THE THERMO MECHANICAL BEHAVIOR OF JOINTS IN MV CABLE SYSTEMS EXPOSED TO HIGH CURRENT LOADS

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ABSTRACT

Breakdowns in joints in medium voltage cable networks were reason for the Dutch network owners to investigate their background. It was found that a large part of the breakdowns was in one or another way related to high current loads and especially high cycling current loads. In many different ways such high loads cause joints to degrade and the dominant degradation mechanism is the fact that under a high load the mechanical forces from the cable conductor in the joint body become considerable, with sometimes unexpected consequences. In this paper the theoretical background of thermo-mechanical forces in cables and joints will be summarized and also the first results of laboratory experiments will be given, showing that the degradation as observed in service conditions can be reproduced in the laboratory.

KEYWORDS

mv cable, medium voltage cable, joint, mechanical behaviour, XLPE, PILC, paper insulated, current load, cycling current load, conductor extension, force

INTRODUCTION

High (cycling) current loads in medium voltage cable networks will become more and more common for economic reasons and because of wind mill parks and other sources of power generation or demand.

Dutch network owners are experiencing a higher rate of outages in the medium voltage networks which are directly related to these higher (cycling) current loads in their grids. These outages mainly come from failing joints. This prompted the Dutch network owners (Enexis, Alliander, Stedin, DELTA Netwerkbedrijf and Westland Infra) to search for the causes of breakdown and their remedies, in cooperation with KEMA (for knowledge and project management) and the Dutch manufacturer of cable joints, Lovink.

- How sensitive are the various types of joints existing already for a long time in the networks?
- How sensitive are the new types of joints that are being applied in recent years and which will be used in future years as well?
- In case also new types of joints suffer from these high (cycling) loads, why did type tests carried out in the past not find their susceptibility for high current (cycling) loads?
- And in case even present type tests do not sufficiently represent high current (cycling) loads, what could be a possible recommendation for an update of these tests?

So far, a study is made of the first two items.

In the paper, in the first place a summary will be given of the possible degradation mechanisms that can be foreseen under high load (cycling) conditions, with a focus on the mechanical performance of joints.

The paper will also show the theoretical mechanical forces that might be the result of high loads. Especially the forces that come with the expansion of a conductor will be shown to be considerable.

After these desk study related matters, the focus will go to some laboratory tests that show that indeed certain types of joints are quite susceptible for the above mentioned forces and moreover that these forces are close to those foreseen from a theoretical point of view.

The laboratory tests so far have been carried out on joints for PILC cables as mastic filled joints and oil-filled joints. Apart from that, attention is given to conductor connectors that have been and are being applied in all types of joints for all types of cables. The paper will show in what way such joints (or joint parts) are indeed susceptible for the expanding and contracting forces that come with load and load cycling.

This subject as treated here had its first publication recently [2]. This paper at hand has a similar content as in [2], however at certain points some more extensive explanations are given.

JOINT PROBLEMS AS EXPERIENCED

The fact that high current loads cause more joint failures is shown in Fig. 1. This is a result from one of the network owners in the Netherlands, created from a database with almost 42.000 joints. Similar experiences were found for other network owners in the Netherlands. Moreover, the network owners in the Netherlands know that a cycling load is more detrimental than a constant load. It was concluded that this fact happened as well for older types of joints (bitumen, oil, silicone or resin insulated), as for