DUCTILE IRON PIPE SYSTEMS

The Annual Journal of the European Association for Ductile Iron Pipe Systems · EADIPS®

49

Sustainably superior –
ductile iron pipe systems

Sustainably superior –
ductile iron pipe systems

Sustainably superior – ductile iron pipe systems

Dear Readers,

The aim of the EADIPS®/FGR® annual journals is to illustrate the practical applications of ductile iron pipe systems – pipes, fittings and valves in ductile cast iron – and the advantages which they offer for the user. The contributions in the current issue, number 49, continue this tradition.

Ductile cast iron is a relatively recent material for producing pipes, but it has been the subject of numerous developments over the years. These have often had to do with jointing technique, e.g. restrained push-in joints which have inspired the development of the trenchless installation technique. But coatings (cement mortar, polyethylene, polyurethane, zinc coating with finishing layer, epoxy coating, enamelling) and linings (cement mortar, polyurethane, epoxy coating, enamelling) have also played their part in expanding the range of application of the system.

Pipe systems in cast iron are robust, durable and sustainable. The ductile properties of cast iron mean that the pipes, fittings and valves produced from this material have excellent adaptability, flexibility and security characteristics.

The joints have a loading capacity up to bursting pressure, they are simple and safe to assemble and thus they meet all the requirements for saving costs in construction.

The linings and coatings are the basis for an improved performance in transporting water of all kinds and for installation in all types of soil. In short they are the basis for a century of working life for the ductile iron pipe system.

These outstanding properties of ductile iron pipe systems crop up again and again as we read the articles in this issue and will inspire solutions for problems in the planning and execution of pipeline construction projects.

Ductile cast iron creates value

We wish you much pleasure in reading the new Issue 49 of **DUCTILE IRON PIPE SYSTEMS**

Yours

Raimund Moisa

EADIPS®
FGR®

European Association for Ductile Iron Pipe Systems
Fachgemeinschaft Guss-Rohrsysteme

The rehabilitation of an old sewer (concrete egg-shaped profile) in a thermal spring protection area and an archaeological monument from the Carolingian period under pressure of time for the planned festivities for the 1200-year anniversary of the death of Charlemagne in 2014 could be a nightmare for the planners in charge. In order to avoid additional obstacles and delays due to the constant presence of urban archaeologists, the work was carried out beneath the archaeologically relevant horizon using the trenchless technique (forepole driving a tunnel). A good measure of cooperation and ductile iron sewage pipes cut to three-metre lengths finally resulted in success.

Lübzer Pils is one of the beacons of the central German beer landscape. After considerable investments in the almost 140 year-old brewery, one million hectolitres a year are now brewed by 200 employees. Over this period, the demands placed on the infrastructure have also increased, above all in matters of water management and environmental protection. Brewery wastewater, with its biochemically active ingredients, requires some sophisticated solutions for the materials of its valves. Corrosion protection and the resistance of materials provide the basis for sustainable operational capability.

Sometimes it is also worth thinking about long-held certainties. One such certainty is the protective effect of cement mortar linings of ductile iron pipes. In this case theoretical analysis of long-known facts and a practical examination of a water pipe in operation for 35 years reinforce the certainty that the cement mortar lining of ductile iron pipes is, as ever, the best form of protection and one which becomes more effective with every year of operation. This knowledge is very valuable because constant "innovations", for example in the area of thermoplastics, can tend rather to create uncertainty in the user.

It is not only in cities that tight spaces can cause difficulties for pipeline construction. Even in rural areas when, for example, the route of a pipeline runs along a narrow forest track, original ideas can help create cost-effective solutions. When it came to replacing an old main transporting pipeline it was essential that operation was not interrupted during the work. So first of all an interim pipeline was laid above ground along the shoulder of the forest road. Once the old pipeline had been dismantled and the new pipes had been laid, the pipes of the temporary pipeline could be taken up and used again on the second half of the route where more space was available. Ductile iron pipes with restrained push-in joints permit cost-saving processes of this kind without difficulty.

A DN 600 mains water pipeline which has seen better days has developed a major leak. 2,000 m³ of drinking water are being lost but a direct repair of the damage is impossible because the pipeline has been built over – in fact built over with the stands of the local football stadium. Because the pipeline is ailing anyway it will be "retired" once a bypass has been laid. DN 600 ductile iron pipes with cement mortar coating and restrained push-in joints laid in open trenches will provide the necessary flexibility here.

As the capital of the one-time Habsburg Empire and rich in tradition, Vienna is the cradle of standardisation in the industrial age: it was here in 1882 that the pipe standards came into being – the forerunners of today's cast-iron pipe standards. And a few of the supply pipelines laid in the ring roads are of a similar age, but they now need to be replaced under the most difficult working conditions. The Vienna water supply department (MA 31) is fully committed to ductile iron pipe systems because it does not want to have to open up the surface of the busiest streets in Austria again for another 100 years.

An example of the ever more complex requirements being placed on system components for drinking water supplies can be seen on an originally simple component, the domestic connection valve. Naturally these valves must meet the demands of durability and functional reliability. But because they need to be able to be used with the widest variety of main pipe materials, they have to be able to be fitted and removed as far as possible by hand and without any additional tool in the pipe trench and they should allow the main pipe to be drilled whether or not it is pressurised. A smart system construction kit is the result of development.

After being in operation for 5 decades, a DN 500 asbestos cement pipeline has been given a new lining by in-situ lining with cement mortar. The access openings created for this every 120 m have been reclosed with short lengths of ductile iron pipes and adapter couplings. The manufacturer and user "trimmed" the adapter couplings to the extreme conditions in the field. After that, their application on site proceeded without problem: a great example of how collaboration between user and manufacturer can automatically bring developments to a successful conclusion.

Evolution is never-ending! However good a butterfly valve might be, there is always room for improvement. And with modern computer programming the structure of the disc of the butterfly can be optimised to the extent that, even with large nominal sizes (DN ≥ 600) and high nominal pressures (PN ≥ 25) and despite increased degrees of stiffness, there is only a minimal narrowing of the free cross-section. To achieve this, the disc eyes are incorporated into the support structure. The ξ-values obtained in numerical simulations can be backed up by flow tests in the field. With additional innovations (such as impact-resistant enamelling) and proven construction details (such as polygonal couplings between shaft and butterfly disc, slider crank drive) all this adds up to a new development stage for the butterfly valve.

Only valves and fittings in ductile cast iron combine with the pipes to form a complete workable system. This becomes particularly apparent when repair or renovation work has to be carried out on existing equipment. Modern valves are tailored to suit these special jobs, for example exchange and repair valves with loose flanges for installation in an elevated tank or a combination of fittings and valves for a buried cross-fitting installation. Modern jointing techniques and above all corrosion protection to the highest level safeguard the functioning of equipment for many more decades.

The trenchless replacement of old pipelines along the same route using the static burst lining process has mainly been carried out in inner-city environments where the creation of open trenches is becoming ever more difficult because of the restricted allocation of space for pipelines underground as well as traffic congestion. Thus the oeconomic success of a trenchless replacement in a local recreation area near Zurich is all the more astonishing. In this case it was topographical and economic considerations which led to the use of ductile iron pipes in the burst lining process.

The single-pipe assembly of ductile iron pipes using the horizontal directional drilling (HDD) technique has become established practice above all in inner-city areas where space is tight. And it is precisely with this technique that ductile iron pipes can proudly show off their advantages, such as short installation times with the maximum permissible tractive force and no waiting times as well as the lowest bend radiuses, as compared with any competing material. Under pressure of time and with restricted inner-city conditions, it is almost inevitable that ductile iron pipes will be the answer whenever a pipeline is to be replaced!

Pressure pipeline for diverting karst water in the access tunnel of a new pumped-storage power plant

In Switzerland, with its topography which is predestined for the production of renewable energy on the basis of hydroelectric power, a large pumped-storage power plant is currently being built. It is capable both of generating power and of storing it for periods of high demand. The shield-driving of the 8 m diameter access tunnel to the machine and transformer cavern cut into two karst water aquifers. The seasonally fluctuating filling of these needs to be diverted so that the construction of the pumped-storage power plant can continue. The two DN 250 ductile iron pipelines required for this were suspended in the upper area of the access tunnel so as to impede the clear cross-section of the tunnel as little as possible. The planning for the iron pipes was a virtuoso performance with restrained and non-restrained joints along a run with a 24 % gradient – a very instructive example of how almost any conceivable problem can be solved with ductile iron pipes.

Home-produced power for processing home-grown wood – Baron Mayr-Melnhof-Saurau backs energy independence

A large Styrian forestry and timber production company is backing renewable energy. As well as woodland, there is also a watercourse which belongs to the group and which has enough of a gradient to be able to generate power with a Pelton turbine. When implementing the Gössbach I project all sustainability aspects were taken into account: fish ladders are provided to help the fish migrating upstream to reach the source unhindered; the machine house, simply built using the company's own wood, blends unobtrusively into the landscape and, naturally, the penstock has been constructed using the most sustainable pipe material – ductile cast iron. With home-generated power, the group can operate its sawmill with complete self-sufficiency in energy.

Extending the Samina pumped-storage plant in Liechtenstein

After more than 60 years of operation, a hydropower station in the Principality of Liechtenstein is being renovated and simultaneously extended to create a pumped-storage plant. And here, once again, DN 900 ductile iron pipes, PFA = 45 bar, with restrained push-in joints are being used because they have all the advantages on their side: simple, fast and secure assembly, coarse-grained excavation material can be put back in the same place, wall thicknesses can be adjusted to the pressures depending on the altitude. When it comes to the development of renewable energy, the sustainable ductile iron pipe is the clear favourite!

Ductile iron pipe systems – durability and sustainability in practice

In April 2014 the Vienna municipal authorities department MA 31 (Wiener Wasser) was the host at the university lecturers conference which EADIPS®/FGR® together with the FIHB (Fördergemeinschaft zur Information der Hochschullehrer für das Bauwesen e. V. / association promoting information for lecturers of construction engineering) traditionally organises every two years. Presentations at the event were given under the motto "sustainability, efficiency, durability" and they were highlighted with the practical experiences of the host in Vienna with ductile iron pipe systems. In addition, specialists from the pipe manufacture reported on trenchless installation techniques and energy efficiency gains with the use of ductile iron pipes.

Trenchless replacement of sewage pipes and the protection of historical monuments

By Dirk Müller

1 Introduction

In 2011, the public utility company Stadtwerke Aachen Aktiengesellschaft (STAWAG) commissioned the engineering firms AGEVA GmbH & Co. KG and Gell & Partner GbR to produce the plans for replacing the supply and waste disposal pipelines in the "Pfalzbezirk", in the heart of Aachen. The Pfalzbezirk covers the area between the Rathaus, or City Hall, and Aachen Cathedral (Katschhof) as far as the Krämerstraße, as well as Ritter-Chorus-Straße, Johannes-Paul-II.-Straße, Klosterplatz and the market. The work was divided into two construction stages. The first stage included the work on the sewer system in the area of the market, as well as the district heating pipeline running parallel to the Rathaus towards Krämerstraße and continuing on to the Couven Museum. Work using the open-trench technique was commenced in 2011.

However, soon after work was started it was clear to all participants just what carrying out excavation work on the site of a listed monument involves.

The fact that the Pfalzbezirk is an extremely valuable archaeological site meant that the almost constant presence of archaeologists in the area **(Figures 1 and 2)** quite frequently resulted in interruptions in the construction work and sometimes in complete standstills. Consequently the considerably smaller construction stage 1 with open trenches was not completed until the middle of 2012 and took many times the construction time actually envisaged.

In view of the anniversary of the death of Charlemagne in 2014, which was very important for the city of Aachen, the time frame for the 2nd construction stage was clearly stipulated: it had to be completed by the end of 2013.

Figure 1:
Archaeologist in an open trench

Figure 2:
Excavation work already close to the surface

2 The initial situation

With the knowledge gained about the archaeological aspects in the first construction stage on the Pfalzbezirk it was decided to scrap the original plan and, instead of using the open technique, to lay the sewer using the considerably more expensive gallery construction method. This process would allow both concerns for safeguarding the archaeological monument and the particular conditions relating to the site to be taken into account in the best possible way. This included the construction site for the Charlemagne Centre at the edge of the sewer installation area, which had also run into time problems because of conflicts regarding deliveries and crane positioning. Also, the extensive surface redesigning work which was running in parallel to all this (Ritter-Chorus-Straße, Johannes-Paul-II.-Straße, part of Klosterplatz) on behalf of the City of Aachen had to be taken into account as well. All of these construction measures demanded close collaboration between all involved if they were to avoid getting in each other's way on the same construction site.

In addition, the numerous events being held and other work being carried out in the surrounding inner city area resulted in immense problems with maintaining the necessary emergency routes and access for the fire services, meaning that the entire construction site along with all the site equipment had to be cleared away for the numerous major events in the Market Square and the Katschhof. In fact the launch pit had to be covered over while continuing to comply with load class SLW 60 for traffic safety.

What is more, a tight network of supply lines (above all the district heating pipeline between the Cathedral Information Office and the Cathedral Treasury and in Ritter-Chorus-Straße), which are located directly above the existing sewer in many places, made the open trench technique pretty much impossible.

All these aggravating factors had to be taken into account when implementing the extensive 2nd construction stage, not forgetting that the "archaeological unknowns" which might crop up could put the construction work well and truly behind schedule. Consequently, given all the constraints described, the gallery was the only possible way of completing the sewer renovation in time for the 2014 Charlemagne celebrations.

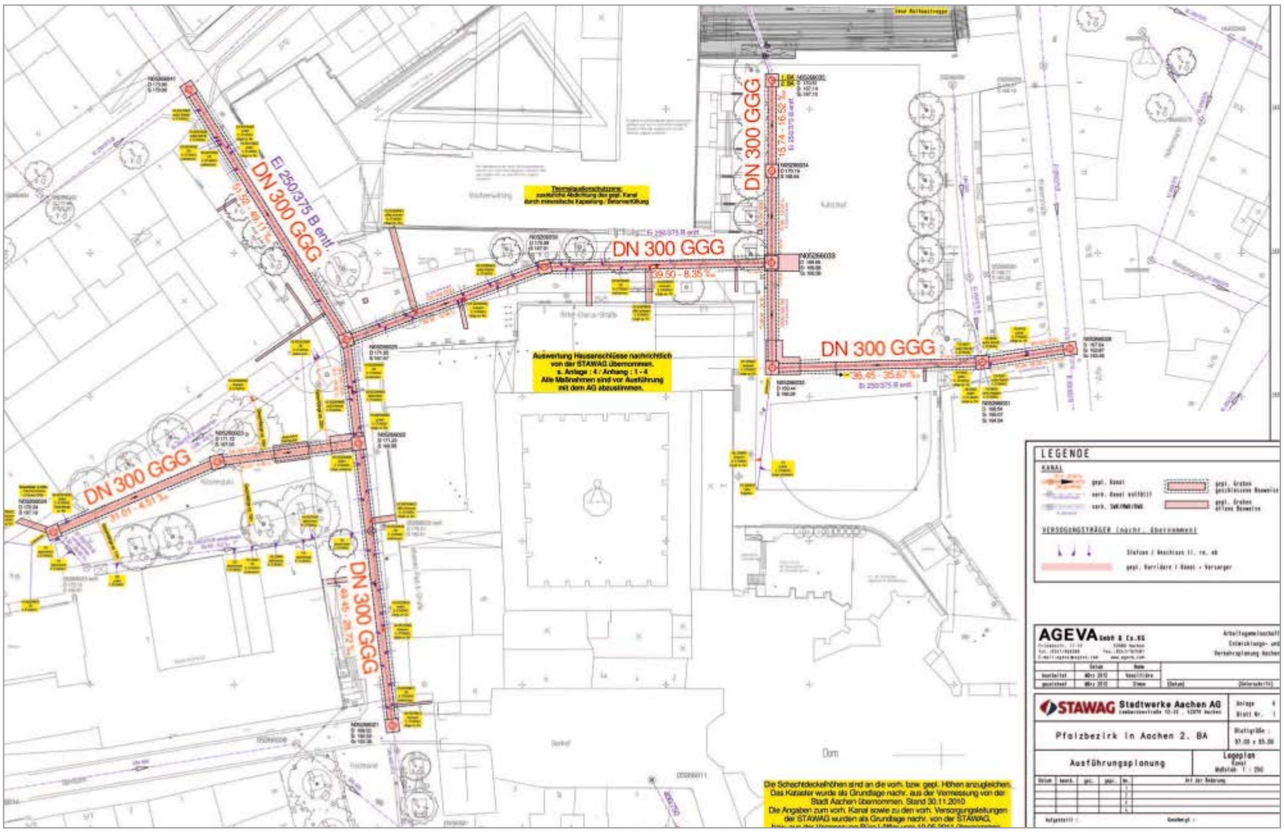

Figure 3:
Construction plan – practically the entire route was laid using the trenchless technique

3 Planning and construction phase

The 2nd construction phase covered the replacement of the sewer pipelines in the Katschhof right down to the lower part of Krämerstraße and also in Ritter- Chorus-Straße, Johannes-Paul-II.-Straße and the Klosterplatz over a total length of around 360 m. The entire gallery system was to be constructed from four shotcrete launch pits, mainly along the route of the old sewer **(Figure 3)**. The only exception was the Klosterplatz. Here, partly for tree preservation reasons and partly because of the proximity of the existing buildings, the gallery had to take a new route.

The sewers to be replaced consisted of concrete pipes with an egg-shaped profile w/h = 250/375 mm with the pipe bed at depths of between 3.2 m and 5.2 m. This meant covering heights for the galleries of between 2.6 m and 4.5 m **(Figure 4)**. As regards the planned pipe material, STAWAG specified the use of DN 300 ductile sewer pipes with zinc coating and an epoxy finishing layer as well as TYTON® push-in joints because the entire renovation project lay within a thermal spring protection zone. For the pipes (standard length 6 m) to be able to be inserted into the confined space of the galleries and into the shotcrete launch pits, they had to be cut down to 3 m lengths **(Figure 5)**. With a clear working space alongside the DN 300 ductile iron pipes and the existing egg-shaped profiles of at least 50 cm on both sides, the clear width of the gallery in the sections between the reinforcement arches was calculated at about 1.4 m. The clear gallery height between the bottom of the steel arches and the floor is approximately 2.0 m, with the invert level of the pipes being around 60 cm beneath the crown.

First of all, after a certain interval of time and with the constant accompaniment of archaeologists, the four launch pits were excavated to the necessary depth **(Figure 6)**. The entire sewer replacement was carried out from these four pits under the particular conditions described.

The precise location of the archaeological findings, above all with reference to the so-called central pillar from the time of Charlemagne, was not known. Therefore the shafts had to be sunk very carefully and with great flexibility so that the right solution could be found, if necessary in agreement with the archaeologists. Hence for example shotcrete launch pit 6033 had to be developed eccentrically so as to minimise degradation to the Carolingian brickwork.

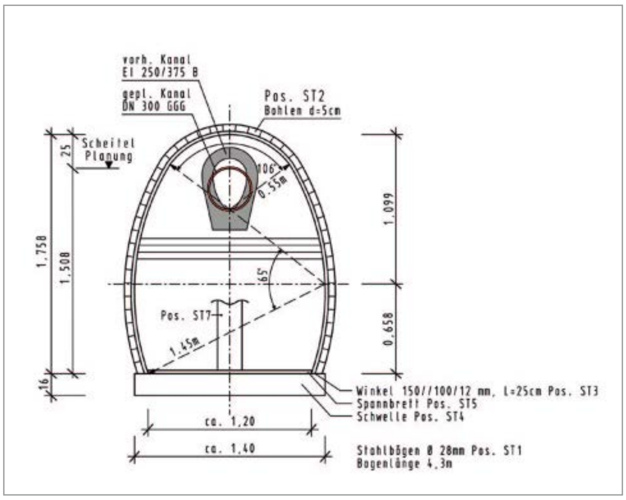

Figure 4:
Cross-section of gallery

Figure 5:
Threading the 3 m pipes into the gallery from the launch pit

Figure 6:
Launch pit with Carolingian brickwork

Figure 7:
Existing pipeline in the crown of the gallery

Figure 8:
Fixing the assembled pipeline into position

Before the brickwork was removed, in addition to the documentation already existing, STAWAG also carried out 3D laser scanning of the situation. The necessary sprayed concrete was applied with a barrier material to protect the masonry which was worthy of preservation so that there was no contact between concrete and brickwork. This way of working offers long-term assurance that, even when the sewer is replaced again in 70 to 100 years' time, no further loss of substance is to be expected.

Working outwards from the four launch pits, depending on requirements the galleries were driven in all directions, in some cases in shotcrete and in some cases preceded by timber sheets. This meant that the impact of stoppages for archaeological reasons could be lessened by moving the gang to other sections of the gallery. Because of the findings which were already known and documented by the city archaeologists, the galleries were positioned as deep as possible. This meant that, in combination with the positioning of the new pipeline just below the crown of the gallery, the galleries could be run through the natural ground beneath the archaeologically relevant layers without affecting the archaeological substance worthy of preservation.

During the construction of the gallery the company carrying out the work – Himmel & Hennig Bauunternehmen GmbH – removed the existing pipeline in the crown and replaced it with a provisional DN 250 water distribution system **(Figure 7)**, to which the house connections were temporarily linked. Once the galleries had been driven, the new pipeline along with the fixing devices **(Figure 8)** was installed and the house connections were connected up. Following the construction of the gallery, the pits were excavated for the remaining shaft constructions and the structures were installed. The gallery was then filled with grouting material to secure it.

4 Conclusion

Thanks to the huge commitment and close collaboration of all involved, the entire project including the surface reconfiguration was able to be completed by the City of Aachen in time for the 2014 anniversary of the death of Charlemagne.

Author

Dipl.-Ing. Dirk Müller
STAWAG
Stadtwerke Aachen Aktiengesellschaft
Lombardenstraße 12–22
52070 Aachen/Germany
Phone: +49 (0)241/181-2651
E-mail: dirk.mueller@stawag.de

Client

STAWAG
Stadtwerke Aachen Aktiengesellschaft
Dipl.-Ing. Dirk Müller
Lombardenstraße 12–22
52070 Aachen/Germany
Phone: +49 (0)241/181-2651
E-mail: dirk.mueller@stawag.de

Planning

AGEVA GmbH & Co. KG
Dipl.-Ing. (TH) Silvia Vassillière
Friedenstraße 11–13
52080 Aachen/Germany
Phone: +49 0)241/968280
E-mail: ageva@agewa.com

Ingenieurbüro Gell & Partner GbR
Dipl.-Ing. Jürgen Knops
Hansmannstraße 19
52080 Aachen/Germany
Phone: +49 (0)241/9559480
E-mail: info@gell-partner.de

Building contractor

Himmel & Hennig Bauunternehmen GmbH
Dipl.-Ing. Patrick Himmel
Layenmühle
56281 Schwall/Germany
Phone: +49 (0)6746/8029836
E-mail: patrick.himmel@himmel-hennig.de

The technical performance of ductile iron pipe systems ensures the highest safety and reliability in all areas of the water industry!

A well-functioning brewery must be able to dispose of its wastewater perfectly

By René Pehlke and Thomas Siegmund

1 Introduction

In addition to its other places of interest, the town of Lübz in the South of Mecklenburg-Western Pomerania has one particular attraction to offer – some good beer! Beer has been brewed at the Lübz Brewery since 1877. After some expansion and considerable investment in new technology the annual capacity of the brewery is currently in excess of one million hectolitres. The classic – Lübzer Pils – is one of the best known beer brands in central Germany.

2 Replacement of a DN 400 valve

The brewery takes its water from its own wells which go down to a depth of 85 m into the lower aquifer. The wastewater produced by the brewing process is collected in a mixing and equalising tank and fed into the public network of the Lübz municipal wastewater service under constant parameters. In August of this year, among other things a DN 400 valve in a shaft of the sewage pressure pipe to the wastewater treatment plant was replaced on behalf of the Lübz wastewater administration **(Figure 1)**; in fact this valve was in the transfer shaft through which the Lübz Brewery feeds its wastewater into the pressure pipeline. The exchange was carried out at night when, naturally, the amount of wastewater from the town is low and this was agreed with the brewery.

3 Materials for wastewater valves

For this special application, wastewater valves in accordance with prEN 1171 [1] in ductile cast iron to EN-GJS-400-15 (GGG 40) were used in combination with a high quality epoxy powder coating to RAL - GZ 662 [2] with

Figure 1:
Replacement and assembly of a DN 400 wastewater valve by employees from DAU Rohrleitungsbau GmbH in Lübz

NBR (acrylonitrile-butadiene-elastomer) rubber coating of the sliding wedge. Particular attention is paid with these valves to the matching of the materials for the spindle (V4A X6CrNiMoTi17122 1.4571) and the spindle nut (brass CuZn40Pb2 2.0402.10) **(Figure 2)** in order to ensure low actuating moments over the long term and to avoid any starting points for corrosion. In this matter, KEULAHÜTTE GmbH were able to draw on their long years of experience working with wastewater. The production programme for wastewater valves in the nominal size range DN to DN 400 and pressures up to 16 bar can be seen in **Table 1**.

The connection options for the wastewater valves in **Table 1** are:

- Flanged joints,
- TYTON® push-in joints,
- PE weld-in ends.

Table 1:
Production programme for wastewater valves from KEULAHÜTTE GmbH

Type	Nominal size DN	Pressure rating PN	Material		
			Spindle	Spindle nut	Rubber coating wedge/seal
Wastewater I	DN 40 to DN 400	≤ PN 16	V2A X20Cr13 1.4021	Brass CuZn40Pb2 2.0402.10	NBR
Wastewater II			V4A X6CrNiMoTi17122 1.4571	Brass CuZn40Pb2 2.0402.10	
Wastewater III			V4A X6CrNiMoTi17122 1.4571	Bronze CuSn12Ni2 2.1060.01	

4 Wastewater III type

Because no standardisation exists for wastewater, when it comes to the long-term functioning capability of valves it is always worth recommending the use of the Wastewater III option. The high quality epoxy powder coating produced by KEULAHÜTTE GmbH according to GSK guidelines for heavy duty corrosion protection [2] is suitable for all types of wastewater and soils. This has been demonstrated by many years of practical research, among other things in collaboration with the Dortmund materials testing institute. As the growing demand in the area of biogas is also increasing in importance, the use of wastewater III type valves is also possible for this medium. Furthermore, in this case the valve is tested with water and air in accordance with DIN 3230-5 [3] in the desired test groups PG 1, 2 or 3.

5 Use of valves in ductile cast iron

The Lübz municipal utility company as the operator of the wastewater system is commercially successful and firmly rooted in the region. Since natural gas supply started in 1991, the Lübz municipal supplier has been providing services in the areas of gas, water, heat and power supply as well as wastewater treatment. The secure supply to almost 7,000 residents with drinking water and gas among other things has meant that, since its establishment, the utility company has had to attend to targeted and systematic renovations and also, with the arrival of industrial enterprises, the expansion of the networks.

With a constant aim of implementing a sustainable investment strategy, the use of valves in ductile cast iron continues to remain valid as a decision of general principle. As well as wastewater applications, this philosophy is also reflected in the drinking water networks **(Figure 3)**.

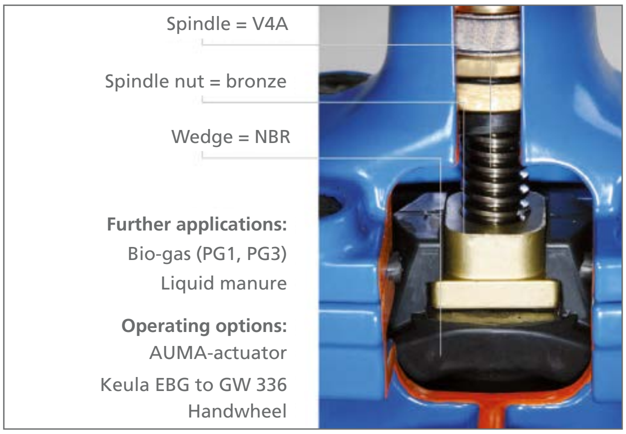

Figure 2:
Sectional view of a ductile cast iron gate valve

Figure 3:
Installation of a new DN 150 drinking water pipeline

Bibliography

[1] prEN 1171
Industrial valves –
Cast iron gate valves
2014

[2] RAL - GZ 662
Güte- und Prüfbestimmungen –
Schwerer Korrosionsschutz von Armaturen und Formstücken durch Pulverbeschichtung –
Gütesicherung
[Quality and test provisions –
Heavy duty corrosion protection of valves and fittings by powder coating –
Quality assurance]
2008

[3] DIN 3230-5
Technische Lieferbedingungen für Absperrarmaturen –
Absperrarmaturen für Gasleitungen und Gasanlagen –
Teil 5: Anforderungen und Prüfungen
[Technical terms of delivery of valves –
Valves for gas installations and gas pipelines –
Part 5: Requirements and testing]
2014-11

Authors

Dipl.-Ing. (FH) René Pehlke
KEULAHÜTTE GmbH
Geschwister-Scholl-Straße 15
02957 Krauschwitz/Germany
Phone: +49 (0)35771/54-0
E-mail: keulahuette@vem-group.com

Dipl.-Ing. Thomas Siegmund
KEULAHÜTTE GmbH
Geschwister-Scholl-Straße 15
02957 Krauschwitz/Germany
Phone: +49 (0)35771/54-0
E-mail: keulahuette@vem-group.com

Ductile iron pipe systems can be shown to produce true sustainability!

An example of the sustainable protection offered by cement mortar linings in ductile cast iron drinking water pipelines

By Florian Häusler and Stephan Hobohm

1 Introduction

The use of cement mortar for the internal corrosion protection of cast iron pipelines carrying water has been known for about 150 years and has proved effective from physical, mechanical and hygienic points of view but also in terms of the chemistry of corrosion. Since the end of the 1960's it has been standard practice to line cast iron pipes with cement mortar at the factory. Despite all these years of experience, questions still arise time and again in practice about cement mortar linings, their possible fields of use and the limits of these and their physical working life. This report will be looking at the last point in particular, the physical working life. We hope to illustrate the advantages of this active protection system on the basis of a practical example.

2 Cement mortar lining

Before the introduction of industrially produced cement mortar lining, the insides of metal pipes were bare or were only coated with a thin finishing layer of tar or bitumen. If water quality was not so good, this led to incrustations **(Figure 1)**, to a reduction in the cross-section of the pipe and so to a loss of hydraulic performance. In rare cases corrosion was also possible. So "rusty water" can still be found today where there are pipe bursts in old pipelines.
In order to avoid these phenomena, about 50 years ago the factory made cement mortar lining of iron pipes was introduced. Cement mortar lining is an active means of corrosion protection. The way it works basically involves two mechanisms:

Figure 1:
Grey cast iron pipe from 1930 with incrustations

1. Firstly the cement mortar lining prevents direct contact between the water and the inside iron wall of the pipe (passive protection). However a small amount of water is diffused through the pores of the cement mortar to the interior surface of the cast iron pipe, thus producing the second protection mechanism.

2. The water (H_2O) diffuses through the non-carbonated cement mortar lining and reacts with the free lime (CaO) of the cement clinker to form calcium hydroxide ($Ca(OH)_2$).

$$CaO + H_2O \rightarrow Ca(OH)_2$$

Calcium hydroxide is strongly alkaline and so increases the pH value at the interface between the cement mortar lining and the cast iron to values > 12, thereby passivating the iron. This active protective effect means that corrosion is effectively avoided.

Over the course of time the calcium hydroxide on the water side is transformed by the CO_2 (carbon dioxide) contained in the water to form calcium carbonate ($CaCO_3$).

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

This causes the pH value of the hydrated cement to fall considerably. At the interface with the drinking water this effect is entirely desirable because the pH value of the drinking water should not be affected (DVGW worksheet W 346 [1]). As regards the active protection effect just described, however, the pH value at the interface between the cement mortar lining and the cast iron should remain at a value > 12 for as long as possible. Whether and for how long this effect is achieved is investigated in the next section.

Cement mortar linings for ductile iron pipes are produced in accordance with DIN 2880 [2]. Accordingly, three different processes for doing this are distinguished, of which only process I (centrifugal rotation process) and process II (centrifuge spray process) or a combination of the two are applied in practice. As regards the protective effect to be expected, according to DIN 2880 [2] the two processes are equivalent.

Process II produces a homogeneous structure in the coating while linings according to process I are characterised by a higher density and/or a lower porosity.

For drinking water pipes, blast furnace slag cement is normally used by German manufacturers. However, according to DIN 2880 [2] and EN 545 [3] the use of Portland cement or high alumina cement is also possible under certain circumstances. High alumina cement is mainly used where the water has a high calcite dissolution capacity (D_C value as per DIN 38404-10 [4]). But since, according to German drinking water regulations (TrinkwV) [5], [6], [7], a calcite dissolution capacity of only 5 mg/l is permissible in the drinking water distribution system (in exceptional cases 10 mg/l), cement mortar linings based on blast furnace slag cement or Portland cement generally suffice. Increased calcite dissolution capacities are usually to be expected with raw water. As from a value of around 15 mg/l high alumina cement should be used instead of blast furnace slag cement. However the same active corrosion protection mechanisms apply for all three types.

The possible areas of use of the different types of cement are given in Table E.1 of EN 545 [3] and in Section 7 and Table 5 of DIN 2880 [2]. **Table 1** shows different water parameters as the area of use for Portland cement, sulphate-resistant cement and high alumina cement.

3 Evidence of protective effects in practice

The experiences described above should be able to be confirmed on a section of cast iron pipe lined with cement mortar dating back to 1979. At the time of its removal the pipe had completed 35 years of operation in a DN 125 drinking water pipeline.

The medium carried was drinking water in lime-carbon dioxide equilibrium **(Figure 2)**. The calcite dissolution capacity was accordingly equal to zero and disintegration or

Table 1:
Areas of use for cement mortar linings as per EN 545 [3]

Water parameters	Portland cement	Sulphate-resistant cement (including blast furnace slag cement)	High alumina cement
Mininum value for pH	6	5.5	4
Maximum content (mg/l) for:			
- Aggressive carbonic acids	7	15	unlimited
- Sulphate (SO^{-})	400	3,000	unlimited
- Magnesium (Mg^{++})	100	500	unlimited
- Ammonium (NH_4^+)	30	30	unlimited

erosion of the cement mortar lining was not likely. The buffering capacity of the water with an m-value 1.35 mol/m³ was classified as low to moderate. The free carbon dioxide content was around 0.5 mg/l and the pH value was 8.3.

The cement mortar lining based on blast furnace slag cement was produced according to process I. The pipe section with the cement mortar lining was investigated in two stages:

1. Optical examination:
   The coating thickness of the cement mortar lining was 5 mm to 5.5 mm. No material loss or disintegration was detected. Sedimentation was practically zero or only in negligibly small traces. After cutting open the pipe section and partial mechanical removal of the cement mortar lining it was also possible to carry out an optical inspection of the contact surface between the cement mortar lining and the cast iron. After checking the surface of the cast iron carefully, no traces of corrosion at all were detected here **(Figure 3)**. On closer analysis of the internal surface of the pipe it could be seen that the adhesion of the mortar to the wall of the iron pipe is greater than the internal cohesion of the mortar: it is not possible to strip the mortar coating from the pipe wall without destroying it; by contrast the layer of mortar next to the boundary surface remained adhered to the inside surface of the pipe. It is a typical characteristic of the cement mortar lining of ductile iron pipes that the adhesion of the lining to the substrate increases during operation. This behaviour, which was described by Gras [8] as early as 1969, is not known with any other pipe lining. It was able to be fully confirmed in the investigation discussed here.

2. Laboratory investigation:
   In a further stage of the investigation, the four layers of cement mortar lining were individually removed **(Figure 4)** and each was examined for its degree of carbonation and thus for the active corrosion protection effect still existing. **Table 2** shows the results of this examination.

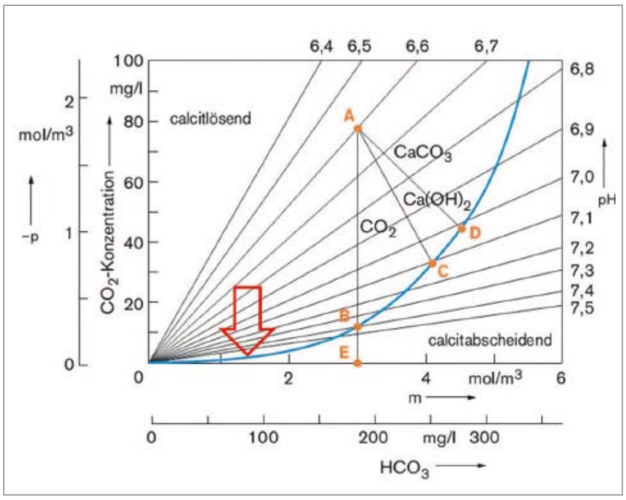

Figure 2:
Tillmann's curve from DVGW Volume 5 – Water chemistry for engineers (the arrow shows the position of the water on the Tillmann's curve)

Figure 3:
Section of cast iron pipe with partially removed cement mortar lining

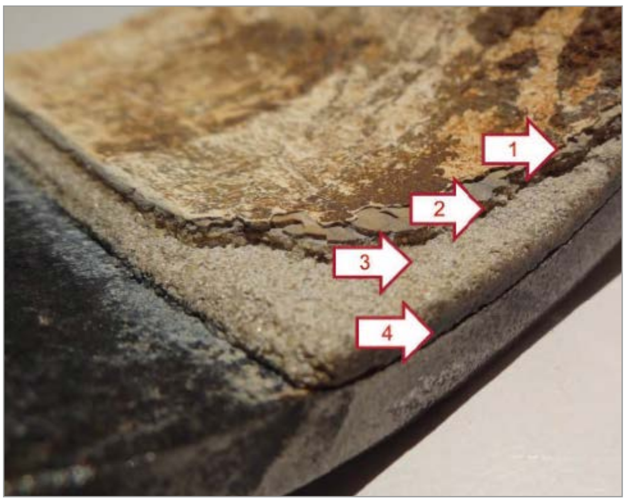

Figure 4:
Layers of cement mortar lining

Table 2:
Degree of carbonation of the individual layers of cement mortar lining

Layer	Carbon-ate (CO_3) [%]	Calcium carbonate ($CaCO_3$) [%]	Free lime (CaO) [%]	Degree of carbon-ation [%]
1	58	79	0	100
2	12.7	21.2	13	47
3	5.6	9.3	1.7	77
4	2.4	4	9	20

It can be seen that the degree of carbonation continuously decreases towards the wall of the iron pipe. Hence layer 1 (fine slurry layer) is completely carbonated by the CO_2 content of the water. The carbonation in layer 1 produced a slight increase in volume and hence a large degree of closing of the pores. This resulted in an almost complete screening (passive protection) of the three other layers lying beneath it against the water inside the pipeline and the CO_2 which it contained. This explains the decrease in the degree of carbonation. While layer 2 still shows a slight degree of carbonation, layers 3 and 4 are almost at the level of a cement mortar lining straight from the factory. The free lime (CaO) content, which is still very high here, can continue to form $Ca(OH)_2$ by reacting with the water trapped in the cement mortar lining and keep the pH value above 12. At the same time the $Ca(OH)_2$ of the lower layers is hindered by the already almost completely tight layer 1 from diffusing into the water in the pipeline and affecting its pH value.

4 Summary and prospects

The speed of carbonation from the boundary on the water side into the cement mortar lining (towards the wall of the iron pipe) depends on various factors:

- Moisture content
  The maximum speed of carbonation occurs at 50 % to 70 % concrete moisture. Therefore dry concrete carbonates more slowly in interior spaces or installation locations protected from the weather than concrete which is exposed to open weathering. However the same also applies to cement mortar linings which are completely wetted or soaked with water (DVGW worksheet W 346, Section 4.2.1 [1]).
- w/z value
  The speed of carbonation is also lower with a low w/z value. The w/z value of a cement mortar lining based on blast furnace slag cement is only about 0.35 to 0.40 according to DIN 2614 [9].
- Porosity of the concrete
  Because of the larger surface area, porous concretes carbonate more quickly than dense concretes. The process of applying the cement mortar lining (centrifugal rotation process to DIN 2880 [2]) and the very high compaction which this produces mean that the cement mortar lining of a cast iron pipe is almost free of pores and therefore carbonates slowly.
- Age of the concrete
  The speed of carbonation decreases as the age of the concrete increases in accordance with the square root of time rule. This means that the speed of carbonation decreases with increasing age.

Depending on these four factors, carbonation can cease as from a certain depth. This has essentially been confirmed by the investigation of the section of cast iron pipe from 1979. According to current knowledge it is therefore to be reckoned that the depth of carbonation will not essentially change during the course of the remaining working life. The active corrosion protection will remain effective far into the future. To summarise it is to be stated that the protective effect of cement mortar lining of ductile iron pipes remains active during the entire operating time. In practice active protection systems such as cement mortar lining offer advantages above all at critical points, for example where the pipe has been cut or tapped, but also where there are smaller cracks or chips. In contrast to passive systems (such as thermoplastic linings for example) the active protection mechanism always guarantees outstanding corrosion protection over the long term. Infiltrations, rust formation and the resulting detachment of the protection system are effectively prevented.

A particularly important aspect relates to the hygiene properties of cement mortar lining as regards drinking water. As the results of the investigations into layer structure and carbonation show, drinking water comes into contact with the completely and thoroughly carbonated boundary layer of the lining exclusively. It consists of inert silicon and calcium hydrates and calcium carbonate. The flowing of drinking water through a pipe with this boundary is directly comparable with the natural passage of water through a cleft in a limestone mountain: anything more natural is scarcely conceivable!

Cast iron pipes and cement mortar linings form an ideal system which can hardly be surpassed when it comes to durable and effective corrosion protection. Similarly, this statement can also be applied to the external protection of iron pipes with a cement mortar coating [10].

Bibliography

[1] DVGW-Arbeitsblatt W 346
Guss- und Stahlrohrleitungsteile
mit ZM-Auskleidung –
Handhabung
[Cast iron and steel pipes and components with internal mortar lining –
Handling]
2000-08

[2] DIN 2880
Anwendung von Zementmörtel-Auskleidung für Gußrohre, Stahlrohre und Formstücke
[Application of cement mortar lining for cast iron pipes, steel pipes and fittings]
1999-01

[3] EN 545
Ductile iron pipes, fittings, accessories and their joints for water pipelines –
Requirements and test methods
2010

[4] DIN 38404-10
Deutsche Einheitsverfahren zur Wasser-, Abwasser- und Schlammuntersuchung –
Physikalische und physikalisch-chemische Stoffkenngrößen (Gruppe C) –
Teil 10: Berechnung der Calcitsättigung eines Wassers (C 10)
[German standard methods for the examination of water, waste water and sludge –
Physical and physico-chemical parameters (group C) –
Part 10: Calculation of the calcit saturation of water (C 10)]
2012-12

[5] Trinkwasserverordnung (TrinkwV 2001)
Bundesministerium für Gesundheit der Bundesrepublik Deutschland
[Drinking water order (TrinkwV 2001)
Federal Ministry for Health,
Federal Republic of Germany]
2001

[6] Erste Verordnung zur Änderung der Trinkwasserverordnung (TrinkwV 2001)
Bundesministerium für Gesundheit der Bundesrepublik Deutschland
[First order amending the drinking water order (TrinkwV 2001)
Federal Ministry for Health,
Federal Republic of Germany]
2011-11-01

[7] Zweite Verordnung zur Änderung der Trinkwasserverordnung (TrinkwV 2001)
Bundesministerium für Gesundheit der Bundesrepublik Deutschland
[Second order amending the drinking water order (TrinkwV 2001)
Federal Ministry for Health,
Federal Republic of Germany]
2012-12-14

[8] Gras, W.-D.: Eigenschaften und Bewährung von Zementmörtelauskleidungen in gußeisernen Druckrohren
[Properties and testing of cement mortar linings in cast iron pressure pipes]
Fgr-Information 4 (1969), S. 16

[9] DIN 2614
Zementmörtelauskleidungen für Gußrohre, Stahlrohre und Formstücke –
Verfahren, Anforderungen, Prüfungen
[Cement mortar linings for cast iron pipes, steel pipes and fittings –
Process, requirements, testing]
1990-02

[10] Rink, W.:
Untersuchungen an Rohren aus duktilem Gusseisen mit Zementmörtel-Umhüllung nach drei Jahrzehnten Betriebszeit
[Examination of ductile iron pipes with cement mortar coating after a period of three decades in operation]
GUSS-ROHRSYSTEME 48 (2011), S. 29 ff.

Authors

Florian Häusler
Duktus Rohrsysteme Wetzlar GmbH
Paul-Schneider-Straße 8
35625 Hüttenberg/Germany
Phone: +49 (0)172/2312257
E-mail: forian.haeusler@duktus.com

Dipl.-Ing. (FH) Stephan Hobohm
Duktus Rohrsysteme Wetzlar GmbH
Sophienstraße 52–54
35576 Wetzlar/Germany
Phone: +49 (0)6441/49-1248
E-mail: stephan.hobohm@duktus.com

Replacement of the pipeline connecting the Seere source to the Eimelrod elevated tank in Willingen-Eimelrod

By Ingolf Bittermann and Karl-Wilhelm Römer

1 Introduction

Eimelrod is a district of the town of Willingen/Upland located in the North-West part of Hesse. Eimelrod is a well-known health resort in rural surroundings with a village-like atmosphere.

2 The initial situation

The water supply pipeline connecting the Seere source to the Eimelrod elevated tank is crucial if a secure supply of water to the districts of Eimelrod and Hemmighausen is to be guaranteed **(Figure 1)**. Without this connection the districts of Eimelrod and Hemmighausen cannot be supplied with water. The existing DN 100 grey cast iron water supply pipeline from the Seere source to the Eimelrod elevated tank was badly in need of repair; every year pipe bursts had to be patched up and this always caused bottlenecks in the supply.

Figure 1:
Eimelrod elevated tank WSP HB 535.14 m above sea level

In the winter months in particular the repair work was rather tough because the major part of the water supply pipeline is located along a forest track with difficult access.

3 Planning

The Upland water supply association commissioned the engineering office of Oppermann GmbH from Vellmar with the planning and construction management and supervision for the replacement of the connecting supply pipeline. This connecting pipeline is the main water supply pipeline for the districts of Eimelrod and Hemmighausen. Therefore throughout the entire construction period and at all stages of progress the transport of water needed to be maintained. Above all the narrowness and difficult accessibility of the terrain and the fact that the construction site could only be reached in one direction with heavy site machinery were a particular added complication here.

As the existing water supply connection was located in the middle of a track used for forestry work **(Figure 2)**, the restricted width of the track with trees standing on either side meant that the new pipeline could not be installed without taking the existing pipeline out of commission. Therefore it was planned to install a temporary emergency water supply pipeline, about 1,200 m long, above ground on an area of wooded land. According to the plans, this DN 150 GGG emergency water pipeline was laid with BLS® push-in joints along the verge of the track **(Figure 3)** and connected to the existing network away from the wooded area. It was then planned to install the new water pipeline parallel to the existing pipeline.

Figure 2:
Difficult access along a forestry track

Figure 3:
Installation of the DN 150 GGG emergency water pipeline

According to the planning, the pipes of the emergency water supply pipeline were to be taken up again after the installation of the first 1,200 m of the replacement connection pipeline and then installed again outside the wooded area as the definitive connection pipeline to the Eimelrod elevated tank. The double use of around 1,200 m of DN 150 GGG piping should mean that costs would be saved. Furthermore the planning provided for the pipeline to be constructed using the open technique since, according to the soil survey, rock was to be reckoned with. The use of a trencher to excavate the pipe trench was left up to the bidder as an alternative solution.

As part of the work on constructing the water supply pipeline, it was also planned that the well collecting shaft of the Seere source should be renovated and that alterations should be made to the Eimelrod elevated tank.

4 Choice of pipe material

As mentioned, the emergency water pipeline over a length of 1,200 m was to be dismantled and then reused. Because of the difficult access to the construction site, after being dismantled the emergency water pipeline had to be in lengths capable of being handled and reused for their definitive installation without damage. The choice here went to 6 m long socket pressure pipes in ductile cast iron to EN 545 [1] with positive locking BLS® push-in joints to DIN 28603 [2] and DVGW type-testing certificate in accordance with DVGW test specification GW 337 [3], [4]. For sealing, TYTON® seals in EPDM to EN 681-1 [5] were used. To protect the piping system an external zinc coating (200 g/m²) was used with cement mortar coating to EN 15542 [6] and a cement mortar lining based on blast furnace slag cement to EN 545 [1] were used. New TYTON® seals were provided for the reuse of the pipes from the emergency water supply.

5 Construction work

The planned construction work was put out to public tender in April 2012. The Jordan company from Bad Arolsen, known to be expert and competent, was commissioned for the work. The work began in June 2012 and was finished in October 2012. As planned, in the first section the emergency water supply was set up from station 0+000 m to station 1+200 m. After locating the existing pipeline, the construction of the new connection pipeline was carried out along with partial dismantling of the old water pipeline **(Figure 4)**.

Figure 4:
Dismantling the old connection pipeline

For the production of the pipe trench (depth of cover of pipe 1.5 m) a rock trencher was used in large sections of the route **(Figure 5)**. This meant that excavated materials could be stored alongside in the wooded area and then backfilled after laying the pipe. The sand required for pipe bedding was distributed over a number of storage sites before work was started and kept there until needed.

After completion of the pipe installation in the section between station 0+000 m and station 1+200 m, the emergency water supply was dismantled again. From station 1+200 m to station 2+400 m the pipes from the former emergency water pipeline were used again **(Figure 6)**. For this the TYTON® seals were replaced as a precaution. The work was completed in exactly the way envisaged in the planning. Altogether the water supply connection pipeline was replaced over a length of 2,900 m.

In the course of the construction work, power and control cables were also installed in empty conduits and a new service connection was produced. Renovation work was also carried out at the Seere source and the Eimelrod elevated tank.

6 Final observations

The detailed planning of the individual construction sections and construction phases and the reuse of the pipes from the emergency water supply meant that construction costs were able to be reduced. The actual construction costs were exactly equal to the agreed price.

Ductile iron pipes were the correct choice for the piping material. Despite the difficult pipelaying situation, the pipe lengths of 6 m were easy to handle and reusing the piping material from the emergency water supply proved to be practical and also saved costs.

Figure 5:
Use of a rock trencher

Figure 6:
Installation of the reused emergency water pipeline and cable conduit

Bibliography

[1] EN 545
Ductile iron pipes, fittings, accessories and their joints for water pipelines – Requirements and test methods
2010

[2] DIN 28603
Rohre und Formstücke aus duktilem Gusseisen – Steckmuffen-Verbindungen – Zusammenstellung, Muffen und Dichtungen
[Ductile iron pipes and fittings – Push-in joints – Survey, sockets and gaskets]
2002-05

[3] DVGW-Prüfgrundlage GW 337
Rohre, Formstücke und Zubehörteile aus duktilem Gusseisen für die Gas- und Wasserversorgung – Anforderungen und Prüfungen
[Ductile cast iron pipes, fittings and accessories for gas and water supply – Requirements and testing]
2010-09

[4] DVGW-Prüfgrundlage GW 337-B1
Beiblatt 1 zu DVGW-Prüfgrundlage GW 337
Rohre, Formstücke und Zubehörteile aus duktilem Gusseisen für die Gas- und Wasserversorgung – Anforderungen und Prüfungen
[Supplement 1 to DVGW test specification GW 337
Ductile cast iron pipes, fittings and accessories for gas and water supply – Requirements and testing]
2012-08

[5] EN 681-1
Elastomeric seals – Material requirements for pipe joint seals used in water and drainage applications – Part 1: Vulcanized rubber
1996 + A1:1998 + A2:2002 + AC:2002 + A3:2005

[6] EN 15542
Ductile iron pipes, fittings and accessories – External cement mortar coating for pipes – Requirements and test methods
2008

Authors

Dipl.-Ing. Ingolf Bittermann
Ingenieurbüro Oppermann GmbH
Adalbert-Stifter-Straße 19
34246 Vellmar/Germany
Phone: +49 (0)561/82907-63
E-mail: ingolf.bittermann@oppermann-ingenieure.de

Karl-Wilhelm Römer
Duktus Rohrsysteme Wetzlar GmbH
Schweinsbühl, Kerbelweg 6
34519 Diemelsee/Germany
Phone: +49 (0)5632/922252
E-mail: Karl-Wilhelm.Roemer@duktus.com

Construction company

G. Jordan GmbH & Co. KG
Gerhard Jordan
Landstraße 40
34454 Bad Arolsen/Germany
Phone: +49 (0)5691/3785
E-mail: g.jordankg@t-online.de

DN 600 drinking water pipeline in Altach

By Werner Siegele and Roland Gruber

1 Partial replacement of a drinking water pipeline in the Altach football stadium

A project for the partial replacement of a drinking water pipeline at the Altach football stadium in the Austrian Province of Vorarlberg was completed in 2014 **(Figure 1)**. Because there was a leak in the inaccessible area beneath the stands of the football stadium at Altach, a section of the old pipeline which had been built over needed to be decommissioned and replaced with a new one. To do this, those in charge at the Rheintal drinking water association placed their trust in the quality of ductile iron pipes. The new "drinking water bypass" at the Altach football ground has a total length of around 660 m.

The rather bleak results faced by the Rheintal water company showed that approximately 2,000 m³ of drinking water was being lost. The leak in the underground pipeline was located directly beneath the toilets and washrooms of the stadium. Rheintal drinking water association supplies the districts of Alberschwende, Dornbirn, Götzis, Hohenems, Lustenau, Mäder and Schwarzach as well as Altach with drinking water from a pumping station in Rhine Foreland near Mäder. Each day it delivers between 8,000 m³ and 14,000 m³. The total annual volume is around 3 million m³ which is routed through approximately 35 km of transport pipelines to the various districts which operate their networks independently of the water association.

2 Planning and construction

The costs for the repairs on site were estimated at €50,000 to €60,000 by the Rheintal drinking water association. But it was clear that, after all this, they would still have an old pipeline. So it was decided that the entire section of pipeline should be replaced by a kind of bypass with DN 600 ductile iron pipes **(Figure 2)**, which would run right around the SCR Altach stadium and training area. The planning work as well as construction supervision on site were assigned to the experienced planning office of Adler+Partner Ziviltechniker GmbH in Klaus. The construction work was carried out by Wilhelm+Mayer

Figure 1:
The SCR Altach football stadium – partial replacement of a water pipeline beneath the stands

Figure 2:
DN 600 ductile iron pipes for installation as a bypass pipeline

Bau GmbH, a construction company from Götzis. Thanks to favourable weather conditions construction work was able to be started as early as the beginning of February 2014.

3 Optimum conditions for pipeline construction

The new route lies just outside one of the most densely populated areas of Vorarlberg, meaning that there were hardly any problems posed by the few existing buildings. Parallel to the new pipeline is a high pressure natural gas pipeline and it was important to keep the necessary distance from this. During the excavation work the digger operators had to pay attention to the overhead lines nearby. The soil is not susceptible to settlement and the groundwater reaches the level of the trench bottom, meaning that dewatering was not necessary. There was enough space available for the interim storage of the ductile iron pipes. For the main part these were laid in the conventional way, on a gravel bed in an open trench **(Figure 3)**. Only in the area of the motorway exit was a 20 m long DN 1000 steel casing driven through the ground so that the ductile iron pipes could be inserted into it.

Figure 3:
Installation of the DN 600 ductile iron pipes in the open trench

4 High flexibility required

The new supply pipeline has the same nominal size (DN 600) as the old one. The new pipes were supplied by TIROLER ROHRE GmbH from Hall in Tirol. The push-in joints of the ductile iron pipes are the restrained type (BLS® system). This type of joint not only ensures a high degree of flexibility for the pipeline but it also makes the installation of concrete thrust blocks unnecessary. Also the proven joint system is very quick to assemble. The pipes used are characterised by a standard lining with cement mortar, which is a condition for a long working life. The lining provides active protection for the cast iron pipe material. You can find more information about how cement mortar lining works on page 20 of this volume. **Table 1** gives a summary of the project data for the Altach drinking water pipeline project.

Table 1:
Project data for the Altach drinking water pipeline project

Name of project	Altach drinking water pipeline		
Application	Drinking water pipeline		
Location	Altach		
Client	Trinkwasserverband Rheintal		
Construction company / contractor	Wilhelm+Mayer Bau GmbH		
Planning	Adler+Partner Ziviltechniker GmbH		
Total construction time	3 months		
Main pipelines	Length: 660 m	Nominal size: DN 600	Wall thickness: K 9
Jointing elements	BLS® push-in joints		
Coating	Cement mortar coating		
Lining	Cement mortar lining		
Particular requirements	High pipeline flexibility; no concrete thrust blocks wanted		

5 Everything first class for SCR Altach

The new pipeline went into operation for the first time at the beginning of April 2014. This meant that Altach was once again very well equipped for match and stadium operations. The Rheintal drinking water association has long been convinced of the quality of ductile iron pipes and with this project it has safeguarded the supply of drinking water for the coming decades – a lasting investment.

Authors

Werner Siegele
TIROLER ROHRE GmbH – TRM
Innsbrucker Straße 51
6060 Hall in Tirol/Austria
Phone: +43 (0)5223/503-108
E-mail: werner.siegele@trm.at

Mag. Roland Gruber
Gruber-Seefriedzek Verlags OG
Lindaustraße 10
4820 Bad Ischl/Austria
Phone: +43 (0)6247/84726
E-mail: office@zekmagazin.at

Client

Trinkwasserverband Rheintal
Dipl.-Ing. Bruno Fussenegger
Rathaus
6850 Dornbirn/Austria
Phone: +43 (0)5572/25475-13
E-mail: bruno.fussenegger@dornbirn.at

Planning office

Adler+Partner ZT GmbH
Ing. Daniel Gross
Vorstadt 17
6833 Klaus/Austria
Phone: +43 (0)5523/62860-0
E-mail: office@adlerconsult.com

Construction company

Wilhelm+Mayer Bau GmbH
Ing. Thomas Ott
Am Bach 20
6840 Götzis/Austria
Phone: +43 (0)5523/62081-20
E-mail: thomas.ott@wilhelm-mayer.at

Ductile iron pipes as an integral element of the Vienna "Gürtel ring road offensive"

By Gerald Pasa and Günter Seefried

1 Introduction

In Vienna the "Gürtel ring road offensive" is fully under way. This is an extensive modernisation project to replace water supply pipelines, in some cases over 100 years old, in the inner and outer ring roads of the city. Four sections have already been completed, in 2012 and 2013, in the 8th, 9th, 18th and 19th districts. In 2014 the water pipes in the 16th and 17th districts were replaced or renovated **(Figure 1)**. In the section of the pipeline on the Hernalser ring road ductile iron pipes were used over a length of around 700 m, securing a problem-free supply service for the next 100 years. With traffic volumes of around 35,000 vehicles per day and per direction of travel, all the contractors involved as well as road users and residents were faced with some enormous challenges.

Figure 1:
Replacement of iron pipes more than 100 years old in the area of the Hernalser ring road

2 Description of the project

Since April 2014 the renovation work on the drinking water pipeline in the Vienna ring road, planned for a number of years, has been running at full speed. In a number of sections, ageing pipes were completely replaced. One of these sections was in the area of the Hernalser ring road. 700 m of ductile iron pipes were installed here over a length of 2.5 km. The project data for the Hernalser ring road water mains can be found in **Table 1**.

The City of Vienna relies on cast iron as its pipe material for two reasons:

- Operational security and durability are given the highest priority by the planners. In the end there is scarcely any comparable pipe material which has proved itself over such a long time. There are water pipelines still in existence today where sections have been in operation for more than 100 years.
- The newly constructed ductile iron pipeline will still be supplying around 136,000 Viennese folk with first class drinking water far into the future.

The replaced sections went into operation in Summer 2014 and the road surfaces were restored in September 2014.

3 The Gürtel ring road offensive – a long-term project

The aim of this far-reaching project is to replace old water mains pipes on the Gürtel ring road. The work is taking several years, alternating between the inner and outer Gürtel ring roads.

Table 1:
Project data on the Hernalser ring road main water pipeline

Application	Replacement of cast iron pipelines, in some cases over 100 years old		
Location	Vienna, 17th district		
Client	Wiener Wasser (MA 31)		
Construction company / contractor	Kraft und Wärme – Baumeister Dipl.-Ing. Mörtinger & Co. GmbH, Vienna		
Planning	Wiener Wasser (MA 31)		
Total construction time	3 months		
Main pipelines	Length: 700 m	Nominal size: DN 700	Pressure: max. 25 bar
Connection elements	BLS® push-in joints		
Coating	Zinc coating with epoxy finishing layer		
Lining	Cement mortar lining		
Particular requirements	Construction under traffic conditions; Wiener Wasser (MA 31) traffic concept		

Figure 2:
Maintaining the flow of traffic – implementation of the Wiener Wasser traffic concept

Figure 3:
Newly installed DN 700 ductile iron pipes in the Hernalser ring road

The very greatest attention was paid here to road traffic as this section of Vienna's roads happens to be one of the busiest in the whole of Austria.

For the two sections completed in 2014 in the 16th and 17th districts, the Vienna water authority (MA 31) developed a special concept to keep the traffic flowing as far as possible **(Figure 2)**. During the installation work from early May to the middle of August 2014, two of the four lanes of the ring road were closed and replaced by a diversion. In addition, work was also carried out at night and at the weekends to keep the construction time as short as possible.

4 Special pipes for a special project

The DN 700 ductile iron pipes supplied by TIROLER ROHRE GmbH, TRM **(Figure 3)** to EN 545 [1] are lined with cement mortar. The cement mortar lining is especially suitable for the transport of drinking water (information on cement mortar coating can be found in the article on page 16 of this volume). In addition the pipes have a zinc coating with an epoxy finishing layer.

This means that the pipes are effectively protected for decades. Ductile iron pipes are diffusion resistant and are perfectly hygienic for the transport of drinking water.

The ease and speed of installation is another important aspect in the installation of ductile iron pipes, providing the basis for swift and smooth progress of a construction project.

5 Conclusion

The client, Wiener Wasser (MA 31), was able to see the work on the ring road completed by the beginning of September 2014 as planned, with the surfaces of the roads and lanes restored and reopened for traffic as usual.

Bibliography

[1] EN 545
Ductile iron pipes, fittings, accessories and their joints for water pipelines – Requirements and test methods
2010

Authors

Gerald Pasa
TIROLER ROHRE GmbH – TRM
Innsbrucker Straße 51
6060 Hall in Tirol/Austria
Phone: +43 (0)664/3228835
E-mail: gerald.pasa@trm.at

Günter Seefried
Gruber-Seefried-zek Verlags OG
Lindaustraße 10
4820 Bad Ischl/Austria
Phone: +43 (0)6247/84726
E-mail: office@zekmagazin.at

Domestic no-screw connection valves for communal water supply

By Thomas Kunzmann and Peter Oppinger

1 Introduction

The protection of our environment demands some challenging engineering and process technologies. This also means that higher requirements are placed on the planners and operators of water supply networks in terms of operational security and the reliability of the valves and fittings used. In addition, from the economic viewpoint, planning engineers, equipment manufacturers and operators are turning more and more towards universally applicable products with installation advantages and a high degree of operational security in their choice of valves. At the same time they place the highest requirements on the quality and ease of operation of the valves. All components must enable absolutely problem-free, fully automatic operation. Valves installed underground such as domestic connections must be durably protected against corrosion and guarantee tightness and functional perfection for decades.

Figure 1:
VAG TERRA®*lock* plug connection

2 VAG TERRA®*lock* house connection system

In order to improve customer benefits in the installation of domestic drinking water connections these days it is no longer enough simply to supply high quality connection valves. Today there is a demand for additional system components on the basis of a technically reliable domestic connection valve. These should be able to be assembled as quickly and easily as possible by hand (without any special tools) and they should also offer multiple combination possibilities so as to meet current technical challenges in the best way possible when replacing or refurbishing domestic connections.

The basic idea for combining all system components in the VAG TERRA®*lock* range of domestic connections lies in the modification of the well-known, tried and tested VAG BAIO®plus bayonet plug-type connection. The VAG TERRA®*lock* plug connection technology developed from this and patented **(Figure 1)** allows fast and simple manual assembly of house connections in the pipe trench. The connection is reliably secured against accidental release by the flexible locking ring. Where necessary the plug connection can subsequently be easily undone by hand. This technology avoids the use of tools in the pipe trench and thus effectively ensures the integrity of the corrosion protection.

Figure 2:
Corrosion in the threaded area of a domestic connection valve

The all-round epoxy powder coating (EP coating) to RAL - GZ 662 [1] (GSK quality) with a coating thickness of 250 µm offers a high degree of corrosion protection. The no-screw connection technology effectively prevents the corrosion problems which used to occur in the area of the threading **(Figure 2)** for fitting the domestic connection valve.

The robust cast iron components of the VAG TERRA®*lock* system **(Figure 3)** are produced to a high quality in the factory's own foundry from material GGG-40. The plug connection is absolutely secure against tensile forces, is flexible in its bending capability and can be rotated sideways. This flexibility reliably avoids stresses in the piping system which can occur when backfilling the trench and compacting the pipe bedding.

Figure 3:
Patented VAG TERRA®*lock* plug fitting

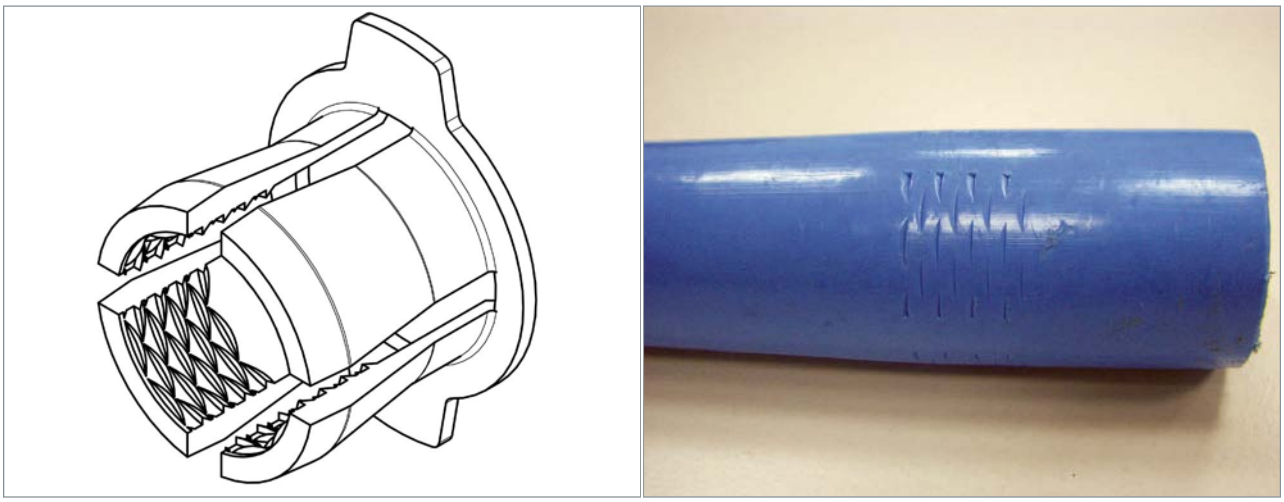

Figure 4:
Tooth impressions in a PE pipe after a pulling test for clamp connectors

The interface between the VAG TERRA®*lock* system and the house connection pipe is a technically new type of patented plug fitting. The one-piece cast iron housing with all-round EP coating provides a stable junction point to the house connection pipe. The patented segmented clamping ring enables the connection to be easily dismantled at a later stage by hand without any additional tools. By avoiding circumferential grooving, the specially developed toothed form of the clamping ring reduces any notching effect on the surface of the pipe **(Figure 4)**.

The versatile combination possibilities offered by the components of the VAG TERRA®*lock* modular system offer maximum customer benefits when

- producing house connections under full operating pressure,
- refurbishing existing house connection pipelines,
- dealing with difficult installation situations

for domestic water connections on supply pipelines with tapping equipment **(Figure 5)**.

The connection pieces or saddle pieces produce technically reliable clamped connections with supply pipelines of cast iron or steel pipes and PVC or PE pipes.

An integral ancillary ball shut-off enables a house connection pipeline to be installed under full operating pressure. The subsequent refurbishing of existing, older installations with non-pressurised supply pipelines can be done cost effectively using connection and saddle pieces without the integral ball shut-off by using a special refurbishing fitting with a sliding sleeve. The pivoting ability of the top of the tapping fitting allows the easy and tension-free connection of the existing house connection pipeline. The types of fitting available in the range enable a simple plug connection for the house connection pipeline which is secure against tensile stresses. By using the appropriate conversion adapter, all known and commercially available tapping equipment can be used for producing the domestic water connection.

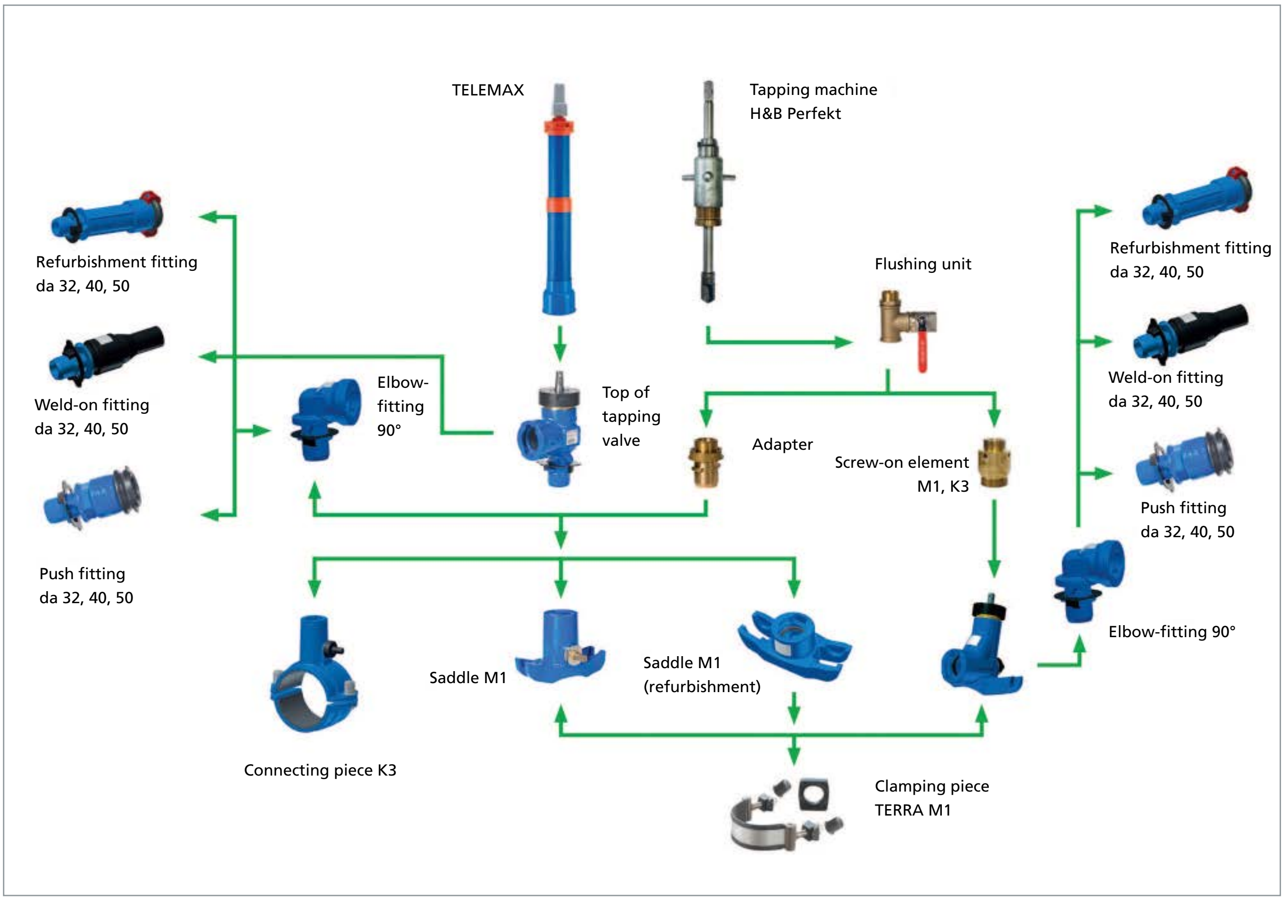

Figure 5:
VAG TERRA®*lock* Systemprogramm

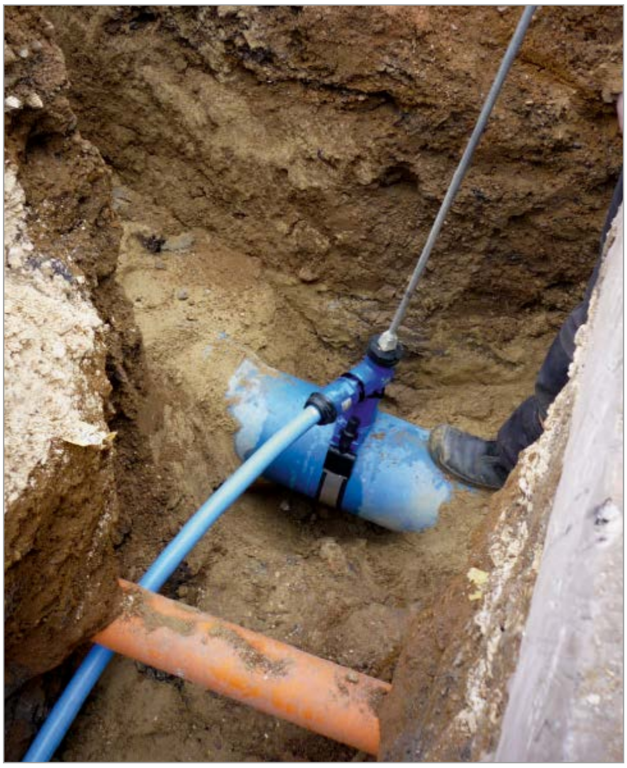

Figure 6:
Commissioning a VAG TERRA®*lock* domestic connection valve in South Germany

Depending on the installation situation and the available space, the system components for a vertical tapping of the supply pipeline from above or a horizontal tapping from the side can be used. According to the operator's choice, the domestic water connection can be installed using the appropriate VAG TERRA®*lock* components with or without the integrated main shut-off device **(Figure 6)**.

3 Conclusion

The VAG TERRA®*lock* system is a logical further development of the proven VAG BAIO®plus bayonet connection for producing domestic water connections on supply pipelines. This technology enables simple and secure assembly and dismantling by hand. The patented plug-type connection optimises secure assembly, avoids errors and offers a high level of corrosion protection and hygiene in drinking water supply pipelines.

Bibliography

[1] RAL - GZ 662
Güte- und Prüfbestimmungen –
Schwerer Korrosionsschutz von
Armaturen und Formstücken durch
Pulverbeschichtung –
Gütesicherung
[Quality and test provisions –
Heavy duty corrosion protection
of valves and fittings by powder
coating –
Quality assurance]
2008

Autoren

Thomas Kunzmann
VAG-Armaturen GmbH
Carl-Reuther-Straße 1
68305 Mannheim/Germany
Phone: +49 (0)621/749-1924
E-mail: t.kunzmann@vag-group.com

Peter Oppinger
VAG-Armaturen GmbH
Carl-Reuther-Straße 1
68305 Mannheim/Germany
Phone: +49 (0)621/749-2106
E-mail: p.oppinger@vag-group.com

Renovating Aggerverband pipeline 10a using adapter couplings

By Dieter Wonka, Klaus Eisenhuth and Martin Herker

1 Introduction and history

The "Aggerverband" water supply company and the replacement of its RS33 pipeline has already been reported in EADIPS®/FGR® volume 47 [1]. At that time we described the renewal of fittings and valves, but this article will concentrate on the replacement of the pipes in section 10a with the subsequent completion of the renovated pipeline with ductile iron pipes and the necessary adapter couplings.

2 Renovating pipeline section 10a

For supply reasons, the DN 500 drinking water pipeline with asbestos cement pipes (year of construction 1967) is lined with an additional cement mortar layer to prevent wearing. Every day some 6,000 m³ of water is conveyed through this pipeline from the waterworks at Eulenhagen to the Müllenbach I and II elevated tanks.

Access for the lining work was achieved by taking out lengths of pipe of about 1.2 m every 120 m on the pipeline. For the final and permanent closing of the gaps ductile iron pipes were selected because of their convincing material properties, all the more so since, like the renovated pipeline, they have a cement mortar lining **(Figure 1)**.

Because of their different external diameters, the cast iron and asbestos cement pipes were connected using stepped U-Flex DN 500 mechanical couplings **(Figures 2 and 3)**. Their mechanical joints are designed to fit the outside diameter of the cast iron pipes on one side and the asbestos cement pipes on the other side. The classic double-wedge shape of the seal was purposely favoured here so that the elastomer material could be evenly pressed on to the pipe surface on either side without twisting the cross-section. The number of bolts on the mechanical connections offers good capabilities to compensate for the ovality existing on the old asbestos cement pipes.

Figure 1:
Closing up the old pipeline with a DN 500 ductile iron pipe section and two adapter couplings

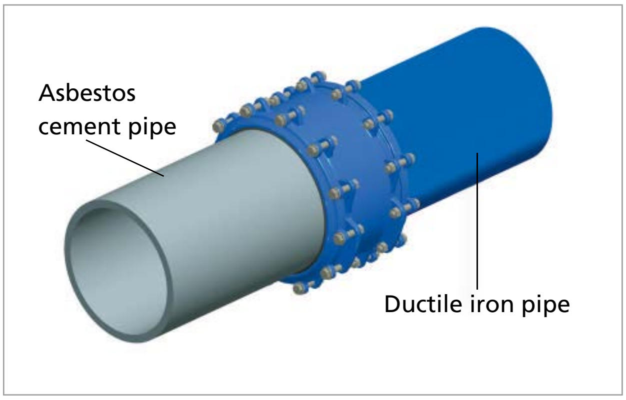

Figure 2:
U-Flex DN 500 adapter from an asbestos cement pipe to a ductile iron pipe

Figure 3:
Installed U-Flex DN 500 adapter coupling

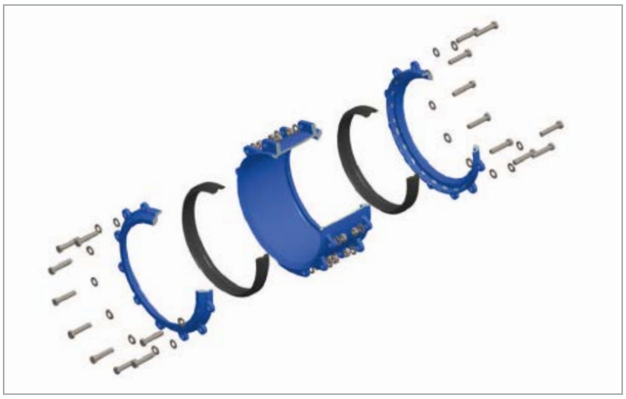

Figure 4:
Sectional exploded view of U-Flex DN 500

The separation of the two sides of the coupling by double bolting (E-book 08.2014 Ductile iron pipe systems, chapter 10 [2]) is in fact more expensive in terms of production and assembly, but it does produce an installation force on the pipe connected in each case so that on the one hand marked surface structures are reliably compensated and on the other hand susceptible pipes (e.g. because of reduced wall thicknesses and/or aged material) are nevertheless protected from being overloaded **(Figure 4)**. With simple screw connections with float-mounted coupling elements and through-bolts which are supported exclusively in the opposing compression rings, the same axial force is present in both mechanical joints, i. e. with structured pipe surfaces it is possible for sensitive pipes to be subjected to unnecessarily high loads on the opposite side in the first connection.

Because of the small difference in cross-sections between the two types of pipe and the stable pipe bedding of the old pipe stock, in this application case almost all the mechanical joints could be flexibly produced with EPDM (ethylene propylene diene monomer) seals, without additional measures to counteract tensile forces, meaning that the more sensitive old pipe stock in asbestos cement is spared additional stresses as far as possible. As the smallest permissible external diameter of the DN 500 ductile iron pipe can be below the approved diameter range of the mechanical joint, in order to safeguard functioning the worst case permissible according to the standards was tested at the coupling manufacturer's works as follows before the order was placed:

- A DN 500 single flange (F) piece was calibrated to the permissible minimum for the DN 500 external diameter (Ø 528.2 mm) according to EN 545 [3] and then additionally deformed to the maximum permissible ovality of 1 % as per EN 545 [3]. This extreme spigot end was assembled with a DN 500 E-Flex mechanical flange adapter which was technically equivalent to the planned DN 500 U-Flex coupling. The axial thrust produced here was compensated with the hydraulic cylinder of a test bench for the tightness testing which is obligatory in series production **(Figure 5)**.

Because of the extreme dimensions of the spigot end the maximum 90 Nm torque required according to the installation instructions was not sufficient to maintain tightness at the small axes of the oval. In order to increase the bolt tightening torque of the mechanical coupling, the water pressure had to be reduced again. Subsequent tightening of the bolts under pressure was avoided because, depending on the internal pressure of the water pushing through the seals onto the compression rings here, different

Figure 5:
Function testing with E-Flex and spigot end with extreme dimensions

torques are necessary, i.e. no concrete specifications can be determined for an installation situation without positive pressure.

With the increased bolt tightening torque of 110 Nm the function testing to EN 545 [3] (two hours of internal hydrostatic pressure of 20 bar) was able to be successfully concluded without defects. The subsequent series production as well as the installation and commissioning of the sections of pipeline went ahead without problem thanks to the extensive preparatory work.

Table 1 gives a summary of the DN 500 Flex connection types available.

Table 1:
Flex-connections DN 500

<table>
<tr><th></th><th>Connection 1</th><th>Connection 2</th></tr>
<tr><td rowspan="6">U-Flex DN 500 couplings</td><td colspan="2">dn500-521</td></tr>
<tr><td colspan="2">dn532-550</td></tr>
<tr><td colspan="2">dn564-582</td></tr>
<tr><td rowspan="2">dn500-521</td><td>dn532-550</td></tr>
<tr><td rowspan="2">dn564-582</td></tr>
<tr><td>dn532-550</td></tr>
<tr><td rowspan="6">E-Flex DN 500 flange adapters</td><td>dn500-521</td><td rowspan="3">Flange DN 500 PN10</td></tr>
<tr><td>dn532-550</td></tr>
<tr><td>dn564-582</td></tr>
<tr><td>dn500-521</td><td rowspan="3">Flange DN 500 PN16</td></tr>
<tr><td>dn532-550</td></tr>
<tr><td>dn564-582</td></tr>
<tr><td colspan="3">dn designates the permissible outside diameter of the pipe [mm]</td></tr>
</table>

Bibliography

[1] Wonka, D., Eisenhuth, K., and Herker, M.: Pipe runs rehabilitated for the Aggerverband supply utility by replacing valves and fittings
DUCTILE IRON PIPE SYSTEMS 47 (2013), p. 13

[2] E-Book 08.2014
Ductile iron pipe systems, chapter 10
Mechanical joints – wide-tolerance couplings and flange adaptors
2014-08

[3] EN 545
Ductile iron pipes, fittings, accessories and their joints for water pipelines – Requirements and test methods
2010

Authors

Dieter Wonka
Der Aggerverband
Abteilung Trinkwasser
Sonnenstraße 40
51645 Gummersbach/Germany
Phone: +49 (0)2261/36350
E-mail: Dieter.Wonka@aggerverband.de

Klaus Eisenhuth
Der Aggerverband
Abteilung Trinkwasser
Sonnenstraße 40
51645 Gummersbach/Germany
Phone: +49 (0)2261/36359
E-mail: Klaus.Eisenhuth@aggerverband.de

Martin Herker
Ludwig Frischhut GmbH & Co. KG
Konstruktion
Franz-Stelzenberger-Straße 9–17
84347 Pfarrkirchen/Germany
Phone: +49 (0)8561/3008-261
E-mail: mherker@talis-group.com

New evolutionary stage for the double eccentric butterfly valve

By Robert Kampfl

1 History

For more than 60 years ERHARD GmbH & Co. KG has been one of the leading manufacturers of double eccentric butterfly valves. ERHARD has more than 140 years experience in the production of valves in general.

The distinctive valve disc design of the new ROCO wave, which also gives the valve its name **(Figure 1)**, represents the next stage of evolution.

2 The wave phenomenon of the closing element

The development of the really rather unusual contour has its origin in a desire to optimise stiffness. The scope of this optimisation also includes the disc eyes, which are usual with double eccentric valve discs.

In the wave design the disc eyes, together with the semicircular bulge lying between them, form a kind of frame which increases the stiffness of the valve disc **(Figure 2)**.

This means that the disruptive material between the valve eyes could be removed. It was disruptive because in this area the constriction of the valve body results in a narrowing of the free flow cross-section. By removing material from the valve disc, this reduction is balanced out again, producing an almost constant cross-section surface in the entire area of the valve. Together with the large seat diameter, this provides outstanding flow values and hence very low pump operating costs. The results of the numerical flow simulations **(Figure 3)** have been verified by practical tests in the field.

Figure 1:
The new ROCO wave butterfly valve

Figure 2:
The wave design has been developed through complex experimental and numerical research

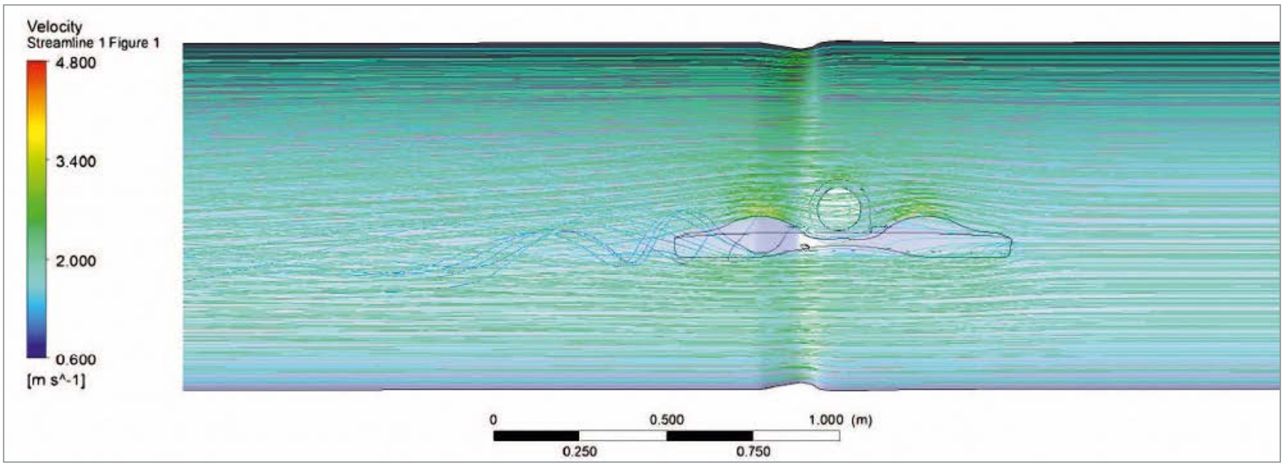

Figure 3:
Flow simulation on a ROCO wave butterfly valve

Figure 4:
Skeleton valve disc for high pressure stages

With nominal sizes > DN 600 and pressure ratings ≥ PN 25 the construction changes with the so-called skeleton design **(Figure 4)**. The ingenious structure means that, with a very high degree of stiffness, a larger flow cross-section is achieved which makes an excellent ξ-value possible even at high pressures, where previously the valve discs had to be designed to be massive.

3 Corrosion protection and drinking water quality

Even the most robust and energy efficient valve is unusable if the materials employed are not optimally matched to the medium to be controlled. In order to safeguard drinking water quality the ROCO wave only consists of materials which have been tested according to DVGW test specification W 363 [1], [2] and DVGW worksheet W 270 [3], as well as EN 1074-2 [4]. If the valve meets all of these tests, it is also given a DVGW type testing certificate which acknowledges not only the individual materials but also the valve as a whole as being suitable for drinking water. The preservation of drinking water quality also includes the prevention of corrosion. The material of the valve body and disc which is at risk of corrosion is 100 % protected against the medium. The standard protection for the ROCO wave is the proven epoxy coating and, for higher demands, Pro-Enamel is used which has been specially developed for valves **(Figure 5)**. For abrasive media, acids or alkalis, which place higher or different demands on the materials, other suitable shaft materials and types of coating are offered for the ROCO wave, such as full rubberisation for example.

The special high-alloy material of the valve seat in non-enamelled valves has a very good resistance against numerous types of aggressive media even in the standard design.

Critical areas which rely on the highest degree of precision and where a coating would have an adverse effect on this are protected against corrosion with ingenious systems such as the patented bearing seals for example **(Figure 6)**. A further plus point is the complete enclosure of the disc eyes using the proven polygonal technique. This shaft-hub joint means that there is no need for additional securing elements, which would inhibit the durable hermetic sealing.

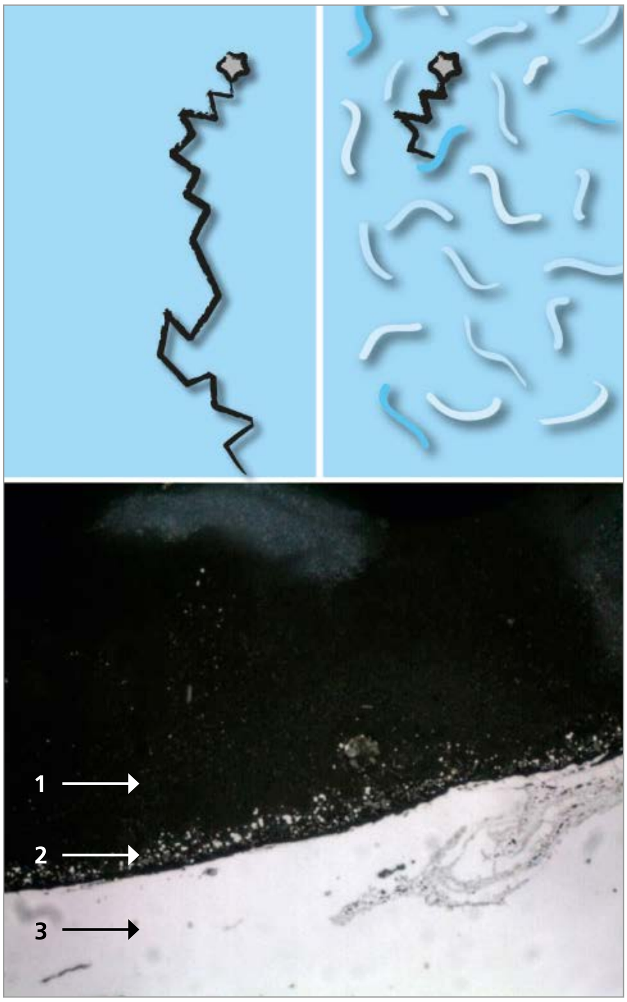

Figure 5:
While small cracks can spread in normal enamels (top left), the fibres of Pro-Enamel put an immediate stop crack development (top right).
The enamel coalesces with the cast iron (bottom) and forms a bonding or adhesion zone (2) between the layer of pure enamel (1) and the cast iron as the substrate (3), in which the iron and the enamel are chemically and physically bonded.

4 Universal design

The complete ROCO wave range of products has been based on a standard construction principle. From nominal sizes DN 150 to DN 1600 and from pressure ratings PN 10 to PN 40 ROCO wave butterfly valves are constructed identically. Construction changes are only made if they bring about a further optimisation. This is the case with the valve disc for example, where the skeleton construction already mentioned is produced for the larger nominal sizes and pressure ratings.

The universal design is also implemented for the valve drive. The familiar SKG slider-crank mechanism will in future be offered for rated torques up to 250,000 Nm **(Figure 7)**.

Thus the outstanding characteristics of the slider-crank mechanism will also be available again for very large nominal sizes and very high pressure ratings in future. Particularly worth highlighting are the kinematic properties of the slider-crank mechanism as, with its proven knee lever system, it perfectly imitates the torque requirement of the valve and thus makes a high torque available precisely when required, i.e. at the end of the closing process or at the beginning of the opening process. This means that the risk of pressure surges is considerably minimised. Because the drive connection is thoroughly standardised to EN ISO 5211 [5], other transmission and drive units can also be fitted for valve applications which do not require any special slider-crank mechanism characteristics.

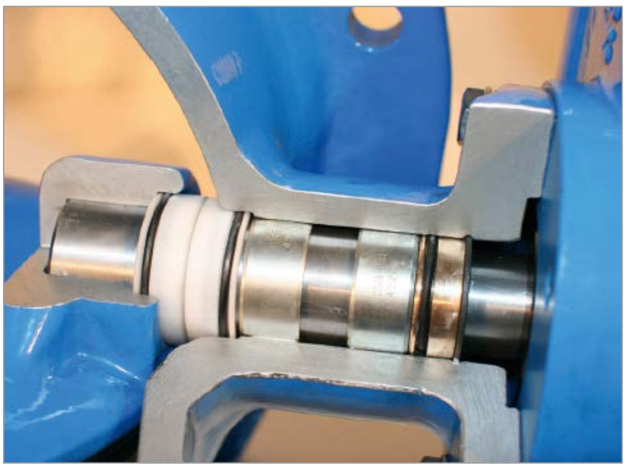

Figure 6:
Enclosed shaft bearings on the ROCO wave

Figure 7:
Slider-crank mechanism also for larger nominal sizes

5 Conclusion

With all its innovative features, the ROCO wave represents a new generation of butterfly valves. Its most important properties are:

- energy saving by the optimised valve disc construction,
- durable corrosion protection offered by enclosed disc eyes and sealed shaft bearings,
- standardised transmission interface to EN ISO 5211 [5],
- continuous drive system for optimum operation without pressure surges,
- drive shaft protected against blow-out to EN 593 [6],
- polygonal coupling for secure torque transmission,
- DVGW certification up to DN 1600.

Bibliography

[1] DVGW-Prüfgrundlage W 363
Absperrarmaturen, Rückflussverhinderer, Be-/Entlüftungsventile und Regelarmaturen aus metallenen Werkstoffen für Trinkwasserversorgungsanlagen –
Anforderungen und Prüfungen
[Butterfly valves, return flow inhibitors, vent/breather valves and control valves in metallic materials for drinking water supply equipment –
Requirements and testing]
2010-06

[2] DVGW-Prüfgrundlage W 363-B1
1. Beiblatt zu DVGW-Prüfgrundlage W 363 –
Absperrarmaturen, Rückflussverhinderer, Be-/Entlüftungsventile und Regelarmaturen aus metallenen Werkstoffen für Trinkwasserversorgungsanlagen –
Anforderungen und Prüfungen
[1st supplement to DVGW test specification W 363 –
Butterfly valves, return flow inhibitors, vent/breather valves and control valves in metallic materials for drinking water supply equipment –
Requirements and testing]
2014-09

[3] DVGW-Arbeitsblatt W 270
Vermehrung von Mikroorganismen auf Werkstoffen für den Trinkwasserbereich - Prüfung und Bewertung
[Microbial enhancement on materials to come into contact with drinking water – Testing and assessment]
2007-11

[4] EN 1074-2
Valves for water supply –
Fitness for purpose requirements and appropriate verification tests –
Part 2: Isolating valves
2000 + A1:2004

[5] EN ISO 5211
Industrial valves –
Part-turn actuator attachments
(ISO 5211:2001)
2001

[6] EN 593
Industrial valves –
Metallic butterfly valves
2009+A1:2011

Author

Dipl.-Ing. (BA) Robert Kampfl
Contact:
Dipl. Wirtsch.-Ing. (FH) Oliver Appel
ERHARD GmbH & Co. KG
Meeboldstraße 22
89522 Heidenheim/Germany
Phone: +49 (0)7321/320-177
E-mail: oappel@talis-group.com

Replacement of gate valves – examples in a gate valve cross-fitting installation and an elevated tank

By Norbert Knekow and Marc Flore

1 Renewal of a gate valve cross-fitting installation in Erkrath

At the intersection of the Am Wimmersberg road and Schlüterstraße in the town of Erkrath a gate valve cross-fitting needed to be replaced because the old valves would no longer always close properly. The immediate trigger for the replacement was the zone separation of supply pipelines planned by Stadtwerke Erkrath GmbH. A domestic gas and water connection was being replaced at the same time.

The previous gate valve cross-fitting installation consisted of a cast iron valve in each of the nominal sizes DN 200, DN 250 and DN 300, constructed in around 1952. The ductile cast iron fittings for the new cross-fitting installation are coated with epoxy powder as per GSK guideline RAL - GZ 662 [1] **(Figure 1)**, while the valves are enamelled in accordance with DIN 51178 [2] and DEV guidelines [3].

At Stadtwerke Erkrath GmbH great value is placed on the use of products made in Germany, so the company Düker GmbH & Co. KGaA was an eligible supplier.

Three type 4004 gate valves, enamelled inside and outside, design to PN 10/16 and nominal sizes DN 200, DN 250 and DN 300 as well as a type 304 underground hydrant were to be installed. The heart of the gate valve cross-fitting installation is an internally enamelled DN 300/DN 250/DN 200 all flanged tee **(Figure 2)**, along with various flange pipes and fittings with epoxy coating. The connection to the existing pipeline was produced with restrained flanged sockets (Düker SPEZIAL type) with screwed socket joints and a special clamping ring **(Figure 3)**.

Figure 1:
DN 200 ductile flange fitting with epoxy coating

Figure 2:
Internally enamelled all flanged tee,
DN 300/DN 250/DN 200

The renovation was completed without complications and the water supply was able to be quickly restored in the neighbouring residential area.

2 New replacement/repair valve in the Brilon AöR public utility company's elevated tank at Wohlhagen

The Brilon AöR public utility company operates the water treatment plant and elevated tank at Wohlhagen with a capacity of 2,000 m³ in the district of Alme. Groundwater from the Alme deep wells I and II is conveyed through the treatment plant into the elevated tank. The district of Alme as well as the town centre are supplied by gravity from the elevated tank. The Wohlhagen elevated tank is therefore one of the most important elements of the drinking water supply system for the town of Brilon.

In the context of the replacement of a defective gate valve with a short face-to-face length (F4) in a rigid pipeline without any dismantling joint, the choice went very quickly to a DN 100, PN 16 replacement/repair valve (model: Düker type 2004) to EN 1074-1 [4] and EN 1074-2 [5] with an overall length (face-to-face length) as per EN 558, basic series 14 [6] **(Figure 4)**.

The advantages of this valve lie in the loose flanges, which make assembly easier. The flange gasket, which is already integrated, makes exchanging the valve childishly easy and quick and saves unnecessary downtime costs. The days when valves in operation had to be taken apart with hammer and chisel, thereby usually damaging the corrosion protection, in order to fit a new flange seal are thus a thing of the past. The rotatable flange allows an optimum adjustment of the flange drill pattern and a secure and tension-free installation in the system.

Figure 3:
Installed Düker SPEZIAL flanged socket – screwed joint system with special clamping ring

Figure 4:
DN 100 replacement/repair valve with loose flange and short overall length to EN 558, basic series 14 [6]

Bibliography

[1] RAL - GZ 662
Güte- und Prüfbestimmungen –
Schwerer Korrosionsschutz von
Armaturen und Formstücken durch
Pulverbeschichtung –
Gütesicherung
[Quality and test provisions –
Heavy duty corrosion protection of valves
and fittings by powder coating –
Quality assurance]
2008

[2] DIN 51178
Emails und Emaillierungen –
Innen- und außenemaillierte Armaturen
und Druckrohrformstücke für die
Roh- und Trinkwasserversorgung –
Qualitätsanforderungen und Prüfung
[Vitreous and porcelain enamels –
Inside and outside enamelled valves and
pressure pipe fittings for untreated
and potable water supply –
Quality requirements and testing]
2009-10

[3] DEV guideline
Qualitätsanforderungen und Prüfvorschriften für emaillierte Gussarmaturen
und Druckrohrformstücke für die Roh-
und Trinkwasserversorgung
[Quality requirements and test regulations
for enamelled cast iron valves and
pressure pipe fittings for untreated and
potable water supply]
2006-09-27

[4] EN 1074-1
Valves for water supply –
Fitness for purpose requirements and
appropriate verification tests –
Part 1: General requirements
2000

[5] EN 1074-2
Valves for water supply –
Fitness for purpose requirements and
appropriate verification tests –
Part 2: Isolating valves
2000 + A1:2004

[6] EN 558
Industrial valves –
Face-to-face and centre-to-face
dimensions of metal valves for use in
flanged pipe systems –
PN and Class designated valves
2008+A1:2011

Authors

Norbert Knekow
Düker GmbH & Co. KGaA
Hauptstraße 39–41
63846 Laufach/Germany
Phone: +49 (0)6093/87-0
E-mail: info@dueker.de

Marc Flore
Düker GmbH & Co. KGaA
Hauptstraße 39–41
63846 Laufach/Germany
Phone: +49 (0)6093/87-0
E-mail: info@dueker.de

Trenchless installation of ductile iron pipes at the Wildnispark Zürich

By Roger Saner

1 Introduction

The woodland of the Sihlwald on the Northern outskirts of Zürich is a unique nature experience and recreational area for the population living in and around the city. In 2008 the Cantonal Office for Forests and Nature published the revised protection order for the Sihlwald concerning the preservation and use of the natural forest. The Zürich Wildnispark foundation is responsible for implementing this protection order on behalf of the Canton of Zürich.

The Zürich Wildnispark, encompassing the Sihlwald forest and the Langenberg wildlife park as well as a visitor centre, is a unique combination of forest, natural countryside and animals. The Langenberg wildlife park founded in 1869 in the municipal district of Langnau am Albis is the oldest animal park in Switzerland, covering around 80 hectares. A third of this consists of generous, natural-looking animal enclosures. The animals can be observed almost as if they were in the wild **(Figure 1)**.

Figure 1:
Wild animal enclosure at Langenberg
(source: Wildnispark Zürich)

2 The initial situation – Langenberg drinking water supply

Previously, the restaurant and other facilities belonging to the wildlife park in the district of Langenberg were provided with drinking water by old DN 100 to DN 125 asbestos cement supply pipelines. The water supply authority responsible for the district of Langnau am Albis planned to replace the existing pipelines over a total length of around 465 m in the context of a defined renovation plan. The topographical conditions of the existing route of the pipeline posed a few challenges for the planning and execution of the pipeline construction. Part of the pipeline to be replaced in the wildlife park ran beneath a children's play area and then a wild animal enclosure. In addition it was a requirement that a functioning drinking water supply for the kitchens and washrooms was maintained and the busy animal park restaurant should remain accessible to visitors at all times during the construction work. Another section of the pipeline in Albisstraße (a main road) passes in a long curve beneath an avenue of trees which needed to be protected **(Figure 2)**.

After some in-depth examination and analysis of the various ways of going about this, it quickly became clear that in these areas, instead of the open construction technique, the only option was static burst lining using the trenchless technique. The burst lining process is suitable for the replacement of almost all common types of old pipeline materials, such as grey cast iron, steel, PE/PVC, stoneware and also asbestos cement.

Figure 2:
Situation in the Albisstraße –
the avenue of trees to be crossed on the left

Figure 4:
HYDROTIGHT push-in joint –
installation using stainless steel sheet protective cones

Figure 3:
DN 125 vonRoll ECOPUR full-protection pipes –
ready for installation on the roadside

Figure 5:
ECOPUR pipe with the traction head fitted
and HYDROTIGHT push-in joint

3 The advantages of ductile iron pipes with external polyurethane protection

For many years the people responsible for the water supply at Langnau am Albis have been relying on the extremely durable vonRoll ECOPUR ductile iron pipes with a reinforced polyurethane coating (PUR) to EN 545 [1] for their drinking water supply system. And the proven ECOPUR pipes were to be used in this project as well.

vonRoll ECOPUR full-protection pipes have an integral internal and external coating of polyurethane (PUR) in accordance with EN 15655 [2] and EN 15189 [3] and, because of their mechanically resistant, smooth PUR coating they are perfectly suited for the trenchless installation technique **(Figure 3)**. The friction forces occurring between pipe and soil are reduced to a minimum. Together with the slender form of the sockets, this results in low pull-in forces.

The flexibly deflecting vonRoll HYROTIGHT restrained push-in joint for trenchless installation safely absorbs the forces produced and is quick and very simple to assemble in the pull-in pits. The sockets of the ECOPUR pipes are protected with stainless steel sheet cones during the installation process meaning that rubber or shrink-on sleeves are not necessary with the integral PUR coating and HYDROTIGHT push-in joints **(Figures 4 and 5)**.

4 Installation work

The pipeline was to be replaced using the burst lining process in the following three areas:

- crossing the wild animal enclosure, Orellistraße to Albisstraße, length approx. 115 m,
- Orellistraße (forest area), length approx. 240 m, in three stages,
- along Albisstraße (main road), beneath an avenue of trees, approx. 110 m **(Figure 2)**.

According to the project planning, the entire pipeline installation work was to be carried out and completed from the end of November 2013 to the beginning of February 2014 with as few disruptions as possible and without restricting the operation and visitor facilities of the Langenberg animal park.

All pipe pulling and installation work was planned and executed according to the requirements of DVGW technical instruction GW 323 [4] and the recommendations of SVGW guideline W4 [5], which classifies the PUR coating to EN 15189 [3] as being ideal for the burst lining process.

Despite cold, damp weather and temperatures around freezing point, the burst lining work was able to be started on time **(Figures 6, 7, 8 and 9)**. The first stage of construction on the stretch running underneath the wild park enclosure and the open trench work for the pipeline connection in the area of the restaurant was completed on schedule before Christmas 2013 **(Figures 10, 11 and 12)**. As from the middle of January 2014, the remaining four burst lining sections in Orellistraße and Albisstraße could be tackled. The entire pipe-pulling process, including the conventional installation work in the launching, intermediate and target pits and for the domestic connection pipelines, was able to be completed to deadline and without incident by the beginning of February 2014.

Altogether some 465 m of vonRoll ECOPUR full-protection DN 125 pipes were installed in five daily stages using the static burst lining process. After cutting open the asbestos cement pipelines using a roller-carried knife, the pull-in channels were widened to 240 mm with an upsizing head while the new vonRoll ECOPUR pipes were pulled in at the same time. The highest traction forces measured during the pipe-pulling process were between 28 kN and maximum 60 kN according to the online measurement – with maximum traction forces

Figure 6:
Lowering the pipe into the launch pit in Albisstraße – burst lining in the area of the avenue of trees

Figure 7:
Starting the pipe-pulling – upsizing head and traction head with traction force measurement

Figure 8:
Bursting equipment in the main road with concrete thrust block and underpinning

Figure 9:
Pulling the ECOPUR pipes in the launch pit

Figure 10:
1st burst lining stage – underneath the play area and wild animal enclosure

Figure 11:
Connection of the pipes in the 1st burst lining stage with the pipes installed using the open technique

Figure 12:
Traction head with ECOPUR pipe after 110 m of pipe pulling – emergence in the target pit

according to DVGW technical instruction GW 323 [4] of 140 kN! These very low traction forces are due among other things to the smooth PUR external coating and the slender form of the socket (external diameter = 205 mm) of ECOPUR pipes.

5 Conclusion

The installation of vonRoll ECOPUR ductile iron pipes using the burst lining process meant that the pipeline was able to be replaced without any disruptive effects on the habitats of the wild animals and without interrupting the operation of the Langenberg wild park restaurant. The whole of the construction work including the installation of the pipes was completed smoothly and on deadline to the satisfaction of all those involved, including the client, planning engineers, construction contractor and pipeline constructor.

The success of the project for the replacement of the Langenberg drinking water pipeline in Langnau am Albis once again confirmed the knowledge that, even under difficult topographical circumstances and with unfavourable installation conditions, installation using alternative processes and an innovative piping material can be environmentally friendly while also being more efficient than conventional installation.

Bibliography

[1] EN 545
Ductile iron pipes, fittings, accessories and their joints for water pipelines – Requirements and test methods
2010

[2] EN 15655
Ductile iron pipes, fittings and accessories – Internal polyurethane lining for pipes and fittings – Requirements and test methods
2009

[3] EN 15189
Ductile iron pipes, fittings and accessories – External polyurethane coating for pipes – Requirements and test methods
2006

[4] DVGW technical instruction GW 323
Grabenlose Erneuerung von Gas- und Wasserversorgungsleitungen durch Berstlining – Anforderungen, Gütesicherung und Prüfung
[Trenchless replacement of gas and water supply pipelines using the burst lining technique – Requirements, quality assurance and testing]
2004-07

[5] SVGW rules W4
Richlinie für Wasserverteilung – Planung, Projektierung sowie Bau, Betrieb und Unterhalt von Trinkwasserversorgungs-systemem ausserhalb von Gebäuden
[Guideline for water distribution– Planning and development as well as construction, operation and maintenance of drinking water supply systems outside buildings]
2013-03

Author

Roger Saner
vonRoll hydro (suisse) ag
von roll-strasse 24
4702 Oensingen/Switzerland
Phone: +41 (0)62/3881237
E-mail: roger.saner@vonroll-hydro.ch

Client

Gemeinde Langnau am Albis
Wasserversorgung Langnau am Albis
Peter Stoll
Birkenstrasse 1
8135 Langnau am Albis/Switzerland
Phone: +41 (0)44/7133383
E-mail: wasserversorgung.langnau@bluewin.ch

Project and construction management

Flütsch Ingenieure AG
Peter Flütsch
Peter Decurtins
Römerstrasse 237
8404 Winterthur/Switzerland
Phone: +41 (0)52/2127000
E-mail: winterthur@fliag.ch

Pipeline construction, burst lining process

Tschanz Grabenlos AG
Rolf Kauer
Industriestrasse 6
4542 Luterbach/Switzerland
Phone: +41 (0)32/6821919
E-mail: rolfkauer@tschanzgrabenlos.ch

Pipeline construction, open method

Kaufmann Rohrleitungsbau AG
Roland Kaufmann
Sihlwaldstrasse 32a
8135 Langnau am Albis/Switzerland
Phone: +41 (0)43/5401030
E-mail: roland.kaufmann@krbag.ch

Directional drilling with cast iron pipes in inner-city areas

By Alexander Bauer and Stephan Hobohm

1 Introduction

FairEnergie GmbH, a subsidiary of Stadtwerke Reutlingen GmbH, is a regional multi-division supply company based in Reutlingen. FairEnergie GmbH supplies its customers with power, natural gas, district heating and drinking water. One of the most important arteries in the FairEnergie GmbH network is the DN 400 drinking water transport pipeline from the "Alte Burg" elevated tank to the "Scheibengipfel" elevated tank. This pipeline runs South-West to North-East straight through Reutlingen and in doing so crosses some major main roads and the railway line to Tübingen. Because of its great importance for the security of supply and its sensitive location in an urban area, it was decided that, as a precautionary measure, the existing 70-year-old steel pipeline should be replaced in certain areas.

2 Planning

The planning for the replacement of the approximately 400 m long "Konrad-Adenauer-Straße" section began in 2013 and was carried out in-house by the "Networks and structures planning" department of FairEnergie GmbH. Any thoughts about replacing this section of pipeline using the open trench technique could be dismissed straight away because, for the main part, the section in question runs beneath a very busy four-lane thoroughfare and it also crosses three Deutsche Bahn railway lines. Consequently the decision went in favour of the trenchless technique for the new pipeline.

The only realistic solution in the area of the main road was installation by the horizontal directional drilling process (HDD) in accordance with DVGW worksheet GW 321 [1]. The principal advantages of this method of construction lie above all in the small amount of space required, the resulting low level of disruption to traffic and residents and the fast progress of the work.

The amount of space needed depends very much on the piping material to be installed. The first thoughts of installing steel pipes again were quickly rejected because, in an inner-city area, it is simply impossible to lay a completely pre-welded 400 m long pipe string, especially since the long welding and subsequent insulation times would mean holding up the traffic for several days. Plastic pipes were rejected for the same reason. The system best suited to the application case turned out to be ductile iron pipes with restrained BLS® push-in joints. The advantages offered by this choice can be summarised as follows:

- no preliminary laying out of the entire pipe string necessary:

€ → with the HDD process ductile iron pipes are mainly assembled in the pipe-by-pipe pulling-in on a launching ramp and then immediately pulled through.

- low space requirements and little disruption to traffic during assembly and installation:

€ → only a 10 m to 12 m long launching ramp is needed, on which the pipes are assembled.

- very short assembly times:

€ → the usual assembly times for a BLS® push-in joint are between 5 min and 15 min including joint protection, depending on the nominal size. For DN 400 steel pipes, approximately 4 hours must be allowed per joint including subsequent coating.

- no cooling time required after assembly:
€ → unlike plastic pipes, restrained push-in joints can be loaded 100 % with the full permissible traction force straight after assembly.
- high traction forces:
€ → the permissible traction force for the DN 400 BLS® push-in joint is 650 kN. According to DVGW worksheet GW 321, Table A.4 [1] the permissible traction force for steel pipes in St 37 = 425 kN.
- constant traction forces even over longer pulling durations and at higher temperatures:
€ → reductions are to be taken into account here with plastic pipes (DVGW worksheet GW 321, Table A.2 [1]).
- lower curve radius:
€ → the minimum radius of a DN 400 BLS® push-in joint is 115 m. According to DVGW worksheet GW 321, Table A.4 [1] the minimum curve radius for steel pipes in St 37 is 203 m.
- proven external protection with cement mortar lining:
€ → for more than 35 years cement mortar lining has proved its worth with ductile iron pipes for the trenchless installation technique and/or for aggressive or stony soils (EN 545, Section D.2.3 [2] and DVGW worksheet W 400-2 [3]).
- comprehensive references from pipeline projects completed with the HDD process:
€ → references can be consulted via the link **www.duktus.com/de/referenz.html**.

Despite the low space requirement, it was necessary to close off one side of Konrad-Adenauer-Straße over a length of about 100 m and to have the traffic pass by the construction site in one lane in each case. This length was needed for

- for processing the drilling mud **(Figure 1)**,
- the intermediate construction pit (branch for crossing the railway lines) **(Figure 2)**,
- the launch pit including the launching ramp and pipe store **(Figure 3)**.

Originally the routing of the pipeline between the starting and finishing point for the entire project was to be as short as possible. However this meant that the railway line would not be crossed at a right angle.

Figure 1:
Mobile equipment for processing the drilling mud

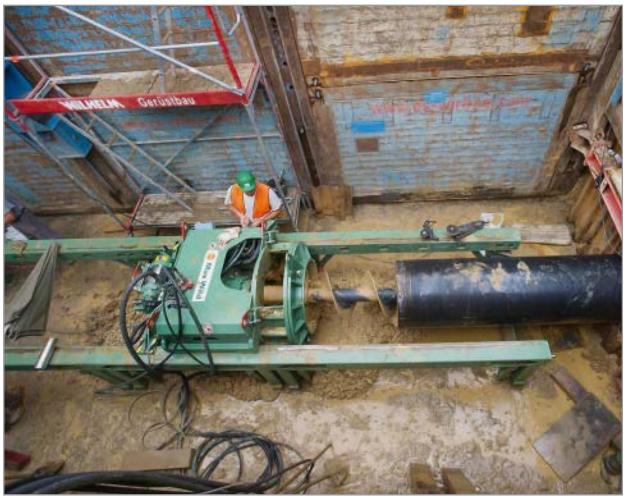

Figure 2:
Jacking the protective pipe under the railway line from the intermediate construction pit

Figure 3:
Pipe store, launching ramp, launch pit and intermediate construction pit

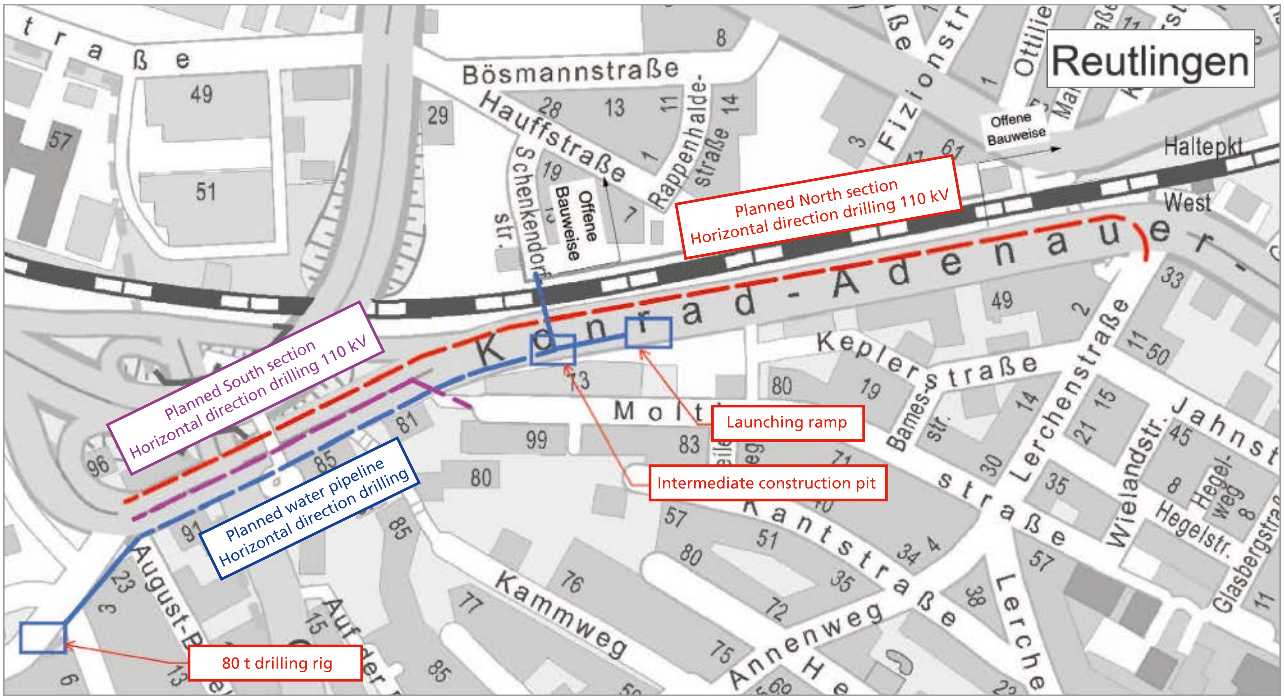

Figure 4:
General plan of the construction project in Konrad-Adenauer-Straße

This is not permissible according to the gas and water crossings guidelines (GWKR 2012) [4]. In accordance with module 877.2201, section 2, paragraph 4 [4] railway systems are to be crossed at right angles in a straight line. GWKR 2012 [4] further states that, when crossing beneath rails, pipe jacking should be used wherever possible and that, before starting the pipe-jacking work a geotechnical report should be produced in accordance with DVGW worksheet GW 304 [5] and [6] (see module 877.2102, section 2 [4]). Since, according to GWKR 2012 [4], the use of the HDD process is not permissible for pipes > DN 200 (module 877.2103, section 2 [4]), for the area of the railway crossing the choice was made to drive through a DN 800 steel protection pipe using the horizontal thrust boring process and then to insert the pipe carrying the medium, a ductile iron pipe with BLS® push-in joints and cement mortar coating **(Figure 3)**. While the pipe jacking is based on DVGW worksheet GW 304 [5] and [6], the subsequent insertion of the media pipe is to be planned and carried out in accordance with DVGW worksheet GW 320-1 [7].

Once the geotechnical report already mentioned had been produced, the detailed planning of the route could start. A traffic island on the corner of Schafstallstraße and Konrad-Adenauer-Straße was established as the starting point (location of the drilling equipment). From there onwards the route followed Konrad-Adenauer-Straße for around 370 m to an intermediate construction pit (branch to the rail crossing) and onward for a further 50 m to the target construction pit (location of the launching ramp). Thus the drilling was approximately 420 m long **(Figure 4)**. The smallest radius was determined to be 120 m, the necessary upsizing 700 mm. The maximum cover was fixed at 7 m. From the available data, the expected traction force of 175 kN to 200 kN was calculated.

The drinking water pipeline (water from Lake Constance) was designed for an operating pressure of 10 bars. The pipes are lined with cement mortar based on blast furnace slag cement. For the fittings, enamel was chosen as the internal and external coating. To the North of the railway lines an additional shaft was included in the planning, used on the one hand to be able to shut off the pipeline, but on the other hand also to enable the steel protection pipe to be drained in the event of a pipe burst underneath the railway lines. This is also a requirement of GWKR 2012 [4]. Above the drinking water pipeline and parallel to it a 110 kV cable was also laid using the HDD process.

3 Construction work

After about one third of the section, the pilot drilling of the planned route began to deviate northwards. Several attempts always produced the same result. According to the preceding soil analyses the directional drilling extends to a depth of about 8 m into the area of the Lias mudstone which was actually assessed as being problem-free. In the end a secondary fissure of the Achalm fault proved to be the reason for the deflection of the drilling. After several attempts they succeeded in driving the drilling from two sides, meeting up in the area of the fault.

The pilot drilling was then widened to 700 mm in order to guarantee the necessary 30 % overcut. With ductile iron pipes the overcut is always defined by the external diameter of the sockets. With a nominal size of DN 400 the BLS® push-in joint has an external diameter of approximately 540 mm including the cement mortar coating, the rubber sleeve and the steel sheet cone. According to DVGW worksheet GW 321 [1], pipes with restrained push-in joints exclusively are to be used, such as the BLS® push-in joint. In order to protect the pipes from being damaged during the pulling process, they should be coated with cement mortar to EN 15542 [8]. The joint areas are to be provided with a suitable protection (shrink-on or rubber sleeves) in combination with a mechanical protection such as a sheet metal cone.

In addition, attention needs to be paid to the permissible traction forces and the minimum permissible curve radiuses as regards the pipeline material to be drawn through. The traction force calculated for this project was between 175 kN and 200 kN. This corresponds to around 40 % of the weight of the pipe string. Because, at 650 kN, the permissible traction force for the BLS® push-in joint is far higher than the calculated values, there was in fact no need to ballast the pipeline. Ductile iron pipes in the DN 250 to DN 300 range are practically ideally ballasted in themselves because of their weight. By contrast, larger diameters tend to lift and, without ballasting, would rub against the crown of the drilled hole, thereby increasing the traction forces. With shorter runs and not very large nominal sizes, however, this is dispensed with because of the faster progress of installation. In fact with the particular pipe-by-pipe assembly used here, ballasting would hinder the work considerably. As regards the possible curve radius, a minimum of 115 m could be assumed with the BLS® push-in joint. Unfortunately, measurement with a gyrocompass showed that, because of the problems with the pilot drilling, the radius of approximately 90 m fell slightly short of this.

In close cooperation with all parties involved, it was nevertheless decided to go along with the planned pipe-pulling while monitoring the traction forces.

Installation commenced on 24.09.2014 at about 8 am. In the first stage the traction head was fitted on the first pipe and coupled to the pull rods **(Figure 5)**. Once the first pipe had been drawn a certain length, the second pipe could be immediately fitted. Now the launching ramp could be precisely adjusted. After the preparatory measures had been completed, the actual assembly and pulling process began. In each case one pipe (overall length 6 m) was assembled and pulled through. Because the drilling rods were 5 m long, there were small interruptions in this process at regular intervals.

Figure 5:
First ductile iron pipe with traction head and pull rods

Figure 6:
Assembly of the BLS® push-in joint on the launching ramp

Nevertheless it was possible to achieve an average assembly time of 8 min to 10 min per pipe. The time involves about 3 min for assembling and protecting the joint and 5 min to 7 min for pulling **(Figure 6)**. Including all interruptions to the work, in this way the last pipe of the approximately 370 m long pipeline was able to be pulled through after 8 hours, at about 4 pm.

The traction forces measured here, of 130 kN to 180 kN, were within the range previously measured. No negative effect due to the low curve radius was able to be detected in this connection. Before it was pulled through, an flanged spigot with a BLS® push-in joint and an blank flange were installed in the last pipe socket. The socket closed in this way was drawn as far as the intermediate construction pit. The connection to the railway crossing was made at this point later.

The railway section was cut using the horizontal thrust boring process with a DN 800 steel protection pipe. The average rate of progress was around 10 m per day with a total length of 35 m. Once drilling was completed, here again DN 400 ductile iron pipes with restrained BLS® push-in joints and cement mortar coating using the relining process to GW 320-1 [7] were pulled through. Metal cones over the sockets were not necessary here as the pipes were laid on sliding skids. Last of all there was the connection of the two pipe sections and the setting of the shaft on the North side of the railway.

4 Summary

Altogether the costs for the construction of the new drinking water pipeline including connecting it up as well as the shaft amounted to just 1.3 million Euros. The total construction time was only three months. Because of the problem encountered with the subsoil, the greatest challenge lay in producing a usable pilot drilling. The actual pipe-pulling operation was the least and technically most simple part of the whole construction project. This means that, once again, ductile iron pipes could put their considerable advantages to good use in cramped inner city conditions. The QR code refers to a video of the construction project in Konrad-Adenauer-Straße **(Figure 7)**.

Figure 7:
Video QR-code

Bibliography

[1] DVGW worksheet GW 321
Steuerbare horizontale Spülbohrverfahren für Gas- und Wasserrohrleitungen – Anforderungen, Gütesicherung und Prüfung
[Horizontal directional drilling process for gas and water pipelines – Requirements, quality assurance and testing]
2003-10

[2] EN 545
Ductile iron pipes, fittings, accessories and their joints for water pipelines – Requirements and test methods
2010

[3] DVGW worksheet W 400-2
Technische Regeln Wasserverteilungsanlagen (TRWV) –
Teil 2: Bau und Prüfung
[Technical rules for water distribution equipment (TRWV) –
Part 2: Construction and testing]
2004-09

[4] Gas- und Wasserleitungskreuzungsrichtlinien (GWKR 2012)
[Guidelines for gas and water pipeline crossings (GWKR 2012)]
2012-04

[5] DVGW worksheet GW 304
Rohrvortrieb und verwandte Verfahren
[Pipe jacking and the processes used]
2008-12

[6] DVGW worksheet GW 304-B1
1. Beiblatt über Bundesfernstraßen und Versorgungsleitungen im DVGW-Arbeitsblatt GW 304:2008-12
Rohrvortrieb und verwandte Verfahren
[1st supplement on federal highways and supply pipelines in DVGW worksheet GW 304:2008-12
Pipe jacking and the processes used]
2012-12

[7] DVGW worksheet GW 320-1
Erneuerung von Gas- und Wasserrohrleitungen durch Rohreinzug oder Rohreinschub mit Ringraum
[Replacement of gas and water pipelines by pipe pulling or pipe insertion with an annulus]
2009-02

[8] EN 15542
Ductile iron pipes, fittings and accessories – External cement mortar coating for pipes – Requirements and test methods
2008

Authors

Alexander Bauer
Duktus Rohrsysteme Wetzlar GmbH
Sophienstraße 52–54
35576 Wetzlar/Germany
Phone: +49 (0)160/7197669
E-mail: alexander.bauer@duktus.com

Dipl.-Ing. (FH) Stephan Hobohm
Duktus Rohrsysteme Wetzlar GmbH
Sophienstraße 52–54
35576 Wetzlar/Germany
Phone: +49 (0)6441/49-1248
E-mail: stephan.hobohm@duktus.com

Client

FairEnergie GmbH
Martin Hermle
Hauffstraße 89
72762 Reutlingen/Germany
Phone: +49 (0)7121/582-0
E-mail: info@fairenergie.de

General contractor

GA Energieanlagenbau Süd GmbH
Schmidener Weg 3
70736 Fellbach/Germany
Phone: +49 (0)711/9573-9
E-mail: info@ga-eas.de

Civil engineering and directional drilling

Max Wild GmbH
Josef Schad
Leutkircher Straße 22
88450 Berkheim/Germany
Phone: +49 (0)8395/920-0
E-mail: info@maxwild.com

Pipe assembly

Norbert Schütz GmbH & Co. KG – Rohrleitungs- u. Anlagenbau
Lothar Schütz
Fellheimer Straße 5
87737 Boos/Germany
Phone: +49 (0)8335/9847-0
E-mail: info@schuetz-boos.de

Investing in ductile iron pipe system pays for itself in low installation and operating costs with, at the same time, an extremely long operating life!

Pressure pipeline for diverting karst water in the access tunnel of a new pumped-storage power plant

By Roger Saner

1 The Linth-Limmern power station in Linthal

In the Swiss Canton of Glarus, close to the source of the River Linth, the tributaries in a catchment area of around 140 km² are used to produce hydroelectric power. Kraftwerke Linth-Limmern AG is owned by the Swiss electricity group AXPO and the Canton of Glarus. It operates the Muttsee and Tierfehd cavern power plants as well as the Linthal power station, which went into operation in 1968 after eleven years of construction. In 2009 the plant was extended for the first time with the construction and commissioning of the Tierfehd pumped storage plant. Today the equipment at the Linth-Limmern power station already represents an important cornerstone of hydroelectric power as an indigenous power source and it makes a significant contribution to Switzerland's power supply.

With the Linthal 2015 expansion project the existing equipment is now due to be further extended and optimized with an additional, powerful pumped storage station. As compared with a simple storage power plant, a pumped storage power station has the advantage that not only can power be produced at peak times but excess power can also be used during low load periods. To do this, for example, water is pumped at night into a reservoir located higher up and is used again at a later point for power production. Thus, with the pumped storage system it is possible to react flexibly and in an environmentally friendly way to supply and demand in the power grid.

2 Linthal 2015 – the highest mountain construction site in Europe

On the Mutten mountain, 2,500 m above sea level and looking down on the municipality of Linthal in Glarus, the project of the century in the form of the gigantic Linthal 2015 pumped storage plant is being built on Europe's highest construction site. The planned investment costs for this project amount to around 2.1 billion Swiss francs. After a construction period lasting several years, the new underground pumped storage station should go into operation as early as 2015/2016. To generate power, water from the Limmernsee reservoir, at approximately 1,850 m above sea level, will be pumped back to the Muttsee reservoir which is a good 630 m higher so that it can be used for power production again during times of peak demand **(Figure 1)**. To achieve this, the capacity of the Muttsee lake has been increased from an original 9 million m³ to 25 million m³ by the construction of an imposing 36 m high, 1,025 m long barrage **(Figure 2)**. With a pumping capacity and a turbine output of 1,000 MW in both cases, the total output of the Linth-Limmern power station equipment, which is currently 480 MW, will increase to 1,480 MW, which approximately corresponds to the output of the nuclear power station at Leibstadt.

3 Access tunnel for opening up the caverns of the new Linth-Limmern pumped storage plant

In order to open up the machine and transformer caverns of the new Linth-Limmern pumped storage plant, an access tunnel with a diameter of 8 m and a length of around 4 km had to be bored from Tierfehd at 811 m above sea level to the underground generator gallery at a height of around 1,700 m above sea level **(Figure 3)**.

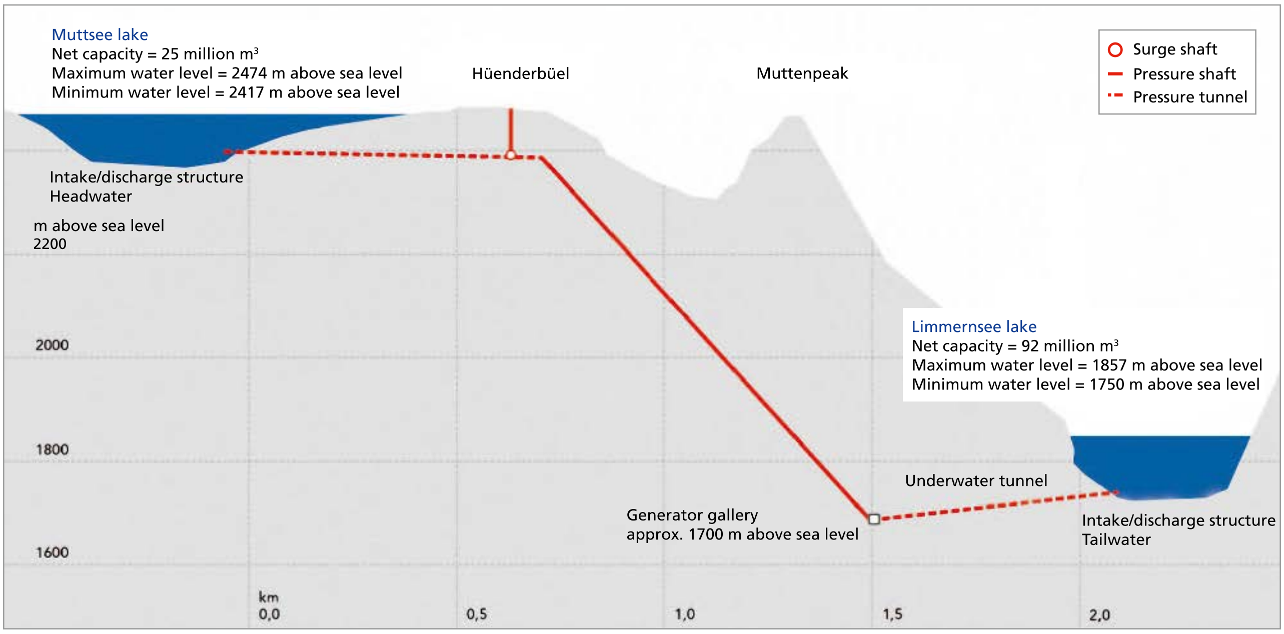

Figure 1:
Longitudinal section of Muttsee – Limmernsee through the pressure tunnel and pressure shaft (source: Axpo Holding AG)

Figure 2:
Completed barrage at Muttsee (source: Axpo Holding AG)

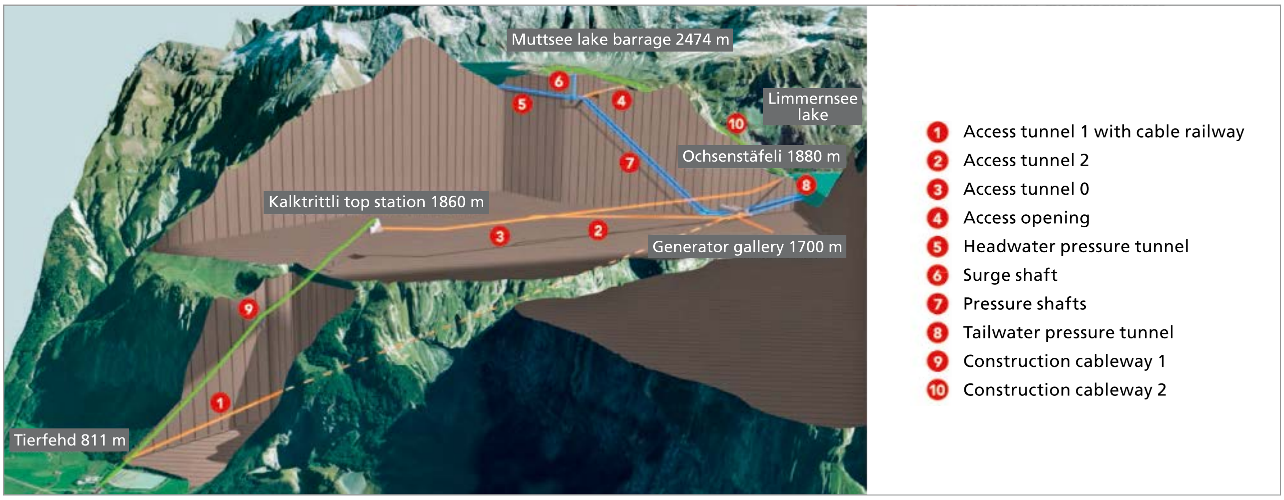

Figure 3:
Section through the mountain – access tunnel 1 (source: Axpo Holding AG)

The access tunnel was equipped with a cable railway for the transport of large and heavy machine parts which, under normal operation, is designed for loads up to 40 t. However it is also possible to transport special loads of up to 215 t, as is necessary for the installation of the large transformers.

The entry tunnel and the cavern of the bottom station were excavated by drilling and blasting and secured with shotcrete. The excavation of the 3,800 m long sloping tunnel to the top station cavern, with a constant gradient of 24 % or 13.5° **(Figure 4)**, was done with a 160 m long, 1.500 t tunnel boring machine. The tunnel was equipped with anchors, nets and two layers of shotcrete. The rubble (predominantly Quintner limestone) with a total weight of close to 500,000 t was for the main part used for modifying the terrain to the Tierfehd bottom station.

Figure 4:
The transition from bottom station cavern to the sloping tunnel

4 Pressure pipeline for diverting karst water in the access tunnel

In the context of the tunnel boring work in the sloping tunnel, at tunnel metre TM 1,279 (left) and tunnel metre TM 1,285 (right) so-called karst water springs, i.e. underground watercourses, which occur in karst rock (weathered by carbonic acid) were broached. The volumes of karst water occurring are subject to severe seasonal fluctuations and can amount to as much as 400 L/s. In Winter the karst water springs are usually frozen.

Figure 5:
Pressure pipelines installed in the sloping tunnel (with sliding consoles)

To collect the water accruing, a collecting tank was constructed at height TM 1,213. The subsequent diversion of the karst water into a valve chamber located 300 m lower down in the portal area, was planned and executed using two DN 250 pressure pipelines lying one on top of the other. The restricted amount of space available in the clearance zone of the tunnel did not allow for a single pressure pipeline with a larger diameter to be used **(Figure 5)**.

When the volume of water in the collecting tank increases sharply, the excess water after the first pipeline has filled up is routed into the second pipeline via overflow edges **(Figure 6)**. The karst water reaching the valley through the valve chamber is also routed via a DN 250 pressure pipeline into a reservoir lying above the portal (40 m of altitude) and reused for turbine cooling. Surplus water is routed through the drainage pipeline of the reservoir into the outfall channel. If the capacity of the reservoir is exceeded, the karst water can also be discharged directly from

Figure 6:
Connection of collecting tank at tunnel metre TM 1,213

the valve chamber through a DN 400 relief pipeline via a purification structure into an equalising reservoir or else into the outfall channel.

Because of the difficult assembly conditions in the access tunnel (the pipelines were assembled to hang freely on the side of the tunnel vault) and because of the maximum static pressure due to the height difference (300 m/30 bar) from the broaching of the spring to the bottom station, the choice of pipe material for the pressure pipelines went to ductile iron pipes with flexible push-in joints from the Swiss manufacturer vonRoll.

The following types of pipe were used in the different areas:

- Access tunnel collecting tank to access portal – free-hanging double pipeline of vonRoll DUCPUR DN 250, classes K 7, K 9 and K 10, total length approx. 2,500 m,
- Exit of access tunnel to valve chamber and supply pipeline to reservoir – buried pipeline of vonRoll ECOPUR DN 250, class K 10, total length approx. 120 m,
- Relief pipeline from valve chamber to combining structure – buried pipeline of vonRoll ECOPUR DN 400, class K 9, total length approx. 90 m.

The standard vonRoll DUCPUR pipe has a zinc coating with a bitumen finishing layer to EN 545 [1] and an internal lining of polyurethane (PUR) as per EN 15655 [2]. The vonRoll ECOPUR full-protection pipes are integrally coated with polyurethane (PUR) in accordance with standards EN 15655 [2] and EN 15189 [3]. Because of their mechanically highly resistant PUR coating they can be used in all types of soil and according to EN 545 [1] they are classified as ductile cast iron pipes with reinforced coating.

An engineering office which specialises in tunnel construction was commissioned for the planning and for this tunnel project they decided on a well-proven concept developed by themselves for free-hanging pressure pipelines. All deflecting forces occurring would be directly transmitted into the tunnel vault.

To achieve this, zinc-coated steel consoles with threaded bolts were anchored directly into the tunnel vault and the ductile iron pipes were mounted on them. Because of unevenness and level differences in the tunnel walls, the base plates of the steel consoles had to be back-filled with high-strength liquid mortar after assembly. For changes of direction in niches and every 60 m on straight sections, the steel consoles were arranged as fixed points in a solid construction. The joint of the pipe or fitting socket at the fixed point as well as two pipe sockets both before and after the fixed point were designed as restrained joints to transmit forces directly into the tunnel vault **(Figures 7 and 8)**.

For this the well-proven vonRoll HYDROTIGHT thrust protection system, Fig. 2806 **(Figure 9)** and Fig. 2807 A **(Figure 10)** was used. In this way the ductile iron pipes are prevented from breaking free by twisting around the fixed point console directly after a redirection of forces. On the free sections between the fixed points the steel consoles were designed as sliding consoles for the ductile iron pipes which can be angled up

Figure 7:
Wall penetration through the tunnel vault with fixed point consoles in the Tierfehd entry tunnel

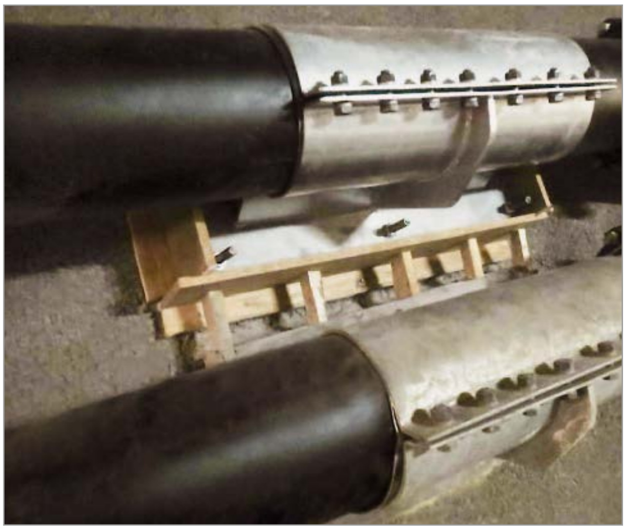

Figure 8:
Formwork on the fixed point console for subsequent filling with liquid mortar

to 5° **(Figure 11)**. In these areas thrust protection was purposely not used so that the pipeline can flexibly take up longitudinal movements.

5 Difficult assembly of the karst water pipeline in the access tunnel

The double pipeline had to be anchored on the side in the tunnel with a longitudinal gradient of 24 % at a height of approximately 2.80 m in the tunnel vault. When doing this, the cable railway was not to be blocked for too long for the pipeline construction work to avoid delaying the transport of the large machine parts for the power station. The ductile iron pipes were carried by the cable railway from the tunnel entrance in the valley to relevant installation location where they were immediately laid on the preassembled steel consoles with the help of a mini-digger **(Figure 12)**. Because of the steep gradient, auxiliary scaffolding and small lifting platforms were also used for the assembly work **(Figure 13)** as these could be quickly and easily moved. Because of the very tight deadline specified by the construction management, the pipeline construction companies were obliged to carry out the assembly of the pipes by shift work around the clock with up to seven workers per shift. The total installation time for one pipeline in the sloping tunnel was only 10 days (the project demanded that the two pressure pipelines running in parallel were installed with a time interval between them of several months!) The assembly of the pipes in the cavern and in the access tunnel in the valley only took 3 working days.

6 Conclusion

For the Linthal 2015 project, smooth-functioning operations through the 4 km long access tunnel is of supreme importance both during the construction period and when in operation. Heavy machine components for the pumped storage power station can only be safely transported to their place of use by means of the cable railway installed.

Unfortunately, unforeseen events can never be completely excluded when working underground and this fact was brought to the attention of all involved again when the karst water springs were breached. Incidents of this kind were able to be solved with the targeted use of high quality construction materials and by experienced engineers and construction specialists.

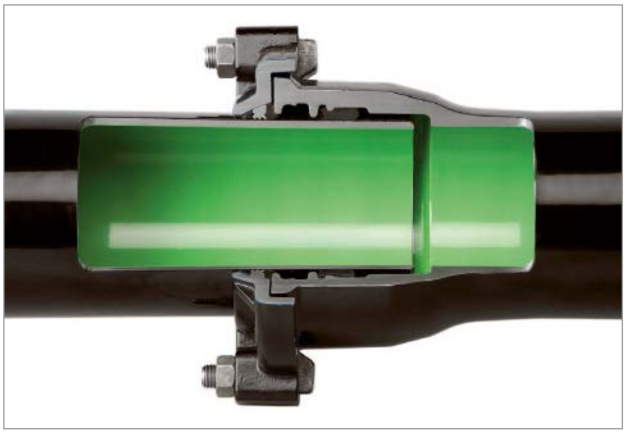

Figure 9:
Push-in joint with external vonRoll HYDROTIGHT thrust protection – Figure 2806

Figure 10:
Push-in joint with internal vonRoll HYDROTIGHT thrust protection – Figure 2807 A

Figure 11:
Grouted sliding points in straight sections

Figure 12:
Assembly of ductile iron pipes with a mini-digger in the sloping tunnel

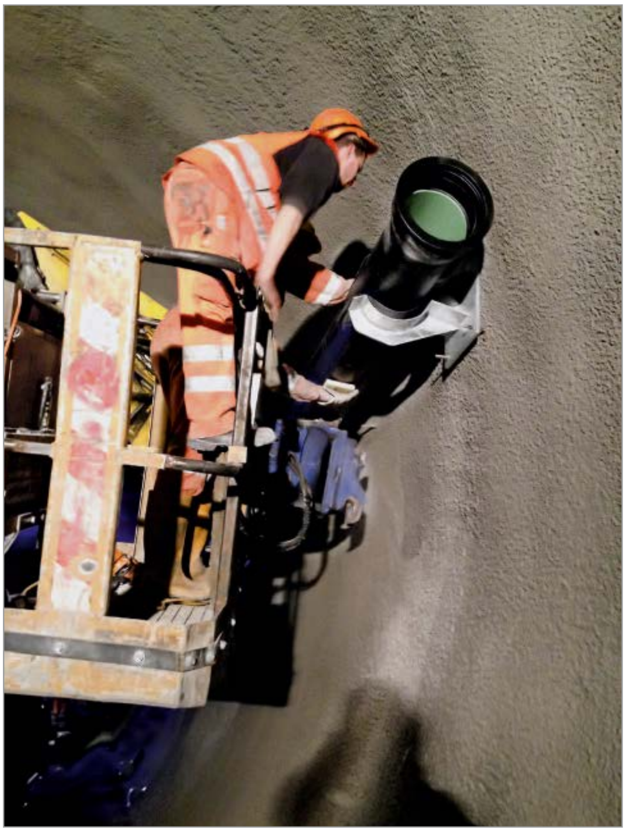

Figure 13:
Assembly of ductile iron pipes with small lifting platforms in the sloping tunnel

In the "karst water pressure pipeline" mini-project, vonRoll ductile iron pipes with their outstanding strength properties, secure restrained push-in joints and innovative coatings made an essential contribution to the safe operation of the access tunnel in the project of the century which is the Linthal 2015 pumped storage plant.

Bibliography

[1] EN 545
Ductile iron pipes, fittings, accessories and their joints for water pipelines –
Requirements and test methods
2010

[2] EN 15655
Ductile iron pipes, fittings and accessories –
Internal polyurethane lining for pipes and fittings –
Requirements and test methods
2009

[3] EN 15189
Ductile iron pipes, fittings and accessories –
External polyurethane coating for pipes –
Requirements and test methods
2006

Author

Roger Saner
vonRoll hydro (suisse) ag
von roll-strasse 24
4702 Oensingen/Switzerland
Phone: +41 (0)62/3881-237
E-mail: roger.saner@vonroll-hydro.ch

Client

ARGE Zugangsstollen AZL, Linthal
c/o Wayss & Freytag Ingenieurbau AG
Bereich Tunnelbau
Christian Korndörfer
Eschborner Landstraße 130–132
60489 Frankfurt am Main/Germany
Phone: +49 (0)69/7929-443
E-mail: christian.korndoerfer@wf-ib.de

Planning

ewp bucher dillier AG Luzern
Matthias Bucher
Industriestrasse 6
6005 Luzern/Switzerland
Phone: +41 (0)41/3680777
E-mail: matthias.bucher@ewp.ch

Pipeline construction access tunnel stage 1

Baumeler Leitungsbau AG
Hans Baumeler
Löwenstrasse 6
6004 Luzern/Switzerland
Phone: +41 (0)41/4103347
E-mail: info@baumelerltg.ch

Pipeline construction access tunnel stage 2

Bauunternehmung Vetsch
Andreas Kasper
Kantonsstrasse 2
7252 Klosters Dorf/Switzerland
Phone: +41 (0)81/4221448
E-mail: andreas.kasper@vetsch-klosters.ch

Pipeline construction outside area

Marti & Co.
Werner Marti
Poststrasse 2
8783 Linthal/Switzerland
Phone: +41 (0)55/6431819
E-mail: marti&co.sanitaer@bluewin.ch

Sustainably superior –
ductile iron pipe systems

Home-produced power for processing home-grown wood – Baron Mayr-Melnhof-Saurau backs energy independence

By Rudolf Stelzl and Roland Gruber

1 Introduction

With the Gössbach 1 power plant, Baron Franz VI Mayr-Melnhof-Saurau has entered into a project which is entirely dedicated to covering his company's energy requirements. The power generated will be used exclusively for the sawmill based in Leoben, Austria. Furthermore, when building the power plant it was also important that the ecological resources of the forest estate should be used sustainably.

2 Description of the project

The initial situation and aims were clearly set out:

- The main intention of the project was to achieve sustainability by linking economic performance with the use of renewable energy from the ecological resources of the forest estate.
- The power plant was to be designed in such a way that existing fishing rights would not be affected and additional synergy benefits would be achieved.

The contract for overall planning and project management went to SchueTo-Austria Ingenieurbüro für Umwelttechnik represented by Dr. Thomas Schützeneder.

3 Planning the powerhouse

In There was a great untapped potential for water power in the extensive grounds of the Mayr-Melnhof property. Therefore it was about time that they built their own power plant. Once they had conceived the idea they entered into the planning phase in order to obtain the necessary approvals. For this they were able to rely on the technical know-how of the interTechno Engineering GmbH planning office, who, together with SchueTo-Austria, assisted with all the official procedures. During the planning in 2012 the form of the future powerhouse was altered. They moved away from the plan already submitted for the usual cube shape with flat roof because it simply would not have sat well in the landscape. Therefore the powerhouse was built in the Norwegian style **(Figure 1)**. This option had the inestimable advantage that part of the roof can be raised at any time so that machine installations can be lifted in and out for any overhaul or repair work without problem. Hence it was 2.5 m shorter and 3.7 m lower than the powerhouse originally planned and thus also more cost effective. In addition, all the material for the timber construction – about 63 m^3 – was able to be produced in the company's own timber mill.

4 High-efficiency Pelton turbine

For the construction of the power plant at Gössbach a four-jet Pelton turbine **(Figure 2)** from GLOBAL HYDRO ENERGY GmbH (GHE) was selected. The standard output capacity is stated as 2.34 GWh. Features of the turbine installed are high efficiency, simple flowrate control and extremely smooth running with a displacement of 0.75 m^3/s. In addition to the impeller the package also included a synchronous three-phase generator from Hitzinger GmbH, shut-off valves and the drainage and bypass pipelines. The machine components were delivered in November 2013 and one month later they went ahead with the initial commissioning. The power plant produces an output of 595 kW.

Figure 1:
Newly built powerhouse in Norwegian style

Figure 2:
Four-jet GHE Pelton turbine equipped with a Hitzinger synchronous 3-phase generator

Figure 3:
Newly laid DN 800 ductile iron pipes in the area of the Maria Kaltenbrunn spring

5 Local company takes care of the hydraulic steelwork

The construction work involving hydraulic steelwork was carried out by Mayrhofer Maschinenbau GmbH from Wenigzell. The equipment consists of a Tyrolean weir, inlet control valve, inlet protection with electromechanical drive, hydraulic flushing sluice, pipe protection for emergency shutdown and the fine screen cleaning system with control technology and hydraulics.

A new screen cleaning machine was developed by Mayrhofer Maschinenbau GmbH for the Gössbach 1 power plant project which, in addition to proven quality, is also characterised as being particularly maintenance-friendly. Hydraulic steelwork construction began in June 2013 and was completed on schedule by the end of the year.

6 Freedom of movement for fish

When it came to the fish ladder, the decision went to a natural-looking pond-type bypass through which a residual flow of 100 L/s water is delivered. In addition a further maximum of 88 L/s is dynamically added. Also, the run-off channel is integrated into the bank revetment in order to improve the aquatic continuity of the changeover ramp constructed.

7 Installation of ductile iron pipes

At the beginning of May last year, work was started on the construction of the turbine pipeline with a total length of around 2,330 m with a gross head of exactly 101.9 m. The ductile iron pipes with a nominal size of DN 800 **(Figure 3)** were supplied by TIROLER ROHRE GmbH – TRM. The project data for the Gössbach 1 power plant turbine pipeline can be found in **Table 1**.

The operator was looking for the highest degree of quality here because this long pipeline had to be laid in Alpine terrain. Tiroler Rohre GmbH develops, produces and markets high quality systems in ductile cast iron for water transport and for the deep foundations of building structures. Durable material properties, innovative product technology and competence in application areas are all needed in the water and civil engineering industries.

Ecological criteria determined the choice of piping material and construction techniques. The ductile iron pipes were manufactured with material from the recycling industry, such as sheet metal bales and sorted steel scrap. This means that their ecological footprint is small. The screened excavation material was reused as bedding material. This avoided the use of heavy vehicles for transporting pipe bedding material.

Table 1:
Project data on the turbine pipeline for the Gössbach 1 power plant

Project name	Gössbach 1 power plant		
Application	turbine pipeline		
Location	Leoben		
Client	Baron Franz VI Mayr-Melnhof-Saurau		
Planning	interTechno Engineering GmbH		
Total construction time	7 months		
Turbine pipeline	Length: 2,330 m	Nominal size: DN 800	Wall thickness: K 9
Connection elements	BLS® - and TYTON® - push-in joints		
Coating	Zinc coating with epoxy finishing layer		
Lining	Portland cement mortar		
Particular requirements	Reliable manufacturer; solution provider; system supplier; responsibility		

8 New forest road and better infrastructure

The work on the route of the pressure pipeline has created a new forest road or path which, for the most part, runs along the route taken by the pipe. In the area of the spring the cast-iron pipeline has been fitted with restrained joints. The substructure of the forest road is secured with geotextile. With the improved accessibility, all the slopes along the roadside can now be cultivated without problem.

A special particularity in implementing the project was the pipe installation above the existing "Augenbründl" mineral spring with the Maria Kaltenbrunn pilgrimage chapel. The spring was heavily polluted and its water was not suitable as drinking water. The mineral spring was completely cleaned up in the context of installing the pipeline.

9 Power supply for the sawmill

The sawmill operates in three shifts which only allowed very small time windows for the construction of the 1.7 km long power line. A system of three electric cables and an empty conduit for optical fibres was installed. The challenge lay in carrying out the cable installation on the premises of the Mayr-Melnhof sawmill while maintaining production.

The sawmill based in Leoben, Mayr-Melnhof Holz Holding AG, will be supplied with the electricity generated. The entire energy supply has been improved by the new 30 kV line, while telecoms used the pipe trench for pulling through fibre optic and telecommunications cables.

10 A project with many benefits

Final acceptance took place in Autumn 2014. The Gössbach 1 power plant in Leoben has proved to be a showcase project with numerous advantages both for the operator and also for the population. Baron Franz VI Mayr-Melnhof-Saurau has built a hydroelectric station on his land which supplies the wood production business with renewable energy in an environmentally friendly way. The infrastructure around the Gössbach stream has been improved so that people have a wonderful hiking trail available with a new destination for their days out.

Authors

Rudolf Stelzl
TIROLER ROHRE GmbH – TRM
Innsbrucker Straße 51
6060 Hall in Tirol/Austria
Phone: +43 (0)664/8348083
E-mail: r.stelzl@aqua-austria.at

Mag. Roland Gruber
Gruber-Seefried-zek Verlags OG
Lindaustraße 10
4820 Bad Ischl/Austria
Phone: +43 (0)664/1150570
E-mail: rg@zekmagazin.at

Extending the Samina pumped-storage plant in Liechtenstein

By Steffen Ertelt

1 Introduction

The Samina power station, the biggest hydroelectric station in Liechtenstein, is being renovated and also extended by the addition of a pumped storage plant. The project started in 2004 with a routine inspection of the pressure pipeline, constructed in 1948, which runs from the apparatus room in Masescha to the central building in Schwefelstraße in Vaduz. The defects discovered in this inspection would have required some very expensive renovation, the cost of which in terms of money and time was disproportionate to the construction of a new pressure pipeline. In initial, basic studies, Liechtensteiner Kraftwerke (LKW) worked out a number of options for the renewal of their fleet of power plants. In the end the client came to the conclusion that, in addition to the construction of a new pressure pipeline, a new power station control centre as well as its extension to a pumped storage station was an important element for the future of the electrical power supply in the Principality of Liechtenstein. The construction costs for the project as a whole amounted to 50 million Swiss francs.

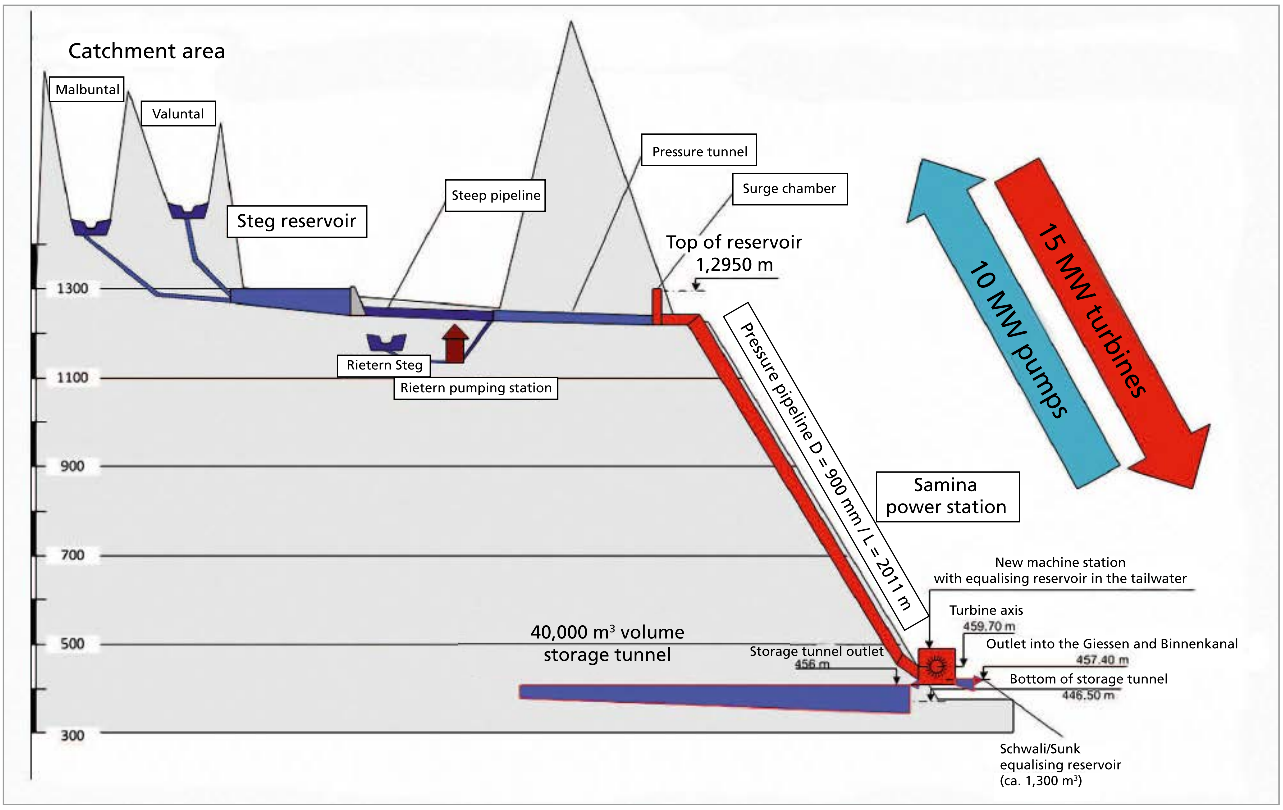

Figure 1:
Longitudinal section – Samina pumped storage station in Vaduz

The existing DN 750 pressure pipeline was decommissioned, dismantled and replaced with a new pipeline. This had the advantage that no new areas of land needed to be used and there were no major difficulties to be expected with the earthworks. The new pressure pipeline with a total length of about 2,100 m is constructed in DN 900 pipe. The new machine centre in Schwefel Vaduz is equipped with two Pelton turbines each with an output of 7.5 MW. In addition there are two 5 MW pressure pumps used to pump the water back into the Steg reservoir **(Figure 1)**.

The water needed for the pumping station is not stored in an open reservoir, as is usually the case. Fortunately the rock directly behind the machine centre is very suitable for the construction of an underground storage tunnel **(Figure 2)**.

2 Use of ductile iron pipes for power station pipelines

A hydroelectric power station needs a certain difference in altitude and a sufficient volume of water. Because of this altitude difference the supply pipelines are usually high pressure pipelines. Furthermore, because of the extreme conditions of the terrain, including steep slopes **(Figure 3)**, difficulties with access and so on, some very high demands were placed on the planning engineers, the construction company carrying out the work and above all the pipe material to be used. The pipe material is expected to meet extreme requirements in terms of functionality and installation and also to have a long working life.

Ductile iron pipe systems to EN 545 [1] are outstandingly suitable for the construction of power station pipelines under extreme requirements. Ductile cast iron as a material has high safety margins. BLS® restrained push-in joints **(Figure 4)** are quick to assemble regardless of the weather.

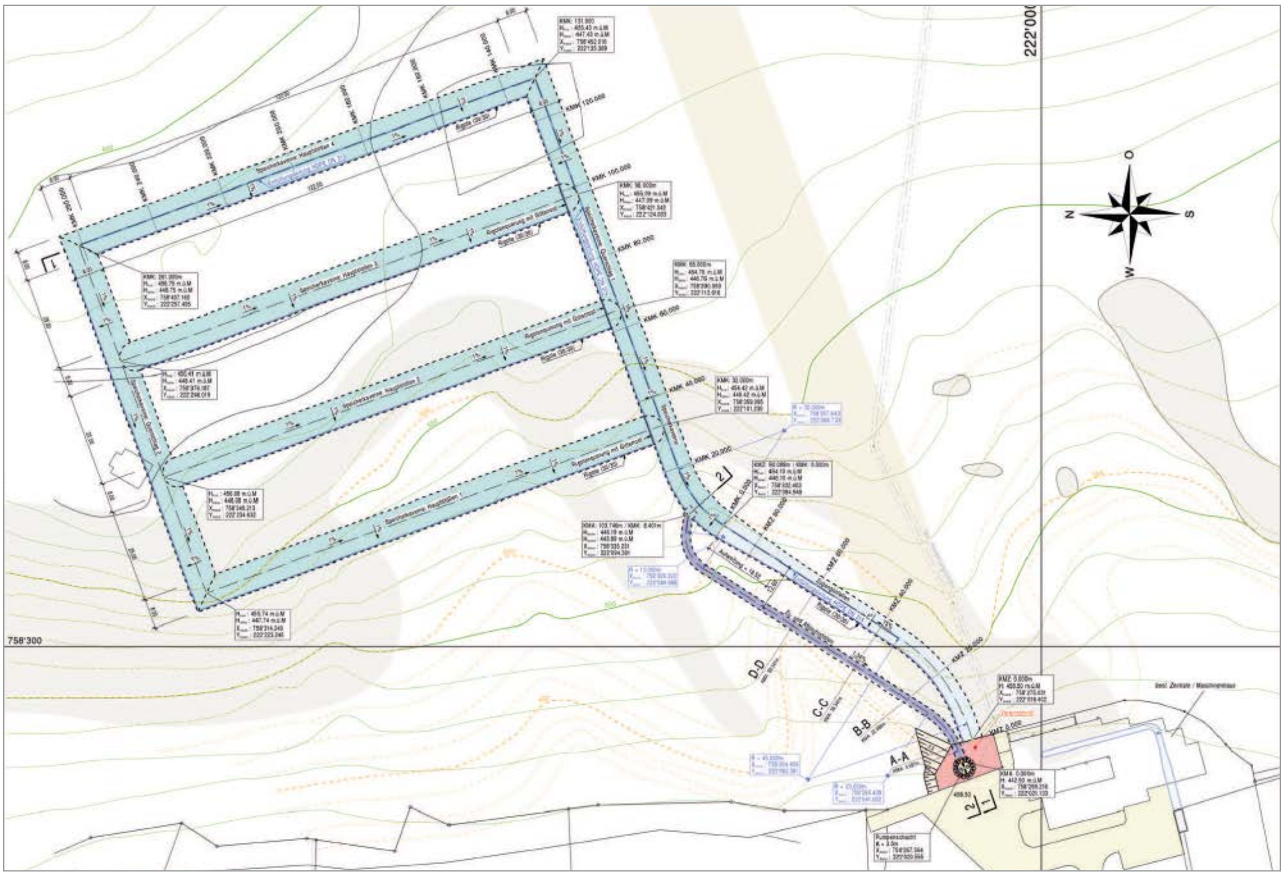

Figure 2:
Storage tunnel with a capacity of 40.000 m³

Figure 3:
Steep slope to the Samina pumped storage station

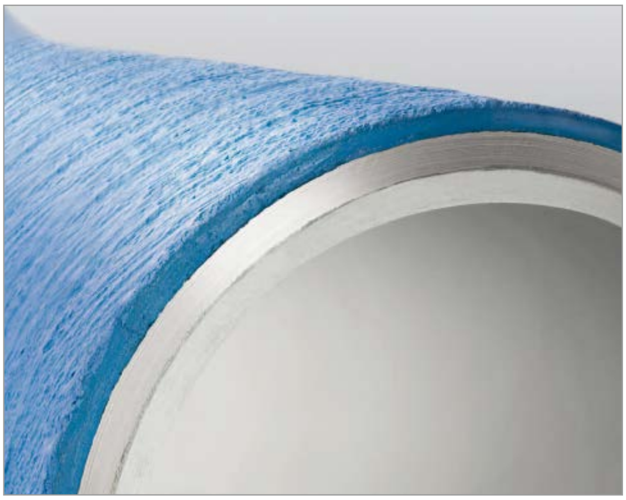

Figure 5:
Cement mortar coating to EN 15542 [2]

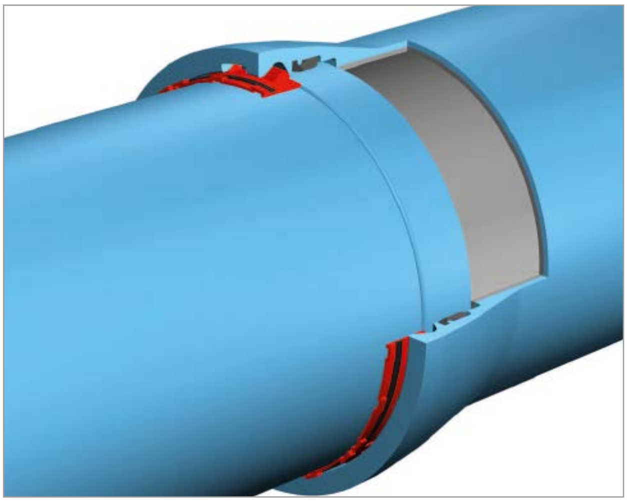

Figure 4:
DN 900 BLS® push-in joint

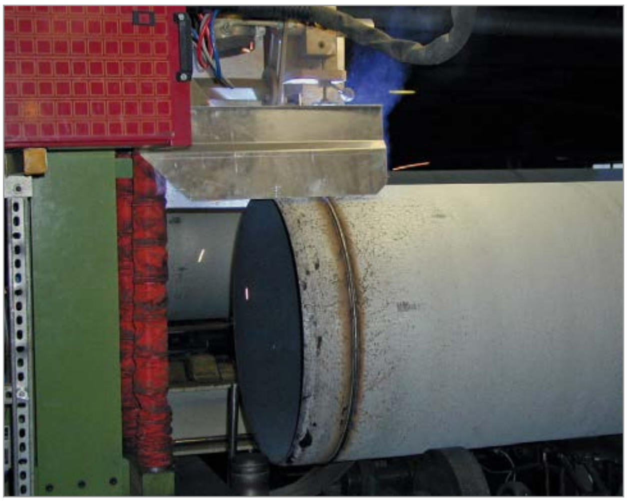

Figure 6:
Welded bead applied at the factory

There is no need for welding work and weld seam inspection to be carried out on site, which turns out to be an advantage especially in steeply sloping areas with extreme gradients, saving time and therefore saving costs. The external protection of the pipe **(Figure 5)**, a layer of zinc (active pipe protection) with cement mortar coating to EN 15542 [2] means that the pipes can be laid in soils with any level of aggressiveness. No preliminary soil investigations were necessary. With its fibre reinforcement and PE net bandaging, cement mortar coating is extremely resistant to mechanical stresses. This means that, with this external protection, the pipes could be laid directly in the existing coarse, stony soil. The BLS® push-in joint is a positive-locking, restrained socket joint with a welded bead applied in the factory **(Figure 6)**.

The locking segments are inserted and secured in a locking chamber cast onto the pipe socket via special window openings in the end face of the socket **(Figure 7)** after the spigot end of the pipe has been pushed in. When there are axial traction forces in the joint, whether due to internal pressure or because the pipes are being pulled through using the trenchless technique, the welded bead is supported on these secured locks or locking segments and these in turn are supported on the front of the locking chamber. From now on the joint is permanently restrained.

Variable sizing of wall thicknesses means that each cast iron pipe and its restrained BLS® push-in joint can be adapted to the pressure ratios in the headrace pipeline.

3 Construction of part of the pipeline with ductile iron pipes

After some preparatory work, installation of the pipes in the pipe tunnel section was commenced in February 2014. Inside the Masescha pipe tunnel (length: 160 m) and surge chamber (length: 80 m) the ductile iron pipes were mounted on bearing brackets every 3 m and then additionally fixed with steel clamps **(Figures 8 and 9)**.

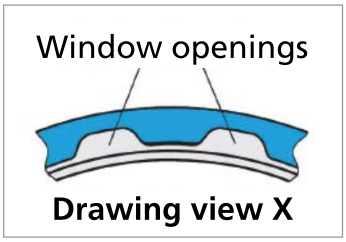

Figure 7:
Window openings in the DN 900 BLS® push-in joint

Inside the tunnel they were handled using a special roller support structure **(Figures 10 and 11)**. With this ingenious transport technique and because the operation was not influenced by the weather, the installation inside the pipe tunnel was able to be completed as early as May.

The installation of the buried pipes in the open was started in the middle of April 2014. The work on the new pressure pipeline to be constructed was very challenging in places here because of the topographical conditions. On the steep slope there was a gradient of up to 80 % in some places. Here once again, the particular installation advantage of ductile iron pipes was displayed because their BLS® push-in joints make joint welding and weld seam inspection on site unnecessary (saving time and costs).

Figure 8:
Masescha pipe tunnel

Figure 10:
Roller support structure for transporting the pipes in the tunnel

Figure 9:
Surge chamber in the pipe tunnel

Figure 11:
Pipe transport in the tunnel using transport rollers

Figure 12:
Pipe transport by cableway

Figure 13:
Pipe transport on the steep slope

Figure 14:
Pipe assembly going downwards

Figure 15:
Pipe assembly on the steep slope

Nevertheless, the installation team was really put to the test in this section. Bad weather conditions and snow increased the potential hazards and necessarily led to a brief interruption of the work.

In order to transport the pipes up the escarpment a cableway was erected just for this purpose **(Figure 12)**. In this way the pipes could be transported to their installation location on the slope and assembled pipe by pipe **(Figure 13)**.

The pipes were installed in the trench **(Figures 14 and 15)** going from top to bottom (going down the slope). This way of going about things offered the advantage that the welded beads and the locking segments of the restrained BLS® push-in joints were constantly kept under tension.

Figure 16:
Access for cleaning and inspection

Figure 17:
Apparatus room with pipe burst protection

In addition this prevents rock fragments from falling into the pipeline which would later inevitably lead to increased and arduous cleaning expenses.

There is a DN 900 all flanged tee with a DN 600 branch set up in the area of the escarpment **(Figure 16)** for cleaning and inspection purposes. On the inside, the branch is provided with a special baffle plate which ensures a continuous piping surface in the crown of the pipe and prevents turbulence at this point. In the apparatus room area **(Figure 17)** a pipe burst protection device provides added security.

4 Summary

Ductile iron pipes with restrained BLS® push-in joints and cement mortar coating can be used cost-effectively in the turbine pipeline area of application. Because of the quick and easy assembly of the push-in joints and the possibility of backfilling the pipe trench with existing excavation material (pipes with cement mortar coating can be laid in bedding materials with a largest grain size of 100 mm), there are considerable savings potentials. With constant material properties, the working life of ductile iron pipes with cement mortar coating is more than 100 years. As a material, ductile cast iron has a high static load capacity and has a high safety margin in case of exceptional loads. For different areas of use, the pipe wall thickness can be adapted to requirements. So for this project for example with a nominal size of DN 900, restrained ductile iron pipes with an allowable operating pressure of up to 45 bars were installed.

Bibliography

[1] EN 545
Ductile iron pipes, fittings, accessories and their joints for water pipelines – Requirements and test methods
2010

[2] EN 15542
Ductile iron pipes, fittings and accessories – External cement mortar coating for pipes – Requirements and test methods
2008

Author

Dipl.-Ing. Steffen Ertelt
Duktus Rohrsysteme Wetzlar GmbH
Sophienstraße 52–54
35576 Wetzlar/Germany
Phone: +49 (0)6441/49-1267
E-mail: steffen.ertelt@duktus.com

Ductile iron pipe systems – durability and sustainability in practice

By Jürgen Rammelsberg

1 Introduction

On 28 and 29 April 2014 the FIHB (Fördergemeinschaft zur Information der Hochschullehrer für das Bauwesen e. V.), an association promoting information for construction engineering lecturers, and EADIPS®/FGR® were invited guests of the Vienna municipal authorities water department MA 31 (Wiener Wasser). Once again, 14 university lecturers from Germany, Austria and Switzerland were able to get to know first-hand the arguments which persuade a major water supplier to implement the idea of sustainable management in their network.

2 A lecture event in the old valve chamber

The "Old Valve Chamber" of the Vienna Waterworks offered the ideal context for a seminar in which the presentations were centred on the motto of sustainability. The history of the Vienna Waterworks, as depicted by **engineer Franz Weyrer**, is typical to the ideal of a company which considers the supply of drinking water to 1.8 million customers primarily as a sustainable public service mission. Vienna Waterworks is neither a privatised supply company, nor a municipal enterprise but a department of the Vienna municipal authority, in other words the city administration. Nevertheless its employees are enthused by the idea of lasting efficiency in their operations.

The water is obtained from high karst water springs in Styria and in Lower Austria and it flows through more than 200 km of mountain spring pipelines (start of construction 1873) by natural gravity to Vienna. A third water resource is derived from river bank filtrate from the Danube.

The supply network is divided into 40 pressure zones. It has a total length of 3,000 km and the proportion of cast iron pipe is 59 % = 1,800 km. The energy potential of the mountain springs is used in fresh water power stations which produce more power than is consumed in the water supply. Pumps are not necessary – the pressure of the elevated tanks is sufficient. The entire network of pipelines is based on a target of maximum sustainability. Operators, manufacturers and scientists have all jointly participated in developing our knowledge about how the system as a whole works. A focal point here is the concern that damage will not accumulate in the future as the repairs would then no longer be affordable.

An exemplary form of cooperation exists between the partners

- TIROLER ROHRE GmbH from Hall in Tirol (production of pipes and fittings, further development of corrosion protection, definition of future customer needs),
- Vienna Technical University (metallurgy, coating technology),
- Graz Technical University (statistics, data collection),
- Vienna municipal authority, department MA 31 (Wiener Wasser).

These four partners have made it their joint task to derive the following strategies from a non-damaged-based status survey:

1. Maintenance and renewal strategy for the supply network based on economic and technical viewpoints
2. Further development of the technically and economically optimum external coating for ductile iron pipe systems.

To this end, whenever a trench is opened up for any reason whatsoever, e.g. when laying a new domestic connection, when moving pipelines because of civil engineering work of overriding importance etc., the status of the exposed pipe is recorded and assessed in a consistent manner using a standardised questionnaire.

Currently around 1,000 sets of data are available with a status report on the external surface of exposed GGG pipes. It is now incumbent upon **Daniela Fuchs-Hanusch, assistant professor and doctor of engineering** studies at the Technical University of Graz to carry out a comprehensive statistical evaluation of the data gathered in the project with the aim of gaining practical knowledge about the pipeline network and how to manage it. If previous damage was already present before the beginning of the status survey e.g. on a certain section of pipeline, then any increased corrosion phenomena are also to be looked for in more recent trench excavations. This is probably due to the fact that in zones of this kind the external conditions (soil type) exceeded the area of application for a given type of coating. This applies above all to the first generation of thin-layer organic coatings ("tar").

The superiority of active coatings (zinc plus finishing layer) over simple organic thin-layer bituminous coatings (tar) is obvious. The direct consequences on the renewal strategy for the network operation are clear: top priority must be given to replacing sections of pipeline in the "tar" category with previous damage. The surveys will continue: in future minor excavations additional parameters will be recorded such as soil characteristics. Details of the surveys are published in [1].

Another presentation by the municipal water department concerned a practical, everyday problem with the piping system. **Engineer Anita Peintner MBA** reported on the maintenance and repair of large valves within the supply network. This often involves extremely valuable and extremely old valves from the 19th century for which spare parts ceased to be available a long time ago. Important documents for work of this kind are the tables showing new and old Viennese standard components and the standard pipe components from 1882.

More recent developments concern the gate valves which are generally used up to nominal size DN 600. Butterfly valves are only used in Vienna as from DN 700. They are provided with a bypass for pressure compensation during actuation which reduces the opening torque and hence reduces wear. Gland packing on old valves which is not completely tight will be replaced during repair work with components developed in-house in PUR elastomers. In addition they are trying to build up a stock of spare parts where usable spare parts will be rescued once they have been dismantled.

The butterfly valves used today are the double-eccentric, soft-sealed type. Hence their maintenance is easy as it is simply a matter of replacing the seal and readjusting the gear mechanism. Adjustable axial piston type control valves are usually installed at the outlet of a water reservoir. Framework contracts for their maintenance are awarded to external contractors.

Two contributions by speakers from EADIPS®/FGR® pipe manufacturers rounded off the programme of lectures. First of all **Roger Saner,** an **engineer** from vonRoll hydro (suisse) ag in Oensingen presented the PUR lining and PUR external coating as a means of improving the energy efficiency of cast iron pipelines. He mentioned various versions of the combination of PUR lining to EN 15655 and PUR coating to EN 15189 based on three projects:

Project 1:
In a Swiss family home, heat is extracted from the used air and wastewater by means of ductile iron pipes and recovered for space heating and hot water, making the house self-sufficient in energy [2].

Project 2:
The number of small hydropower plants is clearly increasing thanks to the promotion of renewable energy. A whole range of technical, economic and ecological advantages bear witness to the superior sustainability of ductile iron pipes and fittings in the sensitive ecosystem between Valais and Ticino [3].

Project 3:
Water is extracted from Lake Geneva via a 12 km long cast iron pipeline. Its thermal capacity is used for the further heating of water which circulates in a primary circuit and is routed to individual buildings. Decentralised heat pumps in each property then provide the required heating energy [4].

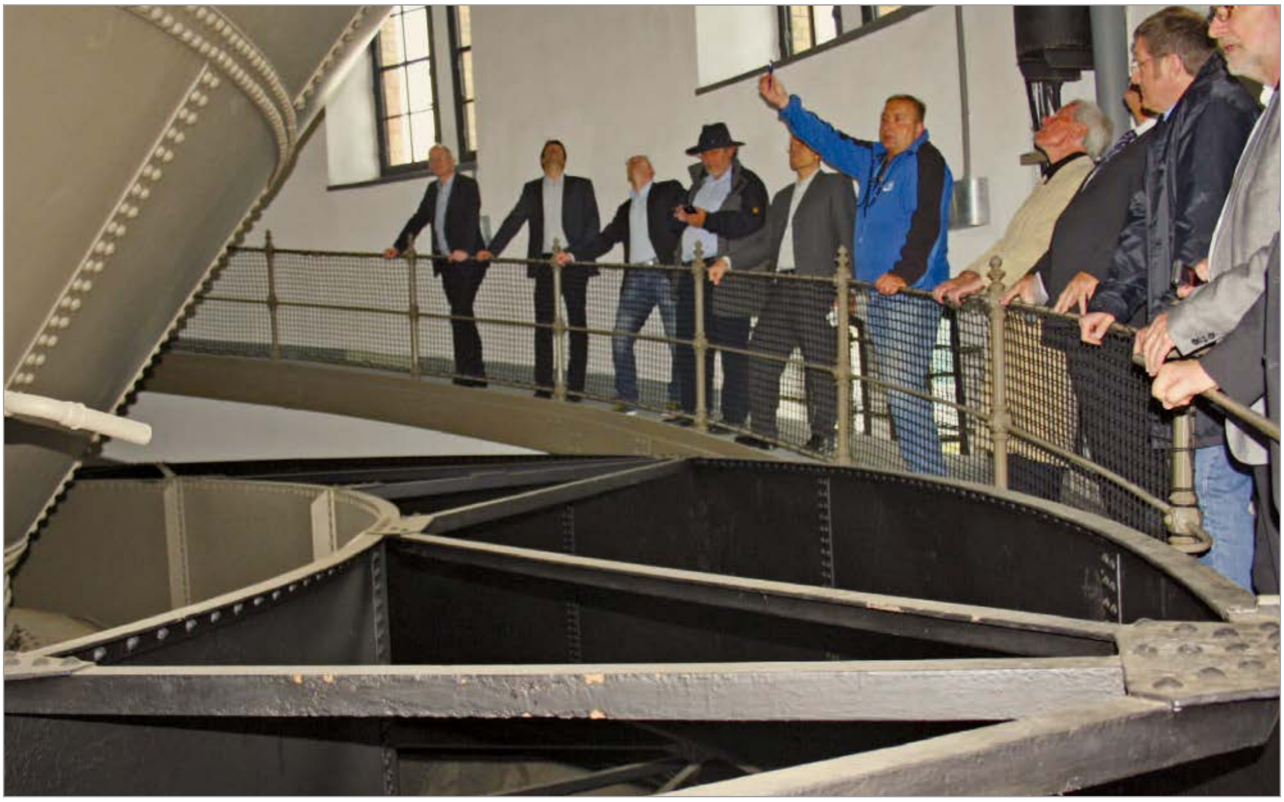

Figure 1:
A tour of the reservoir in the water tower at Wienerberg

Steffen Ertelt, an **engineer** from Duktus Rohrsysteme Wetzlar GmbH, Wetzlar, gave an up-to-date overview of recent developments in the trenchless installation process for ductile iron pipes. The essential features of pipes for this installation technique are joint technology with thrust resistance and external protection with "cement mortar coating to EN 15542" with high mechanical loading capacities. To be highlighted are

- HDD process
  - with pipe-by-pipe assembly and
  - pipe string pulling,
- Burst lining
  to DVGW technical instruction GW 323,
- Long pipe relining
  to DVGW worksheet GW 320-1,
- Ploughing
  to DVGW worksheet GW 324,
- Press-pull technique
  to DVGW worksheet GW 322-1.

Meanwhile, extensive experience has been gained for all of these techniques and this was able to be demonstrated by numerous pictures from different construction sites.

3 Programme of excursions and visits

As the host of the University Lecturers Conference 2014, Vienna Waterworks naturally had a number of highlights ready which they presented with pleasure and enthusiasm to their guests who were, of course, for the most part representatives of teaching and research in the field of water supply and hydraulic engineering.

First of all there was the "Old Valve Chamber" already mentioned, a monumental structure dating back from 1870 to 1873. This previously housed the shut-off valves of the first mountain spring pipeline. These days, with a total area of 280 m^2, it is a popular events space.

Another highlight was the water tower at Wienerberg, erected in 1898 and 1899. Until 1910 when the second mountain spring pipeline was constructed it was used for the supply to the higher altitude areas of the 10th and 12th districts. The storage capacity of its riveted steel tanks was 1,000 m^3. Decommissioned in 1956 and elaborately restored in 1988, the Wienerberg elevated tank serves as a space for exhibitions on the subject of water or other events **(Figure 1)**.

Figure 2:
Group of visitors in front of the door to the water reservoir at Rosenhügel

The Rosenhügel underground reservoir was opened in 1873 in the presence of Kaiser Franz Joseph for the first mountain spring pipeline; even today it is still used to supply the lower-lying districts of Vienna **(Figure 2)**.

In the evening a dinner together in the Vienna "SteirerStuben" offered an ideal occasion for the university lecturers and the EADIPS®/FGR® professionals to get to know each other and exchange experiences.

Author

Dr.-Ing. Jürgen Rammelsberg
European Association for Ductile
Iron Pipe Systems · EADIPS®/
Fachgemeinschaft Guss-Rohrsysteme
(FGR®) e. V.
Im Leuschnerpark 4
64347 Griesheim/Germany
Phone: +49 (0)6155/605-225
E-mail: rammelsberg@arcor.de

Bibliography

[1] Fuchs-Hanusch, D., Weyrer, F. a. Auer, C.:
Status analysis for the piping network of the city of Vienna using non-damage-based data on ductile iron pipes
DUCTILE IRON PIPE SYSTEMS 48 (2014), p. 42

[2] Saner, R.:
Heat recovery in the home using ductile iron pipes
DUCTILE IRON PIPE SYSTEMS 45 (2011), p. 8

[3] Saner, R.:
Small hydroelectric power plant at Ossasco, in the Bedretto valley
DUCTILE IRON PIPE SYSTEMS 48 (2014), p. 56

[4] Transport pipeline for heat from seawater at Tour-de-Peilz on Lake Geneva
DUCTILE IRON PIPE SYSTEM NEWS 05.2014

Updated EADIPS®/FGR® E-book

The EADIPS®/FGR® E-book offers an insight into the world of ductile iron pipe systems – pipes, fittings and valves in ductile cast iron. The current issue is E-book 08.2014, which is available in German and English on the EADIPS®/FGR® website www.eadips.org.

Changes in the German-language version of E-book 08.2014

The following chapters have been updated:

- 1 – Introduction
- 2 – Ductile cast iron as a material
- 3 – Production of pipes, fittings and valves

The following chapters have been edited:

- 7.3 – Isolation valves
- 7.4 – Tapping valves
- 7.7 – Hydrants

Changes in the English-language version of E-book 08.2014

The following chapters have been edited:

- 1 – Introduction
- 2 – Ductile cast iron as a material
- 3 – Production of pipes, fittings and valves
- 7.3 – Isolation valves
- 7.4 – Tapping valves
- 7.7 – Hydrants

EADIPS®/FGR® will be updating the E-book and editing new chapters in 2015.

The current E-book can be downloaded as a PDF under <Publications\E-book> in the download area. Using the free version of Adobe Reader you can open the document and use the extensive search functions of the application for your research. Obviously you can also print out the document and process content such as graphics, pictures or text.

Please refer to the **disclaimer** and **reproduction** notes on page 78.

Imprint

Picture credits

Except where otherwise stated, the pictures appearing in the text were supplied by the authors.

Layout and production

Schneider Media GmbH, Erfurt

Published by and copyright

European Association for Ductile Iron Pipe Systems · EADIPS®/
Fachgemeinschaft Guss-Rohrsysteme (FGR®) e.V.
Im Leuschnerpark 4
64347 Griesheim/Germany

Phone: +49 (0)61 55/6 05-2 25
Telefax: +49 (0)61 55/6 05-2 26
E-mail: r.moisa@eadips.org

Editor

Dipl.-Ing. Raimund Moisa

Press date

20 January 2015

www.eadips.org

Figure 1:
QR-code for EADIPS®/FGR® website

Logos of the full members of EADIPS®/FGR®

Logos of the sponsoring members of EADIPS®/FGR®

EADIPS®
FGR®

European Association for Ductile Iron Pipe Systems

Fachgemeinschaft Guss-Rohrsysteme

www.eadips.org