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Breakdown characteristics of natural and synthetic ester liquids when containing varying levels of moisture

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Natural and synthetic ester liquids offer numerous benefits when compared with conventional naphthenic oils, such as improved biodegradability, low toxicity, high flash and fire points and increased ability to accommodate moisture. It is for these reasons that the power and pulsed power industries are adopting ester liquids as a long term replacement for naphthenic oils. One barrier to the acceptance of esters as a suitable alternative to naphthenic oils is the lack of data on their performance in highly divergent electric fields, and on how they react under these field conditions when high levels of moisture are present within the liquids.
This study is focused on how moisture content can affect the impulsive breakdown characteristics of ester liquids, and on how variations in their breakdown performance compare with changes in the breakdown characteristics observed in naphthenic oils with elevated moisture contents. The chosen liquids (MIDEL 7131, Cargill FR3 and Shell Diala S4 ZX) were exposed to standard lightning impulses of both positive and negative polarity, following the methodology outlined in IEC 60897. Three liquid states were evaluated, specifically: "as received", which refers to liquid taken from a newly opened container provided by a manufacturer; "naturally aged", where the liquid was left in an open container in ambient laboratory conditions, to allow the moisture content to increase slowly; and "accelerated aged", where liquid samples were exposed to humidification to increase their moisture content significantly, over a short time period.
This paper will present and discuss experimental results on the relative breakdown characteristics (breakdown voltage and time to breakdown) of the liquid samples, with the aim of identifying operational dissimilarities between ester fluids and naphthenic liquids. The obtained results will help to understand how both the means of ageing and the ageing time can affect the dielectrics properties of the tested liquids.

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