

Bushings for High Voltage AC Applications

Selection guide



During selection of bushings for high voltage applications several important factors have to be considered to ensure that the correct equipment is chosen. This Selection Guide has been produced to simplify the selection process and to ensure that sufficient information exists to allow the correct selection to be made.

The technical information pertaining to bushings manufactured by ABB has been divided in 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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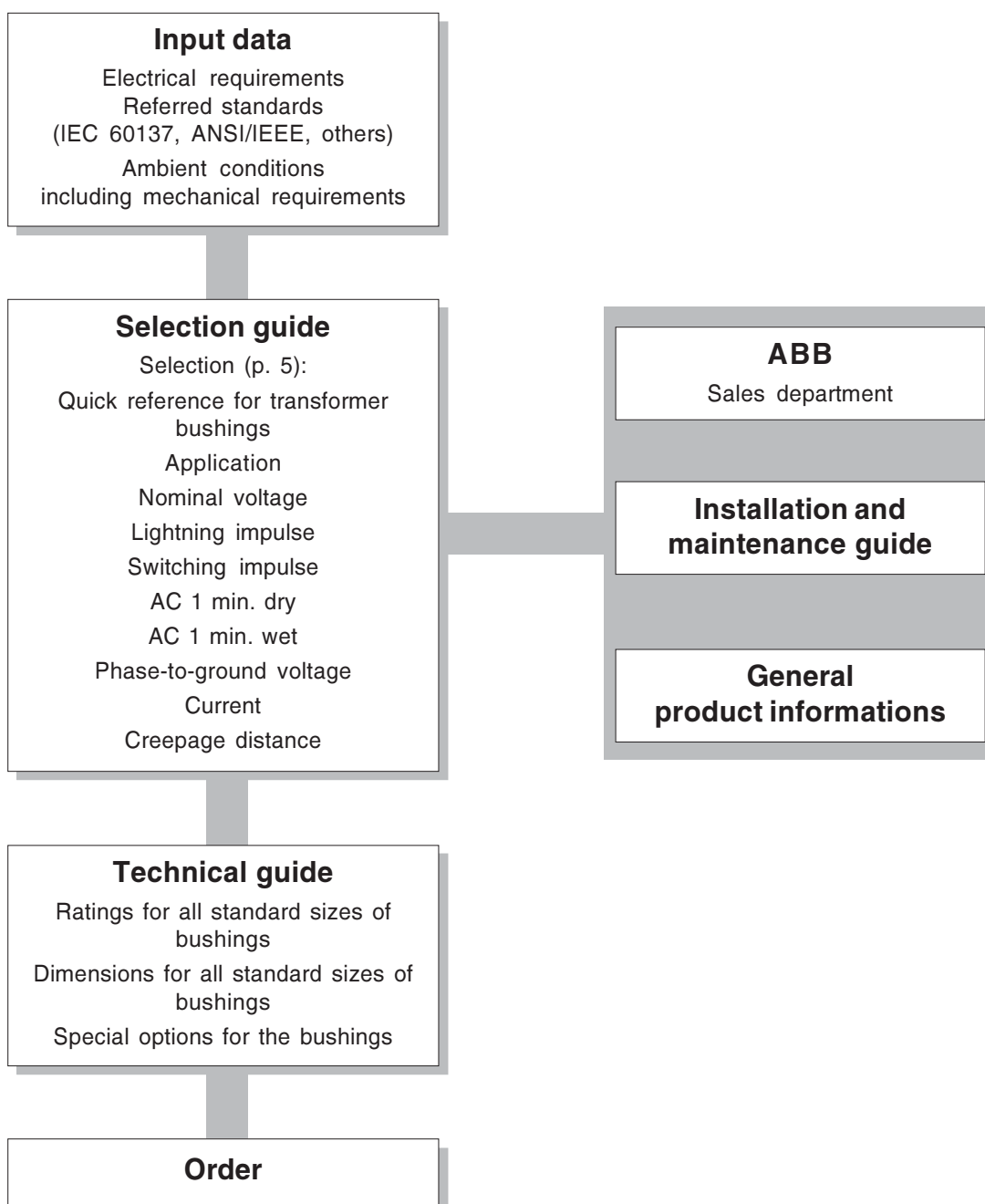
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The selection process for AC bushings

Below is a schematic plan, showing the selection process. Before the selection can start, a number of different input data have to be collected. After that the selection guide can be used to select the most suitable bushing for the application in question. When the type of bushing is identified, the selection of the right size is made in the applicable *Technical Guide*. In the Technical Guide, the special features, such as connection details, oil level indicator, inclination of the bushing etc. are chosen.

Information about mounting and service is given in the *Installation and Maintenance Guide*, available for all types.

For special questions, product informations giving more detailed information are available upon request. For any further assistance, please do not hesitate to contact ABB.



Input data

Type of application

ABB AC bushings are made for five different applications:

- Oil to Air
- Oil to Oil
- Oil to SF₆
- Air to Air
- Air to SF₆

For DC application, please contact ABB for further information.

Electrical requirements

The following electrical data must be known prior to commencing the selection process:

Referred standard

Generally ABB bushings fulfil the electrical requirements according to IEC (IEC 60137) and ANSI (IEEE C57.19.00 and IEEE C57.19.01). If any other standard is required, please contact ABB.

Highest voltage for equipment

Normally highest r.m.s. value of the phase-to-phase voltage for the system where the bushing is intended to be used.

Required lightning impulse level

Normally the same lightning impulse level as for the transformer. The lightning impulse test is a routine test for bushings with a BIL level equal to or above 850 kV.

Required switching impulse level

Normally the same switching impulse level as for the transformer. This is a type test and is made during wet conditions for bushings for outdoor application.

Required test level for the dry 1 minute AC test

Normally 10 % above the test level of the induced test for the transformer. This test is made as a routine test on all bushings.

Test voltage for the wet 1 minute AC test

This is a type test for bushings with a rated voltage below 300 kV.

Phase-to-ground voltage

This is the actual continuous AC voltage that the bushing is subjected to.

Nominal current

This is the maximum continuous AC current the bushing can carry at a certain air temperature and a certain oil temperature with the hot spot of the bushing at maximum 105 °C (120 °C for RIP). The following temperatures applies for IEC and ANSI:

	IEC	ANSI
Air temperature	30 °C	40 °C
Transformer oil temperature rise above ambient	60 K	65 K
Maximum hot spot in OIP bushings	105 °C	105 °C
Maximum hot spot in RIP bushings	120 °C	120 °C

Required maximum power factor limits if other than IEC or ANSI

This is made as a routine test on all bushings. IEC requires the bushing to have a power factor below 0.7 %. ANSI requires the bushing to have a power factor below 0.5 %.

Ambient conditions including mechanical requirements

Referred standard

ABB bushings fulfil the ambient and mechanical requirements according to IEC (IEC 60137). ANSI (IEEE C57.19.0) specify certain dimension requirements which deviate from ABB bushings. Please check in our bushing Technical Guides or directly with ABB for further information. If any other standard is required, please contact ABB.

Required specific creepage distance

IEC defines the specific creepage distance as the total creepage distance divided with the highest voltage for equipment whereas ANSI defines it as the total creepage distance divided by the line-to-ground voltage. This means that there is a conversion factor of $\sqrt{3}$ between IEC and ANSI.

IEC defines four different classes depending on the degree of pollutions in the area where the bushing is intended to be used:

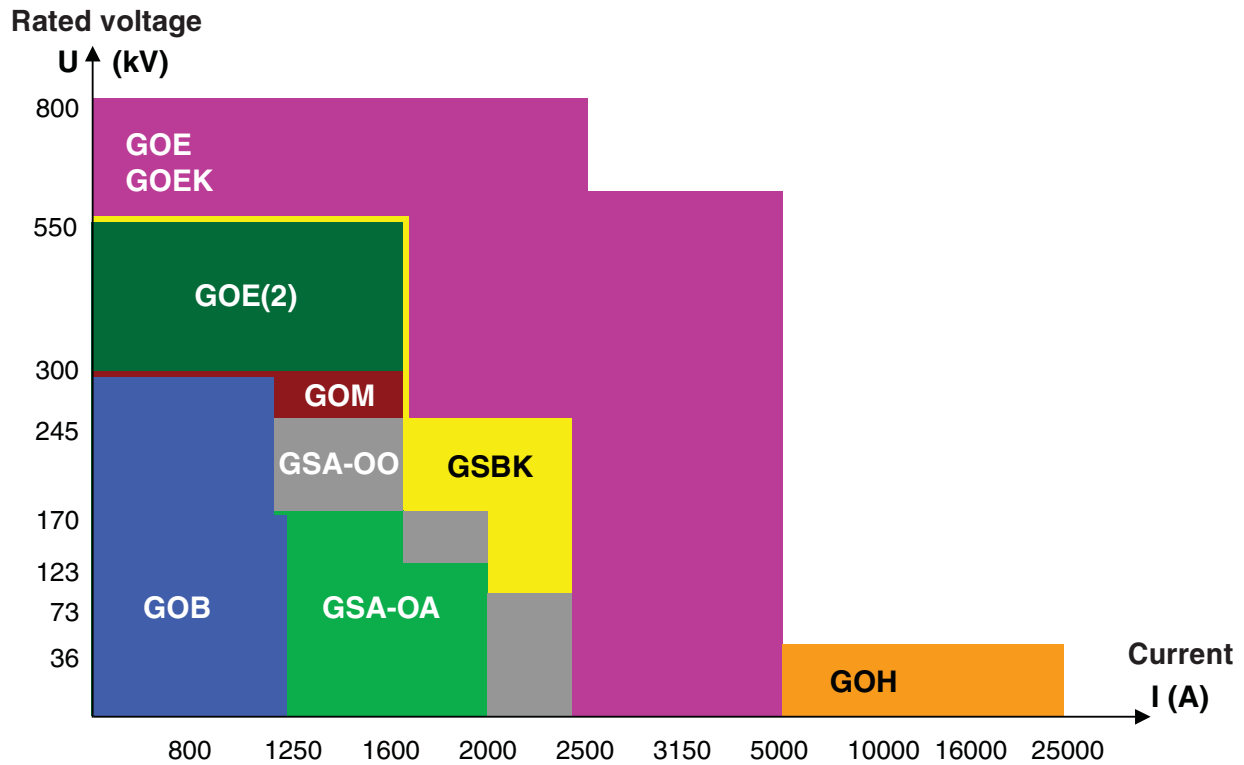
- Class 1 16 mm/kV for lightly polluted atmospheres
- Class 2: 20 mm/kV for medium polluted atmospheres
- Class 3: 25 mm/kV for heavily polluted atmospheres
- Class 4: 31 mm/kV for very heavily polluted atmospheres

The most common classes are 20 and 25 mm/kV.

Required cantilever load

Both IEC and ANSI have specified values for the required cantilever load. In IEC 60137 two different levels for the cantilever load are given: Level 1 for normal application and Level 2 for special applications with severe mechanical loads.

Selection



Quick reference for transformer bushings.

	Highest voltage (kV)	Lightning impulse (kV)	Switching impulse, wet (kV)	Routine AC 1 min. dry (kV)	AC 1 min. wet (kV)	Phase-to-ground voltage (kV)	Current (A)	Creepage distance (mm)
Air to Oil:								
GOB	300	1050	750	510	510	173	1250	7500
GSA-OA	170	750	N.A.	365	325	100	2000	5504*)
GOM	300	1050	850	505	550	200	1600	7550
GOE	800	2550	1600	1000	1000	485	5000	20000
GOE(2)	550	1675	1300	750	750	318	1600	15200
GOH	36	200	N.A.	80	75	36	25000	760
Oil to Oil:								
GSA-OO	245	1050	N.A.	505	N.A.	141	2500	N.A.
Oil to SF₆:								
GOEK	800	2550	N.A.	1000	N.A.	485	5000	N.A.
GSBK	550	1675	N.A.	750	N.A.	317	2500	N.A.
Air to Air:								
GOBL	145	-	N.A.	-	275	145	1250	4080
GSA-AA	-	550	N.A.	230	230	100	4000	3913*)
GOEL	800	2100	1600	1000	1000	485	5000	20000
Air to SF₆:								
GGA	550	1800	1360	800	800	318	4000	13750*)

Maximum ratings for different types of ABB bushings. See also quick reference above.

*) Silicone rubber sheds.

Product scope

Condenser bushings facilitate the electric stress control via the insertion of floating aluminium equalizer screens which are located in the condenser core. A web of creped or Kraft paper is wound onto a conductor or a mandrel to form the condenser core. Conduction inserts made of aluminium are placed at calculated and very precise axial and radial positions in order to create the grading of the electric field. The condenser cores are impregnated with either transformer grade mineral oil, or a curable epoxy resin.

Outer insulation, when applicable, is made either from ceramic materials or silicone rubber. Ceramic insulators are available for oil impregnated bushings in brown and grey colours whereas silicone insulators are available for resin impregnated bushings and only in grey colour. The shed form in both cases is of the anti-fog type with alternating long and short sheds. All bushings are equipped with a insulated test tap on the flange.

Oil Impregnated Paper (OIP) bushings

GOB is available both with and without oil level glass and for voltages from 52 kV to 300 kV. All models are equipped with a 2 kV test tap and the conductor arrangement can be either of draw lead or solid rod type. The GOB can be installed with an inclination of up to 45° from the vertical without any special precautions.

Technical guide 1ZSE 2750-102

Installation and maintenance guide 2750 515-12

GOE is available in two designs. The classical GOE line of bushings is available for the entire voltage range from 52 kV to 800 kV. GOE(2) is a lightweight, compact and cost efficient bushing for lower current ratings and is available for three specific voltage classes; 362 kV, 420 kV and 550 kV. Both GOE and GOE(2) are equipped with a 20 kV test tap and the conductor arrangement can be either of draw lead, solid rod or draw rod type. GOE can be installed with an inclination of up to 60° from the vertical without any special precautions, whereas GOE(2) is limited to 30° from the vertical.

Technical guide 1ZSE 2750-105

Installation and maintenance guide 2750 515-1



GOM is a 300 kV bushing similar in design to the high-end GOB, but for higher currents. This bushing is equipped with a 2 kV test tap and can be installed with an inclination of up to 45° from the vertical without any special precautions.

Technical guide 1ZSE 2750-108
Installation and maintenance guide 2750 515-41

GOH is a 36 kV high current bushing, normally used for generator step-up transformers. Current rating is up to 25 kA and its design facilitates use in bus duct arrangements with high temperatures. GOH can be installed in any angle from horizontal to vertical and is equipped with a 2 kV test tap. Connection is done to terminal plates on both air side and oil side.

Technical guide 1ZSE 2750-107
Installation and maintenance guide 2750 515-85

GOEK is intended for immersed oil-SF₆ or oil-oil service and is available for voltages from 245 to 800 kV. The types up to 550 kV are equipped with an oil expansion system which facilitates installation in any angle from horizontal to vertical without any special precautions. All models are equipped with a 20 kV test tap and the conductor arrangement can be either of the draw rod or tight bottom contact type. To detect possible gas leakage the bushings can be equipped with an oil pressure monitoring system.

Technical guide 1ZSE 2750-106
Installation and maintenance guide 2750 515-116



Resin Impregnated Paper (RIP) bushings

GSA is a line of transformer bushings available for voltage from 52 kV to 170 kV for oil-air applications, GSA-OA, and for voltage from 73 kV to 245 kV for immersed oil-oil service, GSA-OO. Current ratings exceeds some of the more common OIP types for the same voltage classes which means GSA can often be the most economical choice if the current requirements are between 1250 and 1600-2500 A. GSA can be installed in any angle from horizontal to vertical and is equipped with a 2 kV test tap. Conductor arrangement can be either of draw lead or solid rod type. GSA is also available as an indoor-outdoor wall bushing for 73 kV and 123 kV, GSA-AA. Since GSA-AA does not have an insulator on the indoor side it is intended for installation in a non-condensing environment only.

GSA-OA

Technical guide 1ZSE 2750-111

Installation and maintenance guide 2750 515-115

GSA-AA

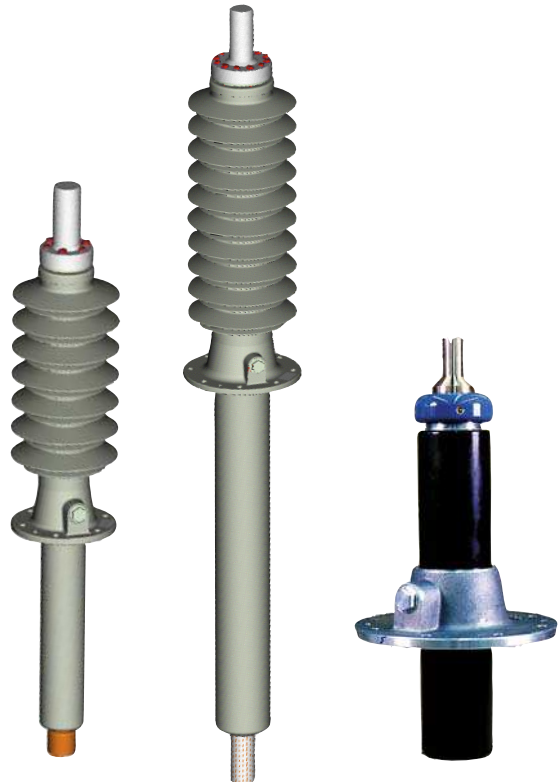
Technical guide 1ZSE 2750-112

Installation and maintenance guide 2750 515-133

GSA-OO

Technical guide 1ZSE 2750-116

Installation and maintenance guide 2750 515-138



GSBK is intended for immersed oil-SF₆ or oil-oil service and is available for voltages from 170 to 550 kV. GSBK can be installed in any angle from horizontal to vertical and is equipped with a 2 kV test tap, 20 kV version on request. Conductor arrangement can be either of draw rod or fixed bottom contact type.

Technical guide 1ZSC000563-AAA

Installation and maintenance guide 1ZSC000563-AAB



Bushings for special applications

A large variety of special designs have been developed in order to cover exceptional requirements, some example are given. Tailored solutions are offered on request.

- Bushings for converter transformers for HVDC applications
- Bushings for DC valve halls connections
- Bushings for gas insulated switchgears
- Bushings for replacement in existing installations



Product documentation

Technical guide

The Technical guide provides ratings and dimensions for all standard sizes of a particular bushing. Several design options are also given.

Colour of air side insulator

Brown and light grey porcelains are available as standard for most of our bushings with brown as the most common one.

Silicone rubber sheds are only available in light grey RAL 7035.

Type of connection

Draw lead: This type of connection is the most common one for low currents. The current is carried by a stranded cable pulled through the bushing. The inner terminal can be connected to the cable either by brazing or crimping. Guidance for the needed area of the cable is also given in the Technical Guide.

Solid rod: This type of connection is used when the current becomes too large to be carried by a stranded cable. The current is carried by a solid rod pulled through the bushing.

Draw rod: This type of connection is used for the GOE, GOE(2), GOEK and GSBK on higher currents to get a simple design of the transformer together with an easy mounting of the bushing on the transformer. The current is carried by a conductor tube, permanently built-in in the bushing. As the draw rod solution simplifies the transformer design it is used quite frequently also at lower currents.

Outer terminal: Aluminium and copper alloy are available as standard for most of our bushings. Other materials and dimensions are available upon request.

Type of shielding

Shield for the transformer side of the bushing is normally available as standard. Depending on voltage level and type of bushing the shield is epoxy coated or insulated with press board. Guidance for the design of the position of the bushing in the transformer is also given in the Technical Guide. If other bottom end shields are used, ABB can assist with field calculations to confirm the compatibility between the bushing, the shield and the transformer. Type tests as well as routine tests are performed with our standard shields mounted on the bushings oil side.

Oil level indicator

Oil level indicators are normally requested on oil-filled bushings. This is an option for smaller bushings. The indicator comprises a sight glass or is of a magnetic type, depending on the type of bushing.

Pressure monitoring

Pressure monitoring equipment is an option on bushings for connection between SF₆ and the transformer oil. This gives the advantage of continuous monitoring including alarm and trip functions.

Installation and maintenance guide

The Installation and maintenance guide provides information on how to handle the bushing. Detailed information about inner and outer connections and maintenance are also important parts of this document. Each product type has its own Installation and maintenance guide.

Product informations

Product informations are available to answer general questions that are not covered in the Technical guides or the Installation and maintenance guides. These questions include the following:

- 2750 515-142* **Bushing diagnostics and conditioning**
- 2750 515-84* **Bushing oil**
- 2750 515-136* **Comparison between porcelain and silicone rubber for use as outdoor insulation on high voltage bushings**
- 2750 515-143* **Different insulation systems in condenser bushings**
- 2750 515-148* **Electrical routine testing of high voltage bushings**
- 2750 514-24* **Epoxy jointed porcelain**
- 2152 4016-3* **Gasket in ABB oil impregnated bushings**
- 2750 515-101* **Mechanical design of bushings type GOE**
- 2750 514-23* **Repair of damaged porcelain insulator**
- 2750 515-130* **Resin impregnated paper bushings**
- 2750 515-6* **Rod gaps for bushings type GOE**
- 2750 515-88* **Seismic calculation on ABB bushings mounted on a transformer tank cover**
- 2750 515-131* **Silicone rubber**
- 2750 515-102* **The condenser body of the GOE bushing**
- 2750 515-118* **Thermal short-time current capability**



**ABB Power Technologies AB
Components**

Visiting address: Lyviksvägen 10

Postal address: SE-771 80 Ludvika, SWEDEN

Tel. +46 240 78 20 00

Fax +46 240 121 57

E-mail: sales@se.abb.com

www.abb.com/electricalcomponents