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Development of DC extruded cables and factory joints in Japan

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Abstract: This paper introduces research work undertaken in Japan to develop DC extruded cables and factory joints. While AC extruded cables have the advantage of being easy to maintain, their problem was their vulnerability to DC voltage due to space charge accumulation in the insulation resulting in a decline of the cable's insulation performance. In 1984, we initiated research for the development of an extruded DC insulating material and have so far succeeded in developing a DC+/-250kV and DC+/-500kV extruded cable as well as a DC+/-120kV coaxial integrated return conductor extruded cable.

Keywords: DC extruded cable, Submarine cable, DC coaxial return conductor cable

Résumé: Le présent article présente des travaux de recherche réalisés au Japon pour le développement de câbles extrudés CC et de raccords en usine. Bien que les câbles extrudés CA aient pour avantage leur facilité de maintenance, ils ont pour inconvénient leur vulnérabilité au "dévoltage" CC consécutif à l'accumulation des charges d'espace dans le matériau isolant du câble, ce qui a pour conséquence une détérioration des propriétés isolantes dudit matériau. En 1984, nous avons entrepris des travaux de recherche dans le but de développer un matériau d'isolation pour câble CC extrudé, et sommes jusqu'ici arrivés à fabriquer des câbles extrudés CC+/-250 kV et CC+/-500kV, ainsi qu'un câble coaxial CC +/-120 kV à conducteur de retour intégré.

Mots clés: câble extrudé CC, câble sous-marin, câble coaxial CC à conducteur de retour intégré

1. Introduction

This paper introduces the DC+/-250kV, DC+/-500kV extruded cable and the DC+/-120kV coaxial integrated return conductor extruded cable and describes the development process. In the past, DC power transmission was used because this power transmission mode presents no charging current problems on long-distance transmission lines. DC cables are either of the Oil-filled (OF) or Mass-impregnated (MI) type, with each type having its advantages and disadvantages. The advantage of the OF cable is its high allowable temperature and its disadvantage is its limited span length due to the limitations imposed by the oil feeding equipment. The advantage of the MI cable is that it is suitable for long-distance transmission as it uses no oil feeding equipment. Yet its disadvantage is that it has a low allowable temperature. Furthermore, both OF and MI cables have possibilities of causing oil leaks when a cable accident occurs. In contrast, extruded cable that do not require oil feeding equipment, have a high allowable temperature, and do not cause oil leak problems is being used on an extensive scale in AC transmission field. In Japan, one research attempting to use extruded insulated cables for DC transmission was undertaken in the 1970s but did not lead to any practical application because of the problem of a decline in the breakdown strength of the insulation due to the accumulation of space charges. We then continued this research to develop an extruded insulated cable for DC transmission in and from 1984 and were able to establish that this type of cable suitable for DC transmission up to the UHV range. In recent years, earth return circuit transmission has been recognized to cause environmental problems. This has led to the development of a DC extruded cable with a coaxial integrated return conductor. This research process can be divided into the following four main stages.

In the first stage, we developed the insulating material for the DC cable (DC material). The results confirmed that filling the cable of certain type filler for the cross-linked polyethylene could enhance the DC insulation performance.

In the second stage, the two types of insulating material developed in the first stage were used to produce DC+/-250kV extruded cables and factory joint (FJ). The 260-days long-term test on this cable demonstrated that it has an adequate application potential.

In the third stage, we made further improvements to the insulating material used in the second stage and added two new types of insulating material; one that was cross-linked polyethylene and the other that was not cross-linked polyethylene. Using these four types of insulating material we then produced