Jicable HVDC'16 Workshop
Topic 1 -Physical phenomena, materials

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Background: <u>Materials</u>, <u>nature of interfaces</u>, mechanical and thermo-electrical stress are particularly critical regarding space charge generation.

Materials

Extruded insulation are used for HVDC application up to 500kV:

- filled (e.g. with mineral or carbon)

- unfilled (e.g. crosslinked polyethylene) or

- thermoplastic (e.g. polyethylene, etc.)

- thermoset (e.g. crosslinked polyethylene, ethylene propylene rubber , etc)

LDPE[1]

XLPE
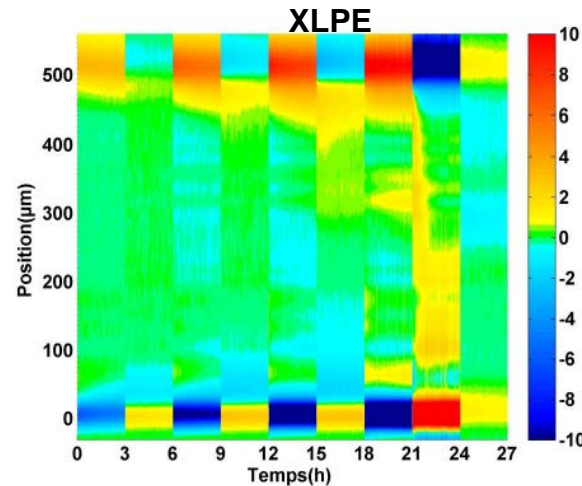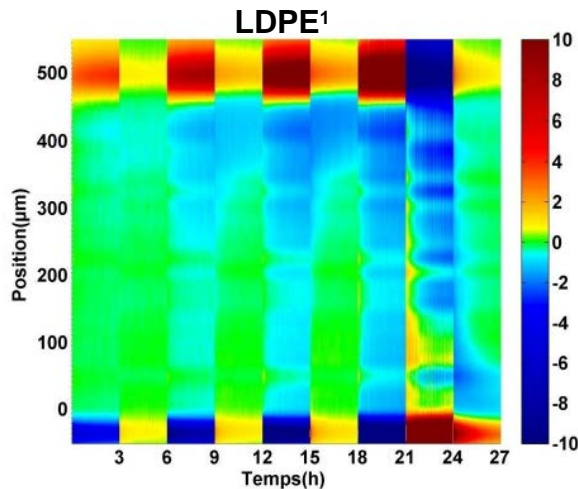
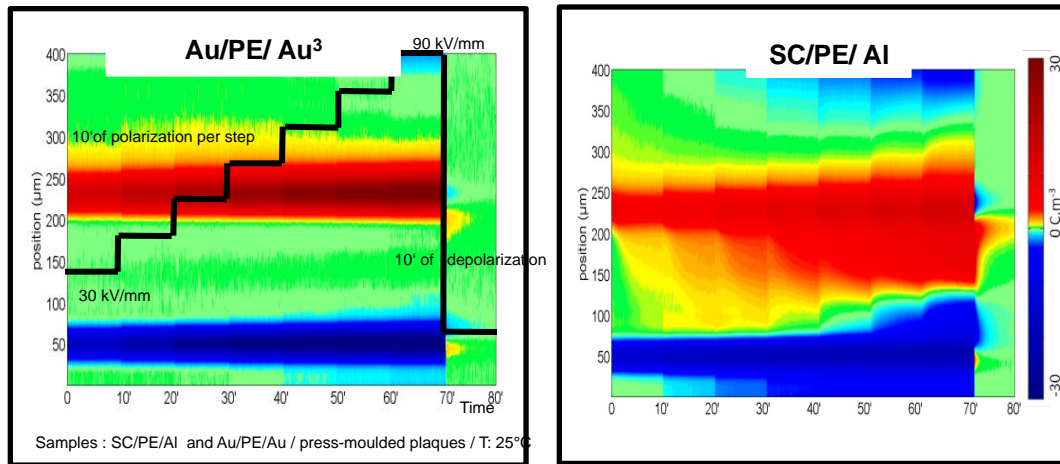New materials as Polypropylene Thermoplastic Elastomer have been developed recently for HVDC application[2].

What will be the new materials in the future?

1 Thèse de doctorat- 2tude des phénomènes de charge d'espace dans les matériaux de câble et câbles modelés destinés à des applications au transport d'énergie en Haute Tension Continue (HVDC)- Thi Thu Nga Vu – Juillet 2014 – Université de Toulouse
2 INTRODUCING HIGH-PERFORMANCE POLYPROPYLENE THERMOPLASTIC ELASTOMER (HPTE) INSULATION FOR MV CABLES IN THE NETHERLANDS – Cigré – 6-9 june 2011

Nature of interfaces

The interface between insulation and different materials are very frequent and are present in cable system.

1-Power cables

<u>SC/ Insulation interfaces</u>

Samples : SC/PE/Al and Au/PE/Au / press-moulded plaques / T: 25°C

➔ Significant impact on the nature of the electrodes on the charge generation

3 Mandana TALEB , Phénomènes aux interfaces des isolants : mesure et simulation, Ph.D Thesis, Paul Sabatier University,Toulouse, 2011.

2-Stress cone in accessories (joints – terminations)
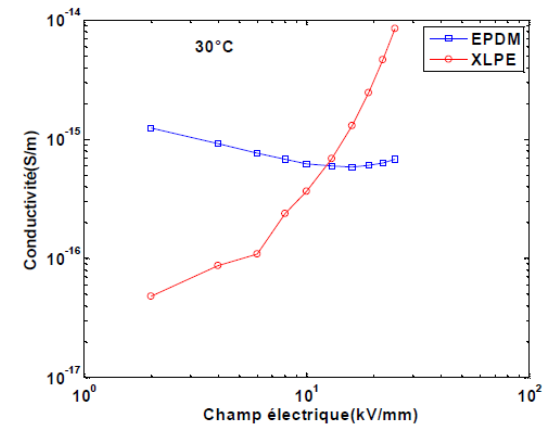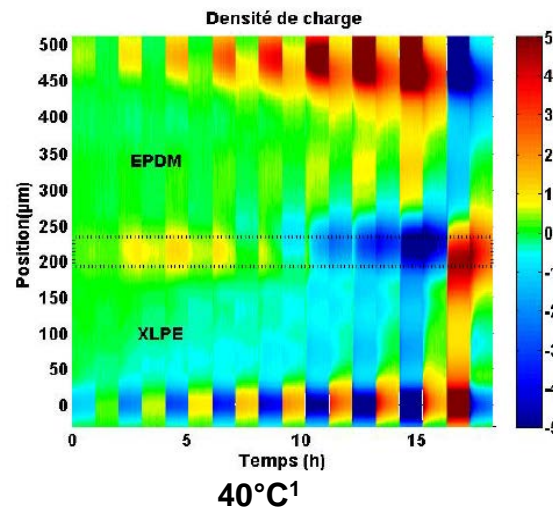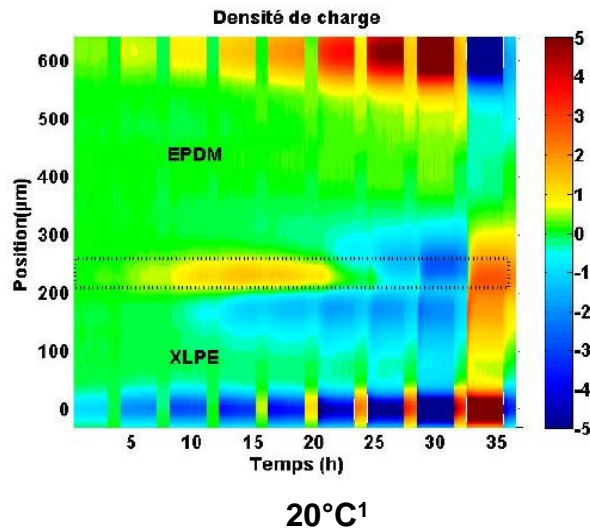
<u>- SC/Lubrifiant/Insulation interfaces</u>

➜ Change of interface behavior and charge generation mechanism in the insulation.

<u>- Insulation/ Insulation interfaces</u>
  EPDM /XLPE , EPR/XLPE …

➜ Interfacial charge can be formed in the interface.
➜ Amount and sign of charge depend on the materials permittivity

20°C[1]

40°C[1]

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TB 496

TB 496 considers that a time equivalent to 10τ must pass to approach the steady state distribution of the divergence. These considerations provide the foundations for the times of the Zero Load, High Load and 48 hour Load Cycle Tests in the recommendations.

Temperature (°C)	ε (F/m)	ρ (Ω.m)	Time for stability, $10\,\tau$ (hours)
20	$2\times10^{-11}<\varepsilon<3\times10^{-11}$	$10^{15}<\rho<5\times10^{16}$	$55<10\,\tau<4300$
60	$2\times10^{-11}<\varepsilon<3\times10^{-11}$	$2\times10^{13}<\rho<5\times10^{14}$	$1<10\,\tau<43$
90	$2\times10^{-11}<\varepsilon<3\times10^{-11}$	$10^{12}<\rho<5\times10^{13}$	$0.06<10\,\tau<4.3$

Testing time has been defined according above hypothesis for <u>insulation</u>.

Condition	Temperature	Testing time (Days)	Time for stability, $10\,\tau$ (Days)
Zero load (Prequalification)	Ambient temperature (20±15°C)	At least 120	$2.3<10\,\tau<180$
48 Hour Load Cycle: (Type Approval)	At least maximal conductor temperature (60°C to 90°C depending on manufacturer design)	1 (heating period)	$0.003<10\,\tau<1.8$

Thus, it is important to select test times that permit <u>all insulation systems</u> to reach a stable electrical stress distribution.

Issues

- Need to standardization of space charge measurements and define the acceptable amount of the charges.

- Add the space charge measurement in the future HVDC standards.

- Taking into account the stabilization time of interfacial charge (XLPE/ EPDM or EPR….) in addition to stability time of electrical field in insulation (XLPE).

- Add the conductivity and permittivity measurements of insulation before starting TT and PQ test, in order to prove that the Cigré 496 test protocol will be applicable.

- Adaptation of test protocols for new materials and also for the higher voltage levels 600, 800kV.