2750 515-115 en, Rev. 2

Transformer bushings, type GSA-OA
Installation and maintenance guide

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Safety information

Keep this instruction available to those responsible for the installation, maintenance, and operation of the bushing.

The installation, operation, and maintenance of a bushing present numerous potential unsafe conditions, including, but not limited to, the following:

- High pressures
- Lethal voltages
- Moving machinery
- Heavy components
- Slip, stumble or fall

Specialized procedures and instructions are required and must be adhered to when working on such apparatus. Failure to follow the instructions could result in severe personal injury, death, and/or product or property damage.

Additionally, all applicable safety procedures such as regional or local safety rules and regulations, safe working practices, and good judgement must be used by the personnel when installing, operating, maintaining and/or disposing such equipment.

Safety, as defined in this instruction, involves two conditions:

1. Personal injury or death.
2. Product or property damage (includes damage to the bushing or other property, and reduced bushing life).

Safety notations are intended to alert personnel of possible personal injury, death or property damage. They have been inserted in the instructional text prior to the step in which the condition is cited.

The safety conditions are headed by one of the three hazard intensity levels which are defined as follows:

DANGER

Immediate hazard which will result in severe personal injury, death, or property damage.

WARNING

Hazard or unsafe practice which could result in severe personal injury, death, or property damage.

CAUTION: *Hazard or unsafe practice which could result in minor personal injury, or property damage.*

Contents

1 Description

1.1 Design

Bushings type GSA-OA are intended for outdoor-immersed Oil-Air service. The design is shown in Fig. 1. For a more detailed description, see Technical Guide, *1ZSE 2750-111*. The bushing is of dry type, with Resin Impregnated Paper (RIP) as main insulation and Silicone Rubber (SiR) weather sheds on the outdoor part. This gives the advantages of mounting in any angle from vertical to horizontal.

All GSA bushings are equipped with a test tap connected to the outer layer of the condenser body. The maximum test voltage for this test tap is 2 kV, one minute at 50 to 60 Hz. It serves as a test tap, and in connection with an external capacitance it can be used as a voltage tap. The operation voltage is limited to 600 V.

The bushing can be connected to the transformer by pull-through conductors of either flexible or solid rod type.

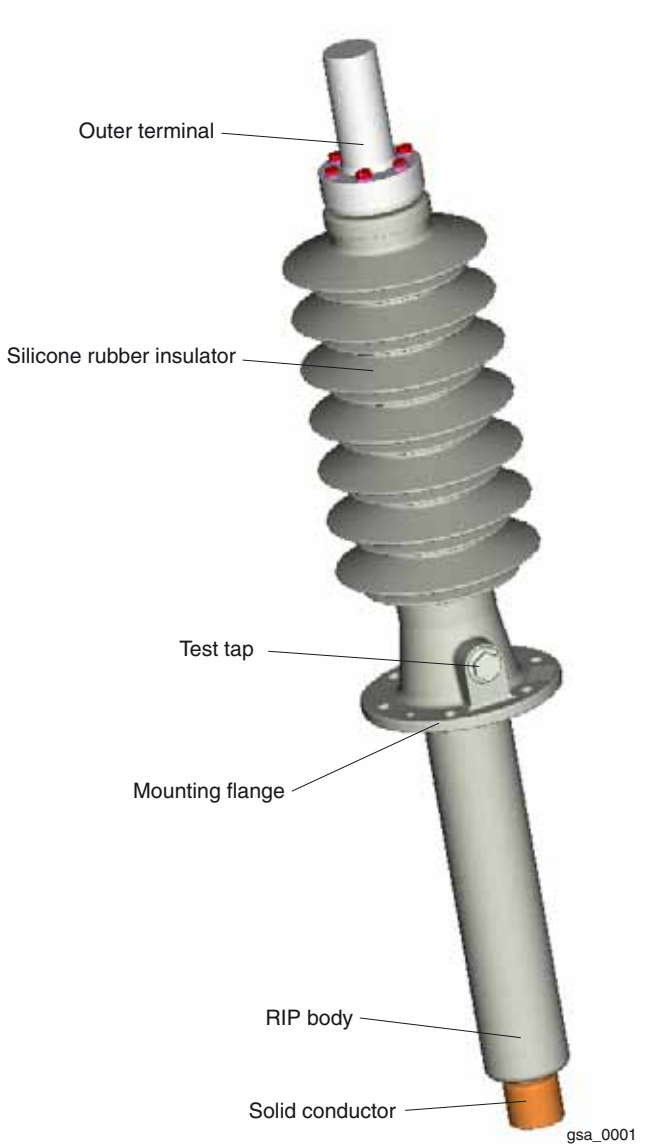


Fig. 1. Design of bushing type GSA-OA.

1.2 Operating conditions

The table below shows the standard technical specifications for the GSA oil - air bushings. For conditions exceeding the below values, please contact ABB.

Common specifications:	
Application:	Transformers
Classification:	Resin impregnated paper, capacitance graded, outdoor-immersed bushing
Ambient temperature:	+40 to -40 °C, minimum value as per temperature class 2 of IEC 60137
Altitude of site:	< 1 000 m
Level of rain and humidity:	1-2 mm rain/min horizontally and vertically, as per IEC 60060-1
Pollution level:	According to specific creepage distance and IEC 60815[1)]
Type of immersion medium:	Transformer oil. Maximum daily mean oil temperature 90 °C. Maximum temporary oil temperature 115 °C.
Oil level below bushing flange:	Maximum 25 mm
Max. pressure of medium:	100 kPa overpressure
Corrosion protection:	The flange and the top piece are protected from corrosion.
Markings:	Conforming to IEC/IEEE

1) IEC 60815 "Guide for the selection of insulators in respect of polluted conditions".

1.3 Mechanical loading

The bushings are designed for the following cantilever loads applied to the midpoint of the top end terminal, perpendicularly to the bushing axis. The bushing mounting angle can be anywhere from horizontal to vertical. The values are valid for all different lengths on the oil side.

Table 1. Mechanical loading.

Bushing(N)	Type test load 1 minute (N)	Max. service load (N)
GSA52-OA/2000	2500	1250
GSA73-OA/2000	3150	1575
GSA123-OA/1600	4000	2000
GSA170-OA/1600	4000	2000

1.4 Spare parts

In case of major damage to the bushing we recommend that it is sent back to ABB for possible repair and re-testing. Certain parts (Figs. 4 and 5), which may be damaged or lost during transport or installation, can be ordered from ABB.

2 Installation

2.1 Tools

- Lifting gear 2183 789-2 for lifting up to 125 kg
- Lifting eye screw M 12 (DIN 580) for mounting at an angle 2183 2001-3
- Pull-through cord with M8 swivel 9760 669-A, -D
- Torque wrench key for hexagon head screws, head width 16 mm (M10) and 13 mm (M8), torque 20 to 40 Nm.
- Key for hexagon head 30 mm or adjustable wrench for 30 mm or bigger. (For test tap cover)

2.2 Consumables

- Water free vaseline, Mobilgrease 28 or other suitable lubricant not harmful to the transformer oil, to lubricate screws that come into contact with the transformer oil.
- Mobilgrease 28 or other suitable grease to lubricate and protect the earthing screw and the outer terminal o-ring gasket.
- Molykote 1000 or other suitable compound to lubricate the screws making the contact and sealing at the outer terminal.

2.3 Transport, storage and handling

CAUTION: *Do not allow the bushings to rest on the silicone rubber sheds during transport or storage because it will make them deformed. Keep the bushings dry and clean and protected against mechanical damage.*

The bushing shall be surrounded by a sealed moisture-proof wrapping material together with a drying agent during storage and transportation.

The supplied protective wrapping shall not be opened if the bushings are intended to be stored. The protective wrapping can be re-sealed, or a similar sealed moisture-proof wrapping can be used together with a drying agent.

The bushings may be transported and stored in any angle from vertical to horizontal.

Carefully inspect the bushings on receiving with regard to shipping damage. Please note that the bushings have been routine tested in oil and some oil may be left, especially in the narrow opening between condenser body and flange.

The bushings are normally delivered from ABB in boxes with the bushing supported by blocks and fibre boards. The boxes are marked with "Top End".

2.4 Lifting from the box

WARNING

For lifting the bushing from the box, apply two clean lifting slings as shown in the figure below. Support the bushing at the same points as in the box if placed on the ground or block it under the flange and the metal top piece. Light bushings may be handled manually. Do not lift the bushing in the silicone insulator.

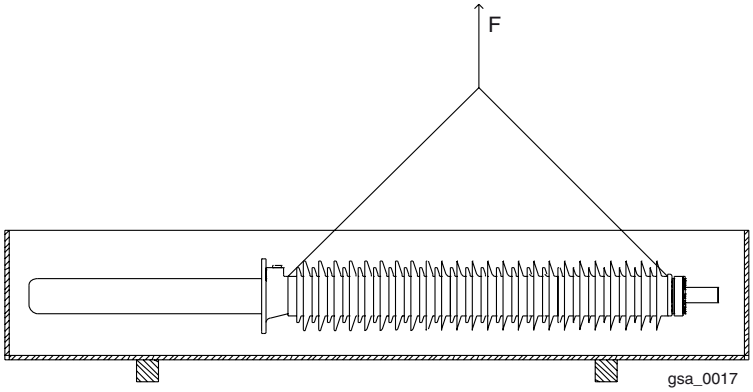


Fig. 2. Lifting from the box.

2.5 Mounting

WARNING

Light bushings may be handled manually. Lift heavier bushings with the aid of a lifting tool, see section 2.1 Tools. Lift the bushing to vertical position and to an angle according to the figures below. Use a soft bedding under the bottom end of the bushing, e.g. a rubber mat.

The mass of the bushing is stated on the marking plate. Carefully clean and inspect the oil end of the bushing and the inside of the centre hole before mounting on the transformer.

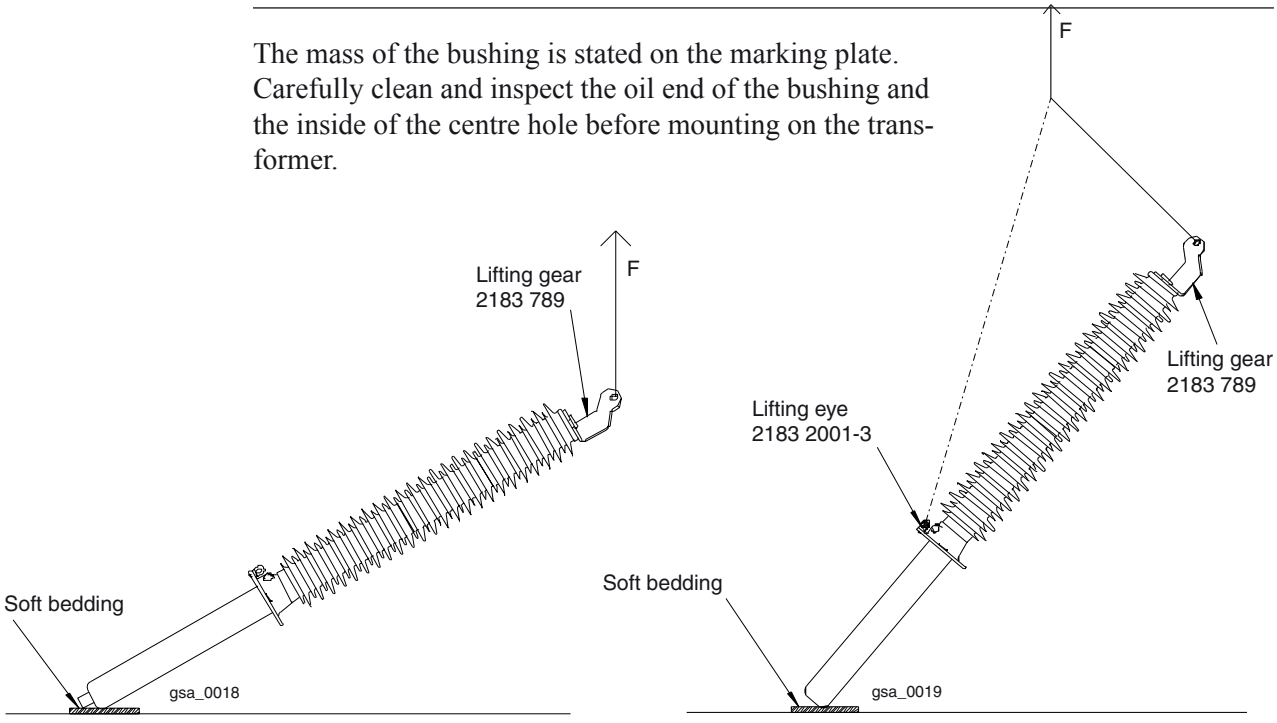


Fig. 3. Mounting.

2.5.1 Inner terminal / Stranded cable

CAUTION: *Mounting of the conductor must be performed according to the procedure below. The contact surfaces must be clean.*

1. Stretch the stranded cable with the brazed inner terminal, normally fastened to the cover plate. Avoid making any loops.
2. Drop the pull-through cord through the bushing centre hole.
3. Lift the bushing above the opening.
4. Fasten the M8 swivel to the inner terminal at the end of the stranded cable. Lower the bushing into the transformer while directing the stranded cable by keeping the pull-through cord taut.
5. Fix the bushing to the cover. Torque M12 to 50 ±5 Nm, 1/2" UNC to 55 ±5 Nm.
6. Place the divided ring around the slot in the inner terminal according to Fig. 4a.
7. Gently release the pull-through cord so the conductor rests on the divided ring.
8. Remove the pull-through cord.
9. Proceed immediately to section 2.6 Mounting of outer terminal.

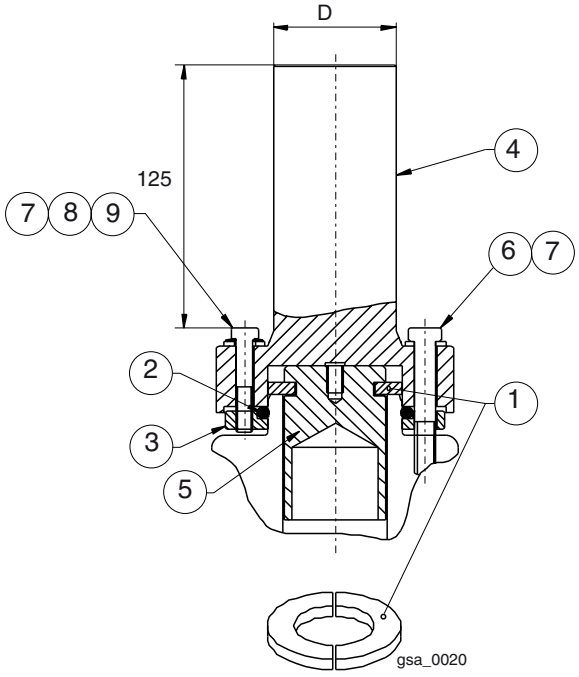


Fig. 4a. Outer terminal assembly.

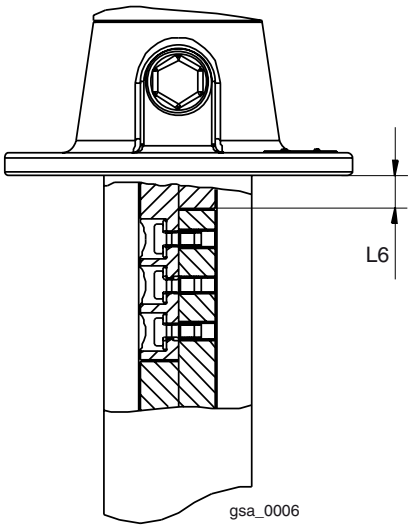


Fig. 4b. Solid rod conductor joint.

1) Divided ring 2151 811-45
2) O-ring 2152 929-75
3) Tightening ring 2744 330-7
4) Outer terminal
5) Inner terminal
6) Hexagon head screw M10x60 Stainless steel A2-70
7) Flat washer 10.5x2x20 Stainless steel A2-70
8) Hexagon head screw M8x45 Stainless steel A2-70
9) Spring washer Stainless steel

2.5.2 Solid rod conductor

CAUTION: *Mounting of the conductor must be performed according to the procedure below. The contact surfaces must be clean.*

1. Mount the lower part of the solid rod in the transformer.
2. Lubricate the 3 x M10 screws with water-free vaseline or Mobilgrease 28 or other suitable lubricant, not harmful to the transformer oil. Insert and tighten to 35-40 Nm, to mount the upper part of the solid rod to the lower part.
3. Lift the bushing above the opening.
4. Drop the pull-through cord through the bushing centre hole.
5. Fasten the M8 swivel to the top part of the solid conductor.
6. Lower the bushing into the transformer while directing the assembled solid rod conductor by keeping the pull-through cord taut.
7. Fix the bushing to the cover. Torque M12 to 50 ±5 Nm, 1/2" UNC to 55 ±5 Nm.
8. Place the divided ring around the slot in the solid rod conductor.
9. Gently release the pull-through cord so the conductor rests on the divided ring.
10. Remove the pull-through cord.
11. Proceed immediately to section 2.6 Mounting of outer terminal.

2.6 Mounting of outer terminal

CAUTION: *Mounting of the conductor must be performed according to the procedure below. The contact surfaces must be clean.*

Please note for aluminium connectors:
The inner contact surfaces of aluminium, both on the bushing conductor and on the terminal stud, are tin/zinc plated and wire brushing must not be carried out.

CAUTION: *Untreated smooth aluminium surfaces must be brushed to remove the oxides, and greased before making the connection.*

Assembly sequence:

1. Clean the contact and gasket surfaces carefully.
2. Lubricate the o-ring with Mobilgrease 28.
3. Assemble the tightening ring, the O-ring, and the outer terminal stud and push them over the inner terminal with the divided ring in place.
4. Grease all bolts on thread and underneath the head with Molykote 1000, or other suitable compound.
5. Insert and tighten the screws M10, with plane washer, which press the stud against the inner terminal (or solid conductor). Tighten stepwise to a final torque of 40 ±4 Nm.

6. Insert the M8 screws, with conical spring washer and plane washer, which hold the tightening ring. Tighten them to press the gasket into place. Tighten stepwise to a final torque of 20 ±2 Nm.

CAUTION: It is extremely important in both cases to tighten evenly. *The bolts shall thus be tightened in steps, alternately on both sides.*

2.7 Flange earthing

The bushing flange is provided with a tapped hole M12. After tightening the bolts fixing the bushing to the transformer tank, the flange should be earthed. This prevents electrical discharges between bushing flange and transformer tank under normal service conditions.

Alternative 1
Insert a heavily greased (Mobilgrease 28 recommended) pointed set screw M12 (stainless steel A4-80 preferrably). Tighten to 40 Nm, penetrating the paint of the transformer tank down to the metal underneath. This makes an electrical connection between the bushing and the transformer tank, keeping them at the same voltage.

Alternative 2
Apply a flexible cable between the M12 earthing hole in the bushing flange and a corresponding connection point in the transformer. Grease the screw (Mobilgrease 28 recommended) and tighten the M12 in the bushing to 40 Nm. Connect the other end of the cable to the transformer.

2.8 Waiting time before energizing

CAUTION: *Some waiting time may be necessary before energizing, in order to avoid flashovers or partial discharges due to air bubbles at the bushing surface. Choose a suitable procedure below.*

Vacuum filled transformer
No waiting time is necessary from the bushing point of view.

De-gassed oil-filled transformer
During mounting, use a clean and dry paintbrush to release surface bubbles. Wait 6 hours before energizing.

Gas-saturated oil-filled transformer
During mounting, use a clean and dry paintbrush to release surface bubbles. Wait 24 hours before energizing.

De-gassed oil filled transformer with reduced oil-level
After restoring the oil-level, wait 24 hours before energizing.

For all alternatives except vacuum-filled transformer, the oil should be allowed to enter the centre tube to at least flange height by releasing the outer terminal sealing system and allowing air to escape this way.

Oil spillage is not harmful to the silicone rubber insulator. Oil should be removed by wiping with a paper cloth to avoid that it attracts dirt that could reduce the insulation performance.

Do not allow oil that has been in contact with silicone rubber to enter the transformer. Such oil may contain small amounts of silicone oil that reduces the surface tension of the transformer oil which could make it foam during forced oil circulation.

2.9 Recommended tests before energizing

The following tests may be performed to check the insulation, sealing and current path of the bushing. The tests should be made after mounting, but before connecting the outer terminal of the bushing to the rest of the switchyard power circuit.

1. Tightness test between transformer and bushing flange.
2. Tightness test of bushing outer terminal.
3. Measurement of capacitance and tan δ.
4. Check of through-resistance.

2.9.1 Tightness test between transformer and bushing flange

Several different methods may be used and we thus refer to instructions given by the company responsible for the field erection. As a simple example, the tightness of the seal between transformer and bushing flange may be checked when the transformer is oil-filled by using chalk or, perhaps easier, with paper strips.

2.9.2 Tightness test of bushing outer terminal

Since the top terminal is often situated above the oil level of the transformer expansion system, a leak at this point is extremely serious, because water could enter directly into the transformer insulation this way. It is thus recommended to make a tightness test after assembly, preferably both with vacuum and over-pressure. Several different methods may be used and we refer to instructions given by the firm responsible for the field erection.

One possible method is the tracer gas method:

1. Put a tracer gas into the centre tube before mounting the outer terminal. The oil level of the transformer must be above the bottom end of the bushing but below the bushing flange.
2. Increase the pressure in the center tube by increasing the oil level as much as possible.
3. Search with a gas detector (sniffer) for leaking gas at the gasket.

2.9.3 Measurement of capacitance and tan δ

WARNING

The new design of test tap is not self-earthing.

Since C_2 usually is relatively small, the test tap must never be open-circuited when applying a voltage to the bushing. It shall always be earthed or connected to an external impedance. No connection may destroy the bushing.

***CAUTION:** When not measuring, always make sure that the cap nut is properly tightened with the gasket in place. This is to prevent dust and water from coming in to the test tap.*

After mounting, a capacitance measurement is recommended. Connect a measuring bridge between the outer terminal and the test tap by using a Ø 4 mm lead coupler or ABB's test tap adapter 2749 510-U. This is possible without removing the bushing as the bushing has an insulated test tap, see Fig. 5. More details can be found in the product information *2750 515-142*, "Bushing diagnostics and conditioning".

Fig. 5a. New design of test tap 2769 531-B (not self-earthing)

1) Bushing for test tap
2) Disc spring
3) Press nut
4) Cover 2749 528-B with O-ring 2152 484-2
5) Contact pin, 4 mm
6) O-ring
7) O-ring
8) Cable

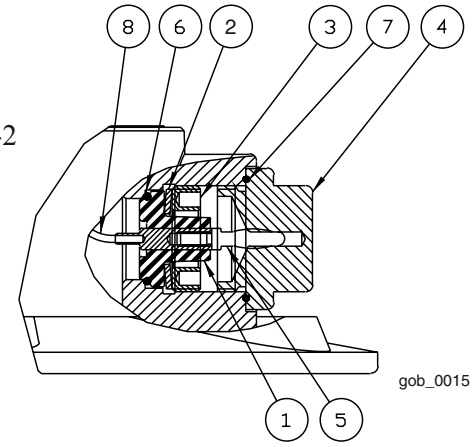
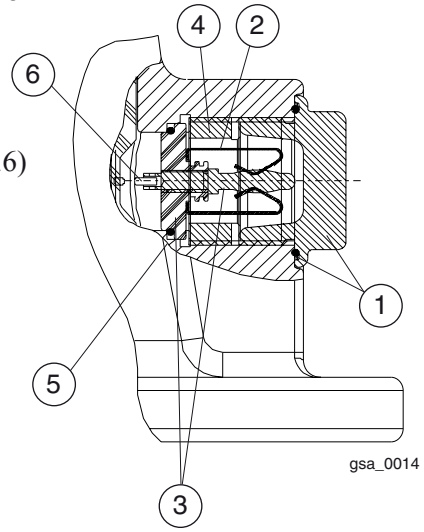


Fig. 5b. Previous design of test tap 2769 530-A (self-earthing)

1) Cover 2749 528-A with o-ring 2152 484-2
2) Earthing spring 2749 527-1
3) Bushing 2769 529-A
4) Press nut 2749 526-1
5) Gasket (o-ring) 2152 484-1 (22.1 x 1.6)
6) Cable 1685 004-1



With the transformer de-energized and the bushing outer terminal disconnected, the test tap cover is removed. The measuring equipment is connected to the test tap and the measuring voltage source to the bushing terminal.

The capacitances C_1 between the outer terminal and the test tap, and the capacitance C_2, between the test tap and the flange are marked on the marking plate. The nominal capacitances C_1 of the different bushing types are listed in Table 2. C_2 is highly dependent on the surrounding parts inside the transformer and it is not possible to give a nominal value valid for all service conditions.

Table 2. Nominal capacitances in pF (Manufacturing tolerances for C1 ± 10%).

GSA-OA	Space for CT = 0 C_1	Space for CT = 300 C_1	Space for CT = 500 C_1
52	207	386	502
73	316	494	610
123	200	295	356
170	282	377	438

2.9.4 Check of through resistance

The through resistance measurement method depends on the design of the transformer. Generally, a current is applied from bushing to bushing. The voltage drop from outer terminal to outer terminal is measured. The resistance is calculated with Ohm's law, $U = R \cdot I$. (U: Measured voltage drop. I: Through current. R: Total circuit resistance.)

The total through resistance is the sum of the transformer winding and lead resistance and the bushing conductor and contact resistance. The additional resistance from the bushing conductor should not be more than 10 ... 100 mΩ. Since the through resistance of the HV winding of a typical power transformer is in the order of 0.1 ..1 Ω, this is a very rough method that can only be used to detect very large faults in the current path, such as disruptions.

Less-than-perfect contacts can only be detected by making a sensitive measurement across each connection point, or by measuring the temperature increase during operation with an infrared sensitive camera (thermovision).

3 Maintenance

The GSA bushings are in principle maintenance free; no regular maintenance is needed.

DANGER

No work at all can be performed on the bushing while it is energized or not earthed.

3.1 Recommended maintenance and supervision

3.1.1 Cleaning of insulator surface

Under conditions of extreme pollution it may be necessary to clean the silicone rubber insulator surface. This should be done by wiping with a moist cloth. If necessary, ethyl-alcohol or ethyl-acetate may be used.

1,1,1 -Trichloroethane or Methylchloride are not recommended due to their possibly harmful and environmentally detrimental properties.

3.1.2 Measurement of capacitance and tan δ

Please refer to Chapter 2, Installation.

3.1.3 Thermovision (infrared camera) check for local overheating on connectors

At maximum rated current, the bushing outer terminal normally takes a temperature of about 35 to 45 °C above the ambient air. Significantly higher temperatures, especially at lower current loading, can be a sign of bad connections.

3.1.4 Check for leakage

Make a visual inspection for oil leakage during normal station supervision.

3.2 Disposal after end of service life

Conductors and outer terminals are separable from the bushing by screw joints. Conductors are of pure copper or low-alloy aluminium. Terminal studs are of pure copper, brass or low-alloy aluminium. Connectors may be plated with for instance silver, tin, gold or nickel in layer thicknesses up to 20 mm.

The bushing flange (cast aluminium AlMgSi7) is fixed with glue and must be broken away by force in the direction downwards towards the transformer end, preferrably at a temperature of 150 °C where the glue starts losing some of its shearing strength. The top piece (wrought aluminium AlMgSi1) is very strongly attached to the condenser body and must be cut or broken off, broken preferrably at an elevated temperature, 150 °C .

The silicone rubber weather sheds contain no heavy metals or poisonous agents and can be deposited or incinerated.

The epoxy resin impregnated paper condenser body contains approximately 1% (by weight) aluminium foils. It contains approximately 2 g of carbon in glue joints, and 1 g of lead in the soldered joint of the measuring tap cable. The epoxy and paper material of the condenser body can be incinerated in an oven suitable for curable plastics and the mentioned metals, or deposited.

Screws and washers are made of stainless steel.

The supplied protective wrapping contains polyethylene, polyester and approx. 11 % (by weight) aluminium. The supplied wrapping can be incinerated in a suitable owen.

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