Transformer Bushing
Type EKTG

Mounting
Operating
and
Maintenance Instructions

SAFETY INSTRUCTIONS

These instructions are valid for mounting, operation and maintenance of transformer bushings type EKTG.

Mounting, operation and maintenance involve following safety risks:

- Perilous, electrical voltages
- High voltage
- Moving machines
- Large weight
- Handling of moving masses
- Injuries caused by slipping, stumbling or falling

Especially rules and instructions for these topics have to be obeyed when handling such equipment. Disregarding of these instructions can induce severe injuries of persons, death, damages of products and materials or following industrial injury and/or consuequential damages.

In addition to these rules national and international safety rules have to be obeyed.

In these instructions we have marked risks of injuries of persons and damage of material with following signs near the texts and mounting steps:

Personal injuries or fatal damages

Industrial injury and/or consequential damages

These operating and maintenance instructions are valid for the type EKTG.
For each bushing type these instructions are valid only together with the respective bushing specification, which contains all technical details and the dimension drawing. It is an integral part of these operating and maintenance instructions.

CONTENT

** optional, see specification

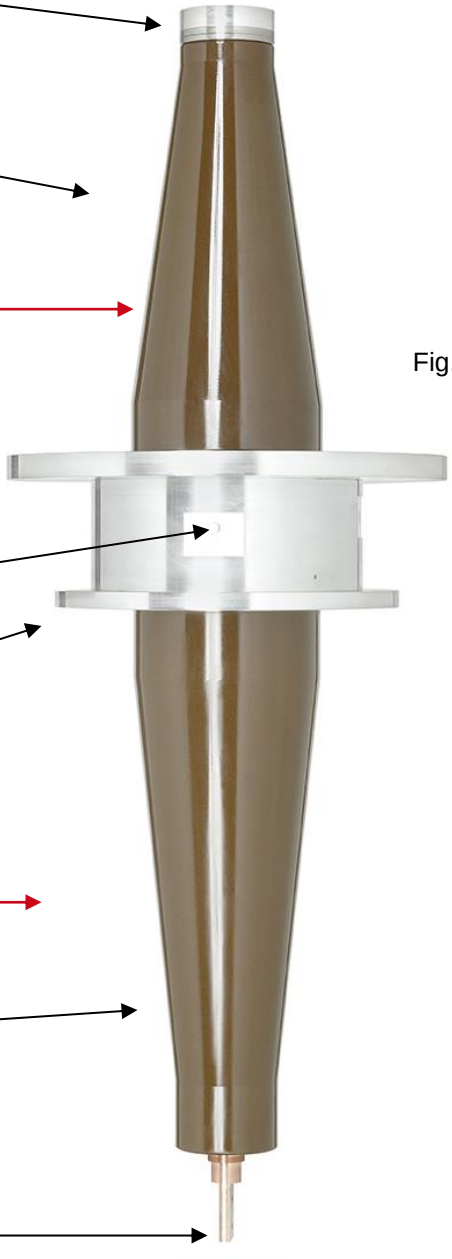
1 Description

1.1 Construction

Fig.1

Connection – Contact plate

Condenser core
High gloss varnish



SF_6 – side

Fig.2

Connecting flange for SF_6 - substation

Test tap

Connecting flange for transformer

Transformer side

Condenser core
Surface oil coated

Connecting termial

Electrical screen, removable
(optional, see specification)

Fig.3

1.2 Design

The main insulation of the transformer bushing EKTG is an insulating body (4). It is made of a special paper impregnated under vacuum with epoxy resin and coaxially placed grading layers made of aluminium foil to guarantee uniform voltage distribution along the insulating body (5).

This insulating body is – upholstered and secured against displacement – impregnated directly onto the copper conductor bolt (6).

The high voltage connection (1) is made of a copper connecting plate with threaded bores. It is designed for direct screw connection to the current carrying components of the SF_6-substation. Underneath this connecting plate there is a threaded ring (2) which with the help of screws guarantees side pressure in the thread of the connecting plate also fixed by screws, thus providing contact.

Underneath there is a special sealing chamber with a liquid sealing (3) encapsuled between two sealing rings. It is made of high viscosity silicone oil, which due to its excellent adhesive features secures high gas tightness even in case of low temperatures.

The bushing flange (9) is sealed directly onto the insulating body with its SF_6-side flange plate by SF_6-resistant sealing rings. The transformer side flange plate (11) is sealed with oil-resistant sealing rings (12). Both flange plates are fixed to the central part of the flange by screws.
The flange is equipped with the test tap (10) and the air release valve (13). This valve seals a circular ring chamber within the flange. Its purpose is to allow gas release in case of leaking sealings on the SF_6-side to prevent building of high gas pressure on the transformer side sealings.
Displaced to the test tap on the transformer side flange plate or in the flange neck the transformer ventilation screw (14) is located.

On the transformer side end of the insulating body there is a sealed O-ring (15). It prevents transformer oil from penetrating into the area between conductor bolt and insulating body. It is not accessible from outside.

The transformer side current connection is designed as round – or optional** as flat connecting terminal.(16)

The contact area is shielded by an electrical screen (17). It is either part of the bushing** or it is located in the transformer

** optional, see bushing specification

Fig.4

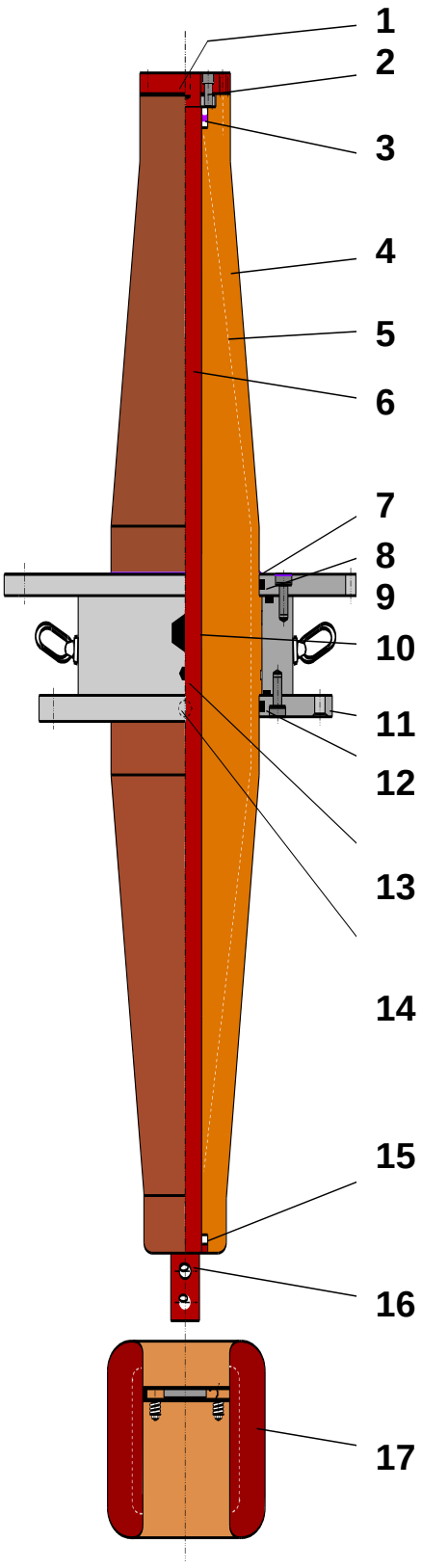


Fig.5

1.3 General Operating Conditions

Application:	Bushing for installation in transformers with direct connection to GIS
Classification:	Epoxy resin impregnated paper, capacitive grading SF_6 - substation – transformer - bushing
Ambient temperature:	SF_6-side: - 30* up + 60°C ** Transformer side: daily mean value + 90°C, limit value 100 °C **
Immersion medium:	SF_6-side: SF_6 or SF_6/N_2 * Transformer side: transformer oil of all common types acc. to standard
Oil level below bushing flange:	max. 15 mm
min. gas pressure: max. oil pressure:	250 kPa** 200 kPa gauge
Possibility to evacuate:	No restrictions regarding level and time
Corrosion protection: materials	All armatures and fixing materials made of corrosion-resistant
Marking:	According to IEC 60137 / IEC 601639 **
Packing:	Wooden crate, ventilated, bushings protected by styro-foam cushions below the flange and both ends, sealed in plastic foil with inlaid dehydrating bags

* < 25°C gas mixture in special cases see bushing specification
** standard values, modifications see bushing specification

1.4 Mechanical Stress

On the high voltage side connection:

Test bending load:	< 245 kV 3000 N ≥ 245 kV 4000 N *
Operating load:	50% of the values for test bending load
On the bushing flange:	for bending moment refer to IEC 601639

* standard values, modifications see bushing specification

2 Montage

2.1 Status of dispatch

The bushing is transported in a ventilated wooden crate (1). It is supported by styro-foam cushions (2) located in the flange area. Additionally in case of bigger bushings the flange is supported and fixed by wooden cross beams (4).

The whole bushing is covered with a plastic foil with inlaid dry bags (3).

Packed like this the bushing can be stored in dry rooms covered by a roof for 12 months.
When the bushing is packed in aluminium coated foil instead of plastic foil it can be stored for 24 months under the same conditions.

Proper long term storage, e.g. for spare parts, can only be achieved by metal protections tanks on both sides of the bushing. Both tanks are filled with dehydrating bags and nitrogen. The tanks are equipped with test valves, which allow to test the condition by using test equipment (see item 7).

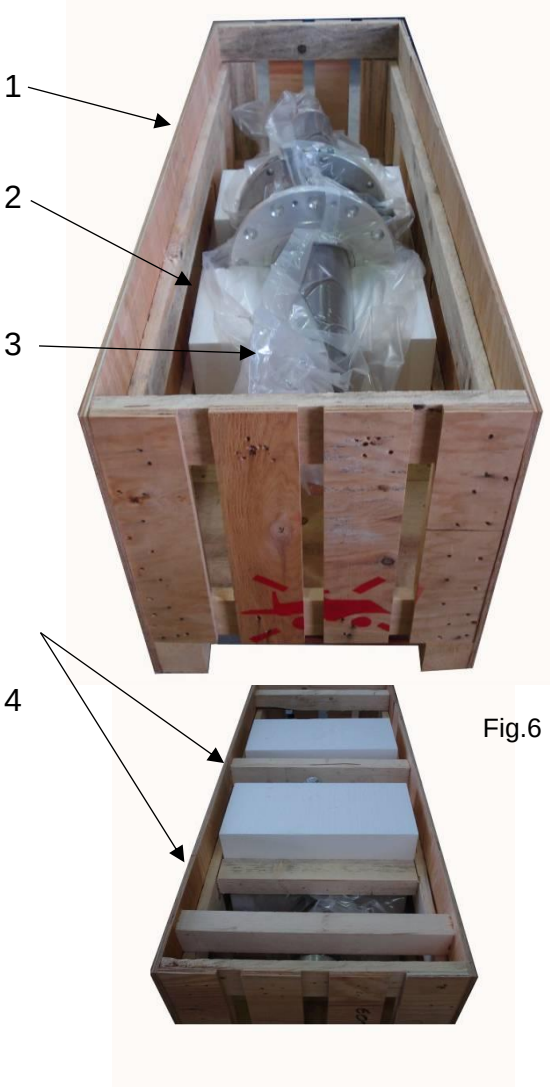


Fig.6

2.2 Handling

To remove the bushing from the crate it may be lifted on the flange only and put down either on the flange or on the insulating body close to the flange.

It is not permitted to put the bushing down on the transformer end and/or on the gas side end. Even in case of an upholstering there is the danger of cracks developing in the insulating material, which may be invisible, but jeopardize operation of the bushing.

With the ends unprotected the bushing can be handled outside for a short period of time during dry weather. Longer storage, e.g. during rain is not permitted. The material RIP is hygroscope and absorbs moisture on its surface, which has a negative influence on the operating behaviour in the transformer.

In case you detect bushings with clear signs of the influence of moisture, please contact the manufacturer.
See comparative picture on the left side (Fig.7).

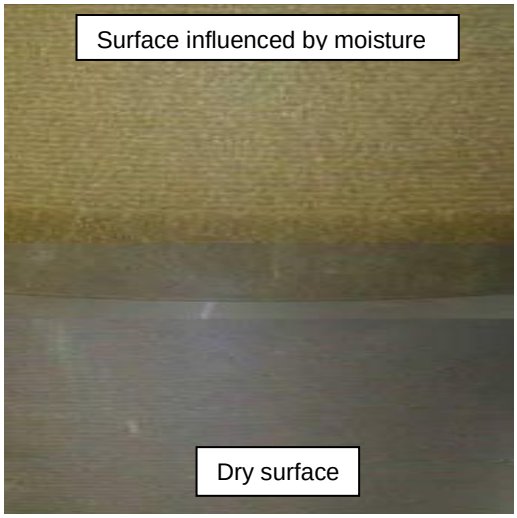


Fig.7

2.3 Lifting and Erection

Use the lifting eyes to lift the bushing. There are either removable ring screws or lifting eyes on the bushing flange.

After installation of the bushing the removable ring screws have to be removed. The threaded bores have to be closed by plastic caps.

The bushing is always lifted on the flange with lifting equipment. Due to the bushing design the centre of gravity is always in the area of the flange, therefore it is sufficient to guide the longer end of the bushing with one hand during the lifting procedure. As a rule the longer part of the bushing is the transformer side, therefore when it is lifted it will move into this direction and in this position is suitable for installation in the transformer.

By no means the bushing must be put down on the insulator end for erection purposes.

Fig.8

2.4 Preparation for Installation

After the bushing was lifted from the crate it has to be put down on the flange or on both sides close to the flange on upholstered supports. The plastic foil is removed – do not use a knife, because the surface of the insulator may be damaged.

If the bushing is equipped with an electric screen which is not yet mounted to the bushing, it has to be put down in such a way that assembly of the connection can be made after installation (see 2.5).

Bushings type EKTG always have an undetachable current conductor. Therefore the connection in the transformer has to be made as plug connection with contact sleeves or as screw connection with access through a mounting hole in the transformer.
This design is necessary because a leakage test is carried out on the bushing in the factory. Subsequent mounting works on a design with detachable bolt would not guarantee tightness.

Instructions of the transformer manufacturer regarding mounting connection have to be obeyed.

Fig.9

2.5 Mounting of a screen on the trans transformer side **

The screen fastening is made of two discs, one of them is movable guided via pins and pressed tight with a recoil spring. In the screen made of epoxy resin with embedded shield three brass pins are inserted. When inserting the screen with its pin into the corresponding openings of the outer disc and by a turn to the right hand side the discs are pressed apart. When turning the screen further the pins will rest in a special fastening slit.

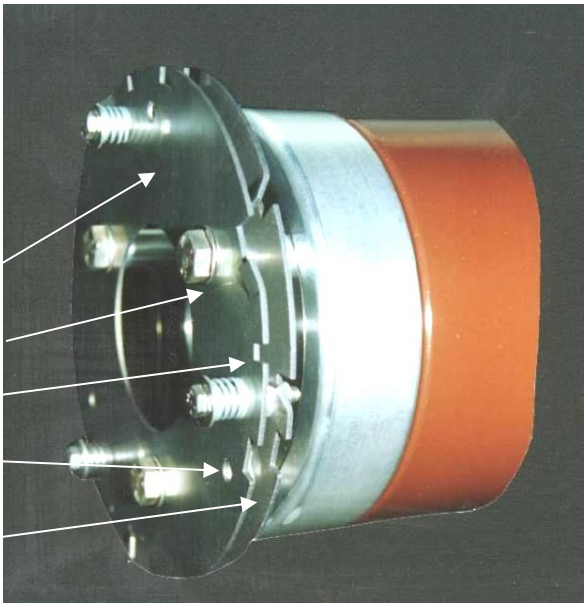


Fig.10

Mounting of the screen
The screen has to be located towards the fastening that the pins are positioned opposite to the opening in the disc. These openings are asymmetrically positioned to avoid wrong installation of the screen. Turn the screen until it can be inserted. With a turn to the right until the pins snap into place the screen is mounted.

Demounting of the screen
By turning the screen to the left it is removed from the pin fastening, then proceed turning until the openings in the disc release the screen.

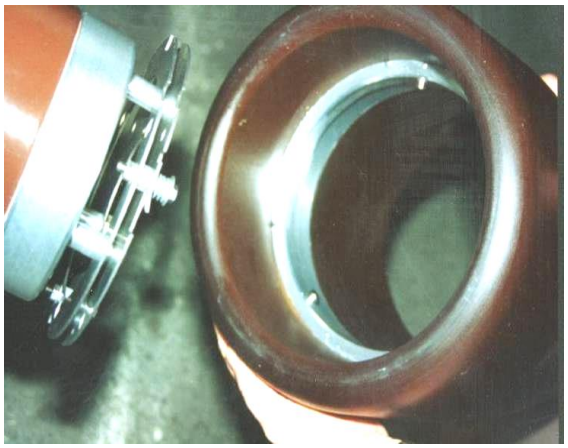


Fig.11

Pushing the screen through
For easy mounting of the current connections the screen can be turned before putting it on to the discs in such a way that it can be guided through the through-going openings of both discs and by slightly turning can be put down on the upper disc (mainly when the bushing is in vertical position).
For mounting purposes proceed as described above.

The turning directions always refer to the position on the bottom side in front of the screen.

** if a screen is provided for the bushing, if necessary, refer to
The bushing specification

3 Mounting of the bushing on the transformer

Mounting of the bushing on the transformer is carried out on the transformer side according to the instructions of the transformer manufacturer. Different connecting techniques have to be taken into account.
In case of a design with connecting plug when inserting the bushing take care that the plug is located vertically and in the center of the contact sleeve before it is lowered. This also applies for a bushing in horizontal mounting position.
In case of screw connections with connecting terminal before mounting the screen has to be moved accordingly. Torques of the screws have to be chosen acc. to the table.
Sealing of the bushing flange is made according to the instructions of the transformer manufacturer, the same applies to the torques for the fastening screws of the bushing flange. If there are no instructions, please refer to the table on the left.

screw	torque (Nm)	torque (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
M 30	510,0	51,0

The given values are reference values and refer to bolted joints with stainless steel screws. Applicable only for flange joints with O-ring seal and metallic contact of the parts. If used with flat gaskets, adequate external brace support is required.

Fig.12

The connections on the SF_6-side are different depending upon the installation design. Proceed according to the rules and instructions of the GIS-manufacturer.
The surface of the insulator and the metal surfaces of the flange which are in contact with the SF_6-gas have to be free of oil and grease and clean (also see 5.3).
For cleaning purposes use cleaning cloths free of fluffs. For this reason the surface of the insulator is high gloss varnished.

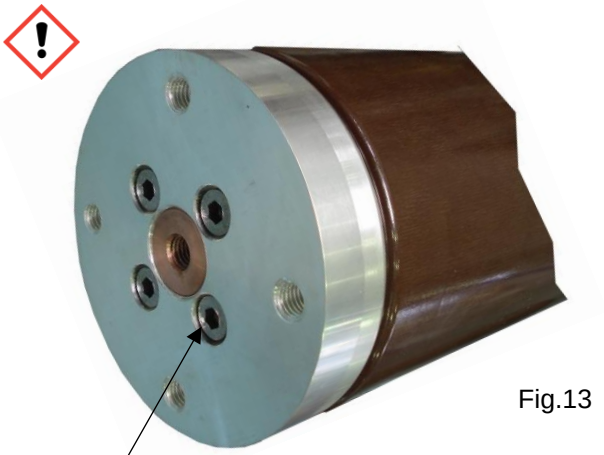


Fig.13

If there are adjusting problems regarding the angle position of the high voltage contact plate, this plate can be turned in a range of ±30°. To adjust the position slightly loosen the locking screws (Fig.15/1) in the contact terminal, it can now be turned in the required direction. After that the screws have to be fastened with a torque wrench acc. to the table (Fig.14) on the adjoining side.
The locking screws pull a threaded ring (2) against the contact plate (3), which is screwed to the conductor bolt with a thread. By fastening the locking screws the thread of the contact terminal is pressed to the conductor bolt and guarantees safe current transition.
This manipulation directly influences the current carrying capacity of the bushing! Therefore it has to be reported in writing in the mounting reports.

torque (Nm)	
M8	12
M10	25
M12	50
M16	100
M20	200

Fig.14

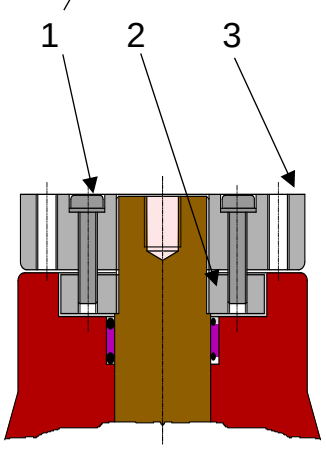


Fig.15

3.1 Grounding of the bushing flange

The bushing flange has grounding screws. Through grounding bands or wires the flange has to be connected to the transformer tank. Apart from following several national rules this secures a safe galvanic connection.

Fig.16

4 Putting into operation

4.1 Ventilation at the bushing flange

To remove possible air bubbles in the area underneath the bushing flange open the air release screw to enable the air to escape. The ventilation screw does not have to be removed completely, it is flattened at its lower end, thus allowing ventilation. For the same reason the air release screw (Fig. 16) has a lateral bore.

As the bushing has an undetachable current conductor, there are no other possibilities for air release.

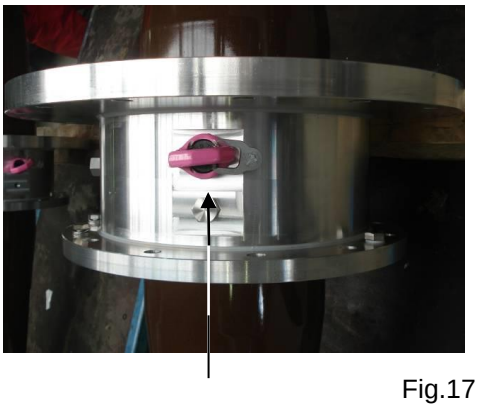


Fig.17

Depending upon the design of the bushing the transformer ventilation is located either on the outer rim of the transformer side flange plate (Fig. 16), on the side of the flange neck (Fig. 17) or in case of big flange plates in front on top of the flange plate

4.2 Evacuation of the transformer

If evacuation of the transformer is necessary, there are no restrictions regarding level and duration up to operating temperature of the bushing. The material RIP is suitable for such treatment.

4.3 Recommended tests before putting into operation

Only a visual check of the visible parts of the bushing for possible damages is possible. All screws must be fastened according to the rules, the cap of the test tap must be closed tightly.
As the bushing was subjected to a leakage test in the manufacturer's factory, gas as well as oil leakages, further testing prior to putting into operation is not required.

4.4 Electrical measurements

By the final tests carried out in the manufacturer's factory the bushings are tested and certified suitable for operation.
But it makes sense and is recommended to carry out a so-called reference measurement on site. This guarantees that in case of later control measurements the measuring conditions are unchanged and comparable results are achieved. This is only possible, though, when the connection on the gas side is interrupted.

There are transformers where such measurements are carried out during the final test of the transformer. In this case comparative data is available already.

Bushing capacity as main capacity C1 and the electrical dissipation factor tan delta are measured. Measurement of the capacity between the last grading layer and the flange is possible, but it does not allow any statement about the main insulation, it only shows the condition of the test tap area.
Description of the procedure see item 5.4 ff

4.5 Test tap

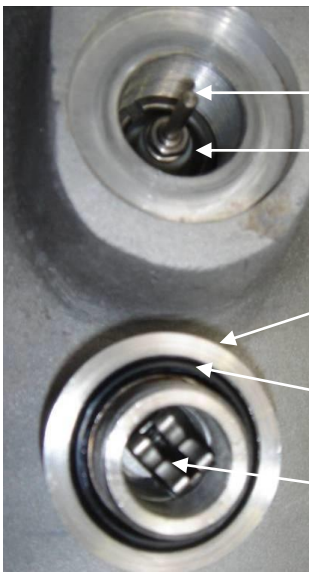
Design of the test tap on bushing type EKTG

Design A	older type (Fig.18)
Design B	new type (Fig.19)

With the test tap the last grading layer of the capacitive grading is led out insulated (1) by means of a small bushing. The removable cap (2) has a contact sleeve or spring (3) in which the connecting pin (4) provides reliable grounding when the cap is closed tightly. The cap has an O-ring sealing (5) to guarantee a moisture-free inner volume of the test tap.
During normal operating conditions this connection is always grounded. For measurements of the bushing in case of de-energized transformer the measuring lead is connected to the pin to determine capacity and dissipation factor.

The test tap is not self-grounding! Therefore during operation the cap has always to be tightly closed! Operation with open test tap leads to a destruction of the small bushing (1) in the test tap with influence on the inner volume of the bushing and following damage!

TEST TAP



DESIGN A

Connecting pin (4)

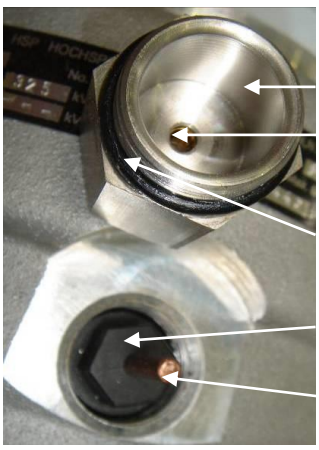
Bushing (1)

Cap (2)

Sealing (5)

Grounding spring made of non-corrosive steel (3)

Fig.18



DESIGN B

Cap (2)

Contact sleeve (3)

Sealing (5)

Bushing (1)

Connecting pin (4)

4.6 Voltage tap**

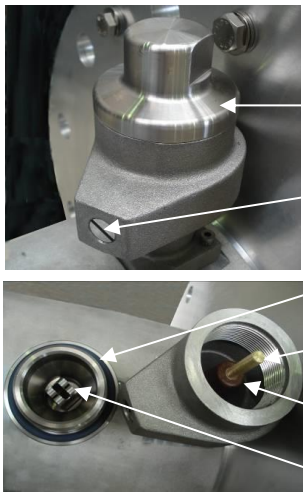
If the bushing has a voltage tap (Fig. 20), not the last but the last but one layer of the capacitive grading is led out galvanically. Due to the higher output voltage of approx. 6 kV the insulating bushing is correspondingly bigger. Above that the volume around this bushing is filled with oil for permanent voltage output.
In the cap (1) there is a contact spring (2) to ground the connecting pin (3) of the bushing (4). The cap is equipped with an O-ring sealing (5) to guarantee a moisture-free inner volume.
During normal operating conditions this connection is always grounded. For measurements of the bushing in case of de-energized transformer the measuring lead is connected to the pin to determine capacity and dissipation factor.

The voltage tap is not self-grounding! Therefore the cap has always to be tightly closed during operation. Operation with open connection leads to a destruction of the insulation of the bushing (4) in the voltage tap with influence on the inner volume of the bushing and following damage!

For permanent connection of voltage tap equipment, which fits with its connecting plug onto the external thread of the bushing (2"), after mounting the inner volume has to be filled with oil through the oil filling hole , take into account approx. 2-3 cm^3 volume for oil expansion.

** Optional, see bushing specification

Fig.19



VOLTAGE TAP

Cap (1)

Oil filling screw (6)

Sealing (5)

Connecting pin (3)

Bushing (4)

Contact spring (2)

Fig.20

5 Maintenance

5.1 Recommended maintenance and checks

The bushing is free of maintenance. Check and maintenance only refers to the visible and accessible area of the flange with respect to corrosion or damages of the varnish. These checks should be carried out during the regular transformer revisions.

Due to the encapsulate installation arrangement electrical measurement is difficult or not possible at all. For such a measurement either the GIS-substation section has to provide access to voltage feed of the measuring equipment through an opening, while the section itself is interrupted, or the whole encapsulant including high voltage connection has to be removed.

We recommend electrical measurements on the bushing after the first 7-10 years of operation, then, depending on the measurement results, in intervals of 3 years or less.

Control measurement on bushings require a certain experience with measuring equipment, test set up and interpretation of the test results. For some part this is a result of the relatively small capacity values, the influence of the environment is rather low, though, due to the existing metal encapsulation. The measurement of the electrical dissipation factor can be influenced by humidity, weather etc.

5.2 Cleaning

Due to its encapsulation apart from the flange area the bushing is protected against environmental influences. Therefore, apart from the flange area, no cleaning is required.

5.3 Cleaning after coating with oil

If during mounting or delivery it is noticed that the gas side surfaces are coated with oil and it is not sure that the oil has not penetrated into gaps, cleaning as described is recommended.

In the flange area (Fig. 21) all gaps, grooves (1) and screw sinks (2) are sealed with sealing material by the manufacturer. Here only remainders of oil have to be removed with a solvent (e.g. Ethylacetat).

Only the gap on the high voltage side between connecting plate and insulating body is not sealed and must be cleaned. Procedure see Fig. 22.

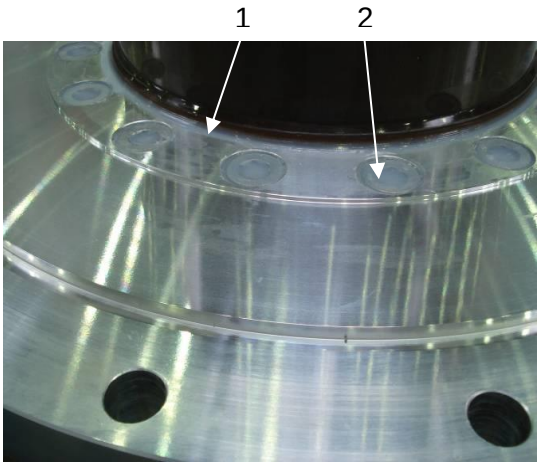


Fig.21

CLEANING AFTER COATING WITH OIL
(Fig.23)

- Loosen and remove locking screws (1)
- Remove contact plate (3)
- Remove threaded ring (2)
- Make front side of the insulating body including ring groove and all removed part free of oil with cleanser.
- Fasten threaded ring (2) in the same position as before disassembly
- Fasten contact plate (3) with screws and adjust position of the bores with reference to the threaded ring. Take care that a gap of min. 1 mm remains between front side of the insulating body and contact plate and contact plate and threaded ring (For this screw the contact plate (3) flush with the Insolation Part front side and afterwards turn it back around 240°).
- Insert locking screws (1) and fastened them with a torque wrench acc. to the table Fig. 14
- For precise position of angle see 3.0

Fig.22

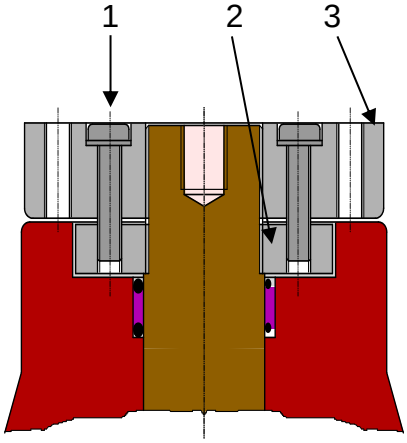


Fig.23

5.4 Electrical measurements

Measurements on bushings require experience with measuring equipment, test set up and the interpretation of measurement results.
This is for some part due to the relatively small capacitance values, which are corrupted by the ambient influence of the environment alone. The measurement of the dielectric dissipation factor can be influenced by the voltage feed on the GIS-side by humidity, weather etc.

5.5 Measuring procedures

Mainly the measuring procedures differ by the coupling of the measuring signal. In case of so-called “not grounded” measurements the test voltage is applied to the conductor of the bushing and the measuring signal is taken at the test tap of the bushing.
The “grounded” measuring procedure is applied, if the bushing which has to be measured does not have a test tap. This is not applicable for the bushing type EKTG.
The devices required for the measurement are usually equipped specifically for the measurement of bushings. The measurement methods are described in comprehensive manuals.

Example of mobile measuring equipment

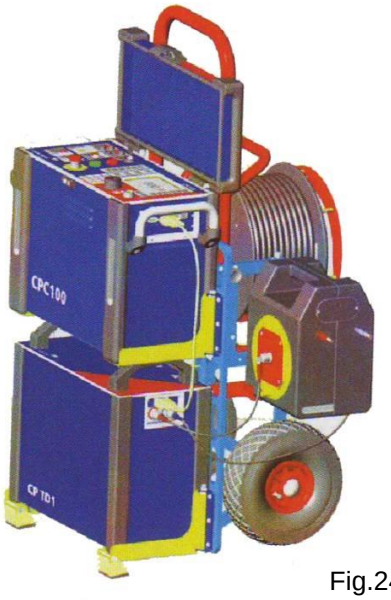


Fig.24

5.6 Equipment

Measuring equipment is available from several manufacturers. Data can be found in the internet or enquired at HSP (Fig.24).

5.7 Limits

For the measurement the influence of the ambient temperature has to be taken into consideration. In the diagram on the left side for C and tan delta the variation through temperature is shown (Fig.25).

For the material RIP, resin impregnated paper there are limit values for the deviation of the capacitance and the dielectric dissipation factor with relation to the “new value”.
This value is reliably deducted from the reference measurement described under 4.4.

In case the deviations are larger than mentioned in the table below, HSP has to be contacted in any case. When there are very large deviations the bushing may have to be taken out of operation.

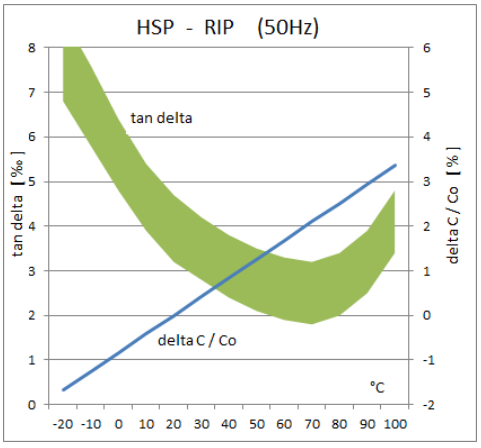


Fig.25

Voltage level	C-Deviation
< 123 kV	10 %
≥ 123 kV	5 %
≥ 245 kV	3 %
≥ 420 kV	1 %
Guide value tan delta	0.004 – 0.006

6 Possibilities of repair

The bushings type EKTG are made of several parts which can be disassembled, therefore repairs are possible. These repairs will mainly be replacements of sealings on the gas and on the transformer side of the bushing. For repair purposes the bushing has to be demounted. Only in case the main sealing on the SF_6-side of the flange is concerned, there may be the possibility that it can be replaced while the bushing is mounted.

These operation and maintenance instructions are valid for bushings type EKTG, therefore in case of a repair different sectional drawings and parts lists are required. Both documents can be ordered from HSP in case of a repair quoting the serial and the specification number and will be sent immediately. (Example of a sectional drawing and a parts list (Fig. 26). Above that depending upon the repair requirements short instructions can be given.

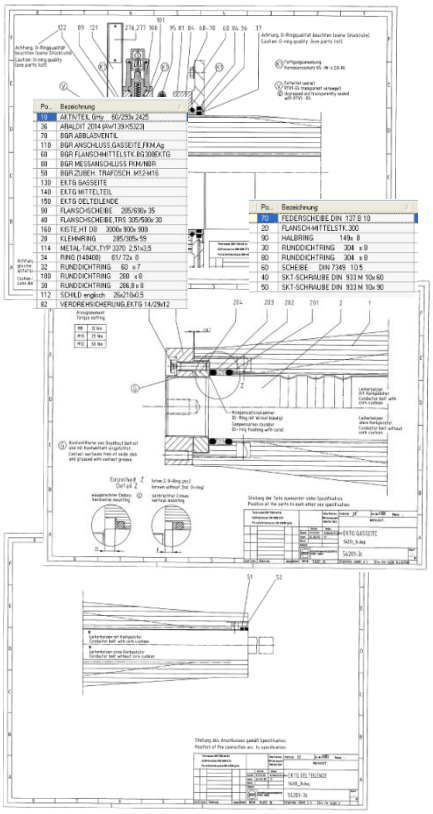


Fig.26

<u>General measures in case of repair</u>

Disassembly has to be made in a dry and dust-free room. The bushing is placed with its insulating body on wooden supports situated close to the bushing flange. The flange plate on the SF_6 side is sealed with silicone and depending upon the design the fastening holes are sealed with silicone as well. Remove this sealing material before you start with disassembly.

After repair an electrical test has to be carried out in any case to guarantee that the bushing was not damaged during the works. (C, tan delta and p.d. measurements up reduced test voltage).

On the insulating body itself no repair can be made. In case of an internal failure we recommend to return the bushing to be manufacturer, who has suitable means and measures and professional investigation methods. But even in case of more simple repairs a return to the manufacturer may be reasonable.

7 Storage

In its original packing the bushing can be stored up to 12 months in dry rooms. In case it is packed in aluminium coated foil with inlaid dehydrating bags, it can be stored up to 24 months.

Long term storage, e.g. as spare bushing, is possible only with a protection tank (Fig. 27) on the gas side as well as on the transformer side. The material RIP is hygroscope and can absorb moisture, especially during long periods of storage.
The protection tank is made of spray-galvanized steel sealed by O-rings and fixed to the flange by screws. The tank has a screw opening with non-return valve (Fig.27). The gas side of the bushing can be stored in dry nitrogen only, therefore it makes sense to fill the transformer side with nitrogen as well, here dehydrating bags are added. A small excess pressure of max. 25 kPa is sufficient. In terms of approx. 1 year the pressure should be check with a pressure gauge (Fig.28)

Fig.27

NON-RETURN VALVE (Fig.28)
The non-return valve is made of a valve body (1) with a movable valve cone (2) This valve cone is pressed against the conical gasket face by a cup spring column. From outside the non-return valve is sealed with an additional locking screw (3). The valve opens when the filling valve is screwed in. The tip of the filling valve presses against the cone and opens it. When releasing the valve is closed again by the pressure of the springs.

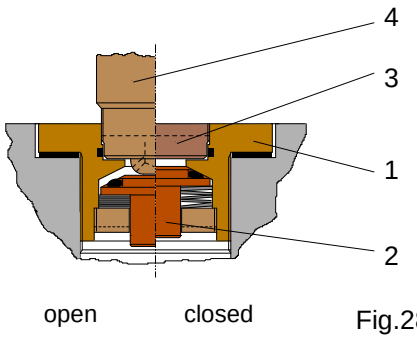


Fig.28

FILLING VALVE
The filling valve (4) (Fig. 29) is equipped with a pressure gauge for pressure measurement. It is screwed into the valve body by a ¼“ - thread. It is possible instead of a pressure gauge to connect a hose with a suitable and common hose nipple to re-fill gas instead of a pressure gauge.

HANDLING
Remove the locking screw with a screw driver. After loosening the screw, it has to be pulled out of the bore, because it is fixed by a radial O-ring. After that the filling valve is screwed in until the valve opens. Take care that after the works have been finished the locking screw is inserted and fixed again.

Fig.29

8 Disposal after end of operation

The bushing does not contain any liquids, the parts are neither toxic, self-inflammable nor physically detrimental. All parts can be disposed of as common industrial waste.

Following components:

- Epoxy resin impregnated special paper with aluminium foils as layers
- Armatures made of aluminium or copper alloys
- Conductor bolts made of E-Cu
- Fastening elements, test tap, screws etc. made of non-corrosive steel, aluminium alloy or brass
- Silicone elastomere (sealings)

In case the flange plates are fixed by screws to the central part of the flange for easier disposal they can be removed.