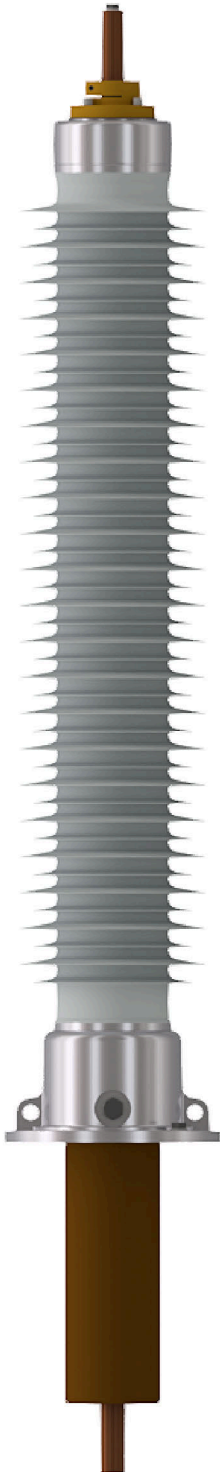




Pioneering  
high voltage.

# Installation, operating and maintenance instructions



## Transformer bushing

Range  
STARIP®-Si



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# 1 Documentation notes

The following describes how the text is presented and to whom the instruction applies.

## 1.1 How the text is displayed in this document

### 1.1.1 Descriptions

Descriptions are normal running text.

### 1.1.2 Instructions

▶	Instruction
▷	Sub-instruction
→	Reaction of product to instruction

### 1.1.3 Cross-references

Chap. XX on Page YY	Reference to a different chapter
---------------------	----------------------------------

### 1.1.4 Lists

●	Bullet point, 1st. level
○	Bullet point, 2nd. level
■	Bullet point, 1st. level for instructions



### 1.1.5 Additional applicable documents

► Please observe:

- All instruction manuals included with the product
- The associated bushing specification
- The transformer manual (not part of HSP scope of supply)

## 1.2 Storage of documents

This documentation and all its associated applicable documents must be stored in the vicinity of the product and be accessible to the personnel.

## 1.3 Validity of instructions

These instructions apply exclusively to the type range **STARIP®-Si**.

## 1.4 Target groups

These instructions are directed to expert operatives:

- Integrator of the bushing
- Installation and maintenance personnel

## 2 Safety

The following safety information applies for the entire instructions.

### 2.1 Classification of the handling-relevant warning instructions

#### **DANGER**

This warning instruction indicates a dangerous situation, which will **inevitably** lead to a severe or fatal accident if it is disregarded.

▶ Handling instruction for danger defense

#### **WARNING**

This warning instruction indicates a dangerous situation, which **may** lead to a severe or fatal accident if it is disregarded.

▶ Handling instruction for danger defense

#### **CAUTION**

This warning instruction indicates a dangerous situation, which **may** lead to slight or medium-severity accident if it is disregarded.

▶ Handling instruction for danger defense

#### **NOTICE**

This warning instruction indicates a dangerous situation, which may result in material damage if it is disregarded.

▶ Handling instruction for danger defense



Information and tips

### 2.2 Intended use

In the event of non-intended use, dangers to life and limb and damage to the product and other assets could be created.

The transformer bushings in the range **STARIP®-Si** are high-voltage bushings for the integration in transformers and for use as outdoor bushings.



Intended use includes:

- observance of all product instructions and instructions concerning the components of the installation
- operation of the product without changes to the product
- operation of the product within the specified operational limits (see bushing specification)
- compliance with all inspection and maintenance conditions

Any use other than those described in the existing instructions, or use that extends beyond those described here, is considered to be on-intended.

**The manufacturer is not liable for damage resulting from non-intended use. The manufacturer's warranty becomes void in the event of non-intended use. The operator bears the risk exclusively.**

## 2.3 General safety instructions

There are dangers associated with the bushings.

- ▶ Observe all the regulations that apply to the following areas:
  - Electrical voltages
  - Moving machines
  - Heavy weights
  - Moving masses
  - Injury caused by slipping, tripping, and falling down
- ▶ Observe all the relevant local regulations and legal stipulations.
- ▶ Observe the local hazardous material instructions.
- ▶ Observe the operating instructions.

### 2.3.1 Danger to life from electrocution

There is a danger of electrocution when working on the bushing.

- ▶ Observe the **five safety rules** before working on the bushing:
  - Disconnect
  - Secure against switching on again
  - Establish freedom from voltage
  - Ground and short-circuit
  - Cover or cordon off adjacent live parts





### 2.3.2 Crush and impact danger from suspended loads

There are injury dangers from suspended loads (lifted bushings etc.).

- ▶ Be aware of uncontrolled movements of the loads with lifted bushings.
- ▶ Never work under a suspended bushing.

## 2.4 Obligations of the integrator/operator

The integrator/operator has the following supervisory obligations:

- Supplementation of general safety information with local regulations
- Provision of first aid kit, fire extinguisher
- Ensure that only qualified personnel work on the product
- Ensure that the personnel are trained in first aid
- Provision of appropriate personal protection equipment
- Make sure that all safety devices are always present and are operating
- Regular training of the personnel in the following subjects:
  - Observance and use of all instruction documents
  - Intended use of the product
  - Knowledge of all safety devices and safety signs at the operating location
  - Observance of the legal regulations
  - Observance of the operating instructions

### 2.4.1 Action in the event of fire

- ▶ Report the fire:
  - Call the local emergency phone number
- ▶ Move to a safe area:
  - Take any endangered persons with you
  - Close doors
  - Follow the marked escape route
  - Wait for instructions
- ▶ Try to extinguish the fire.
  - Use the fire extinguisher

## 2.4.2 Action in the event of an accident

- ▶ Report the accident:
  - Call the local emergency phone number
- ▶ Employ first aid:
  - Secure the site of the accident
  - Provide care for the injured persons
  - Observe the instruction manuals
- ▶ Take any other measures:
  - Direct the ambulance or fire brigade
  - Remove rubberneckers

## 2.5 Qualification of the personnel

All work on the product requires expert technical knowledge. In order to ensure operational safety, only expert operatives or a technically trained person is allowed to work on the product.



The personnel must be able to evaluate the tasks allocated to him, to recognize possible dangers, and to take the appropriate safety measures.

The integrator/operator must ensure the qualification of the personnel.





## 2.6 Personal protection equipment

The integrator/operator is responsible for the provision of appropriate personal protection equipment.

HSP recommends:

	Protective clothing
	Hearing protection



	Head protection (safety helmet)
	Eye protection (safety goggles, possibly close-fitting)
	Hand protection (for protection from mechanical and chemical dangers)
	Foot protection (safety shoes)
For additional special local dangers	Additional appropriate protection equipment

### 3 Structure

The chapter describes the structure and design of the bushing.

#### 3.1 General structure

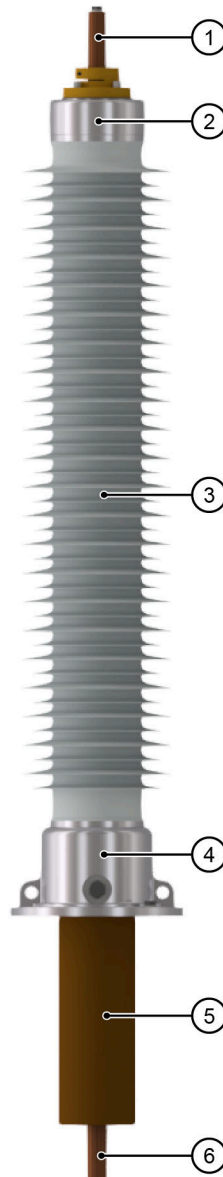
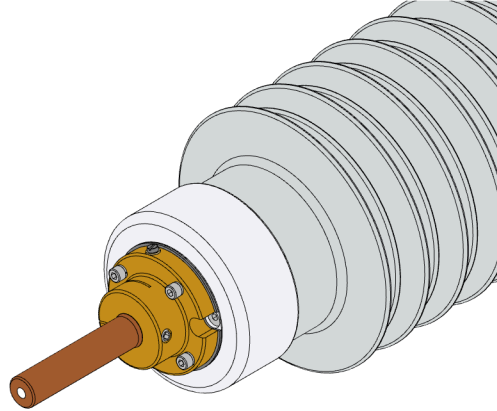


Fig. 1: Structure of the bushing

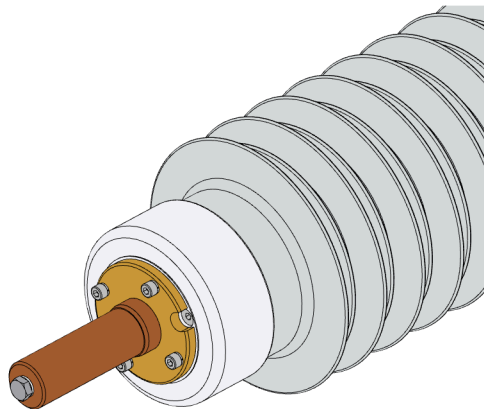
Item	Part	Item	Part
1	Connection terminal outdoor side	4	Flange
2	Head	5	Insulating body
3	Isolator	6	Connection transformer side

### 3.1.1 Version with draw lead bolt or detachable conductor bolt



**Fig. 2: Version with draw lead bolt or detachable conductor bolt**

### 3.1.2 Version with undetachable conductor bolt



**Fig. 3: Version with undetachable conductor bolt**

### 3.2 Design

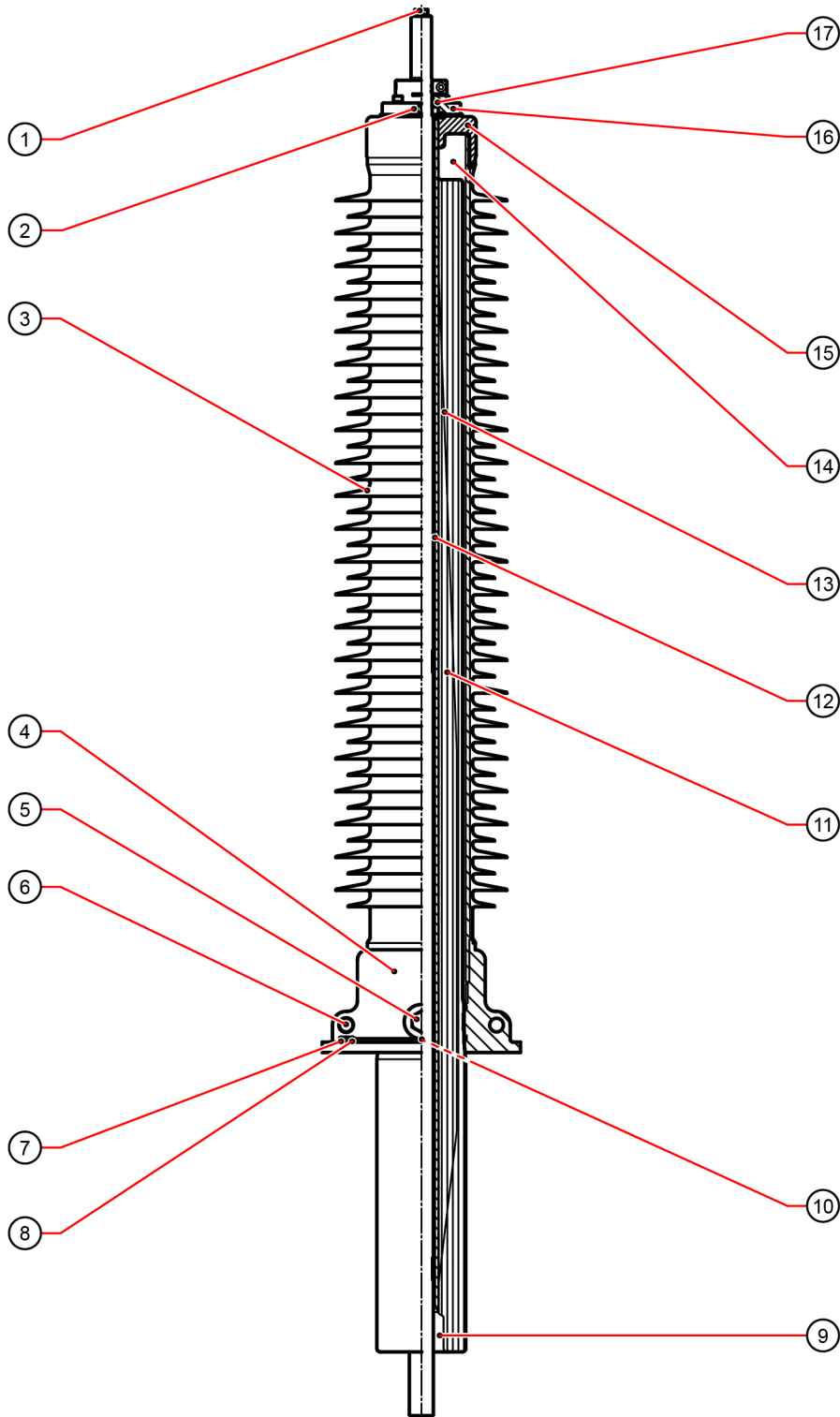


Fig. 4: Bushing design (example)

Item	Part	Item	Part
1	Hexagon screw	10	Transformer vent (not shown → on the back of the flange armature)
2	Air release screw	11	Insulating body
3	Composite insulator	12	Central tube (draw lead or detachable conductor bolt)
4	Flange armatures	13	Aluminum foil
5	Test tap	14	Polyurethane-elastomer
6	Sling points	15	Head armature
7	Grounding screw	16	Clamping piece
8	Lift-off screws	17	Seals
9	Screened mouth end		

The main insulation of the RIP-transformer bushing is an insulating body (11).

### Insulating body

The insulating body consists of a special paper and grading layers:

- The special paper is impregnated with epoxy resin under a vacuum.
- The grading layers are coaxially placed aluminum foils (13) which effect even voltage distribution on the insulating body.

Bushings with undetachable conductor bolts do not have a central tube (12).

### Composite insulator

The insulating body is incorporated in a composite insulator (3).

The composite insulator consists of:

- Filament winding tube
- Silicone sheds (connected to the filament winding tube by vulcanization)

The head armature (15) and the flange armature (4) are connected to the filament winding tube.

### Elastomer-connection

The gap between the insulating body and the composite insulator is filled with a foamed polyurethane elastomer (14). The elastomer rigidly connects the components together. The components can no longer be separated without destroying them.

### Bushing flange

The bushing flange is fitted with:



- A test tap (5)
- Sling points (6)
- Grounding screw (7)
- Lift-off screws (8)
- Transformer vent (10)

### **Bushing head**

The clamping piece (16) is screwed to the head armature of the composite insulator.

Seals (17) are arranged in defined chambers in the interface between the pin and the clamping piece.

### **Air release screw**

The air release screw (2) for venting of the central tube is located at the side on the clamping piece (16).

### **Undetachable conductor bolt**

With an undetachable conductor bolt, there is no clamping piece, but rather a disk as the:

- corrosion protection between the copper bolt and the aluminum armature
- Cover for the bolt sealing underneath

### **Pulling through the bolt**

Draw lead bolts / detachable conductor bolts have a threaded bore with a hexagon screw (1) on the front for pulling through the bolt using a pulling wire or pulling rod.

### **Electrode**

Depending on the scope of supply, a detachable insulated shield electrode is provided on the transformer side of the bushing using a bayonet lock.





## 4 Technical data

Standard values are stated in the technical data.

- ▶ Always observe the bushing specification applicable to the bushing for the product-specific values.

### 4.1 General operating conditions

Classification (STARIP®-Si)	<b>STA</b> Standard
	<b>RIP</b> Resin impregnated paper
	<b>Si</b> Silicone insulator
Ambient temperature (in accordance with IEC 60137)	Outdoor side: -30 ... +40°C Transformer side: Daily mean value +90°C, maximum value 100°C
Operation height	≤ 1000 m above sea-level
Rain level and humidity	In accordance with IEC 60060 - I
Pollution class	In accordance with the specific creepage distance (25 mm/kV, as per IEC 60815)
Immersion medium	Appropriate transformer oil
Oil level below bushing flange	≤ 15 mm
Oil pressure	Max. 200 kPa over-pressure
Possibility to evacuate (transformer tank)	No limitation on height and duration
Corrosion protection	All armatures and fixing material made from corrosion-resistant materials
Marking	On name plate, as per IEC 60137
Standard packaging	In heat-resistant wooden crate (or equivalent material). Carried in bearing shells. Sealed in film with addition of dessicant.



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## 4.2 Mechanical stress

Test bending load	Standard, in accordance with IEC 60137, Table 1, Class II
Operating load	50 % of test bending load



## 5 Installation

The chapter covers the preparation, execution and post-treatment of the installation.

### NOTICE

#### **Material damage caused by mechanical stress**

The bushing can suffer damage (particularly to the porcelain or silicone insulators) from mechanical stresses.

- ▶ When installing, make sure that the bushing is not exposed to mechanical stresses (particularly to porcelain or silicone insulators).

### 5.1 Preparing the bushing

- ▶ Open the wooden crate.
- ▶ Check the film on the bushing for damage.

### NOTICE

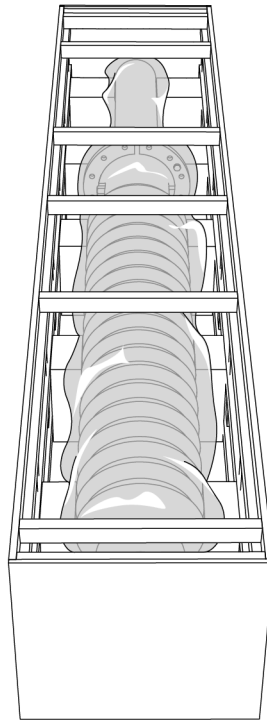
#### **Material damage caused by knives**

The bushing can suffer damage when unpacking with a knife.

- ▶ Always unpack the bushing using a safety knife (with a concealed blade).

- ▶ Open the film.
- ▶ If present, remove the plastic bag with the loose parts from the bushing.

### 5.1.1 Checking the scope of supply



**Fig. 5: Packaging (example illustration)**

- ▶ Check the scope of supply for completeness and damage, using the:
  - Delivery note
  - Bushing specification
  - Packing note (if present)
- ▶ Check whether the bushing was delivered in proper packaging:
  - In a wooden crate
  - Carried in bearing shells
  - Sealed in film with addition of dessicant
  - For larger bushings: Flange supported with wooden cross beams
- ▶ If a data logger is included in the scope of supply, then provide the HSP data of the data logger.

### 5.1.2 Checking the condition of the bushing

#### NOTICE

##### Material damage from moisture on the insulating body

Moisture on the insulating body damages the bushing and endangers operation.

- ▶ Always check the bushing for moisture on the insulating body before installing.

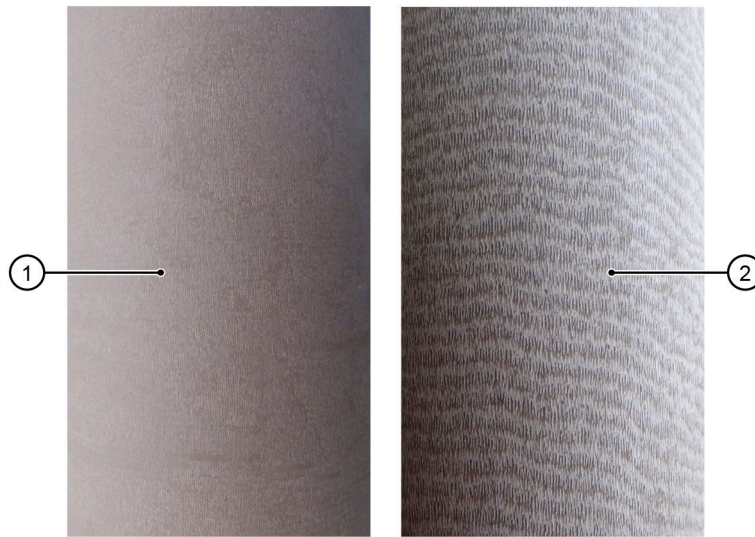


Fig. 6: Condition of the bushing

Item	Status	Item	Status
1	Good (dry surface)	2	Bad (moisture on the surface)

- ▶ Check the condition of the bushing visually for moisture and damage.
- ▶ In the event of clear humidity traces or damage, contact HSP.

### 5.1.3 Slings the bushing

If the bushing needs to be prepared specially (e. g. with a draw lead bolt or detachable conductor bolt, or if an electrode needs to be installed), the bushing must be put down on bearing supports for preparation.

## NOTICE

### Material damage by lifting the bushing improperly

If a bushing with silicone insulator is lifted up on the insulator, the sheds may suffer damage.

- ▶ Never lift a bushing with silicone insulator on the insulator.

## NOTICE

### Material damage by putting the bushing down incorrectly

If the bushing is put down with one end on the floor, then invisible cracks may be created by impacts.

- ▶ Never put the bushing down on the floor.

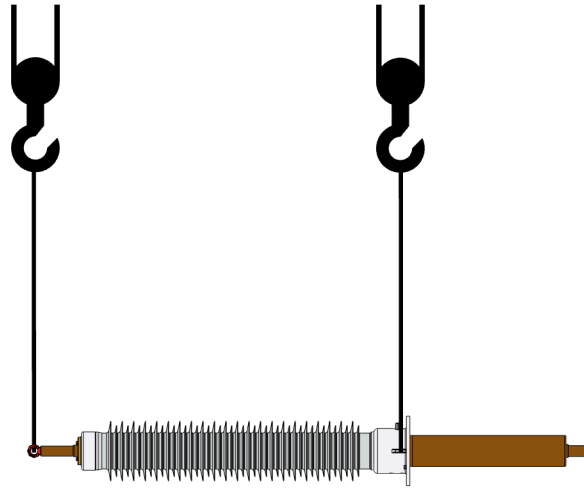
- ▶ Sling the bushing with one of the possible slinging variants:

Lifting versions	Short explanation
<b>Two lifting devices (e. g. cranes)</b> (The recommended variant)	One lifting device is fixed to the flange on the bushing.  The other lifting device is fixed to the head on the bushing.
<b>One lifting device (e. g. crane)</b> (If only one lifting device is available)	The lifting device is fixed both on the flange and on the head of the bushing.
<b>One lifting device (e. g. crane) + mechanic</b> (Applies only to small bushings having a weight < 50 kg)	The lifting device is fixed to the head on the bushing.  The mechanic guides the bushing at the flange.

- ▶ Lift the bushing.

#### 5.1.3.1 Two lifting devices (crane etc.)

Prerequisite: The lifting devices permit any inclined position required for installation.



**Fig. 7: Lifting with two lifting devices (example illustration)**

Threaded bores for removable ring screws are provided at the outdoor side end (either in the connecting bolt or in the head flange).

Sling points are cast into the flange, but they may be provided as ring screws for threaded bores (ring screws included in scope of supply).

- ▶ With ring screws as the sling points on the flange:
  - ▷ Remove the plastic covers from the threaded bores on the ring screws.
  - ▷ Screw the ring screws into the threaded bores.
- ▶ Attach the lifting accessories of the lifting devices to the sling points on the flange and the head.



#### 5.1.3.2 One lifting device (crane etc.)

- ▶ Attach lifting accessories from crane shackle to flange.
- ▶ Suspend a pulley to the same shackle.
- ▶ Guide the lifting accessories on the pulley to the bushing head.
- ▶ Tighten the pulley until the length of both lifting accessories is such that the crane shackle is positioned above the center of gravity of the bushing.

#### 5.1.3.3 One lifting device (crane etc.) + mechanic

Small bushings (weight < 50 kg) must only be lifted using one lifting device and supported by a mechanic.

- ▶ Guide the lifting accessories from the crane shackle to the bushing head.
- ▶ Hold the bushing at the flange with your hand.

#### 5.1.4 Putting the bushing down

##### NOTICE

###### **Material damage by putting the bushing down improperly**

If a bushing with silicone insulator is put down on the insulator, the sheds may suffer damage.

- ▶ Always put the bushing with silicone insulator down only on the head and on the flange.

##### NOTICE

###### **Material damage by putting the bushing down for long periods**

If the bushing is exposed to bad weather (such as rainfall), the surface will take up moisture, which will impair operating performance.

- ▶ Put the bushing down outdoors only for short periods and when the weather is dry.

##### NOTICE

###### **Material damage by putting the bushing down incorrectly**

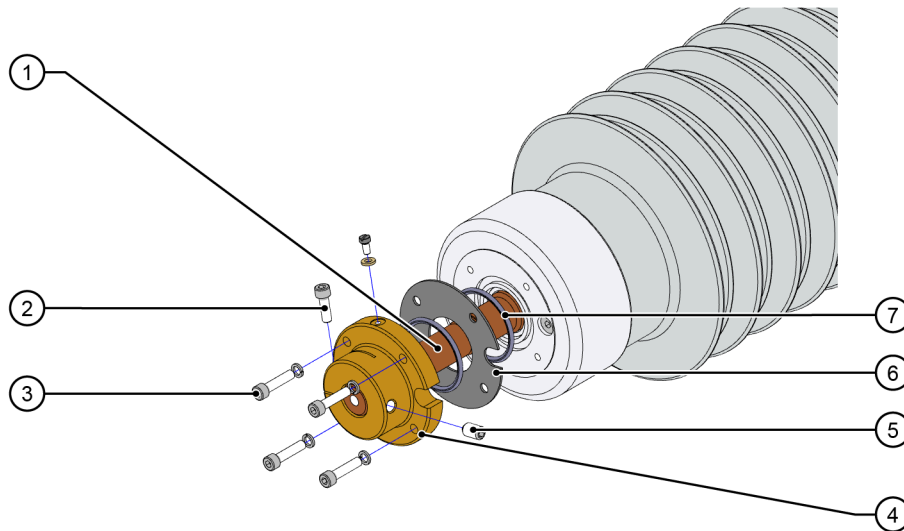
If the bushing is put down with one end on the floor, then invisible cracks may be created by impacts.

- ▶ Never put the bushing down on the floor.



- Put the bushing down properly on bearing supports (supported at the same points as in the crate).

### 5.1.5 Component overview (draw lead bolt / detachable conductor bolt)



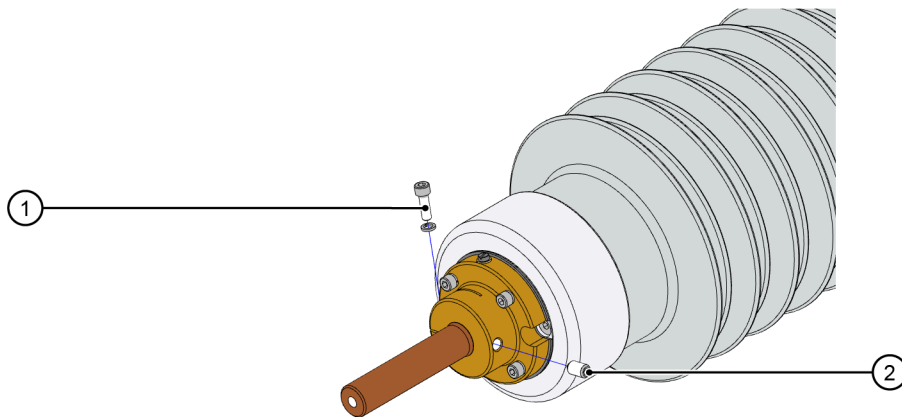
**Fig. 8: Detachable parts of the bushing head**

Item	Part	Item	Part
1	Draw lead bolt / detachable conductor bolt	5	Locking screw
2	Clamping screw	6	Washer
3	Fixing screws	7	O-rings
4	Clamping piece		

### 5.1.6 Removing the draw lead bolt / detachable conductor bolt

The bushing is delivered either with the draw lead bolt / detachable conductor bolt still installed or with it already removed (in the crate lying next to the bushing).

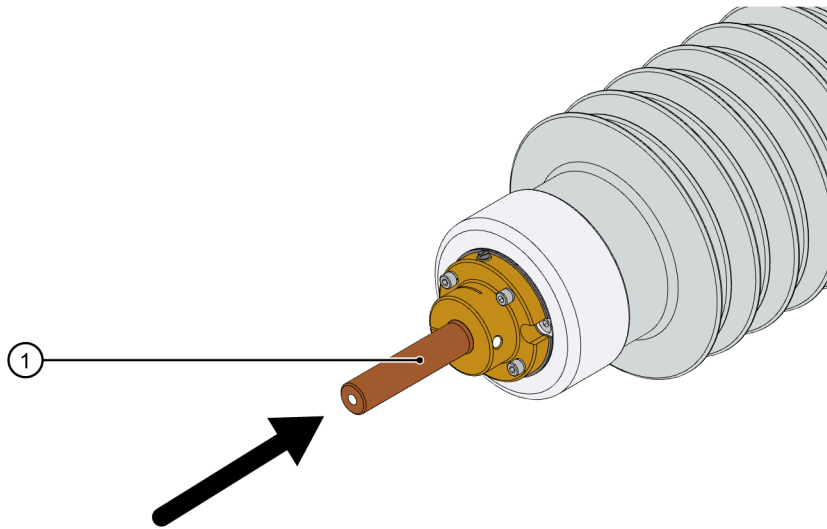
If the bushing has an installed draw lead bolt / detachable conductor bolt, the draw lead bolt / detachable conductor bolt can be removed.



**Fig. 9: Removing the draw lead bolt / detachable conductor bolt (1)**

Item	Part	Item	Part
1	Clamping screw	2	Locking screw

► Release the locking screw (2) and the clamping screw (1).



**Fig. 10: Removing the draw lead bolt / detachable conductor bolt (2)**

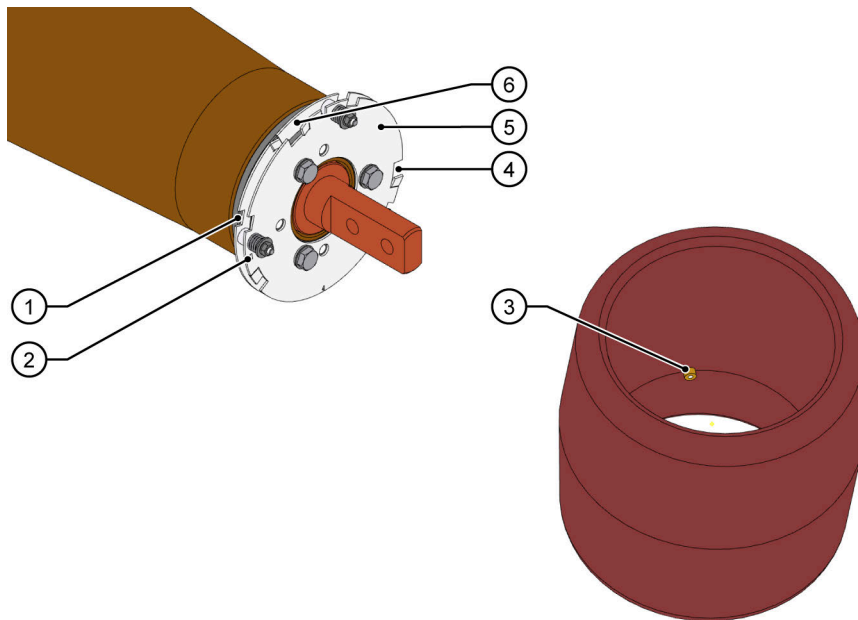
Item	Part	Item	Part
1	Draw lead bolt / detachable conductor bolt		

- ▶ Drive the draw lead bolt / detachable conductor bolt (1) into the bushing using light blows with a rubber hammer.
  - The friction in the seal is overcome by the blows.
- ▶ Push out the draw lead bolt / detachable conductor bolt out of the bushing towards the bushing flange.

### 5.1.7 Mounting the electrode on the transformer side (option)

As an option, the bushing can have an electrode (see bushing specification).

If there is an electrode provided on the bushing, it must be mounted on the electrode holder.

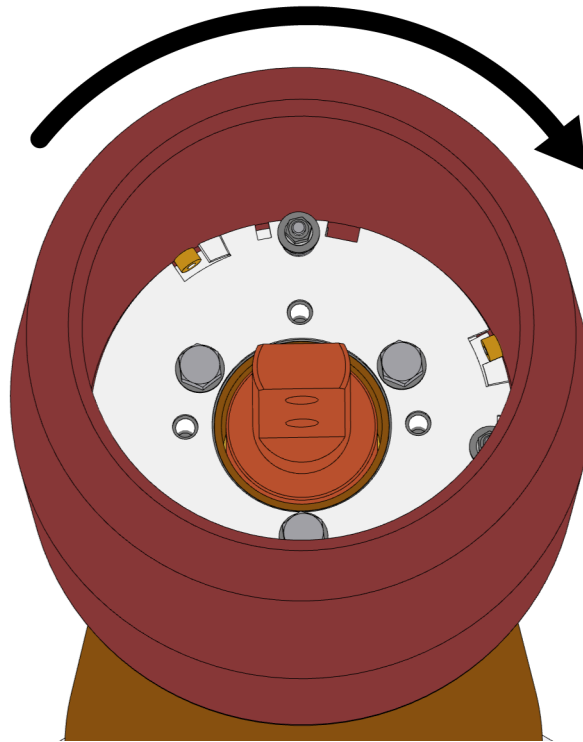


**Fig. 11: Structure of an electrode holder (here as an example with agile inner disk)**

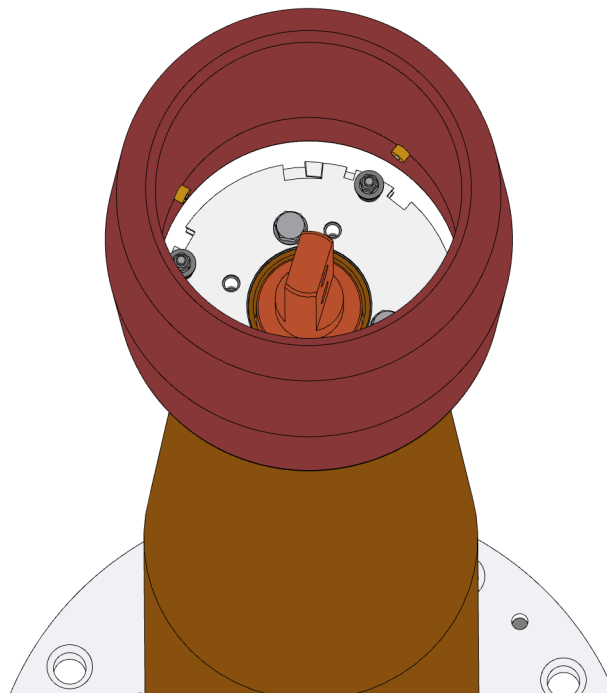
Item	Part	Item	Part
1	Opening to push through the electrode	4	Opening for insertion with inclination
2	Fastening slit	5	Outer disc
3	Brass pins	6	Inner disc

Three brass pins (3) are let into the electrode.

In order to install the electrode, it is guided into the relevant openings (4) in the outer disc (5), together with its three pins, until the pins are in contact with the inner disc (6). The two discs are then pushed apart by turning to the right.



If you continue to turn, the pins engage in the fastening slits.



- ▶ To simplify mounting of the current connections, slide the electrode over the two discs on the electrode holder through the relevant apertures before putting in place.

### 5.1.7.1 Mounting the electrode

#### NOTICE

##### **Broken electrode pins**

If too much force is exerted during mounting, the pins on the electrode may break off.

- ▶ Always mount the electrode carefully, never use excessive force.

- ▶ Place the electrode opposite the electrode holder so that the pins are located opposite the openings in the disc.



The openings in the disc on the electrode holder are arranged asymmetrically in order to prevent incorrect mounting of the electrode.

- ▶ Turn the electrode until it can be mounted.
- ▶ Guide the electrode into the electrode holder.
- ▶ Engage the electrode with a sharp rotation to the right.

### 5.1.8 Cleaning the bushing

- ▶ Clean the bottom end of the bushing with ethyl acetate.

## 5.2 Mounting the bushing on the transformer

- ▶ Observe the transformer manual for mounting the bushing on the transformer (including sealing the bushing and tightening the fixing screws).

### 5.2.1 Slings the bushing for installation

- ▶ If the bushing is resting on the bearing supports and is no longer slung, then sling it again ([Chap. 5.1.3](#) on page 21).

### 5.2.2 Putting the bushing at an inclination

- ▶ Lift the bushing.

### **WARNING**

#### **Danger of injury caused by prohibited inclined tensile force**

In the event of exceeding the permitted angle for the inclined tensile force, screwed sling points can be ripped off the bushing and persons may suffer injury.

- ▶ Select the lengths of the two lifting accessories so that the permitted inclined tensile force is not exceeded (60° out of alignment of the lifting eye).

- ▶ Place the bushing in the inclined position necessary for installation.
- ▶ Continue to work in ...

#### **Option**

**1/2: Bushing with draw lead bolt / detachable conductor bolt** ... [Chap. 5.2.3](#) on page 31

**2/2: Bushing with undetachable conductor bolt** ... [Chap. 5.2.7](#) on page 34

### 5.2.3 Connecting draw lead bolt / detachable conductor bolt to the transformer connection (option 1)

### **NOTICE**

#### **Material damage from a uninsulated draw lead**

An uninsulated draw lead can create stray currents in a draw lead bolt. Stray currents can generate gases when discharging and can destroy the bushing.

An insulation (such as cloth-binding) prevents stray currents between the transformer connection and the central tube.

- ▶ With a draw lead bolt: Insulate an uninsulated draw lead.



The detachable conductor bolt has spacers made of plastic that ensure the insulation of the bolt by equal spacing to the central tube.

- ▶ If not already present, drill a hole in the end (at a diameter appropriate to the transformer connection) of the draw lead bolt / detachable conductor bolt.
- ▶ Slide the end of the transformer connection in the hole on the draw lead bolt / detachable conductor bolt.
- ▶ Connect the transformer connection to the draw lead bolt / detachable conductor bolt (crimp, screw, braze or hard solder).

### 5.2.4 Mounting the draw lead bolt (option)

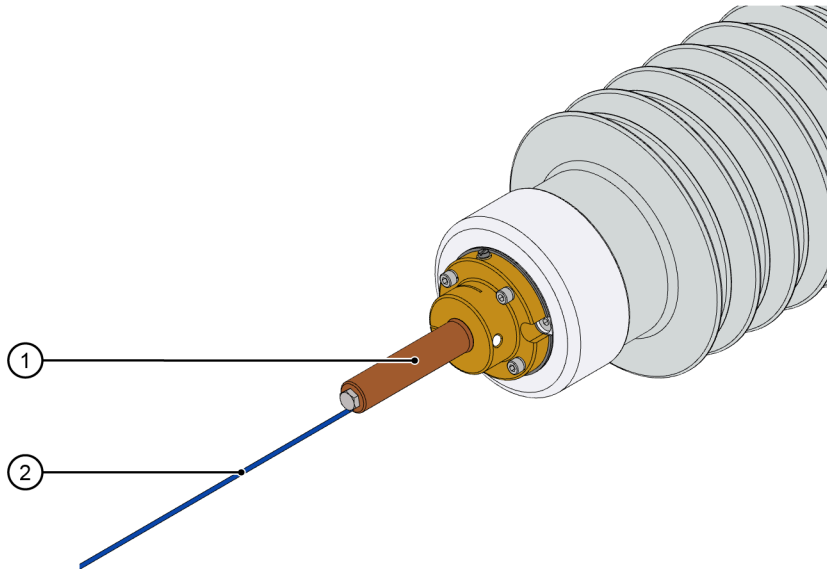


Fig. 12: Mounting the draw lead bolt

Item	Part	Item	Part
1	Draw lead bolt	2	Pulling wire/pulling rod

- ▶ Lower the bushing slowly onto the transformer.

▶ **NOTICE**

**Material damage caused by pulling elements being too big**

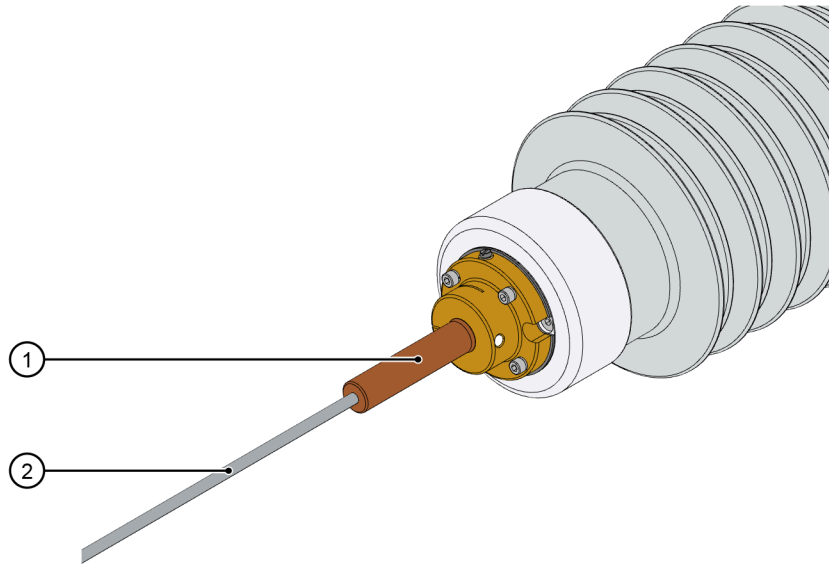
If the pulling elements (pulling wire or pulling rod) are too big, the O-rings may suffer damage when the draw lead bolt is pulled through.

- ▶ Ensure that the pulling elements (including their fixings on the draw lead bolt) have a diameter less than 30 mm.

Whilst lowering, pull the draw lead bolt (1) up through the central tube with a pulling wire or a pulling rod until the draw lead bolt protrudes from the bushing head.



### 5.2.5 Mounting the detachable conductor bolt (option)



**Fig. 13: Mounting the detachable conductor bolt**

Item	Part	Item	Part
1	Detachable conductor bolt	2	Suitable lifting equipment

- ▶ Screw a pulling rod into the drilled hole on the face side of the detachable conductor bolt.
- ▶ Lower the bushing slowly onto the transformer.
- ▶ Whilst lowering the detachable conductor bolt slide the detachable conductor bolt into the bushing with the pulling rod.

## 5.2.6 Installing the draw lead bolt / detachable conductor bolt

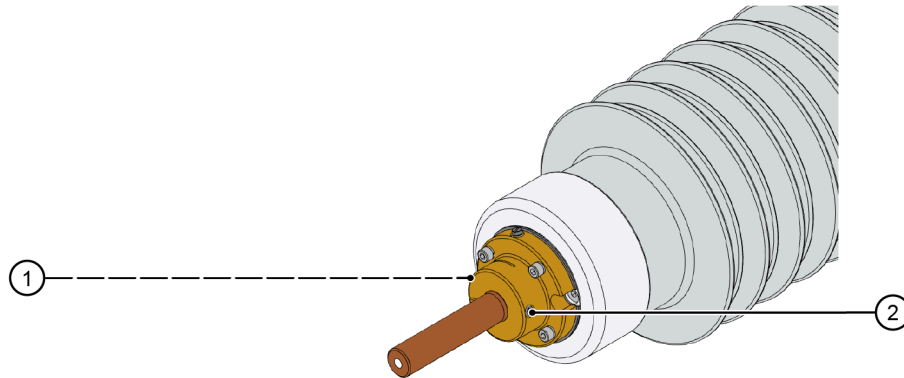


Fig. 14: Installing the draw lead bolt / detachable conductor bolt

Item	Part	Item	Part
1	Clamping screw	2	Locking screw

- ▶ Screw in the locking screw (2) and the clamping screw (1).
- ▶ Tighten the locking screw to the stipulated torque value ([Chap. 11.1](#) on page 52).
  - The locking screw engages in the first wave-form groove and stops the clamping piece on the bolt.
- ▶ Tighten the clamping screw to the torque engraved on the clamping piece (standard torques for brass: 18 Nm and for stainless steel: 24 Nm).
  - The clamping piece is securely clamped on the bolt.
- ▶ Remove the pulling elements from the bolt.
- ▶ Close off the end threaded bores in the bolt again with a screw and seal.

## 5.2.7 Connecting undetachable conductor bolt to the transformer connection (option 2)

Prerequisite: The bushing has an electrode.

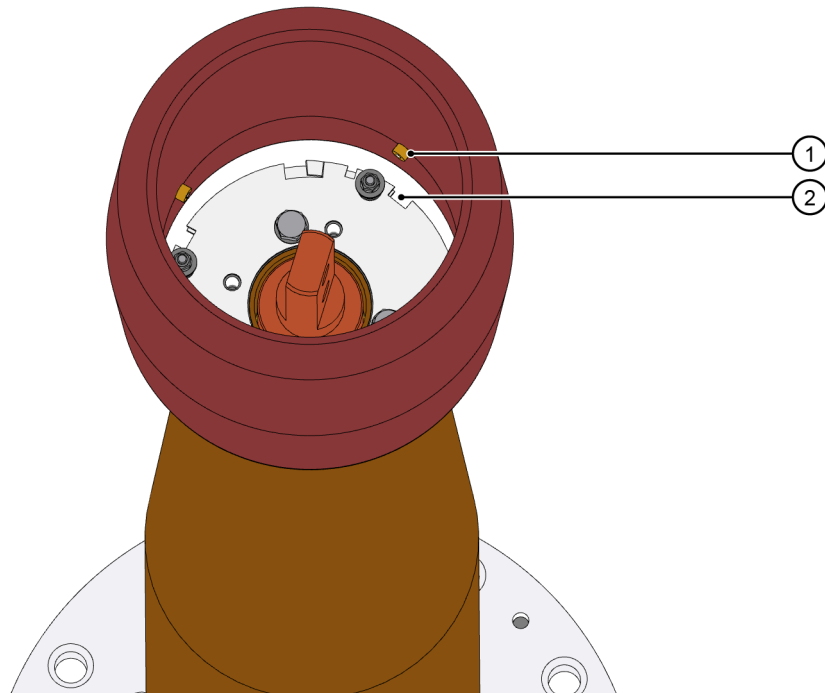
- ▶ Remove the electrode before connecting the undetachable conductor bolt to the transformer connection.

### 5.2.7.1 Removing the electrode

- ▶ Turn the electrode to the left with force until the pins no longer engage in the fastening slits.
- ▶ Continue to turn the electrode until the openings in the disc release the electrode.

### 5.2.7.2 Pushing the electrode through

To simplify mounting of the current connections, the electrode can be slid over the two discs on the electrode holder before putting in place.



**Fig. 15: Pushing the electrode through**

Item	Part	Item	Part
1	Pins	2	Cut-outs

- ▶ Turn the electrode so that its pins can be directed through the through-openings of both discs.
  - ▶ Slide the electrode over the two discs.
  - ▶ Twist the electrode slightly and place it on the inner disc.
- The electrode is now no longer in the way when mounting the current connections.

### 5.2.7.3 Mounting the electrode

#### NOTICE

##### Broken electrode pins

If too much force is exerted during mounting, the pins on the electrode may break off.

- ▶ Always mount the electrode carefully, never use excessive force.

- ▶ Place the electrode opposite the electrode holder so that the pins are located opposite the openings in the disc.



The openings in the disc on the electrode holder are arranged asymmetrically in order to prevent incorrect mounting of the electrode.

- ▶ Turn the electrode until it can be mounted.
- ▶ Guide the electrode into the electrode holder.
- ▶ Engage the electrode with a sharp rotation to the right.

### 5.2.8 Screwing the bushing to the transformer

- ▶ To install the bushing (including tightening the fixing screws and sealing the bushing [sealant not in scope of supply of HSP]):
  - Observe the transformer manual.
  - Observe the operating standard torques ([Chap. 11.1](#) on page 52).
  - With flat gasket seals, ensure appropriate external support.
- ▶ Screw the bushing in place.

### 5.2.9 Grounding the bushing flange

- ▶ Ground the bushing flange in one of the following ways:
  - Connect the flange to the transformer tank with the help of grounding screws (included in scope of supply) and grounding bands or grounding cables.
  - Connect the flange to the transformer tank using a pointed screw (M12) (to prevent from torsion and corrosion, the screw needs to be closed off using a head nut.).



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### **5.3 Post installation tasks**

- ▶ Carry out the concluding work of the installation.

#### 5.3.1 Releasing the ring screws

Prerequisite: The lifting eyes are ring screws.

- ▶ Unscrew the ring screws from the threaded bores.
- ▶ Mount the plastic covers on the threaded bores.

## 6 Preparation for commissioning

The chapter covers activities and tests before commissioning.

### 6.1 Filling the transformer

As long as the operating temperature of the bushing is not exceeded, the transformer can be evacuated for any desired period (if necessary).

- ▶ If necessary, evacuate the transformer.
- ▶ Fill the transformer with oil.

### 6.2 Venting the bushing

#### NOTICE

##### Material damage caused by air in the bushing

Air in the bushing can endanger operation and can damage the bushing.

- ▶ Vent the bushing with the help of air release screws (positions: see bushing specification).

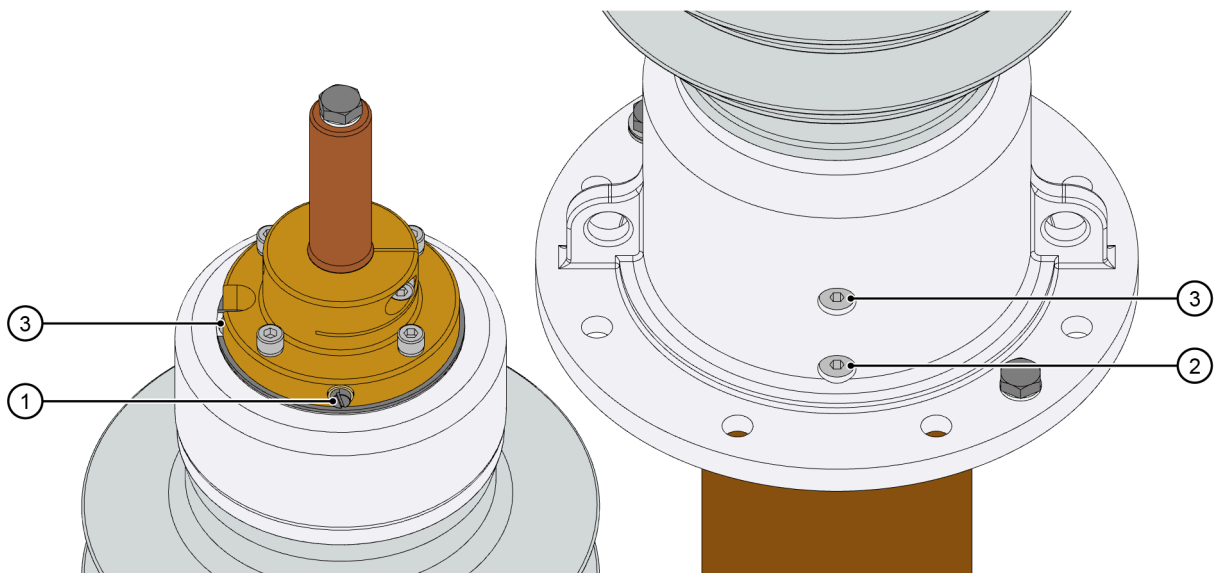


Fig. 16: Air release screws

Item	Part	Item	Part
1	Air release screw head	3	Screw for dessicant
2	Air release screw flange		

- ▶ In order to remove air bubbles under the bushing flange, open the air release screw flange (2) so that the air can escape (partial unscrewing of the screw will suffice).  
The screw (3) serves to fill the bushing with dessicant. It must never be opened.
- ▶ In order to vent the central tube, open the air release screw head (1) (partial unscrewing of the screw will suffice).
- ▶ After venting, tighten all the opened air release screws again.

### 6.3 Check bushing

- ▶ Check the status of the bushing before commissioning.

#### 6.3.1 Visual inspection

- ▶ Check the visible parts of the bushing for damage visually.
- ▶ Make sure that all screw connections are tightened in accordance with the stipulations ([Chap. 11.1](#) on page 52).
- ▶ Make sure that the removable cap on the test tap is screwed on tightly.

#### 6.3.2 Leak test (visual)

The leak testing of the installed bushing can only be carried out to a limited extent.

Transformer oil is not present at all positions on the bushing. The oil is present at the flange, it is adequate for vertically-installed bushings, but does not always reach to the head.

- ▶ Check whether and where oil is coming out of the bushing.

#### 6.3.3 Electrical testing



All bushings are tested in final acceptance tests and are tested suitable for operation.

The electrical measurements include:

- Bushing capacitance as main capacitance  $C_1$
- Power factor of main capacitance  $\tan \delta$



The capacity  $C_2$  between the last grading layer and the flange, and the power factor  $\tan \delta$  of  $C_2$  can be measured. However, they do not facilitate any statement concerning the main insulation, and simply indicate the status of the test tap area and will be influenced by ambient influences (scatter capacity).



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Appropriate reference data will already be available if a reference measurement has been carried out during the final acceptance tests.

- ▶ Carry out a reference measurement of the bushing on site in order to be able to compare later measurements (identical measuring conditions) ([Chap. 7.3](#) on page 43).



## 7 Maintenance

The chapter describes the activities and tests for maintenance of the bushing.

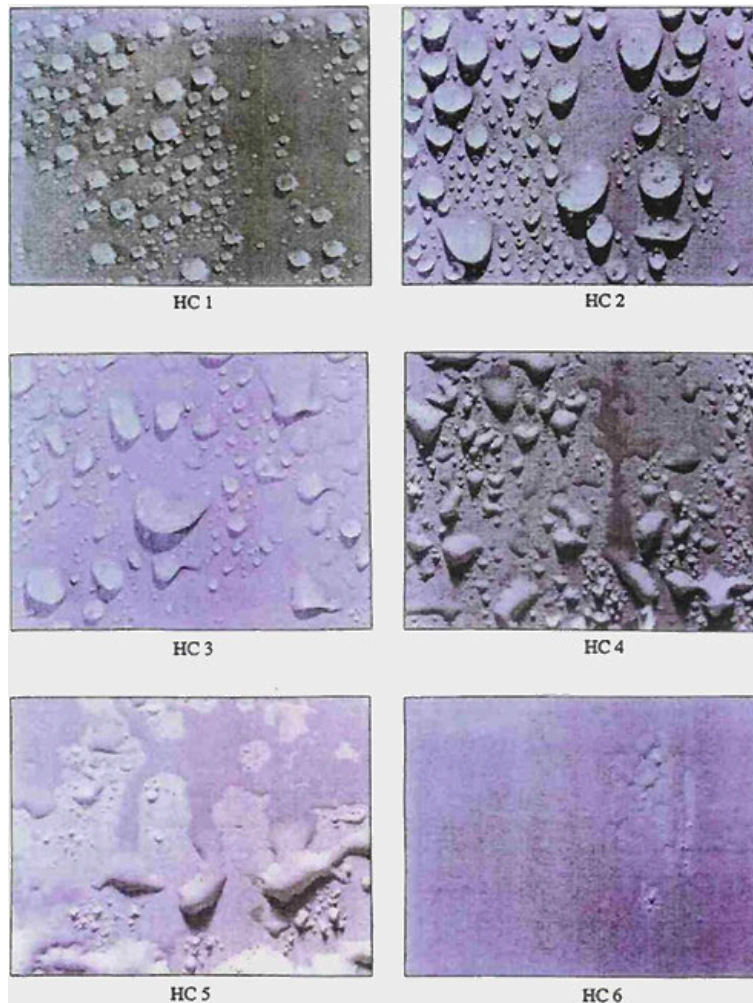
### 7.1 Maintenance schedule

Maintenance work	Interval	Described in ...
Check and clean insulator surface	Check: Annually or together with transformer-maintenance  Cleaning: Only with acute necessity	<a href="#">Chap. 7.2</a> on page 41
Check bushing electrically	After the first 7-10 years of operation  Thereafter according to the measurement result at intervals of 3 years or less	<a href="#">Chap. 7.3</a> on page 43
Check the temperature using a thermal image	At the discretion of the operator	<a href="#">Chap. 7.4</a> on page 47

### 7.2 Check and clean insulator surface (silicone insulator)

The insulator surface is water repellent (hydrophobicity). Discharge traces on the insulator surface change the water repellent features of the composite insulator.

- ▶ Make a visual check of the composite insulator for discharge traces and material damage.
- ▶ In the event of discharge traces, find out the cause of the discharges and eliminate them.
- ▶ Rectify any material damage.



**Fig. 17: HC classification**

The HC classification provides an approximate statement concerning the water repellent features of the composite insulator. The HC classification is simply a rough comparative procedure and does not permit any statement of a guaranteed operating performance.

- ▶ In wind-free and dry weather, spray a hand-size area abundantly with water from a spray-bottle at a distance of approx. 30 cm.
- ▶ Compare the image of the drops with the HC classification.
  - If the image of the drops corresponds to the HC classes HC 1, HC 2 or HC 3, then the water repellent feature of the composite insulator is still adequate.

## NOTICE

### **Material damage from too frequent cleaning of the insulator surface**

Cleaning greatly changes the water repellent property of the insulator surface. The insulator surface gets its water repellent property back approximately 1 ... 2 days after cleaning. If cleaning is too frequent, the water repellent property is reduced over the long-term.

- ▶ Do **not** clean the composite insulator regularly - only as and when required.

- ▶ When cleaning, observe:

- Non-fraying cloth
- Non-aggressive cleaning agent (Rivolta B.W.R. 210)
- Low effort applied

## 7.3 Check bushing electrically

### **DANGER**

#### **Danger to life from electrocution**

There is a danger to life from electrocution during the measurements.

- ▶ Make sure that there are no persons in the vicinity of the bushing during the electrical measurements.
- ▶ Carry out the electrical measurements only if you have experience with the measuring equipment, the measuring layout and the interpretation of the measurement results.

## NOTICE

### **Material damage caused by improperly conducted electrical measurements**

The bushing may suffer damage from improperly carried out electrical measurements. The capacity is influenced by the environment. The power factor  $\tan \delta$  is affected by moisture, the weather etc.

- ▶ Carry out the electrical measurements only if you have experience with the measuring equipment, the measuring layout and the interpretation of the measurement results.
- ▶ Test the bushing electrically with suitable measuring equipment and measuring procedures.

### 7.3.1 Measuring equipment

- Use appropriate measuring equipment or contact HSP.

### 7.3.2 Measuring procedure

The measuring procedure differ by the coupling of the measuring signal:

- With not grounded measurements, the test voltage is applied to the conductor on the bushing and the measuring signal is taken from the test tap on the bushing.
- The “grounded” measuring procedure is used if the bushing to be measured does not have a test tap.

The bushings in this range have a test tap.

- Take further details concerning the measuring procedures from the instruction manuals of the measuring equipment.

### 7.3.3 Threshold values

There are threshold values for the material RIP (resin impregnated paper) for the deviation of capacity and the power factor from the reference value.

The effect of the ambient temperature must be taken into account when carrying out the measurements:

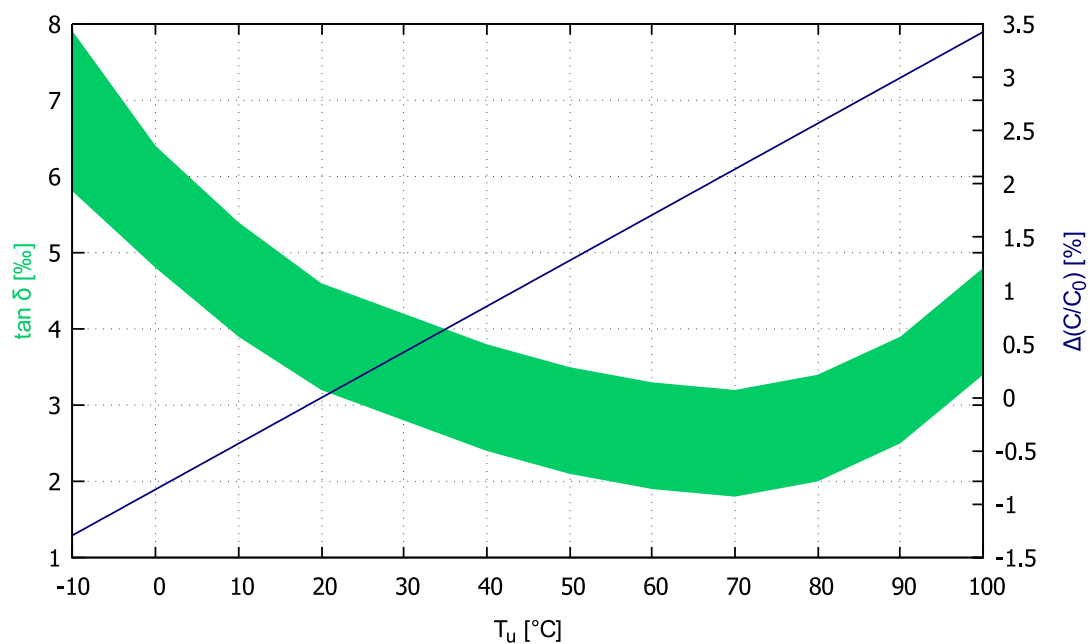


Fig. 18:  $\tan \delta (T_u)$  and  $\Delta C/\Delta C_0 (T_u)$

Axis	Meaning
X	Ambient temperature $T_U$ of the bushing
Y (left)	Power factor $\tan \delta$ depending on the ambient temperature $T_U$
Y (right)	Change of main capacitance $\Delta C/\Delta C_0$ depending on the ambient temperature $T_U$

If the measured capacity  $C$  deviates from the reference capacity  $C_0$  after the temperature correction, the main insulation may have suffered a partial breakdown.

The level of capacity deviation caused by a partial breakdown depends on the grading layers. The grading layers rises with increasing voltage level and the capacity deviation reaches the level of measuring accuracy of the capacity measurement.

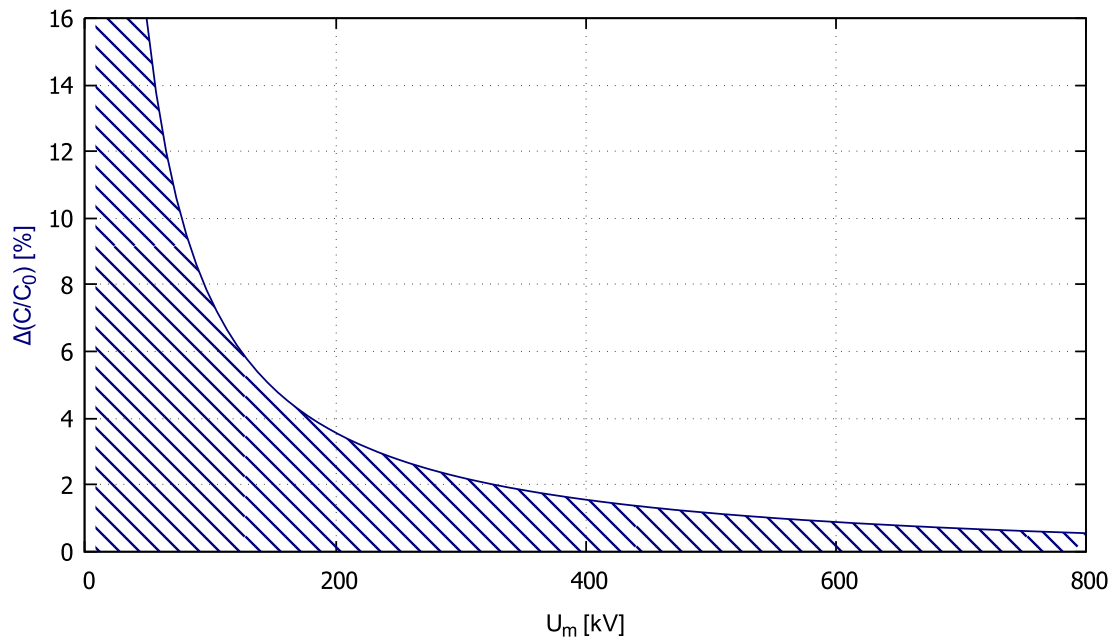


Fig. 19:  $\Delta C/\Delta C_0 (U_m)$

Axis	Meaning
X	Voltage $U_m$ of the bushing
Y	Change of capacity $\Delta C/\Delta C_0$ depending on the voltage $U_m$

- ▶ If the capacity deviation indicates partial breakdowns, then:
  - ▷ Take the bushing out of service.
  - ▷ Contact HSP.

### 7.3.4 Test tap

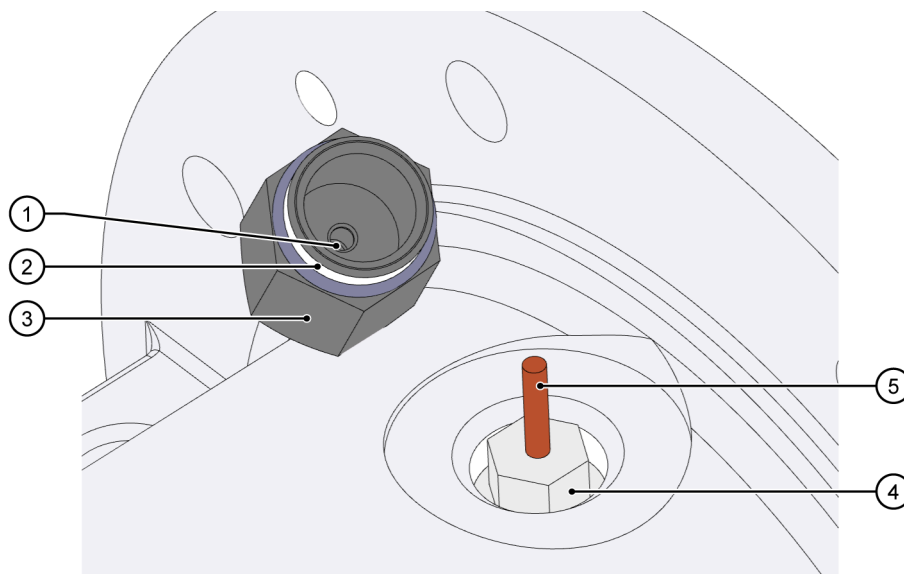


Fig. 20: Test tap

Item	Part	Item	Part
1	Grounding contact	4	Test tap
2	O-ring	5	Insulated bushing with pin
3	Removable cap		

The last grading layer of the capacitive grading is directed out using the test tap (4) (insulated bushing (5)).

The removable cap (3) has an o-ring seal (2) to ensure that the inner space of the test tap remains free from humidity.

In operation, the screwed-on removable cap grounds the pin with the help of a grounding contact (1).

- ▶ Connect the measuring lead to the pin.
- ▶ Carry out the measurements.

#### NOTICE

##### Material damage from missing removable cap

The test tap is not self-grounding. If the bushing is operated with an open test tap, then the insulated bushing in the test tap will be destroyed followed by inner fault of the entire bushing.

- ▶ Always screw the removable cap in place after a measurement.

- ▶ Make sure that the removable cap is always screwed in place before operating.



#### 7.4 Check the temperature using a thermal image

- ▶ If the installations are regularly checked using a thermal image, then observe the following when carrying this out:
  - The temperature at the outer contact point (the lead clamp) normally increases by up to 40 K with regard to the ambient temperature.
- ▶ With an increase of temperature greater than 40 K or with over temperatures under low load, check the contacts.

Hotspots over the outdoor insulator length can cause a nonuniform temperature distribution.

- ▶ Make a more detailed investigation of possible hotspots (possibly contact HSP ).



## 8 Repair

Only those parts of the bushing that are accessible from the outside can be repaired. External damage to silicone sheds must only be repaired using special procedures. The composite insulator on the bushing cannot be removed.

- ▶ In the event of damage, first contact HSP (quoting the serial number of the bushing).
- ▶ Discuss the next steps with HSP in the event of smaller or larger damage to the bushing.

### 8.1 Smaller damages

- ▶ Have the bushing repaired on site by HSP or request repair instructions from HSP.

### 8.2 Huge damages

In the event of huge damages, e. g. after failure of the bushing in an inner fault, the bushing cannot be repaired on site. HSP can use appropriate measures to investigate the bushing in the HSP works.

- ▶ If necessary, send the bushing back to HSP (quoting the returns number issued by HSP in advance).



## 9 Storage

The bushing must be stored in covered dry rooms.

### 9.1 Standard storage

Storage period	
Standard packaging	12 months
Packing with aluminum coated foil	24 months

### 9.2 Long-term storage

For long-term storage (for example as spare bushing), the bushing must be protected on the bottom with a HSP protection tank (coated steel, with pressure gage).

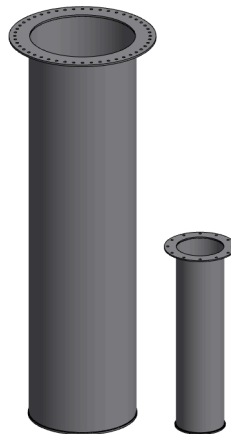


Fig. 21: Protection tanks (example illustration)



### CAUTION

#### **Injuries to persons from over-pressure**

During storage in a protection tank, bushings with draw lead bolt and detachable conductor bolt are under pressure.

- ▶ Before the clamping of the bolt is released, first release the pressure on bushings with draw lead bolt and detachable conductor bolt (air release screw).

### NOTICE

#### **Material damage from moisture**

Penetrating moisture damages the bushing.

- ▶ Check the pressure at the pressure gage of the protection tank/protection hood at regular intervals.
- ▶ If necessary, increase the filling pressure to the stipulated value.

- ▶ Screw the protection tank onto the bushing:
  - ▷ Place the dessicant bag in the protection tank.
  - ▷ Screw the protection tank against the bushing flange.
  - ▷ Fill the protection tank with nitrogen (filling pressure: 0.25 bar [25 kPa]).

## 10 Disposal

The constituent parts of the bushing are non-toxic, not self-inflammable and not physically burdening. They can be disposed of as industrial waste.

### 10.1 Constituent parts of the bushing

The bushing contains:

- Conductor bolt: Cu-ETP or Cu-HCP
- Insulating body: Epoxy-resin impregnated special paper with aluminum foils
- Armatures: made from aluminum alloys, copper alloys, brass or stainless steel, depending on the version
- Flanges: made from aluminum alloys, brass or stainless steel, depending on the version
- Central tube: Aluminum alloys
- Fixing materials, test tap, screw etc.: Stainless steel, aluminum alloys and brass
- Polyurethane-elastomer (dessicant)
  - If the dessicant contains SF<sub>6</sub>: The polyurethane-elastomer with SF<sub>6</sub> must be burnt without residue at min. 1200°C, in accordance with **CIGRE: SF<sub>6</sub> Recycling Guide**.

### Silicone bushings

- Seals: Silicone elastomer



The insulating body is rigidly connected to the composite insulator via the dessicant. It is best to split the bushing into several parts for easy and improved disposal.



## 11 Standard torques

The standard torques apply to:

- Screw connections with stainless steel screws
- Flange connections with O-ring seals and metallic contact of the parts

### 11.1 Standard torques

Screw	Torque [Nm]	Torque [kpm]
M4	1.10	0.11
M5	2.20	0.22
M6	4.00	0.40
M8	10.00	1.00
M10	19.00	1.90
M12	33.00	3.30
M14	52.00	5.20
M16	80.00	8.00
M18	110.00	11.00
M20	160.00	16.00
M22	210.00	21.00
M24	255.00	25.50
M27	370.00	37.00
M30	510.00	51.00

### 11.2 Standard torques for air release screws

Screw	Torque [Nm]	Torque [kpm]
M6	3.40	0.34
M8	7.00	0.70
M10	13.00	1.30
M12x1.5	15.00	1.50
M16x1.5	40.00	4.00

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**Installation, operating and maintenance  
instructions**

**Range STARIP®-Si**

09/21

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