PNO

Condenser Bushing from 36 up to 170 kV
Oil-to-Air - Oil-Impregnated Paper

PNO bushings are capacitance graded bushings with an oil-impregnated paper core. They meet IEC 60137 Standards: insulated bushings for alternating voltages above 1000 V. They are designed for use in power transformers and can be installed up to a maximum of 45° inclination off the vertical.

Design, components and manufacturing technology promote an average lifetime in excess of 30 years under normal operating conditions.

Voltage and Current Ratings

Rated voltage range for PNO bushings, normal cantilever load, is 36 to 170 kV. PNO bushings, for a rated voltage, are designed in order to have the same overall dimensions for all normal service currents and connection types.

There are three connection alternatives for the conductor:
- Draw lead connection for bushings at rated current 800 A and 1000 A
- Draw rod connection for 1250 A
- Bottom connection, using a rigid conductor, for 1600 A and above.

Using suitable accessories, any draw rod 1250 A bushing can be converted to draw lead bushings, only for minimum under flange sleeve length, and vice versa. Minimum 1250 A draw lead conductor sections are listed in fig. 11.

Standards
- IEC 60137

Key Benefits
- Bushings with longer lifetime and higher reliability
- Possibility to use bushings under extreme weather condition (lower pour-point value)
- No performance reduction with age
- Oil level visible from any side

Imagination at work
PNO Bushings Main Features

IEC Standards Condenser Bushings

- Range 36 to 170 kV
- Current up to 3150 A
- Oil-Impregnated Paper
- Air side: porcelain insulator or composite insulator
- Oil side: epoxy resin insulator
- Partial discharge: max. 5 pC at 1.5 Uₘₐₓ/Vₘₚ₃
- Provided with power factor tap (voltage tap upon request)
- Draw lead for 800-1000 A - draw rod for 1250 A; bottom connection for 1600 A applications and above
- Head made of special UHV filter prismatic glass with oil level indication visible at any angle of sight
- Flange made of cast aluminum alloy. Standard angle of installation max of 45° off vertical

Fig. 1: Bushings 36 to 170 kV Normal Cantilever Load

1. HV Terminal
2. UhV filter glass
3. Porcelain
4. OIP Condenser
5. Winding tube
6. Power factor tap or voltage tap
7. Flange
8. Epoxy resin insulator
9. Oil side shield

Fig. 1: Bushings 36 to 170 kV Normal Cantilever load

Bushing Designation

<table>
<thead>
<tr>
<th>PNO</th>
<th>IEC type condenser bushings, oil-impregnated paper (OIP) oil-to-air application</th>
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</thead>
<tbody>
<tr>
<td>145</td>
<td>Insulation class in kV</td>
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<tr>
<td>650</td>
<td>BIL in kV</td>
</tr>
<tr>
<td>800</td>
<td>Rated current in A</td>
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</table>

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**Air Side**

The air side insulator is made of brown porcelain. Grey porcelain or composite insulator (resin fiberglass envelop covered by silicone sheds) is available on request.

The typical creepage distance is suitable for very heavy polluted atmospheres.

The shed configuration is an alternating type: short-long shed. This is the most effective solution, proven by salt spray tests. The shed profile complies with IEC 60815 - 2008 recommendations.

A one-piece porcelain or multiple-piece porcelain, in order to meet standards or special requirements, is used for bushings. Multiple pieces are glued using epoxy resin, without use of gaskets and the final porcelain is considered as a single piece (it passes tests IEC 60233- 1974, clause 6 tests).

**Flange**

The flange is made of cast aluminum, and is equipped with the following accessories:

- Lifting holes
- Power factor tap, tested at 2 kV for 60 s (fig. 3), and/or voltage tap, upon request (fig. 4)
- Buchholz relay connection: 1/2” gas outlet plug
- Oil sampling plug (for 145 kV bushings).

**Top Terminal**

Standard bushing top terminal is made of aluminum without any surface treatment. Upon request, it can be supplied in tinned or silvered copper. Draw lead or draw rod type bushings (800 A and 1250 A) have a removable top terminal. This terminal is connected to the copper inner terminal lug or the draw rod by means of multi-blade contacts and is secured to the bushing head by screws. In bottom connected bushings (1600 A), the inner non-removable rod also acts as the top terminal.

**Head and Oil Level Indication**

The metal components of the head are made of a cast aluminum alloy. Bushings have an oil head reservoir, prismatic in shape, made of borosilicate glass, and containing a UHV filter. This allows for an easy check of the oil level even from a distance and at any angle of sight.
Oil Side

The oil side envelope is made of a molded epoxy resin. This resin is a two-part compound consisting of a resin base and a hardener; the filler material is quartz sand. The epoxy resin envelope permits shapes, thickness and dimensional tolerances not possible with porcelain.

Under flange sleeve length for CT accommodation, different from standard, is available upon request. In this case, the grounded part is obtained by means of a metallic tube or directly by the last metallic layer inside the condenser body.

Oil Side Shield

The bottom end of the bushing is shielded by a proper deflector, made of aluminum alloy. It is designed to reduce the electric field stress in oil and to screen the connection between the lead coming from the transformer winding and the bushing itself.

Assembling

The mechanical coupling among all the parts of the bushing is made by means of springs placed into the head of the bushings.

Insulating Fluid

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 / 2.5 mm)
- 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

Gaskets

Made of Viton®, a fluoroelastomer (FPM), o-ring type. They are compatible with all the fluids they are in contact with (bushing impregnating synthetic oil and transformer mineral oil). Air side gaskets are carefully protected, by means of a sealing, against influence of polluting weather elements.

For special requirements, such as low ambient temperatures (down to -55°C), special o-rings are used.
Arcing Horns

Adjustable arcing horns are available upon request. The upper arcing horn is fixed by means of one screw used to secure the top terminal, while the bottom one is fixed on a proper threaded flange hole.

Transformer Oil

Transformer oil must have a water content less than 15 ppm for voltage up to 145 kV and less than 10 ppm for 170 kV and above rated voltage. Its dielectric strength must be higher than 60 kV, according to IEC 60156.

Tests

All bushings have electrical characteristics and are tested in compliance with the latest edition of IEC 60137 Standards: insulated bushing for alternating voltages above 1000 V and main national Standards.

Type Tests

Measurement of dielectric dissipation factor (tanδ), capacitance and partial discharge quantity before and after the series of type tests:
- Wet power-frequency voltage withstand test
- Temperature rise test
- Verification of thermal short-time current withstand
- Cantilever load withstand test
- Tightness test
- Verification of dimensions

Routine Tests

- Dielectric dissipation factor (tanδ), capacitance and partial discharge quantity measurement
- Dry lightning impulse voltage withstand test (BIL), when prescribed
- Dry power-frequency voltage withstand test
- Measurement of partial discharge quantity
- Test of tap insulation
- Tightness test
- Tightness test at the flange
- Visual inspection and dimensional check

Fig. 5: Discharge distance for a bushing equipped with arcing horns
## PNO Condenser Bushings

### PNO Range from 36 to 170 kV: Ratings / Dimensions

<table>
<thead>
<tr>
<th>Type</th>
<th>Nominal System Voltage</th>
<th>Rated line-to-earth voltage</th>
<th>Bl.</th>
<th>Rated current</th>
<th>Dry power frequency withstand voltage (for 60s)</th>
<th>Wet power frequency withstand voltage for 60s</th>
<th>Flexible draw lead connection</th>
<th>Rigid draw lead connection</th>
<th>Bottom connection</th>
<th>K min. (ICT pocket)</th>
<th>Creepage distance (for very high polluted atmosphere)</th>
<th>Arcing distance</th>
<th>Cantilever load</th>
<th>Weight</th>
<th>Max. Operating Altitude</th>
<th>H (discharge distance) +/-10%</th>
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<td>120</td>
<td>1500</td>
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1) Other available standard: 300 mm
2) For K minimum

| Type | D1 | D2 | D3 | D4 | D5 | D6 | R7 | D10 | D11 | D13 | L2 | L3 | LA | L5 | L6 | L8 | L9 | t1 | n | F |
|------|----|----|----|----|----|----|----|-----|-----|-----|----|----|----|----|----|----|----|----|----|
| 36.200. | 1000 | 100 | 185 | 225 | 40 | 170 | 35 | -- | -- | -- | 690 | 80 | 180 | -- | -- | 14 | 6 |
|       | 1250 | 100 | 185 | 225 | 40 | 170 | 35 | -- | -- | -- | 32 | 125 | 88 | 766 | 525 | 125 | 265 | -- | -- | 16 | 8 |
|       | 1600 | 100 | 185 | 225 | 40 | 170 | 35 | -- | -- | -- | 100 | 265 | 32 | 760 | 125 | 125 | 367 | -- | -- | 16 | 8 |
| 72.5.350. | 1250 | 100 | 185 | 225 | 40 | 170 | 35 | -- | -- | -- | 32 | 125 | 88 | 766 | 525 | 125 | 265 | -- | -- | 16 | 8 |
|       | 1600 | 100 | 185 | 225 | 40 | 170 | 35 | -- | -- | -- | 100 | 265 | 32 | 760 | 125 | 125 | 367 | -- | -- | 16 | 8 |
| 123.550. | 1250 | 100 | 185 | 225 | 40 | 170 | 35 | -- | -- | -- | 32 | 125 | 88 | 766 | 525 | 125 | 265 | -- | -- | 16 | 8 |
|       | 1600 | 100 | 185 | 225 | 40 | 170 | 35 | -- | -- | -- | 100 | 265 | 32 | 760 | 125 | 125 | 367 | -- | -- | 16 | 8 |
| 145.650. | 800 | 145 | 290 | 335 | 40 | 230 | 35 | 225 | 70 | 130 | 1655 | 1495 | 80 | 475 | 1510 | 50 | 19 | 12 | 16 |
| 170.750 | 800 | 170 | 290 | 335 | 40 | 230 | 35 | 225 | 70 | 130 | 1855 | 1685 | 80 | 475 | 1702 | 50 | 19 | 12 | 16 |

1) For K minimum

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**Fig. 6:** H1 head type (Draw lead or draw rod)

**Fig. 7:** H2 head type (Bottom connection)
Fig. 8: Draw lead conductor sections

Fig. 9: PNO Bushings 36 through 170 kV

Fig. 10: Flange fixing holes
Packing - Transportation

After tests and before packing, the bushing is cleaned of any oil and or dust. Thanks to a special device to prevent the diffusion of the nitrogen cushion out of the head and into the lower end of the bushings, each bushing can be packed and shipped secured in horizontal position. This insures minimal crate dimensions and reduced transportation costs.

Proper protection is used for oil side shields. Bushings up to and including 170 kV are normally shipped in crates containing three pieces.

Nameplate

Each bushing is provided with a nameplate, containing complete electrical data and the serial number, in accordance with the requirements of IEC Standards.

The aluminum nameplate, is secured to the flange with rivets and includes the following information (fig. 13):

Fig. 13: Identification Nameplate