MT-180-AC





MAINTENANCE MANUAL

A GUIDE FOR PERFORMING MAINTENANCE AND REPAIRS ON MT-180

SERIAL NUMBER: 117 86 43 AND UP

UPDATED 14.07.2023
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.

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MOTREC INFORMATION

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ABOUT THE MANUAL

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

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



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"AYONE CAN WORK WE PERFORM THAT'S MOTREC"

-Motrec Tagline

1. PREFACE





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 <u>quick maintenance references</u> is included at the back of this document. These references are intended for an MT-180 experienced technician to accelerate the maintenance process. The Quick References should not be used by any untrained or inexperienced personnel.



The MT-180

This resilient tow tractor offers exceptional performance. With its efficient motor and 10,000-lbs towing capacity, the MT-180 is perfectly suited for trailer movement. Its compact size allows it to navigate through most door openings effortlessly. Constructed with high-quality steel and equipped with all-wheel braking, this tugger is designed to withstand heavy usage for years, ensuring both comfort and safety. The superior AC technology, along with its robust features, enables the tractor to handle demanding tasks with ease.



Modular Design

The MT-180 features a modular design that offers versatility and adaptability to various applications. Its modular construction allows for easy customization and configuration, making it suitable for a wide range of tasks. With interchangeable components and modules, the MT-180 can be tailored to meet specific operational requirements. This modular approach simplifies maintenance and repair. Additionally, the modular design facilitates future upgrades and expansions, ensuring that the MT-180 can evolve with changing needs. Overall, the modular design of the MT-180 enhances its flexibility, efficiency, and longevity, making it a reliable choice for diverse electric vehicle applications. For more information on available configurations, please refer to the website www.motrec.com.

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

Ib: Pounds (Weight)

lbf: Pound (Force)

LD: Low Duty

LED: Light Emitting Diode

m: MetermL: Millilitermm: Millimeter

N/A: Not ApplicableN·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 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**.

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3. VEHICULE OVERVIEW

3.1. SPECIFICATIONS AND CONFIGURATIONS

The MT-180 specifications and configurations can vary depending on the specific model and year of the MT-180. 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:

Removing the deck at the back of the vehicle gives access to all the compartments containing the major systems of the vehicle. Refer to Figure 1 for more details.

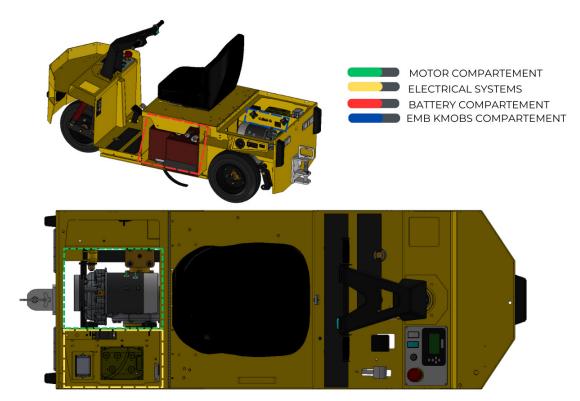


Figure 1. Equipment Compartments.

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

NOTE: To access the batteries located under the driver's seat, you simply need to lift the lid to the right of the driver.

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.

Depending on the configuration, the vehicle's total battery voltage can vary from 36 V or 48 V. The vehicle can be powered by multiple battery types, including:

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

Standard battery Compartment:

This standard battery compartment is devoid of any mechanical components, allowing for easy removal of the batteries simply by lifting them out from the compartment. Additionally, depending on the number of battery boxes, you have the flexibility to choose between voltage options 36V or 48V.

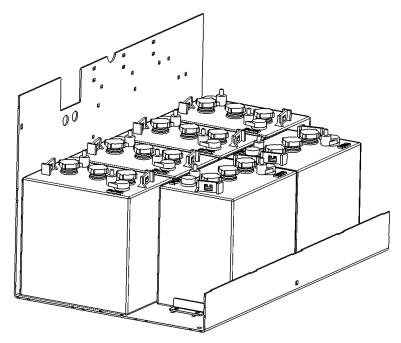
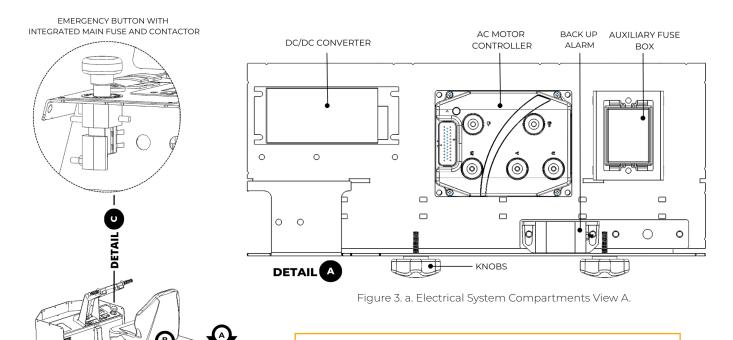


Figure 2. Standard Battery Compartment (36 V).

3.3 ELECTRICAL SYSTEMS



DETAIL B <u>@</u>Н BATTERY CHARGER AL

Figure 3. b. Electrical System Compartments View B.

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

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

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

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

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3.3.1 MAIN ENERGY

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

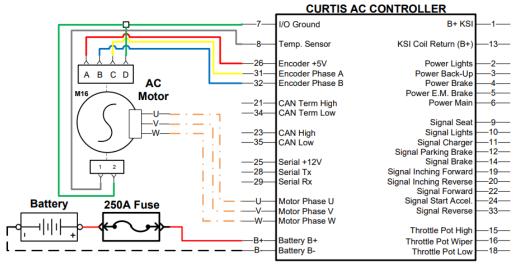


Figure 4. Main Energy Electrical connection (Annexe 5).

3.3.2 AUXILIARY ENERGY

SECTION 03

VEHICLE OVERVIEW

To power the auxiliary systems of the vehicle, including the backup alarm, lights, horn, and others. The DC-DC converter utilizes the battery voltage (36 or 48 VDC) and converts it to an output of 12 VDC / 13.4 VDC. This voltage is then directed through the 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.

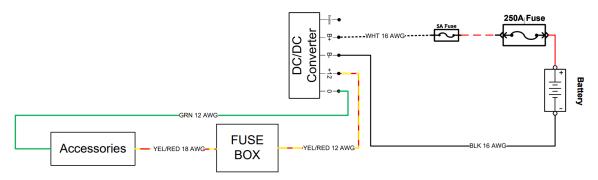


Figure 5. Auxiliary Energy Electrical connection (Annexe 5).

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3.3.3 CHARGING ENERGY

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

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

(!) CAUTION

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

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

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

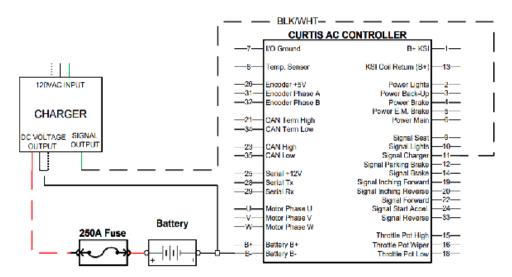


Figure 6. Charging Energy Electrical connection (Annexe 5).

3.4 MOTORS AND REAR AXLE

3.4.1 AC MOTORS

The MT-180 is equipped with a brushless AC direct drive motor that enables forward and backward propulsion of the vehicle. This motor is powered by a 3-phase current supplied by the AC motor controller. For more detailed information, please refer to section 3.3.1 MAIN ENERGY. Additionally, the motor features regenerative braking functionality, which enables the vehicle to decelerate without relying solely on friction brakes and allows a portion of the deceleration energy to be returned to charge the batteries.

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

ENCLOSED

Designed for use in environments with high sanitation requirements or excessive dust, this motor features a sealed casing effectively that prevents sparks from escaping and debris from entering. Primarily utilized in EE-rated applications, it ensures optimal performance and safety. EE-rated NOTE: typically signifies compliance with higher levels of safety and efficiency standards, ensuring the motor's performance aligns with industry regulations.

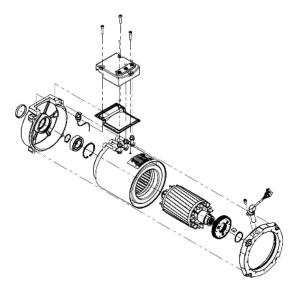


Figure 7. Enclosed Motor.

FAN COOLED

This motor is specifically designed to operate effectively in diverse environments. It features an integrated fan on its rotor, which efficiently draws air through the venting holes to enhance the motor's cooling capacity.

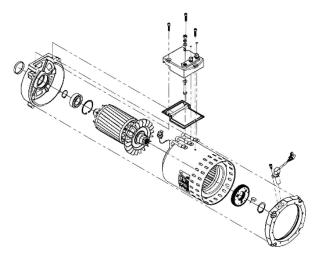


Figure 8. Fan Cooled Motor.

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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.



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

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

3.4.3 ELECTROMAGNETIC BRAKE (EMB)

The MT-180 electric vehicle is equipped with an electromagnetic brake (EMB) that provides reliable and efficient braking performance. The electromagnetic brake is designed to assist in place when necessary.

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

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

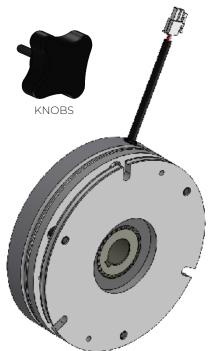


Figure 9. EMB Brake System.

3.5 BRAKE SYSTEM

When the driver applies pressure to the brake pedal (1), the force is transmitted through the assembly (2) as it rotates around the flange bearings (3). These bearings enable smooth movement of the pedal while providing stability and support. This force is then transferred to the hydraulic piston (4), which amplifies it through hydraulic pressure. The pressure is then transmitted via the brake cable (5) to the brake calipers (6) located at the front wheels. As the driver applies the brakes, the brake cable pulls the calipers, causing the brake pads to engage with the brake drums. The resulting friction between the pads and the rotating components generates resistance, gradually reducing the rotation of the front wheels. This process allows the driver to effectively control the vehicle's speed and bring it to a safe stop.

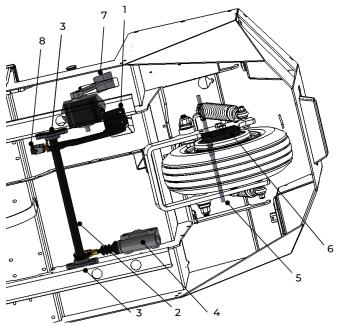


Figure 10. Brake System.

When the accelerator pedal (7) is released, the controller activates the regenerative braking system in the "coasting" state. This utilizes the electrical current generated by the rotating motor armature to decelerate the vehicle and recharge the batteries. When the brake pedal is pressed, the controller activates the "braking" state of regenerative braking, further reducing the vehicle's speed. This optimizes energy recovery during deceleration and minimizes wear on the traditional braking system, maximizing overall efficiency.

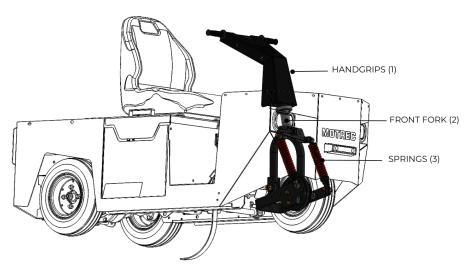
NOTE: Refer to *TECHNICAL TRAINING* on the dealer portal for more information on regenerative braking and its settings. (DC ragan training to be done)

NOTE: A brake switch (8) is typically located near the brake pedal assembly. The proximity of the brake switch allows for the direct mechanical interaction required to detect the engagement or disengagement of the brakes. When the brakes are not engaged, the switch is in its default position, indicating that the brakes are not activated. As soon as the brake pedal is pressed, it activates the brake lights and signaling to other drivers that the vehicle is slowing down, moving backwards, or coming to a stop.

NOTE: The wiring of the brake cable is not shown in the 3D model photo of the MT-180 (depicted by a straight cable) for two main reasons: Firstly, the positioning of the brake cable can vary from one vehicle to another depending on individual specifications and configurations.

It is vital to emphasize that the proper rooting of the brake cable plays a pivotal role in the functioning of the braking system.

3.6 STEERING SYSTEM



COMPANY NAME

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Figure 11. Steering System.

The steering system of an MT-180 is equipped with handgrips (1), right and left, directly connected to the front fork (2). When the driver turns the handgrip to the right, it imparts a rotational force to the front fork, causing the front wheel to turn to the right. Similarly, turning the handgrip to the left results in the front wheel turning to the left.

In addition, the system has two springs with integral shock absorber (3) that help maintain stability and control by absorbing any unwanted oscillations or sudden jolts.

3.6 SUSPENSIONS

VEHICLE OVERVIEW

SECTION 03

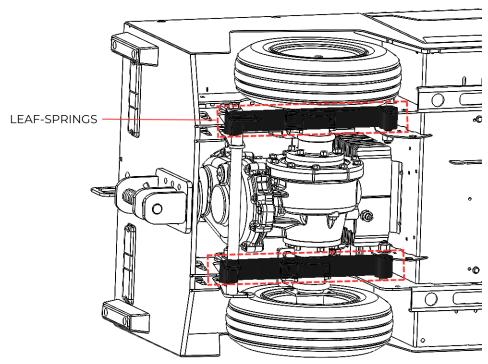


Figure 12. Suspensions.

The two-leaf spring suspension system in the MT-180 electric vehicle provides stabilization by evenly distributing the vehicle's weight, absorbing road shocks and vibrations, and contributing to better handling. Its simplicity, reliability, and load-carrying capacity make it a practical choice for achieving a comfortable and stable ride.

ACCELERATOR

BRAKE

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.

DECK

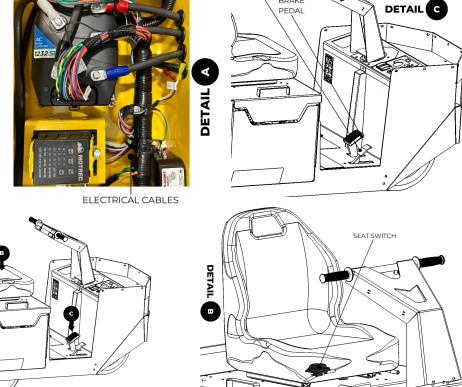


Figure 13. General Components.



The seat switch installed in every driver's seat acts as a dead man's switch. The vehicle cannot be operated if the seat switch doesn't detect a pressure from the operator.

Charging port

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

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

Battery 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.



Figure 14. Charging Port and Indicator

3.9 CONSOLE

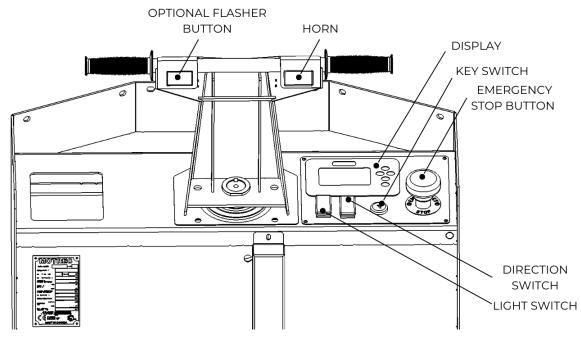


Figure 15. Console.

COMPANY NAME

MOTREC INTERNATIONAL

Direction Switch (Forward/Reverse)

This switch controls the motion direction of the vehicle:

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

Key Switch

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

Display

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

Emergency Stop Button

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



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).

For models equipped with the EMB, 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.

Direction Arrows (Forward/ Reverse)

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

Navigation Arrows

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

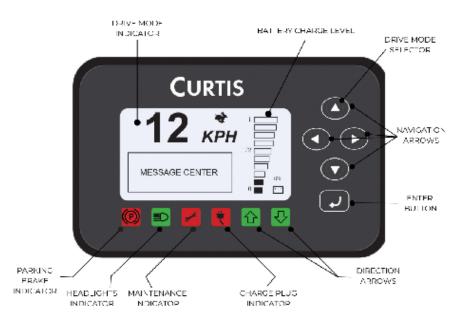


Figure 16. Display.

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.

Drive Mode Indicator

Indicates the current selected drive mode between rabbit and

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 located at the right side of the console's kick panel (refer to Figure 17). It's important to note that the display connector needs to be disconnected each time the handheld programmer is used.

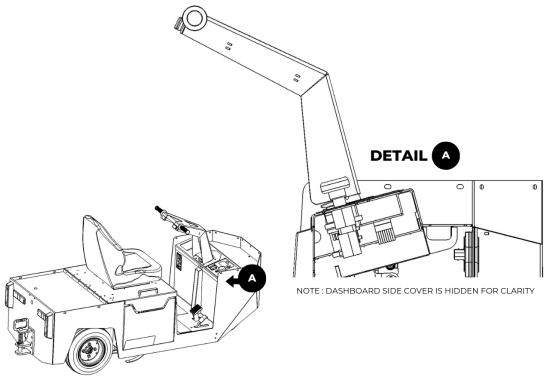


Figure 17. Display Connector.

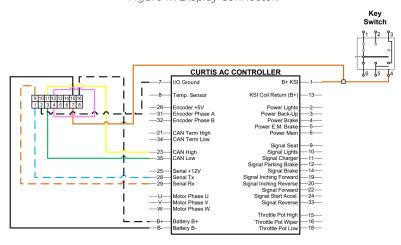


Figure 18. Display Connector Electrical connection (Annexe 5).

Vehicle Speed



WARNING

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

COMPANY NAME

MOTREC INTERNATIONAL

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

4. MAINTENANCE

4.1 GENERAL INFORMATION

This section provides a general overview of the maintenance procedures for a standard MT-180 vehicle. While the images displayed may not match the exact product due to varying configurations and accessories, the maintenance steps outlined here are applicable to all MT-180 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.

COMPANY NAME

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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

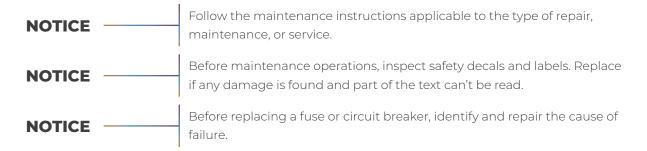
ONLY QUALIFIED AND AUTHORIZED PERSONNEL ARE PERMITTED TO MAINTAIN, REPAIR, ADJUST, AND INSPECT THE VEHICLES AND THEIR BATTERIES. FAILURE TO COMPLY CAN LEAD TO DAMAGE TO THE EQUIPMENT.



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.

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4.1.1 LIFTING POINTS

Please refer to the serial data plate (see Figure 19), positioned on the left side of the console, to determine the total weight of the vehicle. It is important to note that the weight may differ based on the vehicle's specific configuration, accessories, and battery capacity.

COMPANY NAME

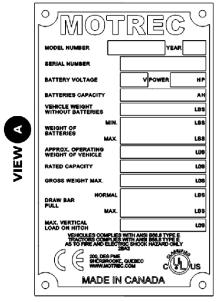
MOTREC INTERNATIONAL

When utilizing a lifting device, ensure that it can support the precise weight of the vehicle. The suggested lifting points are highlighted below (Figure 20) 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.





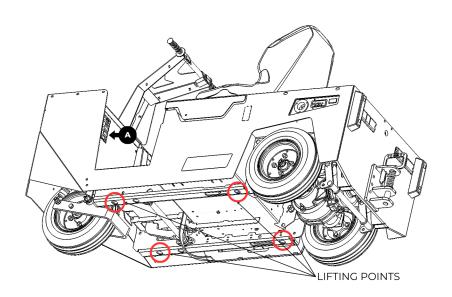


Figure 20. Lifting Points.

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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 ACIDSPLASHING. DURING MAINTENANCE, ALWAYS DISCONNECT THE CHARGER AND USE INSULATED TOOLS THAT DO NOT GENERATE SPARKS. FAILURE TO COMPLY CAN CAUSE SERIOUS INJURIES.

- 4. Lift the lid, to the right of the driver, to access the batteries located under the driver's seat.
- 5. Disconnect the battery pack according to the applicable configuration:

For lifting out the battery compartment:

- 5.1. Disconnect the negative (-) terminal (1) of the last battery.
- 5.2. Disconnect the positive (+) terminal (2) of the first battery.
- 6. To reconnect the electrical circuit, perform this procedure in reverse.

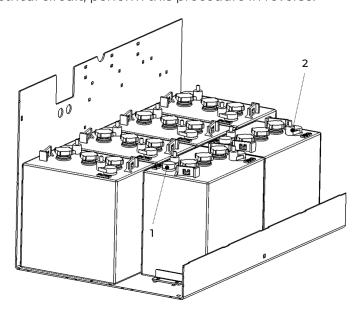
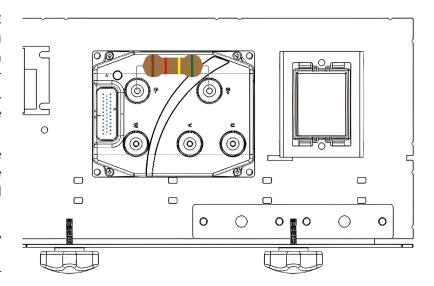


Figure 21. Electrical Isolation (batteries).

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- 7. 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.
- 8. Using a multimeter, validate the absence of voltage between the AC motor controller's (5) B+ and **B-** terminals.
- 9. To reconnect the electrical circuit, perform this procedure in reverse.
 - **NOTE**: No resistor needed for reconnection.



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Figure 22. 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.



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.

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

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

Maintenance Timer Reset

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

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

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

4.2.1 DAILY MAINTENANCE

Special Tools	Consumables
► N/A	► N/A

NOTICE —

Replace any defective component found during the inspection listed below.

Maintenance Procedures

Visible Damage Inspection

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

Fluid Leaks Inspection

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

Proceed as follows to inspect:

1. Inspect the master cylinder (1).

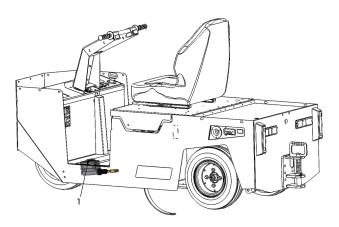


Figure 23. Front Fluid Leaks

2. Remove the deck (2).

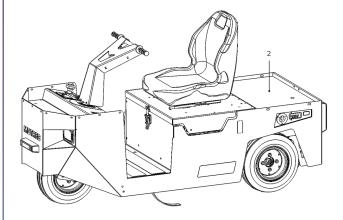


Figure 24. Deck Removal.

- 3. Inspect the drive assembly (3) for signs of leaks at following locations:
 - Covers.
 - Axle ends.
 - Casing mating surfaces.
 - Drain/fill plugs.

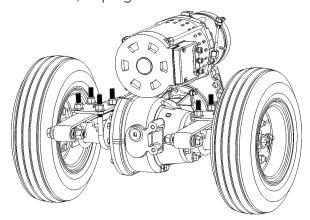


Figure 25. Drive Assembly Fluid Leaks.

4. Reinstall the deck (2).

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Steering Inspection

- 1. Rock the handgrips (steering wheel if applicable), examine the grip surface for excessive wear, tearing, or loss of texture.
- 2. 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.

Seat Switch Inspection

1. Check that the seat switch is operational by sitting on the driver's seat and validating that no fault is generated on the display while sitting.



WARNING

DO NOT EXCEED SPEED OF 1 MPH (2 KM/H) WHEN TESTING THE SEAT SWITCH. THE ACTIVATION OF THE SEAT SWITCH WILL STOP THE VEHICLE SUDDENLY. FAILURE TO COMPLY CAN CAUSE INJURY.

2. Validate that the vehicle stops when removing all weight from driver's seat.

Accelerator Pedal Inspection

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

Brake Pedal Inspection

- 1. Test the pedal's ability to engage and disengage the braking system smoothly. Any inconsistencies or difficulty in brake pedal operation could indicate problems with the mechanical components or linkage.
- 2. Inspect the feel and travel of the brake pedal.

4.2.2 WEEKLY MAINTENANCE

Special Tools	Consumables
► N/A	▶ Distilled water

NOTICE -

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

Maintenance Procedures

Static Strap Inspection

Check the static strap (1) (if applicable) for signs of excessive wear and ensure it has an adequate length. When the vehicle is on its wheels and stationary, the strap should have a minimum of two inches in contact with the ground.

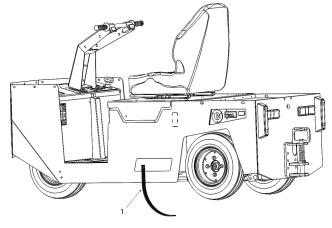


Figure 26. Static Strap.

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.

Battery Electrolyte Inspection and Top-Up



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

1. Fully charge the batteries.

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

2. Disconnect the charger.



WARNING

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

- 3. Lift the lid, to the right of the driver, to access the batteries located under the driver's seat.
- 4. For each battery in the battery compartment, inspect and refill as necessary with distilled water to the recommended manufacturer level.
- 5. Lower the lid to conceal the batteries.

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

4.2.3 EVERY 250 HOURS OR 3 MONTHS MAINTENANCE

Special Tools	Consumables
Resistor: 10 ohms, 25 WLifting device	► Lubricant spray► Compressed air

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

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 2. Remove the dashboard cover (2). essential to follow the subsequent steps to ensure safety during maintenance and enable easy access to components.

1. Remove the deck (1).

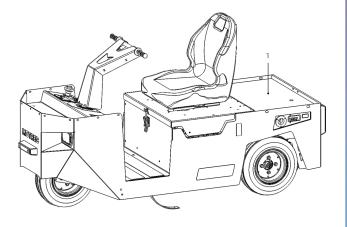


Figure 27. Deck Removal.

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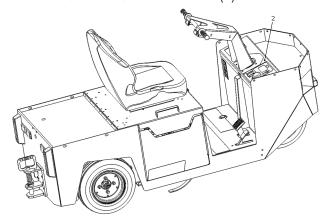


Figure 28. Dashboard Cover.



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.

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

Maintenance Procedures

Rear Suspension Inspection

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

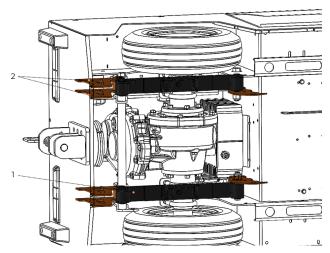


Figure 29. Rear Suspension Inspection.

Steering Inspection

- 1. Check for signs of wear, damage, or cracks on the handgrips (1). Ensure they are securely attached to the handgrips.
- 2. Inspect the front fork (2) for any signs of oil leaks, damage, or excessive rust. Ensure it is securely attached to the frame.
- 3. Test the movement of the front fork (2) by compressing it downward and releasing it. It should respond smoothly without any unusual noises or resistance. Pay attention to any abnormalities in fork travel or rebound.
- 4. Check the springs (3) for signs of wear, sagging, or damage. Ensure they are securely mounted and aligned.
- 5. Check for any unusual noises, vibrations, or inconsistencies in the steering system.

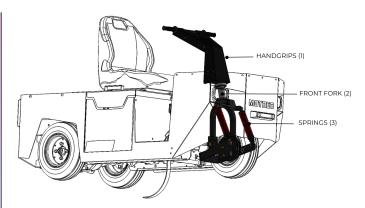


Figure 30. General Steering Inspection.

Lubrication

Lubricate the following components:

- Brake assembly (see Figure 10 part no. 2).
- chain (if applicable).

NOTE: In the case of a steering wheel instead of handgrips configuration, such as in certain vehicle models of the MT-180, lubrication may be required for the chain.

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.

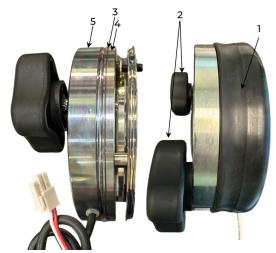


Figure 31. EMB Inspection.

- 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.

Rubber Bellows Inspection

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

AC Motor Dusting

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

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

In the case of a Sealed motor (1), it provides inherent protection against dust and debris. Therefore, no additional dusting or cleaning is necessary for the motor.

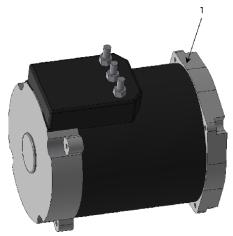


Figure 32. Sealed AC Motor.

Power Circuit Inspection

- I. 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.

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- 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 handgrips and feel for excessive
 - ii. Switch the drive mode from Turtle to Rabbit and test the speed.
 - iii. Depress and release the accelerator to test the electromagnetic brake.
 - iv. Listen for abnormal noise.
- 4. Reinstall the deck.

EVERY 500 HOURS OR 6 MONTHS MAINTENANCE 4.2.4

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

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. Remove the deck (1)



Figure 33. Deck Removal.



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.

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

Maintenance Procedures

Decals and Labels Inspection

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

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Frame Inspection

- 1. Inspect the vehicle's frame for Cracks, damage or Corrosion.
- 2. The following frame locations should be inspected with care:
 - Side panels corners (1) (both sides). There is a possibility of cracks occurring in these corners as they undergo significant stress (see Figure 34).
 - Rear suspension mounting tabs (2) (see Figure 35).
 - Hitch mounting area (3) (see Figure 36).

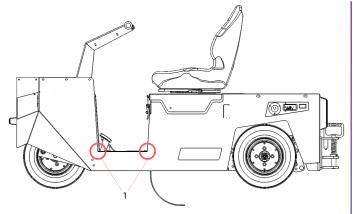


Figure 34. Side Panels.

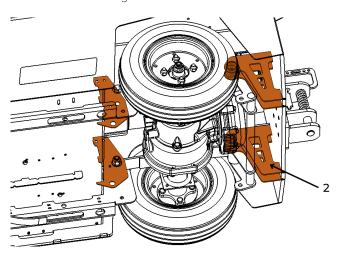


Figure 35. Rear Suspension Mounting Tabs.

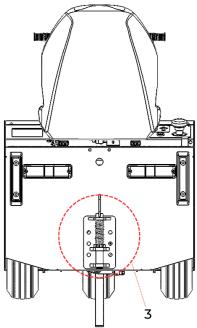


Figure 36. Hitch Mounting.

Front Drum Brakes Inspection

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

- Unfasten screws (1) and split ring lock washers
 (2) on both sides of the front wheel guard.
- 2. Remove the front wheel guard (3).

NOTE: before removing the front wheel guard (3), it is necessary to loosen the screws at the ends of the shock absorber springs on both sides.

3. Remove both coupling nuts (4).

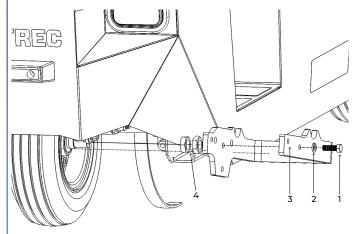


Figure 37. Front Wheel Guard Removal.

- 4. Remove the wheel nuts (5) and wheel (6)
- 5. Remove the brake drum (7).
- 6. Clean brake dust with water.
- 7. Inspect the drum brake (7) for excessive wear or scoring.
- 8. Inspect the drum shoes. Replace the shoes and springs if the lining thickness is 1/16 in (2 mm) or less.
- 9. Inspect the drum brake system (8) for corrosion, wear, brake fluid leak, and brake dust.

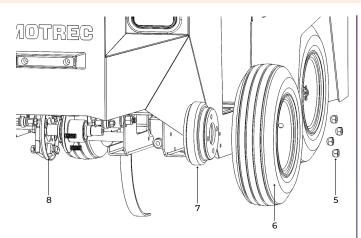


Figure 38. Drum Brakes Inspection.

- 10. Reinstall the brake drum (7)
- 11. Reinstall the wheel (6) and the wheel nuts (5). Torque the wheel nuts (5) to standard values. The appropriate torque value is 80 ft lbs.
- 12. Reinstall the coupling nuts (4). Torque the coupling nuts (4) to standard values. The appropriate torque value for the first coupling nut is 20 ft lbs and 100 ft lbs for the second one.
- 13. Reinstall the front wheel guard (3), screws (1) and split ring lock washers (2).

NOTE: After reinstalling the front wheel guard (3), it is necessary to tighten the screws at the ends of the shock absorber springs on both sides.

Brake System Inspection

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

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

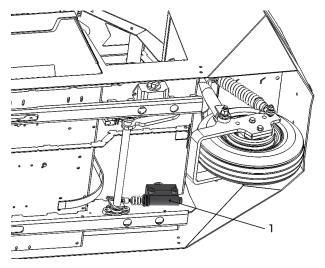


Figure 39. Master Cylinder Inspection.

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 handgrips and feel for excessive play.
 - ii. Switch the drive mode from Turtle to Rabbit and test the speed.
 - iii. Depress and release the accelerator to test the electromagnetic brake.
 - iv. Listen for abnormal noise.
- 3. Reinstall the deck.

4.2.5 **EVERY 1000 HOURS OR 12 MONTHS MAINTENANCE**

COMPANY NAME

MOTREC INTERNATIONAL

Special Tools	Consumables
Resistor: 10 ohms, 25 WLifting device	Differential oil: SAE 80W90 GL5Molybdenum disulfide grease (6g)
► Slings► Oil recipient	▶ Bearing grease▶ Cotter pin (Size: 1/16x2)

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.

Remove the deck (1)

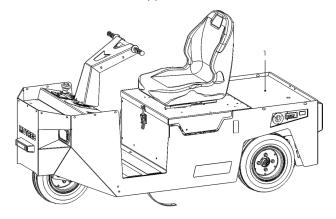


Figure 40. Deck Removal.

/ 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.

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

Maintenance Procedures

Drive Splines Maintenance

- 1. Disconnect all electrical cables from the AC motor (1).
- 2. Place the slings around the motor.
- 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).

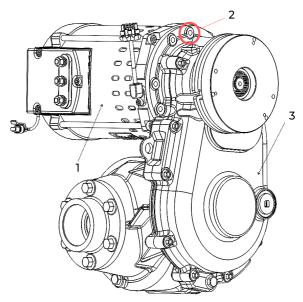


Figure 41. Disconnecting AC Motor.

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

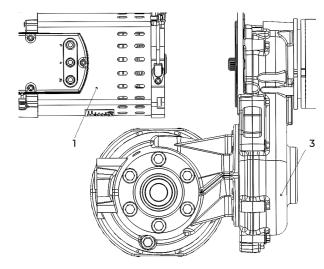


Figure 42. Removing AC Motor.

- 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).

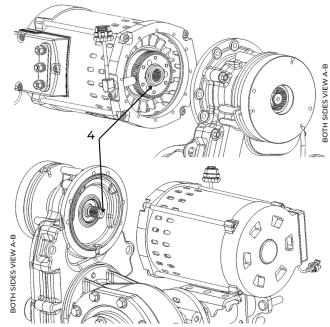


Figure 43. Spline Lubrication.

- 9. Reinstall the AC motor (1) on the differential (3) 4. Add 625 mL (stop if the oil reaches the bottom with the five screws (2).
- 10. Torque the screws (2) to standard values. The appropriate torque value is 24 ft lbs.
- 11. Remove the slings from the AC motor (1).
- 12. Reconnect the electrical cables to the AC motor (1).

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

Differential Maintenance

The MT-180 vehicle is equipped with a Schafer twin-case differential so proceed as follows:

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

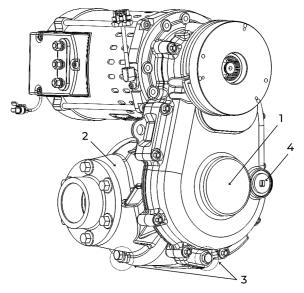


Figure 44. Drain Plugs.

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

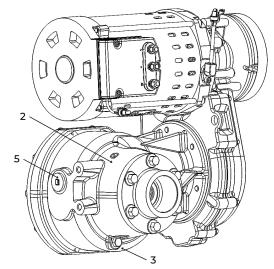


Figure 45. Filler Plug.

Front Hub Maintenance

- 1. Chock the rear wheels.
- 2. Unfasten screws (1) and split ring lock washers (2) on both sides of the front wheel guard.
- 3. Remove the front wheel guard (3).

NOTE: before removing the front wheel guard (3), it is necessary to loosen the screws at the ends of the shock absorber springs on both sides.

4. Remove both coupling nuts (4).

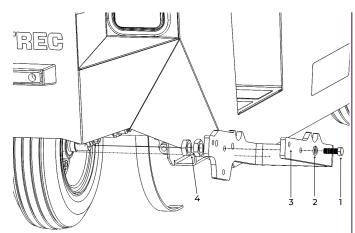


Figure 46. Front Wheel Guard Removal.

- 5. Remove the wheel nuts (5) and wheel (6)
- 6. Remove the brake drum (7).

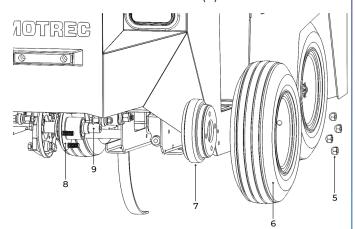


Figure 47. Front Wheel and Drum Removal.

- 7. Remove the hub (8) from the spindle (9).
- 8. Inspect the bearings (10) and their races for wear.
- 9. Discard the seal (11). Refer to the PARTS CATALOG for seal replacement.
- 10. Clean the bearing (10) and if they are still usable, apply the grease.
- 11. Install a new seal (11) and the bearings (10) into the hub (8).
- 12. On the spindle (9), clean the seating surface of the hub (8) from any debris.

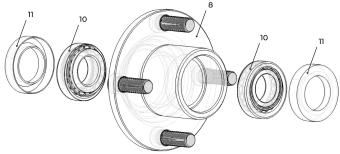


Figure 48. Frony Wheel Hub Inspection.

- 13. Position the hub (8) on the spindle (9).
- 14. Reinstall the brake drum (7)
- 15. Reinstall the wheel (6) and the wheel nuts (5). Torque the wheel nuts (5) to standard values. The appropriate torque value is 80 ft lbs.
- 16. Reinstall the coupling nuts (4). Torque the coupling nuts (4) to standard values. The appropriate torque value for the first coupling nut is 20 ft lbs and 100 ft lbs for the second one.
- 17. Reinstall the front wheel guard (3), screws (1) and split ring lock washers (2). Torque the screws to 90 ft lbs.

NOTE: After reinstalling the front wheel guard (3), it is necessary to tighten the screws at the ends of the shock absorber springs on both sides.

Rear Hub Maintenance

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

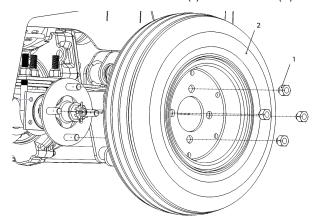
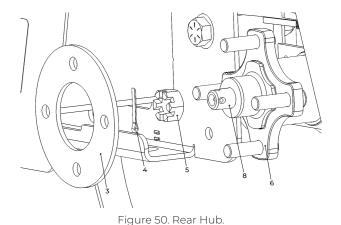


Figure 49. Rear Wheel Removal.

- 3. Remove the wheel spacer (3)
- 4. Remove the cotter pin (4) and unscrew the castle nut (5).
- 5. Remove the rear hub (6) from the spindle (7).



- 6. Examine the rear hub (6) for any abnormal sounds or signs of looseness.
- 7. Adjust the positioning of the hub (6) on the spindle (7).
- 8. Securely reinstall the castle nut (5) and tighten it to 103 ft·lbf.
- 9. Replace the cotter pin (4) with a new one and install it properly.
- 10. Reinstall the wheel spacer (3).
- 11. 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.

Brake System Inspection

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

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

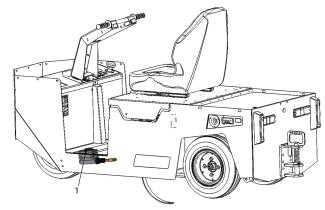


Figure 51. Brake System Maintenance.

Hardware Maintenance

- 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.

- 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 handgrips and feel for excessive
 - ii. Switch the drive mode from Turtle to Rabbit and test the speed.
 - iii. Depress and release the accelerator to test the electromagnetic brake.
 - iv. Listen for abnormal noise.
- 3. Reinstall the deck.

4.2.6 EVERY 2000 HOURS OR 24 MONTHS MAINTENANCE

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

NOTICE -

The 1000 hours or 12 months preventive maintenance should be carried out concurrently with this maintenance. Certain steps may not be necessary due to redundancy. Please consult the maintenance checklist in the QUICK REFERENCES section for the specific steps that are required.

Maintenance Procedures

Hydraulic Brake System Fluid Maintenance

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

- 1. If required, lift the vehicle using a lifting device as per section 4.1.1 LIFTING POINTS.
- 2. Remove the master cylinder's (1) cap.

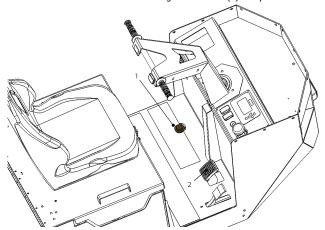


Figure 52. Brake System Bleeding.

3. Bleed front wheel brakes:

- Check the brake fluid level and ensure it's within the recommended range. If low, fill the master cylinder (1) with DOT-3 brake fluid and then reinstall the master cylinder's (1) cap.
- ii. Have a helper sit in the driver's seat and pump the brake pedal three to four times and then hold it down. The pedal should feel firm when held down.

- iii. While the pedal is held down, open the bleeder valve slowly. You should see brake fluid coming out of the tube.
- iv. Close the bleeder valve before your helper releases the brake pedal to avoid air being sucked back into the system.
- v. Repeat this process several times (usually 3-4 times) until you see a steady stream of new brake fluid.

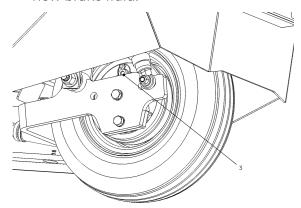


Figure 53. Front Wheel Bleeding.

- 4. Once the front brakes are bled, check the brake fluid level in the reservoir again and top it up if necessary.
- 5. Wipe away any spilled brake fluid.

NOTE: Exercise with caution as oil fluid can potentially damage the paint.

- 6. Apply continuous pressure on the heel of the master pedal for about ten seconds. Note any loss of pressure.
- 7. Inspect the brake lines and fittings for leaks.

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4.3 CORRECTIVE MAINTENANCE

4.3.1 ACCELERATOR

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

4.3.2 HYDRAULIC BRAKES

Maintenance Procedures

Hydraulic Brake System Fluid Maintenance

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

- 1. If required, lift the vehicle using a lifting device as per section 4.1.1 LIFTING POINTS.
- 2. Remove the master cylinder's (1) cap.

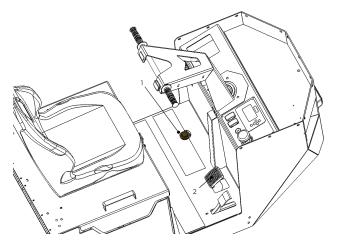


Figure 54. Brake System Bleeding.

3. Bleed front wheel brakes:

- Check the brake fluid level and ensure it's within the recommended range. If low, fill the master cylinder (1) with DOT-3 brake fluid and then reinstall the master cylinder's (1) cap.
- ii. Have a helper sit in the driver's seat and pump the brake pedal three to four times and then hold it down. The pedal should feel firm when held down.

- iii. While the pedal is held down, open the bleeder valve slowly. You should see brake fluid coming out of the tube.
- iv. Close the bleeder valve before your helper releases the brake pedal to avoid air being sucked back into the system.
- v. Repeat this process several times (usually 3-4 times) until you see a steady stream of new brake fluid.

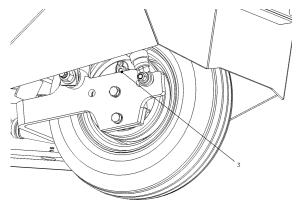


Figure 55. Front Wheel Bleeding.

- 4. Once the front brakes are bled, check the brake fluid level in the reservoir again and top it up if necessary.
- 5. Wipe away any spilled brake fluid.

NOTE: Exercise with caution as oil fluid can potentially damage the paint.

- 6. Apply continuous pressure on the heel of the master pedal for about ten seconds. Note any loss of pressure.
- 7. Inspect the brake lines and fittings for leaks.

Drum Brakes Replacement

- 1. Safely secure the vehicle using jack stands.
- Unfasten screws (1) and split ring lock washers
 (2) on both sides of the front wheel guard.
- 3. Remove the front wheel guard (3).

NOTE: before removing the front wheel guard (3), it is necessary to loosen the screws at the ends of the shock absorber springs on both sides.

4. Remove both coupling nuts (4).

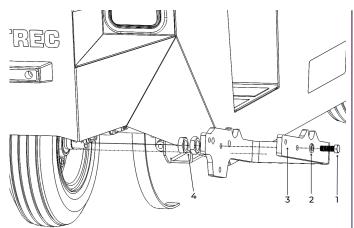


Figure 56. Front Wheel Guard Removal.

- 5. Remove the wheel nuts (5) and wheel (6)
- 6. Remove the brake drum (7).
- 7. Clean brake dust with water.
- 8. Inspect the lining wear of the drum brake system (8).
 - ► Replace the shoes and springs if the lining thickness is 1/16 in (2 mm) or less.

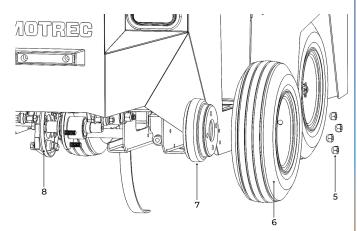


Figure 57. Front Wheel and Drum Removal.

- 9. Fully seat the brake drum (7) in position.
- 10. Spin the brake drum (7) to validate that the shoes aren't overly tightened. The wheels must turn free when the brake pedal is released.
- 11. Reinstall the wheels (6).
- 12. Torque the wheel nuts (5) to standard values. The appropriate torque value is 80 ft lbs.

- 14. Reinstall the coupling nuts (4). Torque the coupling nuts (4) to standard values. The appropriate torque value for the first coupling nut is 20 ft lbs and 100 ft lbs for the second one.
- 15. Reinstall the front wheel guard (3), screws (1) and split ring lock washers (2).

NOTE: After reinstalling the front wheel guard (3), it is necessary to tighten the screws at the ends of the shock absorber springs on both

4.3.3 REAR AXLE

Procedures

Rear Axle Removal

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

- 1. Remove the wheel nuts (1).
- 2. Remove the wheel (2).
- 3. Remove the wheel spacer (3).

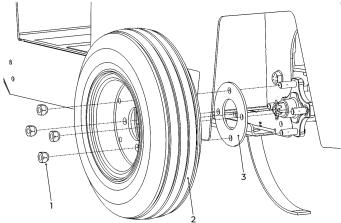


Figure 58. Wheel and Wheel Spacer Removal.

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

7. Remove the spindle (6) to access the axle shaft 13. Reinstall the spindle (6). (7) properly.

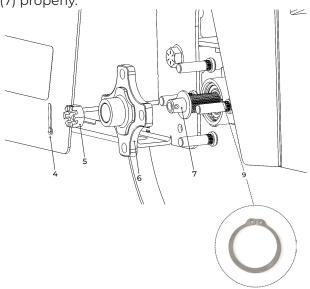


Figure 59. Axle Shaft Inspection.

- 8. Remove the retaining circlip (7) that holds the bearings. Use the appropriate tool, such as snap ring pliers, to remove it. Carefully slide the clip out to release the axle shaft (8).
- 9. Remove gently the axle shaft (8) straight out, being cautious not to damage the seals or surrounding components.
- 10. Inspect it for any signs of damage or wear. If necessary, replace the axle shaft, seals, or any other components that show signs of deterioration.
- 11. Slide the axle shaft (8) back into the differential (9), aligning it with the splines.
- 12. Reinstall the retaining circlip (7) to secure bearings in place. Ensure that the clip is properly seated and holds the axle shaft (8) securely.
- 13. Reinstall the spindle (6).
- 14. Put back and tighten the castle nut (5) using the appropriate socket. The appropriate torque value is 103 ft lbs.
- 15. Slide a new cotter pin (4) through the castle nut's hole and bend the ends of the pin to prevent it from coming loose.
- 16. Reinstall the wheel spacer (3).

- 14. Put back and tighten the castle nut (5) using the appropriate socket. The appropriate torque value is 103 ft lbs.
- 15. Slide a new cotter pin (4) through the castle nut's hole and bend the ends of the pin to prevent it from coming loose.
- 16. Reinstall the wheel spacer (3).
- 17. Torque the wheel nuts (1) to standard values. The appropriate torque value is between 80 ft lbs.
- 18. Validate that the differential oil level is adequate (it should reach the bottom of the filler hole). For more details, refer to section 4.3.4 DIFFERENTIAL subsection OIL CHANGE.

4.3.4 DIFFERENTIAL

Inspection

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

Procedures

Oil Change

The recommended oil for MT-180 equipped with Schafer twin-case differential is 80W90 GL5.

twin-case Differential

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

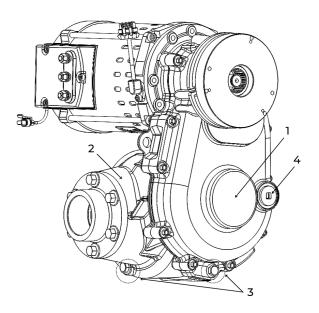


Figure 61. Drain Plugs.

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

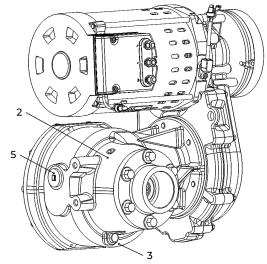


Figure 62 Filler Plug.

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.

Electrolyte Level

NOTE: Does not apply to sealed batteries.

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

NOTE: Some vehicles are equipped with batteries watering system. This watering system consists of a series of water fill tubes attached to each battery cell. These tubes are designed to allow for easy access to add water when needed (see Figure 63).

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



Figure 63. Batteries Watering System.

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.

- 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.

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VERSION 01

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 64).
 - 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 64).
 - 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 64).
 - 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.

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If the measured voltage is not between 11.8V and 14.2V, it indicates a problem with the switch, and it should be replaced.

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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.

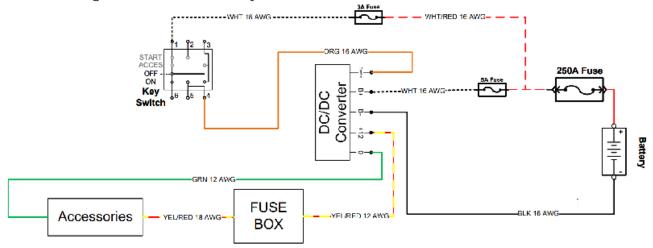


Figure 64. DC/DC Converter Input and Output Terminals Inspection.

BATTERY CHARGER 442



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.

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- 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 or debris in electromagnetic brake.
 - Gripping of rotor hub splines.
- 2.3. Electromagnetic brake not engaging.

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

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

Inspect the Accelerator Pedal

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

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

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

4. Inspect the Vehicle

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

5. Inspect the Main Contactor

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



/! 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

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

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If no voltage is detected, replace the direction switch.

Vehicle Moves Backward Only

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



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 potentiometer (of the main pedal) while monitoring the Throttle command on the display.

Other causes of lower speed:

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

Intermittent Movements During Operation

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

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

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

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

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

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

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

Fault Code List and Diagnostic

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DIAGNOSTICS AND TROUBLESHOOTING

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

Emberdeux ted by VCL code (Sudex \$1–67 in fielde 5) connectional food. here as they will vary from application to application. Refer to the appropriate OEM documentation for information on these faults.

DIAGNOSTICS

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Dispressible information as a be obtained in either of two ways: (1) by reading the display on a 1511 programmer or (2) by observing the fault codes issued. by the Status LEDs. See Table 1 for a summary of LED display formats.

The 130.1 programmer will display all faults that are currently set as wellsees history of the feedbathest hove been versions the history log weedsay elemed. The 1311 displays the faults by name.

The pair of <u>LEDs</u> built into the controller (one red, one yellow) produce: flash codes displaying all the correctly set faults in a repeating cycle. Fach code: consists of two digits. The ted LED flashes once as indicate they 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 seconddigit of the tasks will follow; the yellow LKD flashes the appropriate member: ${
m d}$ of times for the second digit.

Example: Bottery Undervoltage (code 23).

In the Fault menu of the 1311 programmer, the words: **Undervoltage Cuttact**r will be displayed: the ned-time battery voltage: is displayed in the Monitor menu ("Keyswitch Voltage").

The controller's two LEDs will display this repeating patterns:

760	YEUUCW	пер	YISTUONA
*	* *	* *	左 本 本
$(0,\infty,2,q_0(n))$	(2)	(see see digital	(60

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

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.

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	Table 5 TROUBLESHOOTING CHART			
CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS	
12	Controller Overcurrent ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrotsle; FullBrake; ShutdownPump.	 External short of phase U,V, or W motor connections. Motor parameters are mis-tuned. Controller defective. 	Set: Phase current exceeded the current measurement limit. Clear: Cycle KSI.	
13	Current Sensor Fault Shutdown:Motor; Shutdown:MainContactor; Shutdown:EMBrake; Shutdown:Throttle; FullBrake; Shutdown:Pump.	 Leakage to vehicle frame from phase U, V, or W (short in motor stator). Controller defective. 	Set: Controller current sensors have invalid offset reading. Clear: Cycle KSI.	
14	Precharge Failed ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThroisle; 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 capacito bank to the KSI voltage. Clear: Cycle Interlock input or use VCL function Precharge().	
15	Controller Severe Undertemp ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	See Monitor menu - Controller: Temperature. 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 Overlemp 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 Undervollage Reduced drive torque.	 Battery Menu parameters are misadjusted. Non-controller system drain on battery. Battery resistance too high. Battery disconnected while driving. See Monitor menu Battery: Capacitor Voltage. 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.	

CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
18	Severe Overvollage ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrossle; FullBrake; ShutdownPump.	See Monitor menu Battery: Capacitor Voltage. Battery menu parameters are misadjusted. Battery resistance too high for given regen current. Battery disconnected while regen bulking.	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.	See Monitor menu - Controller: Temperature. Controller is performance-limited at this temperature. Controller is operating in an extreme environment. Excessive load on vehicle. 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	Overvollage 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.	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 Sot_DigOut() to turn the driver on again.

,	Tat	ble 5 TROUBLESHOOTING CHART, c	ontinued
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.	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 sorque.	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 cusback disabled.	Motor thermistor is not connected properly. If the application doesn't use a motor thermistor, Motor Temp Sensor Enable should be programmed Off. 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.	Open or short on driver load. Dirty connector pins. 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 Shutdown/Motor; Shutdown/Main/Contactor; Shutdown/EMBrake; Shutdown/Throtsle; FullBrake; Shutdown/Pump.	Open or short on driver load. Dirty connector pins. 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.	Open or short on driver load. Dirty connector pins. Bad crimps or faulty wiring.	Set: Driver 2 (pin 5) is either open or shorted. This fault can be set only when EM Bmke Type © 0. Clear: Correct open or short, and cycle driver
32	EMBrake Open/Short Shutdown EMBrake; Shutdown Throtele; FullBrake.	Open or short on driver load. Dirty connector pins. 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 ShudownDriver3.	Open or short on driver load. Dirty connector pins. Bad crimps or faulty wiring.	Sea: Driver 3 (pin 4) is either open or shorted. Clear: Correct open or short, and cycle driver
34	Coil4 Driver Open/Short ShutdownDriver4.	Open or short on driver load. Dirty connector pins. Bad crimps or faulty wiring.	Set: Driver 4 (pin 3) is either open or shorted. Clear: Correct open or short, and cycle driver

COMPANY NAME

	Tab	le 5 TROUBLESHOOTING CHART, c	ontinued
CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
35	PD Open/Short ShutdownPD.	Open or short on driver load. Dirty connector pins. Bad crimps or faulty wiring.	Set: Proportional driver (pin 2) is either open or shorted. Clear: Correct open or short, and cycle driv
36	Encoder Fault ShutdownEMBrake.	Motor encoder failure. Bad crimps or faulty wiring. See Monitor menu Motor RPM.	Set: Motor encoder phase failure detecte Clear: Cycle KSI.
37	Motor Open ShutdownMotor; ShutdownMainContactor; ShutdownEMBCake; ShutdownThrotsle; FullBrake; ShutdownPtonp.	Motor phase is open. 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; ShutdownPuonp.	 Main contactor tips are welded closed. Motor phase U or V is disconnected or open. 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; ShutdownThrotsle; FullBrake; ShutdownPunp.	Main contactor did not close. Main contactor tips are oxidized, burned, or not malcing good contact. External load on capacitor bank (B+ connection terminal) that prevents capacitor bank from charging. Blown B+ fuse.	Set: With the main contactor command closed, the capacitor bank voltage (B+ connection terminal) did not charge to Clear: Cycle KSI.
41	Throttle Wiper High Shutdown Throttle.	See Monitor menu o Inputs: Throttle Pot. 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 Satup_Pot_Faults()). Clear: Bring throttle pot wiper voltage below the fault threshold.
42	Throttle Wiper Low Shutdown Throttle.	See Monitor menu "Inputs: Throttle Pot. 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	Po12 Wiper High FullBrake.	See Monitor menu o Inputs: Pot2 Raw. 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.

	Tab	le 5 TROUBLESHOOTING CHART, c	ontinued
CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
44	Pol2 Wiper Low FullBrake.	See Monitor menu » Inputs: Pot2 Raw. 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 Satup_Pot_Faults()). Clear: Bring Pot2 wiper voltage above the fault threshold.
45	Pot Low Overcurrent Shutdown Throttle; FullBrake.	See Monitor menu Outputs: Pot Low. Combined pot resistance connected to pot low is too low.	Set: Pot low (pin 18) current exceeds 10m. Clear: Clear pot low overcurrent conditio and cycle KSI.
46	EEPROM Failure ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrotsle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPo; FullBrake; ShutdownPop.	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 Pinputs.	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.	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.	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.)	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.

	Tab	le 5 TROUBLESHOOTING CHART, co	ontinued
CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
68	VCL Run Time Error Shutdown/Motor; Shutdown/Main/Contactor; Shutdown/EMBrake; Shutdown/Throstle; Shutdown/Driver1; Shutdown/Driver2; Shutdown/Driver3; Shutdown/Driver4; Shutdown/Priver4; Shutdown/Priver4; Shutdown/Priver5	1. VCL code encountered a runtime VCL error. 2. See Monitor menu Dontroller: 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; ShutdownInterlock; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPriver4; ShutdownPD; FullBrake; ShutdownPunp.	1. Internal controller fault.	Set: Internal controller fault detected. Clear: Cycle KSI.
72	PDO Timeout ShutdownInterlock; CAN NMT State set to Pre-operational.	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).	Stalled motor. Motor encoder failure. Bad crimps or faulty wiring. Problems with power supply for the motor encoder. See Monitor menu » Motor: Motor RPM.	Set: No motor encoder movement detecte 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 PAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS					
94	Emer Rev Timeout ShutdownEMBrake; ShutdownThrottle.	Emergency Reverse was activated and concluded because the EMR Timeout timer has expired. 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	lllegal Model Number Shutdown/Motor; Shutdown/MainContactor; Shutdown/EmBrake; Shutdown Throttle; FullBrake; Shutdown/Puonp.	Model_Number variable contains illegal value (not 1234, 1236, 1238, or 1298). Software and hardware do not match. 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.					

COMPANY NAME

	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; ShutdownPunp.	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.	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; ShutdownEMBrake; ShutdownThrottle; ShutdownThrottle; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPr); FullBrake; ShutdownPop.	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 Falled to Set ShutdownEMBrake; ShutdownThrottle.	Vehicle movement sensed after the EM Brake has been commanded to set. 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 act vated by the Stall Fault, clear by ensuring encoder senses proper operation, Motor RPM = 0, and Throttle Command = 0.					

9 - MAINTENANCE

MAINTENANCE

MAY 2023

VERSION 01

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

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

CLEANING

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

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

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

- 1. Remove power by disconnecting the battery.
- 2. Discharge the capacitors in the controller by connecting a load (such as a contactor coil) across the controller's B+ and Bterminals.
- 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.



MAY 2023

CODE 62 HPD / SRO Sequence fault: incorrect starting sequence



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



Unii 3 - 5250 Gramer St Burnsby, BC, Canada V6H 2H2 Tall 604 327 8244 Fax: 604 327 (Q40)

SAVE THESE IMPORTANT SAFETY INSTRUCTIONS



SECTION 05

ANNEXES

This manual contains important safety, operating, and Installation instructions - read before using charger.

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. Load acid batteries may generate explosive hydrogen gas during normal operation. Keep sparics, flames, and smoking materials away from buttories. Provide adequate ventilation during charging, Never charge a frozen battery. Study all battery manufacturers' apacific procautions such as recommended rates of charge and removing or not removing cell caps while charging,

Electrical Safety Information

Danger: Rink of electric shock. Connect charger power cord to an outlet that has been property 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 adaptors 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, boon 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 soulement sur les batteries 72V avec un algorithme approprié au type apécifique de batterie - voire le manuel. D'autres types de batteries pourraient éclater et causer des bleusures ou domringes. Les batturies 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 is bonne ventilation lors du chargement. Ne jamala charger une batterio gelée. Prendre connaissance des menures de précaution apécifiées par le fabricant de la batterie, p. ex., vérifier s'il faut enlever les bouchons des cellules lors du chargement de la batterio, et les trux de chargement rocommandés.

Information de Sécurité Électrique

Danger: Ringue de chocs électriques. No pes toucher les parties non isolées du connecteur de sortie ou les bornes non inclúes de la batterio. Toujours connector le chargeur à une prise de courant mise à la terre. Ne pas ouvrir ni desassembler le chargeur – referer toute reperations aux personnes qualifiés. Pas à l'usage dos onfants.

Operating Instructions

- Always use a grounded outful. When using an extension cord, avoid excessive votage drops by using a grounded 3-wire 12 AWG cord
- The charger will automatically turn on and go through a short LED indicator self-test (Models \$12-x00x will fluth as LED's in an up-down acqueroc and Mode's \$12-xx1x will argministricity faush its LED RED-GREEN) for two seconds. If the charger is connected to battery pack, a trickle current will be applied until a mirrorm votage is rejiched. If the charger is used in an off-board application and the charger is waiting to be pagged into a battery pack, the charging eigenthin number will be displayed for 11 seconds (see "Check / Change Charging Agenthm") before utilimately displaying an under-votage fault (fault disappears when plugged into battery pack)
- Once a manners better yieldage is abtocted, the charger will enter the bulk charging constant-current stage. Models 912-xx0x will display the current to the buttery on the bargraph and Model 912-xx1x will flam its LEO GREEN off more than on to indicate 460% charge status. The length of charge time will may by how large and how copieted the battery pack is, the input voltage (the higher, the better), and ambunt temperatures (the lower, the better). If the input AC voltage is low (below 164VAC), then the charging power will be reduced to evoid high input currents (Models 912-xx0x AC LED and Models 912-xx1x single LED both Bash YELLOW). If the ambient temperature is too high, then the charging power will also be induced to maintain a mornium internal temperature (Models 912-xx0x; pargraph fauthes and Models 912-xx1x; single LED fauthes YELLOW).
- When the battery is at approximately 80% state of charge, the bus stage has completed and an 980% charge indication is given (Mode's 912-xx0x turn on the 180% LED and Mode's 912-xx1x with find his LED GREEN on more than off). In the next phase known as the absorption of combinative/large phase, the last 20% of charge is then returned to the battery. The charging could be terminated at this point if the valuate requires emmodiate usage, however, a is highly recommended to well until 100% diarge indication is given to ensure maximum basery capsoly and the
- A low current "finish-charge" phase is next applied to return and maintain manimum battery capacity (Mode's 912-220x will faint the "1001/c" LED).
- When Models 912-∞09, 10016 LED or Models 912-∞x1x single LED is continuously GREEN, the basignost are completely charged. The charget may now be unproged from AC power (always pull on plug and not cord to induce rate of demage to the cord). If left plugged in, the charger will automatically restant a complete charge cycle if the battery pack voltage group below a minimum voltage or 30 days has elapsed.
- If a fact occurred arrange during charging, a fact indication is given by RusiNag RED with a code corresponding to the error. There are several potential condenses that generate errors. Some errors are serious and matter human intervention to first resolve the problem and then to result the charger by Interrupting AC power for at least 15 seconds. Others may be simply transfert and will automatically resover when the fault condition is eliminated. To indicate which error occurred, a fault indication will fault RED a number of times, pause, and then repeat.
 - [1 FLASH] Binnery Votage High: auto-rocover

 - [2 FLASH] Bittlery Votage Low auto-recover
 [3 FLASH] Charge Timeest: the charge on 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 cours not be trickle charged up to the minimum level required for the charge to be started. This may indicate that one or more ostis in the battery pack are shorted or demagded.
 - [6 FLASH] Over-Temperature auto-recover Charger has shaddown due to high internal temperature which hydrosity indicates there is not sufficient airflow for cooling—see installation instructions 1). Charger will restant and charge to complation if temperature connect within accepted limits.

 [8 FLASH] OutO 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

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

Specifications

DC Output - see Operating Instructions

QuiQ Model: 912-	24xx	36100	48 xx	7200		
Voltage-norn (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-rosot					
Short Circuit	Electronic current (mil					

AC	In	put

All models	
Voltago-max (Vims)	85 - 265
Fraquency (Hz)	45 - 65
Current-max: (Arms)	12A @ 104VAC (mduced 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	Sold YELLOW	LED Active		
AC LOW	Floon YELLOW	Flash YELLOW		
Thornal Cutback	Flash Borgraph	Flosh YELLOW		
<80% Charge Indicator	-	Short Flash GREEN		
>80% Charge Indicator	Solid YELLOW	Long Float GREEN		
10016 Charge Indicator	Solid GREEN	Solid GREEN		
Fault Indicator	Flash RED	Flash RED		
DC Ammeter	LED Bargraph	-		
But Temp Compensation	Automatic Optional			
Maintenance Mode	Auto-restart If V<2 1Vpc or 30 days elapse			

Installation Instructions



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

1) Determine Mounting Location:

YANG 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-disalpating quatries. 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 fine, so mounting above open areas or areas with cut-outs for airflow is deximble Control Delta-O for information on other mounting orientations. As the charger may get hot in operation, the charger must be innuffed 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 valible to the user.

2) Mounting Procedure:

Mount the charger by the mounting plate using appropriate fautaners (i.e. 1/4" or M6 with looking hardware). For UL2202 comprance, a 12AVG 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 corrotion resistant hardware (e.g., a \$10 stain/ose steel mechine screw with at least two threads of engagement and, if required, a paint planning washer).

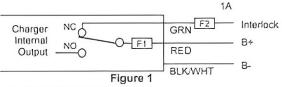
3) DC Battery Connection Procedure:

- a) The green wire outputs battery voltage when the charger is not plugged into AC to provide an interlock function see Fig. 1. If uood, a uoor-oupplied 1A fast-blow external fuse must be inutalled inline to prevent damage. Shorting or drawing more than 1A may damage charger and vold the warranty.
- b) Socurety fasten the black ring terminal from the charger to the negative terminal ("-", "NEG", NEGATIVE") of the buttery pack.
 c) Check that the correct charge algorithm is being used rufer to section 4). Socurety fasten the rud ring terminal to the positive terminal ("-", "POS", "POSITIVE") of the buttery pack.

Mochanical

alobom IIA	
Dimensions	28.0 x 24.5 x 11.0 cm (11 x 9.7 x 4.3°)
Vreight	<5 kg (<11 lbs) w/ standard output cord
Environmental	Enclosure: IP46
Operating Temperature	-30°C to +50°C (-22°F to 122°F), denated 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

Rogulatory			
Sofoty			
EN 60339-1/2-29	Safety of Appliances/ Battery Chargers		
UL2202	EV Charging System Equipment		
UL1684 2nd Edition	Industrial Battery Charger		
CSA-C22.2 No. 107.2	Buttery Chargers- Industrial		
Emissions			
FCC Part 18/ICES 003	Unintentional Radiators Clars A		
EN 55011	Radio disturbance characteristics (Class A)		
EN 61000-3-2	Limits for harmonic current emissions		
EN 61000-3-3	Limits of voltage Ructuations and Bicker		
Immunity			
EN 61000-4-2	Electrostatic discharge immunity		
EN 61000-4-3	Radiated, radio-fraquency, Eliff Immunity		
EN 61000-4-4	Electrical fast transfent/burst immunity		
EN 61000-4-5	Surge Immunity		
EN 61000-4-6	Conducted Immunity		
EN 61000-4-11	Voltage variations immunity		



4) Check / Change Charging Algorithm:

The charger comes pre-louded with algorithms for batteries as detailed in Table 1. If your appeals buttery model is not lated, 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 8 is indicated on the '80%' LED (Models $912{-}\infty0x$) or on the single LED (Models $912{-}\infty1x$). A single digit Algorithm 8 is indicated by the number of blacks separated by a pause. A two digit Algorithm & is indicated by the number of blacks for the first digit followed by a short peuse. then the number of blinks for the second digit followed by a longer pause. To check / change the charging algorithm:

Alg

35

27

26

11

8

6

5

1

Battery Type

Concorde 2xxAh AGM

Crown CR325 dv/dl

Deka 8GGC2 Gel

generic flooded CP dv/ol

Concarde 1xxAh AGM

Trojan J305 dV/dl

DEKA 8G31 Gel

Trojan 30XHS

US Battery US2200

Trojan T-105

Table 1.

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 puriod to the battery pack's positive turninal for 3 seconds and than remove - the Algorithm & will advance after 3 seconds. Repeat until deritted Algorithm # is displayed. A 30 second timeout is extended for every increment Incrementing beyond the last Algorithm moves back to the first Algorithm.

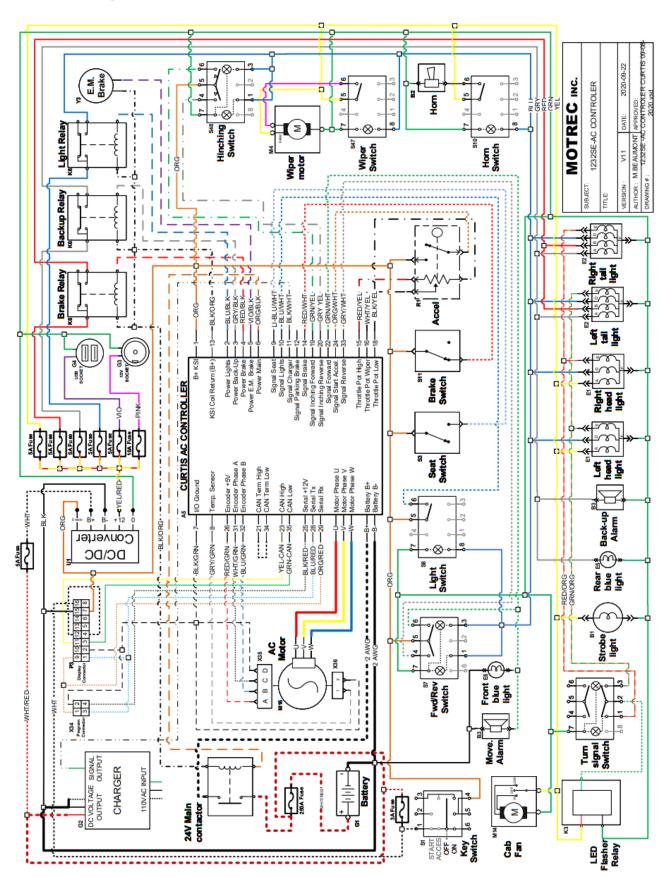
After desired Algorithm & is displayed, touch the charger connector to the battery positive until the output relay is heard to click (~10 seconds) - algorithm is now in permanent memory.

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.

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

Note: This is a Class A product, in a domestic arritronment this product may cause radio interference, in which case the user may be required to take adequate measures. Aug 2009 @ Delta-Q Technologies Corp. All rights reserved. PN: 710-00xx Rev 1 V1.16

Electrical Diagram



MAY 2023

VERSION 01

Standard Torque





BOLT CLAMP LOADS

Suggested Assambly Torque Values



	USS/SAE GRADE 5					USS/SAE GRADE 8				
DIAMETER & THREADS PER INCH	TOUSILE STRENGTH Mov. PSI	Proof Loss LB	CLAMP LOID LB	TOTOUT DET FT LB	LUNIOCATIO FT LB	TUKSILI STRENGTH Max. PSI	Pacor Loss LB	CLAR? LOID LB	Totovi Der FT LB	Luisocario 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	6,690	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	7,980	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	150,080	40,100	30,100	380	280
16	120,000	31,700	23,780	300	220	150,000	44,500	33,500	420	310
7/8-9	120,000	39,300	29,450	430	370	150,000	55,400	41,500	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	39,600	640	480	150,000	72,700	54,500	910	680
14	120,000	57,700	43,300	720	510	150,000	81,500	61,100	1,020	760



MOTREC INTERNATIONAL