OIL TO AIR BUSHINGS SERIES PNO

VOLTAGE 1100 kV

STORAGE, OPERATING

AND MAINTENANCE INSTRUCTIONS

INDEX

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1 DESCRIPTION

1.1 GENERAL

These instructions are applicable to the OIP (oil impregnated paper) condenser bushings of series

“PNO” - Rated voltage 1100 kV

according to IEC 60137 Standard “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 transformer. Other information are 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 made as in the following example:

PNO.1100.2400.2500

P Condenser bushing (“P” from Italian word “Passante”)

N Normal tail type, oil to air

O Oil paper insulation (OIP)

1100 Rated voltage (in kV)

2400 BIL – 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.

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, oil impregnated type (OIP), provided for operation with the upper part in the open air (normally or highly polluted atmosphere) and with the lower part immersed in the transformer oil, for installation with inclination up to 30° from the vertical.

1.3.1 Insulation

The main electrical insulation is given by a condenser body, made of a continuous sheet of pure Kraft paper, wound around a metallic 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 several 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.

1.3.2 Air side

The air side envelope is made of porcelain, brown colour (upon request grey colour or resin fibre-glass envelope covered with silicone sheds). 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 Standards. More pieces of porcelain are used, epoxy resin glued, without using gaskets in between.

1.3.3 Oil side

The oil side envelope is made of two pieces of porcelain glued together.
Versions with under flange sleeve in oil side for CT accommodation are available upon request.

1.3.4. HV terminal

The HV terminal can be removable in case of draw lead or draw rod execution; it is coupled to the conductor by means of multi-blades contacts, and it is fixed on the head by means of six screws. In case of bottom connection execution, it is not removable. Terminal can be made of aluminium or copper, depending from the rated current of the bushing; the aluminium one can be without any surface treatment or silver plated; the copper one is always tinned.

1.3.5. Oil compensation system

The bushing is provided with a compensation system (for oil volume variations with temperature) composed by two metallic oil reservoirs, each one connected to the flange by means of a flexible pipe, with shut-off valves at both sides. Each oil reservoir is fixed to the bushing flange by means of a metallic structure.

WARNING
Do not touch any of the four valves of the oil dilatation compensating system for any reason. Their closing will cause a destructive mechanical failure of the bushing.

1.3.6. Oil side shield

The oil side is shielded by a suitable electrode, made of aluminium sheet, covered by a layer of epoxy resin (thickness: 2-3 mm), with the function of reducing the dielectric stress of the connection. The shield is removable in order to ease the lead connection operations. Under request the shield can be supplied bare or covered by pressboard.

1.3.7. Flange

The flange made of aluminium casting and is equipped with the following accessories:

- Power factor tap;
- Buchholz relay connection;
- Oil sampling valve;
- Lifting holes;
- Potential device tap (voltage tap) – on request;
- Two valves allowing, in case of necessity, the removal of the oil reservoirs.

1.3.8. Gaskets

O-ring type made of fluorocarbon elastomer. They are compatible with both the impregnating oil of the bushing and the hot mineral oil of the transformer.
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 -60°C) special O-rings are foreseen, made of fluorine-silicone mixtures.

1.3.9. Assembling

Mechanical coupling among all the components is obtained by compression springs placed at the head of the bushing. Furthermore, the air side porcelain is cemented to the flange and to the head, and the oil side porcelain is clamped to the bottom part of the flange, in order to have a stronger mechanical resistance.
The cemented used is a monocalcic aluminized type, quick curing type. All the cement surfaces in contact with the external ambient are protected by means of a silicone sealing.

1.3.10. 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.

1.3.11. 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 is made of aluminium and is fixed on the flange by nails. On the plate (fig. 1) the following information are indicated:

1 – Serial number
2 – Month & year of production
3 – Type of bushing
4 – Standard reference
5 – Rated frequency
6 – Max. system voltage
7 – Insulating voltages
8 – Rated current
9 – Main Capacitance measured value
10 – Tap capacitance measured value
11 – Dissipation factor measured value
12 – Max. mounting angle
13 - Weight

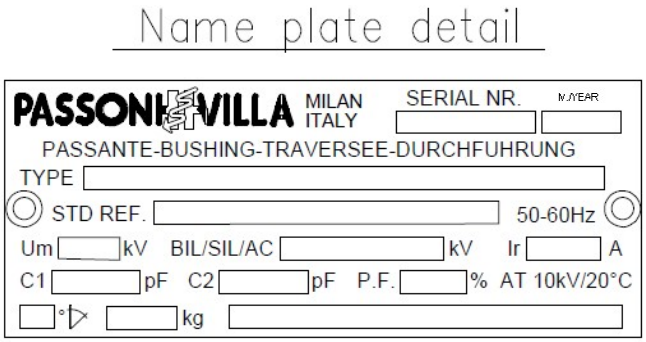


Fig. 1

The month is indicated by a code, as follows:

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

2 PACKING AND STORAGE

2.1 PACKING

After the tests, before packing, the lower part of the bushing is cleaned from the oil (residuals due to the electrical tests in which the oil side of the bushing is immersed in the oil) and the air side insulator from the dust.

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 shall be found;
  - The shock indicator, placed in the external part of each packing case (fig. 2), must be white (NOT ACTIVATED).

Fig. 2

- If the shock 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 bushing, 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 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

2.3 STORAGE

The bushings must be kept in their original packing and in their initial position. On request, for a long period storage (greater than two years) the bushings can also be shipped with the lower part protected by a rigid container, hermetic and containing silica-gel salt, or by a metallic container, oil filled and hermetic: bushings so protected can be shipped and stored for a long time even in the most unfavourable weather conditions.
The temperature range acceptable for the storage is from -25 to +50 °C.
For special requirements regarding low ambient temperatures (see par. 6), where special O-rings are foreseen, bushings can be stored at temperature up to – 60°C.
When a bushing is taken out from the storage is necessary to make a visual check to be sure about the good conditions of any part.

3 LIFTING AND TRANSPORTATION

The bushings type PNO are sturdy, nevertheless, in order to avoid dangerous movements, it is warmly suggested to follow the suggested options.

3.1 PACKED BUSHING

The case containing the bushings can be lifted with a tackle by applying the ropes on the points (where are placed the metal reinforcements) as indicated in fig. 3. Some indications appear also in the packing case.

3.2 UNPACKED BUSHING

To take the bushing out of the case, operate according to the present instructions, which have to be carefully followed by the people charged to make the job.

Considering the heavy weight (more than 6 tons) and the dimensions it is advisable to use two tackles or two equivalent lifting systems, with the lifting kit foreseen for this bushing (fig. 3).

Fig. 3

In order to handle the bushing, the wooden box must be opened, the ropes that fix the bushing to the box structure loosened and all the fixing wooden devices dismantled (fig. 4).

Fig. 4

The lifting kit is composed by five parts (ref. to fig. 5):

- PART 1: A collar to be fixed to the cylindrical porcelain;
- PART 2: A fixing tool for the head of the bushing;
- PART 3: Two ropes to connect PART 1 and PART 2;
- PART 4: The tool provided to maintain parallel the two ropes;
- PART 5: The metallic ropes to lift the bushing.

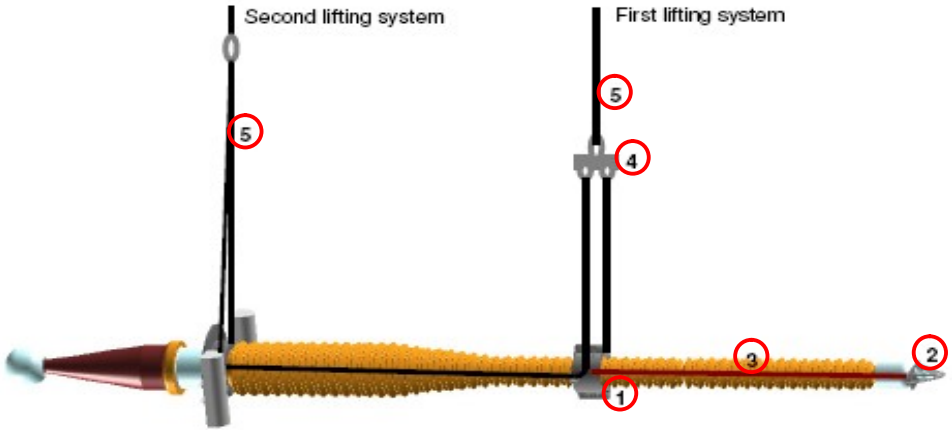


Fig. 5

LIFTING KIT DESCRIPTION AND OPERATIONS TO BE MADE
PART 1 – COLLAR

The PART 1 is an iron collar, made of two pieces, to be fixed on the second section porcelain from the top of the bushing, see fig. 6 and 7. The surfaces of the collar in contact with the porcelain are covered with a 20 mm thick rubber pad. This pad has the function to protect the porcelain from damages when the collar is mounted. It is composed by two symmetrical parts, to be screwed together by three M16 screws for each side, to fix this collar on the bushing.

Fig. 6

Once the collar has been placed on the second porcelain section from the top of the bushing, see fig. 7, in its cylindrical part, it must be remembered to keep it with the two screwing plates in vertical position and the two “ears” for the ropes according to the sketch (fig. 5 and fig. 7).

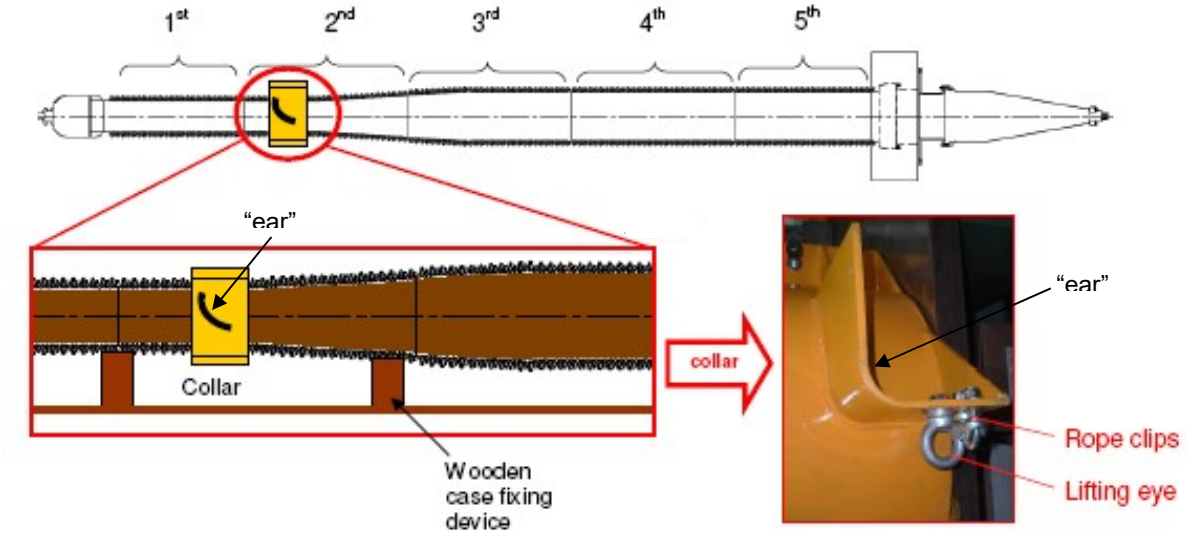


Fig. 7

Be careful to maintain loose the two halves of the collar: the bolts must be tightened in a second time, after having placed the whole lifting system.

PART 2 – HEAD TOOL

The part 2 is an iron fixing device to be placed on the bushing’s head (fig. 8); it must be fixed by means of the 6 fixing holes on its base. These holes must be inserted in M12 threaded rods already placed in the head of the bushing and foreseen for fixing the air side shield (fig. 9).

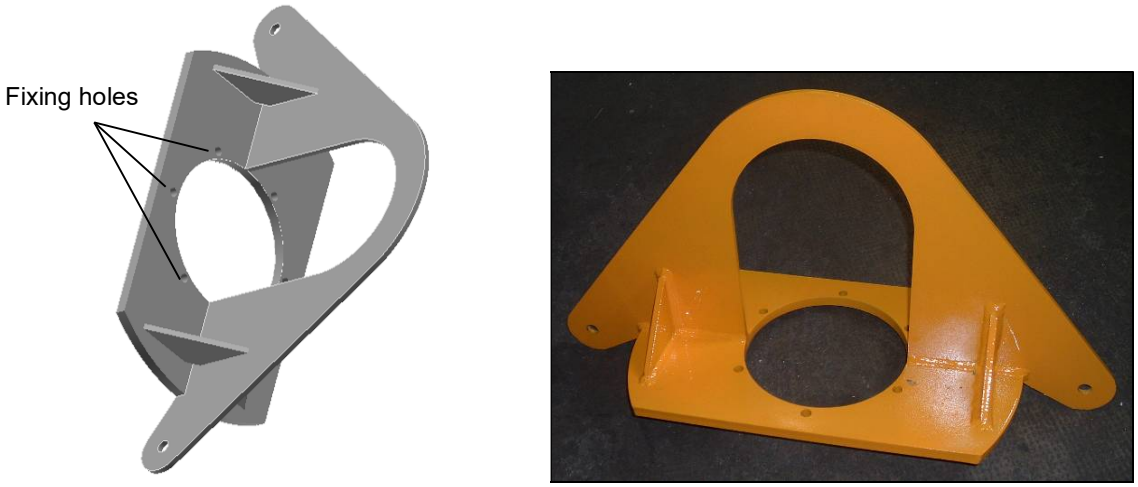


Fig. 8

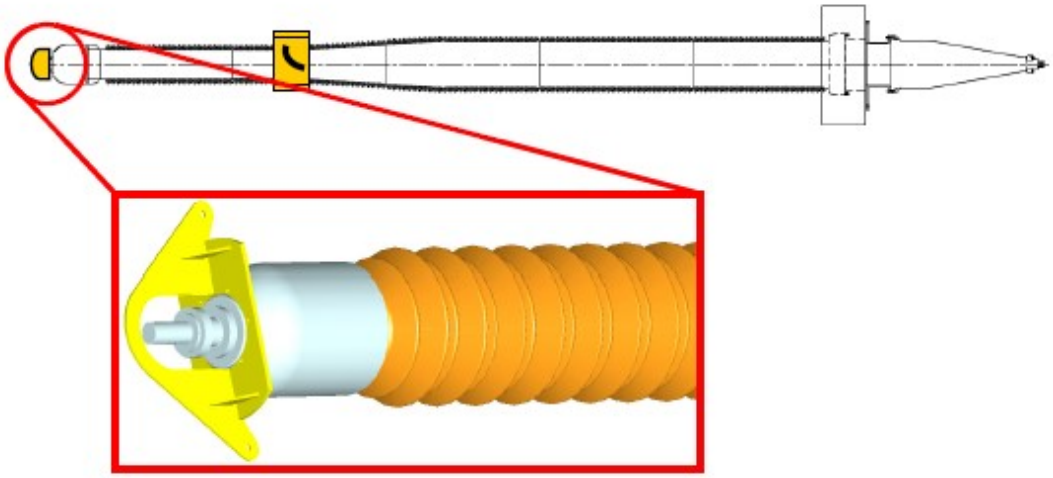


Fig. 9

PART 3 – METAL WIRE ROPES

The part 3 consists of two metallic wire ropes, each of them with a turnbuckle (fig. 8).

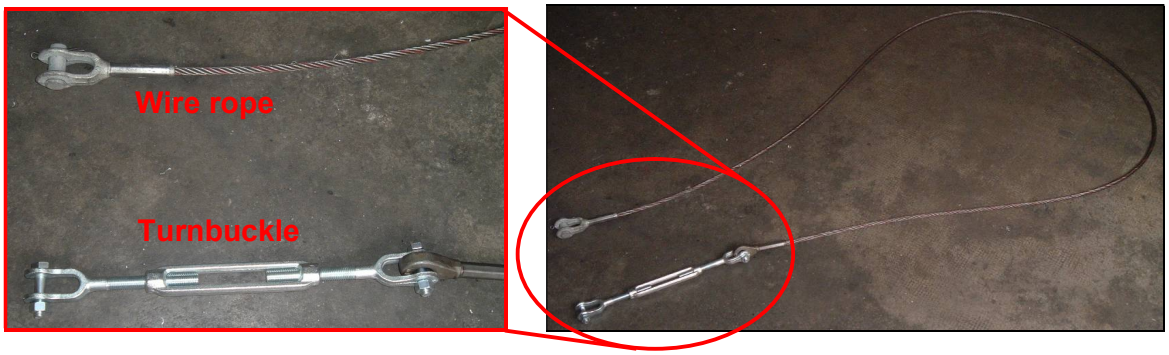


Fig. 10

Each wire rope with its turnbuckle has to be fixed between the hole on the head tool (PART 2) and the lifting eye placed on the “ear” of the collar fixed on the porcelain passing through the green fairlead made of plastic (fig. 11).

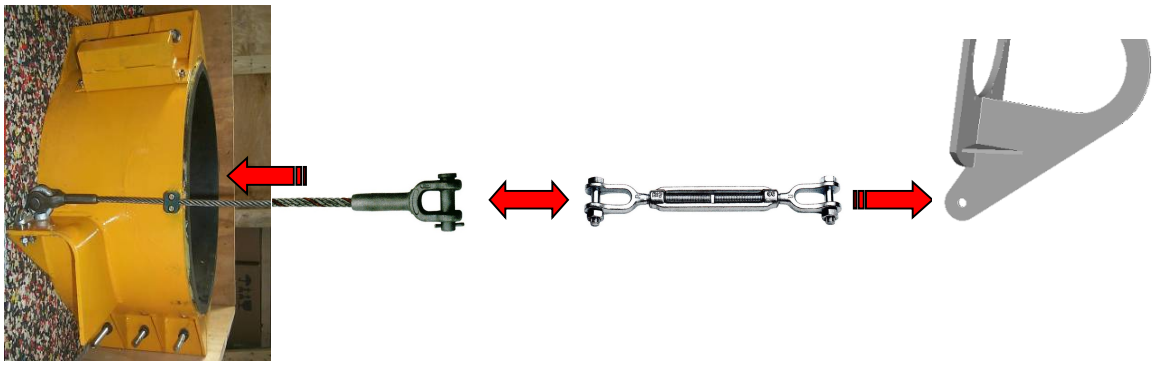


Fig.11

In this way PART 1 and PART 2 are connected together (fig. 12).

Fig. 12

PART 4 – LIFTING DEVICE

The further step consists in preparing the first lifting system, to be equipped with a special device that can lift the bushing maintaining the two ropes parallel (PART 4), at about 75 cm each other (fig. 13).

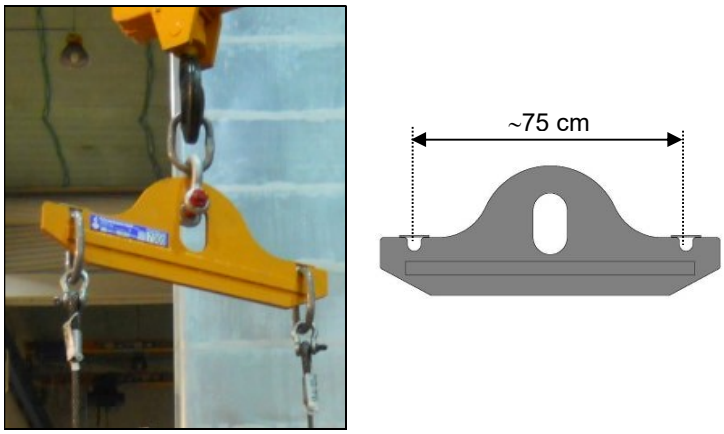


Fig. 13

Connect two flexible metallic ropes (minimum diameter of the metallic lead: 16 mm) to the two opposite eyebolts foreseen on the flange (fig. 14) using two chain shackles. These two ropes will pass parallel along the bushing from the flange up to the lifting system.

From the same chain shackles connect two other metallic ropes going to the second lifting system (fig. 14).

Chain shackle

To the first lifting system

To the second lifting system

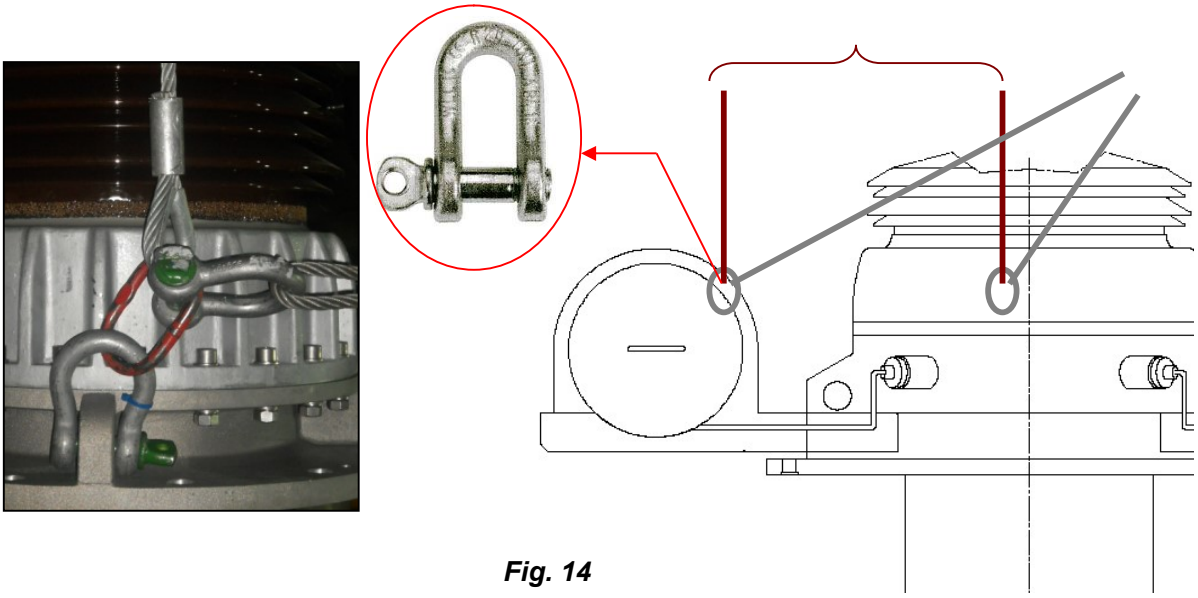


Fig. 14

The two ropes going to the first lifting system must pass along the two “ears” of the collar (PART 1), passing through the two wire rope clips provided for this purpose on the “ears” (fig. 7 & fig. 15).

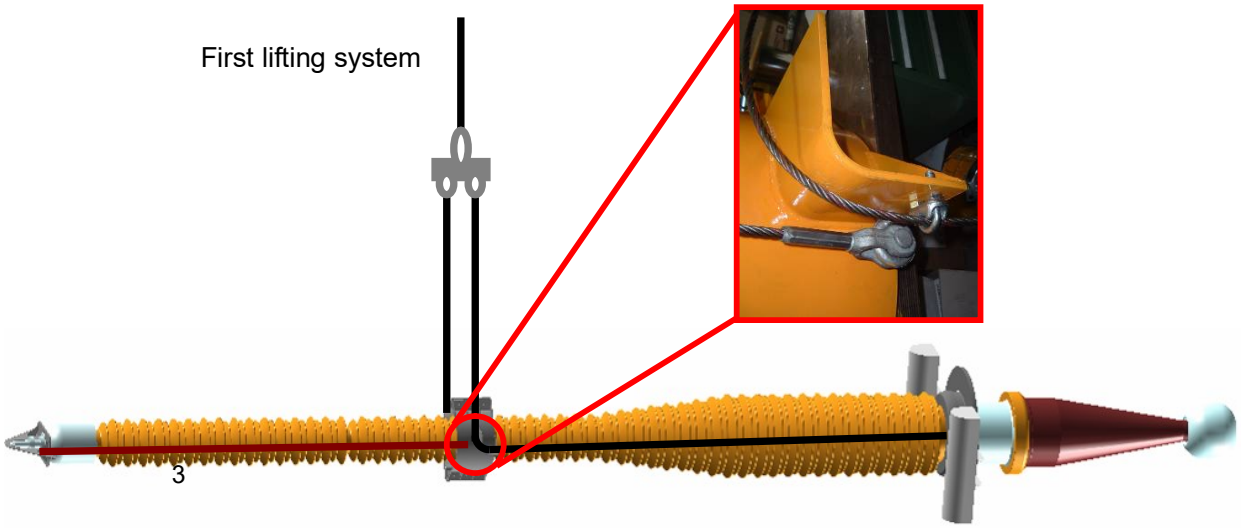


Fig. 15

When the two ropes have been well placed in the way explained, the four operations to be made are the following:

- Adjust the two wire ropes PART 3 acting on the two turnbuckles in order to maintain the collar (PART 1) in a straight way (with its axis parallel to the bushing);
- Tighten the three plus three bolts of the collar (PART 1), being careful to apply a maximum torque of 25 Nm, in order to avoid damaging the porcelain sheds.
- Pull up the bushing with the first lifting system of few mm in order to tighten the two ropes item 4.

CAUTION
Be careful during the screwing operations of this collar: the pressure on the porcelain must be not so high to damage the sheds: the M16 screws must be tightened with a max torque of 25 Nm

- Now the two wire ropes (PART 3) connecting the head (PART 2) and the collar (PART 1) have to be stretched (fig. 16), by means of the two turnbuckles for every wire, in order to avoid that during the bushing's lifting operations the two wire ropes can move.

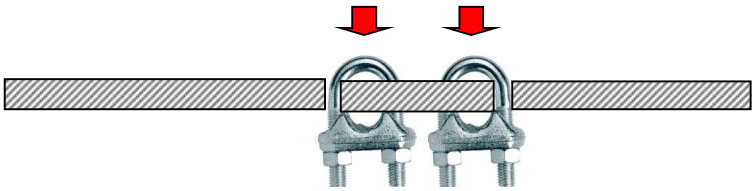


Fig. 16

Now lift the bushing with the two tackles and keep it in horizontal position (fig. 17).

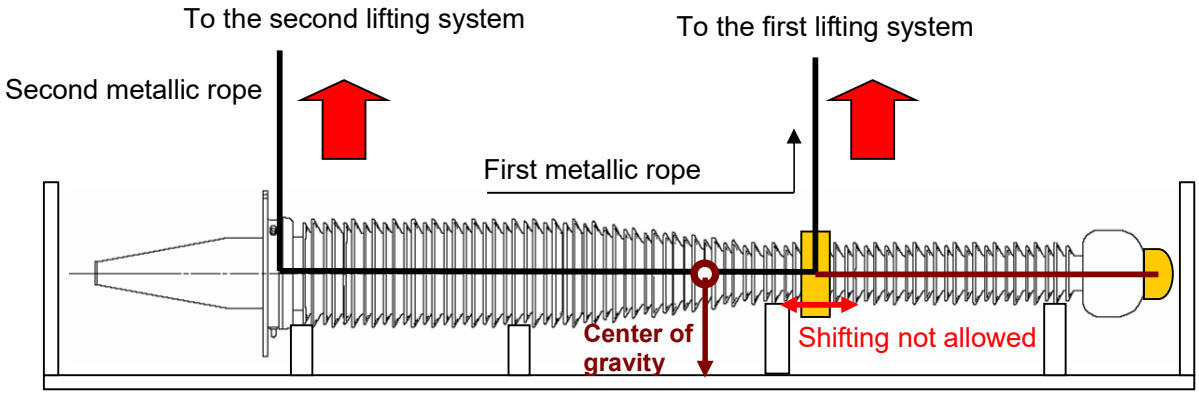


Fig. 17

CAUTION
This is a delicate operation. Before starting the handling, be sure that all the components and the ropes are well placed, fixed, and then move slowly. Make all these operations only with expert people.

Handle carefully using the two tackles to bring the bushing to the vertical position.

CAUTION
NEVER LEAN THE BUSHING ON ITS TAIL (fig. 18)

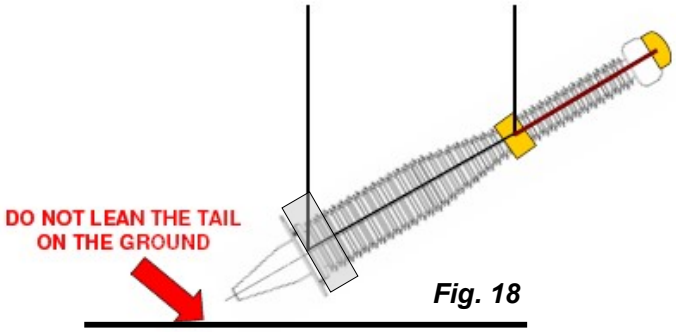


Fig. 18

If necessary, place the bushing on a suitable and stable trestle (Fig. 19).

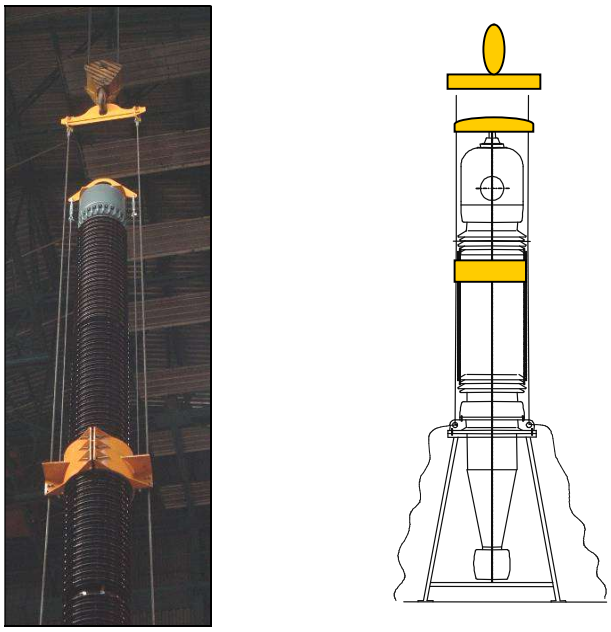


Fig. 19

CAUTIONS

- During the handling, never lean the bushing or its tail directly on the ground, because its heavy weight can seriously damage the bushing.
- The bushing is equipped with 2 external bellow tanks for oil volume compensation and has on the flange a manometer: be sure that this manometer is placed in the upper side of the flange when the bushing is located into the case.
- Be careful to avoid damages of the flexible tubes connecting the bushing flange and the bellow tanks.
- Never touch the two closing valves placed at both ends of each tube connecting each tank to the bushing flange. If these valves are closed, the oil dilatation compensation system of the bushing won't work anymore, with high risk to have a disruptive mechanical failure of the bushing. These four (2+2) valves must be maintained always open to allow the oil passage. A red label reminds this concept with a warning in English and Chinese languages (fig. 20).

WARNING

Do not touch any of the four valves of the oil dilatation compensating system for any reason. Their closing will cause a destructive mechanical failure of the bushing.

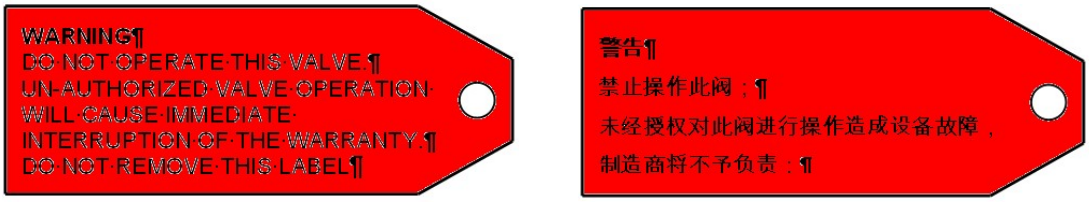


Fig. 20

3.3 SHIPMENT TO THE END USER

Shipment of bushing made by the transformer manufacturer, after the transformer factory tests, shall be made either using the original packing or a new one, made with the same principles.

4 INSTALLATION ON THE TRANSFORMER

4.1 DRAW LEAD CONNECTION

In this type of execution, the current in the bushing is carried out directly by the lead coming from the transformer's winding, up to the lug placed in the upper part of the bushing (fig. 21 and fig. 22).

Complete the assembly as follows:

- The lug must be removed from the head of the bushing in order to make the connection: to disassemble the HV top terminal cap (1), remove the 6 x M8 screws and lock washers (2), which secure it to the bushing head. Pull the HV top terminal (1) from the lug (3), keeping the terminal well centred on the axis of the bushing. The necessary force is small (about 10 kg.) because the multicontact blades (4), located inside the terminal, press softly on the smooth surface of the lug (3). Verify that the O-ring (5) remains seated in the recessed gasket retention groove.
- Remove the locking pin (6) from the lug hole.
- Remove the copper lug (3) from the central tube of the bushing;
- Cut the connection at a right size Lcut plus 20 mm for the soldering of the lug; note that the size Lcut is indicated on the "bushing overall dimensions" drawing, supplied with the bushing's order confirmation;
- Make a hole, in the lug, having sufficient diameter for the connection but a maximum diameter 3mm lower than that of the lug;
- Make the connection, through brazing, of the draw lead to the copper lug;
- Fix a thread to the lug, using the M12 hole (7);
- Place the gasket on the flange on the transformer;
- Slide inside the central bushing's tube from the bottom the lug with the lead;
- Lift and install the bushing according to the instructions of par. 3.
- Align the hole in the lug with the hole in the central tube and secure the lug in position by reinstalling the locking pin (6);

- Be sure the pin is centred;
- Mount the terminal on the lug as described hereunder;
- Place the bolts on the flange of the bushing;
- Insert the HV terminal on the lug, keeping the terminal well centred on the axis of the bushing. The necessary force is small (about 10 kg) because the multicontact blades, located inside the terminal (4), press softly on the smooth surface of the lug (3). The top terminal cap will hold the pin in place. Tighten the screws (2) by a moment of 13 Nm. The gasket placed between the two pieces (5) assures the transformer oil tightness and for this reason it is necessary to block the terminal before filling the transformer with oil. The gasket which is necessary to assure the tightness between the oil of the bushing and the oil of the transformer is not involved in this assembly. The connector to the HV terminal must be of compatible material. Clean well the terminal and apply a specific grease for electrical contact and then assemble the connector to the terminal

For a better bushing's tail insulation, it is advisable to protect the lead coming from the winding of the transformer with paper; it is suggested to insulate with a minimum layer of 1,5 mm and a maximum diameter almost of 2 mm smaller than the internal one of the tube (to allow the oil passage).

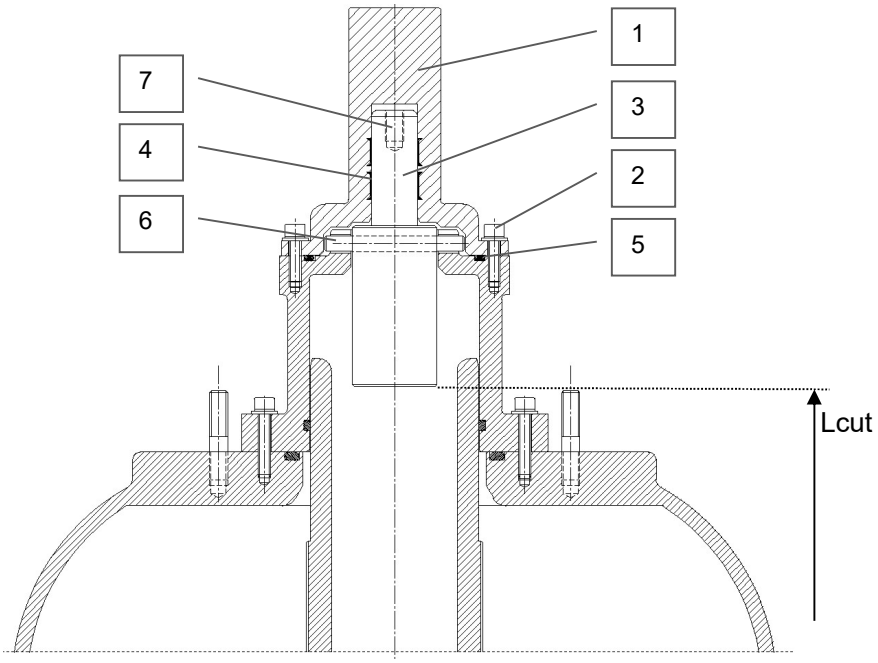


Fig. 21

4.2 DRAW ROD CONNECTION

In this type of execution, the internal bushing's conductor, carrying the current, is rigid and removable. It can be also sectioned in two parts, in order to make easier the transport of the transformer. The procedure is similar as the draw lead execution, but now instead of a lug it is used a conductor that is placed inside the bushing all along it and coming out from the bottom part. The connection coming from the transformer must be brazed to the lower extremity of the conductor, in a similar way as described above.

4.3 BOTTOM CONNECTION

In this type of execution, the current is carried directly by the central bushing conductor; the passage of current from the tube and the top bushing terminal (fig. 22) is obtained by means of special inner lugs (1), equipped with multicontact blades (4).
Each type of bottom connection terminal has a system of holes in order to fix the transformer winding connection.

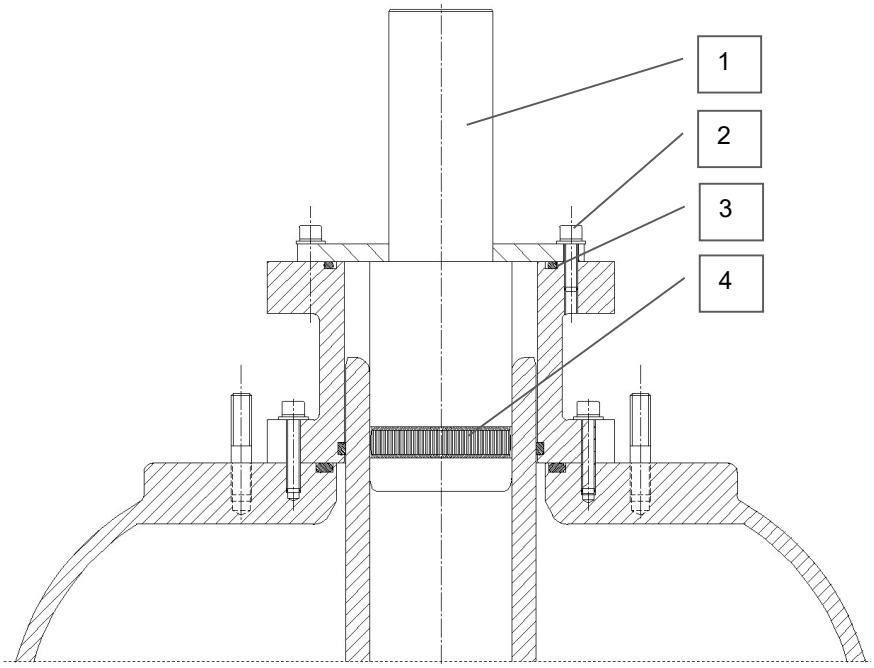


Fig. 22

In this type of bushing connection, the top terminal (1) must not be dismounted. It is fixed with six M8 screws (2) to the bushing head and includes in one piece also the internal connection lug with multicontact blades (4).
Only if the transformer oil filling is not made under vacuum it is suggested to loosen the six screws (2) of the HV terminal and slightly lift it of 2-3 mm, in order to allow to the air inside the internal central tube of the bushing to flow out during filling. Due to the presence of the multicontact blades (4), to lift the terminal is necessary to apply a certain force on the terminal itself. In any case the lifting of the terminal must be made parallel to the bushing axis. The necessary force can be achieved by means of a tackle with a rip knotted on the cylindrical part of HV terminal or making lever on the HV terminal, paying attention to not damage the surfaces of the internal O-ring (3). At the end of the operation the six screws (2) must be tightened with a torque of 13 Nm.

CAUTION
Due to the presence of the multicontact blades, the lifting operation of the terminal can be difficult. Take care during this operation, in order to avoid damaging the multicontact blades.

4.4 OIL SIDE SHIELD

The bottom end of the bushing is shielded by a suitable aluminium electrode, covered by a layer of 2-3 mm of epoxy resin. It has the function of increasing the dielectric strength in oil and screens the connection between the lead coming from the transformer winding and the bushing itself.
The shield is removable upwards to ease the connection between transformer cable and bushing (see fig. 23): the bushing's bottom plate is threaded (M220x2) for a length of 30 mm in the lower lateral surface, while the upper lateral surface is smooth and works as guide for the deflector, that can be unscrewed upwards and lifted. When it is re-screwed, a special system (1) does not allow it to go beyond its correct position.

CAUTION
During handling, take care to not damage the external finishing coat of the dielectric shield, fundamental in the dielectric strength of the bushing oil side.

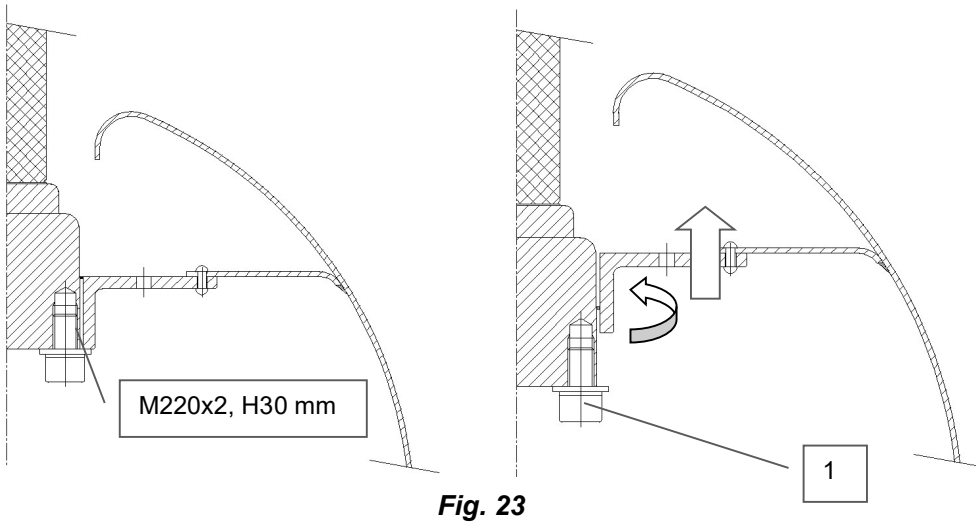


Fig. 23

4.5 ICE AND SNOW DEPOSITS

If the transformer is installed in arctic climate and has to be put in service, it is recommendable before to remove from every bushing's porcelain excessive ice or snow deposits, which can reduce the dielectric withstand capability. In any case the bushing is designed to withstand mechanically up to an ice coating of 10 mm.

4.6 OIL FILLING OF THE TUBE OF THE BUSHING

It is foreseen that the bushing operates with the inner tube filled with the transformer's oil at least up to the flange, in order to improve the bushing cooling.
After the closure of the bushing, it is necessary to make the vacuum on the transformer and then fill it with oil. In case the oil filling is made from the top of the transformer without the vacuum treatment, it is necessary to be sure that the oil level reaches the bushing flange, without the presence of air bubbles. For this purpose, the flange is provided with a plug which allows the air to flow out (fig. 25). Furthermore, lift slightly of about 2-3 mm the HV terminal in order to allow the air to go out and complete the filling of the transformer and of the lower part of the inner tube of the bushing. Note that this operation can be difficult due to the presence in the terminal of the multicontact blades; for this reason, be careful making this operation (refer to par. 4.3).

4.7 PRESSURE CONTROL

The bushing is equipped with a pressure gauge (fig.24), installed on the flange, with two electrical contacts, one of minimum and one of maximum pressure, in order to signal any irregular pressure inside the bushing, caused by oil leakage or anomalous operation temperatures. The alarm pressure value of the two independent contacts is indicated in the pressure gauge quadrant. If requested the pressure gauge can have more contacts, all independent.
The oil pressure depends of the internal temperature of the bushing, according to the diagram pressure-temperature shown in fig. 25 (the real value of pressure according to the temperature is included between the two curves traced on the diagram: this fact depends from the different volumes of oil according to the natural tolerance of dimensions of components for every bushing).

WARNING

The manometer is connected to the bushing's flange through a valve. Don't close this valve (sealed with lead) rotating its cap. Leave the valve in the open original position.

Furthermore, avoid touching the valves placed at both ends of each tube connecting the two tanks of the oil dilatation system to the bushing flange

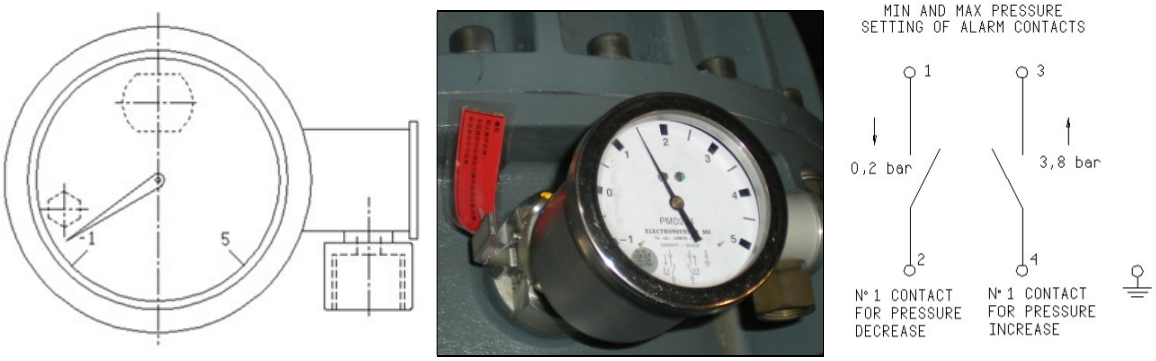


Fig. 24

CAUTION

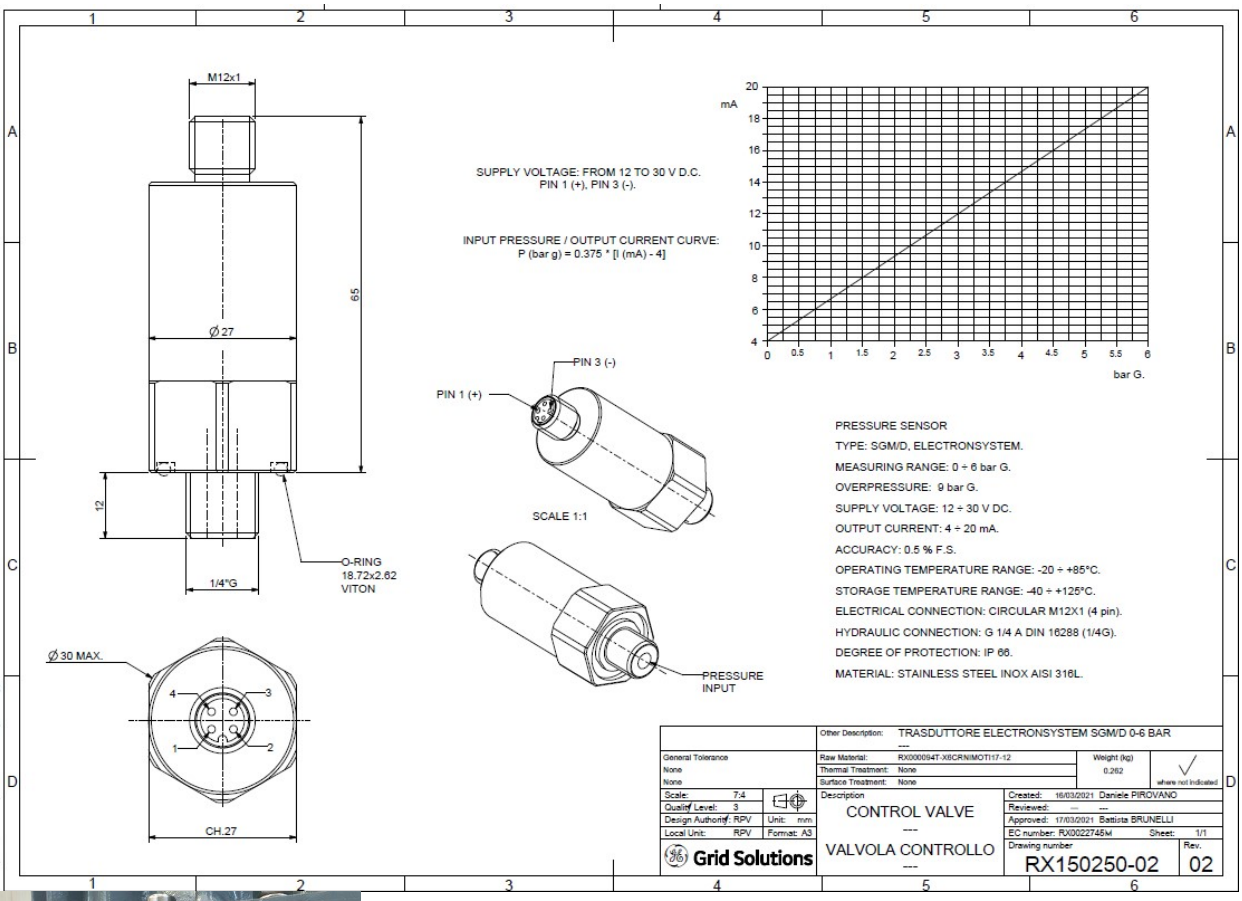
It is of fundamental importance to have permanently monitored the internal pressure of the bushing, to have immediate action in case of anomalous values.

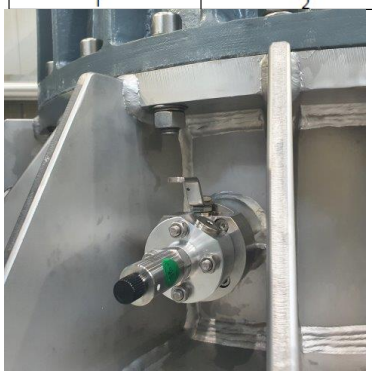
For this reason, it is strongly suggested to connect the alarm contacts of the manometer to the protection system of the substation.

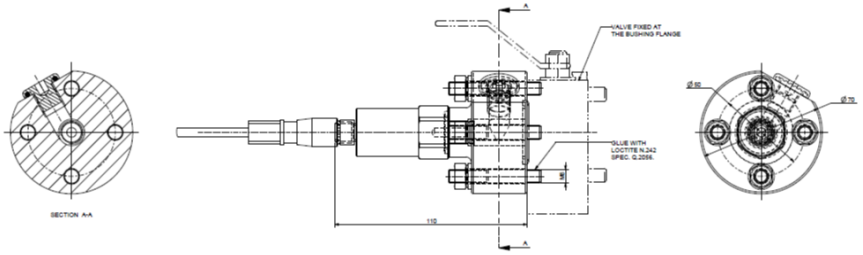
At the beginning of year 2021 the PNO 1100 kV bushings started to be equipped with a pressure transducer to allow an easy and constant digital monitoring of the bushing pressure in the control room.
This device transforms the pressure in an electric signal (4-20 mA) directly proportional to the pressure value, that can be received and read on the control room panel.

The transducer is mounted on the oil sampling valve through a special adaptor flange, equipped with an air purge plug that can be removed for the oil sampling activity.

The technical characteristics and installation drawing are described in Fig.24a.


M12x1
65
Ø 27
12
1/4"G
O-RING
18.72x2.62
VITON
Ø 30 MAX.
CH.27
SUPPLY VOLTAGE: FROM 12 TO 30 V D.C.
PIN 1 (+), PIN 3 (-).
INPUT PRESSURE / OUTPUT CURRENT CURVE:
P (bar g) = 0.375 * [I (mA) - 4]
mA
bar G.
PIN 3 (-)
PIN 1 (+)
SCALE 1:1
PRESSURE
INPUT
PRESSURE SENSOR
TYPE: SGM/D, ELECTRONSYSTEM.
MEASURING RANGE: 0 ÷ 6 bar G.
OVERPRESSURE: 9 bar G.
SUPPLY VOLTAGE: 12 ÷ 30 V DC.
OUTPUT CURRENT: 4 ÷ 20 mA.
ACCURACY: 0.5 % F.S.
OPERATING TEMPERATURE RANGE: -20 ÷ +85°C.
STORAGE TEMPERATURE RANGE: -40 ÷ +125°C.
ELECTRICAL CONNECTION: CIRCULAR M12X1 (4 pin).
HYDRAULIC CONNECTION: G 1/4 A DIN 16288 (1/4G).
DEGREE OF PROTECTION: IP 66.
MATERIAL: STAINLESS STEEL INOX AISI 316L.
Other Description: TRASDUTTORE ELECTRONSYSTEM SGM/D 0-6 BAR
Raw Material: RX0000947-X6CRNIMOTI17-12
Weight (kg) 0.262
Thermal Treatment: None
Surface Treatment: None
General Tolerance
None
None
Scale: 7:4
Quality Level: 3
Design Authority: RPV
Local Unit: RPV
Unit: mm
Format: A3
Description
CONTROL VALVE
VALVOLA CONTROLLO
Grid Solutions
Created: 16/03/2021 Daniele PIROVANO
Reviewed:
Approved: 17/03/2021 Battista BRUNELLI
EC number: RX00227454M
Sheet: 1/1
Drawing number
RX150250-02
Rev.
02




VALVE FIXED AT
THE BUSHING FLANGE
GLUE WITH
LOCTITE N.242
SPEC. Q.2556.
110
SECTION A-A

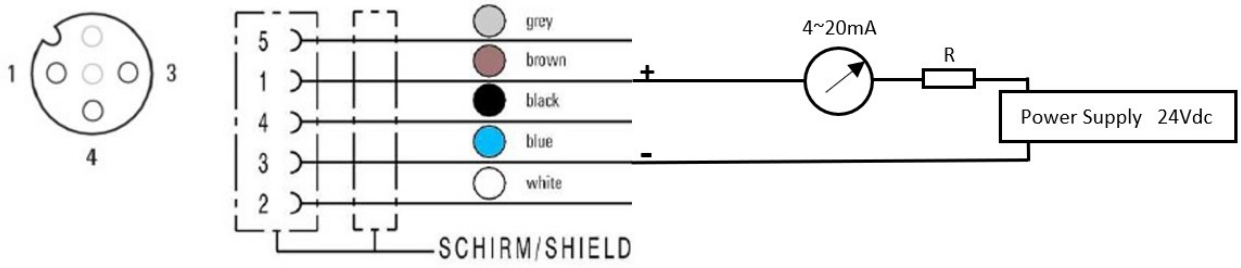

1
3
4
5
1
4
3
2
grey
brown
black
blue
white
SCHIRM/SHIELD
+
-
4~20mA
R
Power Supply 24Vdc

Fig. 24a

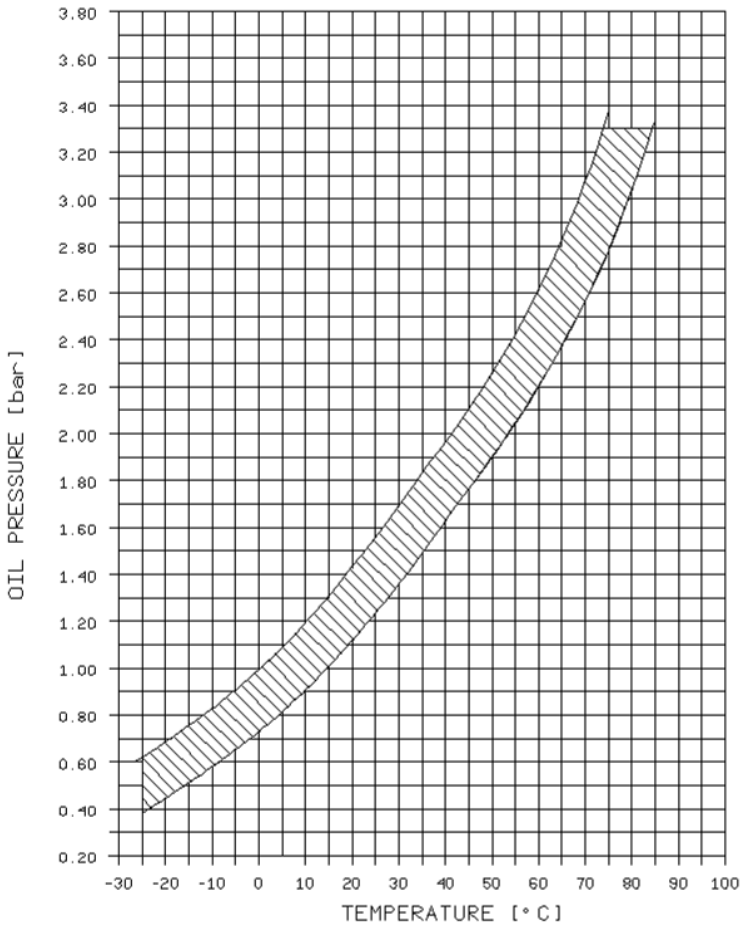


Fig. 25

5 CONNECTION TO BUCHHOLZ RELAY

A 1/2” GAS plug is placed on the bushing flange (fig. 26) in order 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 the transformer not under vacuum.

In this case we suggest unscrewing the plug and leave the air flowing. When the oil begins to come out, close the plug.

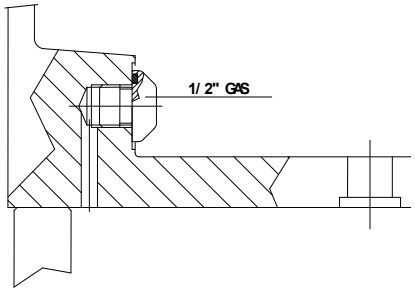


Fig. 26

6 TEMPERATURE LIMITS

Bushings of the series PNO are designed for operation at temperatures according to IEC 60137 Standard:

Ambient temperature:	Maximum:	+ 40°C
	Max. daily mean:	+ 30°C
	Minimum:	- 25°C
Oil temperature:	Maximum:	+100°C
	Max. daily mean:	+ 90°C

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

For special requirements regarding low ambient temperatures (up to –60°C) special O-rings are employed, 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

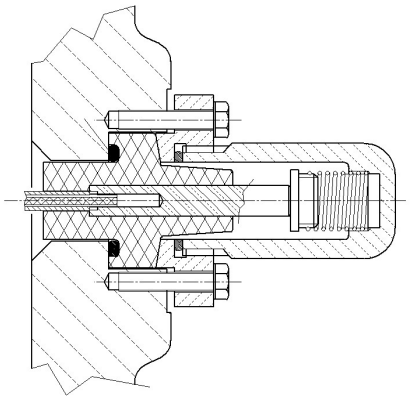
7 SERVICE AND MAINTENANCE

7.1 PAINTING

The flange and the head of the bushing are made of aluminium casting.
Their surface is painted with a polyester varnish, which gives a good resistance to ambient and pollution attack. It is suggested, after a period of 10 years for bushings indoor installation and after 5 years for outdoor ones, to give a further paint coating.

7.2 CHECKS AFTER INSTALLATION

After the installation on the transformer it is advisable to make a check of the bushing capacitance and tanδ.
Normally the measurement (C1) must be carried out between the HV terminal and the Power Factor tap (schematised in fig. 27).
During operation, the PF tap must be grounded maintaining screwed its grounding cap.



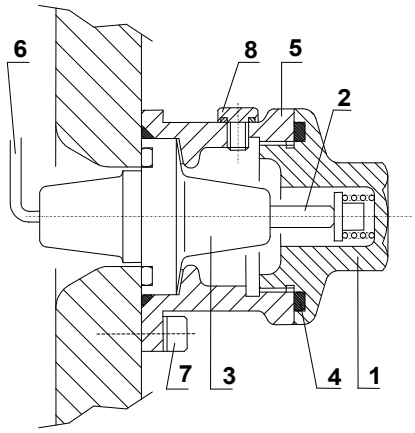
1 - Closing and grounding cap (removable)
2 - Measurement electrode
3 - Insulating bushing
4 – Gaskets
5 - Mounting flange
6 - Last layer
7 – Fixing screw (irremovable)

Fig. 27
Power factor tap (standard)

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. 25) is well screwed. A forgetfulness of this generates during service a voltage on the tap that exceeds its insulation dielectric strength: this may lead to a catastrophic failure.

The capacitance values measured in manufacturer's laboratory are shown in the test report of the bushing.
On request bushings can be provided with PD (Voltage) tap, which is suitable for the connection to a Potential Device system or for the measurement of the power factor (fig. 28).
In bushings provided with PD tap the measurement can be carried out between the HV terminal and PD tap (C1) and another one between PD and PF tap (C2).
If present and not used, the Potential Device tap has to be grounded maintaining screwed its proper cap (see fig. 28).
If present and used, it has to be grounded through the connected measuring instrument.



1 - Closing and grounding cap (removable)
2 - Measurement electrode
3 - Insulating bushing
4 – Gasket
5 - Mounting flange
6 – Internal connection
7 – Fixing screw (irremovable)
8 – Oil filling screw

Fig. 28
Potential Device tap (voltage tap) – On request

WARNING

Don't unscrew the screws item 7 of fig. 27 and 28, that fix the PF and PD 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 tap can be damaged.

If a Potential Device is connected to the potential device tap, we recommend filling with oil the internal part of the connection through the oil filling plug placed in the upper part of the tap (fig. 28 item 8), to avoid possible internal and dangerous sparking.

If not used the voltage tap can remain empty, but we recommend filling it with mineral oil to prevent the entrance of moisture, that during the years can cause the corrosion of the tap connection contact, with dangerous sparking problems.

WARNING
If the potential device tap is not used, we recommend checking if the cap of the oil filling screw (fig. 28 item 8) has been properly applied and screwed. On the contrary moisture entering can cause with time the corrosion of the tap connection contact, with dangerous sparking problems.

7.3 DISASSEMBLY OF THE BUSHING

To disassemble the bushing please 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 flange;
- For draw lead and draw rod type bushings withdraw the terminal from the lug (fig. 21). For this operation it is necessary to draw the terminal in longitudinal way and, at the same time, rotating a little in clockwise and counter clockwise direction. For bottom connected bushings, loose the 6 M8 terminal screws (item 2 of fig. 22), in order to let the transformer oil level to go down inside the bushing central tube, and then remove the connection in the oil side (refer to par. 4.3).
- Secure a pulling device to the hole foreseen in the top of the lug and remove the locking pin (not for bottom connection execution);
- Prepare the bushing for lifting according to par. 3;
- Remove the bolts that fix the flange to the transformer and lift the bushing up following the indication given in par 3.

7.4 MAINTENANCE

The bushings PNO 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) following the instruction given in par. 5.
As for the preservation of the external surfaces, the manufacturer suggests performing the following inspections:

Porcelain

Check for chips, cracks and contamination. Minor chips can be 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 transformer has to be put in service during winter, it is recommendable before to clean the bushing's porcelain 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.
Take particular care to the air side connections, more subject to oxidation than the oil side ones. In case of connections surfaces very oxidised, clean them slightly using fine sandpaper, paying attention not to damage the tinned 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. 27).

Potential device tap (Voltage tap)

If present and not used, check the proper location and the suitable complete screwing of both the tap caps and of the oil filling screw, in order to prevent entrance of moisture (Fig. 28). Voltage tap If not used can remain empty, but we recommend filling it with mineral oil to prevent the entrance of moisture, that during the years can cause the corrosion of the tap connection contact, with dangerous sparking problems

Metal parts

It is advisable after a period of 10 years for bushings indoor installation and after 5 years for outdoor ones, to give a further paint coating.

Oil volume compensation system

Check periodically the pressure indication of the gauge and the absence of oil leakages on the two reservoirs and on their connections to the flange.

7.5 MEASUREMENT OF DIELECTRIC LOSSES

Test in the factory

The Standard - IEC Publication 60137 - states that the oil impregnated paper bushings must have a $\tan\delta$ less than $7x10^{-3}$. This kind of bushing passes the internal quality checks if its $\tan\delta$ has a max value of $4x10^{-3}$.
The measurement is performed in the manufacturer's test Laboratory by means of a Schering bridge (Tettex type) at the voltages requested by the mentioned Standard.
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.

Test on the bushing installed on the transformer

With the bushing already installed on the transformer and the HV terminal disconnected, the measurement can be performed by means of a bridge, by applying a voltage of 10 kV between the HV terminal and PF tap (or PD if present), maintaining grounded the flange (C1 measurement). The bushing is considered good if a $\tan\delta$ less than the maximum one established by the Standards is measured.
If a $tg\delta$ higher than the above one is measured, first of all clean carefully the PF or PD contact from dirt or moisture, clean also the porcelain and repeat the measurement, that should be made during a day not too much humid; if the measured $tg\delta$ value is still high, please contact the manufacturer, who will decide if it is necessary to make other tests before removing the bushing from the

transformer and to ship it back, in order to make a complete check and eventually carry out an oil treatment or 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 maximum voltage of 2 kV and the PF tap must be connected to the bridge.
In case of presence of PD tap, this one can be supplied with a max voltage of 10 kV and the PF tap must be connected to the bridge (C2 measurement).

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, due to stray capacitances, can affect the bushing 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.

7.6 CHECKS ON OLD BUSHINGS

Before re-installing an old bushing, it is advisable to carry out a tightness test and 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 tanδ of capacitance C1 (and C2, if a PD tap is present)
- 100% for tanδ of capacitance Co.

An increase of the last value means a decreasing 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.

7.7 EXTRAORDINARY CHECKS

If the electric measurement detects a tgδ higher than the limits it is suggested to carry out an oil sampling (see par. 7.8) and to perform the following tests as well:

- Humidity content
  Original value: ≤ 10 ppm
  During working: ≤ 20 ppm
- Dielectric strength
  Original value: ≥ 60 kV/2,5 mm
  During working: ≥ 45 kV/2,5 mm
- Dielectric losses (tgδ):
  Original value: ≤ 4*10-3
  During working: ≤ 12*10-3
- Gas chromatography (DGA):
  Refer to Standards (IEC 60599, IEC TR 61464)

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.

7.8 OIL SAMPLING

On the bushing flange there is a valve (see fig. 29 – 29a and 30 – 30a) in closed position: it is the oil sampling valve. On this valve it is screwed a metallic closing disc. To make the oil sampling it is necessary to dismantle this closing disc and to mount another one provided with a suitable hose connector. In case of bushings supplied with pressure transducer, there is an adaptor plate provided with an air purge plug (1/4") that must be removed to install the suitable hose connector.

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

7.8.1 Equipment

To carry out an oil sampling from the bushing, we need the following (see fig. 29):

- A 150 cm^3 oil syringe (item 4) (Lab. Type);
- A semi-rigid pipe (item 2);
- An appropriate small flange suitable for fixing to the sampling valve (having 4 holes positioned at 90° each other's, with a hole wheelbase of 50 mm; the O-ring housing is positioned on the valve body). This small flange will have a suitable hose connector to the sampling semi-rigid pipe (item 1), or just a hose connector (1/4" thread) in case of bushings with pressure transducer.
- A two-way cock (item 3) with a suitable connection to the syringe
- A syringe cap
- Adhesive tape

7.8.2 Preparation

Operate as follows:

- Clean the plug zone accurately
- Prepare all the syringe apparatuses, with the cock (item 3) and the tube (item 2)
- Dismantle the closing flange by unscrewing the 4 screws M8 and fix the sampling flange, or remove the air purge plug and insert the hose connector to the semi-rigid pipe (item 1)
- Wash the syringe with oil two times by repeating the following operations:
- Open 2nd way of cock (item 3)
- Fill-in slowly the syringe with some oil (about 12-30 cm^3), to wash it and to let the exit of the air bubbles contained in the pipe
- Open 1st way of cock (item 3)
- Empty the syringe
- Close 1st way of cock (item 3).

CAUTION
Being the bushing oil always in pressure, the syringe will be filled by means of the oil pressure itself: for this reason, be careful during the operation.

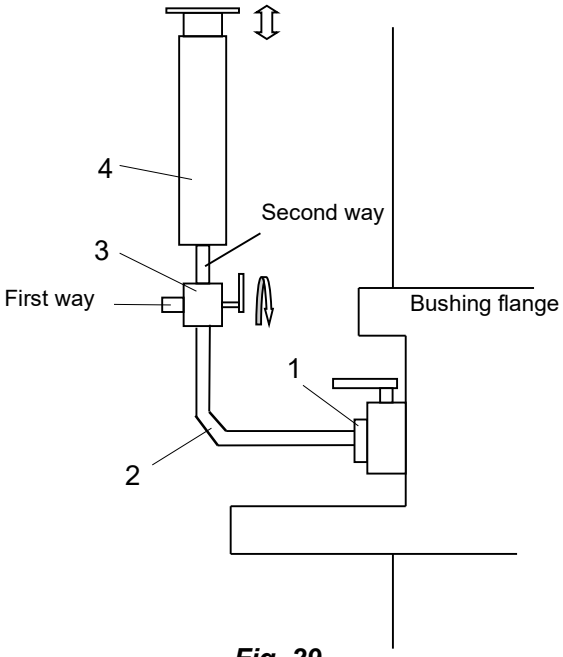


Fig. 29

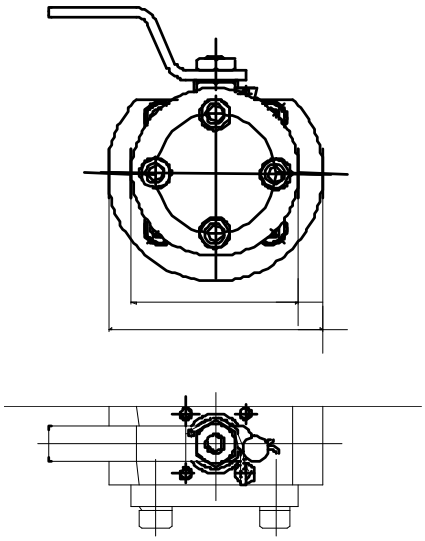


Fig. 30

Bushings without pressure transducer

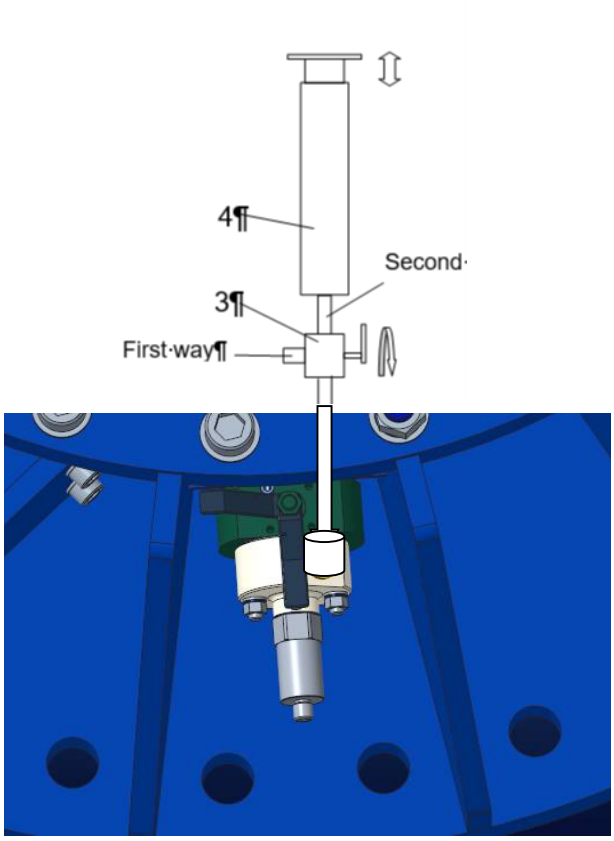


Fig. 29a

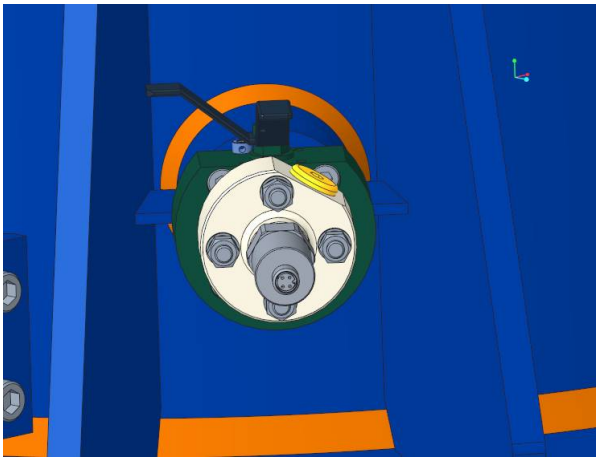


Fig. 30a

Bushings with pressure transducer

7.8.3 Oil sampling

For sampling please follow these instructions:

- Close the 1st way of the syringe cock (item 3) and open the 2nd way
- Slowly fill the syringe with the oil up to the appropriate volume (approx. 60-100 cm^3)
- Shut off both 2nd way of the cock (item 3) and the bushing's valve
- Remove the syringe by unplugging the cock (item 3) from the tube
- Set the syringe with the cock (item 3) being up
- Unplug the cock (item 3) 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
- Remove the pipe from the plug, unscrew the sampling flange and screw the original one

The abovementioned operations involve, on a whole, a sampling of about 0.2-0.3 litres of bushing oil.

After a certain number of sampling operations (6-8), the oil pressure can drop. In this case (if the pressure drop is higher than 0,2 bar respect to the lower curve of par. 4.7 (fig. 25), according to the temperature), it is necessary to restore the correct pressure, according to the curve p-T (fig. 25 of par. 4.7), by means of an injection of mineral oil, under vacuum, trough the same valve used for the oil sampling.

8 DISPOSAL AT THE END OF LIFETIME

The bushing consists of the following material:

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
Top oil expansion vessel	Aluminium alloy
Flange and extension	Aluminium alloy
PF tap and cover	Nickel or tin coated brass, tin coated copper
Top insulator	Either porcelain acc. to IEC60672 or composite insulator made of: Glass fibre reinforced epoxy Silicone
Insulator fittings	Aluminium alloy
Bottom insulator	Either porcelain acc. IEC60672 or epoxy resin
Bottom shield	Aluminium alloy covered with either epoxy paint or epoxy resin