Development of Transition Joint Between OF and XLPE cable for 400kV class

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ABSTRACT

Recently, the number of oil-filled (OF) paper insulated cable transmission lines exceeding 40 years, which is known for the cable lifetime, is increasing. Because the lifetime of cable gives a great impact on the power system stability, maintenance and replacement are required before the end of lifetime. Transition Joint (TJ) is commonly used to make this replacement, but little researches have been done on its development, particularly in the AC 400kV class. Therefore, this paper presents the design of AC 400kV TJ by using electrical and thermo-mechanical analysis and test result in accordance with CIGRE TB 415.

KEYWORDS

OF cable, XLPE cable, transition joint, electric field analysis, thermo-mechanical analysis, CIGRE TB 415, type test.

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INTRODUCTION

The oil-filled (OF) cable is a type of cable that created by impregnated insulation paper with insulating oil. OF cables have widely used for large-capacity transmission lines ranging from AC 66kV to 400kV due to their high reliability and economic benefits [1]. However, the use of insulating oil in cables can raise significant environmental risks in the event of fire or electrical failure. Therefore, it is important to carefully consider the environmental impact when using OF cables.

The development of cross-linked polyethylene (XLPE) cable in the 1950s revolutionized high-capacity power transmission by providing a reliable and eco-friendly alternative to OF cable [2]. Compared to OF cable, XLPE cable has advantage of being "dry type", it does not require an oil equipment, the maintenance of XLPE cable is relatively simple since there is no need to monitor or change the oil periodically. This also reduces the risk of environmental issue from oil leakage. Therefore, XLPE cable is reliable and eco-friendly for high-capacity power transmission.

As the OF cable transmission lines which have exceeded their 40-years lifespan are increasing, the need of replacement with XLPE cable is steadily required [3]. However, due to practical issues related to power system management, it is difficult to replace the entire OF cable transmission line. Therefore, the partial replacement of the line is necessary and OF-XLPE Transition Joint (TJ) should be developed to connect the existing OF cable with new XLPE cable.

There are many cases of the development of TJs up to the AC 230kV. But there is a lack of research and development on TJ for AC 400kV cables. Thus, it is necessary to develop TJ for AC 400kV or higher. To do this, A comprehensive design skills and tests should be needed, including electric field analysis, structural design, jointing techniques, electrical and thermo-mechanical testing, and qualification tests. To verify the design and performance of the TJ, electrical and mechanical tests were conducted in accordance with CIGRE TB 415 [4]. The test was completed successfully. A test report was issued by a third-party certification authority.

TRANSITION JOINT DESIGN

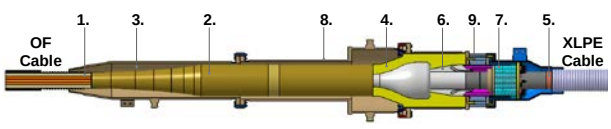
To design the TJ, electrical field analysis and thermo-mechanical analysis was performed. Based on these analyses, the optimal design of TJ and proper jointing were introduced.

The design of the AC 400kV OF-XLPE TJ is depicted in Fig. 1. OF cable joint is positioned on the left side, whereas XLPE cable joint is located on the right side. Each cable is connected to an epoxy unit.

OF cable joint consists of OF cable (1), oil impregnated paper (2), insulating oil (3) and epoxy unit (4). The cable conductor is connected and winded with oil impregnated paper. A slope design of OF cable joint is important to control the electric field and the insulation performance is maintained by filling insulating oil. The oil-tightness should be needed so that the insulating oil does not leak onto XLPE cable joint.

XLPE cable joint consists of XLPE cable (5), stress relief cone (SRC) (6), spring-loaded assembly (7), and epoxy unit (4). SRC is placed on the cable and epoxy unit by pushing it with spring load. The deflector in SRC and a conductor embedded in epoxy unit should be effectively designed to control properly the electric field.

The joint is mechanically protected by enclosing it in a metal casing (8). Additionally, the joint is electrically separated on both sides using an insulation plate (9).



1: OF cable, 2: oil impregnated paper, 3: insulating oil, 4: epoxy unit, 5: XLPE cable, 6: stress relief cone 7: spring-loaded assembly, 8: casing, 9: insulation plate

Fig. 1: AC 400kV OF-XLPE Transition Joint