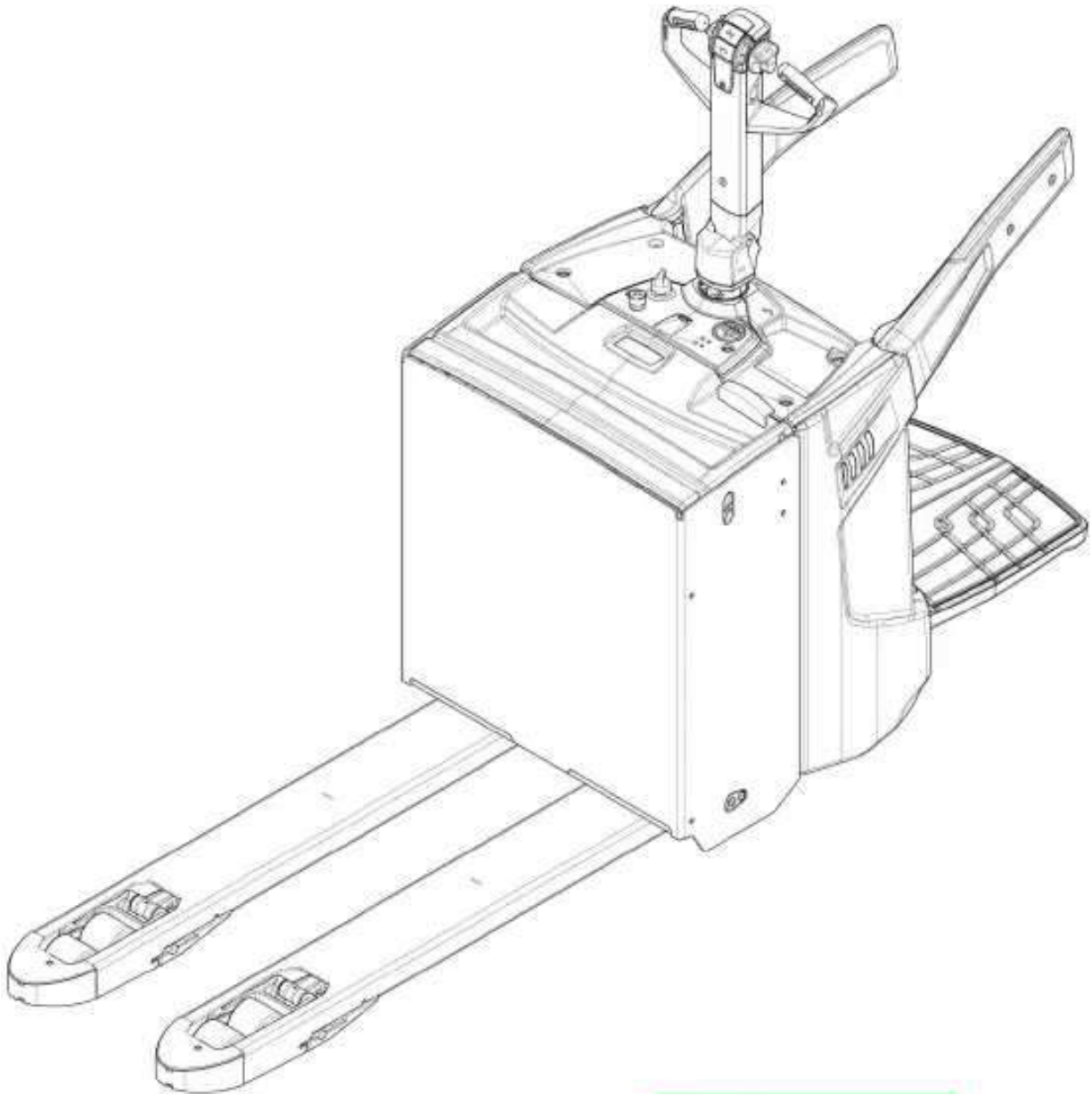
MITSUBISHI FORKLIFT TRUCKS

SERVICE MANUAL

PBV20N2

615023



English 2013

Only adequately trained service persons are allowed to carry out service operations. The terms of the warranty prescribe appropriate maintenance of the truck. All spare parts must be original ones.

It is recommended that you sign a maintenance agreement with the truck dealer, who can also supply spare parts. Only professional service ensures long-term, trouble-free truck operation. Service program monitoring becomes easier if you enter the service dates in a service logbook. Contact our service organisation or your truck dealer for qualified, authorized and efficient maintenance service.

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Approvals and version history

ISSUE	DATE	DESCRIPTION OF CHANGE	APPROVED BY
A	03.10.2012	First issue	R&D
B	03.07.2013	Second issue	R&D

Original instructions ___X___ / Translation of the original instructions _____

Contents

1 Foreword

This service manual is a guide for servicing lift trucks.

The long productive life of your lift truck depends on regular and proper servicing, consistent with the instructions provided in this service manual.

Before starting to test, repair or rebuild a lift truck, read the respective sections of this manual carefully and familiarize yourself with all of the components.

The descriptions, illustrations and specifications contained in this manual are for lift trucks with serial numbers in effect at the time of printing.

The manufacturer reserves the right to change specifications or designs without notice and without incurring obligations. For your convenience, the instructions are grouped by systems as an easy reference.

Unauthorized copying and lending of this material is strictly prohibited.

2 How to read this manual

2.1 Safety-related signs

The following table explains the safety-related signs used in this document.

⚠ DANGER	**DANGER** indicates a hazard with a high level of risk which, if not avoided, will result in serious injury or death.
⚠ WARNING	**WARNING** indicates a hazard with a medium level of risk which, if not avoided, could result in serious injury or death, or damage to your machine.
⚠ CAUTION	**CAUTION** indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury, or damage to your machine.

NOTE: Notes are used to indicate important information and useful tips.

2.2 Symbols and abbreviations

2.2.1 Safety symbols

Hazard symbols

These symbols indicates a hazardous situation or action. Symbols are used to warn of situations, which may cause environmental damage and personal injury.

General hazard symbol

General warning sign

Hazard symbols

Explosion and fire hazard

Corrosive hazard

	Battery hazard		Electrical hazard

Prohibited action symbols

These symbols are used in warnings and notifications to indicate an action that should not be taken. The prohibited action symbols are presented below.

	No smoking		General symbol for prohibited action

Mandatory action symbols

These symbols are used in warnings and notifications to indicate an action that must be taken. The mandatory action symbols are presented below.

	Wear eye protection		Read the manual or instructions
	General symbol for mandatory action		Doctor symbol
	Batteries marked with this sign must be recycled.		

2.2.2 Other symbols and abbreviations

SYMBOL OR ABBREVIATION	DESCRIPTION
OP	Option
COM	Common terminal
NC	Normally closed terminal
NO	Normally open terminal
R1/4	Taper pipe thread (external) 1/4 inch (formerly PT1/4)
RC1/8	Taper pipe thread (external) 1/8 inch (formerly PT1/8)
G1/4A	Straight pipe thread (external) 1/4 inch (formerly PF1/4-A)
Rp1/8	Straight pipe thread (internal) 1/8 inch (formerly PS1/8)

2.3 Units

SI units are used in this manual.

The following table shows the conversion of SI units to customary units.

ITEM	SI UNIT	METRIC UNIT	YARD-POUND UNIT
Force	1 N	0.102 kgf	0.225 lbf
Pressure	1 MPa	10.1972 kgf/cm2	145.038 psi
Torque	1 N m	0.102 kgf m	0.7376 lbf ft
Length	1 mm 1 m	- -	0.039 inch 3.281 feet
Weight	1 kg	-	2.205 lb
Temperature	1°C	-	°F=1.8 x °C+32
Volume	1 L	-	0.264 US.gal.

3 Safety instructions

⚠ WARNING

The proper and safe lubrication and maintenance of these lift trucks as recommended by the manufacturer is outlined in this document. Read this manual before performing any lubrication or maintenance on these trucks. Improper performance of lubrication or maintenance procedures is dangerous and can result in injury or death.

Do not make any alterations or repairs that can weaken the truck's structure or endanger safety.

Do not operate the truck unless you have read and understood the instructions in the operator manual. Improper truck operation is dangerous and can result in injury or death.

Knowledge of the system and/or its components is important before the removal or disassembly of any components.

The following sections list some basic precautions that should always be observed.

3.1 Service area safety

- Keep the service area clean. Oil, grease, and water make the floor slippery.
- If possible, make all repairs with the truck parked on a level, hard surface.
- Before starting to work on the truck, hang a "Do not Operate" sign in the operator compartment.
- The truck must always be supported on jacks, if working underneath it.
- Do not work on any truck that is supported only by lift jacks or a hoist. Always use blocks or jack stands to support the truck before performing any disassembly.
- Lower the forks or other implements to the ground before performing any work on the truck. If this cannot be done, make sure the forks or other implements are blocked correctly to prevent them from falling unexpectedly.
- Use steps and grab handles (if applicable) when mounting or dismounting a truck. Clean any mud or debris from steps, walkways or work platforms before use. Always face the truck when using steps, ladders and walkways. When it is not possible to use the designed access system, use ladders, scaffolds, or work platforms to perform safe repair operations.

- To avoid back injury, use a hoist when lifting components weighing 23 kg (51 lb) or more. Make sure all chains, hooks, slings, etc., are in good condition and of the correct capacity. Make sure all hooks are positioned correctly. Lifting eyes are not to be side-loaded during a lifting operation.
- Make sure all protective devices including guards and shields are properly installed and functioning correctly before starting a repair. If a guard or shield must be removed to perform the repair work, use extra caution.
- Always support the mast and carriage to keep the carriage or attachments raised when performing maintenance or repair work that requires the mast to be in the raised position.

3.2 Personal safety

- Remove all rings, watches and other pieces of metal jewellery before you start working on the truck. If a metal object gets into contact with an electrically conductive part, it may cause a short circuit or a serious burn.
- Always wear protective glasses and protective shoes when working around trucks. In particular, wear protective glasses when using a hammer or sledge on any part of the truck or its attachments. Use welder's gloves, hood/goggles, apron and other protective clothing appropriate to the welding job being performed. Do not wear loose fitting or torn clothing.

3.3 Work safety

- Unauthorized truck modification is not permitted. No modifications or alterations to a powered industrial truck, which could affect, for example, capacity, stability or safety requirements of the truck, shall be made without the prior written approval of the original truck manufacturer, its authorized representative, or a successor thereof. This includes changes affecting, for example, braking, steering, visibility and the addition of removable attachments. When the manufacturer or his successor approves a modification or alteration, the manufacturer or successor shall also make and approve appropriate changes to the capacity plate, decals, tags and operation and maintenance handbooks.

  Only in the event that the truck manufacturer is no longer in business and there is no successor in the interest to the business, may the user arrange for a modification or alteration to a powered industrial truck, provided, however, that the user:

  a. arranges for the modification or alteration to be designed, tested and implemented by an engineer(s) expert in industrial trucks and their safety,

  b. maintains a permanent record of the design, test(s) and implementation of the modification or alteration,

  c. approves and makes appropriate changes to the capacity plate(s), decals, tags and instruction handbook, and

d. affixes a permanent and readily visible label to the truck stating the manner in which the truck has been modified or altered, together with the date of the modification or alteration and the name and address of the organization that accomplished those tasks.

- Switch off the truck's power before opening the cover of the motor compartment or the electrical system.
- Relieve all pressure in the air, oil or water systems before disconnecting or removing any lines, fittings or related items. Release the residual pressure when removing a pressurized device.
- With sit-on trucks, dismount the seat for the duration of the service work.
- Before operating, lubricating or repairing the product, read all warning plates and decals on the truck.
- Do not use your hands to check for oil leaks.
- To avoid burns, pay attention to the hot sections and hot fluids in lines, tubes and compartments, even when the truck is idle or off.
- Only use clean oil in the hydraulic system.
- Repairs requiring welding should be performed only with the appropriate reference information and by personnel adequately trained and knowledgeable in welding procedures. Determine the type of metal and select the correct welding procedure and electrodes, rods or wire to provide a weld metal strength equivalent at least to that of the parent metal.
- When welding, always disconnect the battery and electronic devices. Remove all paint from a 10 cm radius from the welding point to avoid creating toxic gases during welding.
- Use proper lifting procedures when removing any components.
- Be careful when removing cover plates. Gradually remove the last two bolts or nuts located at opposite ends of the cover or device. Before removing the last two bolts or nuts completely, pry the cover loose to relieve any springs or other pressures.
- Be careful when removing filler caps, breathers and plugs on the truck. Wrap a cloth around the cap or plug to prevent being sprayed or splashed by liquids under pressure. Be aware that the danger of being sprayed or splashed is always greater immediately after stopping the truck, as the fluids are very hot.
- Use only well-maintained tools. Also make sure that you use the tools in a proper way.
- Reinstall all fasteners with the same part number. If a replacement is needed, do not use a fastener of lesser quality.
- Do not damage wiring during the removal process. Do not reuse any damaged wiring. When reinstalling, make sure the wiring does not come into contact with any sharp corners or hot parts. Place all wiring away from the oil pipe.

- Loose or damaged fuel, lubricant and hydraulic lines, tubes and hoses can cause fires. Do not bend or strike any high pressure lines or install ones that have been bent or damaged. Inspect all lines, tubes and hoses carefully. Pin hole (very small) leaks can result in a high velocity oil stream that will be invisible close to the hose. This oil can penetrate the skin and cause personal injury, so use cardboard or paper to locate pin hole leaks.
- Tighten connections to the correct torque. Make sure that all heat shields, clamps and guards are installed correctly to avoid excessive heat, vibration or rubbing against other parts during operation. Protective shields against oil sprays onto hot exhaust components in the event of a line, tube or seal failure must be installed correctly.
- Do not operate the truck, if any rotating part is damaged or comes into contact with any other part during operation. Every high speed rotating component that has been damaged or altered should be checked for balance before reusing.

4 General information

4.1 Truck model covered by this manual

This service manual covers the service instructions of the following truck model:

- PBV20N2 - Pedestrian Power Pallet Truck - a five-wheel ride-on and pedestrian-operated electric pallet truck, equipped with a multifunctional tiller control for driving, steering and load handling.

NOTE: Throughout chapters 4 to 14, this manual provides service instructions for the basic truck model. All material related to optional features is available in Chapter 15.

4.2 Identification plates on the truck

NOTE: Check that all the plates and stickers on the truck are legible and securely attached!

Figure 1 below shows the truck's plates and stickers and their locations. For more details on the truck's plates and stickers, see the APPENDIX A.

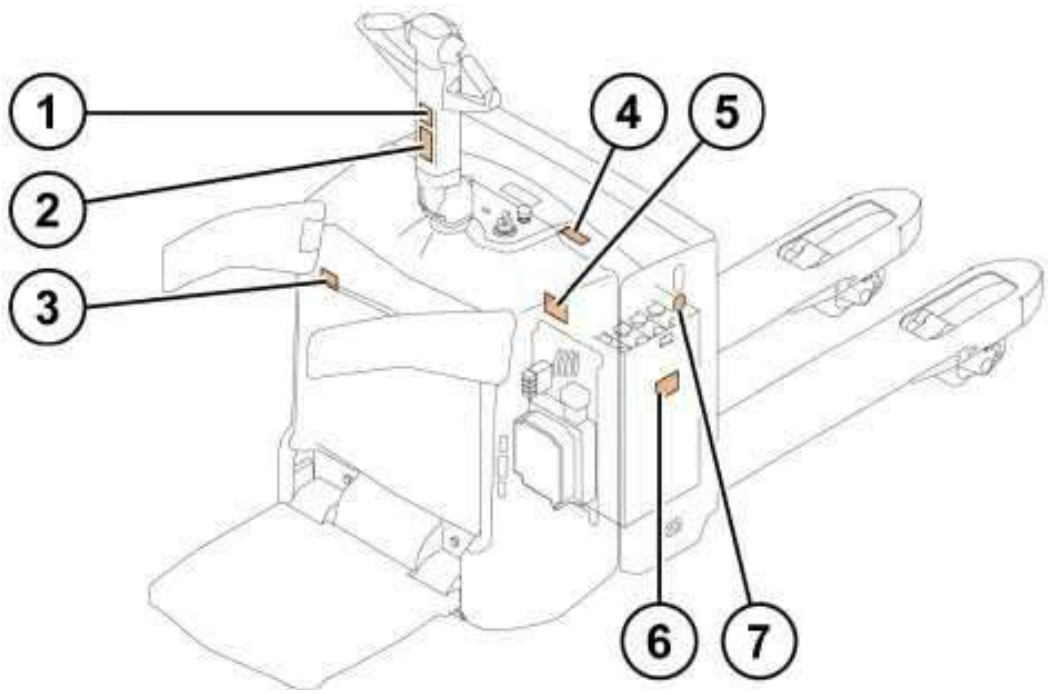


Figure 1. Truck's plates and stickers overview

1. *Operation warning sticker*
2. *Type plate*
3. *Serial number sticker*
4. *Battery maintenance warning sticker*
5. *Electric panel cleanup warning sticker*
6. *Battery type plate*
7. *Hoist point indication sticker*

The truck's type plate states the following:

- Manufacturer
- Truck type
- Serial number
- Battery minimum weight
- Battery terminal voltage
- Truck’s nominal lifting capacity
- Year of manufacture
- CE mark

4.3 Overview of the truck

4.3.1 Operating devices

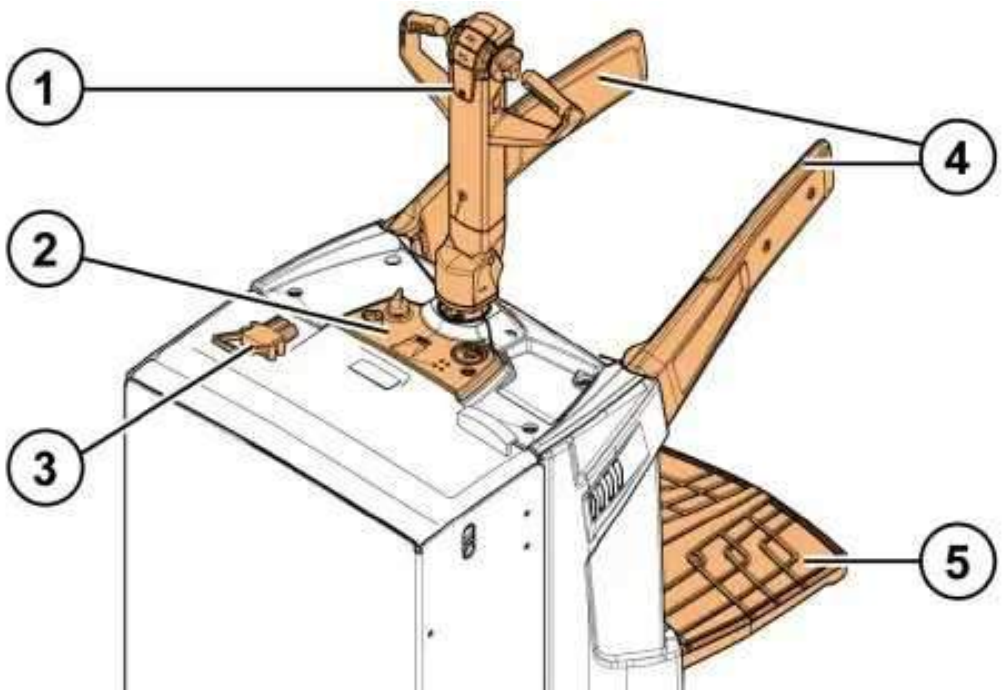
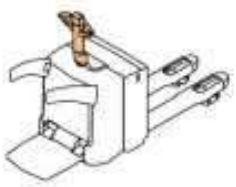


Figure 2. Operating devices

1. *Tiller arm*
2. *Control panel*
3. *Battery connector (under the battery cover)*
4. *Side guards*
5. *Operator’s platform*

4.3.2 Tiller arm

4.3.2.1 Tiller arm controls



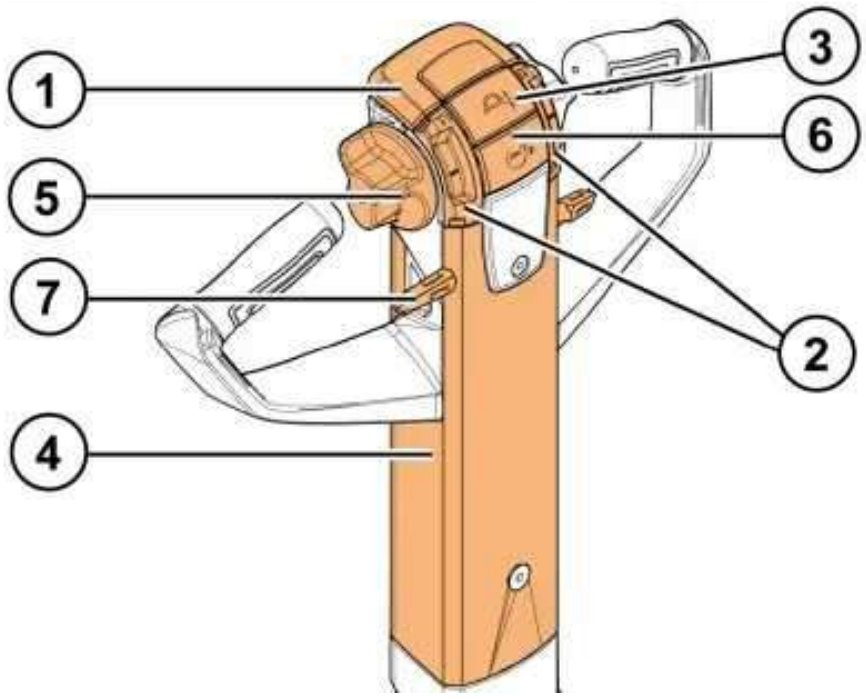


Figure 3. Tiller arm controls

1. *Safety button*
2. *Push buttons for lifting and lowering*
3. *Horn*
4. *Steering*
5. *Accelerator*
6. *Brake release / low speed button*
7. *Lever for lifting and lowering (optional)*

Table 1. Control functionalities

CONTROL	FUNCTIONALITY DESCRIPTION
Safety button (belly button)	The safety button prevents you from getting squeezed between the truck and an obstacle. When the safety button is pushed, the truck reverses its travelling direction. When the button is released, the truck stops.
Push buttons for lifting and lowering	Push the Up button to lift the forks. Push the Down button to lower the forks.
Horn	Press the button to give an audible warning signal.
Steering	The tiller arm turns ± 100 degrees.

CONTROL	FUNCTIONALITY DESCRIPTION
Accelerator	Use the accelerator with your right or left hand. The more you turn the accelerator, the higher the speed. The accelerator returns automatically to the central position, when it is released. Brake smoothly by turning the accelerator to the opposite direction.
Brake release / low speed button	The button has two functions: • Brake release When the tiller arm is in the up position, hold the button down to release the parking brake and turn the accelerator to drive the truck in the slow speed mode. Release the button to apply the parking brake. • Low speed mode When the tiller arm is in the driving position, activate the low speed mode by pressing the button once. The Lo SPd symbol is shown in the multi-function display. Deactivate the low speed mode by pressing the button again.
Lever for lifting and lowering (optional)	Pull the lever up to lift the forks. Push the lever down to lower the forks.

4.3.2.2 Tiller arm positions

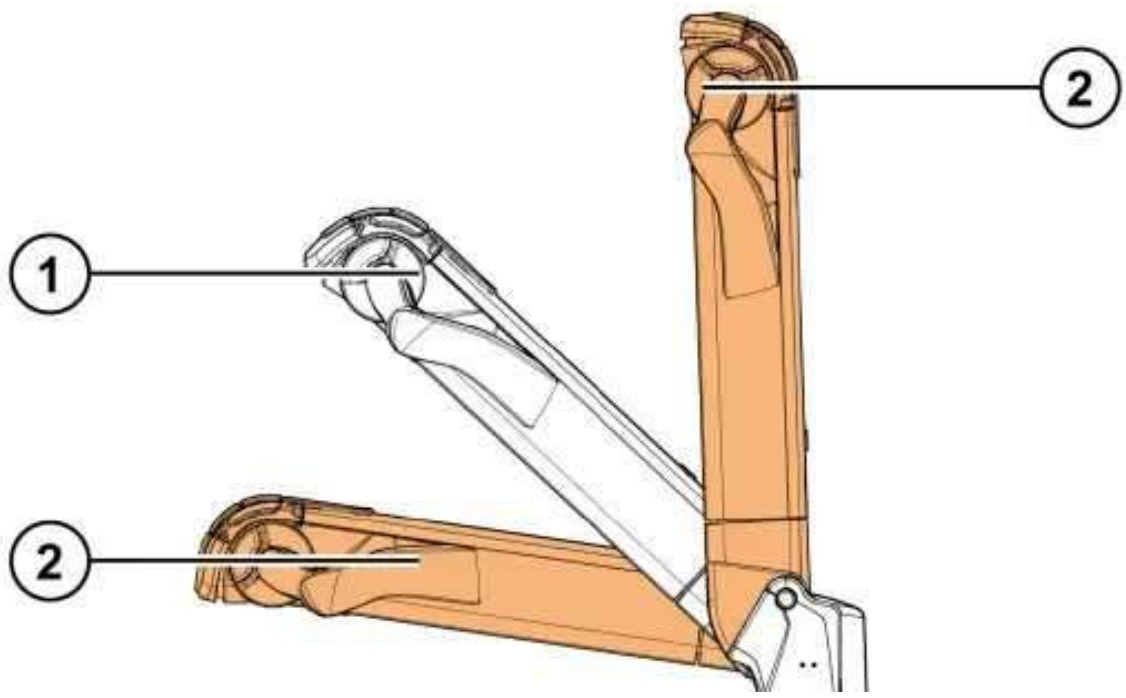
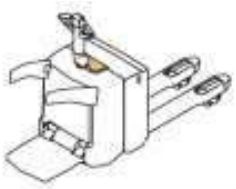


Figure 4. Tiller arm positions

1. *Driving position*
2. *Emergency braking*

4.3.3 Control panel



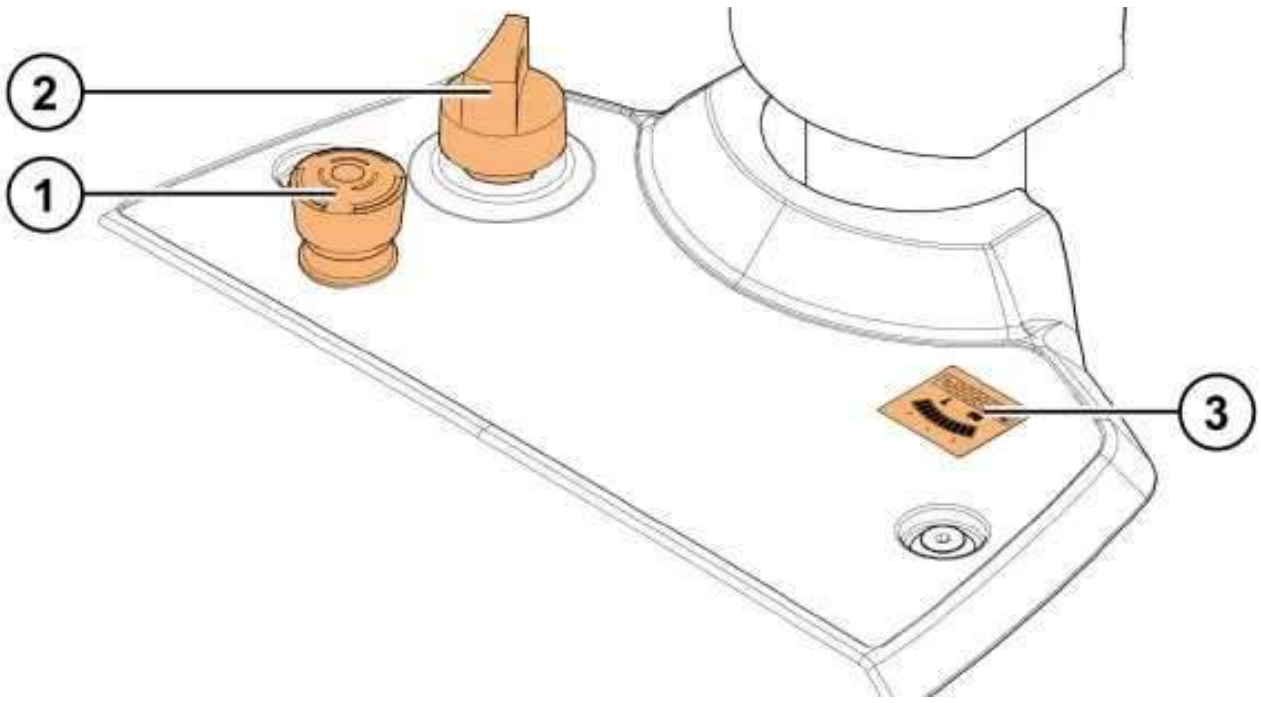


Figure 5. Control panel

1. *Emergency stop button*
2. *Key switch*
3. *Multi-function display*

4.3.3.1 Emergency stop button

Press the emergency stop button to disconnect the truck's power supply. Release the button by turning it clockwise.

Use the emergency stop button in the following cases:

- In case of a short circuit or some other electrical malfunction (for example, if the pump motor does not stop running).
- In case of an accident.

4.3.3.2 Key switch

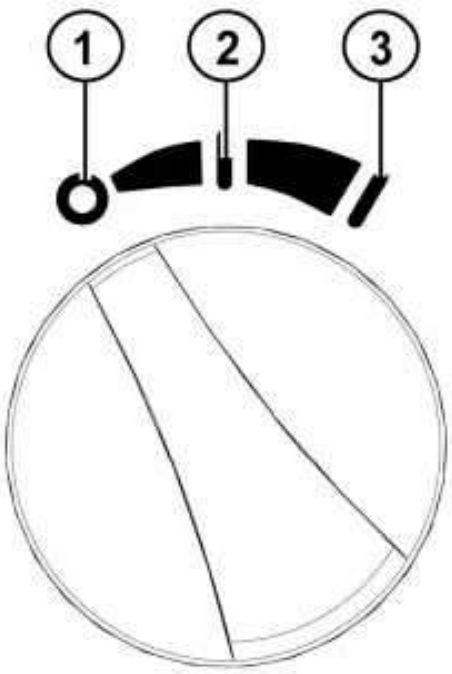


Figure 6. Key switch

1. *Power off*
2. *Power on, economy mode*
3. *Power on, standard mode*

The key switch switches the truck's electrical system on and off.

When the key switch is in the off position, the truck’s electrical system is turned off. Note however that power may be still connected to certain electronic devices.

When the key switch is turned once to the right, the truck’s electrical system is turned on and the economy mode (lower energy consumption and deceleration, maximum speed limited to 6 km/h) is activated. The ECO symbol is shown in the multi-function display.

When the key switch is turned once more to the right, the standard mode (normal energy consumption and deceleration, maximum speed 9 km/h) is activated.

4.3.3.3 Multi-function display

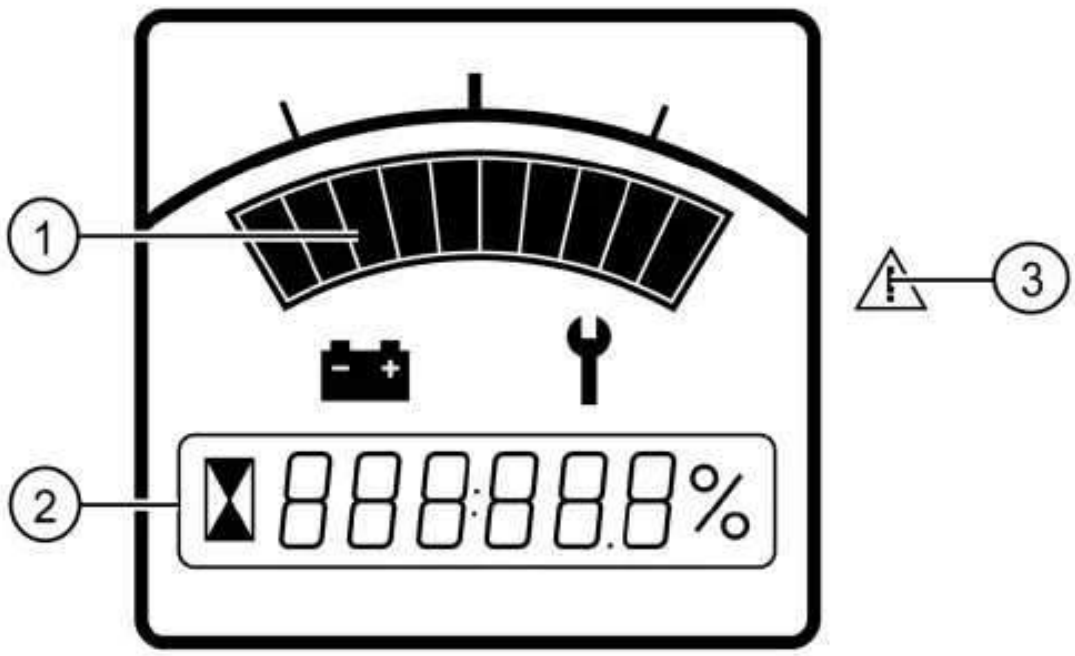


Figure 7. Multi-function display

1. *Level of battery charge*
2. *Indication of operational hours, system messages and fault codes*
3. *LED indicator*

The multi-function display shows the following information:

- Level of battery charge
- Indication of operational hours
- System messages:
  - ECO = Economy mode selected
  - Lo SPd = Low speed mode selected
- Fault codes:
  - Numeric code = warning or alarm. For more detailed information about warnings and alarms, see chapter 13.
- LED indicator:
  - Flashing red = alarm

4.3.4 Driving position

A pallet truck equipped with a foldable operator's platform can be driven either walking behind the truck (the pedestrian mode) or standing on the platform (the riding mode).

4.3.4.1 Pedestrian mode

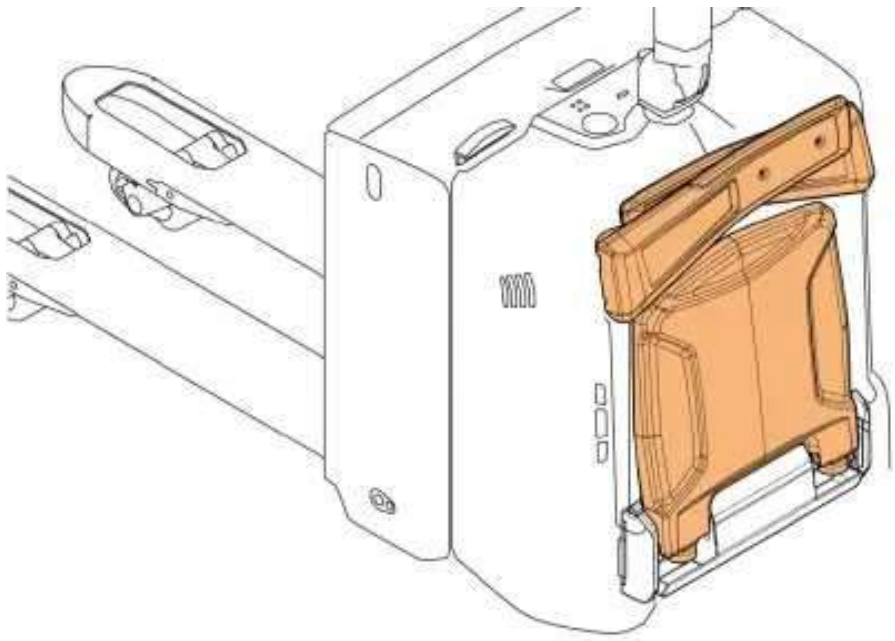


Figure 8. Operator's platform and side guards in the pedestrian mode

To drive the truck in the pedestrian mode, lift the operator's platform up by lifting it slightly and allowing the gas spring to lift it up completely and then fold the side guards in.

To drive the truck in the direction of the forks, walk behind the truck and keep both hands on the tiller arm. To drive in the opposite direction, walk beside the truck and keep one hand on the tiller arm.

NOTE: The maximum driving speed in pedestrian mode has been limited to 6 km/h.

If you only lift the operator's platform up but leave the side guards unfolded, the truck will not move. For more detailed information about the functionalities of the side guards and operator's platform, see the section 8.5.1.

4.3.4.2 Riding mode

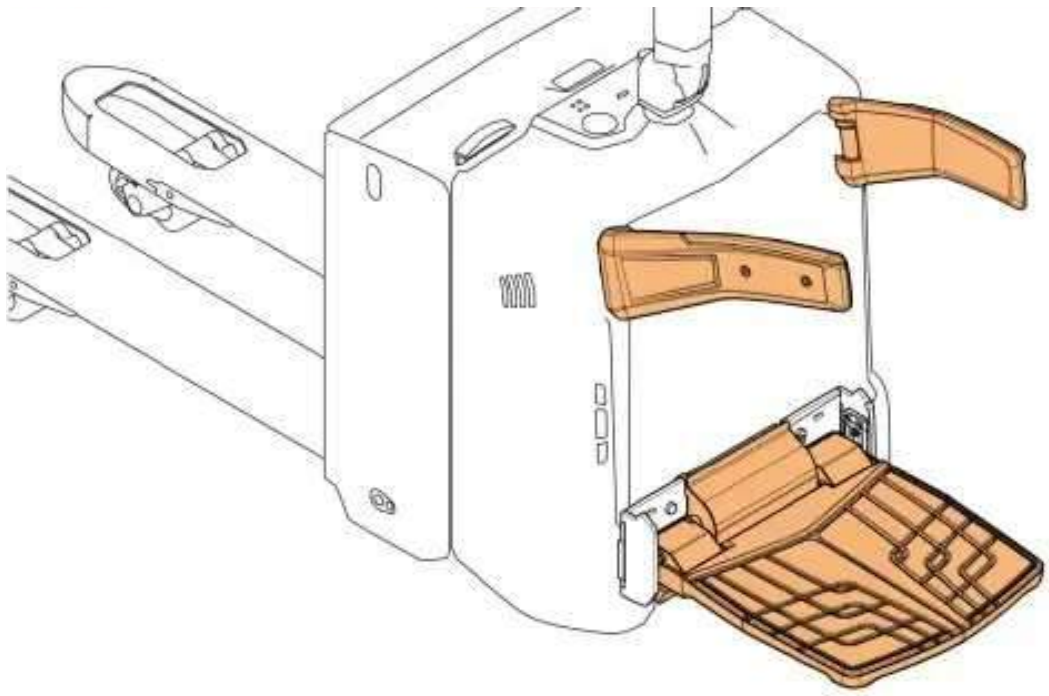


Figure 9. Operator's platform and side guards in the riding mode

To drive the truck in the riding mode, lower the operator's platform to the horizontal position and unfold the side guards. The side guards keep the operator within the outlines of the truck and prevent the operator from losing balance.

To drive the truck in the riding mode, step on the platform and keep both hands on the tiller arm. When you step off the platform, it stays in the horizontal position automatically.

NOTE: The maximum driving speed in the riding mode is 9 km/h.

It is also possible to drive the truck on the platform without unfolding the side guards. In this case, the maximum driving speed has been limited to 6 km/h.

There is also an optional 12 km/h speed mode available, where the top speed is adjusted according to the load.

4.3.5 Driving direction

To go forward, drive the truck in the direction of the forks. To go backward, drive the truck in the opposite direction.

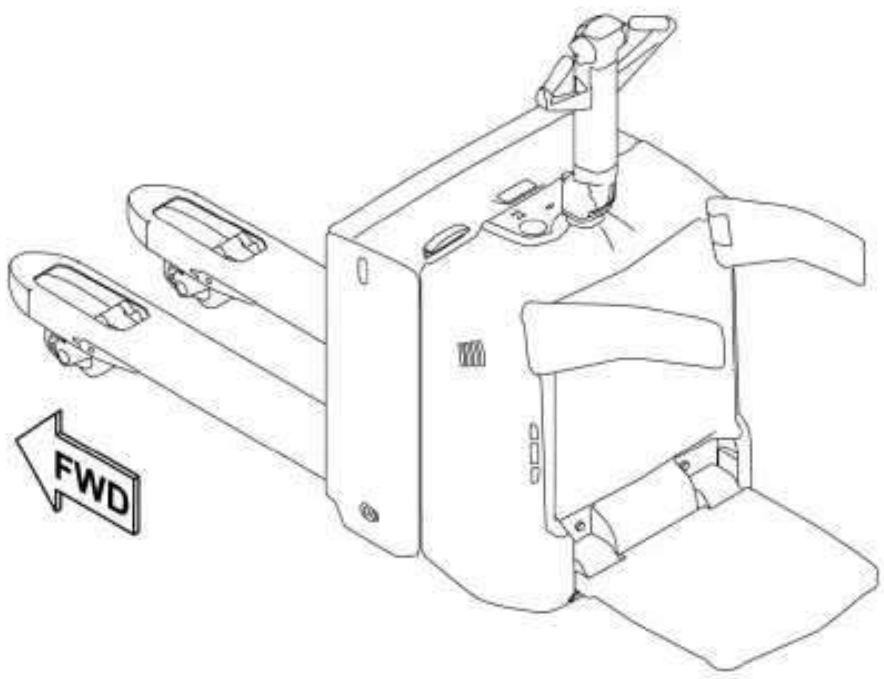
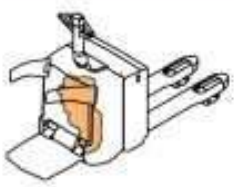


Figure 10. Driving direction

NOTE: The forward-driving direction is determined in EN ISO 3691-1:2012 Annex A.

4.3.6 Motor and electrical system



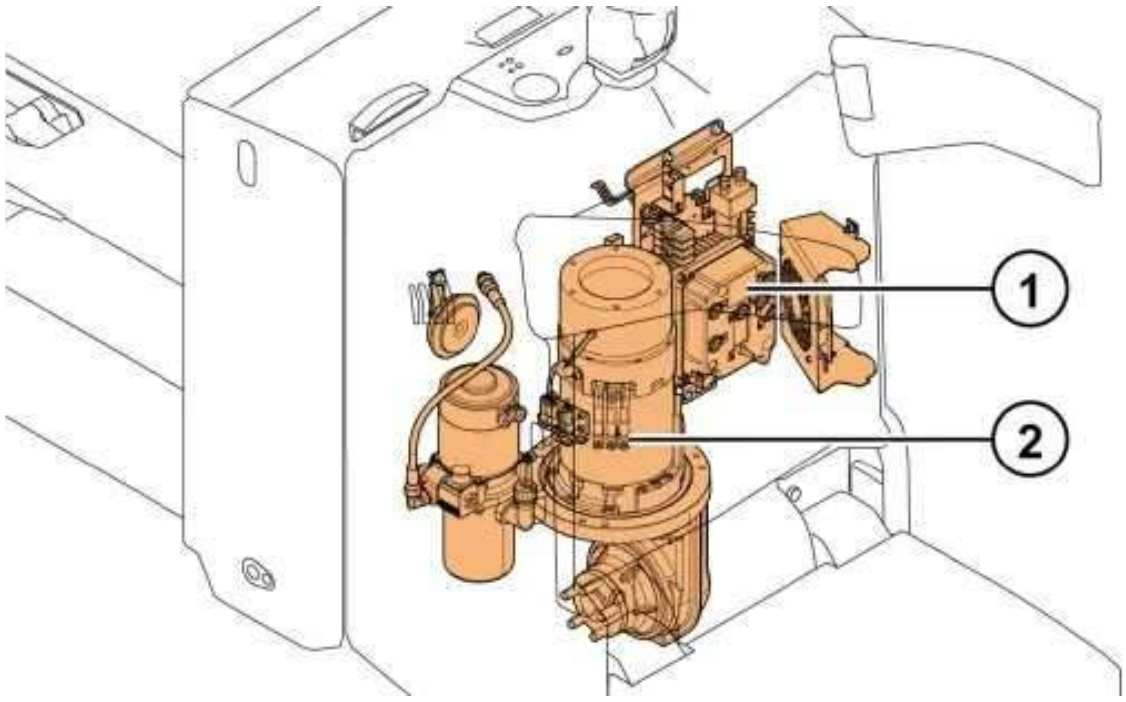


Figure 11. Overview of the motor and electrical system

1. *Electric panel (covered with a plastic electrical panel cover)*
2. *Drive unit*

4.3.6.1 Electric panel

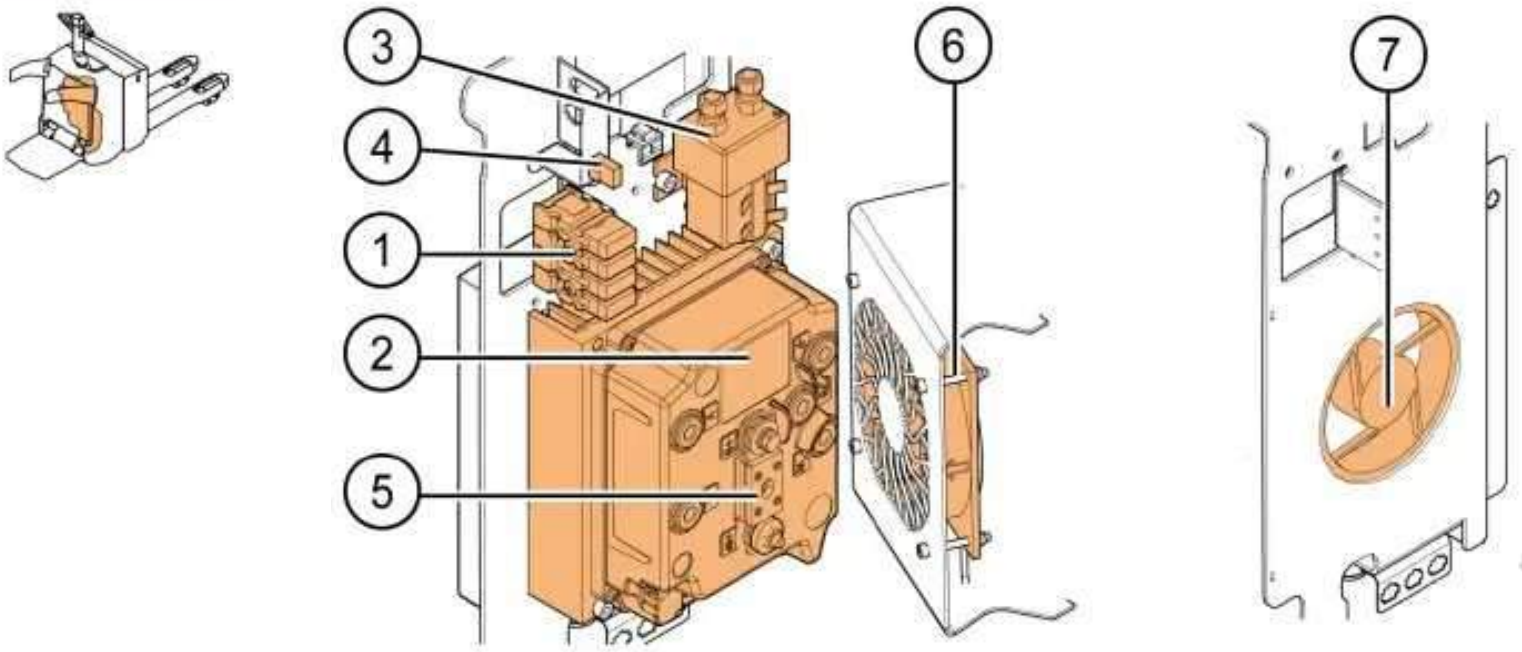
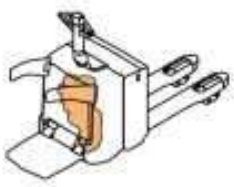


Figure 12. Electric panel overview

1. *Fuse box*
2. *Traction and pump controller COMBIACX A1 with the drive/pump motor fuse*
3. *Main contactor K1*
4. *Diagnostic connector X10*
5. *Main fuse*
6. *Motor fan*
7. *Controller fan (behind the electric panel)*

4.3.6.2 Motor compartment



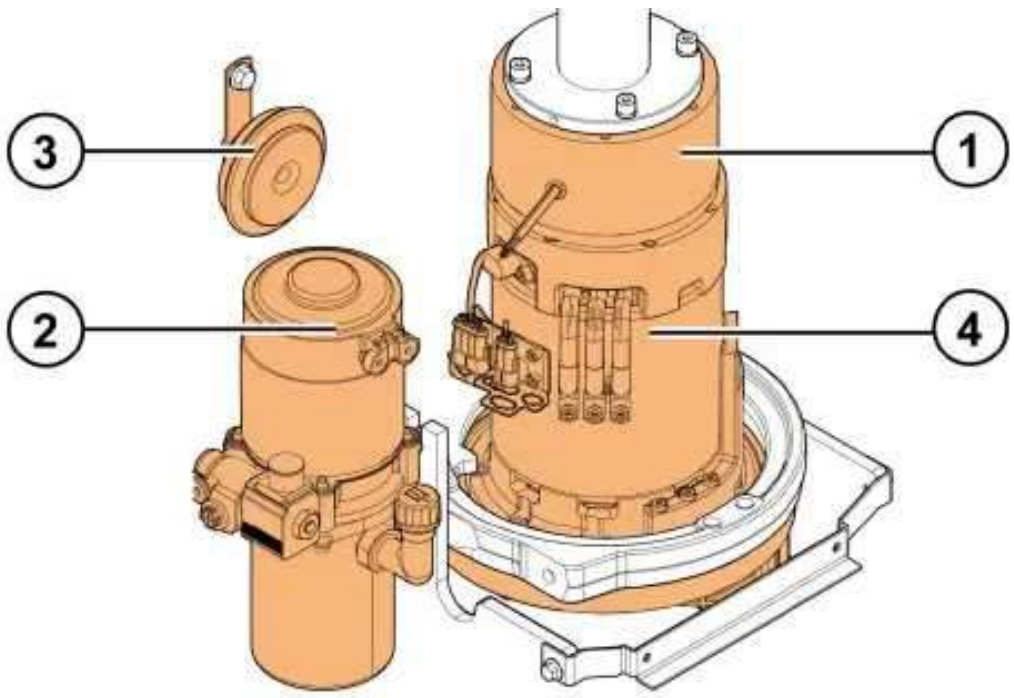
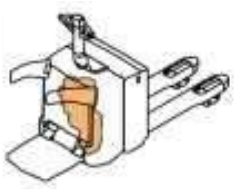


Figure 13. Motor compartment overview

1. *Magnetic brake*
2. *Hydraulic aggregate*
3. *Horn*
4. *Traction motor*

4.3.6.3 Traction motor

Type	3-phase AC
Voltage	16 V
Output power	2.3 kW



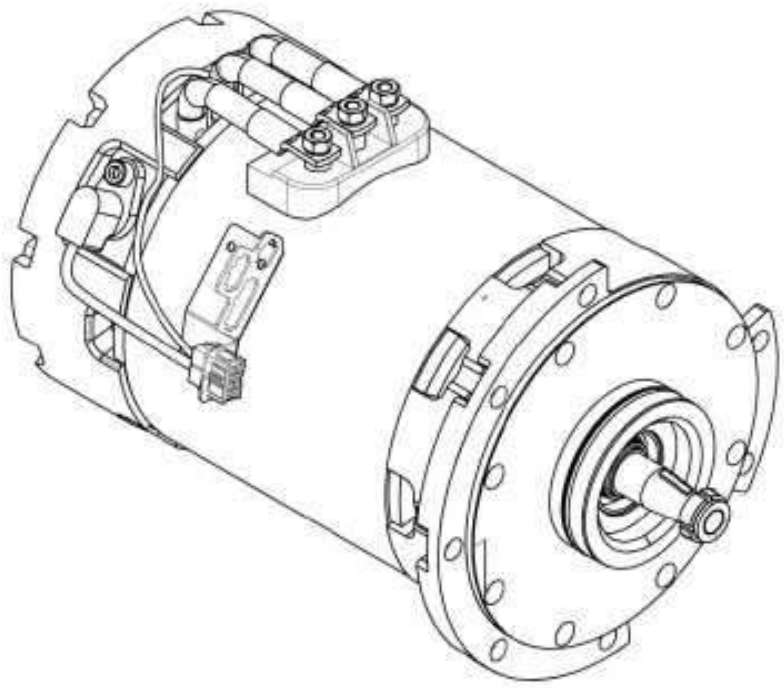


Figure 14. Traction motor

The correct tightening torque for the traction motor power terminals is 6 Nm.

4.3.7 Sensors

An inductive sensor is an electronic proximity sensor, which detects metallic objects without touching them.

The sensor consists of an induction loop. Electric current generates a magnetic field that collapses, thus generating a current that falls asymptotically toward zero from its initial level, when the electricity input ceases. The inductance of the loop changes according to the material inside it and, since metals are much more effective inductors than other materials, the presence of metal increases the current flowing through the loop. This change can be detected by sensing circuitry, which can signal to some other device whenever metal is detected.

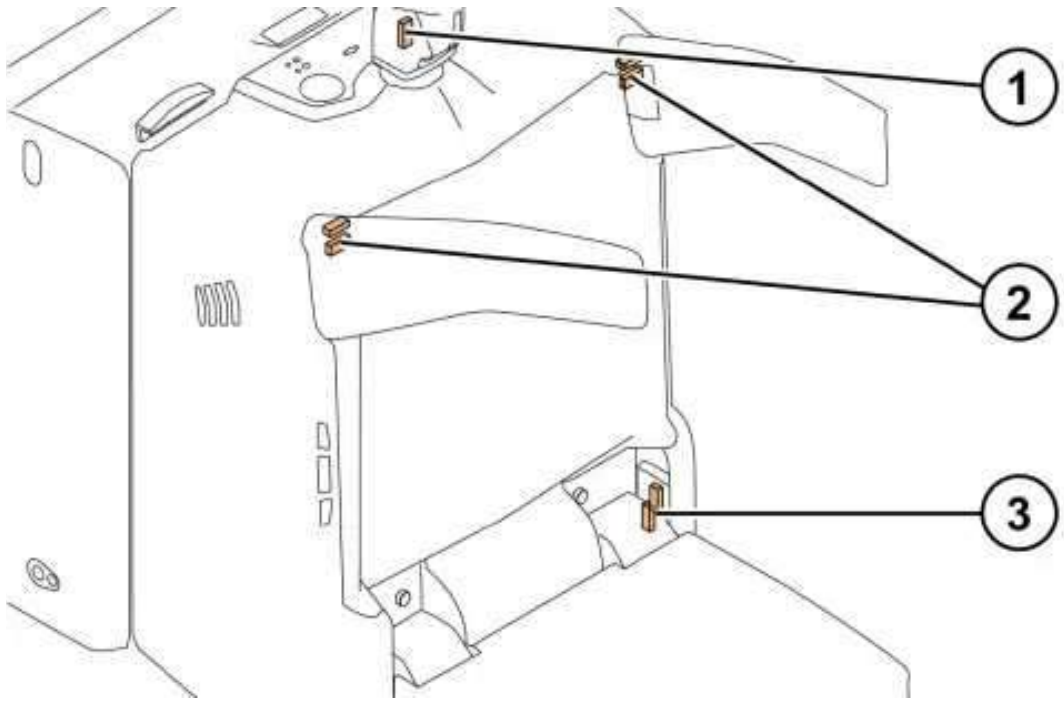


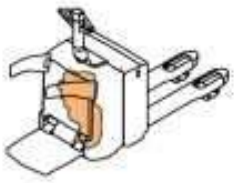
Figure 15. Sensor locations

1. *Tiller sensor*
2. *Side guard sensors*
3. *Operator's platform sensors*

The truck uses the following sensors:

- Tiller sensor
- Four side guard sensors, two on each side guard
- Operator's platform sensors, two on the right-hand side

4.3.8 Truck suspension



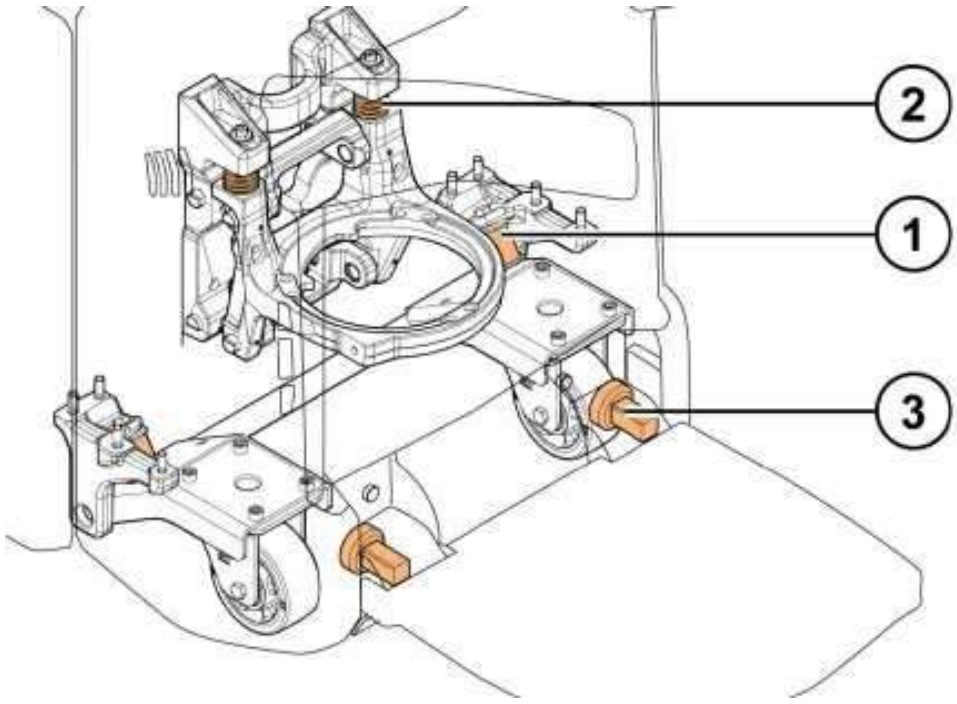


Figure 16. Truck suspension overview

1. *Castor wheel suspension*
2. *Drive unit suspension*
3. *Platform suspension*

The truck has three suspension systems:

- Drive unit suspension
- Castor wheel suspension
- Platform suspension

Together these suspension systems improve the truck's driving experience.

The purpose of the suspension systems is to ensure the truck's driving capabilities regardless of the truck's loading situation. The drive unit and castor wheel suspension systems work together and they are tuned according to the truck's load weight. The platform suspension is designed to reduce the vibration and shock impact to the truck driver.

5 Mechanical maintenance

5.1 Lifting points

⚠ CAUTION

Lift or jack up the truck and support it with safety blocks or rigid stands.

Apply wheel chocks to the load wheels to prevent the truck from moving.

5.1.1 Jack points

Figure 17 below indicates the correct jack points for lifting the truck up for maintenance.

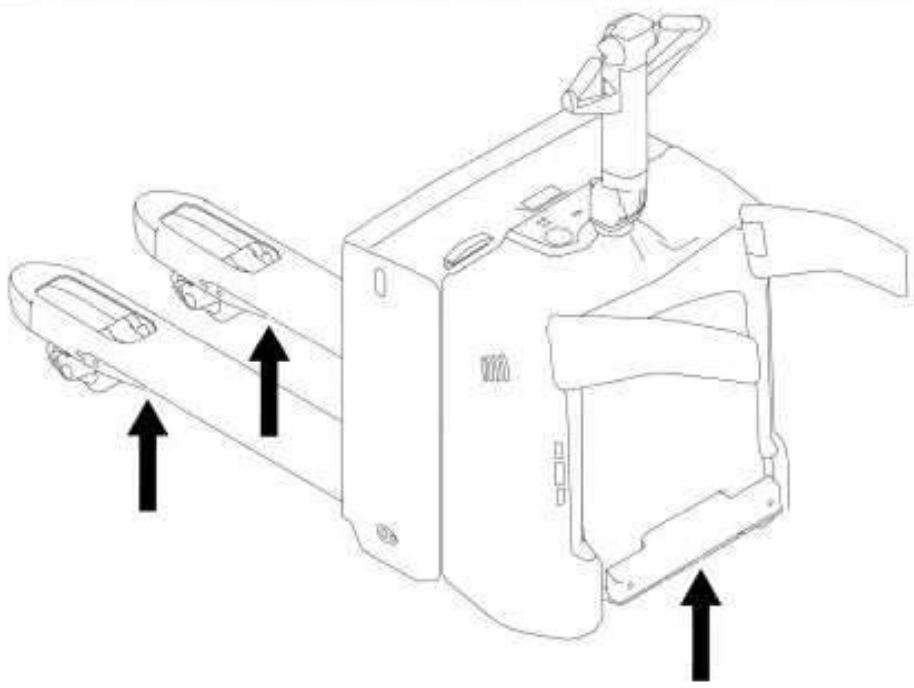


Figure 17. Jack points

5.1.2 Hoist points

Figure 18 below indicates the correct hoist points for hoisting the truck up for maintenance. Make sure that the capacity of the lifting device is sufficient.

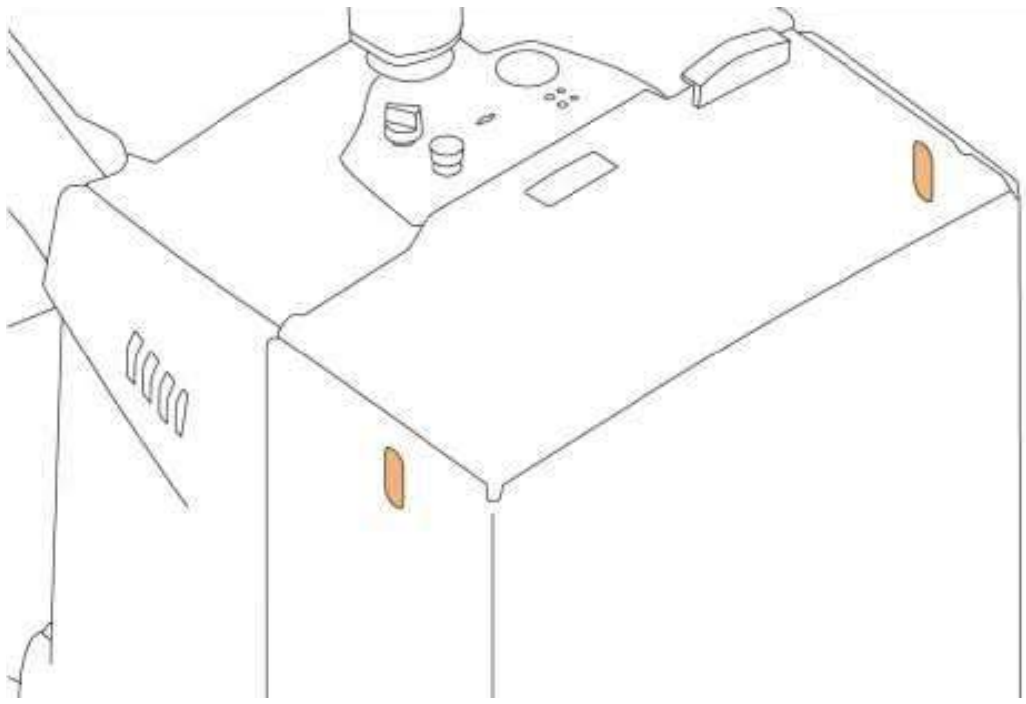


Figure 18. Hoist points

5.2 Transportation

When transporting the truck, it is important that you secure it safely to prevent it from moving. For transport, fold in the side guards and lift the operator's platform up. Also support the traction wheel with blocks.

⚠ CAUTION

Do not tie the truck from the tiller arm or it may break.

Figure 19 below shows an example on how to secure the truck safely for transportation.

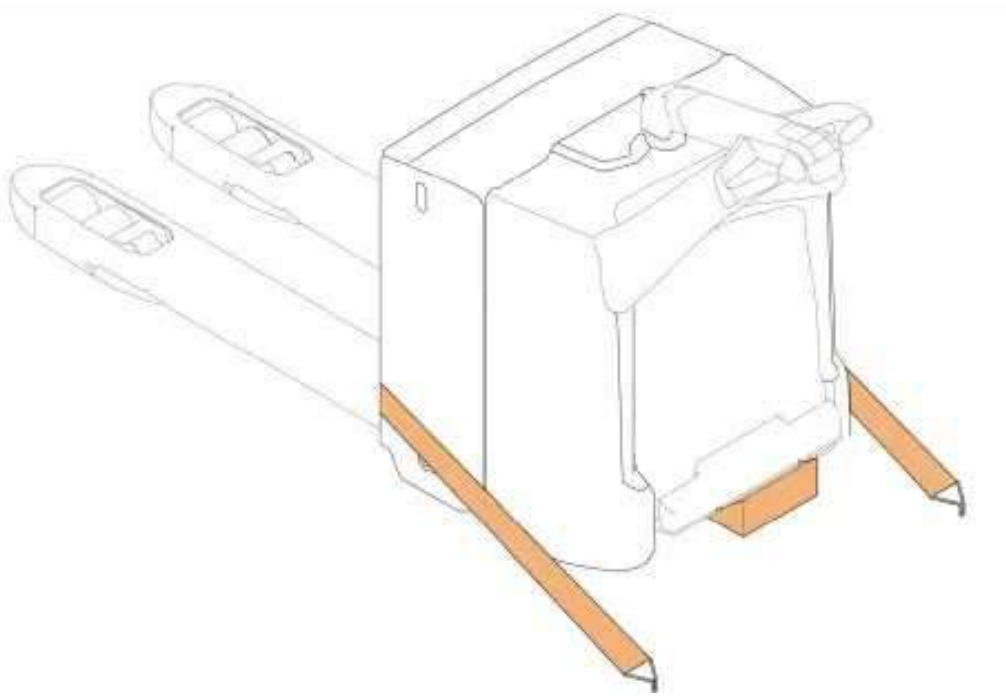


Figure 19. Securing the truck for transportation

5.3 Ordering spare parts

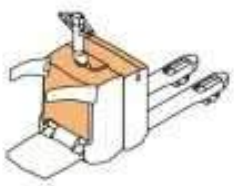
When ordering spare parts, always contact your maintenance centre. Only use original spare parts. To ensure that you receive the correct parts, include the following information in your order:

- Truck type
- Serial number of the truck
- Order number of the part
- Name of the part
- Number of parts ordered

5.4 Opening the covers

⚠ CAUTION

Before opening the truck's covers, turn the key switch to the OFF position and disconnect the battery plug/connector.



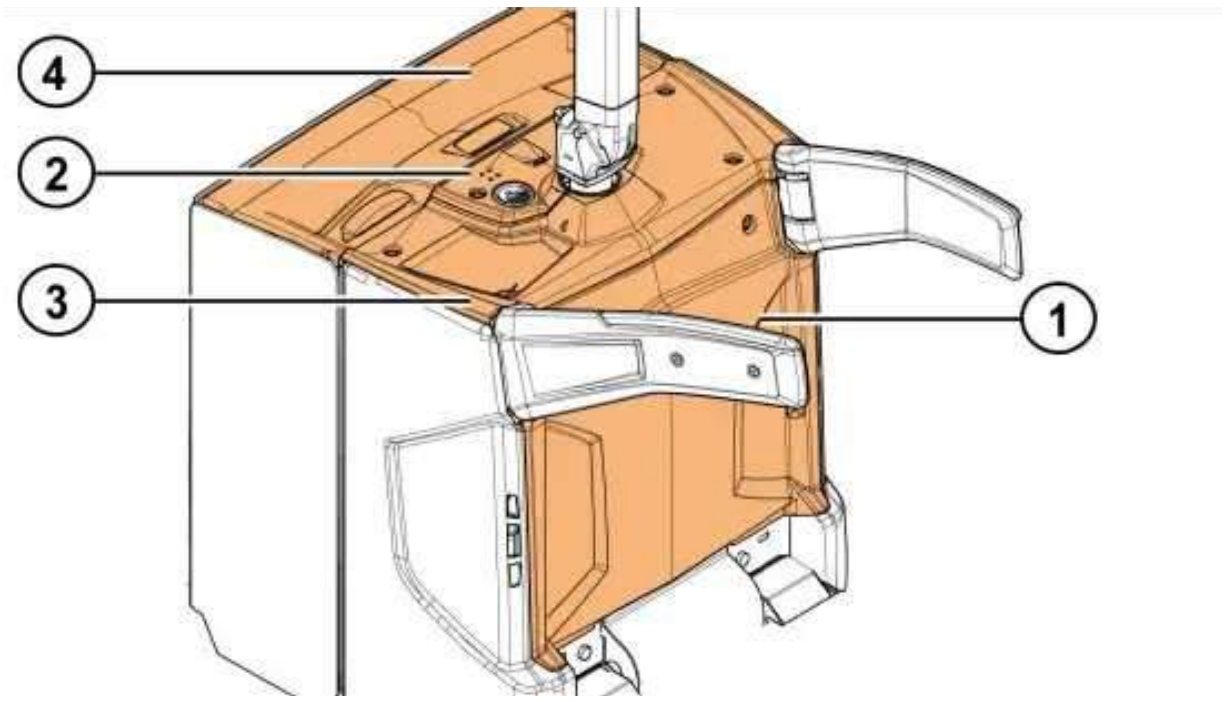
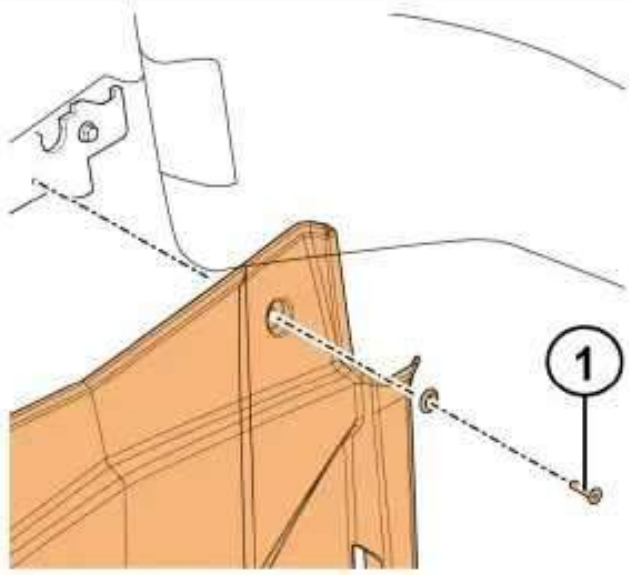


Figure 20. Truck covers overview

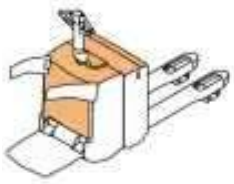
1. *Front cover*
2. *Control panel*
3. *Top cover*
4. *Battery cover*

5.4.1 Front cover

1. Remove the two screws at the top of the front cover.
2. Lift the front cover off the attachment points at the base of the front cover.



5.4.2 Control panel



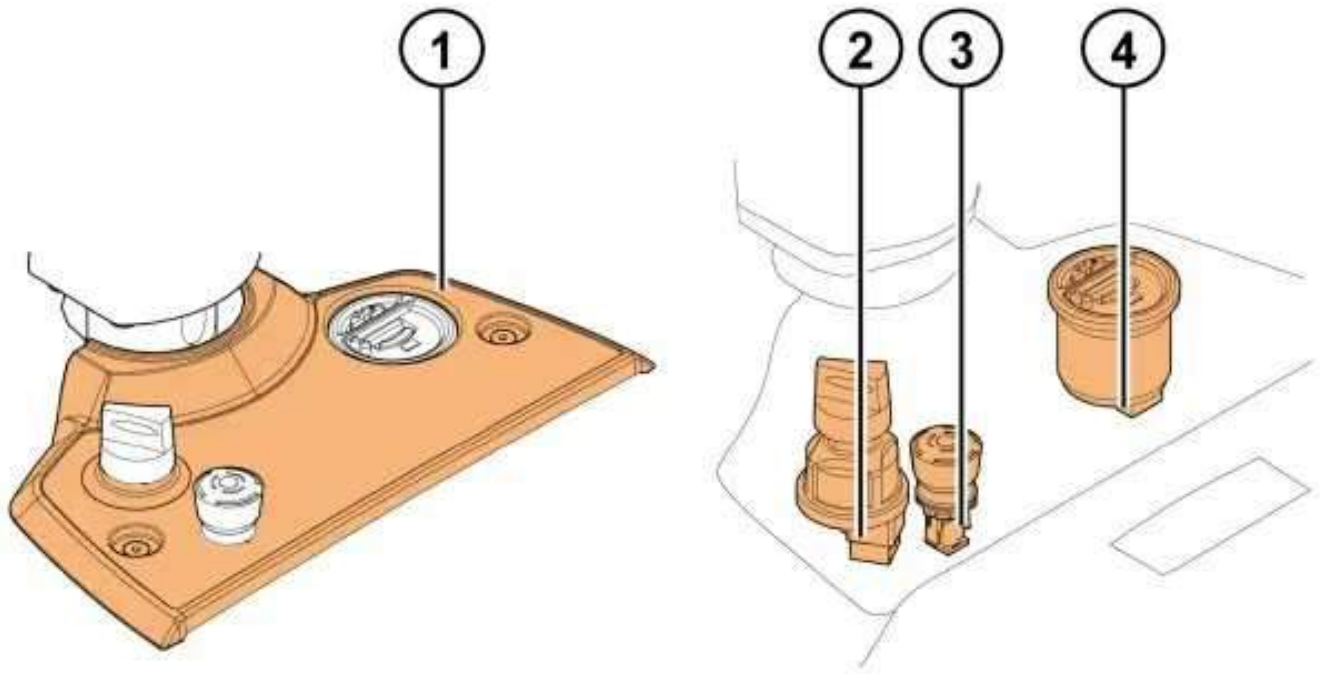
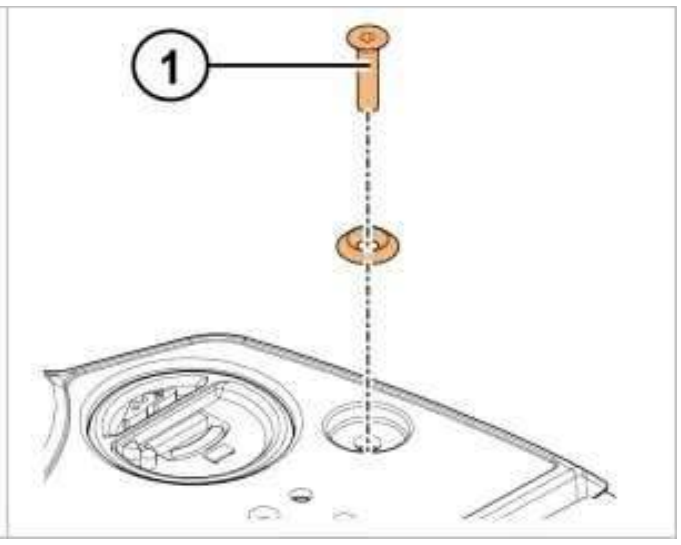
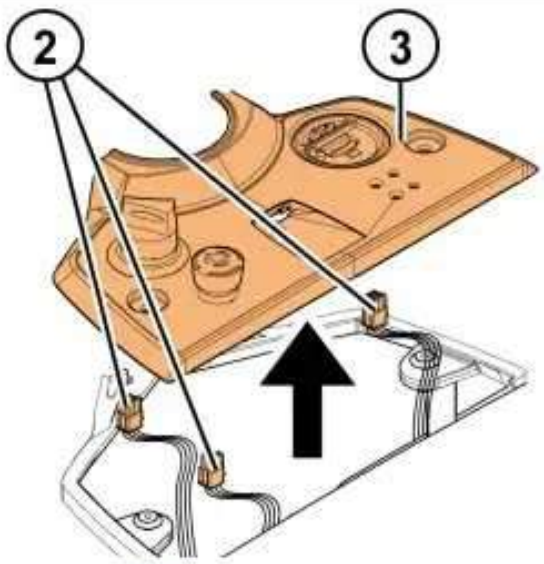


Figure 21. Control panel overview

1. *Control panel*
2. *Key switch connector*
3. *Emergency switch connector*
4. *Multi-function display connector*

1. Remove the two screws holding the control panel in place.	

2. Disconnect the emergency switch, key switch and multi-function display connectors.
3. Remove the control panel.



5.4.3 Top cover

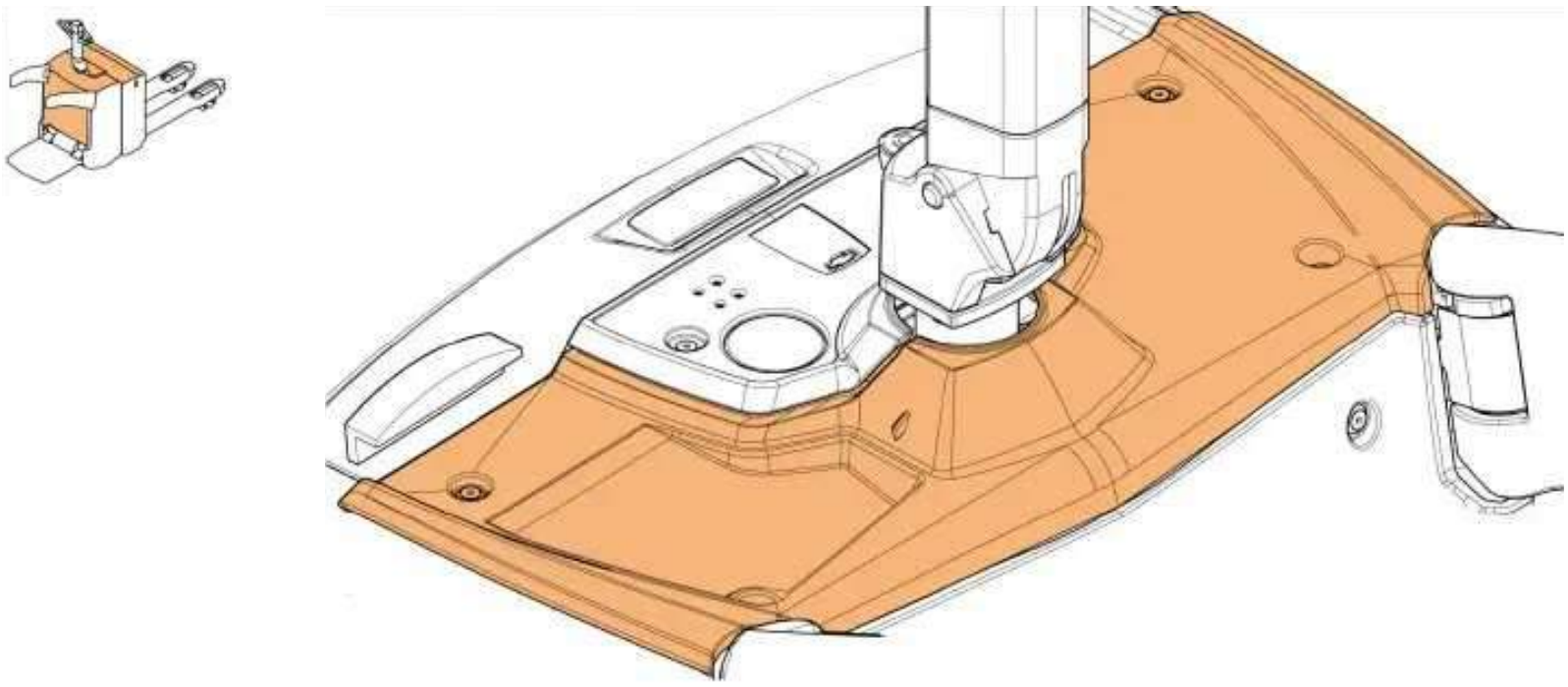
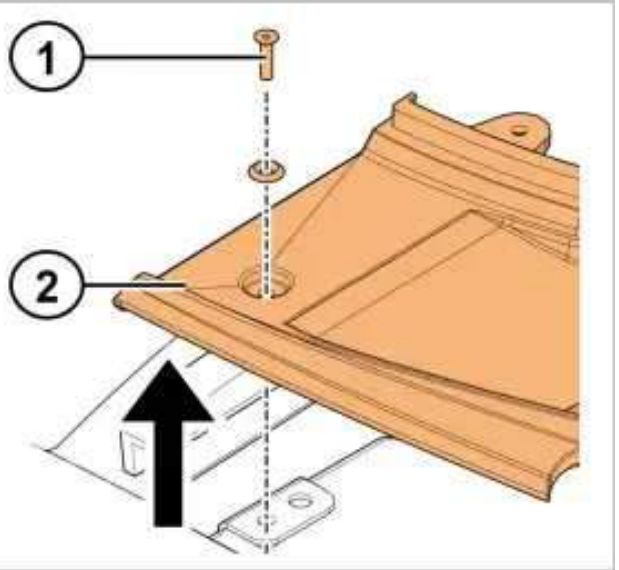


Figure 22. Top cover overview

NOTE: You must remove the control panel before you can open the truck's top cover.

1. Remove the four screws holding the top cover in place.
2. Remove the top cover.



5.4.4 Battery cover

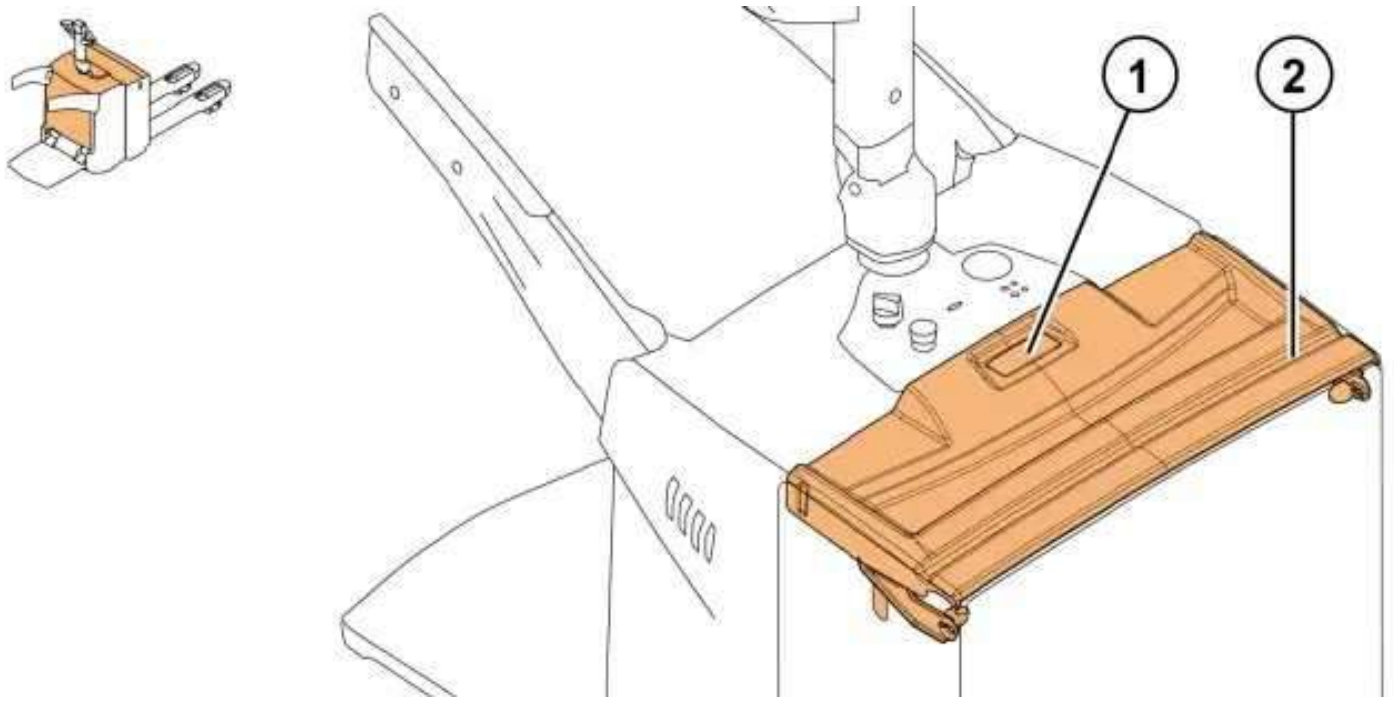
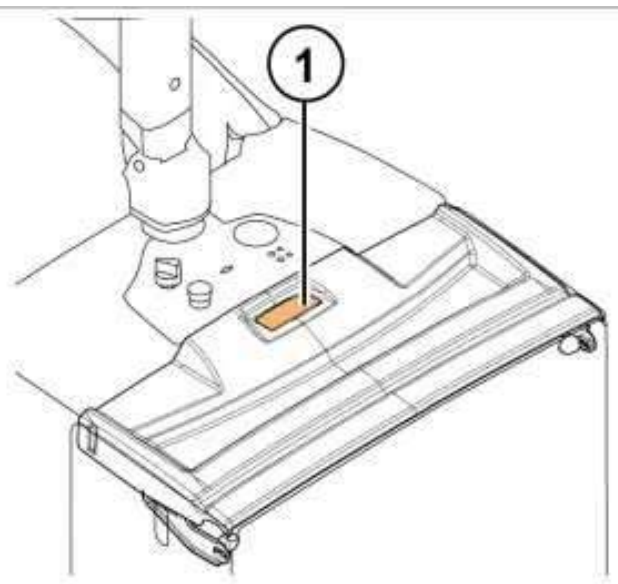
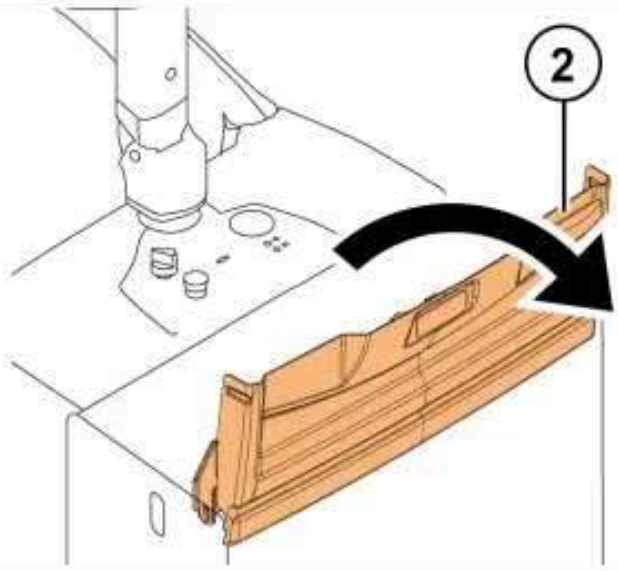


Figure 23. Battery cover overview

1. *Locking button*
2. *Battery cover*

1. Push the locking button down and leave it open.	
2. Open the battery cover.	

NOTE: When closing the battery cover, make sure that the locking button returns all the way to the locking position.

5.4.4.1 Removing the battery cover lock

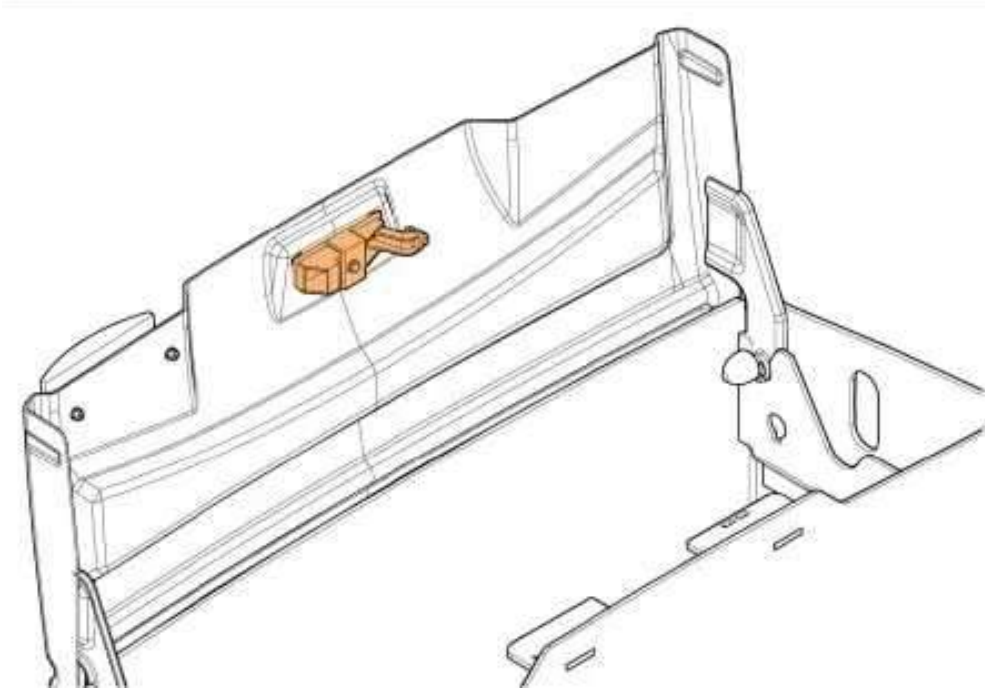
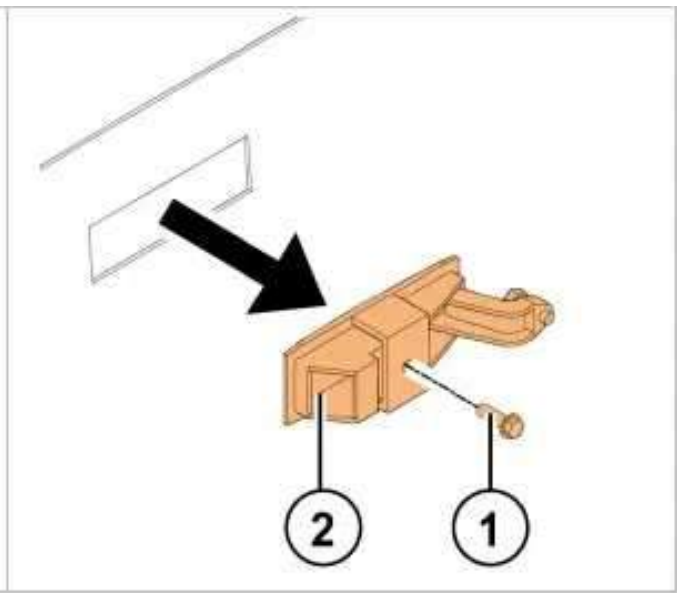


Figure 24. Battery cover lock overview

1. Remove the screw holding the battery cover lock in place.
2. Remove the lock.



5.4.4.2 Removing the battery cover's rubber absorbers

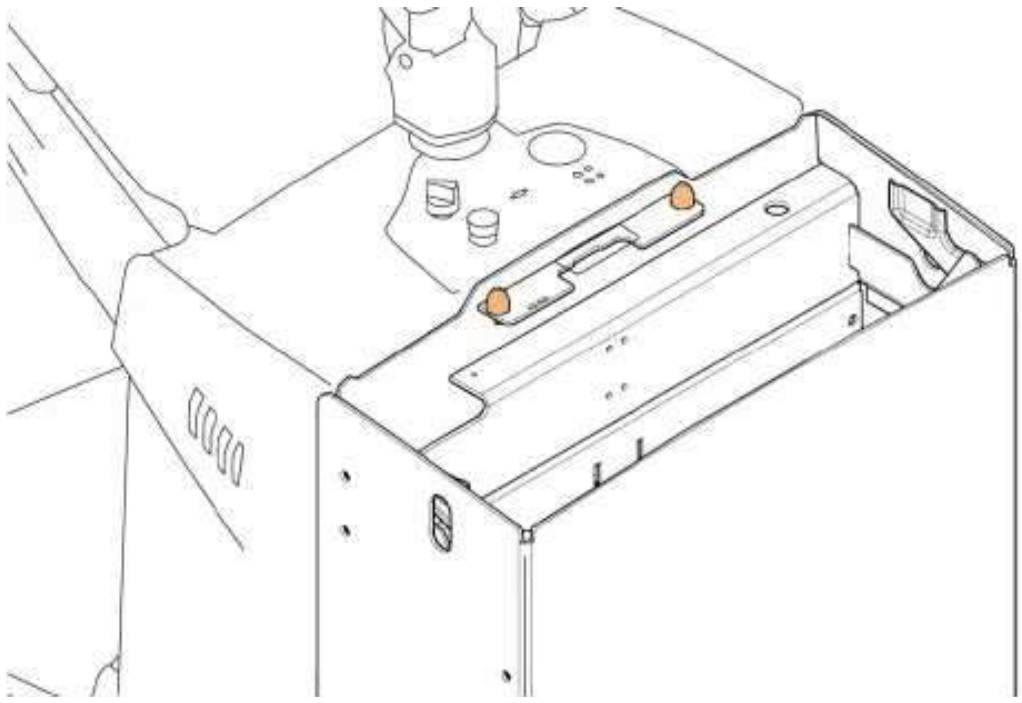
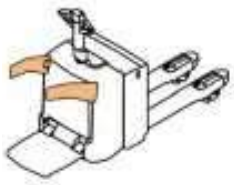


Figure 25. Battery cover's rubber absorbers

Remove the battery cover's rubber absorbers by simply screwing them out.

5.5 Removing the side guards



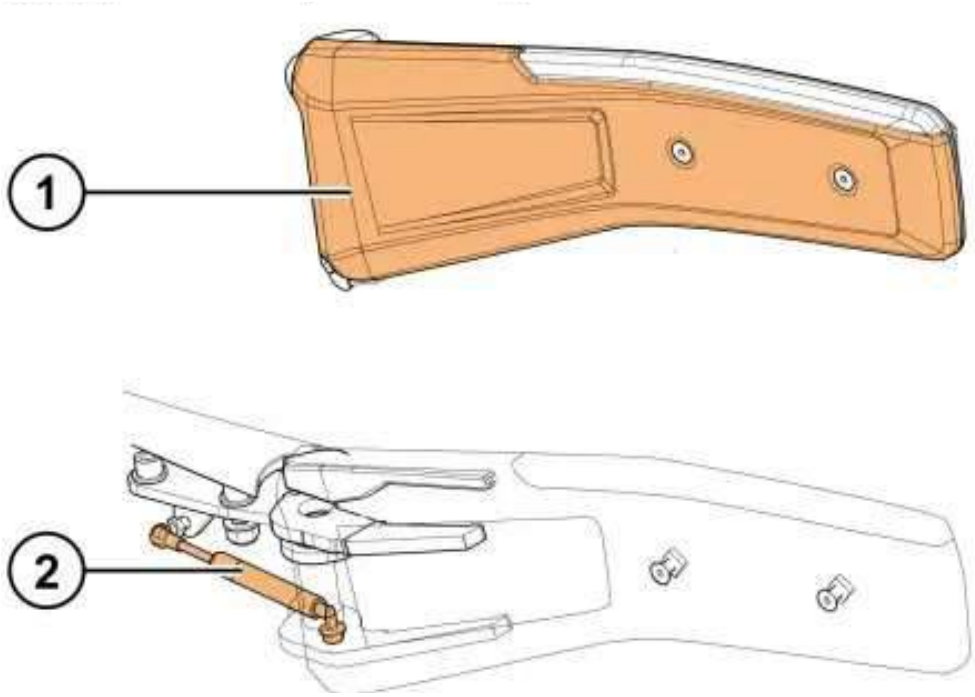
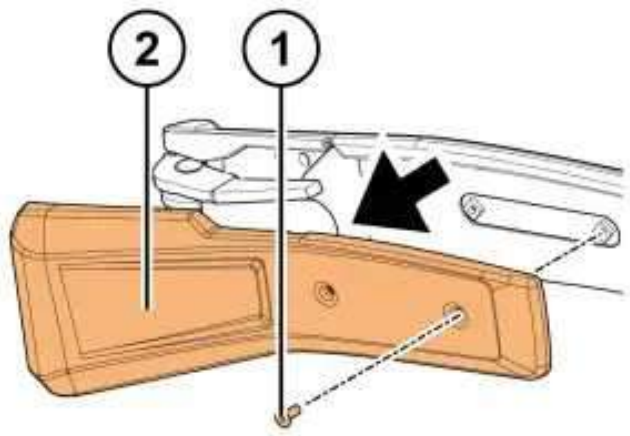
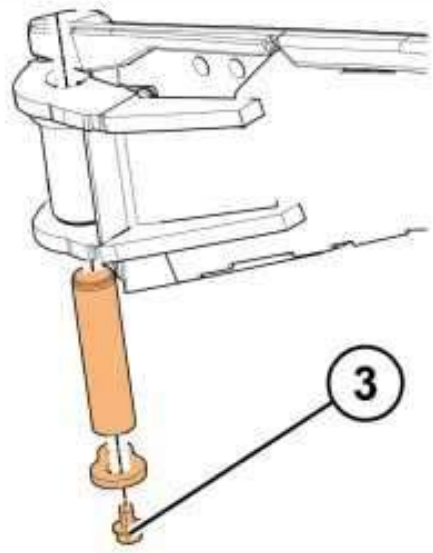
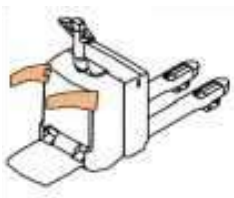


Figure 26. Side guards overview

1. *Side guard*
2. *Side guard's gas spring*

1. On the outside of the side guard, remove the two screws holding the plastic cover in place. **2.** Remove the plastic cover.	
3. Remove the screws at the base of the side guard.	
4. Release the side guard's gas spring. For instructions, see steps 1-3 in the section 5.5.1) below. **5.** Remove the side guard.	

5.5.1 Replacing the side guard's gas spring



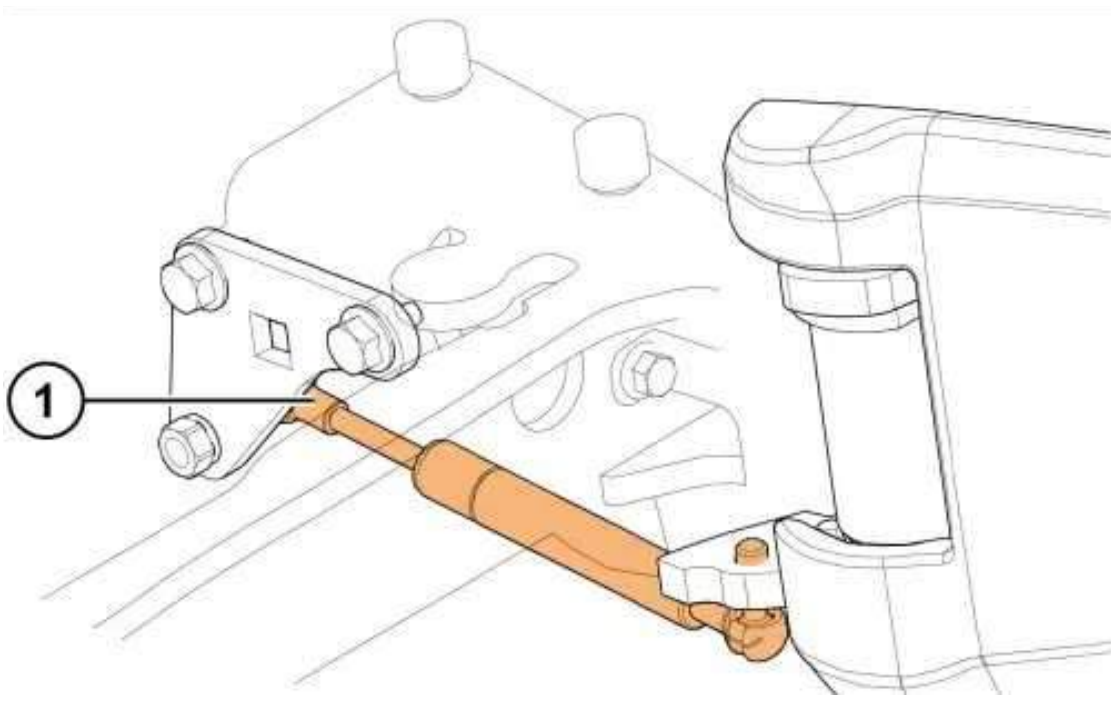
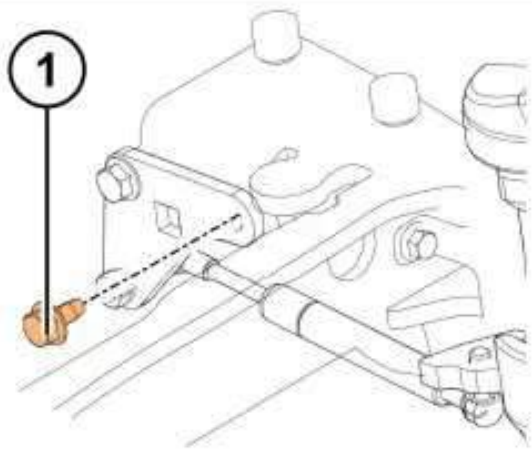
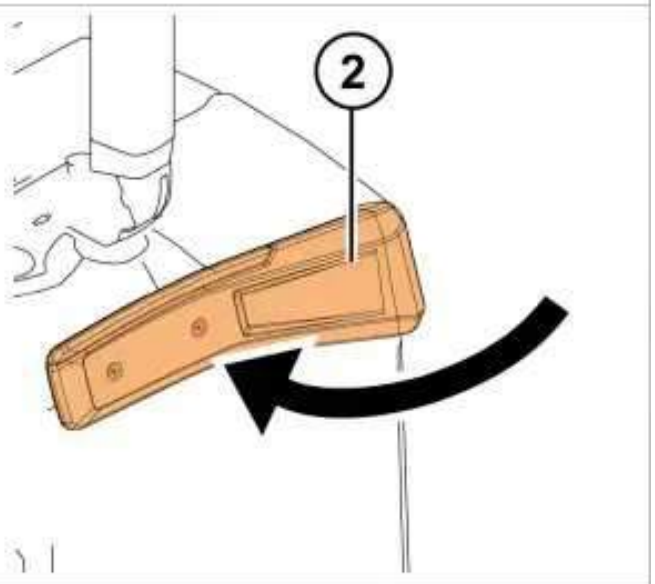
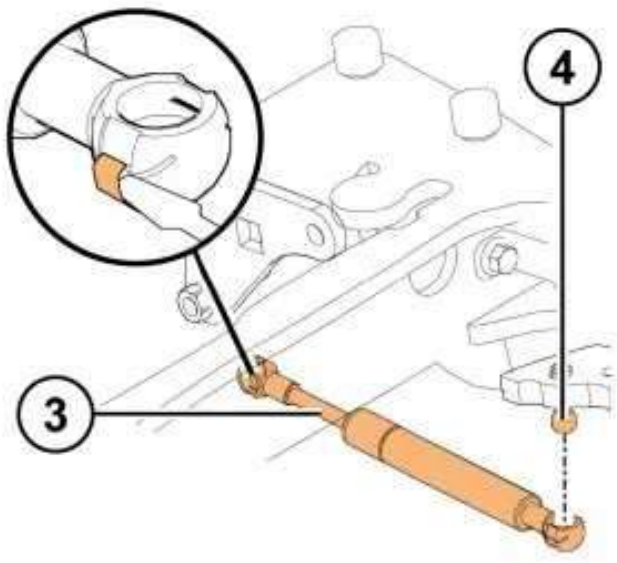


Figure 27. Side guard's gas spring overview

1. Remove the front screw from the gas spring's triangular mounting plate.	
2. Fold the side guard in.	
3. Remove the gas spring. Note the location of the wiring. **4.** Check the condition of the ball joints holding the gas spring in place. Replace ball joints, if needed.	

5. Install the new gas spring. Make sure that the location of the wiring is the same as it was with the old spring.
6. Fasten the front screw on the triangular mounting plate.

5.6 Removing the operator's platform

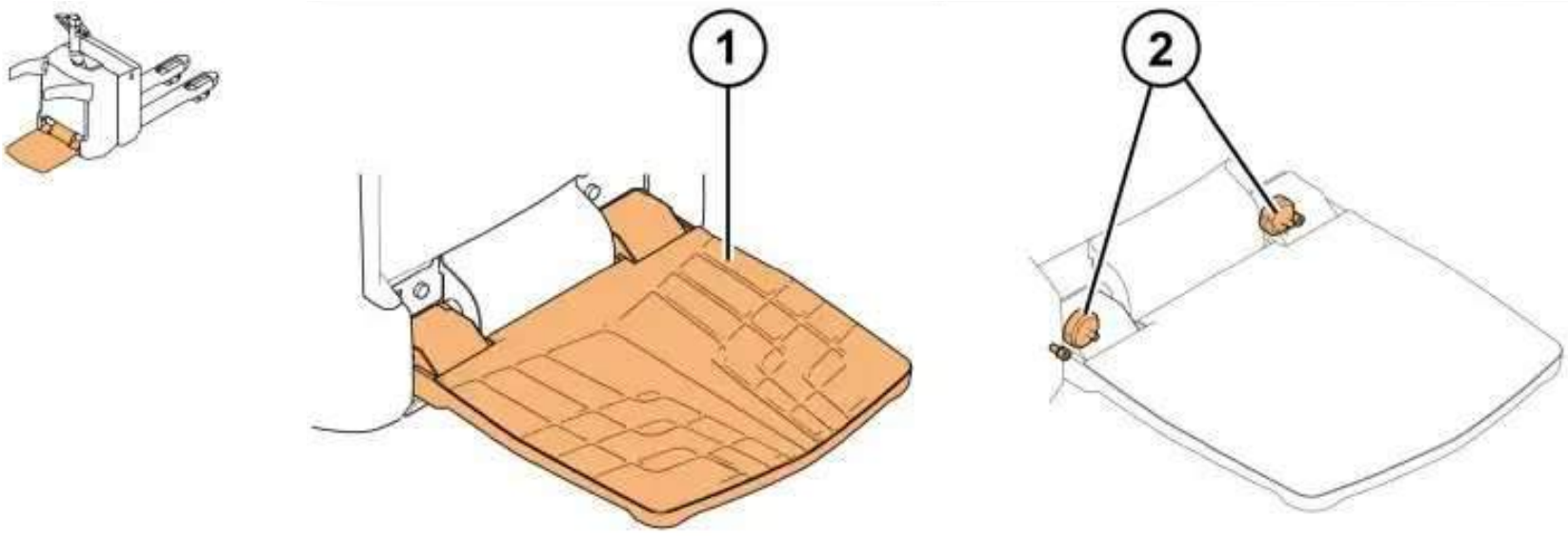
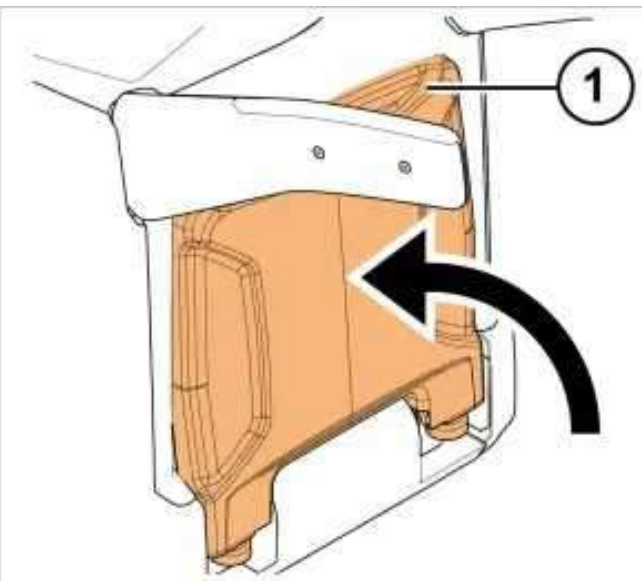
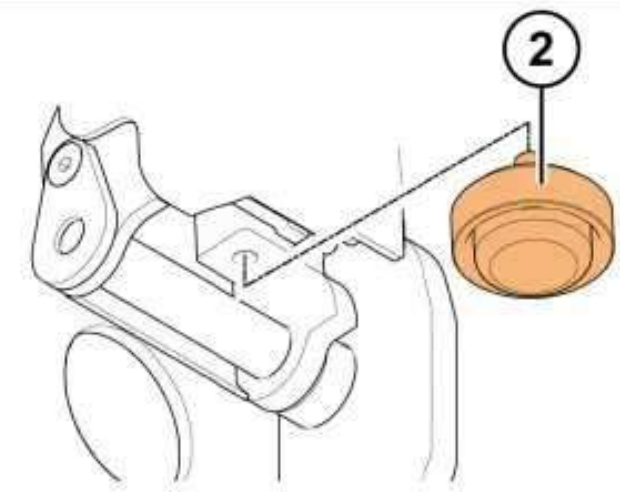


Figure 28. Operator's platform overview

1. *Operator's platform*
2. *Rubber absorbers*

Before you can remove the operator's platform, remove the two rubber absorbers at the base of the operator's platform:

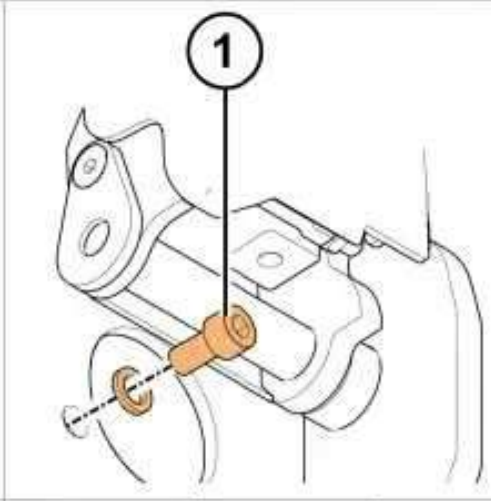
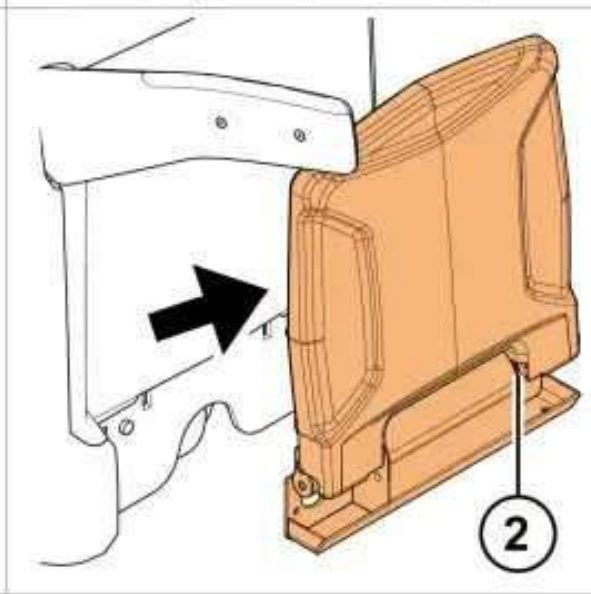
1. Lift the operator's platform up.	
2. Remove the rubber absorbers using a support bar.	

⚠ CAUTION

After removing the rubber absorbers, beware of sharp edges when removing the operator's platform.

When installing the rubber absorbers, remember to use locking glue (for example, Loctite 243).

After the rubber absorbers have been removed, you can remove the operator's platform:

1. Remove the two screws under the operator's platform.	
2. Remove the operator's platform.	

⚠ CAUTION

When removing the operator's platform, note that it weights 35 kg.

NOTE: When installing the operator's platform, place a support, such as a block or similar, between the operator's platform and the mounting bracket to prevent the operator's platform from lifting too much. See Figure 29 below.

Figure 29. Supporting the operator's platform during installation

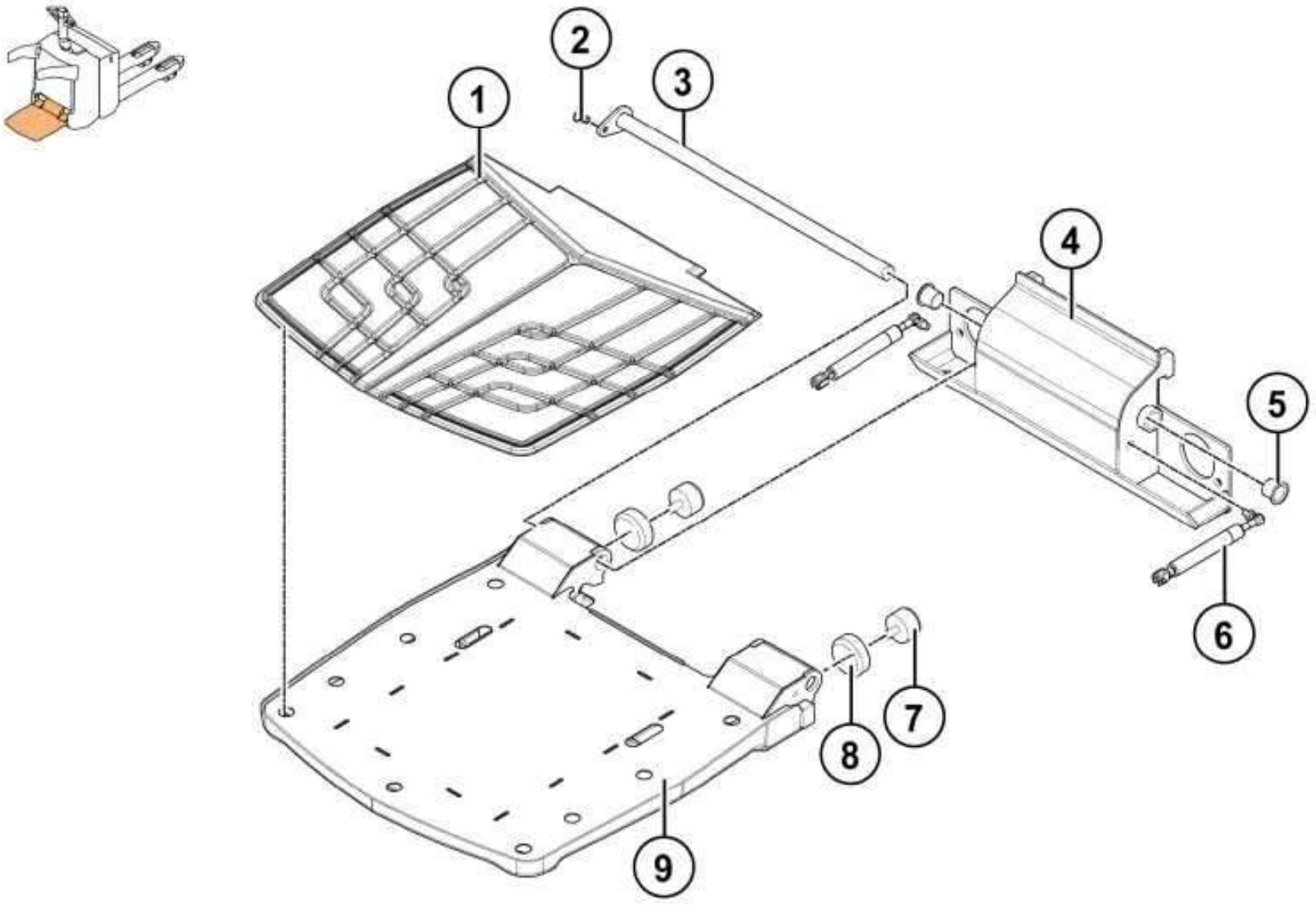
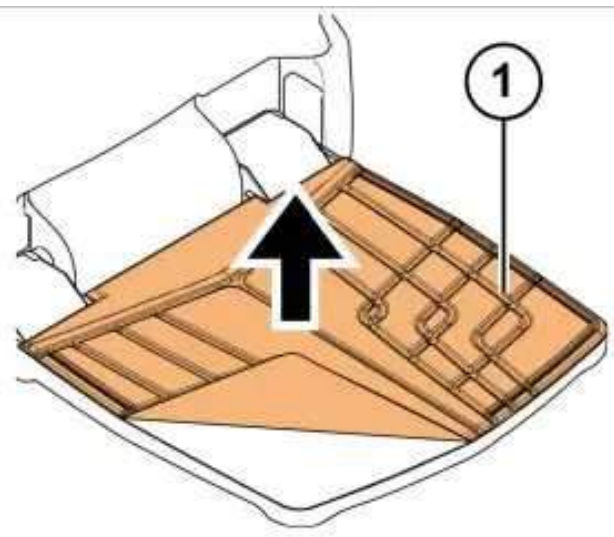
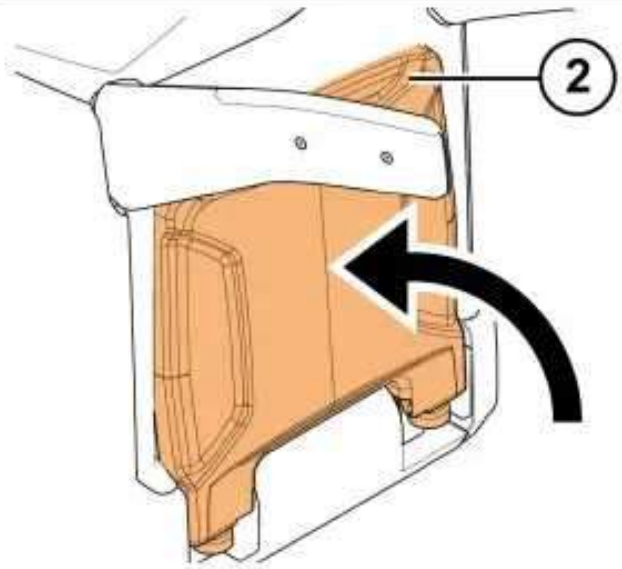
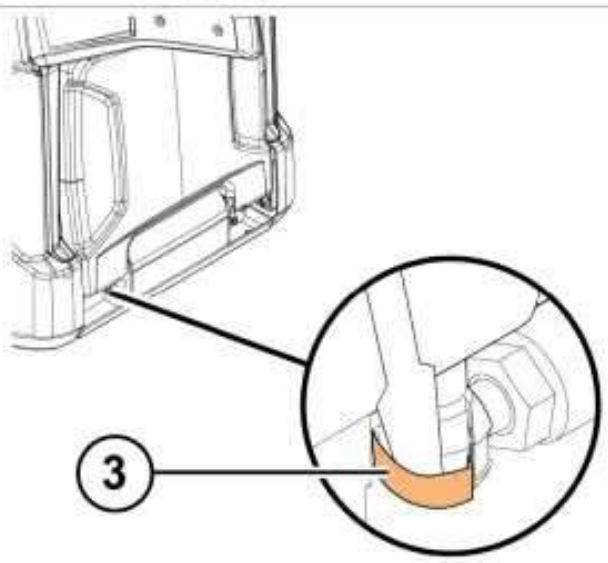


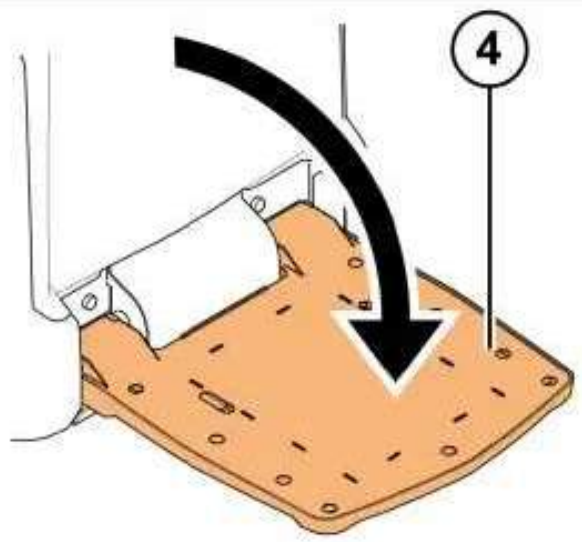
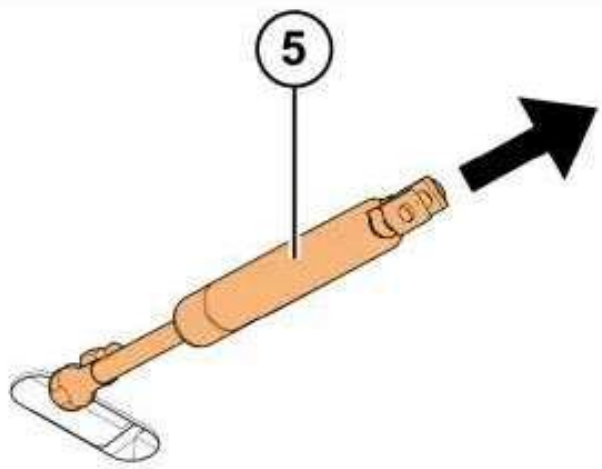
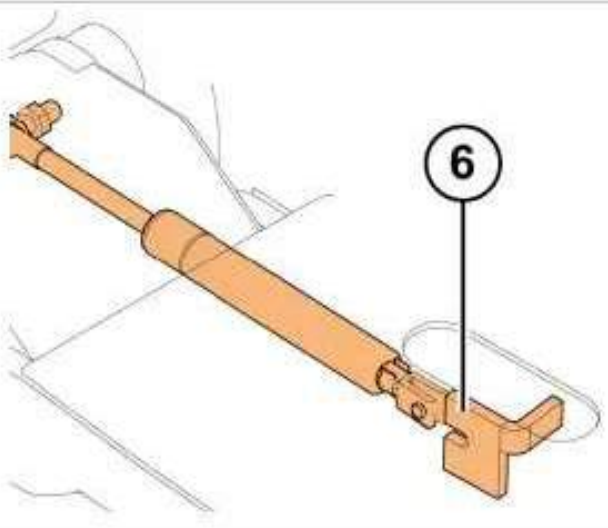
Figure 30. Operator's platform detailed construction

1. *Rubber mat*
2. *Locking screw*
3. *Shaft*
4. *Mounting bracket*
5. *Slide bearing*
6. *Gas spring*
7. *Rubber absorber*
8. *Support*
9. *Operator's platform*

5.6.1 Replacing the operator's platform gas spring

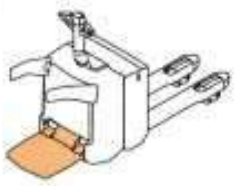
The gas spring of the operator's platform can be replaced either with the platform in place or with the platform removed completely from the truck frame. Instructions for replacing the operator's platform gas spring are provided below, but the same instructions can be applied also while working with the platform removed.

1. Remove the rubber mat from the operator's platform by pulling it from one corner.	
2. Lift the operator's platform up.	
3. Open the locking spring using a screwdriver. Also remove the ball joint if needed.	

4. Carefully lower the operator's platform.	
5. Pull the gas spring out through the hole in the operator's platform.	
6. Push the new spring into place, making sure that the spring's head is positioned correctly into the slot inside the operator's platform.	

7. Carefully lift the operator's platform, making sure that the new spring does not fall out.
8. Tighten the gas spring locking spring and install the ball joint if it was removed earlier.
9. Lower the operator's platform.
10. Attach the rubber mat to the operator's platform.

5.6.2 Removing the operator's platform slide bearing



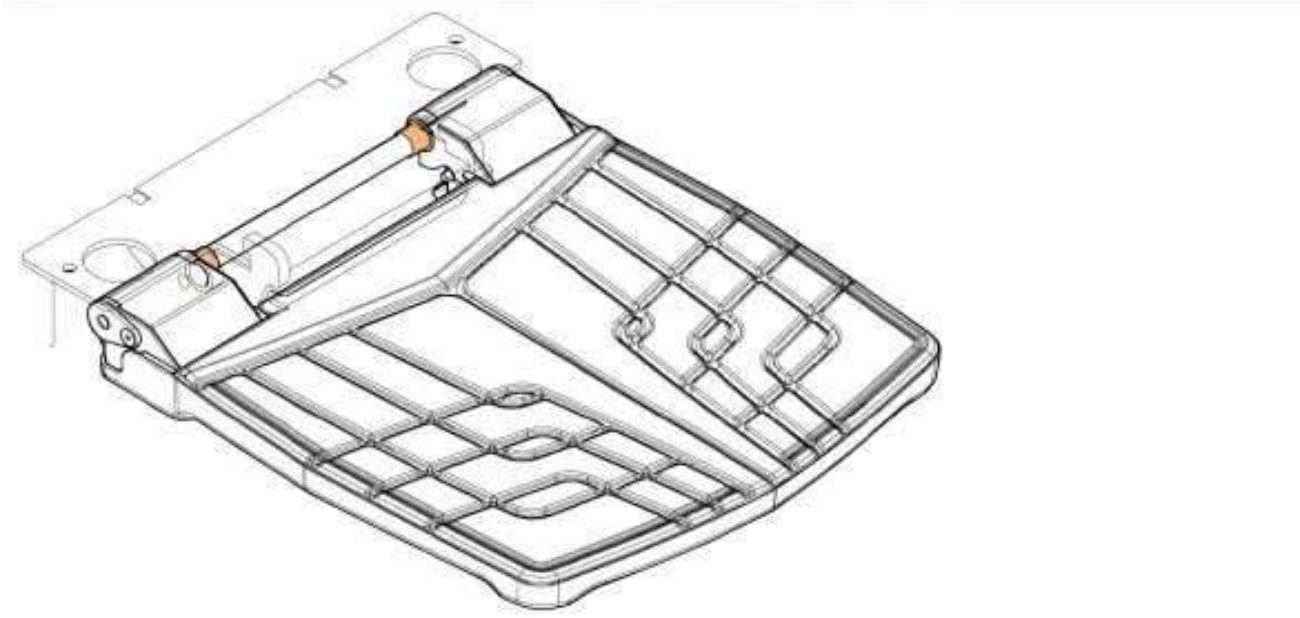
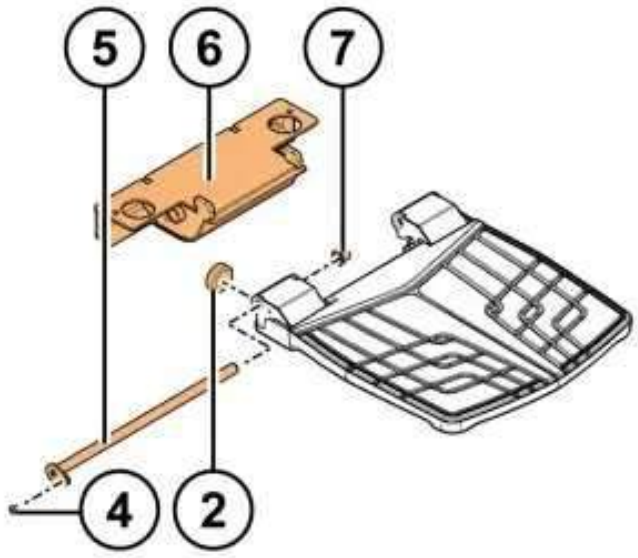


Figure 31. Operator's platform slide bearing overview

1. Remove the operator's platform from the truck frame. For instructions, see the section 5.6.
2. Remove the support at the base of the operator's platform.
3. Remove the operator's platform gas spring. For instructions, see section 5.6.1.
4. Remove the shaft locking screw.
5. Remove the shaft.
6. Remove the mounting bracket.
7. Remove the slide bearing.



5.7 Transmission gear

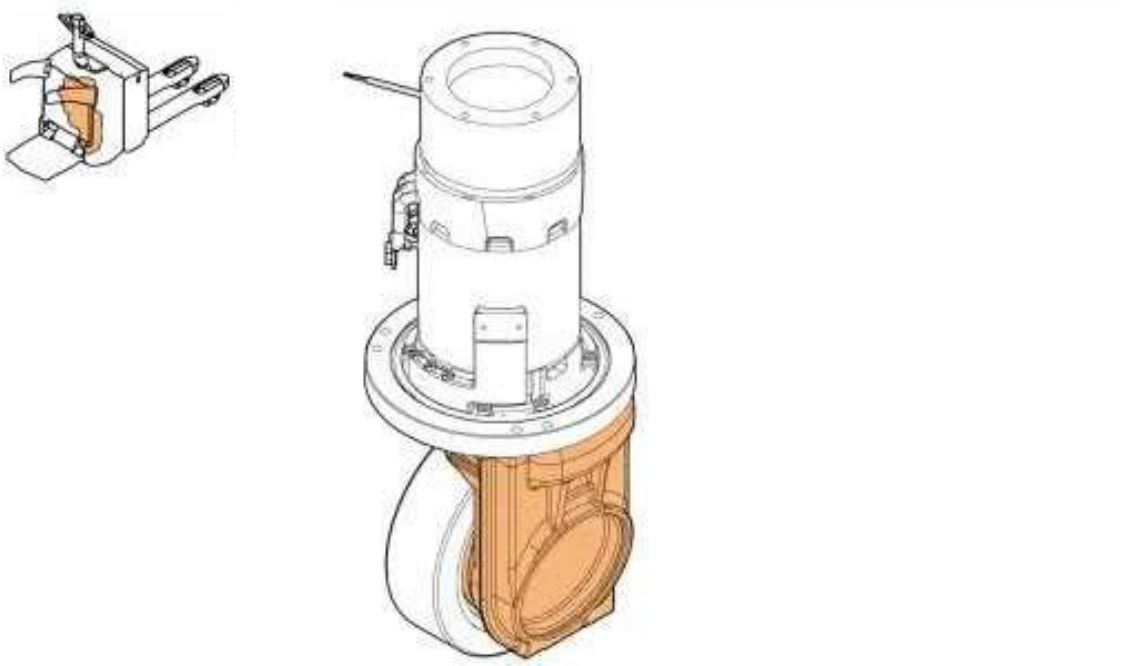


Figure 32. Transmission gear overview

There is no need to change the transmission gear lubricant during the truck's lifetime.

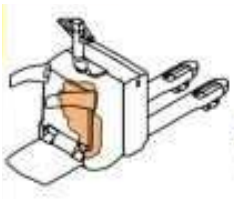
During maintenance, check the transmission gear for any leaks.

Transmission gear oil	SAE 80W/90, API GL-5
Total transmission oil quantity	1.05 L

CAUTION

Transmission oil is hazardous waste that must be disposed of accordingly.

5.8 Bogie bearing



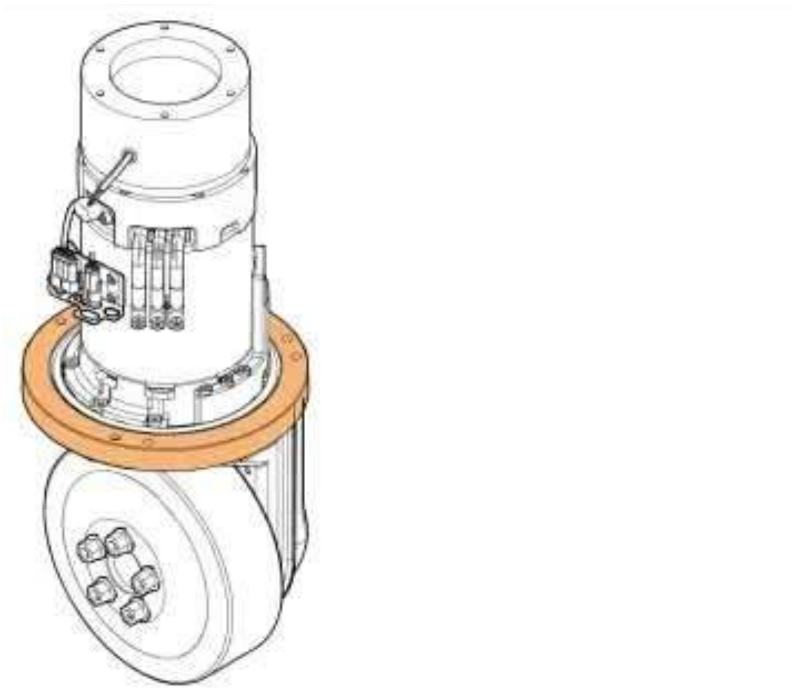


Figure 33. Bogie bearing overview

There is no need to change the bogie bearing lubricant during the truck's lifetime.

During maintenance, check the following:

- The bearing rotates easily when the traction wheel is raised up.
- The drive unit's mounting bolts are tightened properly.

5.9 Traction wheel

⚠ CAUTION

Before installing the traction wheel, make sure that the wheel shaft, the face of the rim mounting, the wheel nuts and wheel bolts are clean, free from grease and undamaged.

NOTE: To access the traction wheel, lift the truck up (see the correct lifting points in the section 5.1 of this manual) and turn the transmission gear so that there is enough space for you to access and remove the wheel.

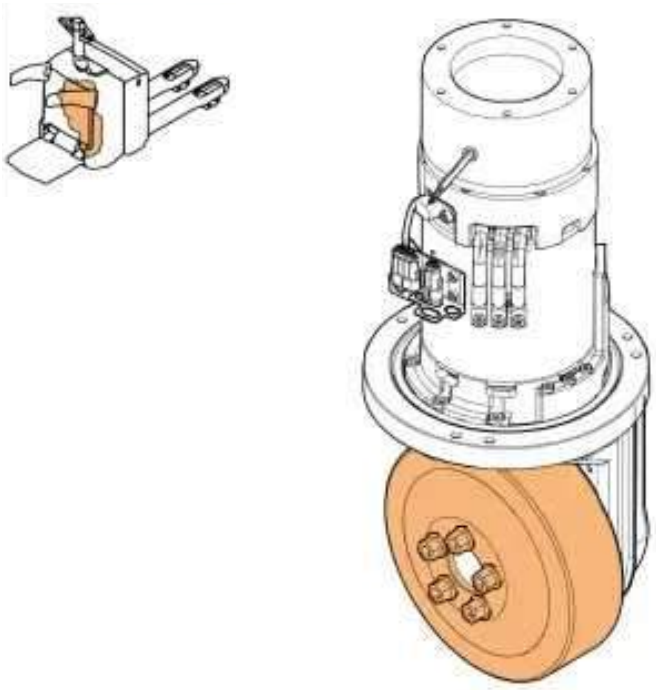


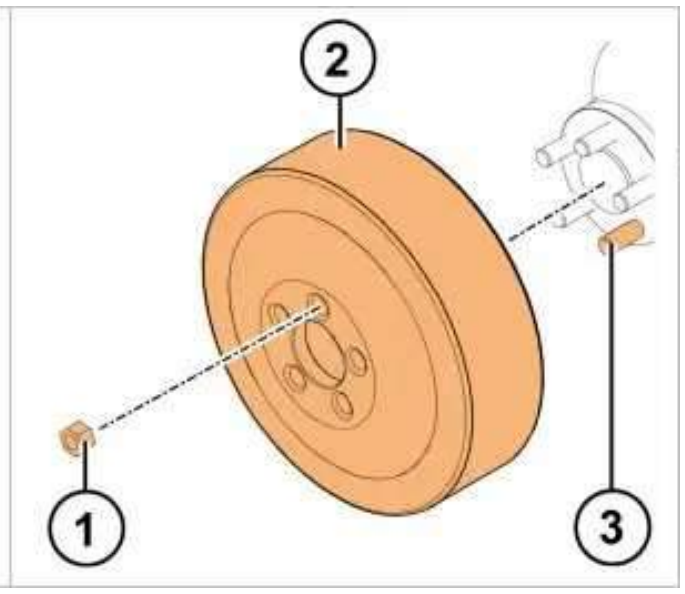
Figure 34. Traction wheel overview

Check the wear of the traction wheel:

- When the traction wheel's diameter reaches 220 mm, adjust the castor wheels as instructed in section 5.12.2.
- When the traction wheel's diameter reaches 214 mm, replace the traction wheel and adjust the castor wheels as instructed in section 5.12.2.

5.9.1 Disassembly of the traction wheel

1. Remove the five rounded cone nuts holding the traction wheel in place.
2. Remove the traction wheel.
3. Check the condition of the wheel shaft bolts. Replace the bolts, if needed. For instructions, see the section 5.9.1.1 below.



5.9.1.1 Replacing the wheel shaft bolts

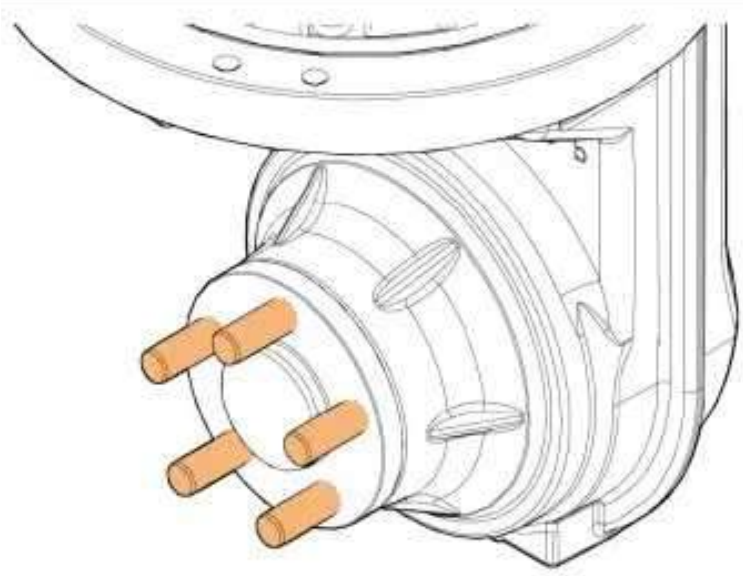
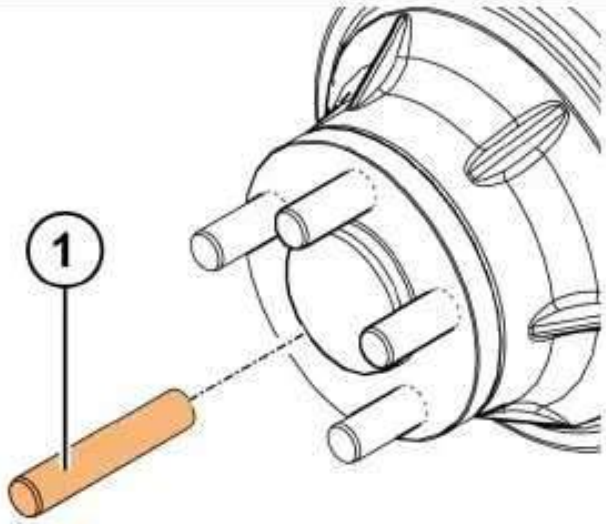
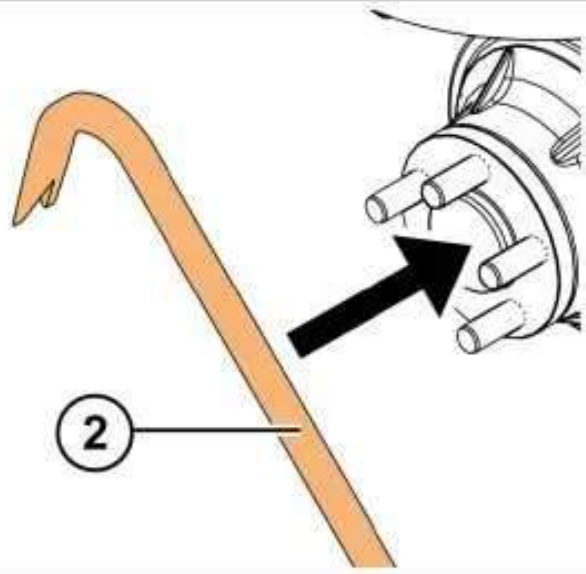
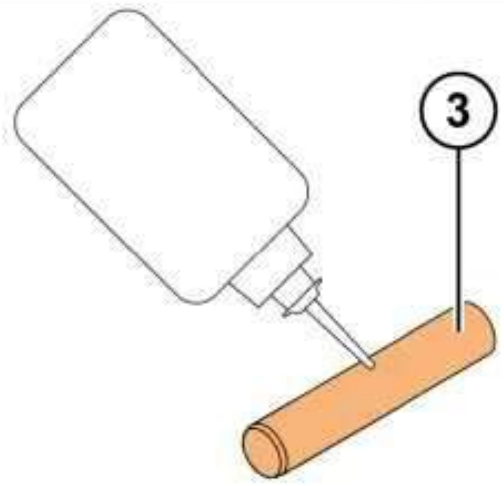
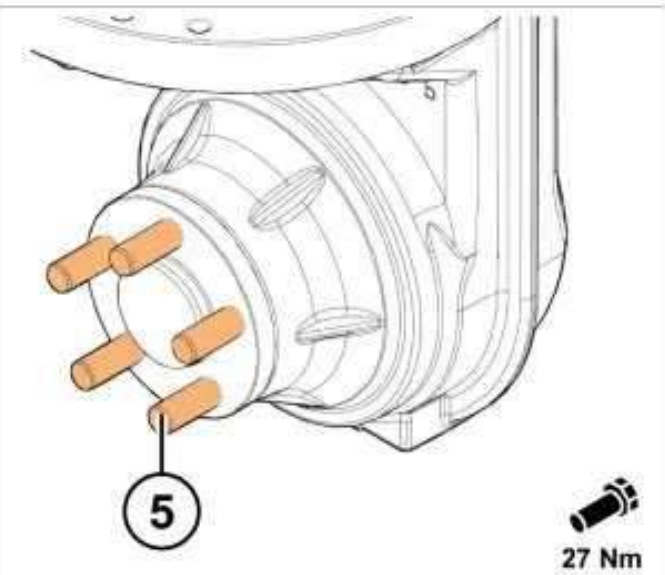


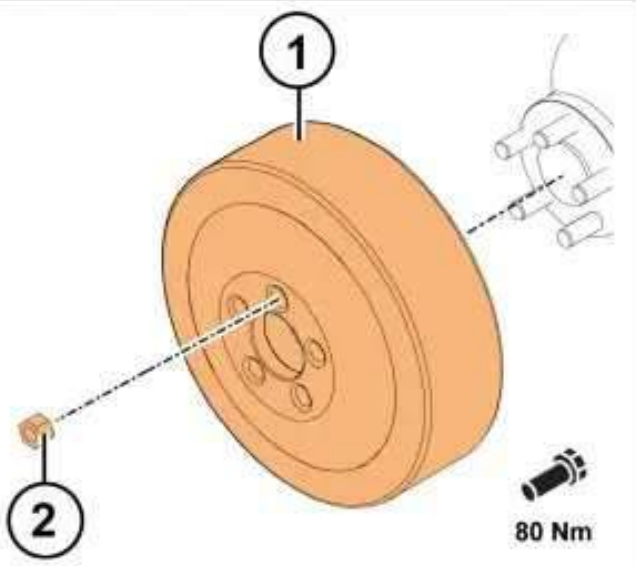
Figure 35. Wheel shaft bolts overview

If the wheel shaft bolts of the traction wheel are defective, you need to replace them.

1. Unscrew the defective wheel shaft bolt.	
2. Use e.g. a rod or a crowbar to lock the wheel shaft in place.	

3. Wet the new wheel shaft bolt with Loctite 243.	
4. Install the new wheel shaft bolt.	
5. Tighten the new wheel shaft bolt. The correct tightening torque is 27 Nm.	

5.9.2 Assembly of the traction wheel

1. Align the rim's hole pattern with the wheel shaft bolts and slide the traction wheel into place. **2.** Install the five rounded cone nuts and tighten them. The correct tightening torque for the nuts is 80 Nm.	

5.10 Load wheels

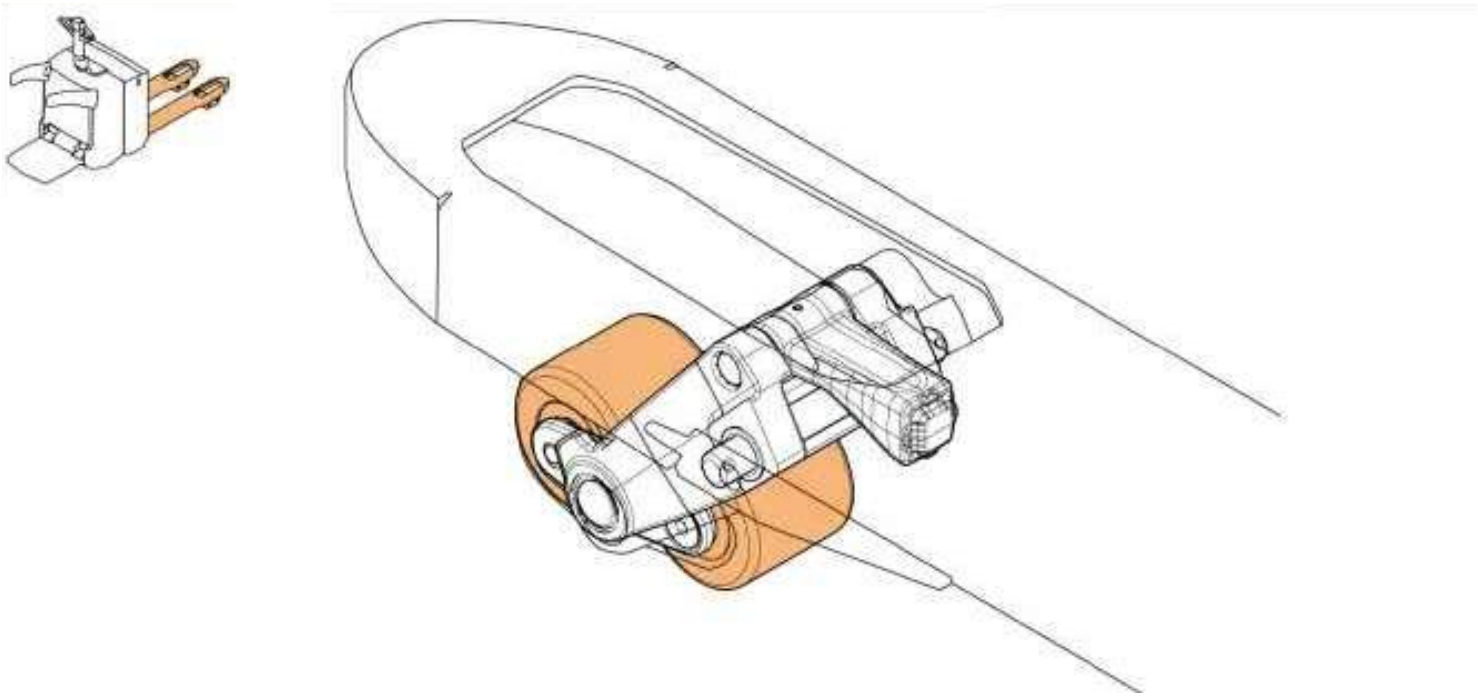


Figure 36. Load wheels overview

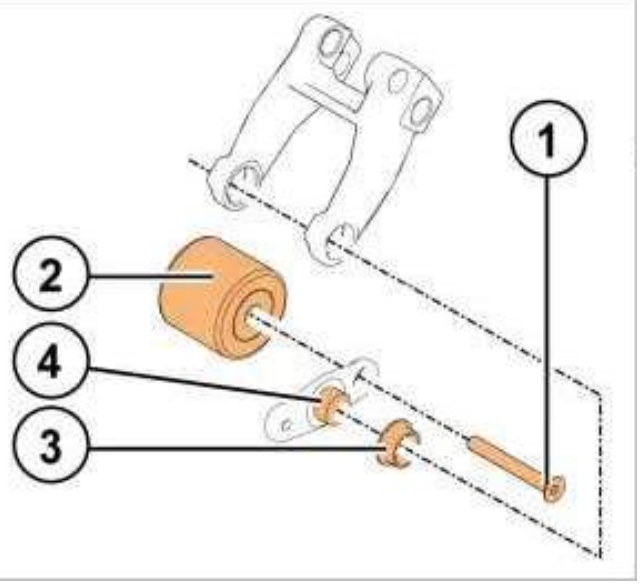
Check the wear of the load wheels:

- The diameter of a new load wheel is 85 mm.
- It is recommended that the load wheel is replaced when its diameter reaches 76 mm.

NOTE: To access the load wheels, lift up the forks and the truck so that the load wheels are off the floor (see the correct lifting points in the section 5.1 of this manual) and turn the load wheel so that you can access the bolt holding the wheel in place.

Disassembly of the load wheel:

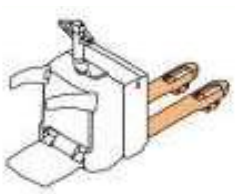
1. Remove the bolt holding the load wheel in the bracket.
2. Remove the load wheel from the bracket.
3. Check the condition of the slide bearing. Replace the part, if needed.
4. Check the condition of the bracket shafts. Replace the part, if needed.



Assembly of the load wheel:

1. Place the load wheel into the bracket.
2. Push the bolt through the bracket and the load wheel. Be careful not to damage the bolt threads.
3. Tighten the bolt holding the load wheel in the bracket.
4. Check that the load wheel rotates properly.

5.11 Lifting system and fork carriage



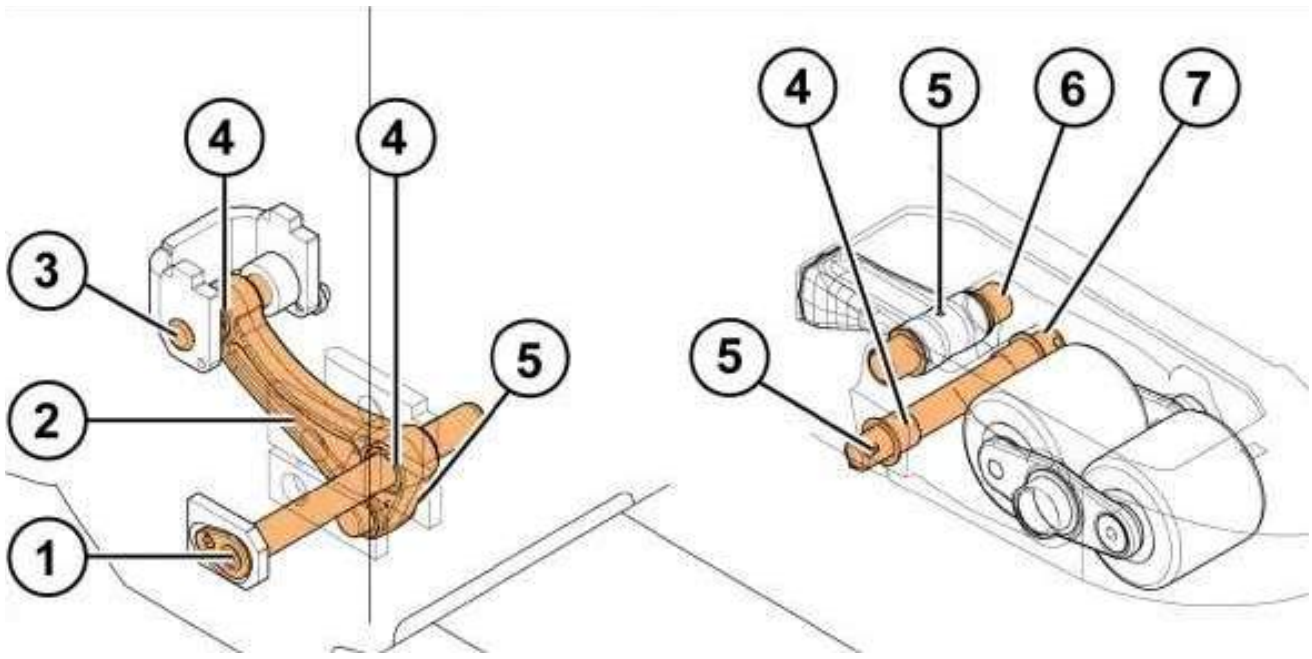
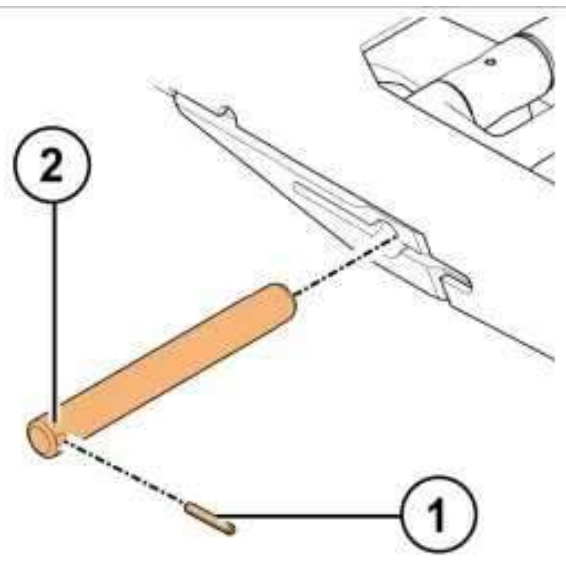
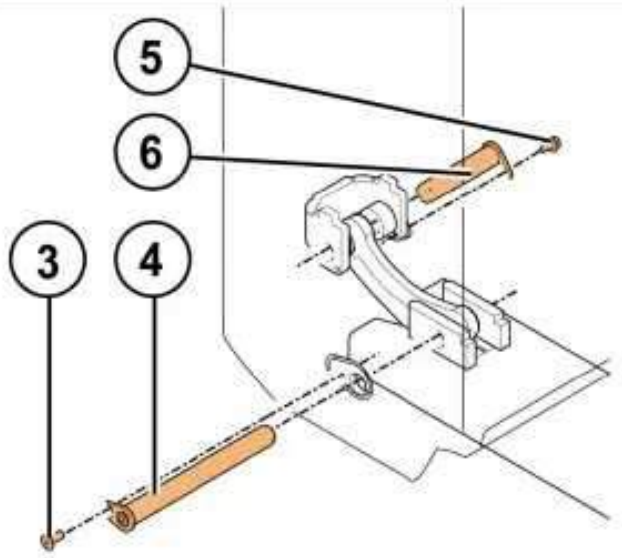
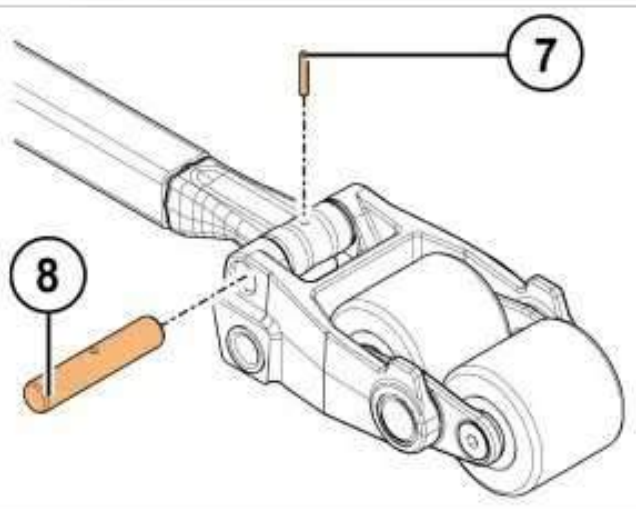


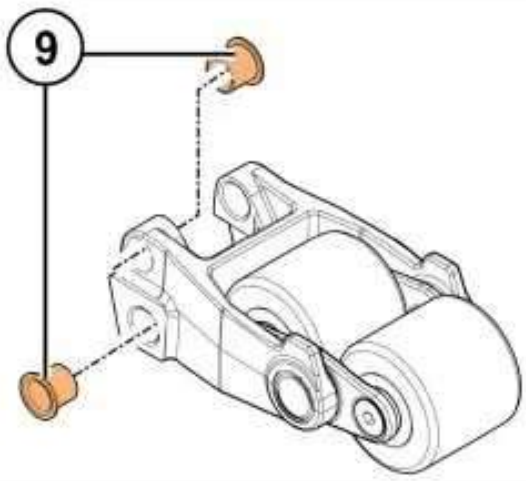
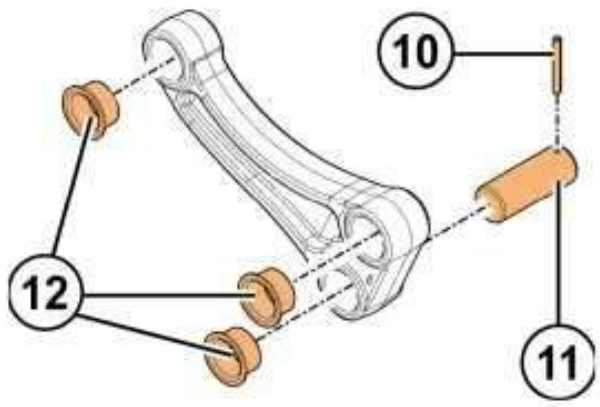
Figure 37. Lifting system and fork carriage overview

1. *Fork carriage shaft*
2. *Link*
3. *Chassis shaft*
4. *Slide bearing*
5. *Tub pin*
6. *Push rod shaft*
7. *Load wheel fork shaft*

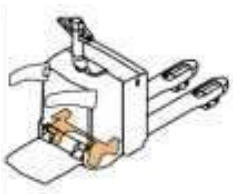
The lift cylinder handles the lifting of the fork carriage, while the push rod mechanism assists in raising the fork tips. For stable lifting, it is important that there is not too much play in the linkage mechanism. Below you can find the instructions regarding the disassembly of the linkage mechanism. Assemble the linkage mechanism by repeating the steps in reversed order.

Disassembly of the linkage mechanism:

1. On the wheel fork side, remove the tub pin from the load wheel fork shaft. **2.** Remove the load wheel fork shaft.	
3. On the linkage mechanism's fork carriage side, open the screw from the fork carriage shaft. **4.** Screw a bolt (size M8) onto the threads at the end of the fork carriage shaft and use a slide pull hammer to pull the shaft out. **5.** On the chassis side of the linkage mechanism, open the screw of the chassis shaft. **6.** Remove the chassis shaft.	
7. Remove the tub pin from push rod shaft. **8.** Remove the push rod shaft.	

9. Remove the slide bearings from the wheel fork.	
10. Remove the tub pin from the link. **11.** Remove the shaft. **12.** Remove the slide bearings from the link.	

5.12 Castor wheels



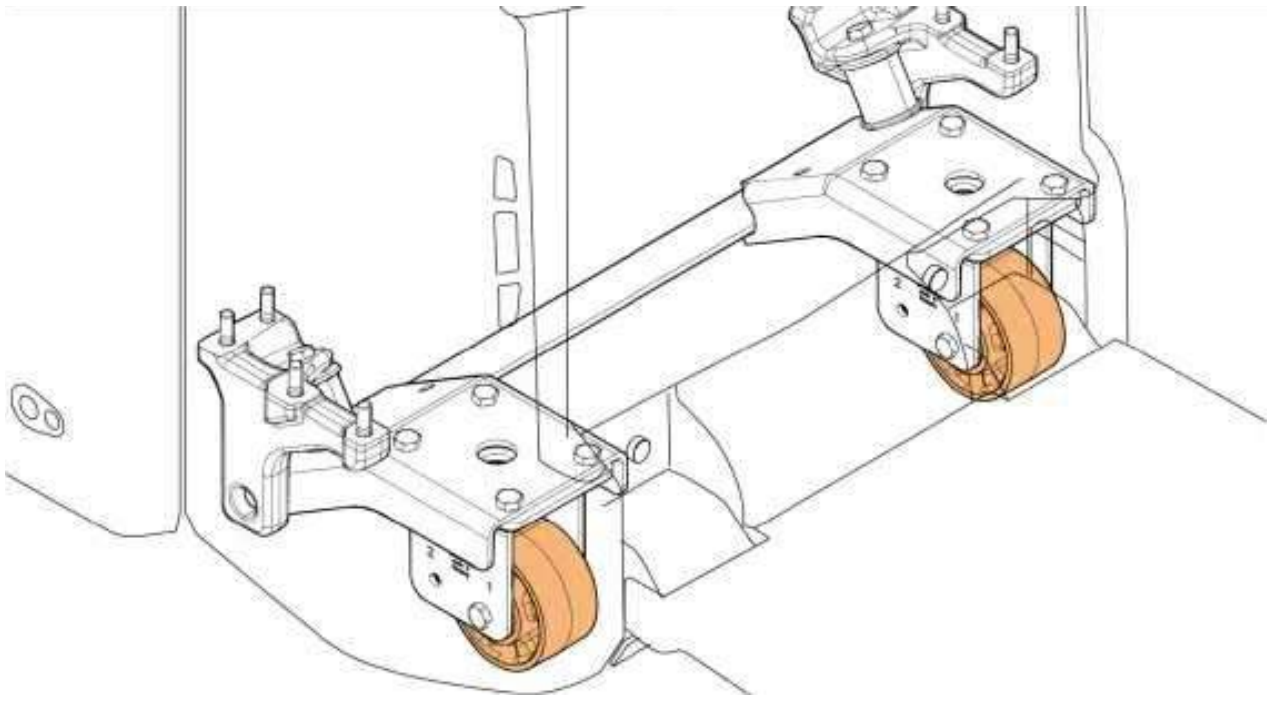


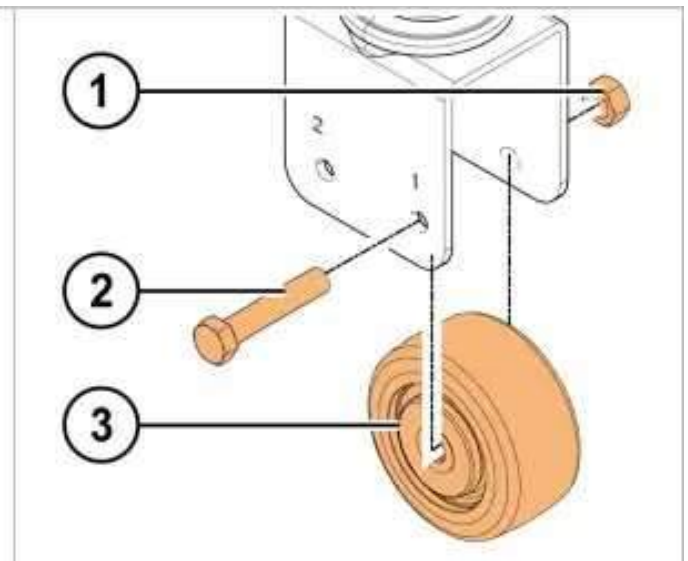
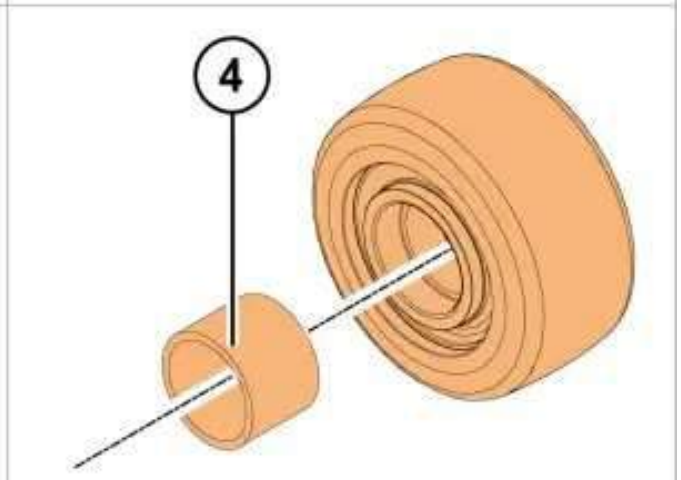
Figure 38. Castor wheel overview

Check the wear of the castor wheels:

- The diameter of a new castor wheel is 98 mm.
- It is recommended that the castor wheel is replaced when its diameter reaches 90 mm.

NOTE: To access the castor wheels, lift the truck up (see the correct lifting points in the section 5.1 of this manual).

5.12.1 Disassembly of the castor wheel

1. Open the nut holding the castor wheel bolt in the bracket. **2.** Remove the bolt holding the castor wheel in the bracket. **3.** Remove the castor wheel from the bracket.	
4. Remove the sleeves from the bearing and save them.	

5.12.2 Adjusting the castor wheels

The castor wheels need to be adjusted according to the wear of the traction wheel:

- In a new truck, the castor wheels are in location 1 shown in Figure 39.
- When the traction wheel's diameter reaches 220 mm, move the castor wheels to location 2.
- When the traction wheel's diameter reaches 214 mm, replace the traction wheel and move the castor wheels back to location 1.

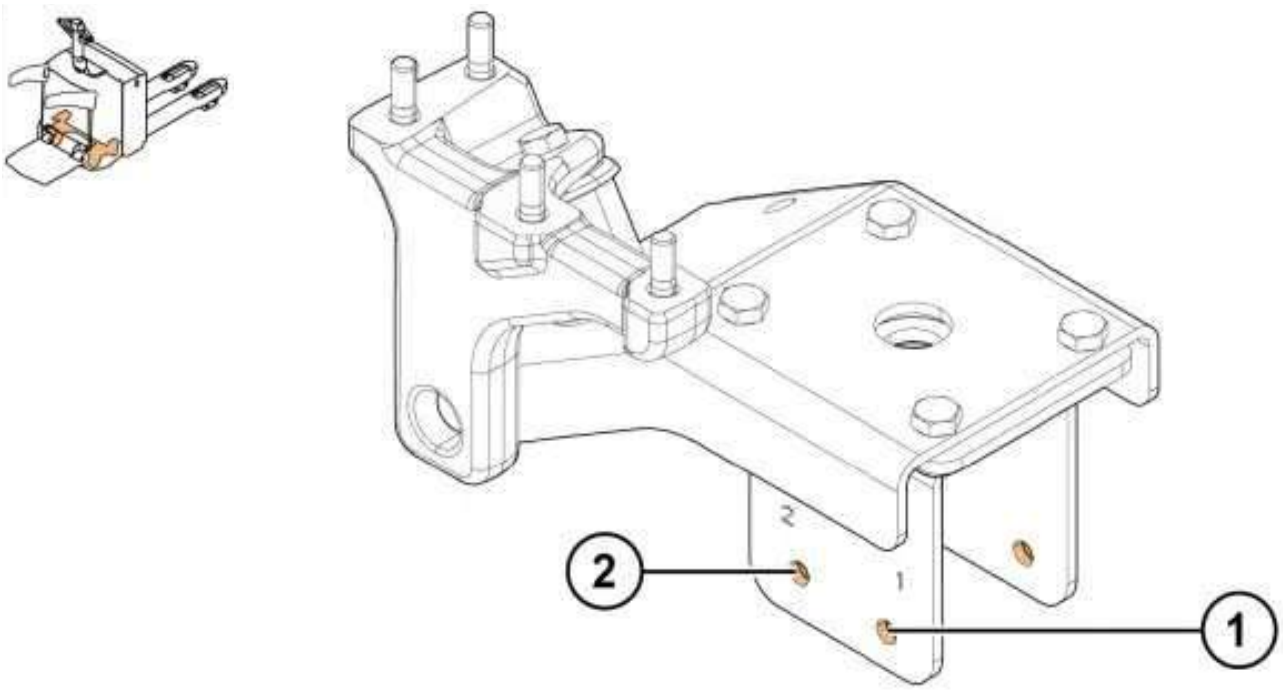


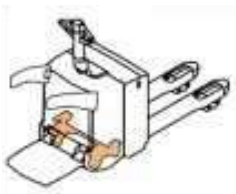
Figure 39. Castor wheel locations

1. *Location 1*
2. *Location 2*

5.12.3 Assembly of the castor wheel

1. Install the sleeves into the new castor wheel.
2. Place the castor wheel into the bracket.
3. Push the bolt through the bracket and the castor wheel. Be careful not to damage the bolt threads.
4. Install and tighten the nut to the bolt.
5. Check that the castor wheel rotates properly.

5.13 Castor wheel suspension



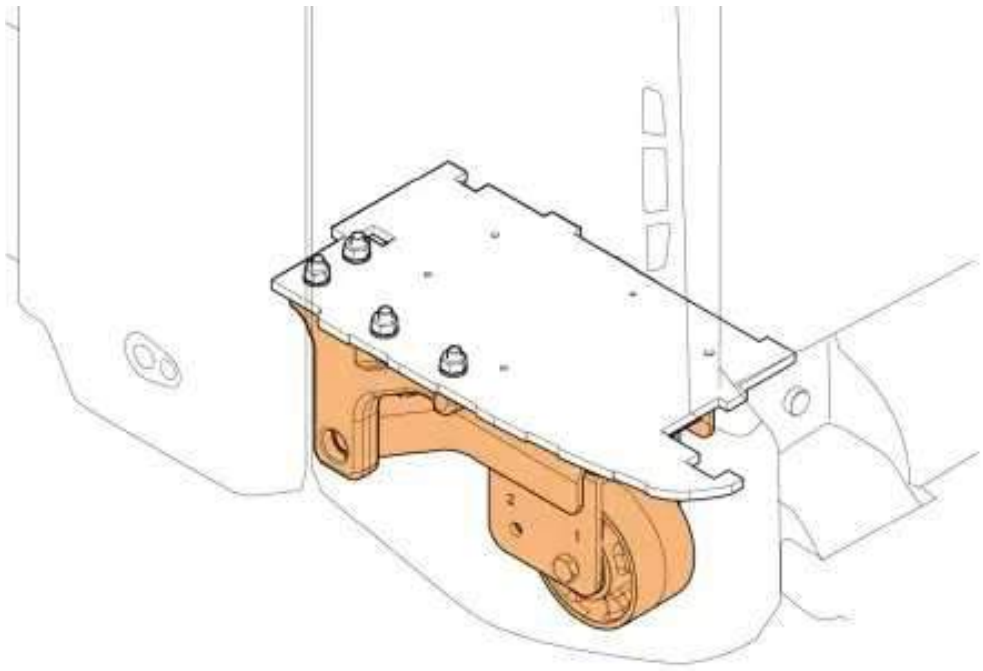


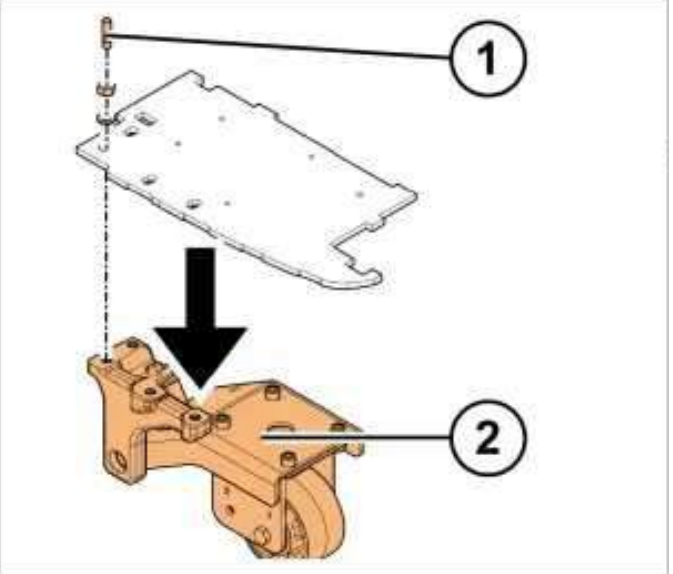
Figure 40. Castor wheel suspension overview

The castor wheel suspension mechanism makes the truck more stable. Check the condition of the suspension rubbers at every maintenance. Also the wear of the castor wheels and the traction wheel have a considerable effect on the truck's driving capability.

When the castor wheel suspension mechanism needs to be serviced, it is easiest to remove the whole system from the truck frame. The procedure is described below.

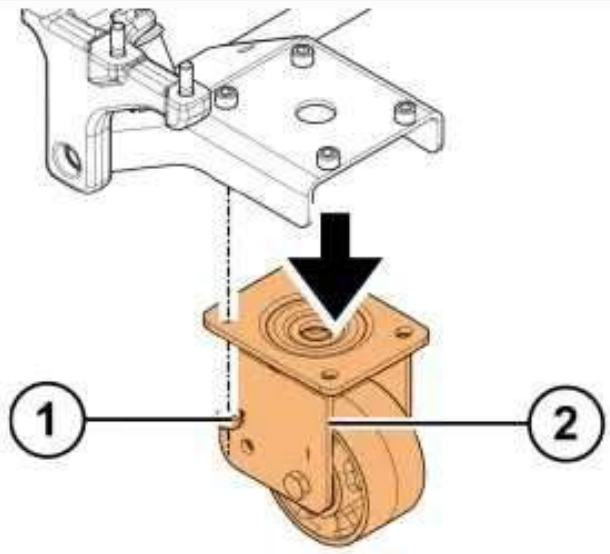
NOTE: To access the castor wheel suspension mechanism, lift the truck up (see the correct lifting points in the section 5.1 of this manual).

1. Remove the four nuts attaching the castor wheel suspension mechanism to the truck frame.
2. Remove the castor wheel suspension mechanism.



Disassembly of the castor wheel unit:

1. Remove the bolts and the nuts attaching the castor wheel unit to the castor wheel suspension mechanism.
2. Remove the castor wheel unit.

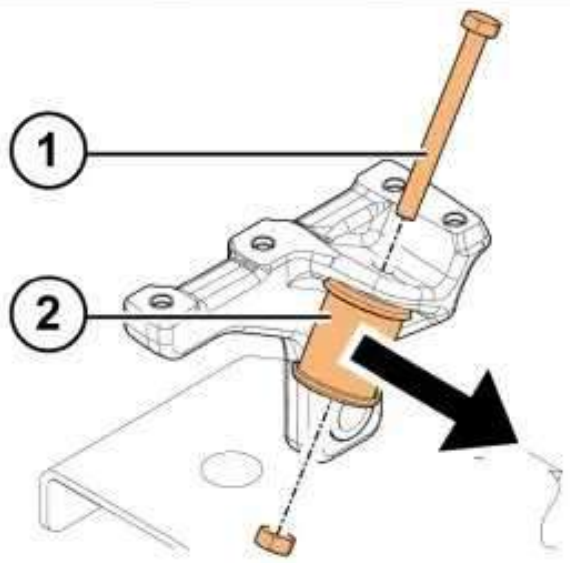


Assembly of the castor wheel unit:

1. Install the castor wheel unit.
2. Tighten the bolts and the nuts attaching the castor wheel unit to the castor wheel suspension mechanism.
3. Check that there is not too much play in the bearing of the castor wheel unit.
4. Check that the castor wheel rotates properly.

Disassembly of the rubber spring:

1. Remove the bolt and the nut holding the rubber spring in place.
2. Remove the rubber spring and the washers by pulling them to the side.



Assembly of the rubber spring:

1. Install the rubber spring and the washers.
2. Tighten the bolt and the nut keeping the rubber spring in place. Do not over tighten! Always use a new locking nut and tighten the nut only so much that the locking part of the nut is on the threads.

5.14 Disassembly of the drive unit suspension

⚠ WARNING

When you lift the truck up, make sure that you support it properly to prevent it from falling.

NOTE: If the truck is equipped with the electrical steering option, you need to disassemble the electrical steering motor unit first before you can perform the steps provided below. For more information about the disassembly of the electrical steering motor unit, see section 15.11.5.

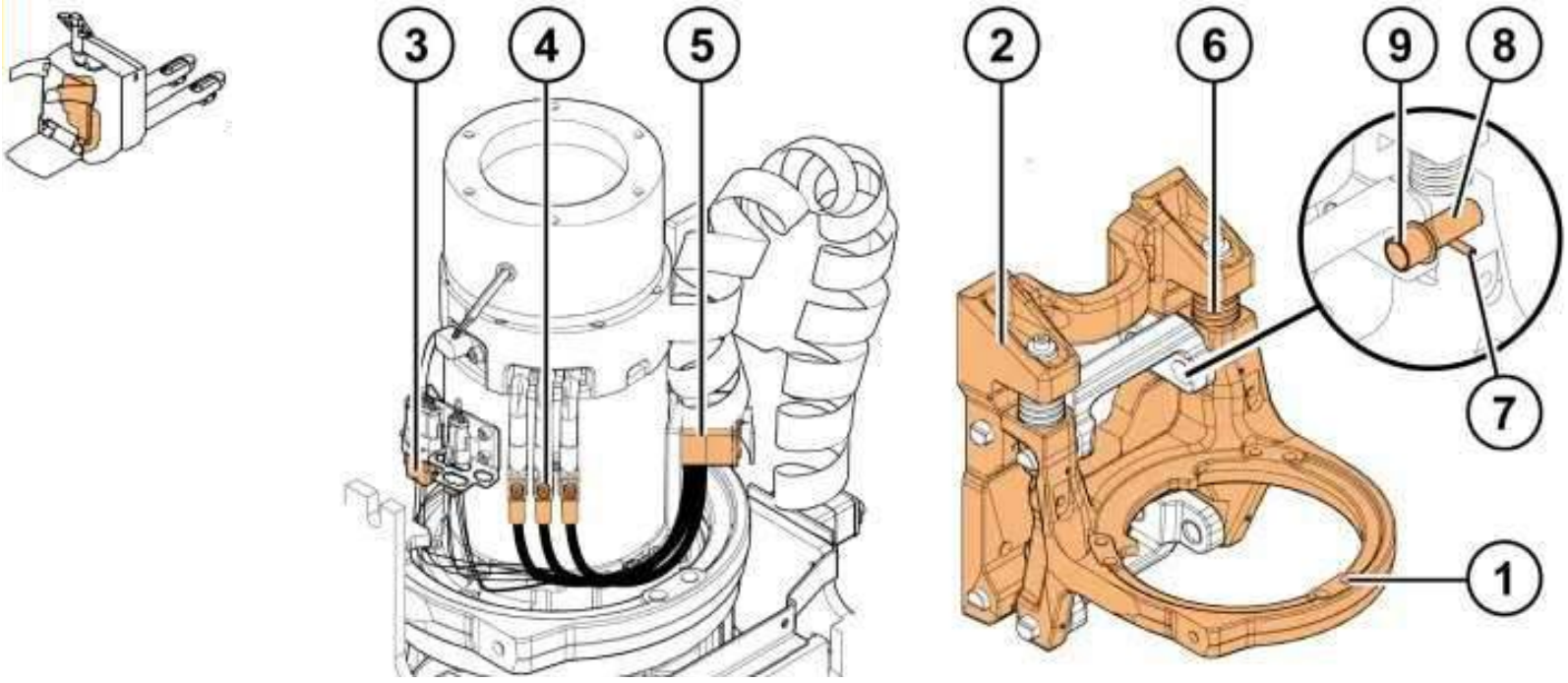
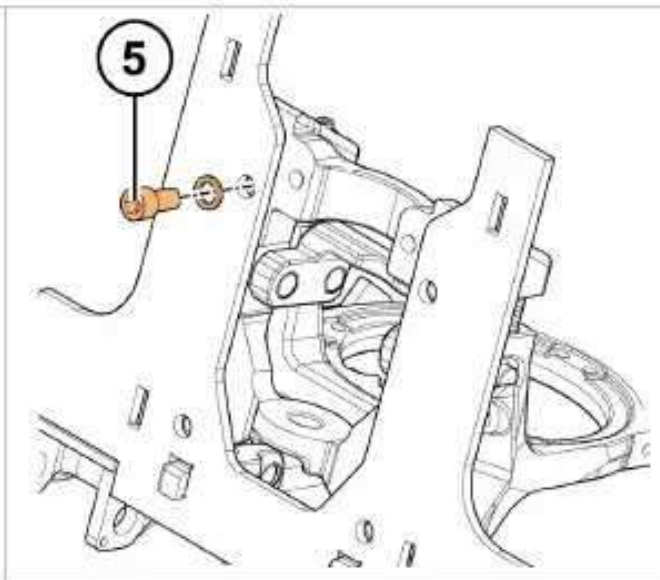


Figure 41. Drive unit suspension overview

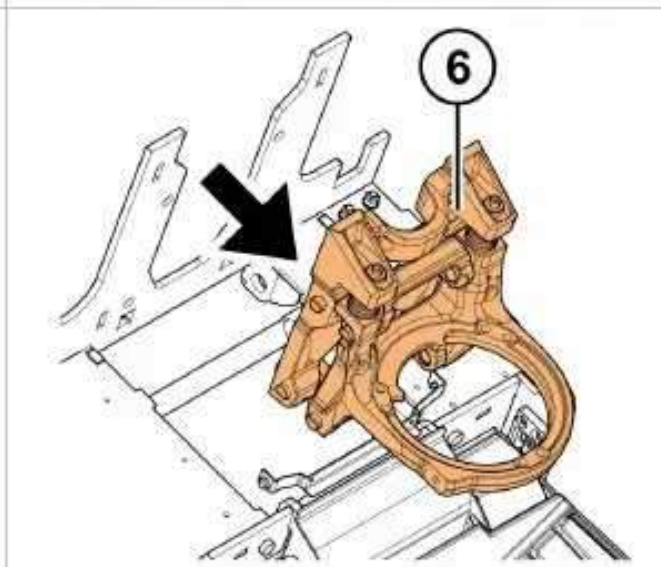
1. *Motor bed*
2. *Motor bed frame*
3. *Motor connector*
4. *Power cable*
5. *Cable mounting bracket*
6. *Spring*
7. *Tub pin*
8. *Shaft*
9. *Slide bearing*

1. Remove all the covers. For instructions, see section 5.4.
2. Remove the tiller arm and the tiller arm fastener. For instructions, see section 5.15.
3. Remove the drive unit. For instructions, see section 8.3.1.
4. Remove the hydraulic cylinder. For instructions, see section 10.5.

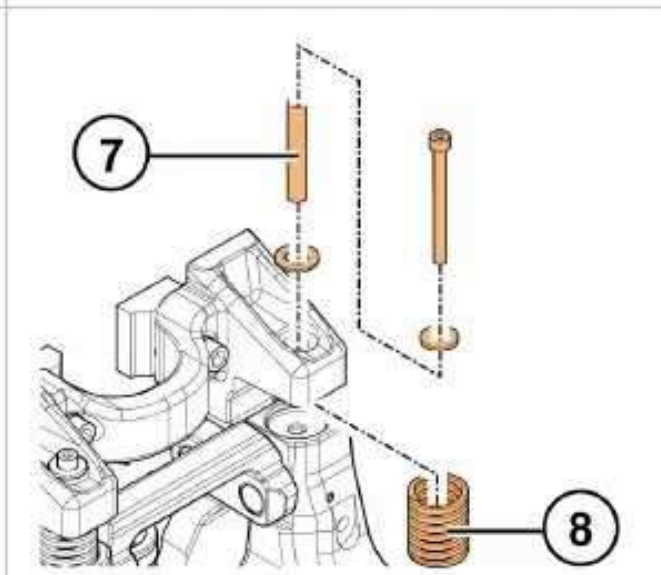
5. Remove the four screws at the back of the motor bed frame.

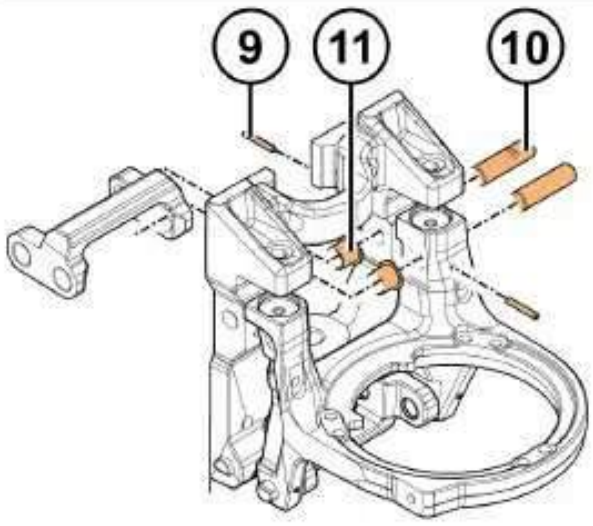
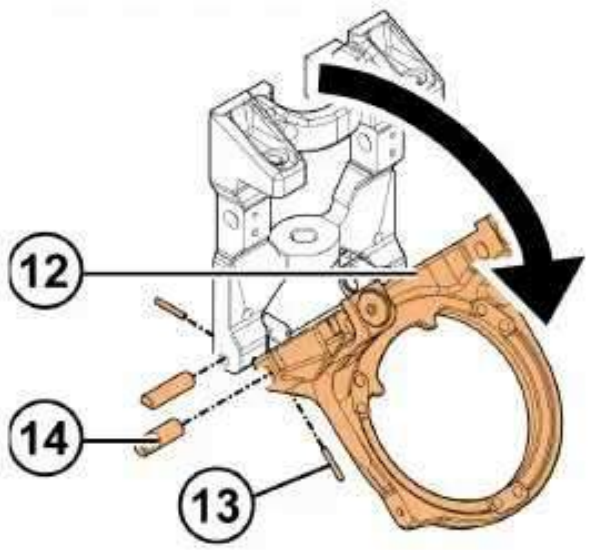
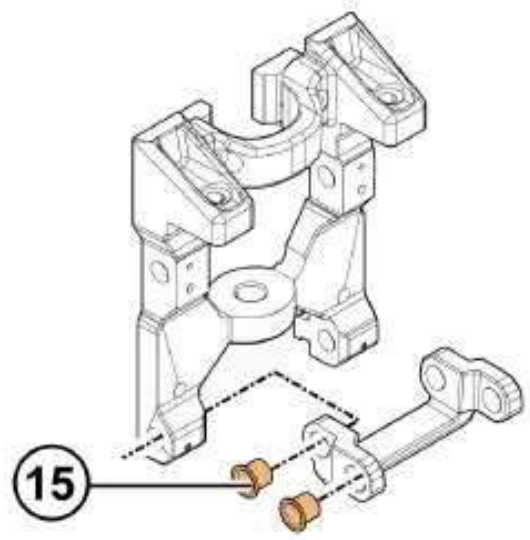


6. Lift the motor bed frame out of its slot.

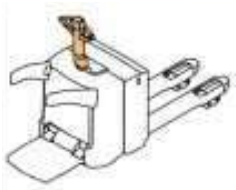


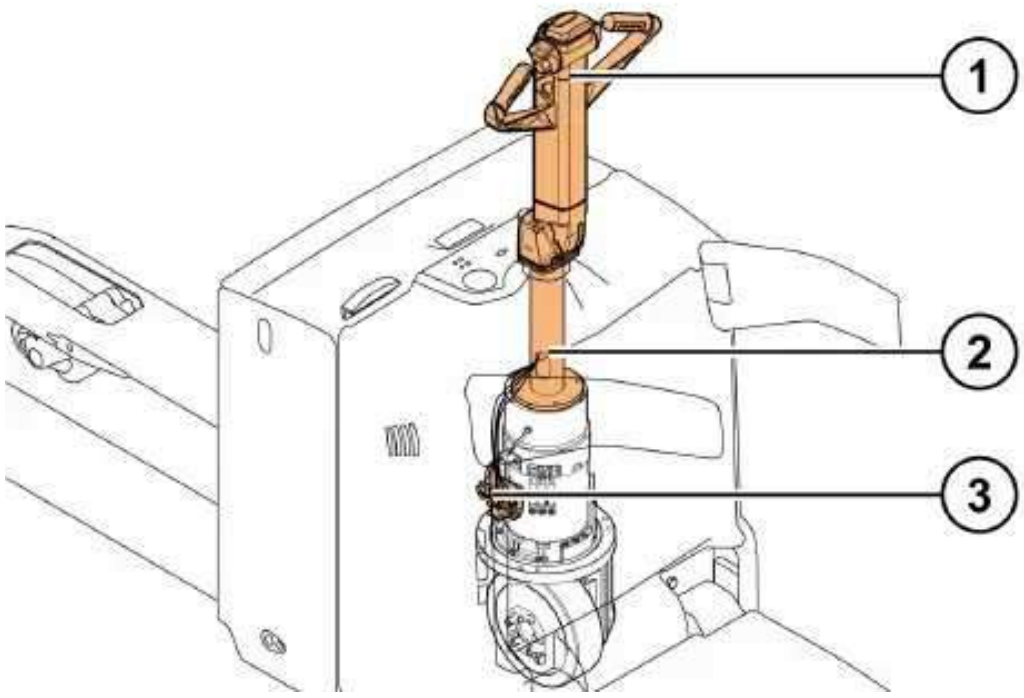
7. Remove the screws and shafts holding the drive unit suspension springs in place.
8. Remove the springs.



9. Push out the tub pins above the motor bed. **10.** Push out the shafts connecting the top part of the motor bed to the motor bed frame. **11.** Remove the slide bearings.	
12. Tilt the motor bed forward approximately 45 degrees. **13.** Push out the tub pins beneath the motor bed. **14.** Push out the shafts connecting the lower part of the motor bed to the motor bed frame.	
15. Remove the slide bearings.	

5.15 Tiller arm



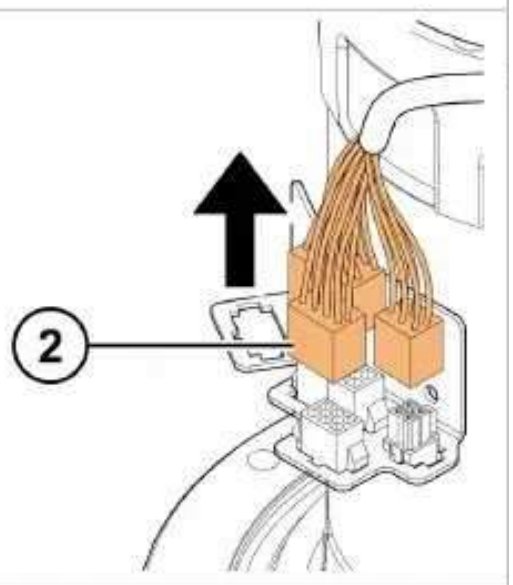


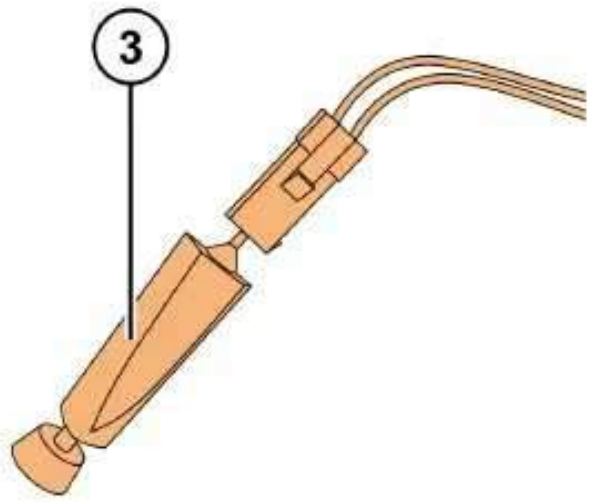
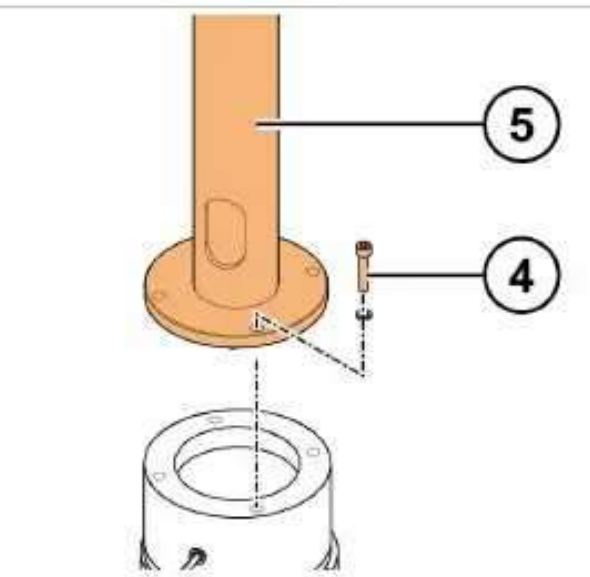
a

Figure 42. Tiller arm overview

1. *Tiller arm*
2. *Tiller arm fastener*
3. *Tiller connector*

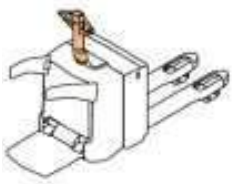
Removing the tiller arm:

1. Remove the covers. For more detailed information, see section 5.4.	
2. Remove the tiller connectors from the motor.	

3. Remove the brake wires from the connector using the extraction tool (360058).	
4. Remove the bolts attaching the tiller arm fastener to the magnetic brake. **5.** Remove the tiller arm fastener and the tiller arm.	

During the installation of the tiller arm, tighten the bolts of the tiller arm fastener first by hand to make sure they fit the threads correctly. After that, cross-tighten the bolts with a power tool, making sure that the fastener is aligned correctly.

5.16 Tiller arm joint



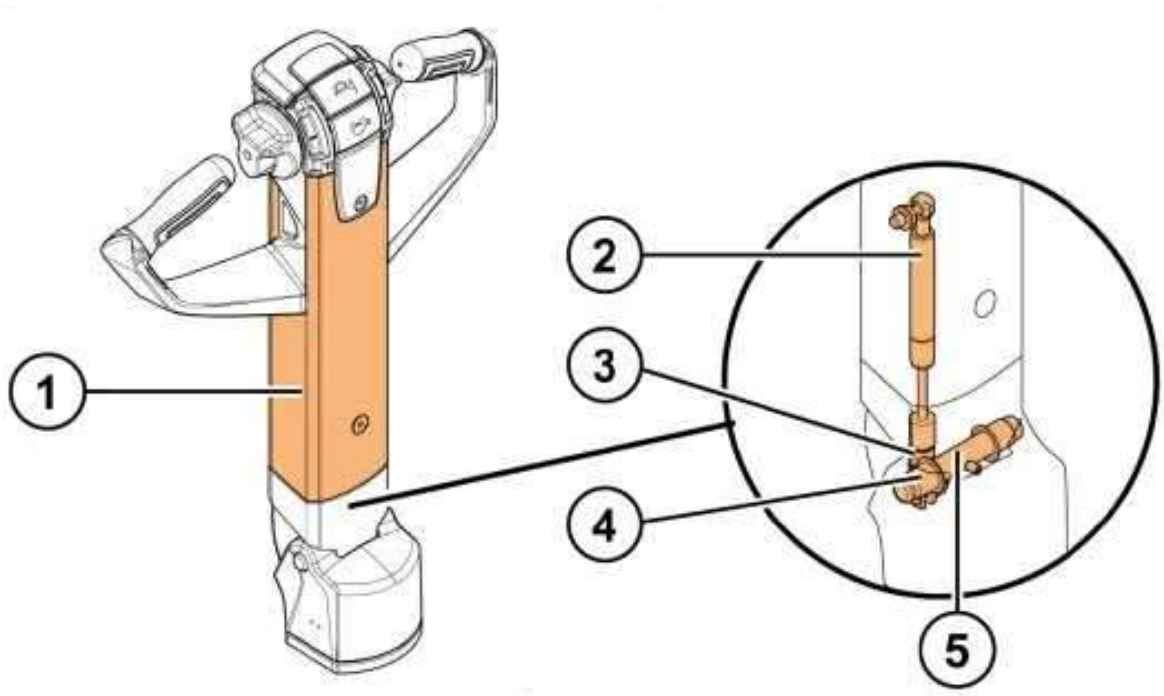
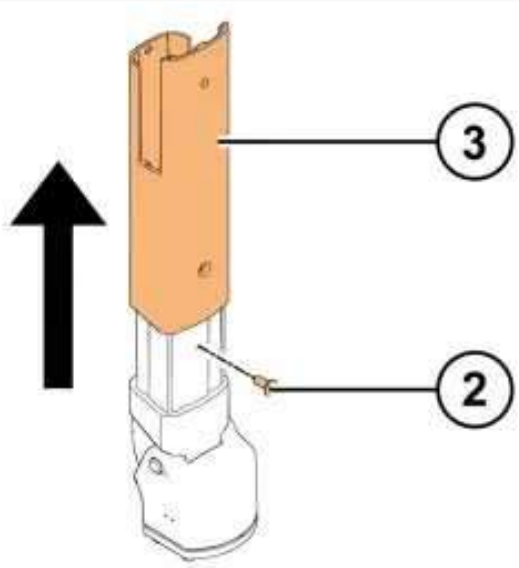
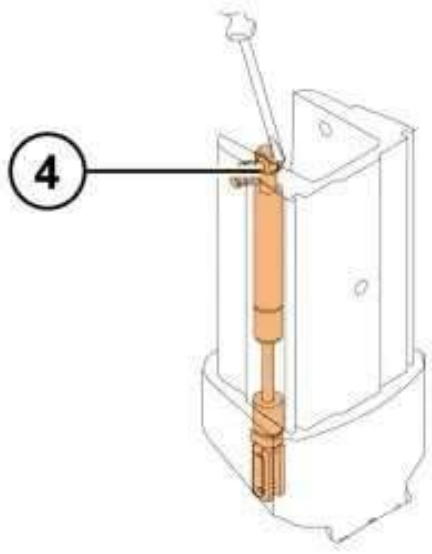
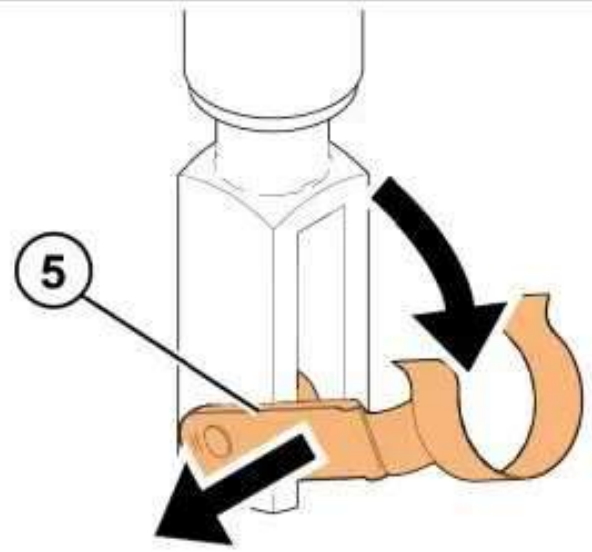
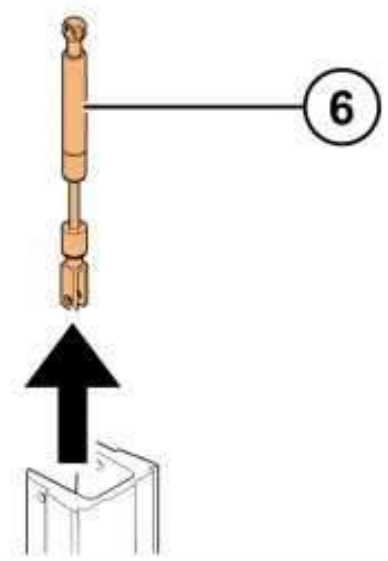


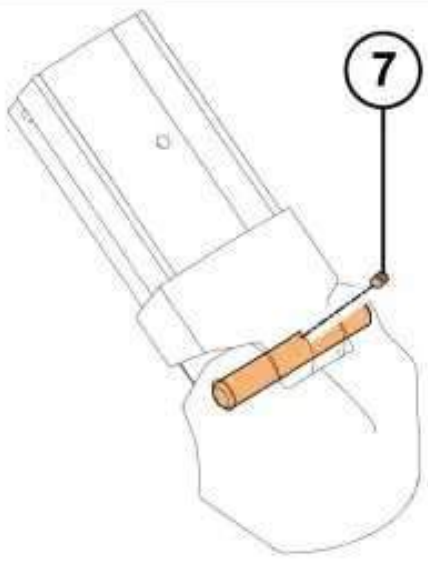
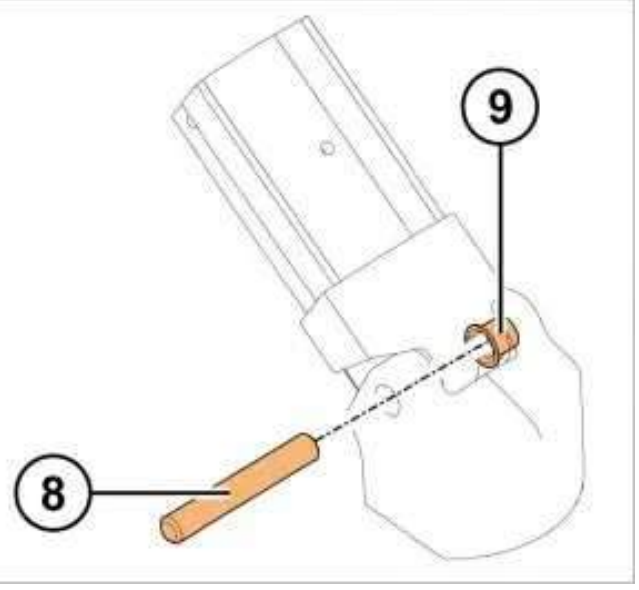
Figure 43. Tiller arm joint overview

1. *Aisle pipe*
2. *Gas spring*
3. *Spring lock*
4. *Bearing*
5. *Shaft*

Disassembly of the tiller arm joint:

1. Remove the tiller head. For instructions, see the section 8.1.1.	
2. Remove the lower bolt from the tiller arm. **3.** Pull the aisle pipe up.	

4. Remove the locking spring from the gas spring's head.	
5. At the base of the gas spring, push the spring lock off its place and move it to the side. Note the orientation of the spring lock.	
6. Pull the gas spring out.	

7. Remove the locking screw.	
8. Remove the shaft. **9.** Remove the bearings.	

6 Electrical operation

This chapter describes the electrical operating principles of the power pallet truck. The standard model and its electrical schematic diagram are used as an example.

⚠ CAUTION

Always use the correct schematic diagram for the specific model you are servicing. The latest schematic diagrams are available from the manufacturer's Web site.

To troubleshoot a particular component, locate the component on the appropriate page of the schematic diagram and check the circuitry associated with it. Keep the schematic diagram at hand for reference while reading the explanation. Make sure that you have the correct schematic diagram with regard to the truck model and its age.

6.1 Using the schematic diagram

⚠ CAUTION

The figures provided in this section are provided as examples only. Therefore the information in the actual schematic diagram of the truck model you are servicing may differ from the figures.

As an example, Figure 44 below shows a part of a schematic diagram.

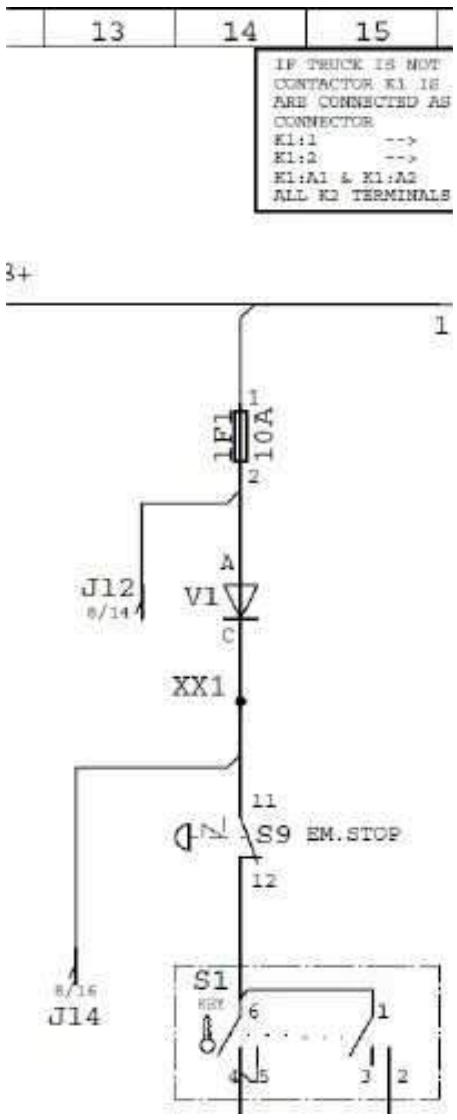


Figure 44. Page 1/8, zone 13, wiring reference J14

Note the numbers above the wiring reference J14. These numbers (8/16) direct you to the page and zone where the wire is connected.

This procedure is used to follow the circuits throughout the schematic diagram. If the numbers are given without the slash (/), the connection is on the same page of the schematics.

Table 2 below explains the different identifiers used in the schematic diagram. # stands for a number.

Table 2. Schematic diagram identifiers

IDENTIFIER	DESCRIPTION
S#	Switches and other state changing devices (for example, most sensors).
#F#	Fuse
J#	Reference. All references marked with an even ”J” (e.g. J2) are positive (+). All references marked with an odd “J” (e.g. J3) are negative (-).

IDENTIFIER	DESCRIPTION
M#	Motor
V#	Diode
A#	Controllers and displays
K#	Contactors and relays
X#	Connector. Contact numbers are marked on individual wires.
XX#	Splice. Multiple wires are connected together at this point.

Figure 45 shows the reference to which Figure 44 referred.

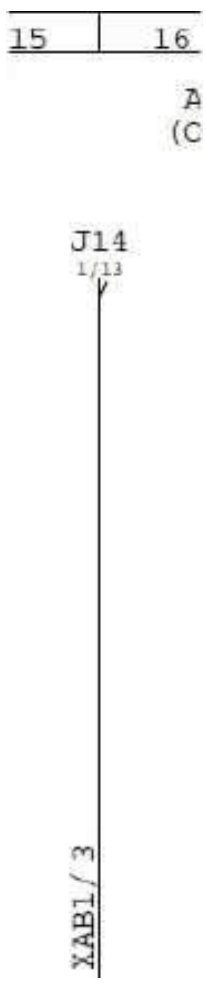


Figure 45. Page 8, zone 16, wiring reference J14

Once again, note the numbers below the wiring reference J14. These numbers (1/13) direct you back to the page (and zone) shown in Figure 44.

Figure 46. Page numbers (4/9), circuit diagram number (3-7109) and revision letter (H)

Page numbers, the circuit diagram number and the revision letter can be found in the bottom right corner of the page.

REV	DATE:	NAME:	CHANGE:
E	2011-09-27	EP	CAN BUS TERMINATION OUTSIDE COMBI-ACX

Figure 47. Page modification history

On the bottom left side of the circuit diagram, you can see the modification history of the page.

6.2 Power source

This truck product family uses wet lead-acid batteries, which consist of 12 cells and supply a nominal voltage of 24 volts. The batteries have the maximum capacity of 500 Ah, depending on the truck model. The batteries reside in a separate compartment and are connected to the system via the X1 battery connector. In the electrical schematic diagram, the battery is presented as G1 in zone 11 on page 1.

6.3 Safety circuit (emergency stop button)

If the emergency stop button (S9) is in its normal closed position, B+ continues to flow to the key switch (S1). B+ also flows to the main power contactor coil (K1). The operator can shut down the system power at any time by pressing the emergency stop button. When the button is pressed, the connection opens and removes B+ from the main contactor coil (K1).

6.4 Key switch

The main key switch S1 controls the electrical power supply to the entire system with the help of the main contactor K1. The coil controlling the K1 contacts is presented in zone 17 on page 1.

The key switch is activated by turning it to the ON position. When the key switch S1 closes, B+ flows to the coil of the main contactor K1, the negative is connected to the battery via the controller pin 6 of the connector XA1B and the contactor K1 closes the contacts. Positive electrical power is supplied to the system through the main fuse 5F1.

The fuse 5F1 is rated at 300 A. In the electrical schematic diagram, the location of the main fuses is illustrated in zone 27 on page 1. After the main fuse 5F1, the +B supply is fed to the contacts of the pump motor M2. The pump motor negative is controlled by the pump controller. In the schematic diagram, the M2 contacts are presented in zone 21 on page 1.

The traction motor is controlled by the traction controller. In the schematic diagram, the M1 contacts are presented in zone 23 on page 1. The main voltage is supplied to the terminal BF on the traction controller.

6.5 Traction

The movement of the truck is controlled by the traction controller. Before the truck can be driven, the battery must be connected, the main key switch must be closed and the system must have passed the self-test procedure.

When the truck is powered on and in the standby mode, it can be driven by turning the accelerator at the end of the tiller arm forward or backward. In the electrical schematic diagram, the accelerator is presented in zones 12 to 15 on page 3 of the electrical schematic diagram. The accelerator unit receives its positive 24 volt electrical supply from the pin 2 of the connector XA1C. The negative connection is supplied directly from - B. When the accelerator is turned forward or backward, it indicates the direction to the traction controller via the pins 4 and 8 of the connector XA1B. It also provides a varying voltage to the pin 4 of the connector XA1C. The voltage varies between 0, 3 and 4.7 volts, depending on the position of the accelerator control. The voltage increases as the accelerator is moved to either extreme.

6.6 AC motor operation

In the induction motor (= asynchronous motor), the stator is powered with alternating current and designed to create a rotating magnetic field, which rotates in time with the AC oscillations. In the induction motor, the rotor rotates at a slower speed than the stator field and therefore the magnetic field through the rotor is changing (rotating). The rotor has windings in the form of closed wire loops. The rotating magnetic flux induces currents in the rotor windings as in a transformer. These currents in turn create magnetic fields in the rotor that interact with the stator field. Due to Lenz's law, the direction of the created magnetic field is such as to oppose the change in current through the windings. The cause of induced current in the rotor is the rotating stator magnetic field, so to oppose it, this rotor starts to rotate in the direction of the rotating stator magnetic field to make the relative speed between the rotor and the rotating stator magnetic field zero.

For these currents to be induced, the speed of the physical rotor must be lower than that of the stator's rotating magnetic field or the magnetic field would not be moving relative to the rotor conductors and no currents would be induced. As the speed of the rotor drops below synchronous speed, the rotation rate of the magnetic field in the rotor increases, inducing more current in the windings and creating more torque. The ratio between the rotation rate of the magnetic field as seen by the rotor (slip speed) and the rotation rate of the stator's rotating field is called "slip". Under load, the speed drops and the slip increases enough to create sufficient torque to turn the load. For this reason, induction motors are sometimes referred to as asynchronous motors. An induction motor can be used as an induction generator, or it can be unrolled to form the linear induction motor, which can directly generate linear motion.

7 Battery maintenance

WARNING

Always keep the truck's battery clean and dry to prevent tracking currents. Cleaning of the battery must be done in accordance with the manufacturer's instructions.

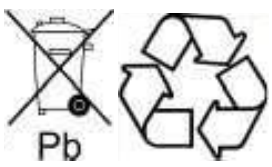
Any liquid in the battery tray must be extracted and disposed of in the prescribed manner. After cleaning, repair all damages to the tray's insulation to prevent tray corrosion and to ensure that the insulation value complies with the standard EN 50272-3.

If the battery is taken out of service for a longer period, make sure that the battery is fully charged and store it in a dry, frost-free room. The storage time should be taken into account when considering the lifetime of the battery.

In case of any malfunctions on the battery or in the charger, contact the battery manufacturer without delay.

When using motive batteries and chargers, always make sure you follow the current standards, laws, rules and regulations in force in the country of use

For batteries according to the ATEX directive 94/9 EC, the instructions for maintaining the appropriate protection class during operation must be complied with (see the relevant certificate).



Batteries marked with this sign must be recycled.

Batteries that are not marked with this sign are not returned for the recycling process and must be disposed of as hazardous waste.

7.1 Safety regulations concerning the handling of lead-acid batteries

Pay attention to the battery's operating instructions and fix them close to the battery.

Work on batteries should be carried out by skilled personnel only!

Use protective glasses and clothes when working on batteries.
Pay attention to the accident prevention rules as well as the standards EN 50272-3 and EN 50110-1

No smoking!
Do not expose batteries to naked flames, glowing embers or sparks, as it may cause the battery to explode.

Acid splashes in the eyes or on the skin must be washed immediately with water.
In case of an accident, consult a doctor immediately!
Clothing contaminated by acid should be washed with water.

Risk of explosion and fire, avoid short circuits!
Metal parts of the battery are always live. Do not place tools or other metal objects on the battery!

Electrolyte is highly corrosive.

Batteries and cells are heavy.
Ensure secure installation. Use only suitable handling equipment, for example lifting gear in accordance with the standard VDI 3616.

Dangerous electrical voltage!

Pay attention to the hazards that can be caused by batteries.

7.2 Battery maintenance

7.2.1 Daily maintenance

Charge the battery after every discharge.

For batteries with electrolyte circulation, check the electrolyte level towards the end of the charging and, if necessary, top it up to the specified level with purified water according to the manufacturer's instructions. The electrolyte level must not fall below the anti-surge baffle, the top of the separator or the electrolyte minimum level mark.

For batteries with filling level sensors, check the illuminated display daily. If the display is green, the level is OK. If the display shows a blinking red colour, the filling level is too low.

Check the electrolyte level visually by opening the standard vent plug or by the position of the float indicator of the water refilling plug and top it up with demineralised water at the end of the charge.

7.2.2 Weekly maintenance

After recharging, check the battery visually for any signs of dirt or mechanical damages to the battery's components. Pay special attention to the battery charging plugs and cables. In special cases when charging with an IU characteristic curve, also an equalizing charge must be carried out.

7.2.3 Monthly maintenance

At the end of the charge, switch the charger on and measure and record the voltages of all cells or bloc batteries.

After the charging has been completed, measure and record the electrolyte density, electrolyte temperature and the filling level (when filling level sensors are used) of all cells. If there are any significant changes compared to earlier measurements or differences between the cells or bloc batteries, charge the battery fully and allow it to rest for the minimum of two hours. If the problem persists, contact the battery manufacturer.

Before contacting the battery manufacturer, measure and record:

- Total voltage
- Voltage per cell
- If the voltage readings are irregular, also check the S.G. of each cell

7.2.4 Annual maintenance

In accordance with the standard EN 1175-1, the insulation resistance of the truck and the battery must be checked by an electrical specialist at least once per year. The tests on the battery's insulation resistance must be conducted in accordance with the

standard EN 1987 part 1. The insulation resistance of the battery must not fall below the value of 50 Ω per Volt of nominal voltage, in compliance with the standard EN 50272-3. For batteries up to 20 V nominal voltage, the minimum value is 1000 Ω.

For batteries fitted with an electrolyte circulation system, check the filter of the air pump and clean or replace it, if needed. The filter may need to be replaced earlier than expected if there are no leaks in the air pipes but for some reason the defect signal of the air mixing system on the charger or on the battery (on the DC air pump or remote signal) is illuminated.

During annual maintenance, also check the correct operation of the air pump.

7.3 Recharging the battery

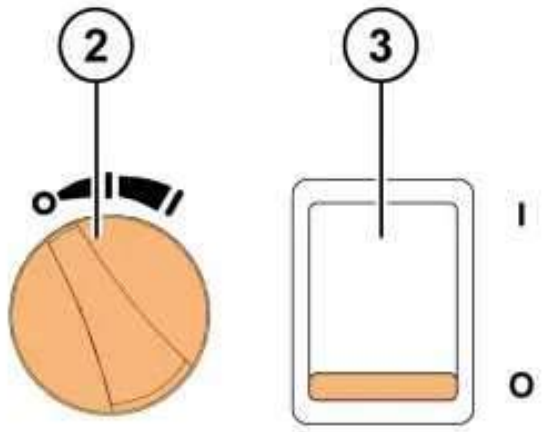
⚠ CAUTION

Make sure that the charger is the appropriate model (correct battery type and voltage) and that the battery has sufficient ventilation.

1. Park the truck in a reserved recharging place.

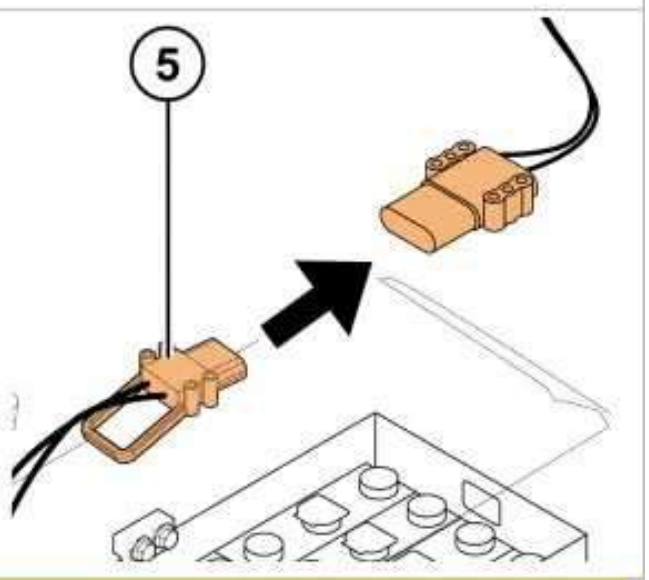
2. Switch the truck's power off.

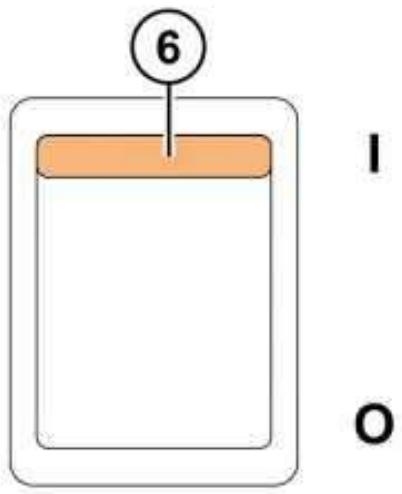
3. Make sure that the charger has been switched off.



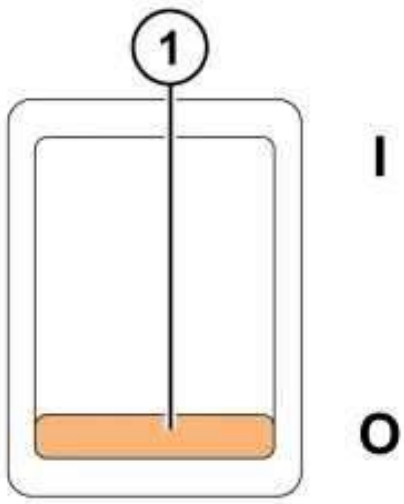
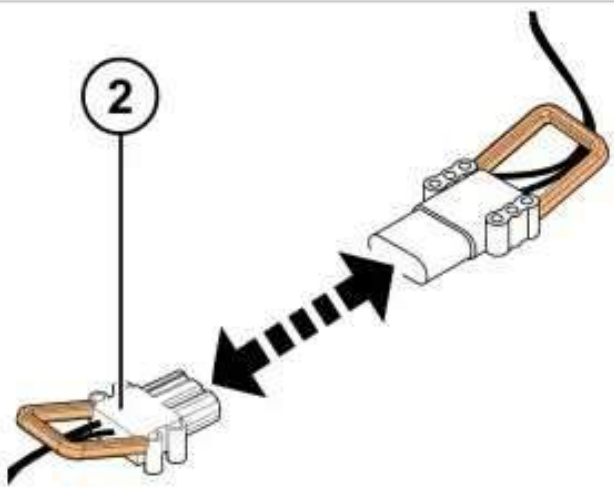
4. Open the battery cover. For instructions, see the section 5.4.4.

5. Disconnect the battery connector and connect it to the charger.



6. Switch on the charger.	

After recharging

1. Switch the charger off.	
2. Disconnect the battery connector from the charger. Grab the plugs; do not pull the cables.	
3. Check the battery according to the battery manufacturer's maintenance instructions. **4.** Connect the battery connector. Make sure that the battery cables remain completely safe within the frame of the truck. **5.** Close the battery cover. Make sure that the locking button returns all the way to the locking position.	

7.4 Measuring the battery's specific gravity

Measure the specific gravity of the battery fluid according to the manufacturer's instructions. The acid density of a fully charged battery is 1.28 to 1.30 at +30°C. The gravity is:

- 1.24 when the battery is 3/4 charged.
- 1.20 when the battery is 1/2 charged.
- 1.16 when the battery is 1/4 charged.
- 1.15 when the battery is empty. Charge the battery immediately.

7.5 Replacing the battery

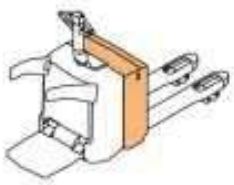
⚠ CAUTION

Always follow the manufacturer’s instructions when replacing the battery.

When replacing the battery, use one with similar dimensions and weight to maintain the stability and the braking properties of the truck. The battery’s minimum weight is indicated on the identification plate of the truck.

When reinstalling batteries, use the appropriate tools for moving, connecting and fastening the battery securely. Do not keep tools or other metal implements on top of uncovered batteries.

Make sure that the capacity of the used lifting device is sufficient. When using a lifting device for lifting the battery, place a non-conductive plate on top of the battery to avoid the risk of a short circuit. This is not necessary, if the lifting device has sufficient insulation and is equipped with a distributor, or if the pole shoes and cell combinations are fully protected.



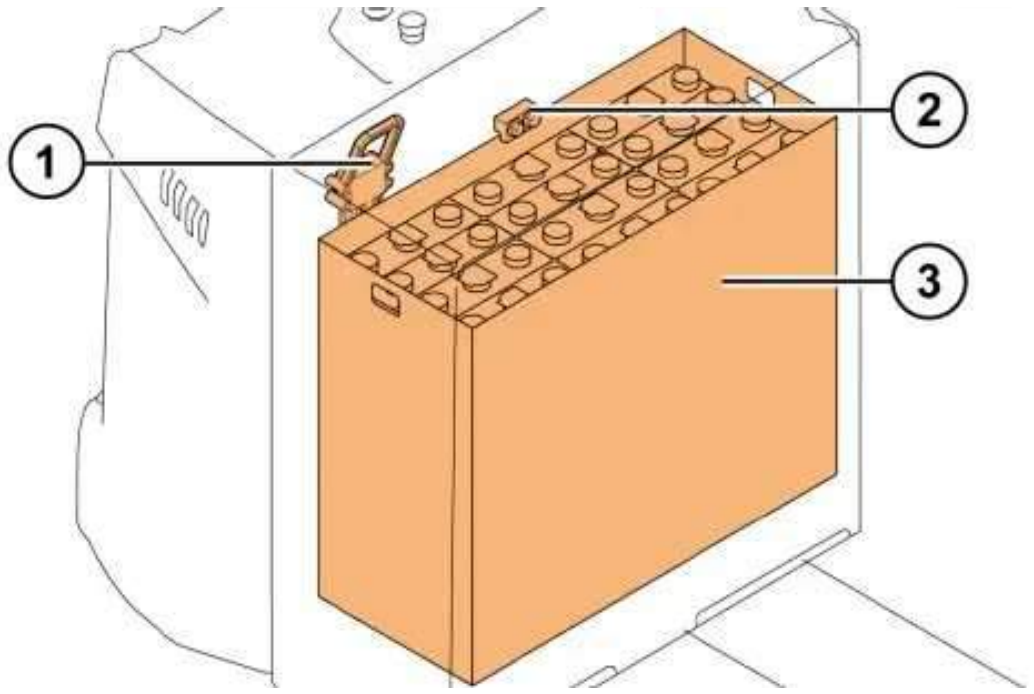
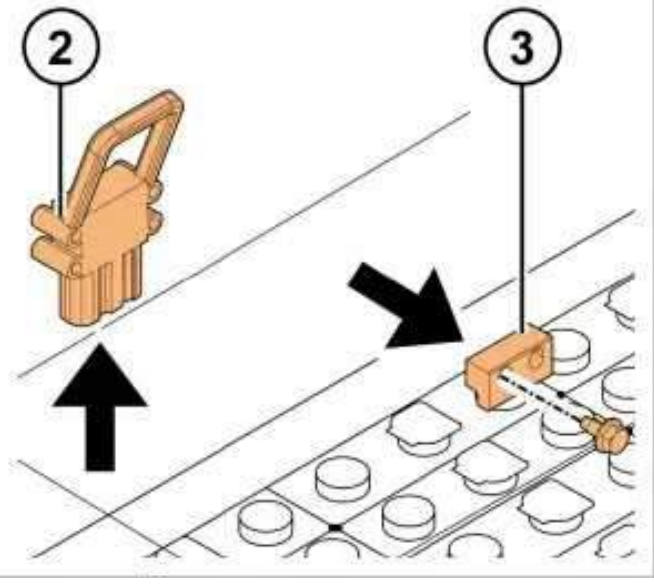
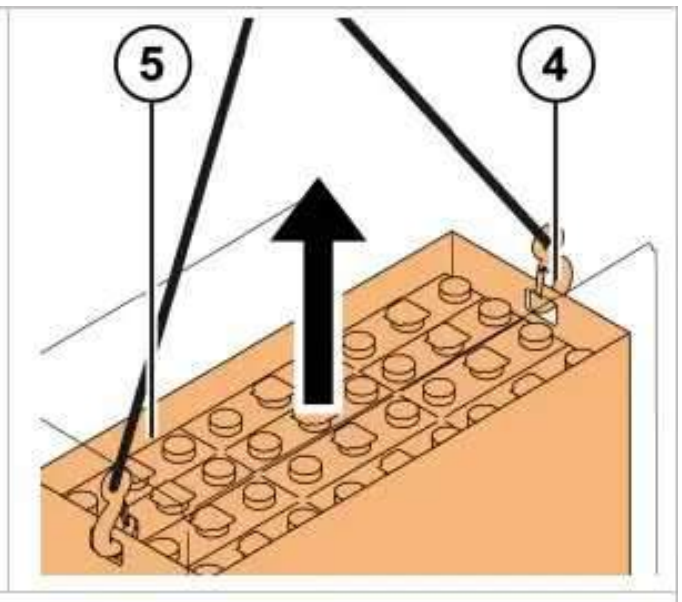


Figure 48. Replacing the battery overview

1. *Battery connector*
2. *Battery holder*
3. *Battery*

1. Open the battery cover. For instructions, see the section 5.4.4.	
2. Disconnect the battery connector. **3.** Open the battery holder with a 13 mm socket wrench to release the latch.	

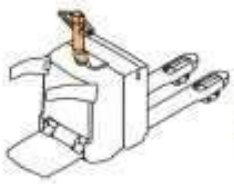
4. Attach self-locking lifting hooks (size 5/6) to the lifting points.
5. Lift up the battery.



6. Insert a new battery (verify the battery type and voltage).
7. Attach the latch and close the battery holder with a socket wrench.
8. Connect the battery connector. Make sure that the battery cables remain completely safe within the frame of the truck.
9. Close the battery cover.

8 Electric system maintenance

8.1 Tiller arm



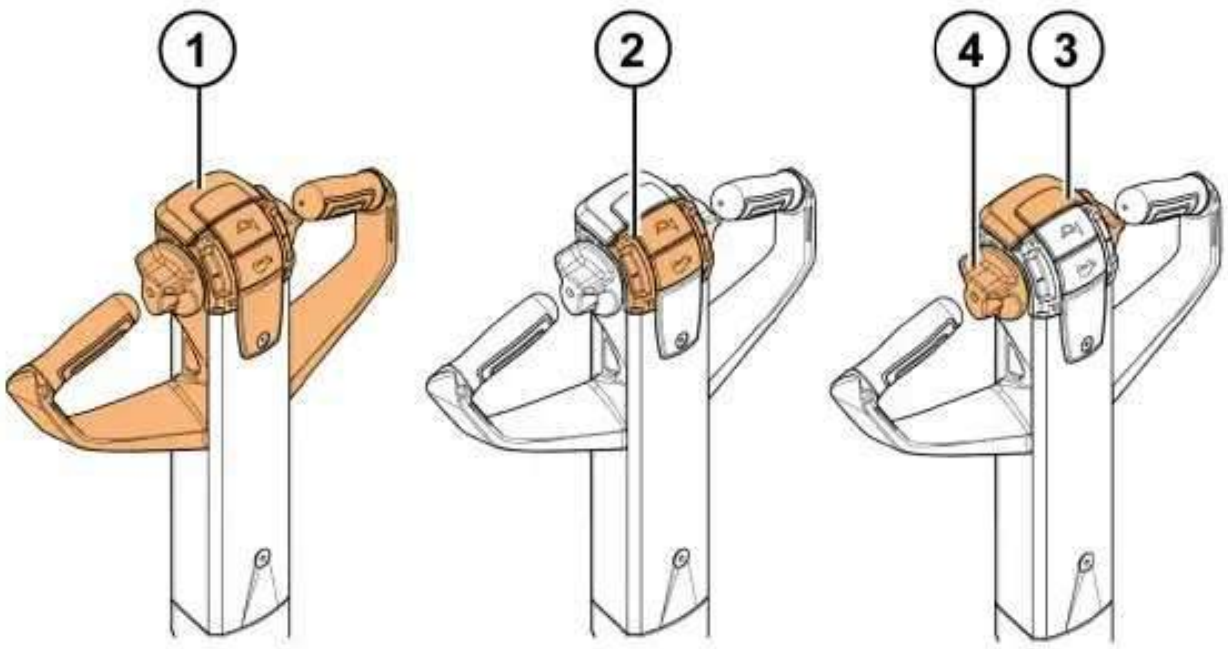


Figure 49. Tiller arm overview

1. *Tiller head*
2. *Tiller head switches*
3. *Safety button*
4. *Accelerator*

8.1.1 Removing the tiller head

⚠ CAUTION

Before opening the tiller head, turn the key switch to the OFF position and disconnect the battery plug/connector. Record the places of the harness connections before disassembly.

When disconnecting the connector, hold the connector housing and plug and then unlock the connector. Holding the case may cause damage to the inside card, while holding the cable may cause wire breakage.

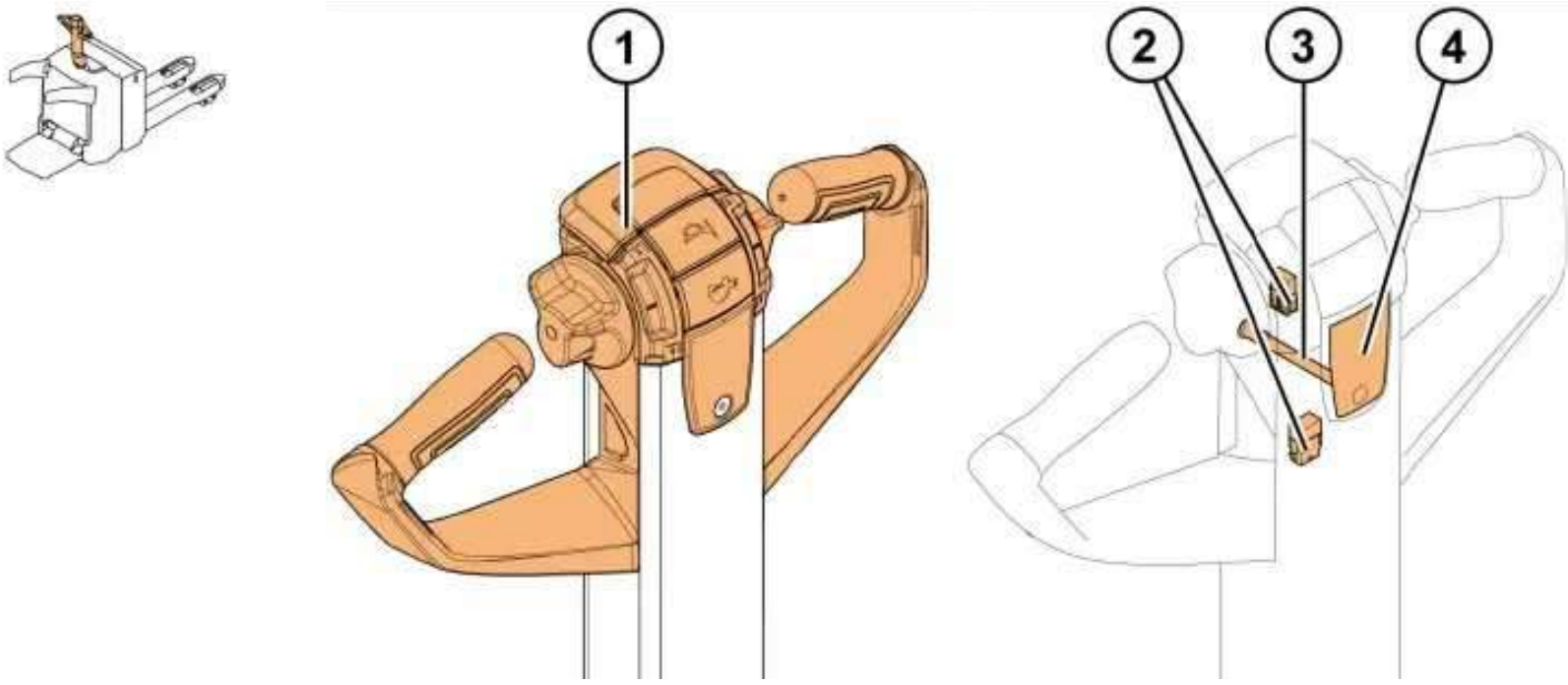
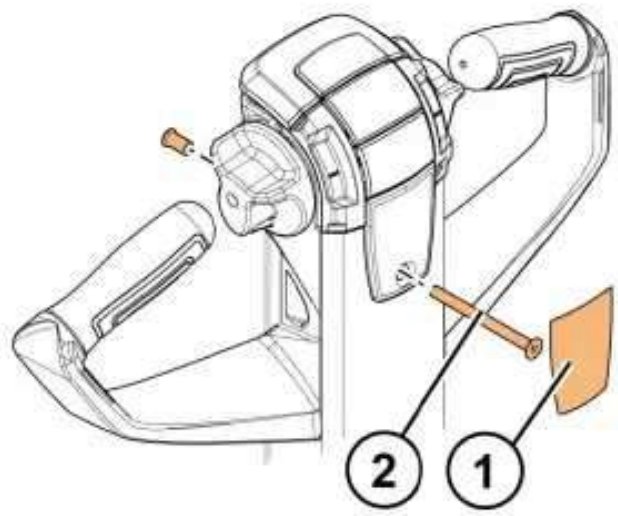
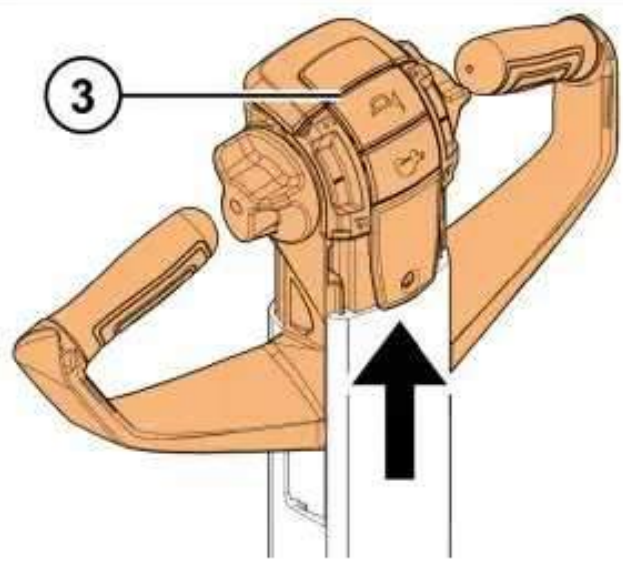
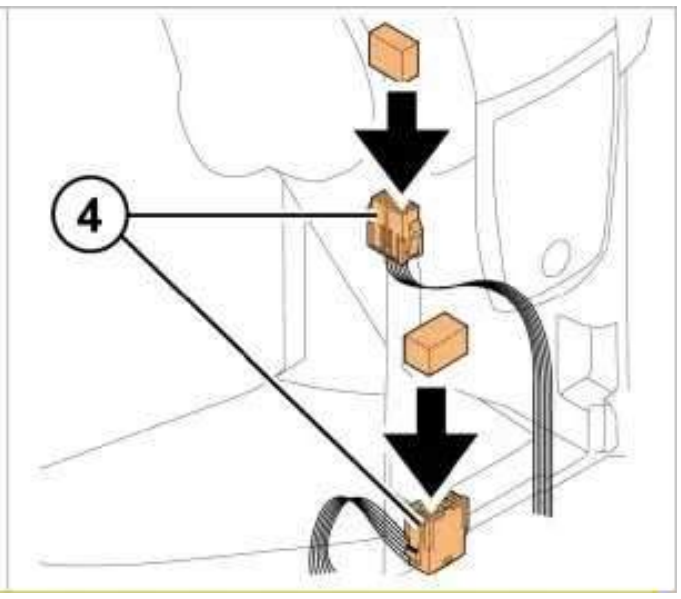


Figure 50. Tiller head overview

1. *Tiller head*
2. *Connector*
3. *Tiller head fixing screw*
4. *Logo plate*

1. Remove the logo plate. **2.** Remove the tiller head fixing screw.	
3. Lift the tiller head carefully upwards until you can feel the connector wires tightening. Be careful not to damage the wiring. When pulling the tiller head up, note that the pipe edges are sharp and may cut you.	

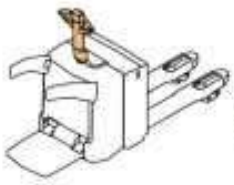
4. Disconnect the connectors.
5. Remove the tiller head from the pipe.



8.1.2 Removing the tiller head switches

⚠ CAUTION

When removing the switches, be careful not to break them.



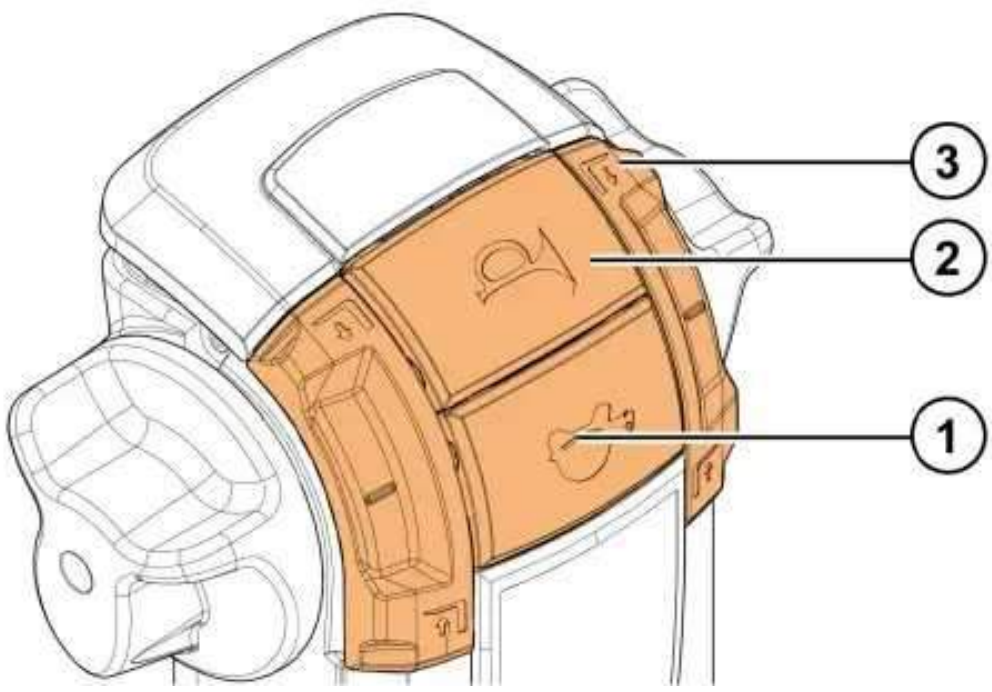
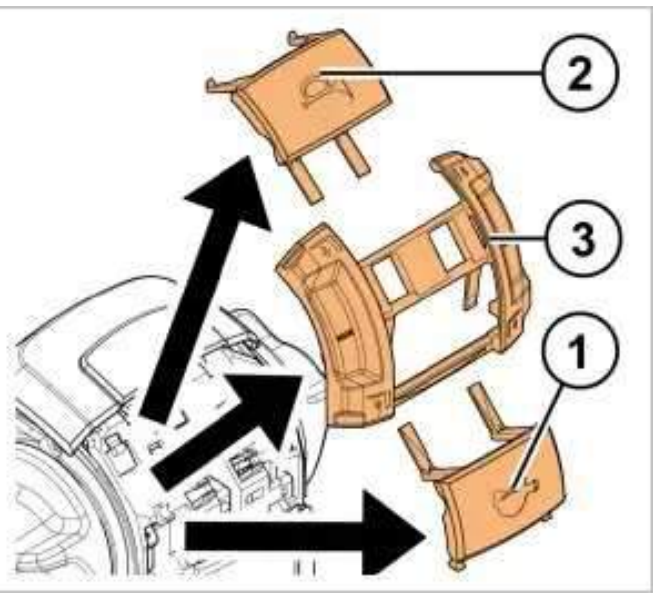


Figure 51. Tiller head switches overview

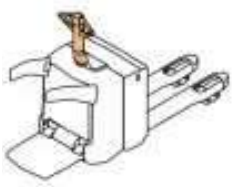
1. *Brake release/slow speed switch*
2. *Horn*
3. *Initial lower/lift switches*

1. Remove the brake release/slow speed switch.
2. Remove the horn.
3. Remove the initial lift/lower switches.



8.1.3 Removing the safety button

NOTE: Before you can remove the accelerator knobs, you have to remove the rubber tiller arm handles to make room.



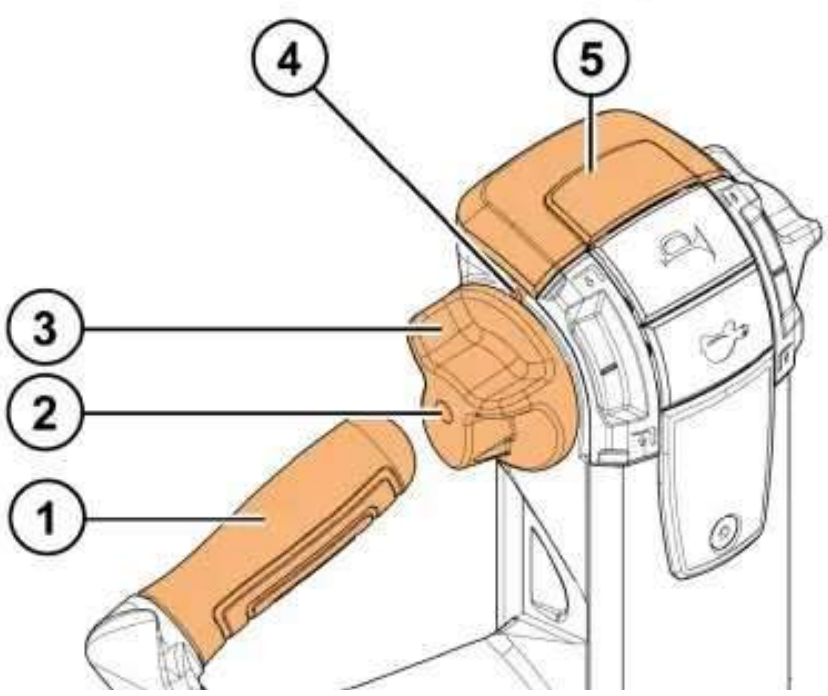
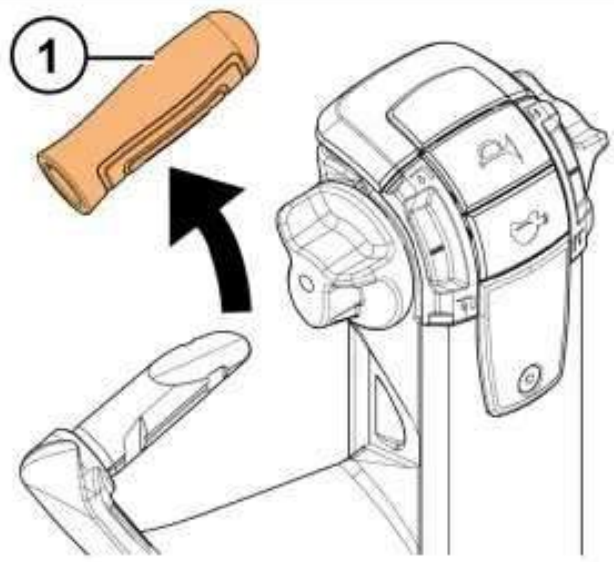
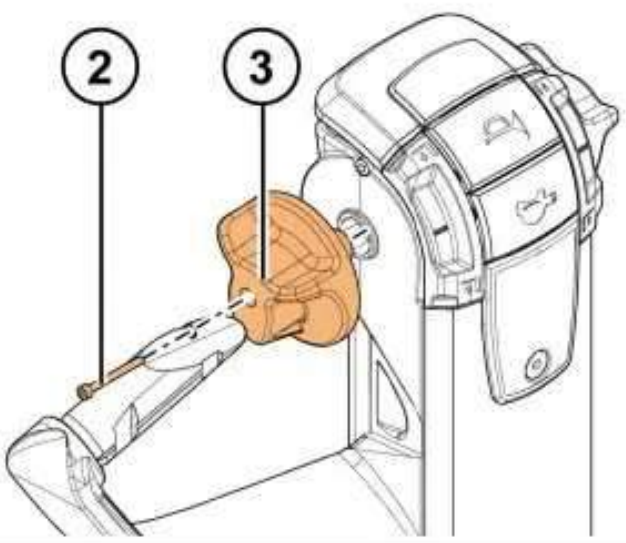
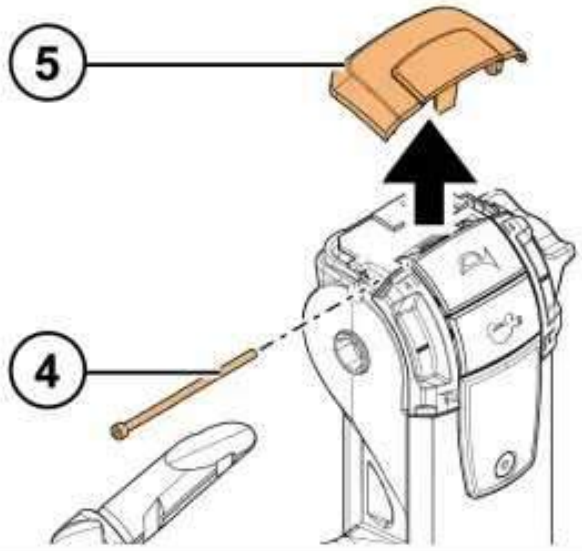
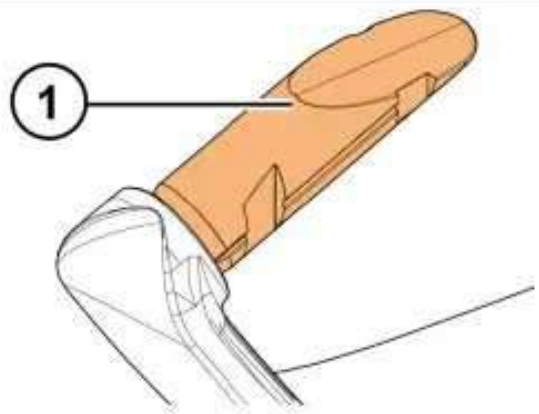
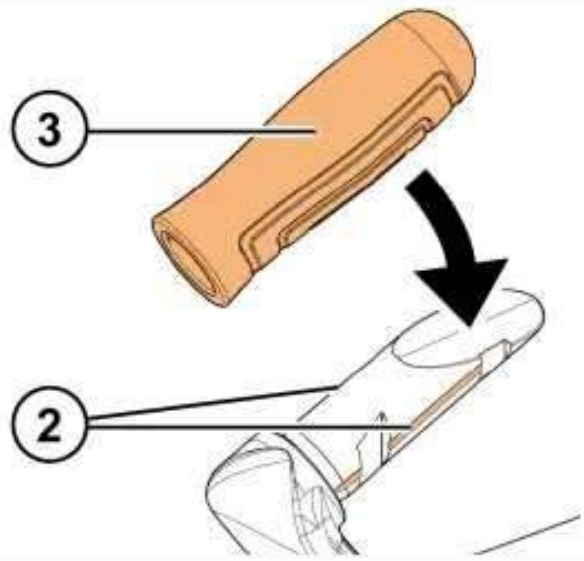


Figure 52. Safety button overview

1. *Rubber handle*
2. *Accelerator knob's fixing screw*
3. *Accelerator knob*
4. *Safety button fixing screw*
5. *Safety button*

1. Remove the right hand side rubber handle.	
2. Remove the right hand side accelerator knob's fixing screw. **3.** Remove the accelerator knob.	
4. Remove the safety button fixing screw. **5.** Remove the safety button.	

8.1.3.1 Installing the rubber handles

1. Clean the surface of the tiller arm handle carefully.	
2. Spread two lines of Loctite 435 glue onto the tiller arm handle. **3.** Install the new handle and place it correctly before the clue dries (10 seconds).	

8.1.4 Removing the accelerator

NOTE: Record the places of the wire connections before disassembly.

Keep the accelerator connector because the new accelerator is delivered without a connector.

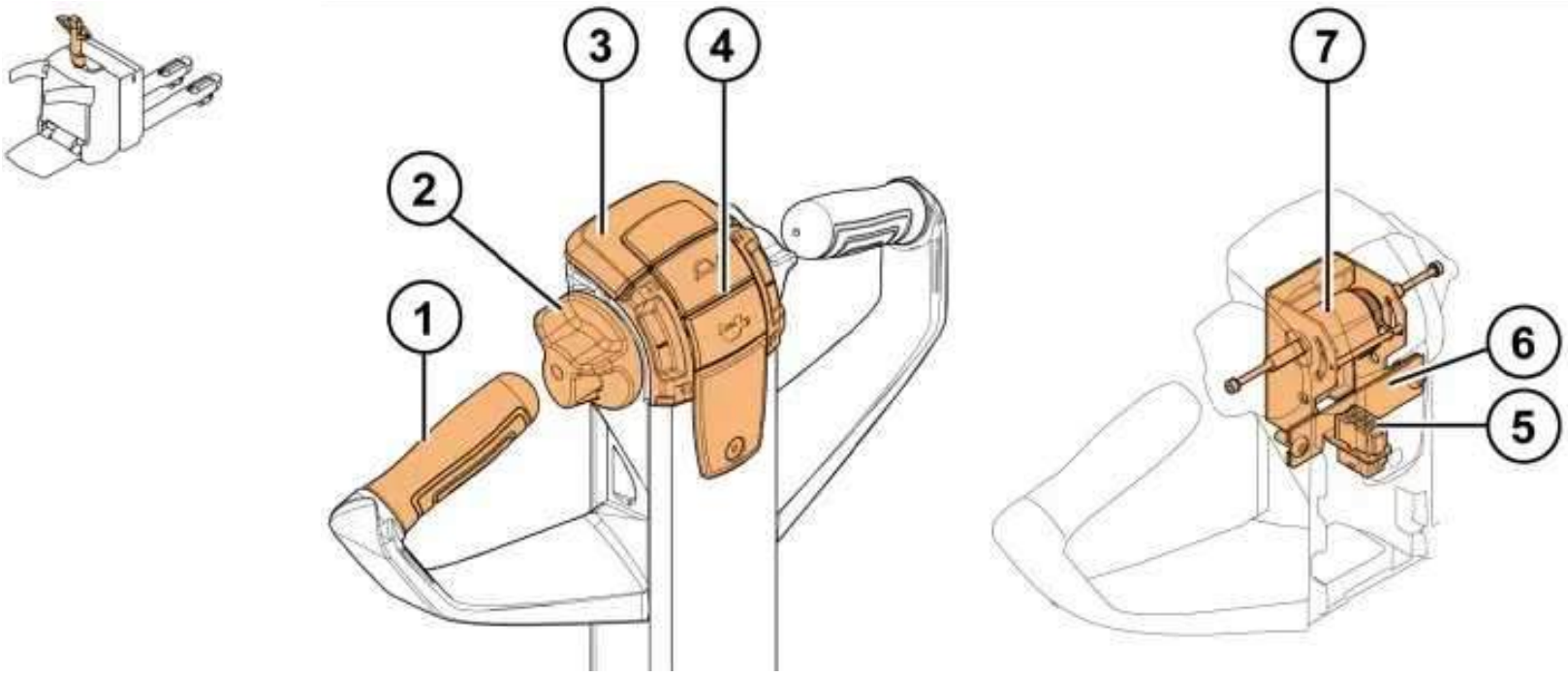
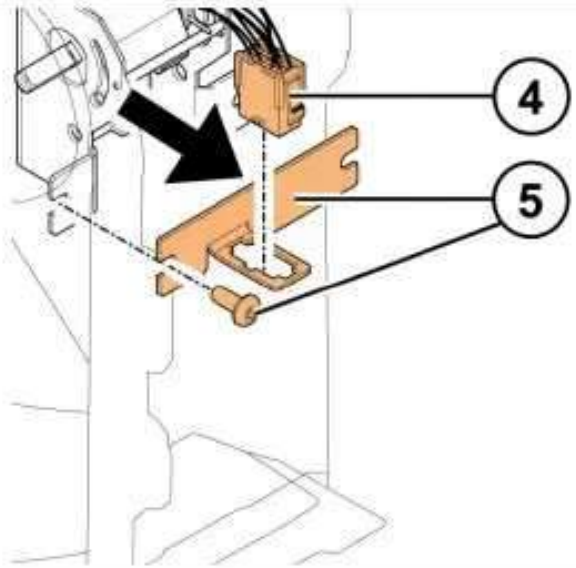
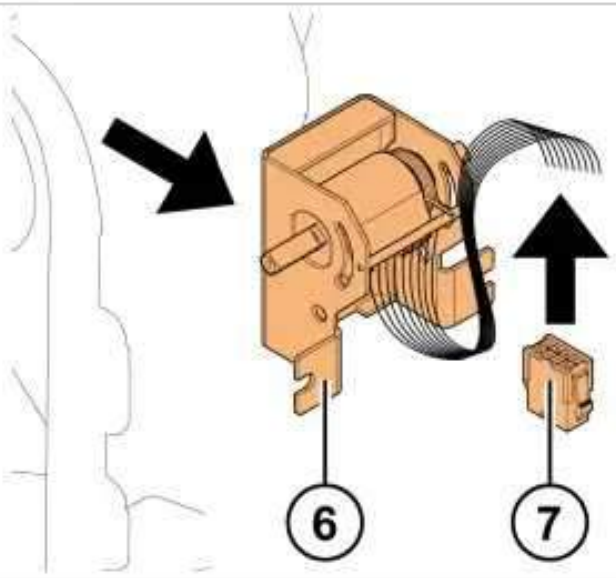


Figure 53. Accelerator overview

1. *Rubber handle*
2. *Accelerator knob*
3. *Safety button*
4. *Microswitch bracket*
5. *Accelerator connector*
6. *Mounting bracket*
7. *Accelerator*

1. Remove the tiller head. For instructions, see section 8.1.1 above.
2. Remove the safety button. For instructions, see section 8.1.3 above.

3. Pull out the microswitch bracket.	
4. Remove the accelerator connector from the mounting bracket. **5.** Open the fixing screws and remove the mounting bracket.	
6. Pull out the accelerator. **7.** Pull out the accelerator wires from the accelerator connector.	

8.1.5 Installing the accelerator

1. Connect the accelerator wires to the accelerator connector. The pin locations from 1 to 3 are marked on the connector with lines and help you in determining the rest of the pin locations. Details of the accelerator wires and their pin locations are available in Figure 54 and Table 3 below.
2. Install the accelerator.
3. Install the mounting bracket and tighten the screws.
4. Fit the accelerator connector to the mounting bracket.
5. Install the microswitch bracket.
6. Install the safety button. For instructions, see the section 8.1.3 above, just perform the steps in reversed order.
7. Assemble the tiller arm. For instructions, see the section 5.15 above, just perform the steps in reverse order.
8. Calibrate the accelerator. For instructions, see the section 9.1.

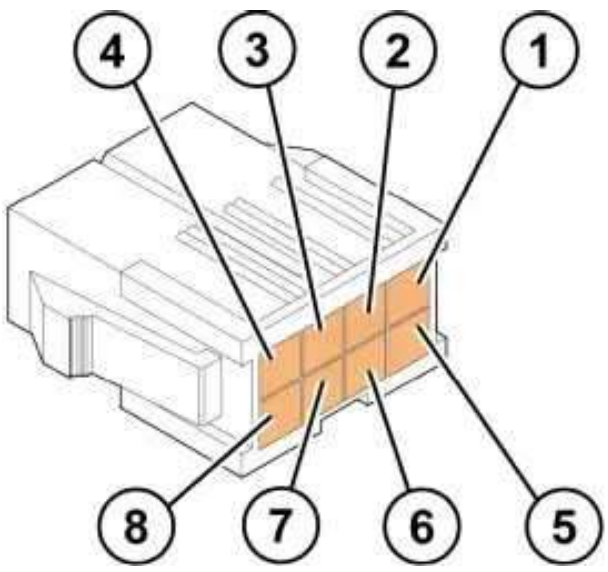


Figure 54. Accelerator pin locations

Table 3. Accelerator wire details

PIN	WIRE COLOR	DESCRIPTION
1	Red/Green	Sensor +24 V
2	-	-
3	White/Black	Backward signal
4	White	Forward signal
5	Orange	Sensor GND
6	Black	Sensor analogue output
7	White/Brown	Sensor 0 V

PIN	WIRE COLOR	DESCRIPTION
8	Grey	Safety button output

8.2 Electric panel

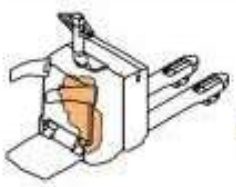
⚠ WARNING

Before inspecting the controller, disconnect the battery plug/connector.

Never drive the truck without the electrical panel cover in place.

⚠ CAUTION

Before inspecting and replacing fuses, turn the key switch to the OFF position and disconnect the battery plug/connector.



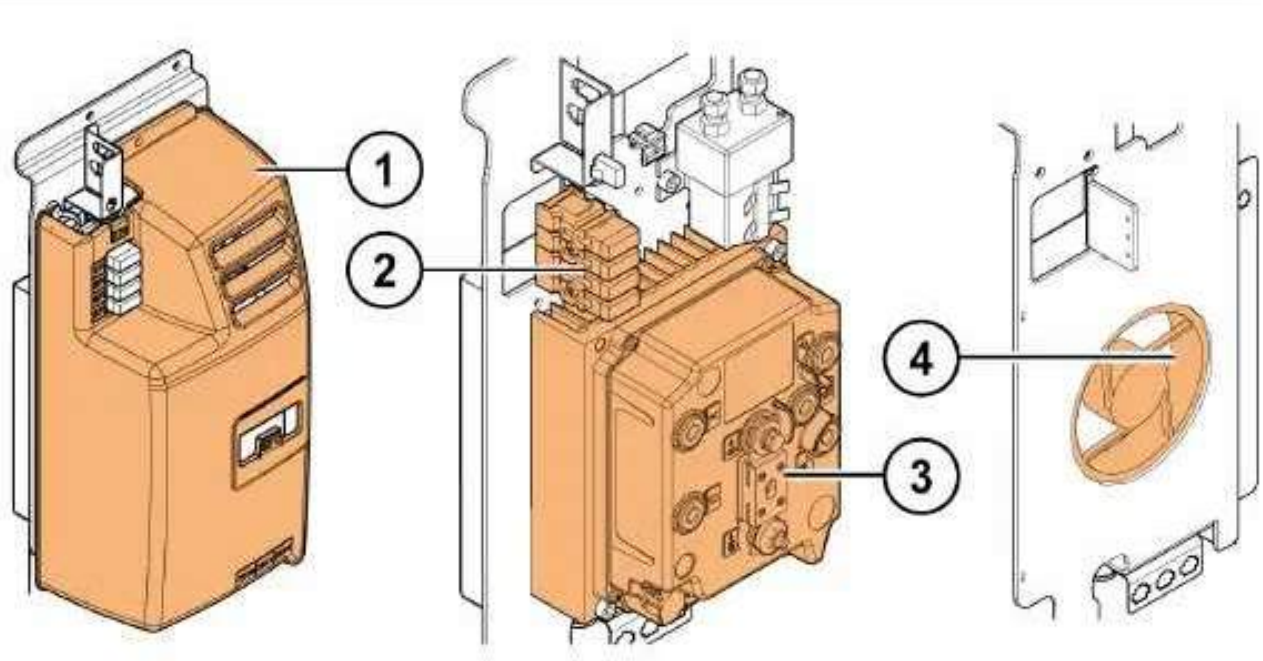
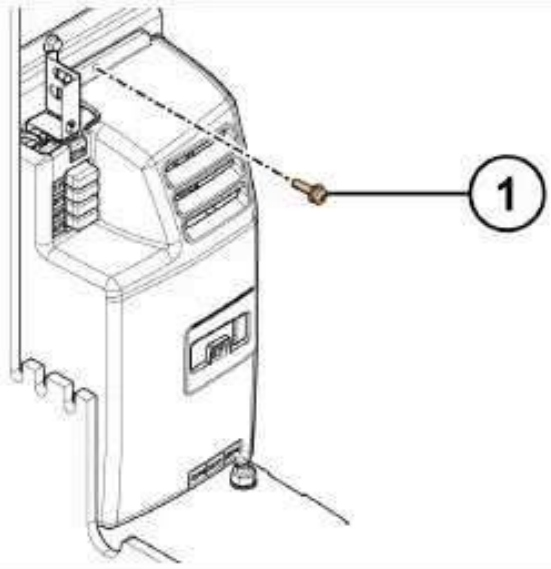
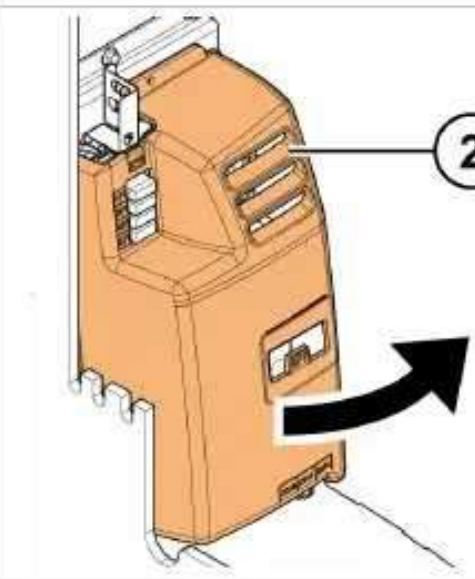
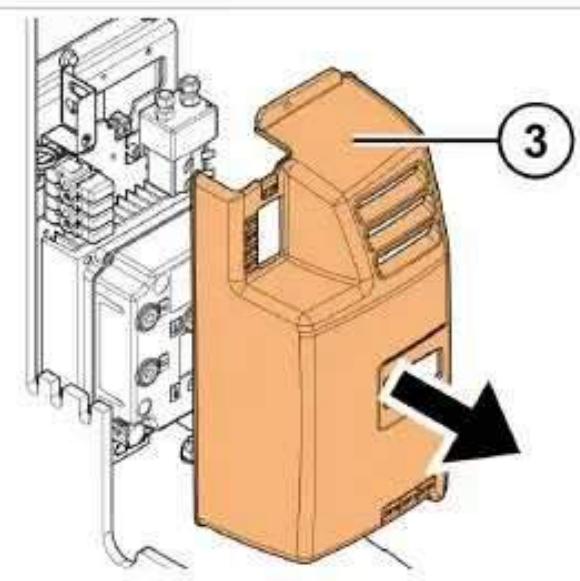


Figure 55. Electric panel overview

1. *Controller cover*
2. *Fuses*
3. *Zapi COMBIACX Power Controller*
4. *Controller fan (behind the electric panel)*

8.2.1 Removing the controller cover

1. Remove the screw holding the controller cover in place.	
2. Pull the bottom of the cover upwards to release the top of the cover.	
3. Remove the controller cover.	

8.2.2 Zapi COMBIACX Power Controller

The COMBIACX inverter has been developed to perform all the electric functions that are usually present in walkie and rider pallet trucks, stackers and low level order pickers.

The controller can perform the following functions:

- Controller for AC 600 W to 2 kW AC motors
- Pump controller for series wounded DC motors up to 5 kW
- Driver for the line contactor coil
- Driver for ON/OFF solenoid valves and for one proportional valve
- Low side and high side (short circuit protected) drives for electric brake coil
- CAN bus interface
- Interface for a CAN bus tiller
- 192 kB flash memory embedded
- Software downloadable via a serial link (internal connectors) or CAN bus (external connector)
- ESD protection on CAN bus inputs CANL and CANH
- Inverter for traction AC asynchronous 3-phase motors plus a chopper for DC series pump motors
- Regenerative braking functions

8.2.3 Zapi COMBIACX connectors

⚠ CAUTION

Before any inspection or repair work, turn the key switch to the OFF position, disconnect the battery plug/connector, discharge all inverters and record the places of the harness connections before disassembly.

When disconnecting the connector, hold the connector housing and plug and unlock the connector. Holding the case may cause damage to the inside card, while holding the cable may cause wire breakage.

If the high-power cable terminals of the battery-operated vehicle are not tightened properly, the increased contact resistance causes excessive heat generation, and can even cause a fire. To prevent accidents and equipment problems, check the tightening torque of the high-power cable terminals regularly. Do not pull the cables to check connections or during adjustment. If the cable terminal sections are moved, re-tighten the connections.

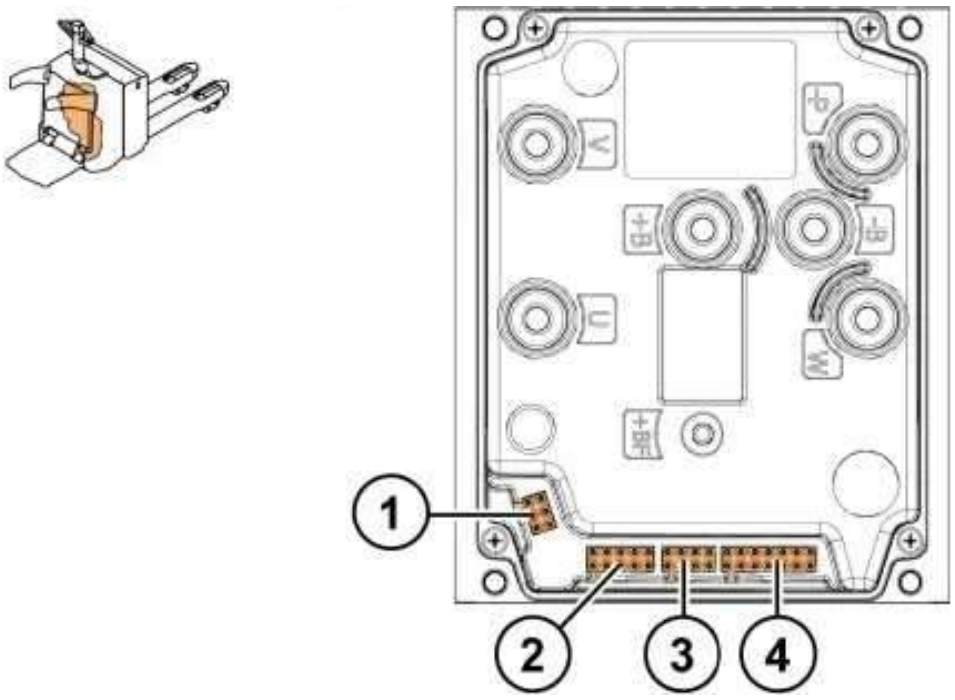


Figure 56. Zapi COMBIACX Power connectors

1. *CND external connector*
2. *CNC external connector*
3. *CNB external connector*
4. *CNA external connector*

The Zapi COMBIACX Power inverter uses four connectors:

- CNA 14 poles connector, spare part: RL450937
- CNB 8 poles connector, spare part: RL450935
- CNC 10 poles connector, spare part: RL450936
- CND 6 poles connector, spare part: RL450661

Contact 0.2 – 0.8 mm2 for CNA, CNB, CNC and CND connectors, Spare part: RL450666

8.2.3.1 CNA external connector

CONNECTION	DESCRIPTION
A1 EV1 (XA1 A/1) (fan control)	Output of the protected ON/OFF electrovalve driver; 1.5 A maximum continuous current (driving to – Batt). Built-in freewheeling diode to B2. This output is activated when the 1ST function (input A12) is requested.
A4 DI5 (XA1 A/4) (platform up S10)	Input of the switch DI5. The input is activated when it is connected to +Batt. The default function is the controller HORN input. When the switch is closed, the horn output is activated.

CONNECTION	DESCRIPTION
A5 DI7 (XA1 A/5) (lift cutoff option S7)	Input of the switch DI7. The input is activated when it is connected to +Batt. The default function is the controller LIFT enable input.
A6 DI9 (XA1 A/6) (side guard out S13 & S17)	Input of the switch DI9. The input is activated when the external switch is opened. The default function is the controller PUMP CUTBACK input. When the switch is opened, the pump speed is reduced.
A7 DI11 (XA1 A/7) (brake release S3)	Input of the switch DI11. The input is activated when the external switch is opened to ground. The default function is the controller CUTBACK1 input. When the switch is opened, the truck speed is reduced. In the sense coil version, this input is connected to the AC motor sense coil.
A10 GND (XA1 A/10) (brake release/lift cutoff option)	This is the ground of the logic board.
A11 DI6 (XA1 A/11) (lower switch S5)	Input of the switch DI6. The input is activated when it is connected to +Batt. The default function is the controller LOWER enable input.
A12 DI8 (XA1 A/12) (economy mode S1)	Input of the switch DI8. The input is activated when it is connected to +Batt. The default function is the controller 1ST input: the pump motor turns at the defined speed.
A13 DI10 (XA1 A/13) (driver present / platform down S11)	Input of the switch DI10. The input is activated when it is connected to +Batt. The default function is the controller 2ND input: the pump motor turns at the defined speed.
A14 DI12 (XA1 A/14) (battery lock sensor option S14)	Input of the switch DI12. The input is activated when the external switch is opened to ground. The default function is the controller CUTBACK1 input. When the switch is opened, the truck speed is reduced. In the sense coil version, this input is connected to the AC motor sense coil.

8.2.3.2 CNB external connector

CONNECTION	DESCRIPTION
B1 PEB (XA1 B/1) (magnetic brake Y31)	This pin outputs the positive supply (equal to +Batt) of the electro-mechanical brake coil. Depending on the hardware configuration, this pin can be controlled by the microcontroller or tied to the B2 input or to the C6 input. See the connection drawing for more details.

CONNECTION	DESCRIPTION
B2 PEV (XA2 B/2) (positive supply of all solenoid valves)	Connect the positive supply of all the solenoid valves (EV1, EV2, EV3, LOWER EVP, HORN OUT) to this pin. Take the positive supply immediately after the main contactor.
B3 NEVP (XA1 B/3) (solenoid valve negative Y1)	Output of the solenoid valve driver (driving to –Batt). A built-in freewheeling diode to B2.
B4 DI3 (XA1 B/4) (backward B1)	Input of the switch DI3. The input is activated when it is connected to +Batt. The default function is the controller BACKWARD request input. When this input is closed, the truck moves in the forward direction.
B5 NEB (XA1 B/5) (magnetic brake Y31)	Electro-mechanic brake coil driver output; PWM controlled; 3 A maximum continuous current (driving to –Batt). A built-in freewheeling diode to B1.
B6 NLC (XA1 B/6) (K1)	Main contactor coil driver output; PWM controlled; 3 A maximum continuous current (driving to –Batt). A built-in freewheeling diode.
B8 DI4 (XA1 B/8) (forward B1)	Input of the switch DI4. The input is activated when it is connected to +Batt. The default function is the controller FORWARD request input. When this input is closed, the truck moves in the backward direction.

8.2.3.3 CNC external connector

CONNECTION	DESCRIPTION
C1 +KEY (XA1 C/1) (S1)	Input of the key switch signal.
C2 DI1 (XA1 C/2) (Safety button S2)	Input of the switch DI1. The input is activated when it is connected to +Batt. The default function is the controller BELLY input. When the switch is closed, the quick inversion function is activated.
C3 NPOT (XA1 C/3) (pressure sensor gnd B42)	Potentiometer’s negative reference (GND).
C4 CPOTTR (XA1 C/4) (accelerator B1)	Accelerator potentiometer wiper input.
C5 CANH (XA1 C/5) (CAN bus yellow)	High level CAN bus voltage I/O.

CONNECTION	DESCRIPTION
C6 DI0 (XA1 C/6) (tiller switch S12)	Input of the switch DI0. The input is activated when it is connected to +Batt. With the logic hardware properly configured, it can be used to supply the EB and MC positive voltage. The default function is the controller TILLER input.
C7 DI2 (XA1 C/7) (side guard in S15 and S16)	Input of the switch DI7. The input is activated when it is connected to +Batt. The default function is the controller H&S (Hard & Soft) request input. When this input is closed, the truck performances are modified.
C8 PPOT (pressure sensor supply B42)	Potentiometer's positive supply. The hardware has to be configured to the output +12 V or +5 V.
C9 CPOTL (pressure sensor output B42)	Lift/lower potentiometer wiper input.
C10 CANL (XA1 C/10) (CAB bus green)	Low level CAN bus voltage I/O.

8.2.3.4 CND external connector

CONNECTION	DESCRIPTION
D1 ENC A (XA1 D/1) (traction motor encoder phase A M1)	Traction motor encoder phase A.
D2 PENC (XA1 D/2) (traction motor encoder supply M1)	Encoder positive supply. The hardware has to be configured to the output +12 V or +5 V.
D3 PTHERM (XA1 D/3) (temperature sensor R31)	Traction motor's thermal sensor positive input 5VDC. The resistance of the sensor is 581 Ω at 20˚C.
D4 ENC B (XA1 D/4) (traction motor encoder phase B M1)	Traction motor encoder phase B.
D5 NENC XA1 D/4) (traction motor encoder gnd M1)	Negative of the encoder.
D6 NTHERM (XA1 D/6) (temperature sensor R31)	Negative (GND) for the motor thermal sensor.

8.2.3.5 Description of the power connections

CONNECTION	DESCRIPTION
- B	Negative of the battery.
+ B	Positive of the battery.
- P	Negative of the pump motor.
U; V; W	Connection bars of the three motor phases.

The correct tightening torque for the COMBIACX Power terminal bolts is 7 Nm (±1.4 Nm).

8.2.4 Contactors and relays

Type	Main / drive contactor
Coil type	24 Vdc continuous duty coil
Electrical wiring	Coil: quick connect terminals 6.3 x 0.8 mm Power contacts: M8 ring terminals
Contact rating	Resistive load: 125/150 A @ 60 Vdc max Overload: 205/225 A / UL 508 Inductive load: 100 A @ 96 Vdc max
Switching output	NO
Spare part	RL490525

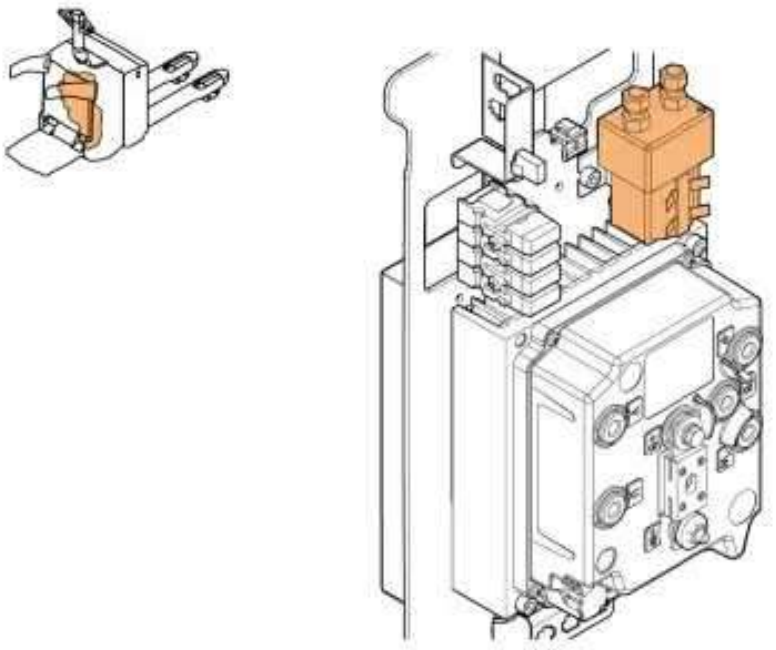


Figure 57. Contactor

A contactor is an electrically-controlled switch used for switching a power circuit, similar to a relay, except with higher current ratings. A contactor is controlled by a circuit, which has a much lower power level than the switched circuit.

Contactor functionality check:

1. Measure the ohms between the coil A1 – A2 terminals.

   The ohms value should be ~55 Ω.

   If the ohms value is ~0 Ω or ~∞ Ω, replace the contactor.

2. Measure the ohms between the main switching contacts 1-2.

   The ohms value should be ~∞ Ω.

   If the value does not match the above, replace the contactor.

3. Supply +24 Vdc between the A1 (+) and A2 (-) terminals.
4. Measure between the main contacts 1 – 2 that the contacts are closed.

   If the contacts are not closed, they are stuck together. In that case, replace the contactor.

8.2.5 Fuses

NOTE: If the truck is equipped with the electrical steering option, the fuse locations are described in section 15.11.3.2.

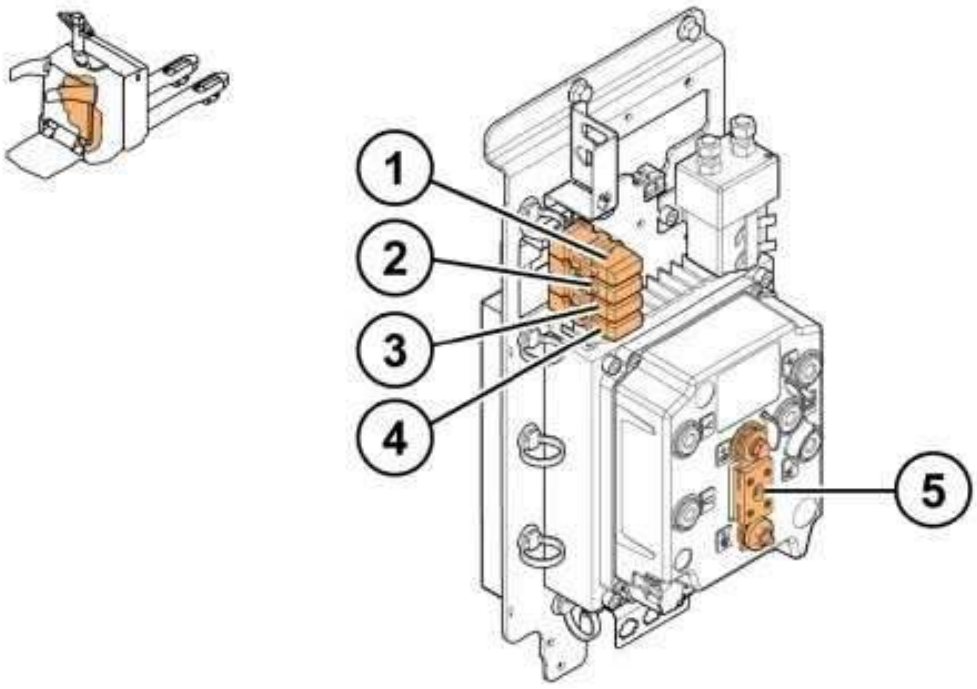


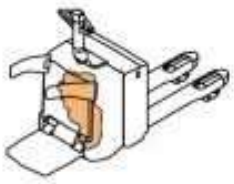
Figure 58. Fuses

1. *Line connector fuse*
2. *Control circuit fuse*
3. *Optional*
4. *Working lights fuse (optional)*
5. *Drive/pump motor fuse*

Table 4. Fuses

IDENTIFIER	RATING	DESCRIPTION
1F1	10 A	Line connector fuse
2F1	50 A	Electric steering fuse (optional)
3F1	10 A	Control circuit fuse
4F1	10 A	Optional
5F1	300 A	Drive/pump motor fuse
6F1	10 A	Working lights (optional)

8.2.6 Accessing the controller fan



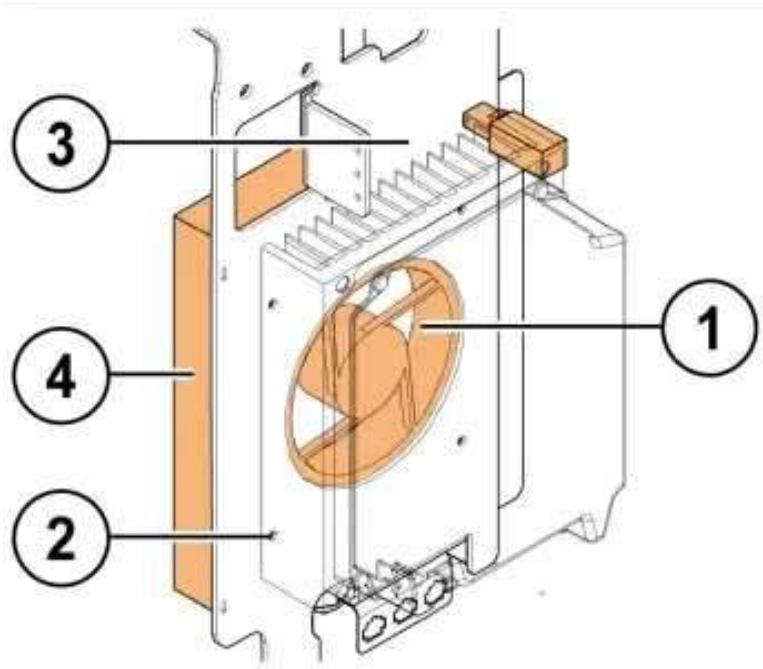
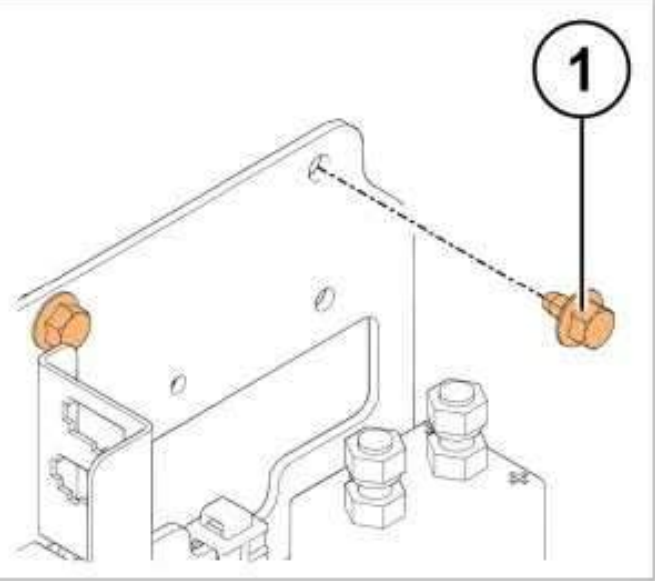
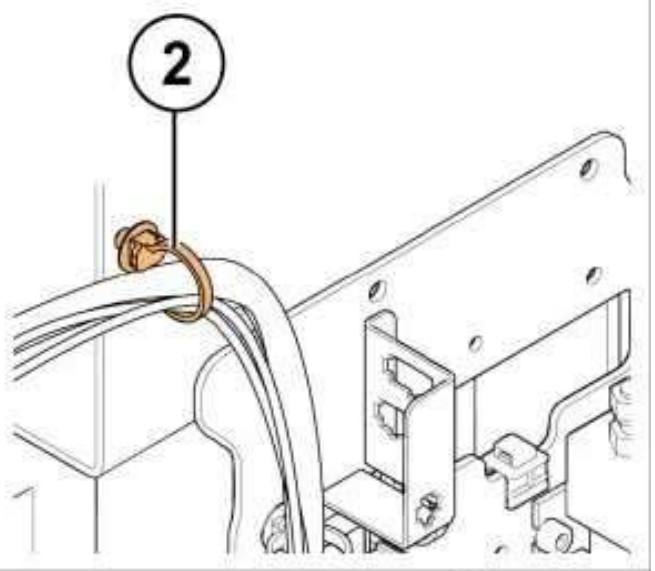
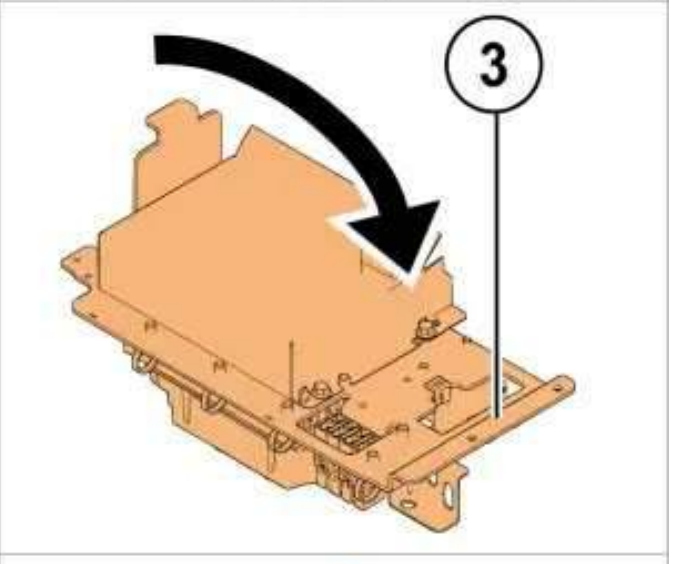
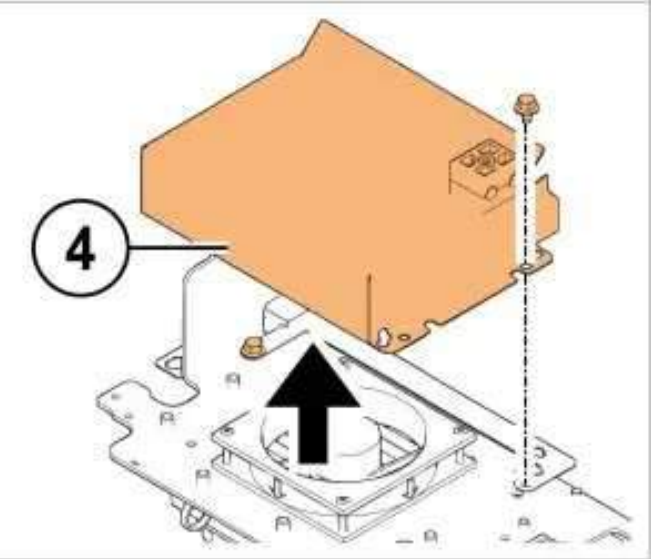


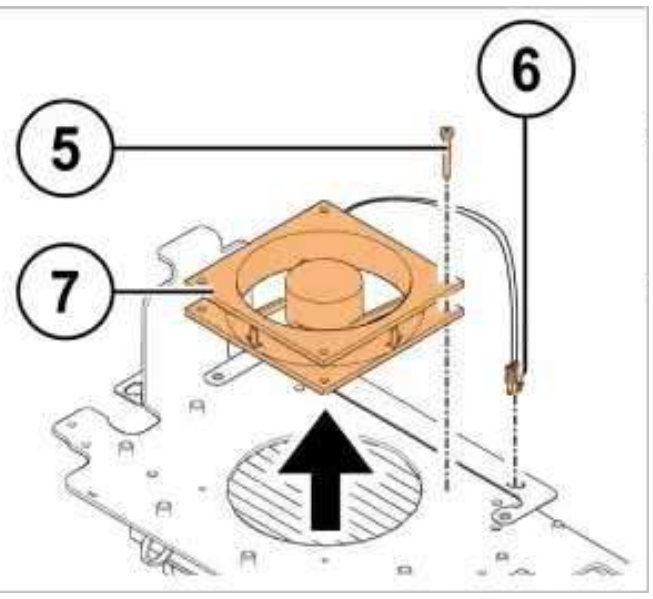
Figure 59. Controller fan overview

1. *Controller fan*
2. *Controller fan fixing screws*
3. *Controller fan connector*
4. *Fan plate*

The controller fan is located behind the electric panel. To clean or replace the fan, you have to move the electric panel out of the way:

1. Remove the two 10 mm bolts from the electric panel.	

2. Remove the cable tie attaching the wires of the electric panel to the truck frame. Record the places of the connectors and wires you remove.	
3. Turn the electric panel to the side to access the controller fan.	
4. Remove the fan plate.	

5. Remove the controller fan fixing screws. **6.** Disconnect the controller fan connector. **7.** Remove the controller fan.	

8.3 Motor compartment

⚠ CAUTION

Before opening the motor compartment covers, turn the key switch to the OFF position and disconnect the battery plug/connector.

Before any inspection or repair work, discharge the inverters. Record the places of cables and harness connections before disassembly.

Use the correct power cables and terminate marked cable ends to the correct terminals marked on the motor. Cables terminated at the wrong terminals may cause the motor to rotate in the opposite direction when activated.

If the high-power cable terminals of the battery-operated vehicle are not tightened properly, the increased contact resistance causes excessive heat generation, and may even cause a fire. To prevent accidents and equipment problems, check the tightening torque of the high-power cable terminals regularly. Do not pull the cables when checking connections or during adjustment. If the cable terminal sections are moved, re-tighten the connections.

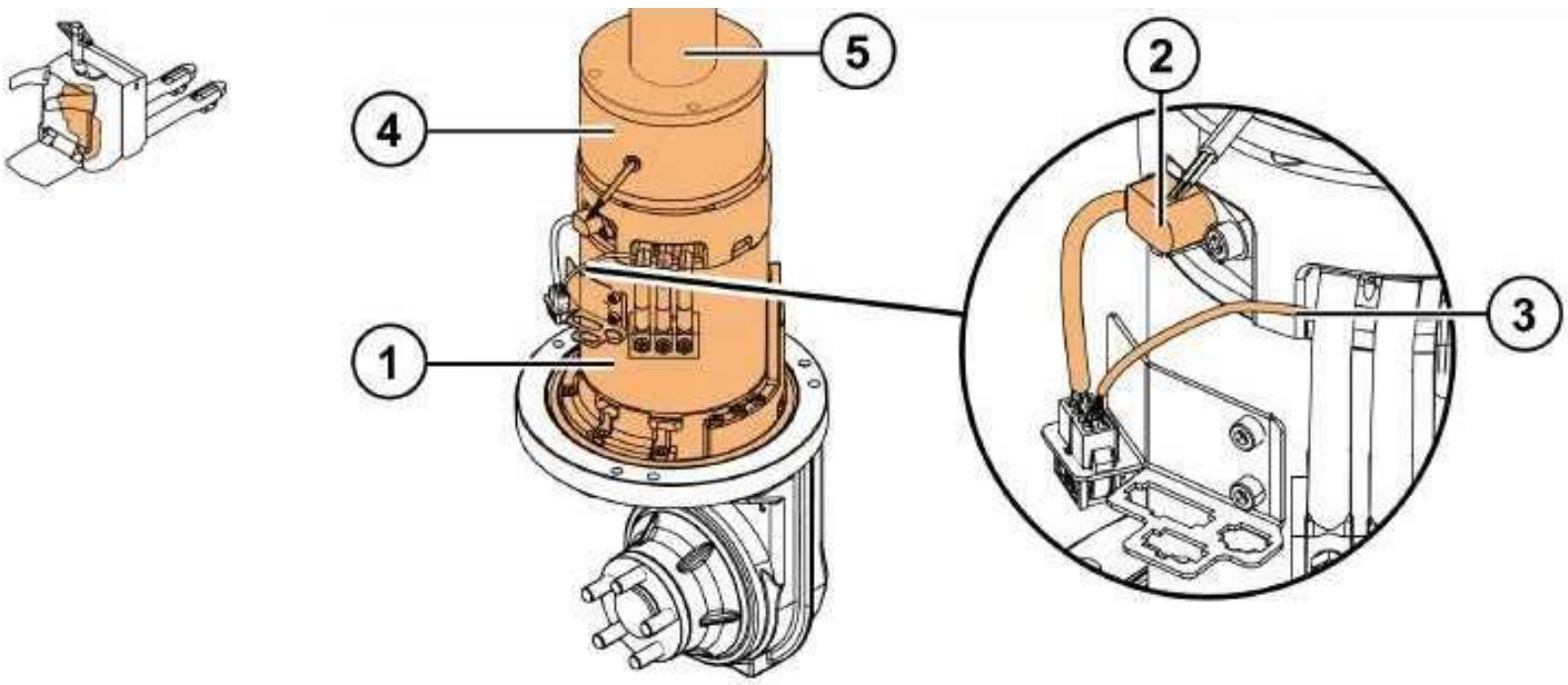


Figure 60. Motor compartment overview

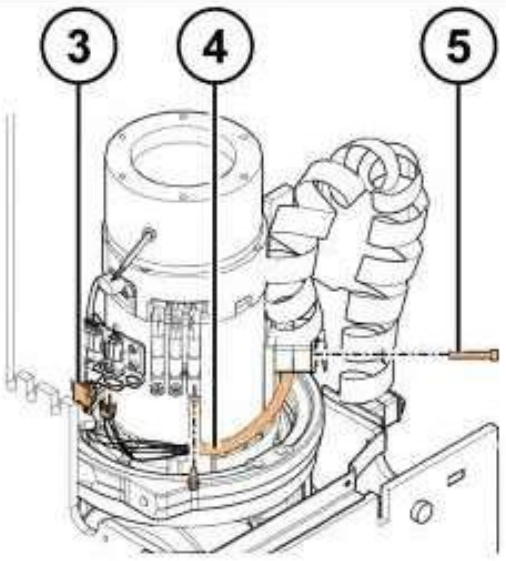
1. *Traction motor*
2. *Temperature sensor*
3. *HALL sensor*
4. *Magnetic brake*
5. *Tiller arm fastener*

8.3.1 Removing the drive unit

NOTE: If the truck has the electric steering option in use, see section 15.11.5 for instructions.

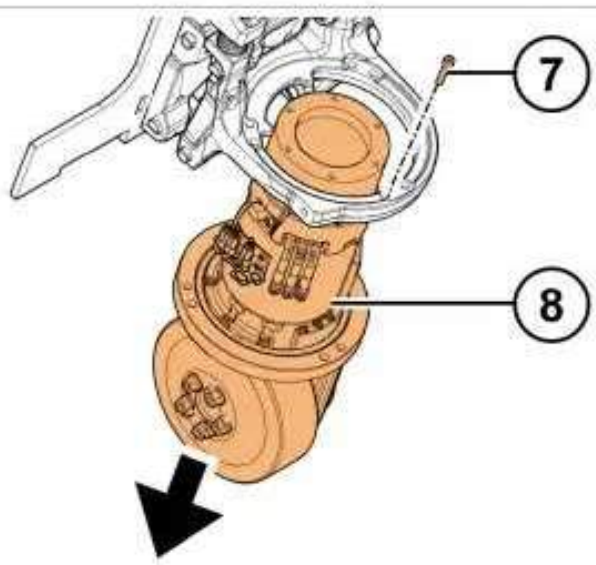
1. Remove all the covers. For instructions, see section 5.4.
2. Remove the tiller arm and the tiller arm fastener. For instructions, see section 5.15.

3. Disconnect the motor connectors.
4. Disconnect the motor's power cables.
5. Remove the two screws from the cable mounting bracket.



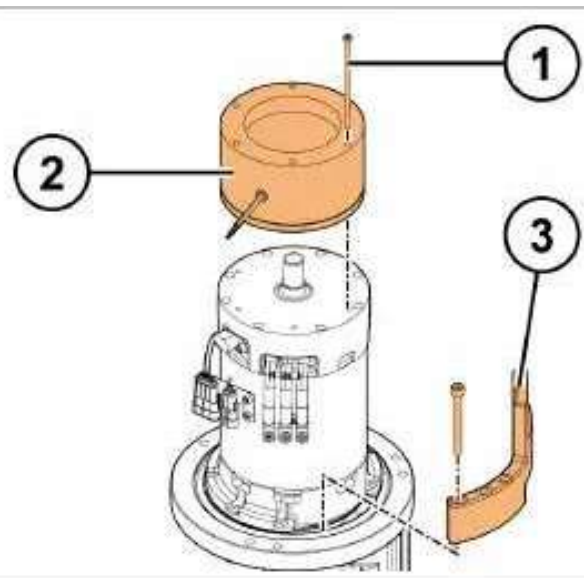
6. Lift the truck up and support it properly to prevent it from falling. See the correct lifting points in the section 5.1 of this manual.

7. While supporting the motor from the traction wheel, remove the six screws from the motor bed.
8. Drop the drive unit through the motor bed.

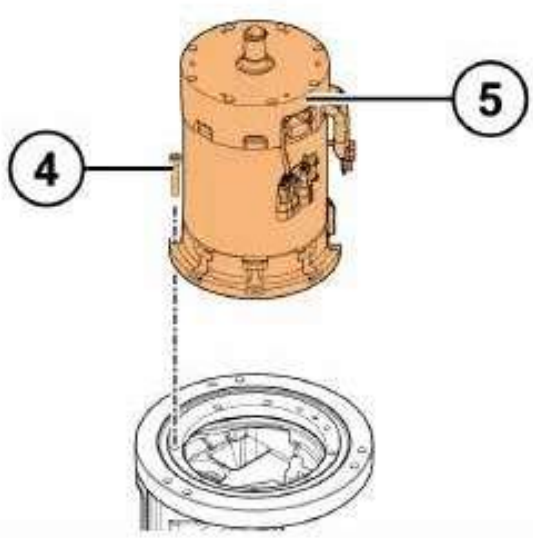


8.3.2 Disassembly of the drive unit

1. Remove the screws attaching the magnetic brake to the traction motor.
2. Remove the magnetic brake.
3. Remove the limiter from the traction motor.

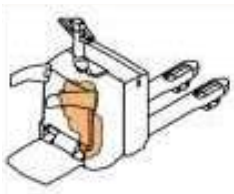


4. Remove the screws attaching the traction motor to the transmission.
5. Remove the traction motor.



8.3.3 Installation of the traction motor

The centring and locating face for connecting the electric motor must be perfectly clean and undamaged. Using a dial indicator or similar tool, check the face run-out of the motor's connecting face to the motor shaft. The run-out must not exceed 0.04 mm.



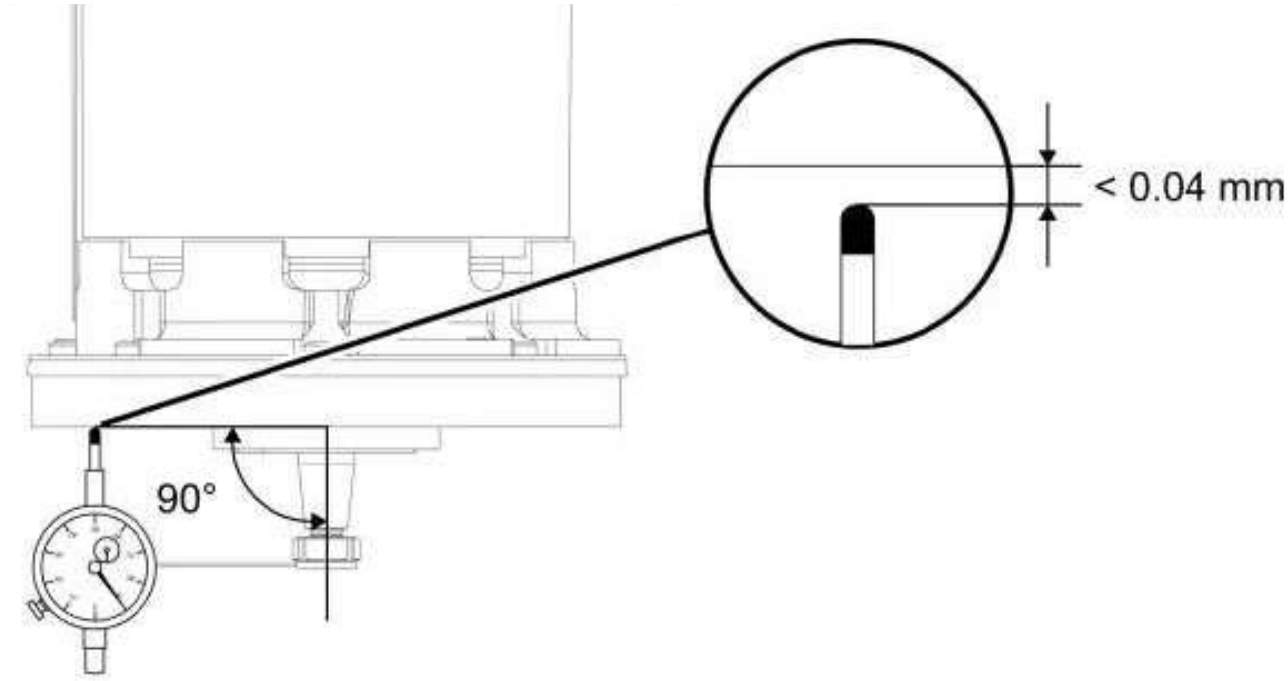


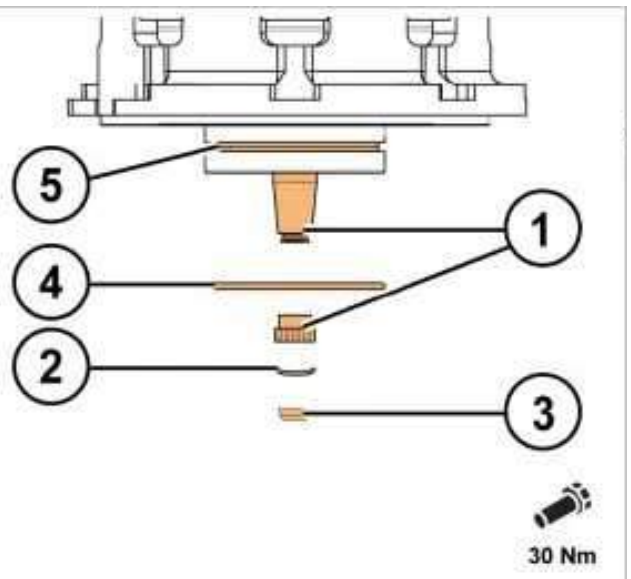
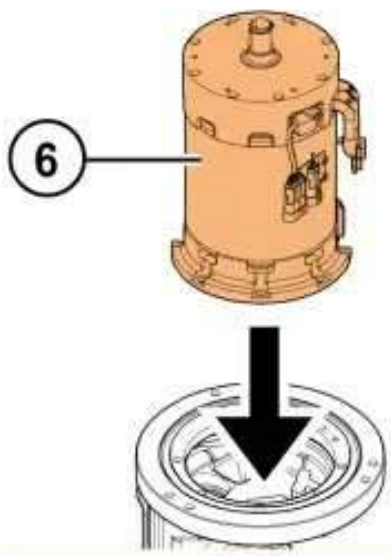
Figure 61. Checking the face run-out of the motor's connecting face

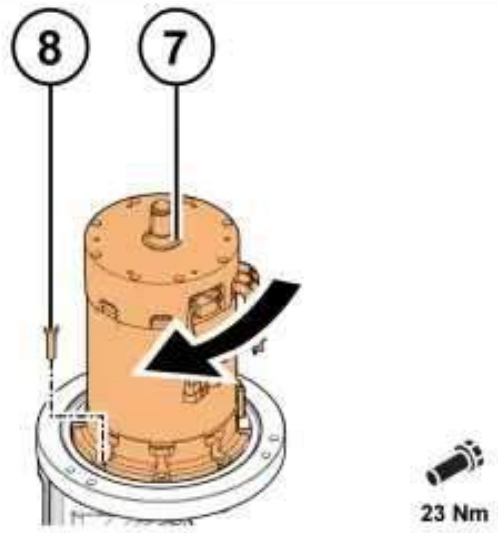
Excessive face run-out can have a negative effect on the noise behaviour and the load-carrying capacity of the helical gear stage or cause unnecessary wear.

8.3.4 Assembly of the splined shaft-hub connection

⚠ CAUTION

If the motor is connected incorrectly to the transmission, the tooth flanks at the drive pinion and the helical gear can be damaged, causing louder noise later on.

1. Clean the motor shaft and the drive pinion carefully. The taper connection must be free from any grease or oil. **2.** For versions with a curved washer, insert the washer into the slot of the motor shaft. Then slide on the drive pinion. **3.** Tighten the slotted nut with a torque spanner. The tightening torque of the slotted nut is 30 Nm. **4.** Wet the O-ring with a small amount of transmission oil or grease. **5.** Insert the O-ring into the slot of the motor centring seat.	
6. Place the motor carefully into the transmission top section.	

7. Turn the motor so that the bolt holes of the motor and the transmission top section are aligned correctly. **8.** Fasten the motor and the transmission top section with the eight cap screws and the locking pieces. The tightening torque of the screws is 23 Nm.	

After replacing the motor or controller, teach the motor resistance with the TruckTool wizard or using the following button combination:

1. During key-on, move the tiller arm to the driving position and press the brake release / low speed and safety buttons for 15 seconds.
2. After the contactor opens and recloses, restart the truck

8.3.5 Temperature sensor check

The temperature sensor is located inside the motor and cannot be changed.

The condition of the temperature sensor can be verified with a multimeter. Measure the ohms between the traction motor connector pins XM1/1 and XM1/2. The value should be ~580 Ω.

Figure 62 below provides a graphical presentation on how the resistance varies according to the temperature.

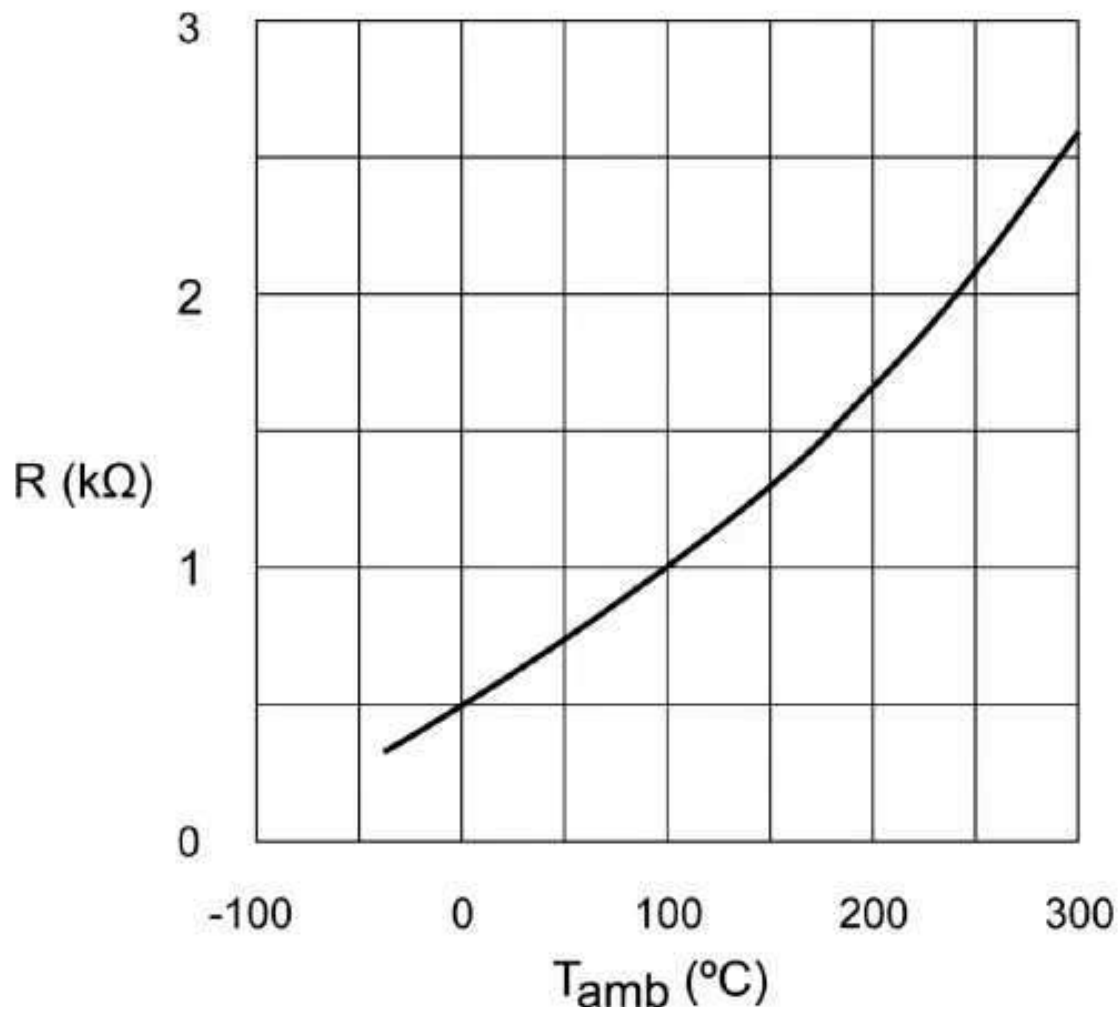


Figure 62. Resistance variation according to temperature

8.3.6 HALL sensor

Type	HALL sensor
Vs	5 - 24Vdc
Output signal	60 imp. / U
Electrical wiring	4-wire, Vs = RED wire, GND = BLK wire, Signal output A = WHT & Signal output B = BLU

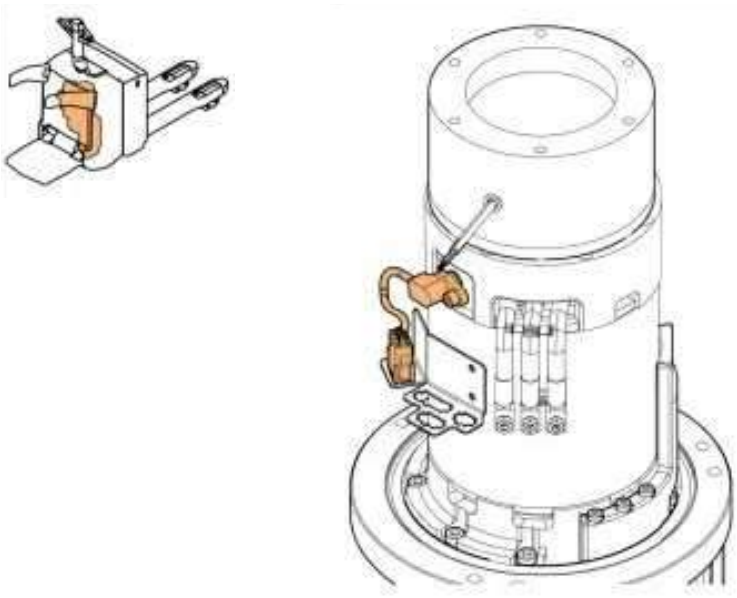
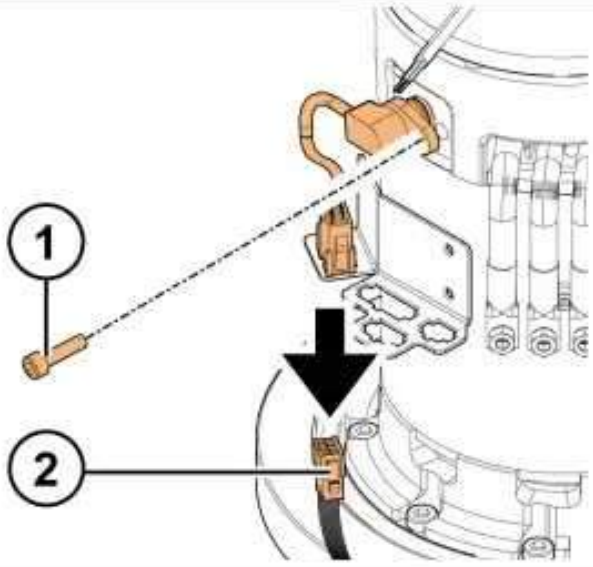
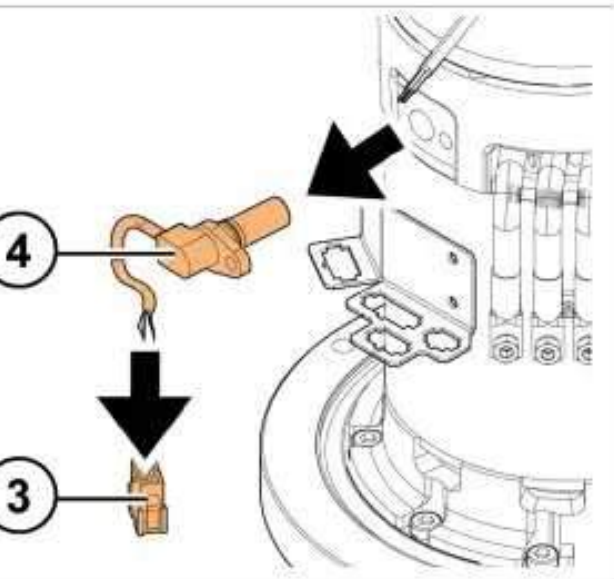


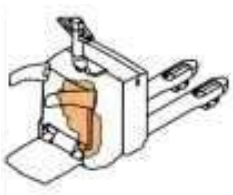
Figure 63. HALL sensor

8.3.6.1 Replacing the HALL sensor

1. Remove the socket screw. **2.** Disconnect the sensor connector.	
3. Disassemble the wires from the sensor connector. Note the pin location of each wire. **4.** Remove the HALL sensor.	
5. Install the new HALL sensor. **6.** Connect the wires to the sensor connector. **7.** Connect the sensor connector.	

8. Install and tighten the socket screw.

8.3.7 Magnetic brake



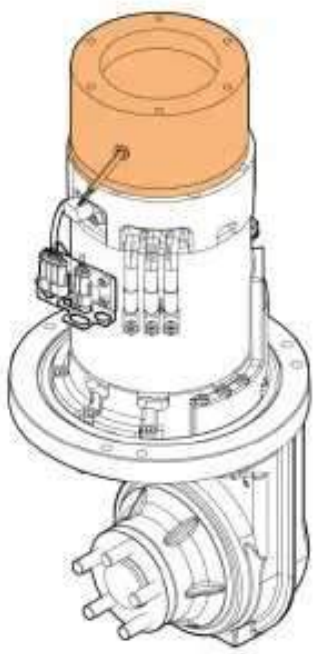


Figure 64. Magnetic brake overview

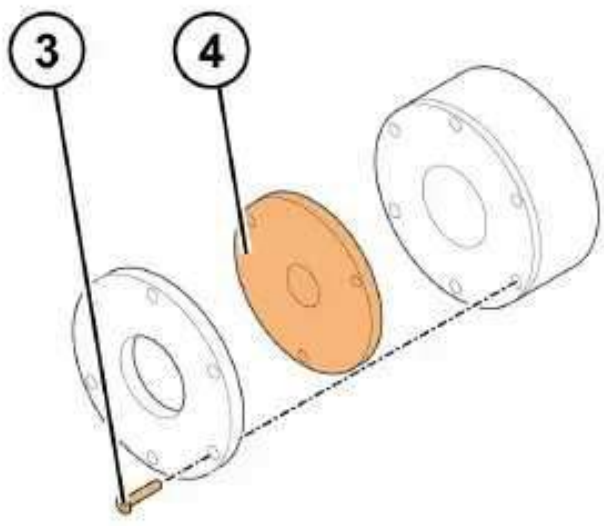
Applying a direct voltage to the exciter winding in the magnet body generates a magnetic force acting on the armature disk, which is then pulled via the air gap against the pressure of the spring to the magnet body. The decelerating rotor is released and the brake torque is neutralized.

The electro-magnetic brake is maintenance-free.

The minimum brake disk thickness is 7.5 mm.

1. Remove the drive unit. For more detailed instructions, see section 8.3.1.
2. Disassemble the drive unit. For more detailed instructions, see section 8.3.2.

3. Remove the screws of the magnetic brake.
4. Check the condition of the brake disk. If the thickness of the brake disk is 7.5 mm or less, replace the brake disk.



8.3.7.1 Coil resistance measurement

Use a multimeter to measure the brake coil resistance. The coil resistance has to be measured between the brake wires. The value should be ~21 Ω.

8.4 Pump motor

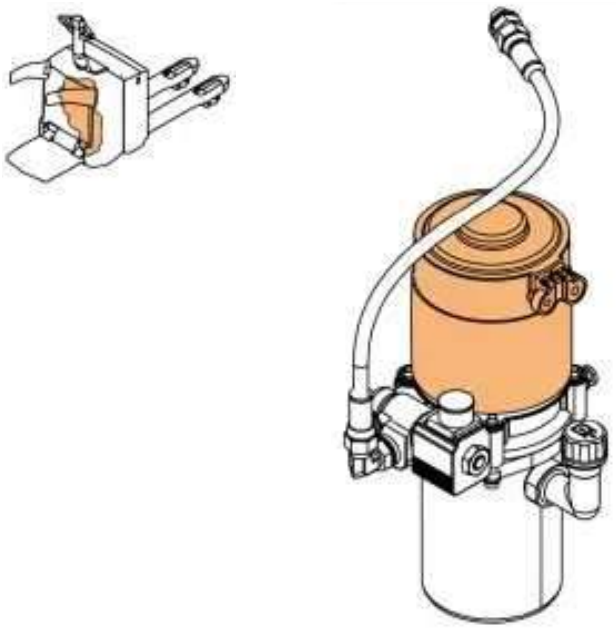


Figure 65. Pump motor overview

The pump motor is an integral part of the hydraulic aggregate. For instructions, see section 10.4.

Type	DC pump motor
Contact rating	24 Vdc / 1.2 kW
Electrical wiring	M6 & M8 bolt terminals

The pump motor is maintenance free. Do not attempt to repair the pump motor.

8.4.1 Solenoid valve

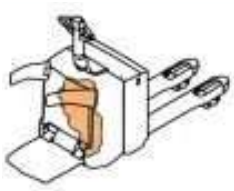


Figure 66. Solenoid valve overview

Solenoid valve is an electrically controlled hydraulic valve that has two main parts: a solenoid (coil) and a valve. The solenoid converts electrical energy into mechanical energy which, in turn, opens or closes the valve mechanically. This basic ON/OFF function is used to control the oil flow to the cylinders.

Type	Solenoid
Contact rating	24 Vdc / 22 W
Electrical wiring	Quick connect terminals 6.3 x 0.8 mm

The basic solenoid test is to measure the ohms between the solenoid terminals XY1/A1 and XY1/A2. The value should be ~27 Ω.

8.5 Sensors

NOTE: If the truck is equipped with the electrical steering option, information about the feedback sensor is available in section 15.11 and its subsections.

8.5.1 Tiller, side guard and operator's platform sensors

Type	Inductive proximity sensor
Size	Flat, 15 mm x 32 mm x 8 mm
V_s	12 - 24 Vdc
Switching output	PNP, NO
Electrical wiring	DC 3-wire, Vs = BRN, GND = BLU, signal output = BLK
Sensing range	2 - 4 mm
Spare part	RL611594

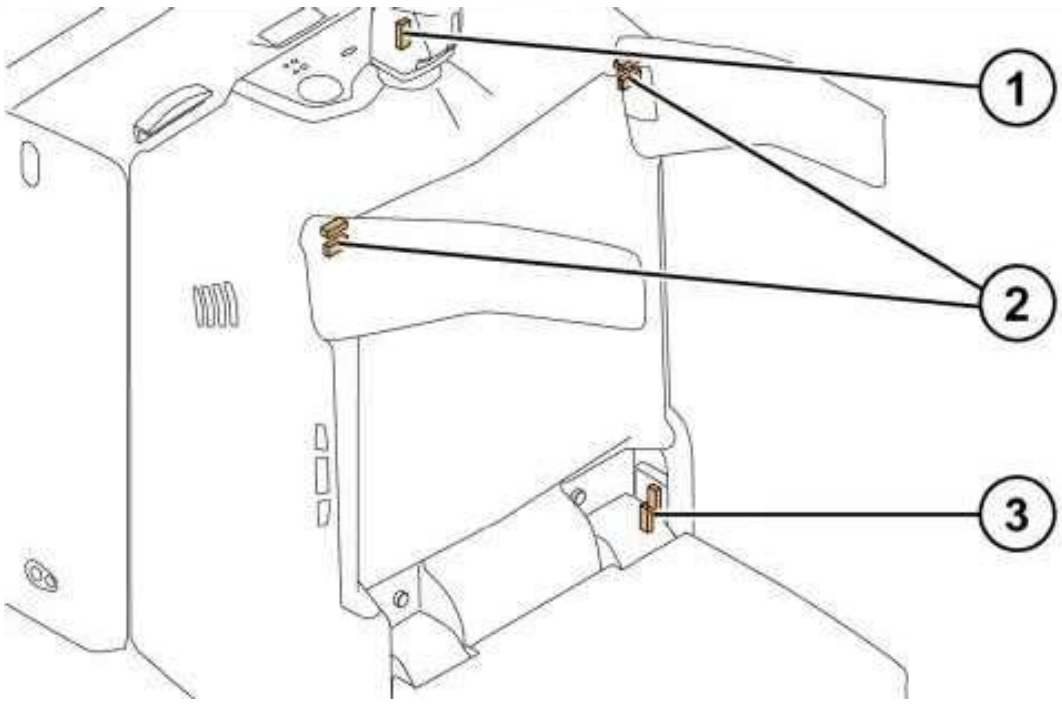


Figure 67. Tiller, side guard and operator's platform sensors

Table 5 below presents a more detailed view of the functionality of the different sensors.

Table 5. Sensor functionality

TILLER, OPERATOR'S PLATFORM AND SIDE GUARD POSITIONS	SENSOR FUNCTIONALITY	TRUCK FUNCTIONALITY
	S10: ON S11:OFF S12:OFF S13:OFF S15:ON S16:ON S17:OFF	Not operational.
	S10: ON S11: OFF S12: ON S13: OFF S15: ON S16: ON S17: OFF	Pedestrian mode with the side guards folded and the operator's platform lifted, maximum speed limited to 6 km/h.
	S10:ON S11:OFF S12:ON S13:ON S15:OFF S16:OFF S17:ON	When the operator's platform is lifted and the side guards are out, the truck does not operate.
	S10: OFF S11: ON S12: ON S13: OFF S15: ON S16: ON S17: OFF	Driving mode without the side guards, maximum speed limited to 6 km/h.

TILLER, OPERATOR'S PLATFORM AND SIDE GUARD POSITIONS	SENSOR FUNCTIONALITY	TRUCK FUNCTIONALITY
	S10:OFF S11:OFF S12:ON S13:ON S15:OFF S16:OFF S17:ON	When the operator's platform is lowered and the side guards are out but there is no operator present, the truck does not operate.
	S10: OFF S11: ON S12: ON S13: ON S15: OFF S16: OFF S17: ON	Operator present, driving mode, maximum speed limited to 9 km/h.

Sensor functionality check

1. Connect the supply voltage between the brown (+) and blue (-) wires.
2. Measure the supply voltage between the wires.

   The value should be +24 Vdc.
3. Measure between the blue (-) and black (output) wires on the voltage area.

   When a supply is connected and there are no metallic objects within the sensing range, the value is approximately 0 V.

   When a metallic object is moved within the sensing range, the value is the same as the supply voltage, i.e. +24 Vdc.

   If the values do not match the above, replace the sensor.

8.6 Switches and buttons

8.6.1 Emergency stop button

Type	Complete emergency stop
Contact rating	24 Vdc / 4 A
Electrical wiring	Quick connect terminals 2.8 x 0.8 mm
Switching output	1 x NC
Spare part	RL611948

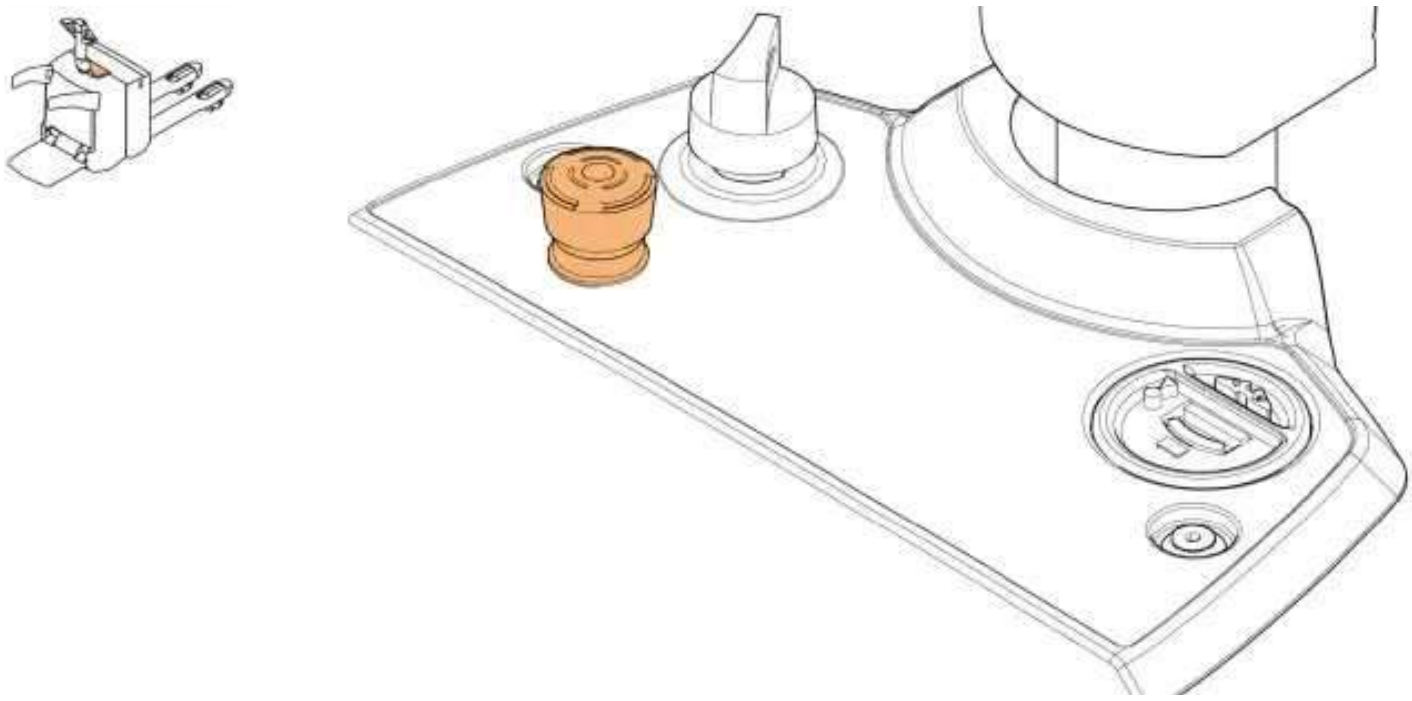


Figure 68. Emergency stop button

Emergency stop button functionality check:

Measure at the ohms area that the contacts inside the emergency stop button are not stuck together.

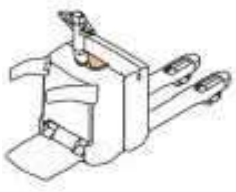
When the emergency stop button is released (the contacts are closed together), the ohms value is ~0 Ω.

When the emergency stop button is pressed down, the ohms value is ~∞Ω.

If the contacts are stuck together or broken, replace the emergency stop button.

8.6.2 Key switch

Type	Key switch
Contact rating	24 Vdc / 5 A
Electrical wiring	Plug-in connector 6 poles
Switching output	3 x NO
Spare part	RL608414



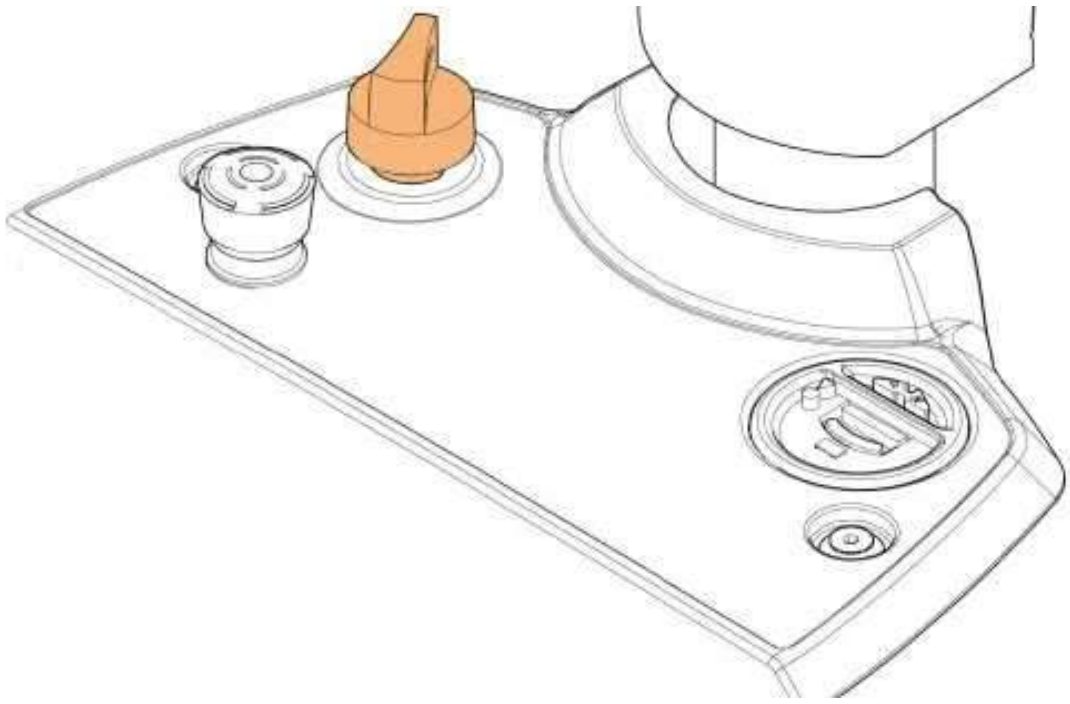


Figure 69. Key switch

Key switch functionality check:

Measure at the ohms area that the contacts inside the key switch are not stuck together.

When the key switch is in the 0 position, the ohms value is ~0 Ω between the pins 6-1 and 4-5.

When the key switch is turned clockwise once, the ohms value is ~0 Ω between the pins 6-1, 4-5, 6-4, 6-3, 1-4 and 1-3.

When the key switch is turned clockwise for the second time, the ohms value is ~0 Ω between the pins 6-1, 4-5, 6-5, 6-2, 1-5 and 1-2.

If the contacts are stuck together or broken, replace the key switch.

8.6.3 Tiller head micro switch

Type	Miniature basic switch
Contact rating	30 Vdc / 10 A
Electrical wiring	Quick connect terminals 6.3 x 0.8 mm
Switching output	1 x NC + 1 x NO
Spare part	RL109007

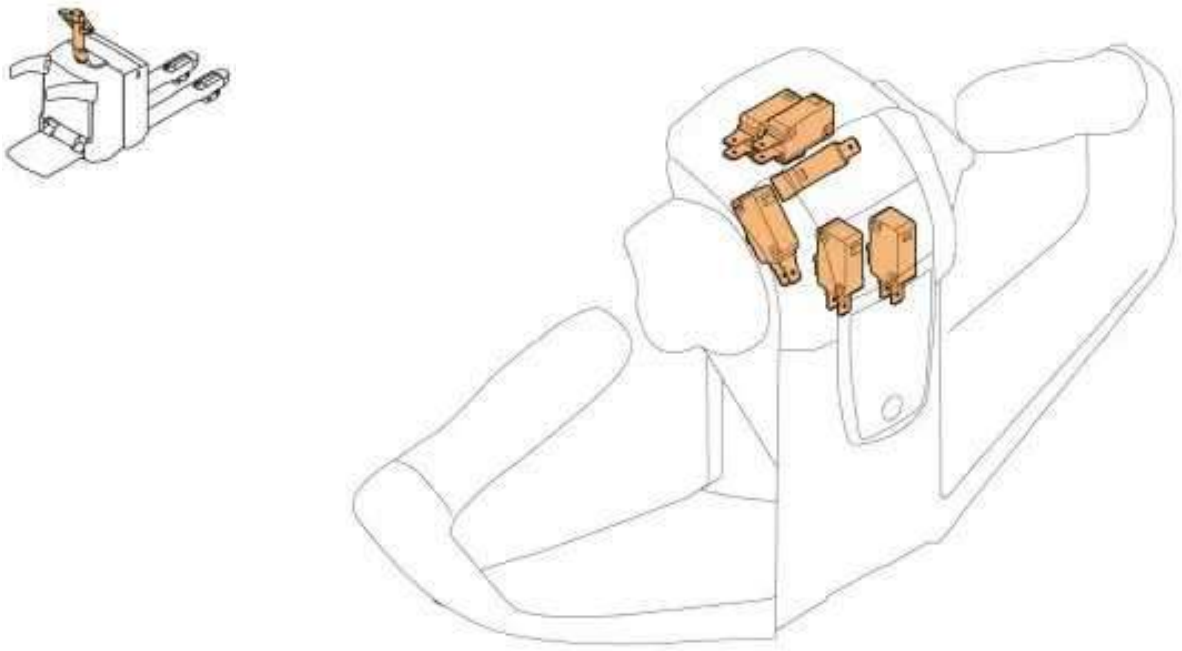


Figure 70. Tiller head micro switch

Micro switch functionality check:

Measure at the ohms area between the COM – NO terminals.

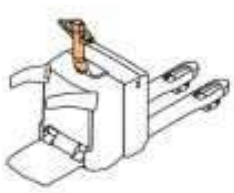
When the micro switch is in the neutral position, the ohms value is ~∞ Ω.

The value between the COM – NC terminal is ~0 Ω.

When the micro switch is actuated, the values are reversed.

If the contacts are stuck together or broken, replace the micro switch.

8.7 Horn



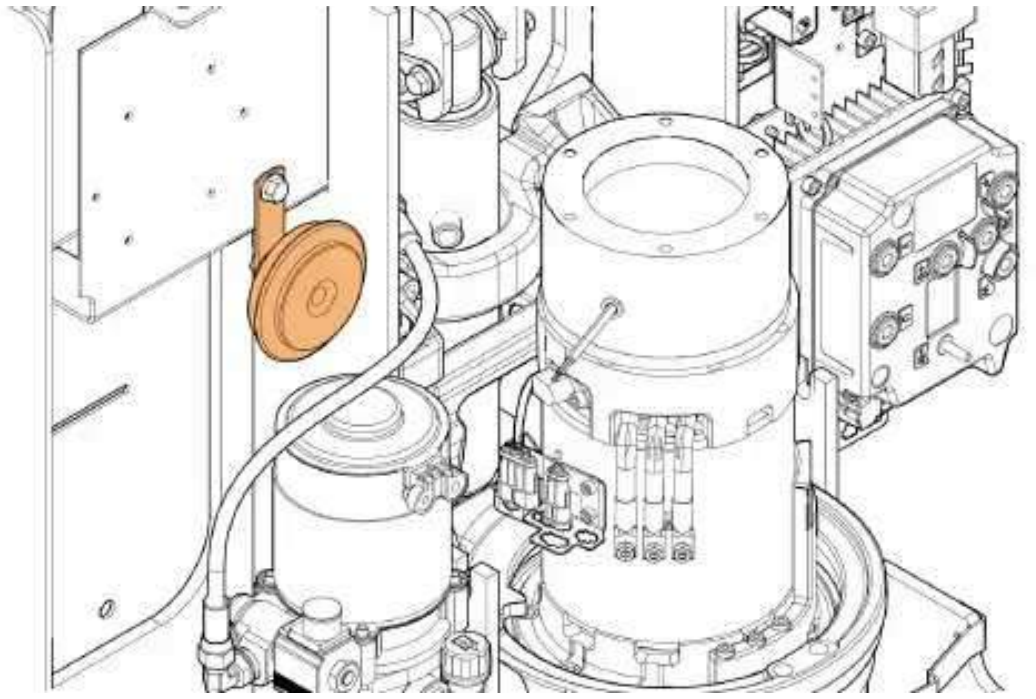


Figure 71. Horn

Type	AMA S.P.A horn
V_s	24 Vdc
Electrical wiring	Quick connect terminals 6.3 x 0.8 mm
Spare part	RL604758

If the horn does not work properly, disconnect it and then measure with a multimeter that the horn is not broken. Set the multimeter to the ohms range, and connect it between the H1/ A1 and H1/A2 terminals. The value should be ~4 Ω.

Normally the horn creates voltage peaks that may cause problems to other electrical devices. To prevent these voltage peaks, a diode (V8 in the circuit diagram) is installed parallel to the horn terminals.

8.7.1 Diode test with a multimeter

The basic diode test is very simple to perform; only two multimeter tests are needed to ensure that the diode works correctly:

1. Remove the horn.
2. Set the multimeter to the ohms or diode range.
3. Connect the diode's cathode terminal to the multimeter's positive terminal and the anode to the multimeter's negative or common terminal.
4. Set the multimeter to read ohms or diode.
   A low or 0 reading should be obtained.

5. Reverse the connections.

   This time a high or OL reading should be obtained.

If the results do not match the expected values, there is something wrong with the diode connection:

- If the results are opposites of the expected values, the diode has been assembled with incorrect polarity.
- If the ohms values are ~0 Ω in both directions, the diode is shorted and needs to be replaced.
- If the ohms values are ~∞ Ω in both directions, the diode is broken and needs to be replaced.

8.8 Wiring harnesses and cables

There are a few issues that need to be checked with the wire harnesses:

- To prevent disconnection of the switches, the protective spiral shield of the motor cables must not touch the key switch or the emergency stop button.
- To prevent connector and pin damages, wires and cables must not be installed too tightly.
- To prevent possible insulation damages, wires and cables must not lie on sharp edges.
- To prevent wire or cable insulation damages, wires and cables must not be installed so that a moving element could cause any damage.

The traction motor cables and wires are placed inside the protective spiral, see Figure 72. The wire harness should travel between the U- and V-cables. The correct order of the cables is important to prevent twisting of the cables.

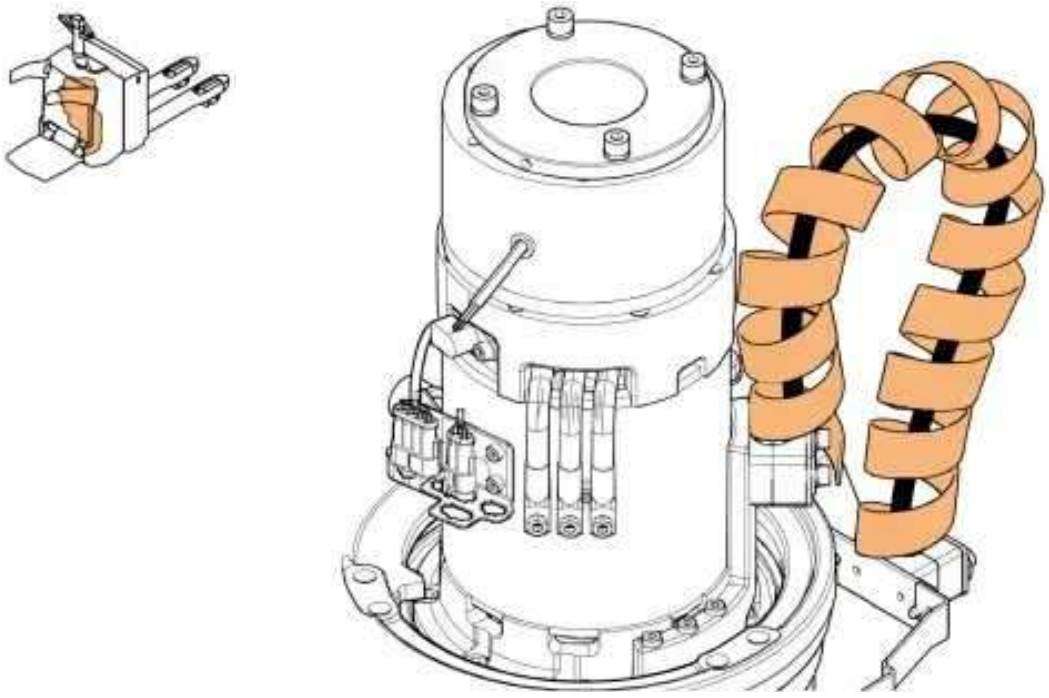


Figure 72. Traction motor cables and wires inside the protective spiral

At the traction motor end, the cable and wiring lengths must be correct to prevent insulation damage, see Figure 73. If you have to disassemble the factory-installed cable set, remember to reassemble the cables and wires with the correct lengths, in the correct order and making sure they are not twisted.

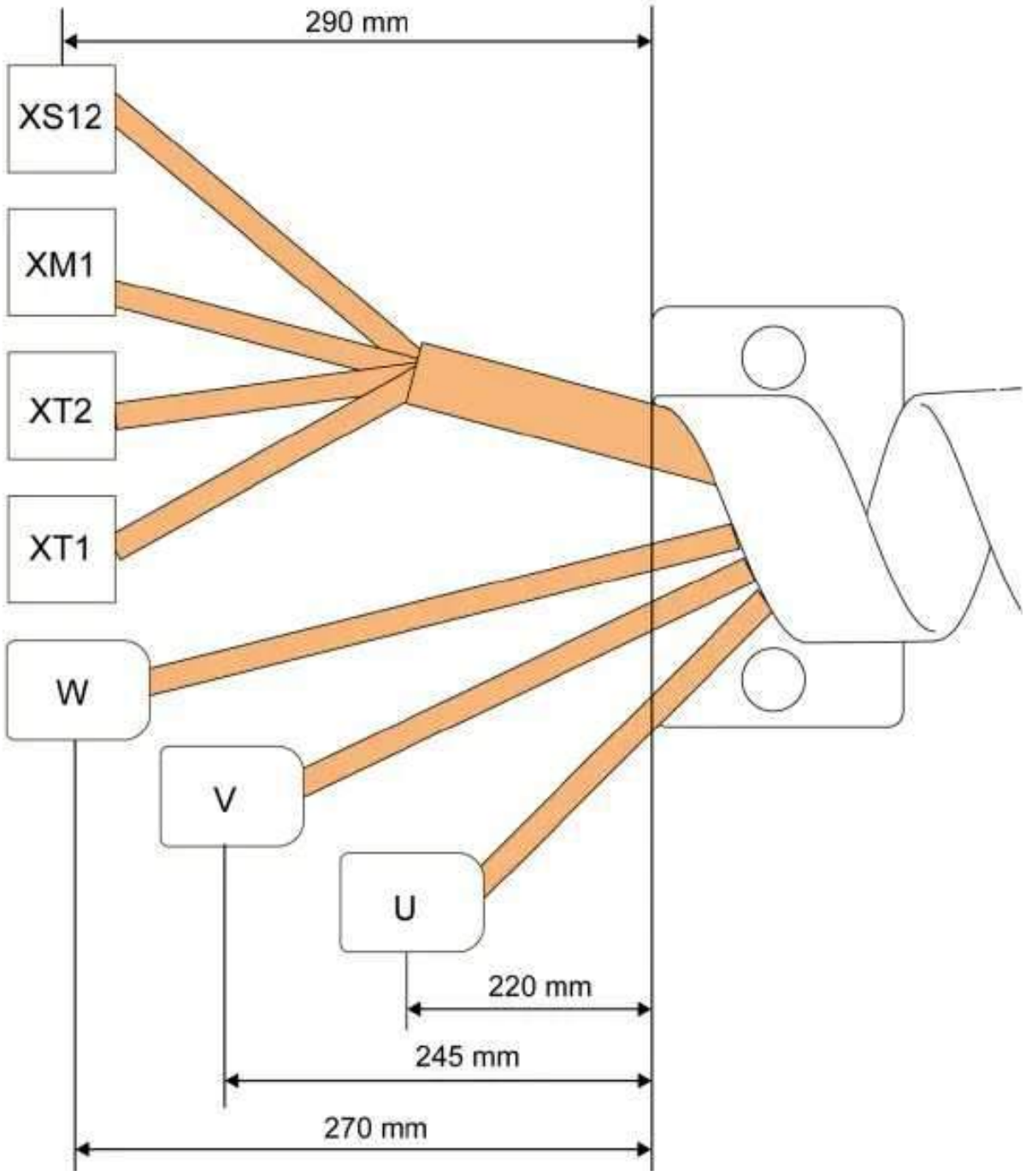
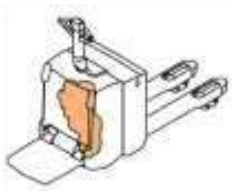


Figure 73. Correct cable and wiring lengths

8.8.1 Installing the traction motor cables



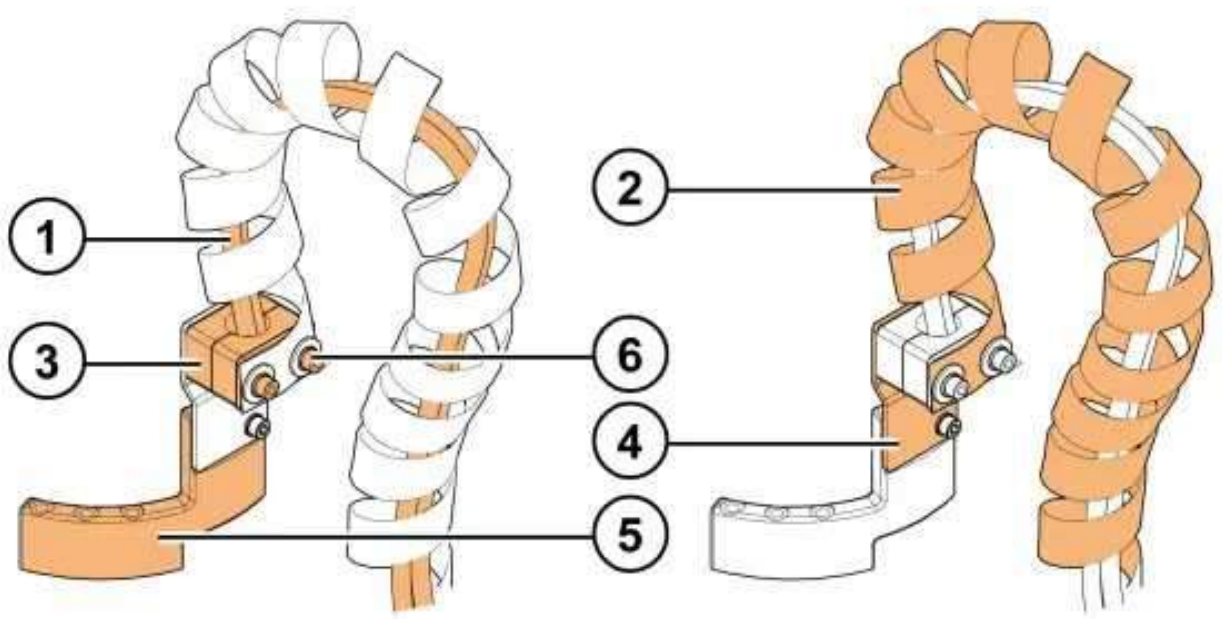
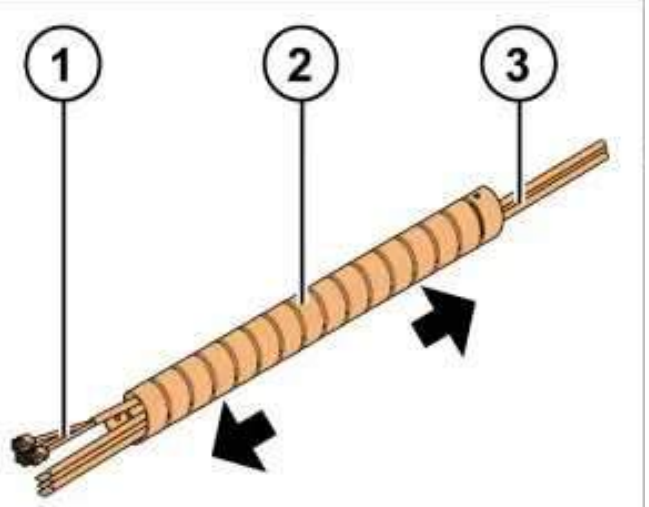


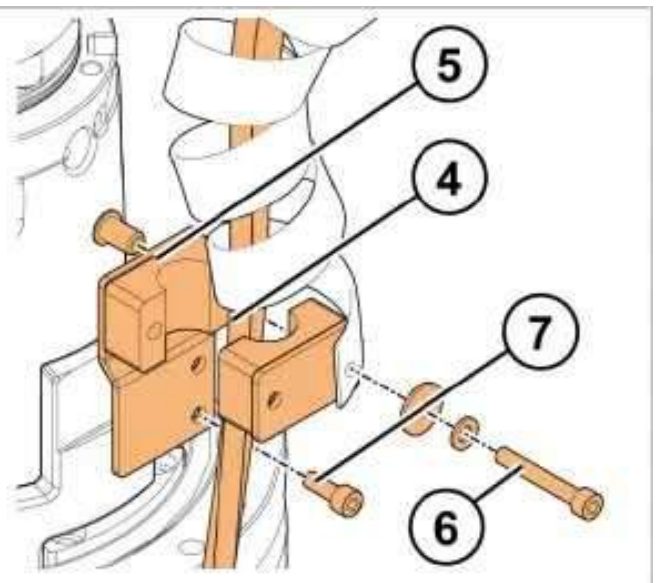
Figure 74. Installing the traction motor cables overview

1. *Wire harness*
2. *Protective spiral*
3. *Cable holder*
4. *Mounting plate*
5. *Support*
6. *Bolt*

1. Install the cables inside the yellow protective spiral.
2. Stretch the protective spiral to check that the cables are not twisted inside it.
3. Secure the wire harness inside the protective spiral so that the bend at the controller side is approximately the same as on the motor side.



4. Install the motor side wires inside the cable holder. Make sure that the cables are in the correct order as shown in Figure 75 below.
5. Install the cable holder and the mounting plate to the support, approximately 10 mm from the cable tie.
6. Insert Loctite 248 glue to the bolts of the cable holder.
7. Install the bolts attaching the cable holder to the support and tighten them so that the distance from the back of the support to the front of the mounting plate is 37 mm (see Figure 75 below).



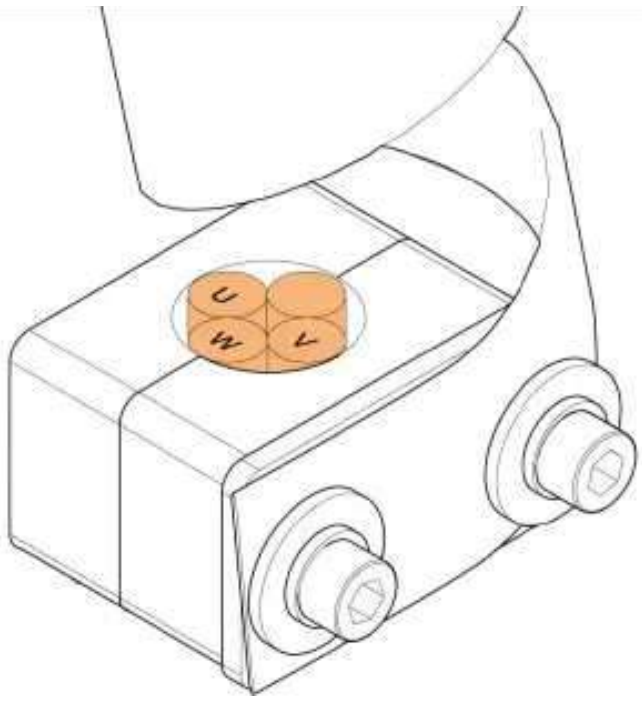


Figure 75. Correct order of wires inside the cable holder

9 Electric system adjustments and measurements

The basis for calibrations is that all of the parameters are correctly set according to the truck parameter list and settings. Before you start adjusting the calibration parameters, make sure that the rest of the parameters are in order.

9.1 Calibrating the accelerator

If the accelerator or the Zapi COMBIACX Power controller is changed, the accelerator must be calibrated. Also if the truck does not drive smoothly, it is recommended that you always first perform this calibration.

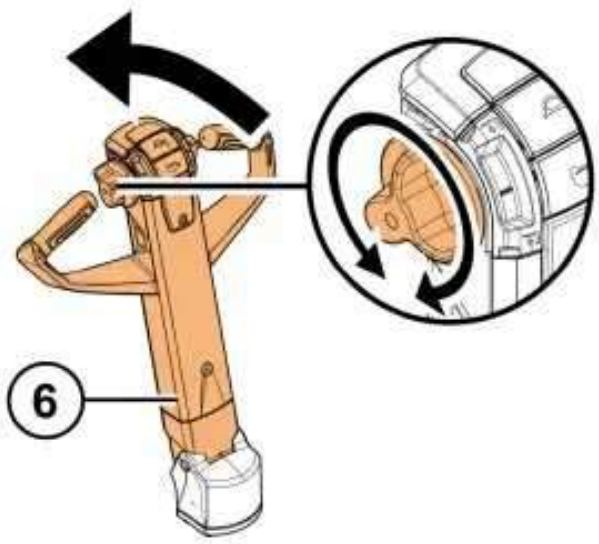
9.1.1 Acquiring the VACC with TruckTool

1. Connect TruckTool to the truck.
2. In TruckTool, go to the Wizards view.
3. Select the "Accelerator calibration" option and click the "Start wizard" button next to it.

4. Make sure that the truck's accelerator lever is in the middle position.

5. In TruckTool, click "Start" in the Wizard popup window.

6. Pull the truck's tiller to the driving position and turn the accelerator lever to one end position and then to the other end position.



7. In TruckTool, check that the displayed values are acceptable and click "Stop".

If the process fails, update the firmware on the controller and try again.

9.1.2 Acquiring the VACC without Truck Tool

1. During key-on, lower the forks and turn the accelerator forward at the same time and hold the buttons down for 15 seconds.

   The truck enters the accelerator teach-in mode.
2. Release all the buttons.
3. Teach the accelerator by turning it first fully forward, then fully backward.
4. Release the accelerator.
5. Press the safety button to save the settings.
6. Restart the truck.

9.2 Insulation resistance test

9.2.1 Test voltage

The insulation resistance of the truck and the traction battery is checked separately. The test voltage is greater than the nominal voltage but no more than 100 V or three times the nominal voltage:

NOMINAL VOLTAGE	TEST VOLTAGE
Up to 24 V	50 V
Over 36 V	100 V

9.2.2 Checking the insulation tester

Connect the test probe to the frame of the truck (for example, to a non-painted bolt or bracket) and the other test probe to another bolt or bracket. The tester should show a zero value.

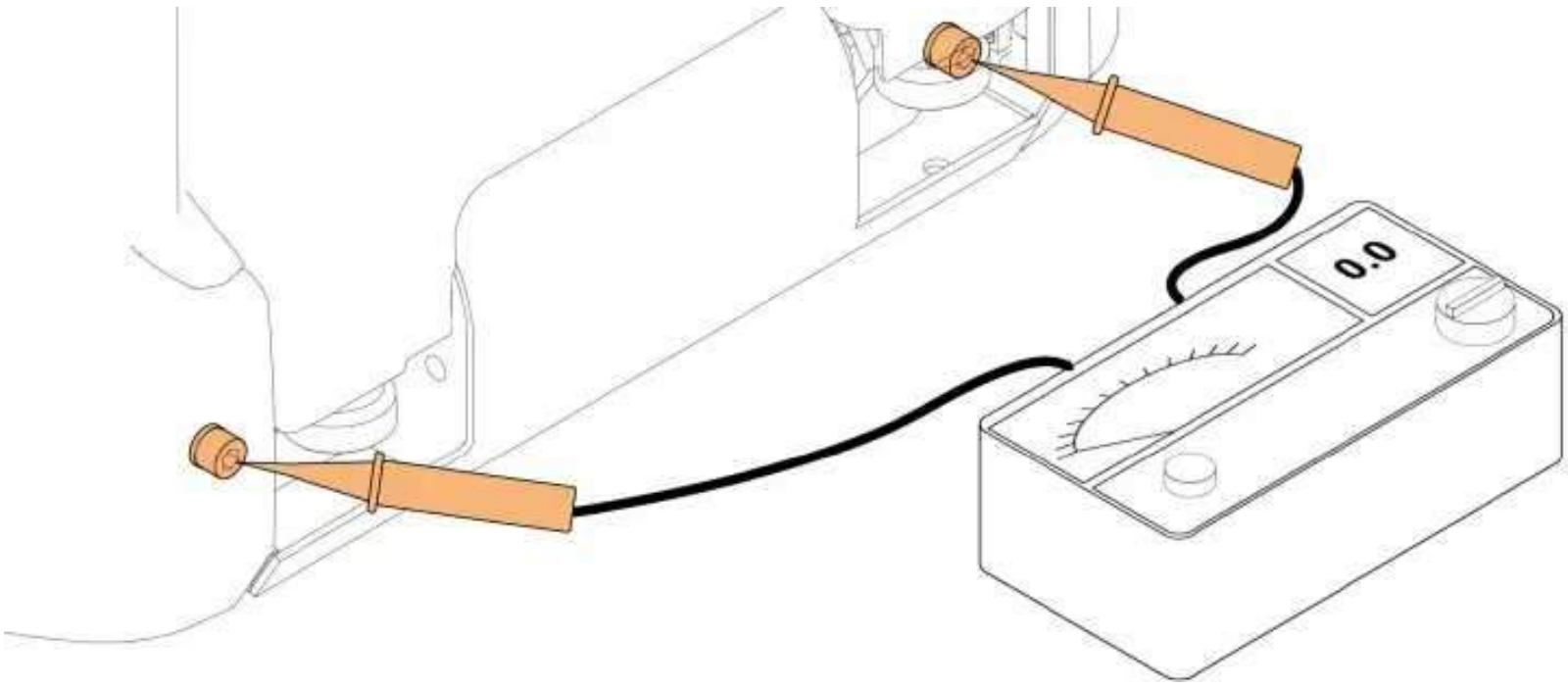


Figure 76. Checking the insulation tester

9.2.3 Measuring the insulation resistance

The test is performed with the battery disconnected from the truck. All the electrical components must be in place.

1. Release the emergency stop and turn the key switch to the ON position.
2. Connect the test probe to the frame of the truck (for example, to a non-painted bolt or bracket) and the other test probe to the plus terminal of the battery connector.
3. Read the resistance value.
4. Measure and read the minus terminal of the battery connector in the same way.

9.2.3.1 Insulation resistance of the truck

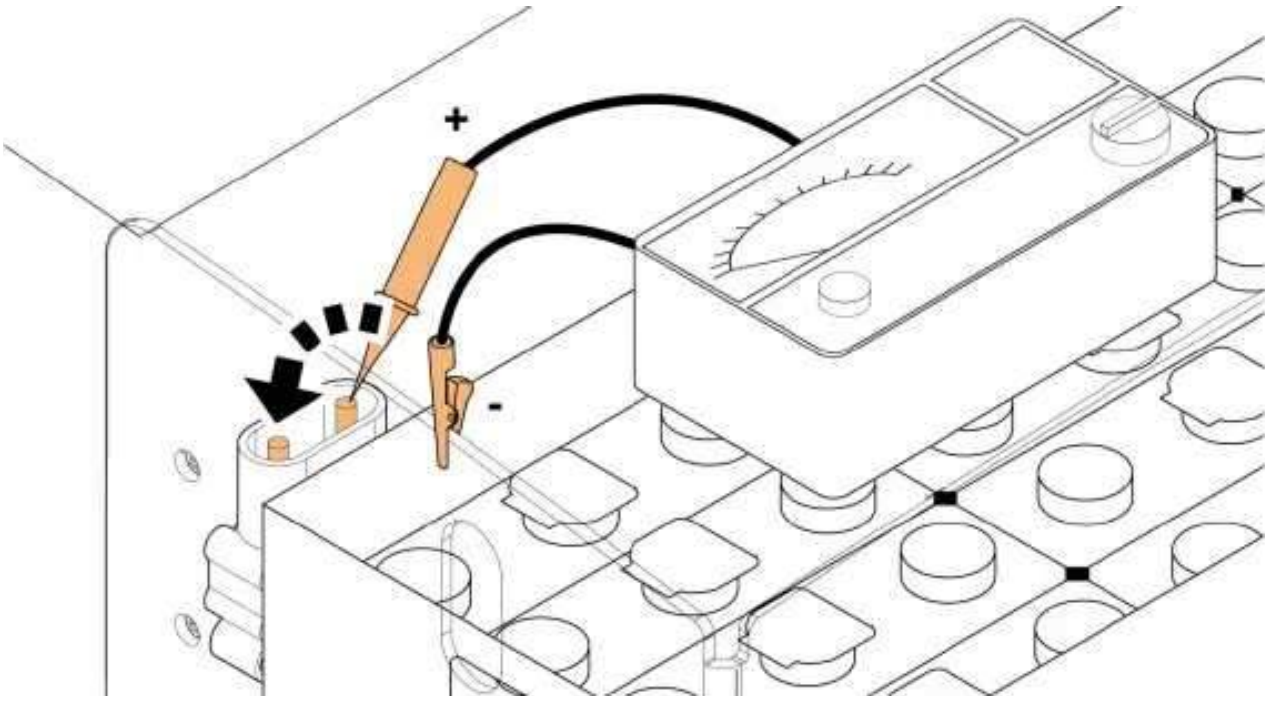


Figure 77. Measuring the insulation resistance of the truck

The insulation resistance between the live parts of all the electric components and the frame of the industrial truck with the exception of the battery is at least 1000 Ω multiplied by the nominal voltage of the truck system.

NOMINAL VOLTAGE	MINIMUM INSULATION RESISTANCE
24 V	24,000 Ω
36 V	36,000 Ω
48 V	48,000 Ω
80 V	80,000 Ω

9.2.3.2 Insulation resistance of the battery

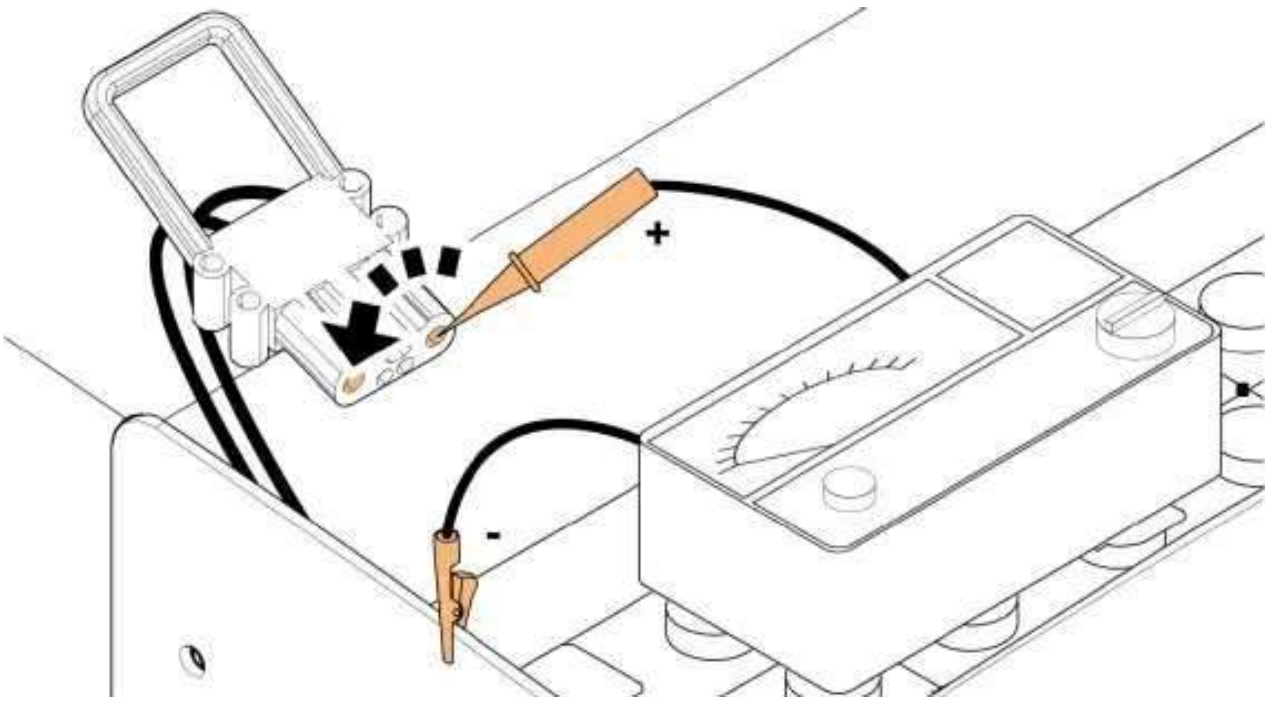


Figure 78. Measuring the insulation resistance of the battery

The insulation resistance of the disconnected, filled and charged traction battery mounted on the truck is at least 50 Ω multiplied by the nominal voltage of the truck system between the live parts and the frame of the truck. If the battery is fitted into more than one containers, this test is carried out with the electrically-connected sections (including metal battery containers).

NOMINAL VOLTAGE	MINIMUM INSULATION RESISTANCE
24 V	1,200 Ω
36 V	1,800 Ω
48 V	2,400 Ω
80 V	4,000 Ω

10 Hydraulic operation

This chapter presents the hydraulic operation of the truck.

⚠ CAUTION

Make sure that you have the appropriate version of the hydraulic schematics for the truck model under maintenance. Contact your supplier or technical support for information on obtaining up to date documentation for your truck model.

The hydraulic schematic diagram shown in Figure 79 illustrates the operation of the hydraulic system.

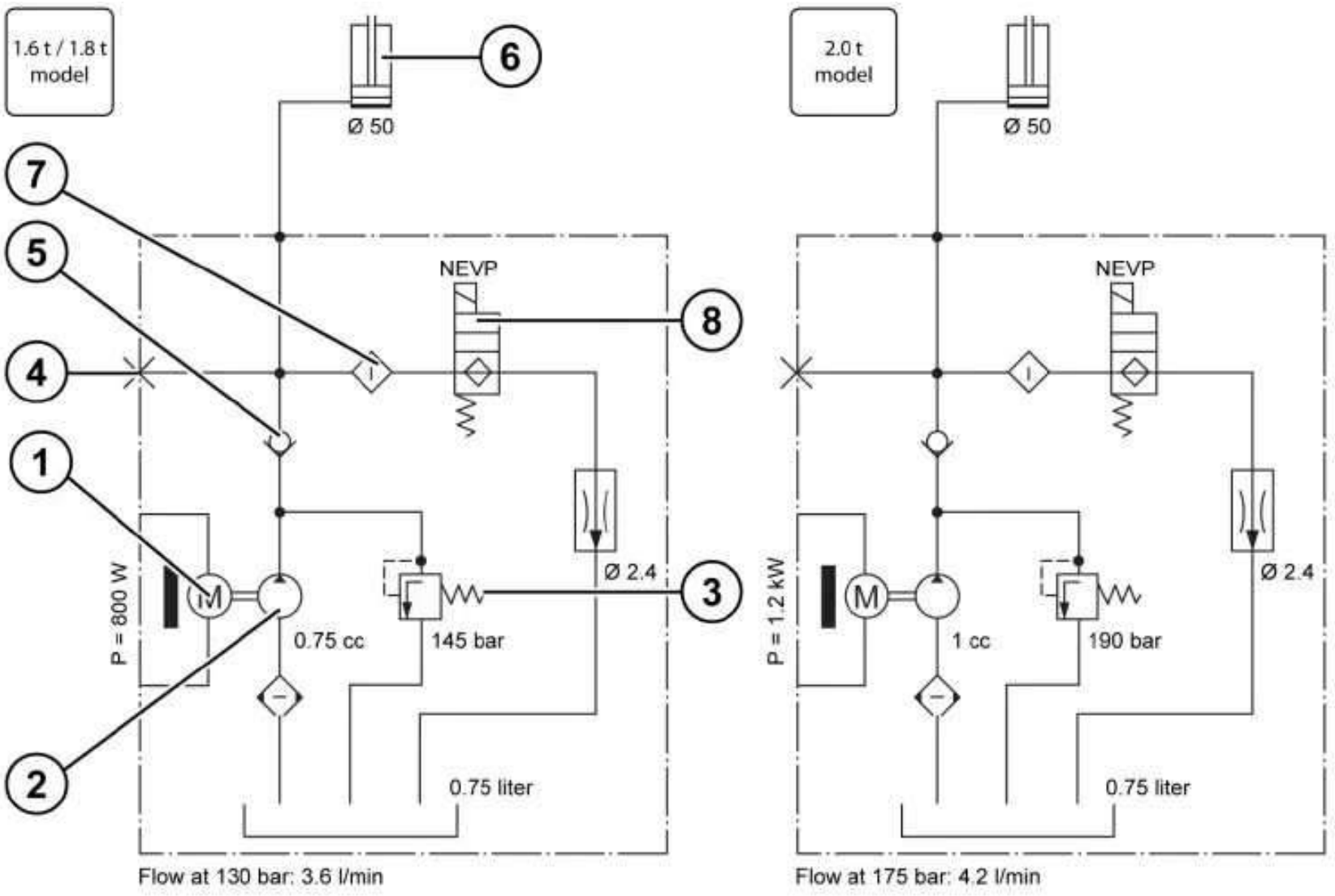


Figure 79. Hydraulic system overview (1.6 t / 1.8 t model and 2.0 t model)

1. *Electrical motor*
2. *Hydraulic gear pump*
3. *Relief valve*
4. *Plugged measuring point*
5. *No-return valve*
6. *Lifting cylinder*
7. *300 µ sieve*
8. *Solenoid valve*

The principle of the truck's hydraulic operation is as follows:

Lifting:

1. The electrical motor operates the hydraulic gear pump.
2. The hydraulic fluid is pressurized.
3. The fluid pressure is maintained using the relief valve, which opens at a certain pressure. In such cases, the hydraulic fluid is returned to the fluid tank. The opening pressure of the relief valve is indicated in the hydraulic schematics.
4. The pressurized hydraulic fluid flows through the no-return valve to the lifting cylinder.
5. The lifting cylinder piston lifts the forks.

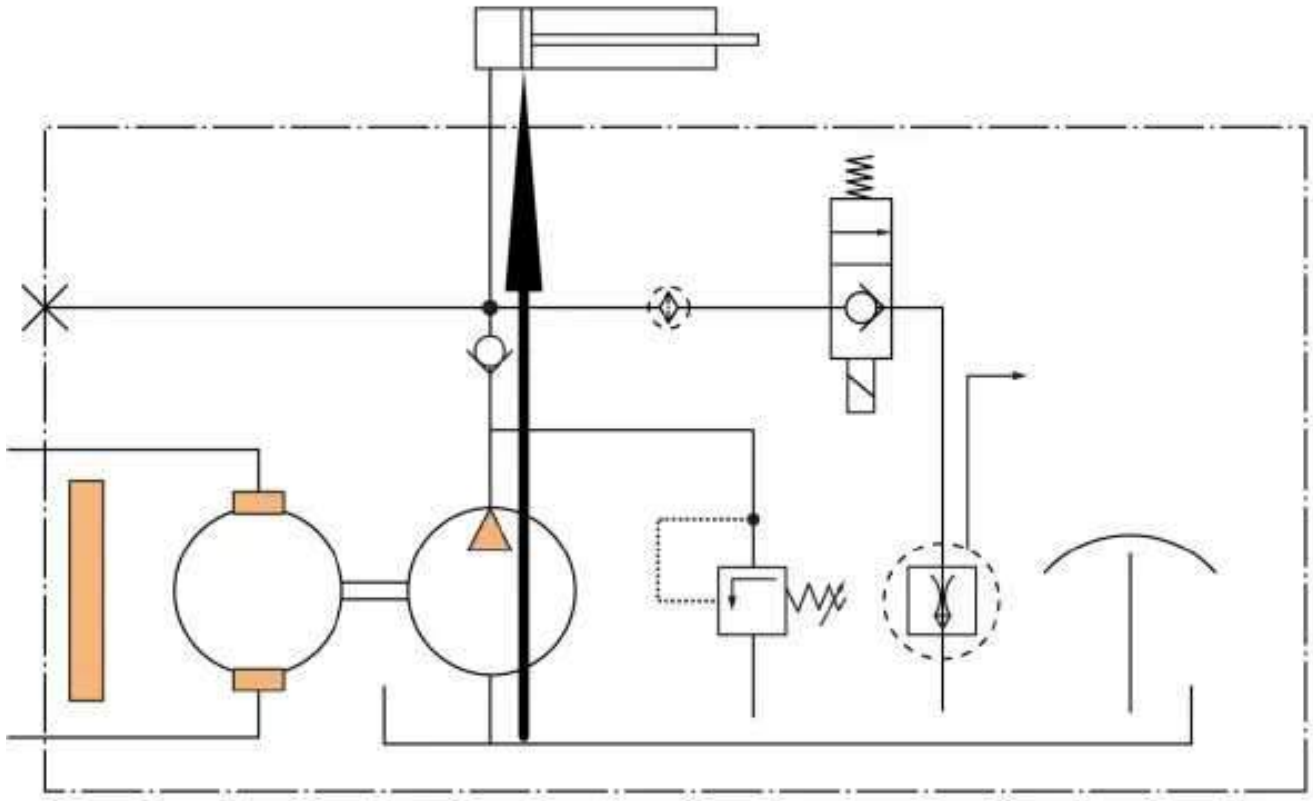


Figure 80. Hydraulic fluid flow during lifting

Lowering

1. The solenoid valve is opened with the lowering switch.
2. The hydraulic fluid flows through the 300 µ sieve back to the fluid tank.
3. As the hydraulic pressure reduces, the lifting cylinder piston retracts and the forks are lowered.

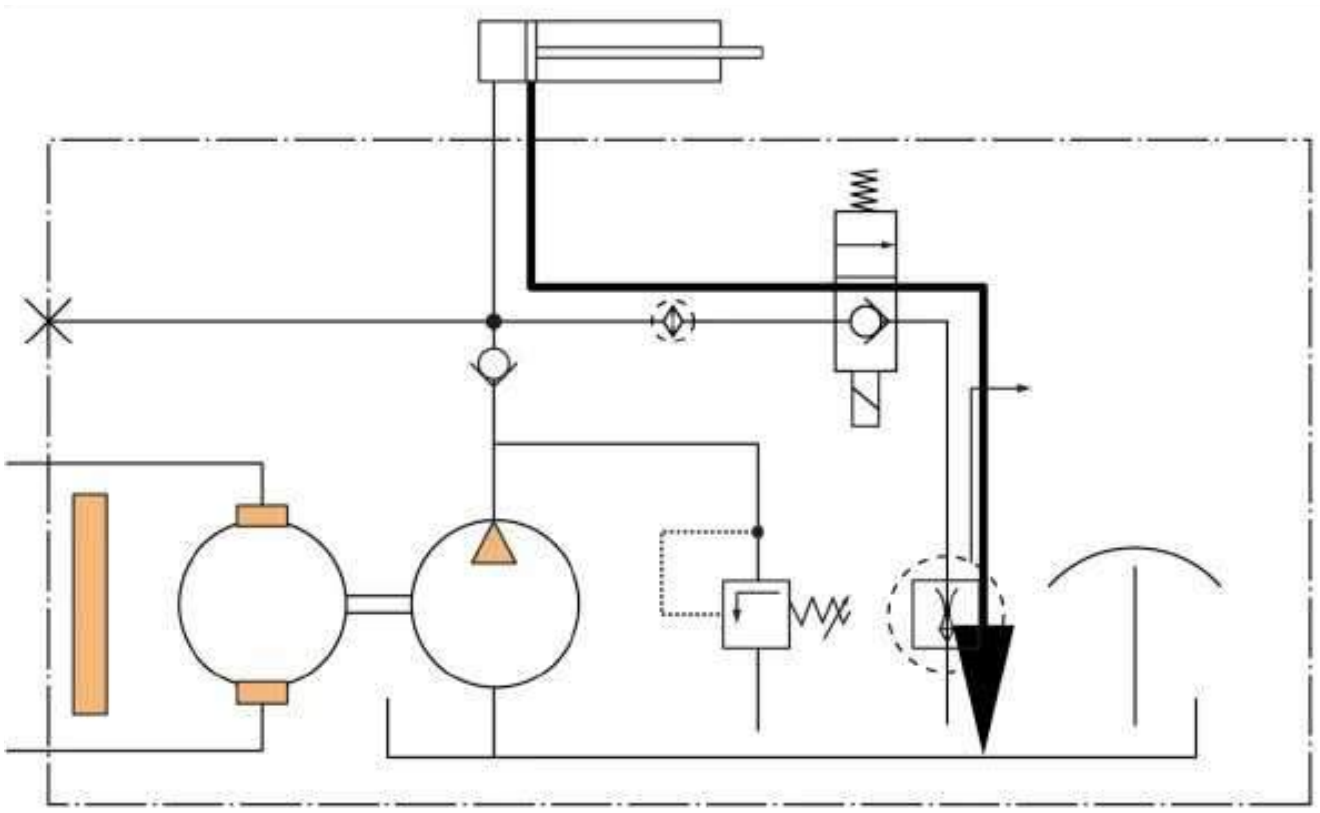
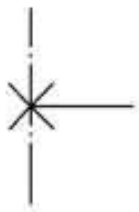
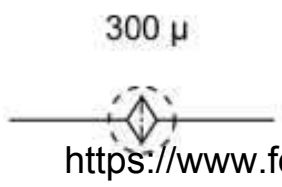
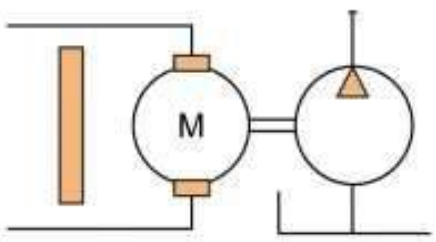
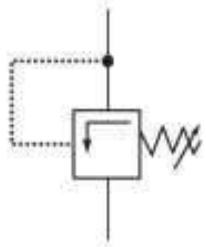
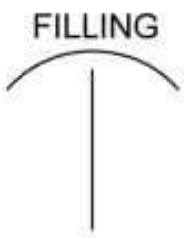


Figure 81. Hydraulic fluid flow during lowering

NOTE: Different truck models can have different hydraulic system configurations.

10.1 Hydraulic symbols

SYMBOL	DESCRIPTION
	Lifting cylinder
	Plugged measuring point
	No-return valve
	300 µ sieve

SYMBOL	DESCRIPTION
	Solenoid valve
	Pump motor and hydraulic pump
	Adjustable pressure relief valve
	Hydraulic oil flow choker
	Hydraulic oil tank filling plug

10.2 Hydraulic oil recommendations

⚠ CAUTION

Hydraulic oil is hazardous waste that must be disposed of accordingly.

Normal operating conditions	ISO VG 32
Cold storage	ISO VG 15
Hot temperatures	ISO VG 46

Fill the hydraulic oil tank up to ¾ of the full volume. The filling hole for hydraulic oil is shown in Figure 82 below.

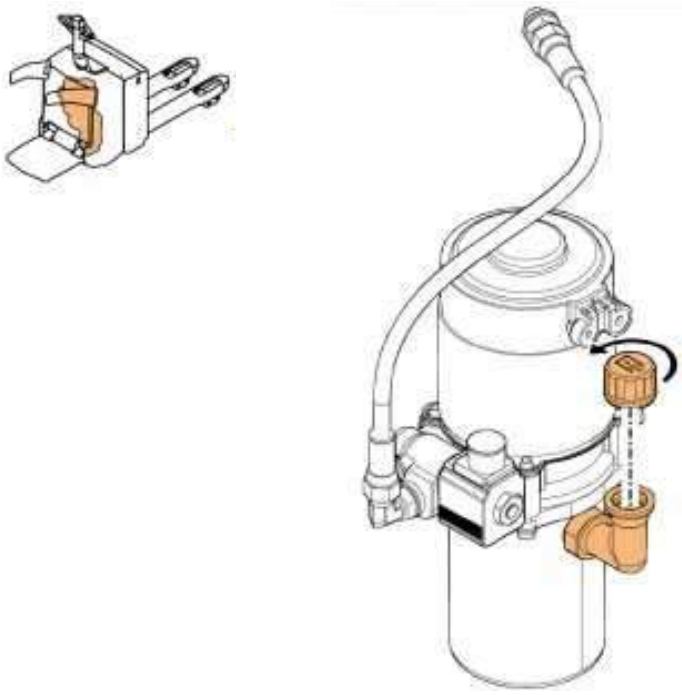
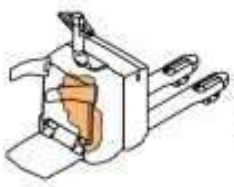


Figure 82. Filling hole for hydraulic oil

10.3 Maintenance points of the hydraulic system

During maintenance, clean the hydraulic oil suction filter in the oil tank.

10.4 Hydraulic aggregate



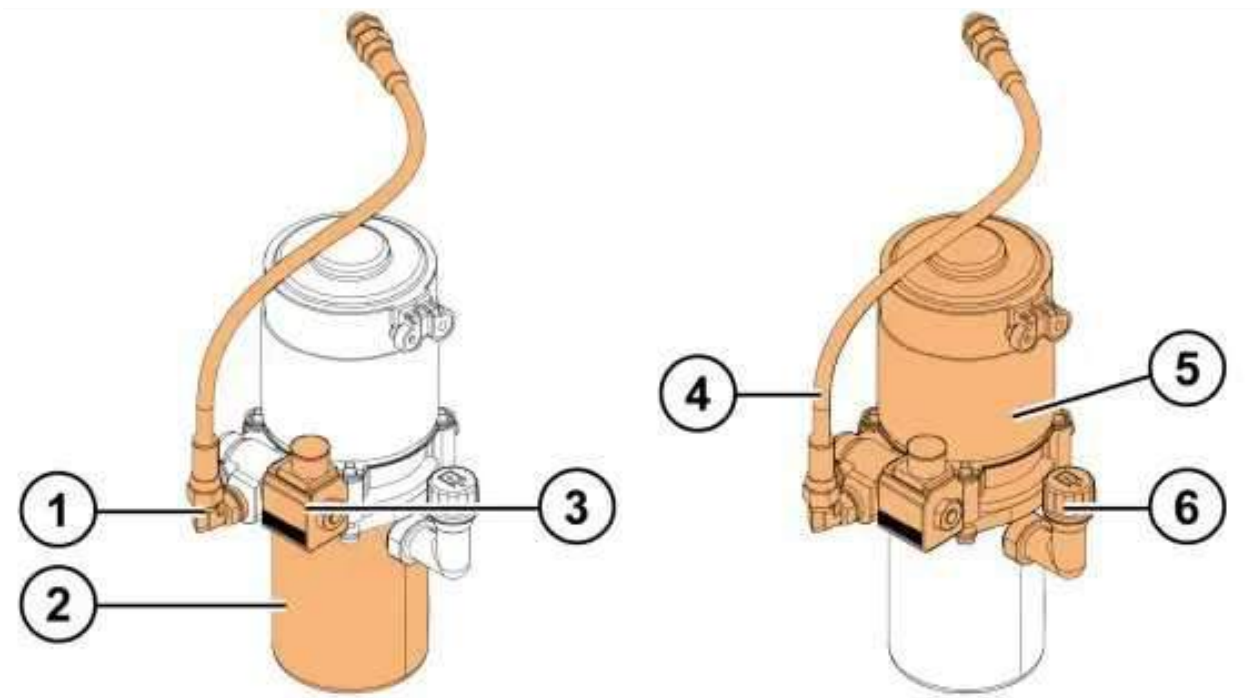


Figure 83. Hydraulic aggregate overview

1. *Hydraulic connector*
2. *Oil tank*
3. *Solenoid valve*
4. *Hydraulic hose*
5. *Pump motor*
6. *Filling hole for hydraulic oil*

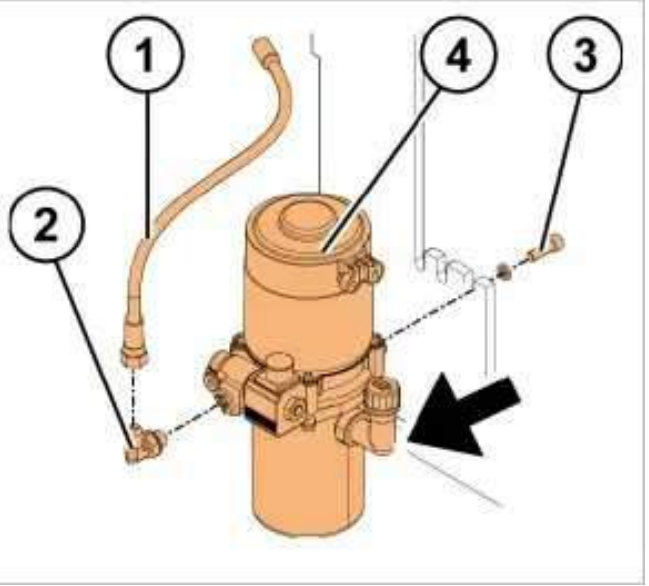
The hydraulic aggregate consists of the electric pump motor, the hydraulic gear pump unit, the oil tank, the suction filter, the pressure relief valve, the solenoid valve, hydraulic hoses and connections for various hydraulic equipment.

The hydraulic aggregate is used to control the load handling device.

10.4.1 Disassembly of the hydraulic aggregate

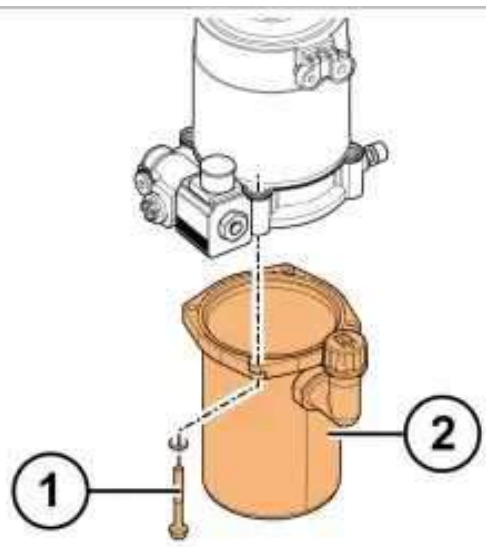
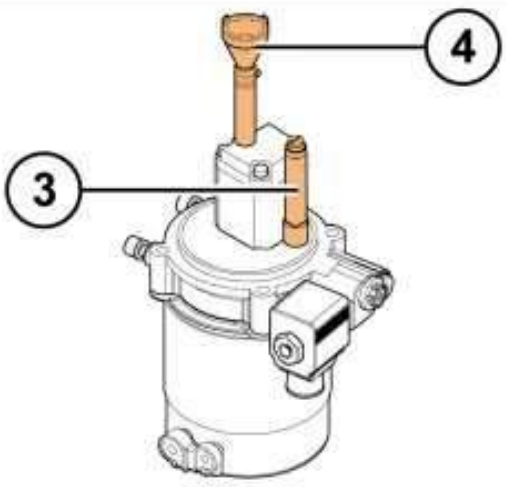
WARNING

Prepare a drip pan to catch any remaining oil in the pipes and hoses before disconnecting each pipe. Take appropriate actions to prevent dust and dirt from entering in the opening of the pipe and valve connections.

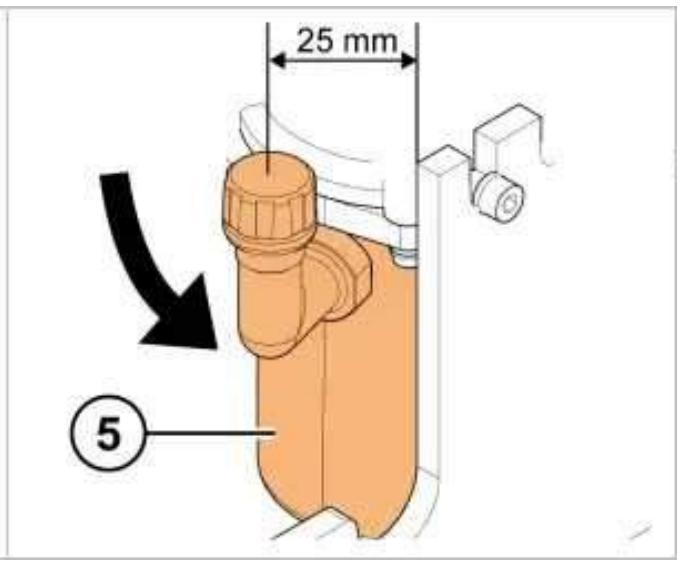
1. Remove the hydraulic oil hose. 2. Remove the hydraulic connector. 3. Unscrew the bolts attaching the hydraulic aggregate to the truck frame. 4. Remove the hydraulic aggregate.	

10.4.2 Disassembly of the oil tank

To adjust the pressure relief valve or to clean the hydraulic oil suction filter, you must disassemble the oil tank.

1. Remove the four bolts attaching the oil tank to the pump motor. 2. Remove the oil tank.	
3. Adjust the pressure relief valve, if necessary. Note that the pressure relief valve has been factory adjusted and normally there is no need for re-adjusting it. 4. Clean the hydraulic oil suction filter and the oil tank.	

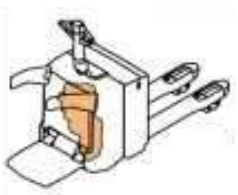
5. Attach the hydraulic oil tank to the pump motor with the four bolts. When assembling it, rotate the tank so that the filling hole is placed as shown in the figure.



10.5 Replacing the hydraulic cylinder

⚠ CAUTION

Attach caps to the cylinder connectors to protect the threads of the connectors and to prevent oil from flowing out of the cylinder when it is removed.



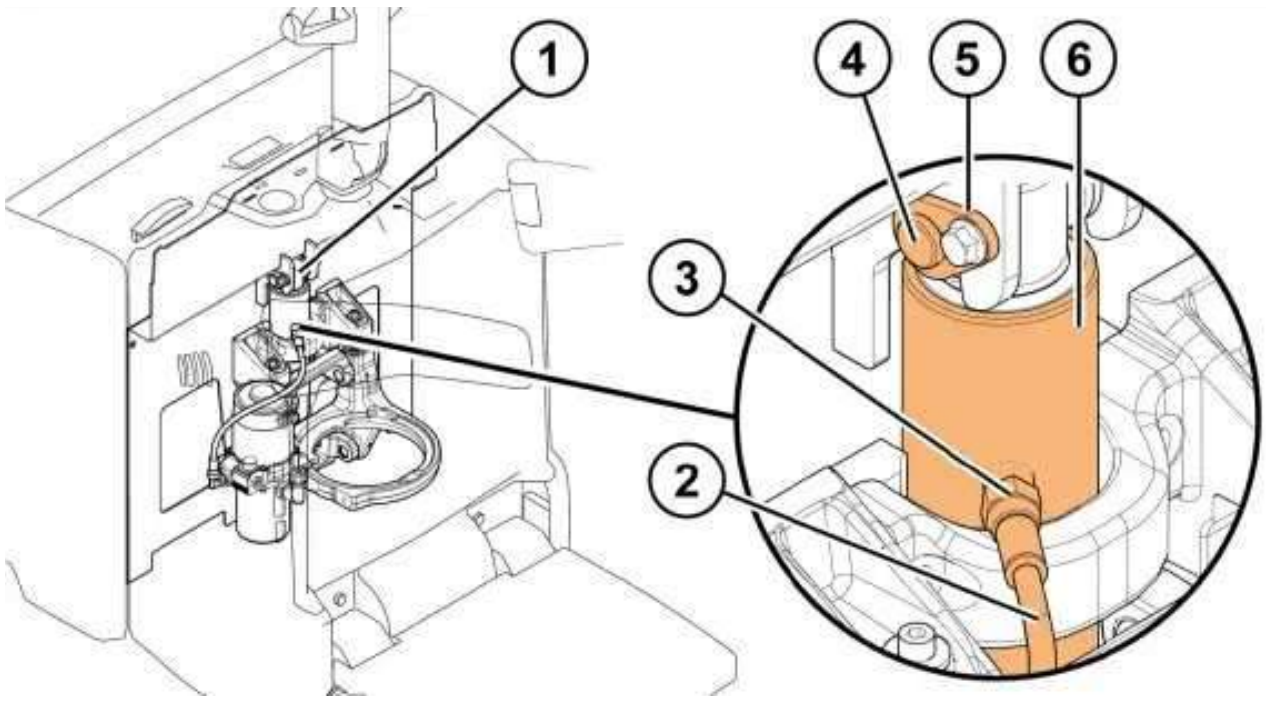
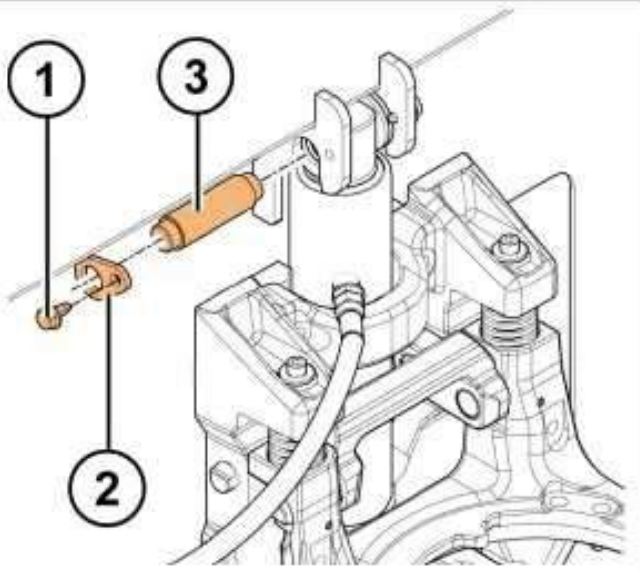
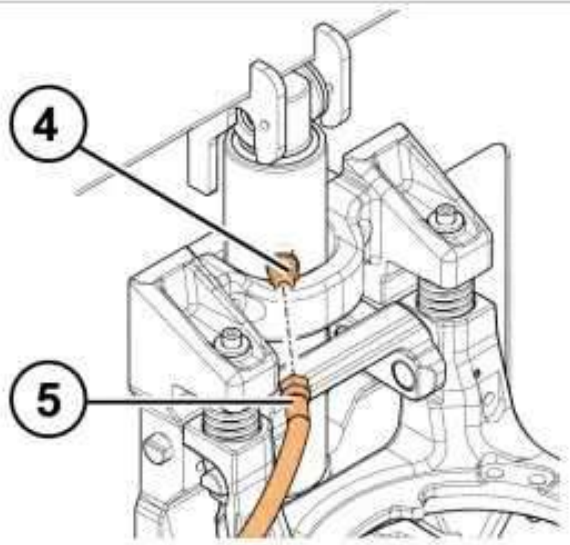
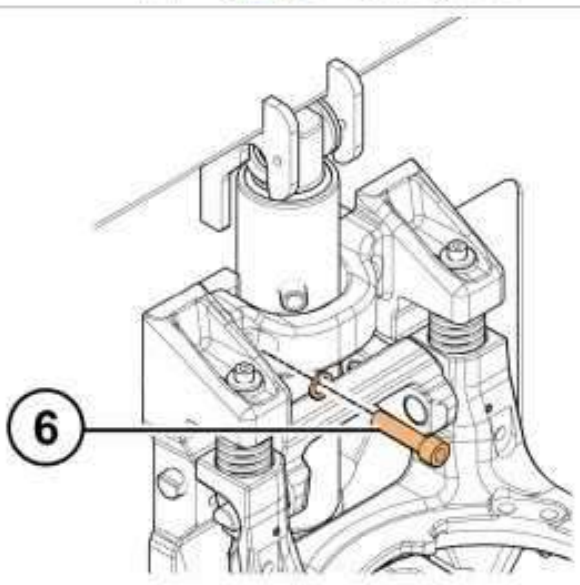
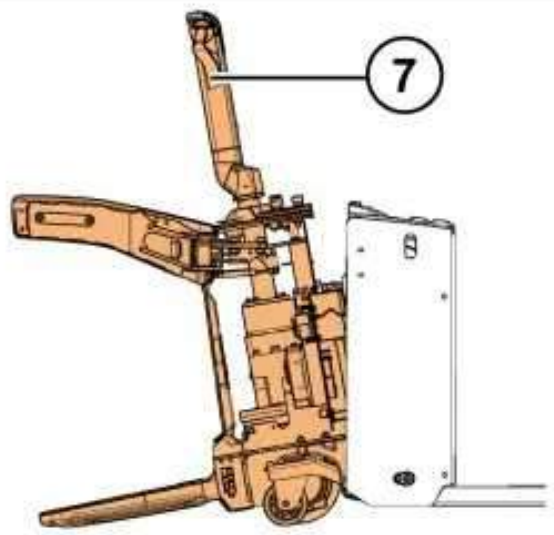
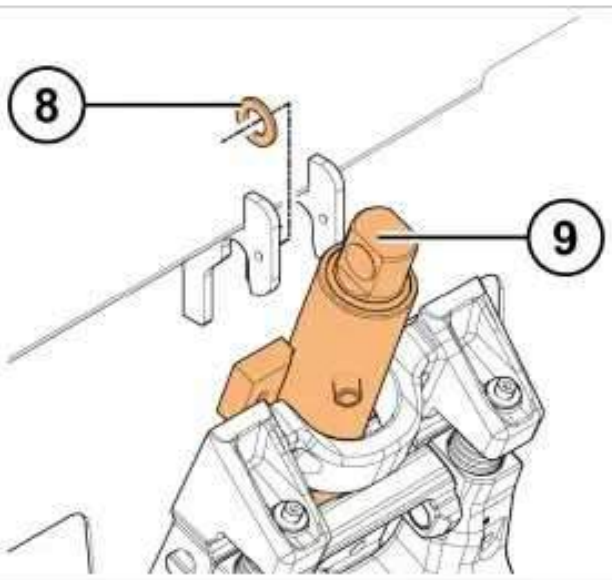


Figure 84. Hydraulic cylinder overview

1. *Hydraulic cylinder*
2. *Hydraulic hose*
3. *Hydraulic hose connector*
4. *Shaft*
5. *Guide bracket*
6. *Cylinder slot*

NOTE: Support the fork sledge to its uppermost position before cylinder removal.

1. Remove the bolts attaching the shaft to the frame. **2.** Remove the guide bracket. **3.** Pull the shaft out.	
4. Disconnect the hydraulic hose connector. **5.** Disconnect the hydraulic hose.	
6. Remove the hydraulic cylinder bolts. Use Nordlock washers.	

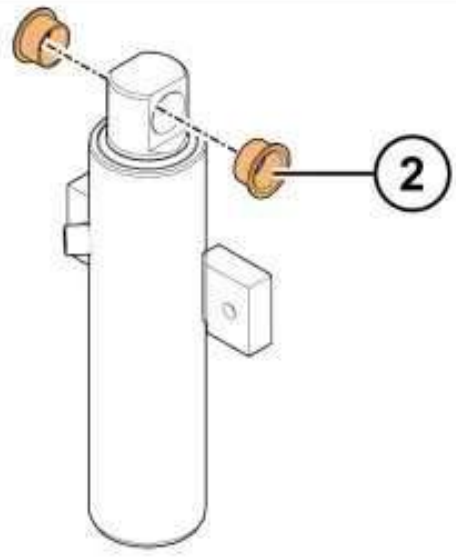
7. Bend the machine slightly backward.	
8. Remove the spacers. **9.** Lift the cylinder out off the slot.	

Install the hydraulic cylinder by repeating the steps in reversed order.

10.5.1 Replacing the hydraulic cylinder's slide bearings

1. Remove the hydraulic cylinder as instructed in section 10.5 above.

2. Remove the slide bearings.



3. Install new slide bearings.

4. Install the hydraulic cylinder by repeating the steps in section 10.5 in reversed order.

11 TruckTool Diagnostics

Software maintenance can be performed with a diagnostics application called TruckTool. This program runs on a laptop PC and connects to the truck's data bus (CAN) via a special adapter and wire harness.

TruckTool can be used to receive, display and modify settings, update (flash) controller firmware, reset settings to hardware defaults, review and clear alarms, perform calibrations, execute a quick truck setup and monitor digital and analogue inputs and outputs.

The TruckTool program’s usage instructions are available in the application itself. Additional training is required to use the program.

Figure 85. TruckTool Diagnostics

12 Parameter descriptions

⚠ CAUTION

Always use the correct parameter list for the specific model you are servicing. The latest parameter lists are available from the manufacturer's Web site.

NOTE: If the truck is equipped with the electrical steering option, the parameter descriptions of the steering controller are available in section 15.11.9.

12.1 Traction controller

Table 6. Main menu, parameter change

PARAMETER	DESCRIPTION
Acceleration ramp ACCELER. DELAY	This parameter determines the acceleration rate of the traction motor in the standard drive mode. Value range: • 0.1: Fastest • 10: Slowest
Acceleration ramp end smoothening STOP SMOOTH	This parameter controls the smoothness when the direction change ramp is stopped. Value range: • 3 Hz: Minimum • 20 Hz: Maximum
Acceleration smoothening ACC SMOOTH	This parameter controls the smoothness of the acceleration ramp. Value range: • 1: Minimum • 5: Maximum
Brake release cutback speed H&S CUTBACK	This parameter controls the speed reduction when the brake release is activated. Value range: • 10%: Enabled • 100%: Disabled
Braking ramp end smoothening STOP BRK SMOOTH	This parameter controls the smoothness when the braking ramp is stopped. Value range: • 3 Hz: Minimum • 20 Hz: Maximum

PARAMETER	DESCRIPTION
Braking smoothening BRK SMOOTH	This parameter controls the smoothness of the braking ramp. Value range: • 1: Minimum • 5: Maximum
Deceleration ramp DECEL. BRAKING	This parameter controls the deceleration rate when the speed is reduced but not stopped while moving in the standard drive mode. Value range: • 0.1: Fastest • 10: Slowest
ECO: Acceleration ramp ACCELER. DELAY E	This parameter determines the acceleration rate of the traction motor in the economy drive mode. Value range: • 0.1: Fastest • 10: Slowest
ECO: Deceleration ramp DECEL. BRAKING E	This parameter controls the deceleration rate when the speed is reduced but not stopped while moving in the economy drive mode. Value range: • 0.1: Fastest • 10: Slowest
ECO: Inversion braking ramp INVERS. BRAK. E	This parameter controls the deceleration rate when the direction switch is reversed while moving in the economy drive mode. Value range: • 0.1: Fastest • 10: Slowest
ECO: Maximum speed forward MAX SPEED FORW E	This parameter controls the maximum speed forward in the economy drive mode. Value range: • 10%: Slowest • 100%: Fastest **NOTE:** For safety reasons, do not exceed the parameter table value!
ECO: Maximum speed reverse MAX SPEED BACK E	This parameter controls the maximum speed backward in the economy drive mode. Value range: • 10%: Slowest • 100%: Fastest **NOTE:** For safety reasons, do not exceed the parameter table value!

PARAMETER	DESCRIPTION
ECO: Release braking ramp RELEASE BRAK. E	This parameter controls the deceleration rate when the accelerator is released in the economy drive mode. Value range: • 0.1: Fastest • 10: Slowest
ECO: Speed limit braking ramp SPEED LIM BRK. E	This parameter controls the deceleration rate when speed reduction is activated in the economy drive mode. Value range: • 0.1: Fastest • 10: Slowest
ECO: Steering cutback braking ramp STEER BRAKING E	This parameter controls the deceleration rate when electrical steering cutback is activated in the economy drive mode. Value range: • 0.1: Fastest • 10: Slowest
Inversion braking ramp INVERS. BRAKING	This parameter controls the deceleration rate when the direction switch is reversed while moving in the standard drive mode. Value range: • 0.1: Fastest • 10: Slowest
Inversion smoothening INV SMOOTH	This parameter controls the smoothness of direction change during a drive. Value range: • 1: Minimum • 5: Maximum
Max speed forward MAX SPEED FORW	This parameter controls the maximum speed forward in the standard drive mode. Value range: • 10%: Slowest • 100%: Fastest **NOTE:** For safety reasons, do not exceed the parameter table value!
Max speed FWD PIN 3 MAX SP. FW PIN3	Maximum speed forward with PIN code 3.
Max speed FWD PIN1 MAX SP. FW PIN1	Maximum speed forward with PIN code 1.

PARAMETER	DESCRIPTION
Max speed FWD PIN2 MAX SP. FW PIN2	Maximum speed forward with PIN code 2.
Max speed REV PIN 1 MAX SP. BK PIN1	Maximum speed backwards with PIN code 1.
Max speed REV PIN 2 MAX SP. BK PIN2	Maximum speed backwards with PIN code 2.
Max speed REV PIN 3 MAX SP. BK PIN3	Maximum speed backwards with PIN code 3.
Max speed reverse MAX SPEED BACK	This parameter controls the maximum speed backward in the standard drive mode. Value range: • 10%: Slowest • 100%: Fastest **NOTE:** For safety reasons, do not exceed the parameter table value!
Maximum load speed cutback MAX SPEED LOAD	This parameter controls the maximum speed forward with maximum load in percentage of absolute maximum driving speed. Value range: • 10%: Slowest • 100%: Fastest **NOTE:** For safety reasons, do not exceed the parameter table value!
Maximum load weight MAX LOAD WEIGHT	This parameter controls the maximum load of the truck. **NOTE:** This parameter is used only if the truck is equipped with the pressure sensor option!
Proportional valve closing ramp EVP CLOSE DELAY	This parameter controls the proportional valve closing delay ramp. Value range: • 0.1: Fastest • 12.75: Slowest
Proportional valve opening ramp EVP OPEN DELAY	This parameter controls the proportional valve open delay ramp. Value range: • 0.1: Fastest • 12.75: Slowest

PARAMETER	DESCRIPTION
Pump acceleration ramp PU. ACCELER. DEL	This parameter controls the acceleration ramp for the pump motor. Value range: • 0.1: Fastest • 25.5: Slowest
Pump deceleration ramp PU. DECELER. DEL	This parameter controls the deceleration ramp for the pump motor. Value range: • 0.1: Fastest • 25.5: Slowest
Pump max speed SPEED LIMIT	This parameter controls the maximum lift speed. Value range: • 10%: Slowest • 100%: Fastest
Release braking ramp RELEASE BRAKING	This parameter controls the deceleration rate when the accelerator is released in the standard drive mode. Value range: • 0.1: Fastest • 10: Slowest
Speed limit braking ramp SPEED LIM BRK.	This parameter controls the deceleration rate when speed reduction is activated in the standard drive mode. Value range: • 0.1: Fastest • 10: Slowest
Steering cutback STEER CUTBACK	This parameter controls the maximum speed when steering is at a 90-degree angle. Value range: • 10%: Slowest • 100%: Fastest **NOTE:** This parameter is used only if the truck is equipped with the electrical steering option!
Steering cutback braking ramp STEER BRAKING	This parameter controls the deceleration rate when electrical steering cutback is activated in the standard drive mode. Value range: • 0.1: Fastest • 10: Slowest

PARAMETER	DESCRIPTION
Turtle cutback speed reduction TURTLE CUTBACK	This parameter controls the speed reduction when the low speed mode is activated. Value range: • 10%: Enabled • 100%: Disabled
Walkie mode cutback WALKING CUTBACK	This parameter controls the maximum speed in the pedestrian mode. Value range: • 10%: Slowest • 100%: Fastest

Table 7. Submenu: adjustments

PARAMETER	DESCRIPTION
Adjust battery voltage ADJUST BATTERY	Because the traction motor controller monitors the battery discharge level, this parameter must be set to match the actual battery voltage. The difference between the ADJUST BATTERY VALUE parameter value and the voltmeter reading should be ±0.2 V. Connect the voltmeter between –Batt and key input K1/1. Use a high-quality voltmeter to check the battery voltage and set this parameter as close to the meter reading as possible. This measurement can be carried out at any time (i.e. regardless whether the battery is full or empty). This parameter should be set after the controller has been changed or if there are problems with battery charge level monitoring.
Battery maximum value adjust BAT MAX ADJ.	This parameter controls the maximum level for charged battery. Value range: • Level = 0: Minimum • Level = 9: Maximum
Battery minimum value adjust BAT. MIN ADJ.	This parameter controls the minimum level for discharged battery. Value range: • Level = 0: Minimum • Level = 9: Maximum
BDI startup correction value BDI ADJ STARTUP	At startup, the BDI is calculated with this voltage adjust parameter. Value range: • Level = 0: Minimum • Level = 9: Maximum

PARAMETER	DESCRIPTION
Check up done CHECK UP DONE	Maintenance request acknowledgement.
Check up type CHECK UP TYPE	• 0 = No maintenance warnings. • 1 = Maintenance warning in 600 h. • 2 = Maintenance warning in 600 h, speed reduction in 640 h. • 3 = Maintenance warning in 600 h, speed reduction in 640 h, truck stop in 680 h.
Electrobrake retain voltage EB VOLTAGE RED.	This parameter controls the brake coil voltage one second after the activation of the brake voltage. The parameter should be set between 60% and 80%. Value range: • 0%: Minimum • 100%: Maximum
Fan start temperature FAN TEMPERATURE	This parameter controls the temperature limit for fans. If any of the measured temperatures exceeds this value, the fans are started.
Main contactor retain voltage MC VOLTAGE RED.	This parameter controls the main contactor coil voltage one second after the activation of the main contactor voltage. Value range: • 0%: Minimum • 100%: Maximum
Maximum lifting time MAX LIFT TIME	Maximum lift time adjustment. • Level = 3: Minimum • Level = 15: Maximum
Throttle 0 zone THROTTLE 0 ZONE	This parameter establishes the dead band in the finger tip input curve (see Figure 86 below).
Throttle curve X-axis THROTTLE X POINT	This parameter changes the characteristics of the finger tip input curve (see Figure 86 below).
Throttle curve Y-axis THROTTLE Y POINT	This parameter changes the characteristics of the finger tip input curve (see Figure 86 below).

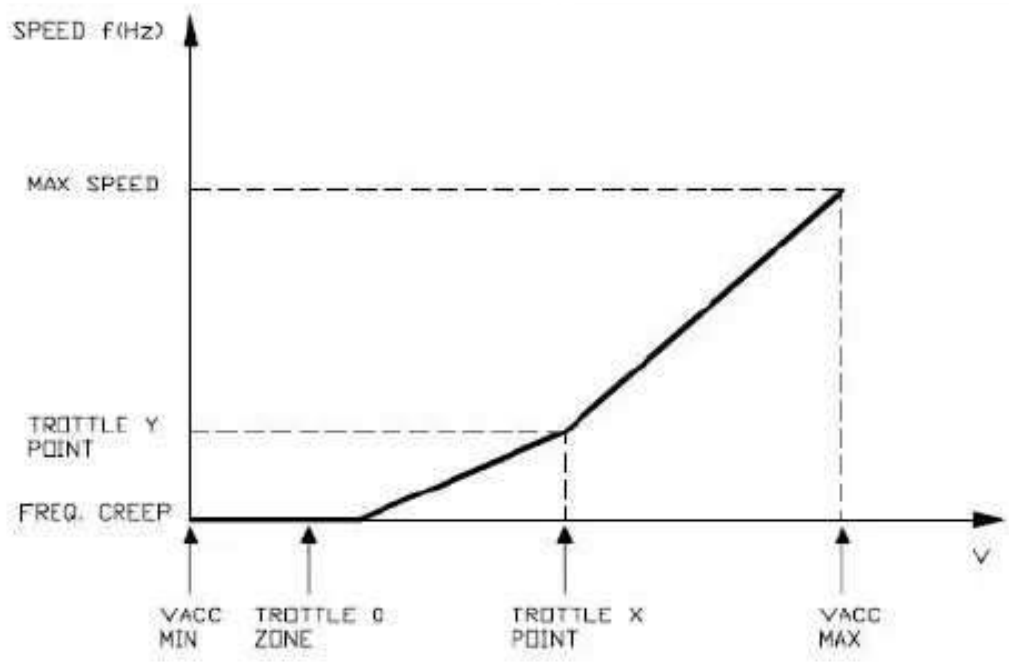


Figure 86. Throttle curve adjustment

Table 8. Submenu: set options

PARAMETER	DESCRIPTION
A14 FUNCTION Input A14 functionality	This parameter controls the functionality of the multipurpose input (XA1_A/14). Value range: • NONE: No functionality • OPTION #1: Battery lock • OPTION #2: Speed cutback **NOTE:** This parameter is used only if the truck is equipped with the battery lock sensor option!
BATTERY CHECK Option: Battery check	This parameter controls the specification of low battery charge detection. Value range: • 0: Nothing happens, the battery charge level is calculated but no action is taken when the battery is discharged. • 1: Lift cut out when the BATTERY LOW alarm is activated. • 2: Traction speed reduction to 24% when the BATTERY LOW alarm is activated.
EPS Option: Electric steering	This parameter defines whether electrical steering is on or off. Value range: • ABSENT: Off • PRESENT: On
HOUR COUNTER Option: Hour meter	Factory setting.

PARAMETER	DESCRIPTION
LOAD SENSOR Option: Load sensor (high speed option)	This parameter defines whether the pressure sensor is in use or not. Value range: • ABSENT: Not in use • PRESENT: In use **NOTE:** This parameter is used only if the truck is equipped with the pressure sensor option!
Option: Controller cooler fan FAN	Option controller cooling fan. Value range: • 0: off • 1:digital
Option: PIN-code lock PIN CODE LOCK	PIN code lock function. Value range: • 0: OFF • 1: ON
Option: Pin code timeout PIN CODE TIMEOUT	PIN code lock timeout. The truck is automatically locked after the time set in this parameter (given in minutes).

Table 9. Submenu: hardware settings

PARAMETER	DESCRIPTION
TOP MAX SPEED Maximum speed	This parameter controls the truck's absolute maximum speed to one direction, depending on the TRUCK DIRECTION parameter. All other speeds are percentages of this set value. **NOTE:** For safety reasons, do not exceed the parameter table value!

13 Alarm codes

This chapter explains the meaning of the various alarms that the different controllers may produce. Refer to the chapter 11 for information on the TruckTool diagnostics application.

NOTE: If the truck is equipped with the electrical steering option, the alarm codes of the steering controller are available in section 15.11.10.

13.1 Traction controller

NOTE: Before you start to troubleshoot the truck, make sure that all the power supplies, fuses and connections are in order. Low voltage in the traction controller can cause different sorts of alarms.

The fault diagnostic system of the traction controller is divided into two main groups:

- Alarms

  These are faults, which open the power bridge and, when possible, also the main contactor is opened and the magnetic brake activated. Failures in the motor, the controller or the safety functions cause alarms.

- Warning

  These are faults, which do not stop the truck or stop the truck by using regeneration braking. The controller is working well, but it has detected some conditions that reduce the performance or stop the truck without opening the power devices. Incorrect operation sequences or conditions requiring performance reductions (for example, high temperatures) cause warnings.

The text “Stored” means that the alarm or warning is stored in the traction controller logbook.

Table 10. Traction controller alarm codes

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
8	Self diagnosis test failed WATCHDOG	(Alarm)	Stored
	This is a safety-related self diagnosis test within the logic between the master (drive) and slave (pump) microcontrollers. The alarm indicates that the master and slave watchdog message is missing or late. This alarm can be caused by a CAN bus malfunction, which blinds the master-slave communication. Check all the CAN bus cables and measure the bus resistance between CAN high and low. The bus resistance value should be 60 Ω. Measure also the CAN cables' resistance between the truck chassis and the 0 cables. There should not be any significant connection and the resistance value should be over 1 MΩ. If CAN bus is OK, the problem is in the controller and it must be replaced.		
13	Controller memory error EEPROM KO	(Warning)	Stored
	This warning is caused by a hardware or software defect of the non-volatile embedded memory supporting the controller parameters. This alarm does not prevent truck operation, but the truck will work with the default values. In case of this warning, perform a CLEAR EEPROM operation. Switch the key off and on to check the result. If the alarm occurs permanently, replace the COMBIACX controller. If the alarm disappears, the previously stored parameter values will have been replaced by the default values.		
17	Hardware high current protection failure LOGIC FAILURE #3	(Alarm)	Stored
	This alarm is caused by a hardware problem in the logic card circuit for high current (overload) protection. This fault is not related to external components, so when it appears, replace the COMBIACX controller.		
18	Motor voltage feedback circuit damaged LOGIC FAILURE #2	(Alarm)	Stored
	This alarm is caused by a fault in the logic board managing the phase's voltage feedback. This fault is not related to external components, so when it appears, replace the COMBIACX controller.		

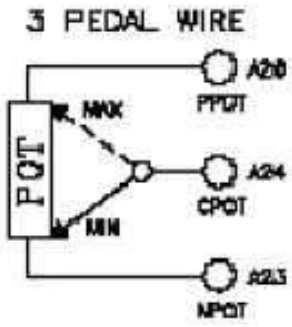
CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
19	Over or under voltage detected LOGIC FAILURE #1	(Alarm)	Stored
	This alarm is displayed when the controller detects an overvoltage or undervoltage condition. The overvoltage threshold is 35 V and the undervoltage threshold is 9.5 V in the 24V controller. If the alarm is displayed at startup or in the standby mode, it is due to an undervoltage. In such a case, check the following: • The key input signal voltage drops below the undervoltage threshold due external loads, such as DC/DC converters starting up or relays or contactors energizing or de-energizing. • If no voltage transient is detected on the supply line and the alarm is displayed every time the key is switched ON, the problem is in the COMBIACX controller. If fault is displayed during motor driving, it is due to an undervoltage or an overvoltage condition. • If the alarm occurs during traction acceleration or driving hydraulic functions, it is caused by an undervoltage condition. In such a case, check the battery charge level and the power cable connections. • If the alarm occurs during release braking, it is caused by an overvoltage condition. In such a case, check the line contactor tips and the battery power cable connections. In some cases, this error can also happen during normal operation. Sharp hits may cause the emergency stop switch contacts to open for a short period of time. This causes a short 0 V pulse to the key line causing this error.		
28	Pump motor output voltage error (low) PUMP VMN LOW	(Alarm)	Stored
	Cause 1: Startup test Before switching the main contactor on, the software checks the power bridge. It turns on the high side power mosfets one by one and expects the phase voltage to increase toward the rail capacitor value. If the phase voltage does not increase, this alarm occurs. In such a case (the main contactor does not close at all), check the following: • Motor internal connections (ohmic continuity) • Motor power connections • Motor leakage to the truck frame If the motor connections are OK, the problem is in the COMBIACX controller. **Cause 2: Motor running test** When the motor is running and the power bridge is on, the motor voltage feedback is tested. If the motor voltage feedback is lower than the commanded value, this alarm occurs. In such a case, check the following: • Motor connections • Whether the motor's phase windings or cables have leakages towards the truck frame • That the main contactor closes properly, with a good contact If no faults are found, the problem is in the COMBIACX controller.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
29	Pump motor output voltage error (high) PUMP VMN HIGH	(Alarm)	Stored
	This test is carried out when the pump motor is turning. The alarm indicates that the pump motor output is higher than expected. In such a case, check the following: • Motor connections • If the motor windings or cables have leakages towards the truck frame If no problems are found on the motor, the problem is in the COMBIAX controller.		
30	Traction motor output voltage error (low) VMN LOW	(Alarm)	Stored
	Cause 1: Startup test Before switching the main contactor on, the software checks the power bridge. It turns the high side power mosfets on one by one and expects the phase voltage to increase toward the rail capacitor value. If the phase voltage does not increase, this alarm occurs. In such a case (the main contactor does not close at all), check the following: • Motor internal connections (ohmic continuity) • Motor power connections • Motor leakage to the truck frame If the motor connections are OK, the problem is in the COMBIACX controller. **Cause 2: Motor running test** When the motor is running and the power bridge is on, the motor voltage feedback is tested. If the motor voltage feedback is lower than commanded value, this alarm occurs. In such a case, check the following: • Motor connections • Whether the motor's phase windings or cables have leakages towards the truck frame • That the main contactor closes properly, with a good contact. If no faults are found, the problem is in the COMBIACX controller.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
31	Traction motor output voltage error (high) VMN HIGH	(Alarm)	Stored
	Cause 1: Before switching the main contactor on, the software checks the power bridge. It turns the low side and high side power mosfets on one by one and expects the phase voltage to decrease down to –Batt. If the phase voltage does not decrease, this alarm occurs. In such a case (the main contactor does not close at all), check the following: • Motor internal connections (ohmic continuity) • Motor power connections • Motor leakage to the truck frame If the motor connections are OK, the problem is in the COMBIACX controller. **Cause 2:** This alarm may also occur when the startup diagnosis has been completed and the main contactor is closed. In this case, the phase voltage is expected to be lower than 50% of the battery voltage. If it is higher than this value, this alarm occurs. In such a case (the main contactor closes and then opens again), check the following: • Motor connections • Whether the motor's phase windings or cables have leakages towards the truck frame • That the main contactor closes properly, with a good contact If no faults are found, the problem is in the COMBIACX controller.		
37	Contactor is stuck closed CONTACTOR CLOSED	(Alarm)	Stored
	Before driving the main contactor coil, the controller checks that the contactor is not stuck (closed). The controller drives the mosfets for some milliseconds, trying to discharge the capacitor bank. If the contactor is stuck, this alarm occurs. In such a case, check the main contactor tips. If needed, replace the main contactor.		
38	Contactor does not close circuit CONTACTOR OPEN	(Alarm)	Stored
	This alarm occurs if the main contactor has been driven by the controller, but the contactor does not close. In such a case, check that the wires to the main contactor coil are not interrupted or disconnected. The alarm can also be caused by a fault in the main contactor itself. If needed, replace the contactor.		
52	Pump current 0A while pump running PUMP I=0 EVER	(Warning)	Stored
	This test is carried out when the pump motor is running, and it verifies that the current feedback sensor is not constantly stuck to 0. If this warning is displayed, check that the motor connection has continuity. If the motor connection is opened, the current cannot flow, so the test fails and the warning is displayed. If the motor circuit is OK, the problem can be in the current sensor. In this case, replace the COMBIACX controller.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
53	Controller current sensor failure STBY I HIGH	(Alarm)	Stored
	This alarm is displayed if the current transducer or the current feedback circuit is damaged in the controller. This fault is not related to external components, so when it appears, replace the COMBIACX controller.		
60	Power capacitor charging error CAPACITOR CHARGE	(Alarm)	Stored
	When the main contactor is open, the rail capacitors are charged from the key line through a charging resistor. If the voltage on the rail capacitors is low and does not increase, this alarm is displayed. In such a case, there are four possibilities: • Another device connected in parallel with the rail capacitors has failed. • Something is draining the current between the main contactor and the controller when the main contactor is open. • There is a problem in the charging section (for example, a bad contact in the key line). • A power failure or a logic failure occurred in the controller. In this case, replace the COMBIACX controller.		
62	Controller has overheated TH. PROTECTION	(Warning)	Stored
	This alarm indicates that the controller temperature is over 85°C. The maximum current is reduced proportionally to the temperature increase. The controller stops when 105°C is reached. If this alarm occurs when the controller is cold, there are three possibilities: • There is a fault in the thermal sensor wiring. • There is a failure in the thermal sensor. • There is a failure in the logic. In all of the above cases, replace the COMBIACX controller.		
65	Traction motor has overheated MOTOR TEMPERAT.	(Warning)	Stored
	This alarm occurs when the analogue temperature sensor has exceeded the threshold 150°C. In such a case, check the following: • The thermal sensor inside the motor and the outside wiring. The resistance of the sensor (type KTY83) is 960 Ω at 20°C. • If the warning occurs when the motor is cold and the thermal sensor is OK, the problem is in the COMBIACX controller. • If the motor is overheating, check that air ventilates freely in the motor compartment.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
66	Battery charge lower than 10% BATTERY LOW	(Warning)	Stored
	This warning occurs when the battery charge is calculated as being less or equal to 10% of a full charge and the BATTERY CHECK parameter is set to a value other than 0 (located in the SET OPTION menu). In such a case, charge the battery. If it does not help, measure the battery voltage with a voltmeter and compare it with the value of the BATTERY VOLTAGE parameter. If they are different, adjust the value of the ADJUST BATTERY parameter. When adjusting the battery voltage, voltage should be measured from the key line, after the reverse polarity protection diode. A good measuring point is, for example, the emergency stop button terminal. If the battery voltage is measured anywhere else, it will cause invalid operation of the battery discharge indicator.		
74	Contactor driver circuit error DRIVER SHORTED	(Alarm)	Stored
	This alarm occurs if the driver of the main contactor coil is shorted or the coil is disconnected. In such a case, check the following: • If there is a short circuit between the connector XA1 C pin 6 and –Batt. • Condition of the wiring of the main contactor related harness. If there is no short circuit and the wiring is OK, the driver circuit in the COMBIACX controller is damaged.		
75	Contactor driver damaged CONTACTOR DRIVER	(Alarm)	Stored
	This alarm indicates that the main contactor driver is not able to drive the load. The device itself or its driving circuit is damaged. This fault is not related to external components, so when it appears, replace the COMBIACX controller.		
78	Accelerator voltage not OK VACC NOT OK	(Alarm)	Stored
	This alarm occurs when the accelerator output voltage differs more than 1 V from the acquired minimum during PROGRAM VACC. In such a case, check the functionality of the accelerator. Perform the accelerator calibration wizard function.		
79	Invalid starting sequence INCORRECT START	(Warning)	
	This warning occurs because of an incorrect starting sequence. Use a tester to check for possible reasons for this alarm. The most likely reasons are: • Incorrect sequence made by the operator. • Accelerator was active at startup. • Tiller sensor was active at startup. • Brake release was active at startup. • Safety button was active at startup. If no signal was active at startup, the problem is in the COMBIACX controller.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
80	Direction switches active simultaneously FORW+BACK	(Warning)	
	This warning occurs when both travel demands are active at the same time. Use a tester to check for possible reasons for this warning. If both directions are active at the same time, check the accelerator and its wiring. If no direction signals are active at the same time outside the controller, the problem is in the COMBIACX controller.		
82	Encoder error ENCODER ERROR	(Alarm)	Stored
	This alarm occurs if the frequency supplied to the motor is higher than 40 Hz and the feedback signal from the encoder has a jump higher than 40 Hz within 20-40 milliseconds. This condition is related to a malfunction of the encoder. In such a case, check the encoder's mechanical functioning and its wirings connections. Also check the encoder's mechanical installation; if the encoder slips inside the housing, it causes this alarm. Also electromagnetic noise on the encoder can cause this alarm. In such a case, replace the encoder. If the alarm persists after replacing the encoder, the problem is in the COMBIACX controller.		
86	PEDAL WIRE KO PEDAL WIRE KO	(Alarm)	Stored
	The software checks for the connection of the two supply ends of the accelerator's potentiometer. The test consists of reading the voltage drop on a sense diode connected between NPOT and GND. If the accelerator gets disconnected on PPOT or NPOT, no current flows in this sense diode and the voltage on the NPOT connection drops down. This alarm occurs if the NPOT voltage is less than 0.3 V and also when the NPOT voltage is higher than 2 V (to detect also the condition of a broken sense diode). In such a case, check the voltage on the NPOT and the accelerator connections. 		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
185	Height sensor mismatch HT SENS.MISM	(Alarm)	Stored
	If the truck is not equipped with side stabilizers, check that the parameter INITIAL LIFT is not set to 2. If the truck is equipped with side stabilizers: • Check the wiring of the height sensor. • Disconnect the height sensor and test the redundant switches. If the states are not equal, test if the switch works by moving a magnet in front of it. • Check that the magnet counterpart (attached to the lifting carriage) is intact. • Check the wiring of the encoder card (extra I/O). If the problem persists, replace the height sensor.		
186	Motor temperature notification WARN. MOT.TEMP	(Warning)	
	This is only a notification. To limit further heat generation, the parameter cutback starts when the motor temperature reaches 120˚C. The truck can be used normally.		
187	Controller temperature notification WARN. TH.PROTECT	(Warning)	
	This is only a notification. To limit further heat generation, the parameter cutback starts when the controller temperature reaches 75˚C. The truck can be used normally.		
188	Load sensor value is out of range LOAD.SEN.OUT RNG	(Warning)	Stored
	This warning indicates a pressure sensor problem. Either the pressure sensor's voltage is not within the calibrated value range or it exceeds the calibrated values too much.		
189	Battery lock not closed BATTERY LOCK	(Alarm)	
	This alarm indicates that the battery lock is not closed. In such a case, check the battery lock state from the tester menu. If the lock is stated to be open while the battery is mechanically locked, check the battery lock sensor operation and wiring.		
190	Motor braking error BRK TIMEOUT	(Alarm)	Stored
	One possible cause for this alarm is too steep braking ramp (parameter). Try to lower the braking ramps from the parameters. Also braking at a slope when the truck is loaded can cause this error.		
192	Waiting for EPS EPS RELAY OPEN	(Alarm)	Stored
	This alarm indicates that there is some problem in the steering and the steering has frozen.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
193	Sideguard inputs illegal state SIDEGUARD INPUTS	(Alarm)	
	This alarm is caused by an invalid combination of side guard inputs. If both the side guards are in the correct position (both open or both closed), check from the tester menu if the logic inputs are the same. Check the correct positioning and operation of the side guard sensors. Also check the wiring of the sensors.		
194	Platform inputs illegal state PLATFORM INPUTS	(Alarm)	Stored
	This alarm is caused by an invalid combination of operator's platform inputs. When the operator's platform is either down with a driver standing on it or up, check from the tester menu that the logic inputs are correct. Check the correct positioning and operation of the platform sensors. Also check the sensor wiring.		
195	Platform inputs inactive WAITING DRIVER	(Warning)	
	This is a general warning indicating only that the truck is waiting for an operator.		
196	Invalid motor resistance MISMATCHED RM	(Alarm)	Stored
	This alarm occurs if the motor resistance is different than the value of the parameter MOTOR RESIST. In such a case, teach the new motor resistance value by setting the parameter MOTOR RESIST to 0 and saving the value while holding the tiller arm in the drive position. Restart the truck after the main contactor is opened. The new settings are active after the restart.		
197	Motor resistance acquiring failed WRONG ACQ	(Alarm)	Stored
	This warning occurs if the controller did not acquire the motor resistance value correctly. In most cases, this alarm signals that the controller cannot inject current in the motor coils for some reason. Check the motor connections. Also make sure that the main contactor is closed.		
198	Sensorless feedback hardware error ERROR FEEDBACK	(Alarm)	Stored
	This alarm indicates damage to the controller's hardware which provides feedback for the sensorless motor control. If the problem occurs permanently, replace the controller.		
199	PIN teach mode TEACHING PIN	(Warning)	
	This warning is displayed when the PIN code teaching procedure is active. It disappears when the teaching is finished. This warning should occur only if the truck is equipped with a PIN code lock.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
200	Waiting for valid PIN code WAITING FOR PIN	(Warning)	
	This warning indicates that the controller is waiting for a valid PIN code. If it occurs in a truck that does not use PIN code lock, check that the PIN CODE LOCK parameter is set to ABSENT. This warning should occur only if the truck is equipped with a PIN code lock.		
201	Accelerator teach mode LEVER TEACH IN	(Alarm)	
	This alarm indicates that the controller entered the throttle lever teaching mode. It disappears as soon as the teaching of the throttle lever is finished.		
202	Lift cutout timer active LIFT TIMEOUT	(Warning)	
	This warning is displayed when the lifting cut off timer has expired (the default value is seven seconds). In case of this warning, release the lift button. If the lift buttons are released and the warning persists: check the following: • The lift inputs are correct in the tester menu. • Operation of the tiller and the lift buttons is correct. • There are no short circuits in the lift button wirings.		
203	Pump voltage error PUMP VMN NOT OK	(Alarm)	Stored
	Cause 1: At startup The software checks the voltage on the –P terminal and expects it to remain at a steady value. This alarm occurs if the value does not remain steady. **Cause 2: During operation** If this alarm is displayed during operation, it indicates that the voltage on the –P terminal is too low when the main contactor is closed. The software waits for 30 seconds before displaying this alarm, because there are situations where the pump motor can rotate while the –P output is not activated (pump deceleration). During this time, it shows the WAIT MOT P STILL warning. In case of this alarm, check the following: • Pump motor internal connections • Pump motor power cable connections • Pump motor leakage to the truck frame If the pump motor connections are OK, the problem is in the COMBIACX controller.		
204	Pump voltage warning WAIT MOT.P STILL	(Warning)	
	See the description of the alarm 203 PUMP VMN NOT OK.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
206	High motor voltage during startup INIT VMN HIGH	(Alarm)	Stored
	Before switching the main contactor on, the software checks the power bridge voltage without driving it. The software expects the voltage to be at a steady state value. If the voltage is too high, this alarm occurs. In such a case, check the following: • Motor internal connections • Motor power cable connections • Motor leakage to the truck frame If the motor connections are OK, the problem is in the COMBIACX controller.		
207	Low motor voltage during startup INIT VMN LOW	(Alarm)	Stored
	Before switching the LC on, the software checks the power bridge voltage without driving it. The software expects the voltage to be at a steady state value. If the voltage is too low, this alarm occurs. In such a case, check the following: • Motor internal connections (ohm continuity) • Motor power cable connections • Motor leakage to the truck frame If the motor connections are OK, the problem is in the COMBIACX controller.		
208	Controller memory error (EEPROM) EEPROM KO	(Alarm)	Stored
	This alarm is caused by a hardware or software defect in the non-volatile embedded memory supporting the controller parameters. This alarm does not prevent the truck from operating, but the truck will work with the default values. In the case of this alarm, perform the CLEAR EEPROM operation. Switch the key off and on to check the result. If the alarm persists, replace the COMBIACX controller. If the alarm disappears, the previously stored parameter values will have been replaced by the default parameter values.		
210	Controller memory error (RAM) WRONG RAM MEM.	(Alarm)	Stored
	This alarm is caused by a hardware or software defect in the volatile embedded memory. The controller could be damaged and it should be replaced.		
211	Traction motor jammed STALL ROTOR	(Alarm)	Stored
	This alarm indicates that the traction rotor is stuck or the encoder signal is not correctly received by the controller. In the case of this alarm, check if the sign of FREQUENCY and ENCODER on the tester menu are the same. Also check that it is not zero during a traction request.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
212	Controller memory error (RAM wrong) WRONG RAM	(Alarm)	
	This alarm indicates that the used program, etc. is incorrect.		
213	Auxiliary output driver error AUX BATT. SHORT.	(Alarm)	Stored
	If this alarm occurs, the POSITIVE EB parameter is probably not set correctly. Set the parameter to LEVEL=0.		
214	Lowering valve circuit open EVP COIL OPEN	(Alarm)	Stored
	This alarm is displayed if the solenoid valve circuit is open. In such a case, check the following: • Wiring, verify that the solenoid valve coil circuit is in order between XA1_B/3 and fuse 3F1. • Solenoid valve coil If the wiring and the solenoid valve coil are OK, the problem is in the COMBIACX controller.		
215	Lowering valve coil, or driver shorted EVP DRIV. SHORT.	(Alarm)	Stored
	This alarm is displayed if the microcontroller detects a mismatch between the valve set-point and the voltage measured on the solenoid valve output. This can be caused by the following: • The solenoid valve coil circuit is shorted. • The COMBIACX solenoid valve driver is shorted. If there is low impedance between the negative of the solenoid valve coil and –Batt, the driver circuit is damaged and the COMBIACX controller must be replaced.		
217	Pump current feedback sensor damaged PUMP I NO ZERO	(Alarm)	Stored
	This alarm indicates that the pump motor's current feedback sensor has detected current flowing in the circuit while the pump motor is not running. This fault is not related to external components, so when it appears, replace the COMBIACX controller.		
218	Motor thermal sensor error SENS MOT TEMP KO	(Warning)	Stored
	This warning indicates a motor thermal sensor knockout, meaning that the motor thermal sensor has either short or open circuited. In such a case, check that the connector contacts and the cables are in order. Measure the resistance of the thermal sensor (960 Ω at 20°C).		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
219	Proportional valve error PEV NOT OK	(Alarm)	Stored
	This alarm indicates that the voltage on the positive line of the EV outputs (B2) is too high or too low. In such a case, check if the voltage dropped down because of a faulty load connected to B2. If not, replace the COMBIACX controller.		
220	Startup diagnosis for key-line failed KEY OFF SHORTED	(Alarm)	
	This is a startup diagnostic for the key line. This alarm occurs if the key line (XA1 C/1) voltage drops below the threshold level of 9.5 V. In such a case, check if the key input signal voltage drops below the undervoltage threshold due to external loads, such as DC/DC converters starting up or relays or contactors energizing or de-energizing. If no voltage transient is detected on the supply line and the alarm occurs every time the key is switched ON, the problem is in the COMBIACX controller.		
222	Magnetic brake driver error SMARTDRIVER KO	(Alarm)	
	This alarm indicates that the built-in smart driver is open and not able to provide the magnetic brake positive. In such a case, check the harness to see if the smart driver output XA1 B/1 is shorted to –Batt. If the output stays at a low level even when disconnecting the wire from the connector pin, the problem is in the COMBIACX controller.		
223	Short circuit main cont. or magn. brake coil COIL SHOR. MC-EB	(Alarm)	
	This alarm occurs when there is a short circuit in the main contactor or magnetic brake coil. The typical root cause for this alarm is a problem in the harness or in the coil. Check the connections and wiring between the controller and coils. If there are no external failures or problems, the problem is in the controller and it needs to be replaced.		
224	Another device is inhibiting controller WAITING FOR NODE	(Warning)	
	This warning indicates that the controller has received a message from the CAN bus that another controller or device in the network has experienced a failure. As a consequence, the traction controller itself cannot operate, but has to wait for the other controller or device to recover from the failure. In case of this warning, check the additional CAN bus devices for faults.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
226	Accelerator voltage out of range VACC OUT RANGE	(Alarm)	Stored
	This alarm is displayed if accelerator voltage is out of range. In such a case: • Teach the accelerator values again. • Check that the connectors and cables are in order. • Replace the accelerator and teach the accelerator new values.		
228	Tiller switch is open TILLER OPEN	(Warning)	Not shown in the display
	This warning occurs when the tiller is released after a fixed time in the standby mode with the main contactor open (30 seconds). After the next travel request, the warning disappears.		
229	Magnetic brake driver output error POS. EB. SHORTED	(Alarm)	Stored
	This alarm is displayed when the output of the built-in smart driver, which supplies the positive to the electromechanical brake coil, is high when the tiller and the brake release switch are open. In such a case, check the wiring to see that there is no extra positive supply connected to the electromechanical brake at the connector XA1 B/1 when the tiller and the brake release switch are open. If the output stays at a low value even when disconnecting the wire from the connector pin, the problem is in the COMBIACX controller.		
231	WATCHDOG#2 WATCHDOG#2	(Alarm)	
	This is a safety related, self-diagnosis test within the logic. The watchdog circuit is composed of two monostable multivibrators, so there is a double-check of the software execution. This alarm can be caused by a hardware failure in one or both of the multivibrators or it can be due to a software execution problem. In both cases, the problem is in the COMBIACX controller, which must be replaced.		
230	Failure in motor control LOW TORQUE	(Alarm)	Stored
	This alarm indicates a failure in the motor control. If this alarm occurs often, some of the hardware settings are probably not correct. Also check the motor connections.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
232	Auxiliary output load too high CONT. DRV. EV	(Alarm)	
	This alarm is displayed if the hydraulic valve coil load is too high for the controller valve driver circuit. In such a case, check the following: • Hydraulic valve coil condition • Wiring If the device or its driving circuit is damaged, replace the controller.		
233	Power MOSFET error in controller POWER MOS SHORT	(Alarm)	Stored
	Before switching the main contactor on, the software checks the power bridge. It turns the low and high side power mosfets on one by one and expects the phase voltage to decrease down to –Batt. If the phase voltage does not decrease, this alarm occurs. This fault is not related to external components, so when it appears, replace the COMBIACX controller.		
234	Electrovalve driver is shorted DRV. SHOR. EV	(Alarm)	Stored
	This alarm is displayed if the solenoid valve EVXX (XX = 01, 02 or 03) driver is shorted. Check if there is a short or low impedance between the negative of one of the coils and –Batt. If not, the driver circuit is damaged and the controller must be replaced.		
235	Electrovalve coil is shorted COIL SHOR. EV.	(Warning)	Stored
	This warning is displayed if one of the solenoid valve's EV (XY1 or XY2) coils is shorted. Check if there is a short or low impedance between the negative of the EV coil and +Batt. If not, the controller is damaged and must be replaced.		
236	Error in controller initialization at manufacturer CURRENT GAIN	(Alarm)	Stored
	This alarm indicates that the maximum current gain parameters are at their default values, meaning that the maximum current procedure has not been carried out. This fault is not related to external components, so when it appears, replace the COMBIACX controller.		
237	Error in analog input values ANALOG INPUT	(Alarm)	Stored
	This alarm occurs when the conversion of the analogue inputs provides frozen values. If the alarm occurs permanently, replace the COMBIACX controller.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
238	TILLER ERROR TILLER ERROR	(Alarm)	
	This alarm indicates that there is a mismatch between the brake release input and the tiller switch input. If both inputs are connected at the same time, TILLER ERROR is displayed. If this alarm occurs, release the brake release button and the tiller arm to the up position.		
239	Software not compatible with controller CONTROLLER MISM.	(Alarm)	Stored
	This alarm indicates that the software is not compatible with the controller. In case of this alarm, flash new software to the controller. If the alarm occurs permanently replace the COMBIACX controller.		
240	Error in lowering valve coil or driver EVP DRIVER OPEN	(Alarm)	Stored
	This alarm is displayed if the solenoid valve driver is damaged or the solenoid valve coil impedance is too low. In such a case, check the following: • Solenoid valve coil impedance • Wiring If the solenoid valve driver circuit is damaged, replace the controller.		
241	Lift and lower demands active simultaneously LIFT + LOWER	(Warning)	
	This alarm occurs when lifting and lowering demands are active at the same time. Use a tester to check the possible reasons for this alarm. If both demands are active at the same time, check the switches and wiring. If no lifting and lowering signals are active at the same time outside the controller, the problem is in the COMBIACX controller.		
242	Incorrect pump starting sequence PUMP INC START	(Warning)	
	This warning indicates an incorrect pump starting sequence. The possible reasons for this alarm are the following: • Pump request is active at startup. • Pump request is active but the tiller arm is not in the driving position. In the case of this alarm, check the following: • Wirings • Micro-switches • The alarm may also be caused by an error sequence made by the operator. If the wiring and micro switches are OK and the alarm was not caused by an operator error, replace the COMBIACX controller.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
243	Error in pump command value range PUMP VACC RANGE	(Alarm)	
	This alarm indicates that the lift lever voltage is out of range. In such a case, check the following: • Teach the lift lever values again. • Check that the connectors and cables are in order. • Replace the lift lever and teach the new values.		
245	Error in the pump command value PUMP VACC NOT OK	(Alarm)	
	This alarm occurs when the lift lever output voltage differs from the values acquired at calibration. In such a case, check the functionality of the lift lever. Perform the lift lever calibration wizard function.		
246	Error in magnetic brake driver error AUX DRIV. OPEN	(Alarm)	Stored
	This alarm indicates that the driver of the electromagnetic brake coil is not able to drive the load. The driver inside the COMBIACX controller is damaged, so the controller has to be replaced.		
247	Acquisition of gain values DATA ACQUISITION	(Warning)	
	This warning indicates acquisition of the current gains. The warning disappears when the acquisition is done. This alarm is a part of normal operation of the controller.		
248	Curtis display not present NO CAN MSG.	(Alarm)	Stored
	This alarm is displayed where there is no CAN message from the Curtis display. This alarm can be caused by a CAN bus malfunction, which blinds the traction-display communication. If not, it is an internal problem in the COMBIACX controller or in the Curtis display.		
249	Call for programmed maintenance CHECK UP NEEDED	(Warning)	
	This is just a warning calling for programmed maintenance. Set the CHECK UP DONE parameter to the ON value after the maintenance is carried out.		
250	Controller thermal sensor failure THERMIC SENS. KO	(Warning)	Stored
	This warning indicates that the output of the controller thermal sensor is out of range. This fault is not related to external components, so when it appears, replace the COMBIACX controller.		

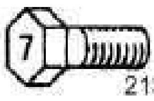
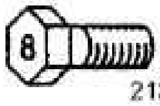
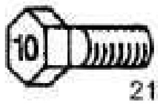
CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
251	Incorrect battery voltage WRONG BATTERY	(Alarm)	Stored
	At startup, the controller checks the battery voltage and verifies that it is within a certain window around the nominal value. If this is not the case, this alarm is displayed. In such a case, do the following: • Check that the controller's SET BATTERY parameter value matches the battery nominal voltage. • Check from the tester menu that the BATTERY VOLTAGE parameter shows the same value as the battery voltage measured with a voltmeter. If it does not match, perform the ADJUST BATTERY function. • Replace the battery. When adjusting the battery voltage, voltage should be measured from the key line, after the reverse polarity protection diode. A good measuring point is, for example, the emergency stop button terminal. If the battery voltage is measured anywhere else, it will cause invalid operation of the battery discharge indicator.		
252	Traction motor feedback amplifier failure WRONG ZERO	(Alarm)	Stored
	The outputs of the amplifiers (used to measure the traction motor voltage) are checked to be within a certain range. This alarm occurs when the voltage signals exceed 3 V or fall below 2 V at the startup. This fault is not related to external components, so when it appears, replace the COMBIACX controller.		
253	Error in motor control parameters SLIP_PROFILE	(Alarm)	Stored
	This alarm indicates that there is an error in the chosen slip profile parameters. Check the value of those parameters in the HARDWARE SETTING menu.		
254	Magnetic brake driver is shorted AUX DRIV.SHRT.	(Alarm)	Stored
	This alarm indicates that the driver of the magnetic brake is shorted. Check if there is a shortcut between XA1 A/4 and –Batt. Otherwise, the driver in the COMBIACX controller is damaged and the controller has to be replaced.		

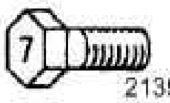
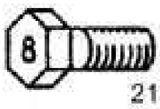
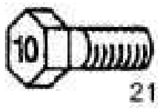
14 Service data

14.1 Special tightening torques

Traction wheel	80 Nm
COMBIACX Power controller terminal bolts	7 Nm (±1.4 Nm)
Traction motor power terminals	6 Nm
Motor and transmission top section	23 Nm

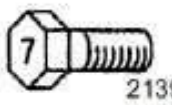
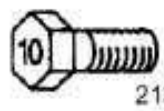
14.2 Tightening torque for standard bolts and nuts

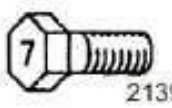
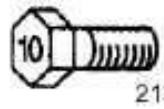
	Nominal size		Pitch		With spring washer								
					 213982			 213983			 213984		
	mm	in.	mm	in.	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
	6	0.24	1	0.04	7.4	0.75	5.4	9.6	0.98	7.1	12.7	1.3	9.4
	8	0.32	1.25	0.05	16.7	1.7	12.3	22.6	2.3	16.6	30.4	3.1	22.4
	10	0.39	1.25	0.05	34.3	3.5	25.3	45.1	4.6	33.3	69.6	7.1	51.4
	12	0.47	1.25	0.05	63.7	6.5	47.0	82.4	8.4	60.8	122.6	12.5	90.4
	14	0.55	1.5	0.06	102.0	10.4	75.2	132.4	13.5	97.6	192.2	19.5	141.8
	16	0.63	1.5	0.06	157.9	16.1	116.5	202.0	20.6	149.0	287.3	29.3	211.9
	18	0.71	1.5	0.06	224.6	22.9	165.6	292.2	29.8	215.5	413.8	42.2	305.2
	20	0.79	1.5	0.06	310.9	31.7	229.3	404.0	41.2	298.0	573.7	58.5	423.1
	22	0.87	1.5	0.06	413.8	42.2	305.2	537.4	54.8	396.4	763.0	77.8	562.7
	24	0.95	1.5	0.06	547.2	55.8	403.6	711.0	72.5	524.4	1006.2	102.6	742.1
	27	1.06	1.5	0.06	794.3	81.0	585.9	1032.6	105.3	761.6	1451.1	148.0	1070.5
	30	1.18	1.5	0.06	1100.3	112.2	811.5	1430.8	145.9	1055.3	2012.3	205.2	1484.2
	33	1.30	1.5	0.06	1467.1	149.6	1082.1	1907.4	194.5	1406.8	2680.2	273.3	1976.8
	36	1.42	1.5	0.06	1918.2	195.6	1414.8	2493.8	254.3	1839.4	3497.1	356.6	2579.3
	39	1.54	1.5	0.06	2461.5	251.0	1815.5	3198.8	326.2	2359.4	4469.9	455.8	3296.8

Metric fine thread	Nominal size		Pitch		With spring washer								
					 213982			 213983			 213984		
	mm	in.	mm	in.	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
	6	0.24	1	0.04	8.6	0.88	6.4	10.8	1.1	8.0	14.7	1.5	10.8
	8	0.32	1.25	0.05	19.6	2.0	14.5	26.5	2.7	19.5	36.6	3.7	26.8
	10	0.39	1.25	0.05	41.2	4.2	30.4	53.0	5.4	39.1	81.4	8.3	60.0
	12	0.47	1.25	0.05	74.5	7.6	55.0	97.1	9.9	71.6	144.2	14.7	106.3
	14	0.55	1.5	0.06	119.6	12.2	88.2	155.9	15.9	115.0	226.5	23.1	167.1
	16	0.63	1.5	0.06	182.4	18.6	134.5	237.3	24.2	175.0	338.3	34.5	249.5
	18	0.71	1.5	0.06	263.8	26.9	194.6	343.2	35.0	253.2	487.4	49.7	359.5
	20	0.79	1.5	0.06	365.8	37.3	269.8	475.6	48.5	350.8	674.7	68.8	497.6
	22	0.87	1.5	0.06	486.4	49.6	358.8	632.5	64.5	466.5	897.3	91.5	661.8
	24	0.95	1.5	0.06	643.3	65.6	474.5	836.5	85.3	617.0	1183.7	120.7	873.0
	27	1.06	1.5	0.06	934.6	95.3	689.3	1216.0	123.9	896.9	1707.3	174.1	1259.3
	30	1.18	1.5	0.06	1294.5	132.0	954.8	1682.8	171.6	1241.2	2367.3	241.4	1746.0
	33	1.30	1.5	0.06	1726.0	176.0	1273.0	2243.8	228.8	1654.9	3153.8	321.6	2326.1
	36	1.42	1.5	0.06	2256.5	230.1	1664.3	2934.1	299.2	2164.1	4114.0	419.6	3035.0
	39	1.54	1.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2776.0	5258.3	536.2	3878.3

Remarks: 1. The tolerance on the torque is ± 10%.

Remarks: 1. The tolerance on the torque is ± 10%
2. The torque is for "dry" condition.

	Nominal size		Pitch		With spring washer								
					 213982			 213983			 213984		
	mm	in.	mm	in.	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
	10	0.39	1.5	0.06	33.3	3.4	24.6	43.1	4.4	31.8	67.7	6.9	49.9
	12	0.47	1.75	0.07	58.8	6.0	43.4	76.5	7.8	56.4	115.7	11.8	85.3
	14	0.55	2	0.08	96.4	9.8	70.9	124.5	12.7	91.9	182.4	18.6	134.5
	16	0.63	2	0.08	147.1	15.0	108.5	191.2	19.5	141.0	274.6	28.0	202.5
	18	0.71	2.5	0.10	203.0	20.7	149.7	264.8	27.0	195.3	383.4	39.1	282.8
	20	0.79	2.5	0.10	286.4	29.2	211.2	371.7	37.9	274.1	536.4	54.7	395.6
	22	0.87	2.5	0.10	383.4	39.1	282.8	499.2	50.9	368.2	725.9	74.0	535.2
	24	0.95	3	0.12	492.3	50.2	363.1	640.4	65.3	472.3	924.8	94.3	682.1
	27	1.06	3	0.12	724.7	73.9	534.5	942.2	96.1	695.1	1350.4	137.7	996.0
	30	1.18	3.5	0.14	969.9	98.9	715.3	1259.2	128.4	928.7	1843.7	188.0	1359.8
	33	1.30	3.5	0.14	1328.8	135.5	980.1	1727.0	176.1	1273.7	2477.2	252.6	1827.1
	36	1.42	4	0.16	1676.0	170.9	1236.1	2180.0	222.3	1607.9	3199.9	326.3	2360.1
	39	1.54	4	0.16	2219.2	226.3	1636.8	2884.1	294.1	2127.2	4118.8	420.0	3037.9
	42	16.5	4.5	0.18	2754.7	280.9	2031.8	3581.4	365.2	2641.5	5137.7	523.9	3789.4

Metric coarse thread	Nominal size		Pitch		With spring washer								
					 213982			 213983			 213984		
	mm	in.	mm	in.	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
	10	0.39	1.5	0.06	39.2	4.0	28.9	51.0	5.2	37.6	79.4	8.1	58.6
	12	0.47	1.75	0.07	69.6	7.1	51.4	90.2	9.2	66.5	135.3	13.8	99.8
	14	0.55	2	0.08	112.8	11.5	83.2	146.1	14.9	107.8	215.7	22.0	159.1
	16	0.63	2	0.08	172.6	17.6	127.3	224.6	22.9	165.6	323.6	33.0	238.7
	18	0.71	2.5	0.10	239.3	24.4	176.5	311.9	31.8	230.0	451.1	46.0	332.7
	20	0.79	2.5	0.10	336.4	34.3	248.1	437.4	44.6	322.6	630.6	64.3	465.1
	22	0.87	2.5	0.10	392.3	40.0	289.3	587.4	59.9	433.3	842.4	85.9	621.3
	24	0.95	3	0.12	578.6	59.0	426.7	753.2	76.8	555.5	1088.5	111.0	802.9
	27	1.06	3	0.12	852.2	86.9	628.5	1008.2	113.0	817.3	1588.7	162.0	1771.7
	30	1.18	3.5	0.14	1140.5	116.3	841.2	1481.8	151.1	1092.9	2168.3	221.1	1599.2
	33	1.30	3.5	0.14	1563.2	159.4	1153.0	2031.9	207.2	1498.7	2915.5	297.3	2150.4
	36	1.42	4	0.16	1972.1	201.1	1454.6	2564.4	261.5	1891.4	3765.8	384.0	2777.5
	39	1.54	4	0.16	2610.5	266.2	1925.4	3393.1	346.0	2502.6	4845.5	494.1	3573.8
	42	1.65	4.5	0.18	3241.1	330.5	2390.5	4212.9	429.6	3107.3	6044.8	616.4	4458.4

Remarks: 1. The tolerance on the torque is ± 10%
2. The torque is for "dry" condition.

14.3 Maintenance check list

Legend: C = Check, R = Repair, Clean or Change, G = Grease

	BEFORE DAILY USE (USER)	MONTHLY (OWNER)	600 h OR ONCE A YEAR (SERVICE)	1,200 h OR EVERY SECOND YEAR (SERVICE)
Drive unit				
Transmission leakage check	C	C	C	C
Steering bearing			C	C
Fastening of the gearbox			C	C
Hydraulics				
Leakage checking		C	C	C
Cleaning the oil filter				R
Hydraulic oil change				R
Oil level		C	C	C
Hose and cylinder		C	C	C
Operation of the hydraulics	C	C	C	C
Pressure relief valves			C	C
Linkage				
Bearings			C	C
Linkage			C	C
Wheels				
Traction wheel	C	C	C	C
Traction wheel has to be replaced when its diameter reaches 218 mm			C	C
Load wheels	C	C	C	C
Castor wheel suspension			C	C
Battery				
Battery water level	C	C	C	C
Battery cable and connector	C	C	C	C

Battery automatic watering system		C	C	C

	BEFORE DAILY USE (USER)	MONTHLY (OWNER)	600 h OR ONCE A YEAR (SERVICE)	1,200 h OR EVERY SECOND YEAR (SERVICE)
Charger			C	C
Electrics				
Sensors			C	C
Tiller arm functions	C	C	C	C
Horn	C	C	C	C
Brake functions	C	C	C	C
Brake air gap and disc thickness			C	C
Controller power cable torque			C	C
Motor’s cable torque			C	C
EMS - Emergency switch	C	C	C	C
Alarm history checking/clearance			C	C
Cables and wiring			C	C
General				
Cleaning	C	C	C	C
Frame and the fork carriage	C	C	C	C
Gas springs	C	C	C	C
Type plate	C	C	C	C
Covers	C	C	C	C
Safety functions • Brake • Safety button • Battery lock • Warning decals • EMS - Emergency switch • Key switch	C	C	C	C
Fastening of the tiller arm	C	C	C	C
Options				
Entry and exit rollers		C	C	C

	BEFORE DAILY USE (USER)	MONTHLY (OWNER)	600 h OR ONCE A YEAR (SERVICE)	1,200 h OR EVERY SECOND YEAR (SERVICE)
DC converter			C	C
Internal charger			C	C
Load backrest	C	C	C	C
Working lights	C	C	C	C
Accessory bracket	C	C	C	C
Quick battery change mechanism	C	C	C	C

14.4 Lubrication

14.4.1 Hydraulic oil

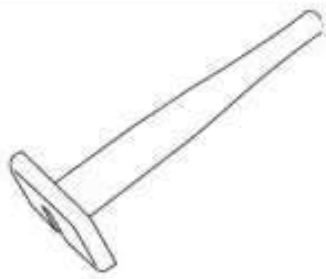
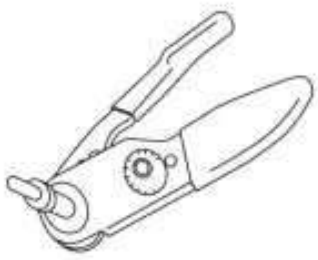
Normal operating conditions	ISO VG 32
Cold storage	ISO VG 15
Hot temperatures	ISO VG 46

14.4.2 Transmission oil

SAE 80W/90, API	**GL-5**

14.5 Special tools

FIGURE	DESCRIPTION	PART NUMBER
	Extraction tool for traction / pump controller signal line connectors	RL350505

FIGURE	DESCRIPTION	PART NUMBER
	Crimp tool for traction / pump controller signal line connectors	RL362138
	Extraction tool for main connector series	RL360058
	Crimp tool for main connector series	RL360400
	Extraction tool for the key switch	RL360402
	Crimp tool for the key switch connector	RL360401

15 Options

This chapter provides information about the optional features available for the truck.

Most of the options, with the exception of quick battery replacement, lever for lifting and lowering and electrical steering, can be installed to the truck after purchase.

Figure 87 below illustrates the available options.

NOTE: Electrical steering is not presented in the figure below.

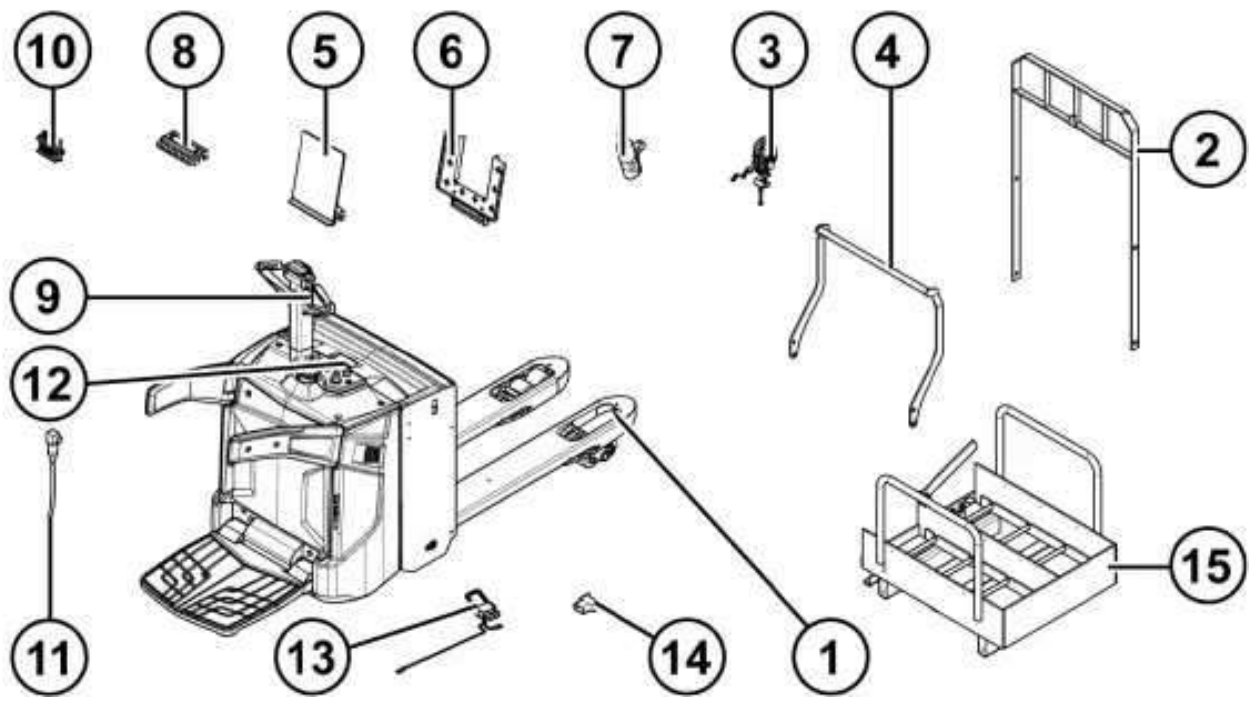


Figure 87. Options overview

1. *Pallet entry/exit rollers*
2. *Load support*
3. *Working lights*
4. *Accessory rack*
5. *List bracket*
6. *Computer rack*
7. *Bottle rack*
8. *Pen rack*
9. *Lever for lifting and lowering*
10. *Voltage converter*
11. *Pressure sensor*
12. *Battery lock sensor*
13. *Battery connector*
14. *Recharging plug*
15. *Quick battery replacement*

15.1 Pallet entry / exit rollers

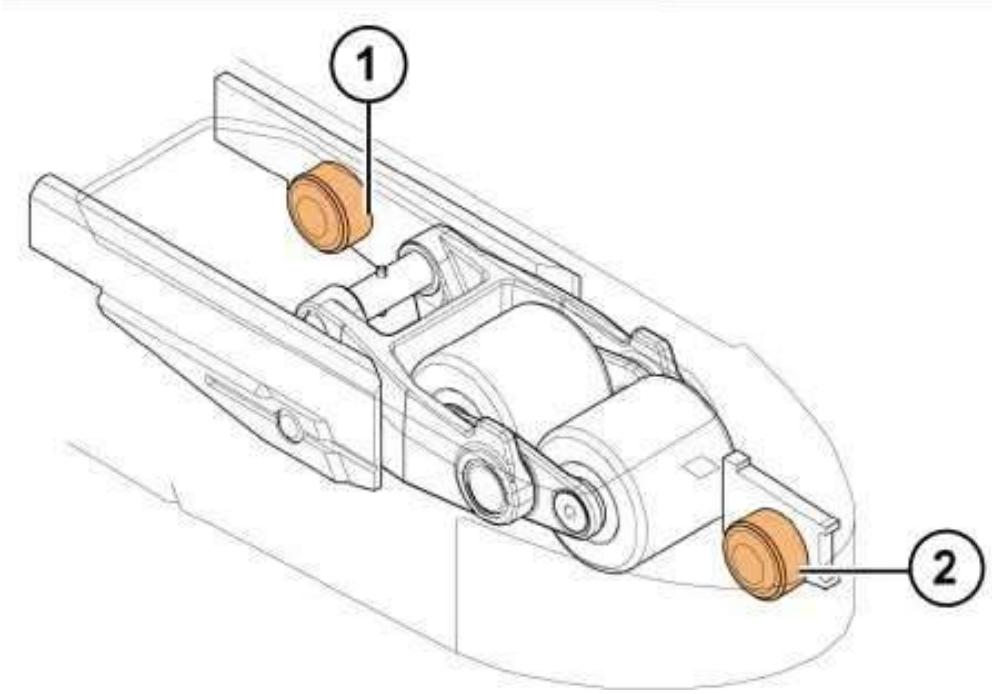
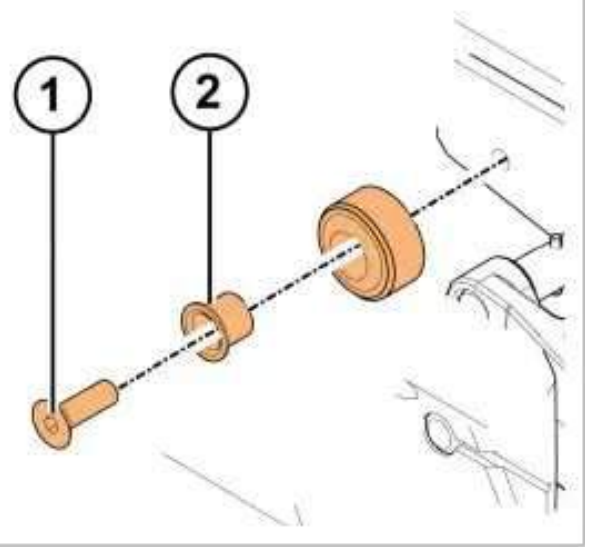


Figure 88. Pallet entry / exit rollers overview

The pallet entry / exit rollers make it possible to handle the truck's load pallets sideways.

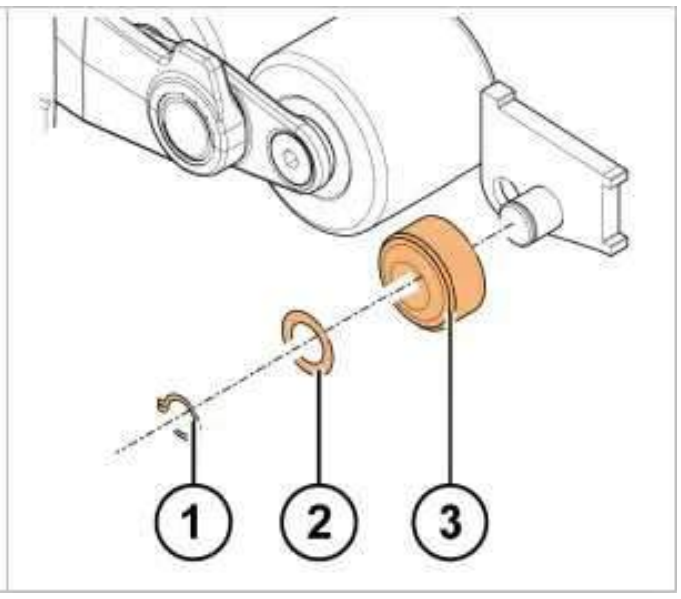
15.1.1 Disassembly of the pallet entry / exit rollers

Disassembly of the rear rollers:

1. Remove the bolts. **2.** Remove the sleeves from the rollers.	

Disassembly of the front rollers:

1. Remove the lock ring.
2. Remove the washer.
3. Remove the roller.



15.2 Load support

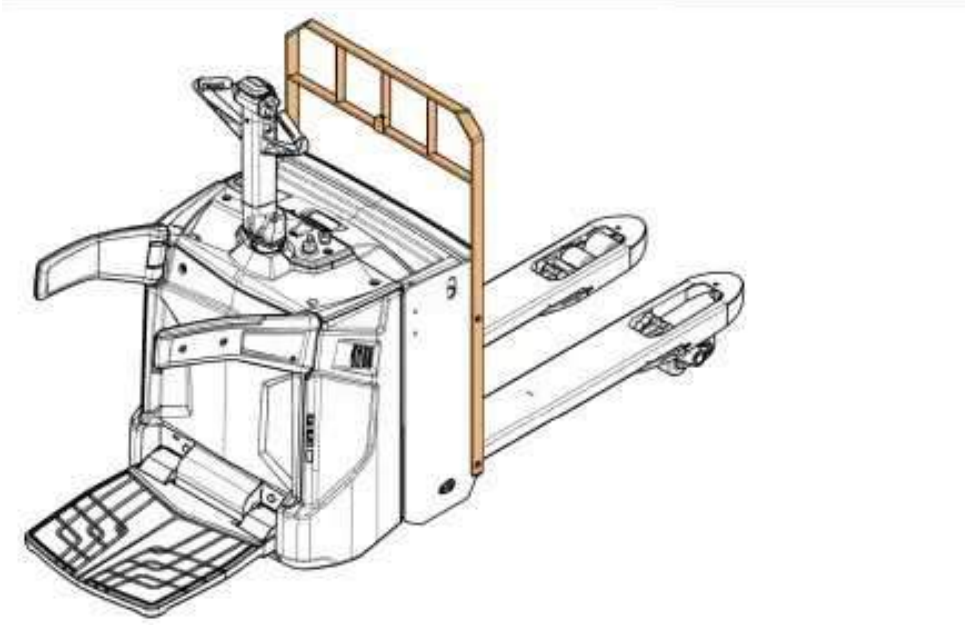
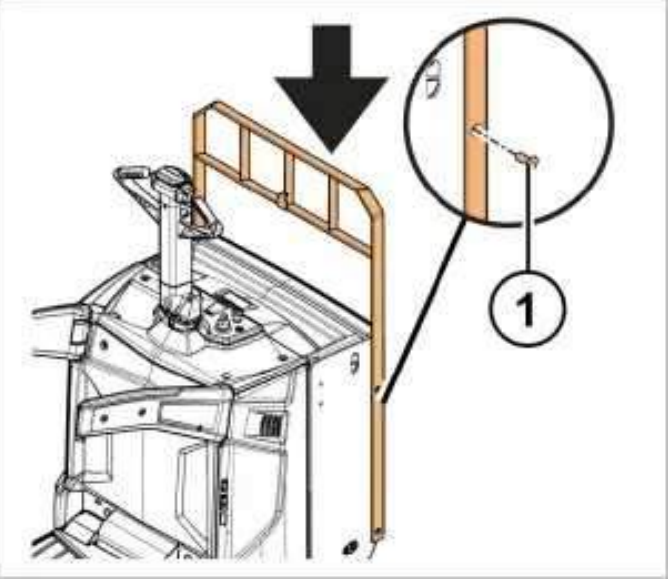


Figure 89. Load support overview

The load support protects the truck operator from unexpected load movements.

15.2.1 Installation of the load support

1. Install the load support to the front of the truck's battery compartment and screw it in place.	

15.3 Accessory rack

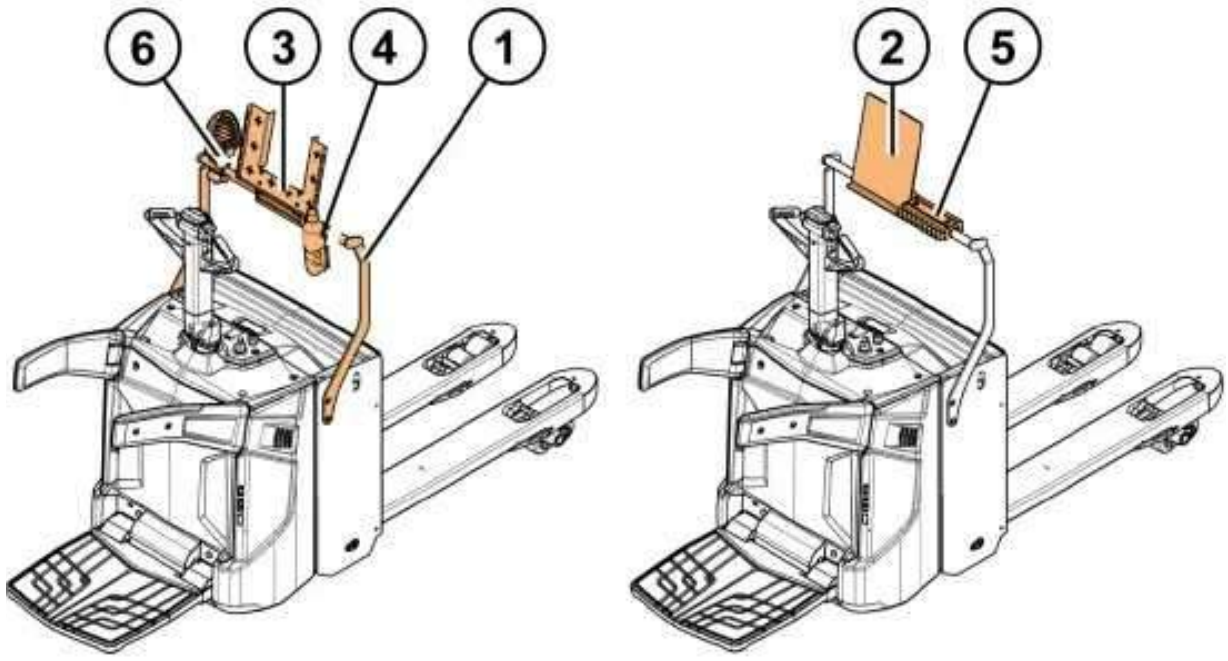


Figure 90. Accessory rack overview

1. *Accessory rack*
2. *List bracket*
3. *Computer rack*
4. *Bottle rack*
5. *Pen rack*
6. *Working light*

With the accessory rack, the truck can be equipped with accessories that make the operator's work easier. The following accessory-specific racks can be installed to the accessory rack:

- List bracket

  With the list bracket, all work papers can be carried conveniently on the truck. The list bracket is equipped with a holder, which keeps the papers in place.

- Computer rack

  With the computer rack, the truck can be equipped with a computer. The computer rack is suited for computers with a maximum width of 345 mm.

- Bottle rack

  The bottle rack provides a holder for drink bottles and cups.

- Pen rack

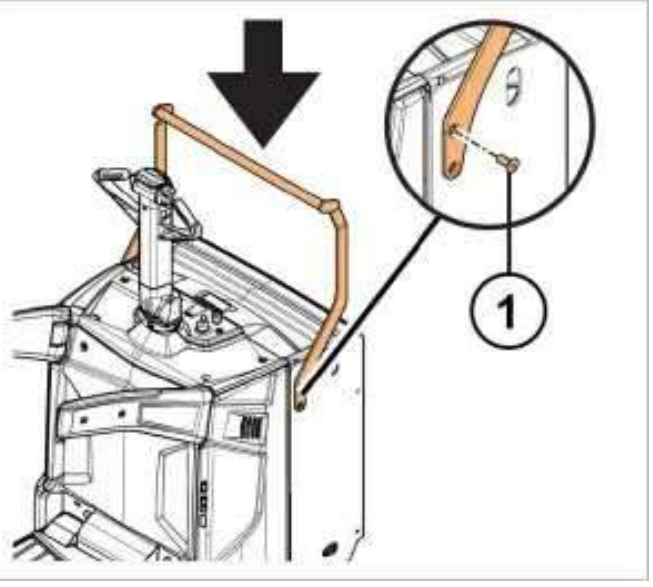
  The pen rack holds the truck operator's pens and small tools in place even during driving.

- Working lights

  Working lights enhance the truck operation in dim lighting conditions.

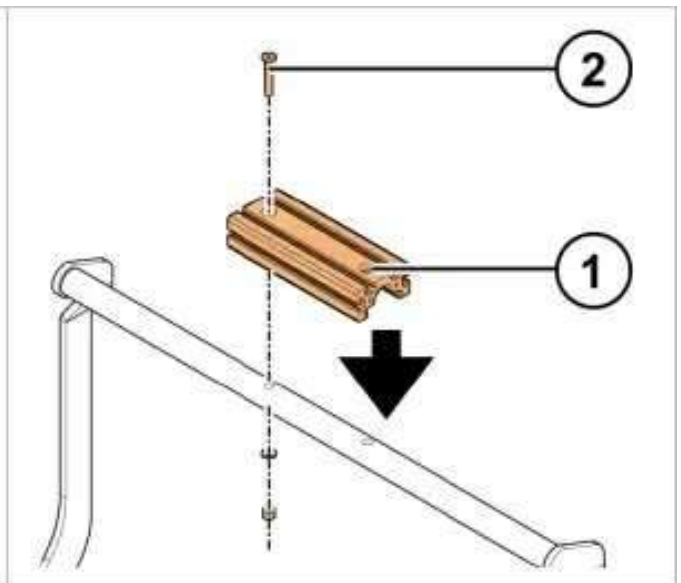
NOTE: Since both the list bracket and the computer rack are installed in the middle of the accessory rack, only one of these options can be installed at the same time.

15.3.1 Installation of the accessory rack

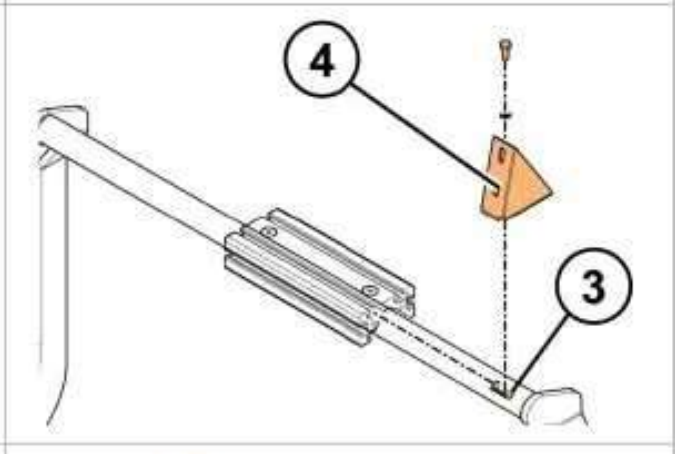
1. Install the accessory rack on top of the truck's battery compartment and screw it in place.	

15.3.1.1 Installation of the list bracket

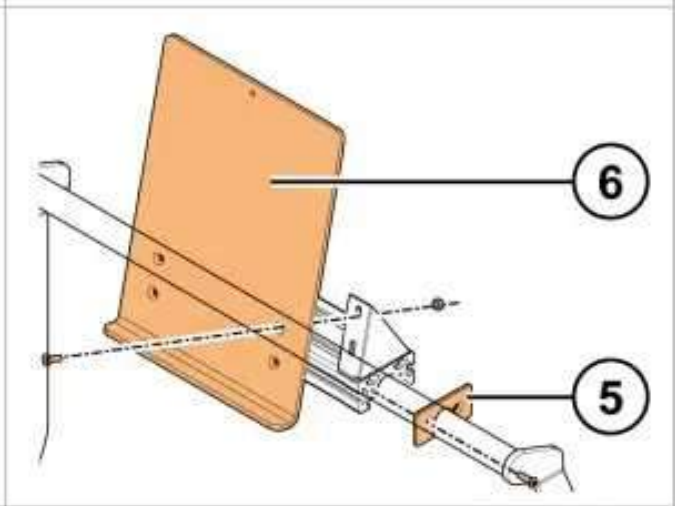
1. Install the list bracket's mounting bracket to the middle of the accessory rack.
2. Install and tighten the screws and nuts attaching the mounting bracket to the accessory rack.



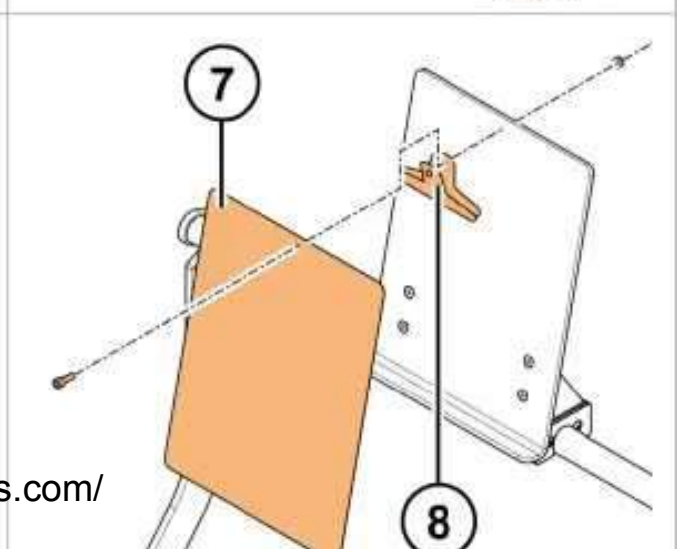
3. Slide the T-slot fasteners into the operator-side groove of the mounting bracket.
4. Screw the two mounting pieces into the T-slot fasteners.



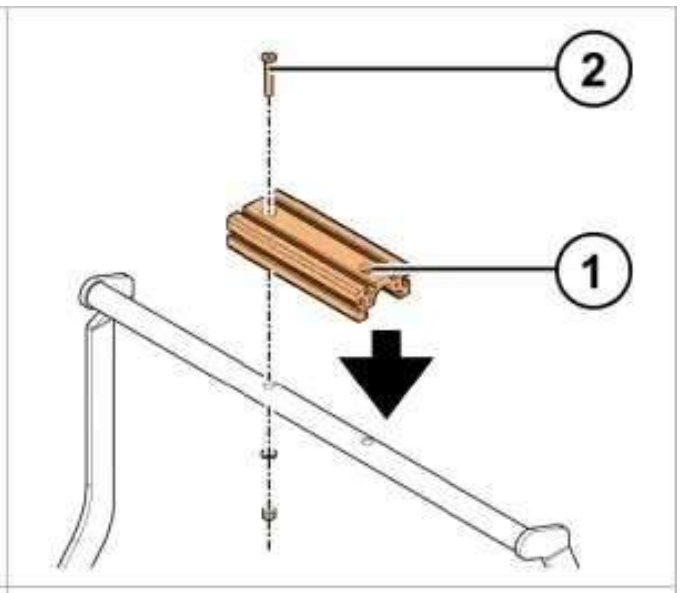
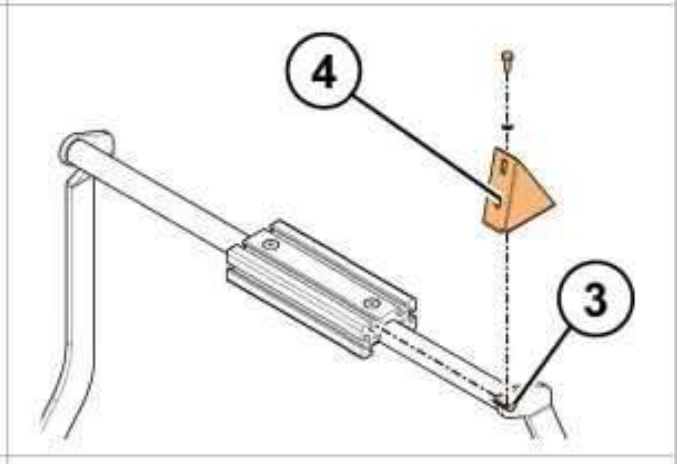
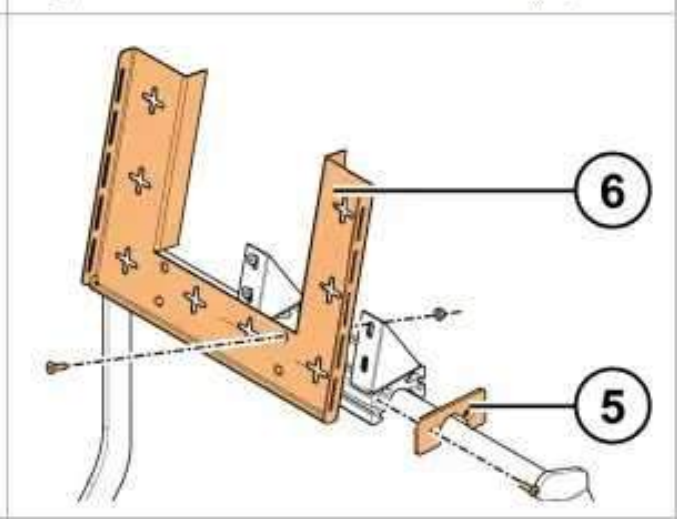
5. Screw the cover plates to the sides of the mounting bracket.
6. Screw the list bracket onto the mounting pieces.



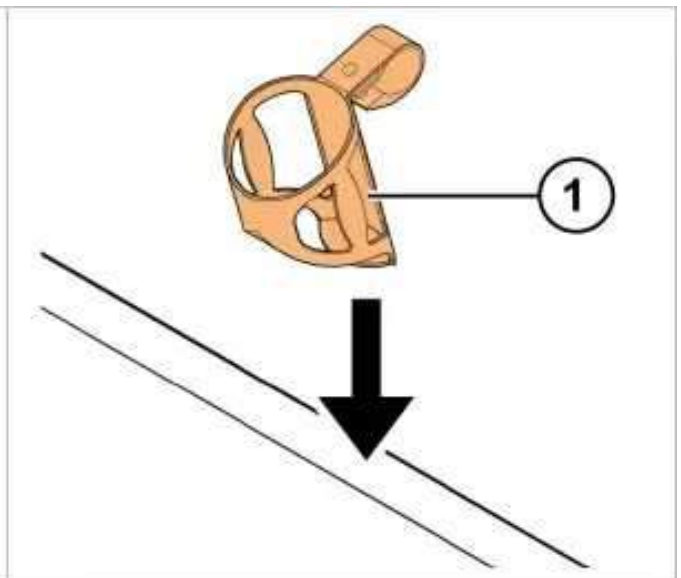
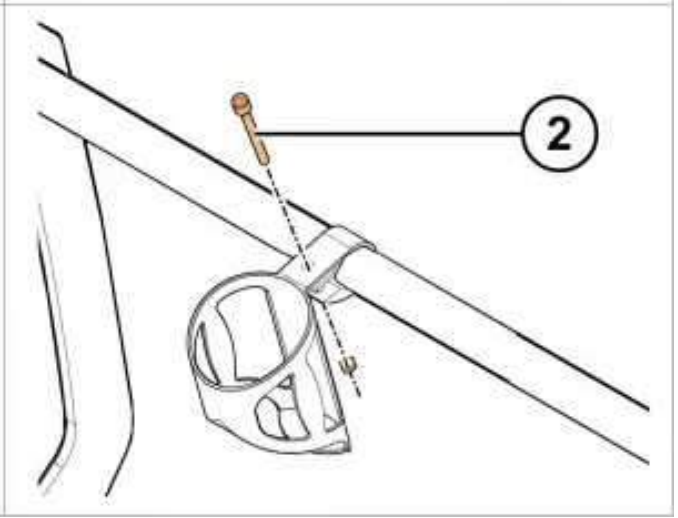
7. Install the writing pad to the list bracket.
8. Screw the writing pad and the holder onto the list bracket.



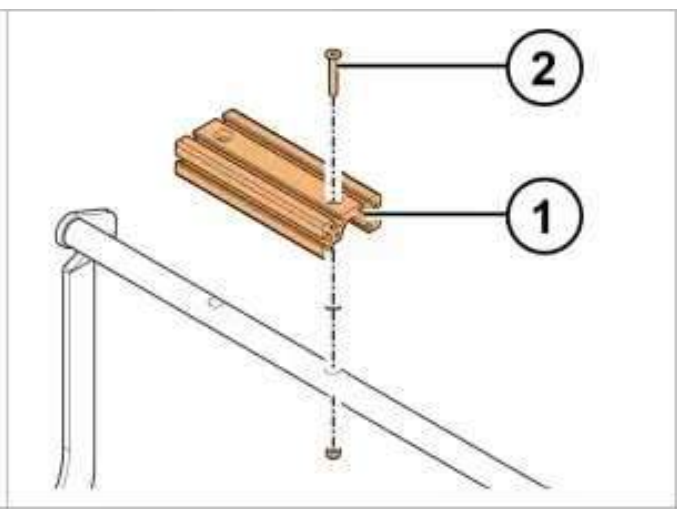
15.3.1.2 Installation of the computer rack

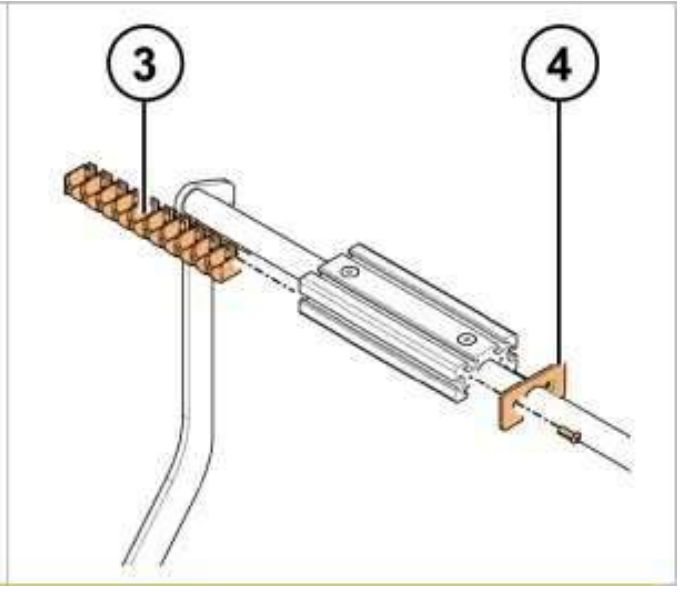
1. Install the computer rack's mounting bracket to the middle of the accessory rack. **2.** Install and tighten the screws and nuts attaching the mounting bracket to the accessory rack.	
3. Slide the T-slot fasteners into the operator-side groove of the mounting bracket. **4.** Screw the two mounting pieces into the T-slot fasteners.	
5. Screw the cover plates to the sides of the mounting bracket. **6.** Screw the computer rack onto the mounting pieces.	

15.3.1.3 Installation of the bottle rack

1. Attach the bottle rack to the accessory rack.	
2. Tighten the bottle rack with the M5x30 screw and M5 nut provided.	

15.3.1.4 Installation of the pen rack

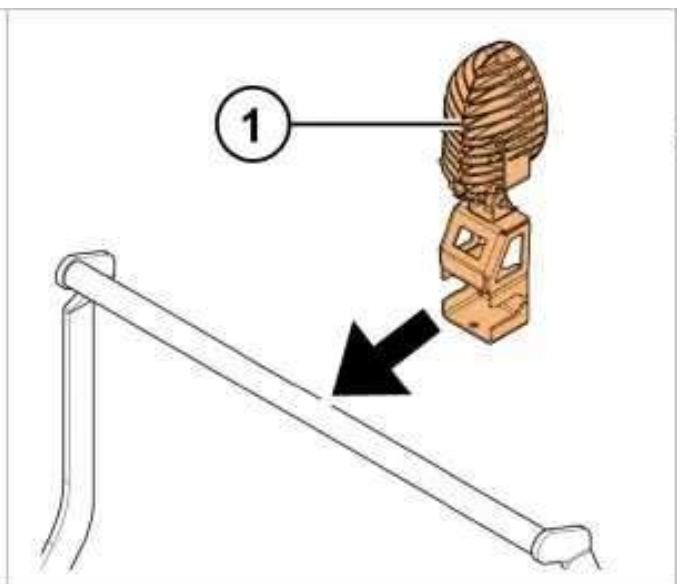
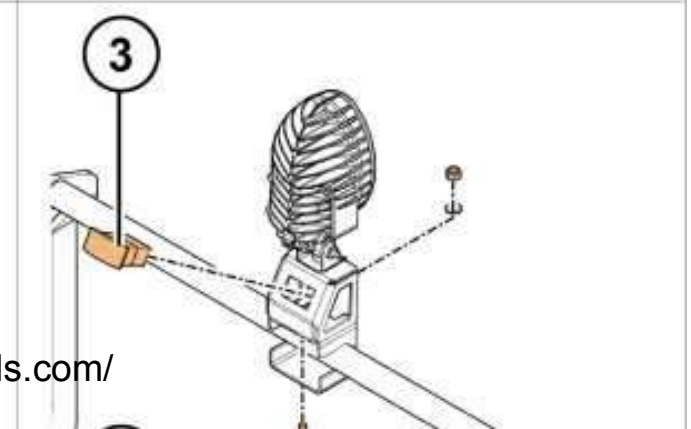
1. Install the pen rack's mounting bracket to either side of the accessory rack. **2.** Install and tighten the screws and nuts attaching the mounting bracket to the accessory rack.	

3. Slide the tool holder into the operator-side groove in the mounting bracket. 4. Screw the cover plates to the sides of the mounting bracket.	

15.3.1.5 Installation of the working lights

⚠ CAUTION

Always use the correct schematic diagram for the specific model you are servicing. The latest schematic diagrams are available from the manufacturer's Web site.

1. Attach the working lights' mounting bracket to the accessory rack.	
2. Install and tighten the screws and nuts attaching the mounting bracket to the accessory rack. 3. Install the working light power button.	

4. Connect the wires to the working light according to the truck model specific schematic diagram.
5. Tie the working light wires to the accessory rack and draw them via the hoist point hole into the battery compartment. See Figure 91 below.
6. Draw the working light wires following the battery cables through the holes in the battery compartment into the tractor compartment. See Figure 91 below.
7. Connect the working light wires according to the truck model specific schematic diagram.

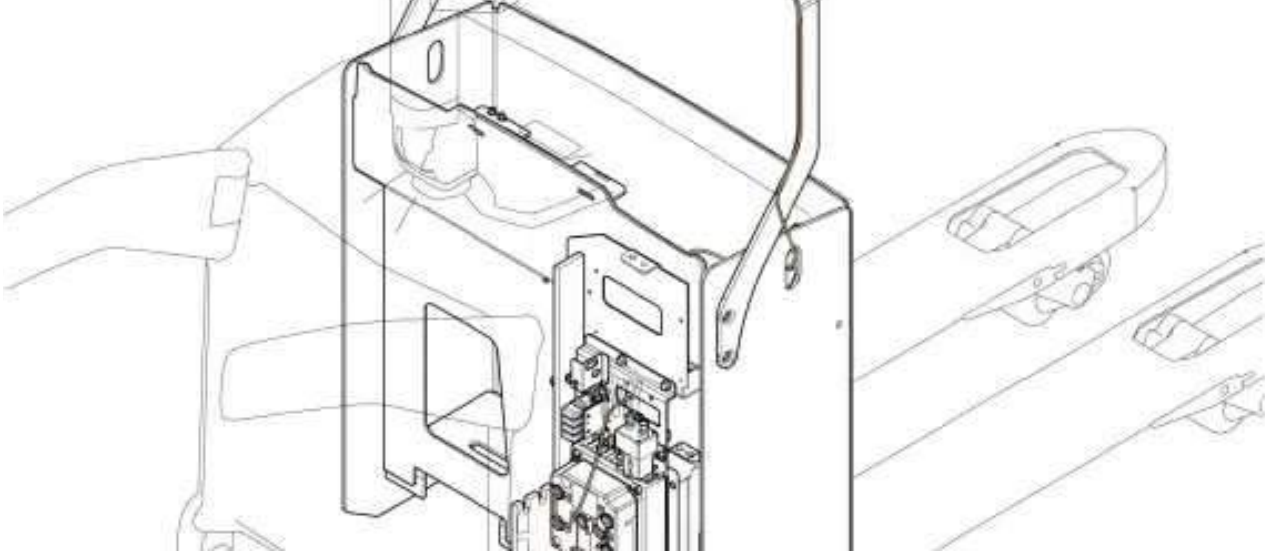


Figure 91. Working lights wiring overview

15.4 Lever for lifting and lowering

NOTE: The lever for lifting and lowering option is installed to the truck during manufacturing, so this option needs to be selected prior to purchasing the truck.

Figure 92. Lever for lifting and lowering overview

The levers for lifting and lowering allow easier operation with gloves on. The levers function in parallel to the lifting and lowering buttons.

15.4.1 Removing the controller for lifting and lowering

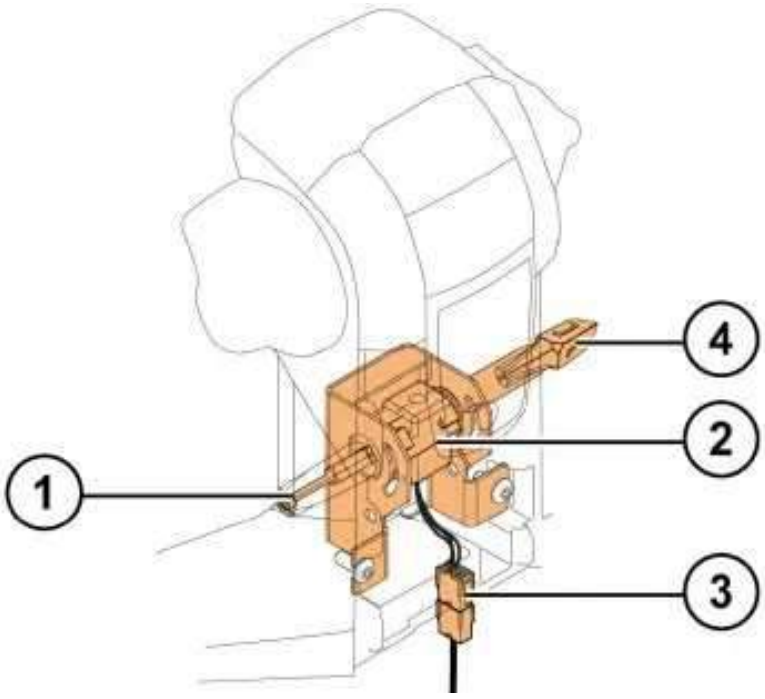
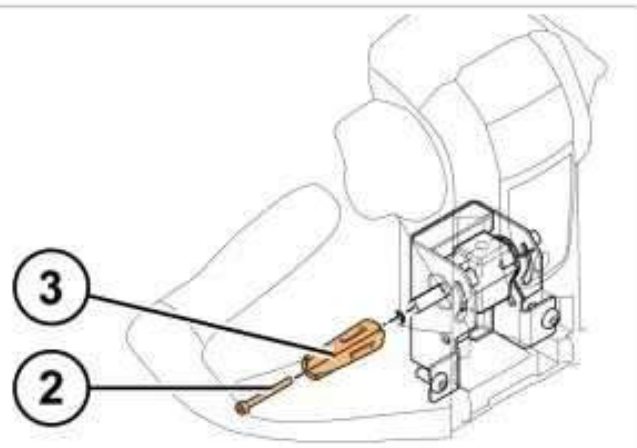
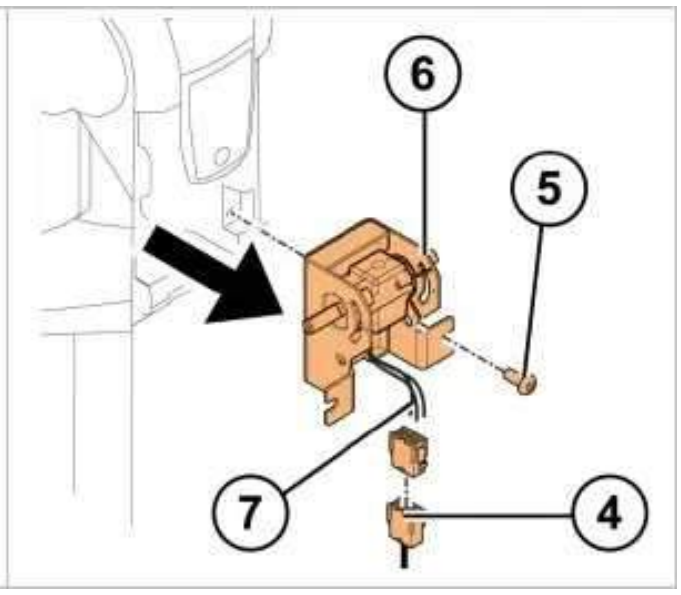


Figure 93. Removing the controller for lifting and lowering overview

1. *Screw*
2. *Controller for lifting and lowering*
3. *Connector*
4. *Controller levers*

1. Remove the tiller head. For instructions, see section 8.1.1.	
2. Remove the screws at the end of the levers. **3.** Remove the levers.	

4. Remove the lever connector.
5. Remove the two screws from the mounting bracket.
6. Remove the controller.
7. Remove the mounting bracket.



15.4.2 Installing the controller for lifting and lowering

1. Connect the lever wires to the connector. The pin locations from 1 to 3 are marked on the connector with lines and help you in determining the rest of the pin locations. Details of the controller wires and their pin locations are available in Figure 94 and Table 11 below.
2. Install the controller and tighten the screws.
3. Connect the controller connector.
4. Install the levers.
5. Tighten the screws at the end of the levers.
6. Calibrate the controller. For instructions, see section 9.1.

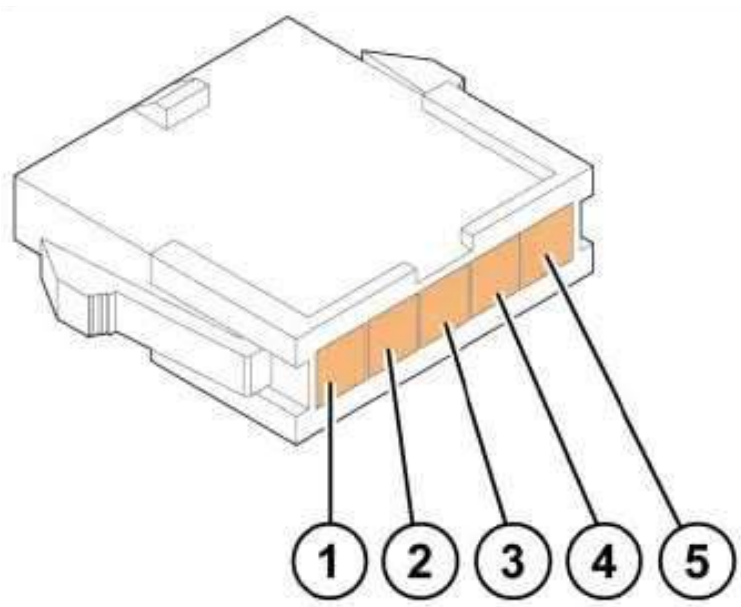


Figure 94. Controller for lifting and lowering pin locations

Table 11. Controller for lifting and lowering wire details

PIN	WIRE COLOR	DESCRIPTION
1	Green	Sensor +24 V
2	White/Brown	Sensor GND
3	White/Black	Output signal
4	-	-
5	-	-

15.4.3 Calibrating the controller for lifting and lowering

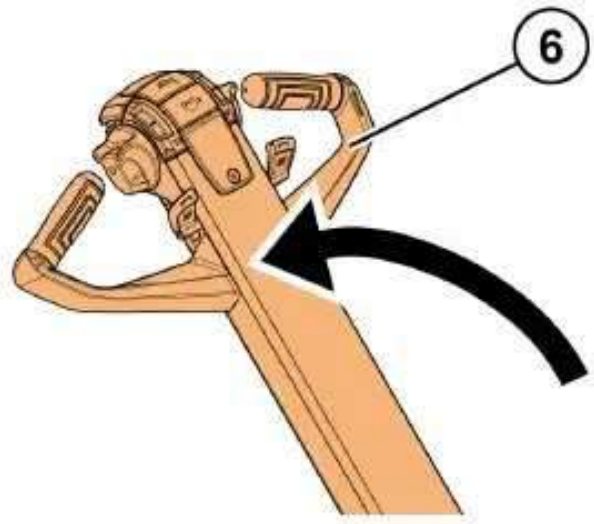
If the controller for lifting and lowering or the Zapi COMBIACX Power controller is changed, the controller for lifting and lowering must be calibrated. Also if the truck does not drive smoothly, it is recommended that you always first perform this calibration.

15.4.3.1 Acquiring the VACC with TruckTool

1. Connect TruckTool to the truck.
2. In TruckTool, go to the Wizards view.
3. Select the "Controller for lifting and lowering calibration" option and click the "Start wizard" button next to it.

4. Make sure that the truck's lever for lifting and lowering is in the middle position.

5. In TruckTool, click "Start" in the Wizard popup window.

6. Pull the truck's tiller to the driving position and move the lever for lifting and lowering to one end position and then to the other end position.	
7. In TruckTool, check that the displayed values are acceptable and click "Stop".	

If the process fails, update the firmware on the controller and try again.

15.4.3.2 Acquiring the VACC without Truck Tool

1. During key-on, lower the forks and turn the accelerator forward at the same time and hold the buttons down for 15 seconds.

   The truck enters the accelerator teach-in mode.
2. Release all the buttons.
3. Teach the controller for lifting and lowering by moving the lever for lifting and lowering to one end position, then to the other end position.
4. Release the lever for lifting and lowering.
5. Press the safety button to save the settings.
6. Restart the truck.

15.5 Voltage converter

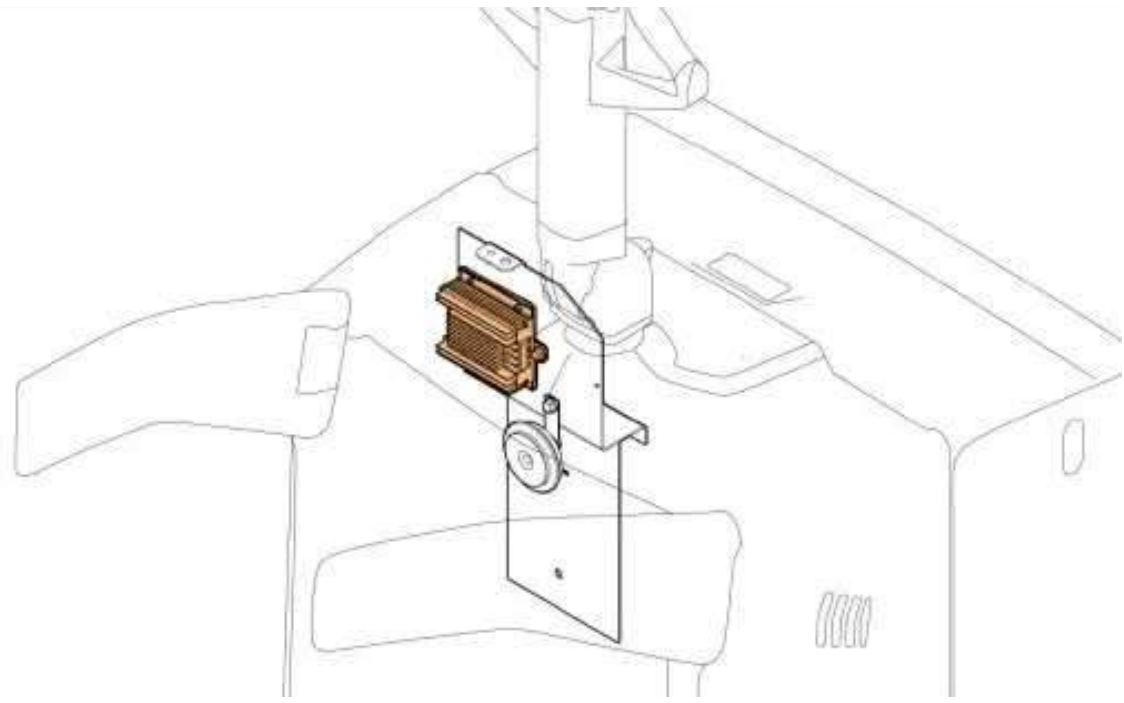


Figure 95. Voltage converter overview

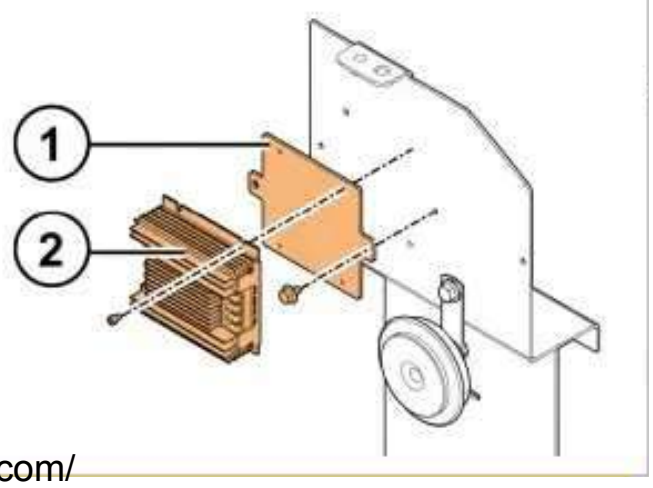
The voltage converter (12 V, 12.5 A) allows multiple peripherals, such as a PC, a barcode scanner or a label printer, to be connected to the truck's electrical system.

15.5.1 Installation of the voltage converter

⚠ CAUTION

Always use the correct schematic diagram for the specific model you are servicing. The latest schematic diagrams are available from the manufacturer's Web site.

1. Screw the voltage converter's mounting plate into the truck frame above the horn.
2. Screw the voltage converter onto the mounting plate.
3. Connect the voltage converter wires according to the truck model specific schematic diagram. See Figure 96 below.



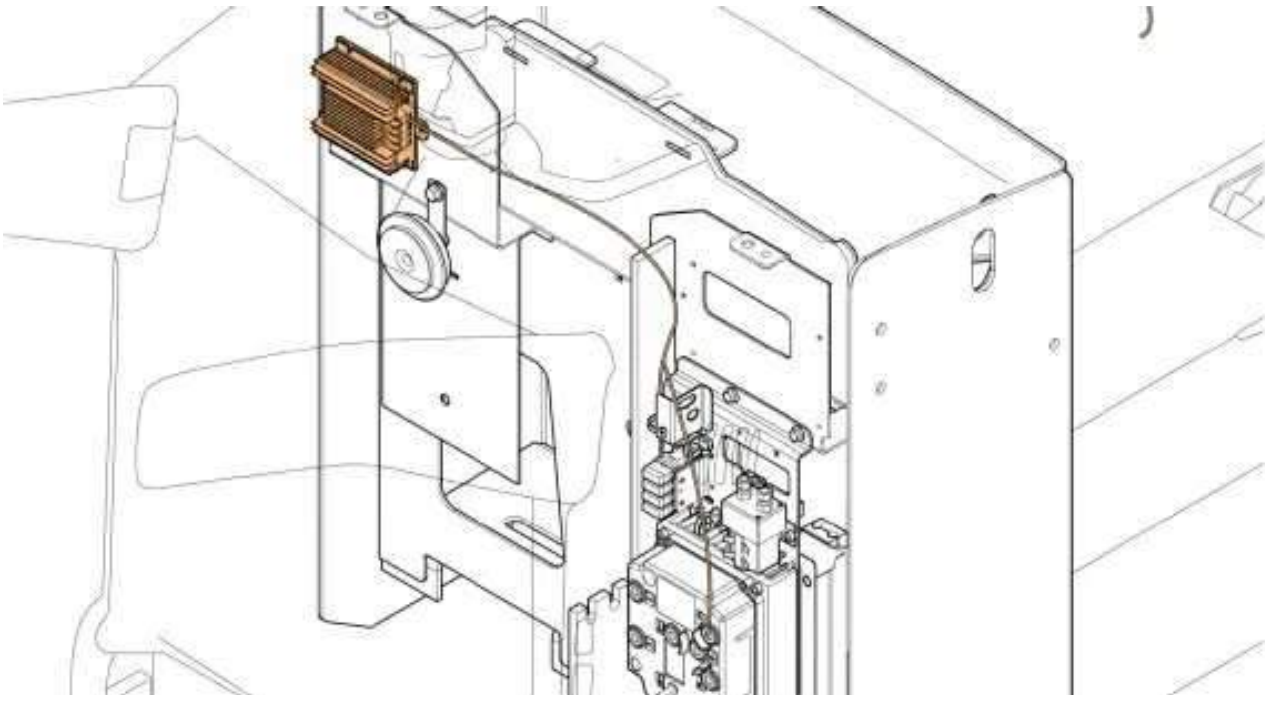


Figure 96. Voltage converter wiring overview

15.6 Pressure sensor

The pressure sensor is used for monitoring the hydraulic pressure of the hydraulic system. With this sensor, the traction controller can adjust the driving speed according to the lifted load. The pressure sensor has an output signal of 1–6 Vdc in the range of 0-250 bar oil pressure.

Type	Pressure transmitter
V_s	9 - 30 Vdc
Output signal	1 – 6 VDC / < 5 mA
Measuring range	0 – 250 bar
Electrical wiring	1 = L+ (Supply) 2 = OUT (output signal) 3 = M (GND)
Spare part	RL469001

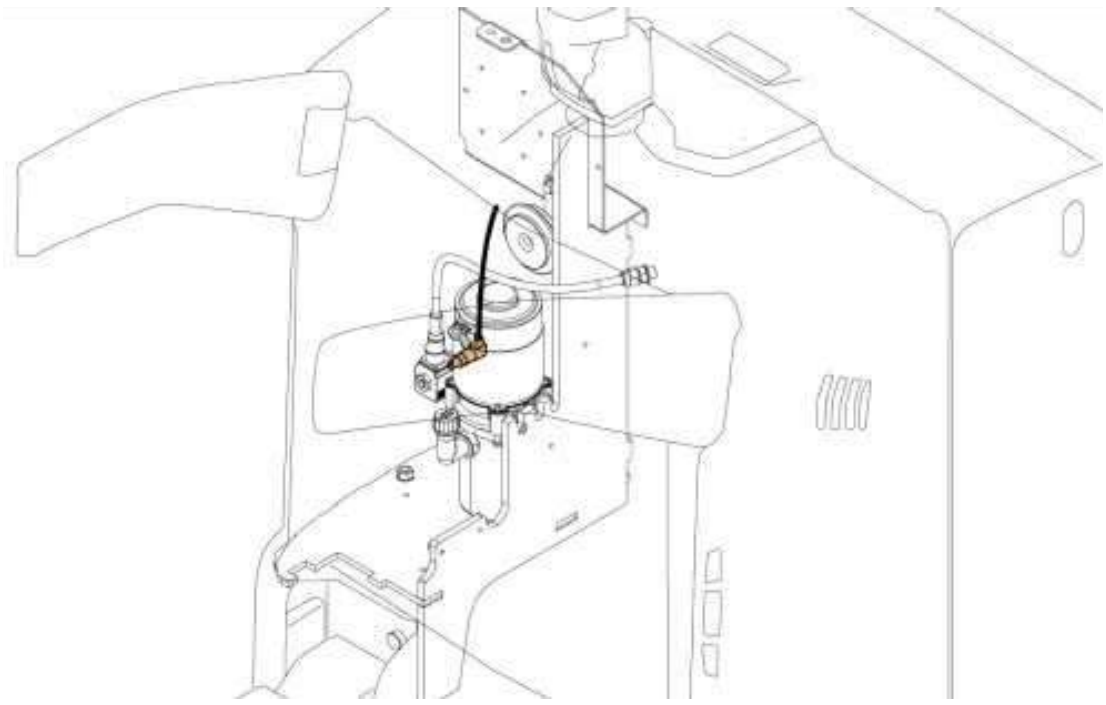


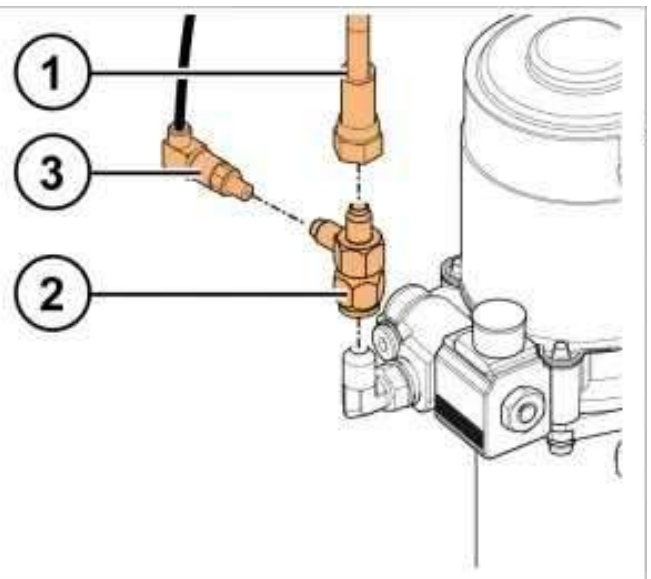
Figure 97. Pressure sensor overview

15.6.1 Installation of the pressure sensor

⚠ CAUTION

Always use the correct schematic diagram for the specific model you are servicing. The latest schematic diagrams are available from the manufacturer's Web site.

1. Disconnect the hydraulic oil hose from the connector.
2. Install a T-fitting between the hydraulic oil hose and the connector.
3. Install the pressure sensor to the T-fitting.



4. Connect the pressure sensor wires according to the truck model specific schematic diagram.

15.6.2 Pressure sensor functionality check

1. Lower the load handling fork to its lowest position to minimize the hydraulic system's oil pressure.
2. Measure the output signal voltage level with a multimeter between the signal output terminal (XB42/2) and the minus terminal (XB42/3).

   The nominal output signal level is ~1 Vdc when the hydraulic pressure is 0 bar.

   The output signal level rises relatively to the hydraulic oil pressure and with the maximum load (2000 kg) the value is close to 4 Vdc.
3. If the pressure sensor values do not match the above, replace the sensor.

15.7 Battery lock sensor

The battery lock sensor prevents the operation of the truck, if the battery is not properly locked in place.

Type	Inductive proximity sensor
Size	Rectangular, 10 mm x 16 mm x 28 mm
V_s	10 - 30 Vdc
Switching output	PNP, NO
Electrical wiring	DC 3-wire, V_s = BRN, GND = BLU, Signal output = BLK
Sensing range	3 - 6 mm
Spare part	RL600362

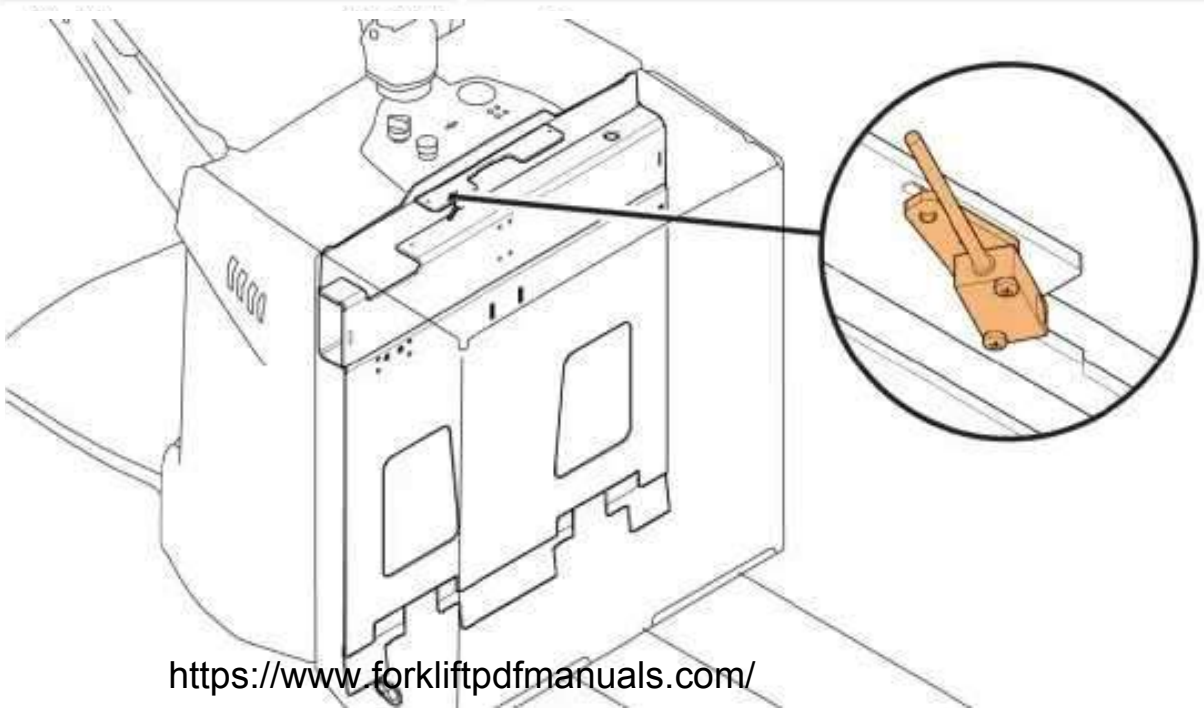


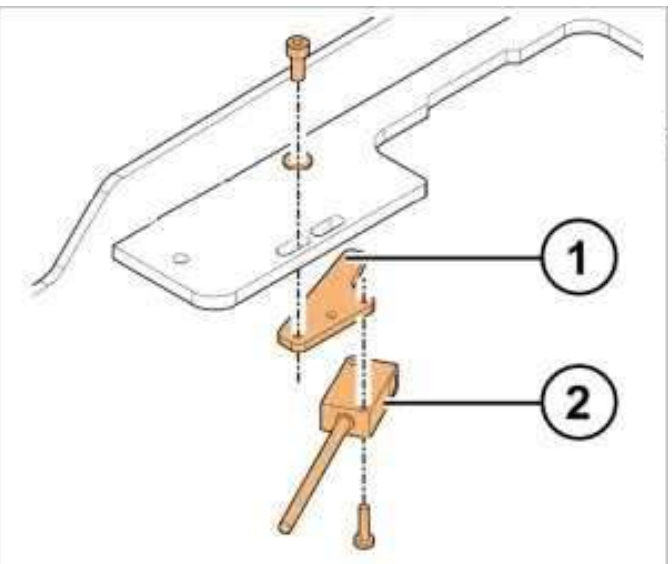
Figure 98. Battery lock sensor overview

15.7.1 Installation of the battery lock sensor

⚠ CAUTION

Always use the correct schematic diagram for the specific model you are servicing. The latest schematic diagrams are available from the manufacturer's Web site.

1. Screw the battery lock sensor's mounting plate into the truck frame next to the battery lock.
2. Screw the battery lock sensor onto the mounting plate.



3. Draw the battery lock sensor wires following the battery cables through the holes in the battery compartment into the tractor compartment. See Figure 99 below.
4. Connect the battery lock sensor wires according to the truck model specific schematic diagram.
5. With TruckTool, set the parameter A14 function to OPTION #1.

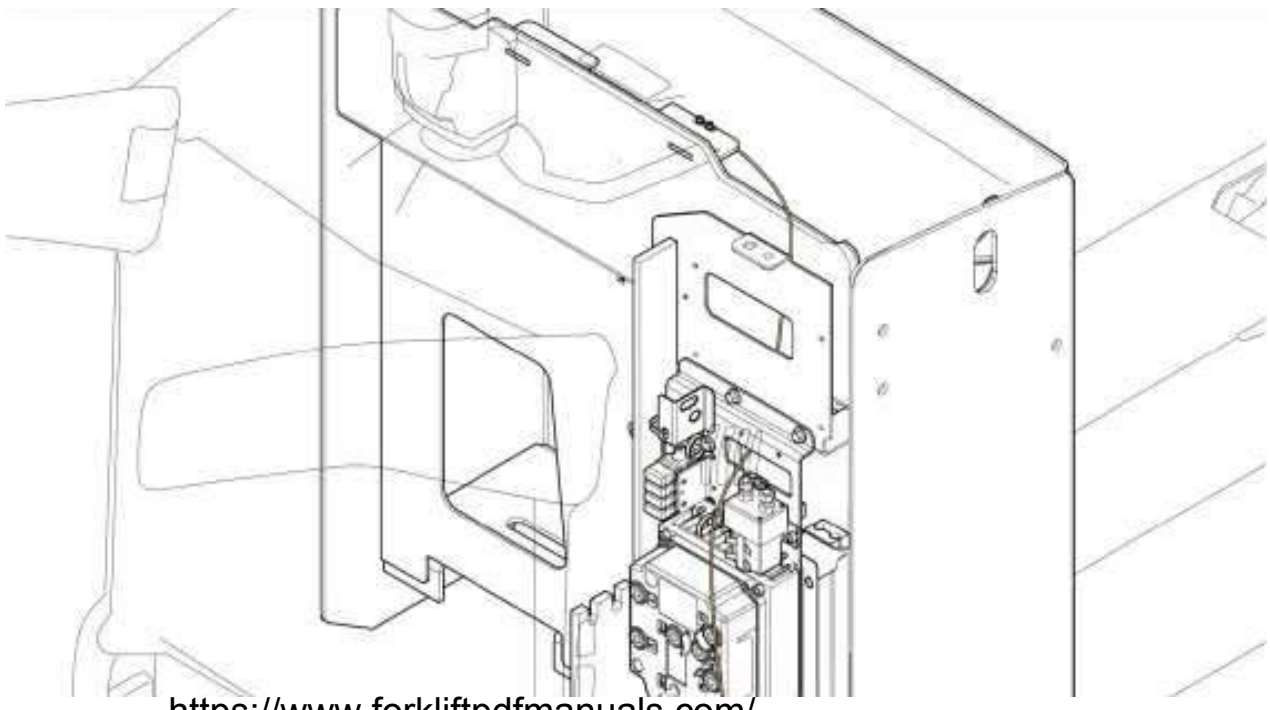


Figure 99. Battery lock sensor wiring overview

15.7.2 Battery lock sensor functionality check

1. Connect the supply voltage between the brown (+) and blue (-) wires.
2. Measure the supply voltage between the wires.

   The value should be +24Vdc.
3. Measure between the blue (-) and black (output) wires on the voltage area.

   When a supply is connected and there are no metallic objects within the sensing range, the value is approximately 0V.

   When a metallic object is moved within the sensing range, the value is the same as the supply voltage, i.e. +24Vdc.
4. If the values do not match the above, replace the sensor.

15.8 Battery connector

This option is a replacement for a defective battery connector.

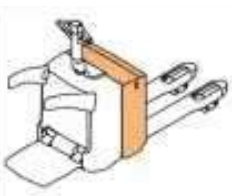
NOTE: Make sure that you set the mechanical voltage selector to the correct battery voltage (24 V)! Also note the polarity of the battery cables.

15.9 Recharging plug

This option is a replacement for a defective recharging plug.

NOTE: Make sure that you set the mechanical voltage selector to the correct battery voltage (24 V)! Also note the polarity of the battery cables.

15.9.1 Replacing the recharging plug



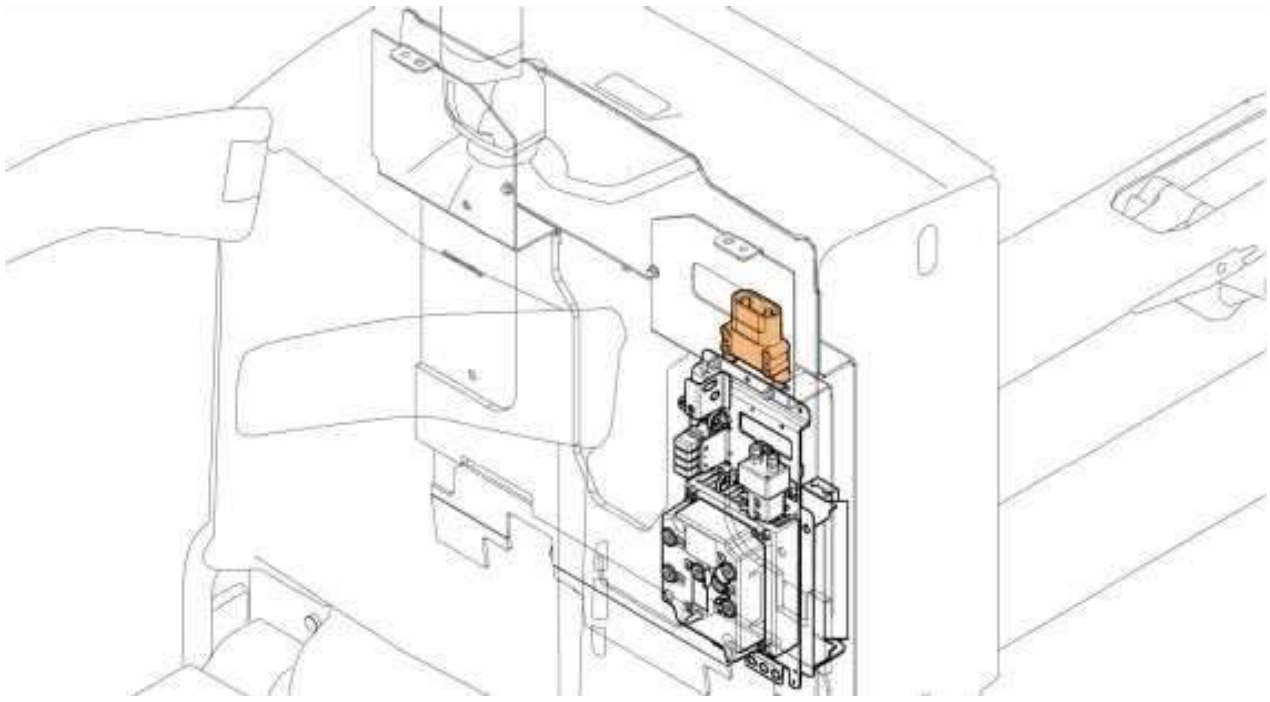
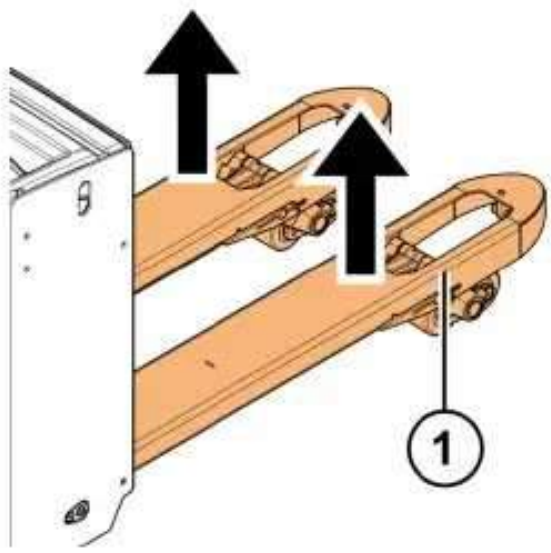
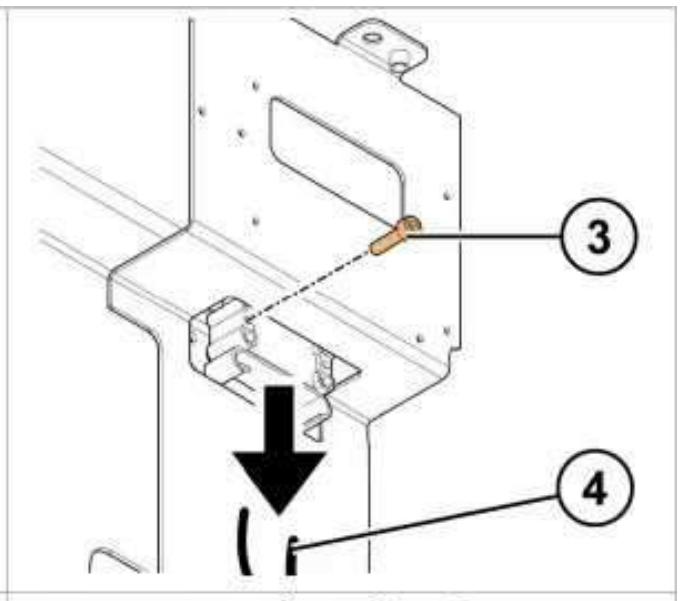
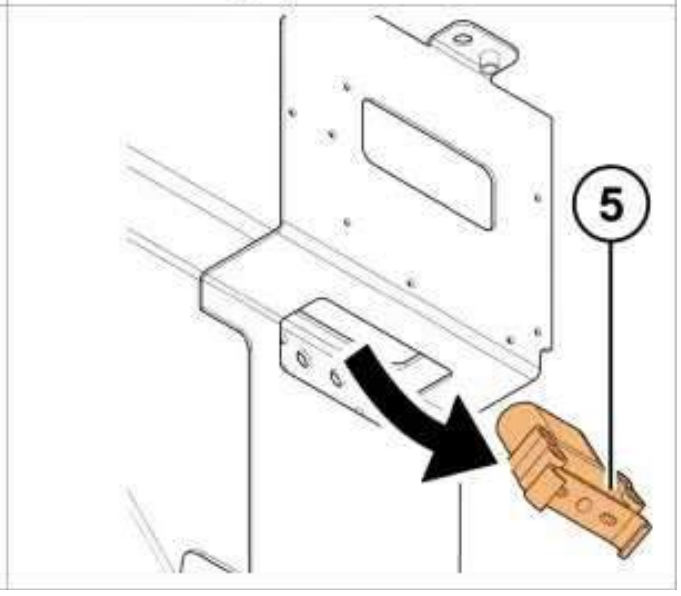


Figure 100. Recharging plug overview

Instructions for removing the recharging plug are provided below. Install the recharging plug by repeating the steps in reversed order.

1. Lift the forks of the truck to their upmost position.	
2. Remove the electric panel. For instructions, see the steps 1-3 in the section 8.2.6.	

3. Remove the bolts of the battery connector. **4.** Disconnect the battery connector cabling.	
5. Remove the battery connector.	

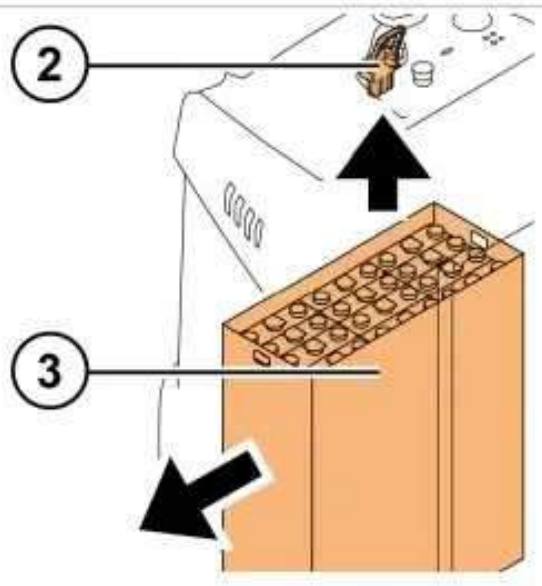
15.10 Quick battery replacement

NOTE: The quick battery replacement option is installed to the truck during manufacturing, so this option needs to be selected prior to purchasing the truck.

The quick battery replacement device enables changing the battery without the use of a lifting device.

1. Open the battery cover. For instructions, see the section 5.4.4.

2. Disconnect the battery connector.
3. Pull out the battery



4. Insert a new battery (verify the battery type and voltage).
5. Connect the battery connector. Make sure that the battery cables remain completely safe within the frame of the truck.
6. Close the battery cover. The cover acts as a battery locking device. Make sure that the locking button returns all the way to the locking position.

15.10.1 Removing the rubber absorbers with quick battery replacement

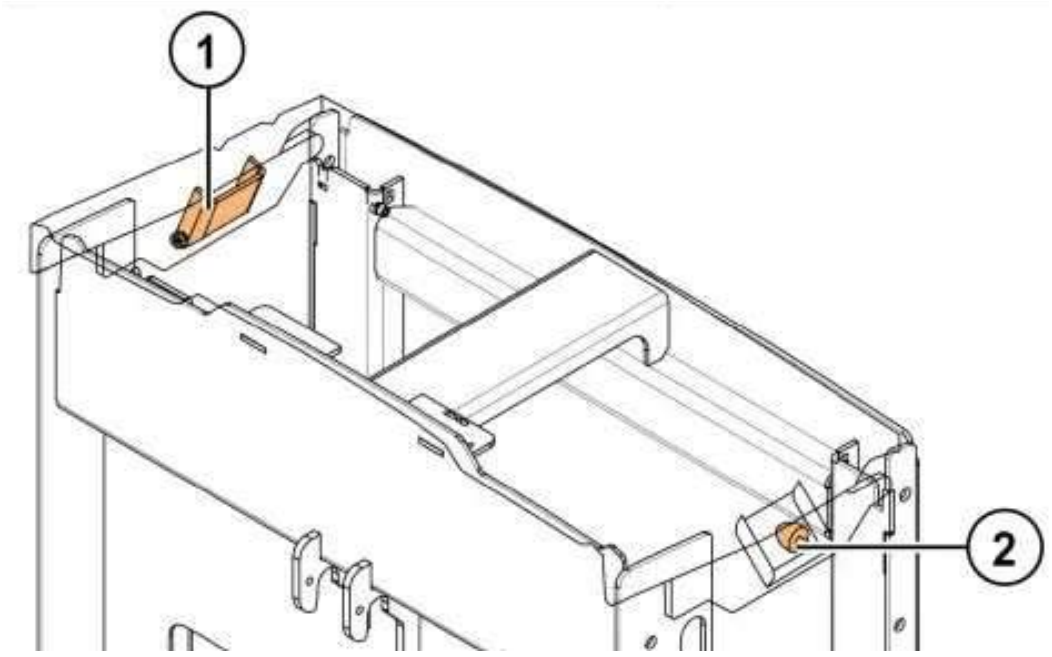
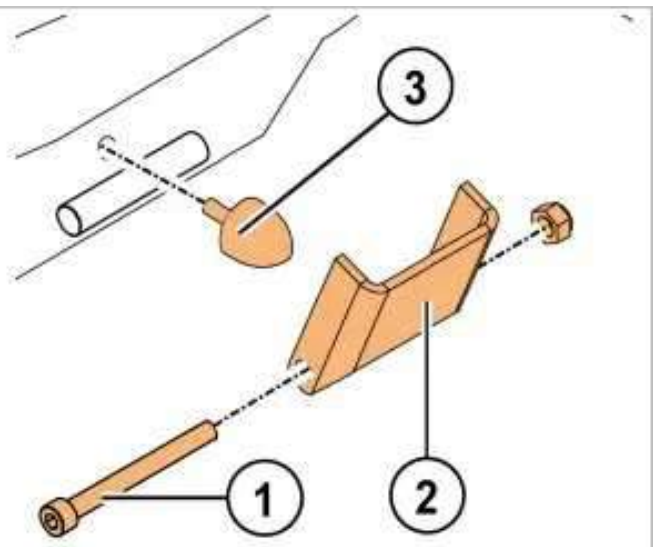


Figure 101. Rubber absorbers with the quick battery replacement option

1. *Battery lock hinge*
2. *Rubber absorber*

1. Remove the bolt holding the battery lock hinge in place. **2.** Remove the battery lock hinge. **3.** Remove the rubber absorber.	

15.11 Electrical steering

NOTE: The electrical steering option is installed to the truck during manufacturing, so this option needs to be selected prior to purchasing the truck.

Electrically powered steering helps the driver to steer the vehicle by augmenting the steering effort of the steering wheel. The electric motor adds controlled energy to the steering mechanism, so the driver needs only a modest effort to turn the truck. Power steering helps considerably when the vehicle is stopped or moving slowly.

The power steering system has no direct mechanical connection to the steering. The electric motor provides assistance force, which is controlled by the electric steering controller.

When the tiller is turned to the right or left, the tiller sensor informs the steering controller that the tiller is turned. The controller starts to turn the steering mechanism with the steering motor. There are two feedbacks devices; the sensor bearing in the steering motor and the outer feedback sensor, which provides feedback information to the controller. With this information, the controller knows the actual position of the turned wheel and can handle the steering movements carefully.

15.11.1 Motor and electrical system with electrical steering

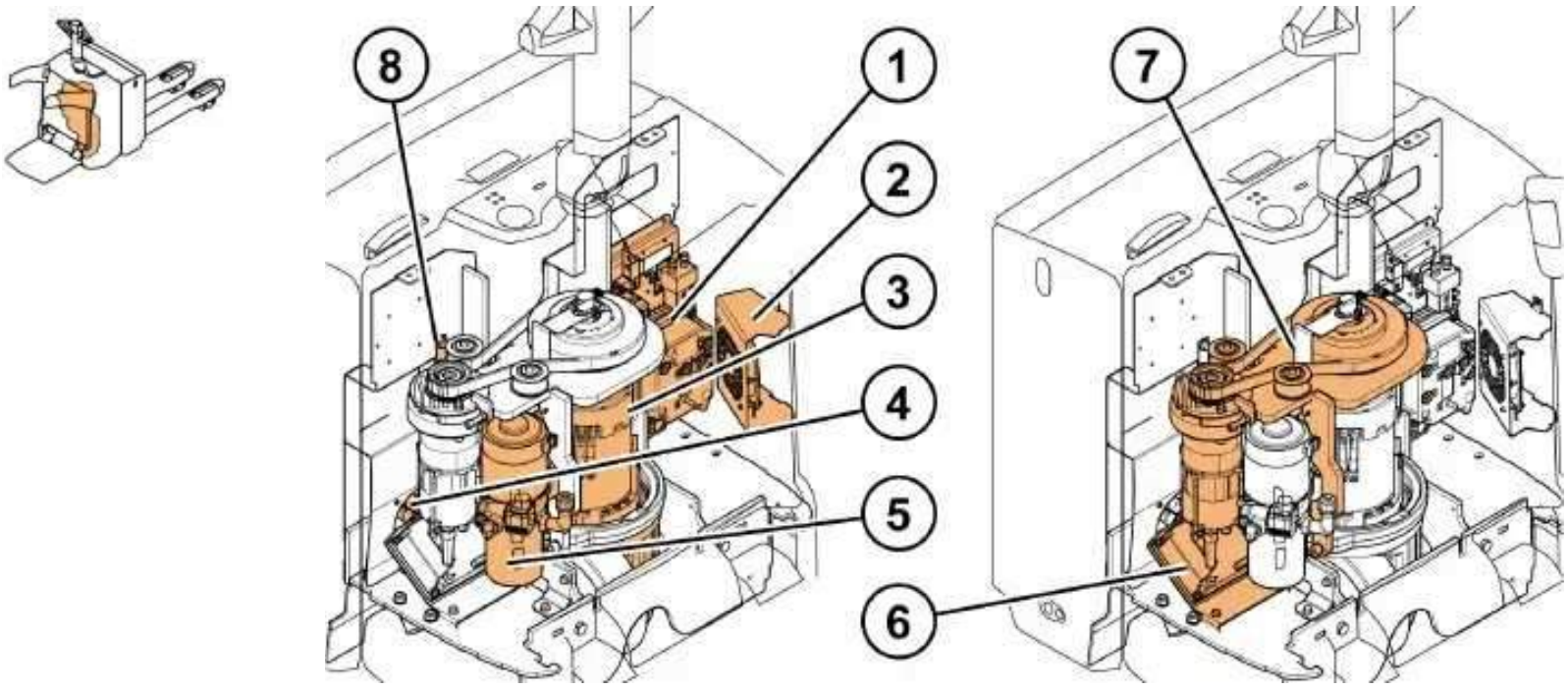


Figure 102. Motor and electrical system with electrical steering overview

1. *Electric panel (covered with a plastic electrical panel cover)*
2. *Motor fan*
3. *Traction motor*
4. *Steering motor fan*
5. *Hydraulic aggregate*
6. *Steering controller (Zapi EPS AC0)*
7. *Motor rack*
8. *Horn*

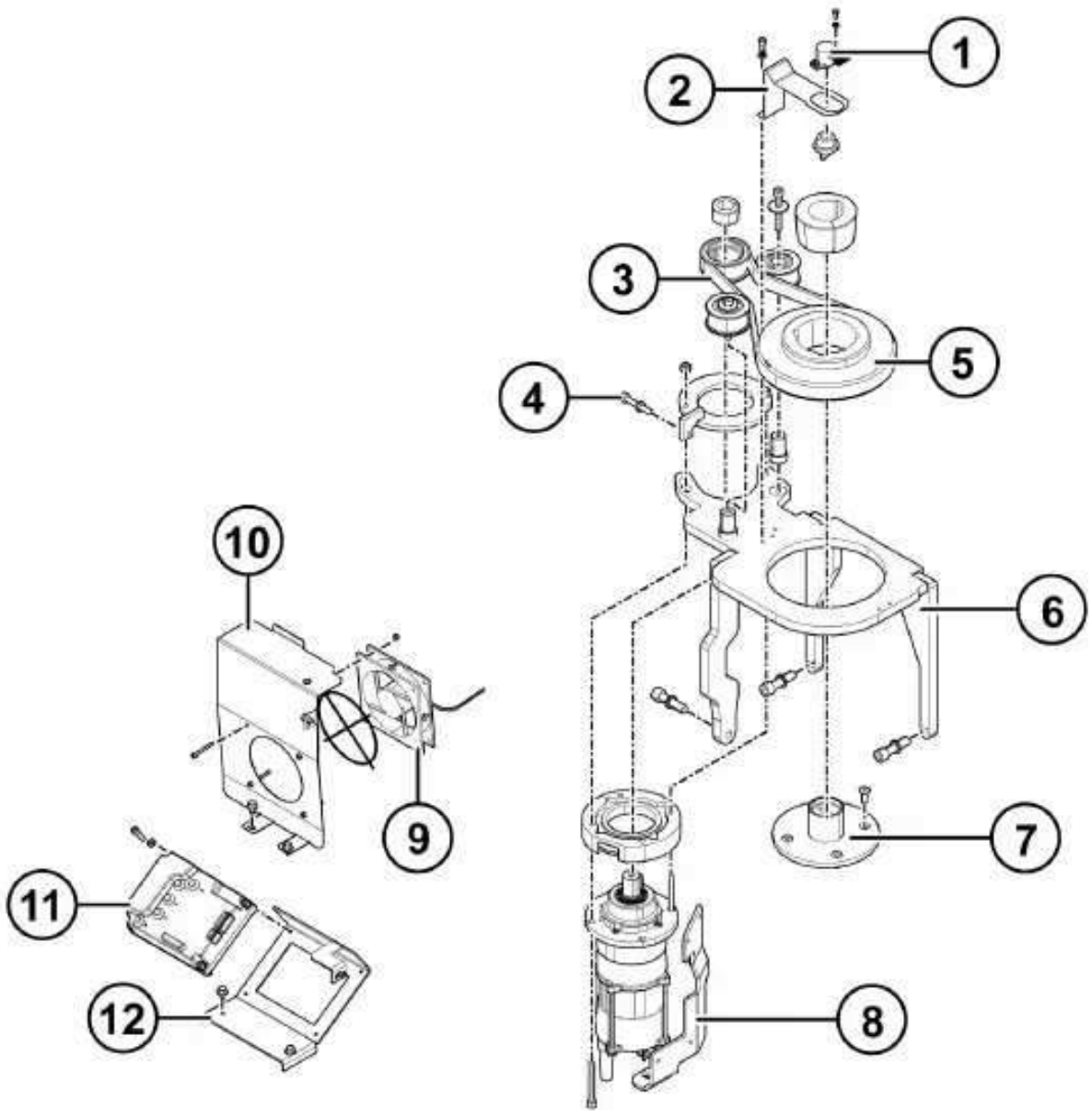


Figure 103. Electrical steering detailed construction

1. *Feedback sensor*
2. *Sensor mounting bracket*
3. *Motor belt*
4. *Motor belt's tightening screw*
5. *Belt roller*
6. *Motor rack*
7. *Belt roller flange*
8. *Hydraulic aggregate's mounting bracket*
9. *Steering motor fan*
10. *Fan plate*
11. *Steering controller (Zapi EPS AC0)*
12. *Steering controller's mounting bracket*

15.11.2 Zapi EPS AC0 Power Controller

The EPS AC0 inverter has been developed to perform steering functions that are usually present in walkie and rider pallet trucks, stackers and low-level order pickers.

The controller can perform the following functions:

- Steering controller for AC asynchronous 3-phase motors
- Digital control using two microprocessors
- CAN bus interface
- Both microprocessors are CAN bus connected
- Encoder interface
- Stepper motor or twin pot interface
- Analogue feedback pot interface (1024 steps resolution)
- Analogue KTY84-130 thermal sensor input
- Analogue input with 1024 steps resolution (one input)
- Analogue input with 4096 steps resolution (one input)
- Two digital inputs
- Double safety relay inside

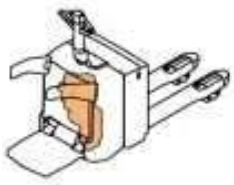
15.11.3 Zapi EPS AC0 connectors

⚠ CAUTION

Before any inspection or repair work, turn the key switch to the OFF position, disconnect the battery plug/connector, discharge all inverters and record the places of the harness connections before disassembly.

When disconnecting the connector, hold the connector housing and plug and unlock the connector. Holding the case may cause damage to the inside card, while holding the cable may cause wire breakage.

If the high-power cable terminals of the battery-operated vehicle are not tightened properly, the increased contact resistance causes excessive heat generation, and can even cause a fire. To prevent accidents and equipment problems, check the tightening torque of the high-power cable terminals regularly. Do not pull the cables to check connections or during adjustment. If the cable terminal sections are moved, re-tighten the connections.



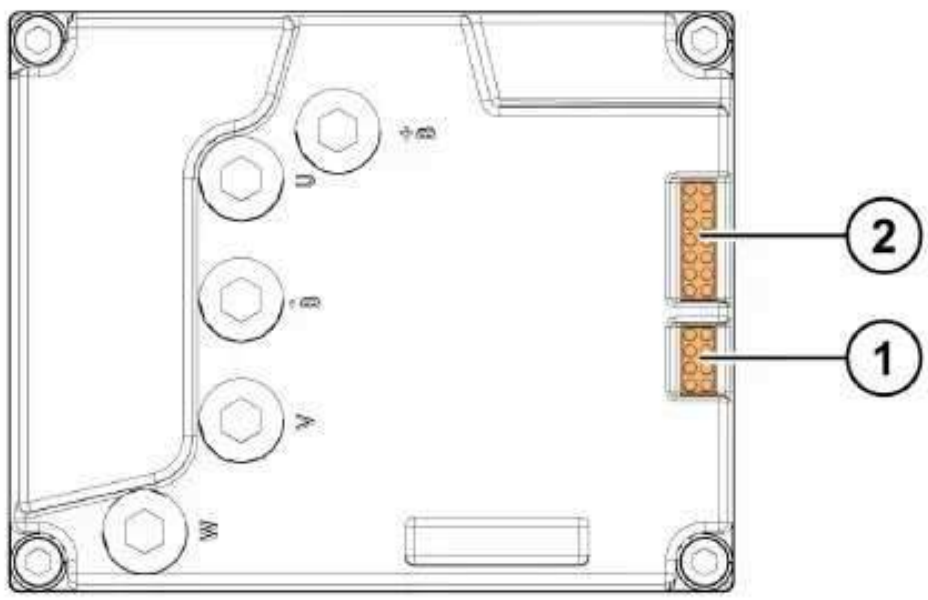


Figure 104. Zapi EPS AC0 connectors

1. *CNA external connector*
2. *CNB external connector*

The Zapi EPS AC0 Power inverter uses two connectors:

- CNA 8 poles connector, spare part: RL450935
- CNB 14 poles connector, spare part: RL450937

Contact 0.2 – 0.8 mm2 for CNA, CNB, CNC and CND connectors, spare part: RL450666

15.11.3.1 CNA external connector

CONNECTION	DESCRIPTION
A4 NK1 (XA2 A/4) (safety pedal K1-)	Safety switch lower voltage point
A5 K1 (XA2 A/5) (safety pedal K1+)	Safety pedal higher voltage point
A6 CANL (XA2 A/6) (CANL)	CAN bus low
A7 KEY (XA2 A/7) (key)	Key in (24-36 V battery).
A11 GND (XA2 A/11) (0V)	GND. Encoder negative supply.

A13 GND (XA2 A/13) (temperature sensor negative)	GND. Motor temperature sensor negative.

CONNECTION	DESCRIPTION
A14 CANH (XA2 A/14) (CANH)	CAN bus high.

15.11.3.2 CNB external connector

CONNECTION	DESCRIPTION
B1 NPOT (XA2 B/1) (GND)	FB POT negative supply.
B2 PPOT (XA2 B/2) (supply)	FB PIT positive supply.
B3 THMOT (XA2 B/3) (temperature sensor positive)	Motor temperature sensor (KTY84-130) input.
B4 +5VDC (XA2 B/4) (+5V)	Encoder positive supply.
B6 CPOT (XA2 B/6) (CPOC1)	FB POT wiper.
B7 CHB (XA2 B/8) (B)	Encoder channel B.
B8 CHA (XA2 B/8) (A)	Encoder channel A.

15.11.3.1 Description of the power connections

CONNECTION	DESCRIPTION
- B	Negative of the battery.
+ B	Positive of the battery.
- P	Negative of the pump motor.
U; V; W	Connection bars of the three motor phases.

The correct tightening torque for the Zapi EPS AC0 terminal bolts is 2.5 – 3 Nm.

15.11.3.2 Fuses with electrical steering

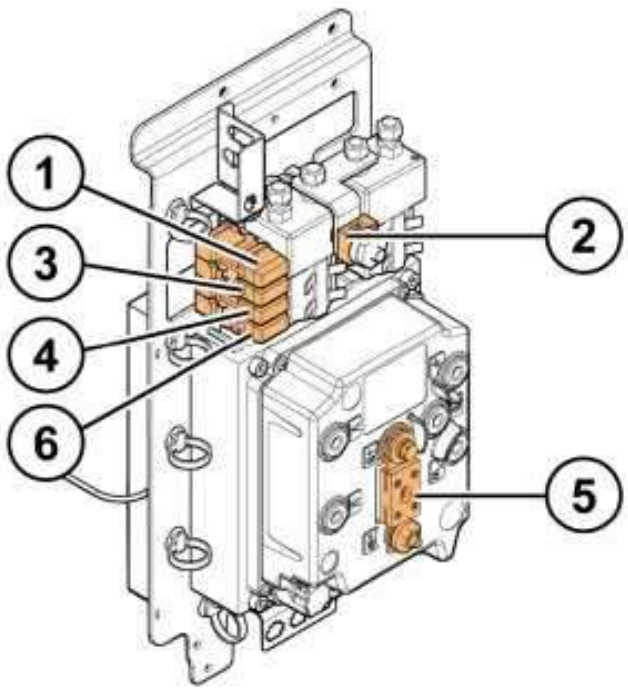


Figure 105. Fuses with electrical steering

1. *Line connector fuse*
2. *Electric steering fuse*
3. *Control circuit fuse*
4. *Optional*
5. *Drive/pump motor fuse*
6. *Working lights fuse (optional)*

15.11.4 Feedback sensor

The feedback sensor is used for monitoring the steering wheel position. With this sensor, the steering controller can adjust the steering angle of the truck. The feedback angle sensor has an output signal from 0.5–4.5 Vdc.

Type	Pressure transmitter
V_s	+5 Vdc
Output signal	0.5 – 4.5 Vdc / < 15 mA (2 signals, crossed signal curves)
Electrical wiring	1 = L+ (Supply) 2 = OUT (output signal 1) 3 = M (GND) 4 = OUT2 (output signal 2)
Spare part	RL601333

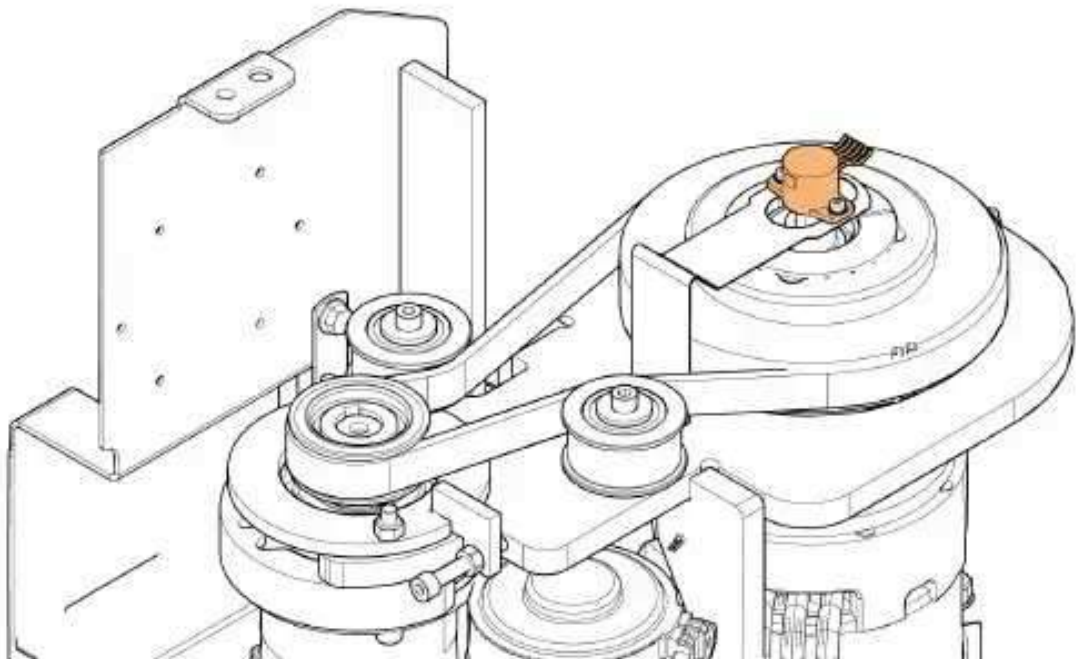


Figure 106. Feedback sensor

15.11.4.1 Functionality check of the feedback sensor

1. Connect the supply voltage +5 Vdc between the supply (XP2/1) and negative (XP2/3) wires.
2. Measure the supply voltage between the wires.

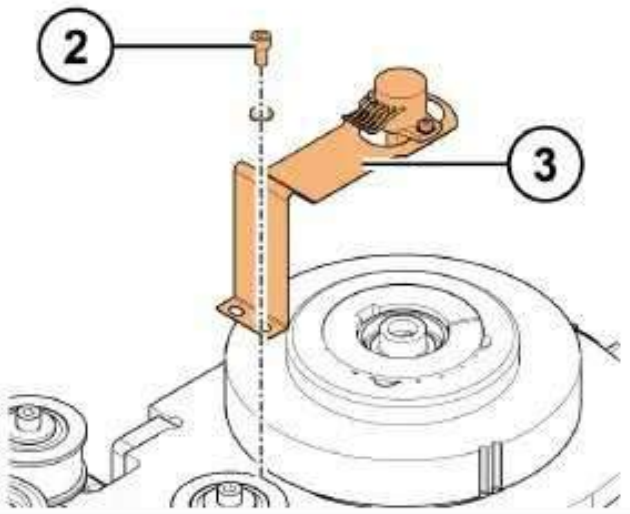
   The value should be +5 Vdc.
3. Measure between the negative (XP2/3) and output (XP2/2) wires on the voltage area.

   When a supply is connected and the sensor axis is rotated, the value varies between 0.5 - 4.5 Vdc. When the value is increasing toward 4.5 Vdc, and the sensor axis is rotating more, the value returns to 0.5 Vdc. Also, when rotating to the other direction, the value decreases.
4. If the values do not match the above, replace the sensor.

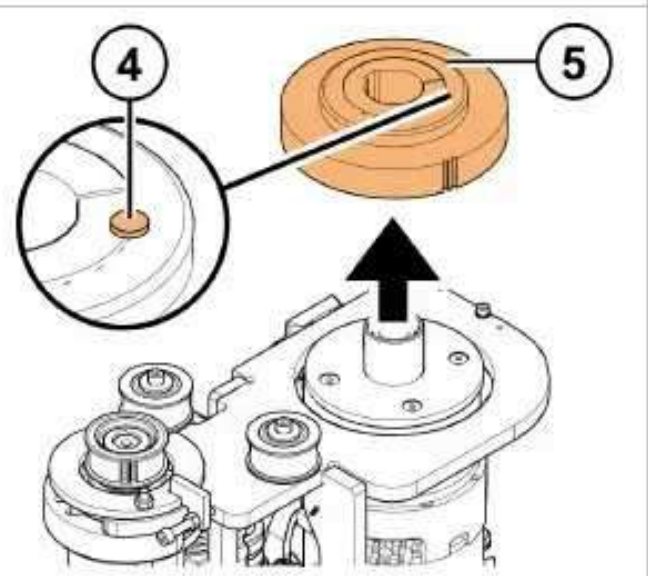
15.11.5 Disassembly of the electrical steering motor unit

1. Remove the motor belt. For instructions, see section 15.11.7.

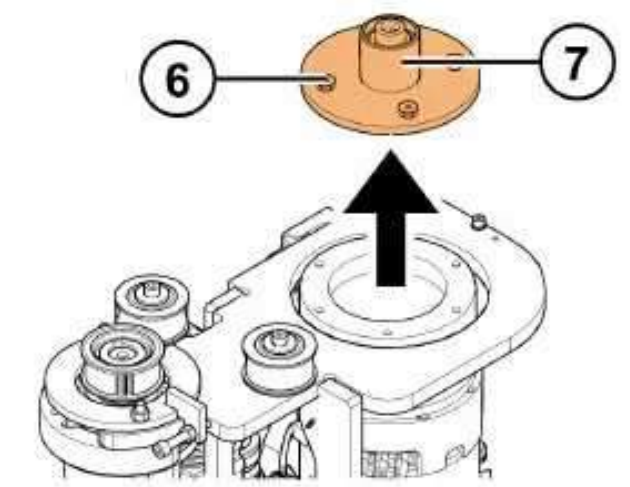
2. Remove the screws of the sensor mounting bracket.
3. Remove the sensor mounting bracket.



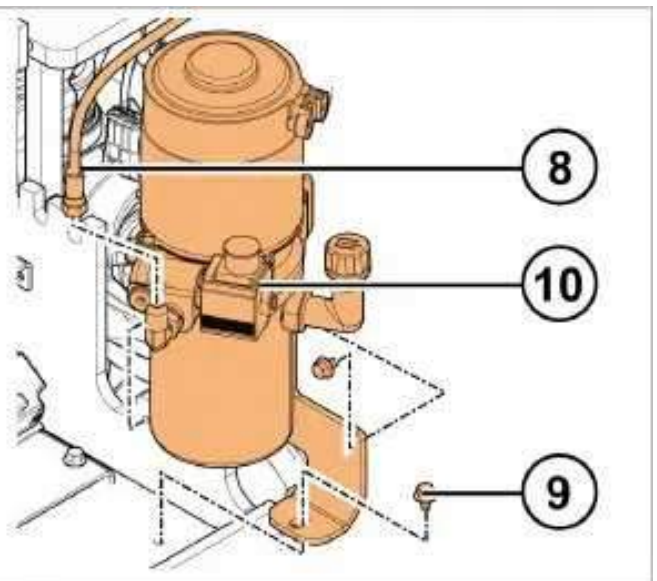
4. Loosen the belt roller's tightening screw.
5. Remove the belt roller.



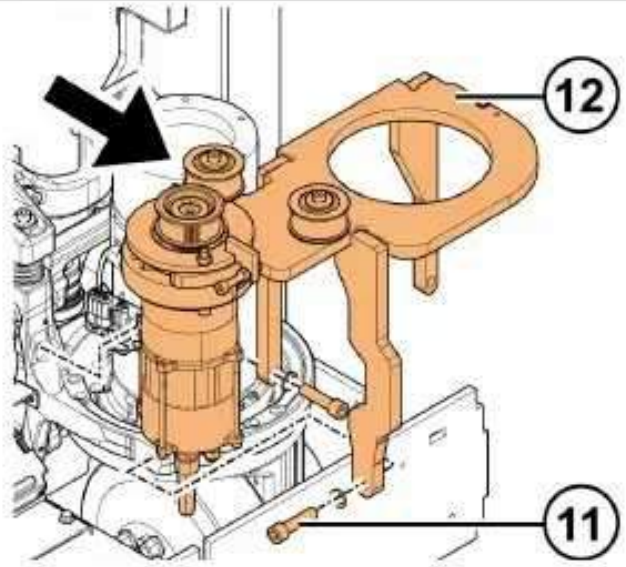
6. Loosen the belt roller flange's tightening screws.
7. Remove the belt roller flange.



8. Remove the hydraulic oil hose.
9. Remove the three screws from the hydraulic aggregate's mounting bracket.
10. Remove the hydraulic aggregate and its mounting bracket.

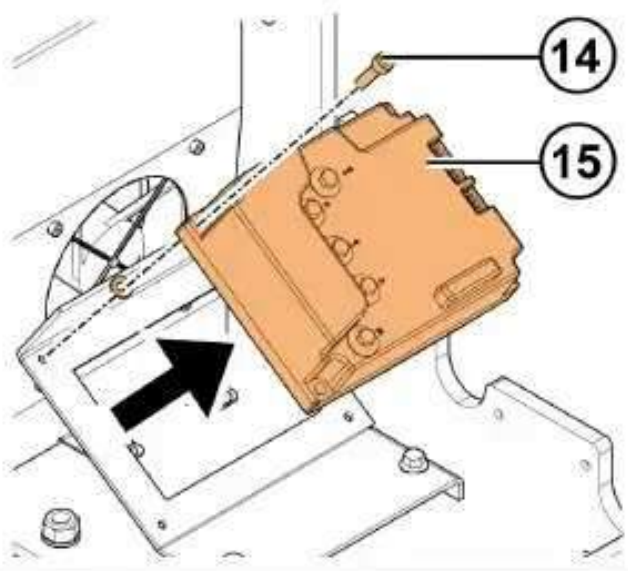


11. Remove the screws of the motor rack.
12. Remove the motor rack.

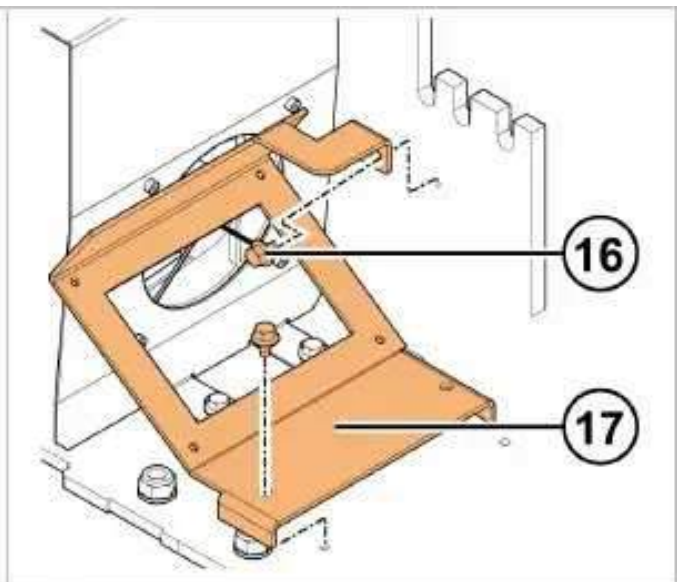


13. Remove the drive unit. For instructions, see section 8.3.1.

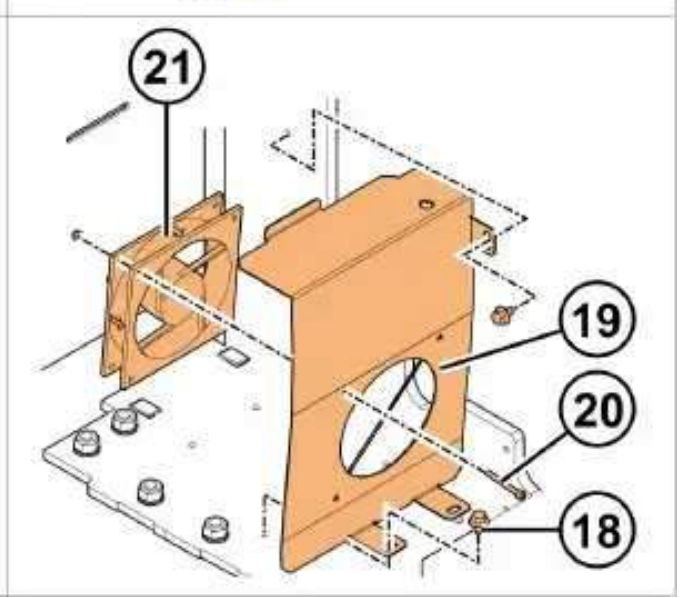
14. Remove the four screws holding the steering controller in place.
15. Remove the steering controller.



16. Remove the three screws of the steering controller mounting bracket.
17. Remove the steering controller mounting bracket.



18. Remove the three screws of the steering motor fan plate.
19. Remove the steering motor fan plate.
20. Remove the four screws of the steering motor fan.
21. Remove the steering motor fan.



15.11.6 Adjusting the motor belt

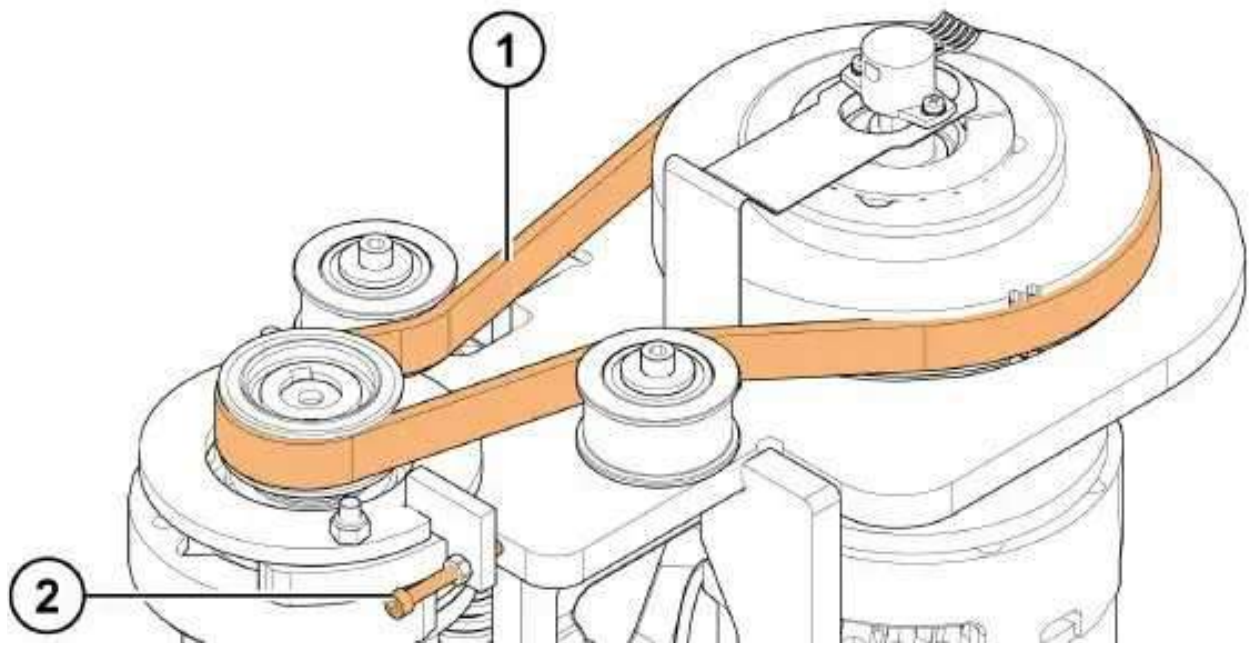


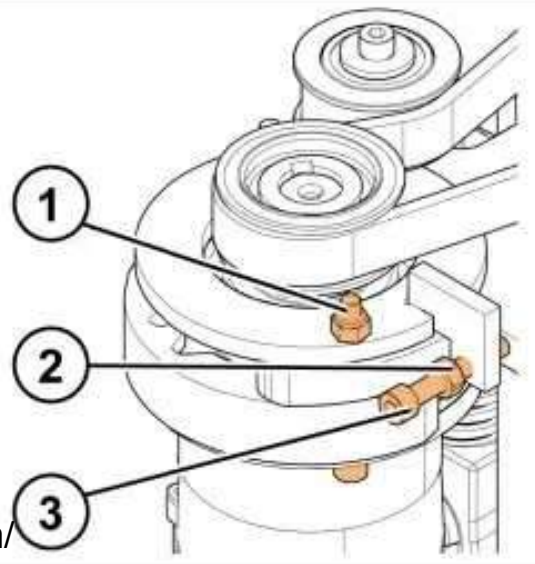
Figure 107. Motor belt overview

1. *Motor belt*
2. *Tightening screw*

During maintenance, check the condition of the motor belt and tighten it, if needed.

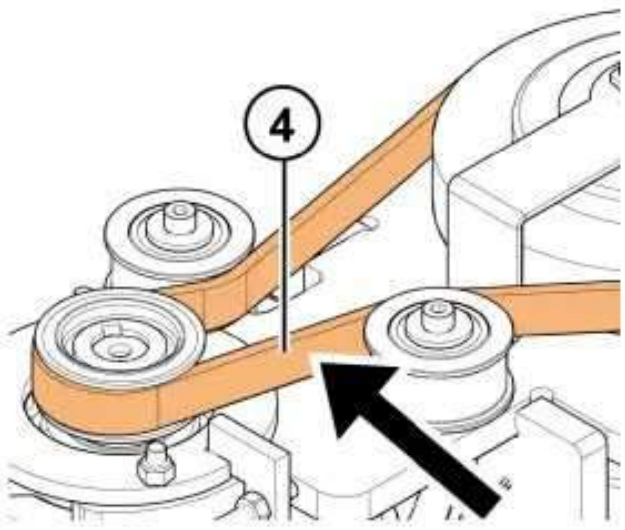
- The strength of a new motor belt is 206 N.
- When the motor belt is in place and tightened, it should give in approximately 1.8 mm. If the belt gives in more or less than that, adjust it accordingly.
- The minimum strength of a used motor belt is 155 N. When the minimum strength is reached, replace the motor belt as instructed in section 15.11.7.

1. Loosen the motor belt fastener.
2. Open the nut of the tightening screw.
3. Adjust the motor belt's tightness as needed.



4. Check the motor belt's tightness by pressing it to see how much it gives in. When correctly adjusted, the belt should give in approximately

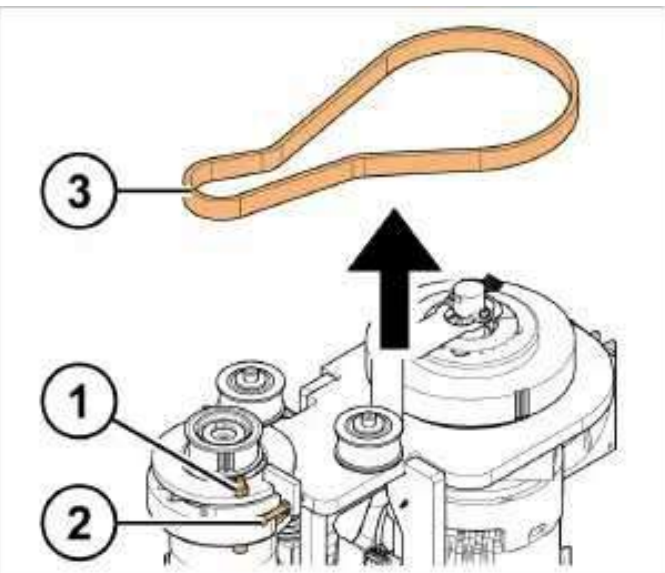
   1.8 mm.



5. Tighten the nut of the tightening screw.
6. Tighten the motor belt fastener.

15.11.7 Replacing the motor belt

1. Loosen the motor belt fastener.
2. Loosen the motor belt's tightening screw.
3. Remove the motor belt.



4. Install the new motor belt.
5. Adjust the motor belt as instructed in section 15.11.6 above.

15.11.8 Adjusting the electrically powered steering

If any of the electric steering components are changed, the electrically powered steering must be adjusted.

15.11.8.1 Adjusting the tiller and feedback sensors

The tiller and feedback sensors have two output signals that are crossed together. Because the output signals are not fully rotating, the sensor axis has to be set to the correct position (center) when installed to the truck.

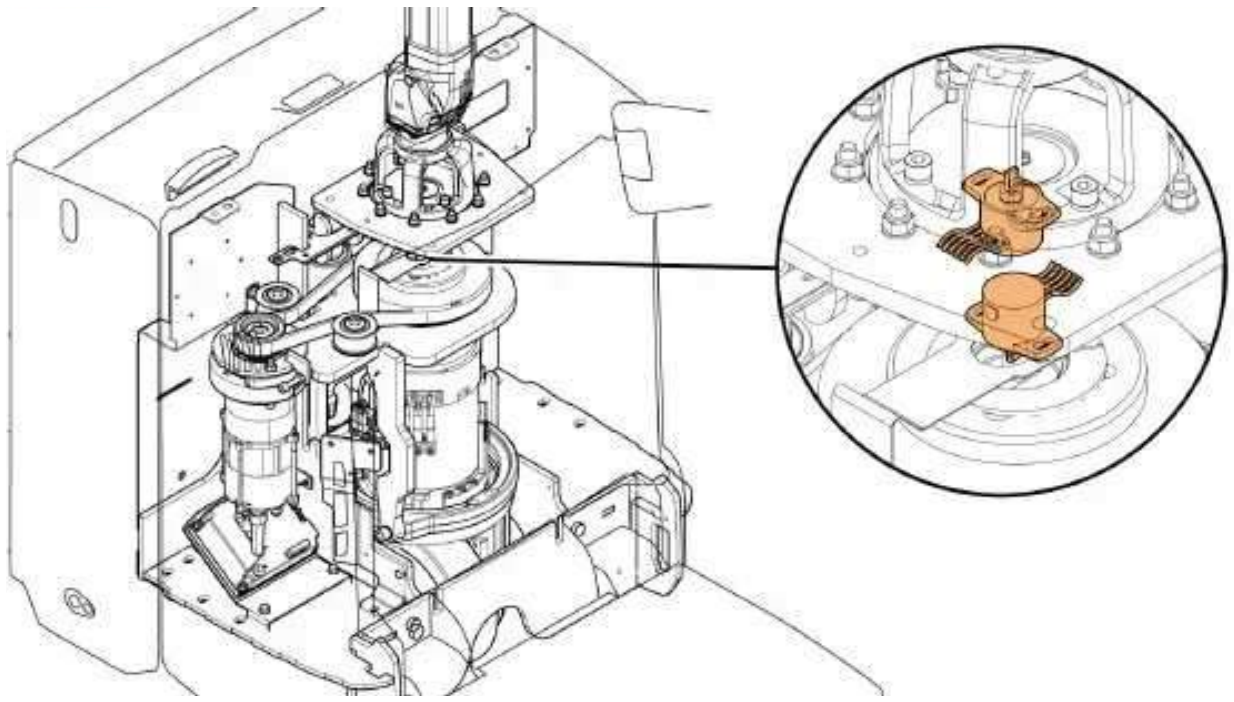


Figure 108. Tiller and feedback sensors

1. Connect the supply voltage +5 Vdc between the + terminal (XP1/1) and the - terminal (XP1/3).
2. With a multimeter, measure the voltage area between the minus terminal (XP1/3) and output 1 (XP1/2) or output 2 (XP1/4).
3. Turn the sensor axis so that the multimeter shows ~2.5 Vdc.

   Now the sensor is centered and can be installed to the truck system.
4. It is very important to assemble the sensor axis in the correct position. When the tiller sensor or the feedback sensor is at the center position, make sure that also the tiller and the steering mechanism are in the center position.
5. To minimize the mechanical strain of the sensor axis, make sure that the sensor is assembled on its bracket as centered as possible.

15.11.8.2 Feedback sensor teaching and steering angle reduction

NOTE: Make sure that all the steering controller parameters are set according to the latest parameter list.

1. Connect the Zapi hand console to the steering controller and switch the truck on.
2. Go to the SET OPTIONS menu and set FEED BACK DEVICE = OPTION1 and LIMIT DEVICE = OFF.
3. Press OUT and ENTER.
4. Restart the truck.

5. Make sure that the tiller and the steering mechanism turn to the same direction

5. Make sure that the tiller and the steering mechanism turn to the same direction.
6. Turn the tiller straight forward.

7. With the Zapi hand console, go to the ADJUSTMENTS menu and to the ZERO SP POT parameter. Then press OUT and ENTER.

   The value should be ~2.5 Vdc.
8. Turn the tiller slowly to the left until the steering mechanism almost reaches its mechanical limit. Stop approximately 5 mm before the limit.
9. With the Zapi hand console, go to the ADJUSTMENTS menu and to the SET MAX FB POT parameter. Then press OUT and ENTER.

   The value should be ~3.5 Vdc.
10. Turn the tiller slowly to the right until the steering mechanism almost reaches its mechanical limit. Stop approximately 5 mm before the limit.
11. With the Zapi hand console, go to the ADJUSTMENTS menu and to the SET MIN FB POT parameter. Then press OUT and ENTER.

    The value should be ~0.7 Vdc.
12. Go to the SET OPTIONS menu and set FEED BACK DEVICE = OPTION2 and LIMIT DEVICE = ON.
13. Press OUT and ENTER.
14. Restart the truck.

15.11.8.3 Tiller sensor teaching

1. Turn the tiller straight forward.
2. With the Zapi hand console, go to the PARAMETERS menu and set 1ST ANGLE COARSE = 6.
3. Go to the 1ST ANGLE FINE parameter and adjust the tiller angle versus the steering mechanism angle to meet the 1:1 transmission ratio. This adjustment is for turning the truck to the left.
4. In the PARAMETERS menu, the second ANGLE COARSE and the second ANGLE FINE parameters are used for adjusting the transmission ratio for turning the truck to the right. The target is to meet the 1:1 ratio.
5. When the adjustments are done, press OUT and ENTER to save the settings.

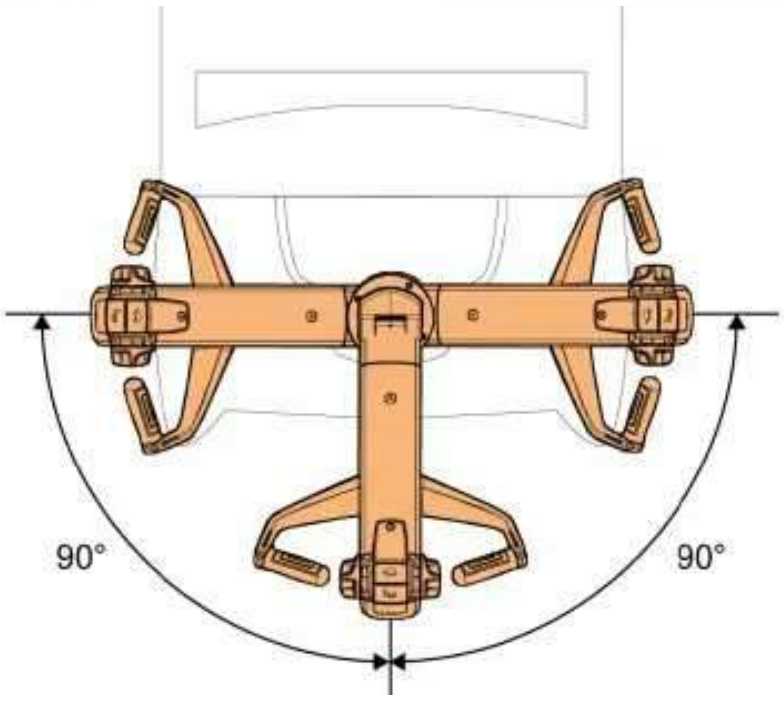


Figure 109. Adjust the steering transmission ratio to 1:1

15.11.8.4 Steering straight forward calibration

1. With the Zapi hand console, go to the SET OPTIONS menu and set TILLER DEAD ZONE = ON.
2. Restart the truck.

   When the truck is restarted, there is a 20 degree dead zone in the middle of the steering area. Inside this dead zone, turning the tiller does not turn the steering mechanism.

   Be careful while calibrating the straight forward position.
3. Go to the ADJUSTMENTS menu and find the SET STEER 0-POS parameter. By increasing this value, the steering mechanism turns to the left and by decreasing this value, the steering mechanism turns to the right.
4. Drive carefully and adjust the tiller and the steering mechanism as straight as possible. Then drive forward and backward to see how straight the truck is travelling. If needed, adjust the SET STEER 0-POS. parameter to adjust the straight forward driving.
5. Press OUT and ENTER to save the settings.
6. After the calibration, restart the truck.
7. After the restart, the TILLER DEAD ZONE parameter has turned to the OFF state and the dead zone is no longer present. When the tiller is in the straight forward position, make sure that the truck really travels straight forward. If not, repeat the calibration steps and restart the truck again.

15.11.8.5 Final adjustment

Make sure that the electrically powered steering runs as it should and no errors are present. ALARM STEER HAZARD is not a relevant error. It is present when the steering mechanism is turned to the left or right end limit.

Remember to clear the controller alarm log:

1. Go to ALARMS.
2. Press ENTER and OUT, and then press ENTER twice.
3. Exit the menu.
4. Restart the truck.

15.11.9 Steering controller parameter descriptions

Table 12. Main menu: parameter change

PARAMETER	DESCRIPTION
Dynamic numbness angle DYNAM NUMB ANG	Dynamic numbness smoothens the operation of the system with small movements. The dynamic numbness angle defines the angle difference between the tiller and the steered wheel on which dynamic numbness is applied. Value range: • 0: No numbness if the angle between the tiller and the steered wheel is greater than five degrees • 9: No numbness if the angle between the tiller and the steered wheel is greater than 60 degrees
Dynamic numbness speed DYNAM NUMB SPEED	Dynamic numbness smoothens the operation of the system with small movements. The dynamic numbness speed defines the maximum reduction of the motor speed. Value range: • 0: At full dynamic numbness, the steering motor frequency is clamped to 40% of the maximum value. • 9: At full dynamic numbness, the steering motor frequency is clamped to 100% of the maximum value.
Max steering angle limit coarse 1ST ANGLE COARSE	This parameter defines the steering angle limitation. It sets the tiller angle on which the maximum steered wheel angle is achieved.

Max steering angle limit fine 1ST ANGLE FINE	This parameter defines the fine adjustment for "Max steering angle limit coarse".

PARAMETER	DESCRIPTION
Min steering angle limit coarse 2ND ANGLE COARSE	This parameter defines the steering angle limitation. It sets the tiller angle on which the minimum steered wheel angle is achieved.
Min steering angle limit fine 2ND ANGLE FINE	This parameter defines the fine adjustment for "Min steering angle limit coarse".
Steering angle cutback AUX FUNCTION 3	This parameter defines the steering angle reduction in respect to the truck speed. The controller limits the maximum steering angle depending on the truck's travel speed. It is strongly recommended that you do not touch this setting. Value range: • 0: Maximum steered angle at full speed is 73% • 9: Maximum steered angle at full speed is 10%
Steering angle cutback start speed AUX FUNCTION 2	This parameter defines the steering angle reduction ramp starting speed. It is strongly recommended that you do not touch this setting. Value range: • 0: Maximum angle starts to reduce when the truck speed is 1% of the maximum speed • 9: Maximum angle starts to reduce when the truck speed is 100% of the maximum speed (= no angle reduction)
Straight ahead steering numbness NUMBNESS	This parameter reduces the steering sensitivity close to the straight-ahead direction. Value range: • 0: No reduction • 9: Maximum reduction

Table 13. Submenu: set options

PARAMETER	DESCRIPTION
Disable slave CPU MICRO CHECK	This parameter is for debug functionality. It disables slave CPU functions and allows the system to run only with main CPU. Safety contacts will remain open, and therefore traction shall stay disabled. Value range: • 1: Slave CPU functions present • 0: Slave CPU disabled
Limit steering angle LIMIT DEVICE	This parameter limits the maximum steering angle. The maximum angles are set by the parameters

	"Minimum wheel angle" (SET MIN FB POT) and "Maximum wheel angle" (SET MAX FB POT).

PARAMETER	DESCRIPTION
Steering feedback type FEEDBACK DEVICE	This parameter defines the steering feedback type. Value range: • 1: Feedback potentiometer only. This setting must be temporary only, and is meant for the setup of the EPS. Set this parameter to 2 after the setup is done. • 2: Feedback potentiometer and encoder.

Table 14. Submenu: set model

PARAMETER	DESCRIPTION
System configuration SYSTEM CONFIG	This parameter sets the configuration of the steering system. Value range: • 0: Stepper motor command signal and feedback sensor • 1: Twin potentiometer command signal and feedback sensor • 2: CAN-demanded position and feedback sensor

15.11.10 Steering controller alarm codes

NOTE: Before you start to troubleshoot the truck, make sure that all the power supplies, fuses and connections are in order. Low voltage in the controller can cause different sorts of alarms.

The fault diagnostic system of the steering controller is divided into two main groups:

- Alarms

  These are faults, which open the power bridge and, when possible, also the main contactor is opened and the magnetic brake activated. Failures in the motor, the controller or the safety functions cause alarms.

- Warning

  These are faults, which do not stop the truck or stop the truck by using regeneration braking. The controller is working well, but it has detected some conditions that reduce the performance or stop the truck without opening the power devices. Incorrect operation sequences or conditions requiring performance reductions (for example, high temperatures) cause warnings.

The text “Stored” means that the alarm or warning is stored in the steering controller

The text "Stored" means that the alarm or warning is stored in the steering controller logbook.

Table 15. steering controller alarm codes

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
0	No alarms NONE		
1	No errors CHOPPER RUNNING	(Warning)	
2	No Communication NO COMMUNICATION	(Warning)	
	Combi AC-0 does not respond to the TruckTool. Check the wiring. Also check the TruckTool functionality by connecting it to some other controller. If the TruckTool is functional with another controller, the problem is in the Combi AC-0.		
13	Controller memory error EEPROM KO	(Warning)	
	This warning is caused by a hardware or software defect of the non-volatile embedded memory supporting the controller parameters. This warning does not prevent the truck from operating, but the truck will function with default values. In the case of this warning, try to execute a CLEAR EEPROM operation. Switch the truck's power off and on and check the result. If the alarm occurs permanently, replace the COMBIACX controller. If the alarm disappears, the previously stored parameter values will have been replaced by the default values.		
16	Output voltage error LOGIC FAILURE #4	(Alarm)	Stored
	This alarm occurs in the rest state if the output of the voltage amplifier Wv-Vv has a drift larger than ±0,25 V. In such a case, replace the steering controller.		
17	Hardware high current protection failure LOGIC FAILURE #3	(Alarm)	Stored
	This alarm is caused by a hardware problem in the logic card circuit for high current protection. This fault is not related to external components, so when it appears, replace the steering controller.		
18	Motor voltage feedback circuit damaged LOGIC FAILURE #2	(Alarm)	Stored
	This alarm is caused by a fault in the logic board, which manages the phase's voltage feedback. This fault is not related to external components, so when it appears, replace the steering controller.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
19	Over or under voltage detected LOGIC FAILURE #1	(Alarm)	Stored
	This alarm is displayed when the controller detects an overvoltage or undervoltage condition. The overvoltage threshold is 45 V and the undervoltage threshold is 9 V in the 24 V controller. If the fault is displayed at startup or in the standby mode, it is due to an undervoltage condition. In such a case, the check following: • The key input signal voltage drops below the undervoltage threshold due external loads, such as DC/DC converters starting up or relays or contactors energizing or de-energizing. • If no voltage transient is detected on the supply line and the alarm is displayed every time the key is switched ON, the problem is in the steering controller. If the alarm is displayed during motor steering, it is due to an undervoltage or an overvoltage condition. If the alarm happens during traction acceleration or driving hydraulic functions, it is due to an undervoltage condition. In such a case, check the battery charge level and the power cable connections.		
32	Steering motor output voltage error VMN NOT OK	(Alarm)	Stored
	This alarm occurs in the initial rest state after startup if the outputs of the motor voltage amplifiers are not in the window from 2.2 V to 2.8 V. In such a case, replace the controller.		
48	Contactor does not close circuit MAIN CONT: OPEN	(Warning)	
	This alarm occurs only when the parameter CAN BUS is set to PRESENT. In such a case, the steering controller must receive event messages from the traction controller. See the traction controller alarms in chapter 12 for the reason for keeping the main contactor open.		
61	Over temperature detected HIGH TEMPERATURE	(Alarm)	Stored
	This alarm occurs if the controller base plate temperature exceeds 75°C. Improve the cooling of the controller; otherwise it is necessary to replace the steering controller.		
65	Steering motor over temperature detected MOTOR TEMPERAT.	(Alarm)	Stored
	This alarm occurs when the analogue temperature sensor has exceeded the threshold of 150°C. In such a case, check the thermal sensor inside the motor and the wiring outside. The resistance of the sensor is 580 Ω at 20°C. If the warning is present when the motor is cold and the thermal sensor is OK, improve the cooling of the motor. If that does not help, the problem is in the COMBIACX controller.		
70	Output over current detected HIGH CURRENT	(Alarm)	Stored

	This alarm indicates that the output current amplifier has been over the maximum current level (not adjustable) for too long. If this alarm occurs permanently, replace the steering controller.

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
71	Steering motor circuit error POWER FAILURE #3	(Alarm)	Stored
	This alarm occurs when the current in phase voltage of the motor is zero and the motor is commanded for turning. In such a case, check the following: • The condition of the main fuse 3F1 • There is positive supply to the controller • Continuity of the phase cable from the controller to the motor If the above points are OK, replace the steering controller.		
72	Steering motor circuit error 2 POWER FAILURE #2	(Alarm)	Stored
	This alarm occurs when the current in phase U of the motor is zero and the motor is commanded for turning. In such a case, check the following: • Condition of the main fuse 3F1 • There is positive supply to the controller • Continuity of the phase cable from the controller to the motor If the above points are OK, replace the steering controller.		
73	Steering motor circuit error 3 POWER FAILURE #1	(Alarm)	Stored
	This alarm occurs when the current in phase W of the motor is zero and the motor is commanded for turning. In such a case, check the following: • Condition of the main fuse 3F1 • There is positive supply to the controller • Continuity of the phase cable from the controller to the motor If the above points are OK, replace the steering controller.		
83	Encoder wiring error BAD ENCODER SIGN	(Alarm)	Stored
	This alarm occurs in this application with the toggle switches applied (straight and 90° position switches) when FREQUENCY and ENC SPEED have opposite polarity. In such a case, swap the encoder channels.		
85	Steering end limit STEER HAZARD	(Warning)	Not shown in the display
	This is just a warning indicating that the steering controller is limiting the angle in steering direction. No speed reduction occurs on traction.		
216	Controller counting error	(Alarm)	Stored

	MICRO SLAVE #8		
	This alarm occurs when the encoder counting of the main microprocessor does not match the encoder counting. In such a case, replace the steering controller.		

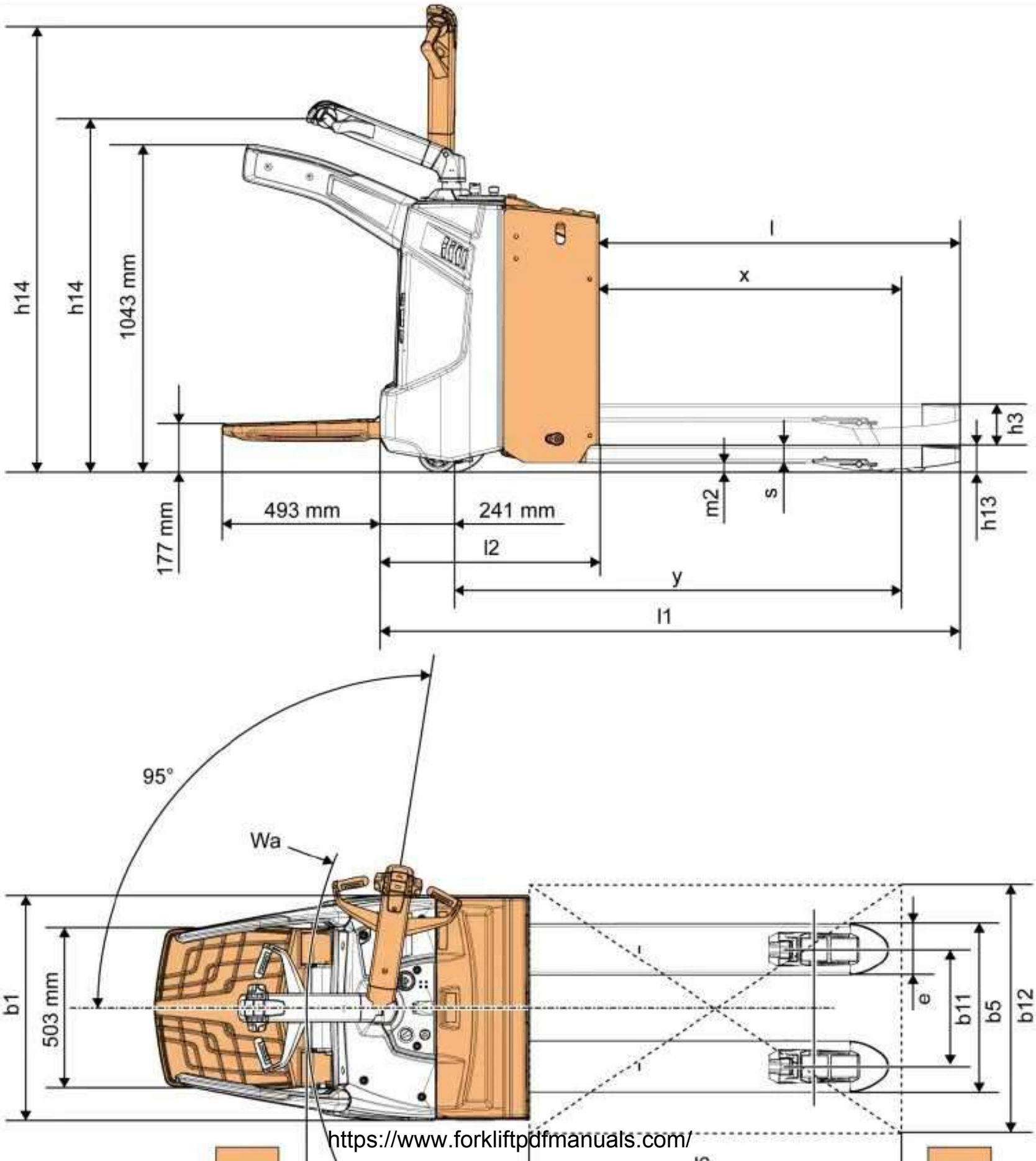
CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
218	Controller internal error CLOCK PAL NOT OK	(Alarm)	Stored
	This alarm occurs if one of the internal analogue signals is incorrect. In such a case, replace the steering controller.		
219	Stepper motor lines mismatch detected STEPPER MOTOR MISM	(Alarm)	Stored
	This alarm occurs if the frequency and the amplitude of the voltages from the stepper motor lines are mismatched in between the D and Q lines of the stepper motor. In such a case, replace the steering controller.		
220	Steering motor mechanical error MOTOR LOCKED	(Alarm)	Stored
	This alarm occurs if the current in the steering motor stays close to the maximum current for longer than one second. In such a case, look if there is a mechanical problem locking the steering motor.		
222	Feedback sensor error FB POT LOCKED	(Alarm)	Stored
	This alarm occurs if the feedback sensor or potentiometer does not change the value (or changes the value to the opposite direction) even if it is commanded to change. In such a case, check the following: • The feedback sensor is not mechanically loosened. • The connectors and cables of the feedback sensor are in order. • The motor phases are OK and the cables are installed in the correct places.		
223	Feedback sensor output signal error JERKING FB POT	(Alarm)	Stored
	This alarm occurs if the feedback sensor or potentiometer voltage changes more than 0.3 V in 16 milliseconds. This alarm is used to catch potentiometer discontinuities. In the case of this alarm, replace the feedback sensor.		
225	Error in controller initialization at manufacturer CURRENT GAIN	(Warning)	
	This warning occurs when the parameters compensate for the gain if the current amplifiers have the default values (the maximum current was not regulated). In such a case, replace the steering controller.		
226	Internal check cycle error NO SYNC	(Alarm)	Stored
	This alarm occurs when the internal checking cycle does not update the information and the controller cuts of the steering and traction. In such a case, replace the steering controller.		

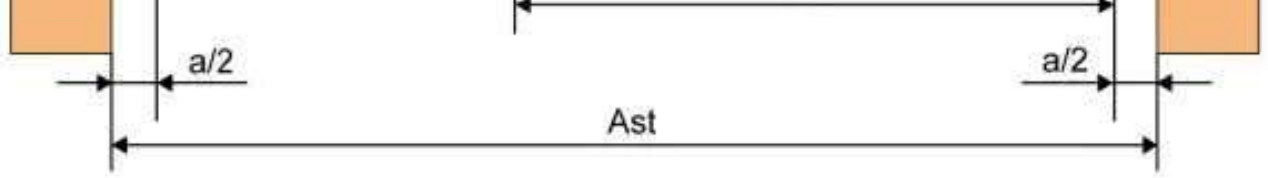
CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
227	Internal communication error SLAVE COM. ERROR	(Alarm)	Stored
	This alarm occurs when there is a problem in the internal communication. In such a case, replace the steering controller.		
237	EPS on idle state WAITING DATA	(Warning)	Not shown in the display
	This is a warning shown while the steering controller receives information from the COMBIACX controller. The safety relays remain open when this warning is shown and the steering is not activated.		
238	Steering initialization error EPS NOT ALIGNED	(Warning)	Not shown in the display
	This is a real alarm, which cuts off the traction function. It occurs at the initial alignment if the straight ahead condition is not met within six seconds. Throughout this time, the steering is not activated, the safety relays are open and the traction is stopped.		
239	EPS waiting for system start. WAITIN FOR TRAC	(Warning)	Not shown in the display
	At startup, the steering controller needs information from the traction controller to close the internal safety contacts and to switch to the operational mode. Until this information is received, this warning occurs. The steering is not activated and the safety relays remain open while this warning is present.		
241	Feedback encoder damaged ENCODER ERROR	(Alarm)	Stored
	This alarm occurs in the application when ENCODER CONTROL is set to ON and the real frequency does not match the commanded frequency. This condition is often due either to a mismatching between the encoder resolution used in the SW and the real encoder resolution, or to a wrong connection between the two encoder channels. In the later case, switch between the two encoder channels.		
244	Controller memory error 2 GAIN EEPROM KO	(Warning)	
	This warning indicates that the parameters to compensate values for current gain are no longer in memory. In such a case, replace the steering controller.		
245	Data acquisition DATA ACQUISITION	(Warning)	
	This warning indicates that the acquisition of the current gains is in progress. The warning disappears when the acquisition is finished.		
246	Steering system damage detected MICRO SLAVE KO	(Alarm)	Stored

	MICRO SLAVE KO		
	This alarm occurs if the microprocessor detects a mismatch between the commanded and active steering directions. In such a case, replace the steering controller.		

CODE	TRUCKTOOL AND DISPLAY DESCRIPTION		
247	CAN-BUS communication error CAN BUS KO	(Warning)	
	This warning occurs if the steering controller does not receive a message from the traction controller within one second. In such a case, check the CAN bus wiring from the COMBIACX controller to the steering controller.		
248	Steering sensor out of range S.P. OUT OF RANGE	(Alarm)	Stored
	This alarm occurs if the command HALL sensor (or potentiometer) signal voltage is out of range (from 0.8 Vdc to 4.2 Vdc). In such a case, check that the connectors and cables are in order and measure that the command sensor signal voltage is within tolerance.		
249	Feedback sensor out of range F.FB: OUT OF RANGE	(Alarm)	Stored
	This alarm occurs if the feedback HALL sensor (or potentiometer) signal voltage is out of range (from 0.3 Vdc to 4.7 Vdc). In such a case, check that the connectors and cables are in order and measure that the feedback sensor signal voltage is within tolerance.		
250	Internal microprocessor error MICRO SLAVE	(Alarm)	Stored
	This alarm occurs when the internal microprocessor information does not match. In such a case, replace the steering controller.		
251	Internal safety contact is open KM OPEN	(Alarm)	Stored
	This alarm occurs when the microprocessor detects that the internal safety contact is open when it is expected to be closed. In such a case, replace the steering controller.		
252	Internal safety contact 2 is open KS OPEN	(Alarm)	Stored
	This alarm occurs when the microprocessor detects that the second internal safety contact is open when it is expected to be closed. In such a case, replace the steering controller.		
253	Internal safety contact is closed KM CLOSED	(Alarm)	Stored
	This alarm occurs when the microprocessor detects that the internal safety contact is closed when it is expected to be open. In such a case, replace the steering controller.		
254	Internal safety contact 2 is closed KS CLOSED	(Alarm)	Stored
	This alarm occurs when the microprocessor detects that the second internal safety contact is closed when it is expected to be open. In such a case, replace the steering controller.		

16 Technical specification





1	IDENTIFICATION		
1.1	Manufacturer		Rocla Oy
1.2	Model		PBV20N2
1.3	Power source		Battery
1.4	Operating mode		Foldable platform with side guards
1.5	Nominal capacity/load	Q [kg]	2,000
1.6	Load center (COG)	c [mm]	600
1.8	Load wheel shaft to fork face (forks lowered)	x [mm]	960
1.9	Wheelbase (forks lowered)	y [mm]	1,421
2	WEIGHTS		
2.1	Service weight (with battery, see 6.5)	[kg]	660
2.2	Shaft loadings (with nominal load and battery weight), drive / load side	[kg]	950 / 1,710
2.3	Shaft loadings (without load / with battery), drive / load side	[kg]	535 / 125
3	WHEELS AND TYRES		
3.1	Tyres, material (R=rubber / PU=Polyurethane / Vul = Vulkollan) drive / load side		Vul / Vul
3.2	Load wheel dimensions	[mm]	85x75
3.3	Traction wheel dimensions	[mm]	230x70
3.4	Castor wheel dimensions	[mm]	125x55
3.5	Number of the wheels (x=driven) load / drive side		4/1x+2
3.6	Track width (centre of tyres), drive side	b10 [mm]	480
3.7	Track width (centre of tyres), load side	b11 [mm]	375
4	DIMENSIONS		
4.4	Lift	h3 [mm]	135
4.9	Height of the tiller arm in travel position (min. / max.)	h14 [mm]	1,180 / 1,350

	max.)		
4.15	Fork height, fully lowered	h13 [mm]	85

4.19	Overall length (battery sideload +72 mm for 250 Ah and 375 Ah)	l1 [mm]	1,852 / 2,346
4.20	Length to face of forks (battery sideload +72 mm for 250 Ah and 375 Ah)	l2 [mm]	702 / 1,195
4.21	Chassis (overall width)	b1/b2 [mm]	720
4.22	Fork dimensions (thickness / width / length)	s/e/l [mm]	55 / 165 / 1,150
4.25	Distance between fork-arms	b5 [mm]	540
4.32	Ground clearance, center of wheelbase	m2 [mm]	30
4.33	Working aisle width Ast, pallet 1,000x1,200, load crosswise	Ast [mm]	1,920 / 2,400
4.34	Working aisle width Ast, pallet 800x1,200, load lengthwise	Ast [mm]	2,120 / 2,600
4.35	Turning radius	Wa [mm]	1,680 / 2,160
5	PERFORMANCE		
5.1	Travel speed, laden / unladen / (unladen opt.)	[km/h]	9.0 / 9.0 / (12)
5.2	Lifting speed, laden / unladen	[m/s]	0.035 / 0.05
5.3	Lowering speed, laden / unladen	[m/s]	0.045 / 0.05
5.7	Gradeability, laden / unladen	[%]	9 / 25
5.10	Service brake		Electric
6	MOTORS		
6.1	Drive motor S2 60 min	[kW]	2.3
6.2	Lift motor S3 15%	[kW]	1.2
6.4	Battery voltage / capacity (min. - max.)	[V/Ah]	24 / 250 - 375
6.5	Battery weight (min. - max.)	[kg]	212 – 291
8	MISCELLANEOUS		
8.1	Speed control type		Stepless
8.4 8)	Level of noise at the driver's ear level according to EN 12 053:2001 and EN ISO 4871 in work LpA	[dB (A)]	66
	Level of noise at the driver's ear level according to EN 12 053:2001 and EN ISO 4871, drive / lift /	[dB (A)]	70 / 68 / 46

	idle LpA		
	Whole-body vibration according to EN 13 059:2002+A1:2008	[m/s^2]	0,8

	Hand-arm vibration according to EN 13 059:2002+A1:2008	[m/s^2]	< 2,5
Manufacturer reserves the right to make technical changes.			
[8)] Uncertainty of 4 dB(A) in section 8.4			

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V

W

Z

APPENDIX A: Stickers

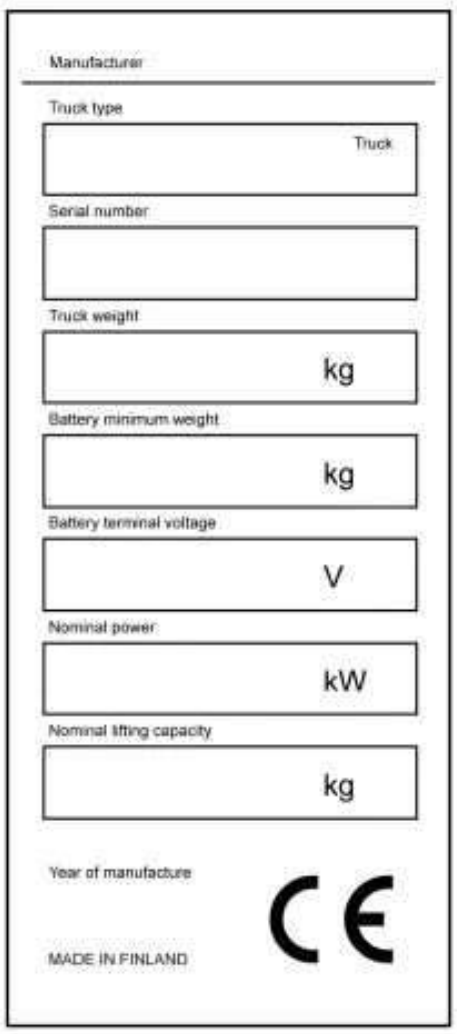


Figure 110. Type plate

Figure 111. Operation warning sticker

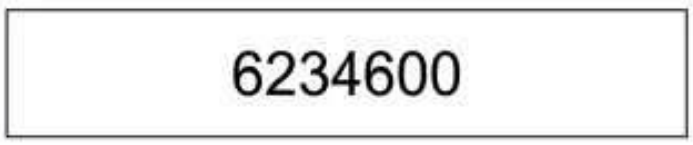


Figure 112. Serial number sticker

Figure 113. Battery maintenance warning sticker

Figure 114. Electric panel cleanup warning sticker

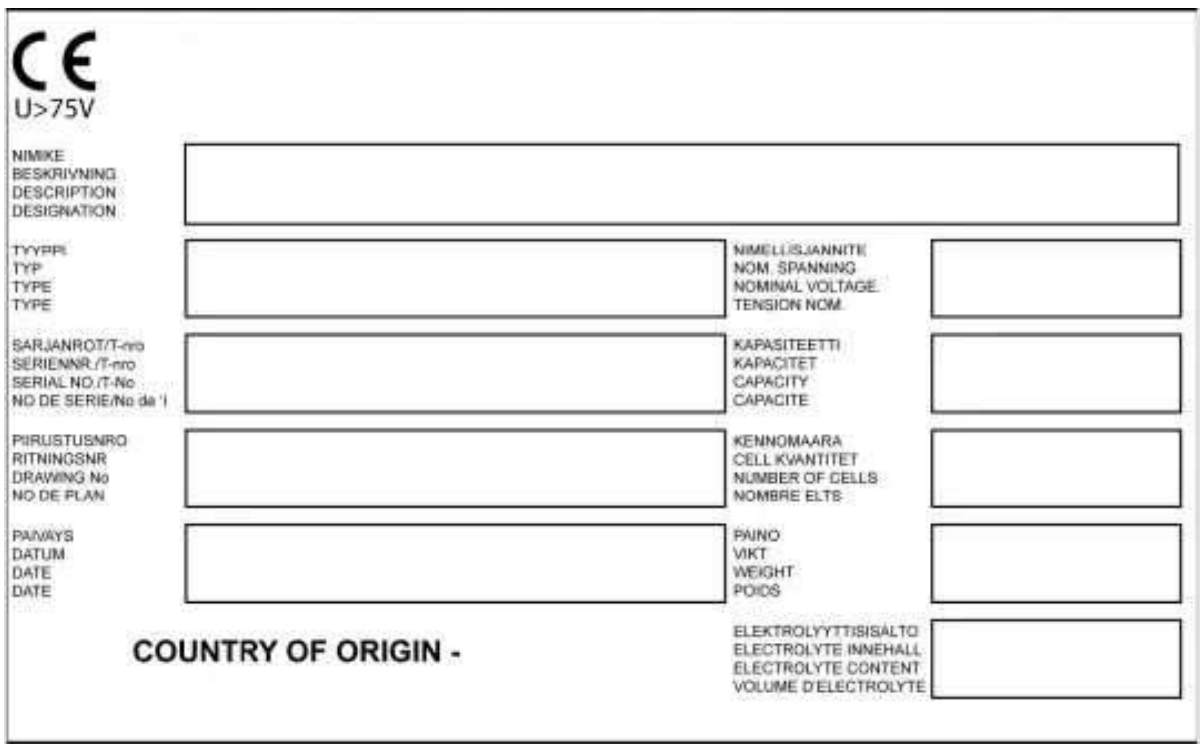
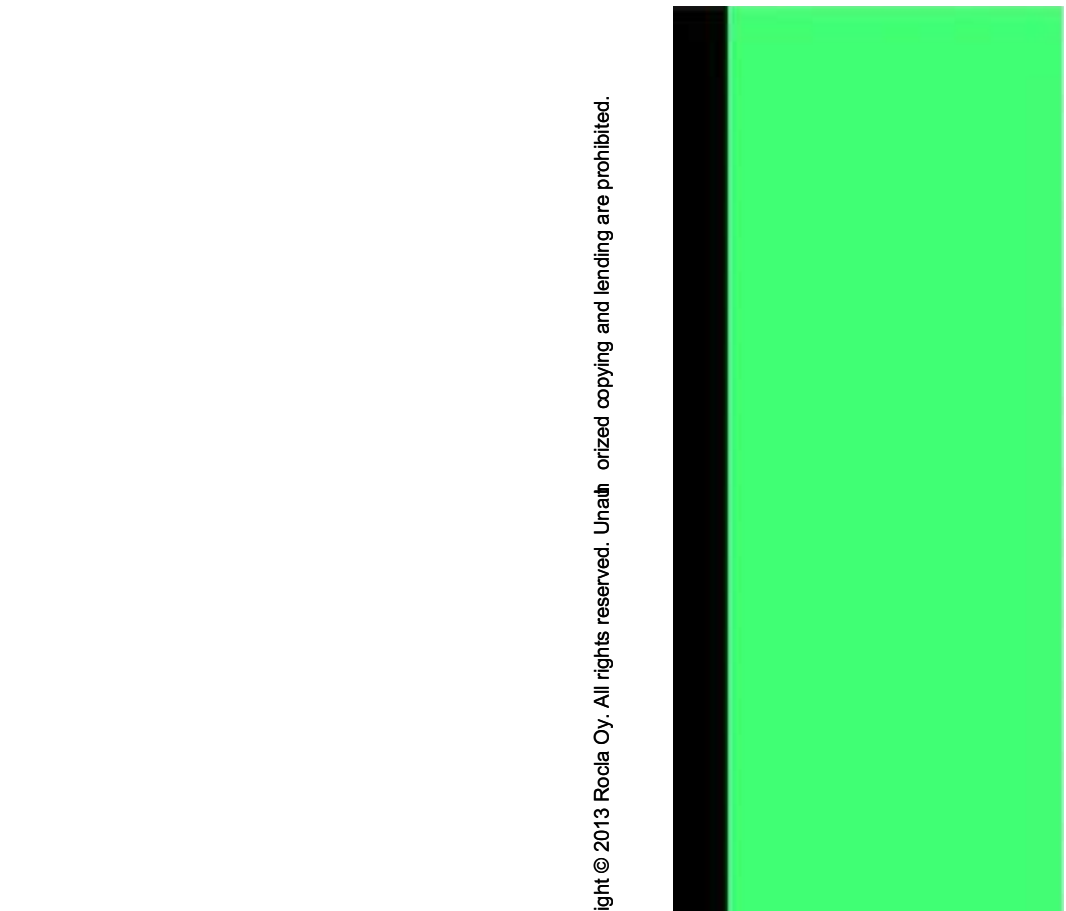


Figure 115. Battery type plate

Figure 116. Hoist point indication sticker



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