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1ZSE 2750-106 EN, REV. 7

# Oil – SF<sub>6</sub> bushings type GOEK

## Technical guide





## **Original instruction**

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 authorized representative.

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# Design

Bushing type GOEK is intended for immersed oil-SF<sub>6</sub> service and can be mounted in any direction from vertical to horizontal. It can also be used for oil-oil applications. The bushing is built up around a centre tube on which the condenser core is wound. The condenser core is wound from full width insulating paper.

The foils are located so that the best possible combination of external flashover withstand and internal puncture strength is achieved.

The insulators and the mounting flange are held by the centre tube and sealing is accomplished by oil-resistant rubber gaskets in grooves.

A set of concentric tubes is prestressed and serves as a spring which holds the main bushing components together and provides adequate pressure on the gaskets at all expected temperatures, load conditions and mounting directions.

The annular space formed between the tubes makes an efficient cooling duct for heat dissipation, thus improving the current-carrying capacity and thermal stability of the bushing.

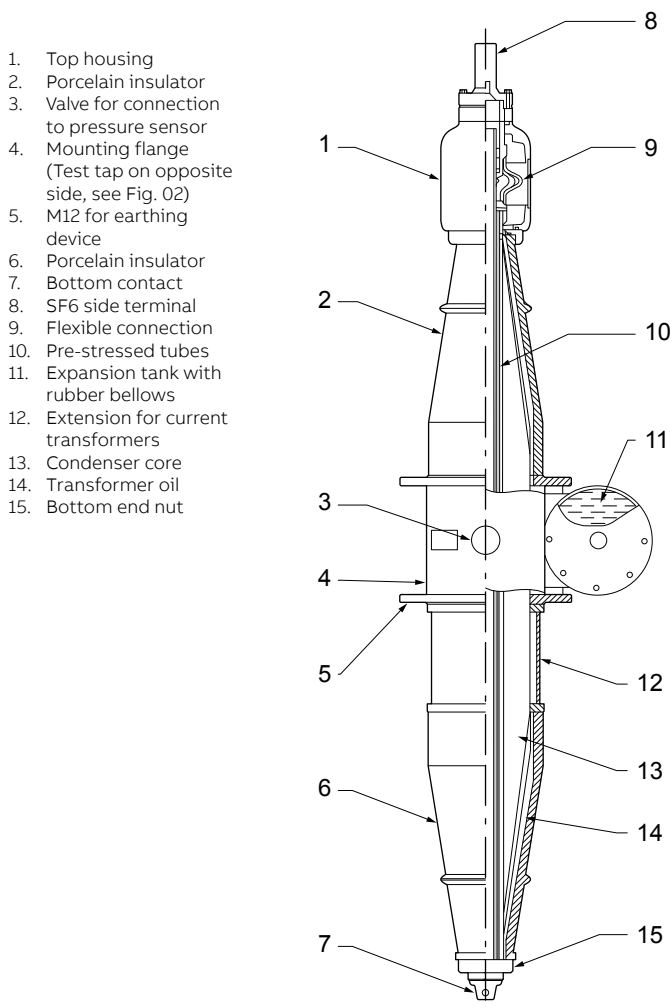
The bushing is equipped with an expansion tank in which a nitrogen-filled rubber bellows is mounted. This is an advantage since it permits mounting at any angle from vertical to horizontal, and also facilitates mounting on the transformer without further connection to separate expansion tanks.

Variations in the length of the centre tube and the housing are compensated by a flexible connection inside the top housing. The mounting flange is an aluminium alloy casting, which is protected by a two-component primer and two-component grey-blue paint. The surface roughness of the gasket area is Ra 6.3 on the oil side and Ra 1.6 on the SF<sub>6</sub> side.

On the mounting flange there is a test tap. This tap is automatically earthed by a protective cap when the tap is not connected to external test or measuring circuits.

To detect possible gas leakage, the bushing can be equipped with an oil pressure monitoring equipment.

The connection of the bushing to the transformer can be made with the draw-rod or tight bottom contact.



The bushing tube between the SF<sub>6</sub> side and the transformer is sealed in two ways. One seal is made by the SF<sub>6</sub> terminal and the other by a plug in the centre tube or by a tight bottom contact.

The mounting flange is equipped with an extension on the oil side to provide space for current transformers. Extension lengths 300 and 600 mm are available. GOEK 1675 can also be supplied without flange extension.

The bushing requires a shield at the oil side. The purpose of this shield is to avoid excess voltages in the oil at the bottom end nut and at the connection between the insulated lead from the transformer winding and the bottom contact in

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

ABB manufactures shields of this type - these are quoted for and supplied separately. The shields are made of aluminium and are insulated with epoxy or pressboard. The shield may be mounted on the bottom end nut of the bushing, or on the bottom contact of the draw rod.

**Table 1. General specifications**

|                                            |                                                                                                     |
|--------------------------------------------|-----------------------------------------------------------------------------------------------------|
| Application:                               | Transformers                                                                                        |
| Classification:                            | Oil impregnated paper, capacitance graded, completely immersed bushing                              |
| Ambient temperature:                       | +40 to -40 °C, minimum value as per temperature class 2 of IEC 60137.                               |
| Immersion medium on switchgear side:       | SF <sub>6</sub> gas. Max daily mean temperature +75 °C                                              |
| Max pressure of medium on switchgear side: | 750 kPa overpressure                                                                                |
| Altitude of site:                          | < 1 000 m                                                                                           |
| Immersion medium on transformer side:      | Transformer oil. Maximum daily mean oil temperature 90 °C. Maximum temporary oil temperature 115 °C |
| Oil level below bushing flange:            | Maximum 30 mm                                                                                       |
| Markings:                                  | Conforming to IEC/ IEEE                                                                             |

# Testing

A tightness test is carried out on the assembled bushing after the final drying and impregnation. The test is carried out according to IEC 60137. Each bushing is subjected to a final electrical routine test. The test is made at room temperature with the bushing submerged in transformer oil (valid for GOEK 1050 and GOEK 1425). Capacitance and tan d are measured in steps up to the power frequency withstand voltage, which is held for one minute.

Capacitance and tan d are also measured with 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, and at the same levels, as the tan d test. It is always demonstrated that the PD-value is maximum 5 pC at a test voltage level equal to the rated system voltage.

Electrical type testing is carried out according to IEC 60137 and IEC 62271-211, i.e. the gas side is placed in a metal cylinder filled with insulating gas at the pressure of 0.35 MPa (absolute) and with the diameter 450/540/650 for GOEK 1050/1425/1675 respectively.

Note: Dimensions of the bushings do not meet requirements shown in IEC 61639, Table 3.

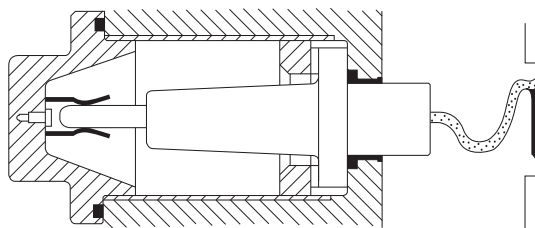
During testing of the transformer, a bushing type GOEK 1050 can be replaced by a bushing type GOE 900-650; a bushing type GOEK 1425 can be replaced by a bushing type GOE 1300-1150; and a bushing type GOEK 1675 can be replaced by a bushing type GOE 1675-1175.

## Test tap

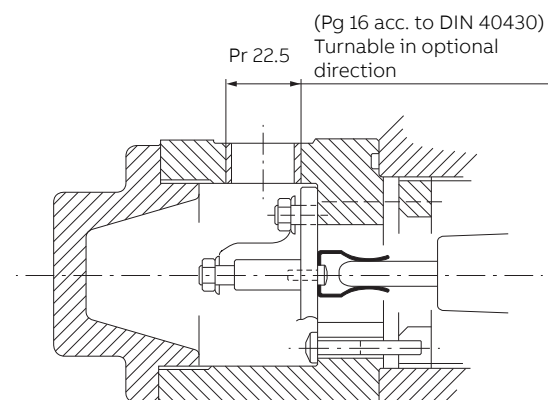
The GOEK bushings are equipped with a test tap connected to the outer layer of the condenser core. The test voltage of the tap is 20 kV, 50 Hz for one minute. Maximum service voltage is 6 kV. In connection with an external capacitance, the test tap can be used as a voltage tap. The test tap has dimensions according to IEEE, Potential tap type A.

## Test tap adapter

For permanent connection of the test tap to measuring circuits, a test tap adapter is required. Catalog number 2769 522-C.

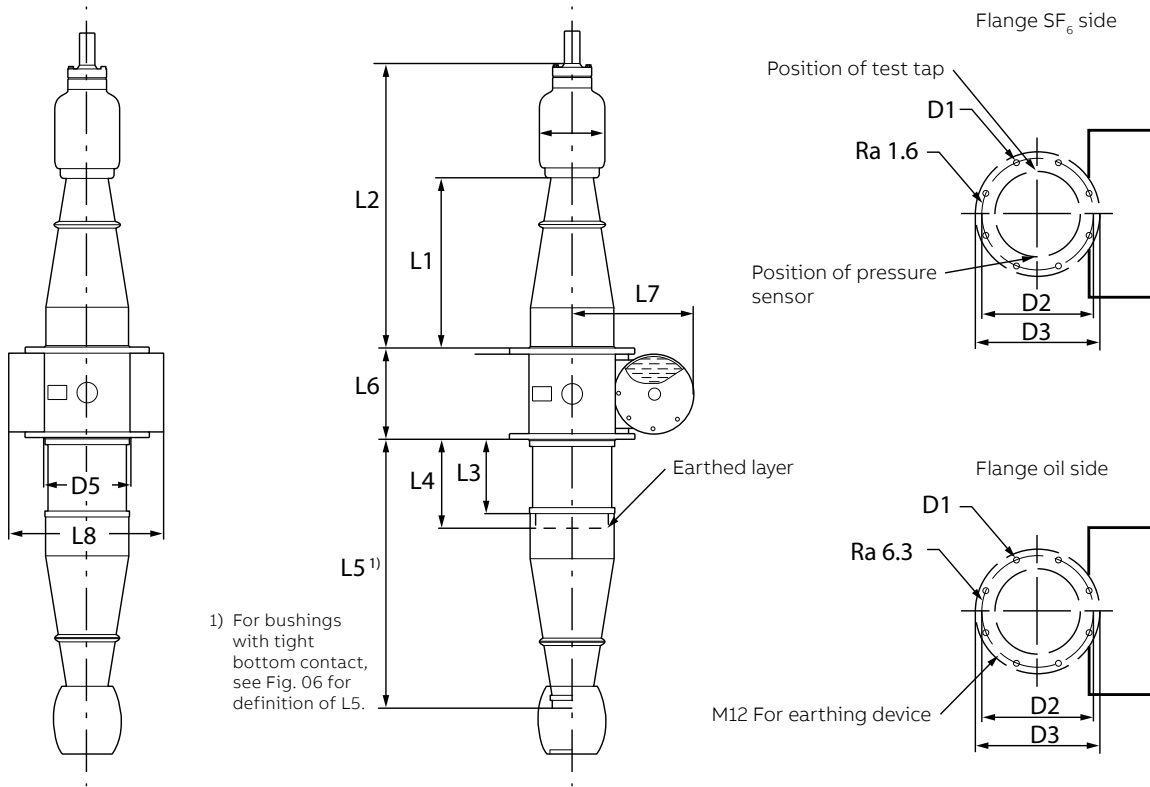


02 Test tap.



03 Test tap adapter.

# Dimensions



04 Dimensions.

Table 1. Dimensions.

| Type GOEK | Extension for current transformers mm | Type bottom contact | Catalog number | Dimensions |      |     |     |      |     |     |     |
|-----------|---------------------------------------|---------------------|----------------|------------|------|-----|-----|------|-----|-----|-----|
|           |                                       |                     |                | L1         | L2   | L3  | L4  | L5   | L6  | L7  | L8  |
| 1050      | 300                                   | Standard            | LF 124 001-B   | 450        | 885  | 305 | 325 | 835  | 230 | 395 | 740 |
|           | 300                                   | Tight               | LF 124 011-B   |            |      | 305 | 325 | 905  |     |     |     |
|           | 600                                   | Standard            | LF 124 001-C   |            |      | 605 | 625 | 1135 |     |     |     |
|           | 600                                   | Tight               | LF 124 011-C   |            |      | 605 | 625 | 1205 |     |     |     |
| 1425      | 300                                   | Standard            | LF 124 002-B   | 650        | 1090 | 305 | 315 | 1035 | 350 | 545 | 520 |
|           | 300                                   | Tight               | LF 124 012-B   |            |      | 305 | 315 | 1105 |     |     |     |
|           | 600                                   | Standard            | LF 124 002-C   |            |      | 605 | 615 | 1335 |     |     |     |
|           | 600                                   | Tight               | LF 124 012-C   |            |      | 605 | 615 | 1405 |     |     |     |
| 1675      | 0                                     | Standard            | LF 124 003-A   | 880        | 1395 | 5   | 150 | 985  | 350 | 695 | 915 |
|           | 0                                     | Tight               | LF 124 013-A   |            |      | 5   | 150 | 1055 |     |     |     |
|           | 300                                   | Standard            | LF 124 003-B   |            |      | 305 | 360 | 1285 |     |     |     |
|           | 300                                   | Tight               | LF 124 013-B   |            |      | 305 | 360 | 1355 |     |     |     |
|           | 600                                   | Standard            | LF 124 003-C   |            |      | 605 | 640 | 1585 |     |     |     |
|           | 600                                   | Tight               | LF 124 013-C   |            |      | 605 | 640 | 1655 |     |     |     |



# Electrical data

**Table 2. Electrical data.** The electrical data are valid in accordance with criteria in IEC 61639.

1) 5000 A available on request.

| Type<br>GOEK | Rated<br>voltage<br>$U_m$<br>kV, RMS | Rated phase-to-<br>earth voltage<br>$U_v$<br>kV, RMS | Dry<br>lightning<br>impulse<br>LI<br>kV, peak | Dry<br>switching<br>impulse<br>SI<br>kV, peak | Routine test<br>1 min dry 50 Hz<br>kV, RMS | Rated current <sup>1)</sup><br>at mounting<br>angle 0° - 75°<br>I <sub>r</sub><br>A | Reduced current<br>for horizontal<br>mounting and<br>up to 15° from<br>horizontal<br>A | Nominal capacitances<br>between conductor and<br>test tap C <sub>i</sub> ±10 % pF |     |     |
|--------------|--------------------------------------|------------------------------------------------------|-----------------------------------------------|-----------------------------------------------|--------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----|-----|
|              |                                      |                                                      |                                               |                                               |                                            |                                                                                     |                                                                                        | Flange extension, mm                                                              |     |     |
|              |                                      |                                                      |                                               |                                               |                                            |                                                                                     |                                                                                        | 0                                                                                 | 300 | 600 |
| 1050         | 245                                  | 170                                                  | 1050                                          | 850                                           | 460                                        | 2500                                                                                | 1600                                                                                   | -                                                                                 | 274 | 364 |
| 1425         | 420                                  | 245                                                  | 1425                                          | 1175                                          | 630                                        | 2500                                                                                | 1600                                                                                   | -                                                                                 | 263 | 335 |
| 1675         | 550                                  | 318                                                  | 1675                                          | 1300                                          | 750                                        | 2500                                                                                | 1600                                                                                   | 231                                                                               | 253 | 308 |

05 Nameplate with  
marking example.

| ABB              |                                           | Ludvika, Sweden<br>2011 |  |
|------------------|-------------------------------------------|-------------------------|--|
| GOEK 1050        | LF 124 001-C                              |                         |  |
| No. 888999       |                                           |                         |  |
| Um/Uy 245/170 kV | I <sub>r</sub> (vert./horiz.) 2500/1600 A |                         |  |
| 50/60 Hz         |                                           |                         |  |
| LI 1050 kV       | SI 850 kV                                 | AC 460 kV               |  |
| M 200 kg         | L 1135 mm                                 | ∠ 0-90°                 |  |
| C1 350 pF        | Tan δ 0.39 %                              |                         |  |
| C2 900 pF        | Tan δ 0.17 %                              |                         |  |

| D1       | D2  | D3  | D4  | D5  | t  | Mass<br>kg | Cantilever load, N              |      |               |
|----------|-----|-----|-----|-----|----|------------|---------------------------------|------|---------------|
|          |     |     |     |     |    |            | In operation, at mounting angle |      | Test for 60 s |
|          |     |     |     |     |    |            | 0°-30°                          | >30° |               |
| 20 (8x)  | 350 | 400 | 244 | 264 | 23 | 180        | 2500                            | 1500 | 5000          |
|          |     |     |     |     |    | 180        |                                 |      |               |
|          |     |     |     |     |    | 200        | 2500                            | 1500 | 5000          |
|          |     |     |     |     |    | 200        |                                 |      |               |
| 20(8x)   | 430 | 480 | 244 | 330 | 23 | 285        | 2500                            | 1500 | 5000          |
|          |     |     |     |     |    | 285        |                                 |      |               |
|          |     |     |     |     |    | 320        | 2500                            | 1500 | 5000          |
|          |     |     |     |     |    | 320        |                                 |      |               |
| 24 (12x) | 660 | 720 | 344 | 428 | 30 | 495        | 2500                            | 1500 | 5000          |
|          |     |     |     |     |    | 495        |                                 |      |               |
|          |     |     |     |     |    | 540        | 2500                            | 1500 | 5000          |
|          |     |     |     |     |    | 540        |                                 |      |               |
|          |     |     |     |     |    |            | 575                             | 1500 | 5000          |
|          |     |     |     |     |    |            | 575                             |      |               |

# Connection details

## Draw rod system with standard bottom contacts

The centre tube of the bushing is used as current conductor. The transformer leads are fitted with cable lugs, which are bolted to a bottom contact. This contact is drawn against the bottom end nut by a steel draw rod. See Fig. 5.

At the level of the flange the draw rod is split into two parts. If required to meet the transport conditions, we can position a joint at any desired level below the flange. This must be stated in the order. The lower part with contact and shield can then be secured to the cover during transport and storage of the transformer. This system has the following additional advantages compared to other methods used for high currents:

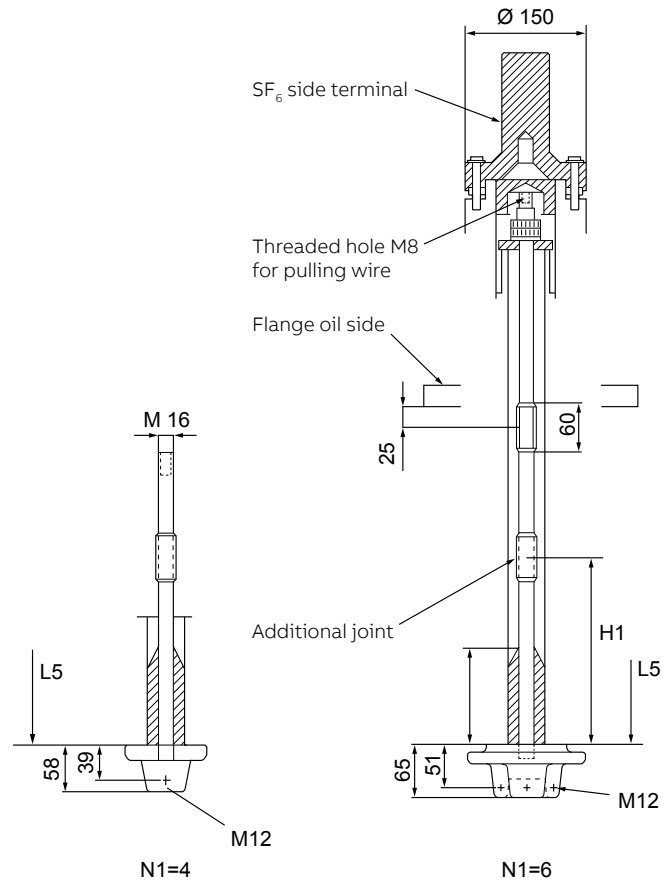
- No hand holes required in the transformer tank.
- The centre tube is used as conductor.
- No special supports required in the transformer as the case with plug contacts.
- Perfect guiding of the bushing into the transformer.
- The end shield may be fixed to the bottom contact and will thus be correctly positioned with respect to the bottom end nut (for contact with N1=6).
- No mechanical forces exerted on the leads from the transformer winding at any time.

## Tight bottom contact

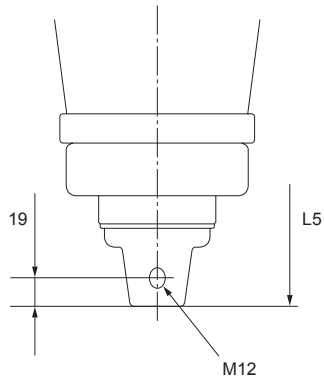
A system with tight bottom contact is also available. This system consists of a bottom contact with 4 threaded holes. The bottom contact is soldered together with the bottom end nut. See Fig. 6.

## SF<sub>6</sub> side terminal

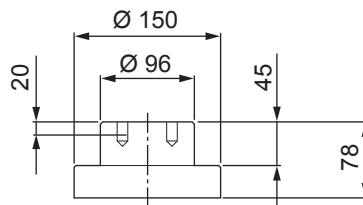
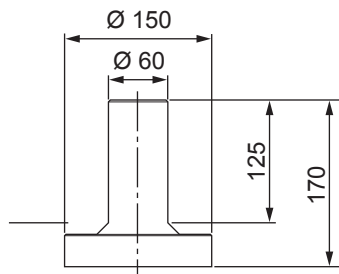
The terminal stud assembly consists of a stud, a tightening ring, a gasket, bolts and washers. The electrical contact function and the sealing function are completely separated. The stud is first fastened to the bushing top with M10 bolts, which provide proper electrical contact. The contact surface is located inside the gasket and is thereby well protected from corrosion. Finally the tightening ring with the gasket is pressed against the stud by means of M8 bolts.



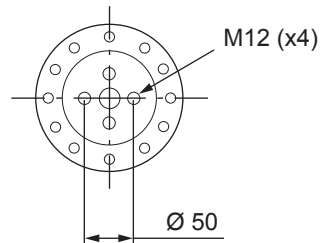
05 Draw rod system with standard bottom contacts.



06 Tight bottom contact.



LF 170 050-AA  
(Aluminium)  
or  
LF 170 050-AL  
(Copper, silver-plated)

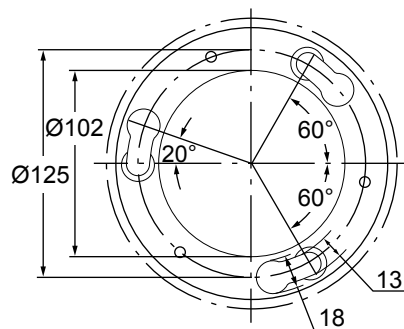
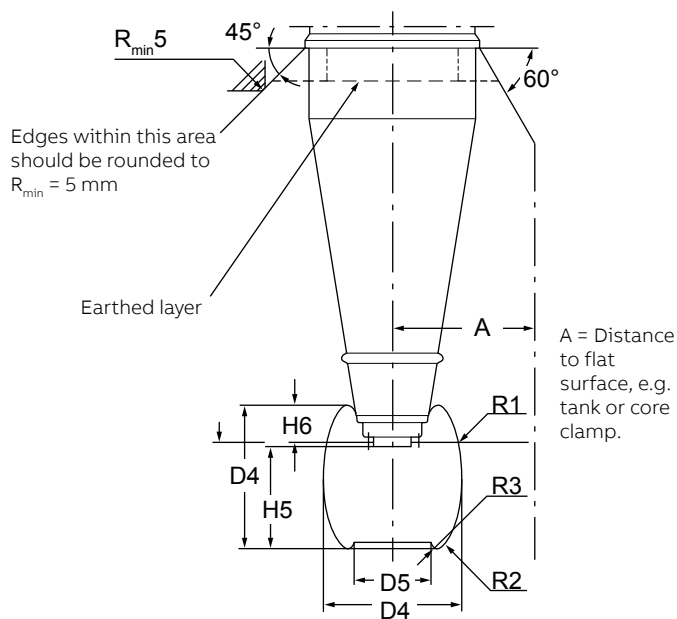


LF 170 050-AH (Copper, silver-plated)

07 Terminal stud, SF<sub>6</sub> side.

# Data for end-shields

The maximum voltages in the oil at the surface of the shield insulation and the parts surrounding the bushing must be limited to those values normal for insulated conductors and other similar components in the same transformer. The withstand voltages in a specific case depend upon many factors beyond the control of the bushing manufacturer. Therefore the configurations and distances given below are only intended as guide lines.

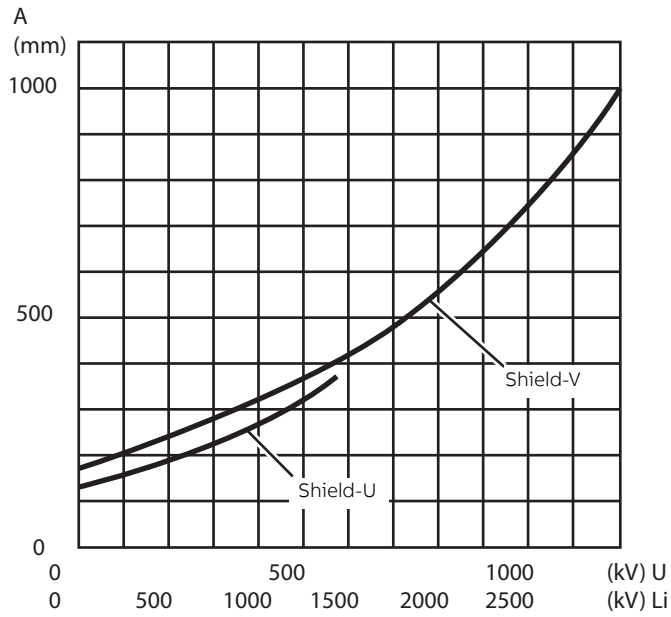


08 Shield, oil side.

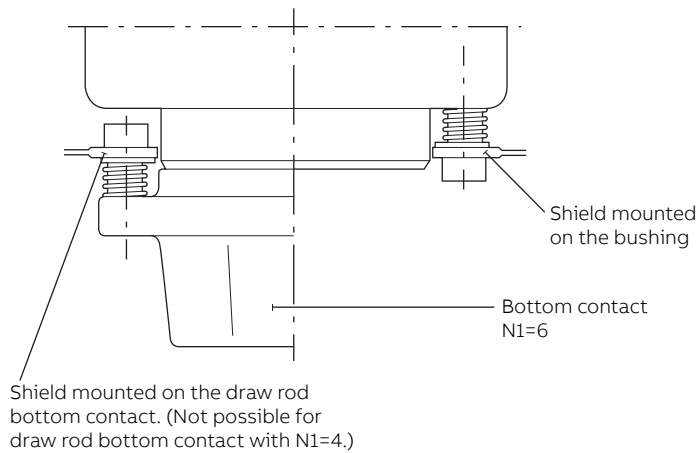
**Table 3. Insulated shield, oil side.**

All dimensions refer to the epoxy insulated shield, which is used as a base. The thickness of the pressboard is 3 mm for -UP and -VP.

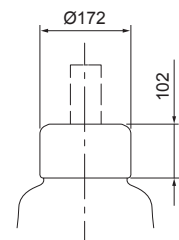
| Dimensions according to Fig. 8 (mm) |                      |     |     |     |     |                           |     |     |    |    |         |            |                 |                                    |
|-------------------------------------|----------------------|-----|-----|-----|-----|---------------------------|-----|-----|----|----|---------|------------|-----------------|------------------------------------|
| Shield                              | To be used with GOEK | D4  | D5  | H4  | H5  | H5 (tight bottom contact) | H6  | R1  | R2 | R3 | Mass kg | Cat. No.   | Epoxy insulated | Pressboard insulated <sup>1)</sup> |
| U                                   | 1050-1425            | 262 | 174 | 265 | 170 | 100                       | 90  | 492 | 30 | 8  | 2.1     | LF 170 046 | -U              | -UP                                |
| V                                   | 1675                 | 352 | 200 | 365 | 240 | 170                       | 120 | 351 | 24 | 14 | 2.5     | LF 170 046 | -V              | -VP                                |



09 Recommended minimum distance A for different shields and test voltages. (U = Power frequency, LI = Lightning impulse)



10 Mounting alternatives, oil side.



LF 170 046-F

11 Shield, SF<sub>6</sub> side.

# Conductor loading

The rated currents specified in this catalog are based on thermal tests and are in accordance with IEC 60137 and apply to the built-in conductors of the bushings. The GOEK bushings conform to the requirements of IEC 60137 and IEEE for currents given in Table 4.

## Short-time current

The rated thermal short-time current ( $I_{th}$ ), as defined in IEC 60137 clause 2, is listed in Table 4 for draw rod system and for tight bottom contact.

## Overload capacity 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 overload conditions according to IEC 60354 without further clarification or tests. This recommendation complies with IEC 60137.

**Table 4. Rated current, short-time current and dynamic current as defined in IEC 60137.**

| Rated current<br>IEC | Current<br>IEEE | Short-time current |                 | Dynamic current |
|----------------------|-----------------|--------------------|-----------------|-----------------|
|                      |                 | $I_{th}$<br>1 s    | $I_{th}$<br>2 s | $I_d$<br>peak   |
| A                    | A               | kA                 | kA              | kA              |
| 2500                 | 2100            | 100                | 100             | 250             |

# Ordering particulars

When ordering, please state:

- Type and catalog number for bushing.
- Catalog number for draw rod, if standard bottom contact is chosen.
- Catalog number for SF<sub>6</sub> side terminal.
- Catalog number for shield on oil side. Shield on SF<sub>6</sub> side must also be specified.
- Catalog number for pressure monitoring equipment.
- Additional accessories or modifications.
- Test required in addition to the normal routine tests.

**Table 6. Pressure monitoring equipment.**  
(For details, see product information 5693 827-6.)

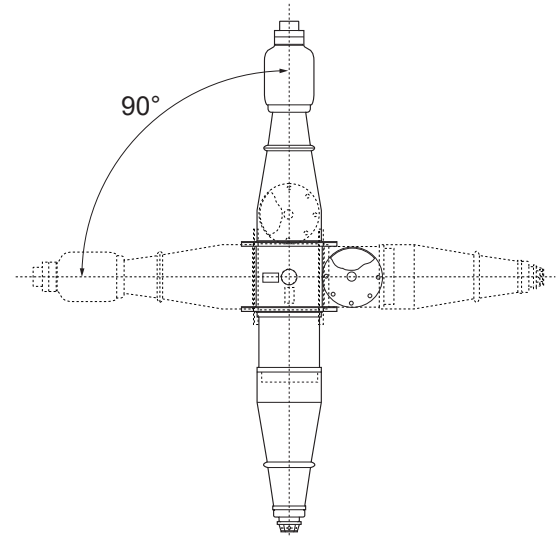
| Supply voltage | Catalog number |
|----------------|----------------|
| 230 V AC       | LF 410 024-K   |
| 115 V AC       | LF 410 024-L   |

**Table 5. Catalog numbers.**

| Type<br>GOEK | Extension<br>for current<br>transf.<br>mm | Type<br>bottom<br>contact | Catalog<br>number for<br>bushing<br>LF 124 ... | Catalog number<br>for draw rod<br>LF 124 ...         |       | Catalog number for<br>SF <sub>6</sub> side terminal<br>LF 170 ... | Catalog number for shields<br>LF 170 ... |                    |                         |                      |
|--------------|-------------------------------------------|---------------------------|------------------------------------------------|------------------------------------------------------|-------|-------------------------------------------------------------------|------------------------------------------|--------------------|-------------------------|----------------------|
|              |                                           |                           |                                                | Number of threaded<br>holes in the<br>bottom contact |       |                                                                   | Oil side                                 |                    |                         |                      |
|              |                                           |                           |                                                | 4                                                    | 6     | Material                                                          | Copper,<br>silver plated                 | Epoxy<br>insulated | Pressboard<br>insulated | SF <sub>6</sub> side |
| 1050         | 300                                       | Standard                  | 001-B                                          | 101-B                                                | 101-E | 050-AA                                                            | 050-AL or -AH                            | 046-U              | 046-UP                  | 046-F                |
|              | 300                                       | Tight                     | 011-B                                          | -                                                    | -     |                                                                   |                                          |                    |                         |                      |
|              | 600                                       | Standard                  | 001-C                                          | 101-C                                                | 101-F |                                                                   |                                          |                    |                         |                      |
|              | 600                                       | Tight                     | 011-C                                          | -                                                    | -     |                                                                   |                                          |                    |                         |                      |
| 1425         | 300                                       | Standard                  | 002-B                                          | 102-B                                                | 102-E | 050-AA                                                            | 050-AL or -AH                            | 046-U              | 046-UP                  | 046-F                |
|              | 300                                       | Tight                     | 012-B                                          | -                                                    | -     |                                                                   |                                          |                    |                         |                      |
|              | 600                                       | Standard                  | 002-C                                          | 102-C                                                | 102-F |                                                                   |                                          |                    |                         |                      |
|              | 600                                       | Tight                     | 012-C                                          | -                                                    | -     |                                                                   |                                          |                    |                         |                      |
| 1675         | 0                                         | Standard                  | 003-A                                          | 103-A                                                | 103-D | 050-AA                                                            | 050-AL or -AH                            | 046-V              | 046-VP                  | 046-F                |
|              | 0                                         | Tight                     | 013-A                                          | -                                                    | -     |                                                                   |                                          |                    |                         |                      |
|              | 300                                       | Standard                  | 003-B                                          | 103-B                                                | 103-E |                                                                   |                                          |                    |                         |                      |
|              | 300                                       | Tight                     | 013-B                                          | -                                                    | -     |                                                                   |                                          |                    |                         |                      |
|              | 600                                       | Standard                  | 003-C                                          | 103-C                                                | 103-F |                                                                   |                                          |                    |                         |                      |
|              | 600                                       | Tight                     | 013-C                                          | -                                                    | -     |                                                                   |                                          |                    |                         |                      |

# Recommendations for positioning

The expansion tank must be in its uppermost position. See Fig. 12.  
For further information see Testing (for SF<sub>6</sub> side spacing) and Data for end-shields (for oil side spacing).



12 Recommendations for positioning.









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