DUCTILE IRON PIPE SYSTEMS

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48

Sustainably superior – ductile iron pipe systems

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Dear Readers,

Six decades after the formation of Fachgemeinschaft Guss-Rohrsysteme (FGR®) e.V. the current Issue 48 once again takes the theme

Iron pipes, then and now.

48 editions of our annual journal, appearing over a period of almost half a century, give a living image of a dynamically developing product which the water, energy and construction industries could not do without.

The stories in this issue cover several centuries of iron pipe technology: from the iron pipes which were used by Landgrave Karl von Hesse three hundred years ago to complete his ambitious fountain displays at Wilhelmshöhe in Kassel right through to the new applications of ductile iron pipe systems in the field of renewable energy. The three hundred year old iron pipes which still feed the fountains to this day are part of the UNESCO World Heritage Site at the Wilhelmshöhe Mountain Park in Kassel which we celebrate in this issue.

The promotion of renewable energy, demonstrated in three separate contributions on the construction of penstock pipelines for hydroelectric power stations, shows the efforts which have been made recently to stem the unbridled use of fossil fuels with their devastating consequences for global climate. And ductile iron pipes are also already playing a major role in the area of solarthermal power generation as foundation piles for the enormous solar reflectors.

Between these two extremes, the report on a main supply pipeline, which had to deal with the constraints of the developing opencast lignite mining industry, bears witness to the problems of a successful turnaround in energy policy.

And not to be forgotten are the trenchless pipe replacement techniques of modern times, illustrated in a report on burst lining.

Overall it is possible to see the concerted efforts towards a sustainable and secure future as the common denominator of the articles in our Issue 48.

We wish you much pleasure in reading the new Issue 48 of **DUCTILE IRON PIPE SYSTEMS**

Yours,

Raimund Moisa

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European Association for Ductile Iron Pipe Systems
Fachgemeinschaft Guss-Rohrsysteme

From the 300-year-old iron pipes at the UNESCO World Heritage Site to the concepts of today – a lasting infrastructure for water management

A monument in the heart of Germany with impressive fountains fed by 300-year-old iron pipes, which has been designated a "World Heritage Site", is the starting point of a fascinating historical story which stretches all the way to the system of ductile iron pipes, fittings and valves which we have today. It may well be that the technical progress between "then" and "now" has led to a remarkable improvement in performance, but there is nevertheless something which all generations of ductile iron pipe have in common: their superior sustainability.

The renaissance of the metallic sealing gate valve in the drinking water sector

Difficult to believe but it's true – a relic of the last century long believed dead and buried is celebrating its revival with lime precipitating waters: the metallic sealing gate valve. The metal wedge gate, which can be immersed in a valve sack, enables solid incrustations to be broken up and crushed. When the wedge gate opens, the fragments are flushed out. The other criteria meet modern technical standards: stem seal, corrosion protection and countersunk and sealed connecting bolts between the top and bottom parts.

Butterfly valves "Made in Germany"

As with gate valves, there is a remarkable history of development with the second major group of shut-off valves – the butterfly valves – in the area of materials and construction. The "sticking" of the rubber seals to the brass seal seating has been remedied with high-grade steel seal seating rings, the bearing bushes have been produced from a new composite material with Teflon and the disks have now been given a "double eccentric" arrangement.

The new low-temperature cast iron with spheroidal graphite EN-GJS-400-18LT could open up new areas of application which were previously only covered by traditional steel casting. The perfection of the corrosion protection with seamless epoxy resin powder coating inside and out make extremely high working lifetimes possible.

New sewage pipeline in ductile cast iron on the Bachweg in Seon

One sometimes comes across constraints in sewer pipeline construction which make the use of traditional building materials impossible. As little cover as possible combined with the smallest gradient possible and an installation position between a drinking water pipeline and the road surface – everything that can create nightmares for a planner. So if he finds a piping system which can solve all his problems at a stroke then he will be forever grateful afterwards when he thinks about the ductile iron pipe system which got him out of a tight spot.

Replacement of the Schwarzbachtal waste water authority's DN 800 and DN 1000 sewage pipeline between Bernau and the sewage treatment plant

The replacement of a worn-out sewer of nominal sizes DN 800 to DN 1000 is in itself no simple thing. But when this sewer is in a drinking water protection zone, when it is made of asbestos cement pipes and when it has to remain undisturbed and securely in operation during the replacement work, then a high degree of professionalism is demanded of all involved. However, with ductile sewage pipes the job could be done elegantly and safely.

Opencast lignite mining not only changes the outward appearance of the landscape, it also involves alterations to the entire infrastructure. Old roads disappear and new ones have to be built. Between Pödelwitz and Neukieritzsch, to the South of Leipzig, an embankment is due to be raised for the new main road, which is going to take quite some time to settle. This road will also take the main water transport pipeline between the two towns. Piping systems need to be selected for it which have sufficient reserves for all the loads associated with this – both planned and unforeseen. That means ductile iron pipe systems.

With a single 40-year-old DN 300 connecting pipeline in ductile iron pipes, the supply of drinking water to 18,000 clients of the Trier water authority was relatively insecure. It was not even possible to take it out of operation in order to produce a status report, let alone carry out repairs in case of damage. A reserve pipeline was urgently required. The technical, economic and administrative constraints for building a second pipeline were extremely difficult to overcome: geological and topographical requirements, the protection of the environment and monuments, the demands of operating and working safety and not least cost effectiveness resulted in the installation of a standby pipeline of the same length along a different route. After the completion of the new pipeline, the old pipes were finally able to be inspected. Apart from cleaning with pigging equipment, no further reinforcement was necessary. Now the water authority has a secure second connection.

An ageing DN 300 main pipeline was no longer able to cope with performance requirements and economic specifications and so it has been replaced with a modern pipeline in DN 500 ductile iron pipe. With well-trained teams and modern machine technology it is possible to achieve high pipe-laying speeds even in rural areas, meaning that with the technically superior ductile cast iron pipe system an economically sustainable solution can be found for the transport of drinking water.

In a large city like Vienna the service of supplying drinking water has been provided by iron pipes for more than 150 years. However, knowledge about the condition of the piping network is always patchy – it is repaired when damage occurs. An attempt has been made to assess and document the external condition as and when the opportunity arises, even when making a house connection for example. The status data obtained in this way can now be combined in a variety of ways with soil maps, areas with strikingly high damage rates, geo-information systems, etc. The benefit for the pipe network operator could lie in an optimised replacement strategy and for the pipe manufacturer in a further optimisation of his protection systems.

Renewable energy from water power in Norway – an immense and not yet fully tapped potential stands ready to store surplus power from Europe's wind and solar power stations in pumped-storage power plants. With its alpine structure of mountains and fjords, the country has water resources at great altitudes which, by means of penstock pipelines, are routed to turbines to produce power. Ductile iron pipe systems have already been making a significant contribution to this technology for decades. This article gives some basic information on the completion of different projects.

Small hydroelectric power plant at Ossasco, in the Bedretto valley

Once again pipe systems in ductile cast iron are making a contribution to the production of renewable energy in small hydroelectric power plants. A variety 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 Tessin.

Hydroelectric power station in Nauders, Tyrol has gone into operation

A small community in the tri-border area of Switzerland, Austria and Italy wanted to use its adequate supplies of water power and make a contribution to the production of renewable energy with a small hydroelectric power station. The topographical conditions were perfect, the planning was under way but it took 6 years of hard work to be able to put the commercial project into practice. In addition to the technical details, an experienced planning engineer also reports on the bureaucratic hurdles which need to be overcome with projects of this kind.

Trenchless replacement of a fire main using the burst lining technique

A fire extinguishing water system in an industrial port in which flammable liquids and gases are constantly being handled – a real challenge for any fire service! When extinguishing water pipelines in the nominal size range DN 300 to DN 500 need to be replaced while maintaining landside goods transport and the functional reliability of existing equipment, planning engineers and contractors are challenged to the extreme. The new pipes in ductile cast iron were installed under the severest constraints using the burst lining process. It's worth a read – there is much to be learned!

100 kilometres of ductile iron driven piles for the CSP power station – KaXu Solar One – in South Africa

Desert regions with high and constant solar radiation can be a real torture for human existence, but they are predestined for the solar thermal generation of energy. The idea of a parabolic reflector in the equatorial sun-belt seems simple at first, but the actual implementation is complicated: gigantic reflector surfaces have to track the sun accurately to the degree, which means that they should not move under the severe influence of the winds which are always powerful here. The absolutely stable foundation of a parabolic reflector of this kind becomes a decisive factor and it is precisely here that ductile driven piles take the stage: more than 100 km of ductile piles are being driven for the first solar thermal power station between Pretoria and Johannesburg in order to stabilise some 10,000 m² of collector surface against winds of up to 140 km/h.

EADIPS®/FGR® member companies are training

The shortage of skilled workers is making itself felt in the construction industry. For this reason, EADIPS®/FGR®member companies are not only offering training in the narrower field of their own production, such as foundry mechanics. In fact they are extending their training activities into occupational areas in which their products should be properly processed, such as pipeline constructors for example. Naturally, these training courses are closely linked with the vocational promotion centre of the construction industry.

From the 300-year-old iron pipes at the UNESCO World Heritage Site to the concepts of today – a lasting infrastructure for water management

By Harald Roscher and Jürgen Rammelsberg

Fig. 1:
UNESCO World Heritage Site – Bergpark Wilhelmshöhe in Kassel with the Hercules monument and cascades
Source: Museumslandschaft Hessen Kassel

1 Bergpark Wilhelmshöhe in Kassel – a World Heritage Site

On Sunday, 23 June 2013 it was reported in the media that Bergpark Wilhelmshöhe, a mountain park in Kassel, with its Hercules monument and cascades **(Fig. 1)** had been proclaimed a World Heritage Site by the UNESCO jury. This recognition includes the Riesenschloss (an octagonal building constructed in 1701) with the 8 m high statue of Hercules (completed in 1717) and the cascades.

At the request of the Kassel Museum to the board of Frontinus Gesellschaft e.V., H. Roscher examined the iron pipes still in operation in the Octagon and reported:

"The pipes found in the Octagon almost certainly date back to the time when the building came into being. They are socket pipes, approximately 2 m in length, which are around 300 years old" [1].

As we were to learn from the German National Committee of ICOMOS (International Council on Monuments and Sites), which provides expert advice for the World Heritage Committee, the authenticity of the technique was an essential criterion for a positive recommendation.

The present-day measures to restore and preserve this significant architectural monument from the beginning of the 18th century resulted in the Frontinus company being asked for help with an appraisal of the iron pipes. H. Roscher was asked to examine damaged pipes which had been removed and estimate their age, along with the pipes inside the Octagon. Right at the beginning of the building work, in 1704 and 1708, it was agreed that the cascades and the superstructure of the Octagon should be constructed. This raises the question of whether the iron piping systems found in the interior of the Octagon date from this construction period or a later one.

At the same time, questions about the preservation and the renovation and/or renewal of the remaining pipelines still in operation were of interest. The preservation of the old pipes as a historic record played an important role here.

Visits were arranged on 11 March 2010 and 8 April 2010 for the inspection and both excavated pipes and also the pipes located in the Octagon were examined and assessed by H. Roscher **(Figs. 2 and 3)**.

Fig. 4 shows pieces of pipe stored in the garden of the Wilhelmshöhe castle park at the time of the inspection and underneath there is also a sand-cast pipe with an eggshell fracture.

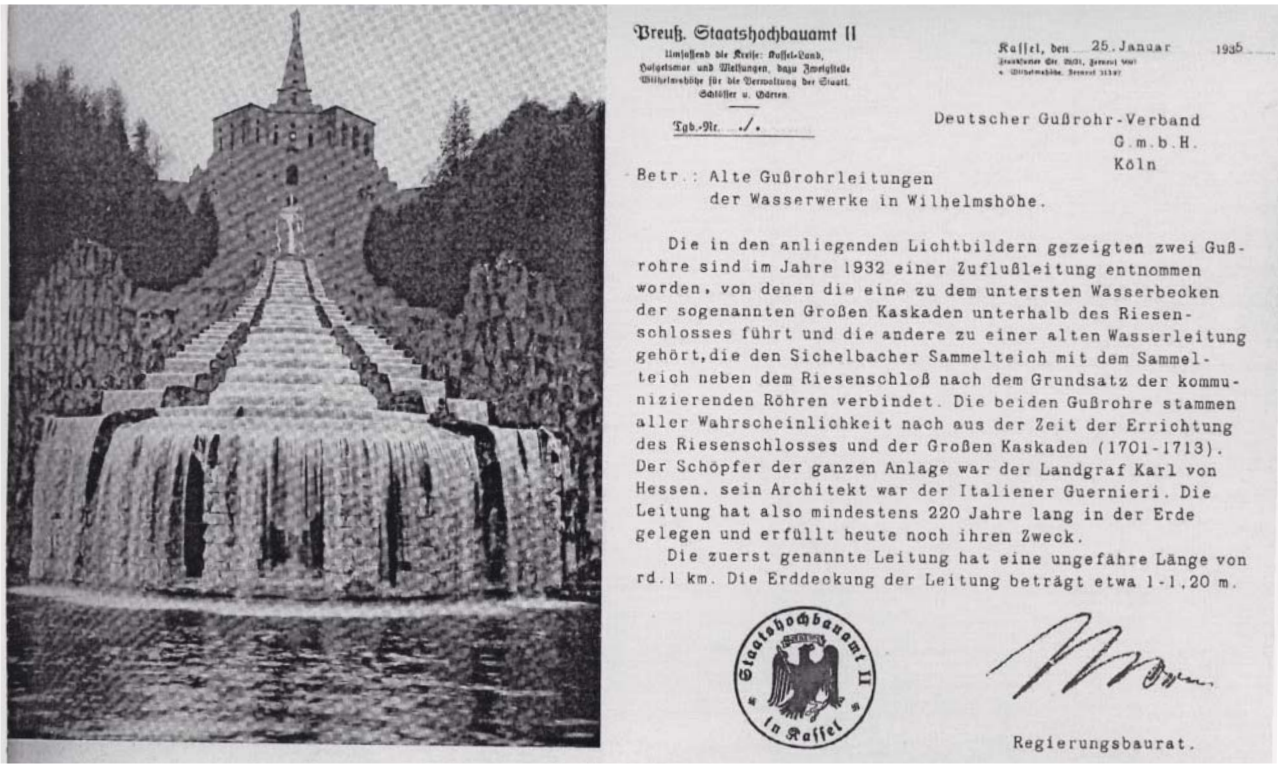
2 Document from the archives of the Association for Iron Pipe Systems helps to determine the age of the iron pipes at Wilhelmshöhe

H. Roscher was able to obtain a copy of the document shown in **Fig. 5** from the archives of the European Association for Ductile Iron Pipe Systems · EADIPS®/Fachgemeinschaft Guss-Rohrsysteme (FGR®) e.V. from which it can be seen that research into "old pipes" was already being conducted by the cast iron pipe industry as early as 1935. In a letter from the Prussian state building authority **(Fig. 5)**, the age of the cast iron pipes is given as more than 200 years [2].

Fig. 2:
The socket joint of an iron pipeline installed in the Octagon
Source: H. Roscher – photographed on 11 March 2010

Fig. 3:
Cast iron pipeline in operation in the Octagon UNESCO World Heritage Site – Bergpark Wilhelmshöhe
Source: H. Roscher – photographed on 8 April 2010

Fig. 4:
Iron pipes stored in the garden of Wilhelmshöhe castle park
Source: Museumslandschaft Hessen Kassel



Preuß. Staatshochbauamt II
Umfassend die Kreise: Kassel-Land, Hofgeismar und Melsungen, dazu Zweigstelle Wilhelmshöhe für die Verwaltung der Staatl. Schlösser u. Gärten

Kassel, den 25. Januar 1935

Tgb.-Nr. ./.

Deutscher Gußrohr-Verband
G.m.b.H.
Köln

Betr.: Alte Gußrohrleitungen
der Wasserwerke in Wilhelmshöhe.

Die in den anliegenden Lichtbildern gezeigten zwei Gußrohre sind im Jahre 1932 einer Zuflußleitung entnommen worden, von denen die eine zu dem untersten Wasserbecken der sogenannten Großen Kaskaden unterhalb des Riesenschlosses führt und die andere zu einer alten Wasserleitung gehört, die den Sichelbacher Sammelteich mit dem Sammelteich neben dem Riesenschloß nach dem Grundsatz der kommunizierenden Röhren verbindet. Die beiden Gußrohre stammen aller Wahrscheinlichkeit nach aus der Zeit der Errichtung des Riesenschlosses und der Großen Kaskaden (1701-1713). Der Schöpfer der ganzen Anlage war der Landgraf Karl von Hessen, sein Architekt war der Italiener Guernieri. Die Leitung hat also mindestens 220 Jahre lang in der Erde gelegen und erfüllt heute noch ihren Zweck.

Die zuerst genannte Leitung hat eine ungefähre Länge von rd. 1 km. Die Erddeckung der Leitung beträgt etwa 1-1,20 m.

Staatshochbauamt II in Kassel

Regierungsbaurat.

Fig. 5:
Letter from the Prussian state building authority – Old cast iron pipelines of the water works in Wilhelmshöhe
Source: Einst und Jetzt, Deutscher Gußrohr-Verband G.M.B.H., Cologne

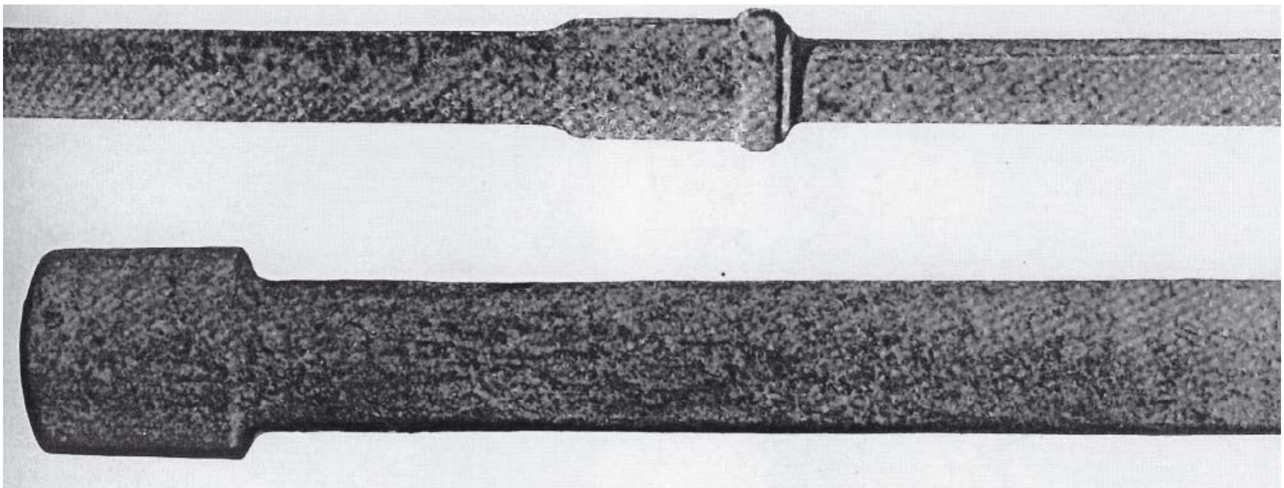


Fig. 6:
Exposed iron pipes at the Wilhelmshöhe castle from 1713
Source: Einst und Jetzt, Deutscher Gußrohr-Verband G.M.B.H., Cologne

This letter is a particularly valuable document as it is useful for determining the age of the pipes still in existence today. **Fig. 6** shows cast iron pipes from Wilhelmshöhe [2].

3 On the further historical development of the iron pipe

The oldest cast iron pipeline known to us in German soil is the water pipe from Dillenburg Castle to the river Dill; this came into being in around 1455. **Fig. 7** shows a pipe from the line which was in use until the destruction of the castle in the year 1760.

The first larger, municipal water pipe networks were constructed by the cities of London and Vienna in around 1800. In Germany, the first municipal water pipelines arrived in Hamburg in around 1858 and in Berlin and Darmstadt in 1850 to 1865.

A brief summary on developments in the manufacture and application of iron pipes for water supply is given in Chapter 1 of the "Ductile Iron pipe systems" E-book, which can be found on the website www.eadips.org by clicking on "Publications" [3].

The most notable milestones are:

1455	one of the oldest iron pipelines was constructed; this was the water supply line for Dillenburg Castle.
1562	a water pipeline was laid in Langensalza to supply the Jacobi and Rathaus fountains.
1661	the water pipeline for the castle in Braunfels was constructed. The iron pipes were in operation until 1875 and were dug up in the course of sewer laying work in 1932.
1664–1668	the pipeline was laid in the grounds of the Palace of Versailles to feed the water fountains there **(Fig. 8)**.
1710–1717	the construction of the cascades in the Kassel-Wilhelmshöhe castle park with the Hercules monument. Cast iron pipeline to supply the water features with water. Since June 2013 the Hercules monument along with the cascades has been a World Heritage Site.
1720	cast iron pipe for the supply of water for the Zwinger Palace in Dresden (Weißeritz pipe, **Fig. 9**).

Fig. 7:
Cast iron pipe, as was installed in Dillenburg Castle until 1760
Source: "Ductile iron pipe systems" E-book, issue 10.2013, Figure 1.1

Fig. 8:
Cast iron pipe from the Palace ground of Versailles
Source: H. Roscher

Fig. 9:
Excavated cast iron pipe from the so-called Weißeritz pipe
Source: Foto Kästner, Dresden

For the municipal drinking water supply networks constructed since the middle of the 19th century, grey cast iron was available as the material almost without exception. Later on, steel came along as an additional material. The statistics of the German gas and water management association show that, until the nineteen fifties, the proportion of cast iron pipes in the existing water supply network was 85 % in the Federal Republic of Germany.

The main area of use of cast iron pipes – and since around 1960 of pipes and fittings in ductile cast iron and valves in spheroidal graphite cast iron – lies in the area of community water supply.

The major steps in the further development of cast iron piping have to do with corrosion protection and assembly techniques, culminating in the perfection of restrained joints enabling the pipes to be laid using the trenchless technique. These development stages are described in [4] and they are identified in terms of generations.

As from 1968, 1st generation pipes and fittings in ductile cast iron are zinc-coated with a protective finishing layer on the outside and lined with cement mortar on the inside. From 1979 onwards, the 2nd generation have an external polyethylene (PE) or polyurethane (PUR) coating or a fibre-reinforced cement mortar coating. These coatings are suitable for soils of every type and have resulted in a further decrease of the damage rate, which was already low to begin with [5].

4 Sustainability in the water management infrastructure – a modern-day challenge

Current demands placed on all those involved in economic processes are characterised by the term "sustainability". In its broadest sense, this is understood to be the conservation of all resources for present and future generations.

Specifically this can refer to the economic aspect, in that the cost of an investment is compared with the running costs throughout its entire useful life, which include the costs of installation, operation, maintenance and also decommissioning.

Because of their long working life and their low damage rates, ductile iron pipes and fittings of the second generation are one of the economically superior pipe systems for the water management industry. This is underlined by their economically efficient connection and assembly technique, particularly in areas where access is difficult or where the trenchless laying technique is used.

As regards the ecological aspect, it is the material properties which take the foreground. Ductile iron pipe systems are diffusion-tight, which is essential for the transport of drinking water where the soil is contaminated for example. By contrast, when waste water and sewage are being carried it is the soil and groundwater which need to be protected against pollutants. Linings have been used in piping systems for decades to ensure the absolute hygienic safety of drinking water.

A particularly important factor when considering things from an ecological point of view is the fact that ductile cast iron is obtained almost exclusively from the recycling of iron and steel scrap and that ductile iron pipes, fittings and valves can be completely recycled again at the end of their technical working life without damage to their material properties [6].

In addition to the economic and ecological advantages, there is a third aspect which involves the technical superiority of ductile iron pipe systems: their performance level offers the highest degree of security in all areas of water transport because the components are mechanically resistant to the highest pressures, longitudinal bending and surface loads. This in turn can result in considerable savings once the pipes are installed. Such a combination of properties has led to new and special applications such as snow-making systems and hydroelectric power stations in mountainous regions, and also to fire extinguishing lines in road and rail tunnels and industrial plants.

As a material with excellent technical performance capabilities, ductile cast iron offers security and lasting economic advantages for water management. Combined with its ecological properties and its extraordinarily long working life, this makes ductile cast iron the only material in the water industry which demonstrably offers true sustainability.

5 Conclusion

What was required of the pipes in the 300-year-old World Heritage Site in Kassel-Wilhelmshöhe at the time was that they should withstand the type of internal pressures which were needed to operate the water features. There were probably no other requirements. Even at the time the pipes were considered "luxurious", but for the pressures desired only cast iron pipes would do [7].

Developments in the period from 1710 to the present day have been characterised by improvements in the material, in the production process, in corrosion protection and in joint techniques, together with progressive installation techniques. All in all it amounts to a successful effort at working in a way which protects resources for current and future generations.

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The renaissance of the metallic sealing gate valve in the drinking water section

By Frank Endreß

1 The historical development of the valve

For a long time the metal sealing valve was something of a relic of times long past in the area of drinking water supply. Until the nineteen sixties, the standard isolation valves for pipes installed underground were designed with metal sealing **(Fig. 1)**.

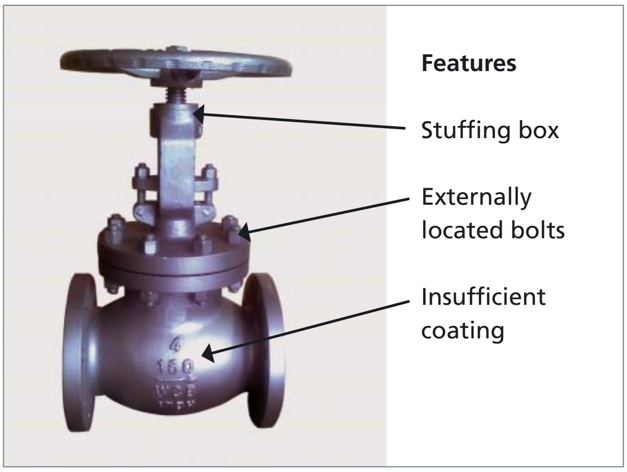


Fig. 1:
Metal-sealed valve from the year 1965

There then began the great procession of valves with soft seals. And so, with soft-seated valves the wedge was rubberised, the casing was coated with epoxy powder as corrosion protection and the stuffing box packing was replaced with an O-ring seal.

2 The current generation of valves

As compared with the grey cast iron valves used previously, the valves produced today in spheroidal graphite cast iron have the advantage of a higher breaking strength and ductility of the casing material. Corrosion protection is achieved these days by the application of epoxy powder using the whirl sintering process [1], which produces a very homogeneous, pore-free coating; enamelling is equally advantageous. The wedge is coated with a vulcanised rubber compound and thus completely protected against corrosion.

But this is now exactly where the possible use of a metal sealing valve comes in. Many operators have problems with a considerable amount of incrustation in the pipeline and in valves due to deposits of:

- manganese compounds,
- iron compounds,
- calcium compounds.

These deposits harden **(Fig. 2)** and can thus have a considerable adverse effect on the closing function.

Fig. 2:
Example of incrustations in pipelines

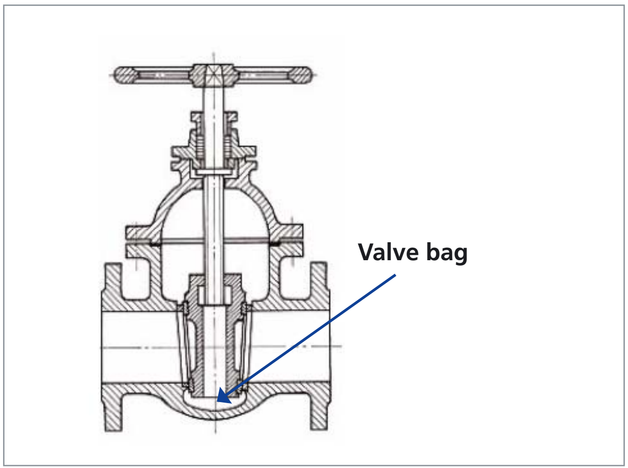
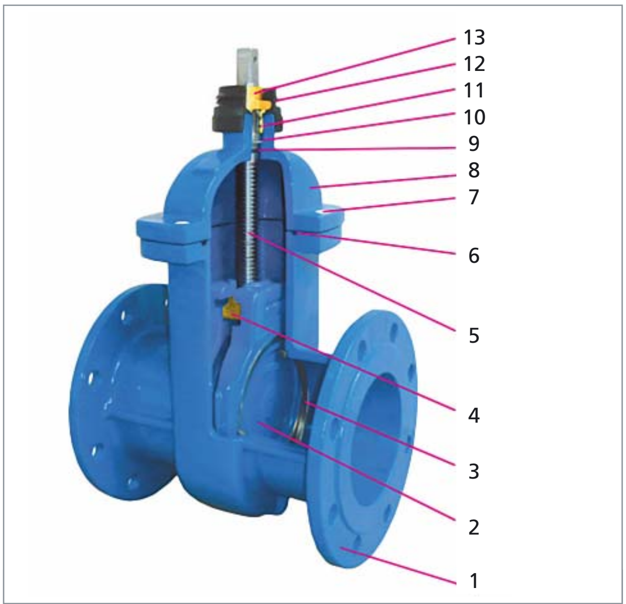


Fig. 3:
Sectional view of a metal sealing valve



Ref.	Description	Material
1	Casing	EN-JS1030
2	Wedge	EN-JS1030
3	Packing rings	Brass/stainless steel
4	Spindle nut	Brass
5	Spindle	Stainless steel
6	Sealing of top part	EPDM/NBR
7	Hexagon socket screw	Stainless steel
8	Top part	EN-JL1040
9	Back seal	EPDM/NBR
10	Sliding disk	Polyamide
11	O-ring seal	EPDM/NBR
12	Thread adapter	Plastic
13	Retaining ring	Brass

Fig. 4:
The construction of a metal sealing valve of the latest generation

3 The future of the metal sealing valve

In areas of use where there is a question of serious incrustation, the metal sealing valve ensures a tight closure because its metal closing device breaks up the deposits and these are then flushed away. Each metal sealing valve has a so-called valve bag **(Fig. 3)**. This too can become clogged with incrustations, but here again the repeated activation of the valve has the effect mentioned above and the valve is able to close reliably and tightly again.

4 Construction of the metal sealing valve

The construction of present-day metal sealing valves reflects the current state of the art **(Fig. 4)**. All parts which come into contact with the medium being carried are approved for drinking water and the valve is characterised by a very long working life. The epoxy resin coating is applied with a minimum thickness of 250 µm, the sealing gland is permanently lubricated and the top part is designed with sealed counter-sunk screws. The spindle, which is on the inside, has a triple O-ring seal and the seat rings are optionally in brass or stainless steel.

This means that the supplier has a valve at his disposal which, taking account of his particular water parameters, promises him secure functioning over a long working life and can thus make a positive contribution to sparing his maintenance budget for civil engineering work.

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Butterfly valves "Made in Germany"

By Johannes Neubert

1 A look back at the history

In its 500th year, the East Saxony/Silesian "Keulahütte" foundry looks back over its documented history as a producer and processor of iron and also more than 100 years as a manufacturer of valves. It began producing metal sealing valves in the 19th century. Later, during the early days of the extension of the European drinking water network, hydrants were to be found in the range produced by the forerunner of the present-day "Keulahütte GmbH", and these incorporated an automatic drainage function at a very early stage. And as early as nearly half a century ago, flange-mounted resilient-seated butterfly valves were also being produced at the company's factory in Krauschwitz, initially in a single eccentric design and with a metallic casing and seat ring in brass. Typical problems at that time such as the dreaded "sticking" of the then newly introduced nitrile seals to the brass parts and the insufficient strength of the brass construction parts were solved by changing the material over to corrosion and acid proof stainless steels.

2 Construction features of butterfly valves

With the reunification of Germany, the pace of development increased. The completely new construction of butterfly valves in DIN length F4, these days GR 14 according to European standards, was the cornerstone for future successful generations of valves. So innovations, which were revolutionary at the time, such as the first use of composite-layer bearing bushes with a sintered polytetrafluoroethylene (PTFE) layer proved to be extraordinarily effective in the water network valve sector. The heavy-duty valves equipped in this way are still functioning today without problem.

In the nineties the disk bearings were changed over to the "double-offset" principle. This meant that the wear on the sealing fittings, caused mainly by the "releasing" of the seal when the butterfly valve opens, could be minimised quite considerably. This innovation, which was scarcely visible to the eye, was an important milestone in lengthening the working life of the valve, which had meanwhile been DIN-DVGW certified.

3 Construction material for butterfly valves

EN-GJS-400-15 has established itself as the construction material for butterfly valves. This modern casting material is recommended for all types of use because of its optimum ratio of tensile strength and elongation at break. The combination of a minimum elongation at break of 15% with a tensile strength of at least 400 N/mm² is the basis for the following security strategy: incorrect overloading is documented by visible plastic deformation long before breaking point. Similar material properties also produced by the manufacturer such as EN-GJS-400-18LT do in fact offer guaranteed very low temperature notched impact strengths. The tensile strength and elongation at break values of these types of ferritic cast iron with spheroidal graphite had previously only been known with classic cast steel.

4 Corrosion protection – epoxy powder coating

In the choice of corrosion protection, more and more users are relying on epoxy powder coating. With the continuing development of processes and materials, this type of protection has long been implemented in pipeline construction.

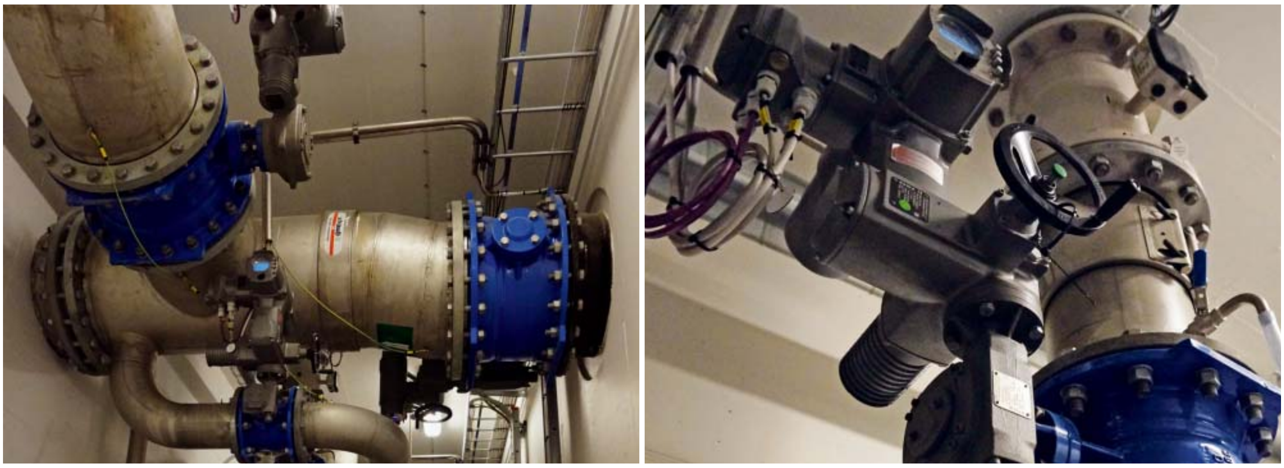

Fig. 1:
Installation of the latest generation of butterfly valves with drive/control in a Scandinavian waterworks

However, it is only with the overall coating of the valve parts that the full potential of epoxy powder coating can be realised. In combination with the process and quality parameters of the coating, these days this so-called "integral corrosion protection" makes working life expectations possible which seemed unachievable at normal expense just a generation ago.

The strict application of this concept to butterfly valves entails the complete coating of the housing seating. This means no more unnecessary breaks in the protective coating which tend to result in defects. An essential condition for coating the valve seat is of course strict observance of all quality parameters. A nominal coating thickness of 250 µm is to be ensured.

In a once-through process, the valve parts are to be blasted with the greatest of care, cleaned, heated and then immediately coated. This is absolutely necessary in order to achieve the desired properties of epoxy powder coating:

- outstanding adhesive strength, technical diffusion tightness of the pore-free coating,
- defined impact resistance also qualifies the valves for harsh operating conditions,
- very good resistance to under-rusting the coating,
- extremely high chemical resistance with simultaneous suitability for the drinking water,
- professional repair kits allow damaged areas to be touched up with the same type of material.

5 The use of butterfly valves

Butterfly valves with full coating of the valve casing have been available in the entire nominal size range since 1998 and now go up to DN 1400. Major European waterworks, beginning in Scandinavia, were able to be won over to this innovative product relatively early **(Fig. 1)**. Users' experiences have been consistently positive. In addition to the quality of the corrosion protection, the users of the valves particularly appreciate construction details such as the PTFE coating of the completely isolated shaft bearing and the thorough corrosion protection of the joint and assembly areas of the valves. A major benefit of this wide range of materials and construction designs lies in a flexible production chain which is capable of producing all individual parts to a high quality standard to one's own specifications and based on clients' requirements. A sign of confidence in the technical competence of the valve manufacturer is the fact that more and more clients are requesting the complete product package consisting of valve, gearing, electrical drive and control from one source. Thanks to the close cooperation between valve manufacturer and drive supplier, even complicated projects can be achieved without problem.

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New sewage pipeline in ductile cast iron on the Bachweg in Seon

By Roger Saner

1 The initial position

In the municipality of Seon in the Aargauer Seetal, to the South of the regional centre of Lenzburg, the Seon Technical Services Department planned to replace the existing utility pipelines on the Bachweg and at the same time to resurface the road including the replacement of the base course.

The general wastewater management plan of the municipality of Seon, produced in 2006, shows that the existing combined sewer, in DN 250 and DN 300 concrete pipes, was overloaded and in an unsatisfactory structural condition. So that the hydraulic capacity required according to this plan could be achieved, the cross-section of the existing sewer needed to be increased from DN 300 to DN 350. The existing combined sewer runs parallel to the edge of the road with a minimum bedding depth of between 0.80 m and 1.30 m and a correspondingly shallow pipe covering.

So that the sewage pipes to the existing buildings could be connected to the new pipeline, this needed to be laid at least at the same depth as the old pipeline. In addition the gradient of the existing sewer was scarcely 3‰. Because of the further course of the sewerage system and the specified elevation at the connection point, it was not possible for the new pipeline to have a higher gradient. Because of this, the new pipeline would have a very low gradient as before.

2 Criteria for the choice of pipe material

The choice of the right piping material for the new sewer was therefore determined by the difficult local circumstances and the technical requirements for dealing with the challenging installation conditions. Because the bedding of the new pipeline was to remain at the same depth, the covering of the pipeline up to the top of the road surface was reduced to just 50 cm. The high requirements set by Swiss standard SIA 190 [1] for the structural design could only be achieved with pipes in ductile cast iron with their advantageous strength properties.

Because of the low gradient of between 2.7‰ and 2.9‰, an inside surface was called for which would favour the drag forces in the open-channel sewer and hence also minimise the maintenance costs of flushing the pipeline.

All other utility pipelines in the road cross-section, i.e. also the drinking water pipeline and a rainwater conduit which runs in a receiving water course, had to be installed beneath the sewage pipeline. Therefore the piping system selected needed to have a permanently tight socket joint in order to exclude the risk of a contamination hazard for the deeper-lying pipelines.

The combination of the local circumstances described was already very severely restricting the choice of material. Only a very few pipe materials have the technical properties which would meet the challenging profile of requirements.

3 The decision in favour of ductile iron full-protection pipes

After an analysis of the imperative requirements for the new sewage pipeline, taking account of

- the installation conditions,
- operational safety,
- sustainability and
- the security of the investment

the project planning engineer and the client decided to opt for the ductile iron pipe with reinforced coating to EN 598 [2]. With the vonRoll ECOPUR ductile iron pipe, the supplier provided a so-called full protection pipe which, because of its polyurethane lining and coating (PUR) covers all the requirements for the new sewer perfectly:

- the highest static strength characteristics (diametral stiffness),
- hydraulically smooth PUR lining with a roughness coefficient of k ≤ 0.01 mm, for a minimum gradient of ≤ 3 ‰,
- absolutely tight but nevertheless flexible push-in joints with optimum resistance to root penetration,
- simple and rapid assembly including branch connections,
- the best corrosion protection by means of integral PUR coating, usable in soils of any level of aggressiveness.

The vonRoll ECOPUR ductile iron pipes are produced in accordance with EN 598 [2] and are characterised by a continuous pore-free polyurethane (PUR) lining and a PUR coating, both of which are applied to the surfaces straight after blasting.

Thanks to its pore-free surface, the PUR lining to EN 15655 [3] is capable of receiving wastewater of any kind with pH values of 1 – 14. The mirror-smooth PUR surface with a roughness coefficient of k ≤ 0.01 mm prevents deposits and incrustation even with the smallest gradients. However, if high-pressure flushing should become necessary, the lining is perfectly suited to this. This is confirmed by the test report from the accredited IRO test institute in Oldenburg (Institut für Rohr-leitungsbau an der Fachhochschule Oldenburg e. V.) with evidence of damage-free high-pressure flushing capability in accordance with DIN 19523 [4] **(Fig. 1)**.

The PUR external coating to EN 15189 [5] is classified as a so-called "reinforced coating" in accordance with EN 598, appendix B.2.3 [2]. vonRoll ECOPUR full-protection pipes can thus be used in soils of all corrosion levels.

With a shallow covering of pipes and the effects of high traffic loads associated with this, mechanical damage or impermissible deformations can be prevented with the use of ductile iron pipes with their high diametral stiffness. The flexibly designed push-in joints of ductile iron pipes can absorb movements underground. For the DN 250 and DN 350 ductile iron pipes selected, proof of structural stability under load and general fitness for purpose in accordance with Swiss standard SIA 190 on pipelines [1] was provided without problem with a pipe height of cover of only 50 cm.

Applicable values for permissible heights of cover for ductile iron pipes can be taken directly from the tables in Appendix D of EN 598 [2] without further calculations. Here again, a height of cover of 50 cm is permissible with good compaction.

4 Installation work

Because of its depth in the ground, the new sewage pipeline was the last utility pipeline to be laid in the roadway and was installed directly below the base course.

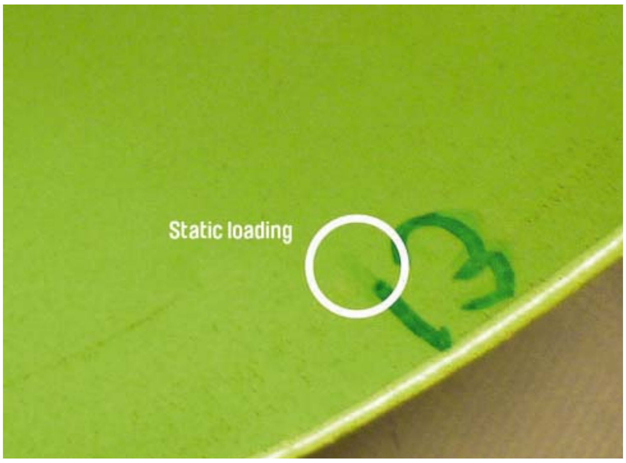

Fig. 1:
Faultless PUR lining after testing by IRO, Oldenburg to determine resistance to high-pressure jet cleaning: internal coating after stationary jetting

Fig. 2:
Branch connection line to an existing building – connection by means of a tapping saddle and iron/plastic pipe transition sleeve

Fig. 3:
Core drilling into a vonRoll ECOPUR pipe – the cutting edge is treated with a 2-component epoxy resin

The 6 m long ductile iron pipes were installed without any concrete bedding directly onto the well-compacted gravel bottom of the trench. The precise formation of the projected gradient of between 2.7‰ and 2.9‰ was monitored using an automatic pipe alignment laser. Thanks to the flexible and easily assembled HYDROTIGHT push-in joints of the vonRoll ECOPUR full-protection pipes, the assembly work in the road area was able to be carried out very efficiently.

Lateral connection lines from existing buildings and street drains were connected using 90° tapping saddles to the ductile iron pipes and transition sleeves to the plastic pipes **(Fig. 2)**. The integral PUR coating of the vonRoll ECOPUR pipes allows for very precise and high quality tapping. The polyurethane is of an ideal coating thickness and has a very high adhesive strength to the iron pipe; it does not need any peeling off. This is also a huge advantage when working with cut pipes. The cutting edges only need to be treated with a 2-component epoxy resin **(Fig. 3 and 4)**.

Clean, graded gravel with good compaction properties was used for bedding and surrounding the pipes. Because of their low depth, all inspection manholes were installed in the conventional way **(Fig. 5)**. Ductile cast iron manhole connectors were used for the insertion of the ductile iron pipes into the shafts.

Fig. 4:
Tapping saddle assembled after treatment of the cutting edge with epoxy resin and transition sleeve assembled on a plastic pipe

Fig. 5:
In-situ concrete manhole with flow channel and shoulder

Fig. 6:
Checking the gradient of the installed vonRoll ECOPUR pipes

Once again the ease of installation of ductile iron pipes convinced all those involved. Both the planning engineer and the construction engineer were impressed at how simple, time-saving and hence cost-effective the work of assembling the vonRoll ECOPUR pipes with HYDROTIGHT push-in joints actually was **(Fig. 6)**.

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Replacement of the Schwarzbachtal waste water authority's DN 800 and DN 1000 sewage pipeline between Bernau and the sewage treatment plant

By Werner Martin and Wolfgang Rink

1 Introduction

The Schwarzbachtal waste water association is responsible for disposing of the sewage from 11 towns and communities and their districts with around 23,000 inhabitants in the area between Neunkirchen in the North and the Bad Rappenauer district of Obergimpern in the South. During the course of inspections of their network, some extreme damage (damage class 0 and 1) was discovered on part of the sewer between the Bernau connection point and the sewage treatment plant. Asbestos cement pipes are installed there and the pipe walls had been severely damaged and almost completely worn through, especially on the bottom, by a ripple effect of mechanical wear. The DN 800 asbestos cement section was located between the connection point at Bernau and the feeder from Neckarbischofsheim within the drinking water protection zone III A of the Bernau water source (Mühlbach water supply association). At this point the pipeline runs directly parallel to drinking water protection zone II. Just before the connection of the sewage pipeline from Neckarbischofsheim there is the DN 1000 asbestos cement sewer in the area of the Krebsbach intersection, just before the sewage treatment plant and partly within drinking water protection zone II.

2 Planning

The task of carrying out the necessary remedial measures was assigned to the Werner Martin civil engineering and environmental protection service in Reichartshausen. The following considerations were important here: a replacement of the sewage pipeline along the original route or renovation of the inside of the existing one using short pipe liners would involve considerable expense for waste water drainage purposes. The site in question lies directly adjacent to the sewage treatment plant. At this point the sewer had to transport the volumes of waste water, including storm water outflows, from the entire area covered by the waste water association. This had to be pumped away over long periods of time. If the drainage system were to fail, the groundwater in the nearby drinking water protection zone II would be severely jeopardised. In the end, these practical constraints led to the decision to replace the sewer via a new route. Additionally, this new route would shorten the sewage pipeline in the Bernau area **(Fig. 1)**.

On the section replaced, it was possible to increase the distances between the prefabricated manholes **(Fig. 2)**. It was also possible to construct the new sewer while the old one remained in operation, without affecting it. Reinforced concrete structures were set up to be used as connection points to the existing sewage pipeline **(Fig. 3)**. Once the new sewer had been fully completed, the cut was made into the old pipelines and the waste water was diverted into the new system. At all the manhole structures, the ductile sewage pipes were connected by means of manhole connectors in ductile cast iron. These are equipped with the TYTON® push-in joint profile and ensure a tight but flexible connection of the sewer pipes to the fixed constructions. This way of working meant that the measures necessary for retaining waste water could be limited to the short period of reconnection.

The new sewers were installed with the same gradient and the same bedding depth as the existing ones. The connection points in Bernau and the manhole upstream of the pumping station for the sewage treatment plant determined the height of the base of the sewage pipes **(Fig. 4)**. At the Bernau connection point, waste water is

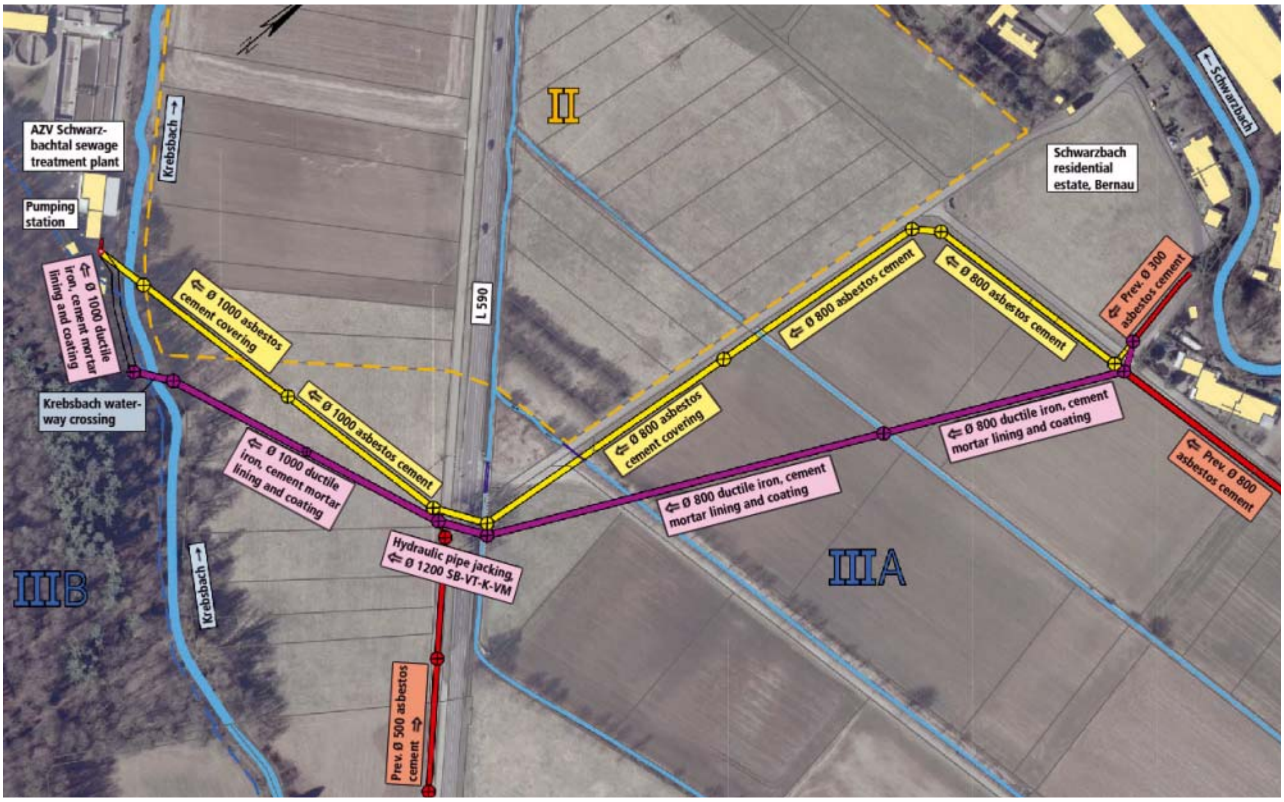

Fig. 1:
View of the site

Fig. 2:
Prefabricated manhole

Fig. 3:
Reinforced concrete structure

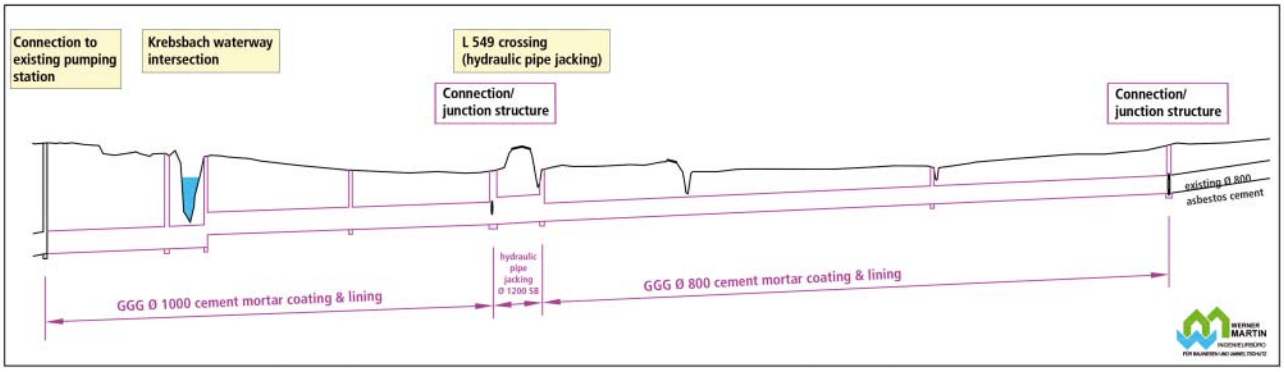

Fig. 4:
Longitudinal section

fed in from the Bernau pumping station. Because of the new route of the sewer, the DN 300 feeder pipe has to be readapted over a length of approximately 8 m. The total length of the new section of sewer is 505 m. Of this, 410 m is constructed with sloping trench walls and 95 m with shored trench walls **(Figs. 5 and 6)**.

Because of the ambitious profile of requirements for the work to be done, the client and the planning engineer decided that the sewage pipes should be in ductile cast iron according to EN 598 [1] with TYTON® push-in joints. Externally the pipes are protected with a zinc coating and a plastic-modified cement mortar coating to EN 15542 [2]. They are lined with high-alumina cement mortar. The pipes have a high stability margin as regards external and internal loads and their 6 m length limits the number of push-in joints needed. The TYTON® push-in joint is flexible, can take length variations, is tight under high internal pressures as well as negative pressures and is resistant to root penetration. It acts as an articulated joint **(Fig. 7)**. The cement mortar coating is resistant to highly aggressive soils and able to take high mechanical loads. Stones in the bedding material are acceptable up to a size of 100 mm. The high-alumina cement mortar is extremely resistant to abrasion and also to highly corrosive sewage.

3 Construction work

The entire area of the route selected is characterised by cohesive but fairly unstable soil (clay, alluvial loess). Therefore, in order to reinforce the pipe bedding, a 25 cm thick layer of 0/90 coarse gravel packed in geotextile was laid in the bottom of the trench. A 0/45 mm mineral aggregate was used for the pipe bedding itself **(Fig. 8)**. Despite the high groundwater level in some places, the sewage pipes were mainly able to be laid with open dewatering. Up to a pipe trench depth of 3 m, it was possible to slope the trench walls to approximately 45 . For the crossing beneath the L 549 road directly before the Neckarbischofsheim connection point, 22 m of DN 1200 reinforced concrete pipes were installed by means of hydraulic pipe jacking. Along its course the sewer had to cross the River Krebsbach, around 45 m above the existing crossing of the old asbestos cement sewage pipeline, through new DN 1000 sewage pipes. As the water was running deep in this area, the base profile had to be raised in this crossing area **(Fig. 9)**. In some places, because of restricted space, the work had to proceed in incremental stages to allow machine access.

The 6 m long pipes were best suited for this (open/close method) **(Fig. 10)**. The external cement mortar protection selected meant that the cohesive excavation material could be used directly again for bedding the pipes **(Fig. 10)**, encasing them in a mineral seal as additional groundwater protection. Backfilling with the excavation material enabled the costs of removing it to landfill to be greatly reduced.

279 m of DN 800 and 204 m of DN 1000 sewage pipe were laid. The reinforced concrete structures installed at the connection points were concreted over or onto the existing sewers. After final completion of the new sewer, the old sewers were cut through into these structures and the waste water was routed into the new sewage pipelines **(Fig. 11)**. Waste water retention in the association's sewage network was necessary here, for which only pressure pipes with fixed pipe couplings were permissible **(Fig. 12)**. In addition a hydraulic calculation was to be submitted for the design of the equipment. The most important thing was that no contaminated water should get into the subsoil during this work (water protection area). The work was only to be carried out during stable dry weather in agreement with the personnel at the sewage treatment plant. The equipment was to be constantly monitored, even during the night. There has to be standby units for all the equipment required for pumping away the sewage (pumps, generators, etc.). In the event of the failure of a machine it was to be guaranteed that a replacement machine could be connected up immediately. After completion of the work, the old sewers were sealed off and the manholes were demolished.

4 Concluding comments

Thanks to the excellent and problem-free collaboration between client, planning and management engineers, construction company, sewage treatment plant personnel and pipe supplier, a challenging project in a drinking water protection zone was able to be completed and put into operation within the period envisaged from September 2012 to July 2013 after successful pressure testing in accordance with EN 1610 [3].

Fig. 5:
Securing the trench with shoring equipment

Fig. 6:
Pipe laying in a shored pipe trench

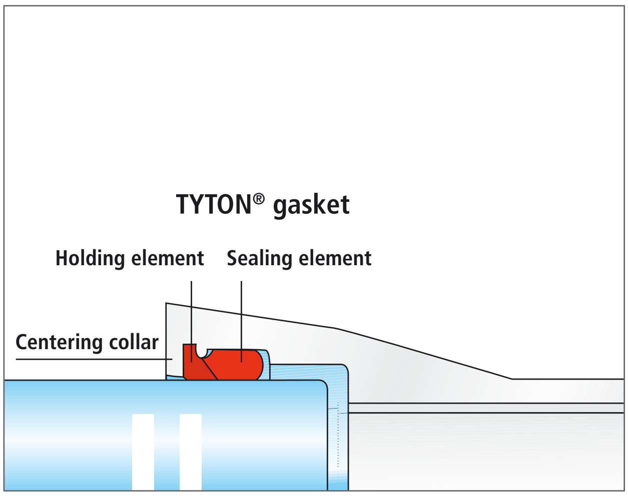

Fig. 7:
TYTON® push-in joint

Fig. 8:
Lower bedding layer with 0/45 mm mineral aggregate

Fig. 9:
Krebsbach intersection with raised base profile

Fig. 10:
Pipe trench backfilled with excavation material

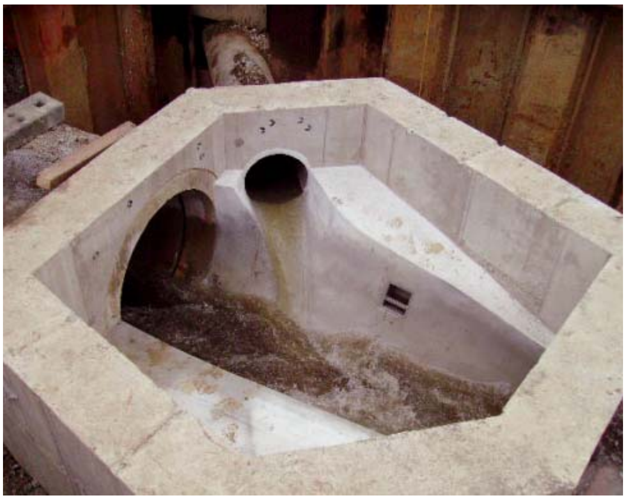

Fig. 11:
Manhole structure after connection

Fig. 12:
Waste water retention during the switchover to the new sewer

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Construction of a new drinking water supply pipeline between Pödelwitz and Neukieritzsch

By Matthias Renger, Stefan Präger, Renaldo Moritz and Uwe Hoffmann

1 Introduction

The Bornaer Land water/waste water association is responsible for everything in connection with drinking water and waste water in the Saxony region of Borna (administrative district of Leipzig). In terms of drinking water this covers the former administrative district of Borna and in terms of waste water it only covers the town of Borna with the district of Thräna, but excluding the districts of Wyhra, Zedtlitz, Eula, Haubitz, Gestewitz and Kesselshain (to the North of the B 176).

In order to cope with these tasks, the association operates more than 750 km of drinking water pipelines. These supply all industrial and commercial locations and more than 62,000 residents of this region from over 14,000 customer connections. Drinking water is extracted and processed in two ultramodern plants in Borna and any additional volumes required are supplied by Fernwasserversorgung Elbaue-Ostharz GmbH. At all times the standard of the drinking water fulfils the requirements of the drinking water regulation and meets the very highest specifications.

2 The reason for the new supply pipeline

With the development of the lignite mining area to the South of Leipzig, there is to be a new extraction field. Because of this the project sponsor, Mitteldeutsche Braunkohlengesellschaft mbH (MIBRAG), cut off the main B 176 road running between Pödelwitz and Neukieritzsch. Among other things, with the demolition of the B 176, the main drinking water supply pipeline between Pödelwitz and Neukieritzsch, which belongs to the Bornaer Land water/waste water association and services the western supply area, was also cut off.

A new Federal highway category road connection was produced as a replacement, which has opened up both areas to traffic again since October 2013. When the new main B 176 n road was being built, it was possible to include the construction of a new main drinking water supply pipeline in this complex project. Planning permission was granted for the construction of Federal highway B 176 and the laying of the drinking water supply pipeline was made possible in this context.

3 Planning

The Bornaer Land water/waste water association commissioned the UKAM GmbH engineering office from Borna to produce the planning for the construction of the new drinking water pipeline between Neukieritzsch and Pödelwitz during the period from January 2011 to January 2012. The project, along with its design and execution planning stages, was integrated into the "Replacement of Federal Highway B 176 from Pödelwitz to Neukieritzsch" planning approval procedure.

The planning of pipe material and construction technology had to be determined under consideration of the constraints of open-cast mining, also taking account of any signs of residual inherent settlement on the construction site which might still be expected from the tipping of spoil material below and above the working level.

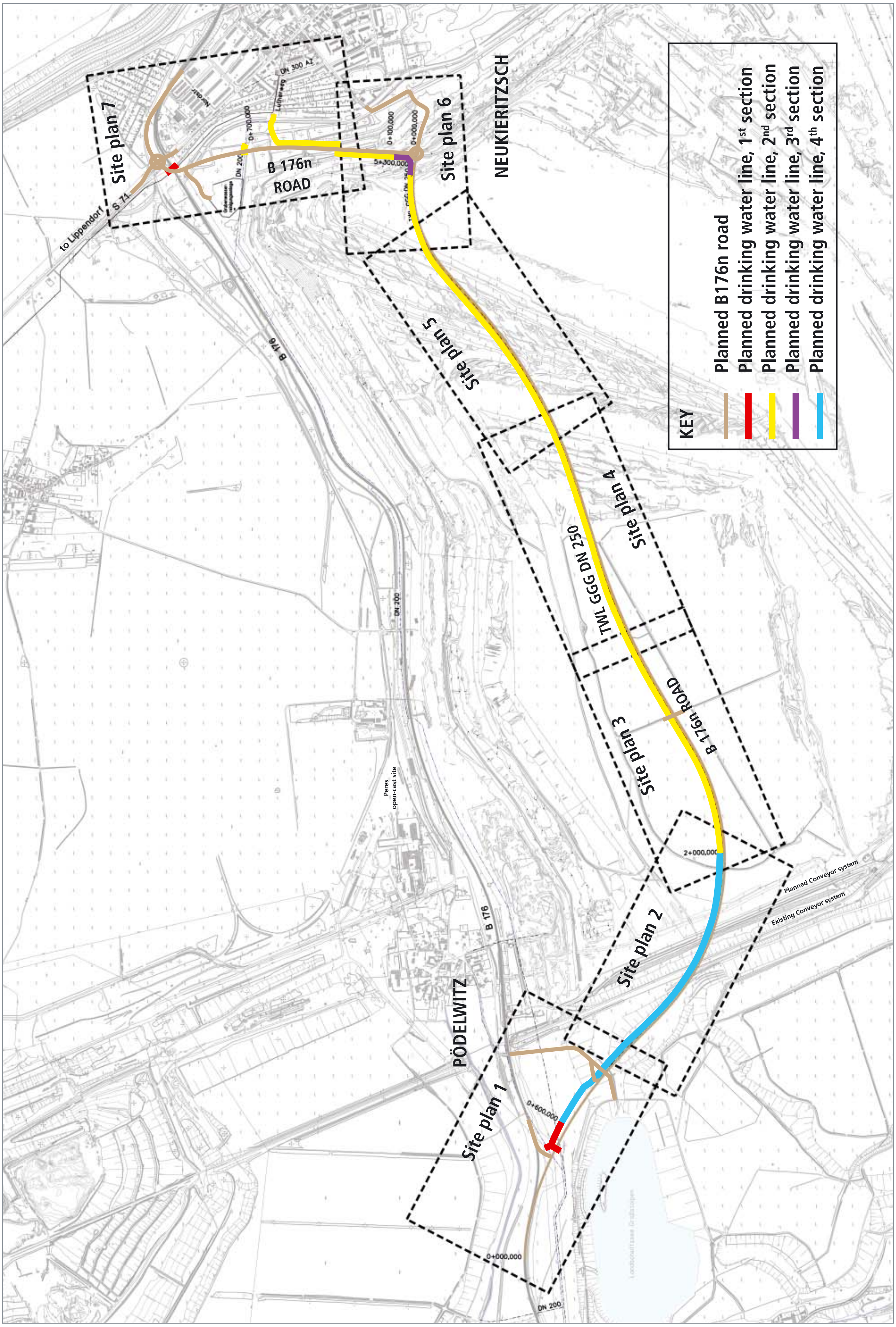

Fig. 1: Site plan with the individual pipeline construction stages between Pödelwitz and Neukieritzsch

For the settlement area in question, additional special installation requirements were drawn up during the planning of the drinking water pipeline. The piping system must be able to withstand the additional loads which can affect a pipeline in the event of unforeseen ground motions without damage during the whole of its technical working life.

4 Choice of pipe material

According to the available geotechnical report, subsidence of the subsoil could occur in the area of the route of the drinking water pipeline **(Fig. 1)** which, in the least favourable case, might amount to 30 cm. The pipe material used was ductile iron pipes (GGG) to EN 545 [1] with BLS® restrained push-in joints for thrust and tension resistance in nominal size DN 250 **(Fig. 2)**. A zinc-aluminium coating (Duktus Zinc-Plus) at 400 g/m² with a blue epoxy resin finishing layer was selected as the external corrosion protection for the pipe material.

Horizontal movements which occur at an angle to the longitudinal axis are taken up by socket joints which can deflected up to 4°. This deflectability means that, with reference to a pipe length of 6 m and 1° deflection, there is a deviation of 10 cm from the axis of the pipe or fitting installed. Hence, for the nominal size DN 250 with 4°, there is a possible deviation of 40 cm available. Subsidence of up to 30 cm, as referred to in the geotechnical report, can therefore be taken up with these socket joints without problem.

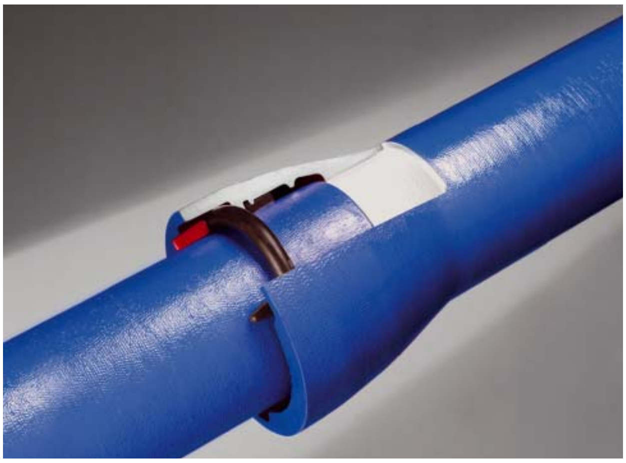

Fig. 2:
BLS® restrained push-in joint with locks and catch inserted

Fig. 3:
Positive locking DN 250 ductile iron pipeline – concrete thrust blocks not necessary on bends

Fig. 4:
Installation of DN 250 ductile iron pipes in the sloped trench

Table 1:
Permissible grain sizes for the cover material according to [3]

Pipe material	Cover	Grain size round material	Grain size crushed material
ductile iron pipes	Zinc/bitumen Zinc/epoxy Zinc-Alu/epoxy	0–32 mm single grains up to max. 63 mm	0–16 mm single grains up to max. 32 mm
ductile iron pipes	Cement mortar coating	0–63 mm single grains up to max. 100 mm	0–63 mm single grains up to max. 100 mm

Hence there is still an additional safety margin available for any greater incidents of subsidence. The danger of the pipe joints being pulled apart as the result of subsidence and the associated variations in length is durably avoided by the positive locking joint system. And push-in joints prove to have an additional advantage: in addition to the available deflection, axial displacements as a result of strain and compression are also possible in the BLS® push-in joints before the thrust system locks. This blocks the possibility of the pipe joints being pulled apart. Hence all conditions are met to make sure that the pipeline remains tight even under movements caused by mining subsidence. Depending on the installation location, an axial displacement of about 10 mm per joint is possible before the flow of forces from the locking chamber across the locking elements to the welded bead is completely closed at the spigot end and hence the axial movement in the individual sockets is restricted. The positive locking joints make concrete thrust blocks at direction changes superfluous **(Fig. 3)**.

5 Construction work

The construction of the approximately 6 km long drinking water pipeline was commenced in the 2nd quarter of 2012. Following the phases of the road construction and after the waiting time for the spoil embankment, the work was done in stages until the 3rd quarter of 2013. A combined system of sloped and shored trenches was used to secure the pipe trenches **(Fig. 4)**. Parallel to the drinking water pipeline, a fibre optic control cable was also installed inside a protective tube along the whole of the route. The pipes were laid into bedding material according to the specifications of DVGW worksheet W 400-2 [2]. The grain sizes permissible for ductile iron pipes can be found in **Table 1** [3].

6 Summary

Despite the difficult conditions when working in a mining disposal area, the project was completed to deadline and to the required quality standards. This was only possible because of the target-oriented collaboration between client, operator, planning engineers, construction supervisors and construction companies. With the successful completion of the pipeline, a stable supply of drinking water is guaranteed for the western supply area of the Bornaer Land water/waste water association over the long term.

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Construction of a new drinking water connecting pipeline from the Ramstein pumping station to the Dackenheid water tower

By Markus Steier

1 Introduction

The Trier-Land waterworks association supplies the communities of the Trier-Land local authority association as well as other neighbouring communities with drinking water. Around 80 % of all customers are supplied by the network connection, constructed in 1974, from the pumping station at Ramstein bei Kordel to the high-level tank at Dackenheid near Butzweiler. Because, after nearly 40 years of operation, the condition of this drinking water pipeline needed to be investigated and during this time no alternative supply was available, the waterworks decided to construct a new pipeline.

The wells in the water catchment area of Kylltal supply 18,000 residents between the Sauer and Kyll rivers via the Ramstein pumping station and the pressure line connecting it to the high-level tank at Dackenheid by means of the Ramstein-Dackenheid connection line exclusively. As from the central elevated tank at Dackenheid, the distribution network splits off into a number of branches running as far as the border between Germany and Luxemburg.

2 Planning

In order to deliver water from the Kyll to Dackenheid, a height of 270 m over a distance of 2.5 km needs to be negotiated. The delivery volume is 360 m^3/h or max. 4,000 m^3/d. The existing pipeline in ductile cast iron has an internal diameter of 300 mm.

In order to carry out a thorough inspection it was been necessary to take the pipeline out of operation for a long time. However this was not possible because it is the lifeline for the supply of drinking water to Trier-Land. The construction of a new, additional connection pipeline was therefore urgently necessary so that investigations could be carried out on the old pipeline and, in case of damage or bottlenecks, the supply could be ensured.

The existing cast iron pipeline was not constructed with TYTON® restrained push-in joints. Enormous pressures occur, especially in the lower area. Therefore it was decided not to install the new pipeline along the existing route in order to avoid damage, to minimise hazards during the construction work and to safeguard the supply.

In addition to the necessity of keeping the old pipeline in operation even during the construction work, there were other framework conditions which needed to be clarified as a priority.

In particular, legal questions regarding nature conservation needed to be addressed. In its lower region, the route runs through the "Lower Kyll and Kordel valleys" area subject to flora and fauna habitat protection guidelines, through the "Meulenwald and Stadtwald Trier" protected forest landscape area and it crosses a natural spring which is classified as a habitat covered by Federal nature conservation legislation. In addition the whole length of the route runs across the "Kylltal waterworks association" drinking water protection area, in a class II protection zone in the lower area and a class III A zone in the upper area.

The top half of the route lies on a plateau where the remains of a "Roman long wall" are located. This had to be crossed at some point and agreements with the Rhineland Landesmuseum were necessary. Additional arrangements needed to be made as regards routing the pipeline across the outstanding "Roman pathway" trail and also with the forestry administration.

In terms of preliminary planning, the terrain was first of all investigated as regards alternative routes, with the stipulation that the existing pipeline should be affected as little as possible and that access should be opened up using existing channels as far as possible **(Fig. 1)**.

Then the planned pipeline route was marked out and measured in the terrain. This meant that the route could be worked out in greater detail and hydraulic calculations could be produced. As a result, it was determined that the planned pipeline was more or less the same length as the existing one. So no elaborate modifications needed to be made to the pumps.

The route of the new connection pipeline mainly runs along forest and farm tracks. Two sections, 240 m and 150 m in length, run over a steep slope with gradients of up to 60 %. Because of the topographical conditions, it was not possible for the existing pipeline to be completely bypassed; there are four line crossings and one 350 m long section where the pipes are laid parallel to each other.

As well as the issues of nature and monument conservation, the geological and topographical conditions also produced some additional difficulties. "Alongside the planned route of the pipeline, there are many steeply dropping sandstone walls and rocky outcrops in the terrain" [1]. The project location is set "in the range of the Upper and Middle Bunter period, formed of mica-rich, red-brown and violet-tinged medium to fine sandstone and brownish red coarse to fine sandstone" [1].

"In order to investigate the subsoil conditions, seven small ramming drillings were carried out, each of which was supplemented by tests with the heavy-duty penetrometer" [1]. In some cases here the transition to the sandstone rock was found to be at a very shallow depth beneath the surface of the terrain.

"As can be seen from the rocky outcrops, the depth of the bedrock horizon varies rapidly in the area investigated" [1]. It was to be expected "that the resistance of the sandstone increases quickly with the depth and the rock to be removed is predominantly to be classified as soil class 7" [1].

Once all the approvals had been received, the initial clearing work could be carried out in Winter 2010/2011 on the planned route of the pipeline in preparation for the actual construction work. The construction work was put out to tender at the same time.

3 Construction work

Because, for a large part, the route runs through a steep slope with inaccessible woodland **(Fig. 2)**, ductile cast iron pipes DN 300 as per EN 545 [2] with cement mortar coating to EN 15542 [3] were selected. With this robust external protection, capable of taking high mechanical loads, bedding the pipes in crushed materials with a maximum grain size of 100 mm is permissible **(Fig. 3)**.

By reusing the material excavated from the trenches for bedding the pipes, significant economic and ecological advantages could be achieved, particularly by avoiding the need of transporting pipe bedding material and removing unwanted volumes of soil and rubble in the poorly accessible and highly sensitive terrain **(Fig. 4)**.

Having submitted the best offer, the UVB company (Universal-Bau GmbH from Bitburg) was awarded the contract for the work. DN 300 ductile iron pipes of pressure class C 50 were used. In the lower, steep area of the pipeline, restrained BLS® push-in joints with wall thickness K 9 and permissible operating pressure 40 bars were used over a length of 1,500 m. The remaining 1,000 m in the higher area was laid with friction-locking BRS® push-in joints with a permissible operating pressure of 25 bars. Both of these pipe connections have the advantage that, to a very large extent, costly concrete thrust blocks could be dispensed with in the area of bends **(Fig. 5)**, meaning that the large-scale transport of concrete could be avoided.

In the steeply sloping area, installation was done from top to bottom and, contrary to common practice, with the socket downwards. This meant that the BRS® push-in joints were easier to lock and better "to pull" **(Figs. 6 and 7)**. At certain distances, clay "aprons" were installed in the trench to avoid a drainage effect in the trench and hence landslips. To prevent the newly laid topsoil from leaching out and being washed away, jute mats stretched over wooden pegs was used for stabilisation on the slopes. These stabilisation barriers, arranged obliquely to the line of maximum slope, were installed at distances of about 10 m and will stabilise the steep slope until the vegetation has

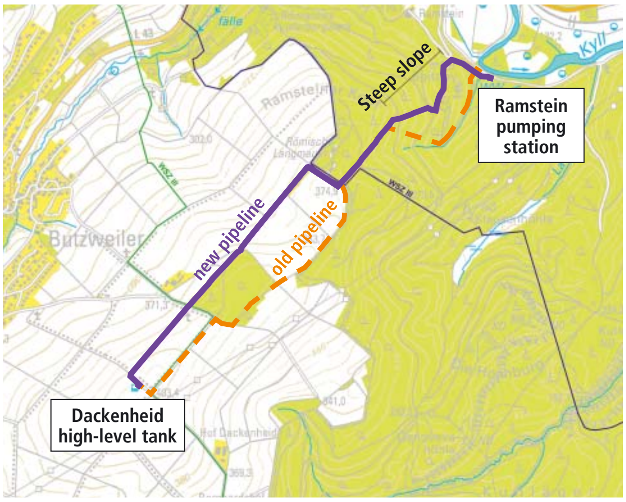

Fig. 1:
Outline map

Fig. 2:
Installation of the pipes in a narrow track through the wood

Fig. 3:
Installation of the DN 300 ductile iron pipes in the flat area

grown back again **(Fig. 8)**. The work was carried out with a Komatsu PC228USLC excavator with a 116 kW engine rating and 23 t weight. This excavator is suitable for gradients of up to 70 %.

In order to transport water from the Kyll to Dackenheid, a delivery head of 265 mWC (= 26.5 bars) is applied in the Ramstein pumping station. The delivery volume is maximum 360 m³/h or 4,000 m³/d. The new DN 300 pipeline is 2,420 m long.

There were also some alterations carried out in the pumping station and to two existing valve shafts on the route of the pipeline, as well as the construction of a further valve shaft in the new pipeline. The new pressure line commences directly at the pressure port of the pumps under the building which was constructed in the 1930's. To do this, the baseplate was opened up and two pipes installed in parallel were run to the outside. The second pipe serves as a new connection to the old riser. In the existing valve shafts, the old valves no longer fit for operation were replaced.

Once pressure testing had been successfully completed, the new pipeline was able to be put into operation in December 2011. And after the completion and commissioning of the new drinking water pipeline, an investigation and assessment of the condition of the old pipeline was carried out as regards any renovation which may be necessary. For this purpose, three sections of the old pipeline were removed in the area of the pumping station and at the two valve shafts. The condition, material properties and structure of these pipe sections were investigated by the North Rhine-Westphalia Material Testing

Fig. 4:
Civil engineering work in the rocky terrain of the wooded slope

Fig. 6:
Assembling the push-in joint with the socket against the direction of flow

Fig. 5:
Curve point at the transition from the BLS® push-in joint to the BRS® push-in joint

Fig. 7:
DN 300 ductile iron pipes – installation in the trench

Fig. 8:
Slope stabilisation of the route with jute mat prevents the topsoil from being washed away down the slope

Institute. According to the test report, two sections met all the requirements of the currently valid technical specifications for ductile iron pipes. On the third section, irregularities were only found on the protective coating. The mechanical material properties are however flawless.

Apart from small, fine deposits, a TV inspection was unable to detect any damage. Therefore the old pipeline was simply cleaned by pigging and then put back into operation.

4 Concluding remark

The pipe installation work started at the beginning of May 2011. An immeasurable advantage was the dry weather in the months of May and June 2011, which made the work a great deal easier. And thanks also to the work by two gangs from the contracting UVB company, after just two months the 2,500 m of DN 300 ductile iron pipes had been installed between the Ramstein pumping station and the high-level tank at Dackenheid.

With the positive result of the inspection of the existing drinking water pipeline together with the construction of a second pipeline from the Ramstein pumping station to the high-level tank at Dackenheid, the security of supply in the territory of the Trier-Land waterworks is considerably increased and guaranteed over the long term.

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Construction of a new DN 500 main supply pipeline from HB Bromberg to Holzgerlingen

By Lothar Schütz and Alexander Bauer

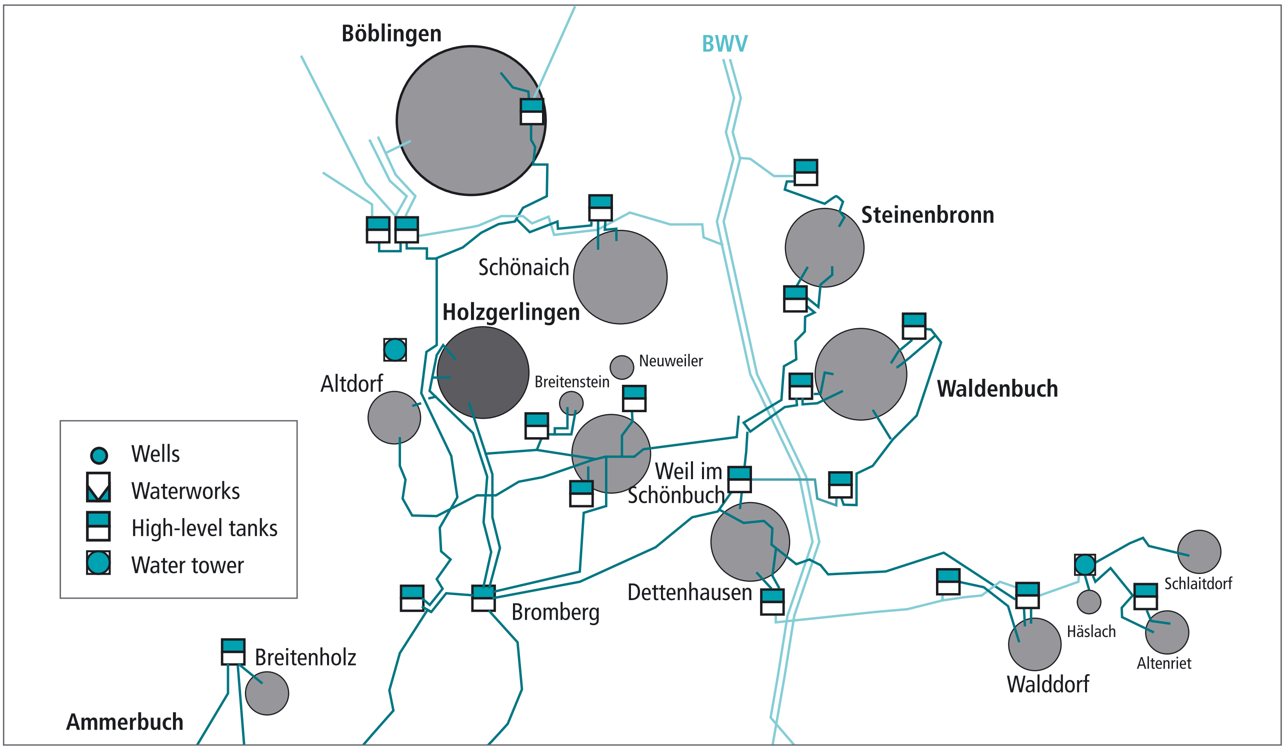

Fig. 1:
Site and contour map of the new DN 500, PN 16 main supply pipeline

1 Planning approach

The Ammertal-Schönbuchgruppe (ASG) association supplies around 120,000 people with high-quality drinking water. To ensure that it can continue to do this in the future, the association has replaced two ageing pipelines with one new pipeline, approximately 4.5 km long, in ductile cast iron in nominal size DN 500 with a Zinc-Plus coating.

The old pipelines in grey cast iron and asbestos cement were designed to DN 300. The hydraulic calculations produced by the Miltenberger und Schmid GmbH design office in Hechingen, which was commissioned for the construction work, showed that with a length of almost 4.5 km only a DN 500 pipeline would be sufficient to provide adequate reserves for the future if there should be an increase in the consumption of drinking water in the communities supplied by the association.

The new drinking water supply pipeline runs from the Bromberg high-level tank to Holzgerlingen **(Fig. 1)** in the administrative district of Böblingen (Baden-Württemberg). A considerable amount of preliminary planning preceded the 1.5 million euro project, not least in order to make sure that the communities, the golf course operator and the local forestry administration would be disturbed as little as possible.

Fig. 2:
Laying the ductile iron pipes along the route using a walking excavator

2 Construction work

The companies Max Wild GmbH from Berkheim and Norbert Schütz GmbH & Co. KG from Boos were commissioned to carry out the civil engineering, road construction and pipe laying work (Wild-Schütz consortium). Max Wild GmbH was responsible for the earth-moving, civil engineering and road building work and Norbert Schütz GmbH & Co. KG was responsible for the pipe laying work.

Work was started at the beginning of February 2012 on the installation of the gravity pipeline with a height difference of 54 m **(Fig. 2)**. The pipes were laid in an open pipe trench.

In total, 19,000 m² of humus was removed. 9,000 m³ of earth had to be excavated simply for the pipe trench in which the iron pipeline had to be laid at a depth of 1.8 m to protect it from freezing.

3 Choice of pipe material

In the choice of pipe material, the method used was an objective one with detailed lists of decision-making criteria. Three lists were produced with economic **(Table 1)**, technical **(Table 2)** and ecological **(Table 3)** points of view. The pipe system to be selected needed to be based on the requirements of the utility company and offer a complete solution of the supply pipeline to be renewed.

Table 1:
Economic criteria

- topographical conditions – height, length, performance, flow rate,
- pressure conditions, supply volumes, geographical conditions,
- price/performance ratio of the piping system and pipe dimensions,
- useful technical life – durability – sustainability,
- operational safety – operational expenditures,
- types of joint – flexibility and assembly time,
- active and passive corrosion protection, possible additional costs,
- quality of the construction work – installation in accordance with the longitudinal section,
- requirements profile – availability and adaptability for use,
- local adaptation – installation site, space restrictions,
- use of machines, equipment and personnel,
- structure of the terrain, land and soil conditions,
- general construction periods – seasons, construction progress time,
- infrastructure – traffic, requirements of landowners, other media,
- planning and tendering costs plus management and supervision costs,
- costs of tests, reports, guarantees,
- additional contributions for indirect costs (reimbursements, compensation payments).

Table 2:
Technical criteria

- quality of the piping system,
- material processing – quality – physical and chemical properties,
- active and passive corrosion protection – internal and external coating,
- QA – standardised series production – quality assurance and works testing,
- jointing technology – welding, socket joints,
- push-in joint system – proven system up to 100 bar operating pressure,
- push-in joint systems classified according to pressure classes and permissible compressive and tractive forces,
- flexibility of joints,
- pipe lengths – transport, storage, processing on site,
- precision of installation, speed of installation, handling of system components,
- pipe bedding, in-situ soil, grain sizes, pipe covering,
- requirements profile – adaptability and performance,
- local adaptation – installation site, space restrictions,
- use of machines, equipment and personnel,
- structure of the terrain, land and existing soil conditions,
- construction periods – seasons, construction progress,
- infrastructure – traffic, specifications, other media.

Table 3:
Ecological criteria

- materials management and cycles,
- energy consumption – CO_2 balance,
- useful life – durability – sustainability – development,
- requirements profile – areas of application – performance,
- local adaptation – installation site width, space restrictions,
- soil compaction – renaturalisation, recultivation,
- structure of the terrain, land and soil conditions,
- construction periods – seasons, construction progress.

After assessing and evaluating the decision-making criteria listed, the choice went in favour of ductile cast iron as the pipe material. Hence the renovation took the form of a new construction with ductile iron pipe. Ductile iron pipe systems have always contributed to the development of reliable infrastructures and they have set the highest standards in drinking water supply.

4 Installation of pipes and fittings in ductile cast iron

The ductile iron pipe system with its push-in joints, in combination with modern installation techniques, makes enormously high levels of daily progress possible.

4,450 m of ductile iron pipes to EN 545 [1], PN 16, wall thickness according to pressure class C 50, with a zinc-aluminium coating in the Zinc-Plus version (400 g/m²) was used. Apart from about 500 m, almost the entire pipeline was constructed with non-restrained TYTON® socket joints **(Fig. 3)**.

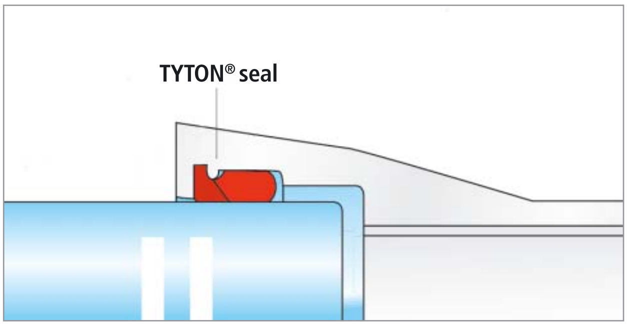

Fig. 3:
Non-retrained TYTON® push-in joint

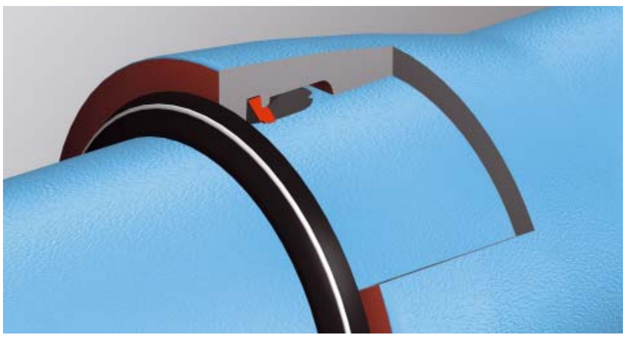

Fig. 4:
Restrained BRS® push-in joint

For the restrained part of the line, the BRS® push-in joint was used. The BRS® push-in joint **(Fig. 4)** is a friction-locking joint. The locking and sealing function is provided by the TYTON SIT PLUS® gasket. Fittings in the BRS® design are coated inside and out with epoxy resin powder to a coating thickness of 250 µm in accordance with EN 14901 [2], DIN 3476 [3] and RAL GZ 662 [4].

5 The construction project

The new pipeline route runs through the Schönbuch and crosses the Schönbuch golf course before it joins the existing piping and distribution network at the Buch/Sol industrial estate. In the context of the installation of the ductile iron pipes, there were also seven manhole structures to be constructed. Because of the restricted space available in the area of the golf course, the new pipeline had to be laid in a precisely determined time window. Both consortium partners provided experienced, well-trained employees and the most modern equipment, in some cases special machines developed in house.

Fig. 5:
Lifting a pipe section into the trench with the innovative system for ductile iron pipes

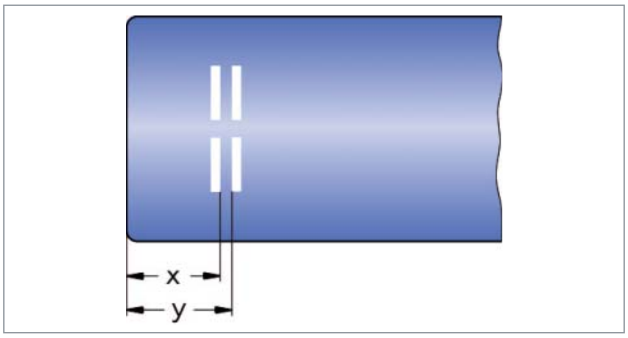

Fig. 6:
Ductile iron pipe – spigot end with push-in marking

A walking excavator with a patented installation rig was used for laying the ductile iron pipes and fittings. The capabilities and advantages offered by this walking excavator are:

- transporting pipes on the road using the walking excavator,
- placing the pipeline along the route in advance where space is restricted,
- cutting the ductile iron pipes,
- rapid and secure assembly of bends,
- very good control and ability to check the pipe joint after assembly with the hydraulic installation rig,
- lifting a pipe section into the pipe trench **(Fig. 5)**,
- axial lifting of a pipe section,
- accurate insertion into the socket followed by back-locking,
- installation of an adapter piece,
- careful lowering of the ductile iron pipe into the pipe trench.

Further patented advantages of the semi-automatic iron pipe installation rig are:

- by changing the grab jaws it is versatile for use with all pipe dimensions,
- simple, fast and secure grabbing, securing and holding the pipe along its axis,
- simple and fast assembly of the pipe joint with retaining bracket and traction line,
- can be used for all pipes, fittings and adapters,
- the pipe is inserted into the socket as far as the push-in marking **(Fig. 6)** by operating the traction cylinder with the finest adjustment of the pushing force,
- installation of the pipes with back-locking of restrained push-in joints.

6 Conclusion

The construction project was completed by the companies involved to deadline and with outstanding collaboration. The pipes were installed using expert site personnel and the most modern machinery, which meant that the project progressed rapidly. While the construction work was being carried out, the supply of drinking water to customers was ensured at all times by the Ammertal-Schönbuchgruppe (ASG) association.

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Status analysis for the piping network of the city of Vienna using non-damage-based data on ductile iron pipes

By Daniela Fuchs-Hanusch, Franz Weyrer and Christian Auer

1 From damage statistics to status analysis

For many decades pipe renewal strategies have been based predominantly on damage rates. Instances of damage are recorded, collected and processed statistically. The analysis of the data should enable working life as well as damage probabilities and the associated operational time remaining to be predicted as precisely as possible. Pipeline replacement should ensure that incidents of damage are still prevented with a high degree of probability, but that the pipe is not taken out of service too early.

To this end, various calculation models have been developed in recent years and major utility companies such as the German DVGW (Deutscher Verein des Gas- und Wasserfaches e.V.) and the Austrian OVGW (Österreichische Vereinigung für das Gas- und Wasserfach) have determined permissible rates per km and per year or per 100 km and per year, based on practical and theoretical findings, and set them as reference values. At the Vienna waterworks, a network information system is operated with damage recording, databanks and GIS (geo-information system).

The way in which a piping system develops over the course of its many decades of working life has not been researched so far, or scarcely so. This may be due in large part to the high technical and also financial expense (e.g. camera inspection). Ductile iron pipes usually fail because of a corrosion attack from outside, meaning that inspection by camera is useless; to date no economic means of assessing the external surface of installed pipes is known.

The entire piping network of Vienna is just about 3,000 km long and the proportion of ductile iron pipes is slightly under 60 %, justifying a major interest in the condition of this type of pipe **(Fig. 1)**. Over the course of time, three different corrosion protection systems have been used in Vienna for ductile iron pipes **(Table 1)**.

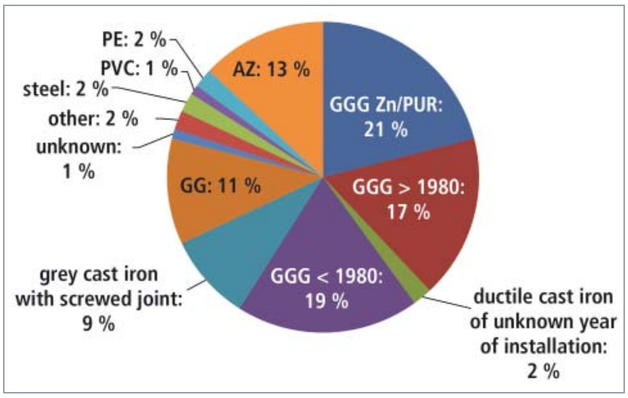

Fig. 1:
Breakdown of pipe materials in the Vienna waterworks piping network
Source: Wiener Wasserwerke

Table 1:
Pipe generations according to type of external coating

Type of external coating	Year
Tar	1968–1980
Zinc/bitumen (BitZn)	1981–1995
Zinc-polyurethane (PURZn)	from 1996

2 Development of status analysis – Practical implementation

In the year 2008, Wiener Wasserwerke and Tiroler Rohre GmbH together with the Technical Universities of Vienna and Graz issued some reflections, for the first time, on a systematic status analysis of the pipeline network. The following thoughts were significant here and promise an important increase of knowledge for piping system operators and manufacturers alike:

- Systematic status analysis will further support and refine the renewal strategies of Vienna waterworks. Meanwhile the oldest ductile iron pipes date back almost 50 years but the damage rate in these pipes is currently moderate.
- There is the question of how the different generations of piping will continue to develop over the coming decades. The focal point of renewal lies in the metallic materials of pipes produced in grey cast iron. When planning for the next decades it is important to know what proportion of grey cast iron pipes will be replaced and at what point. Therefore budget control and timely consideration of renewal methods are particularly essential as from now.
- On the basis of the status analysis, major influencing factors such as the bedding of the pipes, installation, soil, etc. should be systematically investigated and evaluated.
- Tiroler Rohre GmbH has already employed accelerated laboratory tests in the past for the development of new generations of coatings in collaboration with the Technical University of Vienna. For the laboratory tests to be meaningful, a comparison with the behaviour of different coatings in actual use is essential. It should be remembered that, in the area of communal drinking water, a working life of 50 years, and indeed very often periods of use of 100 years, are assigned to iron pipes. This time span must also be covered by the laboratory test.
- Knowledge of the real performance capability of the different generations of ductile iron pipes should make a considerable contribution to the optimisation and development of future coating systems.

This then poses the question of how one can achieve an assessment of pipe status which is systematic and as objective as possible in a huge water supply network with such a large number of people involved.

The following procedure was decided on:

- Each time a pipe is uncovered (e.g. when installing house connection lines) the condition of the ductile iron pipes in situ will be assessed and documented by a Vienna waterworks employee. For this purpose the employee has instructions with standard descriptions and standard images. He documents and assesses the pipe status found on this basis:
  He classifies the pipe into five status classes
  1. "OK – nothing to report"
  2. "slightly corroded"
  3. "severely corroded"
  4. "pitting" or
  5. "perforation, damage"

  and collects the results together in groups. The questionnaire **(Fig. 2)** provides an objective survey of the condition of the pipe/pipeline.

In addition, photo-documentation is produced every time a pipe is exposed, with pictures of the pipe, the trench and the surrounding area.

- Different aspects such as groundwater, pipe bedding, striking features etc. will also be recorded in the documentation.
- The questionnaire has been designed so that, despite the very large number of employees (around 120 people are directly involved) a simple and above all objective assessment can be ensured.

At the beginning of 2009, the "status analysis" project was implemented in practice and started with the collection of data in one area of Vienna; during the course of 2009 the recording of pipe status was extended to the whole of Vienna. Meanwhile, just about 900 datasets have been collected and recorded in a databank where they have undergone preliminary statistical analysis **(Fig. 3)**.

General	Date (incl. time)			
	Name of investigator			
	Office			
	Site address			
Pipe	Date laid			
	Diameter DN			
				Please tick
	Connection type	SGTY (TYTON®)		
		SGSM (screwed joint)		
		SGZ, SGZM (type of restraining, w/o or w cement mortar lining)		
	Coating	blue or black		
		cement mortar coated		
	Optical condition	OK		
		slightly corroded		
		severely corroded		
		pitting		
		perforation, damage		
Soil	Material covering the pipe/pipe section	existing excavation material		
		replacement material		
		concrete		
		uncovered pipe		
		other		
	Groundwater	yes		
		no		
	Small excavations	yes		
		no		
Other	External power source	rail		
		other		
		no		
	Info on pipeline	previous damage	yes	
			no	
Comments:				

Fig. 2:
Questionnaire (extract) for status analysis
Source: Wiener Wasserwerke

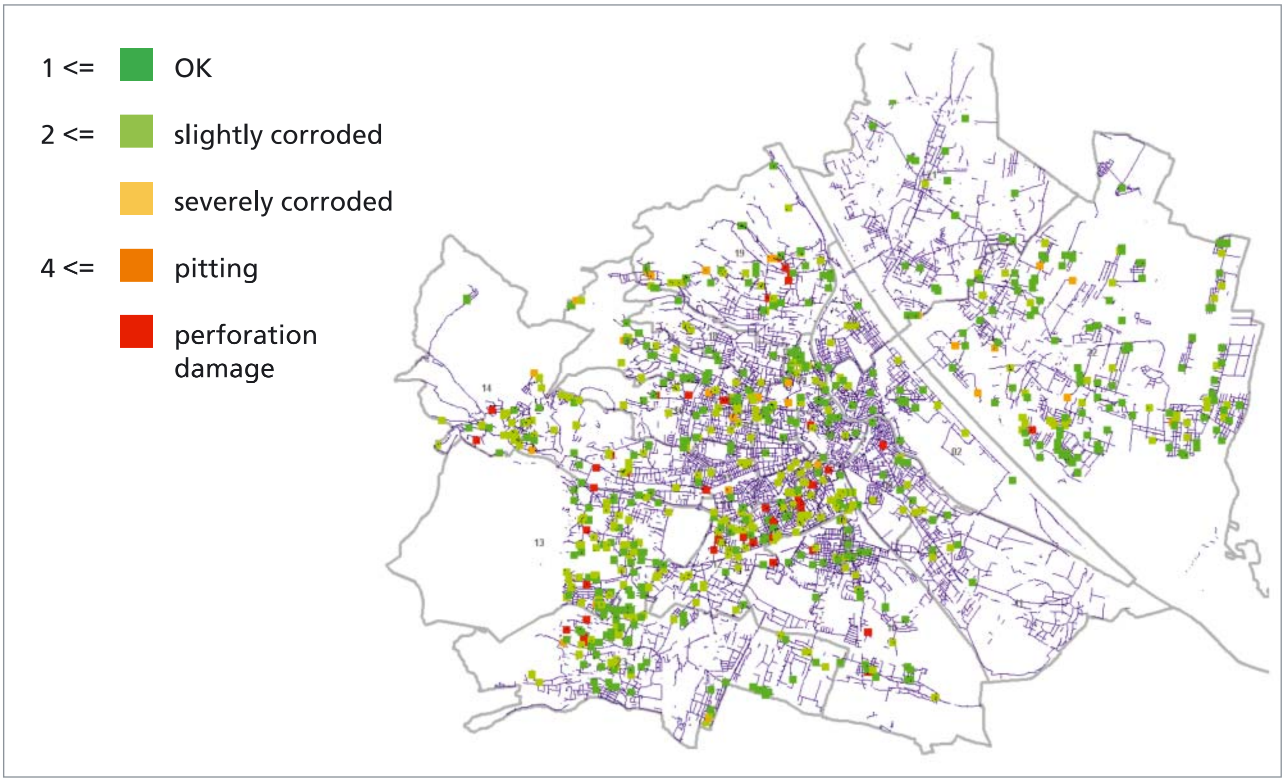

Fig. 3:
Breakdown of the status analyses recorded in the pipeline network of the city of Vienna
Source: Graz Technical University

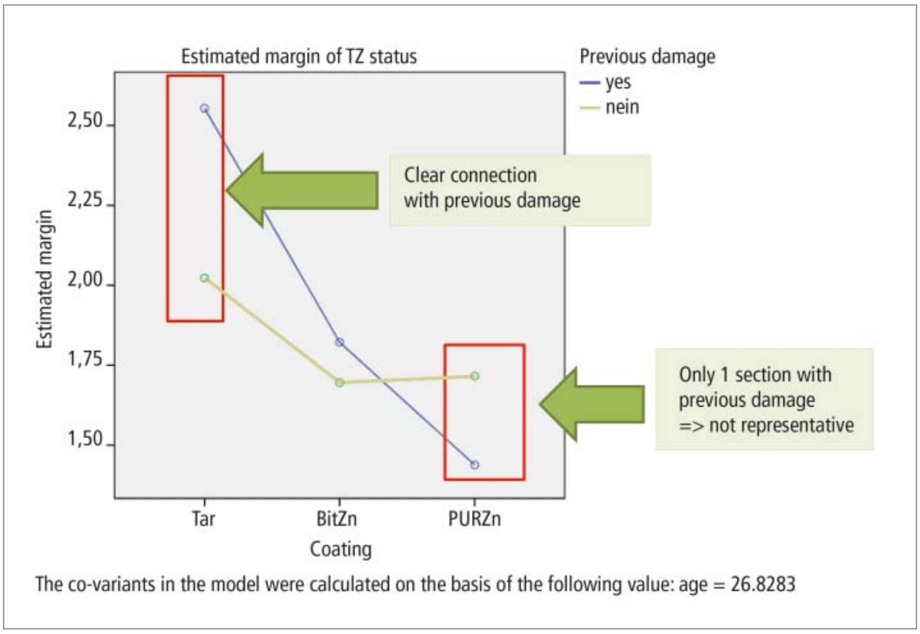

Fig. 4:
Influence of the coating system on the frequency of adverse assessments of pipes in line sections with previous damage
Source: Graz Technical University

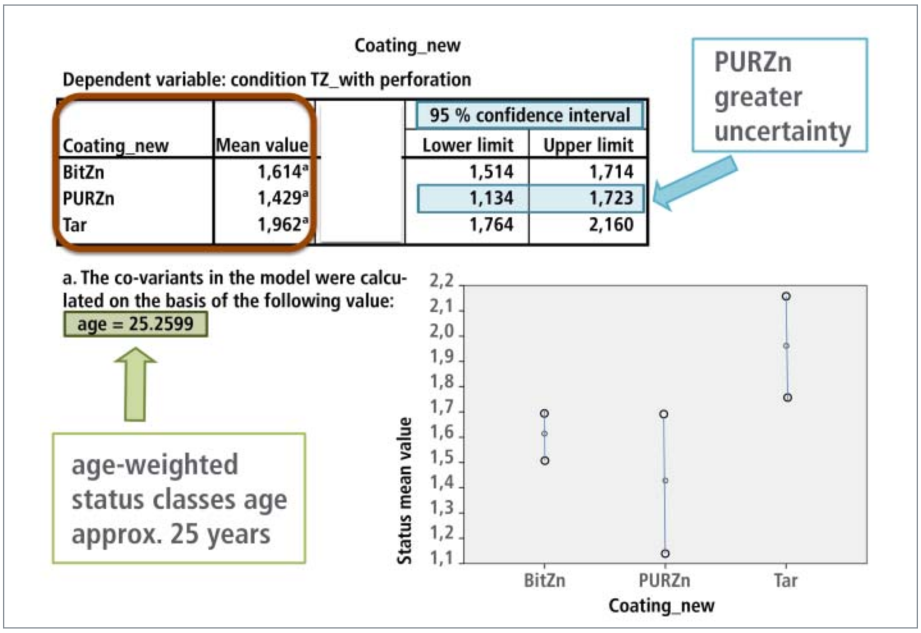

Fig. 5:
Projected points average of the three coating systems considered at the same age of 25 years
Source: Graz Technical University

3 Statistical process of the status analysis

In collaboration with Graz Technical University, work was started in 2012 on updating and localising all the data collected in the GIS. This meant that it was now possible to carry out a systematic comparison with damage statistics on a continuous basis and above all also to integrate a cleaner statistical analysis. The additional advantage here lies in the fact that all pipeline status and damage data can be graphically represented in a map and detailed analyses can also be carried out with maps.

Different findings resulted from the statistical evaluations **(Fig. 4)**:

- For pipelines (tar) with previous damage one generally finds a poorer pipe status and there was a statistically significant influence of previous damage on the condition of the pipeline. Accordingly, with pipelines in which the old tar-based coatings without zinc predominate, poor evaluations are more frequent while sections of line without any striking features to date, but with the same protection system continue to remain relatively unaffected.

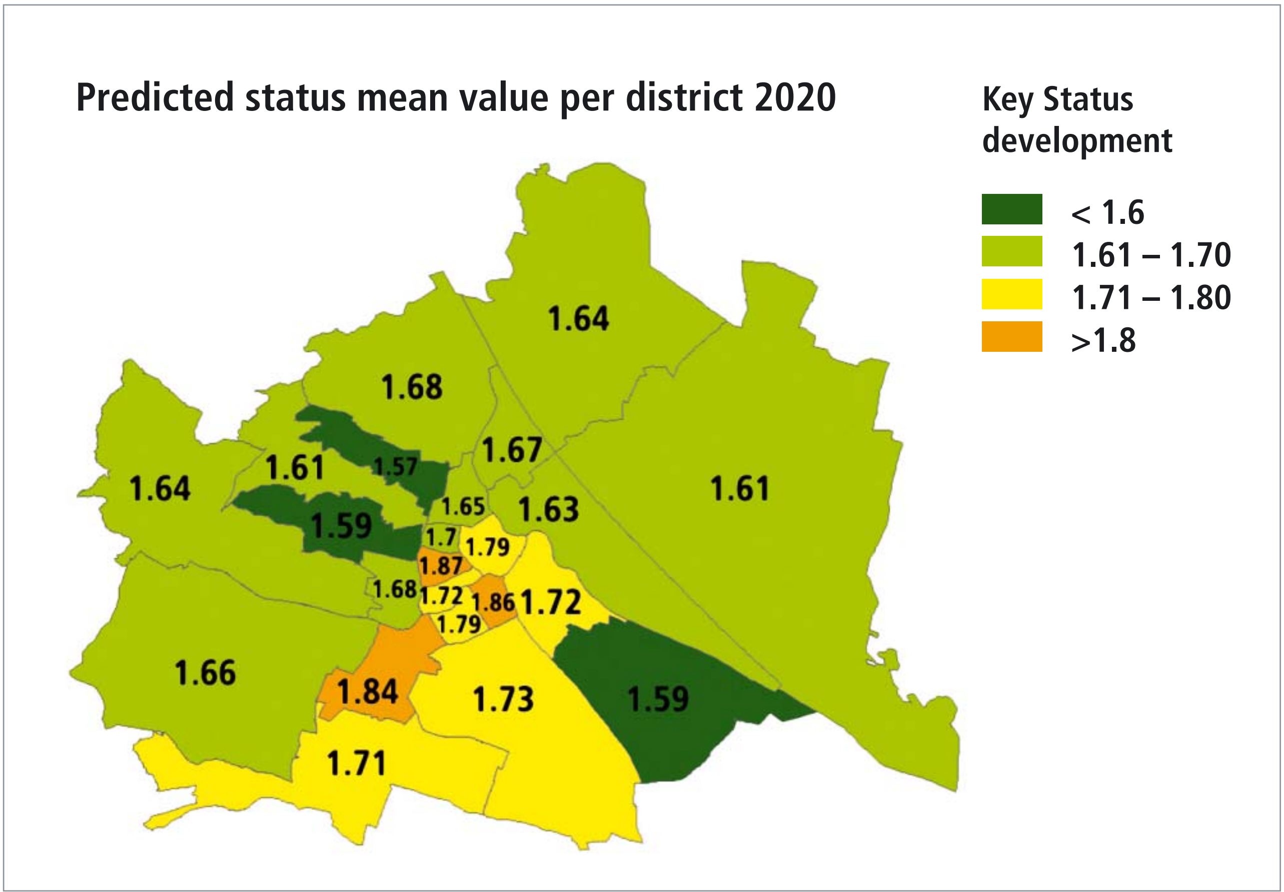

Fig. 6:
Predicted status mean value in the districts of Vienna for the year 2020
Source: Graz Technical University

- With the zinc/bitumen system (BitZn), which was also installed over about 15 years, the assessments are already considerably better; a frequency of poor ratings is broadly independent of the location of the pipe assessed, i.e. damage found correlates less strongly with previous damage to the same section of pipeline.
- With the most recent zinc/polyurethane (PURZn) system used for just about 17 years, no striking features have been able to be discovered to date. There was only an insignificant attack observed on isolated pipes. There are no statistically evaluable datasets.
- All in all the findings suggest that the quality of the bedding and the installation has improved over the last decades.
- In order to eliminate the influence of the age of the different coating systems, a calculation model was developed which computes all coating systems to an age of approx. 25 years (**Fig. 5**): according to this the most recent generation of coatings (zinc/polyurethane) shows the best score average, followed by zinc/bitumen and tar. The greatest step came with the introduction of duplex coating systems (zinc + finishing layer) in the year 1980.
- **Fig. 6** does not yet predict any striking features for the year 2020: the oldest ductile iron pipes will then be over 50 years old. The difference in the average scores in the districts is due among other things to the different coatings and to the different levels of soil aggressivity in the districts. As the amount of data increases over the coming years, predictions will be able to be made for the next decades as to when which pipes can be economically replaced.
- A good correlation was able to be determined between the status analysis and damage statistics. Districts and streets in Vienna which have higher damage rates also come out more poorly in the status analysis.

Table 2:
Evaluation according to type of external coating

Type of coating	Length (km)	proportional sampling rate	needed sampling rate	actual sampling rate
Tar	627	38 %	288	272
BitZn	536	33 %	246	355
PURZn	481	29 %	221	**127**
Total:	1.644	100 %	755	754
Date: 07-2013				

4 Conclusion

The status analysis has become firmly anchored with all the project partners and it has been decided to continue the investigations. For all partners involved in the project (Vienna waterworks, Technical University of Graz, Technical University of Vienna and Tiroler Rohre GmbH) the status analysis has proved to supply a considerable amount of information. Practical knowledge is supported by statistics and also important information is provided regarding pipeline renewal and comparison with laboratory tests (accelerated working life tests).

A few important aspects must nevertheless be considered in greater detail:

- One decisive influencing factor, specifically that regarding the soil, cannot yet be processed with sufficient accuracy: since November 2012, however, soil charts have been available for the whole of Vienna and these are currently being updated and located in the databank.
- The latest zinc/polyurethane (PURZn) generation of pipes still shows a high degree of scatter in the statistical evaluations. The completeness of the records according to **Table 2** is not yet sufficient to reduce the scatter to a reasonable level.
- Other influencing factors, such as small excavations in the area of installed pipes, are not yet able to be statistically evaluated because of their small number and this needs further investigation.

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Renewable energy in the land of the fjords – high performance application of ductile iron pipes for hydroelectric power stations

By Marc Winheim

Fig. 1:
Tverraga, Norway

1 Introduction

Whenever someone mentions Europe's battery, then they are usually referring to Norway. Norway, the land of the fjords, as an energy source **(Fig. 1)** or even as an energy store is mentioned in the same breath as CO_2 reduction and the production of electrical energy by means of the latest generation of hydroelectric power stations. In Norway, hydroelectric energy is the cornerstone of power generation and could in future become more and more important for covering and/or storing electrical energy for the whole of the European Union. The current thinking is that excess capacity from the volatile energy sources of wind and solar power from the European member states will be transported to Norway and stored in the pumped storage power plants existing in the land of the fjords. Norway possesses more than half of this storage capacity in Europe.

Norway is the sixth largest producer of hydroelectric power in the world, with the top places in 2011 being held by China, Brazil and Canada. According to a survey by the Federal Ministry for the Economy into hydroelectric power from the year 2011, more than 1,250 hydroelectric power stations are installed in Norway. The further expansion of the production of renewable energy is strongly encouraged by the Norwegian government. According to forecasts, by 2016 the proportion of renewable energy should be doubled. This also includes plants which work on the principles of osmosis, tide and wave power.

The low price of electricity in Norway contributes to the fact that, in many places, power consumers such as lights are not switched off. Lighting usually stays permanently switched on, even in private households. Because of its geographical location – particularly that of northern Norway close to the Arctic Circle – although it never gets dark during the summer months, in autumn and winter it is scarcely ever light. This means that lighting is in constant use. During the long and hard winter months, low energy prices have meant that most heating systems are operated with hydroelectric power. Therefore the consumption of electricity in Norway is one of the highest worldwide.

1.1 Breakdown of hydroelectric power stations according to installed capacity

Depending on output, power stations are divided into

- micro power stations ≤ 100 kW,
- mini power stations 100 kW–1,000 kW (1 MW)
- small power stations 1 MW–10 MW,
- large power stations > 10 MW.

2 Electricity generation by hydro-power turbines

Rainwater flows from higher regions down to valleys. In hydro-power plants its energy is converted to mechanical energy, or to be more precise rotational energy, by turbines and to electrical energy by generators.

2.1 Traditional types of turbine construction

2.1.1 Pelton turbine

In 1879 the American engineer Lester Pelton built the Pelton turbine in order to use small volumes of water falling from great heights efficiently. The water flows through one or more adjustable nozzles, forming a circular jet which hits spoon-shaped rotor blades arranged in pairs on an impeller **(Fig. 2)** at high speed. The rotor blades deflect the jet of water and convert its impulse into rotational energy. Because of the high speed, the Pelton wheel can be connected directly to the generator shaft.

Fig. 2:
The impeller of a Pelton turbine

Fig. 3:
The impeller of a Francis turbine

2.1.2 Francis turbine

In run-of-river power plants and storage power plants with medium flow rates, Francis turbines are used. The Francis turbine is by far the most widespread type of turbine. The water flows radially onto the stator and is directed by its guide vanes onto the impeller in a favourable direction of flow **(Fig. 3)**. The Francis impeller, with its numerous curved rotor blades, deflects the water from its radial inflow into an axial outflow. At the same time it uses the swirling momentum of the water as it is taken into the rotor to produce a turning moment. A distinction is made between Francis flume type turbines and Francis spiral case turbines.

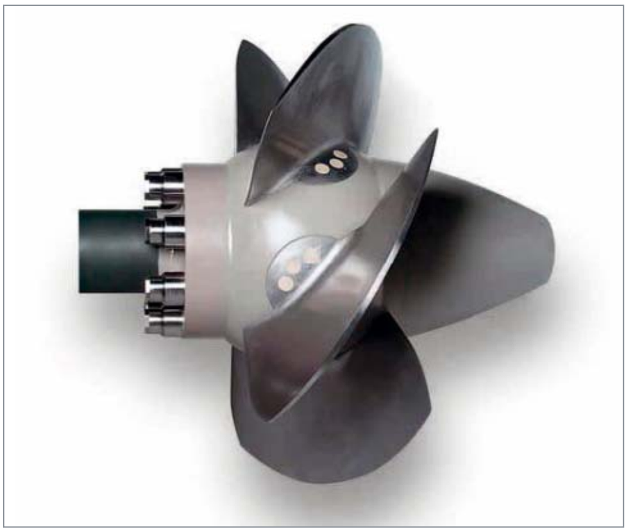

Fig. 4:
The impeller of a Kaplan turbine

2.1.3 Kaplan-Turbine

The Kaplan turbine is suitable for converting the energy contained in rivers with a low falling height and large water volumes. On the basis of the Francis turbine, which was already in existence at the time, Professor Viktor Kaplan from Austria developed the Kaplan turbine named after him in 1913. In the original construction the water flows through a shaft radially to a rotor, is deflected by 90 and then moves an impeller, which is similar to a ship's propeller, in a rotary motion **(Fig. 4)**. A particular feature of the Kaplan turbine is its dual regulation. On the one hand the rotor controls the flow of water with its moving blades. On the other hand the blades of the impeller are also movably mounted and can be hydraulically aligned.

The characteristic conditions for choosing hydropower turbines are summarised in **Table 1**.

The Pelton and Francis turbines described above work with larger falling heights and therefore require a turbine pipeline capable of taking high loads for supplying the water from the high-altitude storage location. Ductile iron pipes have proved to be excellent for these turbine pipelines. For the future expansion of the production of renewable energy using water power in Norway it will be a matter of using the considerable geodesic height difference between the high point (water reservoir) and the low point (turbine). The power station pipelines needed for this are therefore usually high-pressure lines.

The hydroelectric power stations with turbines currently in the planning stage, which go up to an output of that of a small power station (1 MW to 10 MW), mostly require penstock pipelines in nominal sizes DN 200 to DN 1000. The height differences typical in Norway result in operating pressures from 40 bars to more than 80 bars at the turbine inlet. Ductile iron pipes to EN 545 [1] are extremely suitable for high-pressure applications and have proved themselves over many years in this area of use.

3 The advantages of ductile iron pipe systems for the construction and operation of turbine pipelines

The following advantages make ductile iron pipe systems the perfect solution for use in turbine pipelines:

- The wall thickness can easily be adapted to the operating pressures envisaged. The robust cast iron material has a high safety margin in terms of resisting pressure surges.
- Installation is very broadly independent of the weather.
- Because of the robust nature of the pipes and their relatively short length, installation on steep gradients and in rocky substrates is possible without problem.

Table 1:
The main criteria for selecting the appropriate type of turbine

Type of turbine	Pelton	Francis	Kaplan
Falling height	20–1.200 m	1–125 m	2–35 m
Outflow	20–8.000 l/s	100–20.000 l/s	1.000–200.000 l/s
Efficiency	85–90 %	85–90 %	85–91 %

- The pipe joints can undergo a high degree of deflection, which means that the pipeline can be adjusted to the route without extra fittings.
- Additional forces on bends and deflected joints can be dissipated into the substrate.
- When cement mortar coating is used for external protection, the existing earth can be used for backfilling, which dispenses with the need for transporting bedding material.

3.1 Types of joint for ductile iron pipe systems

Since its introduction in 1957, the TYTON® push-in joint **(Fig. 5)** has been the leading joint for pipes and fittings in ductile cast iron on the international market. The profiled seal consists of one hard and one soft rubber compound. The joint can be deflected up to 5 , is root penetration resistant, simple to assemble and remains tight up to the bursting pressure of the pipes. Ductile pipes and fittings with this non-restrained joint are primarily designed for conventional laying in open trenches. With TYTON® push-in joints, thrust blocks must be provided at bends, branches and reductions etc.

The BLS® push-in joint **(Fig. 6)** has proved itself over decades and is assembled together with a TYTON® seal. Depending on the nominal size and type of use, the joint is locked against longitudinal forces by means of 2 to 4 locks or with locking segments in cast iron. It is simple, fast and safe to assemble, allows for high permissible operating pressures and tractive forces and is universally applicable. Pipes and fittings with this joint can take very high permissible operating pressures and the resulting forces on bends, branches and reductions etc. The construction of thrust blocks can thus be avoided, which saves the expensive transport of concrete in mountainous regions.

Turbine pipelines are predominantly laid in extreme types of terrain with steep gradients. When installing pipelines on steep slopes, the BLS® push-in joint also serves as an installation aid: when laid downwards in the open trench, it prevents the pipe joint from being pulled apart during installation.

Fig. 5:
TYTON® push-in joint to DIN 28603 [2] –
DN 80 to DN 1000 (non-restrained)

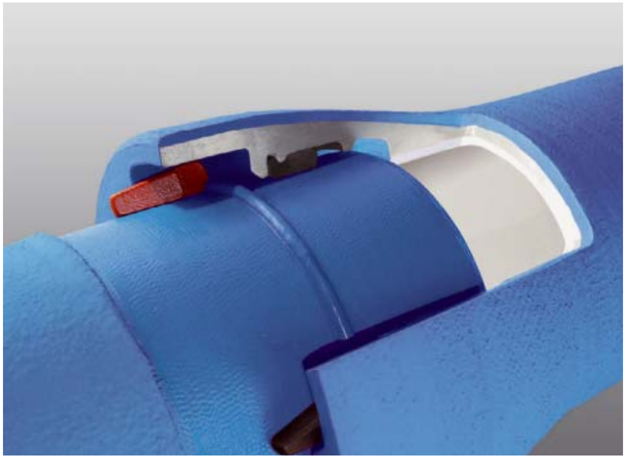

Fig. 6:
BLS® push-in joint with locks inserted –
DN 80 to DN 1000 (restrained)

3.2 Permissible operating pressures for ductile iron pipe systems

With penstock pipelines, depending on the geodesic altitude, the operating pressure increases as you go downwards. Therefore it may be commercially advisable to divide the route into different pressure areas and to select the correct wall thickness of the iron pipe for each.

Tables 2 and 3 show the permissible pipeline component operating pressure (PFA) for the respective nominal sizes, depending on the pipe joint selected. It must first of all be borne in mind here that when using a restrained system, the permissible component operating pressure is lower than that for pipes with non-restrained joints.

Table 2:
Permissible pipeline component operating pressures (PFA) for ductile pressure pipes with TYTON® push-in joints

DN	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
PFA [bar]	205	177	178	155	138	127	100	98	82	61	76	73	57	43
Angular deflection [°]	5	5	5	5	5	5	5	4	3	3	3	3	3	3
PFA stated for TYTON® pipes, not for fittings														

Table 3:
Permissible pipeline component operating pressures (PFA) for ductile pressure pipes with BLS® push-in joints

DN	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
PFA [bar]	100	100	100	100	100	100	100	45	30	40	25	25	25	25
Angular deflection [°]	5	5	5	5	4	4	4	3	3	2	1,5	1,5	1,5	1,5
PFA stated for BLS® pipes, not for fittings, higher pressures on request														

The reason for this lies in the fact that, with non-restrained joints on bends, branches, reductions etc., concrete thrust blocks are constructed in order to dissipate the forces resulting from the internal pressure into the ground. The stress from internal pressure is uniaxial and runs in the circumferential direction. Longitudinal stresses do not occur.

With the restrained system, the joints transmit the resulting forces to the next pipe, meaning that the total force is transferred into the ground by skin friction across a number of pipes. In this case the internal pressure produces a triaxial stress state in the circumferential, longitudinal and radial direction, which reduces the PFA.

3.3 External protection with cement mortar coating

Ductile iron pipes with cement mortar coating **(Fig. 7)** to EN 15542 [3] can be used in all soils to DIN 50929-3 [4]. Cement mortar coating prevents the ingress of aggressive media against the metal material and also withstands mechanical loads during transport and installation.

Penstock pipelines are frequently installed on a steep gradient and here the cement mortar coating offers the advantage that the production of a so-called anode backfill bedding (often a sand and gravel bedding) may not be necessary.

The existing earth, with grain sizes of up to 63 mm (individual stones to max. 100 mm) is used for backfilling. Costly transportation of excavation and bedding materials is thus avoided, during transport to the installation site the cement mortar coating with its high impact resistance protects the ductile iron pipe in harsh day-to-day site conditions. The cement mortar layer is applied to the zinc-coated outside surface of the pipe and the active protective effect of the zinc coating beneath remains effective.

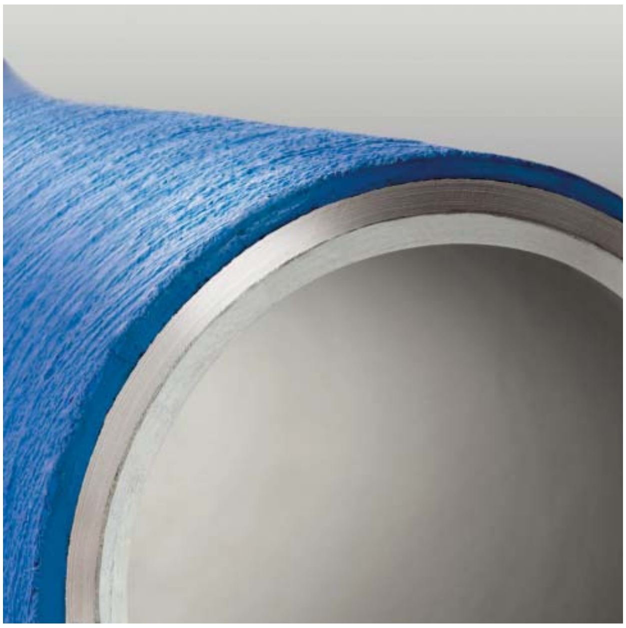

Fig. 7:
Ductile iron pipe with cement mortar coating

4 Calculation of permissible pressures for ductile iron pipes

4.1 Flexible non-restrained push-in joints

For pipes with the non-restrained TYTON® push-in joint the PFA value, depending on nominal size and minimum wall thickness, is calculated with the help of equation (1) as per EN 545 [1] with a safety factor of 3 as against tensile strength. This means that, with penstock pipelines, possible pressure fluctuations are covered and possible pressure surges are minimised by the installation of so-called surge tanks or even by isolation valves with a controlled speed of closing.

$$PFA = \frac{20 \cdot e_{min} \cdot R_m}{D \cdot S_F} \text{ [bar]} \qquad (1)$$

e_{min}	[mm]	minimum wall thickness
D	[mm]	mean pipe diameter ($DE - e_{min}$)
DE	[mm]	nominal external diameter of the pipe
R_m	[MPa]	minimum tensile strength of the ductile cast iron (420 MPa)
S_F	[-]	safety factor (= 3,0)

According to the requirement for flexible restrained joints in EN 545 [1], the joints must prove their performance in accordance with **Table 4** in type tests under the least favourable conditions of limit deviations and angular deflection and/or decentring. For this purpose, a series of tests lasting a number of hours is carried out with one type of pipe. This type test is then considered as representative evidence of the performance of pipes supplied of the same type.

4.2 Flexible restrained push-in joints

The PFA of pipes with flexible restrained push-in joints cannot be calculated with formula (1). Meanwhile, modern calculation processes (e.g. FEM analysis) have become available for this, but the standard prescribes type testing in every case. This is monitored and certified by an accredited test institute. **Figure 8** shows an example of a certificate for type testing in accordance with DIN EN 545.

DUKTUS

Bescheinigung Nr. - DUKTUS 2013 – 00XX

Wetzlar, XX.XX.2013

Bescheinigung
über
Typprüfung gemäß DIN EN 545

Prüfgegenstand: Rohre aus duktilem Gusseisen für die Wasserversorgung
Verbindungssystem BLS/VRS-T
Nennweite DN XXX, Nenndruck PN XX
(repräsentativ für den Bereich DN XX - DN XXXX)

Prüfungen: Prüfung der Funktionsfähigkeit gemäß Abschnitt 7.2 der DIN EN 545

Positiver hydrostatischer Innendruck	Prüfdruck: 000,0 bar Prüfdauer: 2 h	Unter Scherlast Unter Abwinkelung: X°	bestanden bestanden
Negativer Innendruck	Prüfdruck: -0,9 bar Prüfdauer: 2 h	Unter Scherlast Unter Abwinkelung: X°	bestanden bestanden
Positiver hydrostatischer Außendruck	Prüfdruck: 2 bar Prüfdauer: 2 h	Unter Scherlast	z.B.(konform)
Zyklischer hydrostatischer Innendruck	24000 Zyklen	Unter Scherlast	z.B.(nicht erforderlich)

Der Sachbearbeiter — Leitung Entwicklung — Leitung QM

Vorname Nachname — Vorname Nachname — Vorname Nachname

Die durchgeführten Prüfungen und deren Ergebnisse sind im Prüfbericht xxxxxxx -000-00-00 dokumentiert.

Prüfungen beziehen sich ausschließlich auf die Prüfgegenstände. Veröffentlichung und Auszüge bedürfen der schriftlichen Genehmigung der Duktus Rohrsysteme.

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Fig. 8:
Example of a certificate for type testing in accordance with DIN EN 545

Table 4:
Function requirements in accordance with EN 545 [1]

Type of pressure loading	Test pressure [bar]
Positive hydrostatic internal pressure	1,5 PFA + 5
Negative internal pressure	– 0,9
Positive hydrostatic external pressure	2,0
Cyclical hydrostatic internal pressure – 24,000 pressure cycles	between PMA and (PMA - 5)

Fig. 9:
Ductile iron pipe in the pipe store at Tverraga

Fig. 10:
Completed steep-gradient pipeline with restrained BLS® push-in joints

Fig. 11:
Working on a steep slope – preparation for the assembly of a BLS® push-in joint

5 Pictures of penstock pipelines in Norway

Figures 9, 10 and 11 show penstock pipelines recently installed with ductile iron pipes in Norway.

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Korrosion der Metalle;
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Rohrleitungen und Bauteile in Böden und Wässern
[Corrosion of metals;
probability of corrosion of metallic materials when subject to corrosion from the outside;
buried and underwater pipelines and structural components]
1985-09

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Small hydroelectric power plant at Ossasco, in the Bedretto valley

By Roger Saner

1 Introduction

The Bedretto valley in the North of the Canton of Ticino extends from Airolo at the foot of the Gotthard Pass all the way up to the Nufenen Pass into the Canton of Valais. The long valley between the Gotthard and Cristallina massifs has particularly high snowfalls in winter. In summer the Bedretto valley is a versatile hiking and mountain-biking area.

2 Small hydroelectric power plant project

The company CEL Bedretto SA received approval from the Canton of Ticino to use the water from the Riale Cristallina in a small hydroelectric power plant to produce electricity for the Bedretto valley. The water extraction for the new Ossasco small hydroelectric power plant is located at a height of 1,544 m above sea level, from where the water will be transported in an underground pressure pipeline to the production station in Ossasco at 1,311 m above sea level.

The maximum available volume of water is limited to Q = 700 l/s at a maximum static pressure of 23 bars at the level of the turbine shaft. When determining the dimensions of the pressure pipeline, a supplement of 20 % was to be taken into account for the pressure surge. The energy is converted by a multi-jet Pelton turbine with vertical axis and then the water is returned to the Riale Cristallina. The routing of the new pressure pipeline was to be carefully investigated in advance with a view to secure and economical operation.

3 New vonRoll ECOPUR pressure pipeline

vonRoll ECOPUR ductile iron pipes with their technical performance are predestined for the construction of pressure pipelines for small hydroelectric power plants.

In the choice of material the following criteria were of prime importance for the developers:

- the excellent mechanical and static strength characteristics of the ductile iron pipe system,
- the flexible vonRoll HYDROTIGHT restrained push-in joint,
- the PUR lining to EN 15655 [1] for the highest hydraulic performance and
- the pore-free PUR external protection to EN 15189 [2].

So the new pressure pipeline was constructed with DN 600 vonRoll ECOPUR full-protection pipes produced in Switzerland in accordance with EN 545 [3]. The useful hydraulic internal diameter of the polyurethane (PUR) lined vonRoll ECOPUR pipes is 614.8 mm with K 7 pipes and 610.4 mm with K 9 pipes. Together with the mirror-smooth PUR lining **(Fig. 1)** with a roughness coefficient of $k \leq 0.01$ mm, this makes maximum efficiency possible for energy conversion in the production station.

Also used in the pressure pipeline system were the well-proven vonRoll ECOFIT fittings with full-protection epoxy resin coating in accordance with EN 14901 [4] and with the enhanced requirements of RAL GZ 662 [5] of the GSK (Gütegemeinschaft Schwerer Korrosionsschutz von Armaturen und Formstucken durch Pulverbeschichtung e. V.).

Fig. 1:
Mirror-smooth PUR internal coating, hydraulically smooth with a roughness coefficient of $k \leq 0{,}01$ mm

Fig. 2:
Manhole for maintenance and overhaul work in construction, designed with DN 600/600 double-socket tee with flanged 90° branch, coated with epoxy resin. In the final version, equipped with DN 600 black flange incl. baffle plate

The new pressure pipeline was divided into two sections with different pressure stages. On its arrival in the pressure pipeline the water runs through a flow meter in order to record the effective volume of water used and continuously monitor the tightness of the pressure pipeline. Control openings are arranged at regular intervals. These are designed with DN 600/600 double-socket tees with flanged 90° branches **(Fig. 2)** and are also equipped with baffle plates. Here again this means that pressure losses can be restricted to a minimum. In the upper section, along a slightly sloping unpaved road and with a maximum operating pressure of 5 bars, over a length of 345 m the pipeline was constructed with DN 600 vonRoll ECOPUR pipes in wall

Fig. 3:
vonRoll ECOPUR pipes with reinforced coating (PUR) to EN 545 [1], very resistant in rocky terrain, suitable for grain sizes 0-63 mm, largest size 100 mm, secured with vonRoll HYDROTIGHT thrust protection

thickness class K 7. Because of the low operating pressure, thrust protection was not necessary in the pipe joints.

In the lower section the route of the pressure pipeline mainly runs through steep, rocky terrain. In this section, with a maximum operating pressure of 23 bars, DN 600 vonRoll ECOPUR pipes in wall thickness class K 9 with restrained joints were used. The polyurethane (PUR) coating of the pipes, classified as reinforced coating according to EN 545 [3], proves to be extremely resistant in this difficult terrain and grain sizes up to 63 mm, largest size 100 mm, can be used for bedding the pipes **(Fig. 3)**. In order to get over a steep face, the pipes had to be assembled in a channel cut into the rock on steel frames anchored into the rock. At exposed points the pipeline was bedded in concrete.

The entire 575 m length of the pipeline in the high pressure area was secured with restrained vonRoll HYDROTIGHT joints, Fig. 2805 **(Fig. 4)**. In order to avoid having to cut pipes on site, short pipes in different lengths with welded beads applied in works, were supplied by the manufacturer. These pipes too are protected with polyurethane over the whole of their surface. The time-consuming application of welded beads and subsequent repairs to the coating on site was thus unnecessary. The full protection of the pipe system remains secured after the assembly of the vonRoll HYDROTIGHT push-in joints.

Fig. 4:
Assembly of the ductile pipes above ground in the steep rock face

Fig. 5:
Installation of vonRoll ECOPUR full-protection pipes with a site cableway in steep, inaccessible terrain

Fig. 6:
Storage for ductile iron pipes and fittings

In the steep, inaccessible terrain the light weight of the vonRoll EOCPUR full-protection pipes was helpful to the installation contractor, but the installation work had to be accomplished using a site cableway **(Fig. 5)** and helicopter transport.

After completion of the pipe assembly work, the tightness of the entire pressure pipeline system was tested by means of a tightness test with water lasting 24 hours.

After 16 months of construction, the small hydro-electric power plant was able to go into operation in June 2012.

In this project, it was an advantage for the developers that the pipe supplier could react flexibly with short delivery times and means of transport **(Fig. 6)**.

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Hydroelectric power station in Nauders, Tyrol has gone into operation

By Roland Gruber

1 Introduction

The Tyrolean three-border district of Nauders had to wait in trepidation for six long years before they got the approval written down in black and white in December 2011. The authorities had given the green light for the Stiller Bach power station project costing just about 5 million euros. So nothing was standing in the way of the implementation of the district's own small hydroelectric power station.

Meanwhile the construction work has almost been completed. The water catchment area is ready for use and also the work on the machine hall and the pressure pipeline in ductile iron pipes **(Fig. 1)** has been completed as well. Trial operation was commenced in the 4th quarter of 2013. In a normal year the hydroelectric power station will produce about 8.5 GWh electricity, which makes it one of the biggest small hydro-electric power stations in the three-border district.

Fig. 1:
Ductile iron pipes – pipe store for the construction of the pressure pipeline for the Stiller Bach hydroelectric power station in Nauders.

The municipality of Nauders commissioned the experienced design office of BERNARD Ingenieure ZT GmbH based at Hall in Tirol with the production of a permit application design which, in the end, should show a marked difference in terms of the route to be taken as compared with the original power station plans from TIWAG (Tiroler Wasserkraft AG).

2 Feed water from two streams

The main challenge consisted of planning an economic power station which would be low-maintenance over the long term in sometimes difficult topographical conditions. There were no alternatives for the locations of water catchment and machine hall, on the one hand because catchment was arranged to be just beneath the confluence of the Stiller Bach and Labaunbach in order to be able to use as much driving water as possible and on the other hand because the powerhouse needed to be located directly at the point where the Stiller Bach flows into the Inn. However, planning the route of the around 1,080 m long pressure pipeline **(Figs. 2 and 3)** was more time-consuming. In the end it was conceived in such a way that, in the uppermost flat part after the sand trap **(Fig. 4)**, it runs for about 270 m in the Reschenstrasse (B 180), with about 200 m of this being within the structure of the gallery. Shortly before the gallery passes into the tunnel, the pressure pipeline comes out of the road and from there it follows the route along the somewhat exposed "old Reschenstrasse". In this area the route makes a 90° turn and then runs over the steep slope, which has gradients of up to 45°, down to the machine hall on the bank of the Inn. Without doubt the installation of the pressure pipeline in the steep gradient was to be the greatest civil engineering challenge of the project.

Fig. 2:
The route of the DN 800 pressure pipeline for the Stiller Bach power station

Fig. 3:
Pipeline route in rocky terrain

Fig. 4:
Double-chamber sand trap at the catchment structure

3 Water quality becomes a problem

The signs that the power station project could be realised within a manageable period were auspicious to begin with. In the end the operator had a very good argument on his side: all the land involved belongs to the farmers' cooperative of Nauders. And since this is administered by the district authority, the way was open as regards the entire route. But for the future hydroelectric power station operator from the three-border region, this was the first project of its kind – and it was quite soon to emerge that things were not proceeding as quickly as one had hoped. Official requirements regarding the volume of water that could be used as well as the question of residual water proved to be costly and time-consuming for the planning engineer commissioned – and many other stumbling blocks gave the community leaders some headaches.

In the planning phase, deficiencies were detected in the water quality when readings were taken above the planned catchment area. Apparently there had been contamination of the water from the sewage treatment plant, which had a problem at this time. The result of this was that an additional pipeline needed to be envisaged from the sewage treatment plant to the pressure chamber of the sand-trap for the outflow from the sewage treatment plant. This would have added around 300,000 euros to the costs and would have jeopardised the economy of the entire project. Luckily, the problem with the sewage treatment was solved shortly afterwards, meaning that no further contamination could be detected in the water – and this additional pipeline became unnecessary again.

4 Reaching the goal after 5 years

In autumn 2011 there were some jitters once again because there was the fear that the project would have to undergo environmental impact assessment; this would without doubt have taken things right back to square one in terms of planning. An assessment procedure was initiated by the relevant authorities in accordance with environmental impact assessment legislation during the course of which the opinion of official experts was sought. From this it was to be understood that the catchment – based on riverbed extraction via a Tyrolean intake – would not involve any impoundment of water. In addition it was established that, from a hydraulic engineering point of view, there would be a stretch of free-flowing water between the planned Stiller Bach power station and the joint-venture Inn power station also planned in the district of Nauders. In the end these were the crucial arguments as to why there was no obligation to have an environmental impact assessment.

Thus the last big hurdle was overcome and on 5 December 2011 the day had finally come: just 6 years after the first submission of the project, the community officials received planning permission for the Stiller Bach power station. It could go ahead.

5 Traffic should not be held up

Under the leadership of BERNARD Ingenieure ZT GmbH, all the components of the power station were subsequently put out to tender and orders were placed for them by summer 2012 with the contractors with the best assessment. Preliminary preparations, site facilities and the initial construction work were started as early as autumn 2012. Shortly after that the whole construction site had to pause for the winter break.

Nauders itself lies at an altitude of just about 1,400 m above sea level. The site presented the typical challenges of mountainous terrain, added to which was its strategically important position for traffic in the three-border region with the Reschen Pass and the Finstermünz Pass. So that the construction work would not hold up the traffic for too long, the authorities imposed a relatively narrow time frame. The pipeline had to be installed in the B 180 and the two lanes of the Federal highway had to be released to traffic again in time for the busy Whit weekend. The construction team assigned to the task succeeded with this perfectly within 4 weeks.

6 Protection against rock fall

One of the most important tasks for the planners was to protect construction workers against falling rocks because, with the exception of the machine hall location, this hazard was something to be reckoned with along the entire length of the route. Reason enough for the authorities to demand geological construction supervision. The district authority also entrusted this to the Hall design office. Among other things the authorities stated that the hazard areas must be mapped out and defined by the geological construction supervisors. In the "old Reschenstrasse" area, comparatively extensive temporary rock fall protection measures were set up **(Fig. 5)**. During the work on these protective measures, a new cleft opening in the rock was discovered with dimensions not known to date. In view of the rock avalanche event of 2011, somewhat to the North of the planned pipeline route in the area of the "old Reschenstrasse", when a volume of some 150 m^3 broke away and came down, this newly discovered cleft opening was naturally going to attract a great deal of attention. In the end it was decided that the section of rock in question should be monitored with electronic crack control equipment with an optical and acoustic warning device. This crack monitoring was supplied, installed and evaluated by the design office. The purpose and good sense of this measure was confirmed more than once by rock fall events during the construction period – and it contributed considerably to the fact that so far no accidents or damage have occurred.

7 Ductile iron pipes best suited to the job

With these safety measures in place, the installation of the pressure pipeline could now also be tackled in this difficult terrain. Here – and indeed over the whole length of the route – pipes in ductile cast iron with nominal size DN 800, PFA 25 bars **(Figs. 6 and 7)** were used. These had been offered as an alternative by the successful bidder in the tendering process. From the start it was clear that ductile cast iron as the pipe material was best qualified for this purpose. When considering the steep slope, steel pipes were also considered but, on the one hand, this would have meant bringing another contractor on board for the welding work and, on the other hand, with a steel pipeline one could not expect the type of flexibility which – not least thanks to a special solution – was offered with the ductile iron pipes. GRP pipes were ruled out from the start, partly because of the high operating pressures and partly because the substrate is extremely rocky and therefore bedding would be very expensive. Also working in favour of ductile iron pipes is their capacity for movement in the socket, which permits angular deflection of up to 1.5°. This would allow the entire pipeline to be easily adapted to these difficult topographical conditions.

8 Slope creep calls for a flexible pipeline

Particular attention was given to the pipe manufacturer's proposal with a special solution which was conceived for the extremely difficult geological conditions of the steep gradient. Fixed points were determined for the steep section by the planning engineer in collaboration with the internal geological, geotechnical and statics departments and static calculations and dimensions were determined for these. In the top part of the slope, two fixed points were anchored into the rock. Creep movements in the hillside are to be reckoned with in this area and these also entail longitudinal movements in the pressure pipeline. For this case, so-called "expansion pieces" were supplied by the pipe manufacturer

Fig. 5:
Rock fall protection measures along the pipeline route

Fig. 6:
DN 800 ductile iron pipes and fittings ready for installation

Fig. 7:
DN 800 ductile iron pipes with cement mortar lining

which can take up these creep movements up to about 350 mm. Specifically, with a movement of this kind, the pipeline is drawn out of the socket at the top end and pushed by the same amount into the one which is fixed at the lower fixed point via a thrust resistance device. In this way the pressure pipeline is given a certain axial flexibility. The other three fixed points on the steep slope are located on ground bearing vegetation where no slope movements of this kind are to be expected. In order to reduce any slope creep pressures which might occur, the pipes were also covered with pipe protection fleece and the pipe joints were provided with socket cones (socket protection sheets). From the planning point of view, all these measures serve to ensure a lastingly maintenance-free steep section even under difficult geological conditions. Restrained ductile iron pipes with VRS®-T/BLS® push-in joints were used on the steep slope and their installation was anything but simple, even though there were no problems. Only a few operators of walking excavators ("spiders") will venture onto such steep inclines; a specialist handled the work with supreme skill **(Fig. 8)**. In the steepest section the spider was secured by a rope and the pipes were delivered by a special truck with a 30 m boom. Thanks to the simple assembly technique with ductile iron pipes, the installation went quite quickly. Problems arose to some extent when it came to storing materials close to the trench and these also had to be secured.

Fig. 8:
Skilful use of a walking excavator with boring tool in steep terrain

Fig. 9:
Eccentric steel cone – transition from the pressure chamber of the sand trap to the pressure pipeline

9 High quality equipment

The pressure pipeline is already under the earth – pressure testing has taken place. Also the water intake structure with its hydraulic steel equipment, supplied by GMT-Wintersteller GmbH from the Kuchl district of Salzburg, is ready. In addition to various protection devices, the screen for the Tyrolean intake and the fine screen, the hydraulic steel construction company has also delivered two short steel pressure pipeline units with DN 800 and DN 400 for the power station to the North of the Reschen Pass; both pipe sections lined with cement mortar. Also the proven telescopic arm screen cleaning rig with a 2.7 m cleaning range from GMT Wintersteller GmbH. The eccentric steel cone is a one-off design. It tapers off over a length of 2.2 m from DN 1200 to DN 800 and forms the transition between the pressure chamber of the sand-trap to the pressure pipeline **(Fig. 9)**.

Also the work on the machine hall on the bank of the Inn **(Figs. 10 and 11)** was done perfectly to schedule, so that it was only late summer 2013 when the assembly of the machines could start. The contract for the electromechanical equipment of the power station was awarded to the Troyer AG company from Sterzing, which supplied a vertical-axis, four-nozzle Pelton turbine. With the specified hydraulic conditions (water flow rate 1.4 m^3/s and net head height 185 m) this is designed to 2,260 kW. To complete the set of high-quality machines, the contract for the generator went to the Linz engine company HITZINGER GmbH. Together, this duo will produce around 8.5 million kWh of clean electricity from the Stiller Bach per year.

10 The biggest investment by the community

It is still too early for the operator to work out and put together the results of the power station project. Indeed there are not all that many examples where a community, all on its own and without partners, builds a hydroelectric power station. The plant is an investment which will benefit the next generation in Nauders. After all, 4.9 million euros were invested in the project – by far the biggest single investment made by the community in recent years. It will of course be a few years before the investment is amortised. But once it has been paid off, according to current calculations, the community can count on an annual return of about 420,000 euros from the power station. And, for a small community

Fig. 10:
Construction of the machine hall of a considerable dimension

Fig. 11:
New machine hall at the mouth of the Inn

Fig. 12:
Contented faces at the site visit – (from the left) Deputy Mayor Helmut Spöttl, Werner Siegele (TRM) and Mayor Robert Mair

such as Nauders, that is a really large amount. In any case, the community leaders **(Fig. 12)** of the three-border area showed not merely foresight and the courage to innovate but also tenacity and endurance. And they were rewarded in the spring of 2014 when the Stiller Bach power station was able to go into operation on schedule.

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Trenchless replacement of a fire main using the burst lining technique

By Stephan Hobohm and Alexander Bauer

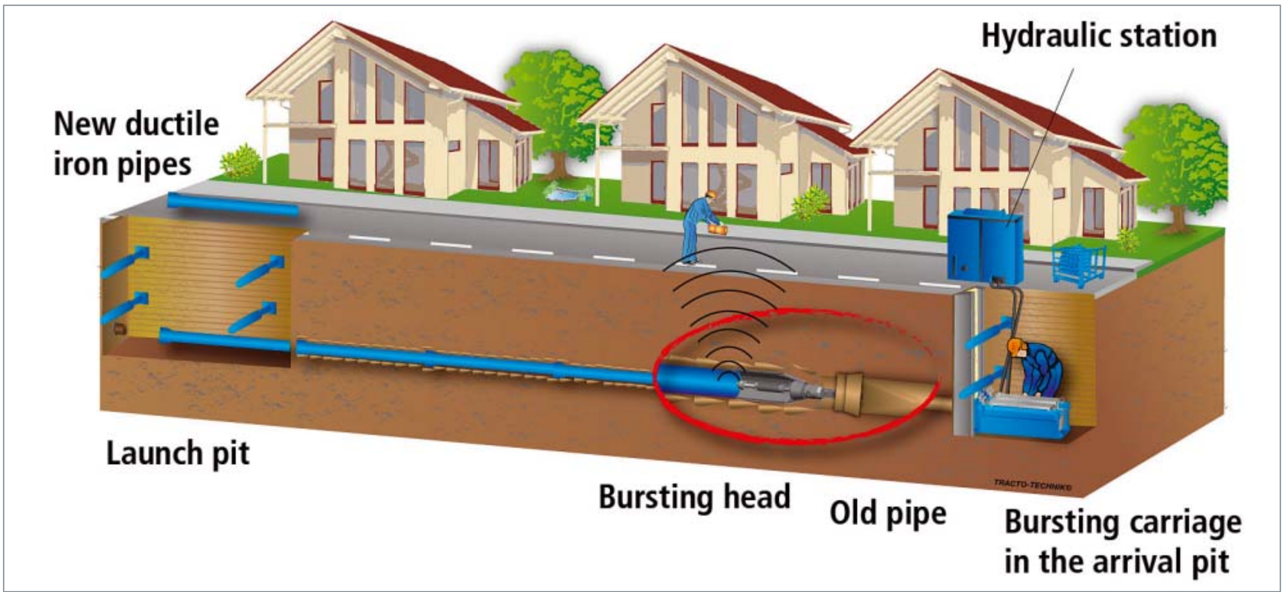

Fig. 1:
Schematic representation of the burst lining process
Source: TRACTO-TECHNIK, Lennestadt

1 Starting point

Since 1976, the BASF northern inland port in Ludwigshafen has been a transhipment point for combustible fluids such as naphtha, methanol and compressed liquefied gases. 2,536 tankers moored here in 2008 and transferred close to 2.86 million tonnes of goods. The port is mainly used to supply BASF with raw materials: around 88 % of the volumes unloaded are input materials and only 12 % of the goods transferred leave the port. Each day the harbour basin – an area of about 140,000 m² – is the destination of seven ships on average. From the control station at the port, BASF personnel monitor the transhipment of goods around the clock with more than ten moving cameras.

If, despite every care, products should get into the harbour basin during loading or unloading, or if other problems should arise, the employees can set the following safety measures into motion immediately from the control station:

- activate pneumatic oil barriers,
- have snake lines installed by the work fire department as an additional barrier,
- arrange emergency shut-off of the flow of product by means of a quick-release system,
- in case of fire, commence extinguishing using foam-water extinguishers.

These foam-water extinguishers have been supplied with water since the commissioning of the port by means of steel pipelines of nominal sizes DN 300, DN 400 and DN 500 installed underground. However, because of the increasing number of leakages, the existing piping system no longer meets the very high BASF safety requirements. Therefore it was decided to replace the existing pipelines.

But there were a few constraints to be taken into account. The security of supply of the extinguishing equipment had to be guaranteed even during the replacement operations and access had to be kept free for works traffic and the fire services. Accordingly the thinking went in the direction of the trenchless laying of a new piping system in order to block circulation areas as little as possible.

Therefore burst lining **(Fig. 1)** came to the forefront as the only realistic possibility. Because only burst lining can

- replace pipes along the same route,
- install a new pipe with the desired working life and pressure stage,
- minimise restrictions to traffic and
- keep construction costs to a reasonable level.

2 Planning

Planning was done in-house by the competent specialist departments of BASF. The most important specifications and constraints to be observed here were:

- The main pipelines had to be replaced using the trenchless technique to the greatest extent possible in order to keep traffic disruptions as slight as possible.
- The branch lines going towards the hydrants could be replaced by open trench method.
- The lengths of the main pipelines to be replaced using the trenchless technique were:
  - 110 m DN 300,
  - 580 m DN 400,
  - 1,050 m DN 500.
- The existing pipeline material was steel (welded), unlined and bitumen-coated on the outside, year of construction 1976.
- All the main pipes mentioned above were to be replaced along the same route and in the same nominal size.
- The pipe cover was on average 2 m to 2.2 m.
- The soil on site consists of non-cohesive, in some places very close grained sand. The entire terrain was dredged and filled in the middle of the 1970's.
- The new pipe material was to be suitable for an operating pressure of 16 bars.
- Excavations were to be kept as small as possible.
- Section lengths of up to 222 m between the changes of direction of main pipelines were to be replaced. Between these points, a straight run was to be assumed.
- Changes of directions and feeder branch lines were to be installed in open trenches. The operability of fire extinguishing equipment was to be ensured at all times.

With these specifications and constraints it became clear relatively quickly that the renewal of the main pipelines using the burst lining process was the means of choice. Other renewal possibilities were excluded for technical reasons, such as the loss of hydraulic performance because of a reduction in the cross-section, or for economic reasons. With ductile iron pipes using the burst lining technique it was possible to meet the conditions stated.

Burst lining is used for the trenchless renewal of pipelines along the same route. It is a process in which the existing old pipeline is broken up by a bursting head and at the same time forced out by an upsizing stage into the surrounding earth while a new pipe string is drawn in. A distinction is made with burst lining between dynamic and static processes. Burst lining was developed in a very dynamic working process from the soil rocket with upsizing head and was originally used for the replacement of sewers made of vitrified clay pipes. However, where distances to adjacent pipelines and structures are too low, these can be put at risk by the vibrations caused. A way out of this dilemma is offered by static burst lining. Here an upsizing head, with a first stage which can be equipped with fracturing ribs, is drawn through the old pipeline by a pulling unit which works continuously and without vibrations, thereby bursting it open. The new pipes are coupled directly onto the bursting/upsizing head and drawn into the channel which is enlarged by an approx. 10 % overcut.

Both burst lining processes, static as well as dynamic, are widely used. DVGW Bulletin GW 323 [1] sets down the criteria for the process along with the associated requirements and tests (further info on burst lining at www.infocenter-berstlining.com).

Burst lining is particularly suitable for old pipes in brittle material such as asbestos cement, vitrified clay or grey cast iron. But also pipes in ductile cast iron or, as in this case, steel can be burst using the static process with the help of special roller cutting heads. An upsizing of nominal size by up to two stages is possible here. With ductile iron pipes the upsizing dimension **(Fig. 2)** must be greater than the external diameter of the socket. Using the upsizing dimension (UD), the required distance to the adjacent utility carriers and the cover height are to be determined according to DVGW Bulletin GW 323 [1]. The following minimum distances are to be observed in accordance with [1]:

- parallel pipeline: > 3 x UD, min. 40 cm,
- parallel fragile pipelines < DN 200: > 5 x UD, min. 40 cm,
- parallel fragile pipelines ≥ DN 200: > 5 x UD, min. 100 cm,
- crossing pipelines within the critical distance, free-lying if possible,
- pipe cover: > 10 UD.

The new pipe material used here is ductile iron pipes to EN 545 [2] for drinking water with restrained BLS® push-in joints **(Fig. 3)** and works-applied cement mortar coating **(Fig. 4)** to EN 15542 [3]. In accordance with [1], only ductile iron pipes with positive locked push-in joints should be used with burst lining. Equally, it is established here that for protection against mechanical loads and damage to the external protection when drawing through, pipes with cement mortar coating are to be used. For the completeness of the external protection in the area of the joint and to avoid the ingress of impurities into the gap between socket and spigot, a combination of a rubber or shrink-on sleeve and a protective steel sheet cone must also be applied. The cement mortar coating provides high-quality corrosion protection as well as being an essential means of mechanical protection for burst lining. Pipes with this coating can be installed in soils of any kind without additional sand bedding. Hence cement mortar coating is both a chemical and mechanical protection. The technical details of the ductile iron pipes with BLS® push-in joints to be installed which are relevant for the project described are summarised in **Table 1**.

The length of the pipes is 6 m. In each case one TYTON® seal, four locks, one rubber sleeve and one steel sheet cone were included in the scope of supply of the pipes.

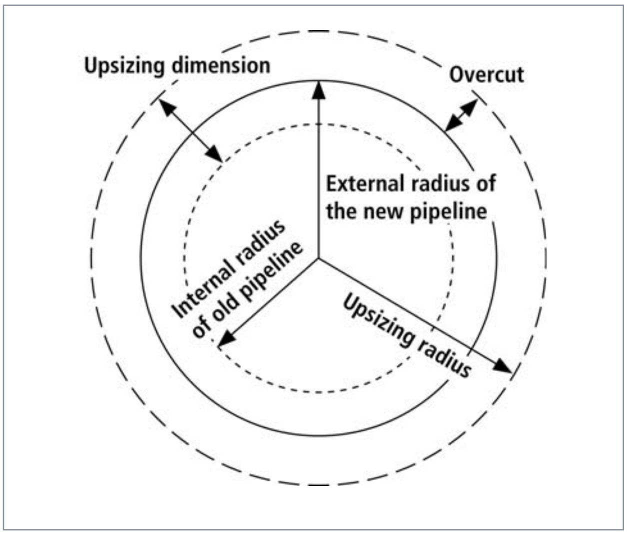

Fig. 2:
Upsizing dimension
Source: DVGW Bulletin GW 323

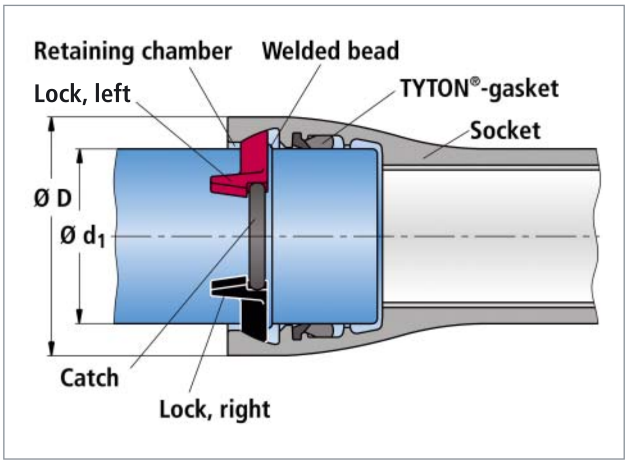

Fig. 3:
BLS® push-in joint
Source: Duktus Rohrsysteme Wetzlar GmbH, Wetzlar

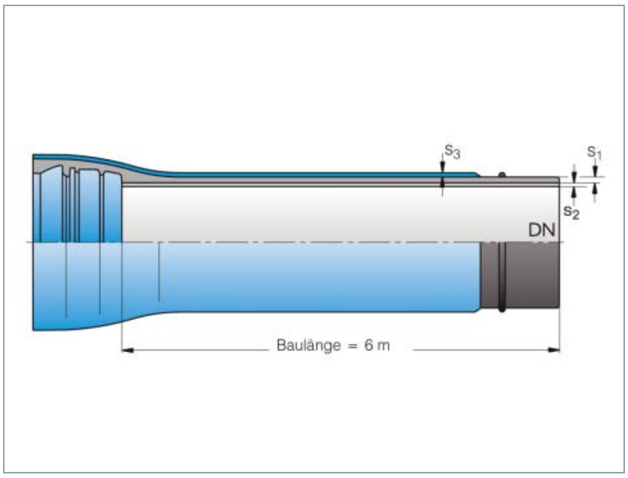

Fig. 4:
Ductile iron pipe with cement mortar coating and BLS® push-in joint
Source: Duktus Rohrsysteme Wetzlar GmbH, Wetzlar

3 Construction work

In order to ensure the response capacity of the fire extinguishing equipment, the emergency water supply was set up first as a preparatory measure. After that the civil engineering work was started. The company commissioned for this, Diringer & Scheidel GmbH & Co. KG, Mannheim branch, had three teams on site for a large part of the construction work – one for civil engineering, one for pipe pulling and one for open-trench pipe laying and for the connections between the drawn pipe sections.

As a first step, the trenches were excavated. According to the planning specifications, 12 machine pits and 11 installation pits were provided. All were produced in similar dimensions of 8 m long x 2 m wide. The length was determined partly by the pipe length of 6 m plus socket and working space and partly by the dimensions of the bursting equipment used including front frame and safety loop. Because there was a steel pipeline running in parallel, the width of the machine pit was restricted. This also had the result that the 250 tonne unit was not used as planned, but instead a somewhat smaller 190 tonne unit was used **(Fig. 5)**. All pits and trenches were produced with corrugated sheeting in the existing banked and quite stable sandy soil. This stability and the difficulty of displacing the soil present would later turn out to be a stumbling block for the planned pull-in lengths. Between the individual installation and machine pits there were distances of between 36 m and maximum 222 m.

So, in May 2012, the actual bursting and cutting open of the old steel pipe and the pulling-in of the ductile iron pipes could begin. Because of the expected high tractive forces of up to 190 t, it was necessary to use thrust blocks to stabilise the traction machine. It was decided that these should not be made of in-situ concrete, but a specially produced, reusable reinforced concrete construction should be used as a thrust block. This could be used for all nominal sizes from DN 300 to DN 500 **(Fig. 6)**.

Then the GRUNDOBURST 1900G including the front frame was positioned in front of the thrust block and the QuickLock bursting string was inserted. It was now possible to assemble the roller-carried knife **(Fig. 7)**, the bursting and upsizing head, the traction gauge and the traction head in the installation pit and couple them to

Fig. 5:
GRUNDOBURST 1900G in the machine pit
Source: BASF SE, Ludwigshafen

Fig. 6:
Reusable reinforced concrete thrust block
Source: BASF SE, Ludwigshafen

Fig. 7:
Roller-knife
Source: BASF SE, Ludwigshafen

Fig. 8:
Upsizing head, traction gauge and traction head
Source: BASF SE, Ludwigshafen

Table 1:
Dimensions, weights, permissible operating pressure (PFA), permissible traction forces and assembly times of ductile iron pipes intended for installation

DN	d_1	D	s_1	s_2	s_3	Weight	PFA	permissible traction force	assembly time
	[mm]					[kg]	[bar]	[kN]	[min]
300	326	410	5,6	4	5	487,9	40	380	8
400	429	521	6,4	5	5	706,9	30	650	10
500	532	636	7,2	5	5	940,9	30	860	12

the bursting string **(Fig. 8)**. The old pipes in steel were first cut open with a special roller-knife and then opened out.

Upsizing was as follows according to nominal size:

- DN 300 ⟶ 495 mm
- DN 400 ⟶ 595 mm
- DN 500 ⟶ 695 mm

In this way, for each nominal size, there was an overcut of 10% to 15% over the BLS® socket of the pipe. Between the upsizing stage and the following traction head was a GrundoLog traction force measuring device. In this way, the actual traction force acting on the pipe material could be checked at any time **(Table 1)**. The data was transmitted by cable to the data logger, because the screening effect of the old pipe material in place made wireless transmission impossible.

The traction head was supplied by the pipe manufacturer. It is the link between the bursting tool and the new pipe string to be pulled in. The connection of the traction head to the first pipe in each case, as with the following pipes as well, was the positive locked BLS® push-in joint.

Once the preparatory measures had been completed, the pipe-pulling began. The first pipe was attached and pulled in. The roller-knives cut open the old steel pipe from underneath on the bottom, while the upsizing head bends the old pipe upwards.

After around 10 minutes and 6 m drawn, the next pipe could be connected up. For this a TYTON® seal to DIN 28603 [4] was inserted into the socket of the pipe already pulled in, the spigot of the new pipe was pushed in, the four BLS® locks plus catch were assembled and the socket protection consisting of shrink-on sleeve and metal cone was applied. This process took approximately 20 minutes. Then the coupled pipe could be

Fig. 9:
Opened steel pipe (foreground) – slight scuff marks on the cement mortar coating of the ductile iron pipe (background)
Source: BASF SE, Ludwigshafen

Fig. 10:
Combination with branches
Source: BASF SE, Ludwigshafen

pulled in straightaway. In this way, installation speeds of up to 72 m (12 pipes) in 5 hours or 30 minutes per pipe were possible.

Unfortunately it quite quickly turned out that the soil could only be displaced with difficulty or scarcely at all. The direct consequence of this was a rapid increase in traction forces and of course also a reduction of section lengths. Because the soil could only be displaced to a limited extent, the cut steel pipe was pushed from the ground onto the sockets of the iron pipes, causing friction and traction force to increase. A further raising of the traction force was caused by the opening up of the steel pipe. This phenomenon occurred directly at the upsizing stage, where the upsizing head pushed the old pipe in front of it and it opened up like an accordion **(Fig. 9)**.

The addition of these individual components quickly led to the permissible traction force, or the traction force limited by the machine technology, being reached. In the end these circumstances halved the average pulling lengths as compared with the planning and thus doubled the number of construction pits. In the end, section lengths of up to 80 m were achieved. Because the machine technology needed to be re-equipped for each new section (duration approx. half a day), the construction time was lengthened accordingly.

From each machine pit there were two drawings – first the section on one side – then the machine was turned round – and then the section on the other side. So in most of the construction pits there were two BLS® spigots facing each other.

These had now to be connected together. In some cases there were also the outlets to branch lines at this point, which had been installed in open trenches. The individual sections were joined with the restrained BRS® system. To do this, first of all the spigots of the pipes were shortened, so that there was no longer any welded bead on them. Then the gap could be completed with flanged sockets, double socket tees with flanged branch, dismantling joints, for example **(Fig. 10)**.

After all the gaps had been closed and the branch lines were connected, all the pipelines could now be tested for leak tightness. As the whole piping system is designed to an operating pressure of 16 bars, the system test pressure was 21 bars. The construction time on the project amounted to half a year.

4 Conclusion

Because of the poor displacement capability of the soil and the resulting number of construction pits, the work took longer and consequently the construction costs also increased. Otherwise the construction work ran more or less without problem. As with all trenchless installation processes, here again it was the terrain which had the overriding influence on outcome and costs. In the present case the construction costs were about 60 % higher than the amount originally scheduled. Sound planning and a qualified specialist are basic requirements for the success of a burst lining project. Here they had to make do with the soil present on site; open-trench installation was excluded for the reasons stated at the beginning.

Because of the low level of intervention in the surface and with traffic, burst lining is an interesting alternative to conventional laying in open trenches. As compared with renovation (e.g. using inliners) the main advantage is that a standard, factory-produced pipe with the full scope of performance (pressure, statics, corrosion protection, working life) can be installed.

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100 kilometres of ductile iron driven piles for the CSP power station – KaXu Solar One – in South Africa

By Erich Steinlechner

Fig. 1:
CSP power station – parabolic reflector on the site of KaXu Solar One

1 The use of ductile iron driven piles

The number of construction projects using ductile iron driven piles has been continuously increasing in recent years. Just how positive this success story is for the ductile pile system is demonstrated by a construction project at the Cape of Good Hope in South Africa – the execution of a truly gigantic project in the Northern Cape region of South Africa on the border with Namibia. Here at the edge of the Kalahari Desert a CSP (Concentrated Solar Power) power station, called KaXu Solar One, has come into existence. With an output of 100 MW, this will look after the energy supply for the cities of Johannesburg and Cape Town **(Fig. 1)**.

2 Connections

ABENGOA, a multinational company which has its head office in Spain and which has entered into a partnership with the state Industrial Development Corporation (IDC), will be operating the KaXu power station for the next 25 years. ABENGOA has entrusted the construction of the power station to its subsidiary ABEINSA EPC which, since the beginning of 2013, is now operating close to Upington. The South African partner of the supplier of ductile iron driven piles, the Geopile company, has been commissioned by ABEINSA EPC to produce 52,800 piling points to stabilise the power station's parabolic reflectors.

3 Pile foundations were started in April 2013

Four sets of equipment have been in use since April 2013, achieving an average performance of 300 ductile iron driven piles a day with PT 118 mm x 6.0 mm piles of a length varying from 1.0 m to 5.0 m **(Figs. 2 and 3)**. The lengths of the piles vary widely because the construction site extends over an area of 3.5 km by 1.5 km. The final volume will not be determined until December 2013. Current projections suggest a total pile length of approximately 103,000 m.

Thus it is already established that KaXu Solar One is the largest project carried out to date with ductile iron driven piles from the Austrian pile supplier. Extensive tests were successfully carried out in advance **(Fig. 4)** in which Geopile demonstrated the load bearing capacity on around 10 test piles which were selected on a random basis. With this project, for the first time it was the "pulling" load case which was decisive because the parabolic reflectors, which are set up exactly in the North-South direction, have a low own weight but they must also keep their position even at wind speeds of 140 km/h. Only at wind speeds of more than 140 km/h do the enormous surfaces move into a secure position. Since these high wind speeds are no rare thing in the Northern Cape, the parabolic reflectors in the East and West area are protected with 5 m high wind breaks **(Fig. 5)**. This will reduce the wind speed and break up wind flow. In the North-South area, where no wind breaks can be erected, earth mounds need to be raised over a length of 3.5 km with a height of up to 10 m. These will also help to break up the wind currents so as to prevent the lifting force (suction effect) such as occurs with an aircraft wing.

4 The challenge

"Managing tolerances" is what the challenge is about. The production of the piles at KaXu Solar One will be monitored by total stations (electronic tachymeters) which allow a precision level of +/- 4 cm. The actual connecting link here is a DN 27 mm bolt which has to be concreted in by Geopile with a precision of +/- 3 mm in position and +/- 20 mm in height. Such precision work was called for because, being at the heart of the solar thermal energy plant, the parabolic reflectors must be installed at precise positions and heights in order to guarantee 100 % effectiveness. A deviation of just 1° reduces the performance by 5 %. Thanks to a well coordinated team **(Fig. 6)**, production of the piles went according

Fig. 2:
Four machines for sinking the ductile iron driven piles

Fig. 3:
Cutting off the surplus length of a driven iron pile

Fig. 4:
Testing the load bearing capacity of the ductile iron driven piles using test piles

Fig. 5:
5 m high wind breaks protect the parabolic reflectors against high winds

to plan and within the required time frame meaning that the requirements in terms of accuracy and deadline could be entirely managed.

5 CSP – Concentrated Solar Power

CSP equipment is set up and operated in the Earth's sun belt, because these desert-like areas have the necessary high levels of direct solar radiation. With CSP, also called solar thermal power, reflectors are used to focus the sun's rays by a factor of 90 onto a heat transfer medium (usually thermal oil or even water) contained in the receiver tube. The energy generated can be used for the production of steam, heat, cold or electricity. If a CSP plant produces electricity with the help of a steam turbine connected to it, then we refer to this as a solar thermal power station. CSP offers an endless potential for

Fig. 6:
Essential for the success of the project – trained construction workers

thermal energy generated from the sun. The energy from CSP stations can easily be stored in the form of heat and then released again later for consumption.

6 The future

South Africa has decided to become increasingly active in the area of solar energy in order to make its energy supply more independent from fossil fuels – especially coal. Coal deposits are rather limited in South Africa. Three crucial factors play a role in solar thermal power stations: sun, because water has to be turned into steam, sufficient volumes of water and a substation, in order to bring the volumes produced to the end clients. In South Africa the ideal conditions are present in order to operate this type of power station economically.

In the Northern Cape region on the border with Namibia the sun shines on average 320 days of the year, and the Orange River which, at 2,160 km long, is the largest river in the country, supplies sufficient volumes of water.

With the KaXu Solar One project, the country is making a start in the matter of generating energy for tomorrow. A further 100 power stations are planned, not only CSP but also traditional photovoltaic plants.

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EADIPS®/FGR® member companies are training

1 Training on offer

The member companies of the European Association for Ductile Iron Pipe Systems · EADIPS®/Fachgemeinschaft Guss-Rohrsysteme (FGR®) e.V., who produce pipes and fittings in ductile cast iron as well as valves in spheroidal graphite cast iron, are recognised for taking on trainees for different skills areas. Great importance is attached to the training of young people in the production companies.

Currently more than 120 trainees are registered. These cover the following vocational fields:

- electrical installation engineer,
- electronics engineer,
- electronics installation engineer,
- IT specialist,
- mould maker,
- foundry mechanic,
- industrial business manager,
- industrial mechanic,
- construction engineer,
- logician,
- mechanical engineer,
- machine and equipment operator,
- mechatronics engineer,
- polytechnician
- production engineer
- pipeline fitter,
- technical pattern maker,
- technical product designer,
- toolmaker,
- cutting machine operator.

In the context of dual tertiary education, students are trained in the fields of engineering, industrial engineering and business administration. In addition the EADIPS®/FGR® member companies offer internships for technical college students (business and management) as well as for students in the fields of engineering and business administration.

Primarily, training will be given for skilled personnel of all kinds in pipeline construction so that they can expertly plan, calculate, produce and install ductile iron pipe systems – pipes, fittings and valves – in their further professional career. An additional but no less important reason for this type of training is to encourage company loyalty in the qualified employees.

In terms of training, EADIPS®/FGR® has made the E-book "Ductile iron pipe systems" available free of charge on their website at www.eadips.org, which covers all relevant areas of ductile iron pipe systems. More information about the practical use of ductile iron pipe systems is published by EADIPS®/FGR® in their annual journal which is issued once a year (see www.eadips.org). Current news is published in the newsletter, "DUCTILE IRON PIPE SYSTEM NEWS" which appears ten times a year and can be obtained by logging on at the www.eadips.org website.

2 Training as a pipeline fitter

The profession of pipeline fitter is presented as an example of a training vocation, in association with Berufsförderungswerk der Bauindustrie NRW e.V. **(Fig. 1)**. This skilled profession can for example be learned in a company which produces valves in spheroidal graphite cast iron and fittings in ductile cast iron.

BERUFSFÖRDERUNGSWERK der BAUINDUSTRIE NRW e.V.

Fig. 1:
The logo of the North Rhine-Westphalia vocational training organisation for the construction industry

Fig. 2:
Trainees in the technical field of pipeline construction

2.1 A summary of tasks and activities

The professional vocation of pipeline fitter covers the following tasks and activities:

- The preparation of individual parts and the assembly of these with standard pipes such as ductile iron pipes to EN 545 [1] and EN 598 [2] **(Fig. 2)**.
- The production and fitting of water, gas and oil pipelines. This includes e.g. the installation of branch lines or shutoff devices in the section of pipeline to be produced.
- Carrying out tightness tests.
- Acquiring knowledge about different types of corrosion protection and their use in different soils and with different media and types of water to be transported.
- A further task is the installation of ductile iron pipe systems using open and trenchless techniques and the production of connections to other pipe materials.
- Learning about installation and joining techniques specific to types of material, such as welding, screwing or bonding for example.

Work on site begins with the excavation of the pipe trench. First of all, pipeline fitters assess the stability of the subsoil and secure the trench. During the subsequent backfilling, they monitor the distribution of soil in order to avoid uneven sinking of the earth (subsidence).

They work mainly in the civil engineering industry, e.g. pipeline construction and sewer construction or in sewage disposal or hydraulic engineering and well production. There are also employment opportunities in energy generation and distribution companies (oil, gas) as well as energy supply (gas, water, district heating). Pipeline engineers mainly work in the open air and at different sites.

2.2 Training at a glance

Pipeline construction is a recognised training according to professional training legislation (BBiG). Training lasts 3 years. It is assigned to the field of structural engineering. Job training is given in industrial operations or small businesses in the construction and utility industry without specialisation in specific areas or specialist subjects. There are two stages to the training; the 1st stage (2 years) provides training in civil engineering work. In the 2nd stage (1 year) a training qualification is acquired in pipeline construction.

EADIPS®/FGR® wish everyone in training a successful outcome and enjoyment of their work in the water industry and pipeline construction.

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