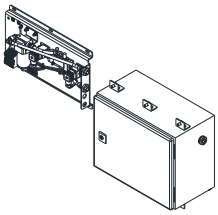
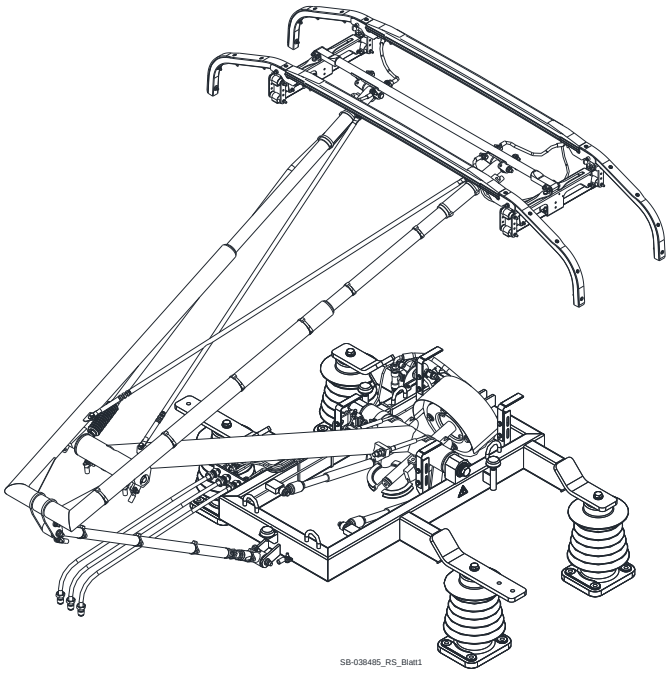
Pantograph
Type: WBL 22.03

Dwg. -No.: SB-035320

Spare Part No.: 10864159





Pneumatic Control

Dwg. -No.: 1-V15.15750 / 1-V15.16074

Spare Part No.: 10601221 / 10609604

Description
Maintenance and
Operating Instructions

Index	Description	elaborated Date / Name	approved Date / Name
-	First Edition	7.2.2019 / MSO	11.2.2019 /FRB

Schunk Bahn- und Industrietechnik GmbH
Aupoint 23
A-5101 Bergheim
Austria
Tel +43 (0)662 459200-0
Fax +43 (0)662 459200-1
www.schunk-sbi.com

TABLE OF CONTENTS

ILLUSTRATIONS

1 Introduction

1.1 General Information

The main objective was to produce a weight as light as possible and simple in structure, and thus low-maintenance pantograph. With these criteria was to achieve an equally good contact behavior, even in the simplest driving lines connected to the maximum operating safety.

The last chapter contains the Illustrated Spare Parts Catalogue. We kindly request you to describe the needed parts as accurately as possible, and in accordance with this catalogue, to assure a problem free order processing, and subsequent delivery.

1.2 Usage Instructions

Sign	Description
⇨	Cross-reference
1., 2., 3.,	Step-by-Step task
☑	Last step
•	listing

2 Safety Instructions

2.1 Classification of Safety Instructions

Warning sign 	S I G N A L W O R D
	Type and source of danger **Possible consequences for individuals, pantograph, tools and work piece** Procedure to avoid the danger

Signal word	Description
DANGER	Dangerous situation. If you do not avoid this situation, death or serious injuries are subsequent.
WARNING	Possible dangerous situation. If you do not avoid this situation, death or serious injuries may be caused.
ATTENTION	Possible dangerous situation for the pantograph or its environment. If you do not avoid this situation, the pantograph or its environment may be damaged.
TIP	Useful information about the pantograph.

For better readability hazard statement are shortened inside step-by-step-instructions. They contain warning sign and warning color:

 **Hazard statement DANGER inside step-by-step-instructions**

 **Hazard statement WARNING inside step-by-step-instructions**

 **Hazard statement ATTENTION inside step-by-step-instructions**

2.2 Possible Risk Types and Risk Sources

- Unsecured shearing and crushing.
- High voltage (catenary).
- Falling from high altitude.
- Injuries due to falling items.

2.3 Possible Consequences of Risks

- Death or injuries (squeezing, amputation, etc.) of involved and not-involved persons.
- Destruction or damage of the pantograph or parts of it.

2.4 Care of the Operator

	W A R N I N G

Untrained staff operating

Death injuries, damage due to improper work.

- Only **QUALIFIED** and **EXPERIENCED** staff is allowed to perform operation, repairs, maintenance and other work.
- Inform staff about **function**, **safety instructions** and **residual risks**.
- **Train** new staff.

- The operator of the vehicle has to **train** (or let train) staff **theoretically** and **practically**, particularly regarding safety.
- All new staff must be trained before working self-reliant.
- It is mandatory for the operator to deploy only **special trained staff**.
- The operator has to care for **protective equipment**.
- The operator has to **arrange safety devices for staff** working on vehicle roof.
- The operator has to meet the **intended use**.

2.5 Intended Use

Your pantograph is exclusively used for **collecting and carrying current** for electric vehicles using a catenary. The current from the overhead line is passed to the actuator by the vehicle. The pantograph is mounted on the vehicle roof, and it is electrically insulated by insulators.

The pantograph is equipped with state of the art and recognized safety rules. Despite this, a risk of physical injury to the user or cause damage to the pantograph and other property can be possible.

- Only use the pantograph in **perfect condition**.
- Only use the pantograph according to **intended use, security and danger**.
- **Disorders** that can affect the safety have **to be eliminated immediately**.
- Typical operation of the pantograph is **carrying current** for electric vehicles **using a catenary**. Usually the pantograph performs THREE raising-and-lowering-cycles per day within typical operation.

Any other use or extended use is considered improper. The manufacturer / supplier is not liable for damages resulting from not-intended use; the user bears sole risk.

The intended use also includes compliance with the operating instructions, inspection and maintenance requirements.

2.6 Not-intended Use

The operating and maintenance staff is required to pay attention to proper use. Safety devices may never be deactivated or bypassed. Maintenance instructions have to be followed.

	**D A N G E R**
Not-intended use of pantograph **Death, injuries, damage, unexpected operating conditions** • Read manuals before start-up. • Operating instructions have to be kept accessible for the staff. • Only qualified and trained staff. • Follow „intended use“. • Perform maintenance according to maintenance instructions. • Only operate pantograph with proper safety devices. • Never bypass safety devices. • Do not perform any improper alterations of pantograph and safety equipment. • Check safety devices for proper function.	

2.7 General Safety Instructions

	**D A N G E R**
High voltage while operation of pantograph **Death, injuries, burn-up** No person is allowed around the pantograph during operation.	
Electrical current in Catenary **Death, burn-up** Catenary – Switch off and ground current. Secure against reset.	
Unsecured squeezing points at raised pantograph **Injuries** Lower pantograph before cleaning, maintenance, repairs or other work.	
Suspended load while transportation with crane or forklift **Death, injuries** No one is allowed to be under the pantograph while transportation.	
Falling tools or items **Death, injuries** After repairs, adjustment or maintenance: Remove tools or loose items from roof.	
Unexpected pressure **Injuries, damage of pantograph** Depressurize pneumatic system before installation work.	
	**W A R N I N G**
Injuries due to lack of protective clothing **Injuries, squeezing, cropping, skin irritation** Always wear protective clothing.	
	**A T T E N T I O N**
Pantograph is upside-down while transportation or storage **Damage** Always transport the pantograph with the proper side up. Always store the pantograph with the proper side up. The pan head must be upside while transport or storage.	

3 Technical Data

Standard ..... IEC 60494-1/2
Static contact force ..... 80 ± 5 N
Rated current ..... 400 A
Nominal voltage ..... 25 kV AC (50 Hz)
Resting position ..... 585 ±10 mm
Insulating distance resting pos. ..... 262 ± 5 mm
Insulating distance working range ..... 259 ± 5 mm
Min. Working height over resting position ..... 100 mm
Max. Working height over resting position ..... 2395 mm
Max. Extension over resting position ..... 2400 mm
Total length in resting position ..... 2335 ± 15 mm
Total weight ..... 184,6 kg
Max. Speed
(Under good overhead line conditions) ..... max. 160 km/h
Ambient temperature ..... -10 to + 50°C
Max. Humidity ..... 100 %
Pan Head .....
Individual suspension of collector Strips, parallel mounted
Pan Head width ..... 1800 ±10 mm
Collector Strips (2 pieces)
Width ..... 35 mm
Distance (middle-middle) ..... 390 ± 5 mm
Material ..... SK 85 Cu Composite carbon

Automatic dropping device

With air-monitored sliding strips

Air bellow drive

Compressed air connection.....High voltage insulation hose

Compressed air supply .....min. 5 bar – max. 10 bar

Dry and oil-free air (insulating characteristics)

Compressed air acc. to..... ISO 8573

Solid components.....Class 4

Humidity.....Class 2

Oil.....Class 4

4 Pantograph Components

4.1 General Information

Main features of the Pantograph are:

- function-oriented design
- minimum maintenance
- excellent dynamic contact behavior
- maximum operating safety

This is mainly achieved through:

- Proven bearing techniques
- Modular construction
- Hydraulic oscillation damping techniques
- Optimized number of components
- Independent suspension of sliding strips
- Optimized weight
- Integrated automatic dropping device (ADD)

4.2 Pantograph

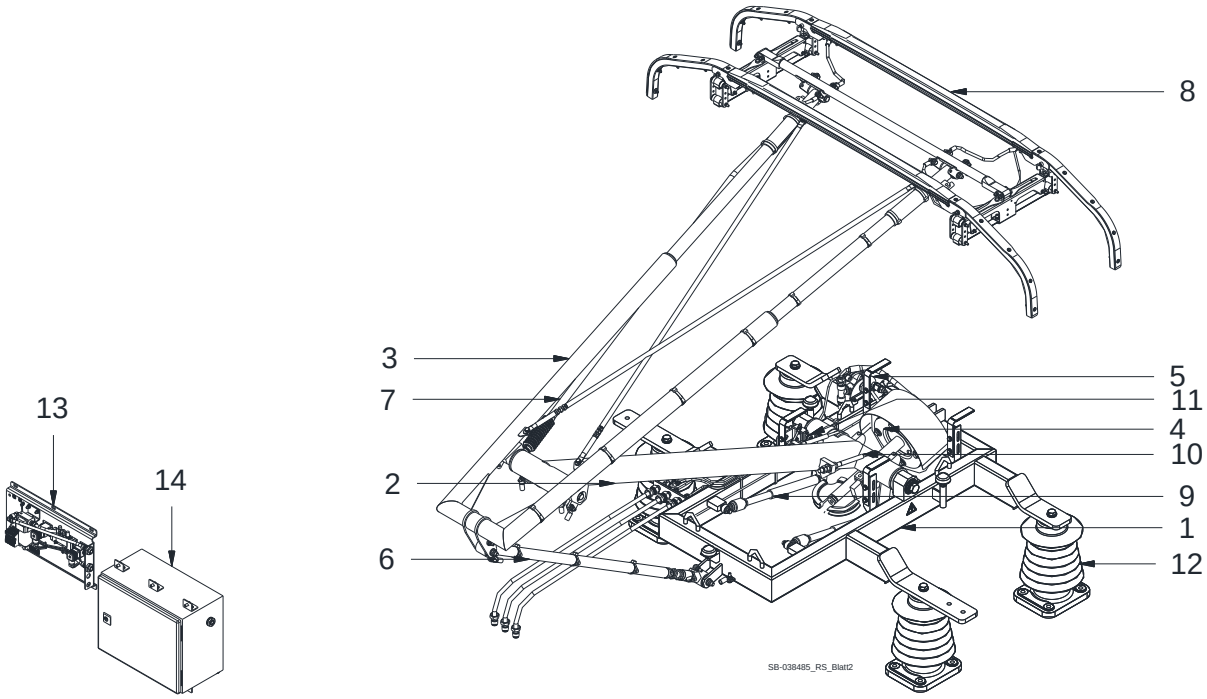


Illustration 1: Components

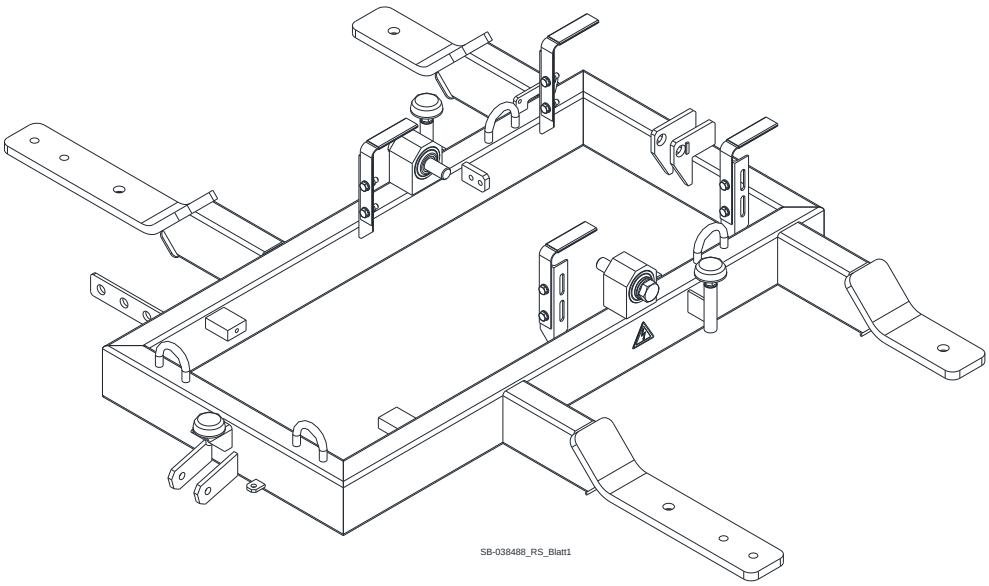
1	*Base frame compl.*	*2*	*Lower frame*
3	*Upper frame compl.*	*4*	*Air bellow drive*
5	*Valve unit ADD*	*6*	*Coupling rod*
7	*Parallel guide bar compl.*	*8*	*Pan head*
9	*Shock absorber*	*10*	*Cable with terminals*
11	*Overreach detection*	*12*	*Insulator compl.*
13	*Pneumatic control unit*	*14*	*Pneumatic control unit*

4.2.1 Base Frame

The welded structure of the base frame is the basis of the pantograph. The component is coated for protection of environmental influences.

The base frame is mechanically attached to the vehicle roof with insulators. The current is led from catenary to vehicle by the current connection at the base frame and the cabling from the vehicle.

Illustration 2: Base frame



All components of the Base Frame are listed in the Spare Parts -List (⇨ Chapter #17.2.1).

4.2.2 Lower Frame

The lower frame is a welded structure which is rotary mounted to the base frame. The component is coated for protection of environmental influences.

The cams assure that the static contact force is constantly over the whole working range of the pantograph.

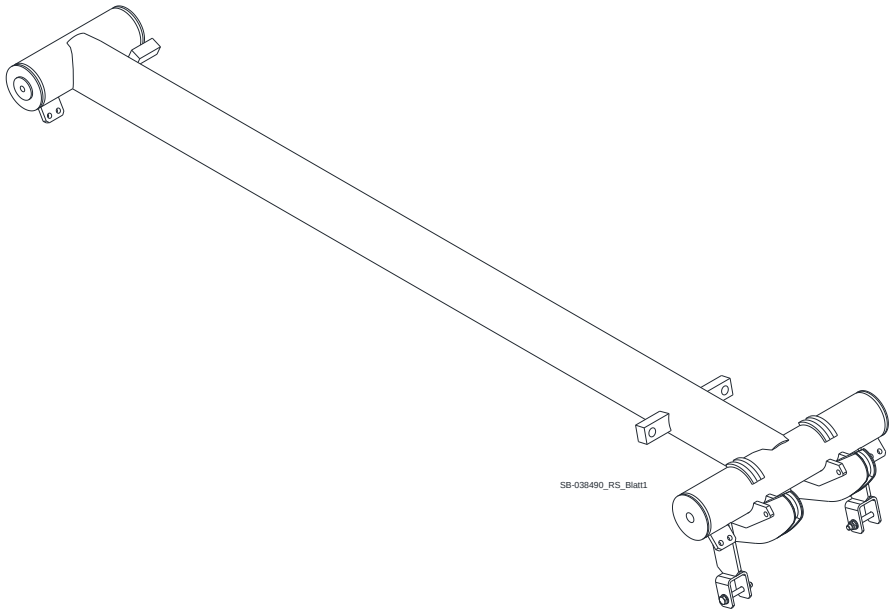


Illustration 3: Lower frame

All components of the Lower Frame are listed in the Spare Parts – List (⇨ Chapter #17.2.2).

4.2.3 Upper Frame

The upper frame is a welded structure made of steel tubes. The component is coated for protection of environmental influences.

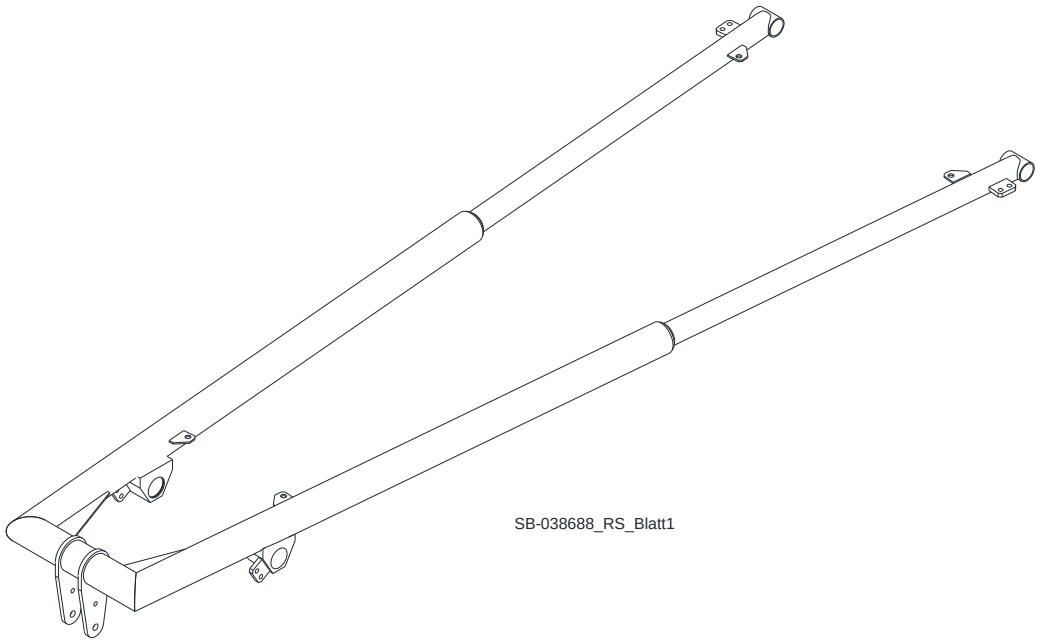


Illustration 4: Upper frame

All components of the Upper Frame are listed in the Spare Parts – List (⇨ Chapter #17.2.3).

4.2.4 Air Bellow Drive

The pantograph is raised with the air bellow drive. The air bellow drive is mounted between base frame and lower frame.

The force of the bellow is transmitted by cables which are running in cams. The air bellow drive is connected with the valve unit ADD with a compressed air hose.

All compressed air settings for the air bellow drive can be adjusted with the pneumatic control.

There is an uplift-stop mounted inside the air bellow drive, which prevents the pantograph from raising above maximum extension.

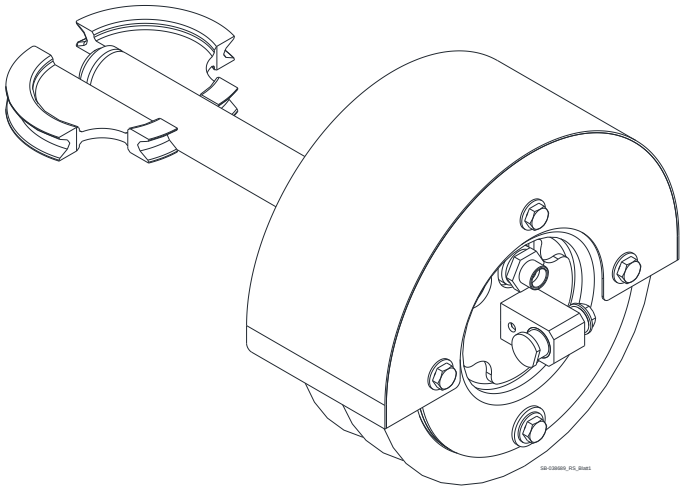


Illustration 5: Air bellow drive

All components of the Air Bellow Drive are listed in the Spare Parts – List (⇨ Chapter #17.2.4).

4.2.5 Valve Unit ADD

The valve unit ADD (automatic dropping device) is used for monitoring the sliding strips to minimize damage of catenary and pantograph due to damaged sliding strips.

If a sliding strip is damaged, a control pipe is opened and compressed air is releasing. The exhaust valve is opened due to the decrease in pressure, the air bellow is ventilated and the pantograph lowers immediately.

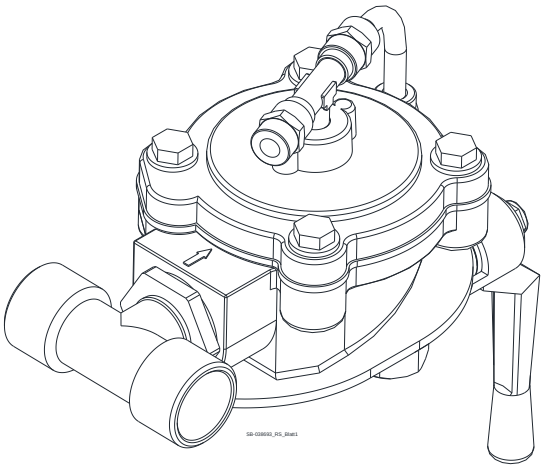


Illustration 6: Valve unit ADD

All components of the Valve Unit ADD are listed in the Spare Parts – List (⇨ Chapter #17.2.12).

4.2.5.1 ADD Activated

The valve unit ADD is in ACTIVATED state when the pantograph is delivered. Therefore, monitoring of the sliding strips is enabled.

⚠	**D A N G E R**
Pantograph raised PNEUMATICALLY. **Valve unit ADD responds, pantograph lowers.** NEVER raise pantograph pneumatically when replacing sliding strips. After replacement of sliding strips: check if all pneumatic connections are connected properly.	

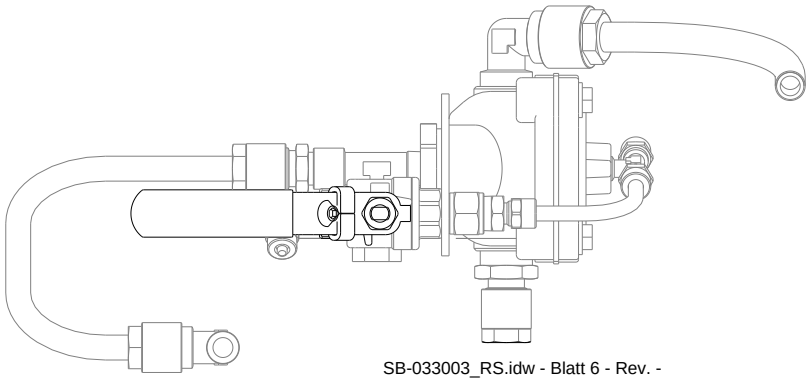


Illustration 7: Lock cock OPEN - ADD ACTIVATED

If the lock cock is in position OPEN, the ADD is ACTIVATED.

⚠	**A T T E N T I O N**
ADD ACTIVATED when performing leaking test. **ADD responds, pantograph lowers** DEACTIVATE ADD when performing leaking test.	

Deactivate ADD (⇨ Chapter #4.2.5.2).

4.2.5.2 ADD Deactivated

The valve unit ADD is in ACTIVATED state when the pantograph is delivered. Therefore, monitoring of the sliding strips is enabled.

Activate ADD (⇨ Chapter #4.2.5.1).

	A T T E N T I O N
	ADD ACTIVATED when performing leaking test. **ADD responds, pantograph lowers** DEACTIVATE ADD when performing leaking test.

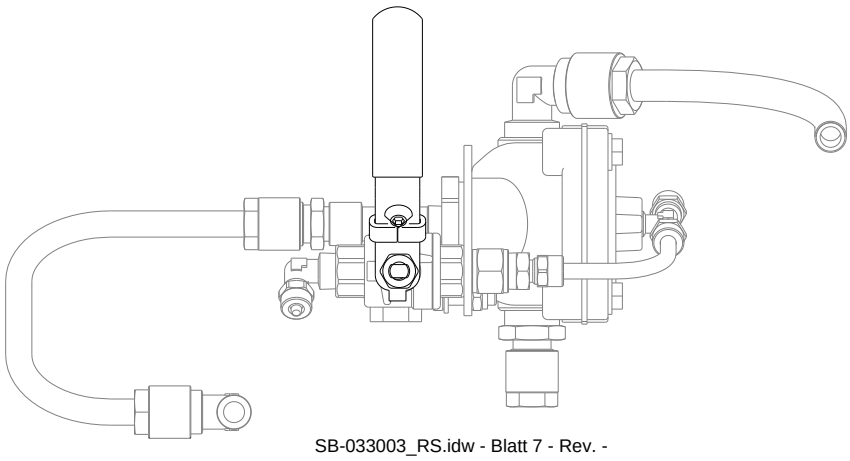


Illustration 8: Lock cock closed - ADD DEACTIVATED

If the lock cock is in position CLOSED, ADD is DEACTIVATED.

4.2.6 Coupling Rod

The coupling rod consists of a connection tube made of a stainless-steel round-tube and two bearing houses (equipped with grooved ball bearings) with left-hand-thread and right-hand-thread. By turning of the connection tube, the geometry of the pantograph will be adjusted and fine-tuned.

The component is coated for protection of environmental influences.

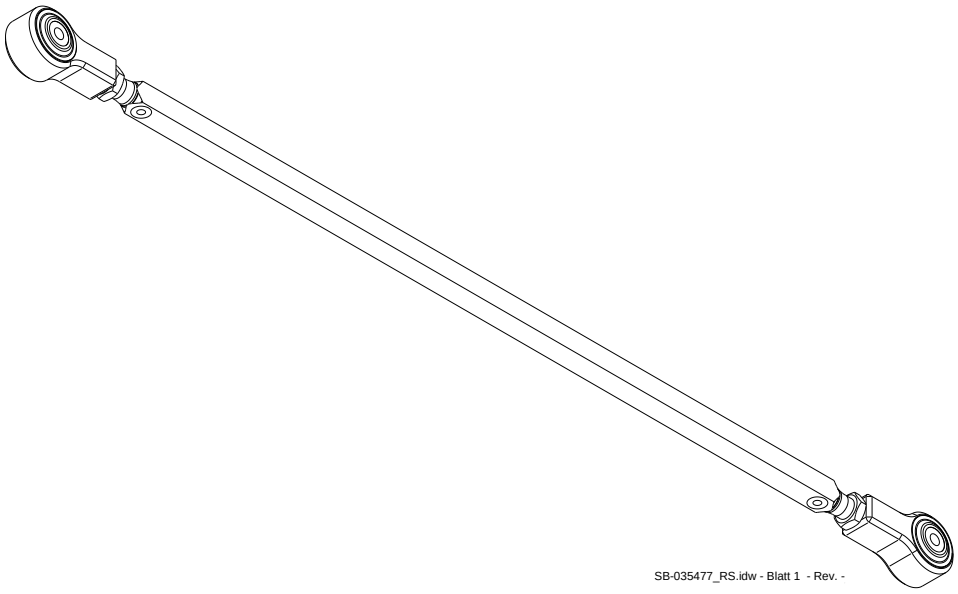


Illustration 9: Coupling rod

All components of the Coupling Rod are listed in the Spare Parts – List (⇨ Chapter #17.2.6).

4.2.7 Parallel Guide

The parallel guide bar prevents the pan head from distorting, while the pantograph is raised or lowered. The turning capacity of the pan head is adjusted by screwing-in and screwing-out the rod end of the parallel guide bar. This achieves equal wear on both sliding strips.

The component is anodized for protection of environmental influences.

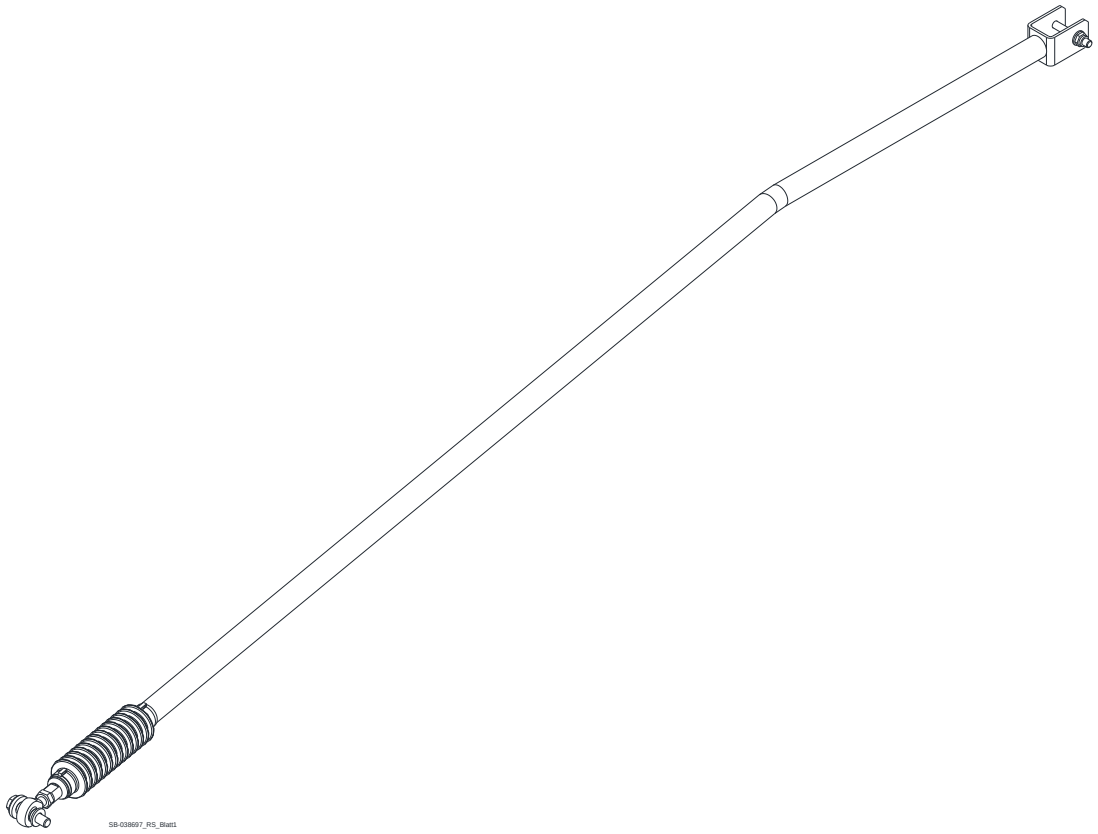


Illustration 10: Parallel guide

All components of the Parallel Guide Bar are listed in the Spare Parts – List (⇨ Chapter #17.2.7).

4.2.8 Pan Head

The Pan Head is mounted onto a shaft, which in turn is located inside the cross tube of the upper frame. Leaf springs are used for the suspension of the sliding strips. The pan head springs (leaf springs) are affixed in the rocker boxes and they carry the sliding strips.

The single suspension of each sliding strip achieves excellent contact behavior and thereby a minimum of wear.

The design of rocker boxes and sliding strip fastenings protects the pan head springs (leaf springs) from destruction at abnormal high horizontal and vertical forces. If the forces exceed a defined value, the channels for monitoring compressed air are deflated and the valve unit ADD lowers the pantograph to avoid subsequent damages.

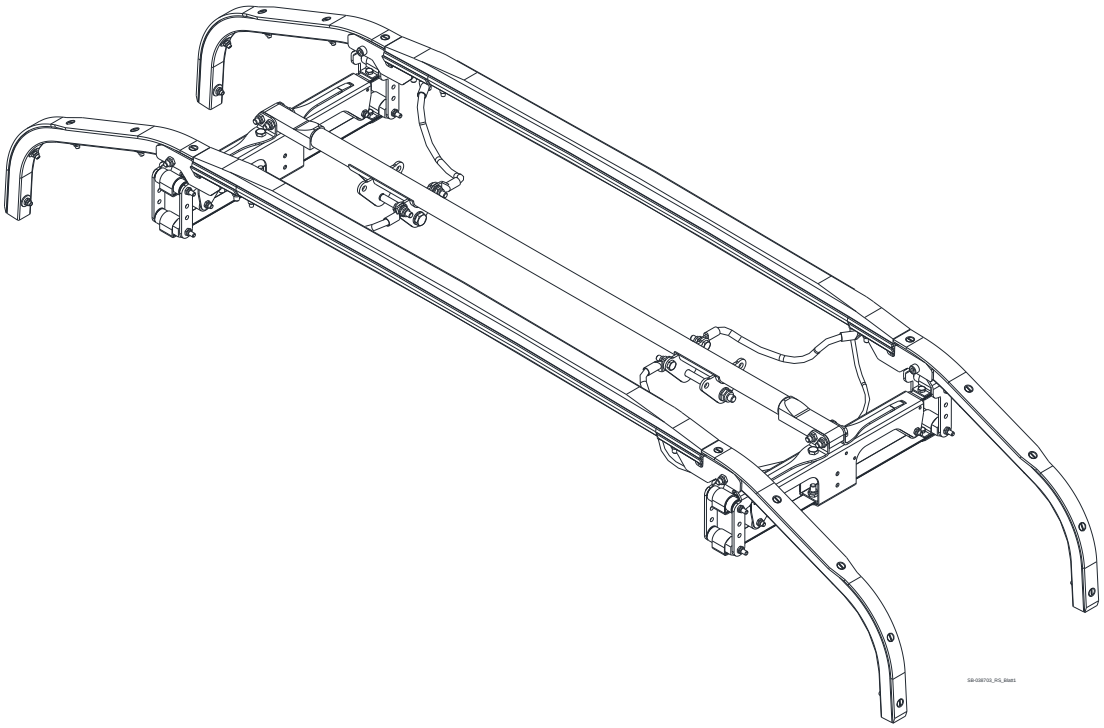


Illustration 11: Pan head

All components of the Pan Head are listed in the Spare Parts – List (⇨ Chapter #17.2.8).

4.2.9 Shock absorber

The shock absorber between lower frame and base frame compensates vibrations of the pantograph. The stages of compression and tension are designed to assure best contact behavior between sliding strips and catenary.

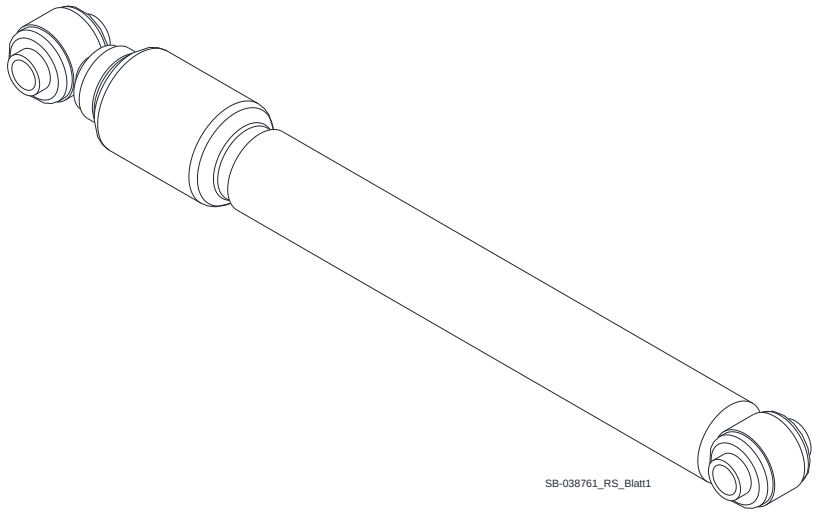


Illustration 12: Shock absorber

All components of the shock absorber are listed in the Spare Parts – List (⇨ Chapter #17.2.9).

4.2.10 Cable with Terminals

The cables with terminals consist of round braids with secured terminals at both ends. The cables are secured against twisting at these secured terminals when detaching / attaching cables.

The cables with terminals are guided by the cable guide of the air bellow drive and at the cams of the lower frame. The cross tube of the lower frame is brought to a rotation. Subsequently upper frame and pan head are raised.

The cables are greased at the contact surfaces to cams and cable guide.
(⇨ Chapter #11.3.3)

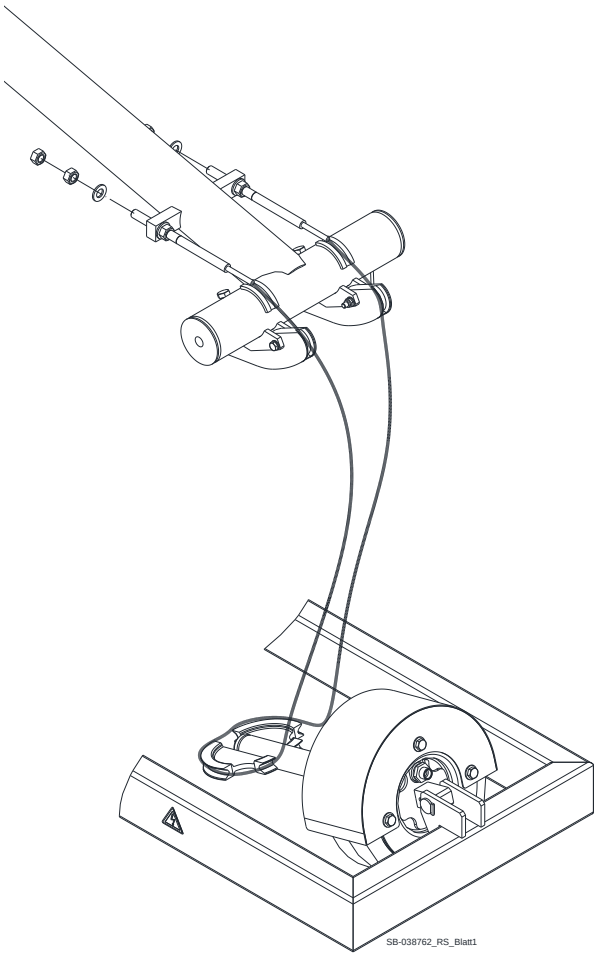


Illustration 13: Cable with terminals

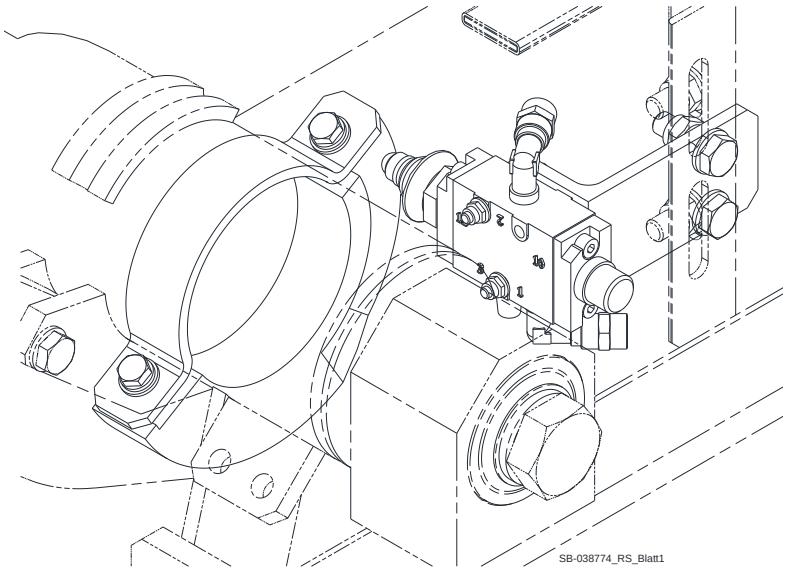
All components of the Cable with Terminals are listed in the Spare Parts – List (⇨ Chapter #17.2.5).

4.2.11 Overreach detection

The overreach detection is used to detect a lifting height.

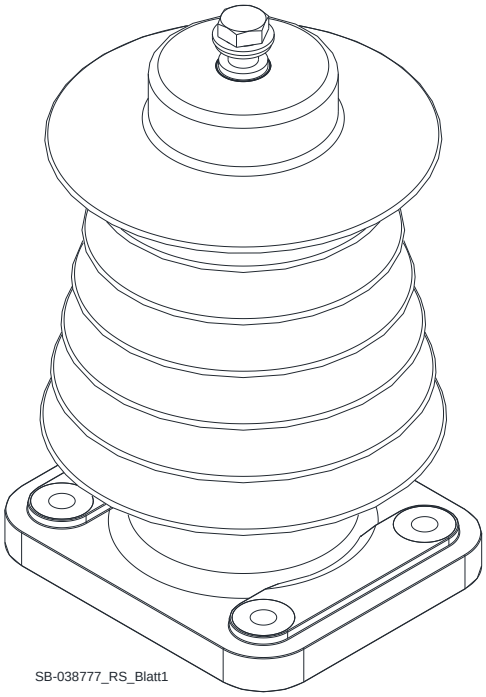
Function:

The overreach detection is supplied with compressed air from the air bellow drive. When the lifting height is reached, the stop switches the 3/2-way valve and compressed air flows to the pressure safeguard. This converts the signal into an electrical, which can be used as needed



4.2.12 Insulator

The pantograph is mounted on supporting insulators. The supporting insulators provide the electrical insulation between the live pantograph and the roof of the vehicle.



SB-038777_RS_Blatt1

4.2.13 Shunts

All bearing locations are bypassed with shunts. This prevents current from flowing through the bearings. The shunts are composed of a copper wire (2) which is provided on both sides with a tubular lug (1).

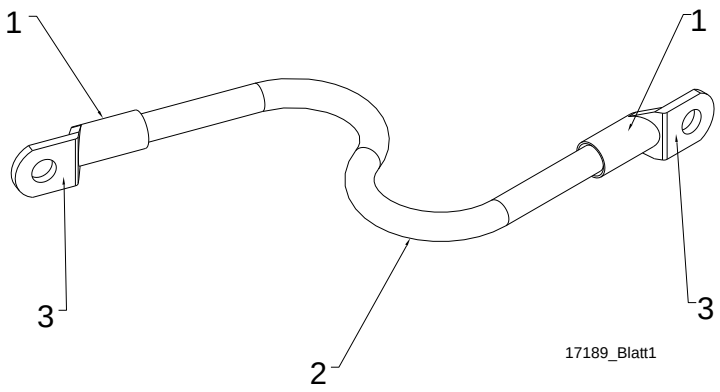


Illustration 14: Shunt

1	*Tubular lug*	*2*	*Copper wire*
3	*Grease contact surface of shunt*		

The tubular lugs (1) of the shunts are lubricated with contact grease (3) in order to ensure a proper current transfer between frame part and shunt.

4.2.15 Type Tag

The type tag is located on the base frame. For questions about your pantograph please indicate **TYPE (4), DWG NO (5)** and **REV.NO (6).**

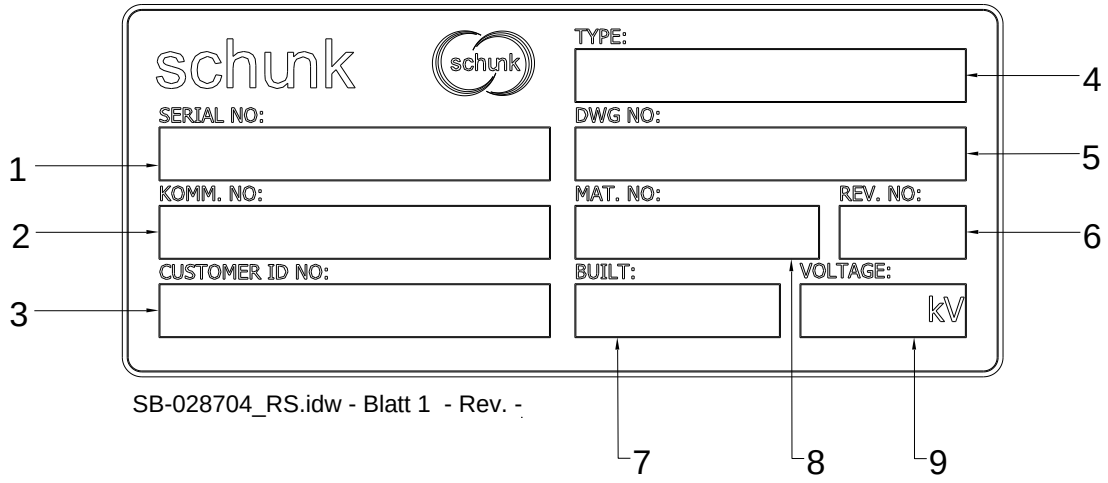


Illustration 15: Type tag

1	*SERIAL NO.*	*2*	*KOMM. NO.*
3	*CUSTOMER ID NO.*	*4*	*TYPE*
5	*DWG NO.*	*6*	*REV. NO.*
7	*BUILT*	*8*	*MAT. NO.*
9	*VOLTAGE*		

4.3 Pneumatic Control

The pneumatic plan can be found ⇨ Appendix A.

The main functions of the pneumatic control are:

- Control of static contact force
- Control of raising and lowering time
- Restriction of compressed air in case of a system failure
- Signal ADD

All components of the Pneumatic control are listed in the Spare Parts – List (⇨ Chapter #17.3).

The arrangement and description of the components is listed in the Pneumatic scheme (⇨ Chapter #Appendix A).

5 Packaging

	A T T E N T I O N

Improper packaging

Damages

- The pan head must be **UPSIDE**.
- All components must be **INSIDE** the packaging.
- Open components (e. g. sockets, hoses) must be **protected against ingress of moisture**.
- Fix components inside package, that they cannot slip due to centrifugal forces, break forces or acceleration forces.
- The package may not be damaged by any load securing (e. g. pressure from belt).

The pantograph is mounted in an appropriate packaging (e.g. wooden crate) in lowered position with the pan head up.

In order to avoid any damage during transportation no parts of the pantograph should protrude beyond the packaging.

The pantograph is foiled as a protection against dirt and humidity.

6 Storage

	A T T E N T I O N

Improper storage

Damages

- Always store the pantograph with the proper side up, the pan head has to be upside.
- Never store other components onto the pantograph or its package.

When storing without package:

- Mount spacers at the bottom of the insulators.

6.1 Storage inside Transportation Package

- roofed
- well ventilated
- dry
- Ambient temperature acc. to technical data (⇨ Chapter #3)

6.2 Storage outside Transportation Package

- Plane ground
- Mount spacers with proper height at the bottom of the insulators to avoid damage of protruding parts.

Storing several pantographs one upon the other outside the transportation package:

- Use proper frames.
- Take additional precautions to assure that protruding parts (e.g. horns etc.) cannot be damaged.

7 Transportation

	**D A N G E R**
<u>Unsecured transportation</u> **Death, injuries and / or damage of pantograph** Transportation of pantograph only when it is LOWERED. Fix upper frame to base frame during transportation (e. g. with belt).	
<u>Falling tools or items from vehicle roof</u> **Death, injuries** After repairs, maintenance and other work: Remove tools and other items from the vehicle roof. No one is allowed underneath the pantograph while it is being lifted or transported.	
	**W A R N I N G**
<u>Risk of improper handling of hoisting devices performed by untrained staff</u> **Death, injuries and / or damage of the pantograph** Trained staff only. Wear protective clothing.	

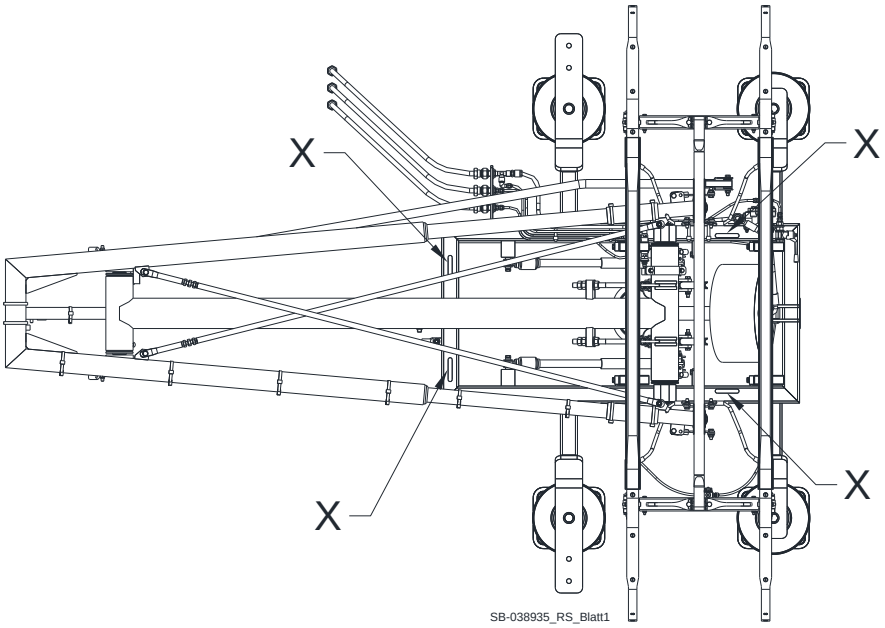


Illustration 16: Lifting eye nuts

Transportation and lifting of pantograph outside the package ONLY at the marked lifting eye nuts.

8 Assembly

8.1 Attachment to Vehicle Roof

The base frame must be mounted tension free onto the vehicle roof. The base tube of the lower frame must be horizontal. If needed washers may be placed underneath the insulators to act as shims.

Procedure:

Shut-off current supply.
Ground catenary.
Secure switch against unintended re-set.

Always keep the proper tightening torque.
⇨ Chapter #11.3.2

1. Attach insulators to vehicle roof.
2. Secure upper frame to base frame (e. g with a suitable belt).
3. Fasten pantograph at the transport hooks on base frame with a suitable harness.
4. Fasten harness to a suitable hoisting device (e.g. crane).

No one is allowed underneath the pantograph while transportation.

5. Lift pantograph on vehicle roof.
6. Place pantograph onto insulators on the vehicle roof.
7. Check, if the upper mounting points of the insulators fit to the base frame:
    a. For longitudinal or transverse deviations loosen screw connections of the insulators to the vehicle roof.
    b. Slide insulators until the upper mounting points fit to the base frame.
    c. If there are height deviations use washers between insulator and base frame.

The base tube of the lower frame must be horizontal. If necessary, washers have to be placed underneath the insulators, to act as shims.

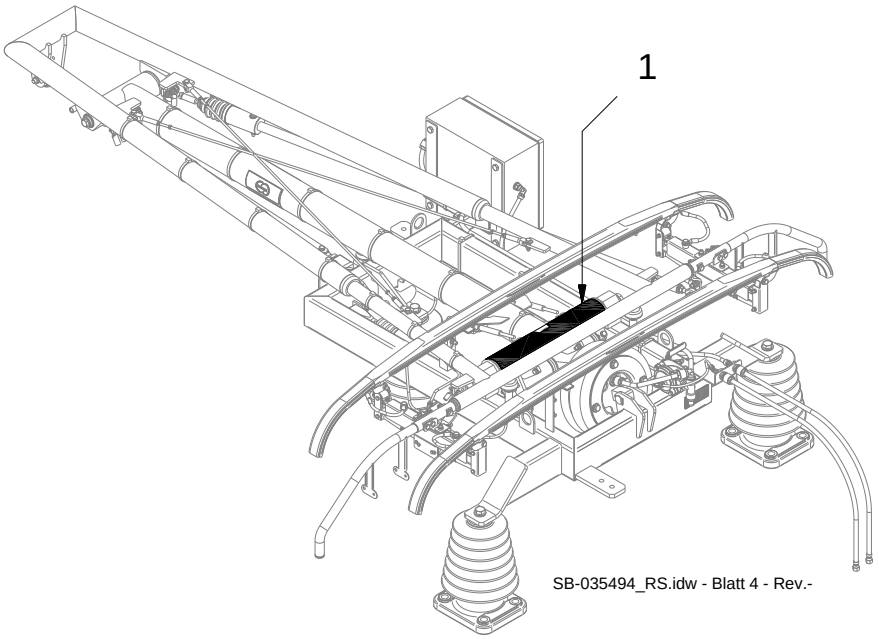


Illustration 17: EXAMPLE: Base tube of lower frame

8. Check, if base tube of lower frame is horizontal.
9. Fix screw connections of the insulators.
10. Connect electrical equipment (⇨ Chapter #8.2).
11. Attach pneumatic connections (⇨ Chapter #8.3).☑

8.2 Attachment of High Voltage Connection

	D A N G E R
Dirty, coated and / or ungreased shunt connections **Inaccurate current flow, injuries, damages** Clean and grease shunt connections and connection boards.	

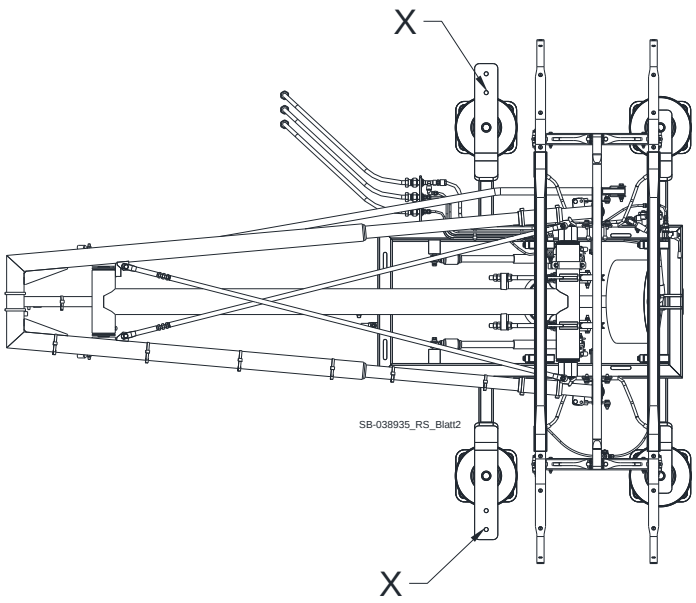


Illustration 18: High voltage connection

The High Voltage Connection has to be mounted at the connection boards (1), which is attached to the base frame.

Assure that the connection board is cleaned and greased with contact grease before assembling.

8.3 Attachment of Pneumatic Equipment

The compressed air supply is connected to the pantograph with insulating hoses.

After assembly, the air connections have to be checked for tightness (e. g. with a leak detection spray ⇨ Chapter #11.3.1).

	A T T E N T I O N
	Improper installation of pneumatic connections **Air leakage, loss of function** Seal all pneumatic connections with Loctite 577.
	Ingress of moisture into the pneumatic control **Damage of the pneumatic control** On bottom of the control box there is a hole for exhaust air and condensate outlet: The vehicle manufacturer has to install a suitable drain to prevent the ingress of moisture into the pneumatic control.

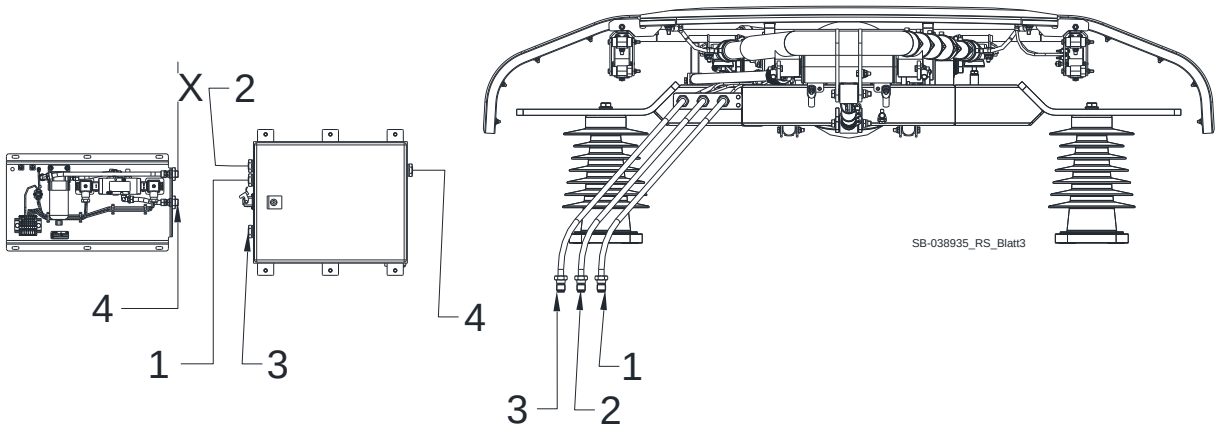


Illustration 19: Air connection

1	*Overreach detection (ORD)*	*2*	*Valve unit ADD*
3	*Main air supply to air bellow*	*4*	*Air supply from vehicle*
X	*Feed line*		

9 Start Up

9.1 Safety Instructions

	**D A N G E R**
<u>High voltage while operation of pantograph</u> **Death, injuries, burn-up** No person is allowed around the pantograph during operation.	
<u>Tools and / or items reducing insulating distance</u> **Current flashover, injuries, burn-up** • Remove tools and / or items on top of the pantograph. • Remove tools and / or items under the pantograph. • Remove tools and / or items in the area of the pantograph.	
<u>Falling tools and / or items from vehicle roof</u> **Death, injuries** After repairs, maintenance and other work: Remove tools and other items from the vehicle roof.	
	**A T T E N T I O N**
<u>Operation of a pantograph in technically incorrect condition</u> **Damages** Only operate the pantograph if it is in technically correct condition.	

9.2 Check List

Before start up check the following:

1. Check if insulating distance according to technical data (⇨ Chapter #3).
2. Assure that the screw connection of the high voltage connection is properly fastened and well-greased (⇨ Chapter #11.3.2 and Chapter #11.3.3).
3. Check tightness of compressed air connections (⇨ Chapter #11.4.7).
4. Check if static contact force according to technical data (⇨ Chapter #3).
5. Assure that the sliding strips are seated friction free (⇨ Chapter #11.4.3.2).
6. Check turning capacity of pan head (⇨ Chapter #14.12).
7. Check if raising and lowering times are according to technical data (⇨ Chapter #3). ☑

10 Operation

	**D A N G E R**
Blocked or invalid safety units **Injuries** Never block safety units or make them invalid.	
Manual unavailable **Death, injuries, damages due to lack of information** Read manual before start-up. Always store the manual accessible for staff.	
	**A T T E N T I O N**
Operation of a pantograph in technically incorrect condition **Damages** Only operate the pantograph if it is in technically correct condition.	
	**T I P**
Follow the manual of the vehicle manufacturer.	

Operation is done from the driver’s cab.

11 Maintenance

11.1 Safety Instructions

	**D A N G E R**
Electrical current in Catenary **Death, burn-up** Catenary – Switch off and ground current. Secure against reset.	
Unsecured squeezing points at raised pantograph **Squeezing, Amputation** Lower pantograph before cleaning, maintenance, repairs or other work.	
Suspended load while transportation with crane or forklift **Death, injuries** No one is allowed to be under the pantograph while transportation.	
Falling tools or items **Death, injuries** After repairs, adjustment or maintenance: Remove tools or loose items from roof.	
Unexpected pressure **Injuries, damage of pantograph** Depressurize pneumatic system before installation work.	
	**W A R N I N G**
Injuries due to lack of protective clothing **Injuries, squeezing, cropping** Always wear protective clothing.	

11.2 Maintenance Intervals

The single arm pantograph requires a minimum of maintenance.

The required maintenance is influenced by the environmental and operational conditions, so the operator has accordingly to adapt.

11.2.1 Interval 1 – Every Week (max. 7000 km)

- Checkup
  - Sliding strips and horns for damage and wear (⇨ Chapter #11.4.3.1.)

Replace sliding strips if necessary (⇨ Chapter #11.5.3.1).

  - Check static contact force after replacement of components (⇨ Chapter #14.8).

11.2.2 Interval 2 – Every Month (max. 21.000 km)

- Checkup
  - Pantograph for obviously damaged components.
  - Check static contact force after replacement of components (⇨ Chapter #14.8).

11.2.3 Interval 3 – Every Year (max. 250.000 km)

- Checkup
  - Static contact force (⇨ Chapter #14.8).
  - Raising and lowering time acc. to technical data (⇨ Chapter #3).
  - Screw connections for proper torque and tight fit (⇨ Chapter #11.3.2).
  - Pneumatic connections for tightness (⇨ Chapter #11.4.7).
  - Functional test of valve unit ADD (⇨ Chapter #11.4.5.)
  - Pan head suspension for easy movement and damage (⇨ Chapter #11.4.3.2).
  - Rod end of parallel guide for damage (⇨ Chapter #11.4.2.1).
  - Shunts for damage (⇨ Chapter #11.4.6).
  - Cable with terminals for damage (⇨ Chapter #11.4.1).
  - Shock absorber (⇨ Chapter #11.4.4).

Replace damaged components (⇨ Chapter #11.4.8).

- Cleaning (⇨ Chapter #15)
  - Insulating hoses
- Greasing (⇨ Chapter #11.3.3)
  - Cable with terminals

11.2.4 Interval 4 – Every 2 Years (max. 500.000 km)

- Replacement of all shunts (⇨ Chapter #11.5.5).

11.2.5 Interval 5 – Every 8 Years (max. 2.000.000 km)

- Detach pantograph and pneumatic control from vehicle roof.
- Overhaul at Schunk Bahn- und Industrietechnik GmbH.
- Attach pantograph to vehicle roof.

11.3 Maintenance Instructions

11.3.1 Consumables

W A R N I N G

Injuries due to lack of protective clothing
Skin irritation, burn of respiratory system
When handling with consumables wear **safety gloves** and **respiratory protection**.

Schunk Bahn- und Industrietechnik recommend the following consumables:

Description	Product	Manufacturer
Grease	Autol Top 2000	Agip Schmiertechnik GmbH
Contact grease	Molykote HSC plus	Dow Corning
Assembly lubricant	Ceramo Paste	Metallit GmbH
Strength thread locker	Weicon Lock AN 306-38 or Loctite 270	Weicon Lock, Loctite
Thread sealant	Loctite 577	Loctite
Cleaning agent for insulators	Toluene (or cleaning solvent)	BP Chemicals
Leak detection spray	394601 Leak detection spray (Productcode 74 0137)	Metallit GmbH

11.3.2 Screw Connections

D A N G E R

Attachment of unsecured and / or used screw connections

Loosened screw connections, damages

Hex nuts according ISO 10511 and conical spring washers according BN 208010-8 must be replaced by new ones after dismounting.

All screw connections have to be checked for damage, corrosion and tight fit.

11.3.2.1 Torque for Screw Connections A2-70

Torques are valid by using an assembly lubricant.

Categorization of the screw connection according to DIN 25201-2-B

Thread [mm]	Fastening torque [Nm]	Thread [mm]	Fastening torque [Nm]
M3	1,0	M10	30,0
M4	1,8	M12	70,0
M5	3,5	M14	80,0
M6	6,0	M16	120,0
M8	15,0	M20	250,0

11.3.2.2 Screw Bonding

Some screw connections have to be secured with a high strength thread locker.

Please note the illustrated spare parts (⇨ Chapter #17).

11.3.2.3 Screw Sealing

All non self – locking pneumatic connections have to be sealed with a thread sealant.

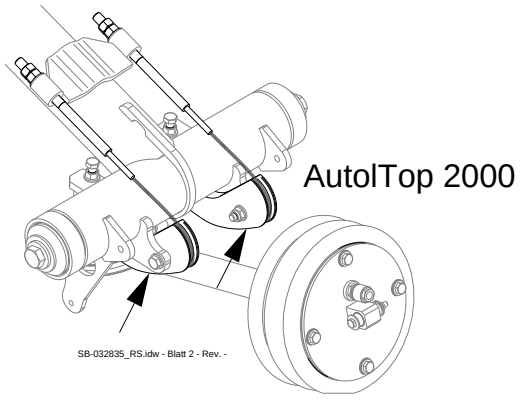
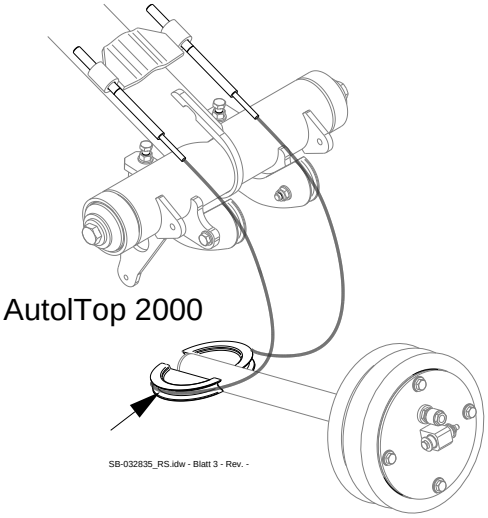
Please note the illustrated spare parts (⇨ Chapter #17).

11.3.3 Greasing

Consumables ⇨ Chapter #11.3.1

	**W A R N I N G**
Injuries due to lack of safety equipment. **Skin irritation, burn of respiratory system** When handling with consumables wear **safety gloves** and **respiratory protection**.	

The following components have to greased when they are replaced:

GREASE	
Cable with terminals at the contact surface to the cams.	
Cable with terminals at the contact surface to the cable guide.	

CONTACT GREASE
Tubular lugs of shunts
Shunt connections
Current connections
Grounding connections

ASSEMBLY LUBRICANT

All screw connections at outer thread and at contact surface of the tightened component (nut-surface or head-surface of screw).

THREAD SEALANT

All pneumatic screw connections which are not self-locking.

11.4 Checkup

11.4.1 Cable with Terminals

The **cable with terminals** has to be checked for breaks of wires and braids.

The cable with terminals has to be replaced:

- within the scheduled maintenance intervals (⇨ Chapter #11.2).
- if more than 10 single wires are broken.
- if 1 single braid is broken.

Checkup:

1. Completely raise pantograph.
2. Check cable **over its whole length** for damage:
3. Check, if the contact surfaces to lower frame, cams and cable guide are well-greased.

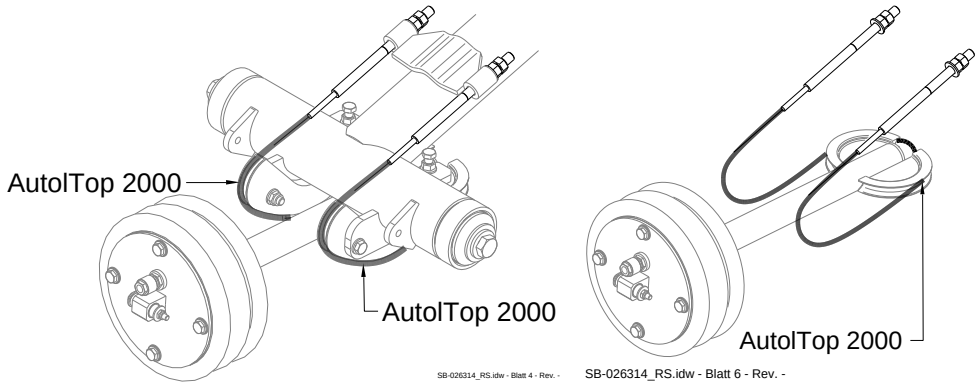


Illustration 20: EXAMPLE: Grease cable with terminals

4. Grease cable with terminals (⇨ Chapter #11.3.3). ☑

Replace damaged components if necessary (⇨ Chapter #11.5.1).

11.4.2 Parallel Guide

11.4.2.1 Rod End

The **rod end** of the parallel guide has to be checked for deformation.

Procedure:

1. Check rod end for deformation.
2. Replace damaged rod end (⇨ Chapter #11.5.2). ☑

11.4.3 Pan Head

11.4.3.1 Sliding Strip

⚠	**D A N G E R**
Dirty, coated and / or ungreased contact surface **Incorrect current flow, injuries, damages** Clean and grease contact surfaces.	
Pantograph raised PNEUMATICALLY. **Valve unit ADD responds, pantograph lowers.** NEVER raise pantograph pneumatically when replacing sliding strips. After replacement of sliding strips: check if all pneumatic connections are connected properly.	
⚠	**A T T E N T I O N**
Improper replacement of sliding strips **Damages of pantograph and infrastructure** Always replace sliding strips (or collector strips) **as pairs**.	

As a guide line to determine the intervals between visual inspections, please consider the following:

- Anticipated operating and wear life.
- Extreme weather conditions (ice, snow, rain, sleet, etc.).

The sliding strips need to be checked for damage and wear at every visual inspection:

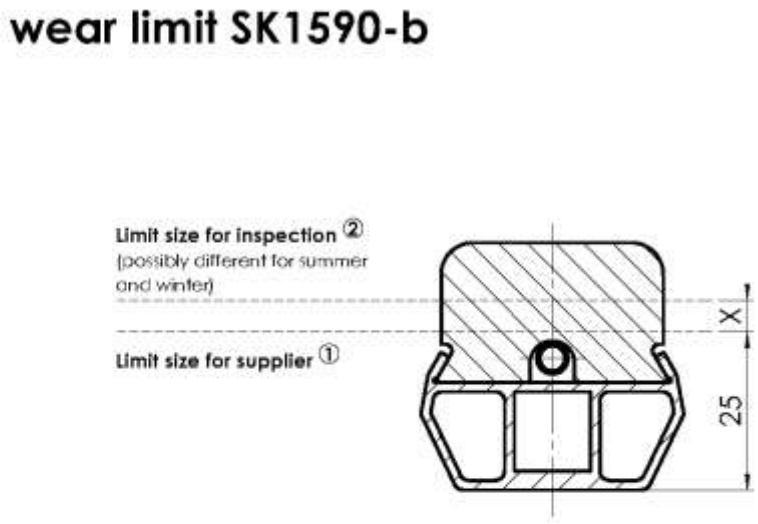
The wear of both sliding strips should happen evenly.

If wear is uneven:

- Check adjustment of parallel guide (⇨ Chapter #14.12).
- Check if pan head suspension or other parts of the pan head are damaged. ☑

Sliding strips must be replaced:

- Damage (break)
- Minimum thickness acc. to illustration (wear).



① *Limit size of supplier: Never fall short in operation*

② *Limit size of inspection: Measure for replacement of strips to avoid to fall short in operation within inspection cycle. Measure is depending on mileage between inspections.*

Illustration 21: Minimum thickness

Replace damaged components (⇨ Chapter #11.5.3).

After replacement of sliding strips:

- Check static contact force (⇨ Chapter #14.8).

11.4.3.2 Pan Head Suspension

The **pan head suspension** (leaf springs and parallel guide of rocker boxes) must be checked for function, easy motion, deformation and corrosion.

Procedure:

1. Raise and fix pantograph at medium working height.
2. Press down both sliding strips with your hands and release them abruptly.
3. Repeat this procedure for several times.

Function and easy motion are proper:
If both sliding strips can be pressed down equally and without jerky motion.
Both sliding strips spring back to their original position when released.

4. Check pan head springs for deformation and corrosion.

NEVER raise pantograph pneumatically during replacement of sliding strips.
Check if all pneumatic connections of the sliding strips are connected properly AFTER replacement.

5. Lower pantograph.
6. Replace damaged leaf springs (⇨ Chapter #17.2.8). ☑

11.4.4 Shock Absorber

The **shock absorber** must be checked for leakage.

Leaking Test:

1. Detach shock absorber (⇨ Chapter #11.5.4).
2. Extend shock absorber to maximum length.
3. Hold shock absorber vertically.

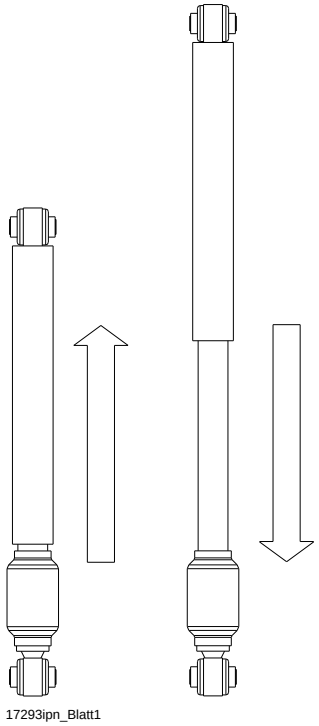


Illustration 22: Checkup of shock absorber

4. Push and pull Shock absorber for several times.

The stage between compression and tension may be max. 25 mm.
Liquid leakage is NOT allowed.

5. Replace leaking shock absorber (⇨ Chapter #11.5.4). ☑

11.4.5 Valve Unit ADD

Checkup of Function

The **valve unit ADD** must be checked for correct function.

Procedure:

1. Lower pantograph pneumatically.

NEVER attach belt at parts of the pan head.

2. Raise pantograph pneumatically and hold it by hand just over resting position.
3. Fix pantograph with belt between base frame and upper frame.
4. UNLOCK Test Valve:
    a. Detach nut (1).
    b. Detach lever (2) and turn it 180° degrees.
    c. Attach lever (2) to the valve unit ADD and fix it with the nut (1).

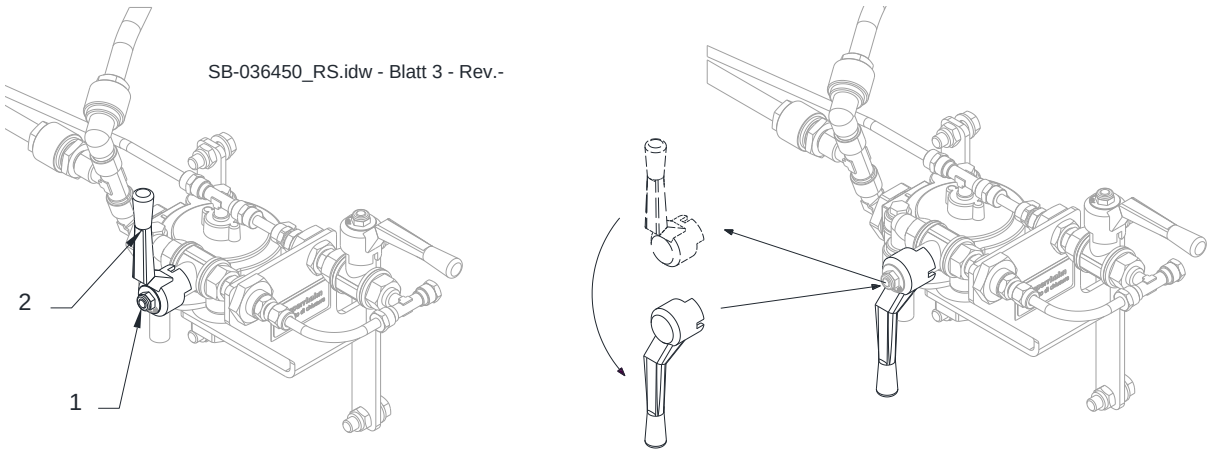


Illustration 23: UNLOCK test valve

5. OPEN Test Valve:
    a. Bring lever (2) to position OPEN:

        Air is blowing – off.

        The quick exhaust valve exhausts.

b. Release belt:

The pantograph stays in resting position.

c. Shut – off compressed air supply.

d. Fix belt between base frame and upper frame.

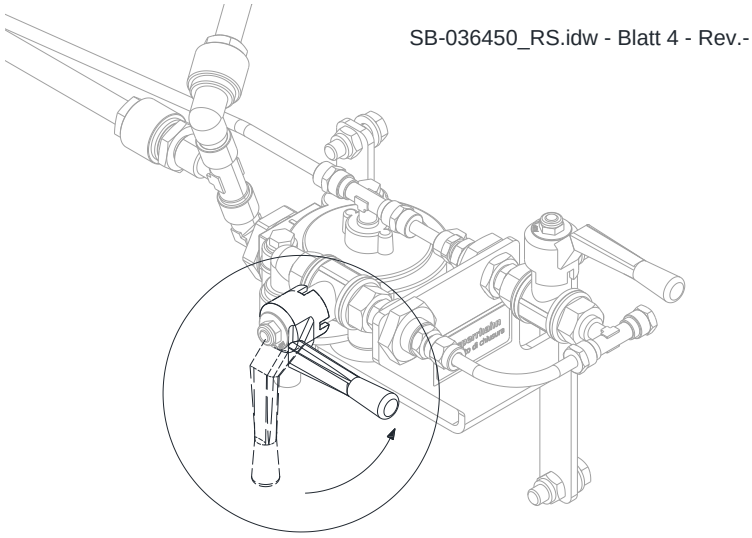


Illustration 24: OPEN test valve

6. CLOSE Test Valve:

a. Bring lever (2) to position CLOSED.

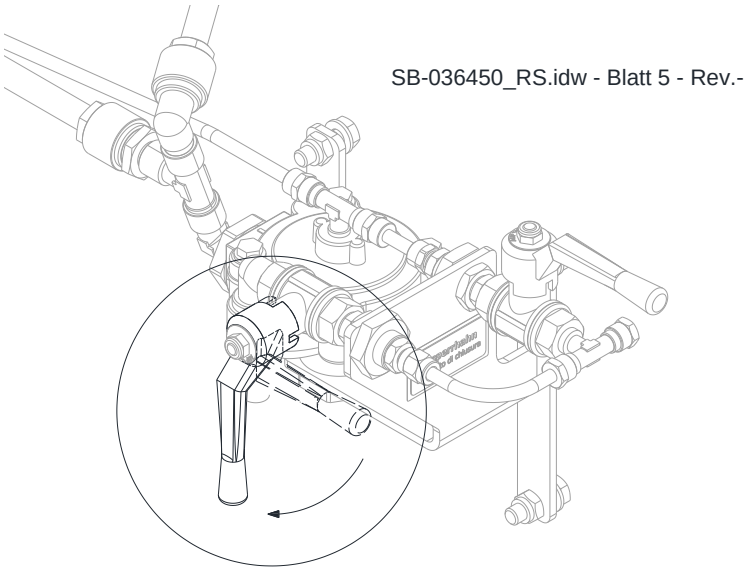


Illustration 25: CLOSE test valve

7. LOCK Test Valve:
    a. Detach nut (1).
    b. Detach lever (2) and turn it 180° degrees.
    c. Attach lever (2) to the valve unit ADD and fix it with the nut (1).
8. Switch – on compressed air supply.
9. Carefully release belt and let pantograph raise.
10. Detach belt when pantograph is fully raised.
11. Raise and lower pantograph for checkup. ☑

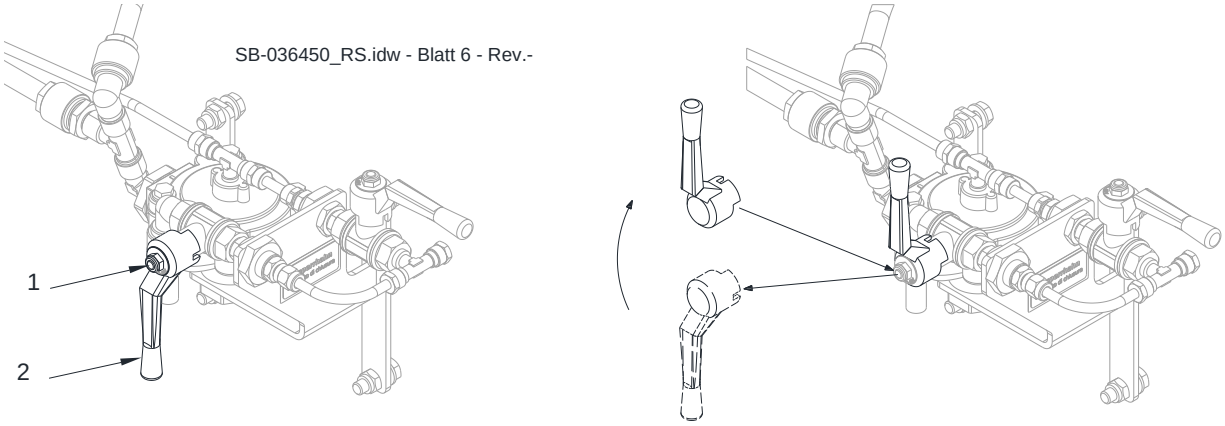


Illustration 26: LOCK test valve

11.4.6 Shunts

Shunts must be checked for damage.

Shunts must be replaced within the scheduled maintenance intervals ⇨ Chapter #11.2

Damaged shunts must be replaced.

Current connections and tubular lugs of shunts must be free from coating, blank and clean.

Procedure:

1. Check shunts for break of wires and braids:

Shunts must be replaced if **more than 5% of the wires are broken**.

2. Check contact surfaces (current connections and tubular lugs of shunts) for dirt, corrosion and / or burn-up.
   a. Detach shunts with dirty, corroded and / or burnt contact surfaces.
   b. Clean dirty contact surfaces.
   c. Grease current connections and tubular lugs of shunts (⇨ Chapter #11.3.3).
   d. Attach new shunts (⇨ Chapter #11.5.5).

11.4.7 Leak Detection

All **compressed air connections** must be checked for leakage (e.g. with a leak – detection spray (⇨ Chapter #11.3.1).

Procedure:

1. Check air connection from vehicle to valve unit ADD.
2. Check air connection from vehicle to pneumatic control.
3. Check air connection from pneumatic control to valve unit ADD.
4. Check sliding strips for damage (⇨ Chapter #11.4.3.1) and leakage.
5. Check connections from valve unit ADD to sliding strips.
6. Check connection from valve unit ADD to air bellow drive.
7. Seal leaking components.
8. Replace damaged components (⇨ Chapter #11.4.8). ☑

11.4.8 Overreach detection

The lifting height limitation must be checked annually for function and damage.

- Lower the pantograph.
- Activate lifting height limitation.
- Lift the pantograph pneumatically.
- Lift the pantograph only up to the specified height (Chapter #3).
- Check the pneumatic cylinder moves in and out without jerking

11.5 Replacement of Wear Parts

11.5.1 Cable with Terminals

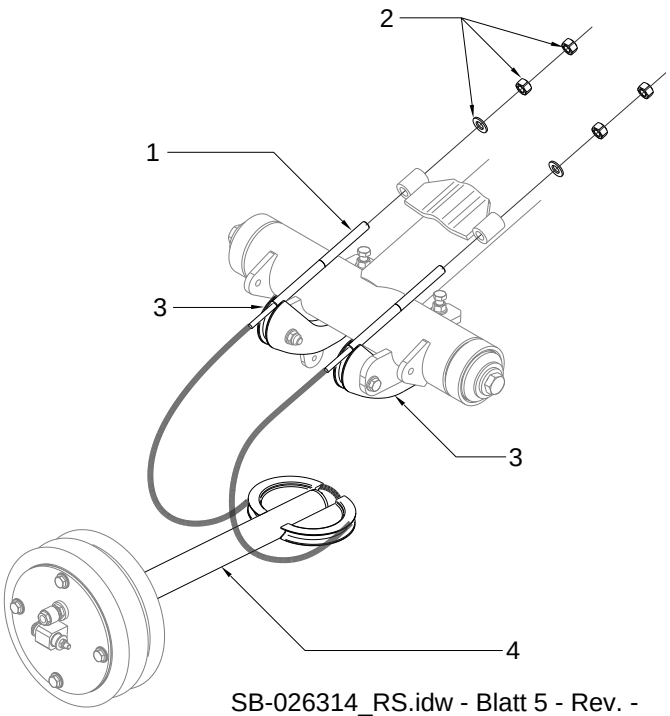


Illustration 27: Example Replace cable with terminals

Detachment:

NEVER raise pantograph pneumatically when replacing cable with terminals.

1. Assure that compressed air supply is shut-off.

Secure cable against twisting at the terminals (S).

2. Loosen screw connections (2) of cable (1).
3. Detach cable with terminals (1). ☑

Attachment:

1. Grease cable with terminals at the contact surfaces to lower frame (4), cam (3) and cable guide (5) (⇨ Chapter #11.3.3).
2. Place check nuts and washer (3) to cable with terminals (1).
3. Place cable with terminals (1) to lower frame (4), cam (3) and cable guide (6).
4. Place screw connection (2).

Secure cable against twisting at the terminals (S).
Only slightly tension the cable with terminals.

5. Slightly tension cable with terminals (1) with nuts and washer (2).
6. Checkup:

Flat side (A) of washers must show OUTSIDE.

Adjust washer if necessary.

7. Adjust air bellow drive (⇨ Chapter #14.6). ☑

11.5.2 Parallel Guide Bar

11.5.2.1 Rod End

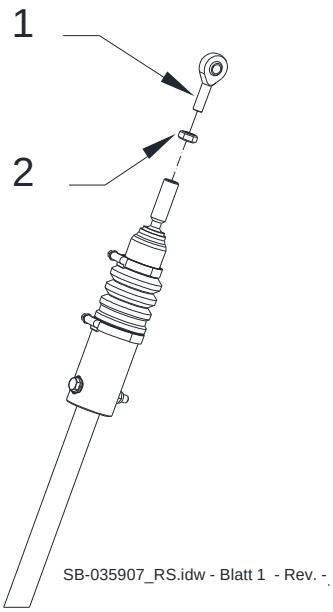


Illustration 28: Replace rod end

Detachment:

1. Loosen check nut (2).
2. Screw-out rod end (1). ☑

Attachment:

1. Grease rod end and check nut (2) (⇨ Chapter #11.3.3).
2. Place check nut (2) to rod end (1).
3. Screw-in rod end (1).
4. Fix check nut (2).
5. Adjust length of parallel guide (⇨ Chapter #14.12) ☑

11.5.3 Pan Head

11.5.3.1 Sliding Strip

D A N G E R

Pantograph raised pneumatically at replacement of sliding strips

Valve unit ADD responds, pantograph lowers

NEVER raise pantograph pneumatically when replacing sliding strips.

After replacement of sliding strips:

Check if all air pressure hoses are connected properly to the sliding strips.

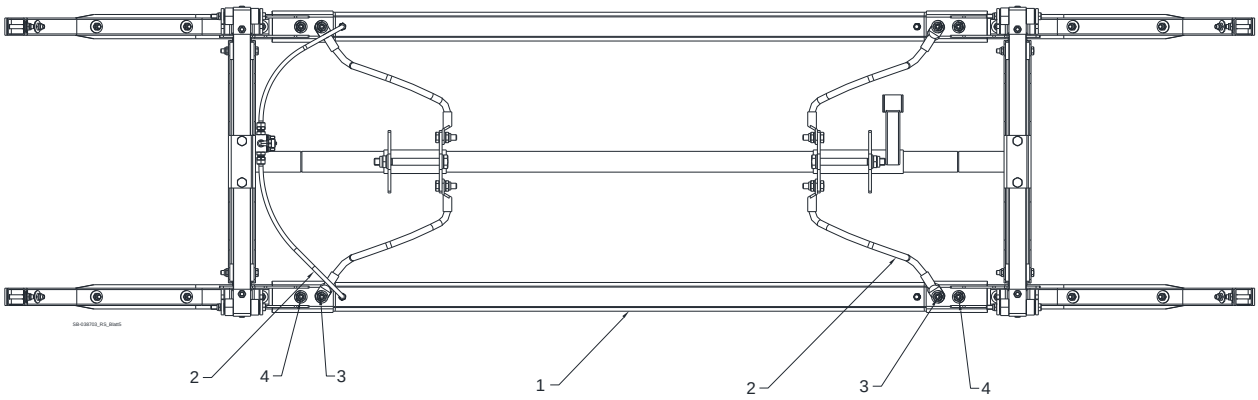


Illustration 29: Replace sliding strips

Detachment:

NEVER raise pantograph pneumatically when replacing sliding strips.

1. Assure that compressed air supply is SHUT-OFF.
2. Detach air pressure hose (2) from sliding strip and secure it against ingress of dirt (e. g. by taping).
3. Loosen screw connection – shunts to sliding strip (3).
4. Loosen screw connections (4) and detach sliding strips (1). ☑

Attachment:

1. Grease (⇨ Chapter #11.3.3) new sliding strip (1).
2. Grease (⇨ Chapter #11.3.3), place and fix (⇨ Chapter #11.3.2) screw connection (4).
3. Attach shunts to pan head and fix it with screw connection (3) (⇨ Chapter #11.5.5.4).
4. Attach air pressure hose (2) to sliding strip.

NEVER raise pantograph pneumatically when replacing sliding strips.

5. CHECKUP: All air pressure hoses are connected to the sliding strips.
6. Check static contact force (⇨ Chapter #14.8). ☑

11.5.4 Shock Absorber

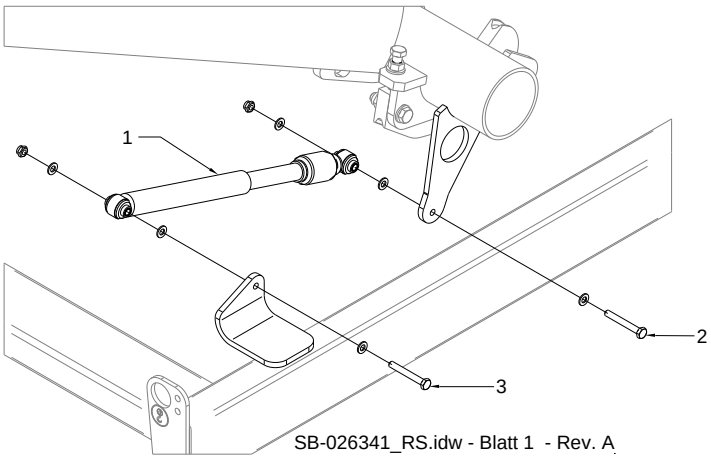


Illustration 30: EXAMPLE: Replace damper

Detachment:

1. Detach screw set (2) from lower frame.
2. Detach screw set (3) from base frame.
3. Detach shock absorber (1) ☑

Attachment:

1. Place shock absorber (1) to lower frame.
2. Grease (⇨ Chapter #11.3.3), place and fix (⇨ Chapter #11.3.2) screw connection (2).
3. Place shock absorber (1) to base frame (5).
4. Grease (⇨ Chapter #11.3.3), place and fix (⇨ Chapter #11.3.2) screw connection (3).

11.5.5 Shunts

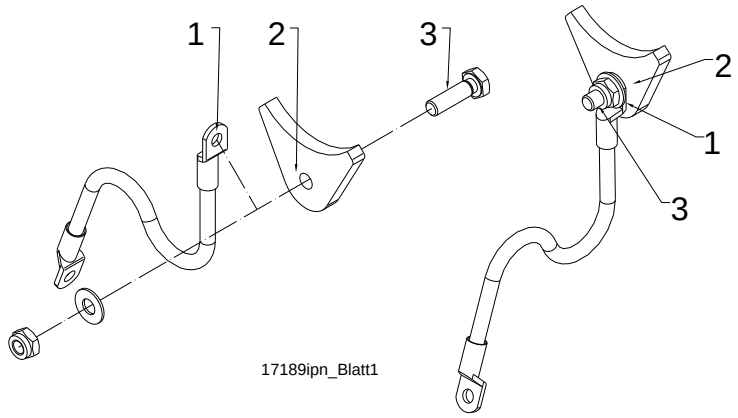


Illustration 31: Replacement of shunts

Before detaching shunts take a close look, how the shunts are attached (e. g. taking a photo, measuring a certain angle, etc.).

Attachment:

Shunt connections (2) and tubular lugs of shunts (1) must be uncoated, blank and clean.

1. Assure pantograph is in resting position.
2. Clean tubular lug (1) and contact surface (2).

If CUPAL-washers are attached, you need not grease with contact grease.

3. Grease tubular lug (1) and contact surface (2) with contact grease (⇨ Chapter #11.3.3).
4. Grease screw connection (3) (⇨ Chapter #11.3.3).
5. Attach shunts.

6. Adjust shunts to following criteria:
    a. Shunts may **never TOUCH EACH OTHER**.
    b. Shunts may **never TOUCH OTHER COMPONENTS** of the pantograph.
    c. Shunts may **never BE TENSIONED**.
    d. Shunts **MUST** always **HANG LOOSELY**.

Move shunts in proper direction.

Slightly bend tubular lugs if necessary.

Keep distance to pantograph while performing checkup.

7. Checkup:
    a. Raise and lower pantograph over whole working height.
    b. Re-adjust shunts if necessary. ☑

11.5.5.1 Base Frame to Lower Frame

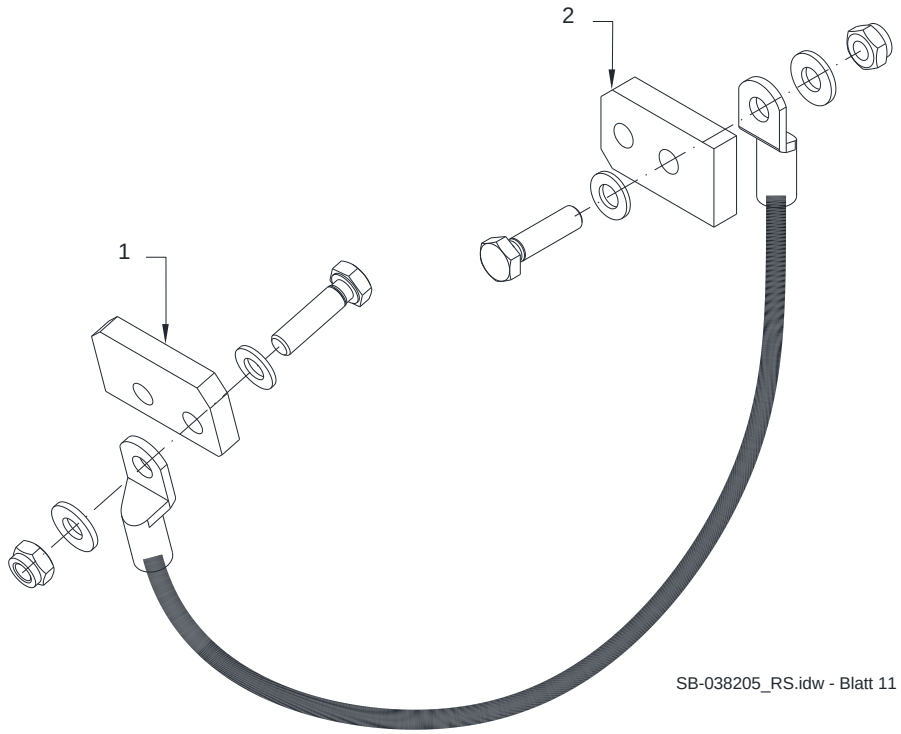


Illustration 32: Shunts between base frame and lower frame

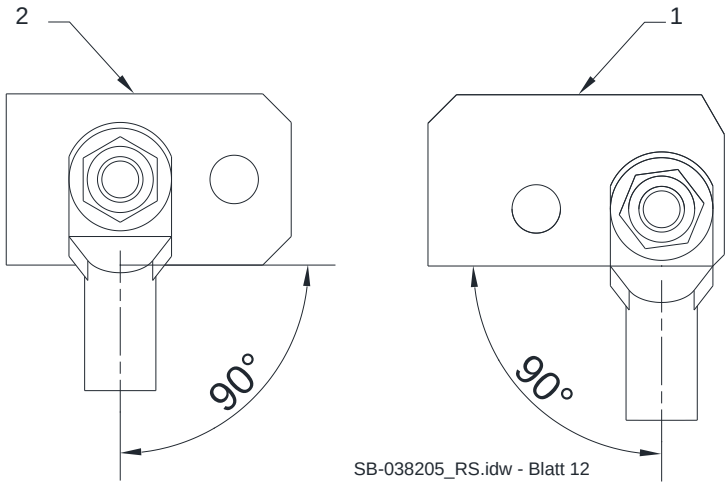


Illustration 33: Mounting angle

11.5.5.2 Base Frame to Coupling Rod

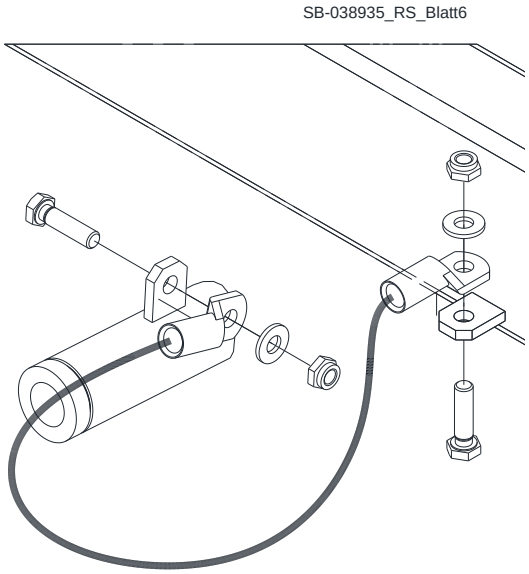


Illustration 34: Shunts between base frame and coupling rod

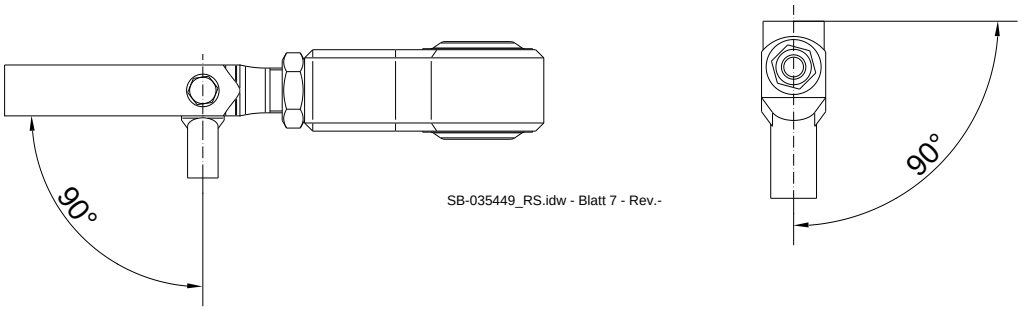


Illustration 35: Mounting angle

11.5.5.3 Upper Frame to Lower Frame

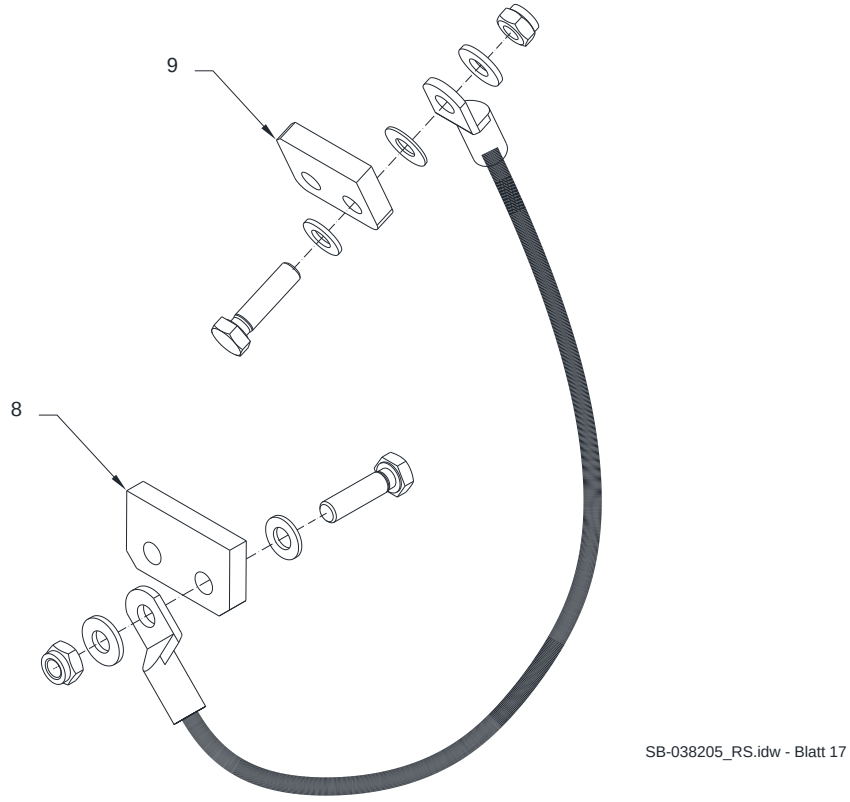


Illustration 36: Shunts between lower frame and upper frame

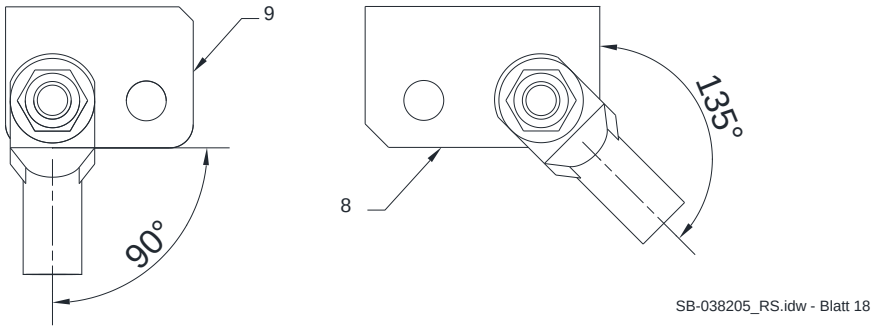


Illustration 37: Mounting angle

11.5.5.4 Upper Frame to Rocker Box / Sliding Strip

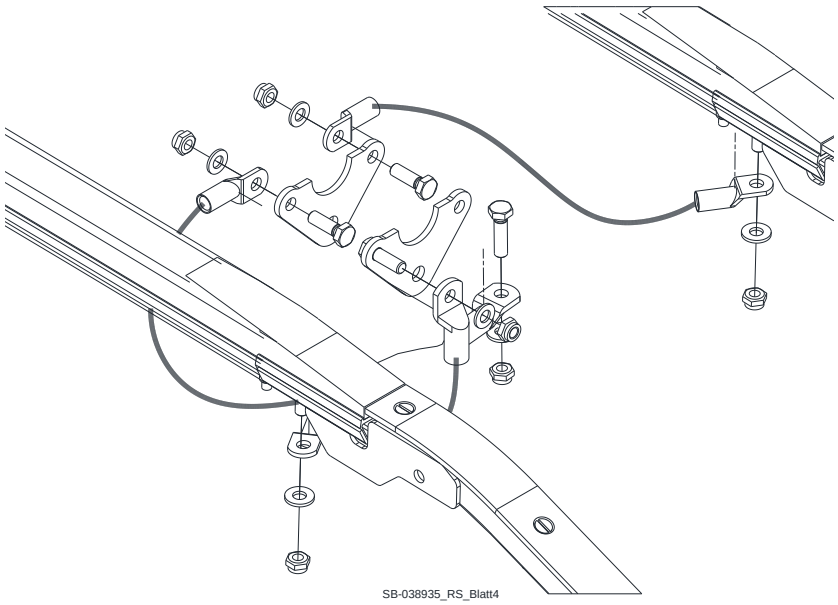


Illustration 38: Shunts between upper frame and rocker box / sliding strip

12 Troubleshooting

12.1 Safety Instructions

	**D A N G E R**
Electrical current in Catenary **Death, burn-up** Catenary – Switch off and ground current. Secure against reset.	
Unsecured squeezing points at raised pantograph **Squeezing, Amputation** Lower pantograph before cleaning, maintenance, repairs or other work.	
Suspended load while transportation with crane or forklift **Death, injuries** No one is allowed to be under the pantograph while transportation.	
Falling tools or items **Death, injuries** After repairs, adjustment or maintenance: Remove tools or loose items from roof.	
Unexpected pressure **Injuries, damage of pantograph** Depressurize pneumatic system before installation work.	
	**W A R N I N G**
Injuries due to lack of protective clothing **Injuries, squeezing, cropping** Always wear protective clothing.	

12.2 Trouble List

DEFECT	REASON(S)	CORRECTION
Pantograph does not raise or lower.	Static contact force is poorly adjusted.	CHECKUP: Static contact force ⇨ Chapter #14.8 ADJUSTMENT: Static contact force ⇨ Chapter #14.9
	Air bellow drive defective.	CHECKUP: Air bellow drive for damage REPLACEMENT: Air bellow drive ⇨ Chapter #17.2.4
	Cable with terminals torn.	REPLACEMENT: Cable with terminals ⇨ Chapter #11.5.1
	Air line defective.	REPLACEMENT: Air line
	Damper between base frame and lower frame defective.	REPLACMENT: Shock absorber ⇨ Chapter #11.5.4
	Inner friction of pantograph too high.	CHECKUP: Static contact force ⇨ Chapter #14.8
		CHECKUP: Pantograph for damaged components. REPLACEMENT: Damaged components
	Valve unit ADD responds.	CHEKCUP: Leaking test ⇨ Chapter #11.4.7 Functional test ⇨ Chapter #11.4.5

DEFECT	REASON(S)	CORRECTION
Frequent interruption of current transmittal (strong arcing).	Static contact force is poorly adjusted.	CHECKUP: Static contact force ⇨ Chapter #14.8 ADJUSTMENT: Static contact force ⇨ Chapter #14.9
	Inner friction of pantograph too high.	CHECKUP: Static contact force (⇨ Chapter #14.8)
		CHECKUP: Pantograph for damaged, especially bearings. REPLACEMENT: Damaged components
	Sliding strips damaged.	REPLACEMENT: Sliding strips (as pairs) ⇨ Chapter #11.5.3.1
	Stiff pan head suspension.	REPLACEMENT: Rocker boxes (⇨ Chapter #17.2.8.)
	Parallel guide poorly adjusted.	ADJUSTMENT: Turning capacity of pan head ⇨ Chapter #14.12
Uneven wear of sliding strips.	Parallel guide poorly adjusted.	ADJUSTMENT: Turning capacity of pan head ⇨ Chapter #14.12
Cable torn	Cable with terminals ungreased	REPLACEMENT: Cable w. terminals (⇨ Chapter #11.5.1) GREASING: Cable w. terminals (⇨ Chapter #11.3.3)
	Air bellow drive poorly adjusted.	REPLACEMENT: Cable w. terminals (⇨ Chapter #11.5.1) ADJUSTMENT: Air bellow drive (⇨ Chapter #14.6)

DEFECT	REASON(S)	CORRECTION
Air bellow drive defective.	Loosened screw connections.	FASTEN: Loosened screw connections ⇨ Chapter #11.3.2
	Leaking air line.	CHECKUP: Leaking test ⇨ Chapter #11.4.7 REPLACEMENT: Air line ⇨ Chapter #4.2.5
	Bellow cylinder leaking.	REPLACEMENT: Air bellow drive ⇨ Chapter #17.2.4

13 Disassembly

13.1 General Information

Prior to disassembling pantograph components, please study the spare parts catalogue and inform yourself about the relationship of the individual component parts (⇨ Chapter #17).

13.2 Safety Instructions

	**D A N G E R**
Electrical current in Catenary **Death, burn-up** Catenary – Switch off and ground current. Secure against reset.	
Unsecured squeezing points at raised pantograph **Squeezing, Amputation** Lower pantograph before cleaning, maintenance, repairs or other work.	
Suspended load while transportation with crane or forklift **Death, injuries** No one is allowed to be under the pantograph while transportation.	
Falling tools or items **Death, injuries** After repairs, adjustment or maintenance: Remove tools or loose items from roof.	
Unexpected pressure **Injuries, damage of pantograph** Depressurize pneumatic system before installation work.	
	**W A R N I N G**
Injuries due to lack of protective clothing **Injuries, squeezing, cropping** Always wear protective clothing.	

13.3 Detachment from Vehicle

Electrical current in catenary.

From inside vehicle:

1. Switch off current in catenary.
2. Secure against reset.
3. Ground catenary.
4. Lower pantograph to resting position.

Unexpected pressure of pneumatic system.

5. Switch off compressed air supply.

On vehicle roof:

1. Detach high voltage connections between pantograph and vehicle.
2. Detach pneumatic connections between pantograph and vehicle.
3. Secure pantograph at the transport hooks (⇨ Chapter #7) with proper belt.
4. Detach pantograph from insulators.

Remove tools or loose items from vehicle roof.
No person is allowed under the suspended load.

5. Lift pantograph off vehicle roof. ☑

14 Adjustment Procedures

14.1 Safety Instructions

	**D A N G E R**
Electrical current in Catenary **Death, burn-up** Catenary – Switch off and ground current. Secure against reset.	
Unsecured squeezing points at raised pantograph **Squeezing, Amputation** Lower pantograph before cleaning, maintenance, repairs or other work.	
Suspended load while transportation with crane or forklift **Death, injuries** No one is allowed to be under the pantograph while transportation.	
Falling tools or items **Death, injuries** After repairs, adjustment or maintenance: Remove tools or loose items from roof.	
Unexpected pressure **Injuries, damage of pantograph** Depressurize pneumatic system before installation work.	
	**W A R I N N G**
Injuries due to lack of protective clothing **Injuries, squeezing, cropping** Always wear protective clothing.	

14.2 General Information

Detach shock absorber while performing adjustment procedures (⇨ Chapter #11.5.4).
Otherwise results will be falsified.

Each pantograph has been properly adjusted by the manufacturer. After repair, replacement of components or disassembly the following adjustment procedures have to be executed:

1. Checkup of resting position.
2. Adjustment of resting position.
3. Adjustment of support springs.
4. Adjustment of air bellow drive.
5. Adjustment of Blow – Off valve.
6. Checkup of static contact force.
7. Adjustment of static contact force.
8. Adjustment of trend of static contact force.
9. Adjustment of raising and lowering time.
10. Adjustment of turning capacity of pan head.
11. After all adjustment procedures have been done, the shock absorber must be attached again (⇨ Chapter #11.5.4). ☑

14.3 Checkup of Resting Position

Procedure:

1. Lower pantograph.
2. Attach spirit level over the whole length of the pantograph.
3. Adjust spirit level at highest point of the pantograph.
4. Measurement of resting position.
5. Compare measured value to value from technical data (⇨ Chapter #3).

The highest point of the pantograph may not exceed the resting position.

If the measured value differs from the value of technical data:

6. Adjust resting position (⇨ Chapter #14.4). ☑

14.4 Adjustment of Resting Position

Resting position is adjusted according to the value of technical data (⇨ Chapter #3).

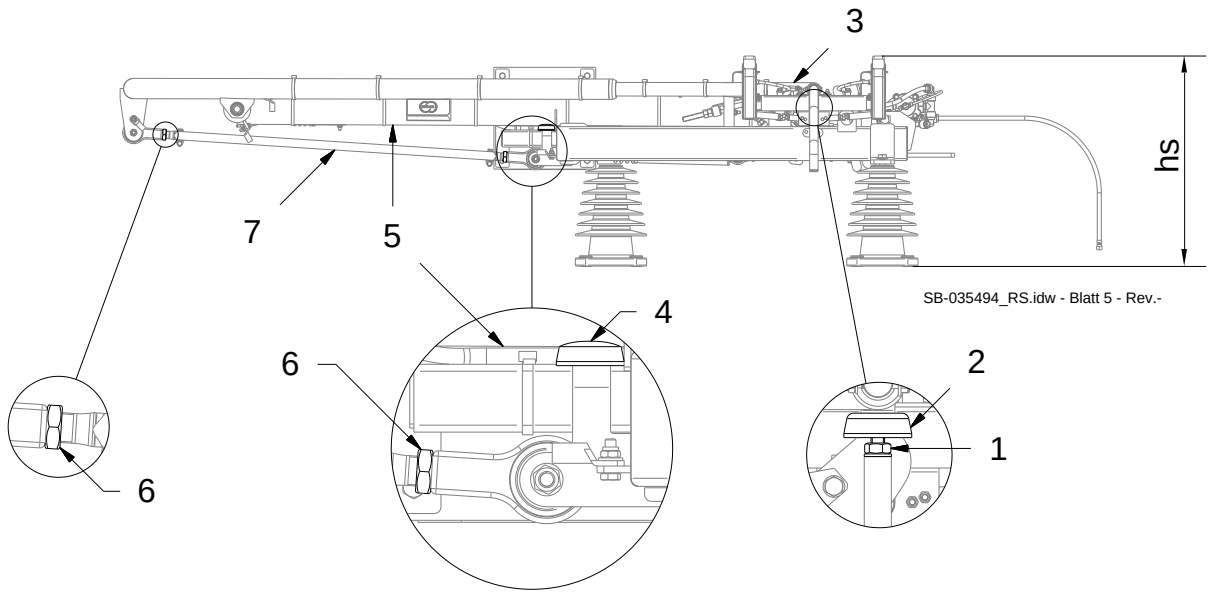


Illustration 39: EXAMPLE: Adjustment of resting position (h_s)

Procedure:

Checkup of resting position (h_s): ⇨ Chapter #14.3

Adjust limit stops for upper frame:

1. Loosen check nut (1).
2. Completely screw-in limit stop (2) for upper frame (3).
3. Screw-out both limit stops (2) equally.
4. Screw-out limit stops (2) until you reach proper resting position.
5. Fix check nuts (1) of limit stops (2).

Change Length of Coupling Rod:

1. Loosen check nuts (6).
2. Lengthen coupling rod:
    a. Turn rod (7) until lower frame (5) loses contact to the limit stop (4).
3. Shorten coupling rod:
    a. Turn rod (7) until lower frame (5) rests on limit stop (4).
    b. Fix check nuts (6).

Both adjustment procedures must be checked and/or fine-tuned until:

- you reach **correct resting position** (h_S) (⇨ Chapter #3)
- AND the **upper frame** (3) rests on **limit stops** (2)
- AND the **lower frame** (5) rests on **limit stop** (4). ☑

By changing the length of the coupling rod, geometry of the pantograph has been modified.
Check trend of static contact force (⇨ Chapter #14.10).
Adjust static contact force, if necessary (⇨ Chapter #14.9).

14.5 Adjustment of Support Springs

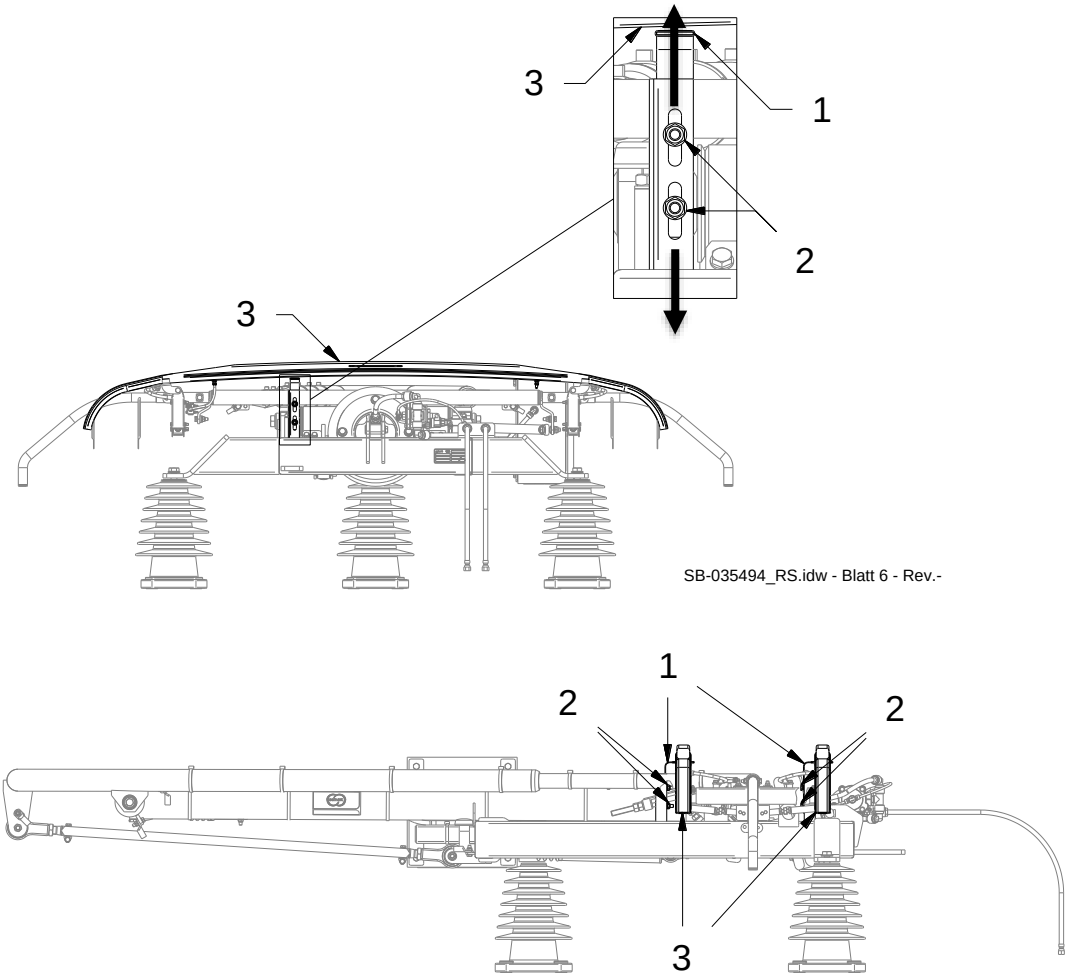


Illustration 40: EXAMPLE: Adjust support springs

Procedure:

1. Loosen screw connection (2).
2. Adjust support springs (1) by sliding:

Both sliding strips (3) must **rest on support springs** (1) **horizontal** and **at same height.**

3. Fix screw connection (2).
4. Checkup of resting position (⇨ Chapter #14.3). ☑

14.6 Adjustment of Air Bellow Drive

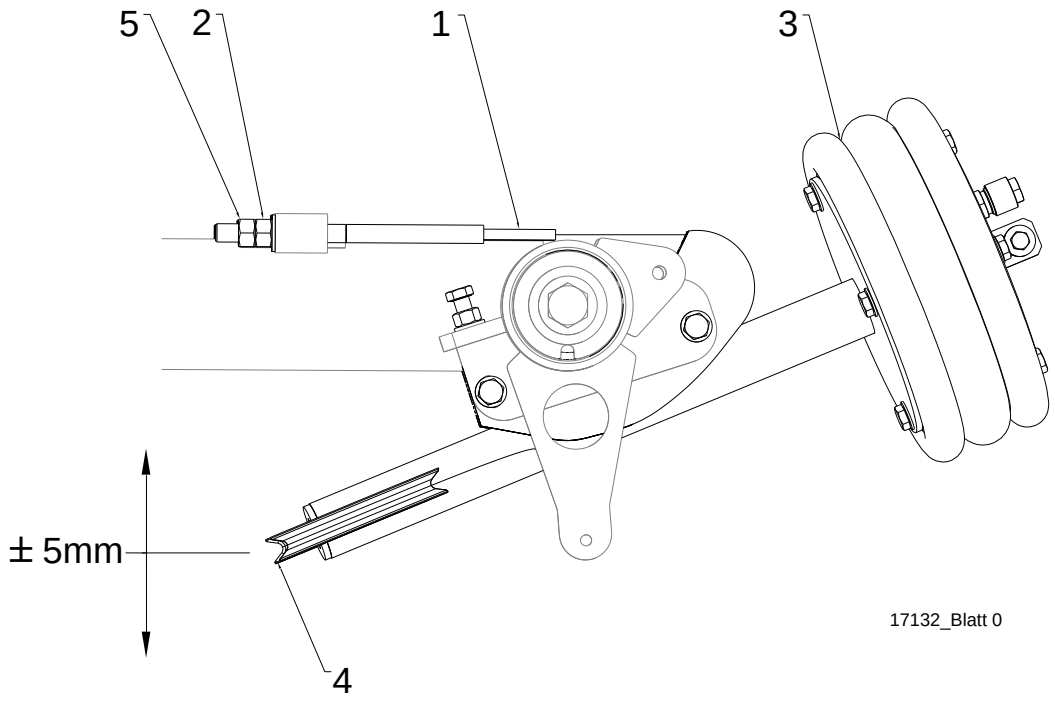


Illustration 41: Adjustment of air bellow drive

Procedure:

Secure cable against twisting ONLY at the secured ends of the cable.

1. Secure cable (1) against twisting.
2. Tension cable (1) with the adjustment nut (2).

At the end of the cable guide (4) the air bellow (3) must have free movement of **5mm** upwards and **5mm** downwards.

3. Slowly raise the pantograph:

The air bellow has to open constantly over the whole working height.

4. Raise and lower the pantograph for several times.
5. Check air bellow again for 5mm -movement upwards and downwards.

Repeat the adjustment if the air bellow can be moved more than 5mm upwards and downwards.

6. Fix lock nut (5). ☑

14.7 Adjustment of Blow-Off Valve

The pressure limiting valve (PLV1 ⇨ Chapter #Appendix A) is properly adjusted by the manufacturer. The blow-off valve must be adjusted if there is a change of operating pressure or if the blow-off valve has been replaced.

Procedure:

1. Loosen check nut (2).

☞ **Adjust exhaust pressure 0,4 bar higher than the operating pressure of the pressure regulation valve stage 2.**

2. Adjustment is done by turning the adjustment screw (3).

Turning **CLOCKWISE**	Exhaust pressure **INCREASES**
Turning **COUNTER-CLOCKWISE**	Exhaust pressure **DECREASES**

3. Fix check nut. ☑

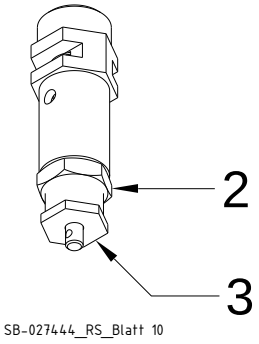


Illustration 42: Adjustment of blow off valve

14.8 Checkup of Static Contact Force

The static contact force has to be checked after every replacement of the sliding strips. The static contact force can be checked with a spring scale or the Schunk KM 11 unit.

For adjustment procedures, the damper must be removed or else results will be falsified.

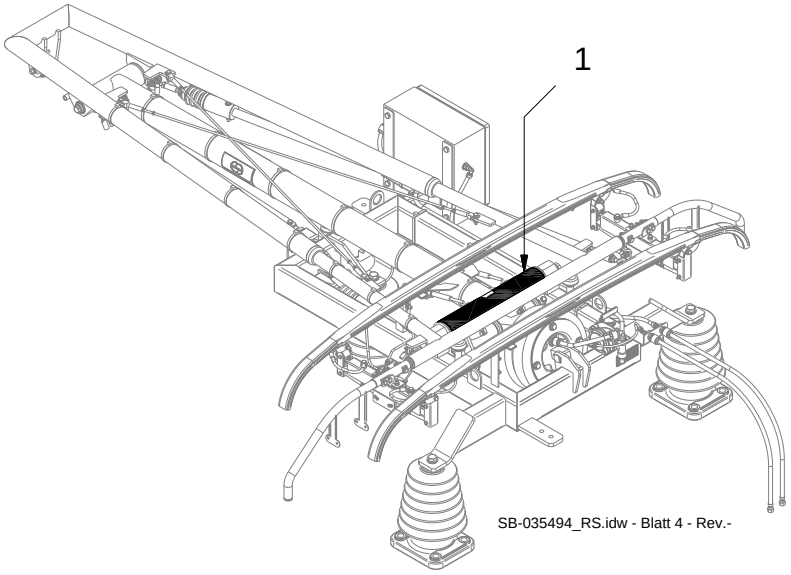


Illustration 43: EXAMPLE: Attachment of measuring device

Procedure:

1. Assure that the damper is detached.
2. You can find the value of the static contact force in technical data (⇨ Chapter# 3).

NEVER attach measuring device to parts of the pan head.
Measuring devices MAY NEVER rub at pantograph parts.

3. Attach measuring device (spring scale or KM11 device) to the middle of the cross tube of upper frame (1).
4. Let pantograph move upwards (▲) to highest position with the measuring device **(50 mm/s speed)**.
5. Let pantograph move downwards (▼) to resting position with the measuring device **(50 mm/s speed)**.

When using a spring scale:

1. Raise and lower pantograph three times.
    a. Take down value1 when raising.
    b. Take down value 2 when lowering.
2. Calculate result:

Value 1	Measuring of static contact force when slowly raising to highest position.
Value 2	Measuring of static contact force when slowly lowering to resting position.
Median static contact force	(value 1 + value 2) / 2
Friction	Balance of static contact force between value1 and value 2

3. Find tolerances:

EN50206-1, Annex A contains tolerances for the balance of the static contact force.

4. When balance is too high:

Search for causes (damaged component, dirty bearings, etc.) and remove them. ☑

After all adjustment procedures have been done, the shock absorber must be attached again (⇨ Chapter #11.5.4).

14.9 Adjustment of Static Contact Force

The value of the median static contact force has been adjusted by the manufacturer. The adjustment has to be checked and re-adjusted if necessary (⇨ Chapter #3).

The static contact force is adjusted with the pressure regulation valve (PRV1 ⇨ Chapter #Appendix A) of the pneumatic control.

Procedure:

For adjustment procedures, the pantograph must be equipped with new slinding strips.

1. Loosen check nut (2).
2. The static contact force is adjusted with the adjustment screw (2) of the pressure regulation valve.

At VERY FIRST adjustment:
Completely screw-out adjustment screw counter-clockwise.

Turning **CLOCKWISE**	= Static contact force **INCREASES**
Turning **COUNTER.-CLOCKWISE**	= Static contact force **DECREASES**

3. Raise pantograph pneumatically.
4. Check static contact force (⇨ Chapter #14.8).
5. Fix check nut (2). ☑

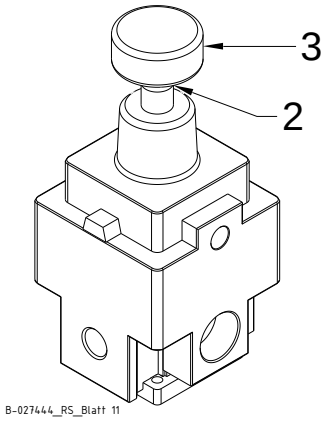


Illustration 44: Adjustment of PRV1

14.10 Adjustment of Trend of Static Contact Force

The static contact force must be almost constantly over the whole working height. This is achieved by the adjustment of cam.

For adjustment procedures, the damper must be removed or else results will be falsified.

14.10.1 Adjustment of Cam

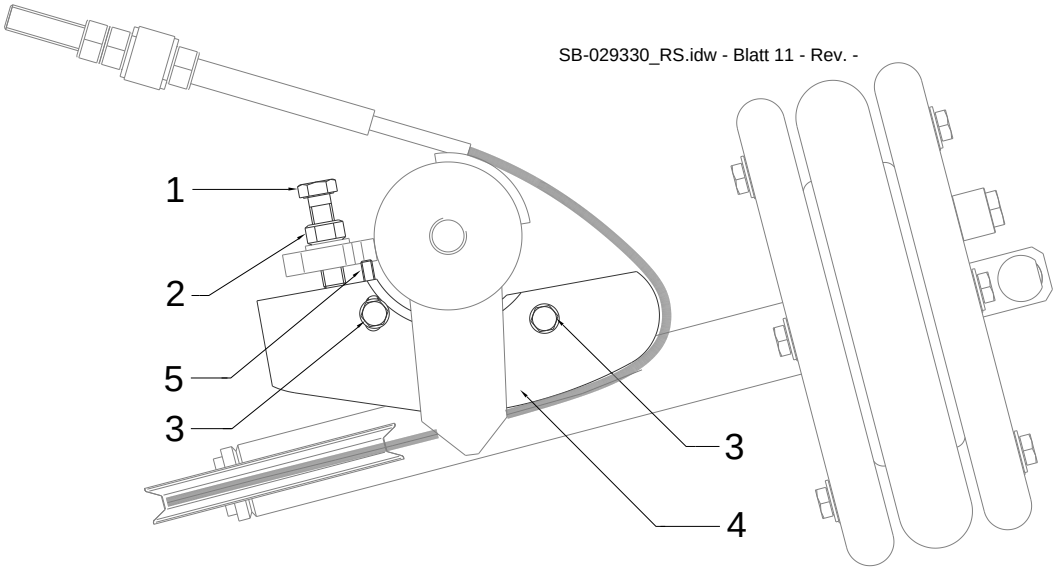
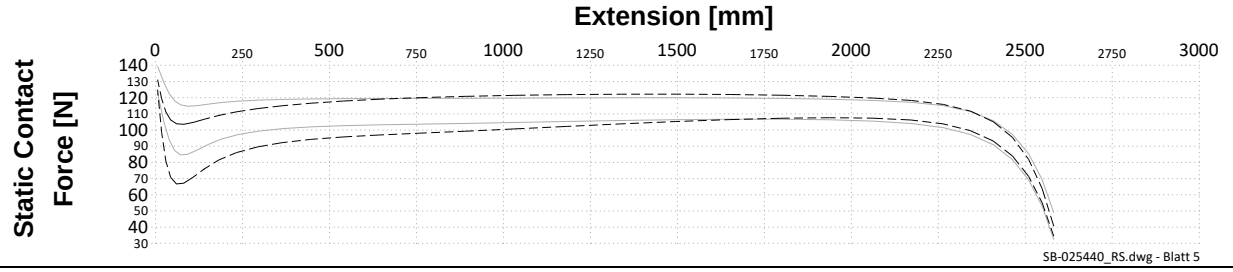


Illustration 45: EXAMPLE: Adjust cam

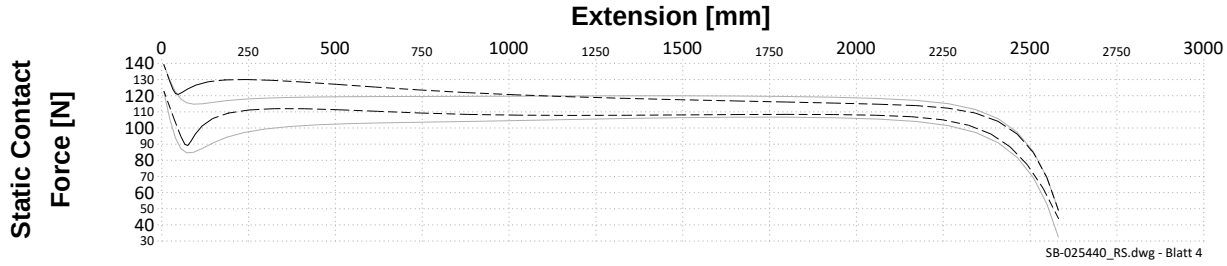
Procedure:

1. Loosen screw connection (3) of cam (4).
2. Loosen check nut (2).
3. Screw – out hexagon socket set screw (5) until it does NOT touch the screw set (3) any more.
4. Adjustment is done by turning the adjustment screw (1) of the cam (4):

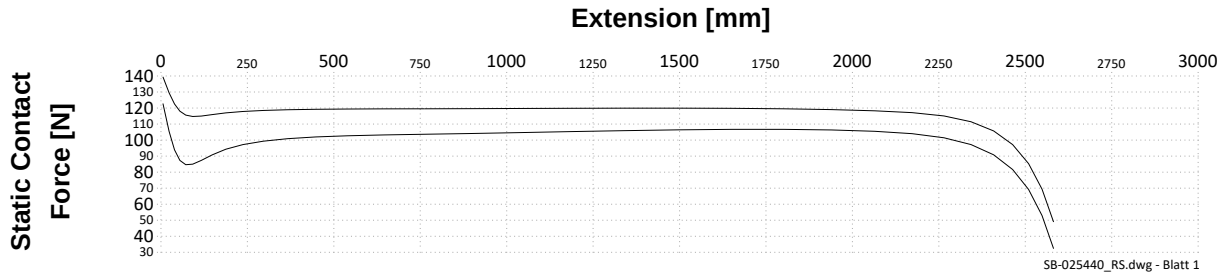
Turning **CLOCKWISE** = Static contact force **increases** in the lower part of working height.



Turning **COUNTER-CLOCKWISE** = Static contact force **decreases** in the lower part of working height.



Adjust until the trend of static contact force is almost constantly over the whole working range:



5. Check static contact force with a spring scale or the Schunk KM11 device (⇨ Chapter #14.8).
6. Screw – in hexagon socket set screw (5) until it touches screw set (3).
7. Fix check nut (2).

8. Fix screw connection (3) of cam (4). ☑

If the result is not satisfactory, the adjustment can be fine-tuned by adjusting the length of the coupling rod (⇨ Chapter #14.10.2).

14.10.2 Adjustment of Length of Coupling Rod

You only need to perform this adjustment procedure if the trend of static contact force is not satisfactory after adjustment of cam. (⇨ Chapter #14.10.1)

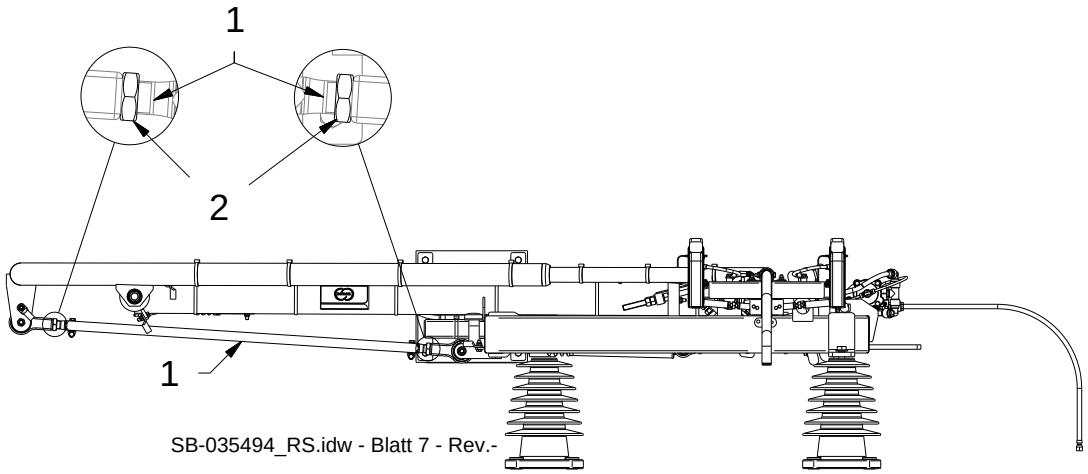


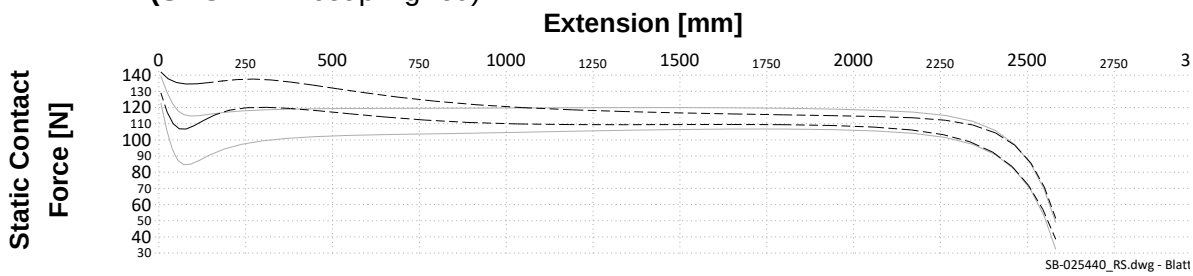
Illustration 46: EXAMPLE: Adjust length of coupling rod

Procedure:

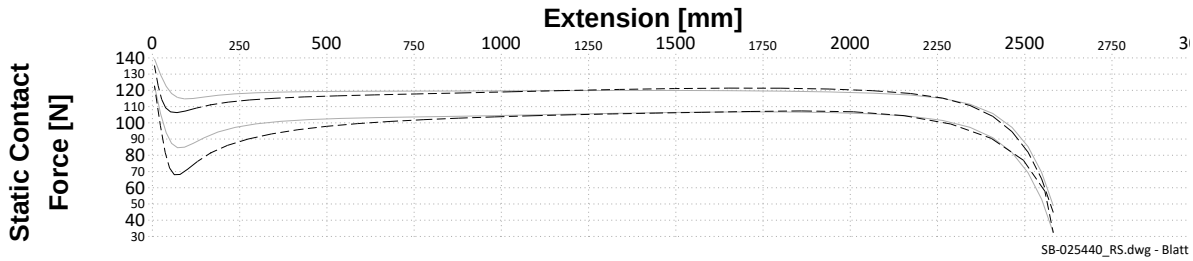
1. Assure pantograph is in resting position.
2. Loosen check nuts (2) at base frame and at upper frame.
3. Adjustment is done by turning the coupling rod tube (1):

Perform adjustment in ¼-turnings.

Turning **CLOCKWISE** **(SHORTEN** coupling rod) **= Static contact force increases** in the lower working height / **friction decreases**



Turning **COUNTER-CLOCKWISE** **(LENGTHEN** coupling rod) **= Static contact force decreases** in the lower working height / **friction increases**



4. Checkup:

The upper frame has to rest on the Limit stops.

6. Fix check nuts (2).
5. Check trend of static contact force.
6. Check resting position (⇨ Chapter #14.3).
7. Repeat adjustment if necessary. ☑

By changing the length of the coupling rod, geometry of the pantograph has been modified.
Check trend of static contact force (⇨ Chapter #14.10).
Adjust static contact force, if necessary (⇨ Chapter #14.9).

14.11 Adjustment of Raising and Lowering Time

Raising and lowering time are adjusted with the throttle relief valve (TRV1) and the throttle silencer (TV1) of the pneumatic control. Valve and silencer are properly adjusted by the manufacturer.

After attachment of the pantograph at the vehicle roof, check adjustment and adapt if necessary.

The **raising time** is adjusted with the **throttle relief valve (TRV1** ⇨ Chapter #Appendix A**)**.

The **lowering time** is adjusted with the **throttle silencer (TV1** ⇨ Chapter #Appendix A**)**.

Procedure:

At VERY FIRST adjustment:
Completely screw-in adjustment screws (pantograph does not move).
Slowly screw-out adjustment screws.

1. Loosen check nut (3,4).
2. Adjust raising time:

Screw-**IN** adjustment screw (5)	Raising / Lowering time **INCREASES**
Screw-**OUT** adjustment screw (5)	Raising / Lowering time **DECREASES**

Adjust throttle relief valve (TRV1) until pantograph raises within the desired time (⇨ Chapter #3).

3. Adjust lowering time:

4. Adjust throttle silencer (TV1) until pantograph lowers within the desired time (⇨ Chapter #3).

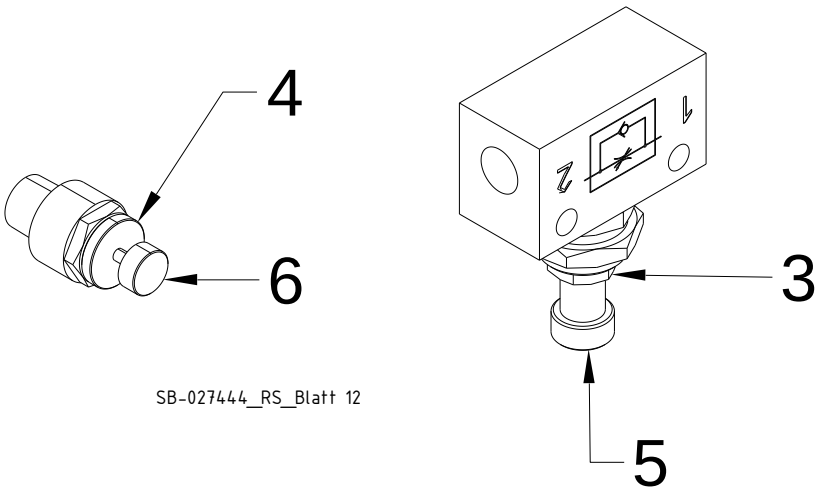


Illustration 47: Adjustment of TRV1 and TV1

Screw-**IN** adjustment screw (6)	Raising / Lowering time **INCREASES**
Screw-**OUT** adjustment screw (6)	Raising / Lowering time **DECREASES**

5. Fix check nuts (3,4). ☑

14.12 Adjustment of Turning Capacity of Pan Head

The pan head has to turn freely from horizontal position in both directions and over the whole working range. The turning capacity is mechanically restricted by the length of the parallel guide bar.

Adjustment is done by turning the rod end of the parallel guide.

Start adjustment in median working height.

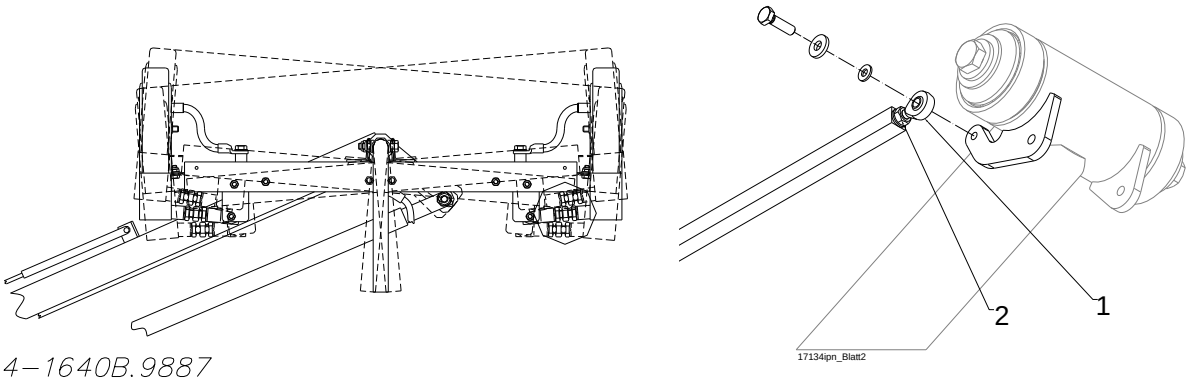


Illustration 48: EXAMPLE: Adjustment of turning capacity of pan head

Procedure:

1. Dismount parallel guide from lower frame.
2. Loosen check nut (2).
3. Adjustment is done by screwing-in and screwing-out the rod end (1) of the parallel guide.
4. Fix check nut (2).
5. Check adjustment once again. ☑

15 Cleaning

	**W A R N I N G**
<u>Injuries due to lack of safety equipment.</u> **Skin irritation, burn of respiratory system** When handling with consumables wear **safety gloves** and **respiratory protection**.	
	**A T T E N T I O N**
<u>Dirty components</u> **Wear and / or damage of components** Adapt your cleaning intervals to your environmental conditions. Clean components regularly.	

The soiling process is accelerated if the component is not cleaned during its service life, or if it is cleaned only irregularly or improperly. Depending on influencing conditions, this may lead to irreparable surface defects (e.g. corrosion, chalking, etc.) and even to a complete loss of decorative appearance.

The component must be cleaned more frequently when operating in areas of environmental pollution, for example in regions with increased salt contamination and/or chemical exhausts, meaning in a direct area of influence or within the vicinity of an industrial or chemical enterprise, or in the immediate vicinity of a sea coast or within a defined chemical/radioactive precipitation zone.

15.1 General Cleaning Instructions

- Only use clean water, with slight additives of neutral washing agents (pH 7), additionally use soft, non-abrasive cloths, rags or industrial cotton. Avoid Strong rubbing.
- Greasy, oily or sooty substances can be removed with white spirit which is free of aromatic compounds or with isopropyl alcohol (IPA). Residues of adhesives, silicone cartouche or adhesive tapes, etc. can also be removed in this way.
- Use no solvents or similar agents, containing ester, ketones, polyhydric alcohol, aromatics, ethylene glycol or halogenated hydrocarbon.
- Never use strong acids or alkaline detergents.
- Immediately rinse with clean cold water after every cleaning procedure.

15.2 Cleaning Instructions for Insulators and Insulating Hoses

- Clean dirty insulators and insulation hoses regularly.
- Remove dirt with clear water.

The forming of individual water drops (hydrophobia) at the surface is an indication for proper cleaning.

If there is greasy / oily staining or if there is continuous moistening instead of individual water drops, an exhalable solvent (e.g. toluene) may be applied.

	A T T E N T I O N
	Solvent remaining on the surface **Damage of the surface** Put solvent on a lintless cloth. NEVER leave the cloth on the surface.

16 Disposal

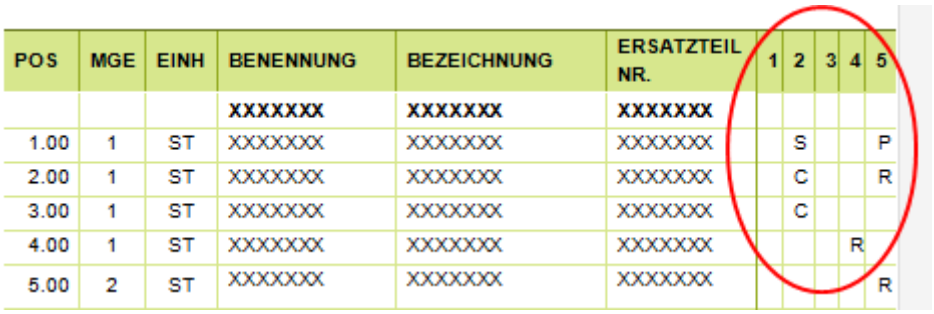
The pantograph does not contain forbidden or declarable substances.
The pantograph does not contain batteries or accumulators.
There are not restrictions in transportation due to hazardous substances.

After disassembling the components can be separated by material and disposed.

17 Spare Parts

17.1 General Information

In the spare parts catalogue, you can find detailed information relating to maintenance.



POS	MGE	EINH	BENENNUNG	BEZEICHNUNG	ERSATZTEIL NR.	1	2	3	4	5
			XXXXXXX	XXXXXXX	XXXXXXX					
1.00	1	ST	XXXXXXX	XXXXXXX	XXXXXXX		S			P
2.00	1	ST	XXXXXXX	XXXXXXX	XXXXXXX		C			R
3.00	1	ST	XXXXXXX	XXXXXXX	XXXXXXX		C			
4.00	1	ST	XXXXXXX	XXXXXXX	XXXXXXX				R	
5.00	2	ST	XXXXXXX	XXXXXXX	XXXXXXX					R

Illustration 49: Maintenance intervals mentioned in spare part catalogue

Each row represents one maintenance interval:

1	Interval 1	Every Week (max.7000 km)
2	Interval 2	Every Month (max. 21.000 km)
3	Interval 3	Every Year (max. 250.000 km)
4	Interval 4	Every 2 Years (max. 500.000 km)
5	Interval 5	Every 8 Years (max. 2.000.000 km)

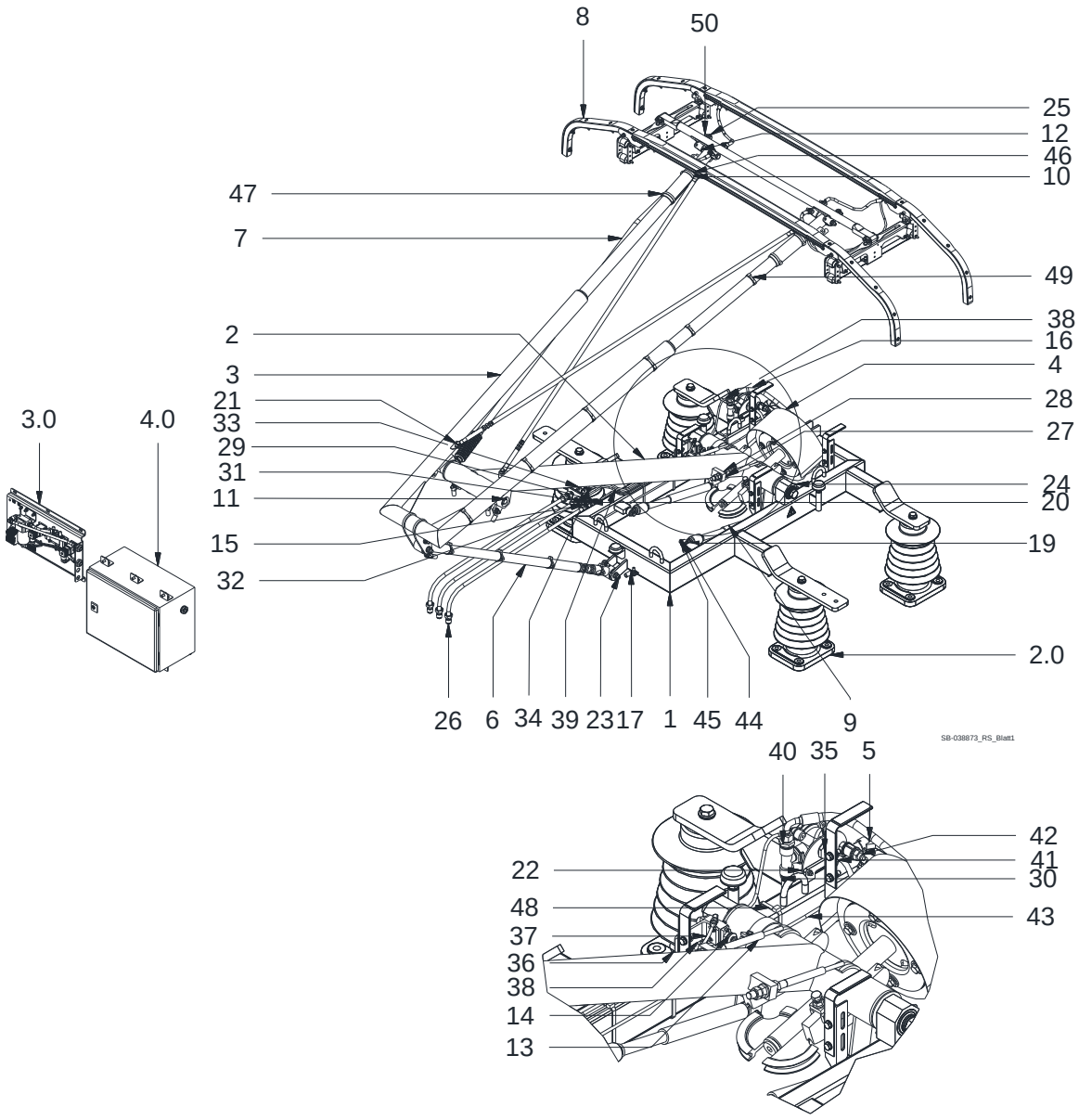
The letters represent the kind of maintenance work:

C	Checkup
G	Greasing
P	Coating
R	Replacement
S	Cleaning
O	Overhaul

In case of an order please indicate:

- **Model** and **serial number** of the single arm pantograph
- **Spare part number**
- Requested **quantity** of spare parts

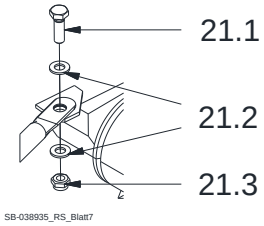
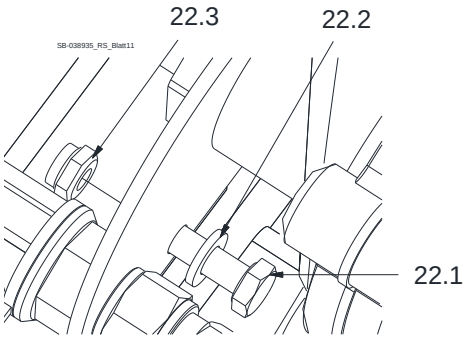
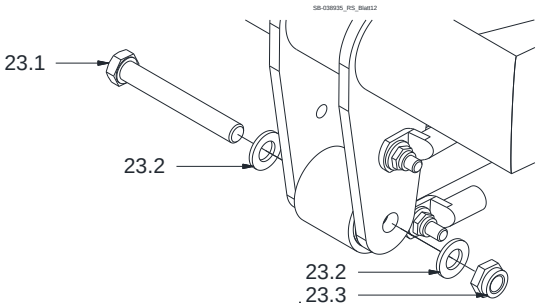
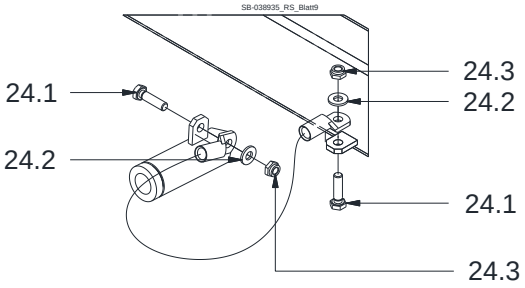
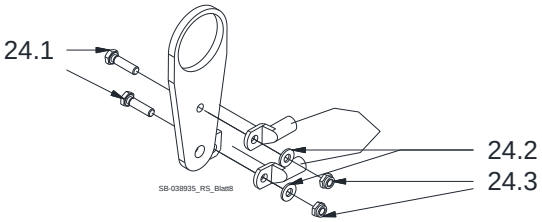
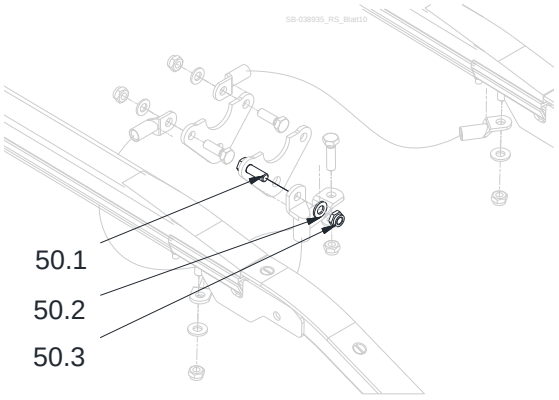
17.2 Pantograph



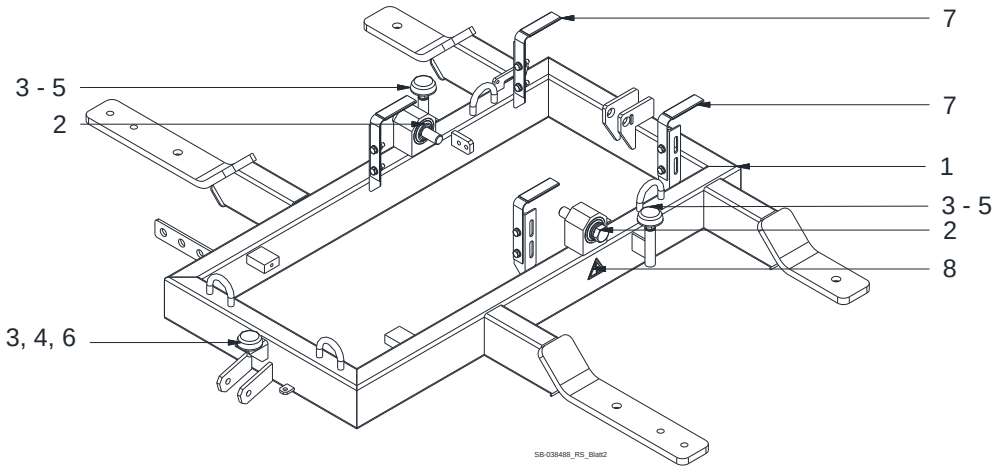
POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Pantograph WBL 32.05	**SB-035320**	**10864159**	**C**				**O**
1.0	**1**	**PCS**	**Pantograph WBL 32.05**	**SB-035685**	**10873448**					
1	1	PCS	Base frame compl.	1-G01.15058	10598903					
2	1	PCS	Lower frame compl.	1-UN02.6422	10602975					
3	1	PCS	Upper frame	1-3913.5326	10512576					
4	1	PCS	Air bellow drive	1-B04.15759	10599740					
5	1	PCS	Valve unit ADD	2-V15.16191	10611489					
6	1	PCS	Coupling rod compl.	2-K16.4276	10512015					
7	1	PCS	Parallel guide bar compl.	2-P07.5333	10512730					
8	1	PCS	Pan head	SB-035115	10871881					
9	2	PCS	Shock absorber	3-7432	10514084			C		
10	2	PCS	Diagonal cable	3-17103.11748	10509942					
11	1	PCS	Upper frame bearing	3-L03.4211	10467307					
12	2	PCS	Pan head bearing	4-L18.2697	10516016					
13	1	PCS	Cable with terminals	3-B14.4338	10513756					
14	1	PCS	Overreach detection	2-V15.15775	10600396					
15	3	PCS	Insulating hose	4-B09.4724	10511644					R
16	1	PCS	Air pressure hose	3-B04.4940	10510114					R
17	6	PCS	Shunt	4-12800.5848	10467358			C	R	R
18	1	PCS	Type tag compl	4-G01.14278	10542445					
19	4	PCS	Axle	4-L09.2694	10467115					
20	3	PCS	Reduction	4-915.4097	10513688					
21	4	PCS	Screw set	4-SV00.14893	10560932			C		R
21.1	*1*	*PCS*	*Hexagon head screw*	*M8x25 ISO 4017 A2-70*	*10508756*					
21.2	*2*	*PCS*	*Washer plain*	*8 ISO 7089 A2*	*10513391*					
21.3	*1*	*PCS*	*Prevailing torque type hex nut*	*M8 ISO 10511 A2-70*	*10508666*					
22	2	PCS	Screw set	4-SV00.14455	10548160			C		R
22.1	*1*	*PCS*	*Hexagon head screw*	*M6x20 ISO 4017 A2-70*	*10508746*					

POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
22.2	*1*	*PCS*	*Washer plain*	*6 ISO 7089 A2*	*10513390*					
22.3	*1*	*PCS*	*Prevailing torque type hex nut*	*M6 ISO 10511 A2-70*	*10467185*					
23	2	PCS	Screw set	4-SV00.14967	10564704			C		R
23.1	*1*	*PCS*	*Hexagon head bolt*	*M12x90 ISO 4014 A2-70*	*10508786*					
23.2	*2*	*PCS*	*Washer plain*	*12 ISO 7089 A2*	*10467195*					
23.3	*1*	*PCS*	*Prevailing torque type hex nut*	*M12 ISO 10511*	*10508661*					
24	14	PCS	Screw set	4-SV00.14276	10542386			C		R
24.1	*1*	*PCS*	*Hexagon head screw*	*M8x30 ISO 4017 A2-70*	*10508757*					
24.2	*1*	*PCS*	*Conical spring washer*	*8 DIN 6796 A2*	*10467198*					
24.3	*1*	*PCS*	*Prevailing torque type hex nut*	*M8 ISO 10511 A2-70*	*10508666*					
25	2	PCS	Shunt	4-S00.4999	10514453			C	R	R
26	6	PCS	Sealing ring	RG-DI-CU-C-12x18	10467171					
27	4	PCS	Washer plain	14 ISO 7089 A2	10513386			C		R
28	6	PCS	Hexagon nut style 1	M14 ISO 4032 A2-70	10508621			C		R
29	3	PCS	Washer plain	16 ISO 7089 A2	10467196			C		R
30	1	PCS	Male connector	d10 R 1/2" 1050 10-1/2 CuZn E3P	10510650					
31	3	PCS	Reducer adapter	G1/4"a G1/2"i RN 1412 MSV CuZn E3P	10467168					
32	2	PCS	Male connector	d6 R1/4" 1050 6-1/4 CuZn E3P	10467160					
33	1	PCS	T Piece	R1/4" G1/4" 2070 1/4-1/4 CuZn E3P	10467169					
34	1	PCS	Elbow male adaptor	d6 R1/4" 1020 6-1/4 CuZn E3P	10515385					
35	2	PCS	Male connector	d10 R1/4" 1050 10-1/4 CuZn E3P	10510649					
36	0,8	m	Tube	d10/6,8 13001000 Dekabon 1300	10513202					R
37	0,5	m	Tube	d6/4 13000600 Dekabon 1300	10467179					R
38	0,9	m	Tube	d6/4 13000600 Dekabon 1300	10467179					R

POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
39	0,5	m	Tube	d6/4 13000600 Dekabon 1300	10467179					R
40	1	PCS	Male connector	d12 G1/2"A GE 12-PL/R1/2 St/Acier/Acero/Acciaio A3C	10510639					
41	0,1	m	Tube	d10/6,8 13001000 Dekabon 1300	10513202					R
42	1	PCS	Elbow male adaptor	d6/4 R1/4" 1500 6/4-1/4 CuZn E3P	10516049					
43	4,5	PCS	Air pressure hose	TFL 6x4	10510051					R
44	2	PCS	Washer plain	8 ISO 7089 A2	10513391			C		R
45	2	PCS	Hexagon head bolt	M8x60 ISO 4014 A2-70	10508827					
46	0,3	m	Tube	EPDM-APZ LW32x4	10513460					
47	14	PCS	Cable tie	7,5x360 2359-464 PA 6.6	10467245					R
48	4	PCS	Cable tie	7,5x450 PA 6.6	10559301					R
49	10	PCS	Mounting clamp	CH-B7 127 043 010	10467243					R
50	2	PCS	Screw set	4-SV00.15777	10600280			C		R
50.1	1	PCS	*Hexagon head screw*	*M8x25 ISO 4017 A2-70*						
50.2	1	PCS	*Washer plain*	*8 ISO 7089 A2*						
50.3	1	PCS	*Prevailing torque type hex nut*	*M8 ISO 10511 A2-70*						
2.0	**4**	**PCS**	**Insulator compl.**	**2-G01.15986**	**10608332**					
3.0	**1**	**PCS**	**Pneumatic control**	**1-V15.15750**	**10601221**					
4.0	**1**	**PCS**	**Pneumatic control**	**1-V15.16074**	**10609604**					

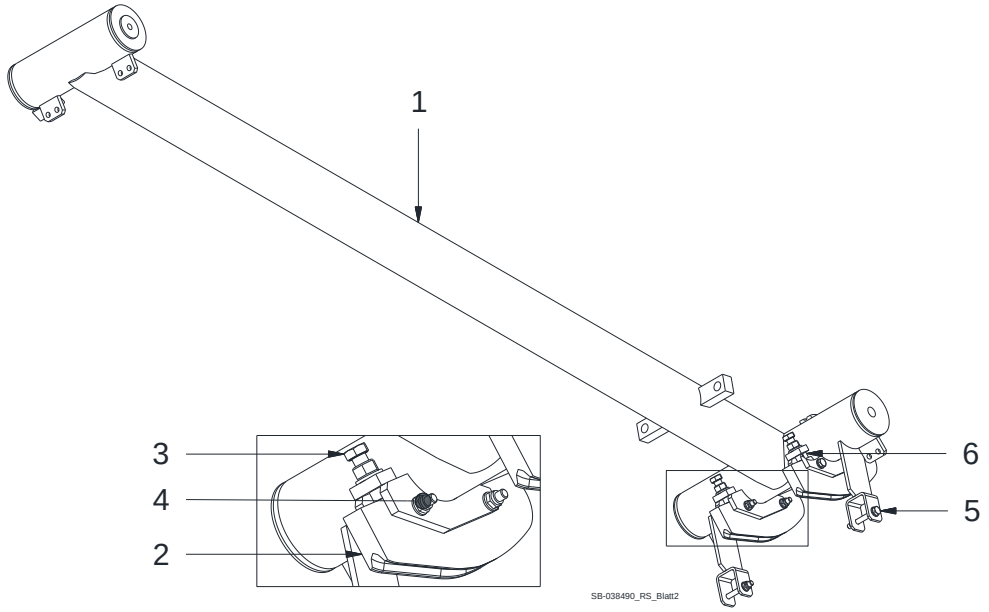
21	22
	
23	**24**
	
24	**50**
	

17.2.1 Base Frame



POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Base frame compl.	**1-G01.15058**	**10598903**					
1	1	PCS	Base frame WA	1-G01.15723	10598674					P
2	1	PCS	Base bearing	3-L01.4206	10482227					
3	3	PCS	Limit stop	d50 h=18 M10x28 GIMPK50.18	10467249			C		R
4	3	PCS	Washer plain	10 ISO 7089 A2	10467194			C		R
5	2	PCS	Hexagon nut style 1	M10 ISO 4032 A2-70	10508618			C		R
6	1	PCS	Prevailing torque type hex nut	M10 ISO 10511 A2-70	10508660			C		R
7	4	PCS	Support spring compl.	SB-024165	10706304			C		R
8	2	PCS	Sticker	4-G01.12955	10509363					R

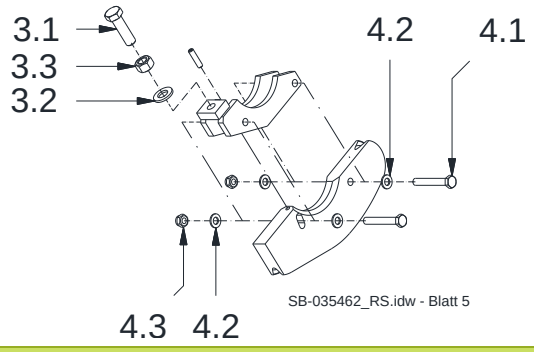
17.2.2 Lower Frame



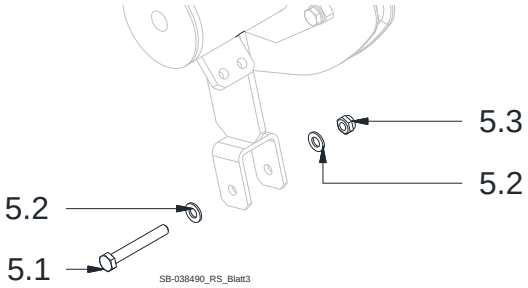
POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Lower frame compl.	**1-UN02.6422**	**10602975**					
1	1	PCS	Lower frame WA	1-UN02.15825	10514790					P
2	2	PCS	Cam	2-UN12.4288	10512091					
3	2	PCS	Screw set	4-SV00.14891	10560929			C		R
3.1	*2*	*PCS*	*Hexagon head screw*	*M12x40 ISO 4017 - A2-70*	*10508708*					
3.2	*2*	*PCS*	*Washer plain*	*12 EN ISO 7089 - A2*	*10467195*					
3.3	*2*	*PCS*	*Hexagon nut style 1*	*M12 ISO 4032 - A2-70*	*10508620*					
4	4	PCS	Screw set	4-SV00.14892	10560930			C		R
4.1	*2*	*PCS*	*Hexagon head bolt*	*M8x55 ISO 4014 - A2-70*	*10508826*					
4.2	*4*	*PCS*	*Washer*	*8 EN ISO 7089 - A2*	*10513391*					
4.3	*2*	*PCS*	*Prevailing torque type hex nut*	*M8 ISO 10511 - A2-70*	*10508666*					
5	2	PCS	Screw set	4-SV00.14874	10560792			C		R
5.1	2	PCS	Hexagon head bolt	M8x60 ISO 4014 - A2-70	10508827					

POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
5.3	2	PCS	Prevailing torque type hex nut	M8 ISO 10511 - A2-70	10508666					
5.2	4	PCS	Washer	8 EN ISO 7089 - A2	10513391					
6	2	PCS	Hexagon socket set screw	M6x25 ISO 4026 - A2-70	10510714			C		R

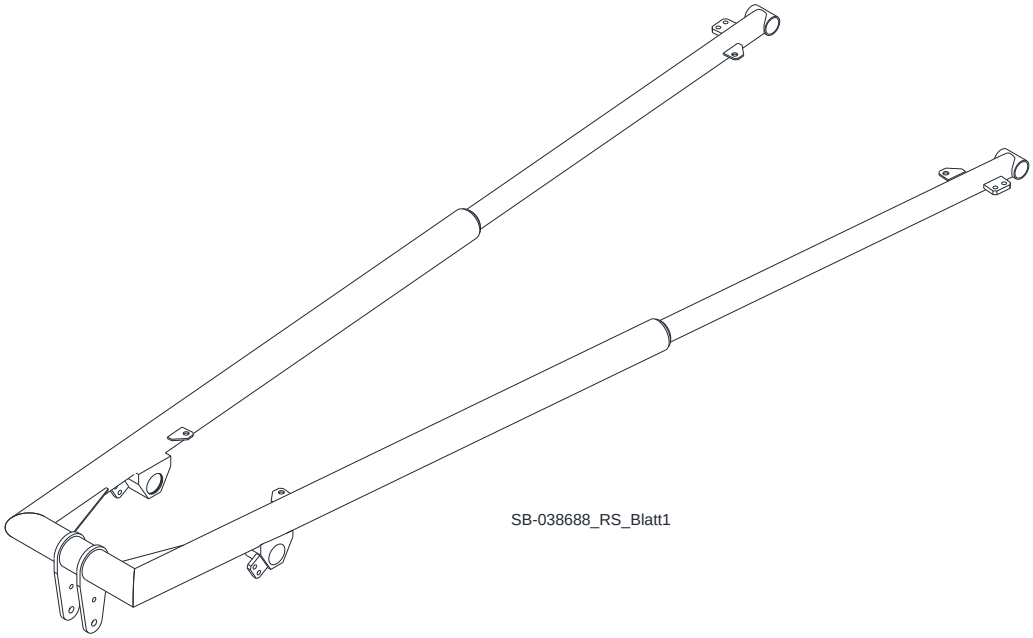
3,4



5



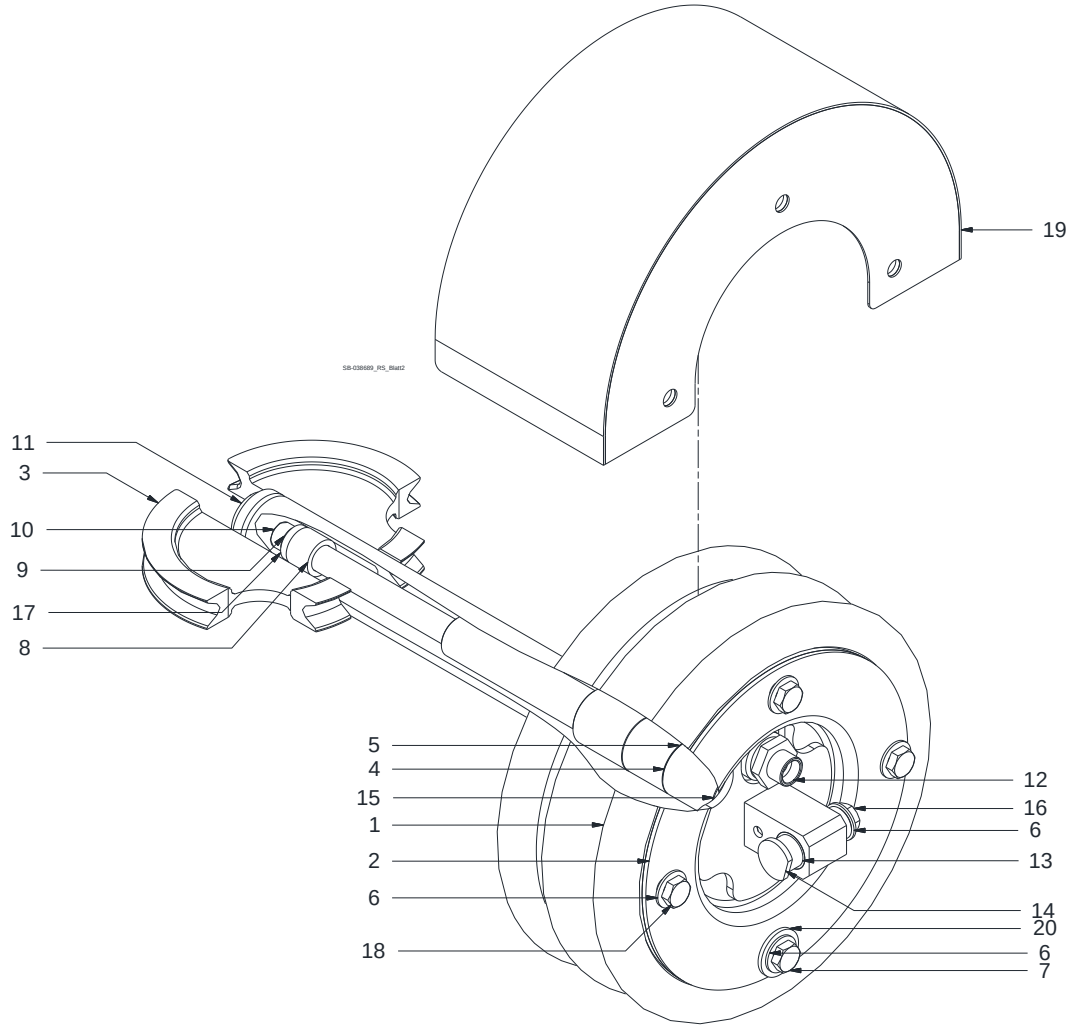
17.2.3 Upper Frame



POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Upper frame compl.	**1-3919.5326**	**10512576**		**C**			**P**

17.2.4 Air Bellow Drive

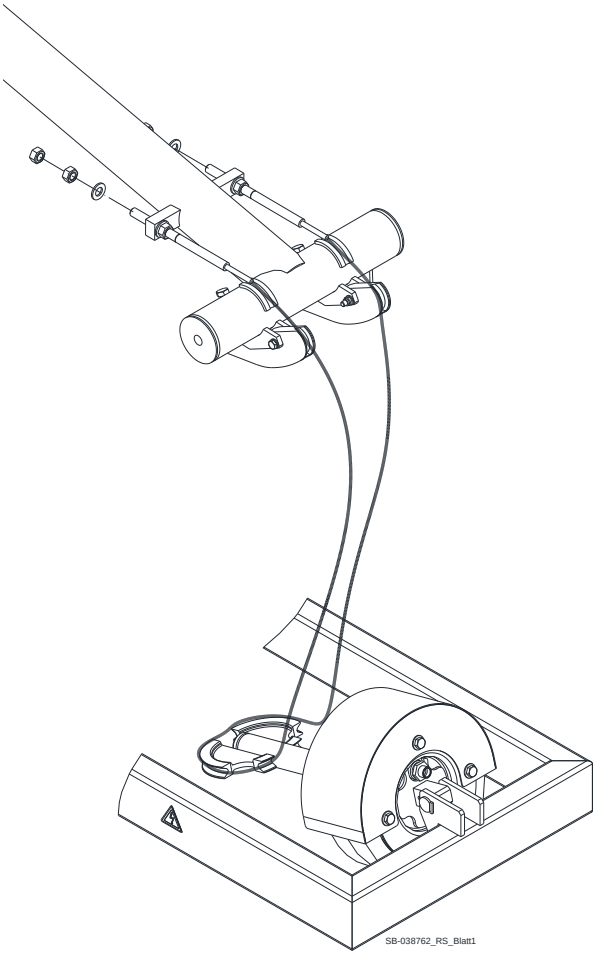
Loctite 577 for all pneumatic connections.



POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Air bellow drive	**1-B04.15759**	1059740					
1	1	PCS	Air bellow	SPA/16010	10509491					
2	1	PCS	Guide unit	1-B14.4510	10510578					
3	1	PCS	Cable guide	1-B14.9213	10513779					
4	2	PCS	Linear slide bearing	RJUM-02-25	10512387					
5	1	PCS	Spacer	4-B14.4548	10510003					
6	9	PCS	Conical spring washer	10 DIN 6796 A2	10467199			C		R

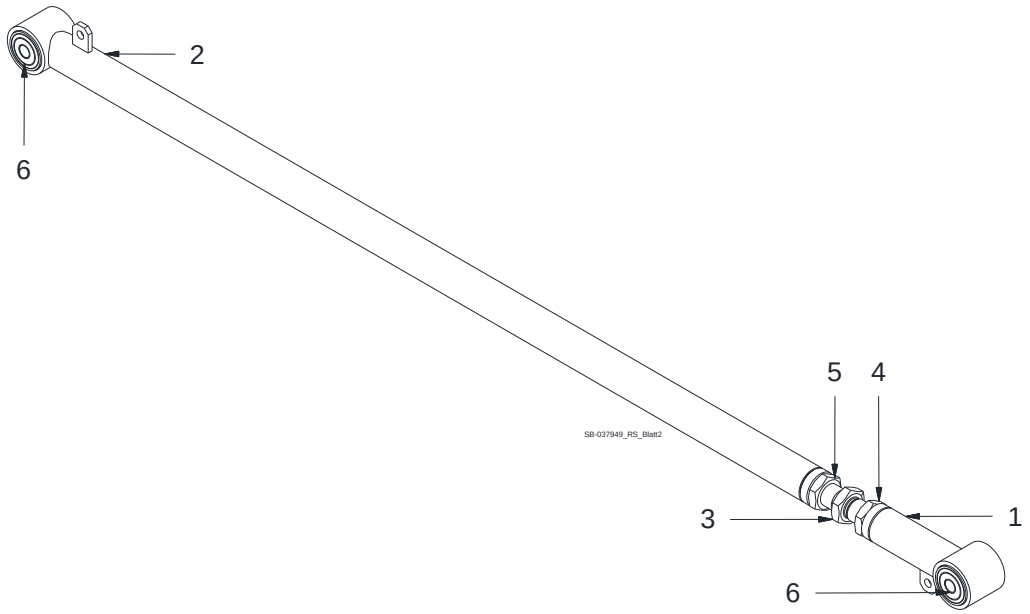
POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
7	5	PCS	Hexagon head screw	M10x18 ISO 4017 A2-70	10764935			C		R
8	1	PCS	Limit stop	4-B14.4511	10509207					
9	1	PCS	Curved spring lockwasher	10 DIN 128 A2	10204409			C		R
10	1	PCS	Hex socket head cap screw	M10x25 ISO 4762 A2-70	10516150			C		R
11	1	PCS	Plug screw	VSTI R 3/4-ED	10515102			C		R
12	1	PCS	Male connector	d12 G1/2"A GE 12-PL/R1/2	10510639					
13	1	PCS	Plain bearing cylindrical	2030DUB ISO 3547-1 DU-B	10510774					
14	1	PCS	Axle	4-B14.4328	10509126					
15	1	PCS	Limit stop	4-B14.4329	10509208					
16	1	PCS	Hexagon head screw	M10x25 ISO 4017 A2-70	10508700			C		R
17	1	PCS	Washer	4-B14.4330	10513370			C		R
18	3	PCS	Hexagon head screw	M10x20 ISO 4017 A2-70	10508699			C		R
19	1	PCS	Air bellow cover	2-B14.15756	10599729					
20	5	PCS	Washer plain large series	10 ISO 7093 A2	10663862			C		R

17.2.5 Cable with Terminals



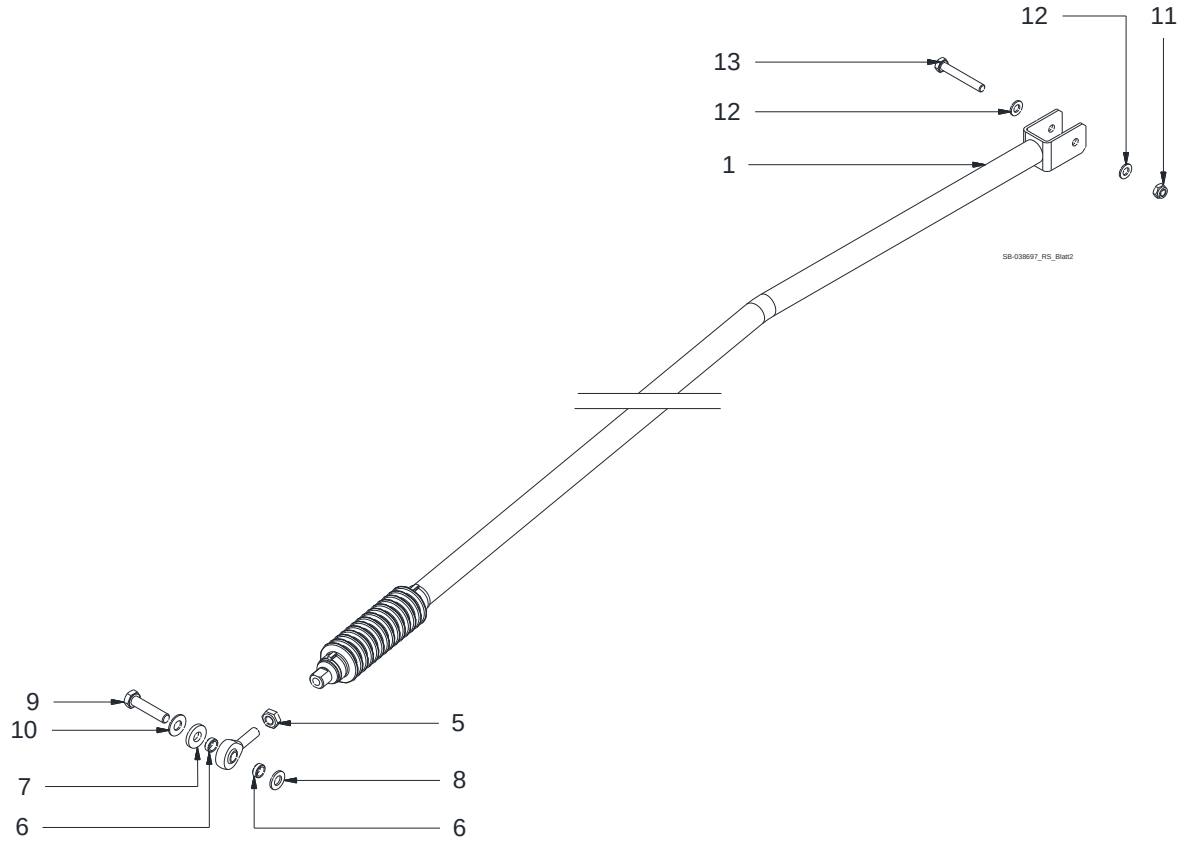
POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
1.10			Cable with terminals	3-B14.4338	10513756			C G		R

17.2.6 Coupling Rod



POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Coupling rod compl.	**2-K16.4276**	**10512015**					
1	1	PCS	Bearinghouse 1	3-K16.9649	10466985					
2	1	PCS	Bearinghouse 2	3-K16.9650	10466986					
3	1	PCS	Turnbuckle	3-K16.9648	10514057					
4	1	PCS	Hexagon thin nut	M22x1,5L ISO 8675 A2-70	10508656			C		R
5	1	PCS	Hexagon thin nut	M22x1,5 ISO 8675 A2-70	10508655			C		R
6	2	PCS	Coupling rod bearing	4-L06.9621	10512061					

17.2.7 Parallel Guide

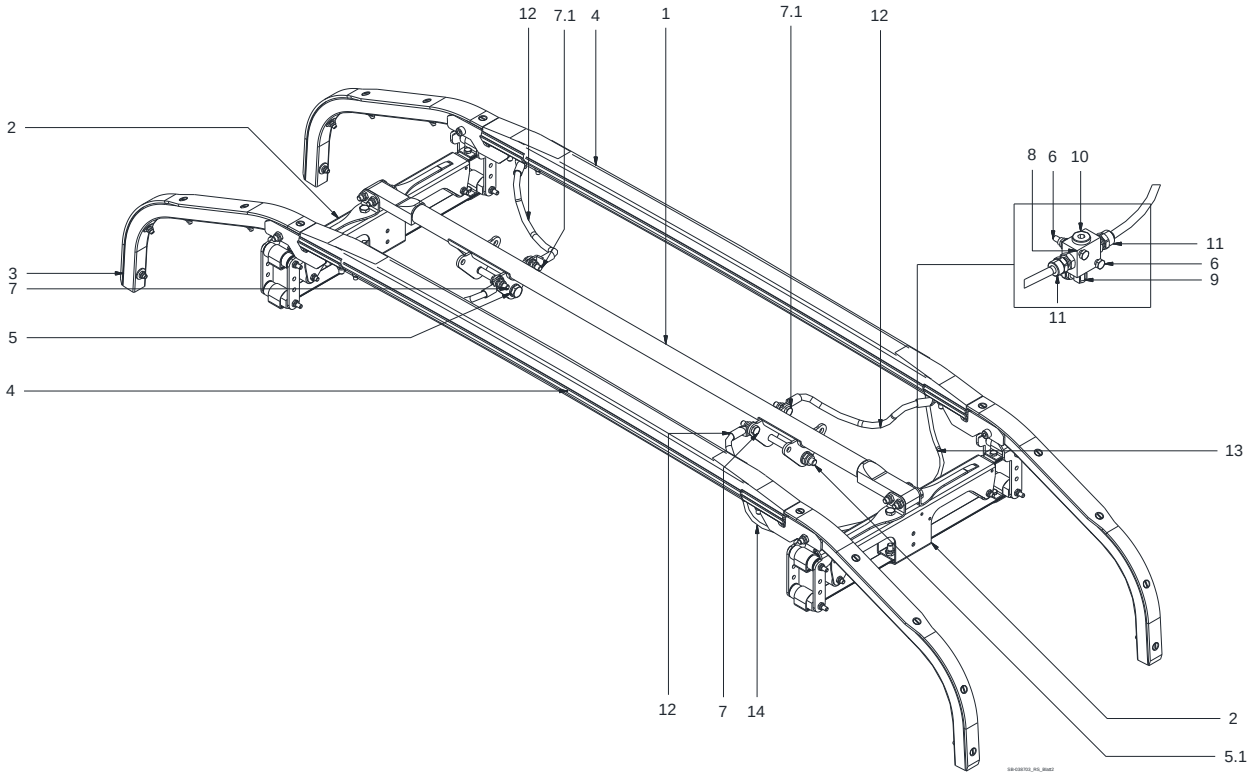


POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Parallel guide bar compl.	**2-P07.5333**	**10512730**					
1	1	PCS	Parallel guide bar WA	2-P07.14436	10721190					P
2	1	PCS	Bellow	AW 1407	10448626					
3	2	PCS	Cable tie	7,8x240 701133 PA 6.6	10467244					
4	1	PCS	Rod end	GARSW 10 R.C3 ISO 12240-4 K	10467224			C		
5	1	PCS	Hexagon nut style 1	M10 ISO 4032 A2-70	10508618			C		R
6	2	PCS	Sleeve	4-P27.2455	10466989					
7	1	PCS	Washer heavy spring pins	10 DIN 7349 A2	10513403			C		R
8	1	PCS	Washer plain	10 ISO 7089 A2	10467194			C		R
9	1	PCS	Hexagon head screw	M10x45 ISO 4017 A2-70	10508704			C		R
10	1	PCS	Conical spring washer	10 DIN 6796 A2	10467199			C		R

POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
11	1	PCS	Prevailing torque type hex nut	M8 ISO 10511 A2-70	10508666			C		R
12	2	PCS	Washer plain	8 ISO 7089 A2	10513391			C		R
13	1	PCS	Hexagon head bolt	M8x55 ISO 4014 A2-70	10508826			C		R

17.2.8 Pan Head

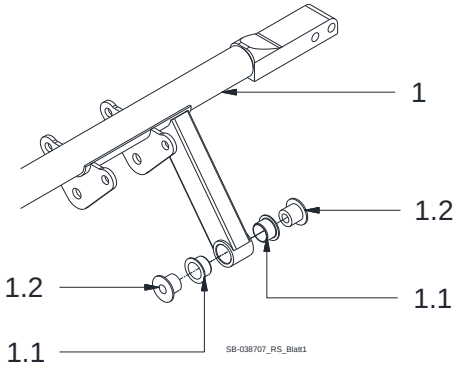
Loctite 577 for all pneumatic connections.



POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Pan head	**SB-035115**	**10871881**					
1	1	PCS	Apex tube compl.	SB-035120	10871873					
2	2	PCS	Rocker box compl.	SB-035853	10871202					
3	4	PCS	Horn	SB-029093	10780474	C				
4	2	PCS	Carbon sliding strip	SK 1590	10591398	C				
5	2	PCS	Screw set	4-SV08.9174	10592905			C		R
5.1	1	PCS	Hexagon head bolt	M10x100 ISO 4014 - A2-70	10508764					
5.2	2	PCS	Washer plain	10 EN ISO 7089 - A2	10467194					
5.3	1	PCS	Prevailing torque type hex nut	M10 ISO 10511 - A2-70	10508660					
6	2	PCS	Screw set	4-SV00.16944	10655646			C		R
6.1	1	PCS	Hexagon head screw	M4x30 ISO 4017 - A2-70	10508731					
6.2	1	PCS	Washer plain	4 EN ISO 7089 - A2	10467190					

POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
6.3	1	PCS	Prevailing torque type hex nut	M4 ISO 10511 - A2-70	10508665			C		R
7	4	PCS	Screw set	4-SV00.15777	10600280			C		R
7.1	1	PCS	Hexagon head screw	M8x25 ISO 4017 - A2-70	10508756					
7.2	1	PCS	Washer	8 EN ISO 7089 - A2	10513391					
7.3	1	PCS	Prevailing torque type hex nut	M8 ISO 10511 - A2-70	10508666					
8	1	PCS	Connector	10515146_(Mader_227219)	10515146					
9	1	PCS	Male elbow connector	10467162_(Camozzi_1500_6-4_1-8)	10467162					
10	1	PCS	Plug screw	10515106_(Mader_LV42.6004)	10515106					
11	2	PCS	Male connector straight	10510642_(Camozzi_1511_6_4_1_8)	10510642					
12	4	PCS	Shunt	4-S00.3575	10467362			C	R	R
13	1	PCS	Air pressure hose	SB-035892	10510051					*R*
14	1	PCS	Air pressure hose	SB-035893	10510051					*R*

1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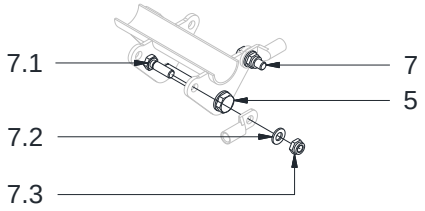
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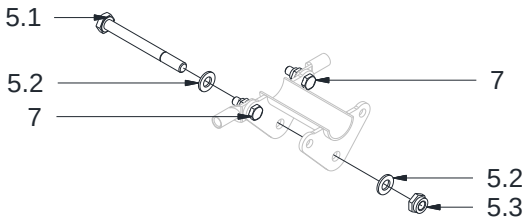
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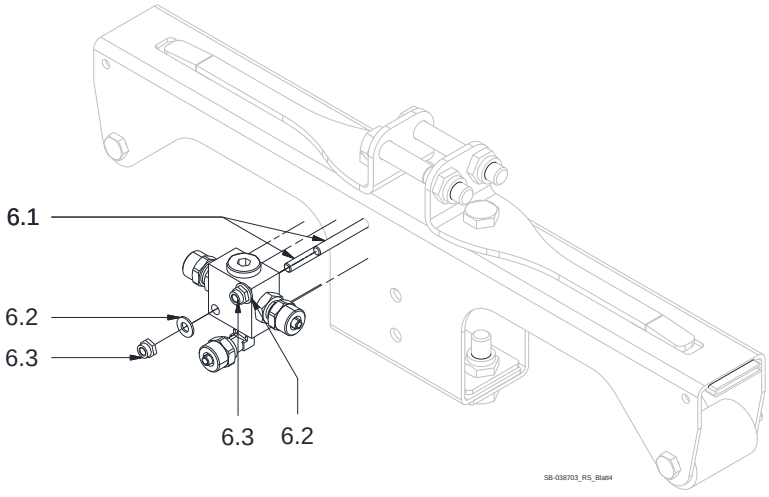
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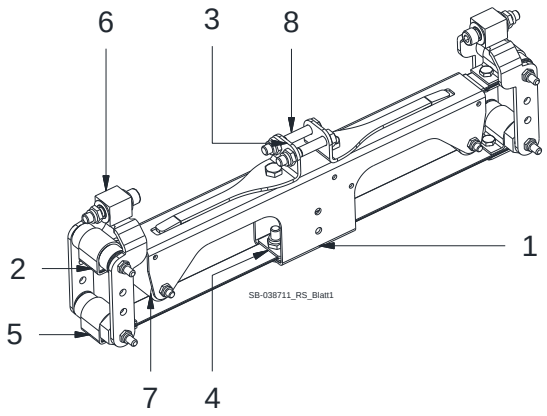
17.2.8.1 Rocker box compl.



POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
1	1	PCS	Rocker box	2-W08.15435	10593037					
2	1	PCS	Leaf spring compl.	SB-031704	10818162			*C*		
3	2	PCS	Support	3-W08.15436	10593085					
4	2	PCS	Underlaying plate	4-W08.15440	10593202					
5	1	PCS	Leaf spring compl.	SB-031703	10818157					
6	2	PCS	Bearing house compl.	SB-035855	10871199					
7	2	PCS	Limit stop	SB-031775	10819037			*C*		
8	2	PCS	Screw set	4-SV00.15447	10584336			C		R
8.1	1	PCS	Hexagon head bolt	M8x50 ISO 4014 A2-70	10508825					
8.2	1	PCS	Prevailing torque type hex nut	M8 ISO 10511 A2-70	10508666					

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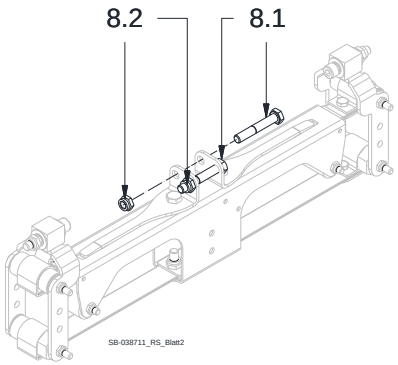
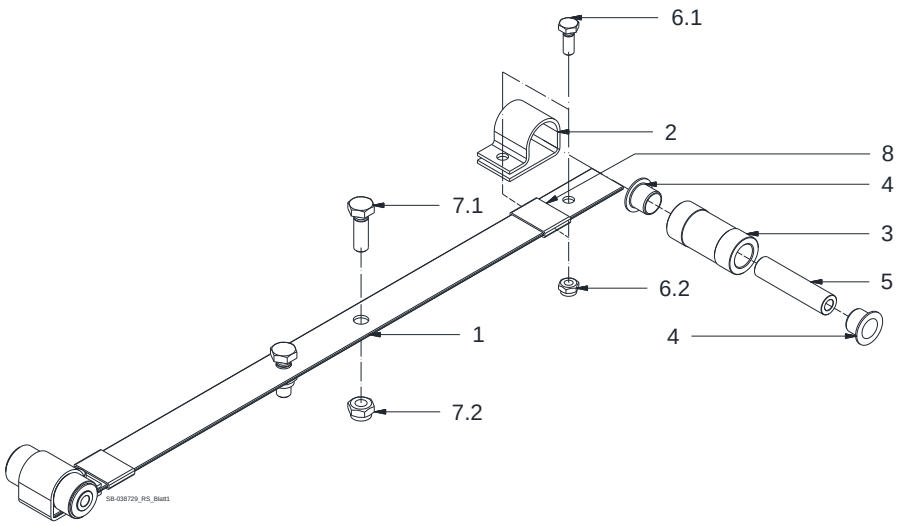
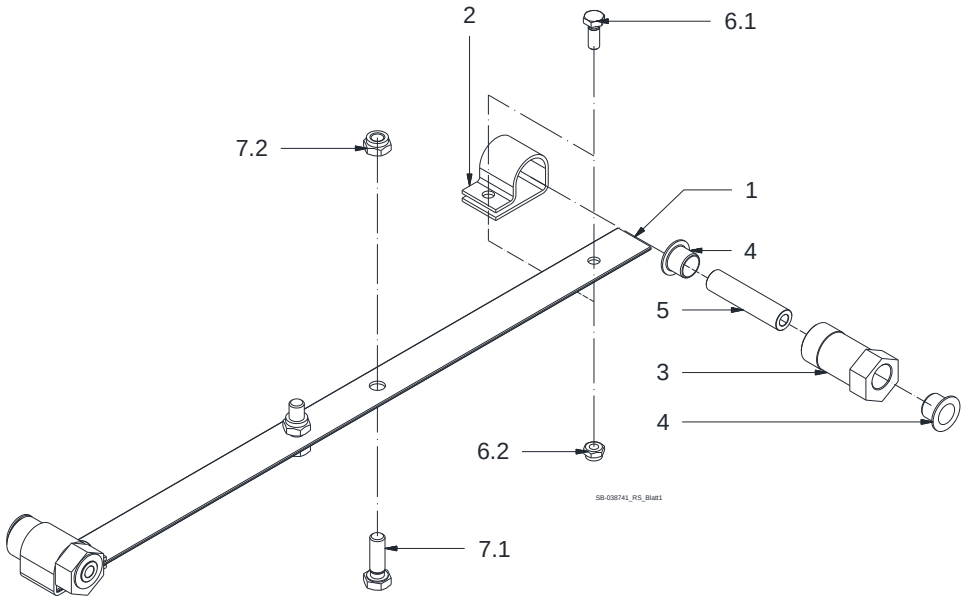


17.2.8.2 Leaf spring compl.



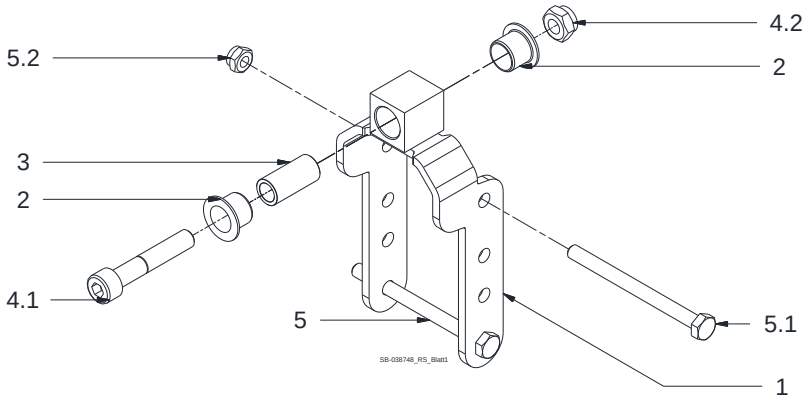
POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Leaf spring	**SB-031704**	**10818162**			**C**		
1	1	PCS	Leaf spring	SB-031701	10818154					
2	2	PCS	Clamp	4-W08.1969	10466996					
3	2	PCS	Spacer	4-W08.15430	10592941					
4	4	PCS	Plain bearing w. flange	GFM-1214-12	10204415					
5	2	PCS	Axle	4-L08.6048	10509111					
6.1	2	PCS	Hexagon head screw	M6x16 ISO 4017 - A2-70	10508745			C		R
6.2	2	PCS	Prevailing torque type hex nut	M6 ISO 10511 - A2-70	10467185			C		R
7.1	2	PCS	Hexagon head screw	M8x25 ISO 4017 - A2-70	10508756			C		R
7.2	2	PCS	Prevailing torque type hex nut	M8 ISO 10511 - A2-70	10508666			C		R
8	2	PCS	Shrink tube	10513710 l=20 x25x2	10513710					

17.2.8.3 Leaf spring compl.



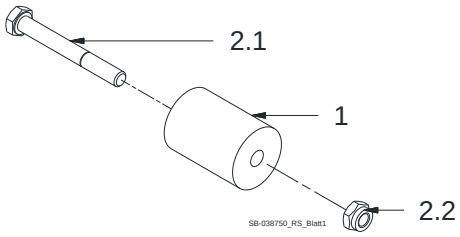
POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Leaf spring compl.	**SB-031703**	**10818157**			**C**		
1	1	PCS	Leaf spring	SB-031701	10818154					
2	2	PCS	Clamp	4-W08.1969	10466996					
3	2	PCS	Eccentric	4-W08.15433	10592973					
4	4	PCS	Plain bearing w. flange	GFM-1214-12	10204415					
5	2	PCS	Axle	4-L08.6048	10509111					
6.1	2	PCS	Hexagon head screw	M6x16 ISO 4017 - A2-70	10508745					
6.2	2	PCS	Prevailing torque type hex nut	M6 ISO 10511 - A2-70	10467185					
7.1	2	PCS	Hexagon head screw	M8x25 ISO 4017 - A2-70	10508756					
7.2	2	PCS	Prevailing torque type hex nut	M8 ISO 10511 - A2-70	10508666					

17.2.8.4 Bearing house compl.



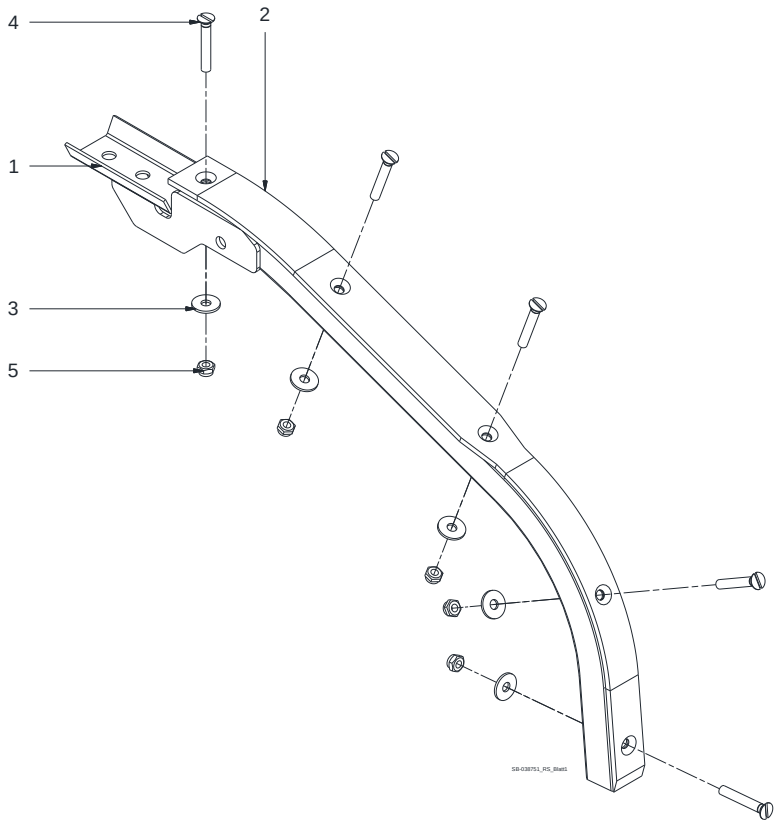
POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Bearing house compl.	**SB-035855**	**10871199**					
1	1	PCS	Bearing house	SB-035850	10871157					
2	2	PCS	Plain bearing w. flange	GFM-1214-12	10204415					
3	1	PCS	Axle	4-L08.1952	10477637					
5.1	2	PCS	Hexagon head bolt	M6X75 ISO 4014 - A2-70	10508814			C		R
5.2	2	PCS	Prevailing torque type hex nut	M6 ISO 10511 - A2-70	10467185			C		R
4.1	1	PCS	Hex socket head cap screw	M8x45 ISO 4762 - A2-70	10516169			C		R
4.2	1	PCS	Prevailing torque type hex nut	M8 ISO 10511 - A2-70	10508666			C		R

17.2.8.5 Limit stop



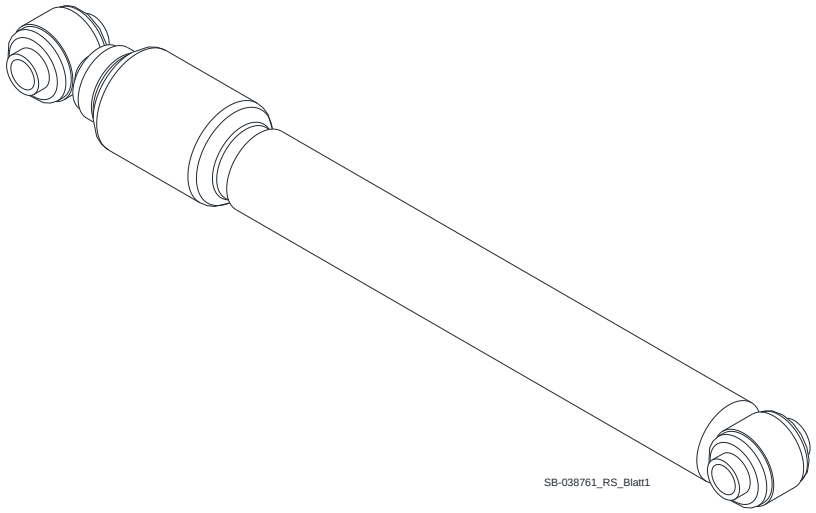
POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Limit stop	**SB-031775**	**10819037**					
1	1	PCS	Spring support	SB-031774	10819032					
2	1	PCS	Screw set	4-SV00.15306	10577412			C		R
2.1	1	PCS	Hexagon head bolt	M6x50 ISO 4014 A2-70	10508809					
2.2	1	PCS	Prevailing torque type hex nut	M6 ISO 10511 A2-70	10467185					

17.2.8.6 Horn



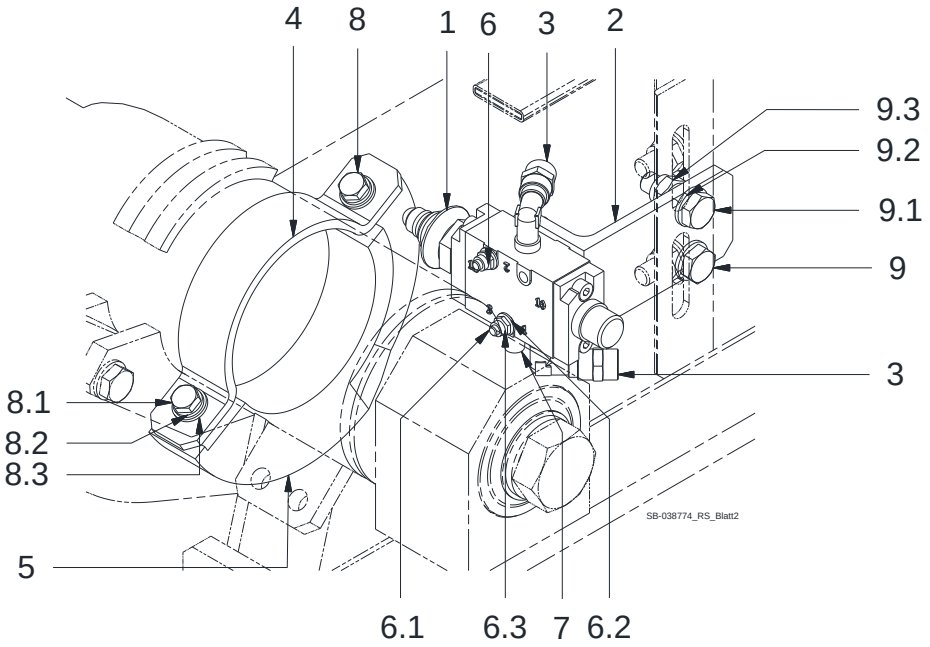
POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Horn	**SB-029093**	**10780474**					
1	1	PCS	Horn compl.	SB-029072	10780463					
2	1	PCS	Wear strip	SB-029094	10780473					
3	5	PCS	Washer plain large series	6 ISO 7093 A2	10467193			C		R
4	5	PCS	Countersunk screw slotted	M6x40 ISO 2009 A2-70	10513828			C		R
5	5	PCS	Prevailing torque type hex nut	M6 ISO 10511 A2-70	10467185			C		R

17.2.9 Shock Absorber



POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Shock absorber	3-7432	10514084			C		

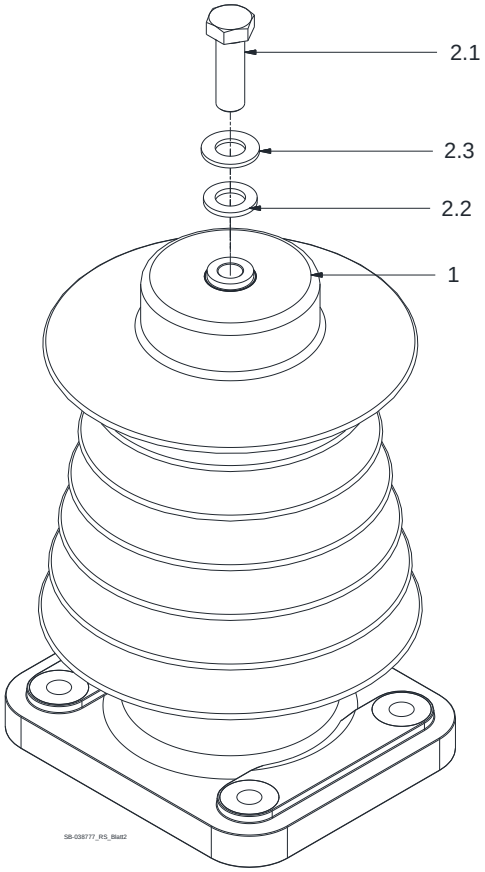
17.2.10 Overreach detection



POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Overreach detection	**2-V15.15775**	**10600396**					
1	1	PCS	3/2 Way valve	CL-104A	10508598					
2	1	PCS	Angle	3-V15.15764	10600300					
3	2	PCS	Male elbow connector	Camozzi_1020_6-1_8	10515388					
4	1	PCS	Clamp P1	2-V05.12169	10511775					
5	1	PCS	Clamp P1	12168	10511769					
6	2	PCS	Screw set	4-SV00.15481	10585765			C		R
6.1	2	PCS	Hexagon head screw	M4x35 ISO 4017 - A2-70	10508732					
6.2	4	PCS	Washer plain	4 EN ISO 7089 - A2	10467190					
6.3	2	PCS	Prevailing torque type hex nut	M4 ISO 10511 - A2-70	10508665					
7	1	PCS	Silencer	2931-1/8"	10513321					
8	2	PCS	Screw set	4-SV00.15776	10600249			C		R
8.1	2	PCS	Hexagon head screw	M6x30 ISO 4017 - A2-70	10508749					
8.2	2	PCS	Washer plain	6 EN ISO 7089 - A2	10513390					
8.3	2	PCS	Conical spring washer	6 DIN 6796 - A2	10513961					
9	2	PCS	Screw set	4-SV00.15777	10600280			C		R
9.1	2	PCS	Hexagon head screw	M8x25 ISO 4017 - A2-70	10508756					

POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
9.2	2	PCS	Washer	8 EN ISO 7089 - A2	10513391					
9.3	2	PCS	Prevailing torque type hex nut	M8 ISO 10511 - A2-70	10508666					

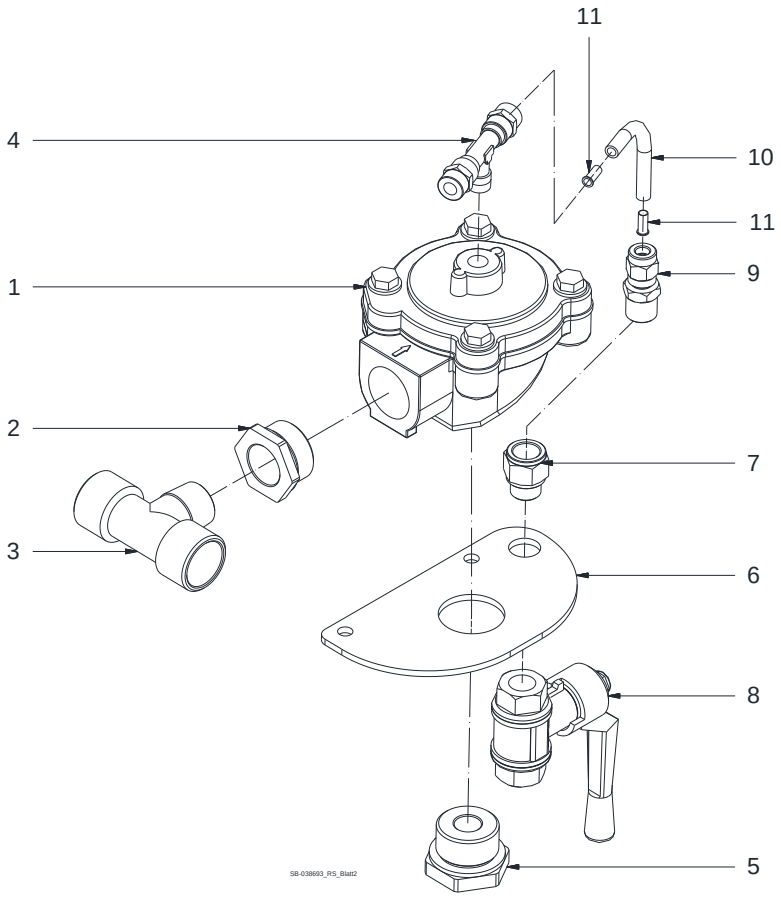
17.2.11 Insulator



POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Insulator compl.	**2-G01.15986**	**10608332**					
1	1	PCS	Insulator	2-G01.15722	10511519			**S**		
2	1	PCS	Screw set	4-SV00.14447	10548027			*C*		*R*
2.1	1	PCS	Hexagon head screw	M16x50 ISO 4017 - A2-70	10508717					
2.2	1	PCS	Washer plain	16 EN ISO 7089 - A2	10467196					
2.3	1	PCS	Conical spring washer ribbed	M16 BN 208 010-8 - A4	10513956					

17.2.12 Valve Unit ADD

Loctite 577 for all pneumatic connections.

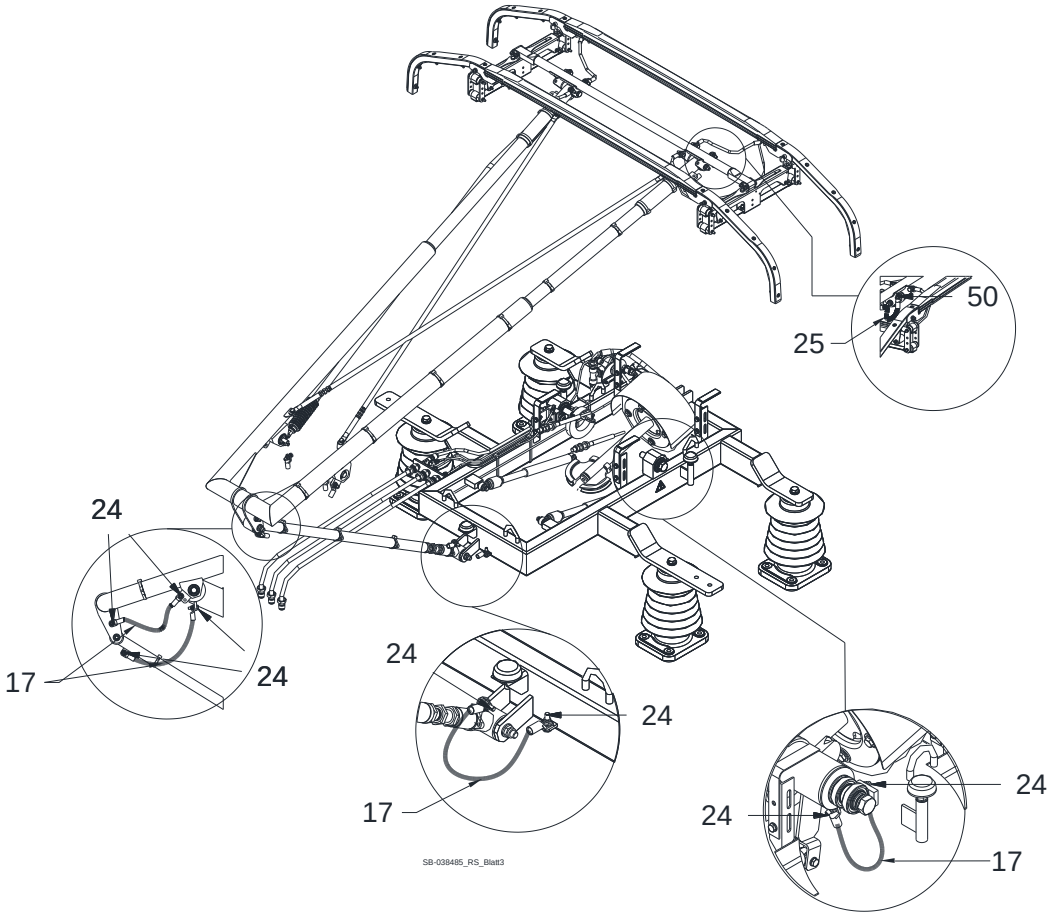


POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
			Valve unit ADD	**2-V15.16191**	**10611489**			**C**		
1	1	PCS	Quick exhaust valve		10467259					
2	1	PCS	Female to male reducer cyl.		10513076					
3	1	PCS	T Piece		10514637					
4	1	PCS	Male brunch tee		10514581					
5	1	PCS	Female to male reducer cyl.		10513077					
6	1	PCS	Valve mounting plate		10611486					
7	1	PCS	Female to male reducer cyl.		10513067					
8	1	PCS	Ball valve		10511968					

POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
9	1	PCS	Male connector straight		10467160					
10	1	PCS	Air pressure hose		10510051					*R*
11	2	PCS	Reinforcement		10515123					

17.2.13 Shunts

The individual shunts and their mounting angles are listed in ⇨ Chapter #11.5.5.

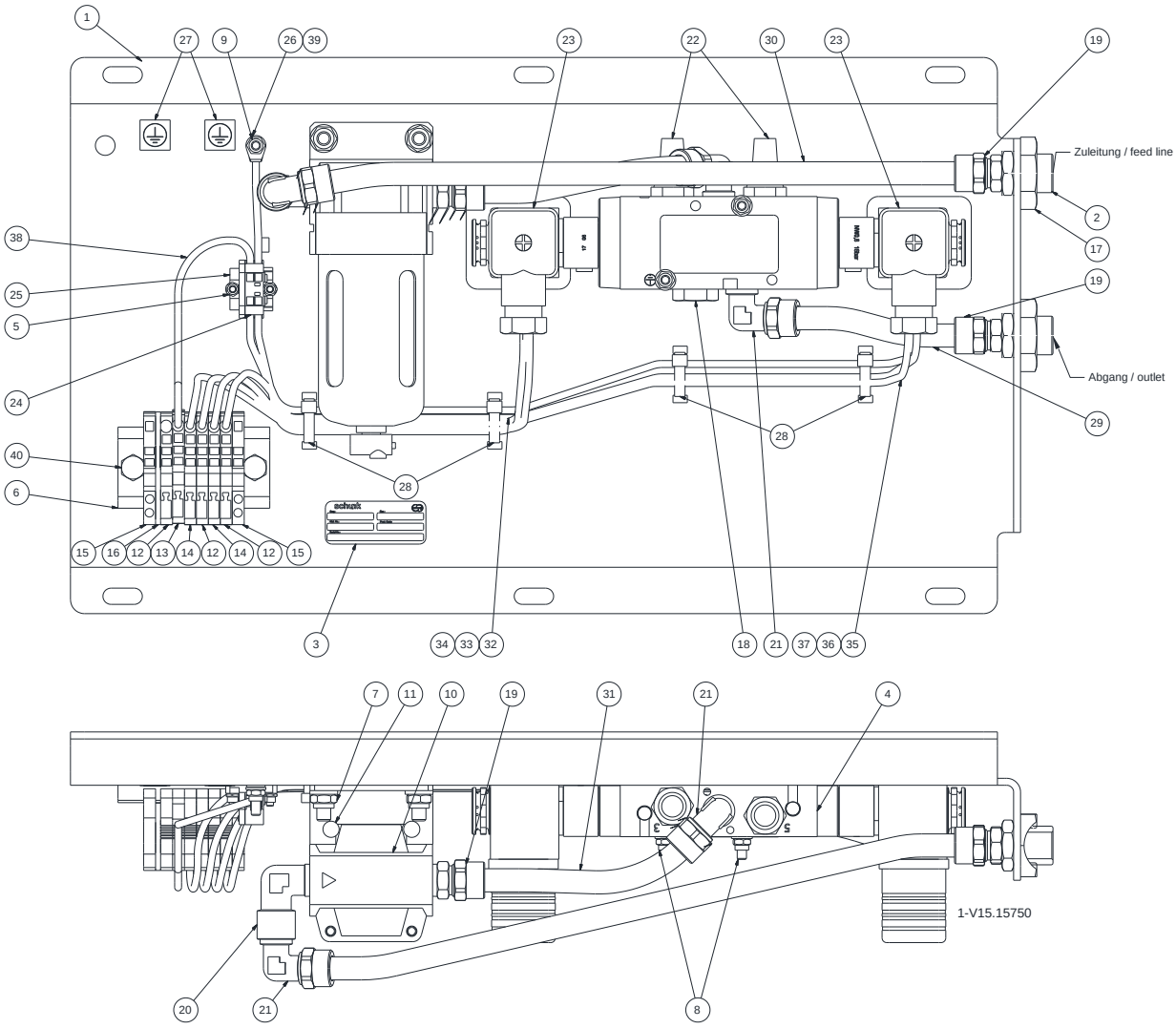


POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
17	6	PCS	Shunt	4-S00.3575	10467362			C	C	R
24	14	PCS	Screw set	4-SV00.14276	10542386			C		
25	2	PCS	Shunt	4-S00.4999	10514453			C	C	R
50	2	PCS	Screw set	4-SV00.15777	10542386			C	R	

17.3 Pneumatic Control

17.3.1 1-V15.15750

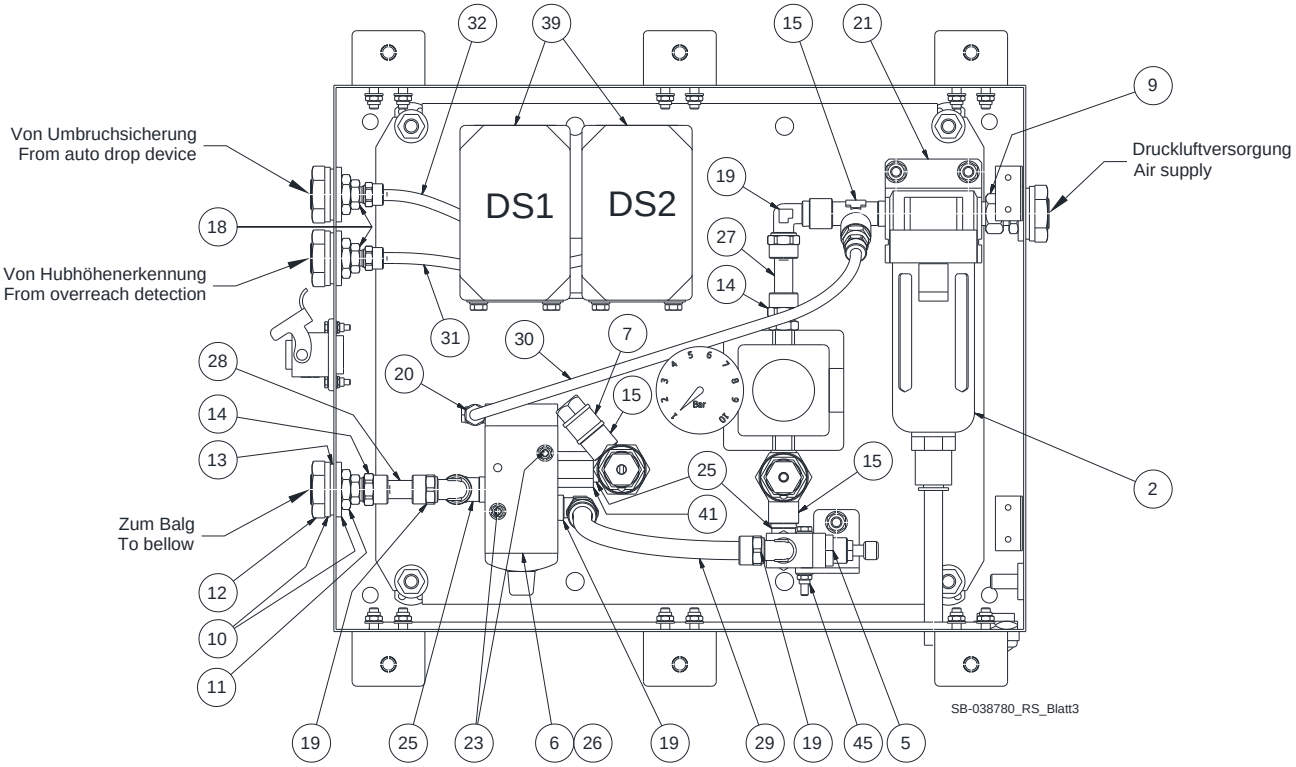
Loctite 577 for all pneumatic connections.

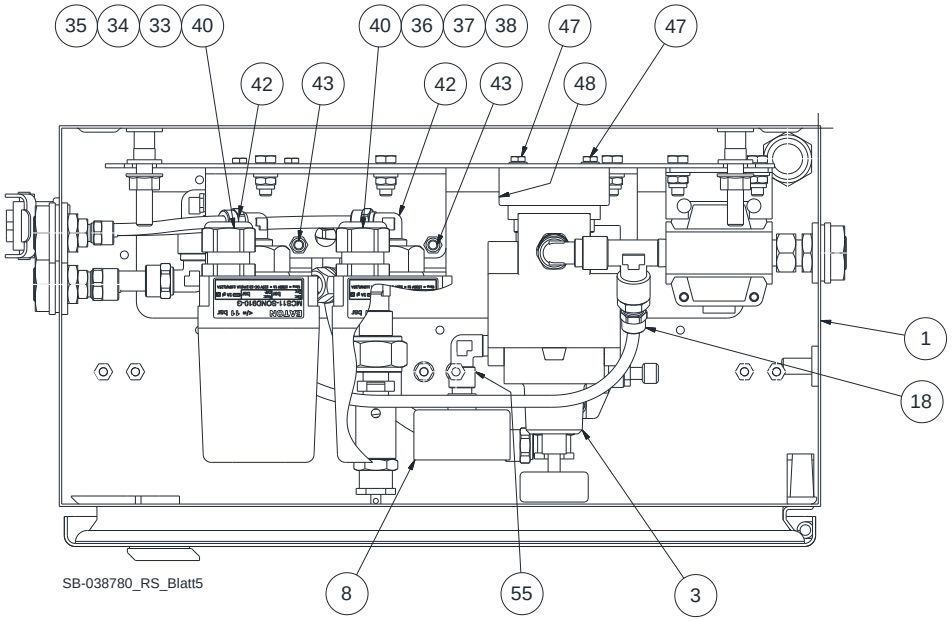


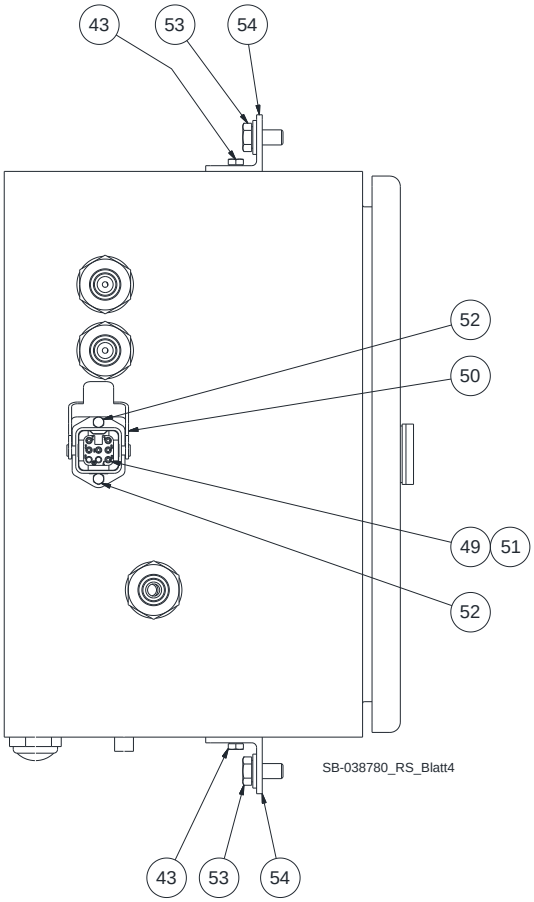
POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
1			**Pneumatic control**	**SB-028194**	**10769992**					**O**
1.1	1	PCS	Mounting plate	SB-026780						
1.2	1	PCS	Filter	AF30-F02-2-X430 G1/4"						
1.3	2	PCS	5/2 Way valve	P2LBX512ESHDDA72 G1/4" 110VDC						
1.4	2	PCS	Pressure regulation valve	IR3020-F02-L G1/4" 0,1-8 bar						
1.5	2	PCS	Pressure safeguard	MCS11-SOND_910-G-W-MCS R1/4" 15 bar						
1.6	1	PCS	Pressure gauge	NG 63 2033 R1/4" 0-6 bar						
1.7	1	PCS	Alternating valve	T65C2800 G1/4"						
1.8	1	PCS	Throttle relief valve	RFU 446-1/4 G1/4"						
1.9	1	PCS	Blow-off valve	3-V05.13667						
1.10	1	PCS	Measuring connector	EMA 4 R 1/4"						
1.11	2	PCS	Throttle silencer	ASN2 - 02 - S G1/4"						
1.12	2	PCS	Cable fitting	HSK-K M20x1,5 6-12						
1.13	1	PCS	Cable kit	SB-028198						
1.14	2	PCS	Terminal clamp	260-337 4polig						
1.15	1	PCS	End plate	260-361						
1.16	1	PCS	Connecting bridge	260-402						
1.17	1	PCS	T - Piece conical	2090 1/4-1/4 R1/4" G1/4"						
1.18	1	PCS	T - connection conical	2060 1/4-1/4 R1/4" G1/4"						
1.19	3	PCS	T Piece	2070 1/4-1/4 R1/4" G1/4"						
1.20	1	PCS	Reducer adapter	RN 1412 MSV G1/4"a G1/2"i						
1.21	2	PCS	Plug screw	S2610 1/4 G1/4"						
1.22	7	PCS	Elbow	2020 1/4 - 1/4 R1/4" G1/4"						
1.23	4	PCS	Silencer	2941 1/4 G1/4"						
1.24	5	PCS	Hex nipple	LV 42.0021 R1/4"a						
1.25	4	PCS	Female to male reducer adapter	2521 1/4 - 1/4 R1/4"a G1/4"i						
1.26	1	PCS	Reduction	4-915.4097						
1.27	1	PCS	Pipe nut	DIN 431 R3/8"						

POS	QTY	UNIT	SPARE PART	DESCRIPTION	SPARE PART NO	1	2	3	4	5
1.28	2	PCS	Reducer adapter	2531 1/2 - 1/4 G1/2"a G1/4"i						
1.29	5	PCS	Elbow male connector	1020 10-1/4 d10 R1/4"						
1.30	1	PCS	Female to male reducer adapter	LV42.2018 a1/4-i1/4						
1.31	1	PCS	Male connector	1050 10-1/4 d10 R1/4"						
1.32	2	PCS	Socket	Socket 3EV290V10 Form A / ISO4400						
1.33	0,17	M	Tube	13001000 d10/6,8 Dekabon 1300						
1.34	0,24	M	Tube	13001000 d10/6,8 Dekabon 1300						
1.35	0,25	M	Tube	13001000 d10/6,8 Dekabon 1300						
1.36	2	PCS	Screw set	4-SV00.15790						
1.37	8	PCS	Screw set	4-SV00.17261						
1.38	6	PCS	Screw set	4-SV00.17246						
1.39	2	PCS	Screw set	4-SV00.15481						
1.40	1	PCS	Screw set	4-SV00.15802						
1.41	2	PCS	Hex socket head cap screw	ISO 4762 M4x8 A2-70						
1.42	1	PCS	Sticker Grounding	41225 13x13						
1.43	1	PCS	Type tag	SB-022261						
1.44	1	PCS	Sticker	EB-LT-050025 50x25, -40…+150°C						
1.45	1	PCS	Sticker SV1	4-ET00.15004						
1.46	1	PCS	Sticker SV2	4-ET00.17222						
1.47	1	PCS	Insert	HAN Mod Dummy						
1.48	1	PCS	Sticker PS1	4-ET00.17224						
1.49	1	PCS	Sticker PS2	4-ET00.17225						
1.50	1	PCS	Angle	SB-026815						
1.51	1	PCS	Connector housing	Han - Eco 6B - agg						
1.52	4	PCS	Screw set	4-SV00.17264						
1.53	1	PCS	Pin insert	Han - Eco PE - Modul						
1.54	1	PCS	Male insert	HAN DD Modul 12						

17.3.2 1-V15.16074



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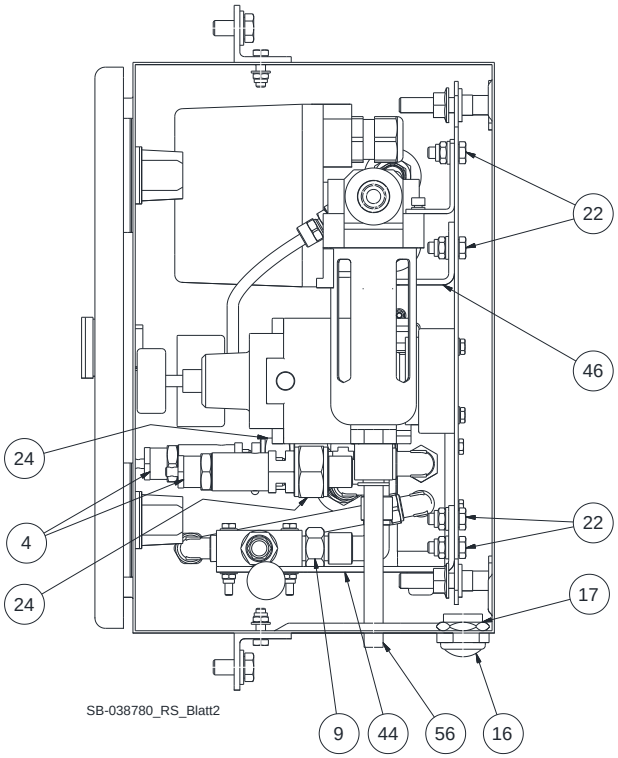
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Appendix A Pneumatic Scheme