Transformer Bushing
Type EKTO

Mounting
Operating
and
Maintenance Instructions

SAFETY INSTRUCTIONS

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

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 consequential 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 bushings type EKTO.
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

1 Description

1.1 Construction

Special electrical screen, removable **

Fig.1

Connecting bolt. Cable box side**

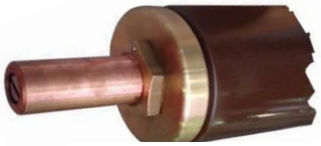

Fig.2

Cable Box – Side

Insulating body Epoxy resin
impregnated with capacitive grading

External test tap**

Test tap wire

Flange

Transformer Side

Insulating body
Transformer side

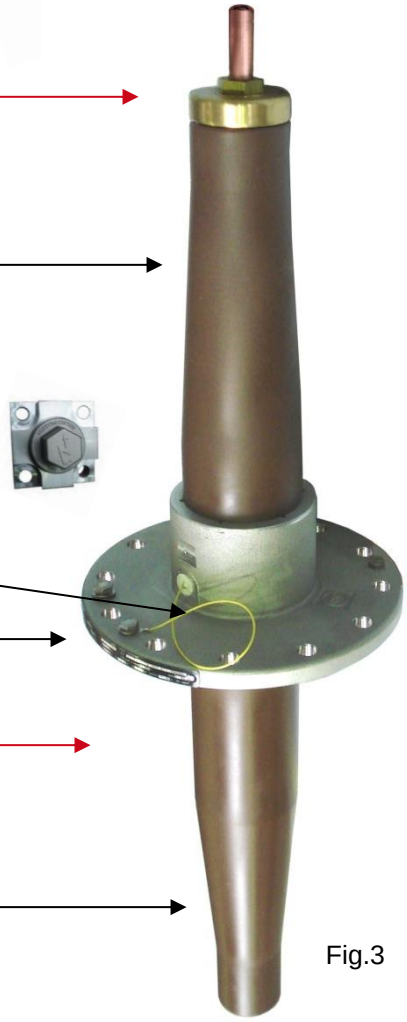

Fig.3

Electrical screen, removable **

Fig.4

**Depending upon design, see bushing specification

1.2 Design

The main insulation of the transformer bushing EKTO is an insulating body (10). 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 (11).
When used with current transformers depending upon design either on the transformer side or on the cable side the grounded last grading layer (16) is designed with an appropriate length

Depending upon the design** this insulating body is impregnated on a steel mandrel which is removed after curing. This creates a central bore which is insulated against the conducting layer. The connecting armature is fixed by a cemented sleeve (7). The draw lead bolt (3) is pulled against the stop rim of this sleeve and is fixed by a hexagonal nut (4) together with the cover (5). The draw lead bolt has a ventilation screw (2,9) to vent the volume of the central tube in case of vertical installation. A pin (8) gripping into a groove in the sleeve avoids torsion.
All sealings (6) are made of Nitril Perbunan.
Another design ** is a conductor rod impregnated into the active part and therefore undetachable connected to the insulating body. The connecting armature has the same design as the armature for draw lead bolt, but without sleeve and without ventilation screw.

The bushing flange (12) is also cemented to the insulating body and sealed by O-ring gaskets (15).
The test tap is led out as insulated flexible wire (13) and is equipped with a traction relief (14) in the flange. When the bushing is dispatched this flexible wire is screwed to the flange plate with a cable lug, thus being grounded. Depending upon the transformer design** this flexible wire is led outside via a test tap fixed outside on the transformer tank (Fig.3, external test tap).

Depending upon the design** on the transformer side of the insulating body there is a recess to insert the transformer lead insulation or another sleeve (17) to fix an additional electrical screen**. In case of an inseparable conductor rod there is an additional O-ring sealing as encapsulated non-accessible chamber sealing against penetration of transformer oil.

For the design with conductor rod the transformer side current connection** is either a round or a flat connecting terminal.

Depending upon the design** the transformer side as well as the cable side can be shielded by electrical screens. The transformer side screen (18) is equipped with a bayonet lock (also see Fig.19). The cable side screen (1) is designed either as coated aluminium screen, if required with 90° entrance for the cable connection, or as insulated screen made of epoxy resin, is either equipped with a clamping connection as on the transformer side or fixed by screws to the armatures (3,4).

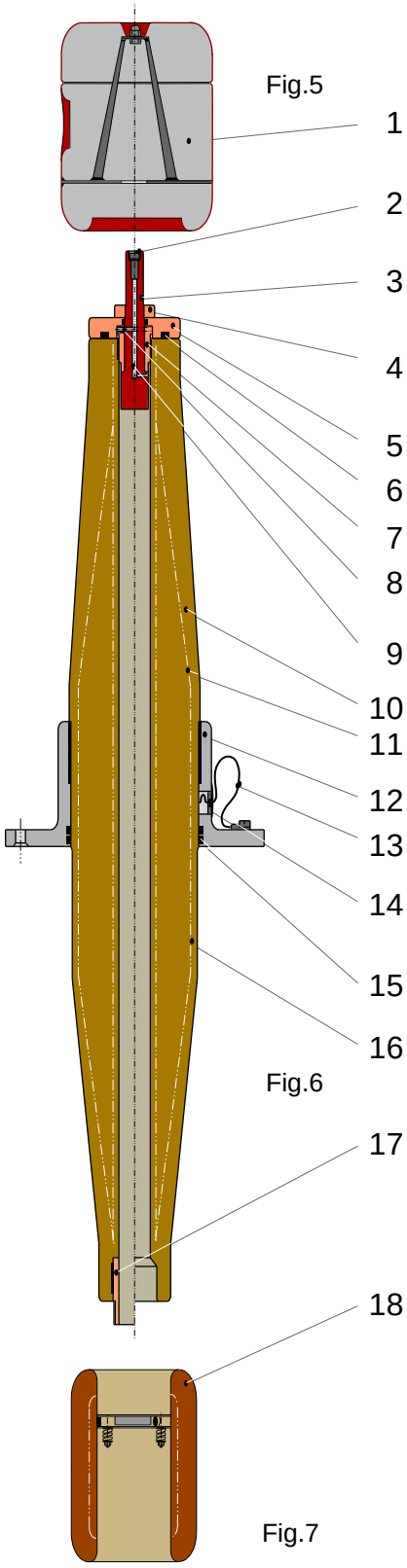

Fig.5

Fig.6

Fig.7

** The designs are different according the requirements of the transformer. For exact description of the design see bushing specification.

1.3 General operating conditions

Application:	Bushing for installation in transformers with direct connection to cable or a connection between separated transformer section
Classification:	Epoxy resin impregnated paper, capacitive grading, Cable box – transformer - bushing (oil-oil)
Ambient temperature:	Cable side: - 30* bis + 60°C ** Transformer side daily mean value + 90°C, max. value 100 °C **
Immersion medium:	Cable side: transformer oil of all common types acc. to standard Transformer side: transformer oil of all common types acc. to standard
Oil level below bushing flange:	Max. 15 mm (in case of vertical installation)
Max. oil pressure:	200 kPa excess pressure
Possibility to evacuate:	No restriction regarding level and time
Corrosion protection materials:	All armatures and fixing materials made of corrosion-resistant
Marking:	According to IEC 60137**
Packing:	Wooden crate, ventilated, bushings protected by styro-foam cushions below the head and the flange, sealed in plastic foil with dehydrating bags.

** Standard values, modifications see bushing specification

1.4 Mechanical stresses

On the high voltage side connection:

Test bending load:	1500-3000N, depending upon bushing size*
Operation load:	50% of the values for test bending load

* Standard values, modifications see bushing specification

2 Mounting

2.1 Status of dispatch

The bushing is transported in a ventilated wooden crate. It is supported by styro-foam cushions, which are located in the flange area. In case of bigger bushings the flange is additionally supported and fixed by wooden cross beams.

The whole bushing is covered by plastic foil with inlaid dehydrating bags.

Several small bushings can be packed in one crate.

With this type of packing the bushing can be stored in dry rooms covered by a roof for 12 months.
If the bushing is packed in aluminium foil instead of plastic foil it can be stored for 24 months under the same conditions.

Long-term storage, e.g. for spare parts, can only be made when the transformer side end of the bushing is covered by a metal protection tank with gas or oil filling. (also see item 7)

Fig.8

2.2 Handling

Bushings up to a rated voltage of 245 kV generally have such a low weight that they can be removed from the crate by two persons without lifting equipment. Bigger bushings have to be lifted at the flange. The bushing has to be put down on upholstered supports on the insulating body on the right and on the left side of the flange.

Bigger bushings are lifted on the flange as shown (Fig. 9). The end with the higher weight is supported by one hand.

The bushing must not be put down on the ground with its transformer end. Even in case of an upholstering there is the risk that cracks are caused in the insulating material by impacts which may not be visible, but jeopardize the operation of the bushing.

Impacts on the insulating body have to be avoided. In case of a scratch on the surface, it can be removed with the help of abrasive paper. The surface of the insulating body is machined and untreated, simply slightly coated with insulating oil.

Fig.9

As the bushings are usually installed in the factory of the transformer manufacturer, the handling during installation can be considered as known there.

If the bushing is installed on site, though, e.g. in case of a replacement, following procedure has to be obeyed:

Bushings with a weight which does not allow to move or lift them without lifting devices, have to be lifted at the flange with a lifting device as shown in Fig.10.
Due to the design the centre of gravity is always in the area of the flange, there it is sufficient to support the bushing end with the higher weight during lifting with one hand.

In no case the bushing must be put down on its insulator end for erection.

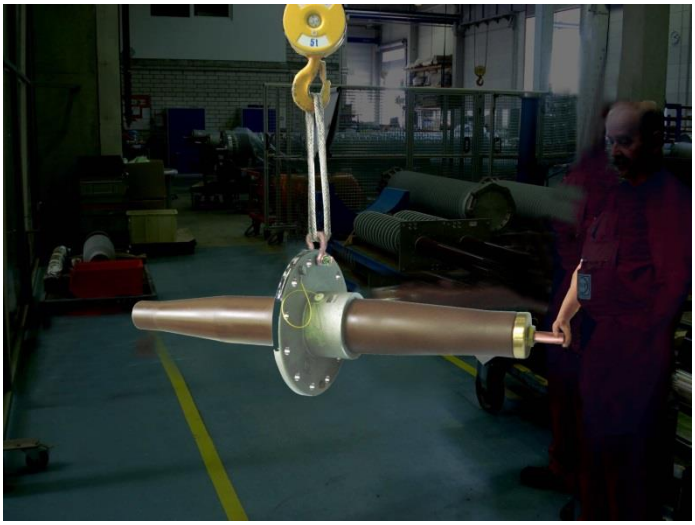

Fig.10

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

In case bushings are detected which show clear signs of the influence of moisture (Fig. 11) contact the manufacturer.

If the degree of penetration of moisture is not too high, the bushing can be dried in an oven at max. 100°C for several hours. In case after drying a measurement of the tan delta is recommended to ensure that the bushing is suitable for operation.

See comparative view (Fig.11).

Fig.11

2.3 Preparation for installation

In case of bushings with draw lead bolt first of all the draw lead bolt is removed to make the connection with the transformer lead.

Armature Parts (Fig.12)

1 Draw lead bolt
2 Round sealing front side insulating body
3 Round sealing draw lead bolt
4 Hexagon. Nut with locking screw
5 Cover
6 Pin torsion protection

Fig.12

First of all loosen (Fig.13) the locking screw in the hexagon. Nut (4)


Fig.13

Then loosen the hexagon. Nut with a suitable wrench (Fig.14)


Fig.14

Pull off the hexagon. Nut (Fig.15)


Fig.15

Pull off the cover (5) (Fig.16)


Fig.16

Remove the pin of the torsion protection (6) (Fig.17)


Fig.17

The draw lead bolt (1) is pushed out to the transformer side of the bushing (Fig.18)


Fig.18

The round sealings (2) and (3) remain in the cover. Its greasing is suitable for re-assembly.

Designs with detachable conductor rod are disassembled following the same procedure.

Designs with undetachable conductor rod cannot be dissembled for installation. The bushing is used without manipulation.

The connection to the transformer lead is usually soft or hard soldered. For this purpose a suitable bore for the connection of the transformer lead has to be made in the draw lead bolt.

Mounting of the bushing on the transformer is made in reverse sequence after it has been fixed.

TIP: If the pin (6) is not in horizontal position after installation of the bushing on the transformer it has to be fixed by axial pressure on the draw lead bolt after insertion that it cannot slip away during mounting of the cover (5).

2.4 Mounting of a shield electrode on the 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.

Movable disc

Opening to push through the whole screen

Fastening slit

Opening for insertion with inclination

Fixed disc

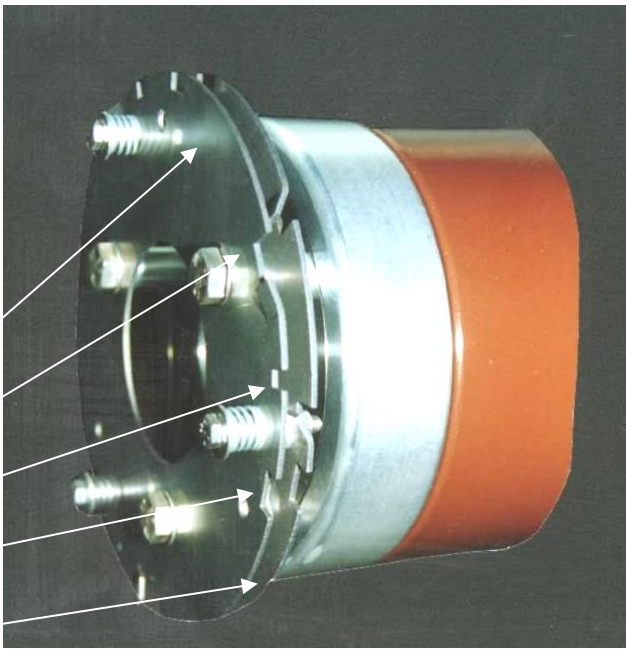

Fig.19

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.

Pushing the screen trough

For easy mounting of the current connections the screen can be turned before putting it on to the discs in such a way that is 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).

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

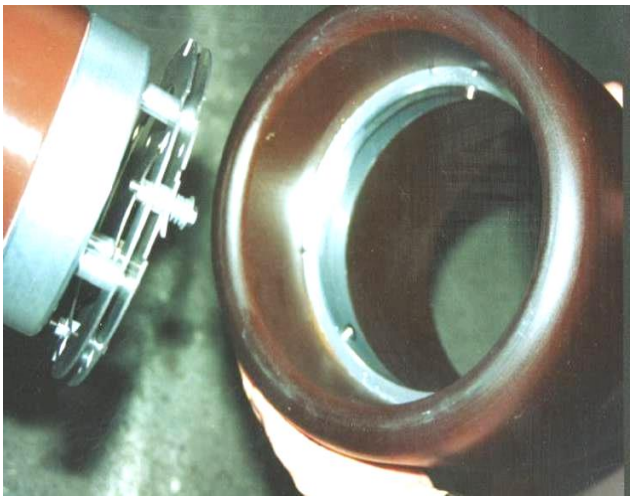

Fig.20

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

3 Installation 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 centre 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 shifted accordingly. The torques of the screws have to be taken from the table, if not specified otherwise.

Sealing of the bushing flange is made according to the instructions of the transformer manufacturer. The same applies for the torques of the screws of the bushing flange. If no data is specified, the table (Fig. 21) applies.

srew	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.21

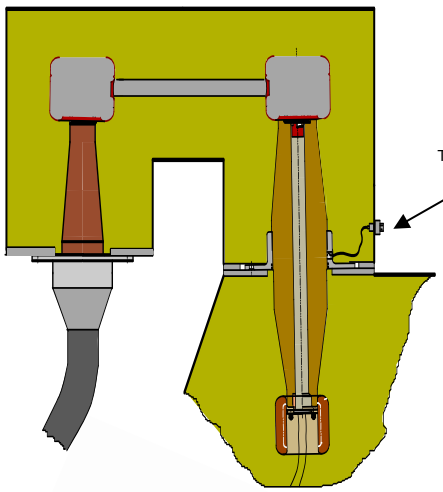

Fig.22

3.1 Grounding of the bushing flange

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

3.2 Connection test tap

If there is an external test tap**, it is connected to the bushing flange by a flexible wire. On its oil side the test tap has a threaded bore with which the cable lug can be fixed by screws.
Usually the test tap is determined on the transformer side. See scheme (Fig. 22 schematic example of an arrangement) and test tap (Fig. 23).

Fig.23

If no external test tap is provided for, the flexible wire has to be connected to the bushing flange by any means, the way determined for the status of dispatch!

3.3 Test tap

Design of the external test tap for bushings type EKTO

Design A	older type (Fig.24)
Design B	new type (Fig.25)

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 operation conditions this connection is always grounded. For measurements of the bushing is case of de-energized transformer the measuring lead is connected to the pin to determine the 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 and the traction relief on the bushing (14, Fig.6) with influence on the inner volume of the bushing and following damage!

TEST TAP

DESIGN A

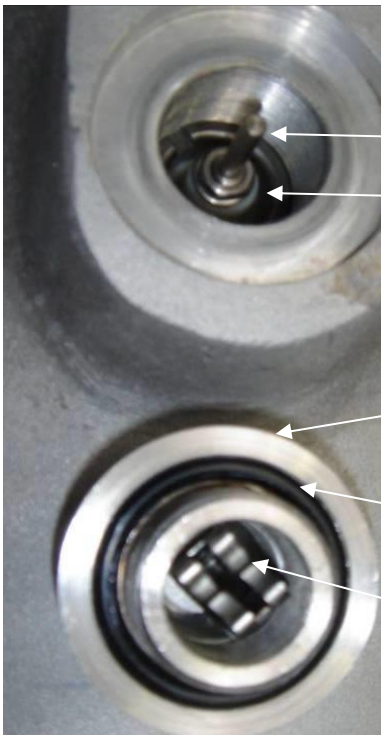

Fig.24

DESIGN B

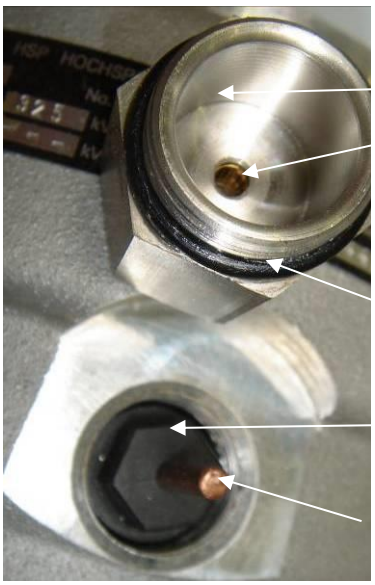

Fig.25

4 Putting into operation

4.1 Ventilation

As the oil volume into which the bushing is immersed on both ends is usually filled under vacuum, bushings type EKTO do not have the possibility of ventilation on the flange.
The draw lead bolt is equipped with a ventilation screw in case the bushing is installed in vertical position.

In case of an undetachable conductor rod there are no further possibilities for ventilation.

4.2 Evacuation of the transformer

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

4.3 Recommended tests before putting into operation

As the bushing is encapsulate on all sides, no final check can be made before putting into operation. By careful installation correct positioning the current carrying connections and, if required, electric screens, is secured.

4.4 Electrical measurements

By the final electrical tests carried out in the manufacturer's factory the bushing are certified as tested suitable for operation.
Nevertheless it is useful and therefore recommended to carry out a so-called reference measurement on site. This guarantees that in case of later control measurements measuring conditions are the same and comparable results are achieved. This is only possible when the cable side connection is interrupted.
There are transformers for which such a measurement is carried out during the final electrical test of the transformer. In this case comparative data is available.

The measurement includes the bushing capacity C1 as main capacity and the dielectric loss factor tan delta. A measurement of the capacity between the last grading layer and the flange is possible, but it does not provide any statement about the main insulation, it only shows the condition of the test tap area.
Limit values see item 5.4.

5 Maintenance

5.1 Recommended maintenance and checks

The bushing is free of maintenance.

Due to the encapsulate installation arrangement electrical measurement is difficult or not possible at all. For such a measurement either the cable side installation 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 measurements on bushings require a certain experience with measuring equipment, test set up and interpretation of 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 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 bushings type EKTO from 52 kV up to 550 kV.
The devices required for measurement are usually equipped specifically for the measurement of bushings. The measurement methods are described in comprehensive manuals.

Example of mobile measuring equipment

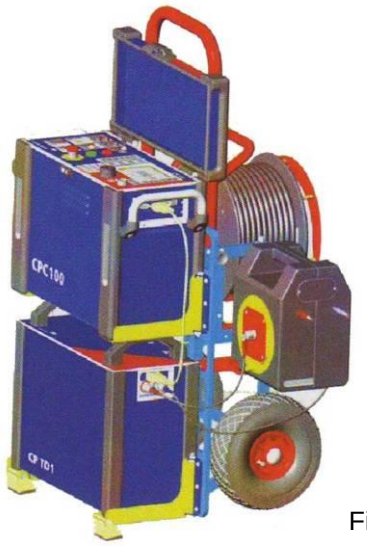

Fig.26

5.3 Equipment

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

5.4 Limits

For the measurements 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.27).

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.

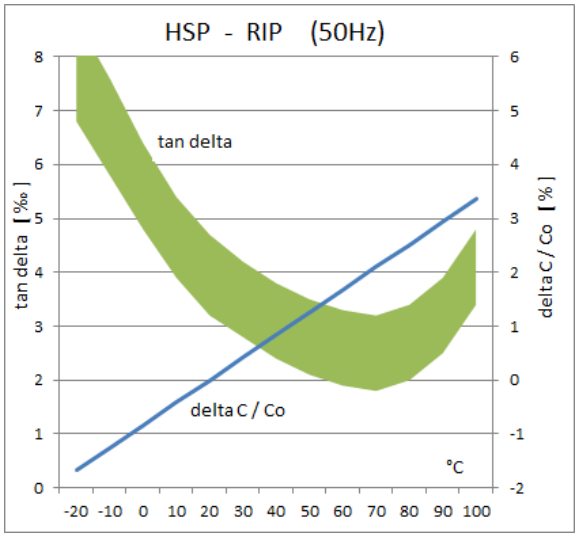

Fig.27

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 EKTO are made of few parts only, a part of which is undetachable, repair is possible to a limited extend only. The bushing flange is glued to the insulating body and cannot be disassembled.
In case of bushings with draw lead bolts the parts fastened by screws can be loosened. If the bushing has a test tap, it is connected to the flange by an insulated wire connection in an opening in the flange collar and traction relief.

These operating and maintenance instructions are valid for bushing type EKTO, therefore in case of a repair different sectional drawings and parts lists are required to explain the mounting steps. For repair purposes both documents can be ordered from HSP quoting the serial and the specification number of the bushing and will be sent immediately. Example of a sectional drawing and a parts list (Fig. 28). Above that depending upon the repair requirements short instructions can be given.
No repair can be carried out on the insulating body itself. In case of a failure we recommend to return the bushing to the manufacturer, who has suitable means and measures and professional investigation methods. But even in case of smaller repairs a return of the bushing to the manufacturer may be reasonable.

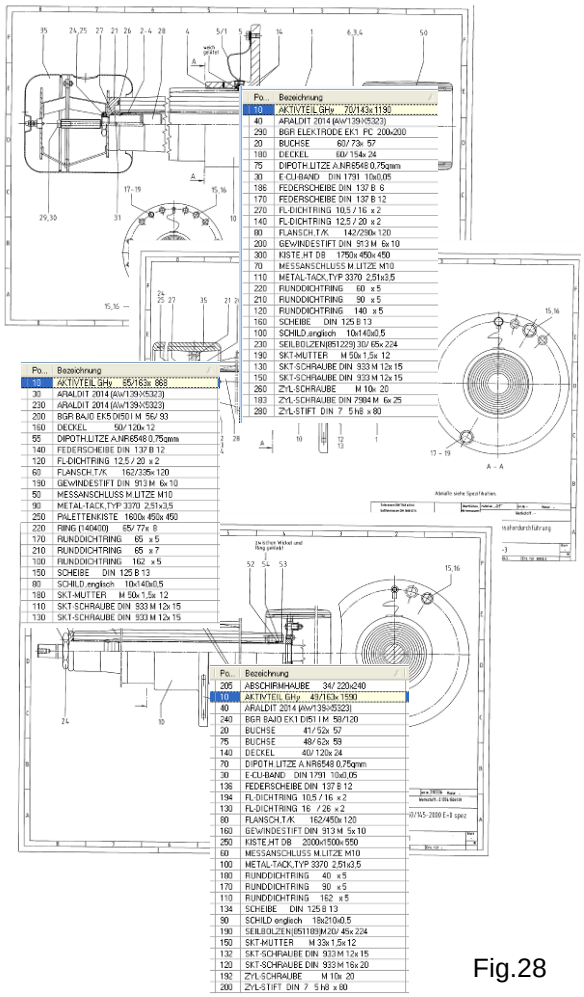

Fig.28

7 Storage

In its original packaging the bushing can be stored in dry rooms up to 12 months. If the bushing is packed in aluminum coated foil with inlaid dehydrating bags, storage time is 24 months.

Long-term storage, e.g. of spare bushings, is possible only with a protection tank on the transformer side as well as on the cable side. The material RIP is hygroscope and can absorb humidity, especially in case of long periods of storage.

The protection tank is made of coated steel and is screwed with sealings to the bushing flange. Typically, this tank is filled with dry nitrogen (approx. 0,25bar gauge) with manometer. At regular intervals this pressure must be checked and, if necessary, resqueezed. At Bushings with draw lead bolt or detachable conductor bolt the pressure within the protection tank has to be released before the clamping of the bolt is detached.

Fig.29

Alternative the tank has a screw through which it is filled with insulating oil, 7% less than the total volume as compensation volume in case of temperature variations. This type of long-term storage has the advantage that checks are limited to visual checks for leakages (Fig.29).

8 Disposal after the 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:

- Epoxy resin impregnated special paper with aluminium foil as layers
- Armatures made of aluminium or copper alloys
- Draw lead or conductor bolts made of E-Cu
- Fastening elements, test tap, screws etc. made of non-corrosive steel,