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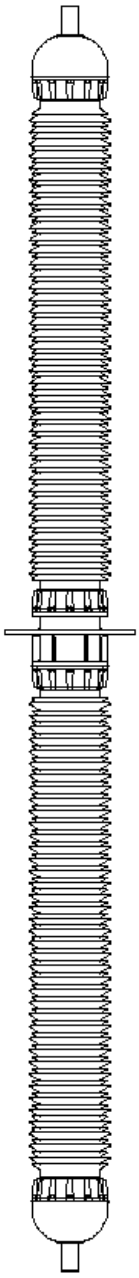
THROUGH WALL BUSHINGS SERIES PWO

VOLTAGE FROM 362 kV TO 420 kV



INSTRUCTION FOR STORAGE, TRANSPORTATION, INSTALLATION AND MANITENANCE

INDEX

Rev. D	August 2019
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1 DESCRIPTION

1.1 GENERAL

These instructions are applicable to the oil paper condenser type bushings of the series:

"PWO" for rated voltage 420 kV

according to IEC 60137, "Insulated bushings for alternating voltages above 1000 V" and give all general information to be followed from the receipt of bushings until their installation on the wall. Additional information is given regarding their service and maintenance.

Design, components and manufacturing technology guarantee an average lifetime longer than 30 years, in normal operation conditions.

The designation of the bushing is the following:

PWO 420. 1425. 2500

P	Condenser bushings ("P" from Italian word "Passante")
W	Through wall type ("W" from English word "Wall")
O	Oil paper insulation (OIP)
420	Rated voltage (in kV)
1425	BIL class -Basic Insulation Level (in kV).
2500	Rated current (in A)

1.2 SAFETY

This manual must be available to the personnel responsible of the installation, operation and maintenance of the bushings.
The installation, operation and maintenance of the bushings, present conditions of no safety and it is necessary to follow carefully specific procedures and instructions. No compliance with these procedures and instructions can involve very severe and dangerous conditions for the personnel and the property.

1.3 TECHNICAL CHARACTERISTIC

These bushings are capacitance graded type with oil impregnated paper insulation, designed to transfer the electrical current through walls or frame works when both sides are exposed to water or to industrial pollution.
They can be mounted in every position, depending of the shed orientation.

1.3.1 INTERNAL INSULATION

The main electrical insulation is given by a condenser body, made of a continuous sheet of pure Kraft paper, wound around a tube.
Heated cylinders and infrared rays dry the paper during winding, to reduce the water content in the paper to 1% maximum.
During the winding a sequence of aluminium foils, cylindrical shape and coaxial disposition, is inserted between the layers of paper. These foils grade the best possible distribution of the radial and longitudinal electrical gradient between the conductor and the fixing flange, which is grounded.
The winding is made by computer-controlled machines, with simultaneous machining to the final shape.
After the winding the bushing is assembled and placed into an oven at 105 °C, treated under vacuum (each bushing individually), kept at $4 \cdot 10^{-2}$ mm Hg for some days and impregnated with oil (having max. humidity content of 3 ppm) and suitably degassed.

The impregnation is made under pressure in order to obtain the best impregnation and to test the perfect tightness.
All this process is automatic, and computer controlled.

1.4 EXTERNAL INSULATION

Both air side envelopes are made of porcelain, brown colour (grey porcelain colour or resin fibre-glass envelope upon request) creepage distance for very high-polluted atmosphere (VHP): >31 mm/kV.
The shed configuration is alternated type (small-large sheds). This is the most effective solution as proved by salt tests and the profile of sheds complies with the recommendations of IEC 60815.
Both porcelains are 3 pieces made, epoxy resin glued, without gaskets in between.

In case of special longer creepage distance or in case of service at altitude higher than 1000 m more pieces can be glued together in order to comply with the requirement.

The under flange grounded part of the bushing is foreseen for standard wall thickness (300 mm).
Other thicknesses are available upon request, useful also for CT accommodation.

1.5 METAL PARTS

All metal components are made of aluminium alloy.

The flange is equipped with the following accessories:

- Two eyebolts (M30) for handling;
- Power factor tap (tested at 2 kV for 60 s), for the measurement of the dielectric characteristics;
- Grounding holes (M12);
- One valve connected to the oil compensation system (see par. 1.3.4).

1.6 OIL COMPENSATION SYSTEM

The bushing is provided with an oil compensation system (for oil volume variations with temperature) composed by a cylindrical oil reservoir and a connecting flexible pipe. The oil reservoir has an oil level indicator, prismatic glass type, laterally positioned.

The upper part of the reservoir is filled with nitrogen.

The oil reservoir is fixed to the bushing flange through a metallic structure. It can be dismounted and fixed to the wall: the fixing dimensions must be in accordance to the drawing shown in fig. 1.

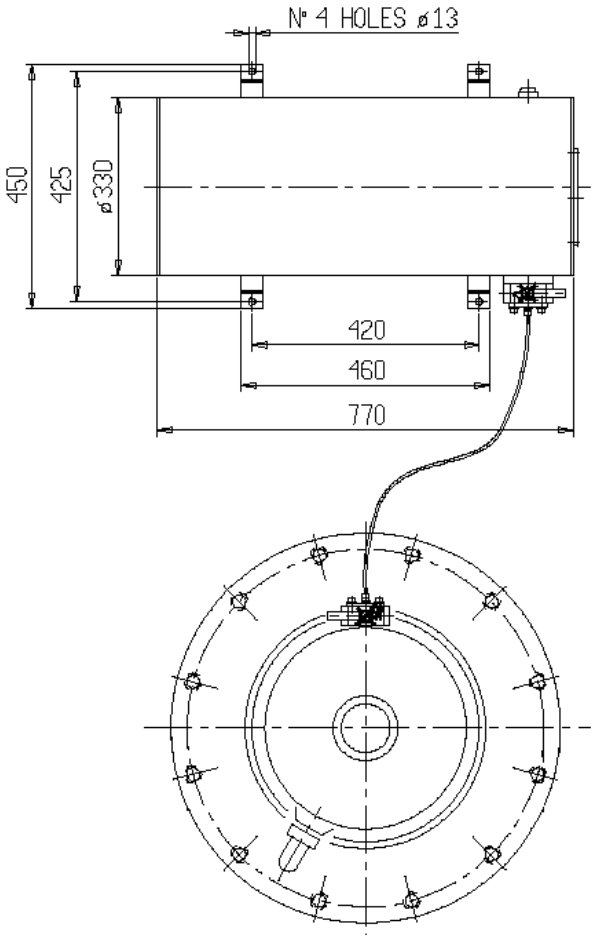


Fig. 1

1.6.1 GASKETS

Made of Fluorocarbon elastomer, O-ring type, they are compatible with impregnating oil of bushing. Flat gaskets are fitted concentrically to O-rings, to prevent the metal parts from a direct contact with the porcelain envelope.
For special requirements regarding low ambient temperatures (up to -55°C) special O-rings are foreseen, made of nitrile mixtures.

WARNING

The bushing is fully filled with oil and is provided with an external oil reservoir for the compensation of the volume variations due to the temperature changes during the operation. This oil reservoir has to be always connected to the bushing, with the valves placed at both sides of the connecting tube opened.

1.6.2 ASSEMBLING

Mechanical coupling among all the components is obtained by compression springs placed at the heads of the bushing.
Cemented porcelains are foreseen for heavy cantilever requirements and for 245 kV bushings.
The cemented used is a monocalcic aluminized type, quick curing. All the cement surfaces in contact with the external ambient are protected by means of a silicone sealing.

1.6.3 TYPE OF DIELECTRIC

The impregnation is made with a top quality inhibited super grade mineral oil, fully complying to Standards IEC 60296 and ASTM D3487, with the following outstanding characteristics:

- High dielectric strength (>70 kV/2,5mm);
- Very good low temperature properties (pour point typically <-60°C);
- Low viscosity even at the lowest temperatures;
- Very good oxidation stability;
- Extremely good heat transfer.

1.6.4 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 plate (fig. 2) is made of aluminium and is fixed on the flange by nails.

On the main plate there are the following information:
1 - Serial number
2 - Month and year of production
3 - Type of bushing
4 – Standard reference
5 - Rated frequency
6 - Max. system voltage
7 - Insulating voltages
8 - Rated current
9 - Measured main capacitance
10 - Measured capacitance of test tap
11 - Measured dissipation factor
12 - Max. mounting angle
13 - Weight

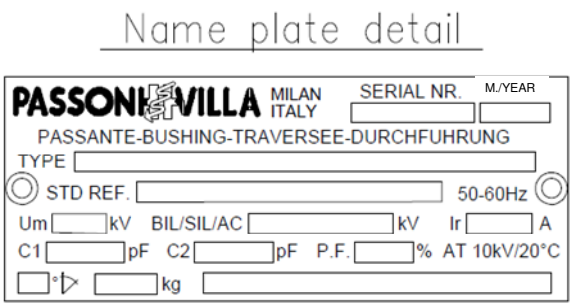


Fig. 2

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

1.7 MOUNTING INSTRUCTIONS

1.7.1 PACKING

These through wall bushings are shipped in sturdy wooden cases in horizontal position, one-piece type.

1.8 ACCEPTANCE

Upon receipt of the goods the Customer should operate as follows:

- Check the external surfaces of the packing cases:
  - No sign of damage shall be found;
  - The shock-watch indicator, placed in the external part of each packing case (fig. 3), must be white.

Fig. 3

If the shock-watch indicator is red (activated) don't refuse shipment, make a notation on delivery receipt and inspect for damage as follow:

- Open the packing case by removing its cover;
- Make sure that the anchoring elements are in order and securely fixed;
- Make sure that there are no leaks from the bushings, especially in the joints between porcelain and metal parts and that there are no breaks or broken parts. Please consider that each bushing has been tested with the tail immersed in oil, therefore some oil traces can be found.

In case any damage is found, leave the bushing in original packaging and request an immediate inspection from carrier within 15 days of delivery. Moreover, give the forwarding agent a written claim and notify the manufacturer with the details of the packing list, including the number of the case and the serial number of the bushing, to the following address:

GRID SOLUTIONS SpA - Unit RPV
Via Mario Villa, 210
20099- Sesto San Giovanni (ITALY)
PHONE: +39-02-24105001

1.9 STORAGE

Although there are no preclusions for the bushings remaining in the open air, it is better to store them in a closed room and in their original packing.
The temperature range acceptable for the storage is from -25 to +50 °C.
For special requirements regarding low ambient temperatures (see par. 2.6), where special o-rings are foreseen, the bushings can be stored at temperature up to – 55°C.
When the bushing is taken out from the storage is necessary to make a visual check to be sure about the good conditions of any part.

1.10 LIFTING AND TRANSPORTATION

Bushing type «PWO» is sturdy, nevertheless, in order to avoid dangerous movements, it is better to follow the suggested options.

1.10.1 Packed bushing

The case containing the bushings can be lifted with a tackle by applying the ropes on the points and with the inclination as indicated in fig.4 and reported directly on the case.

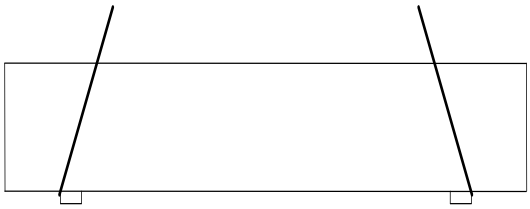


Fig. 4

1.10.2 Unpacked bushing

To take the bushing out of the case, operate as indicated in fig.5.

The best way to transport the unpacked bushing is to keep it in horizontal position; this can be done by means of a main lifting rope with closed hooks applied to the two casted or screwed M30 eyebolts that are placed on the flange, plus control ropes, fastened between the second and the third (from the heads) sheds of the porcelain, to maintain it horizontally (see fig. 5). Pay attention to oil reservoir: the rope has not to touch it during handling.

CAUTION

This is a delicate operation. Before to start the handling, be sure that the ropes are well fixed. Make all these operations only by expert people.

1.11 INSTALLATION

1.11.1 Bushing installation

To mount the through-wall bushings apply the ropes as indicated in the following fig. 6.
Try to find the rope length which permits a better positioning.
Close to the head it is necessary to apply a rope having two extremities which, taken down in horizontal position, allow to guide the bushing on the right and on the left (see fig. 6). After having lifted the piece and before beginning the installation operation, it is better to cover with wooden battens or sturdy cardboard the porcelain destined to the mounting hole. This in order to protect the sheds and to make quicker and easier the operation. When the bushing is correctly positioned, fix the flange at the wall (see fig. 7).

CAUTION

During this operation it is suggested to leave the oil reservoir connected to the bushing, in order to avoid dangerous bushing overpressures caused by little temperature variations that can happen if the bushing is not volume compensated. The oil reservoir is in fact positioned in such a position that it not interferes with lifting ropes.

1.11.2 Oil reservoir installation

The oil reservoir can be left in its original position, over the bushing flange, during service. Nevertheless, it can be mounted on the wall, in both sides of it (see fig. 7).
If it has to be mounted in the wall's same side of its original position, it can be moved from its fixing structure and fixed to the wall horizontally, without disconnect the tube (which is 1,5-2.0 m long and flexible, see fig. 8).
Note that the oil reservoir weights about 50 Kg.
If there is the requirement to mount it in the opposite wall side, the reservoir shall be disconnected from the tube, fixed to the wall, then reconnected to it.

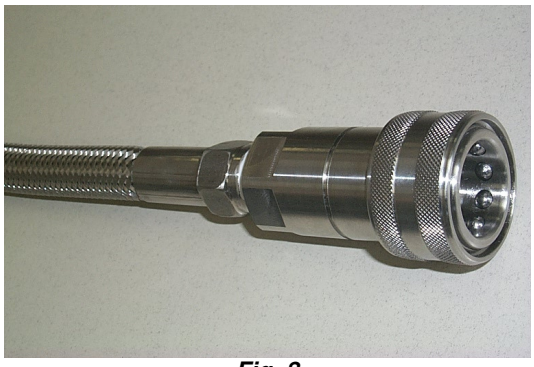


Fig. 8

CAUTION

This operation must be made as fast as possible (few minutes), in order to avoid dangerous bushing overpressures caused by temperature variations.

Both connections of the tube (fig. 8) with bushing flange and with oil reservoir are realized with special self closing valves, that automatically close the oil passage in both sides of the valve (see fig. 9).

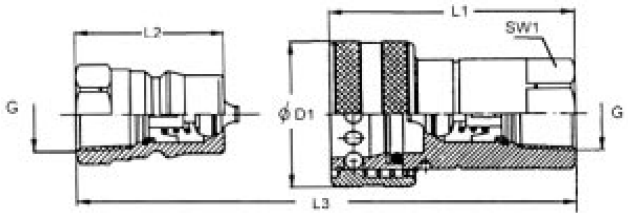


Fig. 9

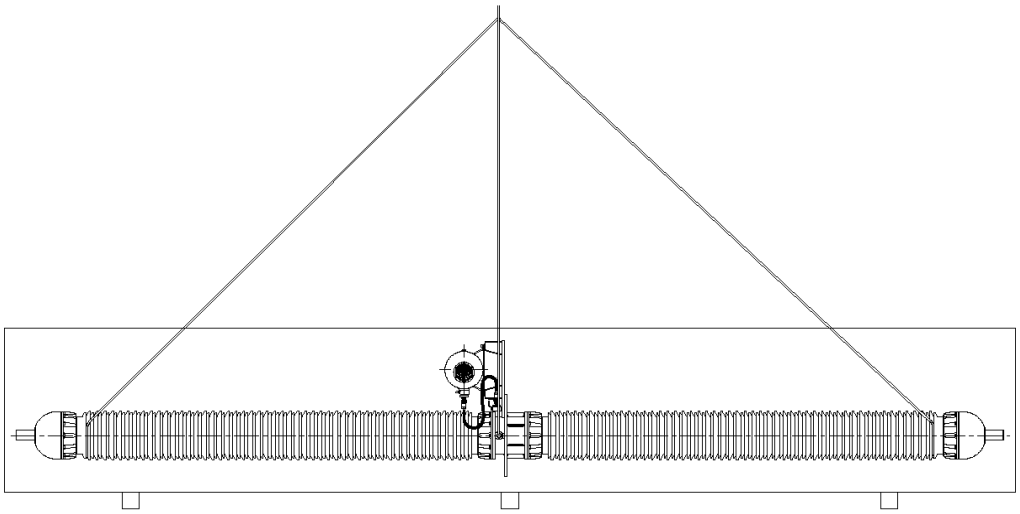


Fig. 5

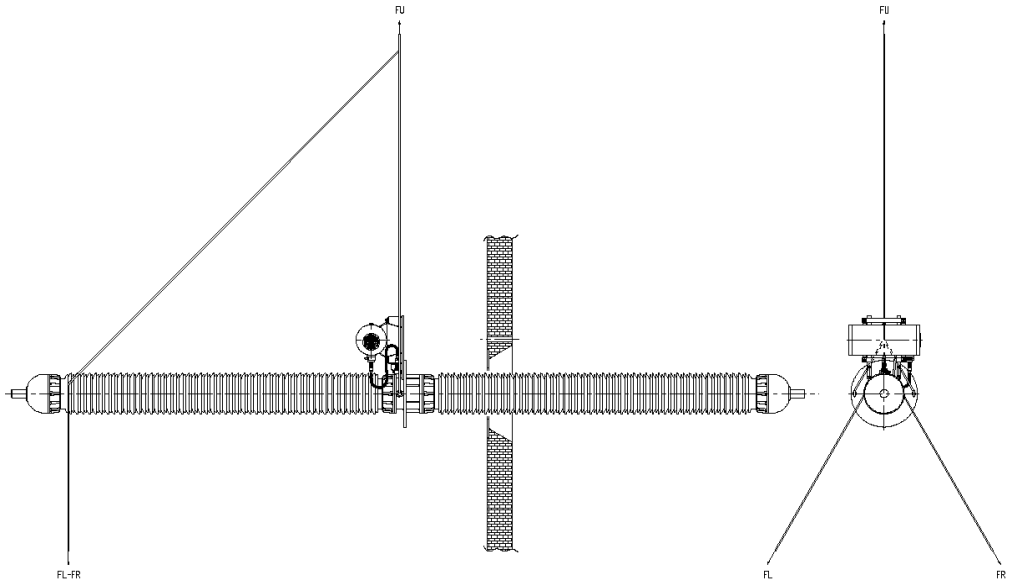


Fig. 6

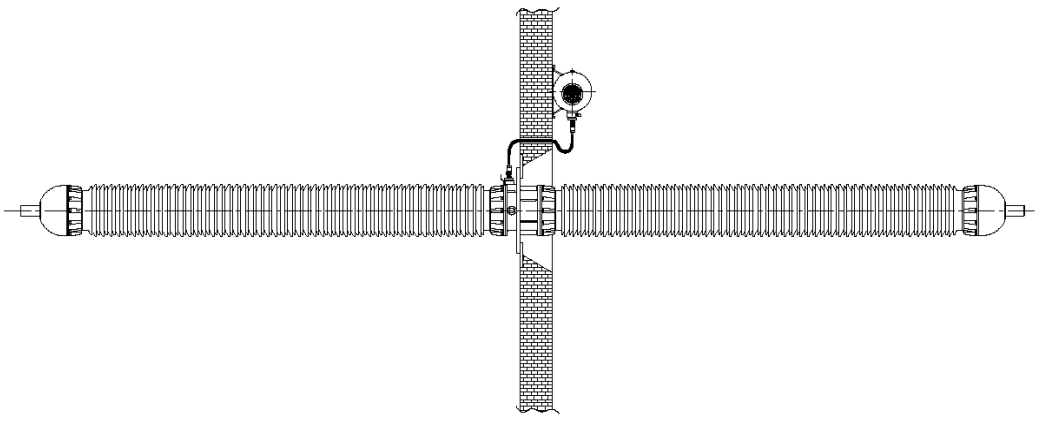


Fig. 7

The disconnection suggested is on reservoir side, in order to let the little bubble air (that could remain in the valve zone after reconnection) goes in the oil reservoir and not in the bushing.

Operate following below instructions:

- Close the oil reservoir cock, rotating its lever (head sealed for safety reasons);
- Disconnect the tube, pulling at first the external knurled valve ring (fig. 8) and then the complete valve;
- Protect the valve with a plastic bag;
- Insert the tube in the wall: the hole in the wall must have a diameter greater than 42 mm, that is the valve external diameter;
- Move the oil reservoir, maintaining it horizontally, from the bushing and fix it to the wall;
- Remove the protecting plastic bag from the valve;
- Reconnect the tube to the reservoir, pulling at first the external knurled valve ring, then pushing the removable valve (female) into the fixed part (male) up to the click, leaving the knurled ring;
- Clean the surfaces from the oil;
- Open the reservoir cock, rotating its lever.

If the oil reservoir is removed from the bushing, remember to remove also its fixing structure from the bushing, unscrewing the four M12 holes screwed on the flange.

1.12 TEMPERATURE LIMITS

Bushings of the series PWO are designed for operation at temperatures according to IEC 60137.

Ambient temperature:	Maximum:	+ 40°C
	Max. daily mean:	+ 30°C
	Minimum:	- 25°C

The over-temperatures allowed are in accordance to IEC 60137.

For special requirements regarding low ambient temperatures (up to –55°C) special o-rings are foreseen, made of nitrile mixtures for low temperatures. The spring closing system is calibrated in order to maintain the bushing hermeticity at these extreme conditions and the oil maintains its proprieties. For any other special or different condition please inform the manufacturer and ask the permission to put in service the bushings.

1.13 OIL LEVEL

The reservoir is provided laterally with an oil level, prismatic glass type.
In the factory, the oil reservoir is filled in order to the oil level reaches about the half of the prismatic indicator (or magnetic one) at 20°C.

The oil level is visible in the whole range of operating temperatures and the level changes of about 1 mm for every Celsius degree.
In case of magnetic indicator, a rotating white/red dial helps the reading.

2 SERVICE AND MAINTENANCE

2.1 METAL PARTS

The flange, the heads of the bushing and the oil reservoir are made of aluminium alloy and do not require any special surface treatment / maintenance.
Only in case of installation in aggressive environment (i.e.: coastal, high pollution, high salinity), it's recommended to protect said metal parts with a layer of antirust coating.

2.2 CHECKS AFTER INSTALLATION

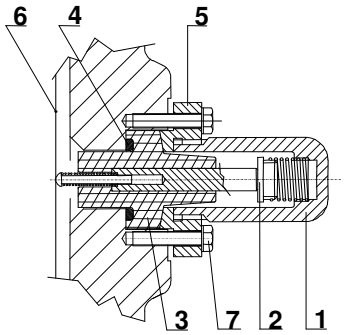
After the installation of the bushing it is advisable to make a check of the bushing capacitance and tgδ.

The measurement (C1) must be carried out between the HV terminal and the Power Factor tap.

The capacitance values measured in manufacturer's HV laboratory are shown in the test report of the bushings.

During the operation, the connection tap must be grounded or directly by screwing the tap cap or through the measuring instrument connected to the power factor tap.

The PF tap is schematised in fig. 10.



1 - Closing and grounding cap (removable)
2 - Measurement electrode
3 - Insulating bushing
4 – Gaskets
5 - Mounting flange
6 - Last layer
7 – Fixing screw (irremovable)

Fig. 10
Power factor tap (standard)

WARNING

The PF tap has to be grounded during the normal operation of the bushing.
Do not apply voltage to the bushing if the PF cap is removed. The cap grounds the tap connection.

It is advisable to check that the cap of the PF tap (see fig. 10) is well screwed. A forgetfulness of this generates during service a voltage on the tap that exceeds the insulation dielectric strength: this may lead to a catastrophic failure.

Upon request on the bushing's flange it can be mounted another type of PF tap (fig. 11), according to the French Standard NFC 52062.

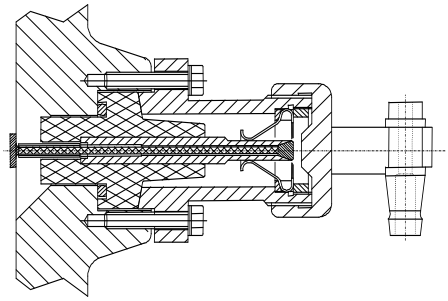


Fig. 11
Power factor tap (on request)

WARNING

Don't unscrew the screws item 7 of fig. 10, that fix the PF flange to the bushing.

If accidentally this operation happens some oil goes out from the bushing and the electrical contact between the internal condenser body and the flange can be damaged.

2.3 DISASSEMBLY OF THE BUSHING

To disassembly the bushing, operate according to the par. 2.5, following inversely the operation here described.

- Protect the porcelain destined to the wall mounting hole;
- Mount the metallic structure for the oil reservoir on the bushing flange;
- Disconnect the tube from the oil reservoir side (see par. 2.5.2), only if the reservoir is placed on the opposite side of the wall;
- Fix the oil reservoir to its structure on the flange;
- Reconnect the tube to the oil reservoir;
- Apply the ropes to the bushing (see fig.6);
- Remove the bolts that fix the flange;
- Move the bushing.

2.4 MAINTENANCE

The bushings PWO are hermetically sealed and therefore an excellent preservation in time of the dielectric properties of the oil paper is ensured.
As for the preservation of the active part, these bushings require no maintenance.
It is recommended to perform every 5 years the measurement of the dielectric losses (tanδ).
As for the preservation of the external surfaces, the manufacturer suggests performing the following inspections.

Porcelain

Check for chips, cracks and contamination. Minor chips maybe painted with an insulating varnish to obtain a glossy finish which will prevent dirt and moisture attack. Bushings with major chips or cracks which appreciably decrease the creepage distance should be removed from service and replaced.
Wash periodically the porcelain surfaces, on which dust, saline compounds, combustion resituates, dirt, oil and other deposits may easily collect and reduce consequently the flashover value.
If the bushing has to be put in service during winter, it is recommendable before to clean the porcelains from ice or snow that can reduce the dielectric withstand capability.

HV terminals

Check the connections in order to avoid poor contacts and consequent overheating.
In case of connections surfaces very oxidised, pass them slightly a fine sandpaper and clean well them with a light solvent (for example alcohol).

Power factor tap

Check the proper location of the tap cap and its suitable complete screwing in order to prevent entrance of moisture (fig. 10).

Oil level

Check the oil level of the bushing's oil reservoir and add oil if necessary. The refilling can be done throughout the tap (M16) positioned in the upper part of the reservoir, by using normal mineral oil, accurately treated and degassed.
The refilling of the gas cushion on the top of the reservoir with nitrogen or dry air is not strictly necessary.

In case the oil level would go down, check carefully if any external leakage is present. If nothing will be detected, then refill the reservoir. If the oil level still

goes down, it is necessary to remove the bushing from the service and to repair it.

CAUTION

To prevent oxidation of the bushing oil and humidity entering, the filling plug placed on the upper part of the oil reservoir must be closed just after the conclusion of the refilling operation.

2.5 MEASUREMENT OF DIELECTRIC LOSSES

The Standard - IEC Publication 60137 - states that the oil-paper bushings must have a tanδ less than $7x10^{-3}$.
The measurement is performed in manufacturer's Test Laboratory by means of a Schering bridge (Tettex type) at the voltages requested by the Standards.
All values are shown in the Test Report.
Measurement at the voltage of 10 kV is carried out in order to have a reference value for comparison with measurements made at site during the service of the bushing.
The measurement can be performed by means of a bridge, by applying a voltage of 10 kV between the HV terminal and PF tap, maintaining grounded the flange (C1 measurement). The bushing is considered good if a tanδ less than the maximum one established by the Standards is measured.
If a tanδ higher than the above one is measured, please contact the manufacturer, who will decide if it is necessary to make other tests before removing the bushing from service or to ship it back, in order to make a complete check and eventually to carry out an oil treatment or eventually to replace the active part with another of new manufacture.
In order to measure the Co value (capacitance between the PF tap and flange) the flange shall be supplied with a voltage maximum of 2 kV and the PF tap has to be connected to the bridge.

A field measurement of tanδ and capacitance can differ from the measurements carried out in the factory due to the different conditions of test and relevant accuracy: for this reason, a light shifting (max 10% for tanδ) is acceptable. Furthermore, the installation conditions can affect the capacitance value.
For this it is advisable to measure capacitance and tanδ upon the installation and use these values as base for future comparison measurements.

2.6 CHECKS ON OLD BUSHINGS

Before remounting an old bushing, it is advisable to carry out a tightness test and an electrical check.

2.6.1 Tightness test

Maintaining the reservoir horizontally, be sure that the oil level is correct, then apply a nitrogen pressure through the oil filling plug placed in the top of the reservoir (M16 threaded hole) and regulate this pressure at 2 bar relatives for 24 hours.
Make a visual check in all parts of the bushing: no leakages have to be detected.
At the end let the nitrogen go out from the plug up to atmospheric pressure and close the tap.

2.6.2 Electrical checks

The old bushings are suitable for service if, as regards the values of reception test, there are no increase higher than (note: values only indicatives):

- 1% for the capacitance C1 (this assure that there isn't a perforation between two layers)
- 30% for tanδ of capacitance C1.
- 100% for tanδ of capacitance Co.

An increase of the last value means a derating of the dielectric characteristic of the external layers of the paper and/or of the oil in the interspace between the condenser body of the bushing and the external housing.

2.7 EXTRAORDINARY CHECKS

If the electric measurement detects a tgδ higher than the limits it is suggested to carry out an oil sampling (See par. 4) and to perform the following tests:

- Humidity content;
- Dielectric strength;
- Dielectric losses;
- Gas chromatography

- *Humidity content*
  Original value: ≤ 10 ppm
  During working:≤ 20 ppm
- *Dielectric strength*
  Original value: ≥ 62 kV/2,5 mm
  During working:≥ 45 kV/2,5 mm
- *Dielectric losses (tgδ):*
  Original value: ≤ $7*10^{-3}$
  During working:≤ $12*10^{-3}$
- *Gas chromatography (DGE):*
  Refer to relevant IEC Standards

If these checks give negative results, it is necessary to ship back the bushing to the manufacturer, who will perform a complete set of electrical tests and eventually will decide to make an oil treatment to the bushing or to replace the active part with another one of new construction.

3 OIL SAMPLING

The oil sampling can be done through the M16 tap located at the top of the oil reservoir.

CAUTION

The operation is to be obviously carried out when the line is off.

3.1 EQUIPMENT

To carry out oil sampling from the bushing, it is needed the following (see fig. 12):

- A 150 cm^3 oil syringe (item 3) (Lab. Type);
- A semi-rigid pipe (item 1);
- A two-way cock (item 2) with a suitable connection to the syringe;
- A syringe cap;
- Adhesive tape.

3.2 PREPARATION

Operate as it follows:

- Clean the plug zone accurately;
- Prepare all the syringe apparatus, with the cock (item 2) and the tube (item 1);
- Open the tap unscrewing it ;
- Insert the tube (item 1) in the oil reservoir, immersing the end of the tube in the oil;
- Wash the syringe with oil two times by repeating the following operations:
  - Open 2nd way of cock (item 2);
  - Fill in slowly the syringe with some oil (about 10-30 cm^3), in order to wash it and to let the exit of the air bubbles contained in the pipe (item 1);
  - Open 1st way of cock (item 2);
  - Empty the syringe;
  - Close 1st way of cock (item 2).

3.3 OIL SAMPLING

For sampling please follow these instructions:

- Close the 1st way of the cock (item 2) and open the 2nd way;
- Slowly fill the syringe with the oil up to the appropriate volume (approx. 60-100 cm^3);
- Shut off 2nd way of the cock (item 2);

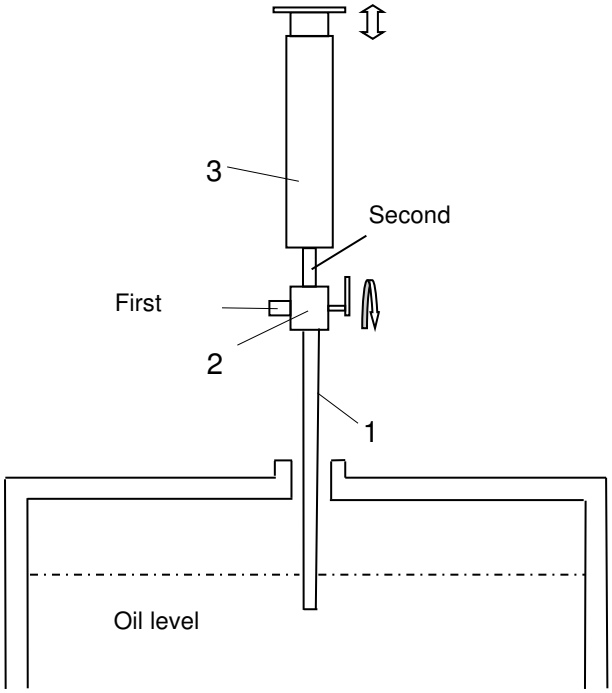


Fig. 12

- Extract the syringe (item 3) and the tube (item 1);
- Set the syringe with the cock (item 2) being up;
- Unplug the cock (item 2) and place a closing cap on the syringe;
- Clean the syringe and block it with adhesive tape on which you will write down the bushing part number;
- Overturn the syringe and keep it with its cap down;
- Screw the filling tap on the reservoir;
- Clean the surfaces.

The abovementioned operations involve, on the whole, a sampling of about 0.2-0.3 litres of bushing oil and lower the oil level of about 2 mm. In this case it is not necessary to restore the oil taken out. If the oil level is therefore lowered more than 2 mm, the oil shall be restored by adding the same quantity of mineral oil, accurately treated and degassed, which is perfectly miscible with the synthetic bushing oil. The refilling must be done through the same hole used for the oil sampling, which must be closed immediately after the end of the operations.

CAUTION

The oil sampling operation has to be carried out as quickly as possible and in a period with a low humidity level, in order to not pollute the oil inside the bushing.

4 DISPOSAL AT THE END OF LIFETIME

Component	**Material**
Winding conductor	Copper or aluminium alloy
Terminals and bottom plates	Copper, aluminium alloy or brass; optional silver or tin coating
Insulating oil	Mineral oil acc. IEC60296
Winding	Cellulose paper and thin aluminium foils
Nuts, bolts, washers and springs	Stainless steel, carbon steel
Oil expansion bellows and covers	Teflon and aluminium alloy
Flange and extension	Aluminium alloy
PF tap and cover	Nickel or tin coated brass, tin coated copper
Insulators	Either porcelain acc. IEC60672 or composite insulator made of: • Glass fibre reinforced epoxy • Silicone
Insulator fittings	Aluminium alloy
Shields	Aluminium alloy covered with either epoxy paint or epoxy resin