CIGRE Study committe B1

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG B1.95

NAME OF THE CONVENOR
Olsen Søren (DENMARK)

TITLE
Mechanical performance and limits of submarine power cable systems

THE WG APPLIES TO DISTRIBUTION NETWORKS: YES

ENERGY TRANSITION
5 / Grids and Flexibility

POTENTIAL BENEFIT OF WG WORK
1 / commercial, business, social, economic benefits
2 / potential interest from a wide range of stakeholders
3 / likely to contribute to new or revised industry standards
5 / Guide or survey on techniques, or updates on past work or brochures

STRATEGIC DIRECTION
1 / The electrical power system of the future reinforcing the End-to-End nature of CIGRE: respond to speed of changes in the industry by preparing and disseminating state-ofthe-art technological advances
2 / Making the best use of the existing systems

SUSTAINABLE DEVELOPMENT GOAL
9 / Industry, innovation and infrastructure

BACKGROUND :

The use of submarine power cable systems is becoming more widespread. Experience from current projects highlights a need for common guidelines to ensure that mechanical performance and mechanical limits of submarine power cables are established and verified consistently across the industry. In particular the mechanical loads exerted on the cable during the installation, operation and repair process, and cases of damage caused, have revealed a need for an even deeper and wider knowledge about mechanical specifications and the conditions serving as basis for their definition.

CIGRE TB 623 and CIGRE TB 862 consider some of these aspects but not in detail and with limited guidance given on aspects like temperature dependency, test setup and success criteria for project specific tests and need for special tests. The majority of the tests are for conformance, not performance, resulting in safety margins remaining unclear. This is now being actively challenged by parties involved in project certification. Crucially, CIGRE TB 490, TB 623 and in part TB 862 do not provide clarity on the Range of Approval which can be derived from mechanical tests. This raises ambiguity about whether a test on a cable with a certain design, having a specific conductor design and armour package, truly mechanically qualifies a cable system of a similar design.

Many of the specifications and mechanical limits are currently set based on earlier experience and conservatism – all based on differing methods, perspectives, and objectives of the different cable suppliers. There is a growing need for calculation methods which show the safe utilisation of the cable, for example tension limits at different bending radii relative to Tensile Strength of the armour wires or crush loads relative to the permissible strain/deformation of the polymeric insulation. The introduction of mechanically dynamic power cables, for example for floating wind farms, increases this need further. In the absence of standardised analysis methods, there is a risk that certifiers or insurers will expect to see full testing of all mechanical performance aspects of all cable system designs used in a project. This would add a considerable testing burden, cost and lead time potentially on the critical path of the projects, which can be disproportional as a risk mitigation due to the absence of a common industry wide approach to mechanical specifications.

PURPOSE / OBJECTIVE / BENEFIT OF THIS WORK :

1. Define mechanical specifications and corresponding boundary conditions that are important for installation and operation of static and dynamic submarine power cable systems of various designs with extruded insulation (AC, DC, single core, three-core, bundled cables).
   - Cable systems include factory joints and accessories such as field & repair joints, pulling heads, pulling stockings, hang-offs and accessories relevant for bundled cable designs (straps, tapes etc.)
2. Document what cable system design parameters and design elements are dominant for the various mechanical specifications / mechanical limits. Give guidance on how cable system design can be adapted for specific mechanical requirements?
3. Consider Range of Approval aspects of the mechanical preconditioning component of a Type Test. Recommend when and how a reduced scope of mechanical testing (Extension of Qualification testing for mechanical aspects) can provide confidence in a design. For instance, covering changes in the cable system construction or design.
4. Consider range of validity of development/special mechanical tests on cable and accessories. In case of a design changes, when are development/special tests recommended to be repeated.
5. Inspired by CIGRE TB 862, provide best practices for both local and global modelling which can be used to derive mechanical specifications under certain boundary conditions. Allowing for consideration of factors such as temperature dependence or varying bend radii without repeated testing. Consider the methods, perspectives, objectives, and conservatisms present in the industry.
   - Provide recommendations on assessing mechanical specifications of the cable system as input to global analyses (during installation and operation). As an example, this also covers mechanical behaviour of cable during operation such as in free-spans and in Cable Protection Systems (as far it concerns interaction between cable and CPS).
   - For the operational period consider aspects related repetitive movement of cables designed and qualified for static application also considering installations where CPS are utilised.
6. Provide best practices regarding verification of submarine power cable systems modelled mechanical specifications to a greater detail than provided in CIGRE TB 623 and TB 862. Observe that the recommendations how to perform various tests are outside the objective of the work.
7. Explain mechanical specifications, limitations, and requirements for a wider audience within the Cigre community – bridging the gap between electrical and mechanical engineers in the industry.

SCOPE :

The cable systems covered by the WG are mechanically loaded submarine power cable systems in the range of 30 kV to 525 kV for both AC and DC for both dynamic and static application - with extruded insulation systems. However, the aspects covered would be relevant for both higher and lower voltages as well.

Appendix:

Mechanical specifications and limitations of the cable system considered – list to be finalised and verified by WG:

- Mass
  - Mass in air
  - Mass in water
  - Specific gravity (flooded/unflooded)
- Tensile related
  - Maximum tensile force with and without factory joints
  - Capacity curve (pulling tension vs. bending radius)
  - Distribution of the tensile force between the conductors and the armour
  - Load sharing between cables in a bundle and between cores and armour
- Bending related
  - Minimum bending radius
  - Bending stiffness – hysteresis curve (stick and slip), temperature dependency
  - Aging aspects of repeated mechanical loading
- Compressive
  - Squeeze load limits
  - Sidewall pressure limits
  - Clamping pressure limits
  - Axial stiffness (tension and compression)
  - Torsional stiffness
  - Maximum allowable compression
- Handling parameters
  - Maximum Tensile load vs. radial compression also considering slippage/friction between layers and elements.
  - Ambient air and water temperatures considered safe for the handling and installation of the cable system
  - Maximum allowable impact energy (for rock placement)
  - Minimum coiling diameter (if coilable) and associated drop height
  - Maximum number of coiling operations
  - Minimum distance between two radii bending the cable in different directions
  - Parameters for coiling or semi-coiling – if applicable
  - Parameters for bundled cables
  - Coiling direction (clockwise or counter-clockwise)
  - of transpooling cycles the cable can withstand
  - Temperature range where handling/installation of the cable system is acceptable

DELIVERABLES AND EVENTS

Deliverables Types

Technical Brochure and Executive Summary in Electra
Tutorial
Webinar

Deliverables schedule

Technical Brochure	Q4	2027	TB for publication

APPROVAL BY TECHNICAL COUNCIL CHAIRMAN:

Rannveig S. J Løken
November 12th, 2024