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Additives for the suppression of electrical treeing in polyethylene

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The principal aim of the work was to identify additives that improve the electrical tree resistance of polyethylene, with the purpose of improving the life expectancy of power cable insulation based on this polymer. The additives studied were selected from those that are commercially available and that are currently used as antioxidants and UV stabilisers.

Although there is some debate amongst workers about how best to test polyethylene for electrical tree resistance, it was decided to opt for a needle test, leading to the determination of a tree inception voltage (TIV). Whilst it does not precisely mimic the situation within cable insulation, it does have the merit of providing a well-defined electrical stress raiser – if the needle can be reliably inserted into the polyethylene sample and repeatable inception voltages can be obtained.

The paper describes the following:

- the needle insertion method, which is shown to give reliable and repeatable results;
- the electrical tree inception method used to rank additives in order of effectiveness;
- thermally stimulated current measurements carried out to clarify the mechanism of additive action.

Results are presented for tree inception voltage (TIV) of conditioned and unconditioned polyethylene, with and without additives. Results were analysed using Weibull statistics. This work showed that:

- thermal conditioning reduces scatter;
- there was a statistically significant improvement in tree inception voltage with one particular additive (an excited state quencher);
- tree inception voltage increases with concentration of additive;
- TIV is reduced with increase of temperature, with and without additive, but the superiority of the best additive is maintained over the blank polyethylene at higher temperatures;
- tree type formed at the inception voltage changed from branch to bush type as temperature was raised.

Thermally stimulated current determination was used to calculate the activation energies of electron traps and the number of traps contained in the samples. The most successful additive investigated was shown to work by increasing the number of traps, rather than by providing a greater trap depth. The number of traps was found to correlate well both with increasing concentration of tree suppressant additive and with the TIV results.