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THROUGH-WALL BUSHINGS SERIES PWO

VOLTAGE FROM 52 kV TO 245 kV

INSTRUCTION FOR STORAGE, TRANSPORTATION, INSTALLATION AND MAINTENANCE

INDEX

Rev. F	September 2022
Rev. E	August 2019
Rev. D	August 2017
Rev. C	April 2015
Rev. B	July 2008
Rev. A	February 2004
First edition	March 1983

1 DESCRIPTION

1.1 GENERAL

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

“PWO” for rated voltage 52 to 245 kV

according to IEC 60137, and give all general information to be followed from the receipt of bushings until their installation on the wall. Other information is given regarding their service and maintenance.
These bushings are manufactured and tested in compliance with Standards IEC 60137 - “Insulated bushings for alternating voltages above 1000 V”.
They can be supplied, on request, in compliance with the ANSI Standards (IEEE C-57.19.01-2000).
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 145. 650. 1250

P	Condenser bushings (”P” from Italian word” Passante”)
W	Through wall type (“W” from English word “Wall”)
O	Oil paper insulation (OIP)
145	Rated voltage (in kV)
650	BIL class -Basic Insulation Level (in kV).
1250	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.
The schematic design is showed in fig. 1.

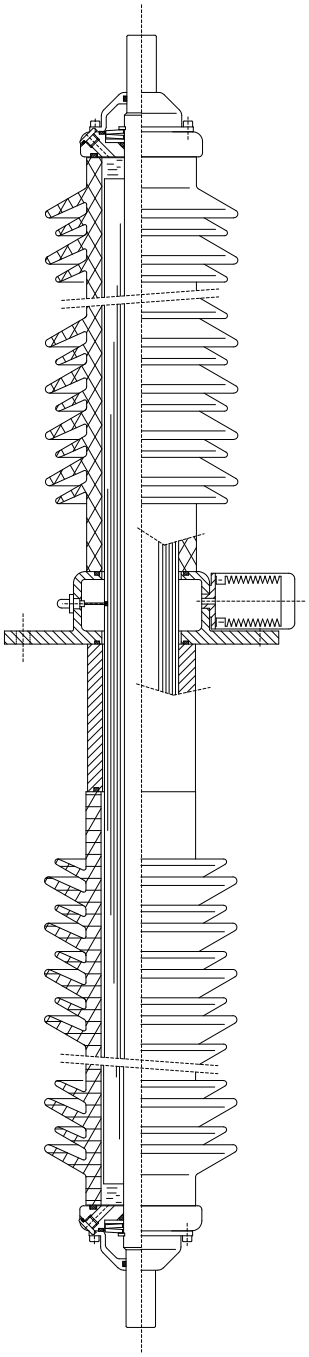


Fig. 1

1.4 INTERNAL INSULATION

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.

1.4.1 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.815-1986.
Normally one-piece porcelain is used for bushings up to 170 kV, and two pieces for 245 kV. The pieces are epoxy resin glued, without using 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 accomodation.

1.4.2 METAL PARTS

HV terminals are made of alluminium or copper, depending of the current and can be tinned or silvered.
All metal components (heads and flange) are made of alluminium alloy casting.

The flange is equipped with the following accessories:

- Two lifting holes or eyebolts for handling;
- Power factor tap (tested at 2 kV for 60 s), for the measurement of the dielectric characteristics;
- One grounding hole (M12).

In the flange one or more teflon bellows are placed (depending of bushing's internal oil quantity), having the function to compensate the oil volume variations with temperature.
These bellows are protected by a metallic cylindrical case, screwed on the flange.

In 245 kV type bushings the bellows are placed in the bushing head and protected by the metallic head itself.

The bellows are filled with oil and and allow the oil expansion without variations of pressure.

WARNING

The bushing is fully filled with oil and is provided with one or more teflon bellows for the compensation of oil volume variations due to the temperature changes during the operation.
For bushings from 52 up to 170 kV bellows are placed into special alluminium cilyndrical cases located on the flange.
These cases are not to be opened for any reason.

1.4.3 GASKETS

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

1.4.4 ASSEMBLING

Mechanical coupling among all the components is obtained by compression springs placed at the heads of the bushing.
Cemented porcelain 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 protecded by means of a silicone sealing.

1.4.5 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.

1.4.6 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 placed on the flange by nails. On the plate there are indicated 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
(*) For bushings with Um > 100 kV only

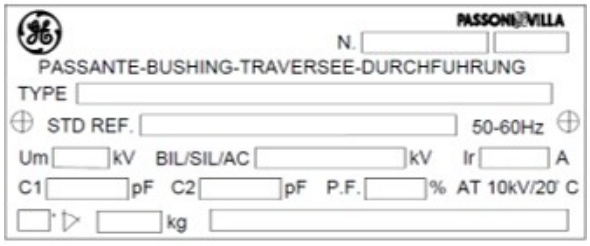


Fig. 2

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 PACKING AND STORAGE

2.1.1 PACKING

These through wall bushings are shipped in sturdy wooden cases in horizontal position. The 245 kV ones are always packed in cases of one piece; the other types can be packed in cases of one or three pieces; this grants that the dimensions of cases are smaller and the transportation less costly.

2.1.2 ACCEPTANCE

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

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

Fig. 3

If the shockwatch indicator is red 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

2.2 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 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.

2.3 LIFTING AND TRANSPORTATION

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

2.3.1 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.4.

Some indications appear also in the packing case.

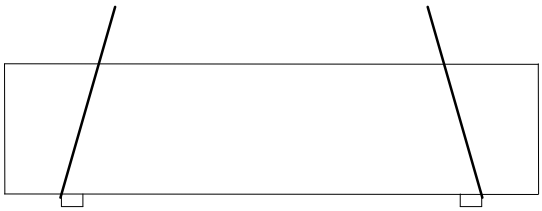


Fig. 4

2.3.2 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 rope with closed hooks applied to the cast or screwed eyebolts that are on the flange, plus a rope fastened between the second and the third (from the head) sheds of the porcelain to maintain it horizontally (see fig.5). Pay attention to cylindrical cases bellows: the ropes have not to touch them 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.

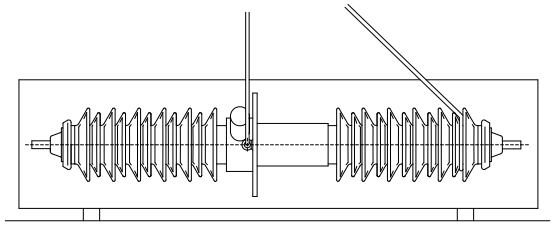


Fig. 5

2.4 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.

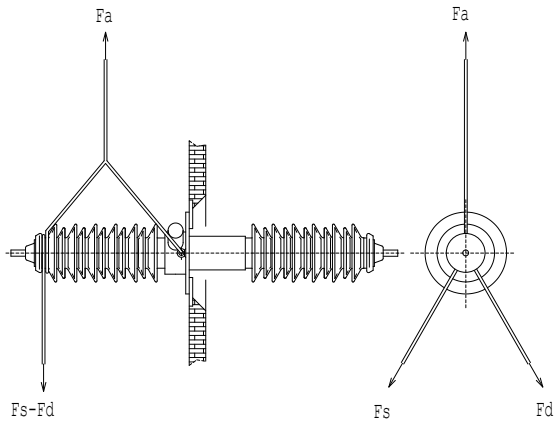


Fig. 6

Close to the head it is necessary to apply a rope having two extremeties 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.

2.5 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.

2.6 ARCING HORNS

Adjustable arcing horns can be provided upon request for all the bushings. The lower arcing horn will be first screwed at one of the fixing threated holes foreseen on the flange for this purpose and then blocked with the nut.
On the head there are the 4 fixing screws of the terminal. The upper arcing horn is provided with a connector and is fixed with one of these screws.
The regulation of the spark distance will be made in accordance with the insulation coordination of the Network. The following table 1 gives the suggested discharge distances between arcing horns.

Rated voltage	"H" discharge distance ±10%
(kV)	(mm)
52	320
72.5	450
100	600
123	750
145	900
170	1000
245	1450

Table 1

3 SERVICE AND MAINTENANCE

3.1 METAL PARTS

The flange and the heads of the bushing are made of aluminium 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

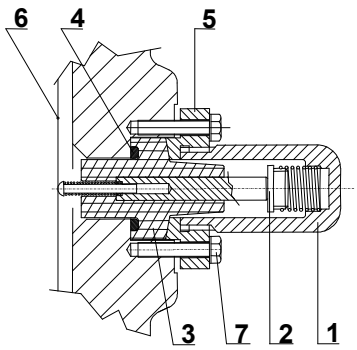
After the installation of the bushing it is advisable to make a check of the bushing capacitance and tgδ.

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.

PF tap is schematised in fig. 7.



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. 7
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. 7) 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. 8), according to the French Standard NFC 52062.

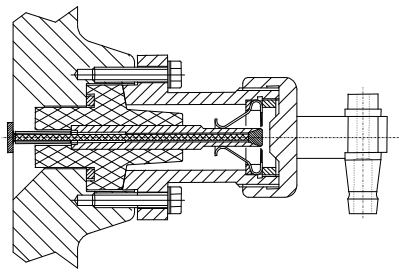


Fig. 8
Power factor tap NFC (on request)

WARNING

Don't unscrew the screws item 7 of fig. 7, 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.

3.3 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;
- Apply the ropes to the bushing (see fig.6);
- Remove the bolts that fix the flange;
- Move the bushing.

3.4 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 (tgδ).
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 can 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, clean them slightly passing fine sandpaper, paying attention to not damage the tinned or silvered 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 (fig. 7).

3.5 MEASUREMENT OF DIELECTRIC LOSSES

The Standard - IEC Publication 60137 - states that the oil-paper bushings must have a tgδ less than $7x10^{-3}$.
The Standard IEEE C57.19.01-2000 state that the oil paper bushing must have a tanδ less than $5x10^{-3}$.

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 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 tgδ less than the maximum one established by the Standards is measured.

If a tgδ 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 has to be supplied with a voltage maximum of 2 kV and the PF tap has to be connected to the bridge.

A field measurement of tgδ 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 tgδ) is acceptable. Furthermore, the installation conditions can affect the capacitance value.
For this it is advisable to measure capacitance and tgδ upon the installation and use these values as base for future comparison measurements.

3.6 CHECKS ON OLD BUSHINGS

Before remounting an old bushing, it is advisable to carry out an electrical check.

The old bushings are suitable for service if, as regards the values of reception test, there is 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 tgδ of capacitance C1;
- 100% for tgδ 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.

The perforation of one or more layers generates a capacitance C1 rise and generally also a tgδ of capacitance C1 rise too.

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 consequently will decide to make an oil treatment to the bushing, to replace the active part with another one of new construction or to replace completely 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