Study Committee D1

Materials and Emerging Test Techniques

Paper D1-PS2-11113

Experimental investigations on electro-thermal ageing of EPDM for HVDC cable joints

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Introduction

- HVDC cable joints considered critical due to dielectric interfaces created manually during installation
- Compatibility between materials present at the interfaces needs to be guaranteed during lifetime of at least 30 years
- Prequalification test is time-consuming and expensive

➢ A simpler experimental setup using material samples is proposed

- Ageing of XLPE has been studied in detail

➢ Focus on electro-thermal ageing of EPDM and assembly grease

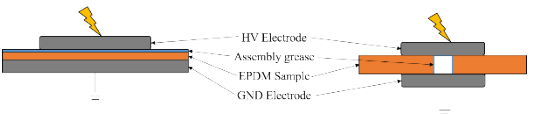
Experimental method

Plate shaped samples made of EPDM

- Electrical field: 0 kV/mm or 10 kV/mm
- Temperature: 20 °C or 120 °C
- Variation of electrode material and lubricant

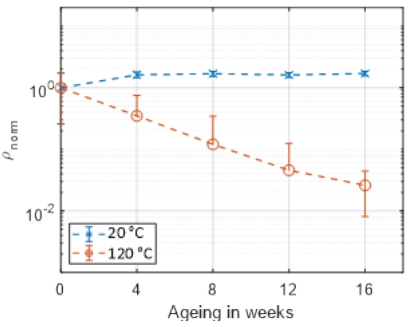
Cylindrical samples consisting of EPDM ring with XLPE piece in the center

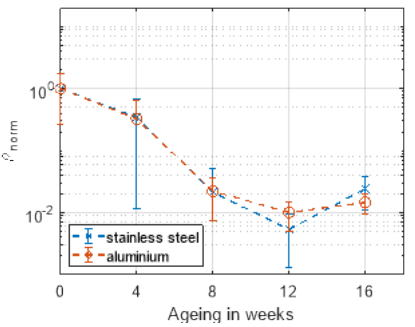
- Electrical field: 0 kV/mm, 3.7 kV/mm or 5.6 kV/mm
- Temperature: 20 °C or 80 °C



Ageing of plate shaped EPDM samples

- Periodic measurement of relative permittivity, dielectric loss factor and resistivity
- Additional TGA and DSC
- Significant impact of high temperature and presence of oxygen (silicone oil vs. other lubricants) on electrical properties of EPDM → thermo-oxidation
- No difference in electrical properties for variation of electrode material or type of lubricant
- Mass residue in TGA increases for samples aged in silicone oil → diffusion and swelling
- Increase in glass transition temperature, especially for samples aged at 120° C → crosslinking of EPDM





Conclusion

- Thermo-oxidation results in increase of relative permittivity, dielectric loss factor and resistivity over time
- Exclusion of air in cable joint prevents oxidation

➢ Ageing experiments should be performed with limited oxygen supply to reflect condition in joints

- Resistivity is sensitive to changes due to accelerated ageing

➢ Materials must be designed carefully to avoid dielectric mismatch

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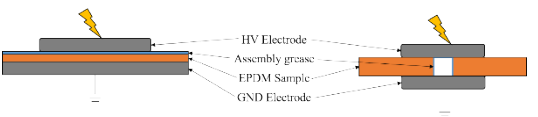

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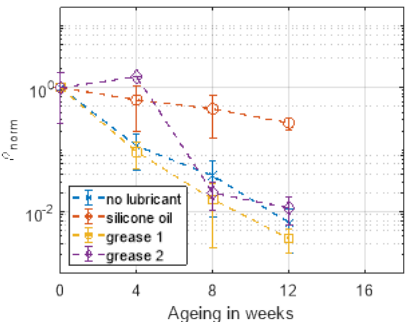

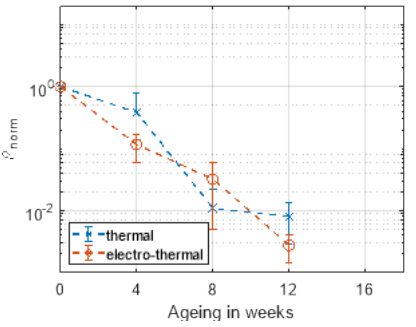

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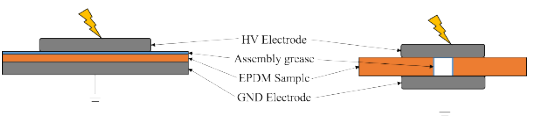
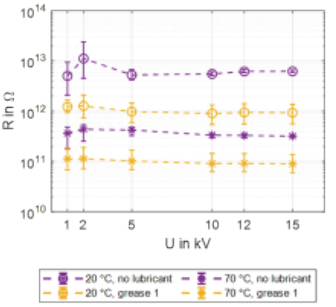


Ageing of cylindrical samples

- Measurement of interfacial resistance at various test voltages and temperature of 20 °C or 70 °C before ageing and after four weeks of ageing
- Higher resistance measured at higher temperature
- Higher resistance measured for dry interfaces compared to interfaces with lubricant at a given temperature
- No change in interfacial resistance at 70 °C after 4 weeks of ageing
- Slight increase in interfacial resistance at 20 °C after 4 weeks of ageing at 80 °C → diffusion of lubricant into EPDM body



Conclusion

- Lower interfacial resistance when assembly grease is used compared to dry interface
- Slight increase in interfacial resistance after 4 weeks of ageing at 80 °C

➢ Diffusion of low molecular weight components from silicone grease into EPDM

- Only minor changes observed during the experiment

➢ Prolonged ageing necessary