Comparison of characteristics and behaviour of XLPE and P-laser MV-cable

Piet **SOEPBOER**
Enexis Netbeheer – the Netherlands
piet.soepboer@enexis.nl

Blandine **HENNUY**
ENGIE-Laborelec - Belgium
blandine.hennuy@engie.com

Jos **VAN ROSSUM**
Prysmian Netherlands – the Netherlands
jos.vanrossum@prysmiangroup.com

Tjeerd **BROERSMA**
Enexis Netbeheer – the Netherlands
tjeerd.broersma@enexis.nl

Robin **SIMAL**
ENGIE-Laborelec - Belgium
robin.simal@engie.com

Sander **LAUWERS**
Prysmian Netherlands – the Netherlands
sander.lauwers@prysmiangroup.com

ABSTRACT

A few years ago, Cable manufacturer Prysmian developed a new insulation material for MV-cables called "P-laser" which is based on PP instead of PE [1]. Dutch DSO Enexis, research institute ENGIE-Laborelec and Prysmian Netherlands together set up and conducted a research project to investigate the behaviour of a P-laser cable in comparison with an identical cable with XLPE-insulation. Based on the outcome of this study Enexis decided to introduce P-laser as one of their standard cable types.

KEYWORDS

Comparison, Insulation, XLPE, P-laser, PP, Polypropylene, High Performance Thermoplastic Elastomer, Ampacity test, Short-circuit test, Low and high temperatures.

INTRODUCTION

The cable tender of Enexis in 2016 was partially awarded to Prysmian Netherlands with the possibility to purchase cable with P-laser insulation. The advantages of this "High Performance Thermoplastic Elastomer" insulation are e.g. its recyclability and lower CO2-emissions during production. Enexis however learned from its experiences after purchasing the 1st generation XLPE cable in the '70's. To prevent a similar scenario, a research project was set up by Enexis in collaboration with ENGIE-Laborelec and Prysmian in order to compare the behaviour of a 1x630Al P-laser 6/10kV cable and an identical XLPE cable.

Based on earlier studies on P-laser and based on how MV-cables are installed and operated in the network of Enexis, the following tests were determined and performed:

1. Verification with standard NEN-HD 620 S2 [2] and setting reference values for cable comparison.
2. Ampacity-in-air test (comparison of temperatures and cable loads of XLPE and P-laser).
3. Overbending test (cable behaviour under a too small bend radius at -15 °C, 90 °C and 110 °C).
4. Short-circuit test (short-circuit behaviour up to 250 °C on the minimum permissible bend radius).
5. Shrinkage test on XLPE and P-laser insulation.

After these electrical and mechanical tests, DSC, DMA, dimension measurements and stereomicroscopy analysis were performed by ENGIE-Laborelec to study the material properties. An investigation on watertree sensitivity was left out because this was already investigated by Enexis and ENGIE-Laborelec in a preliminary phase, showing not a single watertree in P-laser insulation material [3].

VERIFICATION TESTS

During the verification tests it was concluded that both cables for the comparative research fulfil the requirements of standard NEN-HD 620 S2 and that valid type test certificates and test reports are available. Dimension measurements according to IEC 60811-1-1 [4] were performed on straight cable samples. The reference thicknesses are given in table 1.

	Requirement	XLPE	P-Laser
Conductor screen	≥ 0.5 mm	0.623 mm	0.637 mm
Insulation (nom 3.4 mm)	≥ 2.96 mm	3.530 mm	3.620 mm
Insulation screen	≥ 0.5 mm	0.629 mm	0.627 mm

Table 1: Reference thicknesses.

The average insulation thickness of the XLPE cable under test appeared to be 3.53 mm and the average insulation thickness of P-laser 3.62 mm where the standard requires a nominal thickness of 3.4 mm. A theoretical verification of this small overdimensioning showed an insignificant influence of less than 1% on the cable ampacity.

The thermal conductivity was determined by the "Hot Disc TPS" Method according to ISO 22007-2 [5] and out of these results it was concluded that the measured thermal resistivity of P-laser (4.55 K.m/W) is in line with the value in the available literature (4.5 K.m/W).

The DSC analysis showed that the observed melting temperatures are those that can be expected for XLPE and HPTE and that these are sufficiently higher than the nominal operating temperatures of XLPE and P-laser.

The detected glass transition temperatures (-31°C to -49°C) of P-Laser and XLPE cable during the DMA analysis are significant lower than the lowest temperature ever measured in the Netherlands (-27.4°C on 27 January 1942 in Winterswijk). From that it can be concluded that there is no risk for both materials in relation to the usual storage and processing temperatures of cables at Enexis.

AMPACITY-IN-AIR TEST

A piece of P-Laser cable and a piece of XLPE cable with lengths of 8 meters were installed in a test loop according to figure 1. Three thermocouples (Tc) were placed on each cable with a spacing of 1 m in between. The current and the conductor temperatures were recorded by means of a data logger. A current transformer was used to inject the