

INTRODUCING HIGH-PERFORMANCE POLYPROPYLENE THERMOPLASTIC ELASTOMER (HPTE) INSULATION FOR MV CABLES IN THE NETHERLANDS

Jos van Rossum
Prismian – The Netherlands
jos.rossum@prysmian.com

Hanneke Tammenga
Prismian – The Netherlands
hanneke.tammenga@prysmian.com

Lawrence Lamballais
Prismian – The Netherlands
lawrence.lamballais@prysmian.com

Ger Sebregts
Liander – The Netherlands
ger.sebregts@alliander.com

Ben Aerns
Liander – The Netherlands
ben.aerns@alliander.com

Alex Geschiere
Alliander – The Netherlands
alex.geschiere@alliander.com

Alberto Bareggi
Prismian HQ – Italy
alberto.bareggi@prysmian.com

Massimo Comina
Prismian HQ – Italy
massimo.comina@prysmian.com

Abstract

The insulation material that is mainly in use nowadays for MV cables is cross-linked Polyethylene (XLPE). The cross-linking of the material requires specific production facilities and makes XLPE non re-usable.

Some years ago, Prismian started a research for an insulating material with at least equivalent characteristics as XLPE but which is more environmental friendly, resulting in the High performance Polypropylene Thermoplastic Elastomer (HPTE) material with the following benefits: no by-products formation, re-usable, shorter production throughput time, reduced production facilities area and fully compatible with the existing network and network components.

Prismian have started the development of HPTE insulated cores, also referred to as P-Laser[®], resulting in several successful type tests, compatibility tests with MV accessories, pilot projects and regular delivery of HPTE insulated MV cables in Italy and Holland.

This paper comprises:

- *an overview of HPTE cable production history*
- *an overview on (type-) test done on HPTE insulated cables especially for the Dutch market,*
- *cable projects where HPTE insulated cables are installed,*
- *the benefits of HPTE insulation,*
- *the HPTE production homologation procedure at Prismian Delft, the Netherlands*

INTRODUCTION

During the years, after the undisputed supremacy – based on excellent behaviour and performance – held, since the beginning of the XX century, by impregnated paper, the

evolution of insulation technologies and materials for Medium Voltage cables headed for extruded materials, at first thermoplastic (PVC) – soon given up because of reduced dielectric properties – and eventually cross-linked.

Introduced on the market in the early '80s, cross-linked polyethylene (XLPE) in particular, has completely replaced the paper insulation and is nowadays a fully consolidated technology, which relies on outstanding overall characteristics and performances (electrical, thermo-mechanical and installation) and a well-proven track record at all voltages. It appeared difficult, therefore, to find out something new, which could guarantee equivalent, or even improved, performances. For Prismian, the starting point for this new development is the disadvantage of XLPE insulated cables of crosslinking, resulting in by-products with an unmistakable carbon foot-print, an interrupted production flow and the difficulties with XLPE re-use.

Prismian focused therefore on the development of a thermoplastic insulation material with equivalent, or even better characteristics as XLPE and found this in HPTE: High-performance Polypropylene Thermoplastic Elastomere, also called P-Laser[®] [1].

DEVELOPMENT AND TESTING OF HPTE MATERIAL

The development, industrialization and references on HPTE insulated cables are hereafter chronologically given.

2002/2003. The development of the HPTE material started in Italy at the Prismian R&D laboratory where MV cable prototypes were produced and evaluated in terms of physical, chemical and electrical parameters. After these first promising preliminary tests, the capital expense for production of HPTE insulated cable cores in Pignataro Prismian factory (Italy – Caserta) was approved.

2004. HPTE insulated production machinery was installed in 2004 and successfully pre-commissioned.

2005. The first HPTE insulated cable core prototype was industrially produced in Pignataro: 30 km of 1x185 mm² – ARP1H5EX 12/20 kV with reduced insulation thickness for ENEL. After insulation the cable was jacketed and completed on existing machinery of the Pignataro factory.

Hereafter, a 9 km core 240 mm² Solid Al, 6/10 kV full thickness for Nuon/Alliander (Dutch utility) was produced at Pignataro and further finished (lay-up, screening, jacketing) into a 3 core cable at the Prysmian factory in Delft, the Netherlands.



Photo 1 'HPTE insulated' 7-step single production line at Pignataro, Italy'

The approval of investment for completion of Pignataro insulation line with protection phase, including cable screening (overlapped Al tape), water blocking tape application and multi layer jacket extrusion was granted.

2006. The machinery for the protection phase of Pignataro HPTE insulated line was purchased and installed. 10 km of 3x1x185 mm² – ARP1H5EX 12/20 kV HPTE insulated cable was installed and put in service in the ENEL network.

2007. Further industrializing of the HPTE insulated line in the Pignataro plant took place by pre-commissioning the tandemized HPTE insulated line (insulation + jacketing) followed by the production of 300 km of 1x185 mm² – ARP1H5EX 12/20 kV cable core.

2008. 150 km Cores, type 1x185 mm² – ARP1H5EX 12/20 kV was produced for ENEL.

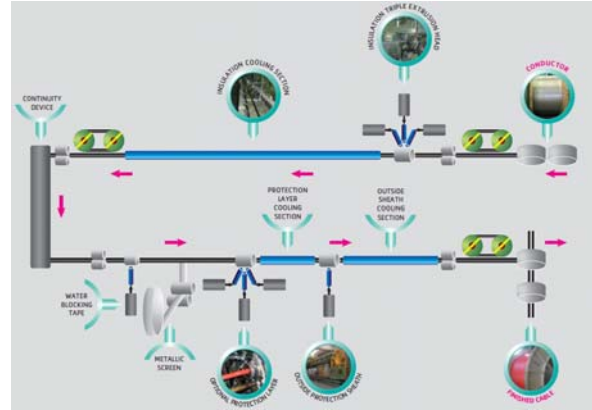


Photo 2 'schematic overview of Prysmian 'HPTE insulated' 7-step single production line at Pignataro, Italy'

2009. More than 2400 km of HPTE insulated cable for ENEL and ACEA was produced. 12 km of 6/10 kV HPTE insulated core 1x 240 mm² Solid Al, with upgraded compound for second field test in Lianders network was produced at Pignataro.

2010. Industrialization on HPTE insulated line of 70, 95 and 240 mm² Al 20 kV cable sizes and Industrialization of 240 mm² Copper, 30 kV. First production of Airbag cable on HPTE insulating line (7 layers extrusion in one single production step). Production on Pignataro line of more than 4.000 km of HPTE insulated cable core. Customers : ENEL, Acea, Acegas and other utilities. HPTE insulated cable core for second field test delivered in Delft and completed. The successful type test and the market interest resulted in the investment for manufacturing of insulated HPTE insulated cores in Prysmian Delft factory, by up-grading of existing horizontal insulation line for MV cables.

2011. Pre-commissioning of the HTPE production line at Prysmian Delft. Further planning on HTPE production line at the Prysmian production facilities at Wrexham, UK.

PERFORMED (TYPE) TESTS, DONE ON HPTE INSULATED CABLES FOR THE DUTCH MARKET

In the Netherlands, three types of MV cable finishing are in use: the non-radial water tight, the quasi radial watertight where the finishing is such that the humidity at the semi-conductive screen remains below 70% during the projected lifetime of the cable, and the radial watertight construction, based on aluminium laminated foil. For the first two constructions, the non-radial and the quasi-radial watertight, the 'long duration test' is mandatory. This is a harmonized test to determine the water tree susceptibility with a 500Hz

test voltage for 3000h, refer to CENELEC HD620 S2, part 10, section J, appendix G [2].

As mentioned in the HPTE history, two pilot projects are realized at Alliander, the first one in 2006/2007 and the second one in 2009/2010 as the HPTE insulated compound was upgraded.

The 500Hz test was performed three times on a HPTE insulated material:

- on the ARP1H5EX 12/20kV 1x150Al core produced in 2005 [3]
- on the 6/10kV 1x240Al HPTE insulated core produced in 2006
- on the second 6/10kV 1x240 Al HPTE insulated core produced in 2010 [4]

All 500Hz tests showed that the HPTE insulated material has at least the same resistance against water treeing as compared to XLPE.

The test results met the requirements and the production of 5 km of 6/10kV 3core cable was initiated, the cores were produced in Pignataro, Italy, and further finished at Prysmian Delft. Hereafter, a type test according to HD620S1, part 6 section J was performed including compatibility tests on cable accessories. Among these selected accessories Prysmian MV terminations, type ELTO, and Prysmian MV joint, type ETJMe, were included as well.

The joints were tested according to the test set-up configuration as depicted in figure 1.

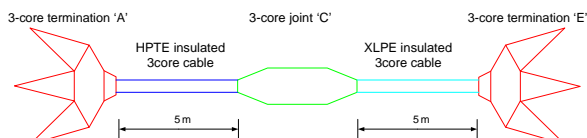


Figure 1 'test set-up for compatibility test HPTE insulated three core cable with standard accessories and XLPE insulated three core cable'

As can be seen in this test set-up, not only the compatibility of the HPTE insulated 3core cable is tested with standard jointing technique, also the compatibility with XLPE insulated cable technology.

In 2007, above tests were successfully finished with the following conclusions:

- HPTE insulation has full-filled 100% the ruling type test electrical requirements for XLPE insulated cables,
- HPTE insulation has full-filled the 500Hz long duration test, proving the excellent capability of withstanding water treeing,
- HPTE insulation insulated cables can be integrated in existing MV grids with standard accessories without any modifications.

After this successful type test, 3 km of 3 core cable was installed (2007) in the Alliander MV grid as a pilot project. The HPTE insulated cable was integrated with standard joints in the existing network with XLPE insulated cables and is three year after installation and commissioning still in service today without any remarks.



Photo 3 'HPTE insulated cable type PMeKrvalqwd 6/10kV 3x240Alrm during compatibility type tests with terminations (left) and joints (right)'

In 2009, Alliander showed interest in a second pilot project with HPTE insulated cables, now for a HPTE insulated 6/10kV single core 630mm² solid aluminium. However, this core size could not be produced on the present HPTE production line at Pignataro. Two actions were unfolded: introducing HPTE production capability at the Prysmian plant in Delft, making the Delft production lines capable of producing MV insulated HPTE insulated cores in the voltage class ranging from 6/10kV up to 20.5/42kV and conductor sizes 35mm² – 1200mm² solid Al, and the installation of a second pilot project, again based on the 6/10kV 3core 240mm² solid Al cable, which was successfully finished in 2010.



Photo 4 'single core 12/20kV HPTE insulated cable (right) joined to XLPE insulated cable'

BENEFITS OF HPTE INSULATED CABLES

The benefits of HPTE insulated cables are summarized in table 1.

Table 1 'benefits of HPTE insulated cables'

CHARACTERISTIC	BENEFIT COMPARED TO XLPE
No chemical reaction (i.e.: no cross-linking)	Re-use of HPTE material
No 'by products' formation (i.e.: no cross-linking)	No degassing required and therefore no emission of rest gasses (e.g. CO ₂) from the HPTE insulated core.
Continuous and more efficient production flow	Shorter production throughput time and reduced energy consumption
No curing or degassing required	Reduced production facility area. Limited number of drums on shop floor. Some cable designs allow one shot production of finished cable
Fully compatible with XLPE insulated systems	XLPE insulated and HPTE insulated cables can be installed in the same link without reservations using same type of accessories

For Prysmian, but also for utilities who uses the HPTE insulated cables, the reduction of the carbon footprint during cable production is an appealing benefit, more than 50% [5] [7] is reachable. Also the savings on water, energy (more than 75% [7]) during cable production, and the feature of easy re-usability, makes the HPTE a 'green' cable compared to the XLPE insulated cable.



Photo 5 'HPTE insulated cable types, on the left type of 3x1x185 mm² – ARP1H5EX 12/20 kV, on the right type PMeKrvaslqwd 6/10kV 3x240Alrm as70.

FURTHER DEVELOPMENT

The installation of the HPTE production line at Prysmian Delft in 2011 resulted in the type test of two cable types: the 6/10kV 1x240mm² solid aluminium HPTE insulated cable for the 500Hz long duration test and a 18/30kV 1x800 mm² solid aluminium single core cable for a complete type test including compatibility test with Prysmian MV accessories,

electrical test program in accordance with ENELEC HD620 S2, part 10, section J [6].

Since above standards do not include HPTE insulation material, Prysmian submitted a proposal for an update of the HD620 to the Dutch National Standardization Committee NEC20. This proposal includes HPTE insulation for 3 and 1core MV cables and follows the XLPE standard in detail, including working temperatures and short circuit temperature. Only difference with the XLPE type test program is the adoption of a pressure test at high temperature on the HPTE core instead of the hot-set test.

The adoption of the XLPE requirements for HPTE insulation underlines that the characteristics of HPTE material are similar or better than that the characteristics of XLPE insulated material.

Prysmian expects a further growth of this environmental friendly insulation technique in the years to come.

REFERENCES

- [1] S. Belli et al. 'P-laser: breakthrough in power cable systems', reference no: 979-1-4244-6300-8/10, ISEI 2010, San Diego, USA
- [2] HD620 S1 prA3 April 2006 'Distribution cables with extruded insulation for rated voltages from 3,6/6 (7,2) kV to 20.8/36 (42) kV, CENELEC.
- [3] IMQ report no. 01SH00275, 01-02-2008, type test report on cable type 3x(1x185)mm² ARP1H5EX – 12/20kV
- [4] KEMA report no TDT 3209-10, '500Hz water susceptibility test on 6/10kV 1x240 solid aluminium insulated HPTE core', December 2010.
- [5] J.J. Dekker et al. 'Environmental analysis 10kV cable Prysmian Delft', report version 1.7, 10-06-2010, Prysmian report.
- [6] FrHD620 S2:2009 part 10 'XLPE insulated single core and 3core cables and single core pre-assembled cables', Section J 'Single core and three core cables with PE sheath (type 10J-1) or PVC sheath (type 10J-2) or PVC flame retardant sheath (type 10J-3)'
- [7] Prysmian internal report.