# 5 TRANSFORMER TERMINALS

## 5.1 HV Bushing "ABB" GOB 550/800; LF 123061-K

- Technical guide ..... 1ZSE2750-102en
- Installation and maintenance guide ..... 2750 515-12en

## 5.2 LV Bushing 20NF 5000 ..... 349004

| Datum Date | Izradio Designed | Odobrio Approved | Promjena Re |
|---|---|---|---|
| VIII 2005. | ing. Tasjak | mr. Biloš | |



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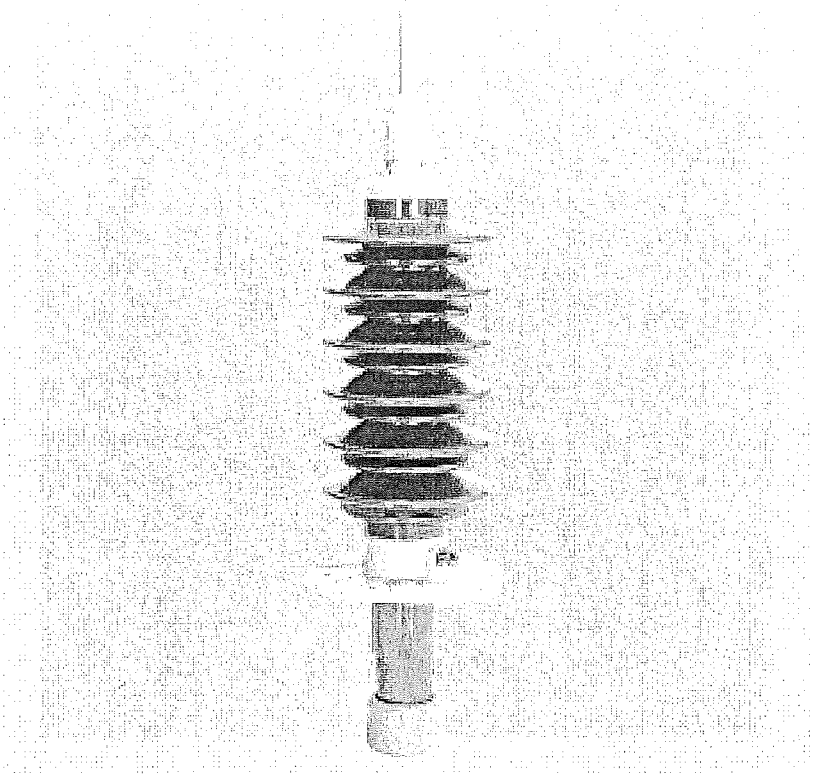
# Transformer bushings, type GOB

Technical guide



This Technical Guide has been produced to allow transformer manufacturers, and their designers and engineers, access to all the technical information required to assist them in their selection of the appropriate transformer bushing. The guide should be used in conjunction with the *Selection Guide* to allow the optimum selection to be made.

The technical information pertaining to bushings manufactured by ABB has been divided into separate documents, with one document for each type.

The information provided in this document is intended to be general and does not cover all possible applications. Any specific application not covered should be referred directly to ABB, or its authorised representative.

ABB makes no warranty or representation and assumes no liability for the accuracy of the information in this document or for the use of such information. All information in this document is subject to change without notice.

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# Design

The bushing is built up around a centre tube on which the condenser body is wound.

The upper insulator, lower insulator and mounting flange are held between the end plates by the centre tube. Sealing is accomplished by oil-resistant rubber gaskets in grooves.

The annular space between the condenser body and the porcelain is filled with transformer oil. A gas-filled expansion space is left at the top.

For GOB bushings without oil level gauge the oil level can be checked by means of a dipstick in the oil filling hole.

The lower end is shielded by an epoxy resin insulated aluminium shield.

The inner terminal is attached to the centre tube by means of a through-going resilient pin which becomes locked when the outer terminal is screwed on. The design with this special resilient pin has been patented by ABB, and the pin ensures effective electrical contact between the inner and outer terminals.

The inner terminal can be chosen for connection to leads either by brazing or crimping.

The outer terminal is available in aluminium or copper alloy and can be supplemented by terminal plates of corresponding material.

The upper insulator is made in one piece of high quality electrical porcelain. The mounting flange is manufactured of corrosion-resistant aluminium alloy.

The mounting flange, the top housing and the top washer are protected by painting with a two-component primer and a grey-blue finishing coat of paint. The standard colour is Munsell 5.5B 55/1.25, environmental class C3.

The bushings are delivered oil-filled and ready for use.

If the bushing is mounted with an inclination of more than 45° from the vertical, special measures may have to be taken to ensure sufficient filling of oil in the bushing. Further information can be obtained on request.

## Shed form

The shed form for all GOB bushings is of the anti-fog type with alternating long and short sheds. For each pair of sheds the ratio between nominal creepage distance and the axial length is 3.43 and the ratio between protected and nominal creepage distance is 0.40.

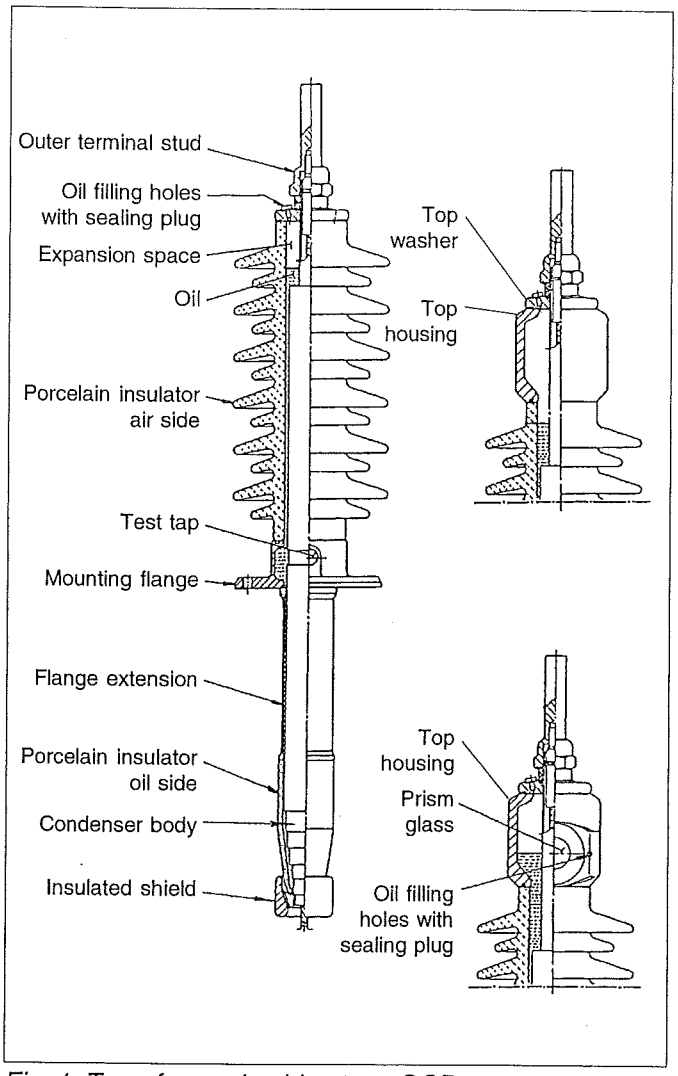



*Fig. 1. Transformer bushing type GOB*

According to IEC 815 the creepage factor C.F. is <3.2 and the profile factor P.F. is >1.1.

For special customer demands regarding creepage distance, other shed forms may be used.

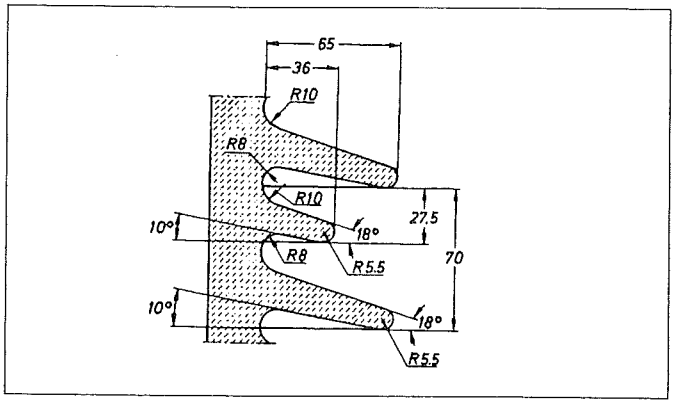



*Fig. 2. Shed form*

## Test tap

The outer conducting layer of the condenser body is connected to an insulated test tap on the flange. During operation the test tap cover must be screwed on, in order to earth the outer layer to the flange. The max. test voltage of the tap is 2 kV, 50 Hz for 1 minute. Max. service voltage is 600 V.

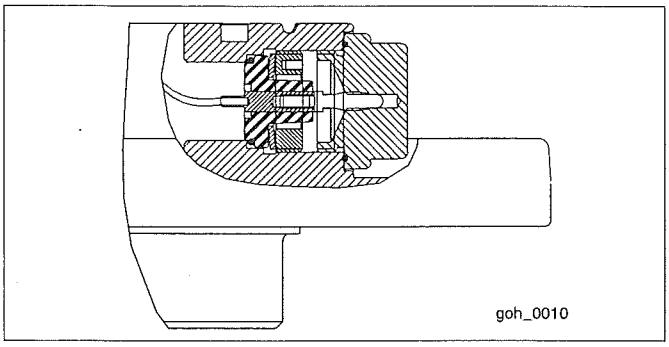



*Fig. 3. Test tap*

# Testing

During the manufacture and on its completion the bushing is subjected to a number of routine tests. A tightness test is carried out on the assembled bushing after the final drying and impregnation. The test is made with an oil overpressure of 180 kPa (1.8 bar) for 12 hours at ambient temperature. No sign of leakage is allowed.

Each bushing is subjected to a final electrical routine test. The test is made at room temperature with the bushing submerged in oil. Capacitance and tan $\delta$ are measured in steps up to the power frequency withstand voltage, which is maintained for one minute.

Capacitance and tan $\delta$ are also measured at decreasing voltage at the same voltage levels as before the one minute test.

Measurements for detection of internal partial discharge (PD measurements) are also made. These measurements are carried out at the same time as the power frequency withstand test. PD measurements are made in steps up to the full test voltage and down. It is always demonstrated that the PD value is max. 5 pC at test voltage equal to the rated system voltage.

Type tests have been carried out according to IEC 137 and IEEE. Type test reports are available on request.

## Test tap adapter

For testing, a special test adapter is required for permanent connection of the test tap to the measuring circuits.

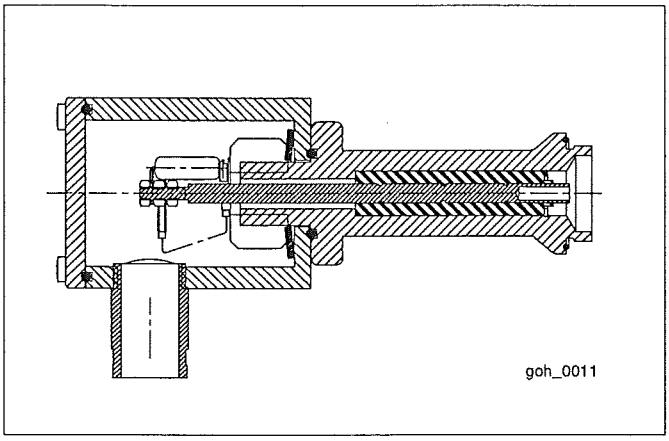



*Fig. 4. Test tap adapter, 2769 531-D.*

# Common specifications

| | |
|---|---|
| Application: | Transformers |
| Classification: | Oil impregnated paper, capacitance graded, outdoor-immersed bushing |
| Ambient temperature: | +40 to -40 °C, minimum value as per temperature class 2 of IEC 137 |
| Altitude of site: | < 1 000 m |
| Level of rain and humidity: | 1-2 mm rain/min horizontally and vertically, as per IEC 60-1 |
| Pollution level: | According to specified creepage distance and IEC 815[1] |
| Type of immersion medium: | Transformer oil. Maximum daily mean oil temperature 90 °C. Maximum temporary oil temperature 115 °C |
| Oil level below bushing flange: | Maximum 30 mm |
| Max. pressure of medium: | 100 kPa overpressure |
| Markings: | Conforming to IEC/ IEEE |

1) IEC 815 "Guide for selection of insulators with respect to polluted conditions."

# Dimensions

## Bushings without oil level gauge

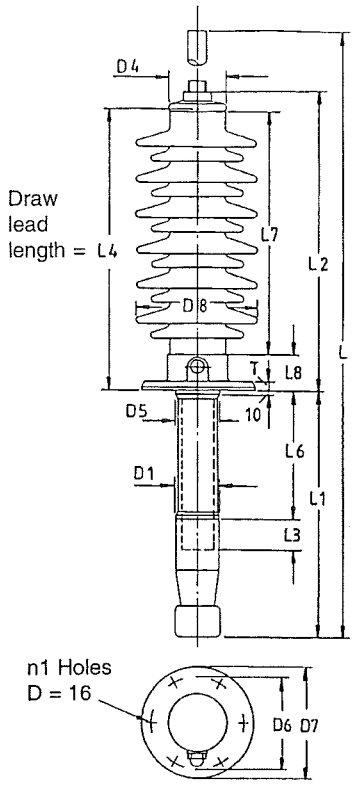



*Fig. 5.1. GOB design*

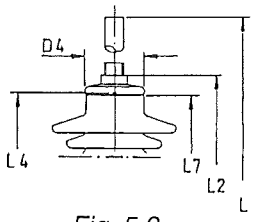



*Fig. 5.2. Top design*

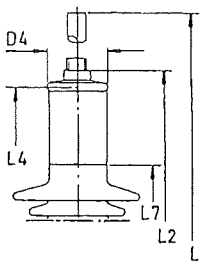



*Fig. 5.3 Top design*

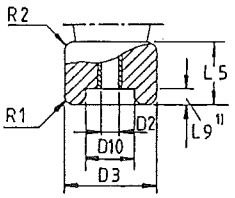



*Fig. 5.4*

[1] The bushings can be provided with a longer shield L9 + 50 mm, in which case dimensions L, L1 and L5 also increase by 50 mm.

| Type GOB | Rated current A | Cat. No. | Space for current trans-former mm | Net mass kg | Top design acc. to Fig. 5. | Dimensions in mm L[1] | L1 [1] | L2 | L3 | L4 | L5 [1] | L6 | L7 | L8 | L9 [1] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 250 | 800 | LF 123 013– | – | 23 | 2 | 998 | 240 | 590 | 65 | 555 | 60 | – | 480 | 70 | 15 |
| | | 015– | 300 | 25 | 2 | 1258 | 500 | 590 | | 555 | | 260 | | | |
| | | 083– | 500 | 27 | 3 | 1558 | 700 | 690 | | 655 | | 460 | | | |
| 250 | 1250 | LF 123 017– | – | 26 | 2 | 1063 | 255 | 605 | 65 | 580 | 75 | – | 480 | 70 | 25 |
| | | 019– | 300 | 29 | 2 | 1323 | 515 | 605 | | 580 | | 260 | | | |
| | | 085– | 500 | 31 | 3 | 1623 | 715 | 705 | | 680 | | 460 | | | |
| 325 | 800 | LF 123 025– | – | 27 | 2 | 1198 | 295 | 735 | 93 | 700 | 60 | – | 625 | 70 | 15 |
| | | 027– | 300 | 31 | 2 | 1458 | 555 | 735 | | 700 | | 260 | | | |
| | | 089– | 500 | 35 | 3 | 1758 | 755 | 835 | | 800 | | 460 | | | |
| 380 | 800 | LF 123 037– | – | 33 | 2 | 1303 | 345 | 790 | 98 | 755 | 60 | – | 680 | 70 | 15 |
| | | 039– | 300 | 37 | 2 | 1543 | 585 | 790 | | 755 | | 240 | | | |
| | | 095– | 500 | 39 | 3 | 1843 | 785 | 890 | | 855 | | 440 | | | |
| 380 | 1250 | LF 123 041– | – | 37 | 2 | 1368 | 360 | 805 | 98 | 780 | 75 | – | 680 | 70 | 25 |
| | | 043– | 300 | 39 | 2 | 1608 | 600 | 805 | | 780 | | 240 | | | |
| | | 097– | 500 | 43 | 3 | 1908 | 800 | 905 | | 880 | | 440 | | | |
| 450 | 800 | LF 123 049– | – | 42 | 2 | 1473 | 345 | 960 | 98 | 925 | 60 | – | 850 | 70 | 15 |
| | | 051– | 300 | 45 | 2 | 1713 | 585 | 960 | | 925 | | 240 | | | |
| | | 053– | 500 | 48 | 3 | 2013 | 785 | 1060 | | 1025 | | 440 | | | |
| 550 | 800 | LF 123 061– | 100 | 70 | 2 | 1823 | 495 | 1160 | 60 | 1125 | 90 | 95 | 1050 | 60 | 25 |
| | | 063– | 300 | 73 | 3 | 2108 | 680 | 1260 | | 1225 | | 280 | | | |
| | | 107– | 500 | 77 | 3 | 2308 | 880 | 1260 | | 1225 | | 480 | | | |
| 550 | 1250 | LF 123 065– | 100 | 105 | 2 | 1868 | 495 | 1170 | 68 | 1145 | 100 | 95 | 1050 | 60 | 30 |
| | | 067– | 300 | 109 | 3 | 2153 | 680 | 1270 | | 1245 | | 280 | | | |
| | | 109– | 500 | 115 | 3 | 2353 | 880 | 1270 | | 1245 | | 480 | | | |
| 650 | 1250 | LF 123 073– | 150 | 116 | 2 | 2153 | 580 | 1370 | 60 | 1345 | 100 | 120 | 1250 | 60 | 30 |
| | | 075– | 300 | 122 | 3 | 2413 | 740 | 1470 | | 1445 | | 280 | | | |
| | | 113– | 500 | 126 | 3 | 2613 | 940 | 1470 | | 1445 | | 480 | | | |
| 750 | 1250 | LF 123 077– | 200 | 180 | 2 | 2468 | 685 | 1580 | 70 | 1555 | 100 | 165 | 1460 | 60 | 30 |
| | | 078– | 300 | 190 | 3 | 2683 | 800 | 1680 | | 1655 | | 280 | | | |
| | | 079– | 500 | 200 | 3 | 2883 | 1000 | 1680 | | 1655 | | 480 | | | |

# Electrical data

| Type GOB | Rating: Rated voltage $U_R$ kV, RMS | Rating: Phase-to-earth voltage $U_Y$ kV, RMS | Rating: Dry lightning impulse kV, peak | Rating: Wet power frequency AC kV, RMS | Routine test: 1 min. dry 50 Hz kV, RMS | Design data: Dry switching impulse kV, peak | Nominal capacitances between conductor and test tap C1 ±10 % [pF] Space for current transformer: - | 100 | 150 | 200 | 300 | 500 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 250-800 | 52 | 52 | 250 | 105 | 120 | 230 | 125 | | | | 205 | 275 |
| 250-1250 | 52 | 52 | 250 | 105 | 120 | 230 | 165 | | | | 270 | 375 |
| 325-800 | 72.5 | 72.5 | 350 | 140 | 160 | 300 | 135 | | | | 200 | 260 |
| 380-800 | 100 | 72.5 | 380 | 150 | 162 | 330 | 145 | | | | 200 | 245 |
| 380-1250 | 100 | 72.5 | 380 | 150 | 162 | 330 | 185 | | | | 265 | 320 |
| 450-800 | 123 | 90 | 450 | 185 | 195 | 410 | 145 | | | | 200 | 245 |
| 550-800 | 170 | 123 | 550 | 230 | 260 | 470 | | 150 | | | 170 | 210 |
| 550-1250 | 170 | 123 | 550 | 230 | 260 | 470 | | 175 | | | 195 | 240 |
| 650-1250 | 170 | 145 | 650 | 275 | 300 | 580 | | | 190 | | 235 | 280 |
| 750-1250 | 170 | 170 | 750 | 325 | 365 | 670 | | | | 205 | 235 | 275 |

*Wet power frequency values apply to both IEC and ANSI requirements.*

**Dimensions are subject to modification without notice.**

| D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D10 | n1 | R1 | R2 | T | Creeepage distance: total mm | Creeepage distance: protected mm | Cantilever load: Max. permitted loading perpendicular to the terminal N | Cantilever load: 60 s Test N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 86 | 22 | 86 | 115 | 88 | 185 | 225 | 230 | 46 | 6 | 8 | 6 | 16 | 1500±50 | 580 | 1800 | 2340 |
| 101 | 34 | 112 | 120 | 101 | 250 | 290 | 245 | 70 | 8 | 12 | 10 | 16 | 1500±50 | 580 | 3000 | 4000 |
| 95 | 22 | 86 | 115 | 96 | 185 | 225 | 230 | 46 | 6 | 8 | 6 | 16 | 1980±50 | 775 | 1500 | 1950 |
| 95 | 22 | 86 | 115 | 96 | 185 | 225 | 240 | 46 | 6 | 8 | 6 | 16 | 2210±70 | 870 | 1400 | 1800 |
| 112 | 34 | 112 | 120 | 112 | 250 | 290 | 245 | 70 | 8 | 12 | 10 | 16 | 2210±70 | 870 | 2900 | 3750 |
| 95 | 22 | 86 | 115 | 96 | 185 | 225 | 245 | 46 | 6 | 8 | 6 | 16 | 2720±80 | 1060 | 1150 | 1500 |
| 126 | 22 | 118 | 145 | 150 | 250 | 290 | 280 | 50 | 8 | 12 | 12 | 18 | 3430±100 | 1350 | 1300 | 1800 |
| 160 | 34 | 140 | 175 | 200 | 290 | 335 | 300 | 70 | 12 | 15 | 15 | 20 | 3430±100 | 1350 | 2400 | 3100 |
| 160 | 34 | 140 | 175 | 200 | 290 | 335 | 305 | 70 | 12 | 15 | 15 | 20 | 4080±110 | 1620 | 2600 | 3380 |
| 184 | 34 | 140 | 230 | 184 | 290 | 335 | 350 | 70 | 12 | 15 | 15 | 20 | 4800±150 | 1700 | 2600 | 3350 |

# Dimensions

## Bushings with oil level gauge

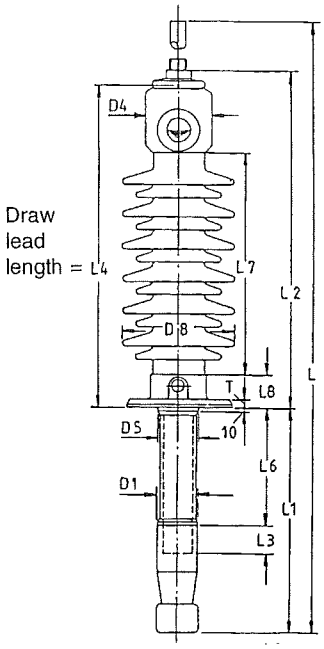



Fig. 6.1. GOB design.

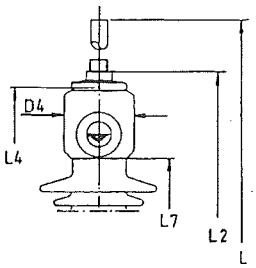



Fig. 6.2.
Top design

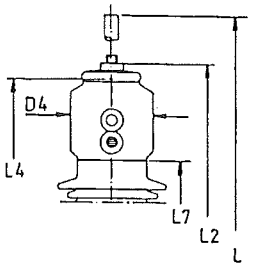



Fig. 6.3
Top design

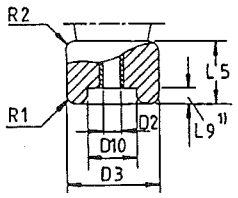
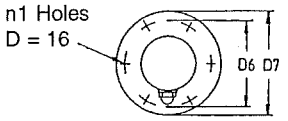



Fig. 6.4




1) The bushings can be provided with a longer shield L9 + 50 mm, in which case dimensions L, L1 and L5 also increase by 50 mm.

| Type GOB | Rated current A | Cat. No. | Space for current trans-former mm | Net mass kg | Top design acc. to Fig. 6. | Dimensions in mm L 1) | L1 1) | L2 | L3 | L4 | L5 1) | L6 | L7 | L8 | L9 1) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 250 | 800 | LF 123 171– | – | 24 | 2 | 1138 | 240 | 730 | 65 | 695 | 60 | – | 480 | 70 | 15 |
| | | 173– | 300 | 26 | | 1398 | 500 | | | | | 260 | | | |
| | | 175– | 500 | 28 | | 1598 | 700 | | | | | 460 | | | |
| 250 | 1250 | LF 123 167– | – | 28 | 2 | 1203 | 255 | 745 | 65 | 720 | 75 | – | 480 | 70 | 25 |
| | | 168– | 300 | 30 | | 1463 | 515 | | | | | 260 | | | |
| | | 169– | 500 | 33 | | 1663 | 715 | | | | | 460 | | | |
| 325 | 800 | LF 123 177– | – | 28 | 2 | 1338 | 295 | 875 | 93 | 840 | 60 | – | 625 | 70 | 15 |
| | | 179– | 300 | 32 | | 1598 | 555 | | | | | 260 | | | |
| | | 181– | 500 | 36 | | 1798 | 755 | | | | | 460 | | | |
| 380 | 800 | LF 123 183– | – | 34 | 2 | 1443 | 345 | 930 | 98 | 895 | 60 | – | 680 | 70 | 15 |
| | | 185– | 300 | 38 | | 1683 | 585 | | | | | 240 | | | |
| | | 187– | 500 | 40 | | 1883 | 785 | | | | | 440 | | | |
| 380 | 1250 | LF 123 101– | – | 38 | 2 | 1508 | 360 | 945 | 98 | 920 | 75 | – | 680 | 70 | 25 |
| | | 102– | 300 | 41 | | 1748 | 600 | | | | | 240 | | | |
| | | 103– | 500 | 44 | | 1948 | 800 | | | | | 440 | | | |
| 450 | 800 | LF 123 145– | – | 43 | 2 | 1613 | 345 | 1100 | 98 | 1065 | 60 | – | 850 | 70 | 15 |
| | | 147– | 300 | 46 | | 1853 | 585 | | | | | 240 | | | |
| | | 149– | 500 | 49 | | 2053 | 785 | | | | | 440 | | | |
| 550 | 800 | LF 123 189– | 100 | 71 | 2 | 1963 | 495 | 1300 | 60 | 1265 | 90 | 95 | 1050 | 60 | 25 |
| | | 190– | 300 | 74 | | 2148 | 680 | | | | | 280 | | | |
| | | 191– | 500 | 78 | | 2348 | 880 | | | | | 480 | | | |
| 550 | 1250 | LF 123 142– | 100 | 106 | 2 | 2008 | 495 | 1310 | 68 | 1285 | 100 | 95 | 1050 | 60 | 30 |
| | | 143– | 300 | 110 | | 2193 | 680 | | | | | 280 | | | |
| | | 144– | 500 | 116 | | 2393 | 880 | | | | | 480 | | | |
| 650 | 1250 | LF 123 192– | 150 | 118 | 2 | 2293 | 580 | 1510 | 60 | 1485 | 100 | 120 | 1250 | 60 | 30 |
| | | 193– | 300 | 124 | | 2453 | 740 | | | | | 280 | | | |
| | | 194– | 500 | 128 | | 2653 | 940 | | | | | 480 | | | |
| 750 | 1250 | LF 123 104– | 200 | 187 | 3 | 2718 | 685 | 1830 | 70 | 1805 | 100 | 165 | 1460 | 60 | 30 |
| | | 105– | 300 | 197 | | 2833 | 800 | | | | | 280 | | | |
| | | 106– | 500 | 207 | | 3033 | 1000 | | | | | 480 | | | |

# Electrical data

| Type GOB | Rating: Rated voltage $U_R$ kV, RMS | Rating: Phase-to-earth voltage $U_Y$ kV, RMS | Rating: Dry lightning impulse kV, peak | Rating: Wet power frequency AC kV, RMS | Routine test: 1 min. dry 50 Hz kV, RMS | Design data: Dry switching impulse kV, peak | Nominal capacitances between conductor and test tap C1 ±10 % [pF] Space for current transformer: - | 100 | 150 | 200 | 300 | 500 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 250-800 | 52 | 52 | 250 | 105 | 120 | 230 | 125 | | | | 205 | 275 |
| 250-1250 | 52 | 52 | 250 | 105 | 120 | 230 | 165 | | | | 270 | 375 |
| 325-800 | 72.5 | 72.5 | 350 | 140 | 160 | 300 | 135 | | | | 200 | 260 |
| 380-800 | 100 | 72.5 | 380 | 150 | 162 | 330 | 145 | | | | 200 | 245 |
| 380-1250 | 100 | 72.5 | 380 | 150 | 162 | 330 | 185 | | | | 265 | 320 |
| 450-800 | 123 | 90 | 450 | 185 | 195 | 410 | 145 | | | | 200 | 245 |
| 550-800 | 170 | 123 | 550 | 230 | 260 | 470 | | 150 | | | 170 | 210 |
| 550-1250 | 170 | 123 | 550 | 230 | 260 | 470 | | 170 | | | 195 | 240 |
| 650-1250 | 170 | 145 | 650 | 275 | 300 | 580 | | | 205 | | 235 | 280 |
| 750-1250 | 170 | 170 | 750 | 325 | 365 | 670 | | | | 205 | 235 | 275 |

*Wet power frequency values apply to both IEC and ANSI requirements.*

**Dimensions are subject to modification without notice.**

| D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D10 | n1 | R1 | R2 | T | Creepage distance: total mm | Creepage distance: protected mm | Cantilever load: Max. permitted loading perpendicular to the terminal N | Cantilever load: 60 s Test N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 86 | 22 | 86 | 140 | 88 | 185 | 225 | 230 | 46 | 6 | 8 | 6 | 16 | 1500±50 | 580 | 1800 | 2340 |
| 101 | 34 | 112 | 140 | 101 | 250 | 290 | 245 | 70 | 8 | 12 | 10 | 16 | 1500±50 | 580 | 3000 | 4000 |
| 95 | 22 | 86 | 140 | 96 | 185 | 225 | 230 | 46 | 6 | 8 | 6 | 16 | 1980±50 | 775 | 1500 | 1950 |
| 95 | 22 | 86 | 140 | 96 | 185 | 225 | 240 | 46 | 6 | 8 | 6 | 16 | 2210±70 | 870 | 1400 | 1800 |
| 112 | 34 | 112 | 140 | 112 | 250 | 290 | 245 | 70 | 8 | 12 | 10 | 16 | 2210±70 | 870 | 2900 | 3750 |
| 95 | 22 | 86 | 140 | 96 | 185 | 225 | 245 | 46 | 6 | 8 | 6 | 16 | 2720±80 | 1060 | 1150 | 1500 |
| 126 | 22 | 118 | 200 | 150 | 250 | 290 | 280 | 50 | 8 | 12 | 12 | 18 | 3430±100 | 1350 | 1300 | 1800 |
| 160 | 34 | 140 | 265 | 200 | 290 | 335 | 300 | 70 | 12 | 15 | 15 | 20 | 3430±100 | 1350 | 2400 | 3100 |
| 160 | 34 | 140 | 265 | 200 | 290 | 335 | 305 | 70 | 12 | 15 | 15 | 20 | 4080±110 | 1620 | 2600 | 3380 |
| 184 | 34 | 140 | 265 | 184 | 290 | 335 | 350 | 70 | 12 | 15 | 15 | 20 | 4800±150 | 1700 | 2600 | 3350 |

# Connection details

## Inner terminal

Stud made of copper for connection of draw lead. The inner terminal must be provided with an outer terminal.

For crimping, hexagonal or other symmetrical dies shall be used. Pressure 200 kN.

| Material and design | Conductor area mm² | Cat. No. | Dimensions (mm) D1 | D2 | L | Mass kg |
|---|---|---|---|---|---|---|
| Copper for crimping or brazing | 50 | LF 170 010-M | 11 | 14,5 | 35 | 0,3 |
| | 70 | -N | 13 | 17 | 35 | 0,3 |
| | 95 | -L | 15 | 20 | 35 | 0,3 |
| Copper for brazing only | ≤ 150 undrilled | LF 170 011-S | 18 | 20 | 35 | 0,3 |
| | | -U | 5 | 20 | 35 | 0,3 |
| | ≤ 285 undrilled | -T | 29 | 32 | 20 | 0,6 |
| | | -V | 5 | 32 | 20 | 0,6 |

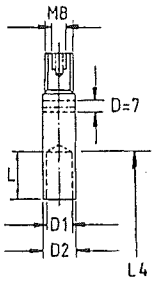



*Fig. 7. Inner terminal.*

## Solid rod conductor

The rod is produced from electrolytic copper and is divided into two parts. For the 800 A conductor the two parts are held together by a centre bolt with a resilient locking pin. For the 1250 A conductor the two parts are connected by counter-sunk screws.

The lower part of the solid rod is designed to enable connection by brazing.

The solid rod conductor can be divided either:
Alt. 1: 20 mm below the bushing flange, or
Alt. 2: 20 mm below the upper end of the bottom porcelain.

The solid rod conductor must be provided with an outer terminal.

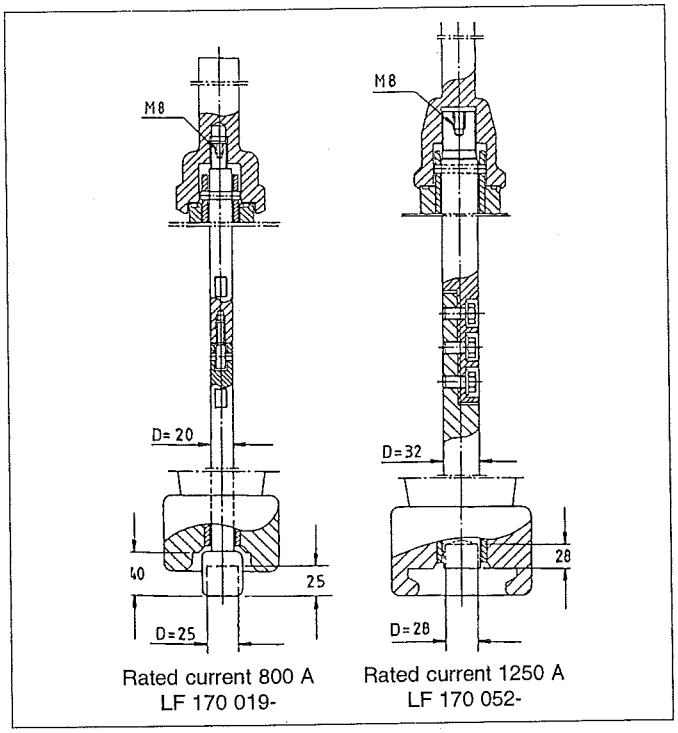



*Fig. 8. Solid rod conductor.*

## Outer terminal assembly

Stud made of copper or aluminium with O-ring and locking pin.

Other types can be provided on request.

| Material | Cat. No. | Dimensions (mm) D | L | N | Mass kg | For bushings with D2 mm |
|---|---|---|---|---|---|---|
| Aluminium | LF 170 001-A | 30 | 170 | 55 | 0.5 | 22 |
| | -B | 30 | 205 | 66 | 0.8 | 34 |
| Copper alloy | LF 170 002-A | 30 | 170 | 55 | 1.2 | 22 |
| | -B | 30 | 205 | 66 | 2.3 | 34 |

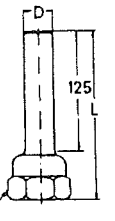



*Fig. 9. Outer terminal assembly.*

## Separate terminal plate with bolts

The separate terminal plate is used for connecting the bushing to the line conductor.

| Material | Cat. No. |
|---|---|
| Aluminium | LF 170 014-A |
| Copper alloy | LF 170 021-A |

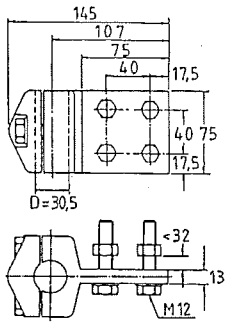



*Fig. 10. Separate terminal plate with bolts.*

## Arcing horns

Arcing horns of galvanised steel can be mounted on the bushing.

The lower rod is fastened onto the flange with one of the fixing screws and the upper rod by means of a bracket on the outer terminal.

The gap distances for standard arcing horns are shown in the table. Other gap distances on request.

| Bushing type | K mm | C mm | H mm |
|---|---|---|---|
| GOB 250 | 230–440 | 315 | 112 |
| GOB 325 | 320–580 | 315 | 112 |
| GOB 380 | 400–620 | 315 | 112 |
| GOB 450 | 400–780 | 315 | 112 |
| GOB 550 | 620–960 | 315 | 114 |
| GOB 650 | 700–1080 | 380 | 224 |
| GOB 750 | 820–1290 | 380 | 224 |

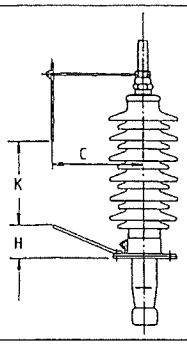



*Fig. 11. Gap distances.*

# Conductor loading

The rated currents listed in this catalogue are the standardised values according to IEC 137 (1995) which, with the largest possible conductor, fulfil the temperature rise test.

The GOB bushings fulfil the temperature rise test requirements according to IEC 137 (1995) and IEEE C57.19.00-1991:

| Rated current of bushing A | Conductor | Permissible current IEC A | Permissible current IEEE A |
|---|---|---|---|
| 800 | Solid rod LF 170 019 | 800 | 730 |
| 1250 | Solid rod LF 170 052 | 1250 | 1200 |
| 800, 1250 | Stranded cable 50 mm² | 165 | 150 |
| 800, 1250 | Stranded cable 70 mm² | 225 | 210 |
| 800, 1250 | Stranded cable 95 mm² | 300 | 285 |
| 800, 1250 | Stranded cable 150 mm² | 475 | 415 |
| 1250 | Stranded cable 185 mm² | 530 | 460 |
| 1250 | Stranded cable 285 mm² | 665 | 570 |

## Overloading of bushings

If the conductor for the bushing is selected with 120 % of the rated current of the transformer, the bushing is considered to be able to withstand the overload conditions stated in IEC 354 without further clarifications or tests, according to IEC 137.

## Short-time current

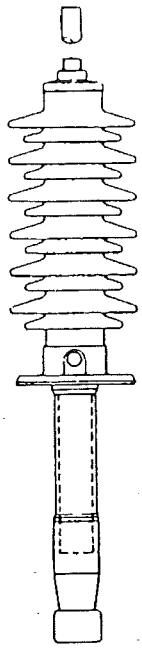
The rated thermal short-time current ($I_{th}$) is calculated according to IEC 137 (1995).

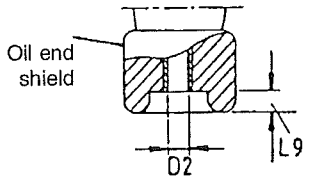
For draw-lead of stranded copper values are given for 100mm². For other areas the short-time current is directly proportional to the area.

| Conductor | Rated current A | Area mm² | Short-time current ($I_{th}$) 1s kA, RMS | Short-time current ($I_{th}$) 2s kA, RMS | Dynamic current ($I_d$) kA, peak |
|---|---|---|---|---|---|
| Solid rod | 800 | - | 30 | 21 | 52 |
| Solid rod | 1250 | - | 70 | 50 | 125 |
| Stranded draw-lead | 365 | 100 | 9.6 | 6.8 | 17 |

# Ordering particulars

## Bushings without oil level gauge



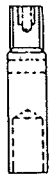



When ordering, please state:

- Type and Catalogue number for bushings.
- Catalogue number for inner and outer terminal assembly.
- Additional accessories or modifications.
- Test required, in addition to the normal routine tests.
- Test tap adapter, if required.

**Note:**
The Cat. No. should have one of the following letters added to it, to indicate the type of insulator and oil end shield:

–K Normal oil end shield, brown porcelain
–L Normal oil end shield, light grey porcelain
–M Longer oil end shield, brown porcelain
–N Longer oil end shield, light grey porcelain

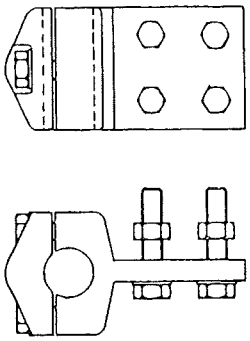


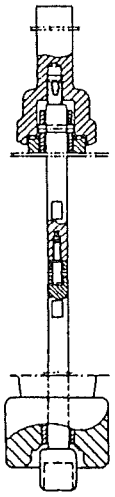
### Bushings

### Connection details

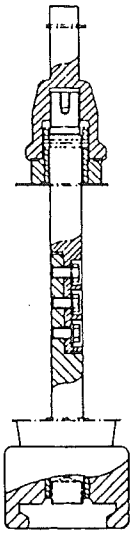
**Inner terminal stud: Cat. No. LF 170**

| Type GOB | Rated current A | Cat. No. | Space for current transformer mm | Bushing tube (See fig.) D2, mm | For crimping or brazing Conductor area 50 mm² | 70 mm² | 95 mm² | For brazing Conductor area ≤150 mm² | ≤285 mm² | Undrilled with pilot hole |
|---|---|---|---|---|---|---|---|---|---|---|
| 250 | 800 | **LF 123 013–**<br>**015–**<br>**083–** | –<br>300<br>500 | 22 | **010-M** | **010-N** | **010-L** | **011-S** | – | **011-U** |
| 250 | 1250 | **LF 123 017–**<br>**019–**<br>**085–** | –<br>300<br>500 | 34 | – | – | – | – | **011-T** | **011-V** |
| 425 | 800 | **LF 123 025–**<br>**027–**<br>**089–** | –<br>300<br>500 | 22 | **010-M** | **010-N** | **010-L** | **011-S** | – | **011-U** |
| 380 | 800 | **LF 123 037–**<br>**039–**<br>**095–** | –<br>300<br>500 | 22 | **010-M** | **010-N** | **010-L** | **011-S** | – | **011-U** |
| 380 | 1250 | **LF 123 041–**<br>**043–**<br>**097–** | –<br>300<br>500 | 34 | – | – | – | – | **011-T** | **011-V** |
| 450 | 800 | **LF 123 049–**<br>**051–**<br>**053–** | –<br>300<br>500 | 22 | **010-M** | **010-N** | **010-L** | **011-S** | – | **011-U** |
| 550 | 800 | **LF 123 061–**<br>**063–**<br>**107–** | 100<br>300<br>500 | 22 | **010-M** | **010-N** | **010-L** | **011-S** | – | **011-U** |
| 550 | 1250 | **LF 123 065–**<br>**067–**<br>**109–** | 100<br>300<br>500 | 34 | – | – | – | – | **011-T** | **011-V** |
| 650 | 1250 | **LF 123 073–**<br>**075–**<br>**113–** | 150<br>300<br>500 | 34 | – | – | – | – | **011-T** | **011-V** |
| 750 | 1250 | **LF 123 077–**<br>**078–**<br>**079–** | 200<br>300<br>500 | 34 | – | – | – | – | **011-T** | **011-V** |

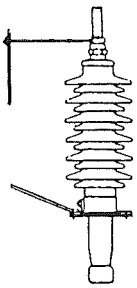




LF 170 019-
800 A



LF 170 052-
1250 A

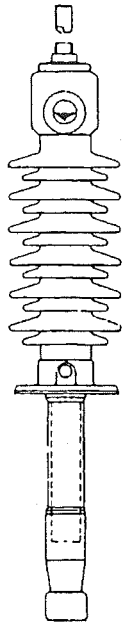


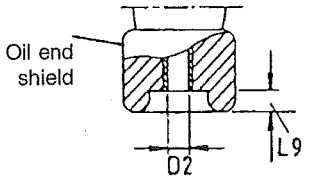
**Outer terminal assembly: Cat. No. LF 170**

| Stud with O-ring and locking pin | | Separate terminal plate with bolts | | Solid rod conductor Cat. No. LF 170 | | | Arcing horns Cat. No. LF 170 |
|---|---|---|---|---|---|---|---|
| Aluminium | Copper alloy | Aluminium | Copper alloy | Alt. 1 | Alt. 2 | Mass kg | |
| 001-A | 002-A | 014-A | 021-A | 019 -A | – | 2.6 | 004 -A |
| | | | | -D | 019 -B | 3.3 | -A |
| | | | | -E | -C | 4.2 | -B |
| 001-B | 002-B | 014-A | 021-A | 052 -A | – | 6.8 | 004 -A |
| | | | | -D | 052 -B | 8.4 | -A |
| | | | | -E | -C | 10.6 | -B |
| )01-A | 002-A | 014-A | 021-A | 019 -F | – | 3.1 | 004 -A |
| | | | | -K | 019 -G | 3.9 | -A |
| | | | | -L | -H | 4.7 | -B |
| 001-A | 002-A | 014-A | 021-A | 019 -M | – | 3.5 | 004 -A |
| | | | | -R | 019 -N | 4.2 | -A |
| | | | | -S | -P | 5.0 | -B |
| 001-B | 002-B | 014-A | 021-A | 052 -V | – | 8.6 | 004 -B |
| | | | | -Z | 052 -X | 10.4 | -B |
| | | | | -AA | -Y | 12.7 | -B |
| 001-A | 002-A | 014-A | 021-A | 019 -BL | – | 4.0 | 004 -B |
| | | | | -BM | 019 -BN | 4.7 | -B |
| | | | | -BP | -BR | 5.5 | -C |
| 001-A | 002-A | 014-A | 021-A | 019 -T | – | 4.9 | 004 -B |
| | | | | -X | 019 -U | 5.7 | -C |
| | | | | -Y | -V | 6.3 | -C |
| 001-B | 002-B | 014-A | 021-A | 052 -AM | – | 12.0 | 004 -B |
| | | | | -AN | 052 -AP | 14.1 | -C |
| | | | | -AR | -AS | 15.5 | -C |
| 001-B | 002-B | 014-A | 021-A | 052 -F | – | 14.0 | 005 -A |
| | | | | -K | 052 -G | 15.9 | -B |
| | | | | -L | -H | 17.5 | -B |
| 001-B | 002-B | 014-A | 021-A | 052 -M | – | 16.3 | 005 -B |
| | | | | -R | 052 -N | 18.0 | -E |
| | | | | -S | -P | 19.5 | -E |

# Ordering particulars

## Bushings with oil level gauge



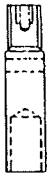



When ordering, please state:

- Type and Catalogue number for bushings.
- Catalogue number for inner and outer terminal assembly.
- Additional accessories or modifications.
- Test required, in addition to the normal routine tests.
- Test tap adapter, if required.

**Note:**
The Cat. No. should have one of the following letters added to it, to indicate the type of insulator and oil end shield:

–K Normal oil end shield, brown porcelain
–L Normal oil end shield, light grey porcelain
–M Longer oil end shield, brown porcelain
–N Longer oil end shield, light grey porcelain

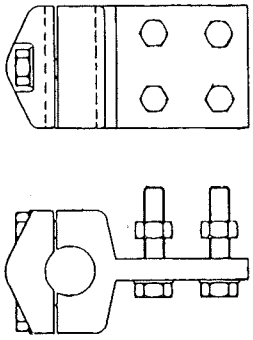


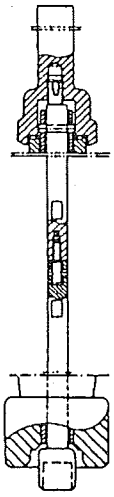
### Bushings

### Connection details

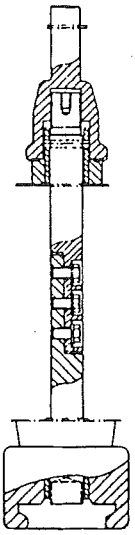
**Inner terminal stud: Cat. No. LF 170**

| Type GOB | Rated current A | Cat. No. | Space for current transformer mm | Bushing tube (See fig.) D2, mm | For crimping or brazing Conductor area 50 mm² | 70 mm² | 95 mm² | For brazing Conductor area ≤150 mm² | ≤285 mm² | Undrilled with pilot hole |
|---|---|---|---|---|---|---|---|---|---|---|
| 250 | 800 | **LF 123 171–** | – | 22 | **010-M** | **010-N** | **010-L** | **011-S** | – | **011-U** |
| | | **173–** | 300 | | | | | | | |
| | | **175–** | 500 | | | | | | | |
| 250 | 1250 | **LF 123 167–** | – | 34 | – | – | – | – | **011-T** | **011-V** |
| | | **168–** | 300 | | | | | | | |
| | | **169–** | 500 | | | | | | | |
| 325 | 800 | **LF 123 177–** | – | 22 | **010-M** | **010-N** | **010-L** | **011-S** | – | **011-U** |
| | | **179–** | 300 | | | | | | | |
| | | **181–** | 500 | | | | | | | |
| 380 | 800 | **LF 123 183–** | – | 22 | **010-M** | **010-N** | **010-L** | **011-S** | – | **011-U** |
| | | **185–** | 300 | | | | | | | |
| | | **187–** | 500 | | | | | | | |
| 380 | 1250 | **LF 123 101–** | – | 34 | – | – | – | – | **011-T** | **011-V** |
| | | **102–** | 300 | | | | | | | |
| | | **103–** | 500 | | | | | | | |
| 450 | 800 | **LF 123 145–** | – | 22 | **010-M** | **010-N** | **010-L** | **011-S** | – | **011-U** |
| | | **147–** | 300 | | | | | | | |
| | | **149–** | 500 | | | | | | | |
| 550 | 800 | **LF 123 189–** | 100 | 22 | **010-M** | **010-N** | **010-L** | **011-S** | – | **011-U** |
| | | **190–** | 300 | | | | | | | |
| | | **191–** | 500 | | | | | | | |
| 550 | 1250 | **LF 123 142–** | 100 | 34 | – | – | – | – | **011-T** | **011-V** |
| | | **143–** | 300 | | | | | | | |
| | | **144–** | 500 | | | | | | | |
| 650 | 1250 | **LF 123 192–** | 150 | 34 | – | – | – | – | **011-T** | **011-V** |
| | | **193–** | 300 | | | | | | | |
| | | **194–** | 500 | | | | | | | |
| 750 | 1250 | **LF 123 104–** | 200 | 34 | – | – | – | – | **011-T** | **011-V** |
| | | **105–** | 300 | | | | | | | |
| | | **106–** | 500 | | | | | | | |

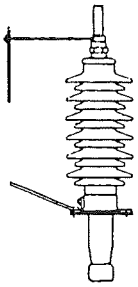




LF 170 019-
800 A



LF 170 052-
1250 A



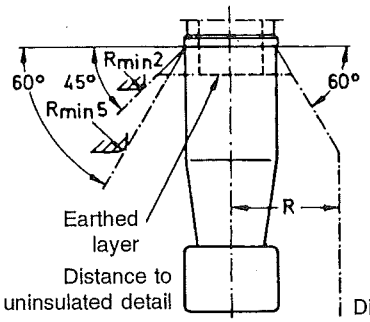
**Outer terminal assembly: Cat. No. LF 170**

| Stud with O-ring and locking pin | | Separate terminal plate with bolts | | Solid rod conductor Cat. No. LF 170 | | | Arcing horns Cat. No. LF 170 |
|---|---|---|---|---|---|---|---|
| Aluminium | Copper alloy | Aluminium | Copper alloy | Alt. 1 | Alt. 2 | Mass kg | |
| 001-A | 002-A | 014-A | 021-A | 019 -AM | – | 3.0 | 004-B |
| | | | | -AS | 019 -AT | 3.7 | -B |
| | | | | -BB | -BC | 4.3 | -B |
| 001-B | 002-B | 014-A | 021-A | 052 -BC | – | 7.7 | 004-B |
| | | | | -BF | 052 -BD | 9.3 | -B |
| | | | | -BG | -BE | 10.8 | -B |
| 001-A | 002-A | 014-A | 021-A | 019 -AN | – | 3.5 | 004-B |
| | | | | -AU | 019 -AV | 4.3 | -B |
| | | | | -BD | -BE | 4.8 | -B |
| 001-A | 002-A | 014-A | 021-A | 019 -AP | – | 3.9 | 004-B |
| | | | | -AX | 019 -AY | 4.6 | -B |
| | | | | -BF | -BG | 5.1 | -B |
| 001-B | 002-B | 014-A | 021-A | 052 -BK | – | 9.6 | 004-B |
| | | | | -BN | 052 -BL | 11.4 | -B |
| | | | | -BP | -BM | 12.6 | -B |
| 001-A | 002-A | 014-A | 021-A | 019 -BS | – | 4.4 | 004-C |
| | | | | -BT | 019 -BU | 5.1 | -C |
| | | | | -BV | -BX | 5.6 | -C |
| 001-A | 002-A | 014-A | 021-A | 019 -AR | – | 5.3 | 004-C |
| | | | | -AZ | 019 -BA | 5.8 | -C |
| | | | | -BH | -BK | 6.4 | -C |
| 001-B | 002-B | 014-A | 021-A | 052 -AT | – | 13.0 | 004-C |
| | | | | -AU | 052 -AX | 14.4 | -C |
| | | | | -AV | -AY | 15.8 | -C |
| 001-B | 002-B | 014-A | 021-A | 052 -AD | – | 14.9 | 005-B |
| | | | | -AE | 052 -AF | 16.1 | -B |
| | | | | -AG | -AH | 17.7 | -B |
| 001-B | 002-B | 014-A | 021-A | 052 -AZ | – | 18.0 | 005-F |
| | | | | -BA | 052 -BB | 19.0 | -F |
| | | | | -AK | -AL | 20.5 | -F |

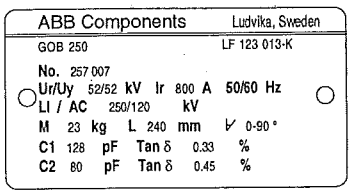
# Recommendations for positioning

The maximum stresses in the oil at the surface of the shield insulation must be limited to those values normal for insulated conductors and similar components in the same transformer.

The adjacent recommendations are intended as guide lines when complete calculations are not carried out.



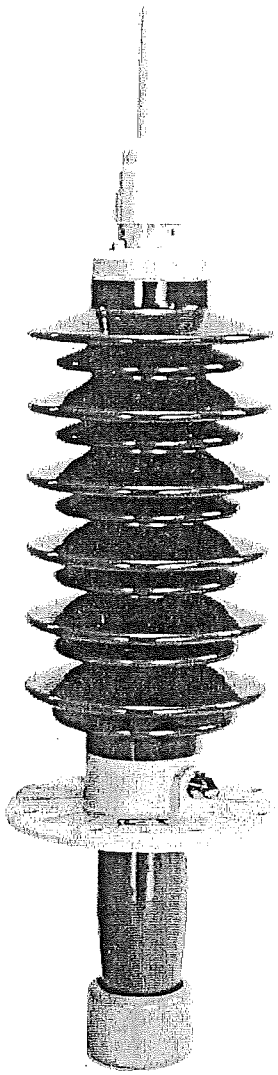

| Type GOB | Internal insulation level of transformer (kV) | R (mm) |
|---|---|---|
| 250/800 | 170-70<br>250-95 | 65<br>75 |
| 250/1250 | 170-70<br>250-95 | 75<br>85 |
| 325/800 | 250-95<br>325-140 | 75<br>100 |
| 380/800 | 325-140<br>380-150 | 100<br>105 |
| 380/1250 | 325-140<br>380-150 | 105<br>110 |
| 450/800 | 380-150<br>450-185 | 105<br>125 |
| 550/800 | 450-185<br>550-230 | 130<br>155 |
| 550/1250 | 450-185<br>550-230 | 140<br>160 |
| 650/1250 | 550-230<br>650-275 | 160<br>185 |
| 750/1250 | 650-275<br>750-325 | 185<br>210 |




Nameplate with marking example.

# Transformer bushings, type GOB

## Installation and maintenance guide



# Safety information

Keep this instruction available to those responsible for the installation, maintenance, and operation of the bushing.

The installation, operation, and maintenance of a bushing present numerous potential unsafe conditions, including, but not limited to, the following:

- High pressures
- Lethal voltages
- Moving machinery
- Heavy components
- Slip, stumble or fall

Specialized procedures and instructions are required and must be adhered to when working on such apparatus. Failure to follow the instructions could result in severe personal injury, death, and/or product or property damage.

Additionally, all applicable safety procedures such as regional or local safety rules and regulations, safe working practices, and good judgement must be used by the personnel when installing, operating, maintaining and/or disposing such equipment.

Safety, as defined in this instruction, involves two conditions:

1. Personal injury or death.
2. Product or property damage (includes damage to the bushing or other property, and reduced bushing life).

Safety notations are intended to alert personnel of possible personal injury, death or property damage. They have been inserted in the instructional text prior to the step in which the condition is cited.

The safety conditions are headed by one of the three hazard intensity levels which are defined as follows:

**DANGER**

**Immediate hazard which will result in severe personal injury, death, or property damage.**

**WARNING**

Hazard or unsafe practice which could result in severe personal injury, death, or property damage.

*CAUTION: Hazard or unsafe practice which could result in minor personal injury, or property damage.*

# Contents

# 1 Description

## 1.1.1 Design

The design and dimensions of bushings type GOB are given in the Technical Guide, *1ZSE 2750-102*. The design principle is also shown in Figs. 1a-e. For bushings with a relatively small oil quantity the expansion space at the top of the insulator is sufficient. For bushings with larger oil quantity the expansion space has been increased with at top housing according to Fig. 1b. An alternative design, with an oil level glass of prisma type according to Fig. 1c is also available. All GOB bushings are equipped with a test tap, see Figs. 2a-b, connected to the outer layer of the condenser body. The test tap can be used for checking of the bushing insulation by capacitance and dissipation factor measurements. The maximum test voltage for the test tap is 2 kV, one minute at 50 to 60 Hz. It serves as a test tap, and in connection with an external capacitance it can be used as a voltage tap. The operation voltage is limited to 600 V. For connection of the test cable an adapter, according to Fig. 3, should be used. An adapter is available for permanent connection to measuring circuits, see Fig. 4.

*Fig. 1. Design principle.*

1) Outer terminal stud
2) Oil filling holes with sealing plug M8, 2522 731-A
3) Oil
4) Expansion space
5) Prism type glass
   a) GOB 250 - 650 2911 720-2
   b) GOB 750 2911 730-1
6) Gasket
   a) GOB 250 - 650 O-ring 49.5 x 3 2152 2012-416
   b) GOB 750 O-ring 34.2 x 3 2152 2011-410
7) Porcelain insulator, air side
8) Test tap
9) Mounting flange
10) Condenser body
11) Insulated shield
12) Flange extension
13) Porcelain insulator, oil side

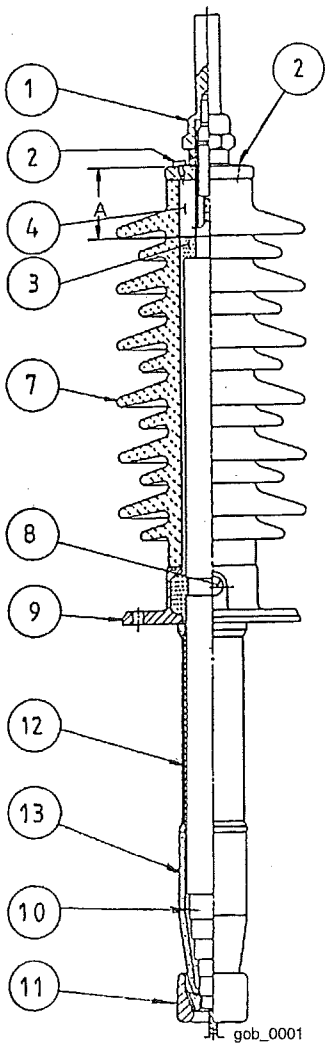



*Fig. 1a*

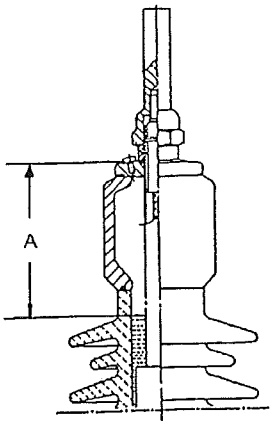



*Fig. 1b*

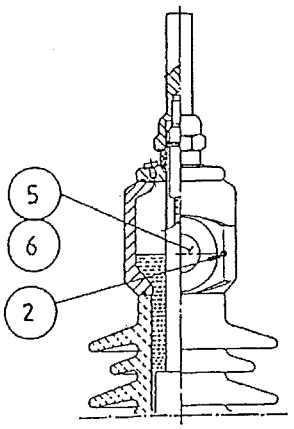



*Fig. 1c*

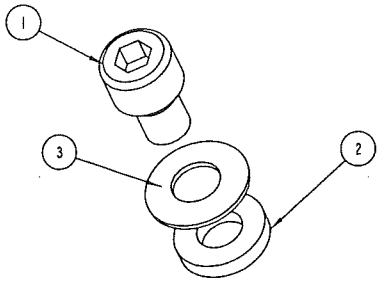



*Fig. 1d. Previous design of sealing plug, 2522 731-A.*

1) Hexagon socket screw, 2121 738-4
2) Gasket, 2152 899-132
3) Conical spring washer, 2154 4004-3

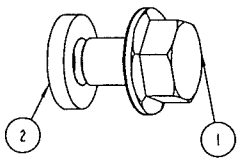



*Fig. 1e. New design of sealing plug, 2522 731-A.*

1) Bolt with flange DIN 6921, 2121 738-18
2) Gasket, 2152 899-132

*Fig. 2a. New design of test tap 2769 531-B (not self-earthing)*

1) Bushing for test tap
2) Disc spring
3) Press nut
4) Cover 2749 528-B with O-ring 2152 484-2
5) Contact pin, 4 mm
6) O-ring
7) O-ring
8) Cable

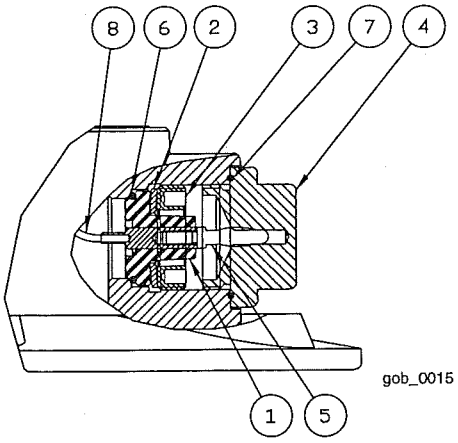



*Fig. 2b. Previous design of test tap 2769 518-A (self-earthing)*

1) Cap nut, 2126 774-33
2) Gasket, 2152 795-5
3) Spring loaded earthing contact
4) Bushing, 2769 506-A
5) Mounting flange
6) Outer layer of condenser body
7) Threaded sleeve, 2129 702-2, 5/8" UNC

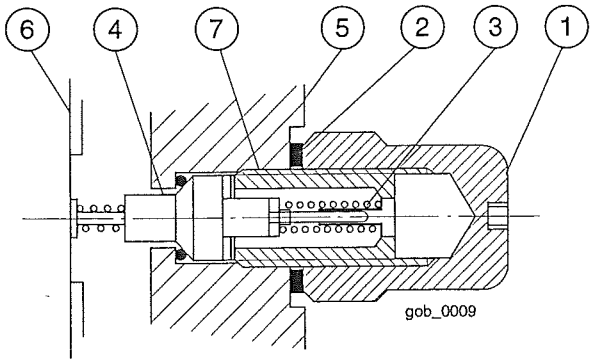


*Fig. 3. Previous design of adapter for temporary connection to test equipment, 2643 762-A.*

1) Clamp nut for test cable
2) Insulation sleeve
3) Barrel nut

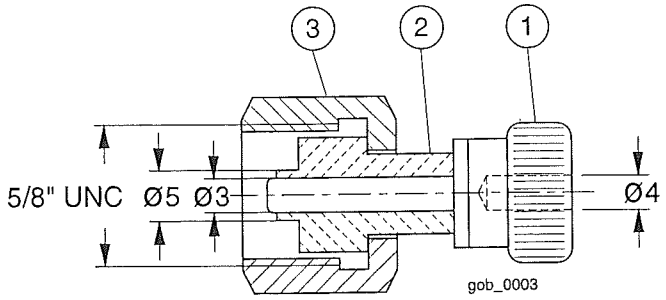



*Fig. 4a. New design of adapter for permanent connection to measuring circuits 2769 531-D.*

) Cover
2) Box
3) Cable gland Pr (screwed steel conduit) 22.5 (Pg 16 acc. to DIN 40430)
4) Protecting resistor, 10 kΩ, 5 W
5) Earthing connection (to be removed before connection of outer cable)
6) Nut
7) Belleville spring washer
8) Connector to test tap
9) O-ring

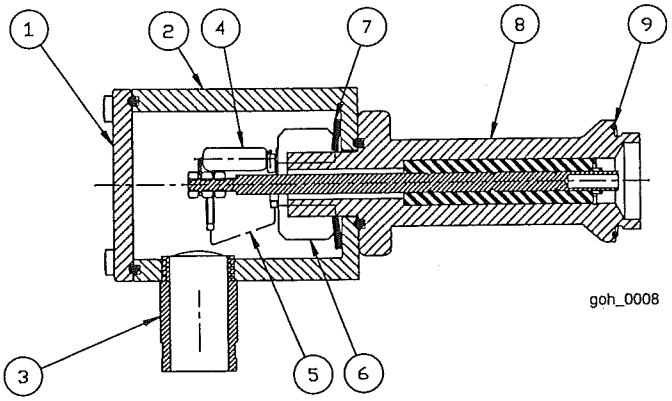
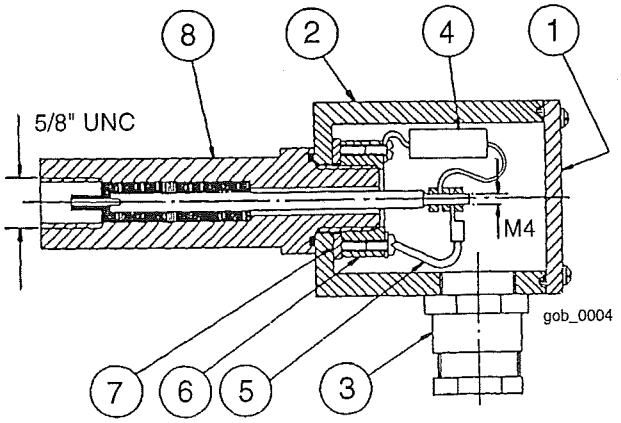



*Fig. 4b. Previous design of adapter for permanent connection to measuring circuits, 2769 513-A.*

!) Cover
2) Box
3) Cable gland Pr (screwed steel conduit) 22.5 (Pg 16 acc. to DIN 40430)
4) Protecting resistor, 10 kΩ, 5 W
5) Earthing connection (to be removed before connection of outer cable)
6) Nut
7) Belleville spring washer
8) Connector to test tap



## 1.1.2 Design of horizontally mounted bushings

If a bushing shall be mounted in horizontal position this must be clearly stated in the order. The bushing flange is then supplied with an oil hole at the oil side of the flange for connection of the bushing oil system to the transformer oil. As horizontally mounted bushings must be completely oil filled this hole will provide the necessary oil expansion for the bushing.

At delivery the hole is covered by a flat rubber gasket and a steel plate as shown in the figure below. This arrangement makes sure that the hole is opened before mounting of the bushing. It is important to check that the gasket on the transformer flange does not cover this hole in service. The hole is located between two mounting holes and at a distance B from the flange edge.

*Table 1.*

| Type GOB | Dimension B |
|---|---|
| 250/800 | 54 |
| 250/1250 | 78 |
| 325/800 | 54 |
| 380/800 | 54 |
| 380/1250 | 78 |
| 450/800 | 54 |
| 550/800 | 60 |
| 550/1250 | 65 |
| 650/1250 | 65 |
| 750/1250 | 60 |

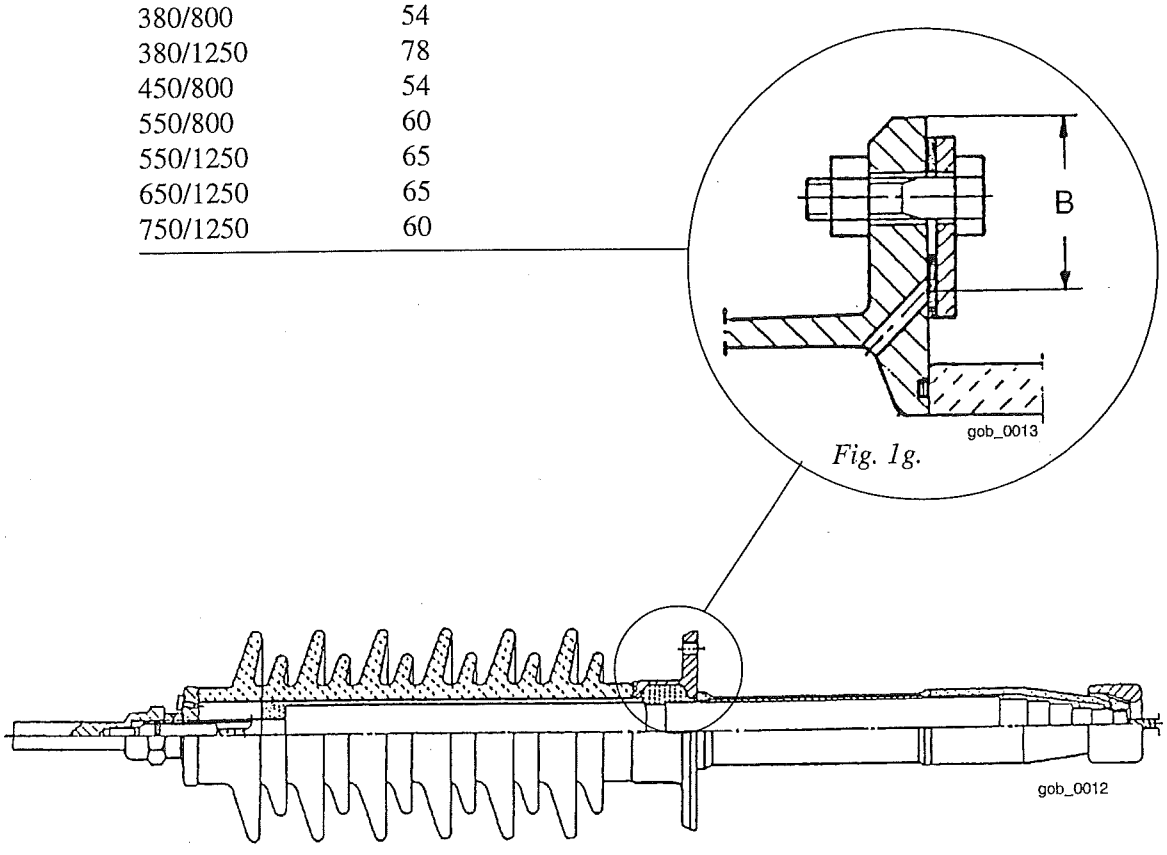



*Fig. 1g.*

*Fig. 1f. Design principle - horizontally mounted bushing.*

## 1.2 Operating conditions

The table below show the standard technical specifications for the GOB Oil - Air bushings. For conditions exceeding the below values, please contact ABB Components.

**Common specifications:**

| | |
|---|---|
| Application: | Transformers |
| Classification: | Oil impregnated paper, capacitance graded, outdoor-immersed bushing |
| Ambient temperature: | +40 to -40 °C, minimum value as per temperature class 2 of IEC 60137 |
| Altitude of site: | < 1 000 m |
| Level of rain and humidity: | 1-2 mm rain/min horizontally and vertically, as per IEC 60060-1 |
| Pollution level: | According to specified creepage distance and IEC 60815[1] |
| Type of immersion medium: | Transformer oil. Maximum daily mean oil temperature 90 °C. Maximum temporary oil temperature 115 °C |
| Oil level below bushing flange: | Maximum 30 mm |
| Max. pressure of medium: | 100 kPa overpressure |
| Markings: | Conforming to IEC/ IEEE |

[1] IEC 60815 "Guide for the selection of insulators in respect of polluted conditions".

## 1.3 Mechanical loading

The bushings are designed for the following cantilever loads applied to the midpoint of the top end terminal, perpendicularly to the bushing axis. The bushing mounting angle can be 0-45° from vertical or horizontal (if the bushing is ordered for horizontal mounting).

In axial direction, the GOB bushings can be loaded with 10 kN continuously. The bushing can withstand 30 Nm torque on the outer terminals.

*Table 2. Mechanical loading*

| Bushing | Type test load 1 minute (N) | Max. service load (N) |
|---|---|---|
| GOB 250/800 | 2340 | 1800 |
| GOB 250/1250 | 4000 | 3000 |
| GOB 325/800 | 1950 | 1500 |
| GOB 380/800 | 1800 | 1400 |
| GOB 380/1250 | 3750 | 2900 |
| GOB 450/800 | 1500 | 1150 |
| GOB 550/800 | 1700 | 1300 |
| GOB 550/1250 | 3100 | 2400 |
| GOB 650/1250 | 3380 | 2600 |
| GOB 750/1250 | 3350 | 2600 |

## 1.4 Spare parts

In case of major damage to the bushing we recommend that it is sent back to ABB Components for possible repair and re-testing. Certain parts (Figs. 1, 2, 7, 8 and 9), which may be damaged or lost during transport or installation, can be ordered from ABB Components.

# 2 Installation

## 2.1 Tools

- Soft slings
- Lifting eye screw M12 (DIN 580) for mounting at an angle, 2183 2001-3
- Pull-through cord with M8 swivel, 9760 669-A
- Torque wrench key for hexagon head screws, head width 16 mm (M10) and adjustable up to 66 mm
- Key for hexagon socket head cap screw 6 mm (Only for previous design of test tap cover)

## 2.2 Consumables

- Water free vaseline, Mobilgrease 28 or other lubricant not harmful to the transformer oil, to lubricate screws that come into contact with the transformer oil.
- Mobilgrease 28 or other suitable grease to lubricate and protect the earthing screw and the outer terminal o-ring gasket.

## 2.3 Transport and handling

*CAUTION: The bushing may be transported and stored horizontally up to 6 months. For storing over 6 months it is recommended to raise the bushing to vertical position with the top end upwards. Keep the bushings dry and clean and protected against mechanical damage.*

*Keep the bushings protected from penetrating water when stored outdoors. This means that the case must not be stored in areas where it can be foreseen that the ground will be wet and muddy during heavy rains. Shelter the case from rain and snow with a tarpaulin or roofing.*

Carefully inspect the bushing on receiving with regard to shipping damage. Please note that the bushing has been routine tested in oil and some oil may be left, especially in the narrow openings between porcelain and metal. Vaseline is used for lubrications of threads, and at some temperatures the vaseline may appear as oil

The bushings are normally delivered from ABB Components in boxes with the bushing supported by blocks and fibre boards. The boxes are marked with "Top End".

## 2.4 Lifting from the box

**WARNING**

For lifting the bushing from the box, apply two clean lifting slings as shown in the figure below. Support the bushing at the same points as in the box if placed on the ground or block it under the flange and the metal top piece. Light bushings may be handled manually.

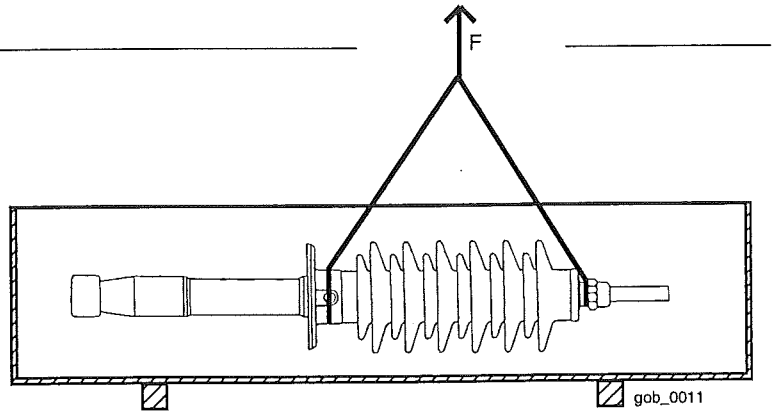



*Fig. 5.*
*Lifting from the box.*

## 2.5 Mounting

***CAUTION:*** *Bushings mounted horizontally must be specially ordered for that, and mounted according to section 2.5.3. If additional requirements are not fulfilled, the bushing can be damaged.*

**WARNING**

Light bushings may be handled manually. Lift heavier bushings with the aid of a lifting tool, see section 2.1 Tools. Lift the bushing to vertical position and to an angle according to the figures below. Use a soft bedding under the bottom end of the bushing, e.g. a rubber mat.

The mass of the bushing is stated on the marking plate. Carefully clean and inspect the oil end of the bushing and the inside of the centre hole before mounting on the transformer.

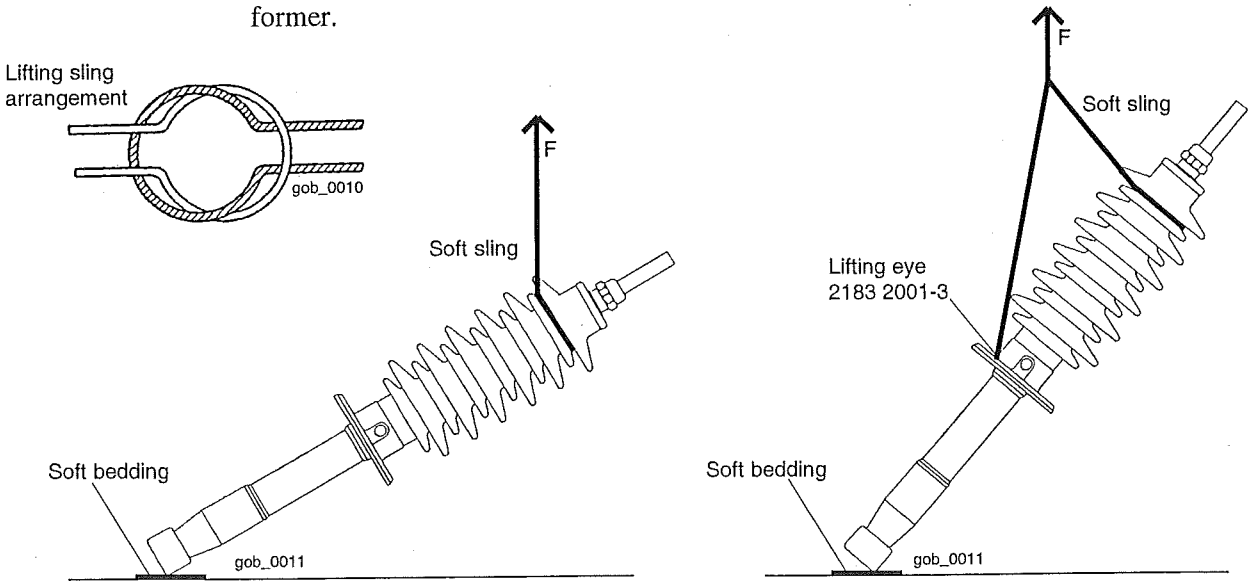



*Fig. 6. Mounting.*

## 2.5.1 Inner terminal / Stranded cable

*CAUTION: Mounting of the conductor must be performed according to the procedure below. The contact surfaces must be clean. The oxide on brazed terminals is to be removed by brushing.*

1. Stretch the stranded cable with the brazed or crimped inner terminal, normally fastened to the cover plate. Avoid making any loops.
2. Drop the pull-through cord through the bushing centre hole.
3. Lift the bushing above the opening.
4. Fasten the M8 swivel to the inner terminal at the end of the stranded cable. Lower the bushing into the transformer while directing the stranded cable by keeping the pull-through cord taut.
5. Fix the bushing to the cover. Torque M12 to 50 ±5 Nm, 1/2" UNC to 55 ±5 Nm.
6. Lock the inner terminal with the locking pin according to Fig. 7.
7. Gently release the pull-through cord so the conductor rests on the locking pin.
8. Remove the pull-through cord.
9. Proceed immediately to section 2.6 Mounting of outer terminal.

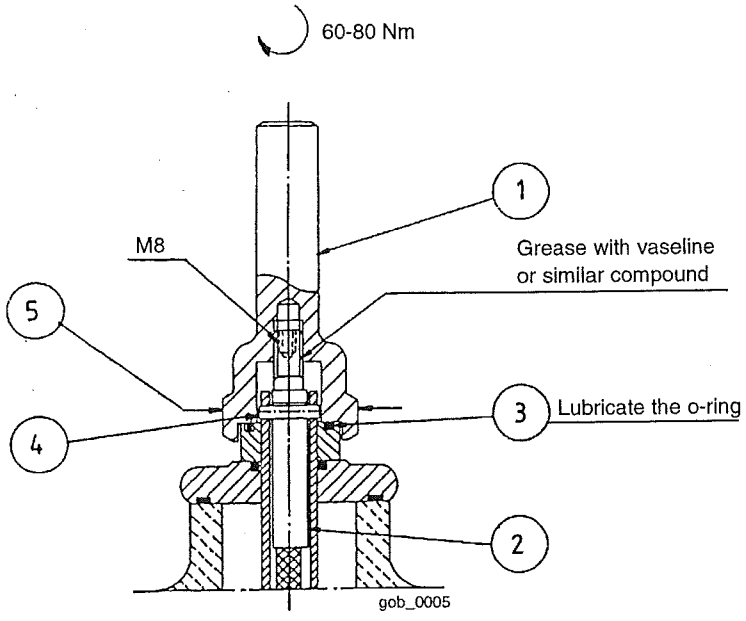



*Fig. 7. Outer and inner terminal stud.*

| | | | |
|---|---|---|---|
| 1) | Outer terminal | | |
| 2) | Inner terminal | | |
| 3) | O-ring | 800 A: | 2152 2011-412; 39.2 x 3 |
| | | 1250 A: | 2152 2012-420; 59.2 x 3 |
| 4) | Locking pin | 800 A: | 2111 764-A |
| | | 1250 A: | 2111 764-B |
| 5) | Width across flats for wrench | 800 A: | 55 mm |
| | | 1250 A: | 66 mm |

## 2.5.2 Solid rod conductor

*CAUTION: Mounting of the conductor must be performed according to the procedure below. The contact surfaces must be clean.*

*If turning of the conductor is needed to line up the holes for the locking pin in the conductor tube with the hole in the conductor, the conductor must definitely be turned clockwise. Turning in opposite direction may loosen the current carrying joint in 800 A conductors.*

The lower part of the solid conductor is normally fastened to the cover plate of the transformer. The top part is usually delivered to site with the bushing.

1. Drop the pull-through cord through the bushing centre hole.
2. Fasten the M8 swivel to the top part of the solid conductor.

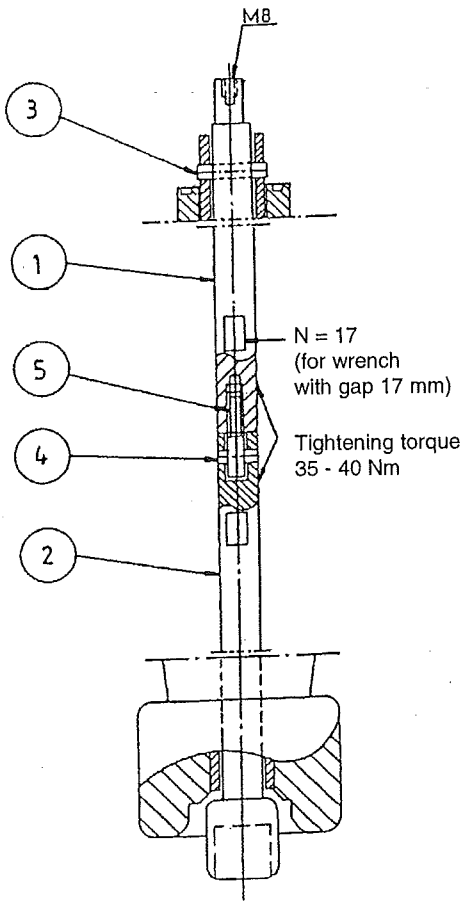



*Fig. 8. Solid conductor 800 A*

1) Upper conductor
2) Lower conductor
3) Locking pin, 2111 764-A
4) Locking pin, 2111 764-C
5) Screw, 2122 751-2

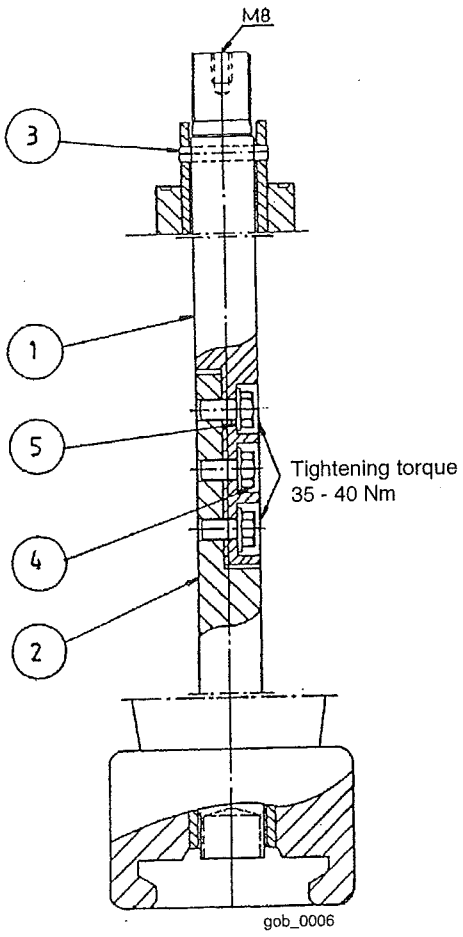



*Fig. 9. Solid conductor 1250 A*

1) Upper conductor
2) Lower conductor
3) Locking pin, 2111 764-B
4) Hexagon head screw M10 x 20
   Previous non-captive design, 2121 2033-490
   New captive design, 2121 738-19
5) Belleville spring washer, 2154 717-5

3. Partly pull the top part of the solid rod up into the bushing centre hole, leaving the part with the jointing hole(s) sticking out.
4. Secure the pull-through cord so the solid rod conductor top part cannot fall out of the bushing.
5. Lift the bushing with the solid rod attached above the opening.
6. Lower the bushing until the two solid conductor parts meet.
7. Lubricate 1 x M12 (800 A) or 3 x M10 (1250 A) screws with water-free vaseline, Mobilgrease 28 or other lubricant not harmful to the transformer oil. Insert and tighten to 35-40 Nm.
8. Lower the bushing into the transformer while directing the assembled solid rod conductor by keeping the pull-through cord taut.
9. Fix the bushing to the cover. Torque M12 to 50 ±5 Nm, 1/2" UNC to 55 ±5 Nm.
10. Lock the solid rod with the locking pin according to Figs. 8 and 9.
11. Gently release the pull-through cord so the conductor rests on the locking pin.
12. Remove the pull-through cord.
13. Proceed immediately to section 2.6 Mounting of outer terminal.

### 2.5.3 Horizontal mounting of bushing

A horizontal GOB bushing normally has the tap to the left, seen from the air side when the bushing is mounted according to the instructions below.

**Alternative 1. At vacuum filling of transformer.**
Open the oil hole in the flange. Mount the bushing with the hole upwards. The bushing will be completely oil filled at the filling of the transformer.

**Alternative 2. Filling of transformer without vacuum.**
Place the bushing vertically and open one of the filling plugs at the top. Add clean and dry transformer oil until the bushing is completely filled. Put back and tighten the plug and place the bushing horizontally with the opening in the flange upwards. Remove the covering plate or plug immediately and mount the bushing in the transformer without turning or tilting it.

## 2.6 Mounting of outer terminal

*CAUTION: Before connection of conductor clamps, the outer terminals of aluminium must be carefully wire brushed and greased with a contact compund or vaseline.*

In order to obtain the correct pressure and a low contact resistance, the following must be carried out:

1. Clean the contact and gasket surfaces carefully.
2. The inner terminal / solid rod thread is to be lubricated with vaseline or other lubricant not harmful to the transformer oil.
3. Lubricate the o-ring before putting it into the groove.
4. Screw on the outer terminal and tighten with 60-80 Nm according to Fig. 7.

## 2.7 Flange earthing

The bushing flange is provided with a tapped hole M12. After tightening the bolts fixing the bushing to the transformer tank, the flange should be earthed. This prevents electrical discharges between bushing flange and transformer tank under normal service conditions.

**Alternative 1**
Insert a heavily greased (Mobilgrease 28 recommended) pointed set screw M12 (stainless steel A4-80 preferrably). Tighten to 40 Nm, penetrating the paint of the transformer tank down to the metal underneath. This makes an electrical connection between the bushing and the transformer tank, keeping them at the same voltage.

**Alternative 2**
Apply a flexible cable between the M12 earthing hole in the bushing flange and a corresponding connection point in the transformer. Grease the screw (Mobilgrease 28 recommended) and tighten the M12 in the bushing to 40 Nm. Connect the other end of the cable to the transformer.

## 2.8 Waiting time before energizing

*CAUTION: When a bushing has been stored horizontally, it must be raised with the top up for at least 12 hours before service voltage is applied and 24 hours before test voltage is applied. If, by mistake, the bushing has been stored horizontally more than one year, it must be placed in the vertical position for at least one week before energizing. Some waiting time may be necessary before energizing in order to avoid flashovers or partial discharges due to airbubbles at the bushing surface. Choose a suitable procedure below.*

**Vacuum filled transformer**
No waiting time is necessary from the bushing point of view.

**De-gassed oil-filled transformer**
During mounting, use a clean and dry paintbrush to release surface bubbles. Wait 6 hours before energizing.

**Gas-saturated oil-filled transformer**
During mounting, use a clean and dry paintbrush to release surface bubbles. Wait 24 hours before energizing.

**De-gassed oil filled transformer with reduced oil-level**
After restoring the oil-level, wait 24 hours before energizing.

For all alternatives except vacuum-filled transformer, the oil should be allowed to enter the centre tube to at least flange height by releasing the outer terminal sealing system and allowing air to escape this way.

## 2.9 Recommended tests before energizing

The following tests may be performed to check the insulation, sealing and current path of the bushing. The tests should be made after mounting, but before connecting the outer terminal of the bushing to the rest of the switchyard power circuit.

1. Tightness test between transformer and bushing flange.
2. Tightness test of bushing outer terminal.
3. Measurement of capacitance and tan δ.
4. Check of through-resistance.

### 2.9.1 Tightness test between transformer and bushing flange

Several different methods may be used and we thus refer to instructions given by the company responsible for the field erection. As a simple example, the tightness of the seal between transformer and bushing flange may be checked when the transformer is oil-filled by using chalk or, perhaps easier, with paper strips.

### 2.9.2 Tightness test of bushing outer terminal

Since the top terminal is often situated above the oil level of the transformer expansion system, a leak at this point is extremely serious, because water could enter directly into the transformer insulation this way. It is thus recommended to make a tightness test after assembly, preferably both with vacuum and over-pressure. Several different methods may be used and we refer to instructions given by the firm responsible for the field erection.

One possible method is the tracer gas method:

1. Put a tracer gas into the centre tube before mounting the outer terminal. The oil level of the transformer must be above the bottom end of the bushing but below the bushing flange.
2. Increase the pressure in the center tube by increasing the oil level as much as possible.
3. Search with a gas detector (sniffer) for leaking gas at the gasket.

## 2.9.3 Measurement of capacitance and tan δ

WARNING

*The new design of test tap is not self-earthing.*

Since $C_2$ usually is relatively small, the test tap must never be open-circuited when applying a voltage to the bushing. It shall always be earthed or connected to an external impedance. No connection may destroy the bushing. Recommended maximum voltage for $C_1$ is 10 kV and for $C_2$ 500 V.

***CAUTION:*** *When not measuring, always make sure that the cap nut is properly tightened with the gasket in place. This is to prevent dust and water from coming in to the test tap.*

After mounting, a capacitance measurement is recommended. Connect a measuring bridge between the outer terminal and the test tap by using a ø 4 mm lead coupler or ABB Components' test tap adapter 2749 510-U. This is possible without removing the bushing as the bushing has an insulated test tap, see Fig. 10. More details can be found in ABB Components' product information *2750 515-142*, "Bushing diagnostics and conditioning".

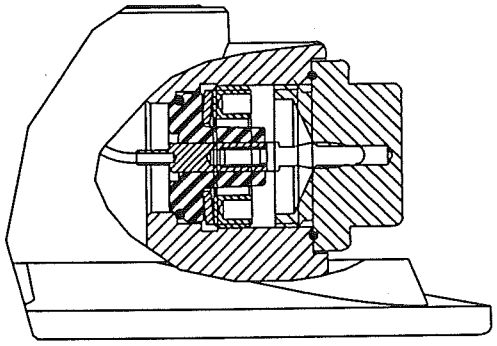



*Fig. 10a. New design of test tap 2769 531-B (not self-earthing)*

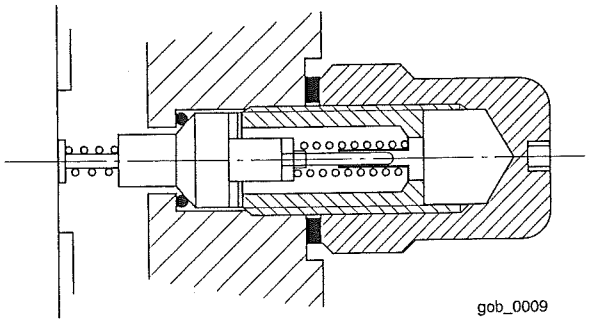



*Fig. 10b. Previous design of test tap 2769 518-A (self-earthing)*

With the transformer de-energized and the bushing outer terminal disconnected, the test tap cover is removed. The measuring equipment is connected to the test tap and the measuring voltage source to the bushing terminal.

The capacitances $C_1$ between the centre tube and the tap, and the capacitance $C_2$, between the test tap and earth are marked on the marking plate. The nominal capacitances $C_1$ of the different bushing types are listed in Table 3. $C_2$ is highly dependent on the surrounding parts inside the transformer and it is not possible to give a nominal value valid for all service conditions.

*Table 3. Nominal capacitances in pF (Manufacturing tolerances for C1 ± 10%).*

| Type | Catalogue No. LF 123 | Nominal capacitance (pF) $C_1$ | $C_2$ |
|---|---|---|---|
| GOB 250 | 013, 014, 171, 172 | 125 | 90 |
| | 015, 016, 173, 174 | 205 | 500 |
| | 017, 167 | 165 | 110 |
| | 019, 168 | 270 | 750 |
| | 083, 084, 175, 176 | 275 | 800 |
| | 085, 169 | 375 | 1200 |
| GOB 325 | 025, 026, 177, 178 | 135 | 95 |
| | 027, 028, 179, 180 | 200 | 200 |
| | 089, 090, 181, 182 | 260 | 425 |
| GOB 380 | 037, 038, 183, 184 | 145 | 110 |
| | 039, 040, 185, 186 | 200 | 335 |
| | 041, 101 | 185 | 150 |
| | 043, 102 | 265 | 550 |
| | 095, 096, 187, 188 | 245 | 550 |
| | 097, 103 | 320 | 1150 |
| GOB 450 | 049, 050, 145, 146 | 145 | 125 |
| | 051, 052, 147, 148 | 200 | 570 |
| | 053, 054, 149, 150 | 245 | 770 |
| GOB 550 | 061, 189, 062 | 150 | 156 |
| | 063, 190, 064 | 170 | 400 |
| | 107, 191, 108 | 210 | 750 |
| | 065, 142 | 170 | 150 |
| | 067, 143 | 195 | 320 |
| | 109, 144 | 240 | 575 |
| GOB 650 | 073,192 | 205 | 200 |
| | 075, 193 | 235 | 340 |
| | 113, 194 | 280 | 550 |
| GOB 750 | 077, 104 | 205 | 390 |
| | 078, 105 | 235 | 565 |
| | 079, 106 | 275 | 950 |

The dissipation factor varies with the temperature of the bushing body, and the measured value should thus be multiplied with the correction factor (multiplier) given in Table 4.

*Table 4. Dissipation factor variations as a function of temperature.*

| Bushing body temperature °C | Multiplier to 20 °C |
|---|---|
| 3-7 | 0.85 |
| 8-12 | 0.90 |
| 13-17 | 0.95 |
| 18-22 | 1.00 |
| 23-27 | 1.05 |
| 28-32 | 1.10 |
| 33-37 | 1.15 |
| 38-42 | 1.20 |
| 43-47 | 1.25 |
| 48-52 | 1.30 |

### 2.9.4 Check of through resistance

The through-resistance measurement method depends on the design of the transformer. Generally, a current is applied from bushing to bushing. The voltage drop from outer terminal to outer terminal is measured. The resistance is calculated with Ohm's law, $U = R \cdot I$. (U: Measured voltage drop. I: Through current. R: Total circuit resistance.)

The total through resistance is the sum of the transformer winding and lead resistance and the bushing conductor and contact resistance. The additional resistance from he bushing conductor should not be more than 10 ... 100 μΩ. Since the through resistance of the HV winding of a typical power transformer is in the order of 0.1 ..1 Ω, this is a very rough method that can only be used to detect very large faults in the current path, such as disruptions.

Less-than-perfect contacts can only be detected by making a sensitive measurement across each connection point, or by measuring the temperature increase during operation with an infrared sensitive camera (thermovision).

# 3 Maintenance

The GOB bushings are maintenance-free. For bushings with oil-level glass, it is recommended to note the oil level during normal routine inspections in the plant.

**WARNING**

No work at all can be performed on the bushing while it is energized or not earthed.

## 3.1 Recommended maintenance and supervision

1. Cleaning of insulator surface
2. Measurement of capacitance and tan δ
3. Thermovision (infrared camera) check for local overheating on connectors
4. Check for leakage
5. Checking and adjustment of the oil level

### 3.1.1 Cleaning of insulator surface

*CAUTION: Avoid having solvent on the bushing gasket and porcelain joints.*

Under conditions of extreme pollution it may be necessary to clean the porcelain insulator surface. This should be done by water-jet or by wiping with a moist cloth. If necessary, ethyl-alcohol or ethyl-acetate may be used.

### 3.1.2 Measurement of capacitance and tan δ

Please refer to Chapter 2 Installation.

### 3.1.3 Thermovision (infrared camera) check for local overheating on connectors

At maximum rated current, the bushing outer terminal normally takes a temperature of about 35 to 45 °C above the ambient air. Significantly higher temperatures, especially at lower current loading, can be a sign of bad connections.

### 3.1.4 Check for leakage

Make a visual inspection for oil leakage during normal station supervision.

### 3.1.5 Checking and adjustment of the oil level

*CAUTION: Oil sampling and dissolved gas in oil analysis.*
*Normally we do not recommend taking oil samples or opening our bushings. The bushing is sealed and tightness tested at the time of manufacturing. An oil sampling means that the bushing has to be opened. Thus, there is also a risk of improper sealing after the sampling is finished. However, when a problem is known, for example high power factor over $C_1$ or visible leakage, there might be a need for oil sampling and gas analysis or oil level check. In this case, ask for product information 2750 515-142 "Bushing diagnostics and conditioning".*

Bushings with one oil level glass should show the oil level in the middle of the glass at 20 °C. The oil level change is approximately 3 mm per 10 °C.

GOB 750 has two glasses and the oil level at 20 °C is to be at the oil level plug between the two glasses. The oil level change for GOB 750 is approximately 6 mm per 10 °C.

The oil level in bushings without oil level glass may be checked through one of the two oil filling holes at the top end. A dry and clean dipstick should be used. In one of these holes there is a rubber plug. This plug may be pressed down into the bushing so that checking of the oil level can be carried out. Correct oil level is shown in Table 5. For bushings mounted at an angle it may be necessary to check at both holes and calculate the average. If the oil level is too high, oil can be sucked out by means of a narrow hose. If the oil level is too low, clean and dry transformer oil must be added. Adjustment of oil level is allowed only when the temperature of the bushing is +5 °C to +35 °C. It is recommended that the sealing plug be provided with a new gasket after the check. The sealing plug is to be tightened with 20 Nm. For further information on oil sampling, see product information *2750 515-142*.

For topping-up of the bushing, any clean and dry transformer oil available at site may be used.

*Table 5. Oil level for bushings without oil level gauge*

| Type GOB | Oil level A mm at 20 ±10 °C Fig. 1a | Fig. 1b | Oil level change mm/10 °C *) |
|---|---|---|---|
| 250 | 110 ±8 | 165 ±10 | 4 |
| 325 | 110 ±8 | 165 ±10 | 5 |
| 380 | 110 ±8 | 165 ±10 | 5 |
| 450 | 110 ±8 | 165 ±10 | 6 |
| 550 | 170 ±10 | 270 ±15 | 7 |
| 650 | 175 ±10 | 275 ±15 | 9 |
| 750 | 275 ±15 | 330 ±15 | 11 |

*) The bushing in vertical position.

### 3.1.6 De-mounting of horizontally mounted bushings

When the bushing is removed from the transformer it is completely filled with oil. Drain a small volume of oil and tighten the flange hole with the gasket and cover plate or plug. Place the bushing vertically and adjust the oil level according to 3.1.5.

## 3.2 Disposal after end of service life

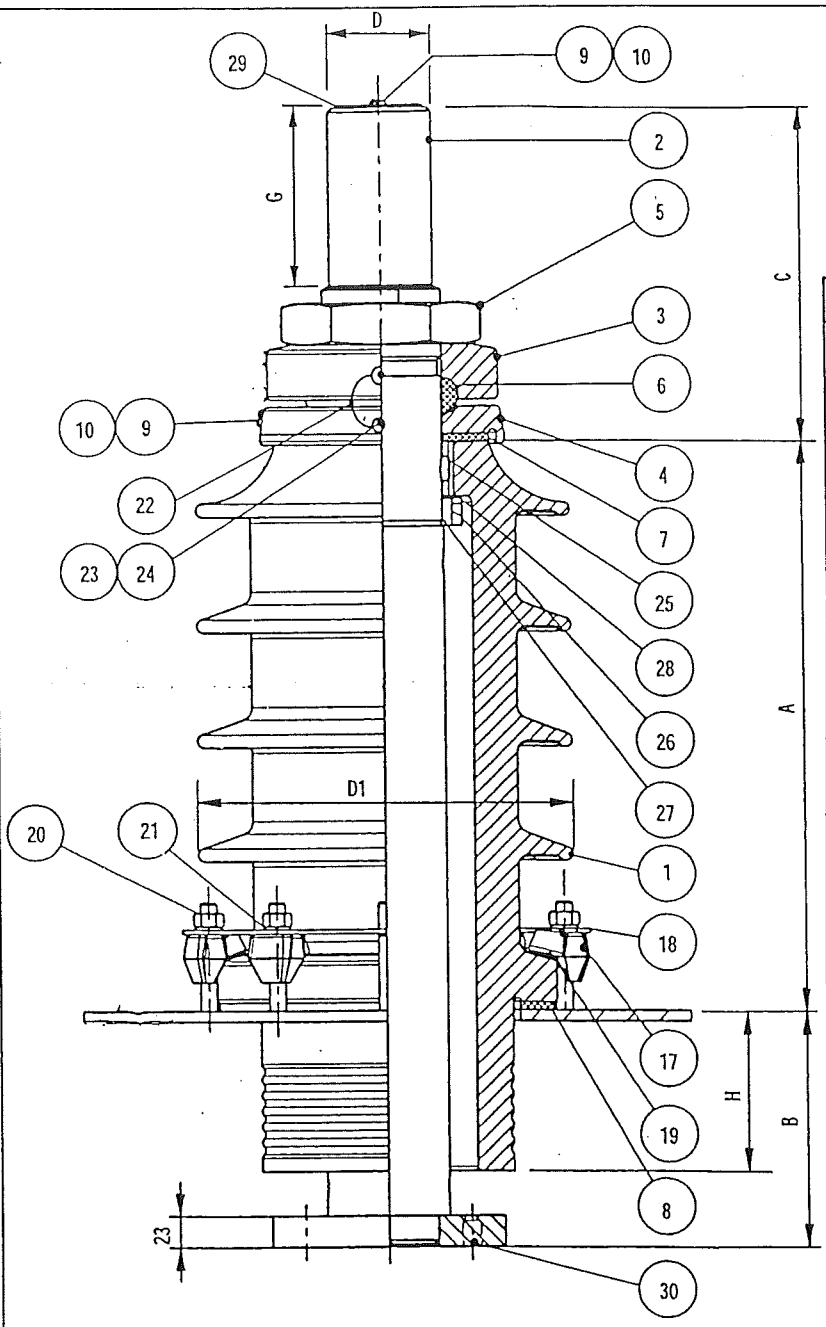
The bushing consists of the following material:

- Conductor of copper or low-alloy aluminium.
- Terminals of copper, brass or low-alloy aluminium may be plated with for instance silver, tin, gold or nickel in layer thickness up to 20 µm.
- Transformer oil as per IEC 60296, class 2.
- Transformer oil impregnated condenser body consists of paper and 1 % Al foils.
- Centre tube, on which the condenser body is wound, consists of Al alloy.
- Top washer, top housing, flange, top nut, flange extension and end-shield consist of Al alloys.
- Press ring for oil level glass and previous design of test tap cap consist of plated brass. New design of test tap consists of stainless steel.
- Prism glass consists of glass.
- Insulators consist of quartz or alumino silicated based porcelain.

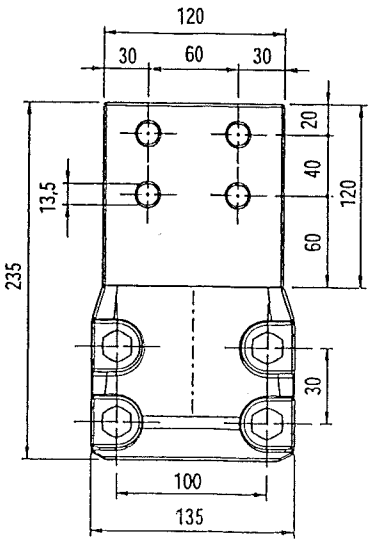
# L.V. BUSHING type 20NF5000

349004






| ITEM | DESCRIPTION | Q.TY |
|---|---|---|
| 1 | PORCELAIN | 1 |
| 2 | BOLT | 1 |
| 3 | WASHER | 1 |
| 4 | CAP | 1 |
| 5 | NUT | 1 |
| 6 | GASKET | 1 |
| 7 | GASKET | 1 |
| 8 | GASKET | 1 |
| 9 | AIR.SCREW | 2 |
| 10 | GASKET | 2 |
| 17 | PRESSBITS | 10 |
| 18 | FLANGE | 1 |
| 19 | RING OF COMPENSATION | 1 |
| 20 | NUT DIN 934 | 12 |
| 21 | WASHER DIN 125 A | 10 |
| 22 | CABLE-LEAD | 1 |
| 23 | WASHER DIN 125 A | 2 |
| 24 | SCREW | 2 |
| 25 | PIN | 1 |
| 26 | PRESSURE RING | 1 |
| 27 | STOP RING | 1 |
| 28 | GASKET | 1 |
| 29 | COPPER DISC | 1 |
| 30 | LOWER WASHER | 1 |




| TYPE | A | B | C | D | D1 |
|---|---|---|---|---|---|
| 24 kV/5000 A | 320 | 150 | 220 | Ø 78 | Ø 275 |

| H | G | N° of sheds | Tank Hole | Weight |
|---|---|---|---|---|
| 100 | 100 | 3 | Ø 200 | 52.5 kg |

| | | |
|---|---|---|
| Rated voltage | :24 | kV |
| Rated current | :5000 | A |
| Lighting impulse voltage | :125 | kVp |
| Power frequency withstand voltage | :50 | kV |
| Creepage distance | :483 | mm |

| Promjena Revision | | |
|---|---|---|
| Odobrio Approved | mr. Biloš | |
| Izradio Designed | ing. Teslak | |
| Datum Date | IV 2005. | |

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