MT-800-AC





MAINTENANCE MANUAL

A GUIDE FOR PERFORMING MAINTENANCE AND REPAIRS ON MT-800

SERIAL NUMBER: 117 92 93 AND UP

UPDATED 06.02.2024
DESIGNED BY MOTREC INTERNATIONAL

MOTREC INTERNATIONAL INC.

5-YEAR LIMITED WARRANTY

FOR VEHICLES PRODUCED AFTER NOVEMBER 1, 2024





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

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

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

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

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

DEFECTS. Subject to the terms and conditions described below, parts, components, or accessories installed on the product by Motrec that fail under normal 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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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



1.1. INTRODUCTION

Read Before Operating

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

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

A list of <u>maintenance instructions</u> is included in this document. These instructions are intended for an MT-800 experienced technician to accelerate the maintenance process. The instructions should not be used by any untrained or inexperienced personnel.



The MT-800

The MT-800 is a compact two-seater vehicle designed to deliver substantial towing power in tight industrial environments. Its 40 HP direct-drive AC motor allows for easy towing of long and heavy loads up to 50,000 lbs (22,680 kg). Dual planetary wheel gearing with enclosed wet disc brakes minimizes maintenance requirements.

Regenerative electric brakes maximize each use's lifespan. With a body constructed from a single thick piece of reinforced welded steel in all impact areas, this vehicle is virtually indestructible.



Modular Design

The MT-800, like other MOTREC vehicles, can quickly adapt to new work requirements. Its modular design allows for a quick change of configurations based on the task at hand. Predefined packages and options are available to fulfill standard needs, as well as a customization process to accommodate specific customer needs.

Refer to our website <u>www.motrec.com</u> for more details on configurations.

1.2. ACRONYMS AND ABBREVIATIONS

°C: Celsius

°F: Fahrenheit

ANSI: American National Standards Institute

AUX: Auxiliary

EMB: Electromagnetic Brake

ft: Feet

A: Amperes

HD: Heavy Duty**HP**: Horsepower

HPD: High Pedal Disable

Hz: Hertz

ITSDF: Industrial Truck Standards Development Foundation

kg: Kilogram

km/h: Kilometer per Hour

kW: Kilowatt

kWh: Kilowatt-Hour

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

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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 (MPV)**.

3.1. SPECIFICATIONS AND CONFIGURATIONS

The MT-800 specifications and configurations can vary depending on the specific model and year of the MT-800. 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.

COMPANY NAME

EQUIPMENT COMPARTMENTS:

Opening 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.



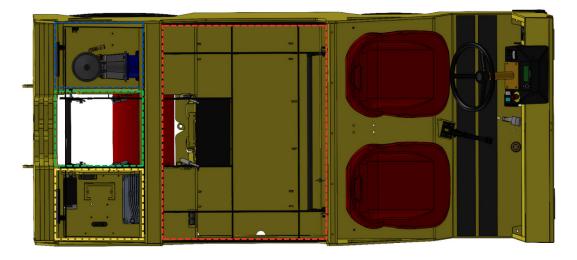


Figure 1. Equipment Compartments.

NOTE: Batteries must be inserted into the designated battery compartment (not shown above in the figure). The client is responsible for selecting which batteries to place in this compartment.

3.2 BATTERY COMPARTMENT



CAUTION

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

The vehicle can only be powered by **Flooded (lead-acid)** batterries.

Standard battery Compartment:

This standard battery compartment is devoid of any mechanical components, allowing for easy removal of the batteries by lifting them out from the compartment. Only the $80 \ V$ total battery voltage option is currently offered.

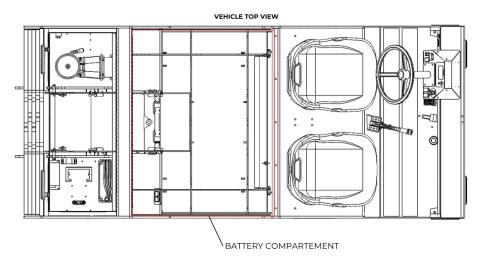
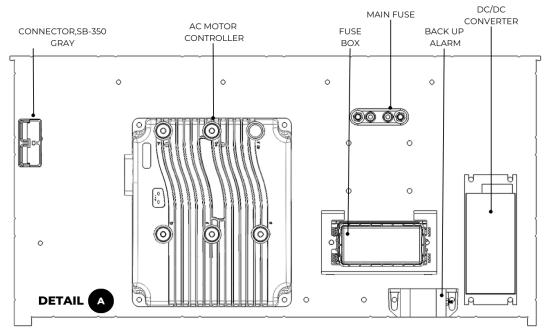


Figure 2. Standard Battery Compartment.

3.3 ELECTRICAL SYSTEMS

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Figure 3. a. Electrical System Compartments Detail A.

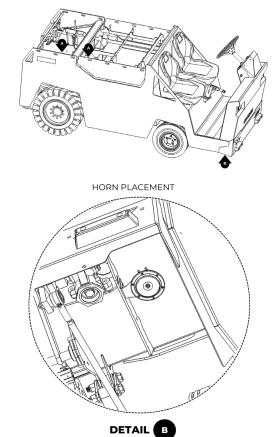


Figure 3. b. Electrical System Compartments Details B and C.

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 two categories:

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

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.

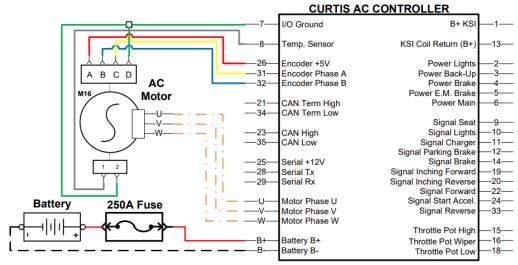


Figure 4. Main Energy Electrical connection (Annexe 5).

3.3.2 AUXILIARY ENERGY

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VEHICLE OVERVIEW

To power the auxiliary systems of the vehicle, including the backup alarm, lights, horn, and others. The DC-DC converter utilizes the 80 VDC battery voltage and converts it to an output of 12 VDC / 13.4 VDC. This voltage is then directed through the auxiliary fuse box and distributed to the vehicle's accessories.

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

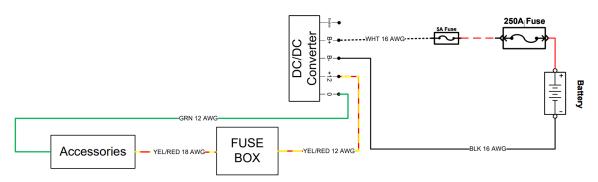


Figure 5. Auxiliary Energy Electrical connection (Annexe 5).

3.4 DRIVE AXLE

The drive axle of the MT-800 is designed for electrical traction, where a high torque is required at the wheel with low load structural capacity. It is composed of three independent and separate parts, and namely:

COMPANY NAME

MOTREC INTERNATIONAL

- 1) The single motor with hollow shaft with mechanical differential.
- 2) The reduction gearboxes.
- 3) The main bodies, containing the wet disks braking system.

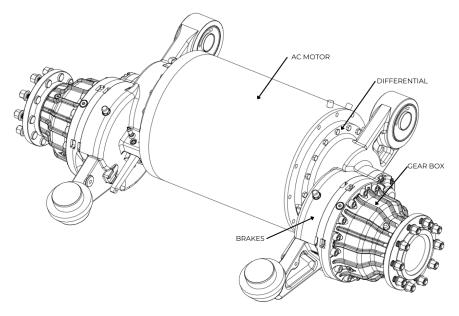


Figure 6. Drive Axle of MT-800.

The patented technical solution of separating the brake chamber from the gearbox optimizes unit performance in several ways. Firstly, it allows for the lubrication of the reduction gear with oil best suited to its characteristics, while enabling the brake to be lubricated with a more fluid suitable for braking units. Additionally, any deposits formed during braking cycles are confined to the cartridge, preventing contamination of the reduction gear lubricant, and providing better protection for bearings and the driving unit. Furthermore, replacing brake discs does not require disassembling the entire reduction gear.



CAUTION

UNDER NORMAL WORKING CONDITIONS THE GEARBOX SHALL NEVER EXCEED A TEMPERATURE OF 120°C. IF THIS TEMPERATURE LIMIT IS EXCEEDED, IT IS RECOMMENDABLE TO SUSPEND USAGE AND ALLOW THE GEARBOX TO COOL DOWN.

The axle is provided with frame mounting arms (eventually equipped with bushings) and positioning arms for fixing damper system as shown in the drawing below (see fig. 7).

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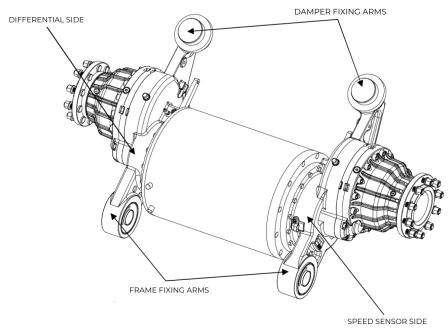


Figure 7. Drive Axle Frame Mounting Arms.

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.

3.5 STEERING PUMP

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VEHICLE OVERVIEW

The power steering pump (1) is driven by the motor (3) connected throughtout to the motor-pump adapter (4), for a continuous supply of hydraulic pressure. It draws hydraulic fluid from the integrated reservoir (2), pressurizes it, and directs it to orbitrol and then to the cylinder.

Proper maintenance of the power steering pump is essential to ensure optimal steering performance. Regular checks for leaks and maintaining appropriate fluid levels are crucial for the longevity of the pump and the overall safety of the vehicle.

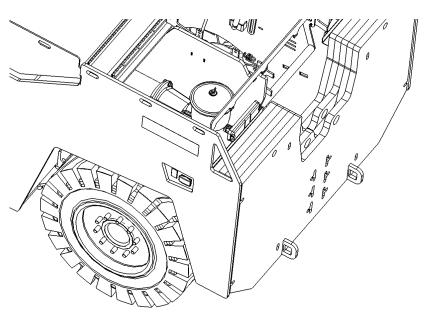
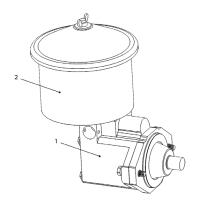


Figure 9. Steering Pumps Compartement.



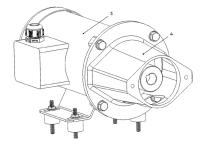


Figure 8. Steering Pump (1) / integrated reservoir (2) and Axial Piston Hydraulic Motor (3) / Motor-differential adapter (4) Assembly.

3.6 STEERING SYSTEM

SECTION 03

VEHICLE OVERVIEW

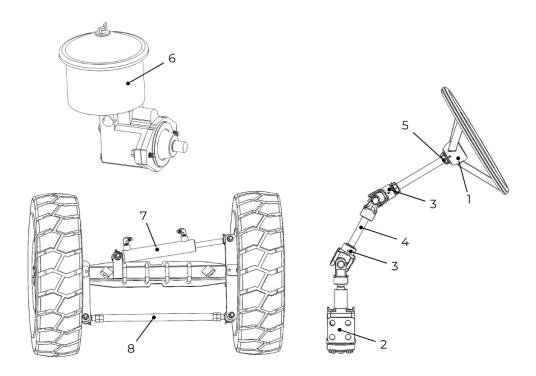


Figure 10. Steering System.

When the driver turns the steering wheel (1), the rotational motion is transmitted to the orbitrol (2) via the universal joint (3), the steering shaft (4) and igus bushing (5). In essence, the orbital steering unit takes the hydraulic pressure generated by the power steering pump (6) and channeled it towards the steering cylinder (7) to be converted into mechanical force to control the movement of the vehicle's wheels, prompting the wheel to turn as required. This coordinated movement is mirrored by the opposite wheel through an interconnected linkage system (8).

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

3.7 BRAKE SYSTEM

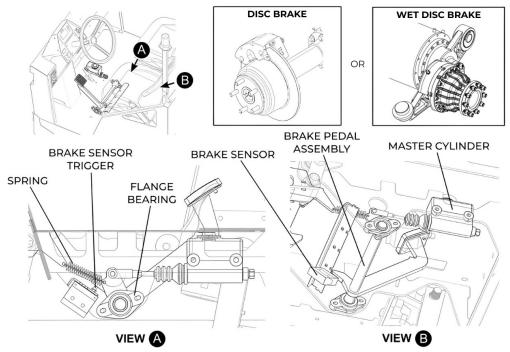


Figure 11. a. Brake System.

When the driver applies pressure to the brake pedal. The applied force is then transmitted to the master cylinder, which pressurizes brake fluid. This pressurized fluid is directed to the front disc brakes and the rear wet disc brake assembly. The front disc brake assembly comprises a rotor and caliper, and when the brake pedal is engaged, the caliper compresses the brake pads against the rotating rotor, generating friction to decelerate the wheel. Wet disc brakes include a sealed housing that contains brake fluid. This housing helps maintain a consistent temperature and provides lubrication to minimize wear.

In addition, a brake switch, situated at the brake pedal, detects the brake system's status. It triggers the brake signal, indicating the vehicle's systems that the brakes are actively in use. To ensure a prompt release of the brake pedal when pressure is released, a spring is integrated, contributing to the overall smooth operation of the braking system. This intricate arrangement ensures a controlled and dependable deceleration of the vehicle whenever the brakes are applied.

Situated adjacent to the driver at the front of the vehicle, a hand brake is linked to the rear wet disc brake assembly through a mechanical parking brake cable also connected to the lever. This arrangement adds an extra level of security for parking and immobilizing the vehicle. The mechanical operation of this system ensures autonomy from the hydraulic braking system, enhancing the overall safety and stability of the parked vehicle.

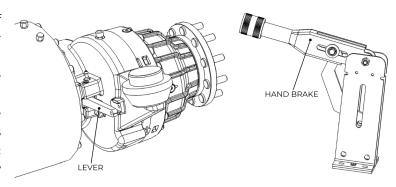


Figure 11. b. Brake System.

3.8 SUSPENSIONS

SECTION 03

VEHICLE OVERVIEW

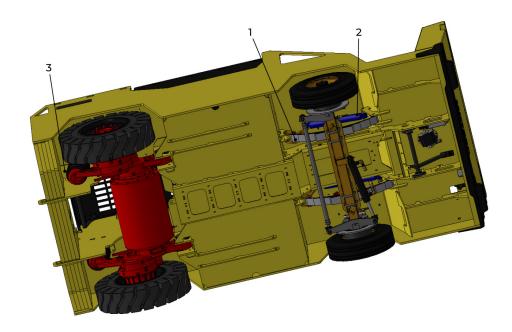


Figure 12. Suspension System.

The vehicle's suspension system features a well-balanced design with two leaf springs and shock absorbers at the front and two rear suspension rubber bumpers at the back. Up front, the leaf springs provide flexibility and support to the front axle, ensuring even weight distribution and adeptly absorbing surface irregularities. Complementing this, the shock absorbers efficiently control and dampen the suspension's movement, enhancing ride comfort by minimizing vibrations and jolts.

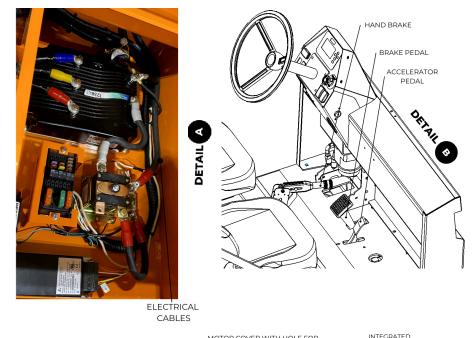
At the rear, the two rubber bumpers serve as crucial cushioning components, absorbing shocks and preventing metal-to-metal contact between suspension elements. Their presence not only contributes to a smoother ride but also aids in limiting rear suspension travel, preventing excessive compression.

This combination results in a well-rounded suspension system that excels in stability, comfort, and performance across various driving conditions.

3.9 GENERAL COMPONENTS

Electrical Cables

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



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Integrated Seat Switch

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.

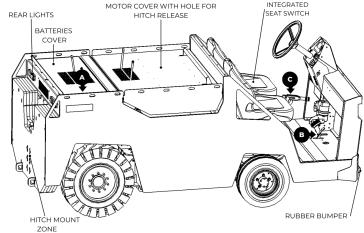


Figure 13. a. General Components (Details A and B).



Figure 13. b. General Components (Detail C).

Parking Brake Lever with Electric Switch:

A magnetic electric switch is integrated into the brake lever, serving a pivotal role in the braking system. This switch is responsible for detecting the position of the brake lever. Additionally, it relays this information to the display, providing real-time feedback on the status of the brake lever to the driver.

3.10 CONSOLE

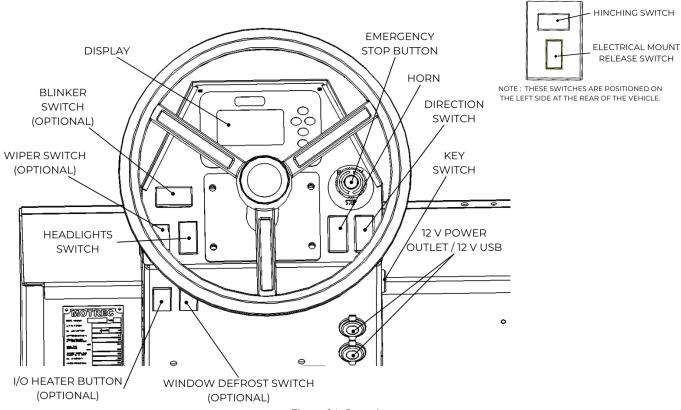


Figure 14. Console.

Direction Switch (Forward/Reverse)

This switch controls the motion direction of the vehicle:

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

Key Switch

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

Display

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

Emergency Stop Button

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



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.

3.10.1 DISPLAY

Parking Brake

This indicator lights up when the parking brake is engaged.

Headlights Indicator

Lights up when the headlights are ON.

Maintenance

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

Direction Arrows (Forward/ Reverse)

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

Navigation Arrows

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

Drive Mode Indicator

Indicates the current selected drive mode between rabbit and turtle.

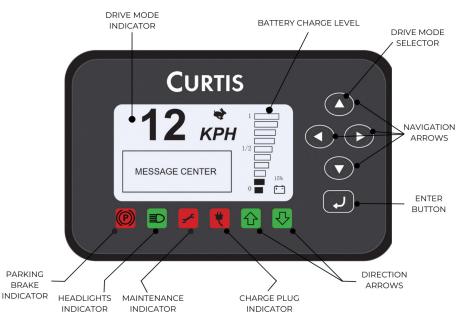


Figure 15. Display.

Enter Button

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

Drive Mode Selector

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

Battery Charge Level

Indicates the state of charge of the batteries.

Vehicle Runtime

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

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

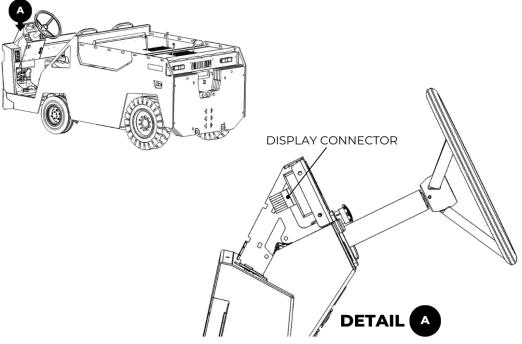
3.10.2 OPERATOR INTERFACE

Login Credentials

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

Four Pin Diagnostics Connector

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



(DASHBOARD COVER HIDDEN FOR CLARITY)

Figure 16. Display Connector.

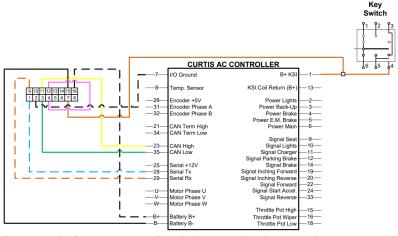


Figure 17. Display Connector Electrical connection (Annexe 5).

Vehicle Speed



WARNING

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

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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.

3.10.3 ALARMS AND FAULTS

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

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

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

3.10.4 REAR LIGHT COLORS SIGNIFICATION

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

4. MAINTENANCE

4.1 GENERAL INFORMATION

This section provides a general overview of the maintenance procedures for a standard MT-800 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-800 models as they cover the fundamental processes. If you have any maintenance-related questions specific to your product's features, please reach out to MOTREC for assistance.

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



WARNING

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



WARNING

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



WARNING

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



CAUTION

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



CAUTION

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



4.1.1 LIFTING POINTS

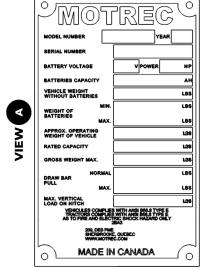
Please refer to the serial data plate (see Figure 18), positioned on the left side of the console, to determine the total weight of the vehicle. It is important to note that the weight may differ based on the vehicle's specific configuration, accessories, and battery capacity.

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



WARNING

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



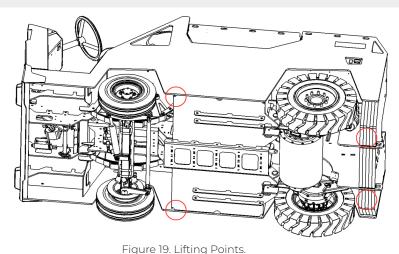


Figure 18. Serial Data Plate.



NOTE: To elevate the vehicle, four jack rubbers located at designated lifting points are employed.



WARNING

ENSURE THAT YOU USE A JACK WITH SUFFICIENT LIFTING CAPACITY TO ELEVATE THE VEHICLE. A REGULAR WORKSHOP JACK IS NOT SUITABLE AND MAY FAIL TO SUPPORT THE VEHICLE'S WEIGHT.



Figure 20. Jack Rubbers Used For Lifting



WARNING

AFTER LIFTING, CAREFULLY CHECK THE VEHICLE'S STABILITY BEFORE BEGINNING ANY WORK UNDERNEATH.

4.1.2 ELECTRICALLY ISOLATING THE VEHICLE



WARNING

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

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

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



/!\ WARNING

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

- 3. Take off the battery cover to reach the batteries.
- 4. Disconnect the battery pack by unplugging the SB-350 connector (See figure 3.a page 11).
- 5. Discharge the capacitor in the AC motor controller (1) by connecting a 10 ohms / 25 W resistor (2) for a few seconds across the AC motor controller's (1) **B+** and **B-** terminals. Do not leave the resistor (2) on the terminals once discharged.
- 6. Using a multimeter, validate the absence of voltage between the AC motor controller's (1) **B+** and **B-** terminals.
- 7. To reconnect the electrical circuit, perform this procedure in reverse.
 - **NOTE**: No resistor needed for reconnection.

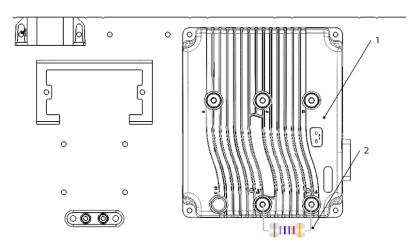


Figure 21. AC Motor Controller Terminals.

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.
- 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).

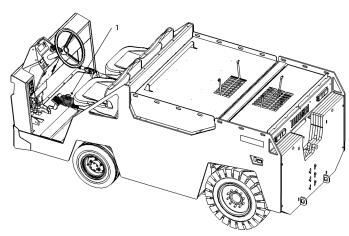


Figure 22. Front Fluid Leaks.

2. Open the motor cover (2).

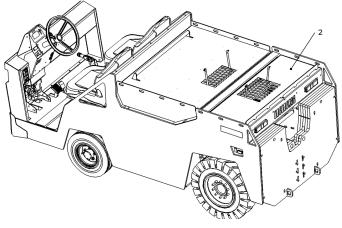


Figure 23. Deck Removal.

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

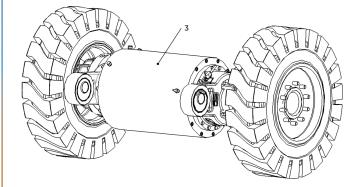


Figure 24. Drive Assembly Fluid Leaks.

4. Close the motor cover (2).

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.

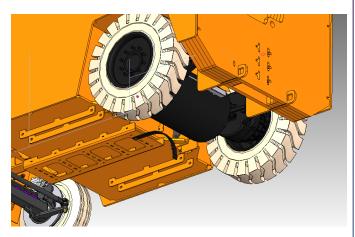


Figure 25. Static Strap.

Steering Inspection

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

Horn and Lights Inspection

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

Seat Switch Inspection

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



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

Accelerator Pedal Inspection

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

Brake Pedal Inspection

- 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 pedal for free movement and firm pedal.

Emergency Button Inspection

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

4.2.2 WEEKLY MAINTENANCE

Special Tools	Consumables
► N/A	1. Distilled water

NOTICE

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

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Maintenance Procedures

Battery Electrolyte Inspection and Top-Up

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. Open the lid, using the handle on the right side of the driver, to access the batteries located under the driver's seat.
- 3. For each battery in the battery compartment, inspect and refill as necessary with distilled water to the recommended manufacturer level.
- 4. Close the lid to conceal the batteries.



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.



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.

EVERY 250 HOURS OR 3 MONTHS MAINTENANCE 4.2.3

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Special Tools	Consumables
Resistor: 10 ohms, 25 WLifting device	Lubricant sprayMulti-purpose Grease

NOTICE

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

NOTICE

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

Maintenance Preparation Steps

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

1. Open the batteries cover (1).

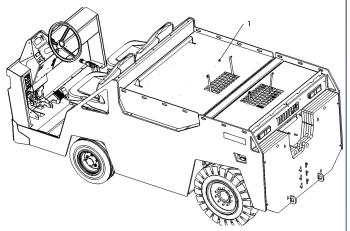


Figure 26. Batteries Cover Removal.

- 2. Remove the control panel (2).
- 3. Remove the dashboard cover (3).

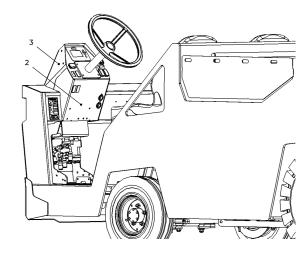


Figure 27. Control Panel and Dashboard Cover.

Take the necessary steps to remove electrical hazards in accordance with Section 4.1.2 **ELECTRICALLY ISOLATING THE VEHICLE** page 27, which provides guidelines for electr ically isolating the vehicle.



WARNING

DO NOT WORK ON ANY COMPONENTS OF THE ELECTRICAL SYSTEM UNTIL THE VEHICLE IS ELECTRICALLY ISOLATED. VOLTAGES OF UP TO 90 V AND HIGHER CAN BE PRESENT. FAILURE TO COMPLY CAN CAUSE INJURIES.

Maintenance Procedures

Suspension Inspection

- 1. Inspect the following equipment for damage, corrosion, cracks or oil stains:
 - Front leaf springs (1) and their fixtures (2).
 - Rear shock absorbers (3).
 - Rear rubber bumpers (4).
- 2. Inspect all suspension frame bearings for play.
- 3. Examine the bushings and mounts for wear or damage.

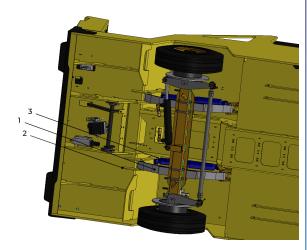


Figure 28. Front Suspension And Shock Absorbers Inspection.

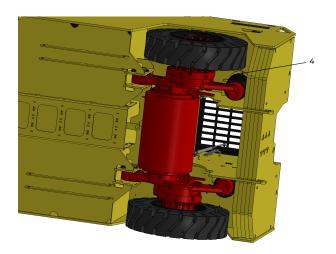


Figure 29. Front Rubber Bumpers Inspection.

Rubber Bumper Inspection

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

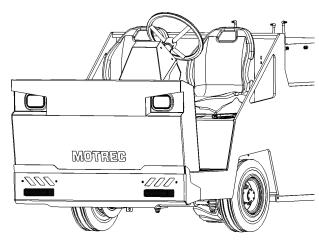


Figure 30. Rubber Bumper Inspection.

Steering Inspection

- 1. Inspect the universal joint (1) and the four tie rods ends (2) for (See Figures 31 and 32):
 - Play.
 - Damage.
 - Binding.
 - Corrosion.

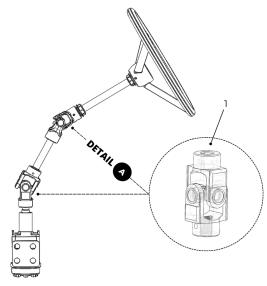


Figure 31. Universal Joint Inspection.

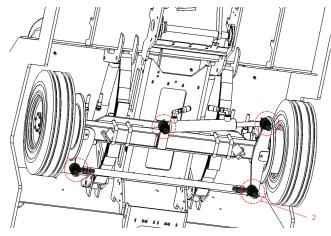


Figure 32. Tie Rods Ends Inspection.

- 2. Inspect the following elements for damage, corrosion or loose:
 - Steering cylinder (3). (See Figure 33)
 - Steering shafts (4). (See Figure 10 page 17)
 - Axle beam (5). (See Figure 33)
 - Right and left spindles (6). (See Figure 33)
 - Tie rod (7). (See Figure 33)

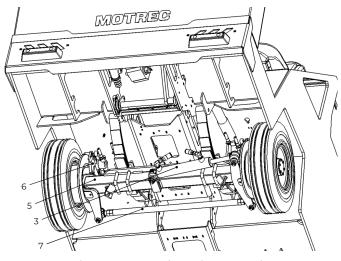


Figure 33. General Steering Inspection.

Grease Fittings Lubrication

Lubricate the grease fittings of the following components (See Figures 31 and 32 on pages 33 and 34) using multi-purpose grease:

- The universal joint (1).
- The four tie rods end (2).
- Steering shaft (see Figure 10 page 17 part no.

Lubrication

Lubricate the following components using lubricant spray:

- Brake pedal assembly and flange bearings (see Figure 11.a page 18).
- Master Cylinder Push Rod (see Figure 11.a page 18).

Power Circuit Inspection

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

Battery Inspection



WARNING

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

- 1. Inspect the batteries for the following elements:
 - Loose connections.
 - Damaged cables.
 - Acid spill.
 - Loose terminal posts.
 - Corrosion.
 - Swelled casing.

- 2. If corrosion is present on battery posts:
 - a. Remove the cable connectors.
 - b. Use a wire brush to remove any particles.
 - c. Clean the terminals with a suitable product.
 - d. Reinstall the removed cables.

(!) CAUTION

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

Test Drive

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

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

4.2.4 EVERY 500 HOURS OR 6 MONTHS MAINTENANCE

Special Tools	Consumables
► Resistor: 10 ohms, 25 W	▶ DOT-3 fluid brake

NOTICE	Replace any defective component found during the inspection listed in this procedure.
NOTICE —	When required, lift the vehicle using a lifting device as per section 4.1.1 LIFTING POINTS.
NOTICE	The 250 hours or 3 months preventive maintenance should be carried out concurrently with this maintenance. Certain steps may not be necessary due to redundancy.

Maintenance Preparation Steps

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

1. Open the batteries cover (1).

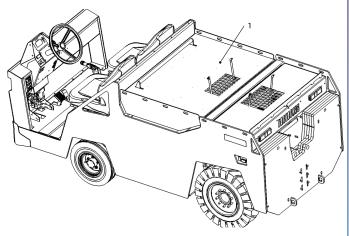


Figure 34. Batteries Cover Removal.

 Take the necessary steps to remove electrical hazards in accordance with Section 4.1.2 ELECTRICALLY ISOLATING THE VEHICLE page 27, which provides guidelines for electr ically isolating the vehicle.

WARNING

DO NOT WORK ON ANY COMPONENTS OF THE ELECTRICAL SYSTEM UNTIL THE VEHICLE IS ELECTRICALLY ISOLATED. VOLTAGES OF UP TO 90 V AND HIGHER CAN BE PRESENT. FAILURE TO COMPLY CAN CAUSE INJURIES.

Maintenance Procedures

Decals and Labels Inspection

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

Frame Inspection

- 1. Inspect the vehicle's frame for Cracks, damage or Corrosion.
- 2. The following frame locations should be inspected with care:
 - Side panels corners (1) (both sides). There is a possibility of cracks occurring in these corners as they undergo significant stress (see Figure 35).
 - Rear suspension mounting tabs (2) (see Figure 36).
 - Weld zones (3) (see Figure 37, not all welds are shown).

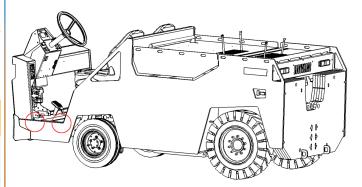


Figure 35. Side Panels.

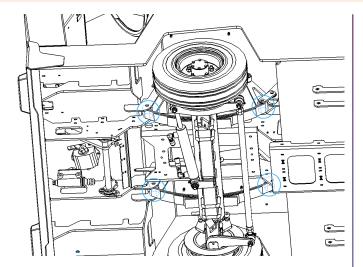


Figure 36. Front Suspension Mounting Tabs.

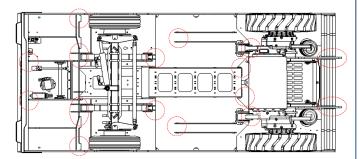


Figure 37. Weld Zones.

Brake System Inspection

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

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

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

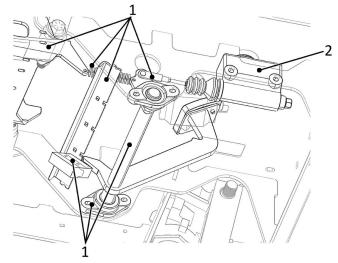


Figure 38. Brake System Inspection.

Front Disc Brake Inspection

proceed as follows for each of the vehicle's disc brake inspection:

1. Remove all wheel nuts (1) to remove the wheel (2).

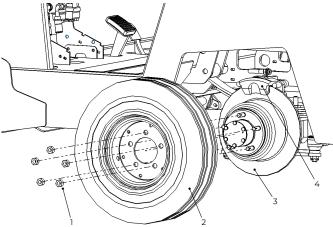


Figure 39. Wheel Removal.

- 2. Remove the slide pins (5) to release the caliper (4) from the disc (3).
- 3. Clean both caliper (4) and slide pins (5) from any dust or debris.
- 4. On the disc (3), clean the seating surface of the caliper (4) from any debris.



Figure 40. Slide Pins and Caliper Removal.

- 5. Inspect the brake pads (6). Replace them if the lining thickness is 1/16 in (2 mm) or less.
- 6. Clean the following elements to remove any dust or debris:
 - Shims (7).
 - Shims holders (8).
 - Gap in the brake pad (9).



Figure 41. Brake Pads and Shims Inspection.

7. Reassemble all components in the reverse sequence and don't forget to grease the slide pins (5) before returning them to their place.

NOTE: Regarding the wheel nuts (1), tighten them to the specified standard torque value of 80 ft lbs.

Front Wheels Bearings Inspection

Inspect all wheel bearings for:

- Play.

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- Stiffness.
- Abnormal noise.

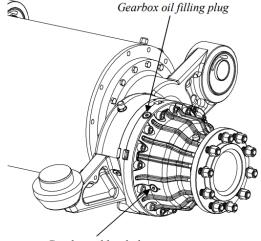
NOTE: Please refer to page 40, specifically the "Front Wheel Bearings Maintenance" section, for instructions on replacing the bearing.

Oil Level Check: Inside The Gearbox

To perform an oil check, follow these steps:

- Unscrew the gearbox oil level plug (refer to Figure 42).
- 2. Verify the oil level, it should be near the oil level plug hole.

NOTE: Verification of oil level inside the gearbox shall be done under normal operative conditions:



Gearbox oil level plug

Figure 42. Gearbox Oil Level Plug Emplacement.

Handbrake Adjustement

Here are the steps for adjusting the handbrake:

1. Loosen the handle locking screw to be able to move the handle adjustment.



Figure 43. Handbrake Adjustement.

2. Then, by hand turn the adjusting handle in the appropriate direction. Turning the adjusting handle clockwise tightens the handbrake, while turning it counterclockwise loosens it

NOTE: If the Clevis Pin is positioned on the lower side, it indicates that the handbrake is loosened. Conversely, if it's on the higher side, it indicates that the handbrake is very tightened.



Figure 44. Clevis Pin Position.

- 3. Continue turning the adjusting handle until the desired tension is achieved.
- 4. Once the adjustment is complete, tighten the handle locking screw securely to maintain the new setting.
- 5. Test the handbrake to ensure it holds the vehicle securely when engaged.

Test Drive

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

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

Special Tools	Consumables
Resistor: 10 ohms, 25 WOil recipient / Drip pan	Hydraulic pump oil: ISO 46Bearing grease

NOTICE

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

NOTICE —

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

Maintenance Preparation Steps

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

1. Open the batteries cover (1).

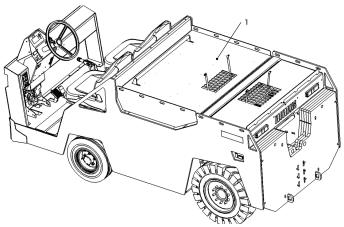


Figure 45. Batteries Cover Removal.

 Take the necessary steps to remove electrical hazards in accordance with Section 4.1.2 ELECTRICALLY ISOLATING THE VEHICLE page 27, which provides guidelines for electr ically isolating the vehicle.

WARNING

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

Maintenance Procedures

Front Wheels Bearings Maintenance

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- 1. Chock the rear wheels.
- 2. Remove wheel nuts (1) to remove the wheel (2).

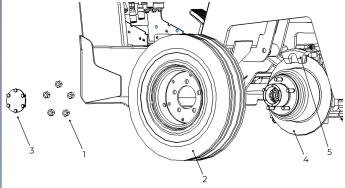


Figure 46. Wheel Removal.

- 3. Remove the dust cap (3).
- 4. Remove the slide pins (6) to release the caliper (5) from the disc (4).
- 5. Remove the disc (4).



Figure 47. Slide Pins and Caliper Removal.

- 6. Remove the cotter pin (7) and unscrew the A. Oil change: castle nut (8).
- 7. Remove the hub (9) from the spindle (10).

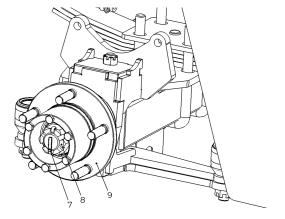


Figure 48. Cotter Pin, Castle Nut and Hub Removal.

- 8. Inspect the bearings (11) and their races for wear.
- 9. Inspect the seal (12) for wear.
- 10. Clean the bearing (11) and if they are still usable, apply the grease.

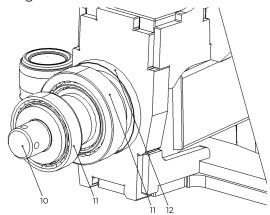


Figure 49. Bearing Inspection.

11. Reassemble all components in the reverse sequence and don't forget to grease the slide pins (6) before returning them to their place.

NOTE: Regarding the wheel nuts (1), tighten them to the specified standard torque value of 80 ft lbs.

Steering Pump Oil Replacement

Here are the steps to change the steering pump oil:

- 1. Place a drain pan beneath the hose connection point to catch the oil.
- 2. Carefully loosen the hose clamp (1) using appropriate tools to disconnect the hose from the pump.
- 3. Allow the old oil to drain completely from the pump and hose into the drain pan.
- 4. Once all the old oil has drained out, reattach the hose to the pump.
- 5. Tighten the hose clamp securely to ensure there are no leaks.
- 6. Remove the cap from the reservoir to access the fill opening.
- 7. Pour ISO 46 power steering oil into the reservoir until it reaches the recommended level indicated on the reservoir or in the vehicle's manual.
- 8. Replace the cap tightly to prevent any leaks.

B. Check for leaks:

- 1. Start the engine and let it run for a few minutes to circulate the new oil throughout the system.
- 2. Check around the hose connection and reservoir for any signs of leaks.
- 3. If any leaks are detected, turn off the key and tighten the connections as necessary.

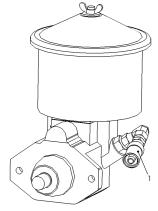


Figure 50. Steering Pump Oil Change.

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!\ WARNING

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



WARNING

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

Hardware Maintenance

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

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

Test Drive

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

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

4.2.6 EVERY 2000 HOURS OR 24 MONTHS MAINTENANCE

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

NOTICE _____

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

Maintenance Procedures

Hydraulic Brake System Fluid Maintenance

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

- 1. If required, lift the vehicle using a lifting device as per section 4.1.1 LIFTING POINTS.
- 2. Remove the master cylinder's (1) cap.
- 3. Bleed rear wheel brakes one at a time:
 - i. Fill the master cylinder (1) with DOT-3 brake fluid, then reinstall the master cylinder's (1) cap.
 - ii. Bleed the rear brakes one at a time by having someone apply steady pressure on the brake pedal (2), open the bleeder valve (5) and fully depress the pedal by maintaining the pedal all the way down, and then close the bleeder valve (3) before allowing the brake pedal (2) to return to the up position. Repeat this process multiple times.
- 4. Bleed front wheel brakes one at a time:
 - i. Fill the master cylinder (1) with DOT-3 brake fluid, then reinstall the master cylinder's (1) cap.
 - ii. Bleed the front calipers (4) one at a time by having someone apply steady pressure on the brake pedal (2), open the bleeder valve (3) and fully depress the pedal by maintaining the pedal all the way down, and then close the bleeder valve (3) before allowing the brake pedal (2) to return to the up position. Repeat this process multiple times.

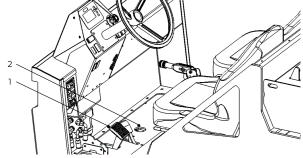


Figure 51. Brake System Bleeding.



Figure 52. Front Bleeding.

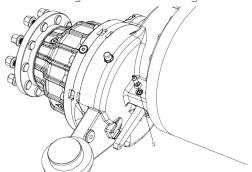


Figure 53. Rear Bleeding.

- 5. Once bleeding is completed, top-up the master cylinder (1) with DOT-3 brake fluid.
- 6. Reinstall the master cylinder's (1) cap.
- 7. Clean every fitting and line and remove traces of oil

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

- 8. Apply continuous pressure on the brake pedal for about ten seconds. Note any loss of pressure.
- 9. Inspect the brake lines and fittings for leaks.

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4.2.7 **EVERY 3000 HOURS OR 36 MONTHS MAINTENANCE**

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Special Tools	Consumables
► Oil recipient / Drip pan	Differential - Gearbox Oil: SAE 80W90 / API GL4SAE 80W / API GL4

NOTICE	When required, lift the vehicle using a lifting device as per section 4.1.1 LIFTING POINTS.
NOTICE	The 2000 hours or 24 months preventive maintenance should be carried out concurrently with this maintenance. Certain steps may not be necessary due to redundancy.

Maintenance Procedures

Gearbox and Differential Oil Change

Here are the steps for changing the oil with the merged steps:

- 1. Place an oil drip pan to catch the draining oil.
- 2. Remove drain plugs (1) and (2) to drain the oil (see figure 54).
- 3. After draining, reinstall drain plugs (1) and (2).
- 4. Locate and remove filling plugs (3) and (4) (see figure 55).
- 5. Refill the oil through filling plugs (3) and (4) until it reaches the required level, ensuring it doesn't overflow, but rather fills until it overflows through oil level plug (5) (see figure 55).
- 6. Repeat the process on both sides, ensuring 1.5 liters of oil are added to each side.

NOTE: Recommended oil for all cases: SAE 80W90 GL4.

CAUTION

PAY ATTENTION TO THE OIL FLOW WHICH WILL START IMMEDIATELY UPON DRAIN PLUGS UNSCREWING. TO FACILITATE OIL DRAINING, ALSO FILLING PLUGS CAN BE REMOVED.

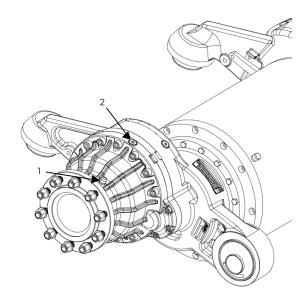


Figure 54. Drain Plugs Emplacement.

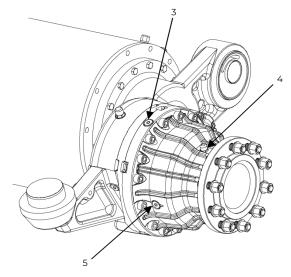


Figure 55. Filling Plugs and Oil Level Plug Emplacement.

Brake Chamber Oil Change

Here are the steps for changing the oil with the merged steps:

- 1. Place an oil drip pan to catch the draining oil.
- 2. Remove brake oil drain plugs to drain the oil (see figure 56).
- 3. After draining, reinstall drain plug.
- 4. Locate and remove brake oil refill plug (see figure 57).
- 5. Refill the oil through refill plugs until it reaches the required level, ensuring it doesn't overflow, but rather fills until it overflows through brake oil level plug (see figure 57).
- 6. Repeat the process on both sides, ensuring 0.8 liters of oil are added to each side.

NOTE: Recommended oil for all cases: DSAE 80W / API GL4.

CAUTION

PAY ATTENTION TO THE OIL FLOW WHICH WILL START IMMEDIATELY UPON DRAIN PLUGS UNSCREWING. TO FACILITATE OIL DRAINING, ALSO FILLING PLUGS CAN BE REMOVED.

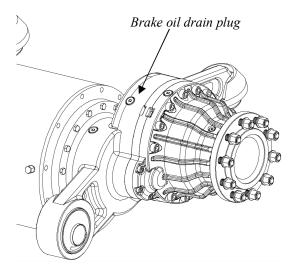


Figure 56. Brake Oil Drain Plug Emplacement.

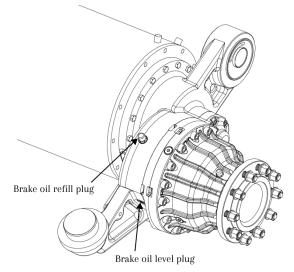


Figure 57. Brake Oil Refill Plug and Oil Level Plug Emplacement.

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4.3 **CORRECTIVE MAINTENANCE** 4.3.2 HYDRAULIC BRAKES

4.3.1 ACCELERATOR

The accelerator can not be repaired and serviced. Here are the steps for adjusting the accelerator:

- 1. Begin by lightly tightening the pedal through the bolt (1).
- 2. Force the pedal to touch the floorboard (this serves to establish the maximum limit to prevent exceeding it and damaging the pedal, as well as to allow it to slide on the shaft).
- 3. Fully tighten the pedal through the bolt (1).
- 4. Release the pedal, it should return to its initial position.

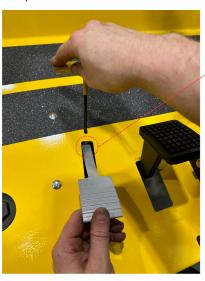




Figure 58. Accelerator Adjustement.

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.
- 3. Bleed rear wheel brakes one at a time:
 - i. Fill the master cylinder (1) with DOT-3 brake fluid, then reinstall the master cylinder's (1) сар.
 - ii. Bleed the rear brakes one at a time by having someone apply steady pressure on the brake pedal (2), open the bleeder valve (3) and fully depress the pedal by maintaining the pedal all the way down, and then close the bleeder valve (5) before allowing the brake pedal (2) to return to the up position. Repeat this process multiple times.
- 4. Bleed front wheel brakes one at a time:
 - i. Fill the master cylinder (1) with DOT-3 brake fluid, then reinstall the master cylinder's (1) сар.
 - ii. Bleed the front calipers (4) one at a time by having someone apply steady pressure on the brake pedal (2), open the bleeder valve (3) and fully depress the pedal by maintaining the pedal all the way down, and then close the bleeder valve (3) before allowing the brake pedal (2) to return to the up position. Repeat this process multiple times.

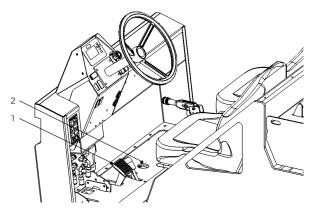


Figure 59. Brake System Bleeding.



Figure 60. Front Bleeding..

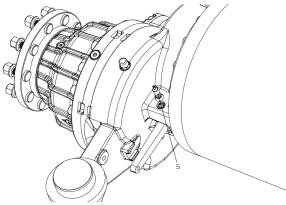


Figure 61. Rear Bleeding.

- 4. Once bleeding is completed, top-up the master cylinder (1) with DOT-3 brake fluid.
- 5. Reinstall the master cylinder's (1) cap.
- 6. Clean every fitting and line and remove traces

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

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

4.3.3 AXLE AND STEERING

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Procedures

Toe-In Adjustment

1. With the wheels in straight forward direction, measure the inside (left to right) distance between the front tires, at the front and rear of the tires.

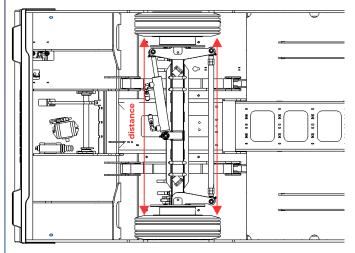


Figure 62. Distance between the front tires.

4.3.4 HYDRAULIC STEERING SYSTEM

The hydraulic steering system within your vehicle functions as an integrated ensemble as illustrated in figure 63.

The power steering pump serves as the primary source of hydraulic pressure, generating force for the system. The orbitrol steering unit, acting as a central control hub, directs the distribution of hydraulic fluid based on steering inputs. The double-acting cylinder then transforms hydraulic energy into rotational movement, facilitating wheel articulation.

This integrated system ensures a smooth and responsive steering experience, with the power steering pump activated in tandem with steering actions, pressure modulation regulated and fluid flow directed by the orbitrol unit.

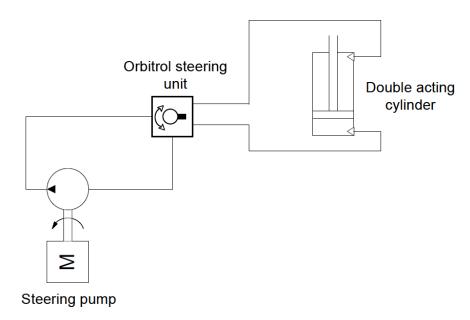


Figure 63. Hydraulic Steering System.

Maintenance procedures

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

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

- 1. Inspect all the hydraulic system components for the following elements:
 - Inspect all components for signs of leaks, damage, or corrosion.
 - Look for loose fittings or connections.
- 2. Check the double-acting cylinder's condition by examining the rod and piston for signs of wear, scoring, and potential alignment issues.
- 3. Examine the power steering pump for any signs of damage and ensure that all connections and hoses are secure. Additionally, check the fluid level in the reservoir and inspect for any leaks.

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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 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.
- 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.

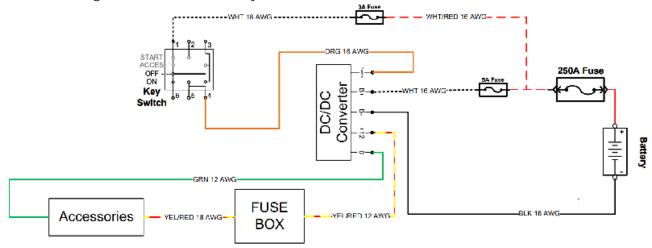


Figure 64. DC/DC Converter Input and Output Terminals Inspection.

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 Accelerator Pedal

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

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

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

4. Inspect the Vehicle

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

5. Inspect the Main Contactor

5.1 Verify the presence of voltage at the positive terminal (B+) of the contactor.

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- If not, check for any fuse or wiring issues.
- 5.2 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.
- 5.3 Check the voltage between the black/orange wire and the orange/black wire of the contactor.
- If no voltage is detected, it is necessary to inspect the wiring and the output wires of the controller.

Vehicle Moves Forward Only

- 1. Place the switch in the reverse position.
- 2. Measure the reverse signal input between pin 33 (Grey/White Wire) on the controller and the negative terminal (B-) (Black Wire).
 - If no voltage is detected, proceed to check the voltage at pin 5 of the switch. If there is still no voltage detected, it is necessary to inspect the wiring leading to the key switch.
- 3. Check for the presence of voltage at pin 4 of the Forward/Reverse switch (Gray/Blue Wire).
 - If no voltage is detected, replace the direction switch.

Vehicle Moves Backward Only

- 1. Place the switch in the forward position.
- 2. Measure the reverse signal input between pin 22 (Green/White Wire) on the controller and the negative terminal (B-) (Black Wire).
 - ◆ If no voltage is detected, proceed to check the voltage at pin 5 of the switch. If there is still no voltage detected, it is necessary to inspect the wiring leading to the key switch.
- 3. Check for the presence of voltage at pin 6 of the Forward/Reverse switch (green/blue wire).
 - If no voltage is detected, replace the direction switch.

Vehicle Travels at Reduced Speed



WARNING

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

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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 safety features (HPD and SRO). The HPD 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 SRO feature prevents the vehicle from moving if the direction switch is activated before the presence signal is sent to the PMC. These safety measures ensure that the vehicle remains stationary until the necessary conditions are met, promoting safe operation.

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

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

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

Fault Code List and Diagnostic

8 — DIAGNOSTICS & TROUBLESHOOTING



DIAGNOSTICS AND TROUBLESHOOTING

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

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

DIAGNOSTICS

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

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

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

Example: Battery Undervoltage (code 23).

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

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

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

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

Summary of LED display formats

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

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

TROUBLESHOOTING

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

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

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

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8 — DIAGNOSTICS & TROUBLESHOOTING

	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/Main/Contactor; 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; ShutdownThrossle; FullBrake; ShutdownPump.	External load on capacitor bank (B+ connection terminal) that prevents the capacitor bank from charging. See Monitor menu Battery: Capacitor Voltage.	Set: Precharge failed to charge the capacitor bank to the KSI voltage. Clear: Cycle Interlock input or use VCL function Pracharga().	
15	Controller Severe Underlemp 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 Overtemp ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1. See Monitor menu • Controller: Temperature. 2. Controller is operating in an extreme environment. 3. Excessive load on vehicle. 4. Improper mounting of controller.	Set: Heatsink temperature above +95°C. Clear: Bring heatsink temperature below +95°C, and cycle interlock or KSI.	
17	Severe Undervollage Reduced drive torque.	1. Battery Menu parameters are misadjusted. 2. Non-controller system drain on battery. 3. Battery resistance too high. 4. Battery disconnected while driving. 5. See Monitor menu • Battery: Capacitor Voltage. 6. Blown B+ fuse or main contactor did not close.	Set: Capacitor bank voltage dropped below the Severe Undervoltage limit (see page 55) with FET bridge enabled. Clear: Bring capacitor voltage above Severe Undervoltage limit.	

	Idu	le 5 TROUBLESHOOTING CHART, c	Ontinued
CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
18	Severe Overvollage ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrotsle; 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 briking.	Set: Capacitor bank voltage exceeded the Severe Overvoltage limit (see page 5) 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.	Normal operation. Fault shows that the batteries need recharging. Controller is performance limited at this voltage. Battery 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 bel the Undervoltage limit (see page 55) wit the FET bridge enabled. Clear: Bring capacitor voltage above the Undervoltage limit.
24	Overvollage Cutback Reduced brake torque.	Normal operation. Fault shows that regen braking currents elevated the battery voltage during regen braking. Controller is performance limited at this voltage. Battery parameters are misadjusted. Battery resistance too high for given regen current. Battery disconnected while regen braking. 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.

COMPANY NAME

	Tal	ble 5 TROUBLESHOOTING CHART, co	ontinued
CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
27	Digital Out 7 Overcurrent Digital Ousput 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 torque.	1. Motor temperature is at or above the programmed Temperature Hot setting, and the requested current is being cut back. 2. Motor Temperature Control Menu parameters are mis-tuned. 3. See Monitor menu » Motor: Temperature and » Inputs: Analog2. 4. If the application doesn't use a motor thermistor, Temp Compensation and Temp Cutback should be programmed Off.	Set: Motor temperature is at or above the Temperature Hot parameter setting. Clear: Bring the motor temperature within range.
29	Motor Temp Sensor Fault MaxSpeed reduced (LOS, Limited Operating Strategy), and motor temperature cutback disabled.	1. Motor thermistor is not connected properly. 2. If the application doesn't use a motor thermistor, Motor Temp Sensor Enable should be programmed Off. 3. See Monitor menu " Motor: Temperature and " Inputs: Analog2.	Set: Motor thermistor input (pin 8) is at the voltage rail (0 or 10V). Clear: Bring the motor thermistor input voltage within range.
31	Coil1 Driver Open/Short ShutdownDriver I.	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. Dirry 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. Dirry 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.	Set: 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: Cotrect open or short, and cycle drive

Table 5 TROUBLESHOOTING CHART, continued			
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 drive
36	Encoder Fault ShutdownEMBrake.	Motor encoder failure. Bad crimps or faulty wiring. See Monitor menu " Motor: Motor RPM.	Set: Motor encoder phase failure detected Clear: Cycle KSI.
37	Motor Open ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; Shutdown Throtsle; 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; ShutdownPuonp.	Main contactor did not close. Main contactor tips are oxidized, burned, or not malking good contact. External load on capacitor bank (B+ connection terminal) that prevents capacitor bank from charging.	Set: With the main contactor commande closed, the capacitor bank voltage (B+ connection terminal) did not charge to E Clear: Cycle KSI.
41	Throttle Wiper High Shutdown Throttle.	See Monitor menu • 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 ShutdownThrottle.	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 » 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.

VERSION 01

Table 5 TROUBLESHOOTING CHART, continued PROGRAMMER LCD DISPLAY CODE POSSIBLE CAUSE SET/CLEAR CONDITIONS EFFECT OF FAULT Pot2 Wiper Low 1. See Monitor menu » Inputs: Set: Pot2 wiper (pin 17) voltage is lower than the low fault threshold FullBrake. Por2 Raw. 2. Pot2 wiper voltage too low. (can be changed with the VCL function Setup_Pot_Faults()). Clear: Bring Pot2 wiper voltage above the fault threshold. Pot Low Overcurrent Set: Pot low (pin 18) current exceeds 10mA. 1. See Monitor menu Dutputs: Shutdown Throttle: Pot Low. Clear: Clear pot low overcurrent condition 2. Combined pot resistance connected FullBrake. and cycle KSI. to pot low is too low. **EEPROM Failure** 1. Failure to write to EEPROM 46 Set: Controller operating system tried to memory. This can be caused by write to EEPROM memory and failed. ShutdownMotor; ShutdownMainContactor; Clear: Download the correct software (OS) EEPROM memory writes initiated ShutdownEMBrake; by VCL, by the CAN bus, by and matching parameter default settings Shutdown Throtale: adjusting parameters with the into the controller and cycle KSI. ShutdownInterlock; programmer, or by loading new ShutdownDriver1; software into the controller. ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPionp. HPD/Sequencing Fault 1. KSI, interlock, direction, and throttle Set: HPD (High Pedal Disable) or sequencing fault caused by incorrect Shutdown Throttle. inputs applied in incorrect sequence. 2. Faulty wiring, crimps, or switches at sequence of KSI, interlock, direction, and KSI, interlock, direction, or throttle throttle inputs. inputs. Clear: Reapply inputs in correct sequence. 3. See Monitor menu » Inputs. Emer Rev HPD Set: At the conclusion of Emergency 47 1. Emergency Reverse operation has ShutdownThrottle; concluded, but the throttle, forward Reverse, the fault was set because various ShutdownEMBrake. and reverse inputs, and interlock inputs were not returned to neutral. have not been 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. Parameter Change Fault 1. This is a safety fault caused by a Set: Adjustment of a parameter setting ShutdownMotor; change in certain parameter that requires cycling of KSI. settings so that the vehicle will not ShutdownMainContactor; Clear: Cycle KSI. ShutdownEMBrake; operate until KSI is cycled. Shutdown Throttle; For example, if a user changes the FullBrake; Throttle Type this fault will appear ShutdownPump. and require cycling KSI before the vehicle can operate. 51-67 **OEM Faults** 1. These faults can be defined by the Set: See OEM documentation. OEM and are implemented in the Clear: See OEM documentation. (See OEM documentation.) application-specific VCL code. See OEM documentation.

OEM CODE CODE 51 Can Initialization: Check PIN 23 (twisted wire green and yellow) CODE 52 Can Operational: Check PIN 23 (twisted wire green and yellow) CODE 53 Foot pedal or Switch Fault: Check PIN 24 / Throttle Accelerator Signal CODE 54 Maintenance is required CODE 55 Throttle active before foward CODE 56 Throttle active before reverse CODE 57 FWD and REV active: Bad switch FWD / REV CODE 58 Driver voltage exceeded: Max voltage for driver is 24V CODE 62 HPD / SRO Sequence fault: incorrect starting sequence

	Table 5 TROUBLESHOOTING CHART, continued			
CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS	
68	VCL Run Time Error ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownInterlock; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPriyer4; ShutdownPi; FullBrake; ShutdownPunp.	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.	 External load on the 5V and 12V supplies draws either too much or too little current. Fault Checking Menu parameters Ext Supply Max and Ext Supply Min are mis-tuned. See Monitor menu » Outputs: Ext Supply Current. 	Set: The external supply current (combined current used by the 5V supply [pin 26] and 12V supply [pin 25]) is either greater than the upper current threshold or lower than the lower current threshold. The two thresholds are defined by the External Supply Max and External Supply Min parameter settings (page 52). Clear: Bring the external supply current within range.	
71	OS General ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; 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 detected Clear: Either cycle KSI, or detect valid motor encoder signals while operating in LOS mode and return Throttle Command = 0 and Motor RPM = 0.	

	Table 5 TROUBLESHOOTING CHART, continued			
CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS	
87	Motor Characterization Fault ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrotsle; FullBrake; ShutdownPuonp.	1. Motor characterization failed during characterization process. See Monitor menu Dentroller: Motor Characterization Error for cause: 0 none 1 nencoder 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 neontroller undertemp cutback fault 6 nundervoltage cutback fault 7 nevere overvoltage fault 8 nencoder 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; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPry FullBrake; ShutdownPunp.	The VCL software in the controller does not match the OS software in the controller.	Set: VCL and OS software do not match; when KSI cycles, a check is made to verify that they match and a fault is issued when they do not. Clear: Download the correct VCL and OS software into the controller.	
92	EM Brake Failed to Set ShudownEMBrake; ShudownThrossle.	1. Vehicle movement sensed after the EM Brake has been commanded to set. 2. EM Brake will not hold the motor from rotating.	Set: After the EM Brake was commanded to set and time has elapsed to allow the brake to fully engage, vehicle movement has been sensed. Clear: Activate the throttle.	
93	Encoder LOS (Limited Operating Strategy) Enter LOS control mode.	1. Limited Operating Strategy (LOS) control mode has been activated, as a result of either an Encoder Fault (Code 36) or a Stall Detect Fault (Code 73). 2. Motor encoder failure. 3. Bad crimps or faulty wiring. 4. Vehicle is stalled.	Set: Encoder Fault (Code 36) or Stall Detect Fault (Code 73) was activated, and Brake or Interlock has been applied to activate LOS control mode, allowing limited motor control. Clear: Cycle KSI, or if LOS mode was activated by the Stall Fault, clear by ensuring encoder senses proper operation, Motor RPM = 0, and Throttle Command = 0.	

Table 5 TROUBLESHOOTING CHART, continued									
CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	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/Pump.	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

9 - MAINTENANCE

MAINTENANCE

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

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

CLEANING

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

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

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

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

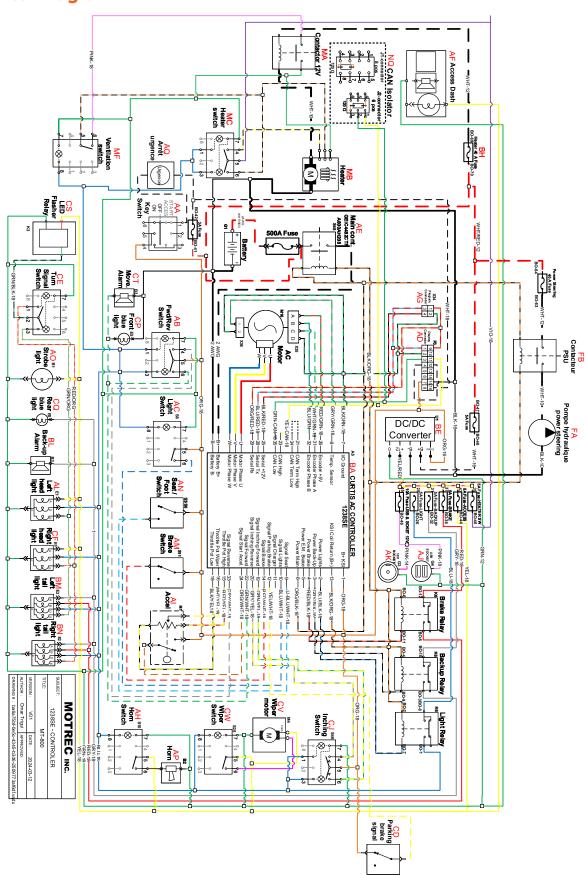
FAULT HISTORY

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.



Electrical Diagram



COMPANY NAME

MOTREC INTERNATIONAL

Standard Torque





BOLT CLAMP LOADS

Suggested Assambly Torque Values



- 111												
	USS/SAE GRADE 5				USS/SAE GRADE 8							
DIAMETER & THREADS PER INCH	TURNU STRENGTH Mrs. PSI	Pioor Low LB	CAMP LOID LB	TOIOUI Dey FT LB	LUMOCATIO FT LB	TUKSILE STRENGTH Mox. PSI	Pagor Load LB	Cuse Loso LB	Totout Der FT LB	Luisicario FT LB		
1/4-20	120,000	2,700	2,020	8	6.3	150,000	3,800	2,850	12	9		
28	120,000	3,100	2,320	10	7.2	150,000	4,350	3,250	14	10		
5/16-18	120,000	4,450	3,340	17	13	150,000	6,300	4,700	24	18		
24	120,000	4,900	3,700	19	14	150,000	6,950	5,200	27	20		
3/8-16	120,000	6,600	4,950	30	23	150,000	9,300	6,980	45	35		
24	120,000	7,450	5,600	35	25	150,000	10,500	7,980	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	14,490	120	98		
9/16-12	120,000	15,500	11,600	110	80	150,000	21,800	16,350	150	110		
18	120,000	17,300	12,950	120	90	150,000	24,400	18,250	170	130		
5/8-11	120,000	19,200	14,400	150	110	150,000	27,100	20,350	210	160		
18	120,000	21,800	16,350	170	130	150,000	30,700	23,000	240	180		
3/4-10	120,000	28,400	21,300	260	200	150,000	40,100	30,100	380	280		
16	120,000	31,700	23,780	300	220	150,000	44,800	33,500	420	310		
7/8-9	120,000	39,300	29,450	430	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		



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