138 kV Transition Joint between High-Pressure Fluid Filled and XLPE Cables

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ABSTRACT

This article discussing the proposed test protocol of a transition joint between pipe-type and solid dielectric cables, including required electrical and hydraulic tests. The proposed test protocol is simulating harsh field condition based on actual operational experience and includes destruction voltage rise to evaluate joint design limits and safety margins.

The article can be interesting for cable and accessories manufacturers, and utility professionals looking to replace pipe-type feeders with solid dielectric cables gradually, which requires transition joints installation.

KEYWORDS

138 kV XLPE Cable, 138 kV High-Pressure Pipe-Type Cable, Transition Joint, Partial Discharge, Partial Discharge Monitoring, IEEE 404 Type Test, Operating Pressure, Service Life, Solid Dielectric Cables, Shirt-Circuit Test, Grounding, Thermo-Mechanical Tests, Hydraulic Tests, Withstand-to-Failure Tests.

INTRODUCTION

Many urban utilities in the United States have a substantial number of underground High-Pressure Pipe-Type feeders (HPPT). An estimated length of existing pipe-type cables in North America is 5,000 circuit-miles. Most of these feeders have been in service for more than 50 years.

While performing cable restoration after occasional failures or external damage, replacement of the entire pipe-type feeder is not always a feasible option. The shortage of pipe-type cable supply and the growing use of Solid Dielectric (SD) cables create a need to connect SD and HPPT cables.

A transition joint connecting cables with different insulating technologies can be instrumental for integrating solid dielectric cables into systems with mixed cable technologies. Additionally, the development of a transition joint connecting pipe-type and solid dielectric cables would result in fewer cost expenditures for maintenance and/or installation of an increasingly limited supply of pipe-type cables.

There is an anticipated need for transition joints connecting HPPT and SD cables in North America.

DESIGN APPROACH AND CHALLENGES

The perfect transition joint should bring mechanical, thermal and electrical continuity between two types of connected cables. Theoretically, such a joint would have the same dimensions, thermal properties, and electrical properties as the cable. However, this is very hard to achieve even for the same type of cable connections. Joints will always have a thicker insulation wall compared to cables in order to match the electrical and mechanical parameters of the cable. The task of matching cable parameters becomes much harder for a transition joint between HPPT and SD cables.

The joint shall connect paper-insulated cable under a relatively high pressure of dielectric fluid to XLPE insulated cable exposed to the environment. The normal operating pressure of HPPT feeders is relatively high and varies between 1400-1724 kPa (200-250 lb/in^2).

First, the mechanical barrier shall be designed to separate pressurized from not pressurized cables.

Second, the live high-voltage conductor shall penetrate this barrier while maintaining operating voltage clearances and effectively sealing the pressurized cable end.

Third, substantial thermo-mechanical forces experienced at the transition point during normal and emergency operations shall be addressed to assure that the joint will successfully operates for its service life.

Another major criterion of transition joint design for urban environments is its size and the space required for its assembly. That is why previously known GIS-type design for different cable type connections was not acceptable for underground installations in heavily populated urban areas.

JOINT DEVELOPMENT HISTORY

Increased use of XLPE SD cables at transmission class voltages in the late 1980's created the need to connect them with existing HPPT feeders.

In 1990 a program to develop 69 kV and 138 kV Transition Joints was conducted and consequently produced and tested transition joints between HPPT feeders and XLPE SD cables.

The test protocol included high voltage AC and DC tests, impulse and cyclic loading tests, vacuum and hydraulic pressure tests, and thermo-mechanical bending tests.

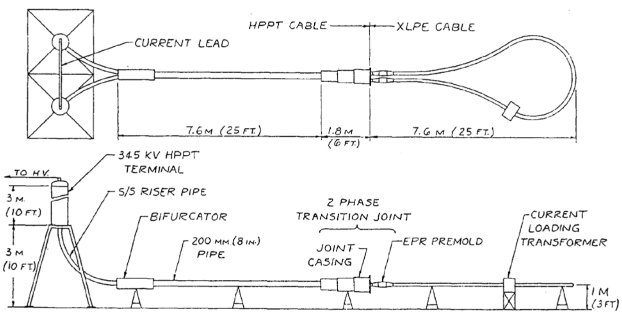

Figure 1
HPPT to SD Transition Joint Electrical Test Setup