Qualification of an extruded HVDC cable system at 525 kV

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ABSTRACT

A new 525 kV DC cable system with a power rating range exceeding 2 GW has been developed for both subsea and underground applications. The extruded HVDC cable system technology is appropriate when power needs to be delivered efficiently through populated or environmentally sensitive areas, or in coastal and open-sea applications.

The successfully tested extruded 525 kV HVDC cable system is the result of long-term focused R&D work and collaboration with a material manufacturer. This system utilizes a new cross-linked polyethylene (XLPE) DC insulation material, an oil- and porcelain-free termination based on HVDC wall bushing technology as well as a land joint and a flexible sea joint.

KEYWORDS

HVDC, extruded cables, 525 kV, non-linear field grading materials, composite insulators

INTRODUCTION

Intensive research and development of extruded DC cables took place in early 1990's. As a result, the first commercial project used ±80 kV and a moderate power level. Innovation in DC insulation materials and manufacturing techniques led to the commercial deployment of extruded high voltage direct current (HVDC) cable systems in different parts of the world. After about 15 years of successful commercial experience, extruded HVDC cables have become a major player in the portfolio of HV cable products.

Over time the number of applications for HVDC cable systems has increased and the highest voltage in service today for extruded DC cable systems is ±320 kV.

The extruded HVDC cable systems enable, for example, solutions for the connection of remote energy resources to the loads, while circumventing public and land owner opposition to the construction of new overhead lines [1][2].

CABLE DEVELOPMENT

A good HVDC cable insulation material, besides all the normal requirements for HVAC cables, such as good mechanical, chemical and electrical properties, (e.g. high breakdown strength), has to meet additional requirements due to the DC voltage. The insulation shall have a low DC conductivity to avoid high thermal losses. The conductivity of insulation materials increases with the electric field and temperature, therefore higher conductivity increases the risk of thermal runaway and electrical failure. This risk is highest during the electrical type testing of the cable when it is exposed to voltages 1.85 times the nominal operation voltage level. Figure 1 provides a comparison between the conductivity of cables with the previous and the new technology as a function of test voltage. As for the previous technology the risk of thermal runaway increases when the type test voltage reaches above 600 kV, but with the new technology this risk is negligible even with much higher voltage levels. In this way the new technology provides a platform for producing HVDC cables for higher voltage levels which was impossible before.

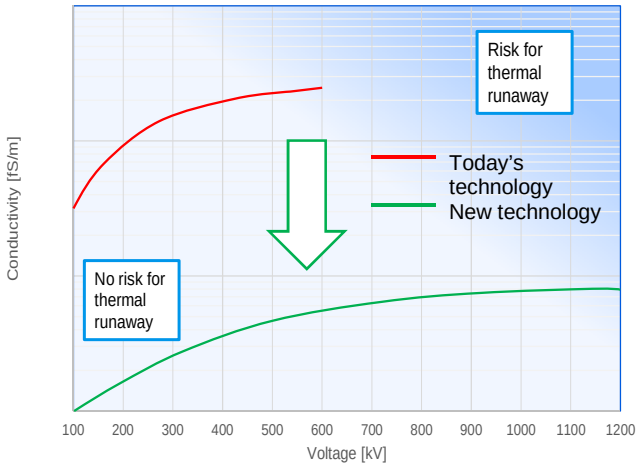

Figure 1: Comparison on conductivity vs voltage for the new and previous HVDC cable insulation system.

Several material compositions were evaluated during the initial stages of the development. Based on several parameters for producing and qualifying full-scale cables the new compound is based on XLPE. References [3] to [6] describe the XLPE compound development and it characteristics in more detail.

The new XLPE insulation system is closely related to the one presently used which is a major advantage. The development of optimal process parameters and quality control techniques has enabled the capability of producing