



**Columbia ParCar Corp.**

# **SERVICE MANUAL**

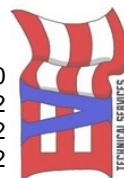
## **SU5**



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The logo consists of a stylized "EVS" acronym. The "E" and "S" are red with white horizontal stripes, and the "V" is blue with white horizontal stripes. Below the acronym, the words "TECHNICAL SERVICES" are written in a small, black, sans-serif font.

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**CHANGE HISTORY – SU5**

DATE	DESCRIPTION	BY
4/29/14	Issued	TS
5/27/14	Added faulty code category table and additional fault codes	TS
8/12/14	Added caliper torque specifications	TS

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**GENERAL**

This service manual has been prepared with two purposes. First, it will introduce the trained maintenance professional to the latest field tested and factory approved major repair methods. Secondly, it will acquaint the reader with the construction of the Columbia ParCar vehicles and assist him/her in performing basic maintenance and repair. We sincerely believe that this manual will make the association with Columbia ParCar vehicles a more pleasant and profitable experience.

In addition to the information given in this manual, Service Bulletins are issued to Columbia ParCar dealers which cover interim engineering changes and supplementary information. Service Bulletins should be consulted for complete information on the models covered by this manual.

To ensure the safety of those servicing our vehicles and to protect the vehicles from possible damage resulting from improper service or maintenance, the procedures in this manual should always be followed exactly as specified. Execution of the procedures and troubleshooting tips as outlined will ensure the best possible service from the vehicle(s). To reduce the chance of personal injury and/or property damage, carefully observe the DANGER, WARNING, CAUTION & NOTICE recommendations throughout this manual. See *Section 1 Safety* for additional details.

If your vehicle is a Low Speed Vehicle (LSV), commonly referred to as NEV or Neighborhood Electric Vehicle, it meets the requirements of the National Highway Traffic & Safety Administration (NHTSA) as stated in the Code of Federal Regulations, Title 49, Part 571, Standard 500, Low Speed Vehicles.

If your vehicle is a Personal Transportation Vehicles (PTV) it does not meet the above requirements and are not designed for over-the-road use and are not equipped for operation on public streets, roads, or highways.

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**PREPARATION FOR SERVICE**

Proper preparation is very important for efficient service work. A clean work area at the start of each job will allow you to perform the repair as easily and quickly as possible, and reduce the incidence of misplaced tools and parts. Columbia ParCar vehicles that are excessively dirty should be cleaned before work begins. Cleaning will occasionally uncover trouble sources.

Tools, instruments and parts needed for the job should be gathered before work is started. Interrupting a job to locate tools or parts is a needless delay. Special tools required for a job are listed at the beginning of each section.

**MODEL IDENTIFICATION**

Always give the vehicle identification number (VIN) when ordering parts or making inquiries about the vehicle. Use of the full and complete vehicle identification number will ensure that the dealer or service provider is supplying you with the correct parts for the vehicle. See *Section 2-General Information* for VIN location and additional information.

**USE GENUINE REPLACEMENT PARTS****WARNING**

**When replacement parts are required, use only genuine Columbia ParCar parts or parts with equivalent characteristics including type, strength and material. Failure to do so could result in product malfunction and possible injury to the operator and/or passenger.**

To ensure a satisfactory and lasting repair, follow the service manual instructions carefully and use only genuine Columbia ParCar vehicle replacement parts. This is the insurance that the parts you are using will fit right, operate properly and last longer. When you use genuine Columbia ParCar vehicle parts, you use the best.

**PRODUCT REFERENCES**

When reference is made in this manual to a specific brand name product, tool or instrument, an equivalent product, tool or instrument may be used in place of the one mentioned.





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**Service Manual**

**Section 1**

**Safety**

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**OVERVIEW**

Statements in this manual preceded by the words **DANGER**, **WARNING**, **CAUTION** or **NOTICE** and words printed in **bold face** are very important. We recommend you take special notice of these items.

**⚠ DANGER**

**Danger indicates a hazardous situation which, if not avoided, will result in death or serious injury.**

**⚠ WARNING**

**Warning indicates a hazardous situation which, if not avoided, could result in death or serious injury.**

**⚠ CAUTION**

**Caution indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.**

**NOTICE:** Notices are messages not related to personal injury. They will provide key information to prevent property damage and to assure procedures are more easily understood or implemented.

It is important to note that some warnings against the use of specific service methods, which could damage the vehicle or render it unsafe, are stated in this service manual. However, please remember that these warnings are not all inclusive. Since Columbia ParCar Corporation could not possibly know, evaluate and advise servicing personnel of all possible ways in which service might be performed or of the possible hazardous consequences of each way, we have not undertaken any such broad evaluation.

Accordingly, anyone who uses a service procedure or tool which is not recommended by Columbia ParCar must first thoroughly satisfy him/herself that neither their nor the operator's safety will be jeopardized by the service methods selected.

**SAFETY INFORMATION**

It is Columbia ParCar's specific recommendation that the following safety information must be observed at all times. Not all are repeated throughout this manual, but the recommendations included must be observed whenever these subjects (indoor vehicle operation hazards) are encountered.

**⚠ WARNING**

**Any modifications or changes to the vehicle that affect the stability or increases vehicle speed beyond factory specifications could result in severe personal injury or death. Always, remove keys and turn the master disconnect switch counterclockwise to the OFF position before servicing or repairing your vehicle. See Section 8-Batteries, for specific details.**

**⚠ DANGER**

**All batteries used in electric vehicles can explode! Always wear full face shield when working on or near batteries. Hydrogen fumes are a natural byproduct of charging and discharging and are extremely explosive.**

**Do not smoke around electric vehicle batteries. Keep sparks and flames away from batteries. Battery charging should only be done in a well-ventilated area. Refer to Section 9-Batteries for details.**

**Batteries contain acid which can cause severe burns. Avoid contact with skin, eyes, or clothing. Wear full face shield and rubber gloves when working on or near batteries.**

**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.
- **Eyes:** Flush with water for fifteen minutes. Call a physician immediately.

**⚠ WARNING**

**When working around batteries, use approved insulated tools, remove jewelry such as rings, watches, chains, etc. and place an insulating material such as wood, plastic, rubber, etc. over batteries covering all connections.**

**If any problems are found during scheduled maintenance or inspections, do not operate vehicle until repairs are completed. Failure to make necessary repairs could result in fire, property damage, severe personal injury or death.**

**⚠ DANGER**

**Only trained maintenance professionals should repair or service this vehicle. Persons performing even simple repairs or service should have working knowledge and experience in general electrical and mechanical repair. Follow all procedures exactly and observe all warnings stated in this manual. Use caution and common sense.**

Proper service and repair is important for safe, reliable operation of all Columbia vehicles. The service procedures recommended and described in this service manual are effective methods for performing service operations. Some of these service operations require the use of tools specially designed for this purpose. These special tools should be used when and as recommended.

**ICONS IN PROCEDURES**

Watch out for icons and symbols in procedures. They are there to help you avoid situations that might expose you to an unnecessary hazard or potential injury.

**⚠ DANGER**

Use insulated tools when working near batteries or electrical connections. Use extreme caution to avoid shorting of components or wiring.

**⚠ CAUTION**



Moving parts hazard! When operating any vehicle in a stationary position, avoid chains, belts, and wheels which could snag clothing or cause severe injury to body parts. A running vehicle must be worked on with the greatest care. Use caution and common sense.

**⚠ DANGER**

Do not wear loose clothing or jewelry such as rings, watches, chains, etc. when servicing the vehicle. Failure to do so could result in personal injury or death.

**⚠ WARNING**

Working on Columbia ParCar vehicles without following proper procedures and using proper lifting equipment may result in vehicle damage or personal injury. See Section 3 - Lifting Instructions detailed instructions. Always wear safety glasses or approved eye protection while servicing vehicle. Wear a full face shield when working with batteries. Failure to maintain vehicle properly could result in decreased vehicle performance, reliability or cause severe personal injury. Exceeding rated vehicle load capacities could result in possible severe injury or property damage.

**⚠ CAUTION**

Check the vehicle for proper location and condition of all vehicle safety and operation decals.

**NOTICE:** The modification of vehicles for use in other than its intended purpose is not recommended. Any unauthorized modification may void your vehicle warranty.

**⚠ CAUTION**



**HOT! DO NOT** attempt to service hot electric motor or resistors. Failure to observe this warning could result in severe burns.

The P5 is a vehicle designed to transport one (1) operator and one passenger unless adequate provisions have been installed to accommodate additional passengers.

If your vehicle is a Low Speed Vehicle (LSV) it meets the requirements of the National Highway Traffic & Safety Administration (NHTSA) as stated in the Code of Federal Regulations, Title 49, Part 571, Standard 500, Low Speed Vehicles.

**SAFETY PREPARATIONS**

**⚠ DANGER**

Before performing any service on the vehicle, always turn Power keyswitch to OFF and remove. Turn Directional knob to NEUTRAL. Block tires.

**DECAL**

Warning/Operating Instructions decal should be ordered and replaced as soon as they are discovered to be illegible or missing. Part number for the Personal Transportation Vehicles vehicle decal is 53258-07 (Figure 1-1) or 43960-07 for Low Speed Vehicles (not shown).

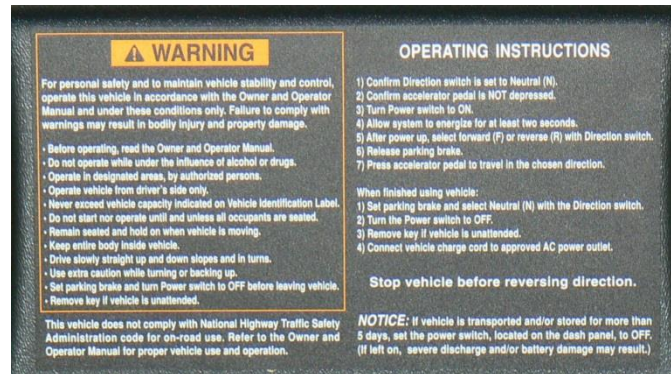


Figure 1-1

To remove a decal, use a heat gun or hair dryer to soften up and remove any damaged sticker. Peel off backing of the new decal and carefully position in place.





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**Service Manual**

**Section 2**

**General Information**

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**VEHICLE IDENTIFICATION NUMBER (VIN)**

Each vehicle has a unique VIN. The VIN describes facts and features of the vehicle and contains thirteen (13) digits.

**VIN MATRIX**

**Personal Transport Vehicle (PVT)**

<b>Digit 1 thru 3 = Abbreviation (Model)</b>	S5L, S5S
<b>Digit 4 = Power System</b>	F = Sep Ex Regen G = AC Induction
<b>Digit 5 = System Voltage</b>	4 = 48V (8 – 6V) M = AGM (8 -6V)
<b>Digit 6 = VIN Spacer</b>	- = Standard # = Special Product
<b>Digit 7= Controller Amperage</b>	4 = 400 Amp B = 450Amp 5 = 500Amp
<b>Digit 8 = Brake System</b>	Y = Rear Hydraulic X = Front & Rear Hydraulic
<b>Digit 9 = Build Year</b>	N = 2014, P = 2015 etc.
<b>Digit 10 Thru 13 – Build Sequence</b>	1234

**Low Speed Vehicle (LSV)**

<b>Digit 1 thru 3:</b>	5FC = CPC Manufacturer Identification
<b>Digit 4: Line</b>	L = Low Speed Vehicle
<b>Digit 5: Series</b>	S = Summit
<b>Digit 6: Body Type</b>	2 = 2 Person 4 – 4 Person
<b>Digit 7: Engine Type</b>	6 = 48V DC Regen 8 = 48V AC Induction
<b>Digit 8: Restraint</b>	A = Type 1 Seat Belt Assembly B = Type 2 Seat Belt Assembly (3 Point)
<b>Digit 9: Check Digit</b>	Calculated per 49CFR 565.4
<b>Digit 10: Model Year</b>	E = 2014 F = 2015 etc.
<b>Digit 11: Plant Location</b>	1 = Reedsburg
<b>Digit 12-17: Sequential Numbers</b>	00019 - 000999

**VIN LABELS**

The VIN for Personal Transport Vehicles is printed on a white label, affixed to the bottom of the front hood compartment and affixed to the steering wheel under the steering wheel cover.

The VIN for Low Speed Vehicles is printed on a white label, affixed to the top of the dash and affixed to the steering wheel under the steering wheel cover. The VIN is also noted on the LSV Vin Label (Figure 2-1) located in the front hood compartment.

**NOTICE: Always provide the complete VIN when contacting Columbia for technical assistance or maintenance and repair parts.**

MFD BY: COLUMBIA PARCAR CORP  
REEDSBURG, WI 53959, USA  
DATE MFD: / MM/YY  
GVWR: KG (LBS)  
GAWR: FRONT - KG (LBS)  
GAWR: REAR - KG (LBS)  
TIRE SIZE: / (SIZE SPEC)  
COLD INF. PRESSURE (FRONT & REAR)  
KPA (PSI)  
RIMS: X  
MAXIMUM LOAD: KG (LBS)  
OCCUPANTS: (FRONT REAR)  
THIS VEHICLE CONFORMS TO ALL  
APPLICABLE FEDERAL MOTOR VEHICLE  
SAFETY STANDARDS IN EFFECT ON THE  
DATE OF MANUFACTURE SHOWN ABOVE.  
**VIN:**  
TYPE: LOW SPEED VEHICLE

Figure 2-2



T

**VEHICLE SPECIFICATIONS**

ITEM	SPECIFICATION
Motor	48 volt, 15.3 hp @ 1750 rpm SU5S 48 volt, 17.3 hp @ 1750 rpm SU5L
Drive	Direct coupled to oil bath, helical geared, rear axle
Rear Axle	16.77 helical gear reduction with integral differential
Charger	Built in, micro-processor control, fully sealed, anti-drive away interlock, 110-240 V AC, 50/60 Hz
Directional Control	Safety Directional Keyswitch with FL, FH (forward), R (reverse) and N (neutral)

ITEM	SPECIFICATION
Steering	Automotive rack and pinion.
Tire PSI	32 psi
Battery Deep Cycle	48 Volt: 8 - 6 volt, heavy duty, 225 Ah
Speed Control	Programmable, solid state, reduced speed reverse with diagnostic LED and calibrator interface
Brakes	2 or 4 wheel hydraulic brakes, foot operated parking brake.

Columbia ParCar Corporation reserves the right to change specifications, equipment or designs at any time without notice and without incurring obligations.

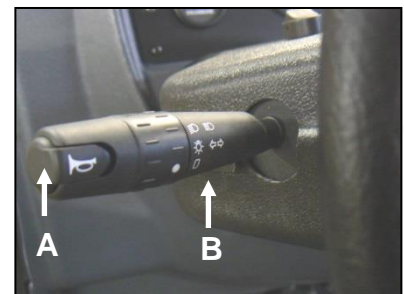
**VEHICLE INFORMATION**



**Figure 4**



**Figure 5**



**Figure 6**

**KEYSWITCH Figure 4**

This is a five position automotive type switch and is located on the right side of the steering column. The first key position is OFF and is marked S. The second is an accessory position marked A which is not used. The third position is not marked and is not a key stop. It is not used. The fourth position marked M is the ON and powers up the vehicle. The last position marked D is not used. If the key is rotated to this position the vehicle power will be turned off.

Turning the keyswitch to OFF is highly recommended whenever vehicle is not in use. Always take the key out of the keyswitch when leaving the vehicle.

**DIRECTION SELECTOR Figure 5**

Selector is located between the seats. In the middle position the vehicle's direction signal is turned OFF or in neutral. Turning the selector to the right from the middle position moves the vehicle in forward direction (high & low speeds). Turning the direction selector to the left moves the vehicle in the reverse direction. A warning buzzer sounds when in reverse.

**TURN SIGNAL/LIGHTS/HORN SWITCH Figure 6**

The horn is activated by pushing in the button at the lever (A). Moving lever up or down will activate the turn signals. A green light on the dash will flash indicating the turning direction. The headlights and taillights are activated by a three position selector (B). OFF is the bottom position, middle activates the parking and tail lights, and the upper position activates the headlights. High and low beams are selected by pulling back on the lever.

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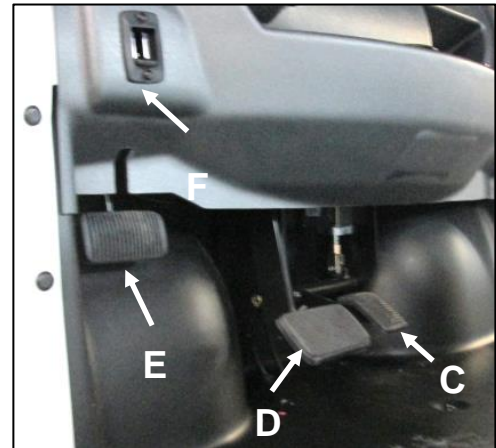


**BRAKE, ACCELERATOR AND PARKING BRAKE Figure 7**

Shown is the accelerator pedal (C), the brake pedal (D), the parking brake pedal (E) and the parking brake release lever (F). Each operate in the same manner as a conventional automobile.

The accelerator pedal should be fully released when changing directions.

Always apply the parking brake when leaving the vehicle. It should be firmly pressed and locked to prevent the vehicle from rolling. It remains applied until released by lifting the release lever.



**Figure 7**

**NOTICE: Never rest your foot on brake pedal while operating the vehicle. This wears the brakes, creates drag and causes excess battery discharge.**

**CAUTION**

**To avoid injury, speed in reverse should always be kept at a minimum.**

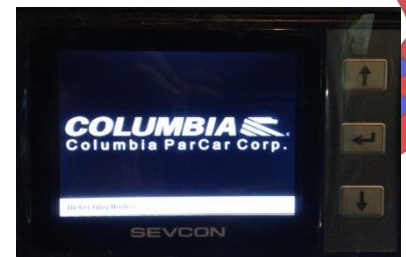
**MULTI-FUNCTION CLEARVIEW DISPLAY PANEL FIGURE 8**

Located on the dash, this panel contains the left and right green turn signal indicators and the AC display. This display will show the battery state of charge as a percentage of full charge, the system status, the operating speed, odometer, and direction selected.



**Figure 8**

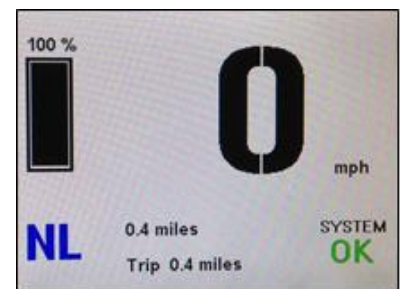
At power on, the display will perform a self-test and load the controller data. You will see the Columbia ParCar Corp logo indicating the system is preparing for operation. (Figure 9).



**Figure 9**

When ready the display will indicate system OK. (Lower right corner). For ease of reading the display lighting may be reversed by pressing the top "Up Arrow" in the upper right corner. There are no other user programmable functions available (Figure 10).

**NOTICE: At 80% discharge, you must immediately charge batteries or vehicle operation will cease and permanent battery damage could occur.**



**Figure 10**

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In addition to standard operations, the display can also be utilized as a vehicle monitoring system. By pressing and holding the right center “Enter” button, a menu will appear with access to vehicle data, status and fault codes, should any be present. To toggle through the menu system, use the “Up” or “Down” arrows. To return to the previous screen, press and hold the right center “Enter” button again (Figure 11).



Figure 11

The Main 2 Menu will show the key “on” hours, the hours the motor has been used, the current, speed in RPM’s if operating, the battery current draw during operation and the percentage the throttle pedal is depressed. This information is helpful in the event of any operational concerns (Figure 12).

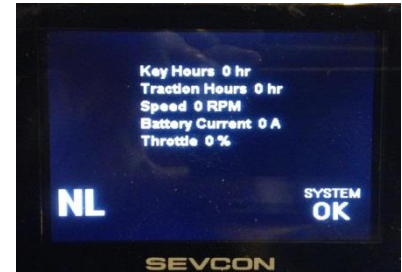


Figure 12

The Vehicle Status selection displays the current state of vehicle data collected at the controller (Figure 13).

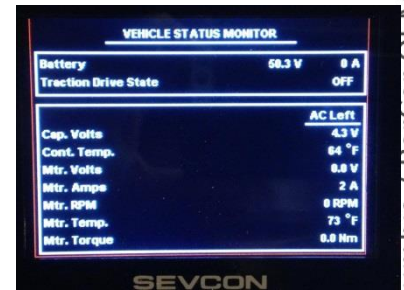


Figure 13

**WARNINGS & OPERATING INSTRUCTION**

Read this information carefully before operating the vehicle. Promptly replace if removed or damaged. Contact Columbia ParCar for replacements if needed. Part number for the Personal Transportation Vehicles vehicle decal is 53258-07 (Figure 14) or 43960-07 for Low Speed Vehicles (not shown).

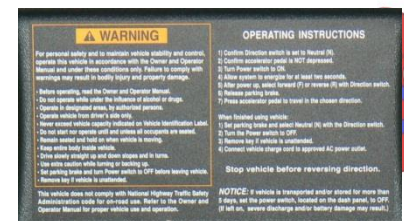


Figure 14

**STEERING WHEEL**

The steering wheel controls the path of the vehicle exactly the same as a conventional automobile wheel.

**CHARGER RECEPTACLE & REMOTE LED Figure 15**

The charger receptacle is located on the left side of the vehicle near the driver’s position. The vehicle can be equipped several different ways.

As shown in Figure 15 an AC cord is plugged in here for battery charging. Another configuration is this opening will have a 20’ retractable electrical cord that can be pulled out and plugged into an AC outlet.

The charger is inter-locked with the traction control system which powers down the vehicle during charging. Near the receptacle is a remote multicolored LED which will indicate the battery charge status. See SECTION 4 ELECTRIC SYSTEMS BATTERY CHARGING for more information on this LED.

Always apply the parking brake when charging.



Figure 15

**NOTICE: Before removing the AC cord, be sure to check the LED status lights.**

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**HAZARD WARNING SWITCH**

The hazard warning toggle switch is located on the top of the steering column.

**FUSE BLOCK - 12V ELECTRICAL CIRCUIT Figure 16**

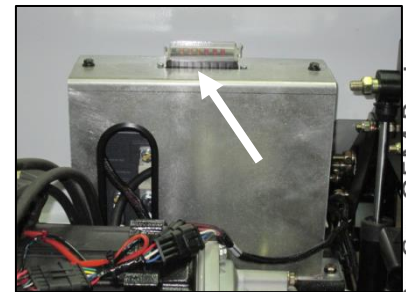
A fuse block protecting the 12V electrical circuits of the vehicle is located under the hood. This system runs the accessories (wiper/washer, dome, etc.). The fuse block has a snap off cover for access to the fuses.



**Figure 16**

**FUSE BLOCK - 48V ELECTRICAL CIRCUIT Figure 17**

A fuse block protecting the 48V electrical circuits (horn, etc.) of the vehicle is located beneath the rear deck atop the controller assembly. The fuse block has a snap off cover for access to the fuses.



**Figure 17**

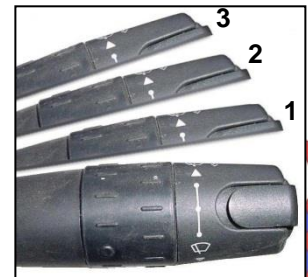
**NOTICE:** If fuses continue to blow and require replacement, check the electrical circuit.

**WINDSHIELD WIPER/WASHER Figure 18**

Wiper switch is located on the right side of the steering console. Wipers have four up positions (Figure 15):

0 = OFF      1 = OFF      2 = Slow      3 = Fast

Pulling lever towards you activates the washer fluid. Pushing the switch down activates a “quick” wipe. The fluid reservoir is located under the hood (See Figure 16)



**Figure 18**

**NOTICE:** To avoid scratching the windshield always apply fluid before wiping..

**TILT BED (If equipped)**

The tilt bed has a remote control for raising and lowering. If maintenance or repair is required, disconnect the actuators.

**BATTERY ACCESS**

Batteries are located under the front seats.

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**OPERATION**

**NOTICE: Controls should operate smoothly and easily without sticking or requiring undue effort.**

1. Set the keyswitch to the on (marked M) position.
2. Set the direction knob to the desired direction of travel (FL or FH=forward, R=reverse).
3. Depress accelerator with the right foot.
4. To stop the vehicle, release the accelerator pedal and apply the brake pedal slowly and completely.

**WARNING**

**Be sure safety direction knob is in desired direction of travel before depressing accelerator.**

**PRE-OPERATION INSPECTIONS**

Each vehicle has been inspected and adjusted to factory specifications before delivery. Upon receipt of vehicle, perform a pre-delivery inspection of the vehicle. Also, before using the vehicle, there are checks that must be performed to ensure that it is in safe working order.

**WARNING**

**Only trained maintenance professionals should service or repair this vehicle. Persons performing even simple repairs or service should have a working knowledge and experience in general electrical and mechanical repair. Follow all procedures and observe all warnings stated in this manual. Use caution and common sense.**

**PRE-OPERATION CHECKLIST**

SERVICE ITEM	SERVICE METHOD/CHECK
Batteries	Check the Clearview display panel for battery charge condition.
Tires	Visually check for wear or damage. Verify proper tire inflation.
Head, Tail or Flasher Lights	Check for proper operation.
Accelerator/Brake Operation	Test drive, check free travel and braking action.
Steering and Linkages	Test drive, check for free movement and proper operation.
Vehicle Body	Visually, check for damaged or loose hardware.
Warning Labels	Visually inspect all labels for readability or missing.
Reverse Warning Beeper	Test drive, check for proper operation.
Charger Plug and Receptacle	Check for damage and proper fit.
Horn	Check for proper operation.



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**Service Manual**

**Section 3**

**Maintenance**



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**ELECTRIC VEHICLE SERVICE**

**⚠ WARNING**

Always turn keyswitch to off, directional keyswitch to neutral, remove key, block tires and separate the battery blue connection before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.

**NOTICE:** When performing Monthly, Quarterly, Semi-Annual or Annual maintenance, ensure that Daily and Weekly inspections are included.

**NOTICE:** The environment that the vehicle operates in can vary widely. Severe service operations will require the periodic maintenance recommendations to be adjusted to shorter time intervals. The following calendar is one example of how scheduling routine maintenance can be managed.

**PERIODIC MAINTENANCE**

A comprehensive maintenance program is important for the safe, reliable operation of all Columbia ParCar vehicles. The recommended procedures described in this service manual are effective methods for performing periodic maintenance and repair. The maintenance procedures outlined in this manual are recommended when servicing the vehicle. Refer to maintenance check-list for frequency of service. Perform only those maintenance instructions described in this manual. If major repairs are needed, contact the local Columbia dealer for assistance. Columbia dealers have the technical experience, training and original Columbia vehicle parts for the vehicle. Always use original Columbia vehicle parts when servicing the vehicle.

PERIODIC SERVICE CALENDAR		
<b>JANUARY</b> Monthly	<b>FEBRUARY</b> Monthly	<b>MARCH</b> Quarterly
<b>APRIL</b> Monthly	<b>MAY</b> Monthly	<b>JUNE</b> Semi-Annual
<b>JULY</b> Monthly	<b>AUGUST</b> Monthly	<b>SEPTEMBER</b> Quarterly
<b>OCTOBER</b> Monthly	<b>NOVEMBER</b> Monthly	<b>DECEMBER</b> Annual

**NOTICE:** Some procedures require the use of special tools. These special tools must be used when and where recommended.

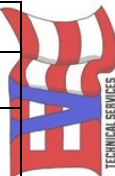
**NOTICE:** Daily maintenance is performed daily before operation of vehicle by owner or operator. Weekly maintenance is performed on a weekly basis to include all daily maintenances and is performed by the owner, operator or trained maintenance personnel.

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**MAINTENANCE SCHEDULE CHECKLIST – BODY/FRAME/CHASSIS**

Component	Procedure	Daily <sup>1</sup>	Weekly <sup>1,2</sup>	Monthly <sup>2</sup>	Quarterly <sup>2</sup> (25 Hours)	Semi-annual <sup>2</sup> (50 Hours)	Annual <sup>2</sup>
Body, Seat & Frame	Visually inspect for damage or tears.	X					
Hardware	Tighten as needed.		X				
Vehicle & Undercarrage	Wash as needed.		X				
Clean Body & Seat	Wash as needed.		X				
Warning & Operating Labels	In place and readable	X					
Windshield	Check for visibility.	X					

<sup>1</sup> Service done by owner. <sup>2</sup> Service done by trained maintenance personnel



MAINTENANCE SCHEDULE CHECKLIST – OPERATING CONTROLS							
Component	Procedure	Daily <sup>1</sup>	Weekly <sup>1,2</sup>	Monthly <sup>2</sup>	Quarterly <sup>2</sup> (25 Hours)	Semi-annual <sup>2</sup> (50 Hours)	Annual <sup>2</sup>
Steering & Linkage	Check for free movement	X					
Accelerator Linkage	Check for free movement and return	X					
Brakes	Check brake operation	X					
	Check parking brake latching release	X					
	Check brake cables for damage			X			
	Clean & adjust brakes						X
	Check rear brake drum/axle nut torque (65.0 ft. lbs.)						X
Direction knob	Check for smooth forward & reverse operation	X					
Light switch	Check for operation	X					
Turn signals & emergency flasher	Check for operation	X					

<sup>1</sup> Service done by owner. <sup>2</sup> Service done by trained maintenance personnel

MAINTENANCE SCHEDULE CHECKLIST – ELECTRICAL							
Component	Procedure	Daily <sup>1</sup>	Weekly <sup>1,2</sup>	Monthly <sup>2</sup>	Quarterly <sup>2</sup> (25 Hours)	Semi-annual <sup>2</sup> (50 Hours)	Annual <sup>2</sup>
Batteries	Check charge (fill cells after charging)		X				
	Clean terminals & wash battery case		X				
	Test batteries					X	
Electrical wires	Check for tightness or damage		X				
Reverse warning beeper	Check for operation (use keyswitch)	X					

<sup>1</sup> Service done by owner. <sup>2</sup> Service done by trained maintenance personnel

MAINTENANCE SCHEDULE CHECKLIST – FLUIDS							
Component	Procedure	Daily <sup>1</sup>	Weekly <sup>1,2</sup>	Monthly <sup>2</sup>	Quarterly <sup>2</sup> (25 Hours)	Semi-annual <sup>2</sup> (50 Hours)	Annual <sup>2</sup>
Differential lubricant	Check level						X

<sup>1</sup> Service done by owner. <sup>2</sup> Service done by trained maintenance personnel

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**MAINTENANCE SCHEDULE CHECKLIST – TIRES AND WHEELS**

Component	Procedure	Daily <sup>1</sup>	Weekly <sup>1,2</sup>	Monthly <sup>2</sup>	Quarterly <sup>2</sup> (25 Hours)	Semi-annual <sup>2</sup> (50 Hours)	Annual <sup>2</sup>
Tires	Check for wear & damage	X					
	Check tire pressure	X					
	Check for dented/damaged rims			X			
Front wheel alignment	Check & adjust as necessary					X	
Lug nuts	Check for tightness	X					
Steering linkage	Check for excessive movement, tightness of hardware			X			

<sup>1</sup> Service done by owner. <sup>2</sup> Service done by trained maintenance personnel

**MAINTENANCE SCHEDULE CHECKLIST – ELECTRIC MOTOR**

Component	Procedure	Daily <sup>1</sup>	Weekly <sup>1,2</sup>	Monthly <sup>2</sup>	Quarterly <sup>2</sup> (25 Hours)	Semi-annual <sup>2</sup> (50 Hours)	Annual <sup>2</sup>
Operation	Test drive for proper operation	X					
Brushes (DC Motor)	Inspect brush length & remove carbon dust. Inspect & apply anti-seize to splines.						X

<sup>1</sup> Service done by owner. <sup>2</sup> Service done by trained maintenance personnel

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**BATTERIES**

Batteries may be recharged if vehicle has been driven 15 minutes or more since the previous charge. Before charging, be sure the key switch is OFF and key is removed.

Refer to *Chapter 9* for all procedures relating to the batteries.

**REAR AXLE**

Check the rear axle oil only if signs of leakage are detected. Change oil at 24 months or 1250 mile (2000 km) intervals, whichever occurs first. Refer to Section 7.

Capacity – Draining 600 ml., Disassembly 800 ml. Gear lubricant SAE #80 oil.

**CHASSIS CLEANING**

Proper cleaning materials and techniques are vital to the care of the vehicle. Wash underside of vehicle to remove all dirt and debris. Wash chassis and body with a mild detergent only. Do not use abrasives on the paint.

**GREASE FITTINGS**

There are 6 lubrication points with grease fittings on the front end of the vehicle. These points should be greased every 6 months with chassis lube.

**⚠ CAUTION**

**Do not direct high pressure water at the controller, speed switch, or top of batteries. Dry the controller and top surfaces of the batteries immediately after washing.**

**SEAT CLEANING**

Proper cleaning will extend the life of the vehicle seat. Use mild soap or detergent and a soft sponge to clean whenever necessary. For stubborn or imbedded dirt, a soft bristle brush may be used.

**NOTICE: Do not use harsh chemicals or abrasives to clean seat material. Cracking, splitting, or “melting” of seat materials may occur. If seat material becomes torn or split, it should be replaced**

**LIFTING INSTRUCTIONS**

**⚠WARNING**

Use extreme caution lifting or working around lifted vehicle. Vehicle should be lifted only when parked on a flat, hard and level surface. Do not work under the vehicle unless it is firmly supported on jack stands. When lifting the vehicle for service, use a sturdy lifting device such as a floor jack or hydraulic lift. Always, wedge wheels and set parking brake of the vehicle to keep it from rolling. Place jack stands or support blocks under vehicle frame to support vehicle weight for added safety. Watch for cables, linkages or wire harness.

**⚠CAUTION**

If any vehicle is raised while loaded, check that the load is secured before lifting vehicle. Failure to do so could cause damage to load, vehicle, or personal injury. Before lifting, always chock tires. Use care to prevent tipping or rolling over. Be careful not to damage the brake cables during lifting operation.

**Tools Required**

- Floor jack
- Chocks or wooden blocks
- Jack stands or support blocks

**FLOOR JACK PROCEDURE**

If a floor jack is used to lift the vehicle, check that the floor jack is rated at a capacity greater than the vehicle weight. Lift the vehicle sufficiently from the floor to allow the placement of jack stands or wooden blocks and hold the weight of the vehicle during service.

**Lifting Vehicle Rear**

1. To lift the rear, place floor jack under the rear cross member between the rear hitch receiver and the motor.
2. Place jack stands under frame at right and left sides to allow access under the vehicle.
3. When work is completed, place floor jack as described above, lift the vehicle and remove the jack stands, then lower vehicle to the floor.

**Lifting Vehicle Front**

1. To lift the front, place a floor jack under the cross member where the A-Arms are attached. Raise vehicle sufficiently to place jack stands underneath chassis frame.
2. Place jack stands under frame at right and left sides to allow access under the vehicle.
3. When work is completed, place floor jack as described above,, lift the vehicle and remove the jack stands, then lower vehicle to the floor.

**JACK STANDS**

Jack stands need to be of sufficient rated load capacity to hold the vehicle safely. See *Section 2 - Vehicle Specification Chart* for empty vehicle weight.

**VEHICLE STORAGE**

**⚠WARNING**

Turn keyswitch OFF. Remove key during storage to prevent unintentional starting of vehicle.

**⚠WARNING**

Do not attempt to charge a battery that is frozen or if battery case is excessively bulged. Frozen batteries can explode. Properly dispose of battery.

Electric vehicles stored over 6 to 8 weeks must be protected to maintain battery life. Several guidelines should be observed when storing the electric vehicle.

1. Charge batteries fully. With electrolyte full in all cells, store batteries in as cool place as possible. If stored above 50°F (10°C), check state of charge every 4 to 6 weeks and charge as necessary to maintain 1.250 to 1.270 specific gravity. If vehicles are stored in temperatures below 40°F (4°C) check state of charge every 15 to 18 weeks. Use table below to determine freezing point of battery and maximum recommended storage temperature. Refer to *Section 9 – Batteries* in this manual for a charging procedure. Remove battery pack negative cable.

SPECIFIC GRAVITY & FREEZE POINTS										
Specific Gravity	1.250	1.225	1.200	1.117	1.110					
Electrolyte Freeze Point	F	C	F	C	F	C				
		65	-54	-39	-39	-18	-28	-2	-19	+17

2. Wash off any corrosion around the terminals with a solution of baking soda and water. Do not allow this solution to enter batteries.
3. Store vehicle in a cool dry place to prevent battery discharge.
4. Maintain tire pressure at 35 psi during storage for 215/50 -13 tires and 30 psi for 205/50-10 tires.
5. Grease steering hubs and continue quarterly lubrication during storage period. Refer to periodic maintenance in the beginning of this section.
6. Clean vehicle body, seat, battery compartment and vehicle underside.
7. Do not engage parking brake. Block wheels to prevent movement.
8. Periodically charge battery during storage to prevent damage to battery. See step 1.

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**RETURNING VEHICLE TO SERVICE:**

1. Reconnect battery negative terminal.
2. Fully recharge batteries.
3. Check tire pressure and readjust if necessary.
4. Perform initial maintenance per periodic maintenance in the beginning of this section.
5. After the batteries have been fully charged, connect the single point watering system to its water supply for 3-5 seconds, then disconnect regardless of whether or not the batteries are completely full.
6. Return the vehicle to its regular service.
7. Place the vehicle back into its regular watering schedule (waiting at least 1 week until next watering).

**TRANSPORTING A VEHICLE**

**NOTICE:** Never transport a vehicle behind an auto or truck unless on an approved trailer.

When trailering a vehicle over long distances or on the highway observe the following:

1. Use trailers specifically designed to carry your Columbia ParCar vehicle that meets all federal, state and local requirements.
2. Secure vehicle to the trailer following trailer manufacturer's instruction.
3. The key should be removed from the vehicle, the parking brake firmly locked, and the wheels blocked.
4. On vehicles equipped with high or wide additions or accessories be certain they are secured properly to prevent loss or damage while trailering.

**CAUTION**

Increased transporting speed adds stress to windshield, cab or suntop and will increase chance of loss, damage, accident or injury.

Use care when transporting on windy days. Example: A 60 MPH speed into a 40 MPH head wind is equal to traveling at 100 MPH. Golf and Industrial vehicles are not rated to withstand this level of stress and parts could be blown from top or cab, causing accident or injury.

**TOWING WITH THIS VEHICLE AS LEAD VEHICLE**

**NOTICE:** If equipped with proper hitch and towing equipment observe these safety rules:.

When using this vehicle as a tow vehicle to pull trailers or a properly equipped other vehicle, observe the following:

- The maximum tongue weight on this vehicle is limited to 350 pounds
- Secure vehicle to the trailer following trailer manufacturer's instruction.
- The maximum towing capacity of this vehicle is 1500 pounds for a trailer without additional electric brakes.
- The maximum towing capacity of this vehicle is 3500 pounds for a trailer equipped with operational electric brakes.
- The towing capacities are reduced by the weight of any load carried on vehicle.

**TOWING THIS VEHICLE IF NON-OPERATIONAL**

The front bumper may be equipped with a receiver for lifting or towing.

**NOTICE:** This vehicle may be towed with the following precautions:

- T** Turn off key.
- O** Occupants and or cargo must be unloaded.
- W** Walk around vehicle to inspect for any loose or dragging items.
- I** Inspect lift mechanism or tow straps/chains for secure fit.
- N** No parking brake, service brake, or wheel chocks should be in place.
- G** Go no faster than 5 mph while towing vehicle.

**TORQUES AND METRIC CONVERSION FACTORS**

Individual component torques and metric equivalents are listed where the maintenance is to be performed throughout this manual. When a specific fastener torque is not specified,

Use the following Torque Table as a general guide in determining proper torque. When a metric equivalent is not listed, use the Conversion Factors Chart to convert to metric values.



Torque Table													
Torque to the value in this table unless specified otherwise.													
Fine or coarse thread fastener	Grade Designation	Tensile Strength Minimum	Material	Screw, Stud or bolt shank size or diameter									
				Torque figures are in ft. lbs.									
				1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
cap screw	S.A.E. 2 A.S.T.M. A-307 steel	64,000 psi	low carbon steel	6	11	19	30	45	66	90	150	202	300
cap screw	S.A.E. 3 steel	100,000 psi	medium carbon steel	9	17	30	47	69	103	145	234	372	551
cap screw	S.A.E. 5 A.S.T.M. A-499 steel	105,000 psi	medium carbon steel or low alloy heat treated	9	18	31	50	75	110	150	250	378	583
cap screw	A.S.T.M A-354BB steel			9	18	31	50	75	110	150	250	378	583
cap screw	A.S.T.M A-325							100		200	355	525	790
cap screw	A.S.T.M A-354-BC steel	125,000 psi	low alloy or med. carbon steel quenched tempered	11	20	34	54	81	119	167	269	427	611
cap screw	S.A.E. 6 steel	133,000 psi	med. carbon steel quenched tempered										
cap screw	S.A.E. 7 steel		med. carbon alloy quenched tempered roll threaded	12.5	24	43	69	106	150	209	350	550	825
cap screw	S.A.E. 8 steel	150,000 psi	med. carbon alloy quenched tempered	13	28	46	75	115	165	225	370	591	893

Conversion Factors Chart					
Into Metric			Out of Metric		
to convert from	To	Multiply by	to convert from	To	Multiply by
<b>Work force measurements</b>					
inch-pound	N. m.	0.1130	Newton-meter	in. lb.	8.8496
foot-pound	N. m.	0.3558	Newton-meter	in. lb.	0.7376
<b>Length Measurements</b>					
inch	mm	25.4	millimeter	in.	0.0394
foot	m	0.3048	meter	ft.	3.281
miles	kilometers	1.6	kilometers	miles	0.621
<b>Liquid Volume Measurements</b>					
fluid ounces	milliliters	29.57	milliliters	fluid ounces	0.034
pints	liters	0.473	liters	pints	2.113
quarts	liters	0.95	liters	quarts	1.06
gallons	liters	3.8	liters	gallons	0.26
<b>Temperature</b>					
Fahrenheit	°C	$^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8$	Celsius	°F	$^{\circ}\text{F} = 1.8^{\circ}\text{C} + 32$

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**Service Manual**

**Section 4**

**Troubleshooting  
(AC & DC Vehicles)**

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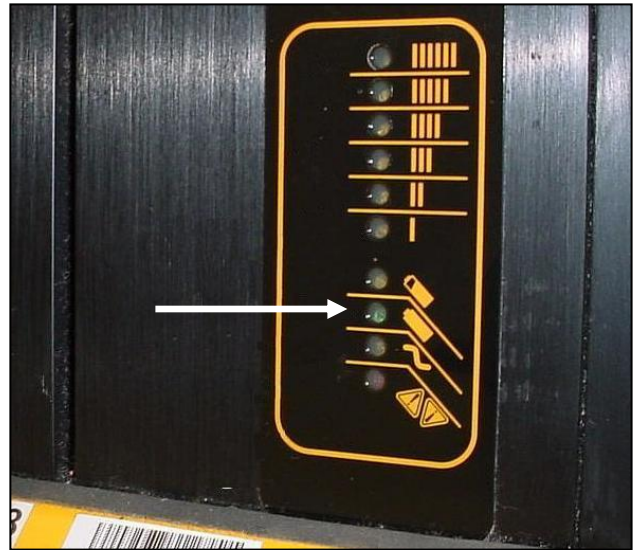
**⚠ WARNING**

Always turn Power keyswitch to OFF, Directional keyswitch to Neutral, remove Power keyswitch, block tires and disconnect the battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible injury.

**PRE-TROUBLESHOOTING STEPS**

Before troubleshooting a vehicle for any problem or symptoms, certain steps must be followed.

- Ensure the vehicle is safe for service. Visually inspect for any obvious signs of hazards such as sharp edges in the body or other parts, open wire insulation or wire connections, or discolored parts of the vehicle indicating heat or chemical presence.
- Record the VIN. This number is necessary to obtain technical help or support, submit warranty, and is essential in order to understand completely the vehicle that is being serviced.



**Figure 4-1**

**BATTERY TESTING**

The first step in servicing any electric vehicle that is not operating properly is to completely test the batteries. The batteries are the source of power for the vehicle drive and auxiliary systems, therefore are the most integral part of the electric vehicle troubleshooting. Battery testing should be done as follows and in the order as follows

Inspect/Test Condition	Corrective Action
Perform a visual examination of batteries and connections. Examine for signs of corrosion and clean/or replace any affected terminals or cables.	The batteries can be cleaned by hose washing with a standard garden hose or with a soft bristle brush (ensure battery caps are present and tight before washing batteries).
Examine the battery hold-down. If the material from the hold-down has been dissolved by the sulfuric acid in the batteries, the hold down can act as a drain on the battery pack.	Replace the hold-down if it appears damaged.
Test each battery with a VOM (volt-ohm meter). With VOM set to a scale able to read DC volts at up to 100 volts (or greater), check each battery individually, and test the entire pack together.	Place the VOM probes on the battery positive and negative post of each battery. Write down the reading from each battery. Each should contain at least 6.0 volts and no battery should be more than .5 volts lower than the highest reading. If any battery tests low on charge, change the battery individually with an auxiliary charger or the entire pack with the onboard Delta Q charger (allow vehicle to charge until the green charger light is illuminated, indicating full charge. See Figure 4.1). If one or more batteries still test low, the battery should be tested individually and replaced as necessary. <i>NOTE: It is recommended that all batteries in a system be changed together to ensure the batteries are the same brand, vintage, and service life.</i>
Test each battery cell with a battery hydrometer.	Any battery or battery cell that tests low should be fully charged and then rechecked. If the cell continues to test low with a hydrometer, the battery should be replaced. See note above.
A battery may test good with a voltage or hydrometer test when no load is being drawn from it. Test using a battery load tester.	A battery must be able to produce 45 minutes of capacity when tested at 55 amp draw after a complete recharge cycle. A battery that is not able to produce this capacity should be replaced. See note above.

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**TROUBLESHOOTING SPECIFIC COMPLAINTS**

Troubleshooting is a matter of investigation and deduction based on the symptoms and the possible causes. Recording every possible solution to every possible cause would be impossible, but this troubleshooting section is designed to assist in solving issues that may arise in the service life of an electric vehicle. The main key problems encountered with the vehicle(s) are:

- Vehicle will not move; forward or reverse
- Vehicle operates slowly
- Vehicle drives in forward or reverse only
- Vehicle drives but operation is jerky or inconsistent
- Vehicle power cuts out



Figure 4-2

**NOTICE: Always follow troubleshooting guide in exact sequence as listed. Performing tests out of sequence will cause inaccurate results and lost time in diagnosing electrical system problems-**

**VEHICLE WILL NOT MOVE; FORWARD OR REVERSE (DC)**

Before attempting to service a vehicle, complete the pre-service inspection and fully test the batteries as described on the previous page. Set the vehicle power keyswitch to “ON”. The green status light (Figure 4-2) on the controller will show one of three conditions; steady off, steady on, or flashing. This can also be seen on the dash SYSTEM light.

*In some lighting situations it is difficult to determine the condition of the fault light. Ensure an accurate reading of the light by shading it.*

Fault Code	Condition	Corrective Action
Fault code light steady OFF.	The controller is not getting the proper voltage or the controller has failed internally.	<p>1. Check to make sure the controller has a good battery negative connection at the B-terminal. Attach the black lead of the VOM to the B- terminal and attach the red lead to the battery pack positive post. On DC volts scale, full battery pack voltage should be observed. If not, check or replace the connections and cable between the main battery pack negative post and the controller B- post. If correct voltage is present, disconnect the 16 pin wire connection from the controller. Set main power switch to ON. Insert the black lead to the B-terminal on the controller and the red lead to the red #1 wire of the 16 pin connector. Full voltage should be observed.</p> <p>2. If voltage is present, reconnect the 16 pin plug connector to the controller and ensure the wires are fully seated in the back of the plug. If there is system voltage between B- post and the #1 pin, and the controller light does not illuminate, the controller has failed internally and must be replaced.</p> <p>3. If there is no voltage present between the #1 pin and the B- terminal, and B- terminal has a good connection to battery pack negative, the red #1 wire circuit is not energizing properly. Make sure the charger positive (red) wire is connected to the main battery pack positive terminal, and then check the table below.</p>

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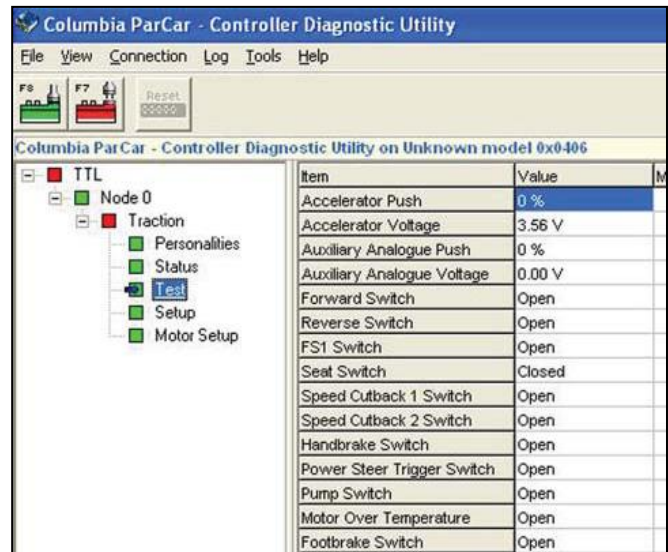
VOM Black Lead	VOM Red Lead	Pass	Fail	Correction Action - Check
Main battery negative post	Green charger interlock wire	Full system voltage	Low or no voltage	Charger red lead to battery positive connection. Charger output wires for damage
Main battery negative post	Red wire #15 side of 1 amp fuse connector	Full system voltage	Low or no voltage	Red wire #15 connection to green charger interlock wire Red wire #15 for damage
Main battery negative post	Red wire #16 side of 1 amp fuse connector	Full system voltage	Low or no voltage	1 amp fuse or fuse connections
Main battery negative post	Red wire #28 at power key switch	Full system voltage	Low or no voltage	Red wire #18 for damage Red wire #28 to red wire #16 connection (at optional low/run connection)
Main battery negative post	Red wire #17 at solenoid positive tab	Full system voltage	Low or no voltage	Wiring from power key switch for damage/poor connections
Main battery negative post	Red wire #1 at 16 pin connector	Full system voltage	Low or no voltage	Wiring from power key switch for damage/poor connections

VEHICLE WILL NOT MOVE; FORWARD OR REVERSE (DC) continued		
Fault Code	Condition	Corrective Action
Fault code light steady ON	Indicates the controller is powered up and ready to perform. If the vehicle fails to operate with the fault code light in the steady on condition, it is likely the controller is not receiving the correct input from the drive system, or a mechanical fault has occurred.	<ol style="list-style-type: none"> <li>1. Check to make sure the parking brake is releasing and the vehicle will not roll when pushed on a level surface.</li> <li>2. Check for other mechanical failures such as stripped hubs or anything that would prevent the vehicle from being able to operate. Make sure a direction of travel is selected (the vehicle will not attempt to drive while set to Neutral). Check the inputs of the electrical system by using the Computer Diagnostics Utilities (Columbia Part No. 30001-04) or the handheld calibrator (Columbia Part No. 30003-04). See the following procedures.</li> </ol>

**TROUBLESHOOTING WITH PCPAK (DC)**

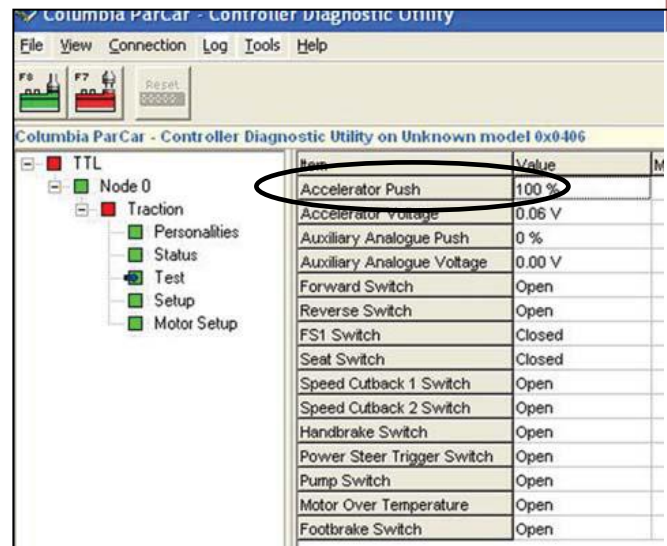
With the vehicle power system off, connect the PCPak (computer diagnostic utility) and then turn the vehicle power on.

1. Open the connection between the controller and the PCPak utility. On the left side of the screen, select the “test” section under the “traction” pull down. This screen will display the inputs the controller is observing at that time (Figure 4-3).



**Figure 4.3**

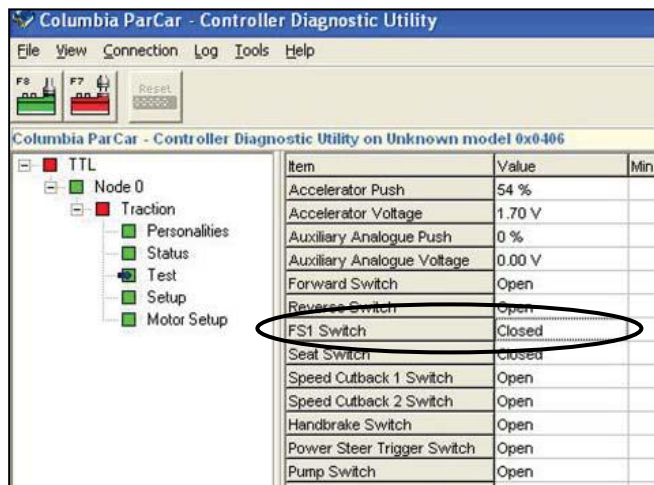
2. With the Forward / Reverse knob set to Neutral, slowly press the accelerator pedal. The “Accelerator Push” value should rise in value from 0-100% smoothly as you press the pedal (Figure 4-4). If the value does not change, the controller is not receiving input from the accelerator control device (potentiometer or linear accelerator device). Check all cable and wire connections regarding the accelerator control device. If the value does rise, but not to 100%, adjust the accelerator cable that attaches to the accelerator device.



**Figure 4.4**

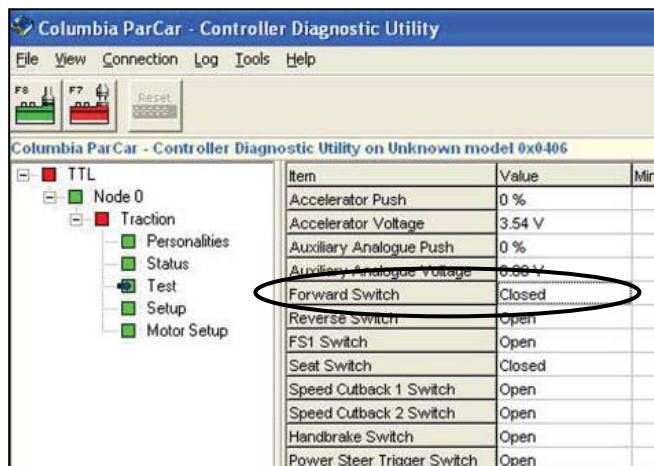
**TROUBLESHOOTING WITH PCPAK (DC) continued**

3. Check the FS1 Switch input on the same screen. With the accelerator at rest, the value for the FS1 Switch should read “open”. When the accelerator pedal is pressed, the value should change to “closed” (Figure 4-5). If the value fails to close, check the FS1 wiring circuit and test the switch with a VOM. Check the wiring back to the controller (Pin 4).



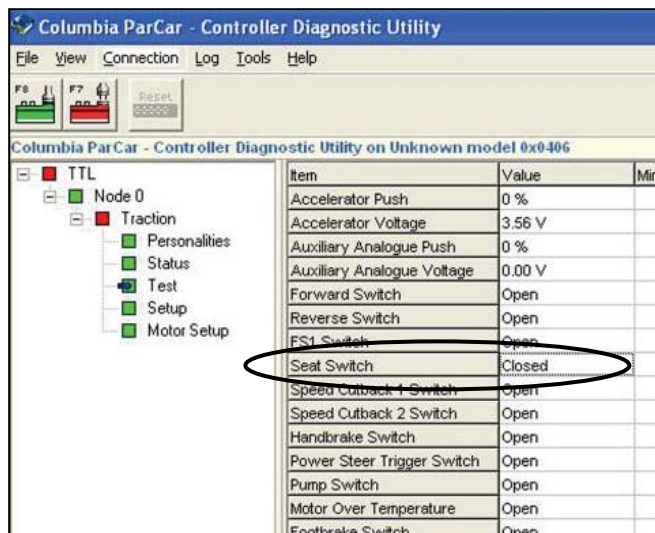
**Figure 4-5**

4. Check the direction input to the controller. Observe the value of the “Forward Switch” item while turning the direction selection knob to “Forward” and to “Neutral”. The switch should read “open” when the knob is in neutral and “closed” when in forward (Figure 4-5). Do the same in reverse by monitoring the “Reverse Switch” item and value. If the switch fails to close in either direction, check the switch with a VOM and the wiring back to the controller (Pin 2 for Forward and Pin 3 for Reverse).



**Figure 4-6**

5. Check the “Seat Switch” item and value (Figure 4-6). For vehicles equipped with a seat switch, the value should read “open” when the operator seat is not occupied, and “closed” when the operator seat is occupied. If the switch fails to close, check the wiring from the B- post of the controller to the seat switch, test the seat switch with a VOM, and check the wiring back to the controller (pin 5). For vehicles without a seat switch, the value should read “Closed”. If the switch does not register as closed, check the black 5 wiring from the B- post of the controller to controller plug (pin 5).



**Figure 4-7**

If the vehicle is receiving the correct inputs and fails to operate, contact Columbia tech support for further assistance.

**TROUBLESHOOTING WITH THE HANDHELD CALIBRATOR (DC)**

- Connect the handheld calibrator to the vehicle and enter the “Read-Only” mode (RON). Scroll down by pressing “Select” button until you reach the “19” menu (location 19.01). The “Test” light on the left side of the calibrator will illuminate when the “19” menu is selected. This menu shows the inputs the controller is observing at that time. At 19.01, the calibrator displays the “Accelerator Push” in percentage.
- With the Forward / Reverse knob set to Neutral, slowly press the accelerator pedal. The “Accelerator Push” value should rise in value from 0-100% smoothly as you press the pedal. If the value does not change, the controller is not receiving input from the accelerator control device (potentiometer or linear accelerator device). Check all cable and wire connections regarding the accelerator control device. If the value does rise, but not to 100%, adjust the accelerator cable attached to the accelerator device.
- Next, check the FS1 Switch input by scrolling to the 19.07 location. At rest, the value for the FS1 Switch should read open, or (3.OP). When the accelerator pedal is pressed, the value should change to closed, or (3.CL).

If the value fails to close, check the FS1 wiring circuit and test the switch with a VOM. Check the wiring back to the controller (Pin 4).

- Check the direction input to the controller. Observe the value of the “Forward Switch” item at location 19.05 while turning the direction selection switch to “Forward” and to “Neutral”. The switch should read open (1.OP) when the switch is in neutral and closed (1.CL) when in forward. Do the same in reverse by monitoring the Reverse Switch at location 19.06 and value. If the switch fails to close in either direction, check the switch with a VOM and the wiring back to the controller (Pin 2 for Forward and Pin 3 for Reverse).
- Check the Seat Switch at location 19.09. For vehicles equipped with a seat switch, the value should read open (5.OP) when the operator seat is not occupied, and closed (5.CL) when the operator seat is occupied. If the switch fails to close, check the wiring from the B- post of the controller to the seat switch, test the seat switch with a VOM, and check the wiring back to the controller (pin 5). For vehicles without a seat switch, the value should read closed (5.CL). If the switch does not register as closed, check the black wire #5 wiring from the B- post of the controller to controller plug (pin 5).

If the vehicle is receiving the correct inputs and fails to operate, contact Columbia tech support for further assistance.

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VEHICLE WILL NOT MOVE; FORWARD OR REVERSE - LED DIAGNOSTIC GUIDE (DC)	
Green LED Flashes	Check/Test
1 Flash	Check all wire connections for good connection and free of corrosion. Call Columbia Technical Support if problem persists.
2 Flash	Perform steps 1 - 5 under <i>Troubleshooting with Handheld Calibrator</i> above.
3 Flash	Check all wire connections. Disconnect all electrical accessories (strobe lights, heaters, etc.) External or internal wiring faults will cause controller 3 Flash. Eliminate all “non-controller” sources first. Plug in calibrator and read location 13.10 fault code for more precise fault cause(s). Call Columbia Technical Support if problem persists.
4 Flash	Bench test 24 volt main solenoid. Check all wiring. Plug in Calibrator and read location 13.01 for more precise fault cause(s).
5 Flash	Motor stall fault. Check motor for damage. Plug in Calibrator and read location 13.10 for more precise fault cause(s).
6 Flash	Accelerator fault. Check all wiring pertaining to the accelerator (pot box) switch. Perform steps 1, 3 and 4 under <i>Troubleshooting with Handheld Calibrator</i> above. Check the Pot box with an analog ohmmeter.
7 Flash	Low or high battery voltage. Check battery voltage with a voltmeter. If battery voltage drops below 15 volts (24 volt system) or 32 volts (48 volt system), the controller will shut down. Read pack voltage both stationary and under hard acceleration if possible. If voltage is good while static, but drops significantly while accelerating, weak or damaged batteries may be the cause.
8 Flash	Over temperature cutout. Call Columbia Technical Support.
9 Flash	Out of range. Call Columbia Technical Support.
10 Flash	Bench test 24 volt main solenoid. Check all wiring. Plug in Calibrator and read location 13.01 for more precise fault cause(s).

**VEHICLE DRIVES SLOWLY**

- Check for all physical/visual signs of damage, low tire pressure or jammed linkages.
- Check for brake drag by turning vehicle power off, releasing parking brake, and attempting to roll vehicle a short distance.
- (DC) Plug in the Handheld Calibrator and check 5.01, 6.01 and 7.01 for appropriate values (maximum speed settings).
- (DC) Perform step 2 in *Troubleshooting with Handheld Calibrator*.
- Check for weak, discharged or damaged batteries, or poor connections.

**VEHICLE DRIVES IN FORWARD OR REVERSE ONLY (DC)**

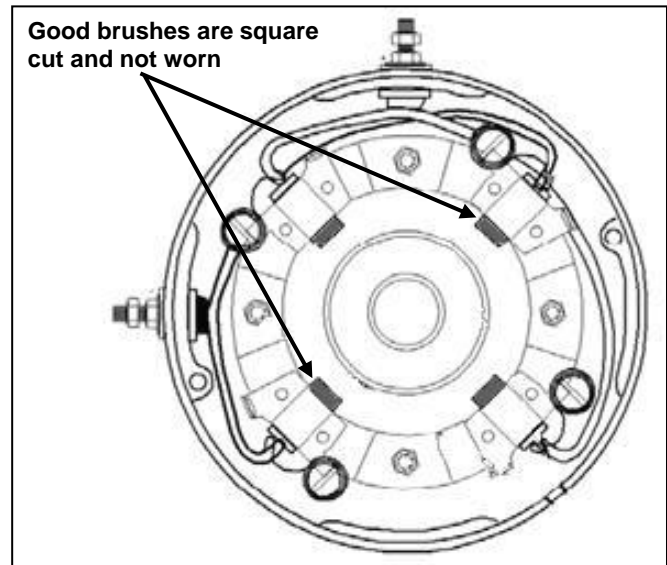
- Perform step 4 in *Troubleshooting with Handheld Calibrator*.

**VEHICLE DRIVES BUT OPERATION IS JERKY OR INCONSISTENT**

- Check speed switch carefully with analog ohmmeter for gradual, smooth resistance sweep.
- (DC) Check motor brushes. Replace if bad or worn (Figure 4-8).
- Call Columbia Technical Support if problem persists. Have the following information ready:
  - VIN
  - (DC) Vehicle Checksum (19.15)
  - Direction of travel where the operation is “jerky”
  - Speeds at which vehicle jerks.

**VEHICLE POWER CUTS OUT (DC)**

The fault for a vehicle that exhibits a cut out symptom can only be diagnosed while the vehicle is in a fault condition.

**Figure 4-8**

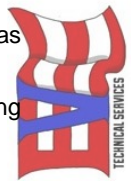
**FLASH CODES AND CORRECTIVE / INVESTIGATIVE ACTION (DC)**

Flash Code	Description	Action	Handset ID fault number	Calibrator reference loc	Correction – If fault does not clear
0 Flash (Light does not illuminate or light turns on and then back off.)	Internal Mosfet failure	Disconnect any electrical accessories and retry	25 / 26	13.01	Controller replacement required, contact Tech Support
	Pin 1 Circuit Fault	Trace current from battery positive to Pin 1	-	-	Replace failed connection, component, or wiring.
	Contactor Circuit fault	Trace current to solenoid and contact connections	-	-	Replace failed connection, component, or wiring.
Flash 1	Personality out of range	Check personality Checksum	81 /71	51.91	Controller replacement required, contact Tech Support
Flash 2	Seat Switch Fault	Check seat switch & seat switch circuit	7	80.91	Repair or replace failed connection or component
	Accelerator not at rest when direction selected	Ensure Accelerator Pedal returns to 0 (rest) position	8 or 9	19.01/19.07	Repair or replace failed connection or component
	Two directions selected	Ensure Direction Key switch is functioning properly	10	19.05/19.06	Repair or replace failed connection or component
	Forward or reverse selected at power up	Ensure Direction Key switch is functioning properly	11	19.05/19.06	Repair or replace failed connection or component
	Speed Switch out of range	Check speed switch range	11	19.01/19.02	Repair or replace failed connection or component
	FS1 not open with pedal up	Ensure Pedal returns to 0 and microswitch is functioning properly	11	19.07	Repair or replace failed connection or component
	Controller pins are cross - shorted	Check wire harness connector pins for good connections	Various	19.01 - 19.09	Repair any faulty connections
Flash 3	Auxiliary wiring short	Disconnect auxiliary electrical components and retry	-	13.01	Controller replacement required, contact Tech Support
	Armature Short Detected	Clean and Check motor and wiring for faults	23	13.01	Motor replacement may be required, contact Tech Support
	Internal controller fault	Disconnect auxiliary electrical components and retry	27	13.01	Controller replacement required, contact Tech Support
Flash 4	Contactor failed or stuck	Bench test contactor	91	13.01	Replace Solenoid, If good - Controller replacement required, contact Tech Support
	Contactor Failed or contactor wiring fault	Bench test contactor and test contactor wiring	20	13.01	Repair or replace failed connection or component
	Motor open circuit or brushes fault	Clean and Check motor and wiring for faults	22	13.01	Motor replacement may be required, contact Tech Support
Flash 5	Motor stall detected	Clean and Check motor and wiring for faults - review application	15	13.01	Motor replacement may be required, contact Tech Support
Flash 6	Input wire disconnected	Check wiring to speed switch & FS1	4	13.01/19.01/10.91	Repair or replace failed connection or component
	Speed switch out of adjustment	Check speed switch range	11	13.01/19.01/19.02	Repair or replace failed connection or component
	Pedal depressed at start up	Ensure Accelerator Pedal returns to 0 (rest) position	8 or 9	13.01/19.01/19.07	Repair or replace failed connection or component

**Flash Codes and Corrective / Investigative Action DC (continued)**

Flash Code	Description	Action	Handset ID fault number	Calibrator reference loc	Correction – If fault does not clear
Flash 7	Battery voltage low	Check Static battery voltage and voltage while operating	12 / 13 or 16	13.01/15.01	Check to see if voltage drops below 32 volts, charge / replace batteries
	Battery voltage high fault	Check Static battery voltage and voltage while operating	12 / 13 or 16	13.01/15.01	Check to see if voltage rises above 63 volts in while operating, see SB - 12-07
	Capacitor voltage is too high	Check Static battery voltage and voltage while operating	14	13.01/15.02	Contact tech support with reading from 15.02
8 Flash	Over Temperature cut - out	Review application and allow vehicle to cool	1	13.01/18.01	Contact Tech Support
	Current Cut - Back	Review application and allow vehicle to cool	3	13.01/18.01	Contact Tech Support
Flash 9	Internal motor tripped	Disconnect any electrical accessories and retry	2	-	Controller replacement required, contact Tech Support
10 Flash	Contacting Coil Disconnected	Bench test contactor and test contactor wiring	-	13.01	Contactor or Controller replacement may be required, contact Tech Support
	Value out of range	Check personality Checksum	43	13.01/51.91	Controller replacement may be required, contact Tech Support
	Internal controller fault	Disconnect any electrical accessories and retry	34	13.01	Controller replacement may be required, contact Tech Support

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**COMPONENT TROUBLESHOOTING**

In addition to the problems/cause/solutions listed in this section, individual sections also contain some testing and problem solution for individual components. Check the appropriate section first, and if the information is not found, check the following when a component is causing a problem:

**Battery Discharge Indicator (DC)**

- Fuse failed. Check fuse and replace if failed.
- Open wiring or failed connection. Check wiring and connections.
- Inoperable BDI gauge. Replace gauge.
- Weak or failed batteries. Test batteries and charge as necessary.

- Weak or failed batteries. Test batteries and charge as necessary.
- (DC) Controller set wrong. Check controller setting using hand held. Reset if necessary.

**Brake Lights and Auxiliary Switch**

- Fuse failed. Check fuse and replace if failed.
- Open wiring or failed connection. Check wiring and connections.
- Bulb failed. Replace bulb.
- Misadjusted or inoperable brake light switch. Check switch adjustment, replace switch if necessary.

**Had Light & Tail Light**

- Fuse failed. Check fuse and replace if failed.
- Open wiring or failed connection. Check wiring and connections.
- Bulb burnt out. Replace bulb (Headlight only source locally).
- Failed power key switch. Test and replace contactor as necessary.
- Inoperable switch. Replace switch.

**Reverse Beeper**

- Fuse failed. Check fuse and replace if failed.
- Open wiring or failed connection. Check wiring and connections.
- Inoperable reverse buzzer. Replace buzzer.



**Power Outlet**

- Fuse failed. Check fuse and replace if failed.
- Open wiring or failed connection. Check wiring and connections.
- Inoperable power outlet. Replace power outlet.

**Brake Light**

- Fuse failed. Check fuse and replace if failed.
- Open wiring or failed connection. Check wiring and connections.
- Bulb burnt out. Replace bulb.
- Failed power key switch. Test and replace contactor as necessary.

**BRAKES****Slow or incomplete release of brakes.**

- Shoes and linings. Shoes improperly adjusted. Shoes are self-adjusting; check parts for wear. Shoes distorted or incorrect. Replace with new parts.
- Mechanical parts. Damaged or weak return springs-replace.
- Cables and linkage sticking, dirty or corroded. Lubricate with a commercial solvent like WD40, PB Blaster, etc. Make sure not to contaminate brake pads with solvent.

**Wheel bearings.**

- Damaged or contaminated-replace.

- Grabbing or pulling-replace.

**Air in hydraulic lines (hydraulic brakes)**

- . Bleed hydraulic lines.

**Severe reaction to pedal pressure and uneven stopping.**

- Shoes and linings. Shoes improperly adjusted. Shoes are self-adjusting; check parts for wear. Shoes distorted or incorrect. Replace with new parts.
- Mechanical parts. Damaged or weak return springs-replace. Cables and linkage sticking, dirty or corroded. Lubricate with a commercial solvent like WD40, PB Blaster, etc..
- Drums are thin (expanding when hot); oversize (beyond .030”) of original specification – replace. Scored, out-of-round – replace.

**Brakes squealing, clicking or scraping noises**

- Shoes and linings. Shoes twisted, distorted, incorrect or broken – replace. Linings worn out, glazed, loose or contaminated – replace.
- Mechanical parts. Damaged or weak return springs-replace. Backing plate loose or failed – replace.
- Drums are thin (expanding when hot); oversize (beyond .030”) of original specification – replace. Scored, out-of-round – replace.

**TILT BED**

Before performing maintenance or repairs disconnect the actuators.

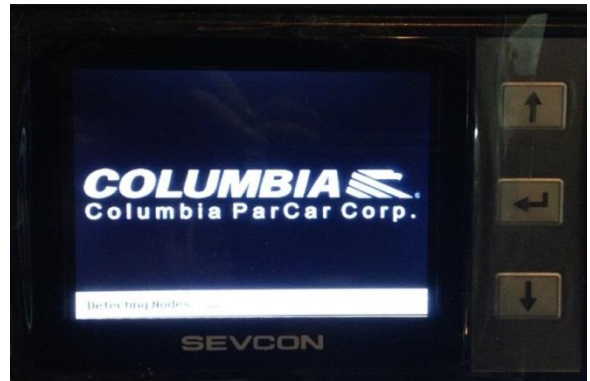


**MULTI-FUNCTION CLEARVIEW DISPLAY PANEL (SEVCON)  
AC Drive**

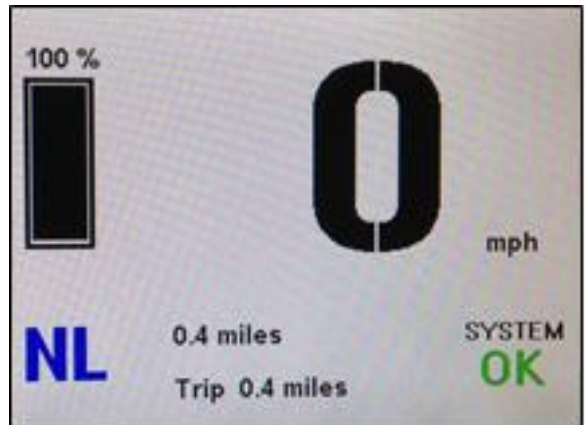
Located on the support panel in front of the steering wheel. This meter will display the battery state of charge as a percentage of full charge, the system status, the operating speed, odometer, and direction selected.



At power on, the display will perform a self test and load the controller data. You will see the Columbia ParCar Corp logo indicating the system is preparing for operation.



When ready the display will indicate system OK (Lower right corner). For ease of reading the display lighting may be reversed by pressing the top "Up Arrow" in the upper right corner. There are no other user programmable functions available.



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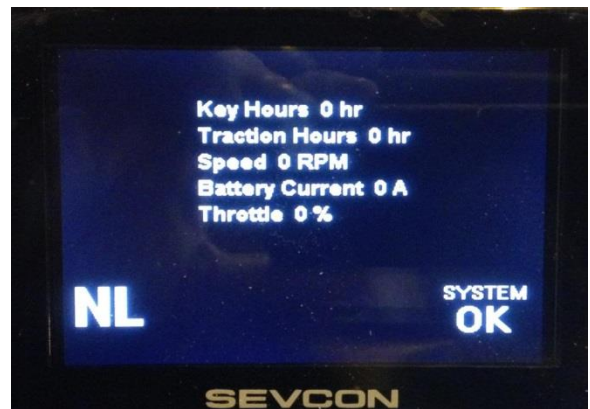


**Section 4 – Troubleshooting  
(AC & DC Vehicles)**

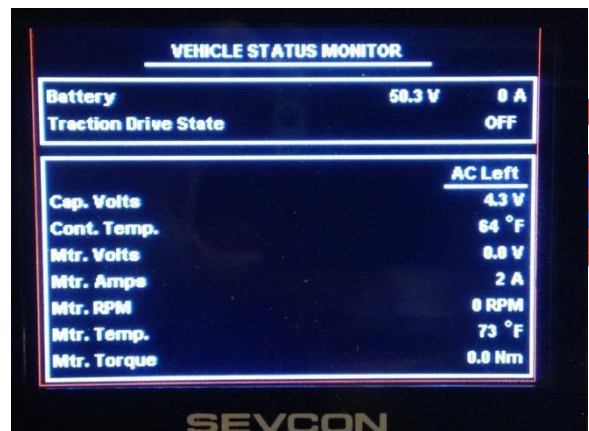
In addition to standard operations, the display can also be utilized as a vehicle monitoring system. By pressing and holding the right center “Enter” button, a menu will appear with access to vehicle data, status and fault codes, should any be present. To toggle through the menu system, use the “Up” or “Down” arrows. To return to the previous screen, press and hold the right center “Enter” button again.



The Main 2 Menu will show the key “on” hours, the hours the motor has been used, the current, speed in RPM’s if operating, the battery current draw during operation and the percentage the throttle pedal is depressed. This information is helpful in the event of any operational concerns.



The Vehicle Status selection displays the current state of vehicle data collected at the controller.



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**AC SEVCON CONTROLLER**

**Faults and warnings**

In the event of a fault Gen4 controller takes the following action:

- 1 Protects the operator and vehicle where possible (e.g. inhibits drive).
- 2 Sends out an EMCY message on the CANbus.
- 3 Flashes the LED in a pattern determined by the fault type and severity.
- 4 Logs the fault for later retrieval.

**Fault identification**

You can identify a fault as follows:

- Check the number of LED flashes and use the table below to determine what action can be taken. A complete and comprehensive fault identification table will be available from Sevcon in due course.
- Pick up the EMCY on the CANbus and read the fault condition using configuration software
- Interrogate the fault on the node directly using DriveWizard or other configuration software.

As shown below, there are 5 categories of faults.

FAULT SEVERITY	CONTROLLER LATCHED OFF UNTIL	CONSEQUENCES
Return to base (RTB)	Cleared by Sevcon personnel	Immediate shut down of the system with the exception of the power steering if needed. Power is removed to nearly all external components.
Very severe (VS)	Cleared by authorized service personnel	Immediate shut down of the system with the exception of the power steering if needed. Power is removed to nearly all external components.
Severe (S)	Keyswitch recycled (turned off then on)	Immediate shut down of the system with the exception of the power steering if needed. Power is removed to nearly all external components.
Drive-inhibit (DI)	User deselects all drive switches before reselecting	Neutral brakes or coasts the traction motor(s) to a stop. The fault prevents the operator initiating drive, but does not inhibit braking function, in particular, controlled roll-off braking.
Information (I)	Not latched	Information faults do not require immediate action, although some cutback of power or speed may occur.

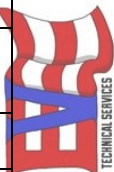


**LED flashes**

Use the table below to determine the type of fault from the number of LED flashes. The LED flashes a preset number of times in repetitive sequence (e.g. 3 flashes - off - 3 flashes - off - and so on). Only the faulty node in a multi-node system flashes its LED. Possible operator action is listed in the right hand column of the table.

LED FLASHES	FAULT	LEVEL	SET CONDITIONS	OPERATOR ACTION
0 (off)	Internal hardware failure	RTB	Hardware circuitry not operating.	
1	Configuration item out of range	VS	At least one configuration items is outside its allowable range.	Set configuration item to be in range. Use 5621h to identify out of range object.
1	Corrupt configuration data	VS	Configuration data has been corrupted.	

1	Hardware incompatible with software or invalid calibration data	VS	Software version is incompatible with hardware. Calibration data for sensor invalid.	
2	Handbrake fault	I	Direction selected with handbrake switch active.	Release handbrake
2	Sequence fault	DI	Any drive switch active at power up.	Reset drive switches
2	SRO fault	DI	FS1 active for user configurable delay without a direction selected.	Deselect FS1 and select drive
2	FS1 recycle	DI	FS1 active after a direction change	Reset FS1
2	Seat fault	DI	Valid direction selected with operator not seated or operator is not seated for a user configurable time in drive.	Must be seated with switches inactive
2	Belly fault	DI	Set after belly function has activated.	
2	Inch sequence fault	DI	Inch switch active along with any drive switch active (excluding inch switches), seat switch indicating operator present or handbrake switch active.	
2	Invalid inch switches	DI	Inch forward and inch reverse switches active simultaneously.	Both inch switches inactive.
2	Two direction fault	DI	Both the forward and reverse switches have been active simultaneously for greater than 200 ms.	Reset switches
2	Invalid steer switch states	VS	Steering switches are in an invalid state, for example, both outer switches are active	Check steer switches
3	Fault in electronic power switching circuit	VS	Fault in electronic power switching circuit (e.g. MOSFET s/c).	
3	Hardware over voltage activated	VS	Hardware over voltage circuit activated	Investigate and reduce battery voltage below user defined maximum level. Ensure suitable over voltage is configured in 2C01h and 4612h
3	Hardware over current trip activated	VS	Hardware over current circuit activated	Check motor load and wiring. Check motor parameters are correct.
4	Line contactor welded	S	Line contactor closed at power up or after coil is de-energized.	Check line contactor condition/wiring.
4	Line contactor did not close	S	Line contactor did not close when coil is energized.	Check line contactor condition/wiring.
5	PST fault	DI	Fault detected on PST power steer module.	Check PST condition.
5	Motor open circuit	S	Unable to establish current in motor.	Check motor condition/wiring.
6	Throttle pressed at power up	DI	Throttle demand is greater than 20% at power up.	Reduce demand
6	Analog input wire-off	VS	Analog input voltage is outside allowable range.	Check analog input wiring
6	Analog output fault (over/under current, failsafe, short circuit driver)	VS	Analog output fault caused by over current (>4A), under current if actual current < 50% target (current mode only), failsafe circuit fault, short circuit driver MOSFET.	Check analog output wiring.
7	BDI warning or cutout	I	BDI remaining charge is less than warning or cutout levels.	Charge battery.
7	Battery low voltage protection	I	Battery voltage or capacitor voltage is below a user definable minimum battery level for a user definable time.	Increase battery voltage above user defined level
		I		



7	Controller low voltage protection		Battery voltage or capacitor voltage is below the minimum level allowed for the controller.	Increase battery voltage above minimum level
7	Controller high voltage protection with line contactor closed.	I	Battery voltage or capacitor voltage is above the maximum level allowed for the controller with line contactor closed.	Investigate and reduce battery voltage below maximum level.
7	Battery high voltage protection	I	Battery voltage or capacitor voltage is above a user definable maximum battery level for a user definable time.	Investigate and reduce battery voltage below user defined maximum level.
7	Motor low voltage protection	I	Capacitor voltage has entered the motor low voltage cutback region defined in 4612h.	Increase battery voltage above start of motor low voltage cutback region.
7	Motor high voltage protection	I	Capacitor voltage has entered the motor high voltage cutback region defined in 4612h.	Reduce battery voltage below start of motor high voltage cutback region.
7	Controller high voltage protection with line contactor open.	S	Battery voltage or capacitor voltage is above the maximum level allowed for the controller with line contactor open.	Isolate controller and investigate high battery voltage
7	Battery voltage below critical level for controller.	S	Battery voltage is below the absolute minimum voltage at which the controller hardware is guaranteed to operate.	Increase battery voltage.
7	Precharge failure	VS	Capacitor voltage is less than 5V after pre-charge operation is complete.	Check controller wiring to ensure there are no short circuits between B+ and B-.
8	Controller too hot	I	Controller has reduced power to motor(s) below maximum specified by user settings due to controller over temperature.	Remove loading to allow controller to cool down.
8	Controller too cold	I	Controller has reduced power to motor(s) below maximum specified by user settings due to controller under temperature.	Allow controller to warm up to normal operating temperature.
8	Motor over temperature	I	Controller has reduced power to motor(s) below maximum specified by user settings due to motor over temperature.	Reduce load to motor to allow it to cool down.
8	Motor too cold	I	Motor thermistor reports less than -30°C.	Allow motor to warm up. Check motor thermistor.
8	Heatsink over temperature	VS	Heatsink temperature measurement has exceeded absolute maximum for controller and system has powered down.	Remove loading to allow controller to cool down.
10	Pre-Operational	I	Controller is in pre-operational state.	Use DriveWizard to put controller into operational state.
10	I/O initializing	I	Controller has not received all configured RPDOs within 5s of power up.	Check CANbus wiring and PDO configuration.
10	RPDO Timeout	I / DI / S	One or more RPDOs have not been received within 3s at power up or within 500ms during operation.	Check CANbus wiring and PDO configuration.
11	Encoder fault	VS	Speed measurement input wire-off is detected.	Check encoder wiring
11	Over current	VS	Software has detected an over current condition	Check motor load and wiring. Check motor parameters are correct.
11	Current Control fault	VS	Software is unable to control currents on PMAC motor.	Check motor load and wiring. Check motor parameters are correct.
12	Communication error	S	Unrecoverable network communication error has been detected.	Check CANbus wiring and CANopen configuration.

**Section 4 – Troubleshooting  
(AC & DC Vehicles)**

13	Internal software fault	RTB	Software run time error captured	
13	Current sensor auto-zero fault	RTB	Current sensor voltage out of range with no current.	
13	DSP parameter error	RTB	Motor parameter written to while motor control is operational.	Recycle keyswitch to allow parameters to be reloaded correctly.
14	3rd Party Anonymous Node EMCY received	I / DS / RTB	3rd party node has transmitted an EMCY message.	Check CANbus wiring and 3rd party node status.
15	Vehicle service required	I	Vehicle service interval has expired.	Service vehicle and reset service hours.

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**Service Manual**

**Section 5**

**Accelerator and Brake System**

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**VEHICLE SERVICE**

When servicing the electric Columbia Industrial/Commercial vehicle always observe the following:

**⚠ WARNING**

**Always turn Power keyswitch to OFF, Directional knob to Neutral, remove Power keyswitch, block tires and disconnect the battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible injury.**

**ACCELERATOR PEDAL**

Accelerator pedal maintenance consists of periodic inspection. No lubrication or adjustment is necessary.

The accelerator pedal works in conjunction with the linear accelerator and the controller to adjust and control vehicle direction and speed.

**HYDRAULIC BRAKE SYSTEM**

**General**

The hydraulic brake system can be two wheel rear drum brakes or four wheel, front disc and rear drum brakes

A mechanical brake pedal/linkage assembly is utilized to actuate a master cylinder. The master cylinder creates hydraulic pressure which operates the brakes. Hydraulic brake systems require a separate mechanical parking brake. A foot operated parking brake, mechanical linkage and cables are utilized to mechanically lock the rear brakes for parking.

**⚠ CAUTION**

**Do not handle hydraulic system parts with greasy hands or permit parts to come in contact with oil or grease. Grease or oil will damage the rubber parts.**

**Periodic Brake Inspection**

Intervals between brake service and inspection may vary depending on driving habits, type of driving, road and climate conditions, and vehicle load.

**⚠ CAUTION**

**Periodic brake inspection is required to prevent potential accident or injury and vehicle damage.**

Periodic inspection should always include the following:

1. With vehicle stationary, depress the brake pedal. Pedal should not travel in excess of 2-1/2" as measured from floor board. If pedal travels in excess of 2-1/2" before resistance is felt, or if pedal feels spongy and soft, repair or maintenance is required.
2. Inspect brake master cylinder and adjoining brake lines for signs of fluid leakage. Remove master cylinder cover. Fluid must be clear and fluid level should be within 1/4" of cylinder top (with vehicle on level ground).
3. Check parking brake operation. Parking brake should not bottom out at the floorboard. Check that ratchet mechanism automatically holds parking brake.. Make sure the release lever frees the parking brake and that the lever returns to full down position.
4. Operate vehicle on level ground, applying brakes to ensure that both rear brakes apply equally. Check that excessive force is not required to apply brakes. Excessive force required to apply brakes could indicate malfunctioning brake system or excessive wear to brake shoes.

**Annual Brake Inspection**

**⚠ WARNING**

**To perform this service, raise vehicle using floor jack and safely support it with jack stands positioned under main frame tubes. See Section 3 Maintenance - Lifting Instructions.**

1. Perform steps 1 & 2 under *Hydraulic Rear Drum Brake Disassembly*.
2. Inspect drum for excessive or uneven wear. Refer to *Brake Drum Service*. Look for cracks radiating from stud holes.
3. Inspect wheel cylinder area for fluid leakage. Also inspect the axle and axle tube area for leakage from the axle bearing
4. Inspect brake shoes for fluid contamination, damage or excessive wear. Measure brake lining thickness at the narrowest point. Lining should measure no less than 1/16" (1.6 mm). If worn beyond this, brake shoes must be replaced. See *Hydraulic Rear Drum Brake Disassembly*.
5. Wash brake assemblies removing mud, brake shoe debris, and dirt. Apply white lithium grease to contact points between brake shoe and brake back plate. Remove excess grease to prevent brake shoe contamination

**⚠ CAUTION**

**Do not use compressed air to blow dust from brake assembly. Brake dust contains potentially harmful contaminants.**

6. Perform steps 5-8 under *Rear Drum Brake Reassembly*.

**Hydraulic Rear Drum Brake Disassembly**

**NOTICE:** It is not recommended to remove the hydraulic brake assembly from the axle for repair or service.

- Before removal of existing parts, note location of springs and other parts for correct reassembly.
- Always use a brake spring tool to remove and install springs.
- Always lay out brake shoes and other parts in order removed. Reinstall in same order.
- Always replace brake shoes that have been contaminated with oils or lubricants.
- Always replace any springs that appear stretched or deformed.
- Never use petroleum based cleaners or lubricants on hydraulic brake parts as they will contaminate the brake fluid.

**NOTICE:** Do not mix parts from left and right brake assemblies as they may differ.

1. Engage the parking brake. Remove rear wheel/tire assembly and wheel spacer. Repeat for other rear wheel.
2. Release parking brake and remove brake drum.
3. Use a brake spring tool and remove the shoe return springs. Carefully pry the top of each spring from behind its tab on the torque spider. Unhook each spring from the torque spider and brake shoe and set it aside.
4. Remove the spring holding the top of each brake shoe together against the adjuster. Remove the adjuster screw and nut.
5. Gently remove each clip securing the brake shoes to the park actuating lever. Remove the brake shoes.
4. Use a brake spring tool and remove the shoe return springs (short and long). Unhook each spring from the brake shoes and set it aside.
5. Remove the spring clips and remove the brake shoes.

**CAUTION**

Do not depress brake pedal while shoes and drum are removed from the vehicle. Pistons will be forced from the wheel cylinders causing fluid leakage and damage.

6. Clean the brake assembly to remove brake debris, dust, dirt and mud.
7. See *Brake Drum Service* and rebore/replace drum as necessary.
8. See *Wheel Cylinder* and replace as necessary.

**CAUTION**

Do not use solvents or other chemical cleaners unless formulated for cleaning brake parts.

Do not use compressed air to blow dust from brake assembly. Brake dust contains potentially harmful contaminants.

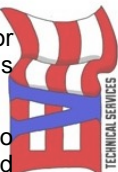
**Brake Drum Service**

1. Rebore or replace drum:
  - if rubbing surface is rough or ragged, or if depth of scoring exceeds .010".
  - if inside diameter of drum at open end exceeds inside diameter at closed end by more than .010".
  - if surface variance exceeds .005" on the side.
  - if hard spots cause noticeable effects such as pedal pulsations or brake roughness. If spots are severe, replace drum.
  - if heat checking is plainly visible or can be felt with a fingernail. If checks are severe, replace drum.
  - if out-of-round condition exceeds .006" total indicator reading or if pedal pulsations or brake roughness is noticeable.
2. To measure a drum diameter, place gauge in drum so contact points are at greatest diameter. Be careful to hold both contact points at same depth (distance from outside edge of drum).
3. Rebore limit is .060" over original drum diameter.
4. Difference in diameter of drums on opposite ends of the same axle must not exceed .010", or when turning drums turn them in pairs to same oversize (within .010") to ensure equal braking effort on all wheels.

**CAUTION**

Never rebore a drum to maximum wear or discard diameter.

5. When re-boring a drum, remove only enough metal to obtain a smooth braking surface. If drum does not clean up when turned to maximum rebore diameter, replace it. Removal of more metal will affect ability of drum to dissipate heat and may cause drum distortion.



**Wheel Cylinder Service**

The wheel cylinder is a one piece cast assembly and is part of the torque spider. When servicing the wheel cylinder, it is not necessary to remove it from the vehicle. Removal of the torque spider and wheel cylinder is recommended only when replacement is required. To remove, see *Section 7 - Rear Axle and Rear Wheel Assemblies*.

Rebuild or replace wheel cylinder/torque spider whenever brake shoes are replaced, or more often when required to correct a leaking cylinder.

*Cleaning and Inspection:*

1. Whenever a wheel cylinder is disassembled, always inspect the cylinder bore for scoring, pitting and corrosion. A hard, crystal-like substance sometimes forms a ring in the cylinder bore near the place where the piston stops, when brakes are released.
2. Fine grade crocus cloth (or an approved cylinder hone) may be used to remove light roughness or deposits from the bore. Hone lightly and use brake fluid as a lubricant while honing. If the bore does not clean up readily, replace the cylinder.
3. After using crocus cloth or a hone, flush inside of cylinder with clean alcohol or brake fluid, and wipe dry with a lint-free cloth. Be sure all dust and grit are removed and bleeder valve and brake tube passages are clean.
4. The clearance between cylinder bore wall and pistons must be checked after the cylinder is cleaned up. If a narrow (1/8"- 1/4" wide) .006" feeler gauge can be inserted between the bore wall and a new piston, the clearance is excessive and the wheel cylinder must be replaced.

**NOTICE:** If the clearance between the pistons and the bore wall exceeds .005", a condition known as heel drag may exist. This causes rapid cup wear and may cause the pistons to retract very slowly when the brakes are released.

*Tips for assembly:*

1. Always use new wheel cylinder repair parts to rebuild wheel cylinder.
2. Dip the pistons and cups in clean brake fluid. Coat the cylinder bore with clean brake fluid.
3. After reassembly is complete, hydraulic system must be bled of air. See *Bleeding the Hydraulic System*.

**Rear Drum Brake Reassembly**

1. Place brake shoes into position on brake actuating lever tabs. Insert retaining pins.  
  
Brake shoes may not be equal in length. The shoe with the shorter lining should be installed on the brake assembly side closest to the front of the vehicle. Shoe with longer lining installs to the rear.
2. Screw adjuster assembly into minimum length position and insert between the tops of each brake shoe. Install blue spring under adjuster.

3. Insert the red spring into the left shoe (facing the brake assembly) onto its mounting post on the brake spider, and pry the top end of the red spring into position behind the torque spider retaining tab. Repeat with green spring mounted on the right side.
4. Check that brake shoes are correctly positioned into the slots provided in each master cylinder piston.
5. Install the brake drum 3/4 over the brake assembly and using a brake spoon or brake adjusting tool, rotate the brake adjuster until drag is felt against the brake drum. Push the drum fully onto the assembly.
6. Apply pressure to the brake pedal, pumping 2-3 times and releasing, then check to see if additional adjustment is required to create drag on the drum. Adjust as necessary to achieve slight drag on the drum.
7. When adequate drag is achieved (very slight drag), install drum fully onto brake assembly and install four new Tinnerman nuts.
8. Reinstall rear wheel/tire assembly and four lug nuts. Engage brake and tighten lug nuts in a crisscross pattern to a maximum 65-70 ft. lbs. Repeat for other rear wheel. Recheck lug nut torque with vehicle on the ground.

**Brake Fluid Maintenance**

The master cylinder is located in the front hood compartment.

1. Maintain fluid level within 1/4" of master cylinder filler opening.
2. Changing brake fluid:

As a result of use, brake fluid loses some of its original qualities and may become contaminated. When performing major brake work to the hydraulic system, remove old fluid and replace it with clean brake fluid.

Brake fluid must be changed following extended usage or contamination. Anytime fluid looks milky or dark, there are contaminants in the fluid.

If any of the hydraulic system parts are corroded, or the fluid is discolored, flush the hydraulic system to remove old fluid, then fill with clean brake fluid.

3. Contamination. Soft or swollen rubber parts, or milky or discolored fluid indicate the brake fluid is contaminated.

Drain old fluid from the system.

Replace cups and seals.

Flush hydraulic system with clean brake fluid.

Refill system with clean brake fluid.

4. Handling and storing brake fluid:

Keep brake fluid clean. Do not allow any foreign material in the fluid.

Prevent any petroleum product (gasoline, kerosene, oil, grease, etc.) from contaminating the brake fluid.

Use only clean containers for dispensing brake fluid.; Do not use containers contaminated with dirt, grease, etc.



Always cover or cap brake fluid containers when not actually dispensing the fluid. If containers are left open or uncovered, the fluid absorbs moisture from the air.

Never reuse old brake fluid drained from the system. Used brake fluid is contaminated to some extent.

Store brake fluid containers in a clean, dry place.

**Bleeding the Hydraulic Brake System**

**⚠ WARNING**

**Brake fluid can cause irritation of eyes and skin, and may be harmful if swallowed. If fluid is swallowed, induce vomiting by administering two tablespoons of salt in a glass of warm water.**

**Call a doctor. In case of contact with skin or eyes, flush with plenty of water. Get medical attention for eyes.**

**KEEP BRAKE FLUID OUT OF THE REACH OF CHILDREN!**

If any line or cylinder has been opened when servicing the brake system, or when satisfactory brake adjustment is unobtainable, or pedal is spongy, bleed air from the hydraulic system as follows:

1. Install a length of appropriate size plastic tubing over the brake assembly bleeder valve.

**NOTICE: On vehicles equipped with only rear hydraulic brakes, bleed the right side wheel first. On vehicles equipped with both front and rear hydraulic brakes, bleed both right side wheels first, then both left side wheels.**

2. Place the other end of tubing in any clear glass jar containing about 1/2" of brake fluid.
3. Open bleeder valve (Figure 5-3) by rotating it counterclockwise about 1/2 turn. With master cylinder full of fluid at all times, slowly depress the brake pedal repeatedly until fluid flows from bleeder valve free of air bubbles.
4. Add fluid to master cylinder to bring 1/4" from cover. Close bleeder valve. Repeat procedure on left wheel.
5. Do not reuse fluid unless it is clear and free of sediment. If it is impossible to bleed all air from system, master cylinder is faulty and a master cylinder repair kit should be installed.

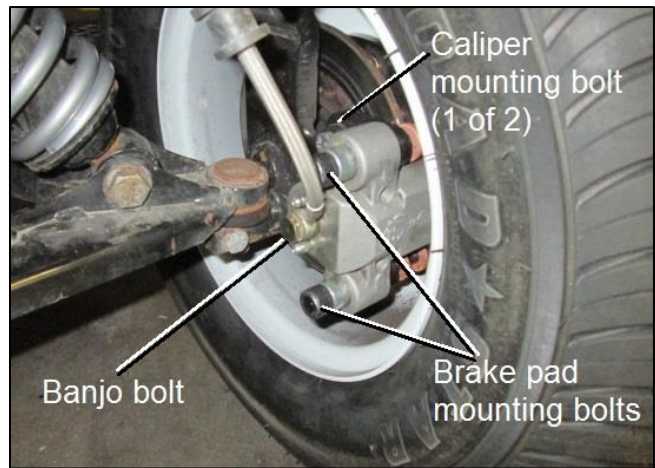
**DISC BRAKE**

Disc brakes are not adjustable and rarely cause problems. If problems are encountered, refer to the following service and inspections procedures for possible causes and solutions.

**Replacing Brake Pads**

**NOTICE: Do not depress brake pedal while shoes and drum are removed from the vehicle. Pistons will be forced from the wheel cylinders causing fluid leakage and damage.**

1. With vehicle on the ground, depress the emergency brake pedal to engage the brakes. Loosen wheel assembly mounting nuts.
2. Raise and secure vehicle as described in *Section 3-Lifting Instructions*.
3. Remove lug nuts and all wheel/tire assembly. Front axle has an axle nut.
4. Disengage the emergency brakes and remove the 2 bolts and lock washer that secure the caliper. See Figure 5-1.
5. Remove old pads and replace with new pads.
6. Reinstall brake pad mounting hardware.
7. Reattach calipers with nut, lock washer and lock-tight. Before applying lock tight, clean and inspect threads.
8. Reinstall wheel/tire assembly and lug nuts. Engage brake and tighten lug nuts in a crisscross pattern to a maximum 65 ft. lbs. Recheck lug nut torque with vehicle on the ground.



**Figure 5-1**

**Torque Specifications**

- Banjo Bolt: 20 – 22 FT. LBS.
- Caliper Mounting Bolts: 17 FT. LBS.
- Brake Pad Mounting Bolts: 32 – 36 FT. LBS.

**Brake Caliper Service**

The pistons must be removed from the bores. Using the vehicle's hydraulic pressure to force them out is the easiest method.

1. With vehicle on the ground, depress the brake pedal to engage the brakes. Loosen wheel assembly mounting nuts.
2. Raise and secure vehicle as described in *Section 3-Lifting Instructions*.
3. Remove four nuts and front wheel/tire assembly.
4. Disengage the brakes and remove the upper brake caliper mounting bolt (Figure 5-1).
5. Remove brake pad mounting bolts and brake pads.
6. Rotate the caliper off the rotor. With caliper still bolted to the vehicle and hydraulic lines connected, press brake pedal until both pistons slide out of the bores. Push one side out, then remove piston from the other side. To prevent brake fluid from squirting out, cover the calipers with a cloth.
7. Remove the seals and boots. Rubber dust boots and seals should be replaced whenever the caliper is disassembled.
8. Clean pistons in alcohol, then wipe dry with a clean lint-free cloth.
9. Blow out all drilled passages with compressed air.
10. Inspect cylinder bores in both sides of the caliper housing for scoring and pitting. Bores that show light corrosion can be cleaned with fine grit crocus cloth. Caliper bores with deep scratches or scoring should be honed with a 1/4" electric drill. The same attachment is used for honing wheel cylinders on drum brakes.
11. The caliper cylinder must not be honed out larger than the manufacturer's specifications-not more than .002" oversize.
12. Black stains on the bore caused by piston seals are not harmful and need not be removed.
13. After honing, take care in cleaning the caliper parts. Flush them with alcohol, wipe dry with a clean lint-free cloth, then flush and dry them again. Clean mating surfaces with No. 400 wet or dry sandpaper, **never** use a file.
14. Lubricate internal areas, pistons and piston O-rings with new brake fluid. Install parts into caliper.
15. Install brake pads and secure with mounting bolts.
16. Rotate caliper with rotor centered in brake pads and install caliper mounting hardware and lock tight. Before applying lock tight, clean and inspect threads.

17. Reinstall rear wheel/tire assembly and four lug nuts. Engage brake and tighten lug nuts in a crisscross pattern to a maximum 65 ft. lbs.
18. Perform all steps in *Bleeding the Hydraulic System*.
19. Recheck lug nut torque with vehicle on the ground.

**Brake Rotor Service**

Disc must be flat with no warping or hot spots. Runout in a disc brake rotor is like out-of-roundness in a drum brake. It causes a loss of brake pedal height because of extra lining clearances. Runout wears the caliper pistons and seats rapidly due to the high speed pulsations created whenever the brakes are applied.

Runout tolerances are critical, usually only about .002".

**NOTICE:** .As much as .015" of metal can be removed from each side of the rotor without exceeding specifications. If removing the maximum specified amount will not clean up a rotor's problems, install new rotors.

**CAUTION**

Do not depress brake pedal while brake calipers are removed from the vehicle. Pistons will be forced from the wheel cylinders causing fluid leakage and damage.

**Front Wheel**

1. With vehicle on the ground, depress the emergency brake pedal to engage the brakes. Loosen wheel assembly mounting nuts and axle nut.
2. Raise and secure vehicle as described in *Section 3-Lifting Instructions*.
3. Remove wheel/tire assembly. Remove axle nut and washer.
4. Remove brake caliper mounting hardware (Figure 5-1 from the hydraulic brake spindle.
5. Remove caliper assembly by sliding off rotor. Do not disconnect hydraulic line from caliper.
6. The rotor may now be removed from the spindle by removing the dust cover, cotter pin and spindle nut.
7. At this point the rotor may be either resurfaced or replaced with a new rotor.
8. Complete reassembly by reversing Steps 1-6.
9. Reinstall brake caliper with mounting hardware (Figure 5-1). Before applying lock tight, clean and inspect threads.

10. Use caution when remounting the brake calipers. Tighten each of the bolts gradually alternating from one to the other. As you tighten the bolts be certain that the pads are parallel to the disk. If they are not, a "spongy" brake pedal may result. Also be sure that the caliper can still move back and forth in the caliper housing mounting. If it can't, uneven pad wear will result.
11. Reinstall front wheel/tire assembly and four lug nuts. Engage brake and tighten lug nuts in a crisscross pattern to a maximum 65 ft. lbs.
12. Torque axle nut to 45 ft. lbs. then tighten until new cotter pin can be inserted.

**HYDRAULIC BRAKE ADJUSTMENTS**

Behind the master cylinder is a lock nut, clevis pun and clevis. Removing the pin will allow the clevis to be adjusted.

**PARKING BRAKE PEDAL ADJUSTMENT**

**NOTICE:** Correct parking brake operation should be confirmed before adjustments are made to cables and mechanical linkage. Check that corrosion has not caused excessive resistance in the operation of the brake cables. If corrosion is present, replace cables before performing adjustments.

Press the parking brake to monitor the amount of travel. The pedal should click or ratchet two or more times before resistance is felt and the parking brake is set. If the pedal bottoms out on the floor board adjustment is required as follows:

1. Parking brake linkage is connected to the brake equalizer, located behind the brake/accelerator pedals.
2. Turn adjusting nut (Arrow Figure 5-2) to shorten or lengthen linkage as required.
3. Recheck parking brake operation to confirm adjustment.



**Figure 5-2**

**/PROPORTIONING VALVE**

If equipped with four wheel brakes, this unit is also equipped with an adjustable proportioning valve. The valve is mounted below the master cylinder, behind the driver's side front tire. Installed in series with the rear brake hydraulic fluid line, the adjustment allows a bias towards increased pressure in the front brakes, to prevent rear wheel skidding during hard braking, downhill braking, or inclement weather braking.

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**Section 6**

**Front Wheels, Steering & Front Suspension**

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**GENERAL**

The steering system is operated by rotating the steering wheel. The steering wheel rotates the steering shaft connected to the rack and pinion steering assembly. The rack and pinion assembly pushes and pulls on tie rod ends to control front wheel steering.

The front suspension consists of two coil over shock absorbers.

**SPECIFICATIONS**

Steering Gear Rack and Pinion

- Automotive type totally enclosed lifetime lubrication

Camber-Mechanical Adjustment

- Wheels at right angle to the ground - 0°

Toe-In Adjustment - 1/4" toe-in

**NOTICE: Always inspect the condition of vehicle steering components before making adjustments. Worn, broken or damaged parts must be replaced before proper adjustment can be performed.**

**FRONT WHEELS AND HUBS**

**Removing**

1. Before raising vehicle, with wheels on the ground, break loose the lug nuts.

**WARNING**

**To perform this service, raise vehicle using floor jack and safely support it with jack stands positioned under main frame tubes. See Section 3 - Lifting Instructions.**

2. Remove lug nuts and wheel assembly from the hub.
3. Remove grease cap (Figure 6-1).
4. Remove cotter pin, axle nut and flat washer. Discard axle nut and cotter pin.
5. Carefully pull hub off the axle.
6. Repeat steps 1 - 5 for the other front wheel.

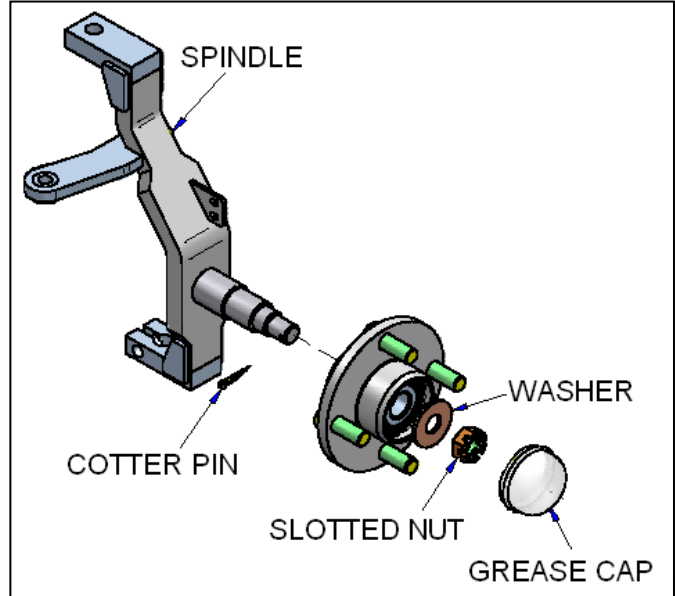


Figure 6-1

**Roller bearings**

Front wheel hubs have roller bearings. Bearings should be replaced whenever wheel hub is removed.

Pack bearings with lithium wheel bearing grease before installing.

**Installing**

1. Clean spindle. Apply a thin coating of grease and install hub and bearing onto the spindle.
2. Install flat washer and new axle nut. Tighten axle nut to 50 ft. lbs. to seat bearing then loosen nut. Hand tighten nut until resistance is felt when turning the wheel hub, then back off until new cotter pin can be inserted.
3. Install grease cup.
4. Place wheel assembly on the hub studs.
5. Tighten four lug nuts by hand and wrench until snug using a crisscross pattern (See Section 5, Figure 5-3).
6. Lower the vehicle to the ground and torque the lug nuts to 65 ft. lbs. (23 Nm) using the same crisscrossing pattern.





**TIRES**

In the event of a flat tire, remove wheel assembly from vehicle and follow standard tire repair procedures.

**⚠WARNING**

Use care when inflating a tire with a high pressure air supply. Due to low pressure requirements of a small tire, over inflation may be reached in a matter of seconds. Over inflation could cause the tire to explode resulting in possible personal injury.

**STEERING WHEEL**

**Removing**

1. Remove steering wheel cover by carefully prying out from steering wheel.

**NOTICE:** If the vehicle has a scorecard holder it will be necessary to first remove the three #10x1 screws that attaching the scorecard holder.

2. Remove two Phillips head screws securing steering wheel to collar (Figure 6-6).
3. Remove steering wheel nut from center of steering wheel.
4. Pull steering wheel from steering shaft.

**Installing**

1. Make sure wheels are pointed straight ahead.
2. Apply Anti-Seize to steering shaft. Install steering wheel centered on splined shaft.
3. Install steering wheel nut and torque to 20 ft. lbs.
4. Connect collar to steering wheel with two Phillips head screws.
5. If equipped attach the scorecard holder.

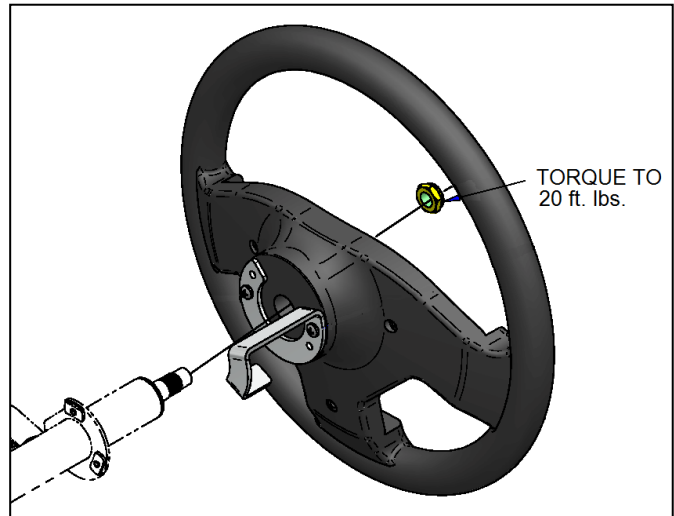


Figure 6-5

**RACK AND PINION STEERING ASSEMBLY**

**⚠WARNING**

To perform this service, raise vehicle using floor jack and safely support it with jack stands positioned under main frame tubes. See Section 3 - Lifting Instructions.

**Removing**

1. To access this assembly remove front wheels and the front lower fascia.
2. Remove steering shaft clamp bolt securing steering shaft to the steering rack (Figure 6-6A).

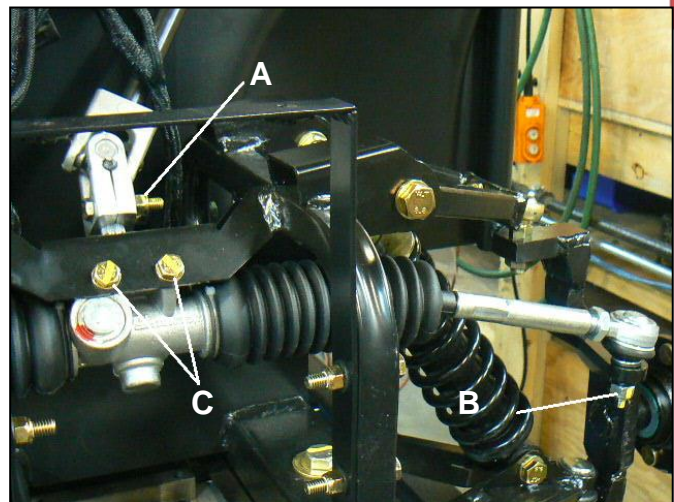


Figure 6-6

3. Remove nuts securing tie rod ends to left and right steering arm assemblies (Figure 6-6B). Lift tie rod ends from steering arms.
4. Remove two bolts securing rack steering assembly to frame (Figure 6-6C).
5. Remove assembly from vehicle.

**Installing**

1. Insert the assembly into the vehicle. Do not install mounting bolts (Figure 6-6C) at this time.
2. Insert steering shaft into steering rack and install clamp bolt (Figure 6-6A). Torque to 25 ft. lbs.
3. Install two mounting bolts through frame and into steering housing (Figure 6-6C) and secure with nuts. Torque to 20 ft. lbs.
4. Install tie rod ends to steering arm assemblies (Figure 6-6B). Install nuts and torque to 35 ft. lbs.

**FRONT SUSPENSION**

**⚠ WARNING**

To perform this service, raise vehicle using floor jack and safely support it with jack stands positioned under main frame tubes. See Section 3 - Lifting Instructions.

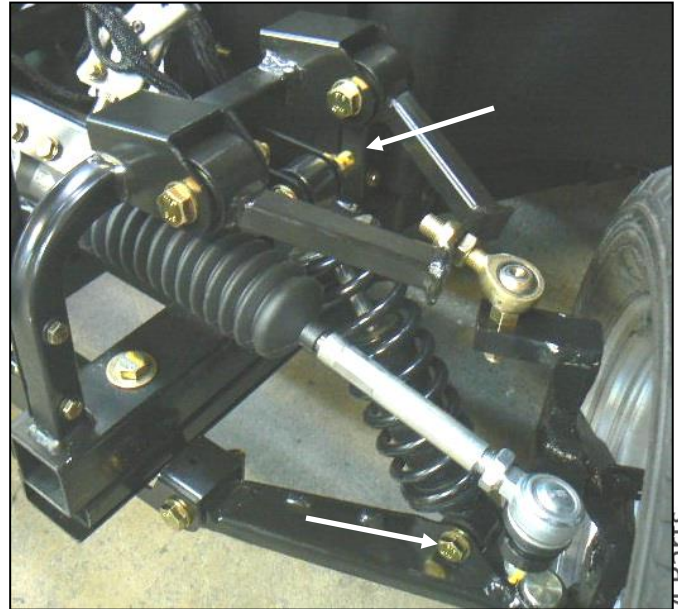
**Replacing Front Shock Coil Over**

Replace shock coil over if dampening effect is not present when shock absorber is collapsed or extended, or there are signs of oil leakage.

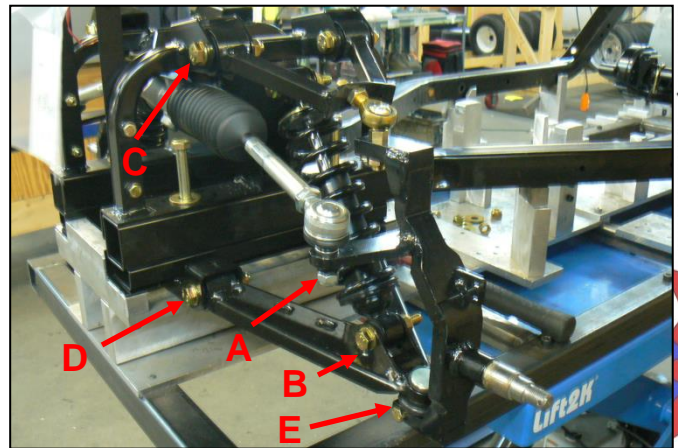
1. Remove wheel/tire assemblies.
2. Remove upper and lower mounting bolts, spacers and nuts securing shock coil over. See Figure 6-7
3. Install new assembly and secure with mounting bolts, spacers and new nylock nuts.
4. Torque to 55 ft. lbs.

**Disassembling Steering Spindles and A-Arms**

1. Remove front wheels and hubs as described in *Removing Front Wheels and Hubs*.
2. Remove tie rod end from steering spindle (Figure 6-8A).
3. Remove bolt and nut securing the lower shock coil over (Figure 6-8B).
4. Remove two bolts and nuts securing the upper A-Arm assembly (Figure 6-8c) to the upper suspension module.
5. Remove the two bolts and nuts securing the lower A-Arm assembly (Figure 6-8D).



**Figure 6-7**



**Figure 6-8**

6. Separate the lower A-Arm assembly from the steering spindle by loosening the securing bolt (Figure 6-8E).

**Assembling Steering Spindles and A-Arms**

1. Attach the lower A-Arm assembly to the steering spindle. Torque to 45 ft. lbs.
2. Secure the upper and lower A-Arm assemblies. Use new nylock nuts and torque to 55 ft. lbs.
3. Reattach the lower shock coil over (Figure 6-8B). Use new nylock nuts and torque to 55 ft. lbs.
4. Reattach the tie rod end to the steering spindle.

**STEERING ADJUSTMENTS**

To perform adjustments, place vehicle on flat, level surface. Position front wheels pointed directly forward.

**Camber Adjustment**

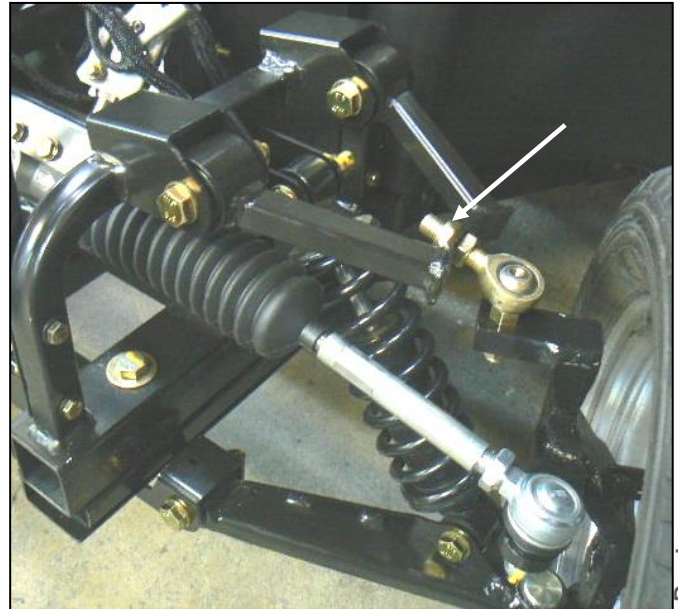
1. Place a carpenters square against left front wheel and check that wheel is straight up and down.
3. If wheel is not vertical, loosen the tie rod end assembly jam nuts (Fig. 6-9) and adjust until wheel is straight up and down.
4. When correct adjustment is obtained, torque jam nuts to 55 ft. lbs.
5. Repeat for right front wheel.

**Toe in Adjustment**

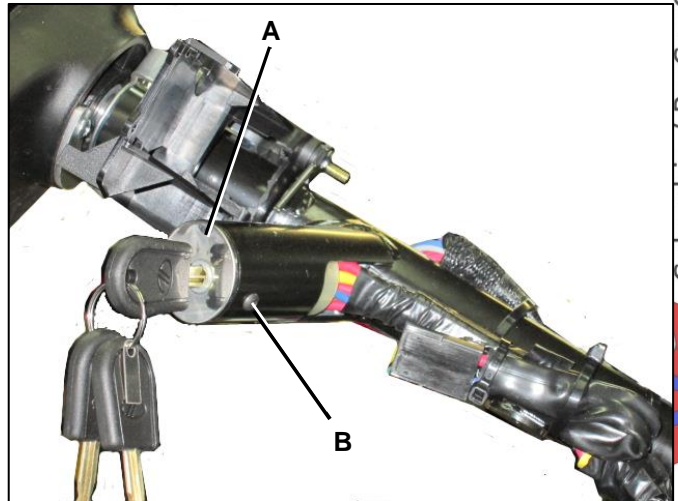
1. With wheels pointed directly forward, loosen jam nuts on tie rod ends.
2. Using a rod or stick approximately 27"-27½" long, check distance between front edge of both tires. Then check the distance between back edge of both tires.
3. The distance between tires at front edge should be ¼"-1/8" less than the distance between the back edge of the tires.
4. If distance between tires (toe in - toe out) is incorrect, rotate tie rods to adjust as necessary.
5. When correct distance is achieved, tighten tie rod jam nuts against tie rods.
6. Recheck measurements.

**KEYSWITCH REMOVAL**

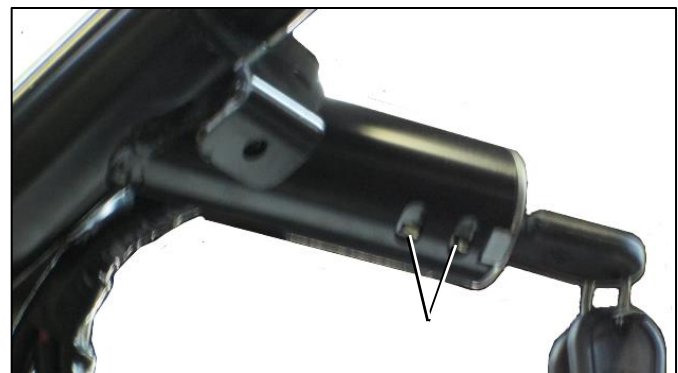
1. Remove the nine screws attaching the upper and lower column covers.
2. Use a 5/64" allen wrench to remove the column set screw (Figure 6-10B).
3. Remove the cable ties and electrical tape securing the keyswitch wires and unplug the connection.
4. See Figure 6-10A. Place the key switch in the unmarked arrow position.
5. See Figure 6-11. Use a flat blade screwdriver to push the two tangs inward while pulling the key switch out of the column.
6. Reverse the procedure to replace.



**Figure 6-9**



**Figure 6-10**



**Figure 6-11**



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**Section 7**

**Rear Wheels, Rear Suspension & Axle Assembly**

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TECHNICAL SERVICES

**WARNING**

To perform the following services, raise vehicle using floor jack and safely support it with jack stands positioned under main frame. See Section 3 - Lifting Instructions.

**REAR WHEELS**

**Removing Rear Wheels**

1. Before raising vehicle, with wheels on the ground, break loose the lug nuts.
2. Raise the vehicle and engage the brake. Remove four lug nuts and remove rear wheel/tire assembly
3. Repeat steps 1 - 2 for the other rear wheel.

**Rear Axle Wheel Bearings**

Rear axle wheel bearings are sealed type bearings and cannot be repacked. Bearings must be replaced if worn or damaged.

**Installing Rear Wheels**

1. Place wheel assembly on the hub studs.
2. Tighten four lug nuts by hand and wrench until snug using a criss-cross pattern.
3. Lower the vehicle to the ground and torque the lug nuts to 65 ft. lbs. (23 Nm) using the same criss-crossing pattern.

**TIRES**

See Section 6-Tires for tire removal and mounting.

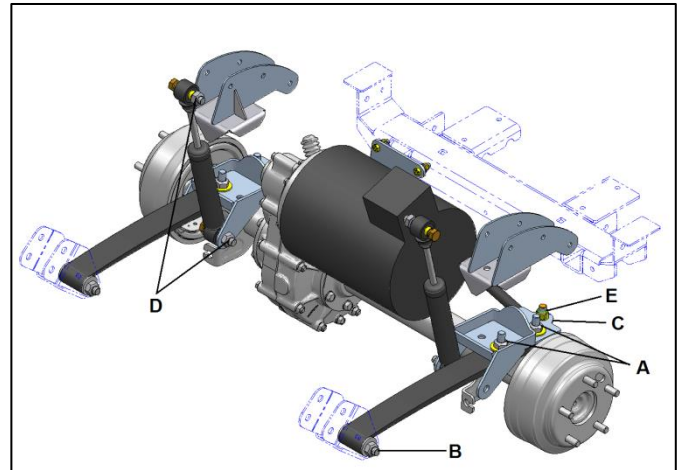
**REAR SUSPENSION**

**Replacing Rear Trailing Link Mono Leaf Springs**

1. With the vehicle on jack stands, use a hydraulic jack to support the rear axle.
2. Remove the 3 bolts, washers and nuts (Figure 7-1A and B) securing the leaf spring to the spring shock seat (Figure 7-1C). Do not reuse nuts.
3. Install new leaf springs. Torque leaf spring and spring shock seat bolts/ nuts (A) to 60 ft.lbs.. Torque bolts/nuts (B) to 85 in. lbs. Do not reuse nuts.

**Replacing Rear Shocks**

1. With the vehicle on jack stands, use a hydraulic jack to support the rear axle.
2. Remove the top and bottom bolts/nut (Figure 7-1D) securing the shock.
3. Remove and replace shock. Torque all bolts/nuts to 30 ft. lbs. Do not reuse nuts.



**Figure 7-1**

**Replacing Coil Springs (Not Shown)**

1. With the vehicle on jack stands, use a hydraulic jack to support the rear axle.
2. Remove the top shock bolts/nuts (Figure 7-1D) and the lower sway bar bolt/nut (Figure 7-1E).
3. Lower the axle until the coil springs can be replaced.
4. Raise the axle and reattach the upper shock. Torque to 30 ft. lbs. Reattach the sway bar and tighten. Do not reuse nuts.

**REAR AXLE ASSEMBLY**

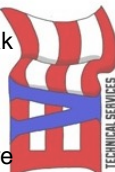
**Removing Rear Axle**

1. Before raising vehicle, with wheels on the ground, break loose the lug nuts.
2. Raise the vehicle and engage the brake.
3. Remove lug nuts and remove rear wheel/tire assemblies. Remove and discard cotter pin and axle nut. Release brake and remove spacer (if equipped) and rear brake drum. Repeat for other side.
4. Remove rear shock absorbers, sway bar lower bolt/nut and leaf springs as described previously.
5. Remove cotter pins, clevis pins and e-rings. Disconnect brake cables from brake assemblies on the rear axle.
6. Place a floor jack under the axle and lower axle.

**DISASSEMBLING REAR AXLE**

The rear axle is a precision assembly and any repair or replacement of parts must be done with great care in a clean environment. Before attempting to perform any axle service, read and understand all the procedures in this section.

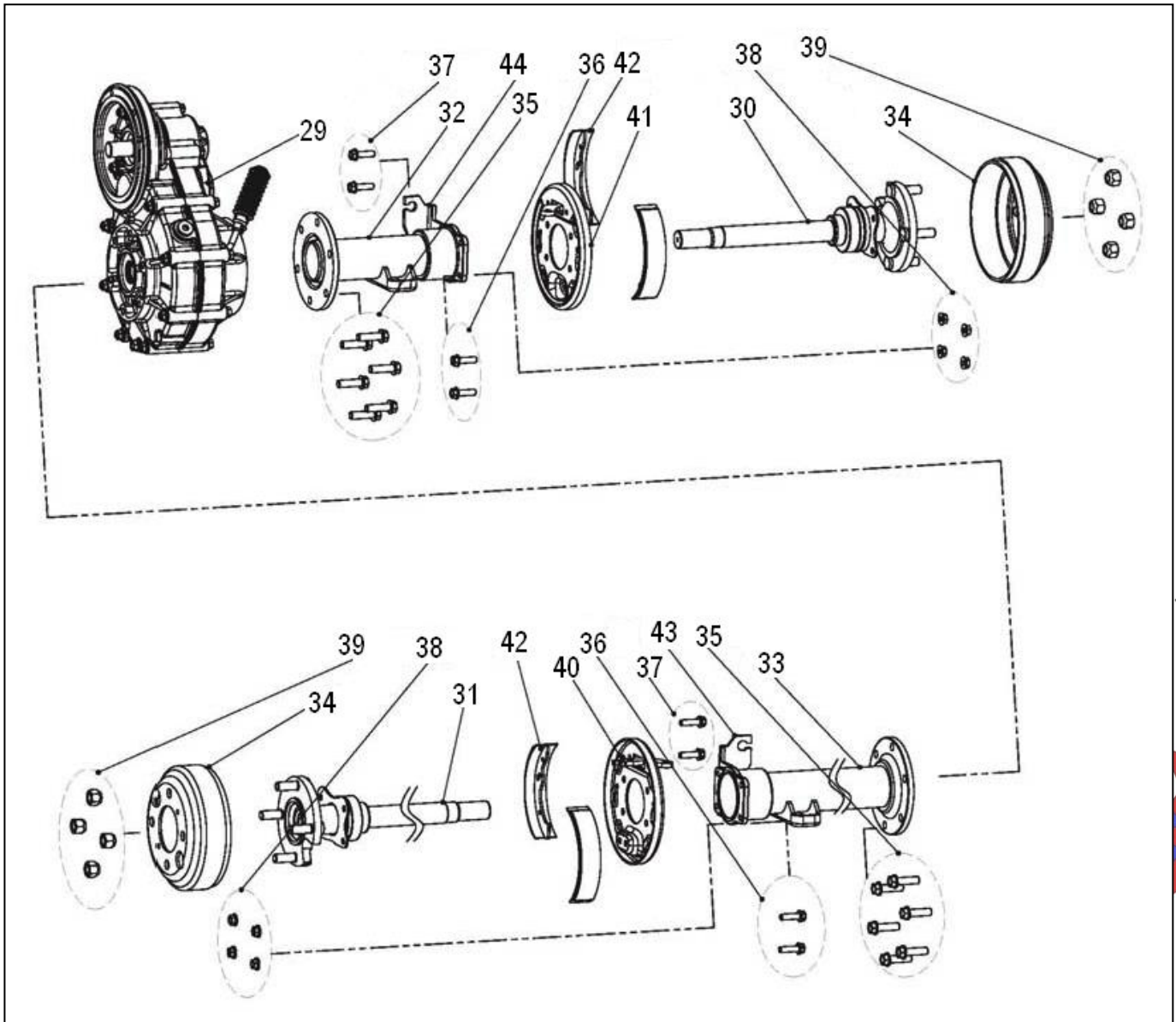
- Handle all gears with extreme care.



- The axle assembly should be degreased prior to disassembly.
- Dirt is an abrasive and will cause premature wear of bearings and other parts. A small wash tank for cleaning parts should be close by when disassembling the axle assembly.
- Use soft, clean, lint-free towels to dry components before cleaning.
- Parts should be cleaned with emulsion cleaners or petroleum based cleaners.
- After drying, parts should be lightly coated with SAE 30 weight oil to prevent corrosion damage. If parts are to be stored for a prolonged period of time, they should be wrapped in newspaper and plastic.
- Bearings, seals and O-rings should be replaced with new parts whenever they are removed. Always wipe seals and O-rings with SAE 30 oil before installing.
- Snap rings must be removed/installed with care to prevent damage to bearings, seals and bearing bores.
- Remove all residual gasket material from sealing surfaces.
- Use soft, clean, lint-free towels to dry components before cleaning.
- Parts should be cleaned with emulsion cleaners or petroleum based cleaners. Inspect all parts for signs of wear or damage and replace if necessary.

**⚠ DANGER****Do not use gasoline as a cleaner.****NOTICE: Bearings should not be dried by spinning with compressed air. This can damage mating surfaces due to lack of lubrication.**

**AXLE BREAKDOWN**



ITEM	DESCRIPTION
1	COVER CASE ASSEMBLY
2	GEAR CASE
3	CARRIER GEAR (See Item 45)
4	GEAR 15T (See Item 46)
5	GEAR 40T (See Item 46)
6	GEAR 18T (See Item 47)
7	BALL BEARING 6207 (See Item 45)
8	BALL BEARING 6303 (See Item 46)
9	BALL BEARING 6203 (See Item 47)
10	BALL BEARING 6205 (See Item 47)
11	SHIM 61X69X1.5t (See Item 45)
12	SHIM 36X44X1.5t (See Item 46)
13	SHIM 32X40X1.0t (See Item 47)
14	SHIM 45X51X1.5t (See Item 47)
15	WASHER 8.2X16X2.0t
16	WASHER 14.5X22X1.0t
17	SEAL 28X55X9h
18	SEAL 25X47X6h
19	BOLT M8XP1.25X100L
20	BOLT M8XP1.25X90L
21	BOLT M8XP1.25X12L
22	BOLT M14XP1.5X9.5L
23	NUT M8XP1.25
24	LOCATION PIN 8.2X10X12L
25	MACHINE KEY (See Item 46)
26	CIRCLIP – SHAFT 32 (See Item 46)
27	BREATHER TUBE
28	RING

ITEM	DESCRIPTION
29	GEAR BOX ASSY
30	SHAFT ASSY R
31	SHAFT ASSY L
32	TUBE ASSY R
33	TUBE ASSY L
34	DRUM
35	BOLT M10X1.25X35L
36	BOLT M8X1.25X25L
37	BOLT M8X1.25X28L
38	NUT SHRAPNEL M8XP1.25
39	NUT
40	BRAKE ASSEMBLY L
41	BRAKE ASSEMBLY R
42	SHOES, BRAKE
43	CABLE PLATE L
44	CABLE PLATE R
45	CARRIER GEAR ASSEMBLY 10.37:1 (Includes Items 3, 7 & 11)
46	INTERMEDIATE GEAR ASSEMBLY 10.37:1 (Includes Items 4, 5, 8, 12, 25 & 26)
47	INPUT GEAR ASSEMBLY 10.37:1 (Includes Items 6, 9, 10, 13 & 14)





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**Section 8**

**Body & Chassis**

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**FRONT BODY**

Removal of the front body is extensive. It requires removal of the cowl, dash panel, front lower fascia and the six screws attaching the body to the chassis. Under the hood disconnect all wiring and remove the four screws attaching the front body to the chassis.

**REPLACING FRONT HEADLIGHT/BULB**

1. Access to the bulb is from the hood compartment.
2. Disconnect the wires from the bulb and using a quarter turn remove the bulb and replace with a new bulb. See P5 Part Book for correct bulb.
3. To replace the light assembly, remove the three screw attach it to the front body.

**REPLACING FRONT TURN SIGNAL**

1. Access to the bulb is from underneath,
2. Disconnect the wires from the bulb and using a quarter turn remove the bulb and replace with a new bulb
3. To replace disconnect the wires. The assemblies have been glued to the bracket (See Fig. 8-1) with seal bond in two locations. It will be necessary to scrape away the seal bond. Once removed depress the two silver tabs.

**NOTICE:** The brackets are secured with double-faced tape. If the decision is to replace the bracket and the light assembly, scrape clean the body/bezel surface, retreat with alcohol and primer before securing with double-face tape.

**REPLACING REAR STOP/TURN/TAIL ASSEMBLY**

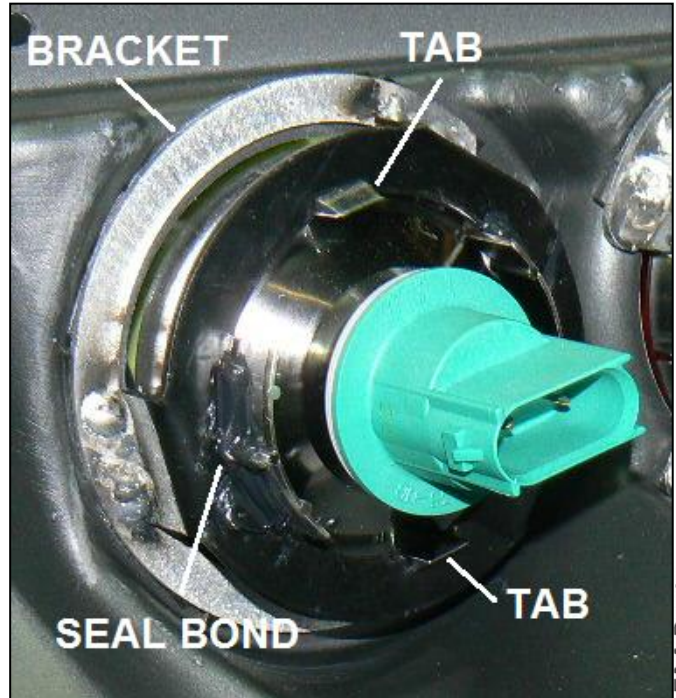
3. Disconnect the wire and remove the assembly. Replace with a new assembly which includes the light and grommet

**SEAT REMOVAL**

1. See Figure 8-2. Lift the seat exposing the seat base.
2. Each seat is attached to the seat base with 4 nuts and washers.

**CONSOLE CONTROLS**

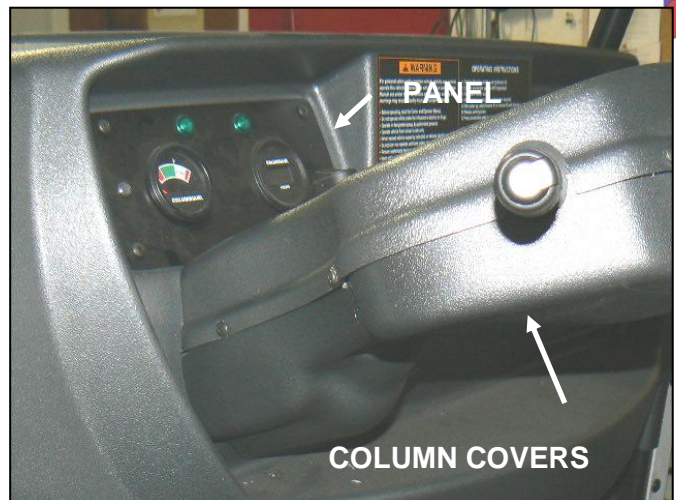
1. See Figure 8-3. To access/replace the hour meter, system status light or the battery discharge indicator (DC) or the Clearview display (AC not shown) remove the 4 screws holding the panel in place.
2. To access/replace the horn/turn signal/light switch, hazard switch or the ignition switch remove the screws attaching the upper and lower column covers.



**Figure 8-1**



**Figure 8-2**



**Figure 8-3**

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**DIRECTIONAL SWITCH REMOVAL**

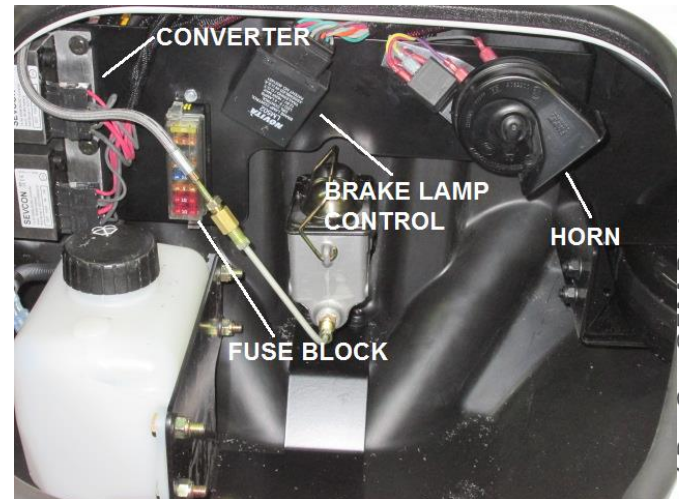
1. See Figure 8-4.
2. Use an allen wrench to remove the knob. See arrow.
3. Under the knob is a 9/16 securing nut. When removed the control unit will drop down.



**Figure 8-4**

**FUSE BLOCK - 12V ELECTRICAL**

1. See Figure 8-5. A fuse block protecting the 12V electrical circuits of the vehicle is located under the hood.
2. The fuse block has a snap off cover for access to the fuses.



**Figure 8-5**

**HORN**

1. See Figure 8-5. The horn is located under the hood.
2. Disconnect wires. Remove the screw/nut securing it to panel.

**BRAKE LAMP CONTROL**

1. See Figure 8-5. Located under the hood.
2. Disconnect wires. Remove the screw/nut securing it to panel.

**DC DC CONVERTER**

1. See Figure 8-5. Located under the hood.
2. Disconnect wires. Remove the screws/nuts securing it to panel.

**FUSE BLOCK - 48V ELECTRICAL**

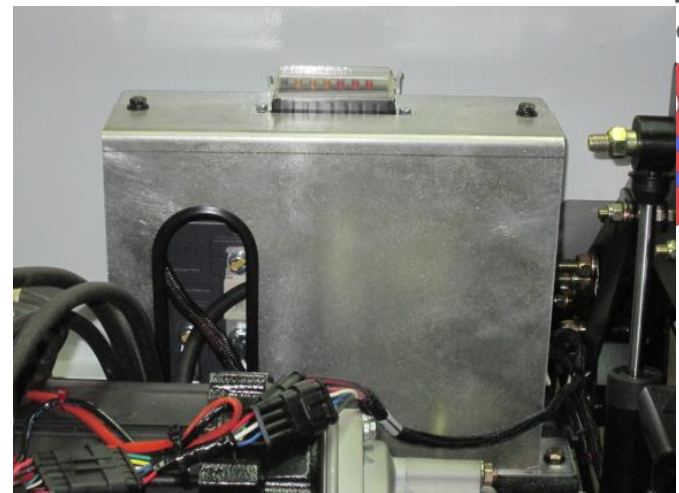
1. See Figure 8-6. A fuse block protecting the 48V electrical circuits (horn, etc.) of the vehicle is located beneath an access panel under the front seats.
2. The fuse block has a snap off cover for access to the fuses.

**CONTROLLER**

1. See Figure 8-6. Located under the rear deck. It is covered with a metal box. The two top screws will allow removal of the front panel to get access to the wires.
2. The controller box is secured with 2 bottom screws and one screw on the left side. To remove, label and undo wires then remove the securing screws.

**CHARGER, RECEPTACLE & REMOTE LED (Not Shown)**

1. The charger receptacle and remote LED is located on the left front fender. The AC cord is plugged in here for battery charging. The receptacle may contain a retractable cord for charging. See *SECTION 9 BATTERY AND CHARGER* for more information on this LED.
2. The charger is located beneath the front seats on the left side of the vehicle. It is secured with 4 screw and nuts.



**Figure 8-6**

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**Service Manual**

**Section 9**

**Battery & Battery Charger**

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**IMPORTANT INFORMATION**

The type of battery used in a Columbia vehicle has a service requirement which is quite different from that of an automotive battery.

The electric vehicle battery supplies all of the power to drive the vehicle. During operation the power stored in the batteries is expended. While the amperage drain rate can vary greatly depending on the type of service, the duration of use and the number of “starts” and “stops” made during a day, the batteries nevertheless progress through each duty cycle from “fully charged” to an almost depleted state. This type of service is known as “deep cycle” service and electric vehicle batteries are specifically designed to handle this type of service.

Proper performance of your Columbia Vehicle can only be obtained from specified deep cycle, electric vehicle batteries.

**SAFETY INFORMATION**

**▲ DANGER**

**All batteries used in electric vehicles can explode! Always wear full face shield when working on or near batteries. Hydrogen fumes are a natural byproduct of charging and discharging and are extremely explosive.**

**Do not smoke around electric vehicle batteries. Keep sparks and flames away from batteries. Battery charging should only be done in a well-ventilated area. Refer to Section 9-Batteries for details.**

**Batteries contain acid which can cause severe burns. Avoid contact with skin, eyes, or clothing. Wear full face shield and rubber gloves when working on or near batteries.**

**Do not attempt to charge a battery if it is frozen or if the case is bulged excessively. Frozen batteries can explode. Dispose of battery.**

**▲ WARNING**

**When working around batteries, use approved insulated tools, remove jewelry such as rings, watches, chains, etc. and place an insulating material such as wood, plastic, rubber, etc. over batteries covering all connections.**

**If any problems are found during scheduled maintenance or inspections, do not operate vehicle until repairs are completed. Failure to make necessary repairs could result in fire, property damage, severe personal injury or death.**

**NOTICE: Automotive batteries should never be used for “deep cycle” application, as their useful life will be very short.**

**Install surge arrestors on incoming AC power lines. Surge arrestors will help protect electrical/electronic components in the charger and vehicle from all but direct or “close proximity” lightning strikes.**

**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.**
- **Eyes: Flush with water for fifteen minutes. Call a physician immediately.**

**BATTERY INSPECTION & MAINTENANCE**

Batteries and connections must be clean and dry. See *BATTERY CLEANING*.

Be sure battery hold downs are properly tightened. A loose hold down may allow the battery to become damaged from vibration or jarring. A hold down that is too tight may buckle or crack the battery case.

Weekly inspect battery posts, clamps and cables for breakage, loose connections and corrosion. Replace any that are damaged.

Check to see that battery cap vent holes are clear. Plugged vent holes will not permit gas to escape from the cell and could result in battery damage.

**BATTERY CLEANING**

Battery terminal connections should be individually cleaned and maintained annually. More frequent cleaning may be required under heavy use, or as batteries age.

**NOTICE: Make note of any accessory wire connections before disconnecting batteries. Refer to wiring diagrams for proper connection.**

1. Remove battery cables and wire connections from all battery terminals.
2. Brush battery cable and wire connections clean using soft brass wire brush.
3. Replace battery cable terminals that are damaged or corroded.
4. Keep the batteries clean, fully charged, properly secured and terminal connections tight. Do not over tighten connections. Acid soaked dirt on the battery tops causes current leakage, reduced battery efficiency and promotes rapid self-discharge during storage.
5. Hose wash battery tops periodically with clean, low-pressure water to keep them free of acid spillage, dirt and other debris. If vented batteries are used, make sure vent caps are secure before washing. Do not hose wash electronic controllers, switches, solenoids, and other electrical control devices. Direct water away from these components. Cover if necessary.



6. Wash battery tops with a baking soda mixture (1/2 cup per quart of water) and a stiff non-metallic bristle brush if a low-pressure hose does not remove the dirt. Rinse with clean water. Take care to ensure that the baking soda mixture does not enter the vent opening in the battery caps.
7. Make sure that the battery tops are clean and dry before putting the batteries into storage.

**BATTERY SERVICE (WATER)**

The operating environment of the electric vehicle could vary widely. Severe service operations will require that periodic maintenance recommendations be adjusted to shorter time intervals.

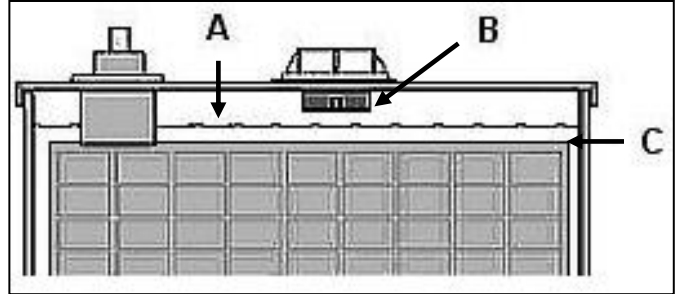
Use only distilled water in your batteries. Vehicle batteries may use up to 16 quarts of water during their useful life and non-distilled water may contain harmful minerals which will have a cumulative adverse effect on battery performance and life.

Watering intervals are dependent on the local climate, charging methods, application, and age of batteries. After the initial watering of new batteries, it is recommended that batteries be checked once a month until you get a feel for your water consumption rate.

Typically for a heavy use application, recommend watering is maximum of once per week, and for light use applications once per month

**Adding Water** (See Figure 9-1)

- Check the electrolyte level on brand new batteries before putting them into service, and at least weekly on batteries in service. Water use increases as batteries age.
- Never allow the electrolyte level to fall below the top of the plates (A). If the plates are exposed, add only enough distilled water to cover the plates before charging.
- Do not overfill batteries. Do not fill the water level up into the well of the filler tube of the cell. Electrolyte expands and can overflow during charging (B). Water added to replace the spillage dilutes the electrolyte and reduces its specific gravity. Cells with lower specific gravity have lower charging capacity.
- Make sure the electrolyte covers the plates before charging (C). Fill cells to the markers only after batteries are charged.

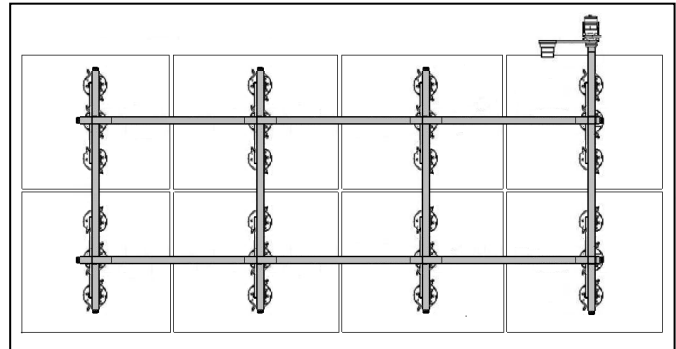


**Figure 9-1**

**SINGLE POINT WATERING SYSTEM (If Equipped)**

**NOTICE: The following information does not apply to sealed batteries.**

The vehicle may have a Single Point Watering System (Figure 9-2) used for adding water to the battery pack. It consists of a fill tube, one end having a filter screen, the other having a female coupler and a rubber squeeze bulb.



**Figure 9-2**

**NOTICE: To avoid overfilling of the Single Point Watering System do not operate this system on brand new batteries. New batteries should be in service 1 to 2 weeks with heavy use or 3 to 4 weeks with light use. System is to be used only after fully charging the batteries and batteries are warm.**

When using this system, check the battery pack water level weekly by:

- Inserting the fill tube filter end in a distilled water supply.
- Attaching the female coupler to the battery pack male coupler.
- Squeeze the rubber ball until firm which indicates that filling is complete. Immediately disconnect the couplers by depressing the push button on the female coupler. If the water supply is left connected after the filling process is finished it could lead to an overflow.

US Batteries features SpeedCap™ battery cell caps. See Figure 9-3. To open SpeedCap™ locate the two tabs on either side of the center cell of the battery. Move these tabs in the directions shown in Figure 9-3.





Figure 9-3

**NOTICE:** Do not use SpeedCaps™ as handles to lift or move battery.

**BATTERY CHARGING**

**▲ DANGER**

Observe all safety information in this section, safety information listed at the beginning of this section, and safety information in *Section 1* of this manual.

Columbia electric vehicles are equipped with a solid state, onboard, fully automatic, Delta-Q Battery Charger as standard equipment. See Figure 9-3.

It is important to be aware of the differences and improvements over prior chargers, which are explained in the Delta-Q Charger Operating Instructions that accompany every vehicle.

Correct charging methods extend battery life and vehicle range between charges. Before the first new vehicle use, completely charge new batteries. Charging time is affected by age of battery, condition of battery, state of discharge, temperature of electrolyte, AC line voltage level, and other variables. Charging time usually takes 12 hours. New batteries need up to four hours more charging time than “mature” batteries.

Always schedule enough charging time so that the charger completes a full charge cycle. Opportunity charging is an acceptable practice for use during a shift to extend the range, but always allow for a full charge cycle at end of shift.

Limit the use of new batteries between charges for the first 15 – 20 cycles. New batteries have less capacity than batteries which have been cycled.

Recharge batteries immediately after use. Leaving batteries in a state of discharge will reduce their capacity and useful life. Battery chargers are voltage specific; 24, 36 or 48 volts. However, chargers can be programmed at the factory for different types of batteries, as well as different brands and capacities of batteries. Refer to Battery Brand Algorithms for Charger Programming, See Table 1.

The lead-acid storage battery supplies electrical power through the chemical action. This action is reversible, which means the battery must be connected to a charger and have an electrical current passed through it in the direction opposite to the direction of discharge in order to restore the battery's active chemicals.

The Delta-Q Charger will not over charge batteries if left plugged in.

**Charger Safety Information**

**▲ WARNING**

Do not attempt to charge a battery if it is frozen or if the case is bulged excessively. Frozen batteries can explode. Dispose of battery.

- Charge batteries in well ventilated area.
- Ventilation fans should be located at the highest point in charging area. These fans should be able to exchange the air 5x per hour. Consult a local HVAC engineer.
- Remove rings and watches prior to service. Only trained technicians should repair or service the charger. Contact Columbia for assistance.
- Replace worn, cut or damaged power cords or wires.
- Do not connect the power cord near fuels, grain dust, solvents, thinners, or other flammables.
- Install surge arrestors on incoming AC power lines. This protects from all but direct or close proximity lightning strikes.
- Do not cover charger cabinet cooling fins. This protects the charger from overheating.
- Make sure all battery and charger connections are clean and tight. This prevents overheating and arcing at the terminal. Replace as necessary.
- Disconnect negative (-) cable first to avoid crossing terminals that would create a spark.

**NOTICE:** When using ordinary automotive chargers, there is the possibility of overcharging and damaging the cells.

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**BATTERY BRAND ALGORITHMS**

ALGORITHM ID	ALGORITHM DESCRIPTION	AMP HOUR	TYPE	DESIGNED FOR	COMPATIBLE WITH
1	Trojan Flooded	225	Flooded	Trojan T105	150 - 260Ah 6V, 8V, 12V flooded golf
3	Trojan Constant Power dv/dt	225	Flooded	Trojan T105	150 - 260Ah 6V, 8V, 12V flooded golf
5	Trojan Group 31 Flooded	130	Flooded	Trojan 30XHS, 31XHS	85 - 150Ah 12V flooded "marine" Exide Orbital AGMs, Optima AGMs
6	Deka 8G31 Gel	100	Gel	Deka 8G31	Deka 98 - 120Ah gel
7	Trojan 305 Constant Power dv/dt	305	Flooded	Trojan L16	Trojan J305
8	Concorde 100Ah AGM	100	AGM	Concorde 104Ah AGM	Concorde 80-150Ah AGM
11	200 - 255Ah Flooded Constant Power dv/dt	230	Flooded	US Battery US125 & 225	200 - 255Ah flooded golf
12	Exide Gel	240	Gel	Exide DF06240	200 - 300Ah gel
21	Exide Flooded	210	Flooded	Exide 3ET200, FF06255, 185PZB210	Exide200 Ah – 300 Ah Flooded
26	Deka 8GGC2 Gel	180	Gel	Deka 8GGC2	Deka 150 - 230Ah gel
35	Concorde 200Ah AGM	200	AGM	Concorde 233Ah AGM	Concorde 200 - 255Ah AGM
38	Trojan 12V Golf 113%	150	Flooded	Trojan T1275	120 - 170Ah 8V, 12V flooded golf
42	Discover 80 - 150Ah AGM	100	AGM	Discover EV31A	other 80 - 150Ah AGM
43	Discover 200 - 400Ah AGM	300	AGM	Discover EVL16A, EVGC6A, EV185A	Discovery 200 Ah – 400 Ah AGM
51	Exide 180Ah Gel	180	Gel	Sonnenschein 180Ah Gel	150 - 200Ah gel
52	Exide 105Ah Gel	105	Gel	Sonnenschein 105Ah Gel	80 - 130Ah gel
62	Trojan Group 31 Flooded dv/dt	130	Flooded	Trojan 30XHS, 31XHS	85 - 150Ah 12V flooded "marine"
71	140 - 200Ah Flooded Constant Power dv/dt	170	Flooded	US Battery 8V-GC	140 - 200Ah Flooded
72	250 - 335Ah Flooded Constant Power dv/dt	305	Flooded	US Battery US-305HC	250 - 320Ah Flooded
73	400Ah Flooded Constant Power dv/dt	415	Flooded	US Battery L-16HC	330 - 425Ah Flooded
93	Trojan 12V Golf	150	Flooded	Trojan T1275	120 - 170Ah 8V, 12V flooded golf
125	Fullriver 160-220Ah AGM	180	AGM	Fullriver DC180-6, DC224-6	Fullriver 160 - 220Ah AGM
126	Fullriver 85-145Ah AGM	110	AGM	Fullriver DC115-12	Fullriver 85 - 145Ah AGM
141	Fullriver 300-370Ah AGM	335	AGM	Fullriver DC335-6	Fullriver 300 - 370Ah AGM
151	Fullriver 220-290Ah AGM	250	AGM	Fullriver DC250-6	Fullriver 220 - 290Ah AGM

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**Table 1**

**NOTICE:** Charger are factory preloaded with algorithms 1, 3, 5, 6, 7, 8, 11 (Default), 27, 43, and 73.



**DELTA-Q CHARGER OPERATION**

Vehicles are equipped with a remote panel (Fig. 9-4A) with a single LED which indicates the Delta Q status. The remote panel will be located near the driver’s position. See SINGLE LED DISPLAY.

Connect power cord at charger receptacle to properly grounded wall outlet.

**NOTICE: Connect the charger AC cord to a source capable of supplying 15 amperes minimum per charge (20 amperes recommended). The charger is equipped with an equipment-grounding AC electric cord, and a grounding type plug.**

Connect the cord to an appropriately installed receptacle grounded in accordance with the National Electric Code ANSI/NFPA 70, and all local codes and ordinances.

**SINGLE LED DISPLAY (Figure 9-4A)**

SOLID GREEN – Charging complete, in maintenance mode

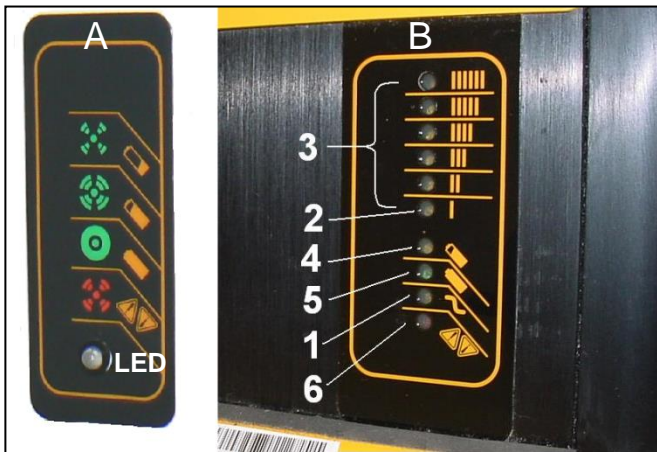
FLASHING GREEN – Short < 80% charge

Long > 80% charge

GREEN when battery not connected – Algorithm number

FLASHING YELLOW – Reduced power mode: low AC voltage or high internal charger temperature.

LASHING RED – Charger error. Reset charger power and see RED LIGHT CHARGER ERROR CODES.



**Figure 9-4**

**DELTA-Q DISPLAY (Figure 9-4B)**

1. The Yellow AC power LED (No. 1, Fig. 9-4B) should remain illuminated while the Charger is plugged into an AC source. If Yellow LED is not lit, before replacing Charger, recheck the AC connection and the AC source fuse or breaker. If this fails to correct the problem, contact your Columbia Dealer for assistance.

2. Charger will automatically turn on and conduct a short self-test and battery pack test. All LED’s will flash in sequence and then a trickle current will be applied to batteries until a minimum voltage is reached. In Figure 9-4B No. 3 indicates the Bar Graph and No. 2 indicates the lowest LED. Three (3) amperes is displayed as the lowest LED on the Bar Graph
3. If the batteries meet the minimum voltage requirements of the Charger, signifying they are serviceable (chargeable), the Charger enters the bulk charging (higher amperage-constant current) stage. The Bar Graph LED’s indicate the electrical current being delivered to the batteries as the Charger moves through its automatic charge profile. The length of charge time at each level will vary due to battery size and battery charge depletion.

**NOTICE: If the batteries are excessively discharged, the Delta-Q will not be able to charge the complete set of batteries. The Delta-Q will have the RED FAULT LED (No. 6, Fig. 9-4B) flashing red (see RED LIGHT CHARGER ERROR CODES). It will then be necessary to follow the instructions in EXCESSIVELY DISCHARGED BATTERIES.**

4. When the Yellow LED (No. 4, Fig 9-4B) is lit, the Charger has completed the bulk stage and the batteries are at approximately 80% state of charge. The 80% LED remains on as the last 20% of charge is returned to the batteries in the second phase (constant voltage phase).

**NOTICE: You can terminate charging at this point if necessary. The vehicle can be used, but completing the charge cycle is highly recommended.**

5. Charge completion is when the 100% Green LED is lit (No. 5, Fig. 9-4B). Repeated “Short Charging” leaving the charge short of 100% will shorten operating cycle distance and reduced battery life.
6. A low current “finish-charge” phase returns and maintains batteries to maximum capacity. The 100% Green LED will blink until “finish charge” phase is complete.
7. A 100% Green LED continuously lit indicates the batteries are completely charged. The Charger may now be unplugged from the AC source. If the batteries will not be used for a length of time, check monthly for the charge level. It is also acceptable to leave the Charger plugged in. The Delta-Q has the capability to test and recharge if necessary.
8. A fault occurring while charging causes the RED FAULT LED to flash with a code relaying the error. Some errors may require repair by a qualified technician and others may be simply transient and will automatically recover when the fault condition is eliminated and the Delta-Q cycled by disconnecting the AC source for a minimum of 11 seconds.

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**NOTICE: A Yellow (Amber) blinking LED in the upper Bar Graph (No. 3, Fig. 9-4B) usually indicates the thermostatic control has limited the Charger output due to ambient temperature conditions. It is still charging, but at a reduced rate.**

**NOTICE: Do not disassemble the charger. There are no serviceable parts.**

**RED LIGHT CHARGER ERROR CODES**

**1 Flash**

Battery Voltage High: Auto-recover. May be temporary condition, or wrong charger installed, i.e. 36 volt charger on 48 volt battery pack.

**2 Flash**

Battery Voltage Low: Auto-recover. Confirm each individual batteries minimum voltage with a volt meter. Two or more 6 volt batteries register less than 5.85 volts, or accumulative total pack voltage has been discharged to less than 20% remaining. Vehicle operation will cease until batteries are recharged. See Special Procedure for Excessively Discharged Batteries in this section.

**3 Flash**

Charge Timeout: The charging did not complete in allowed time, 12-14 hours. This may indicate a battery problem, or that the charger output was reduced due to high ambient temperatures. Disconnect AC supply, confirm sufficient ventilation, allow cool down time, and restart charger.

**4 Flash**

Check Battery: The batteries could not be trickle charged up to a minimum level to start charger. This may be the result of badly discharged batteries, or one (or more) damaged cells. See Special Procedure in this section.

**5 Flash**

Over-Temperature: The charger shut down due to high internal temperature. May require reset (AC unplugged) and a cool down to restart charging cycle. This fault may indicate inadequate cooling airflow or high ambient air temperatures. Check for debris or blockage at cooling fins. Move the vehicle to a cooler better ventilated area, or adjust time of day when charging.

**6 Flash**

Delta-Q Charger Fault: An internal fault was detected and charger may need to be checked/replaced by a qualified dealer technician. It may also be the result of badly discharged batteries, or one (or more) damaged cells. A RED 6 FAULT flash must be validated first by testing individual batteries with a voltmeter, and see Special Procedures, before deciding charger has failed.

**A Steady Red Fault LED**

Confirms an internal electrical fault of the Delta-Q and also requires charger replacement and return.

**CHARGING PROCEDURE**

1. Check electrolyte level in all cells. Add distilled water as necessary to cover tops of plates. Do not over fill, as electrolyte expands during charging.
2. Be sure charger is turned OFF. Insert electrical plug into vehicle's charger receptacle.
3. Charger will start automatically. Check that amp meter rises fully when charger starts. If charger needle only rises to half scale or does not rise at all, check AC outlet for proper power supply or check charger owner's manual for testing and repair information.

**TESTING BATTERIES**

**Specific Gravity Test**

**NOTICE: Specific Gravity Test information does not apply to sealed batteries.**

It is possible to determine a battery's ability to perform by measuring the specific gravity of each cell with a hydrometer. The hydrometer readings indicate two things:

- State of Charge - The amount of electrical power stored in the battery.
- Condition - The ability of battery to store and deliver power.

**NOTICE: Batteries should be fully charged before performing specific gravity tests to determine battery condition. Hydrometer tests of batteries not fully charged are misleading and inconclusive.**

**Hydrometer Test**

1. Squeeze rubber bulb and insert nozzle in cell, release bulb, slowly drawing electrolyte up into barrel.
2. Adjust electrolyte level in barrel so float rides free of bottom but is not striking top of barrel.
3. Hold hydrometer vertically, making sure float moves freely and is not contacting sides of barrel. Read scale at the level of electrolyte in the barrel. Record the reading.



4. Return electrolyte to cell from which it was removed.
5. Repeat these steps on all battery cells.

Hydrometer readings are affected by the temperature of the electrolyte being tested. Measure the temperature of the electrolyte, and correct the readings as follows:

**Above 80°F:** Add .004 to the specific gravity readings for each 10° above 80°F (26°C).

**Below 80°F:** Subtract .004 from the specific gravity readings for each 10° below 80°F (26°C).

**Results Interpretation**

State of charge. Check specific gravity of each cell. See Table 2 & 3.

Specific Gravity vs. State of Charge	
SG Reading at 80° F.	State of Charge
1.250 – 1.270	100%
1.220 – 1.240	75%
1.190 – 1.210	50%
1.160 – 1.180	25%

Table 2

Specific Gravity vs. Action Required				
Battery	SG Reading			Action
	Cell 1	Cell 2	Cell 3	
1	1.100	1.100	1.100	Charge & recheck
2	1.260	1.180	1.250	Cell 2 bad – replace battery
3	1.250	1.260	1.250	Good
4	1.190	1.170	1.120	Charge & recheck Suspect cell 3

Table 3

If the difference between the highest and lowest cell is 0.050 (50 points) or more, the battery is nearing the end of its useful life and should be replaced.

**DISCHARGE (LOAD) TEST**

The discharge, or load test, is the recommended method of determining battery condition because it simulates electric vehicle operation under controlled conditions. A 75 amp draw is applied to the battery bank with a Load Tester. The time it takes the battery bank to drop to 31.5 volts, along with individual battery voltages, is used to determine battery condition.

**NOTICE: Use of automotive type of load tester is not recommended and will offer inaccurate results.**

**Use an appropriate volt tester that gives voltage and minutes of discharge.**

**Test Preparation**

The following preparations must be verified before discharged load testing. Should any of the following recommendations not be performed, results of testing will be inaccurate and misleading.

- Batteries must receive a full charge before conducting Discharge (Load) Test.
- Discharge (Load) Test must be performed within 18 hours of charging.
- Vehicle must not be used, even for short runs, prior to Discharge (Load) Test.
- Electrolyte level must be correct in all cells.

**Test Procedure**

**⚠ WARNING**

**Discharge Load Test must be performed in well ventilated area.**

1. Connect tester leads to battery bank.
2. Check and record electrolyte temperature of center cell of each battery.
3. Turn tester on.
4. After 20-30 minutes, with tester on, check and record individual battery voltages to the nearest 0.1 (1/10) volt.
5. Allow tester to shut off automatically, and record time elapsed from start of discharge.

All six individual battery voltage readings must be made as rapidly as possible to be accurate.

Tester shutoff should occur at a battery voltage of 42v +/- 0.2v (48 volt system) or 21v +/- 0.2v (24 volt system). Check tester shutoff voltage periodically. This setting must be accurate for a valid test.



**Results Interpretation**

1. Compare individual battery voltages recorded in step 4 of *Discharge (Load) Test Procedure* and discard any battery that is 0.2 (2/10) volt lower than the highest battery in bank. If defective battery is found, recharge the entire bank for 12 hours. Then, replace the defective battery with a good fully charged battery of the same brand and date code, if possible. Equalize the bank by placing it on charge for an additional three hours, then retest.
2. If all battery voltages are within 0.2 volts of each other, compare discharge time from step 4 of *Discharge (Load) Test Procedure* with minimum times in Temperature and Time Table. Even if individual battery voltages are satisfactory, but the discharge time fails to meet minimums in Temperature and Time table, the entire battery bank should be replaced.

<b>DISCHARGE LOAD TEST: Temperature &amp; Time</b>	
Electrolyte Temperature (Step 2)	Minimum Discharge Time (Step 5)
40-49° F (4-9° C)	40 Minutes
50-59° F (10-15° C)	45 Minutes
60-64° F (16-17° C)	50 Minutes
65-69° F (18-20° C)	54 Minutes
70-74° F (21-23° C)	57 Minutes
75-79° F (24-25° C)	60 Minutes
80-84° F (26-29° C)	62 Minutes
85-89° F (30-32° C)	64 Minutes
90-99° F (33-37° C)	66 Minutes
100-109° F (38-43° C)	68 Minutes
110-119° F (44-48° C)	70 Minutes
120-129° F (49-54° C)	72 Minutes
130-150° F (55-66° C)	74 Minutes

**Table 4**

**STORING BATTERIES**

- Batteries can remain in vehicle.
- Batteries should be fully charged.
- Clean battery tops and connections.
- Fully charged batteries should be stored in as cold of an environment as possible. Batteries “self discharge” when not in use. The colder the temperature, the slower batteries self discharge.

**⚠ CAUTION**

**Batteries in low state of charge (low specific gravity readings) will freeze at higher temperatures than those fully charged.**

Check specific gravity periodically, and recharge batteries as necessary. Batteries stored in temperatures above 80°F (26°C), will discharge faster and require recharge every few weeks. Batteries stored at or below 0°F (-12°C) may not require recharge for periods up to 4 months. When recharging, bring batteries to 1.250-1.270 specific gravity to prevent freezing. See Table 5.

State of Charge	Specific Gravity	F° Freezing point C°		Risk of Sulfation
100%	1.260	-70	-57	Low
75%	1.230	-39	-38	Low
50%	1.200	-16	-26	Low
25%	1.170	-2	-19	Moderate
Discharged	1.110	+17	-8	High

**Table 5**

As ice forms in a freezing battery, the electrolyte expands and can crack the case, ruining the battery. If a battery is allowed to stand or is operated in a discharged condition for a long period of time, lead sulfate may develop on the plates, which is dense, hard and crystalline, and which cannot be electrochemically converted to normal active material again. Lead sulfate formed on the plates during discharge is relatively insoluble as long as the specific gravity of electrolyte is kept above 1.125 specific gravity, but if allowed to drop below this value, the lead sulfate becomes increasingly soluble and may migrate into the pores of the separators and deposit as a white crystalline mass.

Subsequent charging may convert these deposits into stringy metallic lead which may short the positive and negative plates through the areas affected. These small shorts may cause a condition of low cell voltage when battery is allowed to stand idle in less than 25% charged condition.

**REPLACING BATTERIES**

The batteries are located under the rear deck.

**Removing Batteries**

1. Remove nuts, washers and cables, positive lead and negative lead interconnecting batteries.
2. Remove nuts, flat washers, hold down plates and rods.
3. Remove batteries.

**Installing Batteries**

1. Install batteries.
2. Install rods and hold down plates.
3. Install flat washers, nylock nuts.
4. Install nuts, washers and cables, positive lead and negative lead interconnecting batteries.



## EXCESSIVELY DISCHARGED BATTERIES

**NOTICE:** The Delta-Q Automatic Battery Charger will not charge a dead battery. Each battery will need to be brought up to an acceptable state of charge, and establish that it does not have an internal fault or bad cell. If a battery has remained too long in a discharged state, it may be internally damaged and not capable of accepting a charge. It must be replaced.

If the Delta-Q Battery Charger does not reach the full charging mode, identified by a steady LED in the upper region of the Bar Graph display (18/15/12...), or the RED Fault Light is lit, it may indicate that the minimum voltage is not present to allow the charger to control the charging of the complete set of batteries.

If the electrolyte specific gravity is low (less than 1.140 SG), or the individual battery voltage is less than 10.50 volts for 6 cells, it will need to be recharged with an ordinary automotive style trickle charger at a rate of 3 to 6 amps for several hours each. Follow specific charger instructions. It is not necessary to disconnect the battery cables, as the alligator style clips can be connected to each positive and negative battery post.

**WARNING**

**Always disconnect the AC power first when moving the positive/negative alligator clips to prevent a spark from igniting the gas emitted from the batteries.**

Be sure to charge all of the batteries in the set. Each battery may require 2-3 hours of charging to bring it back to serviceable condition. Measure the Specific Gravity (SG) of each cell after this charging procedure is completed, to verify that the battery is OK for use. Replace any batteries that can not be re-charged (no change or improvement in SG). After all batteries have been individually charged, and with the temporary automotive charger removed, try operating the Delta-Q Charger again to verify operation. Allow the Delta-Q Charger to complete a full charge cycle for proper equalization of batteries. If the 6 Flash Fault persists; an internal fault may be present and the charger will need to be replaced by a qualified dealer technician. A STEADY RED FAULT LED confirms an internal electrical fault of the Delta-Q, and also requires charger replacement and return.



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**Service Manual**

**Section 10**

**Traction Drive System**



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**DC TRACTION MOTOR**

**Maintenance**

A good planned maintenance program will save many hours of future down time and prevent catastrophic failure of major motor components. Maintenance schedules consist of periodic routine inspections of motors, battery and wiring circuitry.

Since operation of equipment varies widely, the following recommendations are suggested for periodic maintenance inspection:

Normal service – 8 hours per day operation

- Routine inspection every 1,000 hours

Severe service – 24 hours of daily operation

- Routine inspection every 500 hours

**NOTICE: Severe service would include; Dusty or sandy locations such as cement plant, lumber or fl our mills, coal dust or stone crushing areas. High temperature areas such as steel mills, foundries, etc. Sudden temperature changes such as continuous indoor-outdoor movement, as in refrigeration plants.**

**External Inspection**

1. Check for clean, tight, terminal studs and mounting bolts.
2. Internal and external spline drives, between motor and final drive axle, must be periodically lubricated with a thin layer of quality, anti-seize compound.
3. Check for any signs of oil leaks from final drive axle, which might cause oil to enter traction motor.

**Internal Inspection**

The brush and commutator inspection is the most important part of motor maintenance. By recognizing undesirable commutator and/or brush conditions, internal repairs can be performed before major component damage or failure occurs.

Brush and commutator inspection can be accomplished by removing the motor head. The brushes and commutator should be inspected for even wear and good commutation.

Good commutation will be indicated by a dark brownish, polished commutator and an evenly polished brush wearing surface. If the commutator appears rough, pitted, scored or has signs of burning or heavy arcing between the commutator bars, the motor should be removed for servicing.

**Removal**

**NOTICE: Studs and jam nuts on the electric motor can be damaged when attaching or removing electrical leads. Hold a thin open end wrench on the electrical stud connector jam nut while loosening or tightening attaching nuts.**

1. Mark traction motor cables (if not already marked), with motor terminal identification Figure 10-1.
2. F1 and F2 terminals are 1/4-20, A1 and A2 terminals are 5/16-18. Hold terminal jam nut with a thin open end wrench when loosening and removing hex nuts, lock washers and flat washers securing electrical cables to traction motor.

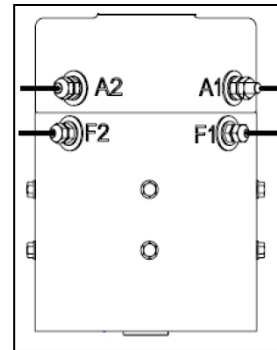


Figure 10-1

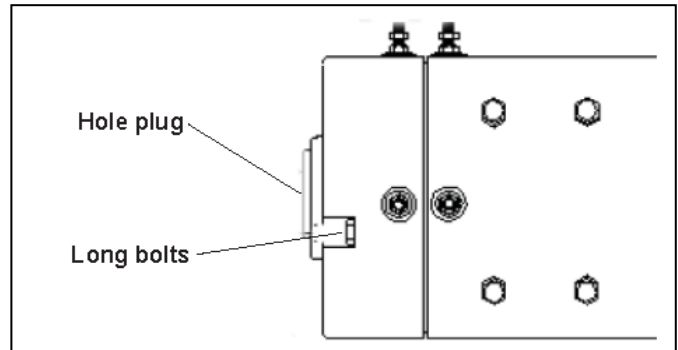
3. Carefully support motor to prevent it from falling.
4. Loosen and remove the three 1/4" bolts, lock washers and flat washers securing motor to rear axle/differential housing.
5. Pull motor away from rear axle housing and clear of the vehicle.

**CAUTION**

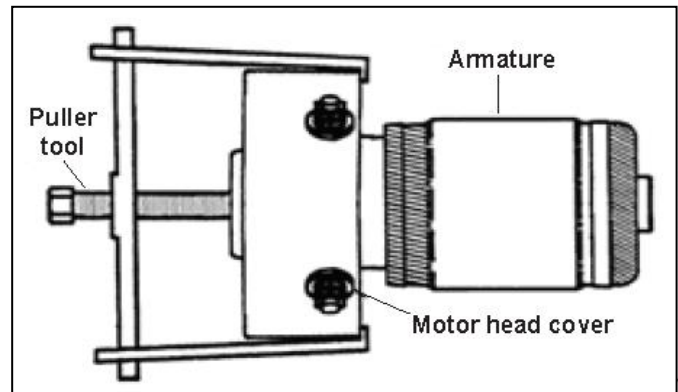
**Traction motor is heavy and awkward to move. Get help stabilizing and removal to prevent possible personal injury.**

**Disassembly**

1. Remove long bolts. Remove motor head hole plug. See Figure 10-3.
2. Pull on motor head to remove armature from frame. A light tap may be required to loosen motor head from frame. Motor head and armature come out together.
3. Place puller around the motor head. Use the center of the shaft to locate puller. See Figure 10-4.
4. Pull motor head assembly off of armature assembly maintaining equal pressure on all sides of head.
5. Move brush springs behind spring hooks shown in Figure 10-5.
6. Remove 1 hex nut, 1 lock washer, 1 hex nut, 1 flat washer and 1 insulator at each brush terminal, A1 and A2. Figure 10-6.
7. Remove 4 brush plate screws (Figure 10-7). Push brush terminal studs through, into the center of the head as the brush box, brushes and terminal assemblies are removed. (See exploded view Figure 10-9).
8. Remove bearing retainer (snap ring) shown in Figure 10-5. Carefully press out the bearing from motor head. Replace the bearing.
9. Remove all the brush dust from motor frame, brush box, and motor head.



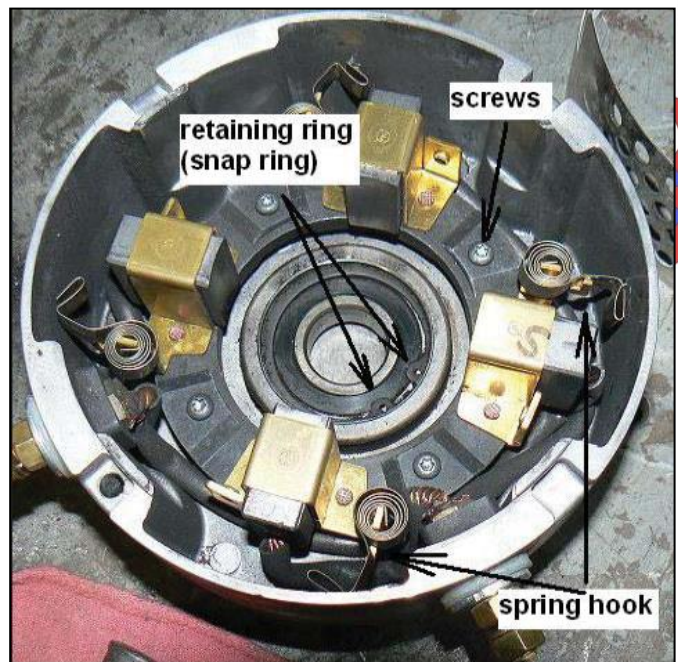
**Figure 10-3**



**Figure 10-4**

**Armature Inspection**

1. Measure the diameter of the armature (Figure 10-8).
  - Max dia. when new 2.92-2.93" (74 mm)
  - Min dia. for re-slotting 2.81" (71 mm)
  - Replacement dia. 2.76" (70 mm)
2. Support the armature at both bearing journals. Check runout of commutator with a dial indicator. Total indicated runout should not exceed 0.005" (0.12 mm). If the readings fall outside this limit, commutator must be turned and undercut. See Figure 10-10.
3. After the commutator has been undercut, if required, the armature should be placed in lathe and the commutator lightly sanded with no. 00 sandpaper. This will remove any burrs left from the undercutting operation.
4. Clean commutator with dry, compressed air. Recheck commutator runout.



**Figure 10-5**

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**Armature Testing**

Before the armature is reassembled into the motor, the following test should be performed.

1. Check armature for grounded circuits by placing one test lead of a Dielectric Breakdown Tester, also referred to as a “growler”, on the commutator and other lead at armature shaft. The ground test light should not flash. A flash indicates failed insulation between core and armature wiring. See Figure 10-11.
2. For short circuit connection, use a hacksaw blade to locate any shorted windings. Rotate armature slowly in growler jaws and hold a hacksaw blade in parallel against top of armature. The steel blade will be attracted to the core and will vibrate when two shorted armature coils are located. See Figure 10-12.

**Brushes**

Brushes should be inspected for uneven wear and signs of overheating, such as discolored brush leads and brush springs. Check brush box for physical damage. Make sure brush holders are not loose on the brush box assembly. See Figure 10-9.

Check brush for correct clearance and freedom of movement in the holder.

New brush length: 1.20" (30.5 mm)

Minimum brush length: 0.60" (15.2 mm)

Replacement brush length: less than 0.60" (15.2 mm). If any brushes are worn to the point that replacement is necessary, the complete brush set should be replaced. Never replace just one pair of brushes.

Do not substitute brushes. The brushes are matched to the motor type and application to provide the best service. Substituting brushes of the wrong grade can cause commutator damage or excessive brush wear.

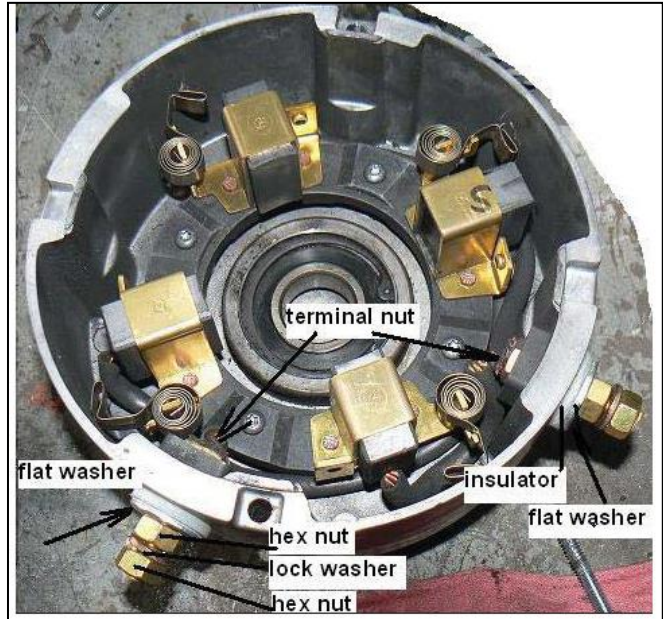
**Brush Springs**

Check the brush springs for correct alignment on the brush. A brush spring that does not apply equal pressure on the center of the brush will cause the brush to wear unevenly.

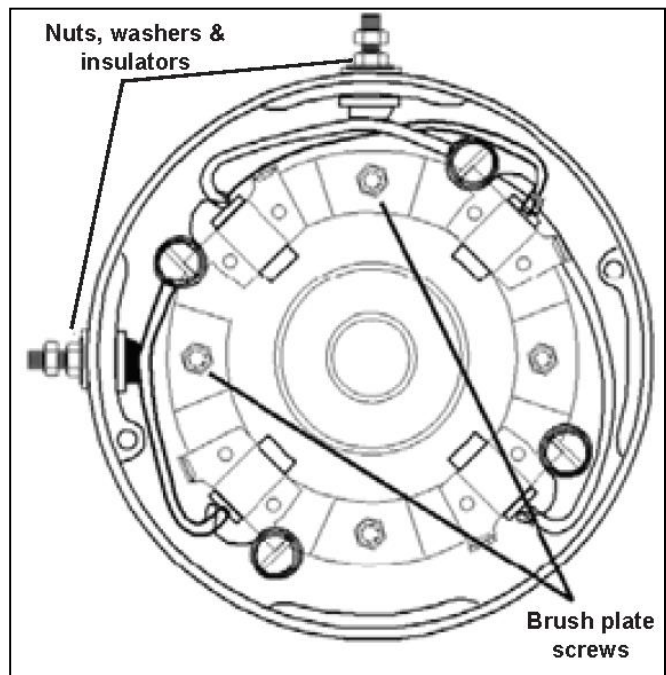
Use the following procedure for checking brushes for proper tension. See Figure 10-13.

1. Place paper strip between brush face and commutator.
2. Hook a commercial spring scale as shown.
3. Pull spring scale on a line directly opposite the spring force. When paper strip can be moved freely, read spring tension on scale.

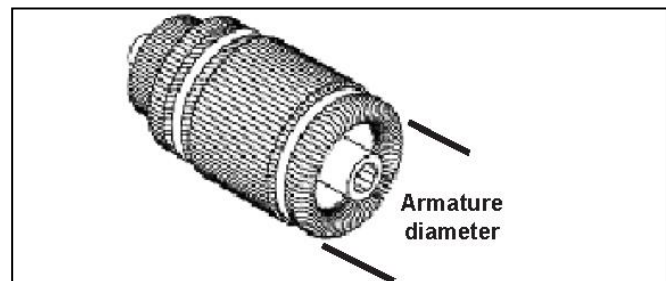
Brush spring tension	New 64 ounces (1792 grams)
	Worn 40 ounces (1120 grams)



**Figure 10-6**



**Figure 10-7**



**Figure 10-8**



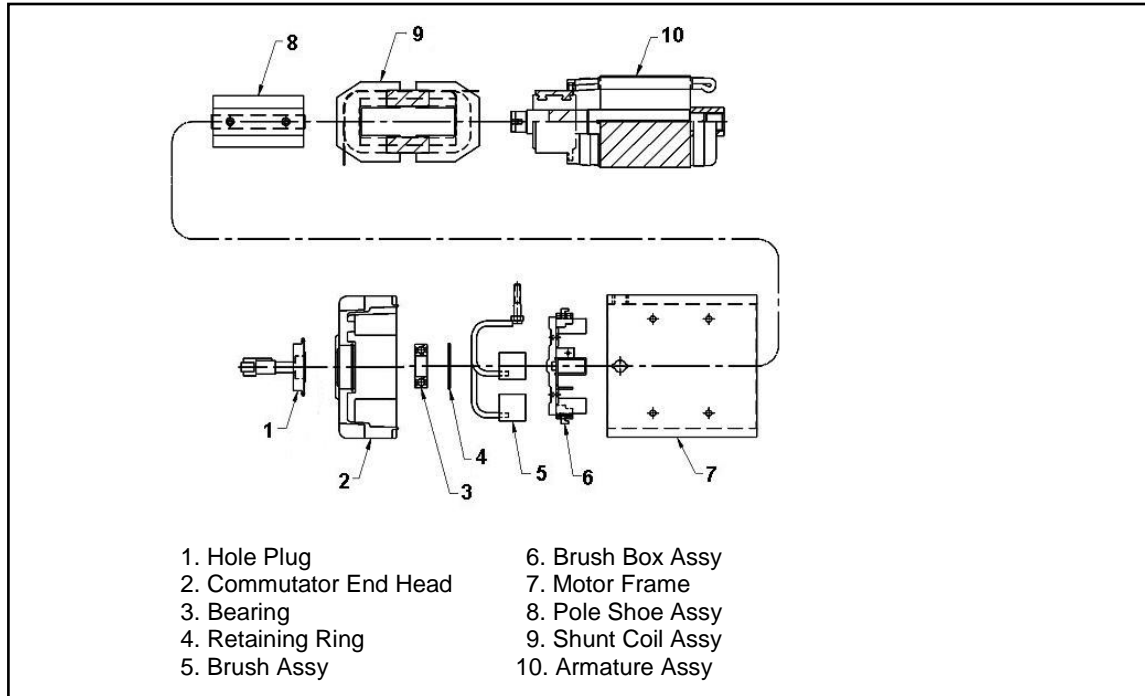


Figure 10-9

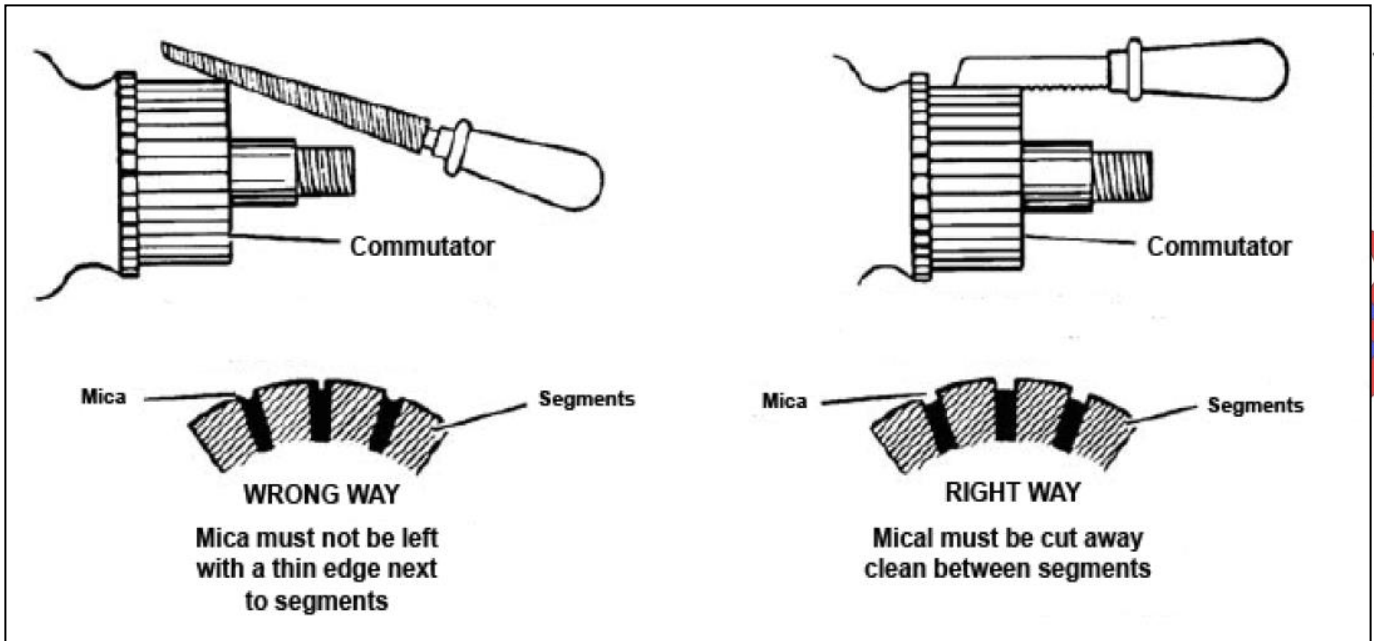
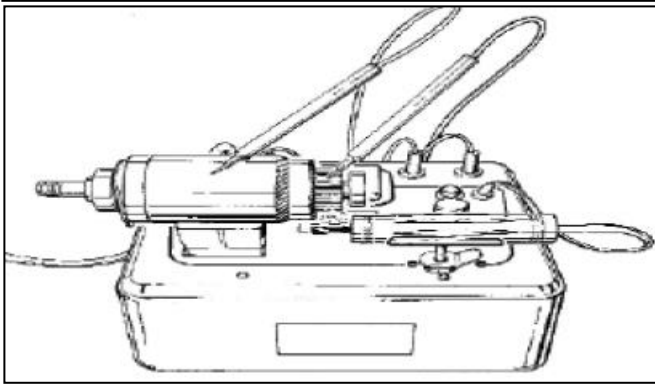
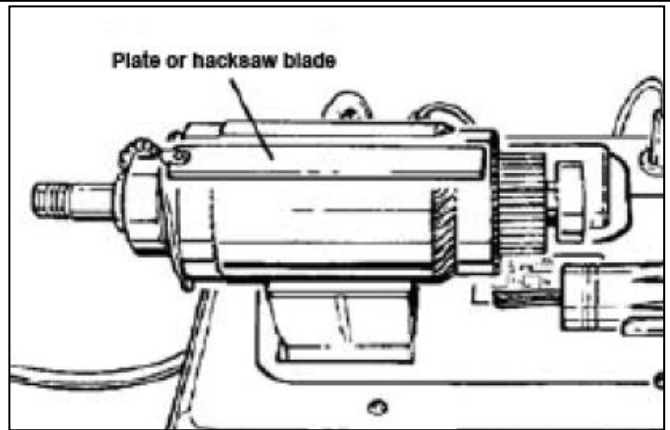


Figure 10



**Figure 10-11**



**Figure 10-12**

**Bearing**

After the motor has been disassembled, it is recommended that a new bearing be installed. Bearing may appear and feel ok; however, bearing may have been damaged during removal.

**Frame and Field Coils**

**NOTICE: Do not remove the field coils (9 Figure 10-9), from the motor frame unless it is absolutely necessary for repair. Removal and re-installation could shorten field coil life.**

There should be no continuity between the frame of the motor and field coil (Figure 10-9). Set the volt ohm meter (VOM) to measure Ohms. See Figure 10-14.

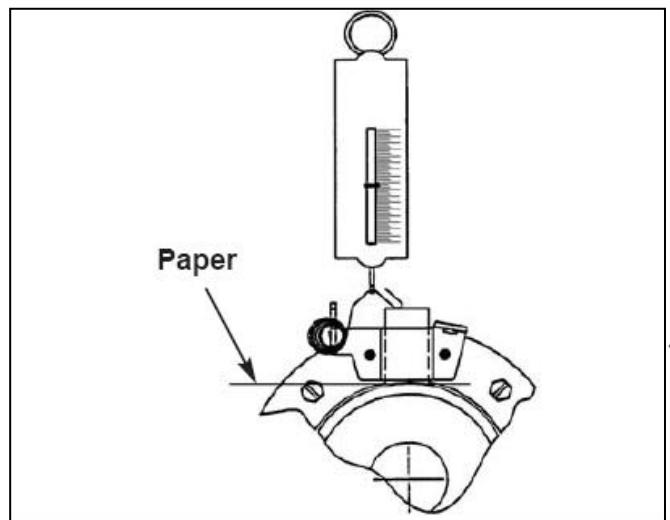
**Field Coil Maintenance** - NOT recommended by Columbia.

**Inspection**

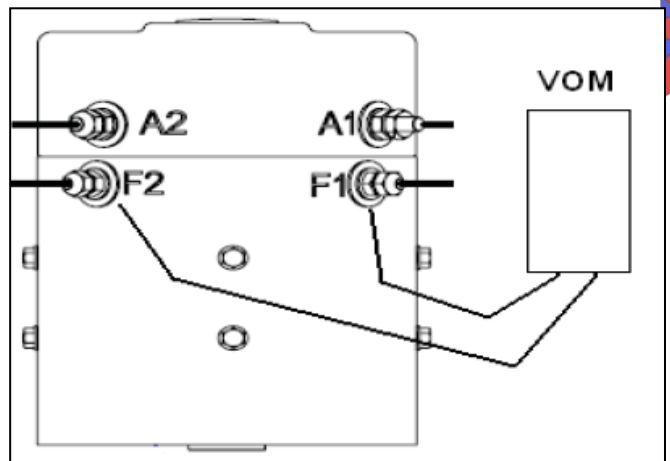
Motors that have been disassembled for servicing should also include a complete inspection of the frame and field assembly. It is not uncommon for the frame and field assembly of a motor to become exceptionally dirty after many hours of operation. This may result in a grounding condition due to dirt, grease and other foreign materials.

**Motor Reassembly**

1. Always use a new bearing when reassembling a motor. Press bearing into motor head. Press only against the outer race. See Figure 10-15. Install snap ring to retain bearing. Figure 10-16.
2. Assemble brush assemblies into brush box assembly.
3. Position brush holder into motor head as shown in Figure 10-16. Make sure that the terminals for the brushes are loose and free.
4. Install insulators and brush leads into motor head. See Figure 10-17. Brush motor terminals, A1 and A2, should be torqued to 140 in. lbs. (15.8 Nm).



**Figure 10-13**



**Figure 10-14**

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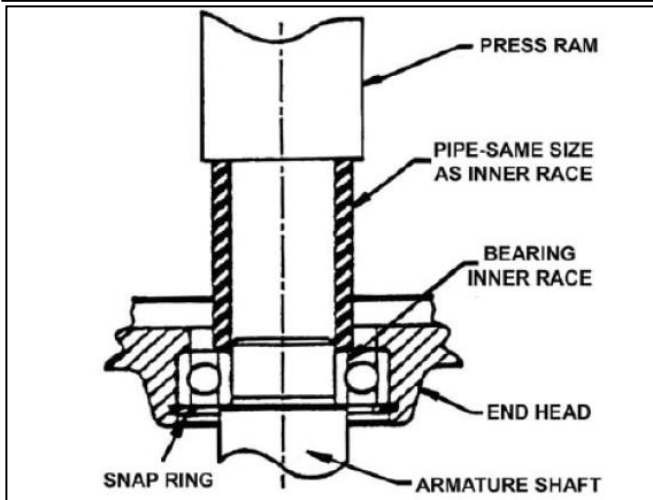


Figure 10-15

5. Pull back each brush in its holder, allowing the spring to rest against the side of each brush. This will hold each brush in place, preventing interference and damage to commutator and brushes during armature installation.
6. Press motor head and bearing onto armature, pressing only against inner race of the bearing. See Figure 10-15.
7. Check that head and bearing rotates freely, without noise or irregular interference. Press brushes inward against armature commutator. Relocate the springs to push on the brushes. Check that brushes ride smoothly on the commutator.
8. Install motor head and armature assembly into field coil and frame assembly, aligning armature terminals to field coil terminals.
9. Install two bolts securing motor head to frame. Make certain motor head is completely seated to the frame before tightening. Torque bolts to 156 in. lb. (17.6 Nm).

**Motor Installation**

1. Coat open end of the armature and rear axle input shaft with Anti-Seize compound. Insert a new rubber bumper into open end of armature. Place motor into vehicle and onto input shaft.
2. Rotate motor to align mounting bolt holes to axle/differential housing. Install 3 bolts securing motor to rear axle/differential housing, while carefully supporting motor to prevent it from falling. Loosely tighten screws A and B, then loosely tighten screw C to draw face of motor up to flange on axle evenly (Figure 10-18). Torque screws A and B to 100 in. lbs. (11.3 Nm). Then tighten screw C to 100 in. lbs. (11.3 Nm).
3. Inspect electrical system cables for terminal identification (A-1, A-2, etc.). Position cables to traction motor, double checking wiring diagram to motor cable installation to ensure connections are correct.

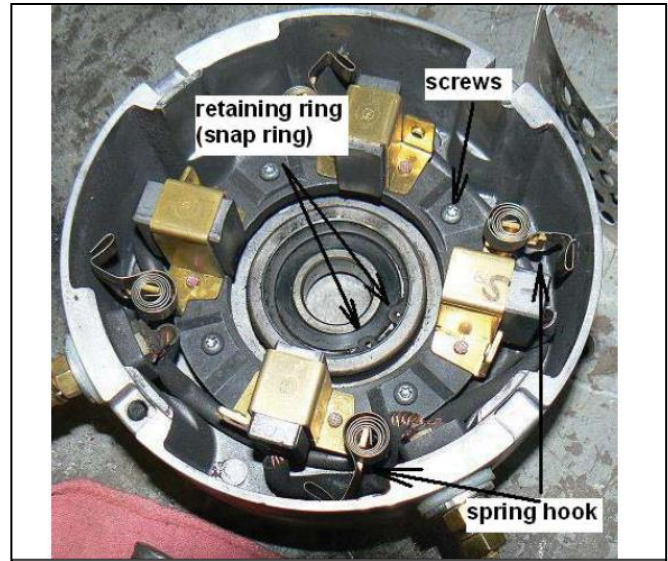


Figure 10-16

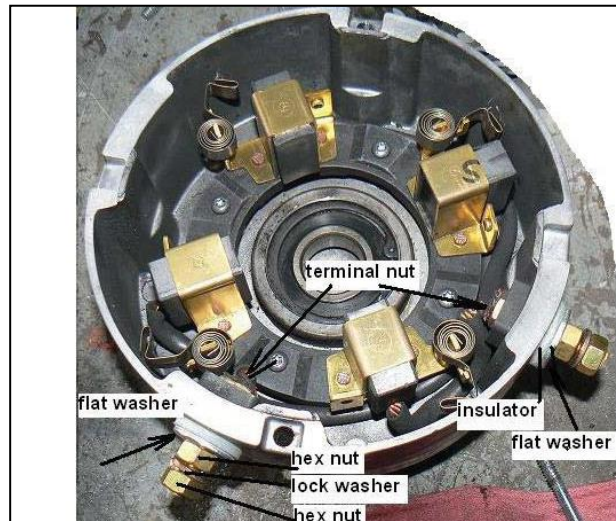


Figure 10-17

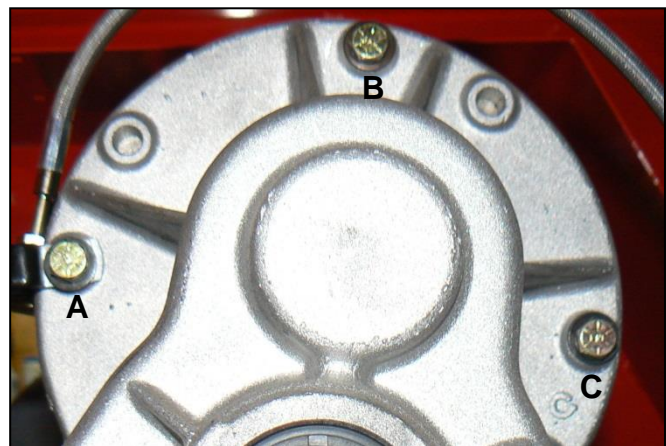


Figure 10-18

4. F1 and F2 terminals are 1/4-20 while A1 and A2 terminals are 5/16-18. Attach cables with flat washers, lock washers and hex nuts. Torque A1 & A2 cable attaching nuts to 110 in. lbs. (12.4 N m), while holding the bottom nut, with a thin open-end wrench. Torque F1 & F2 cable attaching nuts to 50 in. lbs. (5.7 Nm), while holding the bottom nut, with a thin open end wrench.
5. Place vehicle on the ground or onto dynamometer to test motor operation.

**CAUTION**

**Do not run motor at full voltage without a load.**

**DC CONTROLLER**

**ACEplus System**

The ACEplus System is an advanced traction drive system that uses a fully integrated, solid state Sevcon Controller for speed regulation and forward/reverse control. Combined with a separately excited DC motor, the system provides optimized power efficiency through pedal proportional speed control and regenerative braking. This control system is ideal for hilly terrain or areas with multiple ramps. It is also used for towed loads and high braking demands. The ACEplus system is distinguished by a 6 post controller. See Figure 10-19.

**Testing**

Do not remove the controller. It can be tested while still in the vehicle.

1. Look for the steady green light on the dash system status light. If it is a steady green, the system is OK and ready.
2. If it is flashing, count the number the flashes in each sequence. Refer to *Section 4 - Troubleshooting* for controller flash troubleshooting info, and for info on testing controller with Sevcontrol Calibrator or PC Pak computer interface.
3. If the tests indicate that the controller has failed, replace it.

**Removing**

1. Disconnect battery negative cable and remove Power key.
2. See *Section 8 – Body and Chassis* for removal and installation.
3. Label/mark controller cables with controller terminal identification, if not already labeled.

**NOTICE: The controller terminal bolts and washers are Metric. Metric wrenches are required to remove the controller cable fasteners. The fasteners that attach the controller to the vehicle frame are SAE U.S.**

3. Remove six metric bolts, lock washers, flat washers and all the cables and wires connected to the controller.
4. Remove 16 pin controller connector (Figure 10-19).

See *Columbia Service Bulletin 06-010* if the wiring harness or connector is damaged.

**NOTICE: Do not attempt to disassemble the controller. There are no repairable parts inside.**

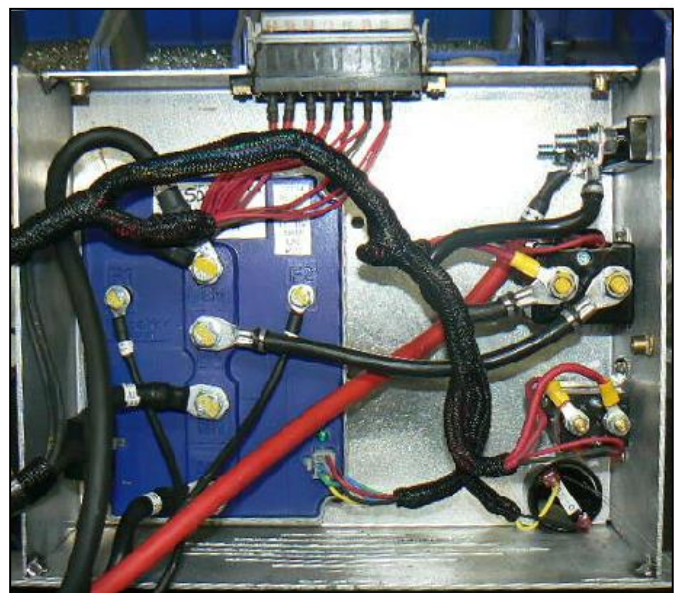
5. After installation perform an operational check of the vehicle's driving abilities.

**DC CONTACTOR(S)**

Contactor is an electro-magnetic switch that energizes when current is applied to the small control circuit terminals. When energized, the solenoid core moves up from magnetism created by the coil and internal contacts, creating a connection between two large terminals, allowing current to pass through.

When control circuit voltage is removed from the small terminals, the magnetic field collapses and a spring returns the core to its rest position. A contact solenoid in the normal position has an open circuit between the large terminals, preventing current from passing through it.

The contactor is located in the controller metal case. See *Section 8 – Body and Chassis* for removal and installation. This case also contains the 300 amp fuse, the reverse beeper, the main contactor, and the accessory contactor. See Figure 10-19



**Figure 10-19**

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**AC POWER SYSTEM**

1. Columbia ParCar vehicles utilize brushless motors with an AC controller.
2. These vehicles will have a Multifunction ClearView Display located on the support panel in front of the steering wheel. This meter will display the battery state of charge as a percentage of full charge, the system status, the operating speed, odometer, and direction selected.
3. See Section 4 for details on the panel.
4. Figure 10-20 show the AC controller and contactor connections.

**AC CONTROLLER**

**AC Controller Testing**

Do not remove the controller. It can be tested while still in the Vehicle. It is accessed from under rear deck.

**Removing**

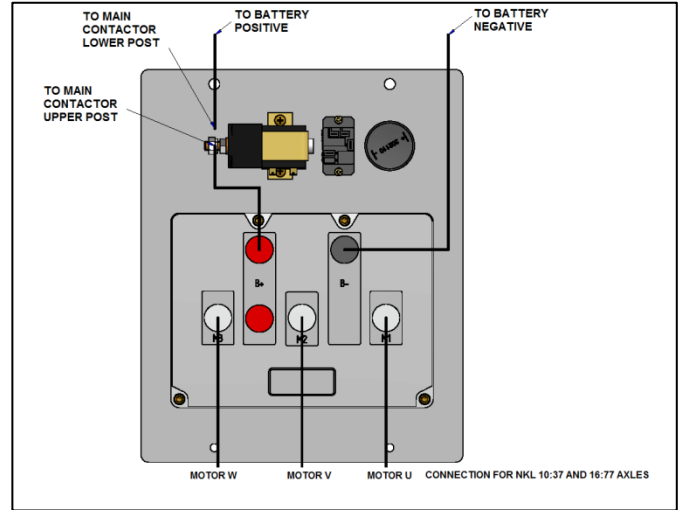
1. Disconnect battery negative cable. Remove Power key.
2. Label/mark controller cables with controller terminal identification, if not already labeled.

**NOTICE: The controller terminal bolts and washers are Metric. Metric wrenches are required to remove the controller cable fasteners. The fasteners that attach the controller to the vehicle frame are SAE U.S.**

2. If the “OK” has been replaced with an exclamation point (!) go to the fault log to determine the error.
3. If the tests indicate that the controller has failed, replace it.
3. Remove six metric bolts, lock washers, flat washers and all the cables and wires connected to the controller.
4. Remove multipin controller connector.

With the key on, if the ClearView panel shows an “OK” in the lower right, the system is “OK” and ready.

2. If the “OK” has been replaced with an exclamation point (!) go to the fault log to determine the error.
3. If the tests indicate that the controller has failed, replace it.



**Figure 10-20**

**Installing**

1. Position controller mounting plate and secure with four bolts, washers and nuts.
2. Install cables to controller terminals according to cable identification labels. Make sure there is a flat washer under the terminal ends of the cables. This will spread the load and help prevent the terminal ends from folding over.
3. Torque controller cable attaching bolts to 50 – 60 in. lbs. (5.7 – 6.8 Nm).
4. Reconnect battery negative cable. Insert Power key in switch and check for an OK on the ClearView panel.
5. Perform an operational check of the vehicle’s driving abilities

**AC CONTACTOR**

This contactor is an electro-magnetic switch that energizes when current is applied to the small control circuit terminals. When energized, the solenoid core moves up from magnetism created by the coil and internal contacts, creating a connection between two large terminals, allowing current to pass through. When control circuit voltage is removed from the small terminals, the magnetic field collapses and a spring returns the core to its rest position. A single contact solenoid in the normal position has an open circuit between the large terminals, preventing current from passing through it.

The contactor is located next to the controller.

**Removing**

1. Label contactor cables with terminal identification. Refer to schematic for correct wire numbers.
2. Remove two nuts, washers and cables from stud terminals.
3. Remove control circuit wires from spade terminals.



4. Remove two nuts, washers, bolts and contactor.

**Installing**

1. Position new contactor to mounting bracket.
2. Secure contactor to mounting plate with two bolts, nuts and washers.
3. Install heavy cables to stud terminals. Install control circuit wires to spade terminals. Double check wiring diagram to ensure connections are correct.
4. Operational Check: Contactor should emit an audible click when the power key switch is set to ON position.