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The development of DC extruded cables and factory joints in Japan

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This paper introduces the DC +/-250 kV, +/-500 kV extruded cable and the DC +/-120 kV 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, 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 insulating strength 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 power 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. The results confirmed that the DC insulating performance could be enhanced by filling the cable of a certain type filler for the cross-linked polyethylene.

In the second stage, the two types of insulating material developed in the first stage were used to produce DC +/-250 kV extruded cables. The 260-days long-term test on this cable demonstrated that it had 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 one that was not cross-linked polyethylene. Using these four types of insulating material we then produced DC +/-500 kV extruded cables. The long-term test run for 101 days confirmed that this cable had an adequate application potential.

In the fourth stage, we developed DC extruded cables with the main and return conductors integrated coaxially to reduce construction costs and minimize earth magnetism deviation (compass error). The objective was to achieve a long-distance small-capacity power transmission line. We then produced DC +/-120 kV coaxial integrated return conductor extruded cables. These cables were subjected to electrical and mechanical performance tests whose results proved that it had an adequate application potential.