PO Blown Film Solutions for Flexible Packaging

BOREALIS

Borealis is a leading provider of innovative solutions in the fields of polyolefins, base chemicals and fertilizers. This year, the company celebrates its 20th anniversary. 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

Contents

Industry trends

Borealis blown film packaging solutions address the major challenges in the film industry and provide benefits throughout the entire value chain.

Current and future innovation efforts within Borealis are targeting the following key market drivers:

Food safety & freshness

- Packaging integrity: securing food quality and shelf life will continue to be the key performance criteria, with a growing tendency for even tighter and more demanding legal guidelines as well as customer needs
- Polyolefins will maintain their principal role as the backbone of most packaging solutions
- New functionalities will be added and improved continuously such as barrier, peelable, breathable, light blocking, sterilisable, microwavable
- Agricultural film markets indicate a high growth potential for polyolefins, as the total amount of arable land will not increase in the future, thereby strengthening the important role of plastics in this market

Sustainability

- Lightweighting will continue to be one of the main drivers for new film developments, as it will be cost, sustainability and legally driven
- Increasing brand owner pressure on sustainability in the sense of downgauging and lightweighting: a win/win scenario offering both a strong environmental marketing argument but also a very important cost improvement factor
- Life cycle performance to become a more important buying criterion
- The entire value chain working together to improve the image of plastics
- Recycling: the potential of incorporating consumer recycled material in food applications

Convenience

- Aesthetics growing in importance: the ability to differentiate the product on the shelf
- Easy opening, re-closable film qualities while maintaining packaging integrity
- Retortable packaging
- New packaging design and tailor-made surface properties, such as soft touch, for improved end-user feeling

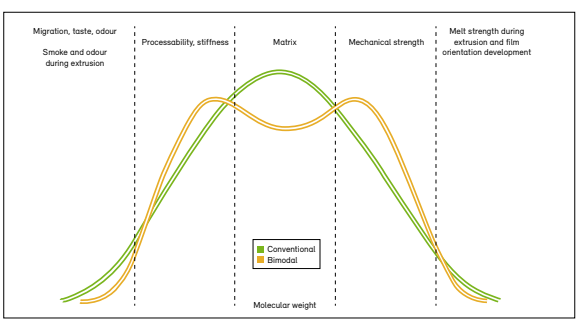
Efficiency & simplification

- Substitution of expensive multi-substrate packaging structures and simplified recipes
- Improved processability and energy reduction

Borstar® technology

To satisfy today's growing demand for advanced plastics, our unique Borstar® technology is a critical element in developing the next generation of innovative, value creating plastics. The Borstar process offers simultaneous improvements in conversion economics and in key environmental aspects, such as source reduction and recyclability.

The fundamental feature of Borstar technology is its dual reactor operation, which allows us to produce materials for film extrusion in a wider range of densities and MFR, with a broad bimodal molecular weight distribution and tailored comonomer distribution. Unlike conventional bimodal processes, which are limited to HDPE and MDPE products, Borstar can also produce bimodal LLDPE resins.



Based on the bimodal polymer design concept, Borstar technology resins offer the flexible extrusion qualities of traditional LDPE, combined with the superior mechanical properties of high alpha olefin linear products. The combination of these properties facilitates increased production efficiency with value generating potential in blown film extrusion as well as in converting and packaging.

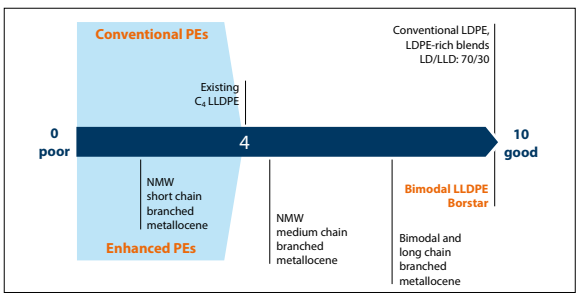
Borstar technology products include:

- Borstar LLDPE
- BorShape™ LLDPE

Borstar LLDPE products

The Borstar LLDPE product mix comprises an extended list of blown film resins. These grades are all very well suited for extrusion on most blown film lines, including coextrusion and blends as well as coextrusion with HDPE on high neck HD extrusion lines.

The diagram below, showing the relative processabilitiesof various types of resins reveals the superior processing behaviour of Borstar LLDPE at the level of LDPE:



Key processing elements	Main benefits
· Bubble stability	· Production regularity
· Few bubble breaks	· Full film thickness range
· No melt fracture	· High output
· Draw down	· Recipe standardisation
· Lower melt pressure vs. LLDPE	· Fast transitions
· Well suited for coextrusion	· Production efficiency
· Blendability	· Reduced production cost

The unique combination of stiffness and mechanical properties such as tear, impact and yield strength offers a genuine downgauging potential for packaging film. Features traditionally obtained by coextruded structures, combining blends of different PEs in each structure, may be achieved with a single material and in most cases with a thinner film.

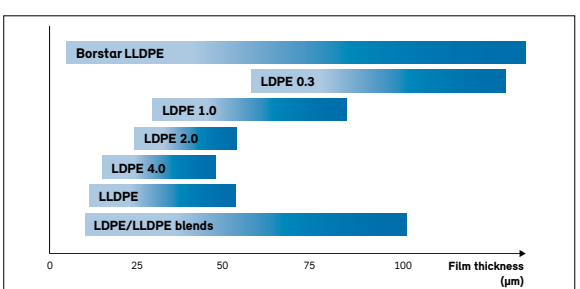
Key film properties	Main benefits
· Very high toughness · High impact vs. stiffness · Extremely low gels · High toughness at frozen conditions · Matt surface	· Improved film strength · Stiffer films at retained toughness · Downgauging · Improved film quality · Printing quality · Non-blocking · Easy COF control

The controlled comonomer distribution results in low taste and odour levels as well as in improved low-temperature properties, compared to traditional PEs. Furthermore, films made of Borstar LLDPE grades have a high seal strength and hot tack force.

Borstar LLDPE offers a unique balance of properties combining the key benefits of LDPE, LLDPE C6/C8, mLLDPE and MDPE/HDPE resins:

LDPE	Processability / bubble stability	Borstar LLDPE
LLDPE C6/C8 mLLDPE	Hot tack force / draw down / elongation / impact	
MDPE/HDPE	Yield stress / tensile strength / secant modulus	

In contrast to other conventional resins, Borstar LLDPE products cover the full film thickness range:



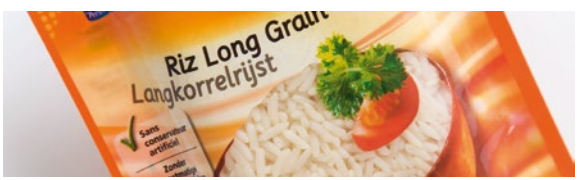
Borstar LLDPE film solutions create benefits throughout the entire value chain:

Converter	• Bubble stability • Production regularity & output	• Film thickness range • High mechanical properties
Packer	• Downgauging • Packaging integrity	• Packaging efficiency • Cost efficiency
Retailer	• Good handling • Packaging intergrity • Innovative design solutions	• No off-taste or flavour • Less product spoilage
Consumer	• Attractiveness • High mechanical properties • Less product spoilage	• No off-taste or flavour • Packaging integrity

Applications

The Borstar LLDPE product range is suitable for a broad variety of film and flexible packaging applications:

- Lamination film
- Deep freeze applications
- Versatile FFS packaging
- Box liners / sheets for fish and meat
- Ice cube bags
- Stand-up pouches
- Consumer and industrial shrink films
- Nappy / diaper packs
- Shipping sacks
- Courier mail envelopes
- Hygiene applications
- Breathable films for nappy / diaper barriers



Processing guidelines

Borstar LLDPE can be conveniently processed on state-of-the-art LD/LLD blown film extrusion lines. The processing conditions will influence the final film properties. Therefore, we recommend adhering to our general guidelines:

	Borstar LLDPE	LDPE	LLDPE
Extruder temperature	190-210°C	< 200°C	200°C
Die gap	1.0-1.8 mm narrow	0.8-1.5 mm narrow	1.8-2.3 mm wide
Cooling ring	mono lip dual lip	mono lip	dual lip
Blow Up Ratio (BUR)	2:1 - 4:1	1.5:1 - 3:1	2:1 - 4:1

BorShape covers several packaging challenges with one solution

Borealis provides a revolutionary solution that addresses the key challenges of the film packaging market:

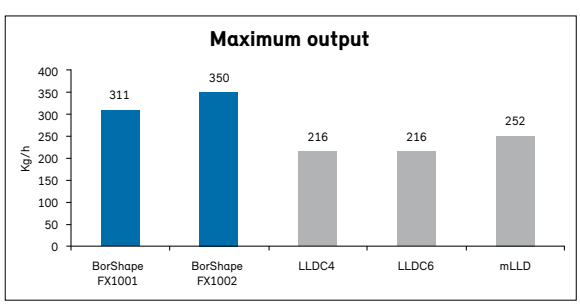
- Cost competitiveness
- Enhanced packaging performance
- Sustainability

BorShape is a new generation of materials based on Borealis' Borstar bimodal technology, focusing on the most challenging sustainability targets: downgauging and light-weighting. Moreover, BorShape offers high packaging rigidity for enhanced end-user feeling and improved packaging integrity without compromising operational performance.

Two grades have been introduced into the market: BorShape FX1001 and FX1002.

Cost competitiveness

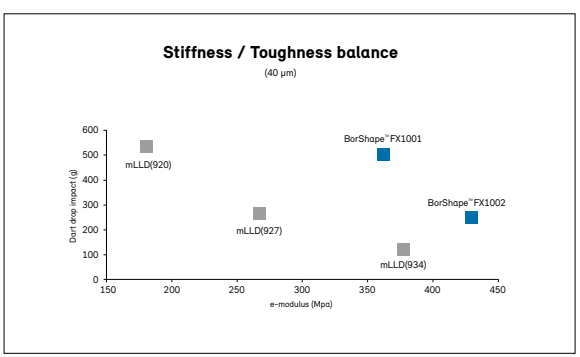
Outstanding processability at the converter allowing, in comparison to other LLDPE / mLLDPE materials, a more than 20% higher output.

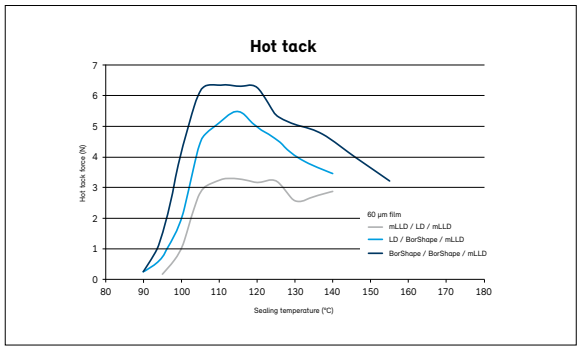


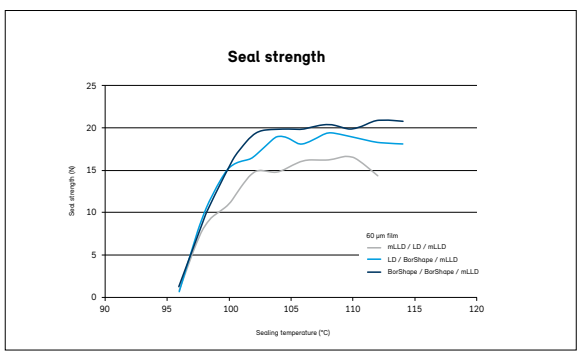
Enhanced packaging performance

To meet the challenges of the flexible packaging industry, the BorShape product family has been designed to become the benchmark in the polyolefin film market when it comes to unparalleled performance in the most demanding film properties:

- Excellent stiffness – toughness balance offering a significant downgauging potential of more than 30%. Downgauging is fundamental in the majority of film application areas due to the focus on cost competitiveness, increased environmental awareness and the aim to reduce overall packaging consumption
- High stiffness for high packaging rigidity, for efficient film converting operations, allowing for superior stand-up ability and enhanced end-user feeling
- High toughness and superior seal strength for excellent packaging integrity allowing a reduced number of default packages
- Good hot tack performance in combination with mLLDPE/plastomer skin solution for high packaging speed and thus improved operational performance







Sustainability

BorShape supports sustainability within the film packaging industry, responding to the demand for more environmentally friendly developments and therefore reduced packaging waste. The easy-to-recycle film solutions have a low green tax impact and offer a lightweight alternative with less material consumption compared to other packaging concepts.

In combination with the optimum processing behaviour, this provides the complementary advantages of lower energy usage during processing and transport as well as environment-related benefits. The performance features and the unique property profile of BorShape translate into benefits along the whole value chain: from the converter of the film, through the packer and brand owner to the final end user.

BorShape film packaging solutions have been developed across the different end uses:

Flexible packaging

Frozen food, hygiene overwrap, nappy / diaper packaging, liquid packaging, produce packaging, lamination

Other packaging

Collation shrink, heavy/medium duty bags, liners, compression packaging, mail bags

Non-packaging

Agricultural films, refuse bags, retail bags and snacks

Borealis MDO film solutions

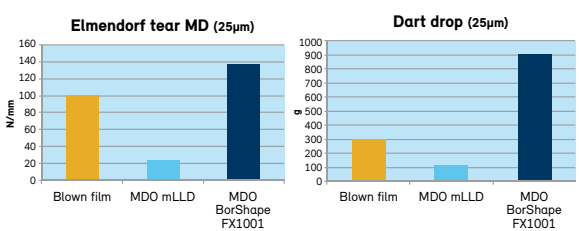
BorShape sets new standards in MDO performance

Borealis recently launched BorShape family of materials, which is bringing step-change innovation to advanced flexible packaging film solutions. Together with MDO (Machine Direction Orientation) converting technology, it offers excellent packaging performance and substantial economic benefits for the key value chain players including converters, brand owners and end users. Furthermore, Borealis-based MDO solutions foster sustainability and environmental responsibility by significantly reducing packaging weight and thus improving the green image of the end product.

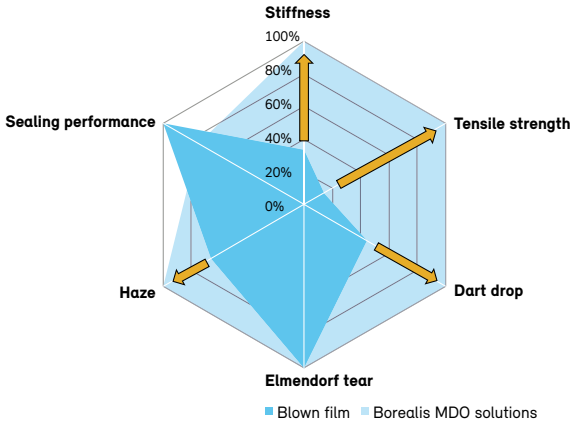
BorShape, combined with the MDO converting technology, allows the flexible packaging market to achieve:

- New packaging performance levels at reduced packaging weight
- Step-change downgauging
- Value generation across the entire value chain

The BorShape product family sets a new standard in performance of MDO films, achieving excellent tear resistance in MD as well as a very high toughness:



These features, complemented by the recognised performance of the MDO technology, contribute to the films' very high MD tensile strength, high stiffness levels, transparency and gloss.



Application areas where BorShape facilitates significant packaging improvements include shipping sacks, twist wraps, magazine wraps, lamination films, compression packaging, labels and many others.

To support the film industry in the development of MDO advanced packaging solutions, Borealis offers application development expertise on MDO, enhanced by an industrial-scale MDO line.

PE blown film data sheet

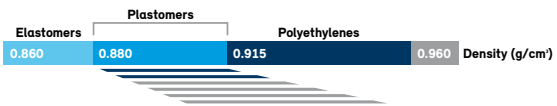
Product	MFR [g/10 min] 190°C / 2.16 kg	MFR [g/10 min] 190°C / 5 kg	MFR [g/10 min] 190°C / 21.6 kg	Density [kg/m³]	Melting Temp.[°C]	AO	Anti-blocking agent [ppm]	Slip agent [ppm]	Other agent additive
Borstar LLDPE									
FB2230		1.0	22	923	124	yes			
FB2310		0.9	20	931	127	yes			
FB4230		2.0	44	923	124	yes			
FB4370		2.1	42	937	128	yes			
FB3450		1.1	25	945	129	yes			
Borstar MDPE									
FB1350		0.6	15	935	127	yes			
BorShape									
FX1001		0.9	20	931	127	yes			
FX1002		2.0	42	937	128	yes			
LDPE Autoclave									
FA3221	0.3			922	110	yes			
FA3227	0.3			922	110	no			UV
FA5223	1.2			922	110	yes	850		
FA5224	1.2			922	110	yes	850	450	
FA6220	2.1			922	111	yes			
FA6224	2.1			922	111	yes	850	500	
FA7220	4.0			922	111	yes			
FA7224	4.0			922	111	yes	1,100	700	
FA7229	4.0			922	111	yes			AF/CA
LDPE Tubular									
FT3200	0.25			920		no			
FT5230	0.75			923		no			
FT5236	0.75			923		yes	800	550	
FT6230	2.00			923		no			

MFR = melt flow rate

Additives:
AO = antioxidant
UV = UV-stabilised
AF = antifog
CA = cling additive

Who is Queo™?

Queo™ plastomers are a range of low-density ethylene copolymers made possible by combining metallocene catalyst technology with the Compact solution polymerisation process. The comonomer used by Borealis plastomers is octene. As the name implies, plastomers bridge the gap between plastics and elastomers. They exhibit many of the physical properties of a rubber and combine this with the processing advantages of a thermoplastic.



Density (g/cm³)	0,87	0.88	0.89	0.90	0.91	0.92
DSC peak melting point (°C)	50-55	60-65	75-80	90-95	100-105	115
1% sec. modulus (MPa)	15	20	40	70	120	180

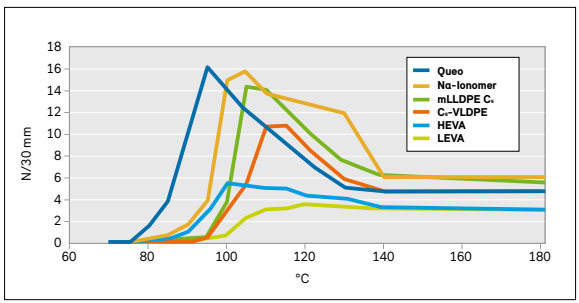
What do Queo plastomers deliver?

Our metallocene catalyst technology affords a highly efficient and consistent incorporation of octene comonomer into a polyethylene backbone. This results in low density and ensures precisely defined polymers with a range of unique performance attributes:

- Lower peak melting points and narrower melting ranges, providing controlled sealing performance and superior sealing against contaminations
- Flexural modulus similar to elastomers and thermoplastic behaviour without plasticisers or polar comonomers
- Exceptional compatibility with other polymers and elastomers to provide tailored attribute-blending opportunities
- Outstanding clarity
- Very low extractables
- Exceptional toughness

Queo plastomers add value in a wide range of film applications, many of which have been demonstrated to exceed the requirements of the plastomer attributes. As a result, Queo plastomers are extensively used as a blend partner, offering the opportunity to tailor performance to the cost balance of finished articles.

Hot tack positioning of Queo.



Queo plastomers data sheet

Product name	Grade	MFR [g/10 min] ISO 1133	Density [kg/m³] ISO 1183	DSC peak melt point [°C] ISO 11357 ASTM D3418	Film applica-tions	Extrusion coating structures	Additivation
Queo	8201	1.1	882	73	●		
Queo	8201LA	1.1	882	75	●		low anti-oxidant
Queo	8203	3.0	882	74	●		
Queo	8210	10.0	882	75		●	
Queo	8230	30.0	882	76		●	
Queo	0201	1.1	902	97	●		
Queo	0201FX	1.1	902	95	●		slip & anti-block
Queo	0203	3.0	902	96	●		
Queo	0210	10.0	902	97	●	●	
Queo	0219	19.0	902	97		●	
Queo	0230	30.0	902	97		●	
Queo	1001	1.1	910	106	●		
Queo	1007	6.6	910	105	●		
Queo	1019	19.0	910	104		●	

PP blown film

Recent polypropylene developments in terms of polymer structure (co-polymers) and special nucleation systems make it possible to use PP much more economically on blown film lines with air cooling. The latest progresses in coextrusion technology support the utilisation of PP's full potential.

Borealis PP blown film grades offer excellent performance, recognised by the film industry, due to such properties as:

High stiffness in blends or as coextrusion layer, which offers
- Downgauging potential
- Very good conversion on packaging equipment
- Good film flatness / punching quality

High heat deflection temperature enabling
- Sterilisation (depending on individual PP grade and conditions) up to 145°C
- Hot fill applications

Good optical properties including
- Surface gloss
- High transparency

Borealis' broad PP blown film product mix allows converters to cover a wide variety of applications.

Grade	Market need / property	Applications
Heterophasic copolymer BA110CF	Balanced stiffness / toughness ratio, sterilisable	Laminated film for food packaging, monoaxial oriented film, hygienic film, siliconisable film
Enhanced heterophasic copolymer BC918CF	High stiffness / toughness balance, good optics after sterilisation	Stand-up pouch, label film
Random copolymer RB707CF	High stiffness and very good optics	Label film, laminated film, food packaging
Random / heterophasic copolymer SA233CF	Low temperature resistance, high softness and toughness	Hygienic film, industrial packaging, stand-up pouch

Processing guidelines

Borealis PP blown film grades may be processed on all conventional PE blown film equipment with air cooling.

Screw configuration

Borealis PP film grades should be processed using screws with a shear and a mixing part and a length of 25-33 D.

Die gap / blow-up ratio

We recommend die gaps in the range 1.2 and 2.0 mm for PP. Narrow die gaps support higher tear resistance in MD. Experience dictates the blow-up ratio should be between 2:1 and 3:1.

Cooling

To achieve optimum film properties (best optical properties and toughness) cooling the film as quickly as possible is required. Chilled air (<15°C) is highly recommended.

PP blown film data sheet

	MFR [g/10 min] 190°C / 2.16 kg	MWD	Melting temp. [°C]	C2 content	Nucleated	Tensile modulus MD/TD [MPa] (50 µm) ISO 527-3	Vicat A50 (°C) ISO 306
PP heterophasic copolymers							
BA110CF	0.85	medium	166	high	no	1,200 / 1,100	150
BC918CF	3.0	medium	168	medium	yes	1,550 / 1,150	155
PP random copolymers							
RB707CF	1.5	medium	145	medium	yes	950 /900	122
PP random / heterophasic copolymers							
SA233CF	1.0	medium	140	high	no	500/500	114

Borealis film solutions for the blown film market

In the following pages, you will find different examples of how Borstar, BorShape and Queo will create value for your film solutions.

Film solution for deep freeze film

Borealis 'Guide' formulation

Film sample – 40 µm 3-layer formulation

Borstar FB4230	25%	Matt distinct look with Borstar
BorShape FX1001 + white MB	50%	For toughness, stiffness, hot tack and processability
Sealing layer	25%	Sealing performance

Value creation potential with a BorShape-based solution:

- Efficient and stable film production at high output
- Excellent film appearance: glossy/matt, defect free, good film flatness and no gels
- Broad sealing window and high hot tack force
- Stiff and tough film, resulting in high puncture and impact resistance, also at low temperatures
- High potential for enhanced performance: more than 50% improvement over existing references
- High downgauging potential: more than 20% improvement over existing references

Film solution for high performing 5-layer collation shrink

The 5-layer polyolefin blown film technology, in combination with BorShape LLDPE, offers the market an ideal solution to further decrease film thickness while keeping the pack integrity intact.

Borealis 'Guide' formulation

Film sample – 40 µm 5-layer formulation to pack tin cans

mLLDPE / LDPE / HDPE blend	10%	For COF, optics and sealing performance
LDPE 0.3 MFR (85%) + HDPE (15%)	25%	For optimal shrink and stiffness
BorShape FX1001 (70%) + HDPE (30%)	30%	For outstanding toughness, puncture resistance and stiffness together with excellent processing
LDPE 0.3 MFR (85%) + HDPE (15%)	25%	For optimal shrink and stiffness
mLLDPE / LDPE / HDPE blend	10%	For COF, optics and sealing performance

Value creation potential with a BorShape-based solution:

- Excellent resin processability with reduced energy consumption at high output as an outcome
- Outstanding stiffness/toughness balance resulting in excellent holding force, reducing goods breakage or waste
- Very good puncture resistance
- Uniform shrink around the goods at normal production speed leading to improved on-shelf appeal
- Proven working solution on high-speed shrink oven
- Downgauging potential up to 30%, leading to packaging cost reduction while maintaining strong pack integrity

Film solution for enhanced PE laminate

In highly demanding lamination applications (e.g. stand-up pouches), the PO film substrate plays a vital role, contributing to properties such as mechanical toughness and sealing.

Borealis 'Guide' formulation

Film sample – 90 µm 5-layer formulation

BorShape FX1001 (60%) + mLLD (40%)		10%	For COF control and gel-free surface	
BorShape FX1002 + white MB		17.5%	For toughness and improved stiffness	
BorShape FX1001 + white MB		45%	For very high toughness, good web planarity and high reel quality	
BorShape FX1002 + white MB		17.5%	For toughness and improved stiffness	
Queo 0201FX (70%) + FT5236 (30%)	Or standard sealing layer	10%	Queo for excellent sealing performance, particularly in seal through contaminations	Good sealing for standard conditions

Value creation potential with a BorShape and Queo-based solution:

- Excellent toughness in demanding SUP applications (e.g. pet food and detergent packaging) for reduced pouch failure and product spoilage
- High stiffness for good web planarity and stand-up ability
- High toughness/stiffness balance for lightweight laminated packages
- High hot tack properties for superior pack speeds
- Optimised COF for rapid filling speeds
- Excellent reel quality for optimal handling in lamination and conversion steps
- Seal against contaminations (pouches, liquid packaging and many others)
- Excellent material flow through shear thinning for difficult seals (3/4 ply constructions)

Up to 30% potential for weight reduction while maintaining or even improving toughness and seal performance!

Borealis film solutions for the MDO market

In the following pages, you will find different examples of how BorShape and Queo will create value for your MDO film solutions.

Film solution for heavy duty shipping sacks

Shipping sacks for packaging of industrial products like polymers, fertilisers or minerals require exceptionally demanding specifications for the film's mechanical performance. With BorShape and MDO, we have focused on the heavy-duty shipping sack (HDSS) area. Film toughness, machine direction tear, creep and sealing are the key properties.

Borealis 'Guide' formulation

Film sample – 80 µm 3-layer formulation

BorShape FX1001 (70%) + Queo 0201FX (30%)	40%	Sealing and toughness
BorShape FX1001	45%	For stiffness and high toughness. Good processability in blown film and wide operating window in MDO
BorShape FX1001 (70%) + Queo 8201 (30%)	15%	Blocking layer

Primary film = 480 µm (blocked film 240 µm x 2)
Stretch ratio = 1:6
MDO HDSS film = 80 µm

Value creation potential with a BorShape and Queo-based solution:

- Significant reduction of packaging weight (37%)
- Reduction of packaging cost
- Sustainable packaging leading to 8% reduction on energy usage per unit
- Reduction of waste disposal
- Very high packaging integrity maintained

Film solution for compression packaging

Voluminous products such as insulation materials and mattresses are normally compressed when packed, in order to save space and transport costs. An MDO film is highly suited to this process, due to its extremely good creep resistance in MD. When produced from BorShape, the film will also provide exceptional toughness and security during transport as well as handling.

Borealis 'Guide' formulation

Film sample – 45 µm 3-layer formulation

BorShape FX1001	40%	Toughness. If higher sealing requirement needed, modify with Queo 0201FX.
BorShape FX1001	45%	For stiffness and high toughness. Good processability in blown film and wide operating window in MDO.
BorShape FX1001 (70%) + Queo 8201 (30%)	15%	Blocking layer

Primary film = 250 µm (blocked film 125 µm x 2)
Stretch ratio = 1:5.5
Compression film = 45 µm

Value creation potential with a BorShape and Queo-based solution:

- 50% downgauging potential
- High impact strength and good tear resistance for high package integrity
- Very high load retention due to excellent creep resistance
- Appropriate sealing

Label film

BorShape-based MDO film delivers a step-change downgauging solution for the label film market.

Borealis 'Guide' formulation

Film sample – 50 µm 3-layer formulation

HDPE	30%	For optical properties and stiffness
BorShape FX1002	55%	For stiffness, toughness and easy punch-ability. Good processability in blown film and wide operating window in MDO.
Queo 8203	15%	Blocking layer

Primary film = 300 µm (blocked film 150 µm x 2)
Stretch ratio = 1:6
Compression film = 50 µm

Value creation potential with a BorShape and Queo-based solution:

- Very good display properties (high gloss and low haze)
- Good printability
- High stiffness for easy dispensing
- Easy punchability
- Recyclable – 100% PE solution

Notes

Notes

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