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BOREALIS

BorSafe™ PE pipe materials – made for generations

Sustainable solutions for pipe infrastructure networks

BOREALIS

Borealis Pipe Systems

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 6,200 and operates in over 120 countries. It generated EUR 7.5 billion in sales revenue in 2012. 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 the unique 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 plant expansion in Abu Dhabi will be fully operational by mid-2014 with a total annual capacity of 4.5 million tonnes. After this Borealis and Borouge will have approximately 8 million tonnes of polyolefin capacity.

Borealis offers a wide range of base chemicals, including melamine, phenol, acetone, ethylene and propylene 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 around 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

Addressing global challenges

Climate, water and sanitation, energy and communication, healthcare and food – there are many challenges the world is facing today.

As part of Borealis' strategy of value creation through innovation, the company contributes to addressing these challenges through providing innovative materials for sustainable pipe systems, reliable energy networks, advanced food-preserving packaging and leading edge healthcare and automotive solutions. The contribution of plastics is particularly evident in the broad range of infrastructures which include drinking water, gas and geothermal and district heating delivery systems.

It is considered that even in industrialised countries up to 40% of distributed drinking water is lost because of old or inadequate pipe materials.

Today the world is facing severe water shortage problems. Climate change, growing populations, unsustainable water practices and unbalanced distribution of the resource are putting lives at risk. Around the world, lack of access to clean water and proper sanitation are a daily reality for more then one third of people.

The rapid growth in demand for energy in developed and developing countries is not only putting a strain on the world's energy resources but also on the infrastructure to deliver it.

Pipe infrastructures are vital and valuable community assets and are also a central aid to sustainable development. Many existing systems, especially in industrialised countries, are old and inefficient through leakage and loss of the gases and fluids they distribute and need replacement. Whether for replacement or the new systems needed to meet future demand, reliable and more durable pipe solutions will be required. Solutions that will eliminate losses, save energy and better serve communities and industries far into the future.

BorSafe PE materials from Borealis can make an important contribution to the production of high-quality, leak-tight network systems which play a key role in maintaining and extending the infrastructures necessary to social and economic development.

Climate

Climate – to limit CO_2 emissions and keep global warming under control.

Water

Water and sanitation – to provide access to water and sanitation to an ever growing population and responding to increasing water scarcity due to climate change.

Energy

Energy access – to provide for the world's increasing energy needs.

Communication

Communication – to extend, secure and strengthen communication networks that are critical to our modern economy and quality of life.

Healthcare

Healthcare – to provide access and an acceptable level of healthcare for a growing and aging global population.

Food

Food – to protect and deliver safe food from 'farm-to-fork' across regions to feed the world's growing population.

Borealis' complete portfolio of pipe solutions

Borealis is the leading global provider of advanced polyolefin plastics solutions for the pipe industry Through continuous dialogue with our customers and stakeholders, we have developed a broad and innovative product and service portfolio.

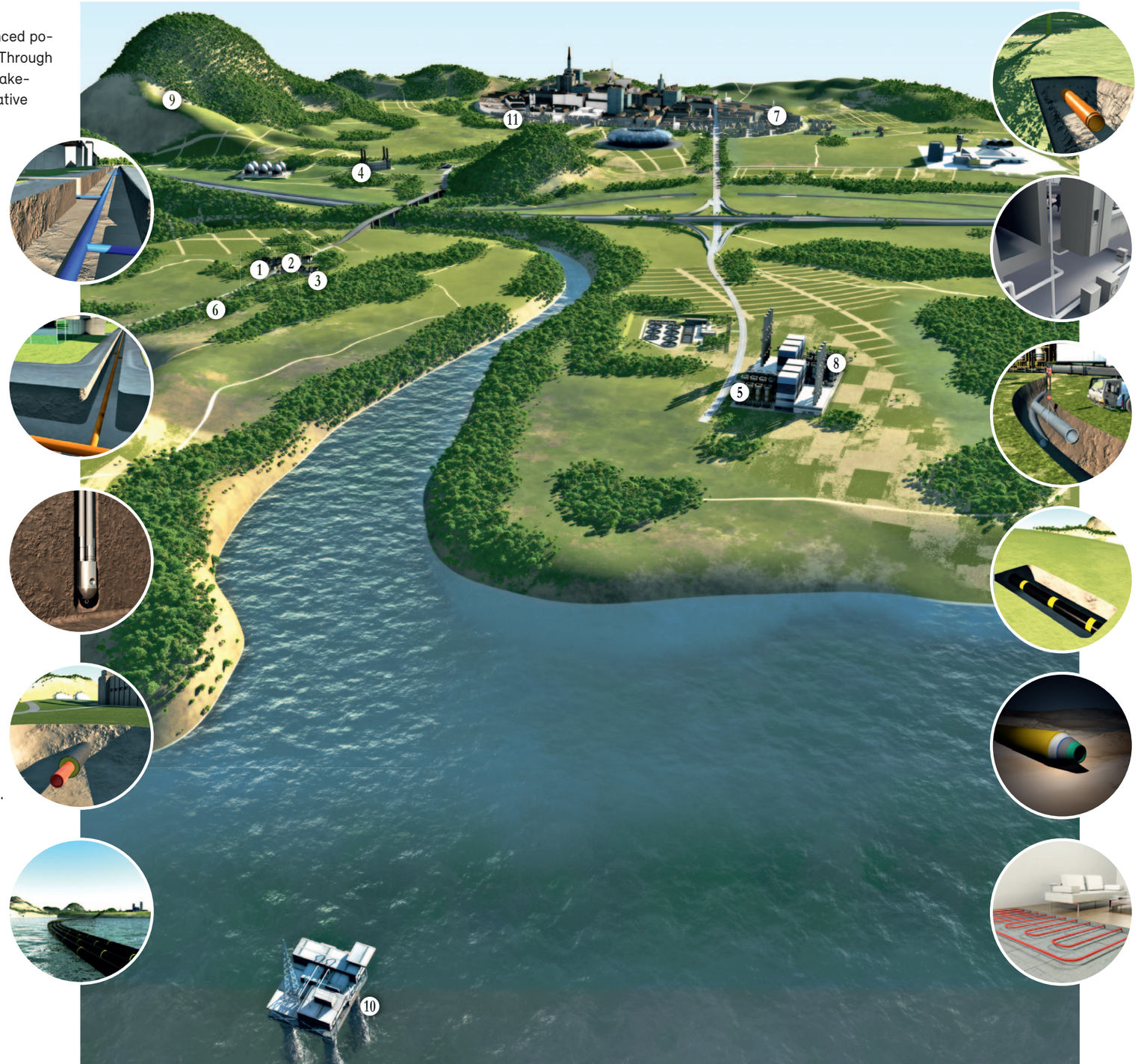
1 Water distribution
BorSafe pressure pipe solutions, developed specifically for both large and small pipes for water mains and domestic connection systems, ensure the elimination of drinking water losses through pipe failures.

2 Gas supply
BorSafe provide optimal solutions for low and medium pressure gas distribution systems. Tough and flexible, they are robust in handling and installation and give the essential leak-free safety demanded by these applications.

3 Geothermal applications
BorSafe materials bring together an outstanding combination of mechanical properties for geothermal pipe applications. Highly durable and flexible, BorSafe PE pipes assure system integrity over a long working life.

4 District heating
BorSafe PE materials provide the protective solution for multi-layer district heating pipes. Used to form the outer casing, BorSafe PE protects the steel heat-conveying pipes and their thermal insulation layer against external damage from abrasion and corrosion.

5 Industrial PE solutions
BorSafe pipes deliver superior resistance to abrasion, corrosion and chemicals giving them a long service life and making them an ideal choice for conveying aggressive industrial fluids and semi-fluids



6 Underground drainage and sewage
BorECO PP materials are specifically developed to improve the performance of solid and corrugated wall pipes for underground, non-pressure sewerage systems that meet the industry's demand for speed and ease of production and installation while protecting ground water and the environment.

7 Domestic soil & waste water disposal
BorECO PP grades provide the ideal platform for sound dampening solutions, a long operating lifetime and resistance to tensides.

8 Industrial PP solutions
PP pipe systems support a large number of industries including chemicals, food processing, pharmaceutical and metal processing, due to their high safety performance and superior physical properties.

9 Onshore pipeline protection systems
Borcoat PE and PP materials for 3 layer coating systems deliver optimum protection, maximise the lifetime performance of oil and gas pipelines and show an impressive global track record.

10 Offshore pipeline protection systems
For challenging offshore projects Borealis can offer 3 layer PE and PP Borcoat solutions as well as multilayer thermal insulation systems based on Borcoat PP.

11 Plumbing and heating systems
PEX and PP materials from Borealis offer the most advanced pressure pipe material solutions currently available for plumbing and heating pipe systems. These include domestic water piping, under-floor heating, radiator connections, wall cooling and heating systems, as well as district heating and industrial pipe networks.

Borealis' broad portfolio of BorSafe PE grades provides specific solutions that match the demands of the full span of pipe infrastructure applications.

BorSafe™ PE: A comprehensive product portfolio

BorSafe is the name of our comprehensive family of PE pressure grades for infrastructural systems, resulting from 40 years of experience. It reflects our strong commitment to contribute to a better availability of drinking water and improved transmission networks for gas, heating and industrial fluids.

With BorSafe materials, we are developing innovative solutions that contribute to improving system quality, reliability and durability. To achieve this we are continuously enhancing the performance of our materials based on years of intensive research and field experience, including feedback from pipe producers, installers, network managers and owners.

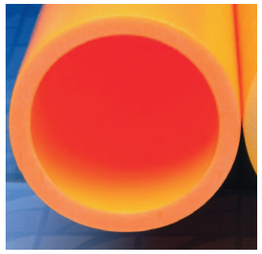
This has resulted in a broad portfolio of BorSafe PE grades from which we are able to provide specific solutions to match the technical demands of the full span of pipe infrastructure projects.

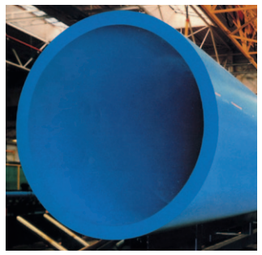
Our ongoing aim is to provide materials that offer cost-effective solutions to real pipeline challenges, and give ever greater reliability over a long service life.

Based on renowned Borstar technology, BorSafe PE products meet or exceed the stringent international standards set for drinking water and gas applications.

Durability, sustainability and very long working life are key BorSafe features that inspire confidence throughout the pipe value chain from producer to consumer.

BorSafe grades have been on the list of PE100+ quality products since the foundation of the PE100+ Association in 1999.





BorSafe™ PE brings advantages that benefit all members of the pipe value chain from the producer to the end-user – today and every day:

Producer	Installer	Facility owner	End-user
• Consistent material quality • Technically innovative products • Higher value pipe solutions	• Simplified installation • High reliability of welding and joints • Lower installation cost	• High asset safety • Low maintenance requirement • Durability and long in-service lifetime	• Security of uninterrupted supply • Protection of precious resources • Environmentally sound solutions

PE pressure pipes: 50 years' experience and success

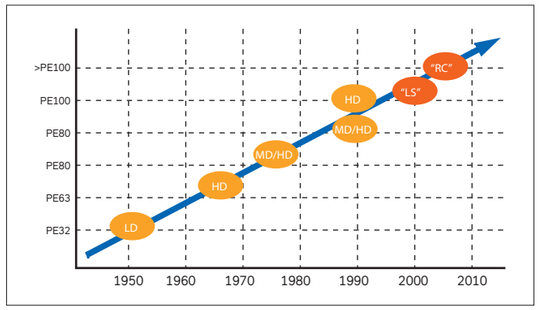
Polyethylene (PE) materials are produced by the process of polymerisation of ethylene obtained from oil. PE comprises a family of both low and high density polymers, each with different performance characteristics and able to match different application end uses. Although the first commercial PE pressure pipe materials were produced in the 1950s, these were very different to the high performance polymers of today.

High quality PE compounds suitable for pipe manufacture are produced by the controlled combination of the polymer powder with the additives necessary to protect the polymer from degradation during manufacture and throughout its service lifetime. The resulting compounds are then rigorously tested by the raw material producer against specifications laid down in the regulatory standards governing them. For example, in accordance with ISO 12162, polyethylene materials must meet defined strength values for a minimum lifetime of 50 years at 20°C. Additional criteria to be met are set out in ISO 4427 or EN12201 for water pipes and ISO 4437 or EN1555 for gas distribution pipes.

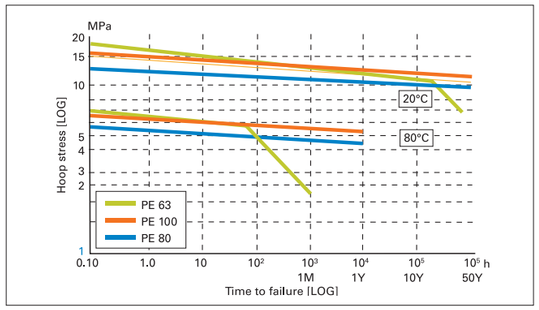
Continuous improvement over the years has, in particular, resulted in a significant increase in the resistance of Borealis' PE to slow crack growth. This enables pipes made from the material to withstand higher levels of installation rough handling and stresses without adversely affecting their performance, thereby improving their durability and longevity. It has also allowed many new, tougher, faster and more economic techniques to be used for pipe installation.

Today PE pipes can be produced in dimensions from 20mm up to more than 2m diameter by conventional extrusion, and more than 3m diameter by techniques such as spiral winding. PE pipes are commonly used for water distribution at pressures up to 25 bar and for gas distribution up to 10 bar.

However, every year, new material developments allow design engineers to reach beyond these performance limits using less material and energy in pipe production. Today, PE pipes find applications in water and gas distribution infrastructures, industrial installations carrying chemical fluids, slurries and other process fluid residues, geothermal applications and district heating systems.



History of PE innovation for pressure pipes



Long-term performance of different pipe material generations

BorSafe PE: key success factors

Flexibility

- PE pipes can be coiled and wound on drums in sizes up to 180mm diameter
- They are flexible and can follow the curves of trenches
- Light and convenient for easy handling and faster installation
- Require fewer joints and connections
- Can withstand ground movements

Weldability

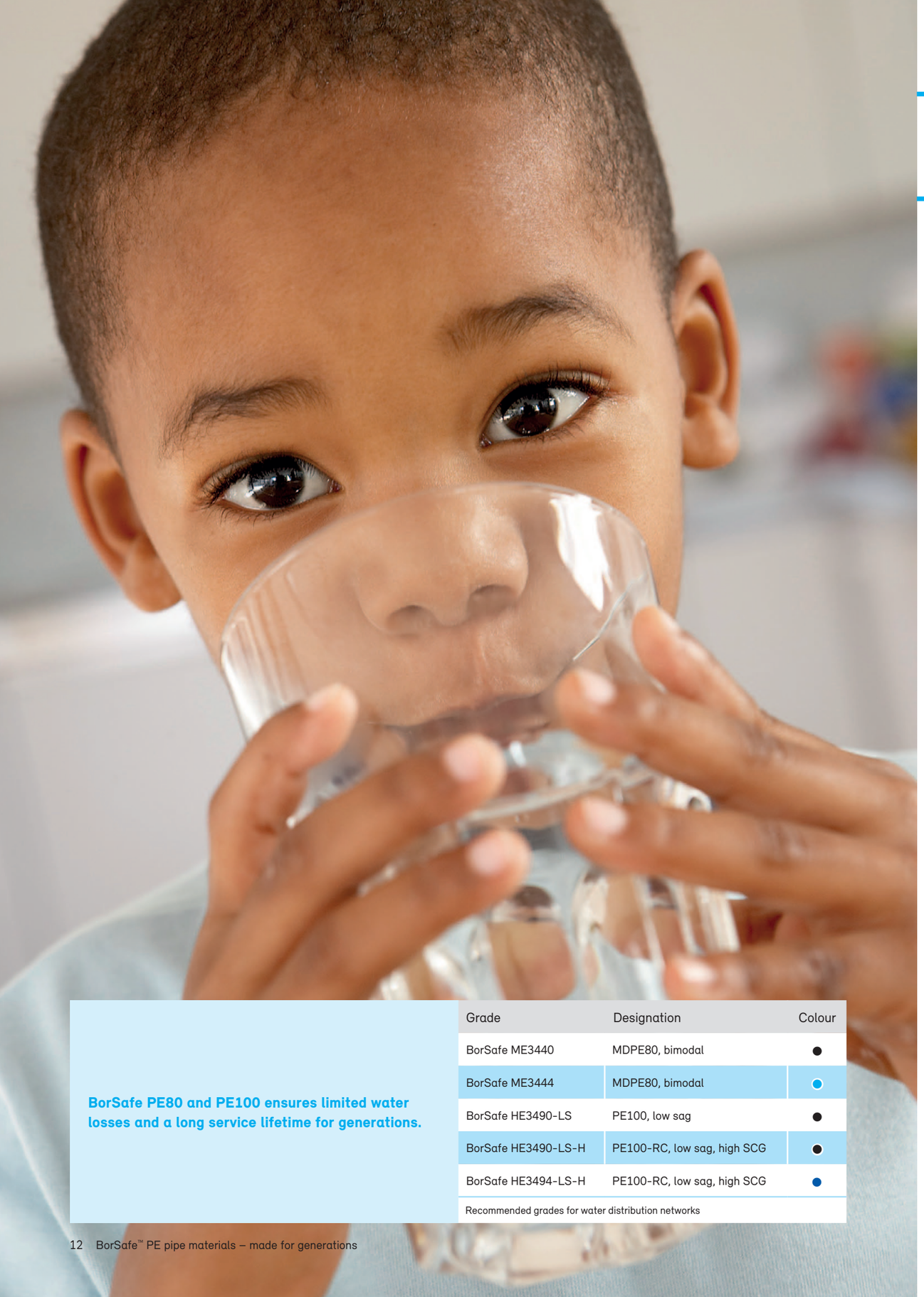
- PE systems can be welded using electro-fusion and buttfusion
- Fusion joints are homogeneous with the pipe giving high integrity
- Use of only one material provides continuity of the pipeline
- Pipe systems are fully end-load resistant. No pull-out when subject to severe ground movement
- No failures even under earthquake conditions
- Leaktightness

Reliability

- Corrosion-free and resistant to chemicals
- Do not impair water quality
- No adverse affect from soil type or environmental conditions
- Expected in-service lifetime in excess of 100 years

Environmentally friendly

- Installation by modern, trenchless technologies – minimising landscape disturbance
- Low weight helps reduce transport and installation, labour and energy costs
- Long lifetime of pipelines and leaktightness help conserve water resources
- PE pipes can be recycled for use in other applications or incinerated for high energy reclamation
- Low energy consumption and emissions over their lifecycle



BorSafe PE80 and PE100 ensures limited water losses and a long service lifetime for generations.

Grade	Designation	Colour
BorSafe ME3440	MDPE80, bimodal	●
BorSafe ME3444	MDPE80, bimodal	●
BorSafe HE3490-LS	PE100, low sag	●
BorSafe HE3490-LS-H	PE100-RC, low sag, high SCG	●
BorSafe HE3494-LS-H	PE100-RC, low sag, high SCG	●

Recommended grades for water distribution networks

Water distribution

Drinking water is fast becoming a scarce and expensive resource – only 1% of the water on earth is suitable for drinking and as living standards rise the demand for water increases at twice the rate of population growth. Currently over 20% of the world's population do not have an adequate supply of drinking water. Fresh water scarcity and the need for its better management and conservation is the major challenge of the 21st century.

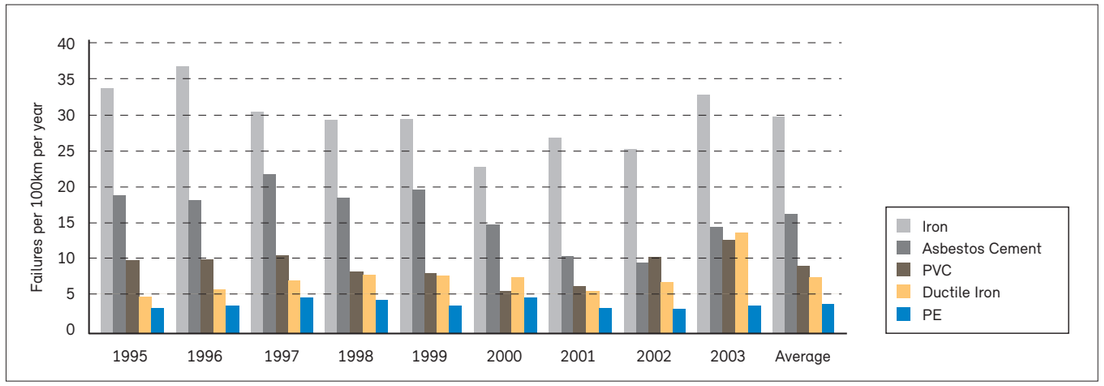
An important part of the solution to this problem is the installation of distribution systems that eliminate or minimise water loss in transit. It is widely recognised that polyethylene (PE) pipes have a valuable role to play in meeting this objective, both for new systems in developing countries and for renovation of existing systems in the developed world, many of which are old and leaking water at an unsustainably high rate.

PE offers an effective and cost-efficient pipe solution. Unlike traditional materials such as iron and steel, PE does not corrode, is longer lasting, easier to install using all pipe installation methods and has the lowest failure rate of current alternative materials. In addition to its long accepted use for smaller diameters, PE is increasingly being adopted and specified for pipes over 500mm in diameter. In fact, thick walled pipes have been developed in PE up to a diameter of more than 2000mm and 100mm wall thickness.

Borealis' broad range of BorSafe PE products satisfies the needs of complete pipe networks from household connections to distribution mains, including all associated fittings.

Classification to ISO 12162	SDR 11	SDR 17	SDR 26	SDR 33
	Pressure (bar)			
PE80	12.5	8.0	5.0	4.0
PE100	16.0	10.0	6.0	5.0

Water pressure rating of PE pipes



UK Water Mains National Failure Database

BorSafe provides optimal solutions for pressure gas distribution systems. Tough and flexible, they are robust in handling and installation and give the leak-free safety demanded.

Grade	Designation	Colour
BorSafe ME3440	MDPE80, bimodal	●
BorSafe ME3441	MDPE80, bimodal	●
BorSafe HE3490-LS	PE100, low sag	●
BorSafe HE3490-LS-H	PE100-RC, low sag, high SCG	●
BorSafe HE3492-LS-H	PE100-RC, low sag, high SCG	●

Recommended grades for gas distribution systems

Gas distribution

The importance of gas as a source of energy for both industry and the domestic environment continues to grow. Over the past two decades, PE has come to replace metal almost entirely in these new distribution networks. PE has been used for gas distribution in Europe for over 35 years with a remarkable degree of success. Its outstanding safety record, low maintenance requirement and cost effective installation have made it the first choice of gas engineers.

Generally the gas industry uses medium density PE80 (MDPE80) materials for low pressure gas distribution up to 4 bar because of their superior flexibility and ease of jointing and installation. Borealis brings the benefits of the bimodal process to medium density PE allowing the polymer properties to be engineered to meet higher targets.

For higher pressure, high density PE100 (HDPE100) materials are used. The maximum operating pressure can be calculated from the 50 year design strength, the pipe wall thickness or SDR and the design coefficient. For gas the minimum design coefficient is 2.0 and the commonly used maximum operating pressures are given in the table below. Available in MDPE80 and HDPE100 grades, BorSafe bimodal PE compounds provide consistent, long-term performance for gas pipes, exceeding the requirements of the relevant international standards, ISO4437 and EN1555.

Available in MDPE80 and HDPE100 grades, BorSafe bimodal PE compounds provide consistent, long-term performance for gas pipes, exceeding the requirements of the relevant international standards, ISO4437 and EN1555.

Earthquake in Kobe, Japan

Material	Mains	Branches	Services	Total
Steel	0	4,607	6,151	10,758
Cast Iron	583	0	33	616
PE	0	0	0	0

Study by Osaka Gas Co.

The Kobe earthquake killed 6,000 people and destroyed 44,000 homes. Afterwards, failures within gas systems were analysed by Osaka Gas Co. In steel systems no pipes failed but many joints did. In cast iron systems both pipes and joints failed. In PE systems no pipe or joint failures were recorded. Publication of these results created a major surge in PE pipe usage in Japan.

Classification to ISO 12162	Max pressure – bar SDR 11	Max pressure – bar SDR 17.6
PE80	4.0	2.0
PE100	10.0	6.0

Geothermal applications

With the increasing cost of energy, the concept of geothermal heating or using the energy of the earth's surface is becoming more and more popular. Geothermal energy is now broadly recognised as an environmentally efficient, cost-effective and virtually inexhaustible alternative to traditional heating and air conditioning systems. PE plastic pipes, to carry the heat transfer fluids used to recover this energy, offer an ideal combination of properties for these applications.

Geothermal Heat Pumps are one of the fastest growing applications of renewable energy in the world today based on either of two types of system, horizontal or vertical. In horizontal systems a pipe network is buried in the ground at a depth of about 60cm. This is laid out in loops to optimise the surface used. For a standard house several hundred meters of small diameter pipes are needed. Vertical collector systems are installed in a well at an average depth of 50m. Small diameter pipes of 32 to 63mm are generally used.

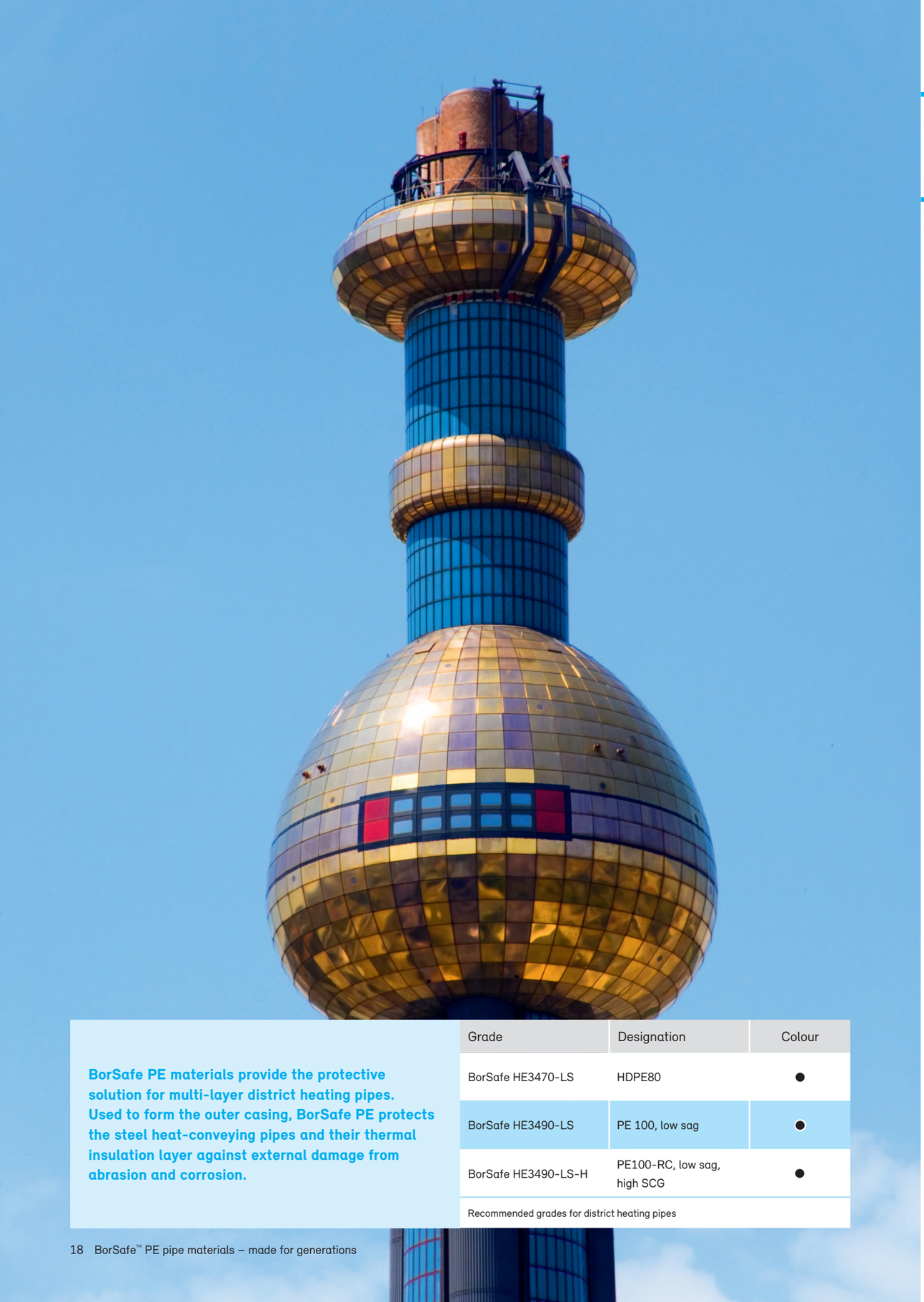
Flexibility and high mechanical resistance are the key parameters for these pipes. Installation conditions are very often aggressive, with risks of scratches, abrasion and point-loading and therefore require outstanding mechanical properties for a long lifetime, and leak-free solution eliminating the risk of chemical fluids, such as glycol, leaking into the environment and contaminating ground water.

Picture courtesy of REHAU

BorSafe PE80 and PE100 materials bring an outstanding combination of mechanical properties for geothermal pipe applications. Highly durable and flexible, BorSafe PE pipes assure system integrity over a long working life.

Grade	Designation	Colour
BorSafe ME3440	flexible PE80, with high mechanical performances	●
BorSafe HE3490-LS-H	PE100-RC, low sag, high SCG	●

Recommended grades for geothermal solutions



BorSafe PE materials provide the protective solution for multi-layer district heating pipes. Used to form the outer casing, BorSafe PE protects the steel heat-conveying pipes and their thermal insulation layer against external damage from abrasion and corrosion.

Grade	Designation	Colour
BorSafe HE3470-LS	HDPE80	●
BorSafe HE3490-LS	PE 100, low sag	●
BorSafe HE3490-LS-H	PE100-RC, low sag, high SCG	●

Recommended grades for district heating pipes

District heating

District heating is the centralised generation of heat for distribution to residential and commercial properties. Very often the central source is a cogeneration plant burning fossil fuels or, increasingly, biomass, and producing both heat and electricity. These types of plant are extremely efficient in converting energy into usable and distributable power.

District heating can also be provided through heat-only boiler stations, geothermal resources and in some instances even solar heating and nuclear energy are used. While district heating plants can provide high efficiencies and improved pollution control than localised boilers, there is research to suggest that cogenerating plants provide the least expensive method to cut carbon emissions and the process has one of the lowest carbon footprints of all types of fossil generating plant.

As a sustainable practice, district heating is progressively being adopted in many parts of the world. Today for example, in Denmark, 60% of water heating is provided through district heating.

The distribution of heat from its central source is made through a network of insulated pipes. These comprise a steel service pipe with bonded polyurethane thermal insulation and an outer protective casing of PE. Meeting the requirements of the EN253 regulation governing buried hot water networks, BorSafe PE provides an effective protection of the insulation and the service pipe from ground water, moisture and mechanical damage, allowing the system to deliver constant performance over its 30 or 50 years minimum lifetime.

Picture courtesy of Powerpipe

BorSafe pipes deliver superior resistance to abrasion, corrosion and chemicals giving them a long service life and making them an ideal choice for conveying aggressive industrial fluids.

Grade	Designation	Colour
BorSafe HE3470-LS	HDPE80	●
BorSafe HE3490-LS	PE 100, low sag	●
BorSafe HE3490-LS-H	PE100-RC, low sag, high SCG	●

Recommended grades for industrial applications

Industrial applications

In addition to their global use in water and gas distribution, PE pipes find applications in many industrial areas such as mining installations, pressure sewage, chemical processing, sea outfalls and water intakes for plants. In many of these systems, their superior resistance to corrosion, abrasion and chemicals allows them to replace metal pipes at lower installation cost and longer in-service lifetime efficiency. For example, the wear rate of PE is four to six times lower than that of steel which makes it ideal for the transport of highly abrasive slurries, such as mine tailings from industrial processes.

Corrosion resistance

Of primary advantage is the corrosion and chemical resistance offered by polyolefin materials. Corrosion is the key disadvantage of metal pipes and it is estimated that up to 3% of the Gross Domestic Product of western European countries is lost each year due to corrosion damage. Typically, corrosion can cause production line shutdowns and the need for capital equipment replacement. In virtually all environments and applications polyolefin pipes are unaffected by corrosion. Even exposure to seawater poses no problem, which makes them ideally suited for submarine outfall pipes or seawater intake pipelines.

Chemical resistance

PE is highly resistant to chemicals and other aggressive media and able to meet the ISO/TR 10358 standard. In fact, acid or alkaline-based industrial fluids, hydrocarbon-based fuels, detergents and other liquid cleaning agents are stored, transported and sold in pipes, containers or packaging made of polyolefin materials.

Pressure resistance

For buried water and gas distribution systems it is usual for PE pipelines to operate at 20°C. However all polyolefin pipelines are able to operate at higher temperatures as long as their basic properties are respected (see the table below). In demanding industrial and chemical applications higher safety margins are crucial, especially when:

- The system is under multi-axial stresses
- Subjected to impact loading, which can occur frequently
- Sudden pressure surges occur in the pipelines

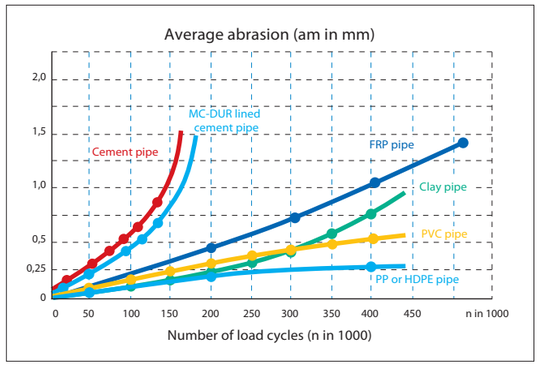
Maximum Operating Pressure (MOP) in accordance with DIN 8074, safety factor C-min 1,25, water conveyance (equivalent to MOP derived from the regression curves reduced by pressure reduction factors according to ISO13761).

Typical operating limits for polyethylene materials

	Max. operating pressures for SDR11 pipe lifetime 50years* / 10years**	
Temp. [°C]	PE80	PE100
20*	12.5	16.0
30*	10.6	13.5
40*	9.1	11.6
50**	8.1	10.4

Abrasion resistance

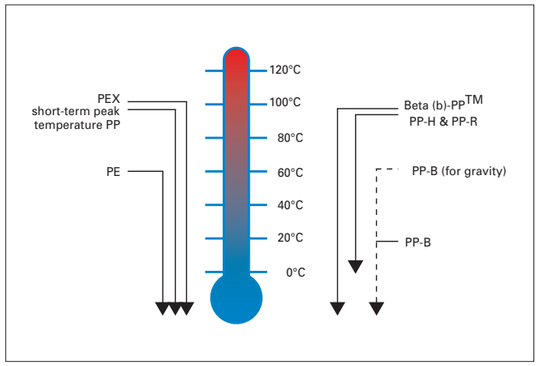
Polyolefins have exceptional abrasion resistance compared to other pipe materials. Versus steel, for example, the wear rate of PE is 4-6 times lower, which is why PE has replaced metal pipes for mine tailing slurry lines. A comparison with other non-metallic materials such as asbestos cement, GRP and clay pipes using the Darmstadt abrasion test method (EN 295) is shown in the graph. PP and PE pipes clearly outperform each of the alternative pipe materials.



Darmstadt test method to determine surface abrasion

Temperature resistance

Polyolefin materials offer a broad range of temperature resistance. Depending on the pressure conditions and expected lifetime, PE pipe systems can be operated at temperatures up to 60°C. For higher temperature, other products, such as PP or PEX, are available from the Borealis' pipe grades portfolio.



Temperature range of polyolefins

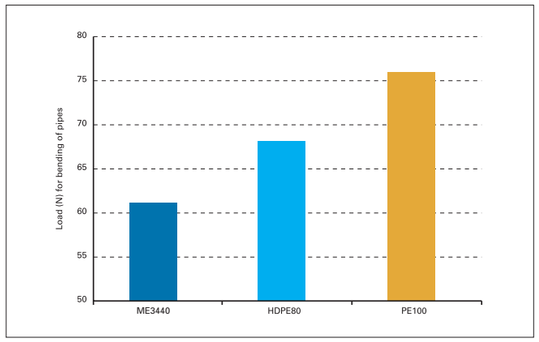
BorSafe MDPE80: Superior flexibility for small diameter pipes

For smaller size pipes, medium density PE80 (MDPE80) materials with superior flexibility are the preferred choice of engineers and installers. Delivered in long, coiled lengths they provide for easier storage, transportation and faster and safer installation. They also give benefits in the installation environment as, when laid, they can be bent around obstacles, thereby saving time and cost.

With Borstar technology, Borealis brings the benefits of the bimodal process to this family of materials, enabling them to be engineered to meet higher mechanical performance levels. Borealis has developed a comprehensive range of bimodal MDPE80 for all applications. BorSafe ME3444 (blue) for water applications, BorSafe ME3441 (yellow) for gas, and Borsafe ME3440 (black) for various applications.

The BorSafe MDPE80 grades are the latest development of this product family. These grades offer a perfect balance of enhanced flexibility and high performance.

BorSafe MDPE80 grades are the ideal solution for small diameter pressure pipes. They combine the high-impact strength and crack-resistant advantages of a high density PE100 with the flexibility of PE80. This simplifies faster installation, making it less expensive without compromising pipe performance.



Compared flexibility of BorSafe ME3440 vs other PE pipe materials

Grade	End-use	Colour
BorSafe ME3440	All applications	●
BorSafe ME3441	Gas pipes	●
BorSafe ME3444	Water pipes	●

Borealis product offering in the MDPE80 segment

Injection moulded pressure fittings

Because systems are only as strong as their weakest link, ensuring the quality of connections is crucial to pipe network integrity. Borealis has, therefore, designed specific materials for the production of high quality fittings.

BorSafe HE 3490-IM
For a long time after the introduction of PE100 pipe material, fittings manufacturers struggled to injection mould connections in what is essentially extrusion grade material in order to deliver pipe matched-performance products. For them this has involved concessions in, for example, cycle time with the consequence of additional costs.

To provide a solution that eliminates compromises in cost or performance, Borealis has developed BorSafe HE3490-IM, a PE100 material specifically designed for the production of injection moulded pressure fittings. BorSafe PE HE3490-IM is hexane-based and combines the long-term strength of BorSafe PE100 with the improved flow characteristics of an MDPE80 material. Easy to process, BorSafe HE3490-IM offers producers:

- Lower processing temperatures
- Faster cycle times
- Less warpage
- Improved surface finish

BA160E-8229-01
Particularly in water applications, smaller diameter mechanical joint compression fittings are sometimes necessary. Borealis has developed a specific PP grade for the bodies of these fittings, BA160E-8229-01, which fulfils the stringent requirements set out for these parts in ISO 14236. BA160E-8229-01 has an MRS 8 classification following full ISO 9080 evaluation. Furthermore, as a black coloured compound it offers excellent UV resistance with high impact strength.

Grade	Designation	Application	Colour
BorSafe HE3490-IM	PE100	Injection moulding of PE pressure fittings	●
BA160E-8229	PPB-80	Body of compression fittings	●

Borealis product offering for injection moulding

Picture courtesy of F.I.P.

Pressure fittings

BorSafe PE100-LS: Fully versatile solutions across all pipe sizes

Large diameter, thick wall PE pipes have always been difficult to process due to material sagging, caused by material flowing to the bottom of the pipe before it has cooled down and solidified sufficiently. To some degree this can be corrected by offsetting the die but this is time consuming and always leads to the use of additional material.

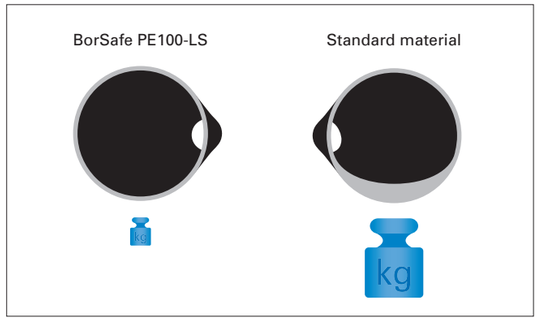
In BorSafe-LS materials the molecular weight distribution has been adjusted to increase the viscosity of the material at low shear rates, while maintaining the same viscosity at normal processing shear rates. This reduces the tendency for the material to sag and makes large diameter, thick wall pipe a practical proposition.

Moreover, excellent processing characteristics have been maintained, so that all sizes of pipe, from 20mm to more than 2000mm, can be easily produced from the same material, thereby simplifying operations for pipe producers.

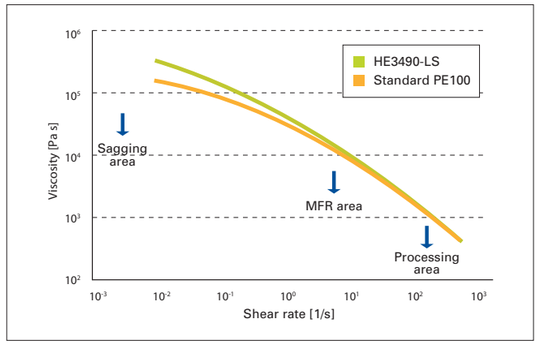
Since the material was launched, many large diameter pipes have been manufactured from BorSafe-LS materials with wall thicknesses of up to 100mm or greater. The low sag properties and resulting lower variation in pipe wall thickness also provides both the pipe producer and contractor with a number of benefits.

Grade	End-use	Colour
BorSafe HE3490-LS	Water, sewage, industrial	●

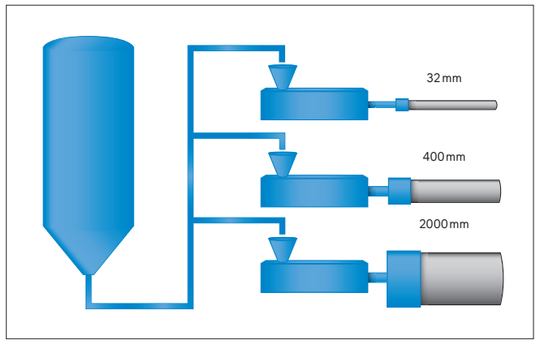
Borealis product offering in the PE 100-LS segment



Low sag properties of BorSafe PE100-LS vs standard material



Viscosity curve for BorSafe HE3490-LS and Standard PE100



BorSafe PE100-LS: one material for all dimensions

Solutions@work

Replacement of older-generation material

- BorSafe HE3490-LS pipes replacing concrete in the supply of water for domestic and industrial use from Lake Hällungen to Stenungsund, Sweden
- Length 6.2km
- Outside diameter 710mm
- Combination of open trench and directional drilling

Sewage outfall to sea

- Largest plastic pipe project in Europe used BorSafe PE100-LS pipes to provide a waste water and treated sewage sea outfall at Montpellier, France
- Length 11km
- Outside diameter 1600mm – wall thickness 61.2mm
- Submerged with concrete collars

Provision of drinking water supply

- BorSafe HE3490-LS pipes were used for the installation of a new drinking water supply network for Palermo International Airport
- Length 7.5km
- Outside diameter 200mm
- Open trench installation

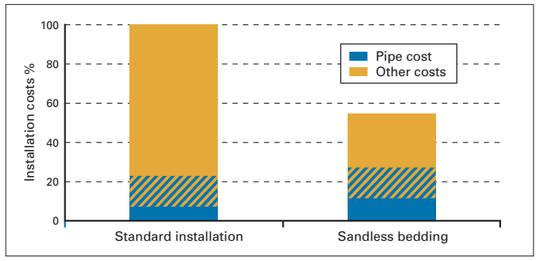
BorSafe PE100-LS benefits for the entire value chain

Pipe producer	Installer	Facility owner	End-user
• Higher output rates and quicker start up times – lower cost • Simpler set-up procedure and less scrap produced – lower cost • Improved logistics with lower stock holding (one material for all pipe dimensions)	• Simpler and higher quality butt welding – lower cost – secure leaktight networks • Less risk of pipe rejection – less risk of delays	• Lower risk of failures • Lower overall installed cost • PE solutions available for more installations	• Security of uninterrupted supply • Protection of precious resources

BorSafe PE100-LS-H: Pipe material for unforgiving laying conditions

High quality material for cost-effective installation

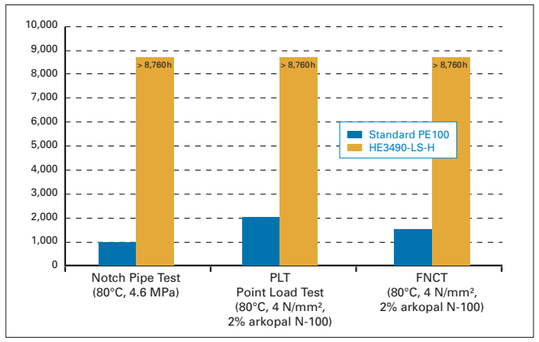
The growing demand for faster and more economic pipe installation with less environmental disturbance has led to new installation techniques. These include sandless bedding, pipe bursting and horizontal directional drilling. Because of their aggressive impact on pipe materials, these new methods have only been made possible through innovative plastic pipe developments.



BorSafe HE3490-LS-H allows for installation cost reductions of up to 50%.

A step change in resistance to slow crack growth

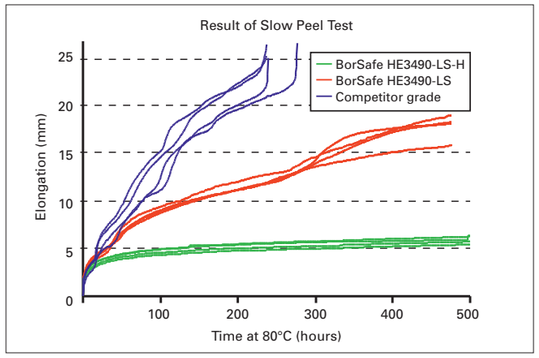
When laid in rocky or sandless bedding conditions, pipes are subject to external damage and high stresses can build up on the bore of the pipe. Over time this can lead to crack development and ultimately pipe failure. Borealis' response to this challenge is BorSafe LS-H, a new generation of high-density PE100-RC grades that have been specifically designed for pipes subjected to elevated stresses and a high level of risk of surface damage caused by modern installation techniques. They provide the most robust PE solution for drinking water and gas applications currently available in the marketplace.



BorSafe LS-H brings additional safety to pipe systems due to its outstanding SCG performance

Exceptional durability: improved quality of joints

An important factor influencing the durability of a pipeline is weld-quality. The Slow Peel Test was developed by Kiwa Gas Technology to simulate the long-term behaviour of electrofused (EF) joints. A recent Slow Peel Test clearly demonstrated that BorSafe HE3490-LS-H, due to its outstanding resistance to slow crack growth, provides better long-term EF joint quality than standard PE100 materials.

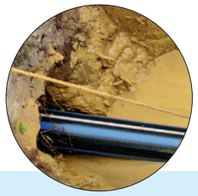


BorSafe HE3490-LS-H ensures high quality electrofused joints

Solutions@work

Fire main installation

- BorSafe HE3490-LS-H pipes were selected for the fire main of a chemicals production site at Porvoo, Finland
- Outside diameters 300mm and 500mm
- Combination of open trench and directional drilling
- Significant conditions to be overcome: very low winter temperature and hard rocky terrain



Drinking water pipeline

- BorSafe HE3490-LS-H was chosen for the installation of a drinking water pipeline linking villages on the Island of Föhr, Germany
- Length 8km
- Outside diameter 160mm – wall thickness 9.5mm
- Installed by directional drilling in order not to disturb the island's landscape

Provision of drinking water supply

- In the regeneration of drinking water and sewerage systems for five provincial communities in West Pomerania, Poland, BorSafe HE3490-LS-H and BorSafe HE3494-LS-H were the pipe materials of choice
- Length of drinking water pipeline 185km – sewerage pipeline 97km
- Outside diameter of drinking water pipeline 63-315mm – sewerage system 63-200mm
- Combined open trench and directional drilling

Grade	Application	Colour
BorSafe HE3490-LS-H	Water, gas, industrial	●
BorSafe HE3494-LS-H	Water	●
BorSafe HE3492-LS-H	Gas	●

Borealis product offering in the BorSafe PE100 LS-H segment

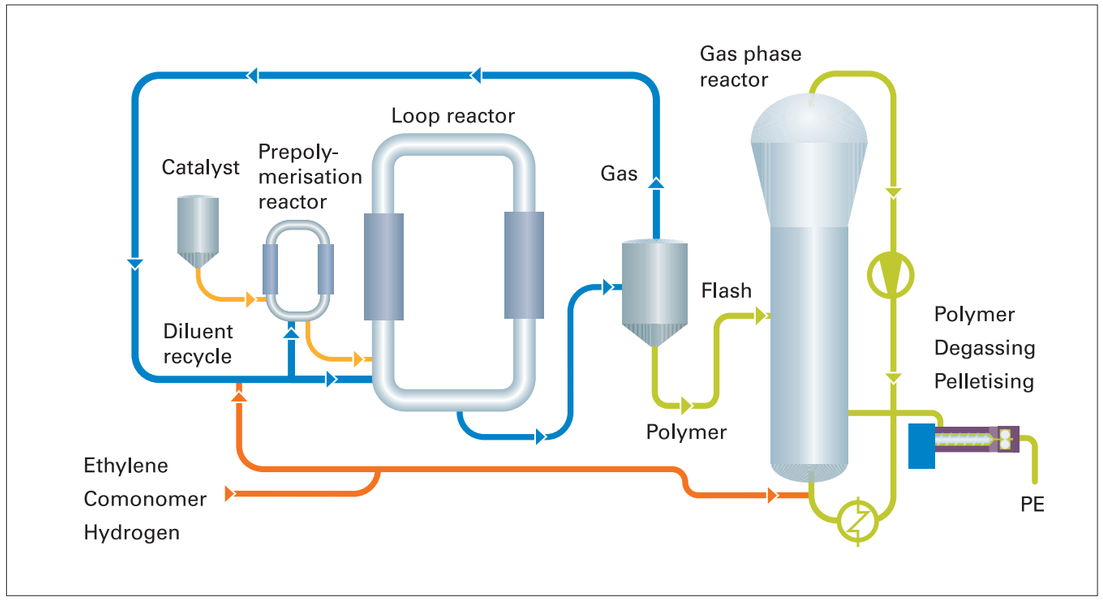
Borstar®: Our leading edge technology

Borealis' leading edge Borstar technology is a critical element in satisfying today's growing demand for advanced plastics and in developing the next generation of innovative, value creating products.

Borstar is the company's proprietary process and catalyst technology that supports the production of a wide range of enhanced polyethylene (PE) and polypropylene (PP) products.

Now, Borstar PE 2G and Borstar PP 2G, Borealis' next generation technology, represent a leap forward in process technology, allowing flexible polymer design from bi-modal to multi-modal PE/PP. It also facilitates the development of an ever-widening range of new plastics that outperform alternative materials in meeting the needs of manufacturers and end users.

By tailoring the molecular structure of PE and PP to exactly match application needs, Borstar PE 2G and Borstar PP 2G extend the product range with more sophisticated, customer-oriented solutions, which are characterised by a combination of outstanding mechanical properties and excellent processability.



Borealis is committed to climate protection through the advancement of innovative plastics solutions that use less material, consume less energy and result in lower CO_2 emissions than alternative materials.

Advancing sustainability

The environmental benefits of PE pipes

Minimising environmental impact and the need to drive sustainable solutions led the SADE Group – one of the world's leaders in the design, construction and maintenance of water and waste water networks – to undertake a carbon footprint analysis of common pipe material solutions. The study took account of all greenhouse gas emissions during the production, transportation and installation of a typical pipe project. The results were then calculated as a carbon equivalent or CO_2 equivalent value using conversion factors provided by 'ADEME', the French Environment and Energy Management Agency.

Emissions from pipe production

As the table shows, while carbon emission per tonne of pipe was similar for the materials, because of the weight difference PE gave a 77% saving per metre compared to iron pipe.

Material	Emission (kg Eq.C/T)	for 80 m, DN 100, PN 16 (kg Eq.C)	Diff. (%)
PE	500	378	-77%
Ductile Iron	585	1,656	

CO_2 emissions during pipe production

Emissions during transportation

Weight was also a key factor in pipe transportation with PE giving a saving of 74%. The baseline assumption was a transportation distance of 500km between the pipe production plant and the installation site.

Material	Emission (kg Eq.C/T/km)	for 80 m, DN 100, PN 16 (kg Eq.C)	Diff. (%)
PE	0,075	28	-74%
Ductile Iron	0,075	106	

CO_2 emissions during pipe transportation

Emissions during installation

Three different installation methods were considered. In standard open trench installation PE provided a saving of 19% compared to ductile iron. However, if no-dig installation techniques could be used, PE carbon emissions were reduced by 78% for horizontal drilling and by 79% for pipe bursting.

Installation	Total Emissions (kg Eq.CO_2/m)		Diff. (%)
	PE	DI	
Open trench	74	91	-19%
Directional drilling	20	*	-78%
Pipe bursting	19	*	-79%

CO_2 emissions during pipe installation.
*Not suitable for this type of installation

Water for the World™ is an initiative established by Borealis and Borouge that aims to contribute to solutions that address the global water challenge.

Water for the World

More than one third of people do not have access to clean water and/or proper sanitation. More then 2.2 million people die each year from diseases associated with poor water and sanitation conditions. This situation represents a major and growing threat to human health and the environment.

The majority of communities in developing countries still lack even the most basic drainage. As a result, effluent is left untreated in the environment to pollute rivers and ground water, giving rise to widespread serious health problems. Even in industrialised countries which have long benefitted from on-tap drinking water, flush toilets and sewerage networks, the rapid population growth of towns and cities is beginning to outstrip services. Today it is estimated that in the European region 120 million people do not have access to safe drinking water and adequate sanitation.

From fresh water supply to sanitation systems, the plastics industry can make a substantial difference. Going beyond business, Borealis and its joint venture partner Borouge have established Water for the World, an initiative that aims to contribute to solutions that address the global water challenge.

Within this programme, Borealis and Borouge have established a number of projects focused on three main areas in the fields of society, business and environment:

- supporting water access projects
- raising awareness in communities
- advancing sustainable water management/ promoting best practices

Solutions@work

The water Footprint of Plastics

In a world of diminishing fresh water supplies a company's water footprint provides a valuable environmental indicator which can help advance sustainable development.

In 2009 Borealis was the first petrochemical and plastics producer to assess the water footprint of its polyolefins operations and products.

Water for L'Aquila

Following the L'Aquila earthquake in Italy, Borealis and System Group Centraltubi supported the construction of a 1.3km water pipeline supplying 1,800 people in temporary housing.

The project, now extended, supports the installation of a complete sewerage network using a BorECO BA2000 solution.

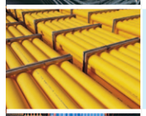
Awareness building and education

Working with Finnish water authorities, Borealis launched the Virtual Water School, an educational website for schoolchildren that aims to create interest and increase understanding of the importance and functioning of water and sanitation systems.

The Virtual Water School is an example of how Borealis is working in partnership to foster knowledge and contribute solutions.

Technical overview:

BorSafe solutions for drinking water, geothermal, district heating and industrial use

	Grade	Colour	Designation	MFR (: g/10 mn@ 190°C/5kg)	Density (Kg/m³)	Typical applications	Description
	ME3440	●	MDPE80	0.85	951	Water, gas, industrial	Bimodal medium density PE80, good mechanical properties
	ME3441	●	MDPE80	0.80	944	Gas	Bimodal medium density PE80, good mechanical properties
	ME3444	●	MDPE80	0.80	947	Water	Bimodal medium density PE80, good mechanical properties
	HE3470-LS	●	HDPE80	0.30	956	Industrial, district heating	Bimodal, high density PE80, bringing good stifness
	HE3490-LS	●	PE100	0.25	959	Water, Gas, Industrial, district heating	Versatile PE100, for all diameters (25mm to > 2m); good Low Sag properties
	HE3490-LS-H	●	PE100-RC	0.25	959	Water, gas, Industrial, geothermal	PE100 for alternative installation techniques, with exceptional resistance to slow crack growth; good Low Sag properties
	HE3492-LS-H	●	PE100-RC	0.30	951	Gas	PE100 for alternative installation techniques, with exceptional resistance to slow crack growth; good Low Sag properties
	HE3494-LS-H	●	PE100-RC	0.30	951	Water	PE100 for alternative installation techniques, with exceptional resistance to slow crack growth; good Low Sag properties
	HE3490-IM	●	PE100	0.55	959	Injection moulded fittings	PE100 dedicated to the production of injection moulded fittings- adpated to the injeciton mouding process
	BA160E-8229	●	PP-B 80	0.30 (230°C, 2.16 kg)	900	Compression fittings	Special PP grades, for compression fittings