CIGRE WG B1.34: Mechanical Forces in Large Conductor Cross-Section XLPE Cables

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ABSTRACT

Thermo-mechanical forces in extruded HV/EHV cables can reach several tons, especially with large conductor cross sections.

As the forces developed during thermal load are of a complex nature and depend on individual cable designs, measurements of full size cables are needed to get realistic cable properties.

With given cable properties various methods are able to describe the thermo-mechanical effects for most installation conditions.

By proven installation and design methods these forces can be reduced significantly down to values which can be handled by cleating/installation methods.

KEYWORDS

Thermo-mechanical forces, large conductors, XLPE cables, installation methods, CIGRE WG B1.34

INTRODUCTION

This paper summarizes the work of CIGRE working group B1.34 dealing with the topic of the thermo-mechanical forces involved with large conductor XLPE cable systems. Such forces can reach several tons of axial thrust and/or significant cycling movements in the cable system installed. The complexity of the physical nature of the problem disallows an easy calculation of the related effects (non-linear effects, hysteresis effects, etc.). Therefore, measurements on full size cable samples and best practice experiences are needed to design a safe cable system.

This paper gives an overview of the different design approaches for:

- Rigid cable systems
- Flexible cable systems
- Transition sections between rigid and flexible installations and
- Duct installations.

The new technical brochure [2] describes in detail the complexity, explains the background and gives guidance on how to handle the individual topics. The state of the art design rules are given and examples for installation with good experiences related to thermo-mechanical issues are shown. A special section deals with the topic of cleating (or clamping) installations, which are an important installation tool to handle the thermo-mechanical forces in a cable system, but are not always considered.

In order to get input data for the design formulae, different measurement methods are described, which are needed to get the specific mechanical cable values for:

- Linear thermal expansion coefficient α
- Axial stiffness $E_{eff}A$
- Bending stiffness EI.

The general basics of the design principles and the thermo-mechanical model, which are described in the CIGRE Technical Brochure 194 [1] are followed, but a deeper background is given. When appropriate, Improvements to be introduced in the future revision of TB 194 are proposed.

Overall, the new brochure is a guide on how to handle this topic and gives a broad overview of the best practices around the world.

This paper is considering possible different analytical mathematical approaches which were verified by FEM simulations for describing transition regions between rigid and flexible sections.

FORCES IN RIGIDLY INSTALLED CABLE SYSTEMS

During load cycling the cable expands longitudinally according to its thermal expansion coefficient α. In a rigid installation this expansion is not possible, but longitudinal forces will develop according to the axial stiffness $E_{eff}A$ of the cable (where E_{eff} is the effective Young's modulus and A the effective cross-section of the cable).

$$F = E_{eff}A\ \alpha \Delta T \qquad [1]$$