

# BODY BUILDER INSTRUCTIONS

Mack Trucks



## Body Builder, General Guidelines and Certification MD BEV

### Introduction

The information in this document was developed to assist our customers throughout the body planning and installation process. This information will assist with the required specifications and guidelines for the completion of your specific applications.

The information in this document does not include each and every unique situation that you may encounter when working on Mack vehicles. Mack Trucks North America cannot possibly know, evaluate or advise someone on all the types of work that can be done on a Mack vehicle and all the appropriate ways to do such work. This includes all of the possible consequences of performing such work in a certain manner. Therefore, any situations or methods of working on a Mack vehicle that are not addressed in this document are not necessarily approved by Mack Trucks North America.

If you require additional assistance, contact Mack Body Builder Support at 877-770-7575.

Unless otherwise stated, following the recommendations listed in this document does not automatically guarantee compliance with applicable government regulations. Compliance with applicable government regulations is your responsibility as the party making the additions/modifications. Please be advised that the Mack Trucks North America vehicle warranty does not apply to any Mack vehicle that is modified in any way, which in Mack's judgement might affect the vehicle's stability or reliability. The information, specifications and illustrations in this document are based on information that was current at the time of publication. Note that illustrations are typical and may not reflect the exact arrangement of every component installed on a specific vehicle.

All data provided is based on information that was current at the time of release. However, this information is subject to change without notice.

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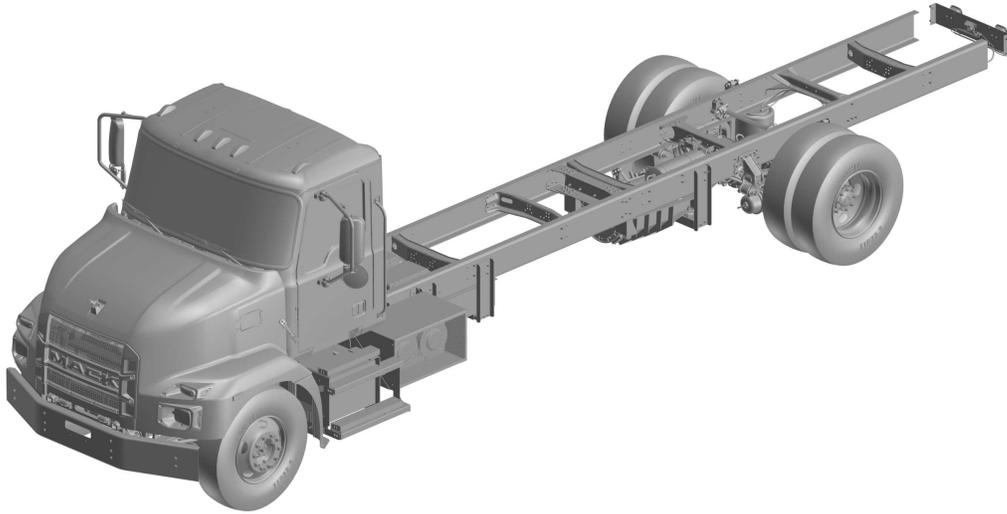
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# BEV (Battery-Electric Vehicle)

## General

### Introduction

This document includes information that is specific to the truck model MD electric. For all other common information related to all MD trucks, refer to the relevant MACK Body Builder Manual.



T8193810

Overview of battery-electric vehicle

## General warnings



### **DANGER**

#### **Risk of electrical discharge**

#### **Traction voltage system, 400 V (nominal value)**

Can cause dangerous electric shocks, arcing or burns, which can result in serious personal injury or death. Service and installation must be carried out by qualified personnel. Always use correct personal protection equipment when working on the vehicle.

The components that contain traction voltage are marked with the warning decal.



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**Note:** Accessory electrical circuits should always be fused. Where possible, use the designated spare fuses or circuit breakers that are already supplied. Never overload the circuit beyond the rated amperage of the fuse or circuit breaker. Inductive loads, such as motors, light bulbs, and relays, cause higher current draw (surge current) in electrical circuits during initial start-up or turn-on. These circuits may require slow-blow fuses or higher-rated fuses or circuit breakers. The installation of add-on circuits for the body installation may interfere with the proper operation of other vehicle electrical components. The body installer is responsible for ensuring the continued proper operation of all electrical systems on the vehicle concerning conducted or radiated signals from the installation.

# Abbreviations

ABS	Anti-lock Braking System
ATVSA	Automatic Traction Voltage System Activation
BMU	Battery Management Unit (in the ESS)
CAN	Control Area Network
CCS	Combined Charging System
CSU	Charging Switch Unit
Commissioning	Reversing the electrical safety process to return the vehicle to service
Decommissioning	Making the vehicle and personnel electrically safe before carrying out an operation
ECC/MCC	Electronic Climate Control/ Manual Climate Control
ECS	Electronically Controlled Suspension
EM	Electric Motor
EMD	Electric Motor Drive
ESS	Energy Storage System
EVAC	Electric Vehicle Air Compressor
FRC	Fuse and Relay Center
HV	High Voltage
HVIL	Hazardous Voltage Interlock Loop
LIN	Local Interconnect Network
LHD	Left-hand drive
LHS	Left-hand side
MCU	Motor Control Unit
MSD	Manual Service Disconnect
OBD	On-board Diagnostic
PCM	Powertrain Control Module
PDU	Power Distribution Unit
RHD	Right-Hand Driver
RHS	Right-hand side
SAE	Society of Automotive Engineering
SOC	State of charge
TVJB	Traction Voltage Junction Box
TVMU	Traction Voltage Monitoring Unit
TVS	Traction Voltage System
VIN	Vehicle Identification Number

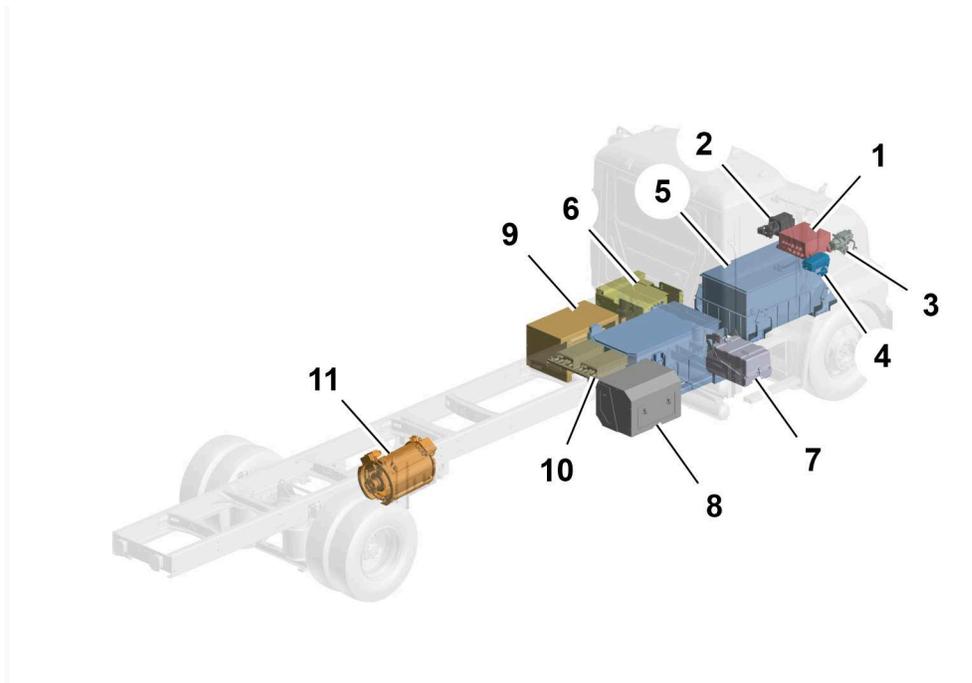
# General description

BEV (Battery-Electric Vehicle) Layout

## CSE 42R

Model	Axle arrangement	Wheelbase	Vehicle maximum load capacity	Number of traction batteries	ESS Total Energy Capacity
CSE 42R	4x2	5235 mm (206 inches) 5615 mm (221 inches) 5995 mm (236 inches) 6375 mm (250 inches) 6860 mm (270 inches)	20 t (44,000 lb)	2	150 kWh
CSE 42R	4x2	5235 mm (206 inches) 5615 mm (221 inches) 5995 mm (236 inches) 6375 mm (250 inches) 6860 mm (270 inches)	20 t (44,000 lb)	3	240 kWh

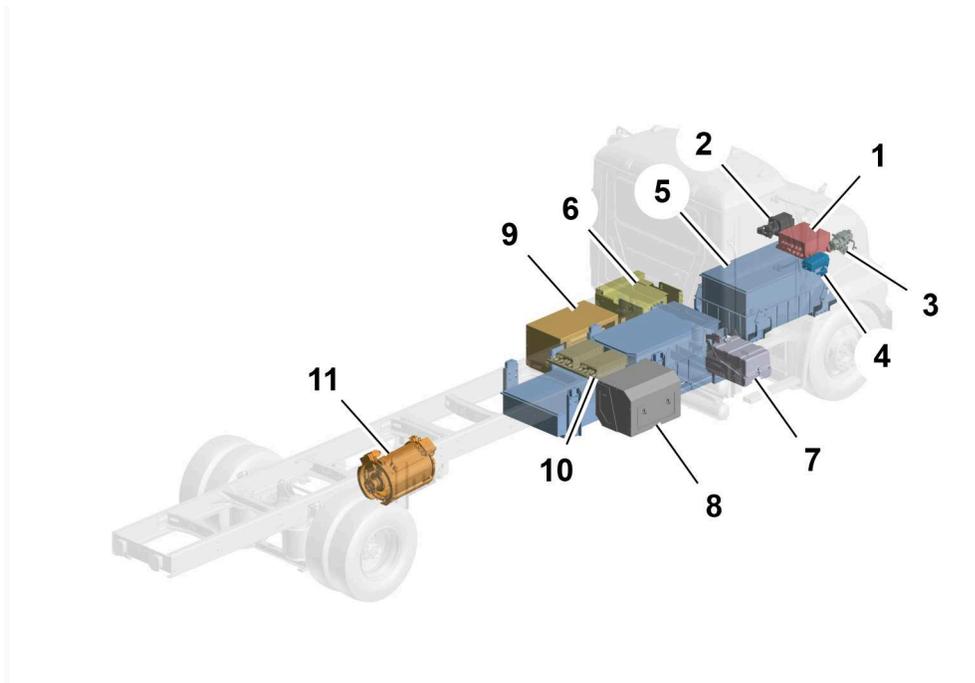
## ESS150K



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- 1 PDU
- 2 Power steering pump
- 3 AC compressor
- 4 Cabin heater
- 5 Traction batteries
- 6 Charger
- 7 HV isolator
- 8 Air compressor
- 9 Cooling box
- 10 Drive motor controllers
- 11 Traction motor

# ESS250K



T8196307

- 1 PDU
- 2 Power steering pump
- 3 AC compressor
- 4 Cabin heater
- 5 Traction batteries
- 6 Charger
- 7 HV isolator
- 8 Air compressor
- 9 Cooling box
- 10 Drive motor controllers
- 11 Traction motor

# Storage, handling and transport of traction batteries

## General

This document is based on STD 871-0004. Contact "Electromobility Technical Support" for any questions about the transportation of traction batteries. Refer STD 871-0003 for information on safety while handling traction batteries.

Always order a new traction battery on an Electromobility Technical Support eService case. Note the VIN (Vehicle Identification Number), DTC (Diagnostic Trouble Code) and necessary additional information before making an order for the traction battery. A traction battery may only be ordered directly by Electromobility Technical Support.

When transporting any type of traction battery (including control system), always install protective caps on the electrical connections and the cooling pipes. This will prevent direct contact with the electrical connections and coolant leakage.

Always remove the protective caps of the traction battery in the presence of a "work activity responsible" as defined in STD 871-0003.

The "work activity responsible" (role defined in standard STD 871-0003) is assigned by the "electric product responsible". Work activity responsible has the ultimate responsibility for the work activity.

A "work activity responsible" (role defined in standard STD 871-0003), who perform detailed status check and classify the battery by physical inspection and via diagnostic tool (Volvo Tech Tool) must be a role 4 person in charge of electrical work activity.

A "work activity responsible" (role defined in standard STD 871-0003) shall have the relevant competence defined locally with consideration to the nature of the operation as well as national regulations and legislation.

Person involved in the transport of traction batteries (loading, unloading, preparing the battery for transport, transport of battery outside the facility) must complete the training in dangerous goods transport adapted to the relevant mode of transportation.

**Note:** Transport of dangerous goods - within the United States excluding Hawaii, Alaska, Puerto Rico and U.S. Virgin Islands is governed under regulations in accordance with 49 Code of Federal Regulations (CFR) Parts 100 to 185. Applicable parties must refer to regulations pertaining to UN3480 'Lithium ion batteries'.

### **For transport to Hawaii, Alaska, Puerto Rico, U.S. Virgin Islands and Other International Destinations:**

Follow the regulations in accordance with IATA (AIR) and IMO (SEA/OCEAN) for the transport to Hawaii, Alaska, Puerto Rico, U.S. Virgin Islands and Other International Destinations.

### **For road transport originating from Canada:**

Follow the regulations in accordance with the Canadian Transport of Dangerous Goods for the transports originating from Canada.

In addition, the people involved in the transportation of traction batteries must adhere to any additional regulations in the destination location (local, state and/or country).

**Note:** Any personnel involved in processing severely damaged or defective batteries for transport and later disposal must complete additional training applicable in the areas that govern the handling, storage and disposal of hazardous waste generated when a battery is severely damaged or defective.

Refer to the 'Safety regulations', 'electric vehicles' in impact under function group 3 for more information about the safety regulations.

# Classification

## Classification of traction batteries

Traction batteries are categorised based on its condition.

For easy identification, colour codes are used as follows:

New or used = Green

Defective = Yellow

Severely damaged = Red

**Note:** While assessing a traction battery, take into account the type of traction battery and its previous use and misuse. A traction battery that has never been used (or misused) or installed is considered as “New or used” and does not require further classification.

A “Work activity responsible” (role defined in standard STD 871-0003) with sufficient battery safety knowledge must collect and combine the information to ensure correct classification of traction batteries into the following categories:

Categories	Colour classification code	Definition	Comments
New or used	Green	<ul style="list-style-type: none"> <li>• Traction battery that is diagnosed before transport and evaluated as not being “Defective” or “Severely damaged”</li> <li>• Traction battery with a (of the UN Manual of tests and criteria) test certificate</li> </ul>	<p>This category includes:</p> <ul style="list-style-type: none"> <li>• New traction battery that has not been used or installed in a vehicle</li> <li>• Fully functional used traction battery</li> <li>• Non-functional traction battery, diagnosed and does not belong to the categories “Defective” or “Severely damaged”</li> <li>• End-of-life traction battery that still conforms to the test criteria (of the UN manual of tests and criteria)</li> <li>• Traction battery with visible housing deformation smaller than what is specified in the technical documentation</li> </ul>
Defective	Yellow	<p>Definition in legislation (referred to as “Defective” or “Damaged”):</p> <p>In assessing a cell or battery as defective, an assessment or evaluation need to be performed based on safety criteria from the cell, battery or product manufacturer, or by a technical expert with knowledge of the module’s or battery’s safety features. An assessment or evaluation may include, but is not limited to, the following criteria:</p> <ul style="list-style-type: none"> <li>• The use or misuse of the cell or battery</li> <li>• The condition of the cell or battery safety features, or damage to any internal safety components, such as the battery management system</li> <li>• Battery that has leaked or vented</li> <li>• Traction battery that has sustained physical or mechanical damage</li> <li>• Traction battery with fault that cannot be diagnosed before transport</li> <li>• Battery that is damaged or defective to such an extent that it no longer conforms to the design type it was approved for in</li> </ul>	<p>This category includes:</p> <ul style="list-style-type: none"> <li>• Traction battery with fault related to internal isolation failure</li> <li>• Battery that is determined by a "work activity responsible" (as defined in STD 871-0003) with sufficient battery safety knowledge to be “Defective”</li> <li>• Traction battery that has been subjected to abnormal violence (e.g. the traction battery has been dropped or hit) and deemed by a "work activity responsible" (as defined in STD 871-0003) as not “Severely damaged”</li> </ul> <p>If you suspect that a traction battery belongs to this category, consult the "Electromobility Technical Service". If the damage is visible, include a photo.</p>

		accordance with the sub-section 38.3 of UN Manual of tests and criteria	
Severely damaged	Red	<p>Definition in legislation:</p> <ul style="list-style-type: none"> <li>• Traction battery liable to rapidly deteriorate, dangerously react, produce a flame or a dangerous evolution of heat or a dangerous emission of toxic, corrosive or flammable gases or vapours</li> <li>• Traction battery that is leaked or vented</li> <li>• Acute hazard such as gas, fire or electrolyte leaking</li> <li>• Signs of physical damage, such as deformation to cell or battery casing, or discoloration on the casing</li> <li>• Battery that cannot be diagnosed prior to transport</li> <li>• External and internal short circuit protection, such as voltage or isolation measures</li> </ul>	<p>This category includes:</p> <ul style="list-style-type: none"> <li>• Traction battery with out-gassed battery cells, identified while opening the service lid and a sweet penetrating smell is sensed.</li> <li>• Traction battery with visible housing deformation that is greater than what is specified in the technical documentation</li> <li>• Traction battery that cannot be diagnosed before transport</li> <li>• Traction battery that is deemed by a "nominated person in control of work activity" as "Severely damaged"</li> </ul> <p>If you suspect that a traction battery belongs to this category, consult the "Electromobility Technical Service". If the damage is visible, include a photo.</p>
Traction battery sent for disposal or recycling	Can be colour coded green, yellow or red, depending on the status If "Non-UN approved battery": Colour classification code + Non-UN approved	A battery that is sent for disposal or recycling Batteries that cannot be used and are intended to be discarded need to be sent for remanufacturing, repurposing, recycling or disposal, whichever is applicable. These batteries may include batteries classified as "Defective" or "Severely damaged".	<p>This category includes batteries sent for remanufacturing, repurposing, recycling or disposal.</p> <p>If a battery belongs to the category "Defective" or "Severely damaged" it shall be handled accordingly.</p> <p>The personnel responsible for transporting must ensure that the traction battery belongs to this category before transport.</p> <p>Now, only a very limited number of traction batteries are sent for disposal or recycling. Additional training to HAZMAT (Hazardous Materials) transport will be required to ensure proper disposal or recycling.</p>

## Documentation

Information regarding the traction battery must be documented by a "Work activity responsible" (role defined in standard STD 871-0003) with sufficient battery safety knowledge and this documentation must accompany the traction battery. This information will be available to all concerned parties.

The nominated person in control of work activity, handling defective batteries or damaged batteries must ensure that all applicable documentation needed for the shipment to the recipient is completed in accordance with applicable laws and/or regulations.

This requirement does not apply to "New" traction batteries.

Information to be documented are:

- 1 Part Number and serial number
- 2 Category (Green, Yellow or Red)
- 3 DTC (Diagnostic Trouble Code) or description of abuse history
- 4 SOC (State Of Charge) level and date
- 5 SOH (State Of Health) level and date
- 6 Signature, name of signatory and date

**Note:** Note down the SOC and SOH of the traction battery before the removal of the traction battery from the vehicle.

# Risk assessment

To assess the risks associated with handling and storage of traction batteries, use a qualitative risk analysis method, such as:

- FMEA (Failure Mode and Effect Analysis), refer STD 105-0005.
- HAZOP (Hazard and Operability Study).
- PHA (Preliminary Hazard Analysis).

The risk assessment should at least cover the following areas:

- Quantity, size and type of traction batteries.
- Location of the traction batteries.
- Traction battery status according to the classification standard (Green, Yellow and Red).
- Type of activity/handling.
- Characteristics of facilities/utilities, infrastructure, installations, safety measures, fire detectors and extinguishing systems in place.
- Other risks/hazards/threats in the facility's surrounding (besides the one in the facility and the operations).
- Objects exposed to risk in surrounding areas (nearby located production, environment, etc.).
- Supplier recommendations.
- The facility's criticality (how critical the facility is), disruption/property damage, including critical processes.

Mandatory roles, as a minimum, for performing the risk assessment are:

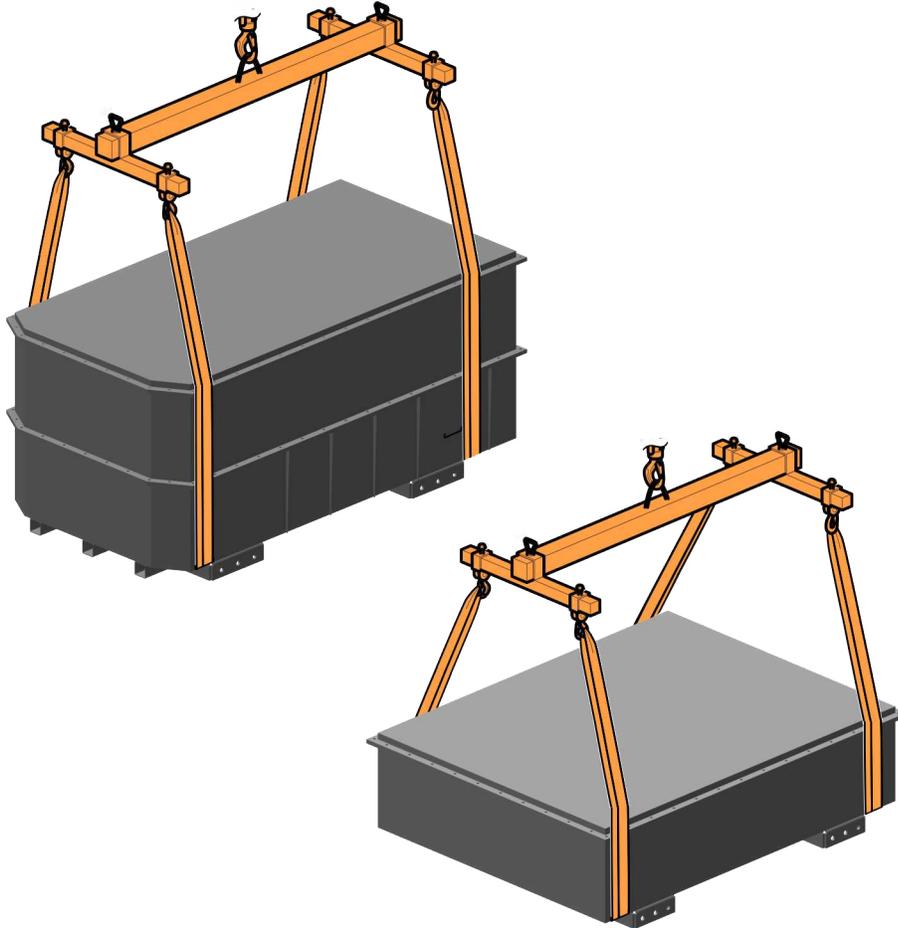
- Site manager or a delegated person by them
- Health and safety representative.
- Person with risk assessment competence.
- "Overall electric responsible" (as defined in STD 871-0003) or a person assigned by them (Refer 'Safety regulation, electric vehicles' under function group 3 for more information).

# Arrival inspection

Packaging and the goods need to be inspected upon arrival, whatever is applicable with regards to the operations. If the packaging is broken upon arrival, the battery need to be reclassified by a "work activity responsible" (as defined in STD 871-0003). Subsequent handling and transport must be in accordance with the new classification.

**Note:** Keep the traction battery in an upright position and use the lifting points when handling the traction battery. See the illustrations below:

## Traction battery:



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LIFTING TOOL : 88810076

**Note:** Lifting force must be vertical.

# Storage

## General

- Remove or hide the labels in the empty traction battery packages to avoid confusion. Do not store empty traction battery packages with packages containing traction batteries.
- Perform a risk assessment before taking a decision on the storage of traction batteries. Local fire department or similar authority must approve storage of traction batteries.
- To avoid mix up store the different categories of traction batteries separately.
- If the packaging is missing or damaged, do not stack the traction batteries on top of each other.
- "Defective or damaged" and "Severely damaged" traction batteries must be clearly marked with packaging label.
- Attach the packaging on the packing box with required information.
- Maintain and update the packaging label during traction battery storage, for easy understanding of the status and classification of the traction battery.
- To avoid long storage, apply "First In, First Out" (FIFO)" principle.

### The storage area:

- The storage area must be equipped with an appropriate automatic fire detection system, gas detectors, automatic water sprinkler system, smoke ventilators and fire alarms. A maximum of five batteries can be stored together without requiring an automatic water sprinkler system. Comply with local laws and regulations.
- Keep it dry and clean and protect the traction batteries from any weather exposure and exposure to direct sunlight.
- Traction batteries can be stored together with other goods, however, not with dangerous goods. A maximum of five batteries may be stored together in a workshop. Batteries belonging to products undergoing service are excluded from this limitation.
- Depending on the risk assessment, it must have direct access to outdoors or other adequate evacuation corridors.
- Have adequate ventilation (comply with local laws and regulations).
- Apply measures to protect the traction battery against physical damage.
- Maintain a temperature within the range defined in the traction battery's technical documentation.
- Have adequate firewater retention facilities.
- Have gas sensors to detect carbon monoxide, hydrogen and hydrogen fluoride.
- Mark clearly, with the owing labels.



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### The traction battery:

- Handle with care
- Handled by trained personnel
- Easily accessible for inspection and firefighters
- Store it in the original packaging with the protective caps in place. To protect the traction battery against any mechanical impact, remove the original packaging at the latest possible stage. ● Stored separately from any hazardous material, such as explosives, highly flammable material or combustibles (other than original packaging).
- Stored on a pallet
- Stored in its original packaging with the connector protective caps in place. The traction battery to be removed from the original packaging at the latest possible stage to maintain protection against mechanical impact
- Keep an upright position
- Protected against moisture (exception- If the sprinkler system is activated due to fire), recommended humidity level is under 60%.
- Regularly inspect for fluid leakage
- Stored not higher than 2 metres (bottom of traction battery) above the floor or in accordance with the risk assessment.

It is recommended that the SOC (State Of Charge) of traction battery must be 40 to 70%, not more than 3 months. Store the traction battery indoor in a dry and ventilated warehouse on an insulated surface. If it is stored for a longer period of time, periodically check the traction battery voltage (every 3 months at least and recharge to 50–60% SOC). Maintain the SOC of the traction battery at recommended level during storage.

### Charging a stored traction battery:

- If the traction battery is stored before its first use, charge it before the deadline shown on the traction battery.
- If the traction battery voltage drops below the recommended SOC.

**Note:** Use appropriate traction battery charger for charging the standalone traction batteries.

### Storage environment temperature

	Item	Requirement
Storage Environment	Short Period, less than 1 month	-20 to +45° C, 90 % RH Max
	Long Period, more than 3 month	-10 to +35° C, 90 % RH Max
	Recommend storage	15 to –35° C, 85 % RH Max

## Category "Defective" (Yellow)

Additional requirements:

- Defective traction battery packs must be clearly marked "Defective" and colour-coded yellow to avoid mix up.
- Maintain clear access to stored traction batteries for monitoring and emergency response.
- Check the traction batteries for leaking fluids, sparks, smoke, flames, gurgling or bubbling sounds. If anything detected, take appropriate action. Categorise the traction batteries in question as "Severely damaged".
- Use an appropriate PPE (Personal Protective Equipment) when handling the traction battery.
- Do not store a "Defective" traction battery for a long time.

# Category "Severely damaged" (Red)

Requirements:

- A traction battery in the category "Severely damaged" must be clearly marked with "Severely damaged" and colour-coded red to avoid mix-up.
- Trained rescue service personnel must only handle the "Severely damaged" traction battery.
- Traction batteries that are classified as severely damaged shall be stored in a safe location, preferably outdoors with weather protection and away from people, operations, and buildings according to the local legislations, regulations, and a risk assessment performed.
- Store the traction battery in such a way as to prevent harm to the environment.
- Use an appropriate PPE when handling the traction battery.
- Do not store a "Severely damaged" traction battery for a long time.
- Move other vehicles away from the severely damaged traction batteries Do not keep severely damaged (RED) batteries near to the fencing or neighbouring properties.

## Emergency procedures

1 Fire or smoke

- Save the one whose life in danger.
- Warn others.
- Activate the fire alarm or evacuation alarm.
- Evacuate and stay away from fire and smoke.
- If there is a fire near a battery and the battery itself is intact, water spray will help to cool down the area surrounding the battery as well as the battery itself to prevent the fire from spreading and to prevent the cells from venting due to excessive heat. If possible, the battery shall be moved to a safe location.

2 Fire department must perform firefighting, internal or external.

3 Any suspected traction battery should be handled by trained rescue service personnel in cooperation with a "work activity responsible" (as defined in STD 871-0003).

Comply with local laws and regulations regarding fire prevention measures. Refer STD871-0004 chapter 6. Precautionary measures against electrostatic discharges shall be taken.

## Electrical safety

### General safety instructions

When the symbol for risk of electric shock or high-voltage hazard symbol is present, carefully read the accompanying information text about risks and hazards.

A "work activity responsible" (as defined in STD 871-0003) must only carry out removal of traction battery.

If the high-voltage hazard symbol is present (see the following illustration), the battery's covers may only be removed by trained personnel and upon authorisation.



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## Marking on the traction battery

The traction battery must be marked with the high-voltage hazard symbol.

## Maintenance charging of stand-alone traction batteries

- A risk assessment shall be made prior to charging the standalone traction battery.
- Charging must be carried out by a "work activity responsible" (as defined in STD 871-0003) with sufficient battery safety knowledge.
- Comply with regulations and approved user instructions when charging.
- Use an appropriate PPE (Personal Protective Equipment).
- Mark the traction battery with next date for recharging.
- Use specified chargers to charge the traction batteries.

Carry out the traction battery charging in a separate fire compartment with walls and floors that can resist fire for a minimum of 1 hour (EI 60) or in accordance with a risk assessment. Charging area must be free of combustibles.

## Transport

Li-ion batteries are classified as dangerous goods. The classification with colour codes (Green, Yellow and Red) defines the hazard status of the traction battery. Comply with the local regulations regarding the transportation of dangerous goods.

Note that it is the consignor's responsibility to fulfil all requirements in connection with the transport of dangerous goods.

When transporting batteries, regardless of category, protection caps shall be mounted on the electrical connections. This shall be done in order to protect against direct contact causing a short circuit of the electrical connections and leakage of coolant liquid. The operator must receive training regarding handling and actions that need to be taken if an accident occurs while transporting the battery.

## Transport of traction batteries within the facility

If possible, keep the traction battery in its original packaging (the same packaging as it arrives in) during transport within the facility.

If the packaging is missing or damaged, place and secure the traction battery on a pallet with frames or in a handling device designed to protect the battery instead of the original packaging. The traction battery must be marked with 'Class 9' and 'UN 3480'.

**Note:** U.S. Hazardous Communications requirements recommend the use of pictograms on the battery to indicate any health hazards (e.g. corrosive, inhalation and/or physical hazards (ex. fire risk). If pictogram is required as per the applicable safety data sheet received from the traction battery manufacturer, add the respective pictogram. If the pictogram is missing or damaged, please contact the nominated person to determine next steps. Next steps may include purchasing the applicable pictogram labels from traction battery manufacturer for applicable labels.

## Transport of traction batteries from a facility

Traction batteries are classified as dangerous goods or hazardous materials. The classification with colour codes (Green, Yellow and Red) defines the hazard status of the traction battery.

Transportation of traction battery categories "Defective" and "Severely damaged" is highly restricted. Depending on applicable transport and hazardous waste regulations, special packaging and training to personnel involved is mandatory.

**Note:** If the packaging is damaged, only approved alternatives listed in the 49 CFR will be authorized for transport. Compliance with these regulations is mandatory to ensure safe transport of hazardous materials or dangerous goods

## Road transport of traction batteries

The traction battery is a hazardous material or dangerous good. Therefore, transport the traction batteries under applicable regulations in accordance with 49 CFR Parts 100-185 within the 48 adjoining states.

For road transports originating from Canada, follow the applicable regulations in accordance with Canadian Transport of Dangerous Goods.

It is the responsibility of the consignor or entity sending the shipment to follow all the applicable transport regulations to ensure successful transport to the consignee. If there are any issues during transport, it is the responsibility of the consignor to correct any deviations reported by the transporting agency. If the consignor cannot correct the deviations while the battery is transit, the impacted shipment must be returned to the consignor immediately.

Within the conterminous United States or 48 adjoining states (plus the District of Columbia), transport guidelines are regulated under the 49 CFR Parts 100-185 (latest published edition). Transport to Hawaii, Alaska, Puerto Rico and U.S, Virgin Islands are regulated under IATA or IMO depending on the mode of transport. The traction battery is considered a hazardous material or dangerous good under these rules and therefore the following information is applicable :

UN number	UN 3480
Proper shipping name	Lithium-ion batteries including lithium ion polymer batteries
Class	9
Relevant special provisions	Reference special provision section 172.102 - 422, A54 and A100
Relevant packing instructions	Packaging A173.185
Quantity limitations	Passenger aircraft /rail – Forbidden cargo aircraft only – 35 kg

**Note:** Under 49 CFR transport guidelines within the 48 adjoining states of the United States (plus the District of Columbia) section 173.185 Lithium cells and lithium batteries transport shall comply with applicable special provisions within this section. It is the responsibility of the consignor to adhere to the most recent regulations about Lithium cells and batteries before shipment.

## Mixed loading by road:

It is prohibited to load batteries, UN 3480, together with dangerous goods class 1 Explosives. They can, however, be loaded together with class 1.4G, UN 0503 Safety devices, pyrotechnic, and class 1.4S, UN 0432 Articles, pyrotechnic.

The batteries can also be loaded together with other dangerous goods in other dangerous goods classes, as well as goods not classified as dangerous goods, for example food.

## Category "New or used" (Green)

### Inside the United States follow applicable regulations 49 CFR parts 100-185:

Shipment instructions include the following:

- Use the same packaging in which, the traction battery was delivered in or a pallet with a frame and packaging with a lid. Use the traction battery lifting points when handling them and place the traction battery securely onto the pallet. It is important to secure the traction battery properly in place to prevent the movement during transport. Secure by fastening the traction battery mounting points to the pallet. Do not include other goods in the pallet or inside the packaging.
- Mark the package with "UN 3480" (minimum text size 12 mm, water resistant).
- Attach "Class 9" to the package. See the following illustration.



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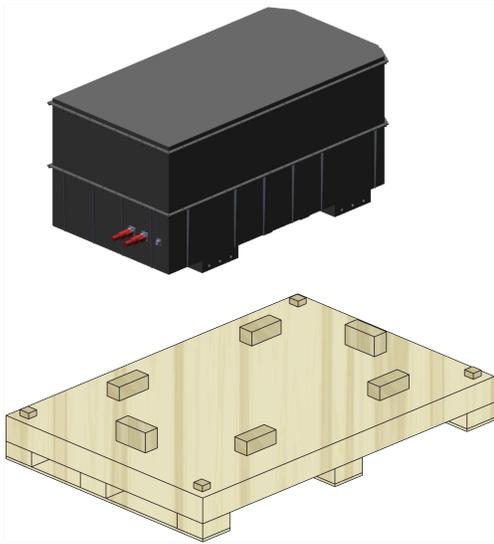
- Write the consignor and consignee addresses on the package.
- Issue a dangerous goods declaration for IATA or IMO. If shipping under 49 CFR, applicable information must be included on the shipping manifest and bill of lading.
- Inform the transporter that this is a dangerous goods transport when ordering the transport (UN 3480, lithium-ion batteries, class 9).
- Write the part number and serial number outside the package.

**Note:** 49 CFR 172.101, the class 9 label shown above is also mandatory for domestic transport. For more instructions regarding packaging instructions, to include but limited to label placement, refer to 49 CFR 172.101 and reference UN 3480 in the HAZMA table.

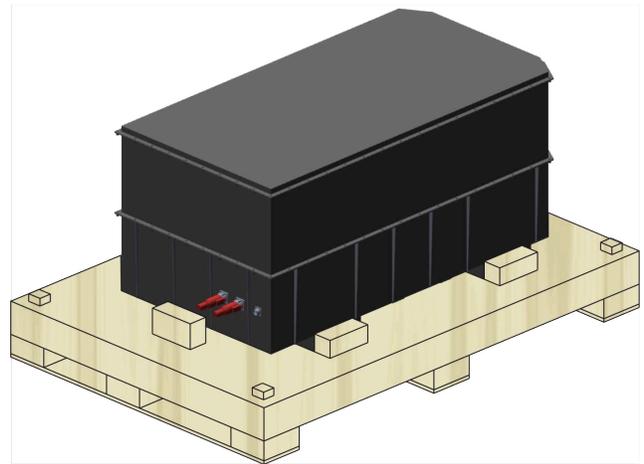
## Packaging instructions

### Traction battery

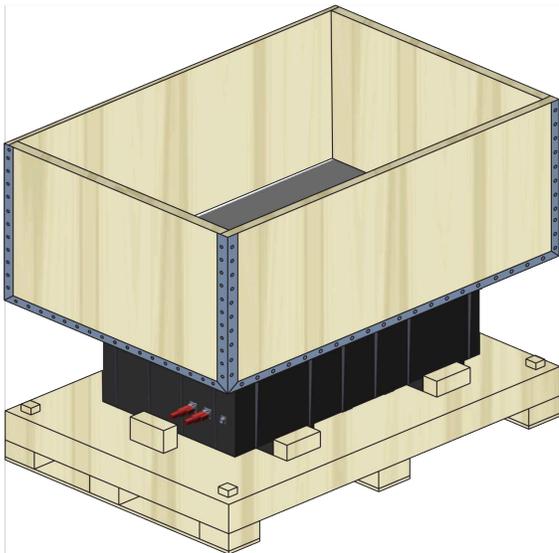
- Place the traction battery in the packing box.



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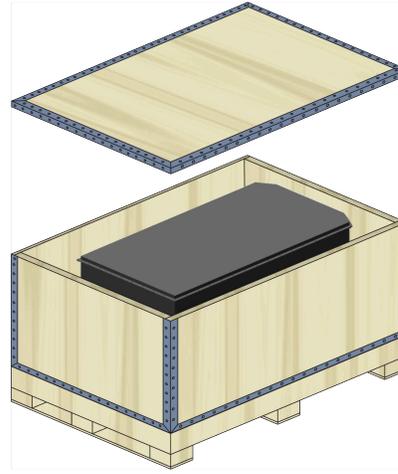


T3208819



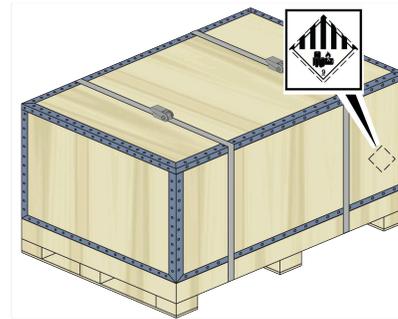
T3208820

- Close the lid.



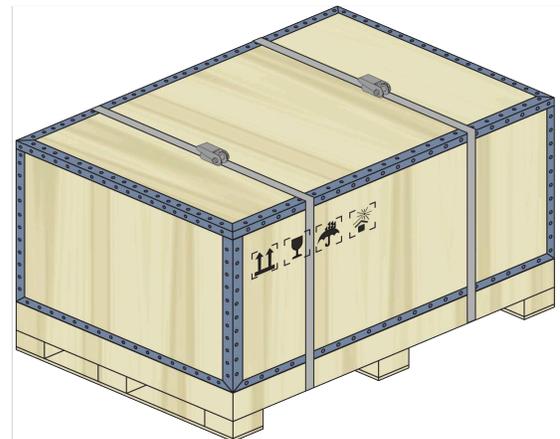
T3208821

- Place the "Label Class 9" on both sides of the packing box.



T3208823

- Strap the packing box firmly.



T3208824

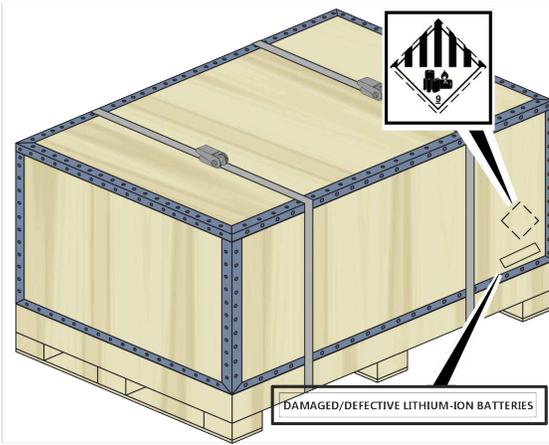
**Note:** Use polyester strap of width 15 mm.

### Category "Defective" (Yellow)

According to STD 871-0004, section 5.4.2.1, follow local regulations for road transport. In addition, pack the battery in accordance with the specific packaging instructions for defective battery classification. Review section 12 of STD 871-0004 for further assistance.

#### After closing lid:

- Place the "Label Class 9 "DAMAGED/DEFECTIVE LITHIUM-ION BATTERIES" on both sides of the packing box.



T3208826

- Strap the packing box firmly.



T3208824

**Note:** Use polyester strap of width 15 mm.

### Category “Severely damaged” (Red)

#### 49 CFR (Transport within 48 states excluding Alaska and Hawaii)

Follow the local, state and federal regulations for road transport. Contact "Electromobility Technical Support" before the transport of traction batteries in the category “Severely damaged”.

Get in touch with local agencies that collect and manage the disposal of traction batteries, as there is a high risk and complexity in the transportation of "Severely damaged" traction batteries. If not possible, the local dealer is responsible to transport the vehicle to breakers yard or repair center, where the traction battery is collected.

For more advice on handling "Severely damaged" traction battery for recycling, contact the "Electromobility Technical Support".

## **Category “Traction batteries sent for disposal or recycling”**

Follow all regulations regarding waste management. Please ensure that your local waste management provider receives correct information about the traction battery for prior approval. Contact Electromobility Technical Support for additional assistance.

Follow the local regulations for road transport of traction batteries in the category “Traction battery sent for disposal or recycling”.

## **Sea transport of traction batteries (IMDG code)**

### **Category “New or used” (Green)**

Same instructions as in "Road transport of traction batteries, Category "New or used" "with the following additions:

- Mark the packaging with the text 'Lithium-ion Battery (minimum text size 12 mm, water resistant).
- Review the advised temperature ranges in the technical documentation.
- Issue multi modal dangerous goods declaration.
- Depending on the type of traction battery and transport route the packaging must include VCI (Volatile Corrosion Inhibitor) protection (VCI bag).

### **Category “Defective” (Yellow)**

Same instructions as for “Road transport of traction batteries, Category "Defective", Inside Europe and countries where ADR (European Agreement Concerning the International Carriage of Dangerous Goods by Road) rules are applicable” with the following additions:

- Review the advised temperature ranges in the technical documentation.
- Issue a multimodal dangerous goods declaration with statement “Transport in accordance with special provision 376”.
- If needed (depending on type of traction battery and transport route) the packaging must include VCI protection (VCI bag).

### **Category “Severely damaged” (Red)**

Do not transport the severely damaged traction batteries by sea. Contact Electromobility Technical Service.

### **Category “Traction batteries sent for disposal or recycling”**

Contact your local waste management provider.

## **Air transport of traction batteries (IATA – DGR)**

### **Category “New or used” (Green)**

Before starting the air transport process, contact 'Electromobility Technical Support'.

Approval from the appropriate authority in the country of origin is required to transport the traction batteries by air. If such approval exists, refer to it for further information e.g. regarding packaging . Make sure that the charge level in the traction batteries is not more than 30% during shipment.

### **Category “Defective” (Yellow)**

It is not permitted to transport the traction batteries categorized under “Defective” by air transport.

### **Category “Severely damaged” (Red)**

It is not permitted to transport the traction batteries categorized under “Severely damaged” by air transport.

### **Category “Traction batteries sent for disposal or recycling”**

It is not permitted to transport the traction batteries categorized under “Traction batteries sent for disposal or recycling” by air transport.

# Returning the traction batteries

## Used traction batteries

Return all end-of-life or used traction batteries to the supplier or a recycling company.

To book for the transport, open an Electromobility Technical Support eService case according to TSB R 31-115-1. The BEV Service Manager will provide the guidelines to arrange the transport.

Refer to 'Packaging instructions' in the chapter 'Transport' for information about packaging the "Green" category traction batteries.

## Defective traction batteries

Follow local regulations before transporting the traction battery. In addition, pack the traction battery in accordance with the applicability or non-applicability of 49 CFR rules.

Refer to 'Packaging instructions' in the chapter 'Transport' for information about packaging the "Yellow" category traction batteries.

## Severely damaged traction batteries

It involves high risk and complexity in transporting the "Severely damaged" traction batteries across the border. So get in touch with local agencies that collect and manage the disposal of traction batteries. If not possible, the local dealer is responsible to transport the vehicle to a breakers yard or repair center, where the traction battery is collected. For more information on handling 'Severely damaged' traction battery for recycling, contact the "Electromobility Technical Support".

# Safety

## Safety working rules

This vehicle is equipped with traction batteries and electric motors with a nominal voltage of 400 V.

**Note:** Contact Mack Trucks dealer for more information on decommissioning/commissioning procedure.



### CAUTION

To perform any work on the commissioned vehicle, turn the chassis switch to the off position.

**Note:** In case of any doubts to perform a specific operation, contact Mack Trucks dealer.

# Electrical safety

The electric system of the truck is designed to keep the person safe, as long as the instructions and safety precautions given in this document are followed.

## **DANGER**

Never attempt to open a battery pack. This vehicle uses a battery pack that operates at Nominal 400 volts DC.

## **DANGER**

Never attempt to remove, unplug or cut any of the ORANGE marked cables or conduit. Orange marked cables carry high voltage.

## **DANGER**

Only authorized personnel are allowed to work on electrical power and/or control systems.

## **DANGER**

Never power wash High Voltage connections.

## **WARNING**

DO NOT carry out any welding or other manufacturing processes like grinding etc. on the vehicle other than what has been directed by SEA Electric. Otherwise serious damage can be caused to the power-system and the electronic control system.

## High voltage interlock (HVIL)

The SEA-Drive® vehicle is fitted with an automated HVIL system. HVIL ensures that high voltage power circuits to the drive motor, inverters and battery management system are only enabled when the SEA-Drive® vehicle's ignition switch is in the ON position and EV control system start-up checks have been completed successfully.

## Low voltage isolation

Isolating the SEA-Drive® vehicle's low voltage battery system will prevent the EV control system from powering up and ensuring the high voltage system remains isolated. The low voltage Isolation switch is located next to the low voltage batteries.

## Loss of electrical power during operation

If the SEA-Drive® vehicle was to lose electrical power while the vehicle is in motion, the steering will become stiff and the vehicle will continue to roll. The regenerative braking system will not assist braking.

### Notes

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## The traction voltage system

The traction voltage system (400 V), which is used to drive the vehicle contains hazardous voltages. To avoid the risk of electric shock or hazardous electrical burn, follow the instructions and safety precautions.

The electric motors is located between the frame rails and to the rear axle. The traction batteries are mounted on the vehicle chassis to the back of cab. In these two areas and also in the area underneath the cab, there are numerous electrical components (400 V), cables and connectors.

### **DANGER**

#### **Risk of electrical discharge**

Incorrect handling of the traction voltage system (>60 V DC (Direct Current)) can cause electric shocks and arcs resulting in serious burns or death.

Do not repair, dismantle, remove or replace any component, cable, connector, cover or electrical traction protection. Any operation must only be carried out by personnel with adequate training according to **Safety regulations, electric vehicles**.

Decommissioning and commissioning must only be carried out by Mack Truck BEV certified dealer.

### **CAUTION**

It is strictly forbidden to connect to the 400 V circuit.

### **CAUTION**

It is strictly forbidden to move any of the 400 V elements.

### **DANGER**

#### **Risk of electrical discharge**

Damaged traction voltage cables and components can cause electric shocks and arcs resulting in serious burns or death. Check that the traction voltage cables and components for any physical damage before any operation is carried out.

Report any damaged traction voltage cables or components **to the responsible person**.

### **WARNING**

#### **Risk of serious personal injury**

The fans for cooling the traction batteries and other components in the traction voltage system can be energized automatically without any warning, even when the key is removed from the starter switch and the truck is parked.

### **WARNING**

#### **Risk of component damage**

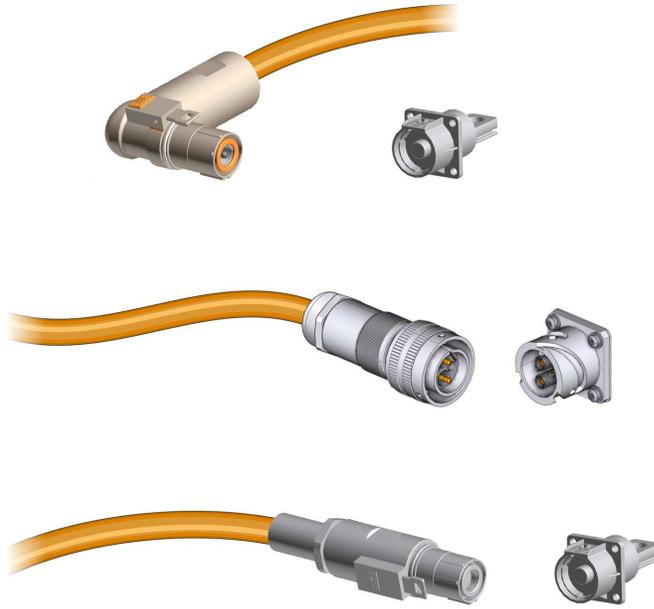
Decommissioning must be performed by Mack Truck BEV certified dealer.

### **DANGER**

#### **Risk of electrical discharge**

Do not remove any covers, hatches or similar components that are marked with the warning decal.

**TVS cables and connectors:**



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**Note: All orange colored cables in the vehicle are traction voltage (400 V) cables.**

*Notes*

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# Fire safety

## Basic principles – Working with lithium-ion batteries

Lithium-ion batteries are electrochemical storage system that use lithium in an ionic form. The battery cells contain electrodes, an electrolyte (lithium hexafluorophosphate (LiPF6) dissolved in a mixture of organic solvents) and different products providing different chemical and physical characteristics.

### Thermal risk

An internal event (quality problem in cells/electronics etc) or an external event (excessive external temperature, mechanical damage, water intrusion etc.) may be the origin of a thermal runaway where exothermic decomposition reactions may occur, resulting in fire and/or explosion.

Traction battery thermal runaway occurs when a battery cell or area within the battery cell exceeds maximum temperature rating set by the battery manufacturer. It is an unstoppable chain reaction result in rising of temperature rapidly within milliseconds and the energy stored in the battery discharge quickly.

Thermal runaway means a serious fault in the traction batteries that will lead to a fire in the traction batteries.

**Note:** Additional information can be found in the drivers manual.

### Chemical risk

The chemical products in the battery cells are flammable and can be dangerous to human health and environment. Decomposition or combustion products may also present a hazard to human health and the environment. These include hydrofluoric acid, phosphoric acid, fluorine compounds, carbon monoxide, hydrogen, hydrocarbon gases and carbon dioxide. The nature and quantity of the flammable and toxic gases emitted depend on numerous parameters such as the composition of the battery cell (cathode, solvents and electrolyte salt, additives, etc.), the state of charge and the mode of failure.

In the event of a fire, smoke or suspicious smell in the truck, it is important to take the correct actions. Refer to the following instructions.

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## Guidelines for Electrical Accident

The core value of Mack is safety. This is also reflected in the design of electric vehicles. Provided that the correct routines are followed and appropriate protective measures are taken, there is virtually no risk of electrical accidents.

Although such accidents are unlikely, it is still good to know what to do in case an electrical accident occurs. The following is a general guideline for how to handle such a situation.

- 1 **Shut off the electric power:** Use the 24 V isolation switch to cut off the electric power during emergency.
- 2 **Attend to the injured and notify rescue services:** Follow local procedures for emergency situations.
- 3 **Report the accident:** This is an important step in preventing the accident from happening again.



T8196328

## Guidelines for Fire Incident

The following guidelines are to be considered general recommendations in case of thermal incidents related to electric vehicles.

In specific cases, other procedures may be more appropriate. Always follow local guidelines and regulations when dealing with thermal incidents.

### In case of fires involving electric vehicles:

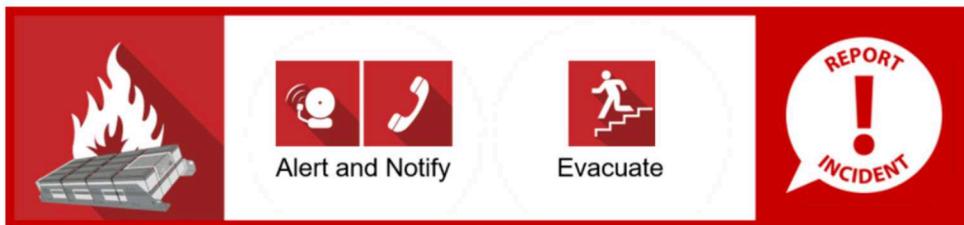
- 1 Alert nearby personnel and notify rescue services.
- 2 Prevent the fire from spreading to the traction batteries if possible. If not possible, evacuate the area.
- 3 Report the incident according to the current reporting procedure.



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**In case of fire in the traction batteries:**

- 1 Alert nearby personnel and notify rescue services.
- 2 Evacuate the area.
- 3 Report the incident according to the current reporting procedure.



T3170876

**Fire, smoke, unusual smell, heat or sounds in traction battery area.**

 **DANGER**

**Risk of serious personal injury or death**  
Do not try to extinguish the fire yourself.

 **DANGER**

**Risk of serious personal injury or death**  
Do not inhale the smoke, it is very toxic.

If there is a fire in or near the traction batteries or if smoke is coming from the traction batteries or the area around them, do the following:

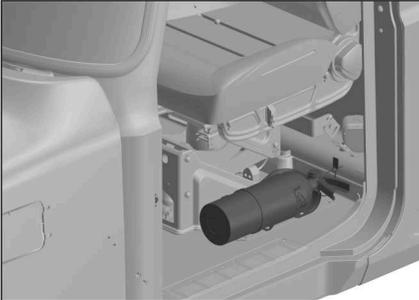
- 1 Evacuate the truck immediately and quickly move away from the truck.
- 2 Alert anyone that is nearby and secure the area around the truck.
- 3 Contact the emergency service in the county you are in. Inform them that your electric truck is on fire.

## Fire in another part of the truck

If there is a fire in another part of the truck (not in or near the traction batteries), do the following:

- 1 Get out of the truck immediately.
- 2 Contact the emergency service in the county you are in. Inform them that your electric truck is on fire.
- 3 If you think that it is safe and if ABC (powder) extinguisher is available, extinguish the fire other than the traction battery area.
- 4 If the fire reaches the traction battery area, move away from the truck immediately.

**Note:** The Mack MD can be ordered with an option safety kit that includes a 5lb fire extinguisher and safety triangle kit. Refer to Driver manual for more information.



T3199297

Fire extinguisher located on the cab floor on the left side of the driver seat.

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# Chassis

## Welding



### DANGER

#### Risk of serious personal injury or death

Welding directly on the ESS is not permitted as this can cause dangerous electric shocks, arcing or burns, which can result in serious personal injury or death.



### WARNING

#### Risk of component damage

Failure to follow the following instructions can result in damage to electrical components.



### WARNING

The vehicle must be fully decommissioned. If welding on the frame position grounding clamps as close to the welding location as possible and ensure the grounding path does not pass through any electrical components.



### CAUTION

It is not permitted to weld on this vehicle without decommissioning.



### CAUTION

Decommissioning and commissioning must only be carried out by Mack Truck BEV certified dealer..

- Welding, in general, is allowed if the vehicle is decommissioned.
- Welding on the frame (in the overhang area) is allowed if the vehicle is decommissioned.
- Welding on the frame (in the wheelbase area) is not allowed – risk of damage to electromobility components, even if decommissioned.

#### The welding process that applies to conventional trucks also applies to electric trucks.

- Carry out the vehicle safety decommissioning procedure.
- Welding directly onto electrical components is not permitted.
- Electric components must be given adequate protection if the welding is carried out close to them.
- Ground the welding equipment as close as possible to the welding area.
- Protect the vehicle from splashing, which may occur during welding.

## Plasma Cutting

Plasma cutting involves creating a high-voltage circuit between the tool head and the workpiece by grounding the plasma cutter to the workpiece, just like with welding. The only difference is that the current flows through the gas plasma instead of a stick electrode in contact with the workpiece. Therefore:

- Plasma cutting is allowed in general if the vehicle is decommissioned to protect the electromobility components.
- Plasma cutting is allowed on the frame (in the overhang area) if the vehicle is decommissioned.
- Plasma cutting is NOT allowed on the frame (in the wheelbase area) – risk of damage to electromobility components, even if decommissioned.

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# Drilling

The drilling process that applies to conventional trucks, also applies to electric trucks.

## **DANGER**

### **Risk of serious personal injury or death**

When drilling, make sure that there are no traction voltage (400 V) circuit components that could be damaged.

## **CAUTION**

It is only permitted to drill outside of wheelbase area without decommissioning.

## **CAUTION**

Decommissioning and commissioning must only be carried out by Mack Truck BEV certified dealer..

# Painting

Contact the vehicle manufacturer before carrying out any painting work.

## **CAUTION**

It is not permitted to paint the BEV without decommissioning and also in an enclosed area.

## **CAUTION**

Decommissioning and commissioning must only be carried out by Mack Truck BEV certified dealer..

## **CAUTION**

To avoid damage to the traction battery (400 V battery), do not exceed the following drying process of the paint:

— The maximum drying temperature (70°C or 158°F).

— The maximum drying time (40 minutes).

If the BEV is painted with more than one color, allow the BEV to cool down to room temperature (20°C or 68°F) before it is sent to the drying oven.

The orange colored cables in the truck are traction voltage (400 V) cables. It is not permitted to paint the orange cables or in any other way that changes their colors.

# Towing



## CAUTION

The vehicle is allowed to tow only when the propeller shaft is disconnected from the rear axle. Failure to remove the propeller shaft may cause damage to the driveline and components.

Refer to the driver's handbook for more information on towing the vehicle.

# Washing



## CAUTION

Do not wash the truck if any connectors in the traction voltage system are not fully connected or if the truck is disassembled in any other way.



## CAUTION

Before washing the truck, make sure that the cover for the charging interface is securely fastened and fully covers the charging interface.

## General

Regular cleaning helps maintain the value of your truck. Wash the truck more often in winter conditions or other dirty driving conditions.

The wastewater from cleaning the truck contains chemicals and pollutants that are bad for the environment. Use environmental friendly detergents and ensure that the truck is cleaned in a facility where the wastewater is collected.

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## Washing with high pressure

Be careful when washing the truck with a high-pressure washer. If water and dirt penetrate components, then that can cause damage over time.

Do not use a high-pressure washer to clean the following:

- Traction batteries
- Components in the traction voltage system
- Universal joint crosses
- Support bearings
- Sliding interfaces
- Joints
- Sealings
- Connectors
- Electrical components
- Air inlets
- Ventilation, for example, oil reservoirs

Tires and air bellows can be cleaned with a high-pressure washer, but do not use pulsating high pressure as it can damage them. The damage is not visible but may eventually cause tires or bellows to rupture.

The radiator can also be cleaned with high pressure, but, be careful as the radiator fins can be easily damaged.

**Note:** Minimum distance between the high-pressure nozzle and the washing surface is:

Approximately 70 cm (27.5 inches) with a round concentrated jet

Approximately 30 cm (11.8 inches) with a flat widespread jet.

## Washing the cab

### CAUTION

When washing the windshield, ensure that the windshield wipers are switched off. Otherwise there is a risk of fingers being trapped by the wiper blades.

The truck must be washed when it is dirty. Especially in winter when road salt and moisture can cause corrosion.

The following points must be followed to avoid paint damage and to achieve good results when washing:

- **Washing method:** Use a pressure washer primarily. For the dirt that cannot be removed using this method, try to remove it with a brush or sponge with a best suited cleaning agent for the type of dirt. There is a risk of scratching the paint using brush washing without high pressure washing or washing in brush washers that are poorly maintained (worn, dirty brushes, etc.).
- **Washing chemicals, general:** Different agents are recommended for different types of dirt. Always follow the manufacturer's recommendations for use, dosage and maximum temperature.
- **Avoid chemicals drying into the paint surface.**
- **Washing detergent:** Avoid using strong alkaline agents (pH >12). Do not wash the truck in direct sunlight. Rinse with plenty of cold water before chemicals are applied. If the temperature is above 86F (30°C), wash small areas and then rinse clean so that long exposure times or drying chemicals are avoided.

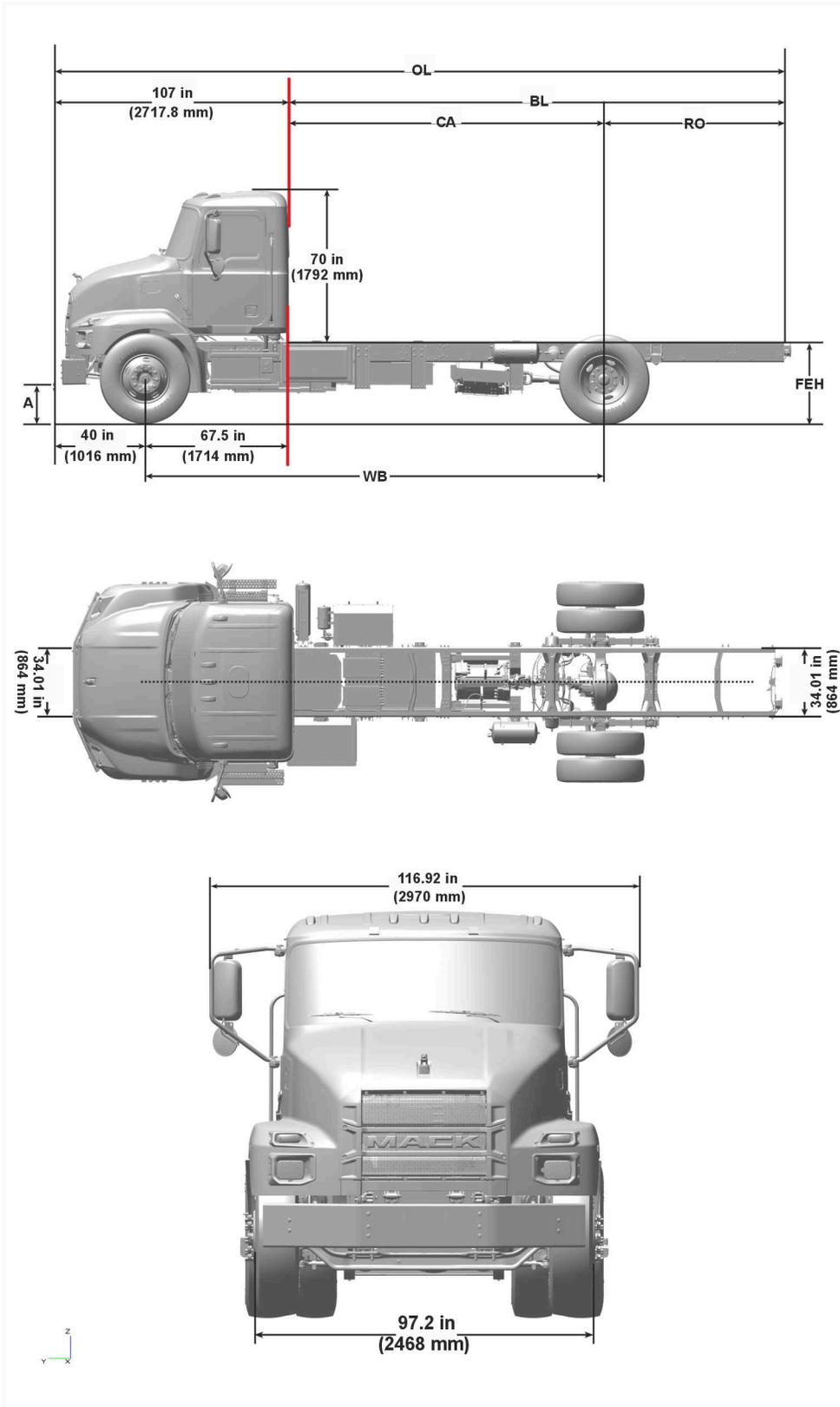
## Washing the chassis

Both the chassis and the cab must be washed when they are dirty. Be careful with high pressure washing of axles, joints, and other moving parts, where water and dirt can be forced in. Avoid flushing away lubricant. Should this still happen, make sure to relubricate the components.

**Washing detergent:** Avoid using strong alkaline agents (pH >12). Do not wash the truck in direct sunlight. Rinse with plenty of cold water before chemicals are applied. If the temperature is above (30°), wash small areas and then rinse clean so that long exposure times or drying chemicals are avoided. Always rinse with plenty of water after using washing detergent.

**Note:** Never spray water directly onto the traction batteries or other components in the traction voltage system. Also, do not spray water directly onto sealings, gaskets or electric equipment (such as cables or connectors) in the 24 V system.

# MMD BEV Generation 2, 4x2 Dimensions/Configurations



T8218794

MD6/MD7, Class-6/Class-7						
Typical Dry Van Body Length <sup>1</sup> (ft.)		18	20	22	24	26
Wheelbase <sup>2</sup> (WB) in inches (mm)		205 (5207)	217 (5512)	235 (5969)	255 (6477)	274 (6960)
Bumper-to-Back-Of-Cab in inches (mm)		107 (2718)	107 (2718)	107 (2718)	107 (2718)	107 (2718)
Bumper-to-Front Axle in inches (mm)		40 (1016)	40 (1016)	40 (1016)	40 (1016)	40 (1016)
Cab to Rear Axle (CA) in inches (mm)		138 (3505)	150 (3810)	168 (4267)	188 (4775)	207 (5257)
Rear Overhang Chassis (RO) in inches (mm)		75 (1905)	85 (2159)	90 (2286)	95 (2413)	100 (2540)
Back-Of-Cab to End of Frame (BL) in inches (mm)		213 (5410)	235 (5969)	258 (6553)	283 (7188)	307 (7798)
Overall Length Chassis only (OL) in inches (mm)		320 (8128)	342 (8687)	365 (9271)	390 (9906)	414 (10516)
Frame End Height (FEH) in inches (mm)	Unladen	40.5 (1029)				
	Laden	38.3 (972)				
Bumper-to-Ground (A) in inches (mm)		17.5 (444)				
Length of rear suspension from center of axle in inches (mm)	Leaf suspension	X	28.5 (723)			
		Y	28.9 (735)			
	Air suspension	X	26.4 (670)			
		Y	32.1 (735)			
Rear suspension full length in inches (mm)	Leaf suspension	Z	57.4 (1459)			
	Air suspension	Z	58.5 (1486)			

1 Typical van body lengths assume level load to maximize GVWR. No specific consideration taken for driver, passengers, or fuel addition of ancillary equipment such as lift gates and refrigeration units not considered in calculations.

2 Wheelbase selection should be based on specific weight distribution.

## Notes

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# Body Mounting

## Body Mounting Considerations



### CAUTION

The addition of a body to a vehicle frame must not adversely affect the safe operation and handling characteristics of the vehicle.



### CAUTION

It is the sole responsibility of the body builder to verify that the axle alignment is corrected after making modifications such as mounting a body.

When mounting a body to a particular type of chassis, the following design considerations must be considered for each type of chassis:

- Accessibility to the various critical locations, including lubrication (grease) points.
- Easy removal of the various powertrain and suspension components.
- Allow maximum spring movement for the rear wheel.
- Ensure proper ventilation and cooling of the brake drums and the battery within the battery box.
- Free movement and safe operation throughout the range of movement for all moving parts of the frame (i.e., springs, drivshafts, etc.) must be maintained.
- Maintain proper load distribution between the right and left-hand sides of the vehicle.
- The body installation must not cause excessive frame rail deflection. Contact MACK Trucks, Inc. Customer Service for assistance in obtaining approval for an installation on a specific chassis. Be prepared to supply detailed information concerning the intended weight distribution of the completed vehicle.
- Body attachment fasteners must be tightened gradually in progressive steps, using an alternating pattern.
- To avoid any sudden change of inertia, the sectioning of subframes or underframes must decrease progressively toward the chassis front.
- Tank bodies must be mounted on a full-length subframe.
- If wheel removal is necessary, take the following precautions:
  - 1 Do not paint the wheel-bearing surfaces of the hubs. Particularly in the case of hub-piloted wheels, the faces of the hub, the flange mounting surfaces of the wheels, and the mounting surfaces of the flange nuts must be clean and free of any foreign material or excess paint.
  - 2 Do not paint the wheel nut bearing surfaces or the surfaces of the wheel nuts themselves.
  - 3 When remounting hub-piloted wheels, an anti-seize compound may be applied to the hub pilot pads to prevent corrosion. Apply two drops of oil to the joint between the nut and flange of each flange nut and a small amount of oil to the lead threads of the stud. On stud-piloted ball socket disc wheels, the wheel nuts are installed dry.
  - 4 Tighten the wheel nuts using proper wheel nut tightening procedures.
  - 5 After any operation that requires removal and reinstallation of the wheel assemblies, the wheel nuts must be retightened with an accurately calibrated torque wrench during the first 800 km (500 miles) of use.

# Body-to-Chassis Matching

Properly matching a truck body and/or accessory equipment to a chassis is important to ensure that the completed vehicle will perform as intended without adversely affecting handling characteristics or weight distribution. Typically, 60 – 70% of the body weight should be forward of the centerline of the rear axle(s). This percentage can be adjusted by either moving the center of gravity forward, which places more weight on the front axle, or moving the center of gravity rearward, which places more weight on the rear axle(s). The addition of a body, associated equipment and the payload should never result in the GAWRs and/or GVWR being exceeded.

When choosing a chassis for a body, the following must be considered:

- How much weight can be placed on the front and rear axles (GAWR).
- How much the vehicle can weigh, including the vehicle with full capacities of oil, coolant, etc., the driver and passenger if applicable, all associated equipment and the body's payload (GVWR).
- Curb or tare weight, or how much the chassis weighs before the body and/or equipment are installed. Tare weight includes the weight of all options, lubricants and coolants.
- Cab-to-axle (CA). This is the dimension from the back of the cab to the centerline of the rear axle, or the centerline of the rear tandem axle assembly.
- Wheelbase (WB). This is the dimension between the centerline of the front axle and the centerline of the rear axle. This dimension is important because it affects body installation, vehicle performance and whether a particular axle is overloaded.
- Back-of-cab (BOC). The distance between the back of the cab and the body.
- Body length (BL). This is the dimension from the front to the rear of the body.
- Overall vehicle length state regulated for straight trucks. If in doubt, contact the appropriate State Department of Transportation.

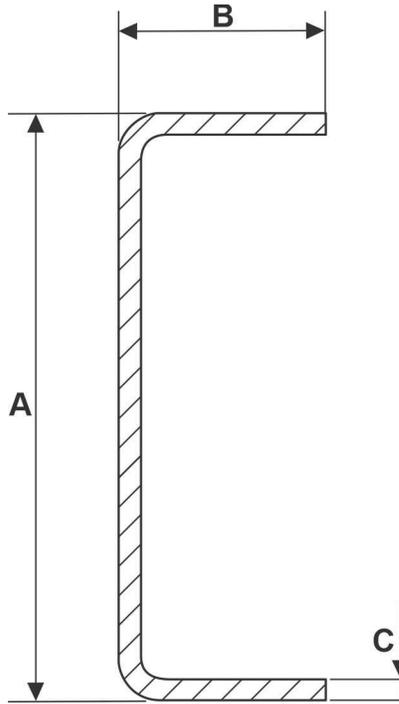
# Frame Rails

Material ..... 827.3 MPa (120,000 psi) yield heat treated steel

Distance between rails	MD6 BE	260 X 70 X 7 mm
	MD7 BE	260 X 70 X 8 mm

Frame rail end taper ..... 27°

## Frame Options



T7169694

<b>Frame Rail Web</b>	<b>A</b>	260 mm (10.47 in)
<b>Frame Rail Flange</b>	<b>B</b>	70 mm (3.25 in)
<b>Frame Rail Thickness</b>	<b>C</b>	<b>MD6 BE:</b> 7 mm (0.275 in)
		<b>MD7 BE:</b> 8 mm (0.312 in)

Incorrectly sized bolt holes weaken a bolted connection and can lead to a dangerous situation when the bolts are holding heavy weight. The two types of bolt holes are pass-through and tapped. Each has different clearance specifications that determine the strength of the connection. The type of material and connection will determine the type of hole needed to secure the materials with the bolt. Using the wrong type of hole will have an adverse effect on the holding ability of the bolt. The chart below show some examples of the ASME B18.2.8-1999 - "Clearance holes for bolts, screws and studs" standard. Please refer to this standard for additional information.

Fastener Size Standard	Mounting Hole Diameter
3/8 in	13/32 in
7/16 in	15/32 in
1/2 in	9/16 in
5/8 in	11/16 in
3/4 in	13/16 in
7/8 in	15/16 in
1 in	13/32 in

Fastener Size Metric	Mounting Hole Diameter
M14	15.5 mm
M16	17.5 mm
M20	22 mm

**Notes**

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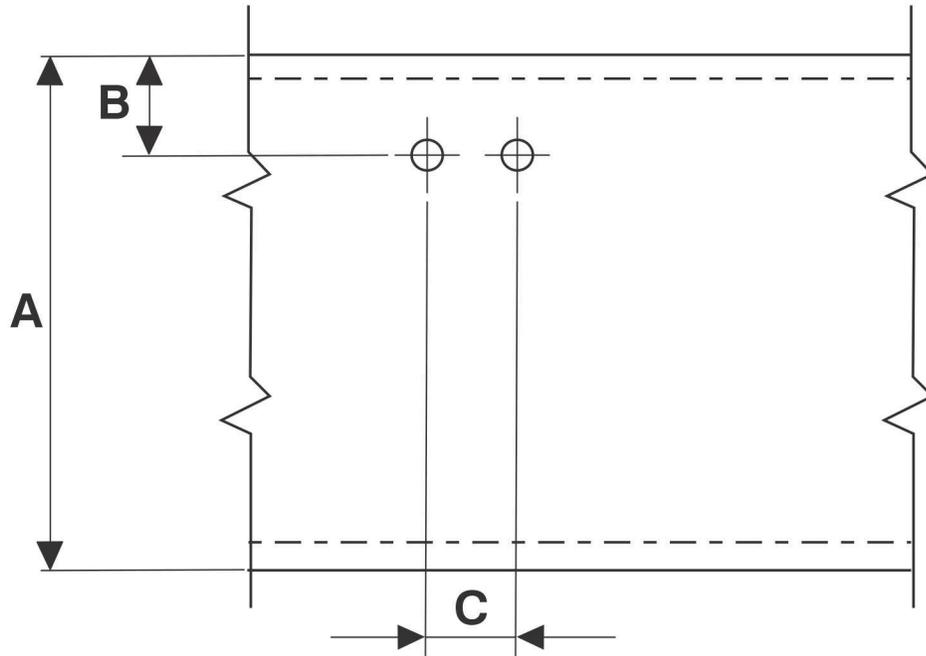
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# Bolt Hole Patterns

Hole spacing ..... 60 mm (2.26 in.) (vert) x 50 mm (1.97 in.) (horiz)

(applicable only from 1685 mm (65.2 in.) from front edge of the rail and rearward). Some components may occupy non-grid locations.

**Note:** Hole size for this spacing must be 15.5 mm (0.61 in.) diameter.



T7169695

**A** 260 mm (10.24 in.)

**B** 60 mm (2.36 in.)

**C** 50 mm (1.97 in.)

# Dimension Calculations Body Length

When selecting a body for an existing chassis, use the following formula to calculate body length:

$$BL = \left[ \frac{(GAWR.R - CWR) \cdot WB}{GVWR - CW} - WB + CA - BOC \right] \cdot 2$$

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Formula for Calculating Body Length

Where:

GAWR.R =	Gross axle weight rating of the rear axle
CWR =	Amount of curb weight at the rear of the chassis
WB =	Chassis wheelbase
GVWR =	Gross vehicle weight rating of the chassis
CW =	Curb weight of the chassis
CA =	Dimension between the rear of the cab and the centerline of the rear axle or tandem
BOC =	Distance between the back of the cab and the front of the body

# Sub-frames

## Sub-frame Design

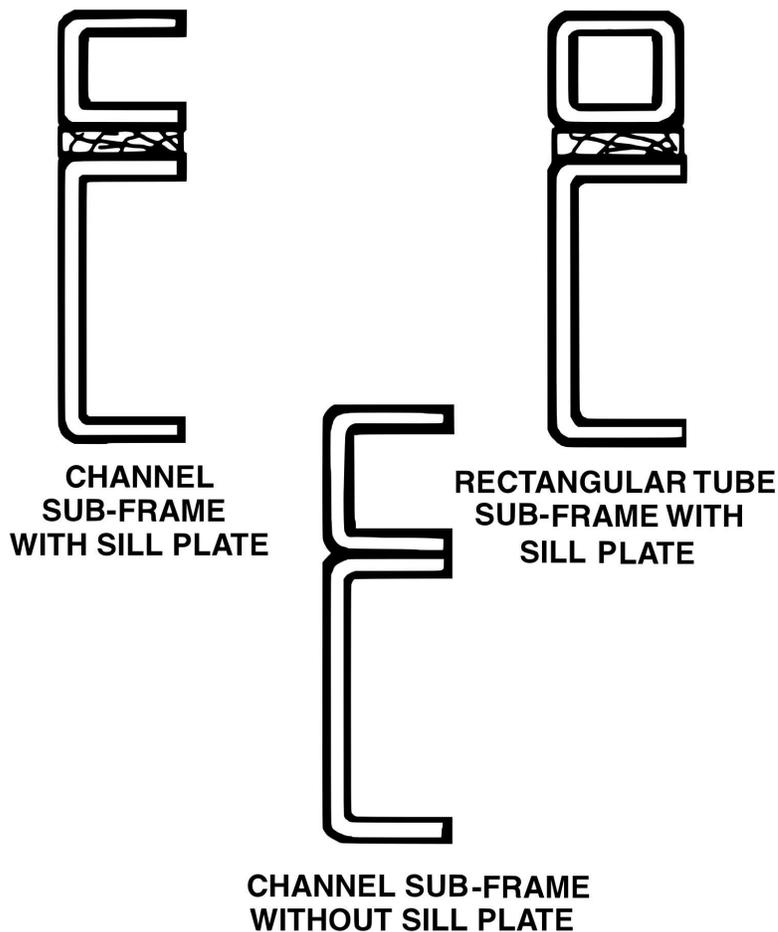


### CAUTION

Do NOT mount bodies directly to the chassis side members by drilling the frame flanges because this weakens the frame and may result in frame failure.

The body must be secured to the chassis frame so that both static and dynamic stresses are transmitted without causing excessive localized stress which could result in frame damage, or affect road handling of the vehicle.

The body unit must be mounted to the chassis frame using a sub-frame assembly. The illustration below shows some typical sub-frame design cross sections.



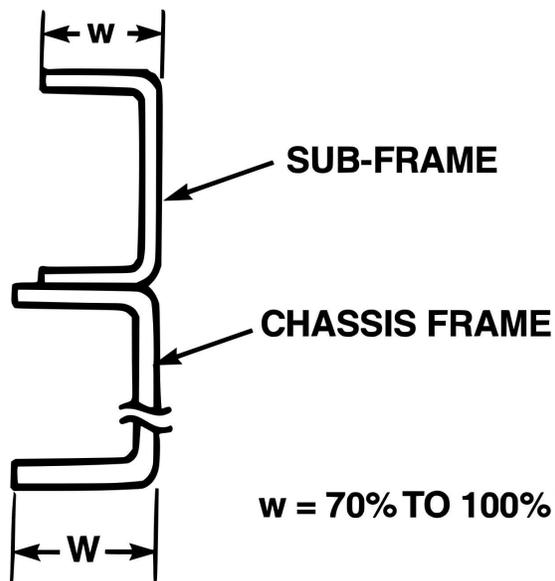
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Typical Subframe Cross Sections

# Sub-frame Construction

The sub-frame should be fabricated from channel steel to form a continuous longitudinal channel. The width of the sub-frame flange must be between 70 – 100% of the frame rail flange width.

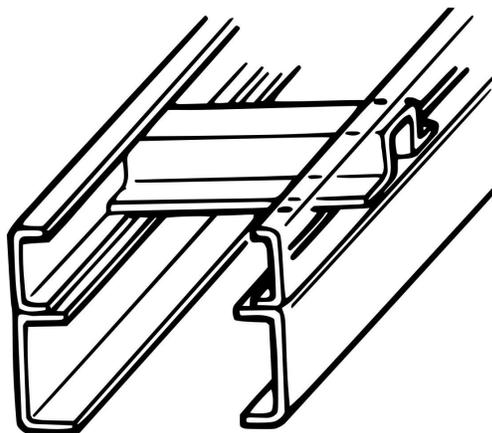


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Subframe Flange Width

The lower sub-frame flange must be mounted flush with the upper flange of the chassis side member. Do not mount the sub-frame at an angle to the chassis. Use either cross members, or the body unit itself, to connect the sub-frame sides together. (Refer to the Body Builder; Chassis, Frame bulletin for additional information.)

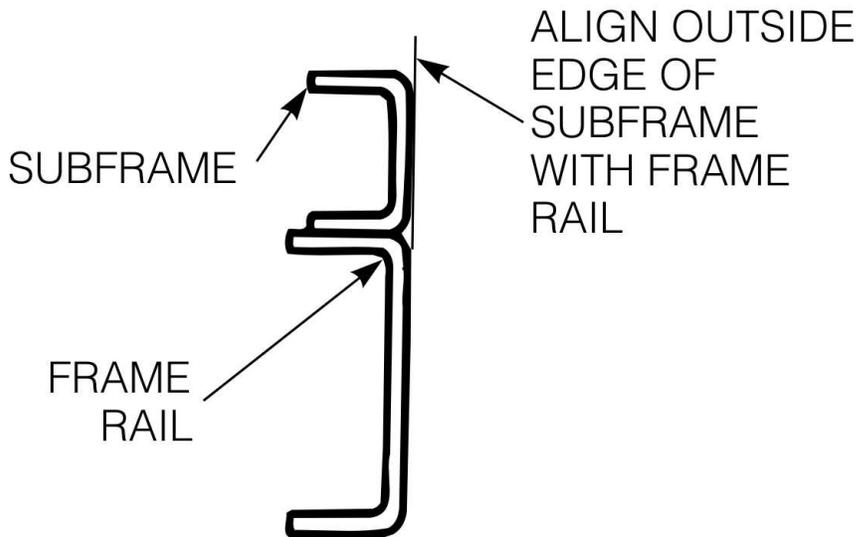


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Subframe Crossmember

The sub-frame channel opening should face inward toward the longitudinal center line of the chassis. Also, the sub-frame web surface should align with the frame rail web as shown in the following illustration.



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Fig. 1 Align Sub-frame to Frame Rail

*Notes*

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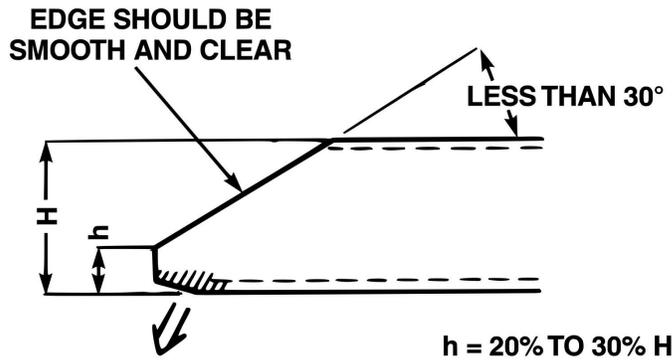
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# Sub-frame End Shape

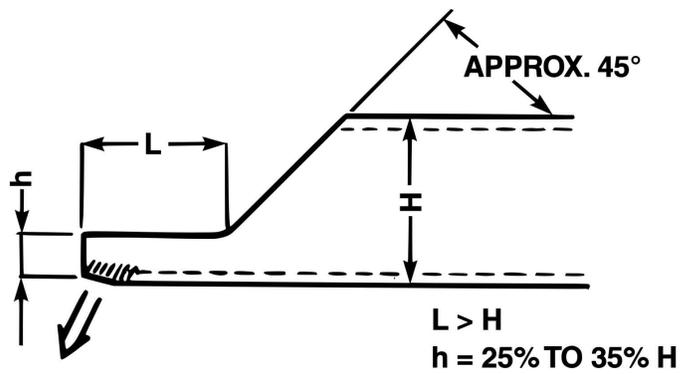
To reduce the possibilities of stress concentration on the chassis frame, the front end of the sub-frame should be shaped so that rigidity gradually decreases. Additionally, the front end of the sub-frame should extend as far forward as possible. The following three figures illustrate three different types of sub-frame end design.



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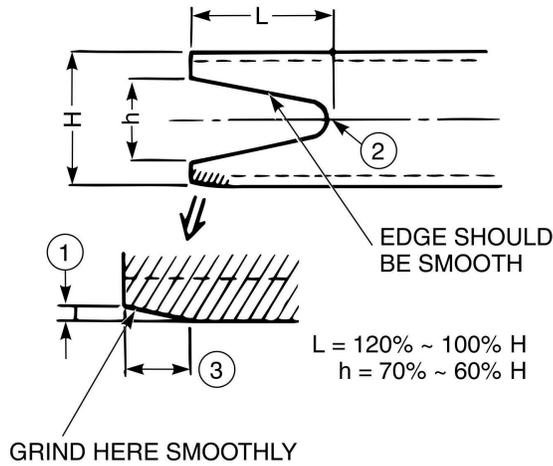
Fig. 2 Preferred Sub-frame End Design



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Fig. 3 Alternate Sub-frame Design



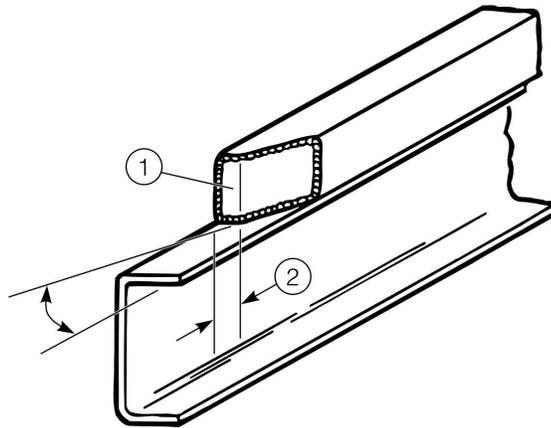
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Fig. 4 Alternate Sub-frame End Design

1. 1 mm (0.04 in)	3. 15 – 20 mm (0.59 – 0.79 in)
2. R = 20 mm – 30 mm (0.79–1.18)	

If the sub-frame is fabricated from square or rectangular tubing, the end should be cut as shown.



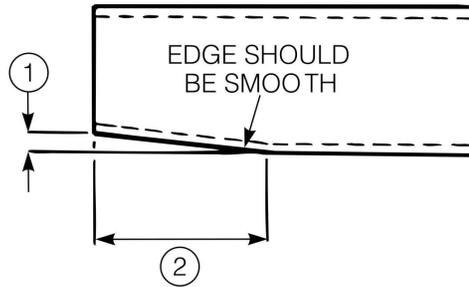
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Fig. 5 End-Cut Design for Square or Rectangular Tube Sub-frame

1. Blank Off with 1.5 mm (0.06 in) Thick Sheet Metal	2. 15 – 20 mm (0.59 – 0.79 in)
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Sub-frame designs shown in figures above are recommended. If body design or other factors prevent any of these designs from being used, the sub-frame shape shown in figure below may be used.



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Fig. 6 Alternate Design

1. 57 mm (0.06 in)	2. Approximately 200 mm (7.9 in)
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If mounting a tank or other rigid type of body, the sub-frame shapes shown in Figure 2,3 and 4 must be used.

**Notes**

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# Sub-frame Attachment

A variety of methods can be used to secure the sub-frame assembly to the chassis frame. They include U-bolts, flexible attachments and bolted plates. When the sub-frame is installed, however, a mounting sill plate made of hardwood or other suitable material may be installed between the sub-frame and the chassis frame to protect the flange surfaces, and to allow for irregularities in the surfaces of the two frame members.

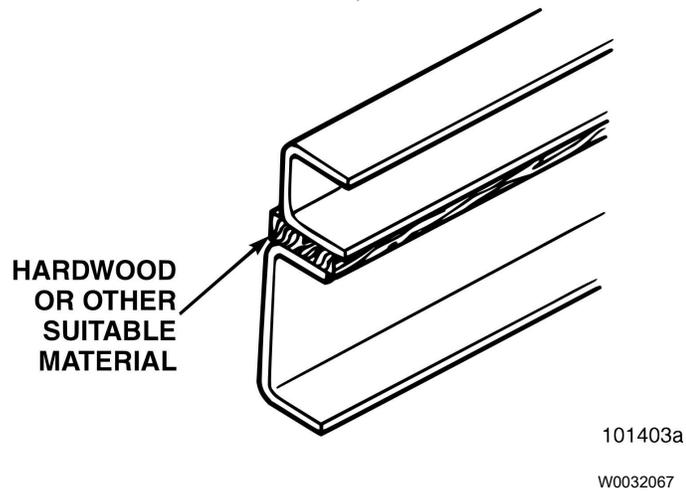
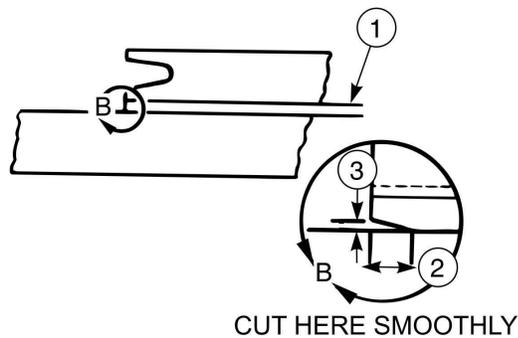


Fig. 7 Sub-frame Sill Plate

Sills must be chamfered 12.7 mm (0.5 in) at the front end, and tapered approximately 25.4 mm (1 in) from the front end of the sill.



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Fig. 8 Sill Plate Chamfer

1. Hardwood Sill Plate Thickness 12.75 mm (0.5 in)	3. 23 mm (0.91 in)
2. Approximately 30.5 mm (1.2 in)	

# U-Bolts, Tie Bars and Other Types of Clamping Devices Attachment

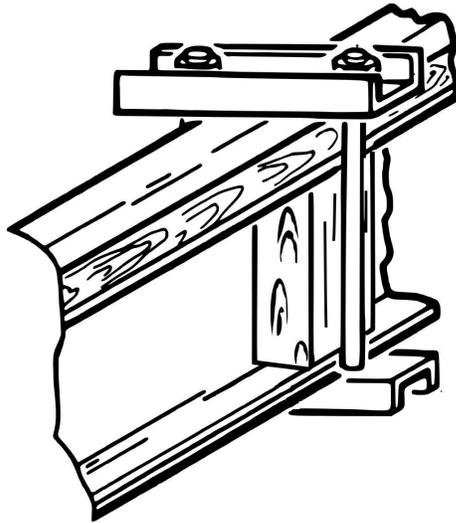
**Note:** U-bolts, tie bars and other similar types of clamping methods rely on friction and a maintained clamping force for attachment. When using these methods of attachment, the surfaces must be free from oils, grease and other agents that could allow slippage and adversely affect the attachment.

When using U-bolts, tie bars or other similar types of clamping methods, install an anti-crush spacer inside the side members to prevent distorting, or crushing the frame when the bolts are tightened. These spacers should be fabricated from seamless angle irons or rectangular/cylindrical tubing, and suitably spot welded into position.



## CAUTION

Do not use U-profile (angle iron) spacers having welded construction. Anti-crush spacers must be of one-piece, seamless construction design.



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Fig. 9 Tie Bar Type Attachment with Anti-Crush Spacers

### Notes

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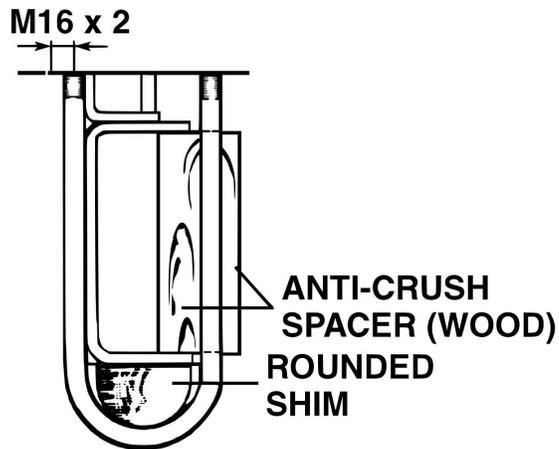
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When round U-bolts are used for body attachment, rounded shims that follow the curvature of the U-bolt must be used.



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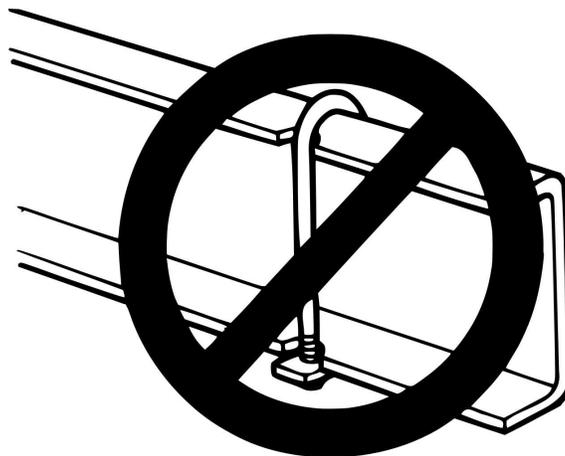
Fig. 10 U-Bolt with Rounded Shim and Anti-Crush Spacer

Body clamps (U-bolts, tie bars, etc.) must not be located in the vicinity of the rear axle or suspension. Additionally, the U-bolts or anchor bolts must not contact the frame rail side member.



**CAUTION**

Do NOT notch the frame rail flanges in order to make a U-bolt or anchor bolt fit. If the frame rail flanges are too wide for the U-bolt, select another size U-bolt or another method of attachment.



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Fig. 11 Do Not Notch Frame Rail Flange

## Bolted Methods of Attachment

The two bolted methods of attachment are rigid mounting and flexible mounting. Both of these methods include clips, brackets and other types of mountings, which are bolted to non-critical areas of the frame rail web. The use of existing holes in the frame is encouraged. But when this is not possible, holes in the frame must be drilled in accordance with the frame drilling methods as outlined earlier in this section.

As a rule, holes in the frame should be located no closer to the top and bottom frame flanges than existing holes that were drilled at the assembly plant.

### Rigid Mounting

Rigid types of mounting should be used for mounting vans or other similar types of bodies. A rigid type of mounting arrangement consists of a bolted plate or bracket welded to the subframe assembly and bolted to the chassis frame. Brackets must be bolted, not welded, to the chassis frame.

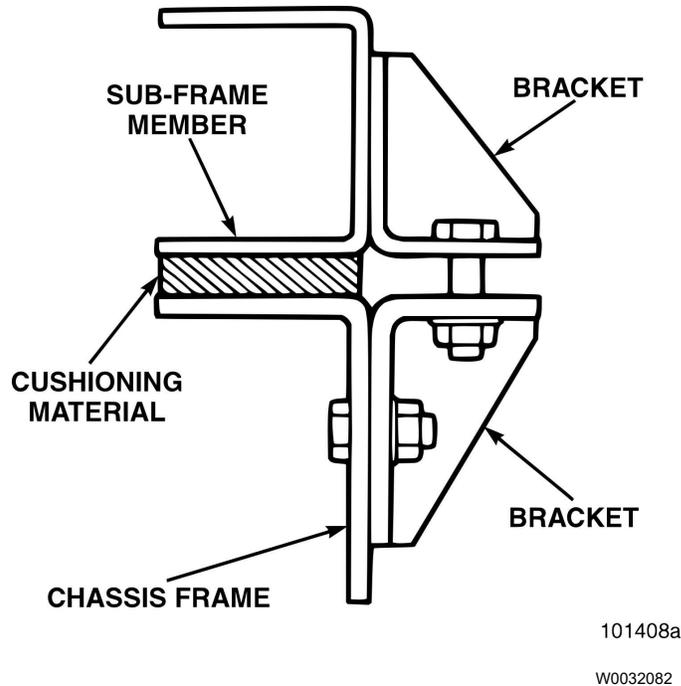


Fig. 12 Bracket-Style Rigid Mount

### Notes

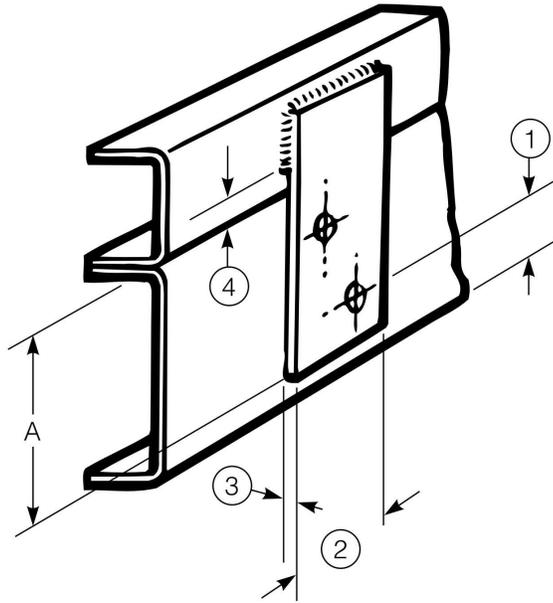
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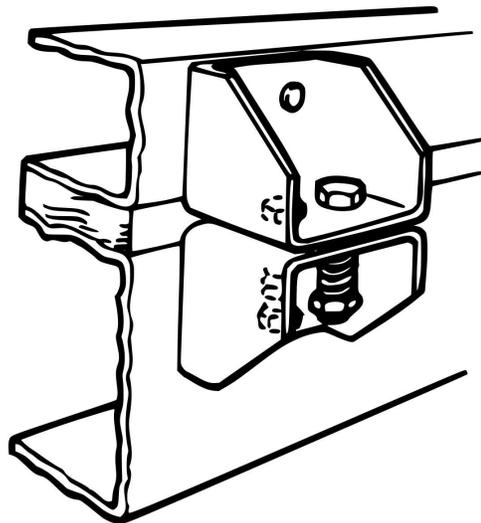
W0032132

Fig. 13 Bolted-Plate-Style Rigid Mount

1. 25.4 mm (1.0 in)	3. 3.8 mm (0.31 in)
2. 60 mm (2.36 in)	4. 15 mm (0.59 in)

### Flexible Mounting

For torsionally stiff types of bodies, such as tanks or refuse bodies, the mounting must allow some flexing of the frame under normal driving conditions. Flexible mounting should be used. Flexible mounting is accomplished by using rubber suspensions or spring-loaded brackets.

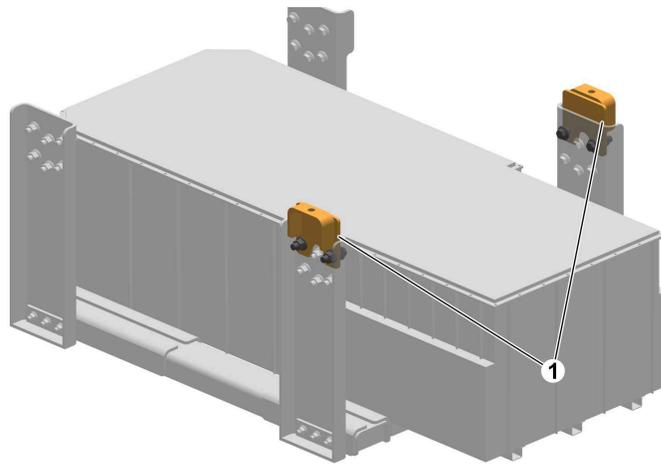


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Fig. 14 Flexible Mounting Arrangement

## Body mounting bracket



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### 1. Bracket

**Note:** Body mounting brackets come standard in the traction battery area. Body builders can use other methods outside of the battery area, as described above in Figs. 9, 10, 12, 13, or 14.

**Note:** Body mounting brackets, as shown in the traction battery area, can be purchased and mounted in other areas where body mounting is desired for cleaner and uniform body mounting. Bracket part 5570-ZS9B1117 can be purchased from your Mack dealer.

# Fasteners

## Fasteners Flange Head, Metric

All metric flange head cap screws used by MACK Trucks, Inc. are zinc or cadmium plated. All metric nuts are cadmium plated and waxed. Torque should be applied to the nut whenever possible. No lubricant is to be used. Where sealer (Alumilastic or equivalent) is used between aluminum and ferrous surfaces, the threads on the bolt must be wiped clean after insertion, and before threading the nut onto the bolt.

**Torque to be applied when the flanged fastener spins on steel plate or ferrous castings:**

### *Screws in Property Class 8*

Size	Torque ft-lb (Nm)
M6	7.4 ± 1.1 ft-lb (10 ± 1.5 Nm)
M8	18 ± 3 ft-lb (24 ± 4 Nm)
M10	35 ± 6 ft-lb (48 ± 8 Nm)
M12	62.7 ± 8.1 ft-lb (85 ± 11 Nm)
M14	103.2 ± 18.4 ft-lb (140 ± 25 Nm)
M16	162.2 ± 25.8 ft-lb (220 ± 35 Nm)
M18	214 ± 33.1 ft-lb (290 ± 45 Nm)
M20	317.1 ± 51.6 ft-lb (430 ± 70 Nm)
M22	428 ± 66.3 ft-lb (580 ± 90 Nm)
M24	545.8 ± 88.5 ft-lb (740 ± 120 Nm)

### *Screws in Property Class 10.9*

Size	Torque ft-lb (Nm)
M6	8.9 ± 1.5 ft-lb (12 ± 2 Nm)
M8	22.1 ± 3.7 ft-lb (30 ± 5 Nm)
M10	44.3 ± 7.4 ft-lb (60 ± 10 Nm)
M12	77.4 ± 14.8 ft-lb (105 ± 20 Nm)
M14	129 ± 22.1 ft-lb (175 ± 30 Nm)
M16	203 ± 33.1 ft-lb (275 ± 45 Nm)
M18	265.5 ± 40.6 ft-lb (360 ± 55 Nm)
M20	398 ± 66 ft-lb (540 ± 90 Nm)

# Electrical/Electronic information



## CAUTION

Follow the parking recommendations whenever the vehicle needs to park for a longer period.  
Failure to follow the parking recommendations can fully discharge the traction batteries and 24 V system batteries.

## Battery Charging

### 24 V System Batteries Charging

The 24 V system has two 12 V batteries connected in series to provide a 24 V output. This system uses a battery Equalizer to equalize the voltage between the two 12 V batteries.

The traction batteries charge the 24 V system batteries through the DC/DC converter. The DC/DC converter steps down 400 V from the traction batteries to 24 V to charge the 24 V system batteries. When the 24 V system batteries are fully discharged, always disconnect the battery cables and charge each battery separately. This prevents damage to other system circuits from the voltage coming into the battery.

### Traction Battery Charging



## CAUTION

Follow the parking recommendations whenever the vehicle needs to park for a longer period.  
Failure to follow the parking recommendations can fully discharge the traction batteries.

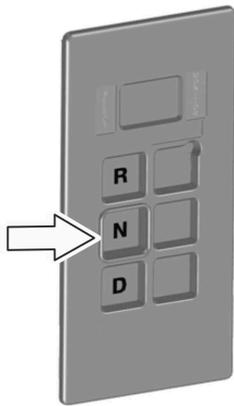
**Note:** If the 24 V system batteries are fully discharged due to any unnoticed battery consumption or for any other reason, then it is important to charge the 24 V system batteries before charging the traction batteries.

In order to deliver maximum efficiency, it is highly recommended that traction batteries are:

- Placed on charge prior to depleting beyond 10% to State of Charge
- Placed on charge until that they charged to full State of Charge

## Charging

1. Park the vehicle safely next to the charging point. Move the Drive Selector to “N” position.



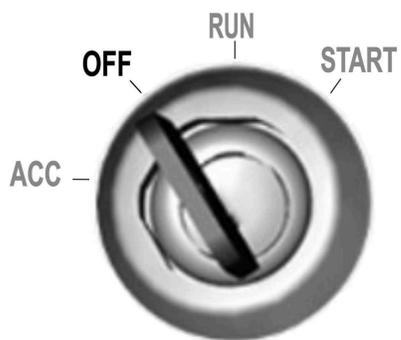
T3196533

2. Apply parking brake.



T3196514

3. Turn the key to the OFF position. Remove the key to secure the vehicle.



T3196515

4. Turn the key to the OFF position. Remove the key to secure the vehicle.

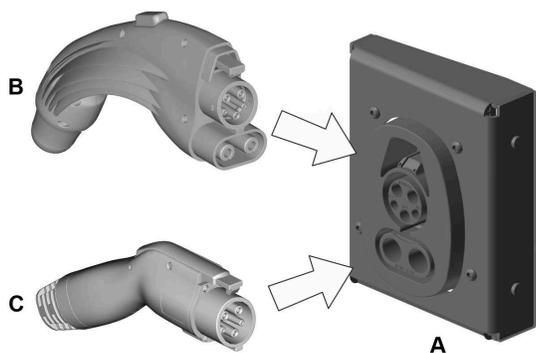
- A mode 2 or 3, type-1 EVSE or mode 4, Combo-1 ECSE can be used to charge.
- Open the charging inlet cap on the charging socket.
- Plug the charging cable into the charging socket.

**Note:** Inspect the charging cable for any damage prior to use:

- Cut or chafin
- Kinking or swelling issues
- Exposed wiring
- Damaged pins, plugs, caps
- Signs of water intrusion
- Signs of shorting.

**Note:** On opening the charging inlet cap, look for dirt, debris and foreign objects. If needed, clean before connecting the charger.

**Note:** Charger socket is never live, just for power input and will not provide output power.



T3196274

A — CCS1 Charging Interface (receiver)

B — Combo-1 connector (for DC fast charging)

C — Type1 connector (for AC Charging)

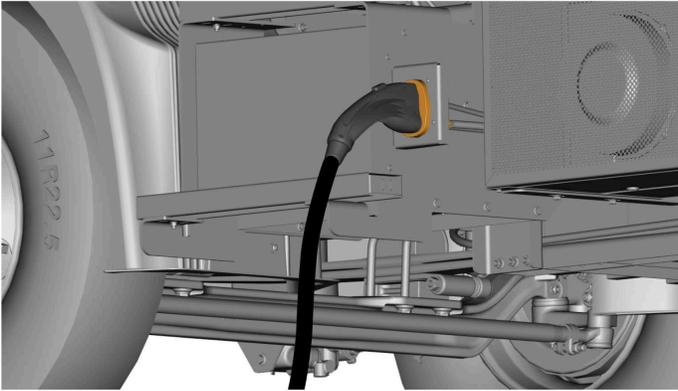
**Note:** For extra safety or to ensure your vehicle cannot be unplugged while charging use a lock to lock in the charger plug.

5. The instrument cluster displays the charging progression and State of Charge (SOC). The instrument cluster displays the rate of charging, time to 100% SOC and SOC level.

6. When fully charged, the charging socket at the vehicle side will stop drawing current.

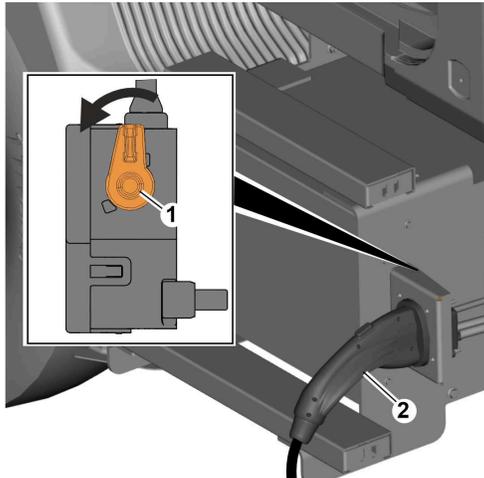
**Note:** If the charging process needs to be interrupted prior to the battery reaching 100% full state, simply turn the starter key to the ON position and the charger will automatically stop.

7. Pull the charging cable plug to unlock the charger.



T3196534

8. If the charging cable plug cannot be disconnected, retract the pin manually to disconnect the plug. Rotate the lever (1) and remove the charging cable plug (2).

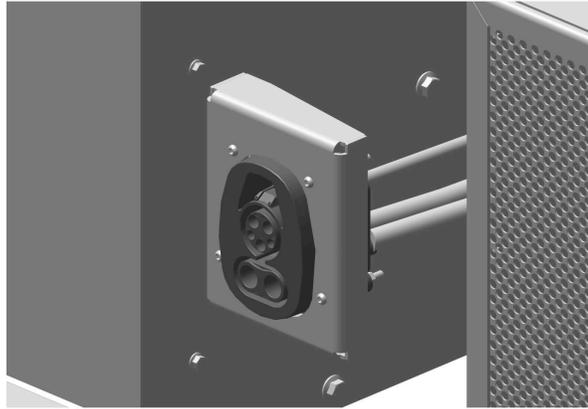


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**Note:** The vehicle cannot be started while charging. It means the vehicle is physically unable to move until the EVSE (Electric Vehicle Supply Equipment) has been completely removed.

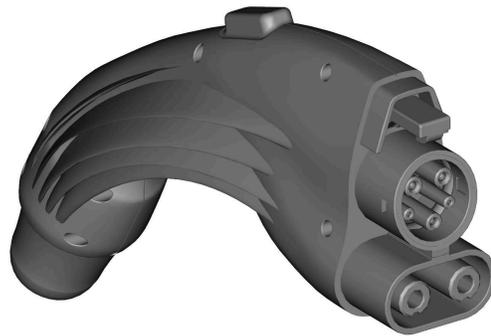
## Charging interface and charging connector

The CCS1 is a charging interface between a charging station or power outlet and a vehicle. The CCS1 charging interface is compatible with the combo-1 connector. The combo-1 connector supports only DC charging.



T3196272

**CCS1 charging interface**



T3166316

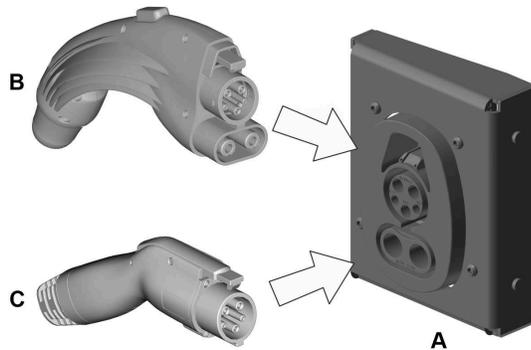
**Combo-1 Connector**



T3196273

**TYPE1, J1772 Connector**

## Start charging



T3196274

A — Charging Socket

B — CCS1, Combo-1 connector (for DC fast charging)

C — Type1 connector (for AC Charging)

The following conditions must meet to start charging the traction batteries:

- The truck is stationary
- The parking brake is applied
- Key in OFF position.

### DANGER

#### **Risk of electrical discharge.**

Damaged charging cable, connector, and charging interface can cause electric shocks and arcs resulting in serious burns or death.

Ensure that the charging cable, connector, and charging interface are not damaged, dirty, or wet.

Do not use charging equipment that is in bad condition.

Report to the responsible person if any damage is found.

### DANGER

#### **Risk of electrical discharge.**

Cleaning the dirty or wet charging interface may cause electric shocks and arcs resulting in serious burns or death.

Do not attempt to clean the dirty charging interface.

Contact your local Mack Trucks dealer.

- 1 Ensure that the charging cable is properly connected to the charging station or power outlet.
- 2 Open the cover of the charging interface.
- 3 Align the connector with the charging interface and push the connector fully into the charging interface.

**Note:** To initiate charging, the charging connector must be connected to the charging interface properly.

When charging is initiated, the yellow LED in the charging interface blinks.

**Note:** It can take up to 15 seconds for the truck to prepare for charging.

- 4 If charging starts automatically, wait for the blinking yellow LED to switch to the blinking green LED.

If charging does not start automatically, wait for the blinking yellow LED to turn into a steady yellow LED, and then start the charging from the charging station.

- 5 During charging, the green LED blinks. When the traction batteries are fully charged, the blinking green LED turns into a steady green LED.

**Note:** During charging, it is normal for the connector and the charging interface to become warm. If the connector or the charging interface appears to be warmer than normal, stop the charging immediately. Contact your local authorized Mack Trucks dealer.

## Stop charging

- 1 To unplug before full charge is reached (during charge), turn the starter key to ON position. This will disconnect the charging circuits.
- 2 Note that the truck cannot be started while the charging cable is connected to the truck. Turning the starter key to ON will stop the charging process but the SEADrive® vehicle will not power up until the charging cable is physically disconnected from the truck.
- 3 Once the vehicle is plugged into the charging socket, the charger plug may be manually released if necessary.



### WARNING

Ensure the cover is closed properly and fully covers the charging interface. The cover protects the charging interface from dirt and water.

## Signals during charging

The LED indicators in the charging interface give basic information about the charging.

LED Indicator Color	Steady/Blinking	Description	Action Required
Green	Steady	The traction batteries are fully charged	Disconnect the charging cable if you want to drive away, otherwise no action is needed
Green	Blinking	Charging is about to start or charging	No action is needed
Yellow	Steady	Charging is paused	Truck or charger has paused charging: If possible, start the charging from the charging station. If it is not possible to start the charging, wait for the scheduled charging to begin
		Charging stop switch is pressed	Disconnect the charging cable
Yellow	Blinking	A charging cable is connected to the charging interface but the charging has not started yet	Wait for the charging to start automatically or, if needed, start the charging from the charging station
Red	Steady	A fault prevents charging	Check that the charging equipment is in good condition and properly connected. Also, check that the charging station is connected to the mains and is working. Contact the authorized Mack dealer if the fault remains
Red	Blinking	The conditions are not met to start charging the traction batteries	Check the following: <ul style="list-style-type: none"> <li>• Parking brake is applied</li> <li>• Chassis switch is in the On position</li> <li>• Truck is stationary</li> </ul>

## Accident While Charging

If the vehicle is involved in an accident while charging:

- Press the charging stop button and wait for the steady yellow LED.
- Wait until the steady yellow LED turns off, disconnect the charging connector from the charging interface.
- If the charging connector is not disconnected, retract the locking pin manually. Perform the procedure given in the “Manually retracting the locking pin”, page 70 section.

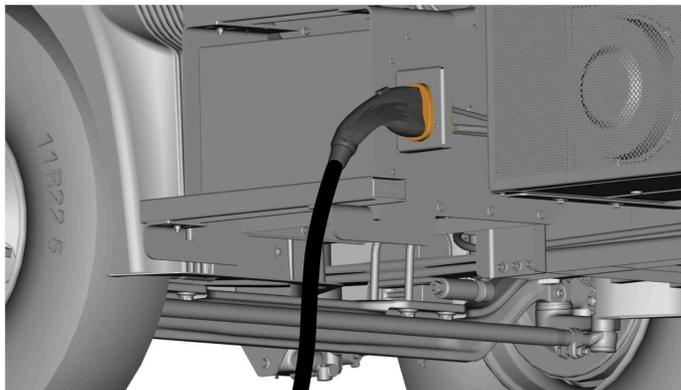
## Manually retracting the locking pin



### WARNING

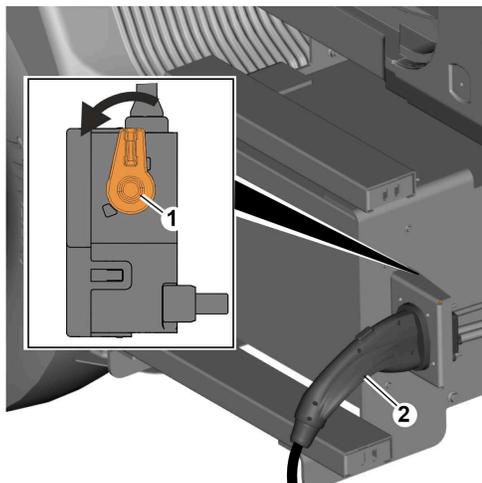
Risk of arc flash (high temperature explosion). Turn off the chassis switch before manually retracting the locking pin.

- 1 Disconnect the charging cable plug to unlock the charger.



T3196534

- 2 If the charging plug cannot be disconnected, retract the pin manually. Rotate the lever (1) and remove the charging plug (2).



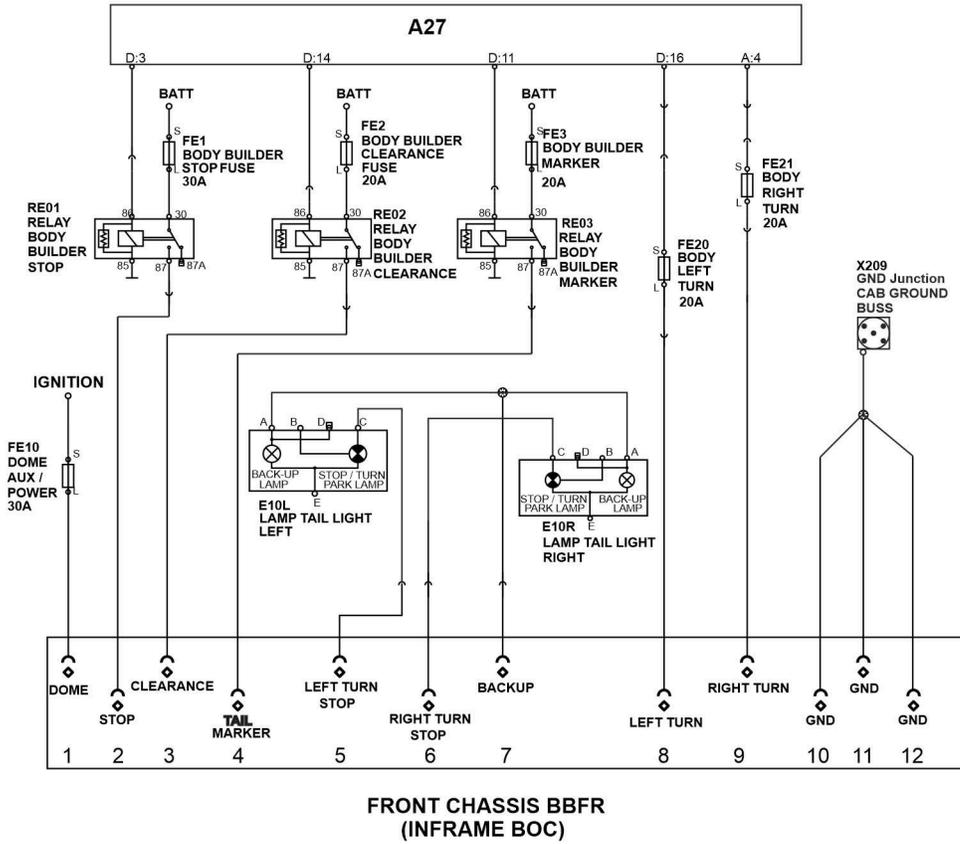
T3196535



# Body Builder Connectors

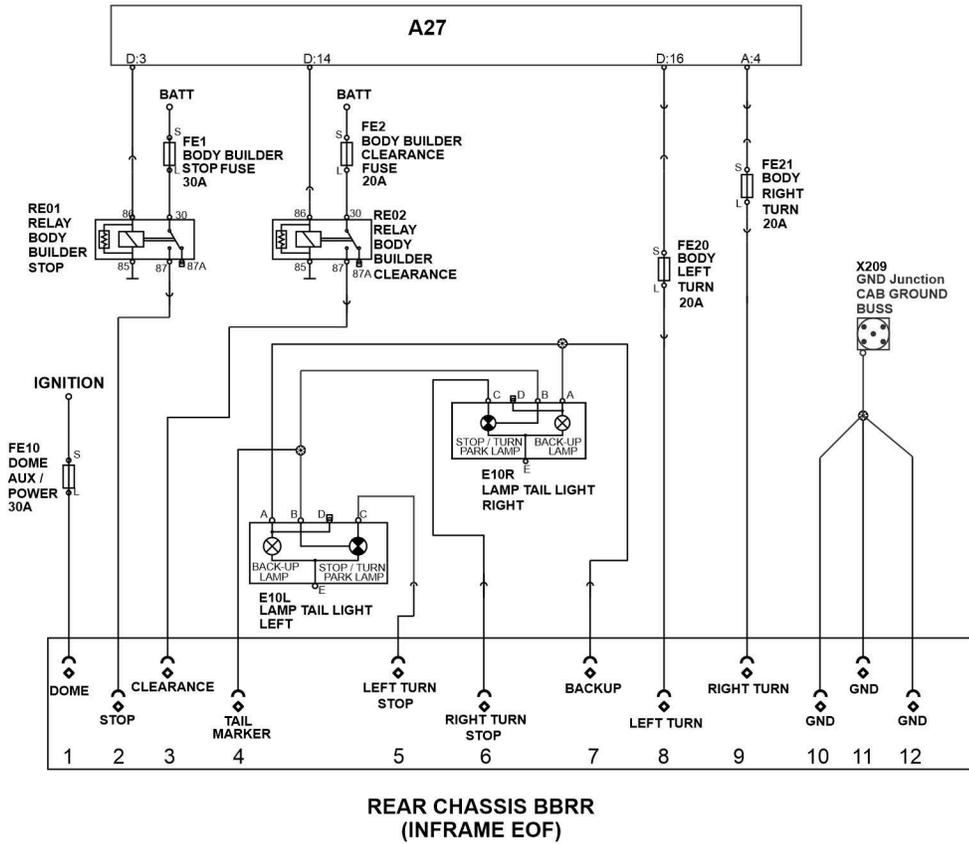
## Body Builder Wiring Inframe Connections

### Body Builder Interface – Front Chassis BOC (Back Of Cab)



T3183468

# Body Builder Interface – Rear Chassis EOF (End Of Frame)



T3159407

## POST DESCRIPTION

Front Chassis BBFR — Inframe BOC	Rear Chassis BBRR — Inframe EOF
1. Dome light	1. Dome light
2. Stop	2. Stop
3. Clearance	3. Clearance
4. Tail Lamp	4. Tail Lamp
5. Left turn stop	5. Left turn stop
6. Right turn stop	6. Right turn stop
7. Reverse	7. Reverse
8. Left turn	8. Left turn
9. Right turn	9. Right turn
10. Ground	10. Ground
11. Ground	11. Ground
12. Ground	12. Ground



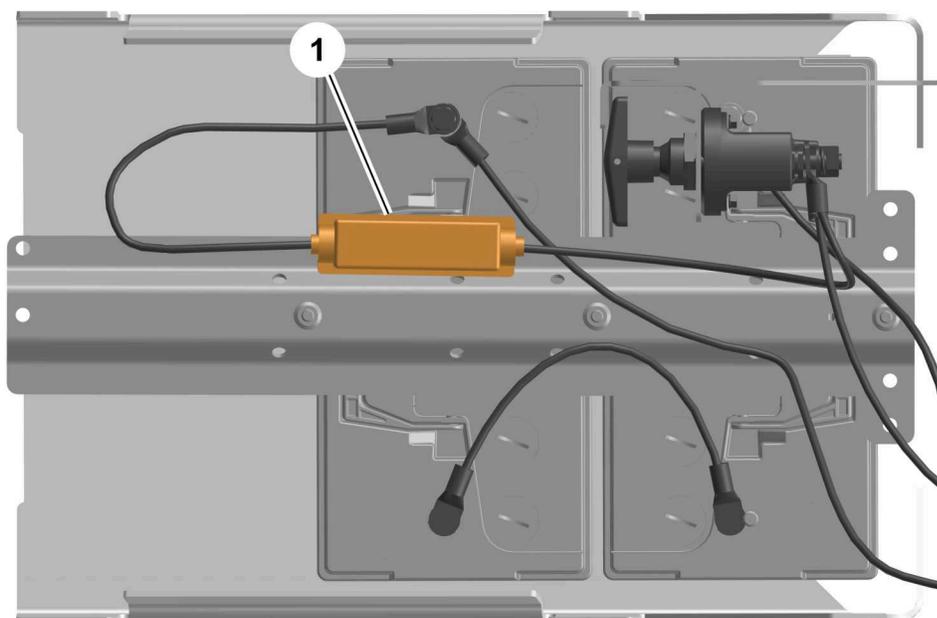
## Fuse and relay box



### WARNING

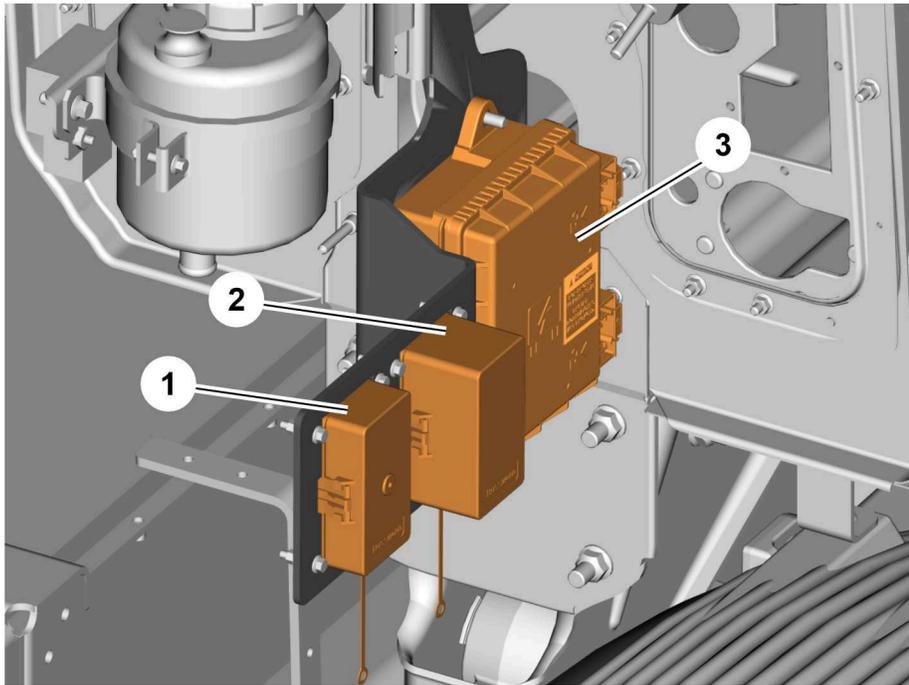
Always use fuses with the correct rating when changing. Never overfuse. Never install a fuse higher than the instructed rating.

Fuses are designed to protect the electrical system's circuits from overload and are usually only tripped as a result of a short circuit. For this reason, if a fuse has blown you should always have an authorized Mack workshop determine the cause.



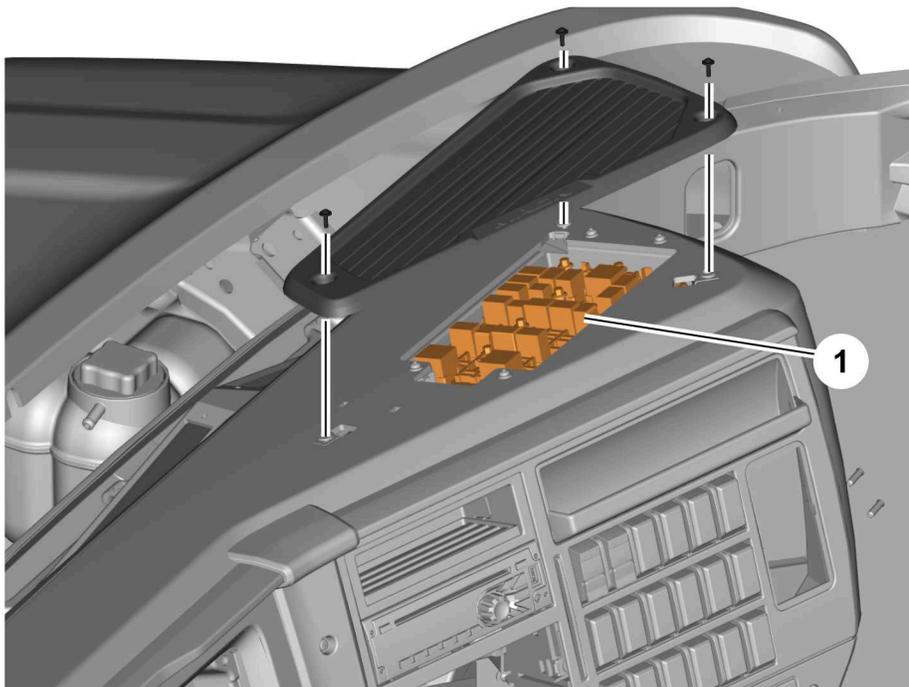
T3196384

1 Main fuse (150A)



T3196385

- 1 External Fuse Box
- 2 External Relay Box
- 3 External Fuse and Relay Center (EFRC)

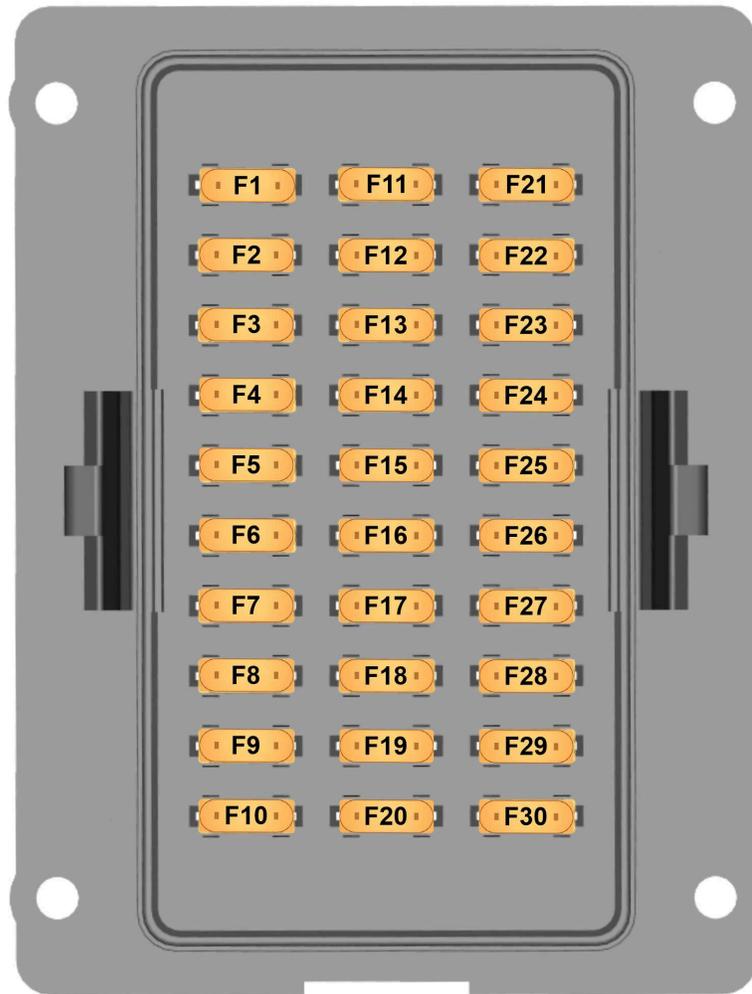


T3196386

- 1 Fuse and Relay Center — Instrument panel

# Fuse box

## External fuse box



T3196387

### Fuse positions

Position	Rated current	Function
F1	2A	Inclination Sensor
F2	5A	MCU 24V Switched
F3	15A	Inverter 24V Unswitched
F4	2A	EPTO
F5	2A	PDU 24V Unswitched
F6	2A	Coolant Sensor
F7	20A	VMU 24V Unswitched
F8	5A	VMU 24V Switched
F9	15A	AC Condenser Fan
F10	10A	Air Compressor Fan
F11	15A	Cooling Pump - 24V Switched
F12	10A	Heater Pump - 24V Unswitched

F13	20A	Radiator Fan 1 - 24V Switched
F14	20A	Radiator Fan 2 - 24V Switched
F15		
F16	10A	BMS - 24V Unswitched
F17	2A	HV Heater 24V SW
F18	5A	PRV - 24V Switched
F19	10A	Reverse Lights - 24V Switched
F20		
F21	2A	HVAC - 12V Switched
F22	2A	HVAC - 12V Unswitched
F23		
F24		
F25	5A	HV Charger - 12V Unswitched
F26		
F27	10A	Cabin Utility - 24V Unswitched
F28	10A	Cabin Utility - 24V Switched
F29	10A	Cabin Utility - 12V Unswitched
F30	10A	Cabin Utility - 12V Switched

**Notes**

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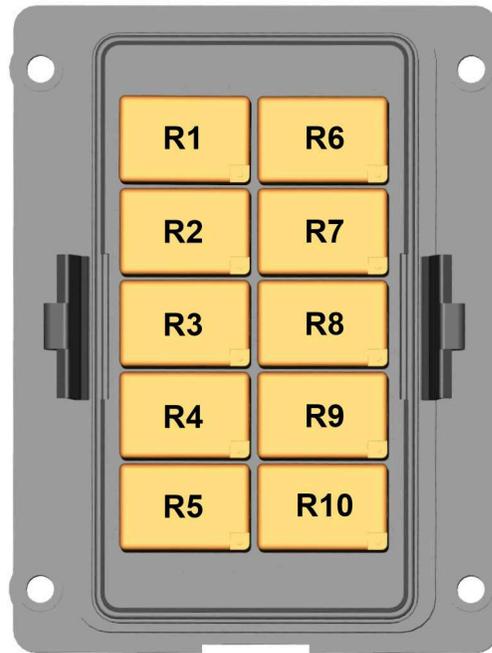


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## External relay box



T3196388

### Fuse positions

Positon	Coil	Function
R1	12V	Reverse Lights
R2	24V	Inverter Activate
R3	24V	Charge Mode for BMS
R4	24V	Air Compressor Fan
R5	24V	Pressure Relief Valve
R6	12V	12V Switched Power, Caution: 12V Coil
R7	24V	Heater Pump
R8	24V	Air Condenser Fan
R9	24V	MCU Activate
R10	24V	Cooling Pump

### Notes

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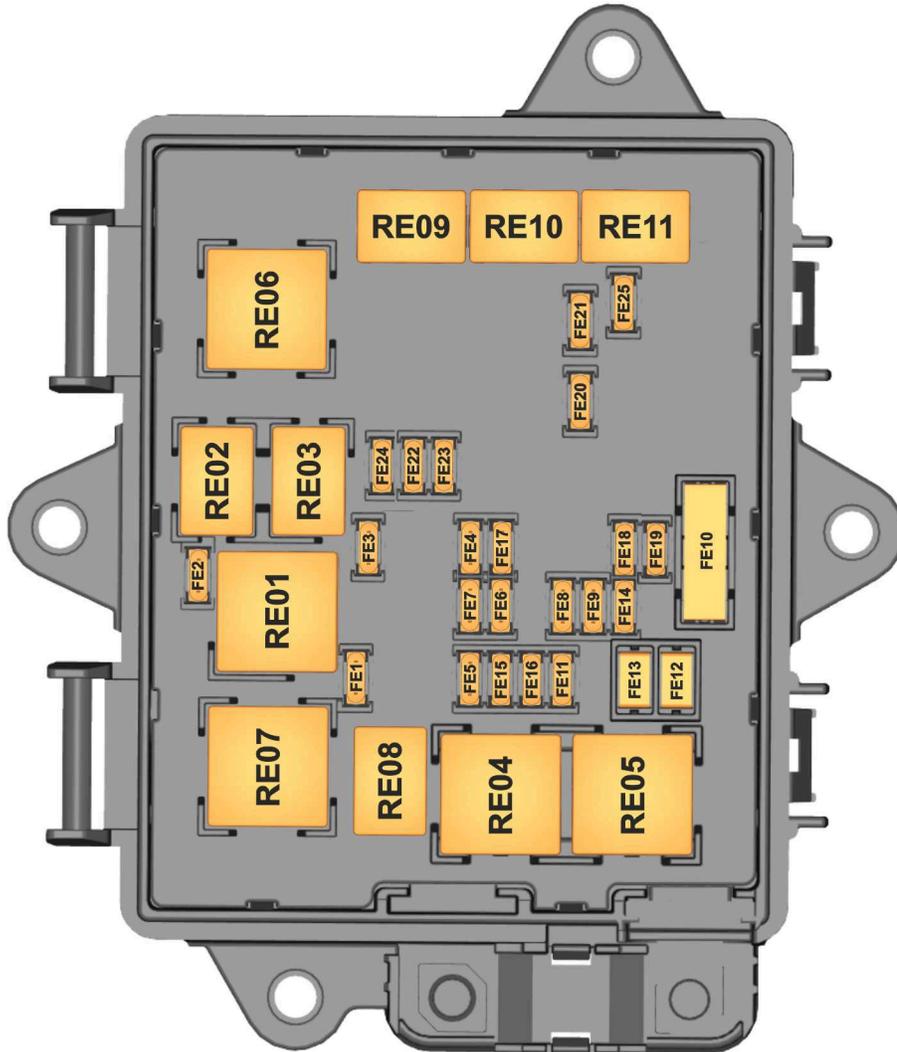


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## External Fuse and Relay Center (EFRC)



T3196389

### Fuse positions

Position	Rated current	Functions
FE1	30A	Body Stop
FE2	20A	Body Clear
FE3	20A	Body Marker
FE4	15A	Spare
FE5	5A	Spare
FE6	10A	Spare
FE7	5A	Spare
FE8	15A	Spare
FE9	15A	Spare
FE10	30A	Body Dome/AUX Power
FE11	10A	ABS IGN

FE12	20A	Spare
FE13	15A	Air Dryer
FE14	5A	Spare
FE15	5A	Spare
FE16	10A	Spare
FE17	15A	Spare
FE18	10A	EVAP/Spare
FE19	15A	Spare
FE20	20A	Body Turn L
FE21	20A	Body Turn R
FE22	10A	Spare
FE23	10A	Voltage Monitor/Spare
FE24	20A	Spare
FE25	15A	Electronic Ignition/Spare

**Relay positions**

<b>Position</b>	<b>Function</b>
R01	Body Stop
R02	Body Clear
R03	Body Marker
R04	EMS Spares
R05	Ignition
R06	Spare
R07	Spare
R08	Spare
R09	Spare
R10	Spare
R11	Spare

# Fuses and Relay Center (FRC), Instrument Panel



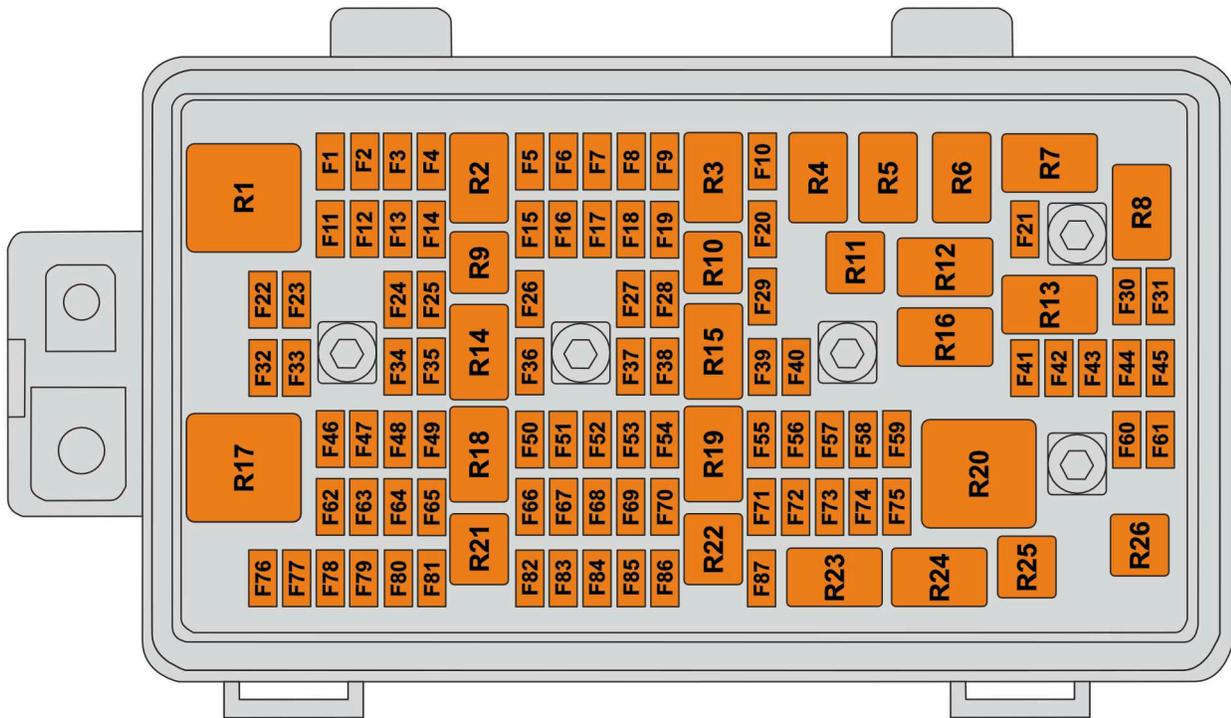
## WARNING

Always use fuses with the correct rating when changing. Never install a fuse higher than the instructed rating.

**Note:** If possible turn off the electrical component, before changing the fuse. The fuse holder may burn, if the electrical component remains switched on.

The fuses and relays are located under the center console of the instrument panel.

Back of the FRC cover, a decal is placed. The decal shows the location of fuses and relays and what they are used for.



T3196440

## Fuse positions

Positions	Coil	Functions
F1		OPEN
F2	10A	HVAC
F3		DR HEATED SEAT/ COOLER
F4	10A	RADIO
F5	30A	SPARE
F6	20A	SPARE
F7	20A	SPARE
F8	15A	BODY BUILDER
F9	10A	USB CHARGE PORTS

F10	20A	CUSTOMER USE (LOW VOLTAGE DISCONNECT 1)
F11	10A	SPARE
F12	20A	DASH POWER PORTS
F13		OPEN
F14		OPEN
F15	30A	BODY BUILDER MODULE
F16	20A	RP 1226 (FUSE NOT SUPPLIED)
F17	15A	SPARE
F18		OPEN
F19	30A	NEUTRAL POWER
F20	10A	HORN
F21		OPEN
F22	20A	DOOR CONTROL PANEL, RIGHT
F23	15A	JUNCTION CONNECTOR
F24	20A	DOOR CONTROL PANEL, LEFT
F25	5A	TELEMATIC GATEWAY, DOOR CONTROL PANEL
F26	10A	DOME/DOOR INTERIOR LAMPS
F27	20A	LCM3
F28	20A	CUSTOMER LVD1
F29	5A	EXTERNAL FUSE RELAY CENTER
F30	5A	SPARE
F31	5A	IGNITION
F32	15A	CUSTOMER IGNITION
F33	10A	AIR SOLENOID SWITCH
F34	10A	RP 1226 (FUSE NOT SUPPLIED)
F35	15A	SPARE
F36	5A	SPARE
F37	5A	SPARE
F38	5A	SPARE
F39		OPEN
F40	5A	LIGHT CONTROL MODULE
F41	30A	ANTI-LOCK BRAKING SYSTEM
F42		OPEN
F43	15A	SPARE
F44	10A	KEY SWITCH / START ENABLE
F45		OPEN
F46		OPEN
F47	30A	BODY BUILDER IGNITION
F48	15A	HEATED WINDSHIELD

F49	15A	REVERSE LAMPS
F50	20A	SPARE
F51	10A	SPARE
F52	10A	INSTRUMENT CLUSTER
F53	5A	BODY BUILDER MODULE
F54	10A	SPARE
F55		OPEN
F56	10A	SPARE
F57		OPEN
F58		OPEN
F59	10A	SPARE
F60	30A	HVAC FAN
F61	5A	SPARE
F62	10A	SPARE
F63	15A	JUNCTION CONNECTOR
F64		OPEN
F65		OPEN
F66	30A	SPARE
F67	10A	RP 1226 (FUSE NOT SUPPLIED)
F68	10A	RADIO
F69	10A	VECU (VEHICLE ELECTRIC CONTROL UNIT)
F70	10A	PTO
F71	15A	SPARE
F72		OPEN
F73	5A	SPARE
F74		OPEN
F75	25A	WIPER
F76	30A	SPARE
F77	10A	SPARE
F78	25A	LIGHT CONTROL MODULE 2
F79	25A	LIGHT CONTROL MODULE 4
F80	10A	DIAGNOSTIC CONNECTOR
F81	20A	LIGHT CONTROL MODULE 1
F82	20A	LIGHT CONTROL MODULE 6
F83	20A	LIGHT CONTROL MODULE 5
F84	10A	SPARE
F85	5A	SPARE
F86		OPEN
F87	15A	CUSTOMER BATTERY 1

**Relay positions**

<b>Position</b>	<b>Function</b>
R1	ACCESSORY POWER
R2	SPARE
R3	NEUTRAL POWER
R4	VENDOR START ENABLE
R5	SPARE
R6	SPARE
R7	OPEN
R8	OPEN
R9	OPEN
R10	CITY HORN
R11	START ENABLE
R12	HVAC BLOWER
R13	OPEN
R14	REVERSE SIGNAL
R15	SPARE
R16	SPARE
R17	POWER IGNITION 1
R18	SPARE
R19	EMS 2 (ENGINE MANAGEMENT SYSTEM 2)
R20	IGNITION +
R21	OPEN
R22	SPARE
R23	INTERMITTENT WIPER
R24	INTERMITTENT WIPER
R25	OPEN
R26	OPEN

**Notes**

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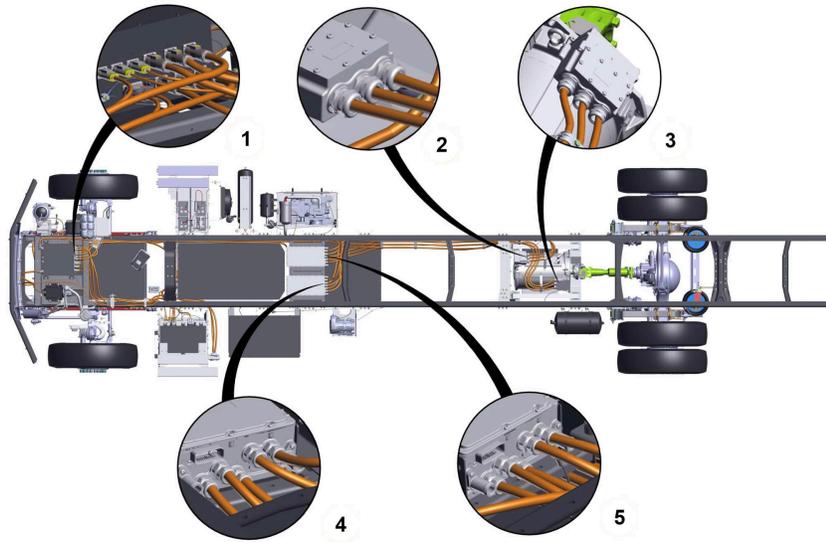


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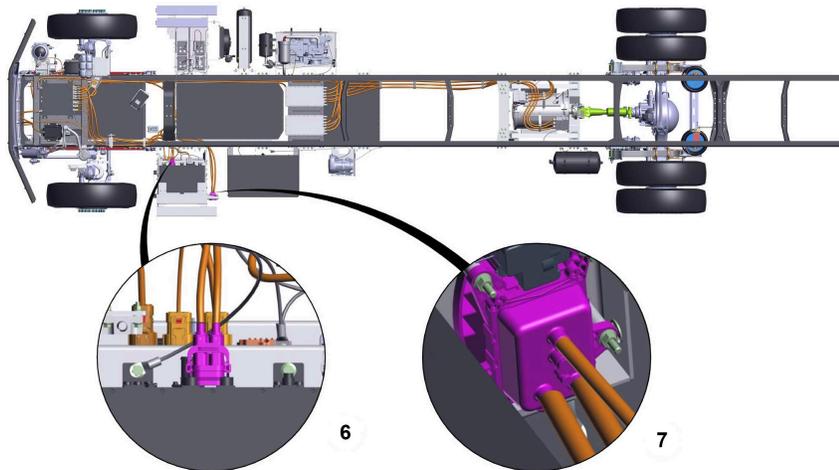


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# 400 V Power Supply

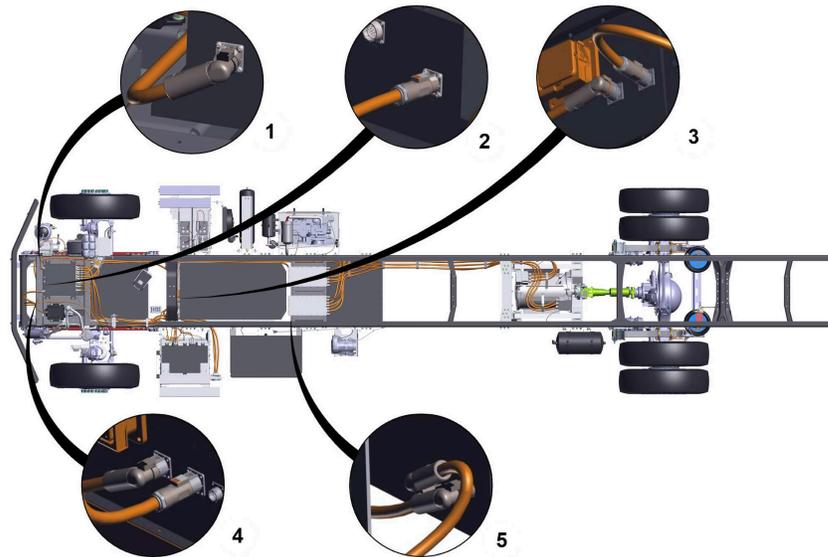


T3196511



T3196512

- 1 PDU Connections
- 2 Front side Motor HV Connections
- 3 Rear side Motor HV Connections
- 4 Primary MCU HV Connections
- 5 Secondary MCU HV Connections
- 6 Charger HV Connection
- 7 Charger Inlet HV Connection



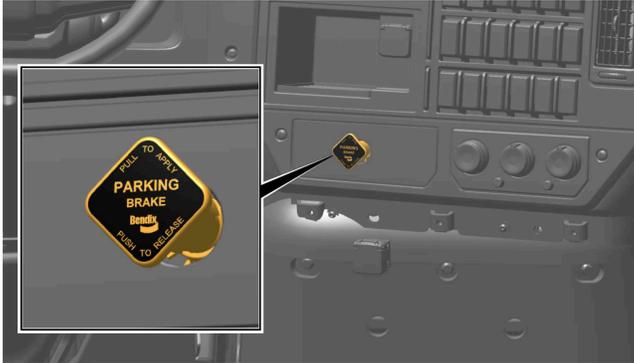
T3196513

- 1 - Rear Traction Battery to - at PDU
- 2 + HV at PDU to + on Front Traction Battery
- 3 + (Right) - (Left) on Front Traction Battery, - Front Traction Battery to + Mid Traction Battery
- 4 + (Right) - (Left) on Mid Traction Battery, - Mid Traction Battery to + Rear Traction Battery
- 5 + (Right) - (Left) on Rear Traction Battery, - Rear Traction Battery to - at PDU

## 24 V system batteries disconnect

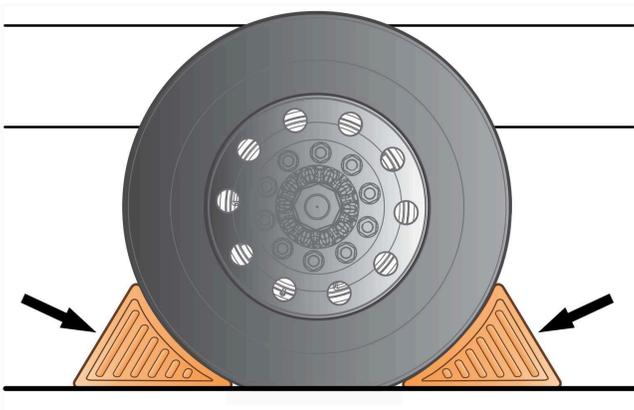
### Procedure to fully disconnect the 24 V system batteries:

1. Apply the parking brake.



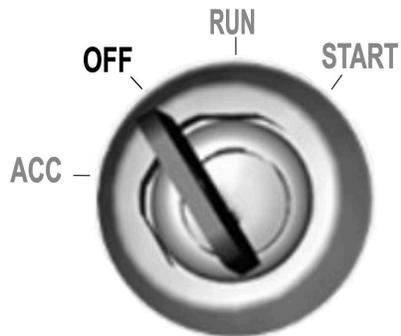
T3196514

2. Chock the wheels.



T3174439

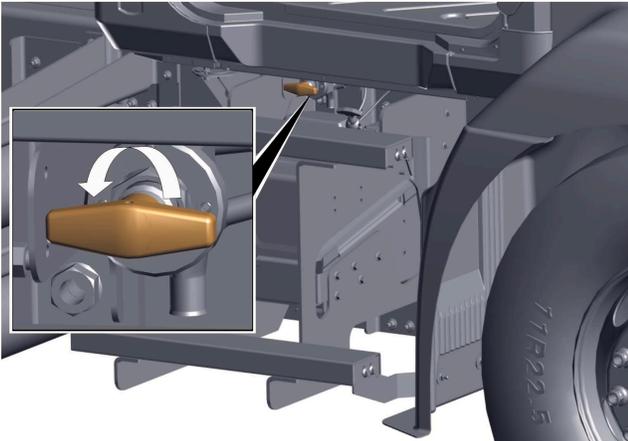
3. Turn off the starter switch and remove the key.



T3196515

4. Turn off the isolation switch to initiate the high voltage disconnection process.

**Note:** The 12V isolation switch isolates power to the vehicle and the BMS. In an emergency do not rely on this switch to disconnect power to all systems.



T3196516

5. To fully disconnect power to the vehicle and the BMS, cut the cable between both the 12 voltage batteries on the right side of the vehicle as well as the cable from the negative post to the chassis. If time allows, these cables can be removed by loosening bolts with a wrench and removing by hand.

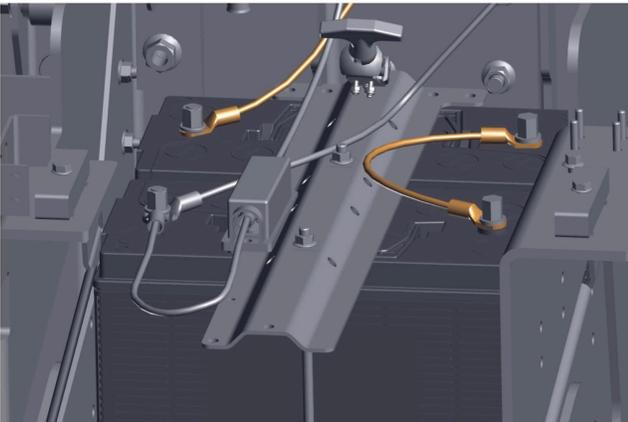
**Note:** Disconnecting the negative cable alone will not cut off the power supply completely to the 24 V / 12 V systems.

**Note:** Use insulated tools to cut the cable.



## WARNING

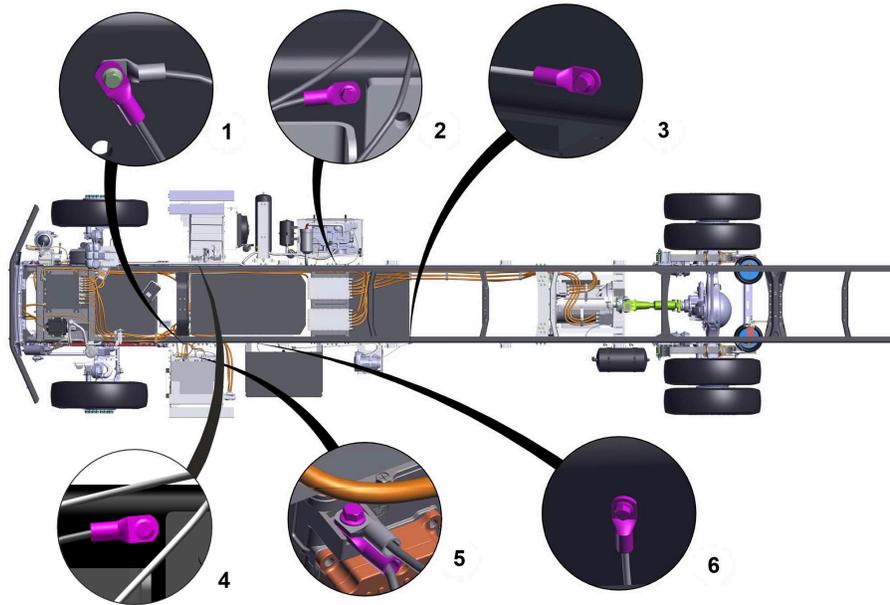
Always assume High Voltage (HV) is still live. Never touch, open, or cut any of the orange cables or components. Wait 10 minutes for the HV to deplete after 24V battery is disconnected.



T3196517

## Grounding locations

### Low voltage grounding location



T3196508

- 1 Converter Ground to chassis rail
- 2 Air Compressor Ground to chassis rail
- 3 ePTO Ground to chassis rail
- 4 12V Battery Ground to chassis rail
- 5 DC/DC Converter Ground post to 3&1 Inverter lug
- 6 Cooling Box Fans Ground to chassis rail

**Notes**

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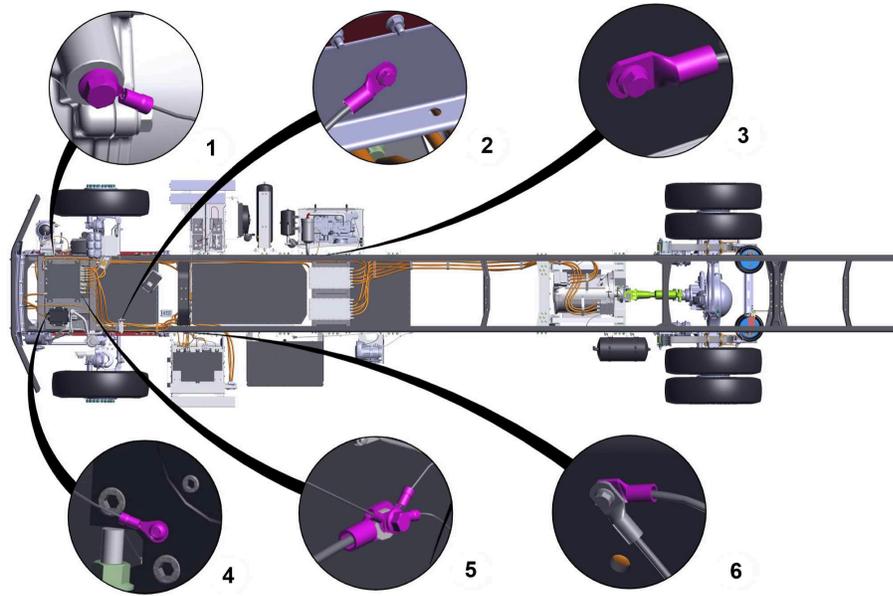


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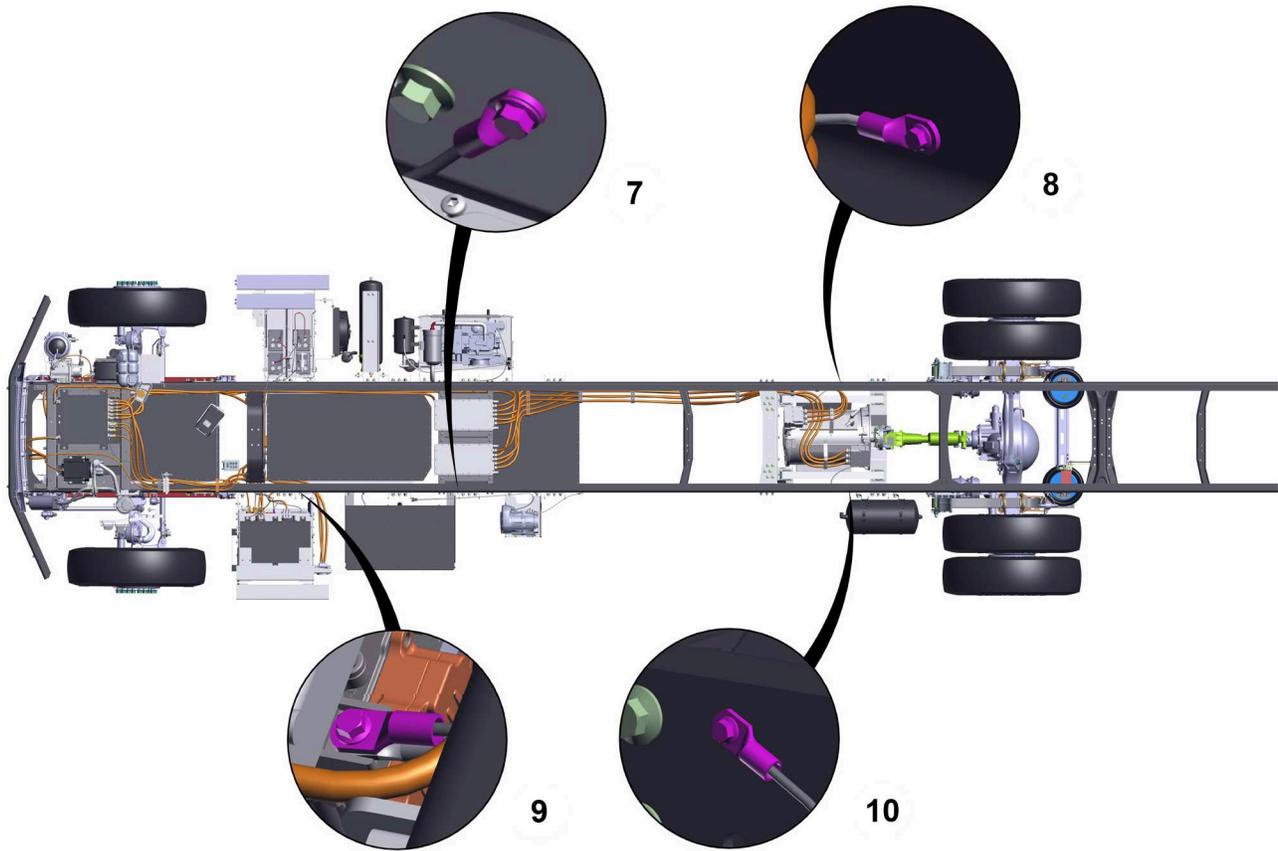


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# High voltage grounding locations



T3196509



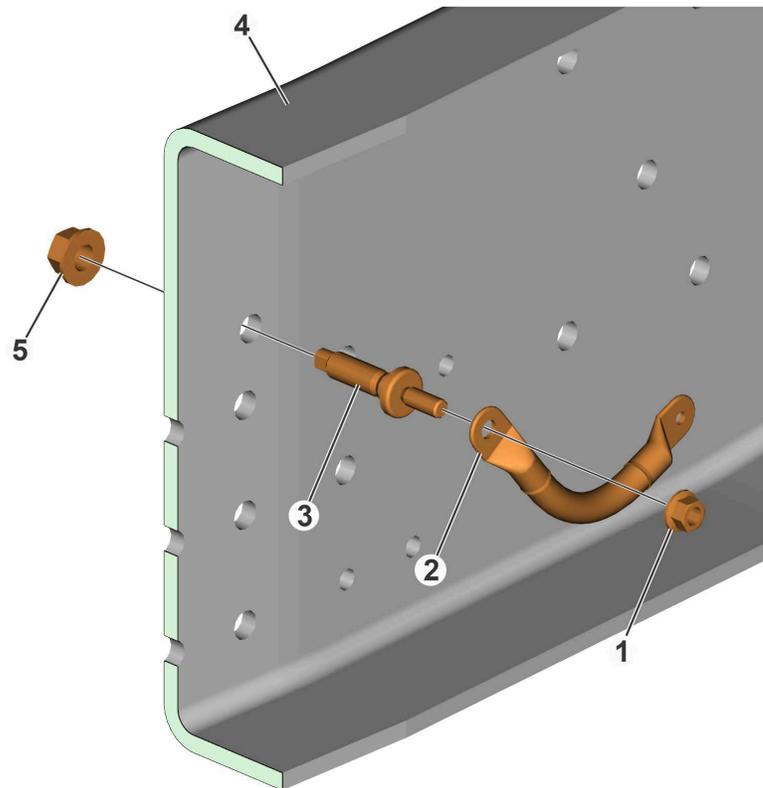
T3196510

- 1 AC Compressor Ground to mounting bracket
- 2 PDU Ground to Cab wall
- 3 Air Compressor Ground to chassis rail
- 4 Steering Pump Ground to steering pump ground lug
- 5 Cab Heater, AC Pump, Power Steering all ground to PDU lug
- 6 Charger Ground to chassis rail
- 7 Driver side MCU Ground to chassis rail
- 8 Front Motor Ground to chassis rail
- 9 Converter Ground lug to chassis rail
- 10 Rear Motor Ground to chassis rail

## Connection to chassis frame

The connection to the chassis should be done according to below.

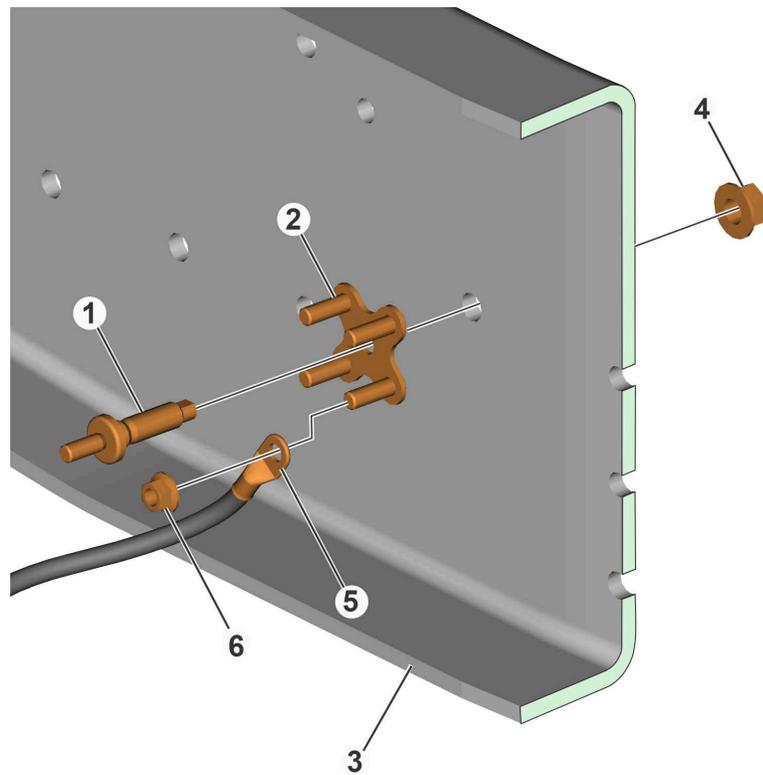
### Single ground connection to chassis frame



T3174456

- 1 Nut (990941)
- 2 Ground terminal
- 3 Press screw (60113900)
- 4 Frame rail
- 5 Nut (990943)

## Multiple ground connections to chassis frame



T3174457

- 1 Press screw (60113900)
- 2 Busbar (22300425)
- 3 Frame rail
- 4 Nut (990943)
- 5 Ground terminal
- 6 Nut (990941)

### Notes

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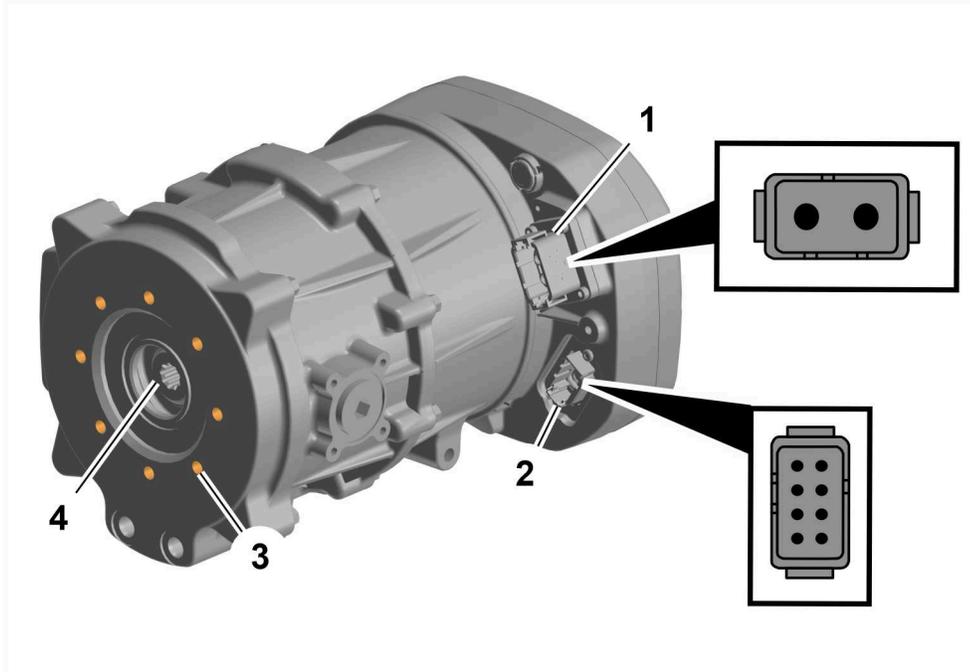
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# Mechanical ePTO

## Overview



T8196480

1	High voltage connector
2	Low voltage connector
3	Mounting screw hole for auxiliary equipment
4	Output shaft

### Notes

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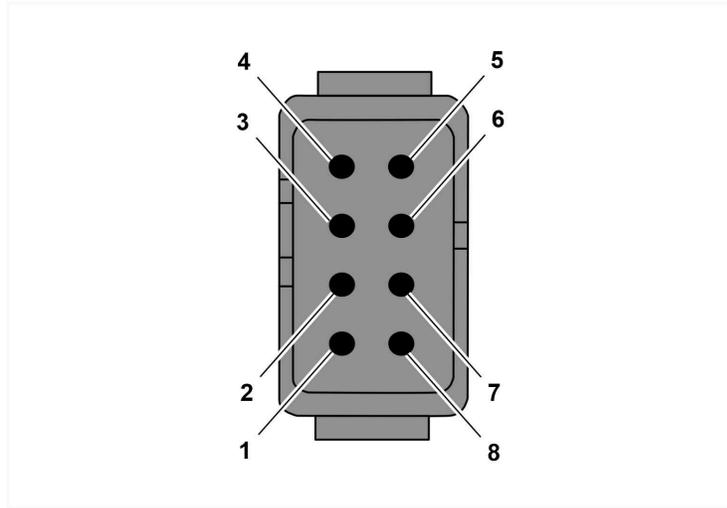
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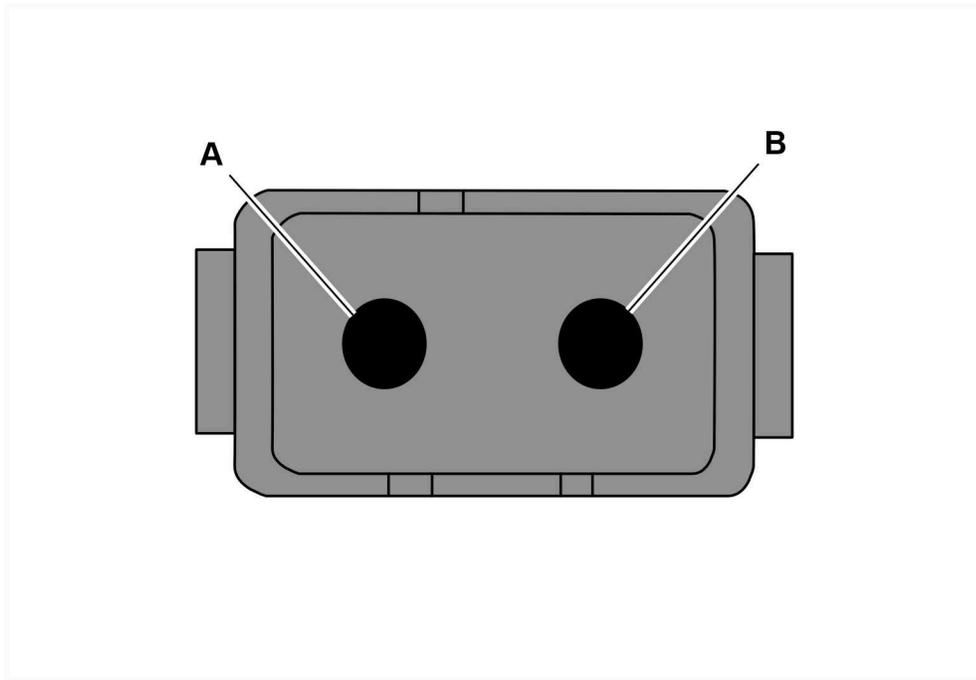
## Low voltage connector



T8196481

Pin number	Name	Description
1	VCC	9 - 36 V DC control power
2	GND	9 - 36 V DC control ground
3	CAN-H	CAN High
4	CAN-L	CAN Low
5	STO-0	E - Stop on
6	STO-1	E - Stop off
7	HVIL-0	HVIL input
8	HVIL-1	HVIL output

## High voltage connector

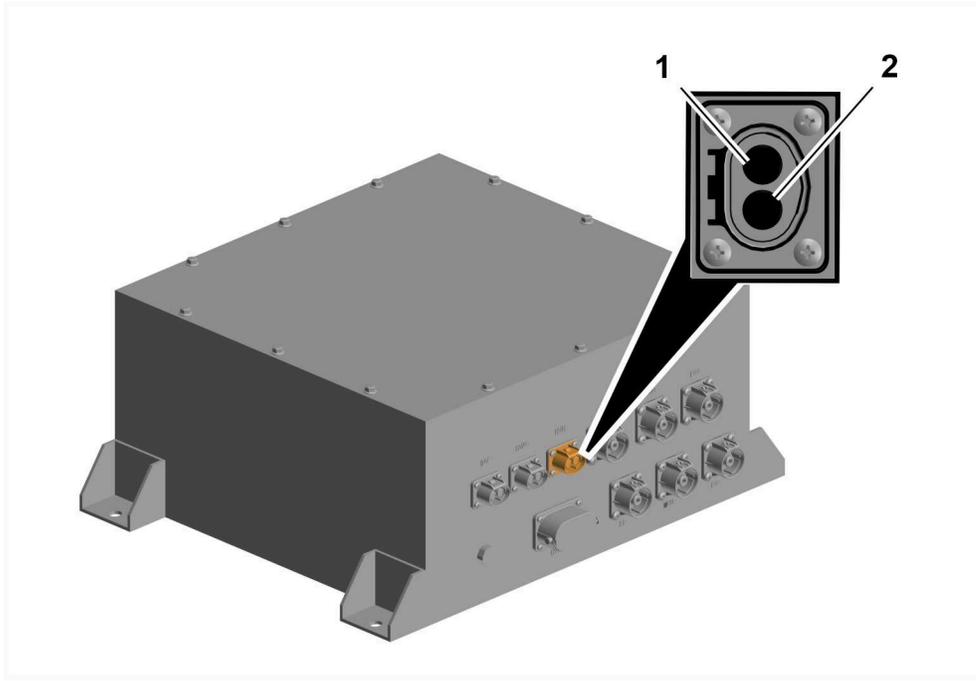


T8196482

Pin	Name	Description
A	BATT +	200 - 800 V DC power
B	BATT -	200 - 800 V DC ground

In an electric vehicle, the power take-off is an electric motor (Mech. ePTO) that converts the electric power to mechanical power. The electric motor (mech. ePTO), is a DC motor and is cooled by the hydraulic fluid work return. It operates at 10 kW DC power. It is connected to a hydraulic pump or other auxiliary equipment. The electric motor (mech. ePTO) receives voltage supply from the traction batteries through PDU (Power Distribution Unit). The gVCU also controls the speed of electric motor (mech. ePTO) and manages the power supply based on different driving condition.

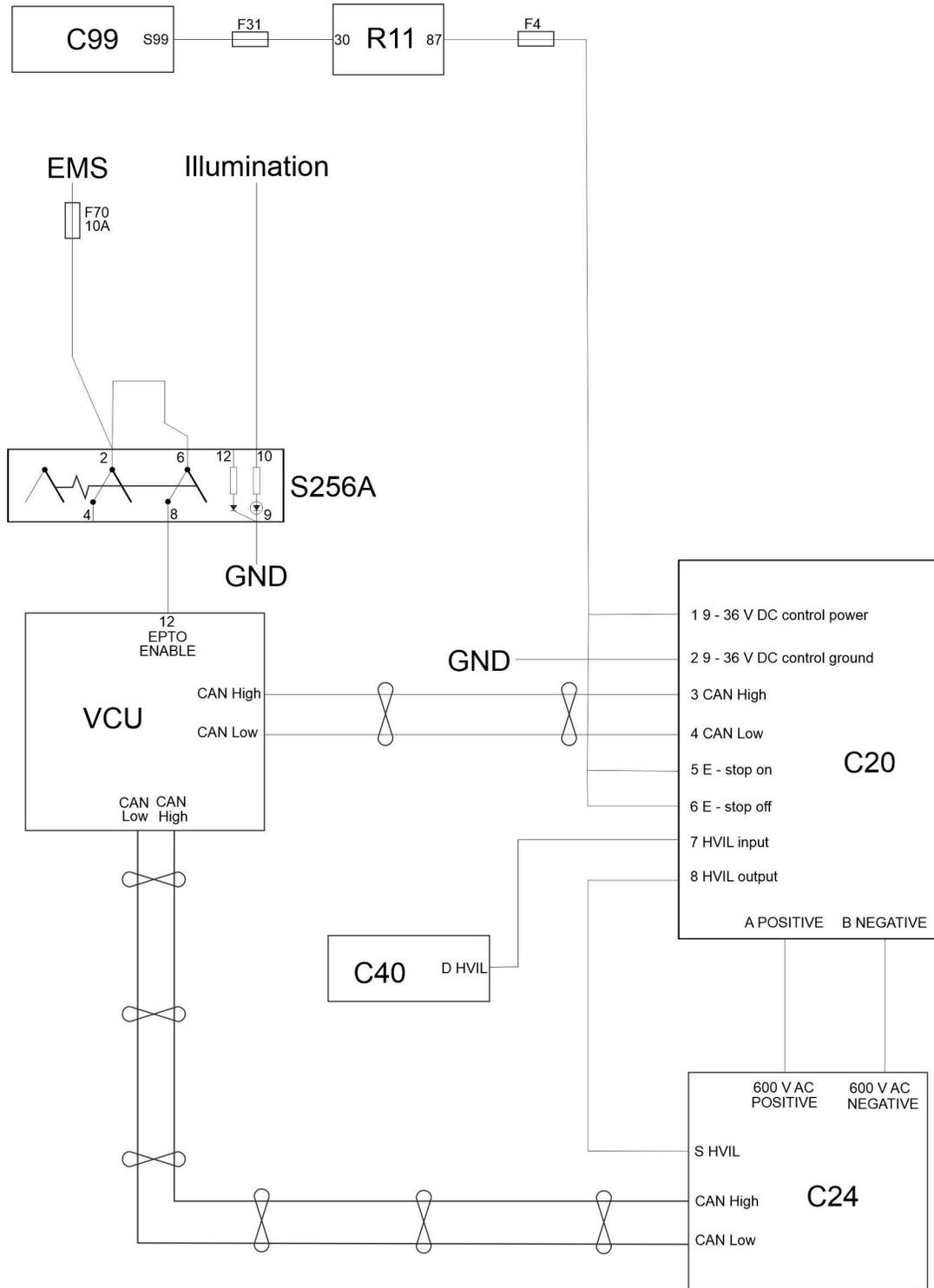
# PDU



T8196483

1	200 - 800 V DC power
2	200 - 800 V DC gound

# Wiring schematic



T3196537

C20	EPTO
C24	PDU
C40	Dilong charger
C99	24/12 Eaton DC DC converter
R11	Ignition relay
S256A	EPTO switch
VCU	gVCU

*Notes*

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# ePTO

Kit part number is 5570-ZS9V0572

**Note:** The PDU must be replaced when adding the ePTO.  
Part #24444597

Part number	Description	Quantity
ZS9V-0535	ASM - ePTO - ISOLATED	1
ZS9B-0992	EHPU MOUNT - ISOLATOR	1
ZS9B-0991	BRACKET - EHPU MOUNT - ISOLATOR	1
ZS9B-0993	BOSS - ISOLATOR	4
ZS9F-0341	MOUNT - VIBRATION 2 PIECE LORD CB-2202-12	4
ZS9F-0160	FW - REBOUND 54.1 OD X 13.5 IN X 3.4 T	8
ZS9V-0321	MOTOR - ELECTRO-HYDRAULIC POWER UNIT - 10 KW - SAE A 2 BOLT 9 TOOTH - 350 VDC	1
ZS9B-0995	BRACKET - EHPU RISER	2
ZS9F-0059	FHHCS- M12-1.75 X 35 - CLASS 10.9	4
ZS9F-0005	FLHN - M12-1.75 - CLASS 10.9 - TOP LOCK	8
ZS9F-0068	FHHCS - M12-1.75 x 90 - CLASS 10.9	4
ZS9F-0332	FHHCS- 3/8-16 X 7/8 - GRADE 8	4
ZS9H-0273	CABLE-HV-MD-EPTO to PDU	1
ZS9H-0274	CABLE-LV-MD-Chassis Harness to EPTO	1
ZS9H-0295	CABLE-LV-MD-EPTO to PE1 GND	1
ZS9C-0201	SWITCH - PTO - MACK	1
ZS9F-0224	CABLE TIE - SELF AFFIXING FIR TREE PUSH MOUNT - 8"L, 0.25" - 0.28" HOLE	1

## Technical Data

Rated Power	10KW (13.4 HP)
Maximum operating speed	3,500 rpm
Operating temperature range	-40 to 85 °C (-40 to 185 °F)
Continuous rated current	30 A
Continuous torque	21 Nm (15 lb·ft)
Peak torque	30 Nm (22 lb·ft)
Pump Mounting Flange	SAE A, 2 Bolt
Rotation	Clockwise

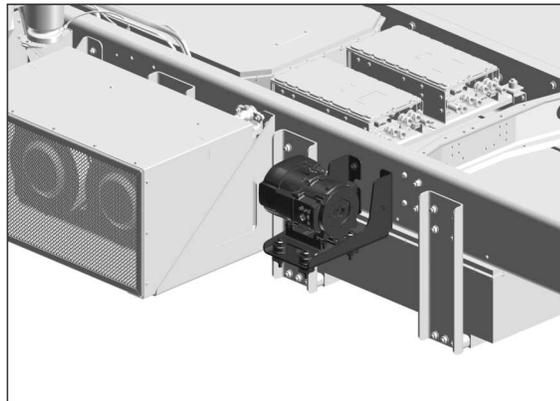
**Note:** ePTO rotates in a clockwise direction viewed from the splined end.

# ePTO Installation Instructions

## CAUTION

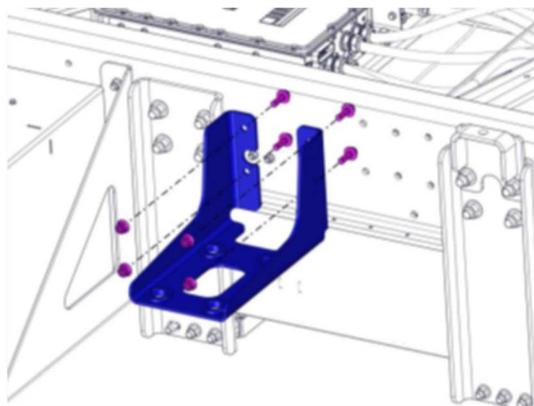
Truck must be decommissioned by a certified Mack BEV dealer before ePTO installation.

1. The location for the ePTO is behind the cooling box on the left side, behind the cab. This is the only designated location provided for ePTO installation.



T3208785

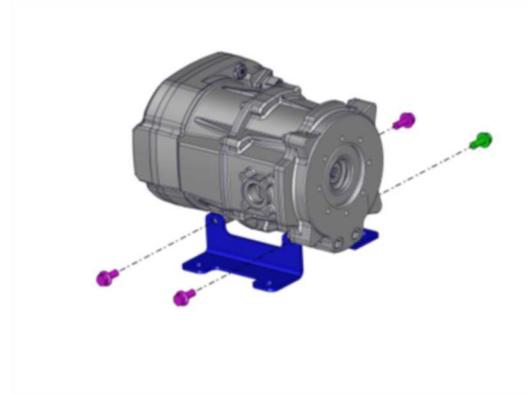
2. Install the ePTO mounting bracket and torque bolts.



T3208786

Diameter	Pitch	Length (mm)	Torque (Nm / lb-ft.)	Class
M12	1.75	35	115 / 85	10.9

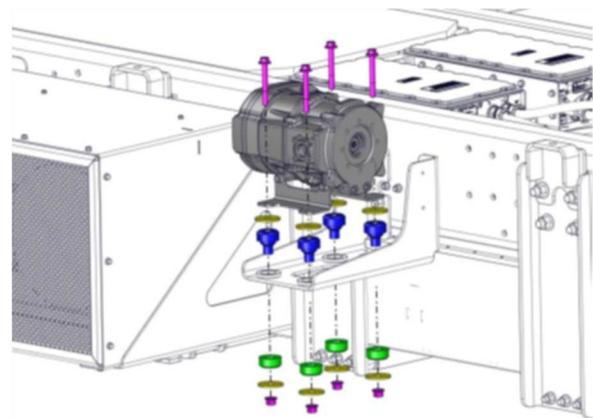
3. Attach the supplied mounting brackets to the ePTO. Do not tighten the green bolt, as it will be used for the ground attachment.



T3208796

Diameter	Pitch	Length (in)	Torque (Nm / lb-ft.)	Class
3/8"	16	7/8"	45 / 33	8

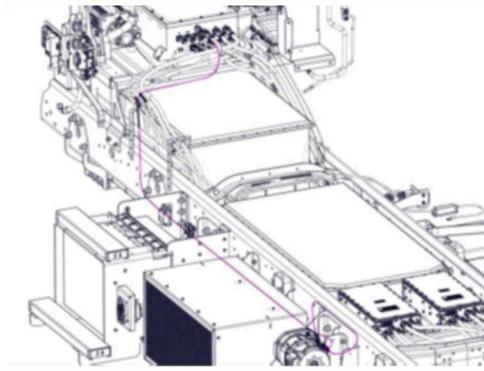
4. Assemble the ePTO to the mounting bracket. Insert the isolators and torque bolts.



T3208787

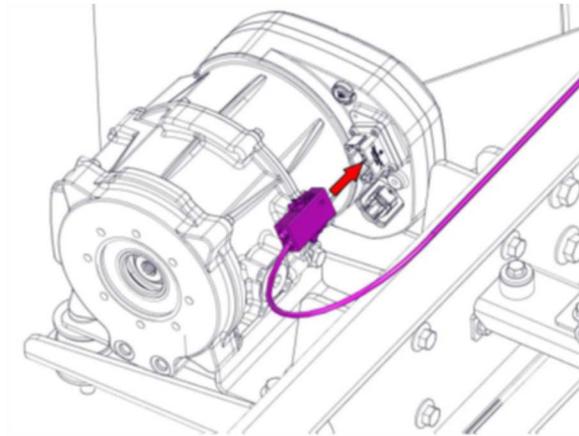
Diameter	Pitch	Length (mm)	Torque (Nm / lb-ft.)	Class
M12	1.75	90	115 / 85	10.9

5. Route the HV cable along the chassis rail from the ePTO to the PDU. Use the existing angle brackets and new zip ties to secure the cable routing.



T3208811

6. Attach the HV connector to the ePTO.



T3208788

7. Use butterfly zip ties approximately every 8 inches. Ensure the butterfly zip ties are used to separate the high-voltage cables from the low-voltage cables.



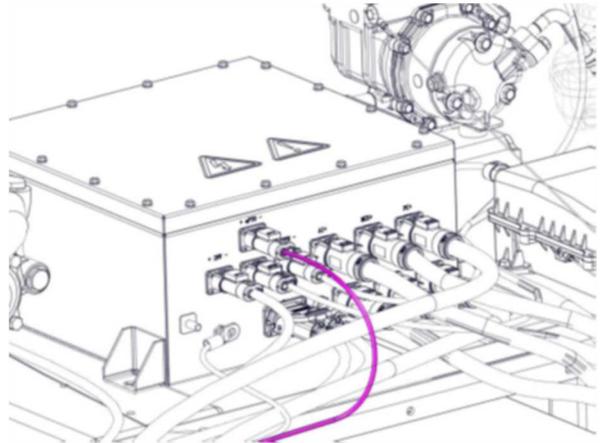
T3208789

8. Use butterfly zip ties approximately every 8 inches. Route the HV cable along the outside of the chassis rail behind the cooling box. Then, route it under the chassis rail and along the inside of the chassis rail towards the PDU.



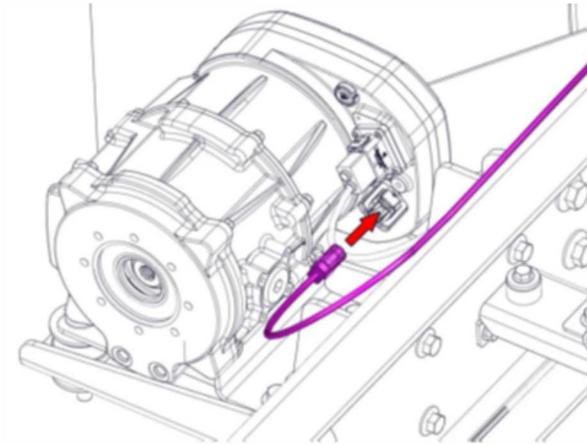
T3208790

9. Replace the PDU with Part #24444597. Re-attach all connections and attach the HV connector to the PDU.



T3208791

10. Attach the LV harness connector to the ePTO, and connect the other end to the C20 connector on the chassis harness, located just inside the frame rail behind the drive motor controllers.

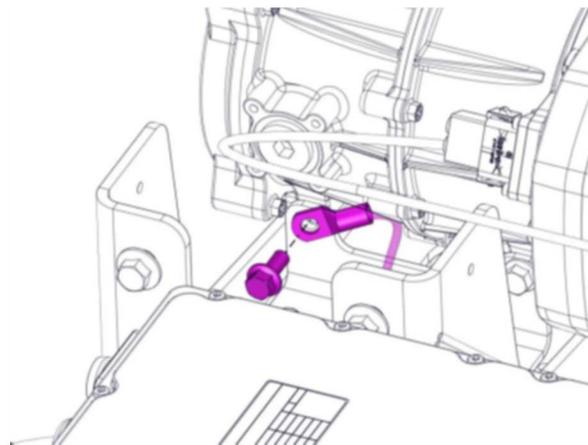


T3208792



T3208793

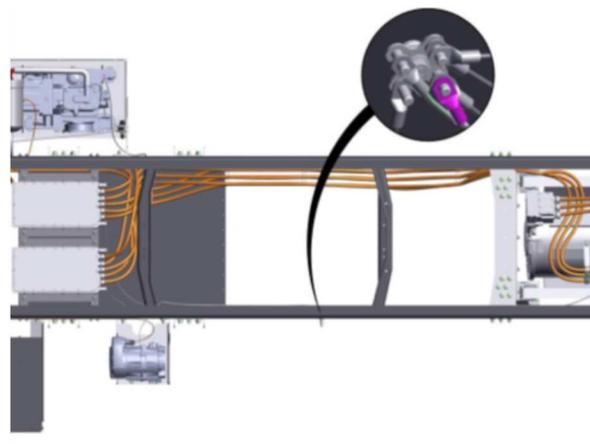
11. Attach the ground to the ePTO bracket and torque it to the specified value.



T3208794

Diameter	Pitch	Length (in)	Torque (Nm / lb-ft.)	Class
3/8"	16	7/8"	45 / 33	8

12. Attach the other end of the ePTO ground wire to the cloverleaf connector located on the inside of the left chassis rail.



T3208795

Diameter	Pitch	Torque (Nm / lb-ft.)	Class
M10	1.5	27 / 20	10.9

13. Contact the certified Mack BEV dealer to commission the truck.

**Note:** If the ePTO does not function as expected, kindly contact Mack Body Builder Support at 877-770-7575 for assistance.

When the ePTO is active, the PTO icon appears in the bottom left corner of the display.



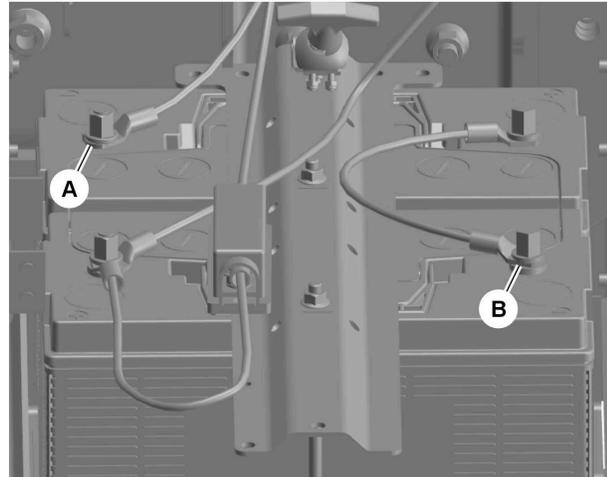
T3208810

# Lift Gate 24 Volt

## Connection

To power a 24V auxiliary hydraulic unit, using existing batteries. Attach the +24V terminal lead (A) (positive leg) to hydraulic/auxiliary power unit.

Attach the -24V terminal lead (B) (negative leg) to hydraulic/auxiliary power unit.



T3208829

# Lift Gate 12 Volt

## Parts Required:

1. **Eaton Sure Power Converter** :24444566

Available in 60A, 80A, and 100A models.

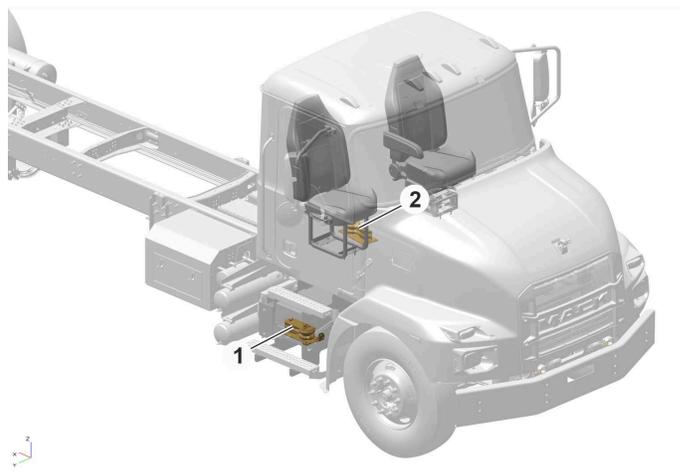
**Recommendation** : Purchase the 100A model, provided the lift gate will not draw more than 100A.

**Note:** If the liftgate draws more than 100 A, additional batteries will need to be installed for the liftgate. These batteries can be charged by the truck using the converter.

2. **RedArc 24V 100A Isolator** #SBI24

Ensure to purchase the 24V version and NOT the 12V version.

**Note:** If the vehicle has tow hooks inside the battery box (1), move the tow hooks inside the cab below the passenger seat (2), as shown in the illustration.



T8218496

# Installation Steps

## 1. Install Eaton Sure Power Converter on the Truck.

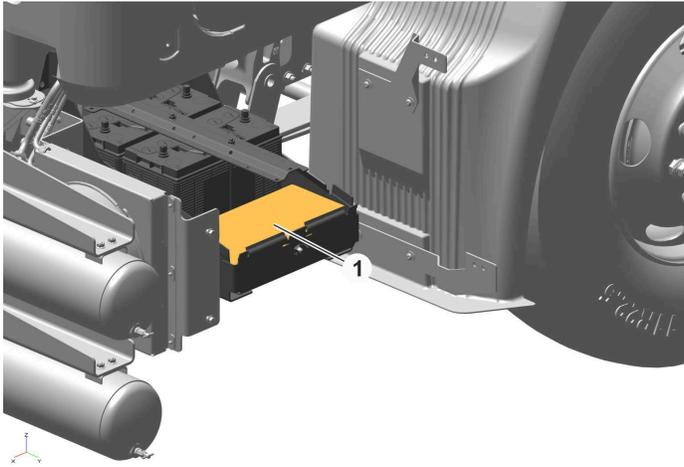
The converter should be mounted in a suitable location on the truck. Possible installation locations include:

Battery box of the truck.

Additional battery box or pump box for the liftgate.

**Required Action :** Make or have made the battery and GND cables based on the location of the converter.

The installation location will determine whether a 12V or 24V cable is required to run from the front to the back of the truck.



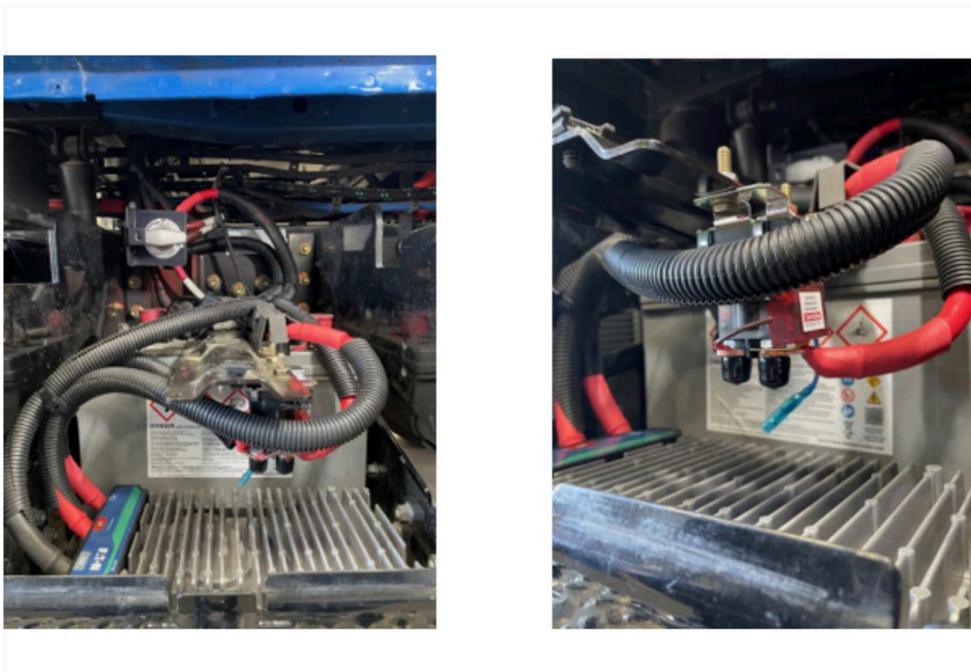
T3218611

**Example Installation :** Converter installed in the truck's battery box.

## 2. Install the Battery Isolator

The isolator should be mounted inside the truck's battery box.

Mounting : Use the battery hold-down to secure the isolator (see image below for reference).



### 3. Wiring the Truck

#### 24V Input Wiring :

Connect a wire from the output side of the truck's main disconnect switch , running it through the battery isolator . Refer to the image below for the location of the output terminal (1) of the disconnect switch.



T3218464

1 Output terminal to wire to the "start" terminal of the battery isolator.

#### Battery Isolator Wiring

Start Terminal : Connect to the output of the disconnect switch.

Aux Terminal : Connect to the 24V input terminal on the converter.

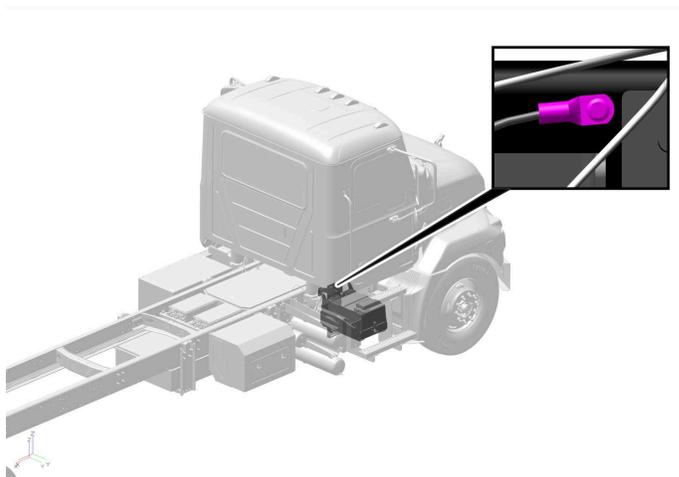
Black Wire : Connect to GND .

Blue Wire : Do not use ; seal it off.

#### Grounding the Converter :

If the converter is placed in the truck's battery box , ground it to ground location #4 (see image below).

If an additional ground connection is needed , use the chassis frame for grounding.



T3218495

Ground Behind battery box

### 12V Output Wiring :

Wire the 12V output from the converter to the liftgate pump or additional batteries.

Fuse Protection : Install an appropriate fuse to protect this wire. The output from the converter is rated for 100A.

### 4. Testing the Converter and Isolator Functionality

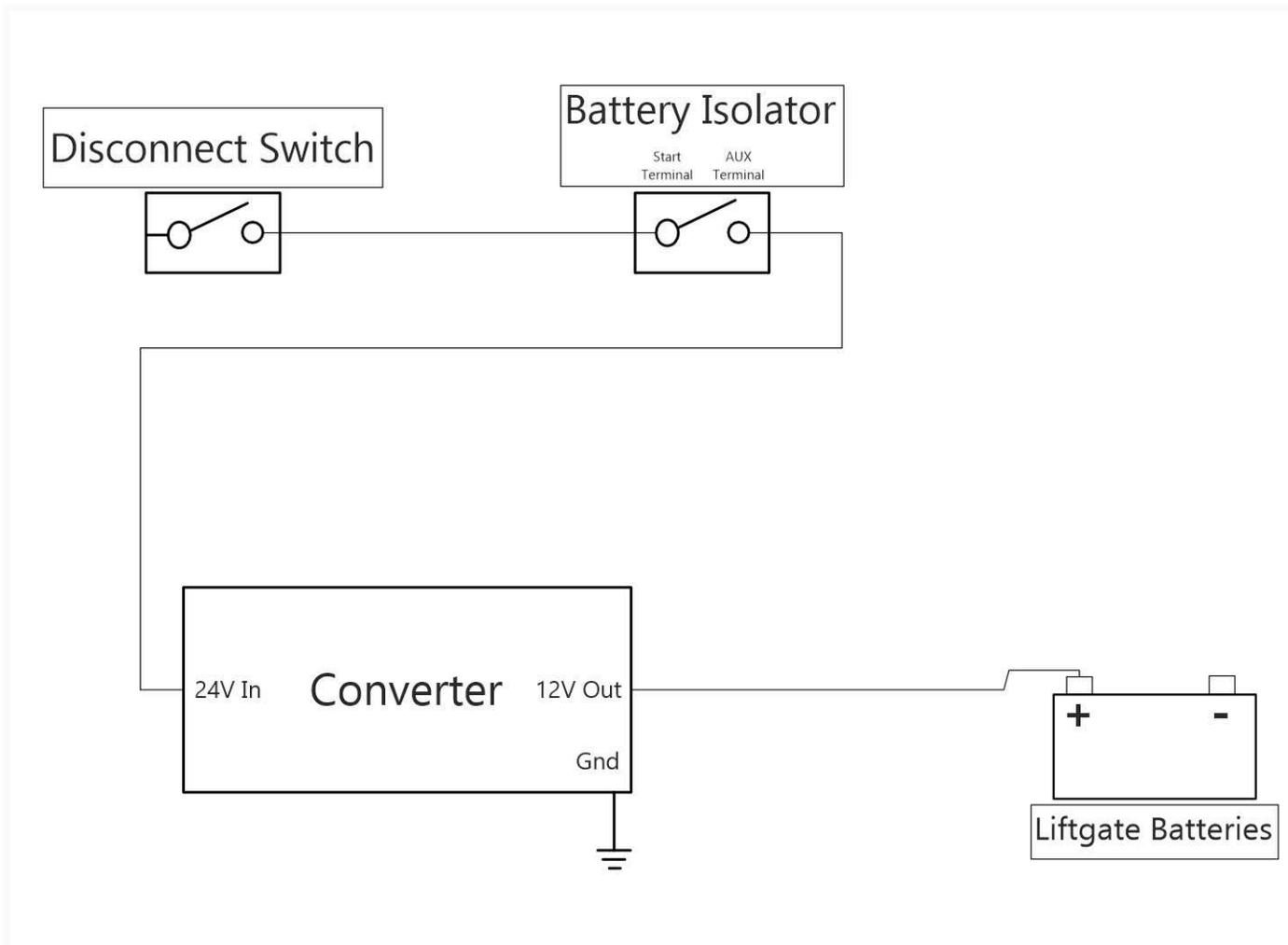
#### Isolator Behavior :

- The isolator should close when the voltage reaches approximately 26.4V or higher, enabling the charging circuit.
- The isolator should open at around 25.4V or lower, preventing charging from the truck to the liftgate batteries.

#### Testing Process :

1. Ensure that the 12V output of the converter is supplying voltage to charge the liftgate batteries.
2. To check the isolator's function, run down the truck's batteries by leaving the headlights on (keep the ignition OFF as the truck batteries charge with the ignition ON).
3. Verify the converter's 12V output at the liftgate batteries when the isolator closes.

### Converter and isolator wiring Schematic



T3218463

# Routing and Clamping

## Definitions

**Abrasive surfaces** :-Items capable of causing damage to the routed commodity in a rubbing condition during vehicle operation (e.g. corrugated conduit, sharp edges, bolt thread, braided hose, etc.)

**Bundled with:** A number of items tied, wrapped or otherwise held together.

**Cable tie:** A plastic self-sizing strap, UV resistant, capable of bundling specified load(s) during vehicle operation.

**Chafing:** To wear away by rubbing/abrasion.

**Damaged:** An item that differs from its original condition.

**Electrical Cable:** Strands of wire encased in an insulated material designed to carry electric current.

**Fretting:** “Micro chafe” between pin terminal and socket terminal which in long term create oxides between the conductors causing misconduct.

**Insulation:** Material having good dielectric properties, which is used to separate close electrical components such as wire conductors.

**Not secured:** Items not fastened, bundled or tied.

**Plastic Conduit:** Corrugated or smooth wall tubing/hose used to protect hoses, harnesses, cables, tubing, pipes etc.

**Routed with:** Items taking the same path but not attached to each other (i.e. parallel but separate).

**Rubbing:** Items that contact each other and have independent movement.

**Screen:** A conducting layer placed around a wire or cable to limit the penetration or escape of electric or electromagnetic fields.

**Sharp edge:** surface capable of cutting or piercing the routed commodity during vehicle operation.

**Signal Wiring Harness:** A set up of electric wires that distributes the electric current.

**Terminal:** The metallic component, applied to the wire, used for connection to a mating part and for further distribution of electric current.

**Traction Voltage:** Electric system operating at voltage level class B over 60V DC or 25V AC RMS defined in ISO 23273-3:2006

**Traction Voltage Power Cable:** Electrical cable used for conducting electrical current between components/units in the traction voltage system.

**Touch:** Items that are in contact but do not have independent movement.

## General

Electrical cables are used for conducting of current and it is therefore important that the routing and clamping are carried out in such a way that the current is not released due to chafing or other type of damage.

Traction voltage power cables are operating at a higher voltage level compared to conventional vehicles. Damages of the cable insulation can cause arcing that creates excessive heat. The traction voltage power cable conduct levels of current and contain voltage levels that when short-circuited or been damaged can cause functional disturbance and human hazards. The mounting, routing and clamping of the traction voltage power cable to avoid damage is therefore of extra importance.



### WARNING

Decommissioning and commissioning must only be carried out by Mack Truck BEV certified dealer.

# Installation guidelines

If damage of traction voltage power cables, terminals or connectors is found before, during or after the assembly process, it is not allowed to repair the cable. New parts must be installed.

Assemble or re-assemble of screws or nuts for terminals are specified to a torque which must be followed. It is strongly prohibited to diverge from this specification.

## Routing

- Traction voltage power cable that route along or through abrasive surfaces must not touch these surfaces e.g. sharp edges, rough edges, bolt thread, braided hose etc.
- If frame routing is used, routing through cross members are prohibited. Brackets must ensure that no contact with the frame is made and that the traction voltage power cables are secured from chafing at sharp edges.
- Where the traction voltage power cables must flex between moving parts, the last supporting clamp/cable tie shall be securely mounted such that relative movement does not promote chafing.
- Traction voltage power cable shall not support any mechanical loads other than their own mass.
- Traction voltage power cables are prohibited from being located in areas that experience routine exposure to hydraulic fluid or oil spillage (i.e. underneath filters, below overflow vents, etc.)
- Minimum bend radius of the traction voltage power cable to be 4 times the cable diameter.
- Traction voltage power cables must not rub each other or surrounding items, but can touch when all items have the same relative movement.
- Traction voltage power cables should always be routed on top of brackets. In such cases where routing underneath is necessary and/or sharp edges exists on the brackets a rubber washer must be used to protect the cable from chafing on the bracket.
- Traction voltage power cable shall be protected from vibration and abrasion. Special attention should be given to under body, splash areas in wheel wells, and propulsion compartments where water and road abrasives can damage the cable.
- Avoid bending of the traction voltage power cable when exiting a connector/inlet, as this may cause a leak path in the rear seal of the connector/inlet.
- If cable tray/duct of metal is used for routing the traction voltage power cable, these must be electrical ground connected.
- Cable tray/duct sections should be connected to each other through the largest possible surface area to ensure a good electrical ground connection.

## Clamping

- The general maximum distance for clamping traction voltage power cable on powertrain is to be 5.9 inches.
- The general maximum distance for clamping traction voltage power cable on vehicle is to be 15.7 inches.
- Clamping high voltage power cable together with hydraulic lines is not allowed.
- When connecting to a component via a connector or inlet the distance between the connection and first clamping point is to be as short as possible to avoid vibrations and/or fretting in the connection. The general maximum distance is to be 3.93 inches.
- The first clamping point after a connection is preferably placed on the component, this to have the same relative movement between parts and in that way avoid vibrations and/or fretting in the connection.
- All bolted connections on the traction voltage power cable must be applied using specified torque and specified number of turns to ensure a good electrical and mechanical contact, else excessive heat may occur.

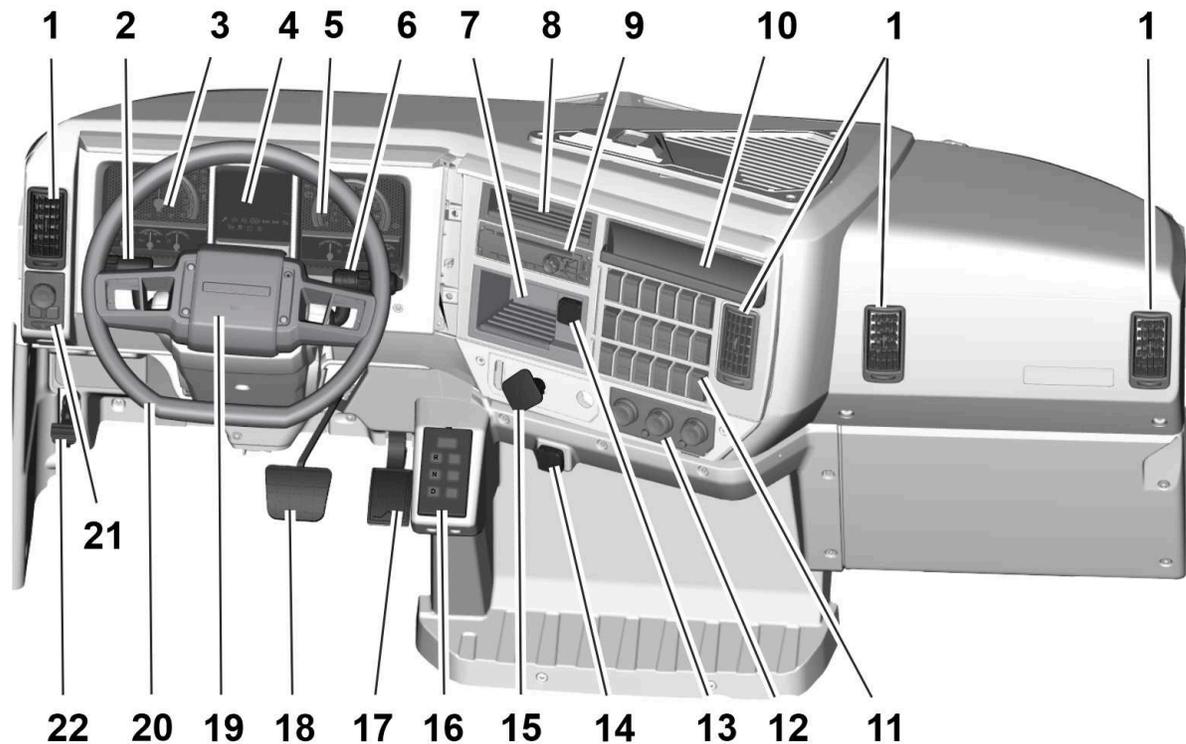
## EMI mitigation

In order to reduce Electromagnetic Interference (EMI) all cables and connectors/inlets operating at traction voltage in Electric Vehicle shall be screened.

- To meet EMC requirements the phases/poles between two units/components shall have the same length (same phase/pole impedance) and same geometrical relation to chassis ground (same impedance to ground).
- Traction voltage power cables and signal wiring harness shall be avoided to be routed in parallel. Minimum distance between the traction voltage power cable and signal wiring harness shall be at least 11.8 inches.
- Unnecessary cable lengths should be avoided to keep coupling capacitances and coupling inductances low.
- When the signal wiring harness must cross the traction voltage power cable secure that it is done at an angle as close to 90 degree as possible.
- To minimize magnetic fields it is important to keep the distance between the phase conductors or the DC pole conductors as short as possible. (i.e. route both DC conductors (plus and minus) together).

# Instrument Panel and Switch Layout

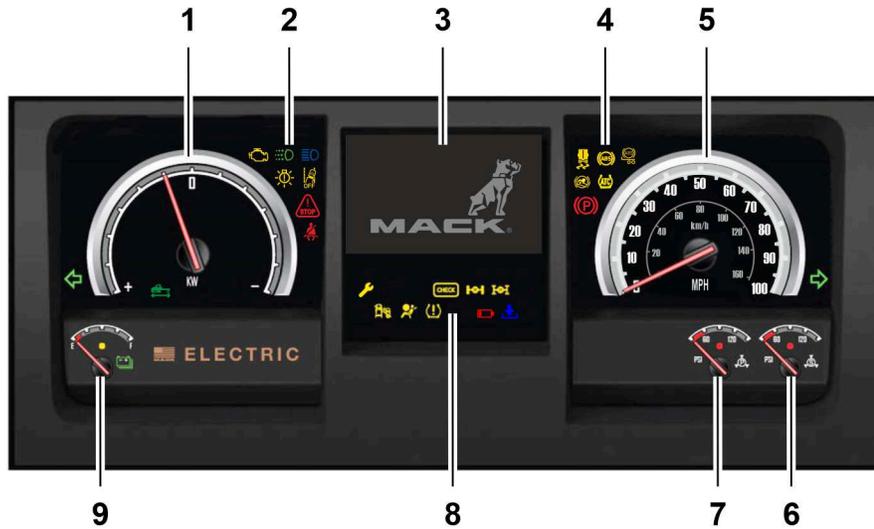
Before driving this vehicle, locate the instruments and controls and become familiar with their operation. After starting and when driving, ensure that the instrument readings are normal.



T3195651

1. Air vent	12. Climate Control Unit
2. Left Stalk Control	13. Power Outlet
3. Power meter	14. USB (Universal Serial Bus)
4. DID (Driver Information Display)	15. Parking Brake
5. Speedometer	16. Gear Selector
6. Right Stalk Control	17. Accelerator Pedal
7. Storage Slot	18. Brake Pedal
8. Storage Slot	19. Electric Horn Button (City Horn)
9. Radio	20. Steering Wheel
10. Storage Slot	21. LCP (Light Control Panel)
11. Dashboard Switches	22. Steering Column Tilt Control Pedal

# Instrument Cluster



T3195653

- 1 Power meter
- 2 Tell-tale Indicators, Left Side
- 3 Mack® Co-Pilot™
- 4 Tell-tale Indicators, Right Side
- 5 Speedometer
- 6 Secondary Brake Air Pressure Gauge
- 7 Primary Brake Air Pressure Gauge
- 8 Tell-tales, Middle
- 9 Traction Battery State of Charge

## Notes

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## Tell-tale Indicators

Tell-tale indicators are shown in the instrument cluster. A tell-tale is a form of display that indicates the actuation of a device, or a correct or defective condition or a failure to function. The operator must become familiar with these symbols to recognize and react (if necessary) to the indicated condition.

### Colors:

To promote visual recognition internationally, specific colors for tell-tale indicators are introduced. Unless governmental regulations (in the area where the vehicle is to be used) or engineering directives specify otherwise, the standard colors are:

- Steady Blue — high-beam headlights
- Flashing Green — turn signals
- Flashing Red — hazard condition involving the safety of personnel
- Steady Green — system in operation
- Steady Red — warning, immediate action required
- Amber — early warning, such as ABS (Anti-Lock Brake System) malfunction

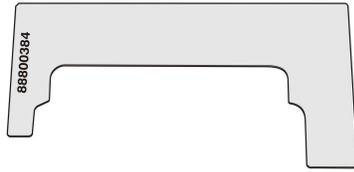
	Tell-tale	Meaning	Description
1		Malfunction Indicator Lamp	Indicates that a government regulation OBD (On-Board Diagnostic) fault exists
2		DRL (Daytime Running Light) Indicator	Indicates that the DRLs are active
3		High Beam Indicator	Illuminates when the high beam lights are engaged
4		Light Indicator	Illuminates when there is a lighting system error
5		LDWS (Lane Departure Warning System) Indicator (Not Used)	Illuminates when the vehicle begins to move out of its lane
6		Stop	<p>Illuminates when conditions require the driver to stop the vehicle. This usually occurs when vehicle conditions fall below designated standards for operation.</p> <div style="background-color: black; color: white; padding: 5px; display: flex; align-items: center;"> <b>DANGER</b> </div> <p>Failure to take necessary action when the STOP tell-tale is on can ultimately result in automatic shutdown and loss of power steering assist. Vehicle crash can occur, resulting in personal injury or death.</p>

7		Safety Belts Reminder	Indicates that a safety belt needs to be fastened
8		Driveline Engaged Indicator	Indicates that the propulsion system is on and the vehicle speed is less than 5 km/h (3 mph)
9		Turn Signal Indicator	Flashes when the turn signals are active
10		Maintenance Indicator	Indicates that there is maintenance required for vehicle
11		Check Indicator	Illuminates when there is an electrical issue
12		Differential Lock (Interwheel) Indicator	Illuminates when the Differential Lock (Interwheel) engaged
13		Interaxle Differential Lock Indicator (Not Used)	Illuminates when the Interaxle Differential Lock engaged
14		LCS (Lane Changing System) Indicator (Not Used)	Illuminates when the system detects lane markers and alerts you when a tire touches a lane marker
15		Airbag Indicator (not Used)	Indicates that there is an airbag error. Maintenance is required
16		TPMS (Tire pressure Monitoring System) Indicator (Not Used)	Illuminates when there is a changes in the tire pressure
17		Traction Battery Low	Indicates that the traction battery is low and must be recharged
18		Software Download In Progress	Indicates that the software download is in progress
19		ESC (Electronic Stability Control) Indicator (Not Used)	Illuminates when the ESC is active
20		ABS (Anti-lock Braking System) Malfunction Tractor	Indicates a tractor ABS malfunction

21		ABS Malfunction Indicator (Trailer) (Not Used)	Illuminates when the fault exists in ABS (Trailer)
22		Grade Gripper Indicator	Indicates the Grade Gripper is active
23		ATC Active Indicator (Not Used)	Illuminates when the ATC is active
24		Parking Brake engaged	Indicates that the parking brake is engaged

# Axle and Suspension

## Special Tools



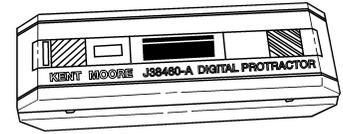
T0070273

**88800384**  
Ride Height Gauge



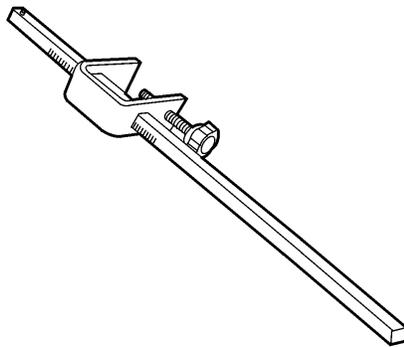
W0001815

**J-44544**  
Ride Height Adjustment Socket



W7000708

**J-38460-A**  
Digital Protractor, Includes **J-38460-25**  
Quick Disconnect Adapter



W0001960

**J-44684** Ride Height Gauge

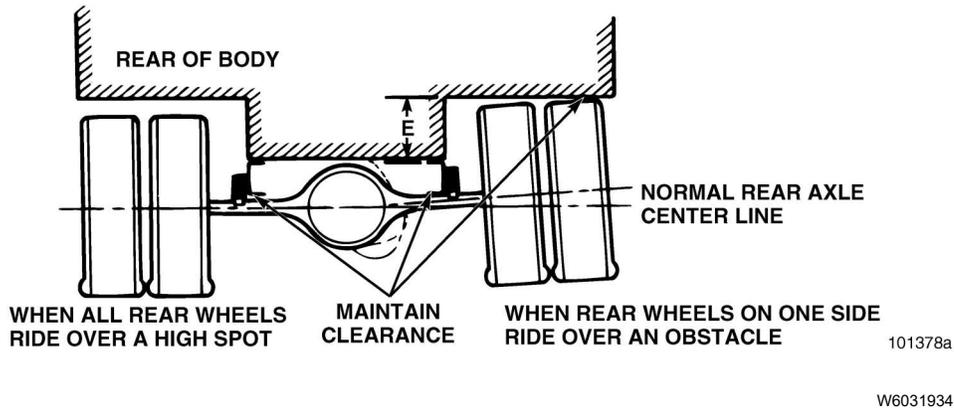


### CAUTION

It is the sole responsibility of the body builder to verify the axle alignment is corrected after making modifications such as, mounting a body, or changing wheel base.

# Clearance Rear Wheels and Axles

Sufficient clearance must be maintained to allow full vertical movement of the rear axles and tires as the vehicle travels over rough terrain or uneven surfaces.



Allow Clearance for Vertical Movement of Rear Axles and Tires

## Notes

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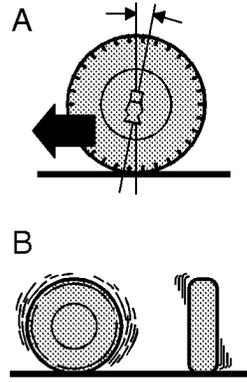
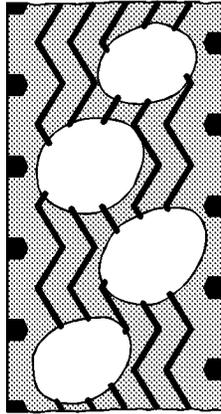
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## Axle Alignment

The following specifications are being furnished to inform the field of the latest MACK axle alignment specifications.

## Caster

The rearward or forward tilt of the steer axle kingpin, in reference to the vertical plane, is measured in degrees. Caster is positive when the steering axis is tilted rearward and is negative when the tilt is forward.



T1006460

- A. Caster Angle
- B. Imbalance

All measurements must be taken with the vehicle in an unloaded condition, and the steering axle and drive axle(s) on a level surface.

Right hand and left hand caster readings should not vary by more than 0.5° (1 mm/m) from side to side (cross caster). Do not bend the axle or otherwise try to adjust the caster angle. Caster shims may be used to correct caster.

<b>Caster Specifications</b>	$4 \pm 1^\circ$
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*Notes*

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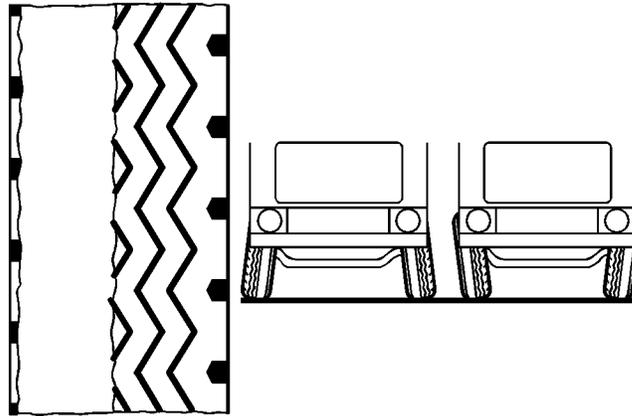
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# Wheel Camber

The angle formed by the inward or outward tilt of the wheel referenced to the vertical plane. Camber is positive when the wheel is tilted outward at the top and is negative when the wheel is tilted inward at the top.



T1006458

Tire Wear Due to Incorrect Camber

<b>Camber Specifications</b>	$0.25 \pm 0.43^\circ$
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Loading the axle will cause the camber to decrease. Right hand and Left hand camber readings should not vary by more than  $0.5^\circ$  from side to side (cross camber). Do not bend the axle or otherwise try to adjust the camber angle. If the camber angle is found to be out of specification, notify the axle manufacturer.

## Straight Forward Position

The thrust angle of the left hand road wheel is set to the 1st drive axle and must be  $0^\circ \pm 0.02^\circ$ . This is the straight ahead position and prepares the vehicle for wheel toe measurement.

## King Pin Inclination

<b>King Pin Inclination</b>	$6.5^\circ$
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### Notes

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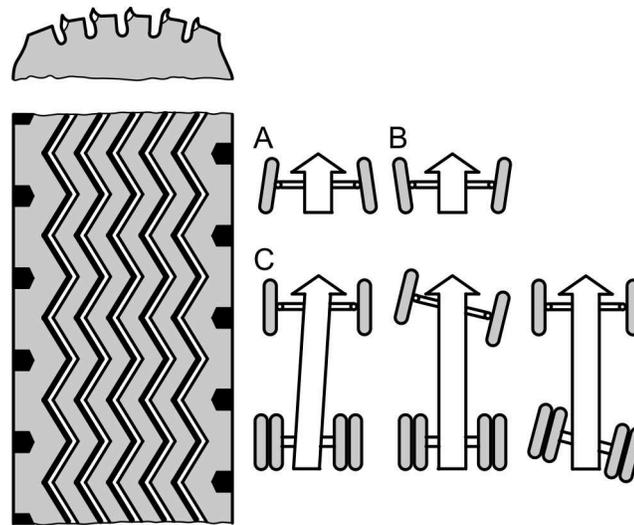
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## Toe Angle

Toe angle is the angle of the horizontal lines drawn through the wheels of the same axle. The angle can also be measured at the tire's front and rear tread center at a distance above the ground equal to the tire's rolling radius.



W1079988

Toe Angle / Thrust Angle

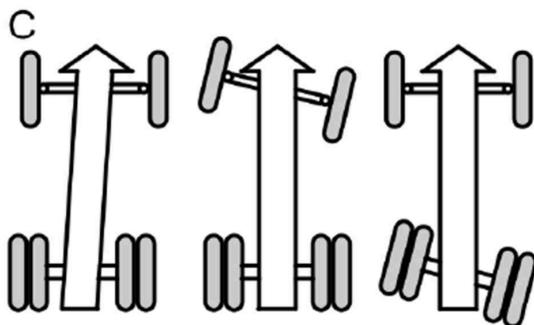
- A. Toe-in
- B. Toe-out
- C. Out-of-line axle

To adjust the toe-in, ensure that the vehicle is in unloaded condition. Toe should be checked at the tire's front and rear tread center at a distance above the ground equal to the tire's rolling radius. It may also be checked with equipment that senses the difference between left and right hand thrust angles.

When adjusting toe, ensure that the tensioning bolt is in the vertical position and behind the tie rod. Improper orientation could result in a loss of adjustment.

Toe Specifications	
Total Toe-In (Chassis without load)	1.5± 0.75 mm/m
Right Wheel Toe-In (Chassis without load)	0.75± 0.375 mm/m
Left Wheel Toe-In (Chassis without load)	0.75± 0.375 mm/m

## Axle Perpendicularity (Thrust Angle) Requirement



W6114032

### C. Out of line axle

Suspension	mm (in.)	deg
MACK AL170 / AL190	1.4 mm (0.55)	±0.04
Hendrickson	2.8 mm (0.11)	±0.08

**Note:** For suspensions not documented in the above table, refer to the manufacturer's instructions.

## Axle Wheelbase

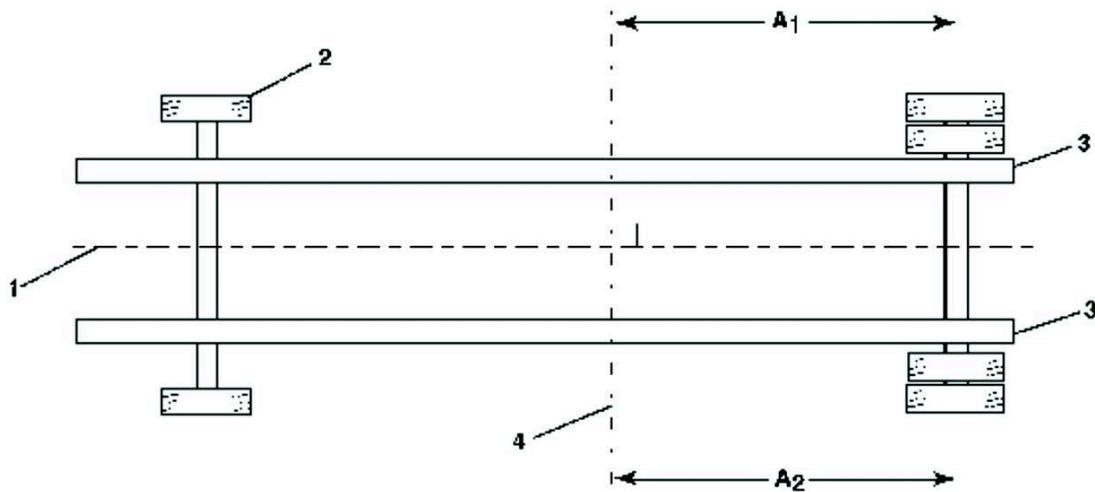
Axle wheelbase side-to-side variation of 3.3 mm (1/8") is to be held on MACK taperleaf suspensions — AL190 and AL170, spring suspensions.



### CAUTION

Axle wheelbase variation may be caused by a broken spring leaf. Prior to proceeding, VERY CAREFULLY inspect all spring leaves to ensure that NONE are cracked or broken. Be especially careful to inspect behind the spring clips (U-bolts). Rust streaks originating from this area are an indicator of broken spring leaves. If a cracked or broken leaf is found, replace the spring assembly before making any additional measurements.

## Chassis Wheelbase



**Figure 5 — 4 x 2 Chassis — A1 = A2 with a Tolerance of No More Than 1/8 Inch (3.3 MM)**

1. Chassis Centerline	3. Frame Rail
2. Front Axle	4. Perpendicular Datum

W6114033

### Tolerance Bands for Scrub Angle

Suspension	mm (in)	deg
Mack AL170/AL190	1.4 mm (0.55)	±0.04
Hendrickson	2.8 mm (0.11)	±0.08

**Note:** For suspensions not documented in the above table, refer to the manufacturer's instructions.

### Axle Alignment

The following specifications have been established for axle alignment on a MACK vehicle under chassis only conditions in order to achieve the optimum in tire wear and subsequent customer satisfaction. Before taking measurements, always drive the vehicle back and forth in a straight line four or five times. Where distance is limited, at least the length of the chassis should be traveled. This operation must be performed to ensure that the suspension has not taken a set.

### Notes

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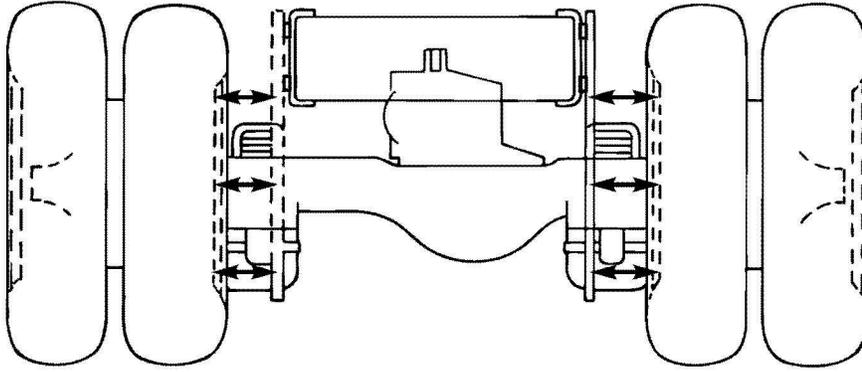
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## Centering Rear Axles

To center rear axles, a measurement must be made between the frame and the brake drums on each axle. A convenient extension straightedge can be made from a straight piece of steel bar stock and attached to the frame rail with magnets. With a tape measure, measure from the straightedge to the brake drum at the three designated points shown in the illustration below.

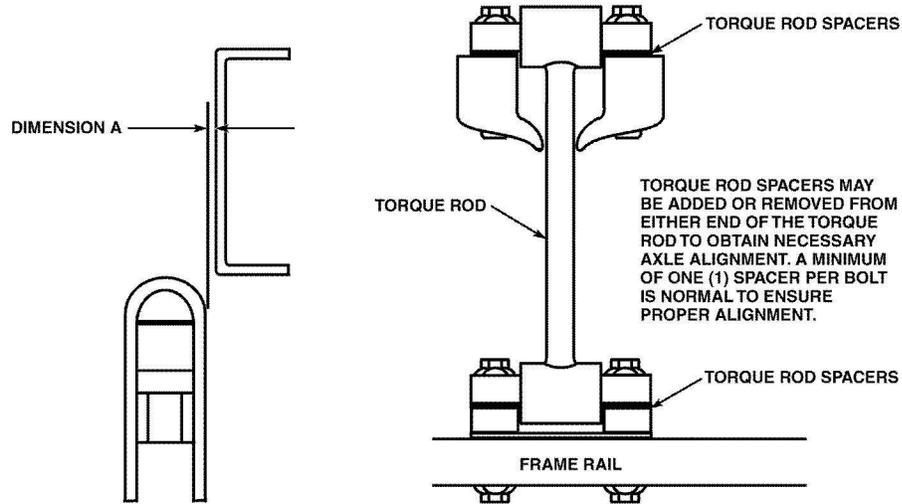


W6078915

## Centering Rear Axles (Chassis Equipped with AL Suspension and Fixed-Length Transverse Torque Rods)

The first step in proper axle alignment is verifying that the rear axles are properly centered on the chassis. Before any alignment measurements are taken, the chassis should be driven back and forth in a straight line several times to allow the suspension to move into its normal operating position. To verify that the rear axles are centered, perform the following steps:

- 1 With the chassis parked on a level surface, block the front wheels to prevent the vehicle from moving, then release the parking brakes. (Air system pressure should be between 110 to 130 psi when performing these procedures.)
- 2 Measure the ride height. Ride height gauges are available to accurately measure chassis ride height. Refer to Ride Height for information on using the gauges and measuring ride height.
- 3 After the ride height has been checked and/or adjusted, determine if the axles are centered by measuring from the outside of the frame rail to the inside edge of the spring clip (U-bolt) (Dimension "A" in the illustration below). The maximum allowable side-to-side difference on any one axle is 6.34 mm (1/4 in). Washer spacers can be added or removed from either side of the torque rod in order to obtain the correct axle positioning.
- 4 After axle centering is verified or corrected, exhaust the air from the suspension and verify that no interference exists between the frame rail and any spring clip (U-bolt).



W6078909

## Rear Axle Literature

Printed copies of the rear axle literature are no longer available from the axle suppliers. Therefore, MACK is unable to supply this printed literature to its dealers.

Service manuals for many of the supplier's rear axles are now available from the official web sites Dana Corporation and Meritor.

To review and download rear axle literature, please visit:

<http://www.dana.com>

<http://www.meritor.com/customer/northamerica/lod/default.aspx>

## Rear Suspension

The following section details the various suspensions. Included is design and function, specification and procedure information.

**Note:** HENDRICKSON, PRIMAAX and QUIK-ALIGN are either registered trademarks or trademarks of (i) Hendrickson USA, L.L.C. in the United States, and (ii) Hendrickson International Corporation outside the United States.

# Alignment and Adjustments

## Lateral Alignment

- 1 Use a work bay with a level floor. Drive the vehicle slowly, straight ahead. Try to slacken or loosen the suspension as the vehicle is positioned. End with all wheels positioned straight ahead. Try to roll to a stop without the brakes being used. Do not set the parking brake. Chock the front wheels of the vehicle.
- 2 Measure from the outside of the frame rail to the rim flange of the inner tire. Record the measurement.
- 3 Measure the same distance on the opposite side of the same axle. Record the measurement.
- 4 Subtract the two measurements to get a difference between the two. If the difference is greater than 1/8 in.(3 mm) it will be necessary to correct the lateral alignment. Adding or removing shims that are located between the transverse torque rod and frame rail accomplishes this. A general rule of thumb is to use a shim with a thickness that is half of the difference between the two measurements.

The mounting fasteners used with the straddle mount transverse torque rods are furnished by the vehicle manufacturer. It is important to check the locknuts for proper torque during preventive maintenance service intervals. Follow the vehicle manufacturer's specifications for tightening torque values. All torque rods must be inspected for looseness by one of the following methods:

- **Method 1:** For Tractor applications only with brakes applied, slowly rock the empty vehicle with power while a mechanic visually checks the action at both ends.
- **Method 2:** With the vehicle shut down, a lever check can be made with a long pry bar placed under each rod end and pressure applied.

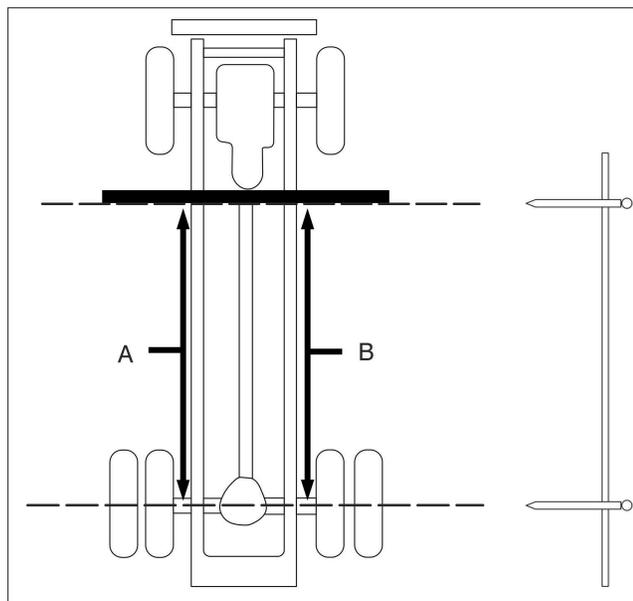
Visually inspect torque rod bushings for torn or shredded rubber, for bent, cracked, or broken torque rods, and also for end hubs that have an elongated "oval" shape. Any of these conditions require component replacement. Rod ends can be renewed by pressing out the worn bushing, and installing a replacement bushing. In the event of structural damage, the entire torque rod assembly should be replaced. The torque rods are made to a specified length or a two-piece transverse torque rod can be cut and welded to the desired length (if available).

**Note:** Hendrickson recommends the use of Grade 8 bolts and Grade C locknuts be used for all torque rod attachments.

# Rear Axle Alignment Inspection

Proper alignment is essential for maximum ride quality, performance and tire service life. The recommended alignment procedure is described below. This procedure should be performed if excessive or irregular tire wear is observed, or anytime the QUIK-ALIGN connection is loosened or removed.

- 1 Use a work bay with a level floor. Drive the vehicle slowly, straight ahead. Try to slacken or loosen the suspension as the vehicle is positioned. End with all wheels positioned straight ahead. Try to roll to a stop without the brakes being used.
- 2 Chock the front wheels of the vehicle. Do not set the parking brake.
- 3 Verify that the proper ride height is set.
- 4 If axle alignment equipment is not available, using "C" clamps, securely clamp a six-foot piece of STRAIGHT bar stock or angle iron across the lower frame flange. Select a location for the angle iron as far forward of the drive axle as possible, where components will not interfere.
- 5 Accurately square the straight edge to the frame using a carpenter's square.
- 6 Using a measuring tape, measure from the straight edge to the forward face of the drive axle arms at the centerline on both sides of the vehicle, **A** and **B**. If both sides measure within the vehicle manufacturer's specifications, alignment of the drive axle is acceptable.



T6163285

Fig. 15 Front drive axle alignment

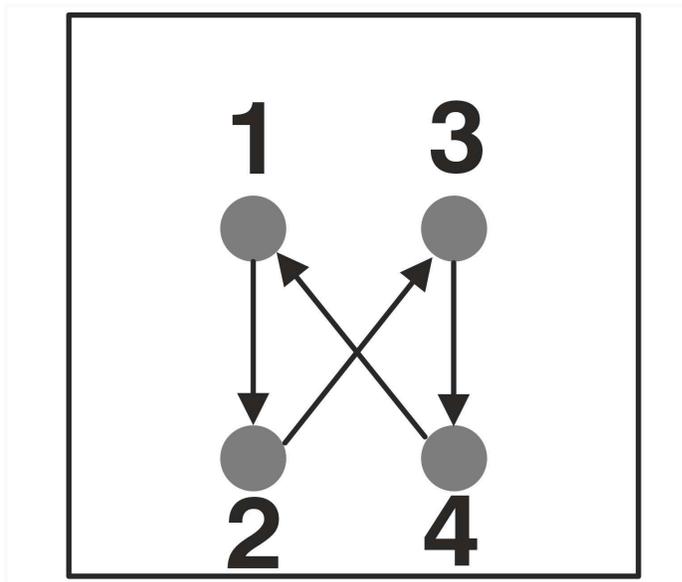
## U-Bolt Torque

### Leaf Spring Suspension

Tighten the U-Bolt locknuts evenly and torque the nuts in a proper sequence.

U-Bolt tightening torque value is  $460 \pm 23$  Nm ( $338.24 \pm 16.90$  ft-lb).

U-bolt protrusion length is 0 – 5 mm (0 – 0.2 in) (ensure that a minimum of two threads are visible).



T7191693

Torquing Sequence

### Air Leaf Suspension

Tightening torque of U-Bolt, nut M22 is  $575 \pm 50$  Nm ( $424 \pm 37$  ft-lb)

**Note:** Tighten the U-Bolt nut diagonally.

### Notes

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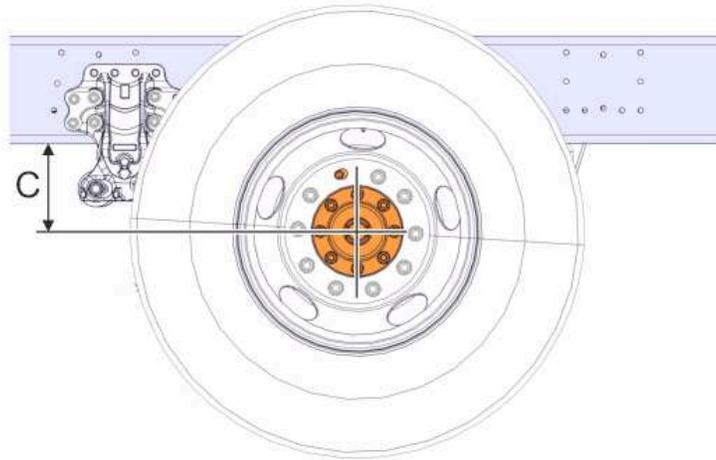
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# Ride Height and Pinion Angle Specifications

## Ride Height for Air Leaf Suspension

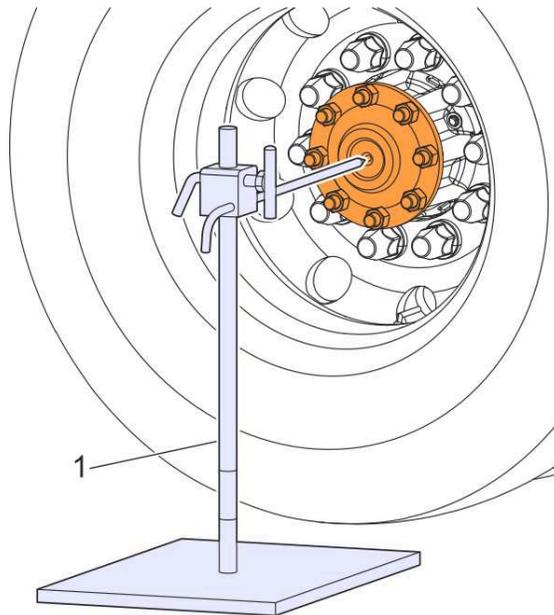
The ride height (C) is measured from the centre of the first drive axle hub to the bottom of the frame.

Ride height (C) is 221 mm (8.70 in).



T7198082

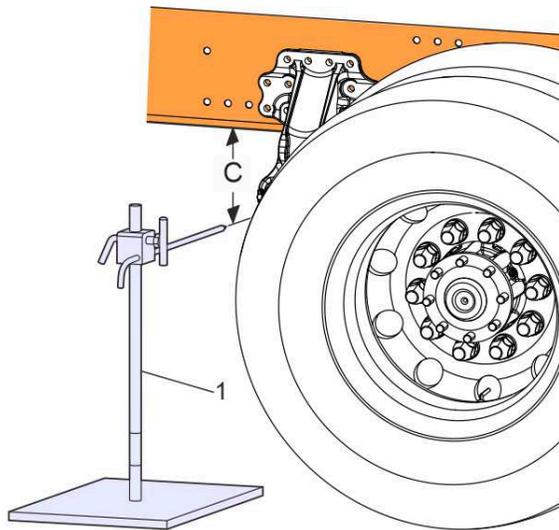
**Note:** The air springs must be filled to the correct pressure before measuring the ride height.



T7198083

1. Place the tool (1) near to the first drive axle and position the pointer to the center of the axle hub.

**Note:** The vehicle must be on level ground.



T7198084

2. Move and position the tool (1) between the drive axles, and below the frame. Measure the ride height (C) from the tip of the pointer to the bottom of the frame.

**Note:** HENDRICKSON, PRIMAAAX and QUIK-ALIGN are either registered trademarks or trademarks of (i) Hendrickson USA, L.L.C. in the United States, and (ii) Hendrickson International Corporation outside the United States.

**Note:** Use only Genuine Hendrickson parts for servicing this suspension system.

This information covers specifications for ride height and pinion angle, including suspension applications and torque specifications.

## Suspension Applications

Suspension Configuration	Maximum GAWR Metric Ton (lb)	Axle Spacing mm (in.)	Required Number of Parking Chambers	Available Axles	
				Models	Metric Ton (lb)
4x2	12.99(25,995)	N/A	TWO	Meritor	10.5 (21,000)

(1) GCW (Gross Combination Weight) rating can be reduced by vehicle operating applications, engine horsepower/torque, axle type/model, axle ratio, and/or vehicle tire size.

### Notes

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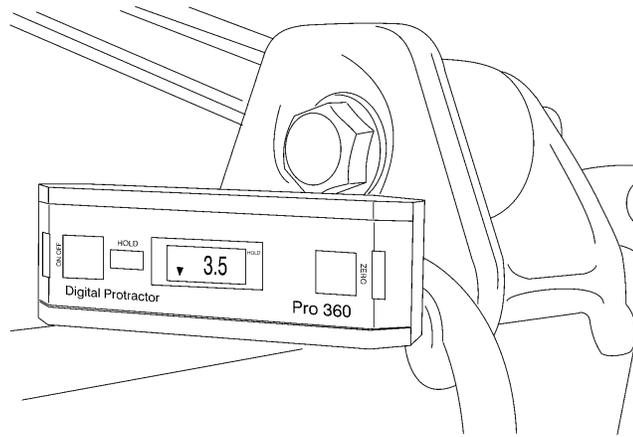
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# Axle Pinion Angle

Drive axle pinion angles are established by the vehicle manufacturer. The suspension axle brackets called out are machined to specific angles to meet the vehicle manufacturer specified requirements. If it is necessary to fine tune the pinion angle, first verify that the suspension is at the proper ride height. Install a digital protractor on the axle housing. Check that the pinion angle is within the specified range.



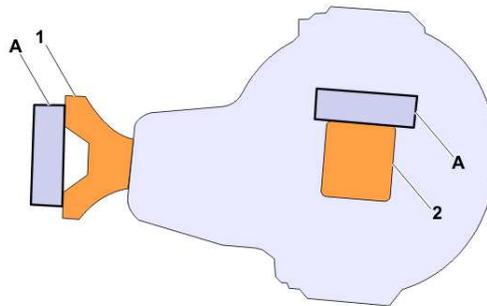
W7001406

Fig. 16 Digital Protractor J-38460-A

## Pinion angle

**Note:** Check ride height before checking pinion angle.

**Note:** Zero the inclinometer before checking pinion angle. Place the inclinometer on the top surface of the side member, above the axle with the height control valve. The inclinometer must be parallel to the side member. Zero the inclinometer on the side member.

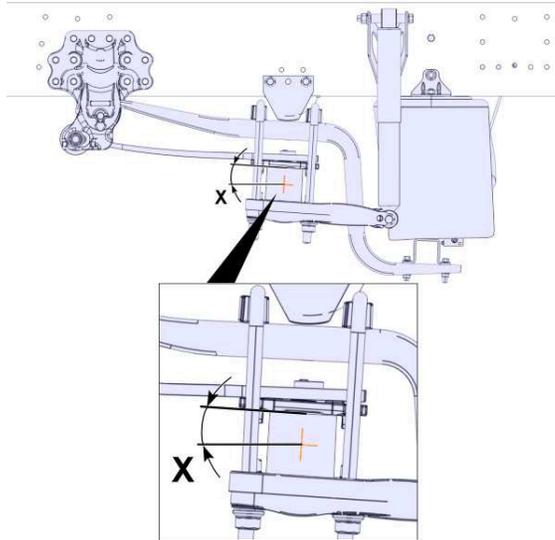


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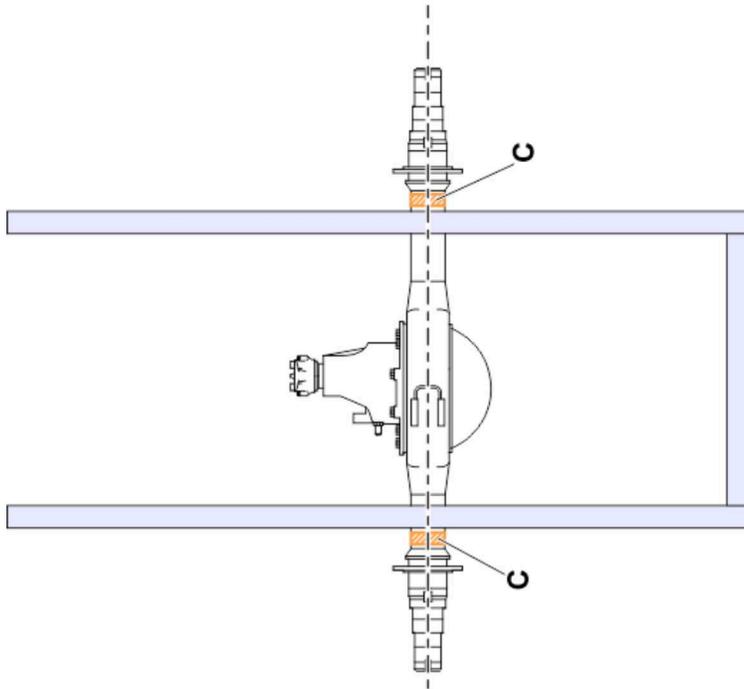
(A) Inclinometer

(1) Yoke

(2) Axle housing



T7198086



T7198109

(C) Area for the axle pinion angle measurement

# Pinion Angle Specification

Rear Axle	Rear Axle Position / Wheelbase Inches (mm)	Pinion Angle (X)
RSS1019A RSS0919A RSS0819B RS1045SM	150 (3810)	7°
	166 (4216)	5.5°
	186 (4724)	
	206 (5232)	3.5°
	221 (5613)	
	236 (5994)	
	251 (6375)	
	270 (6858)	

## Notes

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# ECU Functions and Pin configuration

This section lists functionalities that are of interest to body builders and others who want to modify certain (programmable) aspects of the ECUs. If an ECU is not included in this section, it is because there are no adjustable functions which can be modified in the field.

Not all functions or parameters listed in this document may apply to the vehicle you have, because of running changes and improvements made over time. Using each component's Main Software part number, the Premium Tech Tool knows which parameters apply, and shows only those which are adjustable for that particular vehicle.

All ECUs use some form of input and output devices to perform their functions. These devices may include switches, sensors, solenoids, and relays. **DO NOT** tie or splice into an existing sensor or input device used by an ECU. Failure to follow may affect the proper operation of the sensor. Likewise, **DO NOT** tie into an output device that is controlled by an ECU unless authorized to do so in this document.

Always observe proper Electrostatic Discharge (ESD) precautions while working around the ECUs.

The Inputs and Outputs (I/O) of the ECUs follow a certain "logic" that are important to understand when interfacing to the ECUs. The following information explains the terminology used in this document:

Input/output Type	Definition
Active High (or Active +V)	<p>This input is typically configured with a switch wired to + Voltage. The input has two states; either floating (switch open), or +V (switch closed). The input is considered active when +V is applied.</p> <div data-bbox="662 894 1239 1136" data-label="Diagram"> </div> <p style="text-align: right; font-size: small;">W9000629</p>
Active Low (or Active ground)	<p>This input is typically configured with a switch wired to ground. The input has two states; either floating (switch open), or grounded (switch closed). The input is considered active when grounded.</p> <div data-bbox="662 1356 1239 1598" data-label="Diagram"> </div> <p style="text-align: right; font-size: small;">W9000630</p>
NC switch to +V	<p>This input type typically has a Normally Closed (NC) switch contact connected to +V. The input becomes active when the switch is opened or the circuit is otherwise broken.</p>

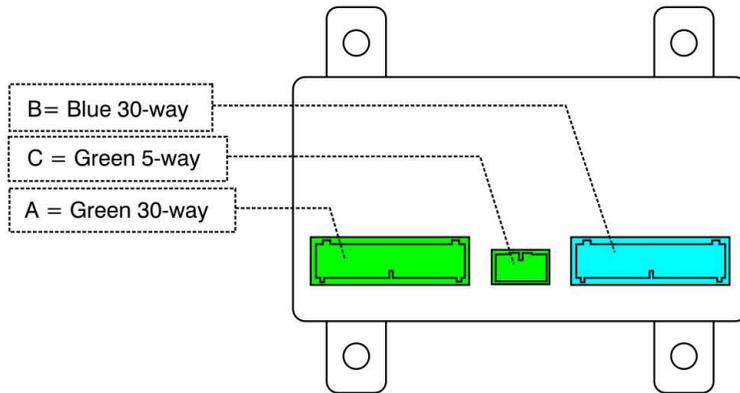
Input/output Type	Definition
	<div data-bbox="737 149 1313 390" data-label="Diagram"> </div>
NC switch to ground	<p data-bbox="516 478 1539 537">This input type typically has a Normally Closed (NC) switch contact connected to the ground. The input becomes active when the switch is opened or the circuit is otherwise broken.</p> <div data-bbox="737 575 1313 816" data-label="Diagram"> </div>

I/O Type	Definition
<b>Outputs</b>	
Active High	<p data-bbox="516 1022 1539 1081">This output source current (the voltage goes high) when active. The other side of the load or controlled device is connected to ground.</p> <div data-bbox="737 1119 1313 1360" data-label="Diagram"> </div>
Active Low	<p data-bbox="516 1444 1539 1503">This output sinks current (the voltage goes low, usually to the ground) when active. The other side of the load-controlled device must be connected to +V.</p> <div data-bbox="737 1541 1313 1782" data-label="Diagram"> </div>

# Vehicle Electronic Control Unit (VECU)

The VECU has many programmable features. The features listed here are included because they are of particular interest to body builders and others who want to modify certain aspects of the VECU. For a complete list of all programmable parameters, see the appropriate Premium Tech Tool parameter and reprogramming information.

## Description of VECU Signals



W3088359

## VECU Connector A (Green)

Pin	Pin Name/Description	I/O	Type	Comment
A1	CC SET/DECEL	Input	Active High	
A2	CC RESUME/ACCEL	Input	Active High	
A3	CC On/Off SW	Input	Active High	
A4	A/C On	Input	Active High	
A5	Brake Pedal Microswitch	Input	NC Switch to +V	NO switch installed. Wired to +V
A6	Key Switch Crank	Input	Active High	
A7	—	—	—	—
A8	—	—	—	—
A9	—	—	—	—
A10	—	—	—	—
A11	—	—	—	—
A12	ECU Ground	ECU Main Power Ground		
A13	ECU Main Power	Input	ECU Main Power	
A14	Key Switch IGN.	Input	Active High	
A15	CAN2-High (J1939H)	Bidirectional Data Link		

Pin	Pin Name/Description	I/O	Type	Comment
A16	CAN2-Low (J1939L)	Bidirectional Data Link		
A17	—	—	—	—
A18	No Connection	—	—	—
A19	No Connection	—	—	—
A20	Regenerative Brake mode	Regenerative Brake mode		—
A21	—	—	—	—
A22	—	—	—	—
A23	Idle Validation Switch-1	Input	Active High	
A24	No Connection	—	—	—
A25	Interwheel Lock	—	—	—
A26	—	—	—	
A27	—	—	—	—
A28	—	—	—	Do not connect; special use only
A29	—	—	—	—
A30	No Connection	—	—	—

**Notes**

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## VECU Connector B (Blue)

Pin	Pin Name/Description	I/O	Type	Comment
B1	—	—	—	
B2	Ignition relay	Output	Active Low	
B3	—	—	—	—
B4	—	—	—	
B5	Output supply	Output	Active Low	
B6	—	—	—	
B7	—	—	—	—
B8	Accelerator Pedal	Input	Analog Sensor	
B9	—	—	—	—
B10	Accelerator Pedal Supply-1 (~5 V)	Output	Sensor Power	
B11	Parking Brake	Input	Active Low	Ground connected N.C. air switch (No air = switch closed = PB applied)
B12	—	—	—	
B13	—	—	—	
B14	—	—	—	—
B15	ECU Power Relay Control	Output	Active Low	
B16	—	Output	Active Low	—
B17	—	—	—	
B18	—	—	—	
B19	Output Supply # 3 (~V batt)	Output	Switch Power	
B20	—	—	—	
B21	—	—	—	
B22	Analog Ground	ECU Sensor Ground		
B23	—	—	—	
B24	—	—	—	
B25	No Connection	—	—	—
B26	—	—	—	
B27	Brake pressure switch	Input	Sensor Power	—
B28	No Connection	—	—	—
B29	Not Used	—	—	—
B30	—	—	—	

## VECU Connector C (Green)

Pin	Pin Name/Description	I/O	Type	Comment
C1	J1587 Information Data Link (B) (SAE J1708 (A))		Bidirectional data link	J1587/1708 Information Data Link (Slow Speed)
C2	J1587 (A) (SAE J1708 (B))			
C3	No connection	—	—	—
C4	J1939 Control Data Link/A (CAN_H)		Bidirectional data link	J1939 Control Data Link (High Speed)
C5	J1939 Control Data Link/B (CAN_L)			

### Notes

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# Data Link

The Mack electric has many Electronic Control Units (ECUs) to operate many of the vehicle's features. Most ECUs are linked together using one or more data links for sharing information.

Some ECUs operate independently of each other, but most rely on interaction with other ECUs to properly perform their functions. All ECUs use some form of input and output devices to perform their functions. These devices may include switches, sensors, solenoids, and relays. **NEVER** tie or splice into a sensor or input device. This could affect the proper operation of the sensor. Likewise, never tie into an output device, unless authorized to do so elsewhere in this document.

## Data Link Communication

Communication between the different ECUs takes place via three data links:

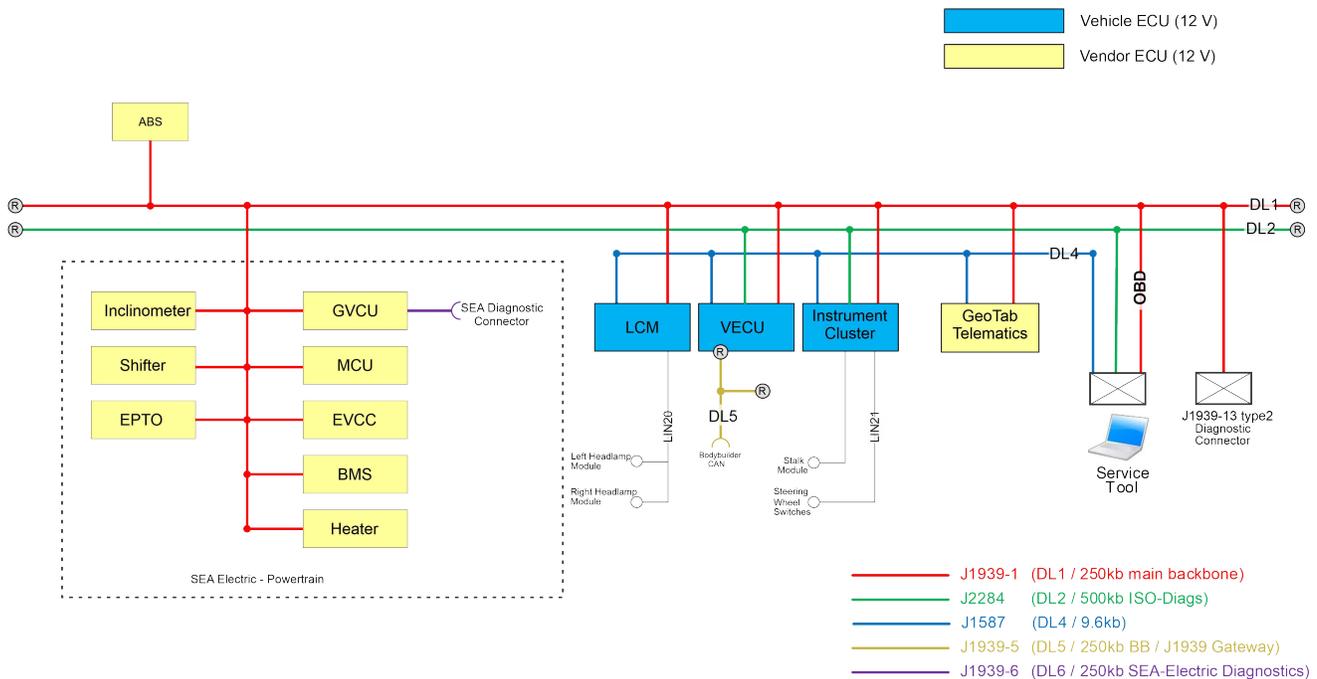
SAE J1939 data link – 250 kbit/s (communication speed)

SAE J1587 data link – 9.6 kbit/s (communication speed)

SAE J2284 data link – 500 kbit/s (communication speed)

All data links and most subnets use CAN bus communication. CAN is a message-based protocol with a twisted pair of cables between control units. All the units within a CAN can initiate communication, but only one can send data at a given time.

## Data Link Flow



T3205015

Electronic Control Unit (ECU)	Description
ABS	Anti-lock Braking System
BMS	Battery Management System
CAN	Control Area Network
ECU	Electronic Control Unit

Electronic Control Unit (ECU)	Description
EVCC	Electric Vehicle Charge Controller
EPTO	Electric Power Take-Off
GVCU	Generic Vehicle Control Unit
LCM	Light Control Module
MCU	Motor Control Unit
OBD	On-board Diagnostic
VECU	Vehicle Electronic Control Unit

*Notes*

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# SAE J1939 Control Data Link

**Control signals** of all systems are communicated via the J1939 data link.

The J1939 is the fastest data link, operating at 250 K bits per second (250K Baud rate). This operating speed allows a system to function more effectively and adapt quickly to changing conditions and vehicle requirements.

This data link complies with SAE standards. It consists of two twisted wires: a yellow wire (CAN\_H), and a green wire (CAN\_L). The wires are twisted at the rate of 0.89 twists per 25.4 mm (1 inch) or 33 twists per meter (3.28 feet). The twisted wires protect the data link from electrical interference.



## CAUTION

No modifications or connections are allowed on the data link wires (CAN\_H (yellow), or CAN\_L (green)). These wires carry the high-speed communications between the electronic systems in the vehicle. **Any modification, connection to, or damage to these wires can result in the failure of the vehicle electronic systems.**

## Terminating Resistor

Terminating resistors are connected to each end of the J1939 (DL1) data link.

It is allowed to have only two terminating resistors in a data link. Never install three in a data link. If the J1939 data link has more than two terminating resistors, damage to the ECU electronics can occur over time. To check whether the data link has two resistors or not, measure the resistance between circuits CAN\_H and CAN\_L using the diagnostic connector, with the starter key in the OFF position. When the data link has two resistors, the resistance should be between 50 - 70  $\Omega$ .

The resistors prevent signal reflections to the data link. They must remain connected to the system to function properly.

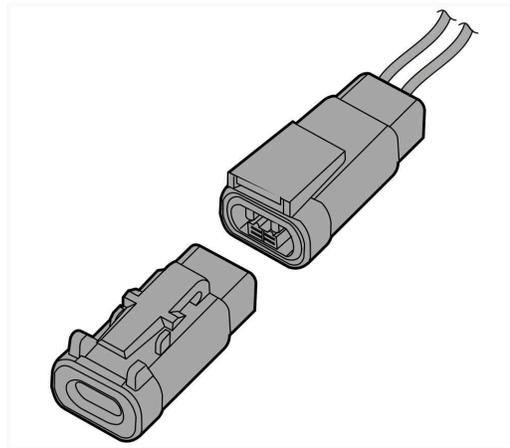


Fig. 17 J1939 Terminating Resistor

## SAE J2284 Control Data Link

The system **Control signals** are communicated via the J2284 data link.

The J2284 is the very fastest data link, operating at 500 K bits per second (500 K Baud rate). This operating speed allows a system to function more effectively and adapt quickly to changing conditions and vehicle requirements.

This data link complies with SAE standards. It consists of two twisted wires: a yellow wire (CAN\_H), and a green wire (CAN\_L). The wires are twisted at the rate of 0.89 twists per 25.4 mm (1 inch) or 33 twists per meter (3.28 feet). The twisted wires protect the data link from electrical interference.



### CAUTION

No modifications or connections are allowed on the data link wires (CAN\_H (yellow), or CAN\_L (green)). These wires carry the high-speed communications between the electronic systems in the vehicle. **Any modification, connection to, or damage to these wires can result in the failure of the vehicle electronic systems.**

### Terminating Resistor

Terminating resistors are connected to each end of the J2284 (DL2) data link.

It is allowed to have only two terminating resistors in a data link. Never install three in a data link. If the J2284 data link has more than two terminating resistors, damage to the ECU electronics can occur over time. To check whether the data link has two resistors or not, measure the resistance between circuits CAN\_H and CAN\_L using the diagnostic connector, with the starter key in the OFF position. When the data link has two resistors, the resistance should be between 50 - 70  $\Omega$ .

The resistors prevent signal reflections to the data link. They must remain connected to the system to function properly.

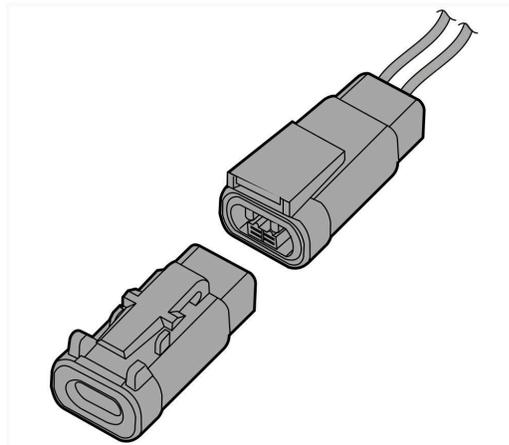


Fig. 18 J2284 Terminating Resistor



# Diagnostic Connector

The diagnostic connector is located in the LHS kick panel. The diagnostic connector is connected to the ISO information link and gives the system a way to communicate with an external PC or diagnostic tool.

The diagnostic connector is an interface for a PC or diagnostic tool to connect and read the error codes from all the control units. This is important in fault tracing to carry out basic checks of all the vital parts of the vehicle electronics.

Also, a PC or diagnostic tool uses the diagnostic connector to program the control units.

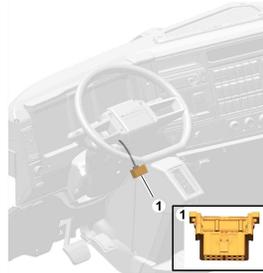


Fig. 19 1. Diagnostic Connector (16 Pin)

Pin allocation for the 2013 SAE J1962 16-pin Vehicle Diagnostic Connector (Global Commonality)

## 16 Pin Diagnostic Connector (OBD 13) Definitions

16 Pin Diagnostic Connector (OBD 13 SAE J1962-Type A Connector)	
Pin	Definition
1	OEM discretionary (assigned as: Key switch – start signal for AM tool)
2	Bus positive line of SAE J1850 (Not Used)
3	OEM discretionary (assigned as: SAE J1939-15_CAN_H)
4	Chassis ground
5	Signal ground 6 CAN_H line of ISO
6	CAN_H line of ISO 15765-4
7	K line of ISO 9141-2 and ISO 14230-4 (Not Used)
8	OEM discretionary (Not assigned)
9	OEM discretionary (Not assigned)
10	Bus negative line of SAE J1850 (Not Used)
11	OEM discretionary (assigned as: SAE J1939-15_CAN_L)
12	OEM discretionary (assigned as: SAE J1708 / J1587 positive)
13	OEM discretionary (assigned as: SAE J1708 / J1587 negative)
14	CAN_L line of ISO 15765-4
15	L line of ISO 9141-2 and ISO 14230-4 (Not Used)
16	Battery positive voltage

## Body Builder CAN Gateway

Body builder CAN gateway is an interface to connect the vehicle internal CAN. This gateway helps the body builder to monitor the standard messages of the J1939 data link via the CAN bus.

Body builder equipment should comply with the standards defined for the following types of communication bus:

- SAE J1939-11 (twisted wires)
- SAE J1939 (physical layers)
- SAE J1939-71 (functional layers)

**Note:** The body builder CAN includes a 120-Ohm terminal resistor inside the VECU.

The external equipment installer is responsible for ensuring the CAN connection has the correct terminal.

For more detailed information, refer to standard SAE J1939.

## Multiplexing Body Builder DL5 J1939 CAN

The multiplexing system BB J1939 CAN provides control and communication between all major functional areas of a vehicle. The system offers simplified communication between the body builder module and other related electrical systems. Multiple signals are sent over a single pair of twisted wires as opposed to individual wires for each function. The J1939 data link sends these signals.

The benefit of this arrangement is:

- fewer wires, and sensors
- fewer connections required for communication between the systems.

Also, there is greater signal consistency and reliability.

## Multiplexing Parameters

SAE (PGN)	CAN Network	Source Address [Decimal (hex)]	Update Rate	PGN Signal Names (SPN)
ACC1 (65135)	J1939-X	42 (2A)	100 ms	Forward vehicle speed Forward vehicle distance ACC Set Speed ACC Mode ACC set distance mode Road curvature ACC Target Detected ACC System Shutoff Warning ACC Distance Alert Signal
ACC Status (65296)	J1939-X	42 (2A)	100 ms	Proprietary message from Bendix
AIR1	J1939-X	17 (11)	1 second	Pneumatic Supply Pressure 46
AMB (65269)	J1939-X	0 (0)	1 second	Ambient Air Temperature, Barometric pressure
CCVS (65265)	J1939-X	17 (11)	100 ms	Vehicle speed, etc.
DD (65276)	J1939-X	23 (17)	1 second	Washer fluid level (SPN 80)

SAE (PGN)	CAN Network	Source Address [Decimal (hex)]	Update Rate	PGN Signal Names (SPN)
DM1 (65226)	J1939-X	0 (0), 3 (3), 11 (B), 61 (3D)	1 second	Fault lamps, etc.
EBC1 (61441)	J1939-X	11 (B)	100 ms	Anti-lock braking system (ABS) Active, etc.
EBC2/WSI (65215)	J1939-X	11 (B)	100 ms	Wheel speeds
EBC5 (64964)	J1939-X	11 (B)	100 ms	Hill Holder Mode
EEC2 (61443)	J1939-X	0 (0)	50 ms	Accelerator Pedal Position 1 Remote accelerator pedal position
ET1 (65262)	J1939-X	0 (0)	1 second	Coolant Temperature 110
ETC2 (61445)	J1939-X	3 (3)	100 ms	Current gear status, requested gear status
HRW (65134)	J1939-X	11 (B)	20 ms	Wheel speeds
LCMD (65089)	J1939-X	55 (37)	1 second and change of state	Light switches, etc.
TRF1 (65272)	J1939-X	3 (3)	1 second	Transmission Oil Temperature 177, etc.
VD (65248)	J1939-X	23 (17)	1 second	Total Vehicle Distance 245 Convert from VDHR
VDHR (65217)	J1939-X	23 (17)	1 second	High-Resolution Total Vehicle Distance 917
VEP1 (65271)	J1939-X	23 (17)	1 second	SPN 168 Battery Potential/Power Input 1

**Note:** Although the VECU sends output messages, the source address is set as the ECU originating the information.

**Note:** Messages that rates “on request” are requested by the J1939 request PGN 59904 described in J1939-21. For example, requesting engine hours is done by sending EAFF or EA00 with data E5 FE 00 (hex values).

**Note:** Not all messages are supported on all vehicles. For example, GFC is currently not available, even for natural gasoline engines. However, in the future, the engine could have GFC message support.

## Application Notes

By default, these commands are not accepted. To enable commands:

- QIW = 1 Bridge on J1939 for Body Builder Enable (1) Level 4 Dealer Programmable
- QKH = 1 External CAN Control Enable (1) Level 4 Dealer Programmable
- QKX = 229 (Body Builder must use this Source address 229)
- A Terminating resistor for the network needs to be installed.

For safety, a brake pedal application overrides the accelerator and speed command signals. If necessary, this option can be turned off with parameter QKD. Perform a safety analysis of the application before disabling.