

1ZSE 2750-105 en, Rev. 7

# Transformer bushings, type GOE and GOE(2) 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 authorized representative.

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# Design

The GOE bushing is available in two designs: GOE and GOE(2). The bushing is built up around a centre tube on which the condenser core is wound. For bushings up to 550 kV paper of full width is employed. Bushings for higher voltages are wound from paper strips in a manner similar to that used for cables. The foils are located so that the best possible combination of external flashover and internal puncture strength is achieved.

The upper insulator, which is made in one piece without gaskets, the lower insulator and the mounting flange are held between the end plates by the centre tube and sealing is accomplished by oil-resistant rubber gaskets in grooves.

For GOE 250 to 900 the top housing is equipped with two oil level gauges of prism type. For GOE 1050 and larger, the top housing is equipped with a magnetic oil level indicator.

The mounting flange is an aluminium alloy casting. The gasket surface is machined flat. On the 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. The mounting flange and the top housing are shot blasted to obtain a thoroughly smooth surface finish. The mounting flange can be equipped with extensions on the oil side, providing space for current transformers.

The rated current is defined according to IEC 60137. It is valid only when the centre tube is used as conductor. For draw lead applications the permissible current will be lower. Please refer to the applicable section.

Bushings GOE 450 and larger require a shield at the oil end. The purpose of this shield is to avoid excessive electrical stresses in the oil at the lower end plate and at the connection between the insulated lead from the transformer winding and the draw lead or other conductors in the bushing. 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.

ABB manufactures shields of this type, which are quoted for and delivered separately. The shields are made of aluminium and are insulated with epoxy or a lining of pressboard. The shield may be mounted on the lower end plate of the bushing, or on the bottom contact of the draw rod. Dimensions and recommendations, see Figs. 18, 19 and 22-26.

It is of great importance that the shield is placed in the right position in order to protect the bottom end of the bushing. Guidelines for positioning of the shield are given in Figs. 24

and 26. ABB can also provide assistance with field calculations to confirm the performance of other shielding systems.

Quotations for modifications in design and additional parts such as special terminal studs, shields, rod gaps, etc., as well as special tests, are given on request.

3D models and dimension drawings can be downloaded from the ABB website.

## GOE features

A set of concentric tubes are pre stressed and serve as springs which hold the main bushing components together and provide adequate pressure on the gaskets in all expected temperature and load conditions. The annular space formed between the tubes makes an efficient cooling duct for dissipation of the heat, thus improving the current-carrying capacity and thermal stability of the bushing.

The bushing is designed to be mounted at an angle of up to 30° to 60° from the vertical. A higher inclination can be obtained on request. The current shall be reduced for horizontal mounting and up to 15° from horizontal.

The top housing is made of aluminium and has expansion space for the oil, sufficient for temperature variations in the bushing between -40° and +80 °C. Variations in the length of the centre tube and the housing are compensated by a flexible connection inside the top housing.

The upper insulator on bushings GOE 1050 and larger are equipped with retaining rings mounted with stainless steel details.

## GOE(2) features

A set of springs in the top housing provides adequate pressure on all gaskets, independently of temperature and load conditions.

The bushing is designed to be mounted at an angle not exceeding 30° from the vertical.

The top housing has expansion space for the oil sufficient for temperature variations in the bushing between -40° and +80 °C. Variations in the length of the centre tube are compensated by the flexible cover of the housing.

For GOE(2) the upper insulator is cemented to a flange which is bolted to the mounting flange.

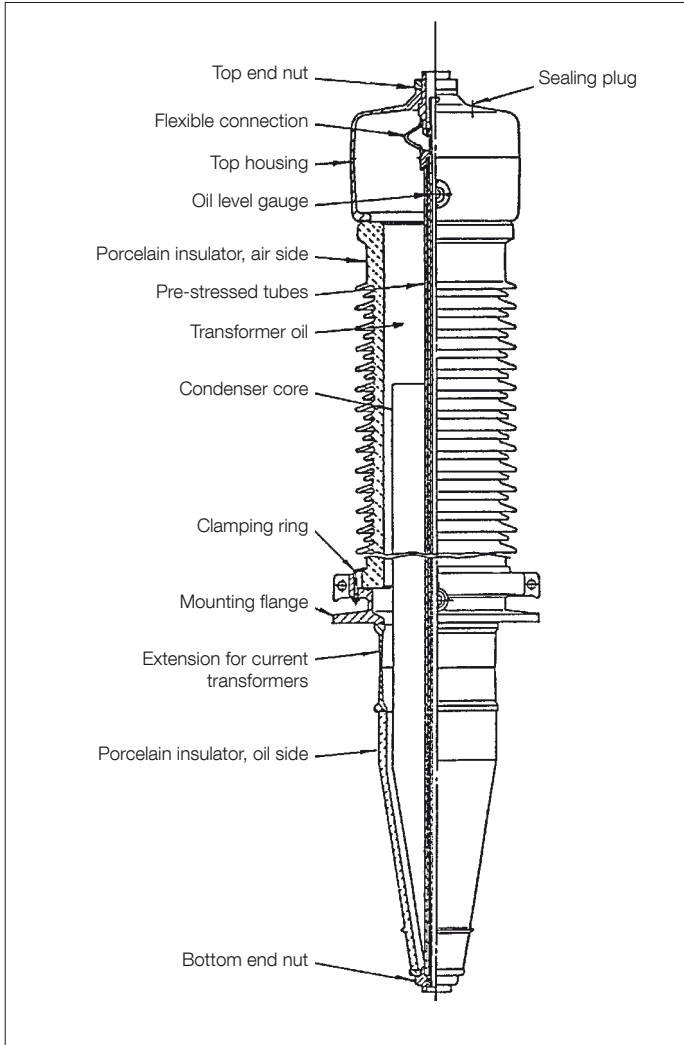


Fig. 1. Transformer bushing type GOE.

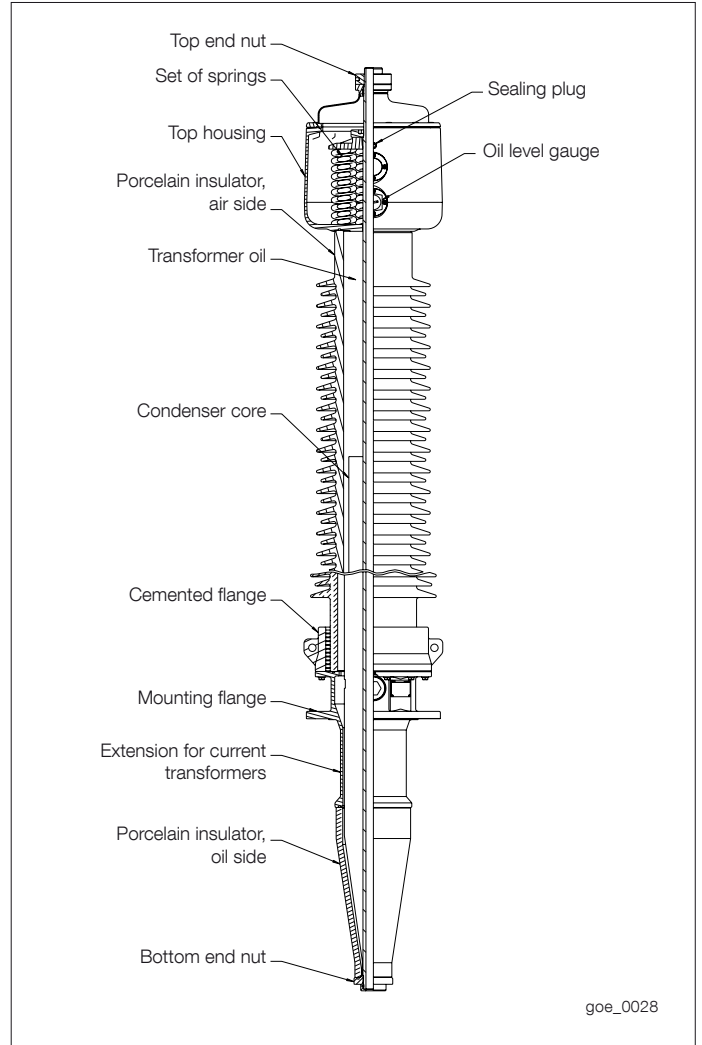


Fig. 2. Transformer bushing type GOE(2).

## Features and benefits

- A complete range and outstanding operational experience from the most demanding applications for more than 30 years.
- Our unique draw rod system facilitates easy field installation and removal without lowering the oil level.
- The world's most used 800 kV bushing. Never any failures in the field.
- 3D models make it easy to incorporate the bushing in its context.
- We use a sealing system proven since 40 years around the world.
- Our test criteria and margins exceeding international standards.
- Only extra long creepage shed profile.

## Shed profile

The shed profile for all GOE bushings is of the anti-fog type with alternating long and short sheds.

### GOE

The shed profile is designed according to IEC 60815. For each pair of sheds, the ratio between nominal creepage distance and the axial length is 4.0. This shed profile is developed and tested specially for heavy pollution.

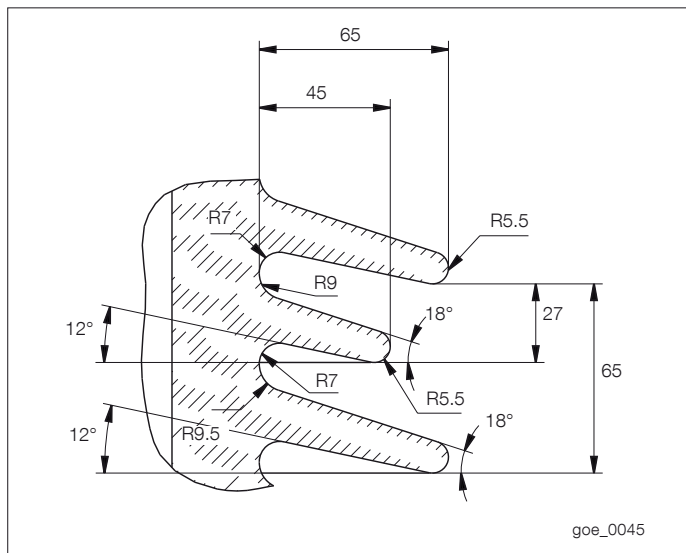


Fig. 3. Shed profile GOE.

### GOE(2)

The shed profile is designed according to IEC 60815. For each pair of sheds, the ratio between nominal creepage distance and the axial length is 3.94.

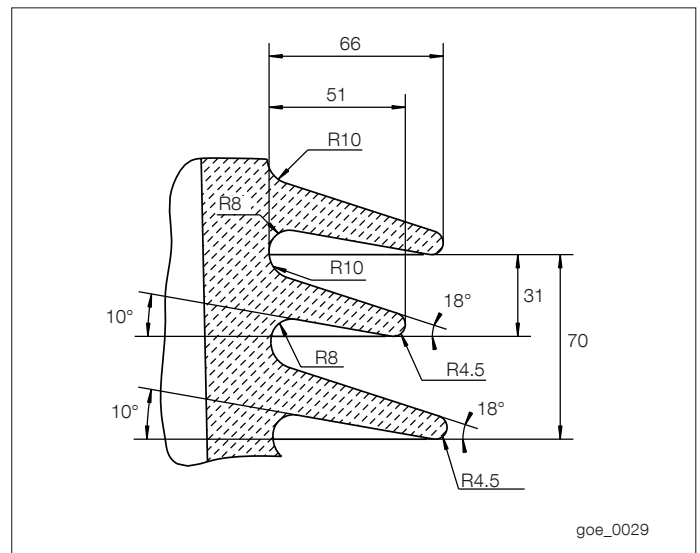


Fig. 4. Shed profile GOE(2).

## Common specifications

Application:	Transformers
Classification:	Oil impregnated paper, capacitance graded, outdoor immersed bushing
Ambient temperature:	+40 °C to -50 °C, minimum value acc. to 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 ("Guide for the selection of insulators in respect of polluted conditions.")
Immersion medium:	Transformer oil. Maximum daily mean temperature 90 °C. Maximum temporary oil temperature 115 °C.
Oil level in transformer:	Not lower than 30 mm from the bushing flange.
Max. pressure of surrounding medium:	100 kPa over pressure.
Markings:	Conforming to IEC/ IEEE

For conditions exceeding the standard specification above, please consult ABB.

# Testing

During manufacture and on completion the bushing is subjected to a number of routine tests, according to IEC 60137 and IEEE bushing standards. However, ABB's requirements for acceptance are generally higher than IEC and IEEE standards.

A tightness test is carried out on the assembled bushing after the final drying and impregnation. The test is made at 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 lower end of 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. The PD value must not exceed 30 pC at the withstand voltage. Capacitance,  $\tan \delta$  and internal partial discharge are also measured with decreasing voltage at the same voltage levels as before the one minute test. It is always demonstrated that the PD value is below 5 pC at rated voltage ( $=\sqrt{3}$  times bushing service voltage).

Requirements for  $\tan \delta$  are max. 0.55 % for  $U_m \leq 362$  kV, max. 0.5 % for  $U_m$  between 362 and 550 kV and max. 0.4% for  $U_m > 550$  kV. These measurements are carried out at the same time, and at the same levels, as the  $\tan \delta$  test.

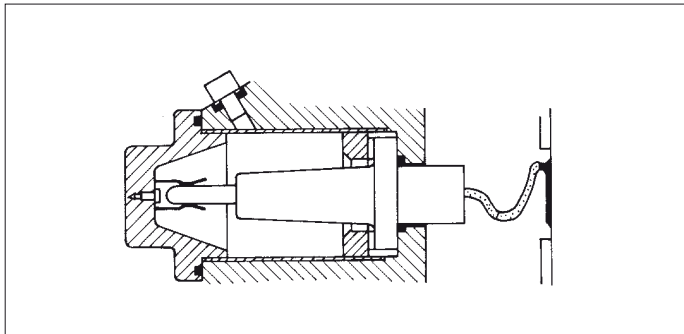


Fig. 5. Test tap

## Oil sampling valve

All GOE bushings are equipped with an oil sampling valve. The oil sampling valve can also be used as connection to pressure sensor or pressure switch using the ISO-G 1/4" inside thread.

Bushings with  $U_m \geq 245$  kV are routine tested with a dry lightning impulse voltage withstand test, in addition to what has been described.

Type tests have been carried out according to IEC 60137 and IEEE. Type test reports are available on request.

## Test tap

All GOE bushings are equipped with a test tap connected to the outer layer of the condenser core. The max. test voltage of the tap is 20 kV, 50 Hz for one minute. Max. 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. Catalogue number 2769 522-C.

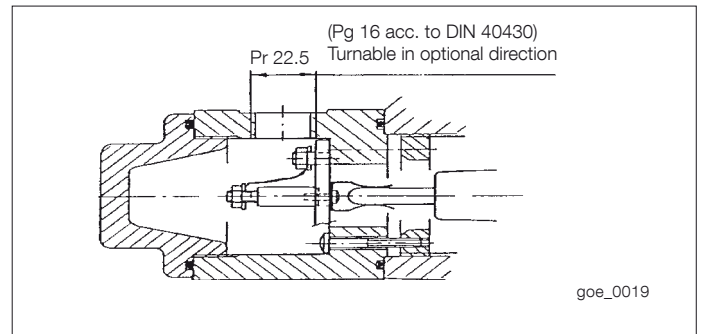


Fig. 6. Test tap adapter.



Fig. 7. Oil sampling valve.

# Dimensions

## GOE 250-210 to GOE 950-650

Nominal voltages 52 kV to 170 kV

Lightning impulse 250 kV to 950 kV

Maximum current 3150 A to 5000 A

Catalog Number	Bushing	Flange extension	Creepage distance	D1	L1	L2	L3	L4	L5±5	Mass	D2	D3	D4	D5	D6	A1	A2	H1
		mm	mm	mm	mm	mm	mm	mm	mm	kg	mm	mm	mm	mm	mm	mm	mm	mm
1ZSC902052-AAA	GOE 250-210-3150-0.3	0.3	2955 ±80	48	825 ±20	1335 ±25	305	375	685	230	224	350	386	350	300	60	60	20 (6x)
-AAB	GOE 250-210-3150-0.6	0.6	2955 ±80	48	825 ±20	1335 ±25	605	670	985	240	224	350	386	350	300	60	60	20 (6x)
-ABA	GOE 250-210-5000-0.3	0.3	2955 ±80	38	825 ±20	1335 ±25	305	375	685	270	224	350	386	350	300	60	60	20 (6x)
-ABB	GOE 250-210-5000-0.6	0.6	2955 ±80	38	825 ±20	1335 ±25	605	670	985	290	224	350	386	350	300	60	60	20 (6x)
1ZSC902072-AAA	GOE 380-300-3150-0.3	0.3	2955 ±80	48	825 ±20	1335 ±25	305	375	685	230	224	350	386	350	300	60	60	20 (6x)
-AAB	GOE 380-300-3150-0.6	0.6	2955 ±80	48	825 ±20	1335 ±25	605	670	985	240	224	350	386	350	300	60	60	20 (6x)
-ABA	GOE 380-300-5000-0.3	0.3	2955 ±80	38	825 ±20	1335 ±25	305	375	685	270	224	350	386	350	300	60	60	20 (6x)
-ABB	GOE 380-300-5000-0.6	0.6	2955 ±80	38	825 ±20	1335 ±25	605	670	985	290	224	350	386	350	300	60	60	20 (6x)
1ZSC902145-AAA	GOE 650-500-3150-0.3	0.3	4775 ±125	48	1300 ±27	1810 ±33	605	400	835	330	264	400	386	350	350	45	90	20 (8x)
-AAB	GOE 650-500-3150-0.6	0.6	4775 ±125	48	1300 ±27	1810 ±33	605	700	1135	350	264	400	386	350	350	45	90	20 (8x)
-ABA	GOE 650-500-5000-0.3	0.3	4775 ±125	38	1300 ±27	1810 ±33	305	400	835	390	264	400	386	350	350	45	90	20 (8x)
-ABB	GOE 650-500-5000-0.6	0.6	4775 ±125	38	1300 ±27	1810 ±33	605	700	1135	410	264	400	386	350	350	45	90	20 (8x)
1ZSC902170-AAA	GOE 950-650-3150-0.3	0.3	6820 ±175	48	1800 ±37	2310 ±42	305	315	835	405	264	400	386	350	350	45	90	20 (8x)
-AAB	GOE 950-650-3150-0.6	0.6	6820 ±175	48	1800 ±37	2310 ±42	605	615	1135	420	264	400	386	350	350	45	90	20 (8x)

Table 1. Dimensions GOE 250 to 950.

Catalog Number	Bushing	Rated current	Rated voltage	Phase-to-earth voltage	Dry lightning impulse	Wet switching impulse	Routine test	Wet power frequency	Dry switching impulse	Nominal capacitance	Max. test load	Max permitted load
		A	U <sub>m</sub> kV, RMS	U <sub>v</sub> kV, RMS	LI kV, peak	SI kV, peak	dry 50 Hz kv, RMS	AC kV, RMS	kV, peak	between conductor and test tap (C <sub>1</sub> )	load 1 min acc. to IEC 60137 (N)	(N) in operation at mounting angle
1ZSC902052-AAA	GOE 250-210-3150-0.3	3150	52	30	250	210	120	120	400	448	5700	2800 1700
-AAB	GOE 250-210-3150-0.6	3150	52	30	250	210	120	120	400	594	5700	2800 1700
-ABA	GOE 250-210-5000-0.3	5000	52	30	250	210	120	120	400	448	5700	2800 1700
-ABB	GOE 250-210-5000-0.6	5000	52	30	250	210	120	120	400	594	5700	2800 1700
1ZSC902072-AAA	GOE 380-300-3150-0.3	3150	72.5	42	380	300	175	170	550	448	5700	2800 1700
-AAB	GOE 380-300-3150-0.6	3150	72.5	42	380	300	175	170	550	594	5700	2800 1700
-ABA	GOE 380-300-5000-0.3	5000	72.5	42	380	300	175	170	550	448	5700	2800 1700
-ABB	GOE 380-300-5000-0.6	5000	72.5	42	380	300	175	170	550	594	5700	2800 1700
1ZSC902145-AAA	GOE 650-500-3150-0.3	3150	145	84	650	500	325	315	650	392	5700	2800 1700
-AAB	GOE 650-500-3150-0.6	3150	145	84	650	500	325	315	650	498	5700	2800 1700
-ABA	GOE 650-500-5000-0.3	5000	145	84	650	500	325	315	650	392	5700	2800 1700
-ABB	GOE 650-500-5000-0.6	5000	145	84	650	500	325	315	650	498	5700	2800 1700
1ZSC902170-AAA	GOE 950-650-3150-0.3	3150	170	98	950	650	395	395	750	377	5000	2500 1500
-AAB	GOE 950-650-3150-0.6	3150	170	98	950	650	395	395	750	466	5000	2500 1500

Table 2. Data GOE 250 to 950.

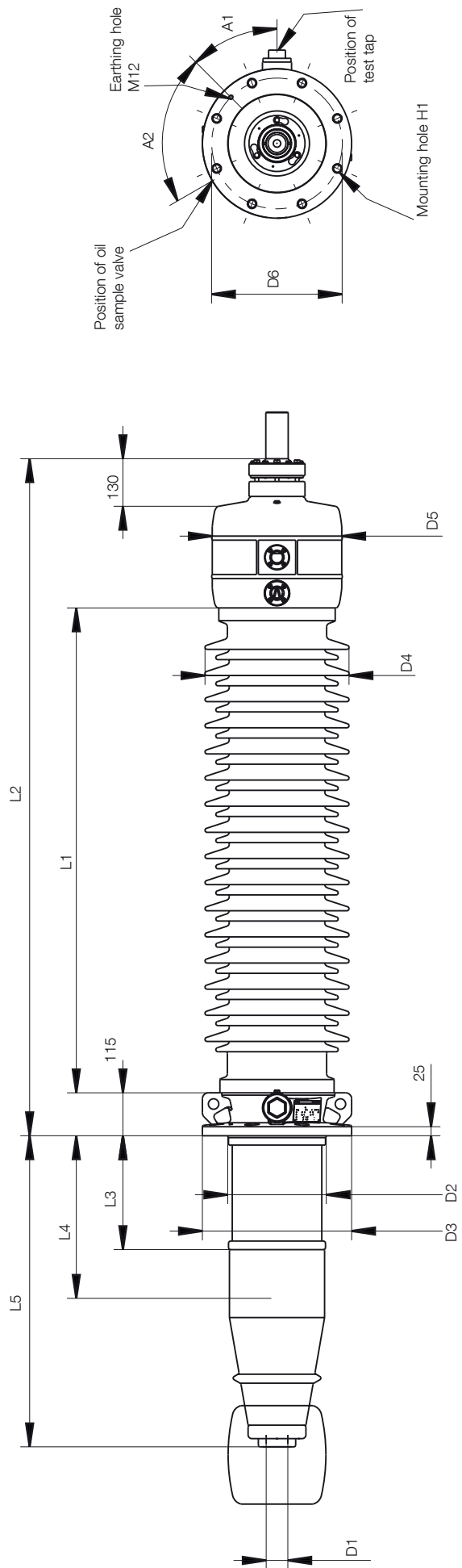


Fig 8. Dimensions GOE 250 to 950.

# GOE 1050-750 to GOE 1800-1360

Nominal voltage 245 kV to 550 kV

Lightning impulse 1050 kV to 1800 kV

Maximum current 2500 A to 5000 A

Catalog Number	Bushing	Flange extension mm	Creepage distance mm	D1 mm	L1 mm	L2 mm	L3 mm	L4 mm	L5+5 mm	Mass kg	D2 mm	D3 mm	D4 mm	D5 mm	D6 mm	A1 mm	H1 mm
1ZSC902245-AAA	GOE 1050-750-2500-0.3	0.3	8190 ±210	48	2230 ±55	3070 ±60	305	390	1035	755	330	480	485	500	430	45	20 (8x)
-AAB	GOE 1050-750-2500-0.6	0.6	8190 ±210	48	2230 ±55	3070 ±60	605	655	1335	775	330	480	485	500	430	45	20 (8x)
-ABA	GOE 1050-750-5000-0.3	0.3	8190 ±210	38	2230 ±55	3070 ±60	305	390	1035	735	330	480	485	500	430	45	20 (8x)
-ABB	GOE 1050-750-5000-0.6	0.6	8190 ±210	38	2230 ±55	3070 ±60	605	655	1335	765	330	480	485	500	430	45	20 (8x)
1ZSC902362-AAA	GOE 1175-850-2500-0.3	0.3	9120 ±240	48	2470 ±55	3310 ±60	305	335	1035	810	330	480	485	500	430	45	20 (8x)
-AAB	GOE 1175-850-2500-0.6	0.6	9120 ±240	48	2470 ±55	3310 ±60	605	610	1335	830	330	480	485	500	430	45	20 (8x)
1ZSC902420-AAA	GOE 1300-1050-2500-0.3	0.3	13745 ±355	48	3620 ±56	4460 ±61	305	320	1035	1070	330	480	485	500	430	45	20 (8x)
-AAB	GOE 1300-1050-2500-0.6	0.6	13745 ±355	48	3620 ±56	4460 ±61	605	320	1035	1090	330	480	485	500	430	45	20 (8x)
-BAA	GOE 1425-1150-2500-0.3	0.3	13745 ±355	48	3620 ±56	4460 ±61	605	620	1335	1070	330	480	485	500	430	45	20 (8x)
-BAB	GOE 1425-1150-2500-0.6	0.6	13745 ±355	48	3620 ±56	4460 ±61	605	620	1335	1090	330	480	485	500	430	45	20 (8x)
1ZSC902550-AAA	GOE 1550-1175-2500-0.3	0.3	18020 ±470	48	4710 ±55	5751 ±61	305	310	1285	1750	428	720	565	600	660	30	24 (12x)
-AAB	GOE 1550-1175-2500-0.6	0.6	18020 ±470	48	4710 ±55	5751 ±61	605	610	1585	1785	428	720	565	600	660	30	24 (12x)
-BAA	GOE 1675-1300-2500-0.3	0.3	18020 ±470	48	4710 ±55	5751 ±61	305	310	1285	1750	428	720	565	600	660	30	24 (12x)
-BAB	GOE 1675-1300-2500-0.6	0.6	18020 ±470	48	4710 ±55	5751 ±61	605	610	1585	1785	428	720	565	600	660	30	24 (12x)
-CAA	GOE 1800-1360-2500-0.3	0.3	18020 ±470	48	4710 ±55	5751 ±61	305	310	1285	1750	428	720	565	600	660	30	24 (12x)
-CAB	GOE 1800-1360-2500-0.6	0.6	18020 ±470	48	4710 ±55	5751 ±61	605	610	1585	1785	428	720	565	600	660	30	24 (12x)

Table 3. Dimensions GOE 1050 to 1800.

Catalog Number	Bushing	Rated current A	Rated voltage U <sub>m</sub> kV, RMS	Phase-to-earth voltage U <sub>y</sub> kV, RMS	Dry lightning impulse LI kV, peak	Wet switching impulse SI kV, peak	Routine test 1 min dry 50 Hz kv, RMS	Wet power frequency AC kV, RMS	Dry switching impulse kV, peak	Nominal capacitance between conductor and test tap (C <sub>1</sub> ) ±10% (pF)	Max. test load 1 min acc. to IEC 60137 (N)	Max permitted load (N) in operation at mounting angle
1ZSC902245-AAA	GOE 1050-750-2500-0.3	2500	245	141	1050	750	505	480	960	383	13000	6500 4300 3100
-AAB	GOE 1050-750-2500-0.6	2500	245	141	1050	750	505	480	960	450	13000	6500 4300 3100
-ABA	GOE 1050-750-5000-0.3	5000	245	141	1050	750	505	480	960	383	13000	6500 4300 3100
-ABB	GOE 1050-750-5000-0.6	5000	245	141	1050	750	505	480	960	450	13000	6500 4300 3100
1ZSC902362-AAA	GOE 1175-850-2500-0.3	2500	362	209	1175	850	560	540	950	420	12000	6000 4300 3100
-AAB	GOE 1175-850-2500-0.6	2500	362	209	1175	850	560	540	950	490	12000	6000 4300 3100
1ZSC902420-AAA	GOE 1300-1050-2500-0.3	2500	420	242	1300	1050	630	650	1155	536	9000	4500 2500 -
-AAB	GOE 1300-1050-2500-0.6	2500	420	242	1300	1050	630	650	1155	570	9000	4500 2500 -
-BAA	GOE 1425-1150-2500-0.3	2500	420	242	1425	1150	695	695	1265	536	9000	4500 2500 -
-BAB	GOE 1425-1150-2500-0.6	2500	420	242	1425	1150	695	695	1265	570	9000	4500 2500 -
1ZSC902550-AAA	GOE 1550-1175-2500-0.3	2500	550	318	1550	1175	750	750	1300	500	13000	6500 4300 1500
-AAB	GOE 1550-1175-2500-0.6	2500	550	318	1550	1175	750	750	1300	512	13000	6500 4300 1500
-BAA	GOE 1675-1300-2500-0.3	2500	550	318	1675	1300	750	870	1430	500	13000	6500 4300 1500
-BAB	GOE 1675-1300-2500-0.6	2500	550	318	1675	1300	750	870	1430	512	13000	6500 4300 1500
-CAA	GOE 1800-1360-2500-0.3	2500	550	318	1800	1360	870	870	1500	500	13000	6500 4300 1500
-CAB	GOE 1800-1360-2500-0.6	2500	550	318	1800	1360	870	870	1500	512	13000	6500 4300 1500

Table 4. Data GOE 1050 to 1800.

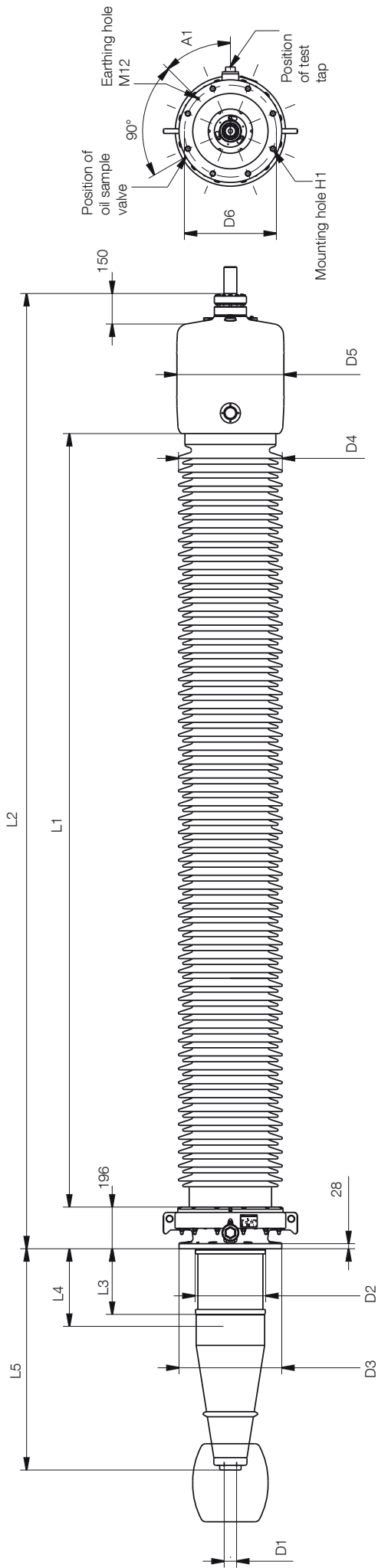


Fig 9. Dimensions GOE 1050 to 1800.

# GOE 2550

Nominal voltage 800 kV  
 Lightning impulse 2550 kV  
 Maximum current 2500 A

Catalog Number	Bushing	Flange extension mm	Creepage distance mm	L3 mm	L4 mm	L5±5 mm	Mass kg
1ZSC902800-AAA	GOE 2550-1675-2500-0.6	0.6	25720 ±670	605	640	1955	3500
-AAB	GOE 2550-1675-2500-0.9	0.9	25720 ±670	905	940	2255	3560

Table 5. Dimensions GOE 2550.

Catalog Number	Bushing	Rated current A	Rated voltage $U_m$ kV, RMS	Phase-to-earth voltage $U_y$ kV, RMS	Dry lightning impulse LI kV, peak	Wet switching impulse SI kV, peak	Routine test 1 min dry 50 Hz kv, RMS	Dry switching impulse kV, peak	Nominal capacitance between conductor and test tap ( $C_1$ ) $C_1 \pm 10\%$ (pF)	Max. test load 1 min acc. to IEC 60137 (N)	Max permitted load (N) in operation at mounting angle
1ZSC902800-AAA	GOE 2550-1675-2500-0.6	2500	800	462	2550	1675	1075	1760	610	12200	0°: 30° 6100 2900
AAB	GOE 2550-1675-2500-0.9	2500	800	462	2550	1675	1075	1760	660	12200	6100 2900

Table 6. Data GOE 2550.

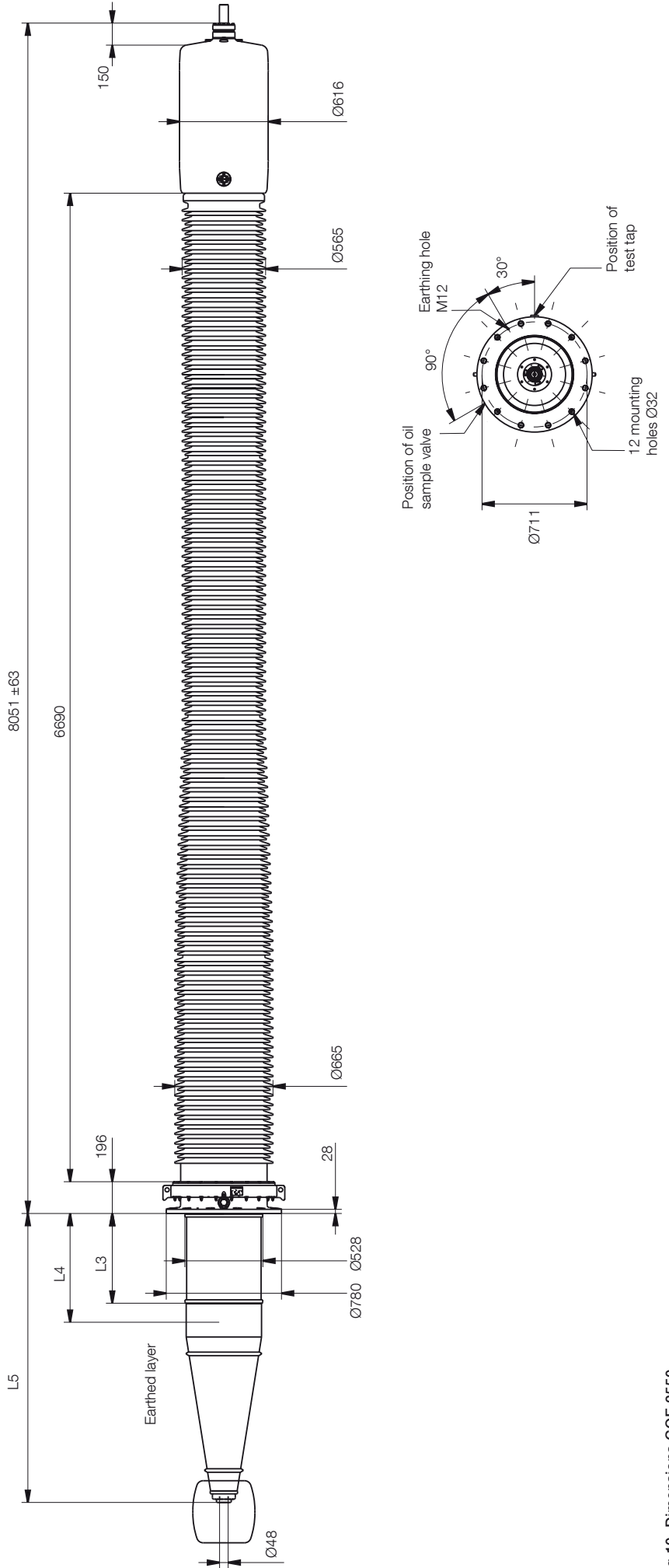


Fig 10. Dimensions GOE 2550.

# GOE 2600

Nominal voltage 1100 kV  
 Lightning impulse 2600 kV  
 Maximum current 2500 A

Catalog Number	Bushing	Flange extension mm	Creepage distance mm	Mass kg
1ZSC902110-AAA	GOE 2600-1950-2500-0.5	±0.5	>33000	±6000

Table 7. Dimensions GOE 2600.

Catalog Number	Bushing	Rated current A	Rated voltage $U_m$ kV, RMS	Phase-to-earth voltage $U_v$ kV, RMS	Dry lightning impulse LI kV, peak	Wet switching impulse SI kV, peak	Routine test 1 min dry 50 Hz kv, RMS	Nominal capacitance between conductor and test tap ( $C_1$ ) $C_1 \pm 10\%$ (pF)	Max. test load 1 min acc. to IEC 60137 (N)	Max permitted load (N) in operation at mounting angle
1ZSC902110-AAA	GOE 2600-1950-2500-0.5	±2500	1100	635	2600	1950	1200	770	8000	2500 -
										0° : 30° : 60° -

Table 8. Data GOE 2600.

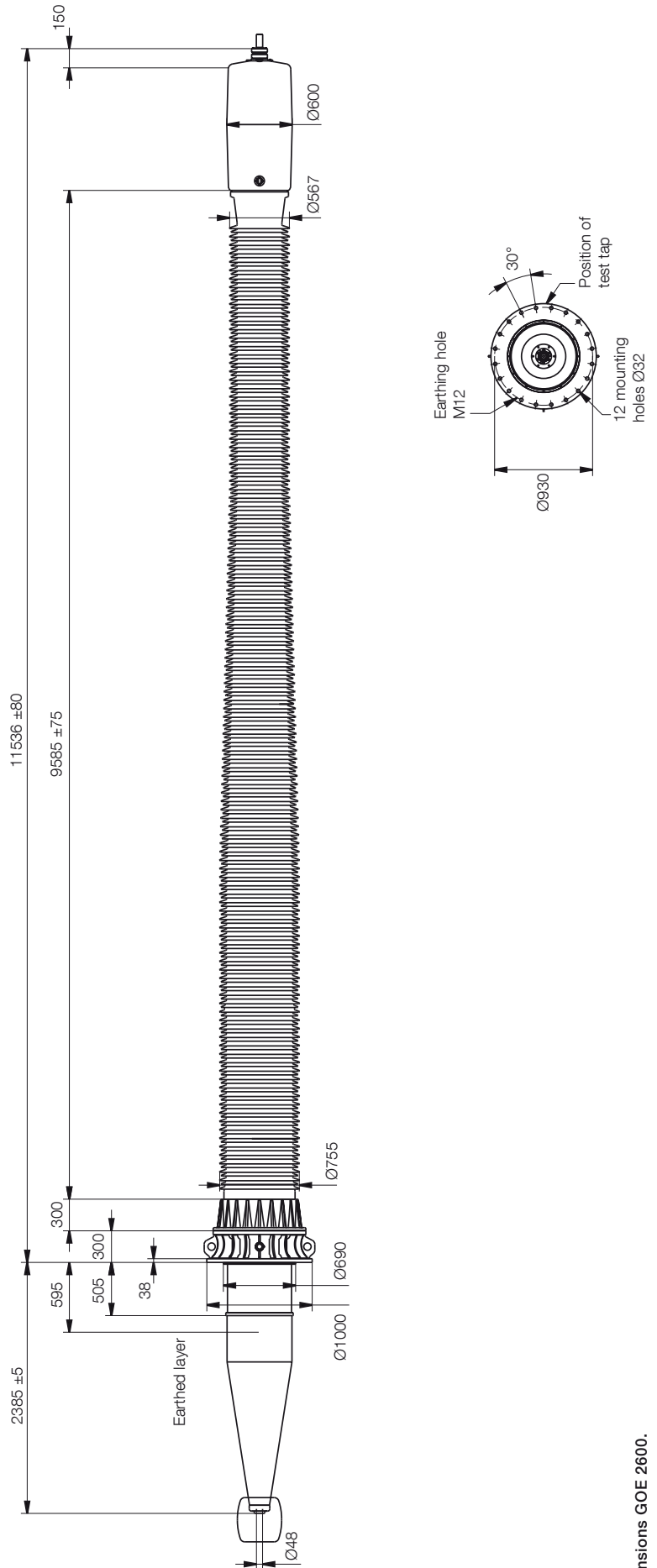


Fig 11. Dimensions GOE 2600.



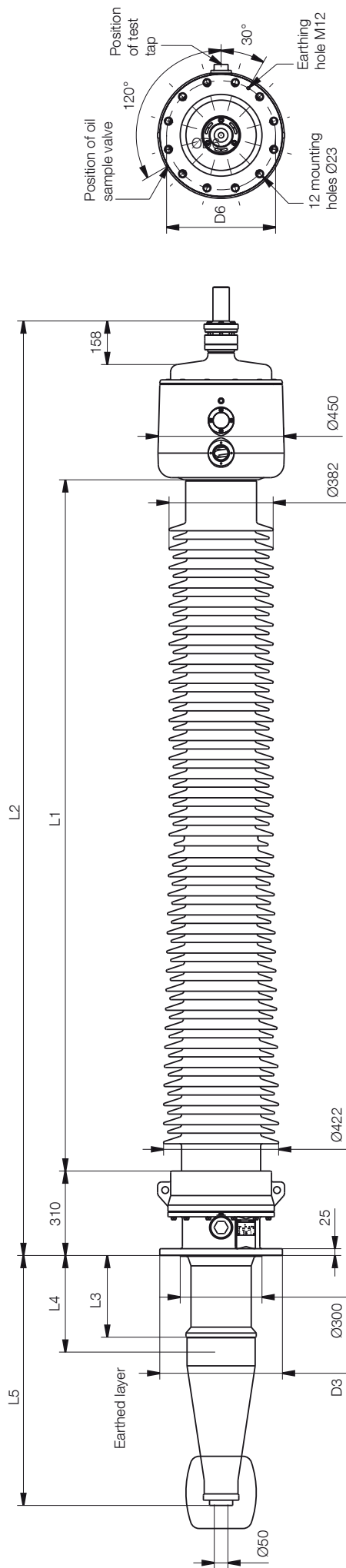


Fig 12. Dimensions GOE(2) 1175-1425.

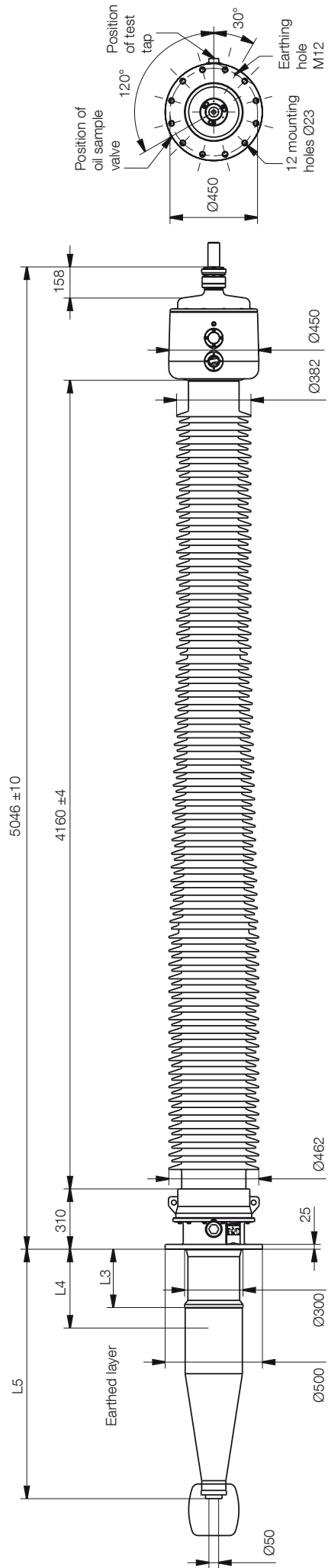


Fig 13. Dimensions GOE(2) 1675.

# Current capacity

The rated currents specified in this catalogue are based on thermal tests and are in accordance with IEC 60137 and apply to the built-in conductors of the bushings. The GOE bushings conform to the requirements of IEC 60137 and IEEE for currents given in Table 11.

## Short-time current

The rated thermal short-time current ( $I_{th}$ ), as defined in IEC 60137 clause 5, is listed in Table 11 for draw rod and fixed bottom end terminal.

For draw lead of stranded copper with the area 100 mm<sup>2</sup> the short-time current ( $I_{th}$ ) is 9.6 kA for 1 second and 6.8 kA for 2 seconds. For other areas the short-time current is directly proportional to the area. The rated dynamic current ( $I_d$ ) is 2.5 times the 1 second short-time current.

## 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.

Rated current IEC A	Current IEEE A	Short-time current		Dynamic current $I_d$ peak kA
		$I_{th}$ 1 s kA	$I_{th}$ 2 s kA	
1600	1450	100	75	250
2500	2100	100	100	250
3150	2700	100	100	250
5000	4250	100	100	250

Table 11. Rated current, short-time current and dynamic current as defined in IEC 60137, for draw rod and fixed bottom end terminal.

# Connection details

The oil side connection can be made with either a draw-rod system or a draw-lead system. For the air side connection the same outer terminals are provided for both systems. When ordering, please specify the items stated below.

## Draw rod system

Fig. 14: The centre tube of the bushing is used as current conductor.

Fig. 15: The transformer leads are fitted with cable lugs, which are bolted to a bottom contact.

Fig. 16: This contact is drawn against the lower end of the bushing tube by a thin steel draw rod.

Fig. 17: During installation on the transformer, the upper end of this rod is bolted to a spring device beneath the outer terminal, which consists of two concentric tubes of different materials and is so designed that it gives the required contact load at all temperatures.

Bottom contacts with 4 or 6 threaded holes for cable lugs are available. The bottom contacts are made of copper and have rounded edges, so that they may be used without any shield for low insulation levels (BIL <450 kV).

At the level of the flange the draw rod is split into two parts. If required to meet the transport conditions, a joint at any desired level below the flange can be offered on request. The lower part with contact end shield can then be secured to the cover during transport and storage of the transformer.

Type of draw rod	GOE type BIL	GOE Cat. No.	GOE(2) Cat. No.
Lower draw rod <sup>1)</sup>	250-2600	LF 170 059	LF 170 098
Upper draw rod <sup>2)</sup>	250-2600	LF 170 057	LF 170 097

**Table 12. Ordering particulars for draw rod system.**

- 1) Lower draw rod includes bottom contact, guiding cone and draw rod up to bushing flange level.
- 2) Upper draw rod includes the complete draw rod above mounting flange level and the temperature compensation device.

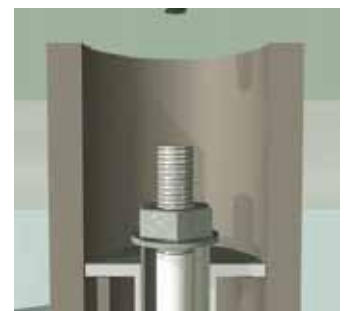
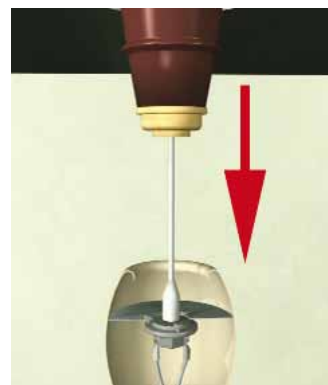
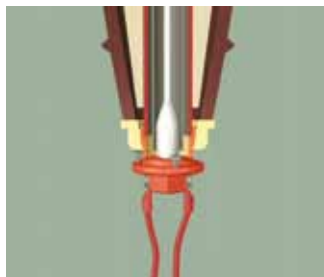
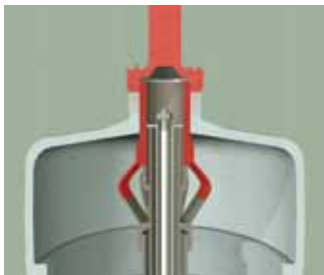


Fig. 14.

Fig. 15.

Fig. 16.

Fig. 17.

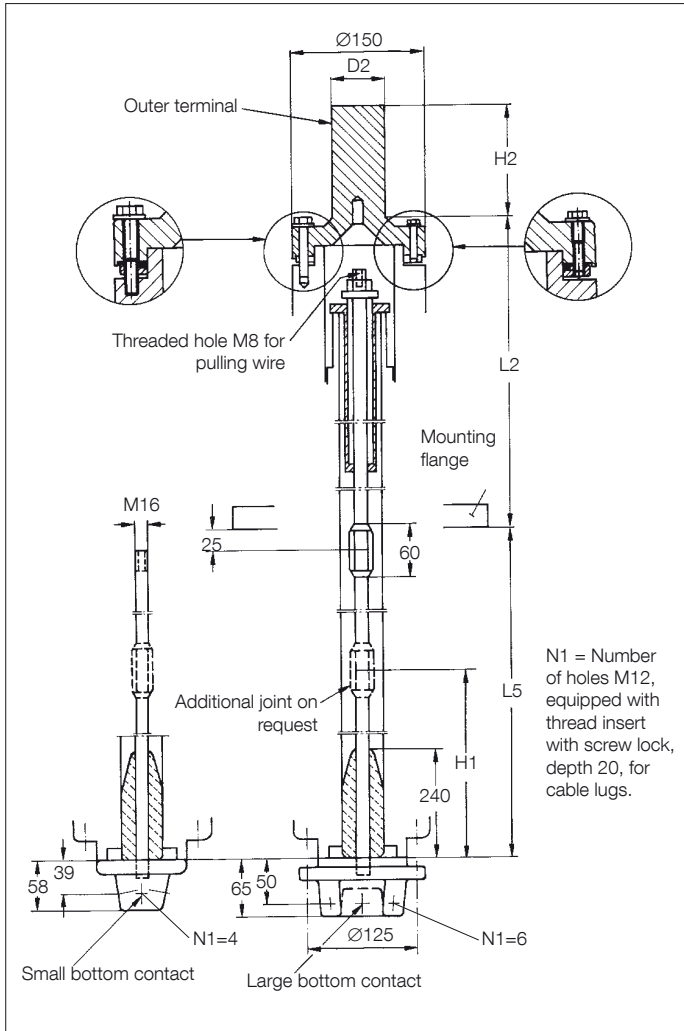


Fig. 18. Draw rod system for GOE. For all currents up to rated current of the bushing. Selection as per Table 12.

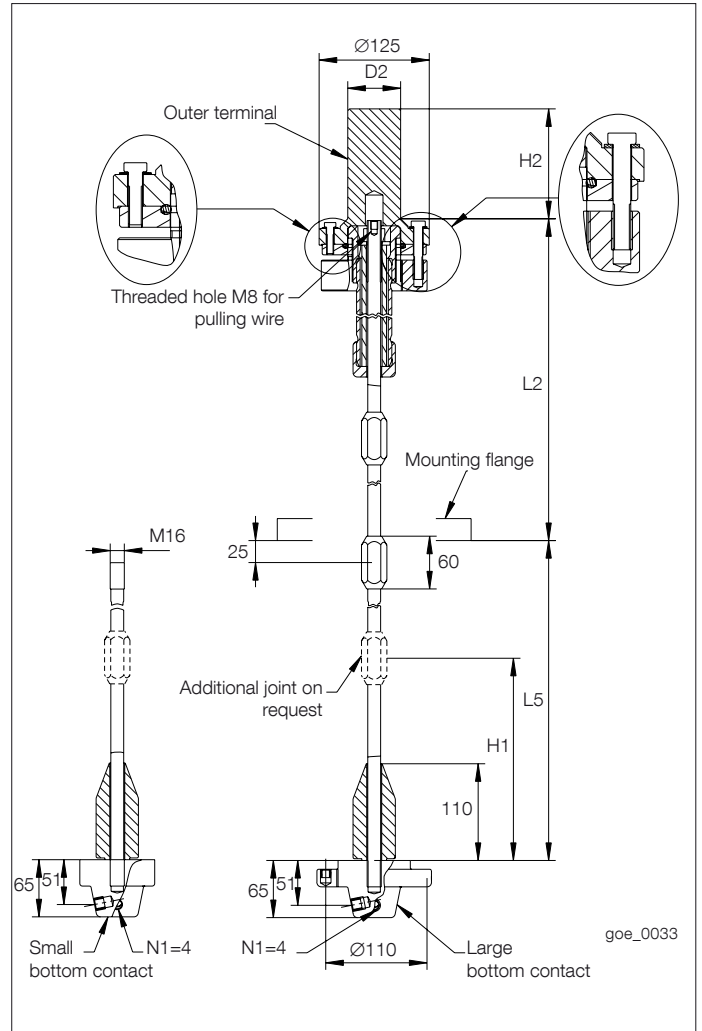


Fig. 19. Draw rod system for GOE(2). For all currents up to rated current of the bushing. Selection as per Table 12.

This system has been supplied by ABB since the seventies with an excellent service record and has the following advantages compared to other methods used for high currents:

- No hand holes required in the transformer tank.
- Easy bushing installation and removal – no connection work inside the transformer at site.
- No special supports required in the transformer as is the case with plug contacts.
- Perfect guiding of the bushing into the transformer.
- The lower end shield may be fixed to the contact and will thus be correctly positioned with respect to the lower end plate of the bushing.
- No mechanical forces exerted on the leads from the transformer windings at any time.

## Draw lead system

### GOE

Suitable copper terminals for flexible draw leads are available for currents up to 1600 A. The terminal system consists of a two-part cable connector with a hole for brazing of the cable or cables. The two parts are screwed together in such a manner that normal tolerances in the cable and bushing lengths can be compensated. The connector is fastened by a hexagon nut to a copper plate placed at the top of the bushing. The GOE outer terminal stud is placed on top of this plate.

### GOE(2)

The terminal system is made in one piece for connection of a draw lead. The terminal is attached by means of a divided ring at the top of the centre tube. When mounting the outer terminal, the ring becomes locked.

Bushing type	D3 mm	D9 mm	Min. inner diameter D1 of bushing, mm	Conductor area mm <sup>2</sup>	Current, A		Complete inner terminal Cat. No.	Mass kg	
					IEC	IEEE			
GOE	0 <sup>1)</sup>	35	38	-	-	-	LF 170 056	-A	3.2
	15	35	38	50	205	200		-B	3.2
				95	390	370			
	30	35	38	150	615	540		-C	3.2
				285	1000	830			
GOE(2)	0 <sup>1)</sup>	45	48	450	1300	1100		-D	4.4
				600	1600	1360			
	0 <sup>1)</sup>	45	48	-	-	-		-E	4.4
	15	-	-	95	300	260	LF 170 091	-A	1.1
	30	-	-	285	630	540		-B	1.0
			740	1300	1110		-C	0.9	
	42	-	-					-D	0.7

**Table 13. Inner terminals.**

1) With pilot hole D=5

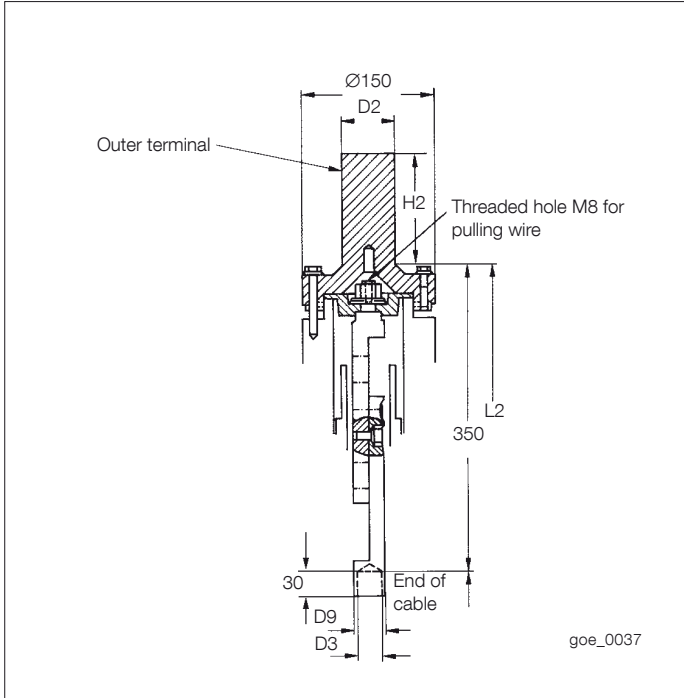


Fig. 20. Draw lead system, LF 170 056, and outer terminal for GOE. Selection as per Tables 13 and 14.

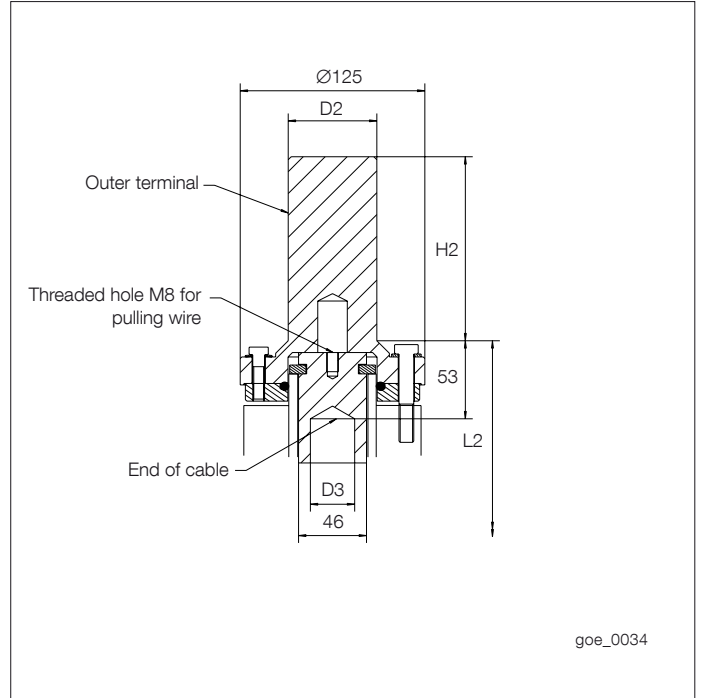


Fig. 21. Draw lead system, LF 170 091, and outer terminal for GOE(2). Selection as per Tables 13 and 14.

## Outer terminal

The outer terminal consists of a cylindrical stud. The mounting arrangements are the same for all GOE bushings, regardless of size, current rating and internal connection system. Copper and aluminium studs are available.

The terminal stud assembly consists of a stud, a retainer 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 give the proper electrical contact. The contact surface is located inside the gasket and is thus well protected from corrosion. Finally, the retainer ring with the gasket is pressed against the stud by means of M8 bolts.

Bushing type	Article No.	Material	D2 (mm)	H2 (mm)	Max. rated current (A)	Mass (kg)
GOE	LF170073-A	Al	60	125	2500	3
	LF170073-B	Cu	60	125	4000	8
	LF170073-G	Cu/Ag	60	125	4000	8
	LF170073-L	Cu/Sn	60	125	4000	8
	LF170073-BA	Cu/Ag	Thread 2"-12UN	125	3000	7.5
	LF170073-AA	Cu	96	125	5000	9
GOE(2)	LF170090-A	Al	30	125	1250	1
	LF170090-B	Al	60	125	1600	1.8
	LF170090-C	Cu	30	125	1600	2.8
	LF170090-E	Cu	60	125	1600	5.1
	LF170090-G	Cu/Ag	Thread 2"-12UN	125	1600	3.9

Table 14. Outer terminals.

# End-shields

The maximum stresses 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 guidelines.

ABB can also provide assistance with field calculations to confirm the compatibility between the transformer and our bushings.

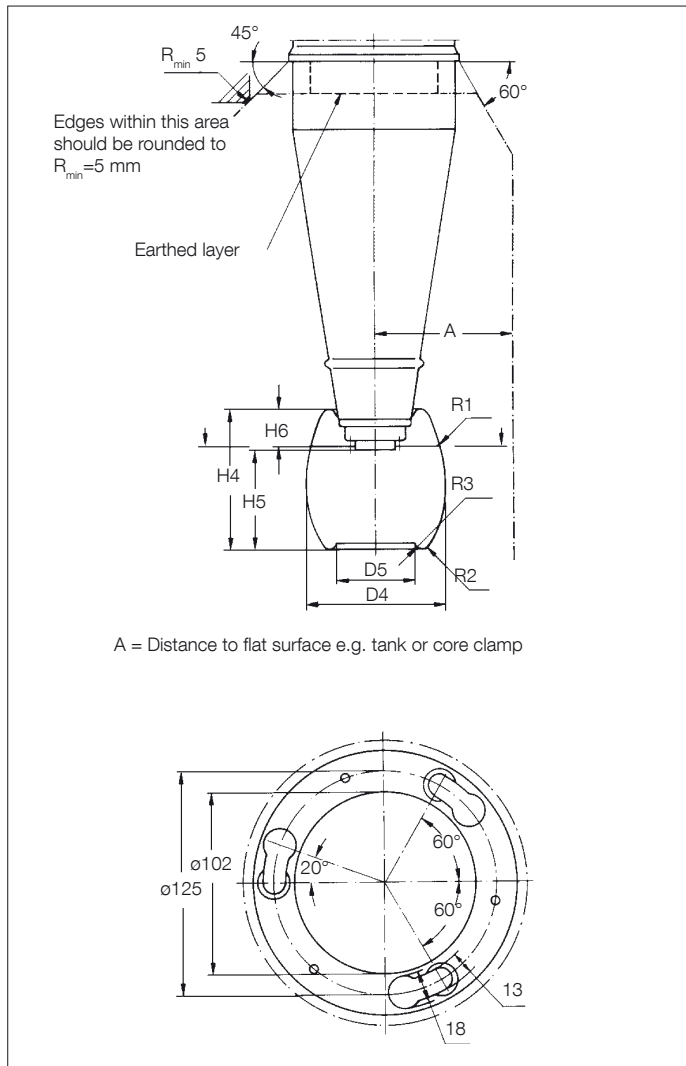


Fig. 22. Recommendations for positioning, type GOE.

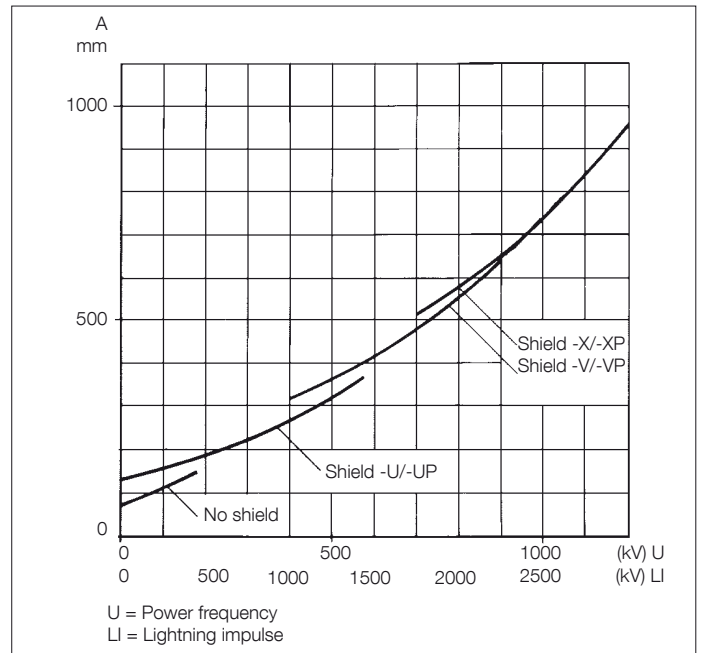


Fig. 23. Recommended minimum distance A for different shields and test voltages.

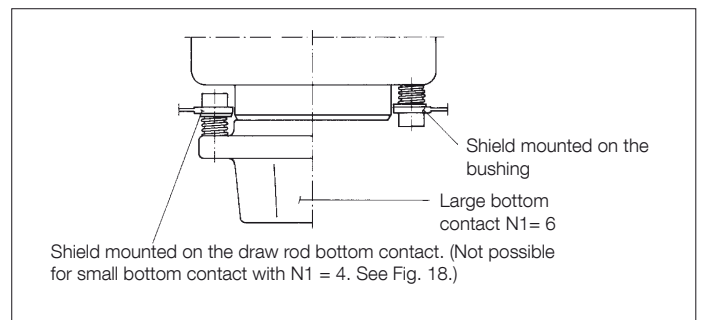


Fig. 24. Mounting alternatives, type GOE.

To be used with GOE	Dimensions according to Fig. 18, mm								Mass kg	Cat. No.	Epoxy insulated	Pressboard insulated <sup>1)</sup>
	D4	D5	H4	H5	H6	R1	R2	R3				
250-1425	262	174	265	170	90	492	30	8	2.1	LF 170 046	-U	-UP
1550-1800	352	207	365	240	120	351	24	10	2.5	LF 170 046	-V	-VP
2550	420	230	420	290	125	533	44	25	3.2	LF 170 046	-X	-XP
2600	500	260	500	350	145	652	57	30	6.4	LF 170 046	-CB	-CBP

Table 15. Insulated shield.

1) 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, and 6 mm for -XP and -CBP.

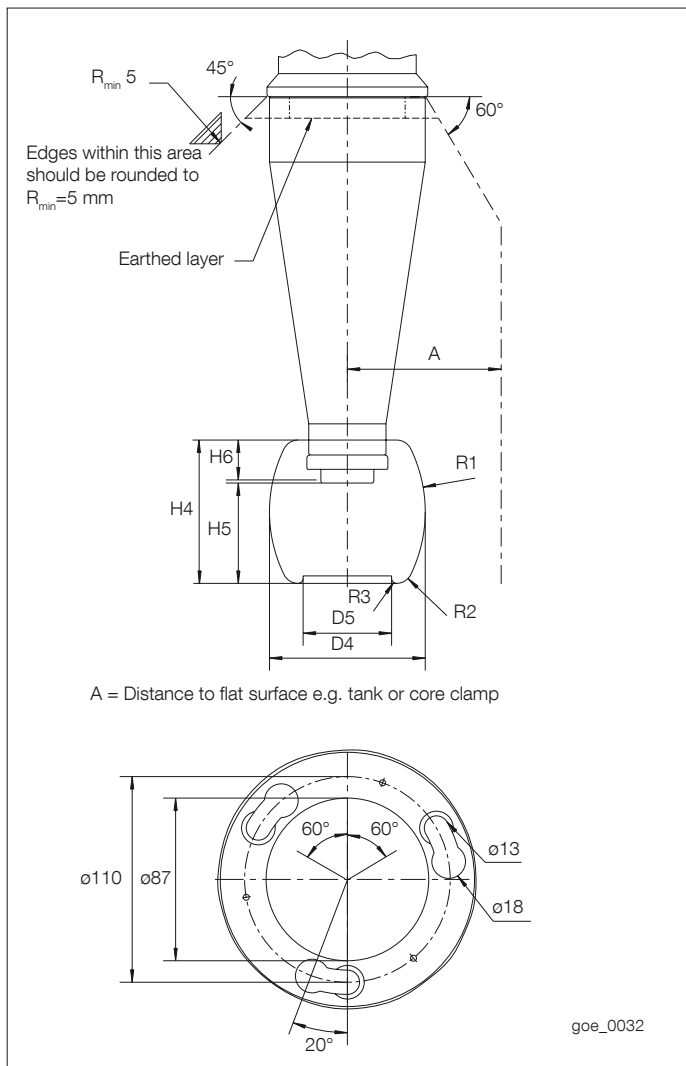


Fig. 25. Recommendations for positioning, type GOE(2).

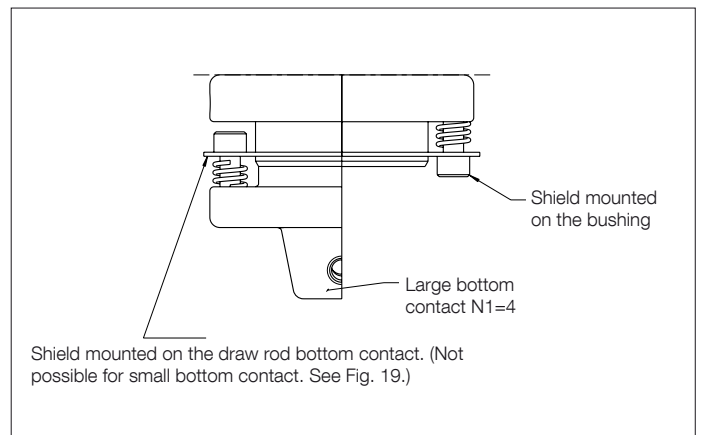


Fig. 26. Mounting alternatives, type GOE(2).

To be used with GOE(2)	Dimensions according to Fig. 21, mm									Mass kg	Cat. No.	Epoxy insulated	Pressboard insulated <sup>1)</sup>
	D4	D5	H4	H5	H6	R1	R2	R3	A				
1175	250	142	230	163	62	230	25	8	370	1.5	LF 170 092	-A	-C
1425	258	142	265	180	80	350	32	9	430	1.8	LF 170 092	-K	-L
1550-1675	258	142	265	180	80	350	32	9	470	1.8	LF 170 092	-K	-L

Table 16. Insulated shield.

1) All dimensions refer to the epoxy insulated shield, which is used as a base. The thickness of the pressboard is 3 mm.

# Ordering particulars

When ordering, please state the following:

- Type and catalogue number for bushing.
- Catalogue number for the outer terminal, or if a non-standard terminal is requested: material, diameter D2 and height H2.
- Specify draw rod or draw lead system.
- If a draw rod system is chosen, the size of the bottom contact (small or large) must be specified.
- If a draw lead system is chosen, the full catalogue number must be given.
- Catalogue number for insulated shield. (A shield is recommended for BIL 450 kV and higher.)
- Other special requirements.

See the ordering examples:

---

## Example 1

Bushing:	GOE 650-500-3150-0.3, 1ZSC902145-AAA
Outer terminal:	LF 170 073-A or -B
Inner connections:	Draw lead, LF 170 056-A
Insulated shield:	Epoxy insulated, LF 170 046-U

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## Example 2

Bushing:	GOE 1550-1175-2500-0.6, 1ZSC902550-AAB
Outer terminal:	LF 170 073-A or -B
Inner connections:	Draw rod, upper part LF 170 057, lower part LF 170 059, small contact (On request the lower part of the draw rod can be sent separately at an earlier delivery date.)
Insulated shield:	Pressboard coated, LF 170 046-VP

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## Example 3

Bushing:	GOE 1300-1050-2500-0.3, 1ZSC902420-AAA
Outer terminal:	Silver plated, D2=50, H2=100
Inner connections:	Draw rod, upper part LF 170 057, lower part LF 170 059, small contact (On request the lower part of the draw rod can be sent separately at an earlier delivery date.)
Insulated shield:	Pressboard coated, LF 170 046-VP
Other requirements:	Test voltage 690 kV Tan $\delta$ over C2 < 1.0 %

# Packing

The bushings are delivered in wooden crates; the same crate used for all flange extensions. When end shields are ordered, they will be delivered together with the bushings in the same crates. All crates are heat-treated according to ISPM15.

Bushings	Wooden crate			Mass (kg)
	L (mm)	B (mm)	H (mm)	
GOE 250-380	3000	640	640	111
GOE 650	3600	590	690	134
GOE 950	4100	590	690	159
GOE 1050	5200	670	770	219
GOE 1175	5400	670	770	227
GOE 1300-1425	6500	670	770	268
GOE 1550-1800	8200	1000	1170	709
GOE 2550	11400	1070	1230	999
GOE 2600	14806	1560	1375	2940
GOE(2) 1175	5300	640	740	213
GOE(2) 1425	6200	690	790	268
GOE(2)1550-1675	7300	690	790	307

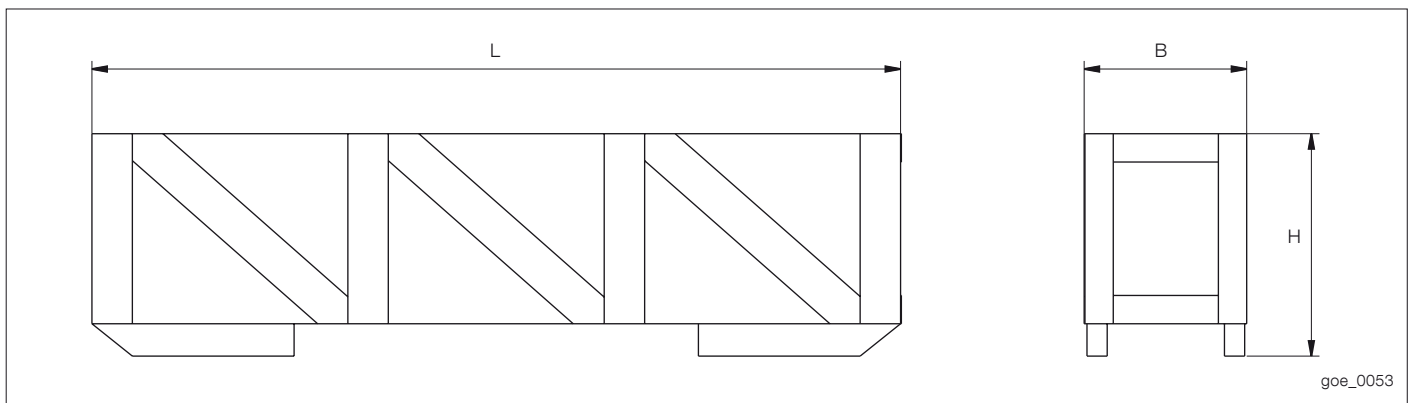


Fig. 27. Packing crate.

# Additional GOE and GOE(2) bushings available on request

The following types of bushings are available on request. Keep in mind that lead times may be longer than for the standard range. Bushings are also available according to certain established customer specifications. For full details, please contact ABB.

All GOE bushings with rated voltage from 52 kV to 800 kV can be supplied with a current rating of 5000 A.

Bushing type	Catalogue Number	Insulator colour Brown/ Light grey	Rated current A	Flange extension mm	Rating plate data				
					Rated voltage $U_m$ kV, RMS	Phase-to-earth voltage $U_\gamma$ kV, RMS	Dry lightning impulse LI kV, peak	Wet switching impulse SI kV, peak	Routine test 1 min dry 50 Hz kV, RMS
GOE 250-210	LF 121 051	-A/-AA	3150	0.6	52	52	250	210	120
		-B/-AB	3150	0.3					
		-C/-AC	5000	0.6					
		-D/-AD	5000	0.3					
GOE 380-300	LF 121 052	-A/-AA	3150	0.6	123	84	450	300	185
		-B/-AB	3150	0.3					
		-C/-AC	5000	0.6					
		-D/-AD	5000	0.3					
GOE 450-400	LF 121 053	-A/-AA	3150	0.6	170	123	550	400	260
		-B/-AB	3150	0.3					
		-C/-AC	5000	0.6					
		-D/-AD	5000	0.3					
GOE 650-500	LF 121 054	-A/-AA	3150	0.6	245	155	650	500	325
		-B/-AB	3150	0.3					
		-C/-AC	5000	0.6					
		-D/-AD	5000	0.3					
GOE 900-650	LF 121 055	-A/-AA	3150	0.6	245	170	950	650	395
		-B/-AB	3150	0.3					
		-C/-AC	5000	0.6					
		-D/-AD	5000	0.3					
GOE 1050-750	LF 121 063	-A/-AA	2500	0.6	362	220	1050	750	505
		-B/-AB	2500	0.3					
		-C/-AC	2500	0					
GOE 1175-850	LF 121 061	-A/-AA	2500	0.6	362	220	1175	850	530
		-B/-AB	2500	0.3					
		-C/-AC	2500	0					
		-D/-AD	5000	0.6					
		-E/-AE	5000	0.3					
		-F/-AF	5000	0					
GOE(2) 1175-850	LF 121 560	-A/-AA	1600	0.6	362	220	1175	850	560
		-B/-AB	1600	0.3					
GOE 1300-1050	LF 121 071	-A/-AA	2500	0.6	420	245	1425	1050	630
		-B/-AB	2500	0.3					
GOE 1300-1150	LF 121 071	-C/-AC	2500	0.6	420	245	1425	1175	680
		-D/-AD	2500	0.3					

Other data for information			Max. test load 1 min acc. to IEC 60137 (N)	Max permitted load (N) in operation at mounting angle		
Wet power frequency AC kV, RMS	Dry switching impulse kV, peak	Nominal capacitance between conductor and test tap (C <sub>1</sub> ) C <sub>1</sub> ±10% (pF)		0°	-30°	-60°
120	400	810 / 594	5700	2800	2300	1700
170	550	594 / 448	5700	2800	2300	1700
240	650	543 / 423	5000	2500	2000	1500
315	650	498 / 392	5700	2800	2300	1700
395	750	448 / 365	5000	2500	2000	1500
480	960	430 / 383 / 308	13000	6500	4300	3100
540	950	490 / 420 / 345	12000	6000	4300	3100
560	1030	470 / 407	10000	5000	4400	-
650	1050	575 / 560	10000	5000	3000	1500
650	1175	575 / 545	9000	4500	2500	-

Bushing type	Catalogue Number	Insulator colour Brown/ Light grey	Rated current A	Flange extension mm	Rating plate data				
					Rated voltage $U_m$ kV, RMS	Phase-to-earth voltage $U_\gamma$ kV, RMS	Dry lightning impulse LI kV, peak	Wet switching impulse SI kV, peak	Routine test 1 min dry 50 Hz kV, RMS
GOE(2) 1425-1050	LF 121 570	-A/-AA	1600	0.6	420	243	1425	1050	690
		-B/-AB	1600	0.3					
GOE 1550-1050	LF 121 072	-A/-AA	2500	0.6	550	318	1550	1050	750
		-B/-AB	2500	0.3					
		-C/-AC	2500	0					
GOE 1675-1175	LF 121 073	-A/-AA	2500	0.6	550	318	1675	1175	750
		-B/-AB	2500	0.3					
		-C/-AC	2500	0					
GOE 1675-1300	LF 121 073	-D/-AD	2500	0.6	550	318	1675	1300	750
		-E/-AE	2500	0.3					
		-F/-AF	2500	0					
GOE(2) 1675-1300	LF 121 580	-A/-AA	1600	0.6	550	318	1675	1300	750
		-B/-AB	1600	0.3					
GOE 1800-1300	LF 121 074	-A/-AA	2500	0.6	550	318	1800	1300	800
		-B/-AB	2500	0.3					
		-C/-AC	2500	0					
GOE 2100-1425	LF 121 081	-A/-AA	2500	0.6	800	485	2100	1425	970
		-B/-AB	2500	0.3					
GOE 2550-1550	LF 121 082	-A/-AA	2500	0.6	800	485	2550	1550	1000
		-B/-AB	2500	0.3					
		-C/-AC	2500	0					
GOE 2550-1600	LF 121 083	-A/-AA	2500	0.6	800	485	2550	1620	1000
		-B/-AB	2500	0.3					
		-C/-AC	2500	0					

Other data for information			Max. test load 1 min acc. to IEC 60137 (N)	Max permitted load (N) in operation at mounting angle		
Wet power frequency AC kV, RMS	Dry switching impulse kV, peak	Nominal capacitance between conductor and test tap (C <sub>1</sub> ) C <sub>1</sub> ±10% (pF)		0°	-30°	-60°
690	1140	532 / 474	10000	5000	4100	-
660	1050	457 / 390 / 342	16000	8000	4700	2500
730	1300	521 / 440 / 433	16000	8000	4700	2500
790	1300	500 / 490 / 450	13000	6500	4300	1500
750	1410	525 / 482	10000	5000	3900	-
800	1300	500 / 490 / 450	13000	6500	4300	1500
900	1550	600 / 575	15700	7850	5400	3600
950	1675	574 / 522 / 476	14000	7000	4400	2500
1000	1760	600 / 550 / 506	13000	6500	3700	1600





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