

Courtesy by Svenshogen, Sweden



Borcell™ physical foaming products for communication cable insulation

About Borealis

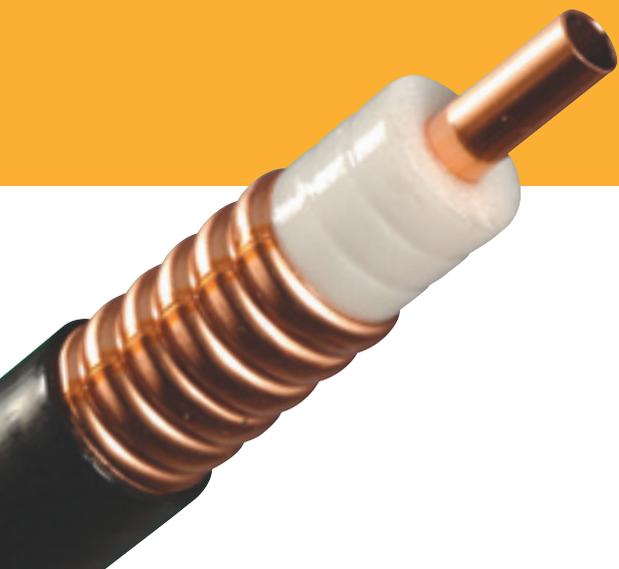
Borealis is a leading provider of innovative, value creating plastics solutions. With more than 40 years of experience in the polyethylene (PE) and polypropylene (PP) business, we focus on pipe systems, energy and communications cables, automotive and advanced packaging markets. We are strong in Europe and growing in the Middle East and Asia-Pacific through Borouge, our joint venture with the Abu Dhabi National Oil Company (ADNOC). Our technology shapes plastic products that make an essential contribution to the society in which we live. We are committed to lead the way in 'Shaping the Future with Plastics'.

With EUR 5 billion revenue in sales and 4,500 employees, Borealis is headquartered in Vienna, Austria with innovation centres, customer service centres, and main production sites in Europe and the Middle East. Borealis has representative offices and operations in Asia, North and South America.

At its heart, the company's four values of Responsible, Respect, Exceed and Nimblivity™, define its way of doing business. For Borealis, success is achieving value creation through innovation.

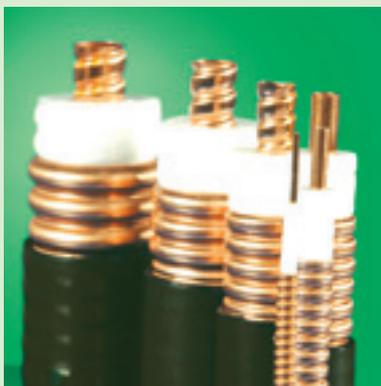
Borstar® is Borealis' proprietary technology supporting differentiated PE and PP products. Borstar is a registered trademark of Borealis A/S.

Learn more about us at
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Picture 1: Polyethylene plant, Stenungsund, Sweden

Meeting the demand for higher quality transmission



Picture 3: Radio frequency (RF) cables

The exponential growth of internet and mobile phone use globally is emphasising the need for accurate and fast transmission of large volumes of data, voice communication and pictures. The increasingly higher operating frequencies used have accelerated the demand for enhanced electrical properties of the insulation materials in communication cables. The insulation performance improvements should also be matched by improvements in processability and material consistency.

To satisfy these dual objectives, Borealis has further developed its extensive range of Borcell chemically and physically foamed polyethylene (PE) compounds. These developments offer improved transmission properties for the end user and easier processability for the cable manufacturer.

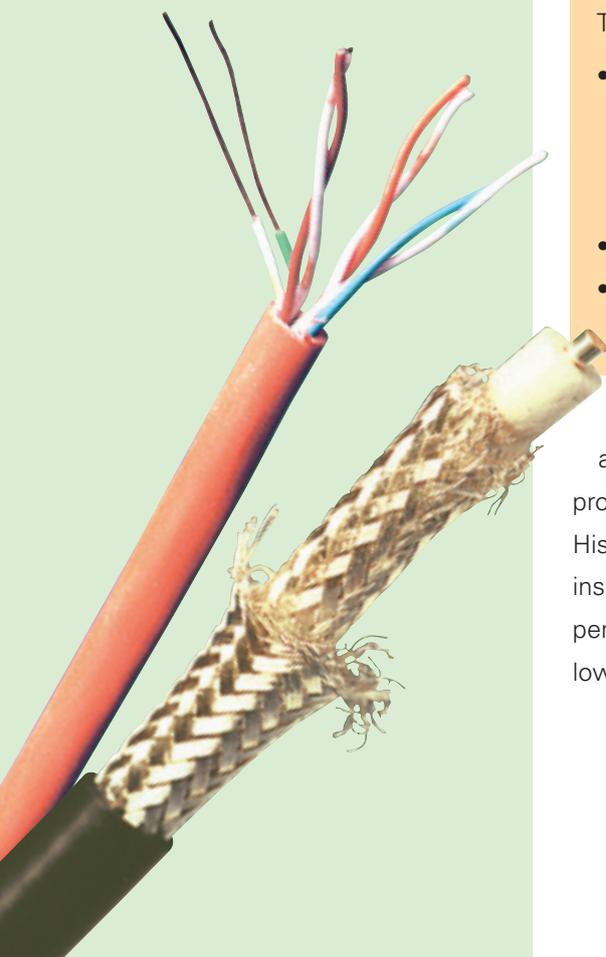
Borcell chemically and physically foamed insulation compounds

Borcell cellular insulation compounds are optimised to generate uniform and evenly distributed cells that enhance transmission properties. In addition, improved flow properties, melt elasticity and purity allow high line speeds in combination with minimised capacitance variations.

Typical applications for Borcell insulation include:

- Multipair telephone cables, smaller coaxial cables, such as community antenna television cables (CATV) and data cables produced by chemical foaming and having expansion degrees up to 50 %
- High expansion (up to 80 %) physically foamed insulations
- 3G mobile phone antenna systems, using 50 ohm coaxial cables, demanding minimal losses

PE is the material of choice for insulation in telecommunication applications because its optimal combination of electrical, physical and processing properties gives it an ideal fit with the performance requirements. Historically, the first use for PE in telecommunication was as solid insulation. Cellular insulation was subsequently developed to improve cable performance. The reason for this is that gases like air and nitrogen have very low relative dielectric constants and therefore offer outstanding insulation



properties. By combining gas with PE (which also has a low dielectric constant) through foaming, an even better insulation material that enables the reduction of cable size, as well as giving improved signal transmission is created.

Initially, creating a sealed cell structure was achieved by chemical foaming of the material through the incorporation of a blowing agent in the compound formulation. A later advance came with the introduction of gas injection technology, allowing PE to be physically foamed and bringing another step improvement in electrical properties. Since then this technology has progressively been adopted by the wire and cable industry where it is now widely used.

In chemical foaming azodicarbonamide is mainly used as the blowing agent. However, this creates carbon oxides and ammonia decomposition products while foaming. Gas injection technology is more attractive from an environmental point of view as nitrogen or carbon dioxide is normally used as the expansion medium.

This brochure reviews the various applications, production technologies and properties of Borcell products Borealis offers to the wire and cable industry for foamed insulation.

Communication cable applications

The main applications for communication cables with a metal conductor are:

- Pair cables, telecommunication
- Data cables
- CATV cables
- Mini coaxial cables
- Radio frequency (RF) cables



Picture 4: Installation of communication cables



Picture 5: Typical constructions with foamed insulation



Picture 6: Installation of communication cables

Solid or chemically blown insulation are the main choices for pair cables and data cables of the twisted pair type. However, there is a significant increase in the use of physical foaming for pair cables as well as for CATV cables on account of the better electrical properties it offers.

For RF cables such as antenna systems in mobile telephone networks, physical foaming is the most commonly used technique, and it has been a prerequisite in the evolution of more efficient systems operating at the highest frequencies.

Recommended insulation products

Historically, the materials used for physical foaming have often been in-house mixtures based on low density polyethylene (LDPE), high density polyethylene (HDPE) and a nucleating agent, made by the cable manufacturer directly at the cable line. The main advantage of this procedure is that for each cable size, the LDPE/HDPE ratio can be optimised in order to achieve the lowest possible attenuation while maintaining good foaming properties.

Hence, optimised blends of Borcell LE1120 and Borcell HE1123, correctly processed, will meet top level requirements for cables with extra high attenuation demands. An alternative possibility is to use ready-made blends such as Borcell HE1102 and Borcell HE1105. These two compounds for physical foaming have been optimised to meet different demands and the needs of a variety of applications.



The Borcell family of compounds exhibits a high degree of foaming and delivers very low dielectric losses. It provides a single source of solutions able to satisfy the full spectrum of communication cable demands.

Pair cables	Coaxial cables	RF cables
Borcell HE1102	Borcell HE1102	Borcell HE1105
	Borcell HE1105	Borcell LE1120
		Borcell HE1123

Borcell HE1102 is a fully formulated compound based mainly on HDPE and a nucleating agent. The components have been chosen to achieve superior processing properties which enable high line speed in combination with minimised capacitance variations. The main use is telecommunication cables, twisted pair data cables and small coaxial cables, normally not exceeding an outer diameter of 10 mm. Borcell HE1102 can be expanded to slightly above 70 %.

Borcell HE1105 is a compound principally based on HDPE but without a nucleating agent. This is designed for use in larger coaxial cable constructions (exceeding 10 mm over the dielectric) and standard demand RF cables. The components are selected to give low attenuation over a wide range of frequencies. Borcell HE1105 can be expanded to slightly above 80 %. A small amount of Borcell HE1102 is recommended as nucleating agent.

Borcell LE1120 and Borcell HE1123 are designed to be used as insulation for radio frequency cables having extra high demand on low attenuation at high frequencies. By dry blending the pellets prior to extrusion it is possible to optimise the Borcell HE1123/Borcell LE1120 ratio for each insulation thickness in order to give the lowest possible attenuation. A variety of nucleating agents developed for gas injection applications can be used in combination with Borcell HE1123/Borcell LE1120. Nucleating master batch Hydrocerol® NUC 5532 from Clariant, containing endothermic blowing agent, has shown good performance in these applications.

Table 1: Borealis products for physical foaming



Picture 7: Mobile phone antenna

Choice of product relative to construction

For pair cables and coaxial cables with an outer diameter up to approximately 10 mm, Borcell HE1102 is recommended. With stricter requirements on attenuation for smaller cables, Borcell HE1105 can be used, with some Borcell HE1102 added for nucleation.

Guidelines are given for the mixing ratio between Borcell HE1102 and Borcell HE1105 in Table 2. The limitation for Borcell HE1105 is the line speed in small constructions when capacitance variations may possibly occur. In general, the addition of Borcell HE1105 can be increased until a tendency to instability becomes apparent in processing.

Cable type	Outer diameter [mm]	Ratio Borcell HE1102/Borcell HE1105 [%/%]
Pair cables	1 ¹	100/0
Coaxial cables	2 - 5	50 - 100/50 - 0
Coaxial cables	6 - 12	25 - 100/75 - 0
Coaxial cables	13 - 22	10 - 25/90 - 75
Coaxial cables	> 22	5 - 10/95 - 90

Table 2: Guidelines for mixing ratios depending on cable size

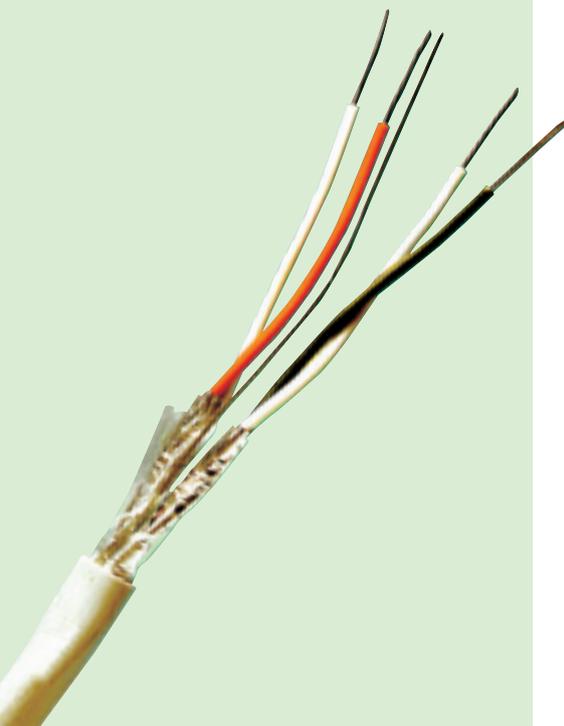
¹ For telecommunication cables, with severe heat ageing requirements, enhanced stabilisation is recommended. A suitable antioxidant master batch is 4051 FT-50 from Polyone. To fulfil IEC 60811, a minimum addition of 2.5 % is recommended.

Processing

In general, higher processing temperatures are required when manufacturing smaller diameter cables or when using higher line speeds.

Typical temperature settings for an extruder with six-barrel zones, neck and die, are given in Table 3. The gas injection point is supposed to be located between zone three and four. The intention is to start with a low temperature to supply energy to the material via the screw for good homogenisation. To obtain activation of the nucleating agent, the temperature is increased at the point where the gas is injected.

It is very important to achieve good homogenisation of the polymer and gas at the gas injection point. To ensure consistent foaming properties a mixing element is recommended. The decrease in temperature following gas injection will result in increased viscosity of the melt and thus improve the cell structure. Increasing temperature at the die improves surface smoothness when no outer skin is used. However, to achieve good adhesion between the conductor and insulation an inner skin is recommended in all constructions.



Recommended temperature settings are seen in Table 3 but it should be emphasised that these are guidelines only. Adjustments have to be made according to the cable size, construction, extruder type etc. The lower temperature profile is recommended for cables processed at line speeds lower than 500 - 700 m/min (approximately).

		Pair cable ¹	Coaxial / RF cable ²
Barrel, zone	1	175	150
	2	195	160
	3	215	180
	4	200	180
	5	200	180
	6	200	180
Neck		205	185
Head		210	185
Die		220	185

¹ Borcell HE1102

² When producing coaxial cables using Borcell HE1102, avoid temperatures over 190 °C in the extruder or head because of the risk of plate out.

Table 3: Recommended temperature settings [°C]

Dielectric properties

Dissipation factor and permittivity is measured on solid plaques, see Table 4 and Figures 1 and 2.

Table 4: Typical values for dissipation and permittivity (dielectric constant) measured on solid plaques. Data should not be used for specification work.

Product	Frequency [MHz]	Dissipation factor	Permittivity
Borcell HE1102	1	0.000056	2.33
	150	0.000116	2.28
	1000	0.000164	2.24
	3000	0.000169	2.22
Borcell HE1105	1	0.000080	2.33
	150	0.000118	2.26
	1000	0.000130	2.25
	3000	0.000120	2.23
Blend ratio 75/25			
Borcell HE1123	1	0.000049	2.33
Borcell LE1120	150	0.000079	2.30
	1000	0.000085	2.28
	3000	0.000088	2.25

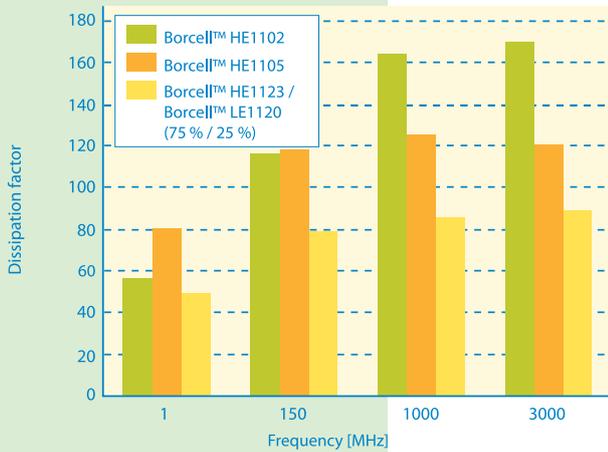
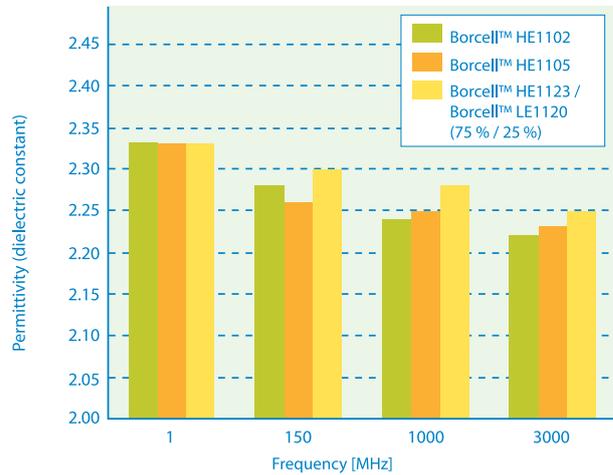


Figure 1: The difference in dissipation factor for the grades increases as the frequency becomes higher

Figure 2: Permittivity (dielectric constant) for the grades follows closely throughout the frequency band



Conclusion

Borealis offers a full set of products for physical foaming. Together they cover the complete range of cable insulation solutions with this technology. Optimally mixed, these Borcell products offer superior processing properties and minimised attenuation, in addition to improvements in respect of environmental considerations.

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Borealis Wire & Cable

Built on experience and successes over more than 40 years, Borealis has grown to become one of the world's leading suppliers of polyolefin plastics for the global Wire & Cable industry. Through the introduction of advanced polymer technologies such as Supercure™, SuperCopo™, SuperTR™, Supersmooth™, Casico™, Visico™, Ambicat™ and Borstar®, Borealis has pioneered developments of insulation systems and sheathing solutions for both energy and communication cables that have contributed to today's industry standards.

Borealis believes that customer-driven innovation is the only way to achieve and sustain progress and we work closely with customers and end users to develop solutions that will meet or exceed their expectations in quality, consistency and processibility, for today's applications and those of the future. In response to customers' needs these include cutting edge solutions for extruded High Voltage and EHV power cables and XLPE materials for Low and Medium Voltage energy cables, together with cost efficient HFFR solutions and advanced insulations for communication cables.

Customers' needs are at the centre of our research programmes and resource deployment, and through ongoing investment in upgrades and new plant programmes, we continue to set new records for output efficiency, product reliability and economy, in addition to product innovation.

Responsiveness is the foundation of successful customer partnerships and Borealis Wire & Cable ensures this through its strategically located production sites in Sweden, Austria, Belgium, Finland, USA and Abu Dhabi, an Innovation Centre in Stenungsund, Sweden with an affiliate in Rockport, New Jersey, USA, as well as a well dispersed sales and agent network around the World.



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IN0096/GB WC 2006 03 NI

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