



## DEVELOPMENT OF DC +/- 250 KV COAXIALLY-INTEGRATED RETURN CONDUCTOR EXTRUDED CABLE



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### ABSTRACT

*This paper describes the development of +/-250 kV HVDC insulation-extruded cable with coaxially-integrated return conductor (coaxial extruded cable). The features of the HVDC coaxial extruded cable allow both environmental and economic advantages. These advantages lead to the development of the +/- 250kV class HVDC coaxial extruded cables, accompanied with the increasing demand of the HVDC cables with large power transmission capacity. We report the results of designing and manufacturing the +/- 250kV class HVDC coaxial extruded cables and accessories for the two transmission capacities of +/- 250kV/180MW and +/- 250kV/300MW and their electric tests.*

### KEYWORDS

HVDC extruded cable, HVDC coaxially-integrated return conductor cable, HVDC transmission

### INTRODUCTION

Recently, the demand of applying the HVDC cables to the long HVDC power transmission lines has been increased. Oil-filled (OF) cables and mass-impregnated (MI) cables are major insulation types of the HVDC cables over insulation-extruded cables such as XLPE cables which are widely applied to the AC power transmission lines. However, OF cables have the limit of transmission length because of the capacity of oil feeding equipment. MI cables have the lower design temperature than OF cables, leading to the increase of the conductor size, although MI cables are suitable for the long HVDC transmission lines. In addition, there is the risk of oil leakage for both OF and MI cables in the event of an accident. On the other hand, extruded cables have the major advantages over OF and MI cables in the above limitations and problems, namely, no limit of transmission length, higher design temperature and no risk of oil leakage, although there is a problem of space charge accumulation in the extruded insulation, resulting in the decrease of the insulation strength under the HVDC application, especially under the operation of HVDC polarity reversal. For that reason, the HVDC extruded cables have been applied to the HVDC transmission lines mainly up to 150kV with no operation of HVDC polarity reversal. Therefore, the HVDC extruded cables for the higher HVDC application with the ability allowable for the operation of HVDC polarity reversal by the suppression of space charge accumulation have been desired to be developed.

In the above background, we have developed the HVDC

extruded cables up to 500kV, which was reported previously [1][2]. The problem of space charge accumulation in the cable insulation is solved by using XLPE with an inorganic filler as the cable insulation which suppresses the space charge formation. This solution contributes to the establishment of HVDC extruded cables with excellent electrical and mechanical properties as well as with the ability allowable for the operation of HVDC polarity reversal.

In the following works, we have conducted the development of HVDC insulation-extruded cable with coaxially-integrated return conductor, what is called a coaxial extruded cable, for monopolar transmission, based on the above technology of the HVDC extruded cable [2][3][4]. The HVDC coaxial extruded cable has the structure of a single HVDC cable consisting of a return cable, i.e., return conductor and insulation, arranged coaxially around the main cable core. The features of the cable allow both the reduction of the environmental impact on the surroundings and the economic effect as described below. First, there is no risk of oil leakage because of using the extruded insulations for both the main and return insulation. Moreover, the designed temperature is higher than MI and OF cables, which enables to reduce the size of the conductor and hence the size of the cable, resulting in lowering the cost of both the manufacture and construction. These are the major advantages over MI type HVDC coaxial cable with the IRC (Integrated Return Conductor) which was reported to be applied to the commercial operation on the Northern Ireland-Scotland (Moyle) HVDC interconnection [5]. Second, there is no outer magnetic field theoretically because of canceling the magnetic fields generated by both the main and return currents. This feature mitigates the magnetic deviation (compass error). In addition, the HVDC transmission with return conductor, using the HVDC coaxial extruded cable, avoids the electrolytic corrosion against underground objects and the impact on the creatures by conducting the return current through the return conductor, not through sea and/or earth. Third, the construction cost is less than that of the two separate cables, the main and return cables, especially in the class of small- and medium-power transmission capacity [2][3][4]. In other words, the HVDC coaxial extruded cable is considered to be the ultimate HVDC cable with environmental-friendly features and economic benefits.

We have first developed the +/- 120kV/54MW HVDC coaxial extruded cable and factory joint (FJ) for the power transmission to isolated islands, reported in [2]. We have confirmed the adequate performance of the cable and FJ electrically and mechanically, and have established the fundamental technologies of the HVDC coaxial extruded cable.