CIGRE Study Committees SC B1 / B3 / D1

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

<table>
<tr><td>JWG N° B1/B3/D1.79</td><td colspan="2">Name of Convenor: Cornelis Plet (NL)
E-mail address: Cornelis.Plet@dnvgl.com</td></tr>
<tr><td colspan="2">Technical Issues #[2]: 3, 9</td><td>Strategic Directions #[3]: 1</td></tr>
<tr><td colspan="3">The WG applies to distribution networks[4]: Yes</td></tr>
<tr><td colspan="3">Potential Benefit of WG work #[5]: 3, 4</td></tr>
<tr><td colspan="3">Title of the Group: Recommendations for dielectric testing of HVDC gas insulated system cable sealing ends</td></tr>
</table>

Scope, deliverables and proposed time schedule of the WG:

Background:

Today, the vast majority of all HVDC systems in use are point-to-point HVDC transmission links. It is anticipated that more multi-terminal and even meshed HVDC transmission systems will be realized in the future, giving rise to a need for DC substations and the required equipment. Even today's point-to-point HVDC links require switchgear, instrumentation and surge arresters at the DC yards of the converter station at each end of the link to disconnect, earth, measure currents and voltages and protect from overvoltages. Future long onshore cable links with many cable joints are likely to need cable transition stations in which incoming and outgoing cables are connected by a busbar in which these functionalities can also be included. Moreover, these transition stations provide an opportunity to avoid the need for a multi-vendor compatible cable joint.

Minimisation of footprint is a main goal for most equipment manufacturers but is particularly relevant for HVDC equipment due to its application offshore where space comes at a premium, or onshore where there is little public support for large infrastructure. For this reason, HVDC gas insulated systems have been developed by several manufacturers in Japan a few decades ago, and recently a 2nd generation with a more compact design was developed, qualified and brought to market by European manufacturers. One of the key differences was the inclusion of a metal-enclosed HVDC GIS cable sealing end in the product range, adhering where possible to the interface requirements described in IEC 62271-209 “Cable connections for GIS >52 kV”.

How to qualify an HVDC GIS cable sealing end has been a subject of discussion. Testing of HVDC cable systems with extruded polymer insulation has been addressed by CIGRÉ technical brochure 496 (*Recommendations for Testing DC Extruded Cable Systems for Power Transmission at a Rated Voltage up to 500 kV*), whereas testing of HVDC gas insulated systems is addressed by the CIGRE joint working group D1/B3.57 (*Dielectric testing of gas-insulated HVDC systems*). Concerning the HVDC GIS cable sealing end, there is a mismatch between the recommended test approaches for each technology:

- Cable tests aim to provide proof of sufficient life-time whereas HVDC GIS tests provide proof of the GIS' ability to withstand operational stresses (but assume no significant ageing occurs)
- HVDC cable current ratings are typically much lower than that of HVDC GIS, which means that in a test loop the maximum operating current and thus conductor temperature of the HVDC GIS cannot be achieved without overloading the cable

- Recommended HVDC cable continuous testing voltages are significantly higher than the recommended continuous testing voltages for HVDC GIS and would lead to different charging behaviour of the HVDC GIS insulators
- Conversely, recommended impulse testing voltages (derived from IEC 60071-1 : *Insulation co-ordination*) for HVDC GIS are significantly higher than that of HVDC cables (prescribed by JWG B4/B1/C4.73 : *Surge and extended overvoltage testing of HVDC Cable Systems*) and can damage the insulation
- Switching operations in HVDC GIS, among which the possible production of (Very) Fast Transient Overvoltages and their impact on the cable sealings needs to be addressed

The purpose of this working group is to provide recommendations for the dielectric testing of HVDC GIS cable sealing ends.

Scope:

The analysis will focus on assessing the impact of recommended dielectric testing approaches for HVDC cables and HVDC GIS on existing technologies for HVDC GIS cable sealing ends for extruded polymer HVDC cable systems.

- Provide an overview of the possible applications of HVDC GIS sealing ends and envisaged benefits
  - Offshore converter platforms
  - Onshore cable transition stations
- Provide a short technology overview (with reference to other relevant CIGRE documents e.g. TB 496 and JWG D1/B3.57):
  - HVDC cables with extruded polymer insulation – main insulation properties
  - HVDC GIS
    - Coating designs
    - Insulator designs
  - HVDC GIS cable sealing ends
- Inventory of stresses in service
- Carry out a comparative analysis of the dielectric testing approaches prescribed by the relevant standards and technical brochures:
  - TB 496 - *Recommendations for Testing DC Extruded Cable Systems for Power Transmission at a Rated Voltage up to 500 kV*
  - WG B1.62 - *Recommendations for Testing DC Extruded Cable Systems for Power Transmission at a Rated Voltage up to and including 800 kV*
  - JWG D1/B3.57 - *Dielectric testing of gas-insulated HVDC systems*
  - JWG B4/B1/C4.73 - *Surge and extended overvoltage testing of HVDC Cable Systems*
  - IEC 60071-1 - *Insulation co-ordination*
  - And any other relevant standards
- Carry out indicative simulation studies to determine the electrical field conditions inside the HVDC GIS cable sealing ends (conic insulator surfaces) for all tests prescribed in both TB 496 and JWG D1/B3.57. The aim of the analysis is to determine if the test requirements of one standard can comprehensively cover the test stresses prescribed by the other. If not, then recommendations for additional tests which can be performed after either one of the test programs to fully qualify the HVDC GIS cable sealing end, will be made. The analysis will be carried out for all developed HVDC GIS cable sealing end technologies. The following aspects will be taken into account:
  - Test voltages (continuous and impulse)
  - Test currents & temperature distributions
  - Pre-stress characteristics
  - Physical orientation

- Transition times of capacitive to resistive fields
- Space charge accumulation

- Develop recommendations for the use of a cable dummy set-up by assessing the impact of the cable termination on the conic insulator surface field conditions on the gas side
- Develop recommendations for testing HVDC GIS cable sealing ends in the absence of HVDC GIS by considering the dimensions of the required metallic enclosure (grounded tube) which does not contain any HVDC GIS insulators to achieve the same electrical field distribution
- Develop recommendations for the required test methods and circuits
- On site (TAI) test recommendations
- Conclusions

Deliverables:

☒ Technical Brochure and Executive Summary in Electra

☒ Electra Report

☒ Tutorial[6]

☒ Webinar[6]

Time Schedule: start: January 2020 **Final Report**: December 2021

Approval by Technical Council Chairman:

Date: November 18, 2019

Notes: [1] Working Group (WG) or Joint WG (JWG), [2] See attached Table 1, [3]See attached Table 2, [4] Delete as appropriate, [5] See attached Table 3,
[6] Presentation of the work done by the WG

Table 1: Technical Issues for creation of a new WG

1	Active Distribution Networks resulting in bidirectional power and data flows within distribution levels up to higher voltage networks
2	Digitalization of the Electric Power Units (EPU): Real-time data acquisition includes advanced metering, processing large data sets (Big Data), emerging technologies such as Internet of Things (IoT), 3D, virtual and augmented reality, secure and efficient telecommunication network
3	The growth of direct current (DC) and power electronics (PE) at all voltage levels and its impact on power quality, system control, system operation, system security, and standardisation
4	The need for the development and significant installation of energy storage systems, and electric transportation, considering the impact they can have on the power system development, operation and performance
5	New concepts for system operation, control and planning to take account of active customer interactions, and different generation types, and new technology solutions for active and reactive power flow control
6	New concepts for protection to respond to the developing grid and different generation characteristics
7	New concepts in all aspects of power systems to take into account increasing environmental constraints and to address relevant sustainable development goals.
8	New tools for system technical performance assessment, because of new Customer, Generator and Network characteristics
9	Increase of right of way capacity through the use of overhead, underground and submarine infrastructure, and its consequence on the technical performance and reliability of the network
10	An increasing need for keeping Stakeholders and Regulators aware of the technical and commercial consequences and keeping them engaged during the development of their future network

Table 2: Strategic directions of the Technical Council

1	The electrical power system of the future: respond to speed of changes in the industry
2	Making the best use of the existing systems
3	Focus on the environment and sustainability
4	Preparation of material readable for non-technical audience

Table 3: Potential benefit of work

1	Commercial, business, social and economic benefits for industry or the community can be identified as a direct result of this work
2	Existing or future high interest in the work from a wide range of stakeholders
3	Work is likely to contribute to new or revised industry standards or with other long term interest for the Electric Power Industry
4	State-of-the-art or innovative solutions or new technical directions
5	Guide or survey related to existing techniques; or an update on past work or previous Technical Brochures
6	Work likely to contribute to improved safety.
7	Work addressing environmental requirements and sustainable development goals.