DUCTILE IRON PIPE SYSTEMS

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

45

Subjects and authors

Dear readers,

Since early 2010, the **Fachgemeinschaft Guss-Rohrsysteme (FGR) e. V. / European Association for Ductile Iron Pipe Systems · EADIPS** has been acting as a European association representing the interests of manufacturers producing pipes, fittings and valves of ductile iron. A large part of its public relations work takes the form of its Journal **Guss-Rohrsysteme**. The Journal appears every year and the Association uses it to raise its profile to a professional audience.

The present issue is No. 45 and the articles it contains once again show the wide variety of possible technical uses which can be made of ductile iron pipe systems in practice. However, these articles can also be seen to demonstrate the **sustainability** of these systems, of which there are three pillars

- environmental protection,
- economy, and
- social desiderata.

An **environmental** aspect of the systems which is well worth considering is the low energy consumption connected with their production and installation, particularly when trenchless techniques are used. Also clearly relevant to environment friendliness are the long life of ductile iron pipe systems and the fact that ductile iron is obtained almost entirely from recycled materials, which reduces the demands on natural resources and brings down CO_2 emissions. As is described in one article, it is even possible for heat to be successfully recovered from waste water with ductile iron pipes.

Economic sustainability is determined by, amongst other things, the very low levels of damage suffered by ductile iron pipe systems and the small amounts that have to be spent on maintaining them. Their long technical useful life does a lot to compensate for today's usual replacement rates of appreciably less than 1 %.

The third pillar, **social sustainability**, is a matter of consumer protection. This includes the outstanding properties of ductile iron pipe systems from the point of view of drinking water hygiene and the optimum quality thereby obtained for the drinking water transported by them. When trenchless laying techniques are used to install ductile iron pipe systems, there is also a clear reduction in the nuisance caused to local residents by noise, dust, exhaust gases and long installation times.

If you have any questions regarding the planning, selection of materials, practical execution or economy of the pipeline projects described in the articles in issue No. 45 or in connection with their sustainability under the Three Pillar Model – Environment, Economy and Social – the authors and the editor will be happy to answer them for you.

We trust you will find this new 45th issue of **GUSS-ROHRSYSTEME** an enjoyable read!

Raimund Moisa

International climate conferences are calling for steps to be taken to reduce CO_2 emissions. National subsidy schemes are prompting innovative solutions: a Swiss property owner and energy specialist is extracting heat from the waste air and waste water from his home with the help of ductile iron pipes and is recovering it to heat rooms and hot water, thereby making it energy self-sufficient.

There is always a potential for improvement, even in highly sophisticated products: valve designers have responded to the suggestions from experts in the fields of plant construction and pipeline laying, and a dismantling type butterfly valve with a loose flange has been developed. This will enable the usual dismantling joint to be dispensed with. It will also mean that the time taken by replacement work will be considerably shorter and this, at the end of the day, will mean greatly improved economy.

Although the task of optimising valves has been largely completed, there are still cost-saving improvements that can be seen. The usual metric thread used to fasten the bronze spindle sealing element in place in the ductile iron top part of the body of a gate valve is being replaced by a round thread which lends itself well to coating. Having been machined, the round thread in the top part of the body can be given a continuous epoxy coating which gives perfect corrosion protection.

In the past, castings were developed to production standard in a laborious series of individual steps. The pattern and gating system were gradually optimised by modifications and trial casts until the quality of the castings was within acceptable limits. With simultaneous engineering, these steps can be overlapped in time and shortened by means of computer-assisted design, finite element methods and casting and solidification simulation. The casting, together with its gate and feeder system, is seen in a true to-life form on the computer before the actual casting pattern is produced. This optimisation phase would previously take weeks or months but now, given suitable experience, it can be shortened to a few days.

It can be a challenge for users when fundamentally new technical rules and new ways of looking at things are introduced in to standards that have been in place for years. It is necessary for the user to ‘bridge’ the content of the old standard to that of the new one. This article looks at the wall thicknesses, which form an axis to which the new pressure classes of ductile iron pipes and their wall-thickness classes can both be referred.

To investigate the durability which can be achieved in practice by ductile iron pipes with a cement mortar coating, test digs were made at various points. The parameters examined included the corrosion nature of the soil, the state of the outer surface of the coating and the surface of the cast iron pipes below the coating. After a period of three decades in operation, the state of all the pipes was as good as new, even under extremely unfavourable conditions. The assumption of a technical operating life of 100 to 140 years which has been made for 25 years was confirmed.

Leipzig's drinking water network is more than 100 years old and is being replaced, redesigned, optimised and adapted over several years to meet present-day requirements. The pipe manufacturers, planners and installing companies continue to show outstanding expertise as they develop and adapt products and techniques to meet local requirements. This is an ongoing task as the demographic of the area is constantly changing.

Mains for process water in the steel industry require the very highest levels of safety and reliability – in itself this may be something of a nightmare for a pipe network engineer. When a main of this kind has to be replaced in a very narrow, almost inaccessible, services duct in an architecturally attractive steel arch bridge then there is really only one solution that can be considered: ductile iron pipes of the type which, with individual laying lengths, can be produced to an accuracy measured in centimetres. Read the story of a masterpiece of Swiss precision!

An aging steel pipeline showing signs of damage needs to be replaced and adjusted to the fall in the demand for water, guaranteeing a secure water supply for the population of 235,000 people in this part of the town of Zwickau. In open trenches, 3,080 m of DN 400 ductile iron pipes are being laid in three sections right next to the existing pipeline and the fourth section will be completely replaced along the same route. The BRS® restrained joint is providing the optimum economic solution.

Strict regulations don't always stop innovation. Due to the fear of releasing asbestos fibres, asbestos cement pipelines are often replaced by the burst lining technique but the fragments are left in the ground for ever. In Berlin, this is not permitted. The press-pull technique was specially developed to meet this demand but it would overstress softened asbestos cement pipes and it is possible that pieces may remain behind in the ground. Recently, it has been possible to strengthen asbestos cement pipes from inside with plastic pipes and concrete, thus enabling them to be removed from the ground leaving nothing behind.

Relaying a sewage pressure pipeline in a popular recreational area of forest and lake close to a big city automatically makes for a technically and logistically demanding installation. Ductile iron pipes of an entirely cylindrical shape, produced by an extra thick cement mortar coating, have been installed by a technique developed in Berlin for trenchless relaying using auxiliary tubes and a pilot bore. The pipes and the installation technique demonstrate further stages of development that have resulted from mutually beneficial collaboration between the client, contractor and pipe manufacturer.

Belgium and the Netherlands have been pioneers in the installation of ductile iron pipes by the horizontal direction drilling technique. The technique of assembling the pipe string from individual pipes in a very small area during the pulling-in has also been perfected there. Had the laying of 342 m of DN 900 pipes right next to an important waterway been carried out in open trenches, costly predraining provisions would have been necessary. This is done much more efficiently in Belgium with the HDD technique and ductile iron pipes.

The drinking water network in Klagenfurt, which uses grey cast iron and PVC pipes, is showing its age and increasingly frequent signs of fracturing on parts of certain streets. The replacement technique and materials for the new pipes are being selected on the basis of sustainability: economic factors (= very low costs) and ecological considerations (= reduction of exhaust gas, noise and dust). The work will be carried out using an optimum installation technique and materials, and in a socially responsible fashion by minimising the nuisance to local residents (= shortest possible installation time). Replacement by burst lining using ductile iron pipes is in line with this strategy.

The burst lining technique is a proven technique for the trenchless replacement of pipelines of brittle materials – and now of ductile materials too. A conical displacing body at the head of the new pipeline is pulled through the old pipeline and bursts it open. When the operation has been completed, the new pipeline is surrounded in the ground by the fragments of the old pipes which have been displaced radially. It is clear from this that the new pipes have to be extremely rugged to withstand the tractive forces and equally resistant to the sharp edges of the fragments of old pipe past which they are pulled. Ductile iron pipes with a cement mortar coating and BLS® restrained joints are an ideal combination for this tough job!

For a long time now, ductile iron pipe systems have been in service as safe and reliable pieces of equipment for fire-fighting in road and railway tunnels and in industrial plants. Further proof of their safety and reliability can now be seen in cereal mills in earthquake prone areas of post-Soviet Turkmenistan, where they are used by European installed systems for fighting fires.

Fraport (Frankfurt Airport), Germany's largest airport, is being given a third terminal. The infrastructure is being brought up to world standards, so the level of functionality and long term reliability has to be very high. For the water supply alone – drinking water, clean water for other purposes and fire-extinguishing water – some 9,000 m of ductile iron pipes of nominal sizes ranging from DN 150 to DN 300 are being installed. Experience over several decades has made planners at Fraport aware of the high reliability provided by ductile iron supply networks so for them there was no other pipe material worth considering.

Many European governments are aiming to increase production of energy from renewable sources in order to reduce CO_2 emissions. Payments in the form of a feed-in tariff act as an incentive for the building of small hydroelectric power stations. The penstock pipelines needed by these stations are a new field for ductile iron pipe systems, which has been on the increase in recent years and demonstrates how wide the field of application for these pipes is.

In April 2010, college and university teachers specialising in the water sector, supply technology and construction, and installation were guests of the Association in the Lusatia region to hear the latest about ductile iron pipe systems. The Lusatia region had been chosen because one of Germany's oldest foundries, the Keulahütte foundry of Krauschwitz, has its home there and had issued an invitation to a works inspection. At the same time the guests were also able to see one of the greatest transformations of a landscape, namely the conversion of the Lusatia region's one-time brown coal mining district into a modern residential and recreational area with water everywhere close at hand.

Heat recovery in the home using ductile iron pipes

by Roger Saner

1 Use of alternative energies to improve the energy efficiency of buildings

A measure that is becoming increasingly important for achieving CO_2 reduction targets is increasing the energy efficiency of existing and new buildings. By thermally insulating the envelopes of buildings it is possible to make major energy savings. The use of renewable energies by means of solar collectors, heat pumps or biomass boilers helps the building to become energy self-sufficient and reduces its ecological footprint.

In Switzerland, under federal legislation, the cantons are putting in place inducements for greater use to be made of renewable energies in the building field in the form of financial subsidies. The federal government however is making global contributions to the funding of those cantons which have a subsidy scheme of their own.

2 Energy schemes for buildings

Early in 2010, a new scheme for buildings was launched in Switzerland. It is scheduled to last ten years and provides a total of 280 to 300 million Swiss francs a year to allow buildings to be rehabilitated from the point of view of energy and renewable energies to be used in them.

In Switzerland, there is the *Minergie* energy standard for houses and other residential buildings which limits the annual heat demand for heating to a maximum of 38 kWh/m². The even more stringent *Minergie-P* standard specifies a separate scheme for buildings which is oriented to low energy consumption. Among the requirements are renewal of air by a heat recovery ducted ventilation system, air-tight building envelopes and a restriction of the additional cost of achieving the standard over the cost of conventional buildings to a maximum of 15 %. There is a basic requirement for the waste heat generated to be made use of in buildings complying with both the standards.

3 A PlusEnergy house in Rebstein in the canton of St. Gallen

Rebstein lies in the part of the Rhine valley known as St. Galler Rheintal (in Switzerland, running along the border with Austria), and in it stands the so-called PlusEnergy house owned by Otto and Bernadette Mattle-Hofstetter. The owners planned the building themselves; it comprises a house with a built-in engineering consultant's office. The initial idea was a house meeting the *Minergie-P* standard but what was finally built was a building whose photovoltaic system produces a net excess of energy able to be fed out from it. On average over the year, the Mattle house actually feeds a certain excess amount of electricity into the public grid.

The building is well insulated thermally to far above the average standard. The heat for the heating does not come from a conventional oil, gas or wood-fired or heat pump heating system, nor are there radiators or an underfloor heating system. Instead, the house is fitted with a ducted ventilation system with heat recovery facilities, which circulates some 150 to 200 m³ of air an hour.

4 Ductile iron pipes for obtaining energy

Otto Mattle, a graduate engineer from one of Switzerland's Federal Institutes of Technology and an energy specialist and owner of the engineering consultants PML Ingenieurbüro AG, has been able to put many of his own ideas into practice in this building. Very interesting are two of his own creations where, to obtain energy, he has taken advantage of the good thermal conductivity of ductile iron pipes and of the minimal frictional flow resistance offered by the polyurethane (PUR) lining of *geopur* sewage pipes.

Ductile iron pipes are considerably better at transmitting heat than the plastic pipes which are usually installed. Also particularly important for his purposes was the fact that the push-in joint used for the *geopur* ductile iron pipes ensures that the system is (gas)-tight in the long term. Today's ductile iron pipe systems complying with EN 598 [1] meet stringent performance requirements for the joints. Allowable component operating pressures of 100 bars can easily be achieved even in (sewage) pressure pipelines.

5 The operation of the heat recovery ventilation system

Depending on the time of year, the fresh air which is drawn in for the heat recovery ventilation system is either heated or cooled in a geothermal heat collector and is then fed into the house. The heat in the waste air is recovered in a heat exchanger and used to heat the fresh air. A ducted ventilation system distributes the warmed fresh air in the building. It keeps the temperature in the interior constant at 22 °C to 23 °C. The house and the office can be heated to a comfortable level in this way. In mid-summer the geothermal heat collector is used to cool the fresh air which is drawn in and in this way the building can be cooled to an additional degree without the need for a special air-conditioning system.

For the geothermal heat collector, a total length of 26 m of DN 200 geopur type pipes produced to EN 598 [1] were installed below the entrance to the garage and the outside parking space **(Fig. 1)**. The owner deliberately selected ductile iron as the material for the pipes. Thanks to their outstanding stress-resisting properties, the pipes were able to be installed at depths from 1.90 to 2.80 m without being encased in concrete. This made considerable savings possible on the cost of excavation work and of materials and transport. Another significant criterion governing the choice of material was the very good thermal conductivity of ductile iron pipes. This enabled the length required for the geothermal heat collector to be optimised and costs once again to be saved.

Fig. 1:
Installation of the air pipeline for collecting geothermal heat – DN 200 *geopur* type ductile iron pipes

Fig. 2:
DN 125 sewage pipeline of *geopur* type pipes. Plastic coated copper tubes for the refrigerant circuit are laid in the bedding

6 Heat recovery

Another capability that the house has is to recover heat from the sewage and wastewater. The use of heat from sewage and wastewater makes good environmental sense because sewage and wastewater contain thermal energy which is constantly available. Once again it was the good thermal conductivity of ductile iron that was crucial to the choice of material. Also, the sewage and wastewater needed to remain in the pipeline for as long as possible to enable their heat to be used to the optimum effect. To satisfy this requirement, the pipe material used had to be one which gave walls of as low a roughness as possible so that the sewage and wastewater pipeline could be laid to as small a fall as possible. The polyurethane (PUR) lining of the geopur type ductile iron pipes to EN 15655 [2] has an extremely low coefficient of friction of $k < 0.01$ mm and meets this requirement.

For these reasons, the new 28 m long sewage pipeline was also laid in *geopur* ductile iron pipes. It runs to the manhole connecting it to the municipality's main sewer and is of a nominal size of DN125.

The way in which this system for recovering heat from sewage and wastewater operates is extremely simple: the heat from the sewage and wastewater is transmitted through the wall of ductile iron and into the clean 0 – 16 mm gravelly sand in which the pipes are bedded. A pipeline of plastic coated copper tubes laid in the bedding **(Fig. 2)** absorbs the heat and transports it to the services room by means of a refrigerant circulating in the system. The heat obtained in this way is then used to heat hot water.

7 To sum up

Property owner and energy specialist Otto Mattle had the striking idea of making use of the outstanding properties of the material of ductile iron pipes to transmit heat. This has enabled him to draw attention to a way of achieving a crucial improvement in the energy balance of residential buildings by the decentralised recovery of heat from waste air and sewage and wastewater.

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[1] EN 598
Ductile iron pipes, fittings, accessories and their joints for sewerage applications – requirements and test methods
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[2] EN 15655
Ductile iron pipes, fittings and accessories. Internal polyurethane lining for pipes and fittings –
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Dismantling type butterfly valves for flexible use in pipe networks and plant construction

by Thomas F. Hammer

1 Introduction

The job that butterfly valves, or rather butterfly shut-off valves, do is to start or stop the flow of media reliably at any time. For decades now, double-eccentric butterfly valves have been proving to be very good at performing this task in practice.
In the fields of plant construction (e.g. chemical plants) and pipeline laying, increasing demands are being made for economical products and procedures and new solutions are all the time being looked for to meet these demands, without of course any sacrifice of the high standard of quality that has to exist. It is not just the cost of the individual components that has to be looked at when assessing economy. Only by a holistic consideration of all the expenditure and operations that a project involves is it possible for a comprehensive statement to be made regarding economy. As well as the straightforward cost of the individual components, what also have to be taken into account are the accessories needed, the hours that have to be worked and any special tools.
One example of an operation which can be considered in this holistic way is the fitting or replacement of valves in plants and pipe networks.

2 Dismantling joints – Fitting and costs

When new plants are being built, valves are often fitted in the pipes by means of dismantling joints. If lengths need correcting when valves are being installed, dismantling joints enable this to be done and they are also a help when valves are being stripped out for inspection or replacement. As well as the cost of the valves, this generates further costs for the dismantling joints and for the increased time spent on fitting these extra connecting parts. Under normal circumstances the amount of time needed to deal with the dismantling joints is several times the amount allowed for installing the valve itself.
An alternative solution on offer in this case is valves with loose flanges able to withstand traction (referred to as dismantling type valves). In the majority of cases, they enable dismantling joints to be dispensed with back at the stage when the plant is being planned.

3 The development of the new dismantling type butterfly valve

After detailed discussions with users and thorough talks with people on the practical side about their experiences, the developers developing the new dismantling type valve put their money on a combination of a fixed flange

Fig. 1:
ERHARD ROCO dismantling type butterfly valve

and a loose flange **(Fig. 1)**. The advantage of a fixed flange at one end is that it makes handling easier on site. In practice, these valves are first fixed to the existing pipeline by the end carrying the fixed flange. The valve is thus secured against twisting out of position and this prevents any unwanted tilting towards the side on which the gearbox is situated. No laborious chocking of the valve with wedges is needed to keep it correctly orientated. In the second stage of the operation, the restrained loose flange is drawn against the second end of the pipeline and is connected to its flange. Even in vertical pipelines, installation **(Fig. 2)** by this process is found to be very easy.

4 Replacement of valves

When replacing already installed valves which do not have dismantling joints, the fitter is often faced with the following problem in practice: due to the compression of the flange seal or gasket, it is not unusual for brute force or special tools, such as flange spreaders or splitters, to be the only possible way of stripping out the valve. The corrosion protection on the pipelines often suffers considerable damage under these circumstances. It is often a challenge to install even an identical valve of the same face-to-face dimensions in this case. New, uncompressed flange seals and the change which often occurs in the positions of the ends of the pipes make it necessary for another special tool, e.g. a hydraulic compression tool, to be used. The bolt-holes in the flanges often no longer line up and need to have their position corrected **(Figs. 3, 4, 5 and 6)**.

The face-to-face dimensions of butterfly valves are defined in EN 558 [1]. The tolerances of up to 6 mm (taking DN 300 as an example) which are permitted under this standard are another problem which may make it difficult for an identical valve to be used. When a replacement is being made without dismantling joints, the ROCO dismantling type butterfly valve can demonstrate all of its advantages. This valve, with its loose flange, is effectively 3 mm shorter than the face-to-face dimension, and the flange seal is already an integral part of the design of the loose flange. This gives a variable face-to-face dimension, which allows the valve to be installed in the existing gap even without dismantling joints. If dismantling joints were used even when the plant was being constructed, a situation not infrequently encountered is that, due to corrosion and fouling, the dismantling joints can be re-used to only a limited degree or even only with considerable cost and effort. This is another case where the ROCO dismantling type valve shows its advantages.

5 Availability and economy

With the advantages which have been pointed out above, savings of at least 5 to 20 % can be achieved with the dismantling type butterfly valve when economy is considered holistically.

Fig. 2:
DN 400 dismantling type butterfly valves – no problem to install in vertical pipes; no complicated supporting of the valve from below during installation because it is first fastened in place by its fixed flange when being installed.

Fig. 3
Replacement of a DN 250 gate valve by a dismantling type butterfly valve in the course of inspection work by the Landeswasserversorgung Baden-Württemberg water supply utility

Fig. 5
Perfect positioning of the valve ensures excellent accessibility in all installation situations. It is even possible to subsequently turn the valve when it is installed.

Fig. 4
Easier valve replacement due to the pulling tight of the loose flange – there is no need for the valve flange and pipe flange to be spread apart to fit the seal.

Fig. 6
Whether in plant construction or in a pipe trench – the dismantling type butterfly valve is the right solution everywhere.

The butterfly valve with a loose flange at one end is an ideal supplement to the existing product range. It has all the features of the well-tried ROCO Premium butterfly valve and is available in nominal sizes from DN 150 to DN 500. The pressure ratings range from PN 10 to PN 16. The corrosion protection is optimised in detail and comprises enamelling on the inside and an epoxy coating of a minimum coating thickness of 250 µm on the outside. With its all-purpose slider crank actuating mechanism, the valve can be used both in plant construction and underground without the need for conversion.

This is a design which is right not just for replacements but also for the inexpensive installation of new valves. It saves on storage space and makes flexible logistics possible.

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Something new in *VS 5000* resilient-seated gate valves –

Full protection by an epoxy-coated round thread for the sealing elements

by Hansjörg Portmann

1 Introduction

Valves used in water and gas supply are designed for a working life of more than 50 years. The majority are used as underground shut-off valves in supply networks. Gate valves are left unoperated for long periods and then have to work perfectly when an emergency does occur and part of the network has to be shut off. They must not therefore suffer any damage due to this idle state. Resilient-seated gate valves with a thick epoxy coating complying with the rules of the GSK (Quality Association for the Heavy Duty Corrosion Protection of Powder Coated Valves and Fittings) [1] and of a minimum thickness of 250 µm meet this requirement.

2 Why the round thread was needed

A prerequisite for full corrosion protection is that the design of the gate valve must lend itself well to coating. Even when operation occurs frequently, the corrosion protection must not be damaged or abraded. This can be achieved for example with plastic tapering guides **(Fig. 1)** and is considered to be state of the art for technically sophisticated gate valves. Threaded bushes, referred to as sealing elements **(Fig. 2)**, are often used in gate valves as the connecting and sealing members between the top part of the body and the spindle. If the seals become faulty, it must be possible for the sealing element to be replaced under pressure. Metric standard

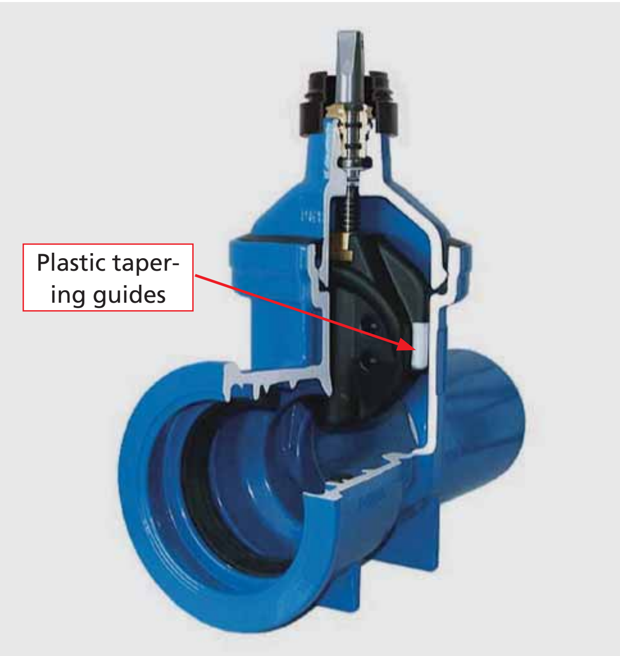

Fig. 1.
Slide gate body guided by plastic tapering guides

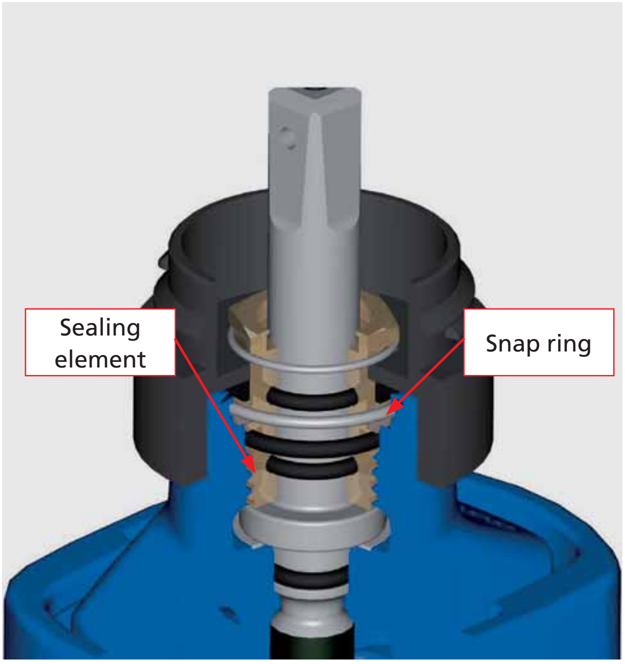

Fig. 2:
Section through the top part of a *VS 5000* fully protected gate valve with a round thread

threads for fastening the sealing elements in position do not lend themselves well to coating because their turns become filled with coating material. Yet uncoated threads can cause corrosion problems.

3 Development of the round thread

For continuous, gap-free, corrosion protection, no further work must be done on the connection after the coating. This is possible for example with bayonet joints and threaded connections. The connection must not release even if the valve is left idle for long periods or is not operated properly or if high closing torques are exerted. It must not be damaged when operation takes place. The tolerances on the thickness of castings and coatings have to be allowed for in the design and this is only possible if the process parameters are kept to.

The round thread, which lends itself well to coating, solves the problem: with it, the advantages of a threaded connection can be exploited to excellent effect in the fully protected *VS 5000* gate valve.
The sealing element is secured in place by a snap ring **(Fig. 2)** seated in a groove of its own; the snap ring stops any unintentional unscrewing.

4 Production and fitting

The ductile iron top parts of the bodies of the *VS 5000* are finish-machined in their entirety. They are then coated with epoxy powder by a standard process complying with the rules of the GSK [1]. There is no need for any further expensive machining operations.

5 Use in practice

The round thread can be used wherever parts coated with epoxy need to have a threaded connection with long-term corrosion protection. Round threads are used in valves of nominal sizes from DN 65 to DN 300 and are produced to pressure ratings of PN 10 and PN 16. For nominal sizes from DN 65 to DN 150, the PN 25 pressure rating is also available.

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[1] GSK
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A new cast of ideas – shortening the time for successful development of demanding designs

by Torsten Stein

1 Simultaneous engineering

Simultaneous (also known as concurrent) engineering is the name of a procedure used in the technical development of a product. Its aim is to cut the development time and costs.

Castings and components of demanding designs are developed by careful application of the methods of simultaneous engineering which works to the customer's benefit. Sequential sub-processes take place one after the other up until the SOP (**S**tart **O**f **P**roduction) **(Fig. 1)** with the idea behind the procedure being that these overlap in time. Optimums are worked out in parallel in the interactive implementation of the CAD (**C**omputer-**A**ided **D**esign) phase, the calculation of strength by **F**inite **E**lement **M**ethods (FEM) and the simulation of mould filling and solidification.

It is true that this may result in more work, depending on how much information is available, but errors are spotted earlier on and fixed in good time thus avoiding high costs in a later phase of development.

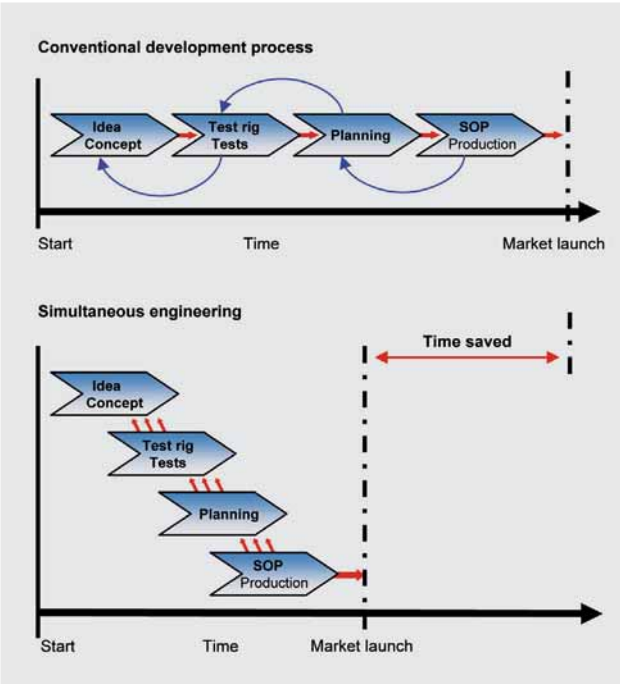

Fig. 1:
Comparison of the time taken by different development processes

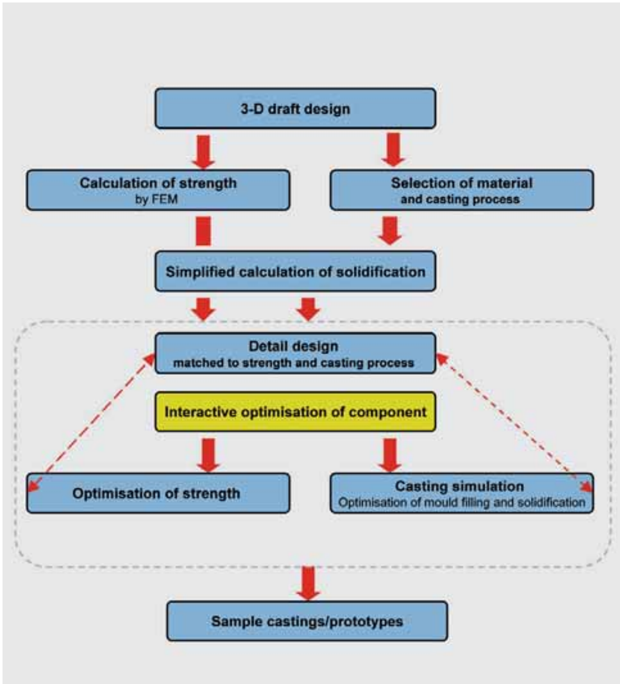

Fig. 2:
Integrated development of cast components

2 Integrated development of cast components

The characteristic feature of the integrated development of cast components is that work simultaneously done on the calculation of strength and the casting simulation and the two processes "talk" to each other. Generally, there are other aspects which are also considered such as the choice of materials or the casting process.

At this point in the development phase it is very important for complex components to be worked on by an interdisciplinary development team. When a new product is being developed, experts on subjects ranging from the development/design of the foundry through to the scheduling of work and logistics are involved.

Because the designs are basically made in three-dimensional form, the 3D models are also available for all the other engineering procedures. It is therefore possible for the FEM calculations and the simulation of solidification to be completed within a few days **(Fig. 2)**.

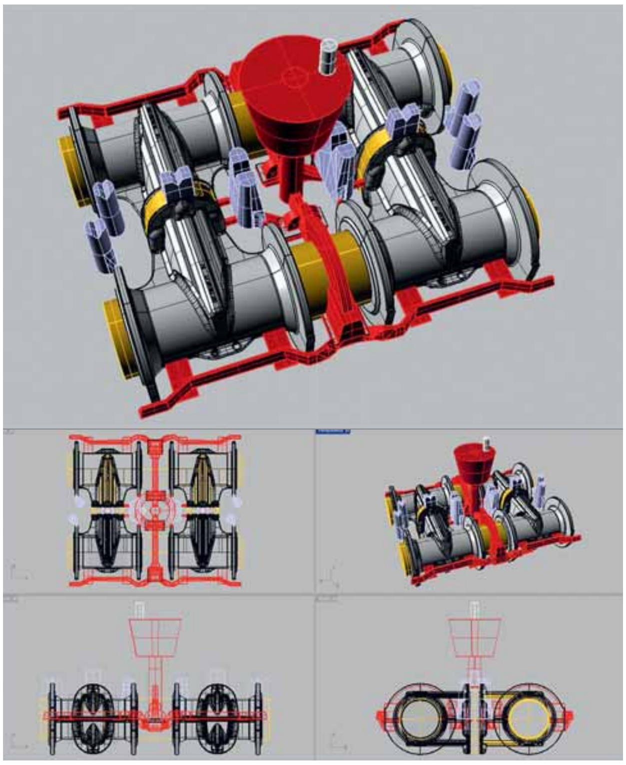

Fig. 3:
CAD design including gating system to prepare for simulation of mould filling and solidification

3 The aims of simultaneous engineering

When a project is being carried out, there are three factors of supreme importance:

- time
- cost
- quality

These factors are interrelated, meaning that a deliberate change in one factor also causes a change in the other two factors. For example, if one wishes to raise quality, one has to expect an increase in the development time and therefore in the cost. The primary aim of simultaneous engineering is to shorten the development time but, at the same time, also to reduce the costs and improve the quality of the product.

4 Simultaneous engineering illustrated by the example of the DN 150, type 4004 FL-FL gate valve

On completion of the 3D design data, the model **(Fig. 3)** was simultaneously designed, i.e. there were a multiple number of models. To enable the molten iron to make its way into the actual mould cavity, the model has to be designed to have a gating and feeder system. The gating system includes all the passages (e.g. the pouring cup, sprue, runner and gates) which convey the molten metal into the mould cavity. The casting shrinks as it solidifies and the feeder is an additional space in the mould, connected to the casting, which compensates for this loss of volume during the solidification.

As well as being needed to decide on the "castability" of a component, casting know-how also comes into play at the very point mentioned above. Correct layout of the model and a gating system of optimum design guarantee a rugged process that produces high quality castings that are free of flaws.

The so-called hot spots are shown in **Fig. 4**. These are the points at which the iron solidifies last. These points tend to have internal casting flaws and must be adequately fed. The results produced by the simulation software always have to be assessed by experienced casting experts to enable the casting system and feeders to be sized in the optimum way. As a rule, it takes more than one try before an optimum is found for quality and costs.

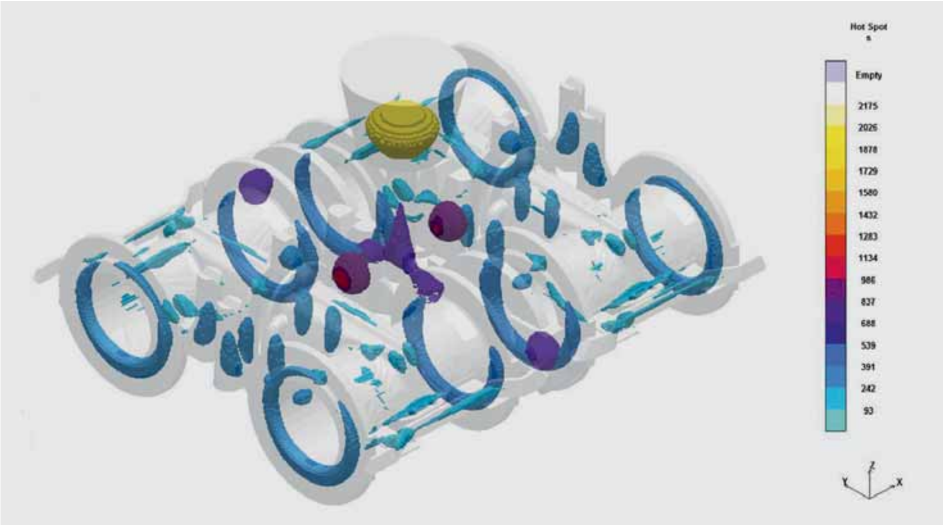

Fig. 4:
Representation of solidification showing the hot spots

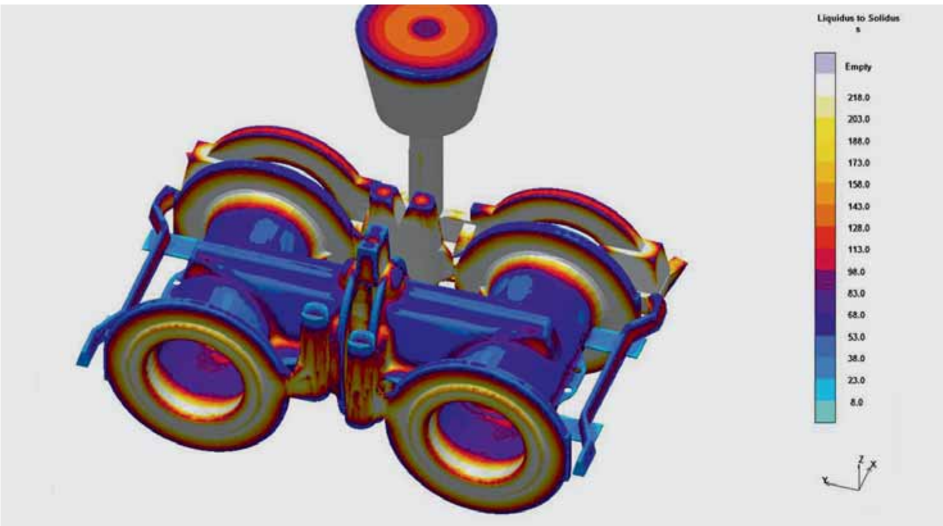

Fig. 5:
A component optimised from the point of view of casting

Fig. 5 shows the optimum from the point of view of casting. Only when good results have been obtained from the simulation of mould filling and solidification is the CAD data converted into actual foundry patterns, the gating and feeder system and into trial casts.

5 To sum up

The simultaneous engineering procedure ensures results of the highest quality right from the first casting and, compared with the conventional trial and error method, it also saves time and money without sacrificing high quality. It has clear advantages for ductile iron fittings and valves, to the benefit of those involved in pipeline installation.

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Wall-thickness classes and pressure classes in EN 545 [1] – Comparison between the 2007 and 2010 versions

by Jürgen Rammelsberg

1 Introduction

Technical standards and other rules are subject to constant ongoing development to adapt them to the changes occurring in their fields of application.

An important innovation in the field of pressure pipelines was the introduction in 2006 of what are referred to as "pressure classifications". These came in with standard EN 14801 [2]: "Conditions for pressure classification of products for water and wastewater pipelines".
Also introduced in this standard were variable installation parameters which divided the regime of external loads into three typical installation conditions. The standard applies to all pipe materials and applications, e. g. to the transporting of drinking water or wastewater. The respective standards governing installation have to be observed in these applications, i. e. EN 805 [3] for the installation of water pipelines and EN 1610 [4] for the installation of wastewater pipelines.

Additional stipulations in EN 14801 [2] relate to the respective product standards, requiring the calculation methods to be stated in them as a function of a combination of installation condition and internal pressure.

It was back in 2002 that a pressure class C 40 was first introduced into EN 545. In the new 2010 version of this standard, pressure classes have been introduced generally for the dimensioning of components of ductile cast iron. The German version, DIN EN 545 [1], contains a national foreword in which there is a table comparing dimensioning by wall-thickness classes (K classes) with dimensioning by pressure classes (C classes).

Certain users asked for this comparison to assist them in making the conceptual transition from the K classes they were used to to the pressure classes (C classes) that were, as yet, unfamiliar.

2 The previous method of dimensioning

Looking at the recent history of the development of ductile iron pipes, it can be seen that by applying process control in centrifugal casting certain manufacturers have been making efforts to optimise wall thickness in a targeted way and at the same time to cut down on its scatter.
In K classes, the nominal wall thicknesses e [mm] were defined, as a function of nominal size DN, by the equation

$$e = K \cdot (0.5 + 0.001 \cdot DN)[mm] \qquad (1)$$

(where K, a coefficient for determining thickness, is a whole number between 7 and 10), for applications involving very high pressures even of more than 20. For drinking water supply, the typical K values were initially 10 and subsequently even 8 or 9. For the nominal wall thicknesses, the bottom limit was 6.0 mm. The following equation then gave the minimum wall thicknesses relevant to sizing.

$e_{min} = e - \Delta e [mm]$ — Δe is the allowable limit deviation on the dimension

$\Delta e = -(1.3 + 0.001 \cdot DN)[mm]$ — where e > 6 mm

$\Delta e = -1.3[mm]$ — where e ≤ 6 mm

Therefore, for the K classes, the bottom limit for minimum wall thickness was 4.7 mm.

What represented a typical ductile iron pipe for drinking water was a pipe of wall-thickness class K 9. This class seemed to be a suitable compromise between the following requirements:

- resistance to internal pressure,
- adequate longitudinal bending resistance (above all at small nominal sizes),
- adequate diametral stiffness (above all at fairly large nominal sizes).

Over the past decade, a further requirement has become increasingly prominent: more and more frequent use is being made of restrained joints in trenchless installation techniques and this is creating a requirement for a maximum permitted tractive force.

Over the same period, the technical rules (GW 320 et seq.) which are laid down by the German Technical and Scientific Association for Gas and Water (DVGW) for trenchless installation and replacement techniques came into being. In these documents, the permitted tractive force, above all for positive locking joints which have a welding bead on the spigot end, plays a crucial part in deciding the length of pipe string which can be pulled in. When a trenchless technique is selected, this force thus determines the distance between installation pits and therefore how economical a given pipe material is.

2.1 Resistance to internal pressure

For an allowable operating pressure PFA, the thickness of the pipe wall was calculated from Barlow's formula

$$PFA = \frac{20 \cdot e_{\min} \cdot R_m}{(DE - e_{\min}) \cdot S_F} [bar] \quad (2)$$

(1 bar equals 0.1 MPa)

where

R_m is the minimum tensile strength in megapascals (R_m = 420 MPa),

e_{min} is the minimum pipe wall thickness in mm,

DE is the nominal pipe external diameter in mm, and

S_F is a safety factor of 3.

For the minimum tensile strength of 420 MPa, Barlow's formula becomes the following:

$$PFA = \frac{20 \cdot e_{\min} \cdot 420}{(DE - e_{\min}) \cdot 3} [bar] \quad (3)$$

or, with the minimum wall thickness as a dependent variable for which the equation is solved as a function of the allowable component operating pressure PFA for a given external diameter DE for the pipe:

$$e_{\min} = \frac{3 \cdot PFA \cdot DE}{8{,}400 + 3 \cdot PFA} [mm] \quad (4)$$

Fig. 1 shows this relationship in the form of a graph; it is clear that, because of the bottom limit of 4.7 mm set for minimum wall thickness, the pipes in the lower part from DN 80 to DN 200 of the nominal size range have tended to be oversized, at least in relation to the internal pressure, which is often 10 bars in drinking water distribution networks.

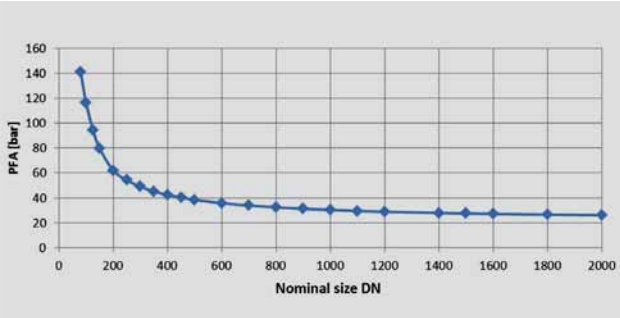

Fig. 1:
Allowable operating pressure PFA [bar] for ductile iron pipes of wall thickness class K 9

The lower limit of 4.7 mm for minimum wall thickness has therefore been reduced. **Table 1** shows the seven pressure classes given in the new version of EN 545 for the entire range of nominal sizes from DN 40 to DN 2000. It also shows the minimum wall thicknesses calculated from equation (4) for the seven discrete PFA values (PFA = 20, 25, 30, 40, 50, 64 and 100 bars), the lower limit for these wall thicknesses having now been reduced to 3.0 mm.

Table 1:
Minimum wall thicknesses e_{min} of ductile iron pipes
as a function of nominal size DN and pressure class (C class)

Minimum wall thicknesses e_{min} of ductile iron pipes								
		Pressure class (C classes) = PFA						
		20	25	30	40	50	64	100
DN	DE [mm]		e_{min} [mm]					
40	56				**3.0**	3.5	4.0	4.7
50	66				**3.0**	3.5	4.0	4.7
60	77				**3.0**	3.5	4.0	4.7
65	82				**3.0**	3.5	4.0	4.7
80	98				**3.0**	3.5	4.0	4.7
100	118				**3.0**	3.5	4.0	4.7
125	144				**3.0**	3.5	4.0	5.0
150	170				**3.0**	3.5	4.0	5.9
200	222				**3.1**	3.9	5.0	7.7
250	274				**3.9**	4.8	6.1	9.5
300	326				**4.6**	5.7	7.3	11.2
350	378			**4.7**	5.3	6.6	8.5	13.0
400	429			**4.8**	6.0	7.5	9.6	14.8
450	480			**5.1**	6.8	8.4	10.7	16.6
500	532			**5.6**	7.5	9.3	11.9	18.3
600	635			**6.7**	8.9	11.1	14.2	21.9
700	738		**6.8**	7.8	10.4	13.0	16.5	
800	842		**7.5**	8.9	11.9	14.8	18.8	
900	945		**8.4**	10.0	13.3	16.6		
1000	1048		**9.3**	11.1	14.8	18.4		
1100	1152	8.2	**10.2**	12.2	16.2	20.2		
1200	1255	8.9	**11.1**	13.3	17.7	22.0		
1400	1462	10.4	**12.9**	15.5				
1500	1565	11.1	**13.9**	16.6				
1600	1668	11.8	**14.8**	17.7				
1800	1875	13.3	**16.6**	19.9				
2000	2082	14.8	**18.4**	22.1				
Notes: The bold figures indicate the standard products which are suitable for most applications.								

2.2 Relationship between pressure classes and wall thickness classes

If **Fig. 1** and **Table 1** are compared, it can be seen that, in for example the region of a nominal size of DN 400, pipes in pressure class 40 and wall thickness class K 9 are of similar wall thicknesses of approximately 6 mm. **Table 2** shows there to be a general comparability between pressure classes and wall thickness classes.

Ranges of similar wall thicknesses, and ranges of the allowable operating pressure PFA which correspond to the pressure classes, have been shaded in the same colours. This gives the experienced pipeline planner an opportunity of adjusting the experience he has gained with K classes over the course of his professional career to the pressure classes which now have to be considered and, in so doing, of always keeping an eye on the actual minimum wall thickness, a point of reference which is common to both of them.

Table 2:
Comparison of pressure classes (C classes) under EN 545: 2010 (left-hand half)
with the wall thickness classes (K classes) of EN 545: 2007 (right-hand half)

Comparison of pressure classes and wall thickness classes																		
DN	DE [mm]	Pressure classes (C classes) = PFA							Wall thickness classes (K classes)									
		20	25	30	40	50	64	100	7		8		9		10		11	
			e_{min} [mm]						e_{min} [mm]	PFA [bar]	e_{min} [mm]	PFA [bar]	e_{min} [mm]	PFA [bar]	e_{min} [mm]	PFA [bar]	e_{min} [mm]	PFA [bar]
40	56				3.0	3.5	4.0	4.7										
50	66				3.0	3.5	4.0	4.7										
60	77				3.0	3.5	4.0	4.7										
65	82				3.0	3.5	4.0	4.7										
80	98				3.0	3.5	4.0	4.7	4.7	141.1	4.7	141.1	4.7	141.1	4.7	141.1	5.0	150.5
100	118				3.0	3.5	4.0	4.7	4.7	116.2	4.7	116.2	4.7	116.2	4.7	116.2	5.2	129.1
125	144				3.0	3.5	4.0	5.0	4.7	94.5	4.7	94.5	4.7	94.5	4.8	97.1	5.5	110.1
150	170				3.0	3.5	4.0	5.9	4.7	79.6	4.7	79.6	4.7	79.6	5.1	85.7	5.7	97.1
200	222				3.1	3.9	5.0	7.7	4.7	60.6	4.7	60.6	4.8	61.9	5.5	71.1	6.2	80.4
250	274				3.9	4.8	6.1	9.5	4.7	48.9	4.7	48.9	5.2	54.2	6.0	62.2	6.7	70.2
300	326				4.6	5.7	7.3	11.2	4.7	41.0	4.8	41.8	5.6	48.9	6.4	56.1	7.2	63.2
350	378			4.7	5.3	6.6	8.5	13.0	4.7	34.9	5.2	38.7	6.0	45.2	6.9	51.7	7.7	58.2
400	429			4.8	6.0	7.5	9.6	14.8	4.7	31.0	5.5	36.4	6.4	42.4	7.3	48.5	8.2	54.6
450	480			5.1	6.8	8.4	10.7	16.6	4.9	28.9	5.9	34.5	6.8	40.2	7.8	46.0	8.7	51.7
500	532			5.6	7.5	9.3	11.9	18.3	5.2	27.6	6.2	33.0	7.2	38.4	8.2	43.8	9.2	49.3
600	635			6.7	8.9	11.1	14.2	21.9	5.8	25.8	6.9	30.8	8.0	35.7	9.1	40.7	10.2	45.7
700	738		6.8	7.8	10.4	13.0	16.5		6.4	24.5	7.6	29.1	8.8	33.8	10.0	38.5	11.2	43.1
800	842		7.5	8.9	11.9	14.8	18.8		7.0	23.5	8.3	27.9	9.6	32.3	10.9	36.7	12.2	41.2
900	945		8.4	10.0	13.3	16.6			7.6	22.7	9.0	26.9	10.4	31.2	11.8	35.4	13.2	39.7
1000	1048		9.3	11.1	14.8	18.4			8.2	22.1	9.7	26.2	11.2	30.2	12.7	34.3	14.2	38.5
1100	1152	8.2	10.2	12.2	16.2	20.2			8.8	21.6	10.4	25.5	12.0	29.5	13.6	33.5	15.2	37.4
1200	1255	8.9	11.1	13.3	17.7	22.0			9.4	21.1	11.1	25.0	12.8	28.9	14.5	32.7	16.2	36.6
1400	1462	10.4	12.9	15.5					10.6	20.4	12.5	24.1	14.4	27.9	16.3	31.6	18.2	35.3
1500	1565	11.1	13.9	16.6					11.2	20.2	13.2	23.8	15.2	27.5	17.2	31.1	19.2	34.8
1600	1668	11.8	14.8	17.7					11.8	19.9	13.9	23.5	16.0	27.1	18.1	30.7	20.2	34.3
1800	1875	13.3	16.6	19.9					13.0	19.5	15.3	23.0	17.6	26.5	19.9	30.0	22.2	33.5
2000	2082	14.8	18.4	22.1					14.2	19.2	16.7	22.6	19.2	26.1	21.7	29.5	24.2	32.9

Table 3:
Allowable bending moments M(x) for DN 80 to DN 200 pipes, for pressure classes (C classes) and wall thickness classes (K classes)

		Allowable bending moments M (x) [kNm]									
		Class 40		Class 50		Class 64		K 9		K 10	
DN	DE [mm]	e_{min} [mm]	M (x)[kNm]	e_{min} [mm]	M (x)[kNm]	e_{min} [mm]	M (x)[kNm]	e_{min} [mm]	M (x)[kNm]	e_{min} [mm]	M (x)[kNm]
80	98	3.0	5.3	3.5	6.1	4.0	6.9	4.7	8.0	4.7	8.0
100	118	3.0	7.8	3.5	9.0	4.0	10.2	4.7	11.8	4.7	11.8
125	144	3.0	11.7	3.5	13.6	4.0	15.4	4.7	17.9	4.8	18.2
150	170	3.0	16.4	3.5	19.0	4.0	21.6	4.7	25.2	5.1	26.7
200	222	3.1	29.2	3.9	36.4	5.0	46.2	4.8	44.4	5.5	50.6
These bending moments, expressed in kilonewton-metres [kNm], correspond to a load of the same value, expressed in kilonewtons [kN], applied at mid-point of a 4 m span.											
Colours mean:		M(x) ≤ 9.9 kNm		10.0 kNm ≤ M(x) ≤ 19.9 kNm		20.0 kNm ≤ M(x) ≤ 29.9 kNm		M(x) ≥ 30.0 kNm			

Table 4:
Combined listing of minimum diametral stiffnesses S of nominal sizes DN 300 to DN 1000, for pressure classes (C classes) and wall thickness classes (K classes)

		Minimum diametral stiffness S [kN/m²]									
		Class 25		Class 30		Class 40		K 9		K 10	
DN	DE [mm]	e_{stiff} [mm]	S [kN/m²]	e_{stiff} [mm]	S [kN/m²]	e_{stiff} [mm]	S [kN/m²]	e_{stiff} [mm]	S [kN/m²]	e_{stiff} [mm]	S [kN/m²]
300	326					5.4	68	6.4	110	8	160
350	378			5.5	46	6.1	67	6.8	89	8.5	120
400	429			5.7	34	6.9	63	7.2	72	9.1	100
450	480			6	28			7.7	61	9.6	86
500	532			6.5	27			8.1	52	10.1	74
600	635			7.7	26			9	41	11.2	58
700	738	7.8	17					9.8	34	12.2	49
800	842	8.6	15					10.7	30	13.2	42
900	945	9.5	15					11.5	26	14.3	37
1,000	1,048	10.5	14.5					12.3	24	15.4	34
The values of S have been calculated with a value of e_{stiff} calculated as follows: $e_{stiff} = e_{min} + 0.5\ (1.3 + 0.001\ DN)$ [mm]											
Colours mean:		S ≤ 29.9 kN/m²		30.0 kN/m² ≤ S ≤ 49.9 kN/m²		50.0 kN/m² ≤ S ≤ 99.9 kN/m²		S ≥ 100 kN/m²			

2.3 Longitudinal bending resistance

If the bedding conditions are not good, if there is ground subsidence or differential settlement, or if trenchless installation techniques are used, relatively high bending stresses may occur in pipes of small nominal sizes. Under EN 545, small nominal sizes are defined as ones whose aspect ratio (length/diameter) is equal to or greater than 25. The bending moments which can be supported without damage occurring are shown in **Table 3** for pressure classes (C classes) and wall thickness classes (K classes). It can be seen that in soils at risk of settlement or when trenchless installation techniques are used, the pipes need to have a higher permitted bending moment than is indicated by the dimensioning given by the pressure class.

2.4 Minimum diametral stiffness

Stresses due to earth loads and traffic loads may cause ovalisation and this must not be more than 4 %. The minimum diametral stiffnesses which ensure this are given in both versions of EN 545, as a function of the pressure class in EN 545: 2010 and as a function of the wall thickness class in EN 545: 2007. **Table 4** is a combined listing of the values.
As would be expected, the higher ranges of diametral stiffness are once again at the higher wall thicknesses. In this case too it is often the wall thickness which is crucial rather than the pressure class.

2.5 Wall thicknesses for positive locking joints

When the installation conditions are difficult or trenchless installation techniques are employed, the pipes used are predominantly ductile iron pipes with positive locking restrained joints. These joints need a welding bead on the spigot end. With trenchless techniques amongst other things, a prerequisite for keeping the permitted tractive force at the requisite level is a minimum wall thickness of approximately 5 mm. Therefore, the K 9 wall thickness class can be used generally for these pipes in the lower part, up to DN 300, of the nominal size range.

3 To sum up

For the ductile iron pipe industry, the introduction in 2010 of the pressure classes in the revised version of EN 545 has opened up a wide range of potential opportunities for making savings. Optimisation of the wall thicknesses will mean less of a demand on the resources used (raw materials, energy, weight for transport, etc.). Given what ruggedness means in practical terms, i.e. longitudinal bending resistance for pipes of small nominal sizes and minimum diametral stiffness for those towards the top of the nominal size range, the dimensioning of pipes by the well-tried method of wall thicknesses classes will probably continue in use. Practical pipeline installation and the demands for sustainability which are being made on modern-day pipeline networks will therefore call for differentiated approaches in applying the new standard. **Table 2**, which combines the two, is a tool for people on the practical side who still think in the traditional K classes but need a "translation" into the "language of pressure classes (C classes)".

References

[1] DIN EN 545
Ductile iron pipes, fittings, accessories and their joints for water pipelines – requirements and test methods
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2010-12

[2] EN 14801
Conditions for pressure classification of products for water and wastewater pipelines
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[3] EN 805
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Examination of ductile iron pipes with cement mortar coating after a period of three decades in operation

by Wolfgang Rink

1 Introduction

It was in 1978 that the then Buderus Aktiengesellschaft, today's Duktus Rohrsysteme Wetzlar GmbH, supplied the first ductile iron pipes with a cement mortar coating. The technical specifications were laid down at that time in DIN 28600 [1]. There was not a standard for the cement mortar coating at that stage. It was only in November 1982 that the draft version of DIN 30674-2 – "Cement mortar coating for ductile iron pipes; requirements and testing" appeared. The definitive version [2] was then issued in July 1984.

At that stage of development, a zinc coating was not applied below the cement mortar coating (ZM-U – **Z**ement**m**örtel-**U**mhüllung) because it was not clear at that point whether the alkaline ZM-U was compatible with a zinc coating. The mixture of cement mortar and glass fibres was sprayed wet-on-wet onto a coating of synthetic resin (a two-component epoxy) on the pipe. Then, as from the early 80's, a zinc coating was applied before the pipes were coated with cement mortar [3]. In the first few years, the ZM-U was also given a final coating of bitumen. The process whereby a bandage is wrapped on in the coating has now become an additional established technique for applying the ZM-U.

2 Checks on coatings

Users often ask how well the ZM-U stands up in practice. These questions prompted test digs to be made on the pipelines laid using the first ductile iron pipes with ZM-U in order to check on the coatings. Three sections of pipeline were examined. Pits were dug to expose the pipelines at each of these points. A window was cut out of the ZM-U. The surfaces of the pipes were checked, and samples of the respective native soils and the bedding materials used were examined under DIN 50929-3 [4].

2.1 Project 1: Test dig – Heilbronn, Böllinger Höfe district, Wannenäckerstrasse

- DN 400 ductile iron drinking water pipes to DIN 28600 [1] and DIN 28610 [5] with a cement mortar coating (ZM-U) to DIN 30674-2 [2]
- Year of installation of pipeline: 1985

A pipe having been exposed, its ZM-U showed itself to be firmly adhering, undamaged and in a good as new state **(Fig. 1)**. To reveal the surface of the ductile iron, an area measuring 30 · 30 cm of the ZM-U was removed. The exposed surface of the pipe had a zinc coating and an epoxy bonding layer; no evidence was found of any corrosive attack **(Fig. 2)**. The native soil was examined under DIN 50929-3 [4]. The result

Fig 1:
Project 1: Test dig – Heilbronn, Böllinger Höfe district, Wannenäckerstrasse – DN 400 ductile iron pipe, year of installation 1985

Fig. 2:
Project 1: DN 400 ductile iron pipe - ZM-U with epoxy bonding layer and zinc coating; no visible signs of corrosive attack

Fig. 3:
Project 1: DN 400 ductile iron pipe – Embedded in slightly aggressive soil

Fig. 4:
Project 2: Test dig – Heilbronn, Böllinger Höfe district, lengthened part of Grundäckerstrasse – DN 500 ductile iron pipe, year of installation 1979

Fig. 5:
Project 2 – DN 500 ductile iron pipe – ZM-U with epoxy bonding layer, no zinc coating; no visible signs of corrosive attack

was a rating figure of 0 points corresponding to soil class I (not aggressive). With a rating figure of –3, the embedding material resting directly against the pipe was of soil class Ib (of low aggressiveness). In this part of the route, the pipeline had been installed in not aggressive or slightly aggressive native soil. The native soil had been used as an embedding material **(Fig. 3)**.

After a period of 25 years in use, the state of the pipeline at the test dig was found to be as good as new. A technical operating life of 100 to 140 years will certainly be achieved.

2.2 Project 2: Test dig – Heilbronn, Böllinger Höfe district, lengthened part of Grundäckerstrasse

- DN 500 ductile iron drinking water pipes to DIN 28600 [1] and DIN 28610 [5] with a cement mortar coating (ZM-U) to DIN 30674-2 [2]
- The pipeline was installed in 1979 in an anode backfill (a bedding of neutral sand).

The pipeline having been exposed **(Fig. 4)**, its ZM-U showed itself to be firmly adhering, undamaged and in a good as new state.
Part of the cement mortar was then detached. The exposed surface of the pipe did not have a zinc coating at that time but did have an epoxy bonding layer. No evidence was found of any corrosive attack **(Fig. 5)**. In this part of the route, the pipeline had been installed in not aggressive or slightly aggressive native soil with chemically

Fig. 6
Project 2 – DN 500 ductile iron pipe – Pipe embedded in not aggressive sand, native soil aggressive

Fig. 7
Project 3: Test dig – Zweckverband Mittelhessiche Wasserwerke ZMW supply utility, connection to Gladenbach, Lohra section – DN 300 ductile iron pipe, year of installation 1978/1979

neutral sand as an anode backfill **(Fig. 6)**. After a period of 25 years in use, the state of the pipeline at the test dig was found to be as good as new. The assumed technical operating life of 100 to 140 years will certainly be achieved.

2.3 Project 3: Test dig – Zweckverband Mittelhessiche Wasserwerke ZMW supply utility, connection to Gladenbach, Lohra section

- DN 300 ductile iron drinking water pipes to DIN 28600 [1] and DIN 28610 [5] with a cement mortar coating (ZM-U) to DIN 30674-2 [2]
- Year of installation: 1978/1979

A detailed report on the installation of the pipeline and the soil tests performed at the time can be found in [6]. The DN 300 ductile iron pipeline having been exposed **(Fig. 7)**, its ZM-U showed itself to be firmly adhering, undamaged and in a good as new state. An area measuring 30 · 30 cm of the ZM-U was then removed. The exposed surface of the pipe had an epoxy bonding layer but not a zinc coating; no evidence was found of any corrosive attack **(Fig. 8)**. In this part of the route, the pipeline had been installed in highly aggressive native soil. The embedding material used had been the native soil or, in the region of the bottom of the pipe, gravel **(Fig. 9)**. The pipeline was also below the water table in this part of the route. The vertical inhomogeneity (gravel at the bottom of the pipe, corrosive cohesive soil as backfill at the sides and over the top of the pipe) resulted in differential aeration cells (corrosion cells) forming. Although the conditions encountered at installation had been highly adverse, no evidence was found of any external attack after a period in use of 32 years. A technical operating life of 100 to 140 years will certainly be achieved.

Fig. 8
Project 3: DN 300 ductile iron pipe - ZM-U with epoxy bonding layer, no zinc coating; no visible signs of corrosive attack

Fig. 9
Project 3: DN 300 ductile iron pipe – Soil in region of bottom of pipe slightly aggressive gravel, pipe embedded in highly aggressive soil at the sides and top, ground water present

Table 1:
Overview of the results of test digs made for the projects:
Assessments of the state of the ZM-U on the ductile iron pipes exposed and of their surfaces

Test dig	Project 1	Project 2	Project 3
Town	Heilbronn	Heilbronn	Gladenbach
Street	Wannenäckerstrasse	Lengthened part of Grundäckerstrasse	Lohra section
Year of installation	1985	1979	1978/1979
DN nominal size	400	500	300
Soil along the route			
B_o/class	0/Ia	–5/II	–11/III
Nature	Not aggressive	Aggressive	Highly aggressive
Soil in contact			
B_o/class	–3/Ib	8/Ia	–11/III (gravel only at bottom of pipe)
Nature	Of low aggressiveness	Not aggressive	Highly aggressive
Heterogeneity	No	No	Yes
Ground water	No	No	Yes
Results of examination of pipe			
Exterior of ZM-U	Not attacked	Not attacked	Not attacked
Adhesion	Good	Good	Good
Surface of metal	Not attacked	Not attacked	Not attacked

3 To sum up

At all three of the points checked, the pipelines were found to be in an impeccable, good as new, state. At all of these points the ductile iron pipes had been installed under different soil conditions. The properties of ductile iron as a material do not change and the coatings were examined so it is safe to say that the whole of the pipes examined are still as good as new even after being in operation for three decades. **Table 1** is a list of the main results.

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Replacement and relaying of DN 200 to DN 800 drinking water pipelines in Leipzig

by Andrea Bauer and Wolfgang Rink

1 Introduction

The replacement and relaying of various drinking water pipelines in the area where Max-Liebermann-Strasse and Olbrichtstrasse cross in Leipzig is no ordinary task given the pipelines, sewers and cables present in the ground below the surface. It is making severe demands on all those involved. Also, the work has to be done in sections and its timing has to be co-ordinated to immediately precede the road-building work; it cannot be deferred **(Figs. 1 and 2)**.

The relocation and re-design of the underground water network is a particular challenge for the planners and installers at this crossroads because a number of pipeline systems for drinking water meet at this point:

- DN 100 to DN 400 supply pipelines,
- one of the four DN 500 supply mains from the "Probstheida" central water distribution station, and
- a DN 800 trunk main from the "Schwarzer Berg" high-level service reservoir situated about 14 km away.

The "Möckern" pressure-raising station is also connected into these pipeline systems. This station, which is located very close to the crossroads, is fed by supply main 1 from the "Probstheida" water distribution station. At the station, the pipeline pressure is raised to the level required for supplying the adjoining area. The outgoing pipelines from the station are connected into the network of supply pipelines in the region of the Max-Liebermann-Strasse/Olbrichtstrasse crossroads.

Fig. 1:
Road building work on the "Mittlerer Ring Nord" ring-road in Leipzig

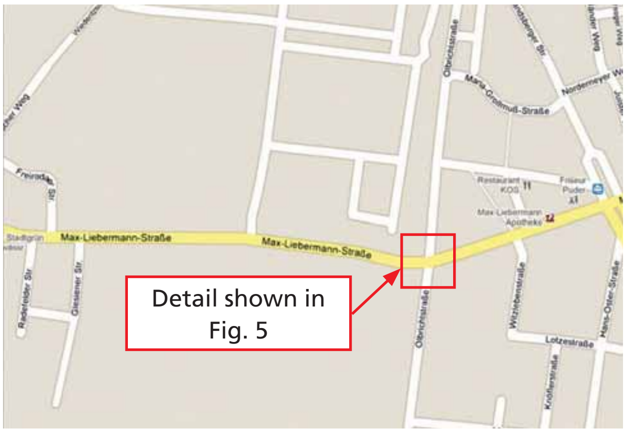

Fig. 2
Position of the Max-Liebermann-Strasse/Olbrichtstrasse crossroads

2 Planning

With the in-house decision by the supply utility KWL (Kommunale Wasserwerke Leipzig) to increase the proportion of drinking water coming from its own Canitz, Thallwitz and Naundorf 1 & 2 waterworks, the "Möckern" station has become of primary importance. For KWL's own water to be distributed from the "Schwarzer Berg" high-level service reservoir via the "Möckern" station, there had to be a basic re-design of the existing pipelines in the area of the Max-Liebermann-Strasse/Olbrichtstrasse crossroads. Different pipeline connections and different directions of flow were needed and additional valves needed to be installed.

The old tangle of pipelines needed to be unravelled, re-designed and optimised so that the pipelines can meet current requirements. Each individual pipeline has a particular importance and all this added up to an extremely demanding task for the planners. An exact timetable which ensured that the supply was maintained at all times had to be developed for the installation work. Interim pipelines and temporary bypasses even had to be set up in certain areas **(Fig. 3)**.

As well as the tangle of drinking water pipelines and large diameter combined sewers, the ground in the area of the crossroads is also full of pipelines and cables belonging to other utilities. The difficult technical and planning task was to co-ordinate the old and new routes in the ideal way for the future pipelines, sewers and cables. As part of the relocation of water pipelines, it has been necessary to replace pipelines. To obtain the clear space needed for the road building and by other utilities, a high proportion of the pipelines (mains and supply pipelines) had to be relaid to follow different routes. Added to this was the considerable age of the existing pipeline network, which meant that it would have been irresponsible to leave old pipelines liable to give trouble in the ground below a new street.

3 Installation work

In all, the following drinking water pipelines have to be replaced, relaid or installed as new in the course of the operation.

- 400 m of DN 200,
- 200 m of DN 300,
- 850 m of DN 400,
- 270 m of DN 500,
- 800 m of DN 800.

Ductile iron pipe systems to EN 545 [1] are being used for this purpose. All the pipes and fittings are equipped with restrained push-in joints, the DN 200 to DN 500 nominal sizes with the friction locking BRS® push-in joint and the DN 800 size with the positive locking BLS® push-in joint. The external protection for the pipes consists of a 200 g/m² zinc coating plus a blue epoxy finishing layer. Internally the pipes have the standard cement mortar lining.

Where the routes lie below Max-Liebermannstrasse and Olbrichtstrasse, the underground installation space in the area is packed with drinking water pipelines and with pipelines and cables belonging to other utilities. This was for example the case where a DN 500 pipeline was connected into the DN 800 pipeline at the point where Max-Liebermannstrasse and Olbrichtstrasse cross **(Fig. 4)**.

Fig. 3:
Connecting up an interim pipeline

Fig. 4:
Connecting the DN 500 ductile iron pipeline into the DN 800 pipeline, also of ductile iron

A DN 400 pipeline runs below these other two pipelines **(Fig. 5)**. All this makes severe demands on the companies doing the laying.

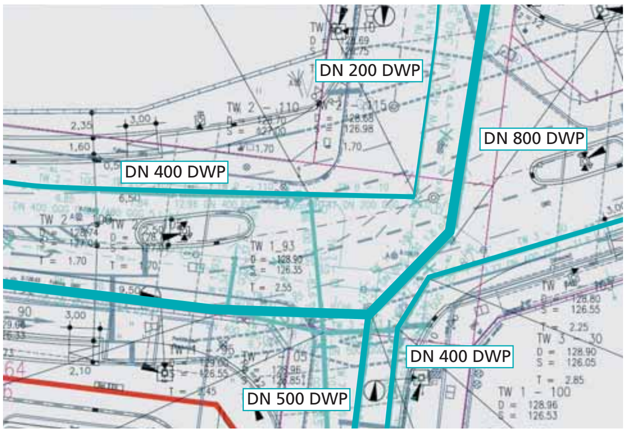

Fig. 5:
Drinking water pipelines (DWP's) occupying the space below ground

4 To sum up

KWL has the period from March 2010 to December 2011 planned as the building and installation period. So far, the operation has proceeded on schedule. All those involved have worked well together, and this and the flexibility of the ductile iron pipe system used have meant that even when they could not be foreseen, difficult situations were coped with successfully.

Experience to date suggests that the planned schedule will also be kept to during the rest of the operation.

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[1] EN 545
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Replacement of a water pipeline in the structure of an arch bridge in Swiss Steel AG's works at Emmenbrücke near Lucerne

by Roger Saner

1 Introduction

Swiss Steel AG has a tradition going back more than 150 years in steelmaking in Switzerland. Today, it is a leading supplier of high-grade steels to the automotive, machinery, plant and equipment industries in Europe.

At any steel works, a secure and reliable supply of water is a basic requirement for the smooth flow of all the production processes and this is equally true of steel production at Swiss Steel's Emmenweid works at Emmenbrücke near Lucerne. Most of the water is needed for cooling the smelting and casting processes and for the further working of the steel billets in the rolling mill. Also, a sprinkler system was installed in 1990 and in the event of a fire it has to be ensured that there is sufficient fire-extinguishing water available for this system and to provide the supply drawn from the hydrants. A relatively small proportion of the water is used as drinking water or as water for the toilet facilities.

2 Ensuring a secure water supply

For this purpose the Emmenweid works has its own water supply system which has three pumping stations for extracting ground water. The pumping capacities of the pumps differ between the stations and vary between 60 m^3/h and 120 m^3/h, with the maximum approved pumping capacities being 120 m^3/h to 384 m^3/h. The pipeline network is designed as a ring pipeline. A 1.3 km long transporting pipeline connects the network to the company's own "Listrig" reservoir, which has a capacity of 229 m^3 (reserve of water for works consumption 153 m^3, reserve of fire-extinguishing water 76 m^3) and compensates for the difference between the volume of water pumped and the works consumption. For increased security, the drinking water network and the hydrant system are connected directly to the water supply networks of the municipality of Emmen and the city of Lucerne. These networks automatically feed in a supply if the pressure on the steelworks' network drops below 5.5 bars. As well as this, the emergency water supply system for the cooling water circuits of the steelworks is also connected directly to the mains network of the municipality of Emmen by a separate lateral. The entire water pipeline network is divided into two parts (the municipality of Emmen side/the city of Lucerne side) by the "Kleine Emme" river. Three pipelines carried on bridges connect the two parts of the network together.

3 The situation at the outset

One of these three bridges, an arch bridge of superbly elegant design **(Fig. 1)**, serves as the access route to the works for materials and carries heavy traffic in the form of heavy goods vehicles and goods trains. Over the years, the surfacing of the carriageway had suffered badly from these loads and from the weather and urgently needed replacing.

Swiss Steel AG's water pipeline network is being replaced in successive stages. The replacement of the carriageway provided an opportunity for the old water pipeline located in the part of arch bridge where the footway is situated to be replaced at the same time. The old water pipeline, a DN 300 grey cast iron pipeline with packed socket joints and with an operating pressure of 7 bars, dated from 1943. Back in 1984, parts of this feeder pipeline off the main body of the bridge and running back to the

Fig. 1:
View of the arch bridge over the "Kleine Emme"

abutments had been replaced by ductile iron pipes with screwed socket joints. The new pipeline was now to be connected-in between these still intact parts of the old pipeline.
The old construction drawings for the arch bridge still existed and showed the special installation situation, in a very narrow, trapezoidal duct for the works pipeline with narrow access openings **(Fig. 2)**. Under these cramped conditions, the old water pipeline, consisting of 4 m long pipes with packed sockets, had been fixed in place and packed simply with wooden supports. The access openings had then been covered with prefabricated concrete slabs and sealed off with a covering of asphalt. The pipeline therefore remained accessible from above for any subsequent maintenance or refurbishment work.

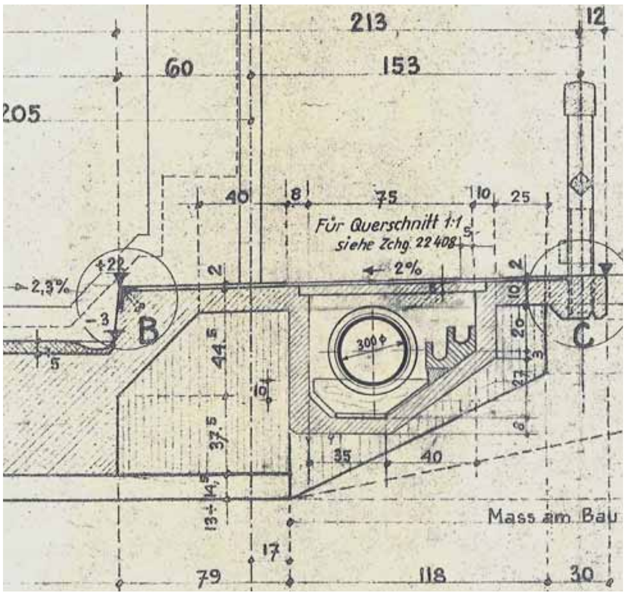

Fig. 2:
Cross-section through the duct for the works pipeline (drawing of 1943)

4 Selection of the pipes

Because of the very cramped conditions in the pipeline duct below the bridge and because of the restricted access openings – clear dimensions of the standard openings: length of 3.40 m and width of 0.75 m – there were some demanding requirements that the new pipes had to meet with regard to length, external dimensions and corrosion protection.

Against the background of this unusual situation for installation, the *ecopur* fully protected ductile iron pipe was the ideal solution: it is coated externally and internally with polyurethane (PUR) to EN 15655 [1] and EN 15189 [2]. The standardised outside diameter of the *ecopur* pipe includes the 0.9 mm thick PUR coating. This catered for the very cramped conditions in the duct for the works pipeline.
What is more, the *ecopur* pipe to EN 545, Annex D.2.3, is a fully protected pipe with a reinforced coating and is therefore resistant to chemical attack of any kind and to mechanical damage.

Another important advantage is that movements in the bridge, such for example as heat-induced changes in length or vibration caused by the railway traffic, are fully absorbed in the push-in flexible joints.

5 Installation work

For the installation of the new *ecopur* ductile iron pipes, the crucial factor was the dimensions of the access openings to the pipeline duct once they had been exposed by the installing company. Not all the openings are of the same clear length. Where they are at the standard spacing of the bridge's suspension rods, their length is 3.40 m **(Fig. 3)**. However, at the concrete abutment at the end of the bridge on the city of Lucerne side, where the new pipeline had to be connected to the existing suspended pipeline, the clear length is only 1.40 m **(Fig. 4)**. These requirements had to be noted when the pipes were being produced. Thanks to the manufacturer's ability to be flexible, the *ecopur* pipes were produced in the factory in a variety of lengths of 1.50 m, 3.00 m, 3.50 m and 4.00 m (the standard length) precisely calculated for the installation work and were coated all over with polyurethane.

Fig 3:
Opened access openings to the duct for the works pipeline, standard length of 3.40 m

Fig. 4:
The short access opening (length of 1.40 m) at the concrete abutment at the end of the bridge on the city of Lucerne side where the connection was made

Fig. 5:
Detail view of the *hydrotight* push-in joint in the narrow duct for the works pipeline

Fig. 6:
A fixing point for the *ecopur* ductile iron pipe using a pipe clip with integral base plate

In the restricted space available in the services duct, the sockets could still be easily, quickly and securely connected with the *hydrotight* joint **(Fig. 5)**. The pipes were mounted on base plates by means of pipe clips **(Fig. 6)**. The floor of the concrete duct is only 8 cm thick so fixing the base plates in place with bolts would have created a risk of spalling. The base plates of the pipe clips were therefore embedded in special mortar by means of auxiliary formwork.

The whole of the water pipeline on the bridge was installed without restrained joints so that the temperature-related changes in the length of the bridge and also the movements due to goods trains travelling over it could be absorbed in the flexible joints of the ductile iron pipes.

Fig. 7:
Connection of the *ecopur* pipes to the existing screwed socketed pipeline on the municipality of Emmen side

Fig. 8:
Connection of the *ecopur* pipes to the existing screwed socketed pipeline on the city of Lucerne side

At the points in the area of the abutments where the new pipeline was connected into the existing screwed socketed pipes, the fittings were connected with restrained joints using the *hydrotight* type external thrust resistance systems and an anchoring clamp for screwed sockets **(Figs. 7 and 8)**. In the duct, the fully assembled pressure pipeline was insulated with glass wool and packed in with bituminous felt to protect it from frost.

Everyone involved worked together well and this enabled the work of installing the pipes to be completed on schedule. The carriageway surfacing having been replaced to complete the job, the client was able to release the arch bridge for works traffic on time; it is now gleaming again but with a new radiance.

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Replacement of the Wilkau-Hasslau connecting pipeline belonging to Wasserwerke Zwickau GmbH

by Thomas Mühlmann

1 General

The Wasserwerke Zwickau GmbH water supply company of Zwickau in the German state of Saxony was founded in 1991 and as a local authority enterprise is owned by the towns and other municipalities in the area supplied. The company operates a pipe network some 1,220 km long. The area supplied extends from the Crimmitschau region in the north to the Kirchberger region in the south. In all, Wasserwerke Zwickau's network supplies around 235,000 inhabitants of 17 towns and other municipalities with drinking water.

2 Purpose of the project

The connecting pipeline (laid in 1976/77) is a feeder main extending from the "Vielau" high-level service reservoir through Wilkau-Hasslau to Zwickau. There is an infeed point to the Zwickau supply network in the area of Bürgerschachtstrasse (a gravity pipeline to the "Hermann-Krasser-Strasse" high-level service reservoir). In the connecting pipeline's system, the "Hermann-Krasser-Strasse" reservoir also acts as an equalising reservoir. The pipeline is a total of 5 km long and in the section on which work was planned it consisted of DN 600 steel

Fig. 1:
Layout plan

Fig. 2:
DN 400 ductile iron pipes on the route

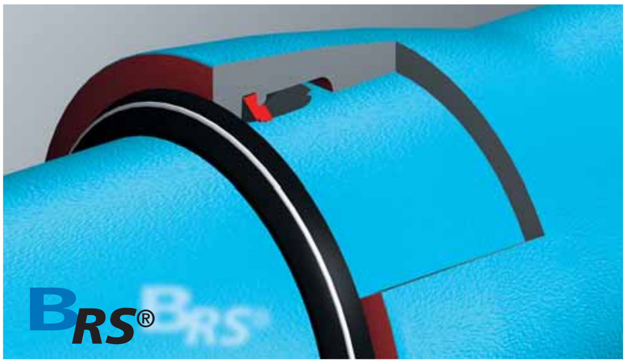

Fig. 3:
The BRS® push-in joint

pipes. Following the construction of the new "Vielau" high-level service reservoir there had been an increase in the number of pipe burst in the section concerned due to the change in pressure. The main reason for these was pitting corrosion on the steel pipes. The possibility of further bursts in the section affected could not be ruled out because the same hydraulic conditions needed to be maintained for the foreseeable future. In view of the security of supply needed in the regions supplied, this section, totalling around 3,080 m in length, had to be classed as in urgent need of refurbishment. For financial reasons, the implementation of the refurbishment measures was divided into four sub-sections planned for the period from 2009 to 2011.

3 Planning

Consumption was declining so Wasserwerke Zwickau GmbH decided to reduce the cross-section of the pipeline from DN 600 to DN 400 in the section on which work was planned **(Fig. 1)**. In three of the four sub-sections an interim pipeline would be needed to maintain the supply. In view of these requirements, a study was made of possible variants at the pre-planning stage. The following were compared:

- internal refurbishment of the pipeline,
- laying of a new pipeline using pipes of different materials (steel, ductile cast iron, HDPE)
- pipeline layouts (laid on same route or laid in parallel).

A technical and economic analysis of the variants showed the optimum one to be the installation of a ductile cast iron pipeline with restrained push-in joints **(Fig. 2)**. Exactly what form the joint would in the end take was left to the competitive process to decide. The best tender from the economic point of view was based in this respect on the BRS® restrained push-in joint **(Fig. 3)**. The pipes are to EN 545 and their standard internal protection consists of a cement mortar lining whose fields of use comply with DIN 2880 [1]. Externally the pipes are protected by a zinc coating and an epoxy finishing layer.

4 The installation work

In sub-sections 1 to 3, the DN 400 pipeline runs parallel to the existing pipeline and in sub-section 4 it follows the same route (no interim supply needed). Seasonal use is made of the areas of farming and pasture land involved and because of this the installation work could only be done in the autumns of the respective years **(Fig. 4)**. Sub-sections 1 and 2 of the installation were completed within four months in 2009. 1,563 m of ductile iron pipes of DN 400 nominal size and a nominal pressure of PN 10 were installed.

Fig. 4:
Installation on the same route of DN 400 ductile iron drinking water pipes with BRS® restrained joints

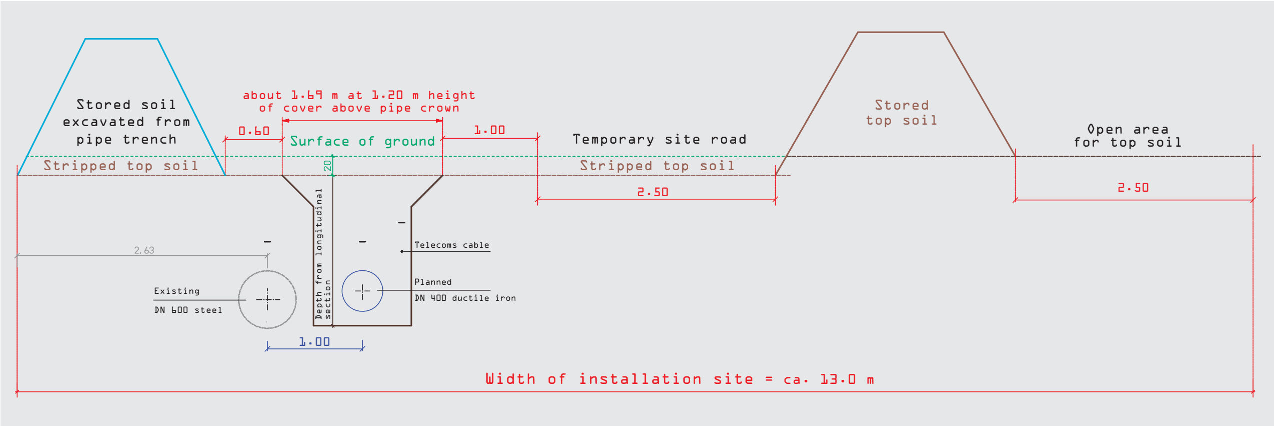

Fig. 5:
Width of installation site – Installation in parallel in the area of unsurfaced land

The contract was placed with the HSE-Bau GmbH company. The new pipeline was positioned directly parallel to the existing one at a clear distance of about 50 cm. The bedding for the pipes was to DVGW Arbeitsblatt W 400-2 [2] or in general conformity with EN 1610 [3], bedding condition type 1. The width of the installation site was approximately 13 m but at narrow points it was reduced to approximately 6 m **(Fig. 5)**.
Following the installation and commissioning, the pipeline was subjected to gasification with CO_2 under DVGW Arbeitsblatt W 346 [4]. This carbonated the cement mortar lining sufficiently for the pH of the soft drinking water from the “Burkersdorf” waterworks to remain stable.

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Trenchless replacement of asbestos cement pipes by special ductile iron pipes in Berlin

by Lutz Rau

1 Constraints affecting the installation project

An old and decrepit asbestos cement sewage pressure pipeline needed to be replaced as part of a large pipeline installation project for sewage disposal in the south-east of Berlin (see the article entitled “With special ductile iron pipes through Berlin’s Müggel Hills” on page 42 ff). For several reasons, this section of pipeline had to be replaced by a trenchless technique **(Fig. 1)**.

In many cases, asbestos cement pipelines are replaced by the burst lining technique because the asbestos cement fragments are left in the soil round the new pipes, therefore avoiding high dumping costs. In Berlin, fragments of old pipes, whatever their origin, cannot be left in the ground and any such material has to be entirely removed. This requirement has prompted the development of special-purpose pipe replacement techniques, namely the press-pull technique under DVGW-Arbeitsblatt GW 322-1 [1] and the auxiliary pipe technique under DVGW-Arbeitsblatt GW 322-2 [2]. In both these techniques, all the fittings, valves and house connections are removed and the old pipes are then pressed out of their bedding axially into an installation pit by suitable hydraulic rams. They are then removed from the pit either as broken-up pieces or complete lengths.

Fig. 1:
Prepared for installation: special ZMU-PLUS ductile iron pipes with BLS® push-in joints

Depending on the nature of the soil and the composition of the water, asbestos cement pipes may, after being in operation for years, lose enough of their strength to be unable to withstand the thrust from the hydraulic rams. This puts at risk the aim of total removal from the ground. There is a detailed description in section 2 of how the old asbestos cement pipes were nevertheless able to be strengthened and recovered.

In all, some 630 m of DN 250 asbestos cement pipes were replaced with DN 200 nominal size ductile iron pipes by trenchless means. To meet the technical requirements of BWB (Berliner Wasserbetriebe, the Berlin water supply company), the new ductile iron pipes are equipped with BLS® restrained push-in joints. External protection is provided by a mechanically extremely rugged cement mortar coating. The proven ZMU-PLUS special ductile iron pipes, with a fully cylindrical outer circumference measuring 310 mm in diameter, were selected as new pipes suitable for this installation project.

The Josef Pfaffinger GmbH installing company put in a low-cost special tender and secured the contract with a special installation technique similar to the press-pull technique **(Fig. 2)**.

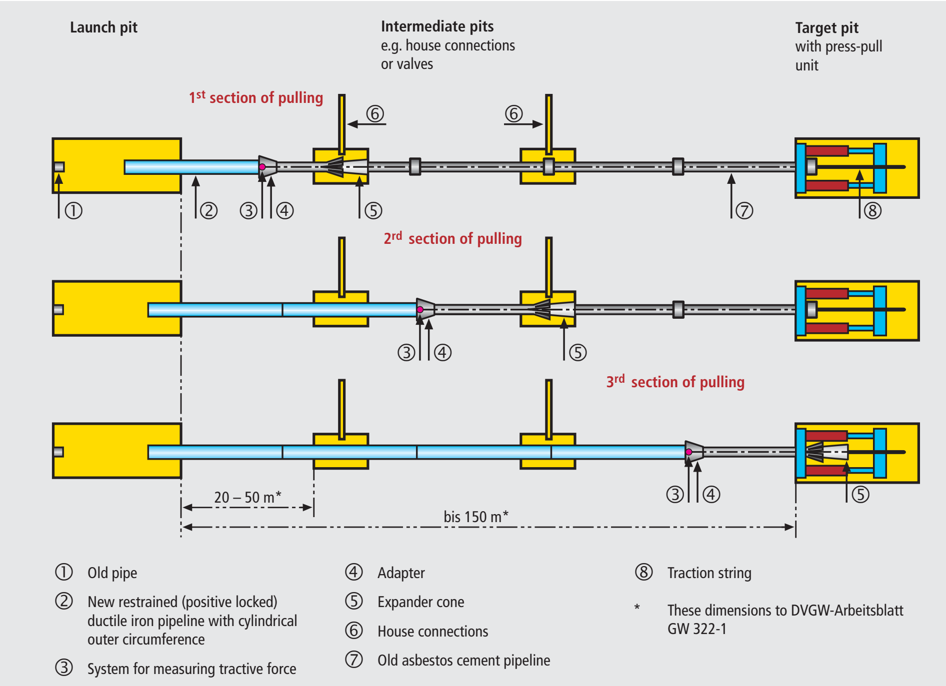

Fig. 2:
Diagram of the press-pull technique for the trenchless replacement of asbestos cement pipes by ZMU-PLUS pipes with BLS® push-in joints

The contract takes into account the following relevant constraints:

- the installation technique,
- traffic flow,
- environmental requirements and
- safety at work.

2 Description of technique and execution of installation work

The machinery and installation pits having been dug out and shored, the old pipeline, once drained, was cut in these pits in accordance with the current stipulations of Berliner Wasserbetriebe (BWB). The distance between pits depends on many factors, such as the local conditions and the position of connections, fittings and also intersecting pipelines belonging to other utilities. Distances of from 18 m to 50 m between pits were selected in this case, with pulling being possible from the machinery pit in both directions.

Fig. 3:
Traction string guided in a plastic pipe

Plastic pipes, into which the traction string was subsequently inserted, were then slid into the exposed sections of the asbestos cement pipeline while held central by spacers **(Fig. 3)**. The annular space between inner wall of the asbestos cement pipe and the outer wall of the plastic pipe was filled with special mortar which, once cured, performed the function of strengthening and supporting the old pipe during the pressing operation **(Fig. 4)**. The hydraulic ram then pressed the old pipe out of the ground by means of the traction string, passing the old pipe, as it did so, over an expander cone which burst the old pipe. To meet safety requirements, this process was sealed off from the surroundings, i.e. the fragments dropped into an impermeable big bag which completely enclosed the expander cone even during the bursting. Once the bag was full, it was sealed, taken out of the side of the pit and stored temporarily under secure conditions before being taken to a suitable dump. As well as this, the area was also sprayed with a constant mist of water to stop any asbestos fibres from escaping and flying about.
Fig. 5 shows the bursting process and some burst fragments. To enable the process to be seen and a photograph taken, the protective big bag was not pulled up and sealed over the top of the expander cone. The mist of sprayed water caused any asbestos cement particles to deposit

Fig. 4:
Pouring in special mortar to fill the annular space

in the pit. Pieces of the mortar filling the annular space, of the plastic pipe and of the asbestos cement pipe itself can be seen among the fragments. As in the usual trenchless replacement techniques, the ductile iron pipes were coupled to the old pipe and pulled along after it as the bursting progressed. The easily connected BLS® push-in joint was particularly advantageous here but still provided great safety during fast installation. As in all conventional techniques, the sections of pipeline were then connected to fittings in the pits and then pressure-tested section by section. The tractive forces were of course measured continuously during the entire pulling process and a record was kept of them.

Fig. 5:
The bursting process combined with the press-pull process

3 Conclusions

The installation technique developed from the press-pull technique and the proven material of the new pipes have enabled an old asbestos cement pipeline to be replaced safely to the current requirements of Berliner Wasserbetriebe, which call for fragments of old asbestos cement pipes not to be left in the ground. The press-pull technique as further developed for asbestos cement pipes has shown itself to be a responsible way of meeting the requirements which have to be met by sustainable pipeline installation.

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Trenchless laying of a new pipeline in difficult terrain

With special ductile iron pipes through Berlin's Müggel Hills

by Olaf Brucki and Lutz Rau

1 Introduction

Berlin's largest catchment area for drinking water is situated in the well-forested lakeland recreational area around the Müggelsee lake in the south-east of the capital's Köpenick district. To ensure that sewage is disposed of safely, Berliner Wasserbetriebe (BWB), Berlin's water supply company, has laid a new pressure sewage pipeline, and has provided an important disposal route, along the road known as Müggelheimer Damm.

The "Müggelheimer Damm" consortium, under the lead management of the Max Bögl group of companies **(Fig. 1)**, was awarded the contract to install the new pressure sewage pipeline, partly by open trench techniques but mainly by trenchless ones. The period for installing the new pressure sewage pipeline, which connects the village of Müggelheim to the Köpenick sewage pumping station, lasted from September 2009 to October 2010.

Fig. 1:
The Max Bögl company's site equipment

2 Installation-related constraint and requirements

The total length of the new pressure sewage pipeline is around 5,600 m. One particular challenge made by the installation of the ductile iron pipeline was its position at the edge of a main traffic artery and also its location in forested land with trees and roots everywhere, which made it difficult for construction vehicles to be used.
Being in a catchment area for drinking water, there were also particular water authority requirements that the route had to meet.

3 Execution of the installation work

Because of the requirements mentioned, the pipeline – apart from some conventional open trench sections – was installed under DVGW-Arbeitsblatt GW 322-2 [1] mainly by the trenchless technique known as the auxiliary pipe technique with a steered pilot bore. This is a relatively new technique and special ZMU-PLUS pipes, were used for it. Any interference with the landscape and nature or with the flow of traffic into and out of the city was kept to a minimum in this way. It also enabled the installation time to be shortened considerably.

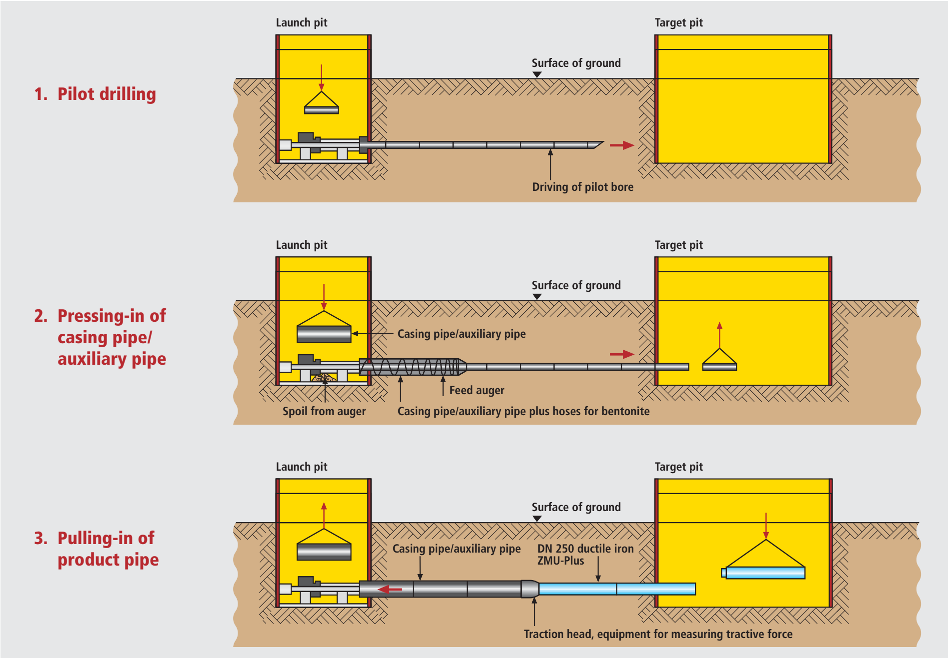

Fig. 2:
Diagram of the auxiliary pipe technique with a steered pilot bore

The contract was awarded in the autumn of 2009. Obtaining consent for the re-routeings of traffic delayed the start of the installation site slightly but after that the set up went perfectly smoothly. What nobody was expecting at that stage was the particularly long and cold winter with almost Siberian temperatures, which hampered the actual installation work and delayed it enormously. Only the preparatory work – clearing the route, relaying other pipelines and laying out the installation pits – could be done in advance. It was only when spring brought the endless months of winter to an end that all the obstacles had been overcome and the real work could start.

The route runs from the road known as Sandschurrepfad along the Müggelheimer Damm to the "Müggelsee Terrassen Rübezahl" restaurant and is divided into different sections where different installation techniques are used.

4 The auxiliary pipe technique with a steered pilot bore

For the trenchless laying of new pipelines, the installing company has to be certified for group GN1 (press-pull techniques) under DVGW-Arbeitsblatt GW 301 [2].

Once the machinery pit and the pit for connection work have been opened and dug out, the exact route is defined by means of a steered pilot bore. A bore forming a small tunnel is then drilled out along the pilot bore, the advancing drilling head being pressed forward by firmly connected steel pipes (auxiliary pipes) and the spoil being fed back to the machinery pit by augers in the auxiliary pipes. The drilling head and feed augers are always surrounded by protective steel pipes which support the bore which is being drilled out. Once the bore has been made, the steel pipes (the auxiliary pipes) are pulled back into the machinery pit and disconnected there together with the sections of feed auger situated inside them. Before the pulling-back takes place, a tool of larger size is mounted at the end of the auxiliary pipes and this cuts away what is referred to as the oversize (**Fig. 2**).

The spoil from the oversize is also fed through the auxiliary pipes to the machinery pit by the augers. The cast iron pipes, which are cylindrical on the outside and have restrained joints, are coupled to the upsizing head (the hole opener)

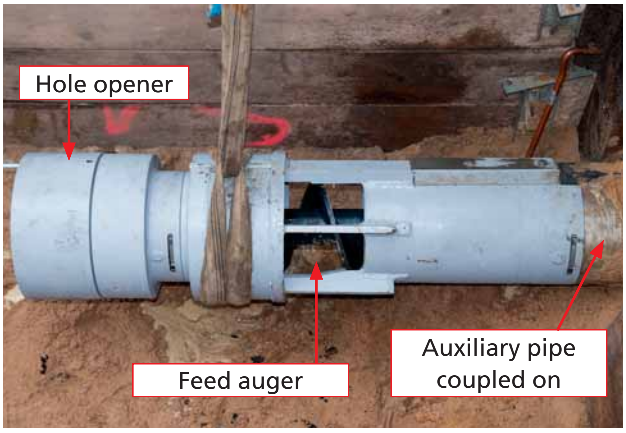

Fig. 3
Hole opener and the drilling head coupled to the auxiliary pipes

Fig. 4:
DN 250 ZMU-PLUS ductile iron pipes with BLS® push-in joints, suitable pipes for the auxiliary pipe technique

Fig. 5:
A sealed gap in the region of the BLS® push-in joint of a ZMU-PLUS pipe

and are pulled, one by one, into the hole which is being opened up. Frictional forces are reduced by lubrication with bentonite **(Fig. 3)**.

The technique allows sections of pipeline up to 80 m long to be installed underground without large areas of the surface (forest, biotopes, traffic routes, etc.) having to be broken open.

5 The special ZMU-PLUS pipe

Many innovations are the result of proven products being cleverly adapted and re-thought to develop them for new conditions of use and new basic requirements. This was the case with the ZMU-PLUS pipe, which has been in general use for several years now in Berlin. It was originally developed at the request of Berliner Wasserbetriebe (BWB) for trenchless replacement techniques for drinking water pipes to allow routes to be accurately maintained in coarse-grained and non-cohesive soils, and it has been successfully used for this purpose. Techniques for the trenchless laying of new pipelines however have opened up entirely new areas of use for it.

In the case of the ZMU-PLUS pipe **(Fig. 4)**, ductile iron pipes with BLS® restrained joints are so thickly coated with cement mortar, to a point level with the external outline of the socket, that they become of a cylindrical shape externally with no apparent socket. The cement mortar coating is extremely rugged mechanically to the requirements of EN 15542 [3]. It will withstand tremendous frictional forces around the entire circumference of the barrel of the pipe, these forces being limited by the fact that no tolerances in the plus direction are allowed on the thickness of the coating. Once the BLS® locks have been fitted, the gap between the end-face of the socket and the spigot end is sealed off with a flexible material and is then bonded over with special adhesive tape **(Fig. 5)**.

For the entire project to proceed smoothly, it was important for the sewage pressure pipes used, DN 250 pipes to EN 598 [4] of wall thickness class K 9 with restrained BLS® push-in joints and ZMU-PLUS coatings, to be produced and delivered quickly and promptly, not forgetting of course the accessories for the restrained joints and for sealing off the gap at the socket.

In the course of the “Müggelheimer Damm” project, a number of machines suitable for carrying out the auxiliary pipe technique with a steered pilot bore were put to work simultaneously. To make up for the delays caused by the long winter, work continued round the clock in various areas.

6 To sum up

Because of the work which was going on simultaneously at a large number of points, the logistical demands on everyone involved were severe. The installation timetables which had been prepared had to be kept to exactly to ensure that the whole sequence would go off without a hitch.

Deserving of special mention in this connection were the punctual deliveries of the ductile iron pipes and accessories required, and the installation site signs and barricades for traffic, which needed constant re-siting and without which traffic chaos would have ensued.

Fig. 6:
The twin DN 250 pipelines as laid in the area of a bend

Fig. 7:
Twin DN 250 ductile iron pipelines – open trench installation

It was possible in this way for twin DN 250 pipelines **(Figs. 6 and 7)**, running at a spacing of 1.00 m from the Sandschurrepfad road in the south-west in an easterly direction to the "Müggelsee Terrassen Rübezahl" restaurant, to be successfully installed by the two variant procedures – trenchlessly and by the technique referred to as the auxiliary pipe technique with a steered pilot bore. The additional connections to the transfer structures were also made.

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Horizontal directional drilling technique used for pipe-by-pipe pulling-in of DN 900 ductile iron pipes in Belgium

by Steffen Ertelt

1 Introduction

Constantly spreading built-up areas, wide multi-lane roads or complicated routes are making it increasingly difficult and expensive to replace existing pipeline systems, or lay new ones, by the open trench technique. This is why trenchless installation techniques have been under development and in use for some 30 years now.

The continuing development of the machinery used is going hand in hand with the modification of a pipe material with a great tradition, namely ductile iron, and with changes in the technology of making restrained joints between pipes of this material. A successful example of such new joints is the positive locking BLS®/VRS®-T push-in joint. This joint is flexible and enables pipes to be laid to tight radiuses by an angular deflection at the sockets. The welding bead, which is applied to the spigot end in the factory, and the metallic locking segments, which are supported in the locking chamber cast into the socket, enable very high longitudinal forces to be transmitted.

Fig. 1:
The BLS®/VRS®-T push-in joint

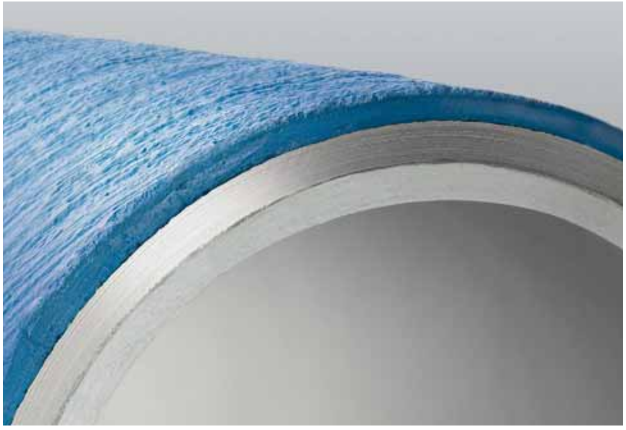

Fig. 2:
The cement mortar coating to EN 15542 [1]

2 The horizontal directional drilling technique using ductile iron pipes

Pipes having the positive locking BLS®/VRS®-T push-in joint **(Fig. 1)**, combined with a cement mortar coating to EN 15542 [1] as an external protection able to withstand high mechanical loads **(Fig. 2)**, are available for the trenchless installation of ductile iron pipes by the **h**orizontal **d**irectional **d**rilling (HDD) technique. The BLS®/VRS®-T push-in joint is a restrained socket joint in which a welding bead is applied to the spigot end in the factory. A locking chamber cast into the socket receives the locks or locking segments which, once the spigot end has been pushed into the socket, are inserted through openings in the end-face of the socket which lead into the locking chamber. If axial tractive forces are exerted on the joint, either by the internal pressure or by the use of the pipes for a trenchless pulling-in technique, the welding bead is supported against these locks or locking segments and in this way transmits a very high force **(Fig. 3)**.

Ductile iron pipes can be trenchlessly installed by the HDD technique both as a fully assembled pipe string and by pipe-by-pipe connection. The possible length of pipeline which can be pulled

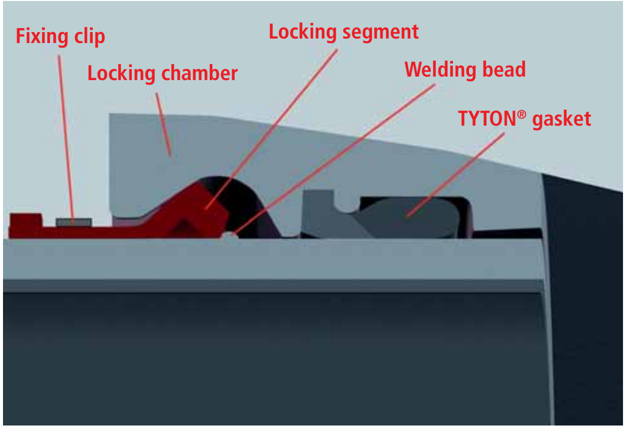

Fig. 3:
Construction of the DN 900 BLS®/VRS®-T push-in joint with fixing clip for trenchless pipeline installation

in is determined by the permitted tractive force on the restrained push-in joint. Details can be found in DVGW-Arbeitsblatt GW 321 [2] and in the manual entitled "Trenchless Installation of Ductile Cast Iron Pipes" [3]. Because of the results of externally monitored type tests (internal pressure tests under product standard EN 545 [4]), the values of permitted tractive force specified in the latter are in some cases higher than those specified in DVGW-Arbeitsblatt GW 321 [2] **(Table 1)**.

3 Installation of a drinking water pipeline using DN 900 ductile iron pipes

Pidpa is one of the largest Flemish water suppliers and supplies fresh drinking water to more than a million people. The company distributes its drinking water by means of a 12,581 km long pipeline network. The municipality of Grobbendonk (a small town with just over 10,000 inhabitants), is situated right next to the Albert Canal, an artificial waterway 129.5 km long which connects the two Belgian towns of Liège and Antwerp. The existing pipeline needed to be relaid due to the construction of a new bridge.

In part of the area, the new pipeline runs directly along the Albert Canal. If open trenches had been used, the water would have had to be predrained from them, an expensive undertaking. This was avoided by the trenchless installation of ductile iron pipes by the horizontal directional drilling

Table 1:
Permitted tractive forces, angular deflections and radiuses of curves for ductile iron pipes with BLS®/VRS®-T push-in joints (sources: DVGW-Arbeitsblatt GW 321 [2] and Manual [3])

Nominal size DN in mm	Allowable operating pressure PFA ¹ [bar]	Permitted tractive force $F_{perm.}$ ² [kN]		Possible angular deflection at sockets ³ [°]	Minimum radius of curves [m]
		DVGW [2]	Manual [3]		
80*	110	70	115	5	69
100*	100	100	150	5	69
125	100	140	225	5	69
150	75	165	200	5	69
200	63	230	350	4	86
250	44	308	375	4	86
300	40	380	380	4	86
400	30	558	650	3	115
500	30	860	860	3	115
600	32	1,200	1,525	2	172
700	25	1,400	1,650	1.5	230
800	16	—	1,460	1.5	230
900	16	—	1,845	1.5	230
1,000	10	—	1,560	1.5	230

¹ Basis for calculation was wall-thickness class K 9. Higher pressures and tractive forces are possible in some cases but must be agreed with the pipe manufacturer.
² When pipelines follow straight routes (max. deflection of 0.5° per pipe joint), the tractive forces can be raised by 50 kN. High-pressure locks are required for DN 80 – DN 250.
³ When of the nominal dimensions
* Wall-thickness class K 10

Fig. 4:
1000 kN drilling rig

technique with the pipes pulled in pipe-by-pipe. It was possible to make use in this case of the experience gained on a project involving DN 600 nominal size pipes which was completed in 2008 in the town of Ghent [5], also in Belgium.

A 1000 kN drilling rig **(Fig. 4)** was used for the drilling and the subsequent pulling-in of the ductile iron pipes. The pilot bore having been made, it was widened step by step by special upsizing heads **(Fig. 5)**. The pipes were connected on one by one on a special connecting ramp. The first pipe was connected **(Fig. 6)** to the traction string and the barrel reamer by means of a BLS®/VRS®-T traction head with built-in force-measuring equipment.

To make the connection, the segments for locking the DN 900 BLS®/VRS®-T push-in joint are inserted, once the spigot end of the pipe has been inserted in the next socket, in the locking chamber **(Fig. 8)** through the opening leading into the socket **(Fig. 7)** and are distributed around the circumference of the pipe alternately to the left and the right. In a trenchless installation technique, the segments are then secured with a steel fixing clip.

This ensures that the locking segments are at all times firmly in abutment as the pipe is pulled in.

Fig. 5:
Upsizing heads

Fig. 6:
Pipes being connected on a connecting ramp

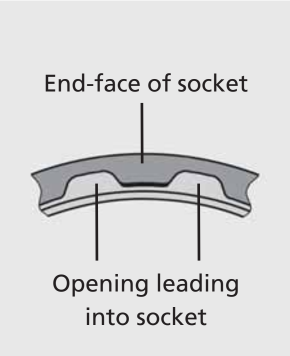

Fig. 7:
Opening leading into socket on DN 600 to DN 1000 size BLS®/VRS®-T push-in joints

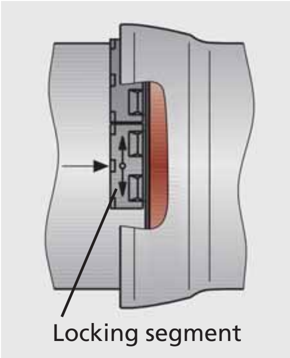

Fig. 8:
Insertion of locking segments

Fig. 9:
Pulling-in of the pipes; the push-in joint is protected by shrink-on material and a sheet-metal cone slid over the top

Once the locking segments have been inserted, the socket joints are protected by a shrink-on sleeve. The sheet-metal cone **(Fig. 9)** which is slid on prevents any possible damage from being done to the shrink-on sleeve in the bore as the pipeline is subsequently being pulled in.

Project data

- HDD installation of individually connected DN 900 BLS® pipes
- Pipe external protection: cement mortar coating to EN 15542 [1]
- Length of pipeline: 342 m
- Drilling rig: 1,000 kN
- Permitted tractive force for DN 900 BLS® pipes: 1,845 kN
- Max. tractive force which occurred: 500 kN

4 To sum up

Ductile iron pipes with restrained BLS®/VRS®-T push-in joints are very well suited to trenchless installation and have already shown this to be the case on a large number of completed projects. The possibility of particularly high forces being transmitted from pipe to pipe allows economical and cost-saving installation and enables very long runs of pipe to be pulled in when using trenchless installation techniques.

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Klagenfurt replaces water pipelines by the burst lining technique

by Stefan Koncilia

1 The situation at the outset

Due to its age and material, the drinking water network in the town of Klagenfurt in Austria was suffering increasingly frequent fractures to its grey cast iron pipelines dating from 1954. Some PVC pipelines which were still in use were also affected.

On the following three streets, parts at risk from pipe fractures were selected for replacement work in 2010:

- Glanfurtgasse DN 80 PVC, length of 500 m with four house connections,
- Krassnigstrasse, DN 100 grey cast iron, length of 250 m with three house connections and
- Toni Strugger Weg, DN 100 grey cast iron, length of 250 m with four house connections.

2 Planning

In the planning phase, the water supply company Stadtwerke Klagenfurt AG carried out hydraulic calculations which showed that a minimum size of DN 100 was required for all three parts.

As well as the straightforward question of cost, other significant planning criteria which would decide how the work was done were the traffic situation, the nuisance to residents and environmental requirements.
The situation was analysed and, in consultation with pipeline rehabilitation specialists SWIETELSKY-FABER, the burst lining technique was determined to be the best method of replacement both technically and economically.

With this technique, the nature of the ground plays a crucial role in deciding whether the technique is feasible. As was expected, test digs found coarse gravel. This type of soil will cause very high mechanical stresses on the new pipe so, when selecting the pipe material, all the criteria and their competing claims had to be carefully considered.

On the short list were butt-welded polyethylene pipes with a protective sheath and ductile iron pipes with BLS®/VRS®-T restrained joints. Calculations to compare the two soon showed that the forces expected would exceed the permitted tractive stress of 10 N/mm² on polyethylene pipes.
It was therefore decided to carry out the burst lining work with ductile iron pipes.
Other factors given a positive rating were the fast connection of the BLS®/VRS®-T push-in joint and the small amount of space needed for installing pipes (no laying-out to the rear of the installation pit needed).

The pipes selected were class K 9 ductile iron pipes to EN 545 with a cement mortar lining (ZM-A), a cement mortar coating (ZM-U) and a BLS®/VRS®-T push-in joint. As well as being protected by the cement mortar coating, the socket areas were given additional protection against damage by the coarse gravel in the form of sheet-metal cones slid onto them.

As well as the usual two locks, the restrained joints were also given an additional high-pressure lock. This enabled the permitted tractive force for the positive locking push-in joints to be increased by about 25 %.

Fig. 1:
The 400 G bursting rig

3 A description of the technique

The burst lining technique can be used to replace old pipes of almost any material. It is possible to replace grey cast iron, PVC, asbestos cement, steel, ductile iron, polyethylene, vitrified clay and concrete pipelines.

By means of a bursting string, the hydraulic traction unit pulls the cutting and expanding head through the old pipe and breaks or cuts it open. At the same time, the expanding head displaces the fragments, together with the surrounding soil, outwards sufficiently far for a new pipe of larger cross-section to be able to be pulled in.

DVGW Merkblatt GW 323 [1] is the technical code for the burst lining technique. All burst lining work is done in accordance with it.

4 Execution of the installation work

Because of the difficult coarse gravel, the parts of the three streets were divided into sections about 150 m long.

Allowance was made for the pipes and cables belonging to other utilities and for the traffic situation when the installation pits were being positioned. The machinery and pipe installation pits having been dug and shored, a TV inspection unit was passed though the old pipeline. The inspection confirmed the route shown on the drawings. There is no need for cleaning the old pipeline when static burst lining is used.

A 400 G bursting rig made by the TRACTO TECHNIK company was used to carry out the technique. It is able to apply a total tractive force of up to 400 kN **(Fig. 1)**.
A pit measuring 3.5 m · 1.5 m was needed for the bursting rig. A pit measuring 8.0 m · 1.0 m was large enough for pulling in the ductile iron pipes.

The old pipe was broken open with roller cutting blades and in the same pass the soil was forced out to a widened diameter of 215 mm with an expander cone. To allow the socket of the ductile iron pipe, whose diameter was 176 mm, to be pulled in, this widening allowed for a 20 % re-contraction of the soil. The ductile iron pipe is fastened in place in the expander cone and is pulled in in the same pass. The pulling-in process was only interrupted for a few minutes for the insertion and the connection of the next

Fig. 2:
A 215 mm expander cone

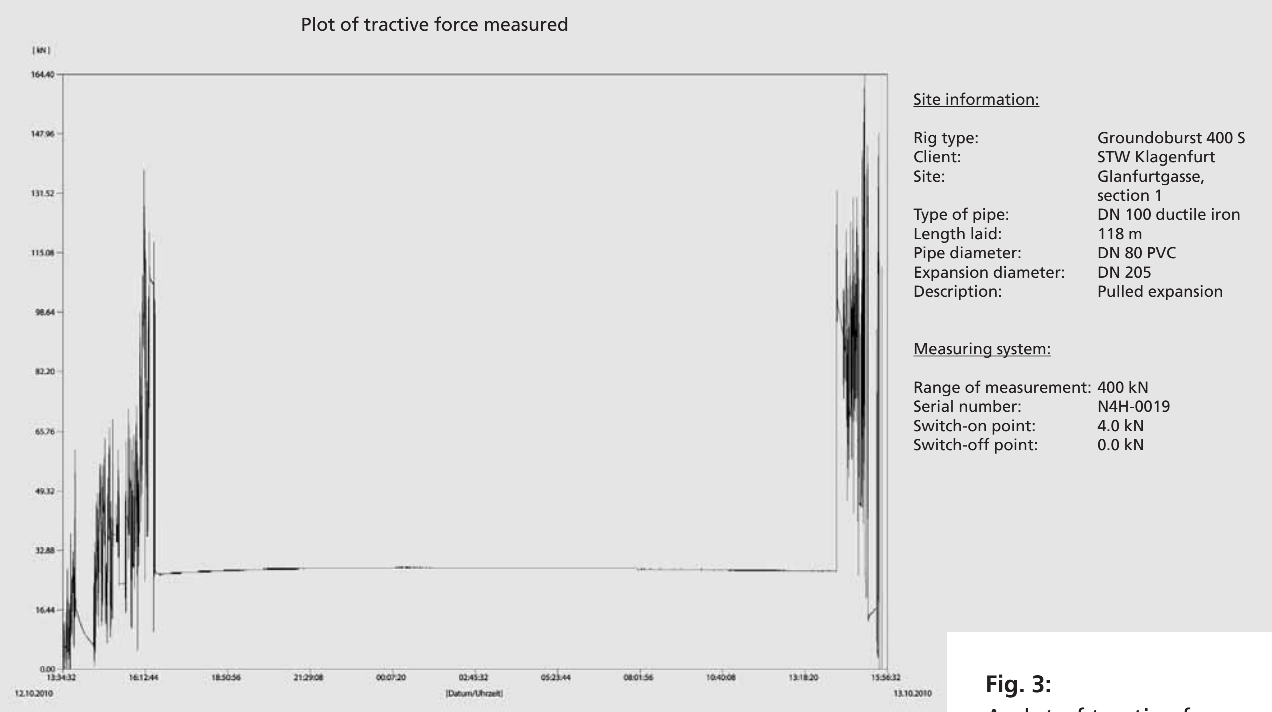

Fig. 3:
A plot of tractive force

Fig. 4:
A section showing a ductile iron pipe which has been pulled in

BLS®/VRS®-T push-in joint. The tractive forces acting on the new pipe are sensed by a built-in electronic data logger and the operator of the machine is told what they are in real time via a receiver in the pit. As required by DVGW-Merkblatt GW 323 [1], this ensures that at no time during the pulling-in process are the permitted tractive forces on the new pipeline exceeded. The plots are handed over to the client as proof of this **(Fig. 3)**.

A stress of 169 kN is permitted for the BLS®/VRS®-T push-in joint with high-pressure locks and at a maximum of 164 kN the tractive forces measured remained below this level in all the sections of the streets.

Regardless of the material of the old pipeline, it was possible for a 150 m long section to be replaced in two working days **(Fig. 4)**. Of this time, one day was needed for installing the bursting rig in the pit. Because of the short connecting times for the BLS®/VRS®-T push-in joint, an installation rate of 50 m/h was achieved.

5 Concluding remarks

The total length of the sections was 1,000 m and the successful use of the burst lining technique enabled the proportion of open-trench work along it to be reduced by more than 80 %. This spared the population of Klagenfurt around 300 journeys by lorries across the town and the noise and dust that these would have caused.

When the economics of the project were later studied, there was found to have been not only a considerable reduction in the overall installation time (11.10.2010 to 11.11.2010) but also a 30 % reduction in costs compared with open trench installation.

In Klagenfurt, it has once again been confirmed that with a client which is open-minded about innovations, with the use of the right installation technique, with the optimum pipe material and with expert specialist companies working with the client, not only can money be saved but there is also a sustainable benefit to our environment.

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requirements, quality assurance and testing
2004-07

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Installation of a DN 200 ductile iron pipeline by the burst lining technique – The "Ithbörde" installation project in Germany's Weser Uplands

by Bernd Richter and Karl-Wilhelm Römer

1 Introduction

The KURT Kanal- und Rohrtechnik GmbH company of Chemnitz in the German state of Saxony put in a tender for the replacement of a drinking water transporting pipeline in Ithbörde.
Its main tender envisaged the replacement of the pipeline with HDPE pipes installed in open trenches but, as an alternative proposal, the KURT Kanal- und Rohrtechnik GmbH company also tendered for replacement by the burst lining technique. Compared with its competitors, the company put in the best tender and was therefore awarded the contract to replace the pipeline, in the way specified in the alternative tender.

2 Preparations

A drinking water pipeline of DN 200 grey cast iron pipes was to be replaced with pipes of the same diameter for a length of approximately 1,200 m by the open trench technique. The contract having been placed for the alternative tender, the decision was made to use DN 200 ductile iron pipes to EN 545. The pipes actually selected were pipes with the BLS® restrained push-in joint.

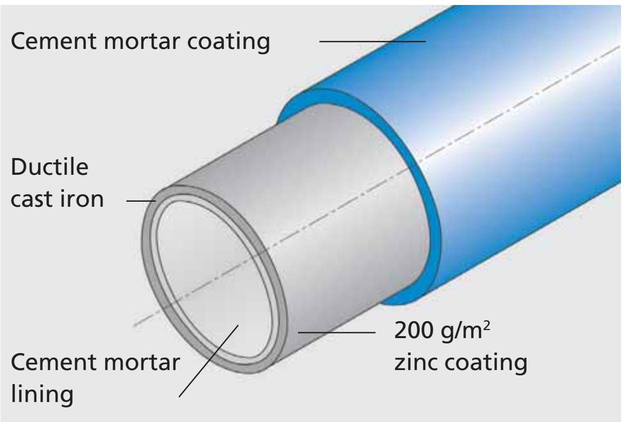

Fig. 1:
Cement mortar coating to EN 15542 [1]

The external protection of these pipes consists of a cement mortar coating to EN 15542 [1] **(Fig. 1)**. This external protection is very strong and is able to withstand high mechanical loads. Added to this, there is the protective effect of the zinc coating below the cement mortar. In the unlikely event of the cement mortar being pierced, the zinc coating provides active protection for the iron. The ductile iron pipes are impermeable to diffusion, and another reason for selecting them was that the old grey cast iron pipeline was surrounded by a coating of tar and the new ductile iron pipes would have the largest safety margins to cater for the unpredictable and uncontrollable loads which occur in trenchless installation techniques. Point supports or longitudinal scoring of the cement mortar coating do not affect the safe operation of the pipeline or its operating life, as may happen in the case of pipes made of, amongst other materials, plastic.

3 Execution of the installation work

The bundles of pipes were unloaded and stored along the farmers road close to the route of the pipeline **(Fig. 2)**. By the static burst lining technique, the old grey cast iron drinking water pipeline was burst for a length of approximately 1,200 m and the new pipeline was pulled in section by section. With the static burst lining technique, a hydraulic bursting rig **(Figs. 3 and 4)** pushes a string of rods into the old pipeline, from a target pit, until it reaches the starting pit.

Fig. 2:
Stored pipes – DN 200 ductile iron pipes with a cement mortar coating

Fig. 3:
The bursting system – the hydraulic unit to control the bursting rig

In the starting pit, the bursting head **(Fig. 5)** is connected to the rod string. As the string is pulled back, the old pipeline is burst and a new pipeline which has been coupled on, of the same size or even of a larger size, is pulled in **(Fig. 6)**. Not only are the pipes protected by the cement mortar coating but the joints also have additional protection in the form of a rubber collar and a sheet-metal cone **(Fig. 7)**.

The tractive forces are constantly monitored during the pulling-in and this ensures that the tractive forces acting on the new pipes do not exceed the levels permitted under DVGW-Merkblatt GW 323 [2] (see Table 1 on p. 51 of the present Journal). Another requirement of DVGW-Merkblatt GW 323 is that the tractive forces should be sensed in real time, the intention here being to ensure that the new pipeline does not suffer any undetected damage even as it is being installed.

In all, the burst lining technique was carried out in twelve sections of individual lengths of around 100 m. The ends of the pipeline were connected in the intermediate pits and at changes of direction by components from the extensive range of fittings equipped with BLS® restrained joints.

The installation project began on 14 June 2010 and ended on schedule after eight weeks of installation time. In consultation with the owners of the areas of agricultural land, the remaining work to restore the surface to its former state was deferred until September 2010 to allow for crop harvesting.

Fig. 4:
A target pit containing a hydraulic bursting rig

Fig. 5:
A bursting head

Fig. 6:
A DN 200 ductile iron pipe being lowered into the pipe connection pit (starting pit)

Fig. 7:
Protection for the restrained push-in joint – a rubber collar and a sheet-metal cone

4 To sum up

To sum up, it can be said that the installation operation was successfully and satisfactorily implemented within the planned budget by close and constructive collaboration between the client, i.e. the Wasserverband supply utility, the engineering consultants, the pipe manufacturer and the installing company.

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Fire protection for five cereal mill complexes in Turkmenistan

by Claudia Mair

1 Introduction

There are many projects which are notable not just for the technical challenges they pose but also where the challenges begin simply with the matter of transport. In the present case, the ductile iron pipes and fittings and the accessories had to be transported for several thousand kilometres from Austria to Turkmenistan sometimes on very difficult roads and in very difficult traffic conditions.

2 Turkmenistan – Location and development

Turkmenistan is a landlocked state in Central Asia which borders on the Caspian Sea and covers an area of 488,100 km². Neighbouring countries are Iran, Afghanistan, Uzbekistan and Kazakhstan. Since 27 October 1991, Turkmenistan has been an independent presidential republic with five provinces **(Fig. 1)**.

Although 90 % of Turkmenistan consists of desert or largely barren land, the country does have a functioning agricultural industry, and from the products of which the population is almost self sufficient. The declared aim of the government is to maintain this independence from imports and to forge ahead with the export of certain products. What are mainly grown are cotton, grapes (for wine) and wheat **(Fig. 2)**.

Only 4 % of the area of the country is usable farmland. This farmland came into being as a result of irrigation projects at the time of the Soviet Union. It was for this purpose that the Karakum (or Qaraqum) Canal, which connects the Amu Darya, a river flowing into the Aral Sea, to the Caspian Sea, was built. Along the two waterways there are extensive irrigated areas which make intensive agriculture possible, wheat for example even being harvested twice a year. After the end of the Soviet Union, the country had hardly any plants for processing its agricultural products because

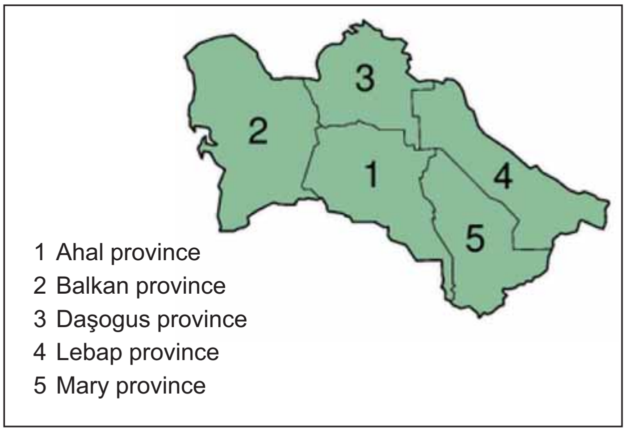

Fig. 1:
The provinces of Turkmenistan

Fig. 2:
The five cereal mill complexes in Turkmenistan

these plants had been sited chiefly in Russia and the goods produced there had been transported back to Turkmenistan. In the immediate post-Soviet era, the products were processed almost entirely in small, antiquated facilities employing manual labour, which were incapable of supplying the population in the long term. In the early and mid-nineties, the government was therefore compelled to redevelop the country's light industry (producing textile products and foodstuffs) from the ground up, which it was possible for it to do because of the income that was now gushing in from the oil and gas business. Because Turkmenistan was maintaining a rather distanced relationship with Russia, and with China too at the time, more European partners were called in to help the country.

At this time, the German plant construction company UNIONMATEX was given contracts for two wheat mills and a textile factory (spinning mill). This policy of step-by-step industrialisation and modernisation of the country is still continuing today. The most important areas of investment are petrochemicals and the construction industry, but for the reasons mentioned above the country is also continuously developing its light industry.

Fig. 3:
A cereal mill complex in Turkmenabad

In this way, an invitation to tender was issued in 2008 for five mill complexes for processing a total of 350,000 t of wheat **(Fig. 3)**. Because of the good experience which the construction of the first mills had been for the client in 1998, UNIONMATEX was again awarded the contract for this project in spite of what was, by now, considerable competition from the Turks, Russians and Chinese. The fact that it was laid down in the terms of tender that the five main items of equipment would come from manufacturers in Germany and Switzerland shows that Turkmenistan puts its money above all on high quality and long life for its capital investments.

3 Use of ductile iron pipe systems for fire protection in cereal mills

Fire protection is a particular concern in cereal mills: in them, a layer of flour a few millimetres thick is itself a fire hazard (risk of a flour dust explosion). This was therefore the very place where it was particularly important to install a reliable, safe and modern fire protection system. It soon became clear that there was no getting round a ductile iron pipe system for this.

The contract for providing the fire protection for a total of five cereal mill complexes and a backshop in the capital Ashgabat was placed with the Total Walther GmbH company. The backshop had already been opened and installation of the buried pipeline began in Ruhabat and Serdar.

For fire protection, a mill complex is surrounded by a ring of external hydrants which are designed as underground hydrants complying with the appropriate GOST standard (gosudarstvennyy standart = Russian state standard).

- The hydrant system is connected to the water supply by a buried ring pipeline of DN 80, DN 100 and DN 150 ductile iron pipes to ISO 2531 [1] / EN 545 [2].
- The minimum depth of the pipelines is 1.06 m + 0.50 m + diameter of the pipeline.
- In addition to the external hydrants, there are also laterals running from the buried ring pipeline to respective internal hydrants in the individual buildings **(Figs. 4, 5 and 6)**. The hydrants enable the local fire brigade to actively fight fires.

Because of the unstable nature of the soil and the earthquake zone rated at IX on the Mercalli scale, what suggested themselves for use were

Fig. 4:
Connection of ductile iron pipes, isolating gate valves and take-offs to underground hydrants

Fig. 5:
A fire-fighting pipeline – a buried ring pipeline

Fig. 6:
Buried ring pipeline partially covered

first and foremost ductile iron pipe systems with flexible VRS®-T push-in joints. What were actually supplied were ductile iron pipes with the already well-proven BLS®/VRS®-T joint restrained against both thrust and traction. **Table 1** is an overview of the nominal sizes and the lengths installed.

Table 1:
Overview of the ductile iron pipes with BLS®/VRS®-T push-in joints which were installed

DN nominal size	Lengths of pipe installed
80	620 m
100	215 m
150	3,190 m
200	100 m

The BLS®/VRS®-T restrained push-in joint has FM (Factory Mutual) approval up to a nominal size of DN 500 and is therefore a reliable solution for fire-fighting pipelines of very great safety and security, something which is particularly important in complex and critical applications such as this one in an area subject to earthquakes. Another inestimable advantage and additional safety factor which the VRS®-T ductile iron pipe system used had in this case was the large angular deflectability of up to 5° which the joint has.

4 Why ductile iron is the very thing that provides particular safety for fire-fighting pipelines

What is special about pipelines for fire-extinguishing water is this: they are almost never used. However, when they are used in an emergency, they have to work immediately and in all respects.

A pipeline of ductile iron pipes for fire-extinguishing water is non-combustible, will withstand tremendous loads and can be relied on to provide fire-extinguishing water in an emergency. Because of the high safety margins they have against loads from the internal pressure (pressure surges) and against external loads, ductile iron pipes have long been used for fire-fighting and fire-extinguishing systems for airports, railway, road and autobahn tunnels and industrial plants.

4.1 Technical advantages

Ductile iron pipes are able to withstand high static loads. They will withstand high internal pressures and high external loads:

- Allowable operating pressures of up to 100 bars.
- Pipe wall has a safety factor of 3 against internal pressure.
- The connecting systems have a safety factor of 1.5 against longitudinal force.
- The pipeline material is heat-resistant and non-combustible.
- Fire resistant for at least 60 minutes at 900 °C.

4.2 Environmental advantages

Ductile iron pipes are produced almost entirely from recycled materials and are therefore themselves recyclable. The lining consists only of cement, sand and drinking water with no other additives.

4.3 Economic advantages

- High installation rates due to the long laying length of the ductile iron pipes and the easily connected BLS®/VRS®-T push-in joint not requiring any welding
- Long working life due to the innovative linings and coatings.
- Material excavated from trenches can be re-used with cement-mortar coated pipes.
- Easy and fast installation.

5 To sum up

A total of more than 250,000 t of cereals can be stored at the five cereal mill complexes located in Ruhabat, Turkmenabat, Serdar, Daşogus and Mary **(Fig. 2)**. Every day, up to 700 t of wheat is processed in the mills by some 500 employees and some of this, totalling just under 100 t, goes off for further in-house processing into bakery products and pasta.

In the event of an emergency due to fire at the cereal mill complexes, enough fire-extinguishing water needs to be available for the damage done to the production plants to remain small and for the cereal mills to remain economically viable. Pipelines of ductile cast iron for fire-extinguishing water are a significant part of the safety equipment of these cereal mills.

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Water supply for the expansion of Frankfurt am Main Airport

by Jolanda Rosenberg and Heinz-Jörg Weimer

1 Introduction

The aprons **(Fig. 2 and 3)** of the planned Terminal 3 are currently being laid at Frankfurt am Main Airport on the land formerly occupied by the US air base. These are part of the expansion in capacity approved by the public works approval decision of 18 December 2007. The aprons include 50 locations for buildings which are to have the requisite infrastructure for handling aircraft.

One of the things that this entails is an extensive network of ducts for electrical and telecommunications cables including their manholes, pipelines for drinking and other water fitted with hydrants, intercepting sewers for storm water plus the associated manholes, and a fuel hydrant system. The aprons are being laid in concrete and asphalt is planned for the taxiways.

2 The installation work

A total of around 9,000 m of ductile iron pipes are being installed in several stages to supply fire-extinguishing water to the building locations and to supply the drinking and other water that will later be needed in Terminal 3. Around half of this length is accounted for by the system for supplying the fire-extinguishing water of a nominal size of DN 300 **(Fig. 3)**. Some 2,500 m of DN 250 pipelines are required for making the various connections to existing pipelines to ensure security of supply during the phases of construction.

The hydrants at the building locations are being connected by about 500 m of DN 150 pipes **(Figs. 4 and 5)** and around 1,500 m of DN 150 pipes are being installed as a ring pipeline for drinking water around what will subsequently be the main building of Terminal 3. The ductile iron pipes have to withstand the network

Fig. 1:
The aprons of Terminal 3 under construction

Fig. 2:
A mobile concrete mixing plant on the apron of the new Terminal 3 soon to be built

Fig. 3:
A pipeline for fire-extinguishing water of DN 300 ductile iron pipes with a DN 150 branch for connecting in a hydrant

Fig. 4:
Ductile iron pipes forming a DN 150 lateral for making a connection to a hydrant

pressure of up to 16 bars which is laid down at Frankfurt Airport and the external loads they will be subject to below the taxiways and aprons. They are therefore being laid in wall-thickness class K 9 and with the well tried BRS® restrained joint. The ductile iron pipes are being given external protection by a zinc coating and finishing layer to EN 545 and DIN 30674-3 [1]. The pipes for drinking water are being given a blue finish and those for other water a green finish as a distinguishing feature.

Fig. 5:
Ductile iron fittings for making a connection to an underground hydrant

3 To sum up

Ductile iron pipes have been in use at Frankfurt am Main Airport for a long time. Their reliability is proven and is an essential prerequisite for the long-term availability of the networks for drinking and other water. They are below the taxiways and aprons so the fact is that access to them for repair work at a later stage would only be possible at considerable cost. This is also true of the expansion work, so only the very best quality can be considered!

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Use of ductile iron pipe systems in high Alpine terrain

Laying of new penstock pipelines for small hydroelectric power stations

by Andreas Moser

1 Introduction

Most turbine pipelines are, naturally enough, laid in extreme terrain. These external conditions and the high operating pressures call for pipes of the very highest performance – ductile iron ones! The joints between the pressure pipes have to be simple, absolutely water-tight, secure and quick to connect. Over the past 20 years, the ductile iron pipe has clearly come out on top over other metallic materials and plastics in the field of pressure pipelines for small hydroelectric power stations.

2 Reasons for using ductile iron pipe systems on turbine projects

If ductile iron pipe systems are involved in the planning and laying of turbine pipelines, this presupposes that they will meet the extreme demands which will be made on their material and on themselves when they are working and being laid. This is what can be said of them:

- System components pressure-tested in the factory provide extremely high safety.
- The well-tried BLS® restrained push-in joint ensures quick laying regardless of the weather.
- No welding and no subsequent on-site testing of the weld are necessary; this means a time saving of up to 50 %
- A well thought-out range of fittings enables widely varying connecting situations, such as valve manholes, to be dealt with easily with a single material.
- The joints can be deflected by up to 5°, enabling savings to be made on fittings and on connecting time at changes in direction.
- At angled joints between pipes, any extra forces caused by possible pressure surges due to faulty closing times of butterfly valves can easily be transmitted straight into the ground without the need for concrete thrust blocks.
- The high-performance coating systems applied in the factory ensure there are no gaps in the corrosion protection.

3 Ductile iron pipe systems being used in extreme conditions in turbine pipelines – some practical examples

Four selected penstock pipeline projects will be looked at to show how well ductile iron pipe systems perform. This applies to the range of nominal sizes, to the system of restrained push-in joints, to the different operating pressures and to the wall thicknesses which these make necessary.

3.1 Turbine pipeline project 1 – The Vernagtsee hydroelectric power station in South Tyrol

- Client:
  Energie Schnals GmbH of Schnals in Italy
- Planner: Ingenieur Team Pohl of Kastelbell-Tschars in Italy
- Installing company: Marx AG of Schlanders in Italy
- Installation time: July to October 2010
- Pipe system:
  - DN 500, DN 700, DN 800 and DN 1000 ductile iron pressure pipes with BLS® restrained push-in joints
  - Wall thickness classes K 9 to K 12
- Length of pipeline: 3,300 m
- Head: 350 m

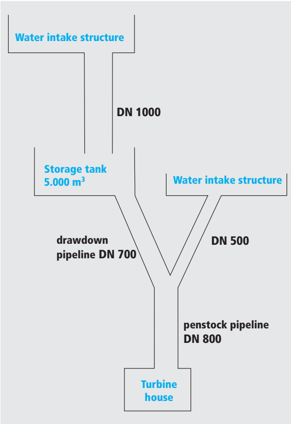

Fig. 1:
Project 1 – The Vernagtsee power station in South Tyrol: Diagram of water intake structures, storage tank and pipelines

Fig. 2:
Project 1 – The Vernagtsee power station in South Tyrol: the storage tank at 2,100 m above sea level

This power station project is supplied with water by two water intake structures. Via a pipeline of DN 1000 ductile iron pipes, the larger of the two structures supplies a storage tank with a capacity of some 5,000 m^3 to enable better use to be made of the sometimes widely varying yield of water.

The second, smaller, water intake structure is situated on a level with the bottom of the storage tank and feeds a DN 500 pipeline of ductile iron pipes. This DN 500 pipeline meets the DN 700 pipeline for drawing down water from the storage tank at a wye, whose third arm is of DN 800 size and forms the penstock pipeline to the turbine house **(Figs. 1 and 2)**. Because of the low pH of the water for the turbine, a special lining of high-alumina cement mortar had to be selected; this is resistant to soft and slightly acid water to the requirements of DIN 2880 [1]. The laying of the pipeline was very demanding technically; for example, three gullies had to be crossed by pipe bridges spanning distances of up to 28 m **(Figs. 3 and 4)**.

The water intake structure is almost 2,100 m above sea level so the time slot of four months for installation was a very tight one. The construction companies doing the work sometimes had up to ten pieces of construction machines on site.

Fig. 3:
Project 1 – The Vernagtsee power station in South Tyrol: a pipe bridge some 25 m long carrying a DN 700 penstock pipeline

Fig. 4:
Project 1 – The Vernagtsee power station in South Tyrol: the ductile iron penstock pipeline fastened in place with pipe clips

3.2 Turbine pipeline project 2 – The Dorferbach hydroelectric power station in East Tyrol

- Client: TIWAG
- Planner: TIWAG Hydro-Engineering
- Installing company: Alpine Mayreder Lienz branch
- Installation time: 2006 to 2007
- Pipe system:
  - DN 800 ductile iron pressure pipes with cement mortar lining and BLS® restrained push-in joints
  - Wall thickness classes K 9 to K 18
- Length of pipeline: 4,400 m
- Head: 760 m

This project has the world's first ductile iron penstock pipeline of 800 mm diameter which was accepted tested with a test pressure of 93 bars. This is equal to a force acting on the blank flange (at the bottom end of the pipeline) of ~ 4,700 kN over ~ 0.5 m² **(Fig. 5)**.

As a comparison, if six Taurus electric locomotives each weighing 80 t were placed on a bar table, the forces acting would be approximately the same. A detailed description of the project appeared in [2].

3.3 Turbine pipeline project 3 – The Furkelbach hydroelectric power station in South Tyrol

- Client: Municipality of Trafoi
- Planner: Dipl.-Ing. Hochschwarzer
- Installing company: Plöstl GmbH of Partschings in Italy
- Installation time: July to October 2010
- Pipe system:
  - DN 400 ductile iron pressure pipes with BLS® restrained push-in joints
  - Wall thickness classes K 9 to K 14
- Length of pipeline: 2,500 m
- Head: 480 m

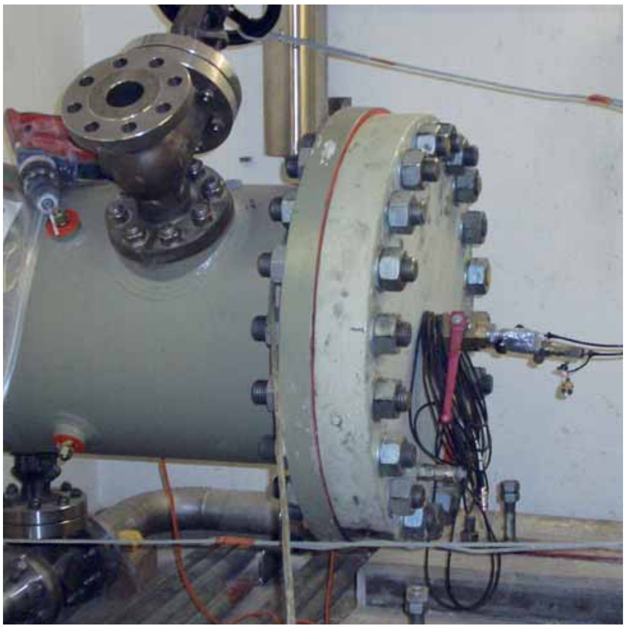

Fig. 5:
Project 2 – The Dorferbach power station in East Tyrol: the flange for connection to the turbine closed off by a blank flange for pressure testing

Fig. 6:
Project 3 – The Furkelbach power station in South Tyrol: cable car with movable track cable

Fig. 7:
Project 3 – The Furkelbach power station in South Tyrol: pipes being brought in by cable car

Fig. 8:
Project 3 – The Furkelbach power station in South Tyrol: extreme conditions for pipe installation

Fig. 10:
Project 4 – The Holzerbach power station: valve manhole for several take-offs from the pipeline

Fig. 9:
Project 3 – The Furkelbach power station in South Tyrol: installation on a 65° slope

On this project, approximately a third of the route had to be blasted out. In the sometimes impassable terrain, the pipes and fittings were taken to their laying point by means of a cable car whose cable could be moved **(Figs. 6 and 7)**. The steepest parts of the ductile iron pipeline sloped at angles of up to 65° **(Figs. 8 and 9)**.

3.4 Turbine pipeline project 4 – The Holzerbach hydroelectric power station in South Tyrol

- Client: Konsortialgesellschaft Prettau
- Planner: Exact-Ingenieure of Brixen in Italy
- Installing company:
  Brunner und Leiter GmbH of Weissenstein in Italy
- Installation time: July to August 2010
- Pipe system:
  - DN 300 ductile iron pressure pipes with a cement mortar lining and BLS® restrained push-in joints
  - Wall thickness class K 9
- Length of pipeline: 1,400 m
- Head: 380 m

It is an increasingly frequent occurrence that there are a number of water rights along a watercourse. Hence, as well as the entitlement to generate electricity, there may also be other rights relating to pipelines for sprinkler irrigation systems and for fire protection facilities.

Hydrant connections are often provided for these additional take-offs. The take-offs and the various items of measuring equipment are housed in valve manholes.
Fig. 10 shows a typical valve manhole of the kind which was installed on the penstock pipeline to the Holzerbach power station in South Tyrol.

4 To sum up

Table 1 gives the most important items of technical data for the four projects described, all of which were completed quite recently. Simply for the installation of turbine pipelines for generating electricity from water power there are a wide range of applications in which ductile iron pipe systems are at home and it is clear from the Table just how wide this range is.
Electricity from hydroelectric power stations is clean energy. Most turbine pipelines are installed in extreme terrain.

Table 1:
Summary of technical data on the four penstock pipelines described

Project (country)	Vernagtsee (I)	Dorferbach (A)	Furkelbach (I)	Holzerbach (I)
Client	Energie Schnals GmbH	TIWAG	Municipality of Trafoi	Konsortialgesell-schaft Prettau
Installation time	July to Oct. 2010	2006 to 2007	July to Oct. 2010	July to Aug. 2010
DN nominal size	500 to 1000	800	400	300
Wall thickness class	K 9 to K 12	K 9 to K 18	K 9 to K 14	K 9
Head [m]	350	760	480	380
Length [m]	3,300	4,400	2,500	1,400

With ductile iron pipes, the work can be done quickly and safely in this case – only narrow trenches have to be excavated, the material excavated can be re-used, the push-in joints can be deflected at an angle, laying is possible even in bad weather, and recultivation is fast. Outstanding strength properties and the restrained push-in joint guarantee trouble-free operation for the power station pipelines for generations.

Because of the diversified and outstanding applications in high Alpine terrain, it has been possible over the past few decades for the trust that is placed in the ductile iron pipe system to be strengthened. This is also the reason why more and more planners are putting their money on the use of ductile iron pipe systems of this kind and are coming to see ductile cast iron as a very economical, efficient, and sustainable type of material which is absolutely safe from the technical point of view.

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What’s new in ductile iron pipe systems?

by Jürgen Rammelsberg

1 Introduction

The Fördergemeinschaft zur Information der Hochschullehrer für das Bauwesen (FIHB) is the German association promoting the dissemination of information to college and university teachers teaching civil engineering and construction, and the goal which it has set for itself is, by close co-operation with industrial trade associations, to make available to its members teaching at colleges and universities the latest knowledge which is of practical relevance at the time. Its most important means of doing so are the long-established conferences which it organises every two years with, amongst others, the Fachgemeinschaft Guss-Rohrsysteme (FGR®) e. V. / European Association for Ductile Iron Pipe Systems · EADIPS®. In late April 2010 some 20 college and university teachers were

Fig. 1:
The Seehotel Großräschen after its renovation

Fig. 2:
The conference attendees in the reception area at Keulahütte GmbH

the guests of FGR® / EADIPS® in Großräschen in the Lusatia region. The Seehotel in Großräschen **(Fig. 1)** was the venue for the conference, where **Prof. Dr. Rolf Kuhn** (on the left) of the IBA (Internationale Bauausstellung Fürst-Pückler-Land 2000–2010 GmbH) of Großräschen gave an enthralling opening address, and further talks relating to the ductile iron pipe system were also given. The conference programme also included two excursions: an inspection of the Keulahütte GmbH foundry works in nearby Krauschwitz **(Fig. 2)** and a tour through the Lusatia region’s former lignite (brown coal) mining district as it is being transformed.

Keulahütte GmbH of Krauschwitz, first mentioned in documents dating back more than 500 years as Eisenhammer Keula, is one of the oldest iron foundries in Germany. Its economic importance to the Lusatia region cannot be overestimated **(Fig. 3)**. Massive capital investments have enabled the new, rejuvenated Keulahütte GmbH to successfully beat the competition with its products for the water industry and its custom castings for the machinery and automotive industries.

Fig. 3:
Modern-day foundry production at Keulahütte GmbH

2 The structural change in the Lusatia region's lignite mining district

The open-cast mining of lignite in the Lusatia region began 120 years ago at Großräschen, with the setting up of the "Ilse" mine. This was followed by the "Victoria" coal briquetting plant, a brickworks, company buildings and houses. 100 years later this was all swept away by the expansion of open-cast mining activities, except for an official's residence and the so-called home for the unmarried. After a masterpiece of renovation, the latter is now the Seehotel Großräschen. It is situated on what will, in the future, be the shore of Lake Ilse, a lake which is being created by flooding the open-cast mine workings and, with the IBA terraces and the pier, it forms the heart of the "IBA-Auftaktgebiet Großräschen-Süd" **(Fig. 4)**. In his opening address at this year's conference, Professor Dr. Rolf Kuhn, formerly director of the Bauhaus Dessau and now the CEO of IBA Fürst-Pückler-Land GmbH, presented the idea behind this body, which is called an International Building Exhibition (Ausstellung) but which is a lot more than that. The vision of developing and rebuilding an entire region in a process which would last ten years finally produced 30 projects by which the landscape is being transformed. The basis for all the projects is the idea of creating from a landscape laid waste by the mining of lignite **(Fig. 5)** a new lakeland, Europe's biggest, on the tri-

Fig. 4
Lakeside terraces on the future shore of Lake Ilse

Fig. 5
Active open-cast mining of lignite at Welzow-Süd

Fig. 6 (on the left)
A prototype of the floating homes at Geierswalde

Fig. 7 (on the right)
The landmark for the Lusatia lakeland

angle of land defined by the towns of Senftenberg, Hoyerswerda and Spremberg. Once all the open-cast mine workings have been fully flooded, in 2015 the Lusatia lakeland will have water covering an area of around 14,000 hectares. This will include ten lakes covering a total of 7,000 hectares and connected by navigable canals. This will give the Lusatia region an invaluable potential for tourism, for new homes in floating houses **(Fig. 6)**, for marinas, for harbours, for water sports and for leisure activities. As a symbol of the tension between industry and nature, the "Lusatia Lakeland Landmark" has been placed at the centre of the lakeland **(Fig. 7)**. It is a 30 m high sculpture and viewing platform of Cortene steel, which has a natural rust-like appearance. It is open to the public and from it there is a view over three lakes to the Boxberg, Schwarze Pumpe and Jänschwalde power stations.

However, as well as these future uses, there is still the old context of energy generation, except that today the processes associated with it are kind to the environment. In this way, wind turbines, solar panels and the growing use of biomass all co-exist in, for example, the Welzow Energy Landscape. This re-development of landscapes and towns is intended to reverse the depopulation of an entire region which has been caused by the local decline in trade and industry. The presentation that Professor Kuhn gave with visionary fervour enthralled the teachers, all of them civil engineers and many even hydraulic engineers, and ended in a lengthy discussion.

Next day, a small number of the 30 IBA projects were inspected on the second excursion. The expert and enthusiastic guide was **Peter Weiser**, who put the sights in their historical context, having formerly worked as a locomotive driver in the mining industry.

3 What's new in ductile iron pipe systems?

This was the motto under which the five talks relating to the ductile iron pipe and its system, comprising pipes, fittings and valves, were given.
To begin with, **Ulrich Pässler**, chairman of the board of the FGR®/EADIPS®, welcomed the guests and explained the changes which had occurred when the former German FGR was converted into the European Association for Ductile Iron Pipe Systems · EADIPS®. He stressed that the long-standing collaboration with the FIHB (Fördergemeinschaft zur Information der Hochschullehrer für das Bauwesen) would be continuing and would continue to be developed.

In his opening address, **Prof. Dr.-Ing. Prof. h. c. Wolfgang Krings**, first chairman of the FIHB, expressed his gratitude for being invited and for the strengthening there would be of future collaboration.

In the first talk, on ductile iron and its application to valves, **Udo Müller**, works manager of Keulahütte GmbH of Krauschwitz, told his listeners about the latest developments in this material. Although the production of spheroidal graphite castings had long been largely perfected as a process, new small steps aimed at optimisation were constantly opening up further applications for the material. In this way, at wall thicknesses of less than 2 mm and with increased fatigue strength, it was being used as a micro-alloyed material in parts contributing to safety in vehicle construction. Spheroidal graphite cast iron doped with silicon was now available as a material for valve bodies for low-temperature use. Its special abilities were also being used in railway axle boxes **(Fig. 8)**. With 3D design and rapid prototyping including simulation of solidification, information technology had also produced drastically reduced development times from drawing board to the start of high-volume production.

In some striking photos, **René Pehlke**, head of design and product development at Keulahütte GmbH of Krauschwitz, showed the wealth of opportunities which there were for the designer in the valves widely used in the water industry – hydrants, gate valves, butterfly valves, non-return valves and valves for house connections. Even coats of arms of individual towns or special designs for old-town areas or even football stadiums are no problem as far as moulds and casting are concerned **(Fig. 9)**.

The second talk was devoted to modern-day corrosion protection systems for buried ductile iron pipe systems and to how they work and where they can be used. **Uni. Prof. DI Dr. Paul Linhardt** of Vienna University of Technology had written an impressive talk but was prevented from giving it himself because of the cloud of volcanic ash which had caused all flights to be cancelled. However, his able and enthusiastic replacements were two experts on ductile iron pipes, **Ewald Titze** and **Dr. Norbert Klein**. They described the differences between passive coatings, whose properties as materials allow them, when of the requisite thickness, to isolate the metallic material of the pipes electrically from the ground and in this way to prevent any corrosive reaction. In active synergistic coatings, use is made of the difference in potential between zinc and iron. The zinc reacts with the electrolytes in the soil and the products of reaction seal the pores and any injuries there may have been to the thin finishing layer, therefore preventing corrosive substances from gaining access to the iron. The speakers felt it important to present a truly hellish scenario covering all the possible processes by which iron can, in theory, be corroded but at the end they slipped in a comforting reassurance that no pipes, fittings or valves ever leave the manufacturer's works until they have been given internal and external protection meeting the product standards.

What **Dr. Norbert Klein** had his sights on in his talk was the commissioning of pipelines equipped with cement-mortar-based linings. This type of lining, based on purely inorganic materials, provides the optimum conditions for ensuring that drinking water will remain hygienically satisfactory when transported and distributed through pipelines. Preventative steps need to be taken even during planning and installation. Finally, cleaning, flushing and disinfection put the pipeline in a hygienically impeccable state. With regard to pressure testing and "running-in", the cement mortar lining has special features that have to be allowed for. The term "commissioning" is a general term for these operations and is an established part of the sets of rules. For some years now, the "air-pulse process" has been a well-established method of flushing and cleaning pipelines. In this process, conditioned compressed air is pulsed into a section to be flushed without the static pressure for the system being exceeded. Air bubbles of a defined size are formed and in the stream of water these create a chain of space-filling blocks of air and water. The space-filling turbulent flow produces high forces locally and these set any deposits in motion and carry them off. A significant advantage is the drastic reduction in the amount of water needed to produce a sufficiently high flushing speed. The discussion

Fig. 8:
A railway axle box of EN-GJS-400-18-LT ductile iron

Fig. 9:
A hydrant for football stadiums

which followed again demonstrated how important hygienically impeccable drinking water is in our society.

A talk on the practical experience of a pipeline network operator showed how very wide the uses are to which ductile iron pipe systems can be put. The supply utility Zweckverband Fernwasser Südsachsen operates a 32 km long DN 1200 connecting pipeline of steel pipes to supply 400,000 people. This "main artery" needed to be rehabilitated section by section with a cement mortar lining. The sections, each about 2,000 m long, needed to be bypassed with an interim pipeline to maintain the supply of water during the rehabilitation work.
With a flurry of pictures, **Wolfgang Rink**, head of the Applications Engineering Division of Duktus Rohrsysteme Wetzlar GmbH of Wetzlar, described how, on open ground and resting on squared timbers, DN 600 pipes and fittings with restrained joints had been fitted together into a 2,000 m long interim bypass pipeline **(Fig. 10)**. After the rehabilitation, the relevant section of the steel pipeline went back into operation. The pipes and fittings forming the DN 600 interim pipeline were then taken apart and immediately moved to a point parallel with the next section for rehabilitation of the main pipeline. There they were joined together again into a new bypass which was tested at a water pressure of 30 bars. This merry dance has now been repeated for the fifth time without any signs of wear having been seen which would interfere with the operation of the ductile iron pipes. Originally, it had been expected that the pipes and fitting could not be used more than three times, one more proof of how economical ductile iron pipes systems are to use.

Fig. 10:
A DN 600 interim pipeline used by Zweckverband Fernwasser Südsachsen

Another talk, on "A DN 500 pipeline for transporting water in the Sonnenberg tunnel in Lucerne" was to have described a typical large-scale Swiss project in Alpine terrain. The speaker, **Roger Saner** of vonRoll hydro (suisse) ag, had, like the previous Austrian speaker, been the victim of a cancelled flight due to volcanic ash. **Michael Schulz**, co-CEO of vonRoll hydro (deutschland) gmbh of Prenzlau, sprang into the breach and presented the wide range of products which are supplied from Prenzlau in the form of pipes, fittings and valves. In the case of the ductile iron pipes, he spotlighted the polyurethane lining to EN 15655 combined with the polyurethane coating to EN 15189. The system-compatible fittings are powder coated with epoxy resin to GSK guidelines (GSK = Quality Association for the Heavy Duty Corrosion Protection of Powder Coated Valves and Fittings) by the fluidised bed powder coating process. In the case of valves, the whole range, from gate valves to butterfly valves, non-return valves, tapping saddles, installation sets and other accessories, is available.

To bring the event to a close, the first chairman of the FIHB, **Prof. Dr. Wolfgang Krings**, spoke on behalf of the college and university teachers and in the name of his colleagues expressed his gratitude for the event, which had been such a complete success.

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