Contents

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Originated from: IS 2638 G	Replaced by: IS 2638 H	Amendments: General revision 13/11/2017 Added bottom connection execution 04/12/2018 Modified cable side shield 16/05/2019 Added PF tap welded type 13/01/2022 Extended range to 420 kV 16/09/2022
Written by: S.Gisy Amended by: M. Campana	Approved by: D. Pirovano	

General design

(See dimensional drawing 4.7 in appendix)

The design of the bushing is of dry type with resin impregnated paper. A continuous sheet of crepe paper is wound on a tube by an automated winding machine to form the insulating core. (1)

Aluminum layers are inserted in the windings at precisely calculated positions for field control. This insulating core is vacuum-dried and then impregnated under vacuum with an epoxy resin system. (1)

After curing a compact oil-tight insulating core is produced. (1)

The flange is mounted and glued onto the insulation core to have it oil tight. In the flange there are two O-rings gaskets included to seal the inner side of the flange against oil from both sides. (2)

The bushing can be of draw lead type or with solid conductor (removable or not removable).

At the cable box side the cable bolt or the removable conductor will be fixed and tightened in the tube. The connection must be shielded by the transformer manufacturer (shielding is always recommended). (3)

The bushing always contains a measuring TAP. Depending on the application this test TAP can be extended for remote measuring from the cable box. (4).

The bushing contains always a bottom side corona shield. Make sure that the surface & coating is not getting scratched, damaged or deformed. (5).

Because the bushing is completely dry, it can be transported, stored and installed in any position.

Construction details of the bushing are to be seen from order specific drawing.

1 Packing, Unpacking, Handling

1.1 Bushing supply conditions

For protection against damage, the bushings are dispatched in wooden transport cases. The cable bolt/stem conductor is assembled within the bushing. The bushing is protected against humidity by a sealed barrier bag with a drying cartridge.

1.2 Transport case

Gross and net weight and dimensions are given in the dispatch notice.

1.3 Lifting and handling

See 4.8 in the Appendix

- Removing the bushing from the packing

Small types can be taken out by hand; larger types require ropes and lifting gear.

- Bringing the bushing into vertical position

The easiest way is by means of two lifting gears and two ropes. One end of the rope is enlaced at the top. Use the foreseen M12 thread in the Top terminal; the other end is fixed with a hook in the eyebolts at the main flange. This eyebolt can be screwed into the designated threading in the flange. The bushing is first lifted horizontally with one lifting gear. Then, the bottom part or flange side can be lowered down. **Protect the shield** before putting it onto the bottom.

CAUTION
The bushing must not touch the floor while lowering down because the insulation body or any other parts (shields) might get damaged. The bushing should not be turned into vertical position with only one rope since the bushing could slip through the noose and fall down.

1.4 Repacking for further transportation

It is necessary to ensure that the quality of packing, the protection against humidity and damage, is as good as on delivery.

2 Storage

Concerning the storage of the bushing, the location (outdoor, rain protected or indoor) and the duration of storage (short, medium, or long term) must be considered. If necessary, a storage canister can be ordered to the manufacturer.

CAUTION
In general, the moisture protection of the bushing must be mounted at any time.

	Outdoor, protected from rain	Indoor
Short term max.1 year	In original transportation box, covered with plastic. Recommended: Additional moisture protection with a second plastic bag and desiccant cartridge.	In original transportation box and original packing.
Medium term max. 2 years	Not recommended	In original transportation box and original packing.
Long term	Not recommended	Upper and lower parts of the bushing in a storage canister, filled with oil or dry nitrogen. or: In original transportation box and original packing. Only in dry rooms, temperature as constant as possible. The desiccant cartridge should be checked regularly. The bushing must be fully wrapped into laminated aluminium foil (PETP/Al/PE). Quantity of desiccant 2½TME/m^2 for moderate climate 25 TME/m^2 for extreme climate TME/ m^2: Desiccant unit per m^2 of the barrier surface

Note: Bushings stored in special storage canisters can be used immediately even after long-term storage without any further testing.

2.1 Proceedings after improper storage

It is possible that humidity diffuses into the insulation core.
If you have doubts whether the storage conditions met the requirements in above table or not, you can verify it by a capacitance and power factor tan (δ) measurement at about 10 kV test voltage applied to the main conductor. If the power factor deviates too much from the original factory test results or if you are uncertain about the conditions please contact the manufacturer for further information. Please be aware and inform about the prevailing temperature at the time of measurement.

3 Installation and commissioning

3.1 Preparation before assembling

The sealing area between the bushings flange and transformer tank should be free of corrosion. To seal the system, O-rings or flat gaskets are suitable. Pay attention to the de-aeration hole at the flange plate since the sealing must not cover it. The surface of the insulation core must not be clawed.

The screw connection should be designed for not deforming the flange. If the threads of the eyebolts will project below the bushings flange on the sealing side, they must be removed before tightening the flange.

3.2 Conductor and terminal

See 4.9 in the Appendix
An inner lug for removable conductor is installed in the central tube of the bushing. The draw lead must be welded into the lug. The lug / conductor can be taken out of the central tube after removing the top terminal and the cover nut. Make sure that it is secured by a rope.

CAUTION
In order to withstand transient over voltages (e.g., switching transients) between draw lead and centre tube of the bushing, the draw lead within the bushings tube should be coated with an insulation layer of minimum 1mm. If your bushing is equipped with a removable conductor, it will have centring rings that keep the conductor distant from the tube to avoid sparking in between in case of transient over voltages.

If your bushing is equipped with an inner lug, it must be soldered or brazed onto the draw lead. Don't forget to remove any vulnerable parts like O-rings or sealing retainer from the cable bolt before doing so. **Damage on the sealing system can result in failures of the bushing and the transformer.** Before welding, a hole has to be drilled into the lug,

adequate in diameter for the transformer lead, up to 170 kV: (max. ∅ 35 mm and max. 65 mm deep), for 245 kV: (max. ∅ 60 mm and max. 150 mm deep). To determine the maximum depth of the hole, consider that the de-aeration hole must not be attained.

Note: In case the draw lead is brazed into the lug, the sealing area, and threads in it, must be cooled during brazing for not deforming and annealing them.

With adequate tools it is possible to crimp the inner lug onto the draw lead.

3.3 Assembling of the bushing onto the transformer

The bushing must reach the ambient temperature before installation in order to avoid condensation on the bushings surface. The upper and lower part of the bushing must be cleaned thoroughly with a clean, dry and fluffy free fabric before installation.

See 4.7 in the Appendix

After connecting the draw lead, a M8 screw can be fixed to the lug for pulling it through the bushing central tube by a rope. The two fixation half rings must be put into the groove of the lug and inserted in the central tube. Now the lug can be fixed with the cover nut by hand. The top Terminal can be mounted by hand. Make sure that all O-rings are mounted properly. Mount the foreseen screws. The de-aeration screw must be reinstalled. Before installation all O-rings must be greased with acid-free grease. For mounting the screws use the foreseen Loctite and right torque.

CAUTION
If the de-aeration screw is not reinstalled properly, the transformer cannot reach the right vacuum before the oil filling process!

3.4 De-aeration and resting time

The bushings central tube must be de-aerated through the de-aeration screw at the top end of the terminal

CAUTION
After de-aeration, make sure the de-aeration screw is set back in place and tightened. High voltage ≥ $U_n/\sqrt{3}$ should be applied to the bushing not earlier than 12 hours after oil filling.

3.5 Evacuation of the transformer

The transformer can be subject to vacuum treatment with mounted bushings. If the transformer is evacuated before oil filling no de-aeration is required.

3.6 Measuring tap

Attention: **For connection only use the appropriate plug. In operation, the cover of the measuring tap must be installed at any time.**

CAUTION
DO NOT OPERATE THE BUSHING WITH REMOVED CAP FROM MEASURING TAP, AS IT WILL RESULT IN CORROSION OF THE GROUNDING CONTACT, DAMAGE THE BUSHING AND CAUSE ELECTRICAL FAILURE OF THE BUSHING AND THE TRANSFORMER. **THE VOLTAGE ON THE MEASURING TAP MUST NEVER EXCEED 1,5 kV WHEN MEASURING POWER FACTOR. FAILURE TO FOLLOW THESE GUIDELINES COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE**

4 Maintenance, repair, disposal

4.1 Maintenance

Before getting the bushing into service, carry out a measurement of dissipation factor tanδ and capacitance C_1 between high voltage conductor and test tap at voltage up to 10kV, to have a reference for later checks.

The bushing is maintenance free.

4.2 Spare parts

When ordering spare parts always indicate serial number and type of bushing mentioned on the name plate.

4.3 Repair

Repair only according to manufacturer's instructions. For this, please have serial number, type of bushing and exact description of damage ready.

4.4 Safety information

CAUTION
THE SCREWS AND CAPS MUST BE MOUNTED AND TIGHTENED AT ANY TIME WITH STANDARD TORQUE. FAILURE TO FOLLOW THESE GUIDELINES MAY RESULT IN DAMAGE TO THE BUSHING AND CAUSE ELECTRICAL HAZARD. THIS COULD RESULT IN SEVERE PERSONAL INJURY, DEATH OR PROPERTY DAMAGE. ANY CONNECTION TO THE BUSHING HAS TO BE MADE WITH THE NECESSARY RESPECT TO LOW CONTACT RESISTANCE.

4.5 Disposal

After reaching the end of lifetime, this product must be disposed correctly according to local laws and regulations.

All the contained substances and material should be recycled separately. The product as a whole and its individual parts do not contain any toxin.

No breathing, nor skin protection, nor any special precautions are required. Apply the common and appropriate safety standards to prevent working accidents. In case of uncertainties please contact the manufacturer for advanced information and instructions.

4.6 NAME PLATE

Each bushing is provided with a name plate, with serial number and all the electrical data, in accordance with the prescription of IEC Standards.

The nameplate (fig. 2) is made of aluminium and is fixed to the flange by special nails. On the nameplate the following information are indicated:

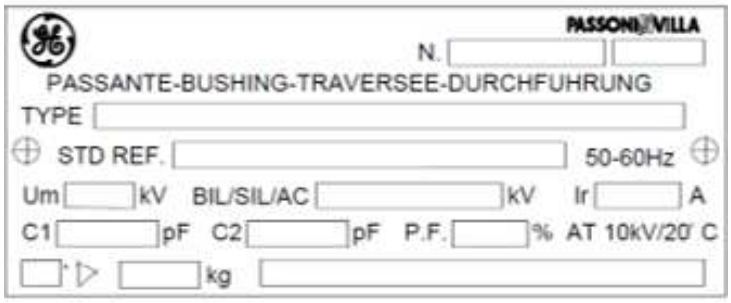


Fig. 2

The month is indicated by a code, as follows:

A = January	L = July
B = February	M = August
C = March	P= September
D = April	R = October
E = May	S = November
H = June	T = December

Appendix

Dimensional drawing

Handling of the bushing / lift out

Conductor / Top terminal assembly

Instruction for operation of measuring tap

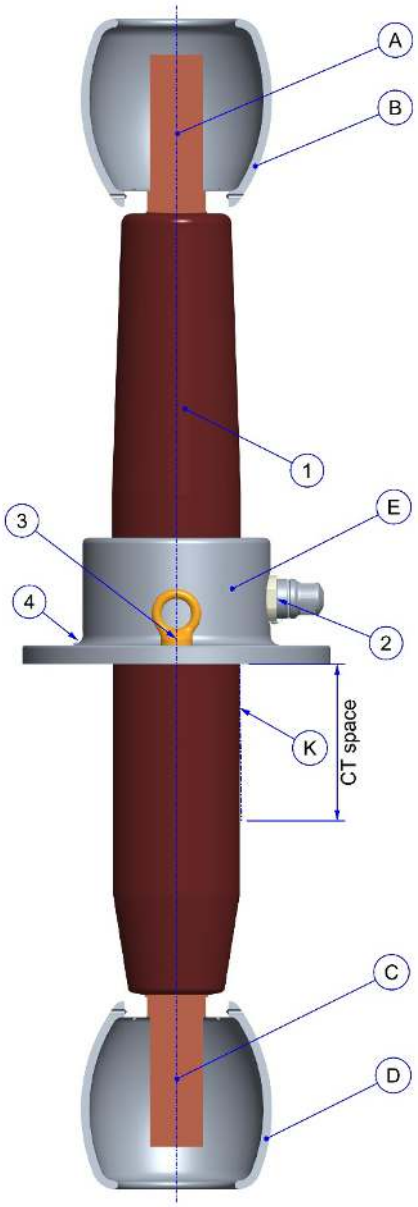
Remote measuring TAP

4.7 General design PCTR Oil-Oil Bushing

1. RIP condenser core with inserted aluminum layers
2. Power factor/test tap
3. Lifting eyes
4. Air outlet screw ¼" gas

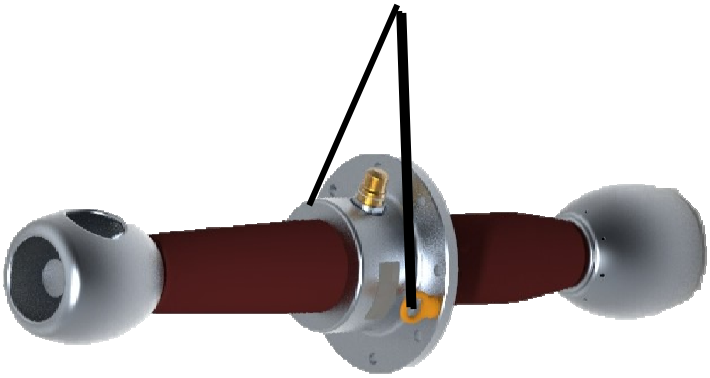
A. Terminal - Cable side
B. Shield – Cable side
C. Terminal - Transformer side
D. Shield - Transformer side
E. Flange
K. Grounded zone for Current Transformer (CT space)

configurable items identified by letters



4.8 Handling of the bushing / Lifting out

Packing and delivery Condition / Lifting out

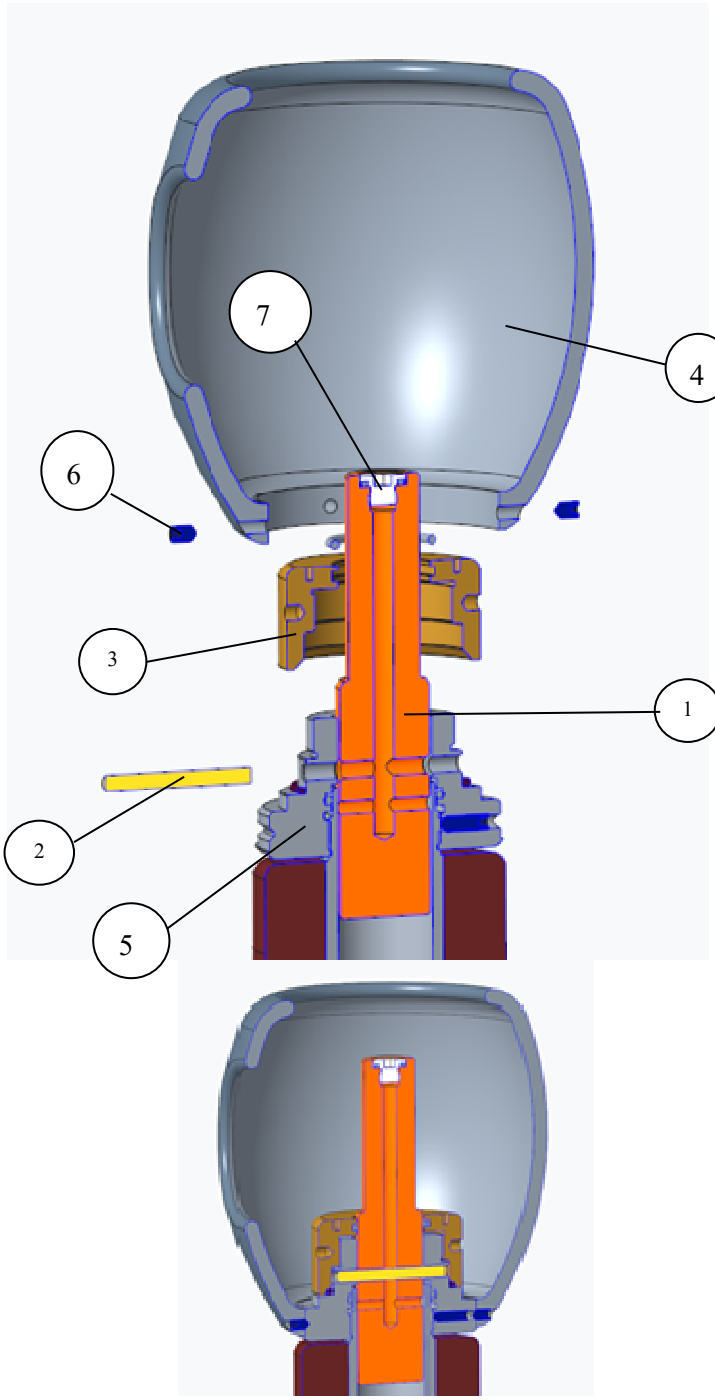


◇

Bushings which cannot be lifted out by hand due to weight reason must be lifted out by using the crane. Fixation must be applied always at flange side (centre of gravity). If the lower part is extended so that the centre of gravity is moving in axial direction the horizontal position can be supported by one hand on the bottom side deflector.

4.9 Conductor, Top terminal, and Shield assembly

4.10 Assembly drawing of conductor, TOP Terminal & Top shield in case of bushings with draw-lead execution



Reference: 4.10 (Draw -Lead execution)

The stud (1) must be pulled through the central tube by using a rope and a M12 eyebolt. Thread at the top of the stud is available to apply the eyebolt. (avoid damaging the thread)

Note: make sure that you not damage the silver plating of the stud.

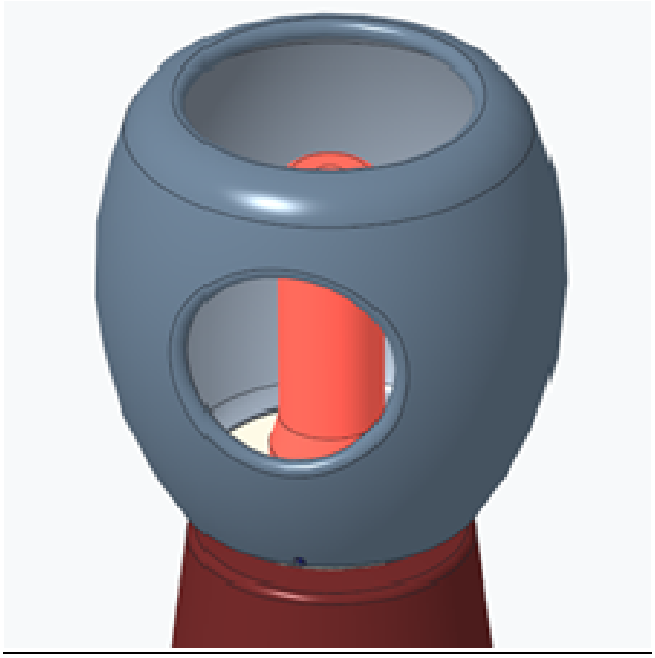
The stud will be fixed with the pin (2) and finally locked with the ring nut (3). The ring nut must be closed hand tight.

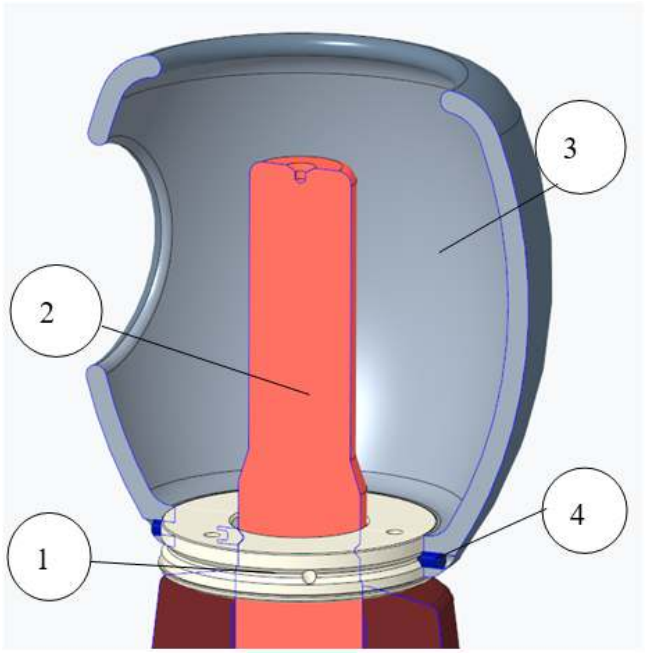
Place the Shield (4) on the adaptor disk (5) that is already fixed to the bushing central tube. Rotate the shield (4) until obtaining the right orientation of the orthogonal outlet and fix it with the four dowels (6).

Mount the de-aeration screw (7) and lock it with the foreseen tool & torque, max.45 Nm.

Note: Make sure that the de-aeration screw (7) with its gasket is always mounted and locked.

4.10a Assembly of Top shield in case of bushings with bottom connection execution



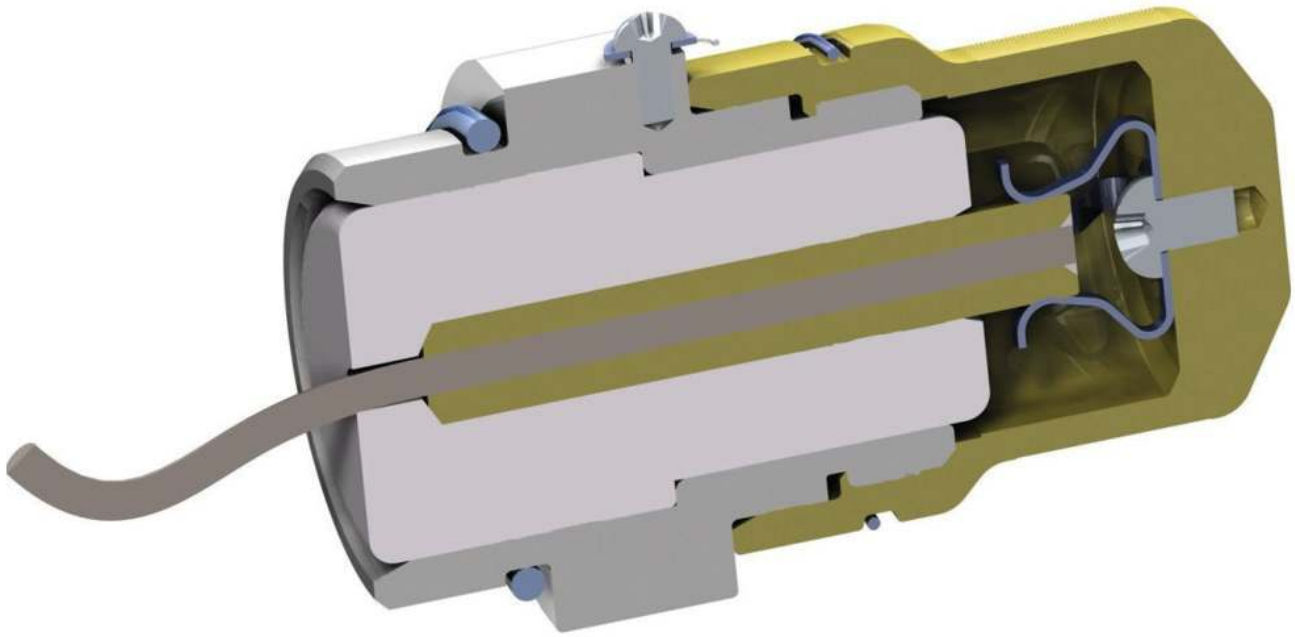


Reference: 4.10a (Bottom connection execution)

The threaded fixing ring (1) is already mounted and fixed into the stud (2) and the Shield (3) is already mounted on the fixing ring. The right orientation of the orthogonal outlet in the shield can be corrected by loosening the four dowels (4) and turning the shield in the right position.

4.11 Measuring Tap

Welded contact type



4.12 General Design

The test tap is an accessory for capacitance graded bushings which makes it possible to access a control layer insulated from the flange from the outside and thus to divide the total capacitance of the bushing into 2 sub-capacitances C_1 (high-voltage conductor - test layer) and C_2 (test layer - flange).

The test tap is designed in order that a connection between the test layer and the flange is automatically established by the grounding cap when the test tap is not in use. For normal operation of the bushing the test tap must always be closed with the supplied grounding cap for protection.

4.13 Purpose

The normal purpose of the test tap is to measure the capacitance C_1 and its loss factor tan δ.
The most common test circuit for this purpose is shown in the enclosed drawing.
The test tap can also be used to carry out a permanent voltage measurement or partial discharge monitoring. The maximum permissible permanent voltage between the test layer and the flange is 1.5 kV. Depending on the rated voltage and the capacitance of the bushing the test tap can be loaded with 5 to 10 kV. An impedance must always be connected in parallel to C_2 to limit the voltage to ≤ 1.5 kV. This impedance is mostly a capacitance C_z that must have a minimum value:

$$U = \frac{U_N / \sqrt{3}}{a^2 + b^2} \cdot \sqrt{a^2 + b^2} \leq 1{,}5kV$$

The values of C_1 and C_2 can be taken from the test report for the particular bushing.
To get a specified voltage U, it is necessary to use a capacitance C_z:

$$C_z = C_1 \cdot \left(\frac{U_N}{\sqrt{3} \cdot U} - 1 \right) - C_2 \geq C_{z\min}$$

To take reactive power from the test tap an ohmic resistor must be put in parallel to C_2. The possible power P that can be taken from the test tap is:

$$P = \frac{\left(U_N / \sqrt{3}\right)^2}{R_z} \cdot \frac{1}{a^2 + b^2} \quad \text{with} \quad a = 1 + \frac{C_2}{C_1} \quad b = \frac{1}{\omega C_1 \cdot R_z}$$

However it is a requirement that U remains ≤ 1,5 kV. This can be checked with:

$$U = \frac{U_N / \sqrt{3}}{a^2 + b^2} \cdot \sqrt{a^2 + b^2} \leq 1{,}5kV$$

CAUTION
Without additional external impedance, the voltage resulting by C_1 and C_2 is always higher than 1.5 kV at the test tap. With live bushings either the test tap must be connected conductively with the flange, or the divider voltage produced must be limited to 1.5 kV by adding impedance. **Otherwise the bushing will be damaged and could explode!**

The obtainable measurement accuracy depends on the changes of C_1 and C_2 as a function of the temperature of the bushing. It can be calculated within < 5%.

4.14 Connection

4.14.1 Capacitance- and power factor measurements

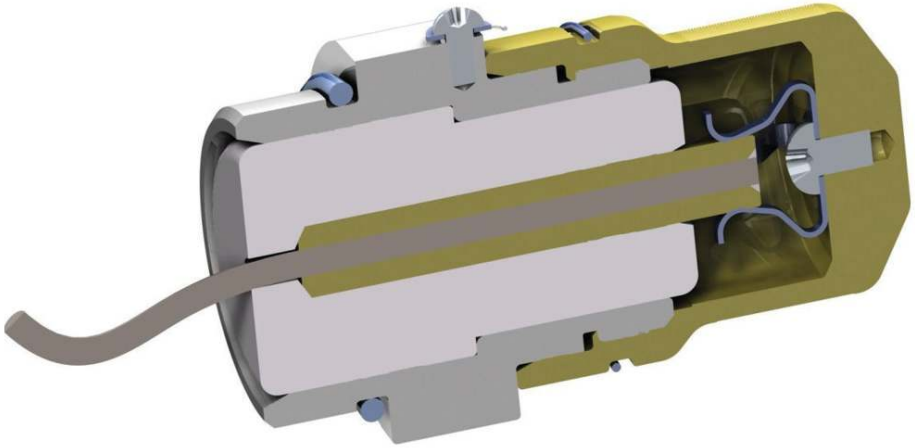
After applying a plug coupler, the connection to a measuring bridge can be performed with a wire with standard plugs.

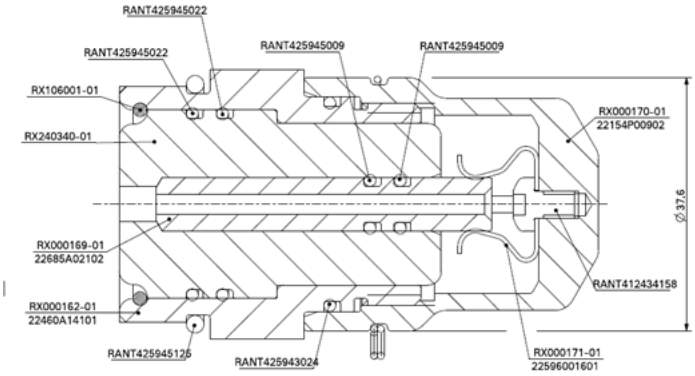
4.14.2 Insulation tests

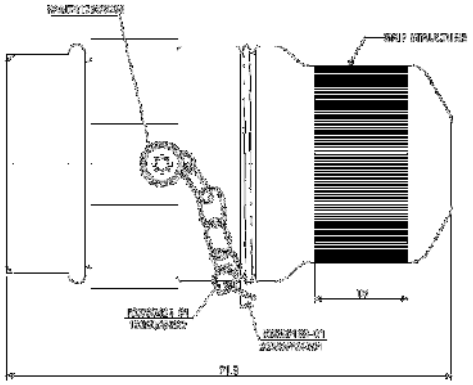
The insulation strength of the test tap of each bushing is checked with 3 kV for 1 min. by the routine test of the bushing acc. to IEC 60137.

4.15 Drawing of measuring tap

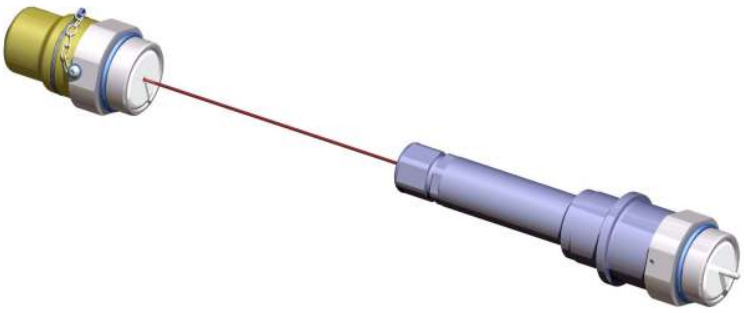
Welded contact type

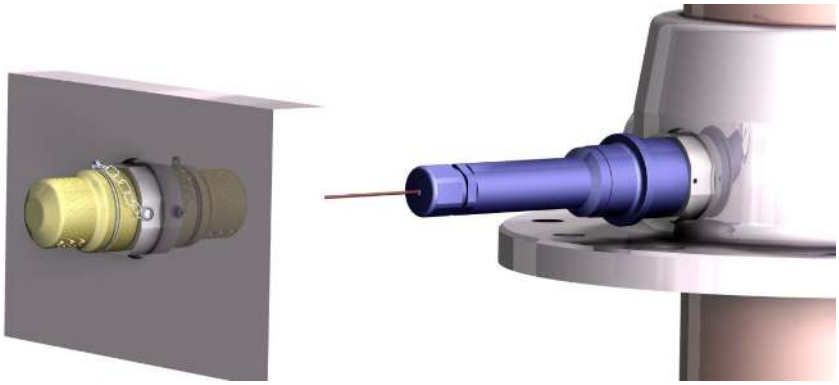






4.16 Remote Measuring tap





Reference: RX001433-01

Power Factor Extension

The Test tap could be led out as insulated flexible wire and is equipped with a traction relief in the flange. If the bushing is dispatched this flexible wire is screwed to the flange with a cable lug which is grounded.

Note:

the cable is led outside of the transformer and fixed on a standard Test Tap.

Note:

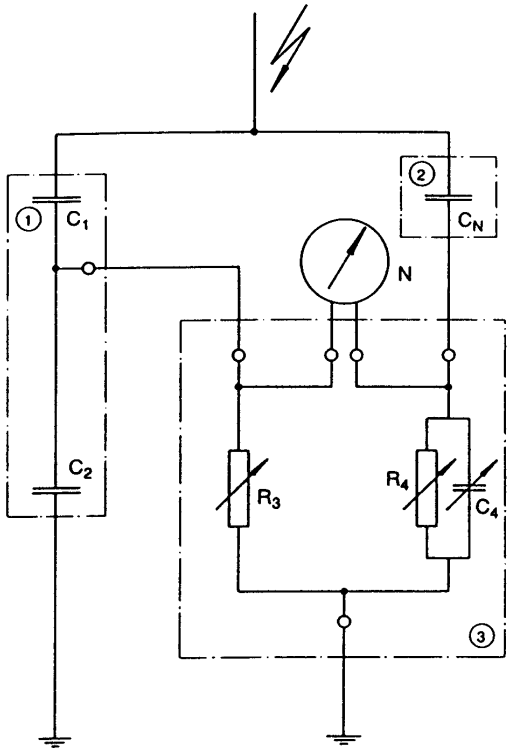
this device is an accessory and not part of the standard delivery

CAUTION
The brass Cap must be closed after measurements. Otherwise the bushing will be damaged and could explode!

4.17 Assembling_Instruction_remote_PF_RX001433-01

Please refer to the relevant specific document.

4.18 Measuring circuit



① Bushing

C1: Capacity high voltage lead– test tap

C2: Capacity test tap- flange

② Standard capacitor CN

③ Schering bridge

R3, R4, C4 } Bridge components

N: Null indicator