A NEW AND INNOVATIVE BUSBAR CONNECTION SYSTEM FOR GAS INSULATED SWITCHGEAR: B-LINK

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INTRODUCTION

Gas Insulated Switchgear are widely used in MV primary distribution networks because of their outstanding performances with respect to safety, availability and reliability. All live parts being located in a hermetically sealed-for-life gas-tank, they are not affected by any environmental influences such as dust, humidity or altitude .In addition, the use of SF6 as insulating gas with its unique insulation features allow the realization of very compact switchgear designs.

GIS primary switchgear are generally of modular design. It means that it consists of individual panels in which the elements needed for one function are assembled. The complete switchboard is assembled at site by lining up the factory assembled switchgear panels and connecting the busbar between adjacent panels.

The traditional way of realizing the busbar connection involved gas handling at site as the assembling of the busbar in the busbar chamber is performed in the ambient air and two adjacent busbar gas chambers have to be hermetically flanged together at erection site. This solution where the busbar is fully insulated in SF6 is still the only one used in the HV GIS.

Although this solution has proven to be very reliable, it requires gas work at erection site and a very accurate assembling work in order to reach the required high level of gas tightness.

To save time on installation and to guarantee a high level of gas tightness of installed GIS, several switchgear manufacturers developed during the last decade solutions that allow to fit panels together without gas handling. In those switchgear, each gas tank is filled with SF6 gas and is checked for gas leakage at factory so that the properties remain unaffected by any severe site conditions.

In this paper existing solutions for connecting busbar without gas handling are briefly reviewed. A new busbar connection system is introduced in detail and its main features in terms of operational flexibility are presented. The reliability is demonstrated based on an extensive testing program including ageing tests.

EXISTING SOLUTIONS

To connect individual GIS panels via the busbar without gas-work different solutions have been developed. They are generally based on the use of one or more elastomer parts per phase. They can be classified in two categories:

Plug-in socket technique

The busbar chamber is closed at both sides with socket bushings that are protruding inwards and are supporting the gas insulated busbars. A connection link for the electrical contact and an insulation tube made of elastomer are inserted in the socket of an existing panel and the next panel can be plugged in by pushing it against. This solution provides a high mechanical resistance to short-circuit currents and need only two dielectric joints per phase. However, with this technique the insulation tube and the connecting link are protruding inside each gas chamber so that the replacement of a center panel or of an eventually damaged insulation tube is only possible with gas work.

Solid insulated busbar technique

The busbar is fully solid-insulated and located outside the gas chamber. Connection to the gas-chamber is realized through an elastomer insulating plug and a bushing which are mostly utilizing the outer cone interface well known for the cable connection. The electrical connection is of screwed type. This solution is limited to low and medium current ratings due to the ratings of the outer cone interface. To overcome this limitation, variants utilizing two special bushings and two elastomer sleeves per phase have been developed where only a part of the busbar is solid-insulated and located outside of the gas tank. All these connection techniques have as a common feature that they need four dielectric joints per phase which are considered to be the most critical part in the busbar system especially because they have all to be assembled at site.

THE NEW B-LINK CONNECTION SYSTEM

The new busbar connection system called B-Link has been developed with following objectives:

-no gas-handling required on site during switchgear erection, extension and at end of life or for panel replacement

-the system must be simple and reliable (reduced number of critical parts, easy assembly procedure)

-the system must cover the high ratings needed for primary distribution switchgear (Ir=2500A, Ik=40kA-3s, Ur=40,5kV, Ud=95kV, Up=185kV)

The busbar connection system is located between two adjacent, gas-filled busbar tanks and consists of following parts for one phase (see Figure 1):
-a single phase insulated sleeve made of silicone elastomer
-a screwable contact clamp for the electrical connection between busbars
-two pressure rings to apply the needed pressure on the dielectric sealing joints of the insulating sleeve
-two screwable steel frames that transmit the pressure force onto the pressure rings.

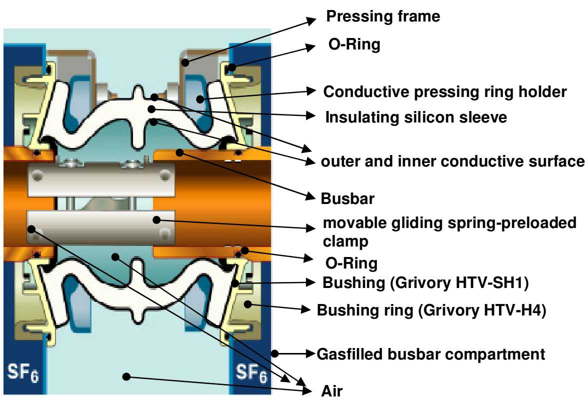

Fig. 1: Cross-section of assembled new busbar connection system B-Link

The busbar itself consists of a conductive tube which is maintained on both sides of the busbar gas chamber in two insulating bushings that have the form of a disc. The gas-tightness of these bushings is realized by means of O-Rings. The insulating silicone sleeve surrounds the busbar ends of two adjacent panels and establishes a direct link between the corresponding bushings when the radial arranged dielectric sealing joints located at each end of the silicone sleeve are pressed on the bushings. This results in a connection system with a minimum of 2 sealing joints per phase.
The electrical field in the silicone sleeve is controlled by means of the electrically conductive inner and outer surfaces. The inner surface is on busbar potential by means of the semi-conductive control electrodes located at each end of the sleeve, and the outer surface is connected to earth via the pressure rings and the pressure frame.
An important feature of the insulating sleeve is its axial flexibility due to the convex shape of the middle portion allowing the sleeve to be axially compressed by several cm with an auxiliary tool.
This compression is required to permit access to the contact clamp for screwing it against the inside surface of the busbar tube.

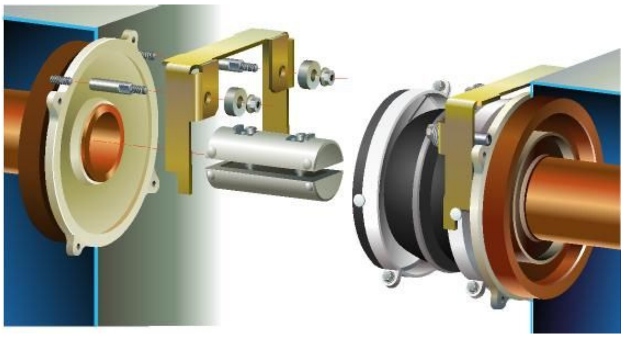

Fig.2: Explosion view of B-Link

The ability to be deformed axially gives the B-Link its unique features with regard to reliability and operational flexibility since the B-Link sleeves can be assembled to one side of the busbar bushings at factory to perform the electrical routine tests and remain in this position until the assembly at site when the free end of the sleeve is axially compressed to assemble and screw the electrical connection clamp prior to be pressed to the bushing of the adjacent panel by means of pressure ring and pressure frame. Figure 2 shows a view of a double busbar GIS panel type GHA with factory assembled B-Link sleeves.

Fig.3: Gas insulated switchgear GHA, 40.5 kV, 2500 A, 40 kA 3 s, Double busbar with B-Link sleeves

Due to the flexibility of the silicone sleeve and the special contact geometry of the contact clamp, the B-Link can compensate for some misalignment of adjacent panels without impairing the technical characteristics or the reliability of the connection.
To electrically seal the busbar of the end panels, silicone busbar caps have been developed which exhibit only one sealing joint the other side being closed . The dimensions of these end-caps have been choosen to be able to be also mounted through the gap between two busbar ends of

adjacent panelsin place of a B-Link sleeve in order to realize a quick isolation of a damaged panel from the remaining switchboard.
A main assessment criterium with respect to the electrical performance and the long term behaviour of a solid insulated busbar connection is the repartition of the electrical field inside the insulating material and especially along the sealing joint between sleeve and bushing.

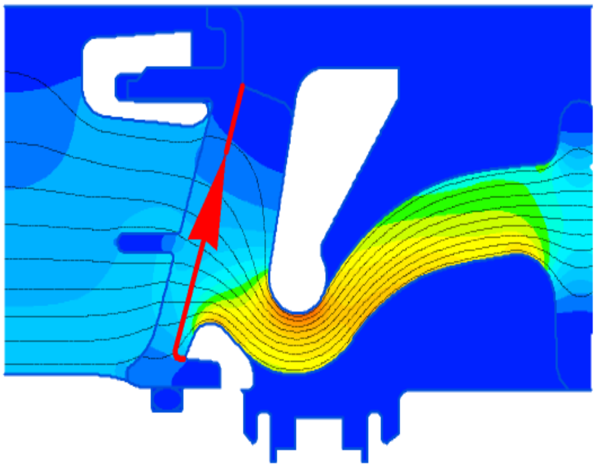

Fig.4: Calculation of electrical field in the B-Link sleeve (the equipotential lines are plotted).

Figure 4 shows clearly that the field repartition on the sealing joint is nearly constant and that the field at the triple points (junction between gas, solid insulation and conductor) is very low. This very advantageous field repartition for a purely geometrical stress control is a result of a several modeling and electrical field calculations which allowed to optimize the shape and the position of the various control electrodes. Special attention has been given to the stress control of the radially compressed busbar O-ring to avoid any risk of partial discharges in the gasket groove.

Many dielectric test have proven the high electrical withstand of this sealing joint as well as of the silicone insulation. Repeated lightning impulse tests and power frequency withstand tests showed that there is no degradation and that the partial discharge inception level remained unchanged at >44kV (1,1 Ur).
The low sensitivity with respect to the cleanliness of the joint has also been tested by polluting the joint with metallic swarf and textile fibre before pressing it against the bushing. In both case the connection withstood a 1 min. power frequency test at 100kV RMS without flashover .

TESTING

The B-Link busbar connection system has been extensively tested to demonstrate its electrical performance and its reliability.

The tests include:
-dielectric type tests up to Ud=95kV, Up=185 kV
-Partial Discharge tests (PD level <2 pC @44kV)
-Peak and short-time short-circuit current test up to Ip=104kA and Ik=40 kA-3s
-Temperature rise type test at Ir=2500A
-Temperature cycling test at –40°C and +115°C
-Test of the gas-tightness

A long term electrical and thermal test of the B-Link has also been performed to prove its long term performance. These ageing tests include extended power-frequency tests, PD tests and lightning impulse tests at high (100°C) and low (-30°C) temperature. The B-Link showed no sign of degradation after these tests.

ADVANTAGES OF THE NEW CONNECTION

-Quick installing of the panels without gas work .The quality of the insulating gas and the tightness of the gas tanks are of factory tested quality
-B-Link sleeve consists of only one insulating silicon part resulting in only two voltage stressed joints per phase
-B-Link sleeve and one joint is electrically routine tested at factory (partial discharge and Power Frequency Withstand test)
-B-Link can compensate for small misalignments
-Assembly of B-Link is performed under visual control (you can see what you are doing)
-When for operational reasons a center panel has to be quickly isolated from the rest of the switchboard, insulating Busbar endcaps can be fitted on busbar ends on both sides of a center panel before reenergizing of the remaining panels
-Removing of a center panel with no gas handling and no works in adjacent panels.

The last feature is of particular importance when a panel has to be exchanged by another one with different equipment (e.g. CT, VT, cable bushings..) after operational conditions have changed.
-End of life management: switchgear with B-Link connection can be easily dismantled without gas working and transported to a competent company for recycling and treatment of the used SF6.

CONCLUSION

The MV busbar connection B-Link described in this paper presents many advantages with respect to reliability and operational flexibility. Applied for busbar interconnection of Gas Insulated Switchgear, it allows assembling, replacement or extension of panels without gas handling while being factory assembled and factory tested thus guarantying a high level of quality.