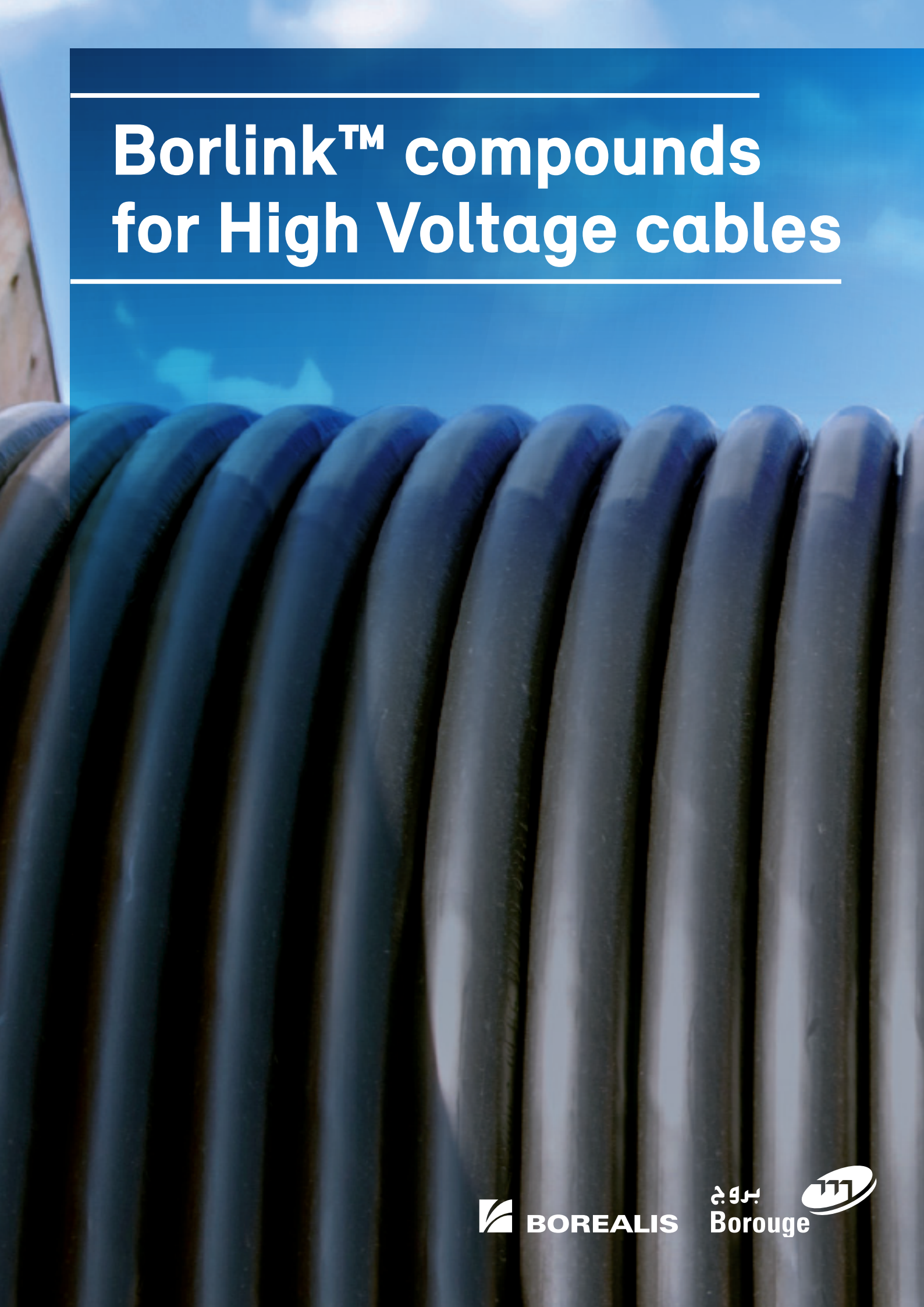
Borlink™ compounds for High Voltage cables



BOREALIS بروج Borouge

About Borealis and Borouge

Borealis is a leading provider of innovative solutions in the fields of polyolefins, base chemicals and fertilizers. With headquarters in Vienna, Austria, Borealis currently employs around 6,400 and operates in over 120 countries. It generated EUR 8.1 billion in sales revenue in 2013. The International Petroleum Investment Company (IPIC) of Abu Dhabi owns 64% of the company, with the remaining 36% owned by OMV, the leading energy group in the European growth belt. Borealis provides services and products to customers around the world in collaboration with Borouge, a joint venture with the Abu Dhabi National Oil Company (ADNOC).

Building on its proprietary Borstar® and Borlink™ technologies and 50 years of experience in polyolefins, Borealis and Borouge support key industries including infrastructure, automotive and advanced packaging.

The Borouge 3 plant expansion in Abu Dhabi will be fully operational in 2014. Borouge 3 will deliver an additional 2.5 million tonnes of capacity when fully ramped up, bringing the total Borouge capacity to 4.5 million tonnes. Borealis and Borouge will then have approximately 8 million tonnes of polyolefin capacity.

Borealis offers a wide range of base chemicals, including melamine, phenol, acetone, ethylene, propylene, butadiene and pygas, servicing a wide range of industries. Together with Borouge the two companies will produce approximately 6 million tonnes of Base Chemicals in 2014.

Borealis also creates real value for the agricultural industry with a large portfolio of fertilizers. The company distributes approximately 2.1 million tonnes per year. This volume will increase to more than 5 million tonnes by the end of 2014.

Borealis and Borouge aim to proactively benefit society by taking on real societal challenges and offering real solutions. Both companies are committed to the principles of Responsible Care®, an initiative to improve safety performance within the chemical industry, and contribute to solve the world's water and sanitation challenges through product innovation and their Water for the World™ programme.

For more information visit:
www.borealisgroup.com
www.borouge.com
www.waterfortheworld.net

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Satisfying the rising demand for High Voltage cable

Recent predictions show a strong increase of energy demand. Renewables will account for significant part (Figure 1). This presents electric power distributors with a very real challenge: 'How to maintain the necessary pace of network development and ensure consistently high system performance?' The reliability that comes from good system performance will become increasingly more important as regulatory frameworks raise expectations in respect to 'supply quality'.

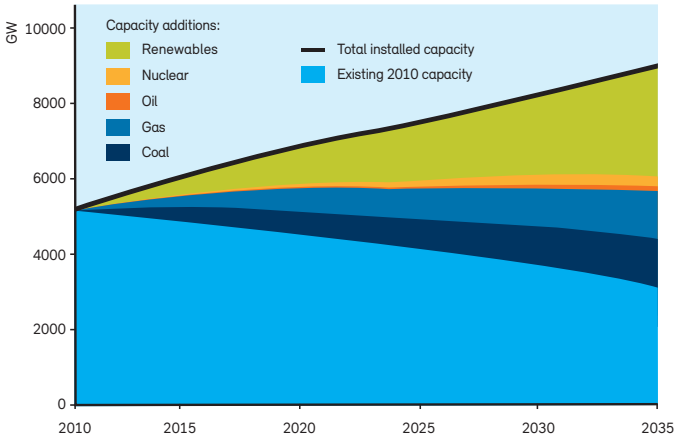

Figure 1: Global installed power generation capacity and additions by technology (Source : International Energy Agency)

Building on the advantages of XLPE insulations

The use of XLPE as the insulation for HV and EHV transmission cables has grown steadily since the early 1990s. Today XLPE insulation is the system that is preferred to traditional lapped insulation (paper or paper polypropylene laminate) fluid-filled cables. This preference stems from the high reliability, low dielectric losses and low environmental impact that can be achieved with XLPE. Consequently XLPE cables are now used at high electrical stresses in a growing number of high voltage applications.

Material quality ensures good electrical performance

Experience has demonstrated that both the cleanliness of the insulation and the smoothness of the semicon employed for power cables have a significant effect on the reliability and longevity of cables. Borealis and Borouge have developed the Borlink™ technology facilitating a range of products for power cable applications. A key difference between these and other materials is that they are produced at higher levels of cleanliness and smoothness.

High Voltage cables use the 'S' quality insulation compounds, which are known as Borlink™ Superclean. These are manufactured using highly developed procedures that are designed to deliver the required cleanliness. Confirmation that the specified level has been achieved is obtained by testing.

All Borlink™ HV insulations are produced and packed on production lines specifically designed for the manufacture of clean products. The special equipment used includes highly sensitive metal separators, automatic contamination detectors for pellet inspection and automated inspection of extruded tapes.

Many studies have shown the degradation caused by large metallic contaminants. Figure 2 shows the influence of size on electrical breakdown strength. The effect of a 5-fold increase in concentration at the 100 micron level is to further reduce strength by 17% and 14% for AC and Impulse currents respectively. As well as showing the reduction in characteristic strengths, the increasing size of contaminants changes the statistical nature of the failures, making them less scattered or more certain.

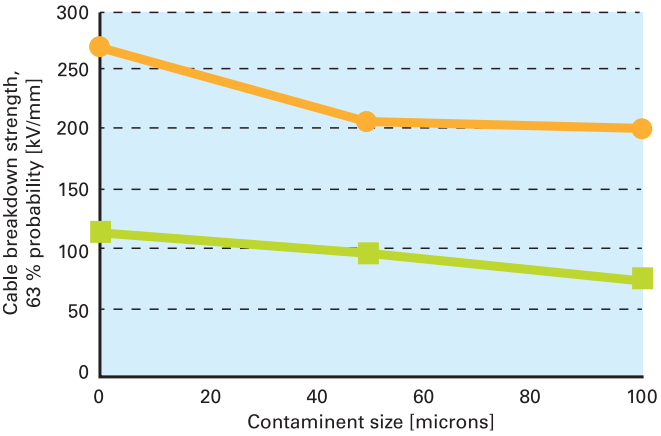

Figure 2: Electrical breakdown strength (AC – lower and impulse – upper) of model cables with artificially added contaminants at a concentration of 5 per meter

Semiconducting screens play an important role in determining cable performance, particularly important is the smoothness of the materials. The smoothness of extruded cable screens is assured by extruding a sample of the complete material in the form of a tape. The tape is then optically examined by an automatic surface smoothness scanner for the presence of pips/protrusions. The presence of these features is enhanced by drawing down and thereby reducing the thickness of the extruded tape. This has the effect of bringing any bulk features to the surface. Once detected, the height and width of these features is measured, enabling width-segregated concentrations to be determined.

In using such a system care needs to be exercised when examining the present generation of extremely smooth (low feature concentration) screens, as the area of tape examined needs to match the likely number of detected features: smooth screens require larger areas to be examined.

By courtesy of NKT Cables, Germany

Material inspection equipment

Benefits of the Borlink™ Superclean material solutions for HV cables

LE4244S Low sag	
Feature	Comparison to Classic LE4201S
Cleanliness	Same
Production technology	Same
Dripping of insulation off of the conductor in CCV lines – easier to manufacture large cables	Less
Sagging of conductor through the supported insulation in MDCV lines – easier to manufacture large cables	Less
Crosslinking speed	Same
Extruder output	Slightly lower

LS4201S High productivity	
Feature	Comparison to Classic LE4201S
Cleanliness	Same
Production technology	Same
Scorch safety – time or temperature for pre-cured material to occur – larger runs	Much higher
Degassing burden – the time/ temperature required to degas a cable, based either on gas or total by-products	Much lower
Crosslinking speed	Same
Extruder output	Same

Table 1: Benefits of LE4244S and LS4201S compared to LE4201S materials

Borlink™ LS4201S

With some configurations of cable manufacturing the CV line speed is not a limitation. In these cases higher productivity comes from increased run length due to lower scorch propensity, and a lower degassing burden resulting from lower initial levels of crosslinking by-products. The much improved scorch safety can either be used to permit longer run times or higher melt temperatures. The lower degassing burden offers the possibility to reduce heat treatment time or temperatures.

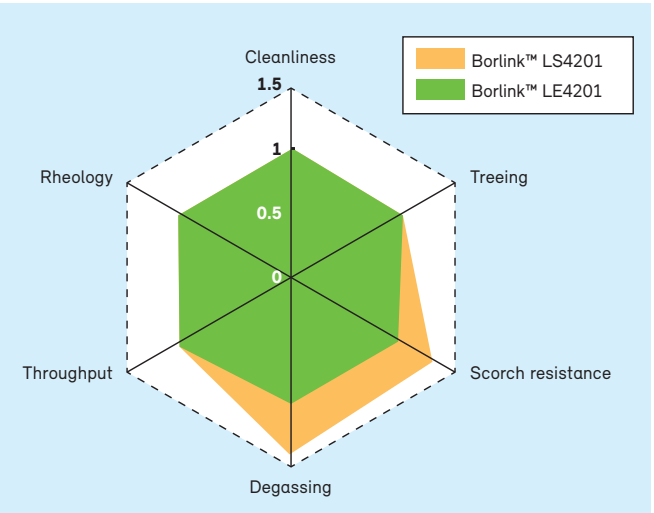

Figure 3: Property chart for Borlink™ LS4201S values >1 indicate improvements

Degassing is a vital process for HV cable designs. In this process cable cores are held at elevated temperatures to speed up desorption of the by-products from the crosslinking process (table 2). The degassing burden is directly related to the size of the cable core and to the level of by-products left in the cable after it exits the CV tube.

Component	Boiling point [°C]	Melting point [°C]
Methane	-162	–
Acetophenone	202	19 – 20
Cumylalcohol	215 – 220	28 – 32

Table 2: Boiling and melting points of different by-products

Borlink™ LS4201S improves the productivity of cable making by reducing the degassing burden, which consumes a major part of cable manufacturing time (figure 4).

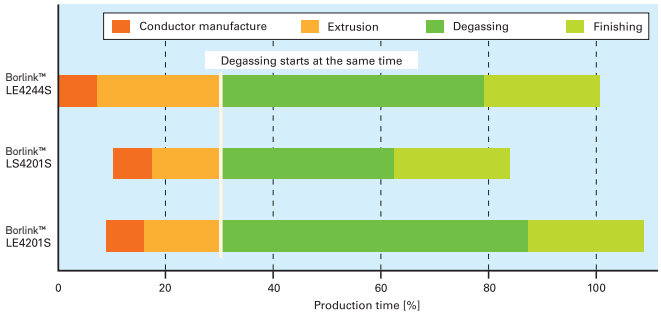

Figure 4: Production cycle for large HV cables manufactured with either Borlink™ LS4201S or Borlink™ LE4244S compared with standard Borlink™ LE4021S

Borlink™ LE4244S

The design of High Voltage cables requires a very smooth and clean compound. Additionally, it requires a concentric conductor inside the insulation. With increased insulation thickness this creates a problem in a CCV line, as the insulation can sag in the intial part of the crosslinking process. In MDCV (horizontal) lines the conductor sags through the molten insulation, requiring use of a more viscous material, Borlink™ LE4244S.

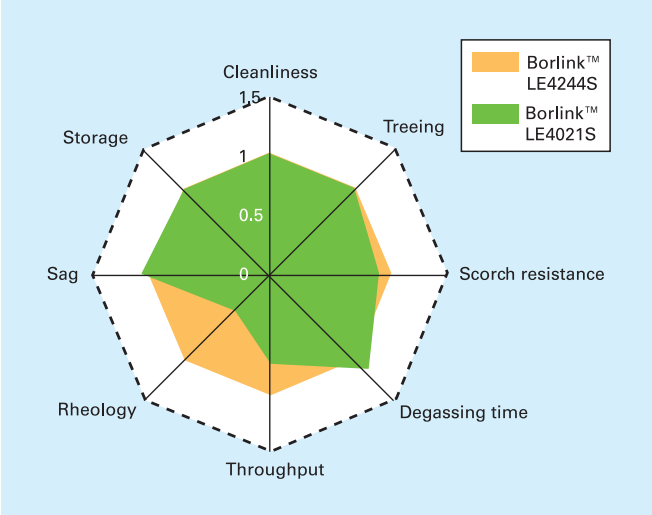

Figure 5: Property chart for Borlink™ LE4244S values >1 indicate improvements

Sagging on modern CCV lines can also be alleviated by the use of core rotation or tempering during curing. Cables with a conductor of 185 mm^2 and 21 mm insulation can be produced with standard viscosity materials using this approach. These techniques are fully compatible with Borlink™ LE4244S, which further extends the range of their operation over that of normal viscosities.

Better scorch safety increases the length of production runs

In addition to the crosslinking process, the formation of scorch (prematurely crosslinked material) within the extruders and the head must be considered. At the temperatures employed for extrusion the development of the crosslinked network is much slower than at crosslinking temperatures. However there is often a desire to run up to 10 days before needing to stop and clean the equipment.

Thus control of this process is very important. Figure 6 shows that the amount of scorch created within a fixed time is quite sensitive to the melt temperature. It also shows the difference between the classic XLPE and Supercure based XLPE in terms of scorch performance where the latter displays lower scorch formation at the same extrusion temperature.

In practical situations the melt temperature is quite difficult to define as:

a) polymer shear within the melt contributes considerable energy, elevating the melt temperature

b) the differential flow lengths within the head can result in cooling of certain areas of the melt

Therefore it is important to establish adequate safety margins for polymer melt temperatures and polymer residence times within the extruder and head.

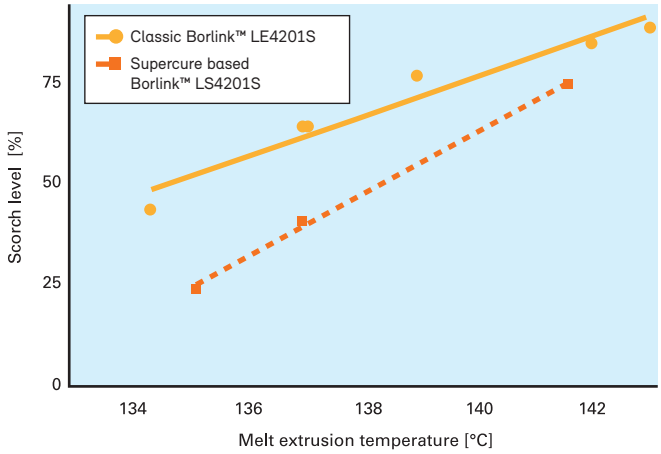

Figure 6: Die extrusion test for scorch – insulations (often referred to as the Carrot Test, low values indicate better scorch)

Experience has shown that extrusion temperatures relating to a maximum of 50% scorch level in the accelerating test shown in figure 6 bring good performance in service. An insulation or semicon which brings lower levels of scorch would enable the melt temperature, and thus the output, to be increased by 2°C.

If the same melt temperature is maintained, then the length of run could be increased by 20% over that of standard materials when using low scorch insulations.

Screen materials ensure consistent electrical stresses

Semiconductive screening materials are used to provide an electrostatic screen and a conducting path for leakage currents. These materials are based on carbon black (manufactured by the complete and controlled combustion of hydrocarbons) dispersed within a polymer matrix (preferably acrylate copolymers manufactured in the high pressure tubular process as these copolymers display a high heat resistance allowing for high surface temperature in the vulcanisation tube and thus increased throughput). The concentration of carbon black needs to be sufficiently high to ensure adequate and consistent conductivity. Incorporation must be optimised to provide a smooth interface between the conducting and the insulating parts of the cable. A smooth surface is highly important as it decreases the occurrence of regions where the electrical stress and, therefore, the chance of failure, is high. To provide the correct balance of these properties it is essential that both the carbon black and polymer matrix are carefully engineered.

Proven technology for clean unloading

To ensure the safe production of HV cables, the handling of compounds must be made without risk of contamination. To manage this effectively and combine economic logistics with safe, clean handling, Borealis developed the Borlink™ Superclean octabin, a system already well-established for the transportation of Extra High Voltage cable material. The octabin, with a product capacity of 1 tonne, is filled and emptied under clean room conditions thus preserving 'as produced' quality during transfer to the cable extrusion plant. The correct design of systems within the cable manufacturing facility and effective, regular cleaning procedures to maintain high levels of purity are a necessary complement to this system.

Borstar® HDPE jacketing gives optimal protection

External protection against mechanical impact and corrosion is provided by a tough, extruded, laminated sheath made from Borstar® High Density Polyethylene (HDPE). Because the performance of the oversheath is critical to the overall performance of the cable, a number of properties are demanded of it: good abrasion resistance, good processing, good barrier properties and good stress crack resistance. Experience has shown that the best composite performance is provided by an oversheath based on polyethylene, as these compounds give far better protection against water than PVC (figure 7).

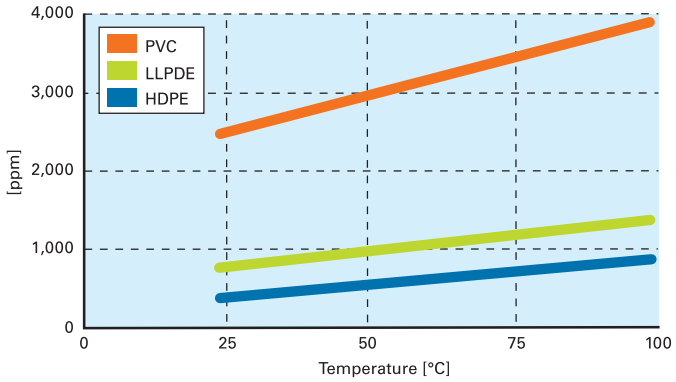

Figure 7: Water absorption of common jacketing materials

In the past there was some reluctance to use HDPE due to a few incidents of cracking. To address this problem special (bimodal) polyethylene materials have been developed. Stress crack performance is assessed by considering the F20 value (time required for 20% of samples to fail by stress cracking); with the significantly increased performance of bimodal materials we must now consider F0 as the appropriate measure of performance (figure 8). Thus bimodal HDPE is able to deliver all of the performance attributes needed for an excellent oversheath.

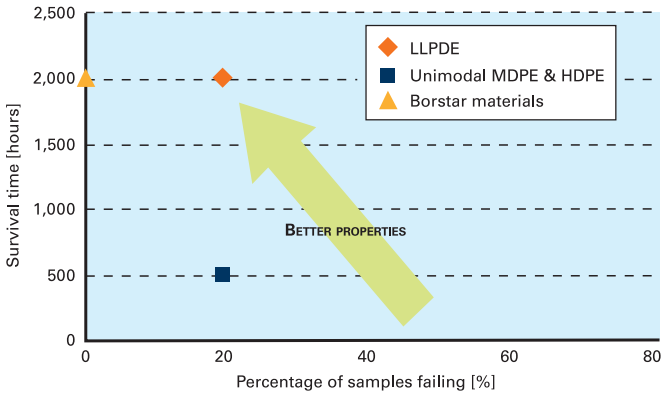

Figure 8: Stress crack resistance

When HV cables use high density jacketing (like HE6062) with a hardness of Shore D ~60, cable laying costs reduce significantly. Trenches can be smaller and the risk of damage to cable during installation is lower. The resulting lean, low-weight cable has several advantages: a greater length of cable can be wound onto any given drum, high eddy-current losses in the cable sheath are avoided and current carrying capacity is optimised.

The jacket option for flame retardants is:

- an extruded flame retardant layer for extra safety in hazardous environments FR6082

The semiconductive jacketing option LE0563 is:

- a compound for diagnostic and/or grounding purposes

Recommended material systems for High Voltage cables (up to 220 kV)

	Borlink™ insulation	Borlink™ semiconductive screen
High productivity* XLPE	LS4201S	LE0592S
High viscosity XLPE (low sag)	LE4244S	LE0592S

* Supercure based compound

Jacket	
Borstar®	HE6062 or HE6063
Casico™ – Flame retardant	FR6082
Semiconductive	LE0563

Sources for further information

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Borealis and Borouge – Dedicated to Wire & Cable Solutions

Borealis and Borouge are the world's leading providers of innovative, value creating plastics solutions for the wire and cable industry. Our solutions are customer-driven and designed to satisfy the industry's continuously evolving demands for higher technical performance. Consequently, they can be found in the most challenging EHV and HV cable applications, as well as MV and LV energy transmission and distribution cables, building wires, and communications cables.

In answer to the need for production, installation and cable-system lifetime enhancements, we create the innovation links that secure world-class, step-change solutions and benefit the whole wire and cable value chain. Through the introduction of unique polymer technologies, which include Borlink™, Visico™/Ambicat™, Borstar®, and Casico™, we continue to pioneer the development of advanced insulation and jacketing systems for both energy and communication cables.

Built on more than 50 years experience, Borealis and Borouge have a well-established track record in serving customers' needs with the consistently high quality products expected of global leaders. We are committed to extending that leadership position and our role as reliable partners for the long-term – a commitment not only supported by our forward thinking in innovative solutions, but also confirmed by ongoing investments for our customers' continued success.

Putting customers' needs at the centre of our planning is reflected in Borealis' largest investment in Europe to date, the new 350,000 t/y high-pressure, low-density PE plant in Stenungsund, Sweden, was inaugurated in June 2010, further strengthening Borealis' capabilities to meet the needs of the growing wire and cable markets. Furthermore, Borouge's expansion of Borstar® and Borlink™ capacity in Abu Dhabi, UAE, allows us to satisfy growing customer demand for wire and cable products in the Middle East and Asia Pacific markets and other emerging markets.

Through ongoing research and development, investment in the future and a dedicated team with solid industry knowledge, we aim to remain fully responsive to our customers' needs throughout the world.

Notes

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