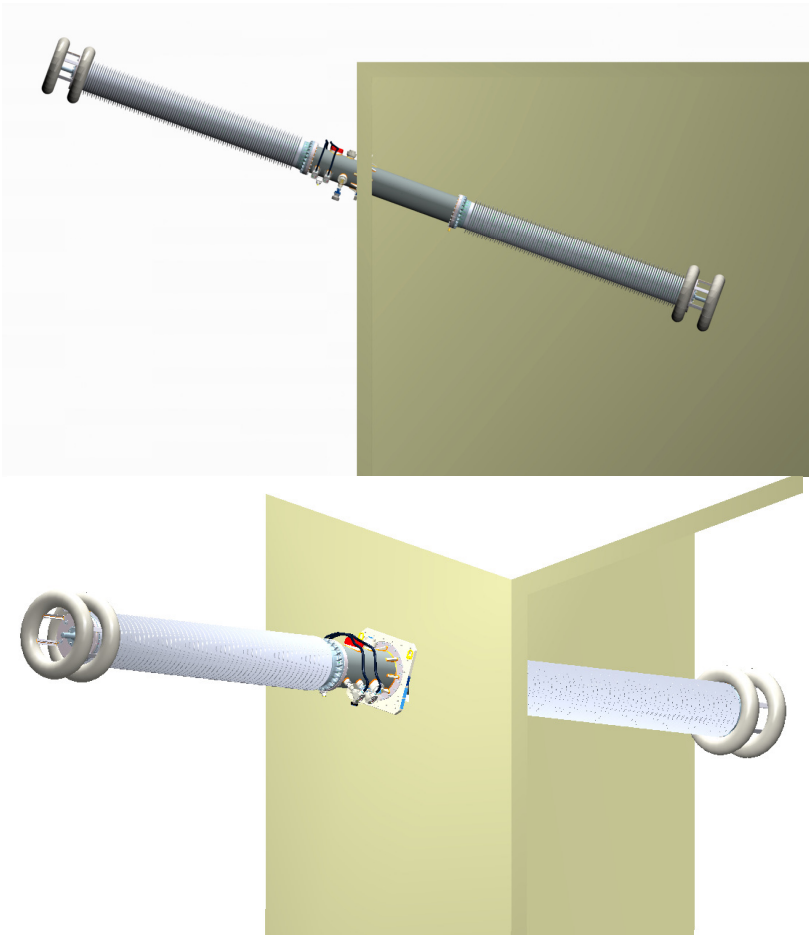
GRID SOLUTIONS

GAS FILLED HV WALL BUSHING

PWS - PWHS



OPERATING AND MAINTENANCE INSTRUCTIONS

Rev.	Description	Date	Prepared	Controlled	
0	Emission	24/11/2014	AF	LP	
1	Substituted specific values with references to drawings. Added Gas Monitor paragraph	06/03/2015	AF	LP	
2	Company name udated	07/07/2016	AF	LP	
3	Storage and transport conditions updated	22/08/2016	AF	LP	IS 2653 GB

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1 Introduction

These instructions are applicable to the gas SF6 insulated HV wall bushings of the series PWS/PWHS and provide all information relevant to:

- Safety aspects.
- Transport conditions.
- Technical characteristics.
- Controls at the arrival and preparation activities.
- Gas filling operation.
- Service and maintenance plan and procedures.

The PWS (HVAC) wall bushings are manufactured and tested in compliance with the following standards:

IEC 60137 Insulated bushings for alternating voltages above 1000V.

The PWHS (HVDC) wall bushing are manufactured and tested in compliance with the following standards:

IEC 62199 Bushing for DC application.

IEC 60137 Insulated bushings for alternating voltages above 1000V

2 Safety

*In this document important safety requirements are highlighted by the word **CAUTION** and important operative instructions are evidenced by the word **NOTE**.*

This manual must be available to the personnel responsible of the installation, operation and maintenance of the bushings.

The wall bushing is a high voltage AC/DC device, filled under pressure with SF6 gas, that has to be installed at relevant height through the wall of the valve building.

The preparation and the installation of the bushing, the gas filling and the periodical maintenance operations must be performed by qualified operators. The operators must be trained to operate in accordance with the guidelines described in this instruction manual.

Every operator must use the prescribed tools and the prescribed safety devices.

Non-compliance with the following procedures and instructions can result in serious and dangerous situations for the personnel and in risks of damages of the equipment and the property.

Main safety risks related to the bushing handling and its operative conditions are:

- Transport and handling of heavy and large parts.
- Lifting and moving of heavy and not well balanced components.
- Work operations under the crane and suspended materials.
- Work at height. All operation at height must be performed on a suitable certified platform.
- Risk of falling down of heavy parts during the installation.
- Risks deriving from un-proper balancing of the masses that can cause un-expected rotation during the installation on the wall.
- Risks due to the use of un-proper tools or wrong operations.
- Risks deriving from un-proper installation or operation on the bushing when filled by SF6 gas at rated filling pressure (explosion).
- Environmental risks related to dispersion of SF6 gas in the atmosphere.
- Severe electrical shock risk related to the extremely high voltage AC/DC level of the equipment.
- Severe electrical shock risk due to un-proper realization of the bushing grounding connections.
- Severe electrical shock risks deriving by the fact that the composite insulator and the other main parts of the bushing could remain electrically charged at high voltage for a long period of time after the plant de-energizing and the bushing grounding. Before starting any work on the de-energized bushing, check the discharge by touching all surface of both indoor and outdoor side composite insulators and all other parts of the bushing with an insulated grounding rod which length must be ≥ 3m. Operators must wear protective insulating gloves and boots and helmet with protective transparent face shield.

2.1 Preliminary operative information

The following notes are mandatory for personnel involved in wall bushing assembly. All problems detected during the bushing installation must be reported to the Foreman and to GE Grid Solutions RPV Supervisor.

- The bushing is a pressurized device. Operations on the valves, pressure gauges, pipes, protective devices must be performed by qualified operators, with the proper equipment and respecting the instructions of this manual. Foreman and operators have to take careful for handling the pressurized equipment.
- It is mandatory to use clean safety gloves and protective clothes, helmets and safety shoes during all bushing moving, assembly, hauling and installation operations.
- Work in quote will be done by trained operators on adequate and certified moving platforms. Workers that will operate in quote must use the above prescribed safety devices and in addition they must wear certified safety harnesses.
- Lifting equipment must be adequate and certified.
- Tools and pieces of clothes or no-fibre fabric used during the installation must be clean.
- The composite insulators sheds are made by silicone that can be mechanically damaged if not properly handled. Protect the insulators with clean plastic foils during the bushing installation and report to Foreman and to GE Grid Solutions RPV Supervisor any event which could have caused a damage of the composite insulators.

CAUTION: *It is strictly forbidden to move, lift and install any equipment that is under pressure. Check through appropriate gauge that the devices are at a pressure less than or equal 0.15 MPa abs (0.5 bar gauge) before operate on them.*

CAUTION: *The bushing is equipped with a safety rupture disk. This is installed on the central flange and protected by a metallic cap. Do not remove this protective cap and its relevant mechanical parts. Never touch the safety disk with the bushing filled with gas, as it can break, causing a violent gas explosion. Maintenance operation on the safety disk is allowed to trained operators and only after removing all gas pressure.*

3 Transport and storage conditions

The bushing is shipped in a wooden box suitable for marine transport, designed to provide protection of the bushing in accordance with the specified transport conditions.

The complete crate must be lifted, loaded on vehicles and transported with great care to prevent damages of the bushing or its accessories. Centre of gravity and lifting points are painted on the crate walls, stacking of crates is not allowed.

Shock indicators of suitable sensitivity are fixed on the crate walls. They turn the status when the shock exceeds the indicator trigger level.

GE Grid Solutions RPV will not respond of any damage due to un-proper operations. Removal or damage of the shock recorders will cause the interruption of the warranty.

3.1 Transport conditions

The bushing can be transported by truck, ship, airplane.
In order to prevent dangerous movement of the crate during the transport, it is responsibility of the transport company to carefully fix it on the vehicle by suitable retain systems like ropes, synthetic pulling bands or any other method.
The maximum allowed transport acceleration along the three axis is 3g (29.43 m/s^2). In case of transport by truck along very bad roads ('bumpy roads) the speed must be adequately reduced to max 30 km/h.
Trucks to be used for road transportation must have a platform of sufficient dimensions to accommodate the overall crate. Crate overhang from any platform and hauling are not allowed.

During the transport by road or ship the good must be protected from rain, sea water and other exceptional environment conditions by tarpaulins, not provided by GE Grid Solutions RPV, suitable to full cover the crate.
Sea transportation on the ship main deck is not allowed.

3.2 Lifting conditions

The crate can be lifted by two cranes. The lifting points are indicated on the crate and are reinforced by steel plates (see **Figure 1**). Lifting by fork lift is not allowed.

Figure 1 – Example of two crane lifting arrangement

Lifting operation must be done by qualified operators and with certified ropes and equipment.

3.3 Storage conditions

The bushings when are not in service have to be store indoor (above -5° degree C); especially in extreme weather condition (+40° to -40/50°) it is forbidden to store them outside even for a short period (mandatory to fulfil warranty conditions).

It is necessary that all the crate is placed inside a suitable warehouse and that a periodical check of the bushing, the gas pressure and of relevant accessories is activated (see Chapter 5.1). The recommended timing is six months.

4 Technical characteristics

PWS and PWHS bushings are based on gas technology (pure SF6 or SF6-N2 mixture). The electric field is controlled by suitable electrodes that are placed inside and outside the bushing. The internal electrical strength capability is ensured by the gas density, while the external withstand capability is ensured by composite insulators of adequate length and creepage distance.

The bushing is made by two sections, the indoor and the outdoor side, that are designed to withstand the different environmental conditions present inside and outside the valve building.

The bushing is designed and tested in accordance with the IEC 62199 and IEC 60137 standard.

Each section is based on:

- A composite insulator with silicone sheds.
- The internal shielding arrangement.
- An internal aluminium tube conductor.
- The top flange with the line terminal.
- The top toroidal electrical shield.

The two sections joined by the central flange make the complete bushing.
The sealing joints between the parts are designed to minimize the risk of gas leaking by using the double gasket concept. This means that the sealing is ensured by two concentric ‘O ring’ gaskets placed in separate grooves.

The bushing is designed in accordance to the customer requests with different environmental conditions and it can operate at low temperatures down to -50° C when filled with pure SF6 gas.

The solution based on gas technology offers the following advantages:

- Simple design.
- Lower mass compared with equivalent solution based on solid insulation. This means less risks in case of earthquake.
- Less different materials that reduces the risks due to DC and PR stresses.
- No aging of the main (gas SF6 or SF6 N2 mixture) internal insulation.
- Fast production and delivery time.
- Full dry explosion-proof solution.
- Limited maintenance and possibility for on line monitoring of the main insulation through gas pressure control (i.e. density control).

The bushing can be installed on the wall with different angles from the horizontal, as previously agreed.

5 Bushing preparation and installation

All operators involved in components unpacking and assembly have to be careful to not damage the objects. During the unpacking operation it is necessary to check that all components supplied by GE Grid Solutions RPV are available and not damaged during the transportation.

All incoming goods must be stored in a covered area and prepared for the installation.

5.1 Controls at the arrival

Before proceeding with the unpacking operation it is necessary to perform the following controls:

- Check the wooden crate status.
- Check the external visual impact recorder(s).
- Open the crate and inspect packaging and goods inside (see next p**aragraph 5.2**).
- Check the pressure of the gas inside the bushing that must be ≥ 0.11 MPa abs (0.1 bar gauge), see **Figure 3**.
- Check the composite insulators status, the top terminals and the relevant accessories.
- Check the bushing instruments and the status of the electric wiring.

Figure 2 – Visual external shock recorder

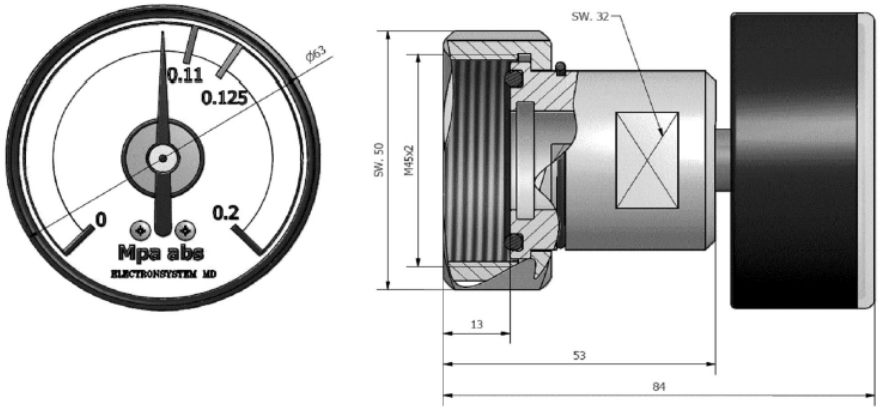

Figure 3 – Example of the transport pressure gauge

Any damage of the crate, of the goods inside or lack of gas pressure must be reported to GE Grid Solutions RPV Supervisor.

5.2 Bushing unpacking

Unpacking operation and the subsequent activities must be performed in a clean and controlled environment ambient. A closed and confined area with a concrete floor and adequate lifting facilities is necessary for all the preparation operation.

Next **Figure 4** shows the bushing arranged in its transport crate. Inside the crate the bushing stands on three wooden supports and it is locked by locking belts. Additional intermediate belts support the composite insulator to a wooden structure.

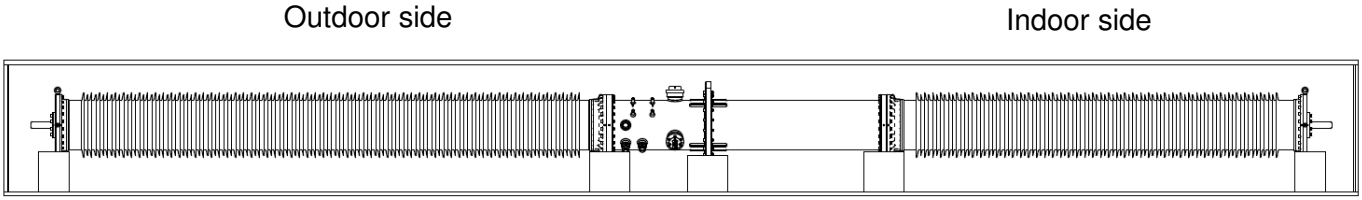

Figure 4 – Bushing crate inside view

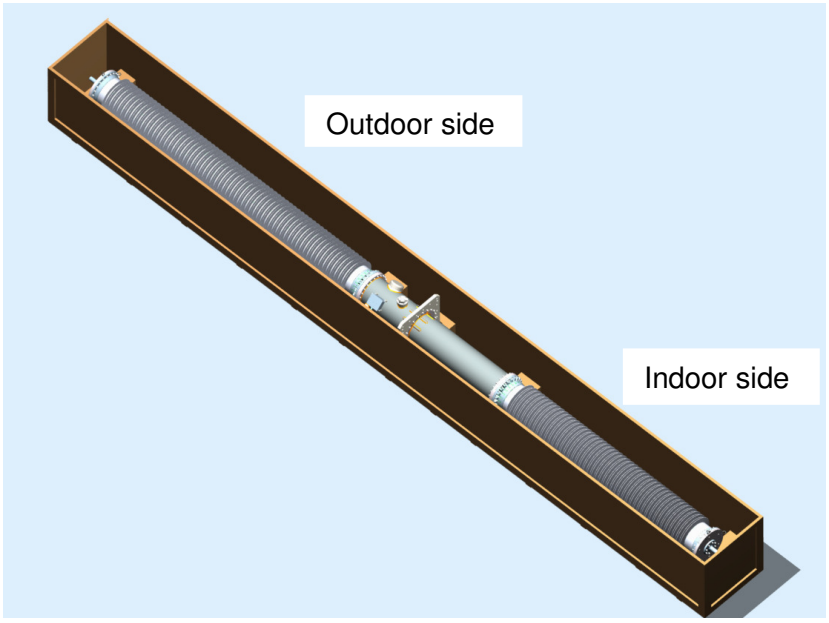

Figure 5 – Bushing inside the crate top view

The transport box can be lifted by a suitable crane.

After the opening of the crate, the visual inspection of the bushing and the removal of the locking ropes and locking blocks, the bushing can be lifted.

For this purpose lifting hooks are placed on the central and on both the side flanges, see **Figure 6** for some typical arrangements.

Lifting operation must be performed by qualified operators, by using adequate synthetic lifting ropes and cranes.

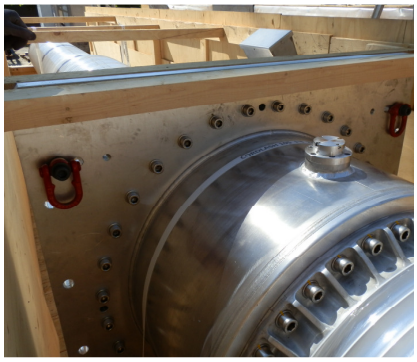

Figure 6 – Example of lifting hooks on main flange and on outdoor and indoor sides extremities

To lift the bushing connect the crane to the central flange hooks and use a pulling device (Tirfor) to connect the hooks placed on the outdoor side flange to compensate the mass unbalancing (see **Figure 7**). Lift carefully and compensate the mass unbalancing by acting on the pulling device until the bushing is approximately horizontal. In any case, ***before lift the bushing please strictly follow the steps indicated into the provided erection and installation manual (IS 2654 GB).***

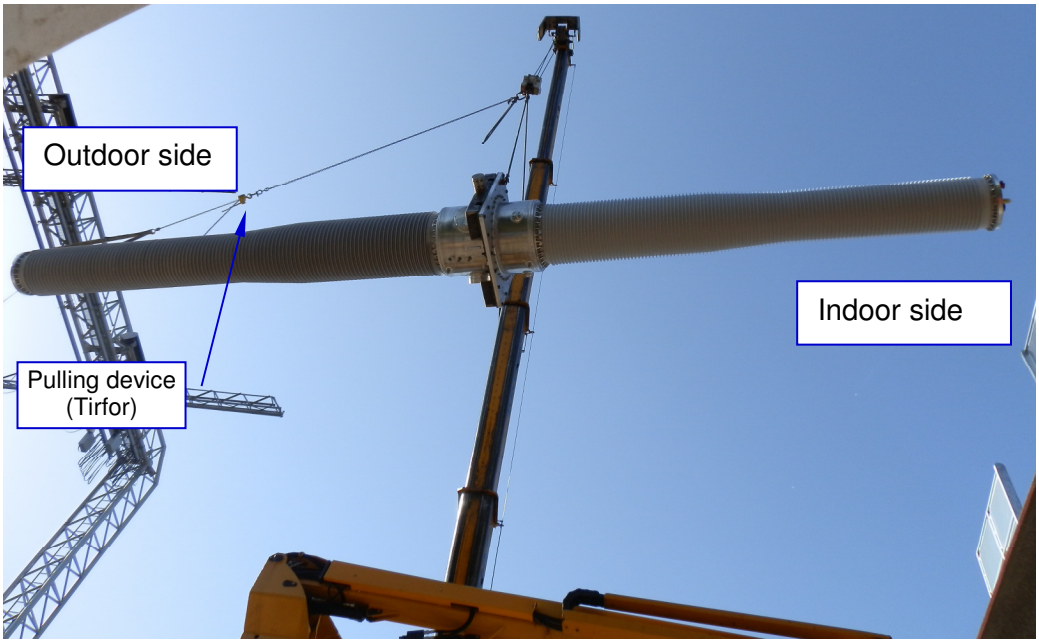

Figure 7 – Example of bushing extraction and lifting

CAUTION: *The two composite insulators are protected by a PE plastic foils. Remove the protection only after the installation of the bushing on the wall and just before the energizing.*

CAUTION: *To lift the bushing do not wrap ropes (i.e. 'tie' lifting method) around the silicone sheds. The composite insulators will be seriously damaged.*

CAUTION: *It is not allowed to step on the composite insulators. The silicone sheds can be seriously damaged.*

CAUTION: *The centre of gravity point is not symmetrical respect the bushing geometry. Care must be taken to compensate the mass unbalancing before and during the lifting operation.*

6 Gas SF6 characteristics and gas filling instruction

The SF6 gas to be used to fill the bushing must comply with the data shown in the following **Table 1**. This table shows the limits stated by GE Grid Solutions RPV specification and the characteristics of a premium Supplier:

Characteristics	Unit	GE RPV limits	Premium Supplier's limits
Min SF6	% by weight	≥99.9%	≥99.993%
Air	ppm by weight	≤500 ppm	≤50 ppm
CF4	ppm by weight	≤500 ppm	≤10 ppm
H_2O	ppm by weight	≤15 ppm	≤0.65 ppm
Mineral oil	ppm by weight	≤10 ppm	≤1 ppm
Total acidity expressed in HF	ppm by weight	≤0.3 ppm	≤0.3 ppm
Hydrolizable fluorides in terms of HF	ppm by weight	≤1 ppm	≤1 ppm

Table 1 - Characteristics of new SF6 gas according to GE Grid Solutions RPV and premium Supplier

The minimum requirement is that the characteristics will be in accordance with the data listed in the GE RPV limits column.

The gas filling must be performed with an equipment that prevents dispersion of the SF6 gas in the atmosphere. As an example, next **Figure 8** shows a gas plant manufactured by the German company DILO GmbH.

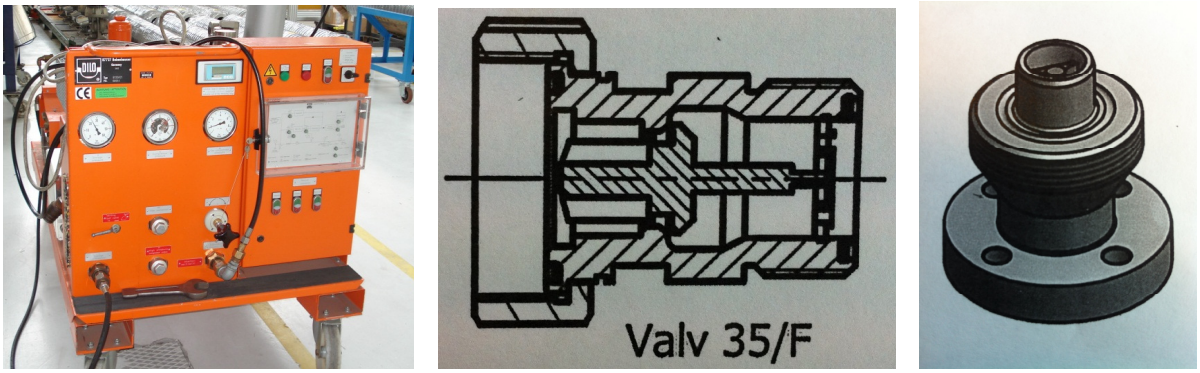

Figure 8 – Vacuum filling gas plant DILO and connecting valves

NOTE: *This bushing has to be operated with pure SF6. In case of need of replacement of SF6 gas with a mixture SF6 N2, before to proceed, please contact GE Grid Solutions RPV for instructions and approval.*

CAUTION: The following safety notes are mandatory.

- *The bushing can be filled at the rated filling pressure only when installed on the valve hall wall.*
- *If, for any reason, the bushing has to be removed from the wall, it is mandatory to reduce the gas pressure to 0.14 MPa abs (0.4 bar gauge), before proceeding with the operation.*
- *All gas filling and gas recovering operations must be performed by a gas plant device (example a DILO machine).*

6.1 Gas first filling operation and control of alarm and tripping signals

The bushing is shipped in slight overpressure of SF6 gas (See Chapter 5.1). If the pressure is positive proceed in the operation as follows, unless contact GE Grid Solutions RPV Supervisor for additional instructions.

- Install a calibrated vacuum / pressure digital gauge to one DILO valve on the bushing
- Connect the vacuum pump to another DILO valve on the bushing
- Start the vacuum pump and reach 1mbar residual pressure and keep it for 12 hours
- Stop the vacuum and connect a dry nitrogen bottles pack to another DILO valve on the bushing
- Fill the bushing at 1,5bar abs (0,5 bar gauge) and maintain the pressure for 12 hours
- Check and record the dew point of the gas and the pressure
- Remove the gas by restarting the vacuum pump and set a vacuum level of 1 mbar residual pressure and keep it for 6 hours
- Stop vacuum and fill with dry nitrogen at 1,5 bar abs (0,5 bar gauge) and maintain the pressure for 12 hours
- Check and record the dew point of the gas and the pressure. The dew point of the gas should be <= -48°C at atmospheric pressure (-44.6°C at 1,5bar abs)
- Start the vacuum pump and reach 1 mbar residual pressure and keep it for 24 hours
- Fill the bushing with SF6 at 1,2 bar abs and wait 24h. SF6 should be of the quality provided in the instruction manual and checked before filling.
- Check the gas parameters the moisture content must be <= 15 ppm weight (122 ppm vol). If gas parameters are OK, proceed with the installation of the bushing, unless contact RPV for additional instructions.
- Carefully reinstall the density meters to avoid any damage on the gaskets.
- Connect the gas plant to the gas filling DILO type valve located on the bushing flange.
- Gradually increase the gas pressure up to 0.2 MPa abs (1 bar gauge). Pressure must be directly measured on the gas density monitors installed on the bushing flange.
- Check all the gas seals for leakages with a suitable SF6 leak-meter device. In case of significant leakages stop activities and contact GE Grid Solutions RPV supervisor.
- If the bushing does not show any leakage, gradually increase the pressure at the rated filling pressure value, the pressure must be directly measured on the compensated gas density monitors installed on the bushing flange.
- During the pressure rising, check the functionality of the alarms signal contacts and record the respective operating pressures on the bushing check list. In case of malfunction, check the wiring and inform GE Grid Solutions Supervisor.
- Keep the bushing at the rated filling pressure for 4 hours, the purpose of this standing time is to allow the gas temperature stabilization, then make the final adjustment of the gas pressure.
- Disconnect the gas plant from the gas filling valve and close it with its cap.

The gas density monitor installed on the wall bushing is fully thermally compensated devices that indicate the pressure independently from the effective gas temperature. Whatever the temperature of the gas, the instrument indicates a pressure equivalent to an average gas temperature of 20°C. This condition is related with the gas density inside the bushing.

6.2 Gas refilling during the bushing normal operation

The bushing is a fully sealed unit and its leakage rate is <0.5% x year. Anyway, after many years of operation it could be necessary to refill it. The bushing refilling can be done with the bushing out of operation. The refilling operation has to be done within 7 – 10 days after Alarm 1 intervention.

Gas refilling can be done from the DN 20 DILO type valve located on the bushing flange by a gas plant or a SF6 bottle, equipped with the appropriate pressure reduction equipment and DILO connecting plug (contact DILO GmbH for information about filling set equipment for direct bottle filling).

The filling procedure is here below described:

- Connect the gas filling equipment (gas plant or SF6 system for direct filling from gas bottles) to the filling valve of the bushing flange.
- Gradually and slowly increase the gas pressure up to the rated filling pressure value, pressure must be directly measured on the temperature compensated pressure gauge installed on the bushing.
- Stop the gas filling equipment and shut the bottle valves.

NOTE: *In case of use of the DILO machine, check that the machine set-up is for gas filling and that the connecting pipe is full of SF6.*
In the case of direct filling from the bottle, check that the bottle is effectively charged with SF6, that the gas quantity is sufficient for the re-filling, the pressure reduction unit and the pipe are compatible with the DILO filling system and all equipment is specific for SF6 filling application and certified for a safe use. Also in this case, before to connect the equipment to the gas filling station, check that the connecting pipe is effectively filled by SF6 gas.

CAUTION: The gas re-filling operation MUST be performed with the bushing de-energized and grounded. Safety prescriptions of Chapter 2 must be followed.

CAUTION: *The refilling action must be performed by qualified operators. Periodical inspection and maintenance of the gas filling station must be accurate to prevent damages to the valves and the equipment installed inside or to the connecting pipe to the bushing.*

CAUTION: *Always use equipment certified for SF6 gas. This will avoid mistakes, safety issues and risk for the environment and the equipment.*

7 Gas density monitor

The bushing is equipped with one or more gas density monitors.

This device ensures a great accuracy in the measurement, as it is based on the continuous and direct comparison between the gas density inside the bushing and the gas density of a built-in reference chamber filled with the same gas.
This system is different and it is more accurate than the normal gas density monitors, which estimate the gas density by correcting the gas pressure measurement with the ambient temperature.

The **Figure 9** shows an example of the instrument and its graduated scale.

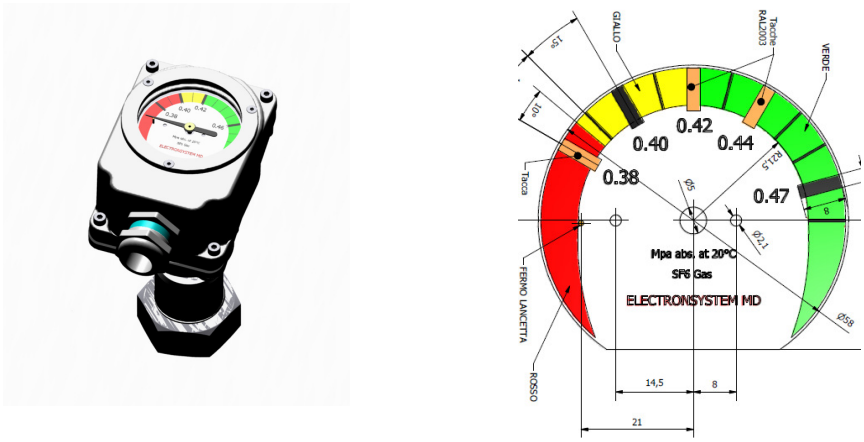

Figure 9 – Example of gas density monitor

The indication on the scale is expressed in MPa absolute, referred to a gas temperature of 20°C. This means that the instrument converts the gas density into a value of pressure referred to 20°C, independently for the effective temperature of the gas.

The instrument reading practically does not change with the gas temperature that is a function of the bushing loading condition and ambient temperature. Changing of reading during the bushing normal operation is an indication of gas leakages or malfunction of the instrument.

NOTE: *Due to the instrument principle of operation, the replacement of bushing gas from SF6 to a gas mixture SF6 N2 is not allowed without replacing the gas density monitors with the proper type. In this case contact GE Grid Solutions RPV for support, instructions and approval.*

Each gas monitoring device is equipped with four change-over micro switches for alarm and tripping signals.
For further information regarding alarm pressure values, see the electrical scheme document.

Each gas density monitor device is installed on a DN 20 DILO Type valve for easy disassembly, without the need to completely empty the bushing from the gas.

In addition, the electrical cables of all devices can be wired in a junction box provided with DIN type terminal boards for easy assembly and maintenance; see the electrical scheme document for details.

8 Power factor taps

The bushing is equipped with two PF taps, one for the indoor side and the other for the outdoor side of the bushing. These taps are used for capacitance, tan-delta and partial discharge measurements during the tests.

In operation they must be accurately closed with their metal caps that ensures also the grounding connection.

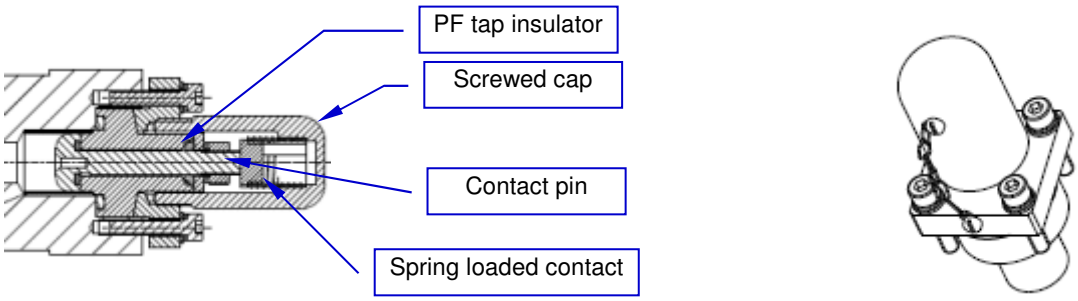

Figure 10 – Power factor tap

CAUTION: *PF tap cap MUST be accurately closed. Missing the cap could be dangerous and it can cause an electrical discharge at bushing energization.*

9 Composite insulators maintenance

Composite insulators are manufactured by qualified and experienced suppliers, require very limited maintenance.
The silicone used for the sheds is highly hydrophobic and it has the property to transfer this characteristic to the pollution layer.

For this reason it is not necessary to proceed with frequent washing operation which may progressively weaken the ability of silicone to regenerate its hydrophobicity. Washing must be done only when strictly necessary, i.e. in case of a heavy pollution of the composite insulator. Keep in mind that after washing, the silicone recovers its hydrophobicity in one or two days.

The composite insulator maintenance and repair procedure is described into the component manual: see reference in the summary prepared for the specific wall bushing.

The composite manufacturer can provide a repairing kit and also a technical support for the repairing activity.

Useful indications about the composite insulator maintenance plan main actions are shown in **Table 2**.

CAUTION: *Severe electrical shock risks deriving by the fact that the composite insulator and the other main parts of the bushing remain electrically charged at high voltage for a long period of time after the plant de-energizing and the bushing grounding. Before starting any work on the de-energized bushing, check the discharge by touching all surface of both indoor and outdoor side composite insulators and all other parts of the bushing with an insulated grounding rod which length must be ≥ 3m. Operators must wear protective insulating gloves and boots and helmet with protective transparent face shield.*

CAUTION: *Bushing washing must be performed with the bushing de-energized. Live washing is not allowed due to the high risk of fatal electrical shocks and dangerous flashovers across the composite insulator.*

CAUTION: *Inspection of indoor side of the bushing with the plant energized must be done by qualified technicians, fully in accordance with the safety rules specific for the access to the valve hall.*

It is recommended to perform all **Table 2** listed actions, as a reference starting point, at the first bushing energizing.

Time base	Visual inspection	UV camera and infrared examination	Wettability
6 Months	X		
1 Year	X	X	
When plant is off	X		X

Table 2 – Composite insulator maintenance plan

Visual inspection:

Carefully check that the composite insulators sheds do not show any mechanical damages and significant tracking or erosion due to electrical stress.
Visually evaluate also the pollution status and identify the areas of concentrated contamination.
Take note of the position of the areas of evidences, to be carefully analysed and taken under control during future inspections. In case of evidence of incipient erosion / tracking, plan an immediate washing action.

UV camera and infrared examination:

Scan all the surface of the composite insulators with an UV camera to identify possible areas of intense UV emissions on the sheds, on the toroids and the incoming line cables. To perform this test, the camera must be properly set in order to avoid false signals and background noise.

In addition, an infrared scan on the line terminal and the incoming cables can reveal incipient hot spots phenomenon that can evolve into a serious damage on the electrical connection and then of the bushing itself.
In case of significant variation of the UV and IR emission, plan the following actions:

UV emission: Immediate washing action on the interested part, in the meanwhile control all electrical connections.
IR emission: Immediate control of all electrical connections.

Wettability:

The hydrophobicity of the composite insulator can be checked by following the methodology described in IEC TS 62073 – 2003 Guidance on the measurement of wettability on insulator surfaces.
The simplest way to assess the wettability is the Method C - Spray method.

Wettability level up to WC4 is acceptable for normal operation. In case of further degradation of wettability level (WC5 and WC6) proceed with an accurate washing and drying and then repeat the test.
If wettability remains low but there are no evidences of tracking or erosion keep the bushing in operation but follows the intensive maintenance plan of **Table 3**.

Time base	Visual inspection	UV camera and infrared examination	Wettability
3 Months	X		
1/2 Year	X	X	
When plant is off	X		X

Table 3 – Composite insulator intensive maintenance plan

10 General maintenance plan

The general maintenance plan is described in the next **Table 4**.

Component	Time base	Description	Notes
Composite insulators	See **Chapter 9**	Inspection and maintenance	See **Chapter 9**
Gas SF6	Monthly	Check the pressure	Record the data
Toroids	When plant is off	Clean the surface and check for scratches or deformation. Check the fixing bolts to the flanges.	Anticipate the controls if UV camera reveals corona inception.
Gas valves, electrical equipment and connecting cables	When plant is off	Clean the cubicle. Check for gas leaks. Check functionality of pressure gauge and DILO Type valves. Check terminal blocks, wiring, cables and cable glands. Check and clean the junction box.	Check all gas joints to the DILO Type valves on the bushing. Check the cables and the cable tray to the bushing.
Current terminals	When plant is off	Check for evidence of hot spots. Check the terminals and tighten the connecting bolts to the bushing flange. Check the cable clamps and the bolting to the terminal.	Anticipate the controls if IR camera reveals hot spots. Contact GE Grid Solutions RPV in case of evidence of hot spots during the inspection.
Grounding terminals	When plant is off	Check for evidence of hot spots. Check the connection integrity and the bolt locking. Verify the effectiveness of the grounding.	Contact GE Grid Solutions RPV in case of evidence of hot spots.

Bushing locking to the wall	When plant is off	Check that all bolts are properly locked to the wall support.	
Component	**Time base**	**Description**	**Notes**
Power factors taps	When plant is off	Open the taps and clean inside. Check the internal spring loaded contact and clean it. Perform a Megger 1 kV insulation test R_{ins} > 1 MOhm. Check for gas leakages by sniffing the indoor side of the tap. Carefully close and tighten the cap.	***CAUTION:*** *PF tap cap MUST be accurately closed. Missing the cap could be dangerous and it can cause an electrical discharge at bushing energization.*
Rupture disk protection cover	When plant is off	Inspect the closure cap and the fixing screws.	***CAUTION:*** *Do not remove the closure cap and do not touch the disk when the bushing is filled with gas. An explosion of the disk could be very dangerous.*
Gas density monitor	5 years	Check calibration and operation of micro switches.	Check the effective and correct operation of the alarms & tripping signal chain from the instruments to the substation systems.
Bushing overall gas leakage	5 years	Check with SF6 leak-meter device all the flanges joints and the gas valves.	Anticipate the control if the leakage rate is excessive and gas re-filling is frequent. Identify the leakage areas. In case of frequent re-filling, plan for the replacement of the bushing and contact GE Grid Solutions RPV.
Gas quality	5 years	Check the moisture content in accordance to IEC 60480.	Regenerate / replace the gas if moisture exceeds the limits stated in the standard (>25 mg/kg).

Table 4 – Bushing general maintenance plan

11 Disposal at the end of life

At the end of the bushing operative life all parts can be recycled or disposed as follows:

Part	**Material**	**Action**
SF6 gas	SF6	Remove by DILO machine, recycle or thermo-destruction
Main central flanges	Aluminium	Dismount and recycle.
Central conductor	Aluminium	Dismount and recycle
Indoor and outdoor side flanges	Aluminium	Dismount and recycle
Top electric terminals	Copper silvered	Dismount and recycle
Toroids	Aluminium	Dismount and recycle
Internal electrostatic shields	Aluminium	Dismount and recycle
Transport supports	Aluminium	Recycle the aluminium
	Teflon	Dispose or thermo-destruction
Composite insulators with flanges	Fibreglass	Dispose or thermo-destruction
	Silicone	Dispose or thermo-destruction
	Aluminium	Dismount and recycle
Electrical wiring	Aluminium	Recycle
	Copper	Recycle
	Plastic	Dispose or thermo-destruction
	Galvanized steel	Recycle
DILO Type valves	Aluminium	Recycle
Pressure gauges	Various	Recycle as electronic products
Gaskets	EPDM rubber	Recycle or dispose or thermo-destruction

Table 5 – Bushing end of life management