Borouge grades for PE pressure pipes and fittings*

Commercial reference	Type of materials	Typical Application
Borstar® HE3490-LS	PE100, HDPE Black compound	Pressure pipe from DN63 to 2000mm
Borstar® HE3470-LS	PE80, HDPE Black compound	Pressure pipe from DN20 to 160mm
Borstar® ME3440	PE80, MDPE Black compound	Pressure pipe from DN20 to 160mm
Borstar® HE3490-IM	PE100, HDPE Black compound	For injection moulding of fittings

* – More grades available e.g. Blue PE100 and PE80

Some web sites, readings and references:

Borouge	www.borouge.com
Borealis	www.borealisgroup.com/pipe
PE100+ Association	www.pe100plus.net
Plastic Pipe (Plastic Europe and Teppfa)	www.plastic-pipes.com
Plastic Pipes Group WRc (UK)	www.wrcplc.co.uk/pe
A technical book about PE pipe installation	"PE100 Pipe systems", by H. Bromstrup, published by Vulkan-Verlag (Germany), www.oldenbourg.de
The United Nations "Water for Life", 2005 – 2015	www.un.org/waterforlifedecade
The World Business Council	www.wbcsd.org
World Wild Life Fund	www.panda.org/freshwater
Paper by W. Becker & M.A. Shepherd	"Replacing London's Victorian Water Mains", Plastics Pipes XIII, Washington, 2006
Paper by H. Nishimura et al.	"Earthquake resistance – evaluation of polyethylene pipes", 3R International 40, 2001
Paper by S. MacKellar	"Leakage survey in UK" Plastics Pipes XIII, Washington, 2006
Paper by M. Shepherd et al.	"Development of a whole life costing model for large diameter water mains", Plastics Pipes XIII, Washington, 2006

About Borouge

Borouge is a leading provider of innovative plastics solutions. Combining the most advanced technologies with world-class production facilities, Borouge is a unique company that brings together the very best of Europe and the Middle East.

With a heritage of reliable customer partnership and value creation through innovation, Borouge provides plastic solutions that make a real difference to everyday life.

Established in 1998 as a joint venture between the Abu Dhabi National Oil Company (ADNOC), one of the world's major oil companies, and Borealis, a leading European plastics provider, Borouge is a groundbreaking international partnership at the forefront of next-generation plastics innovation. Together, Borouge and Borealis employ unique Borstar® technology to produce innovative plastics solutions in end-use plastics applications throughout the Middle East, Asia-Pacific and Africa. Borouge's state-of-the-art petrochemical complex is located at Ruwais, Abu Dhabi in the United Arab Emirates.

Borouge provides a range of differentiated products for high-value infrastructure applications, including water, gas and industrial pipe systems, power and communication cables, advanced packaging and automotive components. The advantages of Borstar are well recognised in the industry and are central to Borouge's success – the technology facilitates the manufacture of high-performance, high-value plastic products that are vital to modern living. Borouge's presence in key strategic locations throughout the Middle East, Asia-Pacific and Africa facilitates speed to market, on-time delivery and customer support. Borouge is also the exclusive regional provider of the entire Borealis product line.

To meet ever-increasing market demand, Borouge plans a multi-billion dollar expansion at Ruwais. The project, 'Borouge 2', is due to commence production in 2010. This world-scale project will triple existing production capacity to two million tonnes per annum, including, for the first time, polypropylene.

At the forefront of one of the world's most exciting industries, Borouge empowers its customers to create products that are vital to global development and has a vision of 'Shaping the Future with Plastics'.

For more information contact: infopipe@borouge.com
or visit www.borouge.com or call: +65 6275 4100

SALES & MARKETING Singapore (Head Office)
Borouge Pte Ltd 1 George Street #18-01 Singapore 049145
Tel: +65 6275 4100 Fax: +65 6377 1233 Email: info@borouge.com

بروج
Borouge
SHAPING *the* FUTURE *with* PLASTICS

PE100 compounds – essential for durable gas and water pipes

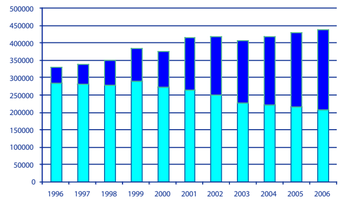
MEMBER OF PE100+ ASSOCIATION

بروج
Borouge
SHAPING *the* FUTURE *with* PLASTICS

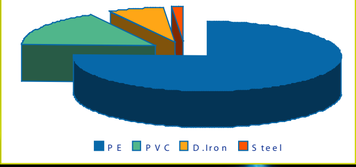
Why has PE 100 pipe been so successful in Europe?

In Europe, PE100 material was first introduced for gas and water pipes and fittings in 1990. Since that time it has made remarkable progress and now accounts for more than half of the PE pipe materials used. In the European water industry, now well over 400,000 tons of PE are used each year and PE now accounts for over 70% of the market in sizes up to 300mm.

Growth of PE in gas & water systems in Europe 1996 - 2006

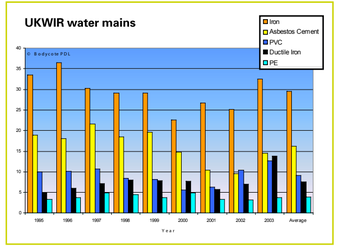


Pie chart of PE usage in water mains up to 300mm



This growth in PE usage in Europe could only have occurred if the gas and water engineers had confidence in the quality of the raw material and pipe systems and are convinced that PE would provide a durable solution – this confidence has been justified by the recently published UK Water Industry failure data which is shown in the chart.

UKWIR water mains



These results show that PE has by far the lowest failure rate compared to other pipe materials. Lower failures mean lower maintenance and repair costs, which reduces the overall cost of ownership of the system.

Borouge is replicating the European success of PE in gas and water in the Middle East and Asia. In Ruwais, Abu Dhabi we follow the European practices in production and quality control testing. The materials produced are of equivalent quality as evidenced by our PE100+ listing for Borstar HE3490-LS.

PE 100+ Association Listing

Product	Manufacturer
Hostalen CRP 100 black	Basell Polyolefine GmbH
Hostalen CRP 100 blue	Basell Polyolefine GmbH
Borstar® HE3490-LS (black)	Borealis A.B.
Borstar® HE3492-LS (orange)	Borealis A.B.
Borstar® HE3494-LS (blue)	Borealis A.B.
Borstar® HE3490-LS (black)	Borouge Pte, Ltd
ELTEX®TUB 121 (black)	Ineos
ELTEX®TUB 125 N2025 (orange)	Ineos
ELTEX®TUB 124 N2025 (blue)	Ineos
ELTEX®TUB 121 N3000 (black)	Ineos
HI-ZEX 7700 MBK (Black)	Prime Polymer Co., Ltd.
SABIC Vestolen® A 6060 R (black)	SABIC Polyolefine GmbH
SABIC Vestolen® A 6060 R (blue)	SABIC Polyolefine GmbH
EL-LENE H1000PC (black)	Thai Polyethylene Co., Ltd
HDPE XS10H (blue)	Total Petrochemicals
HDPE XS10B (black)	Total Petrochemicals
HDPE XS10 OrangeYCF	Total Petrochemicals</<TBODY>

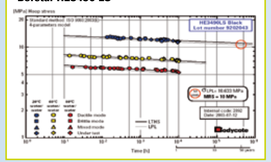
To maintain PE100+ Association listing, the material must meet the higher performance requirements (i.e. above existing specifications) of the Association and samples are regularly and independently tested by to demonstrate continued compliance.

MEMBER OF PE100+ ASSOCIATION

How do raw material suppliers ensure high quality compounds?

Classification of PE pipe materials are based upon ISO 9080 - sometimes called the SEM classification. In this process small diameter pipes made from the PE compound are pressure tested to failure. The 20°C failure points are then extrapolated to 50 years and if the failure strength exceeds 10MPa then the PE compound is deemed to be a PE100 material.

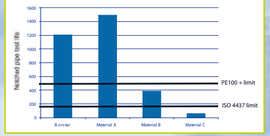
SEM classification curves for Borstar HE3490-LS



However, it must be remembered that a material that meets the 10MPa limit is not necessarily suitable for the production of gas and water pipe as the material must also meet the other requirements of the specification, such as the crack growth resistance.

The Notched Pipe Test measures the material's resistance to the growth of a crack from a sharp notch in a pressure pipe. The slow crack growth resistance can be very different for different PE100 materials as shown in the test data.

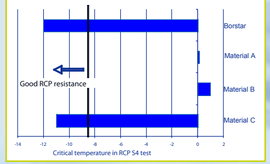
Slow crack growth performance of Borstar HE 3490-LS compared to three other PE100 materials



Rapid Crack Propagation can also occur in a pipe when there is sufficient energy available to overcome the materials resistance to rapid crack growth. This is particularly important for gas pipes and it can be measured in the laboratory using the S4 test equipment. As shown in the test data there can considerable variation in the performance of PE100 materials in this test.

Important for water pipes is that the PE material must not impart any taste or odour to the water that it is carrying. In Ruwais we monitor this on a regular basis with a trained team of people. If a natural polymer and a master-batch are used, then this property can only be monitored on the final pipe by the pipe producer himself – a demanding task not usually carried out!

Resistance to rapid crack propagation Borstar HE3490-LS compared to three other PE100 materials



What can go wrong if fully characterised compounds are not used?

Unfortunately, there have been a number of incidents where poor quality PE pipes have failed prematurely. This is usually due to the use of poor quality raw materials rather than fully characterised compounds. On some occasions this has lead to a complete loss of confidence and a ban on the further use of PE pipes (examples are some parts of India in the mid 1990's and in some Malay states today).

A recent incident in a water project in Asia highlights this problem as shown in the attached photographs.

A total of 7km of 125mm PE100 16 bar water pipe was installed in the narrow city streets (right). The pipe was successfully pressure tested and put into service at 6 – 8 bar pressure (i.e. well below the rated pressure for the pipe).

In a few weeks, the pipe started to fail and over a 7 month period, a total of 15 failures occurred. All the failures were from cracks initiating on the bore of the pipe and growing through the pipe wall (left). Eventually the complete line had to be replaced, greatly adding to the cost of the project and the disruption to the residents.

Post examination of the pipe showed the material had very low thermal stability and contained areas of little or no pigment, typical of a poorly dispersed master-batch in a natural polymer. Clearly this pipe was not produced from an approved and tested PE100 compound material and would not meet the specified performance requirements.

This case shows clearly that the only way to ensure that durability is maintained, is to use a good quality PE100 compound which is regularly tested by the polymer supplier and ideally tested by an independent body as are the PE100+ listed materials.