

# MT-160-AC



## MAINTENANCE MANUAL

**A GUIDE FOR PERFORMING MAINTENANCE AND REPAIRS ON MT-160**

**SERIAL NUMBER : 121 86 22 AND UP**

UPDATED 28.08.2024  
DESIGNED BY MOTREC INTERNATIONAL



# MOTREC INTERNATIONAL INC.

## 5-YEAR LIMITED WARRANTY

FOR VEHICLES PRODUCED AFTER NOVEMBER 1, 2024



### 5-YEAR LIMITED WARRANTY ON AC-POWERED PRODUCTS, STOCK CHASERS AND TRAILERS

### 2-YEAR LIMITED WARRANTY ON DC OR IC POWERED PRODUCTS AND OTHER MOTREC PRODUCTS

Motrec warrants to the original purchaser that its products are free from defects in parts and workmanship.

**STARTING DATE OF WARRANTY.** The present terms and conditions of the Motrec Limited Warranty apply to new Motrec products only and do not replace any pre-existing warranty. The warranty period is effective from the date the purchaser receives the product, provided it is registered within ninety (90) days of reception and in conformity with Motrec's registration process.

**REGISTRATION.** IMPORTANT : AIMPORTANT: AS A PURCHASER OF A MOTREC PRODUCT, IT IS IMPORTANT THAT YOUR PRODUCT BE REGISTERED UNDER YOUR NAME AS REQUIRED BY MOTREC'S PRODUCT REGISTRATION PROCEDURE. PLEASE ASK YOUR MOTREC DEALER TO REGISTER YOUR PRODUCT. MOTREC'S LIMITED WARRANTY WILL BECOME EFFECTIVE AT THE TIME OF PRODUCT REGISTRATION. IF YOU DO NOT REGISTER YOUR PRODUCT, THE STARTING DATE OF YOUR MOTREC LIMITED WARRANTY WILL TAKE EFFECT ON THE DATE THE PRODUCT WAS DELIVERED TO YOUR MOTREC DEALER. IF YOU PURCHASED THE PRODUCT DIRECTLY FROM MOTREC AND NOT FROM A MOTREC DEALER, MOTREC HAS AUTOMATICALLY REGISTERED YOUR PRODUCT./

**DEFECTS.** Subject to the terms and conditions described below, parts, components, or accessories installed on the product by Motrec that fail under normal use within the warranty period, and that are proven to be defective, will be repaired or replaced without charge for parts or labor unless stated otherwise herein. This is Motrec's sole liability under this Warranty. Motrec reserves the right to require that all parts or components claimed to be defective be returned for inspection and verification of defect. The purchaser is responsible for any and all shipping fees of any and all parts or components that it alleges to be defective.

**WARRANTY SERVICES.** All warranty services must be rendered by authorized Motrec distributors and approved in writing by Motrec prior to initiating any repairs or adjustments. All approved warranty services will be paid for based on standard rates established by Motrec. Rather than replace or repair parts or components, Motrec may, at its discretion, replace the product or refund a prorated amount of its purchase price (based on service time, wear and tear) upon return of the defective product.

**AUTHORIZATION PROCESS.** No product shall be returned to Motrec without its prior authorization. All warranty claims must be disclosed to Motrec or its authorized distributor as soon as the purchaser is aware of a suspected defect or any event susceptible to give rise to a claim under the Motrec Limited Warranty. All claims must be processed through an authorized Motrec distributor using the warranty claim procedure approved by Motrec.

**THE ABOVE TERMS AND CONDITIONS REPRESENT THE ONLY REPRESENTATIONS MADE BY MOTREC IN RELATION TO ITS PRODUCTS. MOTREC DOES NOT PROVIDE ANY OTHER PARTICULAR WARRANTY TO THE USER OF ITS PRODUCTS. MOTREC DOES NOT MAKE ANY EXPRESS OR IMPLIED WARRANTIES OR REPRESENTATION WITH RESPECT TO ANY RESULT, PERFORMANCE OR DURABILITY EXPECTED FROM THE USE OF ANY OF ITS PRODUCTS. MOTREC EXCLUDES AND DECLINES ANY OTHER WARRANTY OF SUITABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE WOULD THEY BE PROVIDED BY LAW, BY CONTRACT OR OTHERWISE.**

**PRODUCT MODIFICATIONS ARE PROHIBITED.** Motrec prohibits and disclaims all liability for any modification made to the product, including but not limited to, modifications that are susceptible to altering the weight distribution and stability of the product, increasing its speed or affecting its safety. Such modifications can cause serious personal injury or property damage, which Motrec disclaims and excludes all responsibility. It is the purchaser's responsibility to ensure that any technicians servicing the product are properly trained as required by OSHA (Occupational Safety and Health Administration: <https://www.osha.gov/>) and ANSI-B56 (American National Standards Institute: <https://webstore.ansi.org/default.aspx>). Service technicians shall read, understand and follow the instructions in the Motrec Owner's Manual before servicing the product. Only qualified and authorized personnel shall be permitted to maintain, repair, adjust and inspect the product.

**TRAINING.** It is the purchaser's responsibility to ensure that the driver or any person operating, using, maintaining or handling the product (or its accessories) is properly trained and instructed on the product's safety features and operation, including its stability. Operators shall read, understand and follow the safety and operating instructions in the Motrec Owner's Manual before driving the vehicle. Operators shall not be permitted to operate the product unless complete and adequate training has been provided by the purchaser. Driving an electric vehicle constitutes a hazard. The driver is responsible for the control of the product while driving and must always evaluate all unusual situations that he or she may encounter while driving. The driver assumes the inherent hazards related to this activity. Motrec products are designed for off-road use only.

**EXCLUSION OF LIABILITY.** Motrec disclaims any liability for incidental or consequential damages, including, but not limited to, personal injury or property damage arising from misuse of the product, lack of maintenance or any defect in the vehicle.

**UNDER NO CIRCUMSTANCE WILL MOTREC BE LIABLE FOR ANY DAMAGE, WHETHER DIRECT, INDIRECT OR OTHERWISE, RESULTING FROM THE USE OF ITS PRODUCTS, EVEN IF MOTREC OR ONE OF ITS REPRESENTATIVES WAS AWARE OF THE POSSIBILITY OF SUCH DAMAGE. ANY LIABILITY FOR LATENT DEFECT IS LIMITED TO THE PRICE OF THE PRODUCT.**





### 1. Definitions

*“Product”*: the complete electrical vehicle manufactured and/or assembled by Motrec, including its parts, components and accessories installed by Motrec.

*“Purchaser”*: The party in whose name the product is originally registered at the time of purchase pursuant to the product registration procedure maintained by Motrec at that time, either: (a) the party to whom Motrec sold the product, if that party purchased the product for its own use, or (b) the customer of a Motrec dealer, who bought the product directly from such dealer.

### 2. Warranty Period

Your Motrec product is covered by the Motrec Limited Warranty for a period of five (5) years or **5,000 hours** of use, whichever comes first. This period of three (3) years starts on the date the product is registered, as mentioned hereinabove. This coverage does not apply to wearable parts, normal use or abusive usage of the product.

### 3. Warranty Registration

The warranty registration must be completed within ninety (90) days of purchase of the product. If registration is not completed within this time, the warranty will begin on the date the product was delivered. If you purchased the product from a Motrec dealer, please make sure the dealer has completed the registration. If you purchased the product directly from Motrec, Motrec has automatically registered your purchase.

### 4. Maintenance

Motrec requires that scheduled maintenance be performed at the times shown in the Owner's Manual. If this scheduled maintenance is not done and the product fails as a result of a failure to properly maintain it, repairs will not be covered under any warranty.

### 5. Warranty will be void if :

- The product has been modified in any manner not approved in writing by Motrec.
- The product has been overloaded beyond its rated capacity.
- The product's maximum speed has been increased.
- The product's motor controller parameters have been tampered without Motrec's authorization.
- The product has been used abusively
- (including, but not limited to improper use; twisted, bent, misaligned front or rear axles; any signs of abusive use).
- The product has been involved in an accident.
- The product has been transferred to a second owner without Motrec's authorization.
- The product has been used in extreme environments (including, but not limited to freezers, excessive moisture areas, corrosive environments, etc.).
- The product has had its serial number modified or altered.
- The product was not maintained as specified in the Motrec Owner's Manual.

### 6. The following items are not covered by the limited Motrec warranty :

- Batteries, charger, wheels
- Wearable parts (fuses, tires, wheel bearings, seats, brake pads and shoes)
- Wear and Tear resulting from normal use
- Adjustments, including field set-up
- Damage or defects caused by using non-Motrec parts, components, or accessories
- Shipping damage caused by freight carrier
- Shipping fees for warranty parts
- Travel fees for technical support and repair



# FOREWORD

## WELCOME

MOTREC International Inc. has built a rock-solid reputation as a world-class designer and manufacturer of electric industrial vehicles for the horizontal transportation of goods and people. We innovated, reimagined, engineered, and drove ourselves tirelessly to this preeminent position.

We also consistently exceeded customer expectations, which is why legions of satisfied customers worldwide have been driving MOTREC since 1988.

## INTELLECTUAL PROPERTY

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## MOTREC INFORMATION

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## ABOUT THE MANUAL

Make sure to read the manual in its entirety before operating or servicing the vehicle. Keep the manual close for reference when necessary. Do not discard the manual. If the vehicle is sold or transferred, provide this manual with it.

This manual is based on the latest available information at the time of publication.







**“AYONE CAN WORK  
WE PERFORM  
THAT’S MOTREC ”**

-Motrec Tagline

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# 1. PREFACE

## 1.1. INTRODUCTION

### Read Before Operating

Make sure to read and understand the content of this Maintenance Manual before operating or attempting maintenance on the vehicle. The present document provides a vehicle overview and safety information for the operator, passengers, and others, as well as a detailed list of the maintenance to be executed over the lifespan of the vehicle.

Keep this manual for future reference. If the vehicle is sold or transferred, provide this manual with the vehicle.

A list of maintenance instructions is included in this document. These instructions are intended for an MT-160 experienced technician to accelerate the maintenance process. The instructions should not be used by any untrained or inexperienced personnel.

### The MT-160

This agile 30" stand-up tow tractor is engineered to efficiently handle heavy loads, even through tight spaces like narrow doorways and corridors. Ideal for industrial, commercial, or institutional environments that require maneuverability and a towing capacity of up to 12,000 lbs, it also serves as a stock chaser. Featuring a maintenance-free AC motor, it offers 50% longer runtime, enhancing productivity. Safety and comfort are prioritized with features such as an automatic parking brake, enhanced suspension, 360° visibility, low step height, and anti-fatigue mats, all included as standard.





## 1.2. ACRONYMS AND ABBREVIATIONS

<b>°C :</b>	Celsius
<b>°F :</b>	Fahrenheit
<b>ANSI :</b>	American National Standards Institute
<b>AUX :</b>	Auxiliary
<b>EMB :</b>	Electromagnetic Brake
<b>ft :</b>	Feet
<b>A :</b>	Amperes
<b>HD :</b>	Heavy Duty
<b>HP :</b>	Horsepower
<b>HPD :</b>	High Pedal Disable
<b>Hz :</b>	Hertz
<b>ITSDF :</b>	Industrial Truck Standards Development Foundation
<b>kg :</b>	Kilogram
<b>km/h :</b>	Kilometer per Hour
<b>kW :</b>	Kilowatt
<b>kWh :</b>	Kilowatt-Hour
<b>lb :</b>	Pounds (Weight)
<b>lbf :</b>	Pound (Force)
<b>LD :</b>	Low Duty
<b>LED :</b>	Light Emitting Diode
<b>m :</b>	Meter
<b>mL :</b>	Milliliter
<b>mm :</b>	Millimeter
<b>N/A :</b>	Not Applicable
<b>N·m :</b>	Newton Meter
<b>OSHA :</b>	Occupational Safety and Health Administration
<b>P/N :</b>	Part Number
<b>PMC :</b>	Power Motor Controller
<b>PWM :</b>	Pulse Width Modulation
<b>SOC :</b>	State of Charge
<b>SRO :</b>	Static Return To Off
<b>VAC/AC :</b>	Volts Alternating Current / Alternating Current
<b>VDC/DC :</b>	Volts Direct Current / Direct Current



## 2. SAFETY INFORMATION

### 2.1 SAFETY SIGNAL WORDS AND SYMBOLS

Before operating the vehicle and reading the manual, it is important to familiarize yourself with the signal words and symbols that appear throughout the manual and on the vehicle. Understanding their meanings will help ensure safe and effective use of the vehicle.

#### **WARNING**

WARNING INDICATES A HAZARDOUS SITUATION WHICH, IF NOT AVOIDED, COULD RESULT IN SERIOUS INJURIES.

#### **CAUTION**

CAUTION INDICATES A SITUATION WHICH, IF NOT AVOIDED, COULD RESULT IN DAMAGE TO SOME EQUIPMENT.

**NOTICE** : Notice is used to address practices not related to personal injury.

### 2.2 SAFETY DECALS AND LABELS

#### **WARNING**

DECALS, MARKINGS, OR STICKERS MUST REMAIN UNALTERED AND READABLE AT ALL TIMES. REPLACE ANY UNREADABLE DECALS, MARKINGS OR STICKERS. FAILURE TO COMPLY COULD CAUSE SERIOUS INJURIES.

The vehicle contains numerous safety decals that provide essential information for both the operator and technicians. To view a complete list of all the decals, please refer to the **PARTS CATALOG (MPV)**.



## 3. VEHICLE OVERVIEW

### 3.1. SPECIFICATIONS AND CONFIGURATIONS

The MT-160 specifications and configurations can vary depending on the specific model and year of the MT-160. For more information and the most up-to-date details, it is best to consult with Motrec directly or refer to our website [www.motrec.com](http://www.motrec.com).

#### EQUIPMENT COMPARTMENTS:

All the compartments housing the vehicle's major systems are displayed in Figure 1.

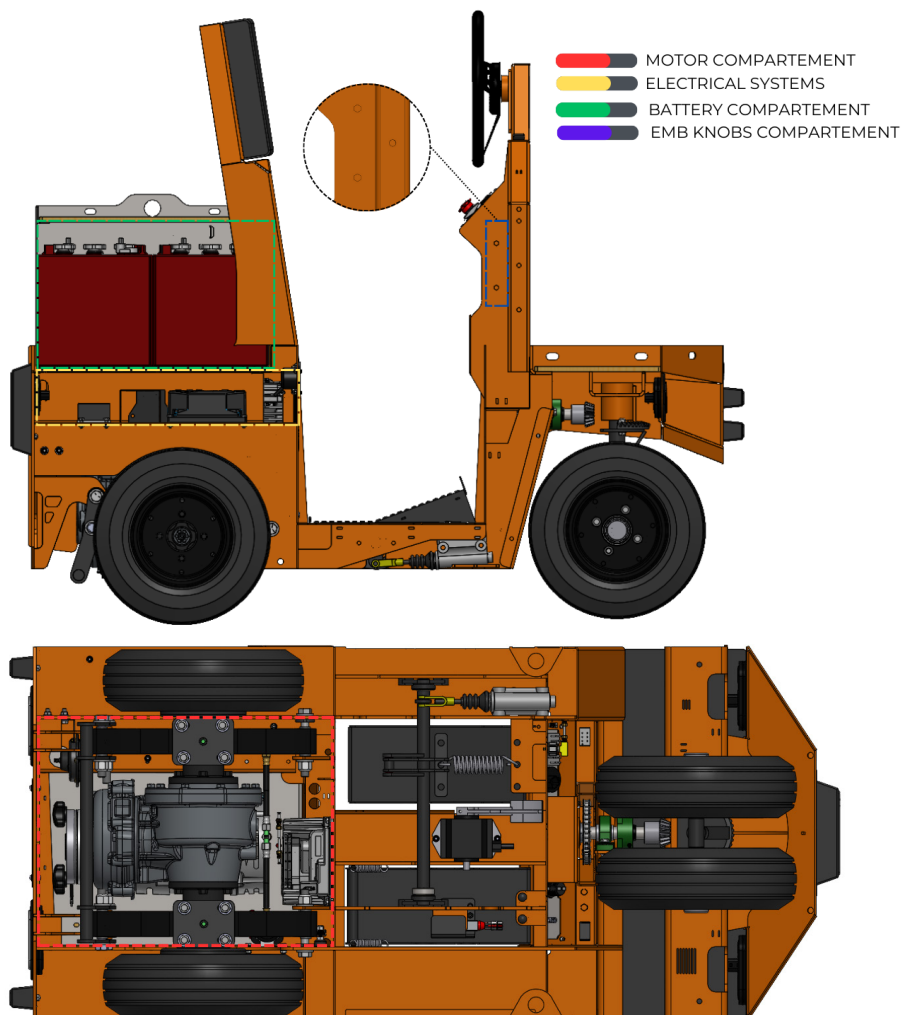


Figure 1. Equipment Compartments.

**NOTE 1 :** Opening the deck at the rear of the vehicle provides access to the battery compartment.

**NOTE 2 :** The EMB Service Knobs Compartment is typically located on the side of the vehicle and is easily accessible for maintenance and servicing purposes. The knobs themselves are usually located within the compartment and tightening and loosening the knobs can be done manually.



## 3.2 BATTERY COMPARTMENT

### ! CAUTION

DO NOT MODIFY THE BATTERY VOLTAGE OR REPLACE THE BATTERY CHARGER. THE INSTALLED BATTERY CHARGER IS SPECIFIC TO BATTERY VOLTAGE. FAILURE TO COMPLY CAN DAMAGE THE EQUIPMENT.

The vehicle offers two voltage options: 36V or 48V, depending on the configuration. It can be powered by various battery types, including :

- Flooded (lead-acid).
- TPPL (Thin Plate Pure Lead).
- GEL.
- AGM.
- Lithium.

#### Battery Compartment :

The battery compartment is free of mechanical components, allowing for easy removal of the batteries by either lifting them or sliding them out of the box. Additionally, depending on the number of battery boxes, you can choose between 36V or 48V voltage options.

**NOTE :** To access the components located beneath it, the battery box must be removed during the maintenance procedures described in Section 4, "Maintenance."

**IMPORTANT :** The SB-350 connector and the electrical connector (for lithium batteries - see Figure 4.c page 12) must be disconnected before removing the battery box.

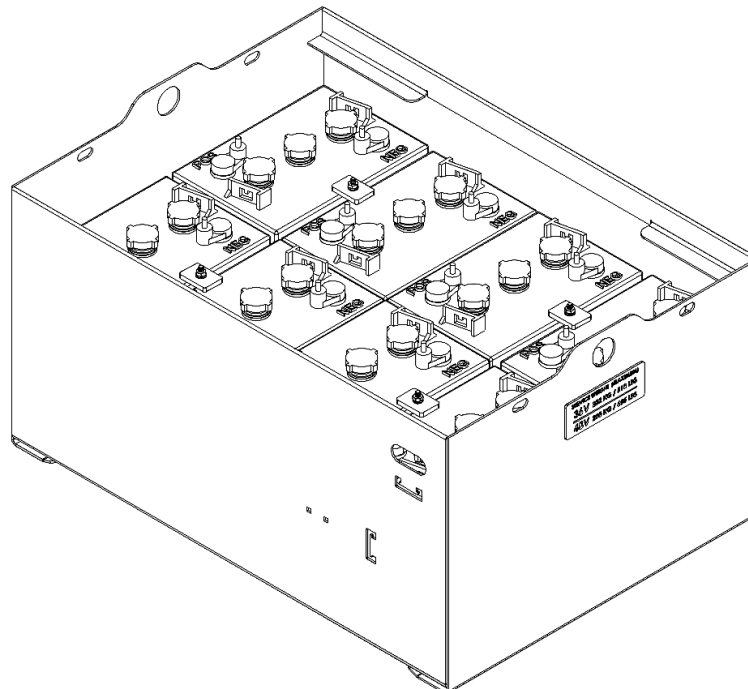


Figure 2. Battery Compartment (48 V).



### 3.3 ELECTRICAL SYSTEMS

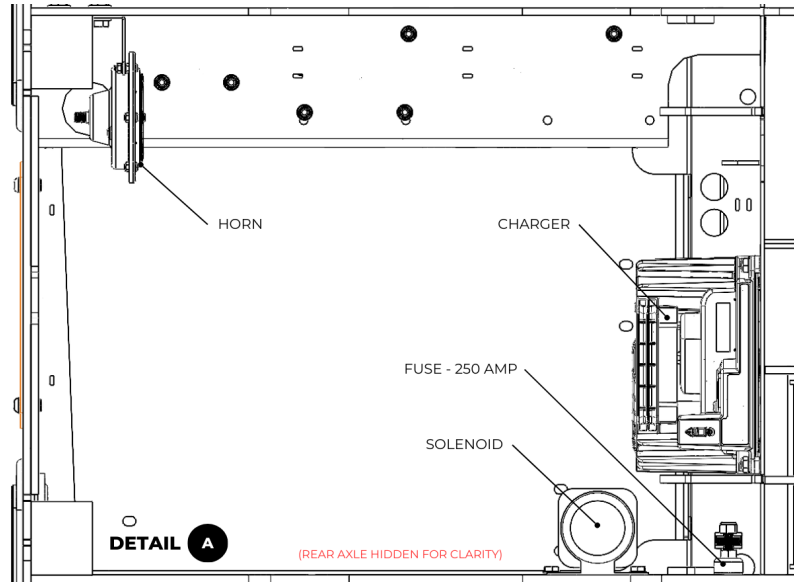
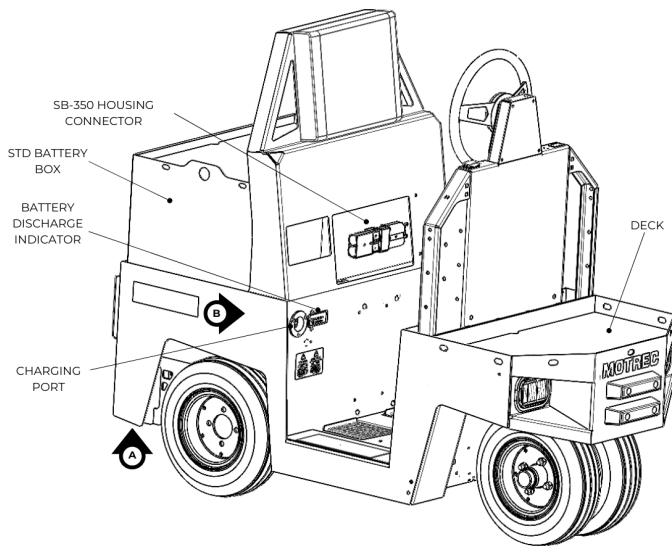


Figure 3. a. Electrical System Compartments Detail A.

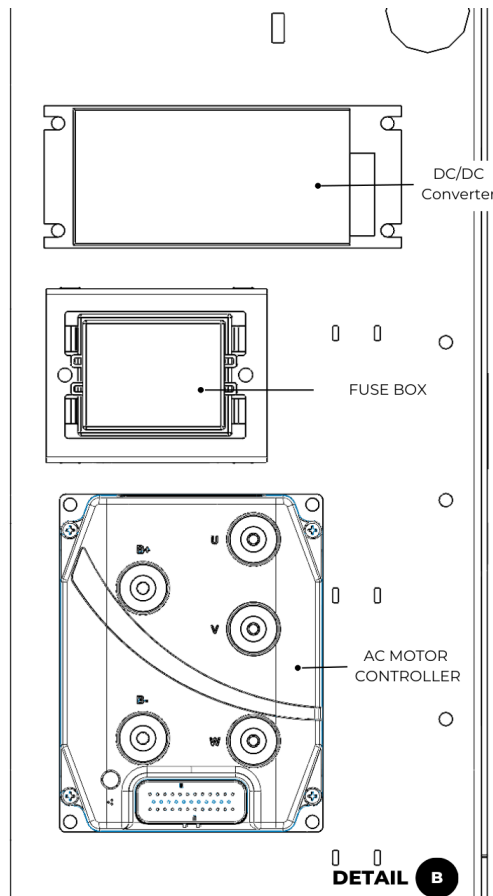


Figure 3. b. Electrical System Compartments Detail B.

This compartment receives the energy from the battery compartment and redistributes it to the different electrical systems of the vehicle. The energy systems can be divided into three categories:

- The Main Energy : which uses the full battery voltage to power various systems. The voltage is also converted to AC voltage by the AC motor controller to power the AC motor.
- The Auxiliary Energy: which powers the different accessories of the vehicle (backup alarm, horn, console, etc.) (12V).
- The Charging Energy: which charges the batteries.

For connection details, refer to the vehicle's electrical schematic in section Annexes.

**NOTE :** The vehicle's frame is not to be considered as a ground. No component is connected to the frame as a closed-circuit loop.



### 3.3.1 LITHIUM BATTERIES

When the MT-160 is powered by lithium batteries, the electrical compartment of the vehicle is reconfigured, as shown in Figures 4.a, 4.b and 4.c.

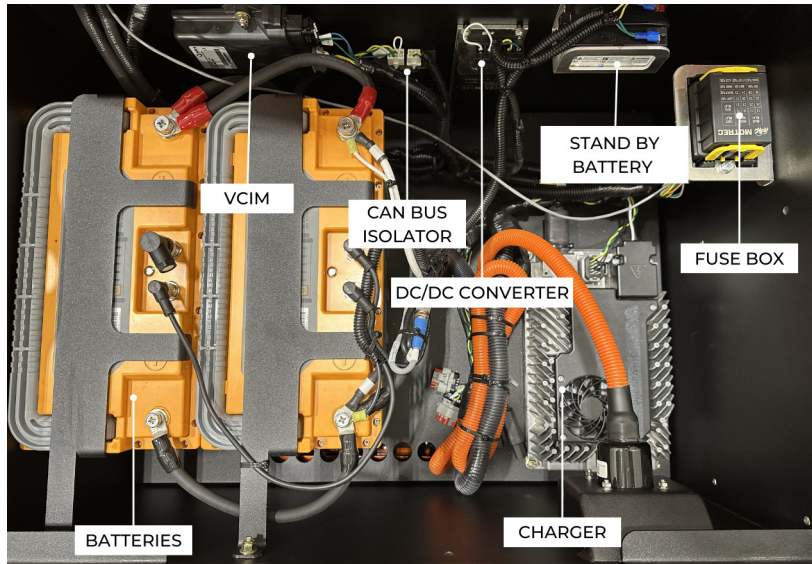


Figure 4. a. Electrical compartments with lithium battery power.

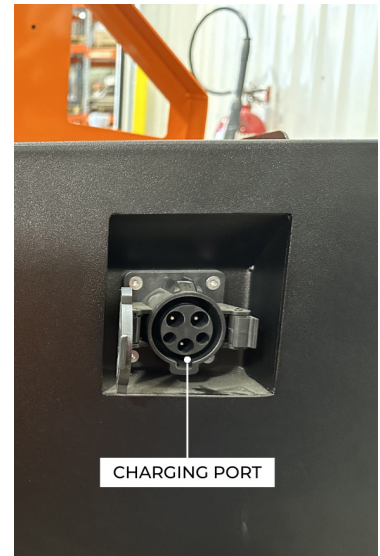


Figure 4. b. Electrical compartments with lithium battery power.

These are the roles of the additional components when using lithium batteries compared to the standard version :

- **VCIM** : Manages vehicle data communication between charger, batteries and the vehicle.
- **CAN Bus Isolator** : Acts as the communication interface between two separate CAN networks.
- **Stand By Battery** : Serves as the signal source that activates the lithium batteries.
- **Electrical Connector** : It facilitates the transfer of electrical signals between the battery box and the vehicle's electrical system, ensuring proper power delivery to various components.

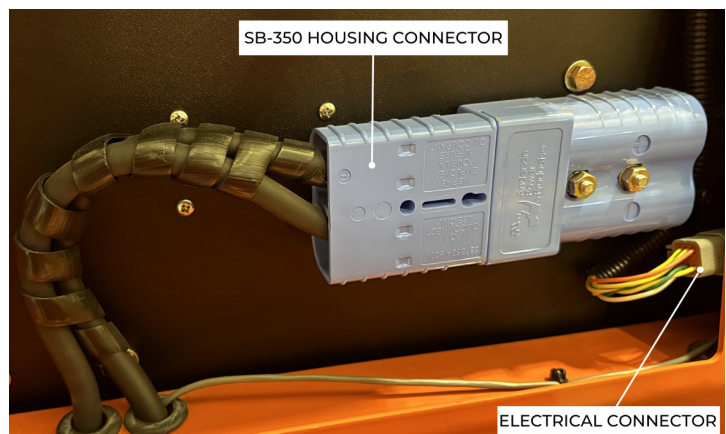


Figure 4. c. Electrical compartments with lithium battery power.



### 3.3.2 MAIN ENERGY

The main energy system encompasses all the elements responsible for the vehicle's movement, such as the AC motor, accelerator, and movement alarms, among others.

The energy flow originates from the batteries and passes through the main fuse and contactor before reaching the AC motor controller. This controller harnesses the DC voltage to supply power to different components while also converting the DC voltage to AC to drive the AC motor.

**NOTE:** The wiring remains the same, but the component placement may vary from one vehicle model to another.

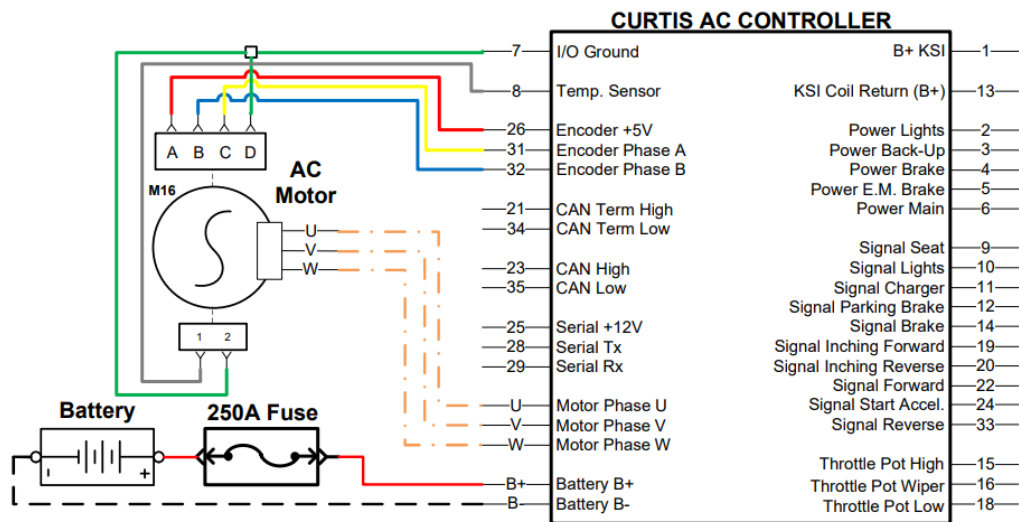


Figure 5. Main Energy Electrical connection (Annexe 5).

### 3.3.3 AUXILIARY ENERGY

In order to supply power to the auxiliary systems of the vehicle, such as the backup alarm, lights, horn, etc., the DC-DC converter utilizes the battery voltage (36 or 48 VDC) and converts it to an output of 12 VDC / 13.4 VDC. This voltage is then directed through the fuse box and distributed to the vehicle's accessories.

**NOTE:** The wiring remains the same, but the component placement may vary from one vehicle model to another.

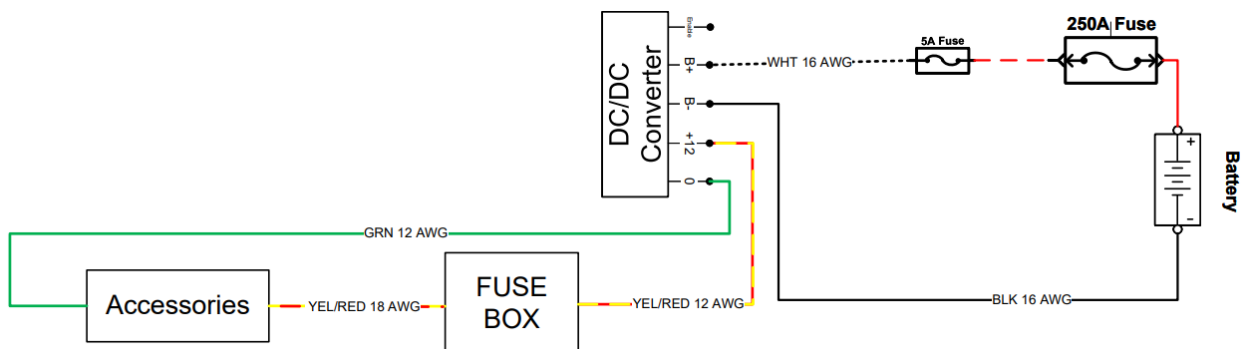


Figure 6. Auxiliary Energy Electrical connection (Annexe 5).



### 3.3.4 CHARGING ENERGY

**NOTE :** This section is applicable to all the vehicles equipped with onboard charging.

Certain configurations include a dedicated battery charger, designed to simplify the charging procedure. The installed charger is customized to match the specific battery voltage and type of the vehicle. The charger generates a voltage of either 36 or 48 VDC, depending on the particular configuration.

#### ! CAUTION

**DO NOT MODIFY THE BATTERY VOLTAGE OR REPLACE THE BATTERY CHARGER. THE INSTALLED BATTERY CHARGER IS SPECIFIC TO BATTERY VOLTAGE. FAILURE TO COMPLY CAN DAMAGE THE EQUIPMENT.**

For battery charging, the charger obtains voltage from the wall outlet and subsequently converts it to match the voltage required by the batteries. The converted current is then directed towards the batteries to initiate the charging process.

**NOTE :** The wiring remains the same, but the component placement may vary from one vehicle model to another.

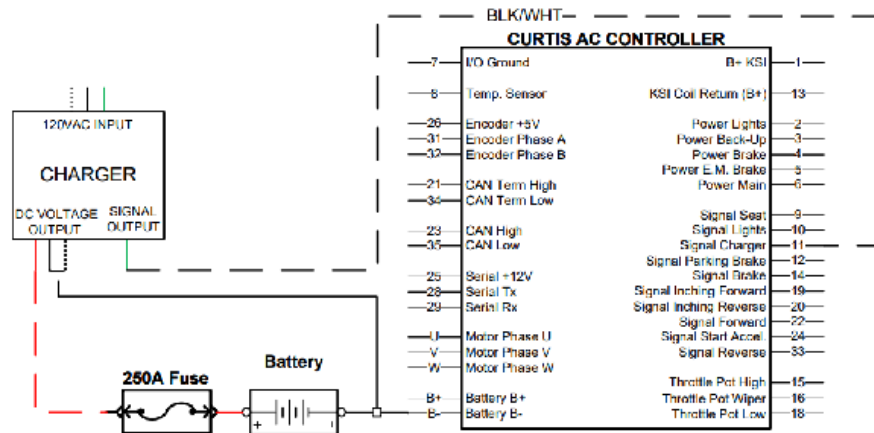


Figure 7. Charging Energy Electrical connection (Annexe 5).



## 3.4 MOTORS AND REAR AXLE

### 3.4.1 AC MOTORS

The MT-160 is equipped with a brushless AC direct drive motor that enables forward and backward propulsion of the vehicle. This motor is powered by a 3-phase current supplied by the AC motor controller. For more detailed information, please refer to section [3.3.1 MAIN ENERGY](#). Additionally, the motor features regenerative braking functionality, which enables the vehicle to decelerate without relying solely on friction brakes and allows a portion of the deceleration energy to be returned to charge the batteries.

Depending on the vehicle's operating environment, the AC motor is available in two different casings.

- A. ENCLOSED :** Designed for use in environments with high sanitation requirements or excessive dust, this motor features a sealed casing that effectively prevents sparks from escaping and debris from entering. Primarily utilized in EE-rated applications, it ensures optimal performance and safety.
- B. FAN COOLED :** This motor is specifically designed to operate effectively in diverse environments. It features an integrated fan on its rotor, which efficiently draws air through the venting holes to enhance the motor's cooling capacity.

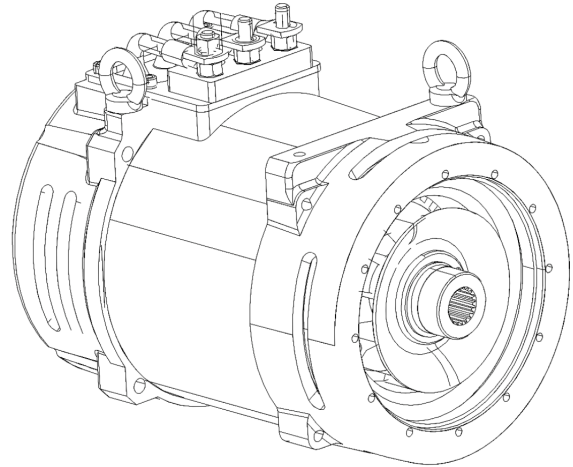


Figure 8. a. AC Motor Side View.

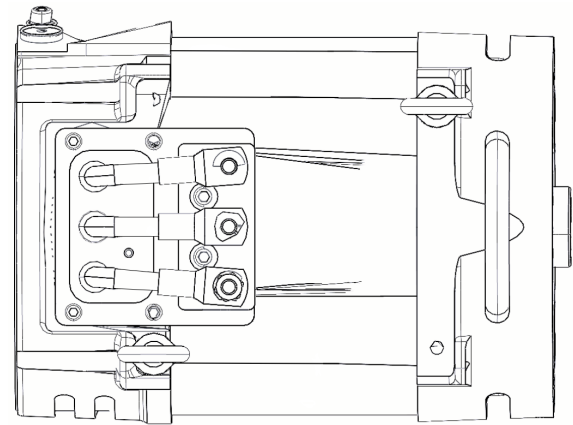


Figure 8. b. AC Motor Top View.



### 3.4.2 REGENERATIVE BRAKING

The regenerative braking feature of the AC motor is specific to the drive wheels of the vehicle. It utilizes the motor's electrical resistance to assist in decelerating the vehicle while simultaneously recharging the batteries. By adjusting the amount of electrical current flowing through the motor, the behavior of regenerative braking can be modified.

There are two distinct states of regenerative braking:

1. Coasting: Regenerative braking is engaged when the accelerator pedal is released, allowing the vehicle to slow down naturally. During this state, the motor acts as a resistance, converting the vehicle's kinetic energy into electrical energy, which is then fed back into the batteries.
2. Electrical Braking Assistance: Regenerative braking is activated when the brake pedal is depressed. In this state, regenerative braking provides additional assistance to the mechanical brakes, enhancing the overall braking performance of the vehicle. The motor's resistance aids in slowing down the vehicle while simultaneously generating electricity to recharge the batteries.



#### WARNING

ALL VEHICLE OPERATORS MUST BE NOTIFIED IF THE REGENERATIVE BRAKING'S DECELERATION LEVEL IS MODIFIED. FAILURE TO COMPLY CAN CAUSE INJURY OR DAMAGE TO THE EQUIPMENT.

Although MOTREC optimizes this feature to deliver significant advantages such as enhanced energy efficiency, prolonged battery lifespan, minimized mechanical brake wear, and the ability to capture and repurpose dissipated heat energy, it may prove overly aggressive for specific applications. Fortunately, the level of deceleration can be customized through the display screen. For detailed instructions on adjusting the regenerative braking settings, please consult the [TECHNICAL TRAINING](#) section available on the dealer portal.

### 3.4.3 ELECTROMAGNETIC BRAKE (EMB)

The MT-160 electric vehicle is equipped with an electromagnetic brake (EMB) that provides reliable and efficient braking performance. The electromagnetic brake is designed to assist in place when necessary.

The electromagnetic brake is in a Normally Applied state and is electrically released during operation. This means it requires current to be released and allow movement of the vehicle. This safety feature automatically stops the vehicle in the event of loss of power, therefore removing the need for a handbrake (parking brake).

The spring-applied brake keeps the vehicle stationary when it comes to a stop, or when the power is cut off. In situations where the vehicle is not powered and requires movement, it is necessary to insert the electromagnetic brake's service knobs.

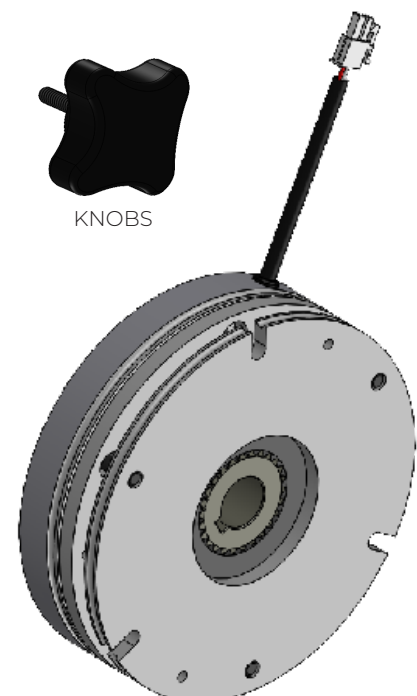


Figure 9. EMB Brake System.



### 3.5 BRAKE-ACCELERATION SYSTEM

The master pedal (1) is a foot-operated lever located on the floor of the driver's compartment, to the right of the operator presence detection pedal (2). It functions as both pedal-operated braking mechanism and an accelerator pedal.

When the driver presses the master pedal, it initiates the acceleration process. The contact between the surface of the master pedal and the electric accelerator pedal (3) sends a signal to the motor to increase its power, thereby accelerating the vehicle.

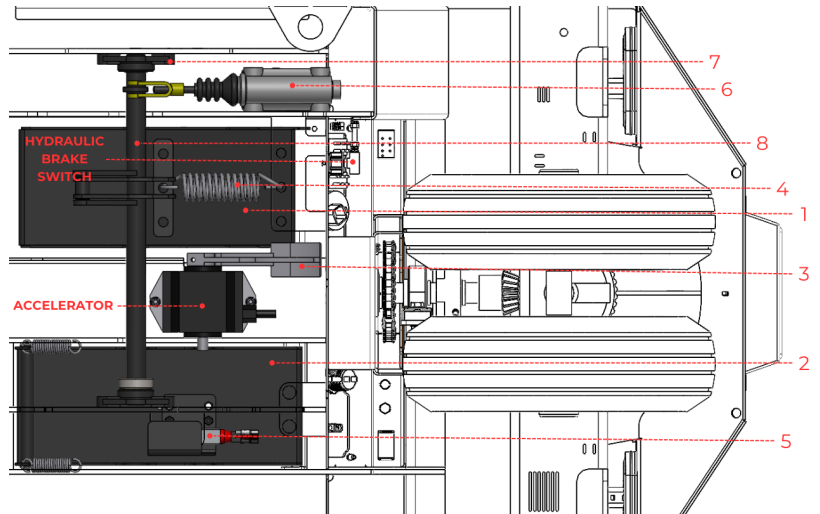


Figure 10. Brake System.

As for the braking mechanism, when the driver releases the pressure on the master pedal, a spring (4) is present to depress the piston and exert pressure. Then the hydraulic piston, activated by the applied force, pressurizes the brake fluid. This pressurized fluid is transmitted through the brake lines and hoses to the wheel cylinders. The resulting force causes the brake pads to engage the drums, generating friction and ultimately slowing or stopping the vehicle.

**NOTE 1 :** A detection switch switch (5) is located near the brake pedal assembly, near the master pedal and the brake master cylinder (6). When the driver slows down or engages the braking mode, the hydraulic piston is engaged, which creates pressure within the braking system. Simultaneously, the brake switch is activated by the oil pressure, activating the brake lights and signaling to other drivers that the vehicle is slowing down, moving backwards or coming to a stop.

**NOTE 2 :** Two flange bearings (7) are positioned at the ends of the brake assembly (8) to facilitate its rotational movement when the master pedal is pressed or released.

**NOTE 3 :** The wiring of the brake lines is not shown in the 3D model photo of the MT-160.



## 3.6 STEERING SYSTEM

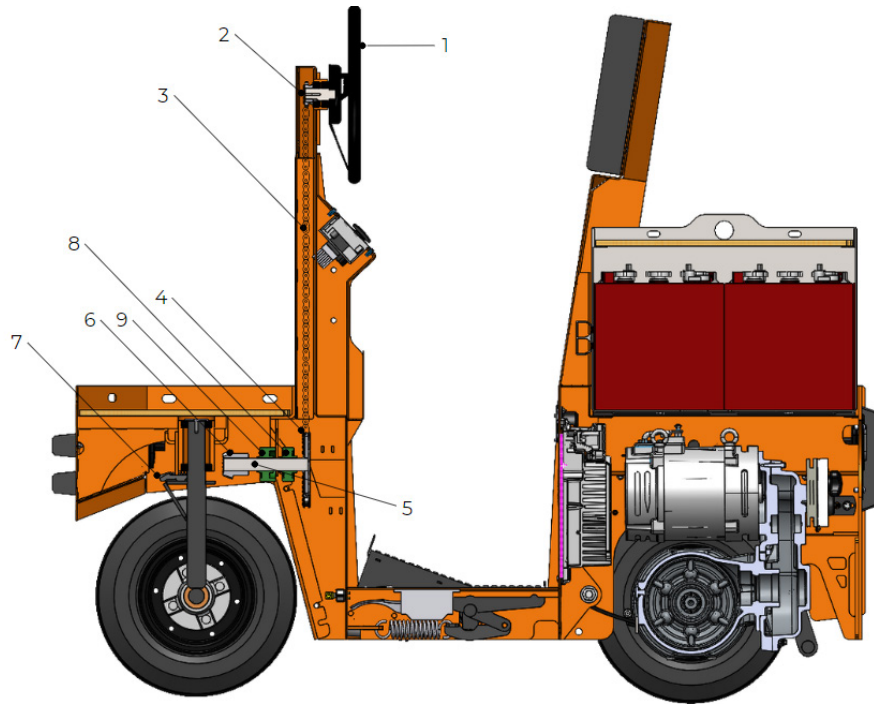


Figure 11. Steering System.

When the driver turns the steering wheel (1), the rotational motion is transferred from the steering sprocket (2) to the chain (3) and then to the sprocket (4). This motion is then transmitted through the steering shaft (5), to the pinion bevel gear (6) and then to the steering gear (7), causing both front wheels to turn simultaneously in the desired direction. The pillow block bearings (8) support the steering shaft, allowing it to rotate smoothly, while the flange block bearings (9) help maintain the alignment and stability of the shaft, preventing unwanted vibrations.

The linkages and components within the steering system ensure that the wheels maintain proper alignment and respond accurately to the driver's steering inputs. The conventional steering system operates solely through mechanical means and does not incorporate any electrical or hydraulic elements.



### 3.7 SUSPENSIONS

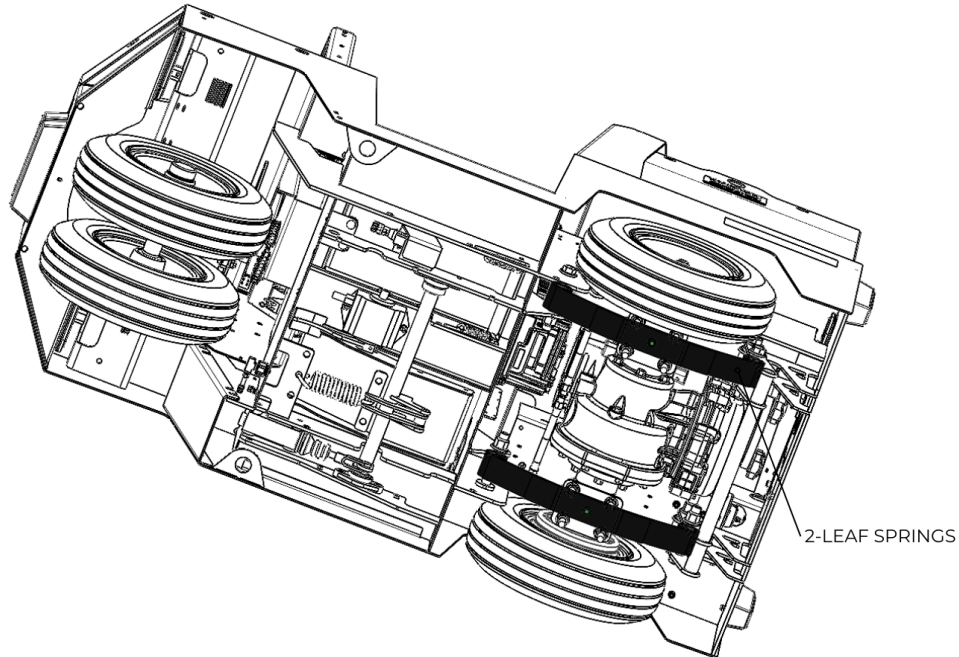


Figure 12. Suspensions.

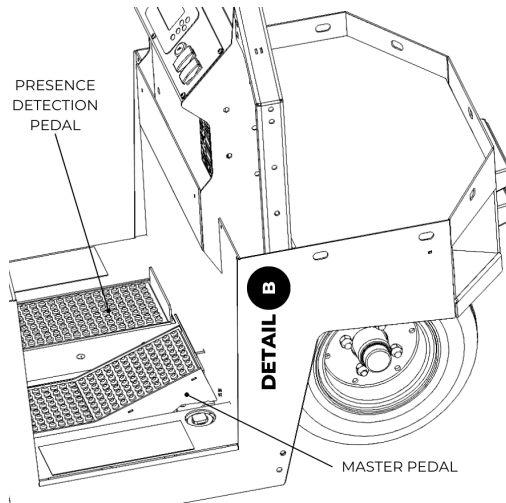
The suspension system of the MT-160 electric vehicle is thoughtfully engineered with a well-balanced design, incorporating two robust 2-leaf springs at the rear. This dual-leaf spring setup plays a crucial role in stabilizing the vehicle by effectively distributing its weight across the suspension, which not only improves load balance but also enhances overall handling. By efficiently absorbing shocks and vibrations from uneven road surfaces, the suspension ensures a smoother and more comfortable ride for the driver. Its straightforward design, combined with its proven reliability and ability to carry significant loads, makes this suspension system a practical and efficient solution for achieving stability, comfort, and durability in daily use.



## 3.8 GENERAL COMPONENTS

### Electrical Cables

The electrical cables are carefully guided and routed beneath the vehicle. They follow the path provided by the frame, which acts as a designated cable tray. This routing ensures that the cables are neatly organized and protected from potential hazards or obstructions. Their ultimate destination is the console, where they connect to various electrical components, allowing for seamless operation and control within the vehicle.



ELECTRICAL CABLES

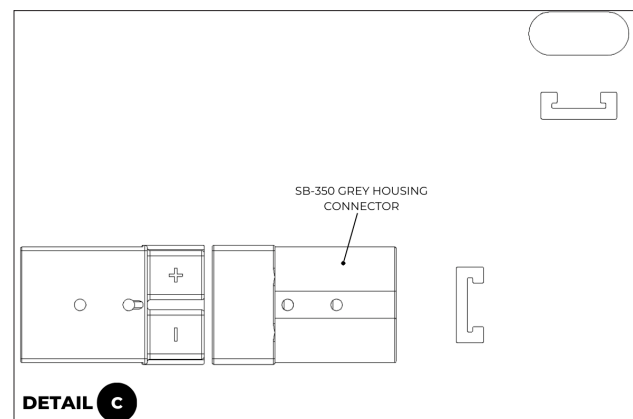
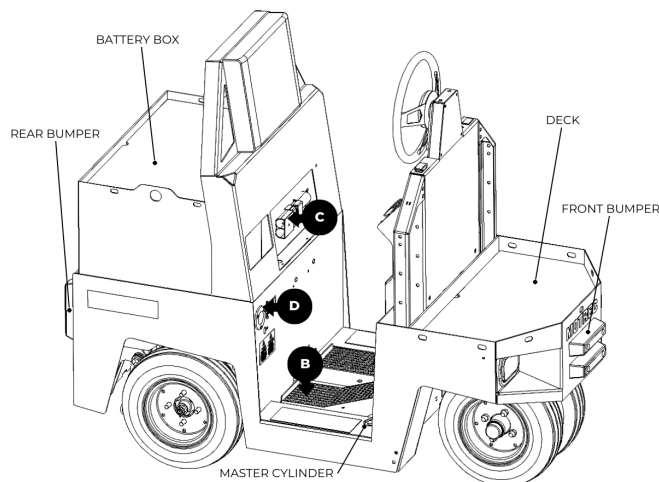
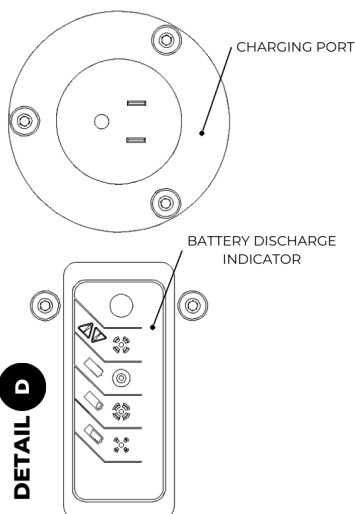


Figure 13.a. General Components (Details A, B and C).



### Charging port

The charging port is conceived for standard wall outlets, such as:

- 120 VAC, 60 Hz North American outlets.
- 240 VAC, 50 Hz European outlets (If paired with the compatible connector).

### Battery discharge indicator

The LED indicator will flash in accordance with the battery charge level.

Its primary goal is to indicate the battery charge level to the operator during the charging process without needing to turn on the vehicle and look at the charge level on the display screen.

**NOTE :** The explanation of all the symbols on the battery discharge indicator can be found in Annexes section at the end of the document.

Figure 13. b. General Components (Detail D : Charging Port and Indicator).



## 3.9 CONSOLE

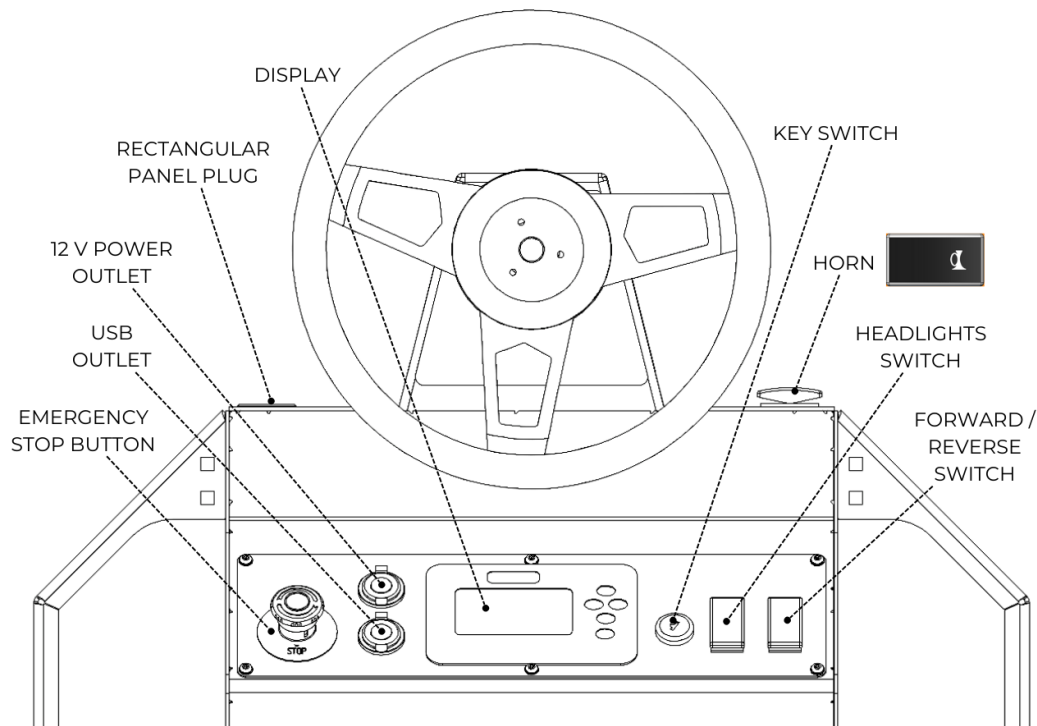


Figure 14. Console.

### Direction Switch (Forward/Reverse)

This switch controls the motion direction of the vehicle:

- Pushing the top part sets the vehicle in forward drive.
- Putting the switch in the middle sets the vehicle in neutral.
- Pushing the bottom part sets the vehicle in reverse drive.

### Key Switch

The key is used to engage or disengage the switch, allowing or preventing the flow of electricity or the operation of the associated device.

### Display

It conveys information effectively and facilitate communication between the system and the user, providing a visual representation of data or content in a clear and understandable manner.

### Emergency Stop Button

The emergency stop button, when present, should only be used in case of emergency.



DO NOT USE THE ENERGY STOP BUTTON TO TURN OFF THE VEHICLE. USE THE KEY SWITCH FOR NORMAL ON/OFF CONTROL. FAILURE TO COMPLY CAN DAMAGE THE EQUIPMENT.



## 3.9.1 DISPLAY

### Parking Brake

This indicator lights up when the parking brake is engaged.

### Headlights Indicator

Lights up when the headlights are ON.

### Maintenance

This indicator lights up when the maintenance timer has reached its limit, or when one of the systems has encountered a problem and requires further investigation.

### Direction Arrows (Forward/Reverse)

These indicators light up depending on the drive toggle's position to inform the operator of the direction the vehicle will move.

### Navigation Arrows

These buttons are to be used when navigating through the operator interface.

### Drive Mode Indicator

Indicates the current selected drive mode between rabbit and turtle.

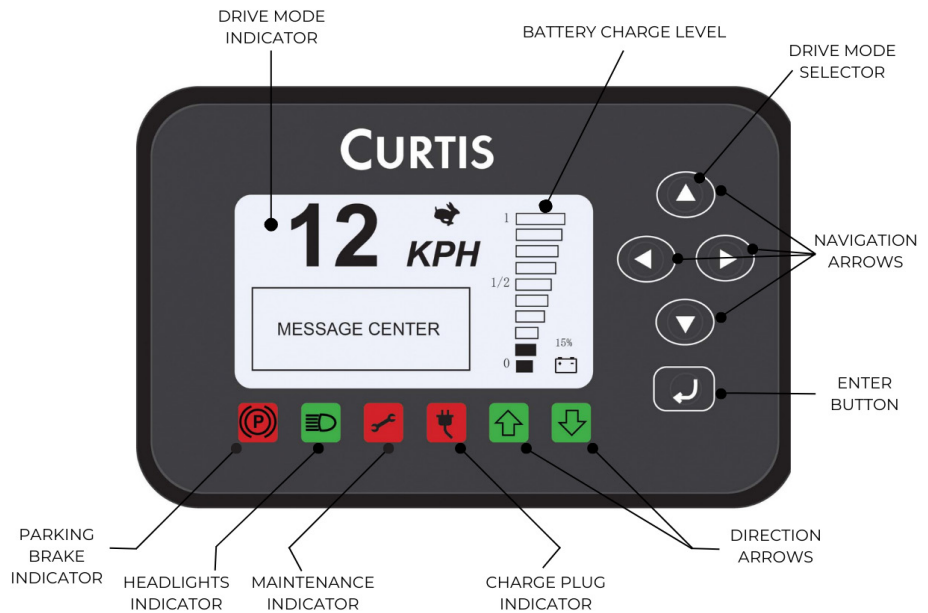


Figure 15. Display.

### Enter Button

This button is to be used when selecting an option in the operator interface. When the button is held down, it initiates the opening of menus.

### Drive Mode Selector

During operation, the up arrow is also used to change the drive mode between turtle and rabbit for a different vehicle speed.

### Battery Charge Level

Indicates the state of charge of the batteries.

### Vehicle Runtime

Indicates the total vehicle runtime. The engine runtime is only calculated while the vehicle is in motion and defines the interval of the preventive maintenance.

For more information, refer to section [4.2 PREVENTIVE MAINTENANCE](#) (page 28).



## 3.9.2 OPERATOR INTERFACE

### Login Credentials

In order to access and modify the vehicle settings through the driver console, specific passwords need to be entered based on the desired settings. For MOTREC settings, the password **“3050”** is required.

### Four Pin Diagnostics Connector

To access an advanced operator interface, you can connect a Curtis handheld programmer to the four-pin diagnostics connector located at the right side of the console's kick panel. It's important to note that the display connector (refer to Figure 16) needs to be disconnected each time the handheld programmer is used.

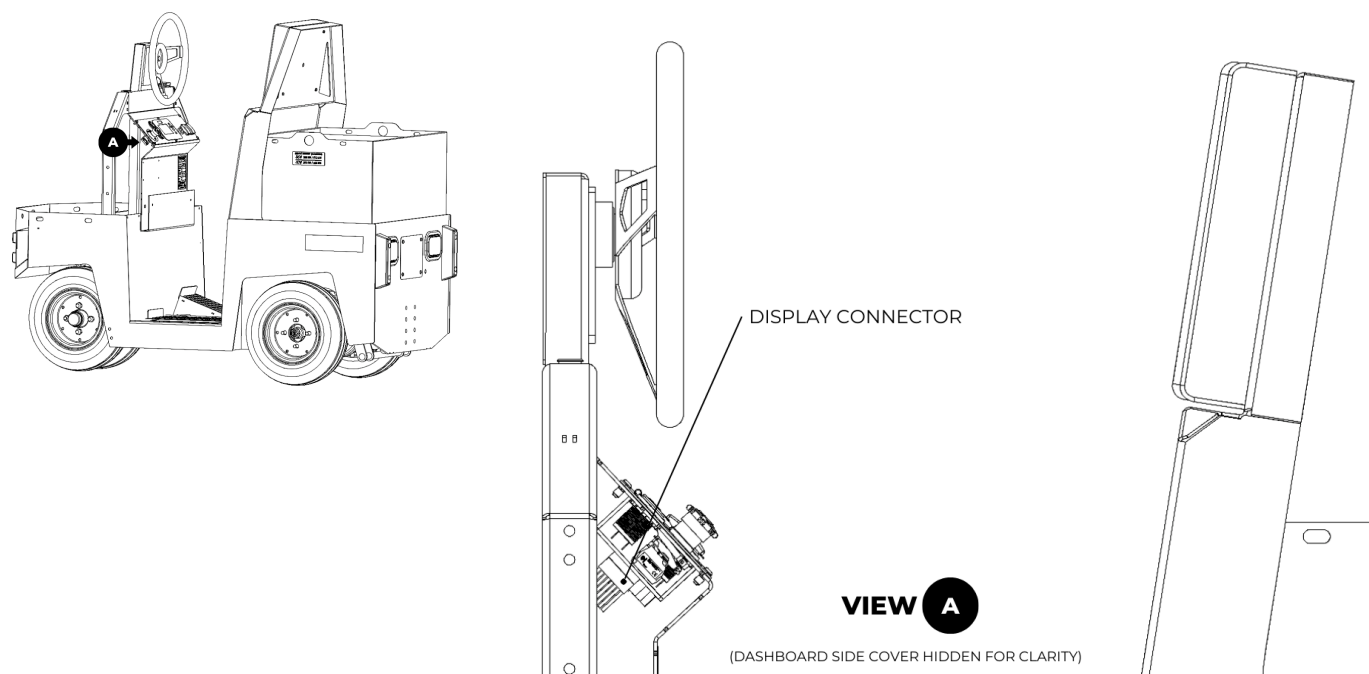


Figure 16. Display Connector.

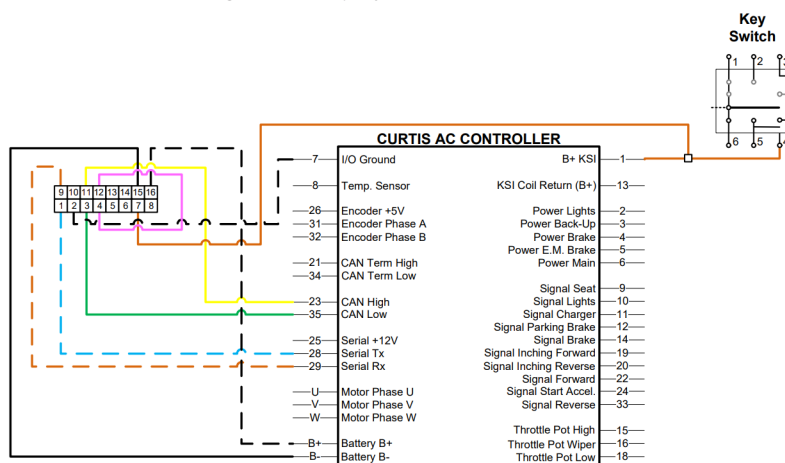


Figure 17. Display Connector Electrical connection (Annexe 5).



## Vehicle Speed



### WARNING

NOTIFY AFTER THE MAXIMUM VEHICLE SPEED HAS BEEN MODIFIED. FAILURE TO COMPLY CAN CAUSE ACCIDENTS AND DAMAGE TO THE VEHICLE.

Prior to changing the maximum vehicle speed, check that the speed modification is truly required by the operator and validate with MOTREC that the speed won't affect the integrity of the vehicle.

To modify the maximum speed:

1. Turn the ignition key to ON.
2. Hold the **Enter** button for 5 seconds.
3. Select **MOTREC Settings**.
4. Select Input Password.
5. Enter the password: **3050**.
6. Navigate as follows: Programmer → **Program** → **MOTREC Parameters** → **MOTREC Speed Limits (KMH)** → **KMH Max Speed Limits** → **Rabbit FWD Max Speed**.
7. Press the right arrow.
8. Adjust the speed value using the up/down arrows.
9. Press the left arrow to exit the value modification.
10. Select **Exit**.
11. Turn the ignition key to OFF.

### 3.9.3 ALARMS AND FAULTS

While operating the vehicle, the display screen may display warnings to alert the driver about vehicle-related events. Each MOTREC vehicle is equipped with a controller that relies on input signals, processes information, and generates output commands. In the event of a malfunction, the controller will generate a fault code to indicate that it has detected a situation that falls outside the specified parameters. These fault codes are stored in the controller's memory until they are cleared.

It is recommended to begin by reading the fault codes in order to diagnose any issue. This will provide valuable information about the nature of the problem.

For a comprehensive list of all the fault codes, please refer to the annexes located at the end of this document.

### 3.9.4 REAR LIGHT COLORS SIGNIFICATION

There are four available rear light colors in the vehicle, which are as follows: *white* is used for reversing, *pale red* (standard) indicates vehicle startup, the intensity of pale red increases under braking becomes *Intense Red*, and *orange* (if applicable) activates as a turn signal when available in the vehicle. These color signals are used to enhance safety and communication on the road.



## 4. MAINTENANCE

### 4.1 GENERAL INFORMATION

This section provides a general overview of the maintenance procedures for a standard MT-160 vehicle. While the images displayed may not match the exact product due to varying configurations and accessories, the maintenance steps outlined here are applicable to all MT-160 models as they cover the fundamental processes. If you have any maintenance-related questions specific to your product's features, please reach out to MOTREC for assistance.



#### **WARNING**

DO NOT MANIPULATE ELECTRICAL CONNECTIONS OR GENERATE SPARKS AROUND BATTERIES. SPARKS CAN CAUSE A BATTERY EXPLOSION AND ACID SPLASHING. DURING MAINTENANCE, ALWAYS DISCONNECT THE CHARGER AND USE INSULATED TOOLS THAT DO NOT GENERATE SPARKS. FAILURE TO COMPLY CAN CAUSE SERIOUS INJURIES.



#### **WARNING**

KEEP CLEAR FROM MOVING PARTS SUCH AS TIRES, SHEAVES, AND MOTOR. FAILURE TO COMPLY CAN CAUSE INJURIES.



#### **WARNING**

WHEN WORKING AROUND BATTERIES, ALWAYS WEAR ACID PROOF PROTECTIVE EQUIPMENT, SUCH AS FACE SHIELD AND THE APPROPRIATE GLOVES. BATTERIES CONTAIN SULFUR ACID THAT CAN CAUSE SEVERE BURNS ON SKIN OR EYES. RINSE CONTAMINATED AREA IMMEDIATELY WITH WATER.



#### **CAUTION**

ONLY QUALIFIED AND AUTHORIZED PERSONNEL ARE PERMITTED TO MAINTAIN, REPAIR, ADJUST, AND INSPECT THE VEHICLES AND THEIR BATTERIES. FAILURE TO COMPLY CAN LEAD TO DAMAGE TO THE EQUIPMENT.



#### **CAUTION**

USE TWO COUNTERACTING TOOLS, DOUBLE-WRENCH TECHNIQUE, WHEN DISCONNECTING OR TIGHTENING TERMINALS ON THE BATTERY OR THE AC MOTOR. FAILURE TO COMPLY COULD CAUSE CRACKING OF THE TERMINAL OR BATTERY POST WELDS.



## NOTICE

Follow the maintenance instructions applicable to the type of repair, maintenance, or service.

## NOTICE

Before maintenance operations, inspect safety decals and labels. Replace if any damage is found and part of the text can't be read.

## NOTICE

Before replacing a fuse or circuit breaker, identify and repair the cause of failure.

### 4.1.1 LIFTING POINTS

Please refer to the serial data plate (see Figure 18), positioned on the right side of the console, to determine the total weight of the vehicle. It is important to note that the weight may differ based on the vehicle's specific configuration, accessories, and battery capacity.

When utilizing a lifting device, ensure that it can support the precise weight of the vehicle. The suggested lifting points are highlighted below (see Figure 19) as a guide for safe and efficient lifting operations.



## WARNING

**BEFORE LIFTING, ALWAYS VALIDATE THAT THE LIFTING DEVICE CAN SUPPORT THE TOTAL WEIGHT OF THE VEHICLE, AS INDICATED ON THE VEHICLE'S SERIAL DATA PLATE. FAILURE TO COMPLY CAN LEAD TO SERIOUS INJURIES OR DEATH.**

**VIEW A**

<b>MOTREC</b>	
MODEL NUMBER	YEAR
SERIAL NUMBER	
BATTERY VOLTAGE	V POWER HP
BATTERIES CAPACITY	AH
VEHICLE WEIGHT WITHOUT BATTERIES	LBS
WEIGHT OF BATTERIES	MIN. LBS
	MAX. LBS
APPROX. OPERATING WEIGHT OF VEHICLE	LBS
RATED CAPACITY	LBS
GROSS WEIGHT MAX.	LBS
DRAW BAR PULL	NORMAL LBS
	MAX. LBS
MAX. VERTICAL LOAD ON HITCH	LBS
<small>VEHICLES COMPLY WITH ANSI SAE TYPE E TRACTORS COMPLY WITH ANSI SAE TYPE E AS TO FIRE AND ELECTRIC SHOCK HAZARD ONLY 2543</small>	
<small>220 DES PNE SHOCKROCK, QUÉBEC WWW.MOTREC.COM</small>	
<small>CE</small> <small>UL US</small>	
MADE IN CANADA	

Figure 18. Serial Data Plate.

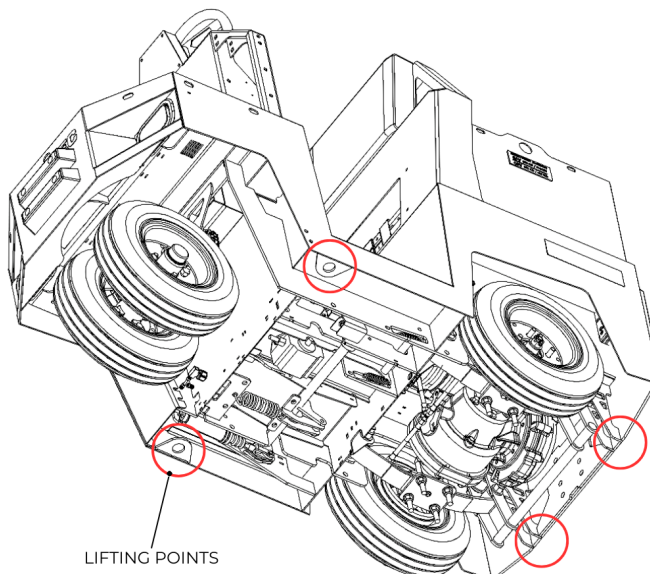


Figure 19. Lifting Points.



## 4.1.2 ELECTRICALLY ISOLATING THE VEHICLE

### WARNING

WHEN WORKING AROUND BATTERIES, ALWAYS WEAR ACID PROOF PROTECTIVE EQUIPMENT, SUCH AS FACE SHIELD AND THE APPROPRIATE GLOVES. BATTERIES CONTAIN SULFUR ACID THAT CAN CAUSE SEVERE BURNS ON SKIN OR EYES. RINSE CONTAMINATED AREA IMMEDIATELY WITH WATER.

This procedure must be followed to isolate the vehicle from any electrical charge:

1. Remove the key.
2. Turn off all switches.

### WARNING

DO NOT MANIPULATE ELECTRICAL CONNECTIONS OR GENERATE SPARKS AROUND BATTERIES. SPARKS CAN CAUSE A BATTERY EXPLOSION AND ACID SPLASHING. DURING MAINTENANCE, ALWAYS DISCONNECT THE CHARGER AND USE INSULATED TOOLS THAT DO NOT GENERATE SPARKS. FAILURE TO COMPLY CAN CAUSE SERIOUS INJURIES.

3. Take off the battery cover to reach the batteries.
4. Disconnect the battery pack by unplugging the SB-350 grey connector (See figure 3.a : Detail C on page 20).
5. Discharge the capacitor in the AC motor controller (1) by connecting a 10 ohms / 25 W resistor (2) for a few seconds across the AC motor controller's (1) **B+** and **B-** terminals. Do not leave the resistor (2) on the terminals once discharged.
6. Using a multimeter, validate the absence of voltage between the AC motor controller's (1) **B+** and **B-** terminals.
7. To reconnect the electrical circuit, perform this procedure in reverse.
  - **NOTE** : No resistor needed for reconnection.

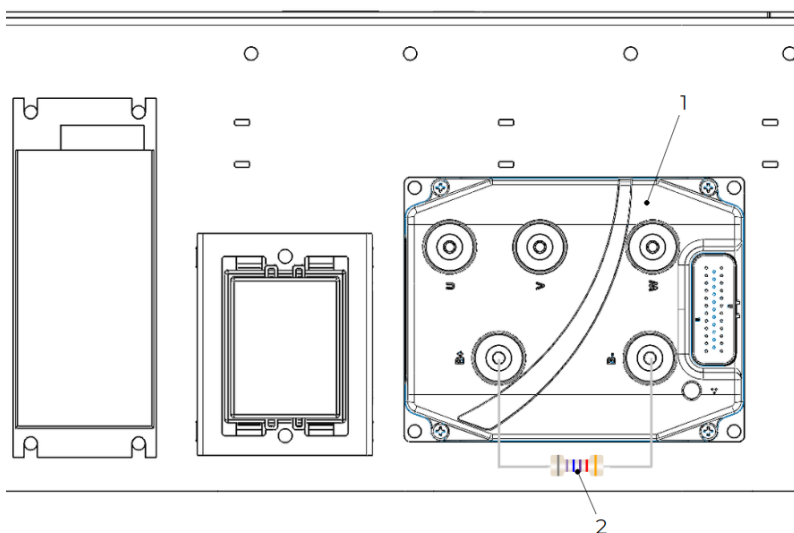


Figure 20. AC Motor Controller Terminals.



## 4.2 PREVENTIVE MAINTENANCE



### WARNING

FOLLOW THE MAINTENANCE SCHEDULE PROVIDED IN THIS MANUAL. FAILURE TO COMPLY CAN LEAD TO INJURIES OR DAMAGE TO THE VEHICLE.

### NOTICE

The preventive maintenance schedule specifies the minimum maintenance requirements based on standard use of the vehicle. An early preventive maintenance could be required if the vehicle is operated under severe conditions.

Preventive maintenance is essential for ensuring the durability of the product and the safety of the operator. Maintenance should be conducted at specific intervals (daily, weekly, 250 hours, 500 hours, 1000 hours, or 2000 hours), depending on the vehicle's runtime or the time elapsed, whichever occurs first. This proactive approach helps identify and address any potential issues before they escalate, contributing to the overall longevity and optimal performance of the product.

**NOTE:** The vehicle runtime is counted while the vehicle is in operation, and won't be affected while the key is in the ON position and the vehicle is idle. The vehicle runtime can be found on bottom left of the display screen when starting the vehicle.

### Maintenance Timer Reset

When the vehicle reaches its predefined vehicle runtime limit, the vehicle speed will be reduced and the fault code 54 will appear on the dashboard to inform the operator that maintenance is due. It does not indicate a defect of any sort.

Once the preventive maintenance is completed, the timer must be reset, and the fault code erased. The timer can be reset as follows:

1. Put the ignition key ON.
2. Hold the **Enter** button for 5 seconds.
3. Select **Operation Menu**.
4. Select **Reset Maintenance Monitor**.
5. Select **Reset** and exit.



## 4.2.1 DAILY MAINTENANCE

Special Tools	Consumables
► N/A	► N/A

**NOTICE** — Replace any defective component found during the inspection listed below.

### Maintenance Procedures

#### Visible Damage Inspection

Inspect for excessive visible damage on the exterior of the vehicle or to components under the vehicle.

#### Fluid Leaks Inspection

A leak could come from the differential or the brake system. The vehicle may be lifted for further inspection of this symptom as required.

Proceed as follows to inspect:

1. Inspect the master cylinder (1).

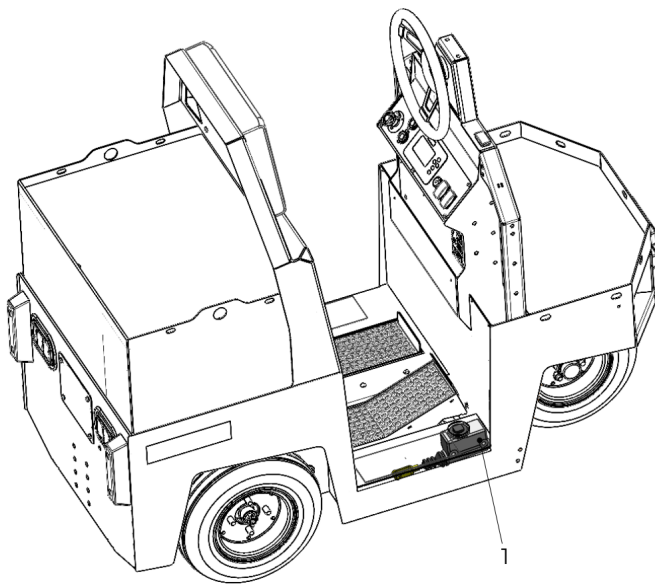


Figure 21. Front Fluid Leaks.

2. Inspect the drive assembly (2) for signs of leaks at following locations:
  - Axle ends.
  - Right and left casings mating surfaces.
  - Drain/fill plugs.

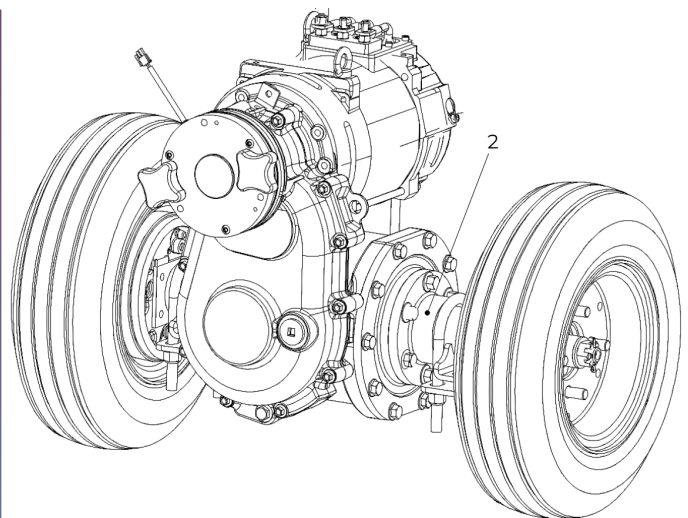


Figure 22. Drive Assembly Fluid Leaks.

#### Steering Inspection

Rock the steering wheel, inspect the steering system for hard steering, excessive play, or unusual sounds when turning.

#### Horn and Lights Inspection

Inspect the correct operation of all lights, strobes, horn, and reverse alarm.

#### Master and Operator's presence detection Pedals Inspection

1. Examine both pedals to check their feel and travel.
2. Apply pressure to the master pedal for a duration of 10 seconds and feel for any downward creasing.



### Accelerator Pedal Inspection

1. Inspect the accelerator pedal for free movement and proper return spring tension.
2. Test the accelerator pedal's sensitivity and response. It should provide a smooth and predictable increase in motor as the pedal is pressed. Any delays or irregularities in the response may indicate a problem.

### Emergency Button Inspection

1. Visually inspect the button for any visible damage or irregularities.
2. Test the emergency button to verify that it activates as intended. Ensure it depresses and releases smoothly without any sticking.

### Static Strap Inspection

Check the static strap (if applicable) for signs of excessive wear and ensure it has an adequate length. When the vehicle is on its wheels and stationary, the strap should have a minimum of two inches in contact with the ground.

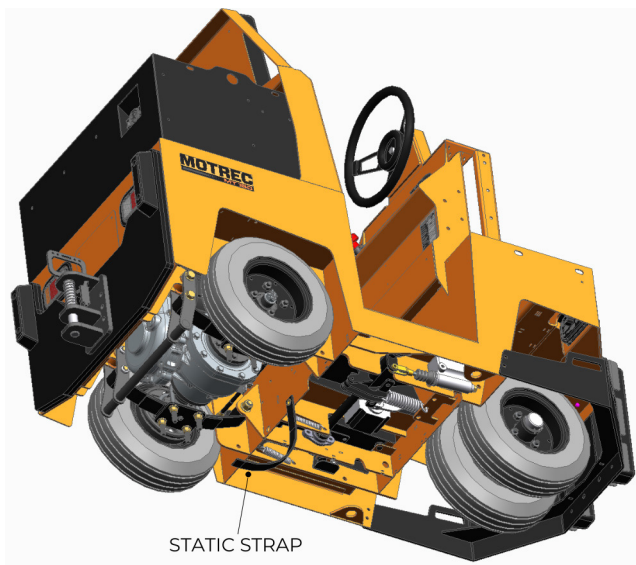


Figure 23. Static Strap.

### Electromagnetic brake (EMB) Inspection

1. Set the vehicle to neutral.
2. Engage the electromagnetic brake (EMB).  
**NOTE** : turn OFF the vehicle in order for the EMB to automatically engage.
3. Push the vehicle to validate that the parking brake is correctly engaged. The vehicle should not move.
4. Confirm the EMB disengagement by listening for a clicking sound when the vehicle begins to move.



4.2.2 WEEKLY MAINTENANCE

Special Tools	Consumables
► N/A	1. Distilled water

**NOTICE** — Replace any defective component found during the inspection listed in this procedure.

Maintenance Procedures

Tire Pressure Inspection

Check that each tire maintains a pressure rating of approximately 60 psi (only if the tires are pneumatic). Additionally, thoroughly inspect the tires for any signs of punctures, damage or excessive wear.

Battery Electrolyte Inspection and Top-Up

**NOTE:** This inspection does not apply to sealed batteries or lithium batteries.

1. Fully charge the batteries.

**NOTE:** When the batteries are charged, the fluid expands and can seep out if overfilled. Refill each cell after full charge when the fluid has expanded to its maximum level.

2. Remove the batteries box cover, to access the batteries located under the driver’s seat.
3. For each battery in the battery compartment, inspect and refill as necessary with distilled water to the recommended manufacturer level.
4. Reinstall the batteries box cover to conceal the batteries.

**NOTE:** Once the regular charging process is completed, it is recommended to disconnect the charger from the battery bank for approximately 10 seconds and then reconnect it. This step is crucial for performing the equalization charging. By briefly disconnecting and reconnecting the charger, you allow the charger to reassess the battery bank’s condition and adjust the charging parameters accordingly. This helps distribute the charging current more evenly among the battery cells. Performing the equalizing charge regularly helps optimize the performance and longevity of the battery bank.



WARNING

WHEN WORKING AROUND BATTERIES, ALWAYS WEAR ACID PROOF PROTECTIVE EQUIPMENT, SUCH AS FACE SHIELD AND THE APPROPRIATE GLOVES. BATTERIES CONTAIN SULFUR ACID THAT CAN CAUSE SEVERE BURNS ON SKIN OR EYES. RINSE CONTAMINATED AREA IMMEDIATELY WITH WATER.



WARNING

DO NOT OPEN THE BATTERY COMPARTMENT BEFORE DISCONNECTING THE CHARGER. BATTERIES EMIT HIGHLY EXPLOSIVE GASES WHICH GREATLY INCREASE WHEN CHARGING. FAILURE TO COMPLY CAN CAUSE SERIOUS INJURIES.



### 4.2.3 EVERY 250 HOURS OR 3 MONTHS MAINTENANCE

Special Tools	Consumables
<ul style="list-style-type: none"> <li>▶ Resistor: 10 ohms, 25 W</li> <li>▶ Lifting device</li> </ul>	<ul style="list-style-type: none"> <li>▶ Lubricant spray</li> <li>▶ Bearing grease</li> <li>▶ Compressed air</li> </ul>

**NOTICE** — Replace any defective component found during the inspection listed in this procedure.

**NOTICE** — When required, lift the vehicle using a lifting device as per section 4.1.1 LIFTING POINTS.

#### Maintenance Preparation Steps

Before conducting any maintenance tasks, it is essential to follow the subsequent steps to ensure safety during maintenance and enable easy access to components.

1. Remove the deck (1).
2. Remove the batteries box cover (2).
3. Remove the dashboard cover (3).

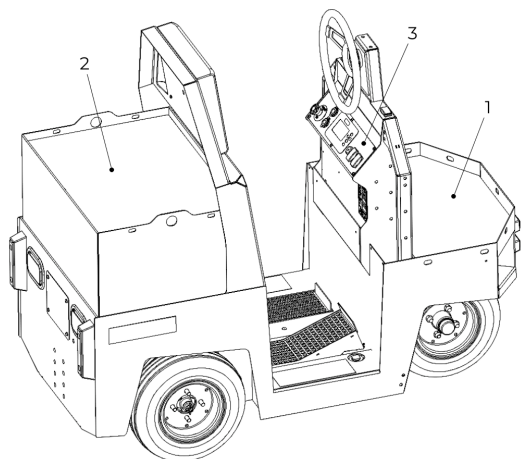


Figure 24. Deck, Batteries Box Cover And Dashboard Cover Removal.

4. Take the necessary steps to remove electrical hazards in accordance with **Section 4.1.2** page 27, which provides guidelines for electrically isolating the vehicle.



#### WARNING

DO NOT WORK ON ANY COMPONENTS OF THE ELECTRICAL SYSTEM UNTIL THE VEHICLE IS ELECTRICALLY ISOLATED. VOLTAGES OF UP TO 50 V AND HIGHER CAN BE PRESENT. FAILURE TO COMPLY CAN CAUSE INJURIES.



## Maintenance Procedures

### Suspension Inspection

1. Inspect the Rear leaf springs (1) and their fixtures for damage and corrosion.
2. Examine the suspensions frame bushings (2) for any signs of looseness or movement.

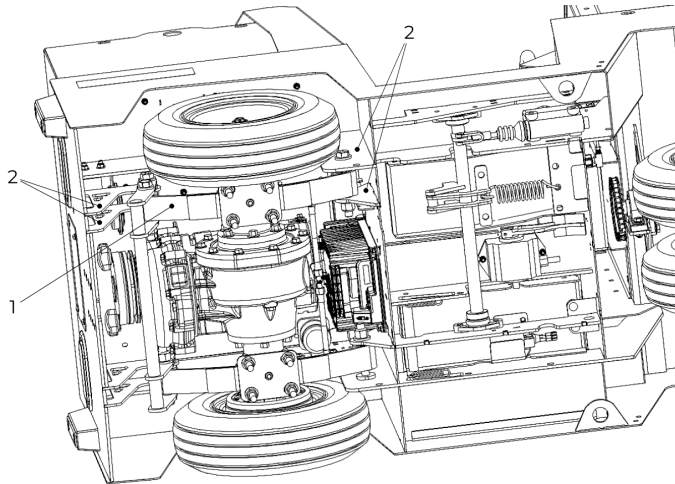


Figure 25. Rear Suspension Inspection.

### Steering Inspection

Inspect the following elements for damage or corrosion:

- Steering sprocket (2)
- Chain (3)
- Sprocket (4)
- Steering shaft (5)
- Pinion bevel gear (6)
- Steering gear (7)
- Pillow block bearings (8)
- Flange block bearings (9)

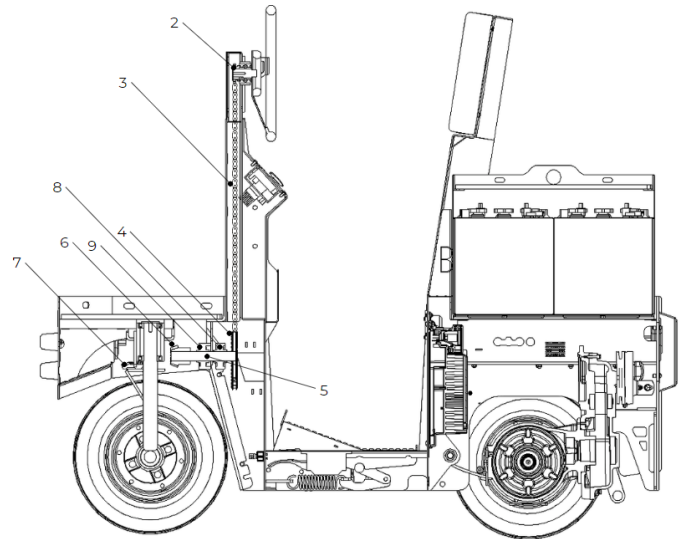


Figure 26. General Steering Inspection.

### Grease Fittings Lubrication

Lubricate the grease fittings of the following components (see Figure 26):

- Pillow block bearings (8)
- Flange block bearings (9)

### Lubrication

Lubricate the following components :

- Brake assembly (see Figure 9 page 17 - part no. 8).
- Chain (see Figure 26 page 33 - part no. 3).
- Steering shaft (see Figure 26 page 33 - part no. 5).

### Electromagnetic Brake Inspection

1. Chock the vehicle's wheels.
2. Remove the electromagnetic brake's rubber shield (1).
3. Insert the service knobs (2) to free the electromagnetic brake's rotor.
4. Clean the gap (3) created with compressed air.

**NOTE :** It is crucial not to breathe during this process due to potential airborne particles.

5. Remove the service knobs (2) from the electromagnetic brake.



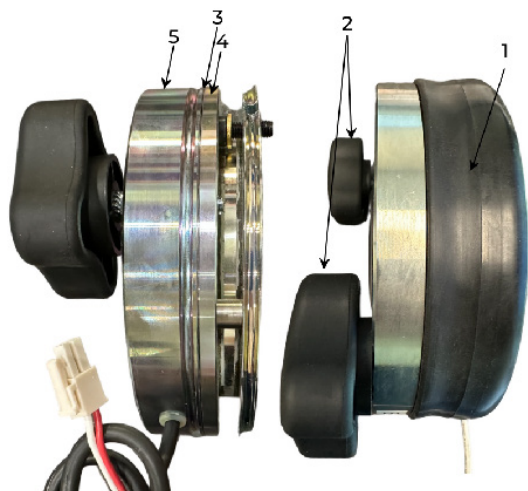


Figure 27. EMB Inspection.

6. Using a feeler gauge, measure the air gap (3) between pressure plate (4) and the electromagnet (5).
  - If the air gap is 0.030" or less, skip to next step.
  - If the air gap is greater than 0.030", check the tag on the electromagnetic brake:
    - Replace the EMB's rotor if a CNX brake is installed.
    - Replace the EMB assembly if a Warner brake is installed.
7. Reinstall the rubber shield (1). Replace rubber shield (1) if the rubber shows any sign of dryness or damages.
8. Remove the knobs (2).

#### AC Motor Dusting

If the vehicle is equipped with the fan cooled AC motor, clean the motor's air vents with compressed air.

**NOTE :** Clean any dust accumulation on other components if necessary.

#### Power Circuit Inspection

1. Inspect the power cables for visible damage.
2. Inspect the electrical connections for:
  - Corrosion.
  - Loose connections.

#### Battery Inspection

1. Inspect the batteries for the following elements:
  - Loose connections.
  - Damaged cables.
  - Acid spill.
  - Loose terminal posts.
  - Corrosion.
  - Swelled casing.
2. If corrosion is present on battery posts:
  - a. Remove the cable connectors.
  - b. Use a wire brush to remove any particles.
  - c. Clean the terminals with a suitable product.
  - d. Reinstall the removed cables.



#### WARNING

WHEN WORKING AROUND BATTERIES, ALWAYS WEAR ACID PROOF PROTECTIVE EQUIPMENT, SUCH AS FACE SHIELD AND THE APPROPRIATE GLOVES. BATTERIES CONTAIN SULFURIC ACID THAT CAN CAUSE SEVERE BURNS ON SKIN OR EYES. RINSE CONTAMINATED AREA IMMEDIATELY WITH WATER.



#### CAUTION

AFTER CLEANING, DO NOT REAPPLY POWER UNTIL TERMINAL AREAS ARE THOROUGHLY DRY. FAILURE TO COMPLY CAN DAMAGE THE VEHICLE.



### Test Drive

After the maintenance is finished, it is necessary to reinstall any disassembled parts and conduct a thorough test on the vehicle to ensure that all systems are functioning correctly.

1. Reconnect the electrical circuit:
  - i. Reconnect the SB-350.
  - ii. Insert the key.
  - iii. Turn on all switches and test lights.
2. Test drive the vehicle:
  - i. Turn the steering wheel and feel for excessive play.
  - ii. Switch the drive mode from Turtle to Rabbit and test the speed.
  - iii. Depress and release the accelerator to test the electromagnetic brake.
  - iv. Listen for abnormal noise.
3. Reinstall the deck.
4. Reinstall the batteries box cover.
5. Reinstall the dashboard cover.



## 4.2.4 EVERY 500 HOURS OR 6 MONTHS MAINTENANCE

Special Tools	Consumables
<ul style="list-style-type: none"><li>▶ Resistor: 10 ohms, 25 W</li><li>▶ Compressed air</li></ul>	<ul style="list-style-type: none"><li>▶ Bearing grease</li><li>▶ DOT-3 fluid brake</li></ul>

### NOTICE

Replace any defective component found during the inspection listed in this procedure.

### NOTICE

When required, lift the vehicle using a lifting device as per section 4.1.1 LIFTING POINTS.

### NOTICE

The 250 hours or 3 months preventive maintenance should be carried out concurrently with this maintenance. Certain steps may not be necessary due to redundancy.

### Maintenance Preparation Steps

Before conducting any maintenance tasks, it is essential to follow the subsequent steps to ensure safety during maintenance and enable easy access to components.

1. Remove the deck (1)

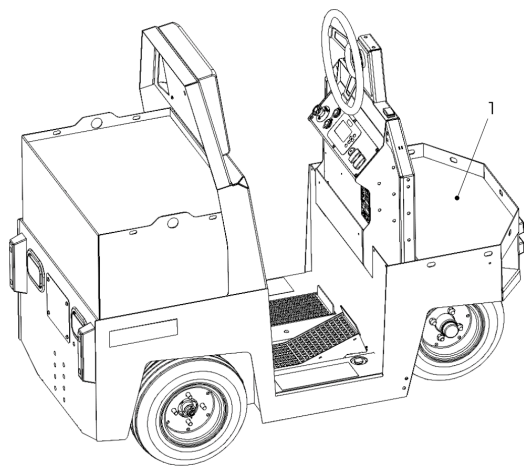


Figure 28. Deck Removal.

4. Take the necessary steps to remove electrical hazards in accordance with **Section 4.1.2** page 27, which provides guidelines for electrically isolating the vehicle.



### WARNING

DO NOT WORK ON ANY COMPONENTS OF THE ELECTRICAL SYSTEM UNTIL THE VEHICLE IS ELECTRICALLY ISOLATED. VOLTAGES OF UP TO 50 V CAN BE PRESENT. FAILURE TO COMPLY CAN CAUSE INJURIES.

### Maintenance Procedures

#### Decals and Labels Inspection

Inspect decals and safety labels for damage. Replace them if any part of the text is illegible.

#### Frame Inspection

1. Inspect the vehicle's frame for Cracks, damage or Corrosion.
2. The following frame locations should be inspected with care:
  - Side panels corners (1) (both sides). There is a possibility of cracks occurring in these corners as they undergo significant stress (see Figure 29).
  - Rear suspension mounting tabs (2) (see Figure 30).
  - Weld zones (3) (see Figure 31, not all welds are shown).



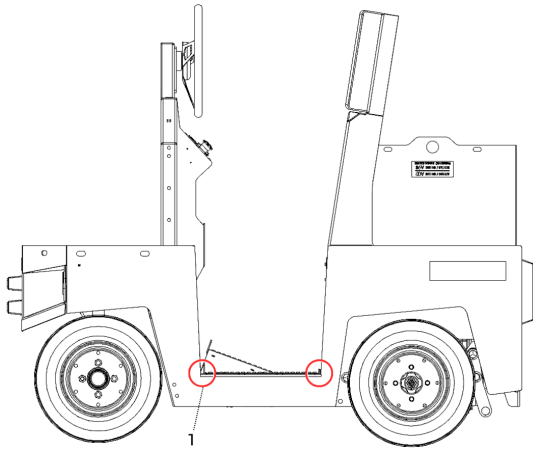


Figure 29. Side Panels.

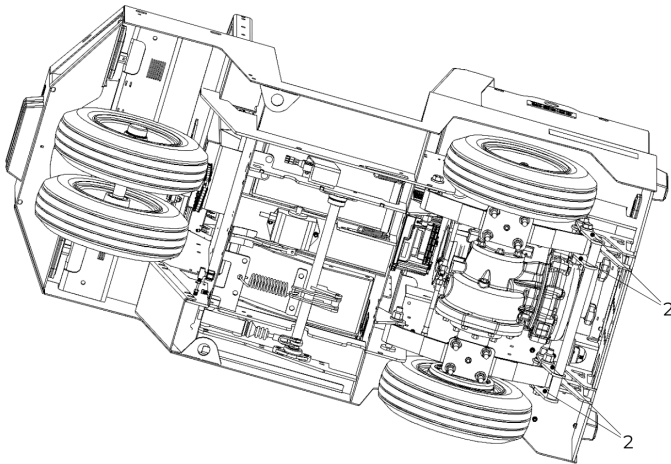


Figure 30. Rear Suspension Mounting Tabs.

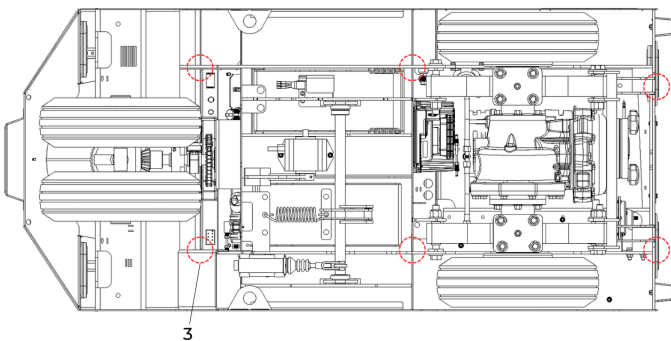


Figure 31. Hitch Mounting.

## Drum Brake Inspection

proceed as follows for each of the vehicle's drum brakes:

1. Remove the wheel nuts (1).
2. Remove the wheel (2).
3. Remove the brake drum (3).
4. Clean brake dust with water.
5. Inspect the brake drum (3) for excessive wear or scoring.
6. Inspect the drum shoes. Replace the shoes and springs if the lining thickness is 1/16 in (2 mm) or less.
7. Inspect the drum brake system (4) for corrosion, wear, brake fluid leak, and brake dust.
8. Reinstall the brake drum (3), the wheel (2), and the wheel nuts (1).
9. Torque the wheel nuts (1) to standard values. The appropriate torque value is 80 ft lbs.

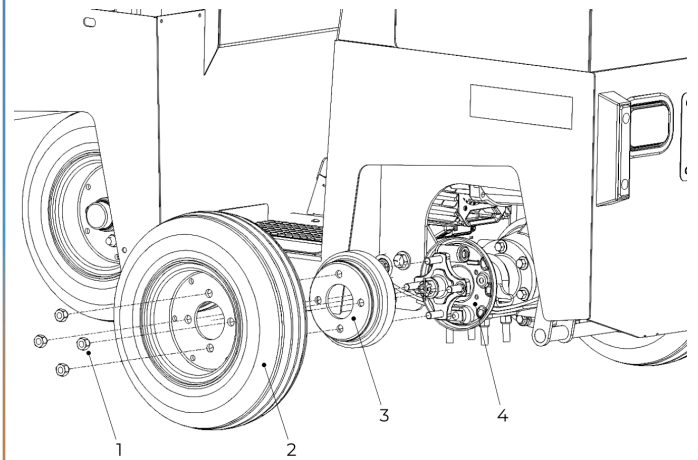


Figure 32. Drum Brake System Inspection.



## WARNING

AVOID INHALING BRAKE DUST; WEAR PROTECTIVE GLOVES AND A MASK WHEN WORKING NEAR BRAKES. PROLONGED EXPOSURE CAN LEAD TO RESPIRATORY ISSUES AND SKIN IRRITATION.



### Brake System Inspection

1. Inspect the brake system components for signs of corrosion, damage or leaks.
2. Inspect the brake fluid level in the master cylinder (1) placed underneath the master pedal mat. Refill with DOT-3 fluid brake if required.

**NOTE :** A low level of brake fluid indicate either brake wear or fluid leaks.

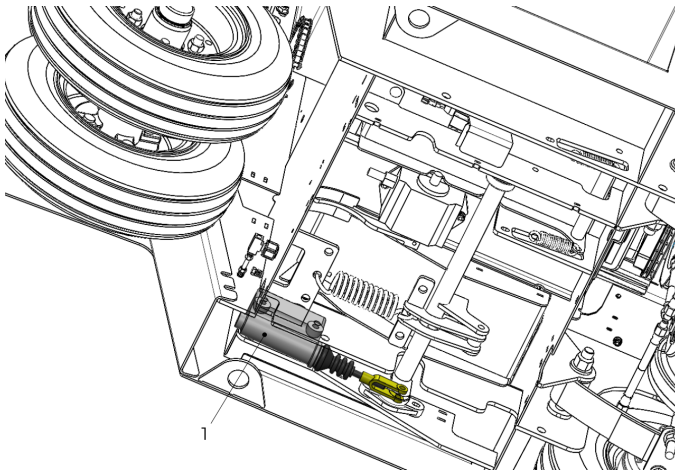


Figure 33. Master Cylinder Inspection.

3. Check brake mechanical linkages for wear and play.
4. Check brake linings for wear ( $1/16$ " (1 mm) minimum lining thickness).

### Bearings Inspection

1. Lubricate the grease fittings of the following components:
  - Pillow block bearings
  - Flange block bearings
2. Inspect all wheel bearings for play, stiffness or abnormal noise.

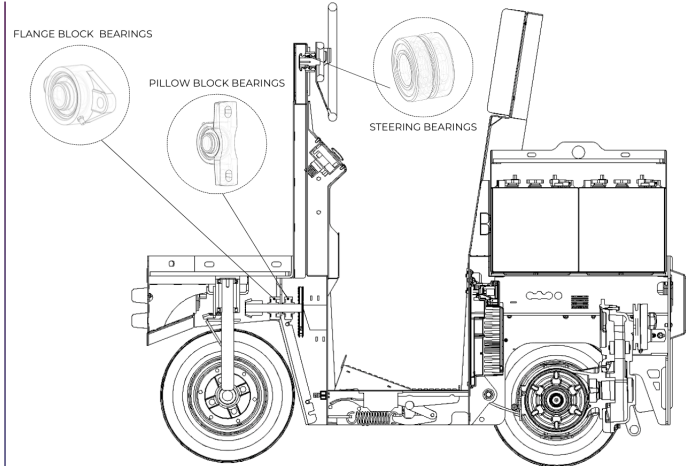


Figure 34. Bearings Inspection and Greasing.



## 4.2.5 EVERY 1000 HOURS OR 12 MONTHS MAINTENANCE

Special Tools	Consumables
<ul style="list-style-type: none"><li>▶ Resistor: 10 ohms, 25 W</li><li>▶ Lifting device</li><li>▶ Slings</li><li>▶ Oil recipient</li></ul>	<ul style="list-style-type: none"><li>▶ Mobil Mobilube 1 SHC 75W-90 oil</li><li>▶ Molybdenum disulfide grease (6g)</li><li>▶ Bearing grease</li><li>▶ Cotter pin (Size : 1/16x2 )</li></ul>

**NOTICE** When required, lift the vehicle using a lifting device as per section 4.1.1 LIFTING POINTS.

**NOTICE** The 500 hours or 6 months preventive maintenance should be carried out concurrently with this maintenance. Certain steps may not be necessary due to redundancy.

### Maintenance Preparation Steps

Before conducting any maintenance tasks, it is essential to follow the subsequent steps to ensure safety during maintenance and enable easy access to components.

1. Take the necessary steps to remove electrical hazards in accordance with **Section 4.1.2** page 26, which provides guidelines for electrically isolating the vehicle.



#### WARNING

DO NOT WORK ON ANY COMPONENTS OF THE ELECTRICAL SYSTEM UNTIL THE VEHICLE IS ELECTRICALLY ISOLATED. VOLTAGES OF UP TO 50 V CAN BE PRESENT. FAILURE TO COMPLY CAN CAUSE INJURIES.

### Maintenance Procedures

#### Drive Splines Maintenance

1. Disconnect all electrical cables from the AC motor (1).
2. Place the slings around the motor.
3. Support the AC motor (1) with the appropriate lifting device so that the motor can be slightly moved horizontally once the screws (2) are removed.



#### CAUTION

DO NOT REMOVE THE AC MOTOR FROM THE DIFFERENTIAL UNTIL IT IS CORRECTLY SUPPORTED. THE MOTOR WEIGHS ABOUT 40 LB (18 KG). FAILURE TO COMPLY CAN DAMAGE THE EQUIPMENT.

4. Remove the screws (2) joining the AC motor (1) to the differential (3).



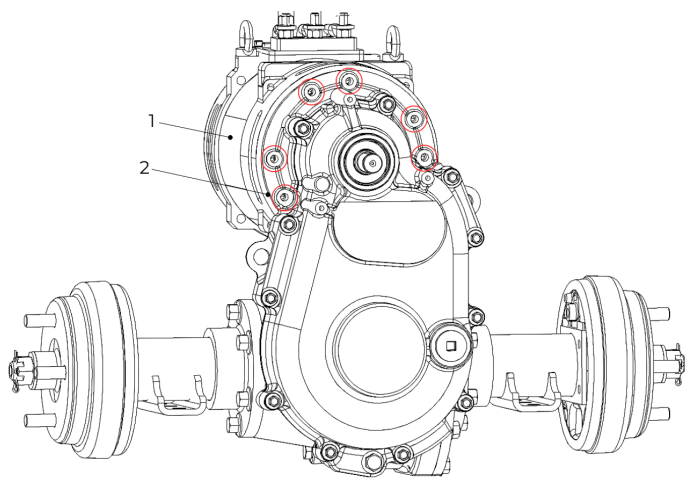


Figure 35. Disconnecting AC Motor.

5. Remove the AC motor (1) from the differential (3), to access the drive splines (4).

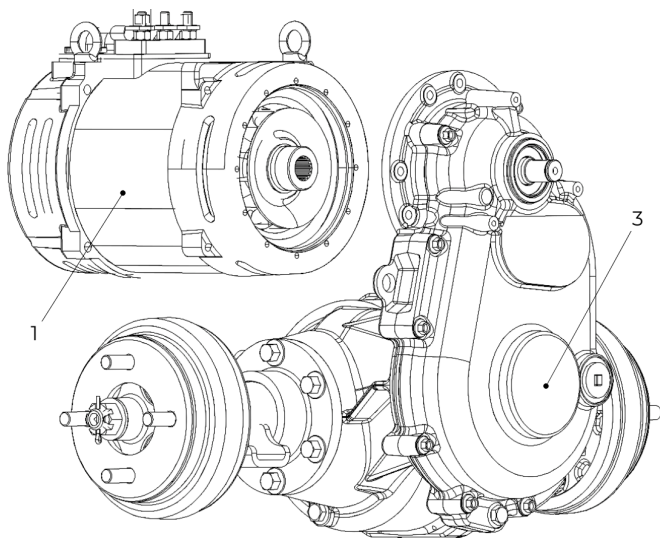


Figure 36. Removing AC Motor.

6. Clean the AC motor (1) from dust or debris accumulation (if applicable).
7. Inspect the AC motor and the differential drive splines (4) for corrosion or damage.
8. Lubricate the AC motor and the differential drive splines (4) with molybdenum disulfide grease (2.5 ml is required).

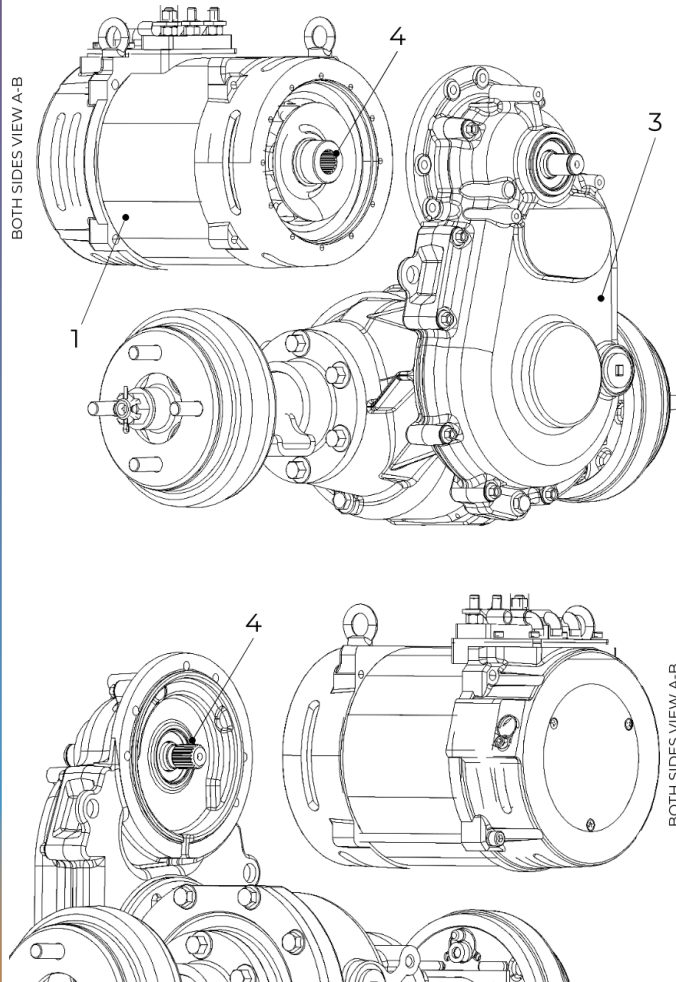


Figure 37. Drive Splines Inspection And Lubrication.

9. Reinstall the AC motor (1) on the differential (3) with the five screws (2).
10. Torque the screws (2) to standard values. The appropriate torque value is 24 ft lbs.
11. Remove the slings from the AC motor (1).
12. Reconnect the electrical cables to the AC motor (1).



**NOTE :** Ensure that the connections are properly reestablished, matching the corresponding letters U, V, and W from the controller with the corresponding letters on the motor.

### Differential Maintenance

Proceed as follows if the vehicle is equipped with the **Schafer twin-case** :

1. Position a recipient under the differential to collect the drained oil in next steps.
2. For the ALUMINUM CASE :
  - a. Remove the filler plug (1).
  - b. Remove the drain plug (2) until the case is completely drained of oil.
  - c. Reinstall the drain plug (2).
  - d. Add **625 mL** (stop if the oil reaches the bottom of the filling hole) of SAE 80W90 GL5 differential oil.
  - e. Reinstall the filler plug (1).

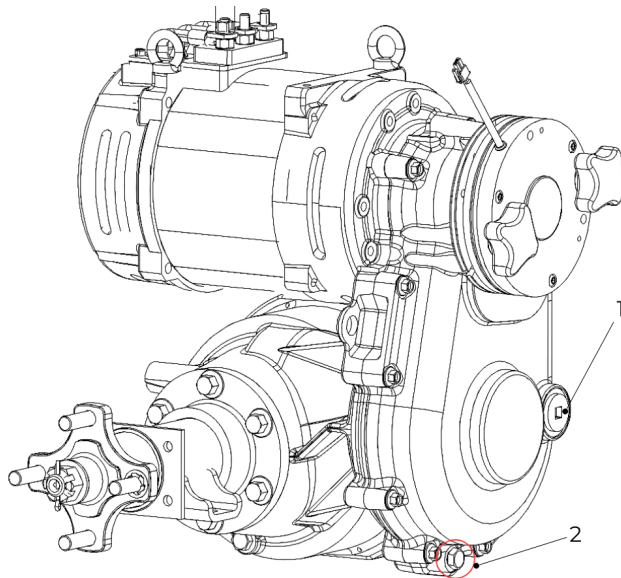


Figure 38. Schafer Aluminum Case.

3. For the CAST-IRON CASE :
  - a. Remove the filler plug (1).
  - b. Remove the drain plug (2) until the case is completely drained of oil.
  - c. Reinstall the drain plug (2).
  - d. Add **390 mL** (stop if the oil reaches the bottom of the filling hole) of SAE 80W90 GL5 differential oil.
  - e. Reinstall the filler plug (1).

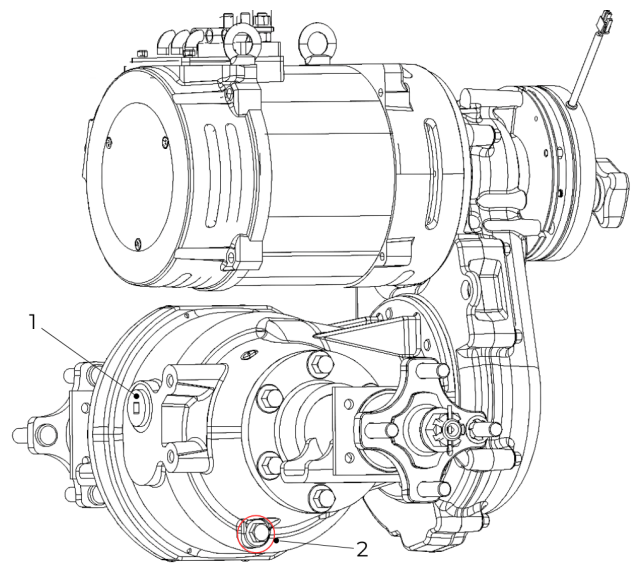


Figure 39. Schafer Cast-Iron Case.



### Front Hub Maintenance

1. Chock the rear wheels.
2. Remove the wheel nuts (1) and wheel (2).

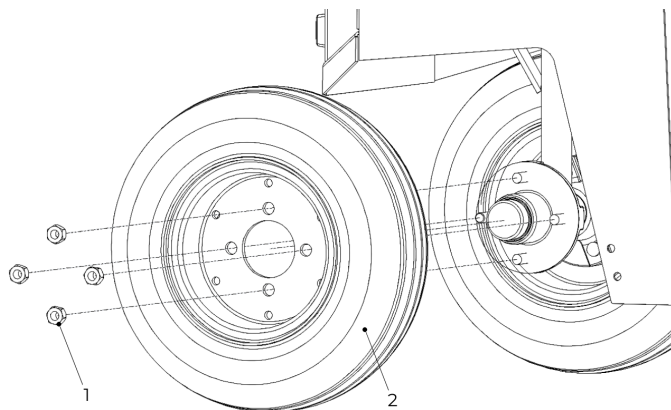


Figure 40. Front Wheel Removal.

3. Remove the dust cap (3).
4. Remove the cotter pin (4) and unscrew the castle nut (5).
5. Remove the hub (6) from the fork pivot axle (7).

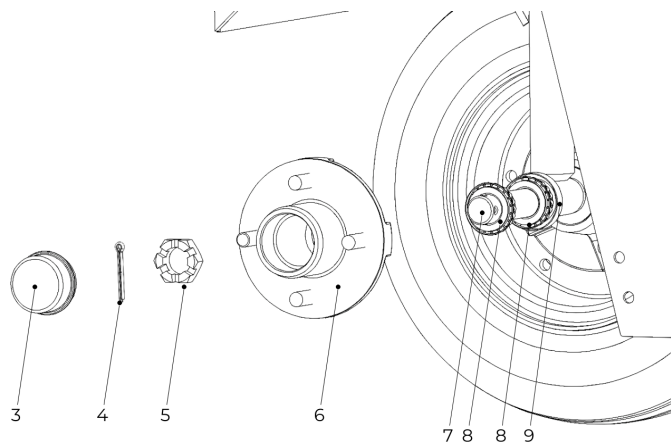


Figure 41. Front Hub.

6. Inspect the bearings (8) and their races for wear.
7. Discard the seal (9). Refer to the *PARTS CATALOG (MPV)* for seal replacement.
8. Clean the bearing (8) and if they are still usable, apply the grease.
9. Install a new seal (9) and the bearings (8) into the hub (6).
10. On the fork pivot axle (7), clean the seating surface of the hub (6) from any debris.

11. Position the hub (6) on the fork pivot axle (7).
12. Tighten the castle nut (5) to 103 ft·lbf to seat the bearings (8), then loosen the castle nut (5) by unscrewing one full turn.
13. Hand-tighten the castle nut (5).
14. Install a new cotter pin (4).
15. Install the dust cap (3).
16. Reinstall the wheel (2) and the wheel nuts (1). Torque the wheel nuts (1) to standard values. The appropriate torque value is 80 ft lbs.

### Rear Hub Maintenance

1. Chock the front wheels.
2. Remove the wheel nuts (1) and wheel (2).
3. Remove the brake drum (3).
4. Clean brake dust with water.

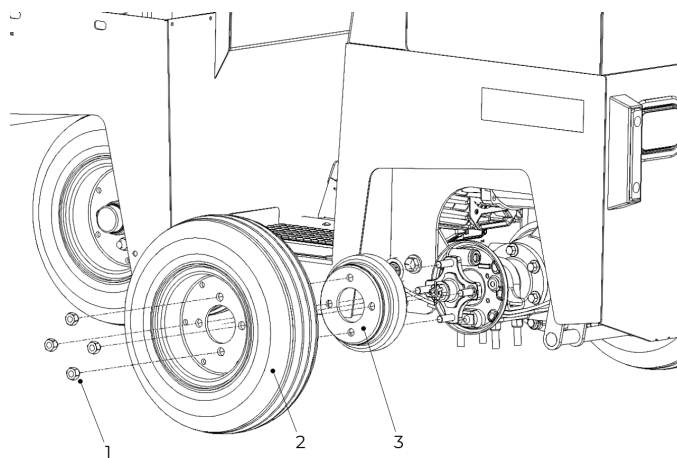


Figure 42. Rear Wheel And Brake Drum Removal.

5. Remove the cotter pin (4) and unscrew the castle nut (5).
6. Remove the hub (6) from the spindle (7).



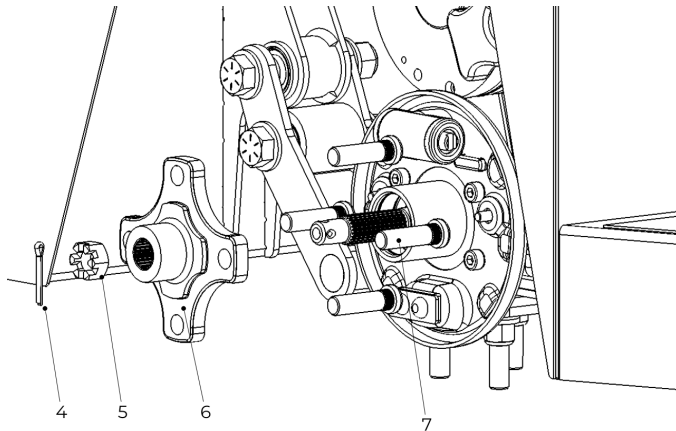


Figure 43. Rear Hub.

7. Examine the rear hub (6) for any abnormal sounds or signs of looseness.
8. Adjust the positioning of the hub (6) on the spindle (7).
9. Securely reinstall the castle nut (5) and tighten it.
10. Replace the cotter pin (4) with a new one and install it properly.
11. Install the brake drum (3).
12. Reinstall the wheel (2) and the wheel nuts (1). Torque the wheel nuts (1) to standard values. The appropriate torque value is 80 ft lbs.

### Hardware Maintenance

1. Inspect and tighten all electrical connections. Clean or replace any connection that shows signs of corrosion or damage.
2. Inspect and tighten all mechanical hardware. Replace any connection that shows signs of damage.

Refer to the **QUICK REFERENCES** at the end of this document for all torque values.



## 4.2.6 EVERY 2000 HOURS OR 24 MONTHS MAINTENANCE

Special Tools	Consumables
► Lifting device	► DOT-3 brake fluid

### NOTICE

The 1000 hours or 12 months preventive maintenance should be carried out concurrently with this maintenance. Certain steps may not be necessary due to redundancy.

### Maintenance Procedures

#### Hydraulic Brake System Fluid Maintenance

**NOTE:** The most recommended approach for brake fluid replacement is utilizing a bleeder ball tank or a comparable automatic bleeding device. Alternatively, repetitive manual bleeding is also acceptable.

1. If required, lift the vehicle using a lifting device as per section 4.1.1 LIFTING POINTS.
2. Remove the mat from the operator presence pedal.
3. Remove the master cylinder's (1) cap.

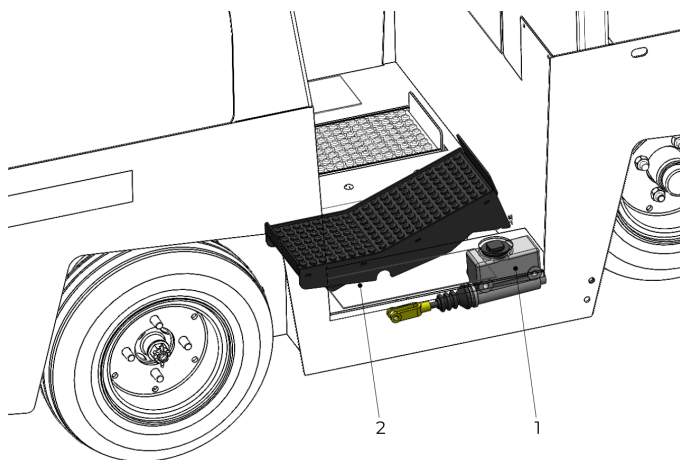


Figure 44. Brake System Bleeding.

4. Bleed rear wheel brakes one at a time:
  - i. Fill the master cylinder (1) with DOT-3 brake fluid, then reinstall the master cylinder's (1) cap.
  - ii. Bleed the rear wheel cylinder one at a time by losing the bleeder valve (3). Before

allowing oil only to come out, the bleeder valve (3) need to be tightened and the master pedal (2) need to be manually returned to its initial position.

**NOTE :** Pump the brake pedal a few times before reopening the bleeder valve.

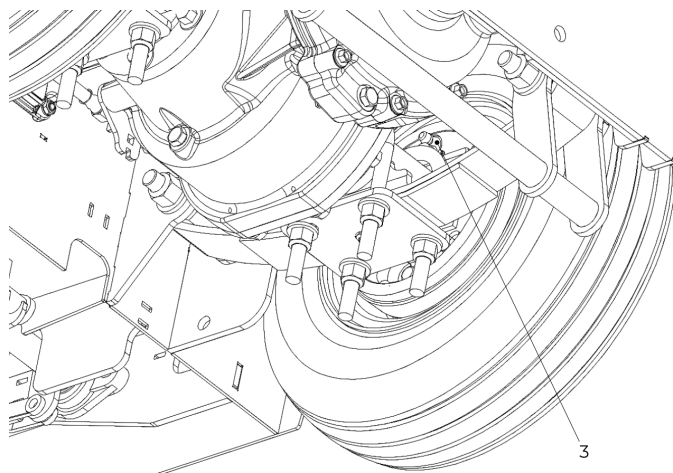


Figure 45. Rear Wheel Bleeding.

5. Once bleeding is completed, top-up the master cylinder (1) with DOT-3 brake fluid.
6. Reinstall the master cylinder's (1) cap.
7. Clean every fitting and line and remove traces of oil.
- NOTE :** Exercise with caution as oil fluid can potentially damage the paint.
8. Put back the mat from the operator presence pedal.
9. Apply continuous pressure on the heel of the master pedal for about ten seconds. Note any loss of pressure.
10. Inspect the brake lines and fittings for leaks.



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## 4.3 CORRECTIVE MAINTENANCE

### 4.3.1 ACCELERATOR

The accelerator cannot be repaired or serviced. Its maintenance only allows for inspection to verify the correct electrical values.

### 4.3.2 HYDRAULIC BRAKES

#### Procedures

##### Brake Pedal Bleeding

**NOTE :** The most recommended approach for brake fluid replacement is utilizing a bleeder ball tank or a comparable automatic bleeding device. Alternatively, repetitive manual bleeding is also acceptable.

1. If required, lift the vehicle using a lifting device as per section 4.1.1 LIFTING POINTS.
2. Remove the mat from the operator presence pedal.
3. Remove the master cylinder's (1) cap.

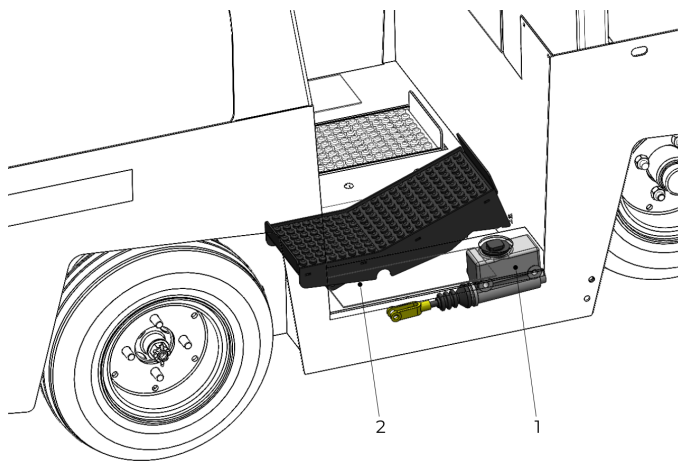


Figure 46. Brake System Bleeding.

4. Bleed rear wheel brakes one at a time:
  - i. Fill the master cylinder (1) with DOT-3 brake fluid, then reinstall the master cylinder's (1) cap.

- ii. Bleed the rear wheel cylinder one at a time by losing the bleeder valve (3). Before allowing oil only to come out, the bleeder valve (3) need to be tightened and the master pedal (2) need to be manually returned to its initial position.

**NOTE :** Pump the brake pedal a few times before reopening the bleeder valve.

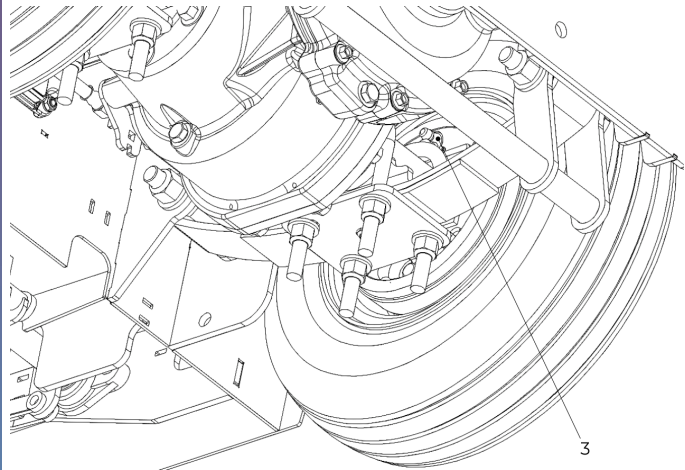


Figure 47. Rear Wheel Bleeding.

5. Once bleeding is completed, top-up the master cylinder (1) with DOT-3 brake fluid.
6. Reinstall the master cylinder's (1) cap.
7. Clean every fitting and line and remove traces of oil.
- NOTE :** Exercise with caution as oil fluid can potentially damage the paint.
8. Put back the mat from the operator presence pedal.
9. Apply continuous pressure on the heel of the master pedal for about ten seconds. Note any loss of pressure.
10. Inspect the brake lines and fittings for leaks.

#### Drum Brakes Replacement

1. Safely secure the vehicle using jack stands.
2. Remove the wheel nuts (1) and wheel (2).
3. Remove the brake drum (3).
4. Clean brake dust with water.



**NOTE :** Block the master pedal (5) before removing the drum brake (3).

6. Inspect the lining wear of the drum brake (4) system.
  - Replace the shoes and springs if the lining thickness is 1/16 in (2 mm) or less.

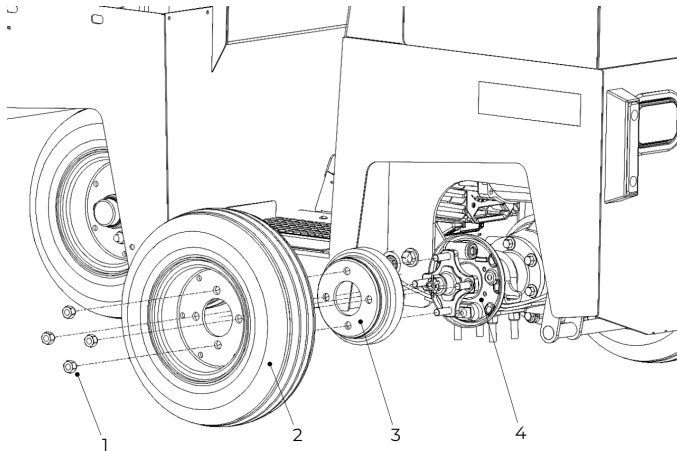


Figure 48. Drum Brake Inspection.

7. Fully seat the brake drum (3) in position.
8. Engage the electromagnetic brake's service knobs to free the wheel axle (if applicable).
9. Spin the brake drum (3) to validate that the shoes aren't overly tightened. The wheels must turn free when the brake pedal is released.
10. Reinstall the wheels (2).
11. Torque the wheel nuts (1) to standard values. The appropriate torque value is 80 ft lbs.

### 4.3.3 REAR AXLE

#### Procedures

##### Rear Axle Removal

**NOTE:** Ensure that the vehicle is properly supported on jack stands or that the wheels are chocked to prevent any accidental movement.

1. Remove the wheel nuts (1) and wheel (2).
2. Remove the brake drum (3).
3. Clean brake dust with water.

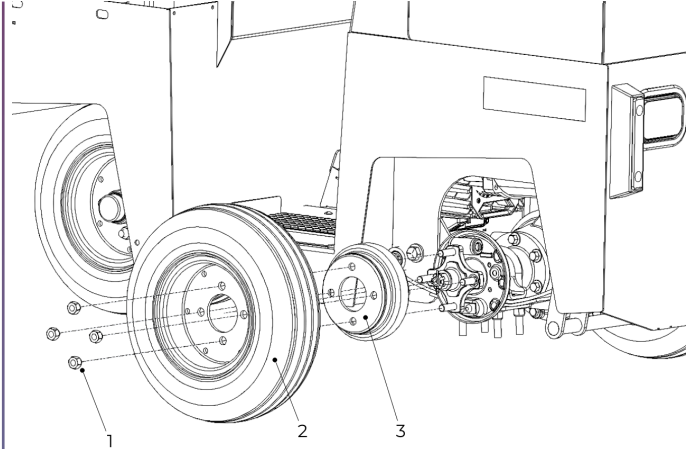


Figure 49. Rear Wheel And Brake Drum Removal.

4. Drain the differential fluid (if necessary). Keep a suitable container to catch the fluid and dispose of it properly.
5. Remove the cotter pin (4) which secures the castle nut. Use a pair of pliers or a cotter pin puller to remove it. Straighten the pin if necessary for easier removal.
6. Remove the castle nut (5) that secures the axle shaft by using an appropriate socket or wrench.
7. Remove the hub (6) from the spindle (7).
8. Remove the spindle (7) to access the axle shaft (8) properly.

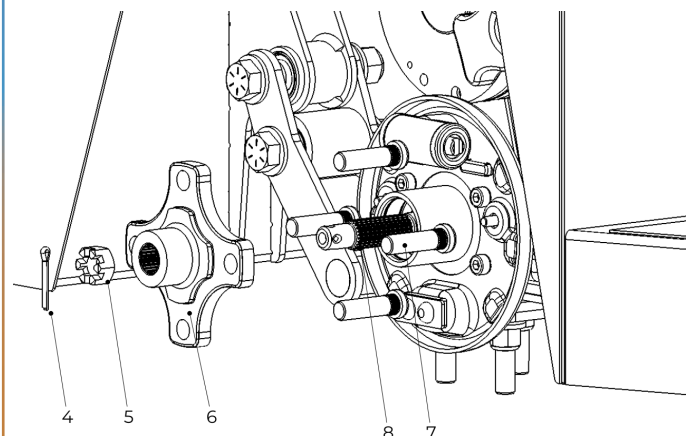


Figure 50. Cotter Pin - Castle Nut - Hub and Spindle Removal.

9. Remove the retaining circlip (9) that holds the bearings. Use the appropriate tool, such as snap ring pliers, to remove it. Carefully slide the clip out to release the axle shaft (8).





Figure 51. Circlip Removal.

10. Remove gently the axle shaft (8) straight out, being cautious not to damage the seals or surrounding components.
11. Inspect it for any signs of damage or wear. If necessary, replace the axle shaft, seals, or any other components that show signs of deterioration.
12. Slide the axle shaft (8) back into the differential, aligning it with the splines.
13. Reinstall the retaining circlip (9) to secure bearings in place. Ensure that the clip is properly seated and holds the axle shaft (8) securely.
14. Reinstall the spindle (7).
15. Reinstall and adjust the positioning of the hub (6) on the spindle (7).
16. Put back and tighten the castle nut (5) using the appropriate socket. The appropriate torque value is 103 ft lbs.
17. Slide a new cotter pin (4) through the castle nut's hole and bend the ends of the pin to prevent it from coming loose.
18. Reinstall the brake drum (3).
19. Torque the wheel nuts (1) to standard values. The appropriate torque value is between 80 ft lbs.
20. Validate that the differential oil level is adequate (it should reach the bottom of the filler hole). For more details, refer to section **4.3.4 DIFFERENTIAL subsection OIL CHANGE** on page 48.

## 4.3.4 DIFFERENTIAL

### Inspection

1. Look for leaks around:
  - Covers.
  - At axle ends.
  - Casing mating surfaces.
  - Drain/fill plugs.
2. Look for signs of external damage cracks, deformed parts, signs of impacts.
3. Inspect for excessive looseness in internal gears by gently rocking wheels.
4. Drain and inspect oil for excessive shavings/debris. (If removing cover, perform visual inspection).
5. Inspect suspension mounting (U bolts, shocks, leaf springs, etc.).
6. Test drive: listen for abnormal noise, feel for excess play, **test while turning** as well.

### Procedures

#### Oil Change

The MT-160 is equipped with a Schafer Twin-Case, which includes :

- The aluminum case.
- The cast-iron case.

**NOTE :** Recommended oil for all cases : SAE 80W90 GL5.



## Schafer Twin-Case Differential

### ALUMINUM CASE

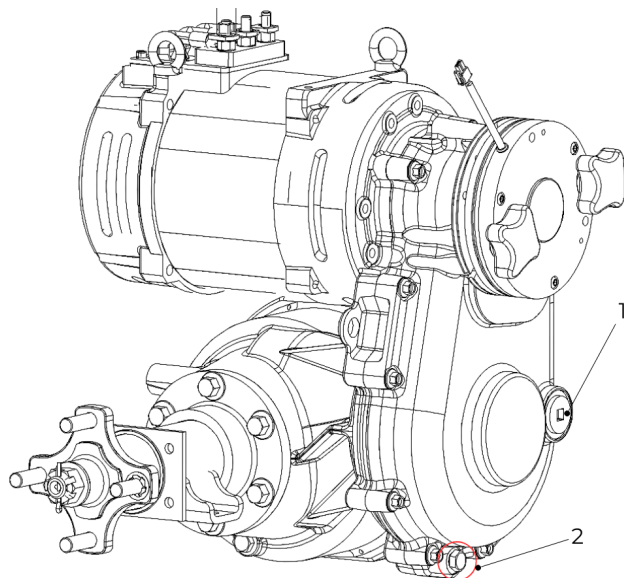


Figure 52. Schafer Aluminum Case.

1. Remove the filler plug (1).
2. Remove the drain plug (2) until the case is completely drained of oil.
3. Reinstall the drain plug (2).
4. Add **625 mL** (stop if the oil reaches the bottom of the filling hole) of SAE 80W90 GL5 differential oil.
5. Reinstall the filler plug (1).

### CAST-IRON CASE

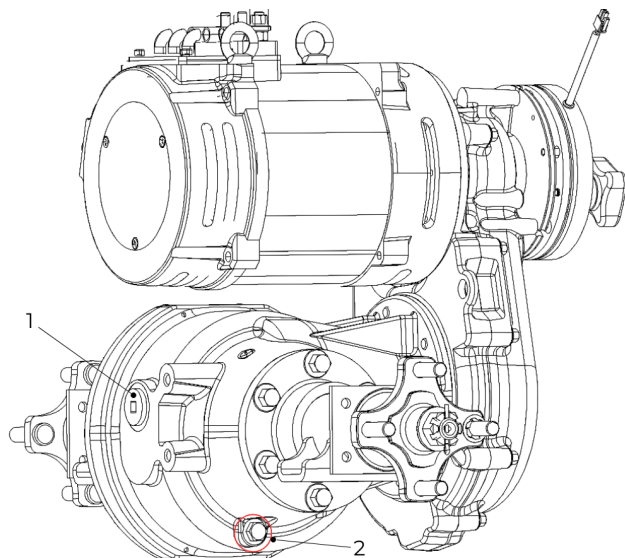


Figure 53. Schafer Cast-Iron Case.

1. Remove the filler plug (1).
2. Remove the drain plug (2) until the case is completely drained of oil.
3. Reinstall the drain plug (2).
4. Add **390 mL** (stop if the oil reaches the bottom of the filling hole) of SAE 80W90 GL5 differential oil.
5. Reinstall the filler plug (1).



### 4.3.6 BATTERY



#### WARNING

DO NOT MANIPULATE ELECTRICAL CONNECTIONS OR GENERATE SPARKS AROUND BATTERIES. SPARKS CAN CAUSE A BATTERY EXPLOSION AND ACID SPLASHING. DURING MAINTENANCE, ALWAYS DISCONNECT THE CHARGER AND USE INSULATED TOOLS THAT DO NOT GENERATE SPARKS. FAILURE TO COMPLY CAN CAUSE SERIOUS INJURIES.



#### WARNING

WHEN WORKING AROUND BATTERIES, ALWAYS WEAR ACID PROOF PROTECTIVE EQUIPMENT, SUCH AS FACE SHIELD AND APPROPRIATE GLOVES. BATTERIES CONTAIN SULFUR ACID THAT CAN CAUSE SEVERE BURNS ON SKIN OR EYES. RINSE CONTAMINATED AREA IMMEDIATELY WITH WATER.

#### Procedures

##### Battery Post Corrosion

If you notice corrosion on the battery posts, disconnect the cable connectors, utilize a wire brush to eliminate any debris, and proceed to clean them with a cloth dampened with ammonia solution.



#### CAUTION

AFTER CLEANING, DO NOT REAPPLY POWER UNTIL TERMINAL AREAS ARE THOROUGHLY DRY. FAILURE TO COMPLY CAN DAMAGE THE VEHICLE.

##### Electrolyte Level

**NOTE:** Does not apply to sealed batteries.

1. Inspect the batteries and fill with distilled water if needed.
2. Regularly used batteries generally require water levels to be inspected weekly. Underwatering leads to a shortened battery life. Over watering leads to battery corrosion. Be careful not to overfill any cell to avoid forcing out electrolyte while charging.

4. Fill each cell to plate level with distilled or deionized water, after battery charging. When the battery is charged, the fluid expands and can seep out if overfilled. Refill each cell after full charge, when the fluid has expanded to its maximum level.
5. Reinstall battery caps before charging.

##### Battery Mounting

A loose battery increases damaging effects of vibrations and is more prone to short circuiting.

##### Defective Battery

Discharging below a 20% SOC cuts down the battery life and the number of cycles available. Inspect specific gravity of each cell; if a cell is shorted, voltage drops may occur only when there is current. Refer to battery manufacturer's specifications for specific gravity of electrolyte.

##### Lithium Battery Maintenance

**NOTE:** Remember that lithium batteries are generally designed to be low maintenance compared to other battery types. However, following these basic maintenance procedures can help ensure the longevity and optimal performance of your lithium battery.



1. Clean the battery contacts: Over time, dust, dirt, or debris can accumulate on the battery contacts, affecting the performance and connection.
2. Gently clean the battery contacts using a dry cloth or a soft brush to maintain good contact.

**NOTE:** avoid deep discharge because Lithium batteries should not be completely discharged as it can lead to irreversible damage. Ideally, recharge the battery before it reaches a critically low level to prolong its lifespan.

**NOTE:** If the lithium battery is not in use for an extended period, store it in a cool and dry place

### **TPPL Battery Maintenance**

**NOTE:** Like lithium batteries, TPPL batteries are generally designed to be maintenance-free. They do not require regular electrolyte level checks or addition of water, unlike some other types of batteries (ex. Lead-acid battery).

1. Inspect and clean the battery terminals to ensure good electrical connections.
2. Remove any corrosion or dirt using a wire brush or a battery terminal cleaner. Proper terminal connections help maintain optimal performance.
3. Monitor electrolyte levels (if applicable). Some TPPL batteries may have removable caps or access points to check and maintain electrolyte levels.

### **Battery Charger Equalization**

Once the regular charging process is completed, it is recommended to disconnect the charger from the battery bank for approximately 10 seconds and then reconnect it. This step is crucial for performing the equalization charging. By briefly disconnecting and reconnecting the charger, you allow the charger to reassess the battery bank's condition and adjust the charging parameters accordingly. This helps distribute the charging current more evenly among the battery cells. Performing the equalizing charge regularly helps optimize the performance and longevity of the battery bank.



## 4.4 TROUBLESHOOTING

### PMC Self-Diagnostic Errors

Active fault codes will be displayed on the display to ease troubleshooting. The PMC also comes with a status LED, which gives a flashing code to help troubleshooting.

Reading fault codes should be your first step in diagnosing any issue.

For a list of all the fault codes, refer to section 5 ANNEXES at the end of this document.

### Battery Voltage



#### WARNING

DO NOT MANIPULATE ELECTRICAL CONNECTIONS OR GENERATE SPARKS AROUND BATTERIES. SPARKS CAN CAUSE A BATTERY EXPLOSION AND ACID SPLASHING. DURING MAINTENANCE, ALWAYS DISCONNECT THE CHARGER AND USE INSULATED TOOLS THAT DO NOT GENERATE SPARKS. FAILURE TO COMPLY CAN CAUSE SERIOUS INJURIES.



#### WARNING

WHEN WORKING AROUND BATTERIES, ALWAYS WEAR ACID PROOF PROTECTIVE EQUIPMENT, SUCH AS FACE SHIELD AND THE APPROPRIATE GLOVES. BATTERIES CONTAIN SULFUR ACID THAT CAN CAUSE SEVERE BURNS ON SKIN OR EYES. RINSE CONTAMINATED AREA IMMEDIATELY WITH WATER.

Some troubleshooting steps require to measure the voltage that the reaches the inspected components. The total battery voltage might be required for these inspections. Make sure batteries are securely connected and measure the voltage between the main fuse terminal (**B+**) and the AC motor controller's (**B-**) terminal for full battery voltage.

### 4.4.1 ACCESSORIES

#### Accessories Not Working

1. Turn the key to the ON position.
2. Measure voltage across DC/DC converter input terminals.
  1. 1. Check for the presence of voltage between the positive terminal (**B+**) (White Wire) and the negative terminal (**B-**) (Black Wire) of the DC/DC converter (As shown in Figure 72).
    - ◆ If no voltage is present, it is necessary to inspect both the fuse and the wiring.
  1. 2. Check for the presence of voltage between the orange wire and the negative terminal (**B-**) (Black Wire) of the DC/DC converter (As shown in Figure 72).
    - ◆ If there is no voltage detected despite the key being ON, it is advisable to examine the wiring.
3. Measure voltage across DC/DC converter output terminals.
  2. 1. Check for the presence of voltage between the yellow/red wire and the green wire of the DC/DC converter (As shown in Figure 72).
    - ◆ If not between 11.8V and 14.2V, it indicates a defective converter that requires replacement.
4. Depress the accessory switch, measure voltage across accessory terminals.







## 2. Inspect the Electromagnetic Brake.

Before troubleshooting the EMB, validate that the non-moving vehicle issue is caused by the electromagnetic brake by screwing in the service knobs, therefore disengaging the electromagnetic brake.

- 2.1. Electromagnetic brake not releasing (vehicle doesn't move).
  - ▶ Excessive air gap (over 0.030 in).
  - ▶ No current to electromagnetic brake.



### WARNING

PLEASE PAY ATTENTION TO THE VOLTAGE VALUE INDICATED BY THE VOLTMETER. THE VOLTMETER MAY NOT ACCURATELY DISPLAY THE REAL VOLTAGE; INSTEAD, IT MIGHT SHOW A HIGHER VALUE (E.G., 48V) RATHER THAN THE AVERAGE VALUE (E.G., 24V) DUE TO THE IMPLEMENTATION OF PULSE WIDTH MODULATION (PWM).

- ▶ Damaged wiring.
  - ▶ Defective magnet.
  - ▶ Mechanically stuck pressure plate.
- 2.2. Electromagnetic brake dragging (burnt smell / lack of power).
    - ▶ Low current to electromagnetic brake.
    - ▶ Defective magnet (partial release).
    - ▶ Mechanically stuck pressure plate or debris in electromagnetic brake.
    - ▶ Gripping of rotor hub splines.
  - 2.3. Electromagnetic brake not engaging.

**NOTE:** This symptom is sometimes the result of the operator regularly using the Emergency Stop button while the vehicle is still in motion. This wears off the thin friction material on the rotor. Such practice should be avoided.

    - ▶ Service knobs installed.
    - ▶ Damaged / broken rotor.
    - ▶ Mechanically stuck open pressure plate.
    - ▶ Damaged transaxle internal component.



### 3. Inspect the Accelerator Pedal

To verify the proper functioning of the accelerator pedal, follow these steps to check the percentage of throttle by accessing the throttle command in the display:

- i. Turn the ignition key to the ON position.
- ii. Hold the ENTER button for 5 seconds.
- iii. Select MOTREC SETTINGS.
- iv. Select INPUT PASSWORD (3050).
- v. Select PROGRAMMER.
- vi. Select MONITOR.
- vii. Select INPUT.

By following these steps, you can monitor the variation of the throttle percentage on the display while stepping on the pedal. This allows you to assess the functionality of the accelerator pedal and ensure it is operating correctly.

### 4. Inspect the Vehicle

1. Make sure that the PMC surface is clean and dry:
  - i. Inspect the terminal areas. Dust particles or acid contamination can create current leaks and cause a PMC malfunction.

### 5. Inspect the Main Contactor

- 5.1 Check the 250 A fuse located next to the contactor.
- 5.2 Verify the presence of voltage at the positive terminal (**B+**) of the contactor.
  - ◆ If not, check for any fuse or wiring issues.
- 5.3 Verify the output of voltage from the contactor to the negative terminal (**B-**) of the controller.
  - ◆ If that's not the case, even if the contactor coil is energized (meaning it is receiving power), it is necessary to replace the contactor.
- 5.4 Check the voltage between the black/orange wire and the orange/black wire of the contactor.
  - ◆ If no voltage is detected, it is necessary to inspect the wiring and the output wires of the controller.



### Vehicle Moves Forward Only

1. Do not place the switch in the reverse position.
2. Measure the reverse signal input between pin 33 (Grey/White Wire) on the controller and the negative terminal (**B-**) (Black Wire).
  - ◆ If no voltage is detected, proceed to check the voltage at pin 5 of the switch. If there is still no voltage detected, it is necessary to inspect the wiring leading to the key switch.
3. Check for the presence of voltage at pin 4 of the Forward/Reverse switch (Gray/Blue Wire).
  - ◆ If no voltage is detected, replace the direction switch.

### Vehicle Moves Backward Only

1. Do not place the switch in the forward position.
2. Measure the reverse signal input between pin 22 (Green/White Wire) on the controller and the negative terminal (**B-**) (Black Wire).
  - ◆ If no voltage is detected, proceed to check the voltage at pin 5 of the switch. If there is still no voltage detected, it is necessary to inspect the wiring leading to the key switch.
3. Check for the presence of voltage at pin 6 of the Forward/Reverse switch (green/blue wire).
  - ◆ If no voltage is detected, replace the direction switch.

### Vehicle Travels at Reduced Speed



#### WARNING

WHEN WORKING AROUND BATTERIES, ALWAYS WEAR ACID PROOF PROTECTIVE EQUIPMENT, SUCH AS FACE SHIELD AND THE APPROPRIATE GLOVES. BATTERIES CONTAIN SULFUR ACID THAT CAN CAUSE SEVERE BURNS ON SKIN OR EYES. RINSE CONTAMINATED AREA IMMEDIATELY WITH WATER.

**NOTE:** Certain faults could cause the vehicle to travel at reduced speeds. The maintenance timer reaching its limit could also cause reduced speeds.

1. Inspect the specific gravity of each battery cell. Cold batteries, highly discharged batteries, or dead cells are the most frequent causes of reduced travel speed.
2. Inspect the potentiometer (of the main pedal) while monitoring the Throttle command on the display.

Other causes of lower speed:

- a. Dragging brakes.
- b. Cold temperature (effects batteries performance).
- c. Turtle Mode ON.
- d. Check for the following fault codes: 17, 22, 28, 29, and 54.



### Intermittent Movements During Operation

A bad potentiometer is the most probable cause of the following:

- Irregular acceleration.
- Erratic maximum speed.
- Sudden stop after a bump or shock.
- Erratic starts, requiring several pedal cycles.

Erratic starts could also be the cause of a misadjusted potentiometer or microswitch. Monitor this value in the monitoring values section of the display troubleshooting function.

The PMC (Power Management Controller) incorporates two HPD (High Pedal Disable) safety features. The first feature prevents the vehicle from moving if the accelerator pedal is depressed prior to turning on the key switch and activating the seat switch (Presence detection pedal). The second feature prevents the vehicle from moving if the direction switch is activated before turning on the foot switch (Presence detection pedal) and activating the foot switch. These safety measures ensure that the vehicle remains stationary until the necessary conditions are met, promoting safe operation.

The PMC also has an SRO safety feature that temporarily keeps the vehicle in the OFF state when the key is turned ON. This brief moment of keeping the vehicle off allows for a safety check before enabling movement.

By placing the direction switch in the neutral position and subsequently selecting forward or reverse, the SRO feature ensures that the vehicle can move in the desired direction. This sequential process helps prevent sudden or unintended vehicle movements and allows for a controlled activation of the vehicle's motion.

The vehicle stops on a steep and long ramp or while towing a heavy load: the PMC monitors the temperature of the motor and is also equipped with an internal thermal protection that cuts back the current until the PMC and/or motor has cooled down, furthermore, an error code 28 is displayed (Refer to Section 5 Annexes for a complete list of all codes).



Fault Code List and Diagnostic

8

DIAGNOSTICS AND TROUBLESHOOTING

These controllers detect a wide variety of faults or error conditions. Faults can be detected by the operating system or by the VCL code. This section describes the faults detected by the operating system.

Faults detected by VCL code (faults 51–67 in Table 5) cannot be defined here as they will vary from application to application. Refer to the appropriate OEM documentation for information on these faults.

DIAGNOSTICS

Diagnostics information can be obtained in either of two ways: (1) by reading the display on a 1311 programmer or (2) by observing the fault codes issued by the Status LEDs. See Table 4 for a summary of LED display formats.

The 1311 programmer will display all faults that are currently set as well as a history of the faults that have been set since the history log was last cleared. The 1311 displays the faults by name.

The pair of LEDs built into the controller (one red, one yellow) produce flash codes displaying all the currently set faults in a repeating cycle. Each code consists of two digits. The red LED flashes once to indicate that the first digit of the code will follow; the yellow LED then flashes the appropriate number of times for the first digit. The red LED flashes twice to indicate that the second digit of the code will follow; the yellow LED flashes the appropriate number of times for the second digit.

Example: Battery Undervoltage (code 23).

In the Fault menu of the 1311 programmer, the words **Undervoltage Cutback** will be displayed; the real-time battery voltage is displayed in the Monitor menu (“Keyswitch Voltage”).

The controller’s two LEDs will display this repeating pattern:

RED	YELLOW	RED	YELLOW
*	* *	* *	* * *
(first digit)	(2)	(second digit)	(3)

The numerical codes used by the yellow LED are listed in the troubleshooting chart (Table 5), which also lists possible fault causes and describes the conditions that set and clear each fault.



### Summary of LED display formats

The two LEDs have four different display modes, indicating the type of information they are providing.

Table 4 TYPES OF LED DISPLAY	
DISPLAY	STATUS
Neither LED illuminated	Controller is not powered on; or vehicle has dead battery; or severe damage.
Yellow LED flashing	Controller is operating normally.
Yellow and red LEDs both on solid	Controller is in Flash program mode.
Red LED on solid	Watchdog failure or no software loaded. Cycle KSI to restart, and if necessary load software.
Red LED and yellow LED flashing alternately	Controller has detected a fault. 2-digit code flashed by yellow LED identifies the specific fault; one or two flashes by red LED indicate whether first or second code digit will follow.

### TROUBLESHOOTING

The troubleshooting chart, Table 5, provides the following information on all the controller faults:

- fault code
- fault name as displayed on the programmer's LCD
- the effect of the fault
- possible causes of the fault
- fault *set* conditions
- fault *clear* conditions.

Whenever a fault is encountered and no wiring or vehicle fault can be found, shut off KSI and turn it back on to see if the fault clears. If it does not, shut off KSI and remove the 35-pin connector. Check the connector for corrosion or damage, clean it if necessary, and re-insert it.



## 8 — DIAGNOSTICS &amp; TROUBLESHOOTING

Table 5 TROUBLESHOOTING CHART			
CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
12	Controller Overcurrent <i>ShutdownMotor;</i> <i>ShutdownMainContactor;</i> <i>ShutdownEMBrake;</i> <i>ShutdownThrottle;</i> <i>FullBrake;</i> <i>ShutdownPump.</i>	1. External short of phase U,V, or W motor connections. 2. Motor parameters are mis-tuned. 3. Controller defective.	<i>Set:</i> Phase current exceeded the current measurement limit. <i>Clear:</i> Cycle KSI.
13	Current Sensor Fault <i>ShutdownMotor;</i> <i>ShutdownMainContactor;</i> <i>ShutdownEMBrake;</i> <i>ShutdownThrottle;</i> <i>FullBrake;</i> <i>ShutdownPump.</i>	1. Leakage to vehicle frame from phase U, V, or W (short in motor stator). 2. Controller defective.	<i>Set:</i> Controller current sensors have invalid offset reading. <i>Clear:</i> Cycle KSI.
14	Precharge Failed <i>ShutdownMotor;</i> <i>ShutdownMainContactor;</i> <i>ShutdownEMBrake;</i> <i>ShutdownThrottle;</i> <i>FullBrake;</i> <i>ShutdownPump.</i>	2. External load on capacitor bank (B+ connection terminal) that prevents the capacitor bank from charging. 1. See Monitor menu » Battery: Capacitor Voltage.	<i>Set:</i> Precharge failed to charge the capacitor bank to the KSI voltage. <i>Clear:</i> Cycle Interlock input or use VCL function <i>Precharge()</i> .
15	Controller Severe Undertemp <i>ShutdownMotor;</i> <i>ShutdownMainContactor;</i> <i>ShutdownEMBrake;</i> <i>ShutdownThrottle;</i> <i>FullBrake;</i> <i>ShutdownPump.</i>	1. See Monitor menu » Controller: Temperature. 2. Controller is operating in an extreme environment.	<i>Set:</i> Heatsink temperature below -40°C. <i>Clear:</i> Bring heatsink temperature above -40°C, and cycle interlock or KSI.
16	Controller Severe Overtemp <i>ShutdownMotor;</i> <i>ShutdownMainContactor;</i> <i>ShutdownEMBrake;</i> <i>ShutdownThrottle;</i> <i>FullBrake;</i> <i>ShutdownPump.</i>	1. See Monitor menu » Controller: Temperature. 2. Controller is operating in an extreme environment. 3. Excessive load on vehicle. 4. Improper mounting of controller.	<i>Set:</i> Heatsink temperature above +95°C. <i>Clear:</i> Bring heatsink temperature below +95°C, and cycle interlock or KSI.
17	Severe Undervoltage <i>Reduced drive torque.</i>	1. Battery Menu parameters are misadjusted. 2. Non-controller system drain on battery. 3. Battery resistance too high. 4. Battery disconnected while driving. 5. See Monitor menu » Battery: Capacitor Voltage. 6. Blown B+ fuse or main contactor did not close.	<i>Set:</i> Capacitor bank voltage dropped below the Severe Undervoltage limit (see page 55) with FET bridge enabled. <i>Clear:</i> Bring capacitor voltage above Severe Undervoltage limit.



Table 5 TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
18	Severe Overvoltage <i>ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.</i>	<ol style="list-style-type: none"> <li>1. See Monitor menu » Battery: Capacitor Voltage.</li> <li>2. Battery menu parameters are misadjusted.</li> <li>3. Battery resistance too high for given regen current.</li> <li>4. Battery disconnected while regen braking.</li> </ol>	<p><i>Set:</i> Capacitor bank voltage exceeded the Severe Overvoltage limit (see page 55) with FET bridge enabled.</p> <p><i>Clear:</i> Bring capacitor voltage below Severe Overvoltage limit, and then cycle KSI.</p>
22	Controller Overtemp Cutback <i>Reduced drive and brake torque.</i>	<ol style="list-style-type: none"> <li>1. See Monitor menu » Controller: Temperature.</li> <li>2. Controller is performance-limited at this temperature.</li> <li>3. Controller is operating in an extreme environment.</li> <li>4. Excessive load on vehicle.</li> <li>5. Improper mounting of controller.</li> </ol>	<p><i>Set:</i> Heatsink temperature exceeded 85°C.</p> <p><i>Clear:</i> Bring heatsink temperature below 85°C.</p>
23	Undervoltage Cutback <i>Reduced drive torque.</i>	<ol style="list-style-type: none"> <li>1. Normal operation. Fault shows that the batteries need recharging. Controller is performance limited at this voltage.</li> <li>2. Battery parameters are misadjusted.</li> <li>3. Non-controller system drain on battery.</li> <li>4. Battery resistance too high.</li> <li>5. Battery disconnected while driving.</li> <li>6. See Monitor menu » Battery: Capacitor Voltage.</li> <li>7. Blown B+ fuse or main contactor did not close.</li> </ol>	<p><i>Set:</i> Capacitor bank voltage dropped below the Undervoltage limit (see page 55) with the FET bridge enabled.</p> <p><i>Clear:</i> Bring capacitor voltage above the Undervoltage limit.</p>
24	Overvoltage Cutback <i>Reduced brake torque.</i>	<ol style="list-style-type: none"> <li>1. Normal operation. Fault shows that regen braking currents elevated the battery voltage during regen braking. Controller is performance limited at this voltage.</li> <li>2. Battery parameters are misadjusted.</li> <li>3. Battery resistance too high for given regen current.</li> <li>4. Battery disconnected while regen braking.</li> <li>5. See Monitor menu » Battery: Capacitor Voltage.</li> </ol>	<p><i>Set:</i> Capacitor bank voltage exceeded the Overvoltage limit (see page 55) with the FET bridge enabled.</p> <p><i>Clear:</i> Bring capacitor voltage below the Overvoltage limit.</p>
25	+5V Supply Failure <i>None, unless a fault action is programmed in VCL.</i>	<ol style="list-style-type: none"> <li>1. External load impedance on the +5V supply (pin 26) is too low.</li> <li>2. See Monitor menu » outputs: 5 Volts and Ext Supply Current.</li> </ol>	<p><i>Set:</i> +5V supply (pin 26) outside the +5V±10% range.</p> <p><i>Clear:</i> Bring voltage within range.</p>
26	Digital Out 6 Overcurrent <i>Digital Output 6 driver will not turn on.</i>	<ol style="list-style-type: none"> <li>1. External load impedance on Digital Output 6 driver (pin 19) is too low.</li> </ol>	<p><i>Set:</i> Digital Output 6 (pin 19) current exceeded 15 mA.</p> <p><i>Clear:</i> Remedy the overcurrent cause and use the VCL function <i>Set_DigOut()</i> to turn the driver on again.</p>



## 8 — DIAGNOSTICS &amp; TROUBLESHOOTING

Table 5 TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
27	Digital Out 7 Overcurrent <i>Digital Output 7 driver will not turn on.</i>	1. External load impedance on Digital Output 7 driver (pin 20) is too low.	<i>Set:</i> Digital Output 7 (pin 20) current exceeded 15 mA. <i>Clear:</i> Remedy the overcurrent cause and use the VCL function <i>Set_DigOut()</i> to turn the driver on again.
28	Motor Temp Hot Cutback <i>Reduced drive torque.</i>	1. Motor temperature is at or above the programmed Temperature Hot setting, and the requested current is being cut back. 2. Motor Temperature Control Menu parameters are mis-tuned. 3. See Monitor menu » Motor: Temperature and » Inputs: Analog2. 4. If the application doesn't use a motor thermistor, Temp Compensation and Temp Cutback should be programmed Off.	<i>Set:</i> Motor temperature is at or above the Temperature Hot parameter setting. <i>Clear:</i> Bring the motor temperature within range.
29	Motor Temp Sensor Fault <i>MaxSpeed reduced (LOS, Limited Operating Strategy), and motor temperature cutback disabled.</i>	1. Motor thermistor is not connected properly. 2. If the application doesn't use a motor thermistor, Motor Temp Sensor Enable should be programmed Off. 3. See Monitor menu » Motor: Temperature and » Inputs: Analog2.	<i>Set:</i> Motor thermistor input (pin 8) is at the voltage rail (0 or 10V). <i>Clear:</i> Bring the motor thermistor input voltage within range.
31	Coil1 Driver Open/Short <i>ShutdownDriver1.</i>	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	<i>Set:</i> Driver 1 (pin 6) is either open or shorted. This fault can be set only when Main Enable = Off. <i>Clear:</i> Correct open or short, and cycle driver.
31	Main Open/Short <i>ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.</i>	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	<i>Set:</i> Main contactor driver (pin 6) is either open or shorted. This fault can be set only when Main Enable = On. <i>Clear:</i> Correct open or short, and cycle driver.
32	Coil2 Driver Open/Short <i>ShutdownDriver2.</i>	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	<i>Set:</i> Driver 2 (pin 5) is either open or shorted. This fault can be set only when EM Brake Type = 0. <i>Clear:</i> Correct open or short, and cycle driver.
32	EMBrake Open/Short <i>ShutdownEMBrake; ShutdownThrottle; FullBrake.</i>	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	<i>Set:</i> Electromagnetic brake driver (pin 5) is either open or shorted. This fault can be set only when EM Brake Type > 0. <i>Clear:</i> Correct open or short, and cycle driver.
33	Coil3 Driver Open/Short <i>ShutdownDriver3.</i>	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	<i>Set:</i> Driver 3 (pin 4) is either open or shorted. <i>Clear:</i> Correct open or short, and cycle driver.
34	Coil4 Driver Open/Short <i>ShutdownDriver4.</i>	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	<i>Set:</i> Driver 4 (pin 3) is either open or shorted. <i>Clear:</i> Correct open or short, and cycle driver.



## 8 — DIAGNOSTICS &amp; TROUBLESHOOTING

Table 5 TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
35	PD Open/Short <i>ShutdownPD.</i>	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	<i>Set:</i> Proportional driver (pin 2) is either open or shorted. <i>Clear:</i> Correct open or short, and cycle driver.
36	Encoder Fault <i>ShutdownEMBrake.</i>	1. Motor encoder failure. 2. Bad crimps or faulty wiring. 3. See Monitor menu » Motor: Motor RPM.	<i>Set:</i> Motor encoder phase failure detected. <i>Clear:</i> Cycle KSI.
37	Motor Open <i>ShutdownMotor;</i> <i>ShutdownMainContactor;</i> <i>ShutdownEMBrake;</i> <i>ShutdownThrottle;</i> <i>FullBrake;</i> <i>ShutdownPronp.</i>	1. Motor phase is open. 2. Bad crimps or faulty wiring.	<i>Set:</i> Motor phase U, V, or W detected open. <i>Clear:</i> Cycle KSI.
38	Main Contactor Welded <i>ShutdownMotor;</i> <i>ShutdownMainContactor;</i> <i>ShutdownEMBrake;</i> <i>ShutdownThrottle;</i> <i>FullBrake;</i> <i>ShutdownPronp.</i>	1. Main contactor tips are welded closed. 2. Motor phase U or V is disconnected or open. 3. An alternate voltage path (such as an external precharge resistor) is providing a current to the capacitor bank (B+ connection terminal).	<i>Set:</i> Just prior to the main contactor closing, the capacitor bank voltage (B+ connection terminal) was loaded for a short time and the voltage did not discharge. <i>Clear:</i> Cycle KSI
39	Main Contactor Did Not Close <i>ShutdownMotor;</i> <i>ShutdownMainContactor;</i> <i>ShutdownEMBrake;</i> <i>ShutdownThrottle;</i> <i>FullBrake;</i> <i>ShutdownPronp.</i>	1. Main contactor did not close. 2. Main contactor tips are oxidized, burned, or not making good contact. 3. External load on capacitor bank (B+ connection terminal) that prevents capacitor bank from charging. 4. Blown B+ fuse.	<i>Set:</i> With the main contactor commanded closed, the capacitor bank voltage (B+ connection terminal) did not charge to B+. <i>Clear:</i> Cycle KSI.
41	Throttle Wiper High <i>ShutdownThrottle.</i>	1. See Monitor menu » Inputs: Throttle Pot. 2. Throttle pot wiper voltage too high.	<i>Set:</i> Throttle pot wiper (pin 16) voltage is higher than the high fault threshold (can be changed with the VCL function <i>Setup_Pot_Faults()</i> ). <i>Clear:</i> Bring throttle pot wiper voltage below the fault threshold.
42	Throttle Wiper Low <i>ShutdownThrottle.</i>	1. See Monitor menu » Inputs: Throttle Pot. 2. Throttle pot wiper voltage too low.	<i>Set:</i> Throttle pot wiper (pin 16) voltage is lower than the low fault threshold (can be changed with the VCL function <i>Setup_Pot_Faults()</i> ). <i>Clear:</i> Bring throttle pot wiper voltage above the fault threshold.
43	Pot2 Wiper High <i>FullBrake.</i>	1. See Monitor menu » Inputs: Pot2 Raw. 2. Pot2 wiper voltage too high.	<i>Set:</i> Pot2 wiper (pin 17) voltage is higher than the high fault threshold (can be changed with the VCL function <i>Setup_Pot_Faults()</i> ). <i>Clear:</i> Bring Pot2 wiper voltage below the fault threshold.



## 8 — DIAGNOSTICS &amp; TROUBLESHOOTING

Table 5 TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
44	Pot2 Wiper Low <i>FullBrake.</i>	1. See Monitor menu » Inputs: Pot2 Raw. 2. Pot2 wiper voltage too low.	<i>Set:</i> Pot2 wiper (pin 17) voltage is lower than the low fault threshold (can be changed with the VCL function <i>Setup_Pot_Faults()</i> . <i>Clear:</i> Bring Pot2 wiper voltage above the fault threshold.
45	Pot Low Overcurrent <i>ShutdownThrottle;</i> <i>FullBrake.</i>	1. See Monitor menu » Outputs: Pot Low. 2. Combined pot resistance connected to pot low is too low.	<i>Set:</i> Pot low (pin 18) current exceeds 10mA. <i>Clear:</i> Clear pot low overcurrent condition and cycle KSI.
46	EEPROM Failure <i>ShutdownMotor;</i> <i>ShutdownMainContactor;</i> <i>ShutdownEMBrake;</i> <i>ShutdownThrottle;</i> <i>ShutdownInterlock;</i> <i>ShutdownDriver1;</i> <i>ShutdownDriver2;</i> <i>ShutdownDriver3;</i> <i>ShutdownDriver4;</i> <i>ShutdownPD;</i> <i>FullBrake;</i> <i>ShutdownPump.</i>	1. Failure to write to EEPROM memory. This can be caused by EEPROM memory writes initiated by VCL, by the CAN bus, by adjusting parameters with the programmer, or by loading new software into the controller.	<i>Set:</i> Controller operating system tried to write to EEPROM memory and failed. <i>Clear:</i> Download the correct software (OS) and matching parameter default settings into the controller and cycle KSI.
47	HPD/Sequencing Fault <i>ShutdownThrottle.</i>	1. KSI, interlock, direction, and throttle inputs applied in incorrect sequence. 2. Faulty wiring, crimps, or switches at KSI, interlock, direction, or throttle inputs. 3. See Monitor menu » Inputs.	<i>Set:</i> HPD (High Pedal Disable) or sequencing fault caused by incorrect sequence of KSI, interlock, direction, and throttle inputs. <i>Clear:</i> Reapply inputs in correct sequence.
47	Emer Rev HPD <i>ShutdownThrottle;</i> <i>ShutdownEMBrake.</i>	1. Emergency Reverse operation has concluded, but the throttle, forward and reverse inputs, and interlock have not been returned to neutral.	<i>Set:</i> At the conclusion of Emergency Reverse, the fault was set because various inputs were not returned to neutral. <i>Clear:</i> If EMR_Interlock = On, clear the interlock, throttle, and direction inputs. If EMR_Interlock = Off, clear the throttle and direction inputs.
49	Parameter Change Fault <i>ShutdownMotor;</i> <i>ShutdownMainContactor;</i> <i>ShutdownEMBrake;</i> <i>ShutdownThrottle;</i> <i>FullBrake;</i> <i>ShutdownPump.</i>	1. This is a safety fault caused by a change in certain parameter settings so that the vehicle will not operate until KSI is cycled. For example, if a user changes the Throttle Type this fault will appear and require cycling KSI before the vehicle can operate.	<i>Set:</i> Adjustment of a parameter setting that requires cycling of KSI. <i>Clear:</i> Cycle KSI.
51–67	OEM Faults (See OEM documentation.)	1. These faults can be defined by the OEM and are implemented in the application-specific VCL code. See OEM documentation.	<i>Set:</i> See OEM documentation. <i>Clear:</i> See OEM documentation.



Table 5 TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
68	VCL Run Time Error <i>ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.</i>	<ol style="list-style-type: none"> <li>1. VCL code encountered a runtime VCL error.</li> <li>2. See Monitor menu » Controller: VCL Error Module and VCL Error. This error can then be compared to the runtime VCL module ID and error code definitions found in the specific OS system information file.</li> </ol>	<i>Set:</i> Runtime VCL code error condition. <i>Clear:</i> Edit VCL application software to fix this error condition; flash the new compiled software and matching parameter defaults; cycle KSI.
69	External Supply Out of Range <i>None, unless a fault action is programmed in VCL.</i>	<ol style="list-style-type: none"> <li>1. External load on the 5V and 12V supplies draws either too much or too little current.</li> <li>2. Fault Checking Menu parameters Ext Supply Max and Ext Supply Min are mis-tuned.</li> <li>3. See Monitor menu » Outputs: Ext Supply Current.</li> </ol>	<i>Set:</i> The external supply current (combined current used by the 5V supply [pin 26] and 12V supply [pin 25]) is either greater than the upper current threshold or lower than the lower current threshold. The two thresholds are defined by the External Supply Max and External Supply Min parameter settings (page 52). <i>Clear:</i> Bring the external supply current within range.
71	OS General <i>ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.</i>	<ol style="list-style-type: none"> <li>1. Internal controller fault.</li> </ol>	<i>Set:</i> Internal controller fault detected. <i>Clear:</i> Cycle KSI.
72	PDO Timeout <i>ShutdownInterlock; CAN NMT State set to Pre-operational.</i>	<ol style="list-style-type: none"> <li>1. Time between CAN PDO messages received exceeded the PDO Timeout Period.</li> </ol>	<i>Set:</i> Time between CAN PDO messages received exceeded the PDO Timeout Period. <i>Clear:</i> Cycle KSI or receive CAN NMT message.
73	Stall Detected <i>ShutdownEMBrake; Control Mode changed to LOS (Limited Operating Strategy).</i>	<ol style="list-style-type: none"> <li>1. Stalled motor.</li> <li>2. Motor encoder failure.</li> <li>3. Bad crimps or faulty wiring.</li> <li>4. Problems with power supply for the motor encoder.</li> <li>5. See Monitor menu » Motor: Motor RPM.</li> </ol>	<i>Set:</i> No motor encoder movement detected. <i>Clear:</i> Either cycle KSI, or detect valid motor encoder signals while operating in LOS mode and return Throttle Command = 0 and Motor RPM = 0.



## 8 — DIAGNOSTICS &amp; TROUBLESHOOTING

Table 5 TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
87	Motor Characterization Fault <i>ShutdownMotor;</i> <i>ShutdownMainContactor;</i> <i>ShutdownEMBrake;</i> <i>ShutdownThrottle;</i> <i>FullBrake;</i> <i>ShutdownPump.</i>	1. Motor characterization failed during characterization process. See Monitor menu » Controller: Motor Characterization Error for cause: 0=none 1=encoder signal seen, but step size not determined; set Encoder Step Size manually 2=motor temp sensor fault 3=motor temp hot cutback fault 4= controller overtemp cutback fault 5=controller undertemp cutback fault 6=undervoltage cutback fault 7=severe overvoltage fault 8=encoder signal not seen, or one or both channels missing 9=motor parameters out of characterization range.	<i>Set:</i> Motor characterization failed during the motor characterization process. <i>Clear:</i> Correct fault; cycle KSI.
89	Motor Type Fault <i>ShutdownMotor;</i> <i>ShutdownMainContactor;</i> <i>ShutdownEMBrake;</i> <i>ShutdownThrottle;</i> <i>FullBrake;</i> <i>ShutdownPump.</i>	1. The Motor_Type parameter value is out of range.	<i>Set:</i> Motor_Type parameter is set to an illegal value. <i>Clear:</i> Set Motor_Type to correct value and cycle KSI.
91	VCL/OS Mismatch <i>ShutdownMotor;</i> <i>ShutdownMainContactor;</i> <i>ShutdownEMBrake;</i> <i>ShutdownThrottle;</i> <i>ShutdownInterlock;</i> <i>ShutdownDriver1;</i> <i>ShutdownDriver2;</i> <i>ShutdownDriver3;</i> <i>ShutdownDriver4;</i> <i>ShutdownPD;</i> <i>FullBrake;</i> <i>ShutdownPump.</i>	1. The VCL software in the controller does not match the OS software in the controller.	<i>Set:</i> VCL and OS software do not match; when KSI cycles, a check is made to verify that they match and a fault is issued when they do not. <i>Clear:</i> Download the correct VCL and OS software into the controller.
92	EM Brake Failed to Set <i>ShutdownEMBrake;</i> <i>ShutdownThrottle.</i>	1. Vehicle movement sensed after the EM Brake has been commanded to set. 2. EM Brake will not hold the motor from rotating.	<i>Set:</i> After the EM Brake was commanded to set and time has elapsed to allow the brake to fully engage, vehicle movement has been sensed. <i>Clear:</i> Activate the throttle.
93	Encoder LOS (Limited Operating Strategy) <i>Enter LOS control mode.</i>	1. Limited Operating Strategy (LOS) control mode has been activated, as a result of either an Encoder Fault (Code 36) or a Stall Detect Fault (Code 73). 2. Motor encoder failure. 3. Bad crimps or faulty wiring. 4. Vehicle is stalled.	<i>Set:</i> Encoder Fault (Code 36) or Stall Detect Fault (Code 73) was activated, and Brake or Interlock has been applied to activate LOS control mode, allowing limited motor control. <i>Clear:</i> Cycle KSI, or if LOS mode was activated by the Stall Fault, clear by ensuring encoder senses proper operation, Motor RPM = 0, and Throttle Command = 0.



Table 5 TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
94	Emer Rev Timeout <i>ShutdownEMBrake;</i> <i>ShutdownThrottle.</i>	<ol style="list-style-type: none"> <li>Emergency Reverse was activated and concluded because the EMR Timeout timer has expired.</li> <li>The emergency reverse input is stuck On.</li> </ol>	<i>Set:</i> Emergency Reverse was activated and ran until the EMR Timeout timer expired. <i>Clear:</i> Turn the emergency reverse input Off.
98	Illegal Model Number <i>ShutdownMotor;</i> <i>ShutdownMainContactor;</i> <i>ShutdownEMBrake;</i> <i>ShutdownThrottle;</i> <i>FullBrake;</i> <i>ShutdownPump.</i>	<ol style="list-style-type: none"> <li>Model_Number variable contains illegal value (not 1234, 1236, 1238, or 1298).</li> <li>Software and hardware do not match.</li> <li>Controller defective.</li> </ol>	<i>Set:</i> Illegal Model_Number variable; when KSI cycles, a check is made to confirm a legal Model_Number, and a fault is issued if one is not found. <i>Clear:</i> Download appropriate software for your controller model.

**OEM CODE**

CODE 51 Can Initialization: Check PIN 23 (twisted wire green and yellow)

CODE 52 Can Operational : Check PIN 23 (twisted wire green and yellow)

CODE 53 Foot pedal or Switch Fault : Check PIN 24 / Throttle Accelerator Signal

CODE 54 Maintenance is required

CODE 55 Throttle active before foward

CODE 56 Throttle active before reverse

CODE 57 FWD and REV active : Bad switch FWD / REV

CODE 58 Driver voltage exceeded : Max voltage for driver is 24V

CODE 62 HPD / SRO Sequence fault : incorrect starting sequence





HFIPFC Battery Charger

**Product Manual for:**  
**QuiQ 912-24xx | 36xx | 48xx | 72xx**



Unit 3 – 5250 Grimmer St.  
Burnaby, BC, Canada V5H 2H2  
Tel: 604.327.8244 Fax: 604.327.8246  
www.delta-q.com

## SAVE THESE IMPORTANT SAFETY INSTRUCTIONS



This manual contains important safety, operating, and installation instructions – read before using charger.

### Battery Safety Information

**Warning:** Use charger only on battery systems with an algorithm selected that is appropriate to the specific battery type. Other usage may cause personal injury and damage. Lead acid batteries may generate explosive hydrogen gas during normal operation. Keep sparks, flames, and smoking materials away from batteries. Provide adequate ventilation during charging. Never charge a frozen battery. Study all battery manufacturers' specific precautions such as recommended rates of charge and removing or not removing cell caps while charging.

### Electrical Safety Information

**Danger:** Risk of electric shock. Connect charger power cord to an outlet that has been properly installed and grounded in accordance with all local codes and ordinances. A grounded outlet is required to reduce risk of electric shock – do not use ground adapters or modify plug. Do not touch uninsulated portion of output connector or uninsulated battery terminal. Disconnect the AC supply before making or breaking the connections to the battery while charging. Do not open or disassemble charger. Do not operate charger if the AC supply cord is damaged or if the charger has received a sharp blow, been dropped, or otherwise damaged in any way – refer all repair work to qualified personnel. Not for use by children.

## INFORMATIONS IMPORTANTES DE SÉCURITÉ

Conserver ces instructions. Ce manuel contient des instructions importantes concernant la sécurité et le fonctionnement.

### Information de Sécurité de la Batterie

**Attention:** Utiliser seulement sur les batteries 72V avec un algorithme approprié au type spécifique de batterie – voir le manuel. D'autres types de batteries pourraient éclater et causer des blessures ou dommages. Les batteries peuvent produire des gaz explosifs en service normal. Ne jamais fumer près de la batterie et éviter toute étincelle ou flamme nue à proximité de ces derniers. Fournir la bonne ventilation lors du chargement. Ne jamais charger une batterie gelée. Prendre connaissance des mesures de précaution spécifiées par le fabricant de la batterie, p. ex., vérifier s'il faut enlever les bouchons des cellules lors du chargement de la batterie, et les taux de chargement recommandés.

### Information de Sécurité Électrique

**Danger:** Risque de chocs électriques. Ne pas toucher les parties non isolées du connecteur de sortie ou les bornes non isolées de la batterie. Toujours connecter le chargeur à une prise de courant mise à la terre. Ne pas ouvrir ni désassembler le chargeur – référer toute réparations aux personnes qualifiées. Pas à l'usage des enfants.

## Operating Instructions

1. Always use a grounded outlet. When using an extension cord, avoid excessive voltage drops by using a grounded 3-wire 12 AWG cord.
2. The charger will automatically turn on and go through a short LED indicator self-test (Models 912-xx0x will flash all LED's in an up-down sequence and Models 912-xx1x will alternatively flash its LED RED-GREEN) for two seconds. If the charger is connected to battery pack, a trickle current will be applied until a minimum voltage is reached. If the charger is used in an off-board application and the charger is waiting to be plugged into a battery pack, the charging algorithm number will be displayed for 11 seconds (see "Check / Change Charging Algorithm") before ultimately displaying an under-voltage fault (fault disappears when plugged into battery pack).
3. Once a minimum battery voltage is detected, the charger will enter the bulk charging constant-current stage. Models 912-xx0x will display the current to the battery on the bargraph and Model 912-xx1x will flash its LED GREEN off more than on to indicate <80% charge status. The length of charge time will vary by how large and how depleted the battery pack is, the input voltage (the higher, the better), and ambient temperatures (the lower, the better). If the input AC voltage is low (below 104VAC), then the charging power will be reduced to avoid high input currents (Models 912-xx0x 'AC' LED and Models 912-xx1x single LED both flash YELLOW). If the ambient temperature is too high, then the charging power will also be reduced to maintain a maximum internal temperature (Models 912-xx0x bargraph flashes and Models 912-xx1x single LED flashes YELLOW).
4. When the battery is at approximately 80% state of charge, the bulk stage has completed and an >80% charge indication is given (Models 912-xx0x turn on the '80%' LED and Models 912-xx1x will flash its LED GREEN on more than off). In the next phase known as the absorption or constant-voltage phase, the last 20% of charge is then returned to the battery. The charging could be terminated at this point if the vehicle requires immediate usage, however, it is highly recommended to wait until 100% charge indication is given to ensure maximum battery capacity and life.
5. A low current "finish-charge" phase is next applied to return and maintain maximum battery capacity (Models 912-xx0x will flash the '100%' LED).
6. When Models 912-xx0x '100%' LED or Models 912-xx1x single LED is continuously GREEN, the batteries are completely charged. The charger may now be unplugged from AC power (always pull on plug and not cord to reduce risk of damage to the cord). If left plugged in, the charger will automatically restart a complete charge cycle if the battery pack voltage drops below a minimum voltage or 30 days has elapsed.
7. If a fault occurred anytime during charging, a fault indication is given by flashing RED with a code corresponding to the error. There are several possible conditions that generate errors. Some errors are serious and require human intervention to first resolve the problem and then to reset the charger by interrupting AC power for at least 15 seconds. Others may be simply transient and will automatically recover when the fault condition is eliminated. To indicate which error occurred, a fault indication will flash RED a number of times, pause, and then repeat.
  - [1 FLASH] Battery Voltage High: auto-recover
  - [2 FLASH] Battery Voltage Low: auto-recover
  - [3 FLASH] Charge Timeout: the charge did not complete in the allowed time. This may indicate a problem with the battery pack (voltage not attaining the required level), or that the charger output was reduced due to high ambient temperatures.
  - [4 FLASH] Check Battery: the battery pack could not be trickle charged up to the minimum level required for the charge to be started. This may indicate that one or more cells in the battery pack are shorted or damaged.
  - [5 FLASH] Over-Temperature: auto-recover. Charger has shutdown due to high internal temperature which typically indicates there is not sufficient airflow for cooling – see Installation Instructions 1). Charger will restart and charge to completion if temperature comes within accepted limits.
  - [6 FLASH] QuiQ Fault: an internal fault has been detected. If Fault 6 is again displayed after interrupting AC power for at least 15 seconds, the charger must be brought to a qualified service depot.

## Maintenance Instructions

1. For flooded lead-acid batteries, regularly check water levels of each battery cell after charging and add distilled water as required to level specified by battery manufacturer. Follow the maintenance and safety instructions recommended by the battery manufacturer.
2. Make sure charger connections to battery terminals are tight and clean.
3. Do not expose charger to oil, dirt, mud or to direct heavy water spraying when cleaning vehicle.

See flip side for **Product Specifications** and **Installation Instructions** for qualified personnel.



## Specifications

### DC Output – see Operating Instructions

QuiQ Model: 912-	24xx	36xx	48xx	72xx
Voltage-nom (V)	24	36	48	72
Voltage-max (V)	33.6	50.4	67.2	100
Current-max (A)	25	21	18	12
Battery Type	Specific to selected algorithm			
Reverse Polarity	Electronic protection – auto-reset			
Short Circuit	Electronic current limit			

### AC Input

All models	
Voltage-max (Vrms)	85 – 265
Frequency (Hz)	45 – 65
Current-max (Arms)	12A @ 104VAC (reduced 20% <104V)
Current – nominal (Arms)	10A @ 120VAC / 5A @ 230VAC
AC Power Factor	>0.98 at nominal input current

### Operation

Charger Model: 912-	xx0x (10 LED)	xx1x (1 LED)
AC ON	Solid YELLOW	LED Active
AC LOW	Flash YELLOW	Flash YELLOW
Thermal Cutback	Flash Bargraph	Flash YELLOW
<80% Charge Indicator	-	Short Flash GREEN
>80% Charge Indicator	Solid YELLOW	Long Flash GREEN
100% Charge Indicator	Solid GREEN	Solid GREEN
Fault Indicator	Flash RED	Flash RED
DC Ammeter	LED Bargraph	-
Bat Temp Compensation	Automatic	Optional
Maintenance Mode	Auto-restart if V<2.1Vpc or 30 days elapse	

## Installation Instructions




**WARNING:** The output of chargers with greater than 48V may pose an energy and/or shock hazard under normal use. These units must be installed in the host equipment in such a manner that the output cable and battery connections are only accessible with the use of a tool by qualified personnel.

### 1) Determine Mounting Location:

While its sealed nature allows the charger to be mounted virtually anywhere, the choice of mounting location and orientation is extremely important. For optimum performance and shortest charge times, mount the charger in an area with adequate ventilation. The charger should also be mounted in an area that will be relatively free of oil, dirt, mud, or dust since accumulations within the fins of the charger will reduce their heat-dissipating qualities. Optimal cooling also occurs when the charger is mounted on a horizontal surface with the fins vertical. More airflow from below the charger will help cool the fins, so mounting above open areas or areas with cut-outs for airflow is desirable. Contact Delta-Q for information on other mounting orientations. As the charger may get hot in operation, the charger must be installed such that risk of contact by people is reduced. The charger's AC plug must be located at least 18" above the floor/ground surface and the status display must be visible to the user.

### 2) Mounting Procedure:

Mount the charger by the mounting plate using appropriate fasteners (i.e. 1/4" or M6 with locking hardware). For UL2202 compliance, a 12AWG green bonding wire with ring terminals must be attached from the bonding stud located on the front of the charger (identified by ) to the vehicle frame. The vehicle connection must be made using corrosion resistant hardware (e.g., a #10 stainless steel machine screw with at least two threads of engagement and, if required, a paint piercing washer).

### 3) DC Battery Connection Procedure:

- The green wire outputs battery voltage when the charger is not plugged into AC to provide an interlock function – see Fig. 1. If used, a user-supplied 1A fast-blow external fuse must be installed inline to prevent damage. Shorting or drawing more than 1A may damage charger and void the warranty.
- Securely fasten the black ring terminal from the charger to the negative terminal ("–", "NEG", "NEGATIVE") of the battery pack.
- Check that the correct charge algorithm is being used – refer to section 4). Securely fasten the red ring terminal to the positive terminal ("+", "POS", "POSITIVE") of the battery pack.

### Mechanical

All models	
Dimensions	28.0 x 24.5 x 11.0 cm (11 x 9.7 x 4.3")
Weight	<5 kg (<11 lbs) w/ standard output cord
Environmental	Enclosure: IP46
Operating Temperature	-30°C to +50°C (-22°F to 122°F), derated above 30°C, below 0°C
Storage Temperature	-40°C to +70°C (-40°F to 158°F)
AC input connector	IEC320/C14 (require ≥1.8m localized cord)
DC output connector	OEM specific w/ 12AWG wire

### Regulatory

Safety	
EN 60335-1/2-29	Safety of Appliances/ Battery Chargers
UL2202	EV Charging System Equipment
UL1564 2nd Edition	Industrial Battery Charger
CSA-C22.2 No. 107.2	Battery Chargers- Industrial
Emissions	
FCC Part 15/ICES 003	Unintentional Radiators Class A
EN 55011	Radio disturbance characteristics (Class A)
EN 61000-3-2	Limits for harmonic current emissions
EN 61000-3-3	Limits of voltage fluctuations and flicker
Immunity	
EN 61000-4-2	Electrostatic discharge immunity
EN 61000-4-3	Radiated, radio-frequency, EMF immunity
EN 61000-4-4	Electrical fast transient/burst immunity
EN 61000-4-5	Surge immunity
EN 61000-4-6	Conducted Immunity
EN 61000-4-11	Voltage variations immunity

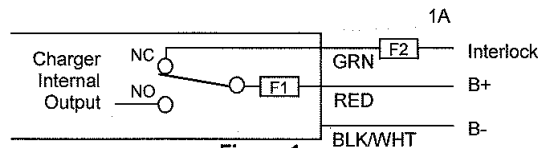


Figure 1

### 4) Check / Change Charging Algorithm:

The charger comes pre-loaded with algorithms for batteries as detailed in Table 1. If your specific battery model is not listed, please contact Delta-Q. Each time AC power is applied with the battery pack NOT connected, the charger enters an algorithm select/display mode for approximately 11 seconds. During this time, the current Algorithm # is indicated on the '80%' LED (Models 912-xx0x) or on the single LED (Models 912-xx1x). A single digit Algorithm # is indicated by the number of blinks separated by a pause. A two digit Algorithm # is indicated by the number of blinks for the first digit followed by a short pause, then the number of blinks for the second digit followed by a longer pause.

To check / change the charging algorithm:

- Disconnect the charger positive connector from battery pack. Apply AC power and after the LED test, the Algorithm # will display for 11 seconds.
- To change algorithm, touch positive connector during the 11 second display period to the battery pack's positive terminal for 3 seconds and then remove – the Algorithm # will advance after 3 seconds. Repeat until desired Algorithm # is displayed. A 30 second timeout is extended for every increment. Incrementing beyond the last Algorithm moves back to the first Algorithm. After desired Algorithm # is displayed, touch the charger connector to the battery positive until the output relay is heard to click (~10 seconds) – algorithm is now in permanent memory.
- Remove AC power from the charger and reconnect the charger positive connector to the battery pack. It is highly recommended to check a newly changed algorithm by repeating step 4) above.

Alg #	Battery Type
35	Concorde 2xxAh AGM
27	Crown CR325 dv/dt
26	Deka 8GGC2 Gel
11	generic flooded CP dv/dt
8	Concorde 1xxAh AGM
7	Trojan J305 dV/dt
6	DEKA 8G31 Gel
5	Trojan 30XHS
4	US Battery US2200
1	Trojan T-105

Table 1.

Product warranty is two years - please contact dealer of original equipment for warranty service.

Note: This is a Class A product. In a domestic environment this product may cause radio interference, in which case the user may be required to take adequate measures.

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## 9

## MAINTENANCE

There are no user serviceable parts in Curtis 1234/36/38 controllers. **No attempt should be made to open, repair, or otherwise modify the controller.** Doing so may damage the controller and will void the warranty.

It is recommended that the controller and connections be kept clean and dry and that the controller's fault history file be checked and cleared periodically.

## CLEANING

Periodically cleaning the controller exterior will help protect it against corrosion and possible electrical control problems created by dirt, grime, and chemicals that are part of the operating environment and that normally exist in battery powered systems.



**When working around any battery powered system, proper safety precautions should be taken.** These include, but are not limited to: proper training, wearing eye protection, and avoiding loose clothing and jewelry.

Use the following cleaning procedure for routine maintenance. Never use a high pressure washer to clean the controller.

1. Remove power by disconnecting the battery.
2. Discharge the capacitors in the controller by connecting a load (such as a contactor coil) across the controller's **B+** and **B-** terminals.
3. Remove any dirt or corrosion from the power and signal connector areas. The controller should be wiped clean with a moist rag. Dry it before reconnecting the battery.
4. Make sure the connections are tight. Refer to Section 2, page 5, for maximum tightening torque specifications for the battery and motor connections.

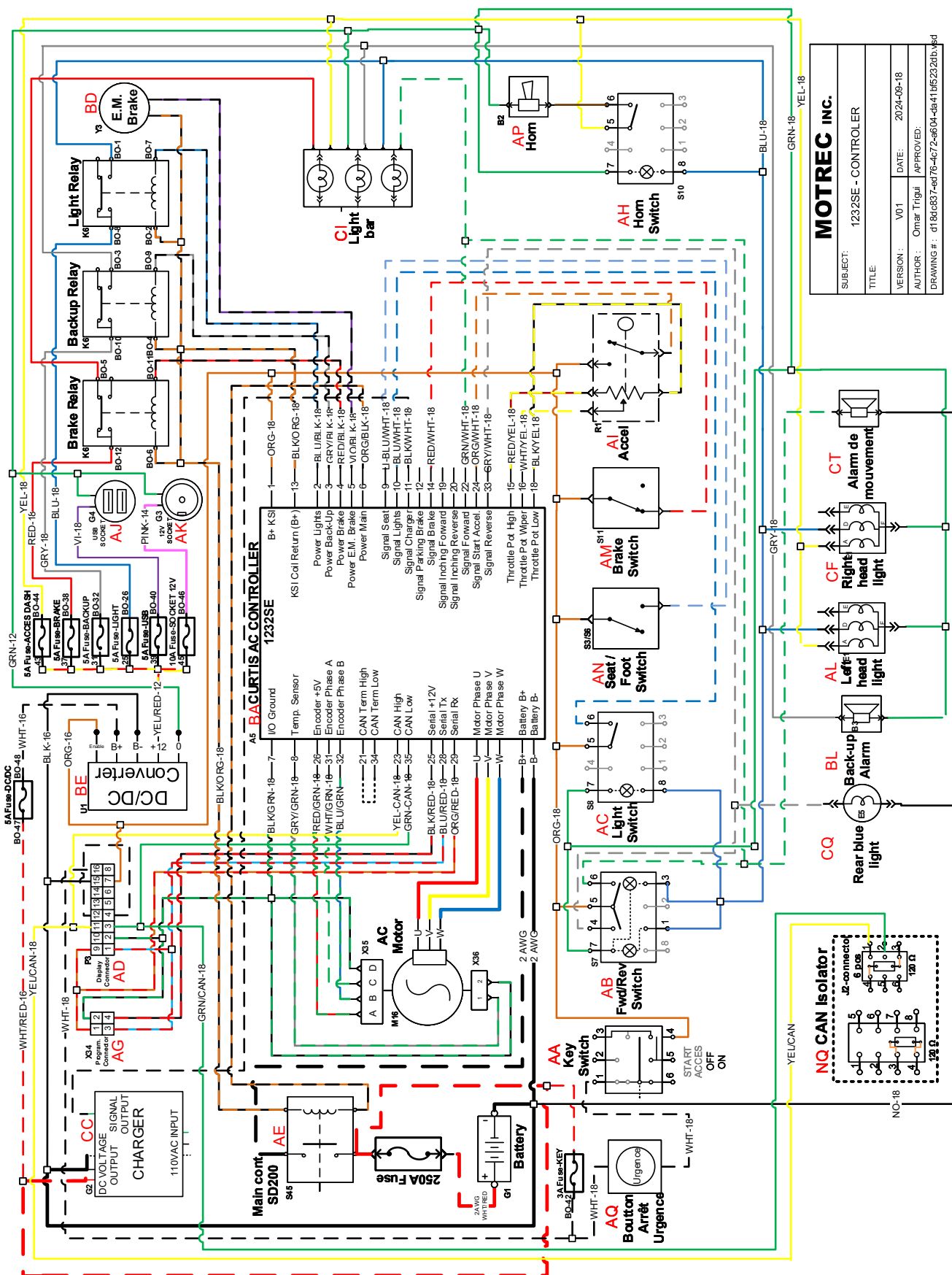
## FAULT HISTORY

The 1311 programmer can be used to access the controller's fault history file. The programmer will read out all the faults the controller has experienced since the last time the fault history file was cleared. Faults such as contactor faults may be the result of loose wires; contactor wiring should be carefully checked. Faults such as overtemperature may be caused by operator habits or by overloading.

After a problem has been diagnosed and corrected, it is a good idea to clear the fault history file. This allows the controller to accumulate a new file of faults. By checking the new fault history file at a later date, you can readily determine whether the problem was indeed fixed.






## Standard Electrical Diagram





Standard Torque

	<div><b>BOLT CLAMP LOADS</b> Suggested Assembly Torque Values</div>									
	USS/SAE GRADE 5					USS/SAE GRADE 8				
	DIAMETER & THREADS PER INCH	TENSILE STRENGTH MIN. PSI	PROOF LOAD LB	CLAMP LOAD LB	TORQUE DRY FT LB	LUBRICATED FT LB	TENSILE STRENGTH MIN. PSI	PROOF LOAD LB	CLAMP LOAD LB	TORQUE DRY FT LB
1/4-20 28	120,000	2,700	2,020	8	6.3	150,000	3,800	2,850	12	9
	120,000	3,100	2,320	10	7.2	150,000	4,350	3,250	14	10
5/16-18 24	120,000	4,450	3,340	17	13	150,000	6,300	4,700	24	18
	120,000	4,900	3,700	19	14	150,000	6,950	5,200	27	20
3/8-16 24	120,000	6,600	4,950	30	23	150,000	9,300	6,980	45	35
	120,000	7,450	5,600	35	25	150,000	10,500	7,900	50	35
7/16-14 20	120,000	9,050	6,780	50	35	150,000	12,800	9,550	70	50
	120,000	10,100	7,570	55	40	150,000	14,200	10,650	80	60
1/2-13 20	120,000	12,100	9,050	75	55	150,000	17,000	12,750	110	80
	120,000	13,600	10,200	85	65	150,000	19,200	14,400	120	90
9/16-12 18	120,000	15,500	11,600	110	80	150,000	21,800	16,350	150	110
	120,000	17,300	12,950	120	90	150,000	24,400	18,250	170	130
5/8-11 18	120,000	19,200	14,400	150	110	150,000	27,100	20,350	210	160
	120,000	21,800	16,350	170	130	150,000	30,700	23,000	240	180
3/4-10 16	120,000	28,400	21,300	260	200	150,000	40,100	30,100	380	280
	120,000	31,700	23,780	300	220	150,000	44,800	33,500	420	310
7/8-9 14	120,000	39,300	29,450	430	320	150,000	55,400	41,600	600	450
	120,000	43,300	32,450	470	350	150,000	61,100	45,800	670	500
1-8 14	120,000	51,500	38,600	640	480	150,000	72,700	54,500	910	680
	120,000	57,700	43,300	720	540	150,000	81,500	61,100	1,020	760





**MOTREC INTERNATIONAL**

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