Effectiveness and comparability of condition tests on MV cables

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ABSTRACT

To determine the condition of aged cable populations testing on (a statistical significant sample of) aged populations is necessary. The tests indicate changes in cable materials and other early warning signals of cable failures.

Testing implies the possibility of an induced failure resulting from stress on the system. We present the results of a survey, which indicated that the advantages for voltage tests outweigh the induced failures.

Sometimes results of measurements on old cables are indecisive. Then a second measurement with another technique can be done. We present some examples of that, both with supportive and contradictory results.

KEYWORDS

Condition assessment; Asset management; Test methods.

INTRODUCTION

As most European utilities, Stedin operates a large population of ageing MV cables as part of its network. Many cables have reached an age of 40 years or more, and are nearing the end of their expected technical life span. As old cables tend to be less reliable, the issue of remaining life expectancy and condition of cables is an important factor in asset management.

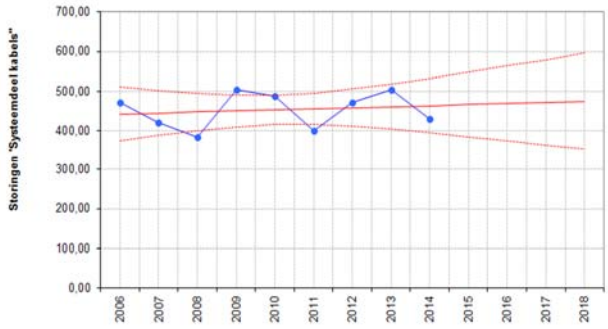

Figure 1: evaluation of MV cable faults at Stedin

Statistics show a slight increase in cable faults at Stedin. To determine the condition of aged cables testing on (a statistical significant sample of) aged populations is necessary. The tests indicate changes in cable materials and other early warning signals of cable failures.

Even if we limit ourselves in this paper to the use of electrical tests, a large number of techniques are available for pro-active testing of cables. These include:

- PD measurements, both on-line and off-line
- Tan delta measurements
- Voltage tests: VLF, 50 Hz, 20-300 Hz oscillating voltage, Damped AC
- Impedance tests
- Etc.

CHOISE OF METHODS

Each measuring technique is tailored to a specific effect and can be linked to certain failure modes of the cable system. Based on failure statistics, the relative frequency of different failures modes can be determined. From this, the optimal mix of measurements, which effectively addresses the most common faults in our grid, can be chosen.

Of course, this has to be re-evaluated periodically, as bad populations are replaced and remaining populations get older. Recent work done at Stedin, indicates no major changes in failure modes in cable circuits [1]. Major sources of cable failures are old types of joints and ageing of paper insulation. No major changes are expected.

In the Netherlands, traditionally paper insulated lead cable (PILC) was used in MV networks. Most of the old circuits at Stedin are made of paper insulated cables. Starting in the 1980's extruded cables were introduced, with XLPE insulated cables in the MV grid. Not only new circuits consist of XLPE cables, but new connections on old cables and rerouting of old circuits also introduced XLPE in the grid. Nowadays, a large proportion of MV-circuits are mixed PILC and XLPE. Testing methods used must cope with this situation, excluding DC test methods.

Partial discharge measurements are very well suited to extruded cables. Any detected PD-activity in XLPE cables must be considered as a deviation from the desired status. Localized PD in paper insulated cables may indicate weak points, notably at joints. But in PILC cables, quite a high level of general PD activity can be present without detrimental effects to the cable. Due to contraction or expansion during the daily or annual load cycle, small temporary cavities in the lapped paper may form, with some PD as a result. Only when those cavities grow over time a problematic situation will develop. To detect these cases repeated tests or on-line tests are necessary. So, PD alone is not a sufficient test.

Tangens delta measurements, especially repeated tests to detect a trend, are an excellent test for degradation of cables. But they offer only general information, no specific information which cable parts or joints are weak parts can be derived from tangens delta measurements. For asset management decisions PD measurements are preferred.

To ascertain the ability of a MV cable to withstand transient voltages, a measurement above U_0 is necessary as part of the condition test.

To conclude, an optimal condition test for MV cables, consists of a combination, with a AC voltage test and PD measurement.

TEST METHODS USED AT STEDIN

At Stedin the VLF voltage test (more specific: the 0.1 Hz test) has been used extensively in the last 30 years. It is the primary test method at Stedin for MV circuits.