Special print from "PE 100 Pipes Systems" | 3rd Edition | Vulkan Verlag

Large-diameter PE 100 pipes for drinking water supply to the Scottish metropolis of Glasgow

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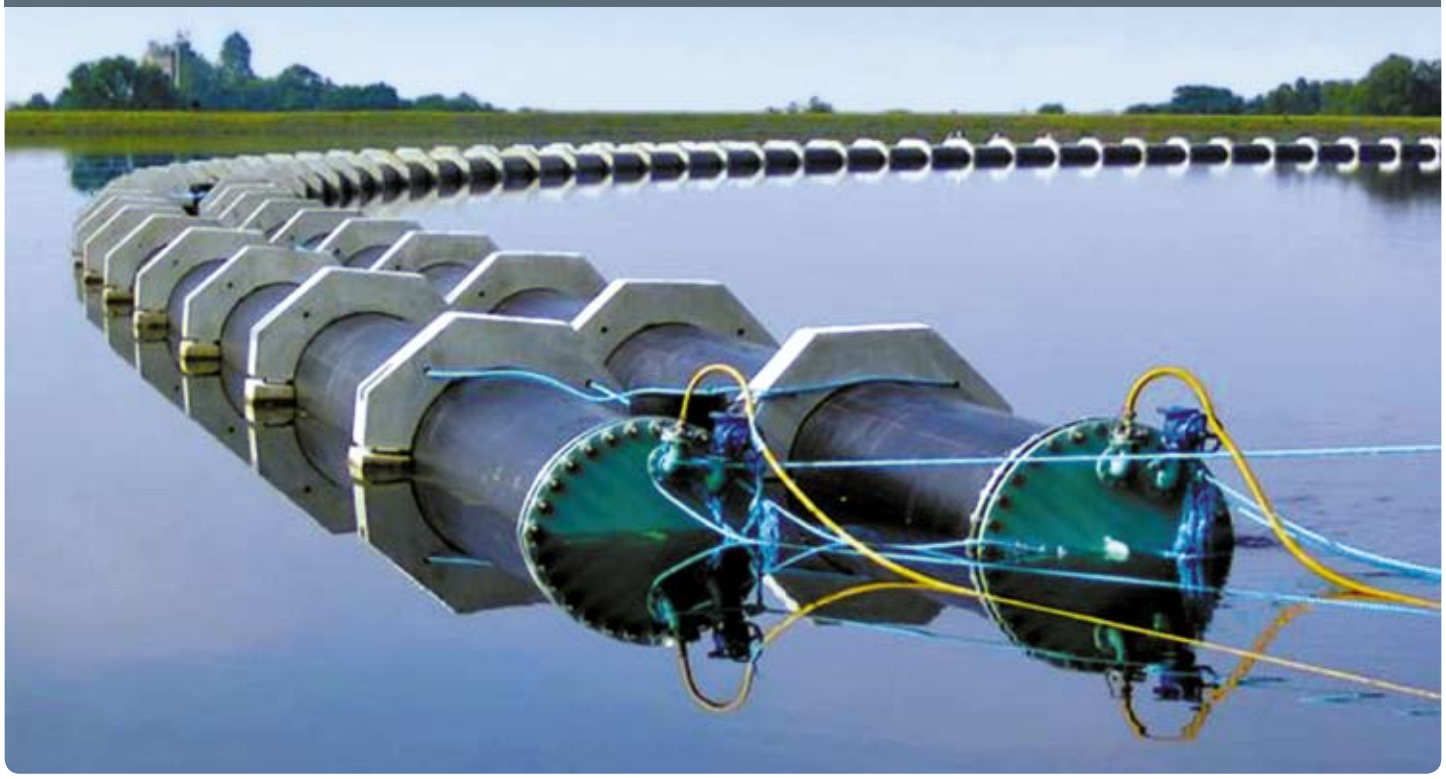

Contents

KWH Pipe many years of practical experience with high-density polyethylene-based (PE-HD) piping systems have continuously enabled the company to develop components and systems which fully conform with the demanding requirements of such diverse fields of application as drinking water supply and plant engineering. High-density polyethylene pipes, in particular, stand out in this field from the other, "classical", materials. The improved performance of modern multimodal pipe materials in performance class PE 100 has also made it possible to improve piping system properties and characteristics. This article describes large-diameter PE 100 pressure pipes from *Hostalen CRP* 100 black for drinking water to supply to the Scottish metropolis of Glasgow for a total length of 5500m.

Introduction

For more than 45 years, polyethylene pipelines have been used successfully for water supply and sewage disposal in widely diverse environments. When installing pipes in difficult terrain and operating under extreme climatic conditions, quality and safety are crucial factors.

Modern multimodal pipe materials in performance class PE 100 are now suitable for pressure pipe applications, which until a few years ago were the preserve of, e.g. steel pipelines [1].

The project described here is an example of an application from the Glasgow area, in which Scottish Water, in conjunction with pipe installation companies, financial service providers, landscape architects and environmental planners, is installing large-diameter PE-HD pipes made from Hostalen CRP 100 black to supply drinking water to the city.

Planning for this large project started in November 2001. Construction activities have been carried out in the area of Mugdock, Milngavie and Balmore between 2003 and 2006. The PE 100 Piping System was successfully commissioned by October 18th 2007.

Brief portrait of Scottish Water

Scottish Water, headquartered in Dunfermline [2], was formed in April 2002 from the previous East, West and North of Scotland water authorities. It was one of the most complex company mergers ever seen in Scotland.

Supply network

The supplier operates and maintains thousands of assets and is responsible for over 46 000 km of water pipes, 39 000 km of sewage pipes, 1896 wastewater treatment works, and 371 water treatment works plus pumping stations sludge treatment centers and reservoirs such as Loch Katrine.

Customer structure

Scottish Water has 5 million customers in 2.2 million households. Business customers number 135 000, the majority being small to medium businesses, with 490 large industrial and commercial users.

Water quality

To safeguard water quality, a considerably amount of water samples are taken every day from a combination of customer taps, water treatment works and service reservoirs.

Every day, 2.5 billion liters of drinking water are supplied and 1 billion liters of wastewater are taken away and treated before being returned to the rivers and lochs.

Loch Katrine – Drinking water reservoir for Glasgow

More than 400 million liters of water are withdrawn daily from Loch Katrine reservoir, some 40 km north of Glasgow to supply over 700 000 customers in the metropolis [2].

Loch Katrine (Gaelic for "Cateran" – meaning a Highland robber) is situated in the Trossach National Park. It is 13 km long, 1.6 km wide and covers an area of 1238 ha. The Loch is famous for the outlaw, Rob Roy McGregor, the novel "The Lady of the Lake" by Sir Walter Scott and the SS Sir Walter Scott, a steamship, which has operated tourist cruises on the lake since 1899 [3].

The water is transported to the water treatment works at Mugdock in a combination of 50- to 60-year-old steel pipes and 80- to 100-year-old cast-iron pipes. From there, it is fed into the supply network of the metropolis.

Katrine Water Project – Investment in Glasgow's drinking water supply

The Katrine Water Project was Scottish Water's largest water treatment investment project in Scotland. The estimated cost of the work accounted 120 to 140 million Euro [4]. At peak times, some 300 people have been employed at the various sites.

The aim of the project, besides safeguarding the supply of drinking water to Greater Glasgow, is to improve drinking water quality. The consumers of Glasgow and six other communities will in future be supplied with drinking water from Loch Katrine that meets European quality requirements.

In the preceding years, the water authority at the time did not modernize the two reservoirs at Mugdock and Craigmaddie and the pipeline network for economic reasons.

It was only the detection of Cryptosporidium – a chlorine-resistant parasite found in surface water and one of the main pathogens causing diarrhea – and the pressure applied by Scottish Water on the responsible Scottish Minister that accelerated the modernization plan.

Experience in Germany over the last 40 years has shown that with a well-functioning flocculation/filtration system for surface water, the transmission of Cryptosporides to drinking water systems need not be feared [5].

Mugdock – Water treatment works with a long history

Mugdock, about 14 km north of Glasgow center, made history in the mid-nineteenth century.

In 1859, Queen Victoria opened the Mugdock water works south of the reservoir and the connecting distribution network which was to supply the households of the metropolis with fresh drinking water.

This drinking water supply system was one of the most modern in the world at the time. Since then, vast quantities of water have flowed through the Victorian pipework. But the ravages of time have not left the drinking water supply system entirely unscathed. At the start of the 21st century, the system was no longer able to supply the population of this large city with drinking water to current safety requirements.

The Mugdock reservoir is about 15 m deep and has a capacity of more than 24 000 cubic meters. In the early days of Mugdock, the water was transported to the city through two pipelines – each 900 mm in diameter. Two additional pipelines were laid in the years 1872 and 1873. The quantity of water stored in 1876 was sufficient to meet demand from the city for 18 days.

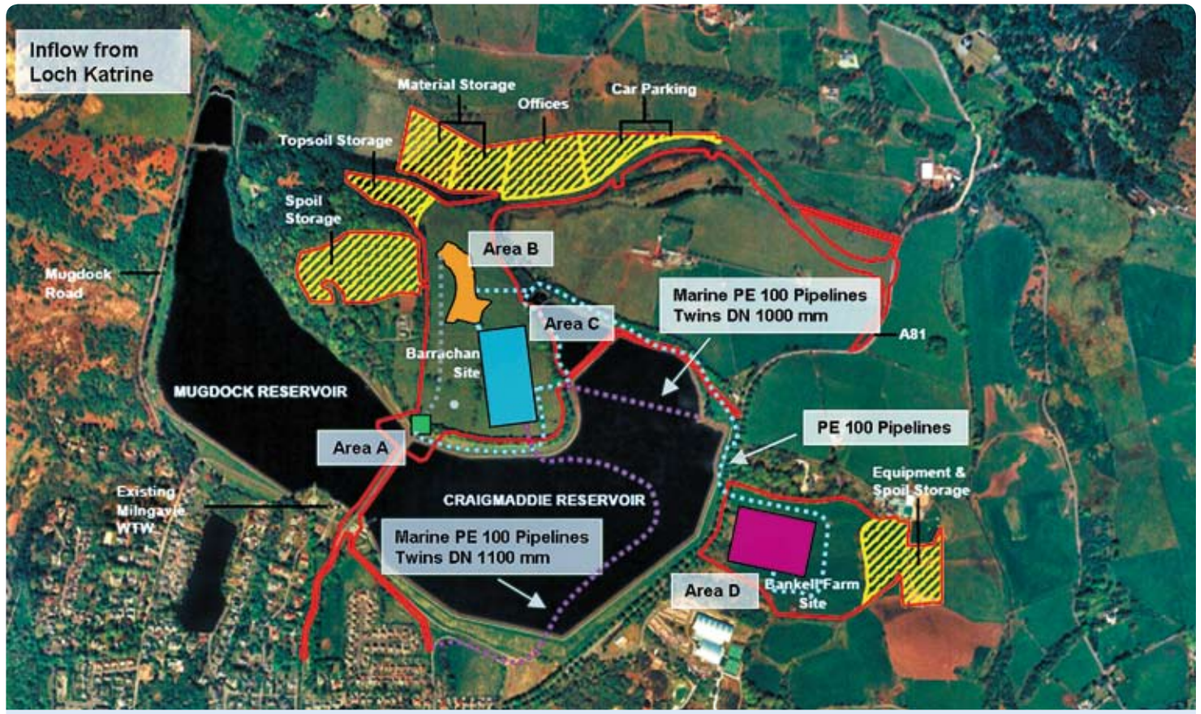

Fig. 1: Site map of the Project including the PE-HD-Pipe system made from *Hostalen CRP* 100 black [7]

Scope of the construction project

The main construction activities in the current project will take place around Barrachan and Bankell. To make it easier to distinguish between them, the construction activities are divided into areas A, B, C and D.

Area A

Construction of a new *raw water pumping station*. The station will be built north of the dam on a site at Barrachan.

Area B

The new *drinking water treatment works* will be built in the hills above Barrachan. The building complex will be designed to harmonize with the contours of the landscape.

Area C

This area, just below the drinking water treatment works, will contain a *drinking water* and a *clearwater reservoir (holding tanks)*.

Area D

The new *drinking water service reservoir (holding tank)* will be situated east of the Craigmaddie reservoir.

The water will be transported from the drinking water holding tanks through smaller-diameter pipes to the city.

Planning obstacles – Engineering and conservation interests finally harmonized

During the planning process [4] there were constant delays.

East Dunbartonshire Council, the local planning authority, initially rejected the plan in August 2002. The Council objected on the grounds that the extensive construction activities would reduce the amenity of the only recreation area in the north of Glasgow.

In October 2002, Scottish Water appealed against the decision of the Council to the relevant Scottish Ministers. At the same time, Scottish Water began to prepare a new planning application based on a revised design, which addressed environmental concerns about the project. Both the water supply company and the general contractor, Gleeson, promised that the new holding tanks would be hardly visible. In addition, Scottish Water set aside a budget of £ 1 million for landscaping measures to minimize environmental impact.

The revised plans were agreed by the Council in November 2002. To improve acceptance of this major project by the public at large, 500 000 leaflets were printed and distributed.

Construction project requirements

The construction firm under contract to implement the project first had to demonstrate that nature conservation requirements would be taken into account during the project.

MJ Gleeson, one of the UK's largest companies in the water supply sector, won top marks from an independent industry watchdog for its planned environmental protection and safety procedures at the sites in the Mugdock area.

Area A

The pumping station will draw some 240 million liters of water every day from the Mugdock and Craigmaddie reservoirs and transport it in buried pipelines to the new drinking water treatment works.

Area B

The new drinking water treatment works is designed to filter 240 million liters of fresh water per day.

In addition, the site will contain the following facilities:

- Administration building
- Filter backwashing and washwater recycling facility
- Orthophosphoric acid and sodium hypochlorite dosing facility
- Emergency power generation
- Water filter treatment facilities.

In the first place, a pilot plant was built and operated for a period of 12 months, during which time a range of filtration technologies was tested. The pilot plant was designed to filter 31 m^3 of water per hour and was capable of operating 24 hours a day.

After a large number of trials, direct filtration proved to be the most technically reliable, ecologically sound and economically attractive solution.
The direct filtration process has two distinct elements, a conditioning and a filtration phase. This approach will reduce the risk of bacterial contamination considerably [4].

The new drinking water treatment works buildings will be partially sunk into the ground between two hills covered with large trees.

Area C

This area, situated just below the drinking water treatment works, will contain a drinking water tank and a clearwater tank.

The drinking water tank will regulate water consumption in the network while the clearwater tank will supply service water after planned and unplanned network maintenance. The two tanks will be made of steel-reinforced concrete and have a total capacity of 160 million liters.

After completion of the construction work, trees and bushes will be planted around the water treatment works and the areas above the two tanks will be sewn with grass. The local populace will be the ultimate judges of how well the water works blends into the surrounding landscape.

Area D

The new service reservoir (holding tank) for drinking water will be situated east of the Craigmaddie reservoir. The service reservoir will be built on agricultural land and will also supply service water after planned and unplanned network maintenance. The service reservoir will have a capacity of 80 million liters and will be large enough to meet Glasgow's demand for 11 hours.

Selection of pipe material

PE 100 – Ideal material for this project

The 2-3 years' application development support by KWH Pipe in advance of this project and the DWI (Drinking Water Inspectorate) approval obtained for the special large-diameter PE-HD pipes and fittings in the UK market were key factors in the decision to use pipes and fittings made from *Hostalen CRP* 100 black for this project.

Scottish Water and the general contractor, Gleeson, had been familiar with the economic and technical advantages of PE-HD pipes for transporting drinking water for a number of years.

In addition, the pipe manufacturer had over 40 years' experience with PE-HD pipe materials.

Cost effectiveness of PE 100

Pressure pipes and fittings made from PE 100 offer significant advantages in handling and installation because of their low density of 0.959 g/cm³. This has a positive impact on installation costs. Pressure pipes with a nominal diameter larger than DN 800 can be economically produced by a flexible production process.

During the planning stage, reference was made to relevant experience in various previous projects and the operator was duly persuaded.

Technical advantages of PE 100

These are, in particular, good chemical resistance, high operational reliability, far superior corrosion resistance to metal pipe materials and weldability that guarantees permanent leaktightness of the system.

Manufacture of pipes and fittings

The pipes are produced by KWH Pipe at Middelfart in Denmark.

The company is headquartered at Vaasa, Finland. KWH Pipe is one of the world's largest pipe manufacturers with operations in Europe, North America and the Far East. The company's modern, flexible pipe production facilities enable it to manufacture pipe to customer specifications in dimensions up to 1600 mm.

To reduce on-site installation costs, the pipe sections are being supplied in a special length of 14.5 meters. Four pipes at a time are delivered to the installation sites on a flatbed trailer. On completion of the project, the total weight of the installed pipes will amount to 750-850 tons.

M.J. Gleeson carried out the design calculations for the bends and pre-weldable stub flanges, which are being produced by Plastitalia at Brolo in Italy.

Implementation of the pipe installation project

Selection of pipe dimensions

To complete the project, a total 4500 meters of 1100 mm-diameter pipe (two pipelines, each 2250 m long) and 550 meters of 1000-mm pipe will be required. Altogether, over 100 pre-weldable stub flanges (bolted flanges) and prefabricated bends will be needed.

To speed up installation, the flanges will be pre-welded to the ends of bends and pipeline sections.

The flange connections on bends and pipeline sections are also required to connect the PE100 pipelines to existing steel pipes and valves.

The following requirement profile was specified for the new pipelines:	
Service life:	50 to 100 years
Service temperature:	5 - 20°C
System pressure:	4 bar

Extensive hydraulic calculations led to selection of the following pipe dimensions:
PE 100: 1100 x 42.0 mm (PN 6.3, SDR 26), designed as double pipeline
PE 100: 1000 x 38.2 mm (PN 6.3, SDR 26)

Pipe jointing technology

The individual pipe lengths supplied are welded together on-site into continuous pipeline sections several hundred meters long with a flange connection. The welding work is carried out using a butt welding machine developed for M.J. Gleeson by KWH Pipe's Technology division in Finland.

This welding machine for pipe dimensions from 800 mm upwards is fitted with automated pressure and stroke control and a data recording unit to control the welding process.

The welding parameters used for joint alignment, heating, changeover, welding pressure build up time and cooling time under welding pressure comply with the guide values specified in the current edition of the British standard WIS 4-32-08.

This welding machine is owned and operated by A.G. Wilson, the welding contractor that is carrying out the welding work for KWH Pipe and M.J. Gleeson. A.G. Wilson has already taken part in previous installation projects by M.J. Gleeson and KWH Pipe that involved welding large-diameter pipelines.

Fig. 2: Pipe lengths made from *Hostalen CRP* 100 black (PE 100), diameter 1100 mm, manufacturer KHW Pipe

Fig. 3: Hot tool butt welding machine by welding contractor, A.G. Wilson, with PE 100 pipe lengths made from *Hostalen CRP* 100 black

Pipe installation

After delivery the pipe length are first placed on a bed of sand beside the trench. After welding on-site, the assembled pipelines are then lowered into the trench with suitable lifting equipment. The trench is backfilled with stone chippings and sandy excavated soil.

The pipe lengths for the marine pipelines are welded on a suitable place on the lakeside by heated tool butt welding, simultaneously, sink weights were installed before the pipelines were pulled on the Reservoir.

Fig 4: Twin Marine Pipelines DN 1100 made from *Hostalen CRP* 100 black (PE 100) prepared to be placed in the Craigmaddie Reservoir

Fig. 5: Installation of two PE 100 pipe sections made from *Hostalen CRP* 100 black in the vicinity of Bankell

Outlook

Scottish Water has been successfully using PE 100 pipes and fittings to transport drinking water for over 5 years.

This project clearly shows that engineering and nature conservation can be harmonized without any problems.

On the basis of the positive experience that Scottish Water has had so far with KWH Pipe and M.J. Gleeson, further use will be made of PE 100 pipes in the Edinburgh Drinking Water Project.

Acknowledgement

The authors would like to express their very grateful thanks to Environmental Resources Management, M.J. Gleeson, Scottish Scenery and Scottish Water for providing photos, illustrations and useful information.

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LB 068 e 05/2009