Study Committee B1

INSULATED CABLE SYSTEMS

11028_2022

Performance and characterization tests on HPTE insulation material

Grazia Berardi, Davide Pietribiasi, Giovanni Pozzati, Stefano Franchi Bononi

Prysmian Group, Italy

Motivation

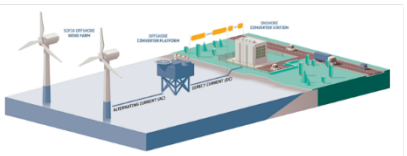
HPTE cable insulating material, provides HVDC systems with **higher power transmission capability** and reliability while **decreasing the environmental impact**. Thanks to its intrinsic characteristics, in recent years HPTE cable systems were **successfully type tested and pre-qualified at 90°C up to 600 kVdc and 525 kVdc**, respectively. A new set of tests is described to further characterize HPTE and its performances.

HPTE Technology and Project Experiences

In the early 2000s Polypropylene was considered not adequate to provide the requested properties of a high-performance electrical insulation for cables. Through the selection of a **special polymer blend** and the application of an **advanced production process**, it was possible to overcome the challenges and to finalize the development of the new insulation type – HPTE, turning polypropylene into a versatile and high-performance insulating material both **in terms of physic-chemical properties and electrical characteristics**.

Today several HVDC projects have been awarded using this insulating technology, the main are:

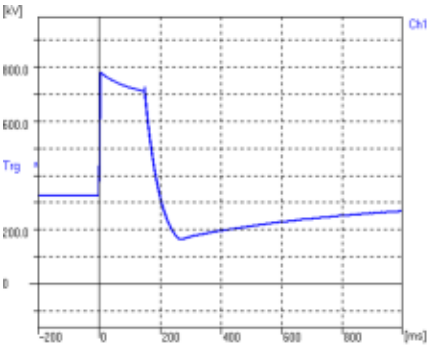
A-Nord, SuedOst Link, SOFIA

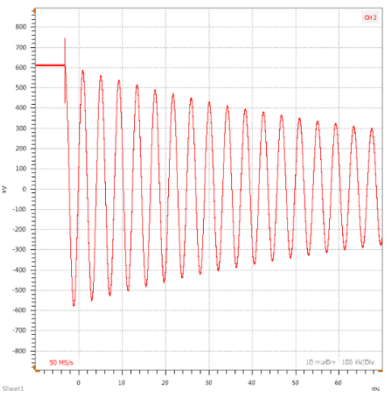


Electrical testing - TEMPORARY OVER VOLTAGES

CIGRE JWG B4/B1/C4.73 and TB 852 introduced two more overvoltages that can be experienced by HVDC and EHVDC cable systems on top of conventional lightning and switching impulses: **Very slow front temporary overvoltage** with same polarity to actual DC voltage and **Zero crossing damped temporary overvoltage.**

Very slow front TOV			Zero crossing damped TOV		
U_1	Peak voltage	1.6 U_0 - 2.5 U_0	f_{LF}	Oscillation frequency LF	<400 Hz
U_2	Plateau voltage	90% U1	f_{HF}	Oscillation frequency HF	>5000 Hz
$t_1 - t_0$	Time to peak	60 us - 10 ms	U_{f1LF}	First peak amplitude	>90% U0
$t_2 - t_1$	Plateau time	30 ms - 150 ms	U_{f1HF}	First peak amplitude	>50% U0
$t_3 - t_2$	Cable discharging time	>10 ms	N_{HF}	Number of oscillations	>14
Second tail discharge: to ground or to U_0			N_{LF}	Number of oscillations	>5





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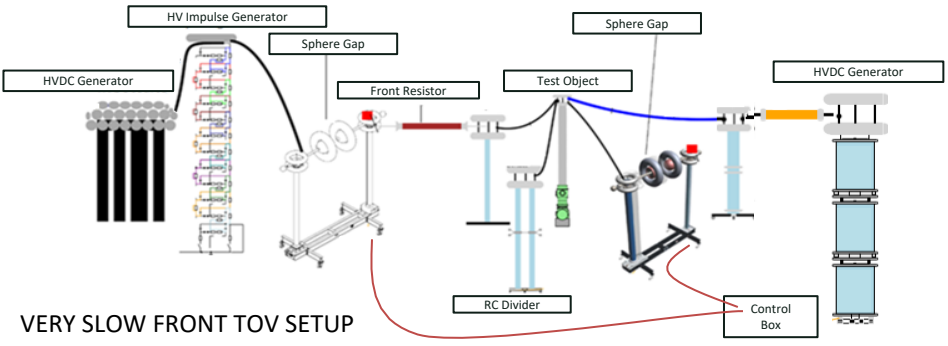
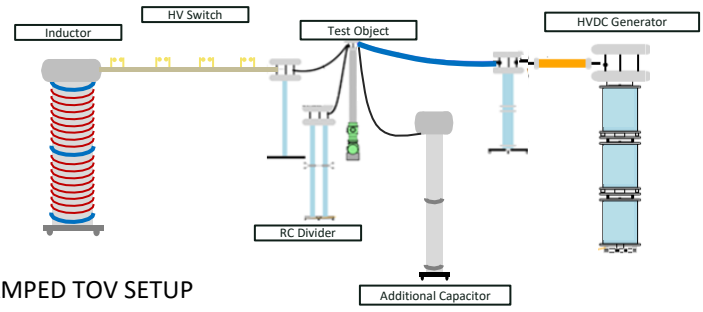
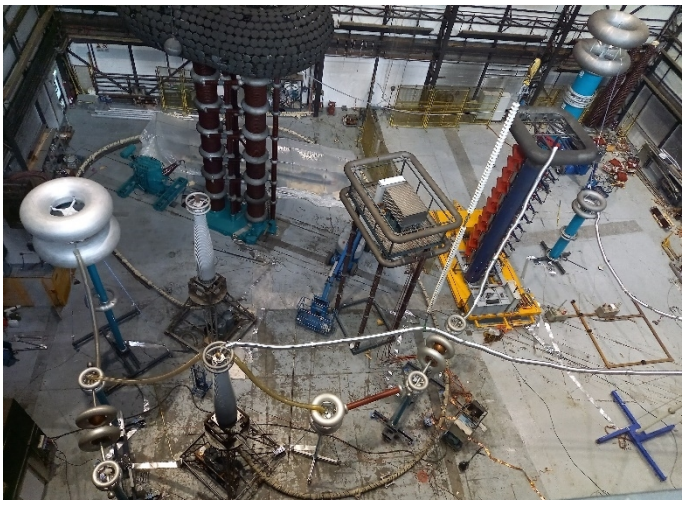


VERY SLOW FRONT TOV SETUP



ZERO CROSSING DAMPED TOV SETUP



Very slow front TOV Setup @ Prysmian Group R&D Lab in Milan

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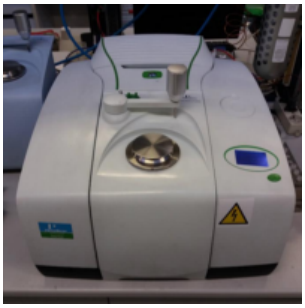
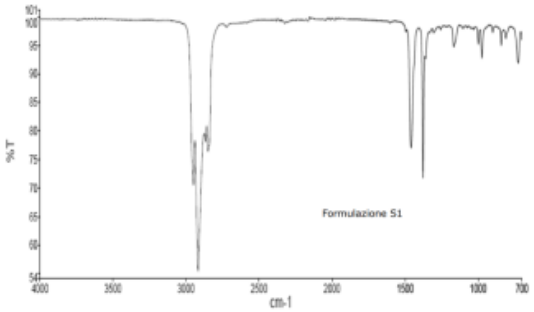
Material characterization - NEW MATERIAL TESTS ON HPTE CABLE SYSTEMS

Fourier Transform Infrared Spectroscopy (FTIR) analysis





Using a FTIR instrument it is possible to obtain a finger-print of the chemical bounds present in HPTE material. HPTE material is characterized by:

- 3 peaks between 3000cm-1 and 2750cm-1
- 2 peaks between 1500cm-1 e 1250cm-1

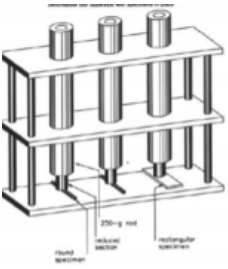
Differential Scanning Calorimetry (DSC) analysis

DSC is another method to obtain the fingerprint of the chemical bounds present in HPTE material. Samples are heated with a rate of 10°C/m and two scanning cycles are executed. HPTE material is characterized by:

- Melting temperature: 160°C
- Melting heat: 24.5 J/g

However, the sensitivity of this test to the process parameters is low and therefore it was discarded

Thermopressure test



Reproduce the thermo-mechanical conditions to which the cable will undergo during its operating life. The test can be performed from 90°C up to 130°C, with a load corresponding to 0.3 bar.

$$D_{\%} = 100 \cdot \frac{T_1 - T_2}{T_1}$$

CONCLUSION

The big demand for transmission of high electrical power over long distances pushed the evolution of both traditional and new technologies and materials. **The recent development demonstrated the suitability of ±525 kV HPTE DC cables to withstand the stressful overvoltages induced by both VSC and LCC systems.** As HPTE is a thermoplastic material, new material tests had to be developed and reference values to be measured: part of these tests are now included in CIGRE Technical Brochure 852 as part of the testing protocol for thermoplastic insulation materials.