MEDIUM VOLTAGE CABLES

TECHNICAL BRIEF - WATER TREES

What are Water Trees

Water trees are a chemical degradation of polymeric insulation such as XLPE or EPR that only occurs in the presence of water and an electrical stress.

Water Trees Failures

In the 1970's and 1980's many cables failed after 3-10 years in service because of water tree degradation of the insulation. The failures were most prominent in North America and in Northern Europe where they had moved rapidly to the new technology of polymeric medium voltage cables. These early cables were almost entirely manufactured by a twin extrusion of inner screen and insulation with a graphite paint and taped outer screen. Most CV lines in those days used steam-curing technology.

Great efforts were spent in researching the cause of these failures and developing preventative measures. Thousands of technical papers have been written on the subject.

Tests To Evaluate Cable Performance

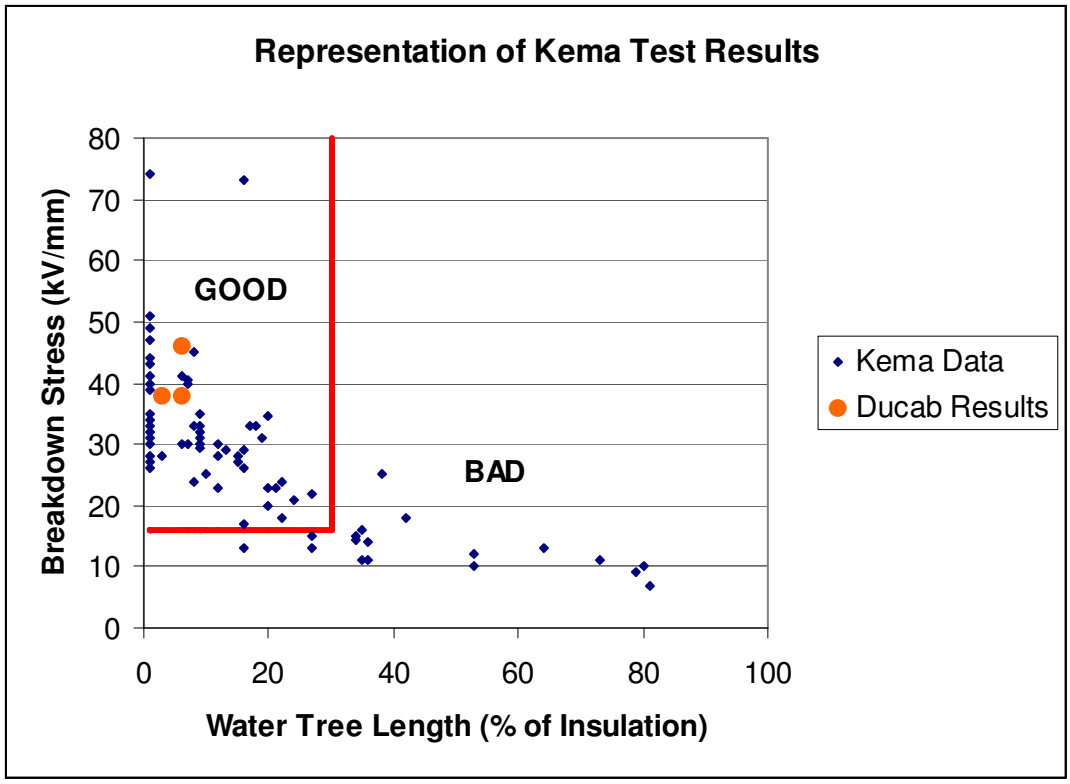
Many tests have been proposed to evaluate cable performance with regard to water trees. The main problem is that to test for a long-term effect requires a long test period. To minimize the test time an accelerated test was developed by Kema, in The Netherlands, who are acknowledged as World experts on water ageing of polymeric cables and have carried out many years of extensive research into this subject.

In this test cables are preconditioned by saturating with water and then subjected to 3000hours ageing in water at 2.5Uo using a high frequency of 500Hz to further accelerate the ageing process. The aged cores are then subjected to voltage breakdown testing and must achieve threshold limits of up to ten times the cable's normal operating to pass the test. This test has been proven to distinguish between cables that are good and bad at resisting water tree ageing.

This is one of two alternative tests accepted in European standards and the majority of European utilities would require that an approved manufacturer has carried out such a test on their MV cable. The alternative test requires two years ageing at normal frequency of 50Hz. Published papers by Kema, CIGRE, BICC and others demonstrate the equivalence of the tests

Results of Ducab Cables

The graph represents the results of tests on Ducab manufactured cable showing the test performance in comparison with the test results carried out by Kema over many years. The top left hand corner of the graph, indicated by the lines, is classified as good cable. This demonstrates that the Ducab results are some of the best results they have recorded. What is also significant is that many cables manufactured by others and tested by Kema have failed the test and are not classified as good. Although Kema will not reveal the identity of these manufacturers they will confirm that these failures include cables manufactured and tested in the last few years. As there are a number of high quality material sources available this suggests that either these manufacturers are either choosing inappropriate materials and/or do not have a high standard of manufacturing process.



GCC Specifications for Tree Retardancy

Many utility specifications do not cover the subject of water treeing. Some utilities specify the use of tree retardant materials without any qualification or test criteria. This does not guarantee good performance, as materials designated as tree retardant by the suppliers are not, in themselves, sufficient to prevent water tree related failure. To get good cable performance requires good material and high quality processing.

The Ducab View

Our view is that users should require companies to carry out long term testing to one of the recognised test standards to ensure that the cables produced are on the high quality necessary to give long and trouble free service performance. We prefer the 500Hz test as it can be completed in a practical time scale.

Although the choice of a high quality material is essential in achieving good electrical performance and long life it is not in itself sufficient. The manufacturing process must also be of the highest standard. Any contamination of the insulation or feature on the insulation-screen interface can provide a site for potential water tree growth and lead to premature failure. Therefore great care must be taken to ensure that the cleanliness of the material is maintained, that the extrusion equipment uses a modern triple head with a dry curing technique and that the process conditions are carefully controlled.

High sensitivity partial discharge testing as a routine test on every length of cable gives great confidence that the insulation is defect free. The IEC standard limit of less than 10pC discharge is inadequate in providing this reassurance and Ducab believe that this should be made more stringent and reduced to a limit of at least 5pC. Ducab regularly achieve sensitivity of less than 2pC in their state of the art test facility.

These measures combined with a stringent quality assurance and control regime will prevent contamination or degradation during the extrusion process. It is the combination of high quality process with appropriate material that gives the cable the necessary properties to ensure a long life

10 Key Points About Water Trees

1. Water trees can grow throughout the entire insulation thickness without causing instantaneous failure but they weaken the cable electrically and lead to premature failure.

2. Water trees need 70-80% relative humidity within the insulation to grow, they do not need free water.

3. Water trees only grow if the electrical stress is above a threshold limit, so do not affect LV cables

4. Water trees initiate from impurities or defects within the insulation or at the insulation/screen interface

5. Trees connected to either screen are called vented trees and those within the insulation are called bow tie trees

6. Generally vented trees continue to grow while bow tie trees reach an equilibrium size.

7. Steam curing introduces thousands of microvoids within the insulation that enable it to hold a greater level of moisture and also provide water tree initiation sites.

8. Some additives can retard the growth of water trees, these additives tend to be highly polar and also affect the dielectric properties of the insulation.

9. Nobody has yet succeeded in making a water tree proof cable.

10. Accelerated ageing tests have been developed that correlate well with service experience and distinguish between good and bad cables