Polyolefin materials in industrial pipe applications
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Polyolefin (PO) pipelines are well known to utility companies throughout the world where they are used for water and gas distribution, and for sewage and wastewater disposal. There are now also a growing number of successful examples of polypropylene (PP) and polyethylene (PE) pipes being used in industrial and mining applications. In most cases the PE and PP pipelines are replacing metallic systems owing to their superior resistance to corrosion, abrasion and chemical attack. This brochure provides information on the properties of these materials and shows some of the success stories from around the world.

Some typical applications for PO pipes in the industrial sector are listed below:

- Sea water intake and outfall pipes
- Water injection lines
- Treated sewage pumping main
- Oil flow lines
- Raw water pumping main
- Collecting and transporting coal seam gas
- Dredging pipeline
- Pre-insulated district cooling and heating pipes
- Slurry transportation in mines
- Factory compressed air lines

Design of polyolefin pipes

For buried water and gas distribution systems it is normal to design PE and PP pipelines for operation at 20°C but polyolefin pipelines are able to operate at higher temperatures and guidelines are given in the relevant standards such as ISO 4427 and DIN 8077 (see Table 1). However these standards tend to be conservative as they have to cover a wide range of materials and rigorous testing has shown that modern materials perform significantly better and it is recommended that designers contact Borouge to obtain the latest information.

### Table 1: Typical operating limits for polyolefin materials

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>PE100 ISO 4427</th>
<th>PP-H DIN 8077</th>
<th>PP-R DIN 8077</th>
<th>Temp °C</th>
<th>PE100 ISO 4427</th>
<th>PP-H DIN 8077</th>
<th>PP-R DIN 8077</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>16 bar</td>
<td>12.4 bar</td>
<td>15.4 bar</td>
<td>60</td>
<td>NA</td>
<td>7.4 bar</td>
<td>7.7 bar</td>
</tr>
<tr>
<td>30</td>
<td>13.9 bar</td>
<td>10.5 bar</td>
<td>13.0 bar</td>
<td>70</td>
<td>NA</td>
<td>4.8 bar</td>
<td>5.1 bar</td>
</tr>
<tr>
<td>40</td>
<td>11.8 bar</td>
<td>10.0 bar</td>
<td>11.0 bar</td>
<td>80</td>
<td>NA</td>
<td>4.7 bar*</td>
<td>4.8 bar*</td>
</tr>
<tr>
<td>50</td>
<td>10.4 bar*</td>
<td>8.3 bar</td>
<td>9.2 bar</td>
<td>95</td>
<td>NA</td>
<td>2.6 bar*</td>
<td>2.6 bar*</td>
</tr>
</tbody>
</table>

Note: - Design lifetime 50 years except where marked with an asterisk where it is a 10 year lifetime
- For critical pipelines laid above ground we recommend the use of an additional 0.8 design factor

Abrasion resistance of polyolefin pipes

Polyolefin materials have an exceptional abrasion resistance compared to other pipe materials. Compared to steel, 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 method (EN 295) is shown in Graph 1 on the right. Clearly PE and PP pipes outperform all the alternative pipe materials.

Corrosion and chemical resistance of polyolefin pipes

Corrosion which is the Achilles heel of metallic pipes - it is estimated that up to 3% of the GDP of Western European countries is lost annually in corrosion damage. In most situations corrosion is not an issue for polyolefin pipes and even sea water poses no problems. This makes them ideal for submarine outfall pipelines and sea water intake pipelines.

PE and PP are both highly resistant to chemicals and other aggressive media (refer to ISO/TR 10358). Indeed acidic or alkaline based industrial solutions, hydrocarbon based fuels, detergents and other cleaning solutions are stored, transported and sold in pipes, vessels or packaging made of polyolefin materials. PP pipelines are particularly resistant to acids and can operate up to temperatures of 80-90°C.
Some examples of polyolefin industrial pipes from around the world

Process water across the desert in Paraburdo, Australia
PE100 pipe transporting industrial water to Hamersley iron ore mine 58 km across the desert. The 500 mm diameter pipeline was installed in 1995 and is still running smoothly.

Crude oil transportation pipes in Sim Sim, Oman
PE100 pipe transporting water-crude oil mixture at 50°C and 10 bar pressure across the desert. Installed in 1997 to replace steel pipes which were failing after only two years, these pipes are still operating and recent tests confirm that they are capable of continuing for many years.

Sea water cooling pipes in Abu Dhabi, UAE
PE100 pipes transporting sea water for cooling the new BOROUGE petrochemical plant at Ruwais. The network comprises of 1600 mm diameter 6 bar pressure inlet pipelines and 6 of 1600 mm diameter gravity outlet pipelines. The initial BOROUGE plant used large diameter GRP pipes but since these suffered from a number of failures they have been replaced by PE100 pipes in the new plant.

Firewater main renovation in Stenungsund, Sweden
PE100 was used for renovating the 40 year old steel fire mains at the Borealis polyethylene plant in Stenungsund, Sweden. Part of the pipeline was replaced by open cut and part by “pipe bursting” the old pipeline.

Kaolin slurry transportation in Cape Town, South Africa
PE100 pipeline transporting kaolin slurry at 16 bar pressure installed in 1996. During the first five years of operation the pipeline wall was monitored regularly but showed no significant loss of wall thickness.

Process water at 80°C in Donauchemie, Austria
Beta PP-H pipes transporting process water at 80°C in a chemical plant in Austria. Installed in the 1980s the 1600 mm diameter pipeline was the largest PP pipeline of its day. In places the pipe is installed to a depth of 5 m and is still operating.

Acids and abrasive slurries in Hindustan Zinc, India
Beta PP-H pipes used to transport abrasive slurries and acids at temperatures of 50-90°C in their plant in India. As well as resisting the abrasion it is important that the pipes are tough enough to withstand the removal of pipeline blockages. Trials using alternative materials showed that as well as meeting these requirements Beta PP-H was also 18% lower in fully installed cost compared to a GRP system and 40% lower than a CPVC system.

Large diameter sea outfall for a new refinery in Abu Dhabi, UAE
The large diameter sea outfall for the cooling water of a new refinery in Abu Dhabi has been constructed using the latest spiral winding technology and high stiffness BorECO BA212E polypropylene from BOROUGE. The external pipe profile was filled with grout to reduce buoyancy and then the 3 metre diameter pipes were butt welded together to form 300 metre long strings ready for installation. This same spiral winding technology of PE and PP materials can be used to produce tanks and silos for storing industrial chemicals and process materials.

Lining a water injection pipeline in Kuwait
Internal corrosion of steel pipe is a major problem for many oil and gas companies, and an alternative to regular replacement of these pipelines is to use “close-fit” internal lining with PE, which will extend the life of the pipeline. The Kuwait Oil Company chooses to test this option and for higher security specified high stress crack resistant BorSafe HE3490-LS-H to protect some of their water injection lines. The PE pipe lengths were welded and pressure tested and then inserted into the steel pipe using “Swagelining™” technology. The lined section of pipe was then put back into service so that the performance could be monitored and compared to unlined sections.
Materials for Industrial applications

**PE Grades**

**BorSafe HE3490-LS**
This is a PE100 pressure pipe compound providing an excellent balance of production and end use properties.

**BorSafe HE3490-LS-H**
This PE100 pressure pipe compound has exceptional resistance to stress cracking making the pipe less vulnerable to failure due to installation damage or point loads.

**BorSafe HE3490-IM**
This is a PE100 compound with improved flow properties, which makes it ideal for the production of injection moulded fittings.

<table>
<thead>
<tr>
<th>Commercial Reference</th>
<th>Material Type</th>
<th>Colour</th>
<th>Application</th>
</tr>
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<tbody>
<tr>
<td>BorSafe HE3490-LS</td>
<td>PE100</td>
<td>Black</td>
<td>Pipe in sizes 63 – 2500 mm</td>
</tr>
<tr>
<td>BorSafe HE3490-LS-H</td>
<td>PE100 HSCR</td>
<td>Black</td>
<td>Pipes for the toughest conditions</td>
</tr>
<tr>
<td>BorSafe HE3490-IM</td>
<td>PE100 High flow</td>
<td>Black</td>
<td>Injection moulded fittings and sheets</td>
</tr>
</tbody>
</table>

**PP Grades**

**Beta(β) – PP BE60-7032**
A unique β nucleated grade with a fine highly crystalline structure which exhibits higher impact strength throughout the complete operational temperature range 0°C to 95°C making it the ideal material for industrial pipes and fabricated components which are transporting hazardous fluids.

**RA130E**
This is a high molecular weight, low melt flow rate polypropylene random (PP-R) material, which is ideal for high temperature industrial pipe and fitting applications.

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<td>Grey</td>
<td>Pressure pipes and fittings</td>
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<tr>
<td>RA130E</td>
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<td>Natural</td>
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<tr>
<td>Alfa(α) BE50 - 7032</td>
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<td>Grey</td>
<td>Non pressure pipes, fittings and sheets</td>
</tr>
<tr>
<td>BorECO BA212E</td>
<td>PP-B HM</td>
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<td>BorECO BA415E</td>
<td>PP-B</td>
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**Alfa(α) – BE50 and BE50-7032**
A high stiffness α nucleated polypropylene homopolymer that is ideally suited for the production of non pressure pipes and sheets.

**BorECO BA212E**
This is a high modulus block copolymer polypropylene (PP-B HM) material specifically designed for the cost effective production of solid and structural wall non-pressure pipes and fittings.

**BorECO BA415E**
This is an intermediate stiffness PP-B material with excellent processing performance which is ideal for twin wall pipe and fitting production.

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**Some useful web sites and references**

- Borouge: www.borouge.com
- Borealis: www.borealisgroup.com/pipe
- PE100+ Association: www.pe100plus.net
- The Gulf Plastic Pipes Academy: www.yourppa.org
- Plastics Pipes for Water Supply and Sewage Disposal: Lars-Eric Janson, 2003
- The Potential of Polyolefins in Industrial Applications: Ettinger, V., Dubai Plast Pro, 2002
Read these case stories where polyolefin materials have provided a durable solution

- Corrosion resistant
- High resistance to acids and other chemicals
- Wide operating temperature range up to 95°C
- Fusion welded leak-proof jointing
About Borouge

Borouge is a leading provider of innovative, value creating plastics solutions. A joint venture between the Abu Dhabi National Oil Company (ADNOC), one of the world’s major oil and gas companies, and Austria based Borealis, a leading provider of chemical and innovative plastics solutions; Borouge is a groundbreaking international partnership at the forefront of the next generation of plastics innovation.

With its base in the United Arab Emirates and Marketing & Sales head office in Singapore, Borouge employs approximately 1,700 people representing more than 40 nationalities and serving customers in more than 50 countries across the Middle East, Asia-Pacific, Indian sub-continent and Africa.

Building on Borealis’ unique Borstar® technology and experience in polyolefins for more than 50 years, Borouge provides innovative, value creating plastics solutions for infrastructure (pipe systems, and power and communication cables), automotive and advanced packaging.

In 2010 Borouge tripled its annual production capacity in Abu Dhabi to 2 million tonnes and together with Borealis has an annual manufacturing capacity of over 5.4 million tonnes of polyethylene and polypropylene. The current Borouge 3 expansion project will be completed at the end of 2013 resulting in an additional capacity of 2.5 million tonnes per year (t/y) being fully operational by mid-2014. Borouge is also investing in plants and logistics hubs in Asia and an Innovation Centre in Abu Dhabi. Focused on our company mission, Value Creation through Innovation, we ensure that our customers throughout the value chain, around the world, can always rely on superior products and security of supply.

Borouge is committed to the principles of Responsible Care® and together with Borealis proactively contributes towards addressing the world’s water and sanitation challenges through their Water for the World™ initiative.

Visit www.borouge.com and see how we are Shaping the Future with Plastics.

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