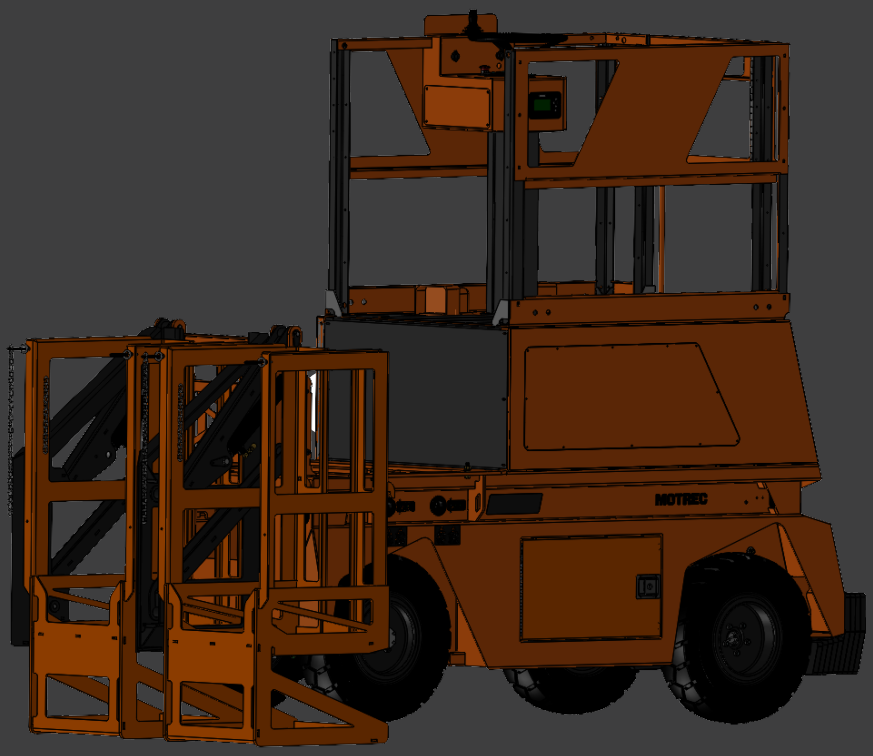
MX-700-AC



MAINTENANCE MANUAL

A GUIDE FOR PERFORMING MAINTENANCE AND REPAIRS ON MX-700 BRIDGE PLATE ELEVATOR

SERIAL NUMBER : 118 07 39 AND UP

UPDATED 02.08.2023
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 usage 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.

MOTREC INTERNATIONAL INC.

5-YEAR LIMITED WARRANTY

FOR VEHICLES PRODUCED AFTER NOVEMBER 1, 2024

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

MOTREC INFORMATION

• Find us :
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• Call us :
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Telephone : + 1 (819) 846-2010
Fax : +1 (819) 846-3050
• Send us an e-mail : support@motrec.com

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.

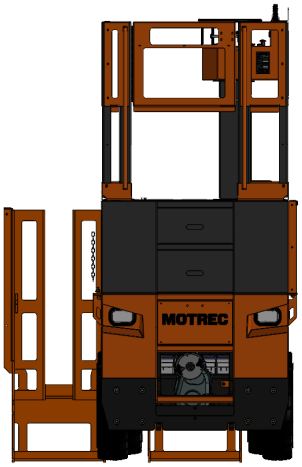
MOTREC®

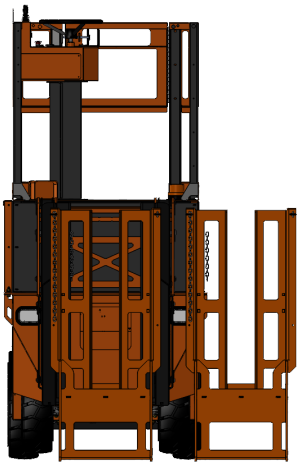
“AYONE CAN WORK WE PERFORM THAT’S MOTREC ”

-Motrec Tagline

CONTENTS

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 quick maintenance references is included at the back of this document. These references are intended for an MX-700 experienced technician to accelerate the maintenance process. The Quick References should not be used by any untrained or inexperienced personnel.

The MX-700

With its elevated platform and bi-directional steering, the MX-700 is the perfect vehicle for elevated work in tight spaces. Its design prioritizes driver safety and productivity. The precise controls enable smooth activation, ensuring maneuverability and simplicity. Made entirely of steel, this sturdy model requires minimal maintenance and is built for intensive use and long-term reliability. Among its key features, this vehicle is equipped with cutting-edge AC technology, resulting in minimal noise and zero emissions during operation. Like all Motrec vehicles, the MX-700 can be customized to precisely meet your specific needs.

Modular Design

The Motrec MX-700 electric vehicle showcases an intelligent and efficient modular design, allowing for various configurations. This design approach provides a host of benefits that elevate the vehicle's functionality, adaptability, and maintenance convenience. In this guide, we will delve into the advantages of the Motrec MX-700's modular design, which includes a scissors lift and front bridge plate elevator, with a focus on its exceptional features.

Refer to our website www.motrec.com for more details on configurations.

1.2. ACRONYMS AND ABBREVIATIONS

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

3. VEHICULE OVERVIEW

3.1. SPECIFICATIONS AND CONFIGURATIONS

The MX-700 specifications and configurations can vary depending on the specific model and year of the MX-700. 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.

EQUIPMENT COMPARTMENTS:

NOTE 1 : The EMB Service Knobs Compartment is typically located in the back 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.

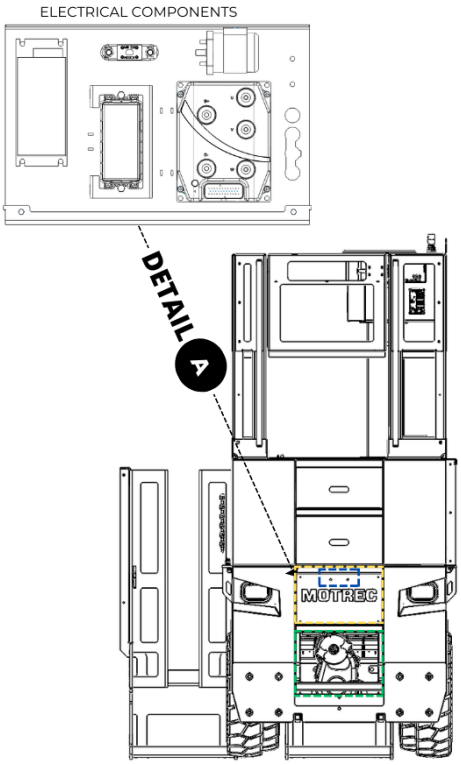


Figure 1.a. Equipment Compartments Front View.

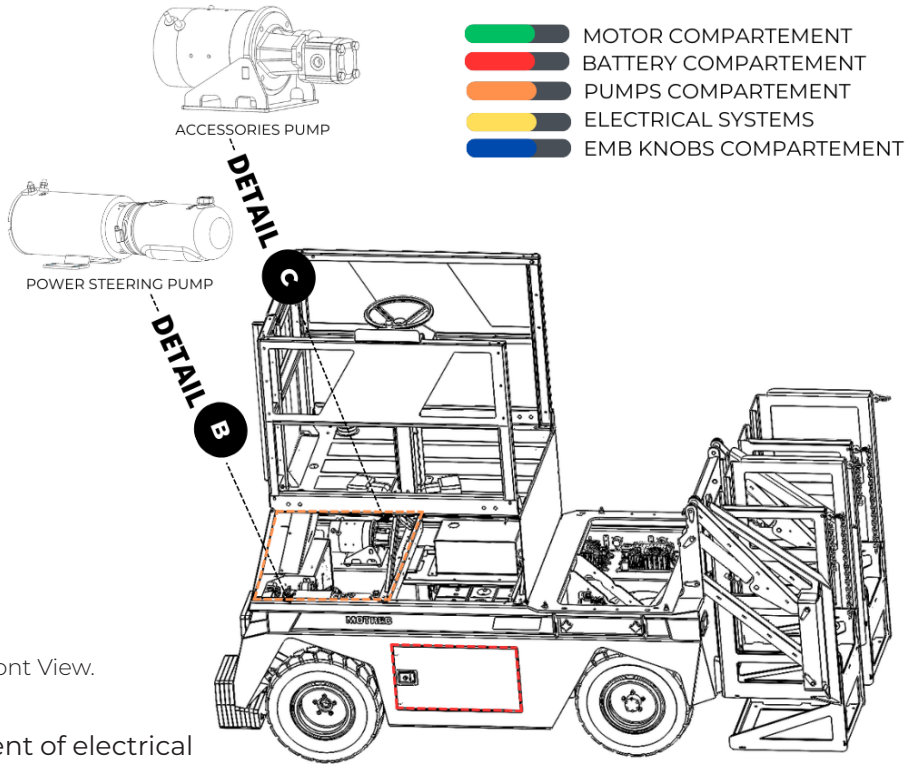


Figure 1.b. Equipment Compartments Side View.

NOTE 2 : To access the compartment of electrical components, you need to remove the Motrec plate of the vehicle.

NOTE 3 : There is a battery access door that allows access to the batteries.

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 can be powered by multiple battery types, including:

- TPPL (Thin Plate Pure Lead).
- Lithium.

Battery Compartment :

The battery compartment is intentionally designed without any mechanical components. In order to access the batteries, an extraction tool needs to be used (as depicted in Figure 2). Furthermore, it's worth noting that the only available voltage battery combination for the MX-700 vehicle is 48V.

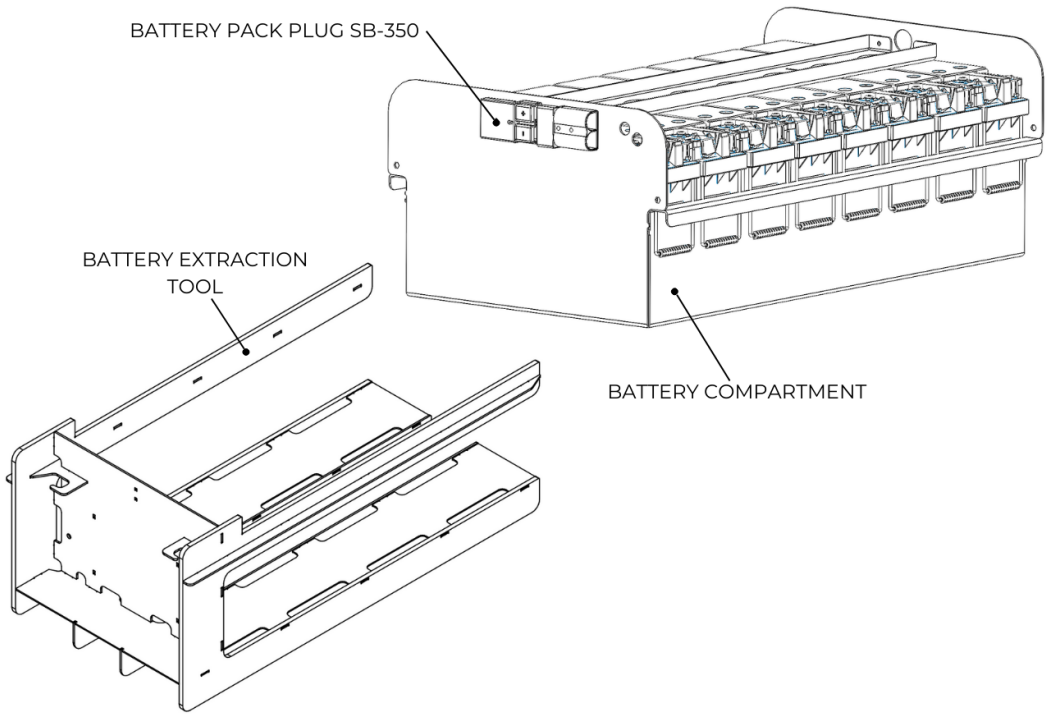


Figure 2. Battery Compartment (48 V).

3.3 ELECTRICAL SYSTEMS

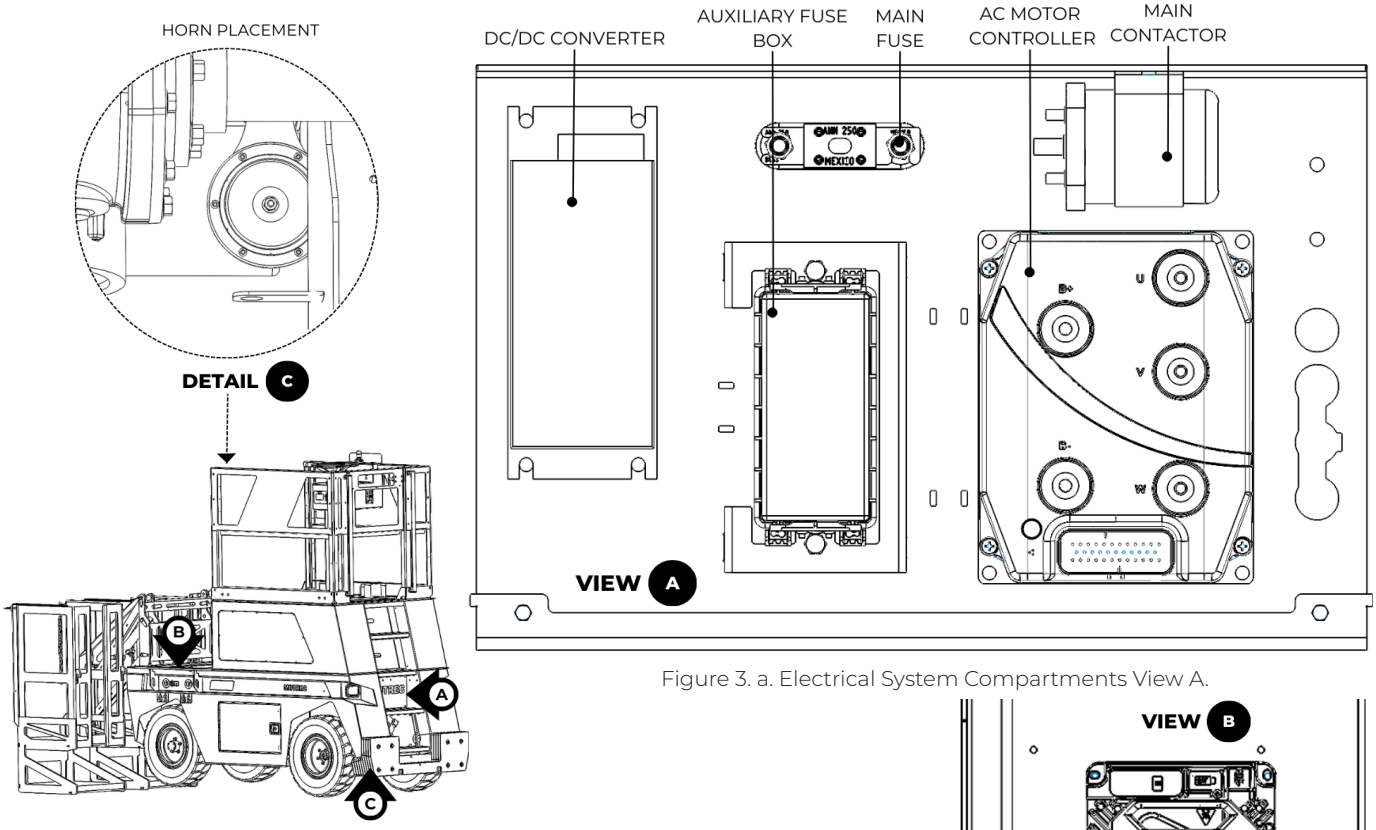


Figure 3. a. Electrical System Compartments View A.

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 5 Annexes.

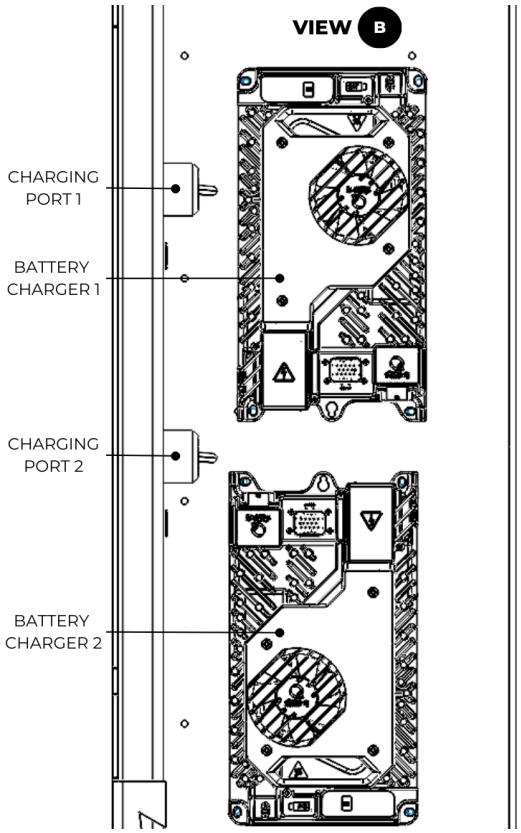


Figure 3. b. Electrical System Compartments View B.

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.

Important : For the chargers please refer to note 2 in page 14.

3.3.1 MAIN ENERGY

The main energy system encompasses all the elements responsible for the vehicle's movement, such as the AC motor, hydraulic pumps, 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.

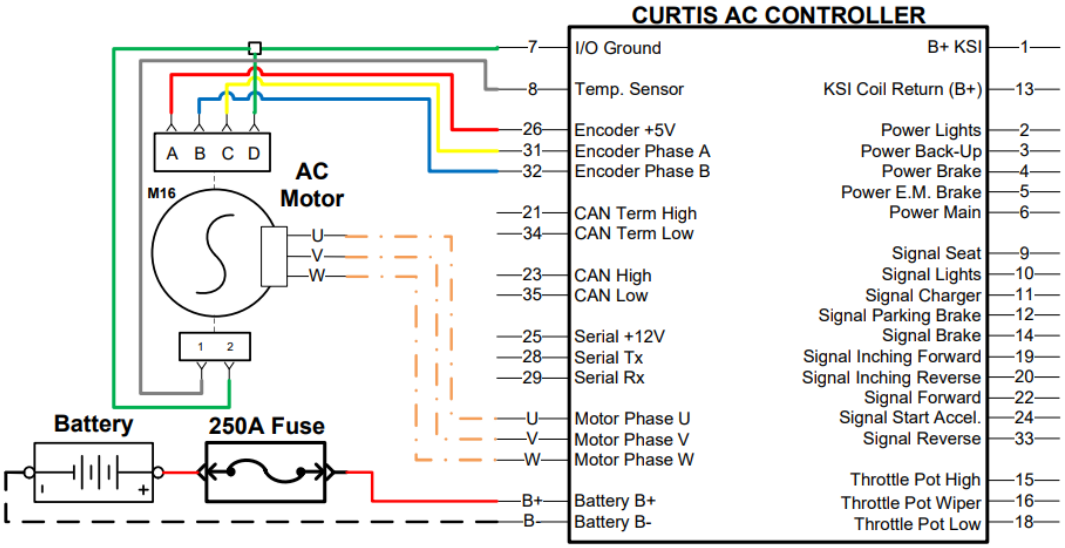


Figure 4. Main Energy Electrical connection (Annexe 5).

3.3.2 AUXILIARY ENERGY

To power the auxiliary systems of the vehicle, including the backup alarm, lights, horn, and others. The DC-DC converter utilizes the battery voltage (48 VDC) and converts it to an output of 12 VDC / 13.4 VDC. This voltage is then directed through the auxiliary 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.

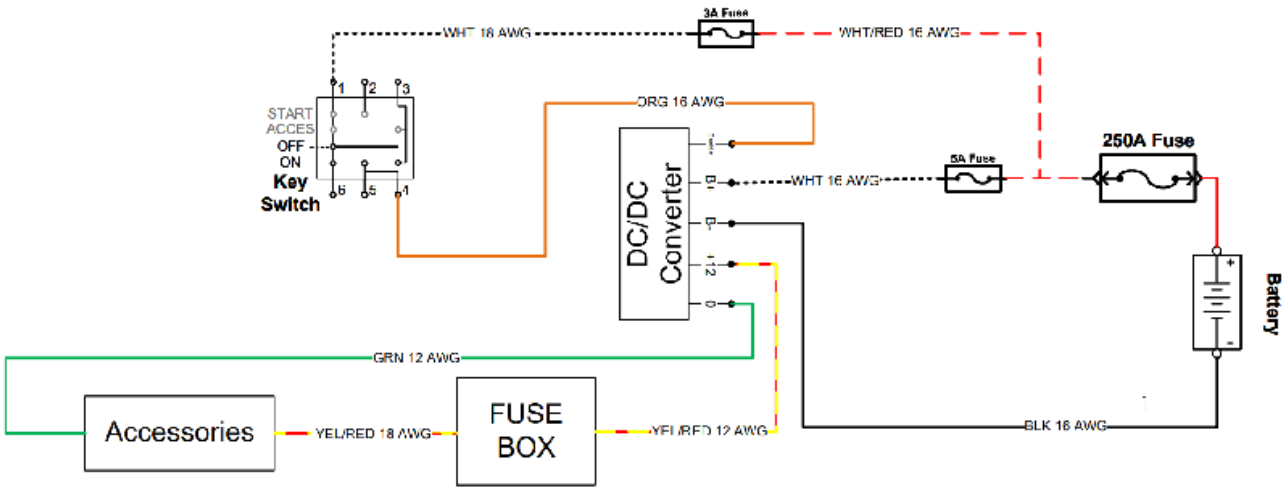


Figure 5. Auxiliary Energy Electrical connection (Annexe 5).

3.3.3 CHARGING ENERGY

NOTE 1: This section is applicable to all the vehicles equipped with onboard charging.

Certain setups incorporate a specialized battery charger tailored to streamline the charging process, considering the sole availability of 48 DC voltage. The adapted charger is designed to align with the precise battery voltage and vehicle type. It generates a voltage, while keeping consistency with the prevailing 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 2: For the MX-700, it's possible that two chargers are installed on board.

NOTE 3: The wiring remains the same, but the component placement may vary from one vehicle model to another.

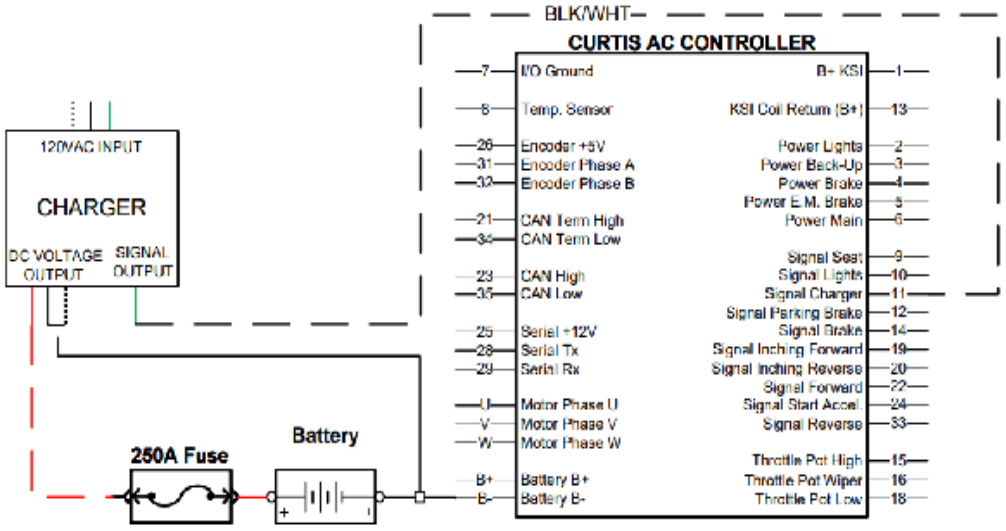


Figure 6. Charging Energy Electrical connection (Annexe 5).

3.4 MOTORS AND REAR AXLE

3.4.1 AC MOTORS

The MX-700 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.

the AC motor is available with one type of casing :

FAN COOLED

The 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.

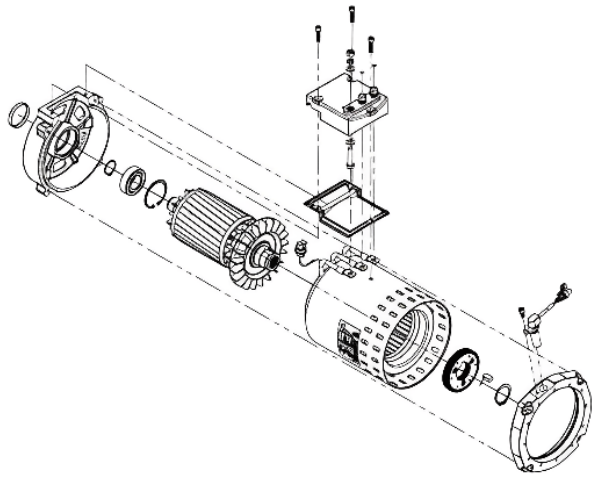


Figure 7. Fan Cooled Motor.

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 MX-700 electric vehicle is equipped with an electromagnetic brake (EMB).

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.

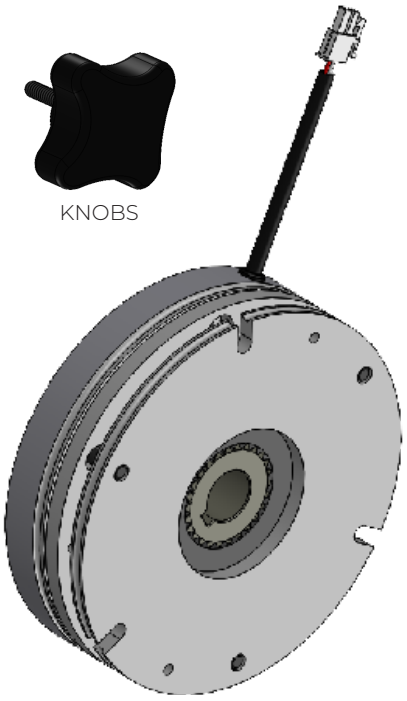


Figure 8. EMB Brake System.

3.5 HYDRAULIC PUMPS

Two hydraulic pumps have been installed within the MX-700.

These are the two types of hydraulic pumps :

1. The accessories pump, equipped with a non-integrated reservoir and powered by a DC motor. This pump finds its purpose in driving the motion of diffrent accessories (ex : bridge plate elevator). The pump generates fluid flow by pressurizing hydraulic fluid (hydraulic oil), the pressurized hydraulic fluid is then directed towards the hydraulic cylinders, which contain pistons. These cylinders are equipped with two chambers, each housing a piston that can move back and forth. As the piston moves, it pushes or pulls the load connected to it. This load could be either the bridge plate elevator or another accessory (not shown).

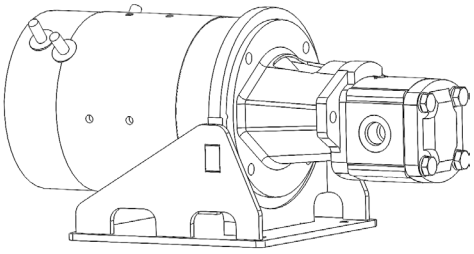


Figure 9. The Accessories Pump (bridge plate elevator).

2. The power steering pump comes complete with an integrated reservoir its only role revolves around being a steering pump, creating an essential connection with the vehicle's steering system. In this context, the pump operates as the driving force that enables effortless steering, skillfully directing hydraulic fluid to guarantee a seamless, controlled, and secure driving journey.

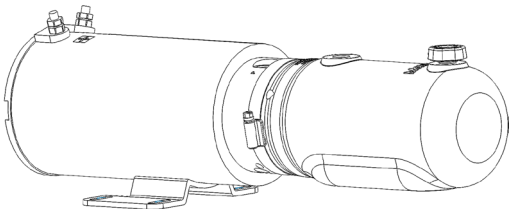


Figure 10. Power Steering Pump.

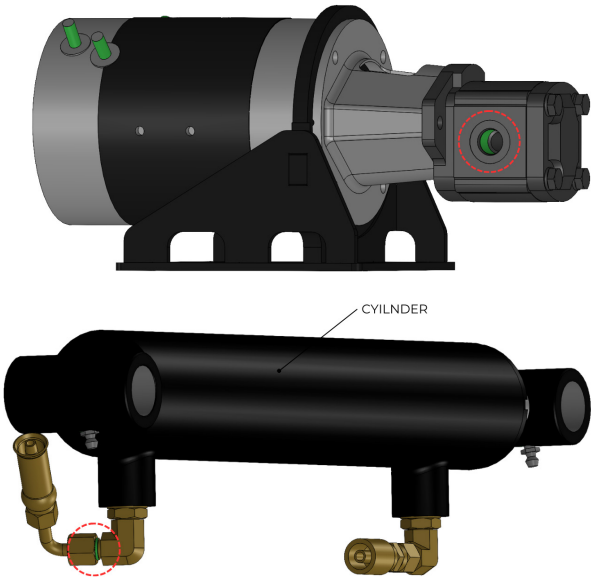


Figure 11. Connections.

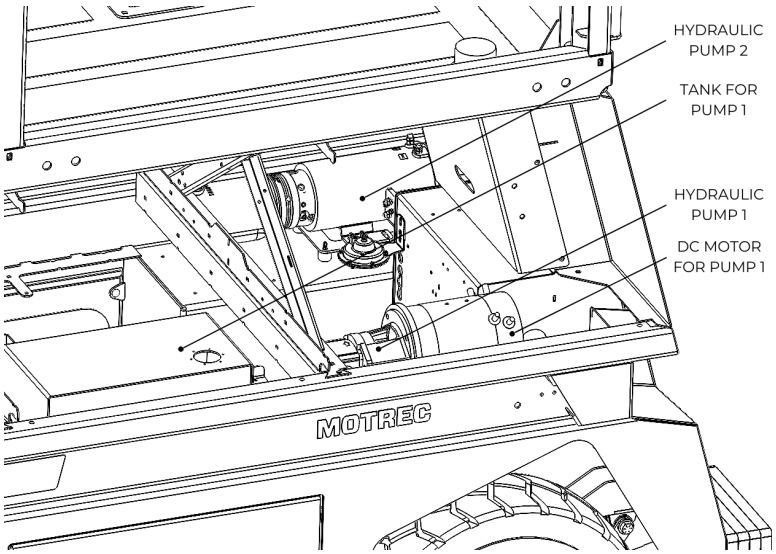


Figure 12. Hydraulic Pumps Compartement.

NOTE : Colors are used to denote connections between elements, as depicted in the figure 11 above with the highlighted green color (encircled in red).

3.6 STEERING SYSTEM

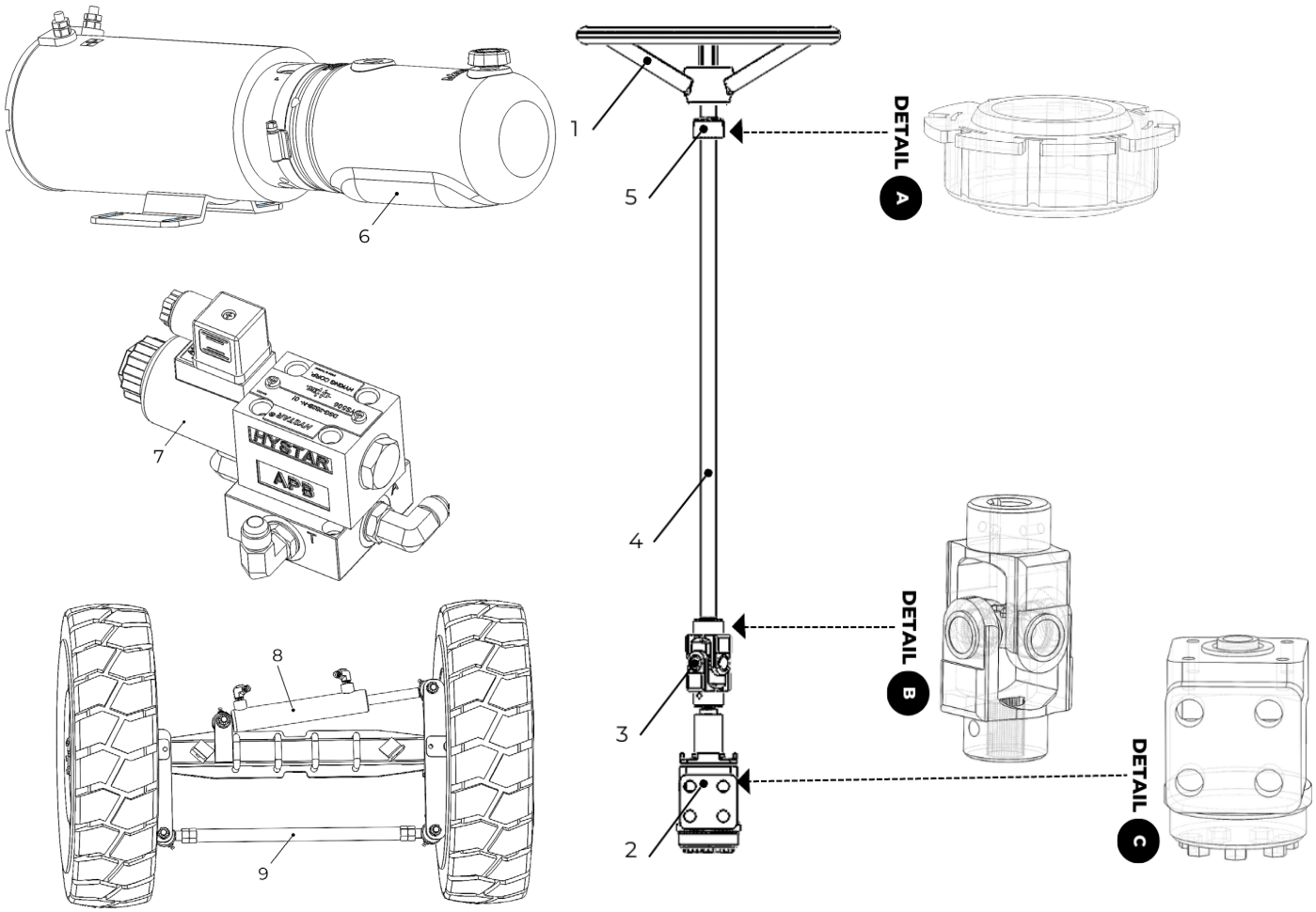


Figure 13. Steering System.

When the driver turns the steering wheel (1), the rotational motion is transmitted to the orbitrol (2) via the universal joint (3), the steering shaft (4) and igus bushing (5). In essence, the orbital steering unit takes the hydraulic pressure generated by the power steering pump (6) and converts it into mechanical force to control the movement of the vehicle's wheels. Furthermore, when the driver changes driving position, the flow diverter valve (7) responds to this adjustment, modulating hydraulic fluid flow correspondingly. The valve ensures that hydraulic pressure is directed to the relevant side of the steering system based on the driver's orientation, leading to wheel movement in the intended direction. This hydraulic pressure is channeled towards the steering cylinder (8) on the appropriate side of the vehicle (determined by the driver's position), prompting the wheel to turn as required. This coordinated movement is mirrored by the opposite wheel through an interconnected linkage system (9).

Collectively, these components harmonize their functions, allowing the driver's touch to translate into precise wheel movements, ensuring effortless steering, and ultimately, enhancing the vehicle's navigation and maneuvering capabilities.

Important : The direction of the wheels strongly relies on the driver's input, closely tied to their position and determined by the presence pedal they press on.

3.7 REAR SUSPENSIONS

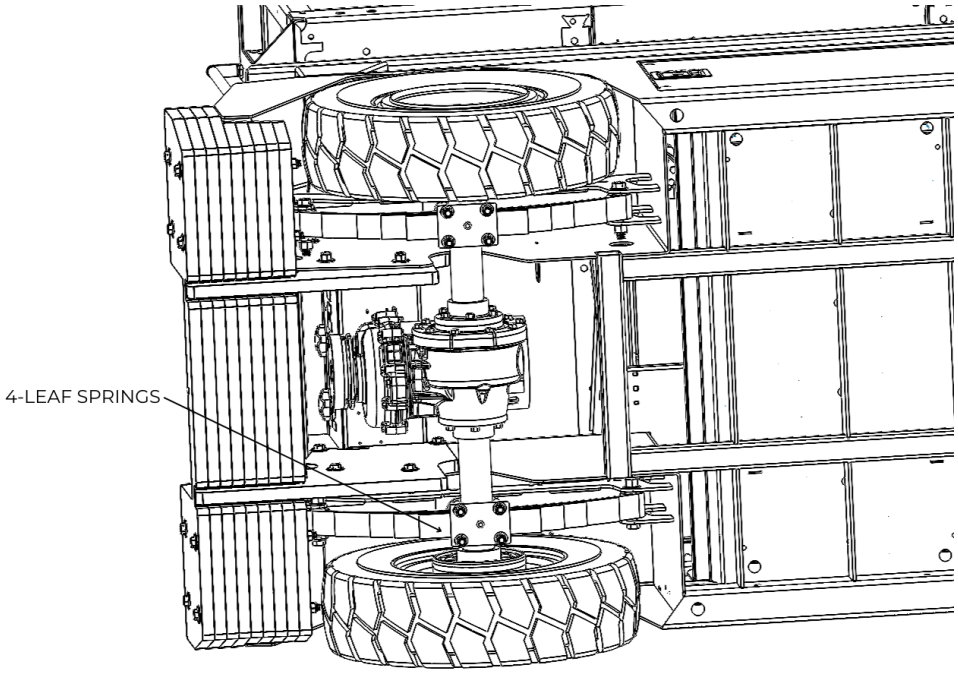
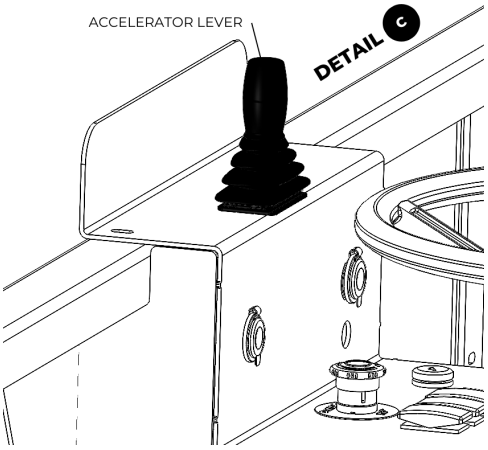


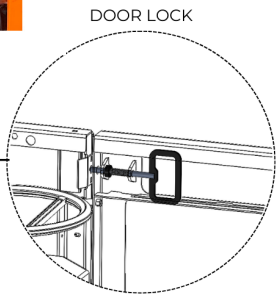
Figure 14. Rear Suspensions.

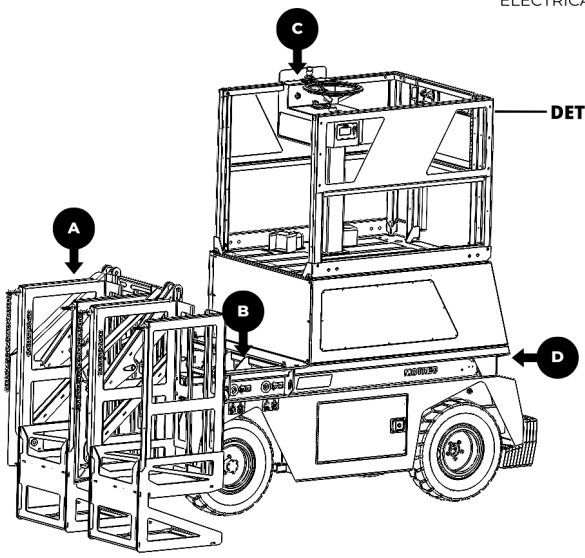
As the default configuration, all MX-700 models feature a leaf spring suspension at the back of the vehicle. This design ensures effective stabilization by distributing the vehicle's weight evenly, absorbing road shocks and vibrations, and enhancing overall handling. The leaf spring suspension's simplicity, reliability, and impressive load-carrying capacity make it a practical and reliable choice, providing a comfortable and stable ride.

3.8 GENERAL COMPONENTS

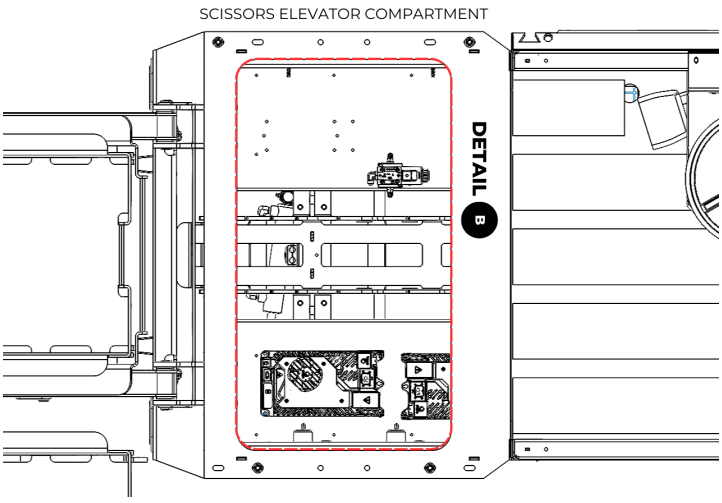
The electrical cables are carefully guided and routed beneath the vehicle. They follow the path provided by the frame, which acts as a designated cable tray. This routing ensures that the cables are neatly organized and protected from potential hazards or obstructions. Their ultimate destination is the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







NOTE : if any of the vehicle's doors is open, the vehicle will not move from its current position. This safety measure is in place to prevent any accidental movement while doors are ajar, ensuring the safety of occupants and the surrounding environment. There's also a 3-second delay after opening a door before the vehicle can be operated, enhancing safety.



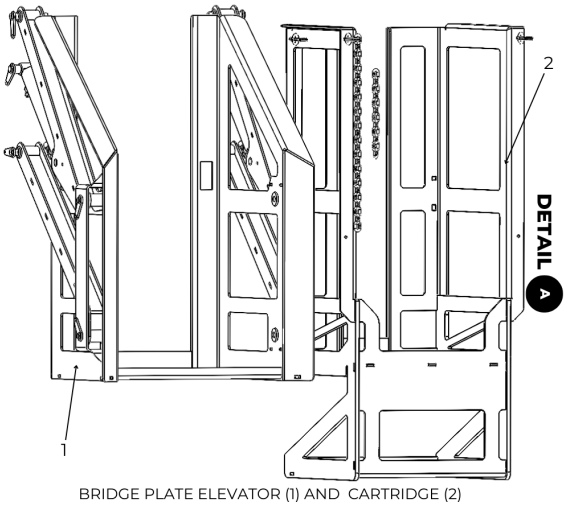


Figure 15. General Components.

Figure 16. Operator's Presence Detection Pedal

Figure 17. Charging Port and Indicator.

Operator's presence detection pedal

Two operator's presence detection pedals are strategically positioned adjacent to the driver's feet with the purpose of discerning the driver's seating orientation. By utilizing these pedals, the system can effectively identify whether the driver is positioned on the front or rear of the vehicle. When the driver's foot engages either of the pedals, the system registers this input and determines the corresponding driving configuration. This information is then utilized to tailor various vehicle functions, such as steering behavior, to suit the driver's specific placement. Additionally, if all the vehicle's doors are closed, engaging the pedal also starts the power steering pump

Charging port

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

- 120 VAC, 60 Hz North American outlets.

Battery charge 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 section 5 Annexes section at the end of the document.

3.9 CONSOLE

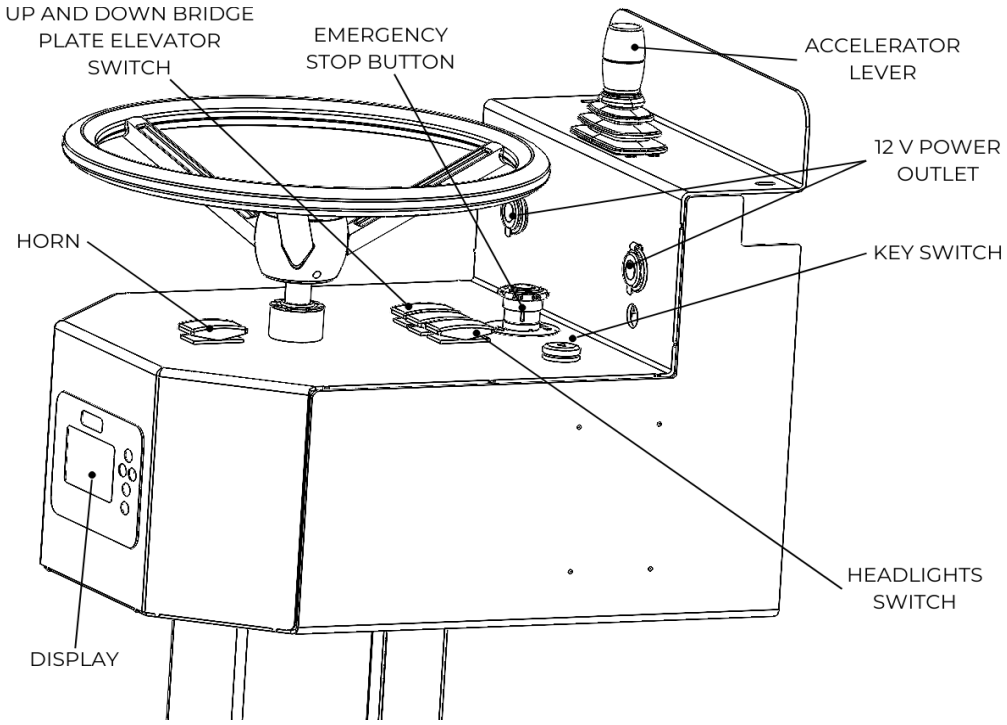


Figure 18. Console.

Accelerator Lever

When activated, the accelerator lever allows the vehicle to move in either the forward or backward direction by being pushed to the front or the rear.

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, should only be used in case of emergency. When applied, it will stop immediately the vehicle by engaging the electromagnetic brake (EMB).

CAUTION

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 (if appicable).

The indicator lights up every time the vehicle comes to a stop, since the EMB engages automatically and acts as a parking brake.

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.

Navigation Arrows

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

Drive Mode Indicator

Indicates the current selected drive mode between rabbit and turtle.

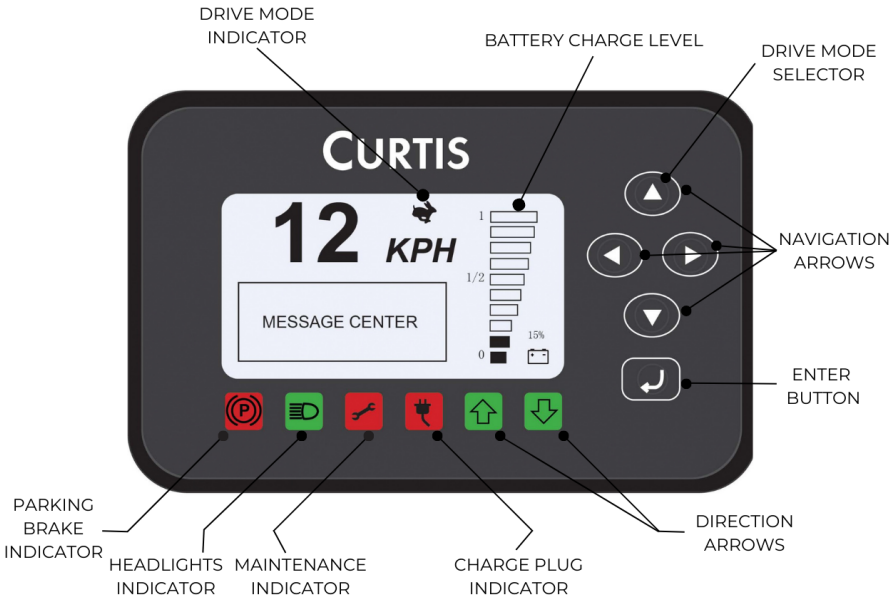


Figure 19. Display.

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.

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 in the console. It's important to note that the display connector (refer to Figure 20) needs to be disconnected each time the handheld programmer is used.

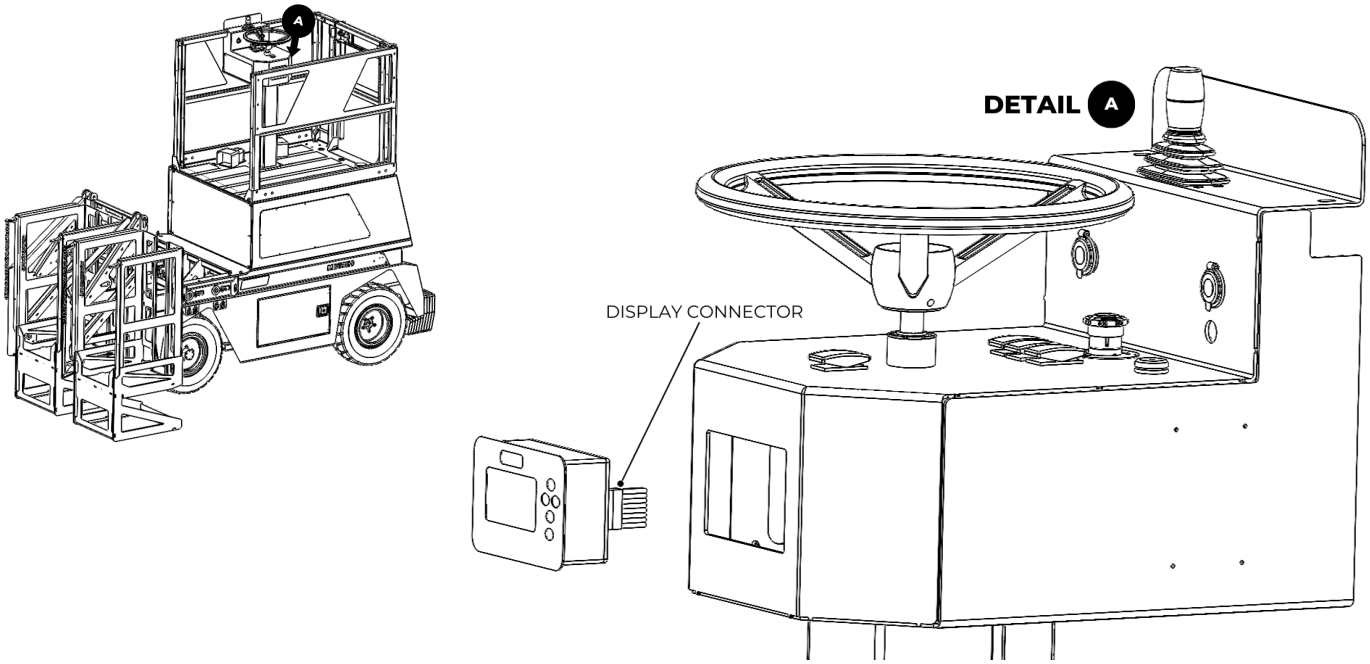


Figure 20. Display Connector.

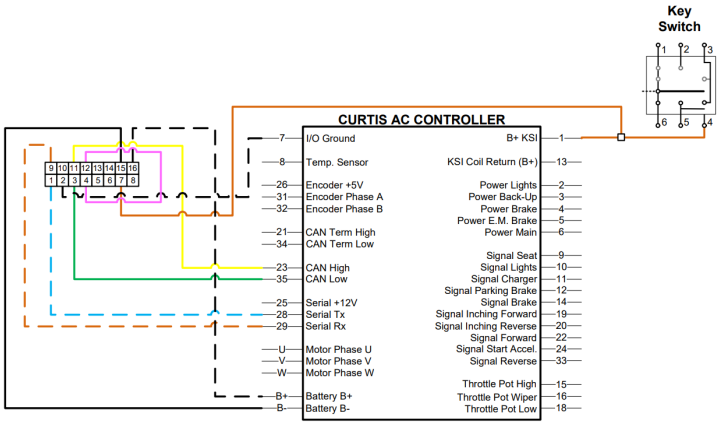


Figure 21. Display Connector Electrical connection (Annexe 5).

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.

3.10 REAR LIGHT COLORS SIGNIFICATION

There are three available rear light colors in the vehicle, which are as follows: *white* is used for reversing, *pale red* (standard) indicates vehicle startup and the intensity of pale red increases under braking, becomes *Intense Red*. 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 MX-700 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 MX-700 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.

Before undertaking any maintenance operations, except for daily and weekly preventive maintenance, it is recommended to remove any obstructing accessories installed on the deck. This will facilitate the necessary manipulations and ensure smoother maintenance procedures.

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. RINCE 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 CONTROLLER. 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 22), positioned on the left or 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 and accessories.

When utilizing a lifting device, ensure that it can support the precise weight of the vehicle. The suggested lifting points are highlighted below (Figure 23) 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.

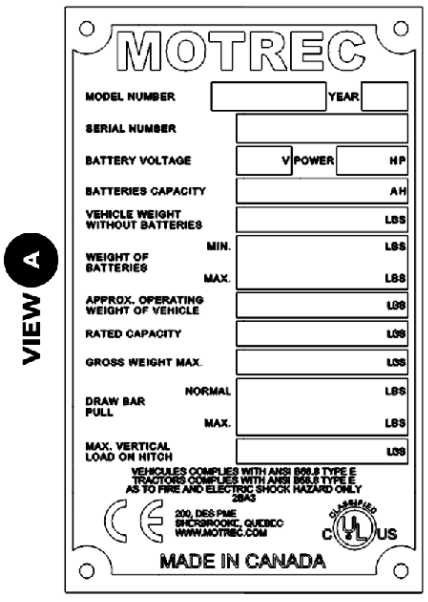


Figure 22. Serial Data Plate.

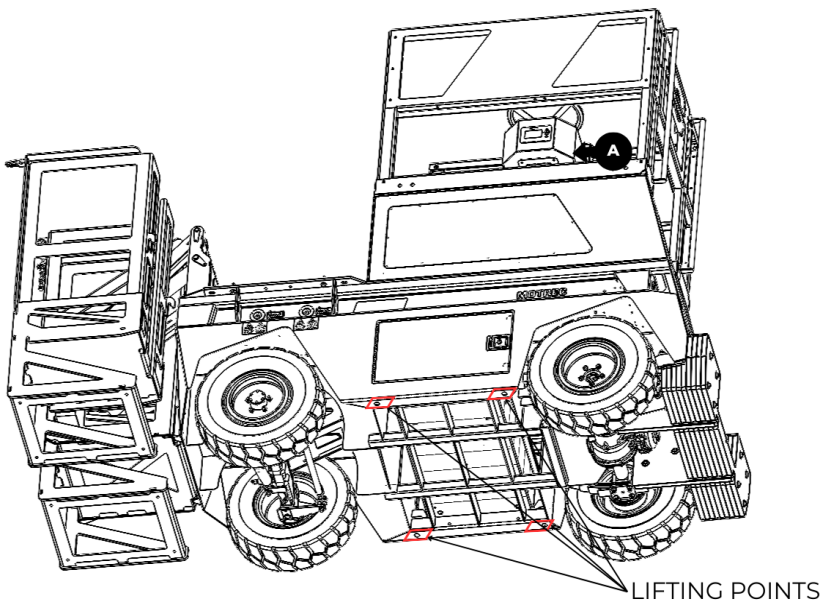


Figure 23. Lifting Points.

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. RINCE 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.
3. Disconnect the charger. It is crucial to verify that the charger is disconnected.

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.

4. Open the battery access door.
5. Disconnect the battery pack.

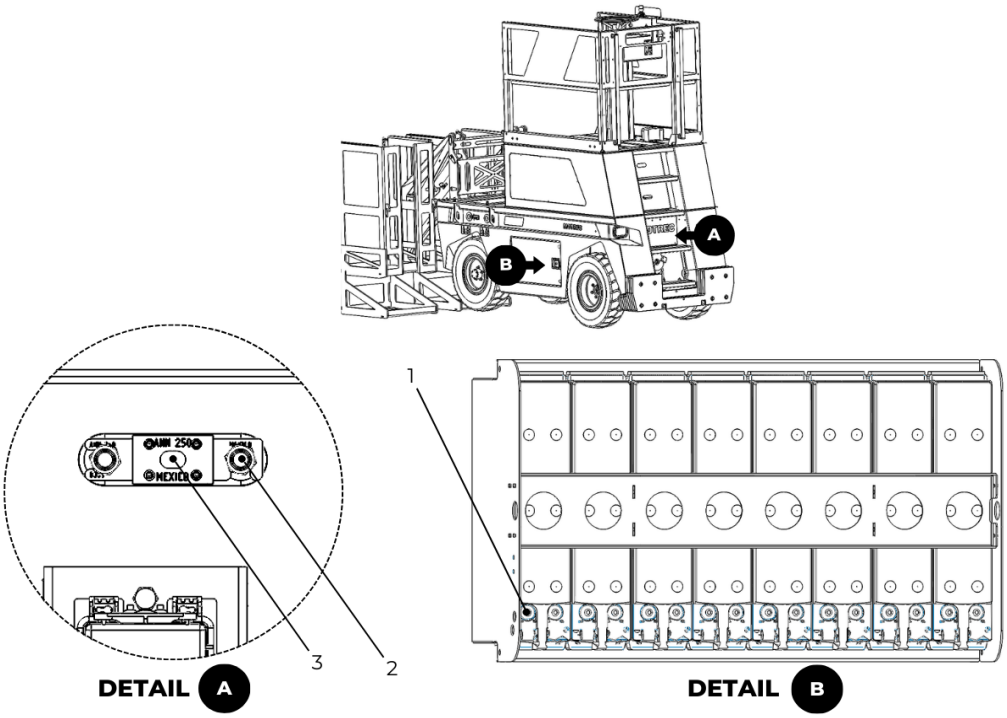


Figure 24. Electrical Isolation.

6. Discharge the capacitor in the AC motor controller (5) by connecting a 10 ohms / 25 W resistor (6) for a few seconds across the AC motor controller's (5) **B+** and **B-** terminals. Do not leave the resistor (6) on the terminals once discharged.
7. Using a multimeter, validate the absence of voltage between the AC motor controller's (5) **B+** and **B-** terminals.
8. To reconnect the electrical circuit, perform this procedure in reverse.
    - **NOTE** : No resistor needed for reconnection.

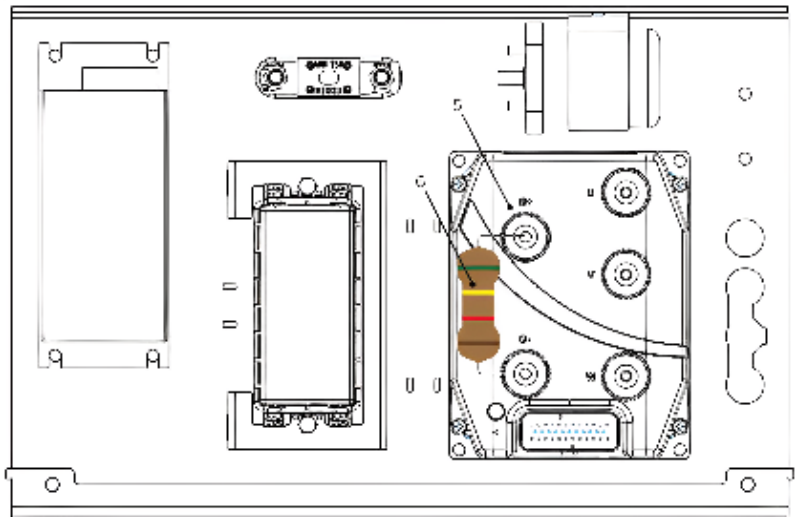


Figure 25. AC Motor Controller Terminals.

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 static. 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.

It could take up to 2 minutes of vehicle run time for the fault code to disappear.

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. The vehicle may be lifted for further inspection of this symptom as required.

Proceed as follows to inspect :

1. Inspect the drive assembly (1) for signs of leaks at following locations:
   - Covers.
   - Axle ends.
   - Casing mating surfaces.
   - Drain/fill plugs.
   - Hydraulic steering system.

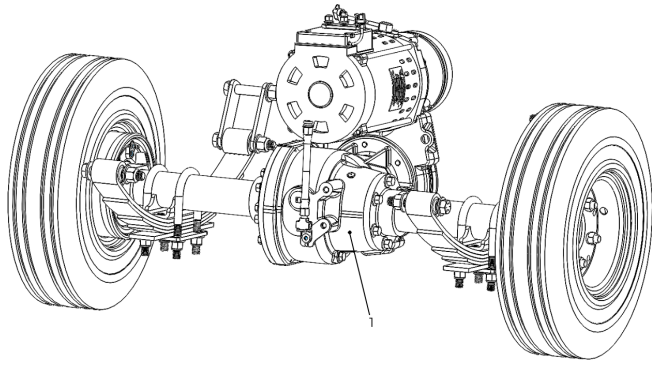


Figure 26. Drive Assembly Fluid Leaks.

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.

Operator's presence detection Pedals Inspection

Examine both pedals to check their feel and travel.

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.

4.2.2 WEEKLY MAINTENANCE

Special Tools	Consumables
▸ N/A	▸ N/A

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 of punctures, damage or excessive wear.

4.2.3 EVERY 250 HOURS OR 3 MONTHS MAINTENANCE

Special Tools	Consumables
▸ Resistor: 10 ohms, 25 W ▸ Lifting device	▸ Multi purpose Grease ▸ Compressed air ▸ Ammoniac

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 dashboard cover (1).

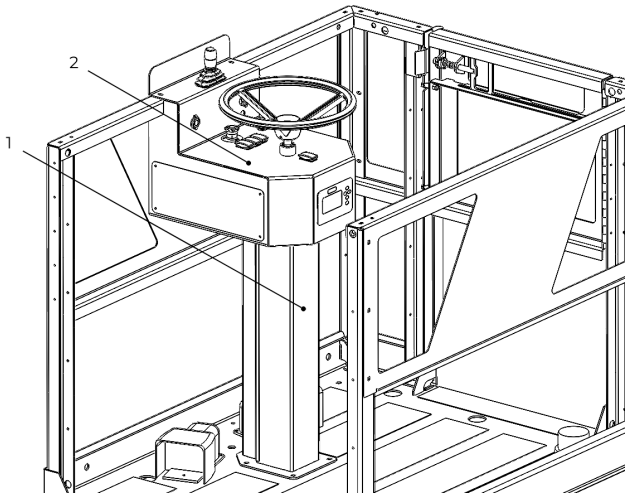


Figure 27. Kick Panel and Dashboard Cover.

2. Take the necessary steps to remove electrical hazards in accordance with **Section 4.1.2**, 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 following equipment for damage and corrosion:
   - Leaf springs (1) and their fixtures(2).
2. Inspect all suspension frame bushing for play.

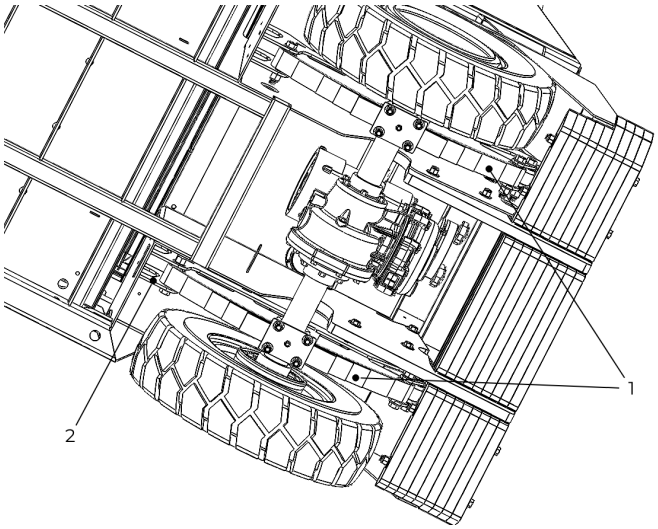


Figure 28. Rear Suspension Inspection.

Rubber Bellows Inspection

Inspect rubber bellows installed on the vehicle components for signs of damage, cracks or dryness.

Steering Inspection

1. Inspect the universal joint (1) and the four ball joint (2) for (See Figures 29 and 30):
   - Play.
   - Damage.
   - Binding.
   - Corrosion.

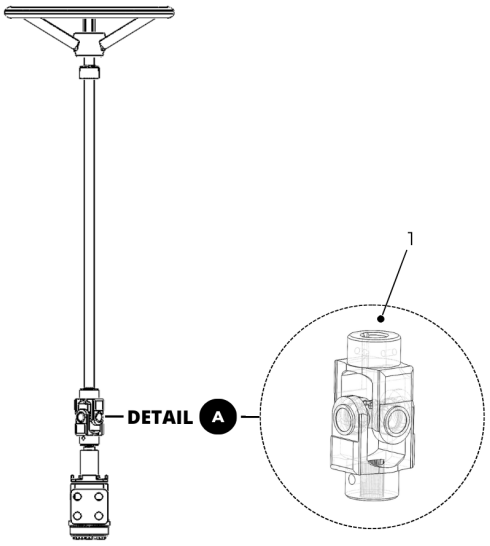


Figure 29. Universal Joint Inspection.

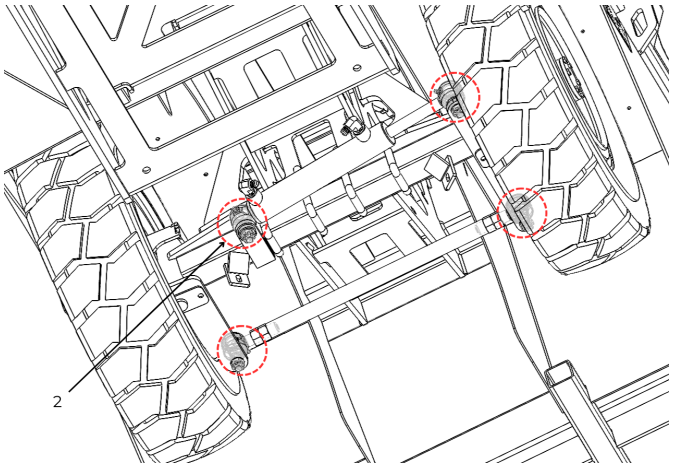


Figure 30. Tie rods Inspection.

2. Inspect the following elements for damage or corrosion:
   - Steering cylinder (3). (See Figure 31)
   - Steering shafts (4). (See Figure 14)
   - Axle beam (5). (See Figure 31)
   - Right and left knuckles (6). (See Figure 31)
   - Tie rod (7). (See Figure 31)

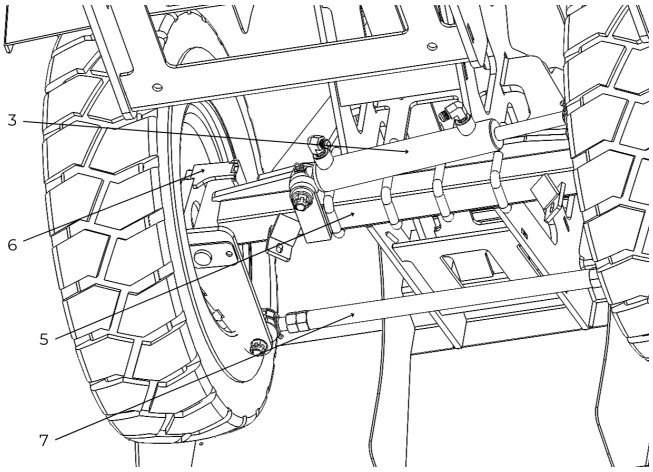


Figure 31. General Steering Inspection.

Grease Fittings Lubrication

Lubricate the grease fittings of the following components (See Figure 29 and Figure 30) :

- The universal joint (1).
- The four tie rods (2).

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

⚠ WARNING

DO NOT BREATHE THE AIR WHILE CLEANING WITH COMPRESSED AIR. USE PROPER RESPIRATORY PROTECTION IF NECESSARY.

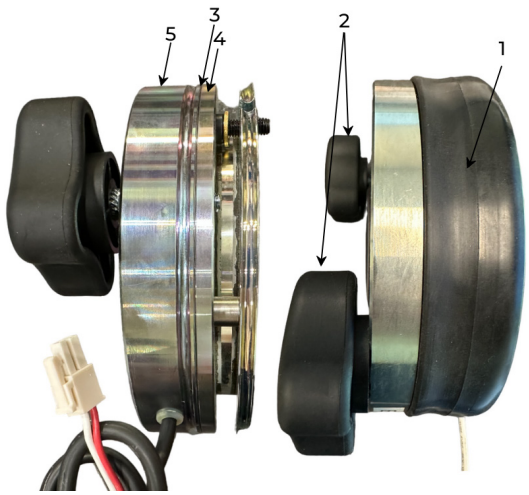


Figure 32. EMB Inspection.

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.

AC Motor Dusting

If the vehicle is equipped with the fan cooled AC motor, clean the motor's air vents (1) with compressed air.

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

In the case of a Sealed motor, it provides inherent protection against dust and debris. Therefore, no additional dusting or cleaning is necessary for the motor.

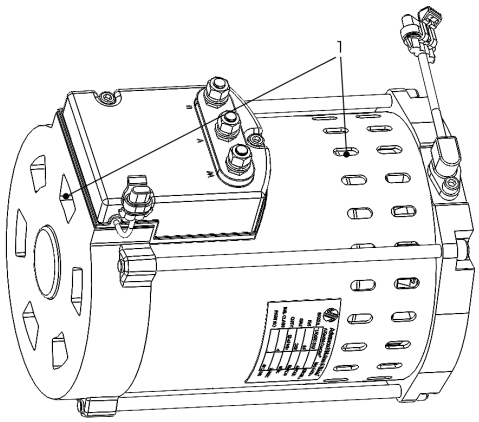


Figure 33. AC Motor.

Power Circuit Inspection

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

Battery Inspection

⚠ 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. RINCE CONTAMINATED AREA IMMEDIATELY WITH WATER.

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.

! 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. Reinstall the dashboard cover.
2. Reconnect the electrical circuit:
   i. Make sure there is no resistor connected across the AC motor controller's **B+** and **B-**.
   ii. Reconnect the battery leads.
   iii. Turn on all switches and test lights.
   iv. Insert the key.
3. 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. Listen for abnormal noise.

4.2.4 EVERY 500 HOURS OR 6 MONTHS MAINTENANCE

Special Tools	Consumables
▸ Resistor: 10 ohms, 25 W	▸ Lubricant spray

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. Please consult the maintenance checklist in the QUICK REFERENCES section for the specific steps that are required.

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**, 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.

Door Maintenance

1. Inspect the following components for signs of rust, corrosion, or damage :

   - Door locks (1).

   - Hinges (2).

2. Lubricate the following components with lubricant spray to reduce friction and prevents squeaking :

   - Door locks (1).

   - Hinges (2).

   NOTE : Apply a bit of lubricant to the hinges pivot points. Open and close the door several times to distribute the lubricant.

3. Inspect the hinge screws on both the door and the frame. If you find any loose screws, tighten them with a screwdriver.

4. Ensure that the door is properly aligned with the frame. If the door is sagging or not closing properly, it might put extra stress on the hinges.

5. Examine the switch (31) for any physical damage or signs of wear. Turn on the power and test the switch to ensure it operates correctly.

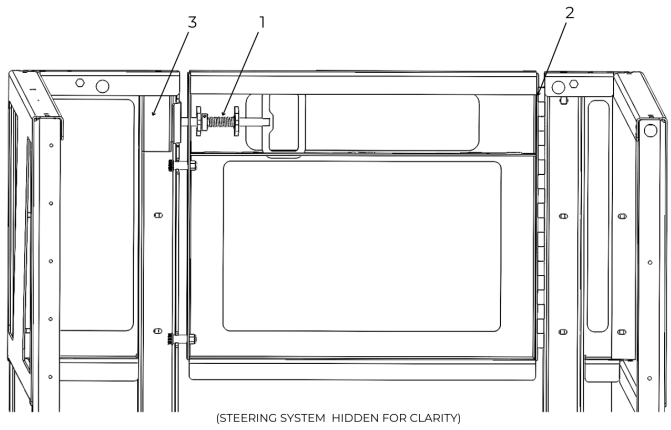


Figure 34. Door Maintenance.

Frame Inspection

1. Inspect the vehicle's frame for the following elements:

   - Cracks.

   - Damage.

   - Corrosion.

2. The following frame locations should be inspected with care:

   – Side panels corners (1) (both sides) and guardrails (2). There is a possibility of cracks occurring in the side panels corners as they undergo significant stress (see Figure 35).

   – Suspension mounting tabs (3) (see Figure 36).

   – The edges and corners of the bridge plate elevator on both sides (see Figure 37) can be prone to wear and damage. Special attention should be paid to these areas to prevent deformation or cracks.

   – Weld zones (see Figure 38 : not all welds are shown).

   – Slip Surface, any dirt or substances that accumulate on it could affect traction and stability when the bridge plate elevator is driven onto it.

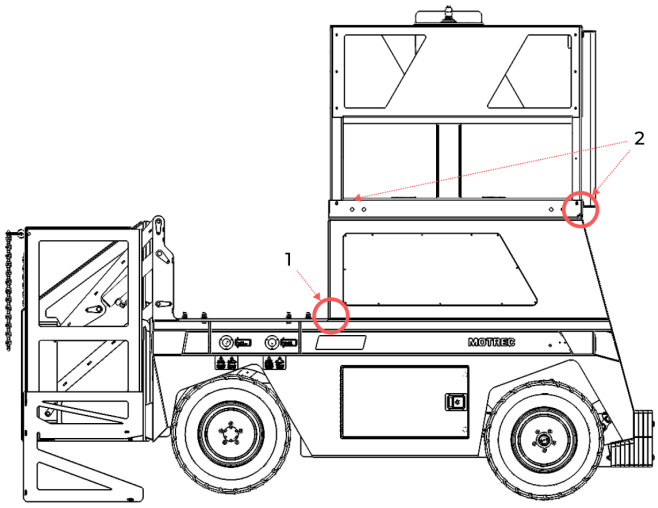


Figure 35. Side Panels And Guardrails.

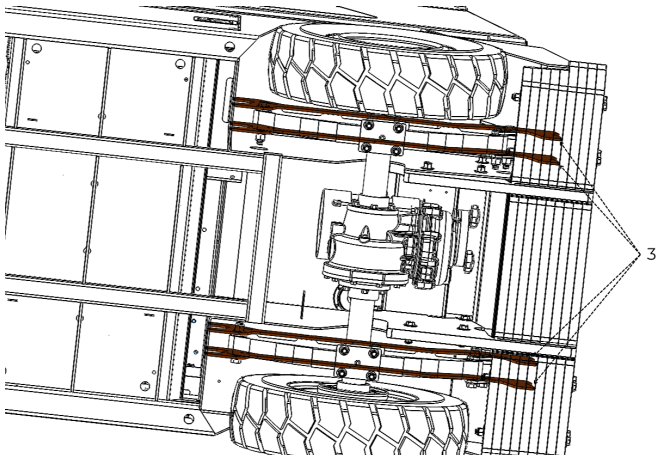


Figure 36. Suspension Mounting Tabs.

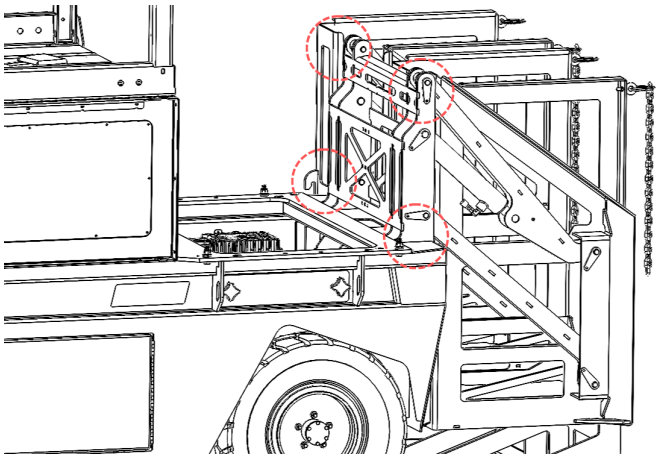


Figure 37. Edges And Corners Of The Bridge Plate Elevator.

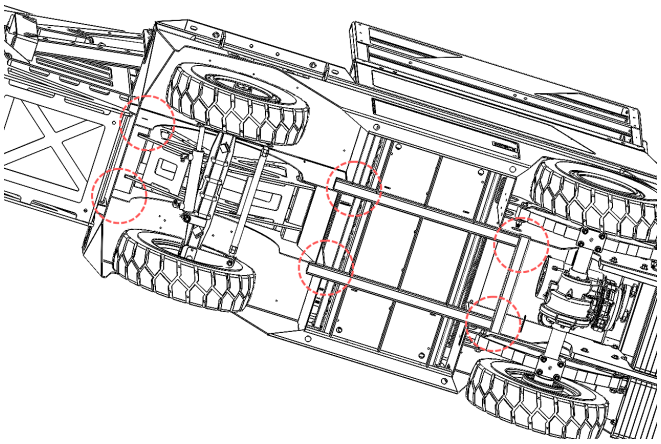


Figure 38. Weld Zones.

Kingpins Inspection

1. Inspect the kingpins (1) assembly of the two front wheels for the following:

   - Play.

   - Damage.

   - Corrosion.

2. Inspect the condition of the castle nut (2) and the cotter pin (3).

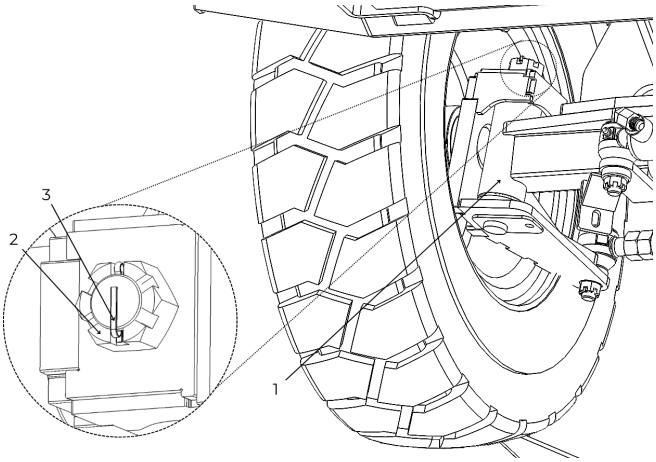


Figure 39. Kingpins Inspection.

Wheel Bearings Inspection

Inspect all wheel bearings for:

- Play.

- Stiffness.

- Abnormal noise.

NOTE : Please refer to page 42, specifically the “Hub Maintenance” section, for instructions on replacing the bearing.

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. Make sure there is no resistor connected across the AC motor controller’s **B+** and **B-**.
   ii. Reconnect the battery leads.
   iii. Turn on all switches and test lights.
   iv. Insert the key.
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. Listen for abnormal noise.

4.2.5 EVERY 1000 HOURS OR 12 MONTHS MAINTENANCE

Special Tools	Consumables
▸ Resistor: 10 ohms, 25 W ▸ Lifting device ▸ Slings ▸ Oil recipient / Drip pan	▸ Differential oil: SAE 80W90 GL5 ▸ Hydraulic pump oil : Iso 32 ▸ Pump filters ▸ Molybdenum disulfide grease (6g) ▸ Lubricant spray ▸ Bearing grease ▸ Hub Seal ▸ Cotter pin (Size : 1/8x2)

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. Please consult the maintenance checklist in the QUICK REFERENCES section for the specific steps that are required.

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**, 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).

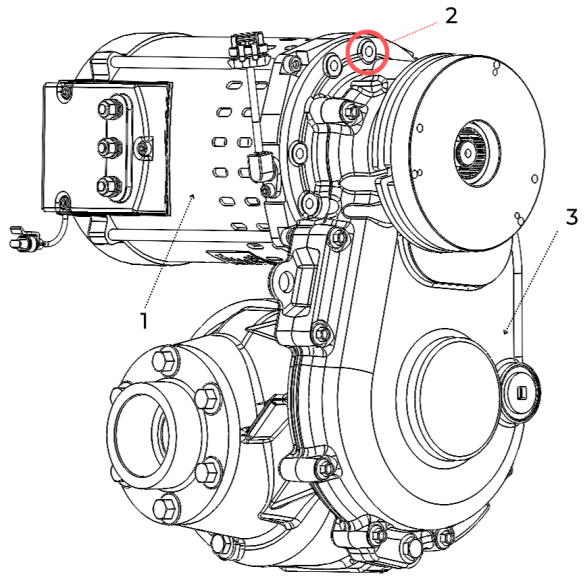


Figure 40. Disconnecting AC Motor.

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

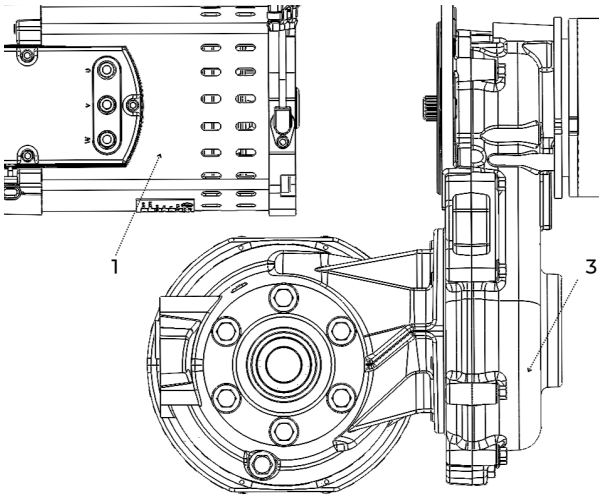


Figure 41. Removing AC Motor.

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).

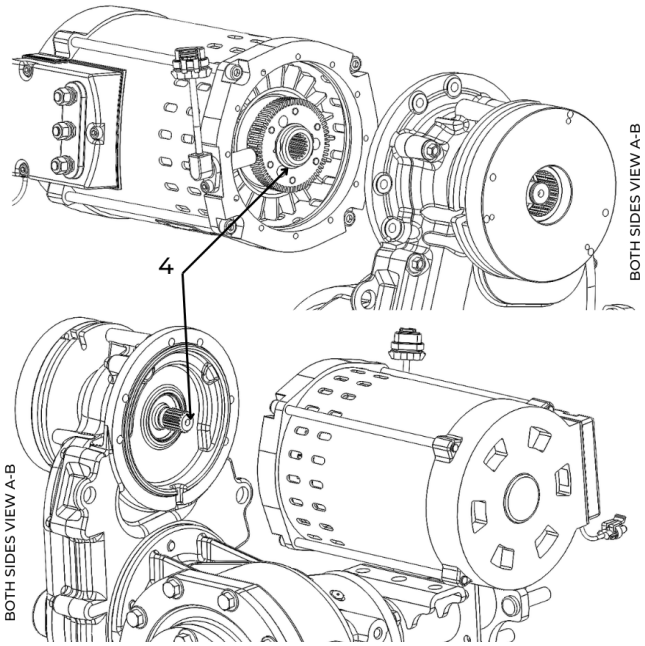


Figure 42. Spline Lubrication.

9. Reinstall the AC motor (1) on the differential (3) with the six 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 for the Schafer twin-case differential :

1. Position a recipient under the differential to collect the drained oil in next steps.
2. Remove the aluminum case filler plug (4). (Figure 43)
3. Remove the cast-iron case filler plug (5). (Figure 44)

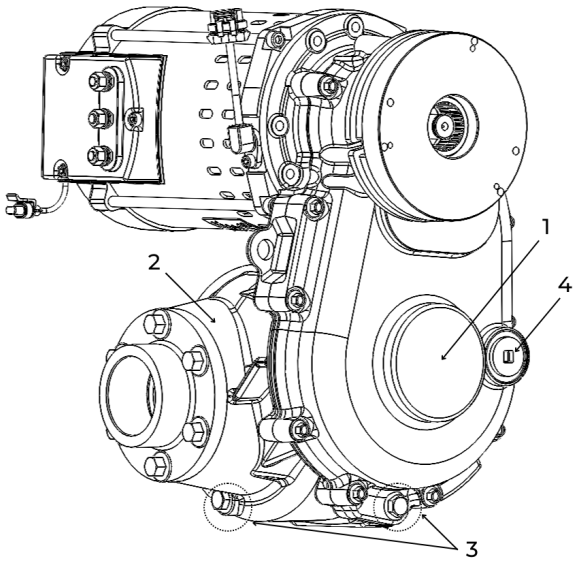


Figure 43. Aluminum Case Drain and Filler Plugs.

4. Remove the aluminium case (1) and the cast-iron case (2) drain plugs (3) to drain the differential oil.
5. Reinstall the drain plugs (3) once the oil is drained.
6. Add 625 mL (stop if the oil reaches the bottom of the filling hole) of SAE 80W90 GL5 differential oil.
7. Reinstall the aluminium case filler plug (4).
8. Add 390 mL (stop if the oil reaches the bottom of the filling hole) of SAE 80W90 GL5 differential oil.
9. Reinstall the cast-iron case filler plug (5).

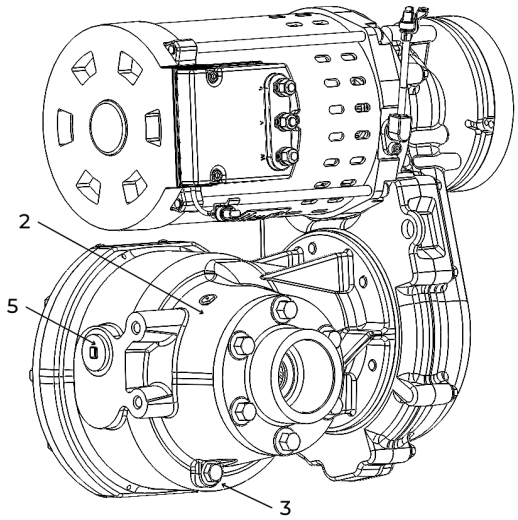


Figure 44. Cast-iron Case Drain and Filler Plugs.

Hub Maintenance

1. Secure the vehicle with jack stands.
2. Remove the wheel nuts (1).
3. Remove the wheel (2).

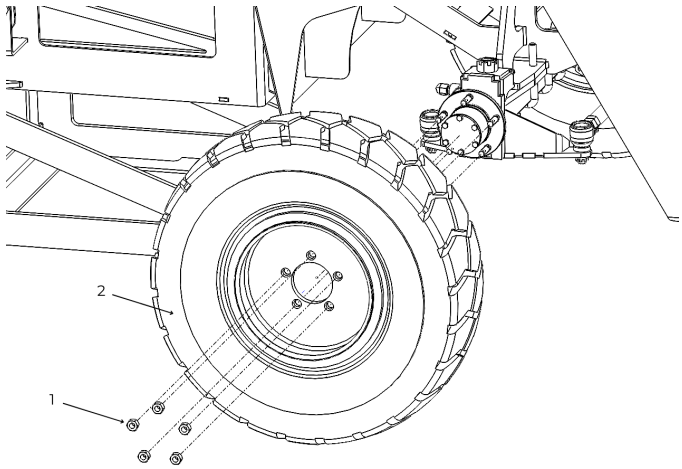


Figure 45. Wheel Removal.

4. Take off the hub cover (3) along with its six bolts (4).
5. Remove the cotter pin (5) and unscrew the castle nut (6).
6. Remove the hub (7) from the spindle (8).

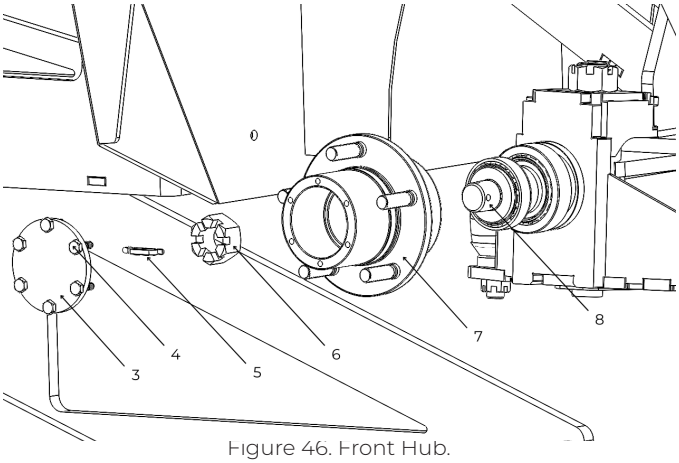


Figure 46. Front Hub.

7. Inspect the bearings (9) and their races for wear.
8. Discard the seal (10). Refer to the *PARTS CATALOG* for seal replacement.
9. Clean the bearing (9) and if they are still usable, apply the grease.
10. Install a new seal (10) and the bearings (9) into the hub (7).
11. On the spindle (8), clean the seating surface of the hub (7) from any debris.
11. Position the hub (7) on the spindle (8).
12. Tighten the castle nut (6) to 103 ft·lbf to seat the bearings (9), then loosen the castle nut (6) by unscrewing one full turn.
13. Hand-tighten the castle nut (6).
14. Install a new cotter pin (5).
15. Install the hub cover (3) and six bolts (4).
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.

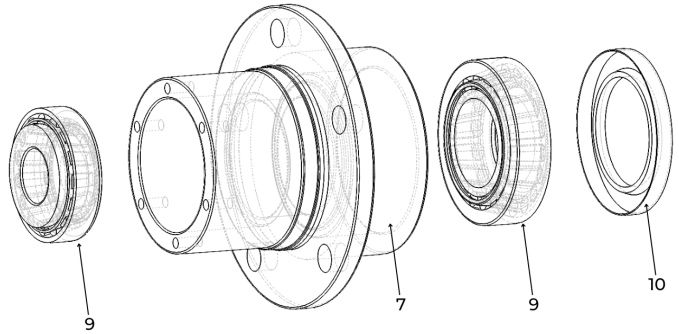


Figure 47. Wheel Hub Inspection.

Power Steering Pump Maintenance

WARNING

ENSURE THAT THE HYDRAULIC SYSTEM IS SHUT OFF AND DEPRESSURIZED BEFORE STARTING ANY MAINTENANCE WORK. THIS WILL PREVENT ACCIDENTAL MOVEMENT OF HYDRAULIC COMPONENTS AND REDUCE THE RISK OF INJURY.

WARNING

WEAR APPROPRIATE SAFETY GEAR, INCLUDING GLOVES AND GOGGLES, TO PROTECT YOURSELF FROM HYDRAULIC FLUID AND OTHER CONTAMINANTS.

NOTE : Prior to conducting any inspection, thoroughly clean the pump and its surroundings. Remove dirt, dust, and any other accumulated debris that could obstruct the components.

1. Examine visually the pump and its components to identify any signs of wear, leakage, or damage. Look for oil leaks, loose components, or corroded parts.
2. Check visually the oil color and clarity within the pump on an annual basis.

   NOTE : The frequency of oil changes, however, can vary significantly depending on usage intensity and environmental cleanliness. Typically, it is determined by the oil's discoloration or the presence of contaminants.
3. Check the oil level in the integrated reservoir. Ensure it falls between the minimum and maximum level marks indicated (the reservoir can hold 2.25 liters of oil). If the level is low, add ISO 32 oil.

   NOTE : In an emergency for cold weather applications SAE 10W oil mixed by volume with nor more than 30% fuel oil or kerosene can be used. (It must be removed when the weather warms)
4. The pump is equipped with filters to maintain the cleanliness of the hydraulic fluid. Inspect the condition of the filter and replace it if necessary.

To clean or replace the filters proceed as follows:

i. Remove the hoses from the valve body.

ii. Remove the filter retainer screws with a ¼" allen key.

iii. Remove and clean or replace filters as required.

iv. Reassemble in reverse order.

NOTE 1 : The filter is a metal strainer located at the pump inlet (inside the reservoir), and it is often cleaned up and reused.

NOTE 2 : Place a drip pan or absorbent materials beneath the filter housing to catch any spilled hydraulic fluid.

5. Inspect the condition of the hoses, fittings, and connections to ensure there are no leaks or signs of damage. Tighten fittings if necessary.

6. Perform operational tests to ensure the hydraulic system is functioning correctly. Monitor temperature levels and operation for any leaks around the filter housings or unusual noises. If you notice any temperature increase, leaks, or abnormal noise, immediately shut down the system and address the issue.

NOTE : The temperature range is between 100°F and 210°F.

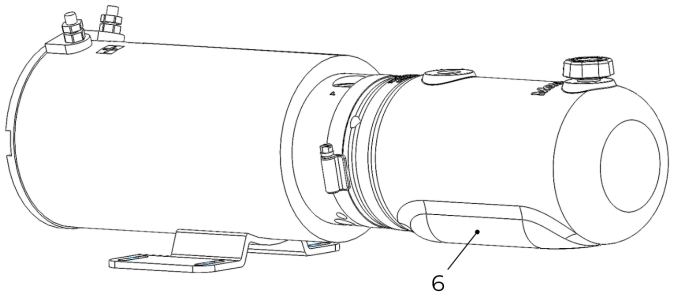


Figure 48. Power Steering Pump.

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.

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. Make sure there is no resistor connected across the AC motor controller's **B+** and **B-**.
   ii. Reconnect the battery leads.
   iii. Turn on all switches and test lights.
   iv. Insert the key.

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. Listen for abnormal noise.

4.2.6 EVERY 2000 HOURS OR 24 MONTHS MAINTENANCE

Special Tools	Consumables
▸ Drip pan	▸ Hydraulic pump oil : Iso 32 - New Pump filters

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. Please consult the maintenance checklist in the QUICK REFERENCES section for the specific steps that are required.

Accessories Pump Maintenance

WARNING

ENSURE THAT THE HYDRAULIC SYSTEM IS SHUT OFF AND DEPRESSURIZED BEFORE STARTING ANY MAINTENANCE WORK. THIS WILL PREVENT ACCIDENTAL MOVEMENT OF HYDRAULIC COMPONENTS AND REDUCE THE RISK OF INJURY.

WARNING

WEAR APPROPRIATE SAFETY GEAR, INCLUDING GLOVES AND GOGGLES, TO PROTECT YOURSELF FROM HYDRAULIC FLUID AND OTHER CONTAMINANTS.

CAUTION

THE ABRASIVE POWDER CAN ACCELERATE SEAL WEAR AND CAUSE LEAKS.

CAUTION

IF THE AMBIENT TEMPERATURE IS BELOW -20°C (-4 °F), SYSTEM SPEED AND PRESSURE MUST BE LIMITED UNTIL THE HYDRAULIC OIL TEMPERATURE EXCEEDS -20°C (-4 °F).

1. Thoroughly clean the area around the pump and motor to remove dirt, dust, and debris that could hinder the maintenance process. Keep the external surface clean, especially in the area of the transmission shaft seal.
2. Conduct a visual inspection of the pump and motor to identify any leaks, corrosion, excessive wear, or other signs of damage.
3. Check the hydraulic fluid level in the reservoir. If needed, add the recommended fluid quantity of iso 32 oil until reaching the suitable level. Ensure not to surpass the specified maximum level of 19 liters.

   NOTE : The oil level must be checked and replaced depending on the system's operation conditions.
4. Replace, if necessary, the filters to keep the fluid clean.

   NOTE : Place a drip pan or absorbent materials beneath the filter housing to catch any spilled hydraulic fluid.
5. Inspect the DC motor for any buildup of dust or dirt that could impede its operation. Gently clean the motor and replace the carbon brushes if required.

   NOTE : For replacing the brushes, refer to the "Carbon Brushes Replacement" subsection under the "Corrective Maintenance" section that follows.
6. Inspect the condition of the hoses, fittings, and connections to ensure there are no leaks or signs of damage. Tighten fittings if necessary.
7. Perform operational tests to ensure the hydraulic system is functioning correctly.

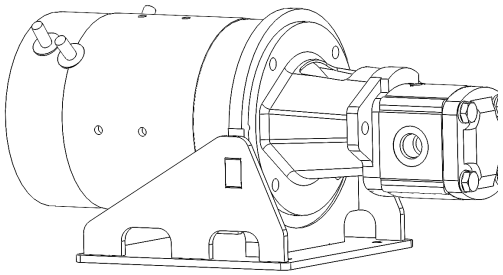


Figure 49. The Accessories Pump.

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4.3 CORRECTIVE MAINTENANCE

4.3.1 REAR AXLE

Procedures

Rear Axle Removal

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

NOTE : In order for the rear wheel bearings to be inspected/replaced, the differential oil must be drained to prevent oil leakage.

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

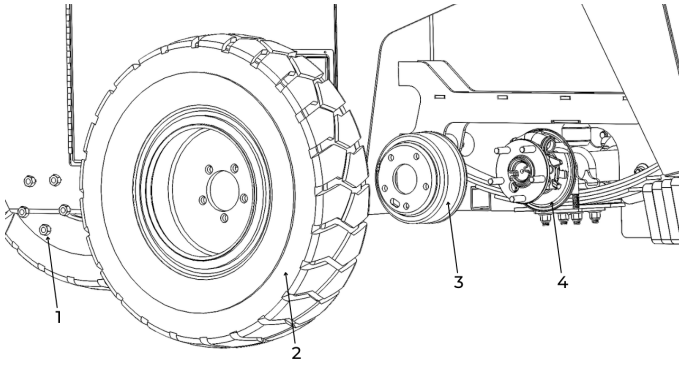

Figure 50. Wheel and Drum Brake Removal.

5. Remove the backplate mounting screws (5) and their washers from the drum brake system (4).

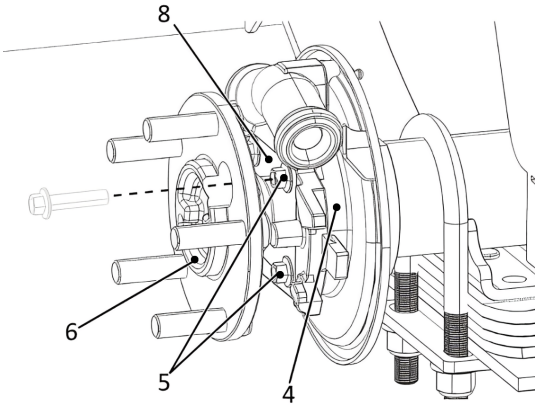

Figure 51. Axle Screws (1 of 2).

7. Remove the axle shaft (6) with the brake drum brake system (4) from the differential's cast-iron case (7).

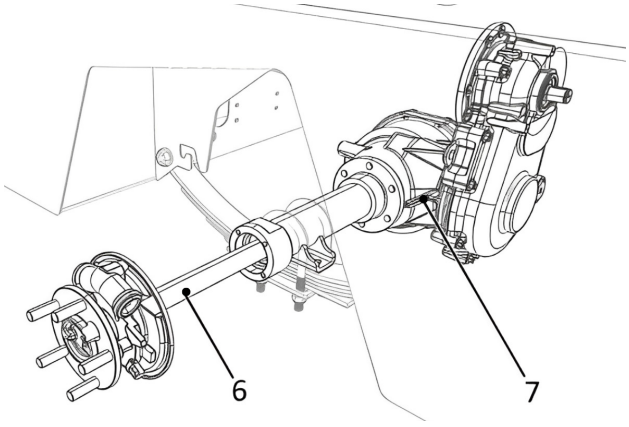

Figure 52. Rear Axle Removal (2 of 2).

8. Inspect the seal (8). Replace if required.
9. Inspect the wheel bearing (9) and its races for wear.
10. Clean and add bearing grease if required.

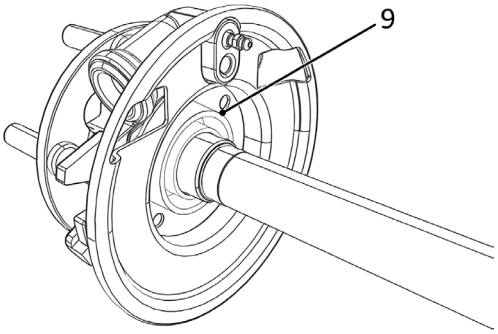

Figure 53. Wheel Bearing.

11. Reinstall the drum brake system (4) and the axle shaft (6) in the differential (7).
12. Reinstall the backplate mounting screws (5) and their washers on the drum brake system (4).
13. Torque the four backplate mounting screws (5) to the recommended standard torque of 58 ft lbs.
14. Reinstall the brake drum (3), wheel (2), and wheel nuts (1).
15. Torque the wheel nuts (1) to the recommended standard torque of 80 ft lbs.

16. Validate that the differential oil level is adequate (it should reach the bottom of the filler hole). For more details, refer to section **4.3.5 DIFFERENTIAL** subsection *Oil Change*.

4.3.2 AXLE AND STEERING

Procedures

Toe-In Adjustment

1. With the wheels in straight forward direction, measure the inside (left to right) distance between the front tires, at the front and rear of the tires.
2. Adjust by turning the tie rod connecting both wheels until the distances are equal and tighten the two lock nuts on the tie rod.

4.3.3 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 MX-700 can be 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

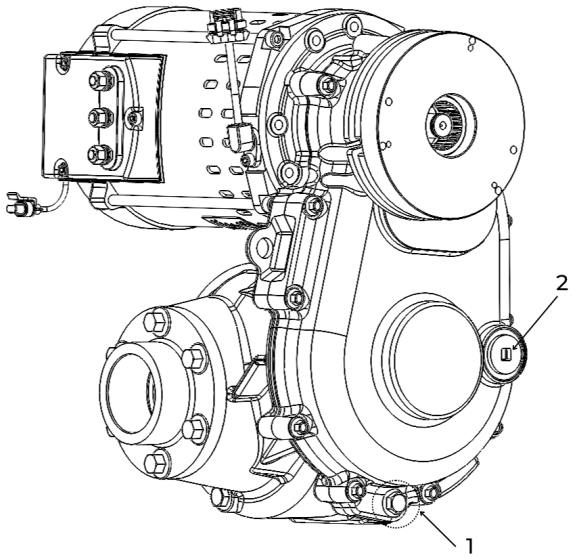

Figure 54. Schafer Aluminum Case.

1. Remove the filler plug (2).
2. Remove the drain plug (1) until the case is completely drained of oil.
3. Reinstall the drain plug (1)
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 (2).

CAST-IRON CASE

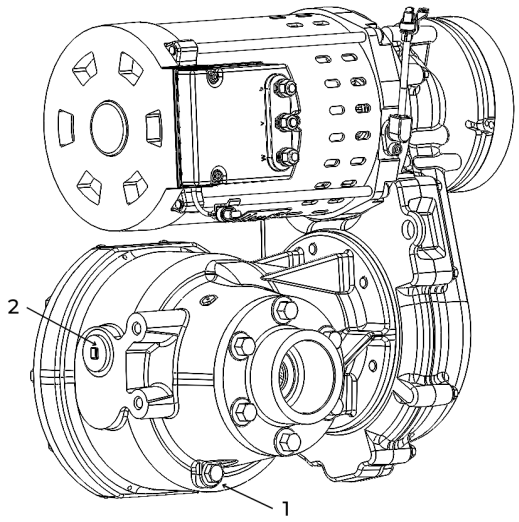

Figure 55. Schafer Cast-Iron Case.

1. Remove the filler plug (2).
2. Remove the drain plug (1) until the gearbox is completely drained of oil.
3. Reinstall the drain plug (1)
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 (2).

4.3.4 CARBON BRUSHES

Procedures

Carbon Brushes Replacement for the DC Motor of the Accessories Pump

1. Detach all electrical components from the motor.
2. Support the DC motor (1) with the appropriate lifting device so that the motor can be slightly moved horizontally once the screws (2) joining the DC motor (1) to the differential (3) are removed. (See Figures 40 and 41)
3. Locate the carbon brushes (4). This may be as simple as removing the enclosure (5) to find them, or in some other cases just locating two clips (or brushes covers) on the outside of the motor.
4. Remove the electrical connections to the carbon brush.
5. Remove the spring (6) holding the brush in place.
6. Pull the carbon brush out, making sure to note the beveled edge's direction as the new brush needs to be installed in the same way. While removing the brush, you can keep track of the beveled edge by drawing an arrow on the motor.
7. Compare the old brush to the new one to ensure you have the correct parts.
8. Install the new brush into place and fasten with the spring (6).
9. Reattach electrical connection to the brush.

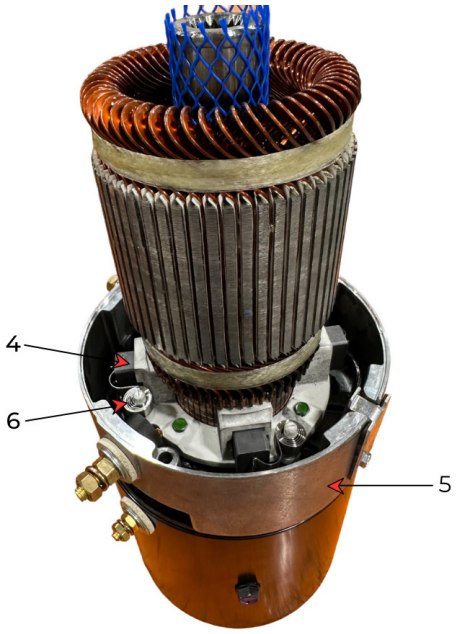

Figure 56. Carbon Brushes Replacement.

10. Repeat the same steps on all four brushes.
11. Reinstall the enclosure (5). It is important to ensure that both A1 and F1 are positioned in parallel. (See Figure 56)
12. Reinstall the DC motor (1) on the differential (3) with the six screws (2).
13. Torque the screws (2) to standard values. The appropriate torque value is 24 ft lbs.
14. Remove the lifting device from the DC motor (1).
15. Replace the motor in the vehicle. Bolt down and reattach electrical connections.

16. Run appliance to test.

Figure 57. A1 and F1 Orientation.

Inspection

1. Inspect the old brush for uneven wear burn marks or shiny rail marks.
2. While the brushes are out take some time to inspect the motor internals. Check the cavity for contaminants like dust, oil, water or carbon buildup from the worn brushes. This buildup can cause an art that will ground out the motor. It can be easily vacuumed with some help from low PSI compressed air.
3. Inspect the commutator for thread marks, grooves, and copper streaks, indicating that the old brushes were of poor quality or contaminated with small pieces of copper from the commutator surface. Signs of sparking indicate that the brushes have been short-circuited, which can also be caused by contamination.

NOTE: If there is any damage to the commutator, it is recommended to have it repaired by a motor repair shop. They have the expertise to machine and undercut the affected sections. Alternatively, it might be more advisable to consider replacing the entire motor.

4.3.5 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. RINCE 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.

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.

4.3.6 POWER STEERING PUMP

Hydraulic Steering System

The hydraulic steering system within your vehicle functions as an integrated ensemble as illustrated in figure 58.

The power steering pump, as the prime mover, engenders hydraulic pressure. The orbitrol steering unit, akin to a control center, orchestrates the hydraulic fluid's distribution in correspondence with steering inputs. The diverter valve operates as a hydraulic switch, managing fluid allocation towards the left or right. Finally, the double-acting cylinder translates hydraulic energy into pivotal motion for wheel articulation.

This collaborative assembly guarantees meticulous and fluid steering response, with power steering pump activation correlated to steering actuation, pressure modulation governed by the orbitrol unit, flow direction supervised by the diverter valve, and kinetic output enacted by the cylinder.

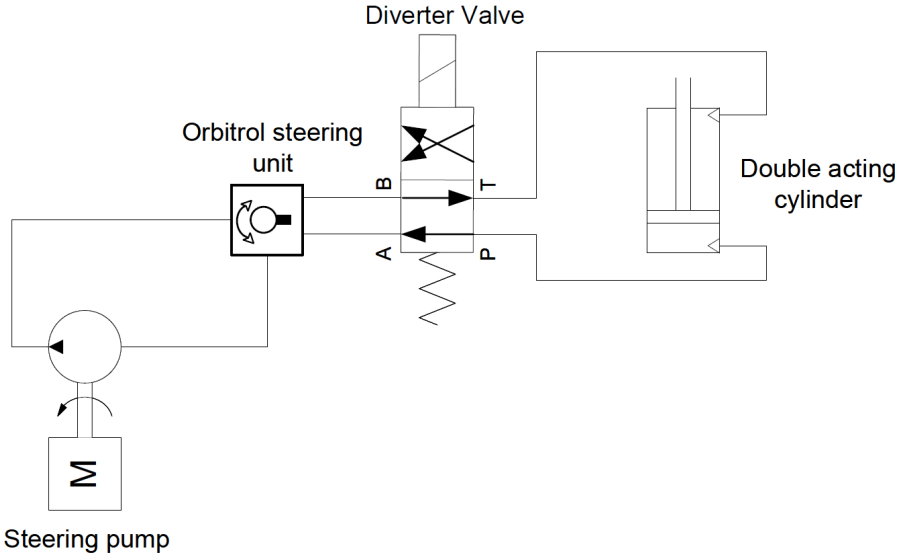

Figure 58. Hydraulic Steering System.

Maintenance procedures

Periodic maintenance of this symbiotic system is imperative to uphold consistent, reliable, and precision-oriented steering performance.

To do preventive maintenance of the following elements of a hydraulic system: power steering pump, orbitrol steering unit, diverter valve and a double-acting cylinder, proceed as follows :

1. Inspect all the hydraulic system components for the following elements:
   - Inspect all components for signs of leaks, damage, or corrosion.
   - Look for loose fittings or connections.
2. Check the double-acting cylinder's condition by examining the rod and piston for signs of wear, scoring, and potential alignment issues.
3. Examine the power steering pump following the inspection procedures outlined in the "*Power Steering Pump Maintenance*" **subsection** within the one-year (1000h) maintenance procedures section page 43.

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. RINCE 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.

   2. 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 59).

   - If no voltage is present, it is necessary to inspect both the fuse and the wiring.

   2. 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 59).

   - 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.

   3. 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 59).

   - 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.

- If the measured voltage is not between 11.8V and 14.2V, it indicates a problem with the switch, and it should be replaced.
- If the measured voltage is approximately 12V, it suggests a fault with the accessory itself, and it should be replaced.

NOTE : Ensure accurate voltage measurements by doing the voltage drop test between the switch's terminals, ensure that the voltage measurement registers 0 V. Alternatively, consider the voltage drop when measuring between the accessory's terminals.

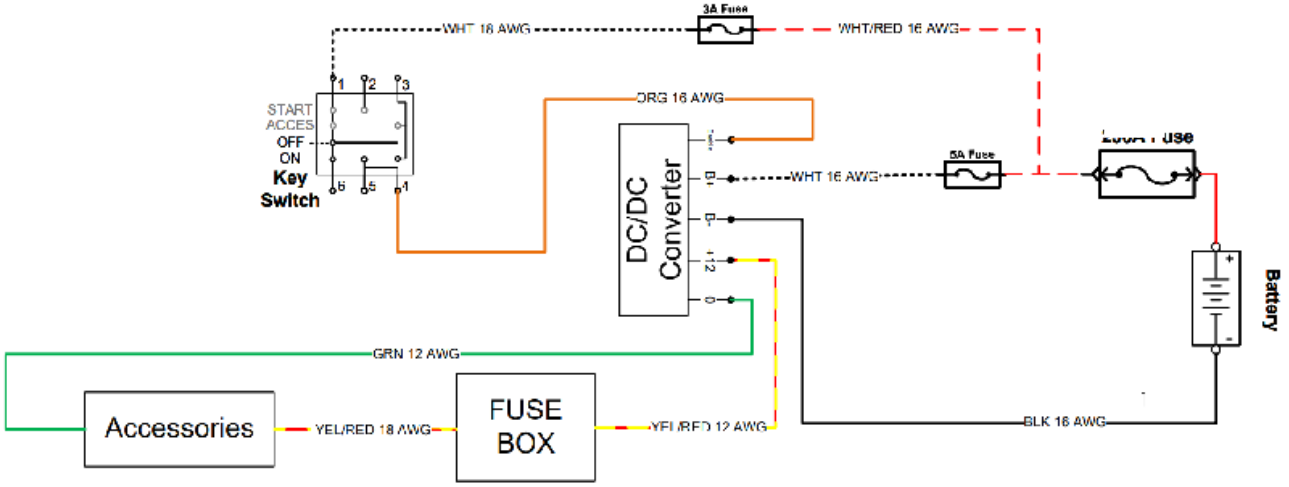

Figure 59. DC/DC Converter Input and Output Terminals Inspection.

4.4.2 BATTERY CHARGER (IF ON BOARD)

WARNING

ALWAYS UNPLUG THE AC AND DC ELECTRICAL CORDS BEFORE ATTEMPTING ANY REPAIRS TO THE CHARGER. FAILURE TO COMPLY CAN CAUSE INJURIES OR DAMAGE TO EQUIPMENT.

Charger Does Not Turn On

1. AC cord of portable chargers must be disconnected from the vehicle after every charging process to re-start.
2. Validate that the charger has not recorded any fault codes. (Please refer to the Annexes section 5 for the meaning/significance of the codes).
3. Measure the voltage of each individual battery at its connector. Repeat this process for the entire battery pack.
4. If there is no voltage output, it means there is no power, resulting in no lights and no display of codes. Assuming the wiring is intact, if the batteries are low, it prevents the charger from operating, and if that's not the case then it's necessary to replace the charger at this point.

4.4.3 VEHICLE MOTION

Vehicle Does Not Move

1. Perform an inspection to detect any fault codes.

Please refer to Section 5 Annexes for the meaning/significance of the codes.

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.
- Defective controller.

2. 2. Electromagnetic brake dragging (burnt smell / lack of power).

- Low current to electromagnetic brake.
- Defective magnet (partial release).
- Mechanically stuck pressure plate.
- 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.
- Defective controller.

3. Inspect the Accelerator Lever

To verify the proper functioning of the accelerator lever, 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. Here is the explanation of the display reading :

- 2.5 volts corresponds to 50%: This represents the neutral position of the accelerator lever.
- 0 volts corresponds to 100% in reverse mode: When the vehicle is in reverse.
- 5 volts corresponds to 100% in forward mode: When the vehicle is in forward mode.

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.

⚠ WARNING : Only applicable to DC vehicles equipped with an EMB brake and 36V

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).

Vehicle Moves Forward Only

If the vehicle only moves forward, it means that the throttle lever is not receiving voltage between 0 and 2.5 volts.

Vehicle Moves Backward Only

If the vehicle only moves backwards, it means that the throttle lever is not receiving voltage between 2.5 and 5 volts.

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. RINCE 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 accelerator lever 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.

Wheels don't turn Right or Left

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 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.

Table 5 TROUBLESHOOTING CHART

CODE	PROGRAMMER LCD DISPLAY / *EFFECT OF FAULT*	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
12	Controller Overcurrent *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	1. External short of phase U,V, or W motor connections. 2. Motor parameters are mis-tuned. 3. Controller defective.	*Set:* Phase current exceeded the current measurement limit. *Clear:* Cycle KSI.
13	Current Sensor Fault *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	1. Leakage to vehicle frame from phase U, V, or W (short in motor stator). 2. Controller defective.	*Set:* Controller current sensors have invalid offset reading. *Clear:* Cycle KSI.
14	Precharge Failed *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	2. External load on capacitor bank (B+ connection terminal) that prevents the capacitor bank from charging. 1. See Monitor menu » Battery: Capacitor Voltage.	*Set:* Precharge failed to charge the capacitor bank to the KSI voltage. *Clear:* Cycle Interlock input or use VCL function *Precharge()*.
15	Controller Severe Undertemp *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	1. See Monitor menu » Controller: Temperature. 2. Controller is operating in an extreme environment.	*Set:* Heatsink temperature below -40°C. *Clear:* Bring heatsink temperature above -40°C, and cycle interlock or KSI.
16	Controller Severe Overtemp *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	1. See Monitor menu » Controller: Temperature. 2. Controller is operating in an extreme environment. 3. Excessive load on vehicle. 4. Improper mounting of controller.	*Set:* Heatsink temperature above +95°C. *Clear:* Bring heatsink temperature below +95°C, and cycle interlock or KSI.
17	Severe Undervoltage *Reduced drive torque.*	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.	*Set:* Capacitor bank voltage dropped below the Severe Undervoltage limit (see page 55) with FET bridge enabled. *Clear:* 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 *ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.*	1. See Monitor menu » Battery: Capacitor Voltage. 2. Battery menu parameters are misadjusted. 3. Battery resistance too high for given regen current. 4. Battery disconnected while regen braking.	*Set:* Capacitor bank voltage exceeded the Severe Overvoltage limit (see page 55) with FET bridge enabled. *Clear:* Bring capacitor voltage below Severe Overvoltage limit, and then cycle KSI.
22	Controller Overtemp Cutback *Reduced drive and brake torque.*	1. See Monitor menu » Controller: Temperature. 2. Controller is performance-limited at this temperature. 3. Controller is operating in an extreme environment. 4. Excessive load on vehicle. 5. Improper mounting of controller.	*Set:* Heatsink temperature exceeded 85°C. *Clear:* Bring heatsink temperature below 85°C.
23	Undervoltage Cutback *Reduced drive torque.*	1. Normal operation. Fault shows that the batteries need recharging. Controller is performance limited at this voltage. 2. Battery parameters are misadjusted. 3. Non-controller system drain on battery. 4. Battery resistance too high. 5. Battery disconnected while driving. 6. See Monitor menu » Battery: Capacitor Voltage. 7. Blown B+ fuse or main contactor did not close.	*Set:* Capacitor bank voltage dropped below the Undervoltage limit (see page 55) with the FET bridge enabled. *Clear:* Bring capacitor voltage above the Undervoltage limit.
24	Overvoltage Cutback *Reduced brake torque.*	1. Normal operation. Fault shows that regen braking currents elevated the battery voltage during regen braking. Controller is performance limited at this voltage. 2. Battery parameters are misadjusted. 3. Battery resistance too high for given regen current. 4. Battery disconnected while regen braking. 5. See Monitor menu » Battery: Capacitor Voltage.	*Set:* Capacitor bank voltage exceeded the Overvoltage limit (see page 55) with the FET bridge enabled. *Clear:* Bring capacitor voltage below the Overvoltage limit.
25	+5V Supply Failure *None, unless a fault action is programmed in VCL.*	1. External load impedance on the +5V supply (pin 26) is too low. 2. See Monitor menu » outputs: 5 Volts and Ext Supply Current.	*Set:* +5V supply (pin 26) outside the +5V±10% range. *Clear:* Bring voltage within range.
26	Digital Out 6 Overcurrent *Digital Output 6 driver will not turn on.*	1. External load impedance on Digital Output 6 driver (pin 19) is too low.	*Set:* Digital Output 6 (pin 19) current exceeded 15 mA. *Clear:* Remedy the overcurrent cause and use the VCL function *Set_DigOut()* to turn the driver on again.

Table 5 TROUBLESHOOTING CHART, continued

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

Table 5 TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY / *EFFECT OF FAULT*	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
35	PD Open/Short *ShutdownPD.*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set:* Proportional driver (pin 2) is either open or shorted. *Clear:* Correct open or short, and cycle driver.
36	Encoder Fault *ShutdownEMBrake.*	1. Motor encoder failure. 2. Bad crimps or faulty wiring. 3. See Monitor menu » Motor: Motor RPM.	*Set:* Motor encoder phase failure detected. *Clear:* Cycle KSI.
37	Motor Open *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	1. Motor phase is open. 2. Bad crimps or faulty wiring.	*Set:* Motor phase U, V, or W detected open. *Clear:* Cycle KSI.
38	Main Contactor Welded *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	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).	*Set:* 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. *Clear:* Cycle KSI
39	Main Contactor Did Not Close *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	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.	*Set:* With the main contactor commanded closed, the capacitor bank voltage (B+ connection terminal) did not charge to B+. *Clear:* Cycle KSI.
41	Throttle Wiper High *ShutdownThrottle.*	1. See Monitor menu » Inputs: Throttle Pot. 2. Throttle pot wiper voltage too high.	*Set:* Throttle pot wiper (pin 16) voltage is higher than the high fault threshold (can be changed with the VCL function *Setup_Pot_Faults()*). *Clear:* Bring throttle pot wiper voltage below the fault threshold.
42	Throttle Wiper Low *ShutdownThrottle.*	1. See Monitor menu » Inputs: Throttle Pot. 2. Throttle pot wiper voltage too low.	*Set:* Throttle pot wiper (pin 16) voltage is lower than the low fault threshold (can be changed with the VCL function *Setup_Pot_Faults()*). *Clear:* Bring throttle pot wiper voltage above the fault threshold.
43	Pot2 Wiper High *FullBrake.*	1. See Monitor menu » Inputs: Pot2 Raw. 2. Pot2 wiper voltage too high.	*Set:* Pot2 wiper (pin 17) voltage is higher than the high fault threshold (can be changed with the VCL function *Setup_Pot_Faults()*). *Clear:* Bring Pot2 wiper voltage below the fault threshold.

Table 5 TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY / EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
44	Pot2 Wiper Low *FullBrake.*	1. See Monitor menu » Inputs: Pot2 Raw. 2. Pot2 wiper voltage too low.	*Set:* Pot2 wiper (pin 17) voltage is lower than the low fault threshold (can be changed with the VCL function *Setup_Pot_Faults()*). *Clear:* Bring Pot2 wiper voltage above the fault threshold.
45	Pot Low Overcurrent *ShutdownThrottle;* *FullBrake.*	1. See Monitor menu » Outputs: Pot Low. 2. Combined pot resistance connected to pot low is too low.	*Set:* Pot low (pin 18) current exceeds 10mA. *Clear:* Clear pot low overcurrent condition and cycle KSI.
46	EEPROM Failure *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *ShutdownInterlock;* *ShutdownDriver1;* *ShutdownDriver2;* *ShutdownDriver3;* *ShutdownDriver4;* *ShutdownPD;* *FullBrake;* *ShutdownPump.*	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.	*Set:* Controller operating system tried to write to EEPROM memory and failed. *Clear:* Download the correct software (OS) and matching parameter default settings into the controller and cycle KSI.
47	HPD/Sequencing Fault *ShutdownThrottle.*	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.	*Set:* HPD (High Pedal Disable) or sequencing fault caused by incorrect sequence of KSI, interlock, direction, and throttle inputs. *Clear:* Reapply inputs in correct sequence.
47	Emer Rev HPD *ShutdownThrottle;* *ShutdownEMBrake.*	1. Emergency Reverse operation has concluded, but the throttle, forward and reverse inputs, and interlock have not been returned to neutral.	*Set:* At the conclusion of Emergency Reverse, the fault was set because various inputs were not returned to neutral. *Clear:* 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 *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	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.	*Set:* Adjustment of a parameter setting that requires cycling of KSI. *Clear:* 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.	*Set:* See OEM documentation. *Clear:* 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 *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *ShutdownInterlock;* *ShutdownDriver1;* *ShutdownDriver2;* *ShutdownDriver3;* *ShutdownDriver4;* *ShutdownPD;* *FullBrake;* *ShutdownPump.*	1. VCL code encountered a runtime VCL error. 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.	*Set:* Runtime VCL code error condition. *Clear:* 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 *None, unless a fault action is programmed in VCL.*	1. External load on the 5V and 12V supplies draws either too much or too little current. 2. Fault Checking Menu parameters Ext Supply Max and Ext Supply Min are mis-tuned. 3. See Monitor menu » Outputs: Ext Supply Current.	*Set:* 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). *Clear:* Bring the external supply current within range.
71	OS General *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *ShutdownInterlock;* *ShutdownDriver1;* *ShutdownDriver2;* *ShutdownDriver3;* *ShutdownDriver4;* *ShutdownPD;* *FullBrake;* *ShutdownPump.*	1. Internal controller fault.	*Set:* Internal controller fault detected. *Clear:* Cycle KSI.
72	PDO Timeout *ShutdownInterlock;* *CAN NMT State set to Pre-operational.*	1. Time between CAN PDO messages received exceeded the PDO Timeout Period.	*Set:* Time between CAN PDO messages received exceeded the PDO Timeout Period. *Clear:* Cycle KSI or receive CAN NMT message.
73	Stall Detected *ShutdownEMBrake;* *Control Mode changed to LOS (Limited Operating Strategy).*	1. Stalled motor. 2. Motor encoder failure. 3. Bad crimps or faulty wiring. 4. Problems with power supply for the motor encoder. 5. See Monitor menu » Motor: Motor RPM.	*Set:* No motor encoder movement detected. *Clear:* Either cycle KSI, or detect valid motor encoder signals while operating in LOS mode and return Throttle Command = 0 and Motor RPM = 0.

Table 5 TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY / EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
94	Emer Rev Timeout *ShutdownEMBrake;* *ShutdownThrottle.*	1. Emergency Reverse was activated and concluded because the EMR Timeout timer has expired. 2. The emergency reverse input is stuck On.	*Set:* Emergency Reverse was activated and ran until the EMR Timeout timer expired. *Clear:* Turn the emergency reverse input Off.
98	Illegal Model Number *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrottle;* *FullBrake;* *ShutdownPump.*	1. Model_Number variable contains illegal value (not 1234, 1236, 1238, or 1298). 2. Software and hardware do not match. 3. Controller defective.	*Set:* 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. *Clear:* Download appropriate software for your controller model.

Table 5 TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY *EFFECT OF FAULT*	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
87	Motor Characterization Fault *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrotsle;* *FullBrake;* *ShutdownPump.*	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.	*Set:* Motor characterization failed during the motor characterization process. *Clear:* Correct fault; cycle KSI.
89	Motor Type Fault *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrotsle;* *FullBrake;* *ShutdownPump.*	1. The Motor_Type parameter value is out of range.	*Set:* Motor_Type parameter is set to an illegal value. *Clear:* Set Motor_Type to correct value and cycle KSI.
91	VCL/OS Mismatch *ShutdownMotor;* *ShutdownMainContactor;* *ShutdownEMBrake;* *ShutdownThrotsle;* *ShutdownInterlock;* *ShutdownDriver1;* *ShutdownDriver2;* *ShutdownDriver3;* *ShutdownDriver4;* *ShutdownPD;* *FullBrake;* *ShutdownPump.*	1. The VCL software in the controller does not match the OS software in the controller.	*Set:* 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. *Clear:* Download the correct VCL and OS software into the controller.
92	EM Brake Failed to Set *ShutdownEMBrake;* *ShutdownThrotsle.*	1. Vehicle movement sensed after the EM Brake has been commanded to set. 2. EM Brake will not hold the motor from rotating.	*Set:* After the EM Brake was commanded to set and time has elapsed to allow the brake to fully engage, vehicle movement has been sensed. *Clear:* Activate the throttle.
93	Encoder LOS (Limited Operating Strategy) *Enter LOS control mode.*	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.	*Set:* 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. *Clear:* 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.

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.

CAUTION

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.

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

QuiQ™ HF/PFC Battery Charger

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

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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 – voire le manuel. D´autres types de batteries pourraient éclater et causer des blessures ou dommages. Les batteries peuvent produire des gaz explosives en service normal. Ne jamais fumer près de la batterie et éviter toute étincelle ou flame nue à proximité de ces derniers. Fournisser 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 desassembler le chargeur – referer toute reparations aux personnes qualifiés. 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	

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

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:
a) 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.**
b) Securely fasten the black ring terminal from the charger to the negative terminal ("-", "NEG", NEGATIVE") of the battery pack.
c) 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.

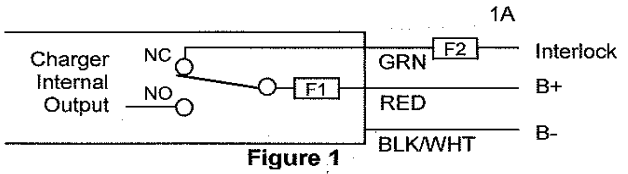


Figure 1

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:
a) Disconnect the charger positive connector from battery pack. Apply AC power and after the LED test, the Algorithm # will display for 11 seconds.
b) 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.
c) 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.

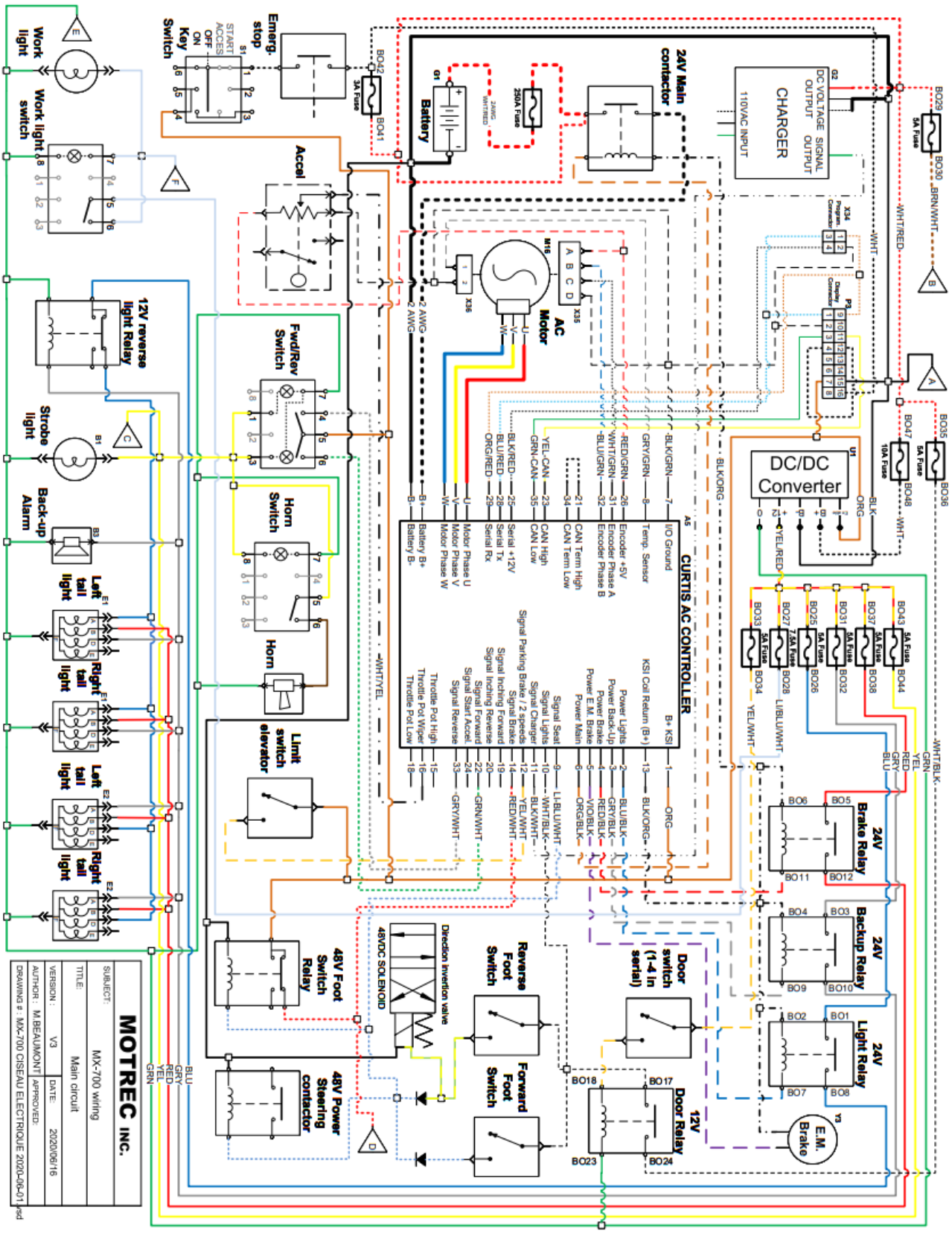
Alg #	Battery Type
35	Concorde 2xxAh AGM
27	Crown CR325 dv/dt
26	Deka 8GGC2 Gel
11	generic flooded CP dv/dt
8	Concorde 1xxAh AGM
7	Trojan J305 dV/dt
6	DEKA 8G31 Gel
5	Trojan 30XHS
4	US Battery US2200
1	Trojan T-105

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.

Electrical Diagram



Fuses positions in the fuse box

LIGHT 5A FUSE	BACKUP 5A FUSE	BRAKE 5A FUSE	ACCESS 5A FUSE	49	24VDC LIGHT RELAY	13	19	63	64
				50		14	20		
WORK LIGHTS 7.5A FUSE	DOOR 5A FUSE	USB 5A FUSE	12V SOCKET 10A FUSE	51	24VDC BACKUP RELAY	15	21	65	66
				52		16	22		
29	FOOT SW. 5A FUSE	KEY 3A FUSE	DC/DC 10A FUSE	53	24VDC BRAKE RELAY	12VDC DOOR RELAY		67	68
30				54				PSU MAXI FUSE 50A	

Standard Torque

BOLT CLAMP LOADS

Suggested Assembly Torque Values

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

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