Thermo-mechanical behaviour of cables installed in vertical shaft

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ABSTRACT

The paper describes the behavior of cables installed in vertical shaft under thermal load cycles.

The shaft installation of cables with large conductor cross section presents some characteristics which are beyond the available experience. For this reason experimental tests have been performed on sample of cables installed vertically with different installation arrangements.

A theory has been then developed both for cables installed in a straight rigid vertical configuration and for cables installed in a flexible/snaked vertical configuration.

The paper provides a presentation of the theory, experimental tests and indications for cable designer.

KEYWORDS

Vertical installation – Cable Snaking – Flexible installation – Rigid installation – Cleats – Cable thrust – HV cables.

INTRODUCTION

Many installations of cables in shaft have been realized with satisfactory service experience. Different type of cables have been used such as OF cables with lead or aluminum sheath, EPR insulated cables without metallic sheath, XLPE cables with a variety of metallic sheath.

The typical application of vertical installation is the connection between Hydro Power Generation plants in a cavern and overhead lines. The cables for this application have normally a limited power capacity that means small conductor section and low operational temperature.

The installation in vertical shaft require special attention (for instance spring loaded cleats), but no great problems are encountered thanks to the small conductor diameter and the favorable service conditions.

The rigid installation is generally preferred due to a simpler laying procedure.

In view of future applications with systems of large power capacity the current design criteria must be revised and adapted to more demanding conditions.

A research program including theory and experimental tests has been developed with particular attention to the possible downward movement of the cable with respect to the cleats or of the cable core with respect to the sheath as a consequence of thermal cycling.

The present study has been extended to the snaking installation that according to preliminary considerations presented significant advantages.

EXPERIMENTAL SET-UP AND TESTS

So far there are few experimental data for cable installation in vertical shaft. For this reason full scale tests have been executed. The scope of the tests was:

- Verification of the design of the cable cleats.
- Checking different cleating arrangements.
- Measurements of the parameters necessary to validate the theory.
- Comparison between flexible and rigid arrangement in vertical cable installation.

Cable data

The tests have been executed on a XLPE insulated 400kV, 2500mm2 aluminum conductor cable.

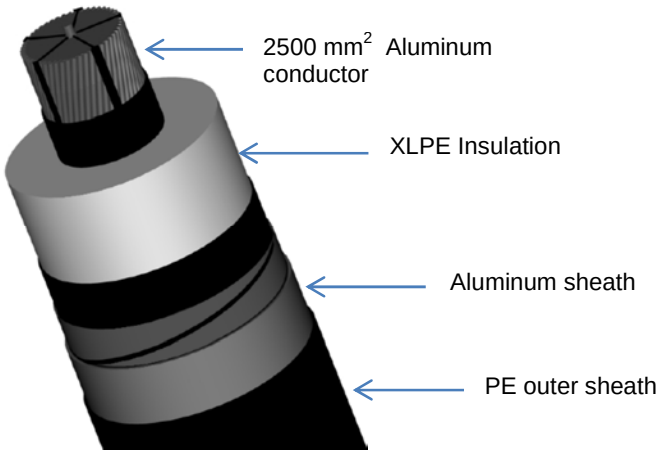

Fig. 1: 400 kV XLPE cable design

Test and verification of cleat design

A test was performed to verify the design of the cleats that is a fundamental aspect of a vertical cable installation.

Cable cleats with spring loading arrangement have been used for the tests. Such cleats are necessary to avoid any lack of lateral pressure on the cable during load cycling which may result in an unacceptable vertical slippage of the cable.

The spring package has been designed in order to compensate for the cable expansion and contraction during load cycling and to provide the necessary clamping force.

The cable deformation at clamp position was measured and the clamping force was assessed. The cleat design has been confirmed.