

## **Reducing Water Losses using Welded Polyethylene Piping Systems**

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### Abstract

It is staggering to realise that today there are over one billion people around the world that have no access to clean water and more than two billion without proper sanitation. With climate change, pollution and population growth the situation will get worse unless we take positive steps to develop new water and wastewater systems in the poorest regions of the world. By contrast in many of the so called developed countries we do not value the underground assets that have been installed and lose almost half of the water before it reaches the tap. We seem to have forgotten the lessons of the nineteenth century when these great water and sewage systems were installed and at last broke the grip of cholera and other water borne diseases and significantly increased the life expectancy of the population. Yet today we have in polyethylene pipe systems the toughest, most durable and easiest to install of any underground system past or present. Modern trenchless laying techniques mean that old mains can be renovated without digging up the street or new systems can be installed using fast and cost effective ploughing or directional drilling. Despite all these developments in the west we face increased water restrictions due to more variable climate conditions and high leakage rates and in the east and south almost 5000 people, mainly children, die each day due to water borne diseases. There are, however some points of light in the darkness – for example in Singapore and Australia major water recycling schemes are being developed and the education of the public on water issues is being given a high importance. The benchmark water companies around the world demonstrate that it is possible to reduce and maintain their water losses in single percentage figures demonstrating that better water management is the solution to many of the challenges we face. In this paper the authors highlight some of the important challenges that we face and show how different groups working together using modern plastics materials can really make a difference to people's lives and provide "leak free" water and sanitation systems for future generations to enjoy.

Keywords: Water, Sanitation, Leak free, Renovation of pipe systems, Polyethylene pipes

## The water & sanitation crisis

It is clear that water and sanitation issues present a major challenge to governments all around the world. In Africa and Asia it is estimated that 4,200 people die every day from diseases related to low quality drinking water and lack of sanitation and over 90% of these deaths are of children under the age of five. This situation prompted the United Nations to include water and sanitation in their “The Millennium Development Goals”. Their specific targets were to reduce by half the proportion of people without sustainable access to safe drinking water and sanitation systems by 2015.

In 2006, nearly halfway through the period, the U.N. reviewed the progress in reaching these targets and published the results in their report entitled “Beyond scarcity – Power, poverty and the global water crisis” (1). The data shows that in many parts of the world these targets would not be reached unless some very special efforts are made during the latter half of the programme. The clear challenge is to make up this shortfall in the remaining seven years to achieve the water and sanitation targets. However it should not be forgotten that even if the Millennium Goals are achieved, there will remain nearly two million people without access to sanitation.

So what can we, as a producer of polyolefin materials, do to make a substantial and sustainable difference to these global challenges? In fact we can do a lot - firstly, working with others in the water and sanitation industry we can bring some of the best practices in water and sanitation systems to those regions in need. Also we can ensure that that local product quality and installation practices ensure the solutions provided are cost effective, leak and maintenance free and sustainable.

With this in mind Borouge and Borealis have embarked on a joint programme which embraces these and other elements under the umbrella of “Water for the World”.

## Borouge & Borealis “Water for the World” programme

The “Water for the World” programme was formally launched in the Middle East by Mr. Abdulaziz Al Hajri the CEO of Abu Dhabi Polymers at the 11<sup>th</sup> Industrialists Conference in Abu Dhabi in January. To an influential audience representing many countries in the Middle East region he outlined the concept and the most important targets of the programme.



Fig.1.The five main strands of the “Water for the World” programme ([www.waterfortheworld.net](http://www.waterfortheworld.net))

The above figure shows the main elements of the current programme and the linkages to other partner organisations. These partnerships will increase as the programme develops around the world.

In supporting “best practice” Borouge and Borealis are co-founders of the Stockholm Water Prizes which are awarded each year at the Stockholm Water Week for the greatest contributions to water and sanitation issues around the world (2). For example last year the recipients of the industrial water prize were the Public Utility Board (PUB) in Singapore who have pioneered water conservation and recycling programmes. They have clearly demonstrated that even in water scarce areas with good water management it is possible to provide sufficient and good quality water for everyone. In other water scarce regions other novel solutions are also being developed (3, 4).

Borouge and Borealis are also members of Water and Sanitation for the Urban Poor (WSUP) which is a cross-sector partnership that is committed to bring improved water and sanitation services to the people living in urban slums. The members of WSUP pool their expertise relevant to water, sanitation and hygiene and work directly with local service providers and with communities to design, develop and implement effective solutions. The first projects are now reaching the implementation stage and by the end of the year it is projected that 60 -100,000 people will have a better life that they do at the moment.

Another important activity within the programme has been the development of the “Water Tool” tool with other members of the World Business Council for Sustainable Development (WBCSD). This is software that is freely available on the internet (5) that enables companies to map and understand their “water footprint” in whichever part of the world they operate. It is particularly important for companies operating in areas of water scarcity that they understand their water footprint and the competing demands from agriculture and communities for the available water.

Spreading “best practice” and knowledge is also an important aspect of the programme and for this reason Borouge has initiated the development of the Gulf Plastics Pipes Academy (GPPA) to support the development of plastics systems in the Middle East region (6). This organisation was launched at last years Dubai Plast Pro and with the active support of other members of the plastics pipes industry can really grow to a powerful educational force in the Middle East.

Whilst the Water for the World programme is not directly linked to markets and financial targets it is worth remembering that the water industry spends around US\$ 260 billions each year. Countries and cities across the globe are actively seeking solutions for their water and environmental water management needs and many of these solutions involve plastic products (pipes, films and mouldings) which we can provide.

#### Best practice - materials & technology selection

If we look at the water distribution systems it is clear that plastics and in particular polyethylene (PE) pipe systems provide the lowest cost and most durable system. Indeed in Europe over 70% of all new water mains are made of polyethylene material with the increasing use of PE100 compounds. In the sewage sector polypropylene is rapidly becoming the material of choice in Europe as explained by Gunter Dreiling of Borealis at a recent conference in Dubai (7).

This preference for PE in water distribution is primarily due to the material's high resistance to corrosion, its flexibility and the ability to weld sections together to make a continuous “leak free” pipeline. These latter characteristics enable PE pipes to be threaded through old leaking iron pipes to renovate them without having to dig up the street or for new systems to be installed by ploughing or directional drilling. These “No Dig” techniques significantly reduce the installation cost of the system. As the installation cost is significantly higher than the pipe and fitting cost and as most of these techniques can only be used with PE it makes it the automatic choice on the basis of total or “Whole Life Costs” (8).

The toughness of the material also enables the welded PE pipes to withstand the stresses due to ground movements which arises due to seasonal weather patterns and even the more severe ground movements due to earthquakes. This was clearly demonstrated by the Osaka Gas investigation following the “Great Earthquake of Kobe” in Japan in 1995 (9) where many failures were observed in their iron and steel networks but none in their PE systems.

Table 1 compares the most popular water main materials with regard to the important properties for the application. This makes it clear why PE is a clear winner in the market not just for renovation but also for new lay projects.

Table1. Comparison of different water main materials

Property & performance	Iron pipe systems	Glass fibre reinforced plastic	PVC systems	Polyethylene systems
Corrosion resistance	poor	good	excellent	excellent
Strength	excellent	excellent	good	good
Toughness	poor - brittle	medium	medium	excellent
Joint integrity	medium	poor	medium	excellent
Flexibility	poor	poor	poor	excellent
Ease of installation	poor	poor	good	excellent
No dig techniques	not possible	Not possible	limited	yes -excellent
Cost pipe & fittings	high	Low - medium	low	med - high
Cost of installation	med - high	Low - medium	low	low
Cost of operation	high	high	medium	low
Whole life cost	high	high	medium	low

To produce good quality PE pipes it is essential to use well characterised PE compounds which form the basis of the European and International standards for pressure pipes. These compounds are subjected to long term pressure testing by the raw material supplier and classified by their 50 year strength properties. Additionally good fracture properties which are required as defined by slow crack growth and rapid crack propagation tests which effectively determine the tolerance of the pipe to the external scoring and other damage that can arise when using modern installation methods.

These requirements are embedded in the latest International standard (10), which forms the basis of many national standards. The PE100+ Association goes a step further by continuously monitoring the performance of members listed materials. The list of qualifying materials is updated regularly on the Association's website (11).

The superior durability of PE for water distribution mains has now been demonstrated by a number of water companies. In the UK for example the Water Industry have gathered failure data on their water mains over many years and in 2006 presented the consolidated results which are presented in figure 2 (12). As one would expect the worst performing pipes are the old cast iron pipes which have been in the ground for many years and are now heavily graphitised and very brittle. The slightest ground movement will cause these pipes to crack and fail as clearly shown by the orange bars on the graph.

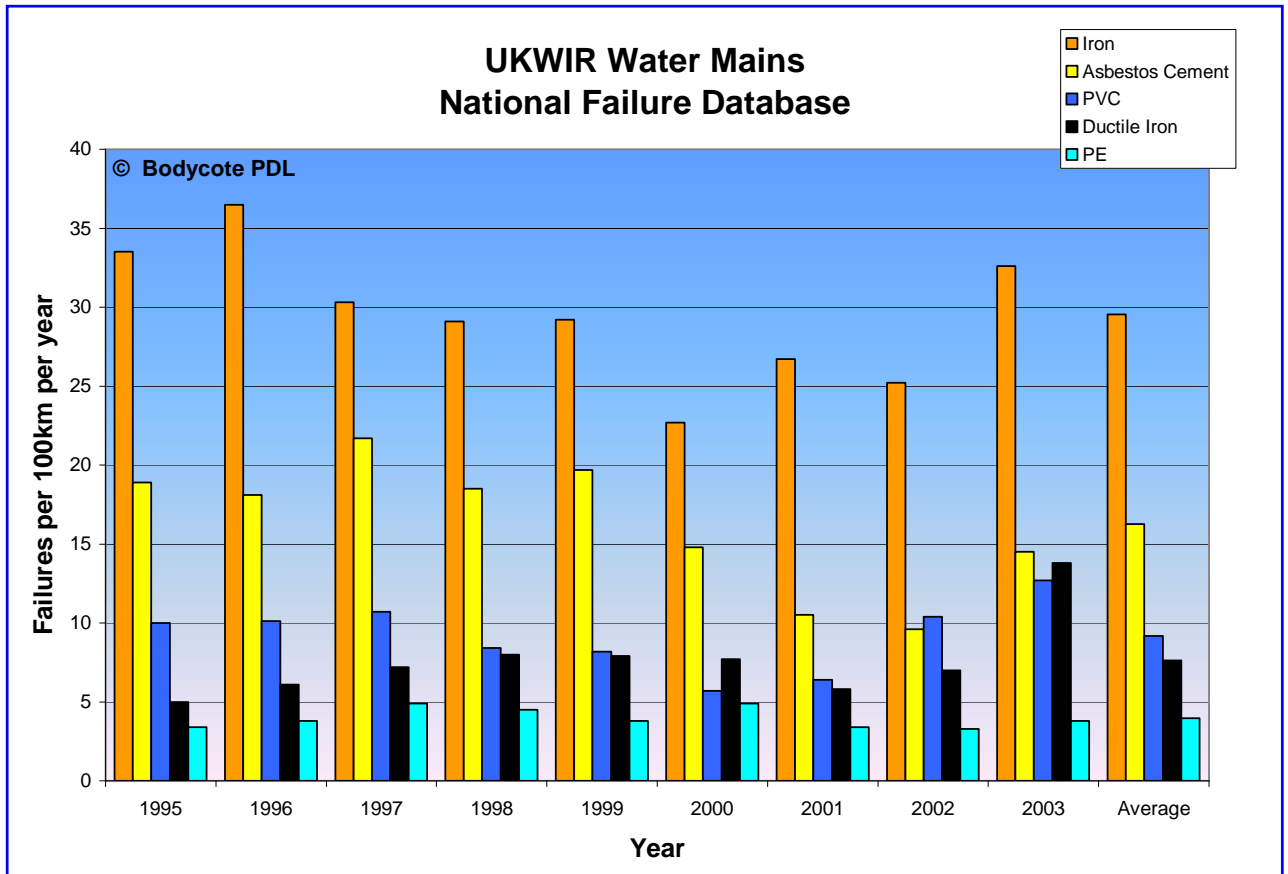


Fig 2. Consolidated water pipe failure data from the UK Water Industry Research (12)

Next poorest are the asbestos cement pipes which in many soil conditions are already coming to the end of their useful life. Many of these pipes were only installed in the 1950's and 1960's but over the years the cement matrix has been leached out of the pipes by the ground water leaving the fibres which are now very vulnerable to collapse under the stresses produced by ground movement and modern traffic loads.

The next highest failure rates are from the PVC and the ductile iron pipes which are of very similar performance being between 5 and 15 failures per 100km per year. Both these systems were introduced in the 1960's so it is somewhat surprising that the failure rates are already this high.

Consistently the lowest failure rates have been the PE pipes always being below 5 failures per 100km per year which is less than half the rate of any other material. Further analysis of the data has shown that second and third generation polyethylene pipes are well below this average value and correlate well with the increase in performance of the materials under test conditions. Therefore despite using modern installation methods where PE pipe is subjected to greater stresses during installation the pipes are still showing a much lower failure rate.

In the next part of the paper some projects are described which make use of the special properties of PE materials to provide cost effective solutions to real problems.

## Bringing Water to Villages in Rural India

To us a continuous supply of drinking water from a household tap is the norm – not so in India where in many cities and rural areas the water supply is only for just a few hours per day. Overloaded systems and high water losses are usually the main causes which results in people queuing for many hours to fill containers for their daily water supply. The Maharashtra State government is committed to improve water supply systems in rural India and Borouge together with some local industry partners are helping them achieve this target by installing “24x7”, leak free water supply systems.

Malkapur is a small village in the State of Maharashtra, India, 400kms to the south of Mumbai. The current population of 30,000 are served by a water supply system which was installed in 1988. This system was designed to supply a population of 14,000 by 2010, but due to the rapid growth in the number of people who live and work in sugar production in the area and due to leakage of around 35% there was now insufficient water to go round. As a

result, residents of Malkapur village have to walk long distance and queue in long lines to collect few buckets of water and store it in their homes to be used during the day.

The objective of the project was to provide every household in the village with fresh water around the clock seven days a week. A new water distribution network is required to distribute the water among the 3,000 homes and minimize the water loss from the system. Maharashtra Jeevan Pradhikaran (MJP) who is financing and owning the project set a requirement for the new network to reduce water loss to less than 5%. This new system has been designed to supply a projected population for 2030 of 67,000 people.

To meet the requirements of the project it was essential to use pipes of the highest quality and durability to ensure the long service life without interruption and minimize leakage. Therefore it was agreed that high quality polyethylene material would be provided by Borouge to produce the 53.55 km of water mains ranging in diameter from 75mm to 140mm. Kimplas Piping Systems manufactured all the pipes and fittings including the service pipes to supply the 3,000 houses in the village. All the pipes were supplied in coils, which significantly reduce the number of joints and speeds up the installation of the system. EPC Industries installed the pipes, and jointed them using electrofusion fittings in six different water districts in Malkapur village.





Now every house in Malkapur village is connected to the new water system enabling the people to enjoy the precious fresh water during the hot summer months. The Malkapur 24/7 water project will become an important reference village in the Maharashtra State government's program to improve the water supply to its rural population

#### Bringing Syria's Quweiq River to Life

One of the most interesting projects in the Middle East region is the regeneration of the Quweiq River which runs through the ancient city of Aleppo in Syria. This has transformed, what was just a few years ago, a bad smelling trickle of contaminated water into a clean and picturesque river flowing through the centre of the city.

Additional water is withdrawn from Lake Al Assad (Buhayrat al Assad), an artificial lake 80km and 8km wide formed in 1973 by the construction of the Tabaqah Dam on the Euphrates River. Three giant pumps extract water from the lake at the rate of 4 cubic metres per second and pump it to up the city of Aleppo set on a high plateau formed by several hills.

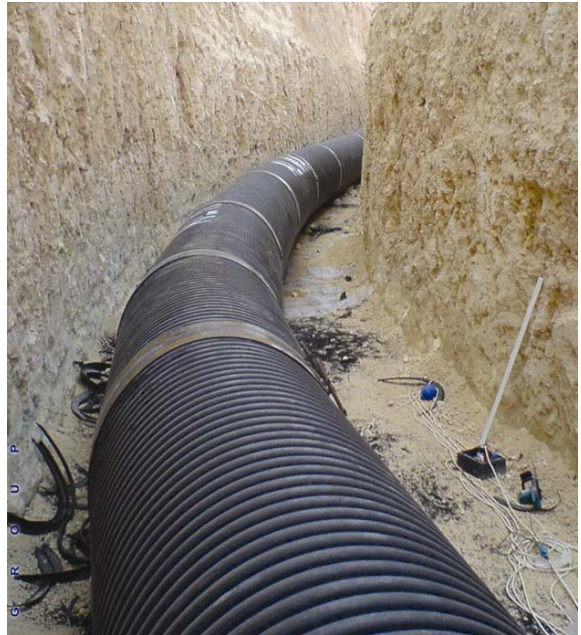


Fig. 4. Pipe installed to great depths

The water transportation pipeline was constructed in three sections and the longest section of over eight and half kilometres is of spiral wound PE pipe. The pipe which is of 1600 and 1800mm diameter is buried to depths of 20 metres in some very unstable and rocky terrain which are challenging circumstances for any pipe system.

The PE pipe was produced from Borouge PE100 material by local pipe producer Al Matin. The pipe lengths were welded together using extrusion welding making it tough and yet flexible and able to resist the soil loading. The pipe itself was produced by winding an extruded profile onto a circular mandrel and welding adjacent sections to each other. This produces a pipe that is strong and flexible yet considerably lighter than alternative pipe designs.

Within the city of Aleppo the river bed and embankments have also been totally renovated to create once again form one of the cities amenities for the 4 million people now living in the region. The river will also provide water for local industry and a source of good quality water for agricultural irrigation.

The project, which cost more than \$20 million was funded by the Ministry of Irrigation and was in 36 months. The Ministry were so pleased with the result that they hope to replicate it with the rivers in Damascus, Homs and Hama. The grand opening of the river was in January 2008 by Bashar al-Assad, the president of Syrian Arab Republic.



## Providing Industrial Cooling Water in Abu Dhabi

The last example demonstrates the use of large diameter PE pressure pipe for industrial applications. The project was the cooling water pipes for the new Borouge 2 polymer plant in Abu Dhabi. One very different feature of the new plant is the replacement of the GRP cooling water pipes used ten years ago in Borouge 1, with large diameter polyethylene pipelines made from Borouge PE100 material (15).

The main reason for this change was the operational failures of the existing GRP pipelines. These 64 inch diameter pipes suffered complete wall failure as shown in figure 5. These are similar to the failures observed in GRP water trunk mains in the UK in which the water breaks through the resin gel coat and gradually breaks down the bonding



between the fibres and the resin eventually causing catastrophic failure of the pipe. The initial break down of the gel coat can be caused by installation damage or by subsequent abrasion of the bore of the pipe. This type of problem has persuaded the water companies in the UK to no longer use GRP pipes in pressure applications and now in many cases they now use PE.

Polyethylene pipes on the other hand are very tough and tolerant to installation surface damage and do not suffer such catastrophic failures. In addition they can be butt welded which avoids all the jointing difficulties experienced when installing large diameter GRP pipes. Therefore for Borouge 2, four 1600mm PE100 pipes would be used for the 3 bar pressure feed lines and the six gravity outlet pipes would also be in PE100 material. These pipes were produced by Union Pipes in Abu Dhabi and are now being welded and installed at the site of the new plant in Ruwais. The pipes were extruded on a new Battenfeld extrusion line which was installed specifically for this project. The special properties of the material means that even these thick walled pipes can be produced at high output rates and with a very even wall thickness thus minimising production problems.

## Concluding Remarks

The need to conserve water is clear to us all and with population growth and climate change this need will increase in the future and the water crisis will effect us all. In these circumstances the quality and durability of our

infrastructure is extremely important and the choice of the pipeline material is a crucial decision.

Evidence from around the world shows that PE is the best choice for gas and water distribution for a number of important reasons:-

- PE systems do not corrode and it is corrosion that is the main reason for failure of old metallic systems
- PE systems are flexible and can be fully welded which minimises water leakage and makes them easy to install.
- PE pipes can be used for a wide range of “no dig” installation methods that can significantly reduce overall project costs and local disruption.
- PE systems are resistant to surface defects and damage which can cause failure of other pipe systems
- PE pipes systems can be designed for a range of applications including large diameter water transportation lines for domestic or industrial use.
- There are many examples where PE has been used in the Middle East region to provide good quality, durable systems for many years to come.

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