·ft (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 25-17, Page 25-15)**.
5. Snap cable end socket (1) onto stud (3) of Forward/Neutral/Reverse shifter handle.
6. Secure shifter cable along chassis with wire ties if required.
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 handle 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 25-18, Page 25-15)**. Tighten jam nuts (6) to 22 lb·ft (29.8 N·m).

SECTION 26 — KOHLER ECH440 - TROUBLESHOOTING AND ELECTRICAL SYSTEM

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

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.

ACCESSORIES

For certain powered accessories, use the 9-pin connector located behind the instrument panel.

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

GROUND LOCATIONS

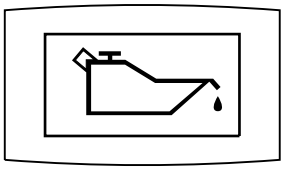
Electrical grounds are located at the following areas:

- **At the Battery:** The starter/generator, voltage regulator, ECU, throttle position sensor and fuel pump module all connect to the main wire harness and goes to the B– battery terminal.
- **Between Engine and Battery:** The engine and chassis each have a separate lead that connects to the main wire harness and goes to the B– battery terminal.
- **Top of Fuel Tank:** The fuel tank has a lead that connects to the main wire harness and goes to the B– battery terminal.

LOW OIL WARNING LIGHT

CAUTION

- **Failure to add oil immediately when the low oil warning light stays on may result in permanent engine damage.**

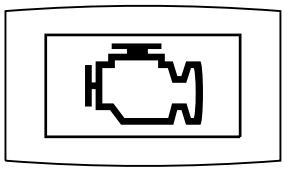


The low oil warning light gives a visual indication of an oil level problem.

Figure 26-1 Low Oil Warning Light

STATUS	CONDITION
OFF	Normal Operation
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



The malfunction indicator light (MIL) gives a visual indication of an engine fault. When the key switch is set to ON, the MIL will turn on for 3 seconds.

If an engine fault is sensed, the MIL will stay on. **See the Kohler Engine Service Manual for more information.**

TROUBLESHOOTING GUIDE

The following troubleshooting guides will be helpful in identifying operating difficulties should they occur. The guides include the symptom, probable cause 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**
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	See the Key Switch (Start Circuit) Test Procedure
	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 Throttle Position Switch Test Procedure
	Key switch failed	See the Key Switch (Start Circuit) Test Procedure
	Transaxle limit switch failed	See the Transaxle Limit Switch 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
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

TABLE CONTINUED ON NEXT PAGE

TROUBLESHOOTING GUIDE		
SYMPTOM	**POSSIBLE CAUSES**	**CORRECTIVE ACTION**
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.	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
Vehicle with Visage Only - Vehicle operates in reverse, but not forward.	Gas car stop module is bad.	1. Disconnect the main harness from the gas car stop module. 2. Connect the main harness directly to the pedal position sensor on the pedal. 3. If the vehicle operates in both forward and reverse, replace the gas car stop module. ***NOTE:*** *Visage will not operate correctly with the main harness connected directly to the pedal position sensor.*

FUSE AND RELAY LOCATIONS

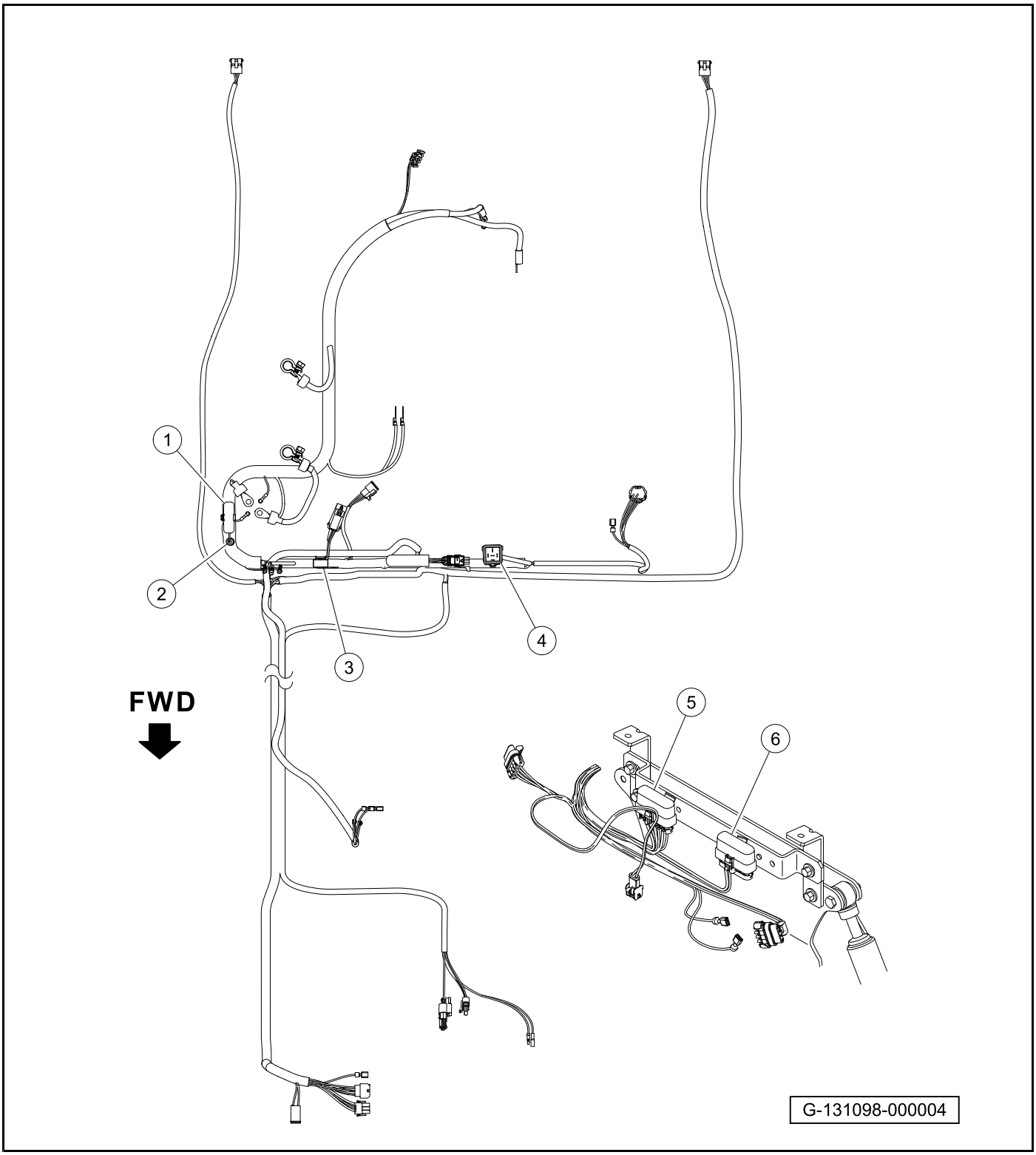


Figure 26-2 Fuse and Relay Locations

See Fuse and Relay Locations on page 26-5.

CALLOUT NUMBER	DESCRIPTION
1	Fuse Holder • 10A Fuse • 5A Fuse • 20A Fuse
2	2A Fuse
3	15A Fuse
4	Fuel Pump Relay
5	Fuse Holder • 7.5A Fuse - Stereo, Visage • 4A Fuse - Accent/Logo and Brake Lights • 3A Fuse - Headlights, Taillights
6	Fuse Holder • 10A Fuse - Horn, Turn Signal

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
- Multi-purpose 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 on page 26-7.**

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. The presence of voltage can cause inaccurate readings.

Index of Test Procedures

1 – Battery
2 – Fuse Inspection
3 – Ground Cables
4 – Key Switch (Start Circuit)
5 – Key Switch (Engine Kill Circuit)
6 – Throttle Position Sensor (TPS)
7 – Solenoid
8 – Maintenance/Operate Switch
9 – Transaxle Limit Switch
10 – Starter/Generator (Generator Function)
11 – Starter/Generator (Starter Function)
12 – Voltage Regulator
13 – Ignition Spark
14 – Multi-Purpose Buzzer and Multi-Purpose Buzzer Limit Switch
15 – Malfunction Indicator Light (MIL)
16 – Low Oil Warning Light (LED)
17 – Battery Test (Under Load)
18 – Fuel Pump
19 – Fuel Level Sending Unit
20 – Fuel Gauge
21 – Hour Meter
22 – 4-Pin Connector (to Visage)

TEST PROCEDURE 1 – Battery

⚠ 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 step 3.2.1.

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.

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.

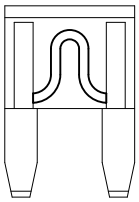
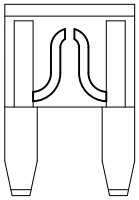
TEST PROCEDURE 2 – Fuse Inspection

See General Warnings on page 1-2.

⚠ WARNING

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

1. Disable the vehicle.
2. Remove the fuse.
3. Examine the fuse. Replace as necessary.

Good Fuse	 G-130998-000004
Blown Fuse	 G-130998-000005

TEST PROCEDURE 3 – Ground Cables

See General Warnings on page 1-2.

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:
   – Check the starter/generator ground cable (black wire) from A1 terminal to chassis or engine.
   – Check the engine ground cable from engine block to negative (-) main harness lead disconnected from battery.
   – Check the ground cable from main harness to negative (-) main harness lead disconnected from battery.
   – Disconnect voltage regulator from main harness. Check from black wire in 3-pin connector to negative (-) main harness lead disconnected from battery. This will test sonic weld _18 and sonic weld _1 in the main wire harness.
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.

TEST PROCEDURE 4 – Key Switch (Start Circuit)

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

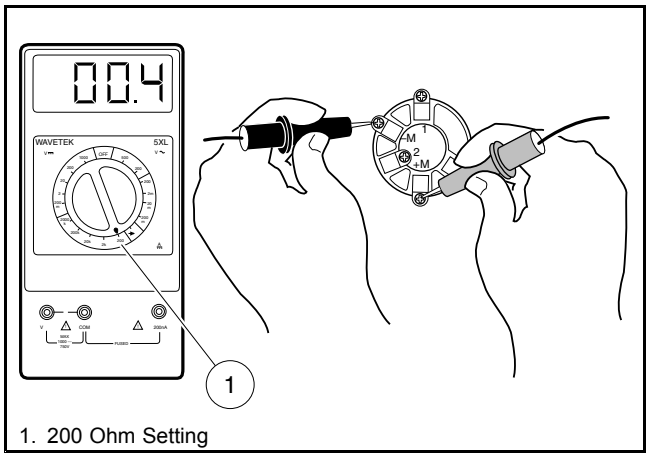
The key switch provides power and KEY INPUT to the ECU.

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 red wire should show battery voltage coming to the switch.
   – The blue 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 blue 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)

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 26-3, Page 26-12)**.



1. 200 Ohm Setting

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Figure 26-3 Key Switch Test – Engine Kill Circuit

6. Put the red (+) probe on the (+M) terminal.
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 – Throttle Position Sensor (TPS)

The throttle position sensor performs the function of two limit switches: the accelerator pedal limit switch and the kill limit switch. This sensor is sealed and is not to be repaired or replaced. If sensor is determined to need replacing through test procedures found in this manual, the accelerator pedal assembly must be replaced. See Accelerator Pedal Removal. The sensor is joined to the main wire harness through a six-pin connector. Tests for the sensor are found in the following two procedures.

Accelerator Pedal Limit Switch Function

See General Warnings on page 1-2.

The green and orange wires connect to the accelerator pedal limit switch function of the throttle position sensor. This is the normally open (NO) portion of the circuit used to energize the starter solenoid.

NOTE: *Keep the battery connected while performing this test procedure.*

1. Set the Maintenance/Operate switch to MAINTENANCE.
2. Disconnect the spark plug wire.
3. Disconnect gray 18-pin connector from ECU.
4. Set the multimeter to the diode test function.
5. Attach the red (+) lead to the orange wire at the starter solenoid.
6. Attach the black (-) lead to the green wire at the limit switch located on the Forward/Neutral/Reverse control (FNR). **See following NOTE.**

NOTE: *It may be necessary to partially pull the green wire from the switch terminal to attach the black lead.*

7. Turn the key switch to the ON position.
8. **With accelerator pedal in the up position:** The meter should indicate an over limit (no continuity) condition. If the reading is incorrect, replace the accelerator pedal assembly.
9. **With accelerator pedal pressed:** The meter should indicate approximately 1.0 volt. If the reading is incorrect, replace the accelerator pedal assembly.

Kill Limit Switch Function

See General Warnings on page 1-2.

The black and white/black wires connect to the kill limit switch function of the throttle position sensor. This is the normally closed (NC) portion of the circuit used to ground the ignition and shut the engine off when the pedal is released.

NOTE: *Keep the battery connected while performing this test procedure.*

1. Set the Maintenance/Operate switch to MAINTENANCE.
2. Disconnect the spark plug wire.
3. Disconnect gray 18-pin connector from ECU.
4. Set the multimeter to the diode test function.
5. Attach the red (+) lead to the negative (-) battery terminal.
6. Attach the black (-) lead to the white/black wire at the limit switch located on the Forward/Neutral/Reverse control (FNR). **See following NOTE.**

NOTE: *It may be necessary to partially pull the white/black wire from the switch terminal to attach the black lead.*

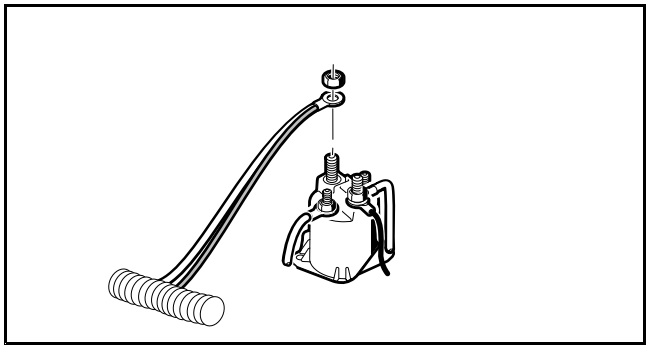
7. Turn the key switch to the ON position.
8. **With accelerator pedal in the up position:** The meter should indicate approximately 1.0 volt. If the reading is incorrect, replace the accelerator pedal assembly.
9. **With accelerator pedal pressed:** The meter should indicate an over limit (no continuity) condition. If the reading is incorrect, replace the accelerator pedal assembly.

TEST PROCEDURE 7 – Solenoid

See General Warnings on page 1-2.

NOTE: *This is a resistance and voltage test.*

1. If necessary, see Testing Basics.
2. Make sure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
3. **Coil Side:** Check the resistance across the small posts of the solenoid. The reading should be 14 to 16 ohms. If the reading is not within limits, replace the solenoid.
4. **Contact Side:** Remove the white wire and 16-gauge red wire from the large post of the solenoid **(Figure 26-4, Page 26-14)**. Do not let the wires to touch the frame or other components of the vehicle. Cover the other large post.



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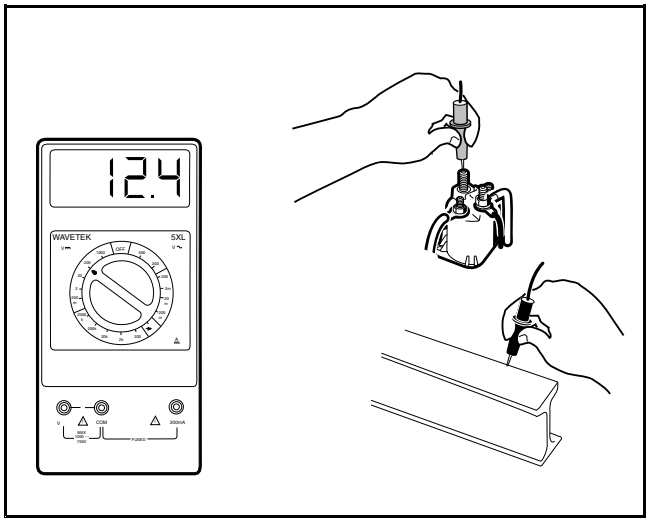
Figure 26-4 Solenoid Wire Removal

4.1. Set the Forward/Neutral/Reverse control (FNR) to N.

4.2. Set the Maintenance/Operate switch to MAINTENANCE.

4.3. Set the key switch to ON.

4.4. Check voltage between the empty large post and ground **(Figure 26-5, Page 26-14)**.



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Figure 26-5 Solenoid Ground Test

– **With accelerator pedal in the up position:** The meter should read no voltage. If the reading is incorrect, replace the solenoid.

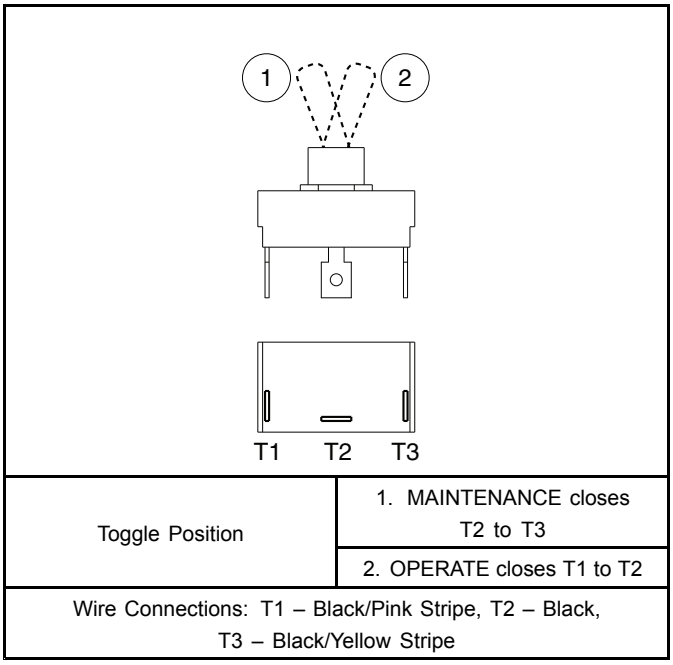
– **With accelerator pedal pressed:** The solenoid should click and the meter should read battery voltage. If the reading is incorrect, replace the solenoid.

TEST PROCEDURE 8 – Maintenance/Operate Switch

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.



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Figure 26-6 Maintenance/Operate Switch Test

3. Set the switch to MAINTENANCE (1) **(Figure 26-6)**:
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 – Transaxle Limit Switch

See General Warnings on page 1-2.

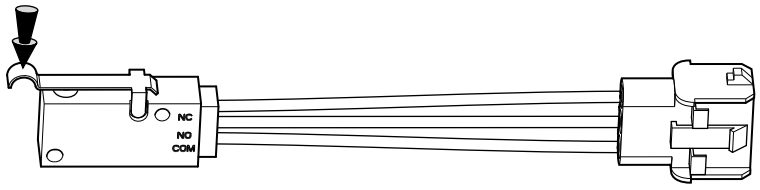
NOTE: *This is a continuity test.*

This switch is located on the transaxle. A black/pink wire, a red wire, and a gray wire are connected to this limit switch with a 3-pin connector.

1. If necessary, see Testing Basics.
2. Disconnect battery and spark plug wire.
3. At the transaxle, disconnect transaxle limit switch three-wire lead from main wire harness.
4. Make sure that the cam lobe on the shift lever is pressing the transaxle limit switch as the Forward/Neutral/Reverse control (FNR) is being shifted.

4.1. If the transaxle limit 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 lever released and continuity with the lever engaged **(Figure 26-7, Page 26-16)**:



PROBE BETWEEN LOCATIONS	TEST RESULT
Between terminal 1 “COM” (black/pink wire) and terminal 2 “NO” (gray wire)	**With lever released:** No continuity
	With lever pressed: Continuity
Between terminal 1 “COM” (black/pink wire) and terminal 3 “NC” (red wire)	**With lever released:** Continuity
	With lever pressed: No continuity

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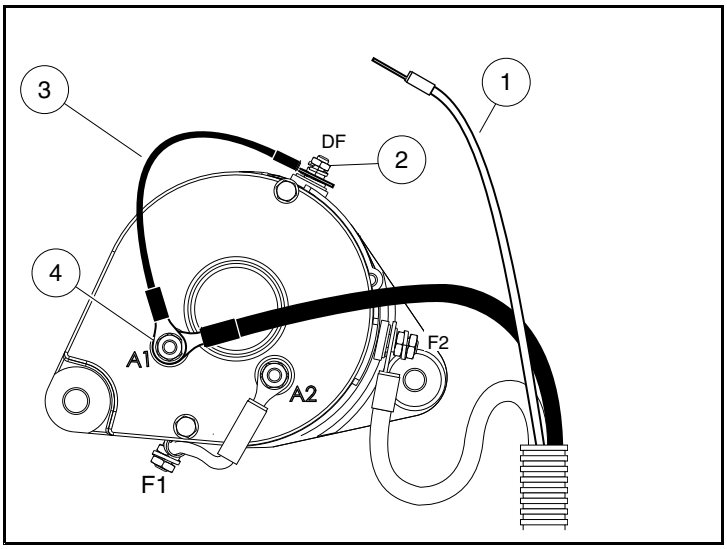
Figure 26-7 Transaxle Limit Switch Test

6. If transaxle limit switch does not work as stated in previous step, replace the transaxle limit switch.

TEST PROCEDURE 10 – Starter/Generator (Generator Function)

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 26-8)**.



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Figure 26-8 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.

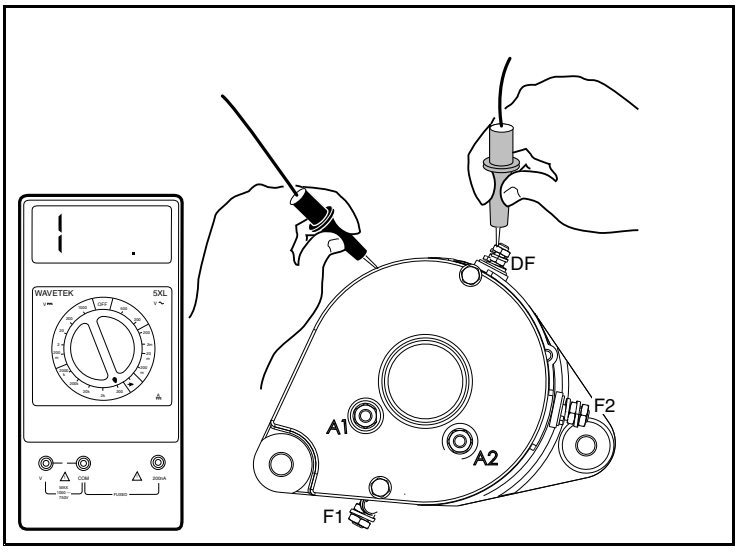
TEST PROCEDURE 11 – Starter/Generator (Starter Function)

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 26-9 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:

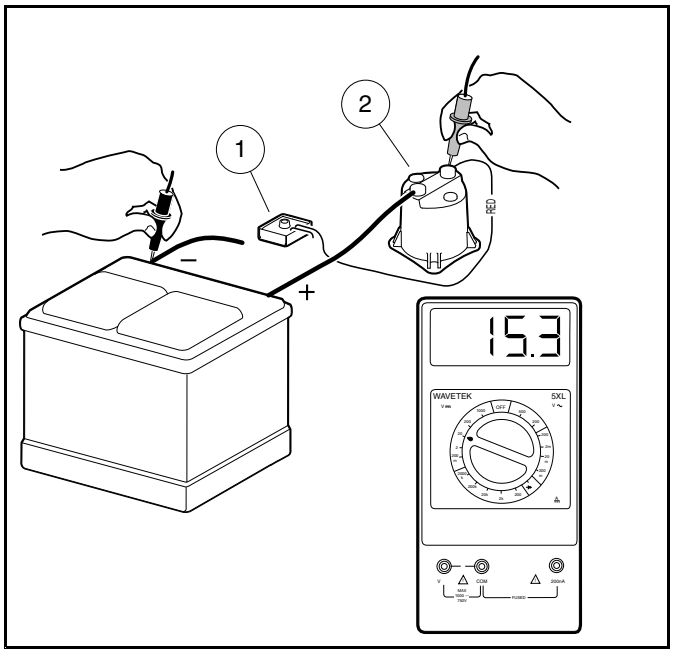
– A grounded DF terminal or a grounded field coil.

10. Make sure that wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.

TEST PROCEDURE 12 – Voltage Regulator

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 26-10 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.

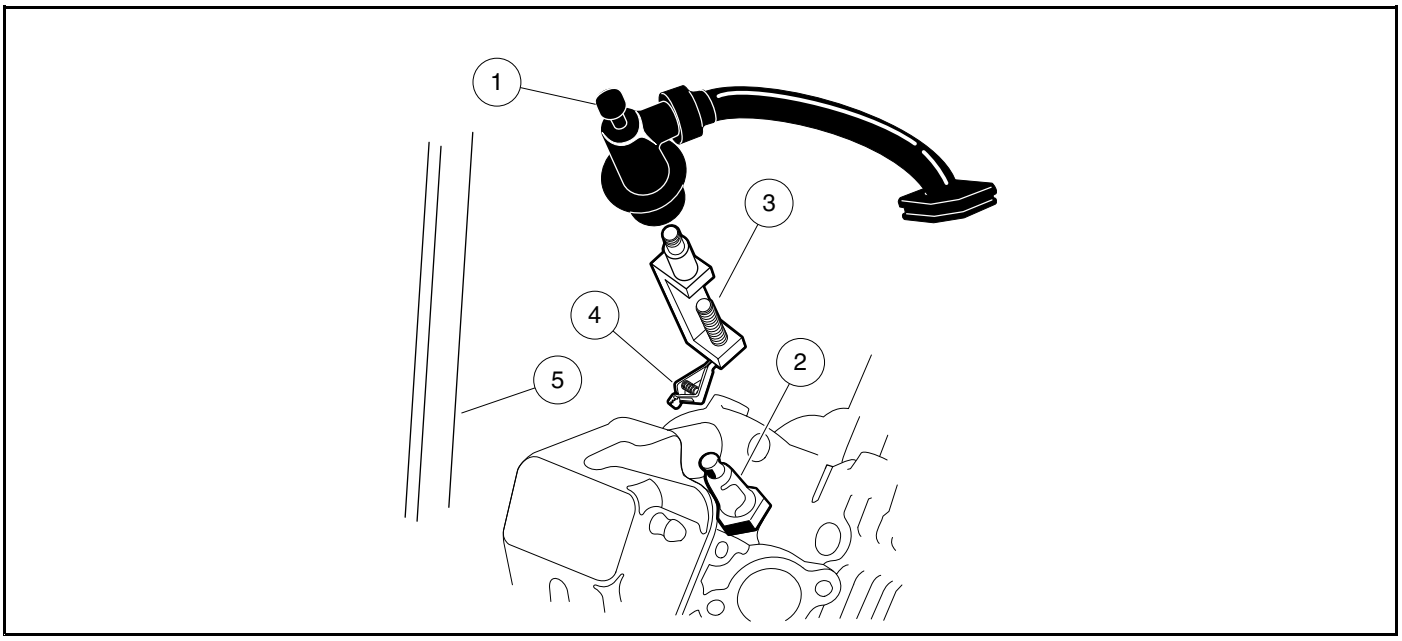
15.4.1. If the starter/generator is good, replace the voltage regulator.

TEST PROCEDURE 13 – Ignition Spark

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 26-11, Page 26-21)**.



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Figure 26-11 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 14 – Multi-Purpose Buzzer and Multi-Purpose Buzzer Limit Switch

NOTE: Multi-purpose Buzzer: *This is a voltage test.*

A multi-purpose buzzer is mounted on the back side of the instrument panel. On some models, another multi-purpose buzzer is also mounted on a bracket at the left rear of the vehicle. The multi-purpose 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 red/white wire at multi-purpose 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 multi-purpose buzzer does not sound, check the multi-purpose buzzer limit switch.

7. Turn the key switch to OFF.

NOTE: Multi-purpose Buzzer Limit Switch: *This is a continuity test.*

The multi-purpose buzzer limit switch is located on the FNR. Red/white and orange wires are connected to it.

1. Disconnect the black wire from the multi-purpose buzzer.
2. Set the FNR to R.
3. Check for continuity between the black wire and ground.

3.1. If there is no continuity, replace the multi-purpose buzzer limit switch.

3.2. If there is continuity, go to step 4.

4. Set the FNR to F.
5. Check for continuity between the black wire and ground.

5.1. If there is continuity, replace the multi-purpose buzzer limit switch.

5.2. If there is no continuity, replace the multi-purpose buzzer.

TEST PROCEDURE 15 – Malfunction Indicator Light (MIL)

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/white 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 16 – Low Oil Warning Light (LED)

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/white 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 yellow wire terminal of the low oil warning light.

5.2.1. If the light illuminates, the low oil warning light is good.

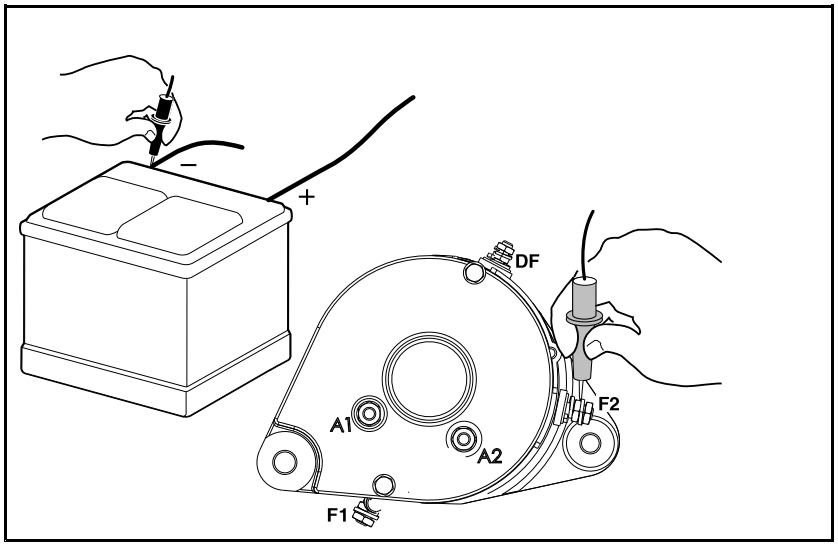
5.2.2. If the light does not illuminate, replace the low oil warning light.

TEST PROCEDURE 17 – Battery Test (Under Load)

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 26-12)**.



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Figure 26-12 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 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 white wire from the solenoid to the starter/generator.

TEST PROCEDURE 18 – Fuel Pump

⚠ 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.*

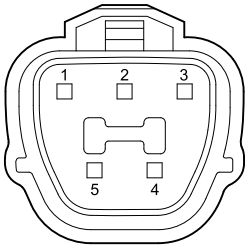
Voltage to Fuel Pump

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 step 3.

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	Sending Unit Positive (+)
3	Black	Sending Unit Negative (-)
4	Black/White	Fuel Pump Negative (-)
5	Red/White	Fuel Pump Positive (+)

Figure 26-13 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.

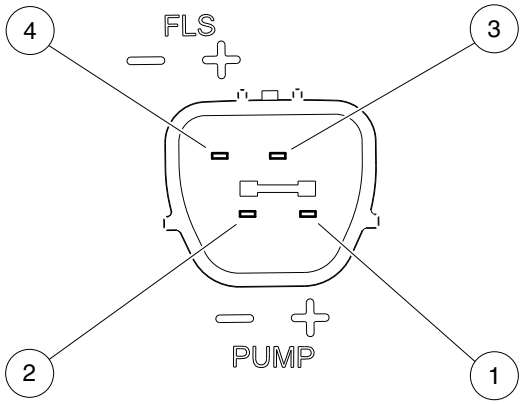
6.2. If there is voltage, check for battery voltage at the black/white wire of the fuel pump relay while the engine is running.

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
4. Sending Unit Negative (–) Black Wire	Black

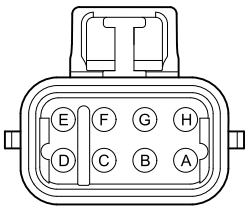
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Figure 26-14 Fuel Pump Module Terminals

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 step 5.2.1. 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.



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 26-15 ECU Connector

TEST PROCEDURE 19 – Fuel Level Sending Unit

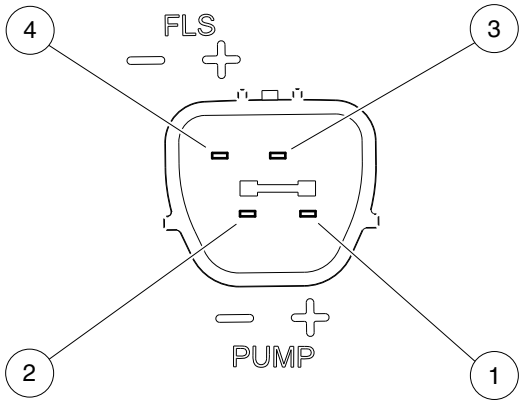
⚠ WARNING

- **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
4. Sending Unit Negative (–) Black Wire	Black

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Figure 26-16 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 step 5.3.1. Leave the battery disconnected while checking continuity.

5.3.1. Check the continuity of the orange wire from the fuel level sending unit to the orange 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 blue wire on the key switch.

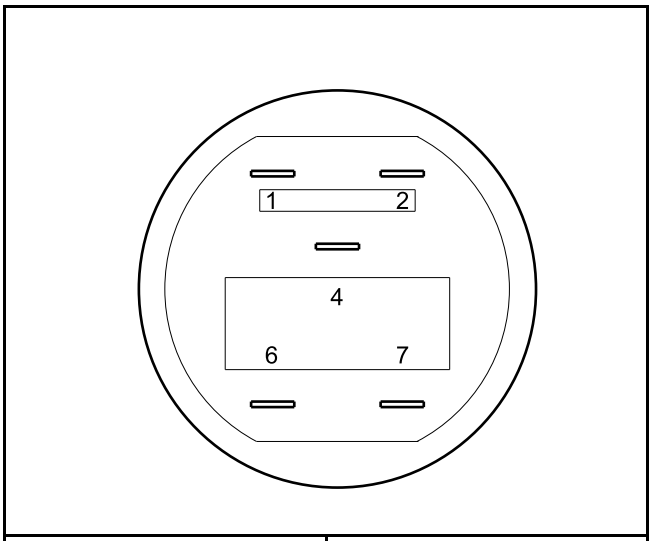
5.3.3. Check the continuity of the black ground wire at the fuel level sending unit.

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 20 – Fuel Gauge

NOTE: *This is a voltage test.*

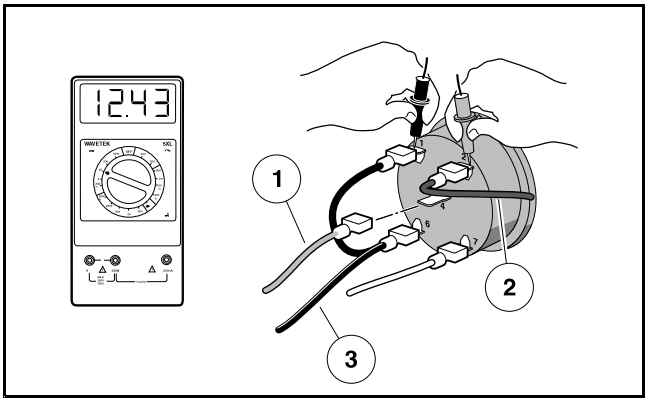


Pin Description	Wire Color
1. Fuel (-)	Black
2. Fuel (+)	Blue
4. Fuel Input	Orange
6. Hour (-)	Black/White
7. Hour Input	Red

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Figure 26-17 Fuel Gauge/Hour Meter

1. Disable the vehicle.
2. Remove the instrument panel to gain access to the back of the fuel gauge/hour meter.
3. 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.
4. Disconnect the orange wire (1) from the fuel gauge/hour meter **(Figure 26-18, Page 26-29)**.



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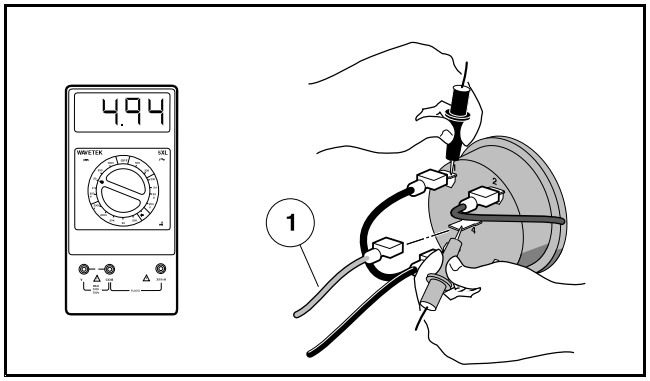
Figure 26-18 Fuel Gauge Voltage Test - Terminal 2

5. Set a multimeter to 20 VDC.

6. Put the red (+) probe of the multimeter on the positive post of the battery.
7. Put the black (–) probe on the negative post of the battery. Record the voltage reading.
8. Put the red (+) probe on terminal 2 of the fuel gauge/hour meter with the blue wire (2) connected.
9. Put the black (–) probe on terminal 1 of the fuel gauge/hour meter with the black wire (3) connected.
10. Turn the key switch ON. The voltage reading should be the same as the battery voltage reading recorded earlier.

10.1. If not, check the continuity of the blue and black wires.

11. Make sure that the orange wire (1) is disconnected **(Figure 26-19, Page 26-30)**.



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Figure 26-19 Fuel Gauge Voltage Test - Terminal 4

12. Put the black (-) probe on terminal 1 of the fuel gauge/hour meter.
13. Put the red (+) probe on terminal 4 of the fuel gauge/hour meter. The voltage reading should be approximately 4.94 volts.

13.1. If the reading is incorrect, replace the fuel gauge/hour meter.

TEST PROCEDURE 21 – Hour Meter

⚠ 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. Disable the vehicle.
2. Make sure that the key switch OFF.
3. 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.
4. Start the engine and let it idle.
5. With engine idling, the "hour glass" icon should flash.

5.1. If not, check the voltage regulator. **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.*

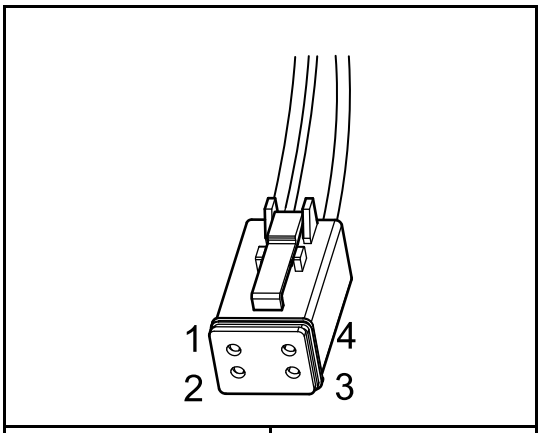
6. If the hour meter still does not function after the voltage regulator and all of the appropriate wires have been checked for continuity, replace the fuel gauge/hour meter.

TEST PROCEDURE 22 – 4-Pin Connector (to Visage)

See General Warnings on page 1-2.

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 – Brown
Pin 2 – Red	Pin 3 – Open (No wire)

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Figure 26-20 4-Pin Connector

1. If necessary, **See Testing Basics on page 26-7.**.
2. Check for continuity between pin 1 (black wire) **(Figure 26-20, Page 26-31)** and pin 18 (black wire) of the black 18-pin connector on the ECU. It should indicate continuity. If not, check sonic welds no. 4, 10, and 14.
3. Probe pin 2 (red wire). It should show battery voltage with the key switch in the ON position. If not, check 2-amp fuse near ATM fuse holder. **See following NOTE.**

NOTE: *The red wire only has battery voltage with the key switch in the ON position.*

4. Probe pin 4 (brown wire). It should show approximately 11.8 volts supplied by pin B (red wire) of the engine harness. If not, check wiring and then ECU. **See following NOTE.**

NOTE: *The brown wire only has voltage with the key switch in the ON position.*

If pin 4 has no voltage, the ECU 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.

Pagination Page

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

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.**
- **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, top post 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,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 lb·in (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. **See Self-Discharge on page 27-2.**
3. Check battery periodically to see that it is in a full state of charge. **See Charging the Battery on page 27-3.**
4. Keep battery hold-down clamp tight. **See Vibration Damage on page 27-2.**

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. **See Battery Storage on page 27-4.**

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

Also see DANGER at beginning of Battery topic.

1. Turn the key switch OFF and remove the key. Place the Forward/Neutral/Reverse handle in the NEUTRAL position. Chock the wheels.
2. Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
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

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

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 41 lb·in (4.3 N·m). A loose battery clamp may allow the battery to become damaged from vibration or jarring.
3. Connect battery and spark plug wire. **See Connect the Battery - Gasoline Vehicles on page 1-4.**

BATTERY STORAGE

Also see DANGER at beginning of Battery topic.

1. Keep the battery clean and free of corrosion. **See Preventive Maintenance on page 27-2.**
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. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
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

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.**

GROUND CABLES

NOTE: *Verify that all cables (fuel tank, engine, battery, starter/generator and voltage regulator) are connected securely.*

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 A1, DF, and F2 terminals of the starter/generator (1).

4. Loosen the pivot nuts (2) and pivot bolts (3) **(Figure 27-1)**.

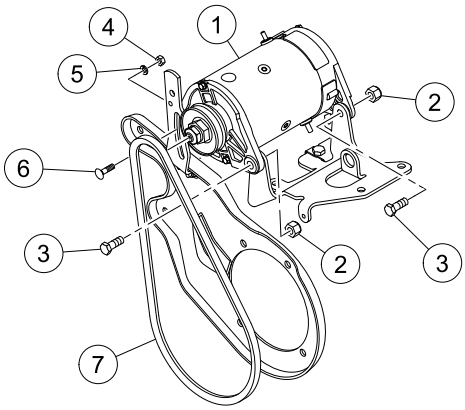


Figure 27-1 Starter/Generator Removal

5. Remove the adjustment nut (4), washer (5) and adjustment bolt (6).
6. Lower the starter/generator and remove the belt (7) from the starter/generator pulley.
7. Support the starter/generator so that when the pivot bolts are removed the starter/generator does 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 jumper wire (1) and terminal hardware (2) **(Figure 27-2)**.

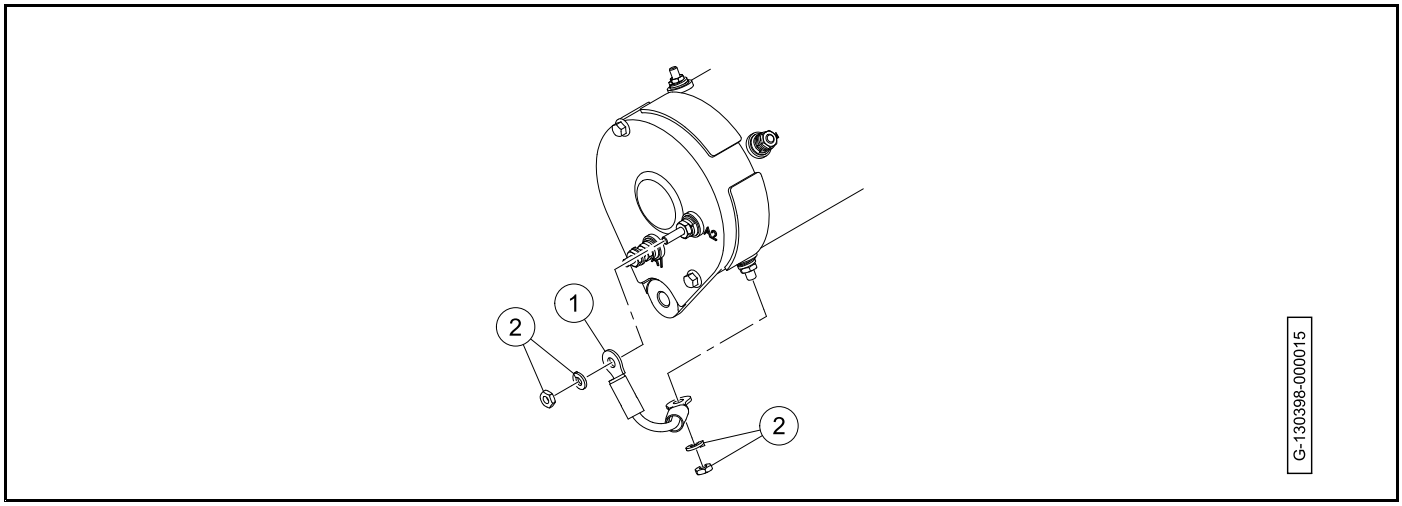


Figure 27-2 Jumper Wire Removal

2. Remove the bolts (1) and pull the commutator end cover (2) free of the field coil housing (3) **(Figure 27-3)**. **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 side of the brushes and help prevent them from sliding towards the center of the cover.*

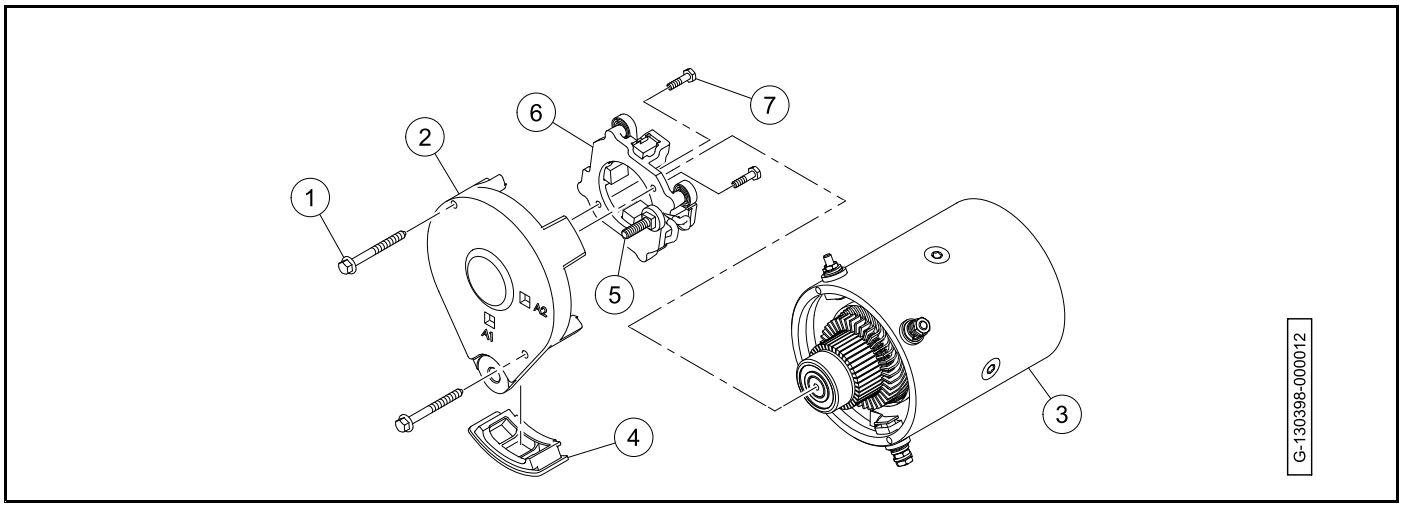


Figure 27-3 Starter/Generator Disassembly - Brushes

3. Remove the brush covers (4) and terminal hardware (5) from the commutator end cover.
4. Remove the screws (7) that attach the brush assembly (6) to the commutator end cover.

BRUSH AND BRUSH SPRING INSPECTION AND REPLACEMENT

1. Visually inspect brushes (1). Replace brushes that are cracked or severely chipped **(Figure 27-4)**.

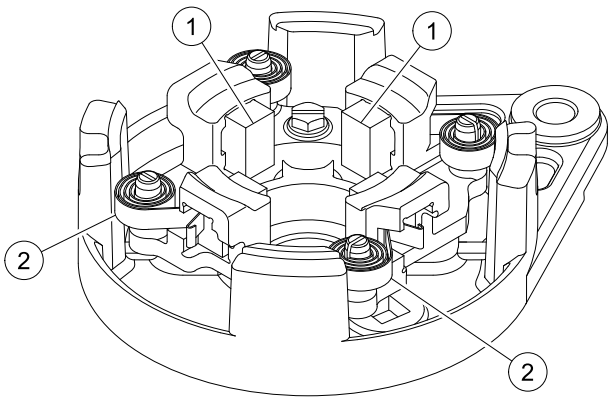


Figure 27-4 Brush and Brush Spring Inspection

2. Measure the length of each brush. Replace the brush set if a brush is less than 0.375 inch (9.5 mm).
3. Visually inspect springs (2). Replace all brush springs if any spring is discolored from heat (straw or bluish in color).
4. Install the brushes (1) into their holders and insert the brush springs (2).
5. Using a spring scale, test brush spring tension. If any spring has a tension less than 24 ozf (0.68 kgf), replace all four brush springs. **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.**

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. Remove the bolts (1) **(Figure 27-5, Page 27-8)**.

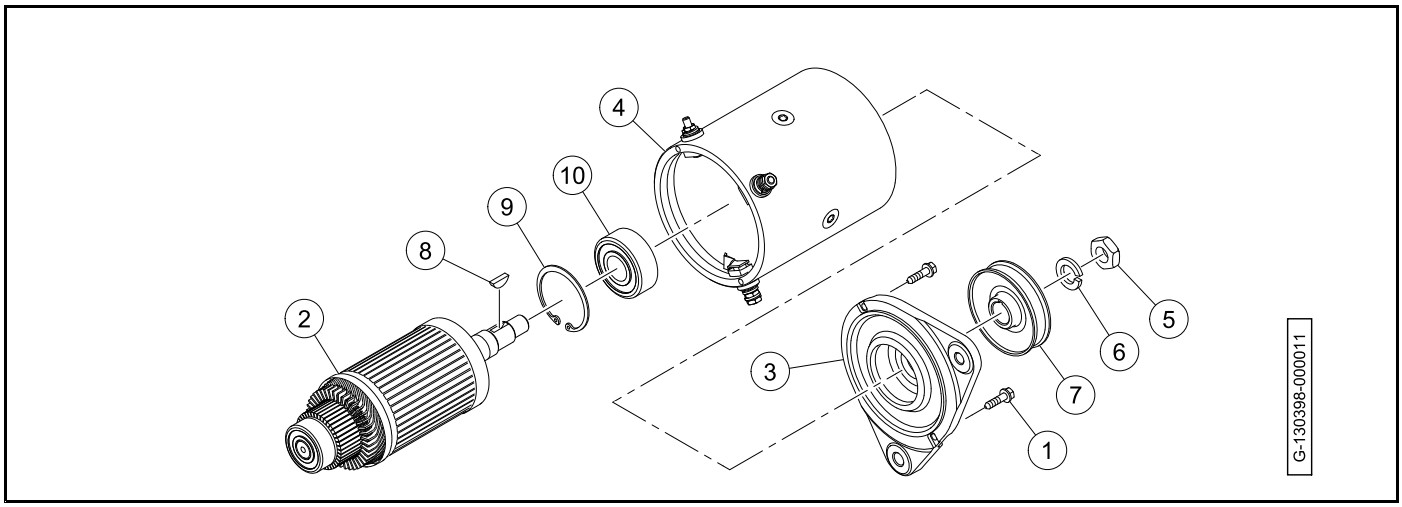


Figure 27-5 Output End Cover Disassembly, Armature and Housing

3. Remove the armature (2) and output end cover (3) from the field coil housing (4).
4. Remove the nut (5), lock washer (6), pulley (7), and woodruff key (8). **See following NOTE.**

NOTE: *It may be necessary to use the wedge attachment tool to remove the pulley from the armature shaft.*

5. Remove the internal retaining ring (9) to release the bearing (10) and armature from the output end cover.

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 and radial play.
2. Replace the bearing if it is noisy, does not spin smoothly, or has excessive play.
3. Check the bearings and replace if rusted, worn, cracked, or if there is an abnormal color change in the metal of the bearing.
4. Bearings should be replaced if there is extensive wear or pitting on the balls or on the rolling surfaces.

NOTE: *Do not remove the bearings unless they are to be replaced.*

BEARING REMOVAL

1. Place the wedge attachment tool between the bearings (1) and the armature (2) **(Figure 27-6, Page 27-9)**. **See following NOTE.**

NOTE: *Make sure the wedge attachment tool is supporting the inner race of the bearing.*

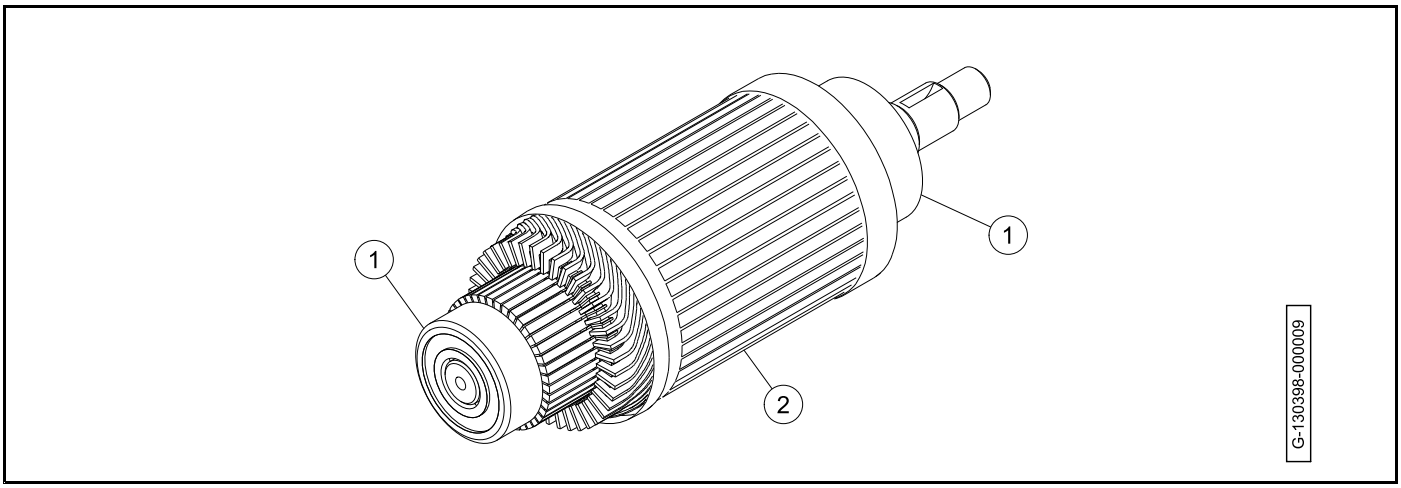


Figure 27-6 Bearing Removal

2. If a press is not available, secure a bearing puller to the wedge attachment tool and pull the bearings off of the end of the armature shaft. **See following NOTE.**

NOTE: *Support the armature so that it will not drop when the bearing is removed.*

FIELD COIL ASSEMBLY

Replace entire field coil housing assembly if coils, pole shoes or terminals are damaged..

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

COMMUTATOR CLEANING AND INSPECTION

1. Visually inspect the commutator for worn, burned or glazed areas.
2. Check for loose or raised commutator bars.
3. Clean the carbon dust, dirt and oil from the commutator. 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.**

4. 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 27-7)**. **See following NOTE.**

NOTE: *Measure each position of the commutator in two places, 90 degrees apart.*

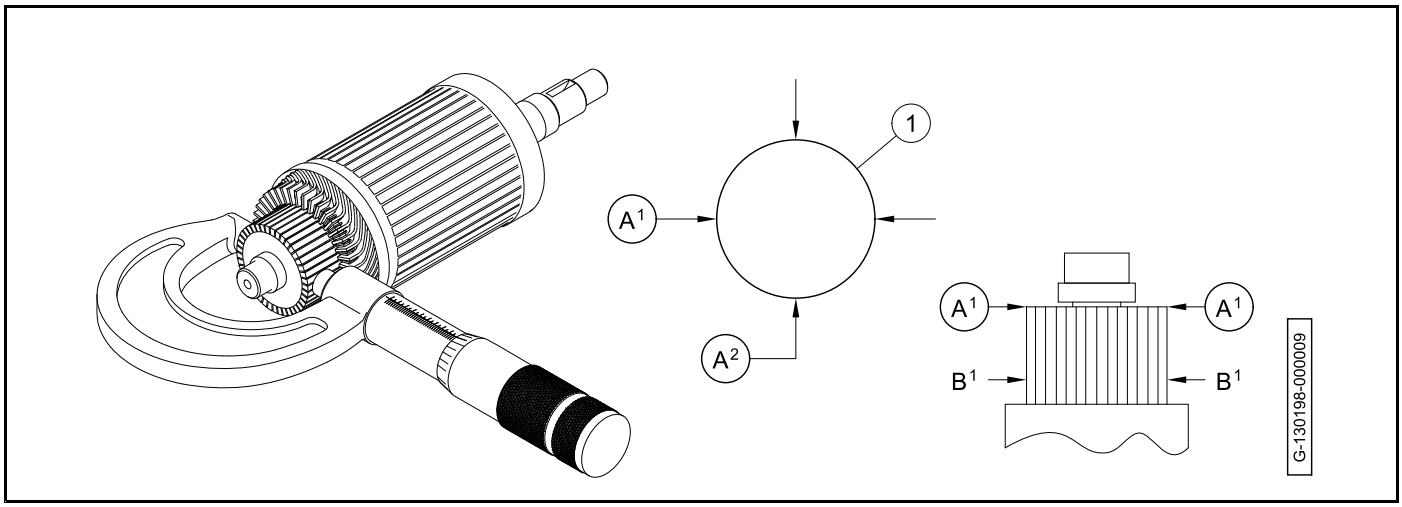


Figure 27-7 Inspect Commutator

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 (1) and the negative (–) probe on the armature shaft (2). The reading should be no continuity. If the reading is incorrect, replace the armature and the two bearings **(Figure 27-8, Page 27-11)**.

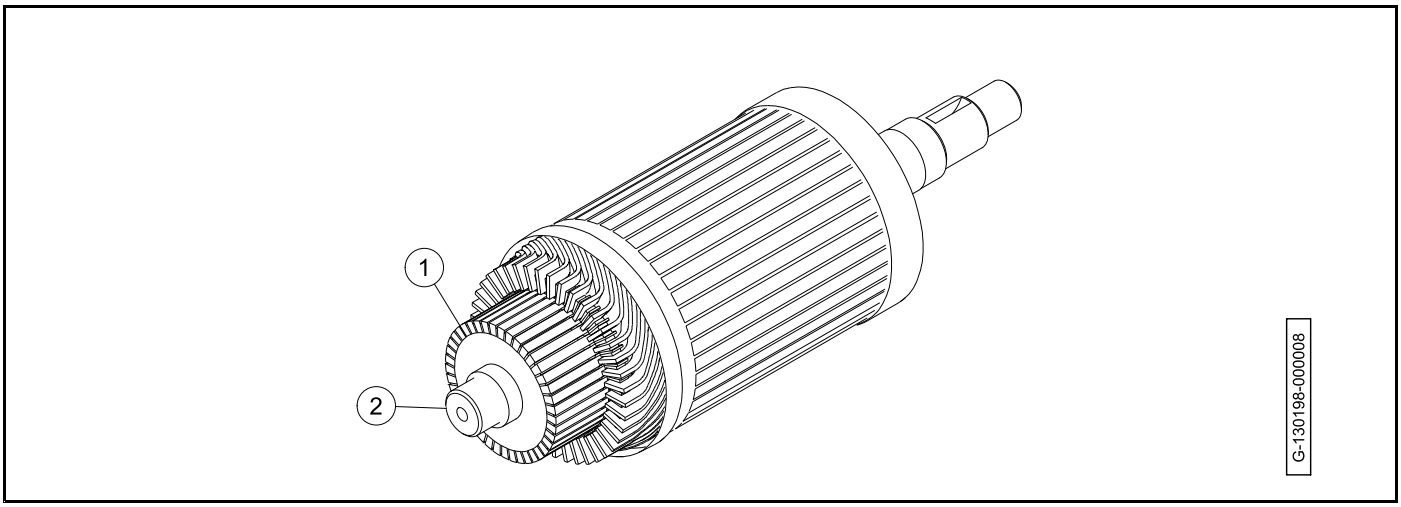


Figure 27-8 Armature Ground Test

VISUAL INSPECTION OF FIELD COILS

If the insulation on the field coils appears blackened or charred, the serviceability of the coils is questionable. Replace starter/generator if necessary.

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 internal retaining ring (9) on the output end of the armature (2) **(Figure 27-9)**.

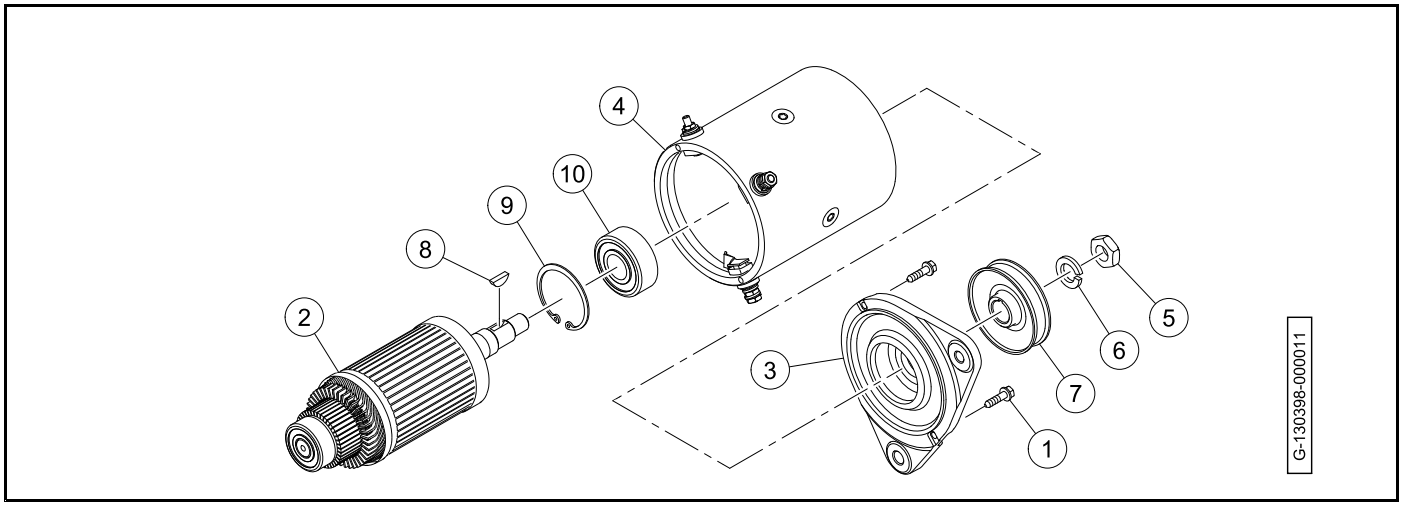


Figure 27-9 Output End Cover Assembly, Armature and Housing

2. Press a new ball bearing (10) onto the output end of the armature. **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 output end cover (3) on the armature. Secure the internal retaining ring.
4. Slide the field coil housing (4) over the armature. Use the tapped mounting holes to align field coil housing to the output end cover. **See following NOTE.**

NOTE: *The terminal insulators should be on the commutator end of the housing.*

5. Install the bolts (1). Tighten the bolts from 49 to 66 lb·in (5.5 to 7.4 N·m).
6. Install the woodruff key (8) and pulley (7) onto the armature shaft.
7. Install the lock washer (6) and nut (5). Tighten the nut from 26 to 32.9 lb·ft (35.3 to 44.7 N·m).
8. Install the screws (7) that attach the brush assembly (6) and terminals (5) to the commutator end cover (2) **(Figure 27-10, Page 27-13)**. Tighten the screws from 22 to 26 lb·in (2.4 to 2.9 N·m).

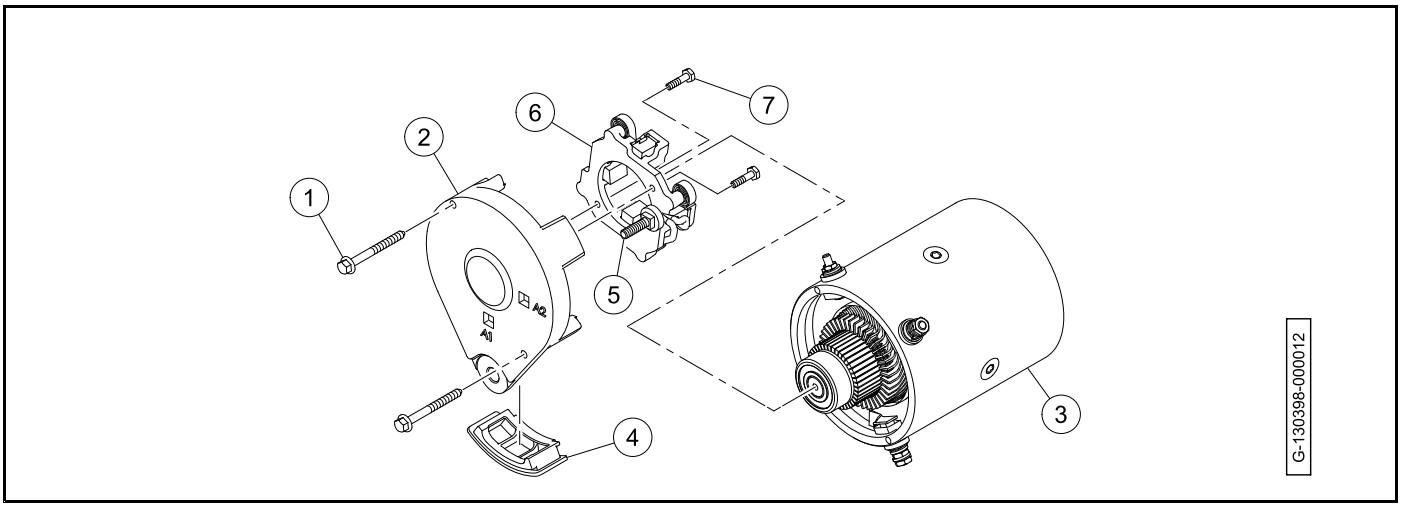


Figure 27-10 Starter/Generator Aassembly - Brushes

9. To prevent contact between the brushes and commutator as the commutator end cover is installed, and possible damage to the brushes:

9.1. Lift the brush springs out of the notches in the brushes and pull the brushes back from the center of the commutator end cover.

9.2. The springs will rest on the side of the brushes and help prevent them from sliding towards the center of the commutator end cover.

10. Install the commutator end cover onto the armature shaft. Use the tapped mounting holes to align housing to the field coil housing (3).

11. Install the bolts (1). Tighten the bolts from 49 to 66 lb·in (5.5 to 7.4 N·m).

12. Install the terminal hardware on the A1 and A2 terminals. Tighten the hardware from 40 to 50 lb·in (4.5 to 5.6 N·m).

13. Push the brushes down into the holders.

14. Place springs into the notches on the brushes. **See following NOTE.**

NOTE: *Check the brush wires to make sure they do not interfere with the springs.*

15. Install the brush covers (4). **See following NOTE.**

NOTE: *The brush cover with the drain hole is installed next to the A2 terminal.*

16. Install the terminal jumper wire (1) on the A2 and F1 terminals on the starter/generator **(Figure 27-11, Page 27-14)**.

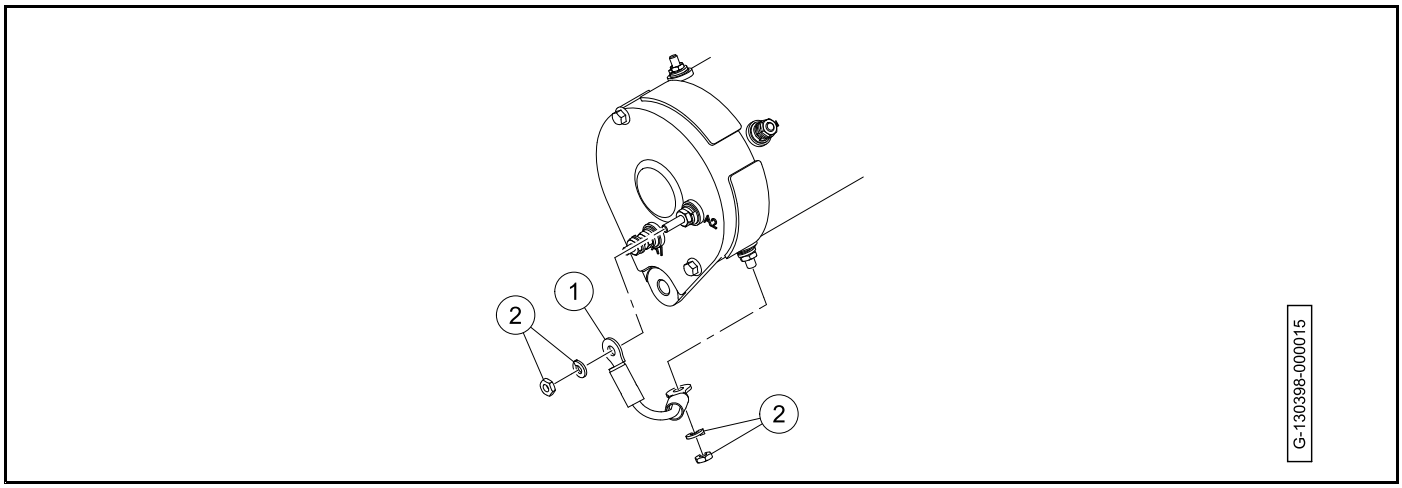


Figure 27-11 A2 to F1 Terminal Jumper Wire

17. Install the terminal hardware (2). Tighten the hardware from 39.8 to 49.5 lb·in (4.5 to 5.6 N·m). **See following NOTE.**

NOTE: *Secure bottom nut of terminal with wrench before tightening top nut.*

STARTER/GENERATOR INSTALLATION

1. Position the starter/generator (1) over the mounting bracket **(Figure 27-12)**.

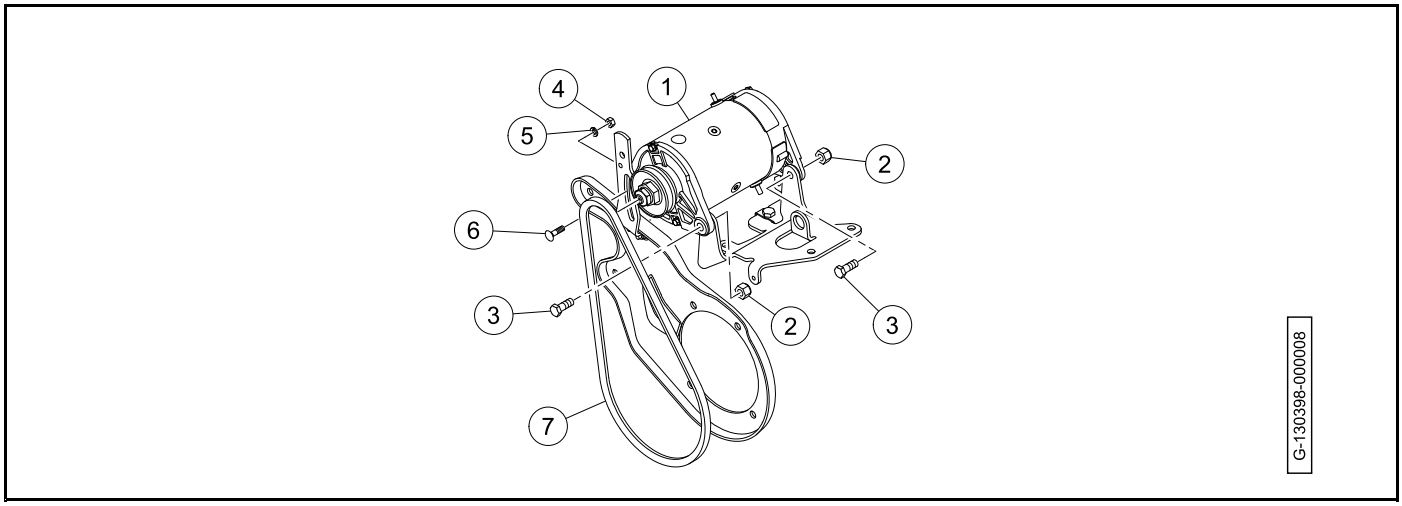


Figure 27-12 Starter/Generator Installation

2. Install the pivot bolts (3) and pivot nuts (2). Tighten the pivot nuts with your hand.
3. Install the adjustment bolt (6), lock washer (5), and nut (4). Tighten the hardware hand-tight.
4. Install the starter/generator belt (7).
5. Adjust the belt tension. See Belt Tension Adjustment for EFI Engines.
6. Connect the yellow wire from the voltage regulator to the DF terminal on the starter/generator **(Figure 27-13, Page 27-15)**.

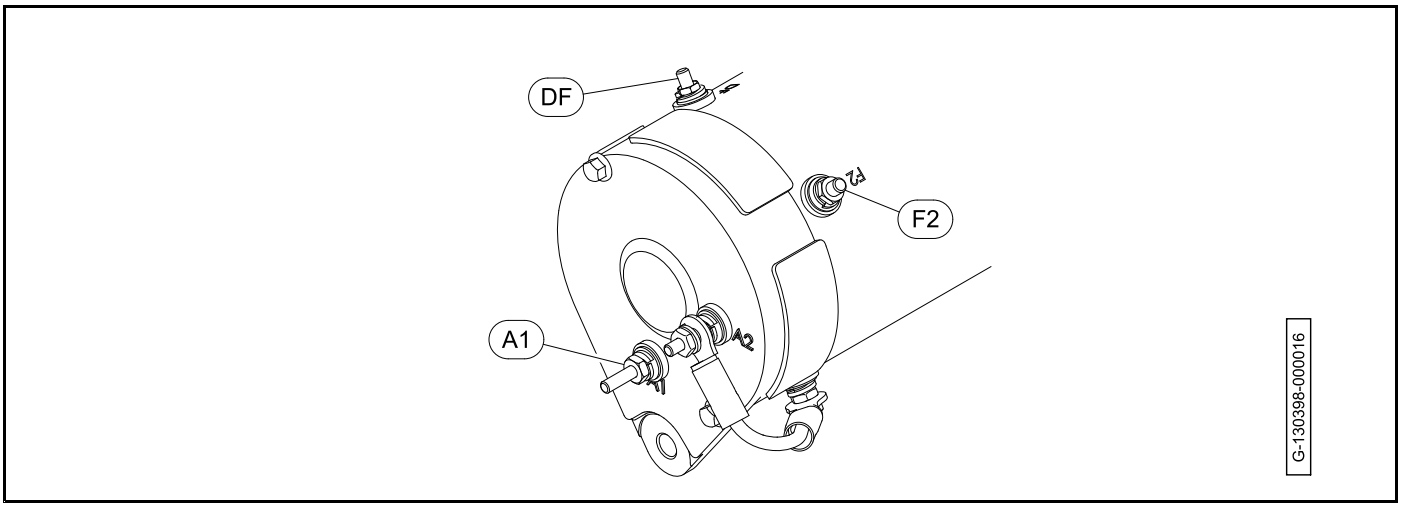


Figure 27-13 Wire Installation

7. Install a flat washer, lock washer, and nut on the DF terminal. Tighten the nut from 15 to 19.4 in·lb (1.7 to 2.2 N·m).
8. Install the white wire from the solenoid to the F2 terminal on the starter/generator.
9. Install the black wire from the frame to the A1 terminal on the starter/generator.
10. Install a flat washer, lock washer and nut on each terminal, and tighten the nuts from 40 to 50 lb·in (4.5 to 5.6 N·m).
11. 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 (1) to repeat tension measurement each time. Use a paint pen or permanent marker of light color **(Figure 27-14, Page 27-16)**.

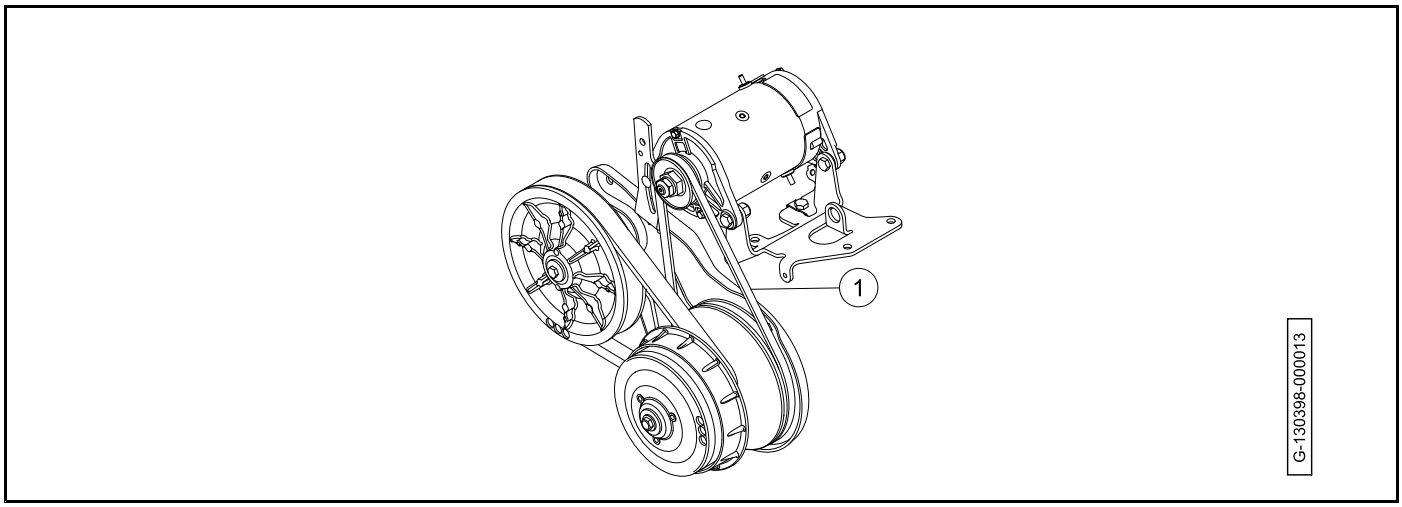


Figure 27-14 Belt Tension

3. Install a Universal Belt Tension Gauge midway between the drive clutch and driven clutch.
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. Disable the vehicle.
2. Disconnect the battery and spark plug wire.
3. Mark a location on belt (1) to repeat tension measurement each time. Use a paint pen or permanent marker of light color **(Figure 27-15, Page 27-17)**.

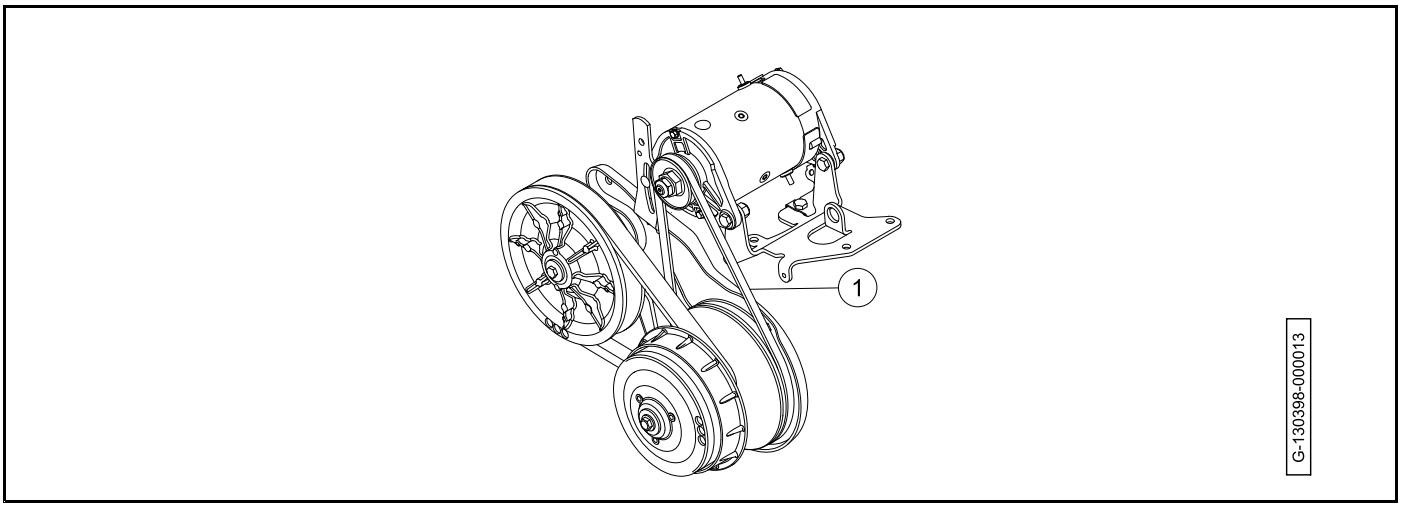


Figure 27-15 Belt Tension

4. Install a Universal Belt Tension Gauge midway between the drive clutch and driven clutch.
5. Loosen, do not remove, the adjustment nut (1) and pivot nuts (2) **(Figure 27-16)**.

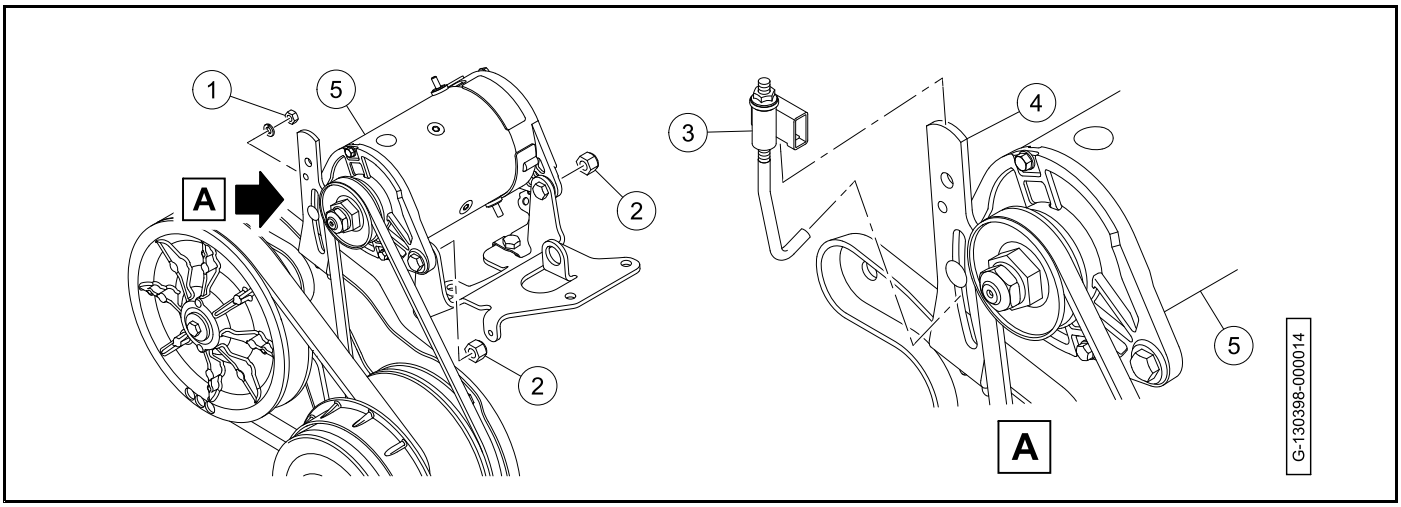


Figure 27-16 Belt Tension Adjustement

6. Install the belt tension tool (3) on the slotted adjustment bracket (4).

6.1. Carefully insert pry bar between starter/generator (5) and slotted adjustment 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.*

6.2. Lift the starter/generator up until the tension tool can be installed into the slotted adjustment bracket.

6.3. Remove the pry bar.

7. Tension the belt.

7.1. 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, loosen then reapply, the Universal Belt Tension gauge between measurements.*

7.2. 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).

8. Seat the belt.

8.1. Remove all other tools.

8.2. The belt tension tool can be temporarily left in place.

8.3. 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.**

8.4. Operate the engine a minimum of 5 seconds and a maximum of 15 seconds to fully seat the belt into the pulleys and help eliminate any slack.

9. Repeat step 7.

10. Maintain tension and tighten the adjustment nut from 15 to 18 ft·lb (20 to 24.5 N·m). Tighten the pivot nuts from 20 to 25 ft·lb (27 to 34 N·m).

11. Remove the belt tension tool.

12. Confirm proper belt tension with a final measurement.

13. Connect the spark plug wire.

BELT TENSION TOOL MODIFICATION

1. Remove the nut (1), washer (2), and spacer (3) from the J-bolt (4) **(Figure 27-17)**.

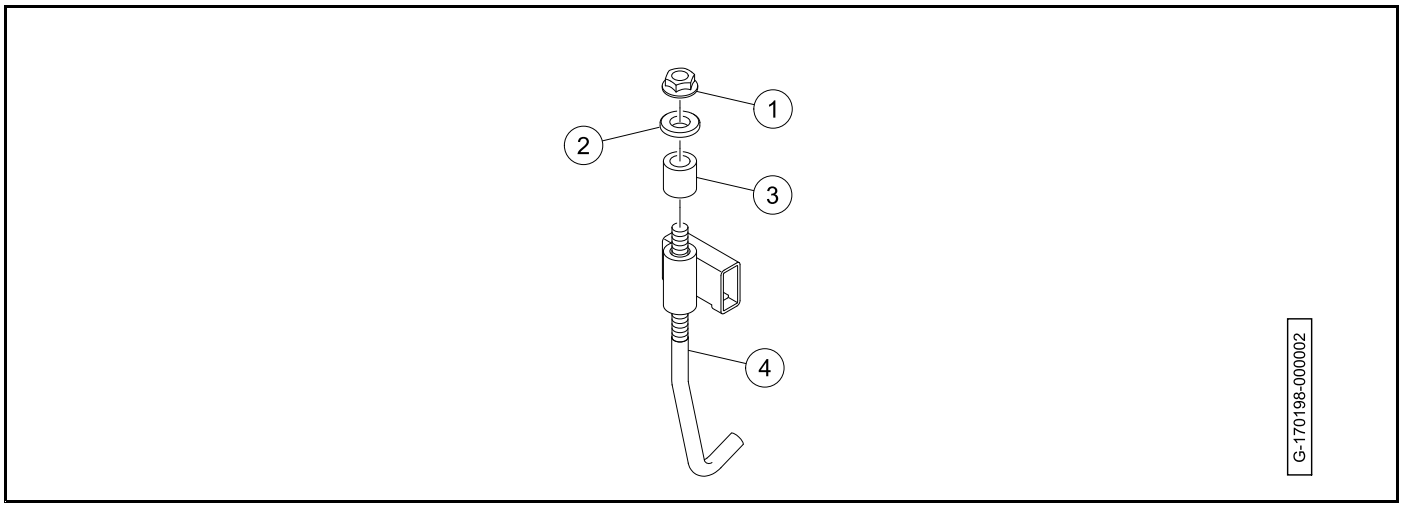


Figure 27-17 Belt Tension Tool Modification

2. Install the washer and nut onto the J-bolt.

SOLENOID

See General Warnings on page 1-2.

SOLENOID REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the nuts (1) from each post **(Figure 27-18, Page 27-19)**.

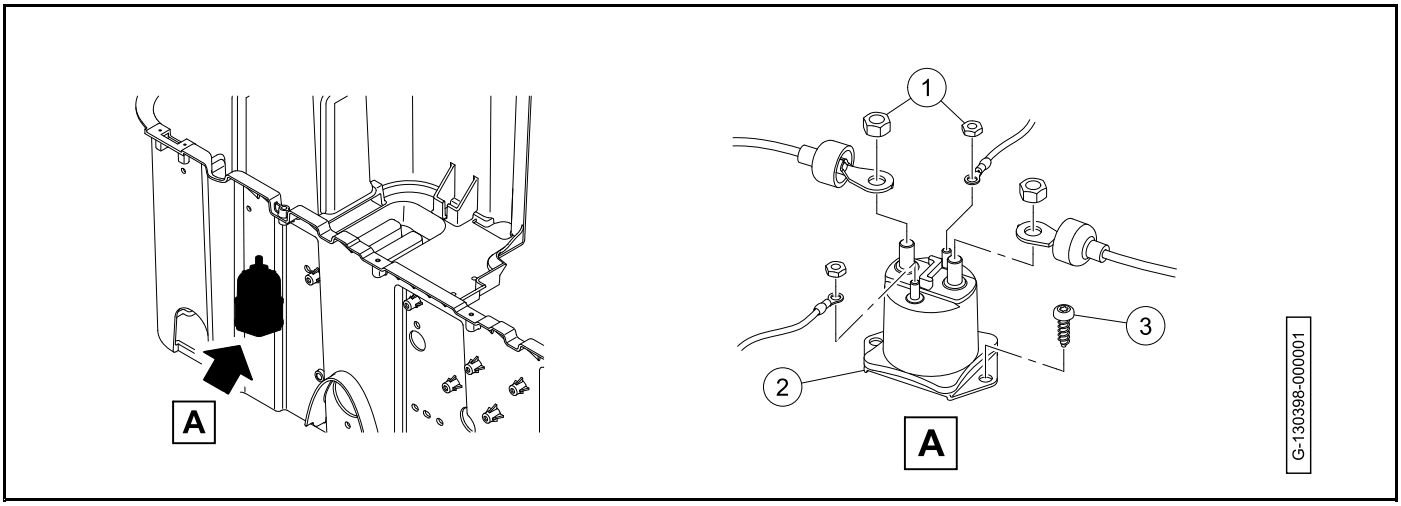


Figure 27-18 Solenoid Removal

3. Disconnect all the wires from the solenoid (2).
4. Remove the two screws (3).
5. Remove the solenoid.

SOLENOID INSTALLATION

1. Install the solenoid (1) in the vehicle **(Figure 27-19, Page 27-19)**.

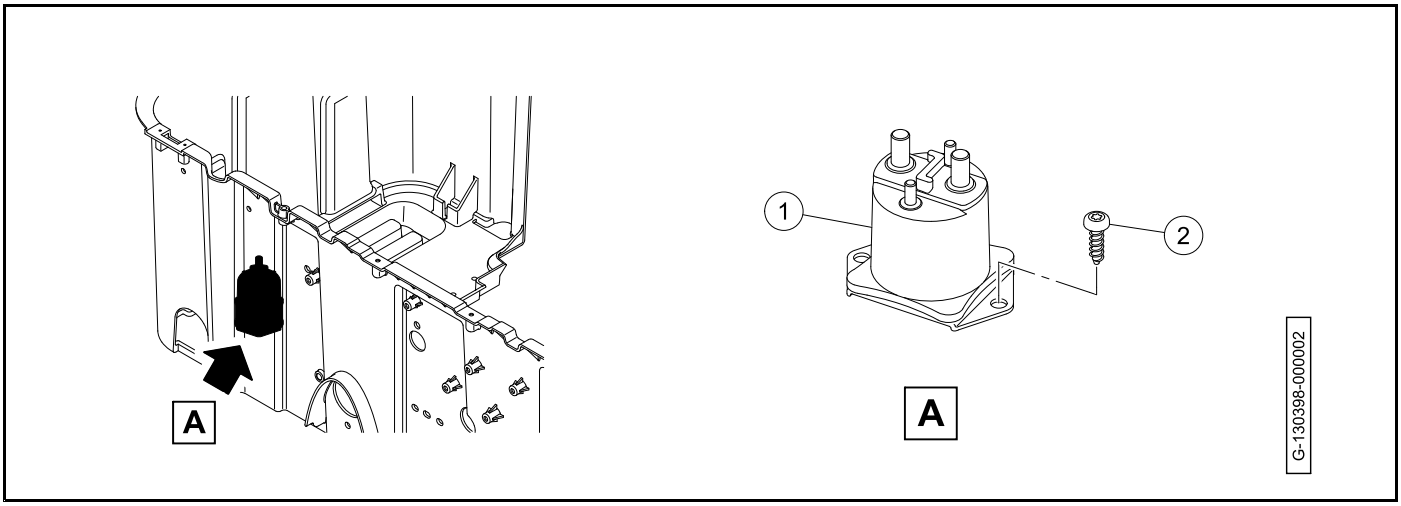


Figure 27-19 Solenoid Installation

2. Install the two screws (2). Tighten the screws to 31 lb·in (3.5 N·m).
3. Connect the white wire to the large post (3) on the solenoid **(Figure 27-20, Page 27-20)**.

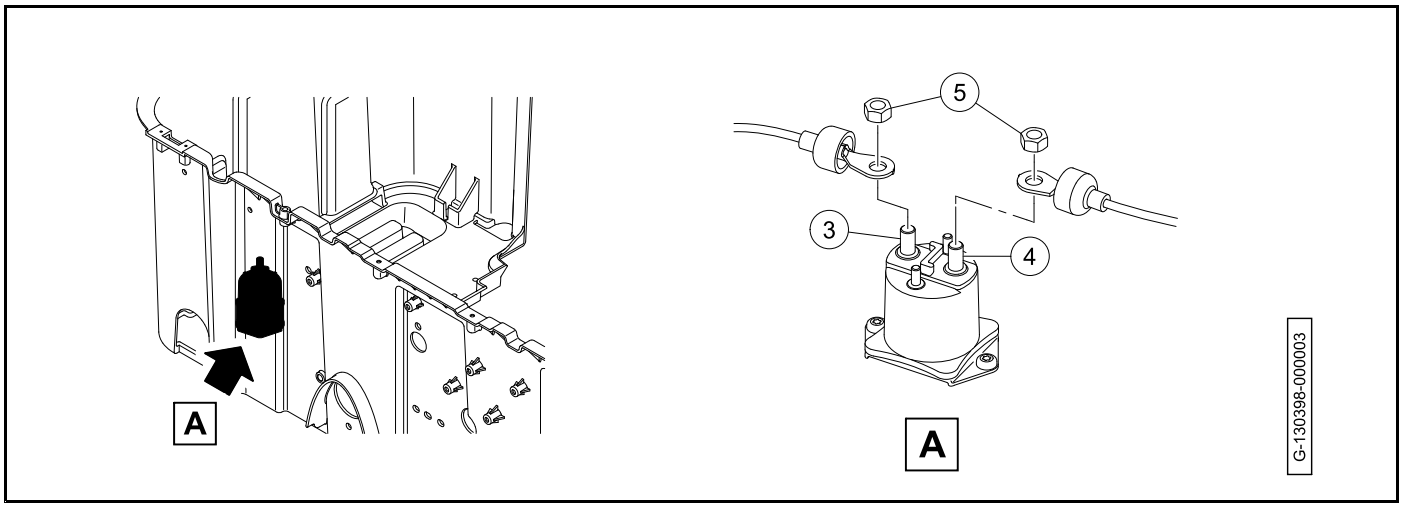


Figure 27-20 Solenoid Large Posts

4. Connect the red wire to the large post (4) on the solenoid.
5. Install the nuts (5). Tighten the nuts to 59 lb·in (6.7 N·m).
6. Connect the blue wire to the small post (6) on the solenoid **(Figure 27-21, Page 27-20)**.

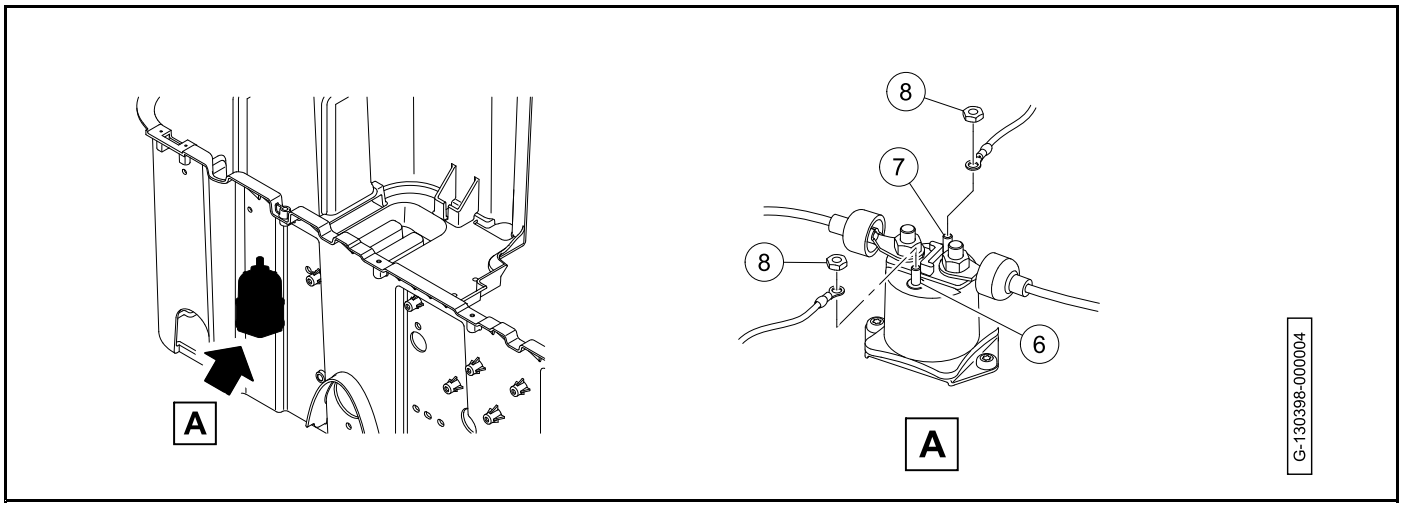


Figure 27-21 Solenoid Small Posts

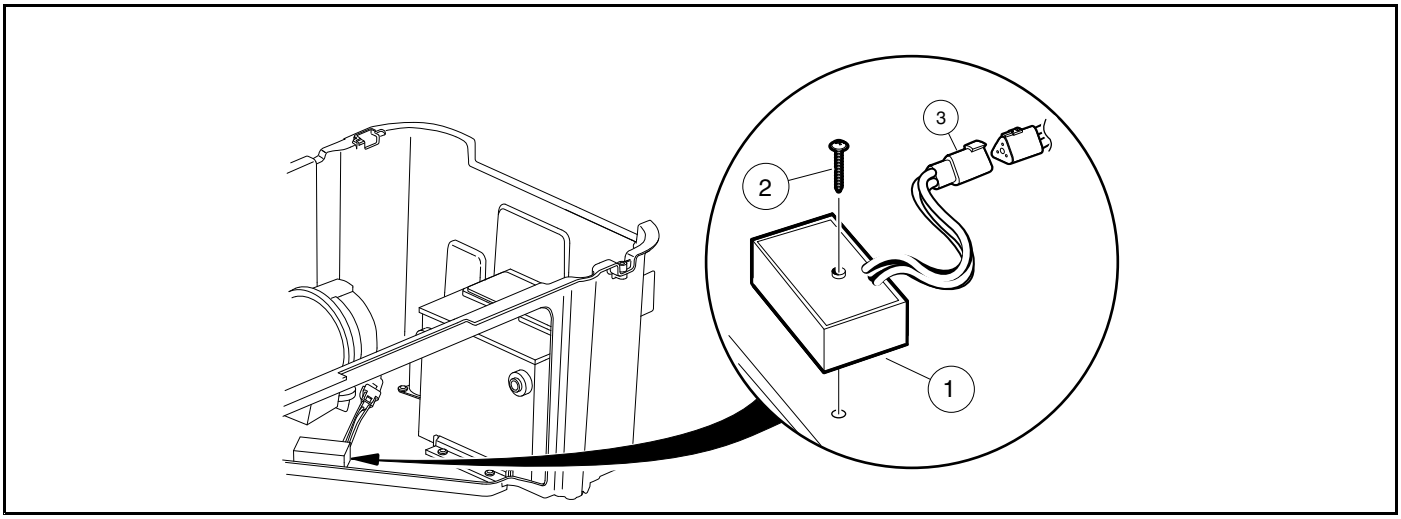
7. Connect the orange wire to the small post (7) on the solenoid.
8. Install the nuts (8). Tighten the nuts to 22 lb·in (2.5 N·m).
9. Connect the battery and spark plug wire.

VOLTAGE REGULATOR

See General Warnings on page 1-2.

VOLTAGE REGULATOR REMOVAL

1. Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Disconnect the voltage regulator connector (3) from the wire harness **(Figure 27-22, Page 27-21)**.
3. Remove the voltage regulator mounting screw (2) and remove the voltage regulator (1).



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Figure 27-22 Voltage Regulator

VOLTAGE REGULATOR INSTALLATION

1. Position the voltage regulator (1) and install the mounting screw (2) **(Figure 27-22, Page 27-21)**. Tighten screw to 23 lb·in (2.6 N·m).
2. Connect the voltage regulator three-pin connector (3) to the wire harness.
3. Connect battery and spark plug wire.
   See Connect the Battery - Gasoline Vehicles on page 1-4.
4. Set the Forward/Neutral/Reverse control (FNR) to N.
5. Set the maintenance/operate switch to MAINTENANCE.
6. Start the engine and check regulator for proper functioning as described in the voltage regulator test procedure.
   See Test Procedure 12 – Voltage Regulator on page 26-20.

ENGINE CONTROL UNIT (ECU)

The ECU is located in the engine compartment.

ENGINE CONTROL UNIT REMOVAL

1. Disconnect battery.
2. Remove ECU mounting plate bolts.
3. Disconnect gray and black wire connectors.

ENGINE CONTROL UNIT INSTALLATION

⚠ 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.**

1. Mount ECU to plate with bolts and tighten to 60 lb·in (6.8 N·m).
2. Install gray connector to the gray port on the ECU. **See preceding WARNING.**
3. Install black connector to the black port on the ECU.
4. Connect the battery.

FUEL LEVEL SENDING UNIT

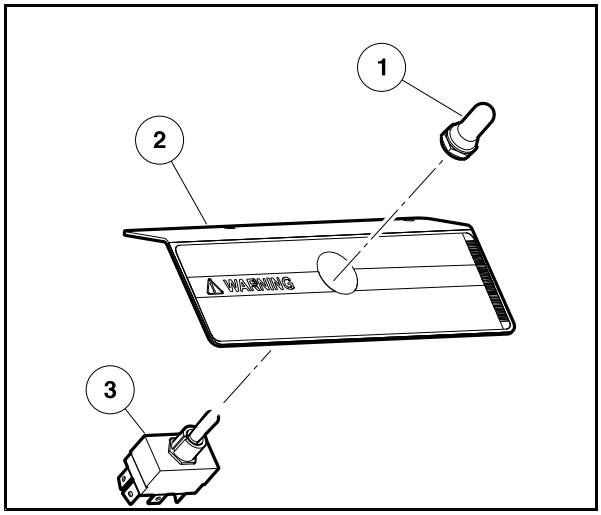
See General Warnings on page 1-2.

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.

MAINTENANCE/OPERATE SWITCH

MAINTENANCE/OPERATE SWITCH REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the boot/hex nut (1) **(Figure 27-23)**.



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Figure 27-23 Maintenance/Operate Switch

3. Remove the Maintenance/Operate switch (2) from bracket (3).

4. Disconnect the wires and remove Maintenance/Operate switch.

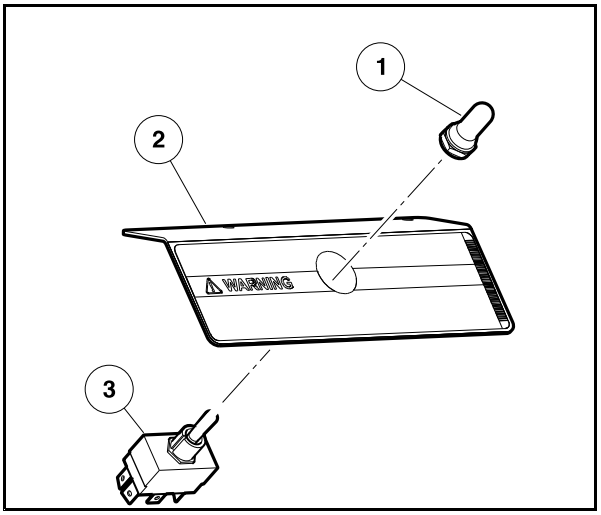
MAINTENANCE/OPERATE SWITCH INSTALLATION

1. Connect the wires to the Maintenance/Operate switch.

   Pedal-Start

Terminal	Wire Color
T1	Black / Pink
T2	Black
T3	Black / Yellow

2. Make sure that the groove switch is aligned with tang on bracket (3) and install the Maintenance/Operate switch (2) **(Figure 27-24, Page 27-23)**.



000755-004

Figure 27-24 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.

ACCELERATOR PEDAL LIMIT SWITCH

See General Warnings on page 1-2.

The accelerator pedal limit switch is housed inside the throttle position sensor. The throttle position sensor itself is not intended to be replaced. If sensor is determined to need replacing through test procedures found in this manual, the accelerator pedal assembly must be replaced.

KILL LIMIT SWITCH

See General Warnings on page 1-2.

The kill limit switch is housed inside the throttle position sensor. The throttle position sensor itself is not intended to be replaced. If sensor is determined to need replacing through test procedures found in this manual, the accelerator pedal assembly must be replaced.

MULTI-PURPOSE BUZZER LIMIT SWITCH

See General Warnings on page 1-2.

The multi-purpose buzzer limit switch is located on the back of the Forward/Neutral/Reverse control (FNR).

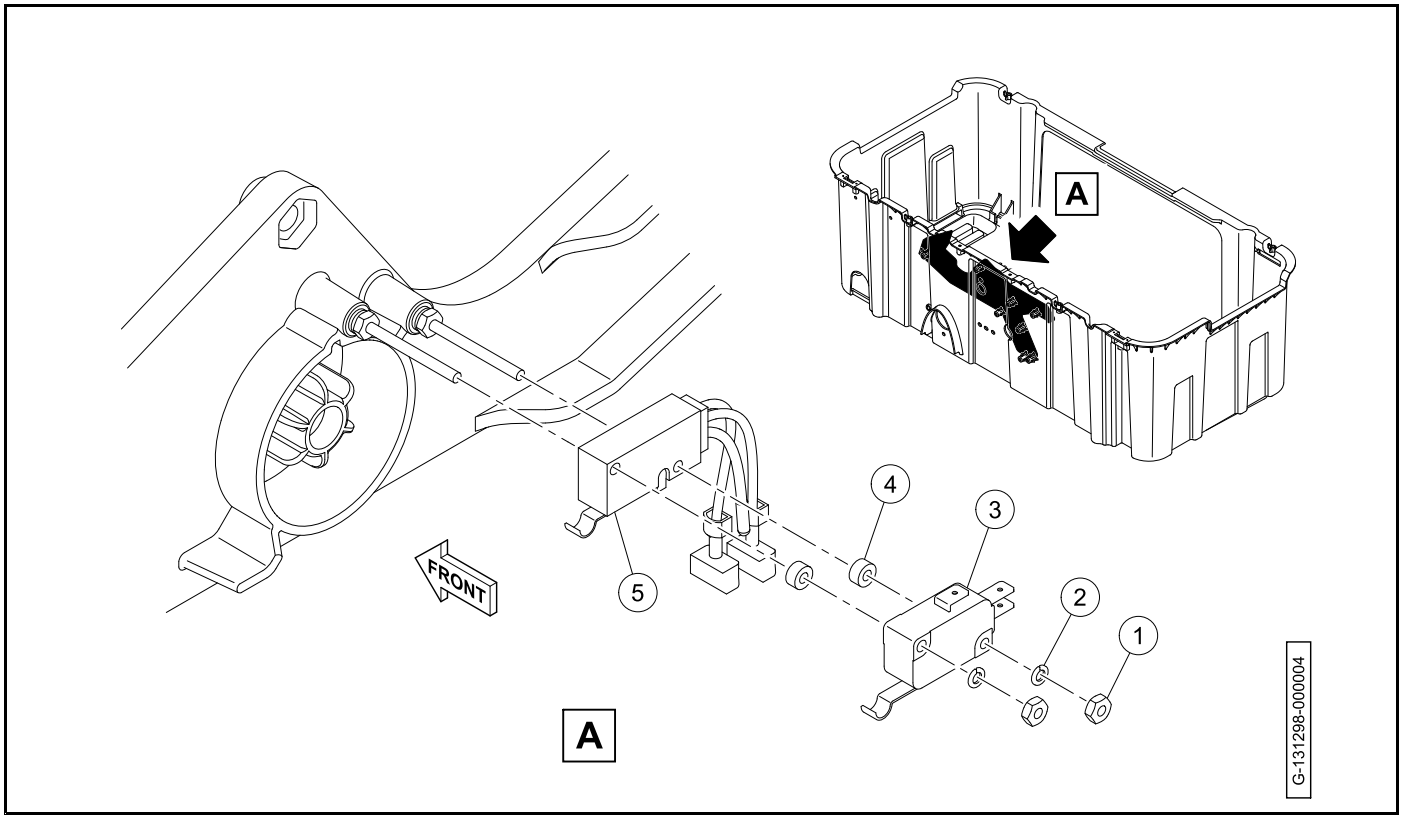


Figure 27-25 Multi-purpose Buzzer Limit Switch

MULTI-PURPOSE BUZZER LIMIT SWITCH REMOVAL

1. Disconnect the battery and spark plug wire.
2. Disconnect the multi-purpose buzzer limit switch wires from the main harness.
3. Remove the nuts (1) and washers (2) **(Figure 27-25, Page 27-24)**.
4. Remove the neutral lockout limit switch (3) and washers (4).
5. Remove the multi-purpose buzzer limit switch (5).

MULTI-PURPOSE BUZZER LIMIT SWITCH INSTALLATION

1. Install the multi-purpose buzzer limit switch (5) on the two bolts **(Figure 27-25, Page 27-24)**.
2. Install washers (4) and neutral lockout limit switch (3).

CAUTION

- **Do not overtighten the nuts. If the nuts are over tightened, the limit switches could be damaged.**

3. Install the washers (2) and nuts (1). Tighten the nuts to 4 in·lb (0.45 N·m).
4. Set the Forward/Neutral/Reverse control (FNR) to R.
5. Make sure that both limit switches actuate.
6. Connect the blue multi-purpose buzzer limit switch wire to the main harness red wire.
7. Connect the black multi-purpose buzzer limit switch wire to the main harness orange wire.

NOTE: *The red multi-purpose buzzer limit switch wire is not connected.*

8. Connect the battery and spark plug wire.
9. Set the FNR to R. Make sure that the multi-purpose buzzer operates.

NEUTRAL LOCKOUT LIMIT SWITCH

See General Warnings on page 1-2.

The neutral lockout limit switch is located on the back of the Forward/Neutral/Reverse control (FNR).

NEUTRAL LOCKOUT LIMIT SWITCH REMOVAL

1.
2. Disconnect the battery and spark plug wire.
3. Disconnect the wires from the neutral lockout limit switch (1) **(Figure 27-26, Page 27-25)**.

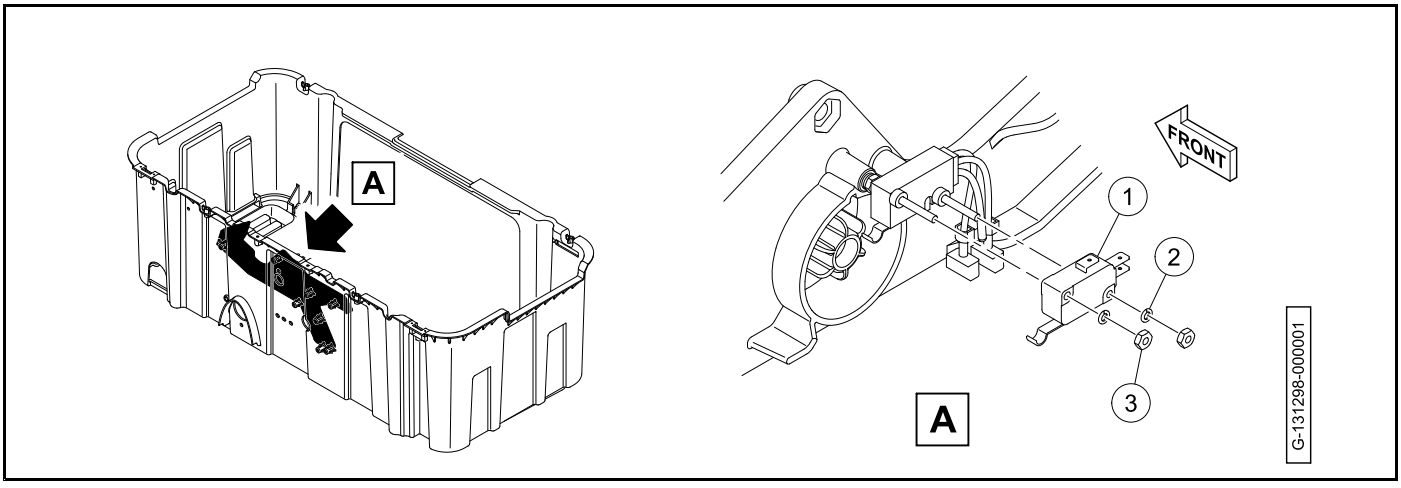


Figure 27-26 Neutral Lockout Limit Switch Removal

4. Remove the nuts (2) and washers (3).
5. Remove the neutral lockout limit switch.

NEUTRAL LOCKOUT LIMIT SWITCH INSTALLATION

1. Install the neutral lockout limit switch (1) on the bolts **(Figure 27-27, Page 27-26)**.

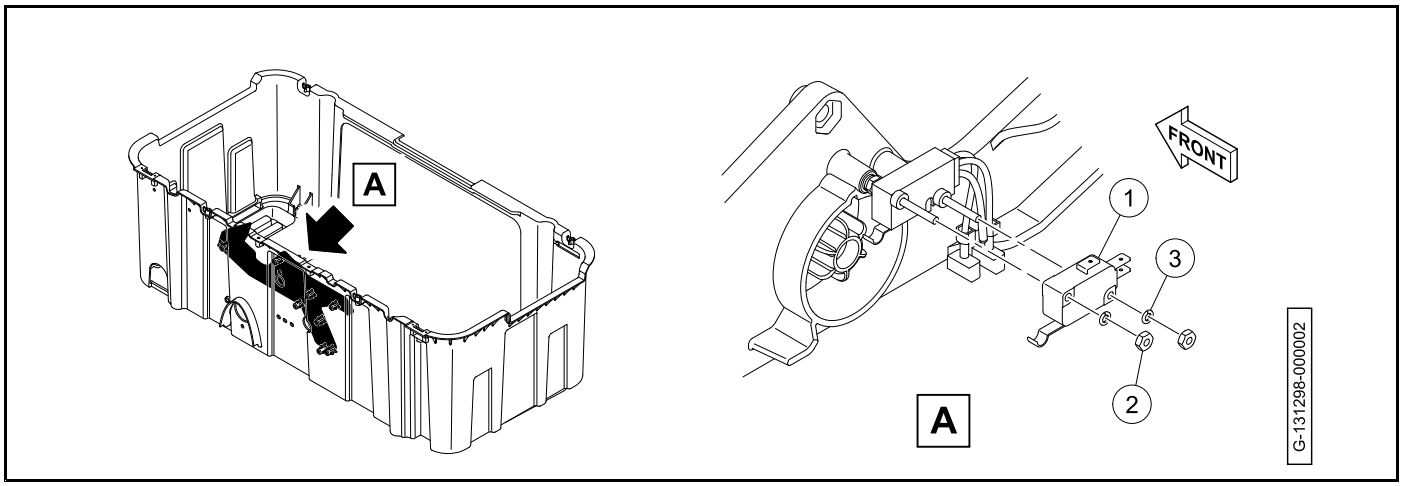


Figure 27-27 Neutral Lockout Limit Switch Installation

CAUTION

- **Do not overtighten the nuts. If the nuts are over tightened, the limit switches could be damaged.**

2. Install the washers (2) and nuts (3). Tighten the nuts to 4 in·lb (0.45 N·m).
3. Set the Forward/Neutral/Reverse control (FNR) to R.
4. Make sure that both limit switches actuate.
5. Connect the black/yellow wire to the COM1 terminal (4) **(Figure 27-28, Page 27-26)**.

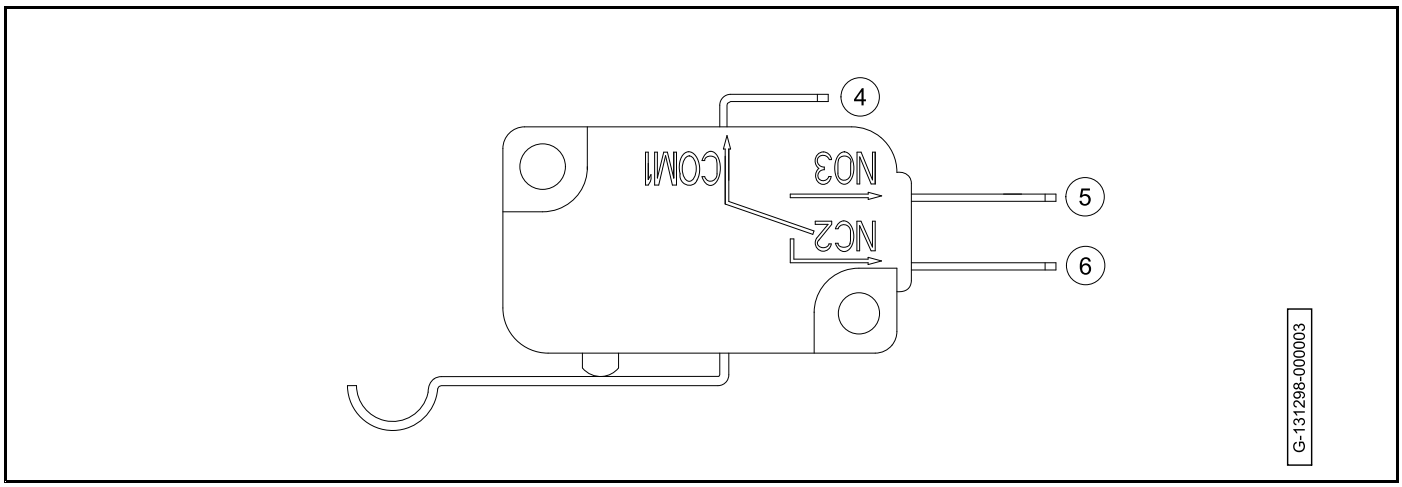


Figure 27-28 Neutral Lockout Limit Switch Terminals

6. Connect the green wire to the NO3 terminal (5).
7. Connect the white/black wire to the NC2 terminal (6).

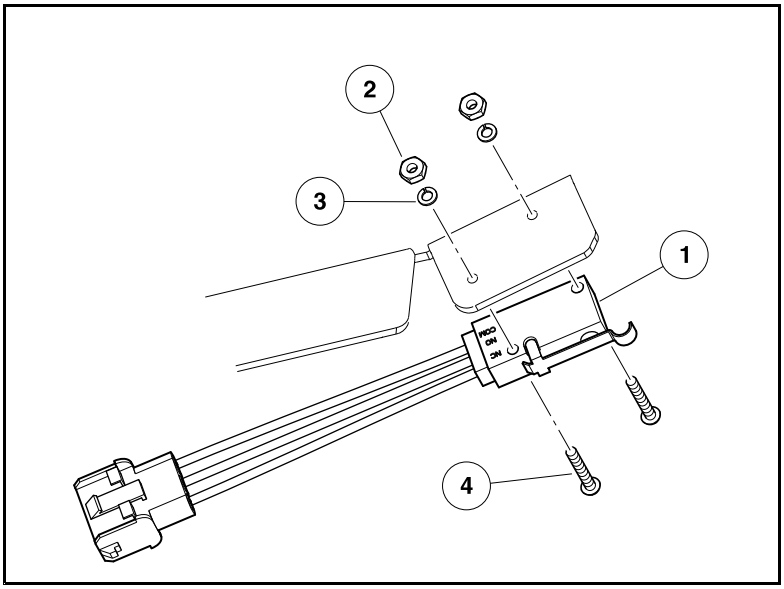
8. Connect the battery and spark plug wire.
9. Set the FNR to R. Make sure that the multi-purpose buzzer operates.

TRANSAXLE LIMIT SWITCH

See General Warnings on page 1-2.

TRANSAXLE LIMIT SWITCH REMOVAL

1. Disable the vehicle.
2. Disconnect the battery and spark plug wire.
3. Disconnect the 3-wire connector from the transaxle limit switch (1) **(Figure 27-29)**.



000999-003

Figure 27-29 Transaxle Limit Switch

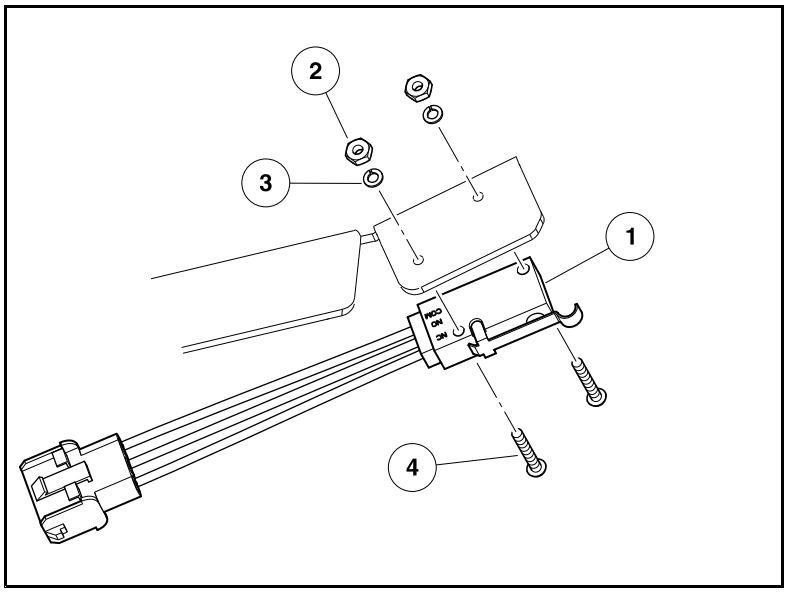
4. Remove the nuts (2), washers (3), and bolts (4).
5. Remove the transaxle limit switch.

TRANSAXLE LIMIT SWITCH INSTALLATION

⚠ CAUTION

- **Do not overtighten the retaining nuts. If the nuts are overtightened, limit switches could be damaged.**

1. Install the limit switch (1) with the bolts (4), washers (3), and nuts (2). Tighten the hardware to 5 in·lb (0.6 N·m) **(Figure 27-30)**.



000999-003

Figure 27-30 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 transaxle limit switch lead.
4. Connect the battery and spark plug wire.
5. Test drive the vehicle in both forward and reverse for proper operation.

BRAKE LIGHT RELAY

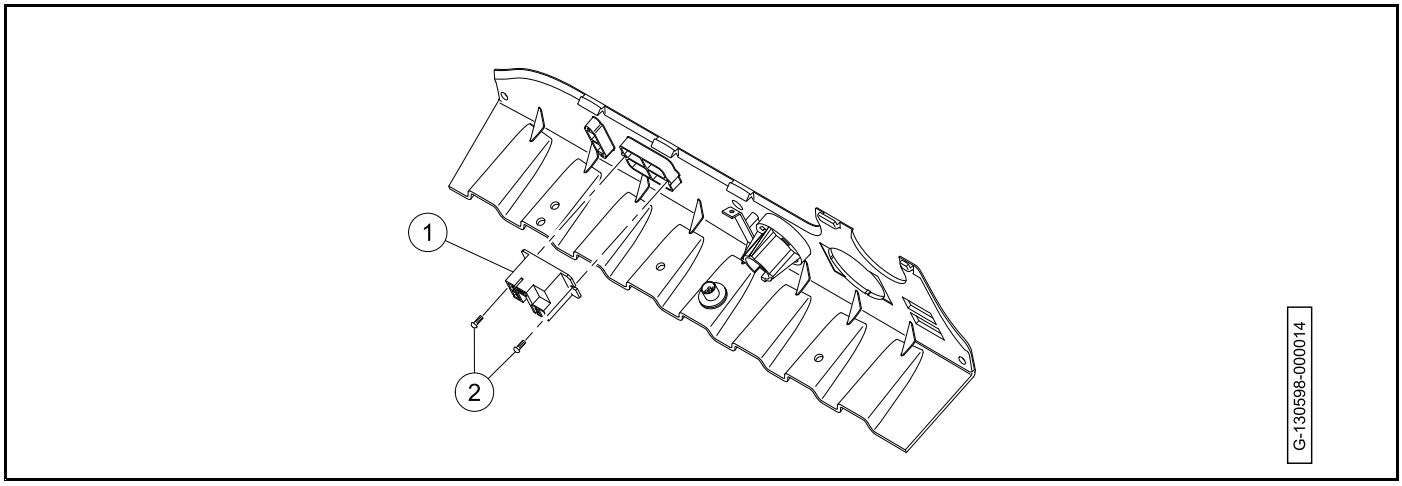


Figure 27-31 Brake Light Relay

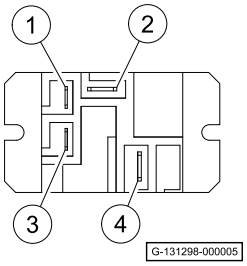
BRAKE LIGHT RELAY REMOVAL

1. Disconnect the battery and spark plug.
2. Remove the instrument panel.
3. Disconnect the wires from brake light relay (1) **(Figure 27-31, Page 27-28)**.

4. Remove the screws (2).
5. Remove the brake light relay.

BRAKE LIGHT RELAY INSTALLATION

1. Install the brake light relay (1) on the instrument panel **(Figure 27-31, Page 27-28)**.
2. Install the screws (2).
3. Connect the wires to the brake light relay terminals **(Figure 27-32, Page 27-29)**.



Pin Description	Wire Color
1	Blue
2	Red
4	Black
6	Green

Figure 27-32 Brake Light Relay Terminals

4. Install the instrument panel.
5. 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.

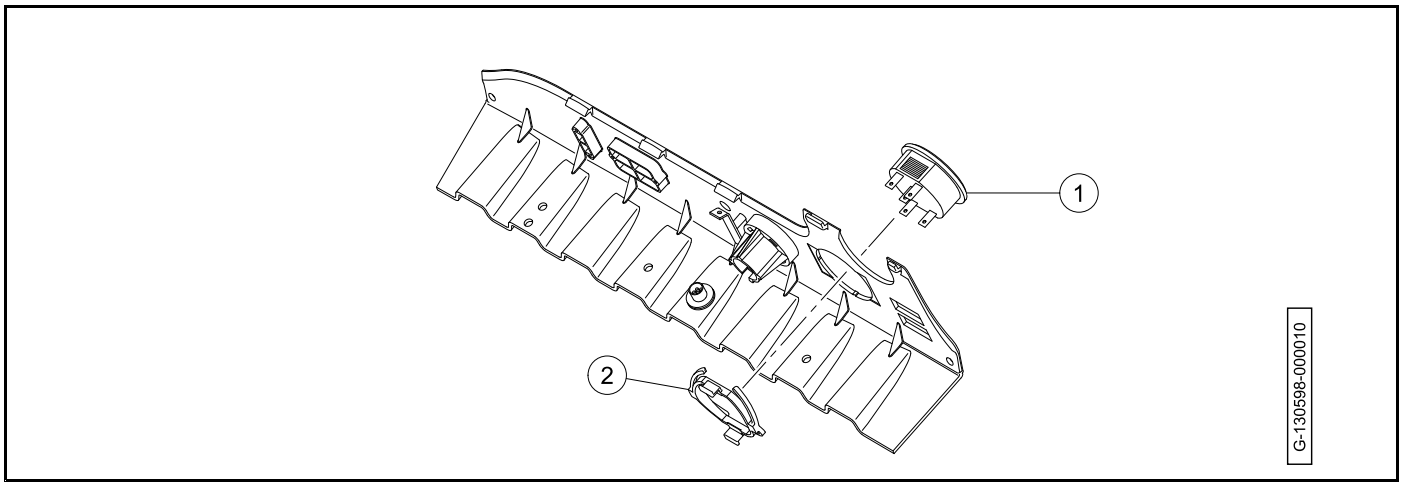


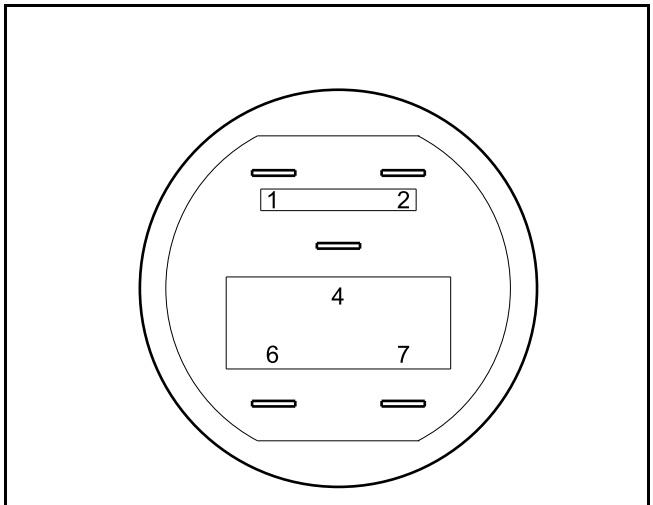
Figure 27-33 Fuel Gauge / Hour Meter

FUEL GAUGE/HOUR METER REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the wires from the fuel gauge/hour meter (1) **(Figure 27-33, Page 27-30)**. Do not allow wires to touch.
4. Alternate pulling the lower and upper tabs away from the gauge housing (2) to remove clip.
5. Remove the fuel gauge/hour 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 27-33, Page 27-30)**.
2. Install the gauge housing (2).
3. Connect the wires to the fuel gauge/hour meter **(Figure 27-34, Page 27-30)**.



Pin Description	Wire Color
1. Fuel (-)	Black

2. Fuel (+)	Blue
4. Fuel Input	Orange
6. Hour (-)	Black/White
7. Hour Input	Red

480

Figure 27-34 Fuel Gauge/Hour Meter

4. Install the instrument panel.
5. Connect the battery and spark plug wire.

HEADLIGHT SWITCH

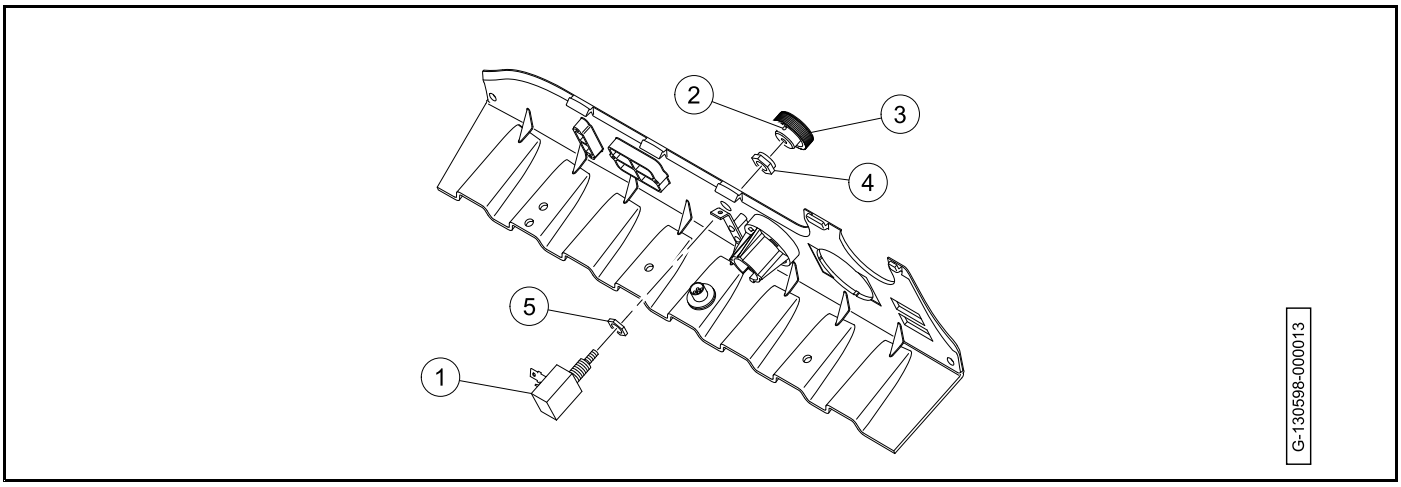


Figure 27-35 Headlight Switch

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 27-35, Page 27-31)**.
4. Loosen the set screw (2).
5. Remove the threaded knob (3).
6. Remove the nut (4).
7. Remove the headlight switch and nut (5).

HEADLIGHT SWITCH INSTALLATION

1. Install the nut (5) onto the headlight switch (1) **(Figure 27-35, Page 27-31)**.
2. Install the headlight switch into the instrument panel.
3. Install the nut (4). Tighten the nut to 2.2 lb·in (0.25 N·m).
4. Tighten the nut (5).
5. Install the threaded knob (3).
6. Tighten the set screw (2).

7. Connect the blue and yellow wires to the headlight switch terminals.
8. Install the instrument panel.
9. Connect the battery and spark plug wire.

KEY SWITCH

See General Warnings on page 1-2.

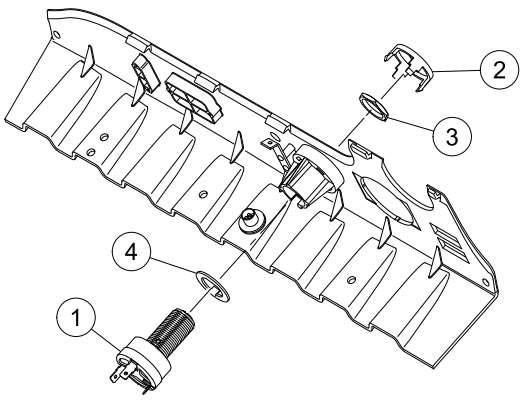


Figure 27-36 Key Switch

KEY SWITCH REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the wires from the key switch (1) **(Figure 27-36, Page 27-32)**.
4. From the back of the instrument panel, push down on the retaining tabs and remove the key switch cap (2).
5. Hold the key switch and remove the switch retaining nut (3) from the outside of the instrument panel.
6. Remove the washer (4) and the key switch

KEY SWITCH INSTALLATION

1. Install the key switch (1) and washer (4) into the instrument panel **(Figure 27-36, Page 27-32)**.
2. Install the key switch nut (3). Tighten the nut to 35 to 45 lb·in (4 to 5 N·m).
3. Install the key switch cap (2).
4. Connect the wires to the key switch terminals. See the following table.

Terminal	Wire Color
1	Blue

TABLE CONTINUED ON NEXT PAGE

2	Red
-M	Black
+M	White / Black

5. Install the instrument panel.
6. Connect the battery and spark plug wire.

LOW OIL WARNING LIGHT

See General Warnings on page 1-2.

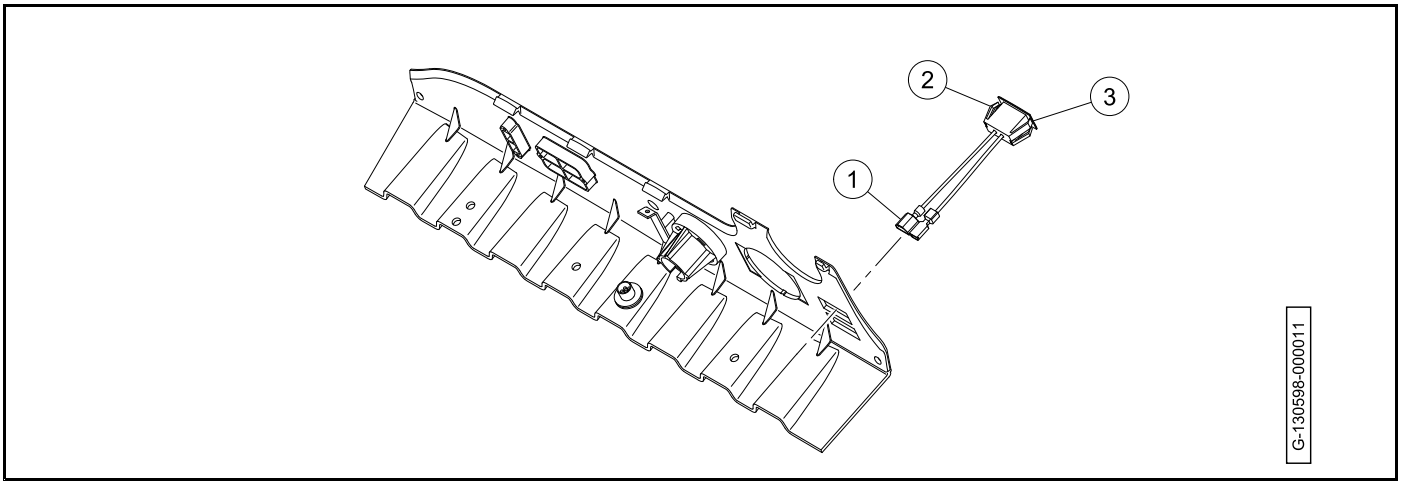


Figure 27-37 Low Oil Warning Light

LOW OIL WARNING LIGHT REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the wires (1) **(Figure 27-37, Page 27-33)**.
4. Push the retaining tabs (2) and remove the low oil warning light (3).

LOW OIL WARNING LIGHT INSTALLATION

1. Push the low oil warning light (1) into the hole in instrument panel until retaining tabs engage **(Figure 27-37, Page 27-33)**.
2. Connect the wires from the wire harness to the low oil warning light.
3. Install the instrument panel.
4. Connect the battery and spark plug wire.

MALFUNCTION INDICATOR LIGHT (MIL)

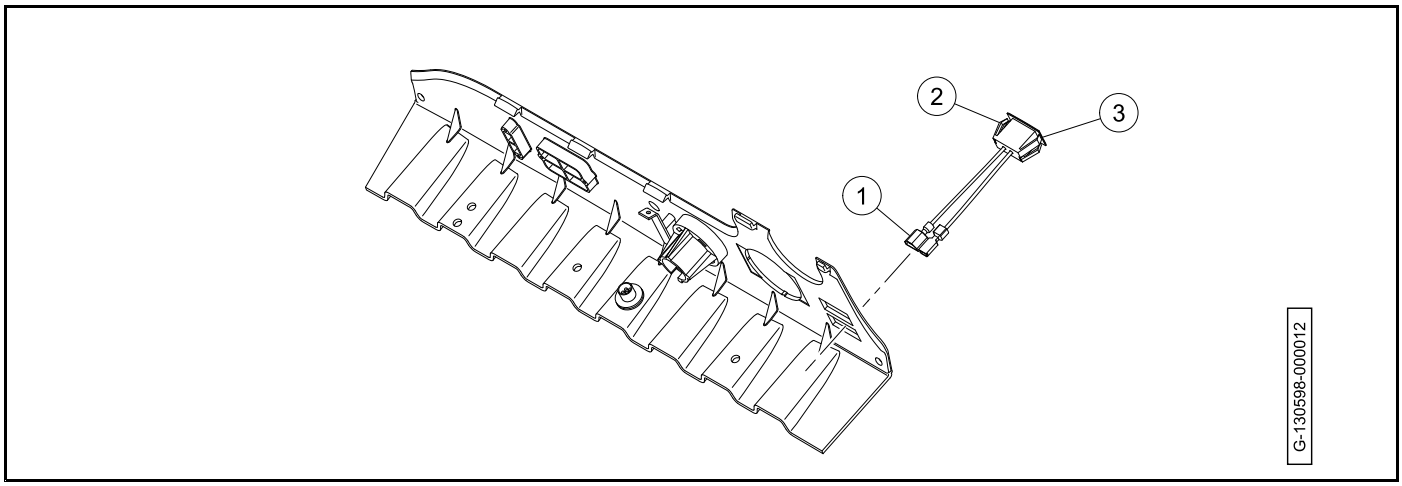


Figure 27-38 Malfunction Indicator Light (MIL)

MALFUNCTION INDICATOR LIGHT REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the wires (1) **(Figure 27-38, Page 27-34)**. Do not allow wires to touch.
4. Push the retaining tabs (2) and remove the malfunction indicator light (3) from the instrument panel.

MALFUNCTION INDICATOR LIGHT INSTALLATION

1. Push the malfunction indicator light (MIL) (1) into the hole in instrument panel until retaining tabs engage **(Figure 27-38, Page 27-34)**.
2. Connect the MIL wires.
3. Install the instrument panel.
4. Connect the battery and spark plug wire.

MULTI–PURPOSE BUZZER

See General Warnings on page 1-2.

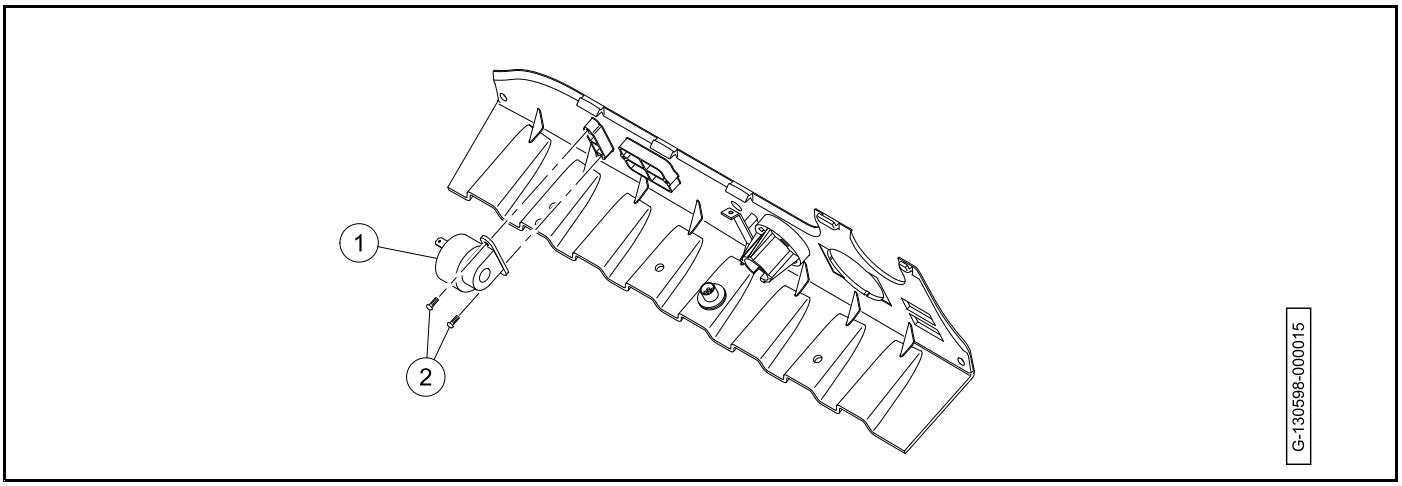


Figure 27-39 Multi-Purpose Buzzer

MULTI–PURPOSE BUZZER REMOVAL

1. Disconnect battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the wires from the multi-purpose buzzer (1) **(Figure 27-39, Page 27-35)**.
4. Remove the two mounting screws (2).

MULTI-PURPOSE BUZZER INSTALLATION

1. Install the multi-purpose buzzer (1) onto the instrument panel **(Figure 27-39, Page 27-35)**.
2. Install the screws (2). Tighten the screws to 3.5 lb·in (0.40 N·m).
3. Connect the black wire to the negative (–) terminal.
4. Connect the red/white wire to the positive (+) terminal.
5. Install the instrument panel.
6. Connect battery and spark plug wire.
7. Set the Forward/Neutral/Reverse control (FNR) to R. Make sure that the multi-purpose buzzer operates.

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. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the USB receptacle wires (1 and 2) from the instrument panel wires **(Figure 27-40, Page 27-36)**.

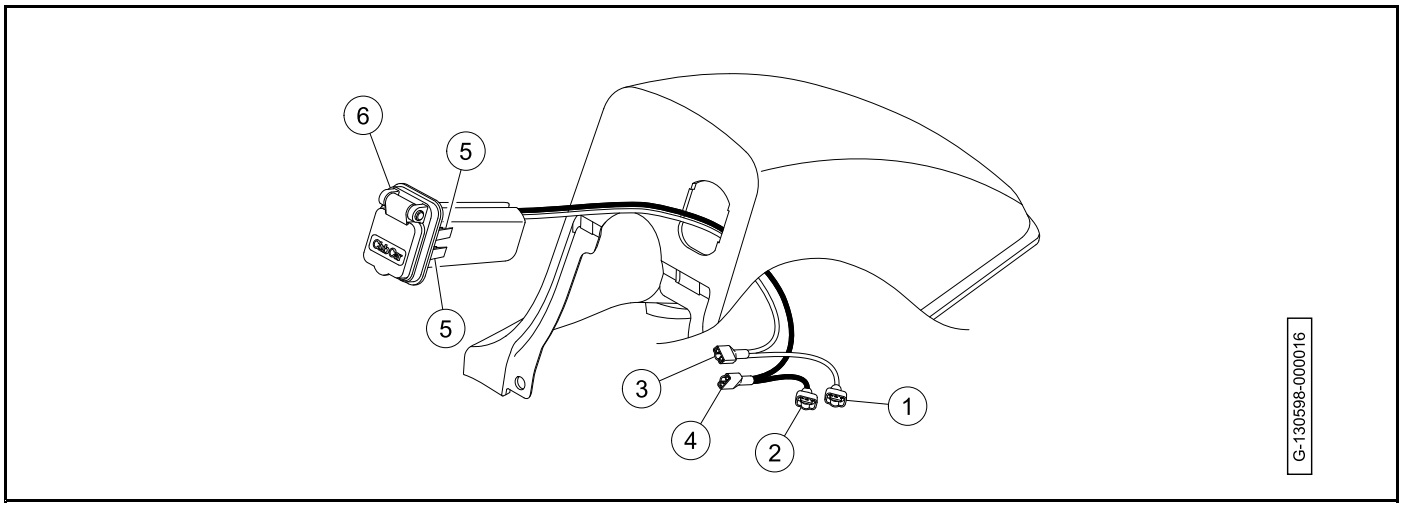


Figure 27-40 USB Receptacle

4. Disconnect the USB receptacle wires (3 and 4) from the key switch.
5. Push the lock tabs (5) on both sides and remove the USB receptacle (6).

USB RECEPTACLE INSTALLATION

1. Put the USB receptacle wires into the dash.
2. Push the USB receptacle (6) into the dash **(Figure 27-40, Page 27-36)**.
3. Make sure that the locking tabs (5) engage.
4. Connect the red instrument panel wire to the red USB receptacle wire (1).
5. Connect the black instrument panel wire to the black USB receptacle wire (2).
6. Connect the red USB receptacle wire (3) to key switch 2 terminal.
7. Connect the black USB receptacle wire (4) to key switch M- terminal.
8. Install the instrument panel.
9. Connect the battery and spark plug wire.

OXYGEN SENSOR

OXYGEN SENSOR REMOVAL

1. Disconnect the battery.
2. Disconnect the oxygen sensor connector from the engine wire harness (1) **(Figure 27-41, Page 27-37)**.

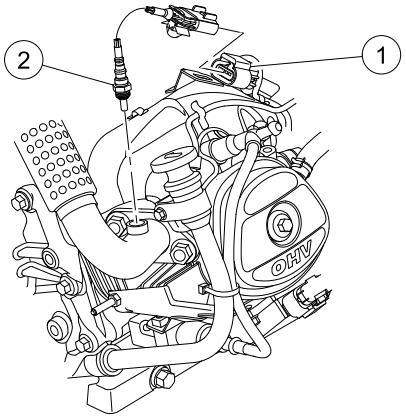


Figure 27-41 Oxygen Sensor

3. Remove the oxygen sensor (2).

OXYGEN SENSOR INSTALLATION

1. Install the oxygen sensor (2) into the muffler tube **(Figure 27-41, Page 27-37)**. 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.

Pagination Page

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

GENERAL INFORMATION

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.

For complete disassembly, rebuild, maintenance, and repair information, **See Kohler Engine Service Manual, Section 32, Page 32-1.**

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.

ENGINE REMOVAL

⚠ 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 28-1, Page 28-2)**

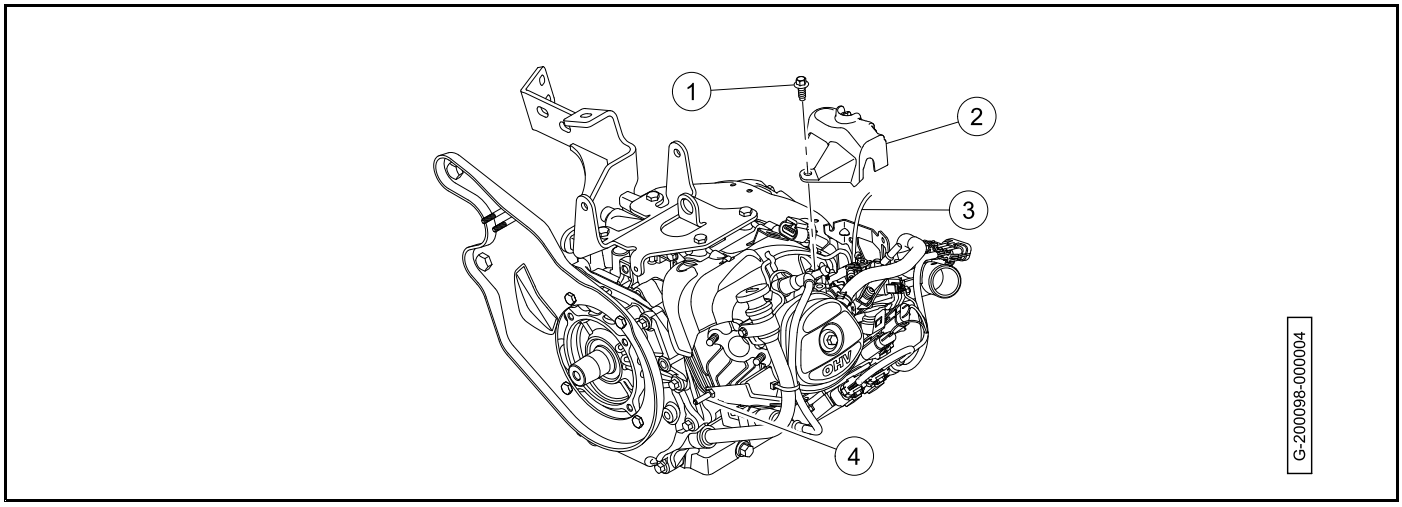


Figure 28-1 Governor Cover and Ground Cable Removal

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 28-2, Page 28-3)**.

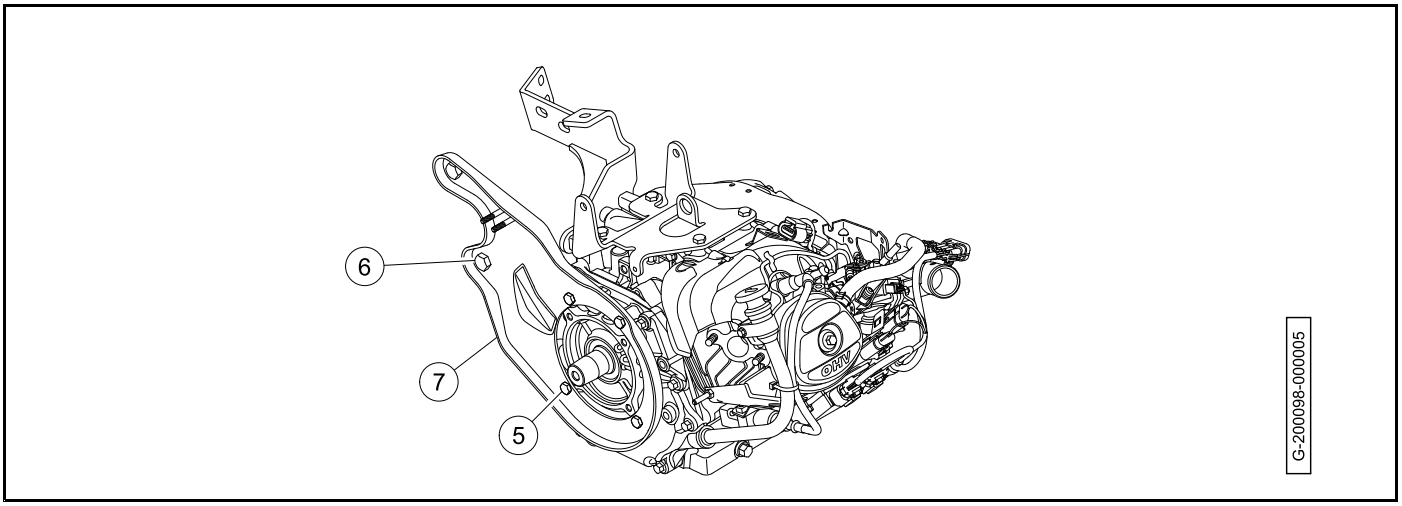


Figure 28-2 Clutch Plate Removal

17. Remove the clutch plate (7).
18. Remove the bolts (8) **(Figure 28-3, Page 28-3)**.

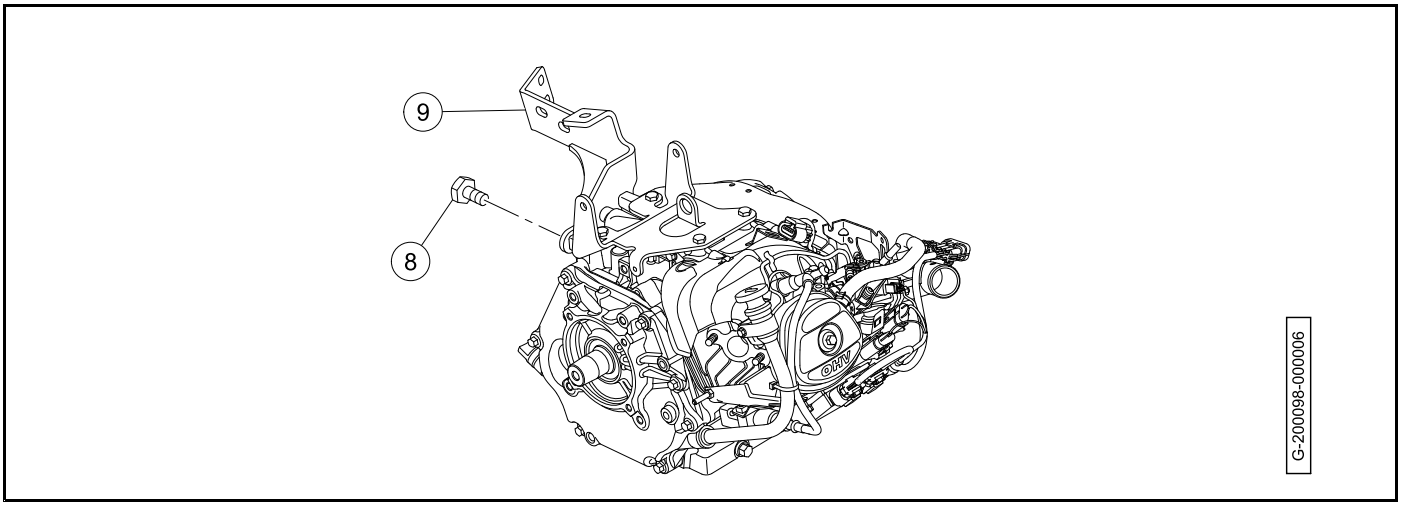


Figure 28-3 Exhaust Weldment Removal

19. Remove the exhaust weldment (9).

20. Remove the bolts (10), washers (11), and nuts (12) **(Figure 28-4, Page 28-4)**.

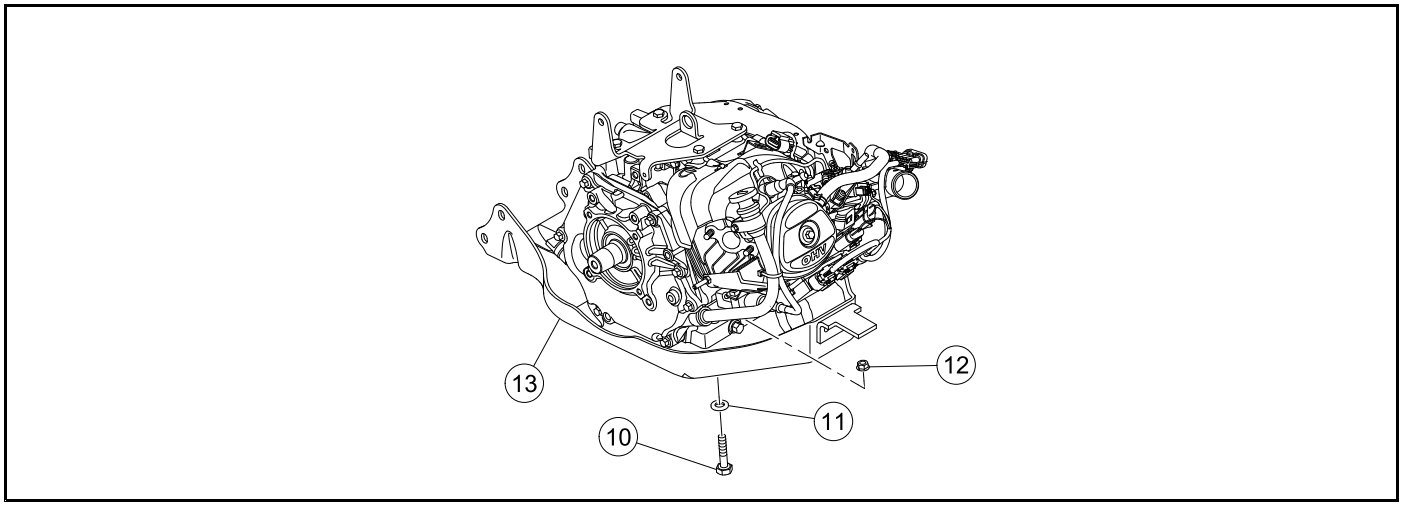


Figure 28-4 Engine Pan Removal

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

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 28-5, Page 28-5)**. Tighten the nuts to 33 ft·lb (40.6 N·m).

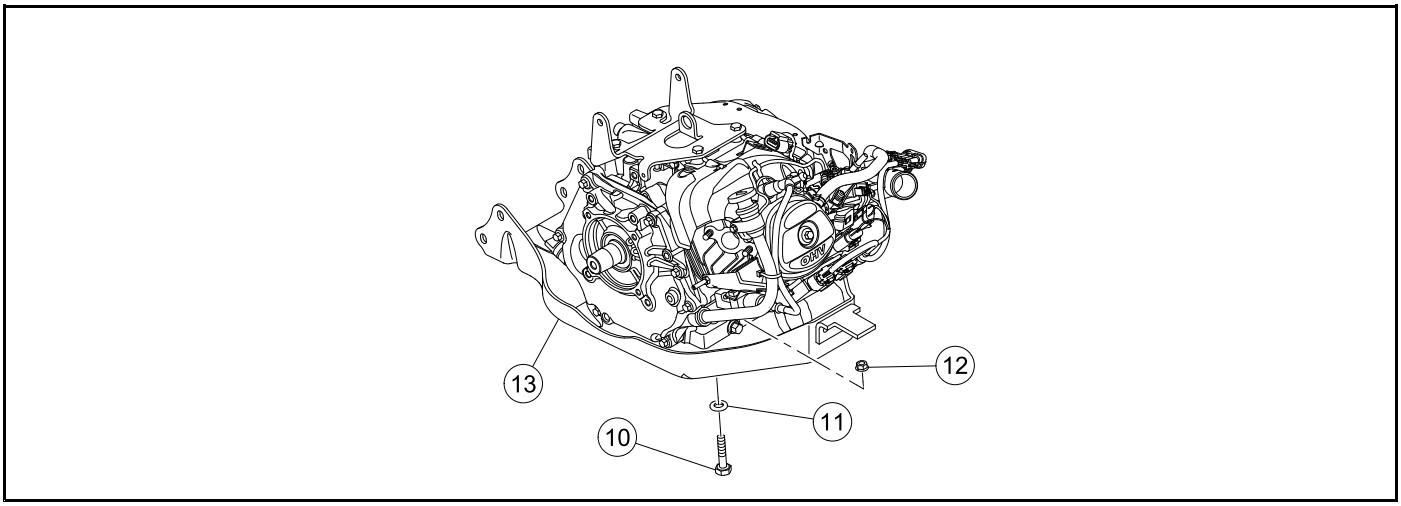


Figure 28-5 Engine Pan Installation

4. Install the muffler weldment (9) with the bolts (8) **(Figure 28-6, Page 28-5)**. Tighten the bolts to 18 ft·lb (24 N·m).

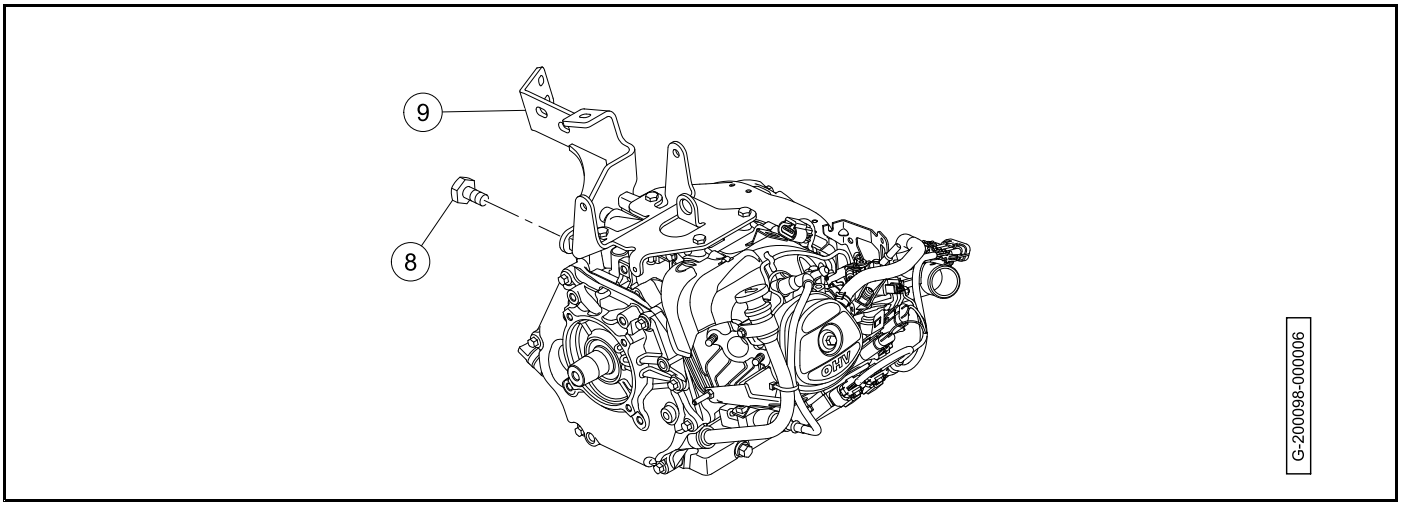


Figure 28-6 Exhaust Weldment Installation

5. Install the clutch plate (7) with bolts (5 and 6) **(Figure 28-7, Page 28-6)**. Tighten the bolts (5) to 27 ft·lb (36 N·m). Tighten the bolts (6) to 50 ft·lb (68 N·m).

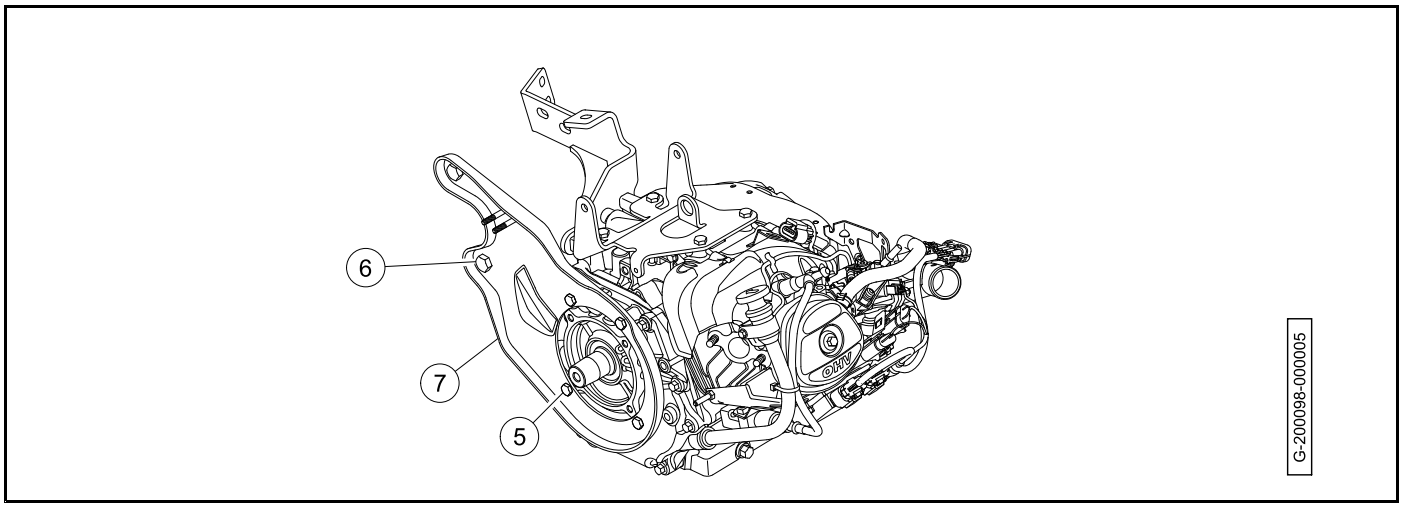


Figure 28-7 Clutch Plate Installation

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 28-8, Page 28-7)**.

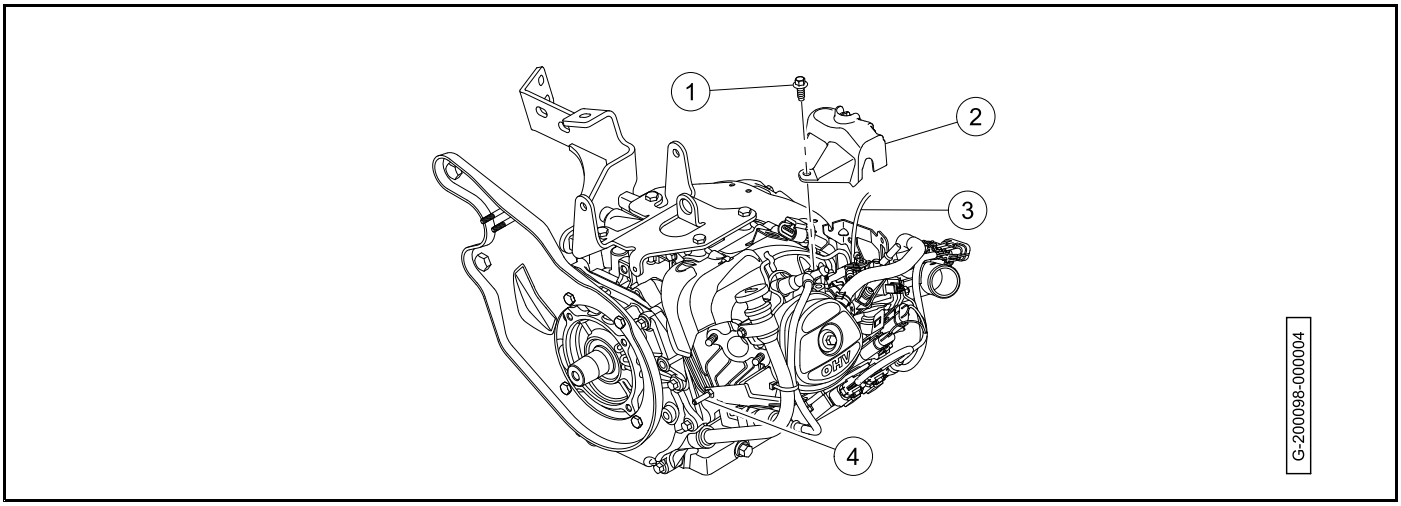


Figure 28-8 Governor Cover and Ground Cable Installation

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

NOTE: *The snubber is installed on the gasoline vehicle only.*

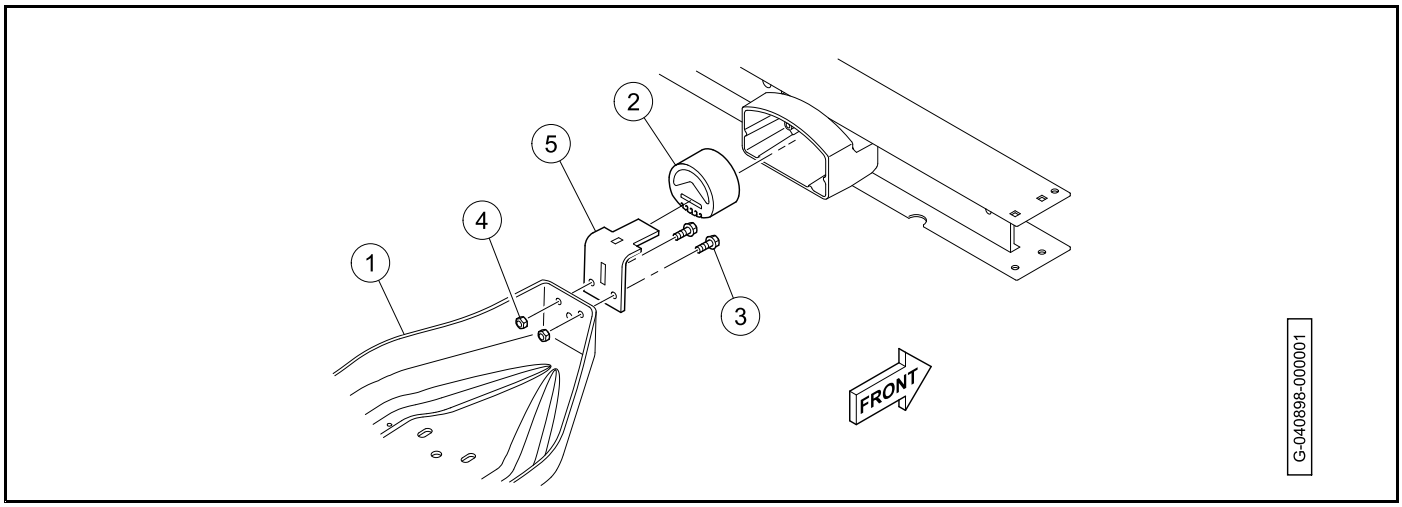


Figure 28-9 Snubber

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 28-9, Page 28-8)**.
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 HOUSING AND SPACER REMOVAL

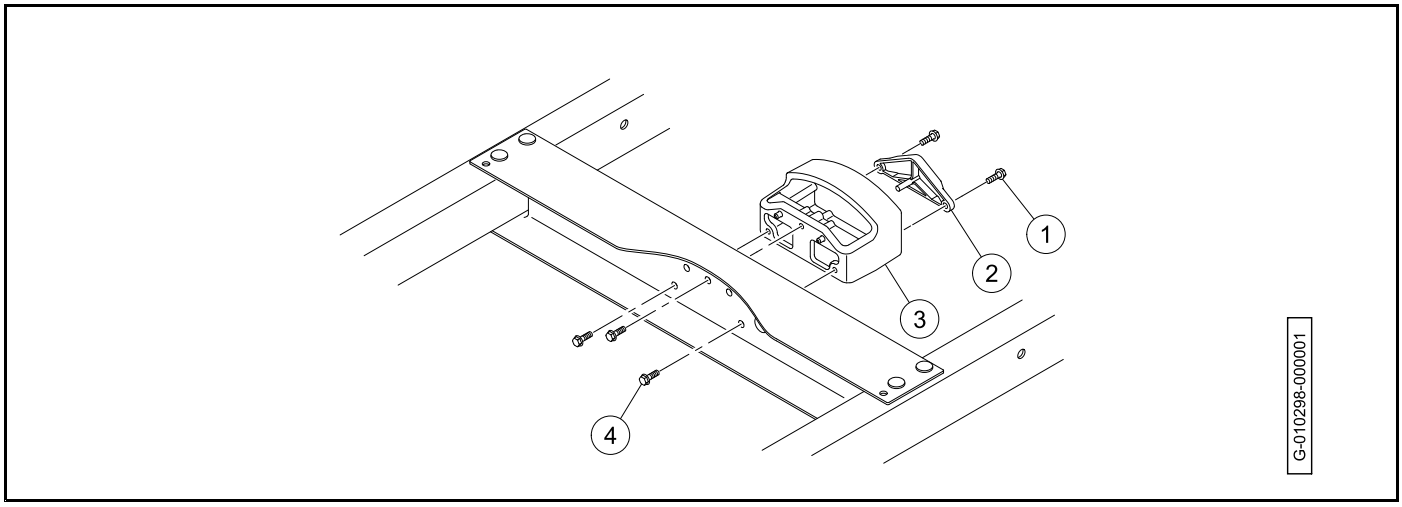


Figure 28-10 Snubber Housing and Spacer

1. Remove the two bolts (1) securing the snubber spacer (2) to the snubber housing (3) **(Figure 28-10, Page 28-8)**.
2. Remove the three bolts (4) securing the snubber housing to the vehicle frame.
3. Remove the snubber housing from the vehicle frame.

SNUBBER HOUSING AND SPACER INSTALLATION

1. Install the snubber housing (3) onto the vehicle frame **(Figure 28-10, Page 28-8)**.
2. Align the holes in the snubber housing with the holes in the vehicle frame.
3. Attach the snubber housing to the vehicle frame with the three bolts (4). Tighten the bolts from 6.6 to 8.1 ft·lb (9 to 11 N·m).
4. Slide the snubber spacer (2) into the snubber housing.
5. Attach the snubber spacer to the snubber housing with the two bolts (1). Tighten the bolts from 3.7 to 5.1 ft·lb (5 to 7 N·m).

SNUBBER INSTALLATION

1. Slide the snubber (2) onto the snubber bracket (5) **(Figure 28-9, Page 28-8)**.
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).

Pagination Page

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

⚠ WARNING

- **Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine.**

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

⚠ DANGER

- **To ensure the vehicle does not run over you while you disconnect or adjust the accelerator push cable, do the following:**
  - **– Turn key switch OFF and remove key, place Forward/Neutral/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 1-3.**

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.

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 29-1, Page 29-3)**.

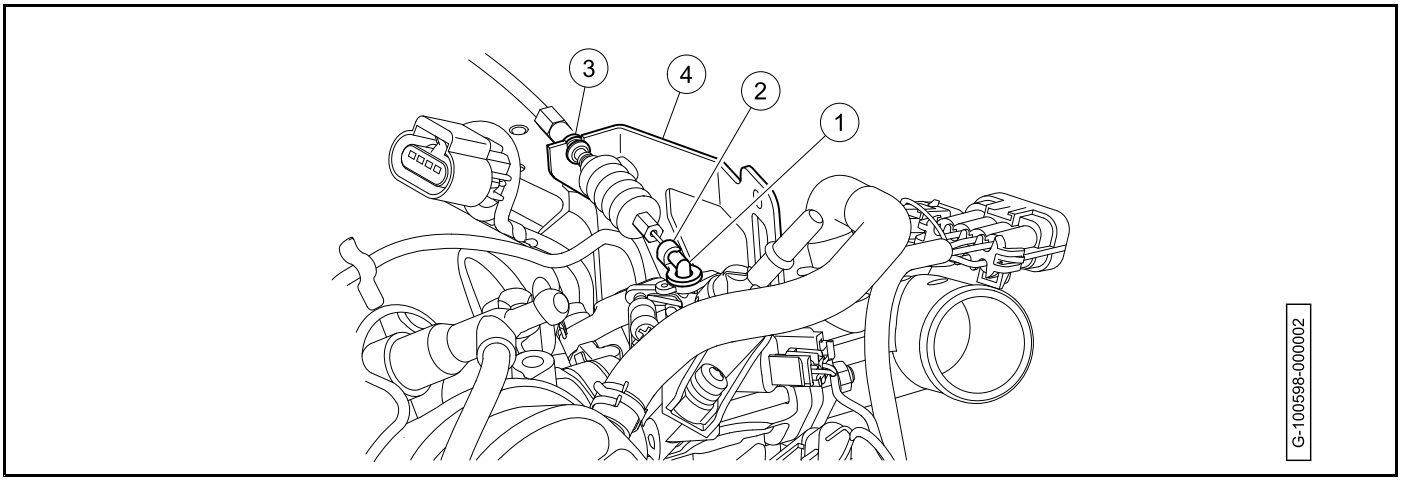


Figure 29-1 Governor Cable Removal - Throttle Body

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 29-2, Page 29-3)**.

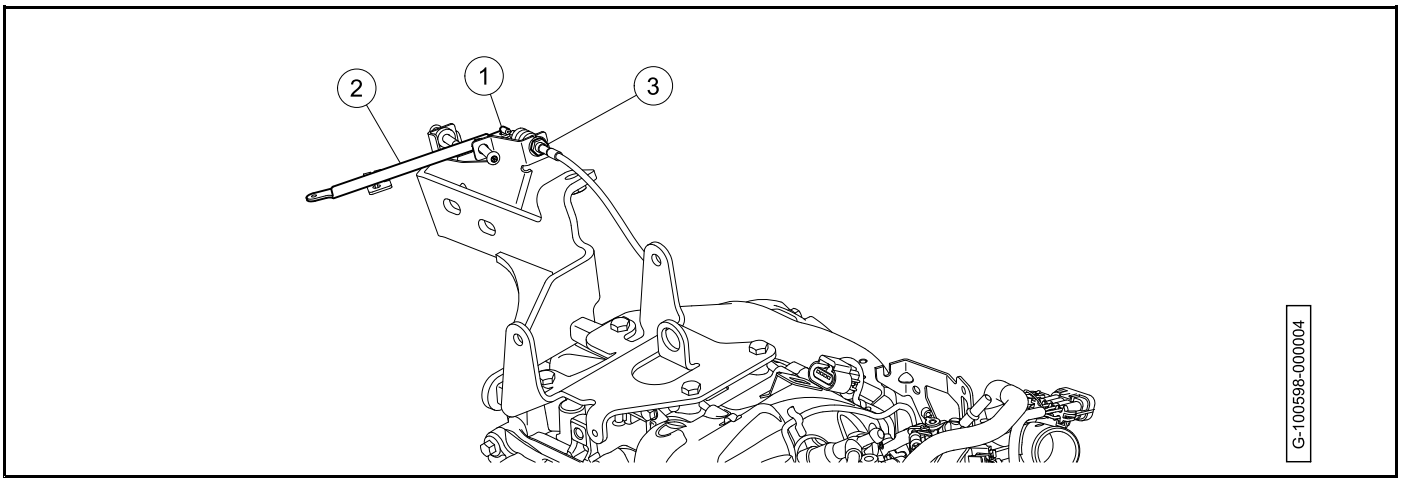


Figure 29-2 Governor Cable Removal - Governor Arm

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 29-3, Page 29-4)**.

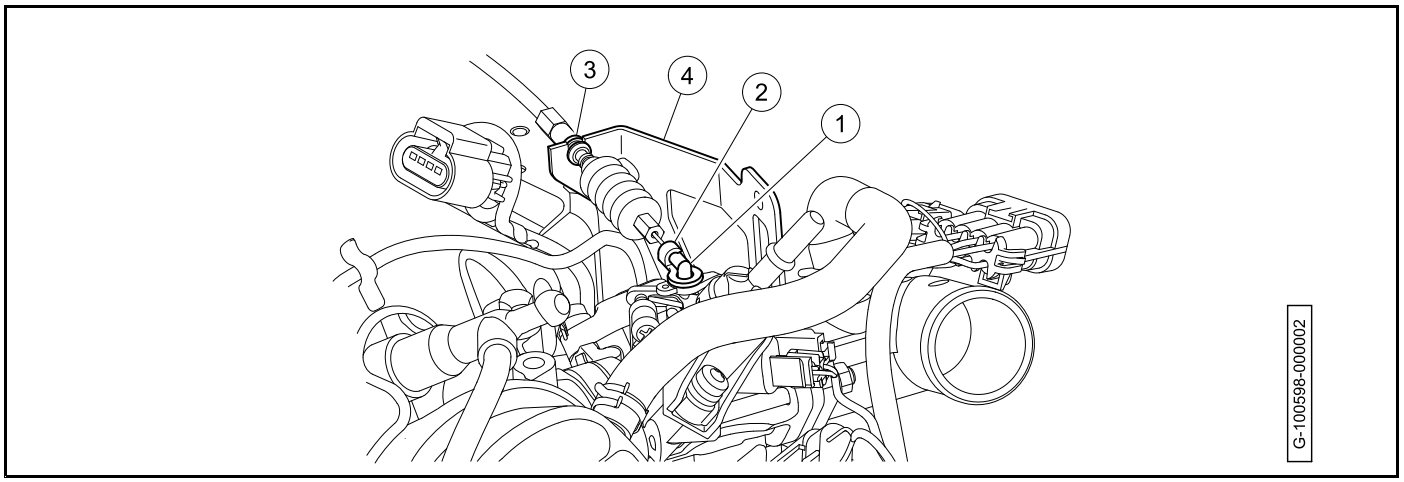


Figure 29-3 Governor Cable Installation - Throttle Body

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 (4) **(Figure 29-4, Page 29-4)**.

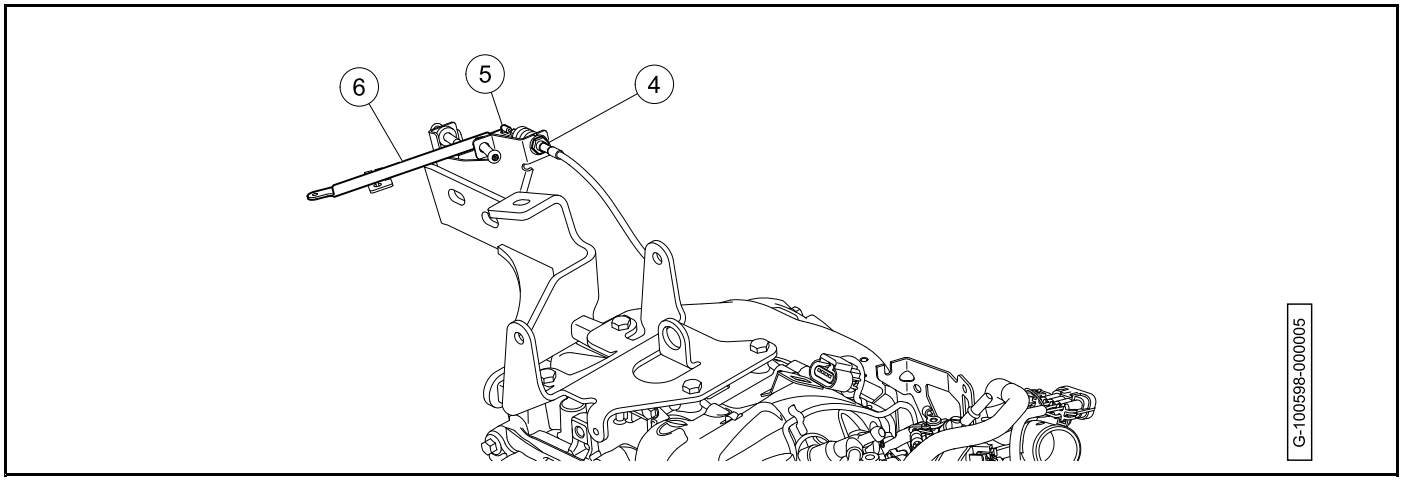


Figure 29-4 Governor Cable Installation - Governor Arm

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 (5) to governor arm (6).

3. Adjustment:

3.1. Connect the diagnostic tool.

3.2. Loosen the jam nuts (7 and 11) and back off the throttle stop screws (8 and 12) several turns **(Figure 29-5, Page 29-5)**.

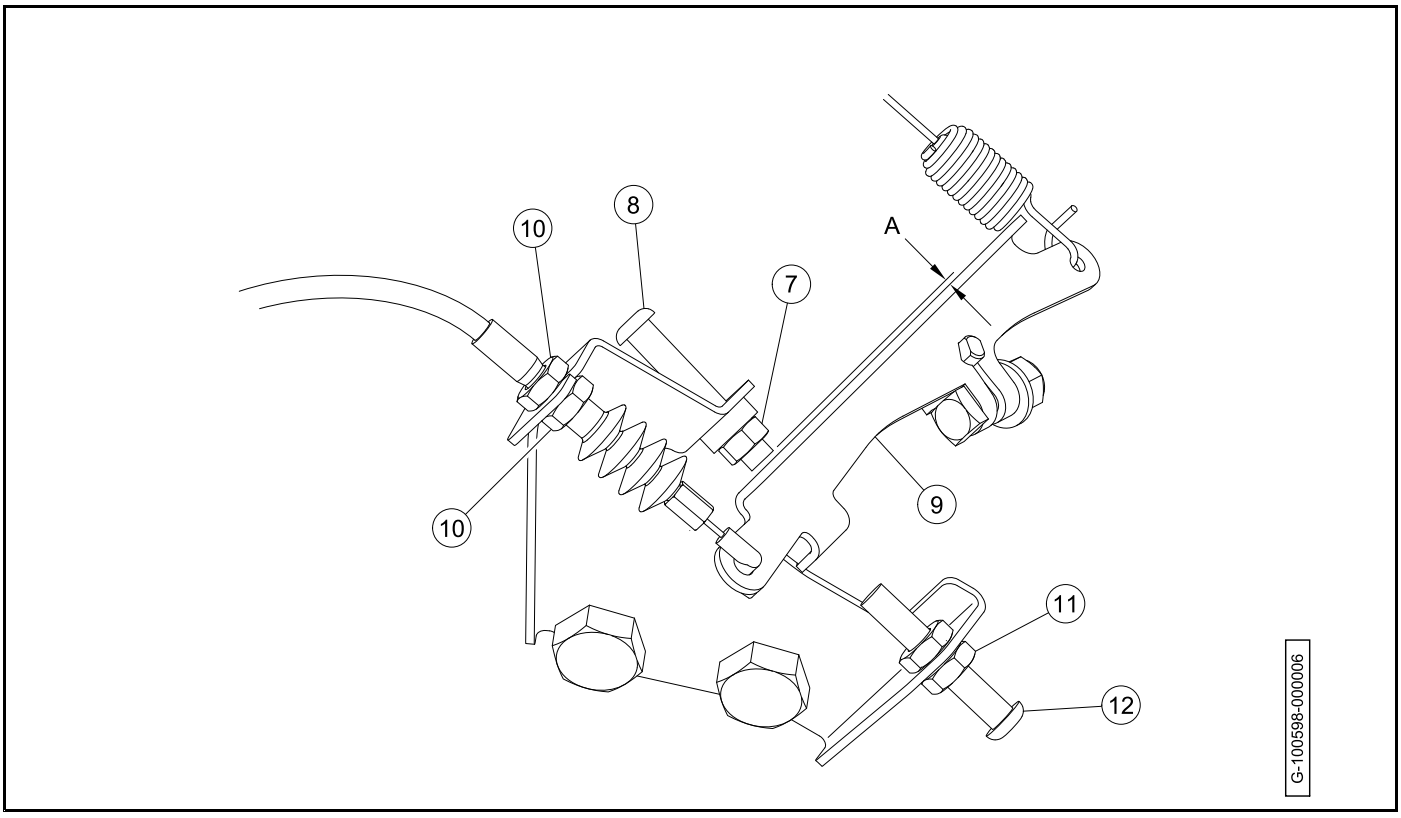


Figure 29-5 Governor Cable Adjustment

3.3. Rotate the governor arm (9) counterclockwise until it stops and hold in this position.

3.4. Adjust the governor cable jam nuts (10) until throttle position sensor is at 100% on the diagnostic tool. Tighten the governor cable jam nuts to 36 in·lb (4.0 N·m).

3.5. Release the governor arm to return to “idle” position.

3.6. Adjust the gap (A) between governor arm and stop screw (8) to 0.055 in. (±0.039) (1.4 mm (±1)). Tighten the jam nut (7) to 36 in·lb (4.0 N·m).

3.7. Rotate the governor arm counterclockwise.

3.8. Adjust the stop screw (12) until the throttle position sensor is between 75 - 80%. Tighten the jam nut (11) to 36 in·lb (4.0 N·m).

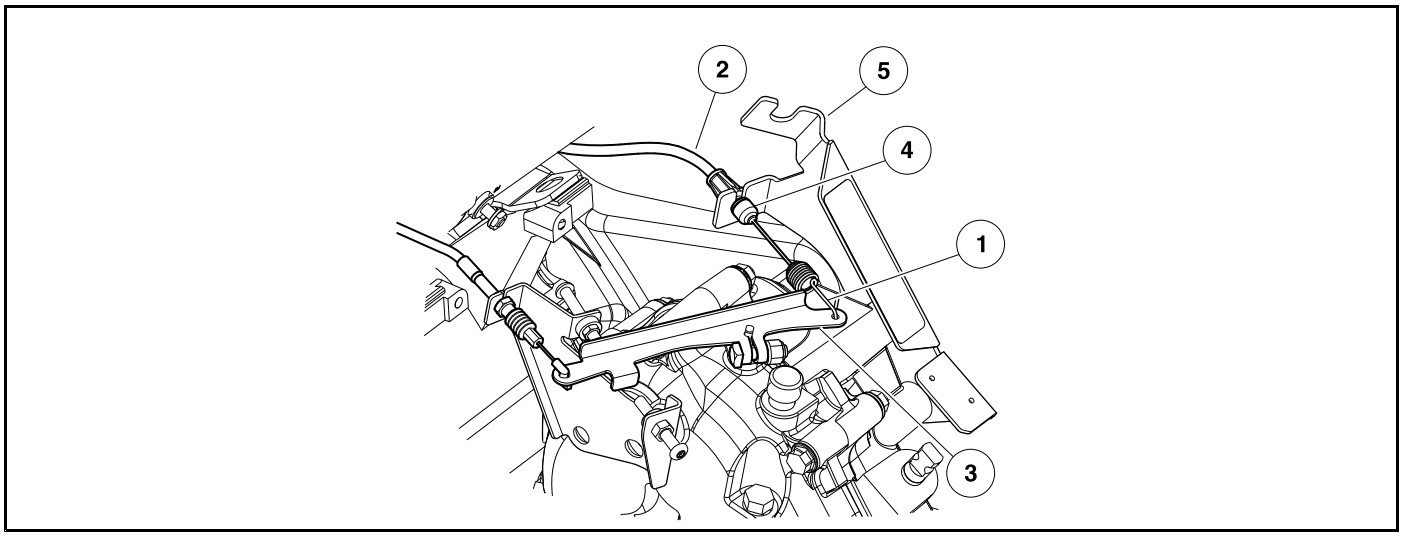
3.9. Check engine RPM adjustment. See Engine RPM Adjustment.

ACCELERATOR CABLE

Accelerator Cable Removal

1. Disable the vehicle.
2. Disconnect the battery and spark plug wire.
3. Remove the P-clamps that secure the accelerator cable to the engine assembly.
4. At transaxle:

4.1. Unhook the spring fitting (1) of accelerator cable (2) from governor arm (3) **(Figure 29-6, Page 29-6)**.



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Figure 29-6 Accelerator Cable At Transaxle

4.2. Remove the dust shield (4) from the end of the cable housing.

4.3. Unsnap the accelerator cable from FNR/accelerator cable bracket (5).

5. At pedal group:

5.1. Remove the floor mat.

5.2. Remove the push rivet (6) **(Figure 29-7, Page 29-6)**.

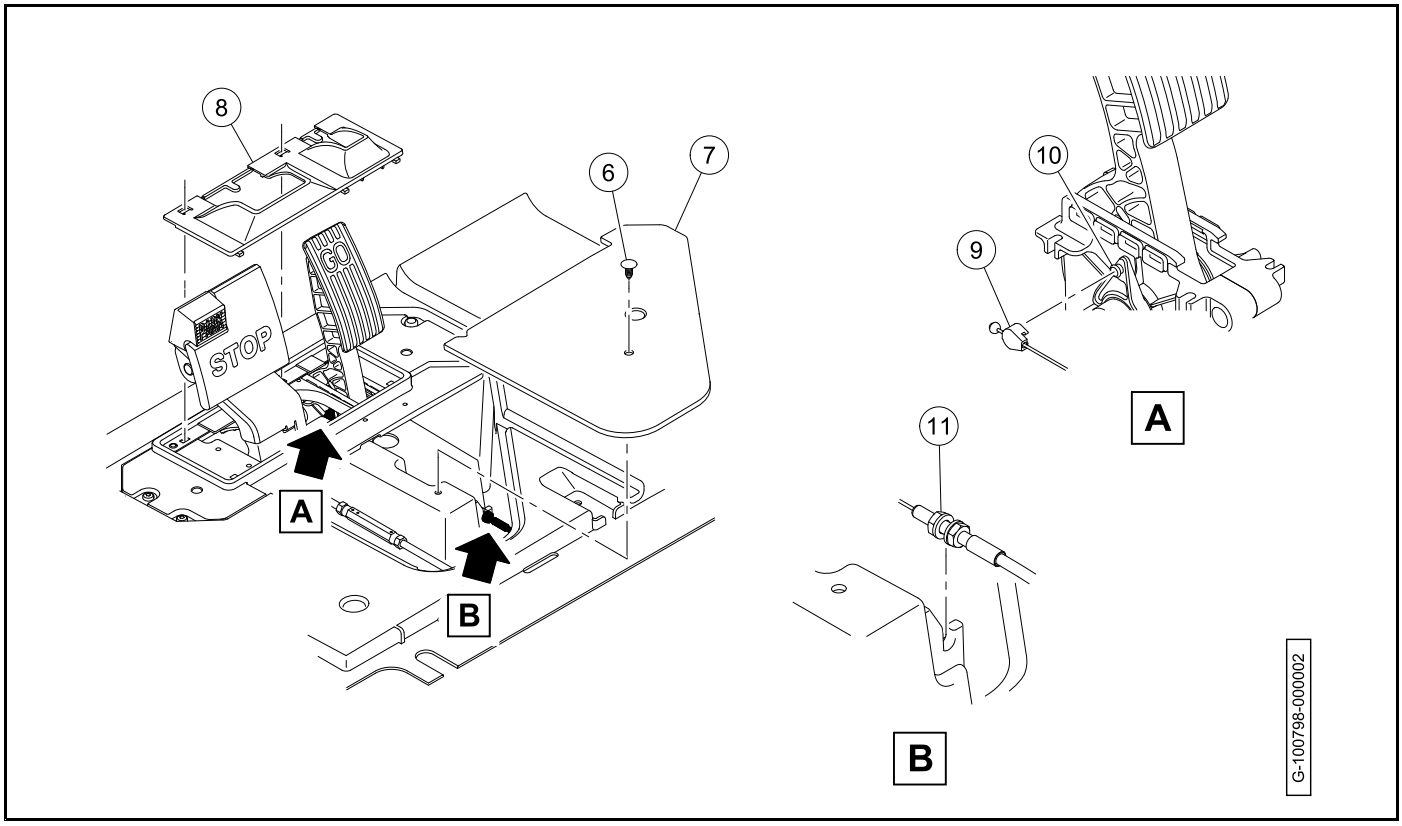


Figure 29-7 Accelerator Cable At Pedal Group

5.3. Remove the floor cover plate (7).

5.4. Remove the debris shield (8).

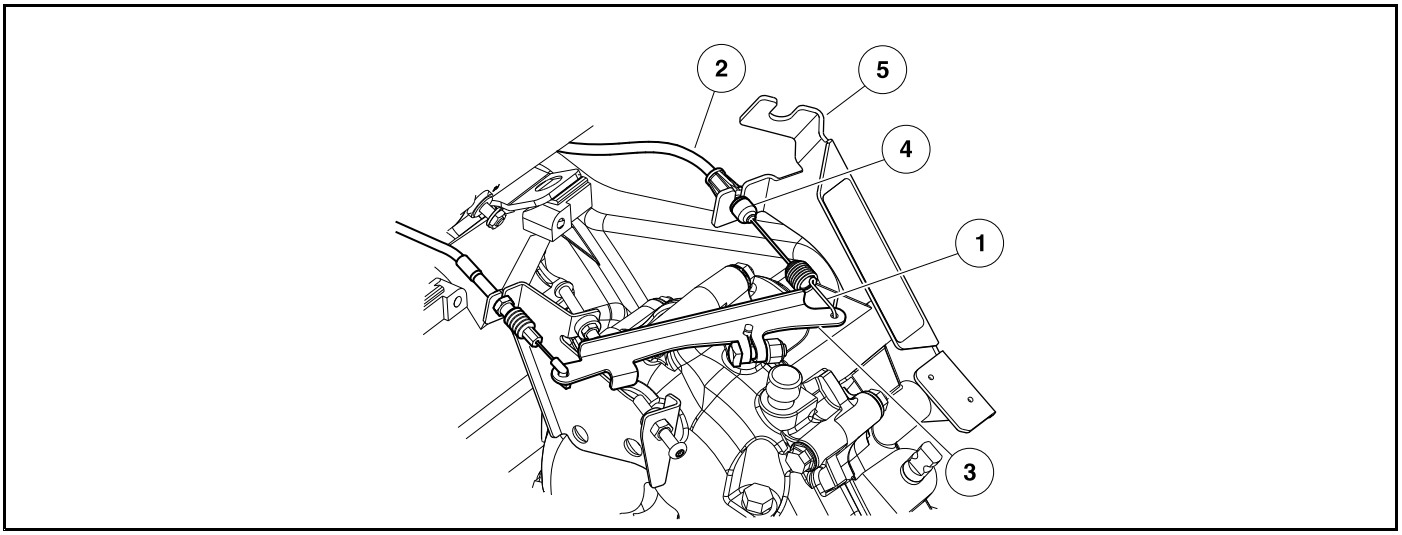
5.5. Disconnect the accelerator cable clip (9) from the accelerator pedal (10).

5.6. Loosen the jam nuts (11) and remove accelerator cable from vehicle.

Accelerator Cable Installation

1. At transaxle:

1.1. Hook the spring fitting (1) of accelerator cable (2) to governor arm (3) **(Figure 29-8, Page 29-7)**.



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Figure 29-8 Accelerator Cable At Transaxle

1.2. Snap the accelerator cable into FNR/accelerator cable bracket (5).

1.3. Push the dust shield (4) onto end of cable housing.

2. At pedal group:

2.1. Insert the accelerator cable through the hole in the frame and feed it towards the pedal group.

2.2. Connect the accelerator cable clip (9) to the accelerator pedal (10) **(Figure 29-9, Page 29-8)**.

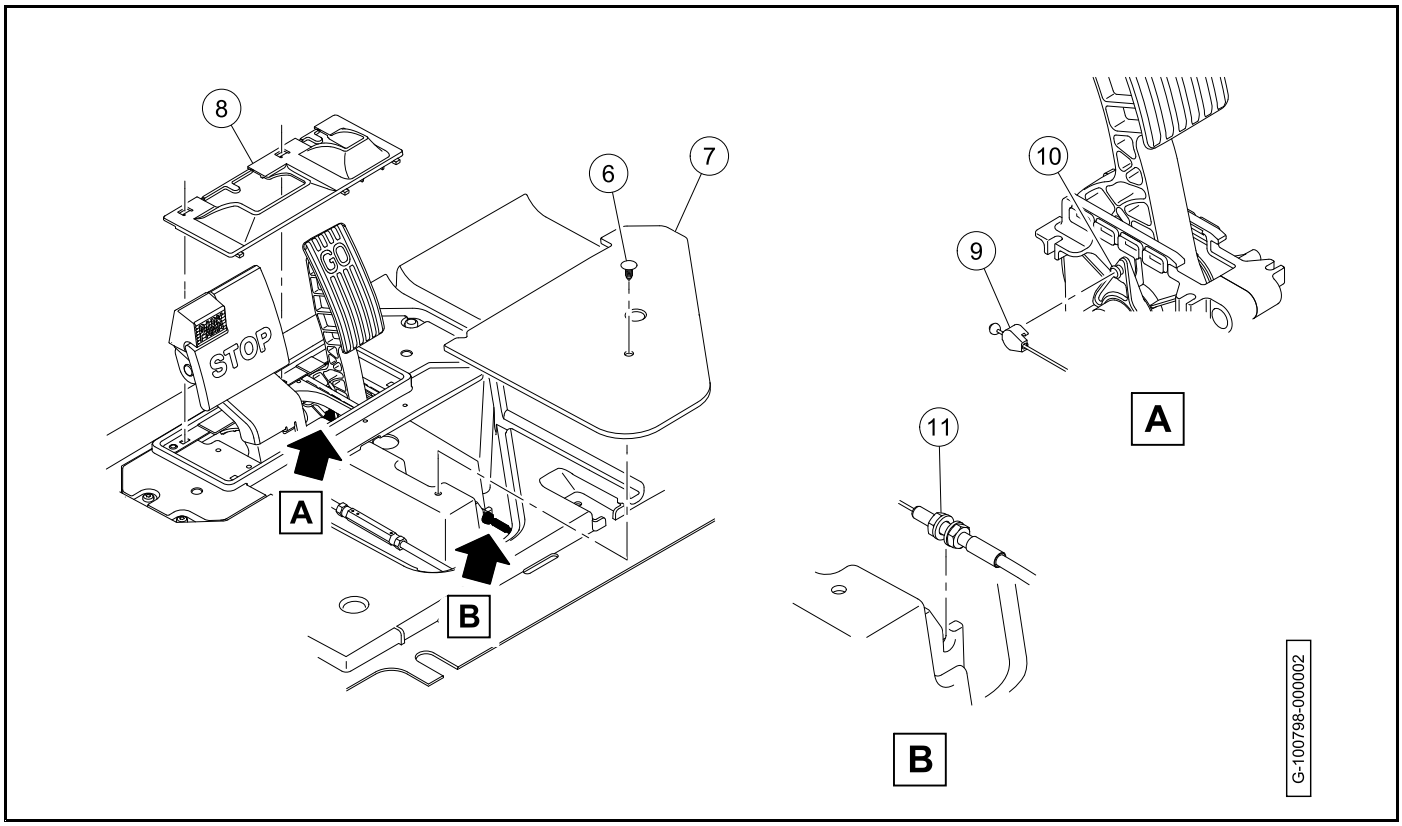


Figure 29-9 Accelerator Cable At Pedal Group

2.3. Install the debris shield (8).

2.4. Separate the jam nuts (11) on cable and put the threaded end into slot in underbody. Tighten the jam nuts finger-tight.

2.5. Before tightening the accelerator cable jam nuts, adjust the engine RPM. See Engine RPM Adjustment.

2.6. Install the floor cover plate (7).

2.7. Install the push rivet (6).

2.8. Install the floor mat.

3. Connect the battery and spark plug wire(s).

IDLE ADJUSTMENT

To adjust the idle, see **ECU Reset Procedure** and **TPS Learn Procedure for Pedal 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, proceed to step 2; otherwise, adjust governor. **See Governor Cable Installation and Adjustment on page 29-3.**
2. Connect battery and spark plug wire(s).
   See Connect the Battery - Gasoline Vehicles on page 1-4.
3. Measure vehicle ground speed. **See How to Measure Ground Speed on page 29-8.**
4. Compare measured ground speed with forward ground speed specified in **Section 2 – Vehicle Specifications**.
5. If adjustment is necessary, use the following procedures:

5.1. To **reduce** RPM, adjust the two jam nuts (6) to move the accelerator cable housing toward the rear of the vehicle until specified ground speed is reached **(Figure 5-6, Page 5-6)**. **See Section 2 – Vehicle Specifications.**

5.2. To **increase** RPM, adjust the two jam nuts to move the accelerator cable housing forward until specified ground speed is reached.

5.3. Be sure both jam nuts are locked against the underbody 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 31 — Kohler ECH440 - Clutches***

AIR INTAKE SYSTEM

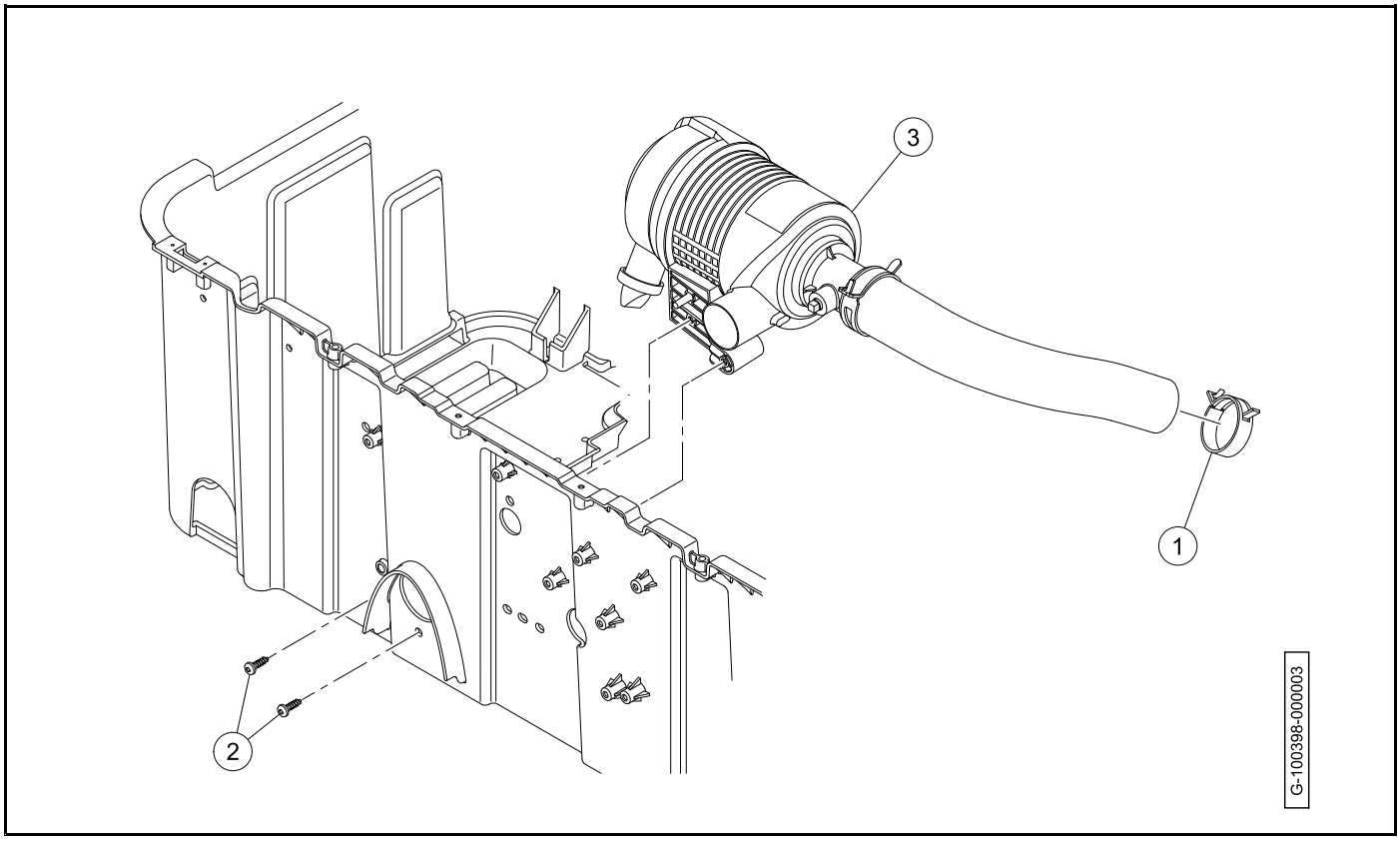


Figure 29-10 Air Intake System

AIR CLEANER REMOVAL

1. Disable the vehicle.
2. Disconnect battery and spark plug wire.
3. Loosen the clamp (1) and disconnect air intake hose from throttle body **(Figure 29-10, Page 29-10)**.
4. Remove the screws (2).
5. Remove the air intake system (3).

AIR CLEANER INSTALLATION

1. Install the air intake system (3) into the vehicle **(Figure 29-10, Page 29-10)**.
2. Install the screws (2). Tighten the screws to 85 in·lb (9.5 N·m).
3. Connect the air intake hose to the throttle body.
4. Install the clamp (1).
5. Connect the battery and spark plug wire.

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.*

CARBON CANISTER

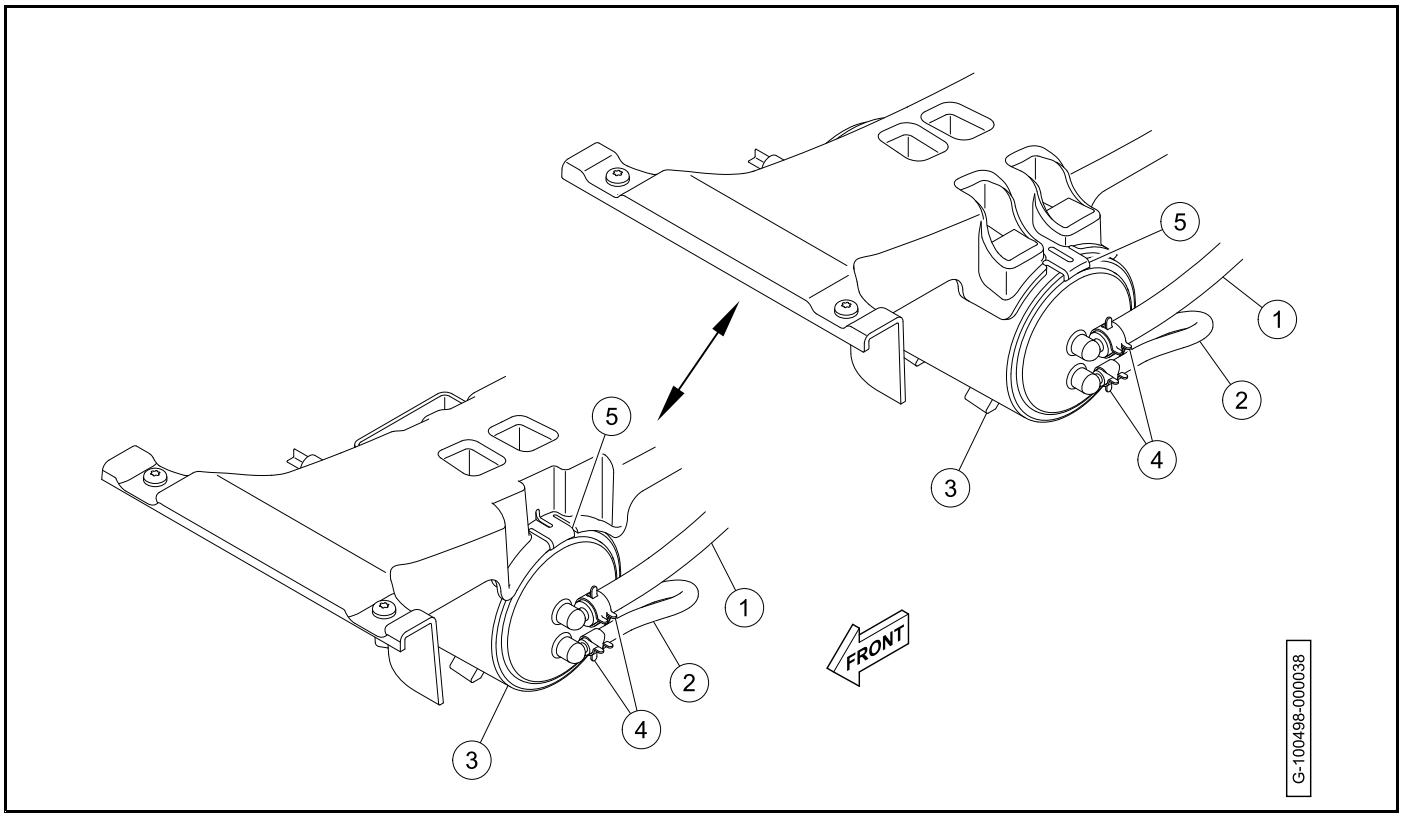


Figure 29-11

CARBON CANISTER REMOVAL

1. Disable the vehicle.
2. Relieve the fuel pressure.
3. Disconnect the battery.
4. Clean the area around the vent line (1) and purge line (2) on the carbon canister (3).
5. Remove the clamps (4).
6. Disconnect the vent line and purge line.
7. Remove the carbon canister from the bucket brace.

7.1. Lift the tab (5).

7.2. Slide the carbon canister towards the fuel tank and remove from the bucket brace.

CARBON CANISTER INSTALLATION

1. Install the carbon canister (3) on the bucket brace. Make sure that the tab (5) is secured **(Figure 29-11)**.
2. Connect the vent line (1).
3. Connect the purge line (2).
4. Install the clamps (4).

FUEL LINE

⚠ 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), washer (2), and P-clamp (3) from the fuel line support bracket (4) **(Figure 29-12, Page 29-14)**.

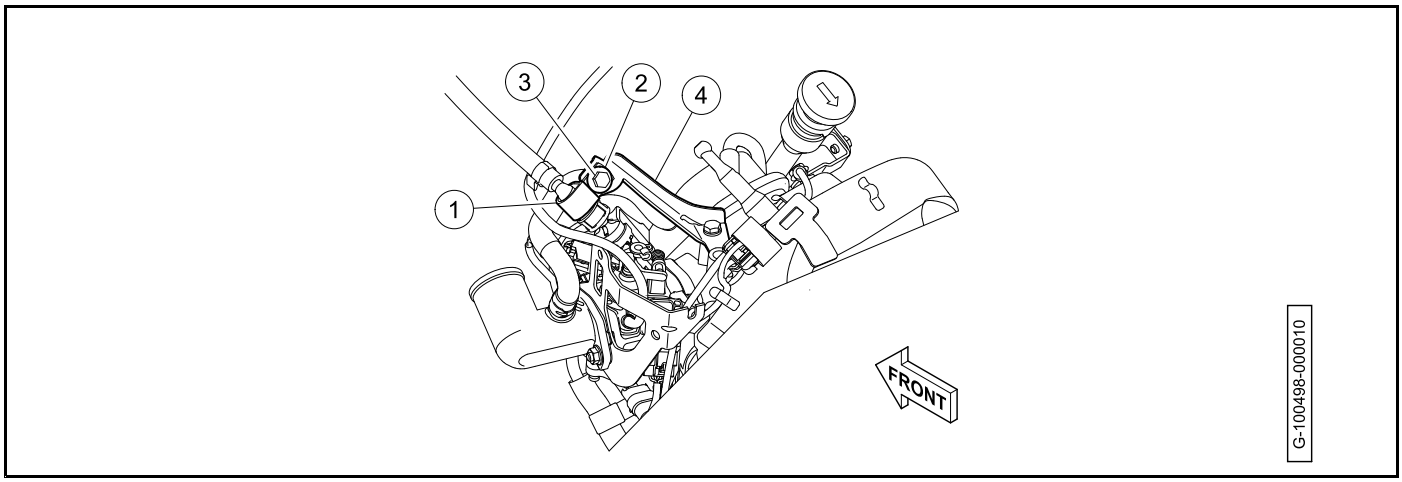


Figure 29-12 Fuel Line Support Bracket - Disconnect

5.2. Pull out the locking clip (4) **(Figure 29-13, Page 29-15)**.

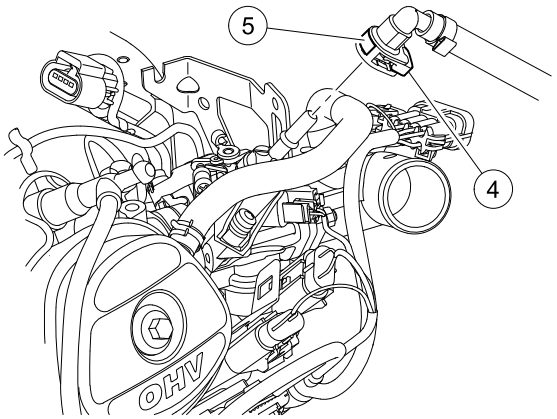


Figure 29-13 Fuel Line Connector – Disconnect

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. Clean the nipple on the throttle body.

⚠ DANGER

- **Make sure that the fuel line is connected properly to avoid a leak that can cause a fire.**

2. Push the fuel line (1) onto the nipple until it locks into place **(Figure 29-14)**.

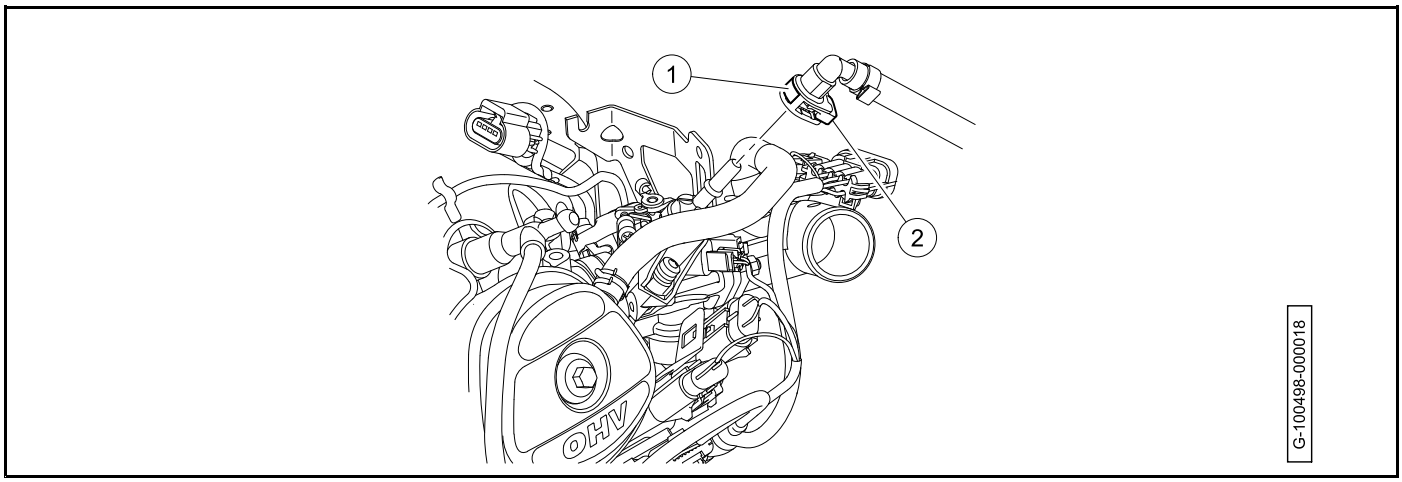


Figure 29-14

3. Push in the locking clip (2) until it is fully seated.
4. Make sure that the fuel line is 8° (± 5°) toward the fuel tank from the bucket brace **(Figure 29-15)**.

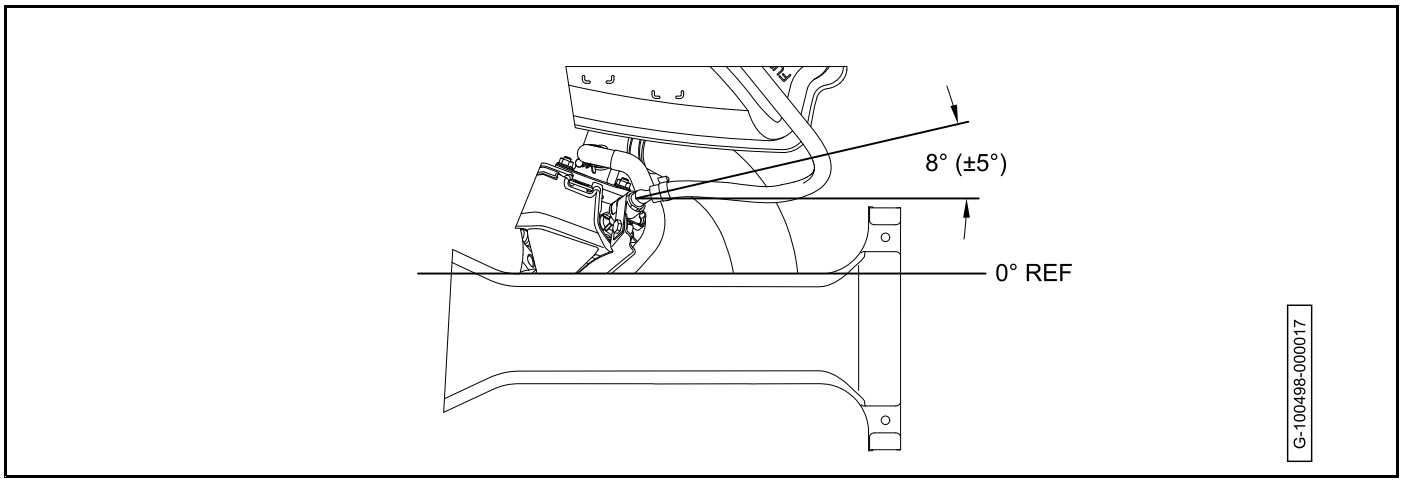


Figure 29-15

5. Install the P-clamp (1), washer (2), and bolt (3) onto the fuel line support bracket (4) **(Figure 29-16)**. Tighten the bolt to 93 to 111 in·lb (10.5 to 12.5 N·m).

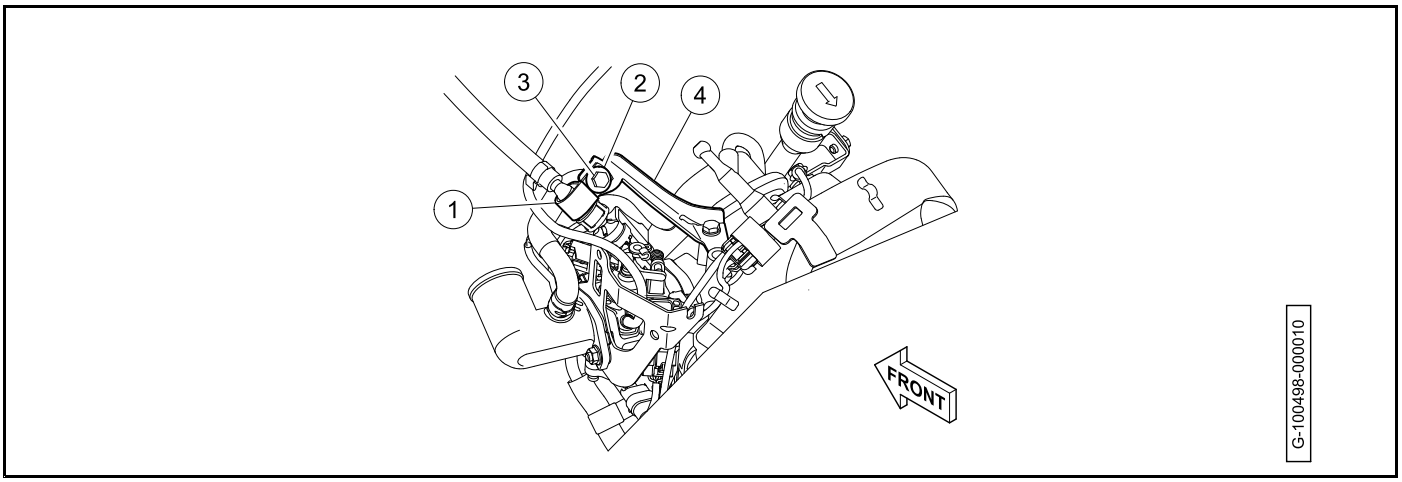


Figure 29-16

6. Clean the nipple on top of fuel pump module.
7. Rotate the fuel line connector (1) 180 degrees and connect it to the nipple **(Figure 29-17, Page 29-17)**.

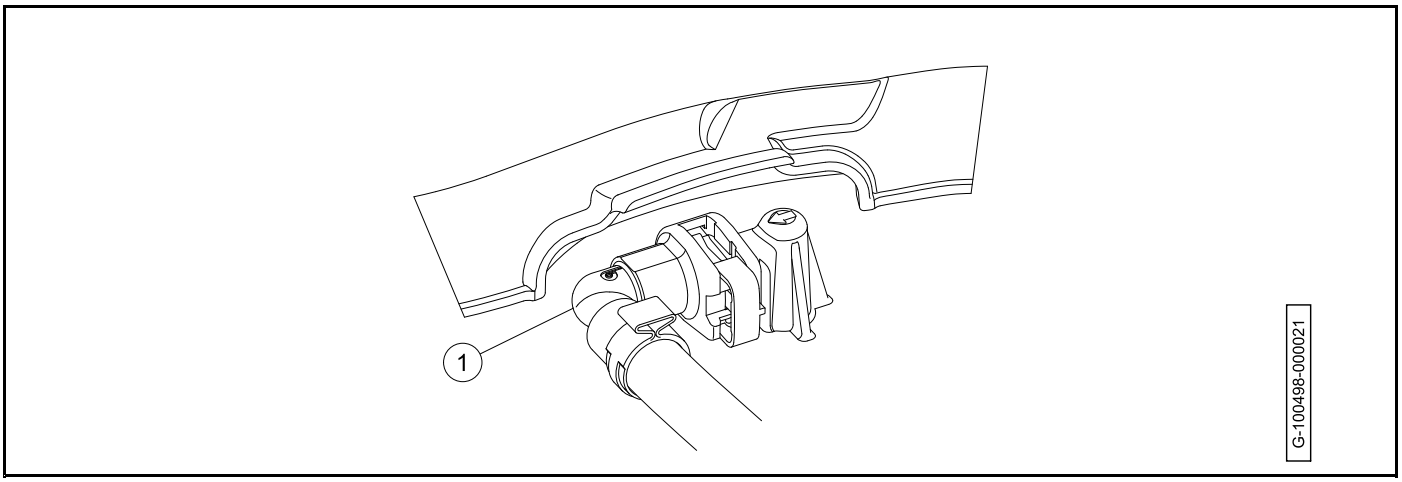


Figure 29-17

8. Push the fuel line until it locks into place.
9. Push in the locking clip until it is fully seated.

⚠ DANGER

- **Make sure that the fuel line is connected properly to avoid a leak that can cause a fire.**
- **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.**

10. Make sure that the fuel line is routed correctly **(Figure 29-18)**.

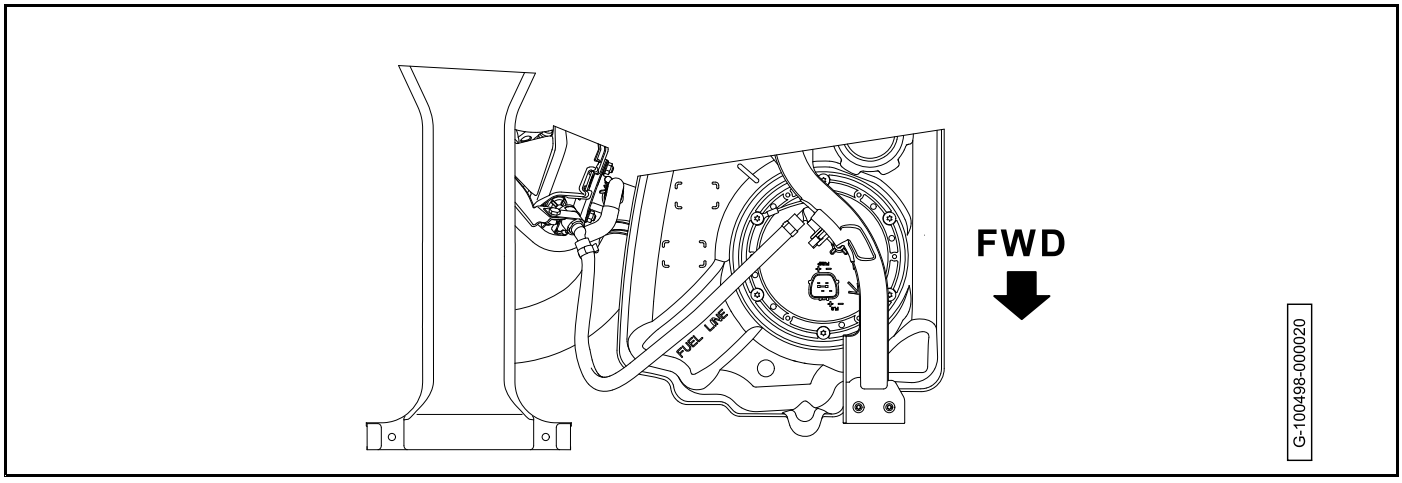


Figure 29-18

11. Clean spilled and remove any drained gasoline from the area.
12. Connect the battery.
13. Disable the vehicle.
14. Set the Maintenance/Operate switch to MAINTENANCE.
15. 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.**

16. If no leaks are found, set the Maintenance/Operate switch in the OPERATE.

FUEL PUMP MODULE

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.

NOTE: *Fuel pump replacement kits will include a fuel level sending unit.*

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

1. Disable the vehicle.

2. Disconnect the battery.
3. Clean the top of the fuel tank and fuel pump module.
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. Remove the screws (1) **(Figure 29-19, Page 29-19)**.

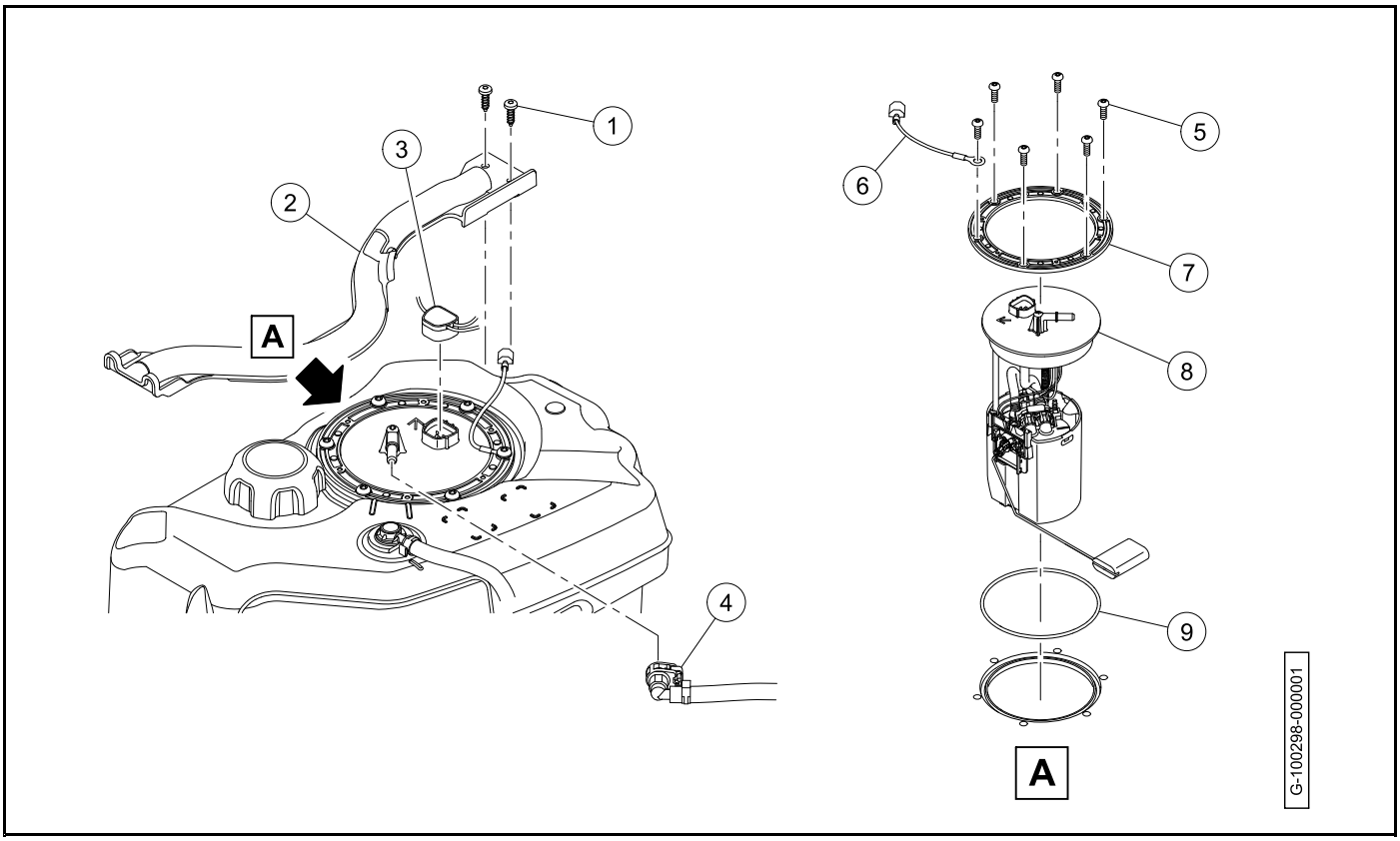


Figure 29-19 Fuel Pump Module Removal

6. Remove the fuel tank retaining strap (2).
7. Disconnect the wire harness from the fuel pump module 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.**

8. Disconnect the fuel line (4) and drain into an appropriate container. See Fuel Line Removal.
9. Remove the screws (5).
10. Remove the ground wire (6) and hold down ring (7).
11. Lift the fuel pump module (8) out of fuel tank and drain into an appropriate container.

NOTE: *If equipped with a fuel level sending unit, carefully maneuver module so as to avoid damaging the float arm mechanism.*

12. Discard the fuel module o-ring (9).

FUEL PUMP MODULE INSTALLATION

1. Clean the groove on top of fuel tank.
2. Install the new fuel module o-ring (9) into groove on top of fuel tank **(Figure 29-20, Page 29-20)**.

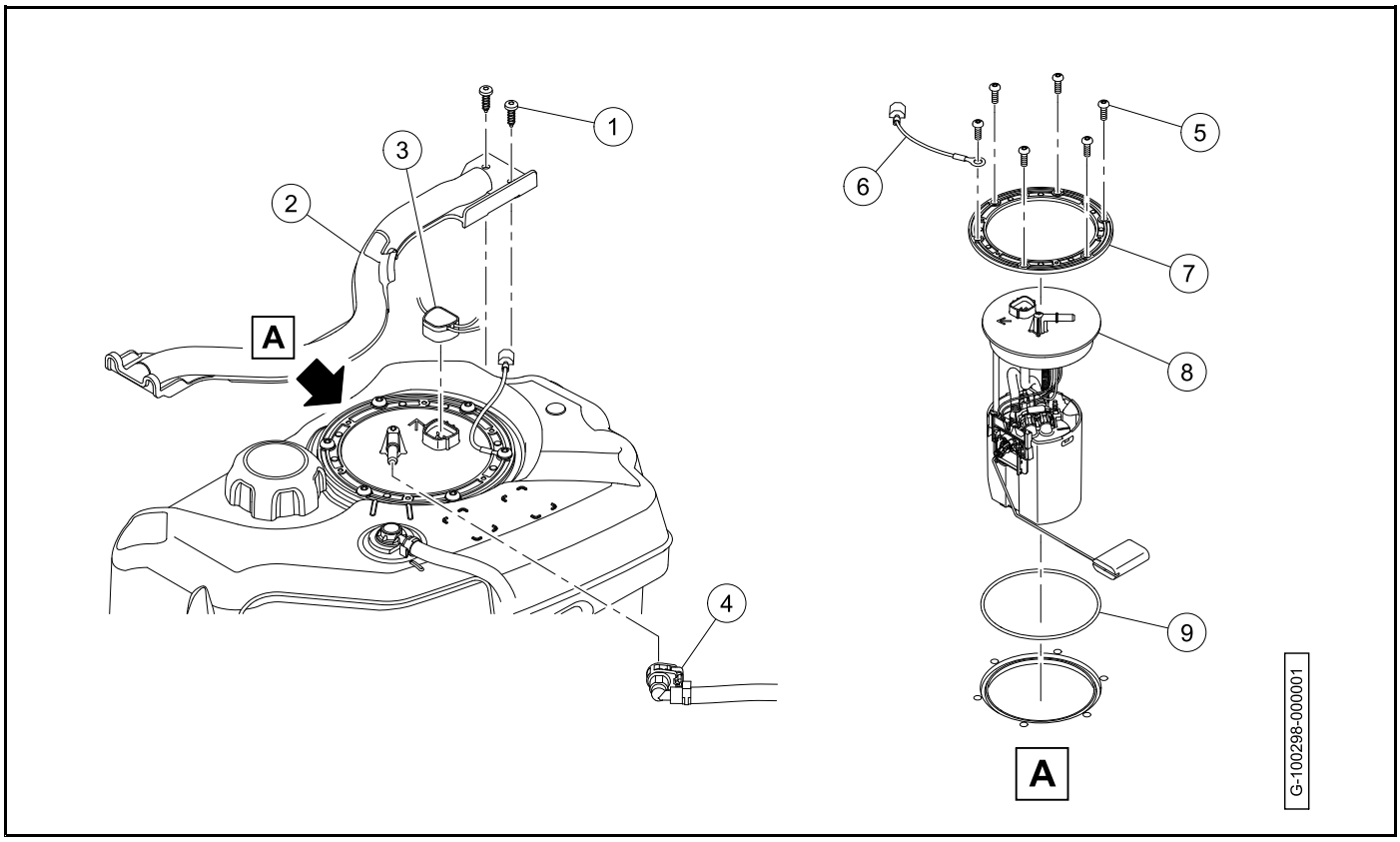


Figure 29-20 Fuel Pump Module Installation

3. Lower the fuel pump module (8) 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 the hold down ring (7)
5. Install the ground wire (6) and screws (5). **See following WARNING.** Tighten the screws in a crisscross pattern to 66 in·lb (7.5 N·m).

⚠ WARNING

- **Always install ground wires during reassembly.**

6. Connect the fuel line (4) to fuel pump module. 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 to the fuel pump module plug (3).
8. Install the fuel tank retaining strap (2).
9. Install the screws (1). Tighten the screws to 31 in·lb (3.5 N·m).
10. Clean spilled fuel. Remove any drained fuel from the area.
11. Connect the battery.
12. Disable the vehicle.
13. Set the Maintenance/Operate switch to MAINTENANCE.
14. 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.**

15. If no leaks are found, set the Maintenance/Operate switch to OPERATE.

FUEL TANK

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

1. Disable the vehicle.
2. Set the Maintenance/Operate switch to MAINTENANCE.
3. Disconnect the battery.
4. Clean the top of the fuel tank and fuel pump module.

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 (1) from the fuel pump module **(Figure 29-21, Page 29-22)**.

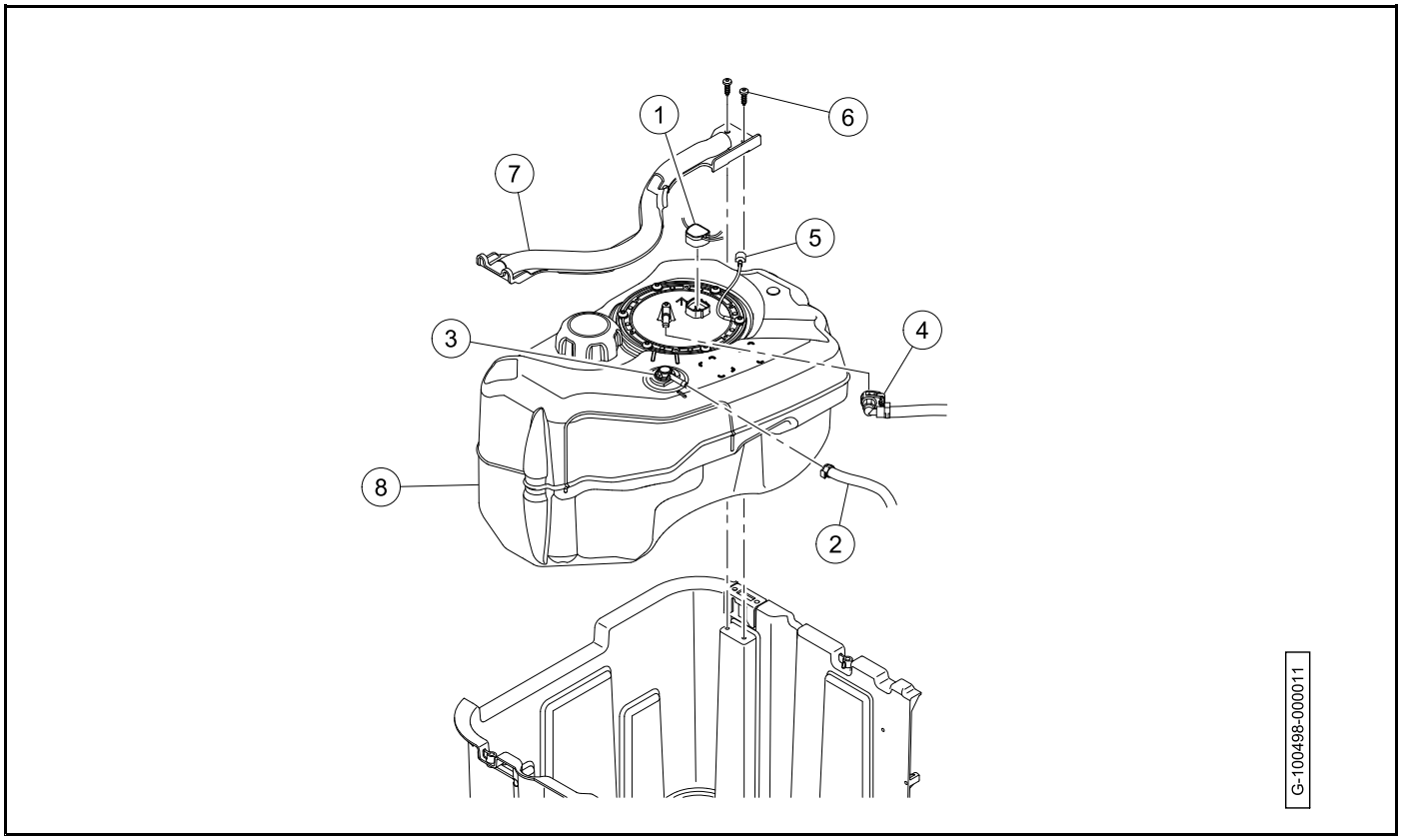


Figure 29-21 Fuel Tank Removal

7. Disconnect the vent hose (2) 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. Remove the screws (6).
11. Remove the fuel tank retaining strap (7).
12. Remove the fuel tank (8).

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. Install the fuel tank (8) in vehicle **(Figure 29-22, Page 29-24)**.

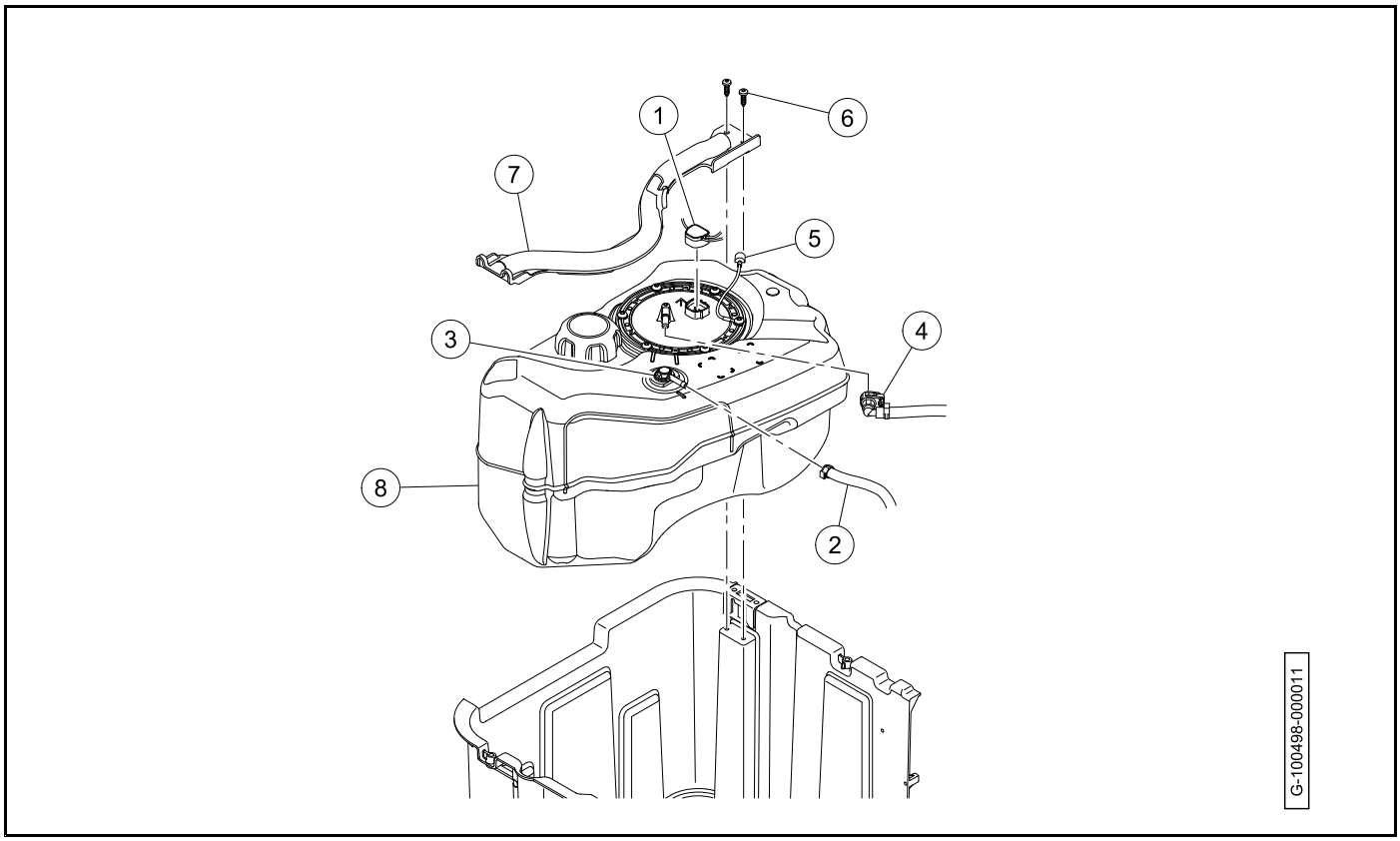


Figure 29-22 Fuel Tank Installation

2. Install the fuel tank retaining strap (7).
2.1. Insert the tabs on the rear of the fuel tank retaining strap into the slots on the back of the bucket.
2.2. Align the front of the fuel tank retaining strap with the mounting holes on the bucket.
2.3. Install the screws (6). Tighten the screws to 31 in·lb (3.5 N·m).
3. Connect the ground wire (5) to main wire harness. **See following WARNING.**

⚠ WARNING

- **Always install ground wires during reassembly.**

4. Connect the fuel line (4) to the fuel pump module. **See following DANGER.**

⚠ DANGER

- **Ensure line is connected properly to avoid a leak that can cause a fire.**

5. Install the vent line (2) onto the fuel tank vent (3).
6. Connect the wire harness (1) 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.**

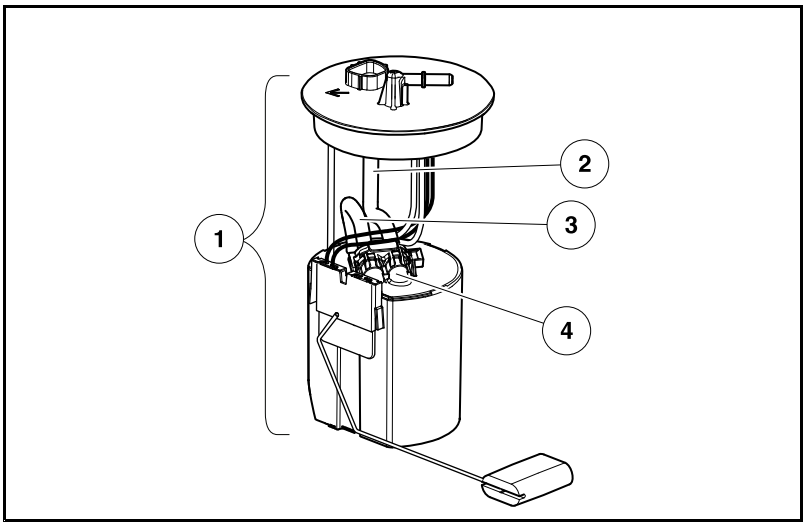
13. If no leaks are found, set the Maintenance/Operate switch to OPERATE.

FUEL FILTER

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



3052E

Figure 29-23 Fuel Filter Removal

1. Disable the vehicle.
2. Disconnect the battery.
3. Remove fuel pump module (1) **(Figure 29-23, Page 29-25)**. 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

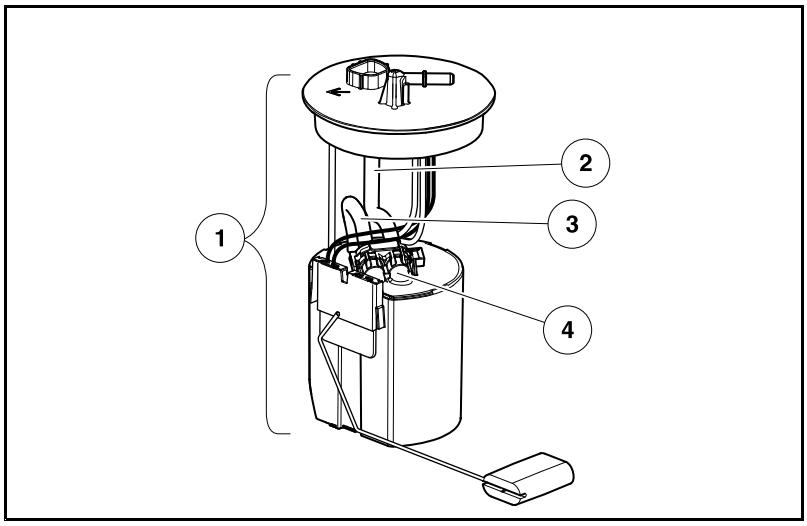
⚠ CAUTION

- **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 29-24, Page 29-26)**.



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Figure 29-24 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 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

MUFFLER

MUFFLER REMOVAL

1. Disconnect the battery and spark plug wire.
2. If necessary, remove the oxygen sensor (1) from the muffler (2) **(Figure 30-1, Page 30-1)**. See Oxygen Sensor Removal.

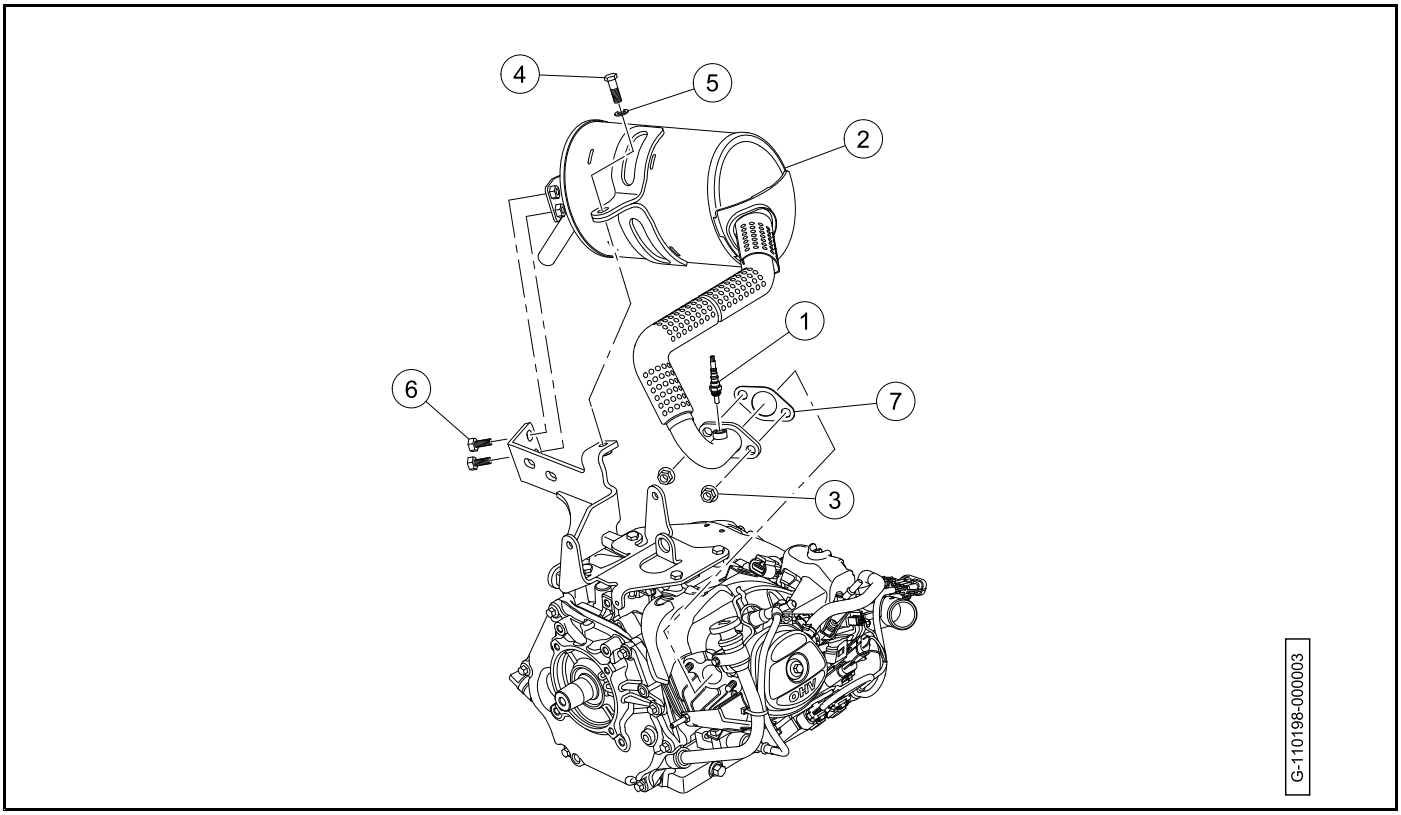


Figure 30-1 Muffler Removal

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 30-2, Page 30-2)**.

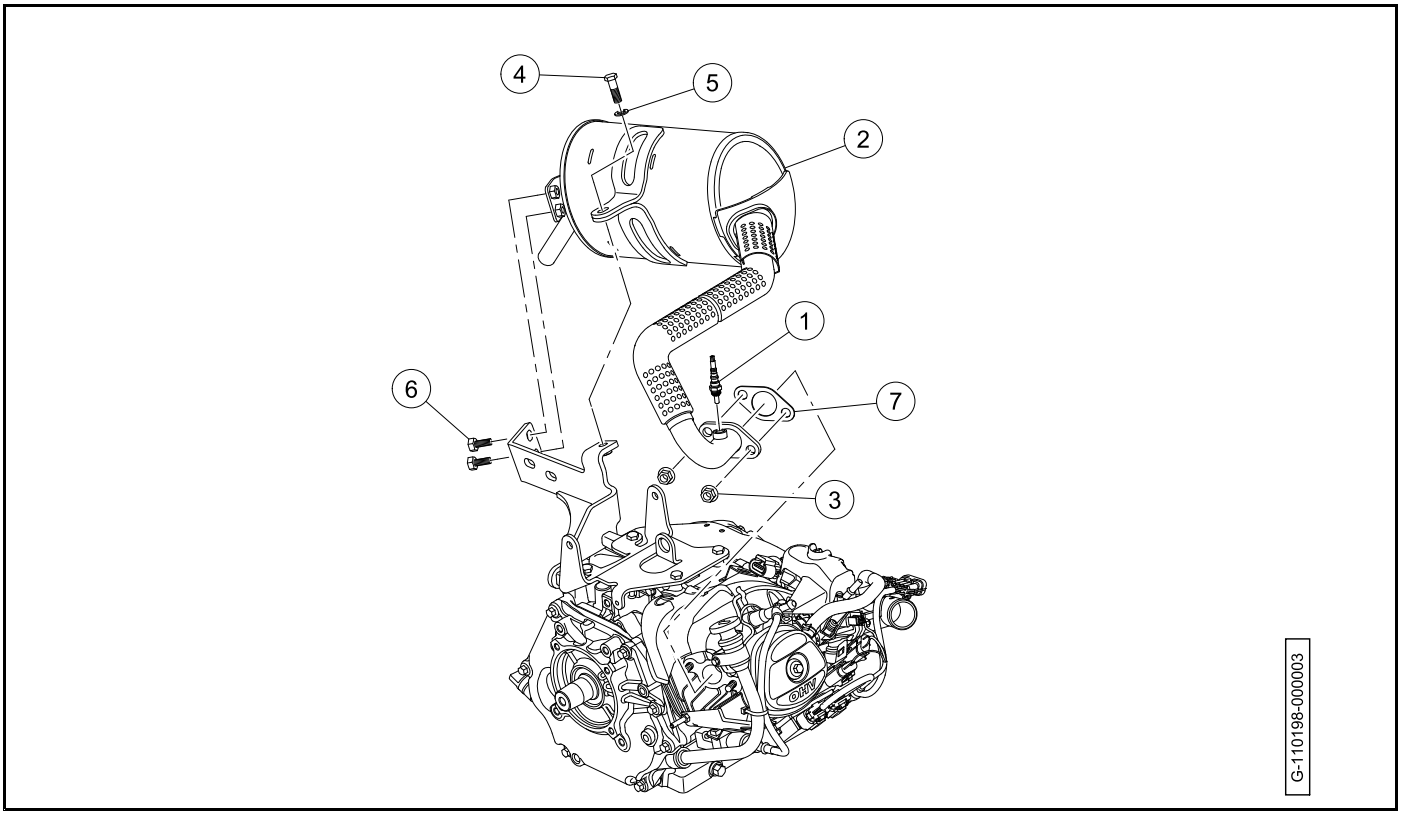


Figure 30-2 Muffler Installation

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.**

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

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

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 31-2, Page 31-4)**.

DRIVE BELT

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

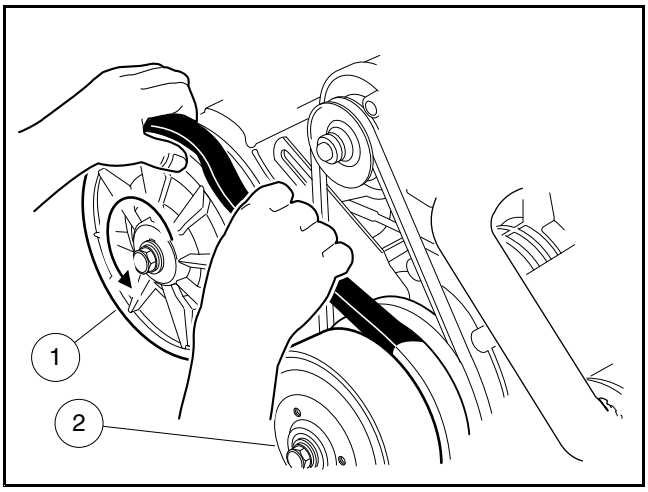
1. Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Grasp the belt midway between the drive (2) and driven (1) clutches. Lift upward on the belt to force the sheaves of the driven clutch (1) apart, then roll the belt off the driven clutch by rotating the clutch counterclockwise **(Figure 31-1, Page 31-3)**. **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).



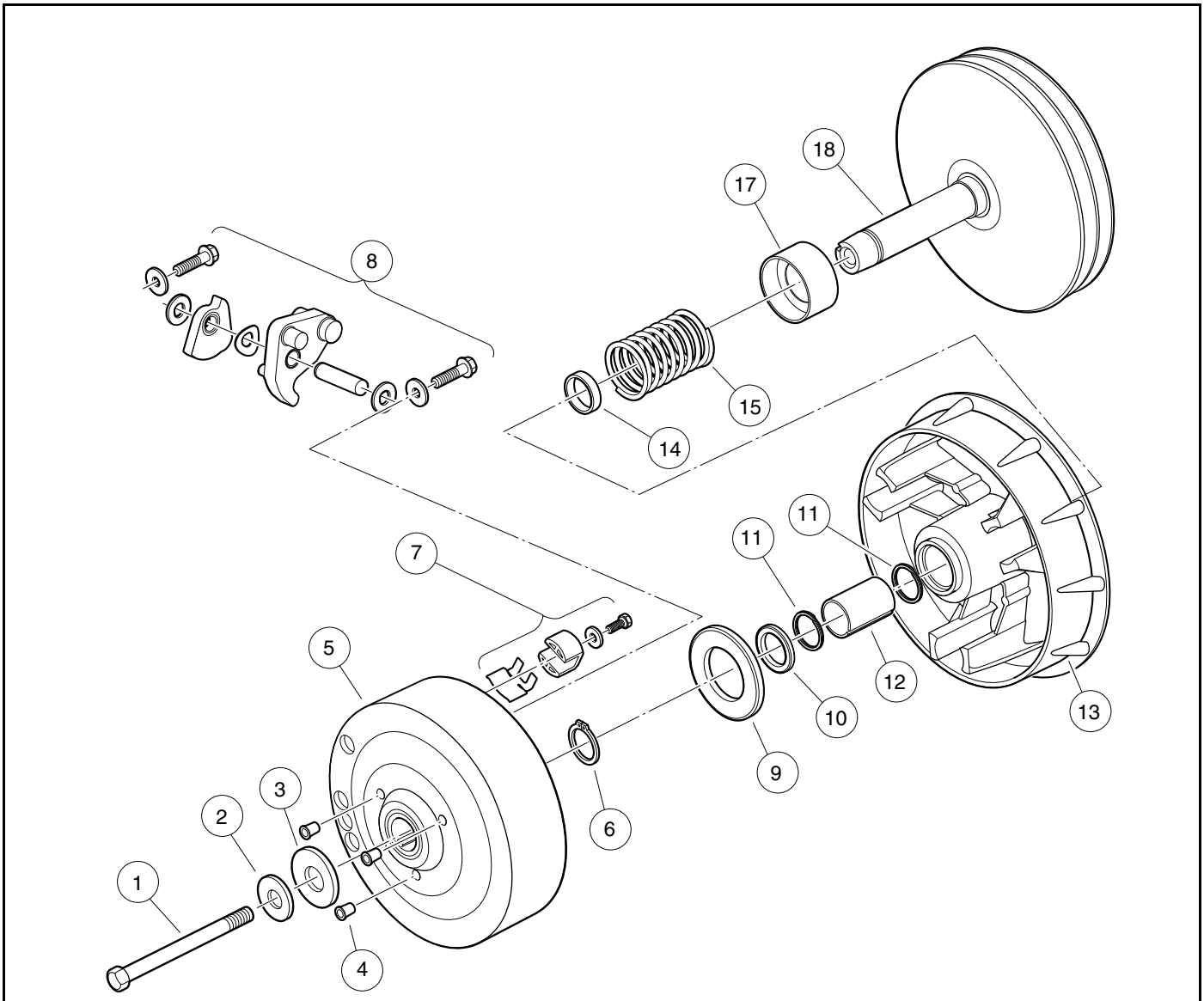
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Figure 31-1 Drive Belt Removal

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



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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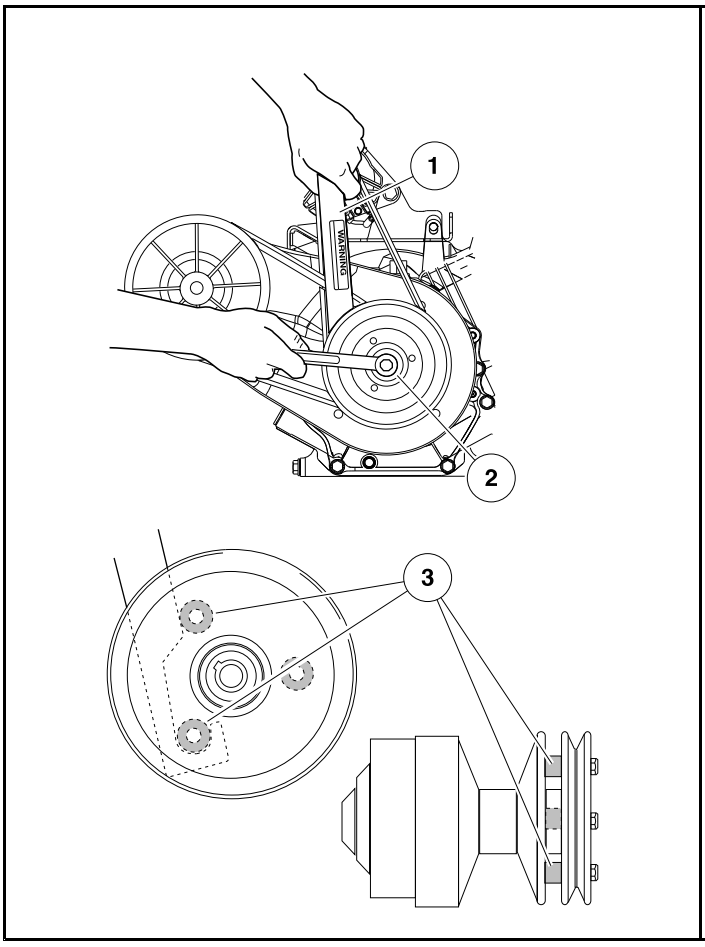
Figure 31-2 Drive Clutch – Exploded View

⚠ 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.**

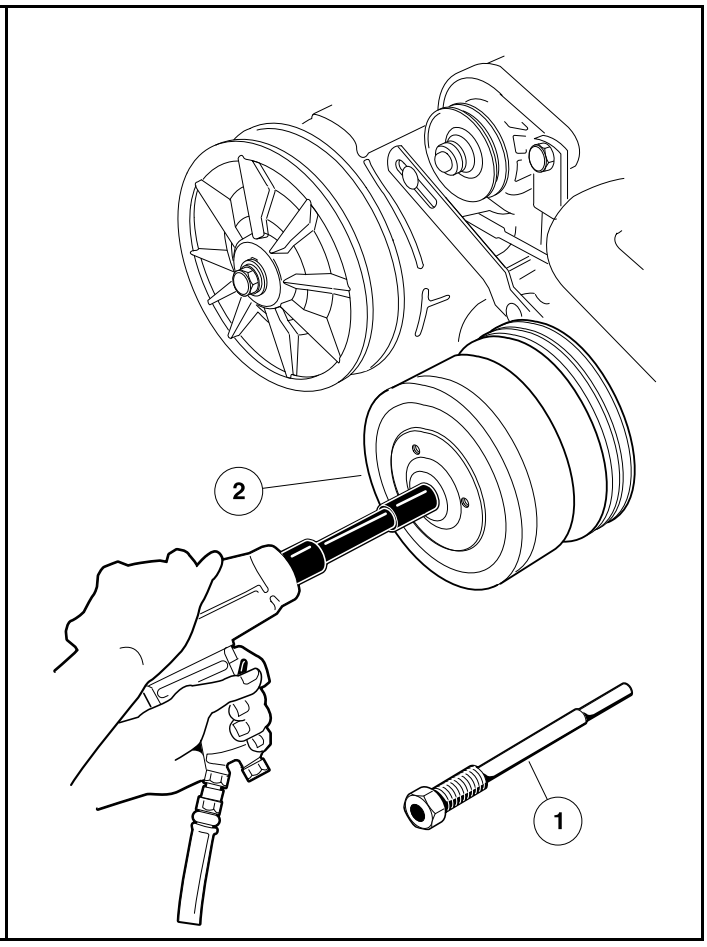
DRIVE CLUTCH REMOVAL

1. Remove the drive belt as instructed. **See Drive Belt Removal on page 31-3.**
2. Loosen starter/generator mounting and adjusting hardware and remove starter belt. **See WARNING "Moving parts! Do not..." in .**



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Figure 31-3 Loosen Retaining Bolt



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Figure 31-4 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**

WARNING CONTINUED ON NEXT PAGE

⚠ WARNING

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 31-2, Page 31-4)**. **See also Figure 31-3, Page 31-5. 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 31-3, Page 31-5)**.

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 31-4, Page 31-5)**.
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 31-2, Page 31-4). 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 31-5, Page 31-7).**

1. Make match marks on the drive clutch hub and on the moveable face **(Figure 31-5, Page 31-7)**.

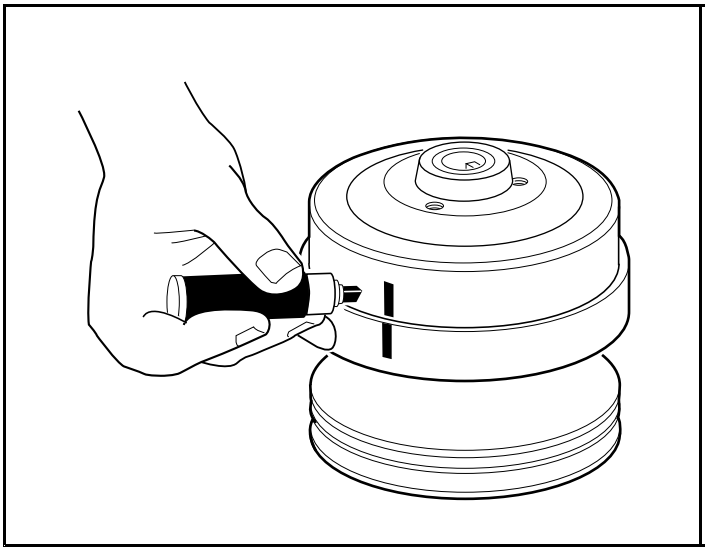
2. Remove the drive clutch hub (5) **(Figure 31-2, Page 31-4)**:

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 31-6, Page 31-7)**.

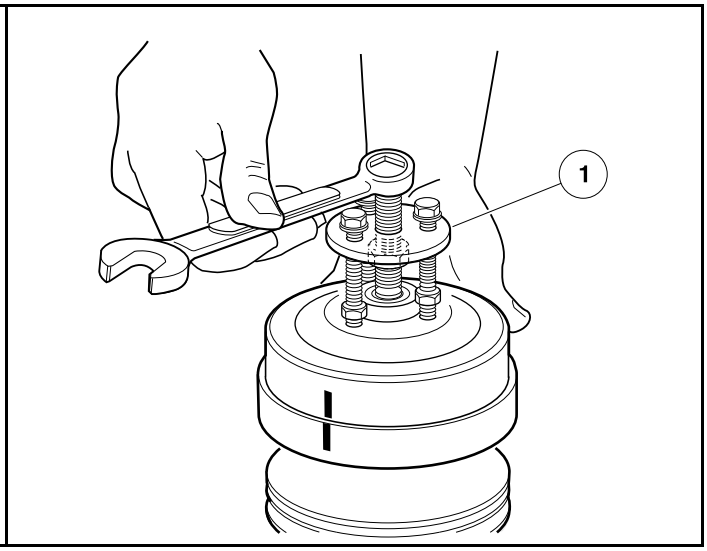
2.3. Thread the three small bolts of the puller into corresponding holes in the clutch. Tighten bolts evenly, making sure the face of the puller plate is parallel to the face of the clutch **(Figure 31-6, Page 31-7)**.

2.4. Unscrew the puller center bolt out of the clutch to pull drive clutch hub off.



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Figure 31-5 Mark Drive Clutch Hub

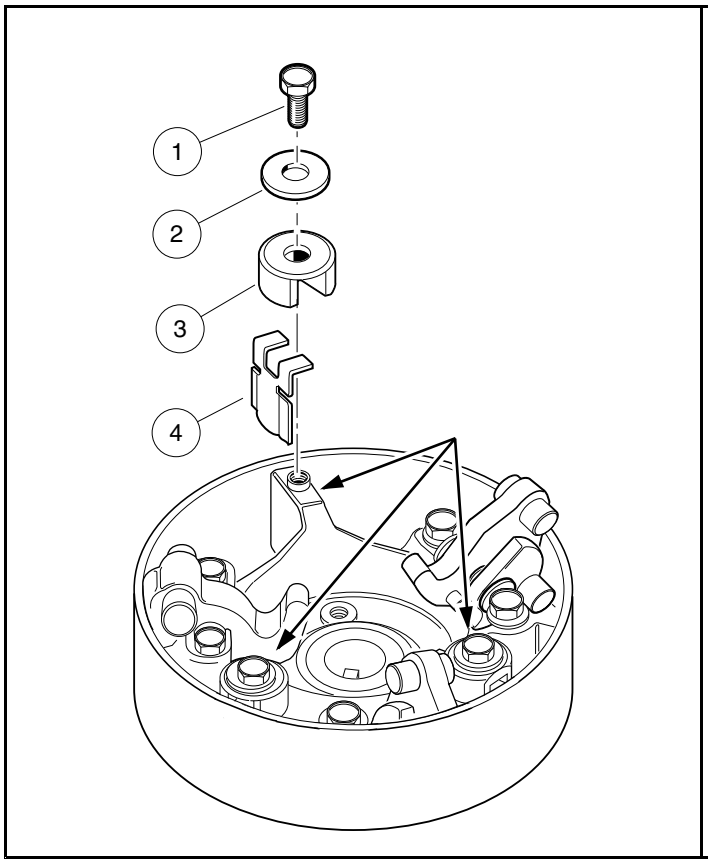


599

Figure 31-6 Remove Drive Clutch Hub

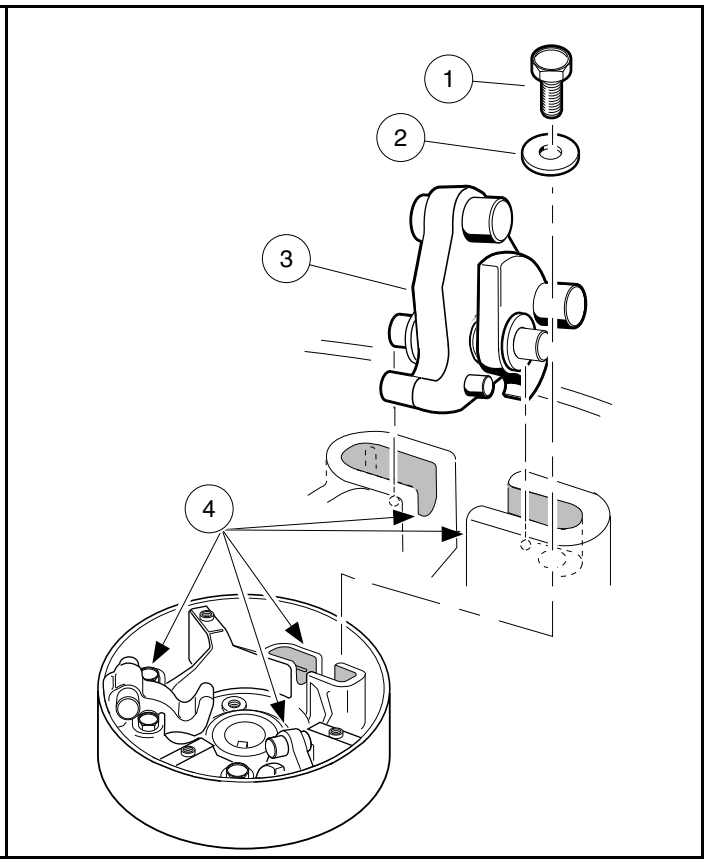
3. Remove the thrust washer (9) from the moveable sheave (13) **(Figure 31-2, Page 31-4)**.

4. Remove the drive buttons (3) by removing the screws (1), flat washers (2), and drive button take-up springs (4) as shown **(Figure 31-7, Page 31-8)**.



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Figure 31-7 Drive Button Mounting



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Figure 31-8 Weight Position

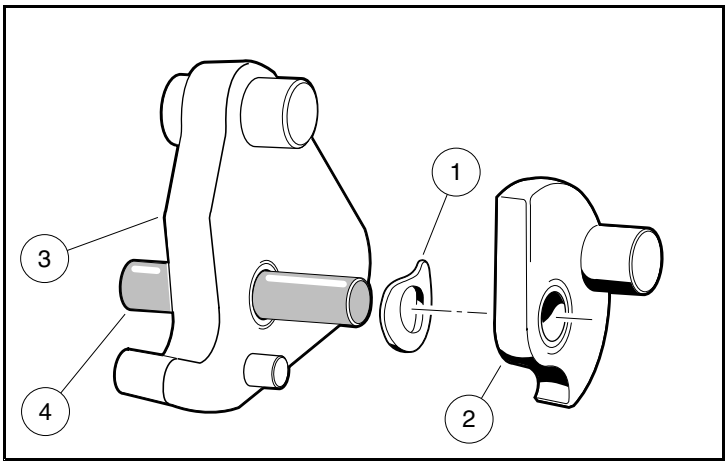
5. Remove the clutch weights:

5.1. Remove the screws (1) and flat washers (2) attaching the weights (3) as shown **(Figure 31-8, Page 31-8)**.

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 31-9, Page 31-9)****.*

5.3. Remove the plastic washers, weights (2 and 3) and wave washer (1) from the pin (4). Retain all parts.



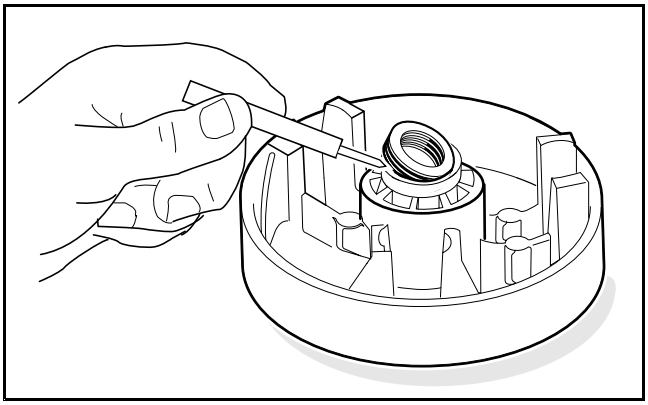
602

Figure 31-9 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 31-2, Page 31-4)**. **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 31-2, Page 31-4)****.*

7. Remove the spacer (14) and spring (15) **(Figure 31-2, Page 31-4)**.
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 31-2, Page 31-4)**. **See also Figure 31-10, Page 31-9.** Discard the rings.



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Figure 31-10 Spiral Back-up Rings

INSPECTION OF DRIVE CLUTCH PARTS

1. Inspect the idler spacer (17) for smoothness **(Figure 31-2, Page 31-4)**.
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 31-2, Page 31-4)**.
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).

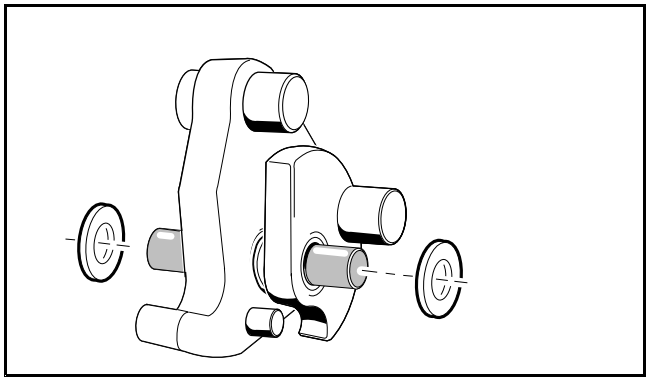
⚠ CAUTION

- **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 31-2, Page 31-4)**.

5. Install the primary weights (3) on the mounting pins (4) **(Figure 31-9, Page 31-9)**.
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 31-9, Page 31-9)**.
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 31-9, Page 31-9)**.
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 31-11, Page 31-10)**.
9. Install the weight assemblies into the slots (4) in the hub casting **(Figure 31-8, Page 31-8)**. Make sure the mounting pin protrudes an equal amount on each side of the weights when the assemblies are in position **(Figure 31-11, Page 31-10)**.



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Figure 31-11 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 31-8, Page 31-8)**. **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 31-12, Page 31-11)**.

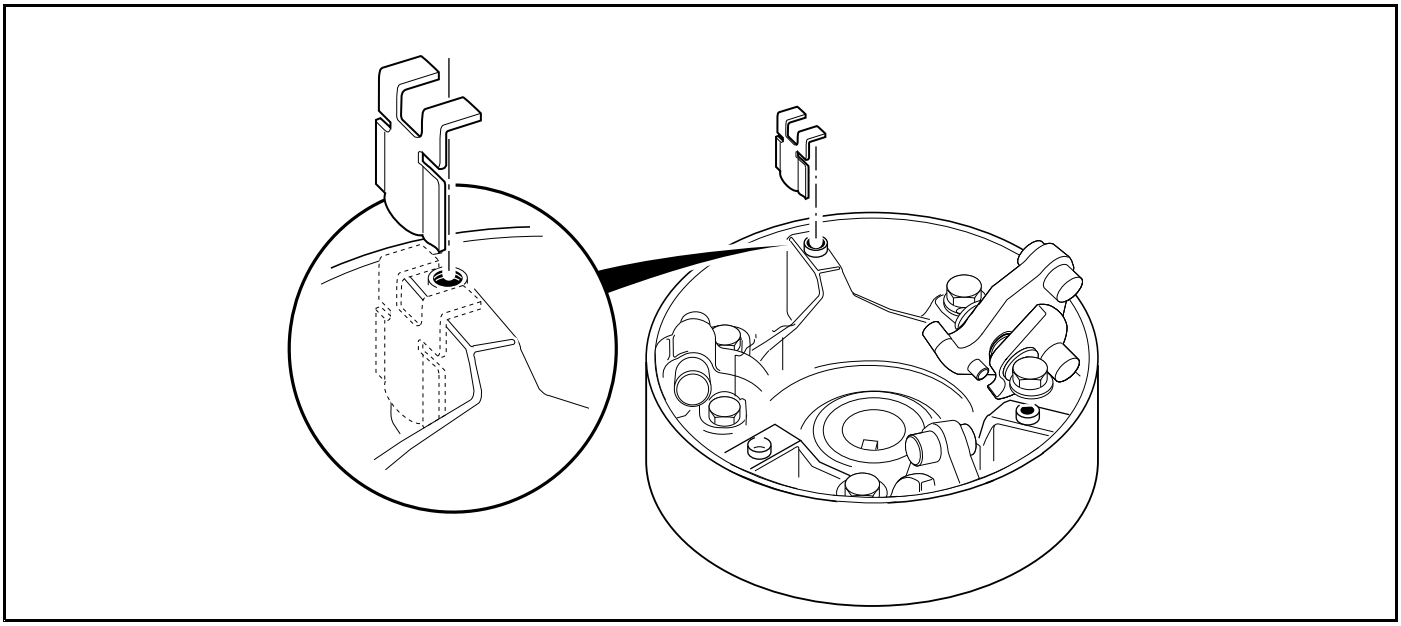
12. Compress each take-up spring and install the drive button over the rib and take-up spring **(Figure 31-7, Page 31-8)**.

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 31-7, Page 31-8)**.

14. Install the thrust washer (9) onto the moveable sheave (13) **(Figure 31-2, Page 31-4)**.

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 31-2, Page 31-4)**.



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Figure 31-12 Correct Orientation of Drive Button Take-up Springs

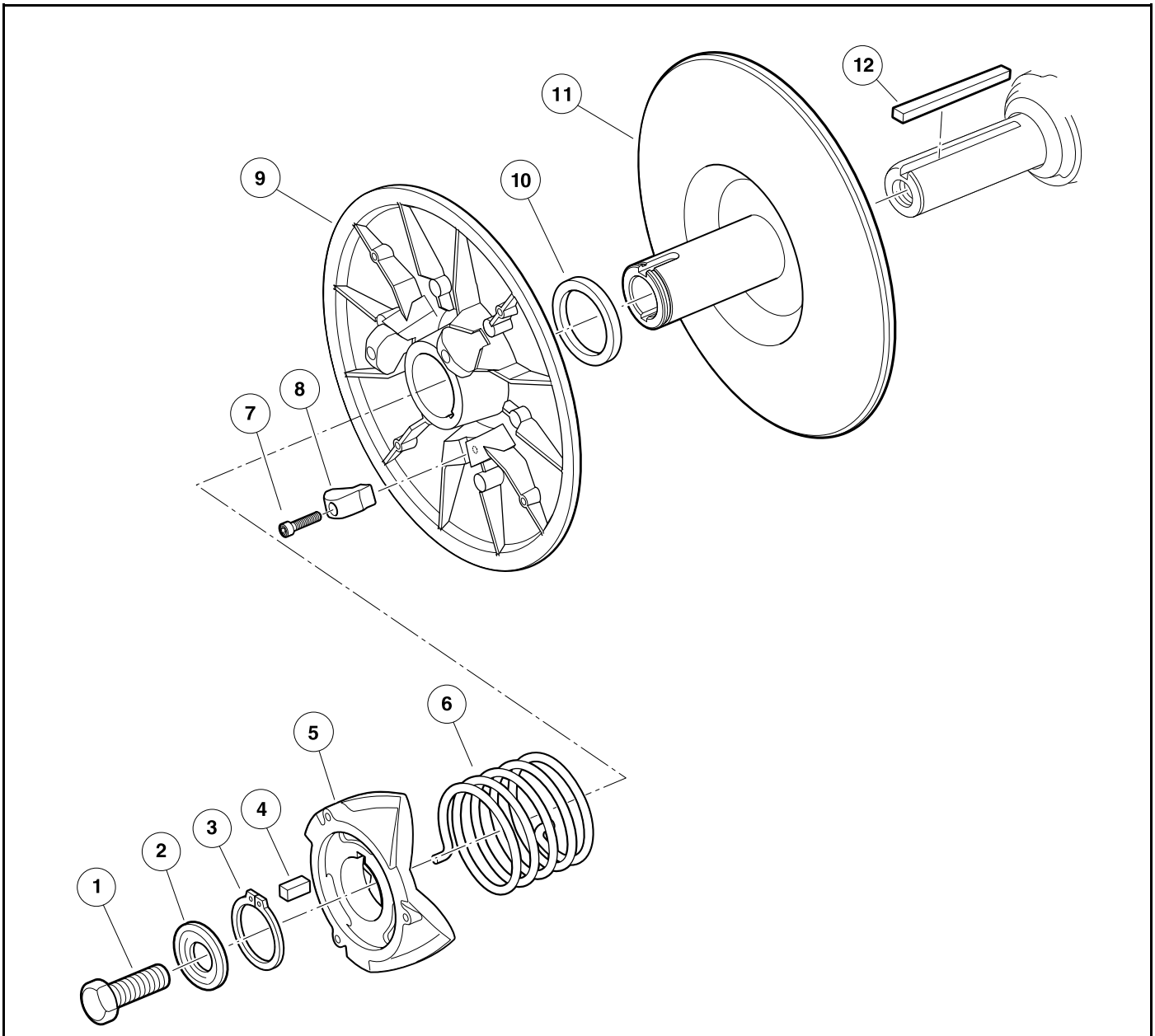
DRIVE CLUTCH INSTALLATION

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 31-2, Page 31-4)**. **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 31-2, Page 31-4)**.
3. Install the starter/generator belt and adjust belt tension as instructed. **See Belt Tension Adjustment For EFI Engines, Section 27, Page 27-16.**
4. Install the drive belt as instructed. **See Drive Belt Installation on page 31-3.**
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



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 31-13 Driven Clutch – Exploded View

DRIVEN CLUTCH REMOVAL

1. Remove the drive belt as instructed. **See Drive Belt Removal on page 31-3.**
2. Remove the bolt (1) and mounting washer (2) from the transaxle input shaft **(Figure 31-13, Page 31-12)**. 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 31-13, Page 31-12)**.
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 31-14, Page 31-13)**.

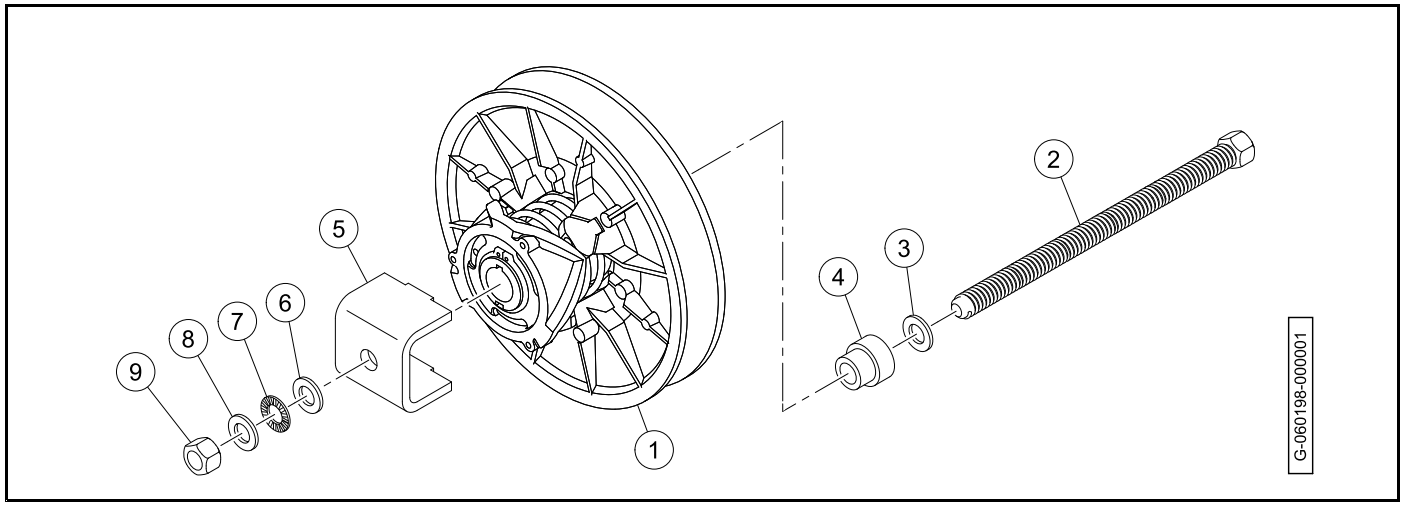


Figure 31-14 Driven Clutch Tool - Disassembly

3. Assemble the threaded bolt (2) through the washer (3) and thrust collar (4).

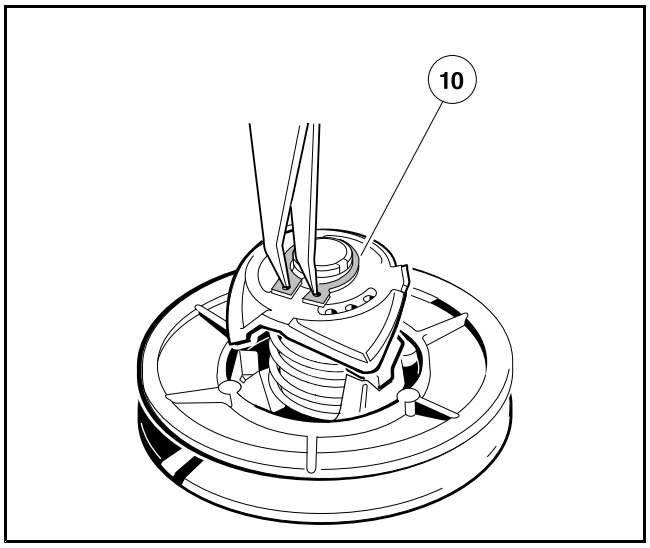
NOTE: *It is very important that the bolt, washers, and thrust bearing assembly be assembled in the order described and shown.*

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.**

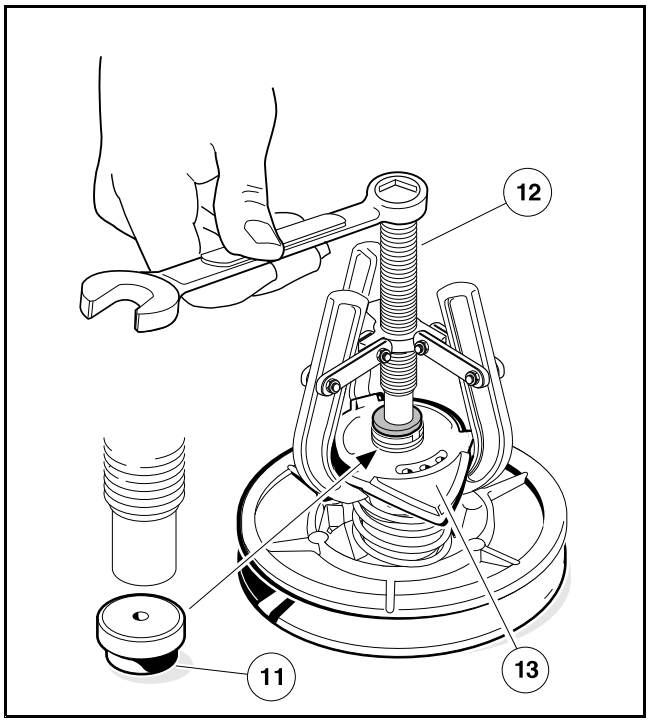
8. Remove the retaining ring (10) **(Figure 31-15, Page 31-14)**.



608B

Figure 31-15 Remove Retaining Ring

9. Insert a puller plug (11) into the shaft bore **(Figure 31-16, Page 31-14)**.

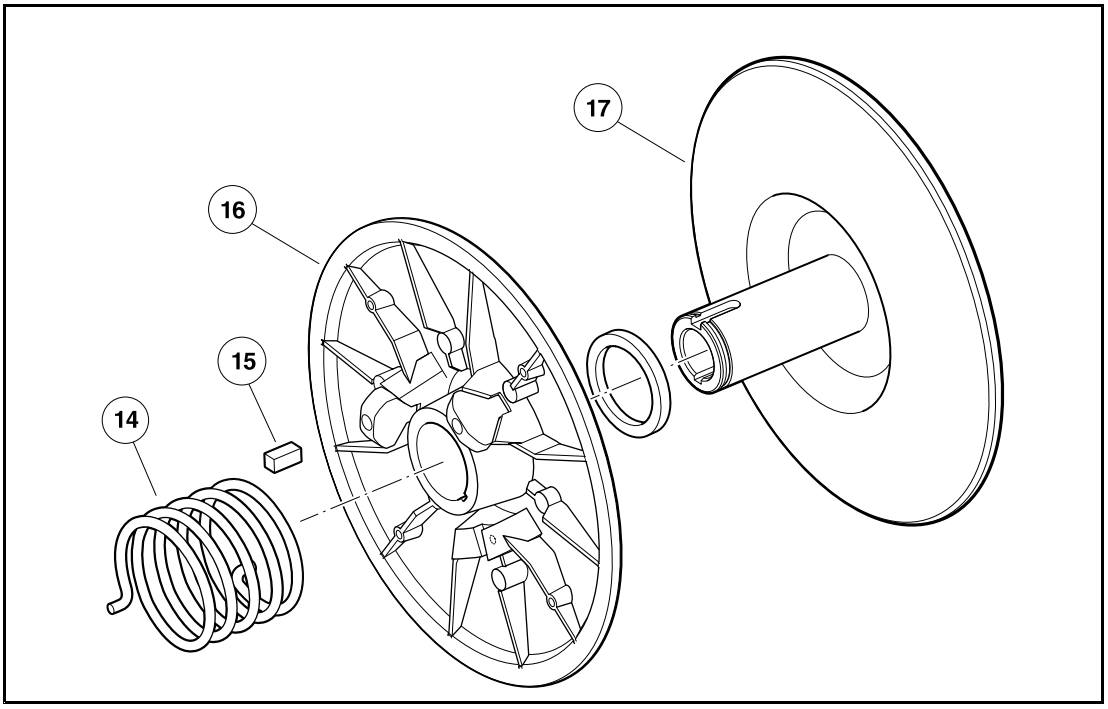


609B

Figure 31-16 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 31-17, Page 31-15)**.



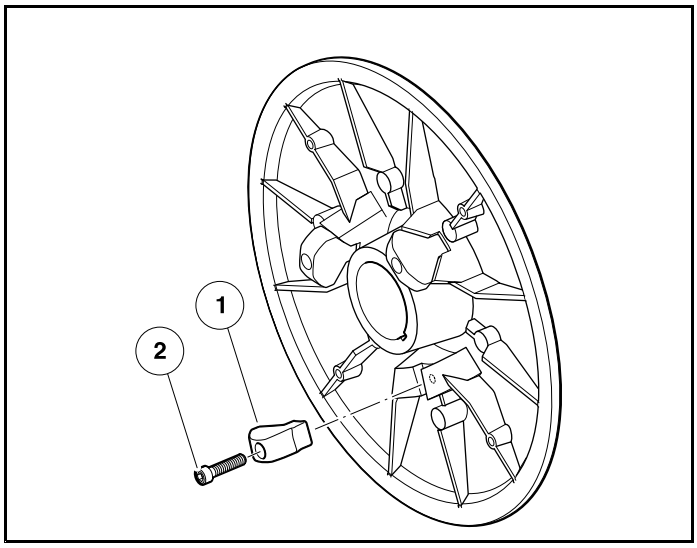
2961B

Figure 31-17 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 31-18, Page 31-16)**. Replace if necessary. To remove the drive buttons, remove the socket-head cap screws (1) and then the buttons.



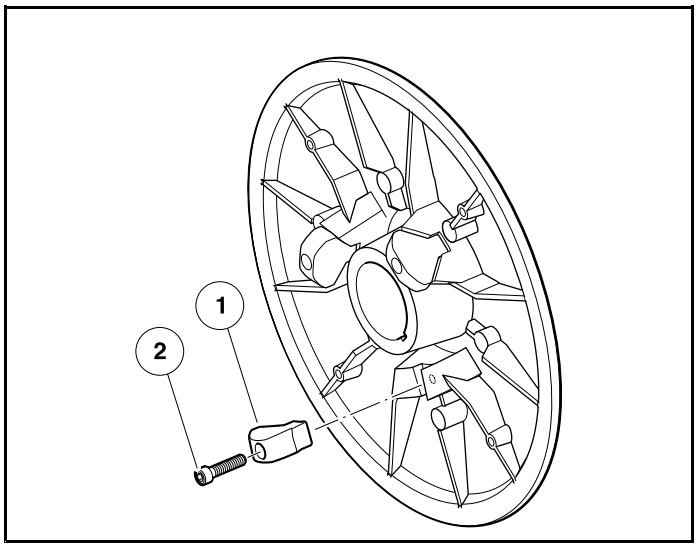
2961C

Figure 31-18 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

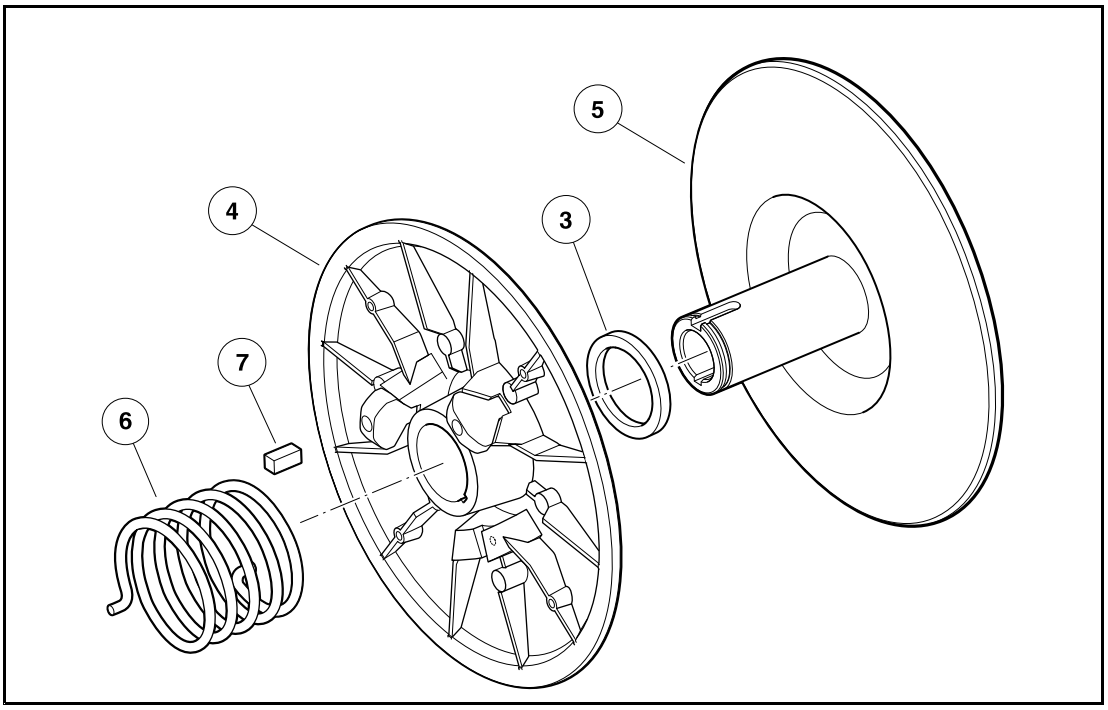
1. Place the three drive buttons (2) in position. Apply one drop of Loctite® 222 to each of the socket-head cap screws (1) and then install and tighten them to 8 in·lb (0.9 N·m) **(Figure 31-19, Page 31-16)**.



2961C

Figure 31-19 Drive Button Installation

2. Slide the acetal washer (3) and moveable sheave (4) onto the fixed sheave (5) **(Figure 31-20, Page 31-17)**.



2961D

Figure 31-20 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 31-21, Page 31-17)**.

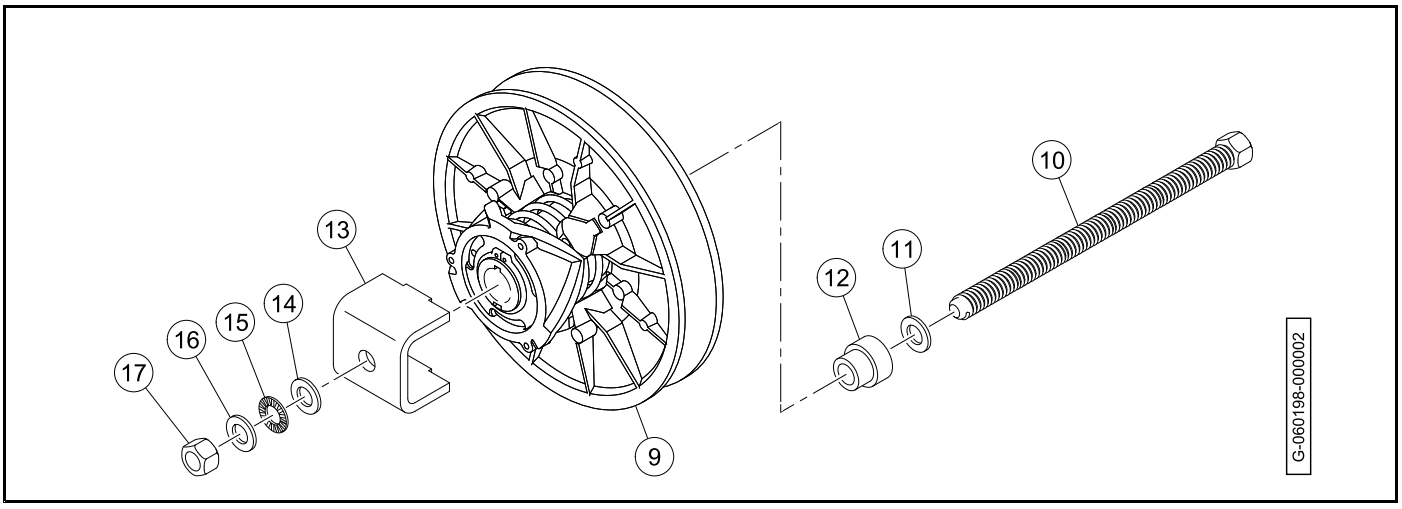


Figure 31-21 Driven Clutch Tool - Assembly

7. Assemble the threaded bolt (10) through the washer (11) and thrust collar (12).

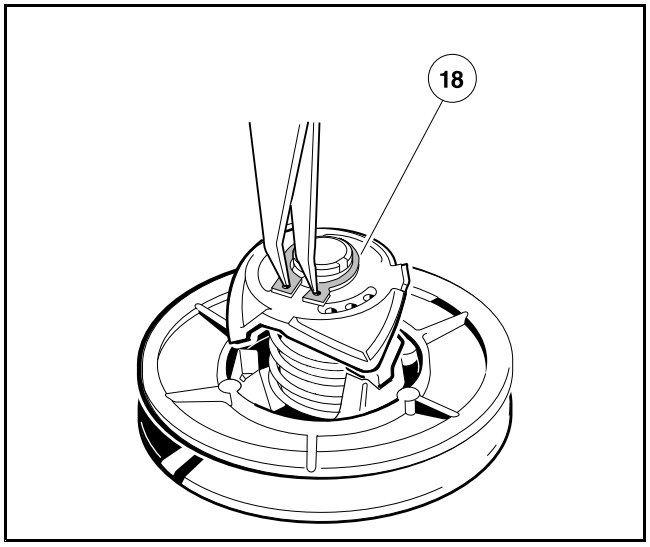
NOTE: *It is very important that the bolt, washers, and thrust bearing assembly be assembled in the order described and shown.*

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 31-22, Page 31-18)**.



608C

Figure 31-22 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 31-13, Page 31-12)**.
3. Tighten the new bolt (1) to 18 ft·lb (24.4 N·m). **See following NOTE.**

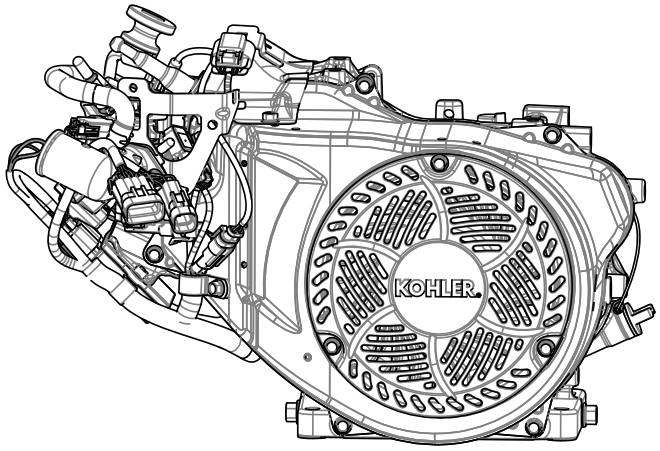
NOTE: *The bolt (1) must be replaced with a new bolt containing a locking patch that will prevent the bolt from loosening.*

4. Connect the battery and spark plug wire.

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.

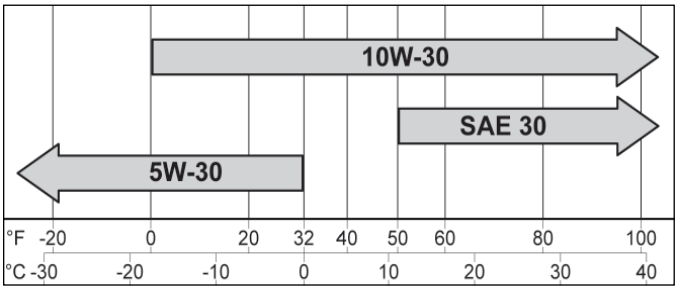
REPAIRS/SERVICE PARTS

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:

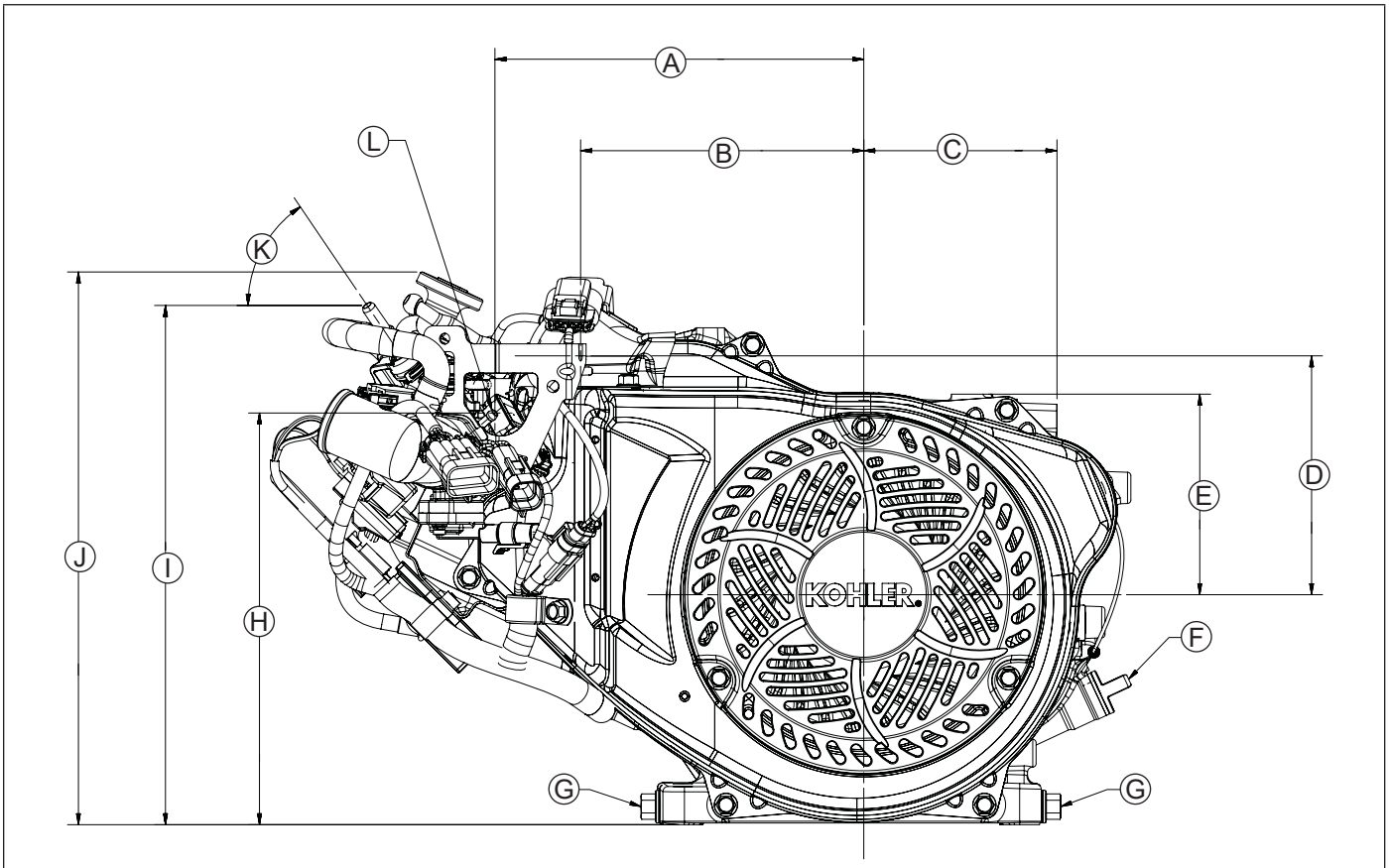
- Clean, fresh, unleaded gasoline.
- Octane rating of 87 (R+M)/2 or higher.
- Research Octane Number (RON) 90 octane minimum.
- Gasoline up to 10% ethyl alcohol, 90% unleaded is acceptable.
- Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blend (max 15% MTBE by volume) are approved.
- Do not 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.

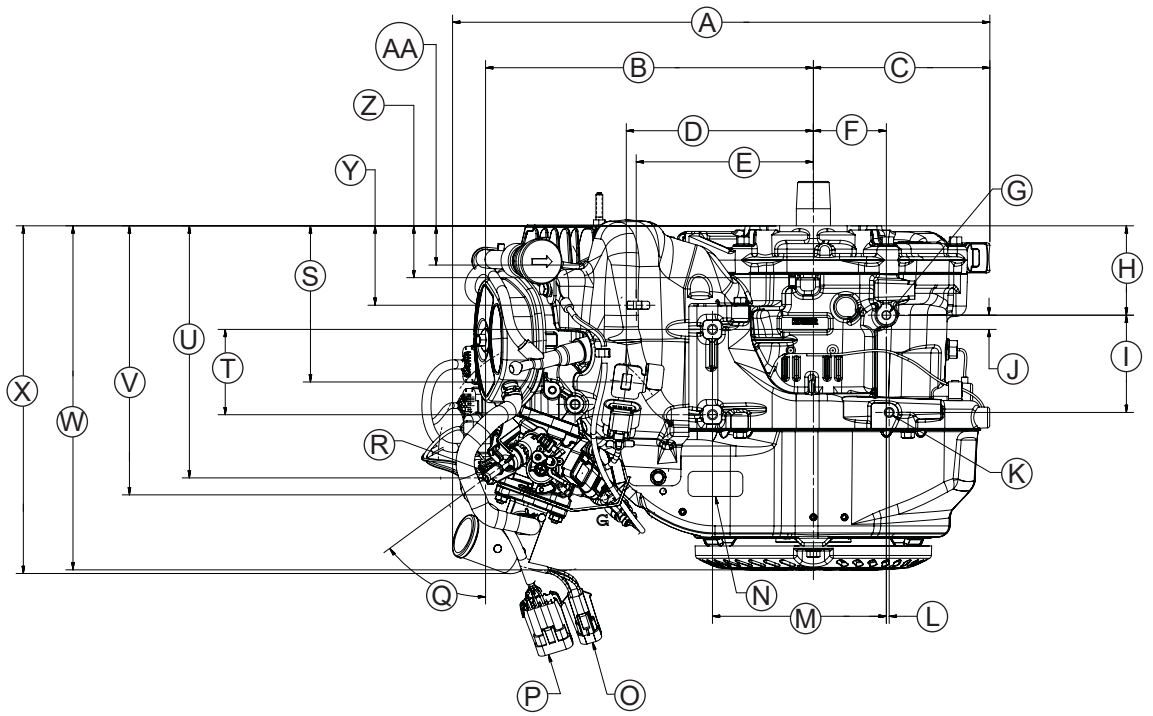
Engine Dimensions-Flywheel Side



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

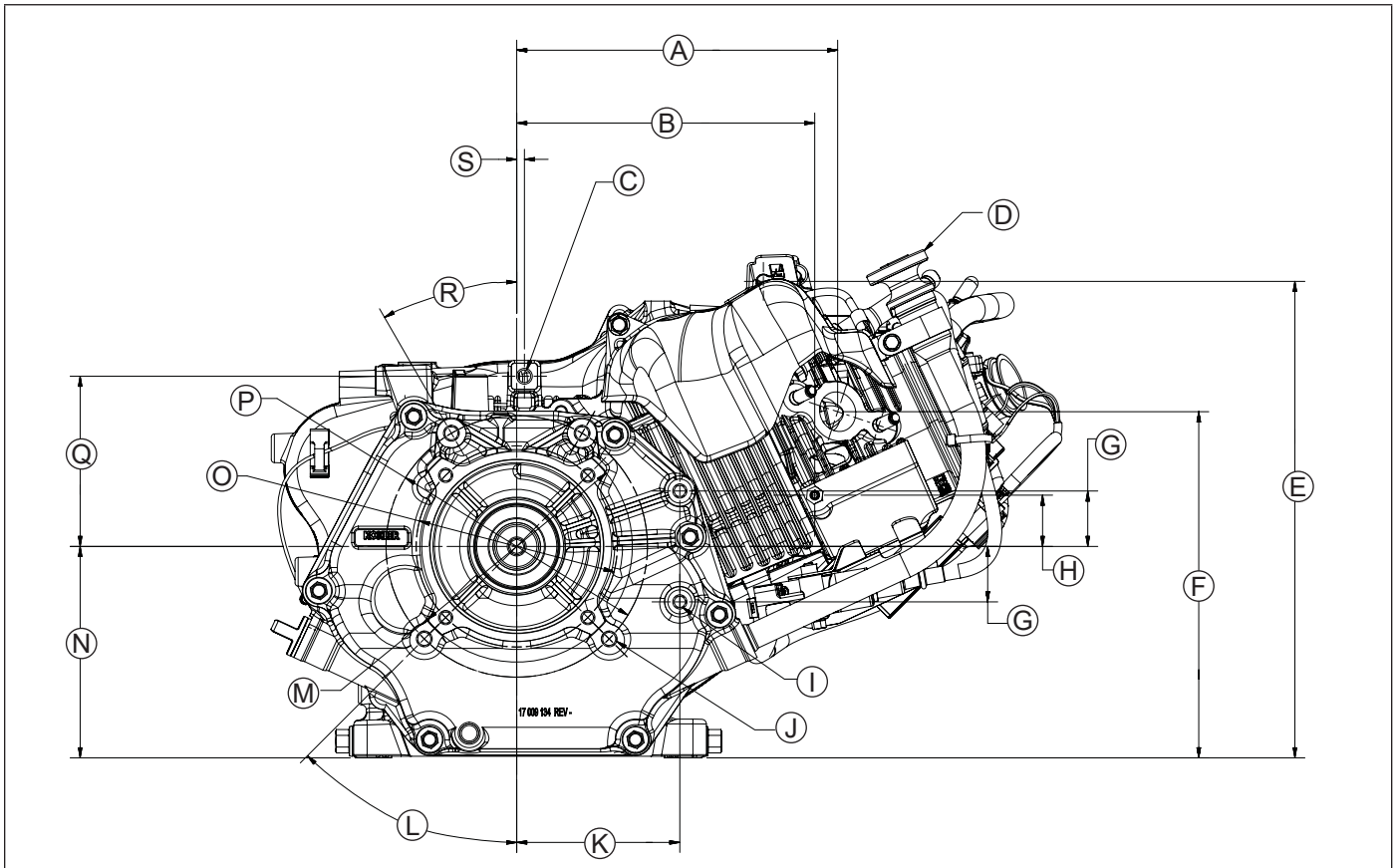
Specifications

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		

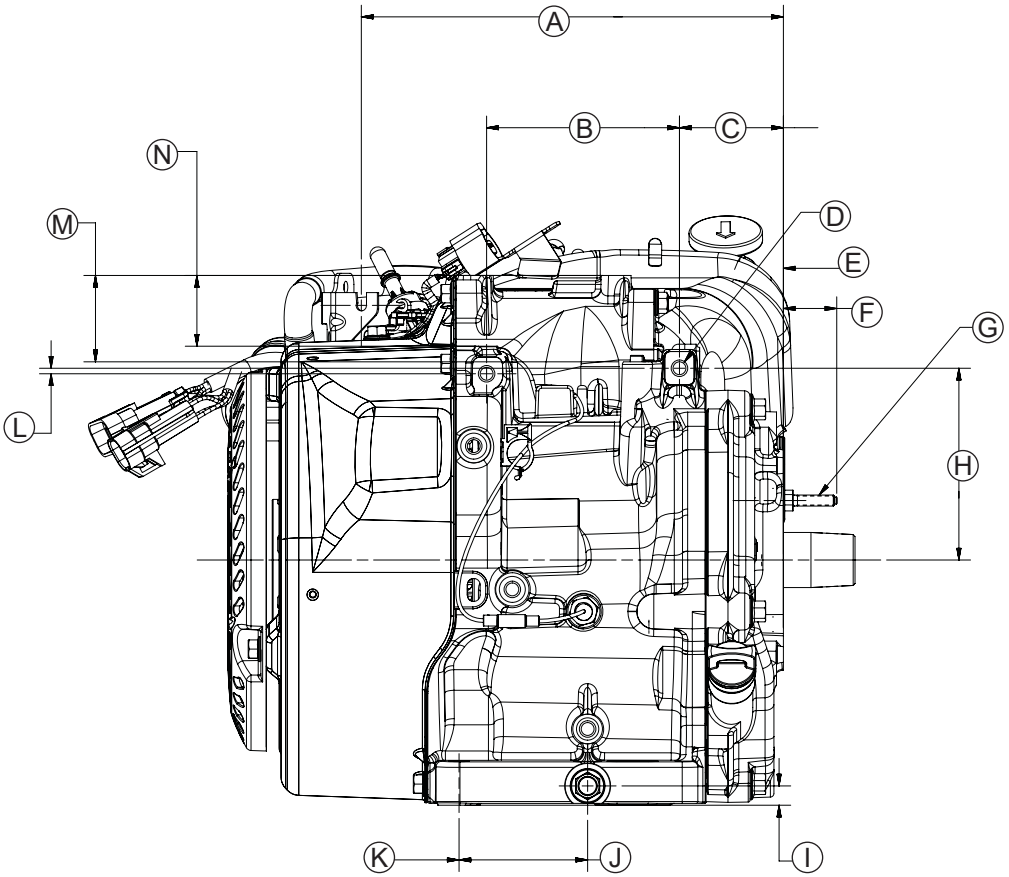
Engine Dimensions-PTO Side



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.)		

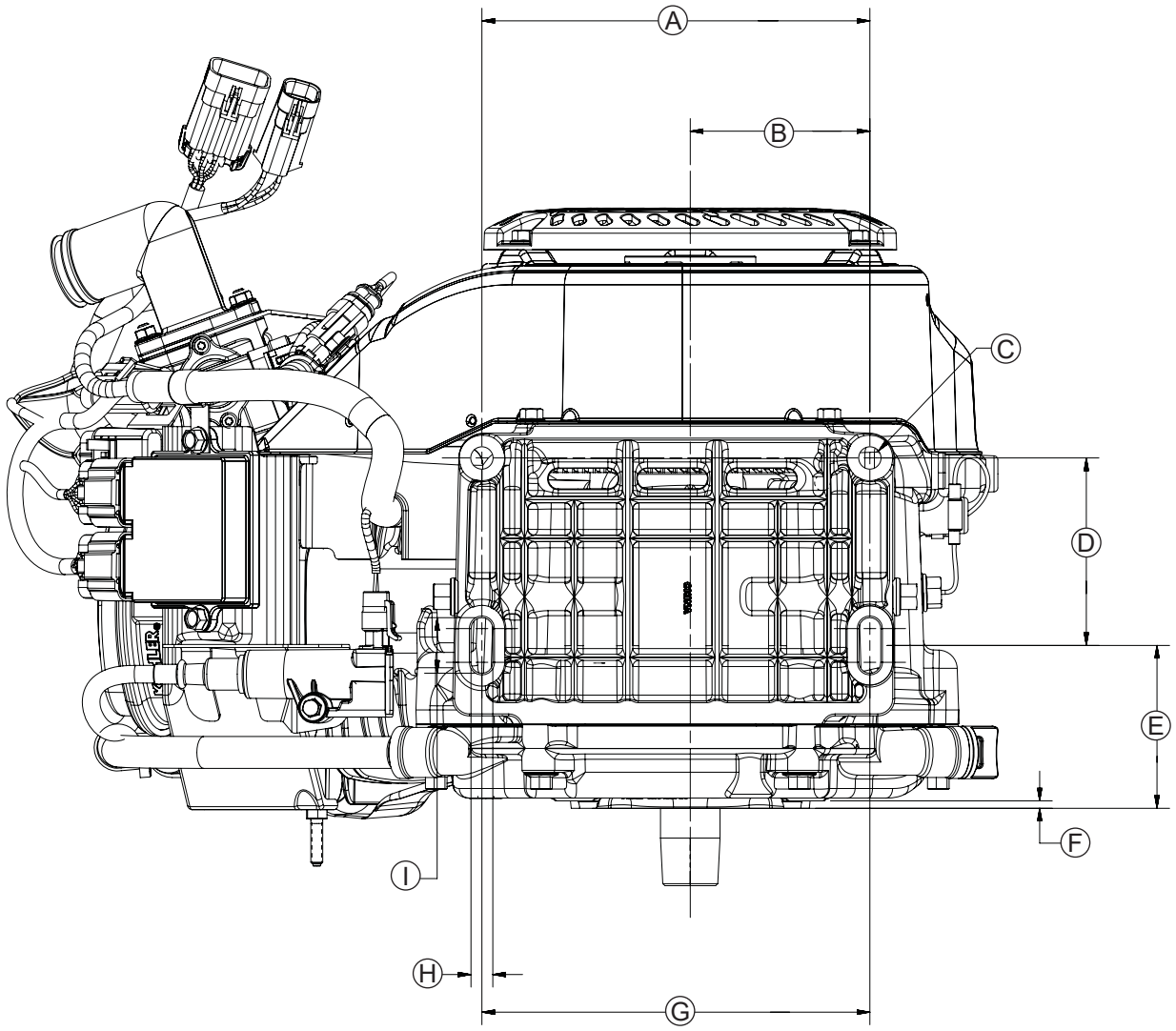
Specifications

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

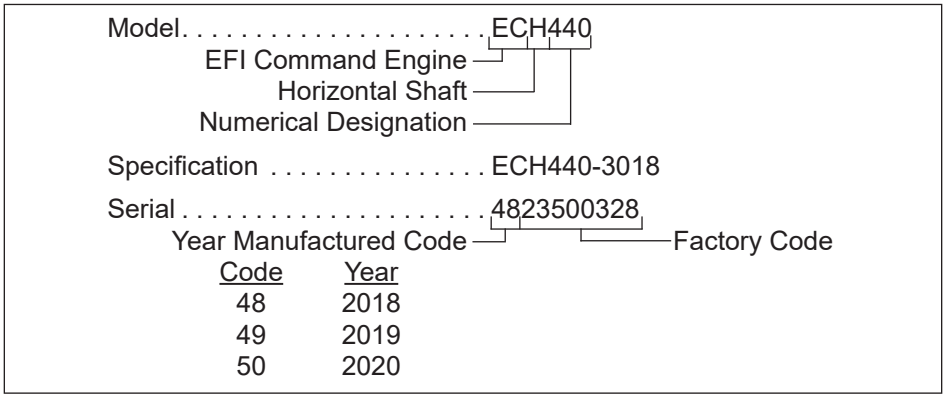


A	195.5 mm ± 0.50 mm (7.70 in. ± 0.02 in.) Machined Holes Distance	**B**	90.5 mm (3.56 in.)	**C**	2 X Ø 11.25 mm ± 0.25 mm (0.44 in. ± 0.01 in.)	**D**	2 X 94.5 mm ± 0.75 mm (3.72 in. ± 0.03 in.)
E	82.1 mm (3.23 in.)	**F**	3.75 mm (0.15 in.) Pilot	**G**	195.5 mm ± 1.0 mm (7.70 in. ± 0.04 in.) Cast Holes 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

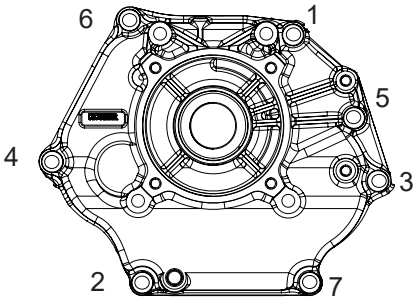
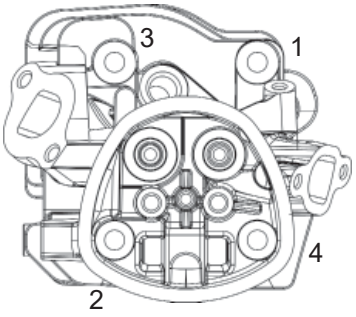
Kohler engine identification numbers (model, specification and serial) should be referenced for efficient repair, ordering correct parts, and engine replacement.



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

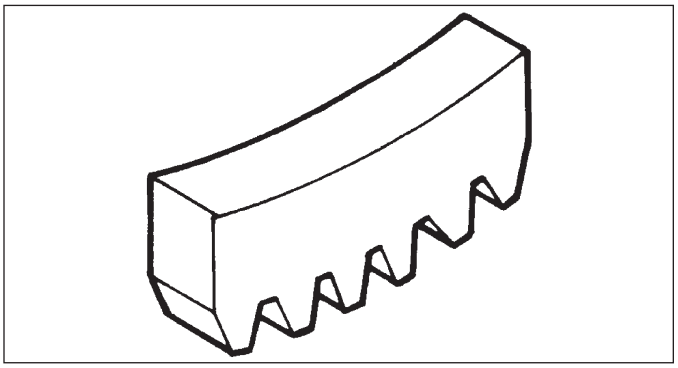
Description	Source/Part No.
Flywheel Puller For properly removing flywheel from engine.	SE Tools KLR-82408
Hose Removal Tool, Dual Size/End (also available in EFI Service Kit) Used to properly remove fuel hose from engine components.	Kohler 25 455 20-S
Hydraulic Valve Lifter Tool For removing and installing 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

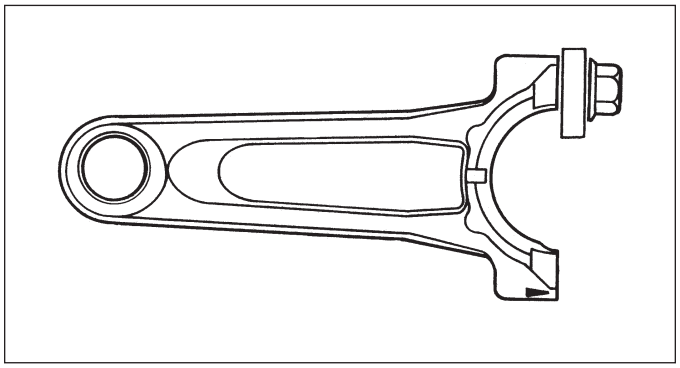
FLYWHEEL HOLDING TOOL



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.

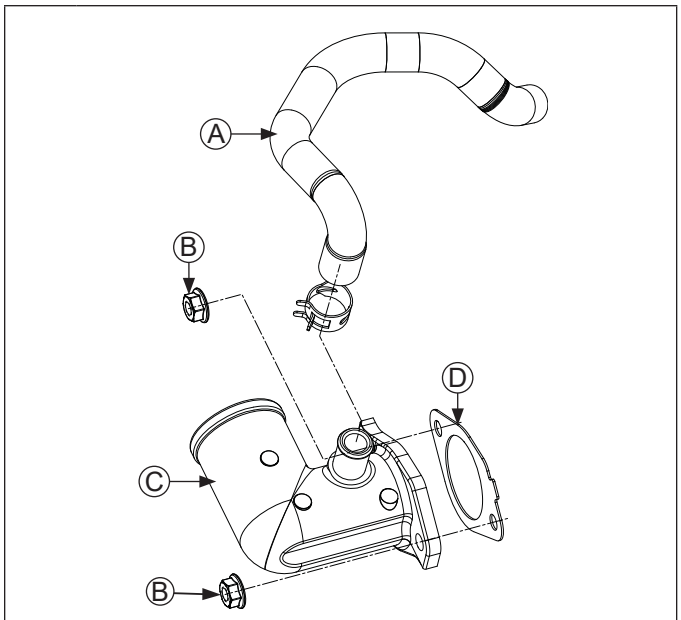
Condition	Conclusion
Air escaping from crankcase breather.	Ring or cylinder worn.
Air escaping from exhaust system.	Defective exhaust valve/improper seating.
Air escaping from intake.	Defective intake valve/improper seating.
Gauge reading in low (green) zone.	Piston rings and cylinder in good condition.
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.

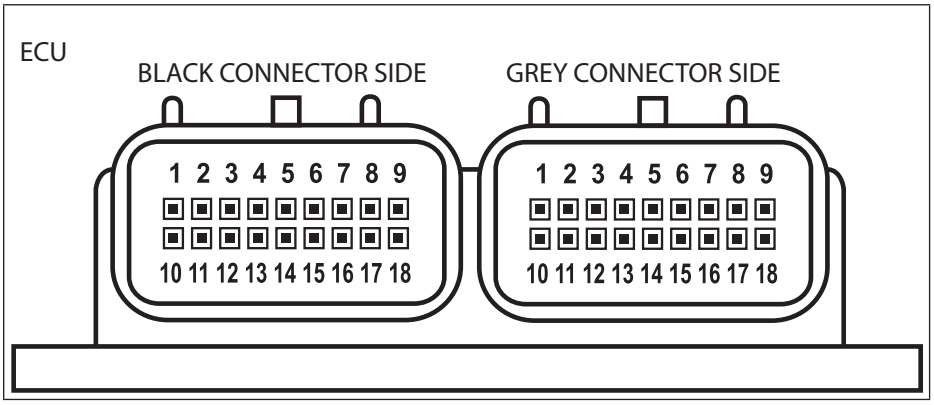
ELECTRICAL COMPONENTS

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.

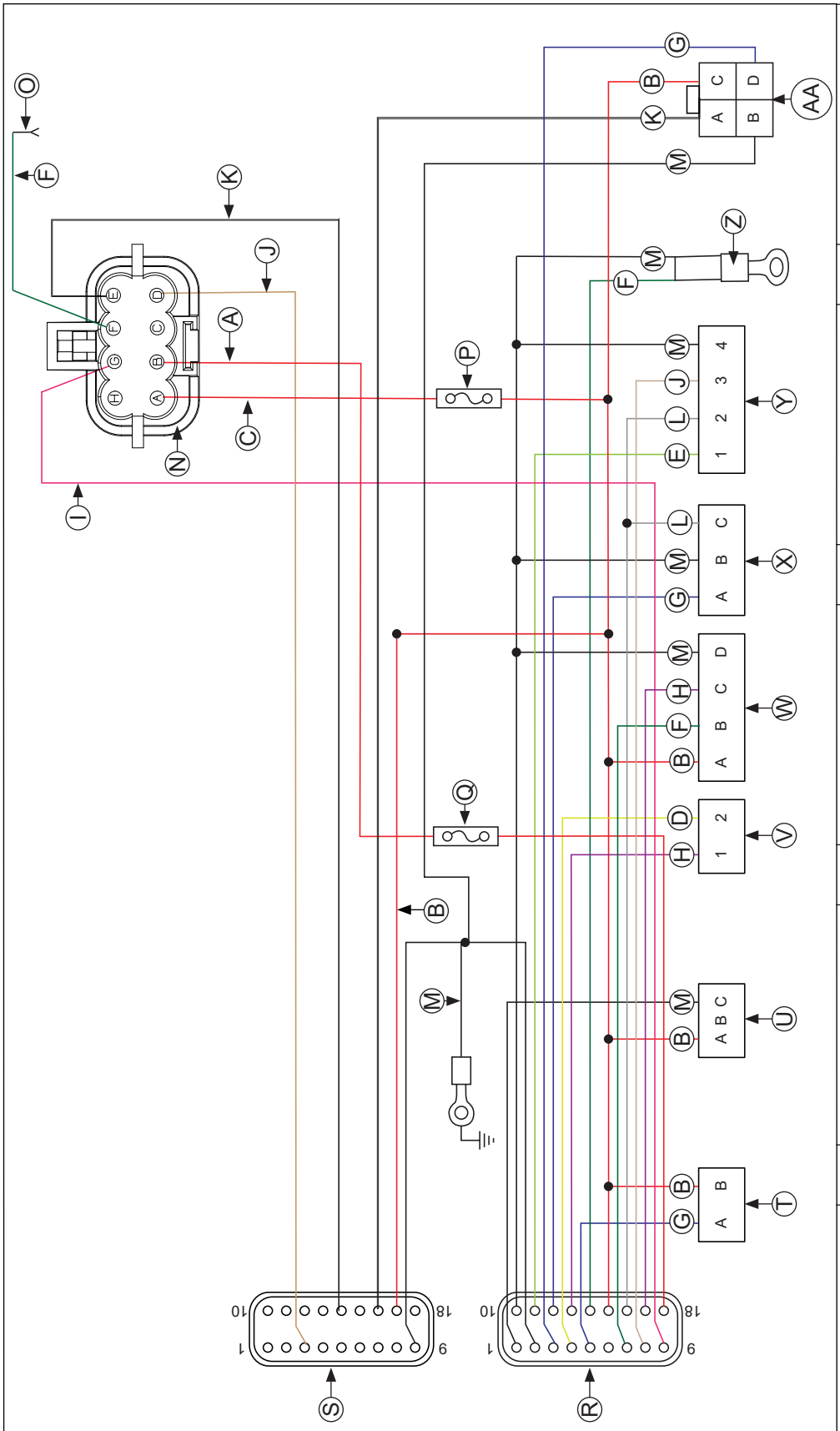
Learn procedure for pedal start application is complete.

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

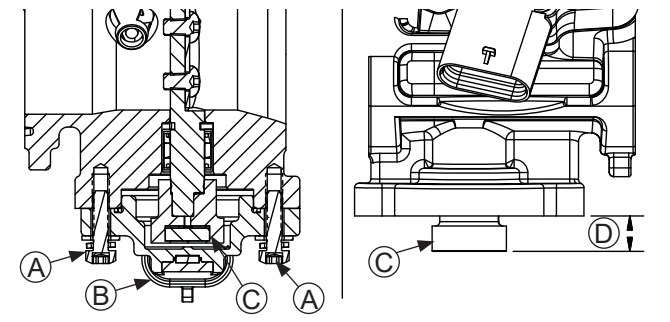
Observe throttle percent and raw TPS values through diagnostic software. With diagnostic software communicating to ECU and key ON engine not running, these values can be observed while throttle is moved from closed to full open position. There should be a smooth and repeatable throttle percent value 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



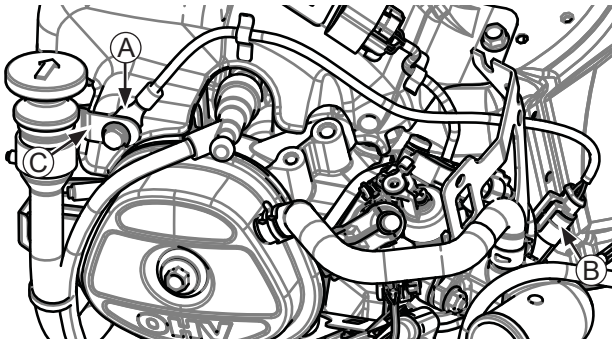
A	TPS Screws	**B**	TPS
C	Magnet Assembly	**D**	Magnet Installation Depth

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:

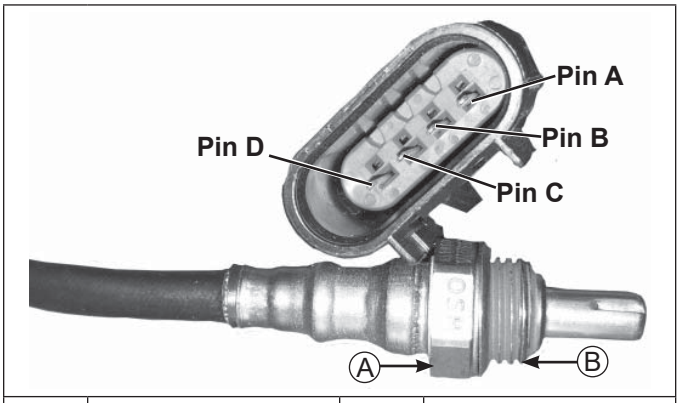
1. Remove TMAP sensor from throttle body.
2. Allow it to reach room temperature (20°C, 68°F).
3. Unplug Black connector from ECU.
4. With sensor still connected, check temperature sensor circuit resistance between Black pin 10 and 8 pin terminals. Value should be 1850-2450 Ω.
5. Unplug sensor from wire 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.

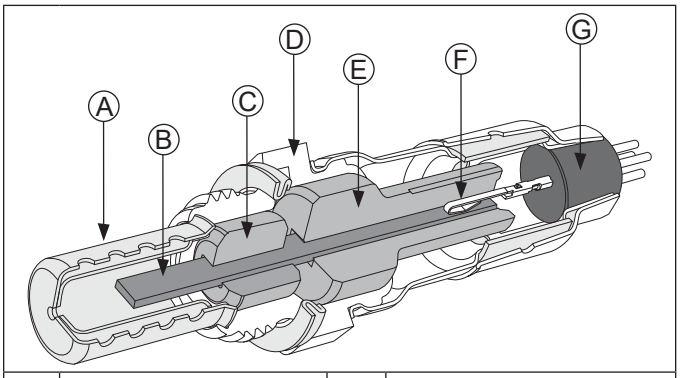
Oxygen Sensor (O2)

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		

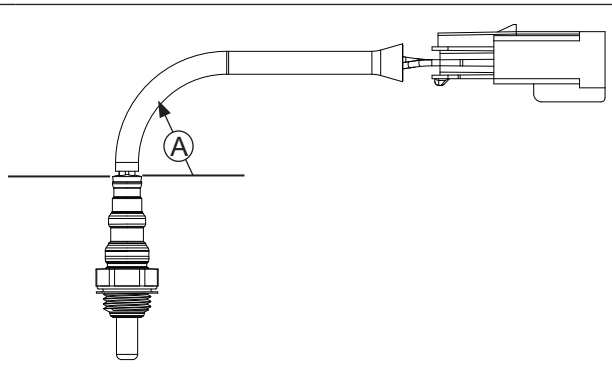
Temperature must be controlled very accurately and gas constituents measured to a high degree of accuracy for absolute sensor measurements. This requires laboratory equipment to determine a good or bad sensor in field. Furthermore, as with most devices, intermittent problems are difficult to diagnose. 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.

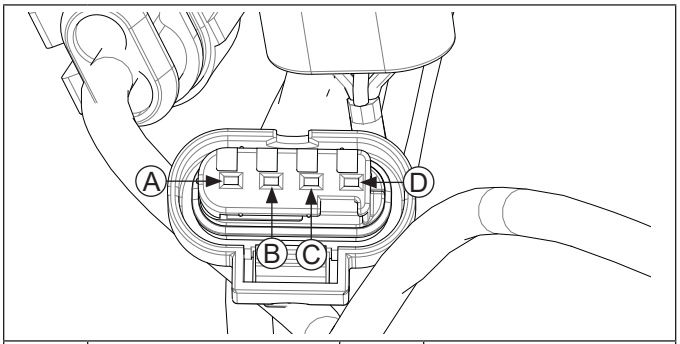
NOTE: **Do not attempt to clean sensor.** Replace as needed.

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

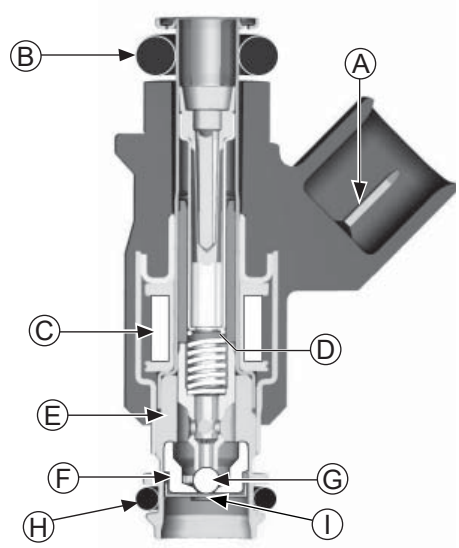
⚠ WARNING

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)

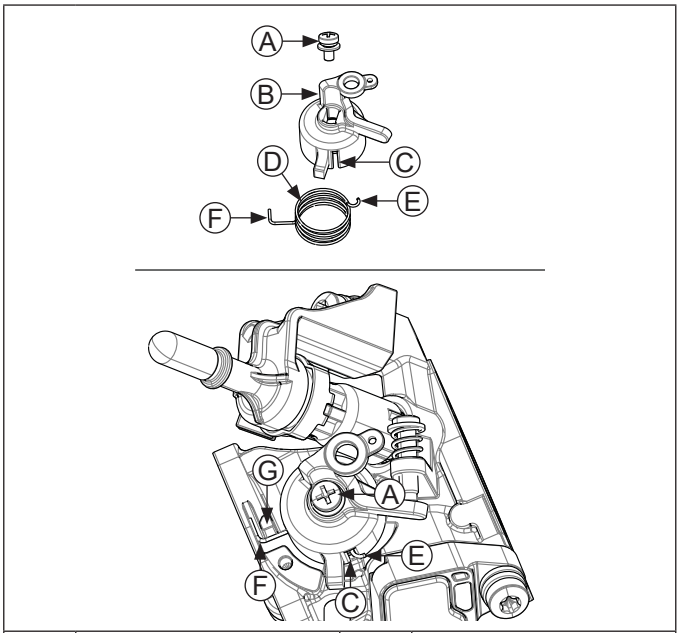
Purge port is located on throttle body by TMAP sensor and no specific servicing is required. No specific servicing is required for vent hose assembly (OEM supplied) unless operating conditions indicate replacement is required. Use only original equipment replacement parts. Visit KohlerEngines.com for 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.

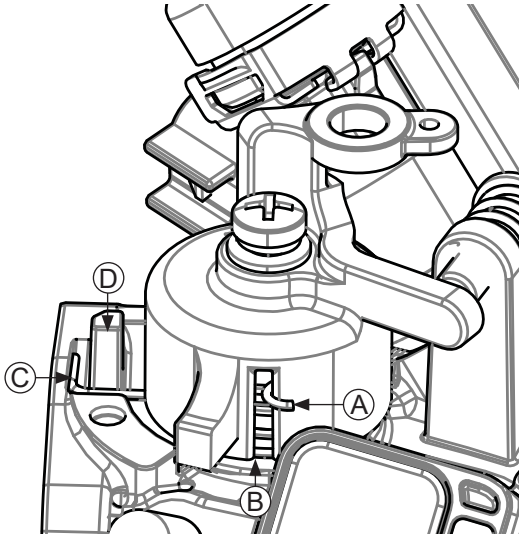
Throttle body is serviced as an assembly, with throttle shaft, TPS, throttle plate, TMAP sensor, fuel injector/cap/bracket assembly, return spring, and idle speed adjusting screw installed. Throttle shaft rotates on needle bearings (non-serviceable), capped with seals to prevent air leaks.

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.

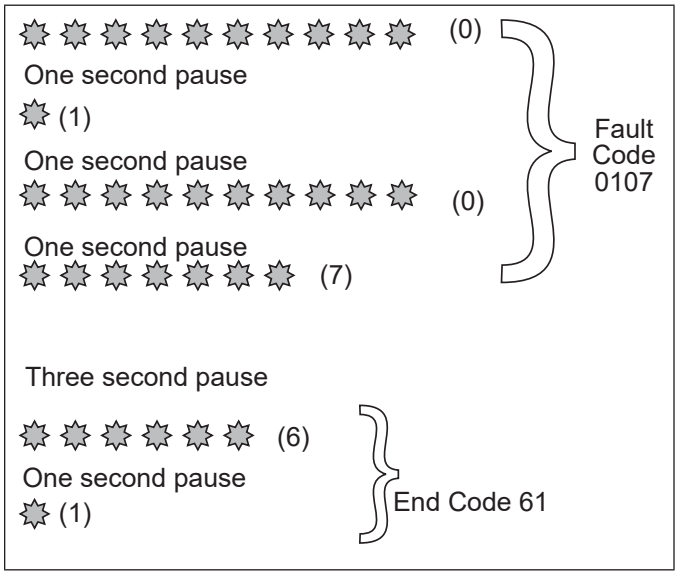
Fluid puncture injuries are highly toxic and hazardous. If an injury occurs, seek immediate medical attention.

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.

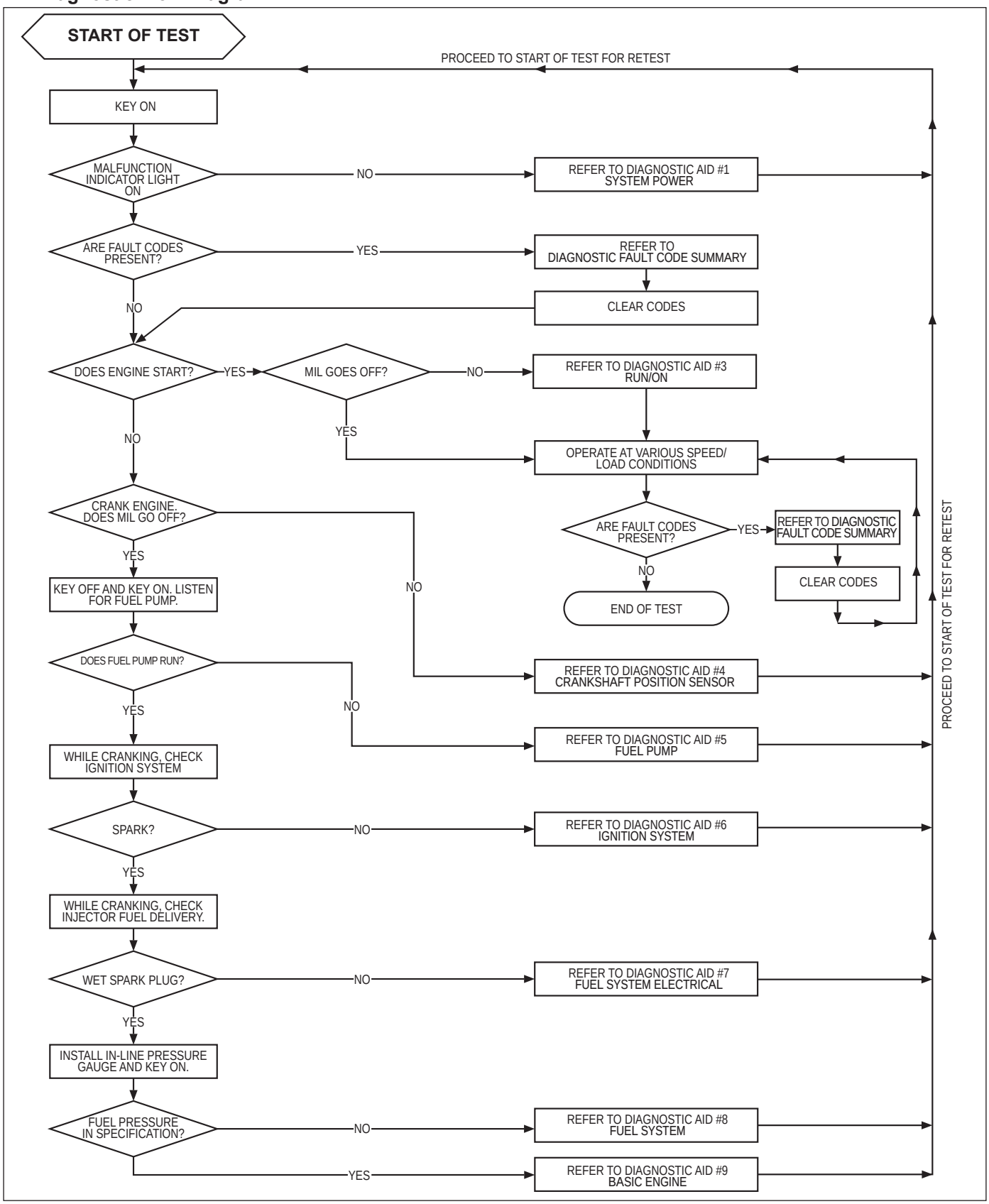
Code 61

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.

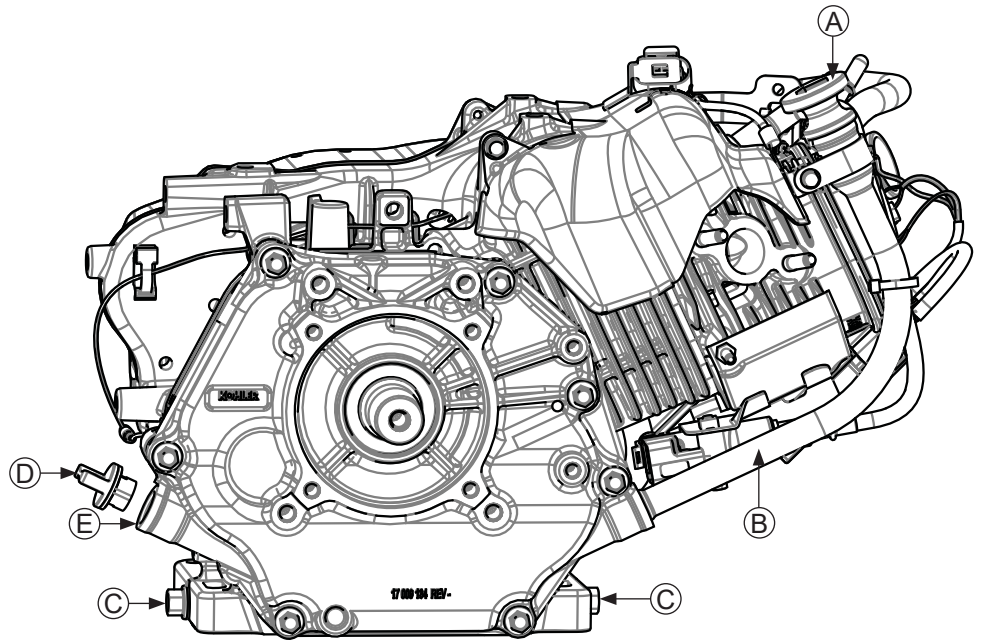
GOVERNOR (OEM Supplied)

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.

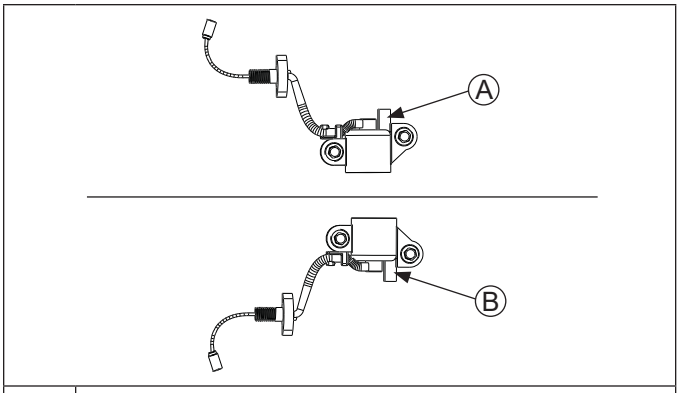
1. Set an ohmmeter to Rx1 scale and zero meter. Connect one ohmmeter lead to Oil Sentry™ oil level switch lead (yellow with green sleeve) and touch other lead to a bare spot on crankcase (ground). Drain oil from crankcase and repeat test.

   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

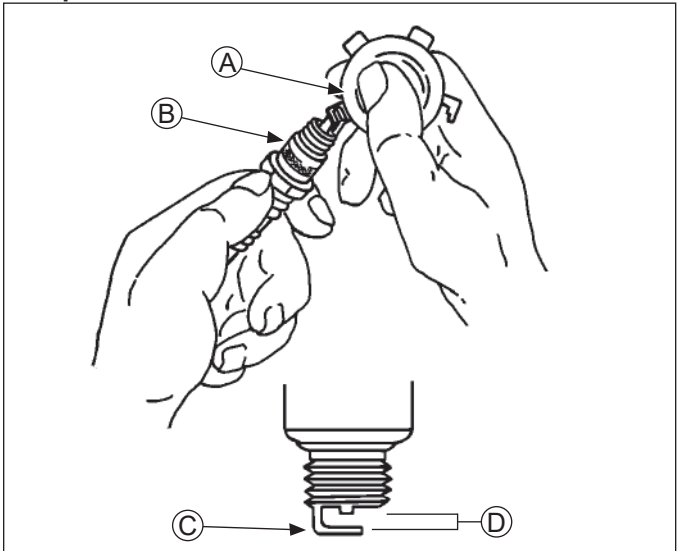
Fuse Replacement

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.

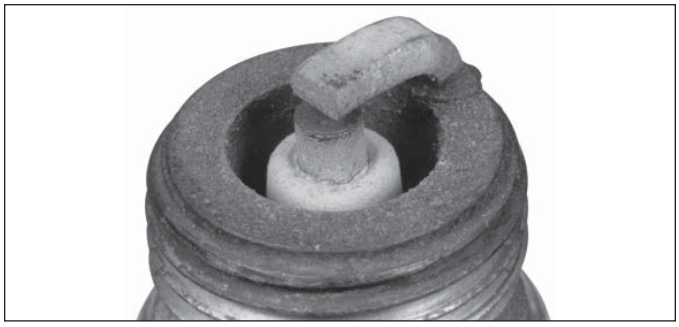
1. Check gap using wire feeler gauge. Adjust gap to 1.11 mm (0.044 in.).
2. Install plug into cylinder head.
3. Torque plug to 27 N·m (20 ft. lb.).

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.

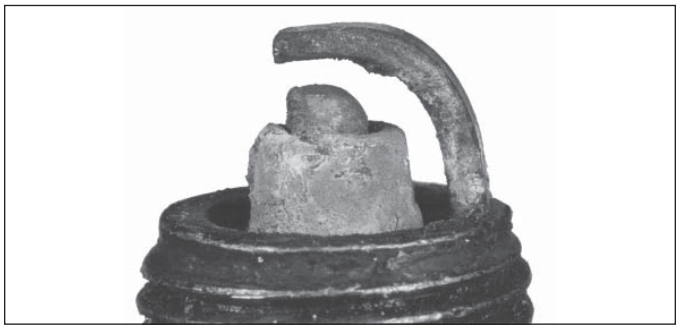
Normal and fouled plugs are shown in following photos:

Normal



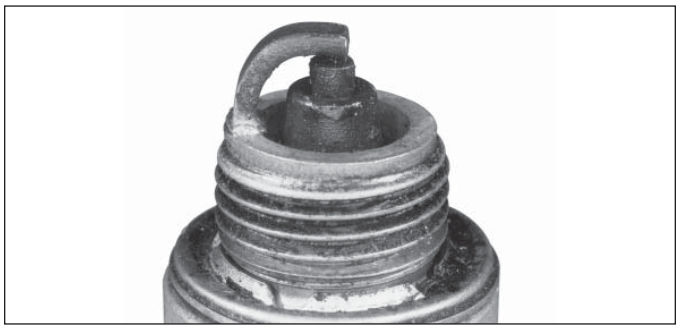
Plug taken from an engine operating under normal conditions will have light tan or gray colored deposits. If center electrode is not worn, plug can be set to proper gap and reused.

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.

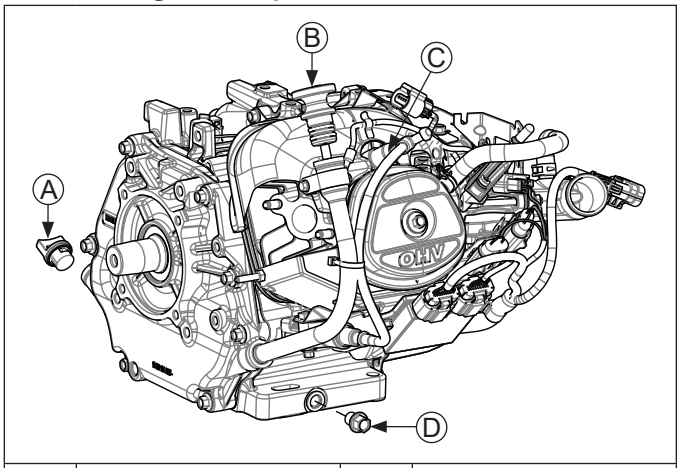
Condition	Possible Cause	Conclusion
Cylinder is not firing or has intermittent spark.	Wiring, Connections, or System Power	Using a DVOM, attach black (-) lead of meter to battery ground, remove primary plug from coil, test voltage at red wire with black tracer at coil primary connector with ignition 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

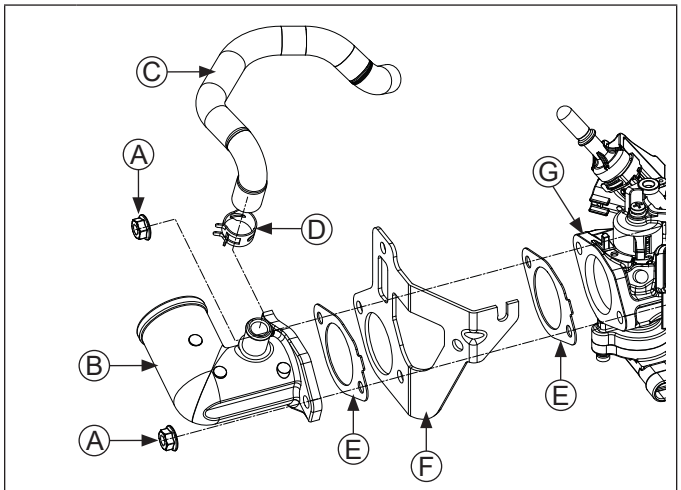
1. Remove 1 oil drain plug and oil fill plug or dipstick.
2. Allow ample time for oil to drain from crankcase.

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.

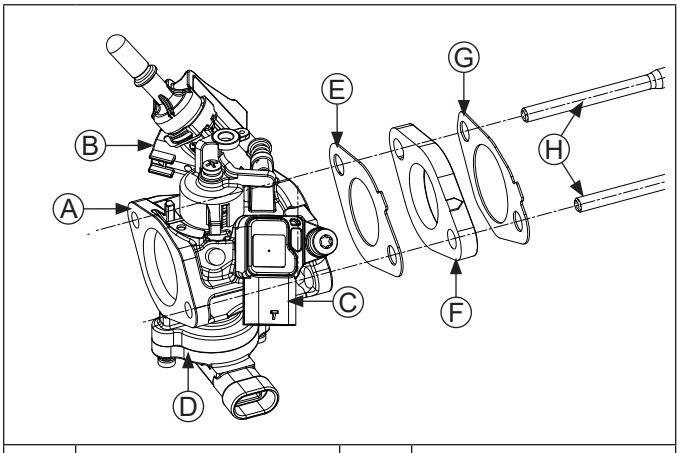
Remove Air Inlet Elbow



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.

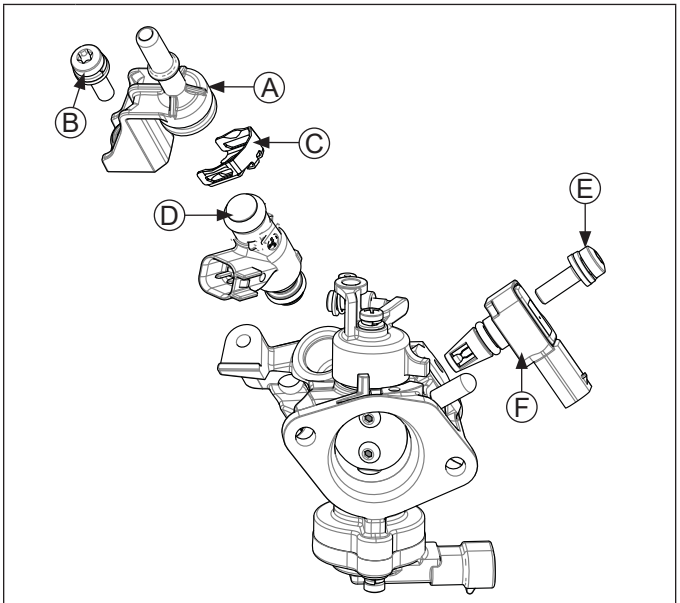
Remove Throttle Body Assembly



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.

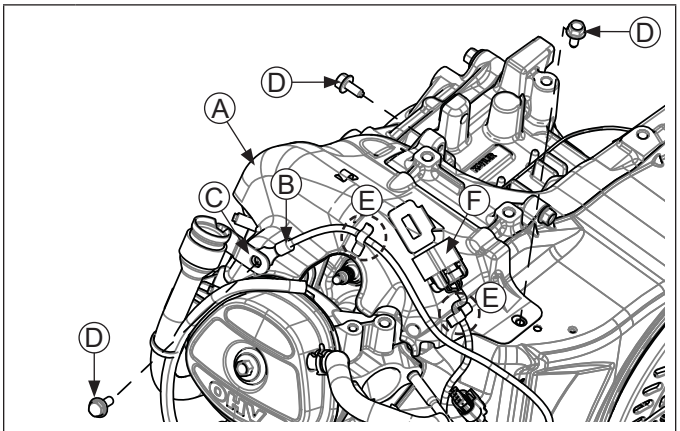
1. Disconnect fuel injector electrical connector.
2. Remove screw and pull injector out of throttle body.
3. When removed, pull metal retaining clip connecting fuel injector to fuel injector cap/fuel cap bracket. There may be some fuel left in line. Any spilled fuel must be cleaned up immediately.

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.

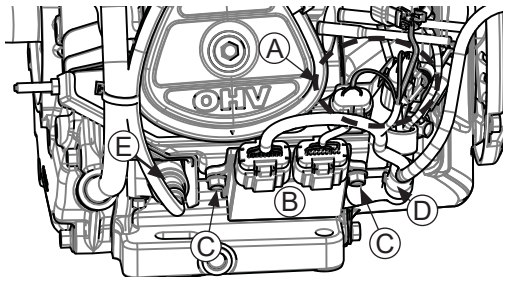
Remove Upper Heat Shield and Engine Temperature Sensor



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		

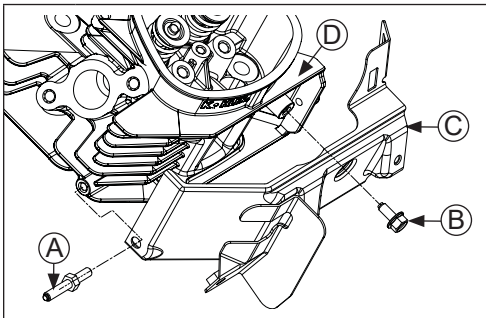
Remove Fuses

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

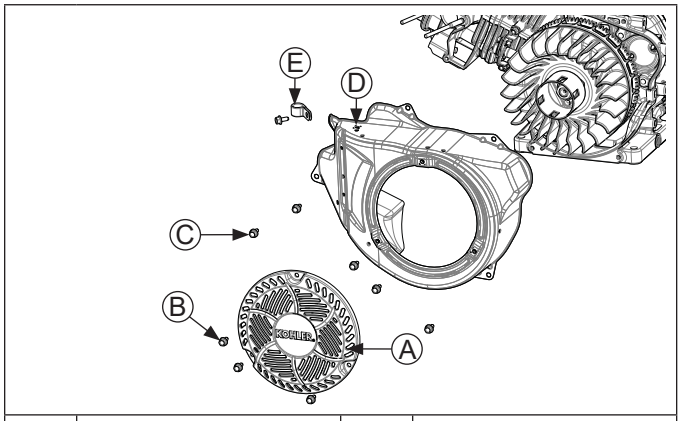


A	Ground Stud	**B**	Screw
C	Cylinder Shield	**D**	Cylinder Head

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

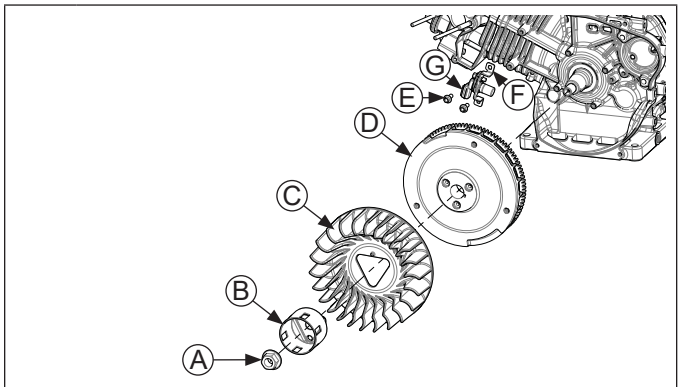
NOTE: Unless blower housing screen is damaged, disassembly from blower housing is unnecessary.

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.

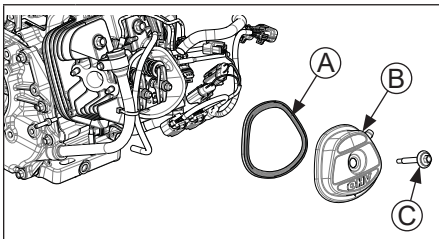
1. Remove flywheel retaining nut.
2. Remove drive cup and fan from flywheel.
3. Remove flywheel from crankshaft using a suitable puller.
4. Remove flywheel key from crankshaft keyway.

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



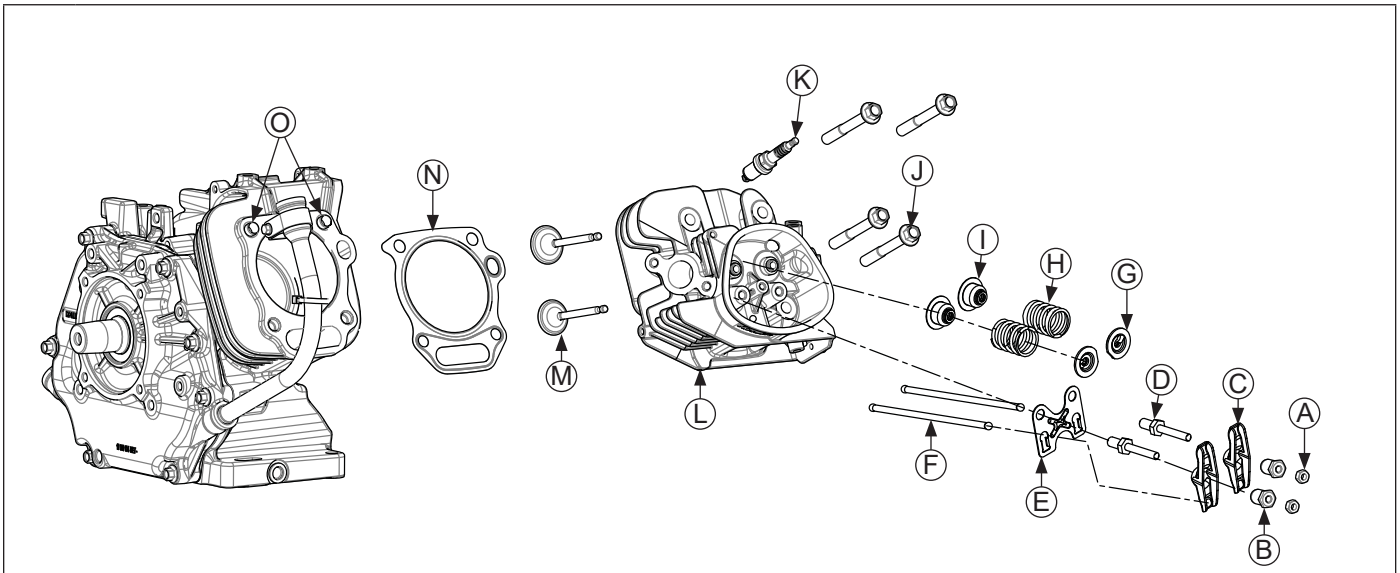
A	Valve Cover Gasket	**B**	Valve Cover
C	Valve Cover Seal Screw Assembly		

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.

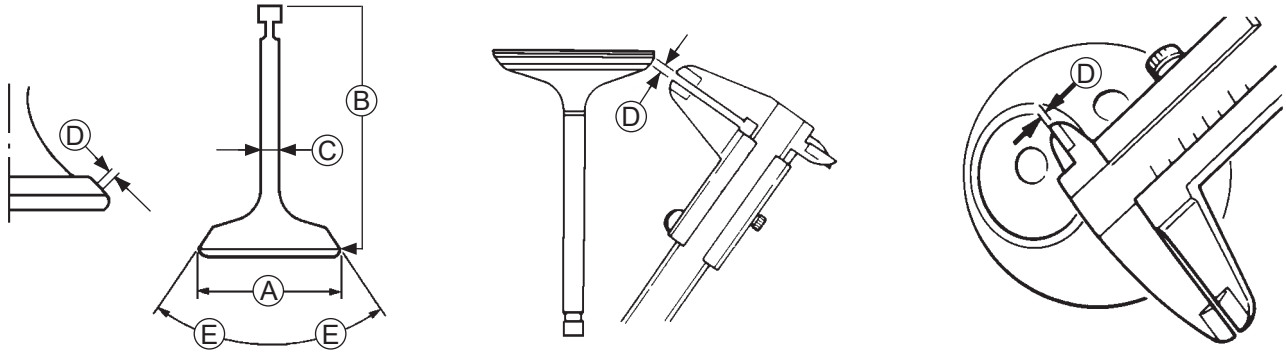
Recondition valve seat inserts following instructions provided with valve seat cutter being used. Final cut should be made with a 44.5° cutter as specified for valve seat angle. Cutting proper 45° valve face angle, as specified, and proper valve seat angle (44.5°) will achieve desired 0.5° (1.0° full 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.

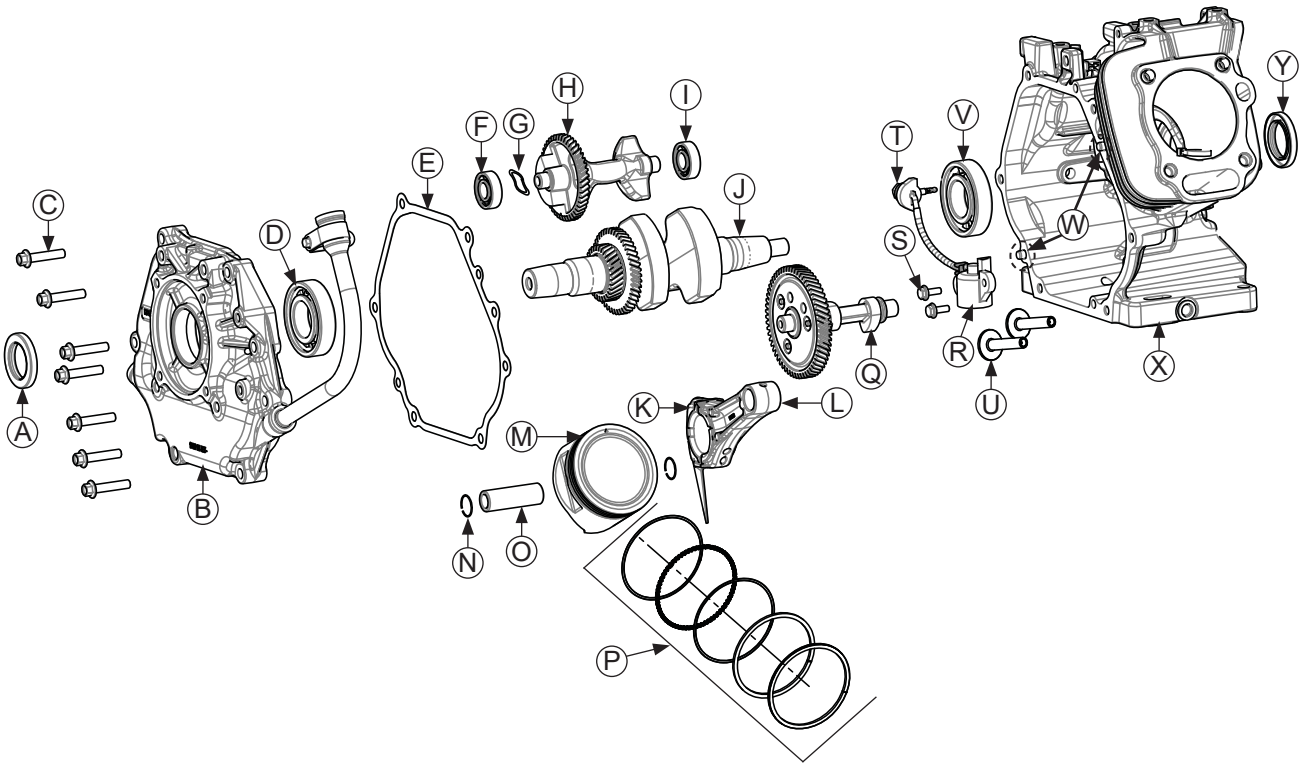
Valve Details



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°

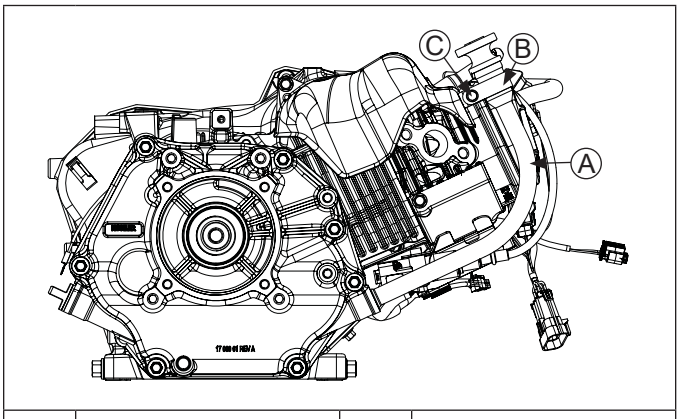
Crankcase/Crankshaft/Camshaft/Closure Plate Components



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

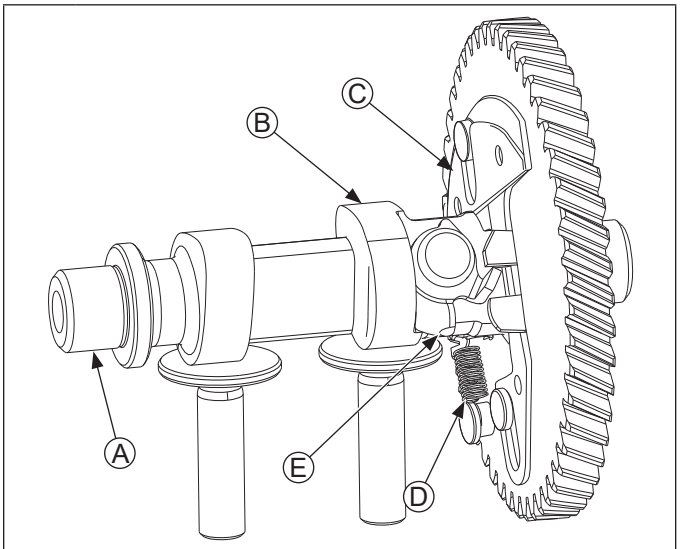
Remove balance shaft (with wave spring) by pulling it straight out of crankcase.

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.

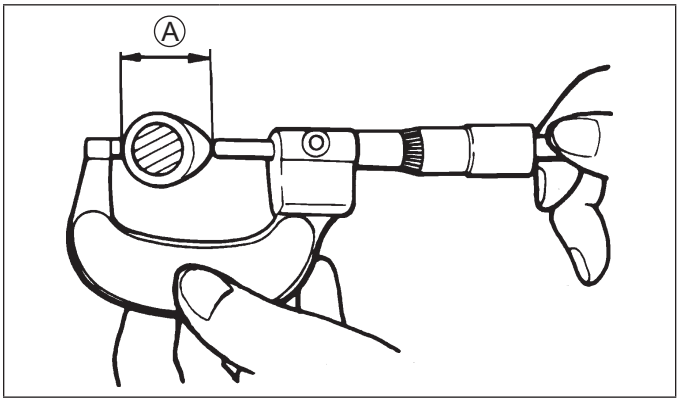
After engine speed increases centrifugal force causes spring-loaded arm to move outward causing pin to retract. When in this position pin has no effect on exhaust valve and engine operates at full compression and power.

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.

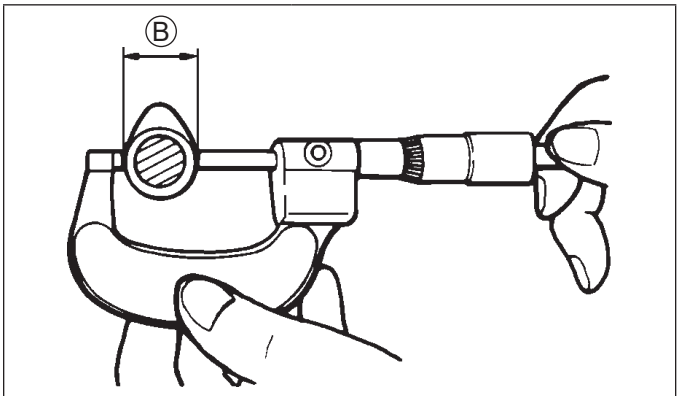
Inspection and Service

Dimension A



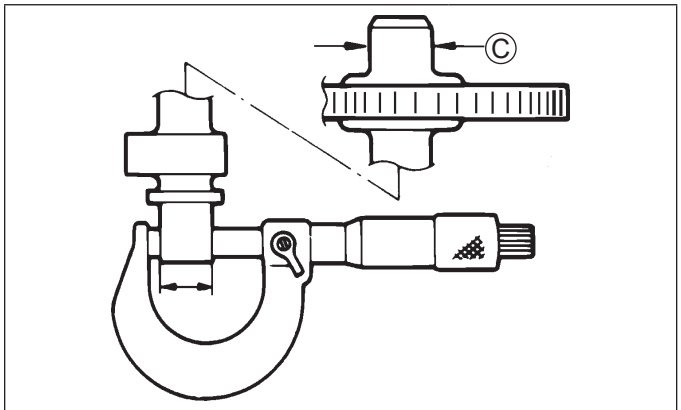
Cam Lobe		
INTAKE	32.286 mm (1.271 in.)	32.032 mm (1.261 in.)
EXHAUST	32.506 mm (1.280 in.)	32.252 mm (1.270 in.)

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.

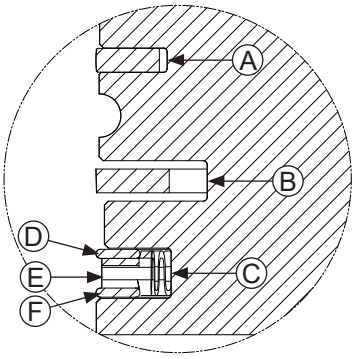
Some important points to remember when servicing piston rings:

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

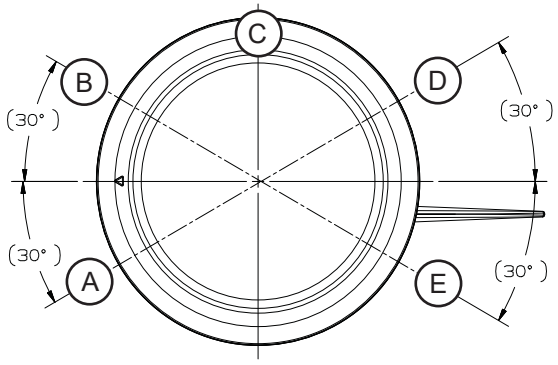
Piston and Rings Components and Details



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.

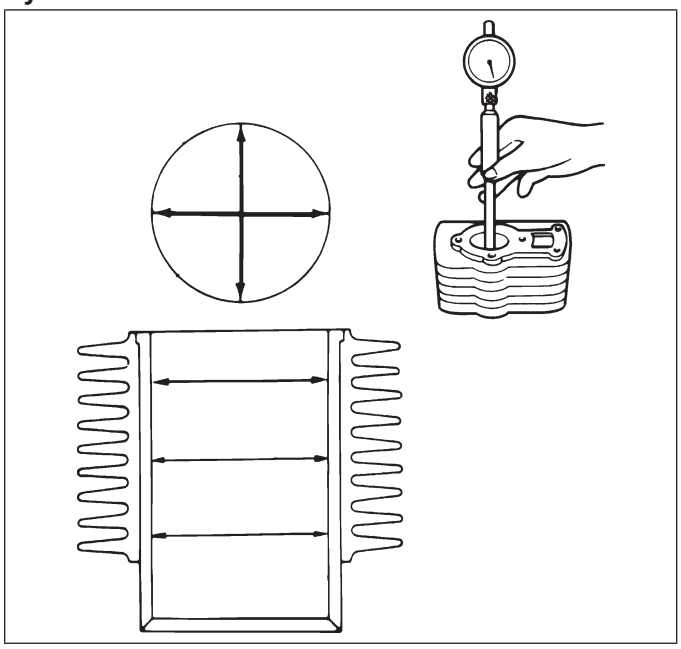
Remove Crankcase and Closure Plate Seals and Bearings

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.

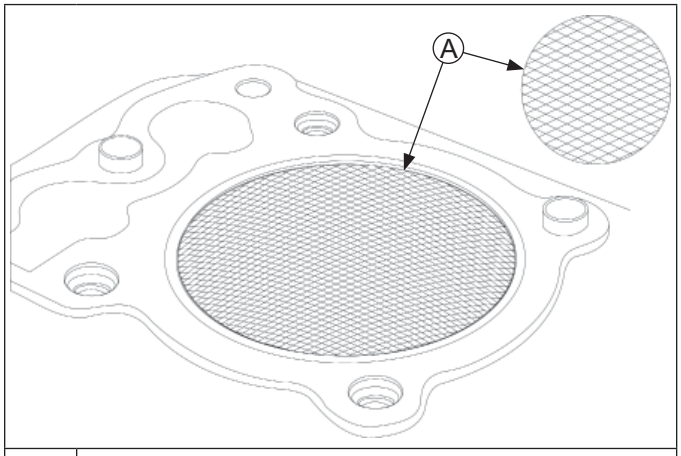
Check all gasket surfaces to make sure they are free of gasket fragments. Gasket surfaces must also be free of deep scratches or nicks.

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.

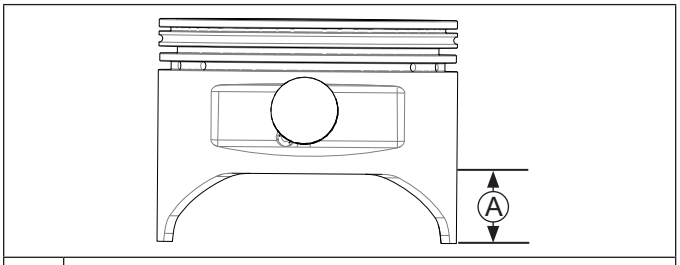
Clean Cylinder Bore After Honing

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.)

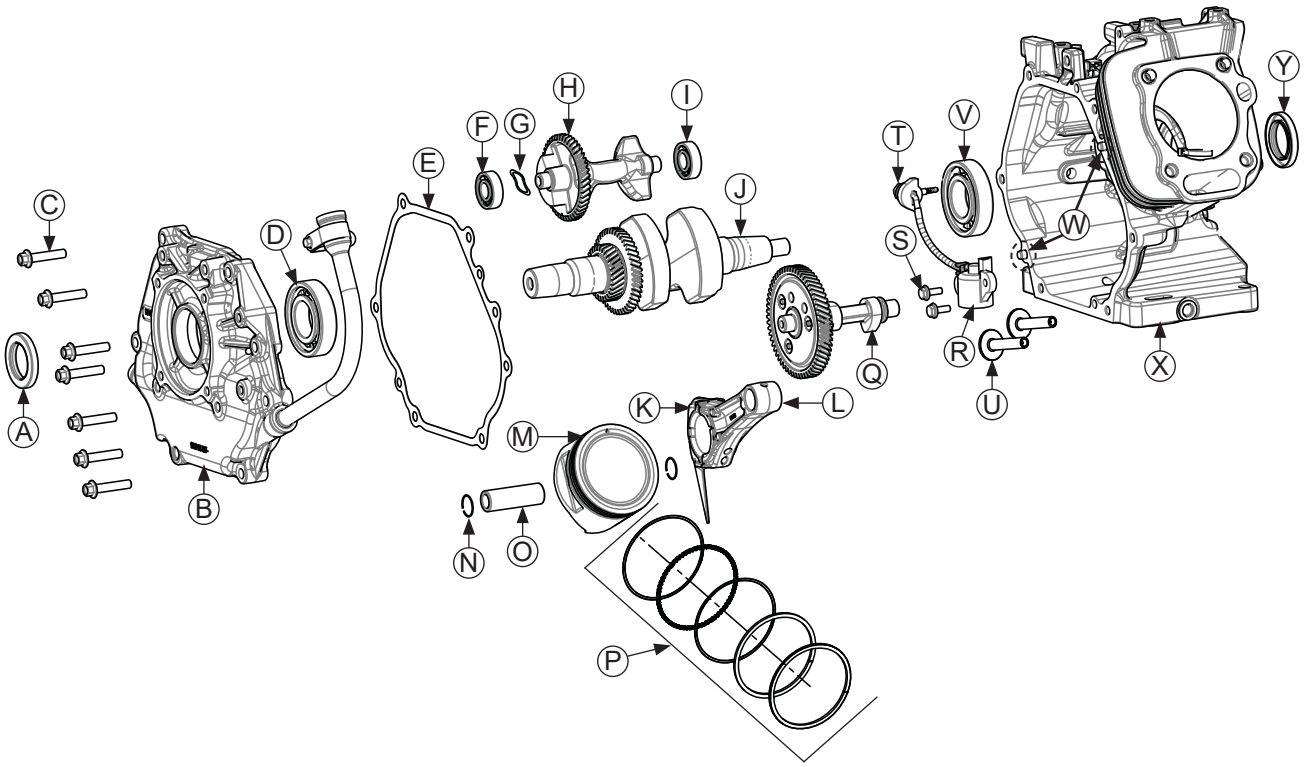
NOTE: Do not use a feeler gauge to measure piston-to-bore clearance, it will yield inaccurate measurements. Always use a micrometer.

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



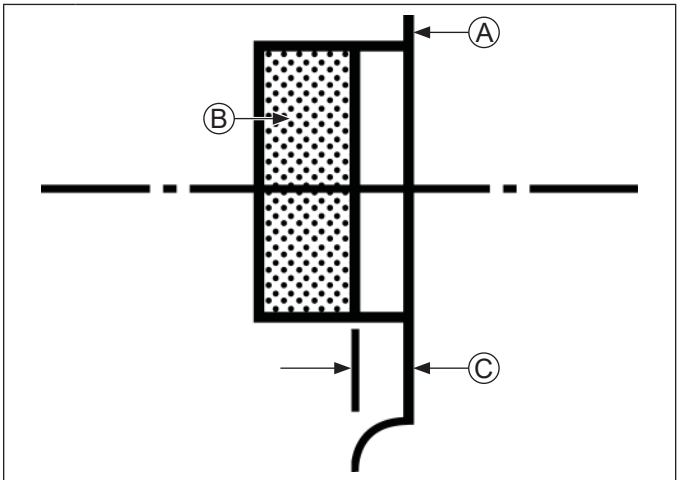
A	Closure Plate Oil Seal	**B**	Closure Plate	**C**	Screw	**D**	Closure Plate Bearing
E	Closure Plate Gasket	**F**	Closure Plate Balance Shaft Bearing	**G**	Wave Spring	**H**	Balance Shaft
I	Crankcase Balance Shaft Bearing	**J**	Crankshaft	**K**	Connector Rod End Cap	**L**	Connector Rod
M	Piston	**N**	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

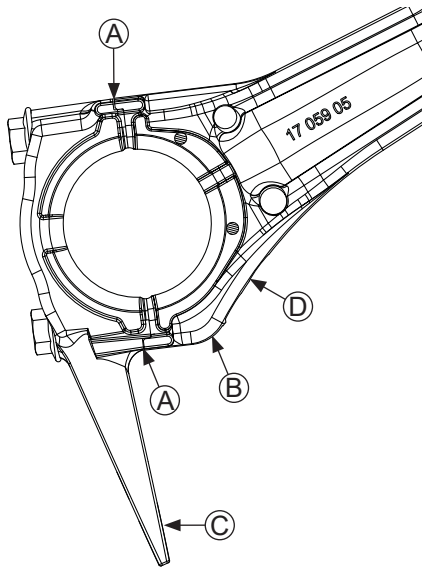
1. Mount Oil Sentry™ switch into crankcase housing using two M6x18 screws and torque to 8 N·m (71 in. lb.).
2. Route wire lead grommet assembly through crankshaft housing.
3. Install nut on grommet assembly external stud and torque to 10 N·m (89 in. lb.).

Install Crankshaft

Carefully slide flywheel end of crankshaft through main ball bearing and seal.

Install Connecting Rod with Piston and Rings

Connecting Rod Details

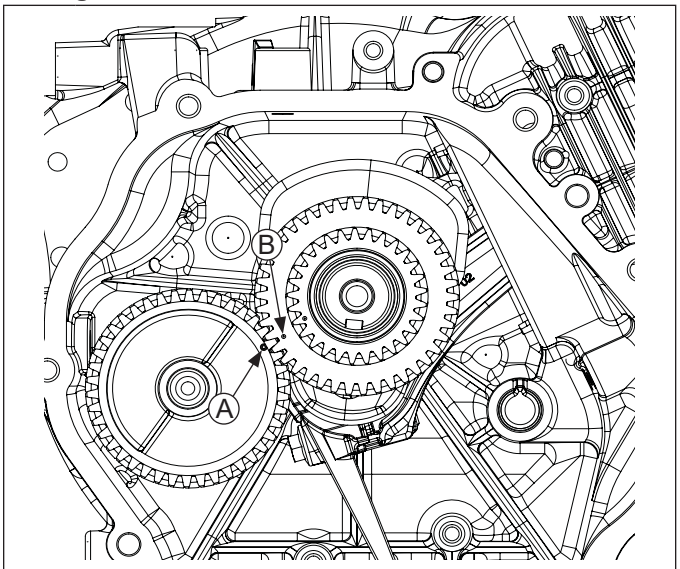


A	Match Marks	**B**	Offset
C	Dipper	**D**	Oil Hole

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

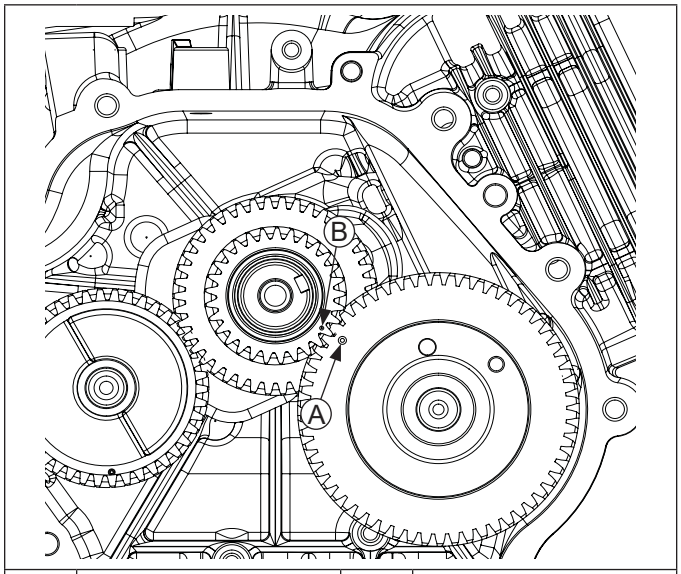


A	Balance Shaft Timing Mark	**B**	Balance Shaft Drive Gear on Crankshaft Timing Mark

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

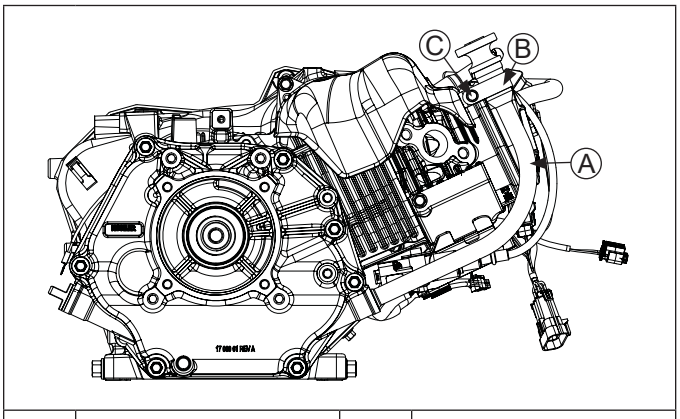


A	Camshaft Gear Timing Mark	**B**	Camshaft Drive Gear on Crankshaft Timing Mark

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

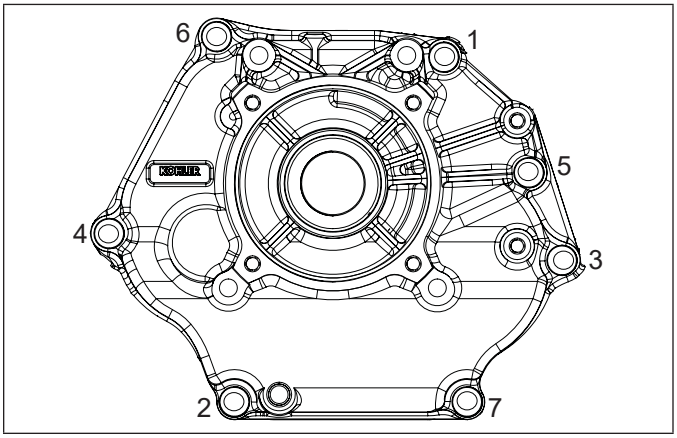


A	Oil Fill Tube	**B**	Oil Fill Tube Bracket
C	Bracket Screw		

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

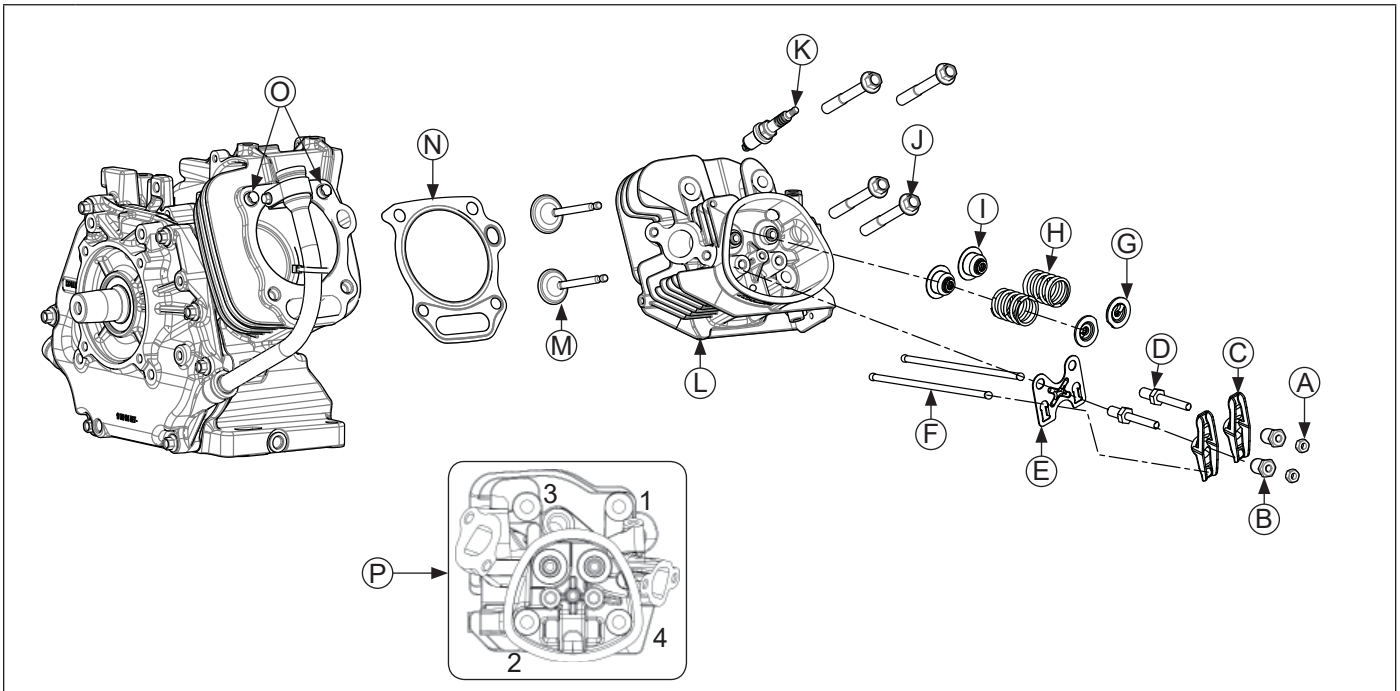
Torque Sequence



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

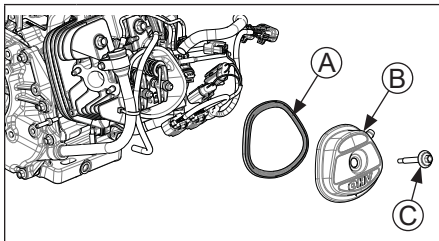
1. Check to make sure there are no nicks or burrs on sealing surfaces of cylinder head or crankcase.
2. Rotate crankshaft to position piston at TDC on compression stroke.
3. Install dowel pins into recesses around upper cylinder head bolt holes.
4. Install a new cylinder head gasket.
5. Apply clean engine 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



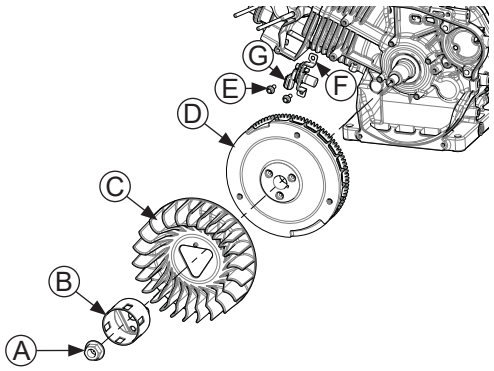
A	Valve Cover Gasket	**B**	Valve Cover
C	Valve Cover Seal Screw Assembly		

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.).

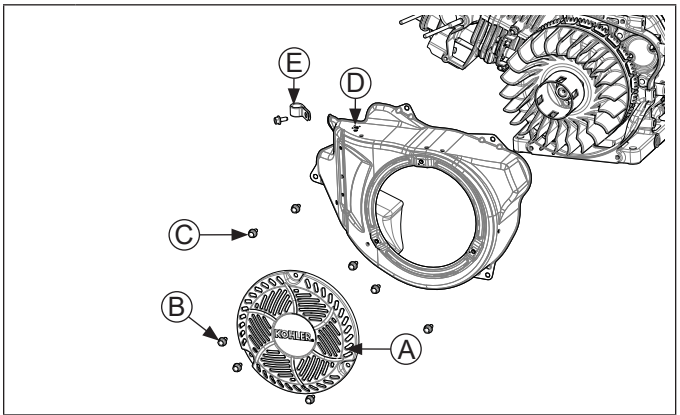
Install Crankshaft Position Sensor

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.).

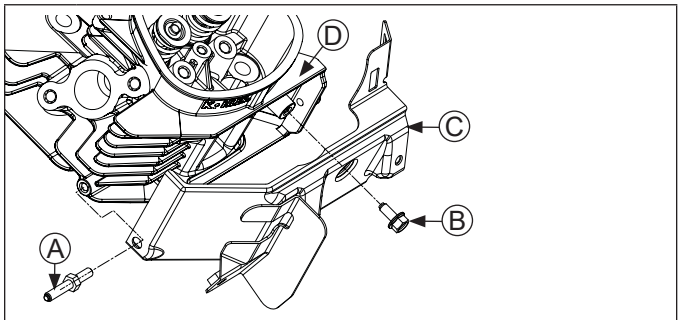
Install Blower Housing Screen

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.

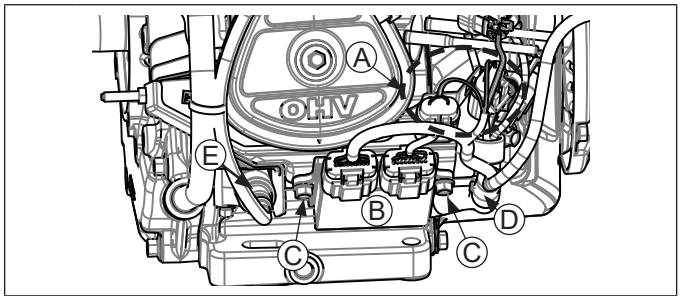
Install Cylinder Shield



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



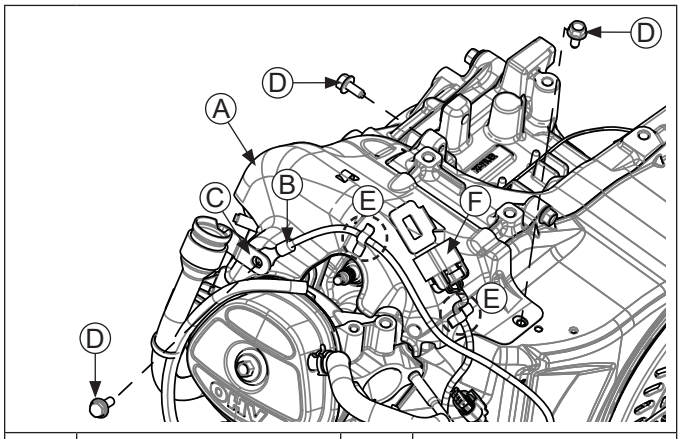
A	Fuses/Fuse Holders	**B**	ECU
C	Screw	**D**	Cable Clip
E	Ignition Coil		

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.

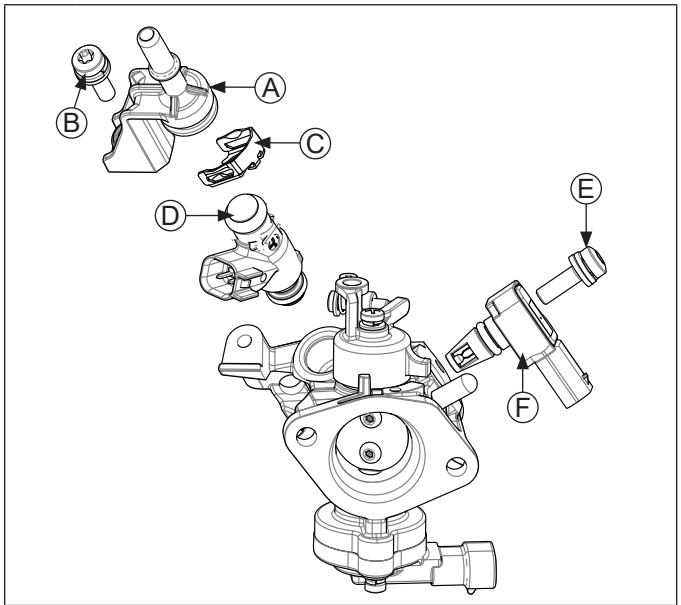
Install Upper Heat Shield and Engine Temperature Sensor



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.

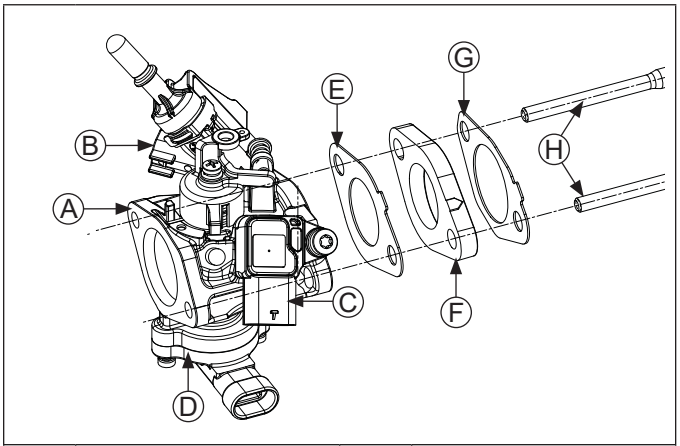
Install Fuel Injector

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

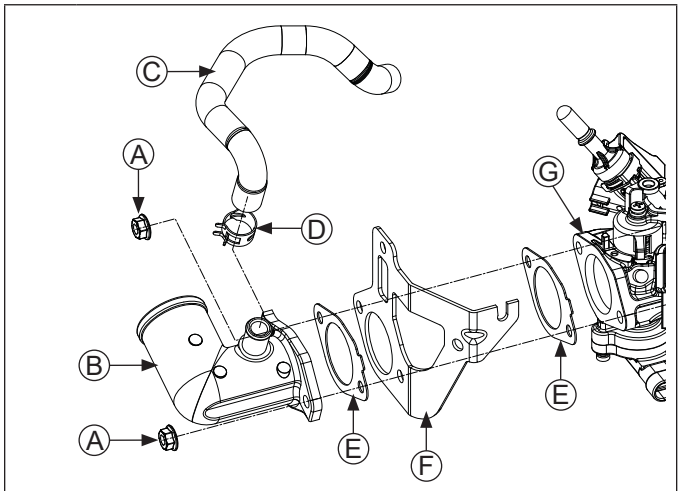
NOTE: Ensure all parts are clean, undamaged, and free of debris and make sure electrical connector has seal in place.

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		

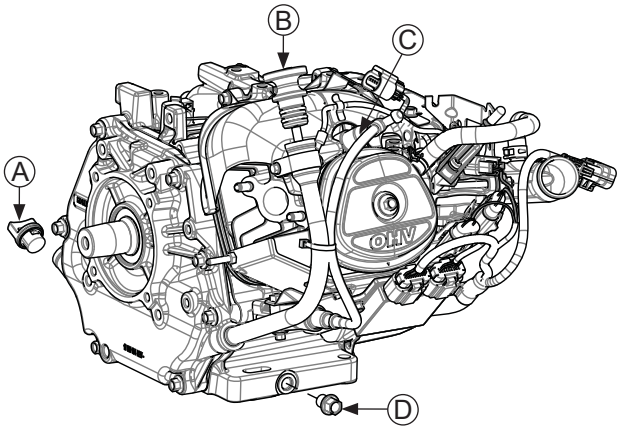
1. Install a new throttle body gasket onto mounting studs followed by air inlet elbow.
2. Install governor bracket onto mounting studs followed by a new throttle body gasket.

   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

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

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.

ACCESSORIES

For certain powered accessories, use the 9-pin connector located behind the instrument panel.

LOW OIL WARNING LIGHT

NOTE: *When the key switch is placed in the ON position, the Low Oil Warning Light will illuminate for approximately 3 seconds as a bulb check function.*

If the Low Oil Warning Light comes ON due to low oil level, and oil is added to correct the issue, the Low Oil Warning Light will still remain ON. Cycle the key switch OFF and ON to reset the Low Oil Warning Light.

The gasoline vehicle is equipped with a low oil warning light (4), located at the top of the instrument panel. If the warning light comes on, oil should be checked and added to the engine as necessary before continuing to use the vehicle. **See following CAUTION.** The vehicle should never be driven when the low oil warning light remains on. If the warning light goes on and off, the vehicle may be driven, but oil should be added at the first opportunity. The light will flash repeatedly to indicate a possible problem with the electronic fuel injection (EFI) system. If the oil level is correct and the warning light stays on, have a trained technician check the vehicle.

CAUTION

- **Failure to add oil immediately when the low oil warning light stays on may result in permanent engine damage.**

GROUND LOCATIONS

Electrical grounds are located at the following areas:

- **At the Battery:** The starter/generator, voltage regulator, ECU, throttle position sensor and fuel pump module all connect to the main wire harness and goes to the B– battery terminal.
- **Between Engine and Battery:** The engine and chassis each have a separate lead that connects to the main wire harness and goes to the B– battery terminal.

- **Top of Fuel Tank:** The fuel tank has a lead that connects to the main wire harness and goes to the B– battery terminal.

FEATURES OF THE ELECTRONIC FUEL INJECTION (EFI) SYSTEM

- Open-loop system (i.e. oxygen sensor not used)
- Controls fuel pump, fuel injector, oil lamp
- Inputs: Manifold Absolute Pressure (MAP), engine block temperature, ignition timing
- Blink fault codes through the Low Oil Warning Lamp
- Separate EFI wire harness
- The ECU and throttle body/fuel injector assembly are matched pairs

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.

ECU ERROR CODES (DISPLAYED BY THE LOW OIL WARNING LIGHT)

Failure Mode Table – When Ignition Is Initially Switched ON

DISPLAY MODE	CONDITION	LAMP CONTROL
Blink Code	No Failure	Step 1: Lamp ON Two Seconds
		Step 2: Lamp OFF Four Seconds
		Step 3: Lamp OFF
	Detect Failure	Step 1: Lamp ON Two Seconds
		Step 2: Lamp OFF Four Seconds
		Step 3: Display Blink Code

Failure Mode Table – After Ignition Has Been In ON Position (i.e. During Use of Vehicle)

DISPLAY MODE	CONDITION	LAMP CONTROL
Blink Code	No Failure	Step 1: Lamp OFF
	Detect Failure	Step 1: Lamp OFF Four Seconds
		Step 2: Display Blink Code

Error Codes – ECU

BLINK CODE	CODE DESCRIPTION	CORRECTIVE ACTION
21	Low Battery Voltage	Check battery voltage. Charge/replace battery as necessary.
22	MAP Sensor: Open or Shorted Connection	Check connector at ECU & Throttle module. If connection is made and no corrosion is present, replace ECU and Throttle Module.
23	Temperature Sensor: Open or Shorted Connection	Check connector at ECU & Throttle module. If connection is made and no corrosion is present, replace ECU and Throttle Module.
31	Fuel Pump: Open Connection	Check fuel pump and fuel system. Check electrical connections at ECU, Throttle module and fuel pump.
41	Fuel Injector: Open Connection	Check connector at ECU & Throttle module. If connection is made and no corrosion is present, replace ECU and Throttle Module.
51	Ignition Pulse: Open Connection	Check spark plug, coil, ECU. Replace failed components.

NOTE: *If codes 22, 23, and 41 blink in-sequence, the gray plug is disconnected from the ECU.*

If no codes blink, the black plug is disconnected from the ECU.

GASOLINE POWERTRAIN

TROUBLESHOOTING GUIDE		
SYMPTOM	**POSSIBLE CAUSES**	**CORRECTIVE ACTION**
Engine does not start easily.	Spark plug is partially fouled or in poor condition	Clean or replace
	Spark plug is damaged or loose	Replace or tighten
	Incorrect spark plug gap	Adjust gap
	Spark plug wire is damaged or loose	Replace or reconnect
	Loose or bad wire connection at ignition coil, EFI sensors, or ECU	Test Procedures 13 – *Ignition Spark* or 15 – *Ignition Coil* or 4 – *EFI System (ECU and Sensors)*
	Intermittent ignition coil failure	Test Procedures 13 – *Ignition Spark* and 15 – *Ignition Coil*
	Low fuel level in fuel tank	Refill
	Fuel line pinched or clogged	Clean or replace
	Poor fuel quality or contaminated fuel	Replace
	Fuel pump malfunction; fuel pressure to throttle body too low	Section 29 — Kohler ECH440 - Fuel System
	Water or dirt in the fuel system and/or throttle body/fuel injector; dirty or clogged fuel filter	Section 29 — Kohler ECH440 - Fuel System
	Throttle body dirty or improperly adjusted	Clean or adjust. Section 29 — Kohler ECH440 - Fuel System
	Low cylinder compression	Section 35 — Subaru EX-40 - Engine
	Cylinder head bolts not tighten properly	Check and retighten. Section 35 — Subaru EX-40 - Engine
	Intake or exhaust valve not sealing	Repair. Section 35 — Subaru EX-40 - Engine
	Incorrect valve clearance	Adjust. Section 35 — Subaru EX-40 - Engine
	Vacuum leak	Retighten hardware or replace gasket(s)
	Starter/generator belt is slipping	
Engine starts but does not run smoothly.	Spark plug is fouled or in poor condition	Section 35 — Subaru EX-40 - Engine
	Spark plug wire is damaged or loose	Section 35 — Subaru EX-40 - Engine
	Intermittent ignition coil failure	Test Procedures 13 – *Ignition Spark* and 15 – *Ignition Coil*
	Water or dirt in the fuel system and/or throttle body/fuel injector; dirty or clogged fuel filter	Section 29 — Kohler ECH440 - Fuel System
	Fuel pump malfunction; fuel pressure to throttle body too low	Section 29 — Kohler ECH440 - Fuel System

TABLE CONTINUED ON NEXT PAGE

TROUBLESHOOTING GUIDE		
SYMPTOM	**POSSIBLE CAUSES**	**CORRECTIVE ACTION**
Engine turns but fails to start.	Fuel tank is empty	Section 29 — Kohler ECH440 - Fuel System
	Fuel line or filter clogged	Section 29 — Kohler ECH440 - Fuel System
	Fouled spark plug	Section 35 — Subaru EX-40 - Engine
	Spark plug wire damaged or loose	Section 35 — Subaru EX-40 - Engine
	Loose or bad wire connection at ignition coil, EFI sensors, or ECU	Test Procedures 13 – *Ignition Spark* or 15 – *Ignition Coil* or 4 – *EFI System (ECU and Sensors)*
	Ignition coil failed	Test Procedures 13 – *Ignition Spark* and 15 – *Ignition Coil*
	Kill circuit grounded	Test Procedures and 5 – *Key Switch (Engine Kill Circuit)*
	Fuel pump malfunction or failure	Section 29 — Kohler ECH440 - Fuel System
Engine overheats.	Fan screen is partially blocked or plugged	Section 35 — Subaru EX-40 - Engine
	Governor is improperly adjusted	Section 29 — Kohler ECH440 - Fuel System
	Excessive back pressure in exhaust	Check and clean or replace
	Fuel/air mixture is too lean; check EFI	Section 29 — Kohler ECH440 - Fuel System
	Overloading	Reduce to rated load
	Poor quality engine oil	Replace
Engine pre-ignites.	Excessive carbon deposits on piston head or in combustion camber	Section 35 — Subaru EX-40 - Engine
	Spark plug heat range is incorrect	Section 35 — Subaru EX-40 - Engine
	Unsuitable or contaminated fuel	Section 29 — Kohler ECH440 - Fuel System
Loss of engine power.	Exhaust valve is restricted with carbon deposit	Section 35 — Subaru EX-40 - Engine
	Muffler or exhaust pipe restricted with carbon or other substance	Section 30 — Kohler ECH440 - Exhaust System
	Ignition coil failed	Test Procedures 13 – *Ignition Spark* and 15 – *Ignition Coil*
	Air filter is dirty or clogged	Section 29 — Kohler ECH440 - Fuel System
	Governor is improperly adjusted	Section 29 — Kohler ECH440 - Fuel System
	Throttle linkage out of adjustment	Section 29 — Kohler ECH440 - Fuel System
	Low cylinder compression	Section 35 — Subaru EX-40 - Engine
	Spark plug failed	Section 35 — Subaru EX-40 - Engine
	Restricted fuel flow	Section 29 — Kohler ECH440 - Fuel System
	Torque converter is not backshifting properly	Section 38 — Subaru EX-40 - Clutches

TABLE CONTINUED ON NEXT PAGE

TROUBLESHOOTING GUIDE		
SYMPTOM	**POSSIBLE CAUSES**	**CORRECTIVE ACTION**
Spark plug fouls repeatedly.	Incorrect plug	Section 35 — Subaru EX-40 - Engine
	Spark plug wire is damaged	Section 35 — Subaru EX-40 - Engine
	Unsuitable fuel, or incorrect (rich) fuel mixture	Section 29 — Kohler ECH440 - Fuel System
	Ignition coil failed	Test Procedures 13 – *Ignition Spark* and 15 – *Ignition Coil*
	Dirt entering combustion camber	Check intake system for leaks. Section 29 — Kohler ECH440 - Fuel System
	Rings are heavily worn, low cylinder pressure	Section 35 — Subaru EX-40 - Engine
Starter fails to operate.	Neutral lockout switch is in the MAINTENANCE position	Place switch in the OPERATE position.
	Fuse is blown	Test Procedure 2 – *Fuse Inspection*
	Battery is dead	Test Procedure 1 – *Battery*
	Starter control circuit is not operating	Test Procedure 4 – *Key Switch (Start Circuit)*
	Starter/generator failed	Test Procedure 11 – *Starter/Generator (Starter Function)*
	Starter solenoid failed	Test Procedure 7 – *Solenoid*
	Accelerator pedal limit switch failed	Test Procedure 6 – *Throttle Position Sensor (TPS)*
	Key switch failed	Test Procedure 4 – *Key Switch (Start Circuit)*
	Neutral lockout limit switch failed	Test Procedure 9 – *Transaxle Limit Switch*
	Loose or broken wire in starter/generator circuit	Section 27 — Kohler ECH440 - Electrical Components Starter/Generator on page 27-4
	Cylinder and/or crankcase flooded with fuel	Section 29 — Kohler ECH440 - Fuel System
Starter/generator does not charge battery.	Loose or broken wire in the starter/ generator circuit	Test Procedure 10 – *Starter/Generator (Generator Function)*
	Generator field coil is shorted	Test Procedure 10 – *Starter/Generator (Generator Function)*
	Brushes are worn or commutator is dirty	Section 27 — Kohler ECH440 - Electrical Components Starter/Generator on page 27-4
	Starter/generator belt is loose or slipping	Section 27 — Kohler ECH440 - Electrical Components
	Voltage regulator failed	Test Procedure 12 – *Voltage Regulator*
	Battery failed	Test Procedure 1 – *Battery*

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	Section 25 — Gasoline Vehicle - Transaxle
	Insufficient (low) level of lubricant or wrong type of lubricant in transmission	Section 25 — Gasoline Vehicle - Transaxle
	Internal gears are damaged or worn	Section 25 — Gasoline Vehicle - Transaxle
	Dog clutch jammed or broken	Section 25 — Gasoline Vehicle - Transaxle
Excessive vehicle vibration.	Engine mounting nuts or bolts are loose	Section 35 — Subaru EX-40 - Engine
	Snubber on frame is worn or damaged	Section 35 — Subaru EX-40 - Engine
	Loose muffler mounting hardware	Section 30 — Kohler ECH440 - Exhaust System
	Damaged drive belt or starter belt	Section 38 — Subaru EX-40 - Clutches
	Damaged drive clutch	Section 38 — Subaru EX-40 - Clutches
	Damaged starter/generator pulley	Section 27 — Kohler ECH440 - Electrical Components Starter/Generator on page 27-4
	RPM setting is incorrect	Section 29 — Kohler ECH440 - Fuel System Engine RPM Adjustment on page 29-9
Clutches do not shift smoothly.	Drive belt is worn, cracked, glazed, or frayed	Section 38 — Subaru EX-40 - Clutches
	Drive clutch malfunction	Section 38 — Subaru EX-40 - Clutches
	Governor is sticking	Section 25 — Gasoline Vehicle - Transaxle
Engine won't stop running.	Kill circuit wire is disconnected from the ignition coil	Test Procedure
	Accelerator pedal linkage out of adjustment causing engine kill limit switch not to activate	Section 29 — Kohler ECH440 - Fuel System
	Fuel mixture is too lean; check EFI	Section 29 — Kohler ECH440 - Fuel System
	Throttle stop screw out of adjustment at governor arm	Section 29 — Kohler ECH440 - Fuel System

FUSE LOCATIONS

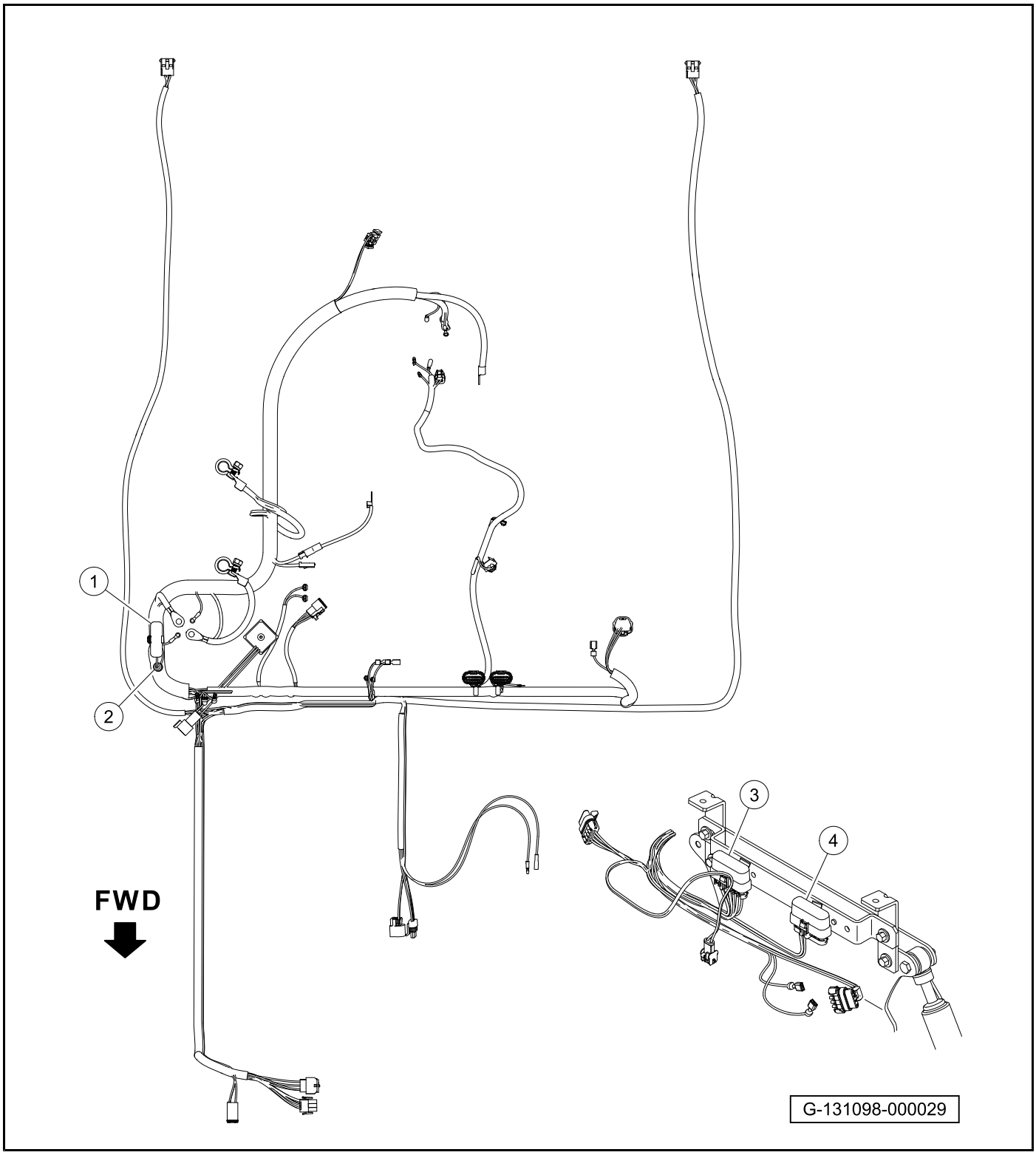


Figure 33-1 Fuse Locations

See Fuse and Relay Locations on page 26-5.

CALLOUT NUMBER	DESCRIPTION
1	Fuse Holder • 10A Fuse • 5A Fuse • 20A Fuse
2	2A Fuse
3	Fuse Holder • 7.5A Fuse - Stereo, Visage • 4A Fuse - Accent/Logo and Brake Lights • 3A Fuse - Headlights, Taillights
4	Fuse Holder • 10A Fuse - Horn, Turn Signal

SONIC WELD AND DIODE LOCATIONS

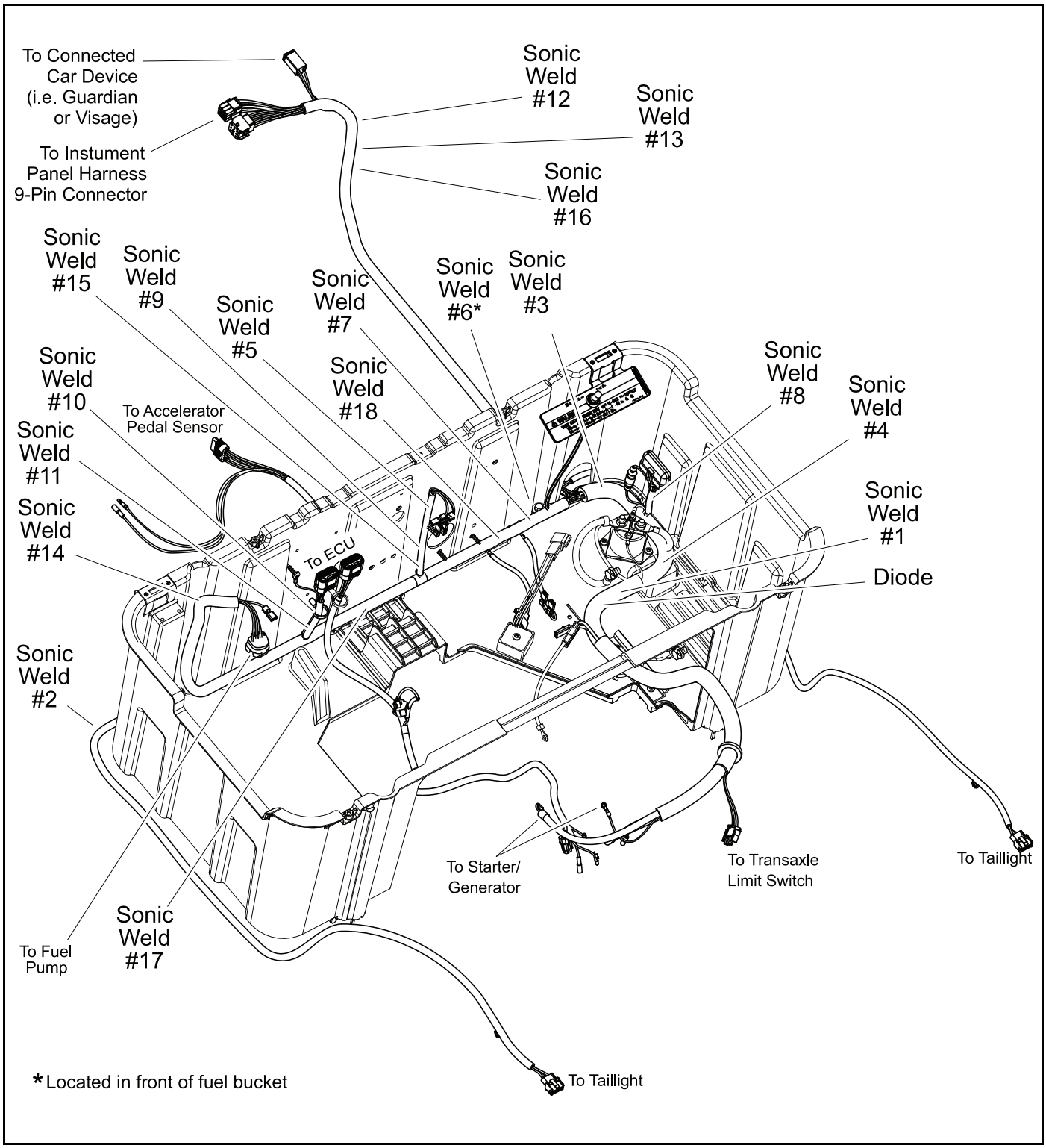


Figure 33-2 Sonic Weld and Diode Locations (Approximate) – EFI

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 on page 26-7.**

For a complete wiring diagram, .

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 **Test Procedure 1 – Battery on page 26-9**.
- The MAINTENANCE/OPERATE switch, in the MAINTENANCE position, grounds and kills the ignition if the FNR shifter is placed in FORWARD or REVERSE.
- 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.

Index of Test Procedures

1 – Battery

2 – Fuses
3 – Ground Cables
4 – EFI System (ECU and Sensors)
5 – Key Switch (Start Circuit)
6 – Key Switch (Engine Kill Circuit)
7 – Throttle Position Sensor (TPS)
8 – Solenoid
9 – Maintenance/Operate Switch – Vehicles
10 – Neutral Lockout Limit Switch – Vehicles Only
11 – Starter/Generator (Generator Function)
12 – Starter/Generator (Starter Function)
13 – Voltage Regulator
14 – Ignition Spark
15 – Ignition Coil
16 – Reverse Buzzer and Reverse Buzzer Limit Switch
17 – Low Oil Warning Light (LED)
18 – Oil Level Sensor
19 – Battery Test (Under Load)
20 – Fuel Pump
21 – Fuel Level Sending Unit
22 – Fuel Gauge
23 – Hour Meter
24 – 4-Pin Connector (for Connected Car Device)

TEST PROCEDURE 1 – Battery

See General Warnings on page 1-2.

⚠ 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, including watering information and allowable mineral content, can be found in section* ***Kohler ECH440 - Electrical Components on page 27-1*** *of this manual.* ***See Battery on page 27-1.***

1. Place the Forward/Reverse handle in the NEUTRAL position and the neutral lockout switch in the MAINTENANCE position. Chock the wheels.
2. Check for loose or corroded battery terminal connections. Remove the negative (–) cable first and clean, tighten, and replace connections as necessary.

Voltage Test

1. Take a voltage reading with a multimeter set to 20 VDC by placing the red (+) probe on the positive (+) battery post and the black (–) probe on the negative (–) battery post. If it shows less than 12.4 volts, recharge the battery. If battery voltage is greater than 12.4 volts, the problem is not with the battery. If the battery does not reach 12.4 volts after charging, replace the battery. **See following NOTE.**

NOTE: *Open circuit voltage should be at least 12.4 volts.*

Load Test

1. Connect a 160-ampere load tester to the battery posts.
2. Turn the switch on the load tester to the ON position.
3. Read the battery voltage after the load tester has been turned ON for 15 seconds. Compare the battery's voltage reading with the following table. Make sure you have the correct ambient temperature.

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

4. If the battery is found to be good, or if the electrical problem continues after the battery has been replaced with a good one, test the electrical circuits.

TEST PROCEDURE 2 – Fuses

See General Warnings on page 1-2.

⚠ WARNING

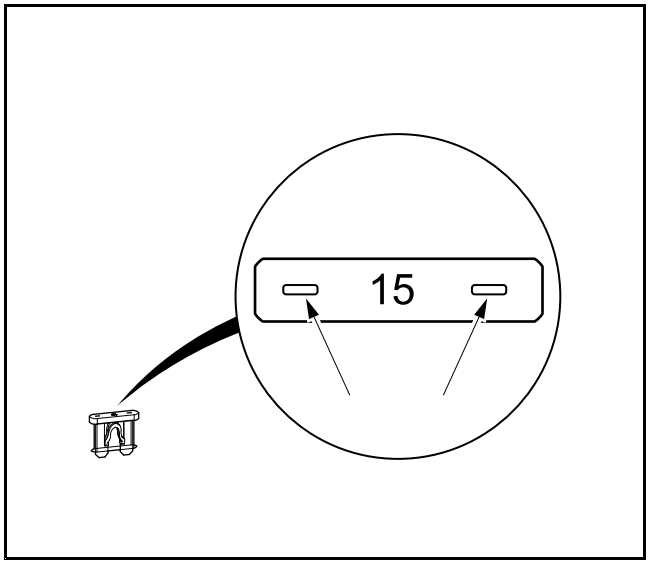
- **Failure to use properly rated fuse can result in a fire hazard.**

NOTE: *This vehicle uses three 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 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.

ATM-style blade fuses are located on the main wire harness in front of the battery.

The ABC-style glass fuse is located on the main wire harness adjacent to the ATM-fuse holder.



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Figure 33-3 Testing ATM-style Blade Fuse

1. If necessary, see Testing Basics on page 26-7.
2. Access the fuse but do not remove it.
3. **20-amp and 10-amp ATM Fuses Only:** With the battery and solenoid connected:

3.1. Probe the two, small metal contacts on the top of the fuse **(Figure 33-3, Page 33-16)**.

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:
- Check condition and connection of large red wires at solenoid.
- Check sonic weld_8 in main wire harness.

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 33-3, Page 33-16)**.

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:
- Check the 10-amp fuse.
- Check the key switch.
- Check sonic weld_3 in main wire harness.

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:
- Check the 10-amp fuse.
- Check the key switch.
- Check sonic weld_3 in main wire harness.

TEST PROCEDURE 3 – Ground Cables

See General Warnings on page 1-2.

NOTE: *This is a continuity test for the main ground wire(s) of the vehicle. An additional ground wire is located on top of the fuel tank.*

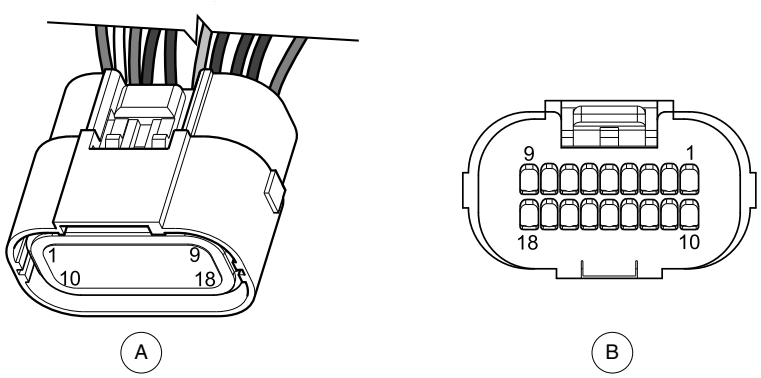
1. If necessary, see Testing Basics on page 26-7.
2. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Check the following wires and cables for clean, tight connections and continuity:
   - Check the starter/generator ground cable (black wire) from A1 terminal to chassis or engine.
   - Check the engine ground cable from engine block to negative (-) main harness lead disconnected from battery.
   - Check the chassis ground cable from frame rail to negative (-) main harness lead disconnected from battery.
   - Disconnect voltage regulator from main harness. Check from black wire in 3-pin connector to negative (-) main harness lead disconnected from battery. This will test sonic weld _18 and sonic weld _1 in the main wire harness.
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.

TEST PROCEDURE 4 – EFI System (ECU and Sensors)

See General Warnings on page 1-2.

⚠ WARNING

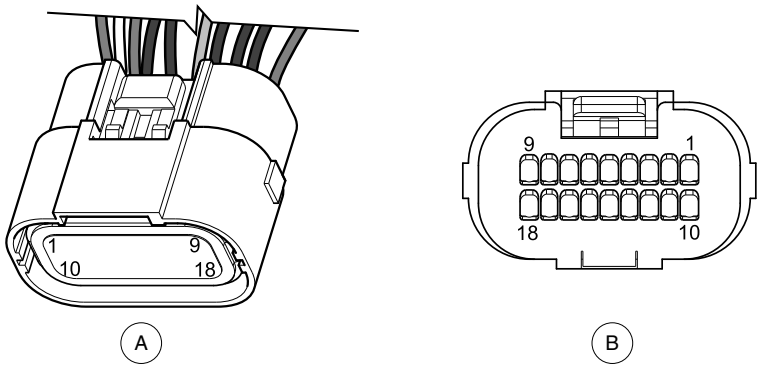
- **This procedure involves testing voltage, resistance and continuity. If necessary, see Testing Basics on page 26-7.**



18-PIN CONNECTOR (GRAY AND BLACK): A. ECU SIDE OF CONNECTOR B. WIRE ENTRY SIDE OF CONNECTOR

PIN I.D.	CONNECTOR COLOR	FUNCTION	TEST TYPE & PROBE BETWEEN LOCATIONS	TEST RESULT	CONDITION
1	Gray	Fuel Injector Control	**Resistance:** ECU Gray Pin 1 (Black/White) and ECU Gray Pin 10 (Red/White)	Approx. 12 ohms	Key OFF or ON
6	Gray	Engine Temperature Sensor Input	**Resistance:** ECU Gray Pin 6 (Orange/Blue) and ECU Gray Pin 15 (Black/Blue)	Approx. 11.5 kOhms @ 70 °F (21 °C) Resistance decreases as temperature rises.	Key OFF
9	Gray	Ignition Coil Input	**Resistance:** ECU Gray Pin 9 (White) and Ground	Approx. 10.1 kOhms	Key OFF
10	Gray	Fuel Injector Positive (+) Voltage from ECU	**Voltage:** ECU Gray Pin 10 (Red/White) and Ground	Battery Voltage	Plug connected to ECU and Key ON
13	Gray	MAP Sensor Input	**Voltage:** ECU Gray Pin 13 (Green/Yellow) and Ground	Approx. 3.9 volts @ sea level & engine OFF / 3.0 volts engine running. Voltage decreases as pressure decreases.	Key ON and engine running
15	Gray	Engine Temperature Sensor Ground	**Continuity:** ECU Gray Pin 15 (Black/Blue) and Ground	Meter should beep	Key OFF
16	Gray	MAP Sensor Reference Voltage (+5)	**Voltage:** ECU Gray Pin 16 (Red/Yellow) and ECU Gray Pin 17 (Black/Yellow)	Approx. 5 volts	Key ON
17	Gray	MAP Sensor Ground	**Continuity:** ECU Gray Pin 17 (Black/Yellow) and Ground	Meter should beep	Key OFF
			Voltage: ECU Gray Pin 17 (Black/Yellow) and Battery (+) Terminal	–Battery Voltage	Key OFF
1	Black	Fuel Pump Input	**Voltage:** ECU Black Pin 1 (Black/White) and ECU Black Pin 10 (Black)	Battery Voltage (after pump stops running)	Key ON

TABLE CONTINUED ON NEXT PAGE



18-PIN CONNECTOR (GRAY AND BLACK): A. ECU SIDE OF CONNECTOR B. WIRE ENTRY SIDE OF CONNECTOR

PIN I.D.	CONNECTOR COLOR	FUNCTION	TEST TYPE & PROBE BETWEEN LOCATIONS	TEST RESULT	CONDITION
3	Black	Ignition OFF Input	**Continuity:** ECU Black Pin 3 (White/Black) and Ground	Meter should beep	Key OFF
				Meter should NOT beep	Key ON
7	Black	Low Oil Sensor Input	**Resistance:** ECU Black Pin 7 (Yellow) and Ground	Approx. 2.3 kOhms	Key OFF
8	Black	Connected Car Link	**Voltage:** ECU Black Pin 8 (Blue) and Ground	11.8 volts	Key ON
9	Black	B+ Input	**Voltage:** ECU Black Pin 9 (Red) and ECU Black Pin 10 (Black)	Battery Voltage	Key ON
10	Black	Ground for ECU Power	**Continuity:** ECU Black Pin 10 (Black) and Ground	Meter should beep	Key OFF
			Voltage: ECU Black Pin 10 (Black) and Battery (+) Terminal	–Battery Voltage	Key OFF
11	Black	Diagnosis (low oil) Lamp Control	**Voltage:** ECU Black Pin 11 (Yellow) and Ground	Less than 1 Volt initially. 7 to 8 volts after lamp is OFF.	Key ON
12	Black	Foot Input	**Continuity:** ECU Black Pin 12 (White/Black) and Black Pin 18 (Black)		Key OFF with:
				Meter should beep	Accel. Pedal UP
				Infinity	Accel. Pedal DOWN
18	Black	Ground for ECU Housing	**Continuity:** ECU Black Pin 18 (Black) and Ground	Meter should beep	Key OFF
			Voltage: ECU Black Pin 18 (Black) and Battery (+) Terminal	–Battery Voltage	Key OFF

TEST PROCEDURE 5 – Key Switch (Start Circuit)

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

The key switch provides power and KEY INPUT to the ECU.

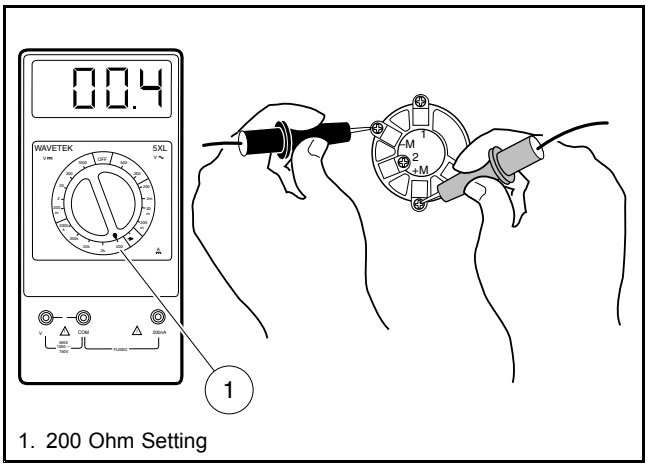
1. If necessary, see Testing Basics on page 26-7.
2. Remove instrument panel to access the back of the key switch but do not disconnect wires. **See Instrument Panel Removal, Section 4, Page 4-17.**
3. With the key switch in the OFF position:
   – The red wire should show battery voltage coming to the switch.
   – The blue 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 blue wire should show battery voltage passing through the key switch to a sonic weld in the instrument panel harness, the 9-pin connector, sonic weld_3, the 5-amp fuse, the solenoid, and the 4-pin connected car plug. If it does not show battery voltage, the switch has failed OPEN and must be replaced.

TEST PROCEDURE 6 – Key Switch (Engine Kill Circuit)

See General Warnings on page 1-2.

NOTE: *This is a continuity test.*

1. If necessary, see Testing Basics on page 26-7.
2. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Remove the instrument panel. **See Instrument Panel Removal, Section 4, Page 4-17.**
4. Disconnect wires from the (+M) and (–M) terminals of the key switch **(Figure 26-3, Page 26-12)**.
5. Place the red (+) probe on the (+M) terminal and the black (–) probe on the (–M) terminal. With the key switch OFF, the reading should be continuity. With the key switch ON, the reading should be no continuity. If either reading is incorrect, replace the key switch.
6. Connect wires to the key switch. Make sure wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
7. Install dash panel in reverse order of removal.



1. 200 Ohm Setting

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Figure 33-4 Key Switch Test – Engine Kill Circuit

TEST PROCEDURE 7 – Throttle Position Sensor (TPS)

The throttle position sensor performs the function of two limit switches: the accelerator pedal limit switch and the kill limit switch. This sensor is sealed and is not to be repaired or replaced. If sensor is determined to need replacing through test procedures found in this manual, the accelerator pedal assembly must be replaced. **See Accelerator Pedal on page 5-10.** The sensor is joined to the main wire harness through a six-pin connector. Tests for the sensor are found in the following two procedures.

Accelerator Pedal Limit Switch Function

See General Warnings on page 1-2.

The green and orange wires connect to the accelerator pedal limit switch function of the throttle position sensor. This is the normally open (NO) portion of the circuit used to energize the starter solenoid.

NOTE: *Keep the battery connected while performing this test procedure.*

1. Place the neutral lockout switch in the MAINTENANCE position, put the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect the spark plug wire from the spark plug.
3. Disconnect gray 18-pin connector from ECU.
4. With battery connected and using a multimeter set to the diode test function (ç), attach the red (+) lead to the orange wire at the starter solenoid and the black (-) lead to the green wire at the limit switch located on the Forward/Reverse shifter assembly. **See following NOTE.**

NOTE: *It may be necessary to partially pull the green wire from the switch terminal to attach the black lead.*

5. Turn the key switch to the ON position. With accelerator pedal at rest in the fully raised position, the meter should indicate an over limit (no continuity) condition.
6. Press the accelerator to engage the starter and engine. With accelerator pedal pressed, the meter should indicate approximately 1.0 volt. If either reading is incorrect, replace the accelerator pedal assembly. **See Accelerator Pedal on page 5-10.**

Kill Limit Switch Function

See General Warnings on page 1-2.

The black and white/black wires connect to the kill limit switch function of the throttle position sensor. This is the normally closed (NC) portion of the circuit used to ground the ignition and shut the engine off when the pedal is released.

NOTE: *Keep the battery connected while performing this test procedure.*

1. Place the neutral lockout switch in the MAINTENANCE position, put the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect gray 18-pin connector from ECU.
3. Disconnect the spark plug wire from the spark plug.
4. With battery connected and using a multimeter set to the diode test function (ç), attach the red (+) lead to the negative (–) battery terminal and the black (-) lead to the white/black wire at the limit switch located on the Forward/Reverse shifter assembly. **See following NOTE.**

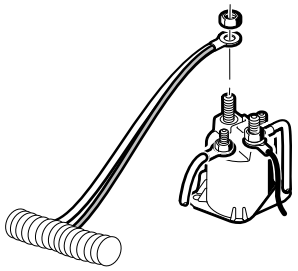
NOTE: *It may be necessary to partially pull the white/black wire from the switch terminal to attach the black lead.*

5. Turn the key switch to the ON position. With accelerator pedal at rest in the fully raised position, the meter should indicate approximately 1.0 volt.
6. Press the accelerator to engage the starter and engine. With accelerator pedal pressed, the meter should indicate an over limit (no continuity) condition. If either reading is incorrect, replace the accelerator pedal assembly. **See Accelerator Pedal on page 5-10.**

TEST PROCEDURE 8 – Solenoid

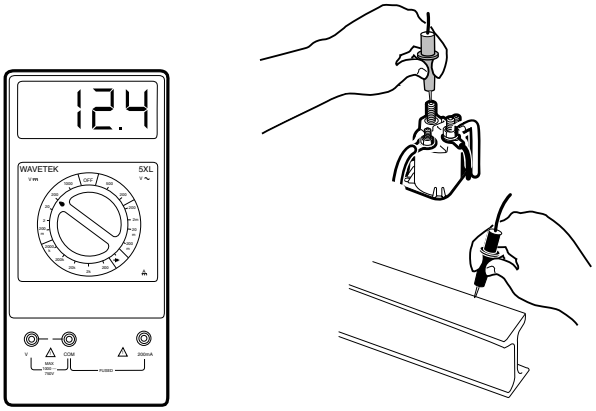
See General Warnings on page 1-2.

NOTE: *This is a resistance and voltage test.*



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Figure 33-5 Solenoid Wire Removal



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Figure 33-6 Solenoid Ground Test

1. If necessary, **See Testing Basics on page 26-7.**.
2. Ensure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
3. **Coil Side:** Check resistance across the small posts of the solenoid. The reading should be 14 to 16 ohms. If the reading is not within limits, replace the solenoid.
4. **Contact Side:** Remove the heavy-gauge white wire and 16-gauge red wire from the large post of the solenoid **(Figure 26-4, Page 26-14)**. Do not allow the wires to touch the frame or other components of the vehicle. Cover the other large post.

4.1. Place Forward/Reverse handle in the NEUTRAL position, neutral lockout switch in the MAINTENANCE position, and key switch in the ON position.

4.2. Check voltage between the empty large post and ground **(Figure 26-5, Page 26-14)**.
- **With accelerator pedal in the UP position:** The meter should read no voltage.
- **With accelerator pedal pressed:** The solenoid should click and the meter should read battery voltage.

4.3. If the readings are incorrect, replace solenoid. **See Solenoid Removal, Section 27, Page 27-19.**

TEST PROCEDURE 9 – Maintenance/Operate Switch – Vehicles

See General Warnings on page 1-2.

NOTE: *This is a continuity test.*

The Maintenance/Operate Switch is also known as the Neutral Lockout Switch.

1. If necessary, **See Testing Basics on page 26-7.**.
2. Remove wires from switch **(Figure 26-6, Page 26-15)**.
3. With switch in position 1 (MAINTENANCE):

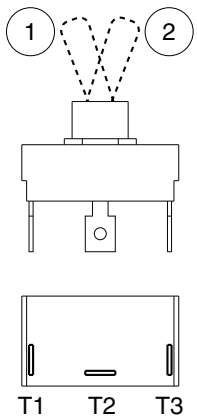
3.1. Check for no continuity between terminals T1 and T2.

3.2. Check for continuity between terminals T2 and T3.

4. With switch in position 2 (OPERATE):

4.1. Check for no continuity between terminals T2 and T3.

4.2. Check for continuity between terminals T1 and T2.



Toggle Position Operates:	1. Position 1 (MAINT.) closes T2 to T3
	2. Position 2 (OP.) closes T1 to T2
3. T1 – Black/Light Blue Stripe, T2 – Black, T3 – Black/Yellow Stripe	

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Figure 33-7 Maintenance/Operate Switch Test – for Vehicles

5. If switch:

5.1. does not work as stated in previous steps, replace switch.

5.2. does work as stated and the MAINTENANCE/OPERATE modes still do not work:
- Check the limit switches.
- Check continuity of the wires involved.

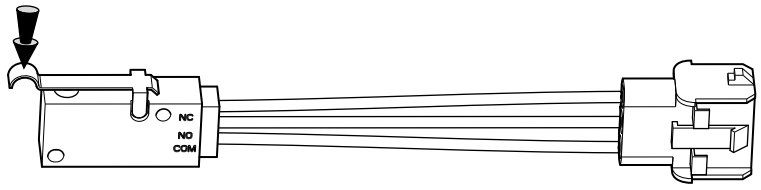
TEST PROCEDURE 10 – Neutral Lockout Limit Switch – Vehicles Only

See General Warnings on page 1-2.

NOTE: *This is a continuity test.*

This switch is located on the transaxle. A black/light blue wire, a red wire, and a blue wire are connected to this limit switch with a 3-pin connector.

1. If necessary, **See Testing Basics on page 26-7.**.
2. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. At transaxle, disconnect neutral lockout limit switch three-wire lead from main wire harness.
4. Check to be sure the cam lobe on the shift lever is pressing the neutral lockout limit switch as the Forward/Reverse shifter is being shifted. The limit switch should make an audible click as it is pressed. If it does not, check for wear on the cam lobe and replace shift lever if necessary.
5. Check the following terminals for no continuity with the lever released and continuity with the lever engaged **(Figure 26-7, Page 26-16)**:



PROBE BETWEEN LOCATIONS	TEST RESULT
Between terminal 1 “COM” (black/light blue wire) and terminal 2 “NO” (red wire)	**With lever released:** No continuity
	With lever pressed: Continuity
Between terminal 1 “COM” (black/light blue wire) and terminal 3 “NC” (blue wire)	**With lever released:** Continuity
	With lever pressed: No continuity

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Figure 33-8 Neutral Lockout Limit Switch Test

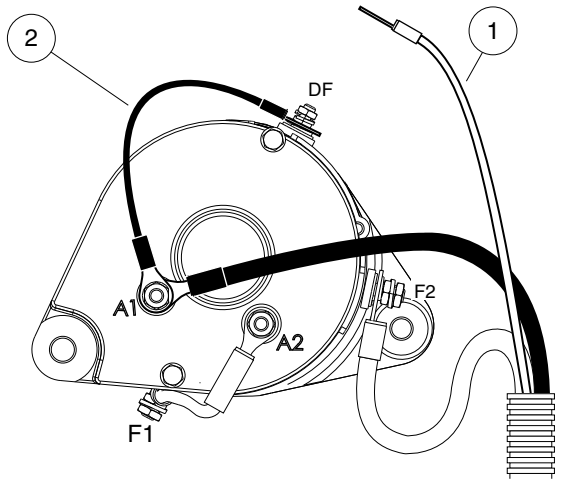
6. If switch does not work as stated in previous step, replace switch. **See Transaxle Limit Switch Removal, Section 27, Page 27-27.**

TEST PROCEDURE 11 – Starter/Generator (Generator Function)

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

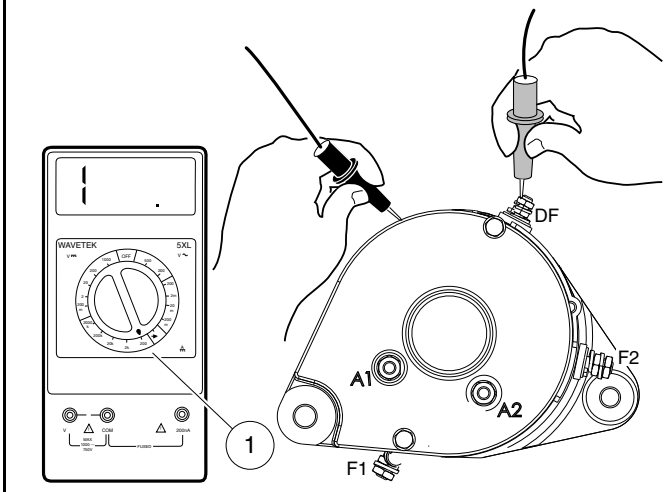
1. If necessary, **See Testing Basics on page 26-7.**.
2. Place the Forward/Reverse handle in the NEUTRAL position and the neutral lockout switch in the MAINTENANCE position. Chock the wheels.
3. Ensure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
4. Disconnect yellow wire from DF terminal on starter/generator. Cover terminal on yellow wire to make sure it will not short to ground. Then, using a jumper wire, ground DF terminal to A1 terminal **(Figure 33-9, Page 33-27)**.
5. Using a multimeter set to 20 volts DC, place the red (+) probe on the positive (+) post of the battery, and place the black (–) probe on the negative (–) post. Start the engine and run it at full governed speed. The reading should show the voltage rising on the meter. If the voltage rises above 15.3 volts DC, test the voltage regulator. **See Voltage Regulator on page 26-20.** If the voltage does not rise, a tear-down inspection of the starter/generator will be necessary. **See Starter/Generator Removal on page 27-4.**
6. Remove jumper wire.
7. Reconnect yellow wire to DF terminal on starter/generator.



1. Yellow Wire 2. Jumper Wire

3029

Figure 33-9 Jumper Wire Ground – DF to A1



1. 200 Ohm Setting

3030

Figure 33-10 Check Starter Terminal Continuity

TEST PROCEDURE 12 – Starter/Generator (Starter Function)

See General Warnings on page 1-2.

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 on page 26-7.**.
2. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Disconnect the wires from all the terminals on the starter/generator. Then place the black (–) probe of a multimeter, set to 200 ohms, on the starter/generator housing (scratch through the finish to ensure a good ground). While holding the black (–) probe against the housing, place the red (+) probe (one at a time) on the A1, A2, F1, F2 and DF terminals respectively **(Figure 26-9, Page 26-19)**. The readings should be no continuity. If the readings are incorrect, the starter/generator will need to be removed from the vehicle and disassembled by a qualified technician. **See Starter/Generator Removal on page 27-4.**
   – An incorrect reading from the A1 or A2 terminal indicates three possible problems: 1) a grounded A1 or A2 terminal, 2) a grounded wire in the brush area, or 3) a grounded armature/commutator.
   – If the F1 or F2 reading is incorrect, it indicates a possible grounded F1 or F2 terminal or a grounded field coil.
   – If the DF reading is incorrect, it indicates a possible grounded DF terminal or a grounded field coil.
4. Using a multimeter set to 200 ohms, place the red (+) probe on the A1 terminal and the black (–) probe on the A2 terminal. The reading should be 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 starter/generator will need to be removed from the vehicle and disassembled by a qualified technician. **See Starter/Generator Removal on page 27-4.**
5. With the wires still disconnected, using a multimeter set on 200 ohms, place 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. If the reading is incorrect, a possible open field coil or bad connections at terminals may be the cause. The starter/generator will need to be removed from the vehicle and disassembled by a qualified technician. **See Starter/Generator Removal on page 27-4.**
6. With the wires still disconnected, using a multimeter set to 200 ohms, place 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. If the reading is incorrect, a possible grounded DF terminal and/or grounded field coil may be the cause. The starter/generator will need to be removed from the vehicle and disassembled by a qualified technician. **See Starter/Generator Removal on page 27-4.**

   Ensure that wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.

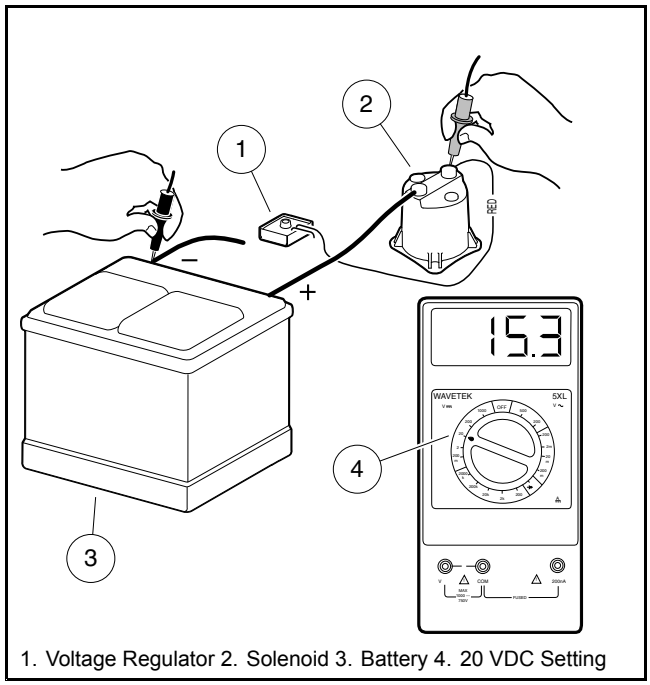
TEST PROCEDURE 13 – Voltage Regulator

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

Keep the battery connected while performing this test procedure.

1. If necessary, **See Testing Basics on page 26-7.**.
2. Place the Forward/Reverse handle in the NEUTRAL position and the neutral lockout switch in the MAINTENANCE position. Chock the wheels.
3. Ensure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
4. Check the engine RPM setting to ensure that it is adjusted correctly. **See Engine RPM Adjustment on page 29-9.**
5. With the battery in good condition and fully charged, run the engine for several minutes to bring the voltage regulator to operating temperature.
6. Turn the key switch to the OFF position, killing the engine. Using a multimeter set to 20 volts DC, place the red (+) probe on the large post of the solenoid with the red wire from the voltage regulator attached. Place the black (–) probe on the negative (–) battery post **(Figure 26-10, Page 26-20)**. Turn the key switch to the ON position. Press the accelerator to start the engine and run it at full governed speed. If the reading is between 14.7 and 15.3 volts, the regulator is good. If the reading is lower than 14.7 volts but rising steadily, check battery condition. If the reading is lower than 14.7 volts and not rising, and the starter/generator is good; or if the reading is over 15.3 volts and continues to rise, replace voltage regulator. **See Voltage Regulator Removal, Section 27, Page 27-21.**



1. Voltage Regulator 2. Solenoid 3. Battery 4. 20 VDC Setting

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Figure 33-11 Voltage Regulator Test

TEST PROCEDURE 14 – Ignition Spark

See General Warnings on page 1-2.

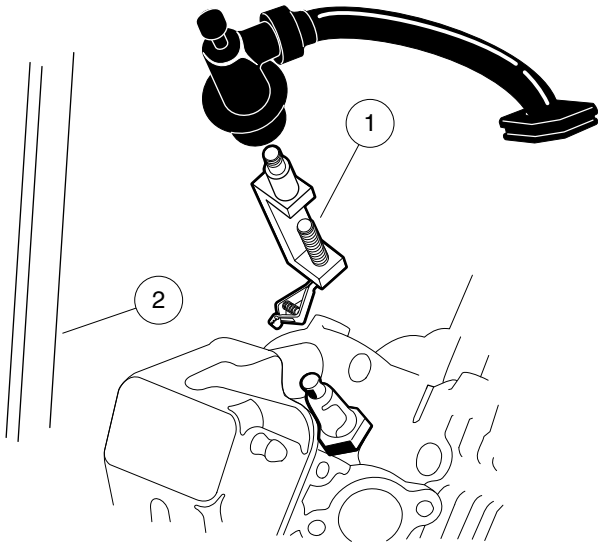
NOTE: *Keep the battery connected while performing this test procedure.*

1. If necessary, **See Testing Basics on page 26-7.**.
2. Place the Forward/Reverse handle in the NEUTRAL position and the neutral lockout switch in the MAINTENANCE position. Chock the wheels.
3. Remove the plug wire from the spark plug. Using an ignition spark gap test tool (Thexton 404® or equivalent), check for correct spark **(Figure 26-11, Page 26-21)**.

3.1. Adjust the tester probes to approximately 18,000 volts (18 kV) setting (SE – *Small Engine Setting* on the Thexton 404 tool). Connect the tester to the spark plug wire, and connect the alligator clip to a solid engine ground.

3.2. Start the engine. There should be a strong blue spark between the probes of the spark gap tester. If there is no spark, or if the spark is a faint yellow or red color, test components of the ignition circuit. **See Ignition Coil on page 33-31.**

4. If the spark gap tester tool indicates a strong blue spark, it is possible the spark plug has failed internally. Check the spark plug gap. The gap should be set at 0.024 to 0.028 in. (0.6 to 0.7 mm). If the gap is correct, replace the spark plug with a new part and test the engine for proper operation.



1. Ignition Gap Test Tool 2. Chassis

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Figure 33-12 Ignition Spark Test

TEST PROCEDURE 15 – Ignition Coil

See General Warnings on page 1-2.

NOTE: *This is a resistance test.*

The following test procedures will properly detect a coil that has failed in most cases; however, in rare cases, some ignition coils can fail to operate at normal (warmer) operating temperatures. If the ignition coil has tested okay in the vehicle and on the bench, but fails to operate reliably, replace the coil with a known good coil and operate the engine for several minutes to ensure that the coil functions at normal operating temperature. If the new coil functions properly, keep the new coil in the circuit.

NOTE: *Resistance value ranges given in these tests reflect a tolerance of ±40%.*

Please note that these values are rough standard and it is impossible to reach an exact conclusion with the resistance reading.

1. If necessary, **See Testing Basics on page 26-7.**.
2. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. At engine, access white wire in ECU wire harness that connects to ignition coil lead at back of engine.
4. Using a multimeter set to 200k ohms, measure resistance between the following locations listed in table below.

IGNITION COIL TERMINALS	TEST RESULT
White Signal Wire to Ground	9 to 11 kOhms
White Signal Wire to Spark Plug Cap	17 to 20 kOhms
Spark Plug Cap to Ground	8 to 13 kOhms

TEST PROCEDURE 16 – Reverse Buzzer and Reverse Buzzer Limit Switch

See General Warnings on page 1-2.

NOTE: Reverse Buzzer: *This is a voltage test.*

Reverse Buzzer Limit Switch: *This is a continuity 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 located on the main wire harness in front of the engine.

The reverse buzzer limit switch is located on the Forward/Reverse shifter. Red/white and orange wires are connected to it.

1. If necessary, **See Testing Basics on page 26-7.**.
2. To test the front reverse buzzer, remove instrument panel. **See Instrument Panel Removal, Section 4, Page 4-17.**
3. Check for proper wiring and tight connections.
4. Check that battery voltage is present in the red/white wire at buzzer.
5. Place the Forward/Reverse handle in the REVERSE position. The buzzer should sound. If not, check limit switch in the next steps.
6. Disconnect black wire from buzzer.
7. With Forward/Reverse handle still in the REVERSE position, there should be continuity between the black wire and ground. With Forward/Reverse handle still in the FORWARD position, there should be no continuity. If either reading is incorrect, replace limit switch. **See Multi-Purpose Buzzer Limit Switch Removal, Section 27, Page 27-24.**
8. If limit switch is operating properly, replace buzzer. **See Multi–Purpose Buzzer Removal, Section 27, Page 27-35.**

TEST PROCEDURE 17 – Low Oil Warning Light (LED)

See General Warnings on page 1-2.

NOTE: *This is a voltage test.*

When the key switch is placed in the ON position, the Low Oil Warning Light will illuminate for approximately 3 seconds as a bulb check function.

1. If low oil warning light does not illuminate for approximately 3 seconds when the key switch is placed in the ON position, proceed with the steps below.
2. If necessary, **See Testing Basics on page 26-7.**.
3. Remove the instrument panel. **See Instrument Panel Removal, Section 4, Page 4-17.**
4. Ensure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary. **See Sonic Weld and Diode Locations on page 33-10.**
5. With key switch in ON position, test for battery voltage at yellow/white wire to low oil warning light. If no voltage, check key switch. **See Key Switch (Start Circuit) on page 26-11.**
6. If battery voltage is present, use a test lead to ground the yellow wire terminal of low oil warning light. Light should illuminate. If not, replace low oil warning light.

TEST PROCEDURE 18 – Oil Level Sensor

See General Warnings on page 1-2.

NOTE: *Keep the battery connected while performing this test procedure.*

This procedure requires the oil to be drained from the engine.

1. If necessary, **See Testing Basics on page 26-7.**.
2. Place the Forward/Reverse handle in the NEUTRAL position, the neutral lockout switch in the MAINTENANCE position, turn the key switch to the OFF position, disconnect the spark plug wire, and chock the wheels.
3. Ensure that the low oil warning light and all connecting wires are functioning correctly. **See Low Oil Warning Light (LED) on page 26-23.**
4. Drain the engine oil into an approved container and properly dispose of used oil.
5. Turn the key switch ON, closing the circuit. The low oil warning light should illuminate. If the low oil warning light does not illuminate, the oil level sensor needs to be replaced. **See Oil Level Sensor Removal on page 35-12.**
6. Fill the engine with new oil before returning the vehicle to service. **See Engine Oil – Gasoline Vehicle on page 35-2.**

TEST PROCEDURE 19 – Battery Test (Under Load)

See General Warnings on page 1-2.

NOTE: *Keep the battery connected while performing this test procedure.*

1. If necessary, **See Testing Basics on page 26-7.**.
2. Place the Forward/Reverse handle in the NEUTRAL position and the neutral lockout switch in the MAINTENANCE position. Chock the wheels.
3. Set a multimeter to 20 volts DC and place the red (+) probe on the F2 (white wire) terminal on the starter/generator. Place the black (–) probe on the negative (–) battery post.
4. Turn the key switch to the ON position, leave the Forward/Reverse shifter in the NEUTRAL position and press the accelerator pedal (with the accelerator pedal pressed, the battery is under load).

4.1. If the voltage reading is over 9.6 volts, with an electrolyte temperature of 70 °F (21 °C), check the starter/generator. **See following NOTE.**

NOTE: *The voltage reading listed is for electrolyte at 70 °F (21 °C). At lower electrolyte temperatures the voltage reading will be lower.*

5. If the reading is below 9.6 volts, with an electrolyte temperature of 70 °F (21 °C), check the battery. **See Battery on page 26-9.**

5.1. If the reading is zero, there may be no continuity across the large posts of the solenoid. **See Solenoid on page 26-14.**

6. If all of the test results are good and the voltage reading is zero, there may be a broken or damaged heavy-gauge white wire from the solenoid to the starter/generator. **See Starter/Generator (Starter Function) on page 26-18.**

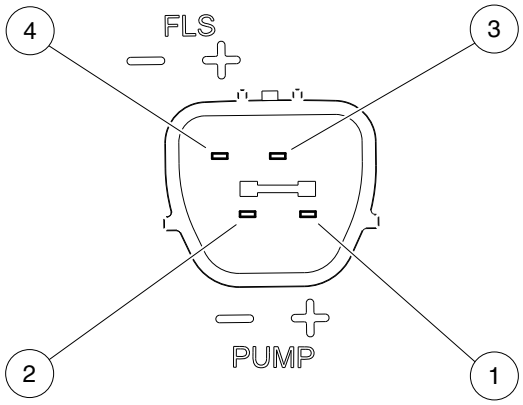
TEST PROCEDURE 20 – Fuel Pump

See General Warnings on page 1-2.

⚠ 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.*



WIRE FUNCTION	WIRE COLOR
1. Fuel Pump Positive (+)	Red Wire
2. Fuel Pump Negative (–)	Black/White Wire
3. Sending Unit Positive (+)	Orange Wire
4. Sending Unit Negative (–) Black Wire	Black Wire

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Figure 33-13 Fuel Pump Module Terminals

Voltage to Pump

1. If necessary, **See Testing Basics on page 26-7.**.
2. Disconnect the 5-pin connector from the top of the fuel pump module.
3. Check that battery voltage is present between ground and the red wire of the 5-pin connector immediately after the key switch is placed in the ON position.

NOTE: *The fuel pump and low oil warning light operate for a few seconds when key switch is turned to the ON position; it stops if no engine RPM is detected by the ECU.*

4. If no voltage, check key switch. **See Key Switch (Start Circuit) on page 26-11.**

Pump

1. If necessary, **See Testing Basics on page 26-7.**.
2. Disconnect battery. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Disconnect the 5-pin connector from the top of the fuel pump module.

4. Probe between pin (1) and pin (2) terminals in module **(Figure 26-14, Page 26-26)**.

4.1. The reading should be approximately 2 to 5 ohms. If the reading indicates no resistance, the fuel pump has failed and the fuel pump module must be replaced. **See Fuel Pump Module Removal on page 29-18.**

4.2. If the reading is correct and the fuel pump does not function correctly, check the continuity of the red wire from the fuel pump to the red wire of the black 18-pin ECU connector. This red wire contains sonic weld 11. Leave the battery disconnected while checking continuity. Also, check the continuity of the black/white wire from the fuel pump to the black/white wire of the black 18-pin ECU connector.

TEST PROCEDURE 21 – Fuel Level Sending Unit

See General Warnings on page 1-2.

⚠ 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 on page 26-7.**.
2. Disconnect battery. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Disconnect the 5-pin connector from the top of the fuel pump module.
4. Probe between pin (3) and pin (4) terminals in module **(Figure 26-14, Page 26-26)**.
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

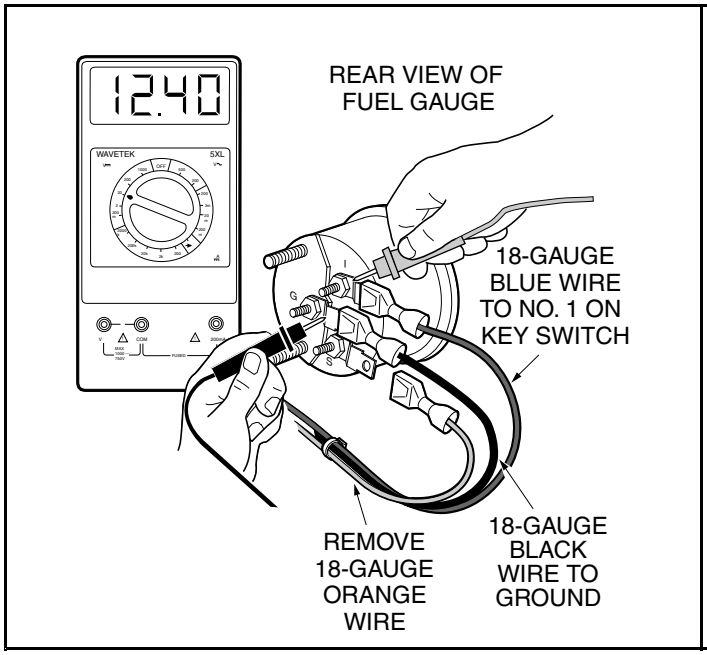
6. If the readings are within the specifications listed above, the fuel level sending unit is working properly. If the readings are incorrect, the fuel level sending unit has failed and the fuel pump module must be replaced. **See Fuel Pump Module Removal on page 29-18.**
7. If the readings are correct and the fuel gauge does not function correctly, check the continuity of the orange wire from the fuel level sending unit to the orange wire on the fuel gauge/hour meter. Leave the battery disconnected while checking continuity. Also check the continuity of the blue wire from the fuel gauge/hour meter to the blue wire on the key switch, and the black ground wires at the fuel level sending unit and at the fuel gauge/hour meter.
8. If the readings are correct according to the position of the float, but give an incorrect reading on the fuel gauge, test the fuel gauge. **See Fuel Gauge on page 33-36.**

TEST PROCEDURE 22 – Fuel Gauge

See General Warnings on page 1-2.

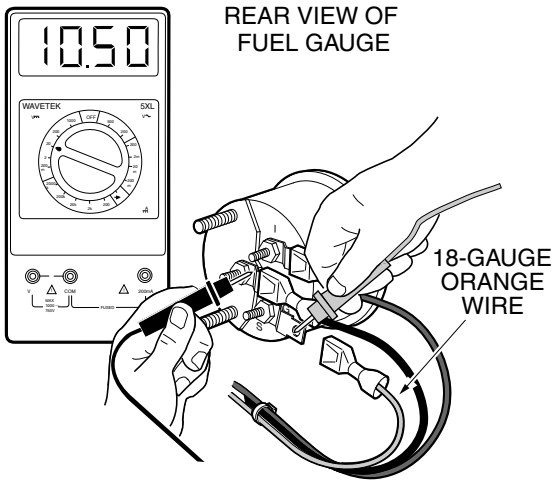
NOTE: *This is a voltage test.*

1. If necessary, **See Testing Basics on page 26-7.**.
2. Turn the key switch OFF and remove the key. Place the Forward/Reverse handle in the NEUTRAL position. Chock the wheels.
3. Remove the instrument panel to gain access to the back of the fuel gauge. **See Key Switch Removal on page 27-32.**
4. Disconnect the orange wire from the fuel gauge.
5. Set a multimeter to 20 volts DC and place the red (+) probe of the multimeter on the blue wire terminal of the fuel gauge. Place the black (–) probe on the black wire terminal of the fuel gauge **(Figure 33-14, Page 33-36)**.
6. Turn the key switch ON. The voltage reading should be battery voltage. If not, check the continuity of the blue and black wires **(Figure 33-14, Page 33-36)**.
7. The orange wire should remain disconnected for this step. With the black probe still on the black wire terminal of the fuel gauge, place the red (+) probe of the multimeter on the terminal for the orange wire. The voltage reading should be battery voltage or less depending on fuel level. If the reading is incorrect, replace fuel gauge **(Figure 33-15, Page 33-36)**.



2429

Figure 33-14 Fuel Gauge Test



2430

Figure 33-15 Fuel Gauge Voltage Test

TEST PROCEDURE 23 – Hour Meter

See General Warnings on page 1-2.

NOTE: *Keep the battery connected while performing this test procedure.*

1. Place the neutral lockout cam in the MAINTENANCE position, put the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Turn the key switch to ON and record the current hour meter reading.
3. Press and hold the accelerator pedal to run the engine for at least six minutes (the meter records in six-minute increments). **See following DANGER.**

⚠ DANGER

- **Do not operate vehicle in an enclosed area without proper ventilation. The engine produces carbon monoxide, which is an odorless, deadly poison.**

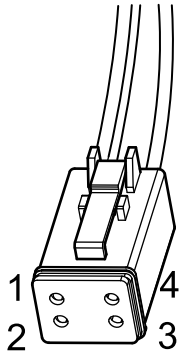
4. If the reading does not change after six minutes, then replace the hour meter.

TEST PROCEDURE 24 – 4-Pin Connector (for Connected Car Device)

See General Warnings on page 1-2.

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 – Blue
Pin 2 – Red	Pin 3 – Open (No wire)

2786

Figure 33-16 4-Pin Connector

1. If necessary, **See Testing Basics on page 26-7.**.
2. Check for continuity between pin 1 (black wire) **(Figure 26-20, Page 26-31)** and pin 18 (black wire) of the black 18-pin connector on the ECU. It should indicate continuity. If not, check sonic welds no. 4, 10, and 14.
3. Probe pin 2 (red wire). It should show battery voltage with the key switch in the ON position. If not, check 2-amp fuse near ATM fuse holder. **See following NOTE.**

NOTE: *The red wire only has battery voltage with the key switch in the ON position.*

4. Probe pin 4 (blue wire). It should show approximately 11.8 volts supplied by pin 8 (blue/white wire) of the black 18-pin connector on the ECU. If not, check wiring and then ECU. **See following NOTE.**

NOTE: *The blue wire only has voltage with the key switch in the ON position.*

If pin 4 has no voltage, the ECU 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.

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

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 A1, DF, and F2 terminals of the starter/generator (1).
4. Loosen the pivot nuts (2) and pivot bolts (3) **(Figure 27-1)**.

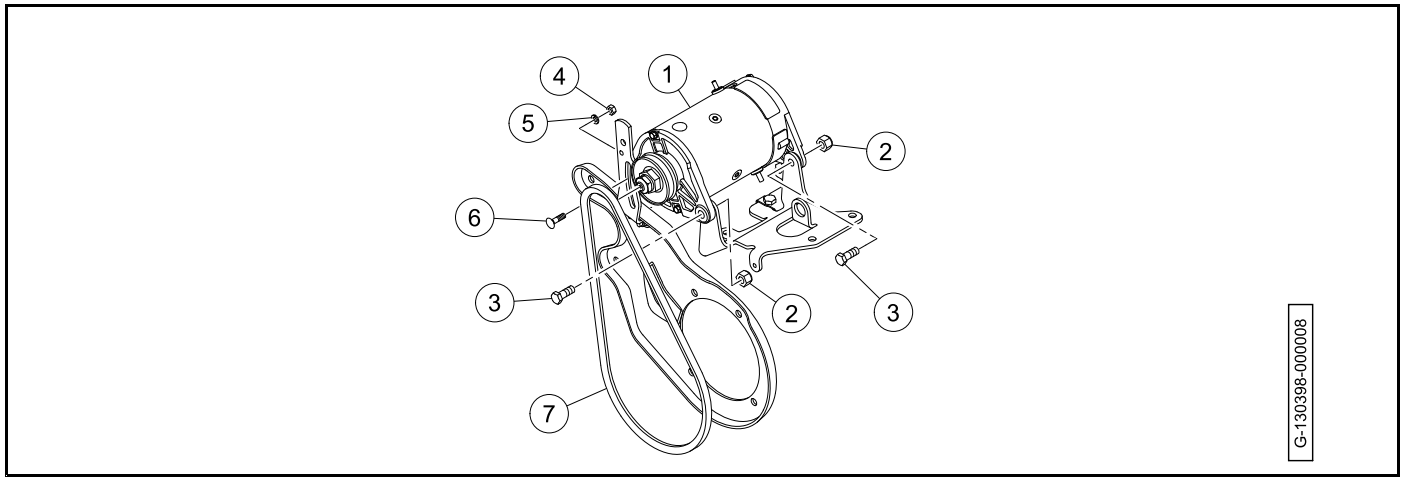


Figure 34-1 Starter/Generator Removal

5. Remove the adjustment nut (4), washer (5) and adjustment bolt (6).
6. Lower the starter/generator and remove the belt (7) from the starter/generator pulley.
7. Support the starter/generator so that when the pivot bolts are removed the starter/generator does 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 jumper wire (1) and terminal hardware (2) **(Figure 27-2)**.

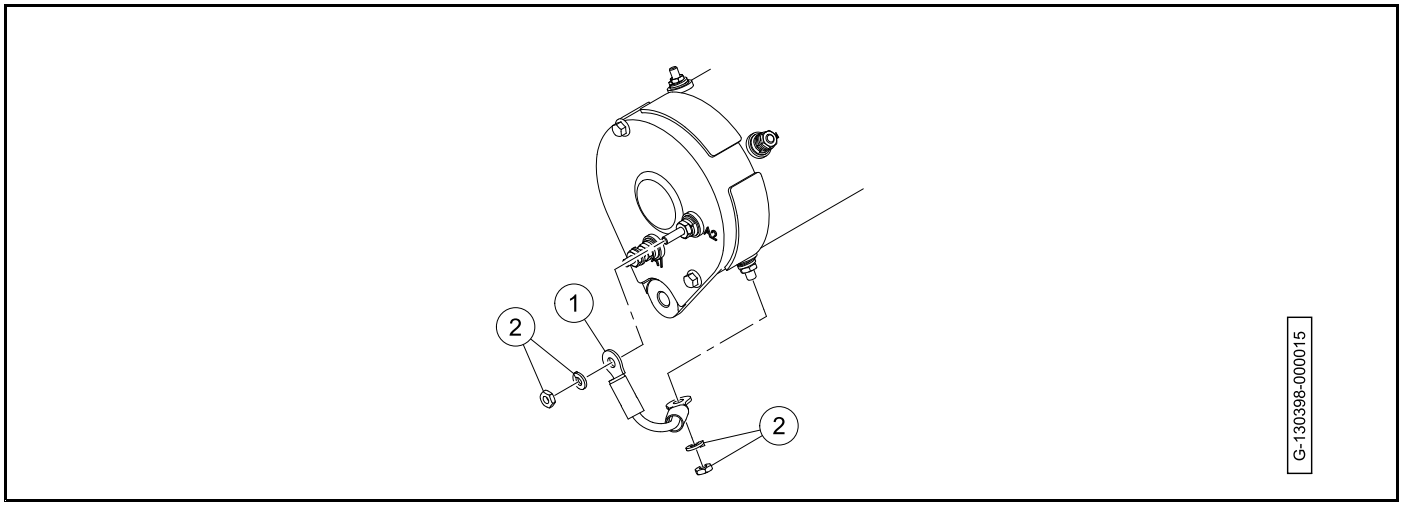


Figure 34-2 Jumper Wire Removal

2. Remove the bolts (1) and pull the commutator end cover (2) free of the field coil housing (3) **(Figure 27-3)**. **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 side of the brushes and help prevent them from sliding towards the center of the cover.*

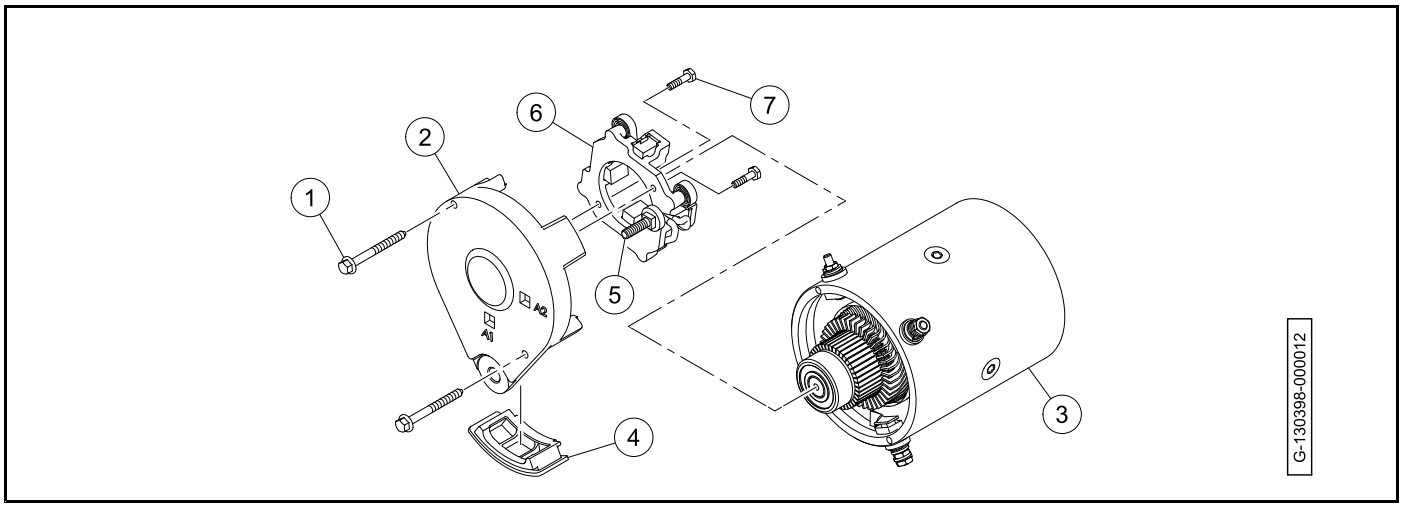


Figure 34-3 Starter/Generator Disassembly - Brushes

3. Remove the brush covers (4) and terminal hardware (5) from the commutator end cover.
4. Remove the screws (7) that attach the brush assembly (6) to the commutator end cover.

BRUSH AND BRUSH SPRING INSPECTION AND REPLACEMENT

1. Visually inspect brushes (1). Replace brushes that are cracked or severely chipped **(Figure 27-4)**.

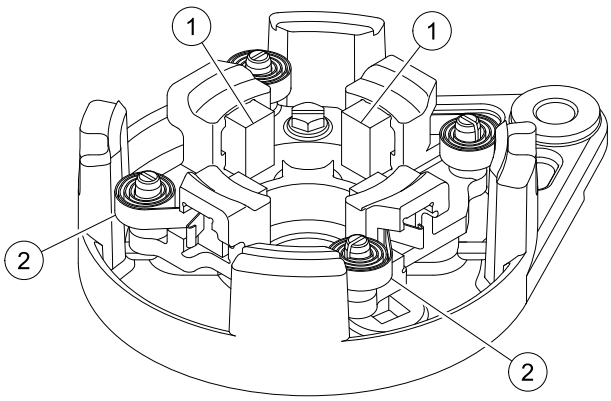


Figure 34-4 Brush and Brush Spring Inspection

2. Measure the length of each brush. Replace the brush set if a brush is less than 0.375 inch (9.5 mm).
3. Visually inspect springs (2). Replace all brush springs if any spring is discolored from heat (straw or bluish in color).
4. Install the brushes (1) into their holders and insert the brush springs (2).
5. Using a spring scale, test brush spring tension. If any spring has a tension less than 24 ozf (0.68 kgf), replace all four brush springs. **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.**

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. Remove the bolts (1) **(Figure 27-5, Page 27-8)**.

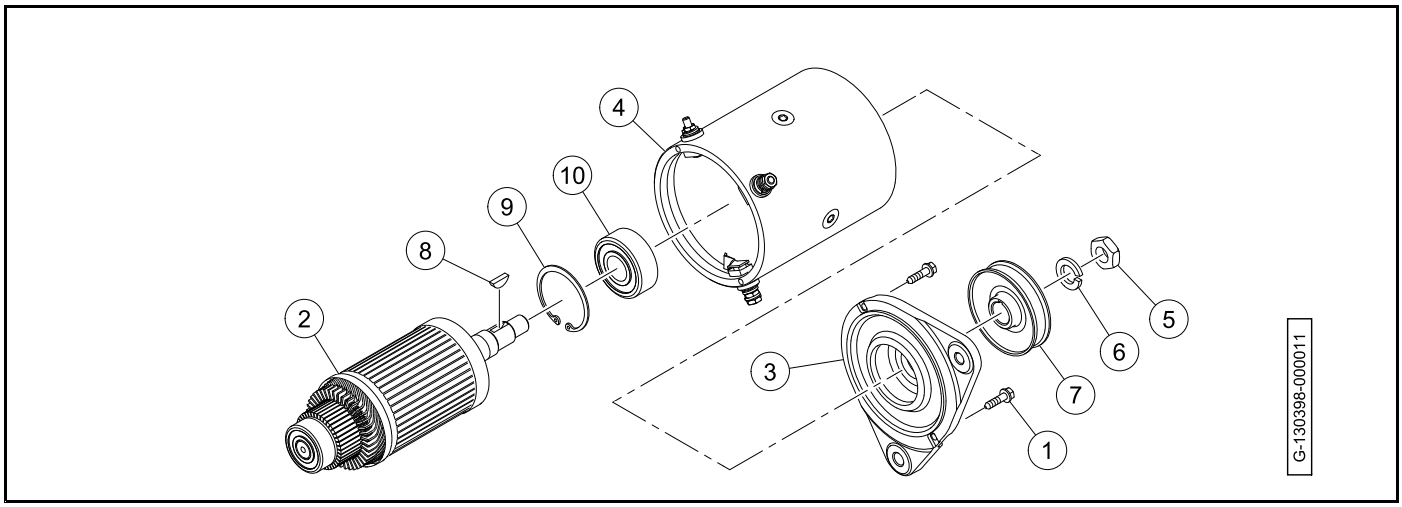


Figure 34-5 Output End Cover Disassembly, Armature and Housing

3. Remove the armature (2) and output end cover (3) from the field coil housing (4).
4. Remove the nut (5), lock washer (6), pulley (7), and woodruff key (8). **See following NOTE.**

NOTE: *It may be necessary to use the wedge attachment tool to remove the pulley from the armature shaft.*

5. Remove the internal retaining ring (9) to release the bearing (10) and armature from the output end cover.

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 and radial play.
2. Replace the bearing if it is noisy, does not spin smoothly, or has excessive play.
3. Check the bearings and replace if rusted, worn, cracked, or if there is an abnormal color change in the metal of the bearing.
4. Bearings should be replaced if there is extensive wear or pitting on the balls or on the rolling surfaces.

NOTE: *Do not remove the bearings unless they are to be replaced.*

BEARING REMOVAL

1. Place the wedge attachment tool between the bearings (1) and the armature (2) **(Figure 27-6, Page 27-9)**. **See following NOTE.**

NOTE: *Make sure the wedge attachment tool is supporting the inner race of the bearing.*

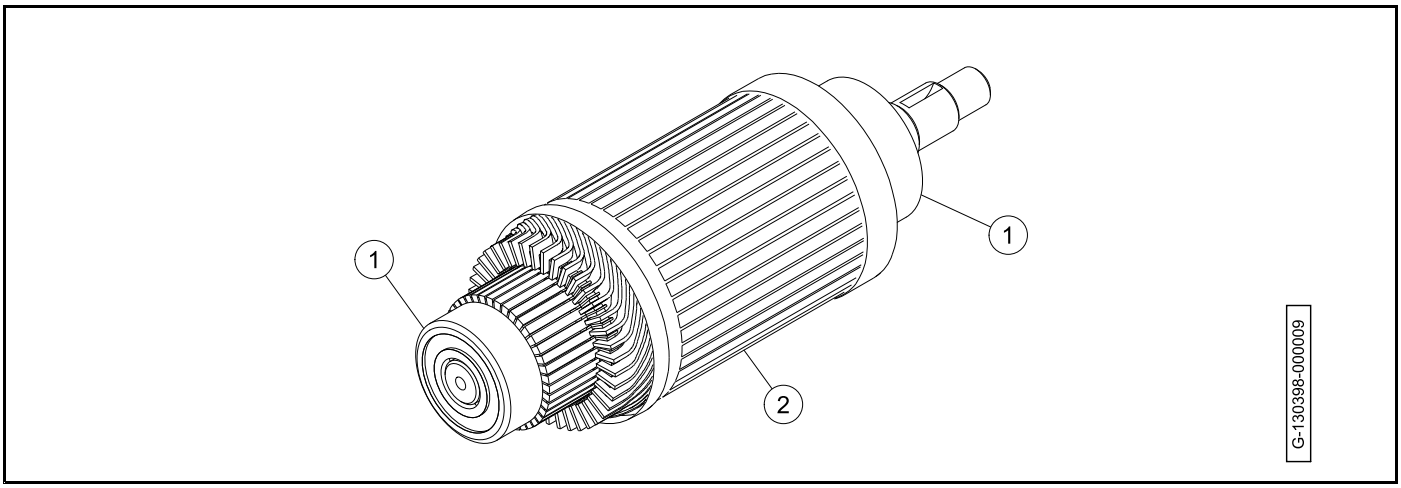


Figure 34-6 Bearing Removal

2. If a press is not available, secure a bearing puller to the wedge attachment tool and pull the bearings off of the end of the armature shaft. **See following NOTE.**

NOTE: *Support the armature so that it will not drop when the bearing is removed.*

FIELD COIL ASSEMBLY

Replace entire field coil housing assembly if coils, pole shoes or terminals are damaged..

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

COMMUTATOR CLEANING AND INSPECTION

1. Visually inspect the commutator for worn, burned or glazed areas.
2. Check for loose or raised commutator bars.
3. Clean the carbon dust, dirt and oil from the commutator. 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.**

4. 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 27-7)**. **See following NOTE.**

NOTE: *Measure each position of the commutator in two places, 90 degrees apart.*

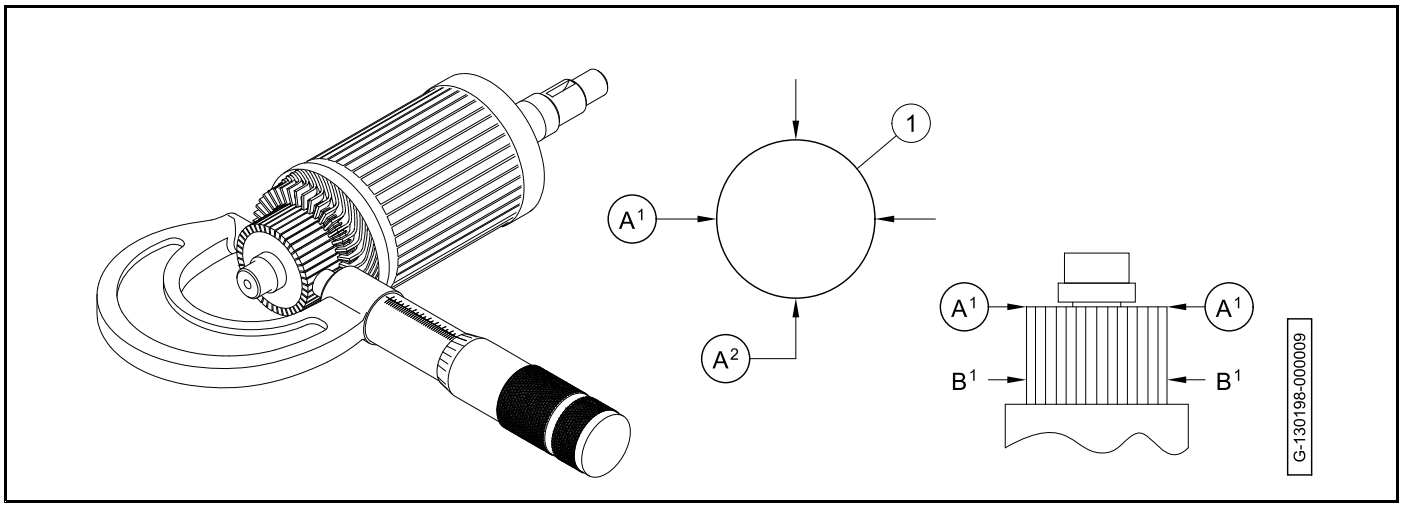


Figure 34-7 Inspect Commutator

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 (1) and the negative (–) probe on the armature shaft (2). The reading should be no continuity. If the reading is incorrect, replace the armature and the two bearings **(Figure 27-8, Page 27-11)**.

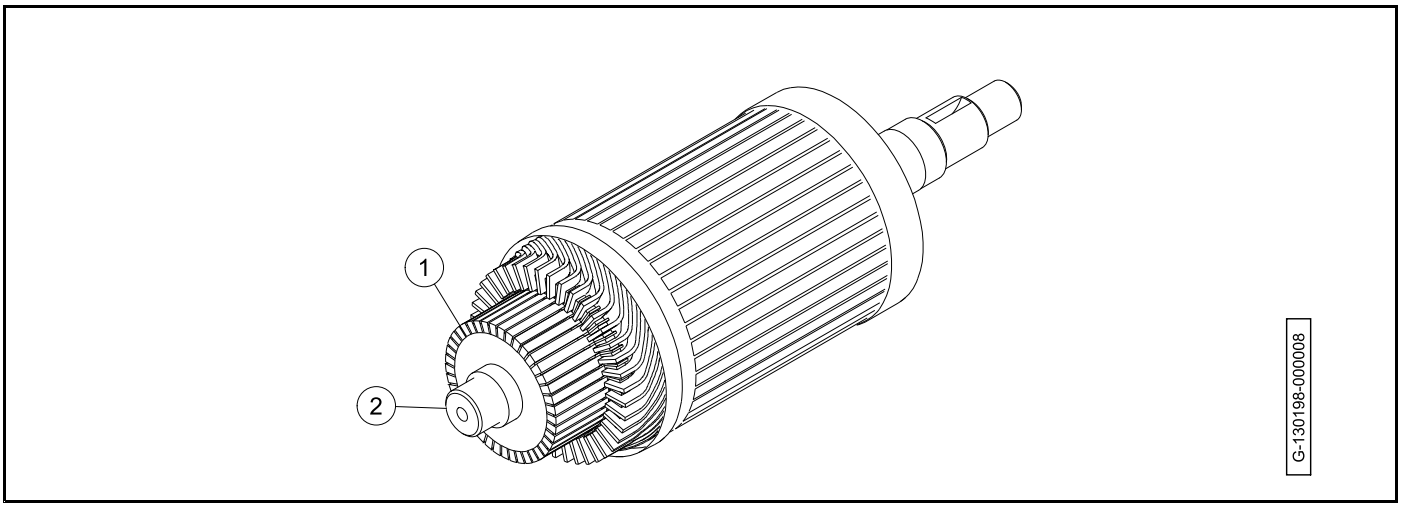


Figure 34-8 Armature Ground Test

VISUAL INSPECTION OF FIELD COILS

If the insulation on the field coils appears blackened or charred, the serviceability of the coils is questionable. Replace starter/generator if necessary.

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 internal retaining ring (9) on the output end of the armature (2) **(Figure 27-9)**.

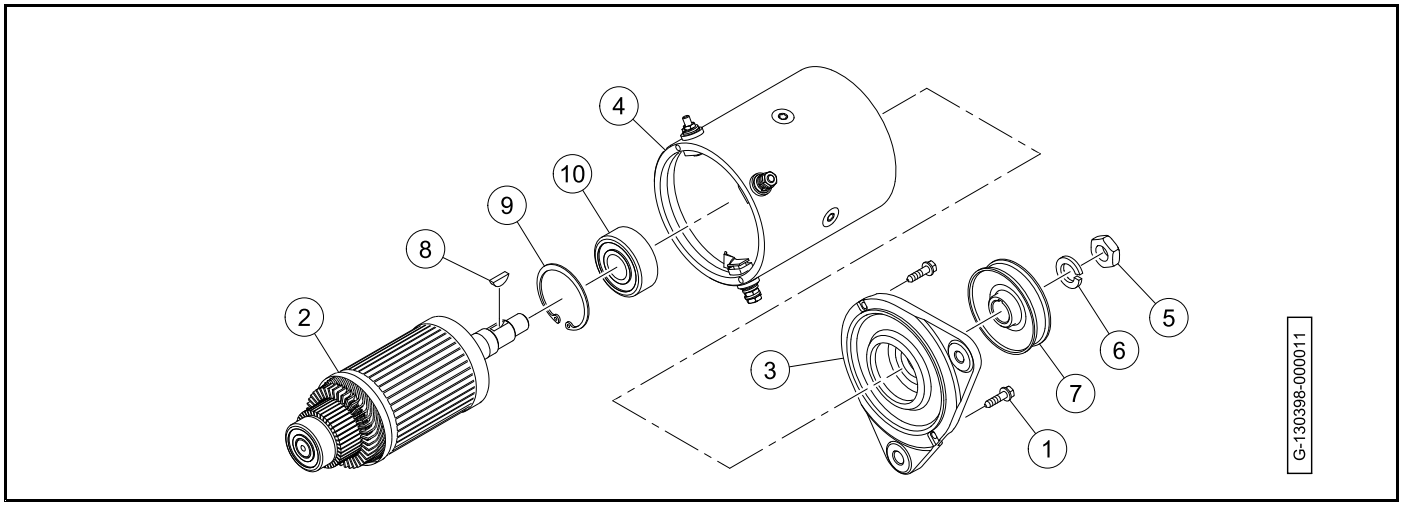


Figure 34-9 Output End Cover Assembly, Armature and Housing

2. Press a new ball bearing (10) onto the output end of the armature. **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 output end cover (3) on the armature. Secure the internal retaining ring.
4. Slide the field coil housing (4) over the armature. Use the tapped mounting holes to align field coil housing to the output end cover. **See following NOTE.**

NOTE: *The terminal insulators should be on the commutator end of the housing.*

5. Install the bolts (1). Tighten the bolts from 49 to 66 lb·in (5.5 to 7.4 N·m).
6. Install the woodruff key (8) and pulley (7) onto the armature shaft.
7. Install the lock washer (6) and nut (5). Tighten the nut from 26 to 32.9 lb·ft (35.3 to 44.7 N·m).
8. Install the screws (7) that attach the brush assembly (6) and terminals (5) to the commutator end cover (2) **(Figure 27-10, Page 27-13)**. Tighten the screws from 22 to 26 lb·in (2.4 to 2.9 N·m).

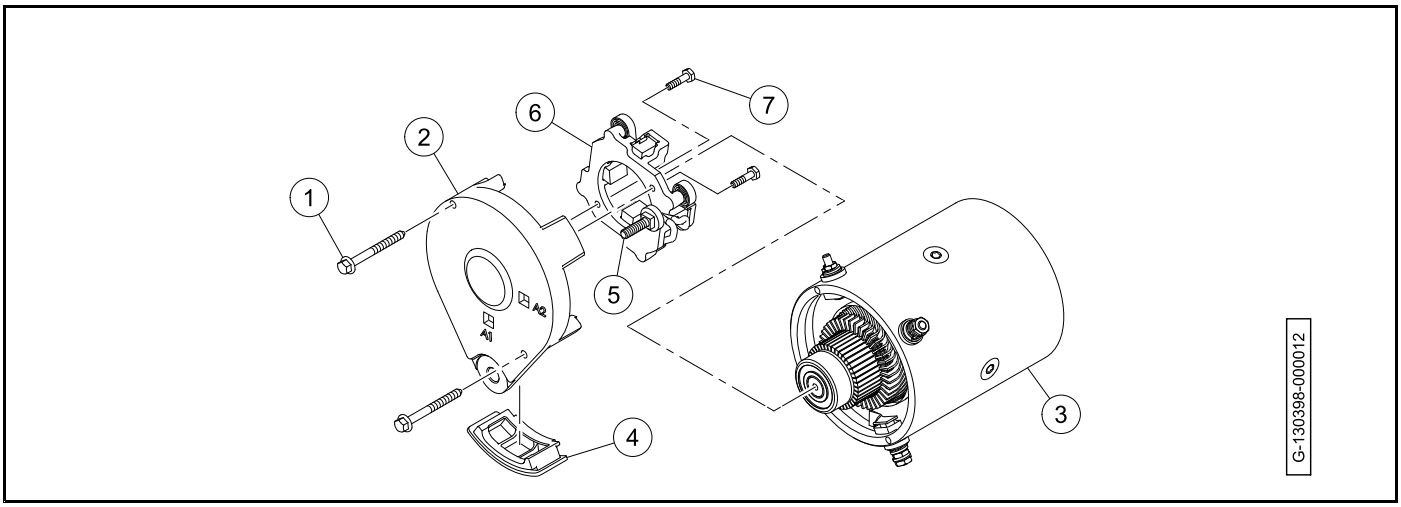


Figure 34-10 Starter/Generator Aassembly - Brushes

9. To prevent contact between the brushes and commutator as the commutator end cover is installed, and possible damage to the brushes:

9.1. Lift the brush springs out of the notches in the brushes and pull the brushes back from the center of the commutator end cover.

9.2. The springs will rest on the side of the brushes and help prevent them from sliding towards the center of the commutator end cover.

10. Install the commutator end cover onto the armature shaft. Use the tapped mounting holes to align housing to the field coil housing (3).

11. Install the bolts (1). Tighten the bolts from 49 to 66 lb·in (5.5 to 7.4 N·m).

12. Install the terminal hardware on the A1 and A2 terminals. Tighten the hardware from 40 to 50 lb·in (4.5 to 5.6 N·m).

13. Push the brushes down into the holders.

14. Place springs into the notches on the brushes. **See following NOTE.**

NOTE: *Check the brush wires to make sure they do not interfere with the springs.*

15. Install the brush covers (4). **See following NOTE.**

NOTE: *The brush cover with the drain hole is installed next to the A2 terminal.*

16. Install the terminal jumper wire (1) on the A2 and F1 terminals on the starter/generator **(Figure 27-11, Page 27-14)**.

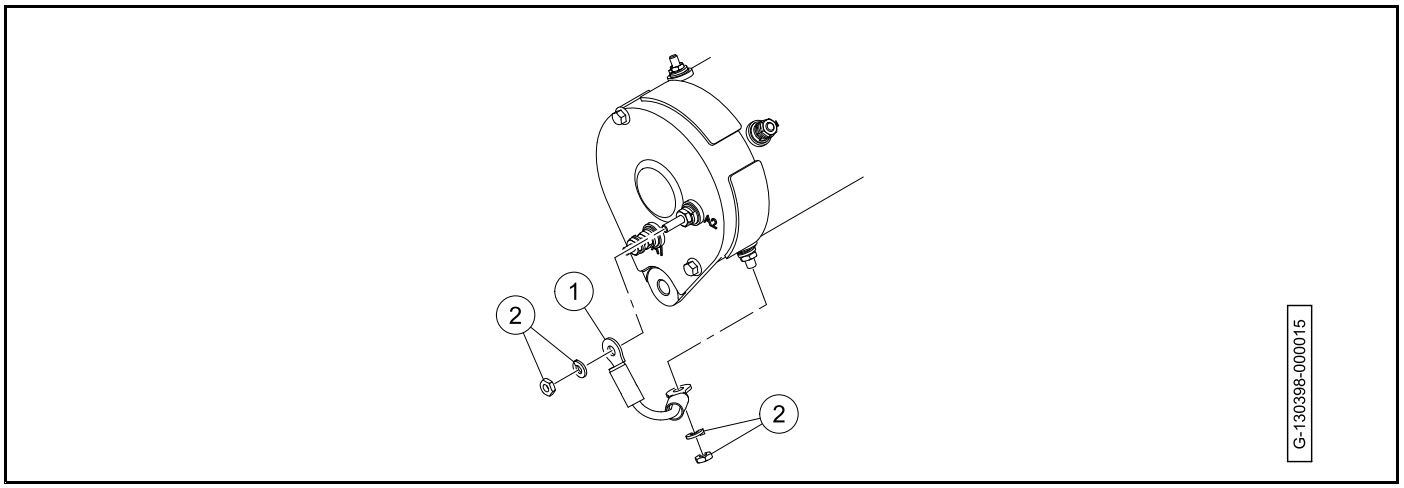


Figure 34-11 A2 to F1 Terminal Jumper Wire

17. Install the terminal hardware (2). Tighten the hardware from 39.8 to 49.5 lb·in (4.5 to 5.6 N·m). **See following NOTE.**

NOTE: *Secure bottom nut of terminal with wrench before tightening top nut.*

STARTER/GENERATOR INSTALLATION

1. Position the starter/generator (1) over the mounting bracket **(Figure 27-12)**.

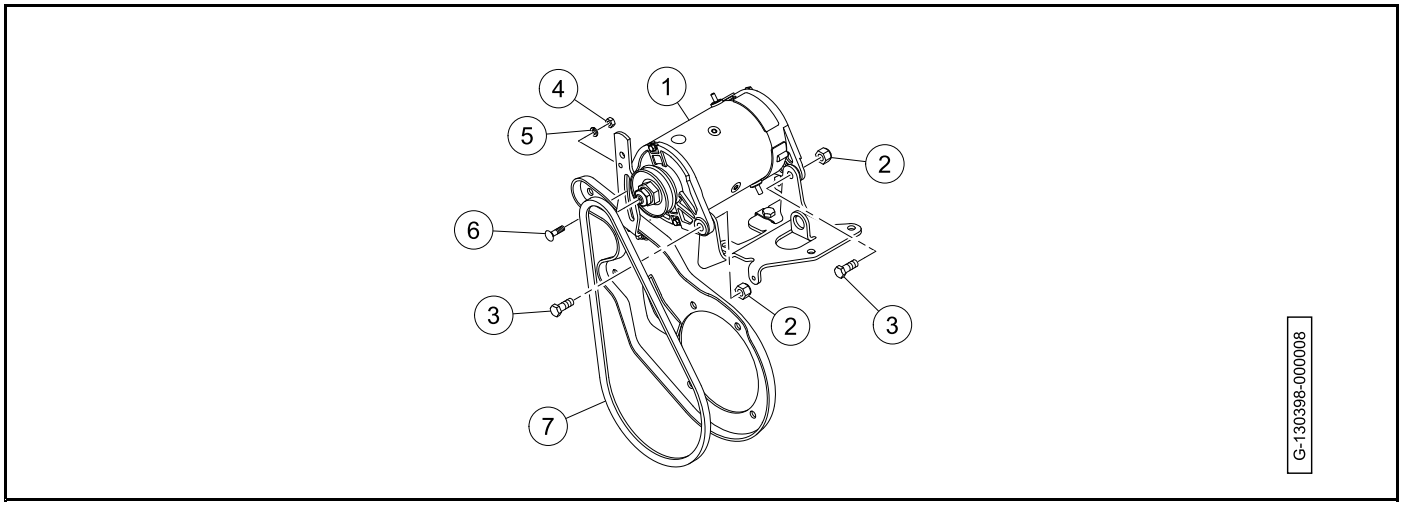


Figure 34-12 Starter/Generator Installation

2. Install the pivot bolts (3) and pivot nuts (2). Tighten the pivot nuts with your hand.
3. Install the adjustment bolt (6), lock washer (5), and nut (4). Tighten the hardware hand-tight.
4. Install the starter/generator belt (7).
5. Adjust the belt tension. See Belt Tension Adjustment for EFI Engines.
6. Connect the yellow wire from the voltage regulator to the DF terminal on the starter/generator **(Figure 27-13, Page 27-15)**.

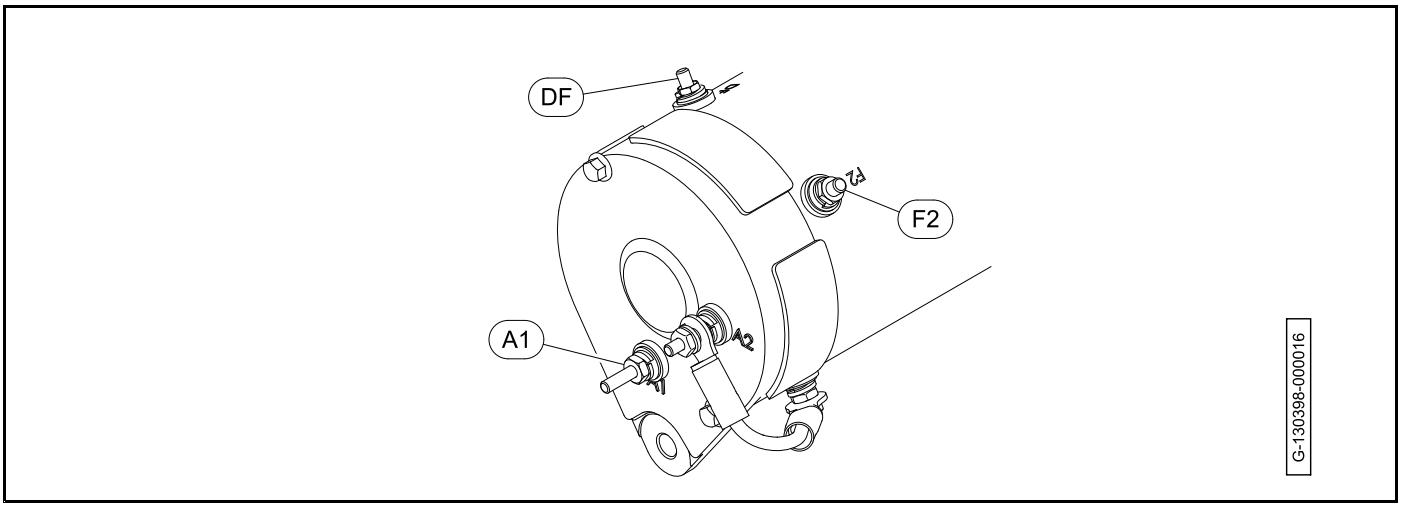


Figure 34-13 Wire Installation

7. Install a flat washer, lock washer, and nut on the DF terminal. Tighten the nut from 15 to 19.4 in·lb (1.7 to 2.2 N·m).
8. Install the white wire from the solenoid to the F2 terminal on the starter/generator.
9. Install the black wire from the frame to the A1 terminal on the starter/generator.
10. Install a flat washer, lock washer and nut on each terminal, and tighten the nuts from 40 to 50 lb·in (4.5 to 5.6 N·m).
11. 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 (1) to repeat tension measurement each time. Use a paint pen or permanent marker of light color **(Figure 27-14, Page 27-16)**.

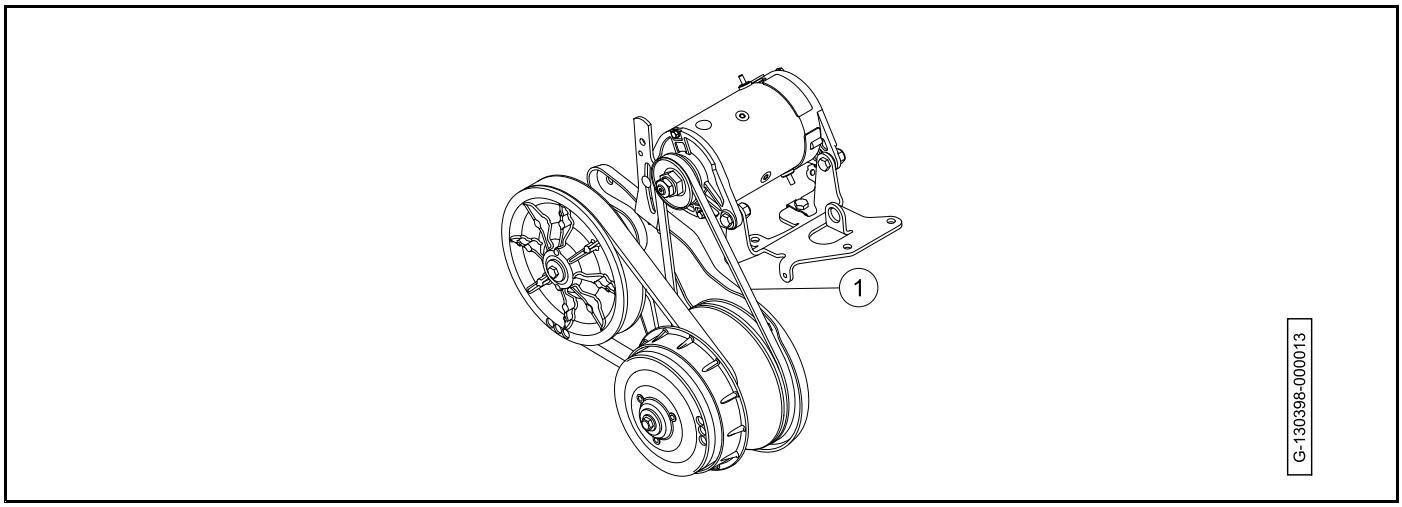


Figure 34-14 Belt Tension

3. Install a Universal Belt Tension Gauge midway between the drive clutch and driven clutch.
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. Disable the vehicle.
2. Disconnect the battery and spark plug wire.
3. Mark a location on belt (1) to repeat tension measurement each time. Use a paint pen or permanent marker of light color **(Figure 27-15, Page 27-17)**.

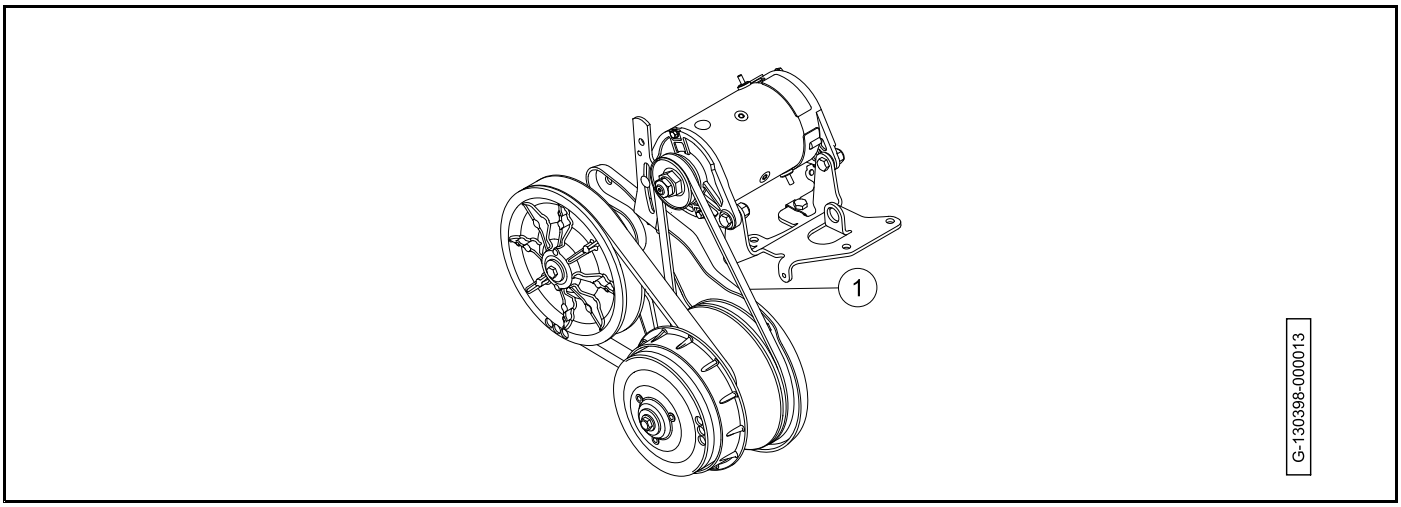


Figure 34-15 Belt Tension

4. Install a Universal Belt Tension Gauge midway between the drive clutch and driven clutch.
5. Loosen, do not remove, the adjustment nut (1) and pivot nuts (2) **(Figure 27-16)**.

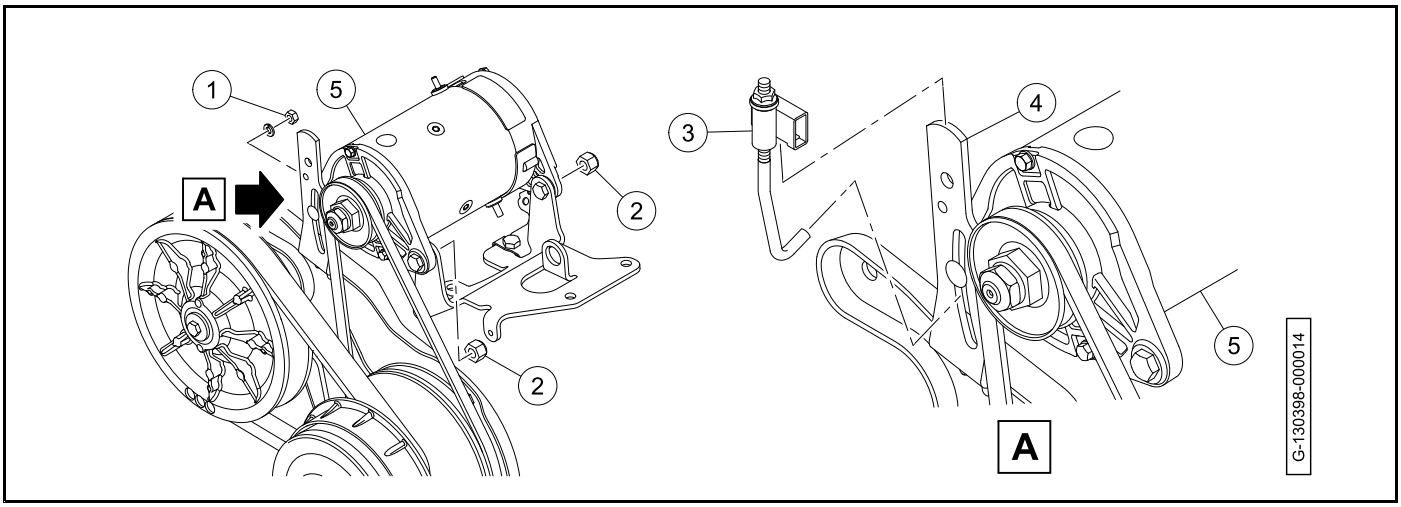


Figure 34-16 Belt Tension Adjustement

6. Install the belt tension tool (3) on the slotted adjustment bracket (4).

6.1. Carefully insert pry bar between starter/generator (5) and slotted adjustment 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.*

6.2. Lift the starter/generator up until the tension tool can be installed into the slotted adjustment bracket.

6.3. Remove the pry bar.

7. Tension the belt.

7.1. 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, loosen then reapply, the Universal Belt Tension gauge between measurements.*

7.2. 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).

8. Seat the belt.

8.1. Remove all other tools.

8.2. The belt tension tool can be temporarily left in place.

8.3. 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.**

8.4. Operate the engine a minimum of 5 seconds and a maximum of 15 seconds to fully seat the belt into the pulleys and help eliminate any slack.

9. Repeat step 7.

10. Maintain tension and tighten the adjustment nut from 15 to 18 ft·lb (20 to 24.5 N·m). Tighten the pivot nuts from 20 to 25 ft·lb (27 to 34 N·m).

11. Remove the belt tension tool.

12. Confirm proper belt tension with a final measurement.

13. Connect the spark plug wire.

BELT TENSION TOOL MODIFICATION

1. Remove the nut (1), washer (2), and spacer (3) from the J-bolt (4) **(Figure 27-17)**.

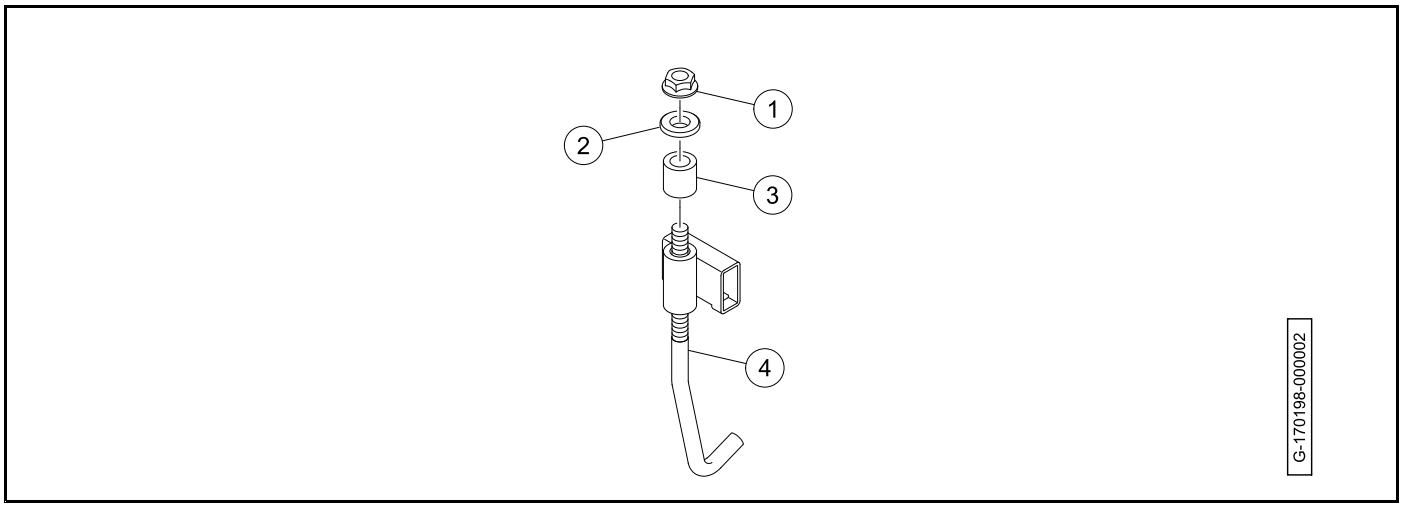


Figure 34-17 Belt Tension Tool Modification

2. Install the washer and nut onto the J-bolt.

VOLTAGE REGULATOR

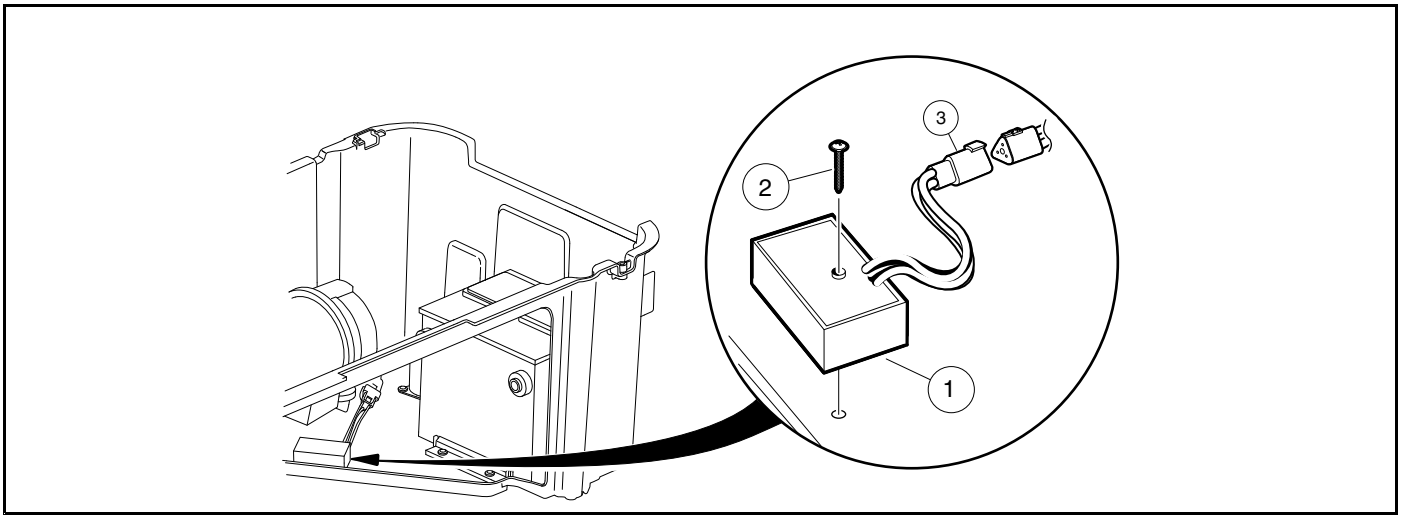
See General Warnings on page 1-2.

TESTING THE VOLTAGE REGULATOR

See Test Procedure 12 – Voltage Regulator on page 26-20.

VOLTAGE REGULATOR REMOVAL

1. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Disconnect the voltage regulator connector (3) from the wire harness **(Figure 27-22, Page 27-21)**.
3. Remove the voltage regulator mounting screw (2) and remove the voltage regulator (1).



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Figure 34-18 Voltage Regulator

VOLTAGE REGULATOR INSTALLATION

1. Position the voltage regulator (1) and install the mounting screw (2) **(Figure 27-22, Page 27-21)**. Tighten screw to 23 lb·in (2.6 N·m).
2. Connect the voltage regulator three-pin connector (3) to the wire harness.
3. Connect battery and spark plug wire(s).
   See Connect the Battery - Gasoline Vehicles on page 1-4.
4. Place Forward/Reverse handle in NEUTRAL and place the neutral lockout cam in the MAINTENANCE position. Start the engine and check regulator for proper functioning as described in the voltage regulator test procedure.
   See Test Procedure 12 – Voltage Regulator on page 26-20.

ENGINE CONTROL UNIT (ECU)

CAUTION

- **The Engine Control Unit (ECU) and Throttle Body are to be purchased as one unit. They are matched pairs with matching serial numbers. Do not mix an ECU with another Throttle Body of a different serial number. Doing so violates emissions standards and warranty.**

The ECU is located in the engine compartment.

TESTING THE ENGINE CONTROL UNIT

See Test Procedure 4 – EFI System (ECU and Sensors) on page 33-18.

ENGINE CONTROL UNIT REMOVAL

1. Disconnect battery. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Remove ECU mounting plate bolts.
3. Disconnect gray and black wire connectors.

ENGINE CONTROL UNIT INSTALLATION

⚠ 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.**

1. Mount ECU to plate with bolts and tighten to 60 lb·in (6.8 N·m).
2. Install gray connector to the gray port on the ECU. **See preceding WARNING.**
3. Install black connector to the black port on the ECU.
4. Connect the battery.

KEY SWITCH

See General Warnings on page 1-2.

TESTING THE KEY SWITCH

See Test Procedure 4 – Key Switch (Start Circuit) on page 26-11.

See Test Procedure 5 – Key Switch (Engine Kill Circuit) on page 26-11.

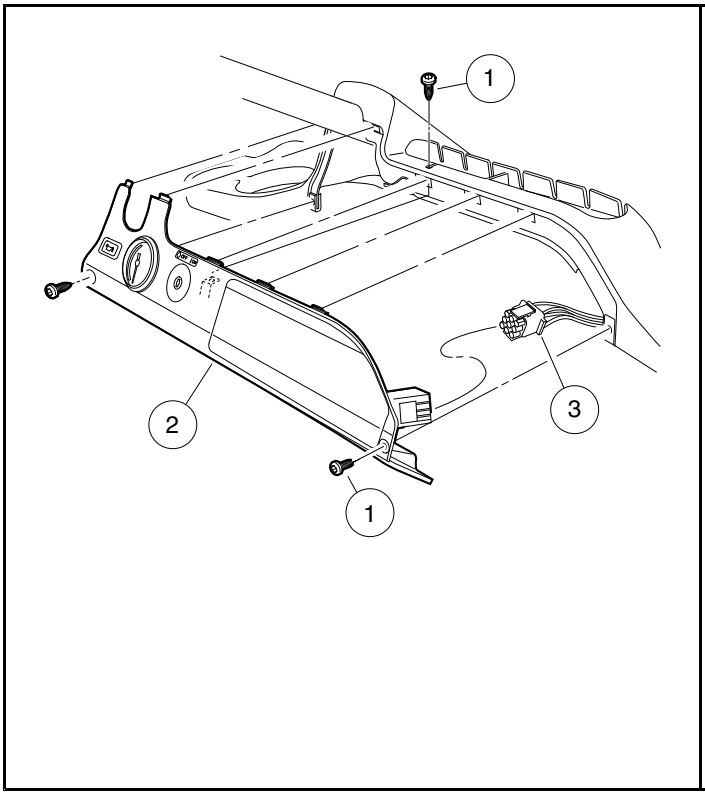
KEY SWITCH REMOVAL

1. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Remove the instrument panel.

2.1. Remove three screws (1) from the instrument panel (2) **(Figure 34-19, Page 34-17)**.

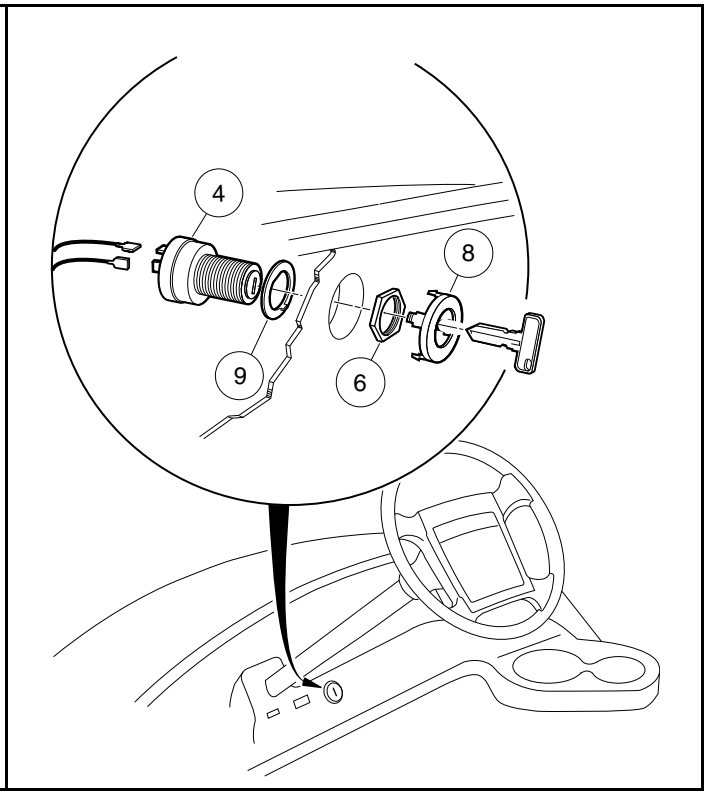
2.2. Rotate the instrument panel up and away from the dash to disengage the tabs at the top of the instrument panel.

2.3. Disconnect the electrical connector (3) to the instrument panel.



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Figure 34-19 Instrument Panel Removal



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Figure 34-20 Key Switch

3. Disconnect the wires from the key switch.
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). Hold the key switch and remove the switch retaining nut (6) from the outside of the instrument panel **(Figure 34-20, Page 34-17)**.

KEY SWITCH INSTALLATION

1. Reverse removal procedures to install key switch in the instrument panel. Connect wires to key switch.
2. Install the instrument panel.

2.1. Connect the electrical connector (3) **(Figure 34-19, Page 34-17)**.

2.2. Position the instrument panel (2) on the dash assembly. Make sure tabs on upper edge properly engage with the corresponding slots on the dash assembly. Ensure that there are no wires exposed or pinched during positioning.

2.3. Secure instrument panel to the dash assembly with three screws (1). Tighten screws to 1.8 lb·ft (2.5 N·m).

3. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.

MAINTENANCE/OPERATE SWITCH

TESTING THE MAINTENANCE/OPERATE SWITCH

See Test Procedure 8 – Maintenance/Operate Switch on page 26-15.

MAINTENANCE/OPERATE SWITCH REMOVAL

1. Disconnect the battery and spark plug wire(s).
2. Using a 5/8 inch (16 mm) wrench, remove maintenance/operate boot/hex nut.
3. Remove maintenance/operate switch from bracket.
4. Disconnect the three spade terminals and remove switch.

MAINTENANCE/OPERATE SWITCH INSTALLATION

1. Connect the three spade terminals **(Figure 26-6, Page 26-15)**.
2. Make sure groove switch is aligned with tang on bracket and install switch. Tighten maintenance/operate switch boot/hex nut to 16 lb·in (1.8 N·m).
3. Connect the battery.

NEUTRAL LOCKOUT LIMIT SWITCH

See General Warnings on page 1-2.

TESTING THE NEUTRAL LOCKOUT LIMIT SWITCH

See Test Procedure 9 – Transaxle Limit Switch on page 26-16.

NEUTRAL LOCKOUT LIMIT SWITCH REMOVAL

1. Turn the key switch OFF and remove the key. Place the Forward/Reverse handle in the NEUTRAL position. Chock the wheels.
2. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Disconnect the 3-wire connector from the neutral lockout limit switch (1) located on the transaxle.
4. Remove two nuts (3) and washers (4) from the neutral lockout limit switch (1) and slide the limit switch off of the screws.

NEUTRAL LOCKOUT LIMIT SWITCH INSTALLATION

1. Install the limit switch (1) with washers (4) and nuts (3) and tighten to 5 lb·in (0.6 N·m). Move the Forward/Reverse handle to make sure the switch actuates. **See following CAUTION.**

⚠ CAUTION

- **Do not overtighten the retaining nuts. If the nuts are overtightened, limit switches could be damaged.**

2. Connect the 3-wire connector to the neutral lockout limit switch lead.
3. Connect battery and spark plug wire(s).
   See Connect the Battery - Gasoline Vehicles on page 1-4.
4. Test drive the vehicle in both forward and reverse for proper operation.

SOLENOID

See General Warnings on page 1-2.

TESTING THE SOLENOID

See Test Procedure 7 – Solenoid on page 26-14.

SOLENOID REMOVAL

1. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Disconnect all the wires from the solenoid.
3. Remove the two screws securing the solenoid in place.
4. Remove the solenoid.

SOLENOID INSTALLATION

1. Install the solenoid in the vehicle. Use two screws to secure the solenoid and tighten to 14 lb·in (1.6 N·m).
2. Connect the ring terminal with the 10-gauge white wire and the 16-gauge red wire on a large post on the solenoid. **See Sonic Weld and Diode Locations on page 33-10.**
3. Connect the ring terminal with the two 10-gauge red wires to the other large post on the solenoid. **See Sonic Weld and Diode Locations on page 33-10.**
4. Connect the 16-gauge blue wire from the main harness to a small post on the solenoid.
5. Connect the 16-gauge orange wire from the main harness to the other small post on the solenoid. **See Sonic Weld and Diode Locations on page 33-10.**
6. Tighten the hex nuts on the large solenoid posts to 55 lb·in (6.2 N·m). Tighten the nuts on the small solenoid posts to 22 lb·in (2.5 N·m).
7. Connect battery and spark plug wire(s).
   See Connect the Battery - Gasoline Vehicles on page 1-4.

FUSE

See General Warnings on page 1-2.

ATM-style blade fuses are located on the main wire harness in front of the battery.

The ABC-style glass fuse is located on the main wire harness adjacent to the ATM-fuse holder.

TESTING THE FUSE

See Test Procedure 2 – Fuse Inspection on page 26-10.

FUSE REMOVAL

1. Disconnect battery. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. **ATM Fuses Only:** Remove fuse holder cover.

   ABC Fuse Only: Open in-line fuse holder.
3. Remove the fuse.

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. **ATM Fuse Only:** Install the fuse holder cover.

   ABC Fuse Only: Assemble in-line fuse holder.
3. Connect battery.
   See Connect the Battery - Gasoline Vehicles on page 1-4.

ACCELERATOR PEDAL LIMIT SWITCH

See General Warnings on page 1-2.

TESTING THE ACCELERATOR PEDAL LIMIT SWITCH

See Test Procedure 6 – Throttle Position Sensor (TPS) on page 26-12.

The accelerator pedal limit switch is housed inside the throttle position sensor. The throttle position sensor itself is not intended to be replaced. If sensor is determined to need replacing through test procedures found in this manual, the accelerator pedal assembly must be replaced.

KILL LIMIT SWITCH

See General Warnings on page 1-2.

TESTING THE KILL LIMIT SWITCH

See Test Procedure 6 – Throttle Position Sensor (TPS) on page 26-12.

The kill limit switch is housed inside the throttle position sensor. The throttle position sensor itself is not intended to be replaced. If sensor is determined to need replacing through test procedures found in this manual, the accelerator pedal assembly must be replaced.

REVERSE WARNING BUZZER

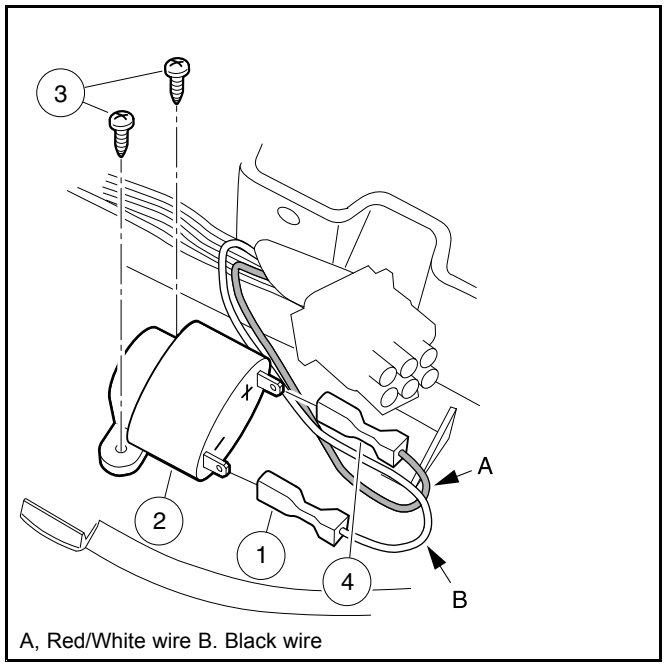
See General Warnings on page 1-2.

TESTING THE REVERSE WARNING BUZZER

See Test Procedure 14 – Multi-Purpose Buzzer and Multi-Purpose Buzzer Limit Switch on page 26-22.

REVERSE WARNING BUZZER REMOVAL

1. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Remove the instrument panel. **See Key Switch Removal on page 27-32.**
3. Disconnect the wires from the reverse warning buzzer (2) **(Figure 34-21, Page 34-23)**.
4. Remove the two mounting screws (3) securing the buzzer to the instrument panel.



A, Red/White wire B. Black wire

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Figure 34-21 Reverse Buzzer

REVERSE WARNING BUZZER INSTALLATION

1. Install the screws (3) through the buzzer bracket tabs and tighten to 3.5 lb·in (0.40 N·m) **(Figure 34-21, Page 34-23)**.
2. Connect the black wire (1) from the wire harness to the negative (–) terminal on the buzzer.
3. Connect the red/white wire (4) from the wire harness to the positive (+) terminal on the buzzer.
4. Install the instrument panel.

4.1. Connect the electrical connector (3) **(Figure 34-19, Page 34-17)**.

4.2. Position the instrument panel (2) on the dash assembly. Make sure tabs on upper edge properly engage with the corresponding slots on the dash assembly. Ensure that there are no wires exposed or pinched during positioning.

4.3. Secure instrument panel to the dash assembly with three screws (1). Tighten screws to 1.8 lb·ft (2.5 N·m).

5. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.
6. Shift the Forward/Reverse handle to the REVERSE position. The buzzer should sound.

REVERSE BUZZER LIMIT SWITCH

See General Warnings on page 1-2.

TESTING THE REVERSE BUZZER LIMIT SWITCH

See Test Procedure 14 – Multi-Purpose Buzzer and Multi-Purpose Buzzer Limit Switch on page 26-22.

REVERSE BUZZER LIMIT SWITCH REMOVAL

1. Disconnect battery and spark plug wire(s).
2. Cut the wire tie that retains the limit switch leads to the instrument panel harness.
3. Disconnect the wire connector from the reverse buzzer limit switch (3) located on the back of the Forward/Reverse shifter assembly **(Figure 34-22, Page 34-25)**.
4. Remove the nuts (4) and washers (5) from the reverse buzzer switch (3) and slide the reverse buzzer switch off of the screws (2).

REVERSE BUZZER LIMIT SWITCH INSTALLATION

1. Install the reverse buzzer limit switch (3) with two screws (2) that attach the buzzer to the shifter assembly **(Figure 34-22, Page 34-25)**.
2. Install washers (5) and tighten nuts (4) to 5 in·lb (0.6 N·m).

CAUTION

- **Do not overtighten the retaining nuts. If the nuts are over tightened, limit switches could be damaged.**

3. Place the Forward/Reverse handle in REVERSE and make sure that both switches actuate.
4. Connect the two wire connector to the reverse buzzer limit switch (3).
5. Connect battery and spark plug wire(s).
6. Shift the Forward/Reverse handle to the REVERSE position. The buzzer should sound.

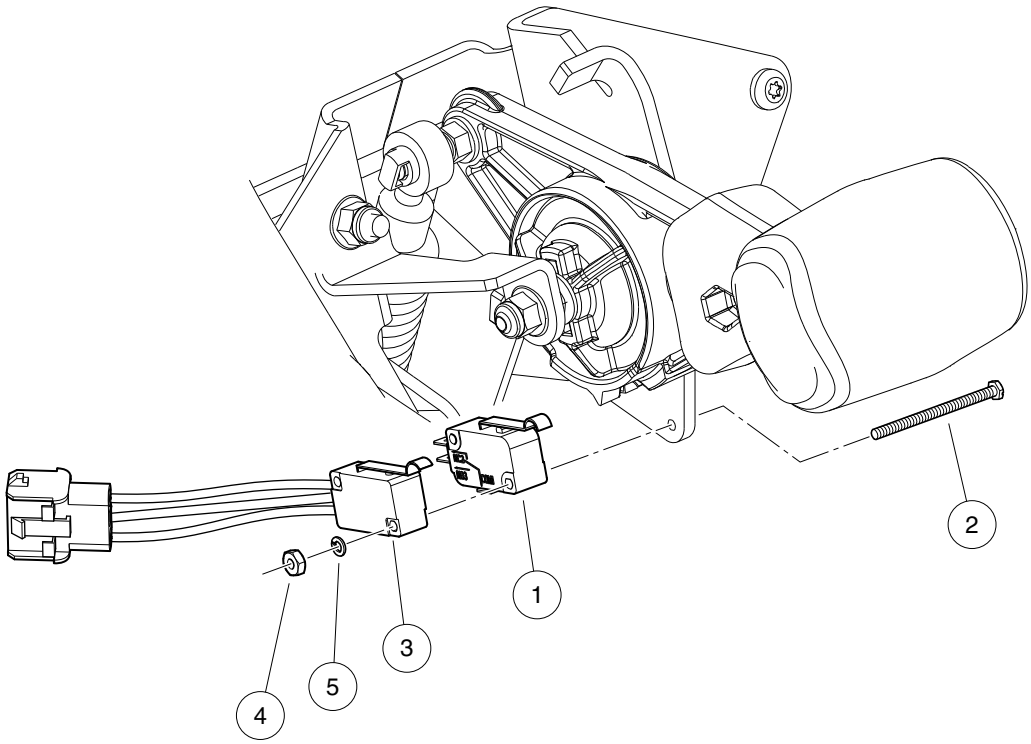


Figure 34-22 Reverse Buzzer Limit Switch

LOW OIL WARNING LIGHT

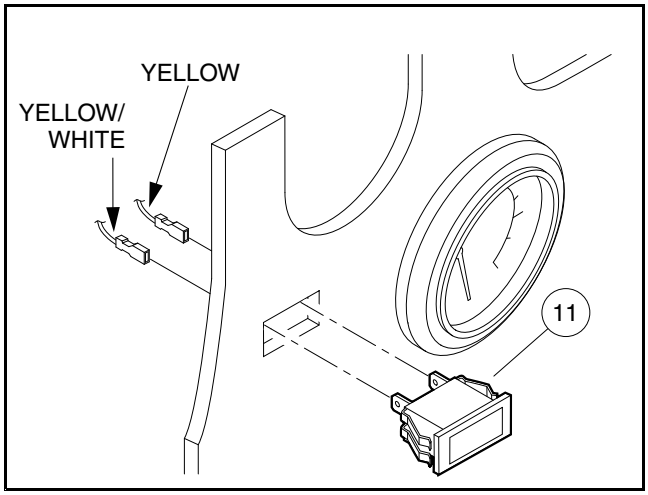
See General Warnings on page 1-2.

TESTING THE LOW OIL WARNING LIGHT

See Test Procedure 16 – Low Oil Warning Light (LED) on page 26-23.

LOW OIL WARNING LIGHT REMOVAL

1. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Remove the instrument panel. **See Key Switch Removal on page 27-32.**
3. Disconnect the wires from the low oil warning light (11) **(Figure 34-23, Page 34-26)**.
4. Press the retaining tabs and remove the low oil warning light from the instrument panel.



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Figure 34-23 Low Oil Warning Light

LOW OIL WARNING LIGHT INSTALLATION

1. Push a new unit into hole in instrument panel until plastic tabs engage **(Figure 34-23, Page 34-26)**.
2. Connect yellow and yellow/white wires from the wire harness to the low oil warning light.
3. Install the instrument panel.

3.1. Connect the electrical connector (3) **(Figure 34-19, Page 34-17)**.

3.2. Position the instrument panel (2) on the dash assembly. Make sure tabs on upper edge properly engage with the corresponding slots on the dash assembly. Ensure that there are no wires exposed or pinched during positioning.

3.3. Secure instrument panel to the dash assembly with three screws (1). Tighten screws to 1.8 lb·ft (2.5 N·m).

4. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.

FUEL GAUGE

See General Warnings on page 1-2.

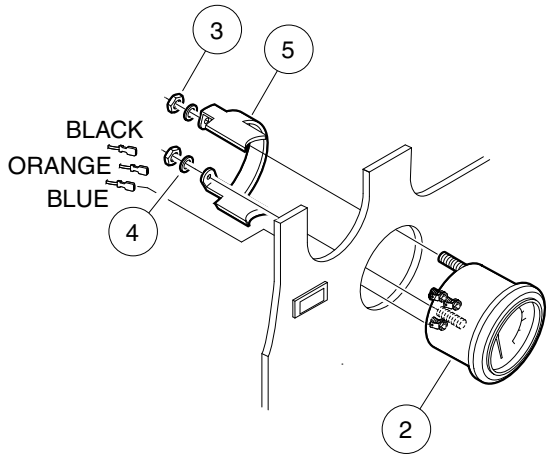
With the key switch in the OFF position, the fuel gauge reads empty. When the key switch is turned to ON, the fuel gauge becomes active.

TESTING THE FUEL GAUGE

See Test Procedure 22 – Fuel Gauge on page 33-36.

FUEL GAUGE REMOVAL

1. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Remove the instrument panel. **See Key Switch Removal on page 27-32.**
3. Disconnect the three wires from the fuel gauge **(Figure 34-24, Page 34-27)**.
4. Remove the two hex nuts (3) and lock washers (4) from the threaded studs on the back of the gauge (2). Remove the mounting bracket (5) from the back side of the fuel gauge and remove the gauge from the instrument panel.



Bracket (5) may vary in appearance.

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Figure 34-24 Fuel Gauge Installation

FUEL GAUGE INSTALLATION

1. Install a new fuel gauge into hole in instrument panel until flange seats against panel **(Figure 34-24, Page 34-27)**.
2. Slide the mounting bracket (5) onto the two threaded studs on the fuel gauge and secure with two lock washers (4) and two hex nuts (3). Tighten to 2.5 lb·in (0.28 N·m). Place one drop of Loctite® on each hex nut. Do not allow Loctite® to come into contact with the fuel gauge casing.
3. Connect the blue wire from the wire harness to the (I) terminal, the orange wire from the wire harness to the (S) terminal, and the black wire from the wire harness to the (G) terminal. **See Sonic Weld and Diode Locations on page 33-10.**
4. Install the instrument panel.

4.1. Connect the electrical connector (3) **(Figure 34-19, Page 34-17)**.

4.2. Position the instrument panel (2) on the dash assembly. Make sure tabs on upper edge properly engage with the corresponding slots on the dash assembly. Ensure that there are no wires exposed or pinched during positioning.

4.3. Secure instrument panel to the dash assembly with three screws (1). Tighten screws to 22 lb·in (2.5 N·m).

5. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.

FUEL LEVEL SENDING UNIT

See General Warnings on page 1-2.

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.

TESTING THE FUEL LEVEL SENDING UNIT

See Test Procedure 19 – Fuel Level Sending Unit on page 26-27.

HOUR METER

See General Warnings on page 1-2.

The hour meter displays the number of hours of use in increments of 0.1 hour.

TESTING THE HOUR METER

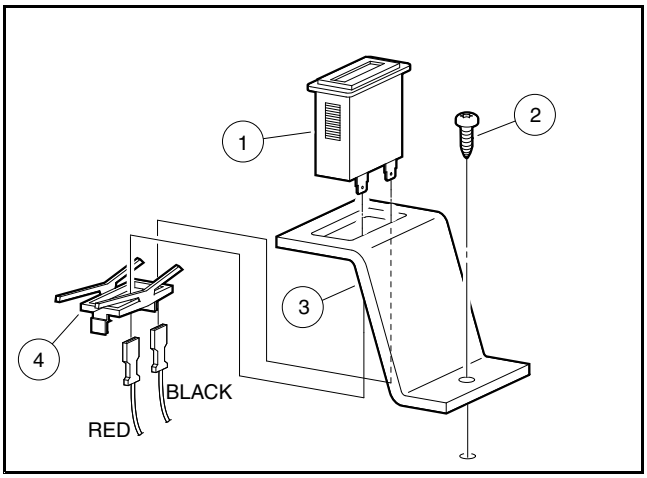
See Test Procedure 23 – Hour Meter on page 33-37.

HOUR METER REMOVAL

1. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Disconnect the wires from the hour meter (1) **(Figure 34-25, Page 34-29)**.
3. Remove screw (2) to release bracket (3).
4. Remove keeper (4) from hour meter to release meter (1) from bracket (3).

HOUR METER INSTALLATION

1. Install a new hour meter into bracket (3) and secure it by sliding the keeper (4) onto it **(Figure 34-25, Page 34-29)**.
2. Connect wires to the hour meter.
3. Position bracket (3) on the vehicle and secure in place with screw (2).



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Figure 34-25 Hour Meter Installation

OIL LEVEL SENSOR

See General Warnings on page 1-2.

TESTING THE OIL LEVEL SENSOR

See Test Procedure 18 – Oil Level Sensor on page 33-33.

OIL LEVEL SENSOR REMOVAL

See Oil Level Sensor Removal on page 35-12.

OIL LEVEL SENSOR INSTALLATION

See Oil Level Sensor Installation on page 35-12.

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.**
- **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, top post 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,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.

TESTING THE BATTERY

See Test Procedure 1 – Battery on page 26-9.

See Test Procedure 17 – Battery Test (Under Load) on page 26-24.

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 lb·in (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. **See Self-Discharge on page 27-2.**
3. Check battery periodically to see that it is in a full state of charge. **See Charging the Battery on page 27-3.**
4. Keep battery hold-down clamp tight. **See Vibration Damage on page 27-2.**

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. **See Battery Storage on page 27-4.**

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

Also see DANGER at beginning of Battery topic.

1. Turn the key switch OFF and remove the key. Place the Forward/Reverse handle in the NEUTRAL position. Chock the wheels.
2. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
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

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

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 41 lb·in (4.3 N·m). A loose battery clamp may allow the battery to become damaged from vibration or jarring.
3. Connect battery and spark plug wire(s). **See Connect the Battery - Gasoline Vehicles on page 1-4.**

BATTERY STORAGE

Also see DANGER at beginning of Battery topic.

1. Keep the battery clean and free of corrosion. **See Preventive Maintenance on page 27-2.**
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. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
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

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.**

GROUND CABLES

NOTE: *Verify that all cables (fuel tank, engine, battery, starter/generator and voltage regulator) are connected securely.*

TESTING THE GROUND CABLES

See Test Procedure 3 – Ground Cables on page 26-11.

Pagination Page

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

GENERAL INFORMATION

See General Warnings on page 1-2.

This vehicle is powered by a Subaru EX40, high-compression, chain driven, overhead cam engine. The engine offers a heavy-duty construction featuring cast iron cylinder liner for longer life, dual ball bearing crankshaft support, low oil level sensor and heavy-duty air cleaner system, to name a few characteristics. **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. For complete instruction on engine disassembly, repair, rebuilding, and reassembly, see your authorized dealer.

Test cylinder compression using a standard compression tester. Low compression would normally indicate a problem in the cylinder assembly such as defective rings, gaskets, etc. Compression should be:

At a normal cranking speed of 1050 to 1100 RPM, the compression should typically be approximately 167 psig (1151 kPa). This value could vary slightly depending on wear of components affecting compression.

See the Subaru EX40 Engine Repair and Rebuild Manual for complete teardown, 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.

ENGINE ROTATION

When turning the crankshaft by hand, always turn it counterclockwise as viewed from the clutch side of the engine.

TORQUE SPECIFICATIONS

ITEM	SIZE	TORQUE	
Flywheel retaining nut	M18	80 lb·ft (110 N·m)	
Crankcase cover to block bolts	M8	250 lb·in (28.3 N·m)	
Cylinder head bolts	M10	**1st Step** **New head and bolts:** 159 lb·in (18 N·m)	**2nd Step** **New head and bolts:** 336 lb·in (38 N·m)
		Used head and bolts: 159 lb·in (18 N·m)	**Used head and bolts:** 265 lb·in (30 N·m)
	M8	159 lb·in (18 N·m)	2nd step not needed
Connecting rod bolts	M8	221 lb·in (25 N·m)	
Spark plug	13/16 in. (21 mm) plug socket	**New:** 120 lb·in (13.5 N·m)	
		Re-tightening: 216 lb·in (24.5 N·m)	
Exhaust flange nuts	M8	177 lb·in (20 N·m)	
Ignition coil	M6	71 lb·in (8 N·m)	
Oil sensor	M6	80 lb·in (9 N·m)	
Oil drain plug	M14	18 lb·ft (24.4 N·m)	
Fan housing screws	M6	90 lb·in (10 N·m)	
Fan cover screws	M6	25 lb·in (2.8 N·m)	
Bolts marked with “4” (when used with nuts)	M8 M6 M5	130 lb·in (15 N·m) 50 lb·in (5.9 N·m) 30 lb·in (3.4 N·m)	

ADJUSTMENTS AND SETTINGS

ITEM	VALUES
Spark plug gap	0.024 to 0.028 in. (0.6 to 0.7 mm)
Valve clearance – Intake & Exhaust (cold)	0.0047 to 0.0059 in. (0.12 to 0.15 mm)
Ignition coil air gap	0.012 to 0.020 in. (0.3 to 0.5 mm)
Compression pressure:	167 psig (1151 kPa) Allowable Lower Pressure: 120 psig (827 kPa)

ENGINE OIL – GASOLINE VEHICLE

Even though the low oil warning light on the dash should illuminate if oil level becomes low, engine oil level should be checked monthly. Vehicle should be on a level surface when checking oil. Do not overfill with oil.

Engine Oil Level Check

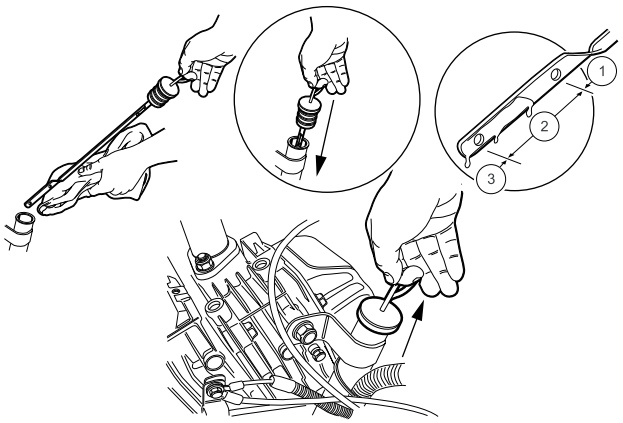
1. Remove the oil level dipstick from the oil filler tube, and wipe oil off dipstick **(Figure 35-1)**. **See following CAUTION.**

CAUTION

- **Do not remove dipstick while engine is running.**

2. Check oil by fully inserting the dipstick into the oil filler tube and immediately removing it.
3. If the oil level is at or below the low level mark on the dipstick gauge, add oil until the level is between low and full levels (safe level).
4. Insert the dipstick into the oil filler tube. **See following NOTE.**

NOTE: *Properly recycle or dispose of used oil in accordance with local, state, and federal regulations.*



1. Full level 2. Safe level 3. Low level

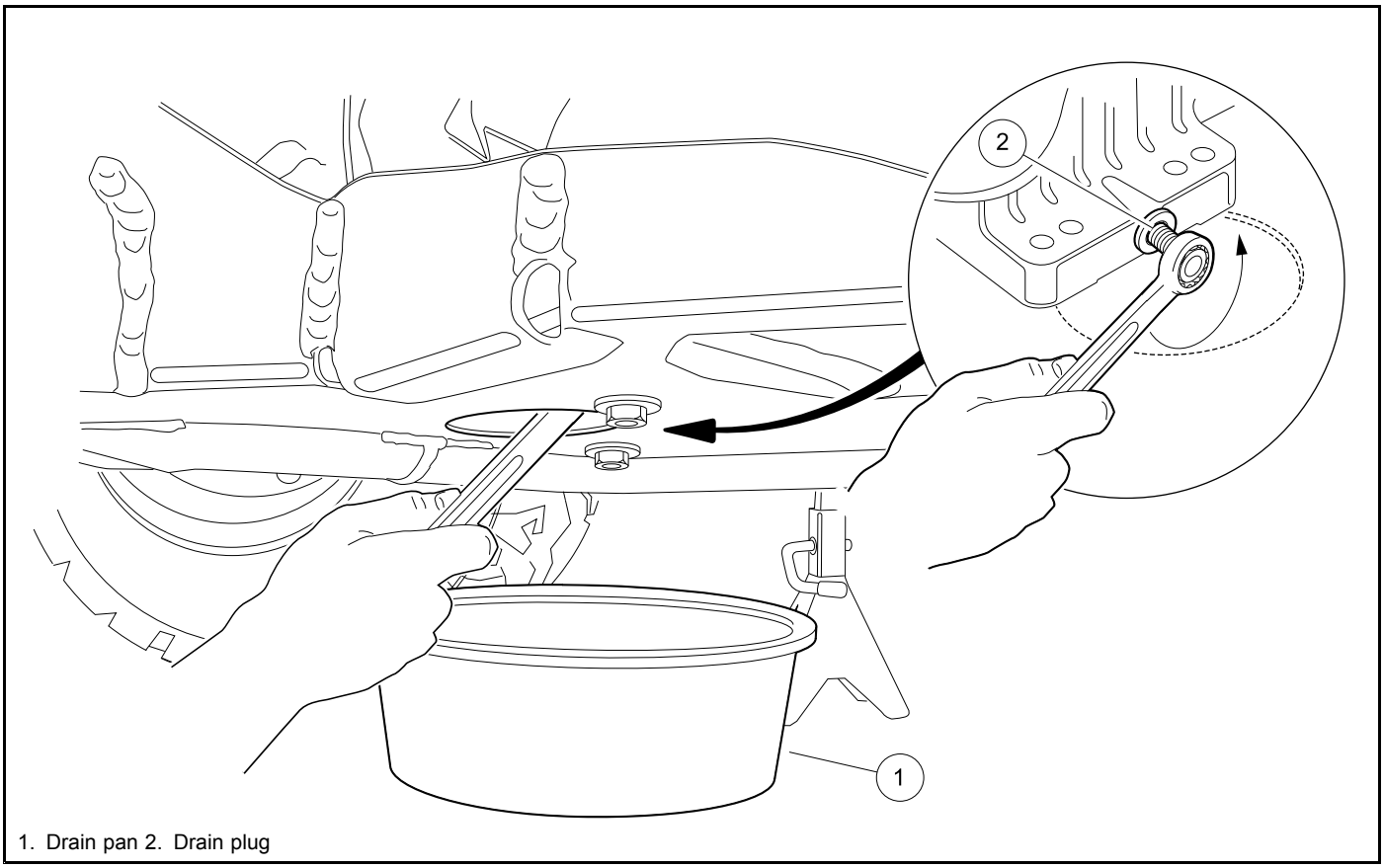
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Figure 35-1 Engine Oil Level Check

Engine Oil Change

Engine oil should be changed after the first 100 hours of operation. After that, it should be changed every 200 hours of operation or annually, whichever comes first.

1. Turn the key switch to the OFF position, then remove the key. Place the Forward/Reverse handle in the NEUTRAL position. Chock the front wheels.
2. Access the engine compartment and place the Maintenance/Operate switch in the MAINTENANCE position.
3. Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
4. Position a pan designed for oil changes under the drain plug (1) **(Figure 35-2)**.



1. Drain pan 2. Drain plug

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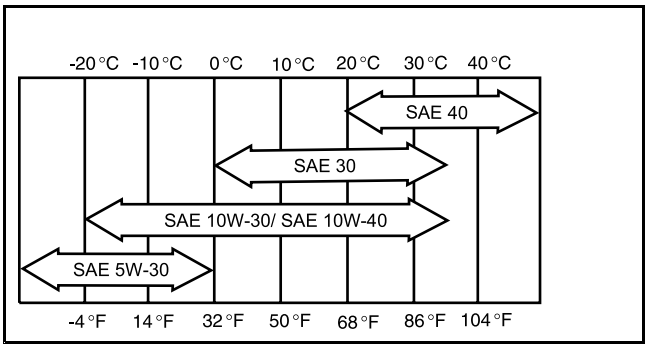
Figure 35-2 Engine Oil Drain Plug and Pan

5. Use a 14 mm socket or wrench to remove the drain plug, turning it counterclockwise, and allow the engine oil to drain into the pan. **See following WARNING.**

⚠ WARNING

- **Do not attempt to change engine oil when the engine is hot or even warm. Engine oil can cause skin burns.**
- **Wear safety glasses or approved eye protection when servicing the vehicle. Wear rubber gloves when handling oil drain plug and oil drain pan.**

6. Clean the oil drain plug threads with solvent to remove oil and oil residue. Make sure that the compression washer remains on the drain plug.
7. Use a 14 mm socket or wrench and replace the oil drain plug, turning it clockwise, and tighten to 18 lb·ft (24.4 N·m).
8. Remove the dipstick and add engine oil into the dipstick port. Use a funnel or pour spout to direct the oil into the dipstick port. The engine requires 40.5 fl-oz (1.2 L) of oil per change. 10W-30 or 5W-30 grade SE or higher is recommended. Refer to oil viscosity guidelines for selection of oil grade **(Figure 35-3)**. Replace the dipstick.



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Figure 35-3 Oil Viscosity Chart

9. Connect battery and spark plug wire.
   See Connect the Battery - Gasoline Vehicles on page 1-4.
10. With the Forward/Reverse handle in the NEUTRAL position and the Maintenance/Operate switch in the OPERATE position, start and run the engine for a few minutes. Observe the drain plug from under the vehicle and watch for oil leaks. If leaks appear, begin with step 1 and repeat the appropriate steps as needed to correct the problem.
11. Remove the dip stick and check the engine oil as a final step. Replace the dip stick.

SPARK PLUG

Spark plugs are selected to suit specific engine design and vehicle operating conditions. The spark plug is designed to give maximum life and efficient combustion of fuel. The spark gap should be set from 0.024 to 0.028 in. (0.6 to 0.7 mm).

Spark Plug Removal

See General Warnings on page 1-2.

⚠ CAUTION

- **Before removal and disassembly, clean the engine.**

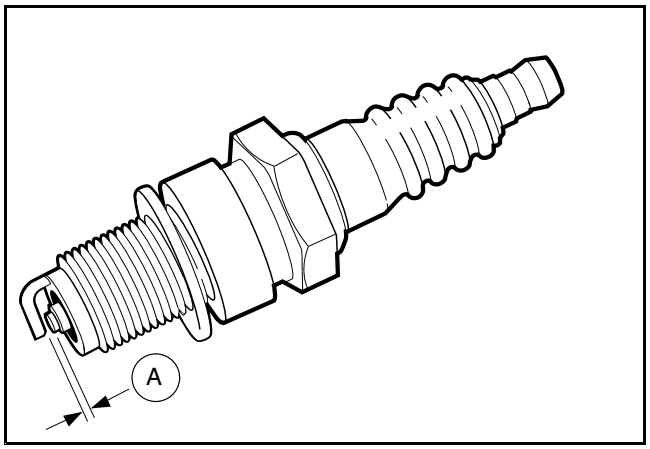
Remove all dirt from plug base in the cylinder head before removing plug. Use a 13/16 in. (21 mm), deep well socket with ratchet or spark plug wrench to loosen the plug.

Spark Plug Cleaning, Inspection and Repair

Examine the plug **(Figure 35-4, Page 35-6)**. The deposits on the plug base and electrode are an indication of the correct heat range and efficiency as well as a guide to the general condition of the engine, fuel and air mixture and ignition system. If all of the above conditions are proper, the spark plug should be a light brown color. There should be no bridging between the electrode and base. The electrode should not be eroded. Black color, excessive carbon, and/or a wet plug indicates that the fuel is too rich. White, burned or melted electrodes indicate the fuel is too lean or pre-igniting. Oily deposits on the plug electrode are an indication of worn rings, valve guides, cylinder wall, etc. Also examine the spark plug wire. Remove rubber boot and inspect internal spring for damage. Inspect spark plug wire for damage and be sure spring coil is securely attached to spark plug. **See following WARNING.**

⚠ WARNING

- **Remove spark plug wire to avoid accidental start up of the engine when servicing vehicle. To avoid ignition of fuel and serious personal injury or death, never try to start the engine with plug removed from engine.**



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Figure 35-4 Spark Plug

Testing the Spark Plug

Check the sparking ability of a cleaned and properly gapped plug on a sparking comparator if possible. Spark should be blue and strong and able to jump a 5/16-in. (8 mm) gap.

Setting the Spark Gap

1. Pass a contact point file between the electrodes to produce flat, parallel surfaces to facilitate accurate gauging.
2. Use a wire type gauge. Bend the outside or ground electrode so only a slight drag on the gauge is felt when passing it between the electrode. Never make an adjustment by bending the center electrode. Set gap (A) from 0.024 to 0.028 in. (0.6 to 0.7 mm) **(Figure 35-4, Page 35-6)**.

Spark Plug Installation

NOTE: *Before installing the plug, check the condition of the threads in the cylinder head. Soften deposits in cylinder head threads with penetrating oil and clean the threads with a tap if necessary.*

Use a high temperature, anti-seize lubricant on the threads of the spark plug to reduce friction when installing a new plug, and reduce "gauling" and thread seizing for future replacements.

Install the spark plug by threading it in until finger tight, then tighten the spark plug to the following torque:

- **New:** 120 lb·in (13.5 N·m).
- **Re-tightening:** 216 lb·in (24.5 N·m).

BREATHER

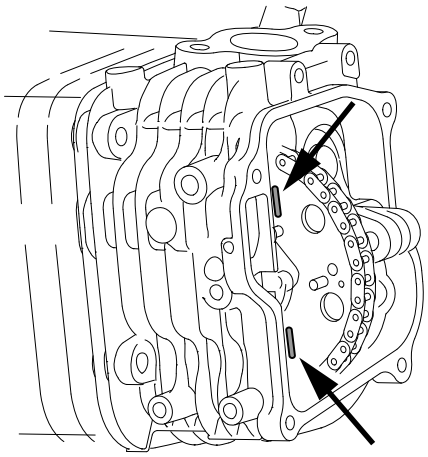
The function of the breather is to create a vacuum in the crankcase which prevents oil from being forced out of the engine through the piston rings, oil seals or gaskets. The breather has a reed valve which limits the direction of air flow caused by the piston moving up and down. Air can flow out of the crankcase, but the one-way reed valve blocks return flow and therefore maintains a vacuum in the crankcase.

Oil laden air in the crankcase passes through the reed valve and expands into the rocker camber. In the rocker camber most oil separates from the air and drains back to the crankcase. The air passes through a tube and vents to the intake manifold.

VALVE CLEARANCE CHECK AND ADJUSTMENT

NOTE: *Check and adjust clearance when the engine is cold.*

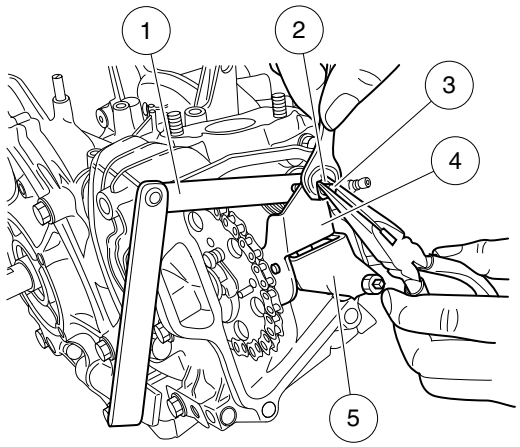
1. If equipped, remove air deflector from top of engine.
2. Remove rocker cover.
3. Turn the crankshaft until the piston is at top dead center of the compression stroke **(Figure 35-5, Page 35-7)**.
4. Using a feeler gauge (1), measure the clearance between the adjuster screw (3) and the top of the valve stem **(Figure 35-6, Page 35-7)**.
5. If necessary, loosen the lock nut (2) and turn the adjuster (3) up or down to adjust the clearance to 0.0047 in. (0.12 mm) for both intake and exhaust. Once clearance is correct, tighten the lock nut (2) to 52 lb·in (6 N·m).
6. After adjusting valve clearances, rotate the crankshaft several full revolutions and verify that the intake and exhaust valve clearance are still correct.



At TDC, the two punch marks on cam sprocket are parallel with the cylinder head surface.

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Figure 35-5 Top Dead Center (TDC) – EX40 Engine



1. Feeler Gauge 2. Lock Nut 3. Adjuster Screw 4. Rocker Arm (exhaust) 5. Rocker Arm (intake)

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Figure 35-6 Setting Valve Clearance – EX40 Engine

ENGINE REMOVAL

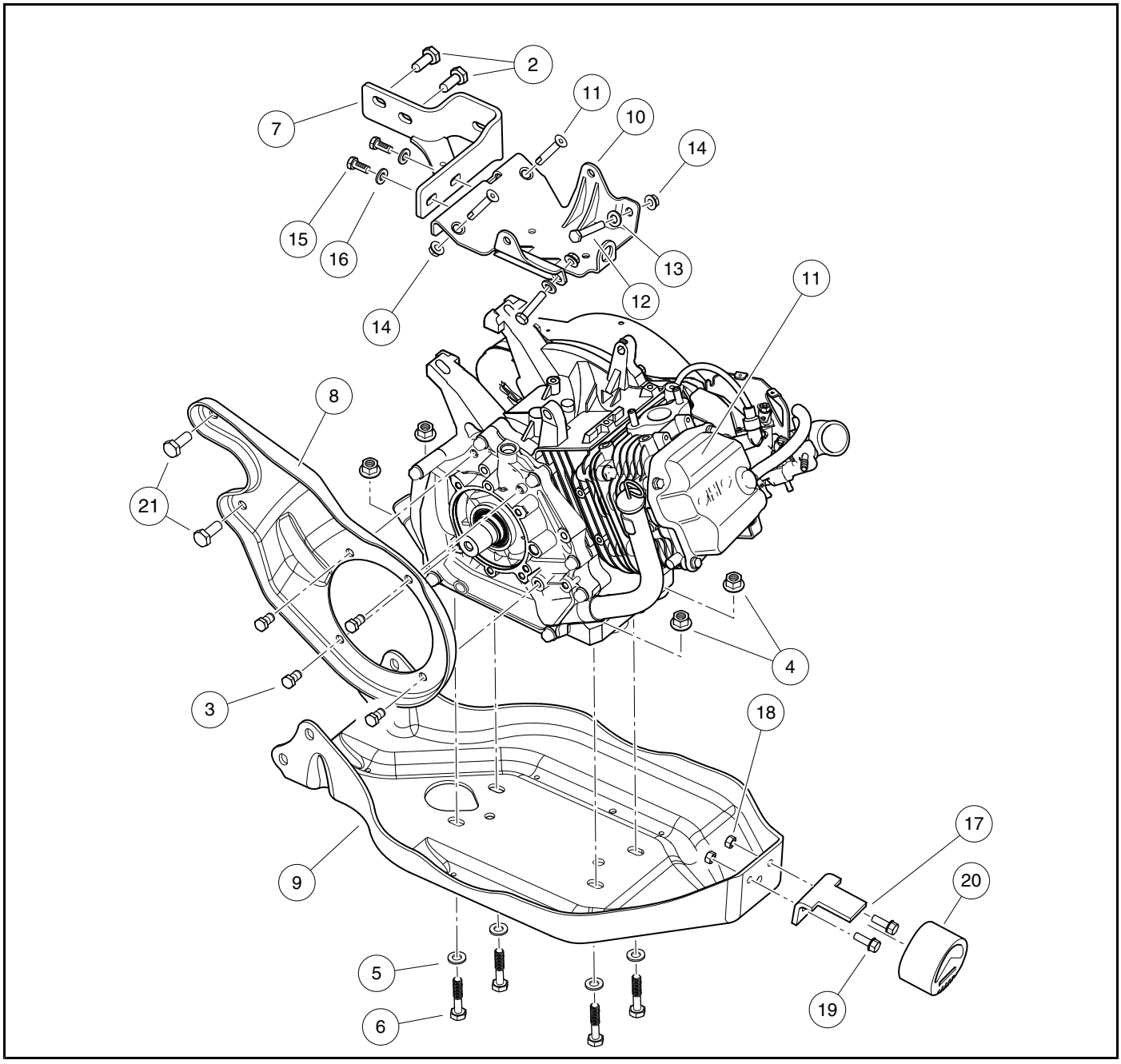


Figure 35-7 EX40 Engine and Mounting Brackets

⚠ CAUTION

- **Before removal and disassembly, clean the engine.**

1. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**

2. For some vehicles, the engine (1) 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 powertrain, **see Transaxle Removal on page 25-10**.
3. If equipped, remove air deflector from top of engine.
4. Disconnect governor cable and P-clamp, air intake hose, fuel line, wire harness connectors, ground cable, and accelerator cable P-clamp. **See Kohler ECH440 - Fuel System, Section 29, Page 29-1.**
5. Remove starter/generator and belt. **See Starter/Generator Removal, Section 27, Page 27-4.**
6. Remove drive clutch. **See Drive Clutch Removal, Section 31, Page 31-5.**
7. Remove muffler. **See Muffler Removal, Section 30, Page 30-1.**
8. Remove engine mounting hardware (2, 3, 4, 5, and 6) from muffler bracket (7), clutch plate (8), and engine pan (9) **(Figure 35-7, Page 35-8)**.
9. Lift engine (1) from engine pan (9). **See following NOTE.**

NOTE: *The engine weighs approximately 54 lb (24.5 kg).*

10. Remove crankcase oil drain plug and drain all oil from crankcase. Dispose of engine oil properly.
11. If replacing engine (1), remove starter/generator mounting weldment (10) and retain for installation on new engine. **See following NOTE.**

NOTE: *If replacing engine and throttle body, the ECU must also be replaced. Throttle bodies and ECU's are matched pairs.*

ENGINE INSTALLATION

1. If replacing engine (1), install starter/generator mounting weldment (10) on engine with screws (11), bolts (12), washers (13), and locknuts (14) **(Figure 35-7, Page 35-8)**. Tighten locknuts (14) only finger-tight at this time.
2. Install oil drain plug and tighten to 18 lb·ft (24.4 N·m).
3. Place engine (1) onto engine pan (9) and secure with mounting hardware (4, 5, and 6). Leave flange nuts (4) loose at this time.
4. Install clutch plate (8) with bolts (3 and 21). Leave bolts loose at this time.
5. Install bolts (2) through muffler bracket (7) into transaxle but do not tighten.
6. Tighten hardware in the following order:

6.1. Tighten bolts (3) to 27 lb·ft (36 N·m).

6.2. Tighten bolts (21) to 50 lb·ft (68 N·m).

6.3. Tighten bolts (2) to 50 lb·ft (68 N·m).

6.4. Tighten flange nuts (4) to 33 lb·ft (40.6 N·m).

6.5. Tighten locknuts (14) and bolts (15) to 17 lb·ft (23 N·m).

7. Install drive clutch. **See Drive Clutch Installation, Section 31, Page 31-11.**
8. Install muffler. **See Muffler Installation, Section 30, Page 30-2.**
9. Install starter/generator and belt. **See Starter/Generator Installation, Section 27, Page 27-14.**
10. If necessary, install powertrain. **See Transaxle Installation, Section 25, Page 25-13.**
11. Connect air intake hose, fuel line, wire harness connectors, ground cable and governor cable. **See Kohler ECH440 - Fuel System, Section 29, Page 29-1.**
12. If equipped, install air deflector on top of engine.
13. Secure accelerator cable and governor cable P-clamps to engine. Tighten P-clamp bolts to 36 lb·in (4.0 N·m).
14. Check all hardware for proper torque/tightness.
15. Fill engine to proper level with correct type of oil. **See Engine Oil – Gasoline Vehicle, Section 35, Page 35-2.**

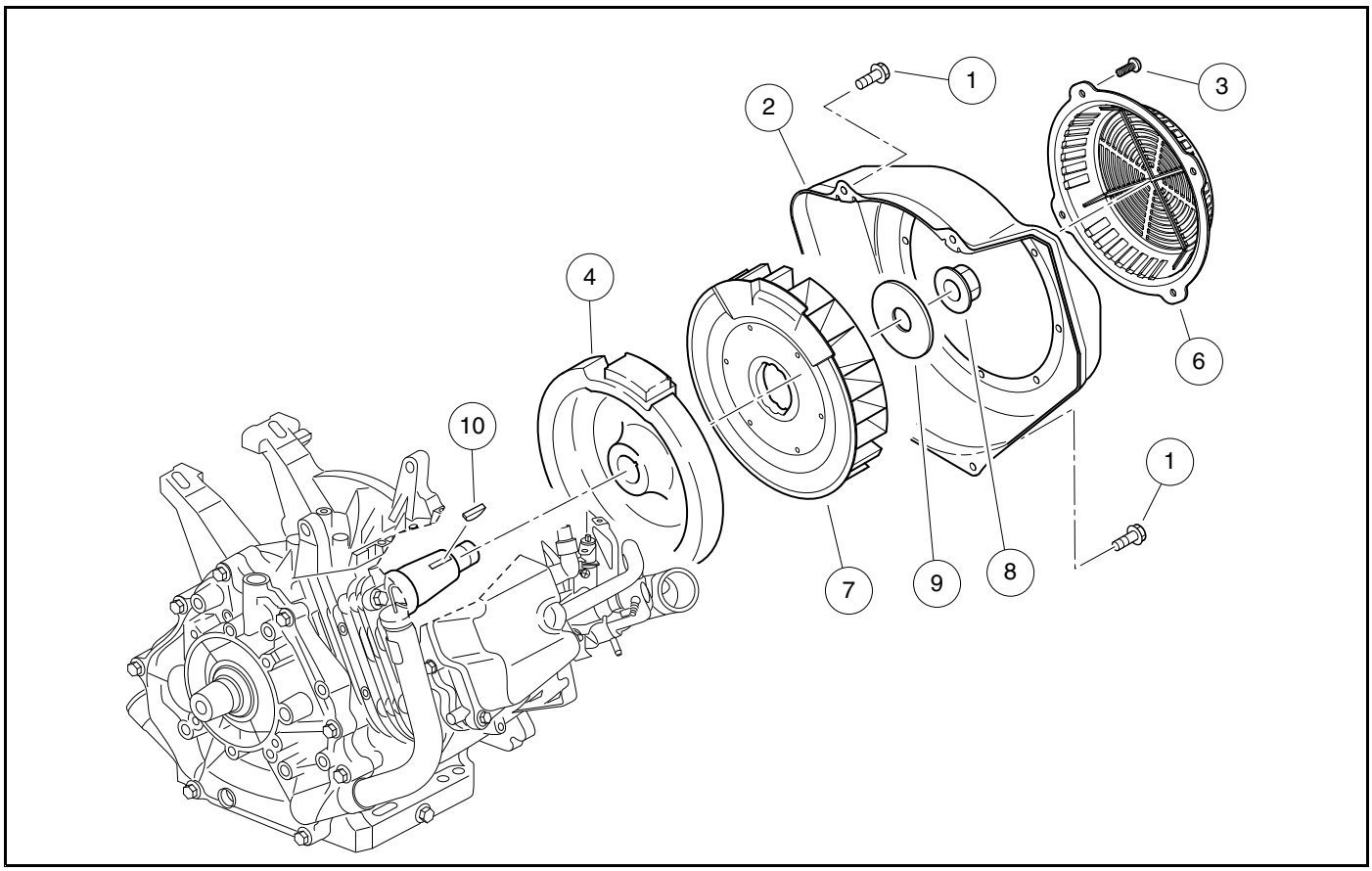
⚠ CAUTION

- **Do not overfill with oil.**

16. Connect battery and spark plug wire(s).
    See Connect the Battery - Gasoline Vehicles on page 1-4.
17. Adjust the engine RPM setting. **See Engine RPM Adjustment on page 29-9.**
18. Test-drive vehicle to ensure all systems are functional and correctly adjusted.

FLYWHEEL

See General Warnings on page 1-2.



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Figure 35-8 Flywheel, Fan and Fan Housing – EX40

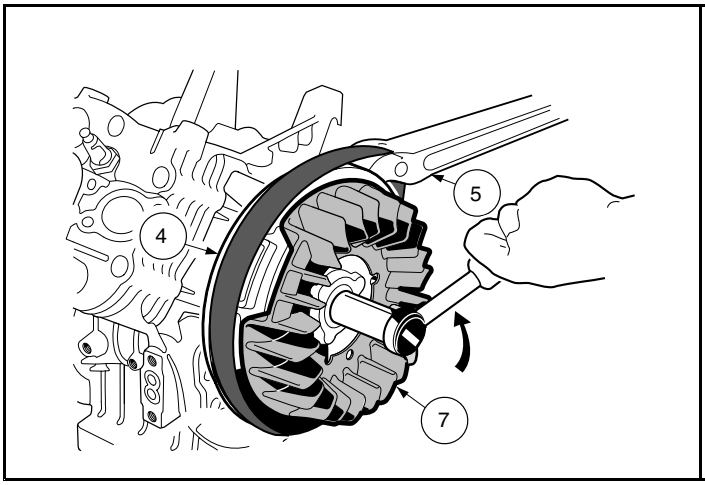
FLYWHEEL REMOVAL

1. Remove screws (1) and fan housing (2) **(Figure 35-8, Page 35-10)**.
2. Hold flywheel (4) only, not fan (7), with strap wrench (5) and use a 24 mm socket to remove flywheel nut (8) and flat washer (9) by turning it counterclockwise **(Figure 35-9, Page 35-11)**. **See following CAUTION.**

⚠ CAUTION

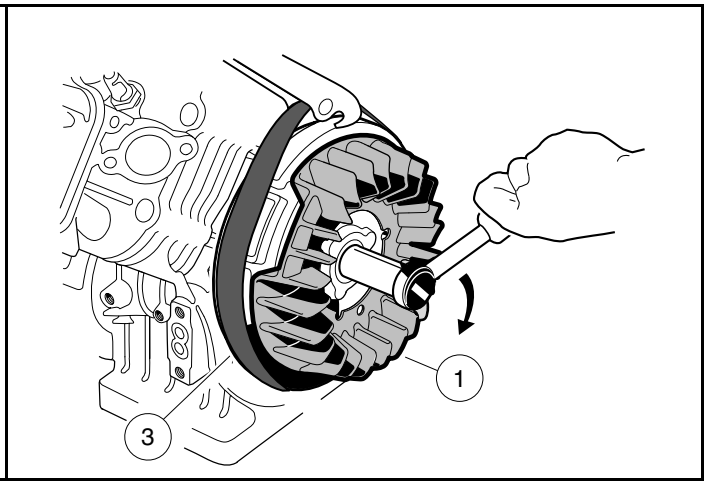
- **The flywheel nut has right-hand threads. Turn it clockwise to tighten, or counterclockwise to loosen.**
- **Do not damage the fan blades with the strap wrench. Do not place screwdriver or pry bar in the fan blades.**

3. Temporarily install flywheel nut (8) onto end of crankshaft to protect threads and to prevent flywheel (4) from falling off while being pulled.
4. Detach flywheel (4) from crankshaft with a large, two-jaw puller.
5. Remove flywheel nut (8) and flywheel (4) from crankshaft.
6. Remove woodruff key (10) from groove in crankshaft.



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Figure 35-9 Flywheel Nut Removal



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Figure 35-10 Fan and Flywheel Installation

FLYWHEEL INSTALLATION

1. Wipe off any oil on tapered portions of crankshaft and flywheel (4) **(Figure 35-8, Page 35-10)**.
2. Insert woodruff key (10) into keyway of crankshaft. Then align groove in flywheel (4) to woodruff key (10) and push flywheel onto crankshaft until it seats. Install and fan (7), flat washer (9), and nut (8) finger-tight.
3. Use a strap wrench (3) to keep flywheel and fan assembly (1) from turning while tightening flywheel nut to 80 lb·ft (110 N·m) **(Figure 35-10, Page 35-11)**. **See following CAUTION.**

⚠ CAUTION

- **The flywheel nut has right-hand threads. Turn it clockwise to tighten, or counterclockwise to loosen.**
- **Be careful not to damage the fan blades. Use a strap wrench to hold flywheel. Do not place screwdriver or pry bar between fan blades.**

4. Install fan housing (2) and tighten screws (1) to 90 lb·in (10 N·m) **(Figure 35-8, Page 35-10)**.

OIL LEVEL SENSOR

TESTING THE OIL LEVEL SENSOR

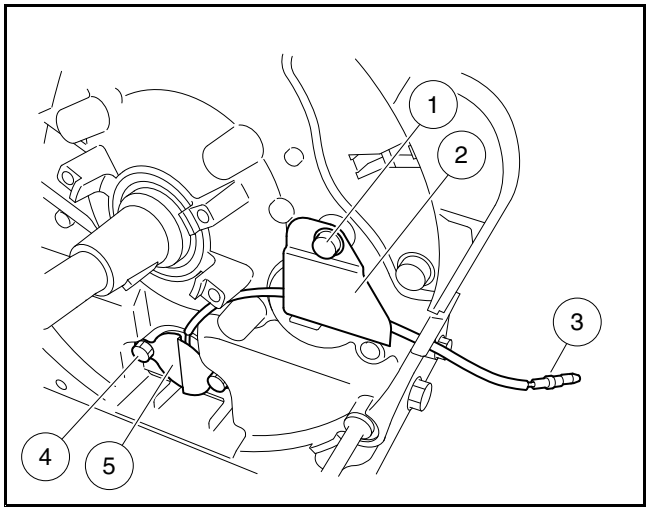
See Oil Level Sensor on page 33-33.

OIL LEVEL SENSOR REMOVAL

1. Drain oil from engine. **See Engine Oil – Gasoline Vehicle, Section 35, Page 35-2.**
2. Remove flywheel. **See Flywheel Removal on page 35-10.**
3. Remove bolt (1) securing oil sensor wire clamp (2) to engine.
4. Disconnect oil level sensor wire (3) from wire harness **(Figure 35-11, Page 35-12)**.
5. Remove two bolts (4) securing oil sensor (5) in engine.
6. Pull oil level sensor (5) out of engine.

OIL LEVEL SENSOR INSTALLATION

1. Lubricate oil level sensor o-ring with oil and carefully insert sensor (5) into engine until fully seated.
2. Secure sensor (5) to engine with two bolts (4) and tighten to 80 lb·in (9 N·m) **(Figure 35-11, Page 35-12)**.
3. Connect oil level sensor wire (3) to wire harness.
4. Secure oil sensor wire (3) with clamp (2) and bolt (1). Tighten bolt to 80 lb·in (9 N·m).
5. Install flywheel and fan shroud. **See Ignition Coil Removal on page 35-13.**
6. Fill engine to proper level with correct type of oil. **See Engine Oil – Gasoline Vehicle, Section 35, Page 35-2.**



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Figure 35-11 Oil Level Sensor – EX40

IGNITION COIL

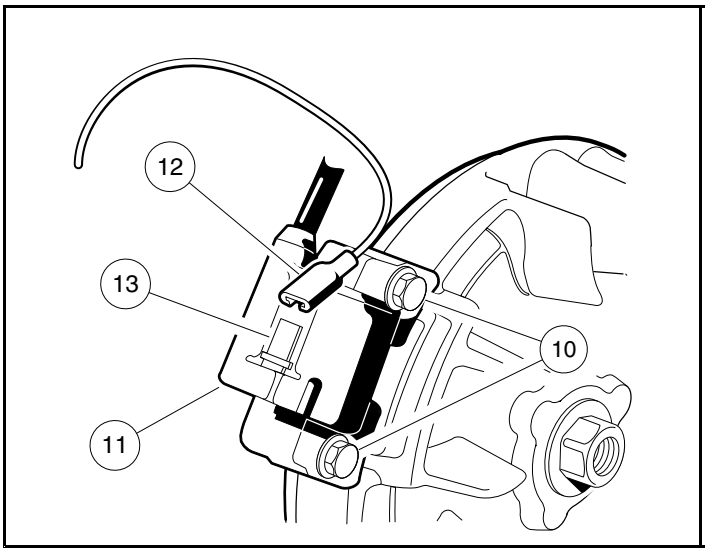
See General Warnings on page 1-2.

TESTING THE IGNITION COIL

See Test Procedure 13 – Ignition Spark on page 26-21 and Test Procedure 15 – Ignition Coil on page 33-31.

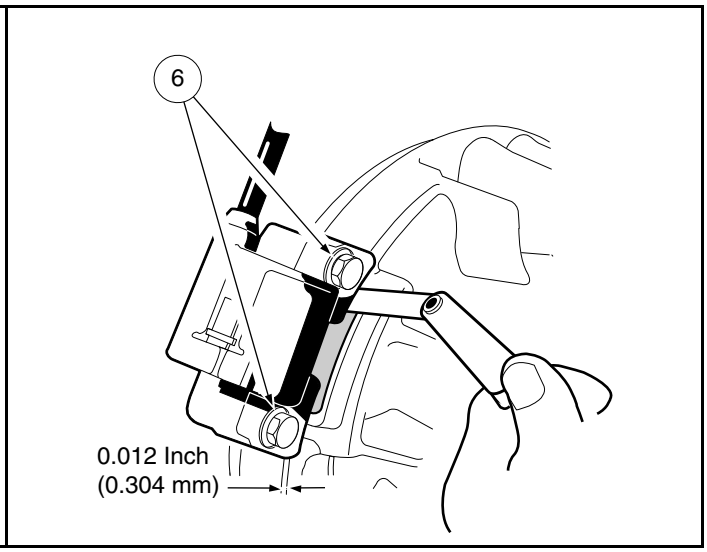
IGNITION COIL REMOVAL

1. Remove screws (1) and fan housing (2) **(Figure 35-8, Page 35-10)**.
2. Disconnect ignition coil primary lead wire (12) from spade terminal (13) on ignition coil (11) **(Figure 35-12, Page 35-13)**.
3. Remove two bolts (10) and pull ignition coil (11) from engine.



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Figure 35-12 Ignition Coil



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Figure 35-13 Adjust Ignition Coil Air Gap

IGNITION COIL INSTALLATION

1. Position ignition coil (11) onto engine and tighten two mounting bolts (10) finger-tight at this time **(Figure 35-12, Page 35-13)**.
2. Rotate flywheel until its magnet is positioned directly under ignition coil (11). Use a bronze feeler gauge to set air gap between ignition coil and flywheel magnet from 0.012 to 0.020 in. (0.3 to 0.5 mm) **(Figure 35-13, Page 35-13)**.
3. Tighten ignition coil bolts (6) to 71 lb·in (8 N·m).
4. Connect ignition coil primary lead wire (12) to terminal (13) on coil **(Figure 35-12, Page 35-13)**.

SNUBBER

See General Warnings on page 1-2.

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 35-14, Page 35-14)**.
2. Remove the two bolts (3) and two lock nuts (4) securing the snubber bracket (5) to the engine pan (1).
3. Slide snubber (2) and bracket (5) assembly toward battery to remove it from vehicle.
4. Slide snubber (2) off bracket (5).

SNUBBER INSTALLATION

1. Slide snubber (2) onto bracket (5) **(Figure 35-14, Page 35-14)**.
2. Install bracket and snubber assembly onto engine pan (1).
3. Tighten lock nuts (4) from 20 to 25 lb·ft (27.1 to 33.9 N·m).

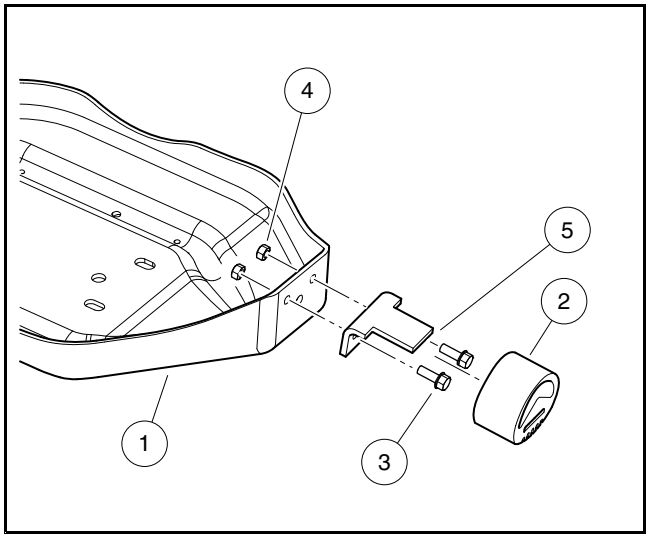


Figure 35-14 Snubber

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**
- **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 on page 29-11.**
- **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.**

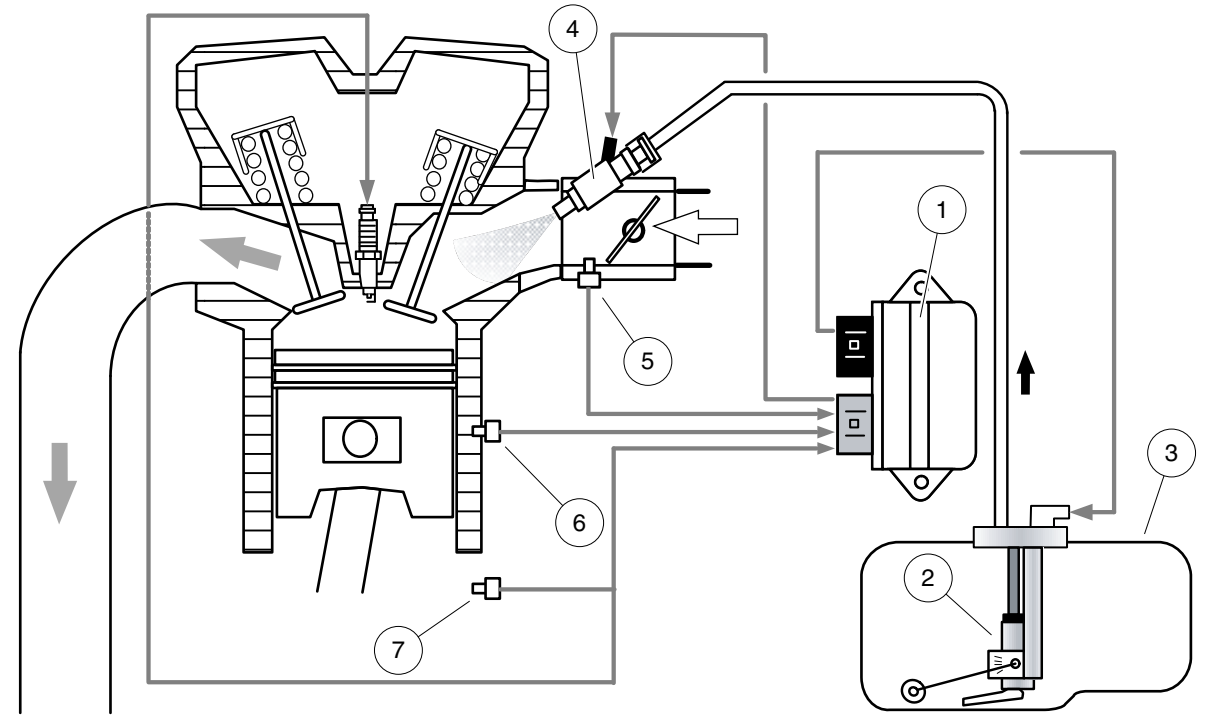
GENERAL INFORMATION

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

NOTE: *This manual covers ECU software version F6i33051.*

- The ECU and throttle body/fuel injector assembly are matched pairs and are not available separately
- Fuel pump and low oil warning light 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 blinks fault codes through the Low Oil Warning Lamp
- In-tank fuel pump
- Return-less system
- High fuel pressure system (36 to 38 psig (250 to 260 kPa))
- Controls fuel pump, fuel injector, and oil lamp
- Automatic altitude compensation
- Flow: 16 L per hour minimum @ 12-volts/36 psig (250 kPa)
- Current draw: 2-amps maximum
- Throttle Body Bore: 31 mm diameter
- Open-loop system (i.e. oxygen sensor not used)
- Separate EFI wire harness
- Fail-safe function



1. ECU 2. Fuel Pump 3. Fuel Tank 4. Fuel Injector 5. MAP Sensor 6. Engine Temperature Sensor 7. CDI Ignition Unit

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Figure 36-1 EFI System Components

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

- Shut off engine, disconnect battery, and wait 15 minutes or more to allow pressure to dissipate.

  – or –

- Unplug fuel pump module at fuel tank and crank engine for 5 seconds to start reducing fuel pressure. Pause and repeat an additional 5 seconds to allow pressure to dissipate.

NOTE: *To absorb any residual fuel that may be present in the fuel hose, place a rag or towel around the hose at the end being disconnected.*

THROTTLE BODY

See General Warnings on page 1-2.

Before suspecting the throttle body as the cause of poor engine performance, make sure the fuel and ignition systems are in proper operating condition. Check the following items:

- Spark plug and gap condition. **See Spark Plug on page 35-5.**
- Air filter element. **See Air Filter on page 36-12.**
- Air intake system (for restriction of air flow). **See Air Intake System on page 36-12.**
- Exhaust system (for restrictions). **See Kohler ECH440 - Exhaust System on page 30-1.**
- Fuel pump. **See Fuel Pump Module on page 29-18.**
- Fuel line. **See Fuel Line on page 29-13.**
- Fuel pickup screen or filter. **See Fuel Filter on page 29-25.**

THROTTLE BODY REMOVAL

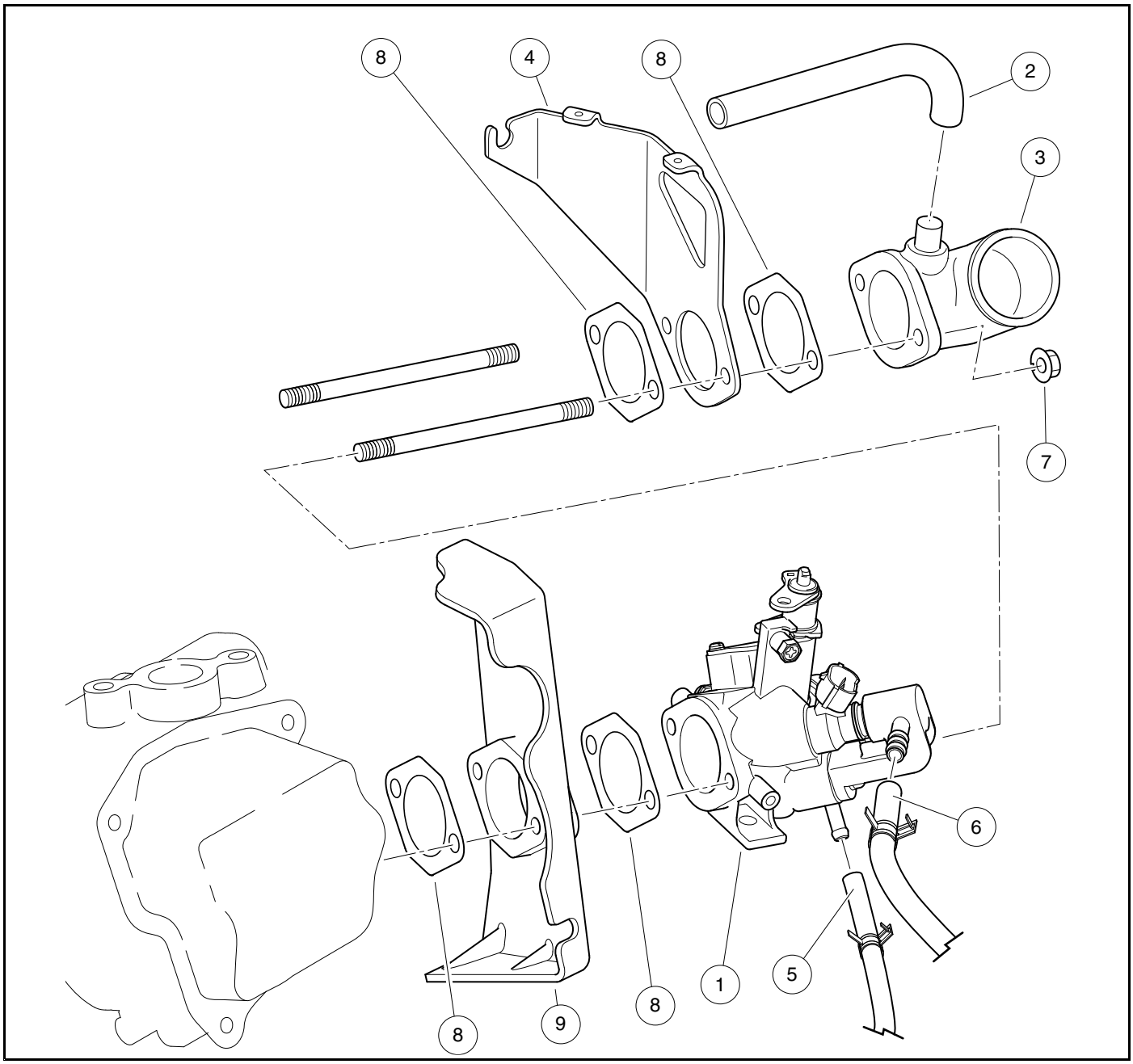
See General Warnings on page 1-2.

1. Turn the key switch to the OFF position and remove the key, place the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect battery. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. If equipped, remove air deflector from top of engine.
4. If necessary, remove fuel tank to increase access to the throttle body (1). **See Fuel Tank Removal, Section 29, Page 29-21.**
5. Clean the throttle body (1) and surrounding area **(Figure 36-2, Page 36-4)**.
6. Disconnect breather hose (2) from air intake adapter (3).
7. Disconnect governor cable from bracket (4).
8. Disconnect fuel injector and MAP sensor.
9. Remove spring clamps securing fuel line (6) and vent hose (5) to throttle body (1) and disconnect vent hose (5).
10. Disconnect fuel line (6) and drain into an appropriate container. **See following WARNING.** Temporarily plug fuel line to prevent fuel leakage.

⚠ 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 on page 29-11.**
- **Carefully drain any fuel into an approved container. Add drained fuel back into fuel tank or dispose of properly.**

11. Loosen air intake hose clamp and disconnect air intake hose.
12. Remove two flange nuts (7) and slide air intake adapter (3), bracket (4), gaskets (8), insulator (9), and throttle body (1) off threaded studs.



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Figure 36-2 Throttle Body – Exploded View

THROTTLE BODY INSTALLATION

See General Warnings on page 1-2.

1. Install throttle body (1) and its related components onto threaded studs in order as shown **(Figure 36-2, Page 36-4)**.
2. Install two flange nuts (7) and tighten to 53 to 71 lb·in (6 to 8 N·m).
3. Connect fuel line (6) and vent hose (5). Secure with spring clamps.
4. Connect fuel injector and MAP sensor.
5. Connect governor cable to bracket (4).
6. Connect breather hose (2) to air intake adapter (3).
7. Connect air intake hose and secure with hose clamp.
8. If removed, install fuel tank. **See Fuel Tank Installation, Section 29, Page 29-23.**
9. If equipped, install air deflector on top of engine.
10. Clean all spills and remove any drained gasoline from the area.
11. Connect battery.
    See Connect the Battery - Gasoline Vehicles on page 1-4.
12. Place the Forward/Reverse handle in the NEUTRAL position, chock the wheels, and the neutral lockout switch in the MAINTENANCE position **(Figure 25-1, Page 25-1)**.
13. 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.**

14. If no leaks are found, place the neutral lockout switch in the OPERATE position **(Figure 25-1, Page 25-1)**.
15. Test drive vehicle to ensure proper operation.

ENGINE CONTROL LINKAGES

See General Warnings on page 1-2.

⚠ 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.**
  - **–**

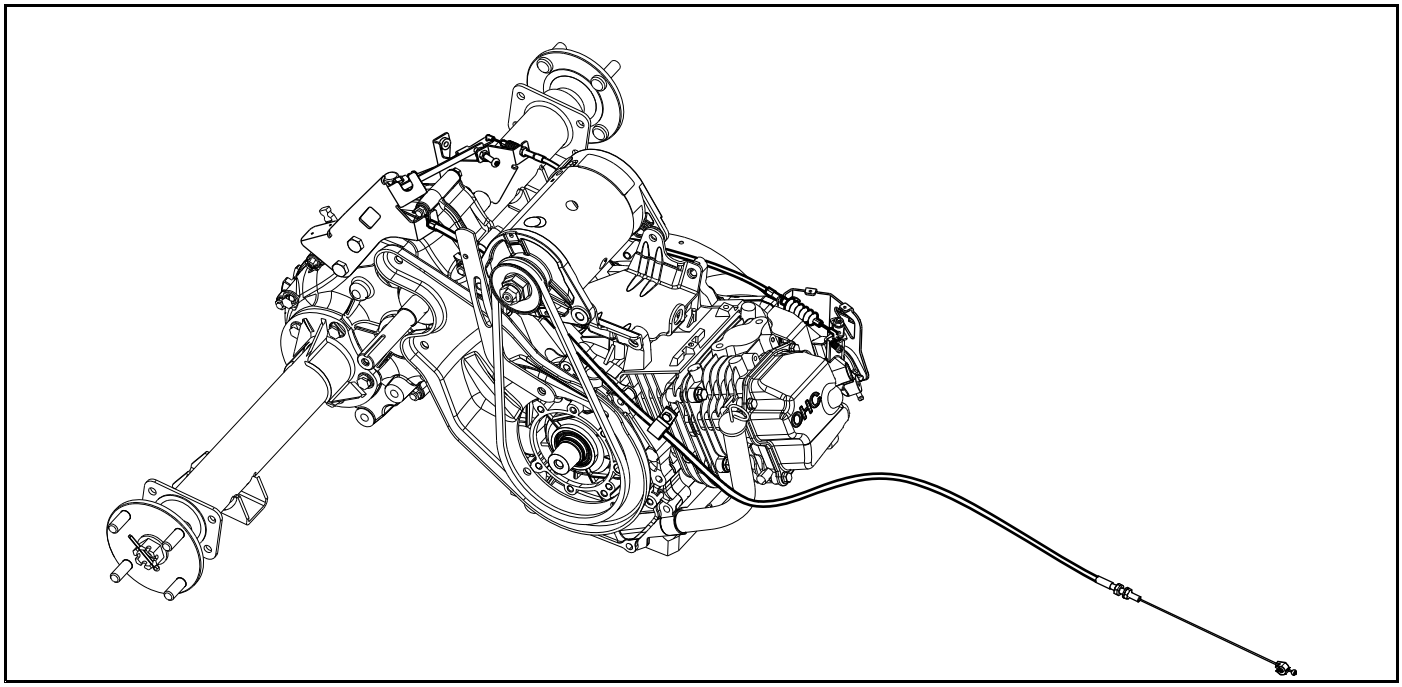
    See Disconnect the Battery - Gasoline Vehicles on page 1-3.

GENERAL INFORMATION

For proper vehicle operation, it is important the accelerator cable, 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.**



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Figure 36-3 Engine Control Linkages – EFI vehicles

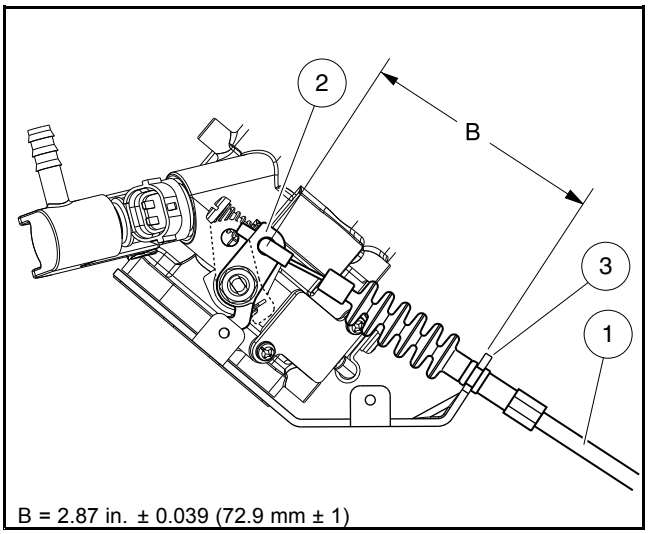
GROUND SPEED

NOTE: *If possible, the manufacturer recommends measuring ground speed when setting engine RPM.*

This vehicle should reach the forward ground speed specified in **Section 2 – Vehicle Specifications**. **See How to Measure Ground Speed on page 29-8.**

GOVERNOR CABLE

Governor Cable Removal



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Figure 36-4 Governor Cable At Throttle Body and Power Limiter Screw Gap Adjustment

1. Turn the key switch to the OFF position and remove the key, place the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. At engine:

3.1. If equipped, remove air deflector from top of engine.

3.2. Disconnect “Z” fitting of governor cable (1) from throttle lever (2) **(Figure 36-4, Page 36-7)**.

3.3. Unsnap governor cable (1) from throttle body bracket (3).

4. At transaxle:

4.1. Disconnect “Z” fitting of governor cable (1) from governor arm (4) **(Figure 36-5, Page 36-8)**.

4.2. Loosen jam nuts at governor bracket (5) and remove cable (1) from vehicle.

Governor Cable Installation and Adjustment

1. At engine:

1.1. Snap governor cable (1) into throttle body bracket (3) **(Figure 36-4, Page 36-7)**.

1.2. Connect “Z” fitting of governor cable (1) to throttle lever (2).

1.3. If equipped, install air deflector on top of engine.

2. At transaxle:

2.1. Slide bellows off threaded end of cable housing, separate jam nuts and place threaded end into governor bracket (5) **(Figure 36-5, Page 36-8)**.

2.2. Finger-tighten 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 (4).

3. Loosen adjustment screw jam nuts (6 and 10) and back off throttle stop screw (7) and power limiter screw (11) several turns **(Figure 36-6, Page 36-8)**.

4. Rotate governor arm (4) counterclockwise until it stops and hold in this position **(Figure 36-6, Page 36-8)**.

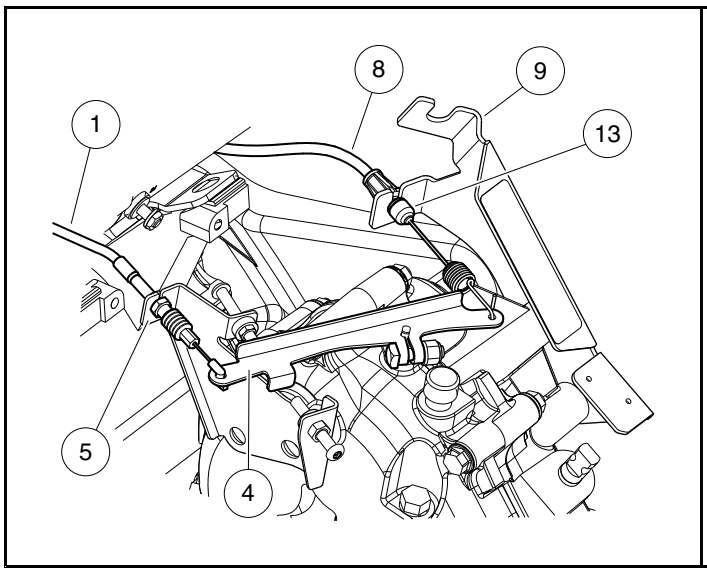
5. Adjust governor cable jam nuts until throttle lever (2) is at “wide open throttle” (WOT) **(Figure 36-4, Page 36-7)** and tighten the governor cable jam nuts to 36 lb·in (4.0 N·m).

6. While still holding this position, adjust power limiter screw (11) **(Figure 36-6, Page 36-8)** to set distance (B) at 2.87 in. (±0.039) (1.4 mm (±1)) as shown **(Figure 36-4, Page 36-7)** between throttle lever (2) and throttle body bracket (3). Tighten limiter screw jam nut (10) to 36 lb·in (4.0 N·m).

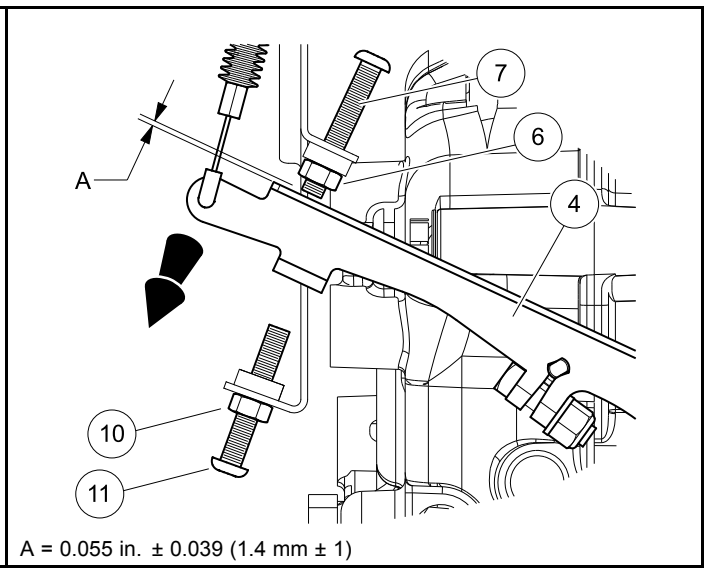
7. Release governor arm (4) to return to “idle” position.

8. Adjust gap (A) between governor arm (4) and throttle stop screw (7) to 0.055 in. (±0.039) (1.4 mm (±1)) as shown **(Figure 36-6, Page 36-8)**. Tighten stop screw jam nut (6) to 36 lb·in (4.0 N·m).

9. Check engine RPM adjustment. **See Engine RPM Adjustment on page 29-9.**



3130
Figure 36-5 Governor and Accelerator Cables At Governor Arm



3131
Figure 36-6 Throttle Stop Screw Gap

ACCELERATOR CABLE

Accelerator Cable Removal

1. Turn the key switch to the OFF position and remove the key, place the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.

2. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**

3. At transaxle:

3.1. Unhook spring fitting of accelerator cable (8) from governor arm (4) **(Figure 36-5, Page 36-8)**.

3.2. Unsnap accelerator cable (8) from FNR/accelerator cable bracket (9).

4. At pedal group:

4.1. Access the pedal group and disconnect accelerator cable clip from the accelerator pedal. **See Pedal Group Removal on page 5-5.**

4.2. Loosen jam nuts securing accelerator cable to underbody and remove accelerator cable (9) from vehicle .

Accelerator Cable Installation

1. At transaxle:

1.1. Hook spring fitting of accelerator cable (8) to governor arm (4) **(Figure 36-5, Page 36-8)**.

1.2. Snap accelerator cable (8) into FNR/accelerator cable bracket (9).

1.3. Push dust shield (13) onto end of cable housing.

2. At pedal group:

2.1. Insert the accelerator cable through the hole in the frame and feed it towards the pedal group. Connect the accelerator cable to the pedal group. **See Pedal Group – Gasoline Vehicle on page 5-5.**

2.2. Separate jam nuts (9) on cable and place threaded end into slot in underbody . Tighten jam nuts finger-tight.

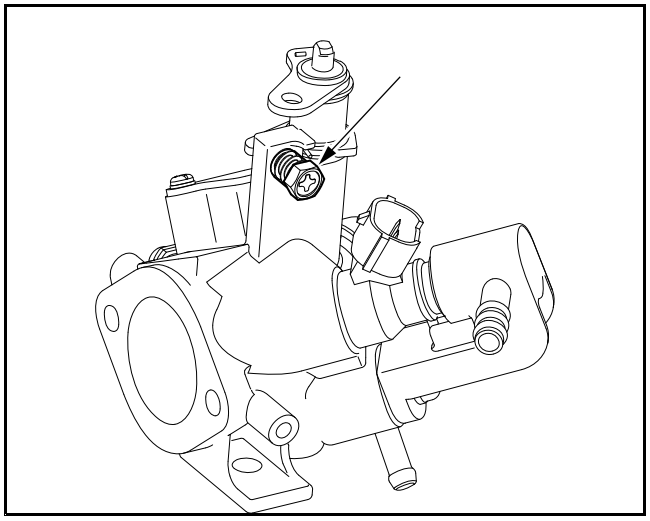
2.3. Before tightening the cable jam nuts, make sure the engine RPM adjustment is correct. **See Engine RPM Adjustment on page 29-9.**

3. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.

CLOSED THROTTLE OR IDLE ADJUSTMENT – VEHICLES

When the accelerator pedal is released, the engine will stop. Therefore, it is not possible to measure or set idling speed under normal vehicle operating conditions. Set throttle valve as follows:

1. Loosen the throttle body idle screw so that it is not touching the throttle lever **(Figure 36-7, Page 36-10)**.
2. Slowly tighten the idle screw until it lightly touches the throttle lever, then tighten it an additional 1 whole turn (360 degrees).



3047

Figure 36-7 Idle Screw

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 traveled, 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, proceed to step 2; otherwise, adjust governor. **See Governor Cable Installation and Adjustment on page 29-3.**
2. Connect battery and spark plug wire(s).
   See Connect the Battery - Gasoline Vehicles on page 1-4.
3. Measure vehicle ground speed. **See How to Measure Ground Speed on page 29-8.**
4. Compare measured ground speed with forward ground speed specified in **Section 2 – Vehicle Specifications**.
5. If adjustment is necessary, use the following procedures:

5.1. To **reduce** RPM, adjust the two jam nuts (6) to move the accelerator cable housing toward the rear of the vehicle until specified ground speed is reached **(Figure 5-6, Page 5-6)**. **See Section 2 – Vehicle Specifications.**

5.2. To **increase** RPM, adjust the two jam nuts to move the accelerator cable housing forward until specified ground speed is reached.

5.3. Be sure both jam nuts are locked against the underbody and check ground speed again. If ground speed needs to be adjusted, repeat previous step. **See following NOTE.**

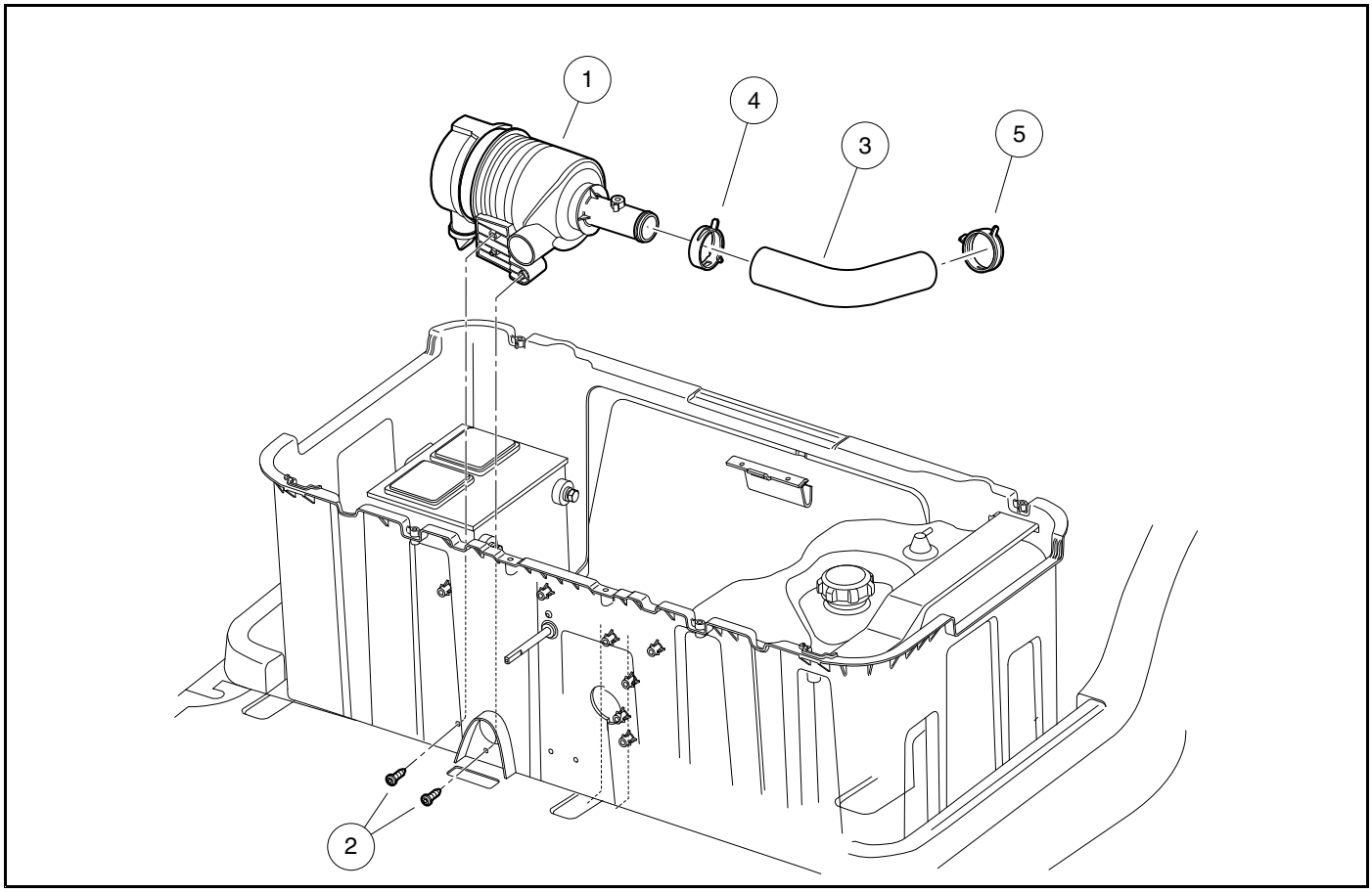
NOTE: *If more adjustment is required than the cable housing will allow, make sure the spring fitting on the other end of the accelerator cable is properly installed. Excessive drive belt and clutch wear can also prevent proper ground speed adjustment. Check them for excessive wear.* ***Section 38 — Subaru EX-40 - Clutches***

AIR INTAKE SYSTEM

See General Warnings on page 1-2.

GENERAL INFORMATION

The air intake system is a simple mechanism requiring very little or no maintenance. The system consists of an air cleaner (1) and air hose (3) mounted under the seat **(Figure 36-8, Page 36-12)**. The air cleaner draws clean, cool air from beneath the vehicle via an opening between the kick plate and the fuel bucket. The air passes through the air cleaner and hose to the throttle body.



3124a

Figure 36-8 Air Intake System

AIR FILTER

The air filter should be checked every year or 100 hours. More frequent service may be required in extremely dirty operating environments. Need for immediate servicing will be indicated by a loss of power, sluggish acceleration, or an engine which runs roughly with excessive black exhaust smoke.

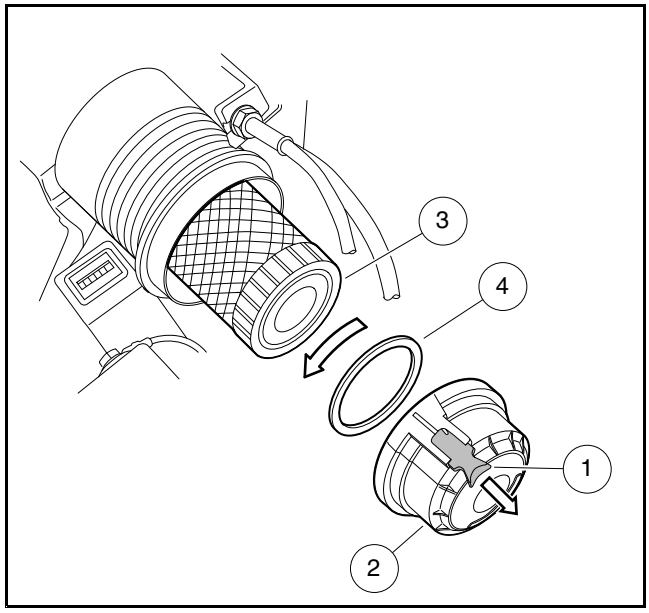
Air Filter Replacement

1. Access the engine compartment.
2. Pull the yellow tab (1) on the air filter cover (2) away from the air cleaner **(Figure 36-9, Page 36-13)**.
3. Rotate the cover counterclockwise to approximately the 10 o'clock position to release the internal locking tabs. Remove the cover.

4. Remove the air filter (3) and dispose of properly.
5. Using a clean cloth, wipe away any dust or dirt from inside the air cleaner. Remove all dirt build-up around the inside lip of the air cleaner housing or the cover will not seal properly.
6. Install new air filter, inserting the open end into the air cleaner housing first.
7. Check that the air intake gasket (4) is in place in the cover (2) and oriented correctly with the coated side of the gasket facing toward the air cleaner housing.
8. **Place the cover (2) over the air cleaner housing. Press firmly to engage the seals and rotate the cover clockwise until the yellow tab is at the 11 o'clock position.**
9. Press in the yellow tab (1) to lock the cover on the air cleaner. **See following CAUTION.**

CAUTION

- **Engine damage will occur if the air filter cover is not properly secured.**
- **If air cleaner is extremely dirty, clean thoroughly.**
- **Use only Club Car replacement air filters or equivalent. The use of other air filters could result in engine damage. If the air filter is too small, the cover will seat before the filter can seal, leaving space for dirt to pass into the engine on all sides of the element. This will damage the engine and void the warranty.**



2688

Figure 36-9 Air Filter

AIR INTAKE SYSTEM REMOVAL

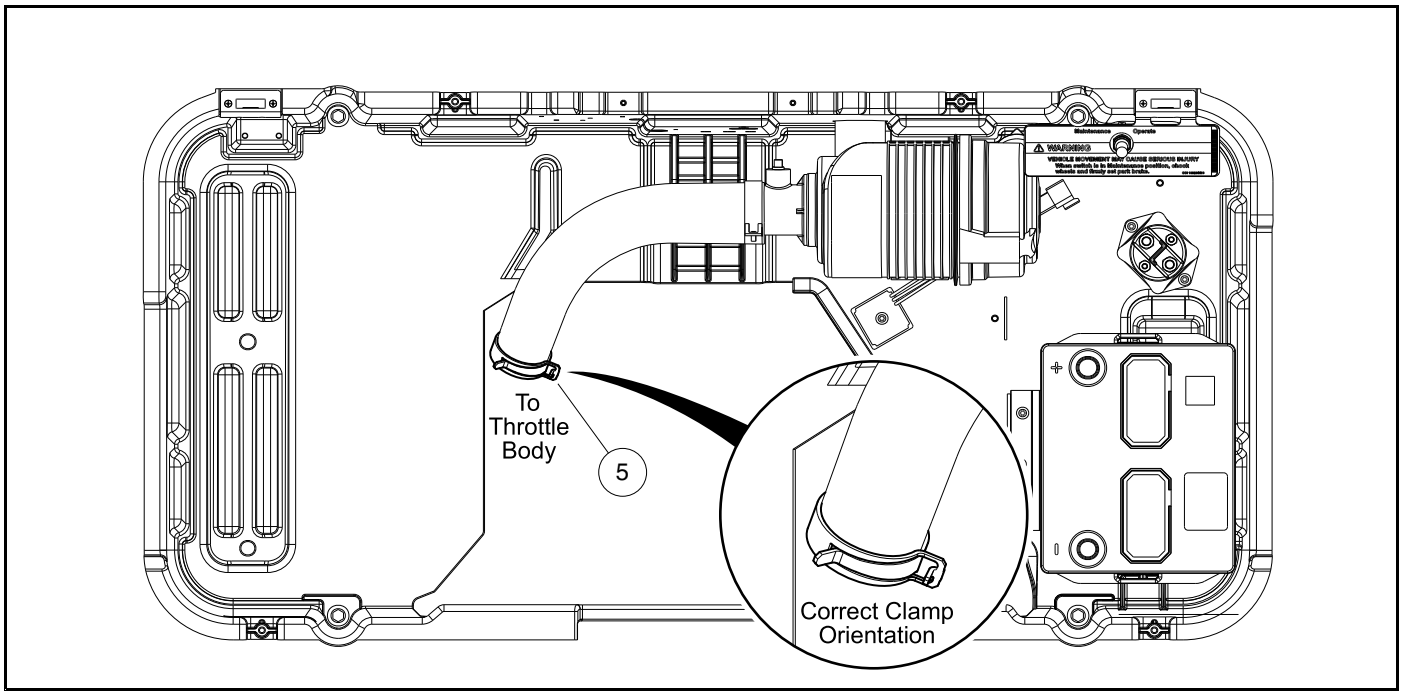
1. Turn the key switch to the OFF position and remove the key, place the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Access the engine compartment.
3. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
4. Hose (3) may be removed by removing the clamps (4 and 5) at the air cleaner (1) and the throttle body **(Figure 36-8, Page 36-12)**.
5. The air cleaner (1) is secured to the fuel bucket with screws (2). Access to the screws requires that the kick plate be removed. **See Kick Plate Removal on page 4-23.**

AIR INTAKE SYSTEM INSTALLATION

⚠ WARNING

- **Intake hose (3) is made from a special fire retardant neoprene material. Use of any hose that does not meet Club Car, LLC specifications could create a fire hazard.**
- **Improper orientation of the hose clamp (5) may result in fuel tank damage (Figure 36-10, Page 36-14).**

1. Position air cleaner (1) inside the fuel bucket **(Figure 36-8, Page 36-12)**. Secure with screws (2). Tighten screws to 2.7 lb·ft (3.5 N·m).
2. Install hose (3) on air cleaner (1) and secure with clamp (4).
3. Install hose (3) on throttle body and secure with clamp (5) oriented as shown **(Figure 36-10, Page 36-14)** with tabs up.
4. Install kick plate. **See Kick Plate Installation on page 4-23.**



3192

Figure 36-10 Hose Clamp Orientation at Throttle Body

FUEL LINE

See General Warnings on page 1-2.

NOTE: *This EFI gasoline vehicle is equipped with SAEJ30R9 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. A small, spring steel band clamp is used on the fuel line connection at the throttle body and must be tight. A plastic, dual-locking connector is used at the fuel tank. **See following WARNING.**

⚠ 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 on page 29-11.**

FUEL LINE REMOVAL

1. Turn the key switch to the OFF position and remove the key, place the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect battery. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Clean the top of the fuel tank and fuel pump module.
4. At engine:

4.1. Remove spring clamp securing fuel line to throttle body.

4.2. Disconnect fuel line and drain into an appropriate container. **See following WARNING.**

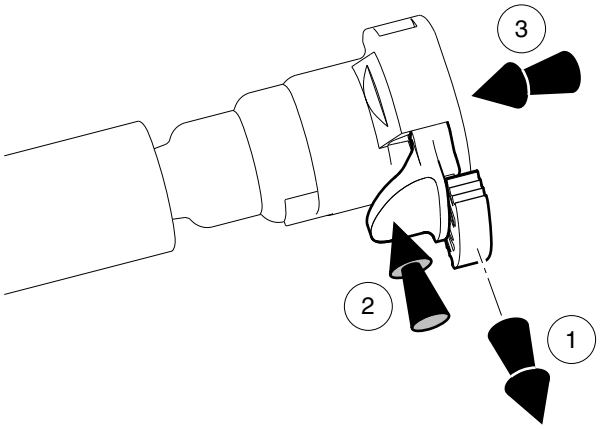
⚠ WARNING

- **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 on page 29-11.**
- **Carefully drain any fuel into an approved container. Add drained fuel back into fuel tank or dispose of properly.**

5. At fuel tank:

5.1. Disengage clip as shown **(Figure 36-11, Page 36-16)**.

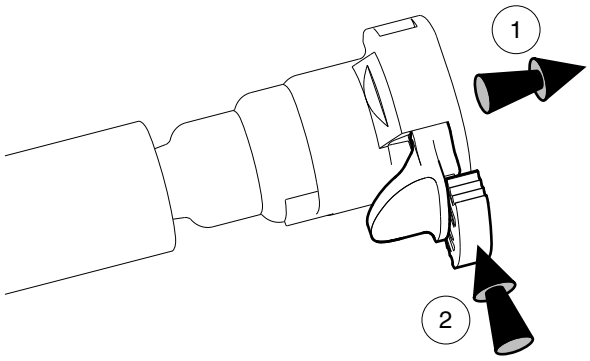
5.2. Push in tab to unlock connector and pull fuel line from nipple on fuel pump module and remove line from vehicle.



1. Pull out locking clip.
2. Push in on release tab.
3. While pushing in on release tab, pull fuel line off nipple.

3050

Figure 36-11 Fuel Line Connector – To Disconnect



1. Push fuel line onto nipple until it locks into place.
2. Push in locking clip until fully seated.

3051

Figure 36-12 Fuel Line Connector – To Connect

FUEL LINE INSTALLATION

1. At fuel tank:

1.1. Clean the nipple on top of fuel pump module.

1.2. Push fuel line fully onto nipple until it locks in place **(Figure 29-17, Page 29-17)**.

1.3. Engage locking clip by pushing in until fully seated and completely prevents the line from being pulled off nipple.

2. At engine:

2.1. Connect fuel line to throttle body and secure with spring clamp. **See following DANGER.**

⚠ DANGER

- **Ensure line is connected properly to avoid a leak that can cause a fire.**
- **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.**

2.2. Make sure that the fuel line is routed correctly **(Figure 36-13)**.

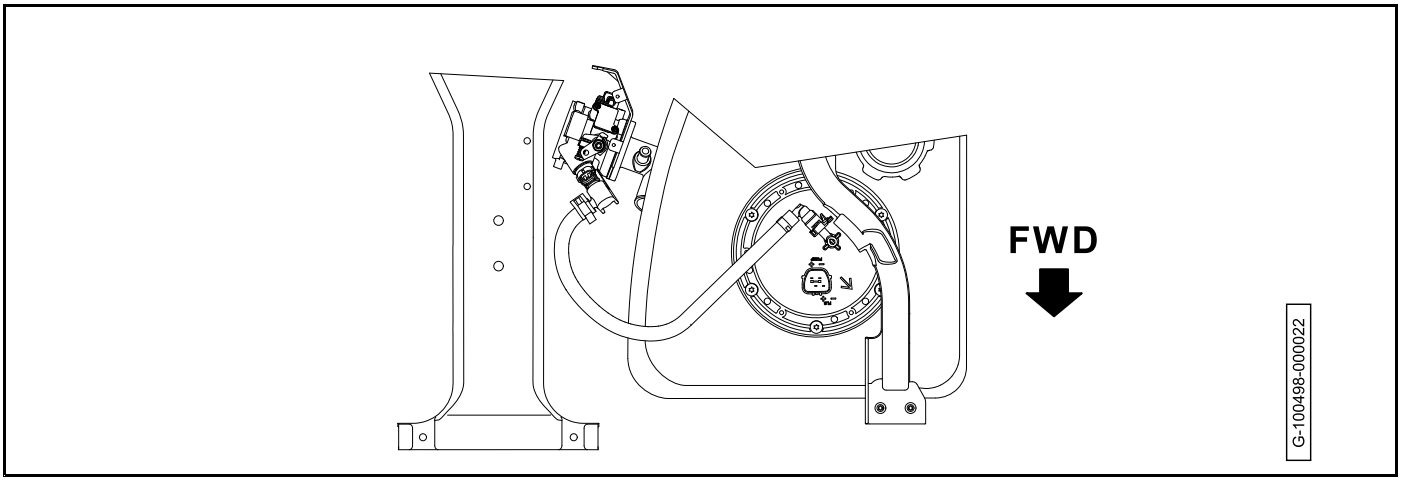


Figure 36-13

3. Clean spilled and remove any drained gasoline from the area.
4. Connect battery.
   See Connect the Battery - Gasoline Vehicles on page 1-4.
5. Place the Forward/Reverse handle in the NEUTRAL position, chock the wheels, and the neutral lockout switch in the MAINTENANCE position **(Figure 25-1, Page 25-1)**.
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, place the neutral lockout switch in the OPERATE position **(Figure 25-1, Page 25-1)**.

FUEL PUMP MODULE

See General Warnings on page 1-2.

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

1. Turn the key switch to the OFF position and remove the key, place the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect battery. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Clean the top of the fuel tank and fuel pump module (1) **(Figure 36-14, Page 36-20)**.
4. With a marker pen, make a mark across the top of the module (1) and onto the tank to note orientation before removal.
5. Disconnect wire harness plug (2).
6. Disconnect the fuel line (3) and drain into an appropriate container. **See Fuel Line Removal on page 29-13. 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 on page 29-11.**
- **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.**

7. Loosen fuel tank retaining strap (4) to allow tank to move and provide access to all of the fuel pump module hardware (5).
8. Remove hardware (5) securing hold down ring (6) and ground wire (7) to fuel tank.
9. Lift fuel pump module (1) out of fuel tank and drain into an appropriate container. Discard fuel module o-ring (8). **See preceding WARNING and following NOTE.**

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 **(Figure 36-14, Page 36-20)**.
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 lb·in (7.5 N·m). **See following WARNING.**

⚠ WARNING

- **Always install ground wires during reassembly.**

5. Tighten fuel tank retaining strap screw (9) to 26.5 lb·in (3 N·m).
6. Connect fuel line (3) to fuel pump module (1). **See Fuel Line Installation on page 29-16. See following DANGER.**

⚠ DANGER

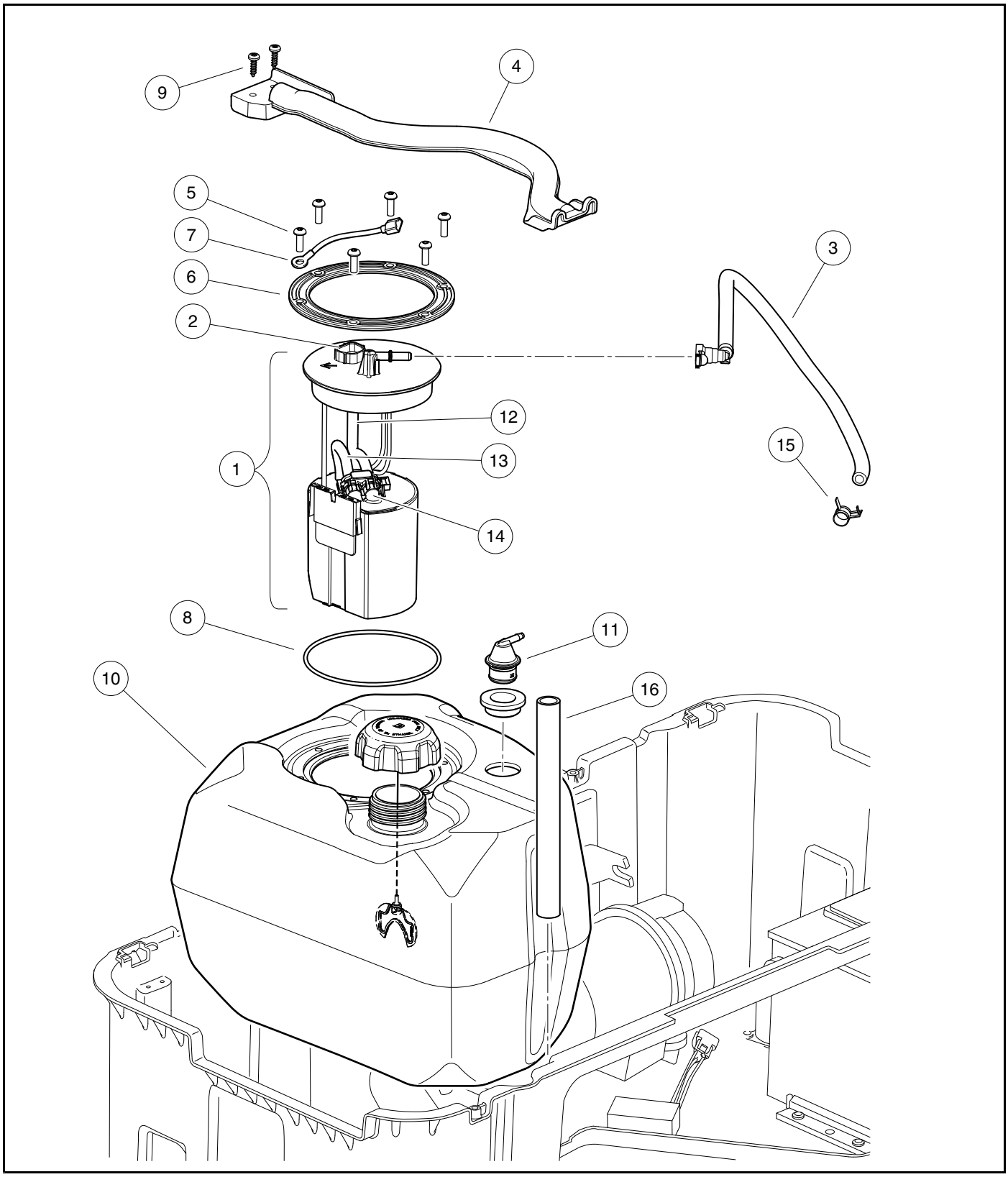
- **Ensure line is connected properly to avoid a leak that can cause a fire.**
- **Make sure fuel line is the correct length and properly routed. Failure to heed this warning could result in damage to fuel line and fire.**

7. Connect wire harness plug (2) to fuel pump module (1).
8. Clean spilled and remove any drained gasoline from the area.
9. Connect battery.
   See Connect the Battery - Gasoline Vehicles on page 1-4.
10. Place the Forward/Reverse handle in the NEUTRAL position, chock the wheels, and the neutral lockout switch in the MAINTENANCE position **(Figure 25-1, Page 25-1)**.
11. 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.**

12. If no leaks are found, place the neutral lockout switch in the OPERATE position **(Figure 25-1, Page 25-1)**.



3125a

Figure 36-14 Fuel System – Exploded View

FUEL TANK

See General Warnings on page 1-2.

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.*

FUEL TANK REMOVAL

1. Place the Forward/Reverse handle in the NEUTRAL position, chock the wheels, and the neutral lockout switch in the MAINTENANCE position.
2. Turn key switch to OFF position and remove key.
3. Disconnect battery. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
4. Clean the top of the fuel tank (10) and fuel pump module (1) **(Figure 36-14, Page 36-20)**.
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 wire harness plug (2) from fuel pump module (1).
7. Disconnect vent hose from fuel tank vent (11).
8. Disconnect the fuel line (3) from the fuel pump module (1) and drain into an appropriate container. **See Fuel Line Removal on page 29-13. 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 on page 29-11.**
- **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 (7).
10. Remove screws (9) holding the forward end of the fuel tank retainer (4). Lift up on the forward end of the retainer (4) and unhook the rear end from the fuel bucket.
11. If equipped, remove retention tube (16) from between fuel tank (10) and fuel bucket.
12. Lift the fuel tank (10) from vehicle.

FUEL TANK DISPOSAL

1. Remove gas cap and fuel pump module from tank. **See Fuel Pump Module Removal on page 29-18.** 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 on page 29-18.**
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 module is completely dry, install in fuel tank. **See Fuel Pump Module Installation on page 29-20.**
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.*

1. Place fuel tank (10) in vehicle.
2. Insert retention tube (16) between fuel tank (10) and fuel bucket.
3. Secure tank with retainer (4).

3.1. Insert the tabs on the rear of the retainer (4) into the slots on the back of the fuel bucket **(Figure 36-14, Page 36-20)**.

3.2. Pivot retainer (4) to place the front edge over mounting holes. Install screws (9) to secure the retainer. Tighten screws to 31 lb·in (3.5 N·m).

4. Connect fuel pump module ground wire (7) to main wire harness. **See following WARNING.**

⚠ WARNING

- **Always install ground wires during reassembly.**

5. Connect fuel line (3) to fuel pump module (1). **See Fuel Line Installation on page 29-16. See following DANGER.**

⚠ DANGER

- **Ensure line is connected properly to avoid a leak that can cause a fire.**
- **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.**

6. Connect wire harness plug (2) to fuel pump module (1).
7. Clean spilled and remove any drained gasoline from the area.
8. Connect battery.
   See Connect the Battery - Gasoline Vehicles on page 1-4.
9. Add fuel to tank.
10. Place the Forward/Reverse handle in the NEUTRAL position, chock the wheels, and the neutral lockout switch in the MAINTENANCE position **(Figure 25-1, Page 25-1)**.
11. 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.**

12. If no leaks are found, place the neutral lockout switch in the OPERATE position **(Figure 25-1, Page 25-1)**.

FUEL FILTER

See General Warnings on page 1-2.

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

1. Turn the key switch to the OFF position and remove the key, place the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect battery. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Remove fuel pump module (1). **See Fuel Pump Module Removal on page 29-18.**
4. Disconnect flex hoses (12 and 13) from filter (14) **(Figure 36-14, Page 36-20)**.

4.1. Pull hose retainer clip straight up and out of filter (14). Do not discard clip.

4.2. Pull flex hoses (12 and 13) straight out of filter inlet and outlet.

5. Remove filter (14) from module (1) 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 (14) and insert into fuel pump module (1) until fully seated **(Figure 36-14, Page 36-20)**.
2. Connect flex hoses (12 and 13) to the fuel filter (14).

2.1. Orient flex hoses (12 and 13) with matching port in filter (14) and push each hose end straight into filter until fully seated.

2.2. Push hose retainer clip straight into filter (14) until fully seated.

3. Install fuel pump module (1). **See Fuel Pump Module Installation on page 29-20.**
4. Connect battery and spark plug wire(s).
   See Connect the Battery - Gasoline Vehicles on page 1-4.
5. Place the Forward/Reverse handle in the NEUTRAL position, chock the wheels, and the neutral lockout switch in the MAINTENANCE position **(Figure 25-1, Page 25-1)**.
6. Start the engine and check for fuel leaks. **See following DANGER.**

⚠ DANGER

- **Repair all fuel leaks before operating the vehicle.**

7. If no leaks are found, place the neutral lockout switch in the OPERATE position **(Figure 25-1, Page 25-1)**.

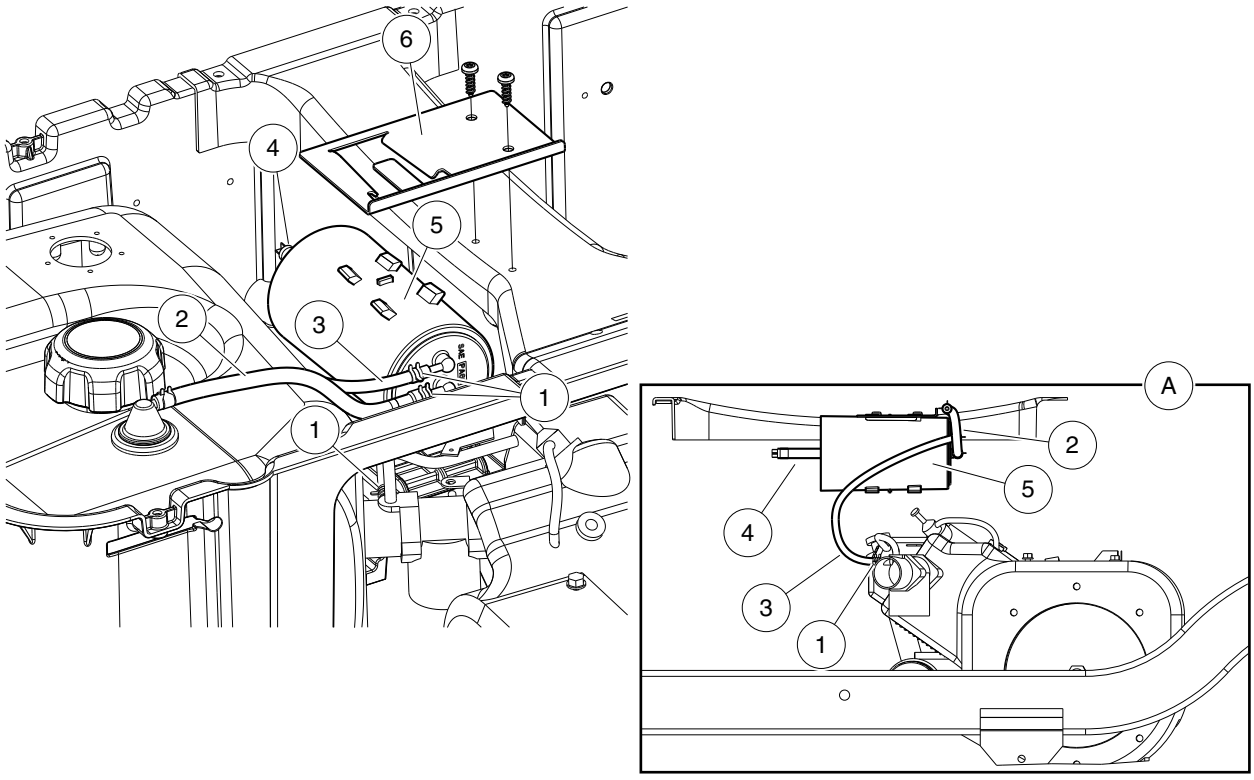
CARBON CANISTER

⚠ WARNING

- **If the carbon canister is damaged, only use an OEM (Club Car) replacement that is specifically designed and approved for use on this vehicle. Do not attempt to repair it. See the following canister removal procedure.**

CARBON CANISTER REMOVAL

1. Disable the vehicle. **See Disabling the Vehicle on page 1-3.**
2. Raise or remove seat bottom from vehicle.
3. Remove hose clamps (1), securing three hoses (2, 3, and 4) to canister (5), and disconnect hoses **(Figure 36-15, Page 36-25)**.
4. Push or pull canister from mounting bracket (6).



Detail A: Side View

1. Clamp 2. Vent Tube (Fuel Tank to Canister) 3. Vent Tube (Canister to Engine) 4. Vent Tube (Canister to Atmosphere) 5. Carbon Canister 6. Mounting Bracket

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Figure 36-15 Carbon Canister, Hoses and Routing

CARBON CANISTER INSTALLATION

1. Align canister mounting tabs with slots in mounting bracket (6) and push canister (5) into bracket **(Figure 36-15, Page 36-25)**. Force it in until fully seated.

2. Attach hoses (2, 3, and 4) to appropriate locations on carbon canister and secure with hose clamps (1).
3. Install and/or lower seat bottom.

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

MUFFLER

MUFFLER REMOVAL

1. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. If equipped, remove air deflector from top of engine.
3. Remove the locknut (1) securing the muffler (2) to its mounting bracket **(Figure 37-1, Page 37-2)**.
4. Remove the hex nuts (3) and lock washers (4) at the cylinder head and remove muffler (2) from vehicle.

MUFFLER INSTALLATION

NOTE: *Any time the muffler is removed from the vehicle, install a new exhaust gasket (5).*

Two different exhaust gaskets have been used; one with a raised port opening, that has since been replaced by the other; a flat, metal-reinforced, graphite gasket. Follow instructions below for proper orientation of the exhaust gasket with raised port opening.

1. If muffler bracket (6) was loosened or removed, tighten bolts (9) to 17 lb·ft (23 N·m) and then bolts (7) to 50 lb·ft (68 N·m) **(Figure 37-1, Page 37-2)**.
2. Replace exhaust gasket (5) on the cylinder head exhaust port studs with a new gasket. For exhaust gasket with raised port opening, orient gasket (5) with raised section of gasket up against the flange of the muffler.
3. Place muffler (2) into position and loosely secure it to mounting bracket with locknut (1) and to cylinder head with lock washers (4) and hex nuts (3).
4. Tighten hardware in the following order:

4.1. At the cylinder head, tighten passenger-side hex nut (3) to 15 lb·ft (20 N·m).

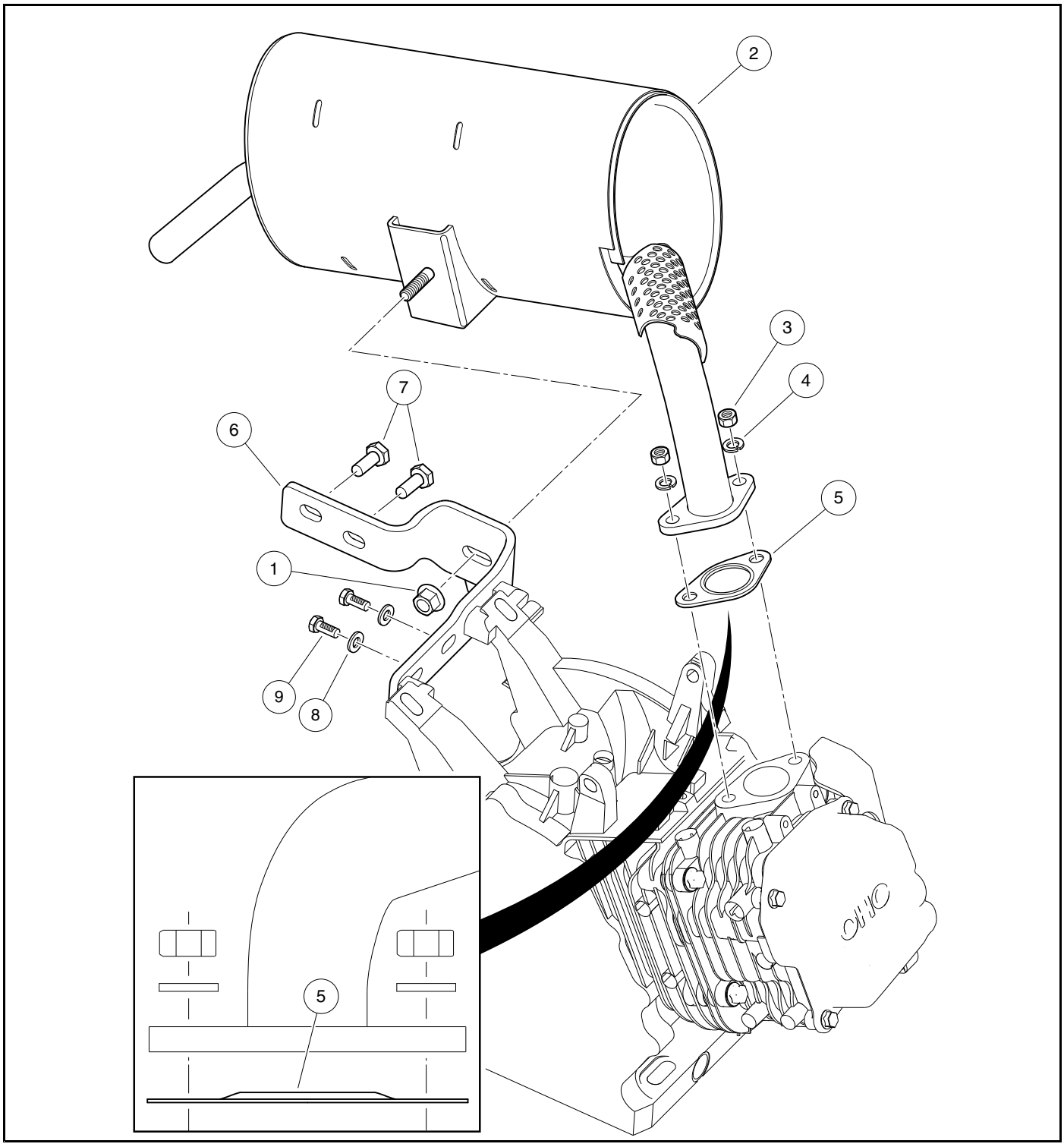
4.2. At the cylinder head, tighten driver-side hex nut (3) to 15 lb·ft (20 N·m).

4.3. At the mounting bracket, tighten locknut (1) to 34 lb·ft (46 N·m).

5. If equipped, install air deflector on top of engine.
6. Connect battery and spark plug wire(s). **See Connect the Battery - Gasoline Vehicles on page 1-4.**
7. Place the shifter handle in NEUTRAL, the neutral lockout switch in MAINTENANCE, and chock the wheels.
8. Start the engine and check for exhaust leaks and proper engine operation. **See following DANGER.**

⚠ DANGER

- **Do not operate gasoline vehicle in an enclosed area without proper ventilation. The engine produces carbon monoxide, which is an odorless, deadly poison.**



3112a

Figure 37-1 Exhaust System

⚠ DANGER

- **See General Warnings on page 1-2.**

⚠ WARNING

- **See General Warnings on page 1-2.**

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:

- Clutch Tools **(Figure 38-1, Page 38-2)**.
- Scribe or small pick (not included with clutch tools).

TROUBLESHOOTING

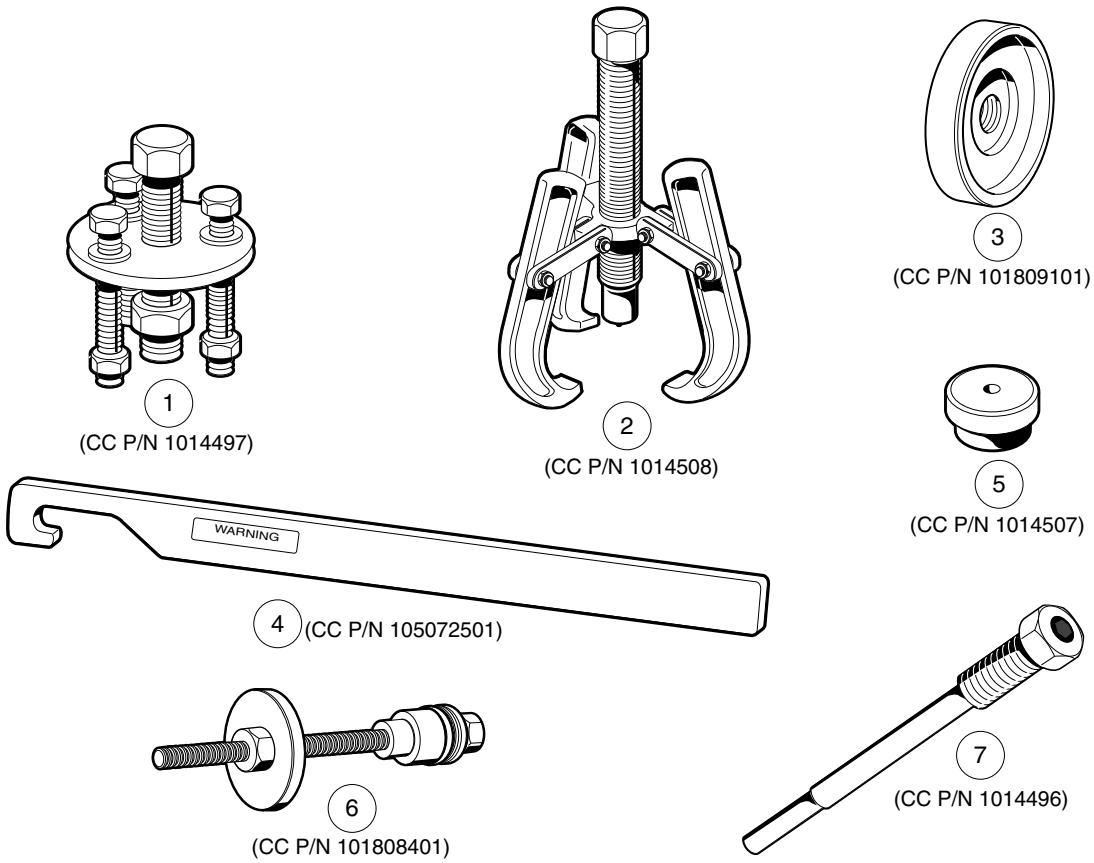
See General Warnings on page 1-2.

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 on page 29-2.**
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 31-2, Page 31-4)**.



1. Drive Clutch Hub Puller 2. Driven Clutch Cam Puller 3. Driven Clutch Cam Press Tool 4. Drive Clutch Holder Tool 5. Driven Clutch Puller Plug 6. Cam Installation Tool 7. Drive Clutch Puller

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Figure 38-1 Clutch Tools

DRIVE BELT

See General Warnings on page 1-2.

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. **Section 2 — Vehicle Specifications**

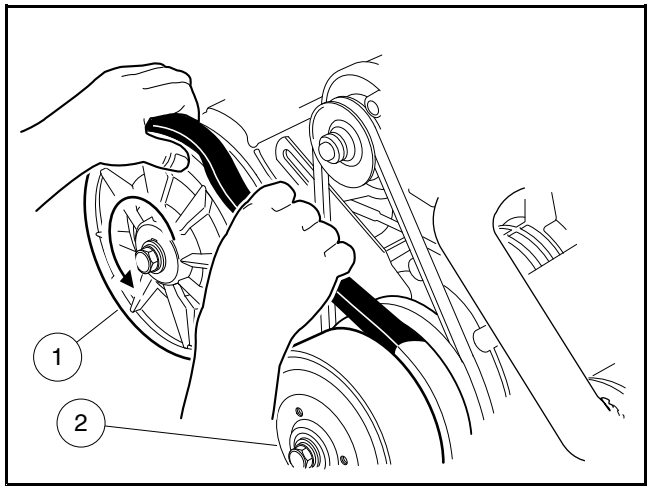
DRIVE BELT REMOVAL

1. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
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 31-1, Page 31-3)**. **See following CAUTION.**

⚠ CAUTION

- **Make sure fingers are not underneath the belt when rolling the belt off the driven clutch.**

3. Remove the belt from the drive clutch (2).



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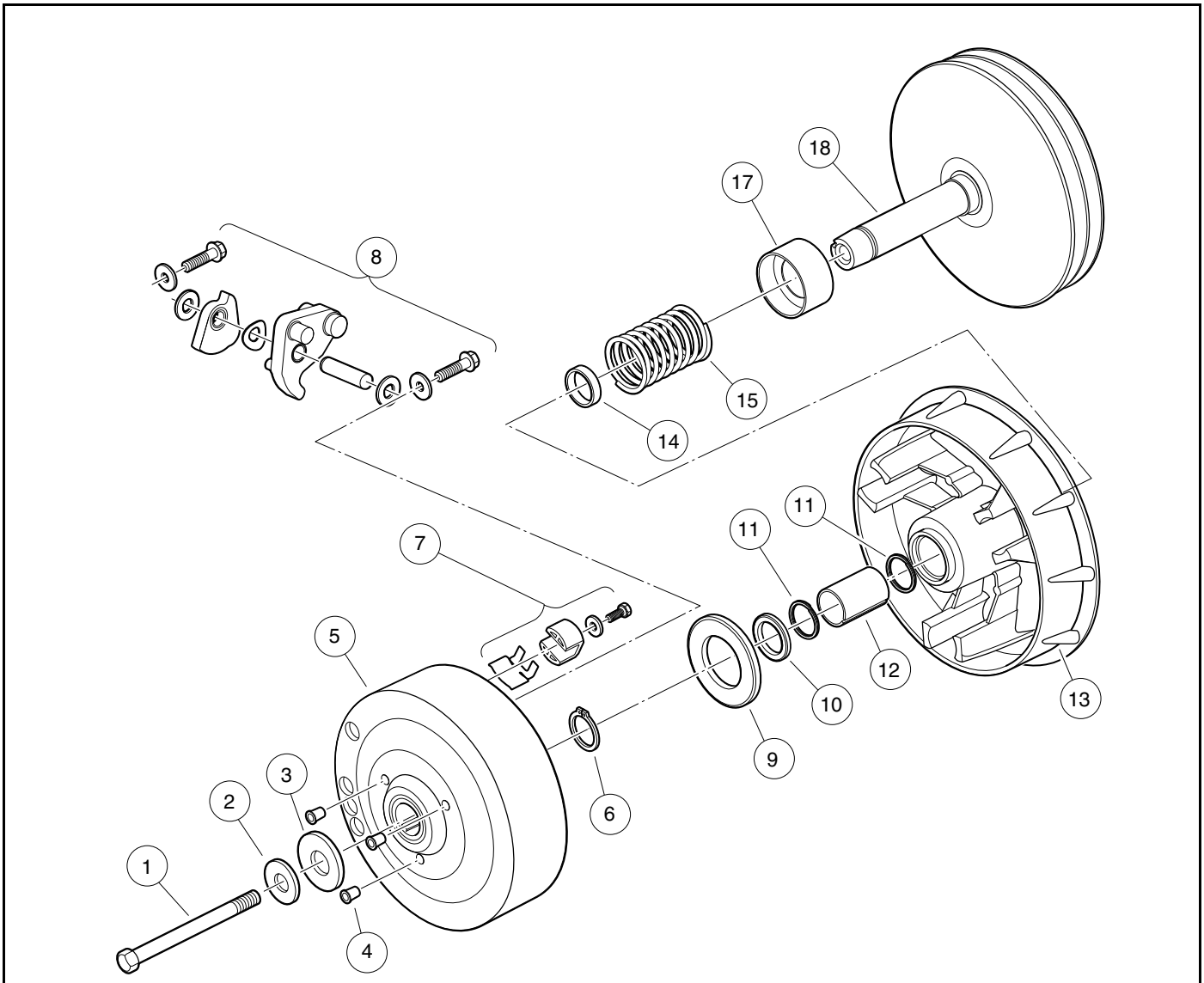
Figure 38-2 Drive Belt Removal

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(s).
   See Connect the Battery - Gasoline Vehicles on page 1-4.

DRIVE CLUTCH

See General Warnings on page 1-2.



1. Screw, 3/8-24 x 5.75, Patch	10. Retainer
2. Washer, 3/8, Type A, Flat	11. Ring, Spiral Backup
3. Washer, Hard, M10	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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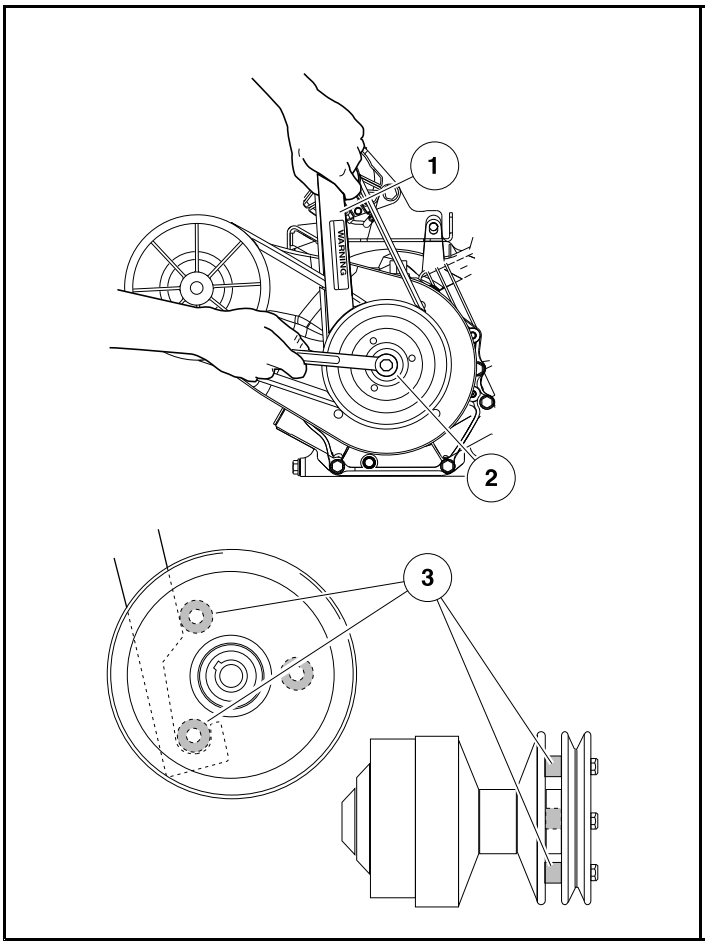
Figure 38-3 Drive Clutch – Exploded View

⚠ 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.**

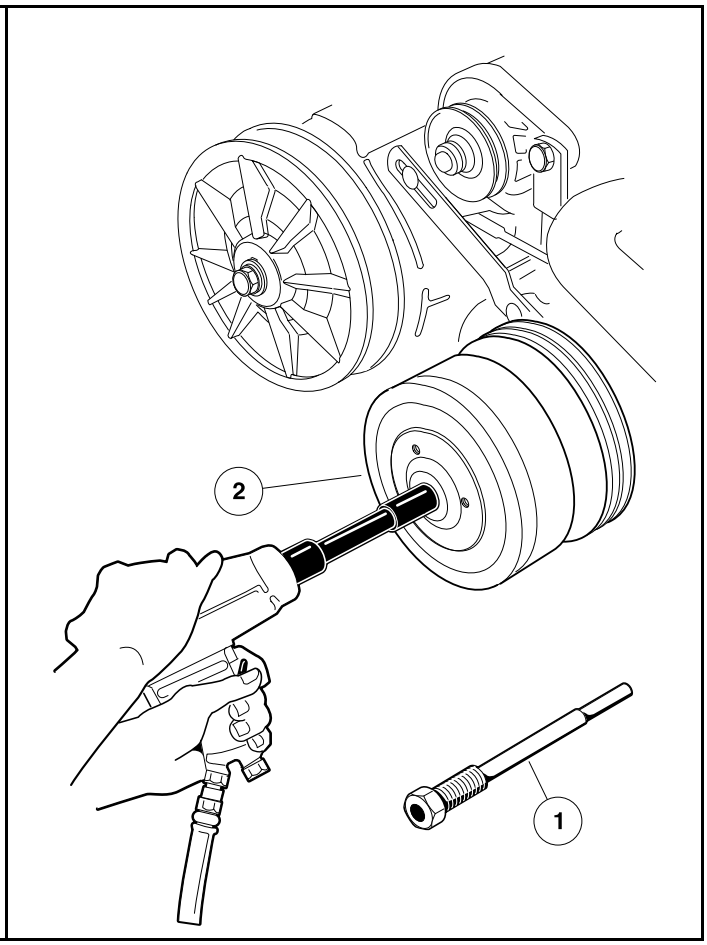
DRIVE CLUTCH REMOVAL

1. Remove the drive belt as instructed. **See Drive Belt Removal on page 31-3.**
2. Loosen starter/generator mounting and adjusting hardware and remove starter belt. **See WARNING "Moving parts! Do not..." in General Warnings on page 1-2.**



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Figure 38-4 Loosen Retaining Bolt



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Figure 38-5 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**

WARNING CONTINUED ON NEXT PAGE

⚠ WARNING

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 31-2, Page 31-4)**. **See also Figure 31-3, Page 31-5. See following NOTE.**

NOTE: *On Subaru EX40 engines, the drive clutch mounting bolt has right-hand threads.*

4.1. Use the drive clutch holder tool (1) while tightening or loosening the drive clutch retaining bolt (2) **(Figure 31-3, Page 31-5)**.

4.2. Hook drive clutch holder tool (1) 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 female thread of the drive clutch **(Figure 31-4, Page 31-5)**.
6. Support the drive clutch with your hand and use a 1/2-in. drive air wrench to tighten the clutch puller tool. The tool will bottom out in the crankshaft and force the drive clutch (2) free of the crankshaft.
7. Remove clutch puller tool from drive clutch.

⚠ 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 31-2, Page 31-4). 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 31-5, Page 31-7).**

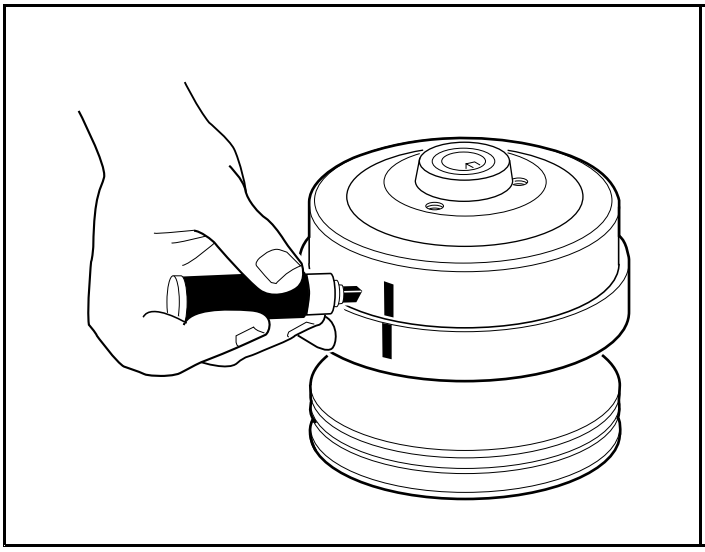
1. Make match marks on the drive clutch hub and on the moveable face **(Figure 31-5, Page 31-7)**.
2. Remove the drive clutch hub (5) **(Figure 31-2, Page 31-4)**:

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 31-6, Page 31-7)**.

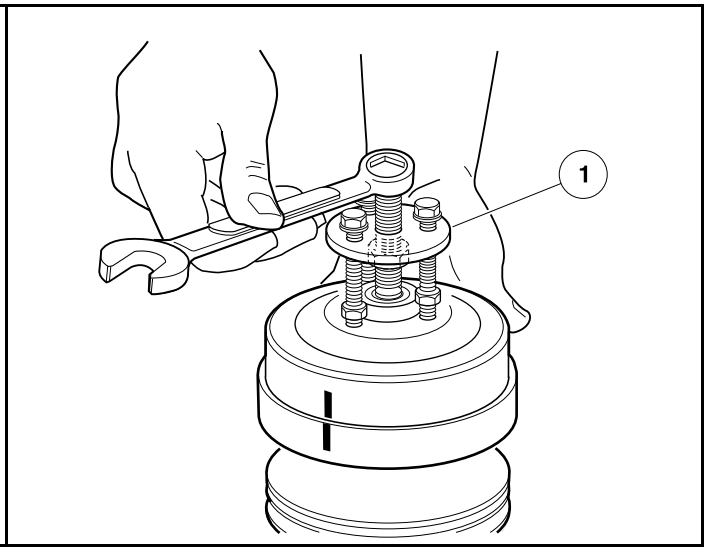
2.3. Thread the three small bolts of the puller into corresponding holes in the clutch. Tighten bolts evenly, making sure the face of the puller plate is parallel to the face of the clutch **(Figure 31-6, Page 31-7)**.

2.4. Unscrew the puller center bolt out of the clutch to pull drive clutch hub off.



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Figure 38-6 Mark Drive Clutch Hub

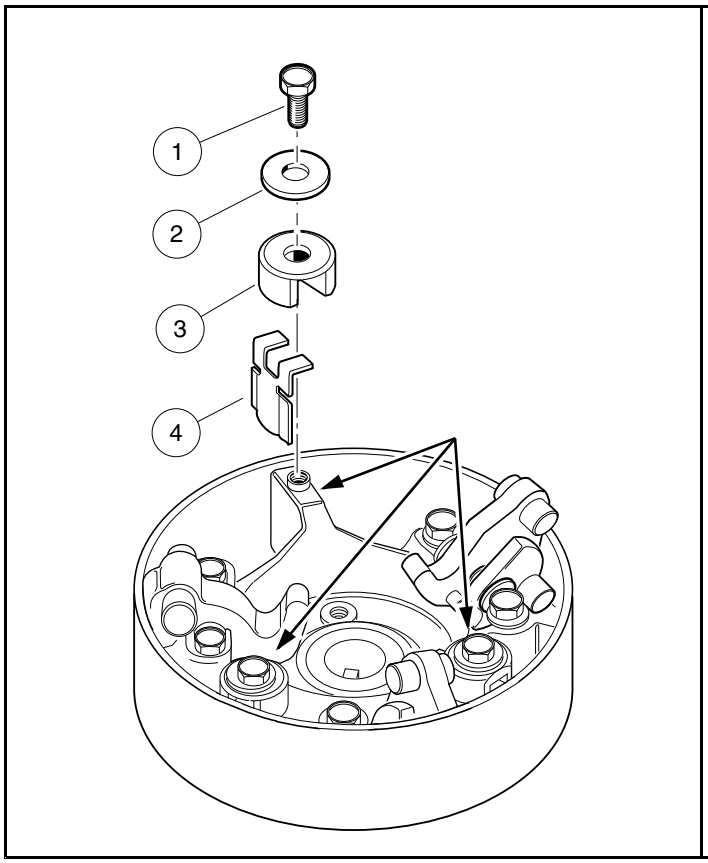


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Figure 38-7 Remove Drive Clutch Hub

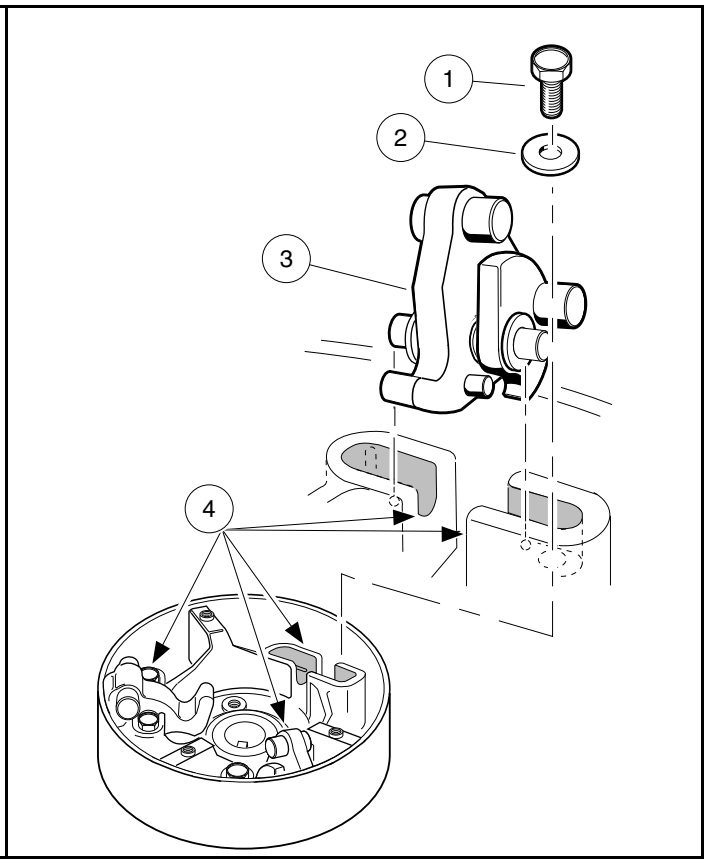
3. Remove the thrust washer (9) from the moveable sheave (13) **(Figure 31-2, Page 31-4)**.

4. Remove the drive buttons (3) by removing the screws (1), flat washers (2), and drive button take-up springs (4) as shown **(Figure 31-7, Page 31-8)**.



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Figure 38-8 Drive Button Mounting



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Figure 38-9 Weight Position

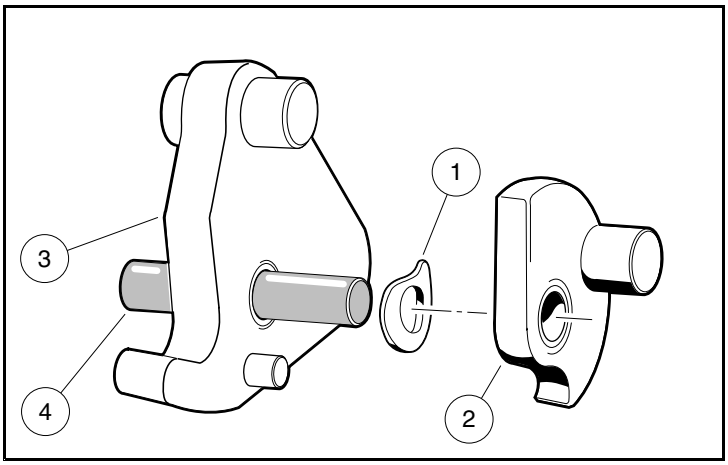
5. Remove the clutch weights:

5.1. Remove the screws (1) and flat washers (2) attaching the weights (3) as shown **(Figure 31-8, Page 31-8)**.

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 31-9, Page 31-9)****.*

5.3. Remove the plastic washers, weights (2 and 3) and wave washer (1) from the pin (4). Retain all parts.

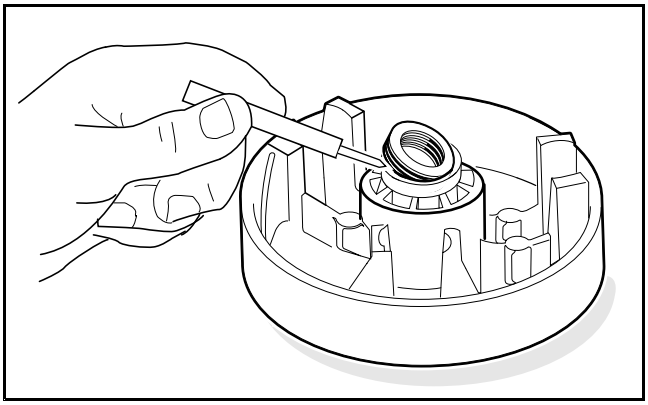


602
Figure 38-10 Primary and Secondary Weights, Wave Washer and Pin

6. Remove the retaining ring (6) from the shaft of the fixed sheave (18) and slide the moveable sheave (13) off the shaft **(Figure 31-2, Page 31-4)**. **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 31-2, Page 31-4)****.*

7. Remove the spacer (14) and spring (15) **(Figure 31-2, Page 31-4)**.
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 31-2, Page 31-4)**. **See also Figure 31-10, Page 31-9.** Discard the rings.



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Figure 38-11 Spiral Back-up Rings

INSPECTION OF DRIVE CLUTCH PARTS

1. Inspect the idler spacer (17) for smoothness **(Figure 31-2, Page 31-4)**.
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 31-2, Page 31-4)**.
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).

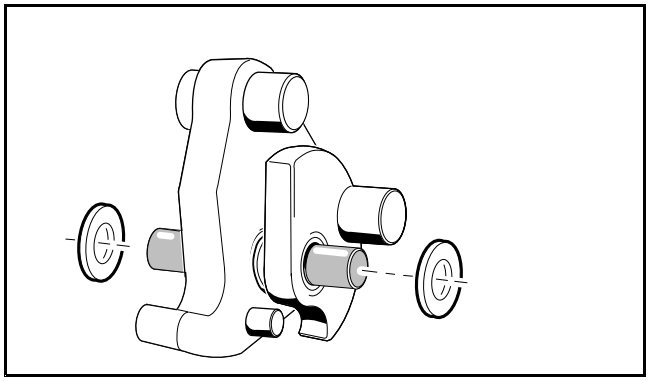
⚠ CAUTION

- **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 31-2, Page 31-4)**.

5. Install the primary weights (3) on the mounting pins (4) **(Figure 31-9, Page 31-9)**.
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 31-9, Page 31-9)**.
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 31-9, Page 31-9)**.
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 31-11, Page 31-10)**.
9. Install the weight assemblies into the slots (4) in the hub casting **(Figure 31-8, Page 31-8)**. Make sure the mounting pin protrudes an equal amount on each side of the weights when the assemblies are in position **(Figure 31-11, Page 31-10)**.



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Figure 38-12 Install White Washers

10. Install the 1/4-20 bolts (1) and washers (2) and tighten them to 10 lb·ft (13 N·m) **(Figure 31-8, Page 31-8)**. **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 31-12, Page 31-11)**.

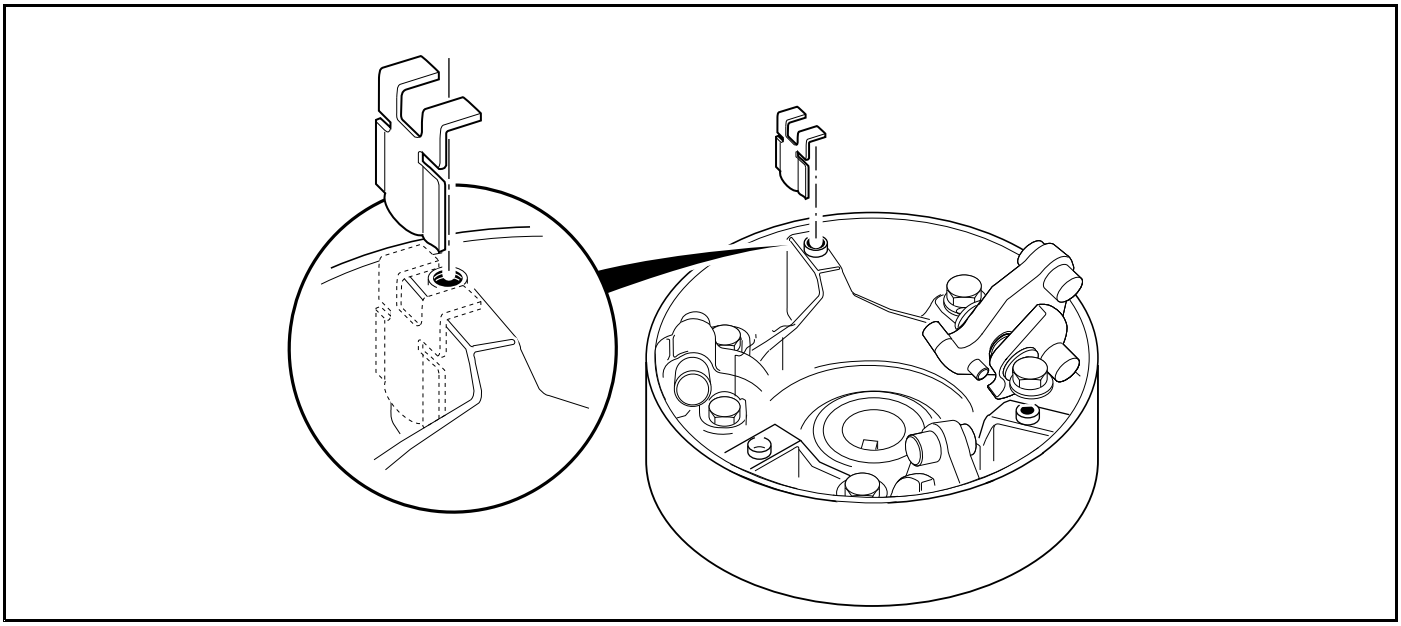
12. Compress each take-up spring and install the drive button over the rib and take-up spring **(Figure 31-7, Page 31-8)**.

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 lb·in (3.8 N·m) **(Figure 31-7, Page 31-8)**.

14. Install the thrust washer (9) onto the moveable sheave (13) **(Figure 31-2, Page 31-4)**.

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 31-2, Page 31-4)**.



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Figure 38-13 Correct Orientation of Drive Button Take-up Springs

DRIVE CLUTCH INSTALLATION

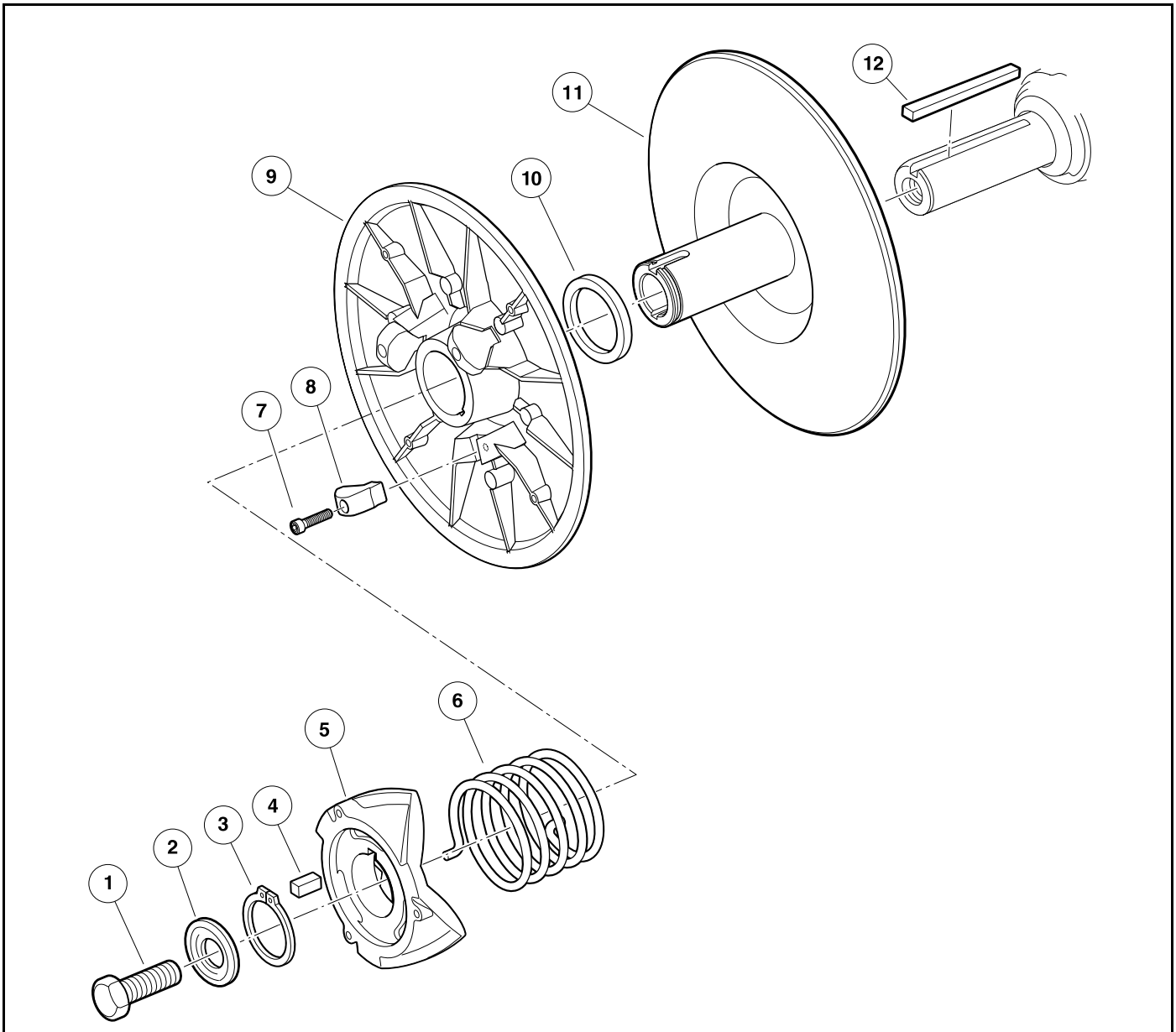
1. Place the drive clutch assembly on the crankshaft taper. Position the mounting washers (2 and 3) on the bolt (1) and start the bolt into the crankshaft **(Figure 31-2, Page 31-4)**. **See following NOTE.**

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 lb·ft (47.5 N·m) **(Figure 31-2, Page 31-4)**.
3. Install the starter/generator belt and adjust belt tension as instructed.
4. Install the drive belt as instructed. **See Drive Belt Installation on page 31-3.**
5. Connect battery and spark plug wire(s).
   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 1-2.



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, 55 Degree	12. Key, 3/16 in. (4.7 mm) Square X 1.50 in. (38 mm) Long

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Figure 38-14 Driven Clutch – Exploded View

DRIVEN CLUTCH REMOVAL

1. Remove the drive belt as instructed. **See Drive Belt Removal on page 31-3.**
2. Remove the bolt (1) and mounting washer (2) from the transaxle input shaft **(Figure 31-13, Page 31-12)**.
3. Grasp the driven clutch assembly and slide it off the shaft.
4. Leave the key (12) in the keyway.

DRIVEN CLUTCH DISASSEMBLY

⚠ CAUTION

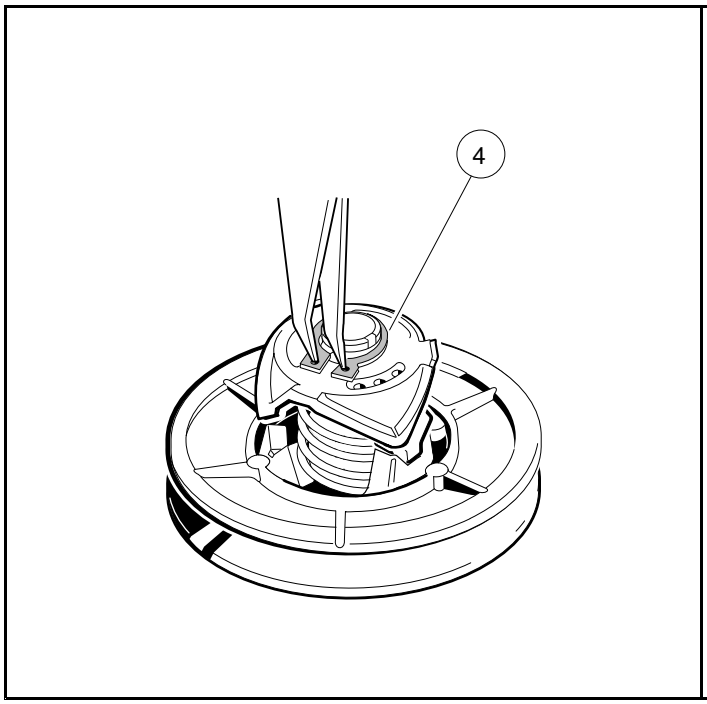
- **The driven clutch is balanced as an assembly. Before disassembly, make match marks on the driven clutch fixed sheave and moveable sheave so they can be reassembled in the same positions.**

1. Make match marks on the driven clutch fixed sheave and on the moveable sheave to maintain balance upon reassembly.
2. Using external snap ring pliers, remove the retaining ring (4) **(Figure 38-15, Page 38-14)**. **See following WARNING.**

⚠ WARNING

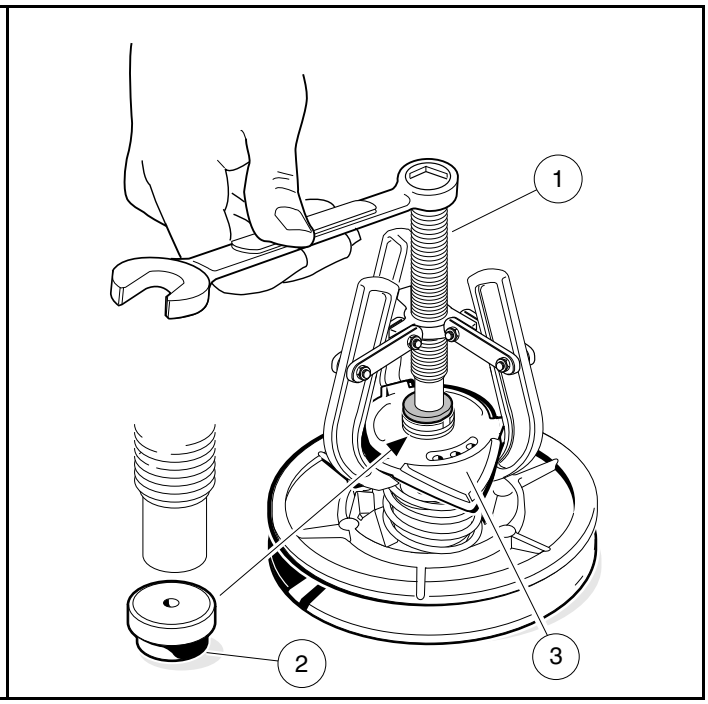
- **Do not place fingers under the cam when removing the cam. The moveable face may spin when the cam buttons release from the cam ramps, resulting in severe personal injury.**

3. Insert a puller plug (2) **(Figure 38-16, Page 38-14)** into the shaft bore and use a driven clutch cam puller (1) to remove the cam (3) from the fixed sheave.
4. Remove the spring (6) **(Figure 31-13, Page 31-12)**.
5. Retain the key (4).
6. Slide the moveable sheave (9) off the fixed sheave (11).



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Figure 38-15 Remove Retaining Ring



609

Figure 38-16 Driven Clutch Disassembly

DRIVEN CLUTCH INSPECTION

1. Inspect the cam (5) for excessive wear **(Figure 31-13, Page 31-12)**. Replace it if necessary.
2. Inspect the drive buttons (8) for excessive wear. Replace if necessary. To remove the drive buttons (8), remove the socket-head cap screws (7) and then the buttons.
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.

DRIVEN CLUTCH ASSEMBLY

1. Place the three drive buttons (8) in position. Apply one drop of Loctite® 222 to each of the socket-head cap screws (7) and then install and tighten them to 8 lb·in (0.9 N·m) **(Figure 31-13, Page 31-12)**.
2. Slide the acetal washer (10) and moveable sheave (9) onto the fixed sheave (11).
3. Place the end of the spring (6) into the hole in the moveable sheave (9).
4. Install the key (4) into the keyway of the fixed sheave (11) shaft.
5. Holding the cam (5) in position for assembly on the shaft, install the other end of the spring (6) into the center spring hole of the cam. Rotate the cam until the keyway is aligned with the key (4) 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).

5.1. **Press Assembly Process:**

5.1.1. Place the clutch assembly in a press and position the cam press tool on the cam (2) as shown **(Figure 38-17, Page 38-15)**.

5.1.2. Hold the fixed sheave (3) and rotate the moveable sheave (1) one-third turn counterclockwise, then press the cam (2) onto the fixed sheave **(Figure 38-17, Page 38-15)**. The match marks made before disassembly should now align.

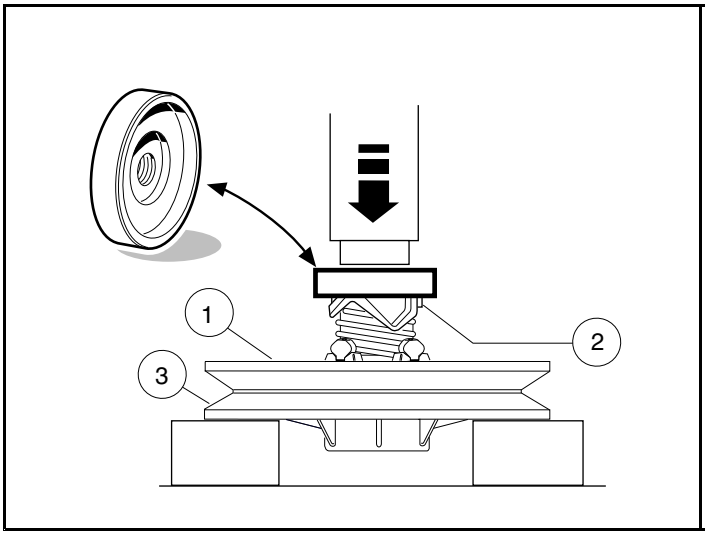
5.1.3. Install the retaining ring (4) **(Figure 38-15, Page 38-14)**. **See following NOTE.**

NOTE: *The retaining ring (4) can be reused if the O.D. does not exceed 1.607 in. (40.82 mm); otherwise, it must be replaced with a new ring.*

5.1.4. While holding onto the cam, tap the end of the fixed sheave lightly with a plastic mallet until the cam seats against the retaining ring (4). **See following CAUTION.**

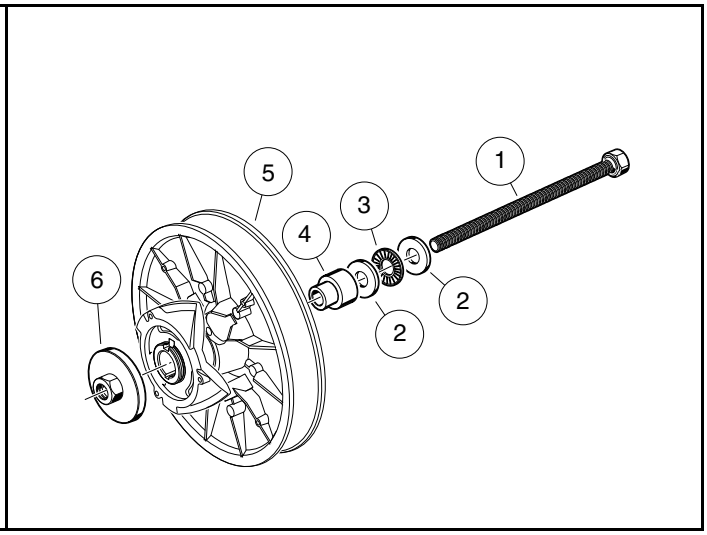
⚠ CAUTION

- **Do not use a metal hammer to tap the fixed sheave. A metal hammer will damage the shaft.**



611

Figure 38-17 Cam Press Tool



612

Figure 38-18 Cam Installation Tool

5.2. **Field Assembly Process:**

NOTE: *This process is for field assembly requirements where hydraulic and pneumatic press equipment is not available. Use the cam installation tool for this process.*

5.2.1. With the clutch loosely assembled, set the edge of the clutch body (5) on a clean, flat surface **(Figure 38-18, Page 38-15)**.

5.2.2. Assemble the threaded bolt (1) through the washer (2), the thrust bearing assembly (3), the second washer (2), and the hub guide (4).

NOTE: *It is very important that the bolt, washers, and thrust bearing assembly be assembled in the order described and shown.*

5.2.3. Slide the bolt (1) through the clutch body (5) until the threaded bolt, washers, bearing, and hub guide are against the fixed sheave **(Figure 38-18, Page 38-15)**.

5.2.4. Hold the clutch assembly and cam installation tool together and place the fixed sheave down on spaced blocks **(Figure 38-17, Page 38-15)**.

5.2.5. Place the cam press hub (6) onto the cam installation bolt and thread it down onto the cam hub, centering the press hub onto the cam hub.

5.2.6. Hold the fixed sheave of the clutch (5) and rotate the moveable sheave of the clutch one-third turn counterclockwise **(Figure 38-18, Page 38-15)**. The match marks made before disassembly should now align.

5.2.7. Use two wrenches and hold the bolt head (1) while tightening the cam press hub (6) to press the cam onto the keyed shaft. Advance the press hub (6) until it is firm against the shaft end.

5.2.8. Remove the cam press hub (6) and installation tool.

5.2.9. Install the retaining ring (4) **(Figure 38-15, Page 38-14)**.

NOTE: *The retaining ring (4) can be reused if the O.D. does not exceed 1.607 in. (40.82 mm); otherwise, it must be replaced with a new ring.*

DRIVEN CLUTCH INSTALLATION

1. To install the driven clutch, reverse the removal procedure. Make sure that the washer (2) is mounted with the flat portion of the washer against the driven clutch **(Figure 31-13, Page 31-12)**. Secure with a new bolt (1). **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.*

2. Tighten the bolt (1) to 18 lb·ft (24.4 N·m).
3. Connect battery and spark plug wire(s). **See Connect the Battery - Gasoline Vehicles on page 1-4.**

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

ENGINE HARNESS WIRING DIAGRAM TABLE

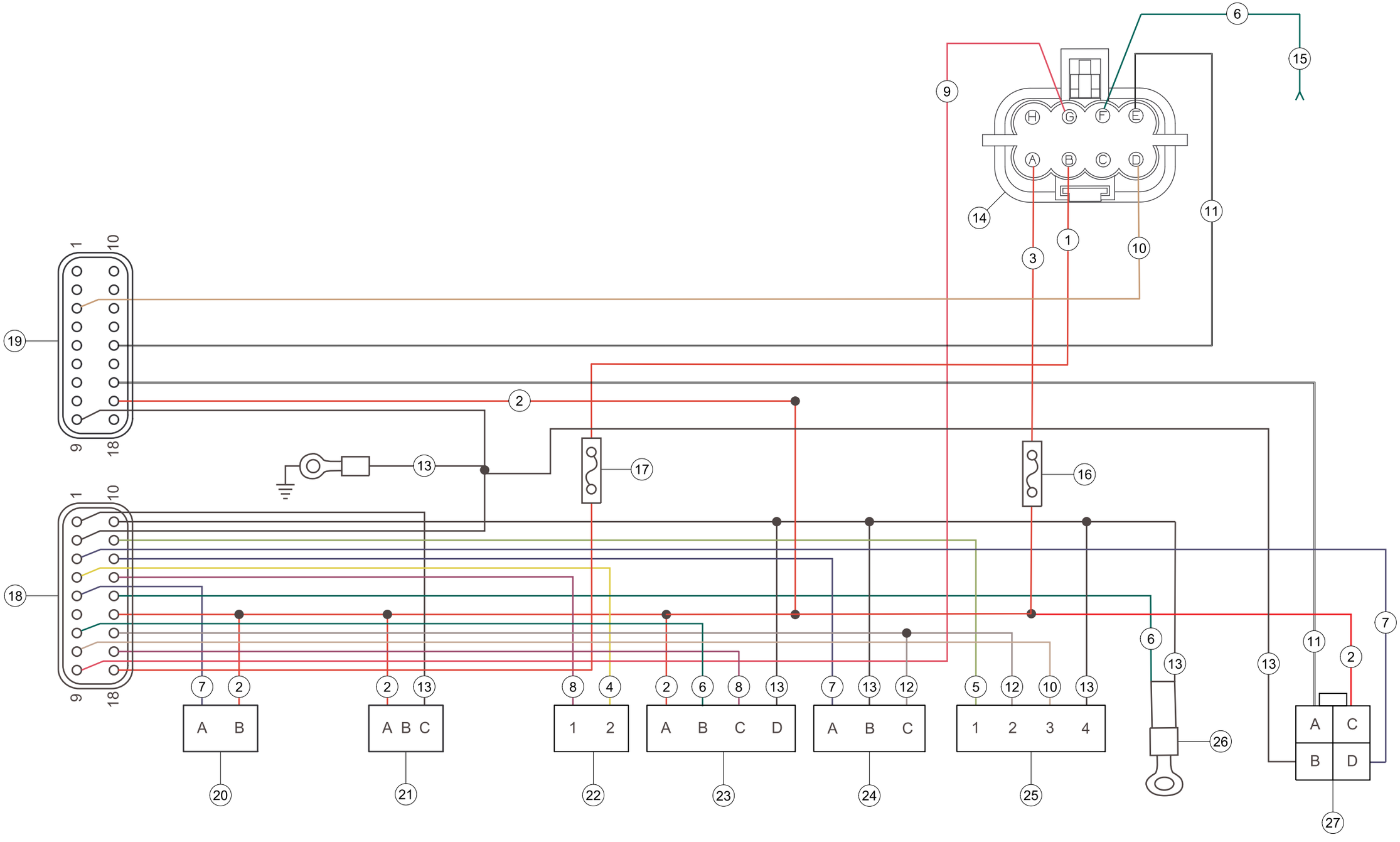
Callout	Description
1	Red
2	Red/Black
3	Red/White
4	Yellow
5	Light Green
6	Dark Green
7	Dark Blue
8	Purple
9	Pink
10	Tan
11	White
12	Grey
13	Black
14	To Main Harness
15	Oil Level Switch
16	10-amp Fuse (Ignition Switch)
17	10-amp Fuse (Battery Power)
18	Black Connector
19	Grey Connector
20	Fuel Injector
21	Ignition Coil
22	Crankshaft Position Sensor
23	Oxygen Sensor
24	Throttle Position Sensor

TABLE CONTINUED ON NEXT PAGE

25	TMAP Sensor
26	Engine Temperature Sensor
27	Diagnostic Connector

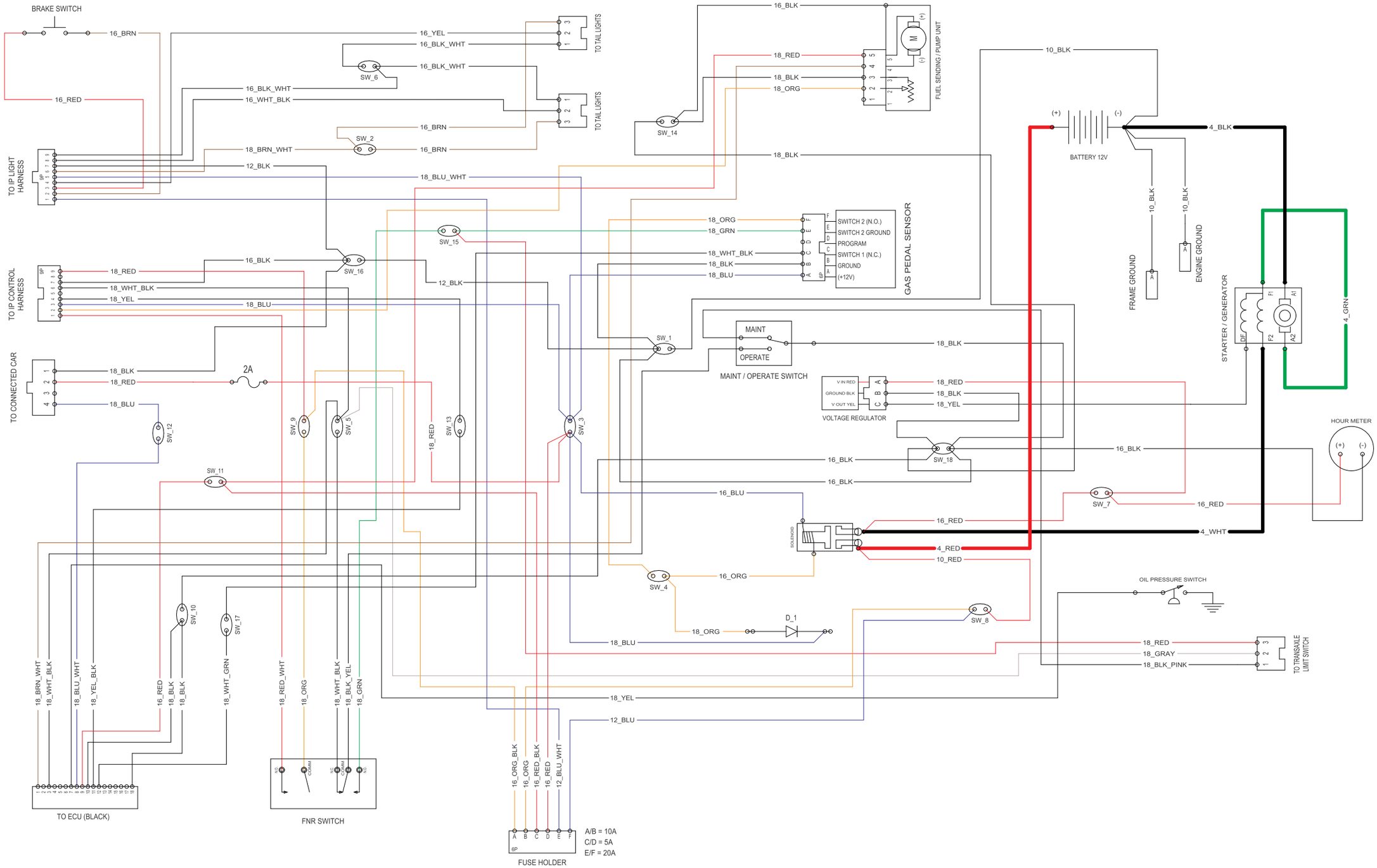
Pagination Page

KOHLER ECH440: ENGINE HARNESS



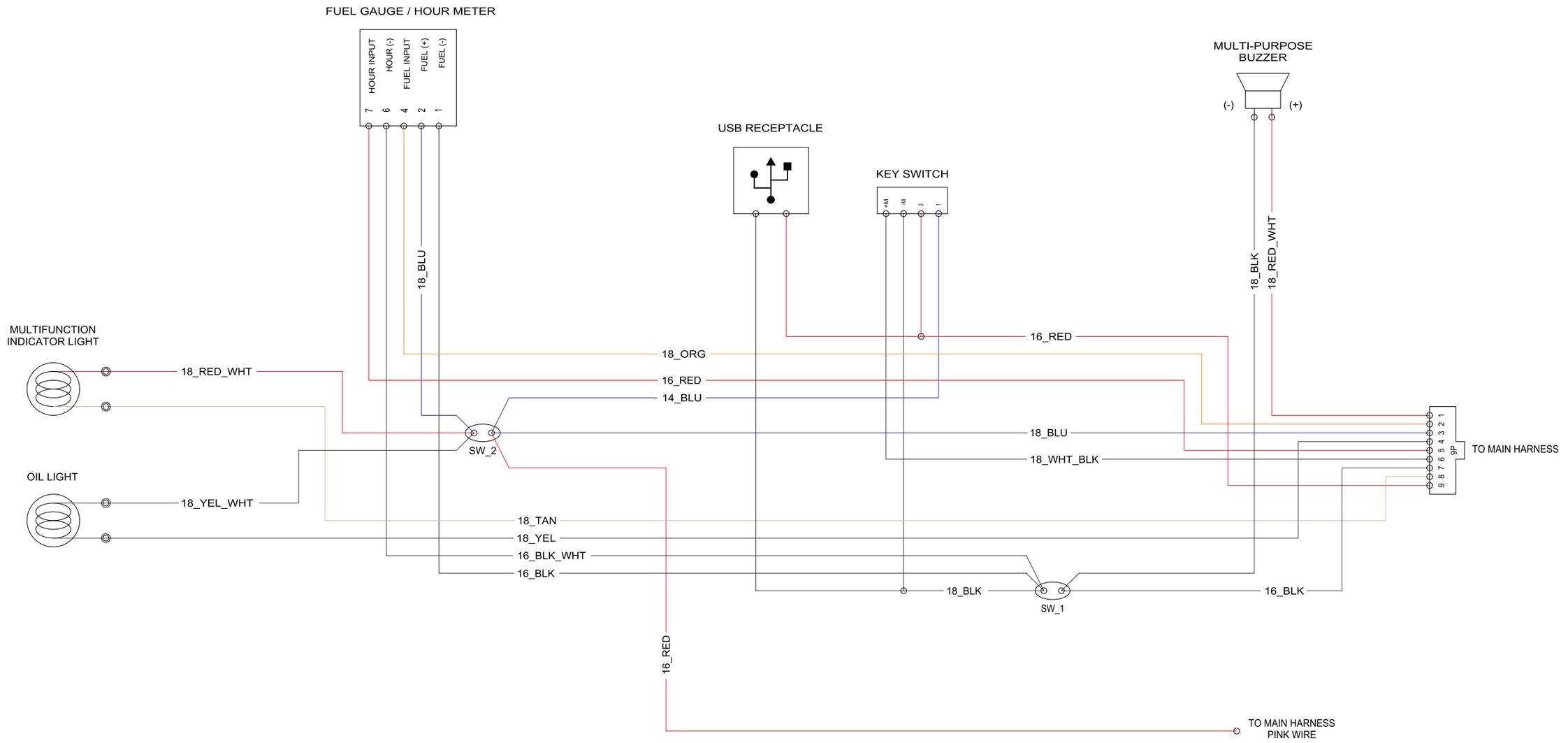
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KOHLER ECH440: MAIN HARNESS



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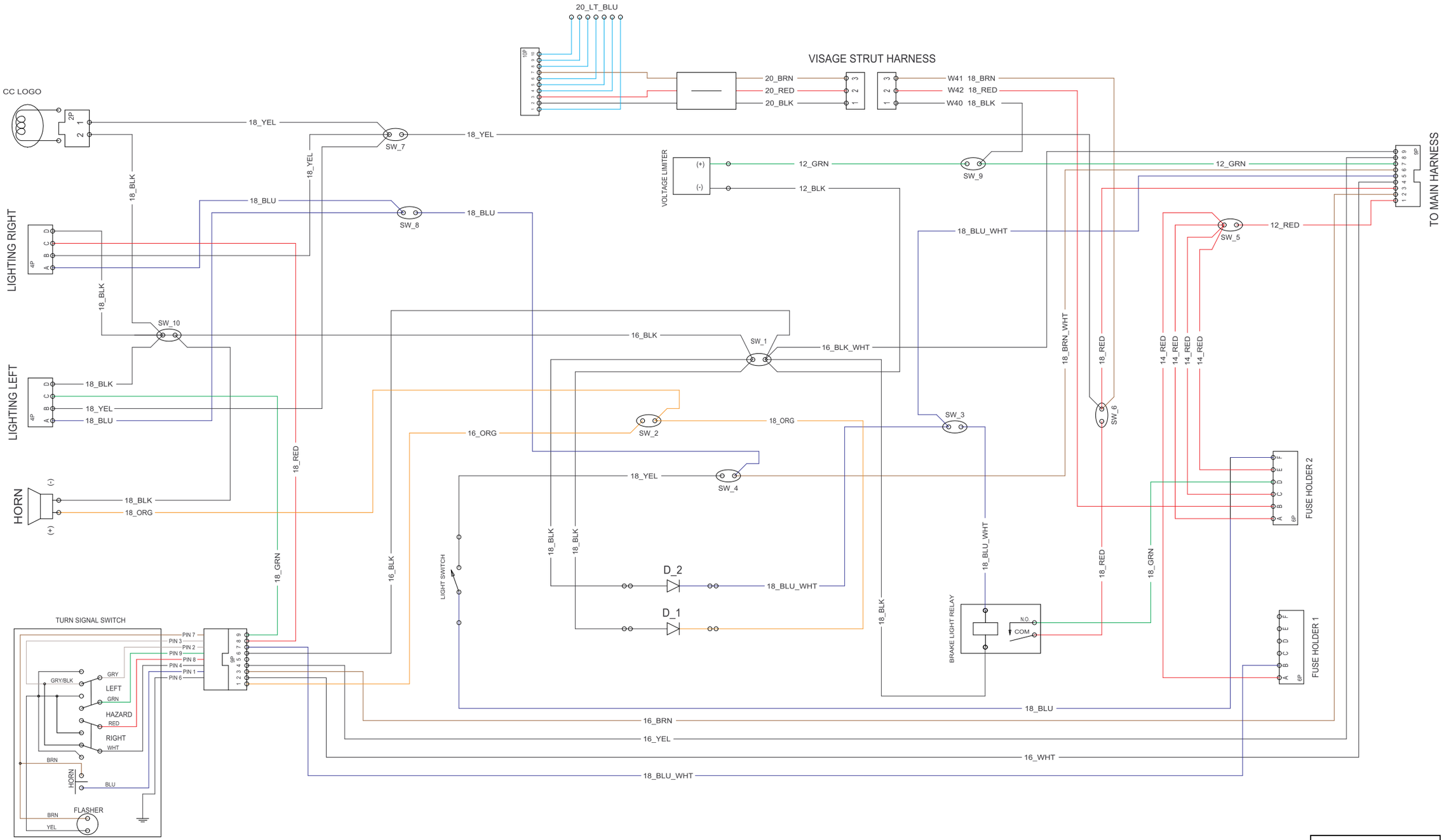
KOHLER ECH440: INSTRUMENT PANEL HARNESS



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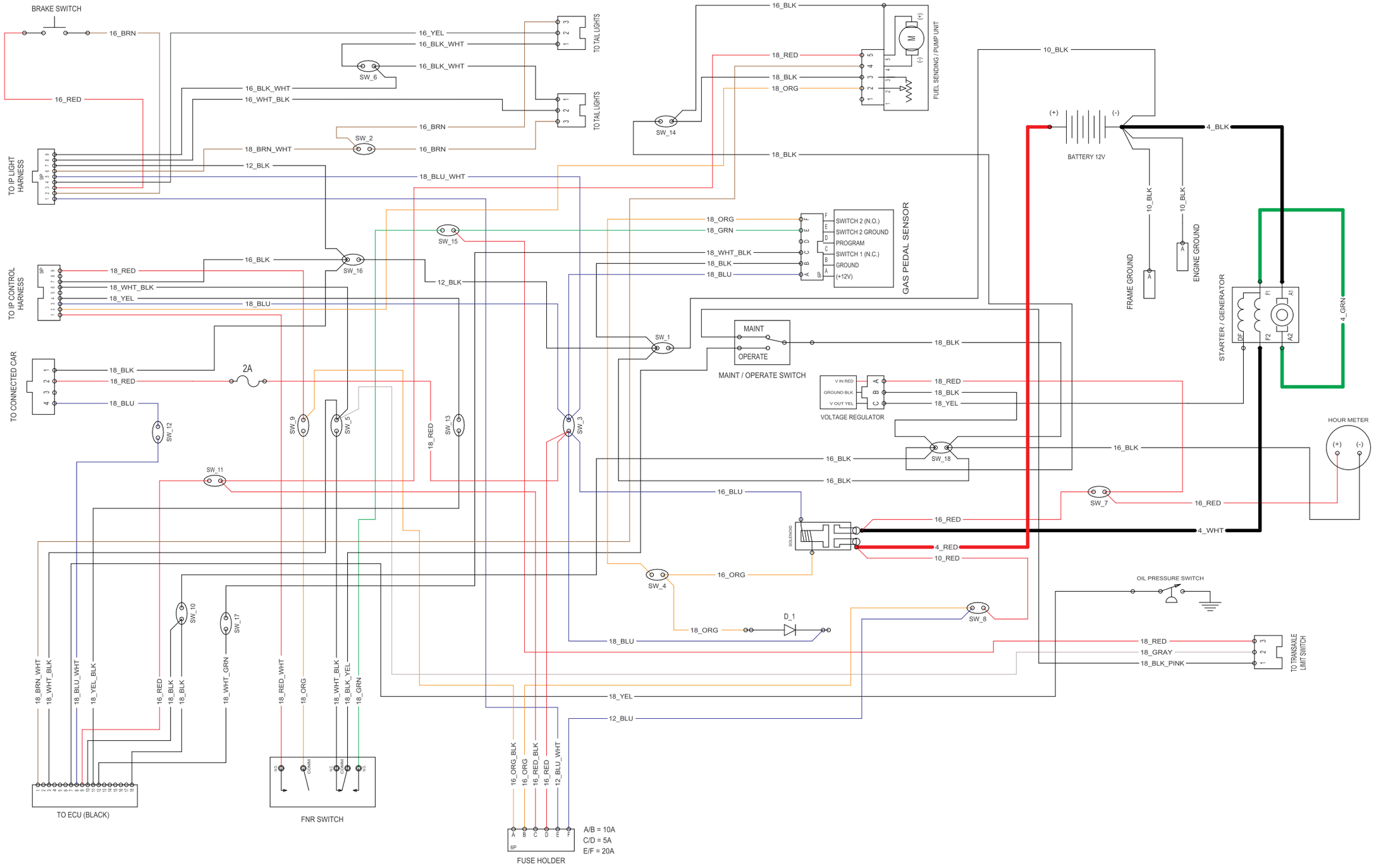
GASOLINE: INSTRUMENT PANEL LIGHT HARNESS



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SUBARU EX-40: MAIN HARNESS



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SUBARU EX-40: ENGINE HARNESS

PIN 1 - INJECTOR

PIN 2 - EMPTY

PIN 3 - EMPTY

PIN 4 - EMPTY

PIN 5 - EMPTY

PIN 6 - TEMP SENSOR

PIN 7 - EMPTY

PIN 8 - EMPTY

PIN 9 - IGNITION SIGNAL

PIN 10 - INJECTOR B+

PIN 11 - EMPTY

PIN 12 - EMPTY

PIN 13 - MAP SENSOR

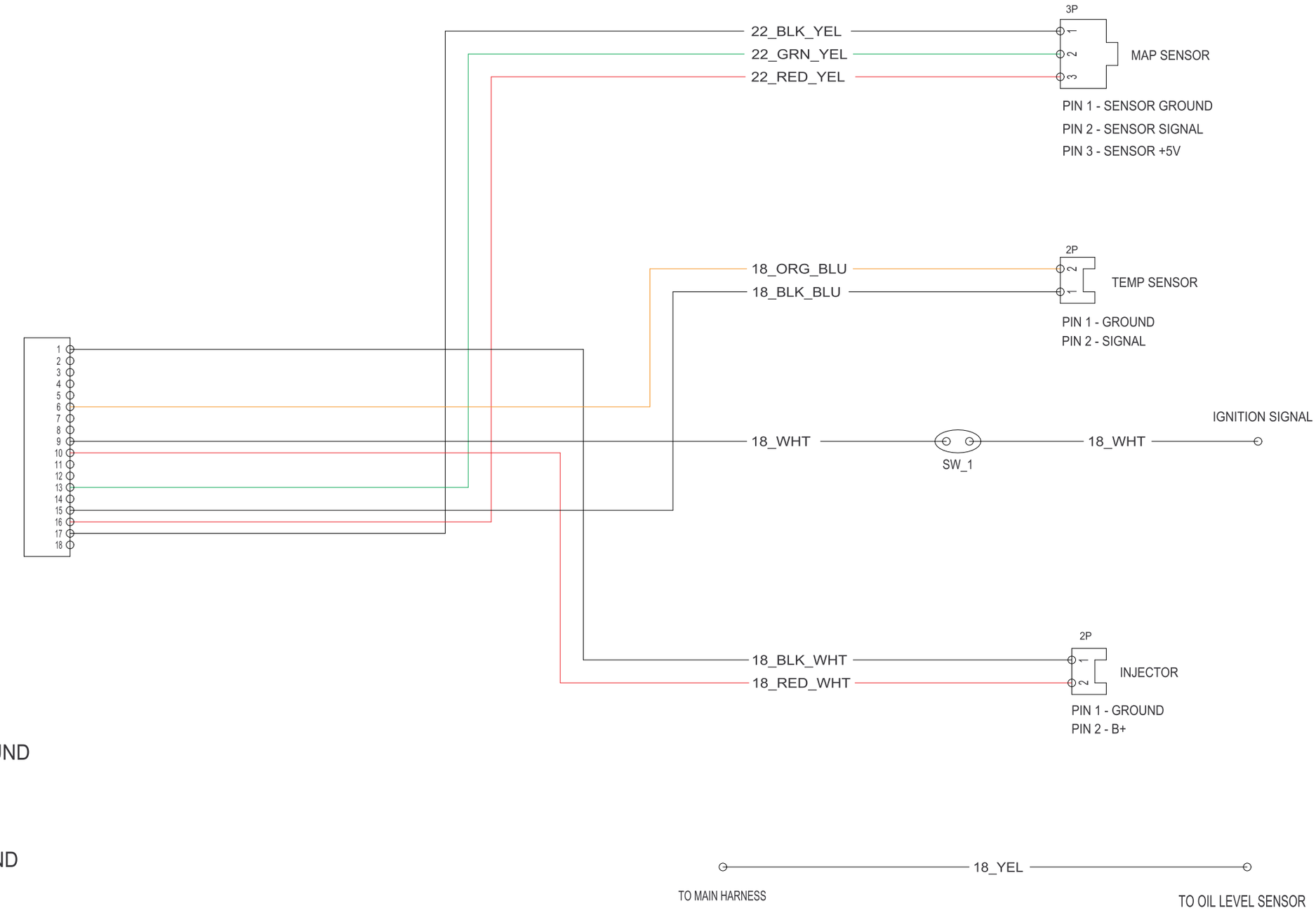
PIN 14 - EMPTY

PIN 15 - TEMP SENSOR GROUND

PIN 16 - MAP SENSOR +5V

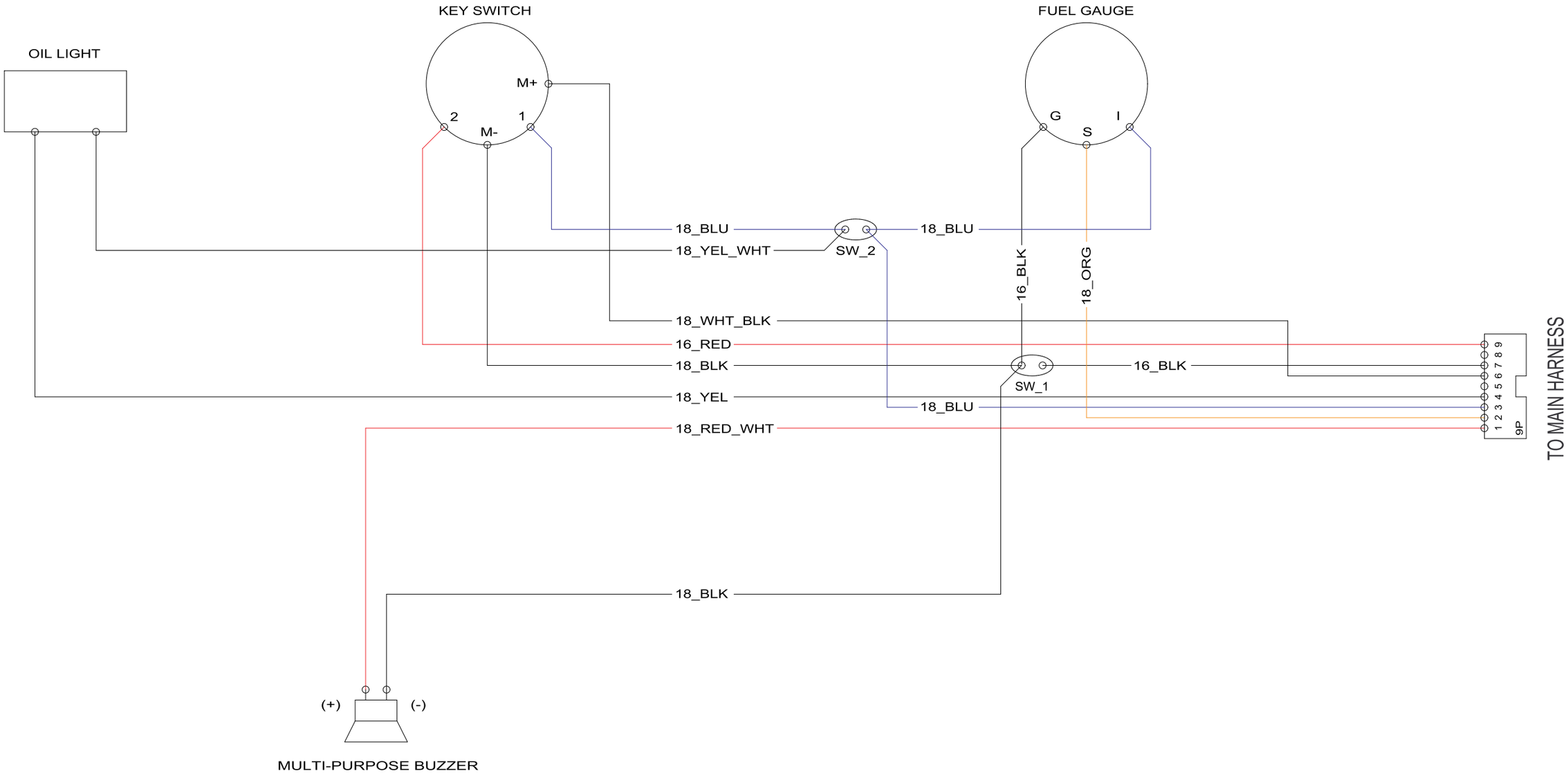
PIN 17 - MAP SENSOR GROUND

PIN 18 - EMPTY



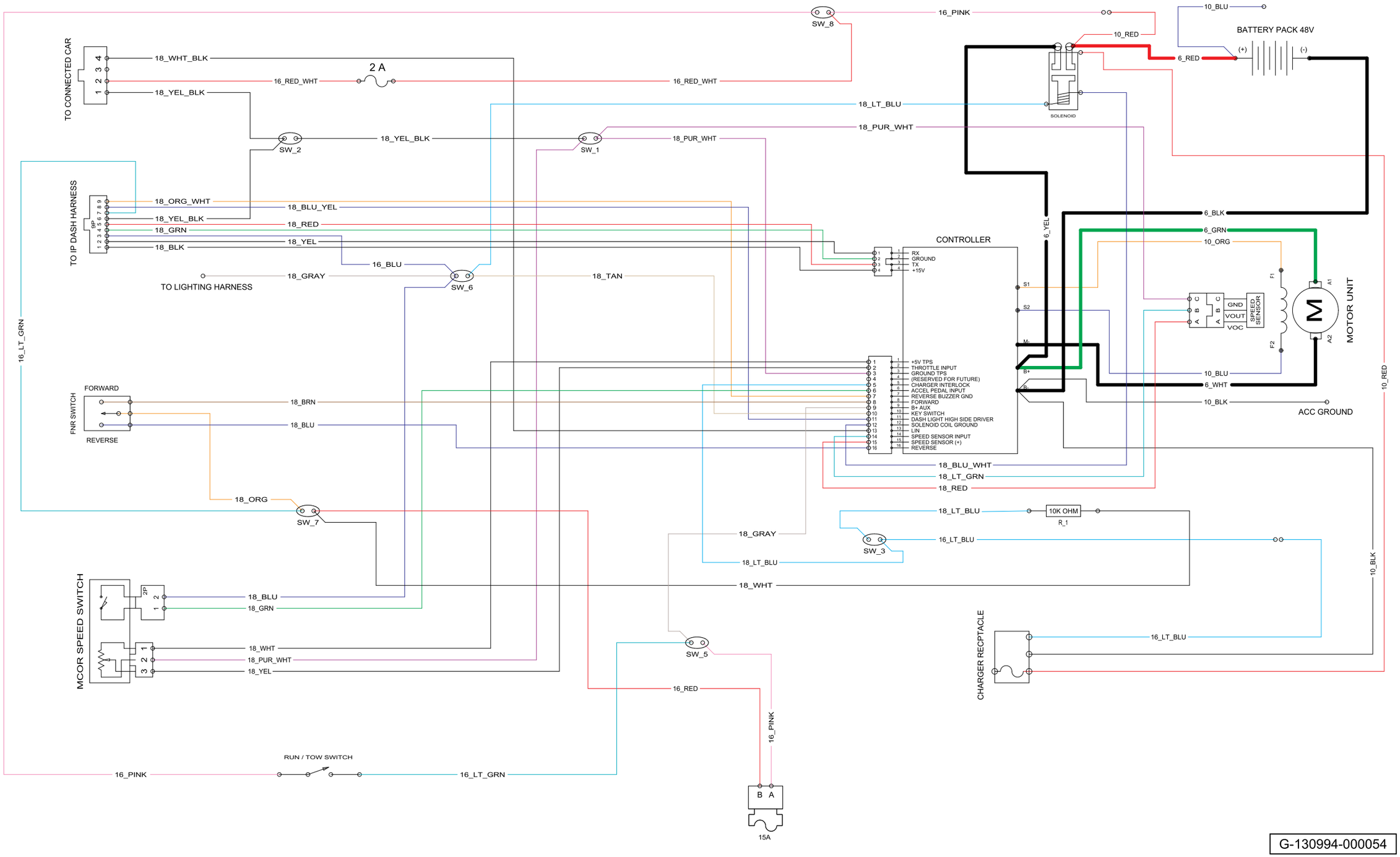
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SUBARU EX-40: INSTRUMENT PANEL DASH HARNESS



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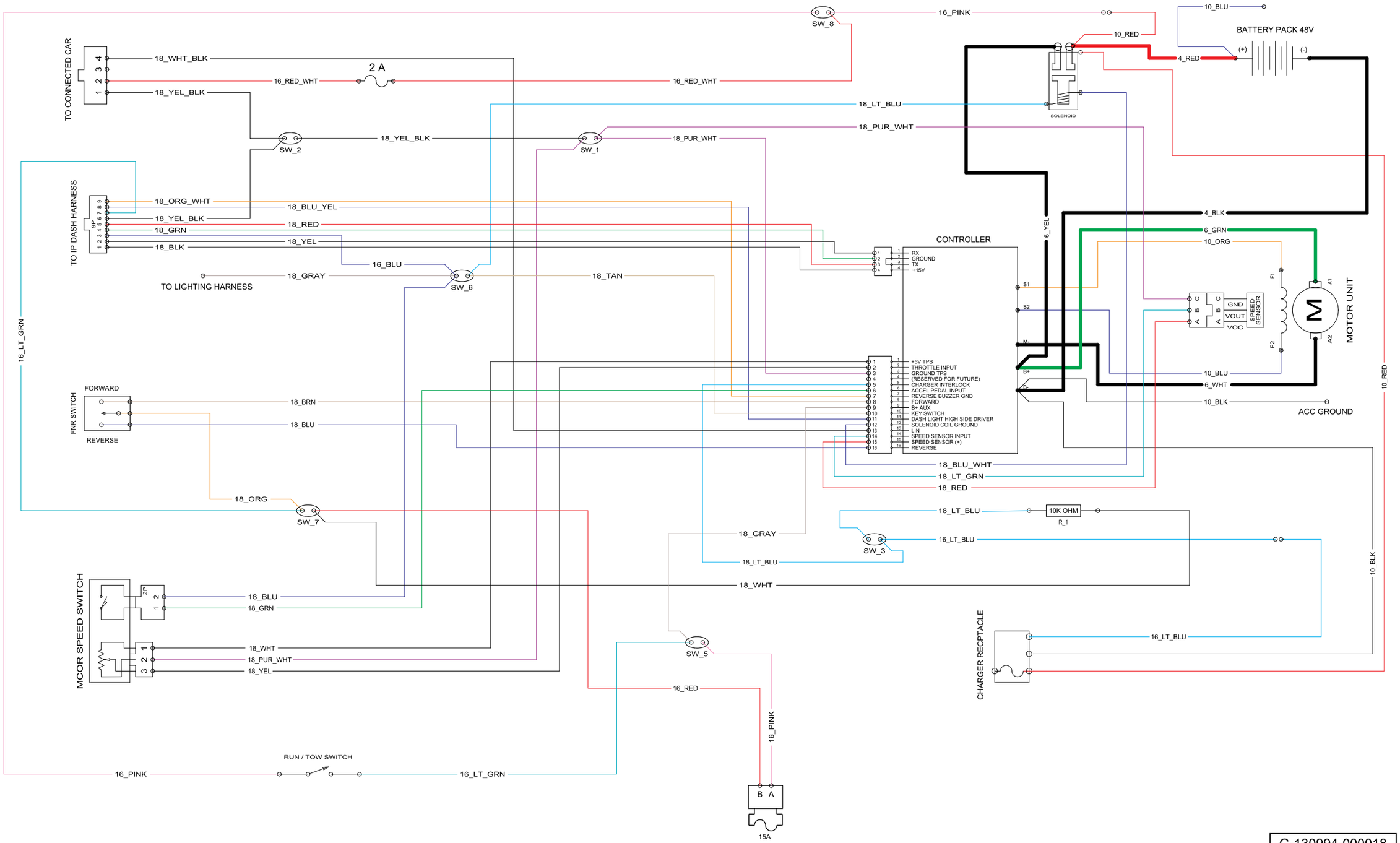
DC ELECTRIC: TWO PASSENGER MAIN HARNESS



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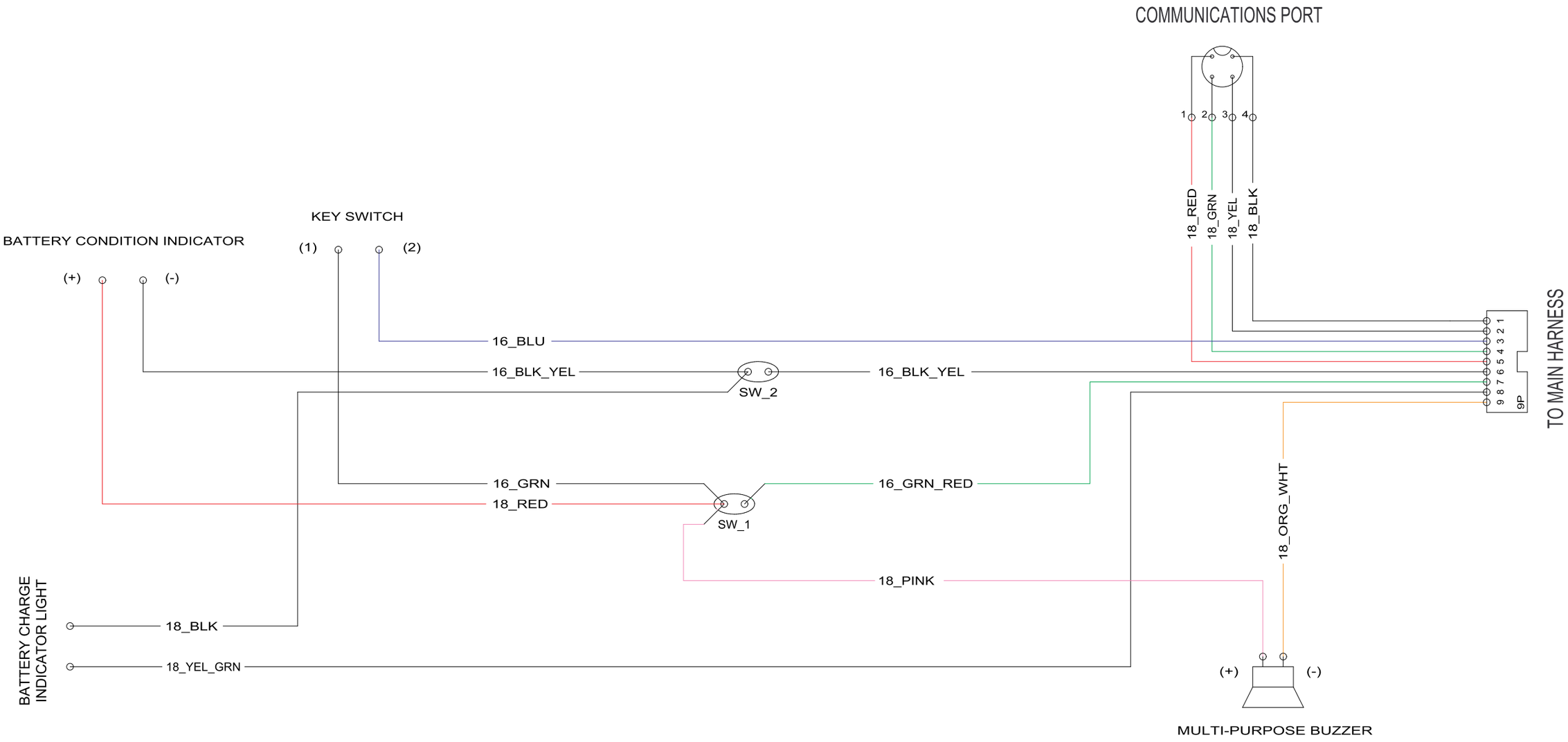
DC ELECTRIC: FOUR PASSENGER MAIN HARNESS



G-130994-000018

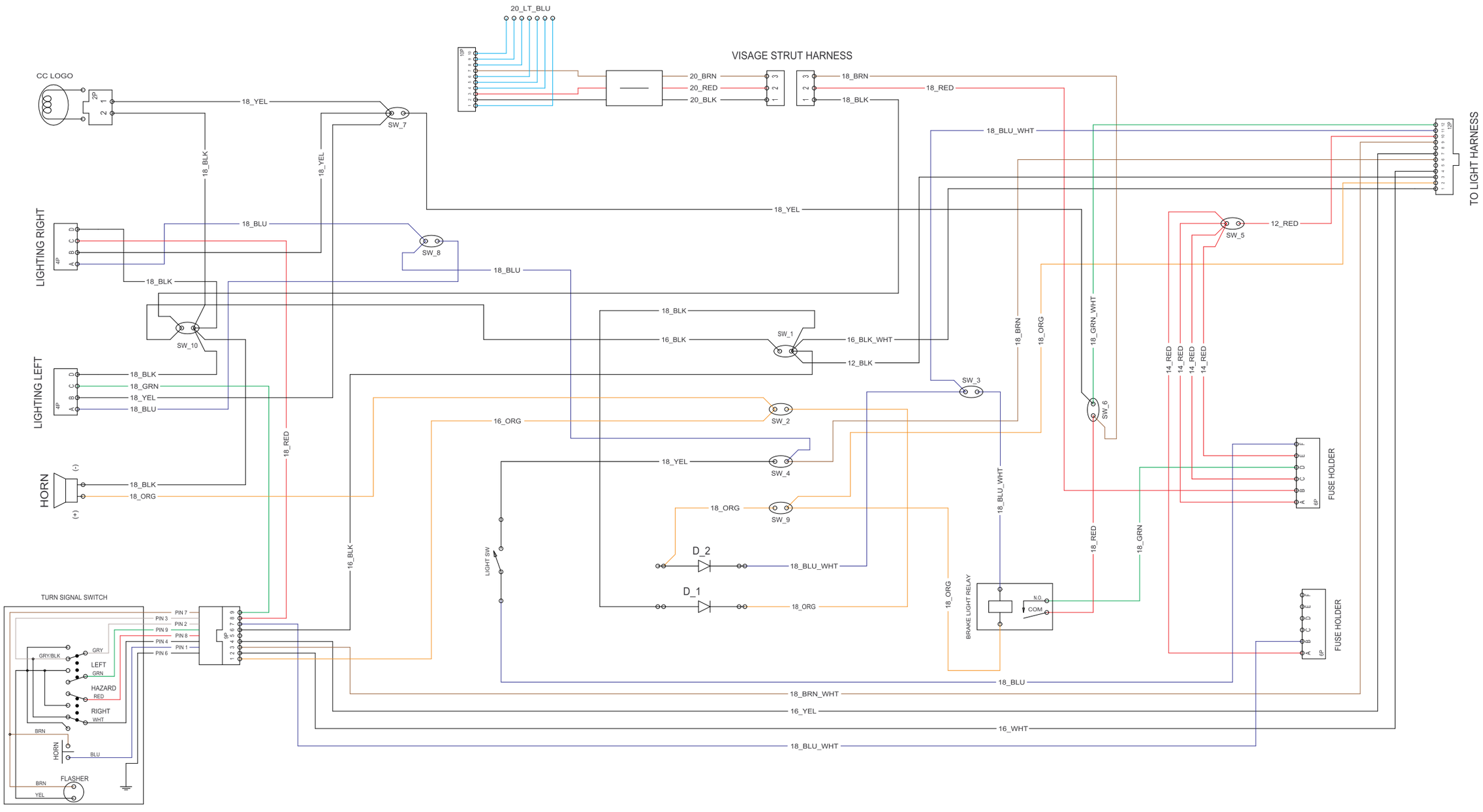
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ELECTRIC: INSTRUMENT PANEL DASH HARNESS



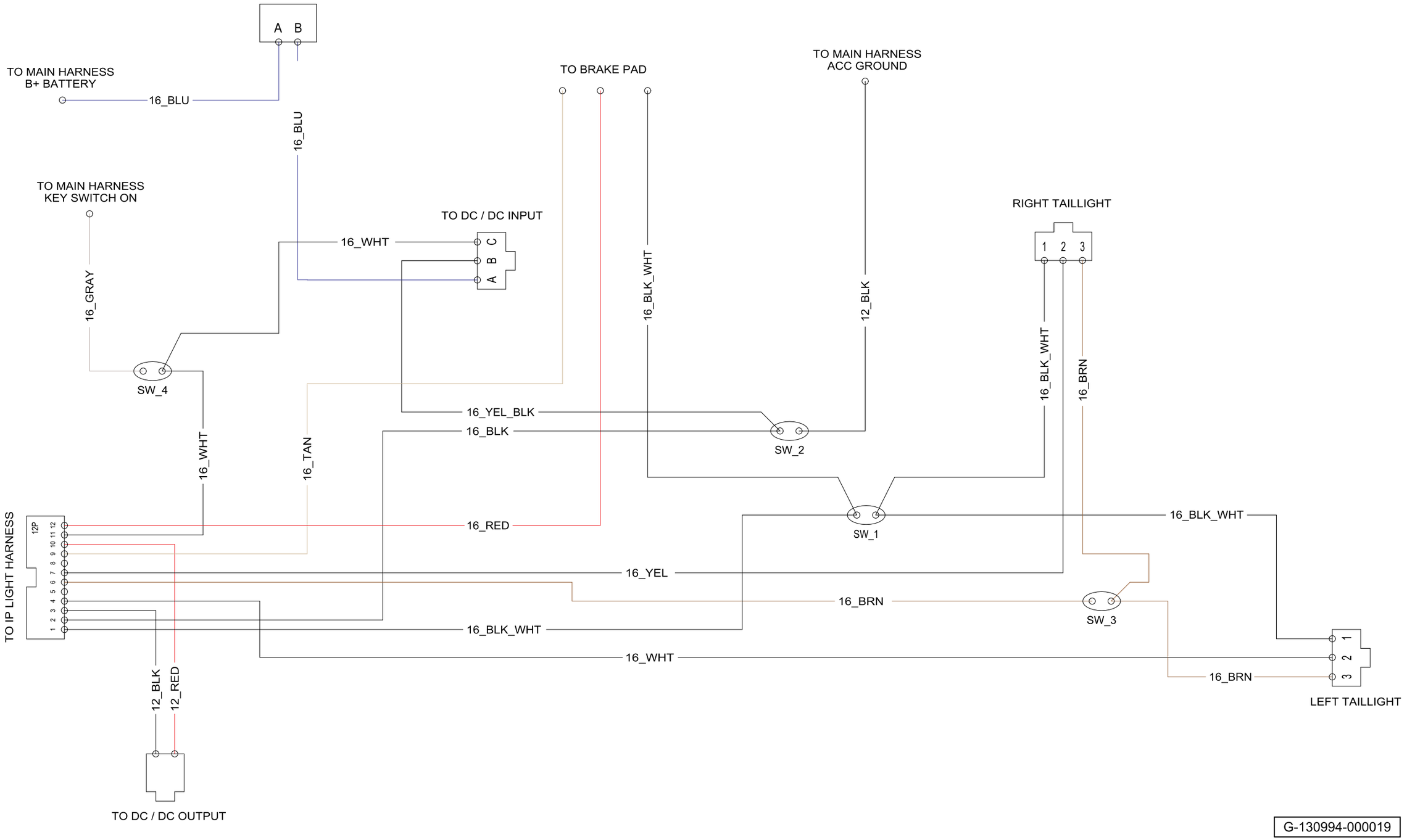
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ELECTRIC: INSTRUMENT PANEL LIGHT HARNESS



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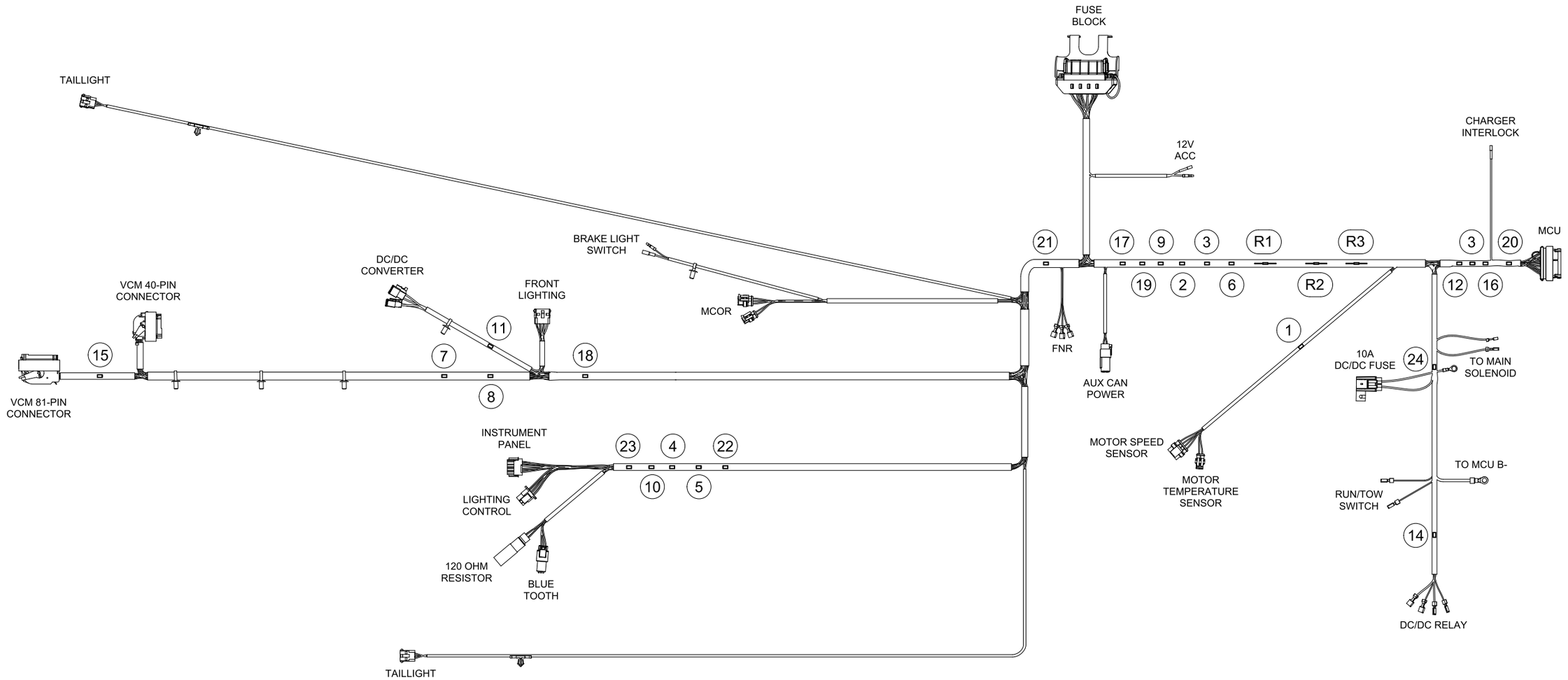
ELECTRIC: LIGHTING HARNESS



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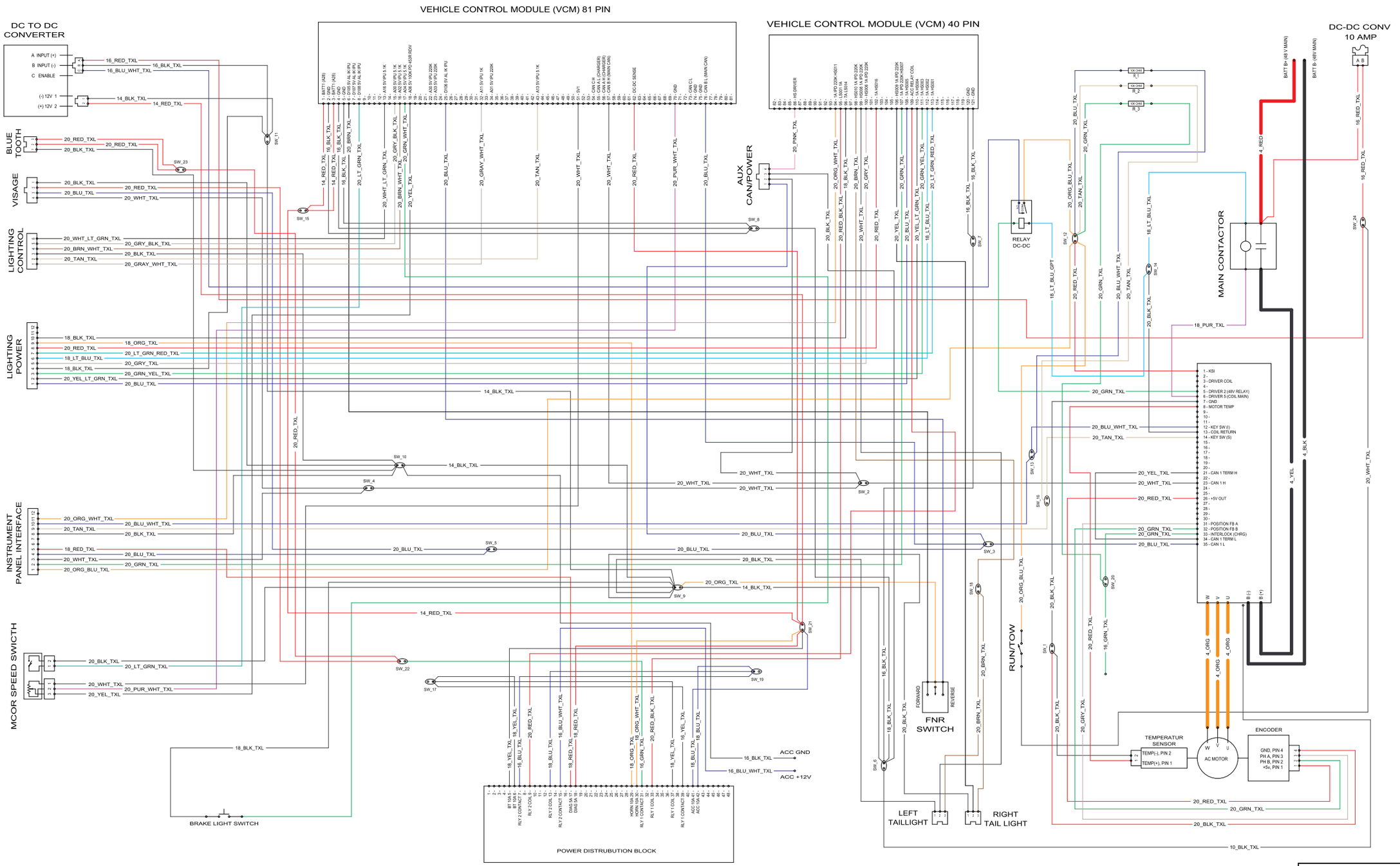
AC ELECTRIC - SONIC WELD AND RESISTOR LOCATIONS



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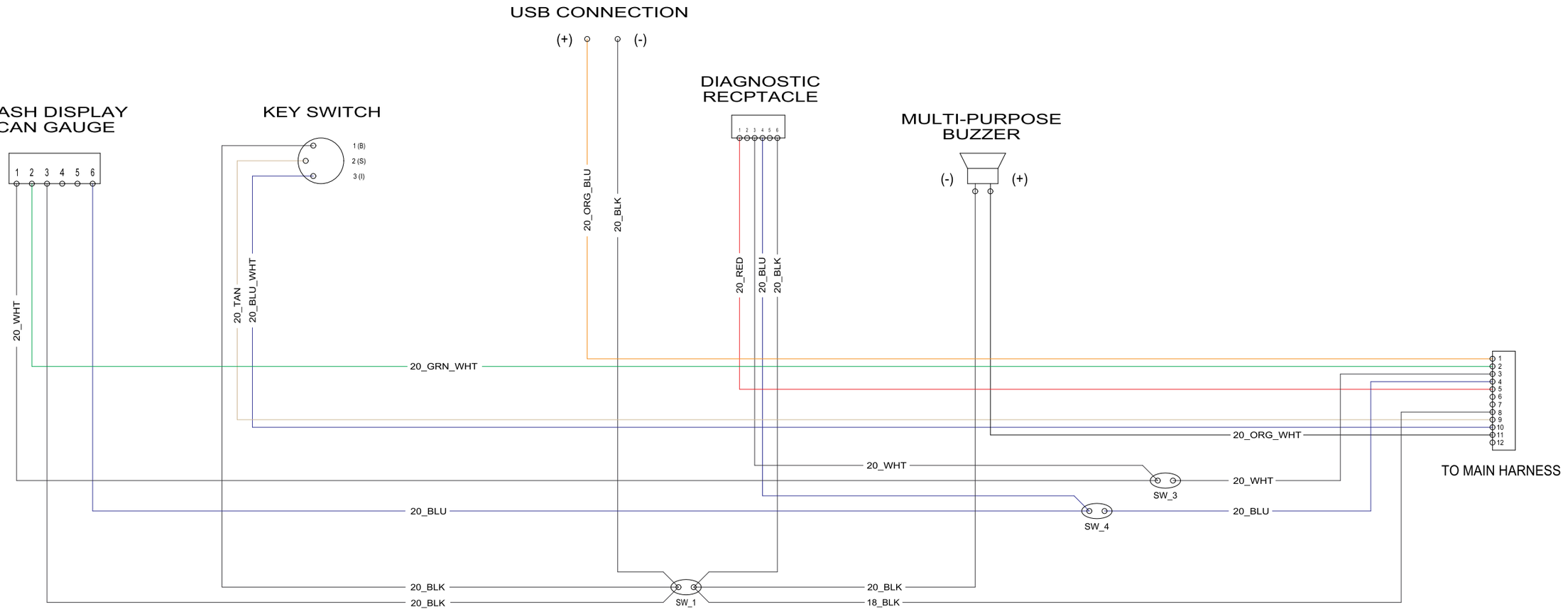
AC ELECTRIC: MAIN HARNESS



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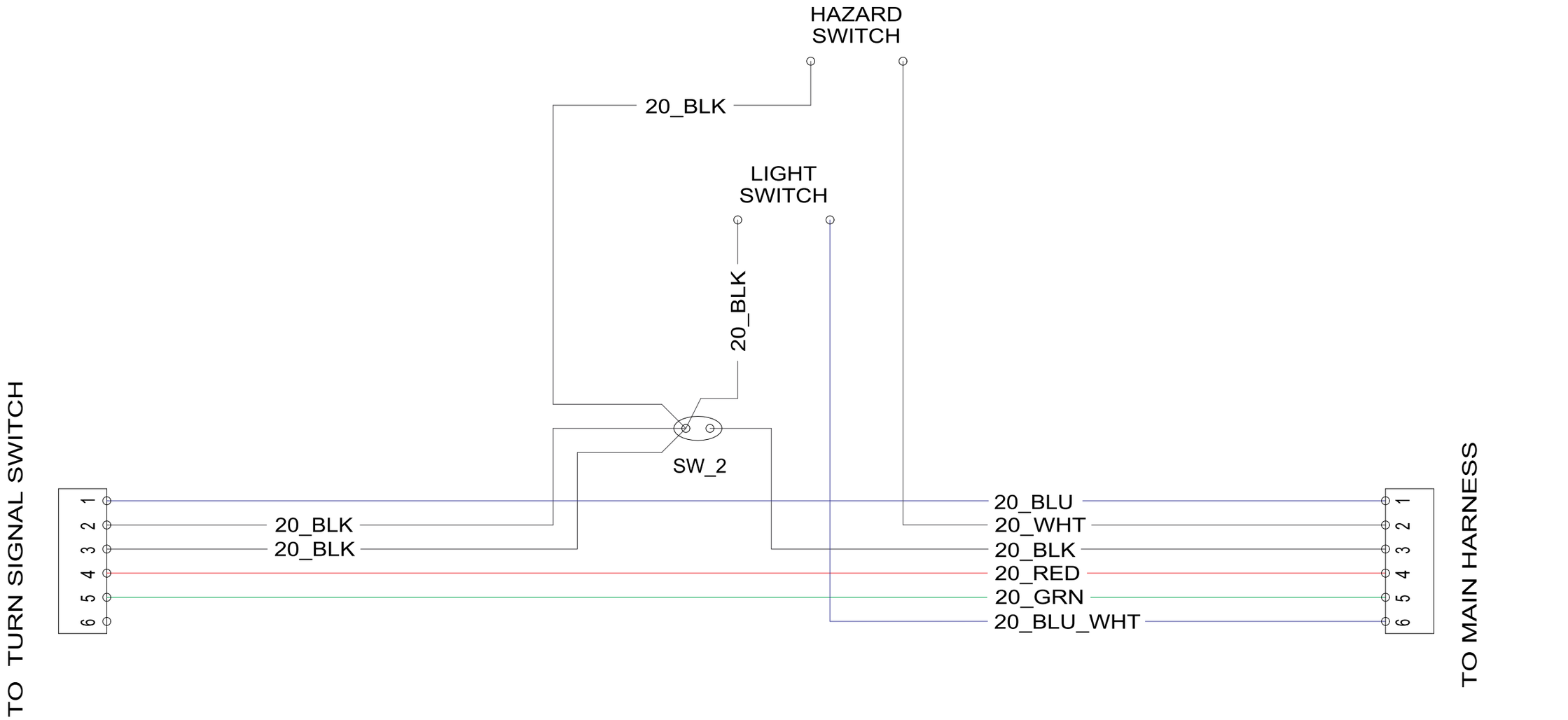
INSTRUMENT PANEL HARNESS



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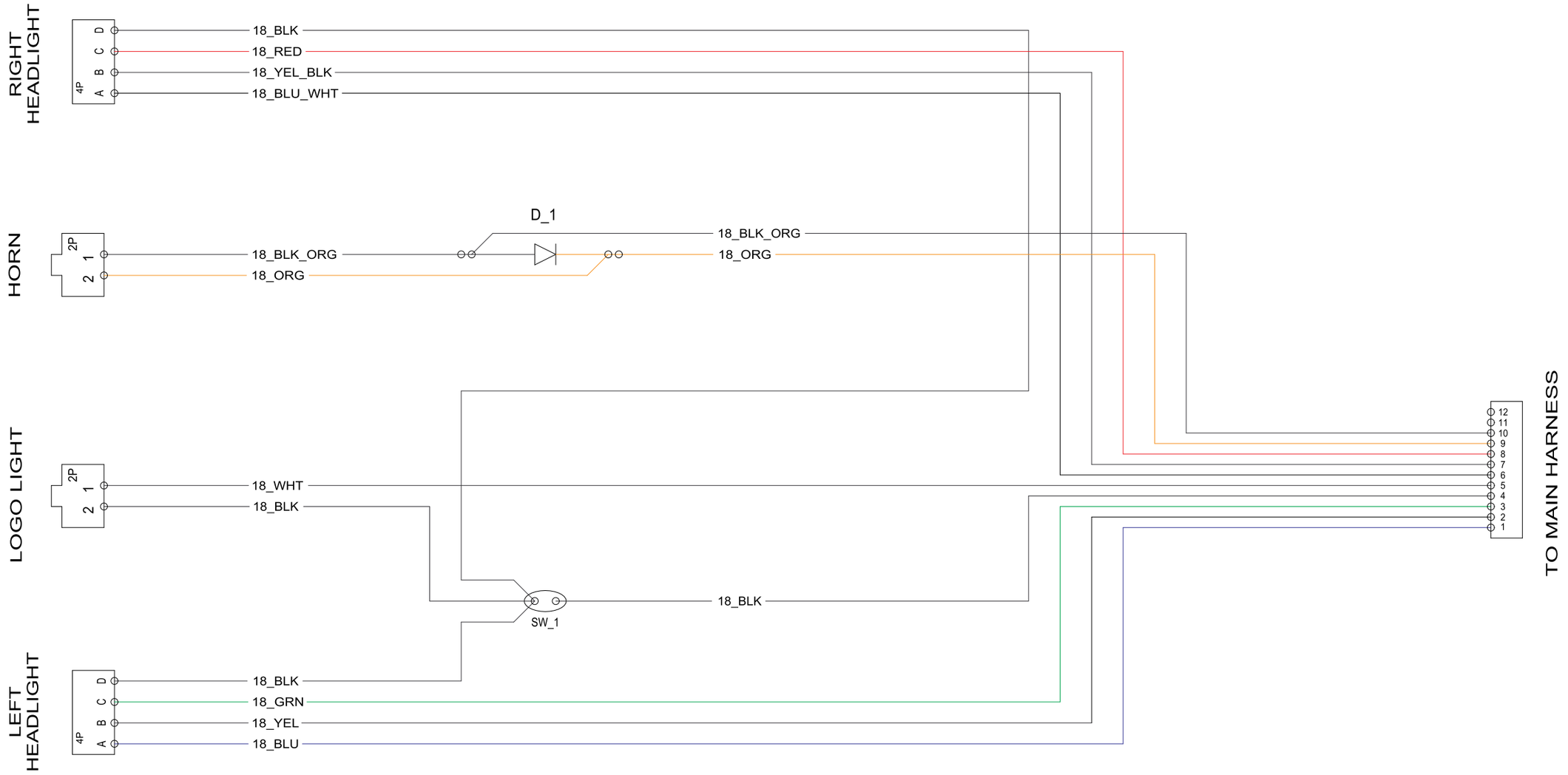
LIGHTING CONTROL HARNESS



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FRONT LIGHTING HARNESS



G-130994-000030

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