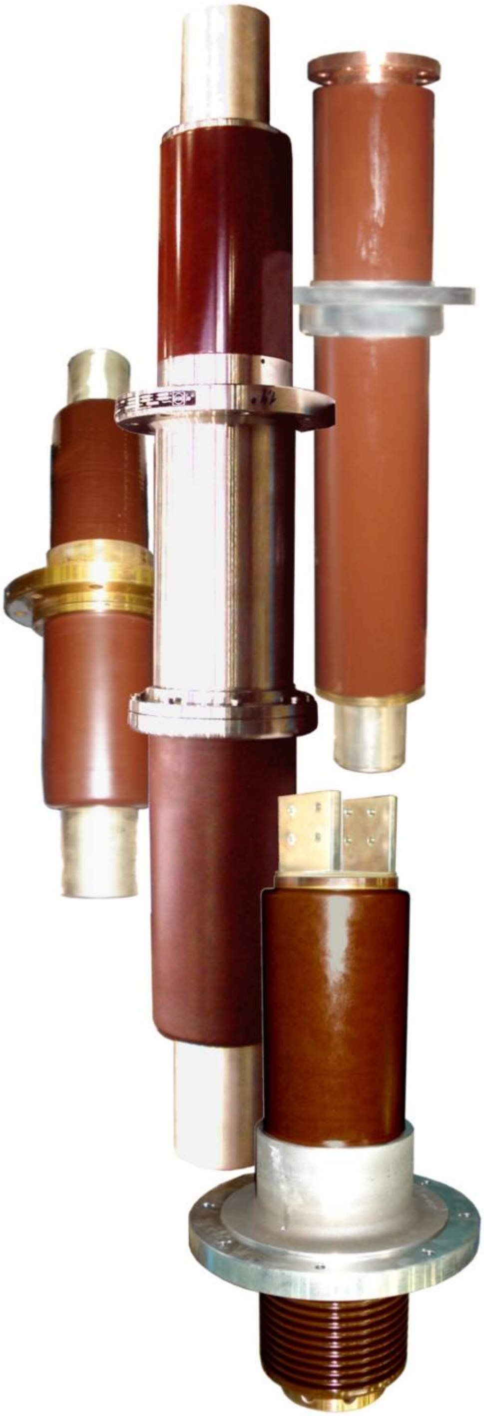

Generator Bushings

Type

EKMI/EMI/EMH

Mounting

Operating

and

Maintenance Instructions

SAFETY INSTRUCTIONS

This regulation applies to the installation, operation, and maintenance of transformer bushings of the EKMI/EMI/EMH series.

During installation, operation and maintenance work, a range of safety risks exist regarding:

- Life-threatening, electrical voltages
- High voltage
- Moving machinery
- Heavy weights
- Handling moving masses
- Injuries due to slipping, stumbling or falling

Regulations and instructions specifically applicable to these areas must be complied with and followed when dealing with such devices. Disregarding the instructions can lead to sever personal harm, death, product damage, property damage or to damage later during operation.

In addition to these rules, the national and international safety regulations must also be complied with.

In this regulation, circumstances involving personal harm or death and product damage are identified with the following markings in the various instructions and installation steps:

Personal harm or damage resulting in death

Product damage and/or consequential damages

This operating and maintenance regulation is applicable to the EKMI/EMI/EMH series.
This regulation is only applicable to the respective bushing version in connection with the related bushing specification, which includes all technical data and the dimensioned drawing.
It is an integral part of the operating and maintenance regulation.

CONTENT

1 Description
1.1 Layout

Type EKMI
Version for natural cooling or liquid cooling

Circular connection, machine side

Insulator, capacitor winding
made of RIP, painted

Bushing flange

Retainer ring for insulator lock bush

In version with liquid cooling connection
area for liquid cooling connection
and continuous cooling channel

Insulator lock bush made of cast-resin
moulded material

Circular connection, air side

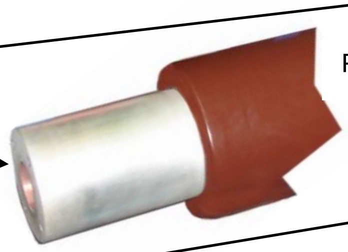

Fig.2

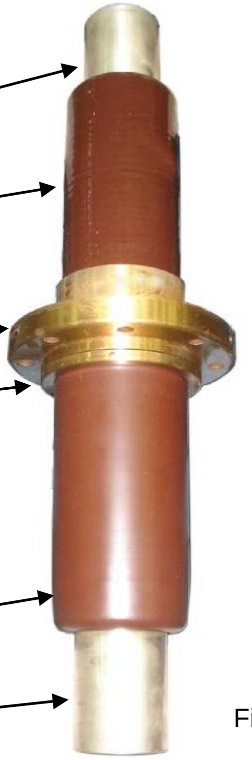

Fig.1

Type EKMI
Version for gas cooling

Flange connection, machine side

Insulator, capacitor winding
made of RIP, painted

Bushing flange

Blade terminal, machine side

Discharge outlets for cooling gas

Connection flange, contact surface

Inlet opening for cooling gas

Insulator, capacitor winding
made of RIP, painted

Retainer ring for electric conductor

Circular connection, air side

Fig.4

Fig.3

<u>Type EMI</u>
<u>Version for liquid cooling</u>

Circular connection, machine side

Supporting disc

Insulator, capacitor winding
made of RIP, painted

Bushing flange with current
transformer extension on the air side

Connection area for the
coolant connection
and continuous cooling channel

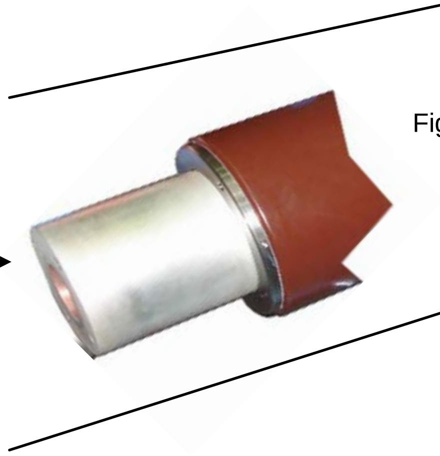

Fig.6

Retainer ring for insulator lock bush

Insulator lock bush made of cast-resin
moulded material

Circular connection, air side

Fig.5

<u>Type EMH</u>
<u>Version for air or gas cooling</u>

Flag terminal, air side

Insulator, capacitor winding
made of RIP, painted

Machine side connection

Discharge outlets on the perimeter

Central inlet opening

Large-area contact for current
connection

Fig.8

Bushing flange

Blade terminal, machine side

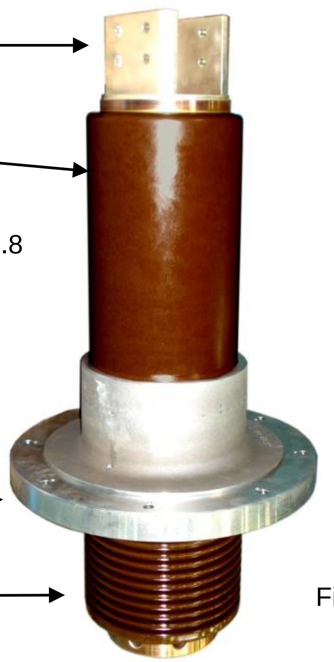

Fig.7

1.2 Design**

A = Version with natural cooling or liquid cooling (EKMI)
B = Version with gas cooling (EKMI)

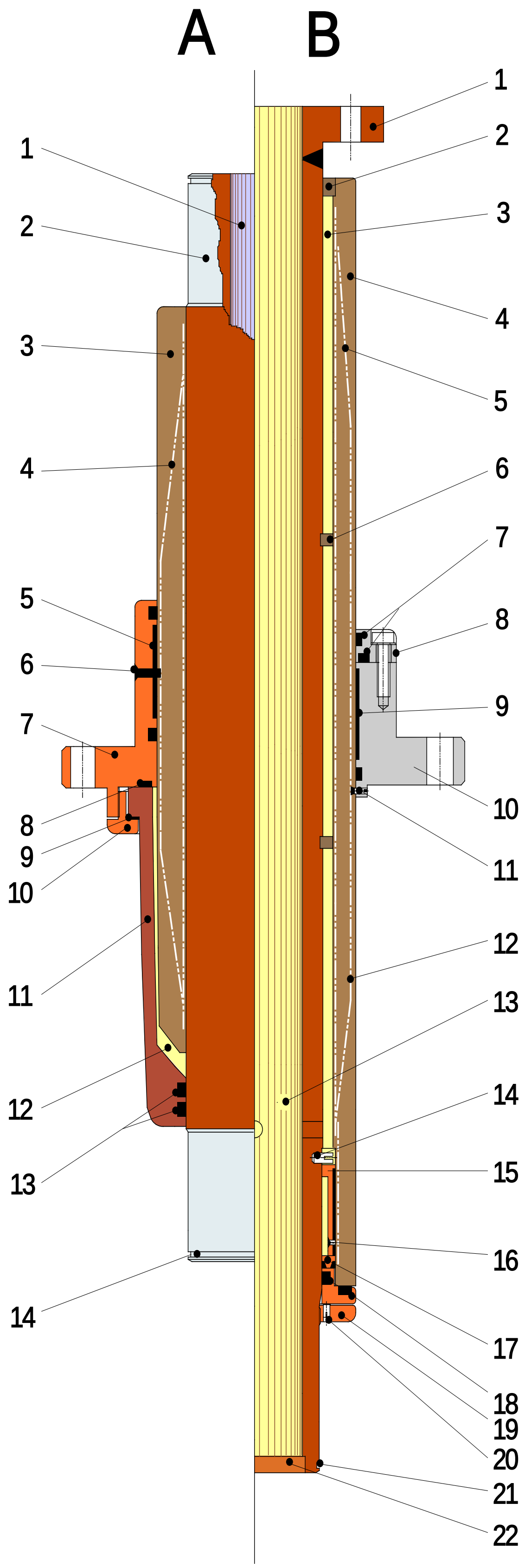

Fig.8

The main insulator of the EKMI generator bushing is an insulator (A3B4). It is made of a special paper impregnated with epoxy resin under vacuum and coaxially configured control layers made of aluminium foil, which effectuates uniform voltage distribution on the insulator (A4B5).
When using with current transformers, the grounded, last control layer (B12) is formed correspondingly long depending on the design on the air side.

Version A:
The insulator (A3) is impregnated directly to the current conductor bolt (A2). The bolt is provided with a cushion made of cork Perbunan for this purpose. It is equipped on the connection ends with a silver-plated circular connection and, for liquid cooling, additionally with a continuous bore (A1) and front fastening thread holes for the liquid fittings.
The bushing flange (A7) is made from a brass alloy and is cemented to the insulator (A5). The last layer of the capacitor control is galvanically connected to the flange through a soldered threaded screw (A6).

On the air side, the insulator lock bush (A11) is bolted to the flange through a cushioning material (A9) with a locking ring and seal (A8). This lock bush is sealed against the conductor bolt with O-rings (A13), creating the gas-tight termination of the bushing.
The gap in the inside (A12) is filled with air which then exchanges with the generator gas through diffusion in the insulator area during operation. The grooves (A14) on the circular connection serve to fixate the junction head during installation.

Version B:

The insulator (B4) is impregnated onto a shaping mandrel, which is subsequently removed during the manufacturing process. That creates a tubular body provided on its air-side end with cemented fittings to anchor the electric conductor. However, in terms of its structure, the insulator is identical with Version A.

The electric conductor (B1) is likewise a tube with welded connection flange and a gas-tight cover (B22). It has openings (B13) which are necessary to flood the cooling gas and which facilitate two-sided cooling of the electric conductor.

The electric conductor is held in place with a cemented sleeve (15) and rests with its stop edge in the area of the anti-rotation block (B14). The inner control layer is galvanically connected with the sleeve (B16).

The O-ring seals are located in the seal ring bodies (B17/18) between the bolt and the insulator. With a ring nut (B19), which in turn is secured against loosening with a setscrew (B20), the bolt is fixated through the sleeve and the seal ring body. Furthermore, the bolt is radially supported against the insulator with spacers (B6).

The bushing flange (B10) is made of an aluminium alloy and is connected to the insulator with cement (B9). The seal is formed through a gasket ring (B8) with O-ring seals (B7) on the gas side.

The last layer of the capacitor control is galvanically connected through a soldered screw connection (B11). The groove on the end of the circular connection (B21) has the same function as described in A14.

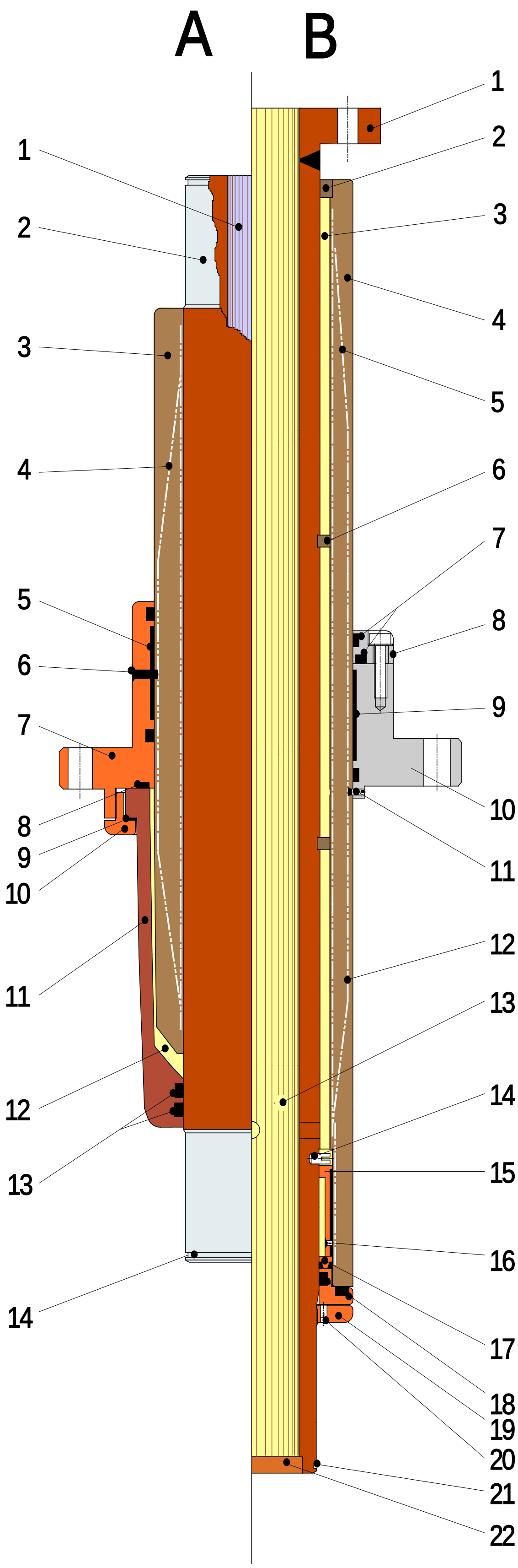

Fig.9

C = Version with liquid cooling (EMI)
D = Version with air cooling (EMH)

The main insulator of the EMI and EMH generator bushing is an insulator (C6D5). It is made of a special paper impregnated with epoxy resin under vacuum and coaxially configured control layers (C7D6) made of aluminium foil, which effectuates uniform voltage distribution on the insulator. It is impregnated directly onto the electric conductor with a cushioning.

Version C:
The electric conductor (C3) is a copper bolt with a continuous bore (C2) for the liquid cooling and face-side tap holes (C1) to connect the liquid fittings. It has silver-plated circular connections (C16) and a groove (C17) to fixate the connection head during installation. It is mechanically secured against slipping with seat locking grooves (C5) and a retaining ring nut (C4).

The bushing flange comprises a welded construction which is made out of stainless steel with low permeability. It is attached with cement (C8) to the insulator. The last layer of the capacitor control is galvanically connected to the flange through a soldered threaded screw (C9).

The flange (C10) has a long-shaped, tubular extension for the layout of the current transformers and on its air-side end, a threaded connection (C12) with gasket (C11) to fasten the insulator lock bush (C13). This lock bush is sealed against the bolt with O-rings (C15).

This layout creates the gas-tight termination of the bushing against the generator gas. The gap (C14) is air-filled, which then exchanges with the generator gas through diffusion in the insulator area during operation. A gauging bore (C18) with a screw plug in the bolt is provided to check the leakproofness.

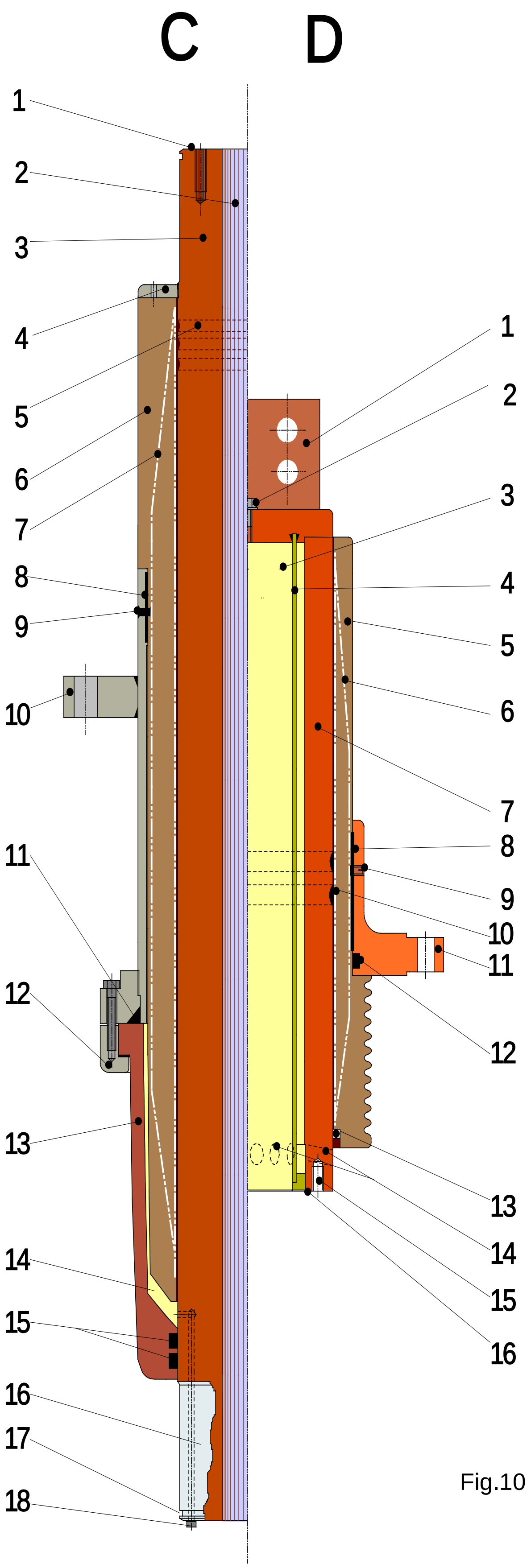

Fig.10

Version D:
The electric conductor (D7) is a copper bolt with connection flags (D1) on the air side of the bushing. It is mechanically protected against slipping by seat locking grooves (D10). The face side (D16) of the contact surface for connection is on the machine side. It is fastened to the bushing with screws (D15).
The boreholes (D14) distributed on the perimeter are flooding openings for the cooling. A guide tube (D4) with flooding openings is positioned in the inside of the electric conductor. Through that, the cooling gas is led past the interior surface of the electric conductor.

The bushing flange (D11) is made of an aluminium alloy and is connected to the insulator with a special, vibration-resistant cement (D8).
The last layer of the capacitor control is galvanically connected through a soldered threaded connection (D9).

An O-ring seal (D13) which cannot be dismantled is provided on the machine-side end of the insulator. It is an additional seal of the connection of the insulator to the conductor bolt and is formed as a chambered O-ring gasket. On this side the insulator is given a ribbed profile to extend the creepage distance.
The screw (D2) is furnished for inspection.

** The versions could deviate from this description in some details depending on the construction status. However, the bushing specifications and the associated construction drawings are binding in all cases.

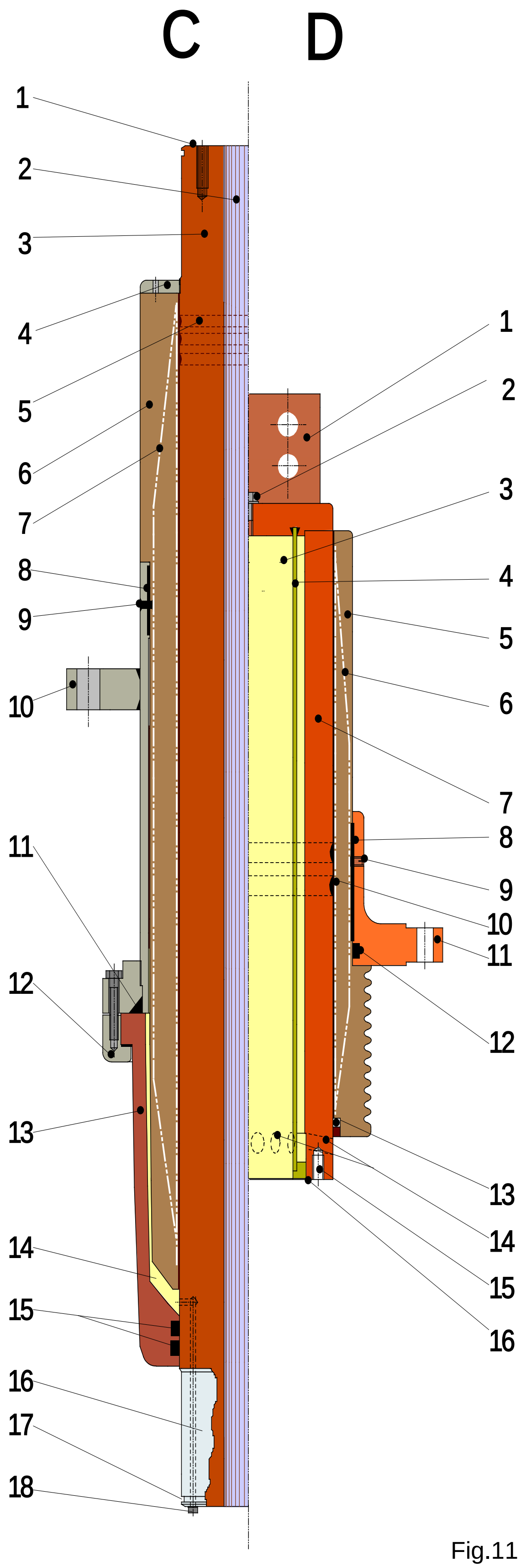

Fig.11

1.3 General operating conditions

Application:	Execution for application on generators and electrical machinery
Classification:	Epoxy resin impregnated paper, capacitor control, Interior generator bushing Connection of generator to generator connection
Ambient temperature:	- 30* to + 65°C ** Interior side Temperature Class 2 acc IEC 60137
Immersion medium:	Machine side: Gas / air Air side: Air (interior)
Installation height:	≤ 1000 m above MSL
Max. gas/air pressure:	600 kPa overpressure (operating overpressure)**
Corrosion protection:	All fittings and fastening devices made of corrosion resistant materials
Marking:	Compliant with IEC 60137 **
Packing:	Wooden crate, ventilated, bushing on foam pads, supported on bolt ends, welded in plastic film with desiccant additive. Up to 6 bushings per crate depending on shipping specifications.

** Standard values, modifications see related bushing specification

1.4 Mechanical loads

On the high-voltage side connection to the air side:

Tested flexural bending load	10 kN
Operating load:	30% of the value of the flexural bending load test

* Standard values, deviations see related bushing specification

2 Installation

2.1 As-received condition

The bushings are shipped in ventilated wooden crates. They are either individually packed (as in Fig. 12) or up to 6 each per crate.
In the connections area, they are stored on cushioned half-bearings on both ends; depending on the version also in the flange area.

The complete bushing is enveloped in a plastic film with inserted desiccant bags (Fig. 13).

This packing allows the bushing to be stored in covered, dry rooms for 12 months. If the bushing is packed in an aluminium laminated film instead of the plastic film, it can be stored under the same conditions for 24 months.

Long-term storage, e.g., as reserves, is only possible in dry indoor rooms, at best in the original packing.

Fig.12

Fig.13

2.2 Handling

Due to the high weight, the bushings have to be lifted out of the packaging on their flange with hoisting equipment.

For interim storage, always place the bushing cushioned on the connection ends. The insulator is sensitive to abrupt stresses!

With the insulator unprotected, the bushing can be handled outdoors for installation work for a short time during dry weather. Longer storage, e.g., during rain, is impermissible. Despite the painting the material RIP is hygroscopic and absorbs moisture on its surface which impairs the operating performance.
If bushings are found that clearly exhibit traces of interacting moisture on their insulator surface, contact the manufacturer (discoloured paint coating, detachments, bubbles, cracks, etc.)

If the degree of moisture penetration has not progressed too far, the bushing can be dried for several hours in an oven at max 100°C. At any rate, it is recommended to perform a tan delta measurement after that to secure the operational capability. Perform this work solely with close contact with HSP.
Comparative illustration opposite (Fig. 14).

Dry surface | Effect of moisture

The difference can also be seen on colourless painted finishes:

Dry finish, painted | Effect of moisture, painted

Fig.14

2.3 Preparation for installation

Lift and move the weight with lifting equipment. If the centre of gravity of the bushing is outside the lifting point, the heavy end can be manually fed if applicable (see Fig. 15) or alternatively a second hoist can be used.
Since the bushings are usually already mounted in the machine in the manufacturer's factory, handling during installation there can be assumed to be known.
However, if the bushing is mounted onsite, for example during a replacement, comply with the following:

Since the installation position is vertical to slightly inclined, a lifting rig is recommended which is attached to the machine side or the air side (clamp, etc.). Then the bushing can be pulled up through the flange opening if it is placed under the machine. If it is on top of the machine, it can be lowered suspended from the air side.

At any rate, follow and maintain the instructions of the machine manufacturer.

When inserting into the flange opening, make sure you avoid impacting the insulator. A hard impact can lead to fissures which under the influence of the machine vibrations later during operation can continue to grow and lead to an electrical failure!

Fig.15

CHECK LIST BEFORE COMMISSIONING		
	Check	Comment
1	Was a visual inspection of all insulator finishes made?	Check for cracks, dents and paint damage
2	Has the torque of the flange fastening been checked?	Corresponding machine manufacturer's specifications
3	Check for seating and tightening torque of the current carrying parts	Corresponding machine manufacturer's specifications
4	Has the insulator lock bush been checked for cracks and damages?	As far as present. If irregularities are found, perform a leak test depending on the version
5	Documentation of the checks!	For machinery documentation

Fig.16

3 Commissioning, maintenance

3.1 Pre-commissioning checks

A check is limited solely to a visual inspection. An electrical test in the installed condition is not possible since these bushings do not have any ground connection: rather the capacitor controls are directly grounded. The checks in the table (Fig.16) are recommended.
If there are no specifications on stipulated tightening torques the table (Fig. 17) can be consulted as an indication. However, especially with current-carrying connections, there may be special requirements that are not covered in the table; be sure to comply with the machine manufacturer's instructions on this!

Schraube	Drehmoment (Nm)	Drehmoment (kpm)
M 4	1,1	0,11
M 5	2,2	0,22
M 6	4,0	0,40
M 8	10,0	1,0
MIO	19,0	1,9
M 12	33,0	3,3
M 14	52,0	5,2
M 16	80,0	8,0
M 18	1 10,0	11,0
M 20	160,0	16,0
M 22	210,0	21,0
M 24	255,0	25,5
M 27	370,0	37,0

The values stated in the table are recommended values and refer to threaded connections with stainless steel bolts. Only applicable for flange connections with O-ring seals and metallic support of the parts. When using flat seals provide a suitable external support.

Fig.17

3.2 Recommended maintenance and checks

Permanent maintenance of the EKMI/EMI/-EMH series bushings is not necessary. Visual checks during normal machine inspections, provided visual contact is possible, cover the undamaged conditions of the insulator and the condition of the electrical connections.
During complete machine general maintenance the bushings should be put through a visual check. Follow up on any abnormalities on the surface of the insulator (cracks, discolourations) and changes in the gaps between the structural elements (discs, nuts, flanges) and put them through an electrical and mechanical check.

Example of a mobile measuring setup

Fig.18

3.3. Electrical measurements

Complete electrical control measurements on the bushings are only possible in the disassembled state. The bushings do not have any test tap; the capacitor control is galvanically connected with the ground potential in the flange area. However, it is possible to determine the capacity of the bushing with a simple capacitance meter; but to do that the electrical connections have to be dismantled. The measurements do not provide any absolute values which would be comparable with the factory test reports but they do permit a comparison of the installed bushings amongst one another. Since the bushings only have very few control inserts, the partial breakdowns make themselves noticeable through deviations in the range of 10 -20%.

3.4 Instruments

If the disassembled bushing is to be measured onsite, it is recommended to work with mobile measurement equipment. Such equipment is available from various manufacturers. Information can be obtained from the manufacturers in the Internet or at HSP.
There are comprehensive descriptions of the measurement procedures for bushing measurements in the documentation (example see Fig. 18).

3.5 Limits

Take the influence of the ambient temperatures into consideration when making the measurements. The deviation of the temperature and tan delta are stated in the adjacent chart (Fig. 19) to correct the results.

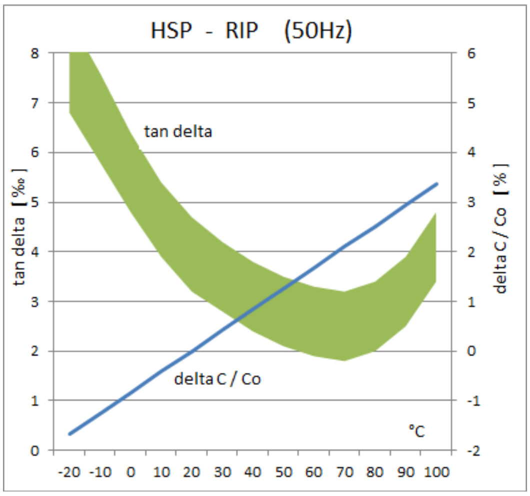

Fig.19

Capacitance deviations >10% indicate a partial breakdown in the capacitor controller. At any rate, always contact HSP in case of large deviations/non-compliances or, if applicable, put out of operation.

For all EKMI/EMI/EMH:

C deviation < 8%
Recommended tan delta value 0.004 – 0.008

4 Repair feasibility

The possibilities of making repairs on generator bushings onsite are restricted.

Certain versions are provided with an insulator impregnated directly on the conductor bolts, which means they cannot be disassembled; in others, it is removable and can be disassembled. For that reason, it is mandatory to request the drawing documentation with specification of the factory number and type designation from HSP to clarify whether and which type of repairs can be made.

Still better, inform us about the intention of making the repair; if applicable, tips on making the repairs can be provided. The bushing flanges are always permanently connected with the insulator with cement. Seals, removable cast resin lock bushes, etc. can be replaced.

HSP recommends returning the bushing for repair if possible. The factory has the appropriate tools and repair methods and if appropriate can re-manufacture the insulators (example of drawing documents Fig. 20).

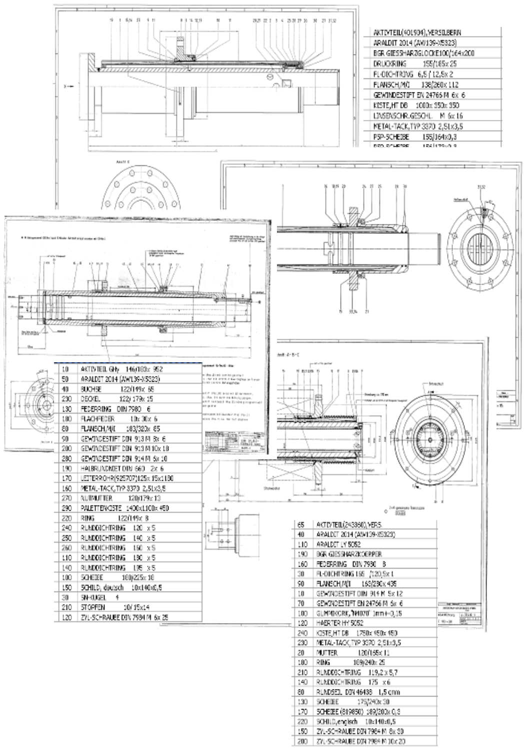

Fig.20

5 Storage

The bushing can be stored in its original packing for up to 12 months in covered rooms. If it is packed in aluminium laminated foil with inserted desiccant bags, the storage time is up to 24 months.

Long-term storage, for instance as a spare bushing, is only possible in dry, interior rooms. The material RIP is hygroscopic and can absorb moisture, especially during long storage times.

6 Disposal after the end of operation

The bushing does not contain any fluids which are toxic, spontaneously inflammable or physically pollutive. All parts can be disposed as normal industrial waste.

Following components:

- Epoxy resin impregnated special paper with aluminium foil as inserts
- Cork Perbunan as the cushioning material
- Current conductor bolt made of E-Cu
- Flange, depending on the version are made of aluminium alloy, brass or stainless steel
- Lock bushes made of epoxy-resin moulded material
- Fittings, depending on the version are made of aluminium alloy, brass or stainless steel
- Seals are made of Perbunan N or Viton
- Mounting elements, screws, etc. are made of stainless steel or brass