# Development of a up to 400 kV XLPE Cable with Low-Smoke Properties to be Installed in a Tunnel

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## ABSTRACT

*The move from self-contained fluid filled cables to solid dielectrics has already reduced the fire risks of installing high voltage (HV) and extra high voltage (EHV) power transmission in tunnels. Nevertheless the materials (insulation and outer sheath) used in an extruded cable are still to some extent flammable. Today more and more cables are installed in tunnels or accessible areas.*

*During our development of a low smoke, flame retardant power cable for the range of between 132 kV and 400 kV, we faced some challenges complying with current standards, especially as recognised industry requirements for smoke emission and flame retardancy were not previously included in standards for cables of this type.*

*We would therefore recommend that these standards should be updated to include the larger sizes of cable used at the high voltage and extra high voltage levels.*

*We have evaluated the performance of several components in these cable designs and have observed variations in their performance.*

*We would recommend adding the type and sample tests detailed in this paper to all specifications where cable of this type are to be installed in a tunnel.*

## KEYWORDS

Fire, Retardant, Smoke Density, Testing, Construction, Tunnel

## INTRODUCTION

The move from self-contained fluid filled cables to solid dielectrics has already reduced the fire risks of installing high voltage (HV) and extra high voltage (EHV) power transmission in tunnels Nevertheless the materials (insulation and outer sheath) used in an extruded cables are still to some extent flammable. The traditional use of poly-vinyl-chloride (PVC) as a fire performance sheathing material is becoming less practical for several reasons, such as the creation of dense obscuring black smoke and the emission of toxic materials that are deleterious to humans and machinery. This is in addition to the well-known limitations of PVC in terms of water transmission and sensitivity to abrasion and impact. This is especially critical, since a tunnel is always humide.

Recent experience shows that more and more high (HV) and extra high voltage (EHV) cables are being installed either in tunnels or in sensitive areas where flame and smoke performance may become an issue, should the cable be subjected to a fire during its operational lifetime. During such an event these cables would normally be de-energised. However, the materials used in their construction should not contribute to the fuel load in the event of an external fire. If they are involved in a fire they should act in a neutral manner and not contribute hazardous gases and energy to it.

Following the installation of our first 380 kV cable systems project in Istanbul in 2008 and a further development of a 500 kV cable system [1] we have tested several solutions to the complex problem of providing both fire and mechanical protection of cables. The performances of different designs were compared with our desire to achieve a cable with low-smoke properties that could be installed in both tunnels and also directly in the ground. The disadvantages of certain FRNH compounds being prone to high water permeability, has also been solved. Investigations were made to check not only the obvious influence of different sheathing materials, but also the inherent blend of such compounds in the jacket materials. These tests were carried out according with IEC 61034, but some deficiencies were observed in the test methods advocated within the standard. Particularly the inclusion of a smoke density correction factor for large cross section cables and the possible revision of the standard to cover such cable sizes.

## TESTED MATERIALS

The following materials were tested:

- Material A: is a black PVC jacketing compound fulfilling the ST2 requirements of IEC 60840
- Material B: are several flame retardant non halogen (FRNH) compounds based on aluminium hydroxide and ethylene vinyl acetate. Here different suppliers and materials were tested. Therefore we have sub-coded these materials further from a to f. The differences are in principle different grades from various suppliers.
- Material C: is a black FRNH compound based on magnesium hydroxide and ethylene acrylate with a synergistic additive. Different lots were tested to evaluate the possible variation between different production batches.
- Material D: is a Black high density polyethylene (HDPE) compound fulfilling the ST7 requirements of IEC 60840. This material was only used as a second layer in combination with a FRNH compound.

We as well tested different thicknesses of the sheath.