GE VERNOVA
PASSONI & VILLA
EXPERTS IN HIGH VOLTAGE

Via Mario Villa, 210
20099 Sesto San Giovanni (MI), Italy
Tel. +39 02 24 10 50 01
www.ge.com

HIGH CURRENT BUSHINGS
SERIES PTFR

STORAGE, OPERATING
AND MAINTENANCE INSTRUCTIONS

INDEX

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1 DESCRIPTION

1.1 GENERAL

These instructions are applicable to the resin impregnated paper condenser type bushings of series

"PTFR" for rated voltages from 15 to 36 kV

and give all general information to be followed from the receipt of bushings until their installation on the transformer.

Other information are given regarding their service and maintenance.

They are manufactured and tested in compliance with Standards IEC 60137 “Insulated bushings for alternating voltages above 1000 V”.

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

The designation of the bushing is made as in the following example:

PTFR.36.170.7500

P	Condenser bushing (“P” from Italian word “Passante”)
T	Transformer application
F	High current (from Italian word “Forte corrente”)
R	Resin Impregnated Paper Technology
36	Rated voltage (in kV)
170	BIL – Basic Insulation Level (in kV)
7500	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.

Please follow carefully all the instructions of the manual and pay attention to the WARNING (severe hazard), and CAUTION (minor hazard) signs.

1.3 TECHNICAL CHARACTERISTICS

These bushings are capacitance-graded type, resin impregnated paper, provided for operation with the upper part in the open air (for highly polluted atmosphere and with the lower part immersed in the transformer oil (see fig. 1).
The body of the bushing is of epoxy resin impregnated paper, condenser execution to improve radial and longitudinal distribution of electric gradients.
Every bushing can be provided, on request, with an under-flange elongation – K – for CT accommodation in accordance with IEC Standard.

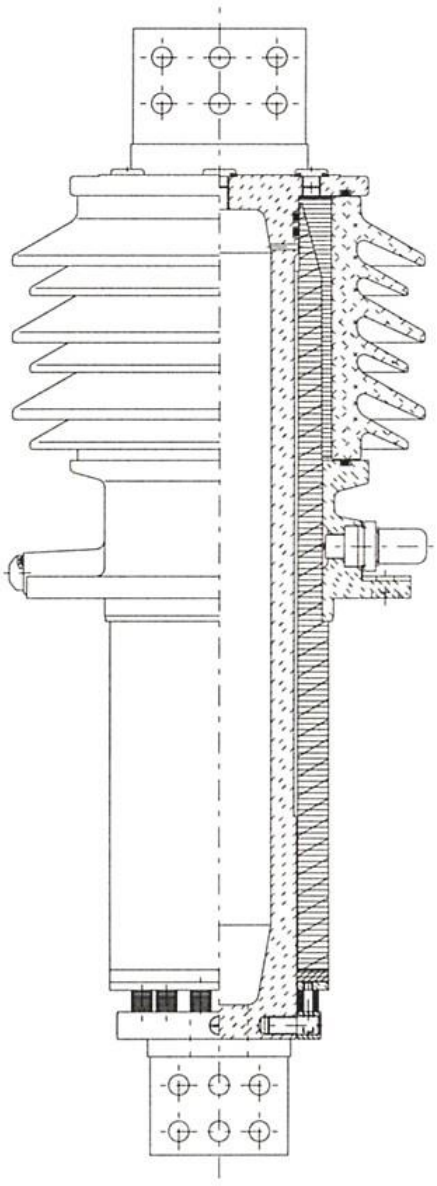


Fig. 1

Mechanical coupling among the components is obtained by springs placed at the lower extremity of the bushing.

All the gaskets are o-ring type, in fluorinate elastomer FPM (VITON®).
Flat gaskets are also provided in order to prevent the contact between porcelain and metal parts.
The inner conductor, complete with its oil side and air side terminal palms, is a single piece of aluminium alloy casting, with IACS conductivity 55%.

Normally the connection surfaces are not treated; upon request, they can be silver-plated.
The air extremity of the inner conductor of the bushing is provided by two or more palms for the connections of the bus bars, which are normally enclosed in a metal clad duct. In the oil side, the inner conductor is provided with one or more terminals for connection to the transformer winding.

1.4 RATED CURRENT

The acceptable operating currents versus temperatures of oil and bus-duct air compared to temperature of conductor can be calculated using the following formula:

$$I_{na} = I_n \cdot \alpha \cdot \beta$$

where

I_{na}	Continuous admissible current (A)
I_n	Nominal bushing's current (A)
α	Temperature coefficient (tables a1 and b1)
β	CT space coefficient (tables a2 and b2)
T_c	Admissible conductor temperature (120°C)
T_a	Ambient (bus duct) air (°C)
T_o	Transformer oil temperature (°C)
K	CT space (mm)

Note that with T_a values between 40°C and 80°C the coefficients α and β can be obtained through linear interpolation.

15 - 24 kV TYPE

$T_c - T_a$ (°C)	Coefficient α				
90	0.83	0.91	1.01	1.09	1.16
80	0.80	0.87	0.97	1.05	1.13
70	0.74	0.83	0.93	1.02	1.11
60	0.69	0.80	0.90	1.00	1.10
50	0.65	0.77	0.87	0.98	1.09
40	0.61	0.73	0.84	0.96	1.08
30	0.57	0.70	0.82	0.94	1.07
20	0.53	0.66	0.79	0.92	1.06
10	0.50	0.63	0.76	0.90	1.05
$T_c - T_o$ (°C)	10	20	30	40	50

Table a1

CT space K (mm)	*Coefficient β*	
	Ta=40°C	Ta=80°C
0	1.00	1.00
100	0.94	0.99
200	0.87	0.97
300	0.81	0.95
400	0.75	0.91
500	0.68	0.87
600	0.61	0.81
700	0.55	0.75

Table a2

36 kV TYPE

$T_c - T_a$ (°C)	Coefficient α				
90	0.76	0.83	0.92	0.99	1.06
80	0.72	0.79	0.88	0.96	1.03
70	0.67	0.76	0.85	0.93	1.01
60	0.63	0.73	0.82	0.91	1.00
50	0.59	0.70	0.79	0.89	0.99
40	0.55	0.66	0.76	0.86	0.96
30	0.50	0.63	0.73	0.84	0.95
20	0.46	0.59	0.70	0.81	0.93
10	0.43	0.56	0.67	0.79	0.91
$T_c - T_o$ (°C)	10	20	30	40	50

Table b1

CT space K (mm)	*Coefficient β*	
	Ta=40°C	Ta=80°C
0	1.00	1.00
100	0.97	0.99
200	0.90	0.95
300	0.84	0.91
400	0.79	0.87
500	0.75	0.83

Table b2

Example of formula's use:

Nominal voltage U_n:	24 kV
Nominal bushing current I_n:	12000 A
Bushing CT space K:	200
Air bus duct temperature T_a:	70°C
Oil transformer temperature T_o:	90°C

T_c-T_a=120-70=50°C
T_c-T_o=120-90=30°C
⇨ From the first table α=0.87

K=200
⇨ From second table and interpolation β=0.94

Continuous admissible current:

$$I_{na} = I_n \cdot \alpha \cdot \beta = 12000 \cdot 0.87 \cdot 0.94 = 9810 \text{ A}$$

1.5 TYPE OF DIELECTRIC

The PTFR bushings are made of epoxy resin impregnated paper.

This material has:

- High dielectric characteristics;
- Low dielectric losses also at high temperatures.

The interspace between the condenser core of resin paper and the porcelain envelope is filled with a dry mass (polyurethane); with this solution, there are not the problems due to the oil presence and, in particular, the bushing can be mounted in any position.
The bottom part of the bushing is very sensitive to humidity.

1.6 NAME PLATE

Each bushing is provided of 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 nameplate, the following information are indicated:

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 - Max. mounting angle

10 - Weight

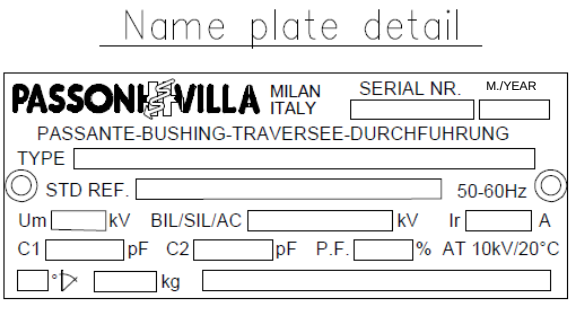


Fig. 2

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

2 MOUNTING INSTRUCTIONS

2.1 PACKING

PTFR bushings are normally shipped in horizontal position in wooden cases of 3 pieces, in order to reduce packing volumes. Every bushing is protected with a polyethylene bag hermetically sealed and containing a silicagel bag (fig.3); in such a way the bushing is protected in dry air against the humidity of the ambient.

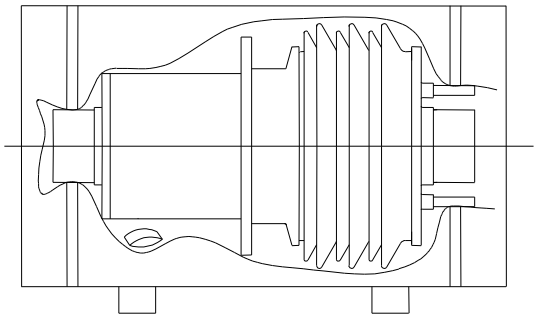


Fig. 3

If a long storage - above one year - is expected, we suggest installing the sealed protection supplied on request.

2.2 ACCEPTANCE

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

- Check the external surfaces of the packing cases:
  - No sign of damage must be found;
  - The shockwatch indicator, placed in the external part of each packing case (fig. 4), must be white.

Fig. 4

- If the shockwatch indicator is red don't refuse shipment, make a notation on delivery receipt and inspect for damage as follows:
  - 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 breaks or broken parts.

Please consider that each bushing has been tested with the tail immersed in oil and so some oil traces can be found. In any case no leakage is possible, because the bushings don't contain oil.
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.

2.3 STORAGE

During the storage period, before the installation of the bushing on the transformer, it is necessary to have the utmost care to avoid that the bottom part of the bushing remains a long time in humid air.
The humidity can be absorbed by the resin paper with deterioration of the dielectric characteristics (increase of dielectric losses and reduction of dielectric superficial strength).

CAUTION

Until the moment of installation on the transformer, the bushing must be considered as an equipment of indoor installation.

Concerning the storage of the bushing, the place (outdoors, rain protected or indoors) and the duration of storage (short term, medium term or long term) refer to table c. If necessary, a storage container can be ordered from the manufacturer.
The temperature range acceptable for the storage is from -25 to +50 °C.
For other temperature limits, please contact the manufacturer.
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. Bushings which have been stored in an oil filled storage container can be used even after long term storage without any further testing of the bushing.
For extended indoor storage and/or for outdoor one, the manufacturer can propose two alternatives: (according to table c)

- Metallic enclosure filled with oil to protect the underflange side;
- Plastic rigid enclosure with silicagel dryers to protect the underflange side.

2.4 LIFTING AND TRANSPORTATION

The bushings type PTFR are sturdy, nevertheless, to avoid dangerous movements, it is better to follow the suggested options.

Packed bushing
The case containing the bushings can be easily lifted with a tackle by applying the ropes on the points and with the inclination as indicated in fig. 5. Some indications appear also in the packing case.

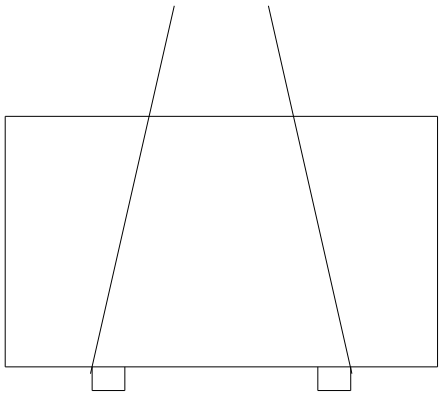


Fig. 5

Unpacked bushing
To take the bushing out of the case lift with 2 ropes (connected to two different cranes) - one on the top second small shed and one on second-last (see fig.6) and then with the same hemp ropes (or flat nylon ropes) do the rotation in vertical position out pack (see fig. 6.1). Using rope A for raise it in vertical position (see fig. 6.2).

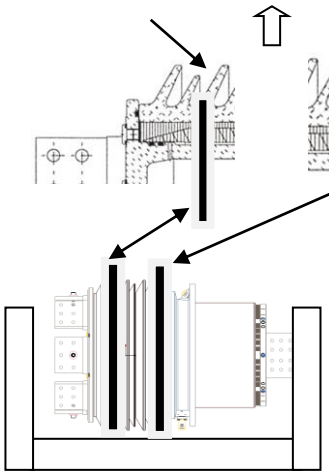


Fig.6

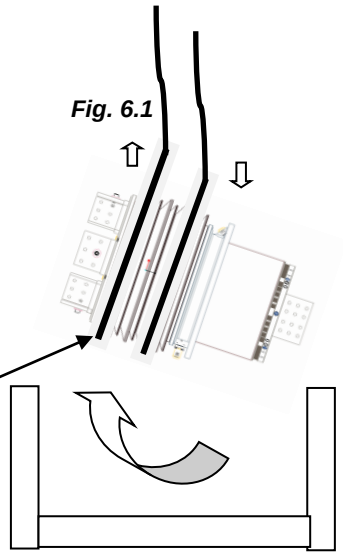


Fig. 6.1

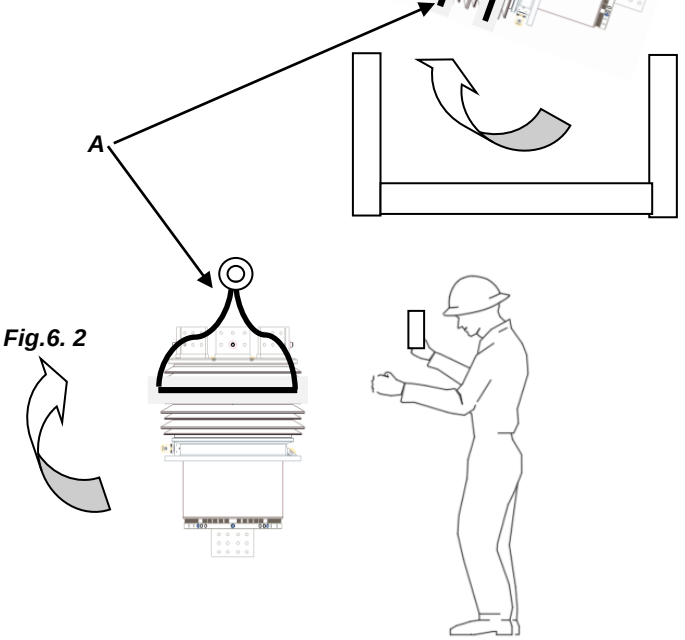


Fig.6. 2

	Short Term (Max. 1 year)	**Medium Term** (Max. 2 years)	**Long Term** (> 2 years)
Outdoors **(Rain protected)**	- In original transportation case covered with plastic. - Good condition of the moisture protection at the lower end. **Recommended:** - Additional protection with plastic cover and silica-gel.	Not Recommended.	Not Recommended.
Indoors	- In original transportation case or unpacked. - At low humidity also without protection.	- In original transportation case or unpacked, with protection in good condition.	- In original transportation case or unpacked with protection in a good condition in a dry room with constant temperature. - The indicator at the silica-gel bag must be controlled regularly. **Best solution:** - Lower part of the bushing in a storage container filled with oil or nitrogen.

Table c

CAUTION
In case of suspect that the storage conditions did not conform to the table above, it is possible that humidity penetrated into the insulation by a diffusion process. This can be verified by capacitance and power factor measurement at about 10 kV. If the deviation of the power factor is too wide, please contact the manufacturer for further information about the possible drying process to be applied for recovery.

2.5 SHIPMENT TO THE END USER

The shipment of the bushing made by the transformer manufacturer, after the transformer factory tests, must be made either with the original packing or with a new one, made with the same concepts.
Particularly the bottom part of the bushings must be enclosed by protection bags with silicagel.
Silicagel salts, used to protect the bushing from the humidity, must be checked: if they have absorbed humidity (i.e. if their colour is pink), they have to be dried in an oven (i.e. brought back to blue colour) before being reused.

2.6 INSTALLATION ON THE TRANSFORMER

This type of bushing can be installed in the transformer in any position: vertical or horizontal or any other.
Note that the accidental breaking of the porcelain envelope (due to mechanical external raisons), does not cause the leak of the transformer oil.
The connection to the plate connections must be made by bars placed on the two sides. The clamping must be made by nonmagnetic steel screws (fig. 7).

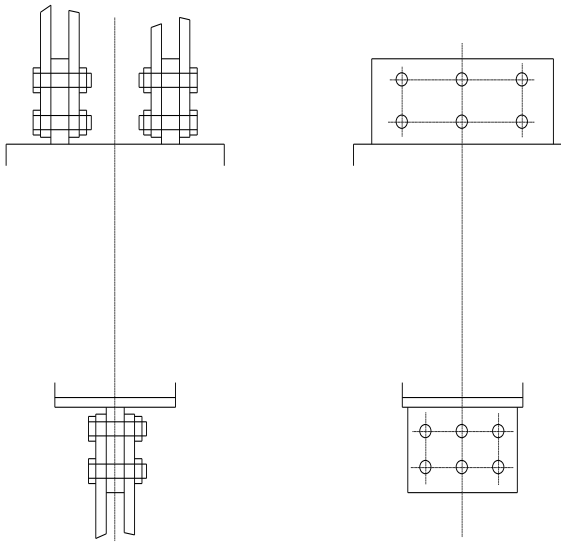


Fig. 7

The suggested clamping couples for inox steel screws (R = 65 daN/mm^2) are:

Screw M16 $\Rightarrow$ clamping couple of 10 daN m

With this clamping couple, the specific middle pressures on the contact surface between connector plate and bars (considered that each screw gives a charge of 3500 daN) are:

160-200 daN/cm^2

Specific current densities on the contact surfaces, referring to the highest currents, are:

- air side: 17,5 A/cm^2
- oil side: 32 ÷ 43 A/cm^2

2.7 OIL FILLING OF THE OF THE BUSHING'S CONDUCTOR

It is foreseen that the bushing operates with the conductor filled with the transformer's oil.

Normally the oil filling of the transformer is made under vacuum: the tightness system and the bushing gaskets allow to withstand this vacuum treatment.

If it is not possible to make the vacuum, the air pockets that may be formed under flange and the air in the internal bushing conductor must be eliminated operating in the following way:

- Remove the plug placed in the middle of the head of the bushing; to unscrew (and close) this plug, use a hexagonal wrench of 6 mm (fig. 8);

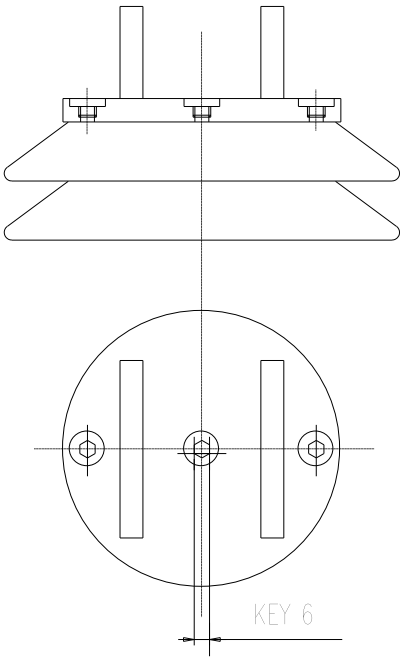


Fig. 8

- Open the ½" gas plug placed on the bushing flange (fig. 9). For this operation use a hexagonal wrench of 10 mm;
- Complete the transformer's filling to allow the air to go out;
- When the transformer oil starts to exit, close at first the flange plug (closing moment: 50 Nm), then the other one (closing moment: 100 Nm).

2.8 CONNECTION TO BUCHHOLZ RELAY

A 1/2" gas plug is placed on the bushing's flange (fig. 9) to:

- Connect the relay tube, if foreseen;
- Eliminate the air pocket which may be formed during some executions and by the filling of the upper part of transformer not under vacuum conditions (see par. 2.7).

In this case during oil filling, we suggest unscrewing the plug and leave that the air flows out. For this operation use a hexagonal wrench of 10 mm.
When the oil begins to come out, please close it (closing moment: 50 Nm).

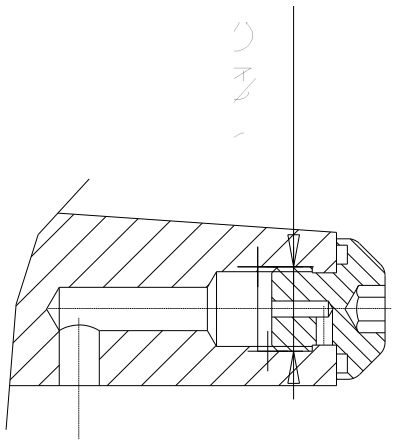


Fig. 9

3 SERVICE AND MAINTENANCE

3.1 METAL PARTS

The flange and the metallic components of the bushings are made of Aluminium alloy casting 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.

3.2 CHECKS AFTER INSTALLATION

After the installation on the transformer, it is advisable to make a check of the bushing capacitance and tanδ.

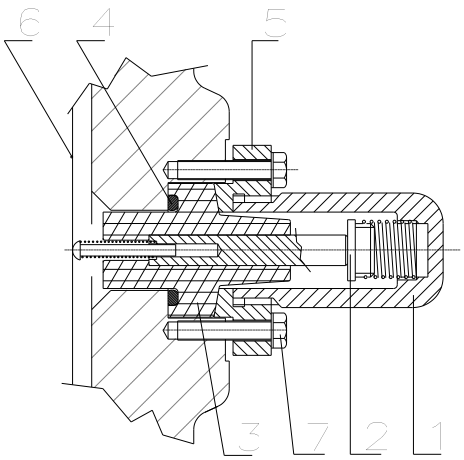
The measurement must be carried out between the HV terminal, and the Power Factor tap.

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

WARNING

The PF tap must 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.

The PF system 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

WARNING

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

If accidentally this operation happens the electrical contact between the internal condenser body and the flange can be damaged.

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.

3.2 MAINTENANCE

The bushings PTFR are hermetically sealed and therefore an excellent preservation in time of the dielectric properties of the resin paper is ensured.
As for the preservation of the active part, these bushings require no maintenance.
It is recommended to perform every 7 years the measurement of the dielectric losses (tanδ) following the instruction under par. 5.
As for the preservation of the external surfaces, the manufacturer suggests undergoing 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's residues, dirt, oil and other deposits may easily collect and reduce consequently the flashover value.

HV terminals

Check the connections to avoid poor contacts and consequent overheating.

Pay special attention to the air side connections, more subject to oxidation than the oil side ones.

In case of plate connections surfaces very oxidised, clean them slightly passing a fine sandpaper, paying attention to not damage the silvered thin layer, if present. After this operation, clean well the surfaces 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.

CAUTION
We recommend checking if the cap has been properly applied and screwed. Moisture entering can cause the corrosion of the tap connection contact. Bad contact is harmful for the good operation of the bushing.

4 DISASSEMBLY OF THE BUSHING

To disassembly the bushing operates according to the constructive solution adopted for the transformer, in parallel with the following suggestions:

- Bring the oil until a level lower than the bushing 's flange.
- Remove the fixing screws of the top and of the bottom connections.
- Remove the bolts that fix the flange.
- Finally lift the bushing.

5 MEASUREMENT OF DIELECTRIC LOSSES

The Standards - IEC Publication 60137 -state that the resin-paper bushings must have a tanδ less than $7x10^{-3}$.

The measurement is performed in our 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 to have a reference value for comparison with the measurement made at site during the bushing life.

The bushing is tested by immersing the lower part into oil, feeding the HV terminal and connecting the P.F. tap to the bridge, keeping the flange connected to earth.

On the bushing mounted on the transformer the measurement can be performed in the same manner, connecting the P.F. tap to a bridge and applying a voltage of 10 kV to the HV terminal.

The bushing is considered as good if a tanδ $7x10^{-3}$ is measured.
If a tanδ higher than the above is measured, it is necessary to disassembly the bushing from the transformer and dry it as follows:

- Unscrew the two plugs placed symmetrically on the head (fig. 8);
- Put the bushing in an oven under vacuum at about 60°C for 2 days at least.

If the above operation is not enough to have a tanδ value under the limits established by the Standards, it is necessary to ship the bushing back to the manufacturer who will replace the active part with another one of new construction.