

# ST470E TRACTOR

## OPERATION, MAINTENANCE AND PARTS MANUAL



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## APPLICABILITY OF THIS MANUAL

ST470E Tractors with a Manufacture Year of 2020 - 2022 (MY2020 - 2022) with Serial Numbers 220120243 - 222121757.

If this manual does not correspond to the Manufacture Year (MY) of your Tractor, the correct manual can be obtained from AvroGSE using the contact details given inside the Front Cover of this manual.

Manual Part Number: PRPW02738

Alternate Equipment Models:      ST470LA (Includes Lead Acid Battery)

ST470LI (Includes Lithium Battery)

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## LIST OF ABBREVIATIONS

A	Amp (Ampere)	lbf	pounds force
Ah	Amp hours	lbs	pounds
C	Centigrade	LED	light emitting diode
cc	cubic centimetres	LOS	Limited Operating Strategy
c/w	complete with	Max	maximum
DBP	Draw bar Pull	MIL	Malfunction Indicator Lamp
Deg	degree (temperature)	mm	millimetres
Dia.	diameter	MPa	Megapascal (1 MPa = 1 Nmm <sup>2</sup> = 145 lbs/in <sup>2</sup> )
D.T.C.	Diagnostic Trouble Code	mph	miles per hour
EM	electromagnetic	MY	manufacture year
F	Fahrenheit	N/A	Not Applicable
ft/lbs	foot-pounds force	Nm	Newton Metre
GSE	ground support equipment	o.d.	outside diameter
HPD	High Pedal Disable	OS	Operating System
kg	kilograms	P/N	Part Number
KSI	keyswitch input	PPE	Personal Protective Equipment
IATA	International Air Transport Association	psi	pounds per square inch (pressure)
i.d.	inside diameter	SAE	Society of Automotive Engineers (specification)
in.	Inches	SWL	Safe Working Load
KN	Kilonewtons	TBA	To Be Advised
kph	Kilometers per hour	Temp	temperature
L	litre	VCL	Vehicle Control Language

## SAFETY

Observe the following safety precautions.

### LETHAL DANGER – CARGO USE ONLY



The Tractor is designed to tow airport ground support equipment only. Do not exceed the Tractors' towing capacity. It is dangerous to do so and an accident or damage to the Tractor may result.

**DO NOT** allow people to ride on the ground support equipment while it is being towed. It is unsafe to do so, and lethal injury may result.

### LETHAL DANGER – DO NOT USE ON PUBLIC ROADS



The Tractor is designed for use in airports. It is **NOT** suitable, or legal, for use on public roads. Attempting to use the Tractor on a public road may result in a lethal accident.

**DO NOT** use the Tractor for purposes for which it was not designed, or operate the Tractor in a reckless manner. Lethal injury may result.

### LETHAL DANGER – DO NOT ALTER FACTORY SETTINGS



**DO NOT** attempt to alter the Tractor's factory settings. Lethal injury may result. The factory settings optimise both the safety of the Tractor and the Tractor's towing performance.

Altering the factory settings invalidates the Warranty on the Tractor.

### WARNING – MAXIMUM SPEED



The maximum speed of the Tractor is limited to 24 kph (14 mph). It unsafe to exceed that speed.

**Do not** attempt to modify the Tractor to exceed that speed. A fatal accident may result.

## WARNING – ALCOHOL AND DRUG USE



The Tractor must not be accessed or operated by anyone impaired by alcohol or drugs.

## WARNING – SIZE AND WEIGHT OF TRACTOR



The Tractor weighs 4300 kg (9480 lbs). When lifting the Tractor for service and maintenance purposes, always use an Automotive Service Lift/Hoist with a Safe Working Load (SWL) rated above the weight of the Tractor. **DO NOT** use a crane with lifting slings or chains, there are no lifting points on the Tractor.

## WARNING – SIZE AND WEIGHT OF TRACTOR



When lifting the Tractor during shipping, always use a forklift truck with a Safe Working Load (SWL) greater than 4500 kg (4.5 Tons). **DO NOT** use a crane with lifting slings or chains, there are no lifting points on the Tractor.

The Tractor must always be towed or moved using a suitable vehicle.

## WARNING – HEAVY ITEMS



Always use correct manual handling techniques. For items positioned below mid-lower leg height, safe lifting capacity is 10 kg (5 kg if not close to your feet) for an able-bodied man and 7kg (3 kg if not close to your feet) for an able-bodied woman.

## WARNING – PETROLEUM, OILS AND LUBRICANTS



Do not eat, drink or smoke when applying oil or lubricant. Do not allow the lubricant to come into contact with your eyes, mouth or nose. Wear Personal Protective Equipment (PPE), for example suitable gloves, eye shields, and overalls. If lubricant is ingested, or comes into contact with your eyes, seek medical assistance immediately.

Oil and lubricants are a slip hazard. Always clean up any spillages, or excess oil or lubricant.

## WARNING – BATTERY SAFETY



**DO NOT** check, or top-up, the battery electrolyte before the battery is charged, or while the battery is being charged. Battery acid **WILL** escape during the charging process as the electrolyte level will rise during charging.

Only use distilled water or de-ionised water to top-up the electrolyte.

**DO NOT** leave any tools on metal/conductive objects on top of the battery. A short circuit of battery cells may result.

## WARNING – BATTERY – FIRE AND HEALTH HAZARD



During charging the battery will release hydrogen and oxygen. When the hydrogen concentration in the air reaches 4% there is risk of an explosion.

When charging the battery, do not smoke within 3 m (10 feet) of the Tractor. Make sure that there are no naked flames or combustibles, or working equipment that may produce sparks, within 3 m (10 feet) of the Tractor. The workshop must have a fire extinguisher suitable for use on electrical fires. Make sure that the workshop is well ventilated.

The acid in the battery is poisonous and corrosive. Do not eat or drink within 2 m (6 feet) of a Tractor that is being recharged. If battery acid is ingested, or comes into contact with your skin, eyes, nose, or mouth, seek medical assistance immediately.

Battery acid spillages must be neutralised and cleaned-up immediately.

## WARNING – BATTERY GASES



Make sure that the cover over the battery compartment is in the raised position when charging the battery. This is to allow any gases generated during charging to escape. Do not close the cover until charging is complete.

Open the battery vent cap slightly to make sure that gases produced during charging do not build up inside the battery.

## WARNING – BATTERY GASES



Do not unplug the Main Power Connector from the charger while the charger is switched On. There will be a spark that could cause an explosion of battery gases.

## WARNING – WEIGHT OF BATTERY



The Battery weighs 1700 kg (3748 lbs). When lifting the Battery for service and maintenance purposes, always use a crane with a four-leg lifting sling or chain with a Safe Working Load (SWL) rated above the weight of the Battery. Always attach the legs of the lifting sling or chain to the four lifting points on the Battery unit.

## PRECAUTION – PERSONAL PROTECTIVE EQUIPMENT



When operating, moving, lifting, servicing, repairing, or transporting the Tractor, always wear suitable Personal Protective Equipment (PPE) to prevent crushing of hands, feet, or other body parts. For example, wear protective footwear, safety glasses, hard hat, protective gloves, and high-visibility clothing.

When preparing the Tractor for transport by air, road, or rail, make sure it is securely packed. Safeguard the Tractor against movement or break-away during transport by applying the brake, and securely strapping the Tractor in place.

## PRECAUTION - READ THIS MANUAL



Read and understand this manual before operating, cleaning, repairing, or servicing the Tractor.

A copy of this manual will have been provided with each Tractor when it was delivered.

Familiarize yourself with the location and correct use of all controls, indicators, and safety devices before operating the Tractor.

## PRECAUTION – OPERATOR TRAINING



**ONLY** people who have been **FULLY TRAINED AND AUTHORIZED** to operate this type of Tractor are permitted to start, operate, and shut down the Tractor.

Anyone operating or maintaining the Tractor must understand the potential risks and hazards associated with it **BEFORE** they operate the Tractor.

Anyone operating or maintaining the Tractor must be familiar with all the required safety devices and procedures.

## PRECAUTION – SAFE WORKING PRACTICES



Be aware of the Tractor's working parts. Keep hands, feet, and loose clothing away from the Tractor's moving parts.

**DO NOT** operate a Tractor that is need of repair. Perform scheduled maintenance in accordance with the maintenance procedures given in this manual.

Only operate the Tractor when:

- (1) All safety devices and guards are in place and in full working order.
- (2) All controls, gauges, lights, and indicators operate correctly.

(3) The Tractor is set-up correctly in accordance with this manual.

## WARNINGS AND PRECAUTIONS – WELDING, GRINDING, AND CUTTING



**WELDING ARC.** A welding arc is bright enough to damage eyesight and cause flash burns. Never look directly at a welding arc with unprotected eyes. Always use an approved welding screen or visor. Cover all exposed skin before welding.



**PROTECTIVE CLOTHING.** Always wear protective clothing and gloves appropriate for welding work.



**HOT WELDS.** Always allow a weld to cool before removing welding slag.

Make sure that there is no combustible material within 4 Meters (13 feet) of grinding, welding, or slag chipping.



**GRINDING, CHIPPING, AND CUTTING.** Always wear eye protection (e.g. protective goggles) when using grinding and cutting tools, and when chipping off welding slag. Always wear eye protection when within 4 Meters (13 feet) of grinding, slag chipping, or cutting with power tools.



**DAMAGE TO ELECTRICAL EQUIPMENT.** To prevent damage to the vehicle electrical system, before performing any welding, remove or disconnect all vehicle batteries, and disconnect all electrical connections to the vehicle electronics.



**TRAINING, AUTHORIZATION AND CERTIFICATION OF WELDERS.** Welding must only be performed by people who have been **FULLY TRAINED IN WELDING AND ARE AUTHORIZED** to perform welding operations. Welders must be **CERTIFIED** by their respective national association of welders, such as CWB and/or AWS.

Grinding, chipping, and cutting with power tools must only be performed by people who have been **FULLY TRAINED IN USING THE POWER TOOLS AND ARE AUTHORIZED** to perform those operations.

Before performing any welding, grinding or chipping operations, make sure that any necessary Hot Work Permits have been obtained.



## INTRODUCTION

The function of the ST470E Tractor is to act as a baggage tractor, towing aircraft ground support equipment (GSE) within the confines of airports. The Tractor is NOT suitable for use on public roads. Multiple GSE can be linked together for towing, up to the towing limit of the Tractor and the regulation limits of the relevant airport/transport authorities.



**Figure 1 – ST470E Tractor**

The Tractor can tow the following types of GSE:

- Cargo Dolly's.
- Baggage Carts.
- Trash Carts.
- Water Service Carts.
- Fuel Carts.
- Lavatory Service carts.
- Gas Bottle Service Carts.

A hitch at the rear allows multiple carts to be linked together. A hitch at the front allows the Tractor to tow carts while reversing.

## SPECIFICATION

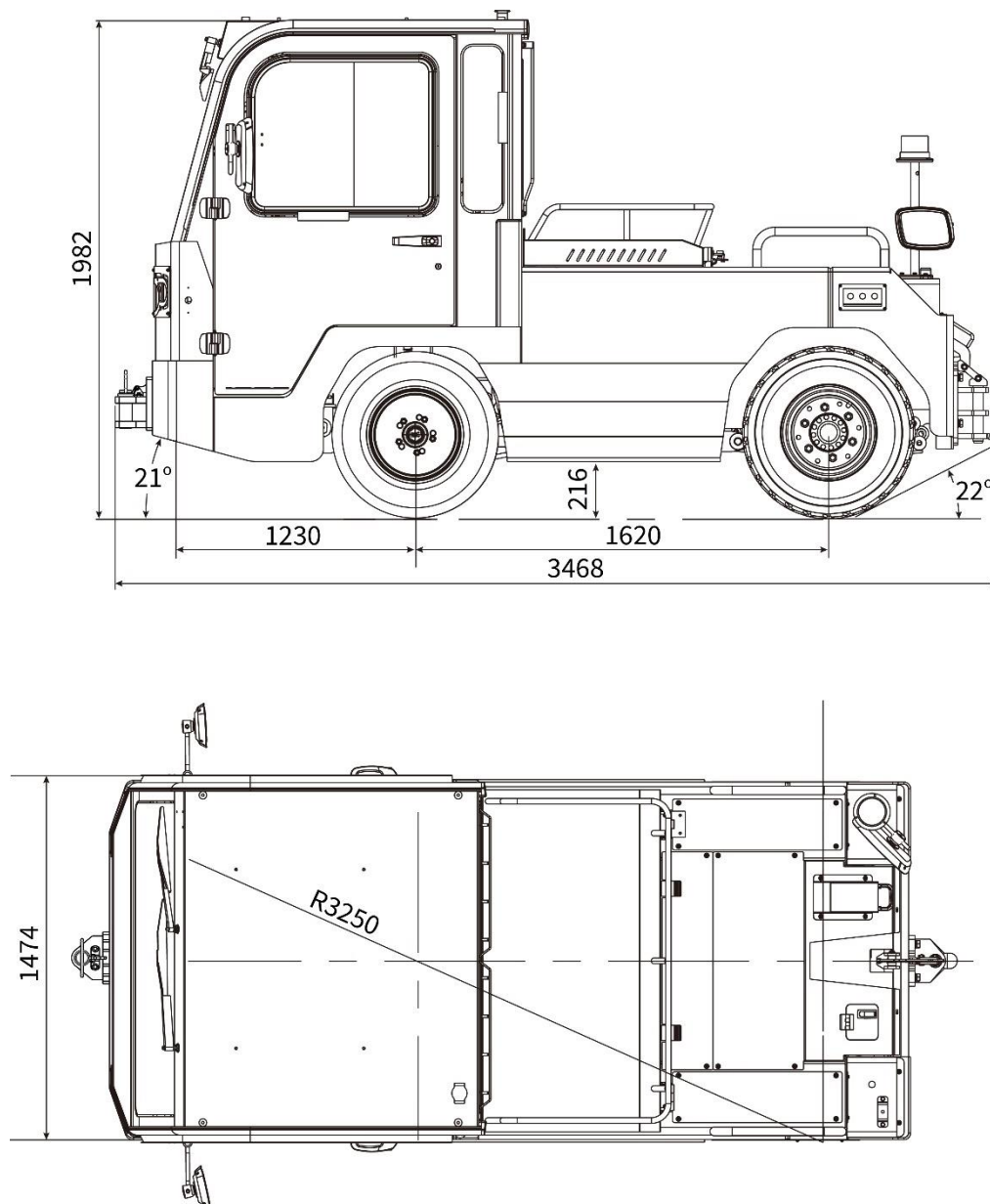
The specification of the ST470E Tractor is given in the following Table.

**Table 1 ST470E Tractor specification**

ST470E Tractor	Value	Units	Notes
Length (overall)	3468 136.5	mm in.	Includes towing couplers
Width (overall)	1474 58.0	mm in.	
Height (overall)	1982 78.0	mm in.	
Wheelbase	1620 63.8	mm in.	
Minimum Ground Clearance	108 4.2	mm in.	
Rear Hitch height	305 12.0	mm in.	
Front Hitch height	318 12.5	mm in.	
Front overhang (inc. front hitch)	1025 40.4	mm in.	
Rear overhang (inc. rear hitch)	675 26.6	mm in.	
Front wheelbase	1230 48.4	mm in.	
Rear wheelbase	1210 26.6	mm in.	
Weight	4300 9480	kg lbs	
Max Traction Power	22 4946	KN lbf	
Max Speed (unloaded)	15.5 25	mph kph	Max speed is regulated.
Max Speed (loaded)	6.2 10	mph kph	

## ST470E Baggage Tractor

ST470E Tractor	Value	Units	Notes
Draw Bar Pull (DBP)	2132 4700	kg lbs	Max value
Minimum Turning Radius	3250 128	mm in.	ST470E has hydraulic power steering.
Gradeability (without load)	30	%	
Operating temperature range	-20 to +50 -4 to +122	deg C deg F	Ambient temperature Optimum battery performance is obtained at temperatures above 0 deg C (+32 deg F)
Storage temperature range	-10 to +40 14 to +104	deg C deg F	Ambient temperature Storage indoors highly recommended
Humidity range	0 to 95	%	Relative humidity
Battery capacity	660	Ah	Lead acid battery
Battery Voltage	80	V	
Traction motor	23	Kw	
Pump motor	2.5	Kw	
Tire size:			
Front tires	18R14LT-8PR		
Rear tires	7.00 – 12 – 12PR		
Tire pressure - Front tires	60 to 65 4.14 to 4.48	psi Bar (gauge)	Max
Tire pressure - Rear tires	90 to 100 6.21 to 6.89	psi Bar (gauge)	Max



**Figure 2 – ST470E Tractor dimensions**

## DESCRIPTION



**Figure 3 – ST470E Tractor Exterior**

1	Warning Beacon	10	Upper brake light
2	Mirror	11	Side Indicator Lights
3	Battery compartment cover	12	Side Mirror
4	Cab	13	Rear electrical compartment
5	Front Hitch	14	Tail Lamp Assembly
6	LED Headlights	15	Main Power Connector
7	Front Indicator Lights	16	Rear Hitch
8	Side Indicator Lights	17	Access hatch (to hydraulic tank)
9	Battery Compartment	18	Rear work light

### Key to Figure 3

## MOTOR CONTROL SYSTEM

The Tractor uses a Curtis 1238E AC Motor Controller, and a 1232E AC Motor Controller, to provide accurate, dependable, and highly efficient control of speed and torque of, respectively, a Drive Motor and a Steering Motor.

These AC controllers each contain two microprocessors to provide exceptional capability and functional safety. The primary microprocessor runs an advanced field-oriented AC motor control while simultaneously running Vehicle Control Language (VCL) software in an embedded logic controller. The second microprocessor continuously monitors the operation of the system, redundantly measuring inputs, crosschecking results, and verifying critical timing and operations.

The two Motor Controllers, together with the Drive Motor, Steering Motor, and associated control electronics, are located in the rear electrical compartment. Electrical power to operate the Tractor is provided by a lead acid battery. Due to the weight of the battery, having the battery compartment mid-wheelbase adds to the stability of the Tractor.

## DRIVE SYSTEM

The Curtis 1238E AC Motor Controller (Traction Motor Controller) controls the application of power from the battery to the Drive Motor. The Drive Motor is attached to the Drive Axle Assembly (rear axle). The Drive Axle Transmission Assembly and the Differential Assembly, that form part of the Drive Axle, transfer mechanical rotary power from the Drive Motor shaft to the drive axle.

## BRAKE SYSTEMS

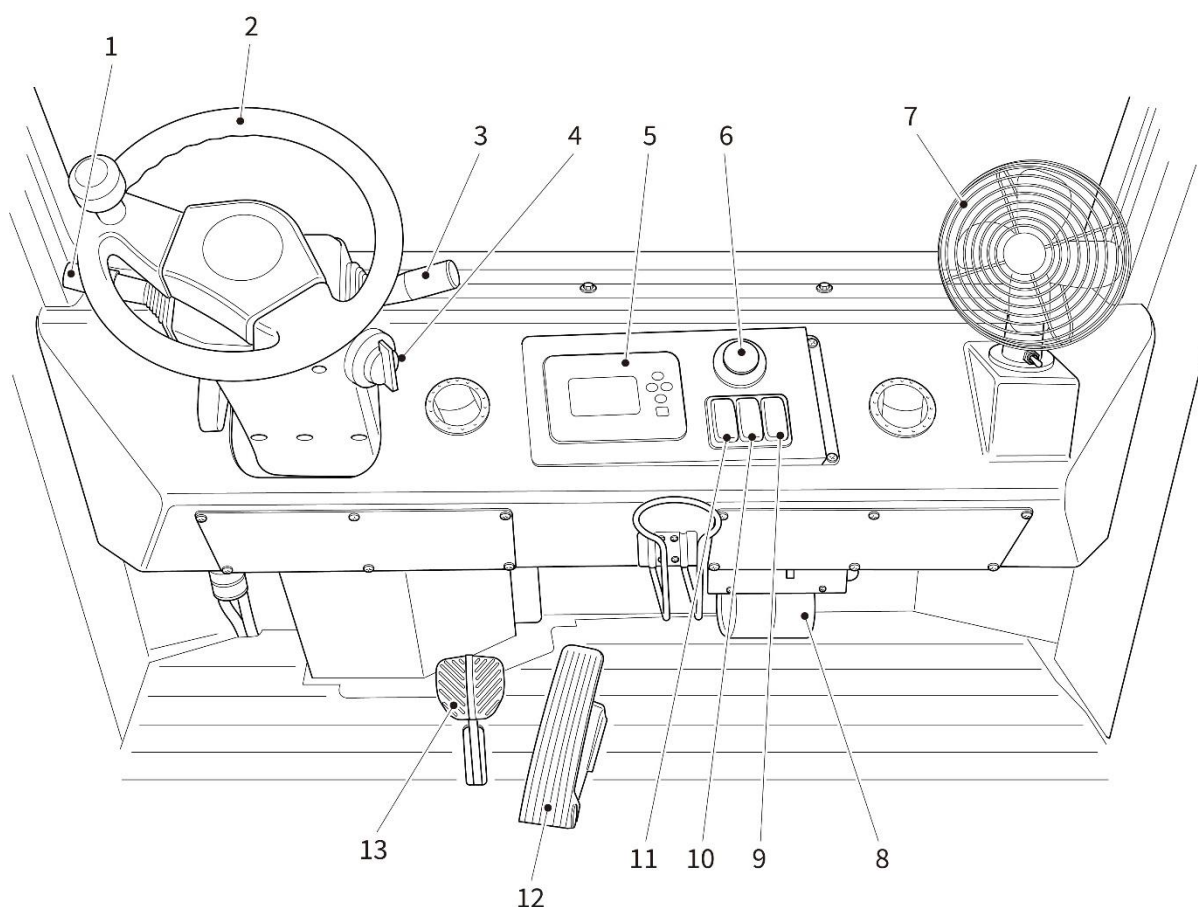
The Tractor has two braking systems, a Foot Brake System (Service Brake), and a Parking Brake (Hand Brake).

The Foot Brake System is a four-wheel braking system. Brake fluid from the main cylinder is routed via a ratio valve to the four independent brakes. The Foot Brake System includes a vacuum assisted boost.

## STEERING SYSTEM

The Tractor is fitted with a hydraulic power steering system.

## DRIVING CONTROLS



- |   |                                     |    |  |
|---|-------------------------------------|----|--|
| 1 | Lights control                      | 8  | Heater                                   |
| 2 | Steering wheel                      | 9  | Switch for 4-way hazard indicator lights |
| 3 | Forward/Reverse direction control   | 10 | Windscreen wiper switch                  |
| 4 | Ignition switch                     | 11 | Switch for Rear Working Lamp             |
| 5 | Dashboard Instrument Display Screen | 12 | Accelerator pedal                        |
| 6 | EMERGENCY STOP switch               | 13 | Brake pedal                              |
| 7 | Fan                                 |    |  |

**Figure 4 –Driving controls**

The function of the drivers' controls and indicators is described in the following Table:

Number	Description	Function
1	Lights control	Controls headlamps, and Left/Right turn indicator lights
2	Steering wheel	Controls Tractor steering. From full left to full right, the steering wheel will make 3 to 4 complete rotations.
3	Forward/Reverse direction control	Used to select forward or reverse direction.
4	Ignition switch	2-position ON-OFF rotary switch used to start-up and switch off the Tractor.
5	Dashboard Instrument Display Screen	Displays speed, battery power, fault information, operating time, and important warning information.
6	EMERGENCY STOP switch	Pressing this switch shuts off the electrical power from the battery.
7	Fan	
8	Heater	The heater On/Off switch, and associated red On lamp, are located on the heater, immediately below the dash.
9	Switch for 4-way hazard indicator lights	Switches 4-way hazard indicator lights On or Off.
10	Windscreen Wiper Switch	Switches windscreen wipers ON/OFF.
11	Switch for Rear Working Lamp	Switches rear working lamp ON/OFF.
12	Accelerator pedal	Drive speed.
13	Brake pedal	Service Brake.

The controls and indicators on the Dashboard Instrument Display Screen (also known as the Dash Display Screen) are shown in Figure 5.

The Tractor control system includes a series of settings that are pre-set at the factory. These factory settings optimise the towing performance and safety of the Tractor. DO NOT attempt to alter the factory settings.

The menu item select button (Figure 5, item 8) allows access to a series of menus that are used to set-up the Tractor. If the menu item select button is pressed, or accidentally tripped, further progress is blocked by a password. DO NOT attempt to proceed further. Press the Menu Item Select button to exit the menus.

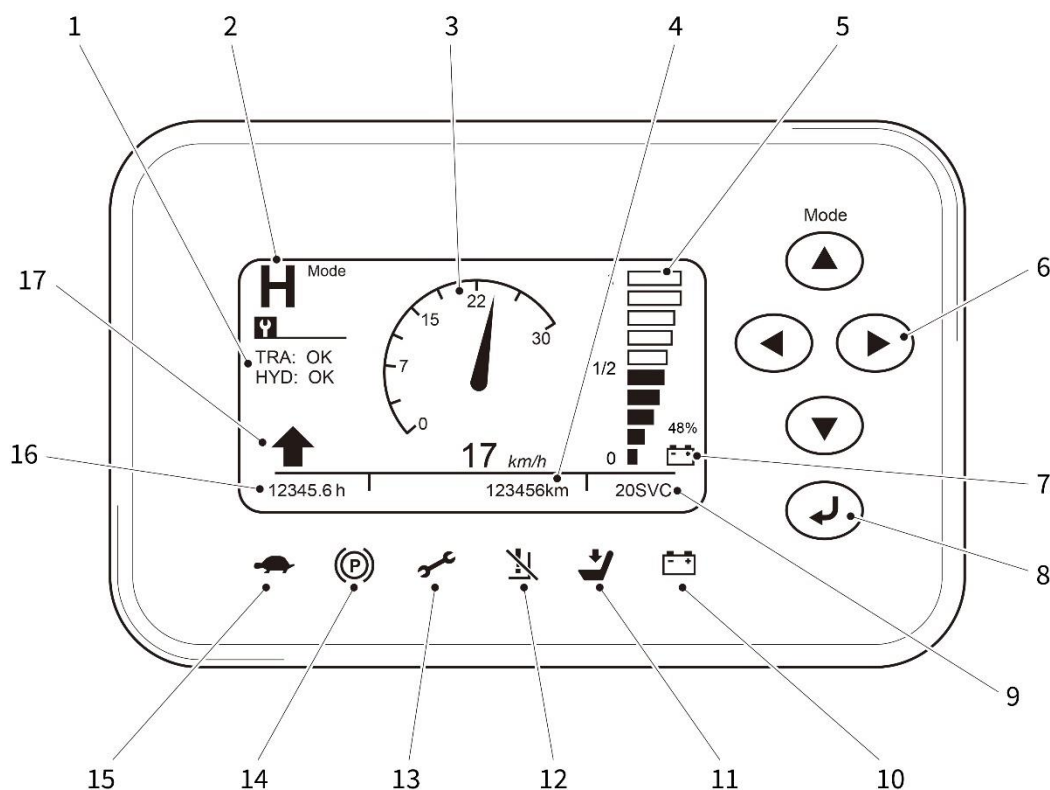
## LETHAL DANGER – DO NOT ALTER FACTORY SETTINGS



**DO NOT attempt to alter the Tractor's factory settings. Lethal injury may result. The factory settings optimise both the safety of the Tractor and the Tractor's towing performance.**

**Altering the factory settings invalidates the Warranty on the Tractor.**



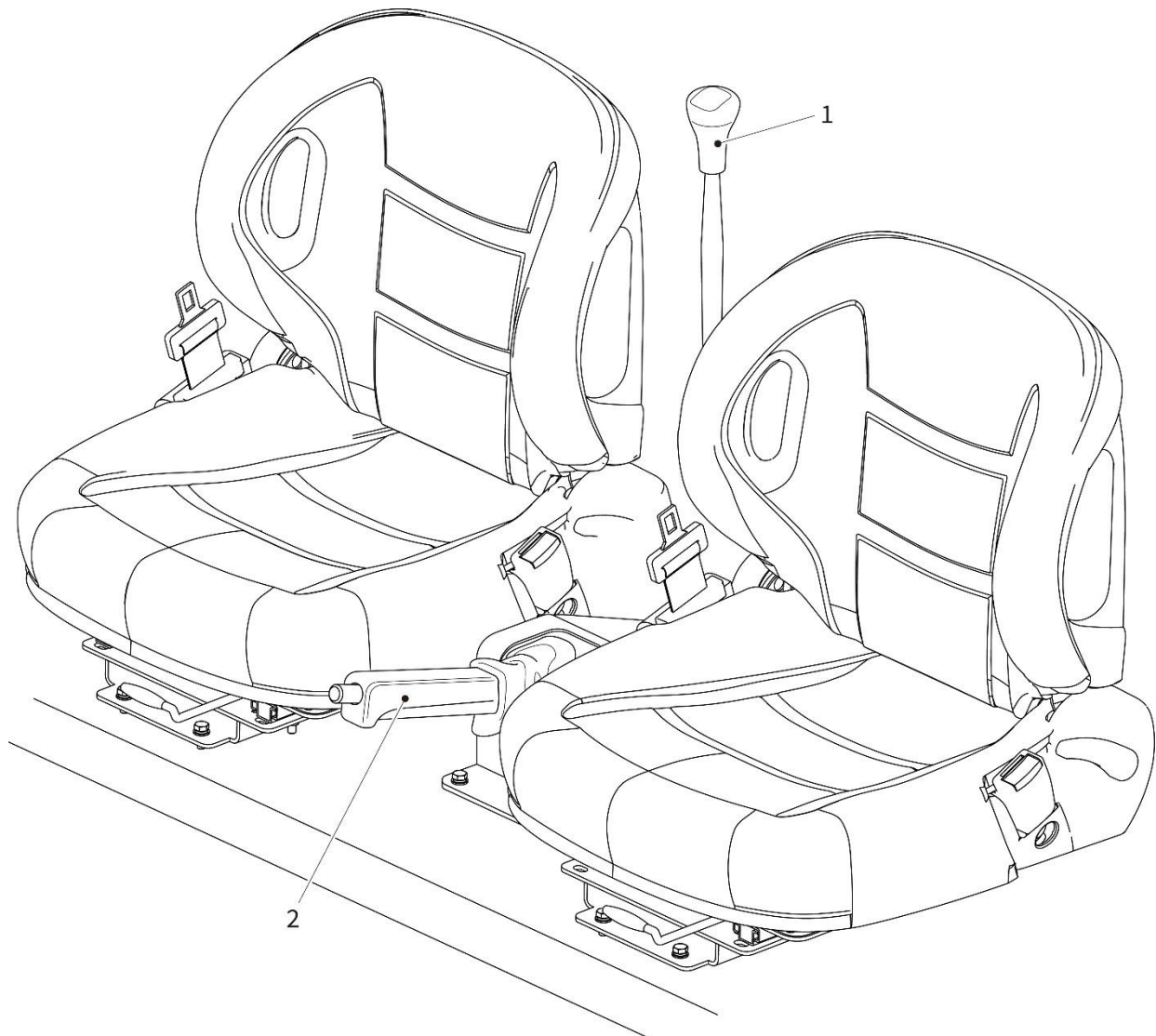


- |   |   |    |                                |
|---|---|----|--------------------------------|
| 1 | Fault Code                                | 10 | Battery low indicator          |
| 2 | Speed mode                                | 11 | Seat switch indicator          |
| 3 | Speed                                     | 12 | Critical battery low indicator |
| 4 | Distance travelled (in km)                | 13 | Fault alarm                    |
| 5 | Bar meter showing remaining battery power | 14 | Park brake indicator           |
| 6 | Menu up/down/left/right buttons           | 15 | Slow Mode indicator            |
| 7 | Remaining battery power percentage        | 16 | Elapsed time                   |
| 8 | Menu item select button                   | 17 | Forward/Reverse indicator      |
| 9 | Maintenance code                          |    |                                |

**Figure 5 – Dash Display Screen (Dashboard Instrument Screen)**

On the Dash Display Screen, the Fault Code Display area is normally “Running Well”. In the event of a fault or malfunction on the tractor it will sometimes (but not always) display a fault code that can be used to identify the problem. Illumination of the Fault Alarm (13) also indicates a fault on the Tractor.

## PARKING BRAKE AND REAR HITCH LEVER



1 Control lever for Rear Hitch

2 Parking Brake

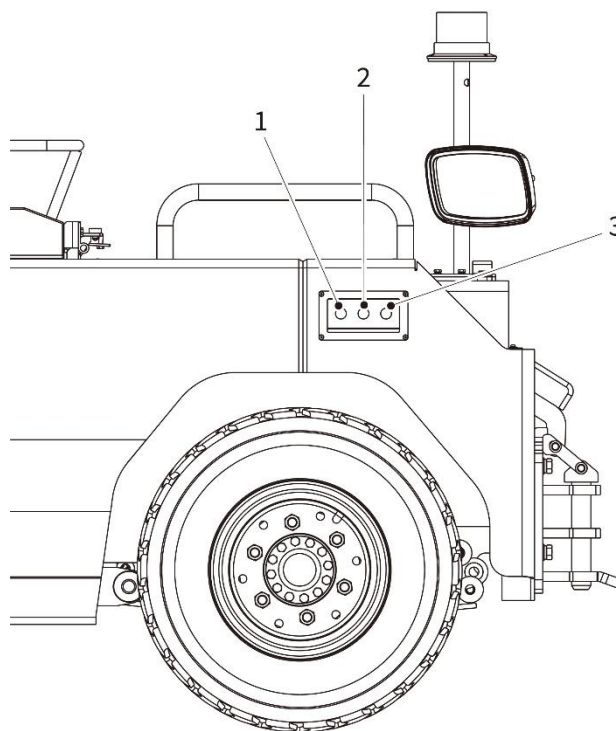
**Figure 6 – Parking Brake and Rear Hitch Lever**

The Parking Brake (Figure 6, item 2) is used to make sure the Tractor does not move when not in use. To apply the Parking Brake, press the button at the front of the Parking Brake and pull the Parking Brake lever upwards as far it will go. To release the Parking Brake, press the button and lower the Parking Brake lever as far as it will go.

The Rear Hitch control lever (Figure 6, item 1) allows the driver to operate the Rear Hitch without leaving the cab. When the lever is moved forward the towing pin in the Rear Hitch is raised. Similarly, the towing pin is lowered under its own weight when the lever is released.

A lifting handle on the Rear Hitch linkage allows the Rear Hitch to be operated by a person standing beside the rear of the Tractor.

## EXTERIOR CONTROLS



1 Forward creep button

3 Reverse creep button

2 EMERGENCY STOP switch

**Figure 7 – Exterior Controls**

Three control buttons are located on the left rear of the Tractor (Figure 7). These control buttons facilitate attaching GSE to the Rear Hitch of the Tractor. Pressing the forward (1) or reverse (3) creep buttons will, respectively, cause the Tractor to slowly creep forwards or backwards. The creep buttons can therefore be used to adjust the position of the Tractor so that the GSE mates with the Tractor's Rear Hitch. Do not press both creep buttons at the same time as they will counteract each other.

The EMERGENCY STOP button (2) performs the same function as the EMERGENCY STOP button located on the Dash.

## CHARGING THE BATTERY

The Tractor battery **MUST** be recharged every day after use. Recharge the Tractor battery as follows:

### NOTE

Leaving a battery in a discharged state for more than 24 hours will reduce battery life and performance.

## WARNING – BATTERY – FIRE AND HEALTH HAZARD



**During charging the battery will release hydrogen and oxygen. When the hydrogen concentration in the air reaches 4% there is risk of an explosion.**

**When charging the battery, do not smoke within 3 m (10 feet) of the Tractor. Make sure that there are no naked flames or combustibles, or working equipment that may produce sparks, within 3 m (10 feet) of the Tractor. The workshop must have a fire extinguisher suitable for use on electrical fires. Make sure that the workshop is well ventilated.**

**The acid in the battery is poisonous and corrosive. Do not eat or drink within 2 m (6 feet) of a Tractor that is being recharged. If battery acid is ingested, or comes into contact with your skin, eyes, nose, or mouth, seek medical assistance immediately.**

**Battery acid spillages must be neutralised and cleaned-up immediately.**

- Make sure that the Tractor is standing on level ground, and that the Tractor is level with the ground.
- Turn Off the main switch (ignition switch). Make sure that the Tractor is shut down.
- Make sure that the battery charger is switched Off. **DO NOT** attempt to connect the battery to a charger that is already switched On.

## WARNING – BATTERY GASES

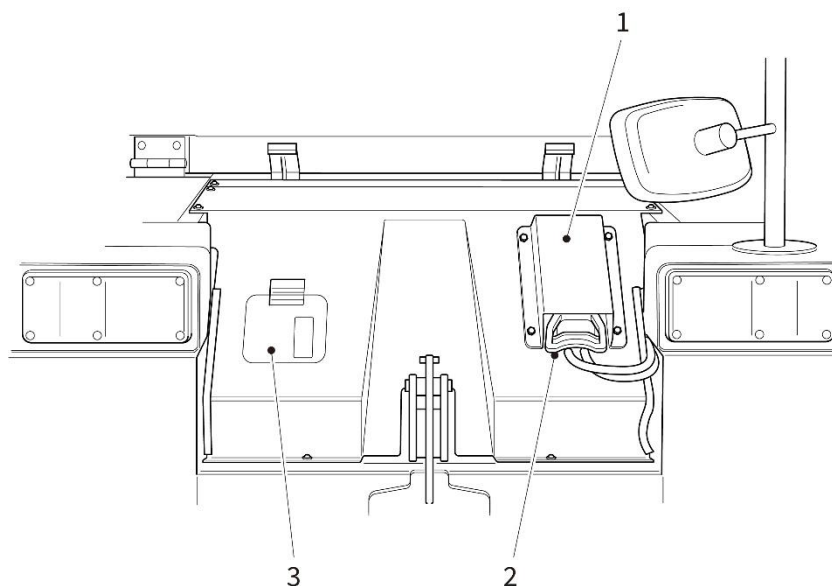


**Make sure that the cover over the battery compartment is in the raised position when charging the battery. This is to allow any gases generated during charging to escape. Do not close the cover until charging is complete.**

**Open the battery vent cap slightly to make sure that gases produced during charging do not build up inside the battery.**

- To maximise the charge of the battery, and to allow gases to escape, open the cover over the battery compartment. Check that there are no metal objects on top of the battery.
- On the battery, open the vent cap slightly to make sure that gases produced during charging do not build up inside the battery.
- Refer to Figure 8. Disconnect the battery side of the Main Power Connector (2) by pulling on its handle. There is no need to remove the guard (1) that protects the Main Power Connector. Note that the battery side of the Main Power Connector is a plug.

- Visually check the Main Power Connector and associated cable for damage. If damage is observed, do not attempt to recharge the battery, and REPORT the fault.



- |   |                      |   |  |
|---|----------------------|---|--|
| 1 | Guard                | 3 | Access hatch (Power Steering hydraulic oil tank) |
| 2 | Main Power Connector |   |  |

**Figure 8 – Recharging the battery**

- Connect the Main Power Connector plug to the charging cable of the charger.
- Switch On the charger and recharge the battery in accordance with the instructions of the battery and charger manufacturers. Make sure that you strictly comply with the safety warnings and instructions for the battery and charger.

## WARNING – BATTERY GASES



**Do not unplug the Main Power Connector from the charger while the charger is switched On. There will be a spark that could cause an explosion of battery gases.**

- Do not unplug the Main Power Connector from the charger while the charger is switched On. There will be a spark that could cause an explosion of battery gases.

- Continue charging until the battery is fully charged. Most chargers are designed to self monitor the voltage and adjust the charge rate as the battery reaches full charge, then it will shut off at full charge. To fully charge a battery will take 8 to 12 hours, depending upon the charger.
- Switch Off the charger.
- Disconnect the Main Power Connector from the charger.
- Connect the Main Power Connector plug to the Main Power Connector socket (located under the proactive cover (Figure 8, item 1). Check that the battery cable is not damaged.
- Close the battery vent cap. The battery can only be used when the vent cap is closed. Make sure that the vent cap is clean.
- Check that all the battery terminal posts are tight and smeared with a small amount of dielectric grease.
- The charging procedure is now complete.

## CHECKING BATTERY ELECTROLYTE LEVEL

After the battery has been charged, check the electrolyte level in the battery as follows:

### WARNING – BATTERY SAFETY

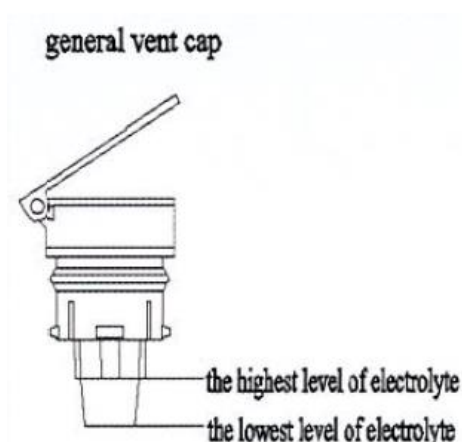


**DO NOT check, or top-up, the battery electrolyte before the battery is charged, or while the battery is being charged. Battery acid WILL escape during the charging process as the electrolyte level will rise during charging.**

**Only use distilled water or de-ionised water to top-up the electrolyte.**

**DO NOT leave any tools on metal/conductive objects on top of the battery. A short circuit of battery cells may result.**

- Check the battery electrolyte level by comparing the electrolyte level with the nominal liquid level. If the electrolyte level is lower than the nominal liquid level the electrolyte needs topping-up.



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### Figure 9 - Vent cap : checking the electrolyte level

- You MUST use distilled water or de-ionised water to top-up the electrolyte. NEVER use ordinary water.
- DO NOT put the distilled water or de-ionised water in a container made from iron or steel. Use either a lead container, or a porcelain/pottery container, or a PVC (plastic) container. Using the wrong type of container will degrade the battery.
- Add the distilled water or de-ionised water to the electrolyte through the flexible plastic tube provided for the purpose on top of the battery. The plastic piping will make sure that the water is distributed to all the cells of the battery.
- Add the water slowly to avoid spilling it.
- DO NOT add too much water, it will result in electrolyte spilling out of the battery.
- Clean the battery surface with a moist cloth. If dust builds up on the top of the battery it can cause self-discharge of the battery. Do not use a dry cloth as it will cause a build-up of static electricity.
- Check the battery harness terminals are securely attached to the battery.
- Check that no tools or metal objects have been left on top of the battery.
- Lower the battery compartment cover.
- The procedure for checking and topping-up the electrolyte is now complete.

## EQUALIZING CHARGE

Perform an Equalizing Charge (also known as a balancing charge) on the battery once per week. The equalizing charge disulphates the battery and reduces unbalance in the battery, thus extending the life of the battery. It is recommended that an “intelligent” charger is used as they automate some of the Equalizing Charge process. Perform the Equalizing Charge as follows:

- Recharge the battery as described above, but do not disconnect the Main Power Connector from the charger.
- Allow the battery to stand for 1 hour. Do not operate the Tractor during that time.
- Read the instructions for performing an Equalizing Charge given in the charger manual.
- All Safety and equipment protection measures given in the recharging procedure apply equally when performing an Equalizing Charge.
- Switch On the charger.
- Follow the Equalizing Charge instructions given in the manual for the charger. An “intelligent” charger will shut off when the Equalizing Charge is complete. It may be necessary to repeat the process several times until the battery voltage and density are stable.
- Switch Off the charger.
- Disconnect the Main Power Connector from the charger.
- Connect the Main Power Connector plug to the Main Power Connector socket located under the guard (Figure 8, item 1). Check that the battery cable is not damaged.

- Close the battery vent cap. The battery can only be used when the vent cap is closed. Make sure that the vent cap is clean.
- Check that all the battery terminal posts are tight and smeared with a small amount of dielectric grease.
- The Equalizing Charge procedure is now complete.

## REMOVING THE BATTERY

Remove the Tractor battery as follows:

- Make sure that the Tractor is standing on level ground, and that the Tractor is level with the ground.
- Turn Off the main switch. Make sure that the Tractor is shut down.
- Raise the cover over the battery compartment. Check that there are no metal objects on top of the battery.
- Remove and retain the rear glass guard.
- Refer to Figure 8. Disconnect the battery side of the Main Power Connector (2) by pulling on its handle. There is no need to remove the guard (1) that protects the Main Power Connector.
- Disconnect the battery harness from the battery. Move the battery terminal ends of the battery harness clear of the battery.

## WARNING – WEIGHT OF BATTERY



**The Battery weighs 1700 kg (3748 lbs). When lifting the Battery for service and maintenance purposes, always use a crane with a four-leg lifting sling or chain with a Safe Working Load (SWL) rated above the weight of the Battery. Always attach the legs of the lifting sling or chain to the four lifting points on the Battery.**

- A crane with a four-leg lifting sling or chain with a SWL of at least 2000 kg (2 tons) is required to lift the battery. Attach the hooks of the lifting sling or chain to the four lifting points on the battery. Using the crane, take-up the slack in the lifting sling or chain, then slowly and carefully lift the battery out of the battery compartment. Make sure that the battery harness does not become trapped as the Battery is lifted. Make sure that the lift is even, and that the battery is not tilted excessively.
- When the base of the battery is clear of the battery compartment, use the lifting equipment to move the battery laterally, away from the Tractor. Lower the battery to the ground or onto a vehicle to transport it.
- The battery removal procedure is now complete.

## BATTERY INSTALLATION

Installation of the battery is the reverse of the battery removal procedure.

## BATTERY STORAGE

If a spare backup battery is required and will not be used for a long period of time, it is recommended that a dry-charged battery is purchased. That is, a battery without any electrolyte present.



If a battery contains an electrolyte, and it is placed in storage for a long period, it will slowly self-discharge. The self-discharge will reduce the capacity of the battery (the amount of power it can store), cause counter electrode vulcanisation, and damage the battery's working life due to time migration hazards. Therefore, if a battery with electrolyte is placed into long term storage, the following measures must be implemented:

- Charge the battery before placing it into storage.
- Store the battery under cover in a dry place, at a temperature within the range 5 to 40 deg C (41 to 104 deg F). A cool temperature is preferable. Keep the battery out of direct sunlight, and away from heat sources, in an area with ventilation. Relative humidity is acceptable.
- DO NOT store the battery on its side or inverted. Move the battery using lifting equipment and keep the battery level while moving it. Do not drag, roll, or push the battery. Do not store anything on top of the battery. DO NOT place metal or conductive items on top of the battery.
- Make sure that the battery does not come into contact with organic solvents or toxic gases. Prevent any impurities entering the battery.
- Charge the battery every month. Even if the measured battery electrolyte density is still very high, the battery must be charged monthly.
- Make sure the battery is fully charged until all of the monomer is emitting gas, and the value is maintained for 2 hours while the battery voltage and electrolyte density remain unchanged.
- After charging the battery, perform an Equalizing Charge. Then check the electrolyte density and level.
- Record this monthly charging.

## OPERATION

Before starting the Tractor:

- Ensure that the EMERGENCY STOP switches are in the open position, and the Gear Lever is in the Neutral position.
- Rotate the Start Switch in a clockwise direction to the On position. The Main Contactor (in the Rear Electrical Compartment) connects and the whole Tractor switches On. The instrument panel will activate, and the Tractor will self-test for approximately 2 to 3 seconds.
- If the self-test detects a fault, do not attempt to use the Tractor and REPORT the fault.
- When the self-test is completed successfully, the Dashboard Instrument Display Screen (Dash Display Screen) will display vehicle data normally.

### NOTE

If the Tractor fails to start after several attempts, REPORT the problem. Have a suitably trained and authorised vehicle mechanic check the vehicle and perform the Troubleshooting Procedure given in this manual.

- When the Dash Display Screen shows TRACTION OK, it means that the motor control system is functioning normally.
- When the Dash Display Screen shows HYD OK the steering pump controller is functioning normally.
- Apply the foot brake.
- Using the Gear Shift, select the required gear.
- Release the Parking Brake. The Parking Brake indicator on the Dash Display Screen will extinguish.
- Check that it is safe to move the Tractor.
- Release the foot brake.
- Press the Accelerator Pedal, the Tractor will move.
- Test the Foot Brake and the Parking Brake before using the Tractor. The brakes MUST have a good and reliable performance. If not, do not use the Tractor and report the problem.
- The high-speed forward gear should only be used for unladen travel on level ground.
- The low-speed forward gear MUST be used when towing, when maximum towing force is required, and when the Tractor is on an up or down gradient. This gear provides maximum torque.
- DO NOT select Neutral gear, or switch OFF the Tractor, when going downhill.

## PARKING

When parking the tractor:

- Make sure that the Tractor is stable on level ground.
- Set the Gear Shift to Neutral.

- Engage the Parking Brake.
- Rotate the Start Switch counter-clockwise to the OFF position.

## STORAGE

If the Tractor is not going to be used for a long time:

- Perform monthly, six-monthly, and 12-monthly lubrication.
- If necessary, perform cold weather maintenance (“winterize”).
- Charge the battery.
- Do an Equalizing Charge on the battery.
- Protect exposed parts against rust, for example, by applying grease.
- Store the Tractor under a suitable cover. Indoor storage is highly recommended.

## RECEIPT AND PREPARATION FOR FIRST USE

On receipt of a new ST470E Tractor, before operating the Tractor for the first time, you **MUST** perform the following:

- Make sure that all loose packaging has been removed from the Tractor.
- Check the Tractor and its components for damage. If there is any visible damage, **DO NOT OPERATE THE TRACTOR**. Contact AvroGSE immediately for assistance. Contact details for AvroGSE are given inside the front cover of this manual.
- Perform an inventory of all parts included with the Tractor and verify that all loose components and fasteners are accounted for. If any are missing, contact AvroGSE immediately for assistance.
- Attach all component parts not already attached to the Tractor.
- Make sure that all necessary fluids (for example, gear oil) are checked and additional fluid added as needed.
- Verify that the Tractor is fully serviceable by performing the Daily Maintenance checks, Weekly Maintenance checks, and Monthly Maintenance Checks described in the Scheduled Maintenance section of this manual.
- Move the Tractor to its operating location.
- Complete any receipt documentation and maintenance records as required.
- Adjust the seat position and the steering wheel angle to give a comfortable operating position.

## NEW TRACTOR RUN-IN PERIOD

Run-in the Tractor as detailed in the Table below.

**Run In Table**

Running Time (Hours)	Load	Travelling Speed
0 to 10	Unloaded	Less than 10 km/hr
10 to 25	Less than 50% Load	Less than 5 km/hr
25 to 50	Rated Load	Less than 7.5 km/hr

During the first 10 to 15 km check the Tractor several times for high temperatures and abnormal sounds in the Motors, Drive Axle (including Transmission), brakes, and steering. Perform Weekly Maintenance as described in the Maintenance Schedule when the Tractor has travelled 10, 25, and 50 km.

The first five times the battery is charged, also do an Equalizing Charge.

## SCHEDULED MAINTENANCE

Scheduled maintenance is limited to the activities specified in the Scheduled Maintenance Table below. The maintenance intervals given are approximate, assume heavy use of the ST470E Tractor, and may be varied by  $\pm 10\%$  without adverse effects. Every Tractor should be inspected and serviced based on its own requirements, for example variation in the hours of use and the environment in which it is used.

An **X** in the Scheduled maintenance Table indicates that the activity described should be performed at that maintenance period.

When fitting fasteners, DO NOT apply thread-locking adhesive. A specific torque setting must be applied to the wheel nuts as detailed on page 64. For other bolts and fasteners, refer to the guidance on torque settings given on pages 64 and 65.

It is not necessary to perform Daily Maintenance if a higher level of maintenance has been performed in the preceding 24 hours.

	Task	Daily	Weekly	Monthly (100 hrs)	6 Monthly (600 hrs)	12 Monthly (1200 hrs)
<b>1</b>	<b>Cleaning</b>					
a.	Use water and degreaser, or a domestic detergent and water solution. Do not use industrial cleaning agents, or caustic agents, or aircraft de-icing and cleaning agents. Use of a spray washer is permitted.	X	X	X	X	X
b.	Remove dirt and dust from the top surface of the battery and the electrode column.			X	X	X
c.	Wipe oil, dirt and dust from wires and electrical harnesses in rear electrical compartment.				X	X
d.	Clean Drive Axle.				X	X
e.	If significant corrosion is present, grind off the corrosion, coat the affected area with corrosion protection fluid (if available), apply primer paint, and retouch paintwork.				X	X
<b>2</b>	<b>Visual Inspection</b>					
a.	Walk around the Tractor and examine the Tractor as described below. During the inspection tighten any fasteners that are loose.	X	X	X	X	X
b.	Check Tractor body and cab are undamaged. Minor damage or corrosion is acceptable. Damage to the body or cab that may impair or affect the operation of the Tractor must be repaired before operating the Tractor.	X	X	X	X	X
c.	Check wing mirrors are present and undamaged. Check rear view mirror is present and undamaged. Replace missing or damaged mirrors.	X	X	X	X	X

	Task	Daily	Weekly	Monthly (100 hrs)	6 Monthly (600 hrs)	12 Monthly (1200 hrs)
d.	Check the windscreen and windows for cracked glass. If glass is cracked, do not use the Tractor until the damaged glass has been replaced.	X	X	X	X	X
e.	Check that the headlights, indicator lights and rear lights are present and undamaged. Switch ON the ignition and check that all the lights work. Repair or replace any that are not serviceable. DO NOT use a Tractor with an unserviceable light.	X	X	X	X	X
f.	Check that the Beacon is present, secure, and undamaged. Check that the Beacon functions correctly. Replace or repair if unserviceable. DO NOT use a Tractor with an unserviceable Beacon.	X	X	X	X	X
g.	Check that the Rear Coupler is undamaged, secure, and functions correctly. Repair if required.	X	X	X	X	X
h.	Check that the Front Coupler is undamaged, secure, and functions correctly. Repair if required.	X	X	X	X	X
i.	Check tires for leaks and damage. Check surface condition of tires. Check tires meet legal requirements for minimum tread depth. Replace if damaged or worn-out.	X	X	X	X	X
j.	Check tightness of wheel nuts. Front wheels: 210 Nm (155 ft/lbs). Rear wheels: 420 Nm (310 ft/lbs). Re-tighten if required.		X	X	X	X
k.	Check pressure of front tires is $65 \pm 3$ psi ( $4.48 \pm 0.21$ Bar (gauge)). Adjust tire pressure if required.		X	X	X	X
l.	Check pressure of rear tires is $95 \pm 3$ psi ( $6.55 \pm 0.21$ Bar (gauge)). Adjust tire pressure if required.		X	X	X	X
m.	Check for oil leaks from power steering, brake system, and drive axle. REPORT the leak and DO NOT use the Tractor until the leak has been repaired.	X	X	X	X	X
<b>3</b>	<b>Battery</b>					
a.	Recharge Battery.	X	X	X	X	X
b.	<u>After</u> recharging the Battery, check the electrolyte level and adjust as required. Refer to the procedure for topping-up the electrolyte.	X	X	X	X	X
c.	Clean battery top surface with a damp cloth. A dust build-up on top of the battery can cause self-discharge of the battery. Do not use a dry cloth as it will cause static electricity.	X	X	X	X	X
d.	Check battery terminal posts are tight and smeared with a small amount of dielectric grease. Check that all connectors are tight.	X	X	X	X	X

	Task	Daily	Weekly	Monthly (100 hrs)	6 Monthly (600 hrs)	12 Monthly (1200 hrs)
e.	Check that no tools, metal, or conductive items have been left on top of the battery.	X	X	X	X	X
f.	Perform an "Equalize Charge" on the Battery.		X	X	X	X
g.	Check for water or electrolyte in the steel tray. Remove water and dry tray. Neutralise electrolyte with alkaline water, dilute with water, remove liquid, and dry.		X	X	X	X
h.	Measure and record all the cells voltage, specific gravity, and temperature after charging. Compare the readings with previous results. If the difference to the previous value is obvious, there may be a problem, obtain professional assistance.		X	X	X	X
i.	Check the connecting busbars that link the battery cells. If any are loose, tighten them. If there is any corrosion on the battery busbars, or where they connect to the battery cells, remove it. Loose busbars and corroded contacts will reduce Tractor performance.			X	X	X
j.	Check that the battery vent cap is clean and closed. Battery can only be operated when vent cap is closed.	X	X	X	X	X
<b>4</b>	<b>Operation</b>					
a.	Start-up the Tractor. Check the operation of the steering and braking systems. If not functioning correctly, report the problem and DO NOT use the Tractor until it has been repaired.	X	X	X	X	X
b.	Check the operation of the electrical system. Check that all readings on the Dash Display Screen are normal. If there is a problem, report the problem and DO NOT use the Tractor until it has been repaired.	X	X	X	X	X
<b>5</b>	<b>Mechanical Checks</b>					
a.	During the mechanical checks, check whether the bolts, screws, and nuts that secure each component are loose. Tighten any that are loose.		X	X	X	X
b.	Check for leaks from pipe/hose joints in the Power Steering system and the Brake System.		X	X	X	X
c.	Check brake fluid level. Top-up brake fluid as required. Refer to the Fuel, Lubricants and Consumables section of this manual for details of the brake fluid.		X	X	X	
d.	Replace brake fluid. Refer to the Fuel, Lubricants and Consumables section of this manual for details of the brake fluid.					X
e.	Check condition and adjust clearance of brake shoes.		X	X	X	X

	Task	Daily	Weekly	Monthly (100 hrs)	6 Monthly (600 hrs)	12 Monthly (1200 hrs)
f.	Check, and if required, adjust the free stroke of the brake pedal and parking brake.		X	X	X	X
g.	Check parking brake cables. Replace if damaged or worn. Adjust if loose.			X	X	X
h.	Replace power steering oil. Refer to the Fuel, Lubricants and Consumables section of this manual for details of the power steering oil.				X	X
i.	Check steering column and steering shaft for damage or other problems. Repair if required. Check play clearance of steering wheel and adjust if required. If necessary, tighten the steering system.				X	X
j.	Clean, check and lubricate all parts of the steering system.				X	X
k.	Check Power Steering System. Replace any damaged components.				X	X
l.	Check the wheel swing of the front left and front right wheels. Adjust if necessary.				X	X
m.	Top-up Drive Axle Differential/Transmission gear oil. Refer to the Fuel, Lubricants and Consumables section of this manual for details of the oil.			X		
n.	Replace Drive Axle Differential/Transmission gear oil. Refer to the Fuel, Lubricants and Consumables section of this manual for details of the oil.				X	X
o.	Check front and rear suspension systems are undamaged and in a satisfactory working condition. Replace unserviceable components.			X	X	X
p.	Clean and lubricate front suspension shock absorbers, springs, and bump stops.				X	X
q.	Check, and if necessary, adjust or replace the front and rear wheel bearings.				X	X
<b>6</b>	<b>Electrical Checks</b>					
a.	Examine cables, wires and electrical harnesses for damage or abrasion to the insulation, loose connections, and anything else that could affect operation of the Tractor.		X	X	X	X
b.	Make sure that all cables, wires, and harnesses are physically secured in place.		X	X	X	X
c.	Start-up the Tractor. Check that the LEDs on the Traction Motor Controller indicate that the Traction Motor Controller is functioning correctly.		X	X	X	X



	Task	Daily	Weekly	Monthly (100 hrs)	6 Monthly (600 hrs)	12 Monthly (1200 hrs)
d.	Check that the LED on the Steering Motor Controller indicates that the Steering Motor Controller is functioning correctly. Then switch Off the Tractor.		X	X	X	X
<b>7</b>	<b>Lubrication</b>					
a.	Lubricate Tractor in accordance with the Lubrication Chart (if not already done in this maintenance sequence).		X	X	X	X
<b>8</b>	<b>Maintenance Records</b>					
a.	Complete all required maintenance records.	X	X	X	X	X

## COLD/HOT WEATHER MAINTENANCE

When the seasons change, perform the following cold weather/hot weather maintenance:

- Perform “Monthly Maintenance”.
- Clean, check and lubricate all parts of the steering system.
- Change lubricating oil.
- Record that this maintenance has been completed.

### NOTE

All elements of cold/hot weather maintenance are included in the 6-monthly maintenance. Therefore, it is not necessary to perform cold/hot weather maintenance if 6-monthly maintenance has been performed and completed within the previous 2 weeks. It may be desirable to schedule maintenance so that cold/hot weather maintenance and 6-monthly maintenance are performed at the same time.

## FUEL, LUBRICANTS AND CONSUMABLES

Fuel/Lubricant	Specification
Lubricating Grease Wheel Bearing Grease	3# Lithium based grease
Drive Axle Oil	ISO 220 Gear Oil
Brake Fluid	DOT 4 Brake Fluid
Power Steering Fluid	Universal Tractor Fluid

### FILL CAPACITIES

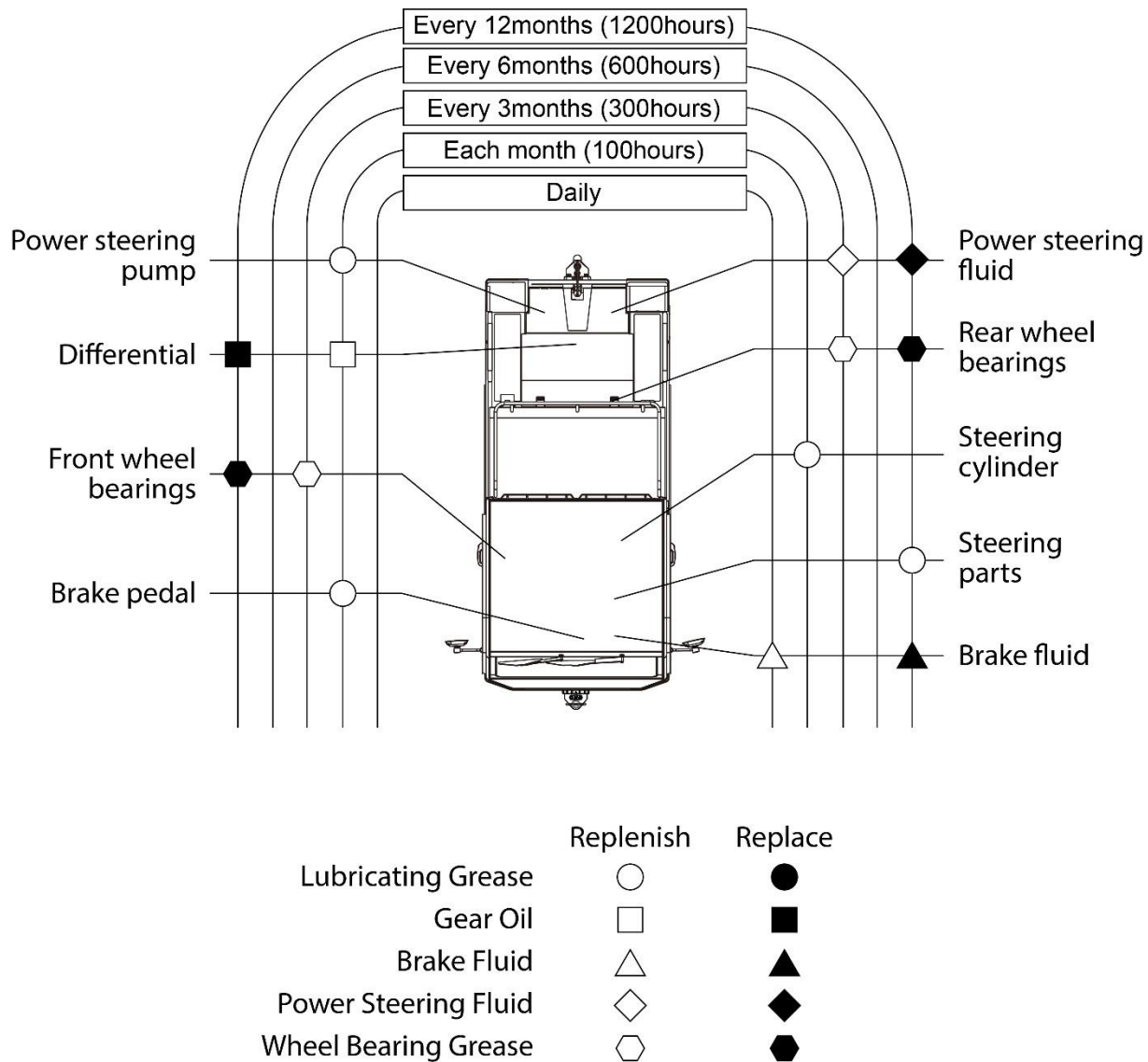
Item	Fill capacities (L)
Grease	As required
Drive Axle Oil	7.5
Brake fluid	0.6
Power Steering Fluid	10

### CONSUMABLES

Consumable	Type
Dielectric Grease	Any reputable brand (Obtain from a reputable auto-parts supplier)
Thermal joint compound (also known as Heat Sink Compound or Thermal Paste)	Any reputable brand (Obtain from a reputable electronics parts supplier)

## LUBRICATION

Lubrication requirements are summarised in this Lubrication Diagram.



**Figure 10 – Lubrication diagram**

## TEST EQUIPMENT

The following Test Equipment is used during the failure diagnosis and troubleshooting procedures.

- A digital multimeter. The multimeter must have a “diode test” function. The use of a multimeter is ESSENTIAL.
- Either a Curtis Model 1313 Handheld Programmer, or a Curtis Model 1314 Laptop Based Programmer.

The Curtis Model 1313 Handheld Programmer (or a Curtis Model 1314 Laptop Based Programmer) is used to configure Curtis motor control systems. With the programmer, you can adjust and save parameter settings, monitor real-time data, and perform diagnostics and troubleshooting.



**Figure 11 - Curtis Model 1313 Handheld Programmer**

The Curtis Model 1313 Handheld Programmer is a more modern replacement for the previous Curtis Model 1311 Handheld Programmer.



**Figure 12 - Curtis Model 1314 Laptop Based Programmer**

For brevity, the electrical failure diagnosis and troubleshooting procedures only refer to the use of a Curtis Model 1313 Handheld Programmer. However, all references to the Curtis Model 1313 Handheld Programmer should be taken to mean either a Curtis Model 1313 Handheld Programmer, or a Curtis Model 1314 Laptop Based Programmer.

The use of either a Curtis Model 1313 Handheld Programmer, or a Curtis Model 1314 Laptop Based Programmer, during the electrical failure diagnosis and troubleshooting procedure is OPTIONAL.

The electrical failure diagnosis and troubleshooting procedure can be performed without a Curtis Handheld Programmer, but some parts of that troubleshooting procedure will have to be omitted. As you proceed through the electrical troubleshooting procedure, just omit any steps that require a Curtis Handheld Programmer and proceed to the next step.

For instructions on how to use the Curtis Model 1313 Handheld Programmer or the Curtis Model 1314 Laptop Based Programmer, refer to the respective manuals for those instruments. The manuals are available from Curtis Instruments Inc.

## TROUBLESHOOTING AND FAILURE DIAGNOSIS

Troubleshooting and failure diagnosis on the XT470LA Tractor is performed by five methods. The nature of the problem will to a large extent determine which troubleshooting methods to use.

- Depending upon the problem, a MIL (Malfunction Indicator Lamp) may be displayed on the Dashboard Instrument Display Screen (Dash Display Screen).
- Visually examine the tractor for obvious problems, using the information given in the Scheduled Maintenance Table as a guide. Also check the ATM Mini Fuses in the Centre Control Box and the two fuses in the electrical compartment.
- For suspected mechanical problems, and simple electrical problems, perform the Troubleshooting Procedure given in the Troubleshooting Table below.
- The Traction Motor Controller for the Drive Motor has two LEDs that indicate the status of the Traction Motor Controller, as described in the Diagnostics sub-section of this manual. Check those two LEDs.
- The Traction Motor Controller includes a built-in Diagnostics capability. If a problem occurs with the Motor Controller, or an associated part of the electrical/electronic systems, a Fault Code will be displayed on the Dashboard Instrument Display Screen (Dash Display Screen). The Fault Code can also be read using the Motor Controller status LEDs. If a Fault Code is shown, refer to the Motor Controller Troubleshooting Table for fault isolation and corrective action.

**Troubleshooting Table**

Sub-Assembly	Trouble	Probable Cause	Corrective Action
Drive Axle	Abnormal noise	1. In the Differential planetary gears, the circular cone gear is worn, or the clearance is too wide.	Replace circular cone gear, or adjust clearance, as applicable.
		2. In the Differential, the cross shaft is worn.	Replace cross shaft.
		3. In the Differential, the tapered roller bearing is worn or loose.	Replace the tapered roller bearing, or adjust its position, as applicable.
Drive Axle	Differential is overheating	1. The bearings of the drive gears are too tight.	Adjust the bearings pre-load.
		2. Too much, or too little, gear oil in the Differential.	Drain or add oil to the Differential. When oil starts to output from the plug the oil level is correct.
Power Steering System	Steering wheel vibration, shaking, or instability	1. Tire pressure incorrect.	Adjust tire pressure to bring it within specification.
		2. Steering link assembly, associated sleeve, or universal joint, is worn.	Replace faulty parts.
		3. Hub bearing is worn, or its clearance is incorrect.	Adjust or replace.
		4. Front wheel or tire is damaged, or deformed, or has uneven wear.	Replace.

## ST470E Baggage Tractor

Sub-Assembly	Trouble	Probable Cause	Corrective Action
Power Steering System	Steering wheel vibration, shaking, or instability	5. Steering System loose, not secure.	Tighten securing hardware.
Power Steering System	Steering wheel is hard to turn.	1. Tire pressure incorrect.	Adjust tire pressure to bring it within specification.
		2. Steering components require lubrication.	Lubricate with grease.
		3. Oil leak from a Steering System seal.	Replace seal.
		4. Oil in steering system contaminated with debris or foreign substance.	Replace oil and Oil Filter.
		5. Steering system oil level low.	Top-up oil level.
		6. Bent or damaged steering column.	Replace.
		7. Steering link assembly, associated sleeve, or universal joint, is worn.	Replace faulty parts.
		8. Hydraulic oil leak, or blockage or restriction in a hydraulic hose.	Repair/replace hoses as required and rectify leaks.
		9. Air trapped in Steering System hydraulic hoses.	Vent air from Steering System hydraulics.
Power Steering System	Steering wheel does not return to normal (centre) position.	1. Steering column unserviceable.	Disassemble, clean, and replace unserviceable parts.
		2. Tire pressure incorrect.	Adjust tire pressure to bring it within specification.
Power Steering System	Tractor turns sharply, or cannot turn at all	1. Air may be trapped in the Power Steering System hoses.	Release trapped air.
		2. The turning angle of the front wheels is not correct.	Adjust the turning angle (inside and outside).
		3. Steering Cylinder is leaking oil.	Replace Steering Cylinder.
		4. In the Power Steering System, a flow valve on the Power Steering Valve maintains a constant volume flow of hydraulic oil. The safe load pressure of the flow valve is too low.	Adjust pressure setting. NOTE: The pressure is factory set and should not normally need to be adjusted.
		5. The body of the Steering Axle is out of shape or damaged.	Replace Steering Axle.
Power Steering System	"Floating" when turning and	1. The volume of oil flowing through the Power Steering System when turning the Tractor is incorrect.	Adjust the volume setting on the flow valve and adjust the bolts

Sub-Assembly	Trouble	Probable Cause	Corrective Action
	stringing of the tires		until the angle adjustment on the steering column is correct.
Power Steering System	“Floating” when turning and stringing of the tires	2. On the Steering Assembly, the lever is not connected sufficiently tight.	Tighten lever.
		3. Wheel nuts are loose, or the bearing in the wheel shell is loose.	Check wheel nuts and wheel bearings. Adjust/tighten, or replace, as necessary.
Power Steering System	Steering pulls to one side.	1. Left and right front wheels unbalanced.	Replace.
		2. Brake clearance incorrect on left or right front wheels.	Adjust.
		3. Steering wheel loose.	Tighten bolt that secures the steering wheel.
		4. Steering Arm loose.	Adjust or replace.
Power Steering System	Abnormal noise coming from Steering System	1. Air trapped in Steering System hydraulic hoses.	Vent air from Steering System hydraulics.
Braking System (Foot Brake)	Overheating	1. Clearance between brake drum and friction plate of the Brake Assembly is too wide, or they are out of alignment.	Adjust clearance and/or alignment. If satisfactory clearance and/or alignment cannot be achieved, replace Brake Assembly.
		2. Return spring (in Brake) unserviceable.	Replace Brake Assembly.
		3. Brake cylinder faulty.	Replace Brake Assembly.
Braking System (Foot Brake)	Insufficient braking force, or brakes do not work at all	1. Brake fluid leak.	Locate and repair brake fluid leak. Top-up brake fluid to correct level.
		2. Air in Braking System hydraulic system.	Vent all air from Braking System hydraulics.
		3. Blockage or restriction in the brake hydraulic system.	Clean and flush hydraulic components to remove blockage or restriction.
		4. Contamination on surface of brake lining.	Replace Brake Assembly and rectify contamination source.
		5. Brake lining is deformed, or brake lining contact is abnormal.	Replace Brake Assembly.
		6. Brake lining is worn.	Replace Brake Assembly.
		7. Clearance between brake drum and friction plate of the Brake Assembly is too wide, or they are out of alignment.	Adjust clearance and/or alignment. If satisfactory clearance and/or alignment cannot be achieved, replace Brake Assembly.
		8. Brake Master Cylinder unserviceable.	Replace Brake Master Cylinder.



Sub-Assembly	Trouble	Probable Cause	Corrective Action
		9. Brake cylinder is faulty.	Replace Brake Assembly.
Braking System (Foot Brake)	Brake only applies on one side	1. Tire pressure incorrect.	Adjust tire pressure to bring it within specification.
		2. Brake clearances are not equal.	Adjust brake clearances.
		3. On the side where the brake does not apply, there is contamination on surface of brake lining.	Replace Brake Assembly and rectify contamination source.
		4. Debris on braking drum.	Clean off the debris.
		5. Brake lining is deformed, or brake lining contact is abnormal.	Replace Brake Assembly.
		6. Brake shoe lining contact is abnormal.	Replace Brake Assembly.
		7. Brake lining is worn.	Replace Brake Assembly.
		8. Brake drum excessively worn or damaged.	Replace Brake Assembly
		9. Bolt securing brake bottom plate is loose.	Tighten or replace bolt.
		10. Hub bearing is worn, or its clearance is incorrect.	Adjust or replace bearings.
Braking System	Brake drags	1. Brake pedal fouling due to insufficient clearance.	Adjust/repair.
		2. Brake Assembly unserviceable.	Replace Brake Assembly.
Braking System	Brake pedal has to much free travel.	1. Brake pedal requires adjustment.	Adjust brake pedal
		2. Brake pedal is unserviceable.	Replace brake pedal.
Parking Brake	Parking Brake does not function correctly.	1. The spring in the Park Brake Assembly is too weak.	Replace Park Brake Assembly.
		2. The clearance between the brake drum and the friction plate of the Brake Assembly is too great.	Adjust clearance. If satisfactory clearance cannot be achieved, replace Brake Assembly.
		3. The Park Brake cable is loose.	Adjust the cable tension.
		4. Movement of the Park Brake lever is blocked or fouled.	Visually examine and correct problem. Operation of the Parking Brake lever should be smooth and linear.
Headlights, direction indicator lights,	Light does not function, or has	1. The electrical connection to the light is loose or has become unplugged.	Plug-in/tighten the connection.
		2. The light has failed.	Replace light.

Sub-Assembly	Trouble	Probable Cause	Corrective Action
brake lights, rear working light.	reduced brightness	3. The respective control switch is faulty or has a bad connection.	Replace the switch.
Headlights, direction indicator lights, brake lights, rear working light.	Light does not function, or has reduced brightness	4. Wiring fault.	Referring to the electrical diagrams, check the wiring associated with the faulty light.
Power Steering pump.	Pump pressure low	1. Sealing ring failure, resulting in oil leak.	Replace Pump.
		3. Surface of the bearing is worn or damaged.	Replace Pump.
		4. Pump gear is worn or damaged.	Replace Pump.
		5. Direction of rotation is wrong.	Correct the direction of rotation: 1. Ensure hydraulic hoses are connected in the correct orientation, to give correct oil flow direction in the hydraulic system. 2. Ensure motor is wired correctly and that the motor is rotating in the correct direction.
		6. Oil leak from hydraulic hose.	Replace hydraulic hose.

## DIAGNOSTICS

The Traction Motor Controller can detect a wide variety of faults or error conditions. Faults can be detected by the operating system (OS) or by the Vehicle Control Logic (VCL) code. Faults detected by the OS are described in the Traction Motor Controller Troubleshooting Table. Faults detected by the VCL are described in steps 5.1 to 6.7 of the Traction Motor Controller Troubleshooting Table.

The Traction Motor Controller has two LEDs that indicate the status of the Traction Motor Controller.

The two LEDs have four different display modes, indicating the type of information they are providing, as described in the Table below.

### Traction Motor Controller LED Display

Display	Status
Neither LED illuminated	Traction Motor Controller is not powered ON; or vehicle has dead battery; or severe damage to the Motor Controller.
Yellow LED flashing	Traction Motor Controller is operating normally.
Yellow and red LEDs both On continuously	Traction Motor Controller is in Flash program mode.
Red LED On continuously	Internal hardware fault detected by the Supervisor or Primary microprocessor. Missing or corrupt software. Interrupting a software download may cause corruption of the software. Cycle Keyswitch Input (KSI) to clear. Reload software or replace Traction Motor Controller if necessary.
Red LED and yellow LED flashing alternately	Traction Motor Controller has detected a fault. 2-digit code flashed by yellow LED identifies the specific fault; one or two flashes by red LED indicate whether first or second code digit will follow.

Diagnostics information from the Traction Motor Controller can be obtained three ways:

- The Fault Code is displayed on the Dashboard Instrument Display Screen (Dash Display Screen).
- By reading the display on a Curtis Model 1313 Handheld Programmer, or a Curtis Model 1314 Laptop Based Programmer.
- By observing the fault codes issued by the Status LEDs.

A Curtis Model 1313 Handheld Programmer will display all faults that are currently set, as well as a history of the faults that have been set since the history log was last cleared. The 1313 Handheld Programmer displays the faults by name.

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

Example of how to read the flashing LEDs: B+ Under-voltage cutback (Fault Code 23) fault occurs.

The Traction Motor Controller's two LEDs will display this repeating pattern:

Red	Yellow	Red	Yellow
*	* *	* *	* * *
(first digit)	(2)	(second digit)	(3)

In the above example, in the Fault menu of the 1313 Handheld Programmer, the words B+ Undervoltage Cutback will be displayed; and the real-time battery voltage is displayed in the Monitor menu (as "Capacitor Voltage").

For brevity, the electrical failure diagnosis and troubleshooting procedures only refer to the use of a Curtis Model 1313 Handheld Programmer. However, all references to the Curtis Model 1313 Handheld Programmer should be taken to mean either a Curtis Model 1313 Handheld Programmer, or a Curtis Model 1314 Laptop Based Programmer.

The use of either a Curtis Model 1313 Handheld Programmer or a Curtis Model 1314 Laptop Based Programmer during the electrical failure diagnosis and troubleshooting procedure is OPTIONAL.

The electrical failure diagnosis and troubleshooting procedure can be performed without a Curtis Model 1313 or Model 1314 Programmer, but some parts of that troubleshooting procedure will have to be omitted. As you proceed through the electrical troubleshooting procedure, just omit any steps that require a Curtis 1313 Handheld Programmer and proceed to the next step.

### Traction Motor Controller Troubleshooting Table

Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
<p style="text-align: center;">NOTE</p> <p>If the Traction Motor Controller diagnostics detects a fault, the message FAULT CODE will be displayed at the top of the Dash Display Screen. Below the FAULT CODE message, further fault diagnosis messages will be displayed.</p> <p>TRACTION refers to the Traction Motor Controller. If the fault is associated with the Traction Motor Controller the appropriate fault code will be displayed. If the Traction Motor Controller functions are working satisfactorily the message OK will be displayed, and the Traction Motor Controller can be ignored during troubleshooting.</p> <p>HYD refers to the Steering Motor Controller. If the fault is associated with the Steering Motor Controller the respective fault code will be displayed. If the Steering Motor Controller is working satisfactorily the message OK will be displayed, and the Steering Motor Controller can be ignored during troubleshooting.</p>			
*, *	Communications failure	1. Communications failure.	a. Update the software to the correct version.
		2. Bus interference.	b. Check whether the Bus terminal resistance is 60 Ohms, and the bus voltage is approximately 2.5V (AC controller pin 23 is CAN_H, pin 35 is CAN_L, pin 3 is CAN_L, 11 pin 11 is CAN_H).
		3. Bus device failure.	c. Check whether the Bus device connection is secure and connected correctly.
			d. Check that the Bus device program is correct, and whether the parameters are set correctly.
			e. Check if there is interference around the Bus.
			f. If pump is reported as a Failure, then check if the pump control model in the meter is selected correctly.
			g. Use elimination method to eliminate faulty equipment.
Battery problem	Inaccurate battery voltage	1. Incorrect instrument voltage selection.	a. Make sure that the instrument's working voltage setting type is correct.
		2. Battery parameter setting problem.	b. Using the 1313 Handheld Programmer. Programme/battery menu nominal voltage: 80V DC
		3. Battery problem.	c. User overvoltage. Reset Volts Per Cell Default 2.09V DC Full Volts Per Cell Default 2.04V DC Empty Volts Per Cell Vent cell voltage 1.73V DC

Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
Vehicle will not move	No Fault Code. Vehicle will not move	1. The power supply line is disconnected.	Check that the power supply line is functioning correctly.
		2. Switch signals such as direction switch, seat switch, and interlock are not input.	Using the 1313 Handheld Programmer, check if the signal of each switch is normal: Monitor/ inputs menu. Throttle command throttle pot. Voltage value of the accelerator sliding plate end. Interlock switch signal. Switch 7 - Forward switch signal. Switch 8 - Back switch signal.
		3. No accelerator signal.	Check that the accelerator signal is normal.
1.2	Controller overcurrent.	1. Encoder failure or line interference.	1. Using the 1313 Handheld Programmer, check the AB phase signal feedback from the encoder: monitor/motor menu/motor speed A and motor speed B. A multimeter can be used to measure the voltage AB relative to pin 7, and the effective value is about 2.5V.
		2. External short of phase U, V, or W motor connections. Examine wiring and repair or replace as necessary.	2. Using a multimeter, check whether the three-phase UVW of the motor is short-circuited or damaged, and whether the three phase UVW of the Controller is damaged. Measurement method: Set the multimeter to the diode position. Measure the UVW voltages with the black test pen on B+ terminal and the red test pen on each UVW phase terminal in turn: voltage should be about 0.43V. Repeat with red test pen on B- terminal and the black test pen on each UVW phase terminal in turn: voltage should be about 0.43V. If a value is abnormal, that phase MOSFET has been damaged.
		3. The motor parameters do not match.	3. Monitor the Controller current at full load, and re-match the motor if necessary. Motor matching process: Using the 1313 Handheld Programmer Programming menu: Program/Motor Control Tuning/Motor Characterization Tests/Test Enable to 1.
(continued)			

Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
1.2	Controller overcurrent.		<p>Motor Control Tuning/Motor Characterization Tests/Test Throttle to +1. At this point, the motor will rotate. If the wheel turns backward, set /Test Throttle to 0, and reset Test Throttle to -1 after the motor stops rotating.</p> <p>Enter the current fault menu after the main contactor is disconnected: Fault/current fault. If there is only one fault Parameter Change Fault, the test is successful.</p> <p>At this point, turn off the Main Contactor after turning on the KSI again, and the preliminary test of the motor is completed.</p> <p>The Main Contactor will be disconnected after the automatic test of the motor is completed.</p> <p>Check the inflection point and slip value setting of the motor. Slip value setting: programme/motor control turning/IM motor characterization tests/slip gain.</p> <p>Knee point setting: programme/motor control turning/field weakening control/FW base speed</p>
		4. Controller failure. Replace Controller.	4. If no problem is found using the above inspection, try replacing the Controller.
1.3	Current Sensor Fault.	<p>1. Leakage or short-circuit to vehicle chassis from phase U, V, or W (short in motor stator).</p> <p>2. Current sensor in the Controller is faulty.</p>	<p>1. Check whether the UVW three-phase power line is short-circuited or leaking. Examine and repair or replace as necessary.</p> <p>2. Replace Controller.</p>
1.4	Precharge fault.	<p>1. External load on capacitor bank (B+ connection terminal) that prevents the capacitor bank from charging.</p> <p>2. The Controller is faulty.</p>	<p>1. Check whether there are other high-power loads connected to the Controller B+ terminal. If necessary, refer to electrical schematics and correct the wiring problem.</p> <p>2. Check the KSI wiring and measure the voltage value with a multimeter to see if it is normal. Normal voltage is 80V DC.</p> <p>3. If no problems are found in the above inspection, try replacing the Controller.</p>
1.5	Controller severe under-temperature.	1. Controller is operating in an extreme environment: - the working environment temperature of the Controller is lower than minus 40 deg C.	<p>1. When the ambient temperature rises above - 40 deg C, restart the ignition switch and the interlock switch. Controller should function correctly, without this Fault Code.</p> <p>2. If this Fault Code is still present at above -40 deg C, try replacing the Controller.</p>

Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
1.6	Controller severe over-temperature.	<ol style="list-style-type: none"> <li>The temperature of the Controller is above +95 deg C.</li> <li>Controller is operating in an extreme environment.</li> <li>Tractor is overloaded due to an excessive towing load on Tractor, and/or the motor is not matched.</li> </ol>	<ol style="list-style-type: none"> <li>Reduce load on Tractor.</li> <li>Check the cooling measures for the Controller. For example, incorrect mounting of Controller (its baseplate acts as a heatsink). Correct if necessary.</li> <li>When the ambient temperature falls below +50 deg C (122 deg F), restart the key switch and the interlock switch. Controller should function correctly, without this Fault Code.</li> <li>Using the 1313 Handheld Programmer, Monitor the current monitor/controller menu /current when the controller is working. If the current is too large, re-match the motor, reset the inflection point and slip value of the motor, and if necessary, properly limit the current.</li> </ol>
1.6	Controller severe over-temperature.	<ol style="list-style-type: none"> <li>The Controller is faulty.</li> </ol>	<ol style="list-style-type: none"> <li>If no problems are found in the above inspection, try replacing the Controller.</li> </ol>
1.7	Severe undervoltage. Reduced drive torque.	<ol style="list-style-type: none"> <li>Battery parameter setting is incorrect.</li> <li>Non-Controller system drain on battery.</li> <li>Battery impedance (resistance) is too high.</li> <li>Wiring problem - Battery disconnected while driving.</li> <li>Blown B+ fuse (main battery fuse).</li> <li>Main contactor faulty (did not close).</li> </ol>	<ol style="list-style-type: none"> <li>Using a multimeter, measure whether: <ol style="list-style-type: none"> <li>Battery voltage is normal (approx. 80V DC).</li> <li>KSI, and B+ terminal, voltages are normal (approx. 80V DC).</li> </ol> </li> <li>Check B+ fuse and Main Contactor.</li> <li>Check Battery wiring.</li> <li>Using the 1313 Handheld Programmer check these Battery parameter settings in Programme/Battery menu: <ol style="list-style-type: none"> <li>Nominal voltage.</li> <li>User undervoltage.</li> </ol> </li> <li>If the Controller fails and the main contactor is not closed, the pump control will report Fault Code 1.7.</li> </ol>
1.8	Severe overvoltage.	<ol style="list-style-type: none"> <li>Battery resistance (impedance) too high for given regenerative current.</li> <li>Battery parameter settings are incorrect.</li> <li>Battery disconnected during regenerative braking.</li> </ol>	<ol style="list-style-type: none"> <li>Using a multimeter, measure the battery voltage and check that it is normal (approx. 80V DC).</li> <li>Check fuses and Main Contactor.</li> <li>Check Battery wiring harness.</li> </ol>



Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
1.8	Severe overvoltage.		<p>4. Using the 1313 Handheld Programmer check these Battery parameter settings in Programme/Battery menu:</p> <ol style="list-style-type: none"> <li>Nominal voltage.</li> <li>User undervoltage.</li> </ol> <p>5. Check the regenerative braking parameter settings in Programme/Current limits menu:</p> <ol style="list-style-type: none"> <li>Regen current limit.</li> </ol>
2.1	Controller under-temperature Cutback. Reduced drive and brake torque.	<ol style="list-style-type: none"> <li>Controller is operating in an extreme environment: - the working temperature of the Controller is lower than minus 25 deg C (minus 13 deg F).</li> <li>Controller is performance limited at this temperature.</li> </ol>	<p>Operate the Tractor within its operating temperature range (see Tractor specification). Problem will clear when the Controller heatsink temperature rises above -25 deg C.</p>
2.2	Controller over-temperature Cutback. Reduced drive and brake torque.	<ol style="list-style-type: none"> <li>Controller is performance limited at this temperature.</li> <li>Controller is operating in an extreme environment and the temperature of the Controller heatsink has exceeded +85 deg C (185 deg F).</li> <li>Excessive towing load on Tractor. Reduce load.</li> <li>Incorrect mounting of Controller. Examine and correct if necessary.</li> </ol>	<ol style="list-style-type: none"> <li>Operate the Tractor within its operating temperature range (see Tractor specification). Problem will clear when the Controller heatsink temperature drops below 85 deg C.</li> <li>Reduce towing load.</li> <li>If the ambient temperature is normal, check the Controller current during operation to see if it is too high, causing the temperature to rise quickly.</li> </ol>
2.3	Under-voltage Cutback. Reduced drive torque.	<ol style="list-style-type: none"> <li>Battery low - normal operation. Fault shows that the battery needs recharging. Controller is performance limited at this voltage.</li> <li>Battery parameters are incorrect.</li> <li>Non-Controller system drain on battery.</li> <li>Battery is aging.</li> <li>Battery disconnected while driving.</li> </ol>	<ol style="list-style-type: none"> <li>Recharge the Battery.</li> <li>Using a multimeter, measure the battery voltage and check that it is approx. 80V DC. If not, perform maintenance on the Battery, or replace Battery.</li> <li>Check fuses and Main Contactor.</li> <li>Check Battery harness for damage, or loose or incorrect connections.</li> <li>Using the 1313 Handheld Programmer check these Battery parameter settings in Programme/Battery menu: <ol style="list-style-type: none"> <li>Nominal voltage.</li> <li>User undervoltage.</li> </ol> </li> </ol>

Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
2.4	Over-voltage Cutback. Reduced brake torque.	<ol style="list-style-type: none"> <li>1. Fault shows that regenerative braking currents elevated the battery voltage during regenerative braking. Controller is performance limited at this voltage.</li> <li>2. Battery parameter settings are incorrect.</li> <li>3. Battery resistance too high for given regenerative current.</li> <li>4. Battery disconnected while regenerative braking.</li> </ol>	<ol style="list-style-type: none"> <li>1. Using a multimeter, measure the battery voltage and check that it is approx. 80V DC. If not, perform maintenance on the Battery, or replace Battery.</li> <li>2. Check fuses and Main Contactor.</li> <li>3. Check Battery harness for damage, or loose or incorrect connections.</li> <li>4. Using the 1313 Handheld Programmer check these Battery parameter settings in Programme/Battery menu: <ol style="list-style-type: none"> <li>a. Nominal voltage.</li> <li>b. User undervoltage.</li> </ol> </li> <li>5. Using the 1313 Handheld Programmer check the regenerative braking parameter settings in Programme/Current limits menu: <ol style="list-style-type: none"> <li>a. Regen current limit.</li> </ol> </li> </ol>
2.5	+5V supply failure.	<ol style="list-style-type: none"> <li>1. External device failure.</li> <li>2. External load impedance on the +5V supply (pin 26) is too low.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check the external equipment for damage.</li> <li>2. Replace the external device with a known good external device. Does the fault clear? If yes, the original external device is faulty. NOTE: The 26th pin of the Controller 35-pin plug is the 5V power output from the Controller.</li> <li>3. With the external device disconnected, using a digital multimeter, is the Controller +5V supply (pin 26) outside the <math>+5V \pm 10\%</math> range. If so, Controller is may be unserviceable, proceed to step 4, below.</li> <li>4. Using the 1313 Handheld Programmer, view Monitor/Outputs Menu/5 Volts.</li> </ol>
2.6	Digital Out 6 failure. Digital Output 6 driver will not turn On.	<ol style="list-style-type: none"> <li>1. External device failure.</li> </ol>	<ol style="list-style-type: none"> <li>1. Using the 1313 Handheld Programmer, monitor: Monitor/ Digital Output 6 to see the percentage of the output signal of Driver 6. NOTE: The 19th pin of the Controller 35-pin plug is the Driver 6 output signal.</li> <li>2. Using the 1313 Handheld Programmer, monitor, check whether the current exceeds 1A.</li> <li>3. Check the external equipment for damage. Check the associated interconnecting wiring. Try replacing the external device with a known good unit.</li> </ol>

Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
2.7	Digital Out 7 over-current.	1. External device failure.	<p>1. Using the 1313 Handheld Programmer, monitor: Monitor/ Digital Output 7 to see the percentage of the output signal of Driver 7. NOTE: The 20th pin of the Controller 35-pin plug is the Driver 7 output signal.</p> <p>2. Using the 1313 Handheld Programmer, monitor, check whether the current exceeds 1A.</p> <p>3. Check the external equipment for damage. Check the associated interconnecting wiring. Try replacing the external device with a known good unit.</p>
2.8	Motor temperature hot Cutback. Reduced drive torque.	<p>1. Motor temperature is at, or above, the "Temperature Hot" parameter setting, and the requested current is being cut back to prevent damage to the Motor due to overheating.</p> <p>2. Motor Temperature parameter setting is incorrect.</p>	<p>1. Check the motor temperature sensor to see if it is damaged. Check the associated wiring is correct and undamaged.</p> <p>2. Using the 1313 Handheld Programmer, check whether the controller motor temperature setting is wrong: Programme/Motor Menu/Temperature Control/Temperature Hot/ Overheating performance reduction value setting. NOTE: The 7th and 8th pins of the Controller 35-pin plug are connected to the motor temperature sensor.</p> <p>3. Monitor the current when the vehicle is running to see if it is too large, causing the Motor to overheat, and re-match the Motor if necessary.</p>
2.9	Motor Temperature Sensor fault. Max Speed is reduced (LOS, Limited Operating Strategy, implemented) and Motor temperature Cutback is disabled.	<p>1. Motor temperature sensor (thermistor) is faulty or is not connected correctly.</p> <p>2. Motor temperature sensor type is not set correctly.</p>	<p>1. Check the motor temperature sensor to see if it is damaged. Check the associated wiring is correct and undamaged. NOTE: The 7th and 8th pins of the Controller 35-pin plug are connected to the motor temperature sensor.</p> <p>2. Using the 1313 Handheld Programmer, check the parameter settings of the of the Motor temperature sensor: Programme/Motor Menu/Temperature Control Sensor Type.</p> <p>3. Replace the motor temperature sensor.</p>

Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
3.1	Coil1 Driver is either open circuit or shorted. Or Main Contactor open/shorted.	<ol style="list-style-type: none"> <li>1. Fault in load equipment attached to Coil1 Driver.</li> <li>2. Dirty connector pins.</li> <li>3. Bad crimp connections or faulty wiring.</li> <li>4. Coil1 Driver line failure.</li> <li>5. Main Contactor faulty.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check load equipment attached to Coil1 Driver for open or short circuits, or other faults.</li> <li>2. Check that the wiring is correct, that the pins are dirt free, and all crimp connections are serviceable. NOTE: The 6th pin of the Controller 35-pin plug is the Coil1 Driver output.</li> <li>3. Using the 1313 Handheld Programmer, monitor the Output Signal Monitor Menu/Outputs Menu/Driver 1 PWM to see if there is a control signal output.</li> <li>4. Check the coil of the Main Contactor and associated electrical connections.</li> <li>5. Replace Main Contactor.</li> </ol>
3.2	Coil2 Driver is either open circuit or shorted.	<ol style="list-style-type: none"> <li>1. Fault in load equipment attached to Coil2 Driver.</li> <li>2. Dirty connector pins.</li> <li>3. Bad crimp connections or faulty wiring.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check load equipment attached to Coil2 Driver for open or short circuits, or other faults.</li> <li>2. Check that the wiring is correct, that the pins are dirt free, and all crimp connections are serviceable.</li> </ol>
3.2	Coil2 Driver is either open circuit or shorted.	<ol style="list-style-type: none"> <li>4. Coil2 Driver line failure.</li> <li>5. Main Contactor faulty.</li> </ol>	<ol style="list-style-type: none"> <li>NOTE: The 5th pin of the Controller 35-pin plug is the Coil2 Driver output.</li> <li>3. Using the 1313 Handheld Programmer, monitor the Output Signal Monitor Menu/Outputs Menu/Driver 2 PWM to see if there is a control signal output.</li> <li>4. Check the coil of the Main Contactor and associated electrical connections.</li> <li>5. Replace Main Contactor.</li> </ol>
3.3	EM Brake open circuit or shorted. Coil3 Driver open/shorted.	<ol style="list-style-type: none"> <li>1. The Electromagnetic Brake coil is open or short circuited.</li> <li>2. Driver3 (pin 4) is either open circuit or shorted due to wiring fault.</li> <li>3. Dirty connector pins.</li> <li>4. Bad crimps or faulty wiring.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check that the wiring is correct, that the pins are dirt free, and all crimp connections are serviceable. NOTE: The 4th pin of the Controller 35-pin plug is the Coil3 Driver output.</li> <li>2. Using the 1313 Handheld Programmer, monitor the Output Signal Monitor Menu/Outputs Menu/Driver 3 PWM to see if there is a control signal output.</li> <li>3. Check the Electromagnetic Brake coil.</li> <li>4. Replace Electromagnetic Brake.</li> </ol>

Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
3.4	Coil4 Driver open circuit or shorted.	<ol style="list-style-type: none"> <li>Coil Driver4 (pin 3) is either open circuit or shorted.</li> <li>Dirty connector pins.</li> <li>Bad crimps or faulty wiring.</li> </ol>	<ol style="list-style-type: none"> <li>Check that the wiring is correct, that the pins are dirt free, and all crimp connections are serviceable. NOTE: The 3rd pin of the Controller 35-pin plug is the Coil4 Driver output.</li> <li>Using the 1313 Handheld Programmer, monitor the Output Signal Monitor Menu/Outputs Menu/Driver 4 PWM to see if there is a control signal output.</li> <li>Check the drive coil.</li> </ol>
3.5	Proportional Driver (PD) open circuit or shorted.	<ol style="list-style-type: none"> <li>Open or short circuit on connected load.</li> <li>Dirty connector pins.</li> <li>Bad crimps or faulty wiring.</li> </ol>	<ol style="list-style-type: none"> <li>Check that the wiring is correct, that the pins are dirt free, and all crimp connections are serviceable. NOTE: The 2nd pin of the Controller 35-pin plug is the PD output.</li> <li>Using the 1313 Handheld Programmer, monitor the Output Signal Monitor Menu/Outputs Menu/PD PWM to see if there is a control signal output.</li> <li>Check the load equipment connected to the PD line for damage, short circuits, open circuits, or other faults.</li> </ol>
3.6	Encoder fault. Control Mode changed to LOS (Limited Operating Strategy).	<ol style="list-style-type: none"> <li>Motor Encoder power supply failure.</li> <li>Motor Encoder damaged or faulty.</li> <li>Dirty connector pins.</li> <li>Bad crimps or faulty wiring.</li> </ol>	<ol style="list-style-type: none"> <li>Check that the power supply to the Motor Encoder is functioning normally.</li> <li>Check that the wiring is correct, that the pins are dirt free, and all crimp connections are serviceable. NOTE: The 31st and 32nd pins of the Controller 35-pin plug are the Encoder phase AB output signal.</li> <li>Using the 1313 Handheld Programmer, check the Motor Encoder parameter settings: Programme/Motor Menu/Encoder Steps/ Encoder Pulse Number.</li> <li>Using the 1313 Handheld Programmer, monitor whether the Encoder Feedback Speed Signal is normal: Monitor Menu/Motor Menu/ Motor Speed/Encoder Phase A Speed Signal.</li> <li>Repeat step 4 for the Encoder Phase A Speed Signal.</li> <li>If steps 1 to 5 above do not identify the problem, replace the Motor Encoder.</li> </ol>

Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
3.7	Drive Motor open circuit.	<ol style="list-style-type: none"> <li>1. Motor phase U, V, or W is open circuit.</li> <li>2. Faulty wiring.</li> <li>3. Motor Controller is unserviceable.</li> <li>4. Drive Motor is unserviceable.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check the UVW three-phase wiring and connections for open circuits.</li> <li>2. Using a digital multimeter, check the UVW three-phase power module of the Motor Controller to determine if it is functioning correctly. If not, replace the Motor Controller and see if the fault clears. The measuring method is as follows: <ol style="list-style-type: none"> <li>a. Set the multimeter to the diode position.</li> <li>b. With the black test lead on the B+ terminal, measure the UVW voltage with the red test lead. The voltage should be approximately 0.43 V.</li> <li>c. With the red test lead on the B- terminal, measure the UVW voltage with the black test lead. The voltage should be approximately 0.43 V.</li> <li>d. If one of the voltage values is not correct, the MOSFET controlling that phase is faulty.</li> </ol> </li> <li>3. If the measurements in step 2 are satisfactory, try replacing the Drive Motor.</li> </ol>
3.8	Main Contactor welded.	<ol style="list-style-type: none"> <li>1. Main Contactor contacts are welded closed.</li> <li>2. Motor phase U or V is disconnected or open circuit.</li> </ol>	<ol style="list-style-type: none"> <li>1. Examine the Main Contactor to determine if the contacts are welded closed. If they are, replace the Main Contactor.</li> <li>2. Measure the Main Contactor coil voltage. It should be 80 V DC.</li> <li>3. Check that the wiring is correct, undamaged, and all connections are serviceable.</li> <li>4. The Drive Motor lacks a phase. Check whether the U or V phase is disconnected.</li> </ol>
3.8	Main Contactor welded.	<ol style="list-style-type: none"> <li>3. Wiring problem. Just prior to the Main Contactor closing, the capacitor bank (B+ terminal) was loaded for a short time and the voltage did not discharge. An alternate voltage path is providing a current to the capacitor bank B+ terminal.</li> </ol>	
3.9	Main Contactor did not close.	<ol style="list-style-type: none"> <li>1. Main Contactor tips are oxidized, burned, or not making contact.</li> <li>2. Main Contactor coil drive voltage to low.</li> <li>3. Blown B+ terminal fuse.</li> <li>4. The voltage drop between the Keyswitch Input (KSI) voltage and Battery voltage is excessive.</li> <li>5. A high-power load is connected to the KSI circuit,</li> </ol>	<ol style="list-style-type: none"> <li>1. Examine the Main Contactor to see if the contact tips are oxidized, burned, or not making contact. If necessary, replace Main Contactor.</li> <li>2. Check B+ terminal fuse. Replace if blown.</li> <li>3. Check whether the KSI circuit is connected to a high-power device, which will cause the KSI voltage to decrease. If found, disconnect the high-power device.</li> </ol> <p style="text-align: right;">(continued)</p>

Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
		causing the KSI voltage to be pulled down.	<p>4. Using the 1313 Handheld Programmer, monitor the KSI and capacitor voltages: Monitor Menu/Outputs Menu/Capacitor Voltage and Monitor Menu/Outputs Menu/Keyswitch Voltage. Make sure that the difference between the two voltages is less than the set value of: Program/Main Contactor/Main DNC Threshold.</p> <p>5. Measure the Main Contactor coil voltage. It should be 80 V DC.</p>
4.1	Throttle Wiper High.	<p>1. The accelerator is disconnected.</p> <p>2. The output voltage of the accelerator potentiometer wiper is too high.</p>	<p>1. Check that the wiring associated with the accelerator is correct, that the pins are dirt free, and all connections are serviceable. NOTE: The 16th pin of the Controller 35-pin plug is the input signal from the accelerator potentiometer wiper.</p> <p>2. Using the 1313 Handheld Programmer, monitor the accelerator potentiometer wiper voltage: Monitor Menu/Inputs Menu/Throttle Pot. It should be lower than the high fault threshold, which can be changed with the VCL function Programme/Setup_Pot_Faults.</p> <p>3. Replace accelerator.</p>
4.2	Throttle Wiper Low.	<p>1. The output voltage of the accelerator potentiometer wiper is too low.</p>	<p>NOTE: The 16th pin of the Controller 35-pin plug is the input signal from the accelerator potentiometer wiper.</p> <p>1. Using the 1313 Handheld Programmer, monitor the accelerator potentiometer wiper voltage: Monitor Menu/Inputs Menu/Throttle Pot. It should be higher than the low fault threshold, which can be changed with the VCL function Programme/Setup_Pot_Faults.</p> <p>2. Replace accelerator.</p>
4.3	Pot2 Wiper High	<p>1. This Motor Controller function is not used on the ST470E Tractor.</p>	<p>This Fault Code should not occur on the ST470E Tractor. In the unlikely event that it does occur, check that the pins of the Controller 35-pin plug are undamaged, clean and debris free.</p> <p>Check that the associated wiring is correct, undamaged, and free of short or open circuits.</p> <p>NOTE: The 17th pin of the Controller 35-pin plug is the input signal from the Pot2 wiper.</p>

Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
4.4	Pot2 Wiper Low.	1. This Motor Controller function is not used on the ST470E Tractor.	This Fault Code should not occur on the ST470E Tractor. In the unlikely event that it does occur, check that the pins of the Controller 35-pin plug are undamaged, clean and debris free. Check that the associated wiring is correct, undamaged, and free of short or open circuits. NOTE: The 17th pin of the Controller 35-pin plug is the input signal from the Pot2 wiper.
4.5	Pot Low over-current.	1. This Motor Controller function is not used on the ST470E Tractor.	This Fault Code should not occur on the ST470E Tractor. In the unlikely event that it does occur, check that the pins of the Controller 35-pin plug are undamaged, clean and debris free. Check that the associated wiring is correct, undamaged, and free of short or open circuits. NOTE: Pin 18 of the Controller 35-pin plug is the Pt Low input signal from Pot2.
4.6	EEPROM failure (Tractor will shutdown).	Controller Operating System tried to write to EEPROM memory and failed. This can be caused by: 1. Software error. 2. By adjusting parameters with the 1313 Handheld Programmer. 3. Motor Controller failure.	1. Download the correct Operating System software version and matching parameter default settings into the Controller, and then cycle KSI. 2. Replace Motor Controller.
4.7	High Pedal Disable (HPD)/Sequencing Fault.	1. The Keyswitch input (KSI), interlock switch, direction switch, and accelerator inputs were applied in an incorrect sequence. 2. Faulty wiring, crimps, or switches at: KSI, interlock switch, direction switch, or accelerator inputs.	1. Using the 1313 Handheld Programmer Monitor Menu/Inputs Menu/ check the status of KSI, interlock, and direction inputs, to determine if there is any abnormality. Check input sequence of each switch and eliminate operation problems. 2. Check the accelerator signal by hand. 3. Replace faulty switch(es). 4. Check that the wiring associated with these switches is correct, and all connections are serviceable.
4.9	Parameter change fault.	1. This is a safety feature to make sure that changes to Parameter Settings are implemented correctly. When a 1313 Handheld Programmer is used to change certain Parameter Settings, the	1. Restart the Keyswitch. The fault will disappear.



## ST470E Baggage Tractor

Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
		Tractor will not operate until the KSI is cycled.	
	<p style="text-align: center;"><b>NOTE</b></p> <p>Fault codes between 5.1 and 6.7 are OEM (Original Equipment Manufacturer) Faults. These faults are defined by the OEM and are implemented in the VCL code specific to the ST470E Tractor.</p>		
5.1	CAN system fault	There is a problem with the CAN (bus) system.	<ol style="list-style-type: none"> <li>1. Check the vehicle Main Electrical Harness.</li> <li>2. Check the CAN (bus) system, using the failure diagnosis method for “Communications failure” faults, as described at the start of this Table.</li> </ol>
5.2	Communications failure.	There has been a communications failure between the instrument panel and the Steering Motor Controller. They cannot receive messages from each other.	<ol style="list-style-type: none"> <li>1. Check the vehicle Main Electrical Harness.</li> <li>2. Check the CAN (bus) system, using the failure diagnosis method for “Communications failure” faults, as described at the start of this Table.</li> </ol>
5.3	BMS communication timeout fault.	Not Applicable.	Fault code 5.3 cannot occur on the ST470E Tractor.
5.4	BMS fault.	Not Applicable.	Fault code 5.4 cannot occur on the ST470E Tractor.
5.5	BMS Warning fault.	Not Applicable.	Fault code 5.5 cannot occur on the ST470E Tractor.
5.8	OEM Faults - Accelerator fault. (Throttle Pedal Switch check.) Vehicle will not move.	In addition to providing a 0-5V (or 1k-10kΩ) input, most single-ended 3-wire potentiometer throttle pedals have a throttle pedal switch, serving as an additional discrete input to provide extra safety features or enable specific functions. On the ST470E, the Throttle Pedal Switch (Switch 1 – Pin 24) is checked at start-up. If the switch is ON during start-up, this fault is triggered.	<ol style="list-style-type: none"> <li>1. Once the accelerator pedal is released, the fault will clear.</li> <li>2. If releasing the accelerator pedal doesn't resolve the issue and the fault persists, it probably indicates that the accelerator pedal switch is stuck. Replacing the accelerator pedal is recommended.</li> <li>3. It could also be a wiring issue, though less likely than item 2., above.</li> <li>4. You can view this input by connecting a 1313 Handheld Programmer to the vehicle, going to Monitor Menu/Inputs Menu/Switch 1, and checking if it remains ON constantly.</li> </ol>
5.9	Dash Display Screen not matching.	Incorrect type of Dash Display Screen, or Dash Display Screen is faulty.	<ol style="list-style-type: none"> <li>1. Check that the Dash Display Screen is the correct type for the vehicle.</li> <li>2. Check that the Dash Display Screen is functioning correctly.</li> </ol>
6.1	Dash Display Screen configuration	Incorrect type of Dash Display Screen, or Dash Display Screen is faulty.	<ol style="list-style-type: none"> <li>1. Check that the Dash Display Screen is the correct type for the vehicle.</li> <li>2. Check that the Dash Display Screen is functioning correctly.</li> </ol>

Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
	communication failure.		
6.2	Not Applicable.	Not Applicable.	Fault code 6.2 cannot occur on the ST470E Tractor.
6.3	Dash Display Screen configuration communication failure.	Incorrect type of Dash Display Screen, or Dash Display Screen is faulty.	<ol style="list-style-type: none"> <li>Check that the Dash Display Screen is the correct type for the vehicle.</li> <li>Check that the Dash Display Screen is functioning correctly.</li> </ol>
6.4 to 6.7	Not Applicable.	Not Applicable.	Fault codes between 6.4 and 6.7 cannot occur on the ST470E Tractor.
6.8	VCL Runtime Error.	VCL code encountered a runtime VCL error. <ol style="list-style-type: none"> <li>Software problem.</li> <li>Motor Controller failure.</li> </ol>	<ol style="list-style-type: none"> <li>Download the correct Operating System software version and matching parameter default settings into the Controller, and then cycle KSI.</li> <li>Replace Motor Controller.</li> </ol>
6.9	External supply out of range.	<ol style="list-style-type: none"> <li>External load on the 5V and 12V supplies draws either too much, or too little, current.</li> <li>The external supply current (combined current drawn by the 5V supply (pin 26) and 12V supply (pin 25)) is either greater than the upper current threshold, or lower than the lower current threshold. Parameter settings Ext Supply Max and Ext Supply Min may be incorrect.</li> </ol>	<ol style="list-style-type: none"> <li>Check the 5V and 12V external loads to see if there is a short circuit, an open circuit, or equipment damage. Replace faulty external equipment.</li> <li>Using the 1313 Handheld Programmer, check whether the Ext Supply Max and Ext Supply Min parameter settings are wrong: Monitor Menu/Monitor Outputs/Ext Supply Current. If necessary, correct the settings.</li> <li>Replace Motor Controller.</li> </ol>
7.1	OS General. Operating System failure.	<ol style="list-style-type: none"> <li>Software problem.</li> <li>Internal Motor Controller fault.</li> </ol>	<ol style="list-style-type: none"> <li>Download the correct Operating System software version and matching parameter default settings into the Controller, and then cycle KSI.</li> <li>Replace Motor Controller.</li> </ol>
7.2	PDO Timeout	<ol style="list-style-type: none"> <li>Software problem.</li> <li>CAN Bus communication failure (Time between CAN PDO messages received exceeded the PDO Timeout Period).</li> </ol>	<ol style="list-style-type: none"> <li>Download the correct Operating System software version and matching parameter default settings into the Controller, and then cycle KSI.</li> <li>Check whether the Bus terminal resistance is 60 Ohms, and the Bus voltage is approx. 2.5V.</li> <li>Check whether the Bus device connection is normal.</li> <li>Check whether the Bus device program is correct and whether the parameters are set correctly.</li> </ol>

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Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
			5. If steps 1 to 4 fail to identify the problem, use elimination method to identify faulty equipment.
7.3	Stall Detected Control Mode changed to LOS (Limited Operating Strategy).	<ol style="list-style-type: none"> <li>1. Stalled Motor.</li> <li>2. Motor Encoder failure.</li> <li>3. Bad crimps or faulty wiring.</li> <li>4. Problems with power supply for Motor Encoder.</li> <li>5. Motor damaged.</li> <li>6. Brake not fully released.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check that operation of the Motor is not blocked or fouled.</li> <li>2. Check that the power supply to the Motor Encoder is functioning normally.</li> <li>3. Check that the wiring is to the Motor Encoder is correct, that the pins are dirt free, and all crimp connections are serviceable. NOTE: The 31st and 32nd pins of the Controller 35-pin plug are the Encoder phase AB output signal.</li> <li>4. Check that the Brake is fully released.</li> <li>5. Check Motor and Motor Controller for damage.</li> </ol>
7.4 7.5	Does not apply to ST470E Tractor.	Does not apply to ST470E Tractor.	Does not apply to ST470E Tractor.
7.7	Supervisor fault.	<ol style="list-style-type: none"> <li>1. The Motor Controller internal processor detects illegal redundant data.</li> <li>2. The internal processor of the Motor Controller is faulty.</li> <li>3. The Motor Controller internal processor detects that the switch signal exceeds the threshold for more than 100ms.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check all switch input signals, check whether the switch is damp or damaged.</li> <li>2. Motor Controller internal microprocessor is faulty.</li> </ol>
7.8 to 8.6	Does not apply to ST470E Tractor.	Does not apply to ST470E Tractor.	Does not apply to ST470E Tractor.
8.7	Motor Characterization Fault.	Motor characterization failed because of an over voltage or under voltage fault, Motor Temperature sensor fault, or Motor temperature exceeded 150 deg C during the characterization process.	<ol style="list-style-type: none"> <li>1. Check whether the Motor Encoder, and Motor serviceable. Check that the associated wiring is correct and serviceable.</li> </ol> <p>For reference only - Motor matching failure code comparison:</p> <p>0=normal.</p> <p>1=The Encoder signal is received, and the impersonation is not recognized, and the encoder pulse needs to be manually set.</p> <p>2=The Motor temperature sensor is invalid.</p> <p>3=Failure of motor high temperature response.</p> <p>4=Failure of Motor overheating response.</p> <p>5=The Motor's low temperature response fail.</p>

Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
			6=Failed to respond to low voltage. 7=Failure of high-pressure reaction. 8=The Controller cannot detect the Encoder signal. 9=The Motor parameter setting is out of range.
8.8	Encoder Characterization Fault. Encoder_Steps set to value=31.	1. Encoder characterization failed during the Motor characterization process. 2. During the Motor characterization process, Encoder pulses were detected but the Motor Encoder pulse rate is not a standard value (32, 48, 64, 80 ppr).	1. Using the 1313 Handheld Programmer, manually set Encoder_Steps to the correct value for the Motor Encoder, then cycle KSI.
8.9	Motor Type Fault.	1. The Motor_Type parameter value is out of range.	1. Using the 1313 Handheld Programmer, set the Motor_Type parameter to to correct value, then cycle KSI.
9.1	VCL/OS mismatch	1. Motor Controller error.	1. Download the correct Operating System software version and matching parameter default settings into the Controller, and then cycle KSI.
9.2	EM Brake Failed to Set.	1. After the electromagnetic (EM) Brake is activated, and time has elapsed to allow the brake to fully engage, the Tractor continues moving. 2. The braking force of the EM Brake is too small and will not hold the Motor from rotating.	1. Using the 1313 Handheld Programmer, check the EM Brake and accelerator settings to see if the parameters are set incorrectly. 2. Check the EM Brake disc to see if it needs to be adjusted or replaced.
9.3	Encoder Limited Operating Strategy (LOS) control mode entered.	1. Limited Operating Strategy (LOS) control mode has been activated; as a result of either an Encoder Fault (Code 36), or a Stall Detect Fault (Code 73). 2. Motor Encoder failure. 3. Bad crimps or faulty wiring. 4. Tractor has stalled. 5. The Motor is blocked, or the Motor Encoder is faulty. 6. The Tractor is blocked.	1. Check that operation of the Motor and Tractor is not blocked or fouled. 2. Check that the power supply to the Motor Encoder is functioning normally. 3. Check that the wiring is to the Motor Encoder is correct, that the pins are dirt free, and all crimp connections are serviceable. 3. Using the 1313 Handheld Programmer, check the Motor Encoder parameter settings: Programme/Motor Menu/Encoder Steps/ Encoder Pulse Number. 4. Using the 1313 Handheld Programmer, monitor whether the Encoder Feedback Speed Signal is normal: Monitor Menu/Motor Menu/ Motor Speed/Encoder Phase A Speed Signal.

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Fault Code	Effect of Fault	Probable Cause	Failure diagnosis method
			5. Repeat step 4 for the Encoder Phase A Speed Signal. 6. If steps 1 to 5 above do not identify the problem, replace the Motor Encoder.
9.4	Emer Rev Timeout.	1. The emergency reverse switch is stuck in the closed (On) position. 2. Emergency Reverse was activated and ended because the EMR Timeout timer has expired.	1. Using the 1313 Handheld Programmer, check whether the Ext Supply Max and Ext Supply Min parameter settings are wrong: Monitor Menu/Inputs Menu/Emer Rev. If it is always ON, replace the Emergency Reverse switch. 2. Check the Emergency Reverse switch and associated circuit. 3. Using the 1313 Handheld Programmer, check the Emergency Reverse program setting.
9.5 to 9.7	Does not apply to ST470E Tractor.	Does not apply to ST470E Tractor.	Does not apply to ST470E Tractor.
9.8	Illegal model number.	1. Motor Controller model cannot be identified. 2. Motor Controller software problem. 2. Motor Controller is faulty.	1. Check Motor Controller is correct model. 2. Check Motor Controller software version. If necessary, download the correct Operating System software version and matching parameter default settings into the Controller, and then cycle KSI. 3. Replace the Motor Controller.
9.9	Does not apply to ST470E Tractor.	Does not apply to ST470E Tractor.	Does not apply to ST470E Tractor.

## REPAIR

Repair of the ST560LA Tractor is by direct replacement of the faulty or damaged component. The Exploded Parts View illustrations show all the components and how the Tractor is dismantled and re-assembled. All the components are listed in the Parts Breakdown List and the numbers on the Exploded Parts View illustrations are keyed to the Parts Breakdown List.

A specific procedure is provided for accessing the Rear Electrical Compartment.

Replacement parts should be sourced from Avro GSE. The use of major components not obtained from Avro GSE will invalidate the Warranty.

### NOTE

It is expected that replacement fasteners may be sourced locally. If sourcing fasteners locally, make sure that the replacement fasteners are the same type and grade of material, and have the same protective coating, as the original. The Parts Breakdown List specifies the required material and, where applicable, finish.

The vehicle chassis is not available as a spare. Any significant damage to the vehicle chassis will almost certainly be part of catastrophic damage to the Tractor. Also, the time and effort required to strip down the Tractor, replace the chassis, and then rebuild, is such that significant damage to the Chassis renders the Tractor “Beyond Economic Repair”.

### FITTING MOTOR CONTROLLERS

In normal operation the two Motor Controllers generate heat, and the Controller Panel Base Plate acts a heatsink for them. When fitting or re-fitting a Motor Controller, it is recommended that a thermal joint compound is applied to the metal base plate of the Motor Controller before the Motor Controller is secured in position on the Controller Panel Base Plate. The thermal joint compound will improve the conduction of heat from the Motor Controller to the Controller Panel Base Plate, thus improving the reliability of the Motor Controller.

### TORQUE VALUES

The Tractor wheel nuts **MUST** be torque tightened to the correct torque settings given below. Failure to torque tighten the wheel nuts to the correct torque setting may result in a wheel coming loose.

**Wheel Nut torque values**

Fastener	Torque setting
Front wheel nuts	210 Nm (155 ft/lbs)
Rear wheel nuts	420 Nm (310 ft/lbs)

The wheel nuts are the only items on the Tractor that have a specific torque setting. For other securing bolts, refer to the general recommended torque values table given on the next page. If in doubt about the strength grade of the bolt, use the lowest figure given for that size of bolt.

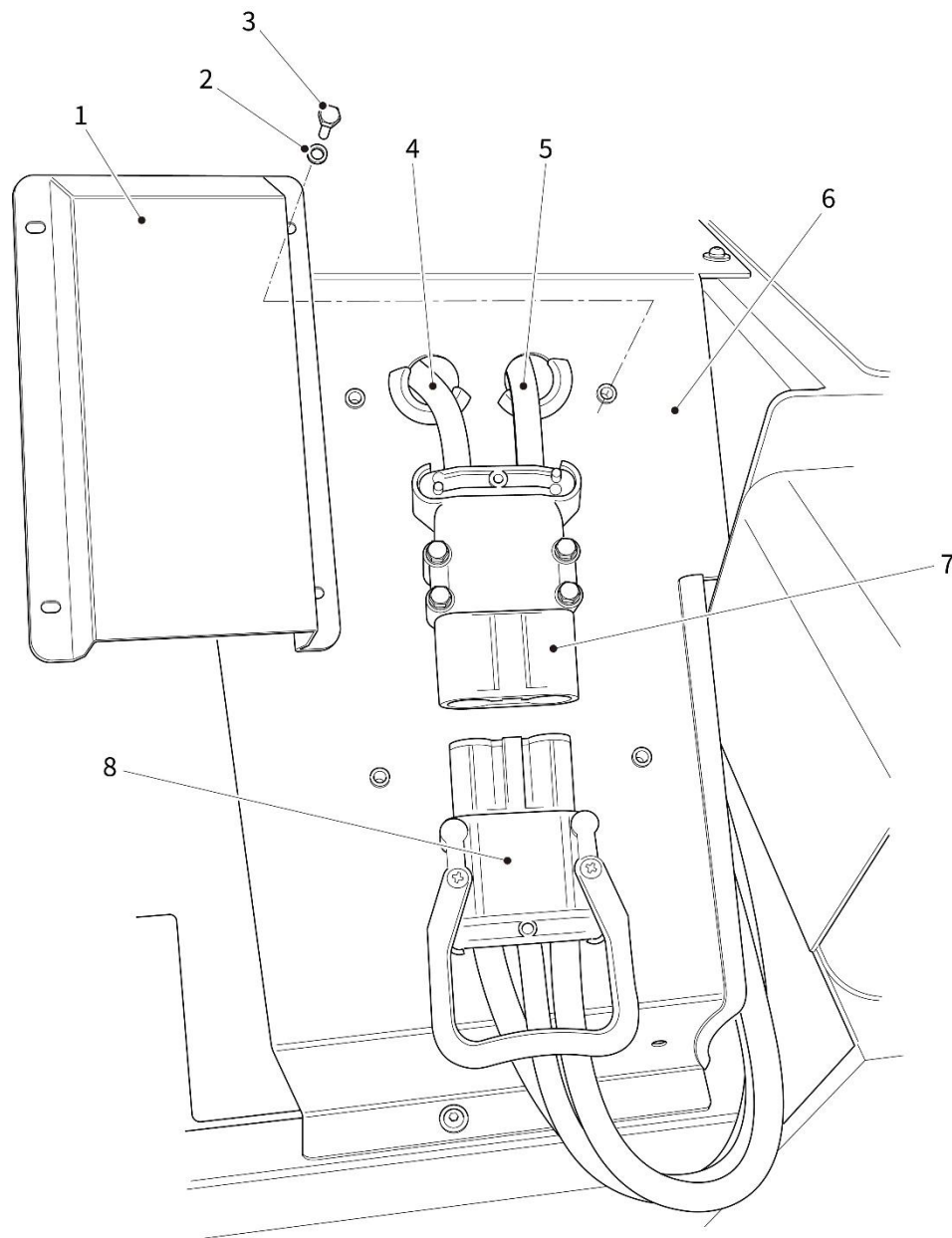
### General recommended torque values

Bolt Strength Grade			4.8	6.8	8.8	10.9
Minimum yield strength			340 MPa	480 MPa	660 MPa	940 MPa
Bolt	Indent hex	Hex Socket	Recommended Torque			
mm	mm	mm	Nm	Nm	Nm	Nm
M6	-	-	-	-	10.4	15
M8	-	-	-	-	25.4	37.6
M10	-	-	-	-	50	72
M12	-	-	-	-	88	126
M14	22	12	69	98	137	165
M16	24	14	98	137	206	247
M18	27	14	137	206	284	341
M20	30	17	176	296	402	569
M22	32	17	225	333	539	765
M24	36	19	314	470	686	981
M27	41	19	441	637	1029	1472
M30	46	22	588	882	1225	1962
M33	50	24	735	1127	1470	2060
M36	55	27	980	1470	1764	2453
M39	60	27/30	1176	1764	2156	2943
M42	65	32	1519	2352	2744	3826

## ACCESSING THE REAR ELECTRICAL COMPARTMENT

The Rear Electrical Compartment is accessed by removing the Rear Main Cover Panel as follows:

- Refer to Figure 13. Disconnect the battery side (8) of the Main Power Connector by pulling on its handle. Note that the battery side of the Main Power Connector is a plug.
- Remove and retain the four screws (3) and associated lock washers (2), then remove and retain the Guard Assembly (1) that protects the Main Power Connector.
- In order to remove the Rear Main Cover Panel, it is necessary to first dismantle the motor/controller side (7) of the Main Power Connector and disconnect the two attached cables. Tag or otherwise identify the Battery Cable (4) and the Controller Return Cable (5) before dismantling the motor/controller side of the Main Power Connector. Retain the Main Power Connector components.



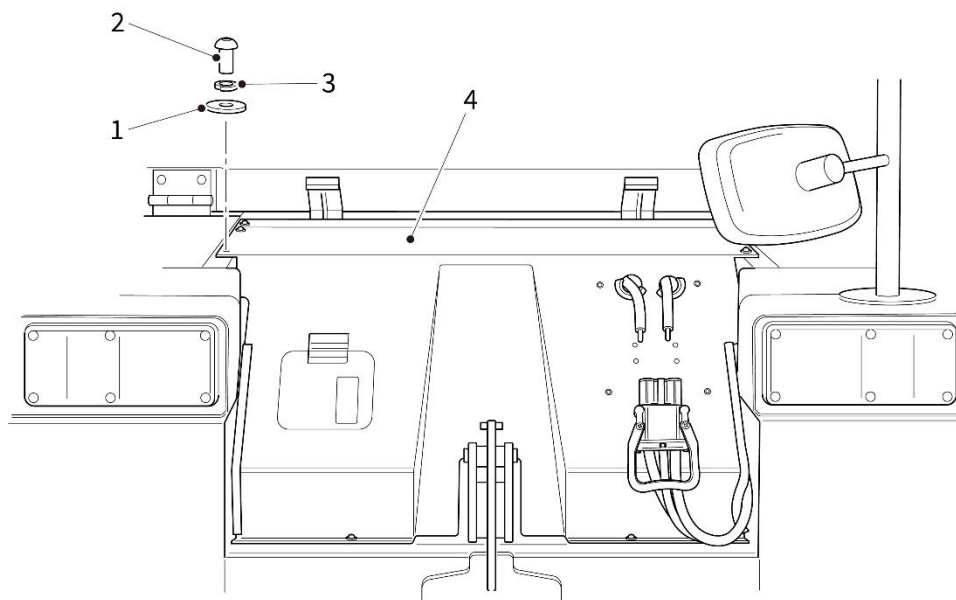
- |   |                  |   |  |
|---|------------------|---|--|
| 1 | Guard Assembly   | 5 | Controller Return Cable                      |
| 2 | M6 x 20 mm screw | 6 | Rear Main Cover Panel                        |
| 3 | M6 lock washer   | 7 | Main Power Connector – motor/controller side |
| 4 | Battery Cable    | 8 | Main Power Connector - battery side          |

**Figure 13 – Accessing rear electrical compartment (stage 1)**

- Taking care not to damage the cables, push the Battery Cable (4) and the Controller Return Cable (5) through the holes in the Rear Main Cover Panel (6).



- Refer to Figure 14. Remove and retain the screws (2), lock washers (3) and flat washers (1) that secure the Rear Main Cover Panel (4).



- |   |                  |   |                       |
|---|------------------|---|-----------------------|
| 1 | M6 flat washer   | 3 | M6 lock washer        |
| 2 | M6 x 12 mm screw | 4 | Rear Main Cover Panel |

**Figure 14 – Accessing rear electrical compartment (stage 2)**

- Remove and retain the Rear Main Cover Panel (4).

At this point the Tractor electrical system is disconnected from the battery. To perform failure diagnosis and verify that the Tractor is working correctly following a repair, it is necessary to reconnect the Tractor electrical system to the battery.

- Refer to Figure 13. Assemble the motor/controller side (7) of the Main Power Connector and reconnect the Battery Cable (4) and the Controller Return Cable (5). Make sure that the two cables are connected to the correct terminals of the Main Power Connector.
- Plug the battery side (8) of the Main Power Connector into the motor/controller side (7) of the Main Power Connector.
- This procedure is now complete.

Re-fitting the Rear Main Cover Panel is the reverse of the access procedures described above.

## REPLACING ELECTRIC MOTORS

When replacing an electric motor, tag or otherwise identify all wiring connected to the motor before disconnecting the wiring. When reconnecting the wiring, make sure that the electrical connections are made the same as they were before they were disconnected. Connecting wiring to a motor incorrectly can result in the Tractor moving backwards when forward travel is selected.

## WARNING – MOTOR CONNECTIONS



**If an electric motor has been removed and is being replaced or refitted, make sure that the electrical connections to the motor are made the same as they were before they were disconnected. Connecting wiring to a motor incorrectly can result in the Tractor moving backwards when forward travel is selected.**

## WELDING REPAIRS, GRINDING, AND CUTTING

If any weld repairs, grinding, cutting with power tools or cutting torches, or similar work is to be performed on a ST470E Tractor, the Safety Warnings and Precautions below **MUST** be complied with.

## WARNINGS AND PRECAUTIONS – WELDING, GRINDING, AND CUTTING



**WELDING ARC.** A welding arc is bright enough to damage eyesight and cause flash burns. Never look directly at a welding arc with unprotected eyes. Always use an approved welding screen or visor. Cover all exposed skin before welding.



**PROTECTIVE CLOTHING.** Always wear protective clothing and gloves appropriate for welding work.



**HOT WELDS.** Always allow a weld to cool before removing welding slag.

**Make sure that there is no combustible material within 4 Meters (13 feet) of grinding, welding, or slag chipping.**



**GRINDING, CHIPPING, AND CUTTING.** Always wear eye protection (e.g. protective goggles) when using grinding and cutting tools, and when chipping off welding slag. Always wear eye protection when within 4 Meters (13 feet) of grinding, slag chipping, or cutting with power tools.



**DAMAGE TO ELECTRICAL EQUIPMENT.** To prevent damage to the vehicle electrical system, before performing any welding, remove or disconnect all vehicle batteries, and disconnect all electrical connections to the vehicle electronics.



**TRAINING, AUTHORIZATION AND CERTIFICATION OF WELDERS.** Welding must only be performed by people who have been **FULLY TRAINED IN WELDING AND ARE AUTHORIZED** to perform welding operations. Welders must be **CERTIFIED** by their respective national association of welders, such as CWB and/or AWS.

Grinding, chipping, and cutting with power tools must only be performed by people who have been **FULLY TRAINED IN USING THE POWER TOOLS AND ARE AUTHORIZED** to perform those operations.

Before performing any welding, grinding or chipping operations, make sure that any necessary Hot Work Permits have been obtained.

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## ELECTRICAL SCHEMATICS


These Electrical Schematics are provided to assist in troubleshooting.

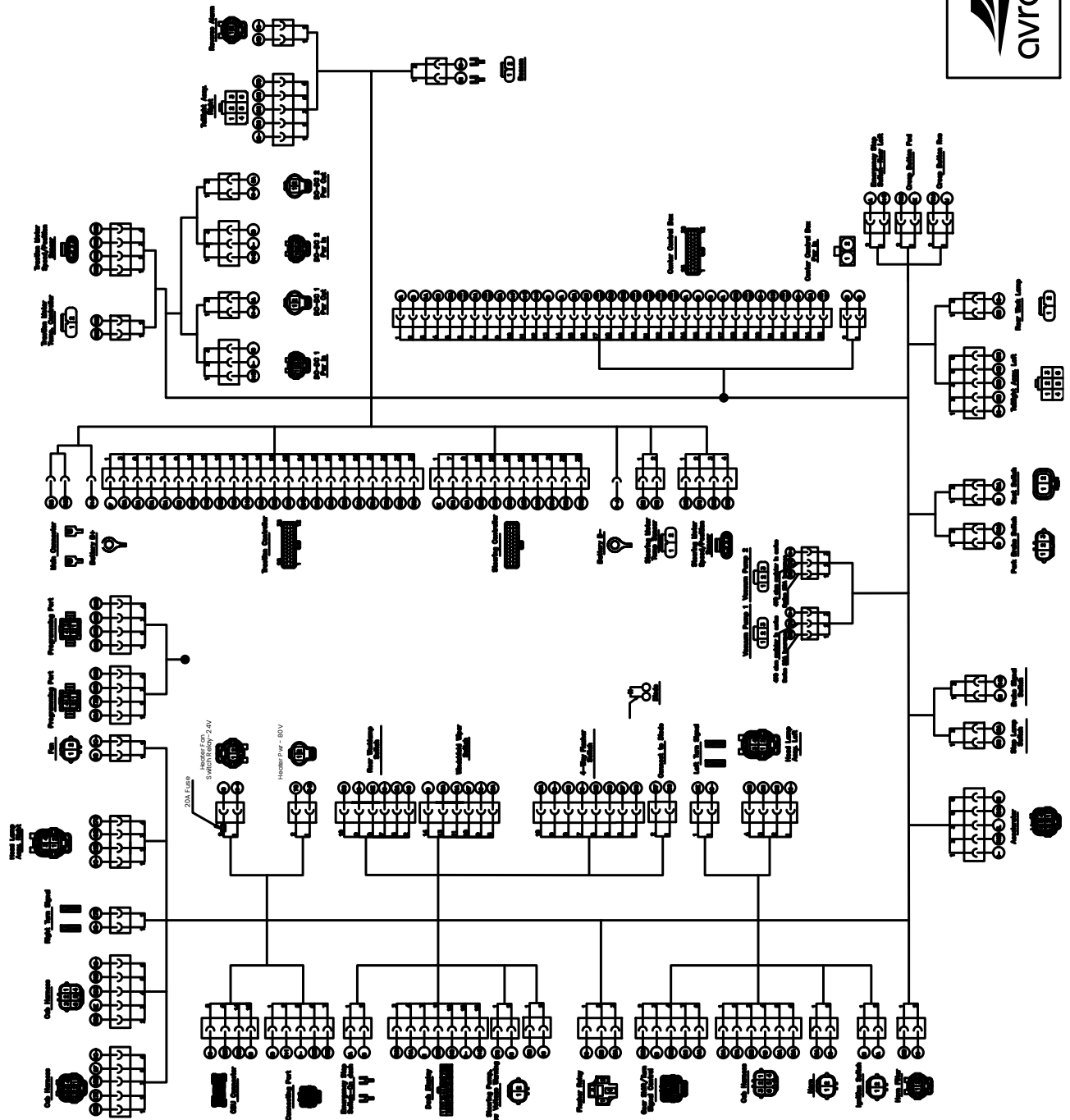
This manual covers the build standard of the ST470E Tractor that were manufactured during 2022.

For the ST470E Tractor with a MY of 2022, the following electrical diagrams are provided (in this sequence):

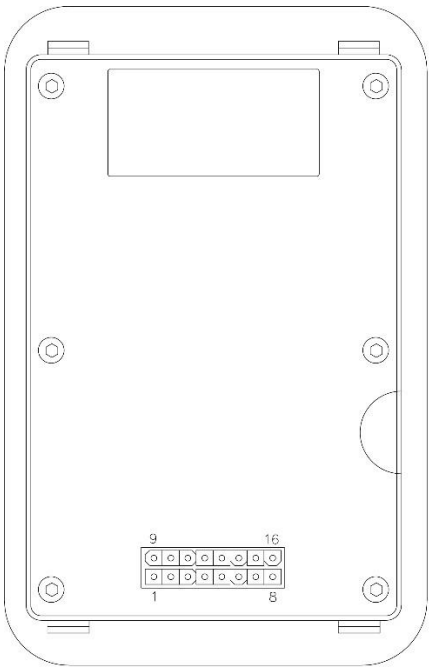
- ST470E Electrical Schematic 2022 MY
- ST470E Main Harness 2022 MY
- ST470E Cabin Harness
- ST470E Dash Display
- ST470E 1238E Traction Motor Controller
- ST470E 1232E Steering Motor Controller
- ST470E Centre Control Box
- ST470 Gear Shift/Turn Signal/Headlamp Control Assembly



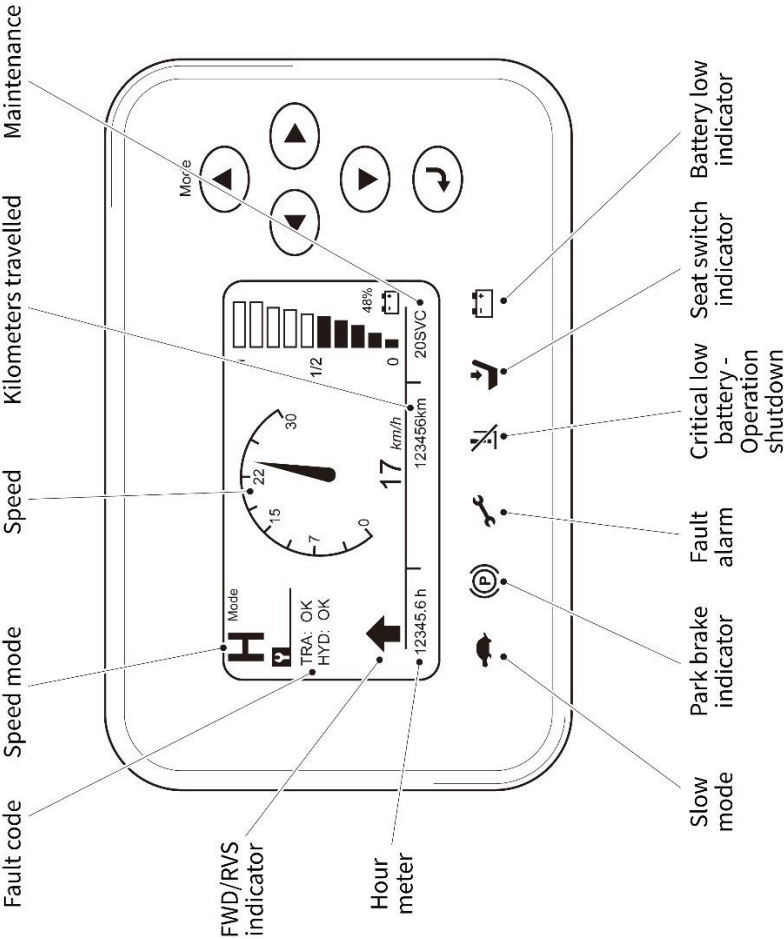
 <b>AVRO GSE</b>	<b>TITLE:</b> ST470LA Main Harness 2022 MY





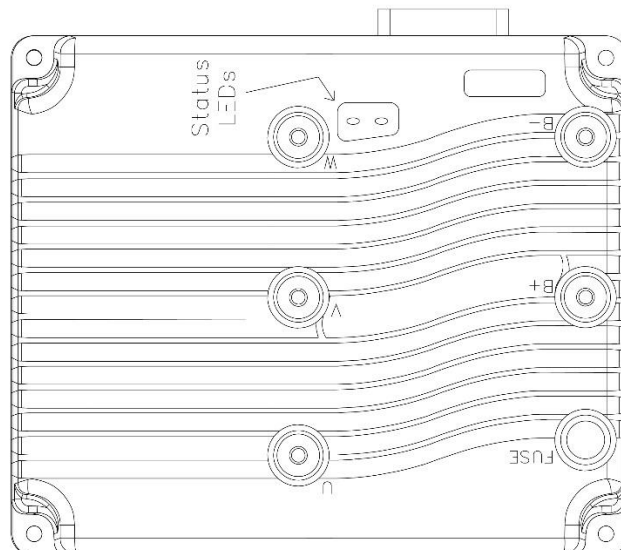
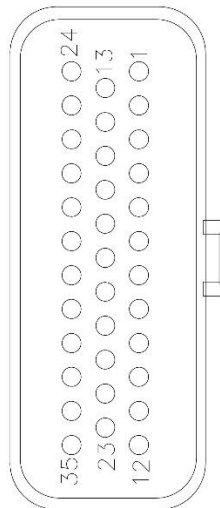


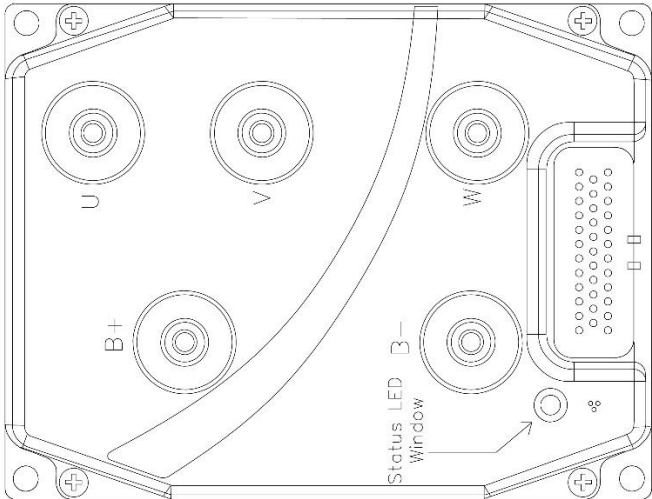
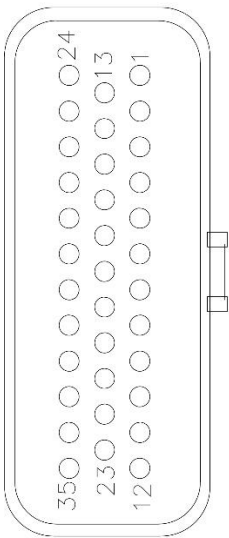
PIN	FUNCTION
PIN 1	SCI Rx
PIN 2	SCI GND
PIN 3	CAN_L
PIN 4	CAN_L Termination
PIN 5	Switch input 1/Frequency Input 1
PIN 6	Switch Input 3/HYD Fault Code Input
PIN 7	KSI
PIN 8	MCSFET Output
PIN 9	SCI Tx
PIN 10	CAN_GND
PIN 11	CAN_H
PIN 12	CAN_H Termination
PIN 13	Switch input 2/Frequency Input 2
PIN 14	Switch input 4/TRA Fault Input
PIN 15	B-
PIN 16	B+





PIN	NAME	PIN	NAME
1	KS1	19	DIGITAL OUT 6
2	PROP DRIVER	20	DIGITAL OUT 7
3	DRIVER 4	21	CAN TERM H
4	DRIVER 3	22	FORWARD
5	DRIVER 2	23	CAN H
6	DRIVER 1	24	ACCELERATOR
7	I/O GROUND	25	+12V OUT
8	THERMIST	26	+5V OUT
9	SEAT SWITCH	27	POT2 HIGH
10	CREEP FWD	28	SERIAL TX
11	CREEP RVS	29	SERIAL RX
12	PARK BRAKE	30	ANALOG OUTPUT
13	COIL RETURN	31	SPEED/POSITION SENSOR FEEDBACK A
14	FOOT BRAKE	32	SPEED/POSITION SENSOR FEEDBACK B
15	THROTTLE POT HIGH	33	REVERSE
16	THROTTLE POT WIPER	34	CAN TERM L
17	POT2 WIPER	35	CAN L
18	POT LOW		

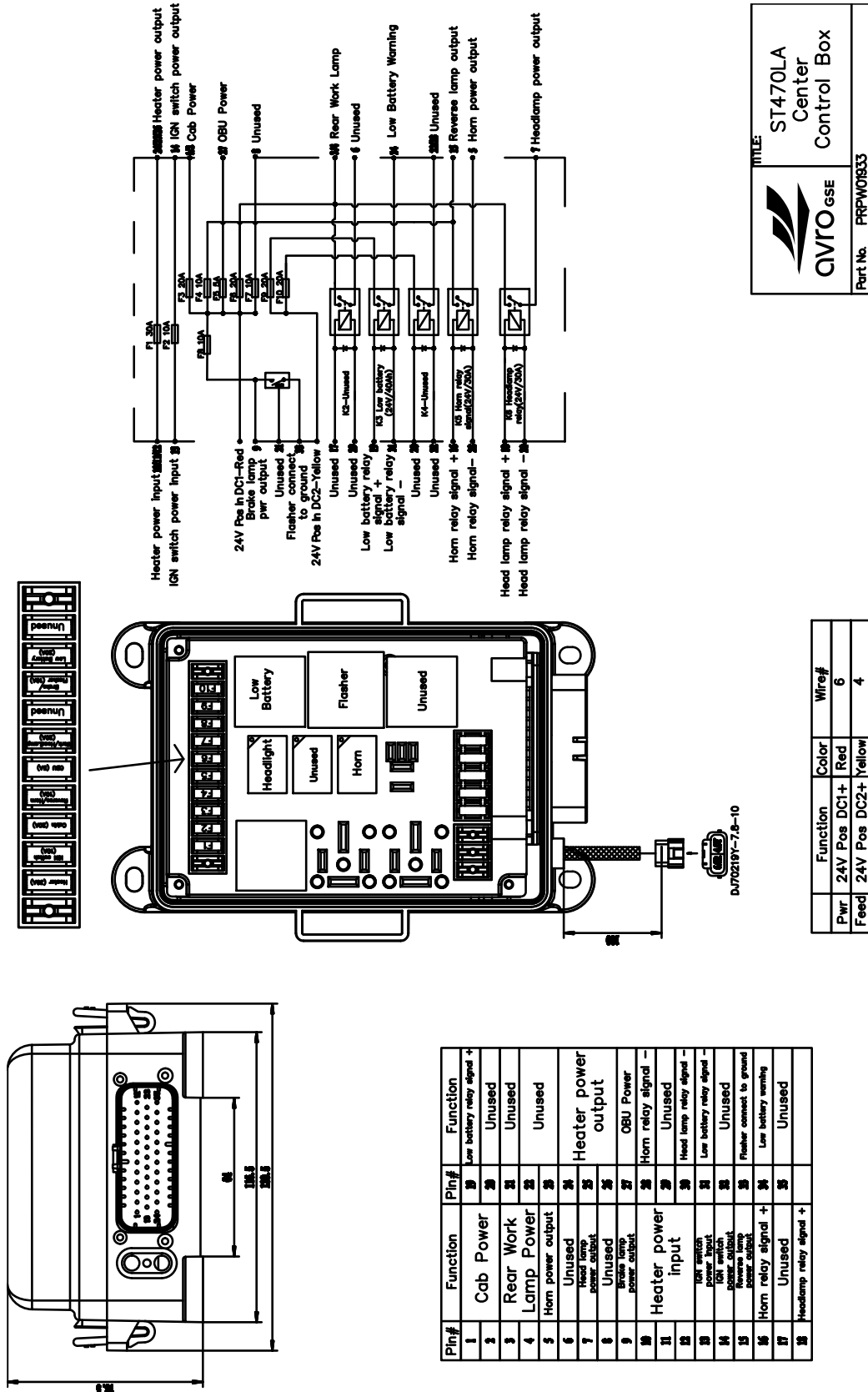




PIN	NAME	PIN	NAME
1	KSI	19	DIGITAL OUT 6
2	PROP DRIVER	20	DIGITAL OUT 7
3	DRIVER 4	21	CAN TERM H
4	DRIVER 3	22	SWITCH 7
5	DRIVER 2	23	CAN H
6	DRIVER 1	24	SWITCH 1 ANALOG 1
7	I/O GROUND	25	+12V OUT
8	Thermister	26	+5V OUT
9	SWITCH 3	27	POT2 HIGH
10	SWITCH 4	28	SERIAL TX
11	SWITCH 5	29	SERIAL RX
12	SWITCH 6	30	ANALOG OUTPUT
13	COIL RETURN	31	SPEED/POSITION SENSOR FEEDBACK A
14	SWITCH 16	32	SPEED/POSITION SENSOR FEEDBACK B
15	THROTTLE POT HIGH	33	SWITCH 8
16	THROTTLE POT WIPER	34	CAN TERM L
17	POT2 WIPER	35	CAN L
18	POT LOW		



TITLE: ST470LA  
1232E  
Steering Motor  
Controller

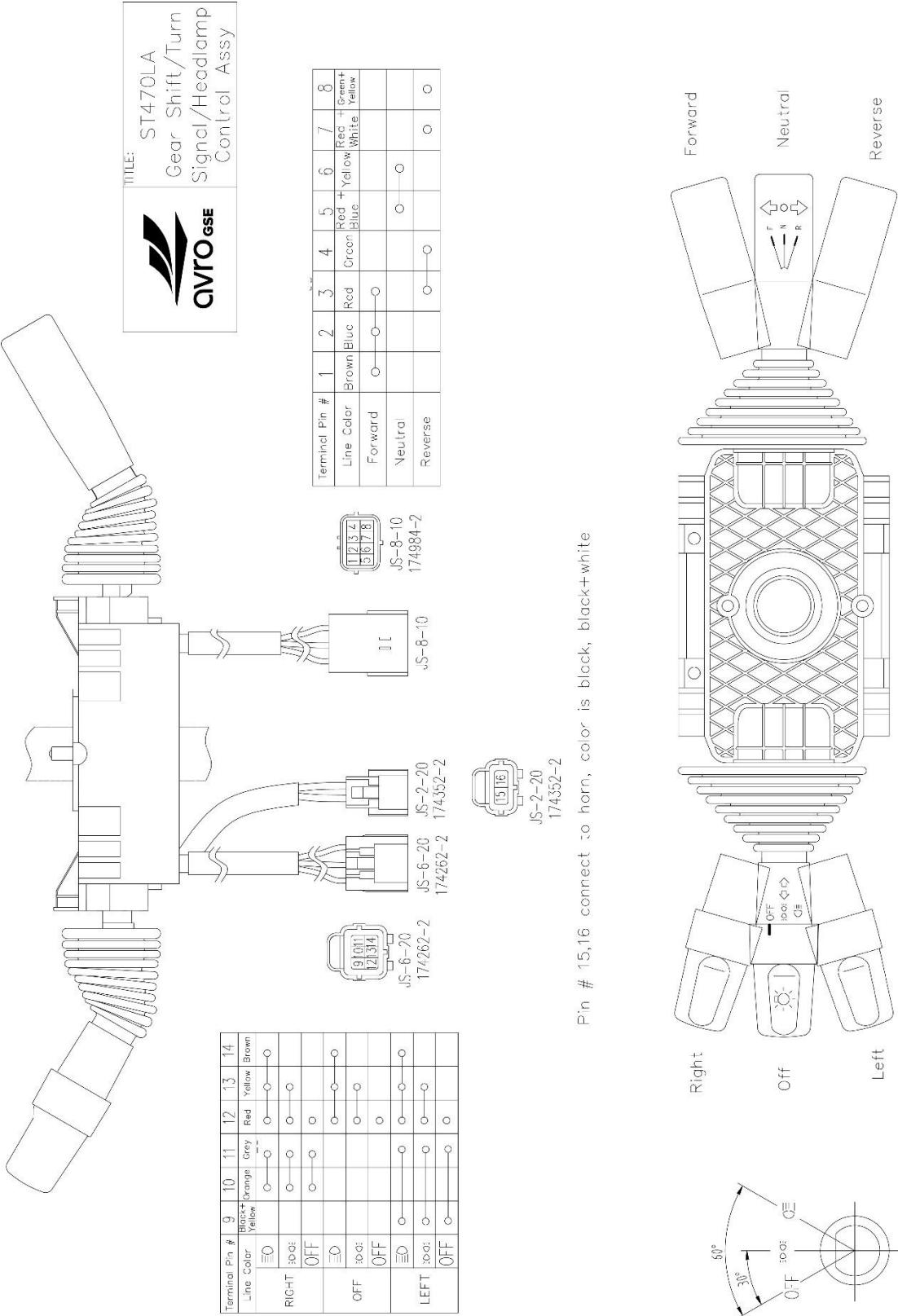


TITLE:

ST470LA  
Center  
Control Box

Part No. PRPW01833

Feed	Function	Color	Wire#
Pwr	24V Pos DC1+	Red	6
Feed	24V Pos DC2+	Yellow	4

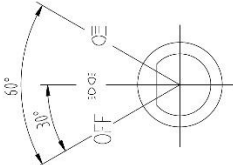




TITLE: ST470LA  
Gear Shift/Turn  
Signal/Headlamp  
Control Assy

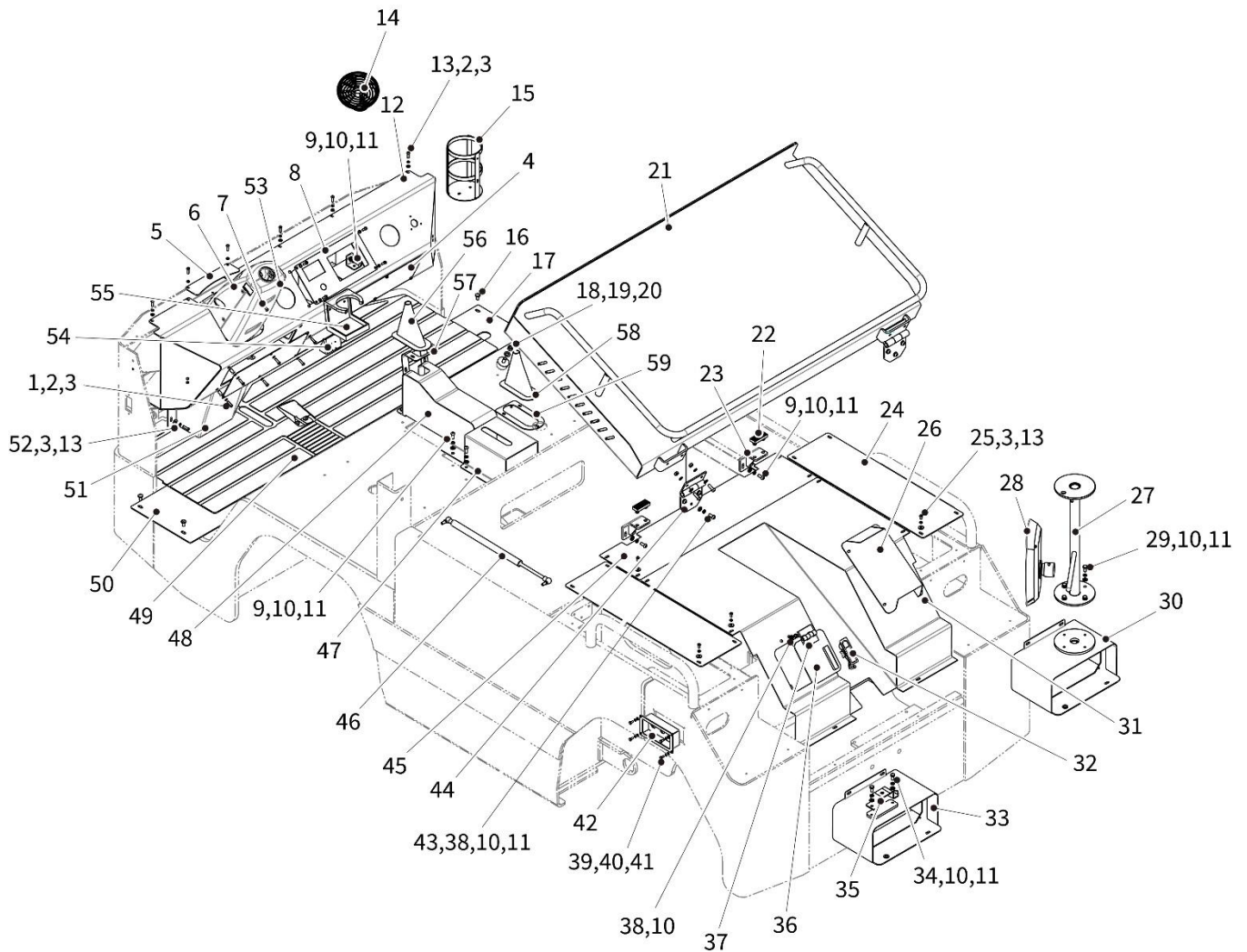
Terminal Pin #	1	2	3	4	5	6	7	8
Line Color	Brown	Blue	Red	Green	Red + Blue	Yellow	White	Red + Green + Yellow
Forward								
Neutral								
Reverse								

Terminal Pin #	9	10	11	12	13	14
Line Color	Black + Yellow	Orange	Grey	Red	Yellow	Brown
RIG-IT						
OFF						
OFF						
LEFT						
OFF						



# EXPLODED PARTS VIEWS & PARTS LISTS

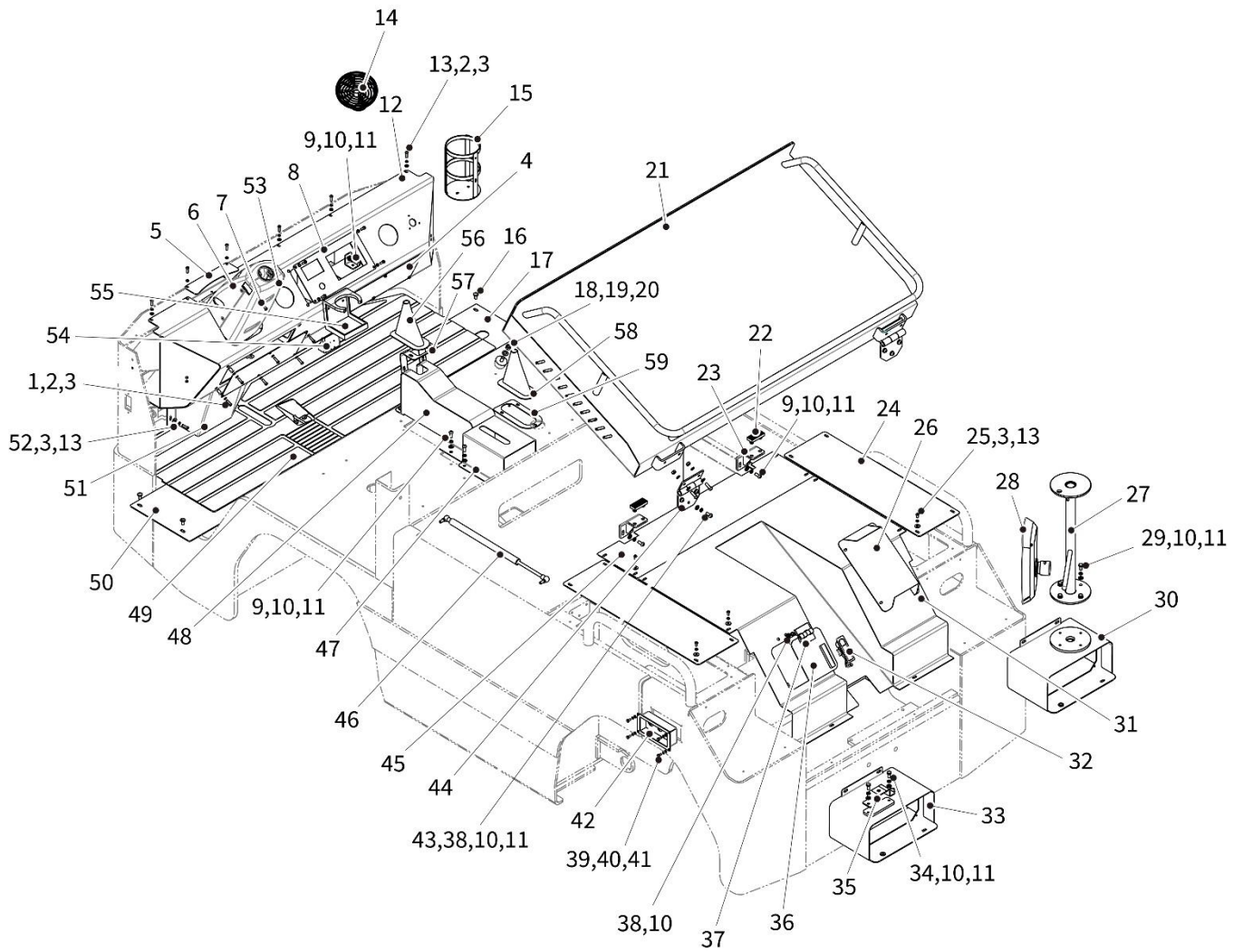
## BODY & EXTERIOR



**Body and Exterior - Exploded Parts View**

### Body and Exterior – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRFA00132	Nut, Special, M6	18	
2	PRFA00038	Screw, M6 x 20 mm	22	
3	PRFA00007	Washer, Lock, M6	48	
4	PRPW01558	Inner Dash Cover Panel	2	
5	PRPW01559	Upper Dash Cover panel	1	
6	PRPW01660	Steering Column Housing - Front	1	
7	PRFA00016	Screw, M6 x 12mm	4	
8	PRPW01661	Control Panel	1	
9	PRFA00038	Screw, M6 x 20 mm	16	
10	PRFA00010	Washer, Lock, M8	34	
11	PRFA00009	Washer, Flat, M8	30	
12	PRPW01662	Dash Panel	1	
13	PRFA00006	Washer, Flat, M6	34	
14	PRPW01663	Fan	1	
15	PRPW01664	Fire Extinguisher Holder	1	
16	PRFA00024	Screw, M8 x 16mm	8	
17	PRPW01665	Floor Panel, Right	1	
18	PRPW01666	Rubber Stop	2	
19	PRFA00011	Washer, Flat, M10	2	
20	PRFA00036	Nut, M10	2	
21	PRPW01667	Battery Access	1	
22	PRPW01668	Rubber Cushion	2	
23	PRPW01669	Cushion Bracket	2	
24	PRPW01770	Rear Side Cover Panel	2	
25	PRFA00016	Screw, M6 x 12 mm	26	
26	PRPW01771	Guard Assembly (for Main Power Connector)	1	
27	PRPW01772	Beacon Mount	1	
28	PRPW00043	Side Mirror-exterior	1	
29	PRFA00061	Bolt, M8 x 16 mm	4	
30	PRPW01774	Taillight Housing, Right	1	
31	PRPW01775	Rear Main Cover Panel	1	
32	PRPW00059	Latch	1	

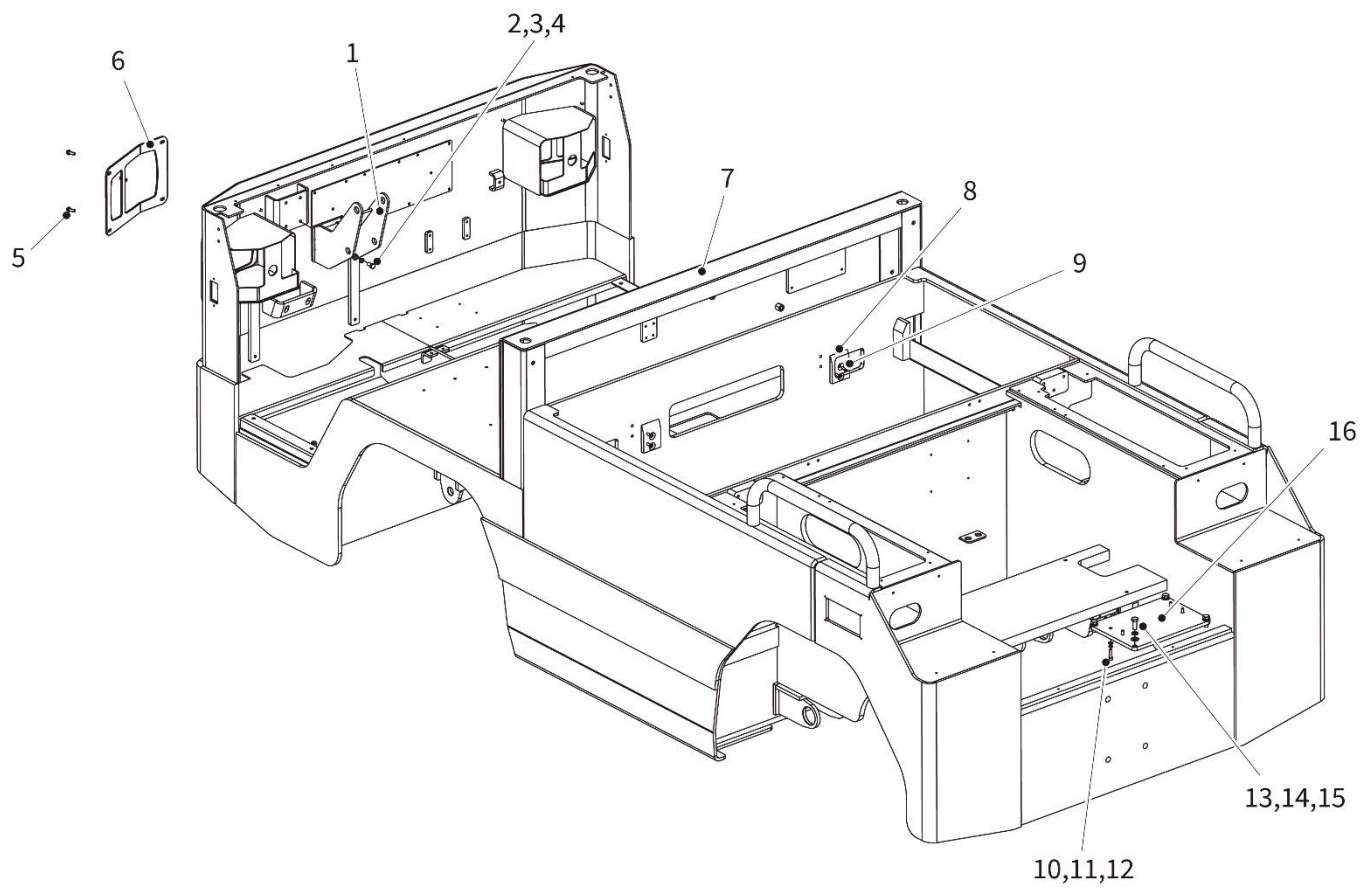


**Body and Exterior - Exploded Parts View**



### Body and Exterior – Spare Parts List

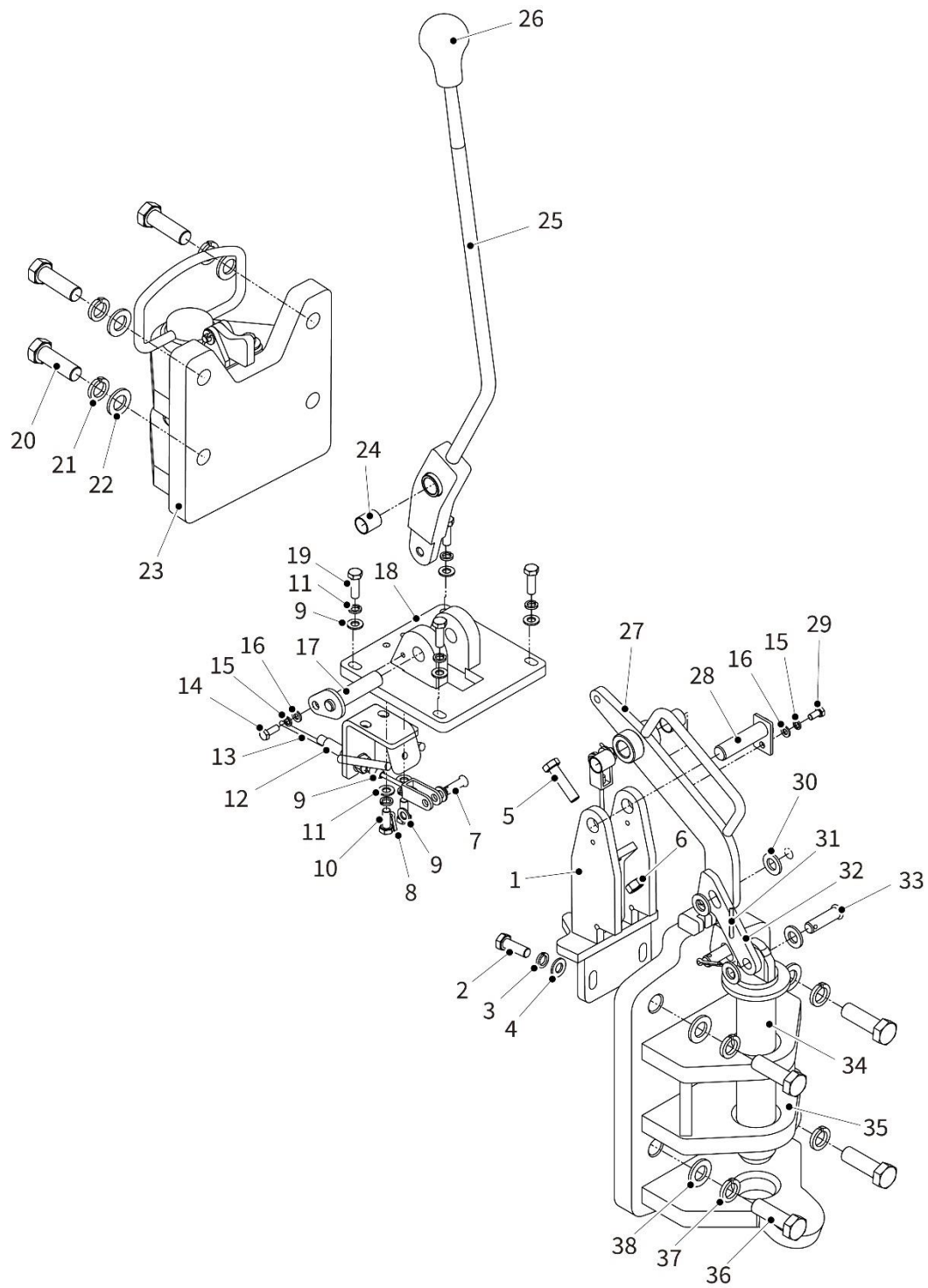
Item	Part No.	Description	Qty	Remarks
33	PRPW01776	Taillight Housing, Left	1	
34	PRFA00133	Bolt, M8 x 12 mm	2	
35	PRPW02210	Work Lamp Mount	1	Rear Light Bracket
36	PRPW01777	Hatch Panel	1	
37	PRPW01778	Hinge	1	
38	PRFA00021	Nut, M8	6	
39	PRFA00114	Screw, M5 x 12mm	4	
40	PRFA00116	Washer, Lock, M5	4	
41	PRFA00117	Washer, Flat, M5	4	
42	PRPW01779	Switch Box	1	
43	PRFA00017	Screw, M8 x 25 mm	4	
44	PRPW01880	Hing, Battery Access	2	
45	PRPW01881	Rear, Forward Cover Panel	1	
46	PRPW01883	Strut, Battery Access Cover	1	
47	PRPW01882	Cover, Hitch Handle	1	
48	PRPW01884	Cover, Park Brake Handle	1	
49	PRPW01885	Floor Mat	1	
50	PRPW01886	Floor Panel, Left	1	
51	PRPW01887	Steering Column Cover	1	
52	PRFA00037	Screw, M6 x 16 mm	4	
53	PRPW01888	Steering Column Housing - Rear	1	
54	PRPW01889	Bracket	1	
55	PRPW01890	Cup Holder	1	
56	PRPW01891	Dust Cover, Park Brake	1	
57	PRPW01892	Dust Cover Mount	1	
58	PRPW01893	Dust Cover, Hitch Handle	1	
58	PRPW01894	Dust Cover Mount	1	



**Chassis Assembly - Exploded Parts View**

### Chassis Assembly – Spare Parts List

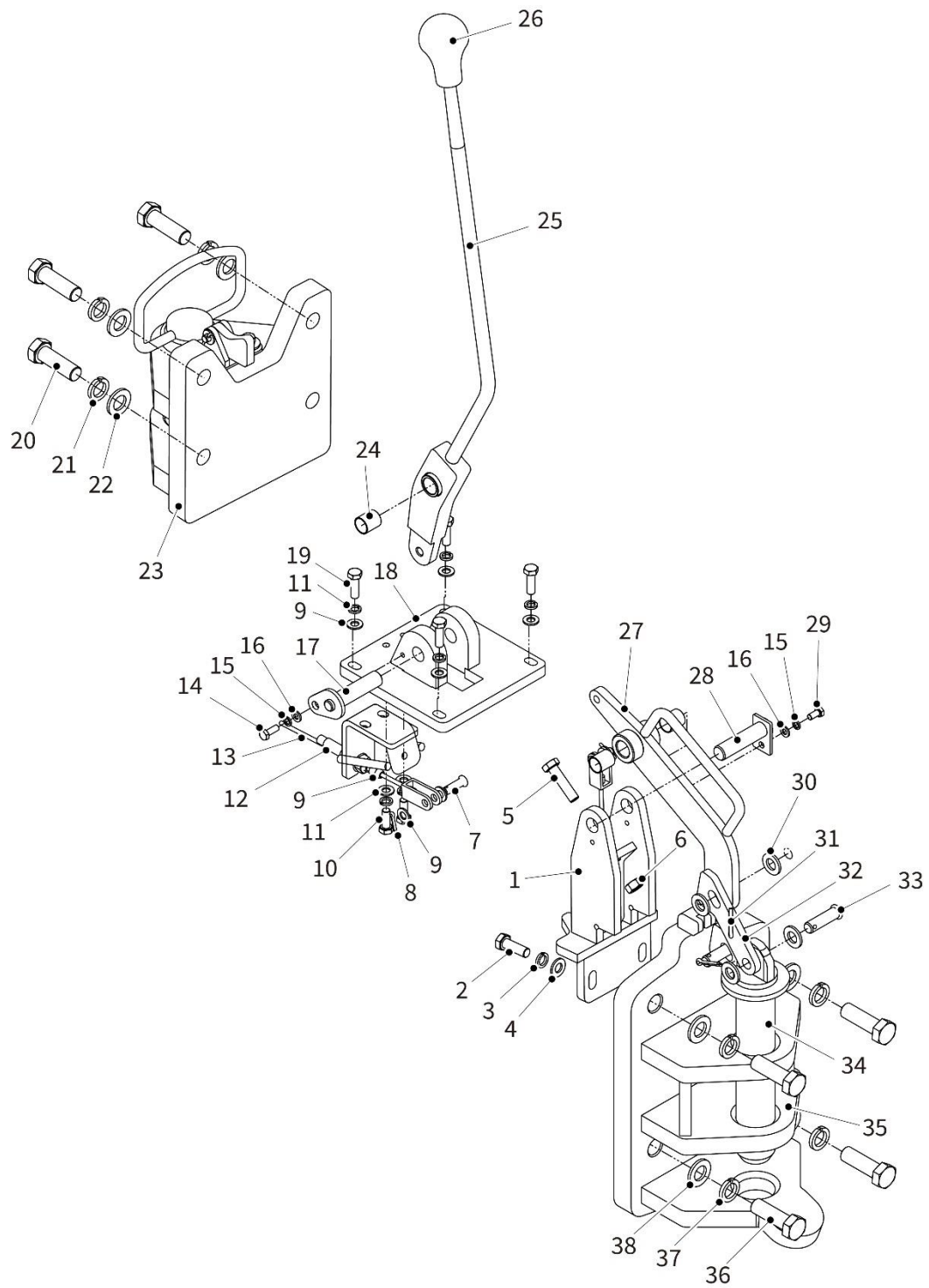
Item	Part No.	Description	Qty	Remarks
1	PRPW01895	Steering Mount	1	
2	PRFA00061	Bolt, M8 x 16 mm	4	
3	PRFA00010	Washer, Lock, M8	4	GB/T 93
4	PRPW00547	Washer, Flat, M8	4	GB/T 97.1
5	PRFA00039	Screw, M8 x 20 mm	8	
6	PRPW01896	Front Light Cover	2	
7	PRPW01897	Chassis	1	
8	PRPW01898	Battery Shim	2	
9	PRFA00037	Screw, M6 x 16 mm	4	
10	PRFA00106	Screw, M6 x 25 mm	4	
11	PRFA00007	Washer, Lock, M6	12	GB/T 93
12	PRFA00006	Washer, Flat, M6	12	
13	PRFA00063	Bolt, M10 x 25 mm	4	
14	PRFA00012	Washer, Lock, M10	4	
15	PRFA00011	Washer, Flat, M10	4	
16	PRPW01899	Steering Pump Mount Plate	1	



**Hitch Assembly - Exploded Parts View**

### Hitch Assembly – Spare Parts List

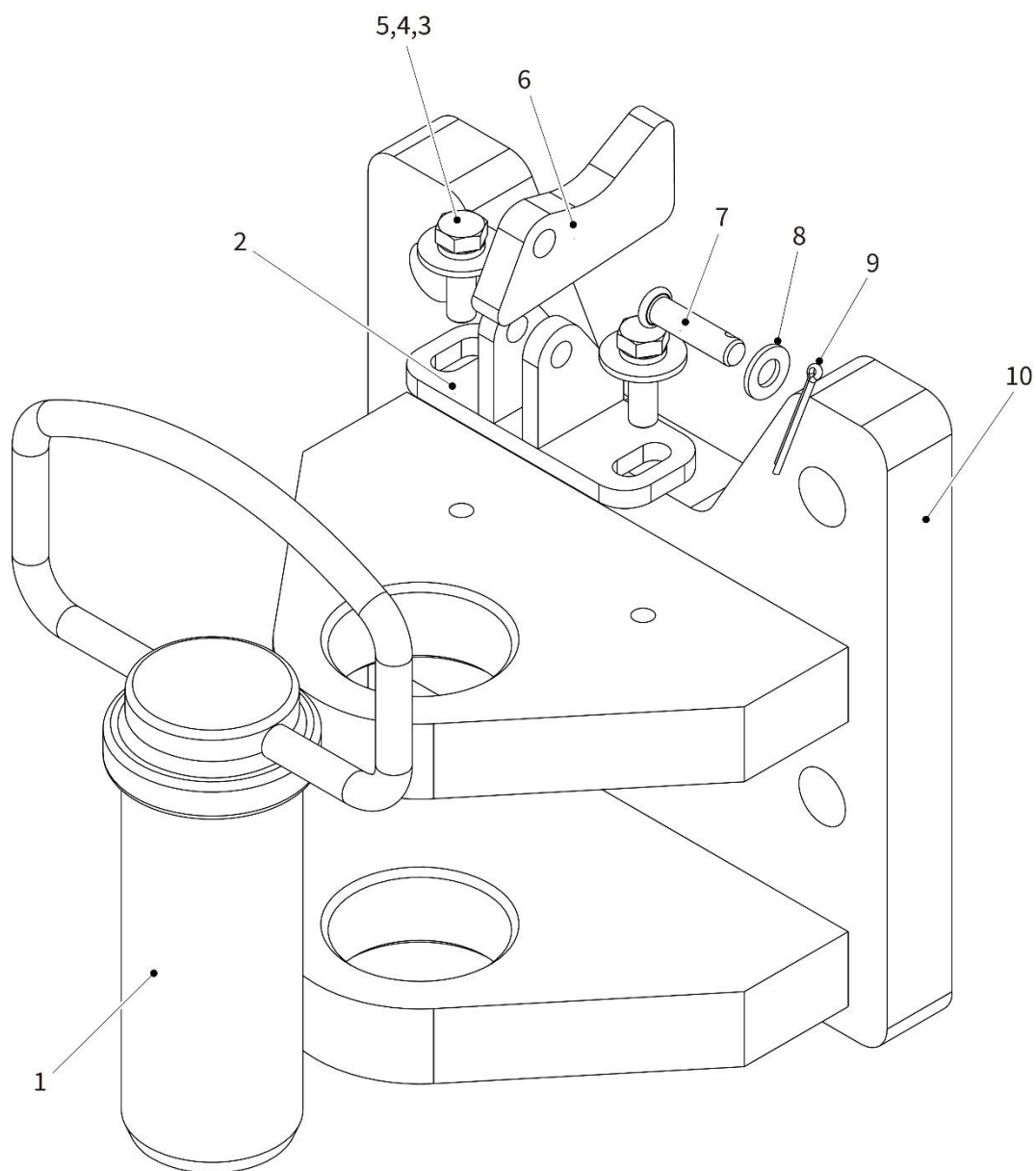
Item	Part No.	Description	Qty	Remarks
1	PRPW01900	Handle Mount	1	
2	PRFA00008	Bolt, M10 x 30 mm	2	
3	PRFA00012	Washer, Lock, M10	2	
4	PRFA00011	Washer, Flat, M10	2	
5	PRFA00049	Bolt, M10 x 40 mm	1	
6	PRFA00036	Nut, M10	1	
7	PRFA00107	Pin, 8 x 26 mm	2	
8	PRFA00135	Pin, Split Cotter, 3.2 x 14 mm	2	
9	PRFA00009	Washer, Flat, M8	10	
10	PRFA00033	Bolt, M8 x 20 mm	2	
11	PRFA00010	Washer, Lock, M8	6	
12	PRPW01901	Cable Mounting Bracket	1	
13	PRPW00156	Rear Hitch Cable Assembly	1	
14	PRFA00108	Bolt, M6 x 16 mm	1	
15	PRFA00007	Washer, Lock, M6	2	
16	PRFA00006	Washer, Flat, M6	2	
17	PRPW00647	Pin Assembly	1	
18	PRPW01902	Actuator Handle Mount	1	
19	PRFA00013	Bolt, M8 x 25 mm	4	
20	PRFA00109	Bolt, M16 x 50 mm	4	
21	PRFA00069	Washer, Lock, M16	4	
22	PRFA00068	Washer, Flat, M16	4	
23	PRPW01903	Front Hitch Assembly incl Pin	1	
24	PRPW02305	Bushing, oilless, Type SF1-1820, self lubricating, composite, i.d. 16 mm, o.d.18 mm, length 20 mm, wall thickness 1.01 mm	3	
25	PRPW01904	Hitch Actuator Handle	1	
26	PRPW00576	Knob, interior hitch handle	1	
27	PRPW01905	Rear Hitch Handle	1	
28	PRPW01906	Pivot Pin	1	
29	PRFA00130	Bolt, M6 x 12 mm	1	
30	PRFA00030	Washer, Flat, M12	4	



**Hitch Assembly - Exploded Parts View**

### Hitch Assembly – Spare Parts List

Item	Part No.	Description	Qty	Remarks
31	PRFA00137	Pin, Split Cotter, 4 x 25mm	2	
32	PRPW01908	Connection Plate	2	
33	PRFA00136	Pin, 12 x 40 mm	2	
34	PRPW01909	Rear Hitch Pin	1	
35	PRPW01910	Rear Hitch Assembly	1	
36	PRFA00110	Bolt, M18 x 75 mm	4	
37	PRFA00111	Washer, Lock, M18	4	
38	PRFA00112	Washer, Flat, M18	4	



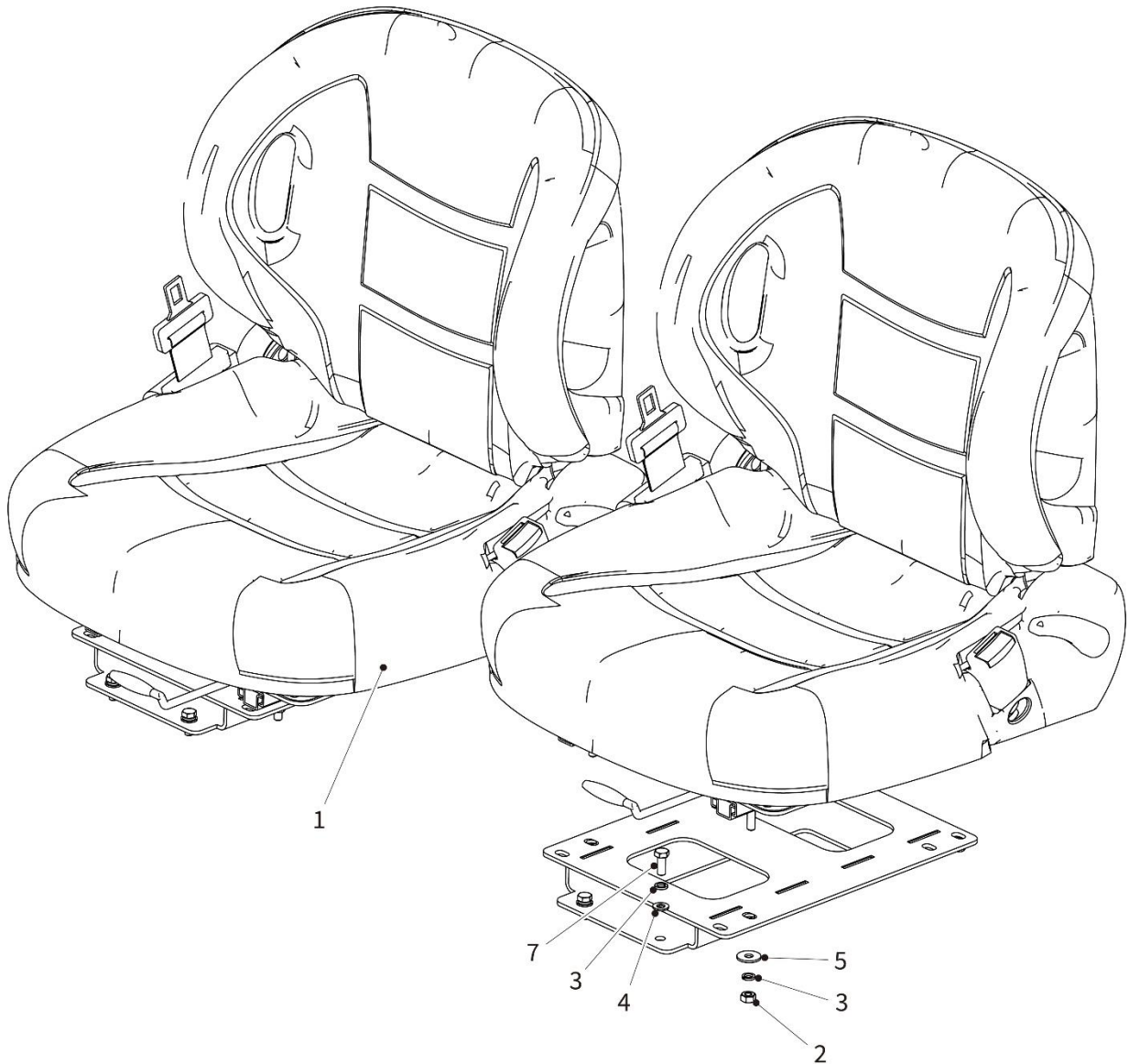
**Front Hitch - Exploded Parts View**



### Front Hitch – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRPW00652	Front Hitch Pin	1	
2	PRPW00653	Pin Lock Mount	1	
3	PRFA00013	Bolt, M8 x 25mm	2	
4	PRFA00010	Washer, Lock, M8	2	
5	PRFA00009	Washer, Flat, M8	2	
6	PRPW00649	Hitch Pin Lock	1	
7	PRFA00089	Pin, 8 x 30mm	1	
8	PRFA00009	Washer, Flat, M8	1	
9	PRFA00105	Pin, Split Cotter, 2.5 x 20mm	1	
10	PRPW00654	Front Hitch	1	

## SEATS

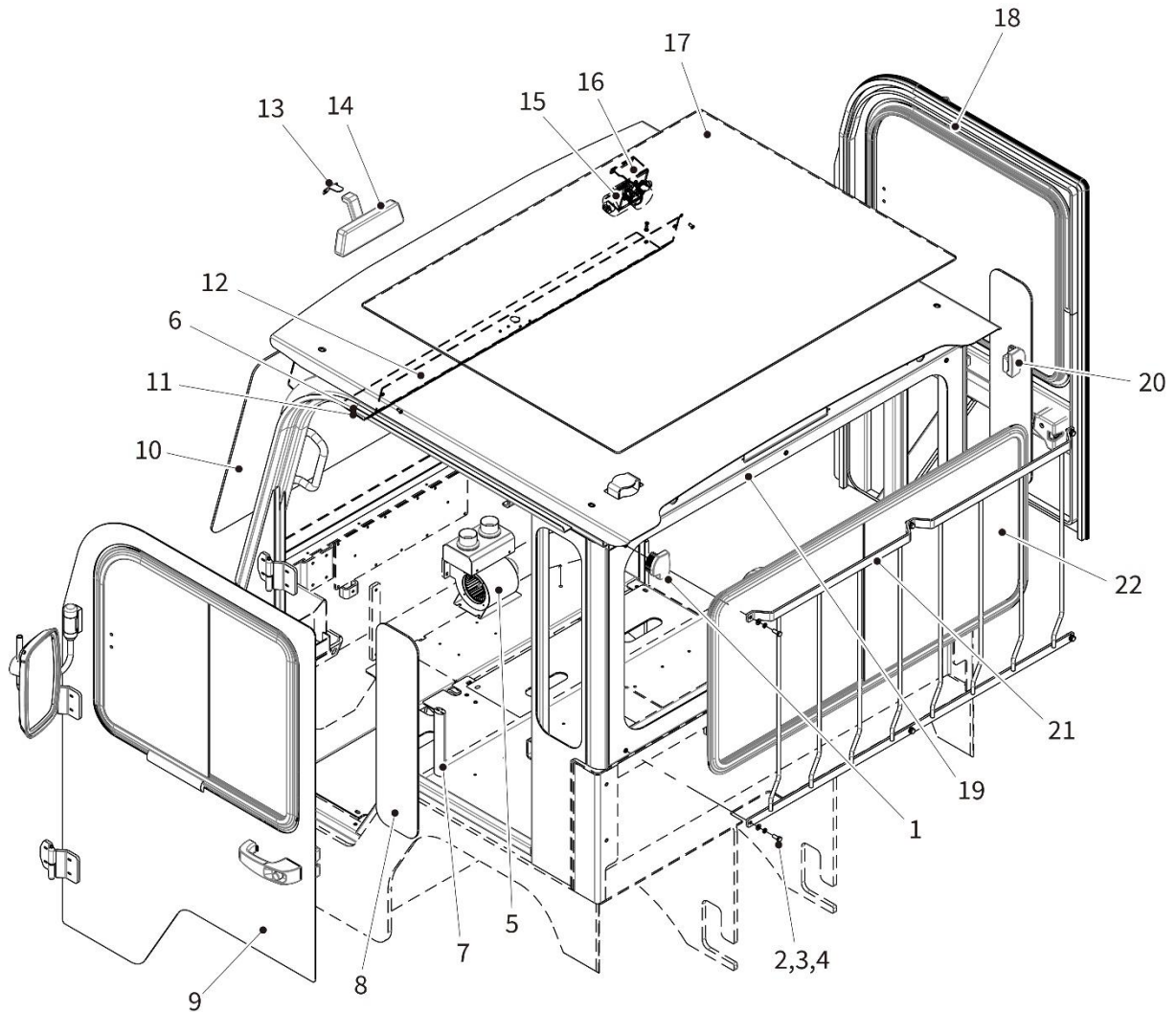


**Seat Assembly - Exploded Parts View**

### Seat Assembly – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRPW01911	Seat	2	
2	PRFA00021	Nut, M8	8	
3	PRFA00010	Washer, Lock, M8	16	
4	PRFA00009	Washer, Flat, M8	8	
5	PRFA00009	Washer, Flat, M8	8	
6	PRPW00656	Seat Mounting Bracket	2	
7	PRFA00033	Bolt, M8 x 20 mm	8	

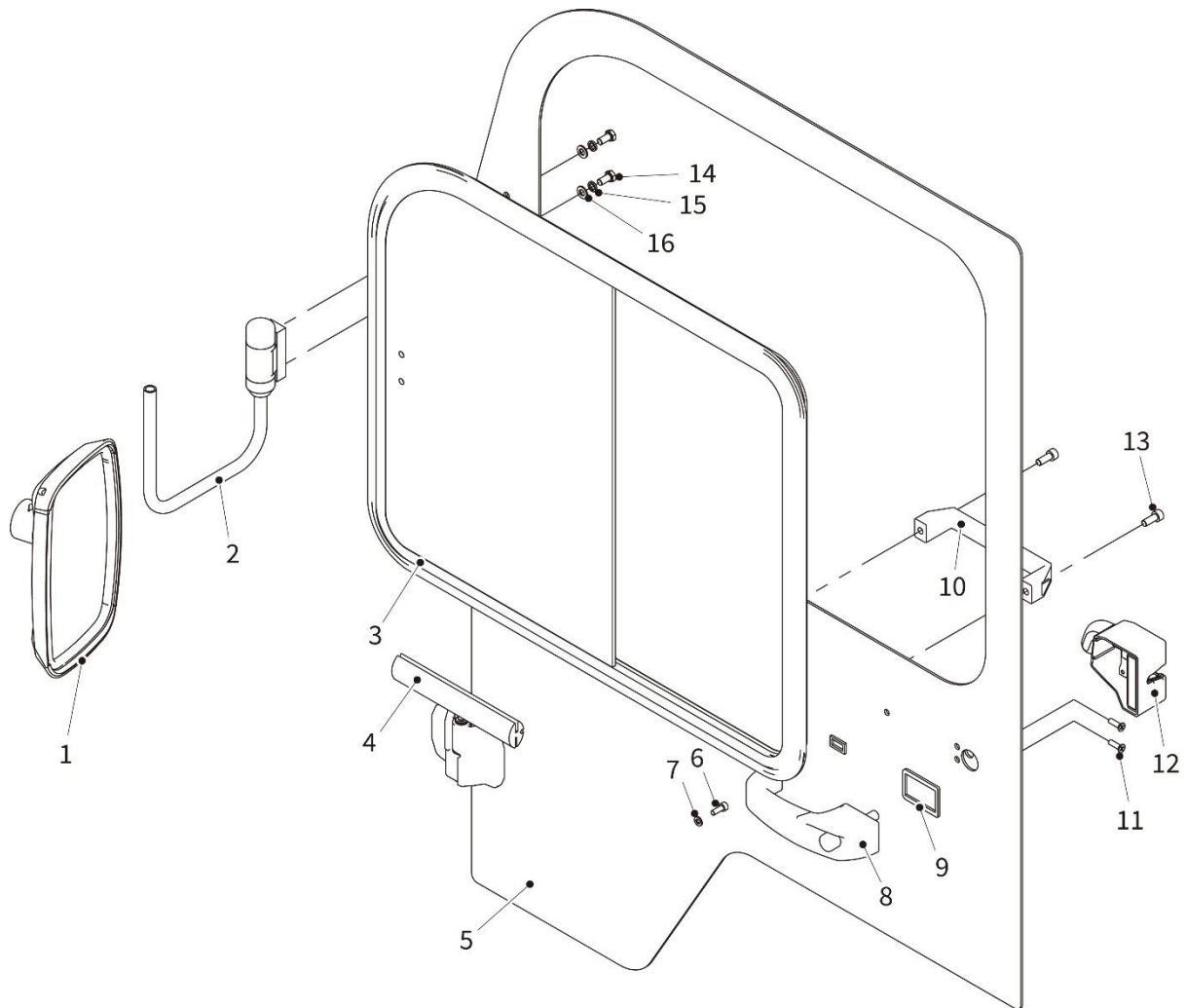
## CAB



**Cab Assembly - Exploded Parts View**

### Cab Mounting – Spare Parts List

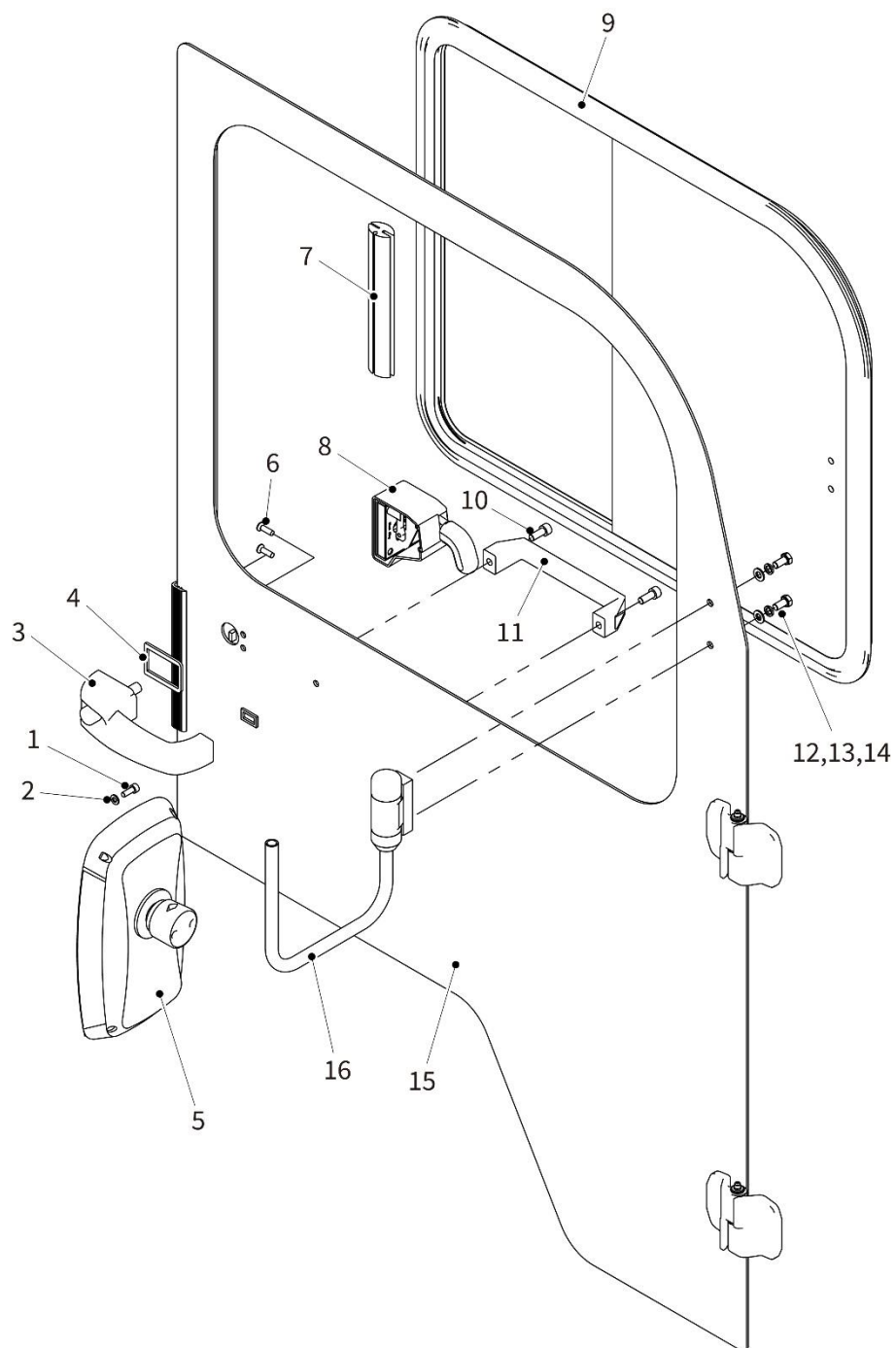
Item	Part No.	Description	Qty	Remarks
1	PRPW00662	Rear Gromet Cover, Left	1	
2	PRFA00033	Bolt, M8 x 20mm	6	
3	PRFA00010	Washer, Lock, M8	6	
4	PRFA00009	Washer, Flat, M8	6	
5	PRPW01912	Heater	1	
6	PRFA00007	Washer, Lock, M6	4	
7	PRPW00364	Seal, Rear Side Glass	1	Set of 3
8	PRPW01913	Rear Side Glass	2	
9	PRPW01915	Left Door Assembly	1	
10	PRPW00152	Front Windshield	1	
11	PRFA00016	Screw, M6 x 12 mm	4	
12	PRPW01914	Access Panel	1	
13	PRPW00667	Rear View Mirror Mounting Plate	1	
14	PRPW00050	Rearview Mirror, interior	1	
15	PRPW01916	Wiper Motor	1	
16	PRPW00671	Wiper Motor Bracket	1	
17	PRPW01917	Ceiling Liner	1	
18	PRPW01918	Right Door Assembly	1	
19	PRPW01919	Cab Assembly	1	
20	PRPW00659	Rear Cover, Right	1	
21	PRPW01920	Rear Window Guard	1	
22	PRPW01921	Rear Glass Assembly	1	



**Left Door Assembly - Exploded Parts View**

### Left Door Assembly – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRPW00043	Side Mirror, Exterior	1	Refer to Item #28, page 81
2	PRPW00045	Side Mirror Bracket	1	
3	PRPW00465	Sliding Glass Assembly, Left-Hand	1	
4	PRPW00364	Seal Rear Side Glass	1	Set of 3
5	PRPW01922	Left Door Panel	1	
6	PRFA00037	Screw, M6 x 16 mm	1	
7	PRFA00006	Washer, Flat, M6	1	
8	PRPW00046	Handle, Exterior		T20G1-40900
9	PRPW00824	Gasket	1	Supplied with PRPW00046
10	PRPW00390	Handle, Interior	1	D30T1-40003
11	PRFA00038	Screw, M6 x 20 mm	2	
12	PRPW00048	Interior door latch - D/S	1	
13	PRFA00039	Screw, M8 x 20 mm	2	
14	PRFA00061	Bolt, M8 x 16 mm	2	
15	PRFA00010	Washer, Lock, M8	2	
16	PRFA00009	Washer, Flat, M8	2	



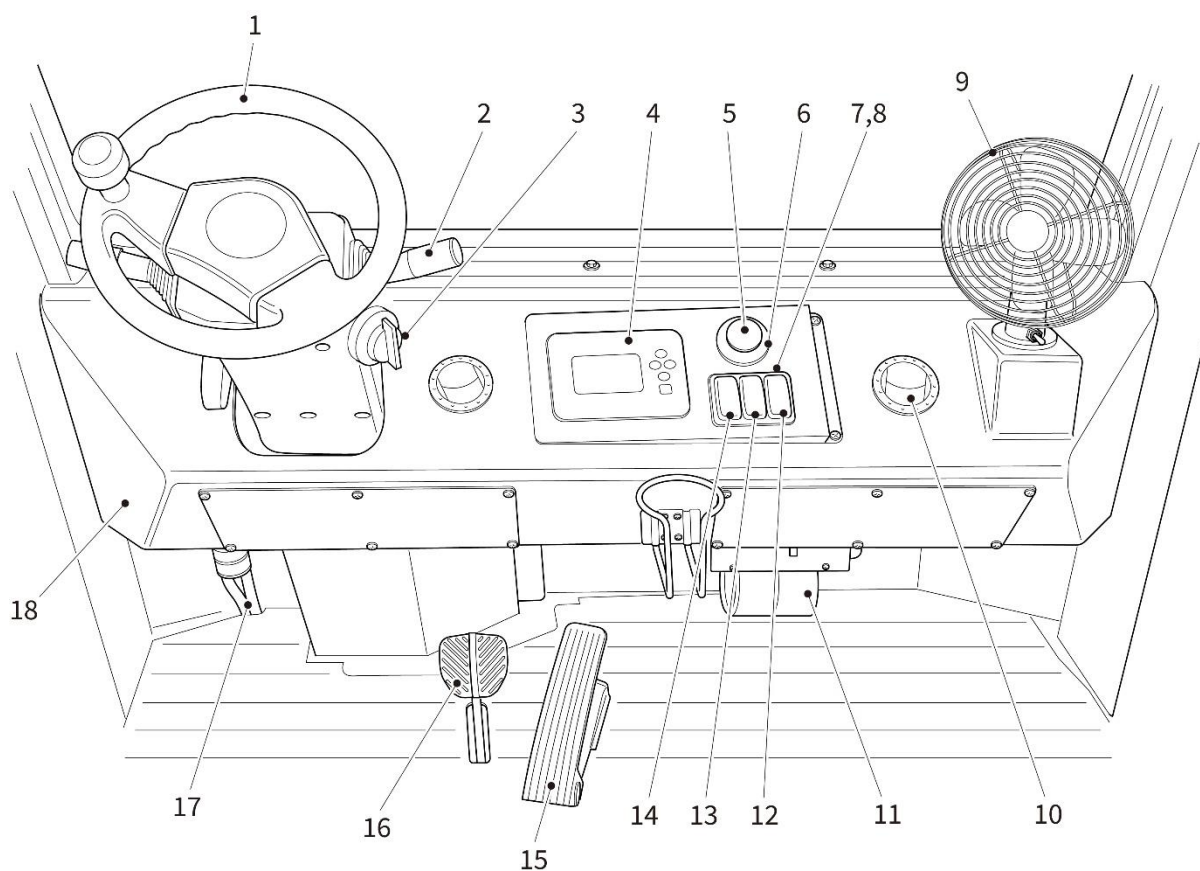
**Right Door Assembly - Exploded Parts View**



### Right Door Assembly – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRFA00037	Screw, M6 x 16 mm	1	
2	PRFA00006	Washer, Flat, M6	1	
3	PRPW00046	Exterior Door Handle		T20G1-40900
4	PRPW00824	Gasket	1	Supplied with PRPW00046
5	PRPW00807	Side Mirror, Exterior	1	
6	PRFA00038D	Screw, M6 x 20 mm	2	
7	PRPW00364	Window Seal	1	Set of 3
8	PRPW00047	Interior Door Latch, Right-Hand	1	
9	PRPW00466	P/S Door Sliding Glass Assy	1	
10	PRFA00039	Screw, M8 x 20 mm	2	
11	PRPW00390	Handle, Interior	1	D30T1-40003
12	PRFA00061	Bolt, M8 x 16 mm	2	
13	PRFA00010	Washer, Lock, M8	2	
14	PRFA00009	Washer, Flat, M8	2	
15	PRPW01923	Right Door Panel	1	
16	PRPW00045	Side Mirror Bracket	1	

## CONTROLS AND INSTRUMENTS

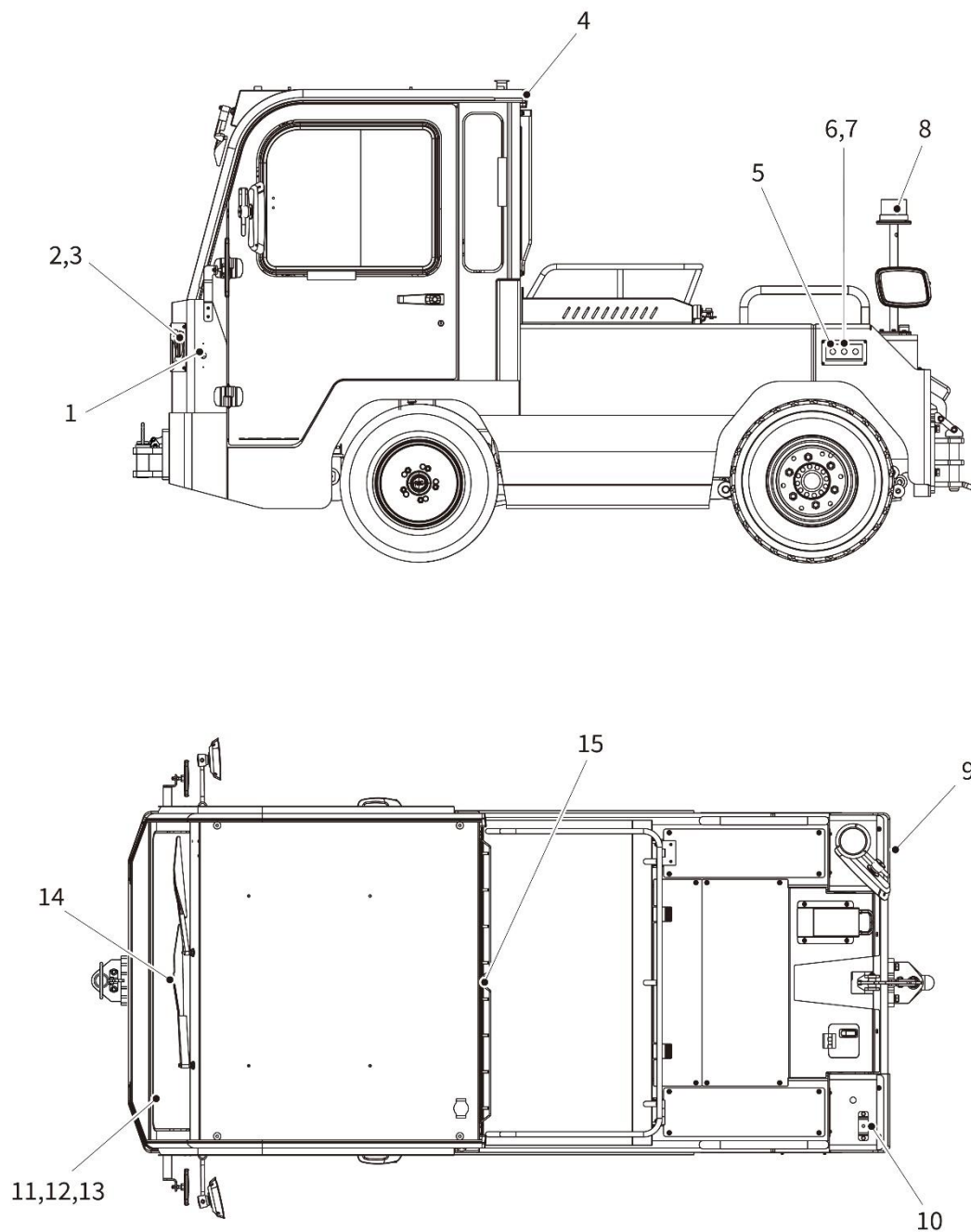


**Controls and instruments - Exploded Parts View**

### Controls and instruments – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	-	Steering Wheel Assembly	1	Refer to Steering System spare parts list
2	PRPW00898	Gearshift/Turn Signal Control Assembly	1	
3	PRPW00428	Keyless Ignition Switch	1	
4	PRPW00896	Dashboard Instrument Screen	1	
5	PRPW00041	Emergency stop switch - Twist release	1	
6	PRPW00681	Label, Emergency Stop Switch	1	
7	PRPW01924	Outer Switch Bezel	2	
8	PRPW01925	Centre Switch Bezel	1	
9	PRPW01663	Fan	1	
10	PRPW02304	Air vent	2	N/A
11	PRPW01927	Heater	1	
12	PRPW01928	Emergency Flasher Switch	1	
13	PRPW01929	Switch, Windscreen Wiper	1	
14	PRPW01930	Work Lamp Switch	1	
15	PRPW00176	Accelerator pedal	1	
16	PRPW01931	Brake Pedal Assembly	1	Refer to Braking System spare parts list
Not shown	PRPW00405	Footbrake Switch	2	Part of the Brake Pedal Assembly
17	PRPW01932	Cab Wiring Harness	1	
18	PRPW00896	Dashboard	1	
Not shown	PRPW00676	Park Brake Switch	1	Mounted on Park Break Handle, under the Park Brake Handle Cover
Not shown	PRFA00113	Screw, M4 x 20 mm	2	Secure the Park Brake Switch

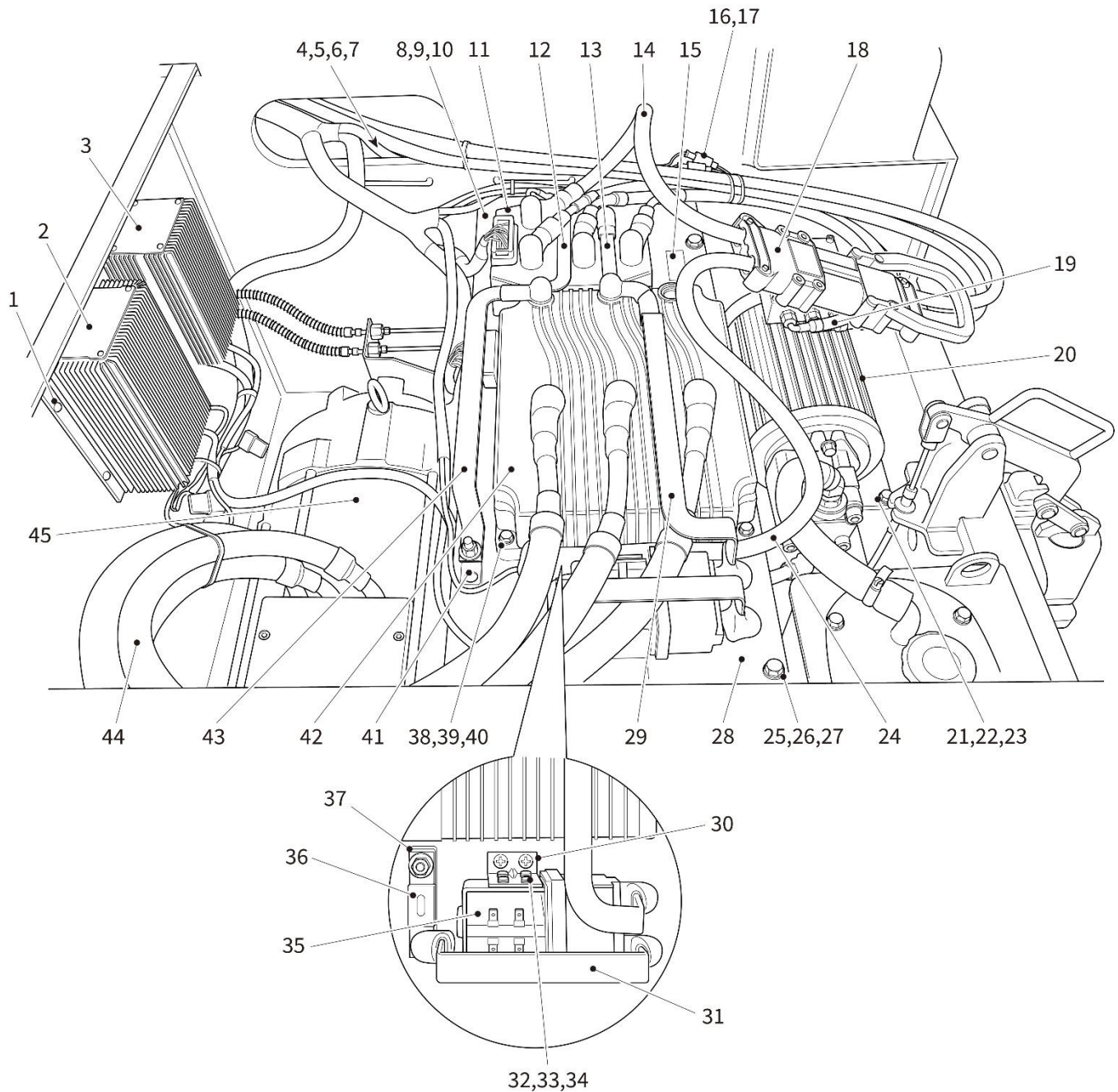
## ELECTRICAL SYSTEM



**Electrical system - Exploded Parts View**

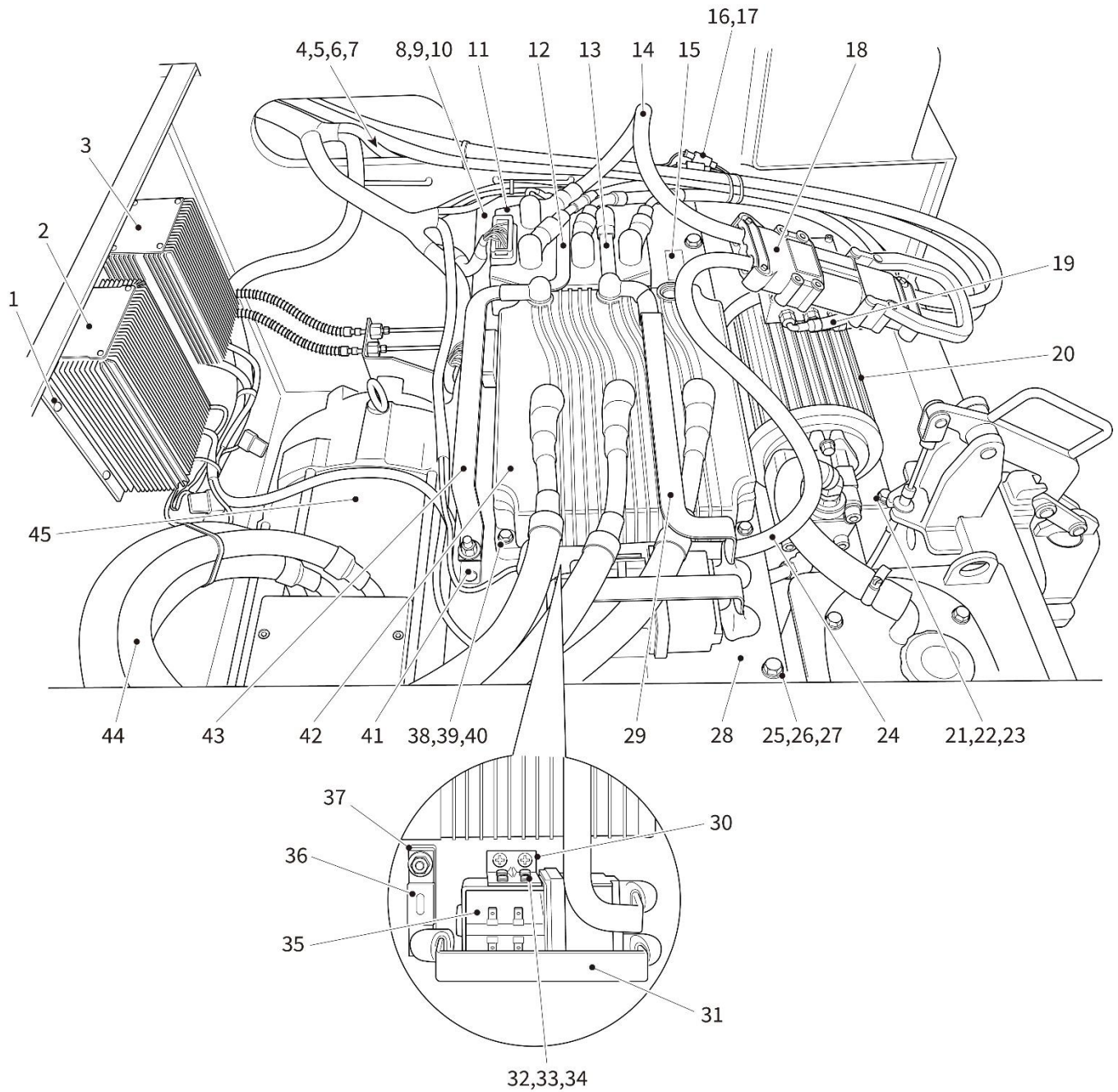
### Electrical System – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRPW00693	Turn Indicator	2	
2	PRPW00178	Headlamp Assembly	2	
3	PRPW01131	Front Turn Signal	2	
4	PRPW00693	Turn Indicator	2	
5	PRPW00107	Forward/Reverse switch, button	2	
6	PRPW00041	Emergency stop switch - Twist release	1	Ref . To Item 5 & 6 of page 101
7	PRPW00681	Label, Emergency Stop Switch	1	
8	PRPW01155	Beacon	1	
9	PRPW00157	Tail Lamp Assembly	2	
10	PRPW00436	Rear Work Light	1	Same name as XT560G
11	PRPW01152	Horn, Electric	1	
12	PRFA00061	Bolt, M8 x 16 mm	1	
13	PRPW01147	Horn Filter	1	
14	PRPW01079	Wiring Harness	1	
15	PRPW00044	Upper Brake Light	1	Same name as XT560G

**Rear Electrical Compartment- Exploded Parts View**

### Rear Electrical Compartment – Spare Parts List

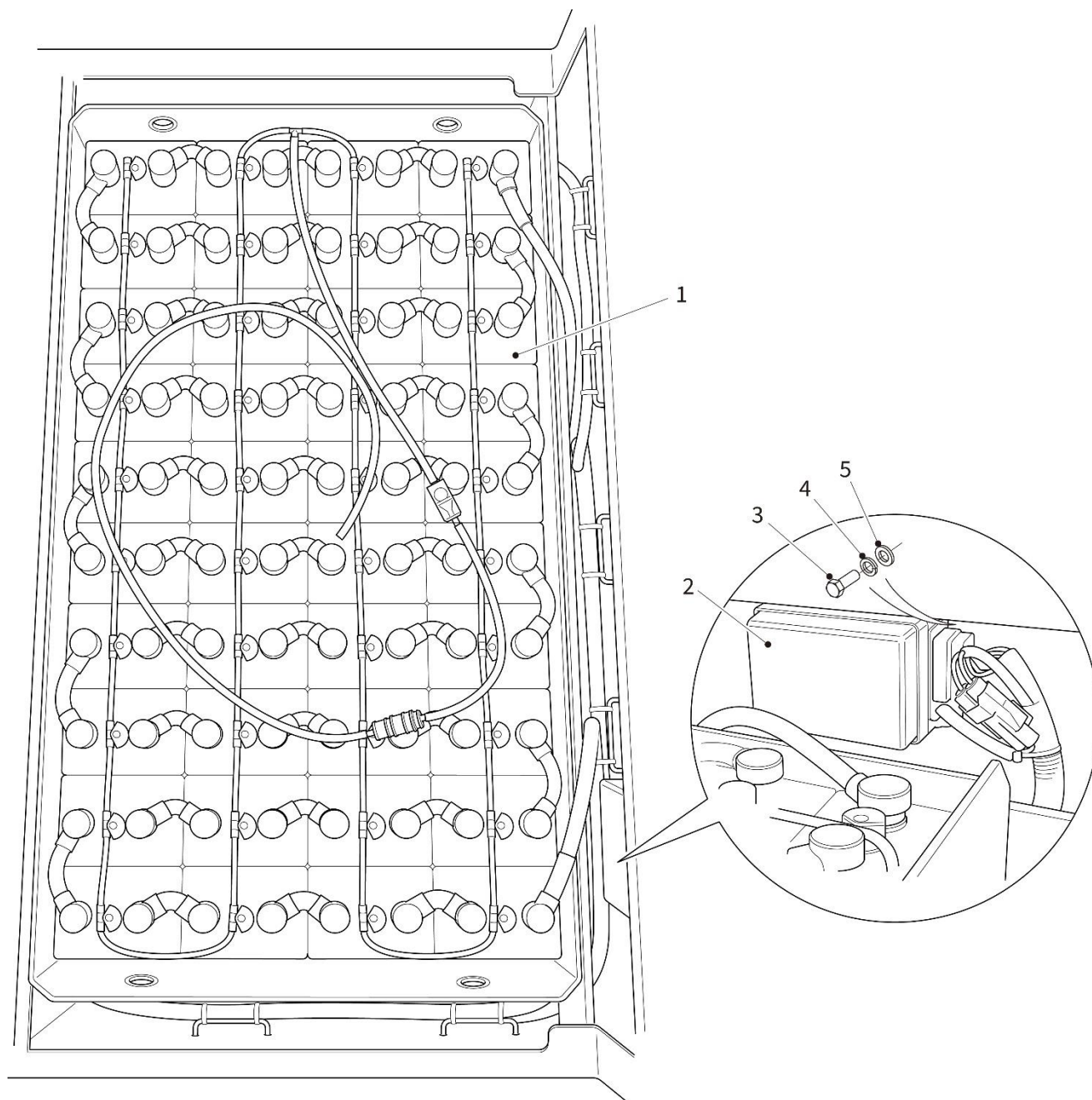
Item	Part No.	Description	Qty	Remarks
1	PRFA00114	Screw, M5 x 12 mm	8	
2	PRPW00499	DC – DC Transformer 80V-24V	1	
3	PRPW01077	DC – DC Transformer 80V-12V	1	
4	PRPW01092	Reversing Buzzer	1	
5	PRFA00108	Bolt, M6 x 16 mm	1	
6	PRFA00007	Washer, Lock, M6	1	
7	PRFA00006	Washer, Flat, M6	1	
8	PRFA00115	Bolt, M6 x 30 mm	4	
9	PRFA00007	Washer, Lock, M6	4	
10	PRFA00006	Washer, Flat, M6	4	
11	PRPW01172	Steering Controller 1232E-6221, T30S2 P Prog	1	
12	PRPW01173	Busbar, Copper, line B-, TB30S2	1	
13	PRPW01096	Busbar, Copper, line B+, T30S2	1	
14	N/A	Battery Cable, B- line	1	Part of item 18
15	18201014-781-404	Label	1	
16	N/A	Sensor, Steering Motor	1	Part of vehicle electrical harness
17	N/A	Encoder, Steering Motor	1	Part of vehicle electrical harness
18	PRPW00598	Battery Connector Assembly, Type REMA320 (Connector normally mounted on Tractor exterior)	1	
19	PRPW01257	Steering Motor Wiring Harness	1	
20	PRPW01139	Steering Motor	1	
21	PRFA00008	Bolt, M10 x 30 mm	4	
22	PRFA00012	Washer, Lock, M10	4	
23	PRFA00011	Washer, Flat, M10	4	
24	N/A	Battery Cable, B+ terminal	1	Part of item 18
25	PRFA00008	Bolt, M10 x 30 mm	4	
26	PRFA00012	Washer, Lock, M10	4	
27	PRFA00011	Washer, Flat, M10	4	
28	PRPW01206	Base Plate, Controller Panel TB30S2	1	
29	PRPW01217	Busbar, Copper, Contactor to B+ terminal, T30S2	1	
30	PRPW01321	Bracket, for SW200 Contactor	2	

**Rear Electrical Compartment- Exploded Parts View**



### Rear Electrical Compartment – Spare Parts List

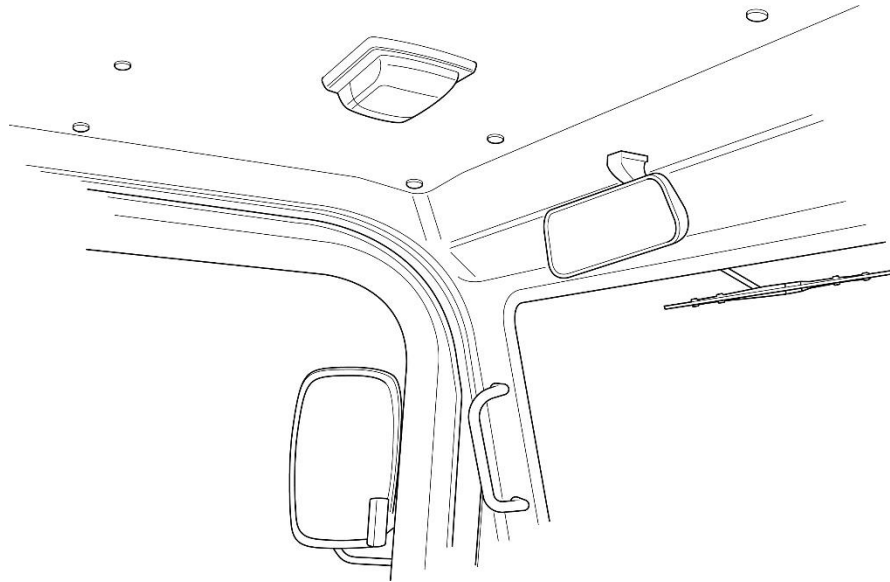
Item	Part No.	Description	Qty	Remarks
31	PRPW01554	Busbar, Copper, Fuse to Contactor	1	
32	PRFA00168	Screw, Pan Head Posidrive, M5 x 8 mm	12	
33	PRFA00116	Washer, Lock, M5	12	
34	PRFA00117	Washer, Flat, M5	12	
35	PRPW01265	Contactor, Type SW200-583, 80DC, Co Dust	1	
36	PRPW01277	Fuse, 425 A, 80 V	1	
37	PRPW01308	Fuse Holder	1	
38	PRFA00008	Bolt, M10 x 30 mm	4	
39	PRFA00012	Washer, Lock, M10	4	
40	PRFA00011	Washer, Flat, M10	4	
41	PRPW01222	Fuse Holder, Type KH_PSA0001-002	1	
42	PRPW01223	Traction Controller 1238E-6521, TB30S2_T Prog	1	
43	PRPW01260	Busbar, Copper, B- terminal to terminal TB30S2	1	
44	PRPW01246	Traction Motor Wiring Harness	1	
46	PRPW01279	Traction Motor	1	
Not shown	PRPW00903	Controller Panel TB30S2 (A complete assembly comprising items 8, 9, 10, 11, 12, 13, 15, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, and 43)	N/A	



**Battery Compartment - Exploded Parts View**

### Battery Compartment – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRPW00353	Battery, 80V/660Ah	1	
2	PRPW01933	Centre Control Box	1	
3	PRFA00134	Bolt, M12 x 40 mm	4	
4	PRFA00034	Washer, Lock, M12	4	
5	PRFA00030	Washer, Flat, M12	4	
Not shown	N/A	ATM Mini-Fuse 1, 30 Amp (located in Centre Control Box)	1	Purchase locally
Not shown	N/A	ATM Mini-Fuse 2, 10 Amp (located in Centre Control Box)	1	Purchase locally
Not shown	N/A	ATM Mini-Fuse Fuse 3, 20 Amp (located in Centre Control Box)	1	Purchase locally
Not shown	N/A	ATM Mini-Fuse Fuse 4, 10 Amp (located in Centre Control Box)	1	Purchase locally
Not shown	N/A	ATM Mini-Fuse 5, 5 Amp (located in Centre Control Box)	1	Purchase locally
Not shown	N/A	ATM Mini-Fuse Fuse 6, 20 Amp (located in Centre Control Box)	1	Purchase locally
Not shown	N/A	ATM Mini-Fuse Fuse 8, 10 Amp (located in Centre Control Box)	1	Purchase locally
Not shown	N/A	ATM Mini-Fuse Fuse 9, 20 Amp (located in Centre Control Box)	1	Purchase locally
Not shown	N/A	ATM Mini-Fuse, DC, 10 Amp (located in Centre Control Box)	2	Purchase locally

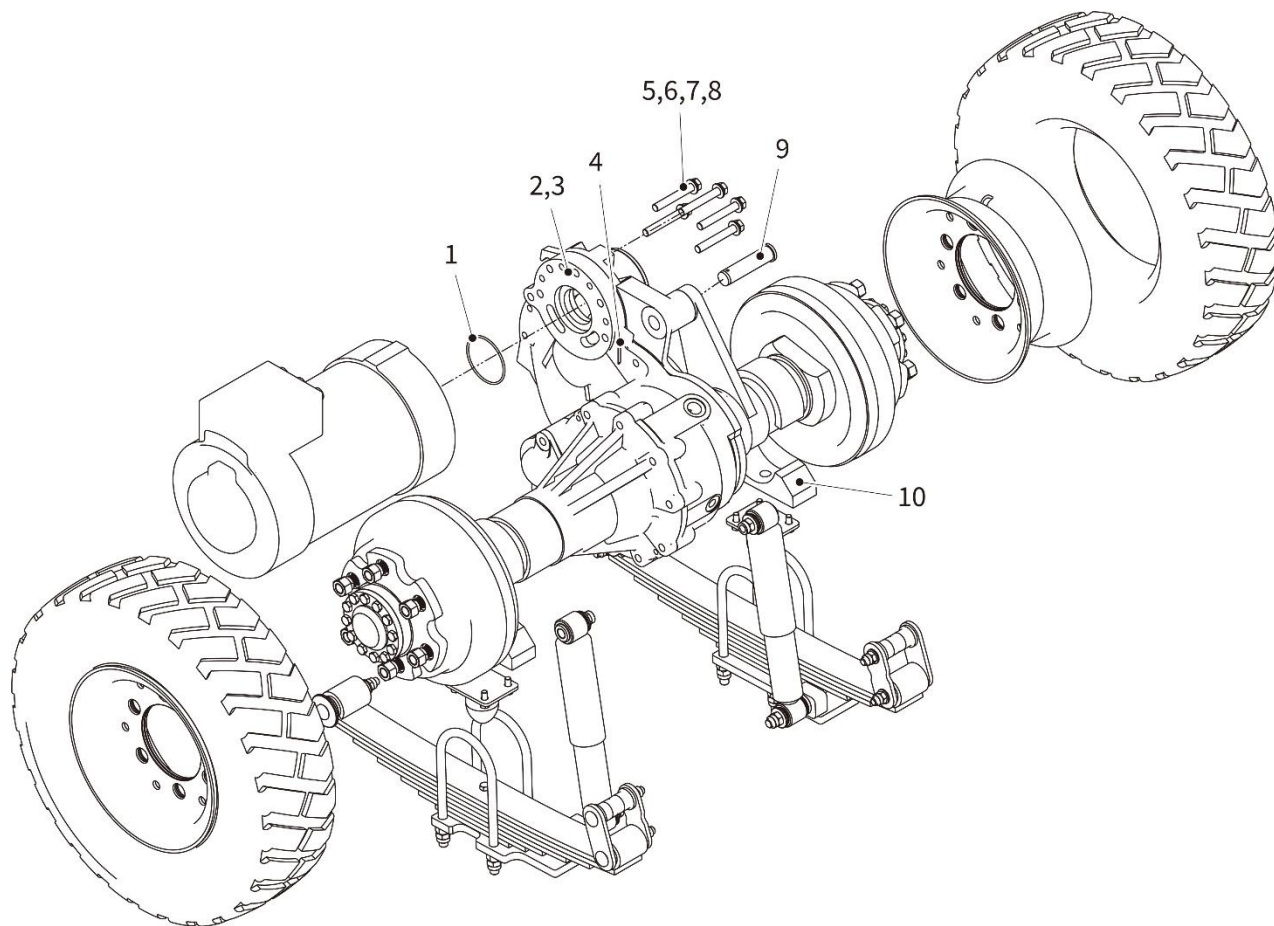


**Cab interior light - Exploded Parts View**

**Cab interior light – Spare Parts List**

Item	Part No.	Description	Qty	Remarks
1	PRPW01934	Cab Interior Light (supplied complete with necessary fasteners)	1	If failed, replace complete light

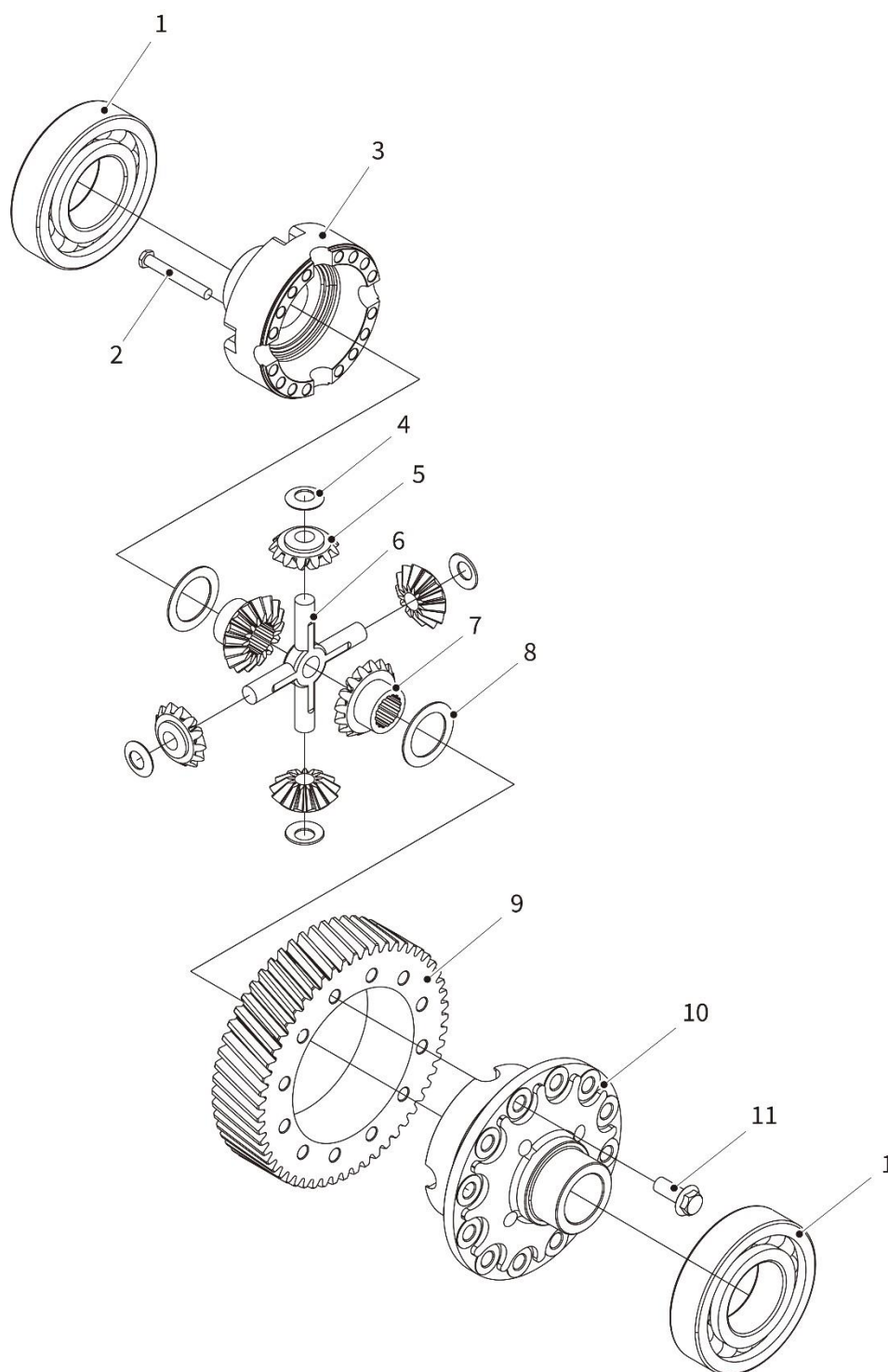
## DRIVETRAIN



**Drive Axle Assembly - Exploded Parts View**

### Drive Axle Assembly – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRPW01546	O-Ring, dia. 90.0 mm x 3.55 mm	1	
2	PRPW01935	Axle Box Assembly	1	
3	PRPW01936	Rim Assembly	1	
4	PRFA00138	Pin, Split Cotter, 5 x 40mm	1	
5	PRFA00072	Washer, Flat, M14	5	
6	PRFA00118	Washer, Lock, M14	5	
7	PRFA00119	Bolt, M14 x 1.5 x 95 x 35mm	3	
8	PRFA00120	Bolt, M14 x 1.5 x 100 x 35mm	2	
9	PRFA00139	Pin, Special	1	
10	PRPW01937	Rear Plate Spring Bracket	2	

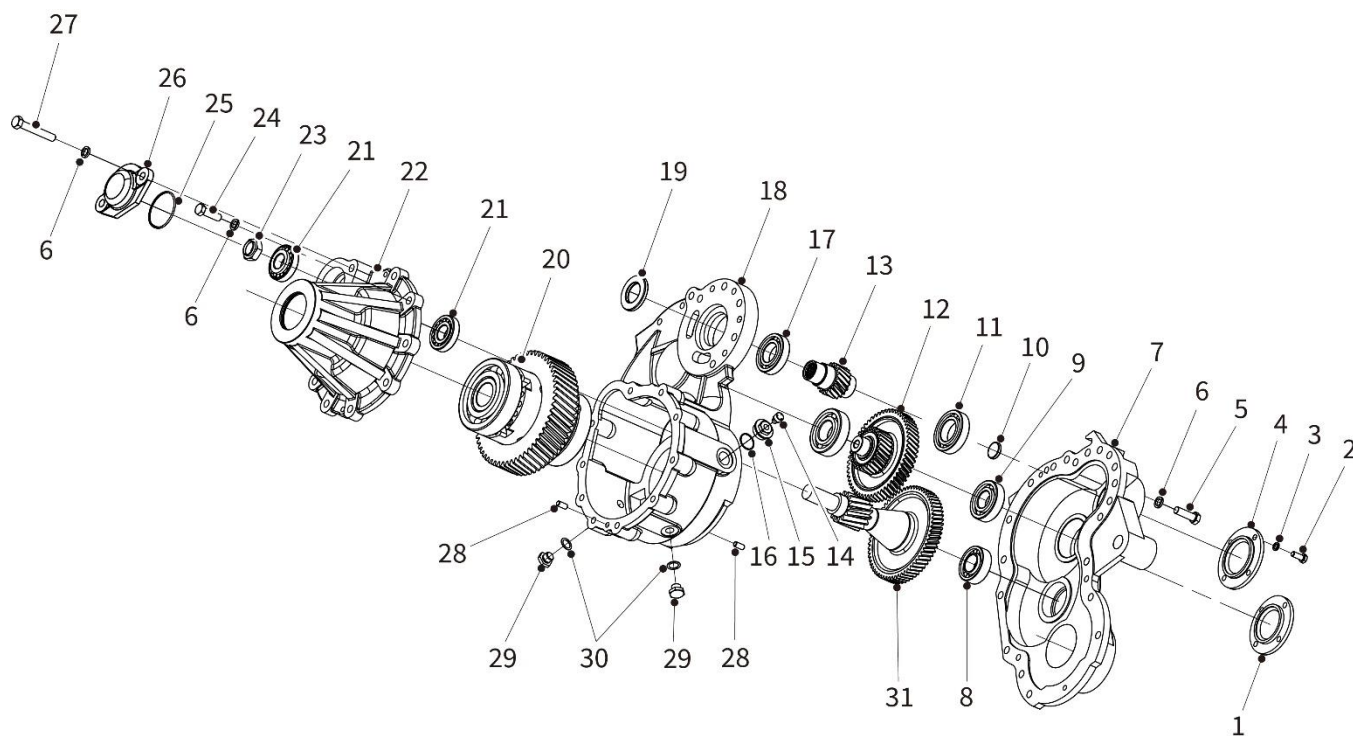


**Differential - Exploded Parts View**



### Differential – Spare Parts List

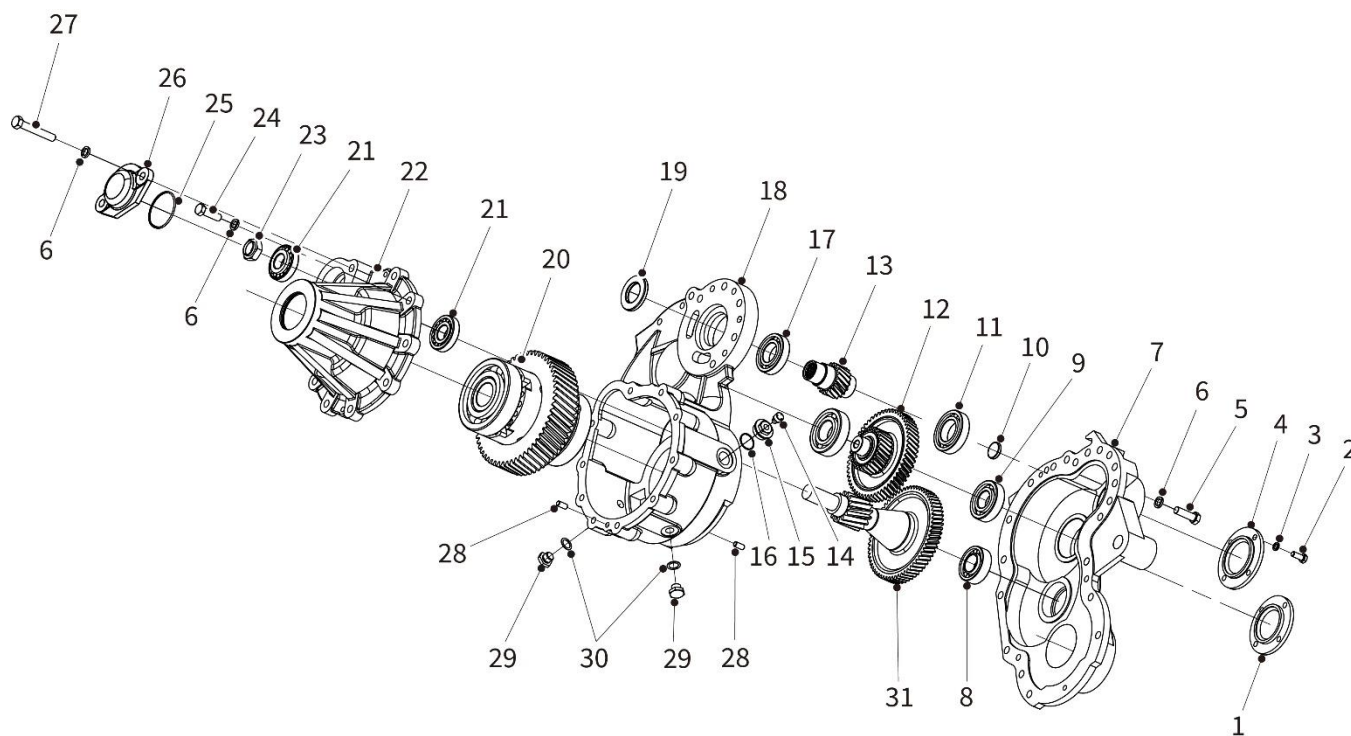
Item	Part No.	Description	Qty	Remarks
1	PRPW01943	Deep Groove Ball Bearing, Type 6214, single row, i.d. 70 mm, o.d. 125 mm, width 24 mm, chamfer 1.5 mm	2	
2	PRFA00121	Bolt, M10 x 1.25 x 75 mm, grade 12.9	16	
3	PRPW01938	Case, Differential, Left-Hand	1	HDQX25-5002
4	PRPW01939	Planetary Washer	4	HDQX25-5006
5	PRPW01940	Planetary Gear	4	HDQX25-5005
6	PRPW01941	Cross Shaft	1	HDQX25-5004
7	PRPW01942	Gear, Side	2	HDQX25-5008
8	PRFA00140	Half-Shaft Washer	2	HDQX25-5007
9	PRPW01944	Gear, Ring	1	HDQX25-5001
10	PRPW01945	Case, Differential, Right-Hand	1	HDQX25-5003
11	PRFA00163	Bolt, Flange Face, M14 x 1.5 x 35mm, grade 10.9	12	



**Drive Axle Transmission Assembly - Exploded Parts View**

### Drive Axle Transmission Assembly – Spare Parts List

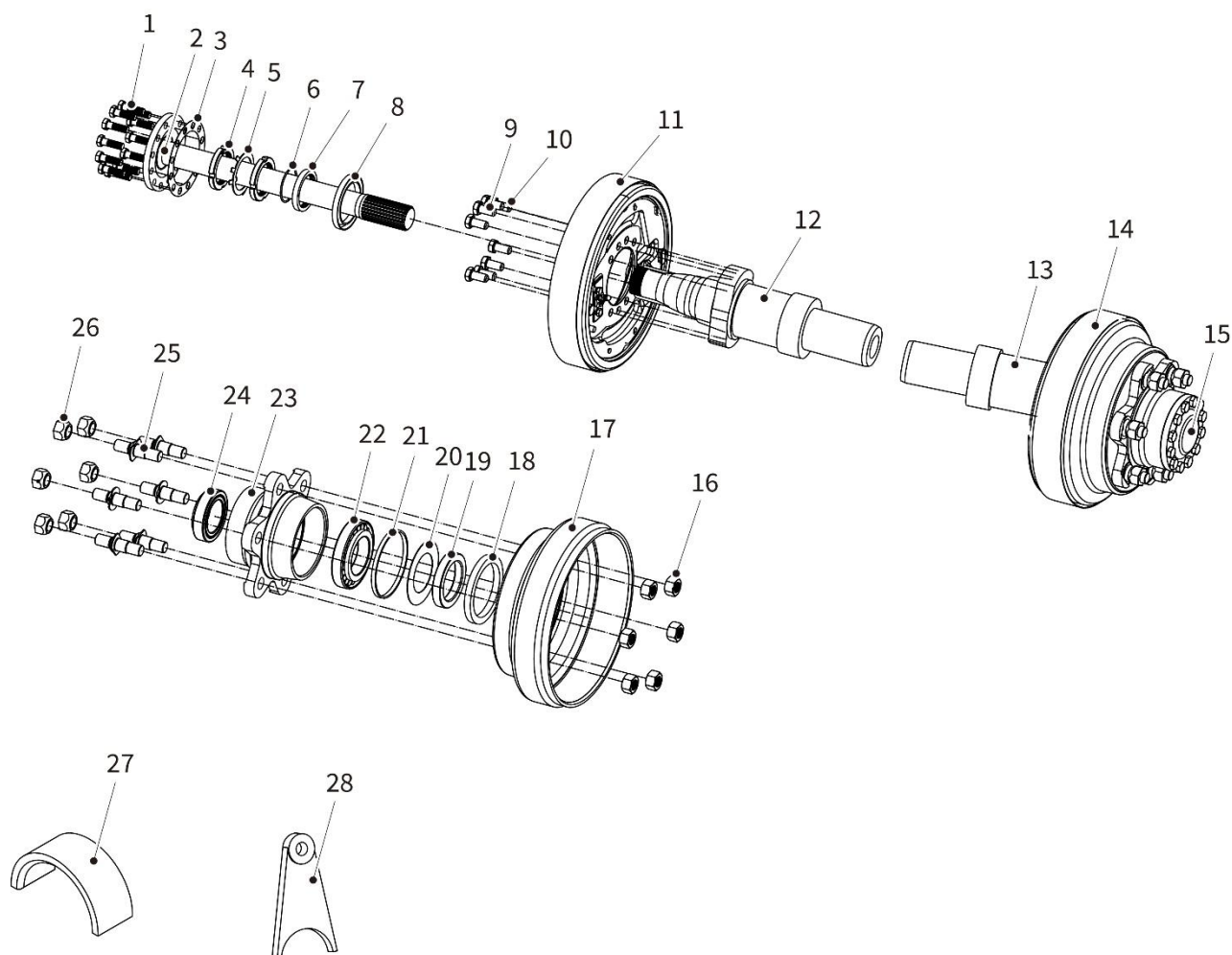
Item	Part No.	Description	Qty	Remarks
1	PRPW01946	Cover Plate, Bearing	1	HDQX25-01020
2	PRFA00063	Bolt, M10 x 25mm	8	
3	PRFA00123	Washer, Spring, M10	8	
4	PRPW01946	Cover Plate, Bearing	1	HDQX25-01019
5	PRFA00122	Bolt, M14 x 1.5 x 40 mm, grade 10.9	17	
6	PRFA00123	Washer, Spring, M14	27	
7	PRPW01947	Housing, Axle, Left	1	HDQX25-01002-1
8	PRPW01948	Bearing, Cylindrical Roller, Type NJ2207, single row, glass fibre reinforced, i.d. 35 mm, o.d. 72 mm, width 23 mm, external chamfer at least 1.1 mm	1	
9	PRPW01949	Ball Bearing, Deep Groove, Type 6307, single row, i.d. 35 mm, o.d. 80 mm, width 21 mm, chamfer 1.5 mm	2	
10	PRPW02306	Sealing Cap	1	HDCS25-02002-1
11	PRPW01950	Ball Bearing, Deep Groove, Type 6209, single row, i.d. 45 mm, o.d. 85 mm, width 19 mm, chamfer 1.1 mm	1	
12	PRPW01951	Gear, Double	1	HDQX25-03000-3
13	PRPW01952	Input Shaft	1	HDQX25-02001-3
14	PRPW01953	Vent Plug	1	J30H-01100
15	PRPW01954	Oil Filler Plug	1	HDQX25-01011
16	PRPW01955	Gasket, Combined, M30	1	
17	PRPW01956	Ball Bearing, Deep Groove, Type 6010, single row, i.d. 50 mm, o.d. 80 mm, width 16 mm, chamfer 1 mm	1	
18	PRPW01957	Housing, Axle, Middle	1	HDAX15-01001-1
19	PRPW01958	Oil Seal, 50 x 70 x 10 mm	1	
20	PRPW01959	Differential Assembly	1	HDQX2505000-1
21	PRPW02307	Tapered Roller Bearing, Type 30306, single row, i.d. 30 mm, o.d. 72 mm, width 20.75 mm	2	
22	PRPW01960	Housing, Axle, Right	1	HDQX25-01003-1
23	PRFA00141	Nut, Special	1	HDQX25-04002
24	PRFA00125	Bolt, M14 x 1.5 x 50 mm, grade 10.9	8	
25	PRPW01962	O-ring, 75 x 3.1 mm	1	



**Drive Axle Transmission Assembly - Exploded Parts View**

### Drive Axle Transmission Assembly – Spare Parts List

Item	Part No.	Description	Qty	Remarks
26	PRPW01963	Bearing Cap	1	HDQX25-01012
27	PRFA00127	Bolt, M14 x 1.5 x 90 mm, grade 10.9	2	
28	PRFA00166	Pin, 10 x 22 mm	2	
29	PRPW01965	Plug	2	DCS25-0008
30	PRPW01966	Gasket, Combined, M18	2	
31	PRPW01967	Gear Shaft	1	HDQX25-04001-1

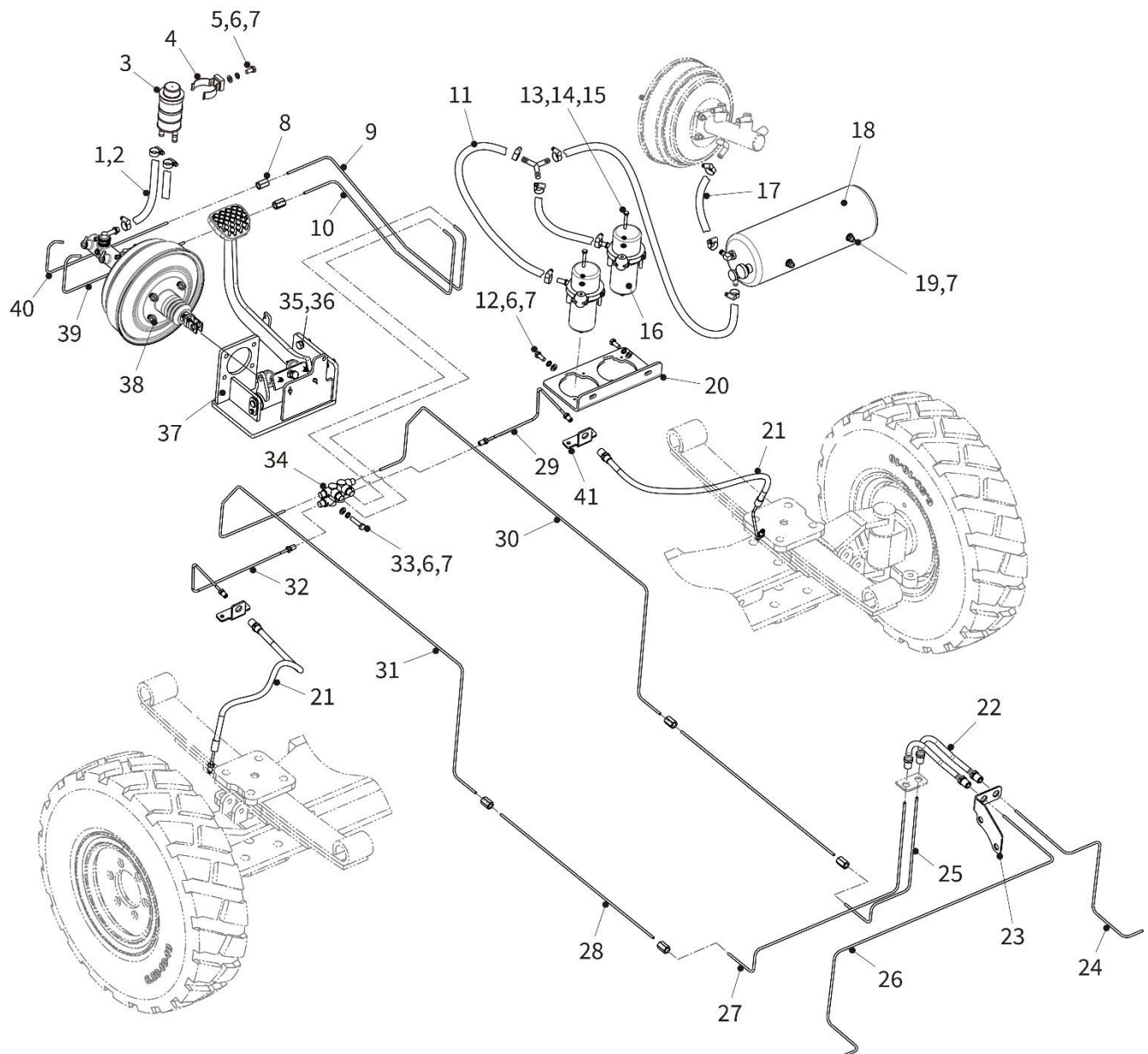


**Rear Brake /Hub/Axle Assembly - Exploded Parts View**

### Rear Brake /Hub/Axle Assembly – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRFA00142	Bolt, Special	24	24453-02061B
2	PRPW01969	Shaft, Drive, Left-Hand	1	HDQX15-00021
3	PRPW01970	Paper Gasket	2	A22A3-02031
4	PRFA00128	Nut, M58 x 2 mm	4	25555-00004
5	PRFA00129	Washer, Lock, M58	2	25555-00006
6	PRPW01971	O-Ring, 59.6 x 2.4 mm	2	25555-00008
7	PRFA00143	Bushing, Special	2	25555-00007
8	PRPW00350	Oil Seal, 75 x 100 x 10mm	2	25555-00009
9	PRFA00144	Bolt, Special, M14 x 1.5 x 30 mm	12	A22A3-02051
10	PRFA00145	Bolt, Special, M14 x 1.5 x 38 mm	4	25953-72001
11	PRPW01185	Rear Brake Assembly, Left-Hand	1	L02A1-20300
12	PRPW01975	Axle Pipe Assembly, Left-Hand	1	HDQX15-02001
13	PRPW01976	Axle Pipe Assembly, Right-Hand	1	HDQX15-02002
14	PRPW01186	Rear Brake Assembly, Right-Hand	1	L02A1-20200
15	PRPW01977	Shaft, Drive, Right-Hand	1	HDQX15-00031
16	PRFA00102	Nut, M20 x 1.5	12	B4223-00020B
17	PRPW01978	Drum, Brake	2	22673-02031
18	PRPW00685	Oil Seal, Sd, 100 x 125 x 12 mm	2	Z6351-01004
19	PRPW01979	Retainer, Oil Seal, 100 x 16 x 2 mm	2	24453-02121G
20	PRPW01980	Retainer, 72.5 x 118 x 1 mm	2	22493-00030G
NOTE. Items 20 and 21 form a pair, if either requires replacement, both must be replaced.				
21	PRPW01981	Seal, Metal, 119 x 125 x 1 mm	2	22493-00020G
NOTE. Items 20 and 21 form a pair, if either requires replacement, both must be replaced.				
22	PRPW02308	Tapered Roller Bearing, Type 30214, single row, i.d. 70 mm, o.d. 125 mm, width 26.25 mm	2	Z-30214
23	PRPW01982	Hub, Front	2	A20A3-02011JXX
24	PRPW02309	Tapered Roller Bearing, Type 32012, single row, i.d. 60 mm, o.d. 110 mm, width 23.75 mm	2	Z-30212
25	PRPW00569	Wheel Stud, Rear	12	24353-72001B
26	PRPW00570	Wheel Nut, Rear	12	243543-32311B
27	PRPW01983	Receptacle Bracket, Fixed	2	HDQX15-02010
28	PRPW01984	Bracket, Reinforcing	1	HDQX15-02013

## BRAKING SYSTEM

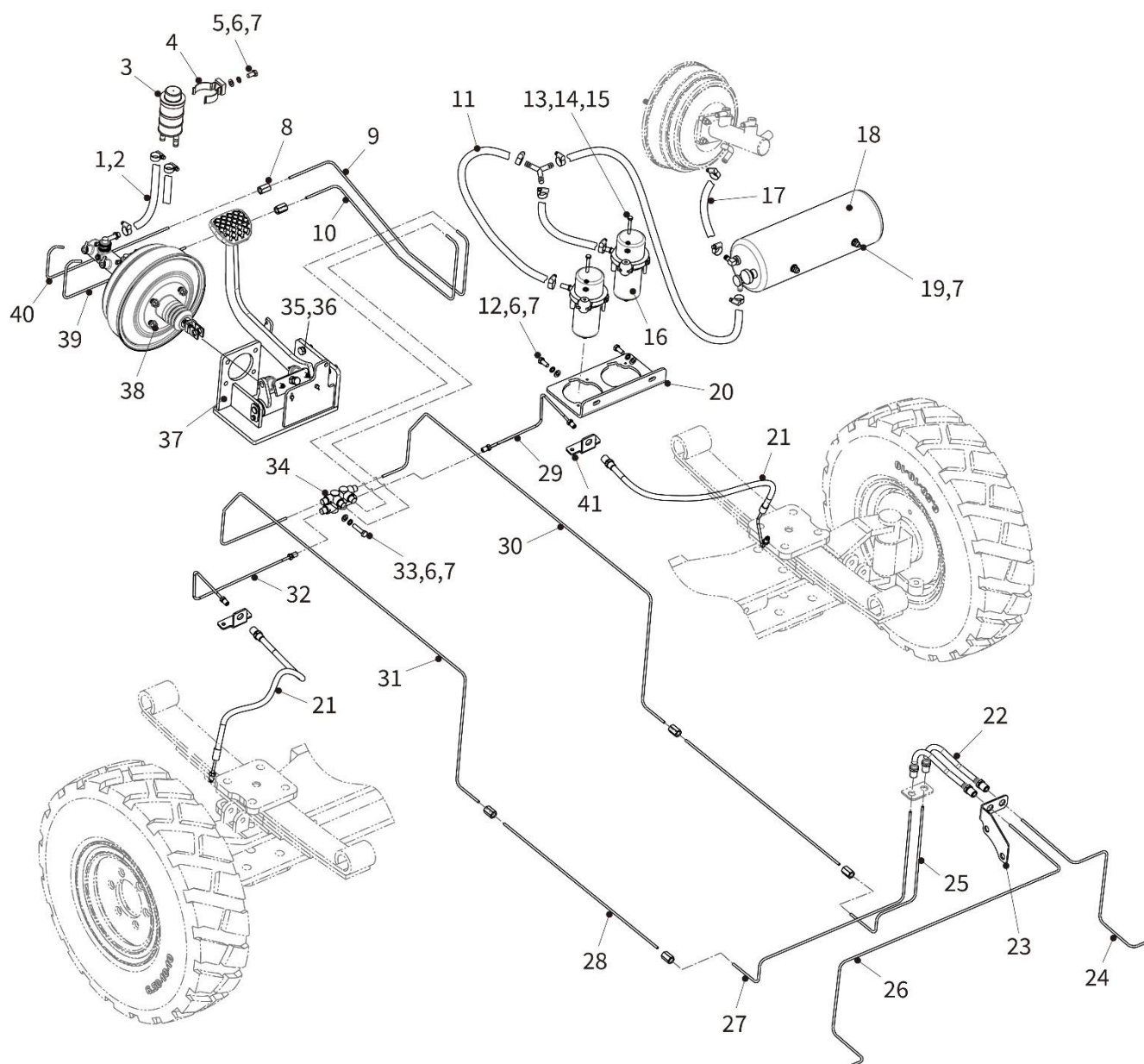


**Brake System- Exploded Parts View**



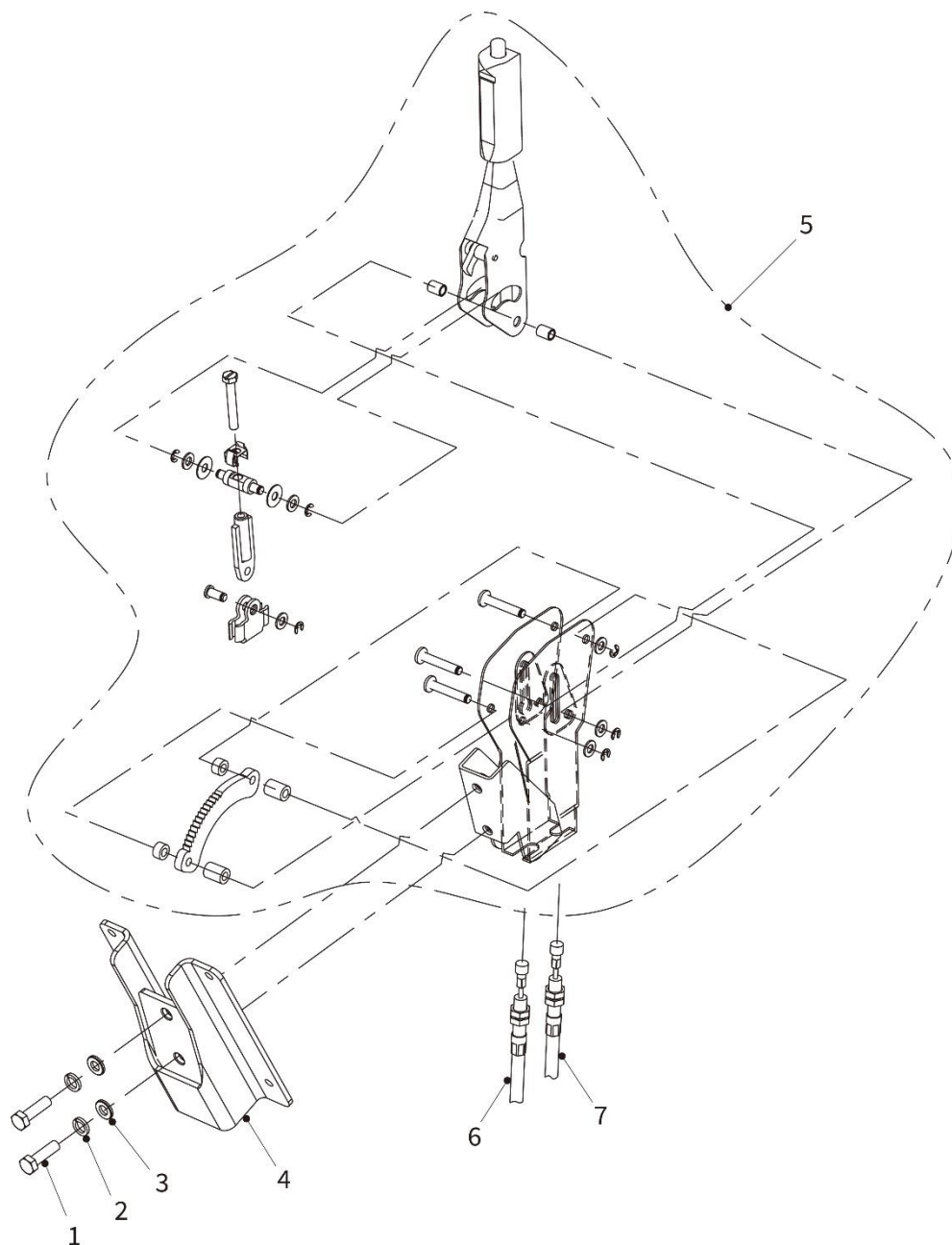
### Brake System – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRPW01985	Reservoir Hose, dia.10 mm, length 600 mm	2	
2	PRPW01986	Clamp, Hose, 20 mm x 12 mm	12	
3	PRPW01987	Brake Fluid Reservoir	1	
4	PRPW01988	Brake Fluid Reservoir Mount	1	
5	PRFA00130	Bolt, M6 x 12 mm	2	
6	PRFA00010	Washer, Lock, M8	4	
7	PRFA00009	Washer, Flat, M8	6	
8	PRPW01989	Coupling, Hydraulic	6	
9	PRPW01990	Brake Line No. 2	1	
10	PRPW01991	Brake Line No. 1	1	
11	PRPW01992	Vacuum Hose, dia.10 mm, length 400 mm	3	
12	PRFA00033	Bolt, M8 x 20 mm	2	
13	PRFA00131	Bolt, M6 x 40 mm	4	
14	PRFA00007	Washer, Lock, M6	4	
15	PRFA00006	Washer, Flat, M6	4	
16	PRPW00057	Vacuum Pump	2	T20G7-10300
17	PRPW01993	Vacuum Hose, dia.10 mm, length 1000 mm	1	
18	PRPW00822	Vacuum Accumulator Tank	1	
19	PRFA00021	Nut, M8	2	
20	PRPW01994	Vacuum Pump Mounting Bracket	1	
21	PRPW01995	Front Brake Hose, Flexible	2	
22	PRPW00445	Rear Brake Hose, Flexible	2	
23	PRPW01996	Rear Brake Hose Mounting Bracket	1	
24	PRPW01997	Right Rear Brake Line	1	
25	PRPW01998	Brake Line No. 5	1	
26	PRPW01999	Left Rear Brake Line	1	
27	PRPW02000	Brake Line No. 6	1	
28	PRPW02001	Brake Line	2	
29	PRPW02002	Brake Line, Right-Hand	1	

**Brake System - Exploded Parts View**

### Brake System – Spare Parts List

Item	Part No.	Description	Qty	Remarks
30	PRPW01961	Brake Line No. 3	1	
31	PRPW01968	Brake Line No. 4	1	
32	PRPW01972	Brake Line, Left-Hand	1	
33	PRFA00047	Bolt, M8 x 35 mm	1	
34	PRPW00214	Brake Proportioning Valve	1	T20G7-10009
35	PRFA00063	Bolt, M10 x 25 mm	3	
36	PRFA00012	Washer, Lock, M10	3	
37	PRPW01931	Brake Pedal Assembly	1	
38	PRPW00174	Master Cylinder c/w Booster	1	
39	PRPW02003	Master Brake Line No. 1	1	
40	PRPW02004	Master Brake Line No. 2	1	
41	PRPW02005	Brake Line Securing Bracket	2	

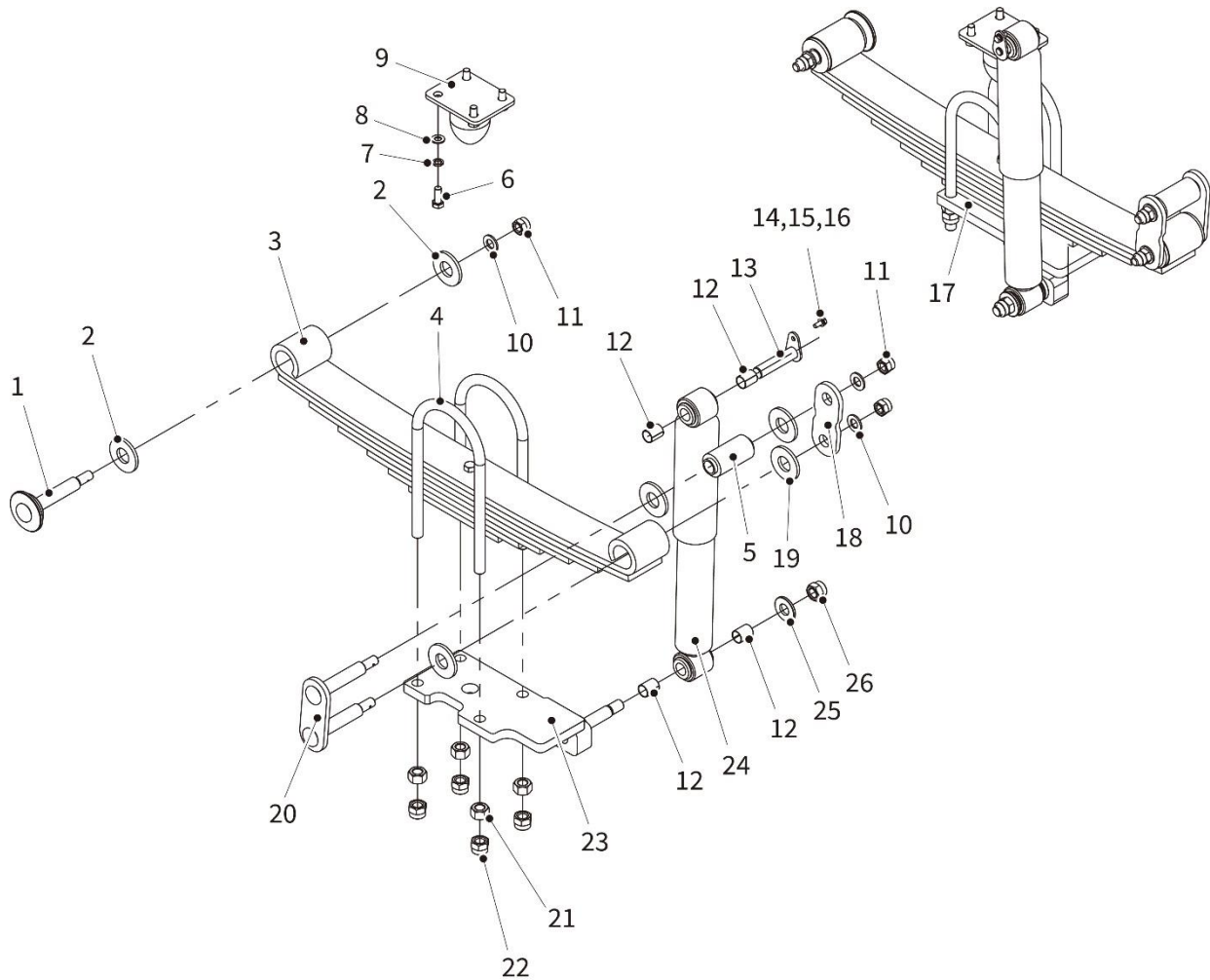


**Park Brake Handle Assembly - Exploded Parts View**

### Park Brake Handle Assembly – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRFA00008	Bolt, M10 x 30 mm	2	
2	PRFA00012	Washer, Lock, M10	2	
3	PRFA00011	Washer, Flat, M10	2	
4	PRPW02006	Park Brake Handle Mount	1	
5	PRPW02007	Park Brake Handle Assembly	1	
6	PRPW01974	Park Brake Cable 1	1	
7	PRPW02008	Park Brake Cable 2	1	

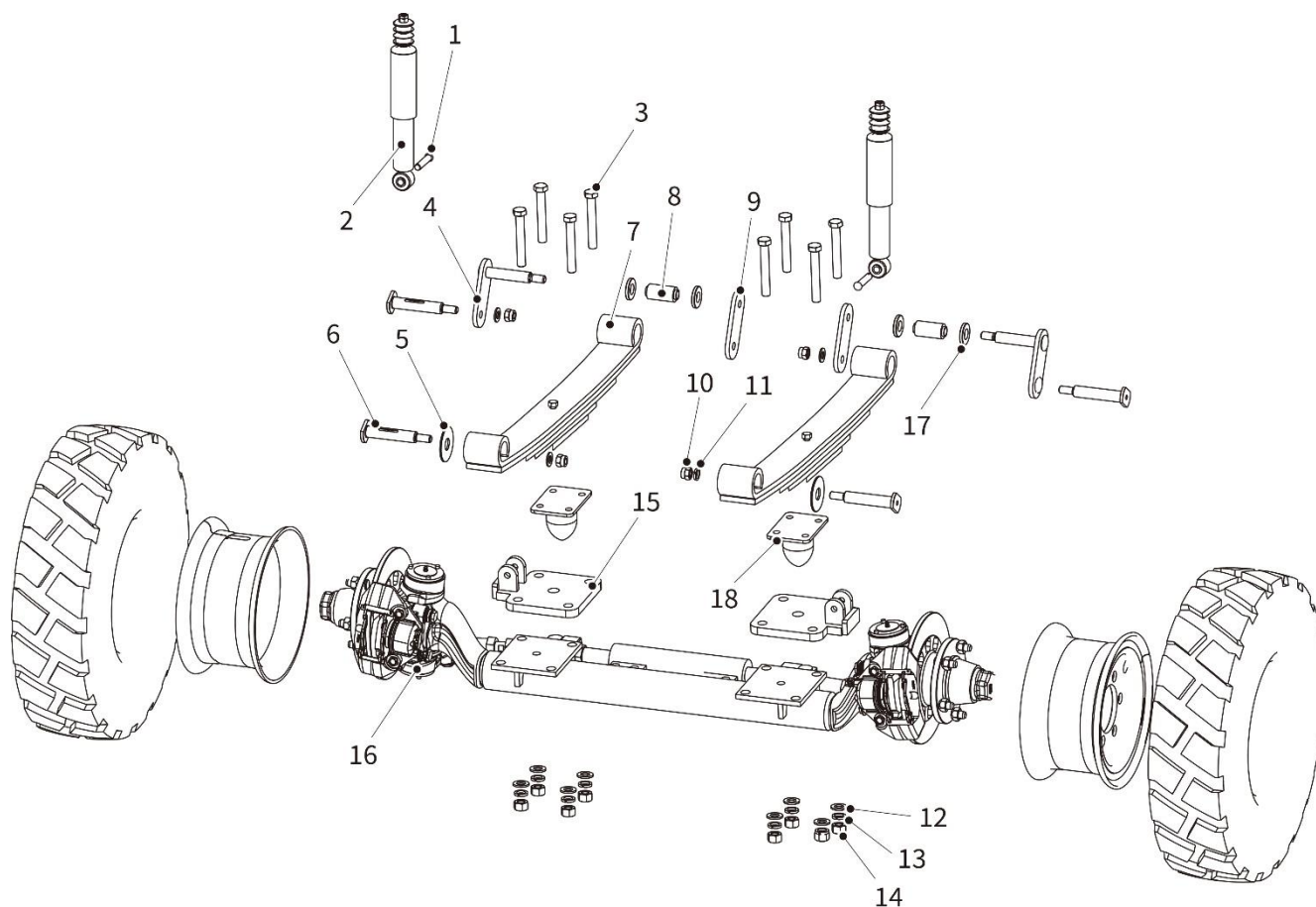
## SUSPENSION



**Rear Suspension Assembly - Exploded Parts View**

### Rear Suspension Assembly – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRFA00097	Spring Bolt	2	
2	PRPW02009	Gasket, Nylon	8	
3	PRPW02010	Rear Leaf Spring Assembly	2	
4	PRFA00167	U-Bolt	4	
5	PRPW00414	Bushing, Rubber	2	
6	PRFA00063	Bolt, M10 x 25mm	8	
7	PRFA00012	Washer, Lock, M10	8	
8	PRFA00011	Washer, Flat, M10	8	
9	PRPW00829	Bump Stop	2	
10	PRFA00072	Washer, Flat, M14	6	
11	PRFA00080	Nut, M14	6	
12	PRPW00830	Bearing Bushing, Type SF-1-1825, self lubricating, composite, i.d. 18mm, o.d. 20mm, length 25mm, wall thickness 1.01mm	8	
13	PRPW02011	Pin Assembly	2	
14	PRFA00006	Washer, Flat, M6	2	
15	PRFA00007	Washer, Lock, M6	2	
16	PRFA00108	Bolt, M6 x 16mm	2	
17	PRPW02012	Leaf Spring Seat, Right-hand	1	
18	PRPW00828	Hanger Plate	2	
19	PRPW02023	Shim	4	
20	PRPW00823	Spring Hanger	2	
21	PRFA00073	Nut, M16	8	
22	PRFA00073	Nut, M16	8	
23	PRPW02013	Leaf Spring Seat, Left-hand	1	
24	PRPW00201	Rear Shock Absorber	2	
25	PRPW00826	Gasket	8	
26	PRPFA00079	Nut, M16 x 1.5 mm	4	



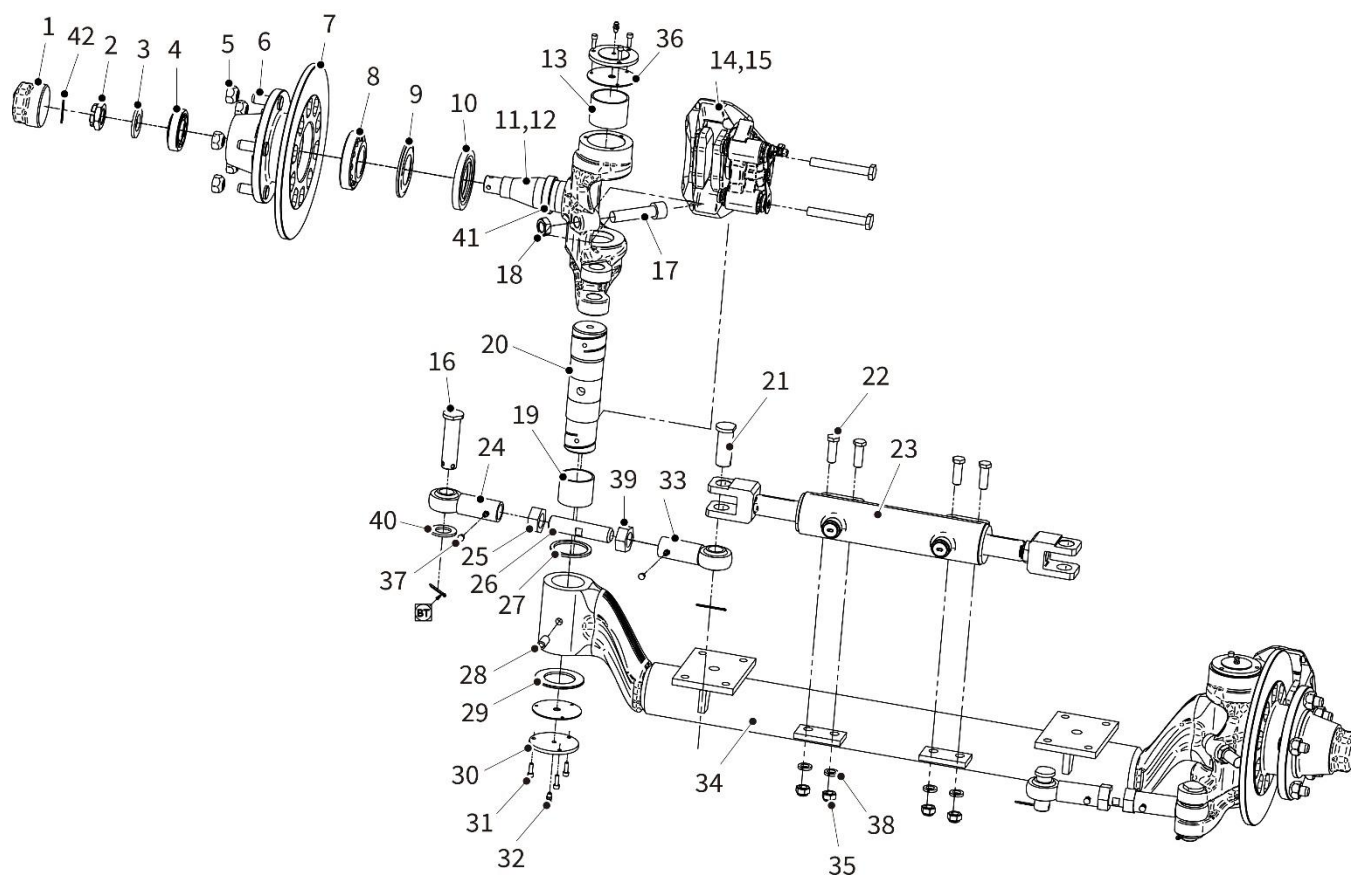
**Front Axle Suspension - Exploded Parts View**



### Front Axle Suspension – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRFA00164	Pin, 12 x 60 mm	2	
2	PRPW00200	Front Shock Absorber	2	
3	PRFA00165	Bolt, M16 x 100 mm	8	
4	PRPW02016	Welded Spring Pin	2	
5	PRFA00146	Washer, Special	8	
6	PRPW02020	Spring Pin	4	
7	PRPW02021	Spring	2	
8	PRPW00414	Bushing, Rubber	2	
9	PRPW02022	Shell Lug	2	
10	PRFA00080	Nut, M14	2	
11	PRFA00118	Washer, Lock, M14	2	
12	PRFA00068	Washer, Flat, M16	8	
13	PRFA00069	Washer, Lock, M16	8	
14	PRFA00073	Nut, M16	8	
15	PRPW02017	Spring/Shock Mounting Plate	2	
16	PRPW02018	Steering Axle Assembly	1	
17	PRPW02019	Gasket	4	
18	PRPW00829	Bump Stop	2	

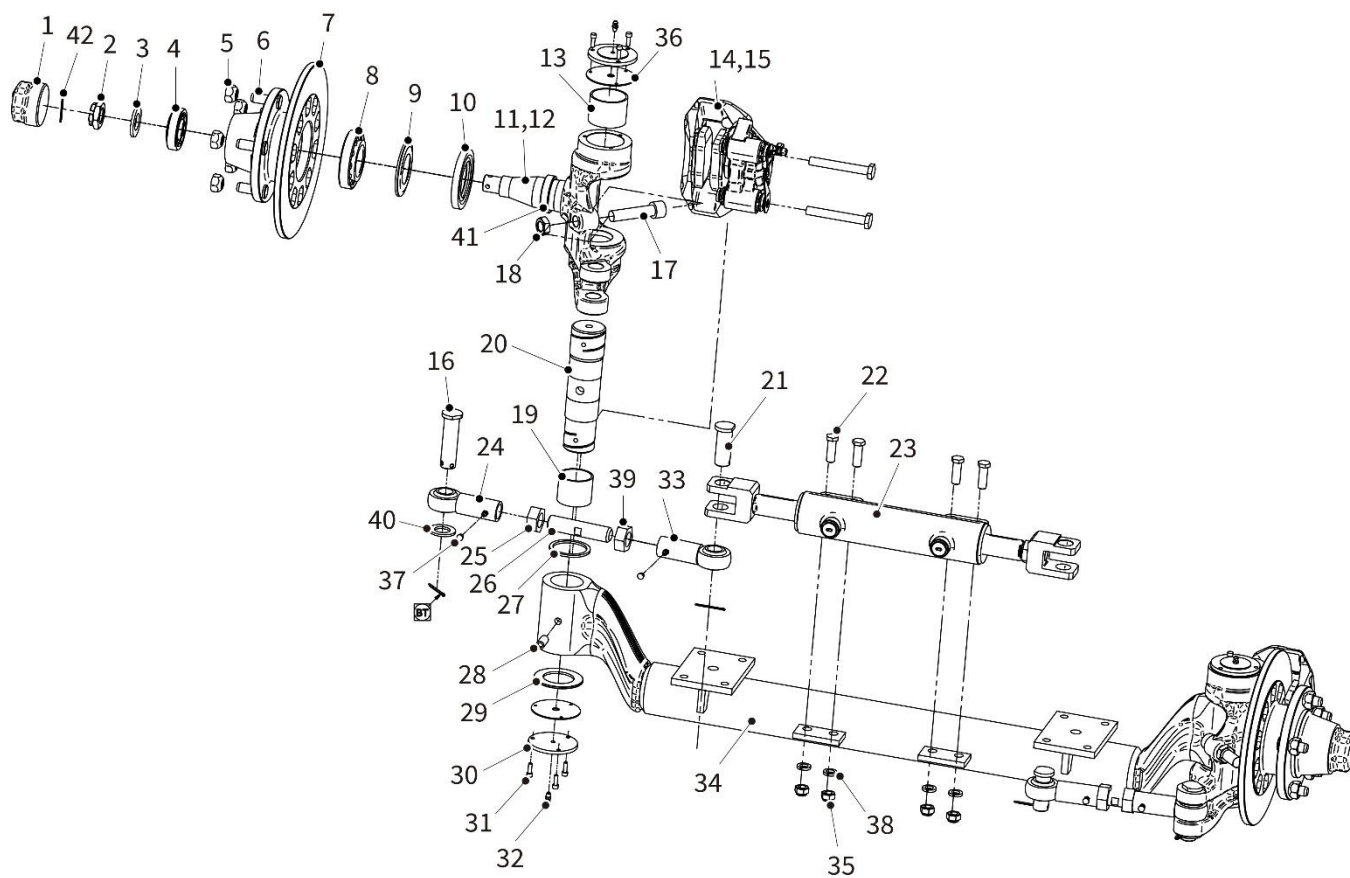
## AXLE



**Front Axle - Exploded Parts View**

### Front Axle – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRPW02024	Dust Cap, M63 x 150	2	324100300
2	PRPW00161	Nut, Special, M24 x 2 mm	2	330200300A
3	PRPW00162	Washer, Special, 25 x 45 x 4 mm	2	351300Q030
4	PRPW00441	Tapered Roller Bearing, Type 30206, single row, i.d. 30 mm, o.d. 62 mm, width 17.25 mm, chamfer 1.5 mm	2	30206
5	PRPW00462	Wheel Nut, M14 x 1.5 mm	2	331400Q04A
6	PRPW00463	Stud, M14 x 1.5 x 40 mm	10	331500Q05A
7	PRPW00164	Front Hub/Brake Rotor	10	412200Q020
8	PRPW00498	Tapered Roller Bearing, Type 30209, single row, i.d. 45 mm, o.d. 85 mm, width 20.75 mm, chamfer 1.5 mm	2	30209
9	PRPW00165	Seal, Steel	2	339200600A
10	PRPW00166	Oil Seal, i.d. 55 mm, o.d. 88 mm, width 10 mm	2	339101Q020
11	PRPW02025	C-Shape, Right	2	410701Q01C
12	PRPW02026	C-Shape, Left	1	410700Q01C
13	PRPW02310	Bushing, Bronze, 50 x 55 x 40 mm	1	316101Q010
14	PRPW00167	Brake Caliper, Right	2	332000Q020
15	PRPW00168	Brake Caliper, Left	1	332001Q030
16	PRPW02027	Clevis Pin, D22	1	415000Q03F
17	PRFA00158	Screw, M16 x 2 mm x 55 mm	2	320300Q440
18	PRFA00155	Nut, M16 x 2 mm pitch	2	320202Q010
19	PRPW02311	Bushing, Bronze, 45 x 55 x 40 mm	2	316101Q000
20	PRPW02312	King Pin	2	474201Q02B1
21	PRPW02313	Clevis Pin, 22 mm	2	415000Q00G
22	PRFA00156	Screw, M12 x 35 mm, x 1.5 mm pitch	2	320300Q460
23	PRPW02028	Steering Cylinder	4	357201Q080
24	PRPW02029	Steering Rod End, Right, M22 x 1.5 mm	1	352000Q00A
25	PRFA00157	Nut, M22 x 1.5 mm pitch	2	320200Q00A
26	PRPW02030	Steering Arm	2	474202Q00C
27	PRFA00169	Washer, Rubber, o.d. 60 mm, i.d. 50 mm, dia. 3 mm	2	316103Q100
28	PRFA00170	Grubscrew, Special, M12 x 25 mm, pitch 1.75 mm	2	320304Q01B
29	PRFA00171	Washer, Bronze, o.d. 72 mm, i.d. 45.5 mm, width 3 mm	2	316102Q02A
30	PRPW02031	Cover	4	419200Q01B



**Front Axle - Exploded Parts View**

### Front Axle – Spare Parts List

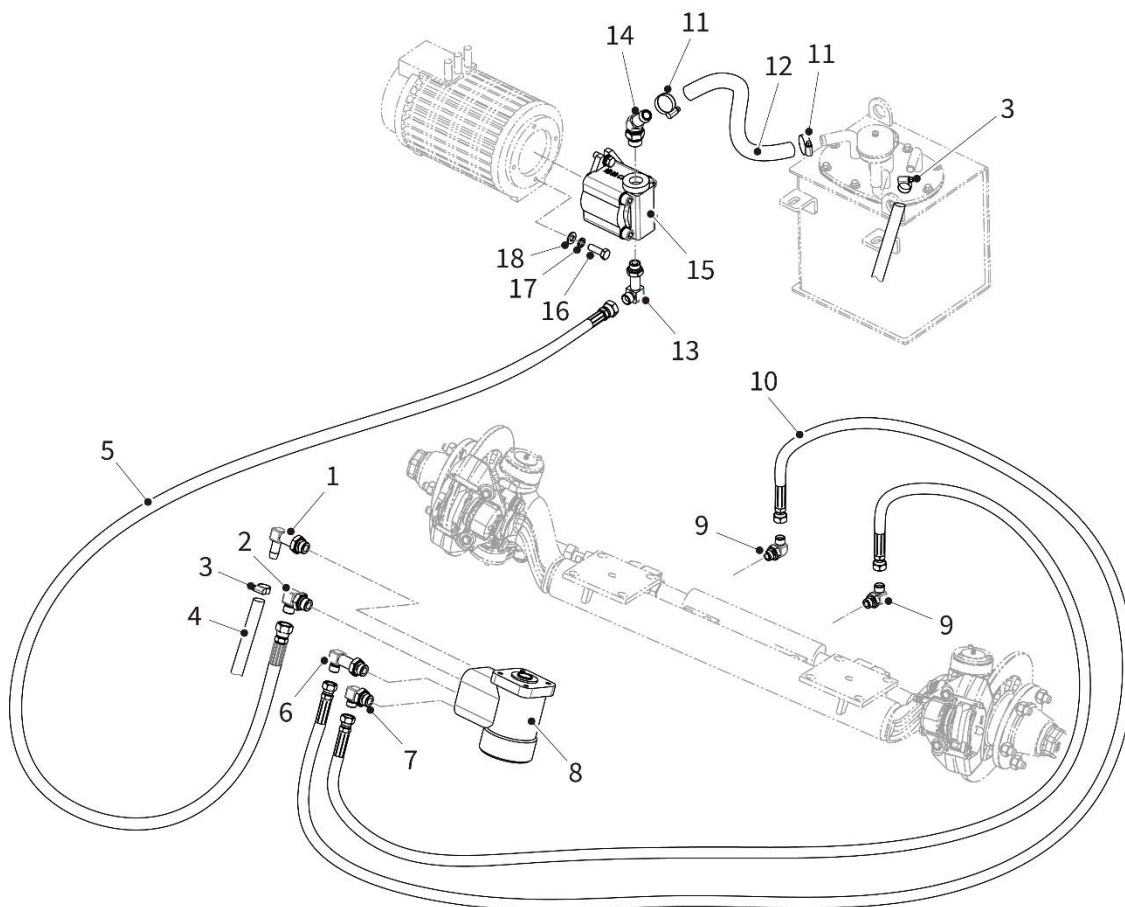
Item	Part No.	Description	Qty	Remarks
31	PRFA00147	Screw, M5 x 15 mm, pitch 0.8 mm	12	320301Q01B
32	PRPW02314	Grease Nipple, Straight, M6	4	3371001000
33	PRPW02032	Steering Rod End, Left, M22 x 1.5 mm	2	352001Q00A
34	PRPW02033	Front Axle	1	574304Q060
35	PRFA00148	Nut, M12 x 1.5 mm pitch	4	320203Q150
36	PRFA00172	Washer, Rubber	4	310700Q00A
37	PRPW02034	Cap, Grease Nipple	8	156002Q000
38	PRFA00045	Washer, Lock, M12	4	320403Q010
39	PRFA00157	Nut, M22 x 1.5 mm pitch	2	320200Q040
40	PRFA00173	Washer, Special, o.d. 39 mm, i.d. 23 mm, width 3 mm	2	320400Q08A
41	PRPW02035	Spare Ring	2	343403Q110
42	PRFA00149	Pin, Split Cotter, 5 x 45mm	4	336200Q000

This exploded view diagram illustrates the assembly of a mechanical device, likely a pump or actuator. The components are numbered 1 through 26. The assembly is shown in a disassembled state to show the relationship between parts. Key components include a base plate (1), a central shaft assembly (10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26), a motor or actuator (3), and a handle or lever (7). The diagram uses dashed lines to indicate the alignment and assembly sequence of the parts.

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### Steering Assembly – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRFA00150	Bolt, Special	2	
2	PRFA00151	Washer Nylon, Special	2	
3	PRPW02036	Steering Wheel Assembly	1	
4	PRFA00153	Nut, M14 x 1.5	1	c/w Steering Column
5	PRFA00072	Washer, Flat, M14	1	c/w Steering Column
6	PRPW02037	Steering Column Assembly	1	
7	PRPW02038	Lever	1	
8	PRFA00152	Bolt, Special	1	
9	PRPW02039	Clamp, Sleeve, No. 2	1	
10	PRPW02040	Clamp, Sleeve, No. 1	1	
11	PRPW02041	Universal Joint	1	
12	PRFA00154	Bolt, M8 x 45mm	1	c/w Universal Joint
13	PRFA00010	Washer, Lock, M8	1	c/w Universal Joint
14	PRPW02315	Grease Nipple, M10	1	
15	PRPW02042	Sheath, Sealing	1	
16	PRPW02043	Steering Linkage Assembly	1	
17	PRFA00011	Washer, Flat, M10	4	
18	PRFA00159	Bolt, M10 x 45mm	8	
19	PRFA00012	Washer, Lock, M10	4	
20	PRFA00067	Bolt, M12 x 1.25 x 25mm	2	
21	PRFA00034	Washer, Lock, M12	2	
22	PRFA00030	Washer, Flat, M12	2	
23	PRPW02316	Bushing, Rubber	4	
24	PRPW02206	Sleeve	4	
25	PRFA00045	Washer, Special	4	
26	PRFA00036	Nut, M10	4	

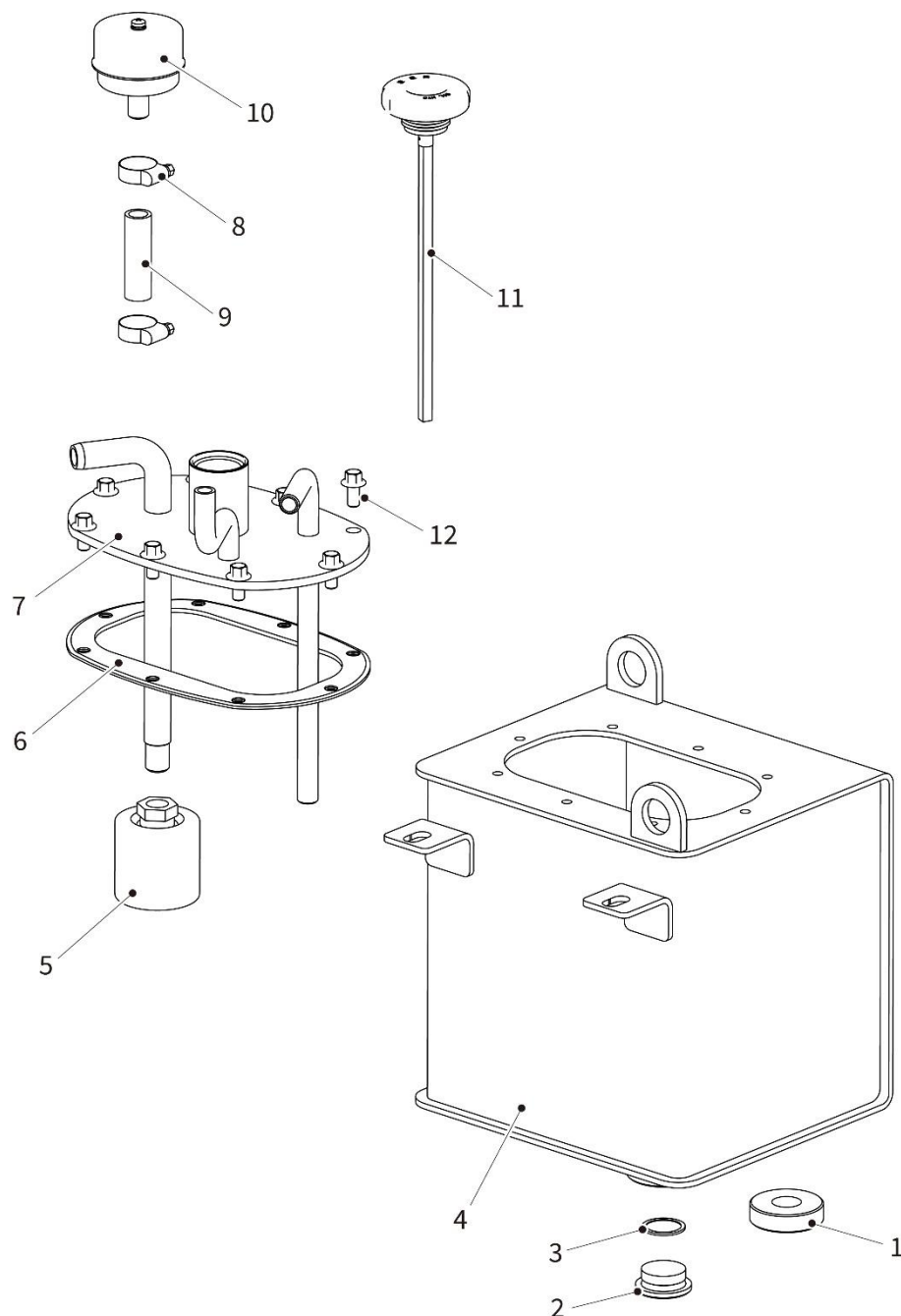


**Power Steering System - Exploded Parts View**



**Power Steering System – Spare Parts List**

Item	Part No.	Description	Qty	Remarks
1	PRPW02183	Right Angle Connector	1	
2	PRPW02184	Right Angle Connector	1	
3	PRPW02317	Clamp, Hose, 20 x 12 mm	2	
4	PRPW02318	Oil Return Hose, dia. 13 mm, length 500 mm	1	
5	PRPW02185	High Pressure Hose	1	
6	PRPW02186	Right Angle Connector	1	
7	PRPW00884	Right Angle Connector	1	
8	PRPW02187	Hydraulic Steering Valve	1	
9	PRPW02188	Right Angle Connector	2	
10	PRPW02189	High Pressure Hose	2	
11	PRPW2190	Clamp, Hose, 32 x 20 mm	2	
12	PRPW02191	Pump Supply Hose, dia. 19 mm, length 500 mm	1	
13	PRPW02192	Right Angle Connector	1	
14	PRPW02193	Joint, 135 deg	1	
15	PRPW00153	Power Steering Pump	1	
16	PRFA00008	Bolt, M10 x 30 mm	2	
17	PRFA00012	Washer, Lock, M10	2	
18	PRFA00011	Washer, Flat, M10	2	

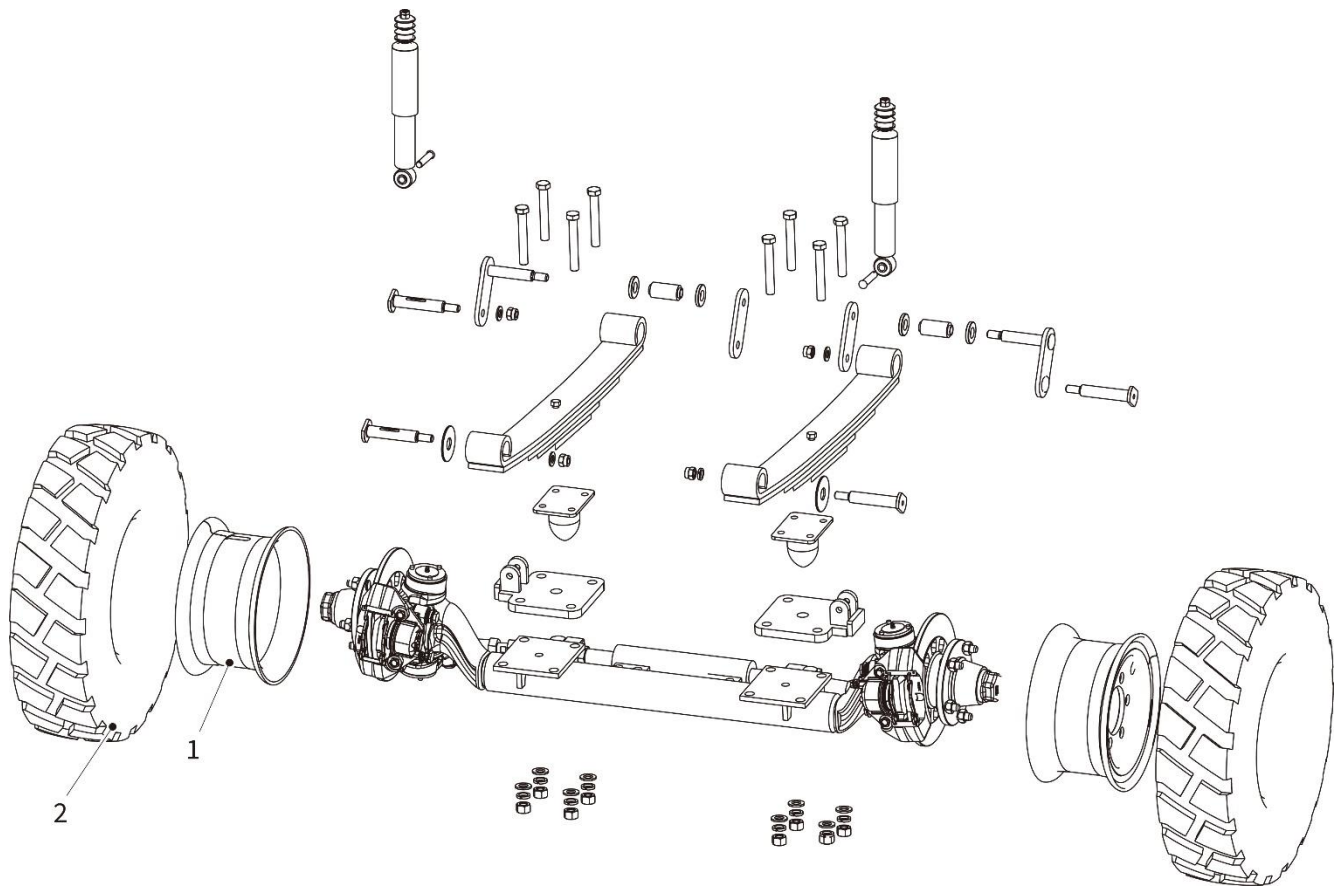


**Power Steering Hydraulic Oil Tank - Exploded Parts View**

### Power Steering Hydraulic Oil Tank – Spare Parts List

Item	Part No.	Description	Qty	Remarks
1	PRPW02194	Magnet	1	
2	PRPW02195	Oil Drain Plug	1	
3	PRPW02196	Sealing Ring, Type ED26, i.d. 26 mm	1	
4	PRPW02197	Oil Tank	1	
5	PRPW02319	Filter	1	
6	PRPW02198	Cover Gasket	1	
7	PRPW02199	Hydraulic Oil Tank Cover	1	
8	PRPW02200	Hose Clamp, 25 x 16 mm	2	
9	PRPW02201	Hose, Oil Resistant, Low Pressure, dia. 13 mm, length 60 mm	1	
10	PRPW02202	Respirator	1	
11	PRPW02203	Tank Cap	1	
12	PRFA00061	Bolt, M8 x 16 mm	8	

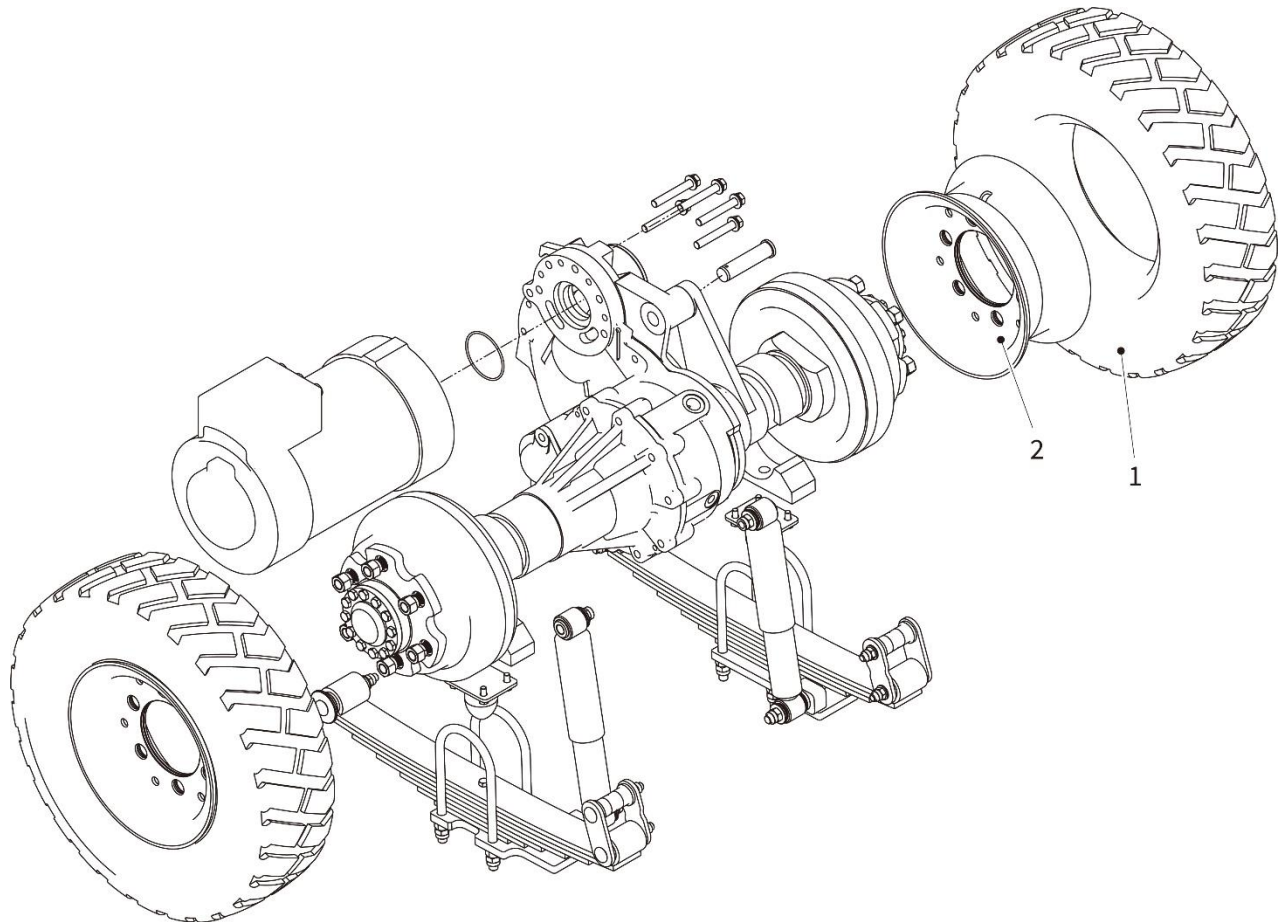
## WHEELS & TIRES



**Front Wheels and Tires - Exploded Parts View**

**Front Wheels and Tires – Spare Parts List**

Item	Part No.	Description	Qty	Remarks
1	PRPW00380	Front Rim Assembly	2	
2	PRPW02204	Tire (185R14)	2	

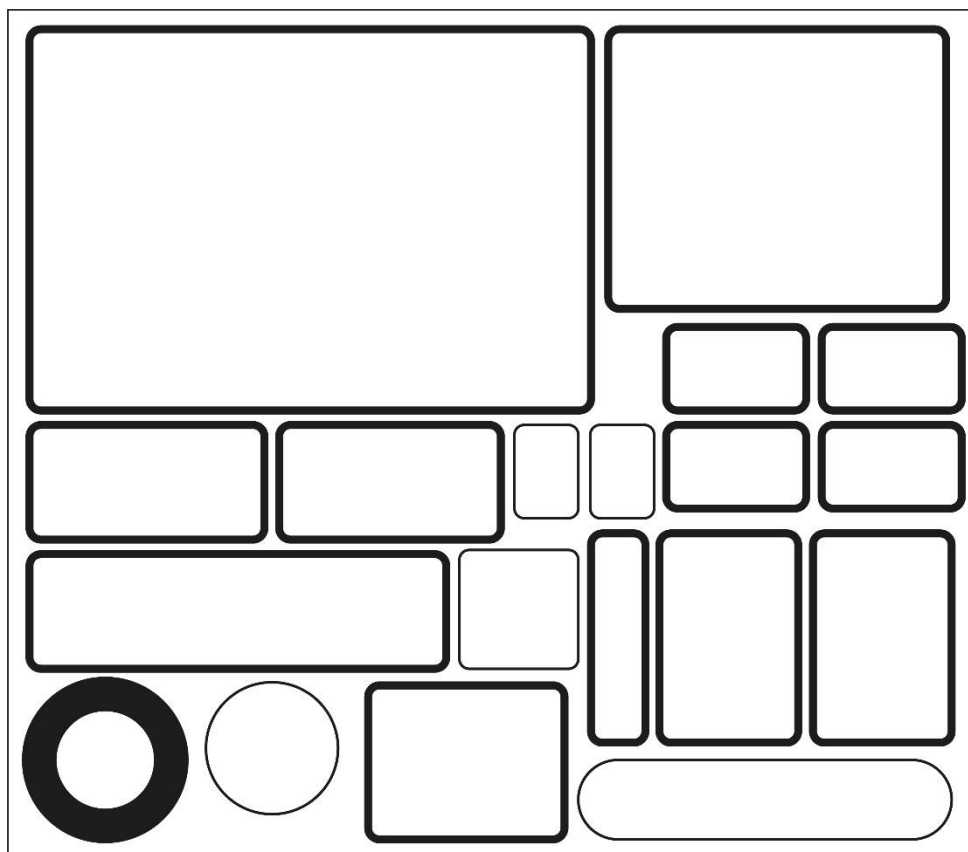


**Rear Wheels and Tires - Exploded Parts View**

**Rear Wheels and Tires – Spare Parts List**

Item	Part No.	Description	Qty	Remarks
1	PRPW00181	Tire (7.00-12-12PR)	2	
2	PRPW00182	Rim, Rear Wheel	2	

## LABELS



Sheet of Labels



**Labels – Spare Parts List**

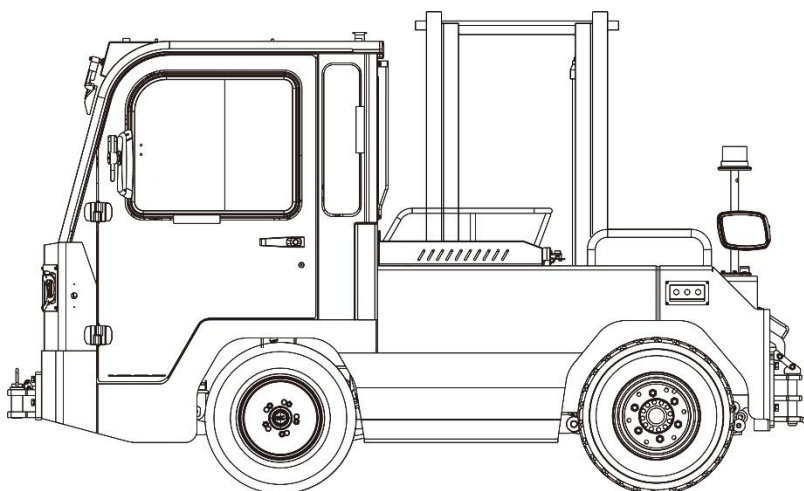
Item	Part No.	Description	Qty	Remarks
1	PRPW03220	Set of Labels for ST470E Tractor (complete set of labels for Tractor)	1	GCIY1229

# SUPPLEMENTARY INFORMATION

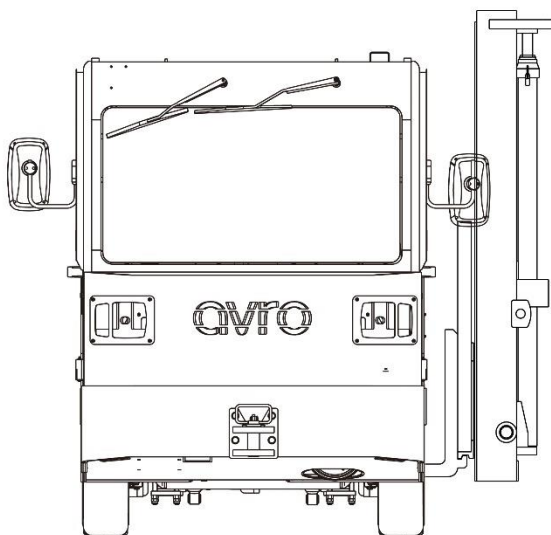
## LIFTING/SHIPPING THE TRACTOR

The recommended method of loading (or off-loading) the Tractor on to (or off) a truck, is to use a suitable loading dock to slowly and carefully drive on/drive off.

If a suitable loading dock is not available, lift the Tractor using a forklift. There are NO lifting points on the Tractor to which lifting slings or chains can be safely attached.



Side view



Front view

**Figure 15 - Lifting diagram**

The Safe Working Load (SWL), also known as Rated Capacity, of the forklift MUST be at least 5,000 kg (5 Tons). The length of the forks MUST be at least 1500 mm (5 feet).

## WARNING – SIZE AND WEIGHT OF TRACTOR



**The Tractor weighs 4300 kg (9480 lbs). When lifting the Tractor, always use a forklift truck with a Safe Working Load (SWL) of at least 5,000 kg (5 Tons). DO NOT use a crane with lifting slings or chains, there are no lifting points on the Tractor.**

**The Tractor must always be towed or moved using a suitable vehicle.**

When lifting the Tractor using a forklift, insert the forks from the side of the Tractor, between the front and rear wheels, as shown in the Lifting Diagram.

## WARRENTY

All Avro GSE products are covered by our Warranty Policy. If you require a copy of our Warranty Policy, please contact us using the contact details given on page 2 of this manual.

## DISPOSAL

The ST470E Tractor contains electrical components, including a vehicle battery. A Tractor that is damaged beyond economic repair, or worn out, should be recycled at a metal recycling facility.

Disposal of waste batteries. The disposal of waste batteries must strictly comply with the environmental laws and regulations of the country where the Tractor is used, and the laws and regulations on waste disposal. The disposal of waste batteries must also strictly follow the instructions of the battery manufacturer.

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