GE
Grid Solutions

PABS

Air-to-SF_6 Gas-insulated Bushings
72.5 - 800 kV

PABS bushings are gas-insulated types that meet IEC 60137, ANSI/IEEE or other National Standards. They are designed for connection, in any ambient conditions, of GIS, GIL or Dead Tank Circuit Breakers to overhead transmission lines.

According to the operating temperature, the gas used for filling is pure SF_6 or a mixture of SF_6 and N_2.

Voltage and Current Ratings

Standard rated voltage range, at 50/60 Hz, is:

- 72.5 kV to 800 kV for composite design
- 72.5 kV to 500 kV for porcelain design

Standard rated current is 2000 A through 5000 A, according to the rated voltage; it is possible to realize bushings up to 8000 A. For non-standard ratings, consult GE's Grid Solutions' sales teams.

Standards

- IEC 60137
- ANSI/IEEE C57.19.00-1991

Key Benefits

- Bushings with longer lifetime
- and higher reliability
- Explosion and fire-proof design (with composite insulator)
- Non-aging internal insulation
- Installation in any position
- Online monitoring in service for types with segregated gas zone from GIS/GIL

Imagination at work

PABS Bushings Main Features

Gas-insulated Bushings IEC and ANSI Standards

- Range 72.5 to 800 kV
- High continuous withstand current up to 8000 A
- High short-circuit current up to 100 kA - 1s; 63kA-3s
- Gas-insulated bushings with pure SF6 or SF6-N2 mixture
- Non-aging internal insulation
- Air side: porcelain or composite insulator
- Standard design as common gas zone with GIS/GIL
- Explosion and fire-proof design
- High quality sealing system and efficient gas leakage control: gas leakage less than 0.5% per year (usual 0.1%)
- Installation in any position
- In-service monitoring of main gas insulation throught density (pressure) control for types with segregated gas zone from GIS/GIL
- Polyester-varnished aluminum flanges

Bushing Designation PABS.420.1425.4000.X

PABS	Gas-insulated bushings, air-to-SF_6 application
420	Insulation class in kV
1425	BIL in kV
4000	Rated current in A
X	Type of insulator: P = Porcelain C = Composite (fiberglass tube with silicone sheds)

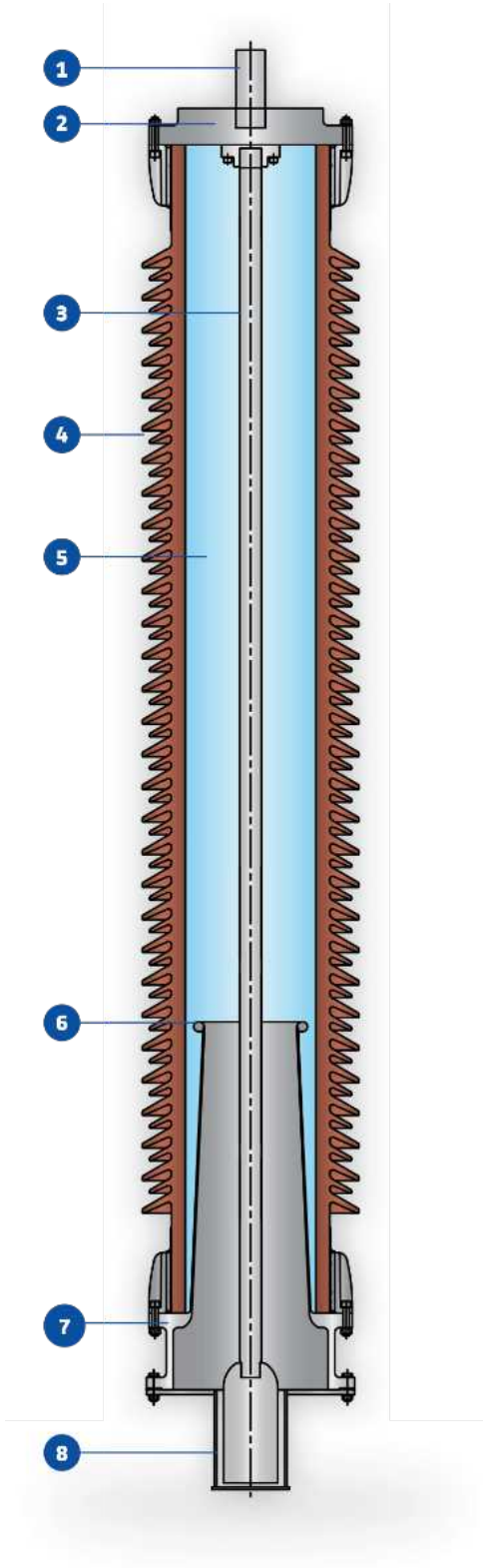


Fig. 1: Section

Fig. 1: Section

1. HV Terminal
2. Top closing plate
3. Inner conductor
4. Porcelain/composite insulator
5. SF_6 gas zone
6. Internal shield
7. Flange
8. Transport cover

Design

Standard bushing type PABS are designed with gas zone in common with GIS/GIL or HV CB gas compartments. The accessories like filling plug, insulator support (barrier) and pressure relief device are at GIS/GIL manufacturer care. Main internal insulation is pure SF_6 or a mixture of SF_6/N_2 at proper density (measured as gas pressure at 20°C - 68°F), while external insulation is provided by the high strength porcelain or composite insulator. Bushings up to and including 362 kV are designed with internal screen(s), while bushings at 420 kV and above are designed with internal semi-graded insulation made of gas-impregnated synthetic films. This solution grants compact dimensions with more uniform internal/external electric field distribution.

If required, all bushings, at 420 kV and above, can be equipped with a voltage tap and an associated voltage indicator. With the proper capacitance design, it is possible to achieve the low voltage U_2 (few tens of volt) for indicators or measuring devices. Bushings at 420 kV and above can also be provided, with test tap for tanδ, capacitance and partial discharges quantity measurement. During service, if not used, voltage tap must be grounded by using the voltage tap cap.

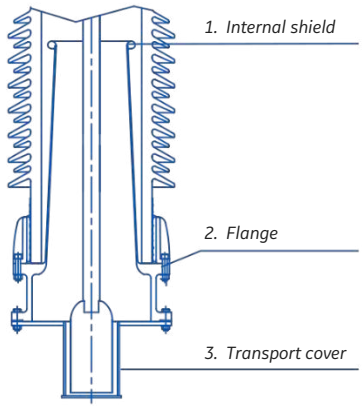


Fig. 2: Section of bushings up to 362 kV

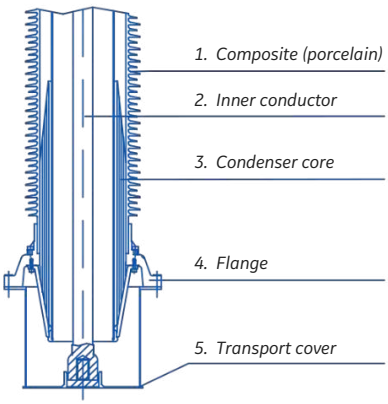
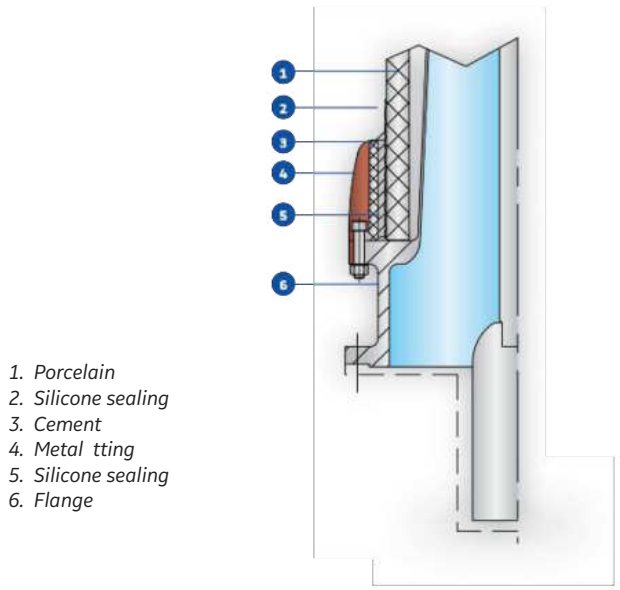


Fig. 3: Section of bushing at 420 to 800 kV

Manufacturing

All manufacturing procedures (certified to EN 29001- ISO 9001) comply with GE's Grid Solutions' Quality Assurance System and procedures. The manufacturing process for PABS bushings is shorter than oil-insulated bushings thanks to the lower sensitivity of SF_6 insulation to humidity and air presence. The assembling is made in a pure and unpolluted ambient in order to avoid internal insulation contamination. For bushings manufactured with porcelain envelopes, both sides of the porcelain are cemented to the metal flanges (see fig. 4).

All cemented surfaces, potentially in contact with the external environment, are silicone sealed. For bushings manufactured with a composite insulator, the fiberglass tube is tightly glued to the metal flanges, and a unique silicon cast realizes the sealing and the sheds for the requested creepage distance. Before factory tests, bushings are treated under vacuum and then filled with gas at minimum operating pressure.



1. *Porcelain*
2. *Silicone sealing*
3. *Cement*
4. *Metal tting*
5. *Silicone sealing*
6. *Flange*

Fig. 4: Particularities of the porcelain cemented to the flange

Terminals and Conductor

The cylindrical top terminal is made of aluminum or copper and is fixed to the upper closing plate. Different terminals, such as NEMA types, are available upon request. The main conductor is a central rod made of aluminum or copper according to the rated current.

The bottom terminal connection to the GIS/GIL or CB is silver plated or copper plated. Its dimensions and shape are designed according to the customers request.

Air Side

The external insulator is made of brown porcelain, (grey upon request) with cemented flanges, or composite insulator (resin fiberglass envelope covered by silicone sheds) glued to the metal parts. This system offers high mechanical strength during normal and above normal service conditions.

The alternating shed configuration (shortlong sheds) is the most effective solution and has been proven by salt spray tests.

The shed profile complies with the new IEC 60815 recommendations.

Composite insulators are recommended for all bushings with ratings from 245 kV through 800 kV, as it significantly improves bushing reliability throughout its lifetime.

Other benefits include:

- better behavior against weather elements, such as pollution and rain, due to the hydrophobic property of silicon rubber
- high mechanical withstand in case of impact, shocks and/or vibrations during handling, transportation or in service, such as for seismic activity
- higher safety for personnel and equipment in case of an internal fault (explosion-proof design).

Flange

Dimensions, flange type and lower conductor terminals, are designed in order to match the dimensions of the GIS/GIL or CB conductor.

For Dead-Tank Circuit Breaker installation, thoroidal cores for measurement and protection, according to ANSI/IEEE, IEC or other National Standards, are supplied on request.

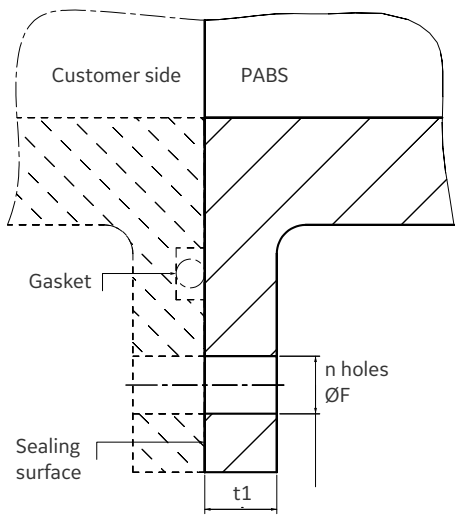


Fig. 5: Flange fixing holes (based on customer requirements)

Insulation

The basic insulation is Sulphur-hexafluoride (SF_6), which is not poisonous no flammable and has good dielectric, arc-exstinguishing and thermal capabilities. These characteristics enables it to be widely used in MV and HV equipments.

The insulation characteristic of SF_6 depends on the internal apparatus density and can be expressed in bar (PSI) at a temperature of 20 °C (68 °F). At approx. 3 bar (43.5 PSI) SF_6 gas has the same dielectric strength as oil and several times higher than air.

The main SF_6 insulating features are:

- non aging
- compressibility
- less sensitivity to humidity and air
- possibility of controlling the dielectric strength through the control of SF_6 gas density (pressure).

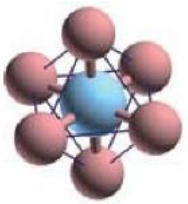


Fig. 6: SF_6 atomic model

Thanks to these characteristics, air-to-SF_6 bushings have a long life and a very high service reliability.

In case of very low ambient temperatures (down to -40 °C/-40 °F) a mixture of SF_6 and N_2 is used.

Gaskets

The sealing system is of fundamental importance for any pressurized equipment. Specifically, it has to guarantee leakage of less than 0.5 % per year. For this purpose Passoni & Villa has a very severe regulation and tolerances concerning the choice, control and tests of gaskets and their grooves (i.e. material, resistence to high temperatures, ozone, radiation and other ambient contaminants that may influence the aging process of the gaskets). Our internal standards permit the leakage less than 0.1 % per year. O-ring type gaskets are made of EPDM which grants the usage in a wide range of temperatures: from -45 °C to +150 °C. With our double-gasket system, flange and grooves are lubricated with a special grease in order to guarantee the highest tightness and to prevent corrosive influences in severe ambient conditions.

Metal Surface Treatment

Upon request, according to specific customer requirements, finishing or final painting can be provided.

Tests

Type and routine tests are performed according to the latest edition of IEC 60137 or ANSI/IEEE Standards or other specific requirements. Important leakage tests assure service reliability.

By measuring total leakage using a highly sensivity leak-meter ("Qm" method in accordance with IEC 68-2-17/94) a leakage of less than 0.5 % per year is ensured. However, normally it is less than 0.1 %.

In addition to routine and type tests prescribed by Standards, bushings from 420 kV through 800 kV are subjected to the Very Fast Transient (VFT) withstand tests.

In order to verify the bushing electrical withstand capability the bushing with semi-graded internal insulation is tested with lightning impulses chopped in SF_6, this simulating possible flashovers in GIS during its on-site tests according to IEC 62271-102 standard. The repetition of type tests is performed in order to ensure that the bushing has preserved all its characteristics after VFT tests.

Packing - Transportation

All bushings are protected with a plastic envelope and are horizontally transported in wooden cases. Bushings up to and including 170 kV are usually shipped in crates containing three pieces, while crates containing a single piece are used for higher voltages.

During transportation, the lower part of the bushing is closed and protected by a transport cover which is used also for fixing the central conductor. Bushings at 420 kV and above are transported with a relatively small overpressure of dry nitrogen (0,2-0,3 bar). The gas zone is filled through the automatic non-return valve.

Gas Filling and Refilling

After the bushing is connected to the network and before energizing, it has to be vacuum treated together with the GIS/GIL or CB and then filled with gas. For filling, use pure SF_6 gas or a mixture of SF_6 and N_2 according to the prescription of the Standards (IEC 60378 or other National Standard).

1. *Porcelain/composite*
2. *Toroidal*
3. *Flange*
4. *H.V.C.B.*

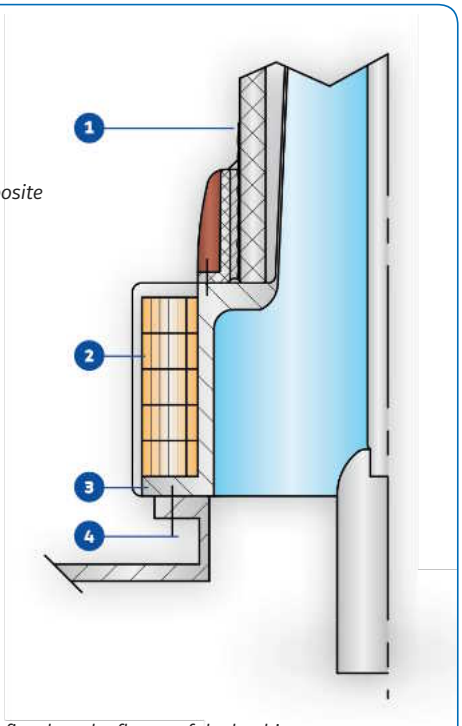


Fig. 7: Toroidal core fitted on the flange of the bushing

PABS Bushings with Porcelain and Composite Insulators - From 72.5 to 800 kV: Ratings / Dimensions

Bushings with Porcelain Insulators

PABS Type	Nominal System Voltage	Rated line-to-earth voltage	BIL (Dry lightning impulse withstand voltage)	Dry and wet power frequency withstand voltage (for 60s)	Wet switching impulse withstand voltage	Rated continuous current (standard value) up to	Rated thermal short-time current (1s)	Rated dynamic current	Minimum operating pressure (abs.)	Normal Cantilever load (test) up to [1]	Heavy Cantilever load (test) up to [1]
Type	kV	kV	kV	kV	kV	A	kA	kAp	bar/MPa (PSI)	N (lbf)	N (lbf)
72.5.325.2000.P	72.5	42	325	140	...	2000	50	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	2000 (450)	3150 (700)
100.550.2000.P	100	58	550	230	...	2000	50	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	2000 (450)	4000 (900)
123.550.2000.P	123	72	550	230	...	2000	50	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	2500 (562)	4000 (900)
145.650.3150.P	145	84	650	275	...	3150	80	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	4000 (900)	4000 (900)
170.750.3150.P	170	98	750	325	...	3150	80	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	4000 (900)	5000 (1125)
245.1050.3150.P	245	141	1050	460	...	3150	80	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	4000 (900)	5000 (1125)
300.1050.3150.P	300	173	1050	460	850	3150	80	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	5000 (1125)	5000 (1125)
362.1175.4000.P	362	209	1175	520	950	4000	100	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	5000 (1125)	5000 (1125)
420.1425.4000.P	420	242	1425	650	1050	4000	100	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	5000 (1125)	5000 (1125)
550.1550.4000.P	550	318	1550	675/710/740	1175	4000	100	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	5000 (1125)	5000 (1125)

Note: For non-listed ratings, please consult Grid Solutions. D13 is variable according to the rated current. Flange dimensions (Fig. 6) are based to customer requirements.

PABS Type	Arcing distance (L12)	C (Creepage distance)	Approx. weight	Max. operating altitude (asl)	L4	L10	L11	L14 (max.)	D4	D5	D14
Type	mm (in)	mm (in)	kg (lb)	m (ft)	mm (in)	mm (in)	mm (in)	mm (in)	mm (in)	mm (in)	mm (in)
72.5.325.2000.P	600 (23.6)	Min. 25 mm/kV Min. 0.984 in/kV	90 (198.5)	1000 (3281)	130 (5.12)	...	288 (11.34)	...	50 (1.97)	240 (9.45)	...
100.550.2000.P	1260 (49.6)	Min. 25 mm/kV Min. 0.984 in/kV	115 (253.5)	1000 (3281)	130 (5.12)	...	293 (11.53)	...	50 (1.97)	290 (11.41)	...
123.550.2000.P	1260 (49.6)	Min. 25 mm/kV Min. 0.984 in/kV	115 (253.5)	1000 (3281)	130 (5.12)	...	293 (11.53)	...	50 (1.97)	290 (11.41)	...
145.650.3150.P	1260 (49.6)	Min. 25 mm/kV Min. 0.984 in/kV	115 (253.5)	1000 (3281)	130 (5.12)	...	293 (11.53)	...	60 (2.36)	290 (11.41)	...
170.750.3150.P	1260 (49.6)	Min. 25 mm/kV Min. 0.984 in/kV	115 (253.5)	1000 (3281)	130 (5.12)	...	293 (11.53)	...	60 (2.36)	290 (11.41)	...
245.1050.3150.P	1980 (78.0)	Min. 25 mm/kV Min. 0.984 in/kV	310 (683.4)	1000 (3281)	130 (5.12)	...	313 (12.32)	37 (1.45)	60 (2.36)	340 (13.38)	...
300.1050.3150.P	2200 (86.6)	Min. 25 mm/kV Min. 0.984 in/kV	350 (771.6)	1000 (3281)	130 (5.12)	...	305 (12.01)	100 (3.93)	60 (2.36)	420 (16.53)	...
362.1175.4000.P	2750 (108.3)	Min. 25 mm/kV Min. 0.984 in/kV	650 (1433.0)	1000 (3281)	130 (5.12)	...	333 (13.11)	100 (3.93)	60 (2.36)	420 (16.53)	...
420.1425.4000.P	3300 (129.9)	Min. 25 mm/kV Min. 0.984 in/kV	1175 (2590.4)	1000 (3281)	130 (5.12)	90 (3.54)	392 (15.43)	309 (12.16)	60 (2.36)	570 (22.44)	750 (29.52)
550.1550.4000.P	3830 (150.8)	Min. 25 mm/kV Min. 0.984 in/kV	1250 (2755.8)	1000 (3281)	130 (5.12)	90 (3.54)	392 (15.43)	309 (12.16)	60 (2.36)	570 (22.44)	750 (29.52)

Note: For non-listed ratings, please consult Grid Solutions. D13 is variable according to the rated current. Flange dimensions (Fig. 6) are based to customer requirements.

Bushings with Composite Insulators

PABS Type	Nominal System Voltage	Rated line-to-earth voltage	BIL (Dry lightning impulse withstand voltage)	Dry and wet power frequency withstand voltage (for 60s)	Wet switching impulse withstand voltage	Rated continuous current (standard value) up to	Rated thermal short-time current (1s)	Rated dynamic current	Minimum operating pressure (abs.)	Normal Cantilever load (test) up to [1]	Heavy Cantilever load (test) up to [1]
Type	kV	kV	kV	kV	kV	A	kA	kAp	bar/MPa (PSI)	N (lbf)	N (lbf)
72.5.325.2000.P	72.5	42	325	140	...	2000	50	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	2000 (450)	3150 (700)
100.550.2000.C	100	58	550	230	...	2000	50	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	2000 (450)	4000 (900)
123.550.2000.C	123	72	550	230	...	2000	50	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	2500 (562)	4000 (900)
145.650.3150.C	145	84	650	275	...	3150	80	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	4000 (900)	4000 (900)
170.750.3150.C	170	98	750	325	...	3150	80	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	4000 (900)	5000 (1125)
245.1050.3150.C	245	141	1050	460	...	3150	80	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	4000 (900)	5000 (1125)
300.1050.3150.C	300	173	1050	460	850	3150	80	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	5000 (1125)	5000 (1125)
362.1175.4000.C	362	209	1175	520	950	4000	100	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	5000 (1125)	5000 (1125)
420.1425.4000.C	420	242	1425	650	1050	4000	100	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	5000 (1125)	5000 (1125)
550.1550.4000.C	550	318	1550	675/710/740	1175	4000	100	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	5000 (1125)	5000 (1125)
800.2100.4000.C	800	462	2100	880/960	1425	4000	100	2.5 x Ith	4.0-6.5/0.4-0.65 (60-95)	5000 (1125)	5000 (1125)

Note: For non-listed ratings, please consult Grid Solutions. D13 is variable according to the rated current. Flange dimensions (Fig. 6) are based to customer requirements.

PABS Type	Arcing distance (L12)	C (Creepage distance)	Approx. weight	Max. operating altitude (asl)	L4	L10	L11	L14 (max.)	D4	D5	D14
Type	mm (in)	mm (in)	kg (lb)	m (ft)	mm (in)	mm (in)	mm (in)	mm (in)	mm (in)	mm (in)	mm (in)
72.5.325.2000.C	600 (23.6)	Min. 25 mm/kV Min. 0.984 in/kV	70 (154.3)	1000 (3281)	130 (5.12)	...	288 (11.34)	...	50 (1.97)	185 (7.28)	...
100.550.2000.C	1260 (49.6)	Min. 25 mm/kV Min. 0.984 in/kV	80 (176.4)	1000 (3281)	130 (5.12)	...	293 (11.53)	...	50 (1.97)	205 (8.07)	...
123.550.2000.C	1260 (49.6)	Min. 25 mm/kV Min. 0.984 in/kV	80 (176.4)	1000 (3281)	130 (5.12)	...	293 (11.53)	...	50 (1.97)	205 (8.07)	...
145.650.3150.C	1260 (49.6)	Min. 25 mm/kV Min. 0.984 in/kV	80 (176.4)	1000 (3281)	130 (5.12)	...	293 (11.53)	...	60 (2.36)	205 (8.07)	...
170.750.3150.C	1260 (49.6)	Min. 25 mm/kV Min. 0.984 in/kV	80 (176.4)	1000 (3281)	130 (5.12)	...	293 (11.53)	...	60 (2.36)	205 (8.07)	...
245.1050.3150.C	1980 (78.0)	Min. 25 mm/kV Min. 0.984 in/kV	190 (418.9)	1000 (3281)	130 (5.12)	...	307 (12.08)	37 (1.45)	60 (2.36)	310 (12.20)	...
300.1050.3150.C	2200 (86.6)	Min. 25 mm/kV Min. 0.984 in/kV	210 (463.0)	1000 (3281)	130 (5.12)	...	295 (11.61)	100 (3.93)	60 (2.36)	310 (12.20)	...
362.1175.4000.C	2750 (108.3)	Min. 25 mm/kV Min. 0.984 in/kV	350 (771.6)	1000 (3281)	130 (5.12)	...	333 (13.11)	100 (3.93)	60 (2.36)	420 (16.53)	...
420.1425.4000.C	3300 (129.9)	Min. 25 mm/kV Min. 0.984 in/kV	420 (925.9)	1000 (3281)	130 (5.12)	70 (2.76)	335 (13.19)	309 (12.16)	60 (2.36)	455 (17.91)	750 (29.52)
550.1550.4000.C	3830 (150.8)	Min. 25 mm/kV Min. 0.984 in/kV	500 (1102.3)	1000 (3281)	130 (5.12)	70 (2.76)	335 (13.19)	309 (12.16)	60 (2.36)	610 (24.01)	750 (29.52)
800.2100.4000.C	5000 (198.6)	Min. 25 mm/kV Min. 0.984 in/kV	700 (1543.2)	1000 (3281)	130 (5.12)	90 (3.54)	335 (13.19)	450 (17.71)	60 (2.36)	610 (24.01)	1100 (43.30)

Note: For non-listed ratings, please consult Grid Solutions. D13 is variable according to the rated current. Flange dimensions (Fig. 6) are based to customer requirements.

Dimensions

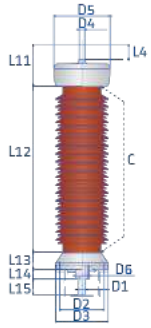


Fig. 8: Bushings with porcelain housing 72.5 to 362 kV

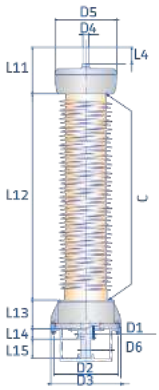


Fig. 9: Bushings with composite housing 72.5 to 362 kV

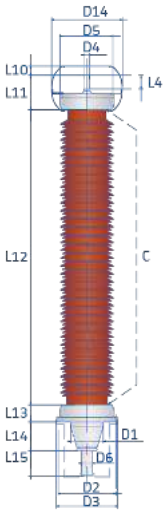


Fig. 10: Bushings with porcelain housing 420 to 550 kV

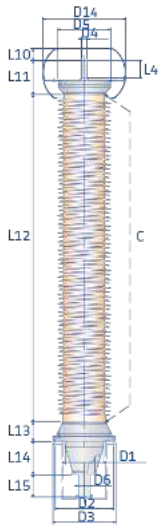


Fig. 11: Bushings with composite housing 420 to 800 kV

Nameplate

Each bushing is provided with a name plate, (fig. 12) with all the electrical data and serial number, in accordance with the prescription of IEC standards. The aluminum plate is placed on the flange by rivets.

1. *Bushing type*
2. *Insulating voltage*
3. *Rated current*
4. *Max. mounting angle from the vertical*
5. *Weight*
6. *Drawing number*
7. *Serial number*
8. *Month - year of manufacturing*
9. *Gas used: pure SF_6 or SF_6-N_2 mixture percentages*
10. *Minimum service pressure (relative)*
11. *Filling pressure (relative)*
12. *Max. internal pressure (relative)*

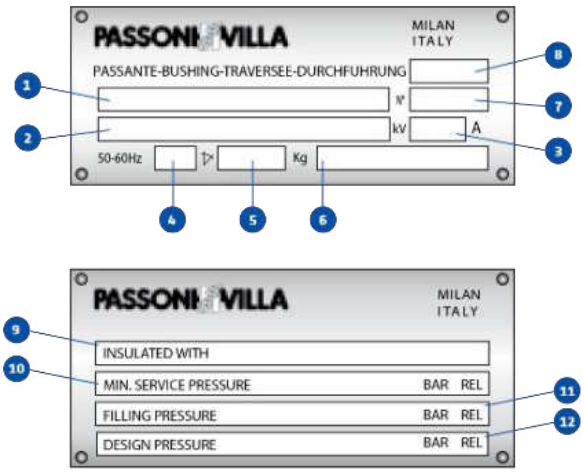


Fig. 12: Name Plates

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