



Borcoat™ coating systems for oil & gas exploration and transportation

 **BOREALIS**

بروج
Borouge 

SHAPING *the* FUTURE *with* PLASTICS

About Borealis and Borouge

Borealis and Borouge are leading providers of innovative, value creating plastics solutions. With more than 40 years of experience in polyolefins and using our unique Borstar® technology, we focus on the infrastructure, automotive and advanced packaging markets across Europe, the Middle East and Asia. Our production facilities, innovation centres and service centres work with customers in more than 170 countries to provide materials that make an essential contribution to society and sustainable development. We are committed to the principles of Responsible Care® and to leading the way in 'Shaping the Future with Plastics'™.

Borealis is owned 64 % by the International Petroleum Investment Company (IPIC) of Abu Dhabi and 36 % by OMV, the Austrian oil and natural gas group. With EUR 5.7 billion revenue in sales in 2006 and 4,500 employees, the company is headquartered in Vienna and has manufacturing operations in Austria, Brazil, Belgium, Finland, Germany, Italy, Sweden and the United States. Borealis also has two innovation centres and customer service centres across Europe.

The company's main products are polyolefins and it produces also nutrients and base chemicals such as melamine, hydrocarbons, phenol and acetone.

Borouge is a joint venture established in 1998 between Borealis and one of the world's leading oil companies, the Abu Dhabi National Oil Company (ADNOC). Its headquarters, counting 830 employees, and its state-of-the-art world-scale petrochemical complex are located respectively in Abu Dhabi and Ruwais, the United Arab Emirates. Borouge is currently implementing a multi-billion dollar expansion at its Ruwais production facility. The project, called Borouge2, is due for completion in 2010 and will triple the company's polyolefin production capacity.

For more information:

www.borealisgroup.com

www.borouge.com



Borealis plant in Stenungsund, Sweden



Borouge plant in Ruwais, Abu Dhabi, UAE



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Borcoat PP thermal insulation system

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Borealis and Borouge Pipe: the innovative, committed, solution provider

Borealis and Borouge pipe products are used in a wide range of applications. The current list includes water supply, gas distribution, sewerage & drainage, plumbing & heating, oil & gas exploration and transportation, district heating, irrigation and a broad variety of industrial applications.

A high level of investment into research and development in close co-operation with our customers ensures the continual development of innovative new products and pipe system solutions.

Market overview

Steel pipelines are used for the transport of natural gas, crude oil, petrochemicals and water at high pressure over long distances. These pipelines are protected against corrosion by external coating systems and cathodic protection.

Five main coating alternatives are commonly specified for pipelines: Three Component PE and Three Component PP, Fusion Bonded Epoxy (FBE), coal tar, asphalt enamel and polyurethane (PUR). Basically, a geographical or a segment split can be defined for each system:



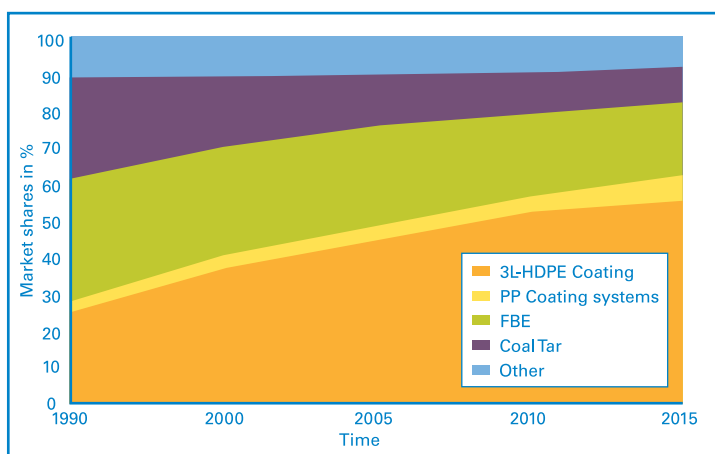
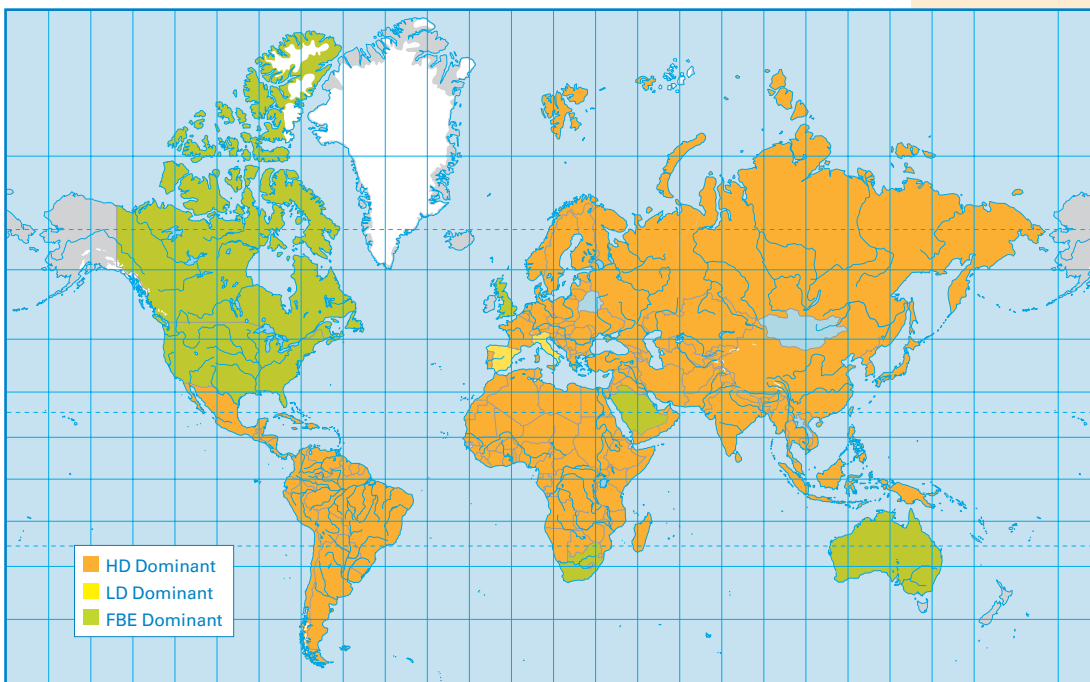
Pipe storage, Iran

- Three Component PE is strongly dominant worldwide, with the exception of North America. The trend is increasing with a greater number of projects coated with Three Component PE in China and the Middle East.
- Three Component PP and multi-component PP systems (several functional PP layers combined) are recognised as excellent systems for onshore and offshore projects with elevated operating temperature above 85°C and up to 140°C and extreme mechanical stresses on the pipes. Recent projects in the North Sea, Africa, Gulf of Mexico and Arabian regions have set new project standards for PP coatings, which provide access to deeper gas and oil fields.

- FBE, still dominant in North America, United Kingdom and a few other countries and projects, is specified but the trend is declining in favour of Three Component PE and PP Systems.
- Coal tar and asphalt enamel: both solutions are still applied in some countries. Both systems are declining and suffer from health and environmental concerns.
- PUR systems are mostly used for pipeline rehabilitation projects or girth weld coating. They also suffer from health concerns.

What is a Three Component System?

A Three Component System consists of an epoxy primer and an adhesive to bond the epoxy primer with a polyolefin topcoat. Polyolefin-based systems offer excellent mechanical protection and long-term ageing performance.





Transport of coated steel pipes

What Borealis and Borouge offer

Borealis has many years of experience and expertise in the plastic pipe industry and more than 20 years in steel pipe coating. Within this period, the group developed and supplied an extensive number of projects all over the world, initiated with the supply of low density (LDPE) and medium density (MDPE) compounds and its first bimodal high density PE system in 1997. In parallel, Borealis introduced its first PP system in 1990.

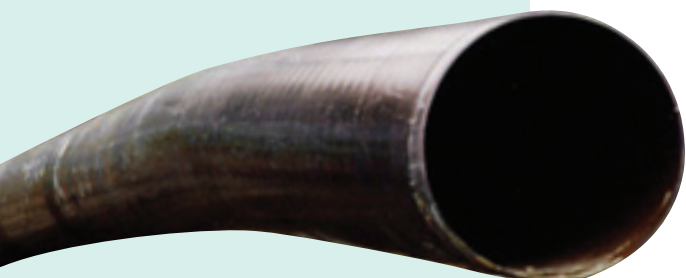
Current Borcoat solutions :

- Borcoat high density polyethylene system, for operating temperatures from -45°C to $+90^{\circ}\text{C}$
- Borcoat polypropylene systems for operating temperatures up to $+110^{\circ}\text{C}$
- Borcoat PP thermal insulation systems for offshore projects, for operating temperatures up to $+140^{\circ}\text{C}$

Borcoat products for pipe coating systems

PE System

- **Borcoat HE3450:** Black bimodal HDPE top coat for pipe coating, produced with Borstar technology.
- **Borcoat ME0420:** Grafted adhesive in granule form, in combination with HE3450 provides superior adhesion properties at low and elevated service temperatures, from -45°C to $+90^{\circ}\text{C}$.
- **Borcoat ME0433:** Grafted adhesive in powder form, in combination with HE3450 provides superior adhesion properties at low and elevated service temperatures, from -45°C to $+90^{\circ}\text{C}$.



PP system

- **Borcoat BB108E-1199:** White PP top coat for three component system, service temperature up to +110°C. Excellent thermal ageing resistance and UV protection. Compatible with Borcoat BB127E.
- **Borcoat BB127E:** Grafted adhesive for extreme service temperature up to +140°C, multi-layer structure system. Available in granule and powder form.
- **BA202E:** PP copolymer for thermal insulation.
- **Borcoat BA213E & WB130HMS:** High modulus PP copolymer and high melt strength PP for thermal insulation - deep water applications.
- **Borcoat BB700E-7032:** Grey PP compound for deep water applications.
- **Borcoat EA165E:** PP for field joints, injection moulding.
- **Borcoat MA115E:** High density PP for weight coating.
- **Borcoat BB108E-1199 POWDER:** White PP compound in powder form for rough coating and repairs.

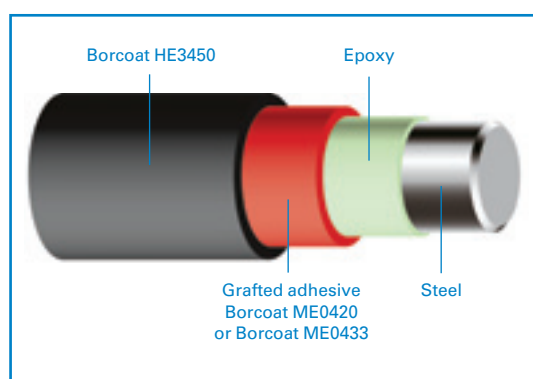


Figure 3a: Three Component Coating Borcoat HDPE

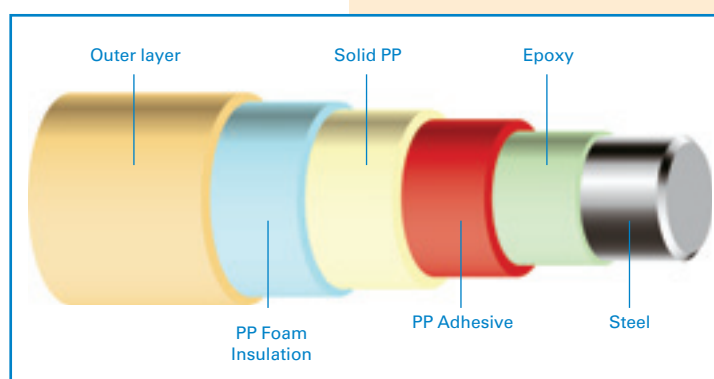


Figure 3b: Multilayer PP coating systems for offshore applications

Selection and design of coating systems

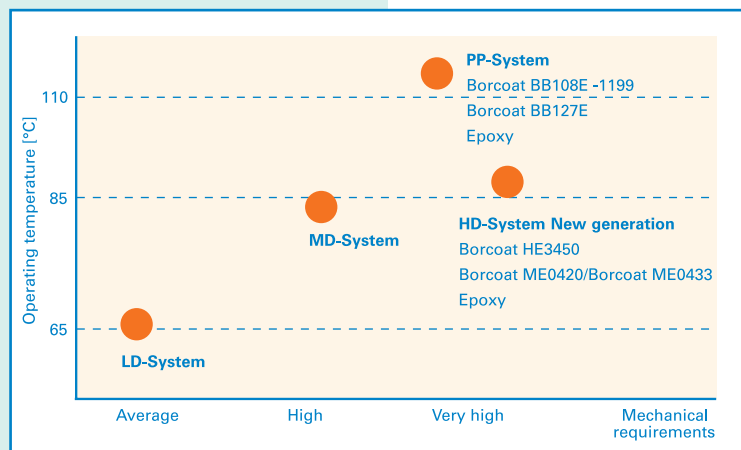


Figure 4: Selection guidelines for Three Component Borcoat systems

Operating temperature

Once the pipeline design temperature range is known, the selection can be limited to the few systems providing the optimal performances.

The polyolefin Three Component System covers the broadest design service temperature range:

from -45°C to +90°C for HDPE systems and from -10°C to +110°C for a PP onshore system and up to +140°C for specific offshore projects.

Durability

Safeguard your investment with long-term, low maintenance service life by using Borcoat durable systems. Pipe dimensions, storage conditions, pipe handling, transport and installation conditions will drive the choice of a coating system. Some of these are not strictly defined when the coated pipe is manufactured. The design should be based on worst case scenario and have some additional safety margins built in by specifying the most durable materials: Borcoat PE or Borcoat PP solutions. The most important factors for durability, based on material selection, are indentation resistance, impact properties, abrasion resistance, notch resistance, chemical resistance and bond strength between the layers.

UV protection

This must be addressed as one of the critical properties. Both Borcoat HE3450 and Borcoat BB108E-1199 pass the most stringent UV requirements in existing standards.

Why choose polyolefin coating systems?

Conservative tendencies and old habits are still key decision drivers for a large number of projects. The existing type of coating equipment in the country also plays a significant role when the type of coating is chosen: polyolefin systems are attractive when compared to other solutions such as FBE or asphalt because overall costs will be reduced over the pipeline service life due to the limited passive protection and lower handling and maintenance costs, etc. Raw material costs for Three Component Polyolefin Systems are typically a small percentage of the total pipeline budget.



Pipe storage in the Middle East

PE coating systems for demanding onshore & offshore pipelines

Borcoat adhesives

The purpose of the adhesive is to bond the epoxy layer to the top coat. Borealis and Borouge offer grafted adhesives. PE Maleic Anhydride (MAH) grafted adhesives are characterised by superior adhesion properties at elevated operating temperatures versus conventional copolymer adhesives.

Due to a stronger focus on the overall performances of the coating systems, the use of conventional copolymer adhesive with lower peel strength properties is declining. Borcoat adhesive grades for PE and PP systems are listed in the product tables.

Each batch of PE and PP adhesive is carefully controlled in our laboratories during all the production stages. These controls include peel strength tests carried out on coated pipe from our pilot line located in Finland.

Borcoat HE3450

This well established system, (bimodal black high density Borcoat HE3450 and grafted adhesive Borcoat ME0420 and an appropriate primer epoxy), has demonstrated outstanding properties versus traditional low and medium density solutions.

Since its introduction in 1997, Borcoat HDPE has substituted low density and medium density PE systems in many countries and been applied for an extended number of large projects worldwide.

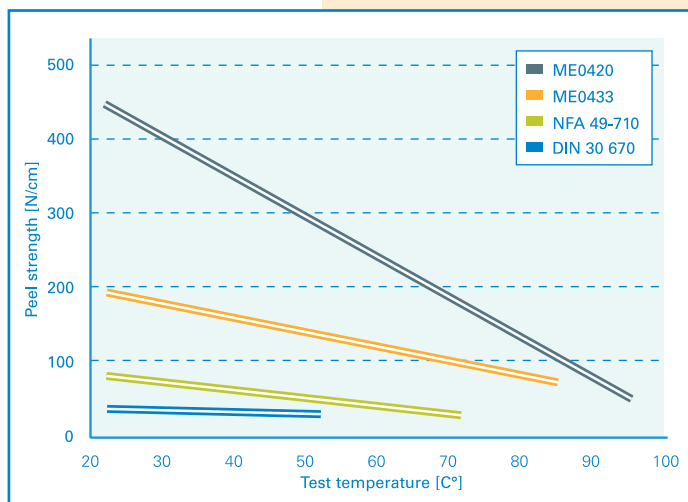


Figure 5: Peel strength of Borcoat adhesives



Pipe coating cooling rack

Borcoat coating systems showcase world-class durability under testing conditions



Borstar technology

Borstar PE and PP production technology has been developed by Borealis and is unique to Borealis and Borouge. Borcoat HE3450 is served from our plants located in Sweden, Finland and Abu Dhabi, UAE.

Bimodal PE vs. Unimodal PE features in pipe coating applications

A comparison of Borcoat HE3450 and unimodal PE highlights the advantages of the Borstar process. The Borstar process makes it possible to combine the best properties of various conventional PE types into one product, thereby creating new products to set new standards. The most important properties to design a suitable top coat HDPE for pipe coating are:

- Processability, maximised output
- Improved melt strength
- Stress cracking resistance
- Improved impact at low and elevated temperature
- Indentation resistance
- Low shrinkage
- Improved abrasion resistance

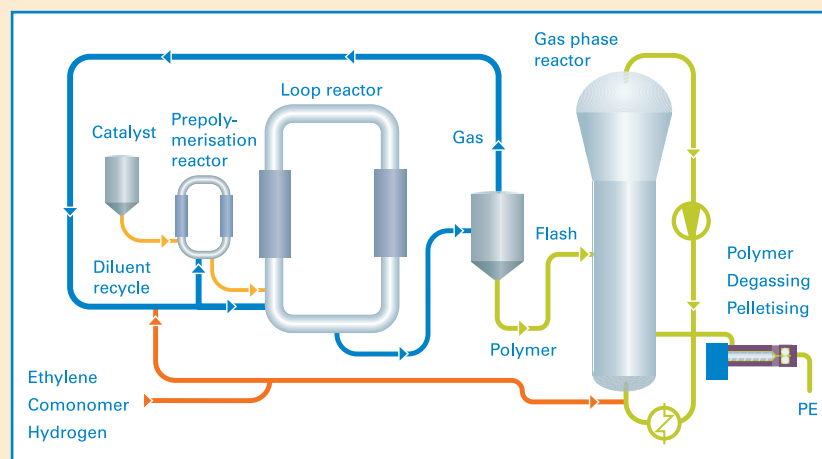


Figure 6: Borstar PE Bimodal process

Comparison of polyolefin coating systems

Properties	PP Borcoat BB108E1199	LDPE	MDPE unimodal	HDPE unimodal	HDPE Bimodal Borcoat HE3450	Comments on Borcoat HE3450
Impact, low and elevated	●●●	●●	●●●	●●	●●●●●	Excellent at low and elevated temperature (-45°C to +90°C)
Indentation	●●●●●	●●	●●●●	●●●●●	●●●●●	Excellent at elevated temperature versus LDPE
Low shrinkage	●●●●	●●●●●	●●●	●●	●●●●	Low shrinkage for bimodal versus unimodal PE
Processability (output)	●●●●●	●●●●●	●●●	●●●	●●●●●	Even better versus LDPE with appropriate extruder
Melt strength	●●●	●●●	●●	●●	●●●●●	Excellent behaviour in the melt stage - no break during extrusion
Abrasion	●●●	●●	●●●●	●●●●●	●●●●●	Taber CS17 wheel, 1,000 hrs, resistance 23°C, wear index 12
Stress cracking resistance	●●●●●	●●	●●●	●●	●●●●●	>5,000 Hours 10% Igepal, IEC811 4-1/B

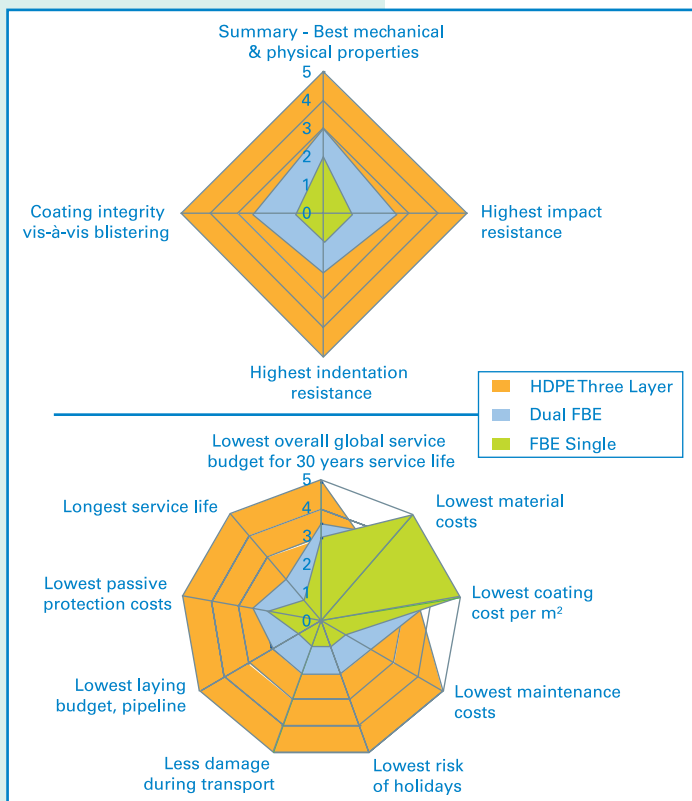


Figure 7: Comparison 3 Layer HDPE systems versus FBE
 – a. Physical and mechanical properties
 – b. Cost elements

Processability

Borcoat HE3450 is recognised by coaters as a user-friendly material to process. Production output on conventional extrusion lines with barrier screws are in line with LDPE rates, and even greater. Melt strength is far better than unimodal HDPE and MDPE, which makes Borcoat HE3450 easier to apply on pipes.

Bimodal high density versus low density systems

A period of 5 years from 1997 to 2001 was sufficient to switch the European coating market from LDPE to bimodal high density systems. Benefits like optimised processability, better mechanical properties and coating thickness reductions have contributed to this transfer; this trend is still ongoing in southern Europe.

PP coating systems for challenging onshore and offshore pipelines

Onshore pipelines

Polypropylene three layer systems (Borcoat BB108E-1199 and/or Borcoat BB125E/BB127E and epoxy primer) are typically used where the design temperature is above +90°C and up to +110°C.

Offshore pipelines

As a pipe coating material, polypropylene has long been recognised as one of the best technical and economical solutions for ensuring the long-term corrosion protection of steel pipelines in offshore applications.



Borcoat pipes being prepared

Polypropylene is a suitable material for thermal insulation applications due to its:

- High temperature resistance over a wide temperature range from -10°C to +140°C
- Flexibility
- Low water absorption
- Thermal conductivity
- Impact resistance
- Abrasion resistance
- Creep resistance, long term performance
- Easy and stable processing
- High welding capability
- Environmental friendliness

Over the last 15 years PP foam has shown its excellence as a thermal insulation of sub-sea pipelines. Beneficial properties such as low water absorption, good insulation due to low thermal conductivity and good compression strength have promoted its use in global thermal insulation projects with water depths up to 2,200 m.



Examples of Borcoat PP thermal insulation systems



Borcoat PP thermal insulation system cutbacks

As water depth increases for offshore gas and oil production, thermal insulation becomes increasingly important. In order to design these pipelines, Borealis has developed specific compounds for this new market area.

PP compounds for foamed insulation

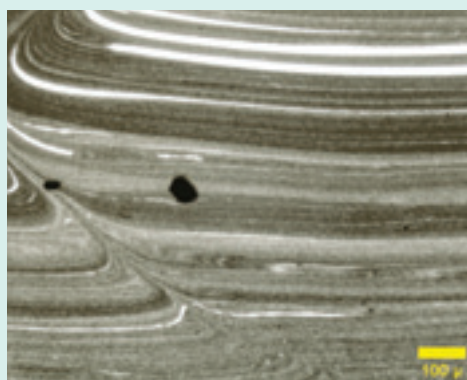
With a combination of PP stiff and high melt strength PP, an even distribution of bubbles is formed with a closed cell structure to provide higher compression strength and higher creep resistance than standard PP foam.

Other types of systems can be designed and evaluated according to the project requirements.

Ready-made compounds

PE and PP products for pipe coating are produced by compounding in all the necessary additives with the polymer powder in a highly controlled manner.

The additives protect the polymer from degradation during the coating process and its service life. With inline compounding and more than 30 years of experience, Borealis and Borouge have all the necessary competence and experience to design products with optimum properties



Inadequate dispersion of additives and pigments

and consistent high quality. Mixing additives and pigments into natural resin prior to extrusion or re-compounding polymers designed for other purposes will not guarantee properties such as processability and long term performance.

Compatibility with epoxy powders

Borcoat grafted PE and PP adhesives are compatible with a broad range of epoxy powders present in the market. Nevertheless, the latest generation of epoxy has a broader process window and provides better short and long-term properties.

Contact with Borealis and Borouge is recommended if you have any specific questions about compatibility and suitability to meet project specifications. Borealis operates a pilot line coating plant in Finland for 4" pipes. Used both for quality control and development work, the pilot can model a wide range of commercial facilities including cross head and side wrap extrusion and powder adhesive application, enabling all personnel to investigate the performance of different systems with all combinations of components. This unique tool is also used to train staff of pipe coaters and for technical co-operation with partners.

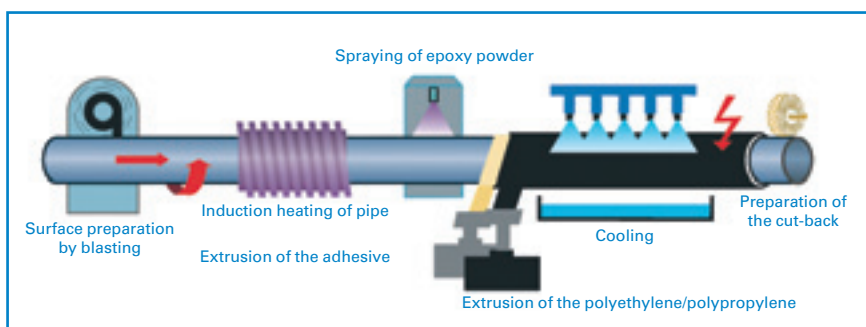
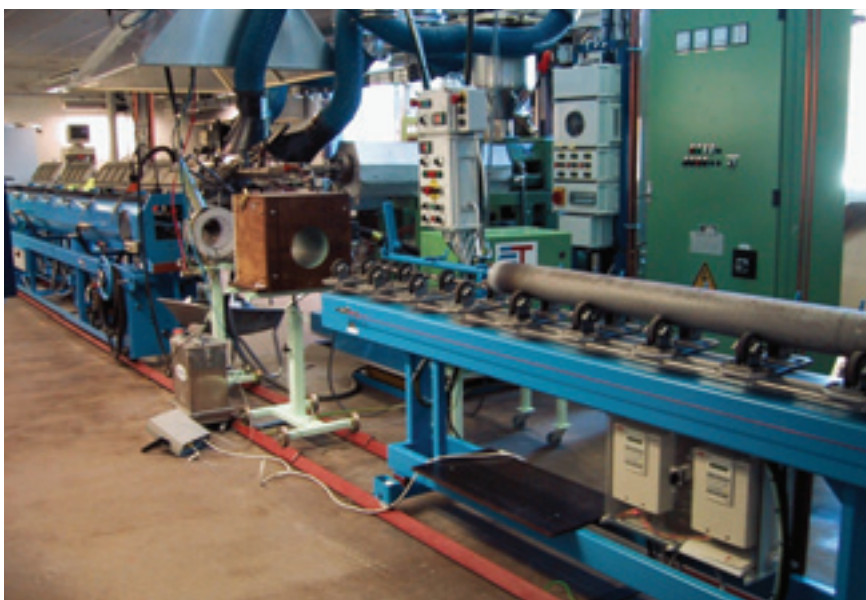


Figure 8: Coating pilot line – technical knowledge and expertise



Borealis pilot line in Porvoo, Finland

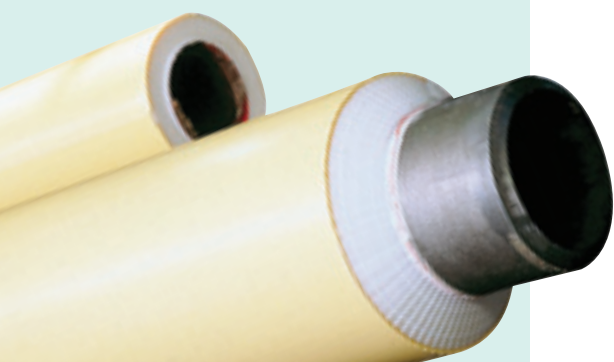
Selected track records of Borcoat systems

Borcoat HDPE system

Project name	End-user	Pipeline dimensions	Country	Year
Yamal, Russia	Gazprom	1,800 km 56"	Germany	1997-99
Bapetco, Egypt	Bapetco	400 km 36"	France	1997
TAG Loop 2, Austria	OMV	300 km 42"	Germany and Italy	2000
Maqta-Jabel Ali Gas UEA	Atheer	160 km 48"	UEA	2000
Marches du Nord Est, France	Gaz de France	40 km 40"	Germany	2001
GKI, Russia	Gazprom	100 km 56"	Germany	2001
IGATT, Iran	NIGC	200 km 56 & 48"	Iran	2001
WEP	CNPC	600 km 42"	China	2001-02
BTC	Botas	1,100 km 36 & 42"	Turkey	2003
West East Pipeline Project	CNPC	900 km 40"	China	2002-03
Vizag Secunderabad LPG Pipeline	GAIL	588 km 10 & 12"	India	2003
Gas Infrastructure Delp. Project	SNGPL	804 km 8 to 36"	Pakistan	2002-03
NIGC-I&II	NIGC	626 km 24 to 56"	Iran	2002-04
Multi Products Pipeline Project	SPCC	741 km 12"	Sudan	2004
B-Sharara Melitah Onshore Pipeline	AGIP Oil	327 km 30"	Libya	2005
Inter refineries Pipeline project	Takreer	515 km 10 & 12"	UAE	2005
Dolphin Energy Project	Dolphin	360 km 36 & 48"	Qatar	2005-06

Borcoat PP system

Project name	End-user	Pipeline dimensions	Country	Year
Åsgard	Statoil	150 km 10 & 12"	Bredero Shaw, Norway	1997-01
PDO	Shell	80 km 28"	Eupec, France	1998
Corvette/Ketch	Shell	40 km 3 to 20"	BSR, UK	1998
Sudan	Shell	70 km 38"	Yadong, China	1998
Gaz de France	Gaz de France	30 km 30"	Eupec, France	2000-01
Ringhorne	Statoil	40 km 6, 8, 10"	Bredero Shaw, Norway	2001
Rang Dong	-	70 km 10, 14, 20"	Bredero, Malaysia	2002
Thunder Horse Field	BP and Exxon Mobil	80 km 219 to 329 mm	Bredero Shaw, USA	2005-06
Dolphin Energy Project	Dolphin	20 km 36"	PSL Limited, India	2006



Approvals and certifications

Since its introduction to the market in 1997, the Borcoat bimodal HDPE system has been approved and recognised as a reliable and efficient system by a large number of gas companies and gas authorities.

The Borcoat bimodal HDPE system and Borcoat PP Three Component System both pass the major existing standards and local specifications with superior safety margins, eg. DIN30678, NFA 49711, CSA-Z 245.21-02 and Draft ISO 21809-1.

Some major approvals and qualifications achieved so far on pipes coated with Borcoat high density systems:

- France: Gaz de France, Sollac
- Italy: Snam Rete Gas
- Austria: OMV
- Poland: Institute of Oil Mining and Gas
- Russia: Vniist and Vniigas – Gost norms
- China: CNPC
- India: EIL, Tractebel, Gail, BPCL, HPCL, GSPL
- Iran: NIGC, NIOC, NIOEC
- Egypt: Petrojet
- Pakistan: SNGPL
- UAE: Takreer, GASCO, DEWA, ATHEER
- Qatar: Dolphin, Total
- Kuwait: KOC
- Oman: PDO, Sohar Refinery, Galfar
- Sudan: SPCC
- Libya: AGIP Oil Company

Some major approvals and qualifications achieved so far on pipes coated with Borcoat PP systems:

- France: Gaz de France
- Norway: Statoil
- Brazil: Petrobras
- UAE: Takreer, GASCO, DEWA, ATHEER
- Qatar: Dolphin



Real ship used to lay offshore pipelines

All Borcoat manufacturing units are ISO 9001 certified by a third party. A copy of the certificate is available on request.



How to contact Borealis

Borealis sales offices and Technical Services are available to support your coating projects. We welcome inquiries from all sectors of the pipeline business (eg. coater, gas and oil company, engineering company, equipment supplier, etc.), and wherever your location. We invite you to check the nearest office under 'Borealis location' via the Borealis website.

Website: www.borealisgroup.com/pipe

E-mail: pipe@borealisgroup.com



How to contact Borouge

Borouge has commercialised the full range of Borcoat materials in the Middle East and Asia.

Website: www.borouge.com

E-mail: infopipe@borouge.com

Within the Borealis and Borouge pipe group, there is a team dedicated to the steel pipe coating market segment. Our experienced technical team is ready to provide support at any stage of your pipeline projects e.g. specification tasks, component compatibility, production settings etc. Please do not hesitate to contact us for advice.

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Borcoat, Beta-PPR, BorECO, BorSafe, BorPEX and Shaping the Future with Plastics are trademarks of Borealis A/S.

Borealis and Borouge are leading global suppliers of advanced polyolefin plastics solutions for the pipe industry. Through more than 30 years of close dialogue with customers and other stakeholders, we have developed a broad and innovative product and service portfolio. The applications cover water and gas distribution, waste and sewage disposal, chemical and industrial projects, in-house plumbing and heating and oil & gas exploration and transportation. Borealis and Borouge believe that customer-driven innovation is the only way to achieve and sustain progress. In the pipe industry, Borealis and Borouge have pioneered the development of stiff PP grades for sewage and storm water pipes (BorECO™) and "low sag" PE grades for large diameter PE pipes (BorSafe™). In hot and cold water systems the widest range of PEX and PPR materials (including BorPEX™ and the new Beta-PPR™) provide plastics solutions in worldwide plumbing and heating markets. Steel pipe coating solutions are also addressed with the widest range of PE and PP materials and adhesives (Borcoat™), which have been used in many of the world's largest oil and gas pipeline projects. Through foresight and focus on customer needs, Borealis and Borouge continue to provide innovative solutions for the pipe and fittings industry that adds real value throughout the value chain. We also know the high value that our customers in the pipe and fittings industry place on product consistency and processability. We pride ourselves on the performance of our products, and through ongoing investment in upgrades and new plant programmes, we continue to set new records for output efficiency and product reliability. Borealis and Borouge believe that responsiveness is the foundation of fruitful customer partnerships. We ensure this through highly skilled and experienced technical, marketing and product development people. In addition we have a strong sales force around Europe, the Middle East and Asia.



For more information:

visit www.borealisgroup.com and www.borouge.com

Borealis AG | IZD Tower
Wagramerstrasse 17-19 | A-1220 Vienna | Austria
Tel +43 1 22 400 000 | Fax +43 1 22 400 333

Borouge Pte Ltd | Sales and Marketing Head Office
1 George Street 18-01 | Singapore 049145
Tel +65 6275 4100 | Fax +65 6377 1233



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