

TRENCHLESS INSTALLATION TECHNIQUES

using ductile iron pipes



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Trenchless installation techniques using Duktus ductile iron pipes

1. Foreword

When the infrastructure of our present-day towns and cities was being created and developed, large numbers of workers had to be employed on the installation sites. Trenches for laying pipes were excavated by hand, the pipes were lowered into the trenches without any mechanical lifting gear and vast amounts of sand and backfill material were shovelled in by hand.

The most widely used material for the pipes was cast iron and the joints between the pipes were sealed with hanks of hemp and poured lead.

Today, after more than 100 to 120 years, there is a need for the networks of pipes that were laid at the time to be rehabilitated and replaced.

In the town and city streets where there was once plenty of space for pedestrians to stroll and elegant carriages to drive, there are now several lanes of dense motor traffic and kerbs are blocked by parked cars, which means that delivery vehicles often double-park and hold up the traffic even more.

If the rehabilitation or replacement work on the existing networks of pipes had to be done in conventional open-cut trenches, traffic generally would almost grind to a halt (see Fig. 2.1) and it would be the community that had to suffer the additional costs of delays and exhaust fume and noise emissions and the loss of retail income caused by the obstruction to public travel.

Therefore, as long as 30 years ago, it was only logical that it was in the centres of population of the industrialised countries that the first steps in the development of trenchless pipe installation techniques were taken. Initially this was for the renovation or relaying of sewer pipes, which are generally situated on the lowest tier of the layers of pipes below the surface.

Developers then transferred their attention more and more to the replacement and rehabilitation of drinking water and gas pipelines. A sector of industry devoted to trenchless installation grew up, with its own special machinery, installation techniques, technical rules and standards and of course, not least, its own pipes, which had to be suitable for these trenchless installation techniques.

Over past decades, the Duktus company, with its ductile iron pipe, has made a crucial and impressive contribution to these developments and it is the story of this contribution that the present manual wishes to tell. The intention is also to describe the present state of the art, or in other words what installation techniques the ductile iron pipe can be used for, what are the performance features that it has and who are some of the satisfied customers who have put its ability to perform to the test.

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Duktus Manual

Trenchless installation of ductile iron pipes

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2. Why trenchless?

2.1 The development history

The roots of the methods of pipeline laying or installation known as trenchless installation techniques lie in the rocket or mole plough technique. In the early 80's, the burst lining technique was developed from this. It was at this time that British Gas used extensively modified rocket ploughs for the burst lining replacement of pipes. British Gas and the installing company D. J. Ryan and Sons applied for some initial patents on this technique in 1981. Since then, more than 50,000 km of pipeline are said to have been laid, or replaced, by the burst lining technique all over the world.

Over the years, development of the burst lining technique continued. This was how Berliner Wasserbetriebe, Berlin's water supply company, working in collaboration with the Karl Weiss company, came to introduce the so-called Berlin technique, better known nowadays as the press-pull or hydros technique, in 1990. The auxiliary pipe technique was later developed from this technique. Since then Berliner Wasserbetriebe has been using both these techniques for ductile iron pipes. In Berlin alone some 10,000 m of pipeline of nominal sizes from DN 80 to DN 500 are being rehabilitated in this way every year.

In parallel with this, techniques for replacing pipelines following the same route were being developed, there were also developments in techniques for the trenchless laying of new pipelines.

Chief among these is the horizontal directional drilling technique. What can be considered the first pipeline successfully installed by this technique is the 180 metre or so long pipeline crossing below the river Pajaro near Watsonville, California, which was installed in 1972. Significant features of this technique were taken over from the deep drilling technique used for

such things as oil wells and were developed to a higher standard. In the years that followed up to 1980, further rapid development of the horizontal directional drilling technique took place. This was also the time when the first projects using the HDD technique were carried out in Europe. The first time ductile iron pipes from Wetzlar were used for the HDD technique was in 1994, for the culvert pipeline under the river Mosel at Kinheim (see the list of reference installations on p. 55).

As well as these classic trenchless techniques, there is now another established way of replacing old pipelines trenchlessly – the technique known as pipe relining. This technique is based on pulling a new, smaller, pipeline into an old pipeline which needs to be rehabilitated or which is now over-sized. Some initial operations of this kind using ductile iron pipes date back to 1987.

Over the course of time other techniques have been developed and these are available on the market for use on large and not so large scale projects. Some of these techniques, namely ploughing-in, floating-in and pulling-in, will be described in detail further on in this Manual.



Fig 2.1
How installation sites obstruct traffic

2.2 The economics of trenchless installation techniques

Nowadays, if a technique for installing pipes is described as economical, what this is generally accepted to mean is that a pipeline installed by it can be tendered for and installed at the lowest price. When things are considered in this way, it is very rare for any thought to be given to the cost of operating and maintaining the pipeline, let alone to that of replacing it when it come to the end of its normal operating life.

However, today specialist commentaries interpret as follows the requirement laid down in §23, No. 2 of the German VOB/A (General provisions relating to the award of construction contracts) that tenders should be vetted from the economic point of view:

There is a close connection between the checking of tenders from the economic point of view and their consideration from a technical point of view. A reasonable price is determined by the best price-to-performance ratio and this includes the operating life, the cost of operation and maintenance and other costs to be expected in the near and distant future.

It is even stated in paras. 2 and 3 of §23, No. 3 of the VOB/A that:

“... the economics of the construction or installation technique, the technical solutions selected, and other advantageous conditions affecting the work done should be considered when assessing what is reasonable.”

“... the award shall be made to that tender which appears to be the most economical from all points of view, e. g. from the point of view of price, completion date, operating and consequential costs, earning power and technical merit. The lowest tendered price alone is not crucial.” [1]

What have not generally been considered in the past are the costs which arise from the installation of a pipeline in its surroundings and which, in the form of obstructions to traffic, noise and environmental pollution, the community has to acquiesce in paying with no hope of recovering them in any way. This being the case, it is almost impossible for a fair financial comparison to be made between trenchless and open trench techniques because, although it is perfectly possible to quantify the “social” costs paid by the community, this is not done when a contract is being awarded.

Where however the external constraints make it more difficult from the engineering point of view for a pipeline to be installed in open trenches, then increasingly there are better opportunities for trenchless techniques. The wealth of highly developed variant techniques which are now available allow the most suitable and most economical technique to be selected for any project.

The operator of a drinking water network needs it to be safe and this need is reflected in DVGW (German Technical and Scientific Association for Gas and Water) Hinweis (advisory document) W 409 "Effects of installation techniques on the economics of the operation and maintenance (operating costs) of water distribution systems" [2]. From the operating point of view there are advantages to open trench pipeline installation because people have had plenty of reliable experience with it:

- Existing pipelines can be seen, so specified minimum spacings can be deliberately maintained from them.
- The pipeline can be installed, pressure tested and measured under "visual control".
- The possibility of any adverse effects on the new pipeline (e. g. from stones) can be almost entirely ruled out.
- All the pipe joints can be checked before the trench is re-filled.
- Hydrants or connecting pipelines can be installed retrospectively at any time.
- If there is any damage to pipes, there are state of the art techniques for fully locating leaks.
- The pipeline structure can easily be laid to observe any high and low points and lateral spacings stipulated in the plans.
- The possibility of damage to third party pipes, cables, etc. can be very largely ruled out.

For trenchless techniques on the other hand, W 409 makes the proviso that increased costs have to be paid for installation monitoring and quality control because the pipeline is not fully visible.

Nevertheless, it is gradually becoming accepted, from experience, that trenchless installation and replacement techniques may, in general, be more economical than conventional open trench techniques if tenders are asked for on pipeline installation projects in a region and the resulting competition centres on the question of economy. One regional gas and water supply company has for example published a comparison between open trench and trenchless installation techniques and this is shown in Table 2.1.

	Open trench technique	Trenchless techniques
Length of pipeline	100 %	100 %
Surface area of underground work	100 %	15 %
Installation time	100 %	30 %
Costs	100 %	50 - 70 %
Operating life	100 %	70 - 100 %
Saving on resources	20 %	80 %
Noise, pollution, interference	100 %	Unquantified benefit

Table 2.1 Overall comparison of open trench technique with trenchless ones [1]

A rough comparison between the costs of trenchless replacement techniques with those of the open trench technique likewise shows clear potential savings for the trenchless techniques (Table 2.2).

Open trench techniques	Trenchless techniques					
	Burst lining	Rocket ploughing	Press-pull	Relining		
100 %	70 %	70 %	80 %	Annular space	No annular space	CIPP liner
				60 %	70 %	60 %

Table 2.2 Rough comparison of the cost of installation techniques [1]

On quite a large project to replace a sewer in Friedrichshafen by the burst lining technique, the figure found for the reduction in costs compared with open trench replacement was 34 %, the figures given in [1] thus being confirmed [3].

A case where 800 metres of DN 400 ductile iron pipes were replaced by the static burst lining technique with no change of size showed a cost saving of 22 % [4].

Open trench techniques reach their economic limits when the density of house connections exceeds a certain level because there is then a disproportionate rise in the cost of underground work and of restoration work on the surface [5].

To ensure that the work done to install or replace drinking water pipelines trenchlessly is done to the requisite quality standards, the DVGW has, over the past few years, developed an extensive series of technical rules in the form of its GW 320-1 ff. series which meets this very need. Quality-related parameters are defined for the current trenchless installation and replacement techniques and limiting values and measurement specifications are laid down for them. DVGW Hinweis W 409 stresses how important the pipe system selected is in connection with the selection of the installation technique.

The following are given as the main points governing the selection of the pipe system:

1. Bedding conditions and conditions of use (e. g. diffusion characteristics, performance reserves)
2. Good functionality of corrosion protection systems and joint technology
3. Existing satisfactory experience with given systems
4. Reasonable availability (delivery times, stockholdings, system continuity).

In the following, the system comprising ductile iron pipes with BLS® joints and a cement mortar coating (ZMU) will be looked at in detail to see how well it meets these four main requirements, because, as will become clear in the remainder of this manual, this combination represents the standard for trenchless installation techniques using ductile iron pipes.

1 above

Experience shows that ductile iron pipes have very little sensitivity to bedding faults. A disadvantage of trenchless installation techniques is that the pipe bedding cannot be checked and this is the type of pipe where this disadvantage is least significant, a fact that is proved by, not least, the outstandingly good results achieved in the damage statistics for water compiled by the DVGW [6]. In contaminated soils, the diffusion characteristics of ductile iron pipe systems make them preferable to plastic pipes [8]. Because of their high energy of deformation, ductile iron pipes have the highest performance reserves, both to resist static and dynamic loads due to internal pressure and the earth cover and to resist the allowable tractive forces (see section 3.5).

2 above

In trenchless installation techniques the bedding and support conditions are unknown and cannot be checked and what are therefore used for these techniques are ductile iron pipes with, in principle, a cement mortar coating to EN 15 542 [7]. On these pipes, a layer of plastic-modified cement mortar at least 5 mm thick incorporating a net-like bandage is applied to a 200 g/m² layer of zinc. The resulting coating is able to carry extremely high mechanical loads and is resistant to scoring by pipe fragments in the burst lining technique and by stones in the HDD technique. In the unlikely event of the coating being damaged, active protection is provided by the layer of zinc and this protection acts remotely over a distance of up to 20 millimetres.

The greatest advantage that ductile iron pipes have is the joint technology represented by the restrained BLS® push-in joint. This is due firstly to the highest allowable tractive forces of all the pipe materials used in water supply (see section 3.5), which has a beneficial effect on the lengths which can be used for part-runs. Secondly, the short assembly time of just 5 to 20 minutes each for the BLS® push-in joint is the most important prerequisite for economy. Pipe-by-pipe assembly allows for short installation pits, highly localised installation sites and installation rates which are determined by the time taken to change over the drilling and traction strings at the machinery end. The allowable tractive forces can be applied in full immediately after the short time taken to assemble the joint and there is no cooling time or other temperature-related losses of time. These factors are the key to economic success when ductile iron pipes are used for trenchless installation and replacement techniques.

3 above

Cast iron is the oldest material used for industrially produced pipes for water pipelines. About half the existing water supply network consists of pipes made of this group of materials. The resistance of ductile iron pipes and their long life are the basis for the excellent practical experience had with them in the past, experience which has again been corroborated in very recent times [8 and 9].

4 above

Duktus is an important manufacturer in the German cast iron pipe industry and particularly in very recent times its technical developments intended for trenchless installation techniques have made it a trendsetter, though without its losing sight of its close links with the traditional techniques. For Duktus, reliability of supply and system continuity have always been the primary considerations of a customer-oriented business strategy in the past, and in the future they will continue to play their part in the group's success.

Fig. 3.1

A DN 30 water pipe from the water pipeline supplying Dillenburg castle which was laid in 1455.



3. Why ductile iron pipes?

3.1 The history

The history of the cast iron pipe begins back in the middle ages in about the year 1455, when Count Johann IV had a cast iron water pipeline laid for his castle in Dillenburg. The design was still very primitive, the wall thicknesses were very uneven and at about a metre the laying lengths were very small. Even so, these pipes remained in used for more than 300 years until the castle was destroyed in July 1760 (Fig. 3.1)

Over the following centuries, production techniques developed only very slowly.

Fig. 3.2 A letter of 1934 from the Lord Mayor of the town of Koblenz, and the pipes in use at the time



The Metternich water pipeline for example, which was laid from 1783 to 1786, consisted of DN 80 pipes with a laying length of only 1.5 m. Given the average output of about 25 pipes a week of the foundry then operating (the Sayner Hütte) and the total length to be laid of 6 km, it is no wonder that the pipeline took 3 years to lay. The letter reproduced in Fig. 3.2 mentions that the pipeline was still in use in 1934 after 130 years in operation.

The year 1668 marked a minor milestone in the development of the cast iron pipe when Louis XIV had the famous fountains installed in the gardens of the Château de Versailles. It was for these that flanged pipes were used for the first time. The network of pipes was 40 km long and had a maximum nominal size of DN 500. The flanges had bolt holes cast into them and were sealed with inserted sheets of lead and copper. Pipes from the time of the Sun King are still doing their duty today at Versailles (Fig. 3.3).

The three examples described above are impressive proof of what was already the legendary longevity of cast iron pipes. Today, it is still this unrivalled long life that makes cast iron pipe systems an excellent economic proposition, because their economy depends, in the end and to a crucial degree, on the technical operating life that the material used for the pipes can be expected to have. Further details relating to the operating life of pipe systems can be found in DVGW W 401 [10].

When industrialisation began in earnest in Germany in around 1900, it ushered in the laying of extensive gas and water supply networks in cities and large towns. This inevitably led to a rapid development of the foundries and their capacities.



Fig. 3.3 Flanged pipes from the gardens of the Château de Versailles

Carousels carrying upright sand moulds were introduced and these made it possible for larger quantities of cast iron pipes to be produced on an industrial scale (Fig. 3.4). However, even with this the laying lengths were still limited and the pipe walls were still pretty uneven in thickness. This all changed in about 1925 with the introduction of the de Lavaud centrifugal casting process (Fig. 3.5). This process has been used for producing cast iron pipes right up to the present time.



Fig. 3.4 Carousel carrying upright sand moulds of about 1900



Fig. 3.5 A centrifugal casting foundry of around 1930

Measured by the rate of development which existed in the previous 500 years, the years that followed saw an absolute flood of new developments in types of joint and varying coating processes.

In around 1930, the screwed socket joint and the bolted gland joint were introduced and the pipes were asphalt coated internally and externally. The lead caulked joint which had been standard up till then disappeared from use.

Then, in the 60's, followed ductile cast iron and the introduction of the TYTON® joint which is still standard today. This new and easily assembled joint produced a major increase in the laying rate of cast iron pipes.

Ductile cast iron came into use in the mid-60's, and a few years after this it was the trigger for the introduction of various coating systems. Since then, ductile iron pipes have been given a zinc coating and, initially, an additional bituminous finishing layer but subsequently an epoxy-based finishing layer. This was the period which also saw the development of the cement mortar coating. This is still being used today for, amongst other things, the trenchless installation techniques which will be described further on in this manual.

Then, in the 1970's, the development of restrained push-in joints got underway. Initially designed as a replacement for concrete thrust blocks, these joints were soon being widely and successfully used for trenchless installation techniques. The BLS® system constitutes the current state of the art in the field of restrained push-in joints. Its distinguishing features are that it is very easy and quick to assemble but nevertheless has a very high load-bearing capacity.

3.2 Production

Only materials of the very best quality are used as starting materials for the Duktus company's ductile iron pipes. What is used to obtain the pig iron is exclusively recycled material (iron and steel scrap). This makes ductile iron pipes particularly sustainable because most of them are produced from recycled material and they can be almost completely recycled at the end of their very long technical operating life of up to 140 years.

The scrap used is smelted with coke and other additives in a cupola furnace and is then fed off for treatment with magnesium. The pig iron and the treated iron are of course checked for their chemical composition and mechanical properties at short intervals.

After the treatment with magnesium, ductile cast iron is now distributed to the various centrifugal casting machines. In these, the "pipe blanks" are cast by the de Lavaud process. Sand cores whose external configurations differ to suit the type of joint are inserted in the centrifugal casting mould (permanent mould) to create the internal contours of the socket. This is followed by annealing at approx. 960 °C which, in the end, gives the pipes their ductile properties.

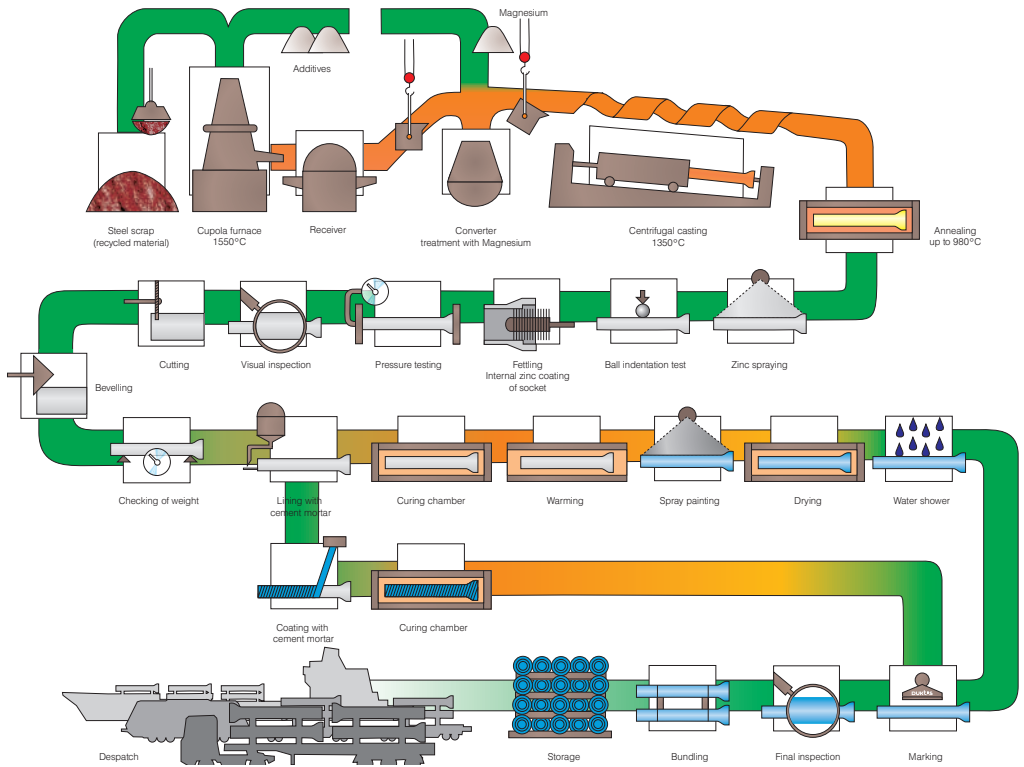
The annealing furnace is followed by the fettling and testing line. It is here that the pipes get their zinc or zinc-aluminium coating, that their dimensions amongst other things are checked and that they are tested for leaks at up to 50 bars. Samples of the material are taken at regular intervals and are checked to ensure that the prescribed parameters are being maintained.

The process continues with a welded bead being applied to the pipes which have BLS® joints before all the pipes are given a lining of cement mortar. This is done by method I under DIN 2880 [13].

All that is now missing is the external coating. There are a number of options available in this case. The standard one is a finishing layer of epoxy. However, what also can be applied to the zinc-coated pipe as an alternative is a cement mortar coating. Pipes having a coating of this kind, which is referred to for short by its German initials ZMU, can subsequently be used in soils with grain sizes of up to 100 mm or in soils of any desired corrosiveness, or can be installed trenchlessly. What is more, the ZMU means that the expected technical operating life is lengthened to up to 140 years [10].

In the final part of the production process, markings are applied, caps are fitted to drinking water pipes, the pipes are bundled, and a final quality control is carried out.

Fig. 3.6
A schematic representation of the production process



3.3. The material

Ductile cast iron is a tough iron-carbon material in which the volume of carbon exists predominantly in a free form as graphite. It differs from grey cast iron principally in the shape of the graphite particles. The word “ductile” comes from the Latin verb ducere, ductus = to lead or reshape and means to be able to be stretched or shaped into a new form. From the point of view of stress analysis, ductile iron pipes and fittings are considered to be flexible tubes.

In grey iron (Fig. 3.7), flakes or lamellae of graphite have a notch effect and thus reduce the relatively high strength of the microstructure, bringing the elongation of the material after fracture down to less than 1 %.

In ductile iron the graphite is in a spheroidal form (Fig. 3.8). These spheroids of graphite have only a minor effect on the properties of the microstructure of the metal. Whereas in cast iron with lamellar graphite the stress lines become highly concentrated at the tips of the graphite lamellae, in ductile iron they flow round the graphite which has separated out in spheroidal form almost undisrupted. This is why ductile iron is able to deform under load.

Treatment of the molten iron with magnesium causes the carbon to crystallise in a largely spheroidal form as solidification takes place. This results in a considerable increase in strength and deformability compared with grey iron.

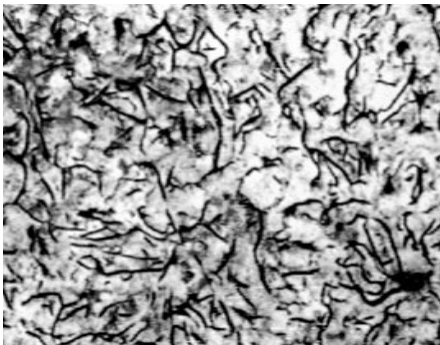


Fig. 3.7
Grey iron at 100 x magnification

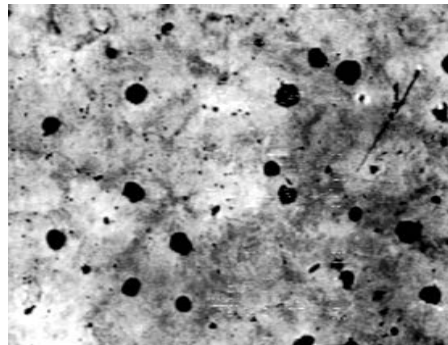


Fig. 3.8
Ductile iron under the microscope

Under EN 545 [11] and EN 598 [12], the authoritative standards, the volume of carbon which is present as graphite has to be in a predominantly spheroidal form if the workpieces are to have the required properties. The microstructure of pipes is intended to be very largely ferritic, because ferrite allows the maximum ductility while being of very low hardness. Fittings and accessories are produced in sand moulds and have a ferritic-pearlitic structure. They do not need any further heat treatment.

Under EN 545 [11] and EN 598 [12], tensile strength and elongation after fracture have to be tested on cylindrical test bars. The hardness of the material also has to be determined. An upper limit is set for hardness so that stock-removing machining is possible on the material, e. g. on flanges. The standardised values for the mechanical properties of the material are given in Table 3.1. Higher hardnesses are allowed in the region of the heat affected zone of manufacturing welds. In the case of centrifugally cast pipes, the tests laid down in the standards may be supplemented in the factory by routine tests of ductility using flattening test specimens or ball indentation specimens.

Type of casting	Minimum tensile strength R_m [MPa]	Minimum elongation after fracture A [%]	
	DN 40 to DN 2000	DN 40 to DN 1000	DN 1100 to DN 2000
Pipes centrifugally cast	420	10	7
Pipes not centrifugally cast, fittings and accessories	420	5	5

The 0.2 % proof stress ($R_{p0.2}$) may be measured. It shall not be less than:

- 270 MPa when $A \geq 11$ % for DN 40 to DN 1000 or $A \geq 10$ % for DN > 1000
- 300 MPa in all other cases.

For centrifugally cast pipes of DN 40 to DN 1000 and having a design minimum wall thickness of 10 mm or greater, the minimum elongation after fracture shall be 7 %..

Table 3.1: Material properties of ductile cast iron under EN 545 [11]

3.4 Coating and linings

Ductile iron pipes can be provided with a variety of internal linings and external coatings matched to the particular application. As an internal lining, the Duktus company uses solely a cement mortar lining, because experience extending over decades has shown this to be the optimum way of covering the interior of cast iron pipes.

The external coatings mainly consist of a zinc or zinc-aluminium coating plus a finishing layer. The finishing layers may have widely varying properties.

However, the respective color has no influence on the field of application and the durability of the product.

3.4.1 Internal lining

Basically, we cover our ductile iron pipes internally with a 4 to 6 mm thick cement mortar lining (often abbreviated to its German initials ZMA). Depending on the medium carried (drinking water, sewage, surface water, raw water, etc.), a choice can be made between blast furnace cement and high-alumina cement.

The advantages of a ZMA are amongst other things its extremely good abrasion resistance and the active corrosion protection it gives. In contrast to plastic linings, the corrosion protection is maintained even if slight damage (e. g. cracks) occurs.

The ZMA of ductile iron pipes is an integral part of the product. The requirements and test methods for it can therefore be found in the product standard EN 545 [11]. The fields of use and limits of use for the cement mortar lining described here are given in informative annex E to EN 545 [11]. This indicates that the standard lining using blast furnace cement as a binder is generally suitable without restriction for the field of drinking water if the drinking water transported complies with the European drinking water directive or with national drinking water regulations. For other types of water (e. g. raw water, non-drinking water), other cements can be used as binders, as shown in Table 3.2 and ATV-DVWK M 168 [16]. DIN 2880 [13] provides a wide range of basic information on the fields of application and special features of cement mortar linings for metal pipes. In it, the behaviour of the linings and the requirements to be met by them are described for all types of water, salt water and brine. There are also directions for assessing drying and shrinkage cracks in cement mortar linings and notes on their autogenous healing characteristics. DVGW Arbeitsblatt W 346 [14] gives recommendations with a practical slant for the pressure testing, flushing, disinfection, running-in and operation of drinking water pipelines with a cement mortar lining. DVGW Arbeitsblatt W 347 [15] contains drinking water hygiene requirements and test methods for cement-bound materials in the drinking water field, which thus include cement mortar linings of ductile iron pipes and fittings.

Water characteristics	Portland cement	Sulphate-resisting cements (including blast-furnace slag cements)	High alumina cement
Minimum value of pH	6	5.5	4
Maximum content [mg/l] of:			
Aggressive CO ₂	7	15	No limit
Sulphates (SO ₄ ²⁻)	400	3,000	No limit
Magnesium (Mg ⁺⁺)	100	500	No limit
Ammonium (NH ₄ ⁺)	30	30	No limit

Table 3.2: Fields of use of cement mortar linings

3.4.2 External coatings

External coatings provide long-lasting protection for cast iron pipelines. Factory-applied external coatings of ductile iron pipes depend on the soil conditions and the installation technique.

Basically, pipes are supplied with factory-applied external coatings. It is important for the provisions for corrosion protection to be selected in such a way as to ensure that the pipeline will be durable.

What is necessary for this is an exact knowledge of the types of soil in which pipelines are to be installed.

In the product standards EN 545 [11] and EN 598 [12], the limits of use of various coating systems for pipes, fittings and accessories are given in an informative annex D on the basis of important soil parameters which encourage the corrosion of ductile iron. These include:

- soil resistivity
- pH
- acidity reserve
- position relative to the water table
- heterogeneity (mixed soils)
- presence of refuse, cinders, slag or effluents
- peaty soils
- existence of stray currents.

For trenchless installation techniques as described further on in this Manual, the above parameters are of only minor significance because what are used in such techniques are almost always pipes with a cement mortar coating (ZMU) to EN 15 542 [7] (Fig. 3.9).

Ductile iron pipes with a ZMU can be used in soils of any desired corrosiveness and of a grain size up to a maximum of 100 mm. The ZMU prevents corrosive media from gaining access to the pipe and also withstands mechanical loads during transport and installation. Above all because of the increasing use being made of trenchless installation techniques, this coating has proved to be outstandingly successful. Under [7], the mechanical load-bearing capacity of the ZMU is determined by its ability to meet three requirements:

- freedom from cracking in the diametral stiffness test,
- strength of adhesion,
- impact resistance.

The requirements are formulated in such a way that the possibility of damage to the cement mortar coating can be ruled out both during proper transport and during installation in very difficult terrain.

Should damage nevertheless occur (e. g. during installation by the burst lining technique), active protection is provided for the damaged area by the layer of zinc and its remote action.

For trenchless installation techniques, the joint regions have to be provided with a protective rubber sleeve or shrink-on plastic sleeve and a sheet metal cone, as shown in Fig. 3.10.

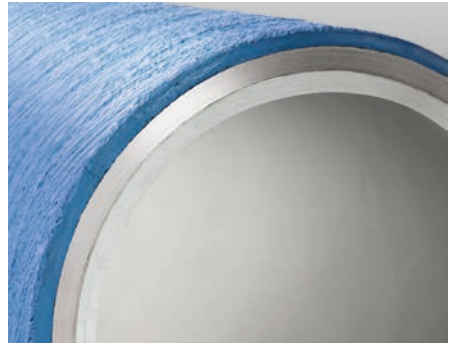


Fig 3.9 A ductile iron pipe with a ZMU



Fig. 3.10 Joint protection for trenchless installation techniques

3.5 The joint technology

In the case of ductile iron pipes, a basic distinction is made between non-restrained and restrained push-in joints.

Non-restrained joints include for example the TYTON® push-in joint to DIN 28 603 [50]. There are limits to how far such joints are suitable for trenchless installation techniques. The only technique which can actually be considered is pipe relining by pushing-in under DVGW Arbeitsblatt GW 320-1 [17]. The pushing-in transmits the thrust force from the spigot end via the end-wall of the socket to the next pipe (Fig. 4.71). The allowable pushing-in forces are given in the Arbeitsblatt mentioned and later on in this Manual.

Restrained push-in joints can be divided in turn into friction locking and positive locking ones.

Under DVGW Arbeitsblätter GW 320-1 [17] to 324 [38], joints of the first type are not suitable for trenchless installation techniques. Under these Arbeitsblätter it is only positive locking joints which should be used (except in pipe relining by pushing-in).

What Duktus supplies for this purpose is the BLS® joint (Fig. 3.11) of nominal sizes from DN 80 to DN 1000. The notable features of the BLS® joint are as follows:

- very easy to assembly without any special tools (see Installation instructions, chapter 7)
- assembly takes just a few minutes (see Table 3.3)
- can be used in all weathers, both in mid-summer and the depths of winter
- constant tractive forces even at temperatures above 20 °C and when the loading is protracted
- no cooling times – loads can be applied immediately after installation
- very high allowable tractive forces and hence safety (see Table 3.3)
- deflectable angularly by up to 5° = radius of 70 m (see Table 3.3)
- can be used for pipe-by-pipe assembly or for pulling-in as a pre-assembled pipe string
- very easy pressure testing using quickly fitted and removed BLS® fittings (pipe ends do not have to be braced against pit walls) – after or before pulling-in



Fig. 3.11 The BLS® joint

DN	Allowable operating pressure PFA [bar] ¹⁾	Allowable tractive force F_{zul} [kN] ²⁾		Max. angular deflection at sockets ³⁾ [°]	Min. radius of curves [m]	Number of fitters	Assembly time without joint protection [min]	Assembly time when using a protective sleeve [min]	Assembly time when using a shrink-on sleeve [min]
		DVGW	Duktus						
80*	110	70	115	5	69	1	5	6	15
100*	100	100	150	5	69	1	5	6	15
125*	100	140	225	5	69	1	5	6	15
150*	75	165	240	5	69	1	5	6	15
200	63	230	350	4	86	1	6	7	17
250	44	308	375	4	86	1	7	8	19
300	40	380	380	4	86	2	8	9	21
400	30	558	650	3	115	2	10	12	25
500	30	860	860	3	115	2	12	14	28
600	32	1,200	1,525	2	172	2	15	18	30
700	25	1,400	1,650	1.5	230	2	16	–	31
800	16	–	1,460	1.5	230	2	17	–	32
900	16	–	1,845	1.5	230	2	18	–	33
1000	10	–	1,560	1.5	230	2	20	–	35

Basis for calculation was wall-thickness class K9. Higher pressures and tractive forces are possible in some cases and should be agreed with the pipe manufacturer. 2) When the route is straight (max. of 0.5° deflection per joint), the tractive forces can be raised by 50 kN. High-pressure lock is required on DN 80 to DN 250 pipes. 3) At nominal dimension; * Wall-thickness classes K10

Table 3.3 Technical data and assembly times for the BLS® joint

To the experts at Berlin's water supply company Berliner Wasserbetriebe (BWB), who were pushing ahead with the trenchless replacement of their old networks of grey cast iron pipes, the allowable tractive forces given in GW 320-1 [17] to GW 324 [38] appeared to be too low. Hence, as a joint endeavour of the cast iron pipe industry, the Karl Weiß company and BWB, axial tractive tests were carried out on pipes of nominal sizes ranging from DN 100 to DN 200, with no internal pressure, until they began to fail [18].

The results obtained in these tests showed there to be a threefold safety margin in comparison with the figures given in the DVGW Arbeitsblätter.

FEM calculations carried out by Prof. Bernhard Falter [19] showed very good agreement with the experimentally determined figures for allowable tractive force.

The very safe nature of the figures which were given for the permitted tractive forces on positive-locking joints in ductile cast iron pipes in the DVGW rules had three consequences:

1. In its internal technical rules, BWB made a very large increase in the allowable tractive force from the figures given in the DVGW rules. This was because a wide range of practical experience had convinced it of the high performance of the joints.

2. A footnote was added to the tables in the DVGW rules saying that, with pipelines following straight paths and with an angular deflection of less than 0.5° (\approx a radius of curvature of 687 metres), the allowable tractive force could be increased by 50 kN (see Table 3.3).
3. Duktus increased its allowable tractive forces for the BLS® joint to the values given in Table 3.3.

3.6 To sum up

Of all the materials currently used for water pipelines, those used in Duktus ductile iron pipes with positive-locking BLS® joints have the highest allowable tractive forces. This allows installation pits to be spaced further apart when ductile iron pipes are being used and thus makes the pipes more economical without the need for safety to be sacrificed in any way. Additional increases, both in the operating pressure and in the allowable tractive force, are possible by increasing the wall-thickness class, but special agreements have to be made with our Applications Engineering Division for this purpose.

As a pipeline feature for the trenchless laying of new pipes and the trenchless replacement of old ones, the BLS® joint, when combined with the cement mortar coating, is the perfect combination. While the BLS® joint ensures maximum tractive forces and hence the greatest possible safety and longest possible lengths of run installed at a time, the cement mortar coating gives the best possible corrosion protection paired with excellent protective properties against mechanical damage.

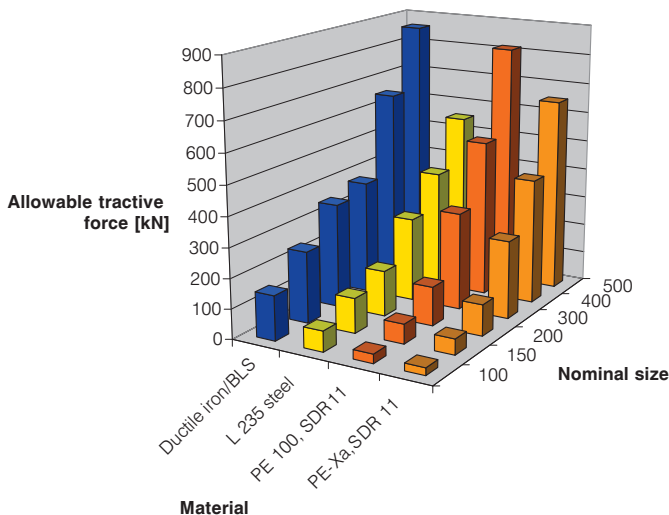


Fig. 3.12 Maximum allowable tractive forces for various materials under DVGW GW 320-1 [17] to GW 324 [38]

4. Trenchless installation techniques

From this point on in the manual we shall be making a basic division of trenchless installation techniques into:

- Techniques for the trenchless replacement of existing pipelines along the same route.
These include the burst lining, press-pull and auxiliary pipe techniques. In these techniques, the existing route followed by the pipeline is used to introduce a new pipeline of the same or a different size.
- Techniques for the trenchless laying of new pipelines
The usual techniques of this kind for ductile iron pipes are horizontal directional drilling (HDD), ploughing-in and milling-in but they also include steered pilot drilling.
- The relining technique
What is meant by relining is the pulling or pushing of a new pipeline into an old, larger, pipeline for carrying a medium. This normally involves a reduction of cross-section.
- Other techniques
The “other trenchless installation techniques” which are described in this Manual can be classified as trenchless in the widest sense. Those mentioned are temporary pipelines, the floating-in of ductile iron pipelines, and culvert pipelines.

The above techniques will now be explained one by one and special features they have will be pointed out in connection with the uses made of ductile iron pipes.

4.1 Techniques for the trenchless replacement of existing pipelines along the same route

4.1.1 The burst lining technique

General

The burst lining technique is used for the trenchless replacement of pipelines along the same route. For this purpose, the existing old pipeline is destroyed by means of a bursting head while at the same time it is pressed into the surrounding soil by an upsizing head (see Fig. 4.2) and the new pipe string is pulled in. The material of the old pipes is left in the soil in the form of fragments. Depending on the material, this may have advantages with regard to disposal but there are also disadvantages with regard to the stresses on the new pipeline. If however ductile iron pipes with a cement mortar coating (ZMU) are used, it can be assumed that the bodies of the pipes and the ZMU will not be affected by the stresses created (e. g. by fragments).

The burst lining technique is divided into the dynamic and static techniques.

The dynamic mode of operation (Fig. 4.1) of the burst lining technique was developed from the soil rocket and upsizing head and was originally used to replace sewers of vitrified clay pipes.

However, where adjacent pipelines and structures were too short a distance away, they were found to be at risk from the vibrations that were generated.

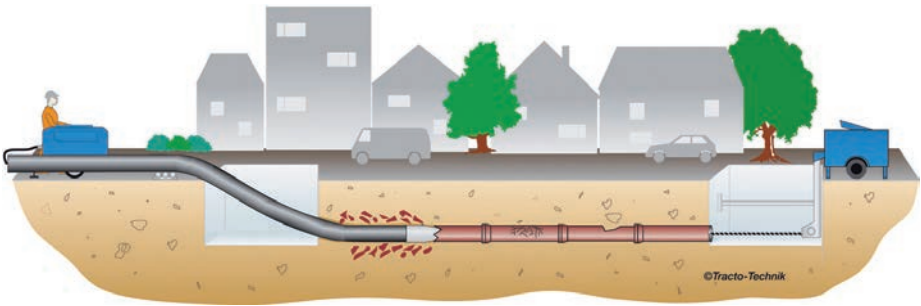


Fig. 4.1 The dynamic burst lining technique

This was why the static burst lining technique was subsequently developed. In this case an upsizing head (Fig. 4.2), the first section of which may be fitted with breaker ribs, is pulled through the old pipeline by traction units which operate continuously and without any vibration, and in this way the old pipeline is burst open. The new pipes are coupled straight to the bursting/upsizing head and are pulled into the passage, which is widened to approximately a 10 % oversize.



Fig. 4.2 Bursting head with ribs, upsizing section and BLS® traction head

Both the burst lining techniques, i. e. both the static one and the dynamic one, are in practical use at the present moment and are widely used. The DVGW has catered for this fact with its Merkblatt GW 323 [20] and has thus established criteria for the execution of the techniques and also the related requirements and quality assurance measures.

The burst lining technique is particularly well suited to old pipes made of brittle materials such as asbestos cement, vitrified clay and grey cast iron. However, by using the static technique and special cutting heads it is also possible for steel and ductile iron pipes to be “burst”. The new pipeline which is pulled in may be of the same nominal size as the old pipeline or, as dictated by the upsizing head which is used, of a larger size.

An increase in nominal size of up to two increments is possible. If the new pipeline can be smaller than the old one, an attractive alternative is pipe relining.

With ductile iron pipes, the upsized dimension (see Fig. 4.3) selected should be larger than the outside diameter of the pipe sockets. The spacing required from adjacent supply pipelines, cables, etc. and the height of cover have to be determined from the upsized dimension AM, taking GW 323 [20] as a guide. Under GW 323, the minimum spacings to be maintained are as follows:

- parallel pipelines: $> 3 \times AM$, min. of 40 cm
- parallel pipelines at risk of fracture $< DN\ 200$: $> 5 \times AM$, min. of 40 cm
- parallel pipelines at risk of fracture above $DN\ 200$: $> 5 \times AM$, min. of 100 cm
- intersecting pipelines at a critical spacing should be exposed if possible
- height of cover: $> 10\ AM$

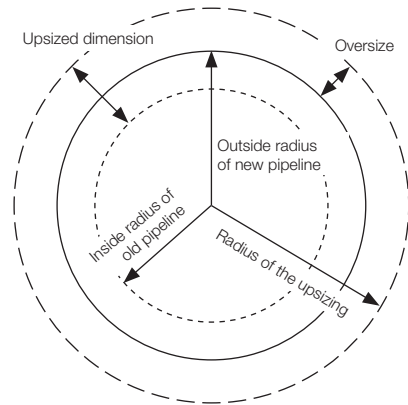


Fig. 4.3 Definition of the upsized dimension

Another advantage of the burst lining technique can be seen when old asbestos cement pipes are being replaced, namely that there are none of the problems and difficulties with safety at work when dealing with the old pipes which there would be if the pipes were replaced in open trenches [21].

In the field of distribution networks, the use of the burst lining technique (or of any trenchless replacement technique) depends mainly on the number of intermediate pits required. Intermediate pits have to be set up for house connections, valves, changes of direction and cross-section and branch pipes. Bends of up to 11° can usually be negotiated. If there is too close a succession of house connections, open trench replacement may be more economical [5]. Equally important is the accuracy of the documentation on the existing old pipeline. The points on which documentation is needed are, amongst others:

- the diameter and material of the old pipes
- any changes of nominal size and material
- height of cover
- changes of direction
- horizontal and vertical offsets (right-angled changes of level)
- branches or connections
- condensate drains
- valves
- concrete thrust blocks
- fittings, clips, etc.
- parallel and crossing pipelines and cables.

If there are too many "surprises" during the installation phase due to shortcomings in establishing the basic information, the customer may find himself faced with a plethora of additional charges.

Description of the technique

In the way already described, there is a division in the dynamic and static techniques.

In both, a bursting head is used to apply forces to the old pipeline which destroy it. Brittle materials are burst apart into fragments (Fig. 4.4) and all the others are cut open (Fig. 4.5). The fragments or the cut-open pipes are pushed into the surrounding soil.



Fig. 4.4 Fragments of grey cast iron

The dynamic technique

The force required for bursting is applied in the longitudinal direction of the pipeline by a sort of soil rocket. This is driven by a compressor which is connected to it by a flexible hose. To feed the bursting head through, it is pulled along from the target pit on a traction cable which is pulled through the old pipeline by a winch. The dynamic technique is particularly suitable for highly compacted and stony soils and for old pipes which are brittle, but cannot be considered suitable for laying new ductile iron pipelines.



Fig. 4.5 An old pipe cut open under control

The static technique

In this technique the force is applied to the bursting head by a string of traction rods which, starting from the target pit, runs from the traction unit through the old pipeline to the bursting head (Fig. 4.6).

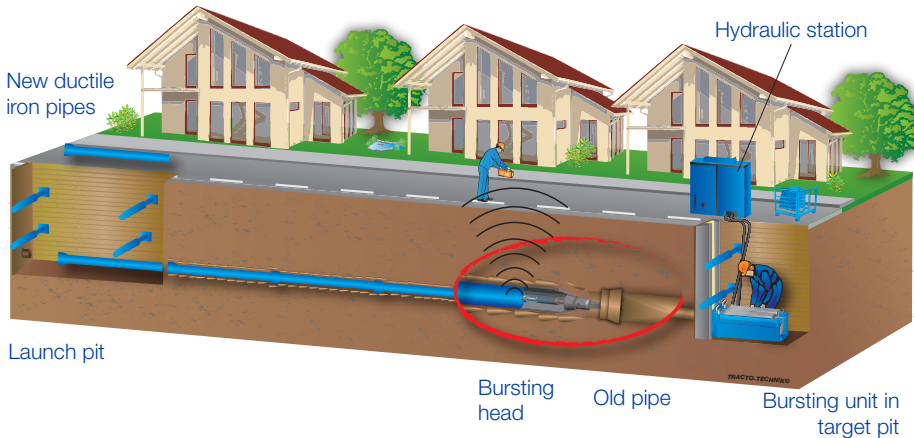


Fig. 4.6 A schematic representation of a burst lining site

During the pulling process, the traction unit is supported against the wall of the target pit. The traction string is taken apart in successive steps. The static technique is well suited to homogeneous soils which can be displaced easily and is suitable for laying new ductile iron pipelines.

The largest nominal size which has been pulled in so far by the burst lining technique is DN 600. However, any nominal size can be used in principle, including DN 1000. The tractive powers of the machines used have to be designed to suit the nominal size to be burst and the upsizing expected. As a rough division, the tractive powers required as a function of the diameter of the old pipeline can be assumed to be as follows (see [22] on this point).

- $\leq \text{DN } 250 \rightarrow 400 \text{ kN}$
- $> \text{DN } 250 \leq \text{DN } 400 \rightarrow 770 \text{ kN}$
- $> \text{DN } 400 \leq \text{DN } 600 \rightarrow 1250 \text{ kN}$
- $> \text{DN } 600 \text{ to DN } 1000 \rightarrow 2500 \text{ kN}$

However, the tractive forces which can be expected also depend on certain other factors such as: the upsized dimension, the native soil and the length of the run. The major proportion of the tractive forces are required for the breaking open of the old pipes and the upsizing. Added to this there is a relatively small proportion due to skin friction.

The usual lengths of run are between 50 and 200 m. Greater lengths are possible in theory because it is in fact only a small proportion of the tractive forces which is attributable to the pipeline and its length and hence to skin friction. However, what generally limits the length of run is local factors such as bends causing a change of direction or other items installed along the pipeline. What lengths are in fact possible and sensible has to be decided separately for each pipeline.



Fig. 4.7 Cutting wheel for ductile materials



Fig. 4.8 Roller-equipped cutting blade with upsizing section

There has now been practical experience of the replacement of ductile pipe materials (ductile iron and steel) with ductile iron pipes. In this case the old pipes are cut open with special perforating and cutting wheels (Figs. 4.7 and 4.8) and are bent open by the upsizing head which follows sufficiently far away to allow the new pipeline to be pulled in after the head. Trials of the use of this technique have been conducted up to a nominal size of DN 400 [4].

Coating and type of joint

As already mentioned in chapter 3, a cement mortar coating and the BLS® joint are required for almost all the trenchless installation techniques including the burst lining technique.

The cement mortar coating provides unrivalled mechanical and chemical protection against the native soil and above all against the fragments of material from the old pipes. In the socket region this protection is supplemented by a rubber sleeve or a shrink-on sleeve and by a sheet metal cone which provides effective protection for the sockets, in their exposed position, against mechanical stresses (see Fig. 3.10). Plastic pipes on the other hand may only be used if they have a protective outer sheath. (Note: the investigations described in GWF 3/2000 [23] clearly indicate that even this protective sheath does not always provide protection against damage to the pipe within it caused by point loads.)

As always when the BLS® joint is used in trenchless applications, an additional high-pressure lock has to be used on pipes of nominal sizes from DN 80 up to and including DN 250. At a nominal size of DN 600 and above, the locking segments are fixed in place by a special metal clip. The possible tractive forces for BLS® joints of all nominal sizes are given in DVGW Arbeitsblatt GW 323 [20] and in Table 3.3 in this Manual. The tractive forces which actually occur have to be measured and documented in the way described in [20]. An example of a printout of a graphic log of tractive force can be seen in Fig. 4.9.

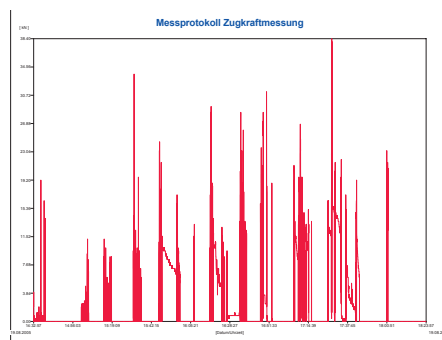


Fig. 4.9 Example of a log of graphic force

Requirements for the installing company

The company which is given the job of carrying out the burst lining operation must have the requisite qualifications. Evidence of this must be provided for the client and such evidence is considered to have been provided if the company has a DVGW certificate to DVGW Arbeitsblatt GW 301 [31] and 302 [32] in the appropriate group (GN 3).

The crew given the job of carrying out the work must consist of skilled operatives and trained workers. Under DVGW requirements at least one (internal) training course has to be taken every year. Equipment may only be operated by trained personnel who have been familiarised with the operating instructions for the equipment and with installation instructions.

List of reference installations (excerpt)

Installation	DN (new pipeline)	Length [m]	Year of installation
Ludwigshafen	300	110	2012
	400	580	2012
	500	1050	2012
Linz – Landstrasse	400	200	2012
Wilgersdorf	100	150	2011
Zürich - Opfikon	600	240	2011
Marburg	150	1,200	2011
Lauenförde	200	1,200	2010
Brixen	150	60	2010
Klagenfurt	100	1,000	2010
Wien	150	530	2009
	150	750	2008
	300	480	2008
Salzburg	200	300	2008
Wien	200	450	2007
Zittau	200	600	2007
Siegen	150	250	2007
Bad Laasphe	200	400	2007
Ober Rabenstein	250	3,000	2006/07

4.1.2 The press-pull technique

General

The greatest impetus to innovate in the field of trenchless pipeline replacement has come from Berlin. With some pipes which are up to 120 years old, Germany's oldest operating network of grey cast iron water pipes urgently needs to be replaced. There are two external constraints above all that make replacement more difficult in Berlin:

1. In the streets, there are rows of trees running along the pavements and the pipelines are situated down where their roots lie. The trees are strictly protected and under no circumstances may their roots be damaged. It is out of the question for pipeline trenches to be dug for conventional laying.
2. Replacement techniques where the old pipes are left in the ground, either complete or in fragments, cannot be used. All items that are not actually being used have to be completely removed.

The development of two special pipeline replacement techniques – the press-pull technique and the auxiliary pipe technique – was thus almost bound to occur; a firm basis for both of these has now been established in technical rules issued by the DVGW in the form of Arbeitsblätter GW 322-1 [24] and GW 322-2 [25].

With both these techniques, old pipelines can be trenchlessly replaced along the same route by new pipelines of the same or a larger nominal size (e. g. old DN 100 by new DN 125/150, see Table 4.1). The pipes making up the old pipeline can be recovered either as fragments or full-length pipes. This gives the following advantages:

1. Valuable raw materials can be fed back into the recycling loop.
2. There is only minimal interference with surfaces and the world of nature.
3. The space below ground is not obstructed by any additional pipeline routes.
4. Reduction of the environmental impact by avoiding old pipe material remaining in the ground.

Nominal size of old pipeline	Maximum nominal size of new pipeline
DN 80	DN 150
DN 100	DN 200
DN 150	DN 200
DN 200	DN 300
DN 300	DN 400
DN 400	DN 400

Table 4.1 Maximum increase in nominal size for trenchless replacement under GW 322-1 or GW 322-2

Some additional plus factors which both the techniques have are these:

- The stops used by public bus services do not have to be moved.
- There is hardly any interference with delivery vehicles in shopping streets.
- Other services conveyed by pipelines or cables are not put at risk by dug trenches.
- The maximum noise emission from the machinery used is < 54.5 dB(A) so particularly “quiet” and dust-free installation is possible. It is even possible for the work to be done in residential areas without over-night breaks.

Above all when installation is being done in inner city areas where pipelines and cables are densely packed, there is a considerable risk to parallel and intersecting pipelines and cables when large excavators are used in open trenches. This risk is minimised by the use of trenchless replacement techniques.

Both the techniques (the press-pull technique and auxiliary pipe technique) are used for supply pipelines ranging in nominal size from DN 80 to DN 400. Requirements are:

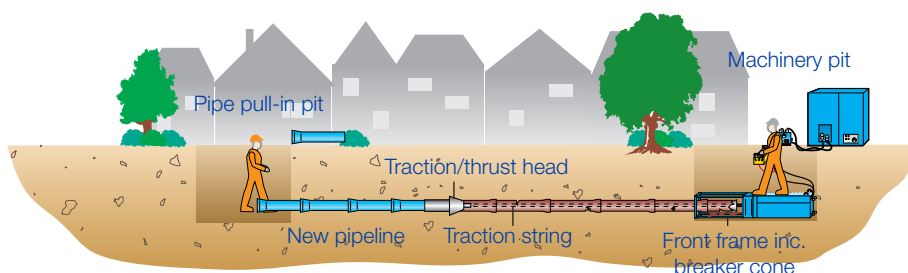
- a machinery pit to hold the machinery,
- an assembly pit (approx. 7 m long) for the new pipes,
- intermediate pits for house connections and branch pipes.

The distance between the intermediate pits depends on the nominal size of the old pipeline and its condition, on the nominal size of the new pipeline, on the machinery used, on the type of soil, on the existing trees and roots and of course on the conditions set by traffic and the other supply services. Depending on the technique and location, the distance between the intermediate pits should not exceed 25 to 50 metres. On a straight route or with a minimum radius of curvature of 170 metres the distance between the launch and target pits is normally 100 to 180 metres.

The old pipeline is taken out of service before the replacement operation. The supply to adjoining houses and other premises continues through temporary or interim pipelines, the water from which is fed into the sealed-off house connection pipes in the house connection pits.

Description of the technique

In the press-pull technique, the old pipeline is pressed onto a bursting or breaker cone and shattered and is removed from the machinery pit or intermediate pit in fragments. The new pipes, which have restrained joints – e. g. BLS® joints – are hooked onto the end of the traction string by means of a traction/thrust head and are pulled into the passage which is left free. The two steps take place simultaneously. As already described, an upsizing section can be inserted behind the traction head and this can enlarge the passage by up to two increments of nominal size (see Table 4.1).



Once the launch, target and intermediate pits required have been dug and shored, the sections of old pipeline contained in them are cut out and removed. This means that the old pipeline does not have to be freed from the surrounding soil all in one go for its entire length but only between the individual pits. The result is a lower tractive force. Specially prepared assembly/launch pits make it easier for the pipes to be assembled and stop any fouling or contaminants from getting in (Figs. 4.10 and 4.11). Because of the laying length of ductile iron pipes, the length of the pits should not be less than 7 m to 8 m.



Fig. 4.10 Launch and assembly pit



Fig. 4.11 Accessories for assembly

A traction string which can be coupled together is first pushed through the old pipeline and anchored to an adjusting adapter at the end of the old pipeline (Fig. 4.12), thus allowing the old pipes to be pressed out of the earth in the course of the replacement operation. No fragments are left in the bedding zone for the new pipeline. The new pipes are fastened to the adjusting adapter and, as the old pipeline is pushed out, they are pulled in behind it at the same time.

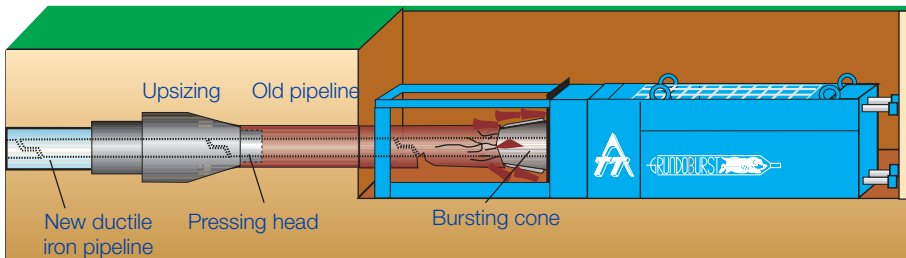


Fig. 4.12 Traction machine with bursting cone and press-pull head with upsizing section

Via the traction string attached to the adjusting adapter, the tractive forces are applied to the end of the old pipeline as axial thrust forces. It may possibly happen that the old pipeline is already so weak that it is unable to withstand the thrust forces generated and thus cannot be pressed out of the earth. In cases like this the old pipeline has to be reinforced beforehand. This can for example be done by pulling in an empty pipeline and then filling the cavity between the old and empty pipelines with concrete.

The only traction-generated forces which act on the new pipe string that is being pulled in are those generated by its own weight and the skin friction against it. The socket acts in a similar way to an upsizing device, which means that it is generally only at the socket that forces are generated by skin friction. The 6-metre long main body of the pipe on the other hand, which is smaller in diameter, plays no part in generating any forces due to skin friction.

Arbeitsblatt GW 322-1 [24] requires the forces concerned to be continuously measured and recorded so that the new pipeline will not be stressed by tractive forces higher than the maximum ones allowable. The measurement of the tractive forces is proof that the allowable load has not been exceeded during the replacement operation (for quality assurance). Points of intended fracture, audio warnings of overloads, and similar provisions are not good enough as a guarantee of safety.

The hydraulic press-pull unit is supported against the rear wall of the target pit via a steel abutment plate for example (Fig. 4.13). This plate is sized to suit the reaction forces and the nominal size of the pipes and there is only a small gap between it and the pipe so that, as far as possible, no earth will be forced into the pit.

The hydraulic traction cylinders of the press-pull unit allow the old pipes to be pressed out without percussion or jerks.

In the intermediate pits, the old pipeline is slid over a breaker cone or is smashed into pieces by an automatic pipe smasher (Fig. 4.14). In this way, it is only ever the section of the old pipeline upstream of the breaker cone which is pressed out, which causes a not inconsiderable reduction in the traction forces required. The position and size of the intermediate pits are decided locally on the basis of, for example, the house connections, branch pipes and items installed in the pipeline. The distance between them is usually 20 to 50 metres.

The fragments produced in the intermediate and target pits are conveyed to the surface in bins. In the final pull-in step, the old pipe, as it is pulled into the arrival pit, is generally broken as the traction cylinders made their backward stroke.

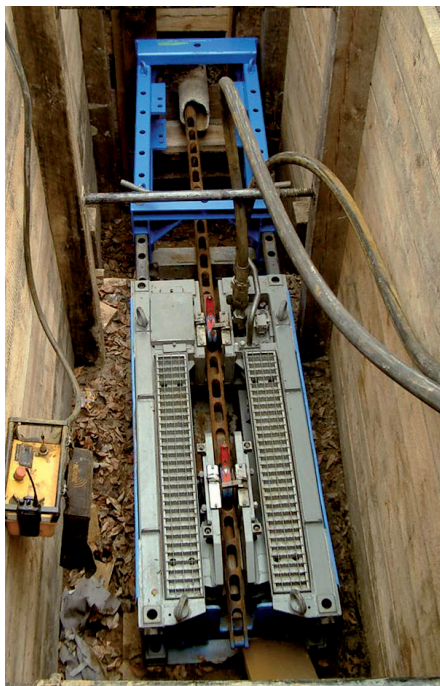


Fig. 4.13 Traction machine



Fig. 4.14 Hydraulic pipe smasher

In this case, just as with the burst lining technique (see section 4.1.1), the upsized dimension selected should be larger than the outside diameter of the pipe sockets. The spacing required from adjacent supply pipelines, cables, etc. and the height of cover have to be determined from the upsized dimension AM, taking GW 323 [20] as a guide. Under GW 323, the minimum spacings to be maintained are as follows:

- parallel pipelines: $> 3 \times \text{AM}$, min. of 40 cm
- parallel pipelines at risk of fracture $< \text{DN } 200$: $> 5 \times \text{AM}$, min. of 40 cm
- parallel pipelines at risk of fracture above DN 200: $> 5 \times \text{AM}$, min. of 100 cm
- intersecting pipelines at a critical spacing should be exposed if possible
- height of cover: $> 10 \text{ AM}$

In advance of a press-pull operation, what also needs to be done is to document very accurately the existing pipelines, cables, etc. – see section 4.1.1.

Coating and type of joint

Because the press-pull technique is closely related to the burst lining technique which has already been described, it too requires a cement mortar coating and the BLS® joint.

The cement mortar coating provides unrivalled mechanical and chemical protection against the native soil. In the socket region this protection is supplemented by a rubber sleeve or a shrink-on sleeve and by a sheet metal cone which provides effective protection for the sockets, in their exposed position, against mechanical stresses (see Fig. 3.10). Plastic pipes on the other hand may only be used if they have a protective outer sheath. (Note: the investigations described in GWF 3/2000 [23] clearly indicate that even this protective sheath does not always provide protection against damage to the pipe within it caused by point loads.)

As always when the BLS® joint is used in trenchless applications, an additional high-pressure lock has to be used on pipes of nominal sizes from DN 80 up to and including DN 250. The possible tractive forces for BLS® joints of all nominal sizes are given in DVGW Arbeitsblatt GW 322-1 [24] and in Table 3.3 in this Manual. The tractive forces which actually occur have to be measured and documented in the way described in [24]. An example of a printout of a graphic log of tractive force can be seen in Fig. 4.9.

The latest developments

A development of the press-pull technique made its world debut on the Construction Site Day which formed part of the Wasser Berlin 2011 fair.

Jointly with the Tracto Technik company of Lennestadt, the Berlin branch of the Josef Pfaffinger company has developed, on the basis of the press-pull technique, a possible way of replacing pipelines when there are even larger differences of nominal size and even with small heights of cover.

This was achieved by means of a new soil removal system positioned between the press-pull head and the new pipeline. The soil which is removed is fed away to the launch pit by a feed auger through a steel tube extending through the new pipeline. The old pipeline is pressed into the target pit at the same time and is burst open there.

In this way, it was possible to replace an old DN 300 sewer pipeline of grey cast iron pipes with a new ductile iron pipeline of the DN 500 nominal size with a height of cover of just 1.5 m. The lengths of run which were tried out in this case were around 50 m. The sewer pipes used were ductile iron ones to EN 598 [12] with BLS® joints and a ZMU Plus external coating. The ZMU Plus coating and the very small oversize allowed subsequent settlement to be reduced from about 15 mm to a minimum.



Fig. 4.16 A ZMU Plus sewer pipe with the feed tube inserted, and the feed auger string

Fig. 4.15 Looking into one of the site pits



Fig. 4.17 The traction head with the feed auger inside it



4.1.3 The auxiliary pipe technique

General

As already mentioned in section 4.1.2, the auxiliary pipe technique was developed from the burst lining and press-pull techniques. In broad terms, the same principles apply as have already been described in sections 4.1.1 and 4.1.2.

In contrast to the press-pull technique described above, the auxiliary pipe technique is used for the replacement along the same route of pipelines made of ductile materials, i. e. ones which cannot be burst open in a target or intermediate pit (e. g. steel ones). If pipelines of such materials are to be entirely removed from the ground trenchlessly and a new pipeline is to be pulled in along the same route, what is used is the auxiliary pipe technique under DVGW Arbeitsblatt GW 322-2 [25]. With this technique too, increases of up to two increments of nominal size are possible (see Table 4.1). As stated in sections 4.1.1 and 4.1.2 and in [25] applies, *mutatis mutandis*, to the upsized dimension and the minimum distances from adjacent supply pipelines, cables, etc. and from the surface which are closely related to it.

Description of the technique

In the auxiliary pipe technique, the replacement process is divided into a number of steps.

As in the press-pull technique which was described in section 4.1.2, in this case a machinery pit and an assembly pit are required as well, together with intermediate pits at house connections or branch pipes. The distances between the individual pits are similar.

In the first step, the installing and intermediate pits are dug, the connecting pipes to houses are sealed off and the pipes to provide an emergency supply are connected up (Fig. 4.18).

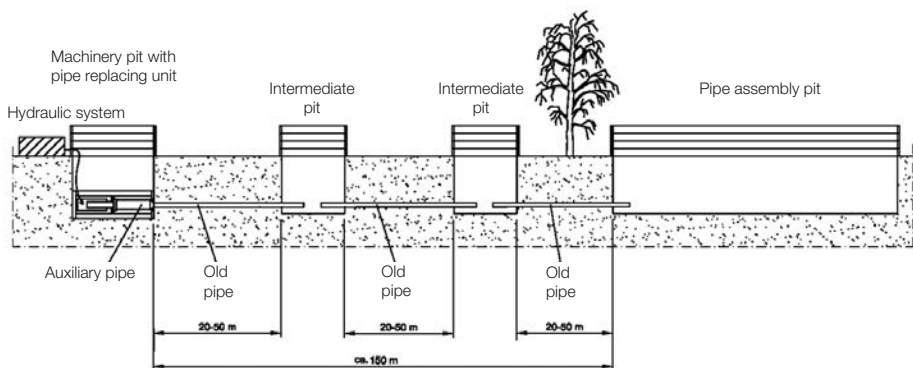


Fig. 4.18 Digging of the installation pits and cutting of the old pipeline in the intermediate pits

Missing pieces of the old pipeline, resulting from the cutting out of house connections or other fittings, are replaced by transition pieces. Then, by means of auxiliary steel pipes connected by restrained joints, the pressing unit presses the old pipes into the assembly pit until they have all been removed (Fig. 4.22).

If the old pipeline is unable to withstand the compressive forces which can be expected, it is cut in the intermediate pits and removed in short sections.

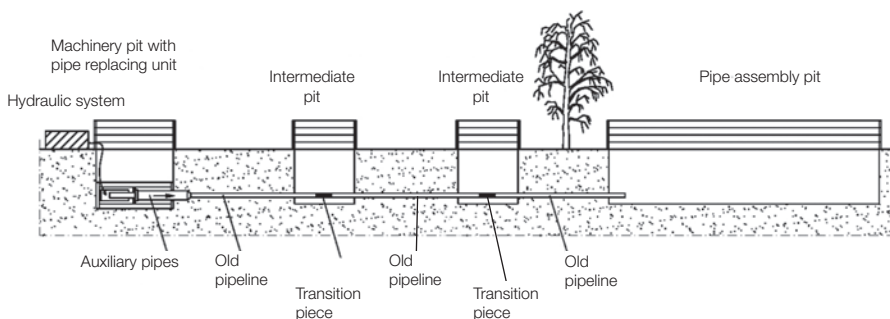


Fig. 4.19 Pushing out of the old pipeline by means of auxiliary pipes

It may be helpful in this case for individual sections to be detached from the soil by means of hydraulic rams before the entire run of old pipes is pushed through into the assembly pit. Because sections measuring up to 6 metres in length can be removed from this pit, the technique is also an obvious one to use for the replacement of old steel pipelines, because these cannot be burst over a breaker cone (Fig. 4.21).



Fig. 4.20 Launch pit containing machinery and auxiliary pipes



Fig. 4.21 A steel pipeline which has been pressed out

Once the last old pipe has been completely removed, the passage defining the route is occupied by the re-usable auxiliary pipes (Fig. 4.22). These now carry the loads from the cover and the traffic load and thus safeguarding the passage for the pipeline.

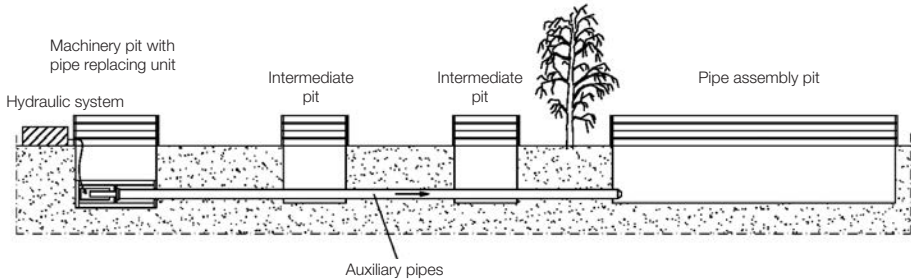


Fig. 4.22 Pipeline passage occupied by auxiliary pipes

In the final stage of the operation, the new pipeline is coupled to the auxiliary pipes present in the passage for the pipeline by means of a traction head with built-in facilities for measuring tractive force. The auxiliary pipes are pulled back into the machinery pit and the new pipeline is drawn into the existing passage (Fig. 4.23). The assembly of the new pipes in the assembly pit proceeds in parallel with the disassembly and removal of the auxiliary pipes in the machinery pit. If a traction head which upsizes the passage is used, new pipes of larger sizes can be pulled in. Operations usually take place with a small oversize of 10 to 15 % on top of the outside diameter of the sockets.

The allowable tractive forces for the new pipeline and its joints must not be exceeded.

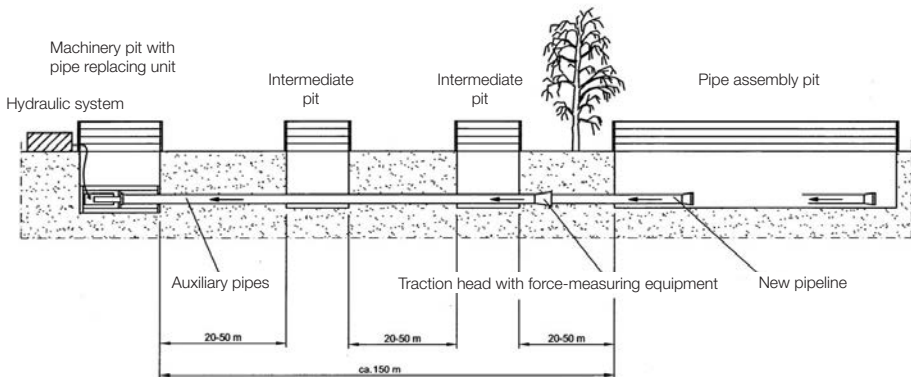


Fig. 4.23 Pulling back of auxiliary pipeline with new pipeline coupled to it

Coating and type of joint

The same applies in this case, *mutatis mutandis*, as applies to the burst lining and press-pull techniques. A ZMU coating which has socket protection consisting of a rubber sleeve or a shrink-on sleeve must be used and a sheet metal cone must be used on the BLS® joint.

As always when the BLS® joint is used in trenchless applications, an additional high-pressure lock has to be used on pipes of nominal sizes from DN 80 up to and including DN 250. The possible tractive forces for BLS® joints of all nominal sizes are given in DVGW Arbeitsblatt GW 322-2 [25] and in Table 3.3 in this Manual. The tractive forces which actually occur have to be measured and documented in the way described in [25]. An example of a printout of a graphic log of tractive force can be seen in Fig. 4.9.

Requirements for the installing company

The company which is given the job of carrying out the installation operation must have the requisite qualifications. Evidence of this must be provided for the client and such evidence is considered to have been provided if the company has a DVGW certificate to DVGW Arbeitsblatt GW 301 [31] and 302 [32] in the appropriate group (GN 1).

The crew given the job of carrying out the work must consist of skilled operatives and trained workers. Under DVGW requirements at least one (internal) training course has to be taken every year. Equipment may only be operated by trained personnel who have been familiarised with the operating and installation instructions.

Reference installations

Applications of the two installation techniques described above, namely the press-pull and auxiliary pipe techniques, have so far been concentrated almost entirely in the region supplied by Berlin's water supply company Berliner Wasserbetriebe (BWB). The list of reference installations is therefore very short but it still very meaningful.

Since 2007, using Duktus pipes alone, more than 40,000 m of pipeline of the DN 80 to DN 400 nominal sizes have been successfully rehabilitated with these two techniques in the area covered by the city of Berlin.

As well as in the region supplied by BWB, the press-pull technique is also being used in large areas of Switzerland and Western Europe. Over the past few years, around 10,000 m of ductile iron pipes with BLS® joints and a cement mortar coating have been installed by this technique in Switzerland alone.

4.2 Trenchless laying of new pipelines

In contrast to the techniques described in section 4.1 for replacing existing pipelines along the same route, what will be described in the present section are techniques for the trenchless laying of new ductile iron pipelines. The techniques on offer in this case are principally the horizontal direction drilling (HDD), ploughing-in and milling-in techniques. While the last two techniques are of fairly minor significance, HDD is a form of trenchless installation of ductile iron pipes which is now used routinely.

4.2.1 The horizontal directional drilling technique

General

Since the early 1990's, there has been a close relationship between the development of this technique and ductile iron pipes. Back in 1993, Nöh [26] conducted some exploratory tests in which 60 m long DN 150 pipelines with positive locking joints were installed and were then withdrawn again from the passage to allow the surface stresses which had occurred to be assessed. The excellent results provided the justification for a 2 x DN 150 double culvert pipeline about 200 metres long which was pulled in under the river Mosel in 1994 near Kinheim, partly through rocky subsoil.



Fig. 4.24 A pre-assembled DN 500 pipe string



4.25 Arrival in the target pit

After this positive experience, development went ahead at a very rapid pace:

In 1996 the pipes were of DN 500 size [27] (Figs. 4.24 and 4.25), in 2000 the bar was raised to DN 600 [28] and in 2003 DN 700 pipes were pulled in by the horizontal directional drilling technique in the Netherlands [529].

The current record – held by Duktus pipes with BLS® joints and a ZMU coating – is approximately 500 metres of DN 900 pipes in Valencia in Spain [36] (Figs. 4.26 to 4.28).

It can therefore be said nowadays that pipelines of nominal size from DN 80 up to and including DN 1000 can be laid with Duktus ductile iron pipes using the HDD technique.

In parallel with the above, the DVGW was developing technical rules for the technique, and these took the form of Arbeitsblatt GW 321 Steuerbare horizontale Spülbohrverfahren für Gas- und Wasserrohrleitungen – Anforderungen, Gütesicherung und Prüfung, which was published in October 2003 [30].



4.26 A pre-assembled DN 900 pipe string in a floodable trench

4.27 The pipe string afloat



4.28 Beginning of the pulling-in with a barrel reamer



Description of the technique

The horizontal directional drilling technique (HDD), which will be referred to below simply as the directional drilling technique, is the most widely used trenchless technique for installing new pressure pipelines for gas and water supply. DVGW Arbeitsblatt GW 321 [30] gives rules for it relating to requirements, quality assurance and testing to ensure that quality is properly assured.

The sequence of operations in the directional drilling technique is generally divided into the following three successive steps:

- a pilot bore
- an upsized bore or bores
- pulling-in

The pilot bore

This is the first step in producing a drilled passage, running from the starting point to the target pit, into which the string of pipes can be pulled. The pilot bore is driven under steered control by a drilling head at the tip of a drilling string. Emerging at high pressure from the drilling head as it drives is an aqueous suspension of bentonite, the so-called drilling mud, which is pumped through the drilling string to the drilling head by the drilling machine. The drilling mud serves both to carry away the material which is cut away and to support the bore. There are different designs of drilling heads for all types of soil. In sandy soils, all that is generally needed for detaching and carrying away the cuttings are the outlet nozzles. In rocky soils, drilling heads fitted with roller-equipped chisels can be used.

The pilot bore is steered by controlled rotation of the bevelled steering surface of the drilling head. This surface moves off-line and it can be forced to move off-line in the desired direction by rotating it (Fig. 4.29).

The actual position of the drilling head is detected above the path of the bore by means of radio signals from a transmitter housed in the drilling head. Any deviations from the desired line are corrected by appropriate steered movements. Today, the accuracy of steering is so high that, after being driven for a length of more than 1000 metres, pilot bores can be made to arrive within a target area measuring only a square metre in size.



Fig. 4.29 Drilling head for the pilot bore

5.2.2 The upsized bore or bores

If the pilot bore needs to be upsized, suitable tools are used to upsize it, in a number of stages, to a diameter suitable for the pulling-in of the medium-carrying pipeline. For this purpose, an upsizing head is fitted to the pilot drilling string, the size and configuration of this head being governed by the particular soil conditions and the size of the pipeline which is subsequently going to be pulled in (Figs. 4.30 and 4.31).

The upsizing head is pulled through the pilot bore while rotating continuously and in this way it enlarges the size of the pilot bore. The soil which is cut away is carried out with the drilling mud and this latter supports the bore at the same time.

The upsizing process is repeated with increasingly large heads until the bore is of the desired inside diameter. With ductile iron pipes the diameter of the drilled passage depends on the outside diameter of the sockets. An oversize of 20 % to 30 % is usually needed on top of the diameter of the sockets.



Figs. 4.30 and 4.31 Upsizing heads

Pulling-in

Once the drilled passage has reached its final diameter, the string of pipes can be pulled in. A reaming tool (Fig. 4.32), then a rotary joint that stops the string of pipes from turning with the reaming tool, and then a traction head (Fig. 4.33) matched to the pipes that are going to be pulled in is fitted to the drilling string which is still in the passage. The traction head is connected to the string of pipes by friction locking and positive locking.

The maximum possible length of the string of pipes to be pulled in depends on local conditions. To find it, it is necessary to make an estimate of the tractive force which can be expected. According to [35], this can be done with the following formula:

$$F = (L + D - K) \cdot X$$

where

F = estimated tractive force [kN]

L = length of drilled passage [m]

D = pipe diameter [mm]

K = correcting value = 500 [kN]

X = soil factor

Soils well suited to HDD → X = 0.5

Normal soils → X = 1.0

Difficult soils → X = 1.5

The maximum possible length of the pipe string can then be found from the estimated tractive force, assuming the latter complies with the values given in Table 3.3 or the allowable tractive forces from [30]. It has been found in practice that the tractive forces which occur are usually in the range of 40 % to 70 % of the weight of the pipes.

As well as the tractive force, what also has an important part to play is the radius which is planned or possible for the drilled passage. This is determined by:

- the drilling string
- the pipes
- the soil and local conditions.

Depending on the nominal size, the BLS® joint which needs to be used for the HDD technique can be deflected angularly by between 1.5° and 5°. This is equivalent to curves with minimum radiuses of 230 m to 69 m.

In the case of curves in three dimensions, i. e. curves which extend in both the vertical and horizontal directions, the combined radius can be calculated as follows

$$R_{comb.} = \sqrt{\frac{R_h^2 \cdot R_v^2}{R_h^2 + R_v^2}}$$

The combined radius is smaller than the individual radiuses.

With regard to the height of cover, it should not be less than a minimum of 5 m or 10-15 times the diameter of the pipes.

When the pipeline is being pulled in too, drilling mud is pumped through the drilling string. It emerges from the reaming tool and as it does so enables the cuttings to be carried away and it reduces the frictional forces at the same time.

The forces acting on the string of new pipes as it is pulled in have to be measured and a record has to be kept of them.



Fig. 4.32
Reaming tool with rotary joint and traction head



Fig. 4.33 Traction head with sheet steel cone

Requirements for the installing company

The company which is given the job of carrying out the directional drilling operation must have the requisite qualifications. Evidence of such qualifications is considered to have been provided if the company has a DVGW certificate to DVGW Arbeitsblatt GW 301 [31] or 302 [32], or as the case may be, in the appropriate group (GN 2). A supervisor who is qualified under DVGW Arbeitsblatt GW 329 [33] must also be appointed by the company.

Pipeline materials

The pipes and joints must be suitable for the stresses caused by the technique. The allowable tractive forces and the radii of bends, i. e. the angular deflections are laid down in Anhang A to Arbeitsblatt GW 321 [30] for the usual pipe materials, namely steel, PE-X, PE 100 and ductile iron (see also Table 3.3). Depending on the material, the pipes also need to have suitable external protection which will protect them from damage such as scoring for example.

Ductile iron pipes to EN 545 [11] or EN 598 [12] (for sewage) are particularly well suited to trenchless laying by the HDD technique. The first crucial feature which may be mentioned is the material of the pipes themselves. Ductile iron has the ability to withstand extreme loads without being damaged. The possibility of the pipe wall ever being damaged by articles lying hidden in the earth can therefore be almost completely ruled out.

Another crucial feature is the external coating. Ductile iron pipes for the HDD technique are provided with a plastic-modified cement mortar coating (ZMU) approximately five millimetres thick to EN 15 542 [7]. This is an effective means of preventing damage to the body of the pipe and is suitable for soils of any desired aggressiveness (DIN 30 675-2 [34]).

The third essential for the use of ductile iron pipes by the HDD technique is the BLS® joint.

The restrained positive locking BLS® push-in joint combines functionality, ruggedness and simple, swift and secure assembly. It can be assembled in just a few minutes even under the most adverse conditions, such as ice and snow, and economically and easily. In this way it shortens the stoppages that pipe-by-pipe assembly or the assembly of part strings of pipes involves to an absolute minimum. At the same time, its material has, under DVGW Arbeitsblatt GW 321 [30], the highest allowable tractive forces of all the usual materials used for the installation of water pipelines (see Fig. 3.12). These allowable tractive forces can be applied, in full, immediately the joint has been assembled.

When ductile iron pipes are being assembled, it is unknown for there to be any cooling times or reductions in tractive force due to high pipe wall or ambient temperatures or due to protracted pulling-in times.

The allowable tractive forces, operating pressures and angular deflections are shown in Table 3.3.

To obtain the allowable tractive forces shown in the Table, it is laid down that an additional high-pressure lock must be used in pipes of the DN 80 to DN 250 nominal sizes. The operating pressures and tractive forces shown are based on a wall-thickness class of K9. Higher values both for operating pressure and for tractive force are possible by, for example, increasing the wall-thickness class. If the angular deflections are $\leq 0.5^\circ$ per joint, the values given can be increased by a further 50 kN.

The angular deflections of up to 5° which are possible at each joint allow pipes to be laid in curves of a minimum radius of only 69 metres.

With regard to protection for the joints, there are the following options:

- a sleeve of heat-shrink material to DIN 30 672 [39] with a sheet steel cone
- a sleeve for protecting cement mortar with a sheet steel cone.

The protection selected for the joints depends to a crucial degree on the method of installation selected.

Basically, ductile iron pipes can be pulled in by two variant methods:

1. pulling-in of a pipe string or part pipe strings
2. pipe-by-pipe pulling-in

A point in favour of the first variant, the pulling-in of a pipe string, is that the pipe string is first assembled from individual pipes, filled with water, and pressure tested, before then being pulled into the passage for the pipeline which has now been completed. For a long time this variant was even stipulated by insurers of installation work because it was considered the safest.

During the pulling-in, there are only brief breaks in operation for the disassembly of the traction string at the machinery end. These times have to be kept as short as possible so that the thixotropic effect does not occur in the drilling mud and cause it to solidify.

What is essential for this method is enough space for assembling the pipe string or the part pipe strings lying next to one another. Something that has an adverse effect is the total weight of the pipe string, which increases the tractive forces required due to the friction between the string and the earth below it. This can be reduced by for example sheet metal skids greased with lubricant on which the pipe string is mounted or by inflated rubber rollers. If there are passages/pipeline trenches filled with water or bentonite, the string can then float in them (Fig. 4.27).

One thing which is true in general is that the pulling-in of pipe strings (Fig. 4.24) does away with the advantage that trenchless installation techniques normally have of highly localised (point) installation sites. Basically, this is true of pipes made of all materials.

The second variant, pipe-by-pipe pulling-in, is in turn best suited to small, point installation sites. It should be remembered in this case that pipe-by-pipe pulling-in cannot generally be used with pipes which have to be joined together into pipe strings by welding because the time needed for making, cooling and testing the welds is too long. The inevitable consequence is that the drilling mud solidifies due to the thixotropic effect.

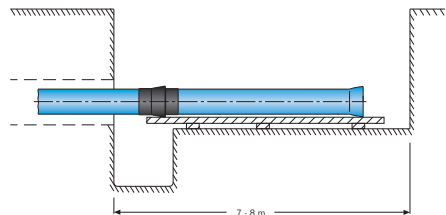


Fig. 4.34 General diagram of an assembly pit

This is the very place where the advantage of Duktus's BLS® joint becomes apparent. The time taken to assemble this joint takes the same time needed to disassemble the traction string at the machinery end (see Table 3.3). This gives ductile iron pipes with BLS® joints a lead over pipes of other materials which cannot be matched. The space needed at the pipe pull-in end is only slightly more than the length of one pipe and installation pits seven to eight metres long are generally all that are needed (Fig. 4.34). Otherwise the pipes are assembled on an assembly ramp. A point site becomes possible with pipes assembled in these ways. No allowance has to be made for forces due to friction against the earth below and it is usually even possible for the next smaller machine to be used, something which once again has a beneficial effect on costs. Another advantage that pipe-by-pipe assembly on a ramp has is that the work can be done at eye level, under workshop conditions as it were, which is important from an ergonomic point of view (Fig. 4.35). Also, the assembly of the joints on a ramp some distance away from dirt and sludge is an inestimable advantage as far as the drinking water hygiene constraints and the subsequent release of the pipeline for use are concerned.

Fig. 4.35 Assembly ramp for pipe-by-pipe pulling-in

It is clear that the gain in speed provided by the variant methods which have been described must not be lost due to the fitting of a heat-shrink sleeve. This is where the sleeve for cement mortar protection, which can be folded back easily and quickly and which is protected against unknown roughnesses in the drilled passage by a sheet metal cone, comes into its own. Together with the sleeve, the cone is slid over the pipe socket before the pipe is assembled and following the assembly of the joint it is moved into position (Fig. 4.36) and folded over if required.



Fig. 4.36 A BLS® joint with a sleeve for cement mortar protection and a sheet steel cone



Table 4.2 provides an overview of the possible ways of covering the joints to protect them when the different variant methods are used.

Table 4.2 Possible ways of protecting the joints

Variant	External coating	Joint protection
Pipe-by-pipe pulling-in	ZMU	Protective sleeve for cement mortar plus sheet steel cone
Pulling-in of (part) pipe string(s)	ZMU	Protective sleeve for cement mortar or shrink-on sleeve plus sheet steel cone ¹⁾

1) Relevant information can be found in our product catalogues. If possible, shrink-on sleeves of tape material should not be used on pipelines installed by HDD.

Which of the two methods of installation mentioned above, namely pipe-by-pipe assembly or pulling-in of a pre-assembled pipe string or part pipe strings, is used will depend on how much space is available on the site.

What is considered in the majority of cases in built-up city-centre areas is pipe-by-pipe assembly. A launch pit approximately seven to eight metres long is required for this. Assembly and the protecting of the sockets take place in the pit. The incursion made into the surface of the road may be even smaller if the pipes are assembled on a movable ramp.

Depending on the constraints which apply such as the nominal size, the soil and the preparing of the surface for sliding of the pipe string, lengths of some hundreds of metres can be pulled in.

To sum up

In their current form, the ductile iron pipes made by the Duktus company with a plastic-modified cement mortar coating and the BLS® joint are not only suitable for installation in open trenches but are also an interesting alternative when modern-day trenchless installation techniques such as horizontal directional drilling are going to be used. They combine a very simple design of joint which can be assembled quickly and under almost any conditions but at the same time is able to carry high loads with a coating system which is equal to the demands made on it. What is more, the pipes will withstand virtually all the external stresses which occur in horizontal directional drilling and according to DVGW Hinweis W 401 [10] their material has by far the longest technical operating life of all those used for pipes.

Ductile iron pipes are the first choice when it comes to making a sustainable investment. Word of this has already got around and is proved by the large numbers of installation operations which have been carried over past years and decades with the horizontal directional drilling technique. The reference installations listed in the following Table are only able to show you a few of the most interesting HDD projects which there have been.

List of reference installations (excerpt)

Installation	DN nominal size	Length [m]	Year
Grobbendonk, Belgium	600	380	2015
Osthofen	400	240	2015
Badrina	500	480	2015
Lochmühle Körner	200	250	2014
Berlin – Bühringstraße	100	175	2014
Reutlingen	400	370	2014
Milei Leutkirch	300	590	2013
Berlin –Wuhlheide	600	285	2012
Sinntal – Oberzell	125	54	2012
Rio Alberche (Toledo), Spain	400	510	2011
Saint Dizier – France	300	102	2011
Berlin – Havelchaussee Tiefenwerder	700	480	2011
Rügen – Dreschwitz	300	132	2010
Grobbendonk – Albertkanaalstraat, Belgium	900	342	2010
Döllnitz – HWS Halle	500	360	2010
Toba – Wiedermuth connecting pipeline	100	240	2010
Göteborg – Marienholmsgatan, Sweden	400	90	2010
Asperg	150	4 x 100	2010
Potsdam – Fahrland	250	4 x 170	2010
Berlin – Stahnsdorf	250	600	2008
Gent – Belgium	600	384	2008
Bad Suderode, buried cross-country pipeline (Saxony-Anhalt)	400	280 + 342	2008
Valencia, Spain	900	540	2007
Blankenfelde Mahlow, Crossing of L40 road	300	90	2006
Schwante, Dorfstraße	300	192	2006
Nieder Neuendorf, Havel Canal culvert pipeline	200	360	2006
Wolfenbüttel	500	246	2006
Halle, Maxim-Gorki-Straße	150	286	2006
Rügen, Prora 3. BA	300 + 250	625 + 450	2005
Großbeeren, Kleinbeerener Straße	300	126	2005
Nieder Neuendorf, 1 BA	200	366	2005
Eichwalde	300	126	2004
Berlin Frohnau	100	78	2004
Münster near Dieburg	100	90	2004

4.2.2 Ploughing-in/milling-in

General

For quite some time now, it has been the practice in rural areas for cables and plastic pipelines to be ploughed in off a reel along routes on which there is no existing infrastructure or other obstacles. Where this is mostly done is along farm roads and along the edges of areas used for agricultural purposes. The technique was successfully tried out for the first time with ductile iron pipes in 2000, as part of a research project, and it has now developed into a standard technique which has been covered in the sets of rules issued by the DVGW and DWA.

What is used for the installation of ductile iron pipes is the trailing plough procedure detailed in ATV-DVWK Merkblatt M 160 [37] and DVGW Arbeitsblatt GW 324 [38].

Description of the technique

A cavity is produced by a widening body shaped like the nose of a rocket at the bottom end of a ploughshare. A pipe string, which is attached to the widening body, is pulled into this cavity in the same stage of the operation. Fig. 4.39 shows the principle of the technique. So far it has been used with pipes of nominal sizes from DN 80 to DN 300.

The machinery required consists of a traction vehicle (Fig. 4.38) and a plough (Fig. 4.39) carrying a ploughshare. To ensure that the vertical position of the pipeline remains constant when the profile of the terrain varies, the depth of penetration of the ploughshare can be controlled hydraulically.

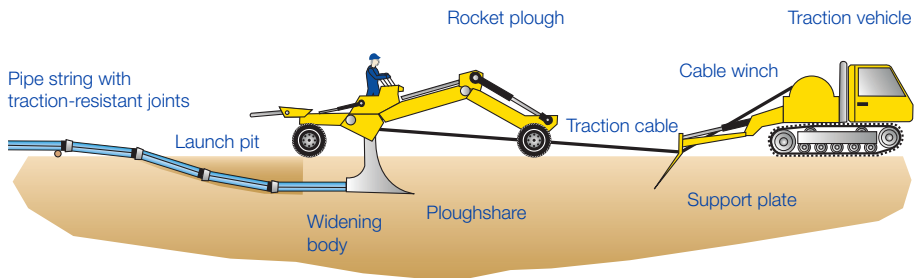


Fig. 4.34

A steel cable (Fig. 4.40) connects the plough to the traction vehicle and the latter can be supported on the ground by means of a support plate, to enable the tractive forces to be transmitted into the ground. The string of ductile iron pipes, which is connected by restrained positive locking joints, is laid out along the line of the route. The string is then hooked onto the widening body (Fig. 4.41) and is ploughed into the ground (Fig. 4.43) from a launch pit with an inclined ramp (Fig. 4.42). The length of the launch pit depends on the angular deflection of which the restrained push-in joints are capable.



Fig. 4.38



Fig. 4.39

Fig. 4.41



Fig. 4.40

Fig. 4.42



External coating

With the rocket plough technique, the external protection of the pipes is particularly important because the string of pipes which is hooked on is generally ploughed into the native soil without any lubricants (bentonite or the like). Because there is generally no exact knowledge of just what the conditions are in the subsoil, the pipes require an external coating which is able to carry high loads and which will remain undamaged even when subjected to extreme mechanical stresses and will thus stay effective for the entire life of the pipeline.

What is used for this purpose in the case of ductile iron pipes is a plastic-modified cement mortar coating (Fig. 4.44) to EN 15 542 [7].

What is used to protect the socket joints is either polyethylene shrink-on material to DIN 30 672 [39], with an additional sheet metal cone (Fig. 4.45) to provide the shrink-on material with mechanical protection during the pulling-in process, or a sleeve for cement mortar protection with a sheet-metal cone for mechanical protection.



Fig. 4.43

Fig. 4.44

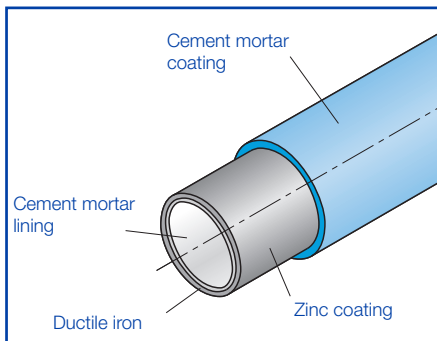


Fig. 4.45



Joints

The BLS® restrained push-in joint is used for the rocket plough technique. Over the size range from DN 80 to DN 250, this BLS® joint is supplemented by a high-pressure lock (Fig. 4.46) to enable the transmission of the tractive forces to be maximised.

The allowable tractive forces and the minimum radii for curves are given in DVGW Arbeitsblatt GW 324 [38] and in ATV Merkblatt ATV-DVWK M 160 [37] or can be seen in Table 3.3. With regard to the design and construction of the components of the restrained joints, the VRS® joint which is dealt with in the DVGW Arbeitsblatt and the ATV-DVWK Merkblatt corresponds in all respects to the BLS® joint.



Fig. 4.46

The pipe string is coupled to the plough or the milling cutter by means of a BLS® traction head (Fig. 4.47)

Fields of use and advantages of the installation technique

The rocket plough technique is particularly suitable for the installation of pipelines in rural areas and in areas where ground water and surface water are subject to statutory protection. The crossing of small, shallow bodies of surface water (Fig. 4.48) and installation in embankments do not present any technical problems for this installation technique. Installation below the water table is equally possible. The terrain must not be surfaced and must not contain any obstacles of any great size in the area through which the route of the pipeline runs. The exact position of any intersecting pipelines or cables must be precisely known in advance. The rocket plough technique is very suitable for use in types of soil which can be easily displaced. Displaceable soils include unconsolidated deposits of mixtures of gravel and silt, gravel and clay, sand and silt and mixtures of sand and clay.



Fig. 4.47 A BLS® traction head

Additional protective tubes, cables and warning strips can be installed at the same time as the pipeline is being pulled in (Fig. 4.49). A suspension of bentonite can be fed in to fill up the annular gap or to reduce the frictional forces.

Individual strings of pipes are connected together by means of collars (Figs. 4.50 and 4.51).



Fig. 4.48 Crossing a body of surface water



Fig. 4.49



Fig. 4.50



Fig. 4.51



Fig. 4.52

The disturbed soil that is left on the surface after the pipeline has been pulled in (Fig. 4.52) is then smoothed down again by running the excavator over it.

These are some other advantages of the rocket plough technique:

- low installation costs compared with the conventional technique
- short installation times
- no removal of top-soil required
- routes are not very wide (up to about six metres)
- there is no mixing of soils
- depths of installation of up to two metres.

A feature which needs to be stressed is the speed of installation which can be achieved: it is generally between two and seven metres a minute.

Requirements for the installing company

The company which is given the job of carrying out the installation operation must have the requisite qualifications. Evidence of this must be provided for the client and such evidence is considered to have been provided if the company has a DVGW certificate to DVGW GW 301 [31] and 302 [32] in the appropriate supplementary group GN 4 (milling) or GN 5 (ploughing).

The crew given the job of carrying out the work must consist of skilled operatives and trained workers. Under DVGW requirements at least one (internal) training course has to be taken every year. Equipment may only be operated by trained personnel who have been familiarised with the operating instructions and installation instructions.

The list of reference installations below shows some of the pipeline installation projects which have been carried out in recent years with the rocket plough technique.

List of reference installations (excerpt)

Location	Nominal size DN	Length [m]	Year
Laue-Poßdorf (near Delitzsch)	200	1,248	2000
Impflingen	150	797	2001
Hergenstadt	150	2,500	2002
Untersollbach	150	2,037	2004
Öhringen	100 + 150	1,000	2005
Adelsheim – Hergenstadt	150	2,500	2005
Bad Wimpfen im Tal	200	800	2006
Öhringen – Eckartsweiler	150	500	2010

4.2.3 Pilot tube guided auger boring technique

General

An interesting variant technique for the trenchless installation of new ductile iron pipelines was seen for the first time in 2006 at the Wasser Berlin fair [44] – the technique known as pilot tube guided auger boring. A steered pilot bore was driven to the target pit over a distance of approximately 70 metres using a jacking machine for microtunneling. As a second step, this pilot bore was upsized to a diameter of 480 millimetres by soil removal through auxiliary tubes containing a feed auger. The third step was to withdraw the auxiliary tubes while at the same time pulling in ductile iron pipes one by one. The accuracy which can be achieved with this variant technique is so great that even the stringent requirements of draft DWA Arbeitsblatt A 125 [45] for gravity sewers can be met.

The basic requirements for pilot tube guided auger boring are a displaceable soil, lengths of run of < 120 m, no stones > 80 mm along the route of the pipeline and a water table rising to less than 3 m above the pipeline.

At the moment, the machinery available allows pipes of a maximum outside diameter of 1000 mm to be installed. This is equivalent to a DN 800 nominal size ductile iron pipe with a BLS® joint.

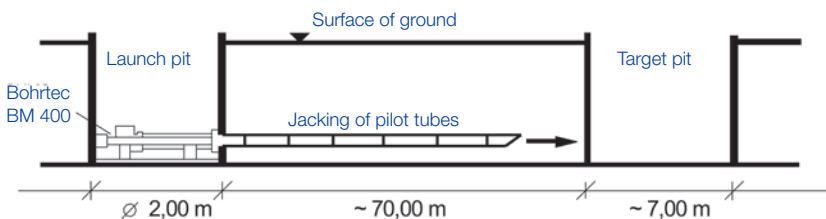
The main advantage of this technique is that, although it is a jacking technique, the pipeline is pulled in, so new pipelines can be laid trenchlessly with great accuracy even using pipes which are not normally available as jackable pipes.

Description of the technique

The first step is to make the pilot bore. Starting from the launch pit, the pilot tubes are jacked through the displaceable soil to the target pit. An optical system, a steering head, a theodolite fitted with a CCD camera and a display are used to enable the target point to be homed in on exactly while direction and inclination are constantly monitored (Fig. 4.53).

Fig. 4.53 Step 1: Driving the pilot bore

1. Pilot bore



In the second step, the pilot bore is upsized by pressing in protective steel casing tubes connected by restrained joints (Fig. 4.54).

Even at this stage the bore can, if required, be upsized to the final size required. Together with the steel casing tubes, the lengths of pilot tube in the pilot bore are pushed to the target pit, disconnected there and recovered. The soil that is dug out as the bore is upsized is fed back to the launch pit by a feed auger which is in one metre long sections. In the launch pit the soil is collected in a bin, raised to the surface with the site hoist and collected in containers to be taken away.

2. Jacking in of casing tubes

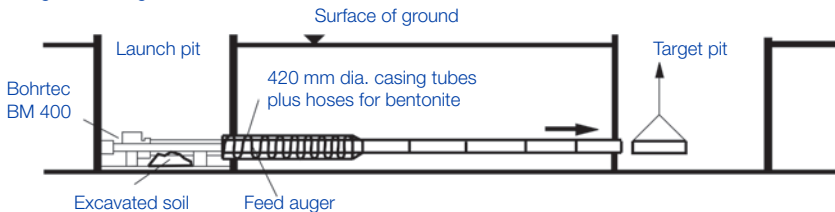


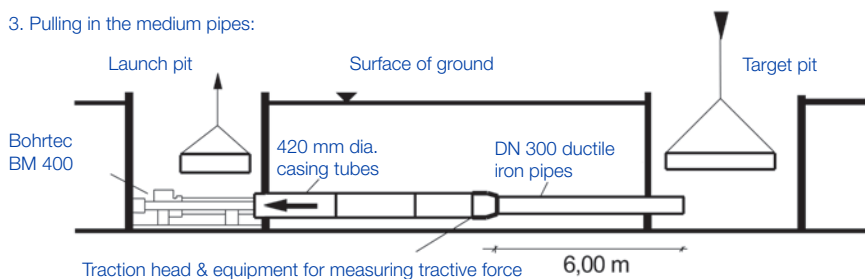
Fig. 4.54 a + b

Step 2: Jacking-in of the casing tubes

In the third step of the operation, the first ductile iron pipe with a BLS® joint is lowered into the target pit and coupled to the traction head on the front casing tube. The casing tubes, which are connected by restrained joints, are then pulled back to the launch pit; there they are recovered together with the feed auger (Fig. 4.55).



3. Pulling in the medium pipes:



The casing tubes and medium pipes must be fitted with restrained joints

Fig. 4.55 Step 3: Pulling in the new pipeline by pulling back the steel casing tubes

It takes next to no time for all the other medium pipes to be coupled onto pipes pulled in previously (see Table 3.3). The traction head carries equipment for measuring the tractive force; this is used to measure the pulling-in forces acting on the string of pipes and, later on, to document them in a print-out.



Fig. 4.57 Coupling on a fresh pipe

Fig. 4.56
Lowering a pipe into the target pit

As an alternative to the traction head, what can also be used is a so-called hole opener (Fig. 4.58). This tool has the advantage that the medium pipeline to be installed can be laid to an accuracy of millimetre order, which is particularly important for the laying of gravity pipelines. The forces generated by skin friction can be reduced by lubrication with bentonite. If required, the bentonite mixture can be forced between the new pipeline and the soil in the region of the hole opener through a supply line extending through the pipeline.



Fig. 4.58 a + b Hole opener with connector for ductile iron pipes

External coating

Basically, it is pipes with a cement mortar coating to EN 15 542 [7] which are used for this technique. In the way that has already been described a number of times, the sockets are protected by a rubber sleeve for cement mortar protection and a sheet steel cone.

However, in many cases it will be necessary to use a development of the proven cement mortar coating. 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, and 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. 4.59), 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. 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. 4.59 ZMU Plus pipes

Because the medium pipes are pulled in by pilot tube guided auger boring, this is another case where the BLS® joint has to be used. The allowable tractive forces and operating pressures for the BLS® joints are shown in Table 3.3.



Fig. 4.60 The BLS® joint

Other points

The individual sections of a pipeline can then be connected together in the conventional way in the assembly pits (which were previously the launch and target pits) using standard fittings. For pipelines connected entirely by restrained joints, restrained BLS® fittings are available (Fig. 4.61). In the case of pressure pipelines, these fittings can also be used to seal off the ends of the sections for pressure testing prior to the full connection. There is thus no need for the ends of the pipeline to be supported against the pit shoring in this case.



Fig. 4.61 BLS® fittings for subsequent connecting together and pressure testing

One advantage of pilot tube guided auger boring is the very small oversize. As a result there is no or only a very small amount of settlement. The technique is fully developed in technical terms. It combines the well known steered jacking technique which has proved its worth in the field of sewage pipe installation with the technique of pulling in ductile cast iron pipes with restrained joints. There is only a small amount of interference with traffic and the environment. This technique is proving to be very economical and the reasons for this are the short installation times, the saving on below-ground and other work, such for example as the lining of pipe trenches, the temporary storage of soil, and transport to and from the site, does not impinge on any adjacent infrastructure, and the low-emission nature of the installation work.

Requirements for the installing company

DVGW Arbeitsblatt GW 304 [57] has this to say on the subject:

“Only qualified companies which have the requisite expertise, standard of performance and reliability and which possess adequate technical and economic resources may be given the job of carrying out pipe jacking operations. If invitations to tender are issued on the basis of DIN 1960 (VOB Part A General provisions relating to the award of construction contracts), it is recommended that use be made of § 3, No. 3 paragraph 2a (restricted tender by the open competitive pre-qualification procedure).

Evidence of the requisite expertise for carrying out steerable techniques and bursting techniques for sewer installation is considered to have been provided if the company submits a certificate in the appropriate group under the RAL-GZ 961 quality assurance requirements of the Quality Association for “Installation and maintenance of sewer mains and laterals” or appropriate evidence of qualification under the “RAL-GZ 961 quality and testing requirements” and a contract for RAL quality assurance for the operation. References relating to the carrying out of comparable pipe jacking operations should be asked for.”.

4.3 The pipe relining technique

General

When pipelines are renovated by the relining technique, a new pipeline is pulled or pushed into an existing pipeline. This always results in a reduction in the clear inside diameter. When relining is carried out with ductile cast iron pipes, the reduction in the cross-section of the pipeline depends on the outside diameter of the sockets in the new pipeline. It is generally two increments of nominal size. The pipeline suffers a loss of hydraulic performance. However, this is compensated for to some degree by the smooth interior surface of the new pipeline (the low roughness of its walls). Old pipelines are often encrusted on the inside and the roughness of their walls is therefore high. The relining technique can be used for pipelines for drinking water and non-drinking water, and for pressure sewage and wastewater pipelines and gravity sewage and wastewater pipelines. Relining is governed by DVGW Arbeitsblatt GW 320-1 [17].

In Germany, the consumption of drinking water by the population and by industry has been going down for years now. In 1990, the per capita consumption was still about 145 l per person per day [40] but by 2007 it had dropped to around 120 l per person per day. There are very wide regional variations in this case of between 90 and 135 l per person per day [40]. A reduction in the hydraulic cross-section of a pipeline is therefore often an advantage to the operator, because the rate of flow of the water is accelerated again and the dwell time of the water in the pipeline is shorter, by which means it is often possible for health problems to be avoided.

With sewage and wastewater pipelines too, the rate of flow goes up as a result of relining, and in many cases this is a way of stopping the solids carried in the sewage and wastewater from settling. Because of deposits of solids, sewage and wastewater pipelines often have to be cleaned at relatively short intervals by high-pressure flushing or by using pigs. It is possible that the use of a smaller diameter may make this unnecessary.

Wherever there are pipelines where the intervals between changes of direction or lateral connections are not too short, renovation by the relining technique is always more economical than renovation by relaying in open trenches. This is true above all of runs of pipes below paved or metallised surfaces (e. g. surfaces carrying traffic) or in built-up areas.

Depending on the existing constraints, sections up to well over 1000 m in length can be renovated in a single operation by the relining technique. All that are needed for this purpose are a launch and a target pit. There are no limits on the nominal size of the new pipeline.

Description of the technique

In the relining technique, ductile iron pipes to DIN EN 545 [11] or DIN EN 598 [12] are pushed or pulled into the existing, old pipeline. They slide on their sockets when this technique is carried out and are protected by a sheet metal cone (Fig. 4.61). Because of the high longitudinal bending resistance of ductile iron pipes, each pipe needs only one support (which is the socket in this case). No other supports/skids for sliding are normally needed.

The first step is for launch and target pits to be dug along the line of the pipeline to be renovated. Their position will depend above all on fixed points such as changes of direction and of course on the beginning and end of the pipeline. The size of the pits depends on the machinery used and on the new pipes. The crucial factor for ductile iron pipes is their length of approx. 6 m, which means the length of the pits has to be about 8 m. The width of the assembly pit depends on the nominal size of pipes to be installed.

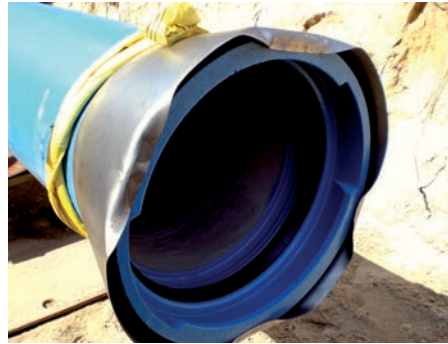


Fig. 4.61 A sheet steel cone to protect the sliding socket

Fig. 4.62 A launch pit



Fig. 4.63 A target pit



The old pipeline is then cut open in the installation pits. What is then important is for the old pipeline to be properly prepared. When work of this kind was done in the past, it was found that a coefficient of friction of $\mu < 1.0$ can always be achieved if the old pipeline is properly prepared – if encrustation is removed (Fig. 4.64), if gaps in the floor of the pipe at the sockets are closed off, if lubricant is applied to the floor of the pipe, and so on. What this means is that only a part of the actual weight of the pipes has to be pulled.



Fig. 4.64 Tool for removing encrustations

In special cases, such as when additional supply pipes and cables or empty tubes are being introduced at the same time, what are also used are roller-equipped clips (Fig. 4.65). These have the additional advantage of considerably reducing the tractive forces compared with the conventional method. Because of the high longitudinal bending resistance of ductile iron pipes, only one clip per pipe is generally needed, positioned a short distance behind each socket.

When a number of pipelines are being pulled/pushed in simultaneously, at least one guide rail should be provided to stop the string of pipelines from twisting.



Fig. 4.65 a and b Roller-equipped clips

In almost all cases, the pipes are assembled pipe by pipe. Even when this is the case, the short assembly times (see Table 3.3) allow quick progress to be made with the installation operation.

Assembly having taken place, the pipe string is pushed forward or pulled onward by the length of one pipe. This continues until the entire length of the run is occupied by new pipes.

Generally speaking, the annular gap left between the old pipeline and the new pipeline is then filled with an alkaline filler material. Whether this is done however depends on the constraints, such as the mode of operation, the external coating, the size of the annular gap and the static load-bearing capacity of the old pipes.

The final steps consist of leak testing, connecting up the individual sections which have been renovated and then backfilling the installation pits.

Fig. 4.66 Preparations for leak testing



Fig. 4.67 Connecting together part-runs



Pulling-in

The BLS® positive locking restrained push-in joint needs to be used for pulling-in. The allowable tractive forces, the maximum possible angular deflections for the BLS® restrained joint and the minimum radius which is possible for curves can be found in Table 3.3 or in DVGW Arbeitsblatt GW 320-1 [17]. Higher figures, both for operating pressure and for tractive force, are possible by, for example, increasing the wall-thickness class. If the angular deflections at the sockets are $\leq 0.5^\circ$, then the figures given can be increased by a further 50 kN.

It has proved successful for the new string of pipes to be pulled in with traction rods (Fig. 4.68) and a report on this appears in [41]. Pulling-in with a winch and steel cable (Fig. 4.69) is not recommended nor is the use of friction-locking restrained joints.

A traction head is always required for pulling in the new string of pipes. This is produced from a BLS® push-in socket (Fig. 4.70). Duktus is able to make traction heads available on hire to installing companies for a deposit and a hire charge.

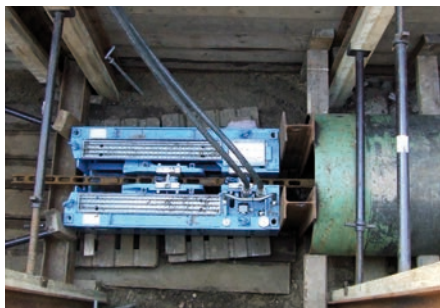


Fig. 4.68 Traction machine using rod string



Fig. 4.69 Traction machine using cable



Fig. 4.70
Pipe with traction head and sheet steel cone

Pushing-in

For pushing-in, ductile iron pipes with TYTON® non-restrained push-in joints are pushed into the old pipeline. When this is done, the axial thrust is transmitted to the end-wall of the TYTON® socket from the end-face of the spigot end. Because the spigot ends of the pipes are bevelled, it is not the entire cross-section of the pipe-wall that is available to transmit the axial thrust (Fig. 4.71).

Also, allowance must be made under DIN EN 545 [11] for the least outside diameter that is possible for the pipes and for the smallest allowable wall thickness.

The compressive strength of ductile iron is $\sigma_D = 550 \text{ N/mm}^2$. Leaving aside any safety factor, a pressing force of $P = \sigma_D \times A_{\text{wall}}$ is thus possible, where A_{wall} is the cross-sectional area of the force-applying wall of the cast iron.

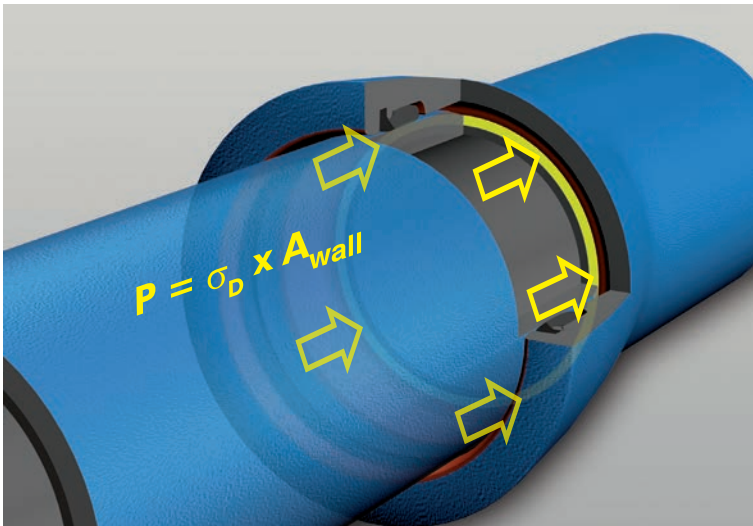


Fig. 4.71
Transmission of force during pushing-in

The allowable push-in forces are given in DVGW Arbeitsblatt GW 320-1 [17] or in Table 4.3. The figures given there do not include any safety factors. Before planning or the beginning of installation we recommend getting in touch with our Applications Engineering Division to agree the correct figures in the particular case. Different safety factors need to be adopted as dictated by the path followed by the route (inclination, radiuses) and the state of the old pipeline.

Table 4.3 Allowable push-in forces under DVGW Arbeitsblatt GW 320-1 [17] for ductile iron pipes (regardless of the sockets and with no safety factor included – the latter has to be matched to the local conditions, i. e. in particular to angular deflections and the radiuses of curves, and has to be agreed with Duktus's Applications Engineering Division).

DN	Outside diameter d_e [mm]	Wall-thickness class	Wall thickness s_{min} [mm]	Allowable compressive stress σ_{all} [N/mm ²]	Allowable push-in force F_{all} [kN]
80	98	K 10	4.7	550	138
100	118	K 10	4.7	550	168
125	144	K 9	4.7	550	206
150	170	K 9	4.7	550	244
200	222	K 9	4.8	550	339
250	274	K 9	5.2	550	513
300	326	K 9	5.6	550	723
350	378	K 9	6	550	968
400	429	K 9	6.4	550	1,246
500	532	K 9	7.2	550	1,912
600	635	K 9	8	550	2,750
700	738	K 9	8.8	550	2,425
800	842	K 9	9.6	550	3,350
900	945	K 9	10.4	550	4,330
1000	1,048	K 9	11.2	550	5,500



Fig. 4.71 Pushing in a pipe

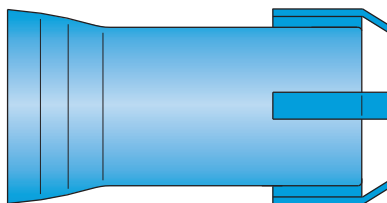


Fig. 4.73 A centring head

Relining operations performed by this technique are reported on in [42] and [43].

When pipes are being pushed in (Fig. 4.72), it is always the spigot end which leads and which is pushed into the socket of the pipe that was pushed in previously. The spigot end of the first pipe which is pushed in has to be fitted with a centring head (Fig. 4.73). This can be made available on hire by Duktus.

As with pulling-in, at least two pits are required. The size of the pushing and assembly pit depends on the length of the pipes (which is usually six metres), on the pushing equipment used and on the nominal size of the pipes that are going to be installed. The size of the target pit depends on the nominal size and on any other items which are going to be fitted into the pipeline.

External coating

If the annular gap left between the old pipeline and the new one is filled with an alkaline filler material, all that the pipes require is the external coating consisting of a zinc or zinc-aluminium (Duktus Zinc Plus) coating plus a finishing layer. The sockets are protected by sheet metal cones during pulling-in or pushing-in (Fig. 4.74).

If the annular gap which is left is not filled, we recommend the use of pipes with a cement mortar coating (ZMU) to EN 15 542 [7]. The push-in joints are protected by rubber sleeves for cement mortar protection or by shrink-on polyethylene material to DIN 30 672 [39]. The push-in joints are given additional mechanical protection in the form of sheet metal cones when being pulled in or pushed in (Fig. 4.74).



Fig. 4.74 A ductile iron pipe with a BLS®, sheet steel cone and ZMU being pulled in

Advantages of ductile iron pipes

Ductile cast iron pipes are capable of carrying high loads. This ensures that all the forces which act on the pipeline both from inside and outside can be withstood without any problems just as they would be by a new pipeline that was laid in an open trench. The state and behaviour of the old pipeline and whether it is likely to move do not affect this. This is not something that is always ensured with plastic pipes.

The economic advantage comes from the push-in joints, which are quick and safe to assemble (see Table 3.3).

Depending on the nature of the pipeline and its nominal size, with steel pipes the joints have to be welded in most cases, as they also do with plastic pipes. This is usually very time-consuming. During the welding and the subsequent cooling-down phase, the rest of the site personnel have to take a break and all the machines and other equipment are standing idle.

Another point that Duktus ductile iron pipes have in their favour is their long technical operating life (see [10]).

Requirements for the installing company

The company which is given the job of carrying out the installation operation must have the requisite qualifications. Evidence of this must be provided for the client and such evidence is considered to have been provided if the company has a DVGW certificate to DVGW Arbeitsblatt GW 301 [31] or 302 [32] in supplementary group R 2.

The crew given the job of carrying out the work must consist of skilled operatives and trained workers. Under DVGW requirements at least one (internal) training course has to be taken every year. Equipment may only operated by trained personnel who have been familiarised with the operating instructions and installation instructions.

Reference pulling-in (excerpt)

Location	Old pipeline	New pipeline DN	Length [m]	Year
Carlsfeld	800 concrete	300	1,900	2015
Hattersheim	700 grey cast iron	400	590	2015
Hattersheim	700 grey cast iron	400	490	2014
Wedemark	800 grey cast iron	600	2,350	2012
Halle	600 grey cast iron	400	410	2012
Frankfurt	600 grey cast iron	400	266	2011
Budapest	800 grey cast iron	600	159	2011
Berlin	1000	800	1,400	2010

Reference pushing-in (excerpt)

Location	Old pipeline	New pipeline DN	Length [m]	Year
Nördlingen	gallery	250	800	2014
Hinkelstein	700	400	110	2011
Leipzig	1100 grey cast iron	900	950	2009
Berlin	1000 steel	800	300	2005
Leipzig	1100 grey cast iron	900	372	2004

5. Other installation techniques

5.1 Floating-in

General

The floating-in of ductile iron pipes is probably the most unusual of the “trenchless” techniques available.

At sizes of DN 250 and above, the buoyancy of a sealed ductile iron pipe is so great that it is able to float without the need for any other bodies to provide buoyancy. This means that basically there are two possible ways of getting a pipe string out onto the water and, in the end, down below the water. At sizes up to and including DN 200 and depending on the wall thickness, additional floats are required, while at sizes of DN 250 and above the pipe string can be installed as a self-supporting floating unit.

Due to unpredictable loads from the waves, the sinking process, the nature of the bed of the body of water and subsequent movements of the bed, etc., it is generally only pipes with the positive locking BLS® push-in joint which should be used for floating-in. This in turn means that the pipeline should be pulled in so that the joints remain extended and thus securely locked.

Description of the technique

Floating-in at up to DN 200

As already indicated, a ductile iron pipe not filled with water, of wall-thickness class K9 and of a nominal size up to and including DN 200, is not capable of floating on its own. This means that its average weight per metre is greater than the buoyancy which can be expected resulting from the displacement of the water by the body of the pipe. At DN 200, buoyancy and weight are almost equal.

Consequently, additional floats are required to enable pipes of the DN 80 to DN 200 sizes to be pulled out over a body of water. These may be special flotation bags or even lengths of polyethylene pipe sealed at both ends (see Figs. 5.1 and 5.2). The floats should be sized to suit the weight of the pipe string and the buoyancy of the nominal size being used.

Fig. 5.1 Traction head with floats



Fig. 5.2 Floats for DN 200



Table 5.1 shows the theoretical weights (F_{down}) per metre of pipe string for ductile iron pipes of wall-thickness class K9 with BLS® push-in joints, zinc coating and finishing layer. It also gives the theoretical buoyancy (F_{up}) of the given nominal size, assuming a weight per unit volume of 10 kN/m³ for the water displaced, together with the difference between the two values (ΔF) and the volume (V_{FL}) of the float required for each 6 m pipe.

Table 5.1

Theoretical values for buoyancy and downward force and for the volume of a float for each pipe

DN	Outside Ø d _s [mm]	F _{down} [kN/m]	F _{up} [kN/m]	ΔF [kN/m]	V _{FL} [m ³ /pipe]
80	98	0.155	0.075	0.08	0.048
100	118	0.191	0.109	0.08	0.049
125	144	0.235	0.163	0.07	0.043
150	170	0.279	0.227	0.05	0.031
200	222	0.384	0.387	0.00	0.000

Proceeding in a sensible way, either one float is positioned in the region behind each socket or if there is more than one float per pipe they are distributed along it. It should also be remembered that the floats have to be flooded or removed in a controlled way so that the sinking of the pipeline can be properly co-ordinated.

Depending on the space available or other constraints such as tides, the weather, deadlines, etc., a relatively free choice can be made with ductile iron pipes between pipe-by-pipe assembly or the assembly of (part) strings. Because the assembly times are very short (see Table 3.3), it is not absolutely necessary for a complete string to be assembled and then pulled in as a whole. Due to the uncomplicated design of the BLS® joint, a compact site layout is perfectly possible without any serious reductions in the pulling-in rate. Figs. 5.3 and 5.4 show pipe-by-pipe assembly and string assembly of pipes of the DN 1000 nominal size with BLS® joints.

The pipe string is pulled through the water by means of a traction head (Fig. 5.1).

Fig. 5.3 Pipe-by-pipe assembly in Binz [47]



Fig. 5.4 String assembly near Magdeburg [48]



Once the pipe string has been brought into position, the sinking process can start. In a controlled way, the floats are flooded or are removed one after the other for this purpose. The pipeline should now begin to sink. Alternatively, the sinking may be initiated by filling the pipeline with water or by a combination of the two methods.

As soon as the pipeline is on the bed of the body of water, the next option is to begin anchoring it. Whether this is necessary depends on the local conditions such as the topography and currents. As an alternative to anchoring, the pipeline can also be buried in banked-up material or in a previously dredged trench (see Fig. 5.5).

Fig. 5.5 A trench being excavated underwater by a dredger



The sinking process can start once the pipe string is in its final position and the leak test has been carried out. In the BLS® range there are special fittings such as the P socket plug (Fig. 5.6) and the flanged sockets and flanged spigots (Fig. 4.61) available for testing pressure pipelines. This enables pressure testing to be carried out very easily without the need for additional abutments.



Fig. 5.6 Pressure testing a DN 200 pipeline

Floating-in at DN 250 and above

When sealed, ductile iron pipes of DN 250 and above sizes of wall-thickness class K9 are capable of floating. This means that their buoyancy is greater than their weight. Consequently, no other floats are needed unless there are, along the pipeline, fittings such as a traction head or flanged sockets whose weight would pull the pipes down in the water. When this is the case, what should be done is shown in Fig. 5.1.

The pipe string can be assembled pipe by pipe in the way already described and can then be pulled forward 6 metres at a time, or a part string of pipes or even the entire string can be assembled and pre-extended on land and then moved into the water.

The main difference from smaller diameters is that the only way of sinking the pipeline is to fill it with water. What in turn are required for this purpose are air admission and release valves (Figs. 5.7 and 5.8).

Fig. 5.7 Traction head with filling valves

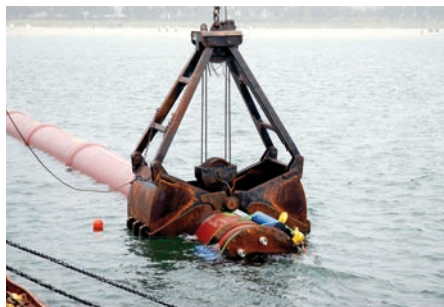


Fig. 5.8 Air release valves



Once the pipeline has been tested for leaks and then sunk (or vice versa), it can be secured in position if the particular constraints make this necessary. One consideration amongst others which is important in this connection is that a pipeline of DN 250 size or above might float up again if it had not been completely emptied of air. If this is likely, the pipe string should be secured against this happening. As well as burying the pipeline or weighting it down with, for example, concrete anchor blocks, use may also be made, as shown in Fig. 5.9 and Fig. 5.10 of a deep foundation which uses pipe cradles mounted on piles and clamping straps.

Fig. 5.9 View of a deep foundation (anchorage) for a DN 1000 ductile iron pipeline

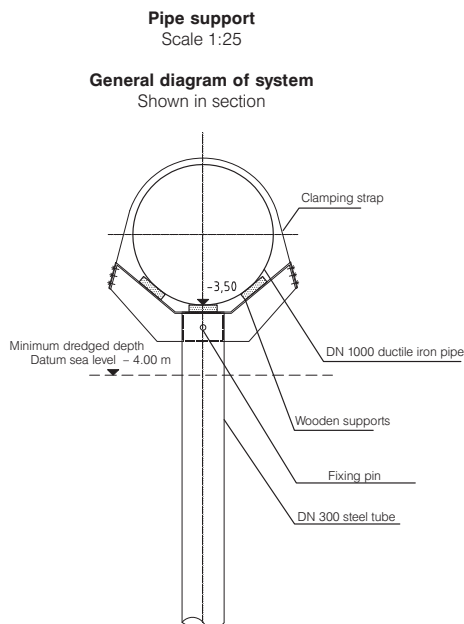


Fig. 5.10 Driving the driven piles

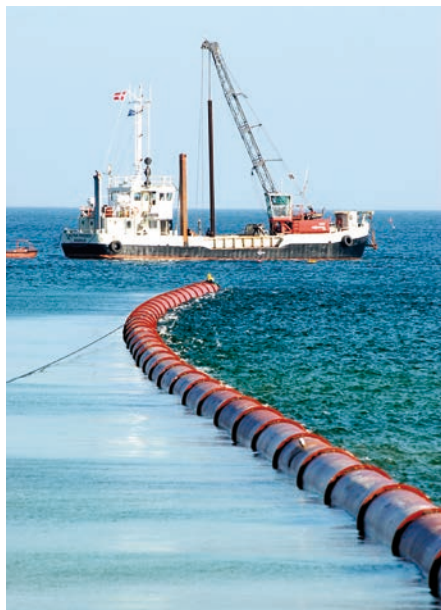


If there is no danger of the pipeline emptying and there are no other reasons for securing it in position, then it can be assumed that a fully filled ductile iron pipeline will not float up.

The pipe joints

Basically, only positive locking joints, i. e. the BLS® push-in joint, should be used for trenchless installation techniques of the kind represented by floating-in in its widest sense. The reason for this is the sometimes unpredictable stresses which occur with floating-in, due principally to surf, waves, currents and wind loads and to the bed of the body of water, which is generally not level and often unstable. Even the sinking process itself may generate considerable forces. Figs. 5.11 and 5.12 are a very vivid illustration of the forces that may act on a pipe string even when the currents are very low.

Figs. 5.11 and 5.12 The floating-in of a DN 1000 pipeline [47] and the deflection of the pipe string caused by the current



As can be seen from the pictures above, the BLS® joint is not in any way rigid but can, depending on the nominal size, be deflected angularly by up to 5°. This means curves with a minimum radius of around 70 m.

Other advantages of the joints are:

- easy assembly
- high laying rates
- allowable operating pressures of up to more than 100 bars (see Table 3.3)
- extremely high tractive forces (see Table 3.3)
- extensive range of fittings and other components including gate valves, butterfly valves, hydrants and air admission and release valves

External coating

As well as the type of joint, another crucial feature is the external coating. There are three different coatings which suggest themselves for use in floating-in:

- zinc coating with finishing layer
- zinc-aluminium coating with finishing layer (Duktus Zinc PLUS)
- zinc coating with cement mortar coating (Duktus ZMU).

Which of these coatings is used in floating-in depends mainly on the position of the pipeline relative to the water level or water table and on the nature of the water. If the pipeline is completely below water level a zinc coating with a finishing layer is normally all that is needed. The cement mortar coating is essential on the other hand in conditions where air and water alternate. It is also required if the pipeline is buried in coarse material after being sunk.

To sum up

Ductile iron pipes up to DN 200 size for drinking water supply (EN 545) or sewage disposal (EN 598) are not able to float, when sealed, and must therefore be provided with buoyancy aids. Above that size, ductile iron pipes float on their own. As soon as the pipe is filled and is on the bed of the body of water, its intrinsic weight prevents it from floating up. Because of the BLS® joint the pipe string can be assembled in next to no time, can be deflected angularly and will withstand even unscheduled stresses.

Lfd. Nr.	Location	Nominal size	Length [m]	Year of installation
1	Gstaad – Switzerland	DN 200	1200	2007
2	Binz a. Rügen	DN 1000	462	2008
3	Kreuzlingen/Bodensee – Switzerland	DN 150	100	2010
4	Jersleben/Ohre	DN 1000	72	2010

5.2 Temporary or interim pipelines

General

Temporary or interim pipelines are pipelines which are laid above ground to provide a temporary replacement water supply. Hence this is not a trenchless installation technique in the conventional sense. However, no trenches are of course needed for a pipeline laid above ground and that is why such pipelines are featured in the present manual.

Where temporary or interim pipelines are usually encountered is where the diameters are fairly small and the distances are fairly short, namely where the normal water supply to houses or parts of streets has to be taken out of service for a time in the course of work to change the connections of old pipelines or house connections. The operating pressures in this case are generally a few bars. However, it is equally possible for there to be quite long distances, quite large diameters and quite high pressures. Detailed reports on such pipelines can be found in the articles entitled “Interimsleitung DN 600 sichert die Wasserversorgung in Südsachsen” [51] and “Neue Lebensadern für ein Berliner Wahrzeichen – Das Olympiastadion” [52].

The reasons for using ductile iron pipes, and above all ones having the restrained, positive-locking BLS® joint, are obvious:

- very easy and above all quick assembly (see Table 3.3)
- quick and easy disassembly without the joint or the pipe being damaged
The pipe can thus be re-used repeatedly
- increased security against vandalism
- operating pressure of up to 100 bars are possible
- diameters up to DN 1000
- pipes are layable in all weathers
- constant material characteristics whatever the temperature
- resistant to UV

Fig. 5.13 A DN 600 interim pipeline with BLS® joints



Description of the technique

Temporary pipelines are, as already indicated, laid across the surface of the ground. When this is done the pipeline may be rested straight down on the ground (it is best for squared-off lengths of wood to be inserted) or may be fixed to pipe bridges, load-spreading girders or other means of support.

Fig. 5.14 Support on squared-off lengths of wood



Fig. 5.15 Connection to a pipe bridge



What presents problems for laying above ground is, above all, the forces which occur due to the internal pressure. These cannot be transmitted into the ground in the way they are with conventional buried laying by thrust blocks or a certain length of restrained pipes. Instead, it is necessary for the entire string of pipes, including the connections at the ends, to be laid in a restrained form. What should be used for this purpose are only positive locking joints such as the BLS® joint system. Friction locking joints should be avoided on safety grounds and because of the time taken to disassemble them.

As well as this, it is also necessary for the pipeline to be secured against shifts in position, some of which result from the internal pressure. Extensions of the joints (of between 5 mm and 10 mm per socket) and, as a result, shifts in the position of fittings can be expected particularly in the course of commissioning. To prevent any excessive extension of the joints and, in the end, any shifts of fittings, all the joints should, as far as possible, be locked, i. e. extended, on being assembled. This is done by pulling on the pipe by means of an excavator, laying tool or hydraulic cylinders (Fig. 5.18). In spite of this, there will continue to be extensions of the pipeline when pressure is applied to it but these will not be nearly so large. The movements of the pipeline while pressure is building up should be monitored, particularly at bends (Fig. 5.16). To stop any non-allowable angular deflections from occurring at the sockets of bends, the joints should also be laid at the maximum allowable angular deflection in the negative direction. During commissioning the bend will move from this position to the “normal” position (Fig. 5.17).

It must also be ensured that restraint exists at the points where the interim pipeline is connected to the existing water pipeline. How, if at all, a restrained connection can be made to the existing pipeline will depend on the material of the existing pipeline or in other words on how it is restrained. Because there are so many different materials and connecting systems, it is not possible to make any blanket recommendations in this case. Each individual case should, if necessary, be discussed with the experienced engineers at our Applications Engineering Division.



Fig. 5.16 Monitoring position at a bend

Temporary pipelines too have high and low points and may be subject to pressure surges. Air admission and release valves are therefore needed (Fig. 5.19). To set these up, use may for example be made of double socket tees with flanged branches or all-socket tees with 90° branches, both with BLS® joints, and the valves may be fixed to these fittings. What is also possible however is a welded-on connector with a 2" threaded female outlet into which the valve is screwed.



Fig. 5.18 Locking by means of hydraulic cylinders

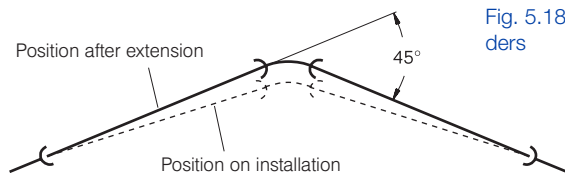


Fig. 5.17 Angular deflection in the negative direction at bends

Fig. 5.19 Air-release valve on double socket tee with flanged branch and BLS® joint



The pipe joint

Positive locking joints such as BLS® joints should always be used for ductile iron pipes and fittings which are not laid below ground, i. e. for temporary or replacement water supply pipelines for example. The reasons for this are, above all:

- the easy and quick laying
- the quick and above all non-destructive disassembly
This means that the pipes and fittings can be re-used repeatedly
- joints are secure in the long term even under frequent alternating loads
- high operating pressures and high safety factors
- deflectable to angles of up to 5° (approx. 50 cm per pipe)
Enables a saving to be made on fittings
- can be assembled in almost all weathers.

On fittings, it is of course also possible for flanged joints to be used.

External coating

Because temporary pipelines are temporary structures, the external coating is only a fairly minor consideration. A zinc coating and a finishing layer should usually be all that is needed. However, there may be circumstances where the external coating selected should be decided on in the light of the use that is subsequently to be made of the pipes. As mentioned above, ductile iron pipes with BLS® joints can be non-destructively disassembled and can thus be re-used.

For pipelines which are to remain in place for quite some time, including during cold weather, it is advisable that thought should be given to using WKG thermally insulated pipes. These pipes are a good idea particularly for fairly small pipelines or ones where the rate of flow is low and the dwell times are long. In extreme case these pipes can also be fitted with trace heating. You can find further information on them in our product catalogue.

To sum up

Ductile iron pipes with BLS® joints are an excellent solution for the laying of temporary pipelines (interim or replacement water pipelines). They are notable above all for their ruggedness in resisting external attacks and internal pressure stresses and because of the ease with which they can be non-destructively disassembled they can be re-used repeatedly. The use of the BLS® positive locking restrained joint means that no thrust blocks are needed.

Reference installations (excerpt)

Installation	DN	Length [m]	Year of installation
Berlin, Olympic stadium	250	240	2005
Hartenstein – Chemnitz	600	8 x 2000	2007-2011
Netphen, trunk main TL 19	500	2 x 100	2011
Vianden	500	420	2011

5.3 Culvert pipelines

General

There are various technical or economic reasons why it may not always be sensible for a crossing below a body of water to be made by conventional trenchless techniques as described in Chapter 4. It may prove very difficult for a pipeline to be floated in on an actively flowing body of water or the soil may stop it from being installed by the HDD technique. There may be a wide variety of reasons.

In cases like this, use may be made of a very special technique, culvert pipeline laying – the pulling-in of the pipe string across the bed of the body of water on a supporting structure. Reports on this technique appear in the articles entitled “Bau eines Abwasserdükers von der Rheininsel Niederwerth zur Zentralkläranlage der Stadt Koblenz” [53] and “A convincing demonstration: a sewer pipeline across the river Main” [54]. Both these operations were carried out by the Hülskens company of Wesel.

The advantages of this technique are mainly the relatively low installation costs and the opportunity for the entire pipe string to be checked for leaks prior to being pulled in. Also, any desired number of supply pipelines of any diameter and any other ducts or cables can be pulled in at the same time. Even complicated cross-sections are not a problem. As well as this, the risks posed by the soil are reduced to a reasonable level.

Description of the technique

For this technique, the entire culvert pipeline has to be assembled for its full length before being pulled in. The amount of space required is correspondingly large.

The first step is to produce the supporting structure on which the pipeline or pipelines will later be assembled. This usually consists of a structure of steel profiles which will later be filled with concrete (Fig. 5.20). The concrete serves to ballast and stabilise the culvert pipeline.

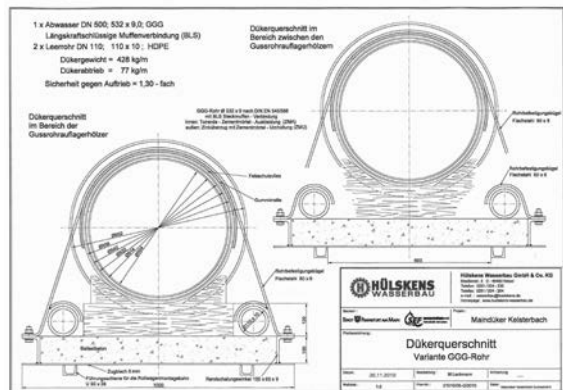


Fig. 5.20 Example of a supporting structure seen in cross-section

The supporting structure is itself supported in such a way that the lowest possible pull-in forces will need to be applied during the subsequent pulling-in. This can very easily be done by mounting it on steel plates or by positioning it on rollers (Fig. 5.21).

Fig. 5.21 Positioning on rollers



The supporting structure having been completed and filled with concrete, work can begin on assembling the supply pipeline(s) and other ducts. There are almost no limits to the freedom which exists to choose shapes and sizes. Virtually as many drinking water or sewage pipelines or empty ducts as desired can be fastened in place. This is usually done by "strapping" them to the supporting structure (Fig. 5.22). However, what may also be used are pre-produced steel pipe clips which are connected to the supporting structure.

Fig. 5.22 How the pipes are fastened to the supporting structure.



When the pipes are being assembled it is vital to see that the BLS® joint is properly locked. Once the locks have been inserted, this is best done by extending the joint with a laying tool or hydraulic cylinders (Fig. 5.23).

Fig. 5.23 Locking the BLS® joints



This step needs to be taken because, if it were not locked, every joint would extend by up to 1 cm as soon as the pipeline became subject to internal pressure. The result would be a lengthening of the pipeline followed by movement and possibly severe angular deflections of bends. A further result might be non-allowable forces being applied to the supporting structure or the fastenings.

Depending on the nature of the installation site, it can be expected that there will be a number of bends along the pipeline to create what are known as ascending sections. Ascending sections are usually situated at the two ends of the pipe string and serve to swing the axis of the pipes up above what will later be the water level (Fig. 5.24).

Because considerable forces may be exerted on the bends in an ascending section by internal pressure (e. g. during pressure testing), it must be ensured that the supporting structure is sufficiently large in size there, as shown in Fig. 5.24.

Once the pipe string and the ascending sections have been assembled, the pressure test can begin. When pipes and fittings with BLS® joints are used, this is not a problem. The ends of the pipeline are sealed off with restrained flanged sockets or spigots. The ends of the pipeline do not usually need to be braced against anything else. When the pressure test has been successfully passed the fastening straps or clips are fully tightened.



Fig. 5.24 Assembling an ascending section of a culvert pipeline

In parallel with the assembly of the pipeline, a traction head also has to be fixed to the supporting structure. This serves as the means of fixing to the traction cable (Fig. 5.25). The traction cable runs from that point along the bed of the body of water and via a diverting frame to a cable winch (Fig. 5.26).



Fig. 5.25 The traction head



Fig. 5.26 View from the diverting frame over to the other bank and the cable winch

In the majority of cases it will be necessary for a trench to be dug or dredged beforehand in the bed of the body of water. In the first place this will level the supporting material on the bed and will shape the entry and exit ramps for the culvert pipeline and secondly it will enable the culvert pipeline to be buried at a later stage and thus protected against external damage (e. g. by anchors).

All the preparatory operations having been completed, the pulling-in can then begin. The culvert pipeline is pulled through the water along the prepared trench until the first ascending section comes to the surface at the other bank (Fig. 5.27). The whole of the traction force is absorbed by the traction head and the supporting structure and the pulling-in process applies virtually no loads to the material of the pipeline.

Following the pulling-in, the pipeline trench has to be filled, the ascending sections have to be connected to the on-land pipelines, the shored boxes at the two banks have to be removed and the surface of the ground has to be restored.

The pipe joint

Because the pressure test takes place before the pulling-in, it is essential for a positive locking restrained joint such as the BLS® joint to be used. What is more, a joint of this kind ensures that a certain degree of safety exists against unpredictable changes of position during the pulling-in process and during subsequent operation.

The fast and easy assembly of the joint (see Table 3.3) is a guarantee of fast progress for the installation work. Bends do not need to be safeguarded by concrete thrust blocks.

External coating

In theory, any of the external coatings available can be used, as dictated by the existing constraints. However, for the reasons given below, it is advisable for only pipes with a cement mortar coating (ZMU) to EN 15 542 [7] to be used:

- Maximum corrosion protection – Because some of the pipes are situated in the area where water changes to land, excellent corrosion protection is needed. The trench filling material may also be corrosive. Under EN 545 [11], ductile iron pipes with a ZMU can be laid in soils of any desired corrosiveness.



Fig. 5.27 Arrival at the cable winch



Fig. 5.28 Pre-assembled ascending section with BLS® joints

- Maximum mechanical protection – The pipes are usually buried by backfilling with the excavated or dredged material. Under DVGW Arbeitsblatt W 400-2, pipes with a ZMU can be bedded in soils with a maximum grain size of up to 100 mm.
- Maximum life – Under Hinweis W 401 [56], ductile iron pipes with a ZMU can be assumed to have an average life of around 120 years.

In the final analysis, the ductile iron pipe with a ZMU coating can be used in very versatile ways and for the present installation technique it provides the best of prerequisites for the chemical and mechanical stresses which can be expected and for a long operating life.

To sum up

The pulling-in of a pipe string through a body of water on a supporting structure is an interesting alternative to the other installation techniques which would usually be used. Because the technique is “semi-open-trench” it is virtually certain that it will be successful given that all the obstacles can be spotted in advance.

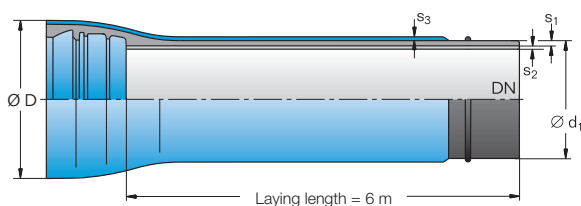
6 Technical data sheets

6.1 The BLS® pipe

Ductile iron pipes to EN 545/598 with BLS® joints

External: Cement mortar coating (Duktus ZMU) to EN 15 542

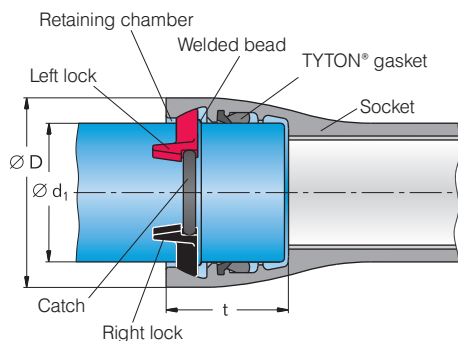
Internal: Cement mortar lining (ZMA) to EN 545/598



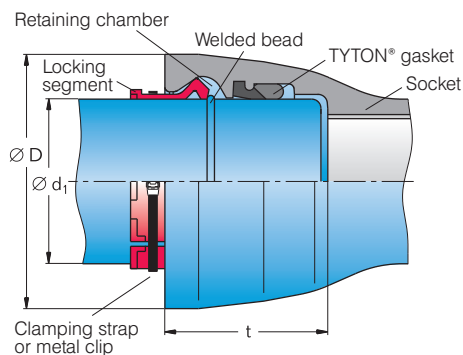
DN	Dimensions [mm]				PFA ¹⁾ for water [bar]	Masse [kg] ~		
	d ₁ [mm]	D [mm]	cast iron s ₁	ZMA s ₂		ZMU s ₃	One pipe ²⁾ (6 m)	ZMU
80 ³⁾	98	156	4.7	4	5	100/110 ⁴⁾	96,7	19,5
100 ³⁾	118	182	4.7			75/110 ⁴⁾	120,3	24
125 ³⁾	144	206	4.8			63/110 ⁴⁾	156,4	28
150 ³⁾	170	239	4.7			63/75 ⁴⁾	192,0	33
200	222	293	4.8			40/63 ⁴⁾	248,3	43
250	274	357	5.2	5	5	40/44 ⁴⁾	330,3	52
300	326	410	5.6			40	424,9	63
400	429	521	6.4			30	624,9	82
500	532	636	7.2			30	839,9	101
600	635	732	8.0			32	1,118,6	121
700	738	849	8.8	6	5	25	1,410,1	140
800	842	960	9.6			16/25 ³⁾	1,768,0	160
900	945	1,073	10.4			16/25 ³⁾	2,131,3	179
1000	1,048	1,188	11.2			10/25 ³⁾	2,524.4	199

1) PFA: allowable operating pressure; higher pressures on enquiry; 2) Theoretical masses inc. ZMA and zinc coating; 3) Wall-thickness class K10 under EN 545:2006; 4) With high-pressure lock

6.2 The BLS® push-in joint



DN 80 - DN 500



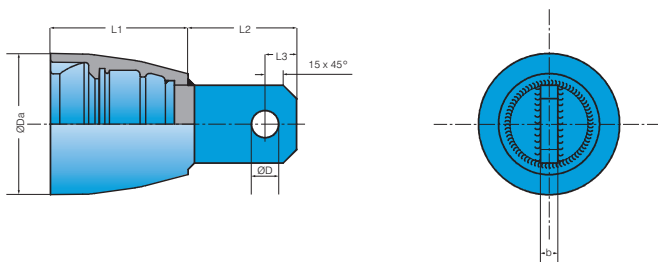
DN 600 - DN 1000

DN [mm]	PFA [bar] ¹⁾	Allowable tractive force F _{zul} [kN] ²⁾		Possible angular deflection [°]	Min. radius of curves [m]	Num- ber of assem- blers	Assembly time without joint protec- tion [min]	Assembly time when using a protective sleeve [min]	Assembly time when using a shrink-on sleeve [min]
		DVGW	Duktus						
80 ⁴⁾	100/110 ³⁾	70	115	5	69	1	5	6	15
100 ⁴⁾	75/110 ³⁾	100	150	5	69	1	5	6	15
125 ⁴⁾	63/110 ³⁾	140	225	5	69	1	5	6	15
150 ⁴⁾	63/75 ³⁾	165	240	5	69	1	5	6	15
200	40/63 ³⁾	230	350	4	86	1	6	7	17
250	40/44 ³⁾	308	375	4	86	1	7	8	19
300	40	380	380	4	86	2	8	9	21
400	30	558	650	3	115	2	10	12	25
500	30	860	860	3	115	2	12	14	28
600	32	1,200	1,525	2	172	2	15	18	30
700	25	1,400	1,650	1.5	230	2	16	-	31
800	16/25 ⁴⁾	-	1,460	1.5	230	2	17	-	32
900	16/25 ⁴⁾	-	1,845	1.5	230	2	18	-	33
1000	10/25 ⁴⁾	-	1,560	1.5	230	2	20	-	35

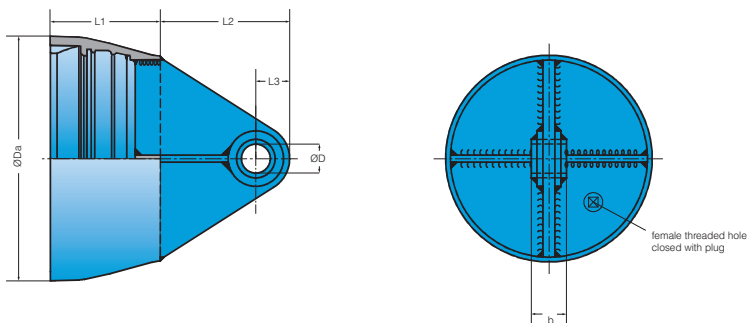
- 1) PFA: allowable operating pressure; higher pressures on enquiry; 2) The tractive forces can be increased by 50 kN when the route followed is straight (max. of 0.5° angular deflection per joint); 3) With high-pressure lock; 4) Wall-thickness class K10 under EN 545:2006

6.3 BLS® traction heads

DN 80 – DN 200



DN 250 – DN 1000



DN	L1 [mm]	L2 [mm]	L3 [mm]	Da [mm]	ØD [mm]	b [mm]	Allowable tractive force F_{zul} [kN]	IG [°]
80	158	109	35	156	30	26	115	-
100	166	114	46	182	36	35	150	-
125	178	132	50	206	44	45	225	-
150	181	144	56	239	46	50	240	-
200	191	159	65	293	55	60	350	-
250	231	270	87.5	357	62	75	375	¾
300	231	300	107.5	410	62	75	380	¾
400	260	335	147.5	521	75	95	650	¾
500	280	450	165	636	110	140	860	¾
600	370	432	180	732	115	145	1,525	¾
700	350	520	140	849	120	145	1,650	¾
800	350	520	140	960	120	145	1,460	¾
900	450	700	175	1,073	115	145	1,845	¾
1000	500	770	190	1,188	115	145	1,560	¾

7. Installation instructions

7.1 Installation instructions for ductile iron pipes and fittings with BLS® push-in joints: DN 80 – DN 500

Applicability

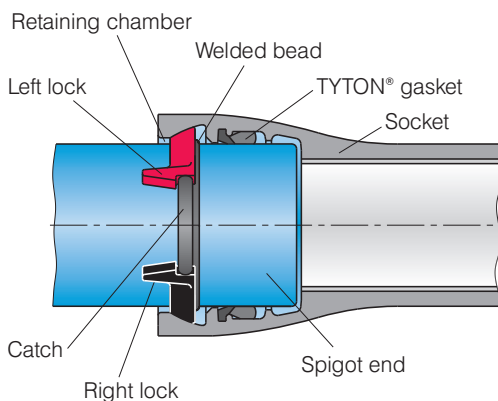
These installation instructions apply to ductile iron pipes and fittings to EN 545 and DIN 28 650 with DN 80 – DN 500 restrained BLS® push-in joints to DIN 28 603. There are separate installation instructions for the installation and assembly of other restrained joints and/or of pipes with a cement mortar coating (ZMU).

In the DN 80 – DN 250 nominal sizes, an additional high-pressure lock should be used when there are very high internal pressures (e. g. in snow-making systems) and when trenchless installation techniques are used (e. g. the press-pull, rocket plough or horizontal directional drilling techniques).

The number of joints which have to be restrained should be decided on in accordance with DVGW Arbeitsblatt GW 368.

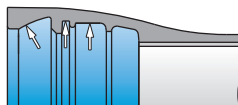
Allowable tractive forces for trenchless installation techniques are laid down in DVGW Arbeitsblätter GW 320-1, 321, 322-1, 322-2, 323 and 324 and in Table 3.3.

Construction of the joint

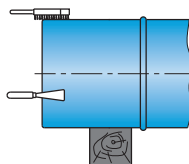


Cleaning

Clean the surfaces of the seating for the gasket, the retaining groove and the retaining chamber which are indicated by the arrows and remove any build-ups of paint from them. Use a scraper (e. g. a bent screwdriver) to clean the retaining groove.



Clean the spigot end. Remove all fouling and any build-ups of paint.



Positions of the openings in the socket end-face when the pipe is in the pipeline trench



DN 80 – DN 250



DN 300 – DN 500

For inserting the locks or bolting on the clamping ring, it is advisable for the openings in the end-face of the socket to be positioned as shown.

For fittings, the position of the openings will depend on the particular installation situation.

Note: Clamping rings must not be used for trenchless installation techniques!

Inserting the gasket

At large nominal sizes it may be useful for lubricant also to be used under the gasket.

For this purpose, carefully wipe a thin layer of the lubricant supplied by the pipe manufacturer over the sealing surface indicated by the oblique lines.

Note: Do not put any lubricant in the retaining groove (the narrow chamber)!

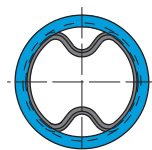
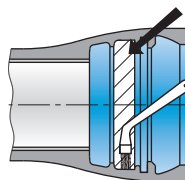
Clean the gasket and make a loop in it so that it is heart-shaped.

Fit the gasket into the socket so that the hard-rubber claw on the outside engages in the retaining groove in the socket.

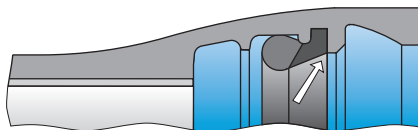
Then press the loop flat.

If you have any difficulty in pressing the loop flat, pull out a second loop on the opposite side. These two small loops can then be pressed flat without any difficulty.

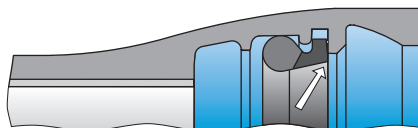
The inner edge of the hard-rubber claw of the gasket must not project below the locating collar.



Right



Wrong



Apply a thin layer of lubricant to the gasket.

Spigot end with welded bead

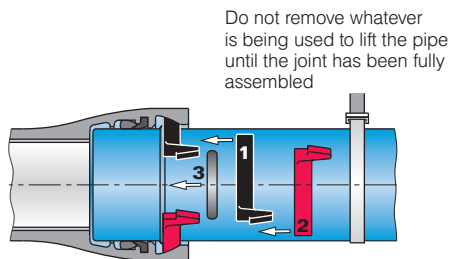
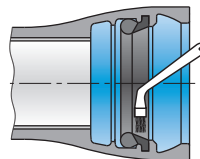
Apply a thin layer of lubricant to the cleaned spigot end, and particularly to the radiused edge, and then pull or push it in until it is fully home in the socket (is in abutment). Pipes must not be at an angular deflection when they are being pulled in or when the locks are being inserted.

Insert the “right” lock (1) in the opening in the socket and slide it to the right as far as possible.

Insert the “left” lock (2) in the opening in the socket and slide it to the left as far as possible.

Press the catch (3) into the opening in the socket.

On joints of DN 300 size and above, steps 1 to 3 have to be carried out twice because 2x2 locks and 2 catches are used in this case.



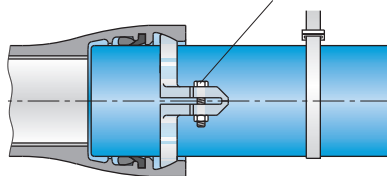
Spigot end without a welded bead

Inserting the split clamping ring. First insert the two halves of the clamping ring into the retaining chamber separately and then connect them together loosely with the two bolts.

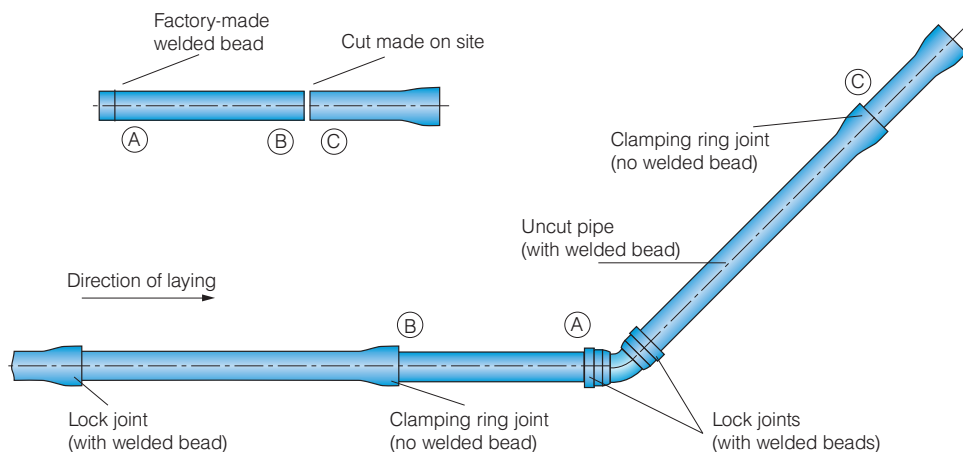
Mark the depth of insertion (the depth of the socket) on the spigot end.

Pulling in the spigot end. Apply lubricant to the cleaned spigot end, and particularly to the radiused edge, and then pull or push it in until it is fully home in the socket (is in abutment). Pipes must not be at an angular deflection when they are being pulled in. After the pulling-in, the mark previously made on the spigot end should be almost in line with the end-face of the socket.

Tightening torque 60 Nm (M12, AF 19 mm)



Pull the clamping ring towards the end-face of the socket as far as possible and then tighten the bolts with a torque wrench. Attention – model change! 60 Nm only applies for new zinc coated (colour = silver) clamping rings.



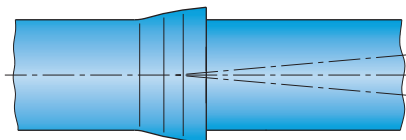
Note on clamping ring joints

If clamping rings are installed, care should be taken to see that they are **not** used in above-ground pipelines or pipelines subject to pulsations or for **trenchless installation techniques**. For single socket bends, double socket bends, 90° flange socket duckfoot bends and 90° duckfoot bends with side outlets, the PFA is a maximum of 16 bars.

For installation in bends as above where the operating pressure is > 16 bars, an adaptor, a piece of cut pipe with two spigot ends, is turned through 180° so that the end carrying the welded bead mates with the socket of the bend.

Before the remaining piece of the cut pipe with the socket is installed, an uncut pipe is laid, and the spigot end of the piece of uncut pipe, which carries a welded bend, is inserted into the socket of the latter.

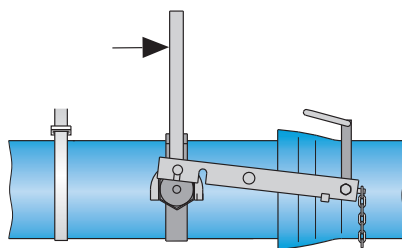
Our Applications Engineering Division should be consulted before clamping rings are used in culvert or bridge pipelines and before they are laid on steep slopes or in casing tubes or pipes or in utility tunnels or in above-ground pipelines or pipelines subject to pulsations. Clamping rings should not be used in these cases or in trenchless installation techniques. The pieces of adaptor pipe required should be provided with welded beads.



Locking

Pull or push the pipe out of the socket, e. g. with a laying tool, until the locks or the clamping ring are/is in firm contact in the retaining chamber.

The joint is now restrained.



Angular deflection

Once the joint has been fully assembled, pipes and fittings can be deflected angularly as follows:

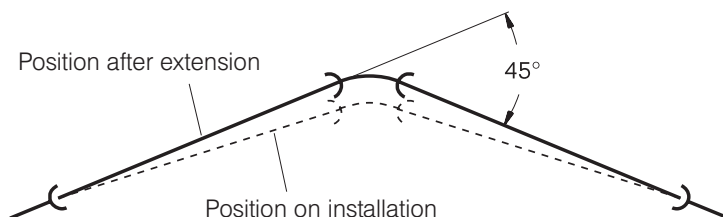
DN 80	to	DN 150	– 5°
DN 200	to	DN 300	– 4°
DN 400	and	DN 500	– 3°

For a pipe length of 6 m, 1° of angular deflection causes the axis of the pipe to lie approx. 10 cm off the axis of the pipe or fitting installed previously, i. e. 3° = 30 cm.

Note on assembly

Remember that, as a function of the internal pressure and the tolerances on joints, it is possible for extensions of up to about 8 mm per joint to occur.

To allow for the travel of the pipeline when it extends when pressure is applied, joints at bends should be set to the maximum allowable angular deflection in the negative direction.



Cutting of pipes

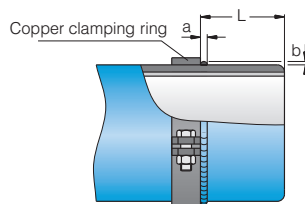
Ensure that the pipes are suitable for cutting. If pipes have to be cut on site, the welded bead required for the BLS®- push-in joint has to be applied using an electrode as specified by the pipe manufacturer. The welding work should be done in accordance with Merkblatt DVS 1502.

The distance between the end of the spigot end and the welded bead and the size of the welded bead must be as shown in the table below.

Electrode type, e. g. Castolin 7330-D, UTP FN 86, Gricast 31 or 32.

The electrode diameter should be 3.2 mm, and 4.0 mm for DN 400 and above.

DN	80	100	125	150	200	250	300	400	500
L	86±4	91±4	96±4	101±4	106±4	106±4	106±4	115±5	120±5
a	8±2	8±2	8±2	8±2	9±2	9±2	9±2	10±2	10±2
b	5 ^{+0.5} ₋₁	5 ^{+0.5} ₋₁	5 ^{+0.5} ₋₁	5 ^{+0.5} ₋₁	5.5 ^{+0.5} ₋₁	5.5 ^{+0.5} ₋₁	5.5 ^{+0.5} ₋₁	6 ^{+0.5} ₋₁	6 ^{+0.5} ₋₁



To ensure that there is a good welded bead at a uniform distance from the end, a copper clamping ring must be fastened to the spigot end at the specified distance from the end (see Table) as a guide for application. The area to be welded must be bright metal. Any fouling or zinc coating must be removed by filing or grinding.

When the clamping ring is removed, the cut edge of the spigot end should be matched to the form of an original spigot end and it and the area of the weld should be cleaned. Both these areas should finally be given an appropriate protective coating.

Disassembly

Push the pipe as far as possible into the socket along its axis. Remove the catch through the opening in the socket end-face. Slide the locks round and remove them through the opening. If a high-pressure lock is fitted, slide it round from the bottom of the pipe to the opening with a flat object (e. g. a screwdriver) and remove it.

Disassembly of clamping ring joints

Push the pipe into the socket along its axis until it is in abutment.

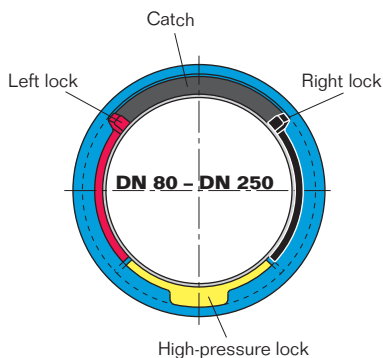
Remove the clamping bolts and then loosen the halves of the clamping ring by hitting them with a hammer. Ensure that the halves of the clamping ring remain loose during disassembly (if necessary by again hitting them with a hammer as the spigot end is pulled out). They can also be stopped from jamming on the spigot end during disassembly by inserting a square steel bar between the lugs at the ends of the halves. Do not under any circumstances hit the socket or the barrel of the pipe with the hammer!

High-pressure lock

An additional high-pressure lock should be used when the internal pressures are very high (e. g. in the case of snow-making systems and turbine pipelines) and when trenchless installation techniques are used (e. g. the press-pull, rocket plough or horizontal directional drilling techniques).

Before the left and right locks are inserted, the high-pressure lock is inserted in the retaining chamber through the opening in the end-face of the socket and is positioned at the bottom of the pipe. The locks can then be inserted and the high-pressure lock is thus situated between their flat ends. The locks are then fixed in place in the usual way with the catch.

The illustration on the right shows a fully assembled BLS® socket with a high-pressure lock. The high-pressure lock is used for pipes of nominal sizes from DN 80 to DN 250.



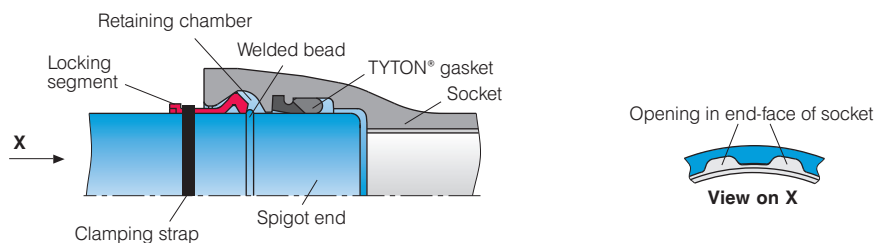
7.2 Installation instructions for ductile iron pipes and fittings with BLS® push-in joints DN 600 – DN 1000

Applicability

These installation instructions apply to ductile iron pipes and fittings to EN 545 and DIN 28 650 with DN 600 – DN 1000 restrained BLS® push-in joints to DIN 28 603. There are separate installation instructions for the installation and assembly of other restrained joints and/or of pipes with a cement mortar coating (ZMU).

The number of joints which have to be restrained should be decided on in accordance with DVGW Arbeitsblatt GW 368. Allowable tractive forces for trenchless installation techniques are laid down in DVGW Arbeitsblätter GW 320-1, 321, 322-1, 322-2, 323 and 324 and in Table 3.3.

Construction of the joint

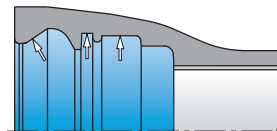


Number n of locking segments per joint

DN	600	700	800	900	1000
n	9	10	10	13	14

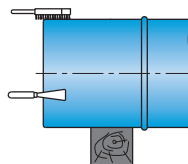
Cleaning

Clean the locking segments and the surfaces of the seating for the gasket, the retaining groove and the retaining chamber which are indicated by the arrows and remove any build-ups of paint from them.



Use a scraper (e. g. a bent screwdriver) to clean the retaining groove.

Clean the spigot end. Remove all fouling and any build-ups of paint.



Positions of the openings in the socket end-face

The openings in the end-face of the socket should always be situated at the top of the pipe.

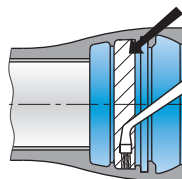
Opening in end-face of socket



Inserting the gasket

At large nominal sizes it may be useful for lubricant also to be used under the gasket.

For this purpose, carefully wipe a thin layer of the lubricant supplied by the pipe manufacturer over the sealing surface indicated by the oblique lines.



Note: Do not put any lubricant in the retaining groove (the narrow chamber)!



Clean the TYTON® gasket and make a loop in it so that it is heart-shaped.

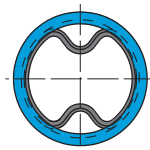
Fit the TYTON® gasket into the socket so that the hard-rubber claw on the outside engages in the retaining groove in the socket.



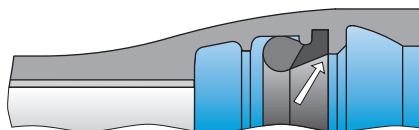
Then press the loop flat.

If you have any difficulty in pressing the loop flat, pull out a second loop on the opposite side. These two small loops can then be pressed flat without any difficulty.

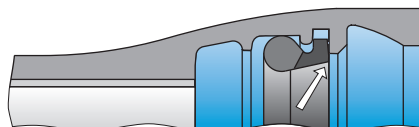
The inner edge of the hard-rubber claw of the TYTON® gasket must not project below the locating collar



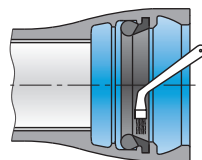
Right



Wrong

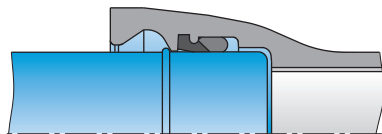


Apply a thin layer of lubricant to the TYTON® gasket.



Assembling the joint

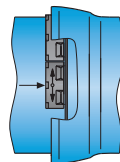
Apply a thin layer of lubricant to the cleaned spigot end, and particularly to the radiused edge, and then pull or push it in until it is fully home (is in abutment). The pipes must not be at an angular deflection when they are being pulled in or when the locks are being inserted.



First insert the locking segments through the openings in the end-face of the socket and distribute them around the circumference of the pipe, working alternately left and right.

Then move all the segments round in one direction until the last segment can be inserted through the openings in the end-face of the socket and can be moved to a position where it provides secure locking.

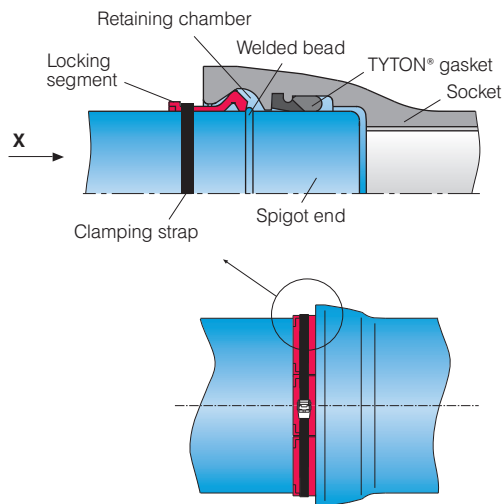
Only a small part of the humps on the last locking segment should be visible through the opening in the end-face of the socket. Should segments jam, they should be moved to their intended position by gentle taps with a hammer by moving the pipe as it hangs from the sling.



Do not under any circumstances hit the socket or the barrel of the pipe with the hammer!

Locking

Pull back all the locking segments in the outward direction until they are in abutment against the slope of the retaining chamber. Then fit the clamping strap around the outside of the segments as shown in the illustration. Tighten the clamping strap only sufficiently far to still allow the locking segments to be moved. Now line up the locking segments. They should be resting against the barrel of the pipe over their full area and should not be overlapping. Then tighten the clamping strap until the locking segments are bearing firmly against the pipe around the whole of its circumference. It should now no longer be possible to move the locking segments. By pulling on it axially (e. g. by means of a locking clamp), pull the pipe out of the joint until the welded bead comes to rest against the segments. When the pipe is in an undeflected state, the locking segments should all be approximately the same longitudinal distance away from the end-face of the socket.



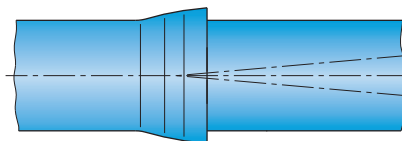
Note: Use a metal clip rather than a clamping strap for all trenchless installation techniques.

Angular deflection

Once the joint has been fully assembled, pipes and fittings can be deflected angularly by up to:

DN 600	–	2.0°
DN 700	–	1.5°
DN 800	–	1.5°
DN 900	–	1.5°
DN 1000	–	1.5°

For a pipe length of 6 m, 1° of angular deflection causes the axis of the pipe to lie approx. 10 cm off the axis of the pipe or fitting installed previously, i. e. 2° = 20 cm.



Note on assembly

Please remember that, as a function of the internal pressure, it is possible for extensions of up to about 8 mm per joint to occur as a result of the locking segments adjusting.

To allow for the travel of the pipeline when it extends when pressure is applied, joints at bends should be set to the maximum allowable angular deflection in the negative direction.

Cutting of pipes

Ensure that the pipes are suitable for cutting.

If pipes have to be cut on site, the welded bead required for the BLS® push-in joint has to be applied using an electrode as specified by the pipe manufacturer. The welding work should be done in accordance with Merkblatt DVS 1502.

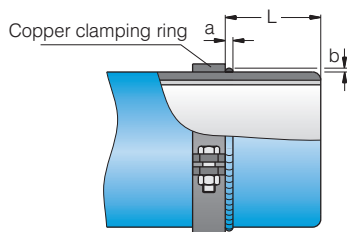
The distance between the end of the spigot end and the welded bead and the size of the welded bead must be as shown in the table below.

Electrode type, e. g. Castolin 7330-D, UTP FN 86, Gricast 31 or 32.

DN	600	700	800	900	1000
L	116	134	143	149	159
a	9±1	9±1	9±1	9±1	9±1
b	6	6	6	6	6

To ensure that there is a good welded bead at a uniform distance from the end, a copper clamping ring must be fastened to the spigot end at the specified distance from the end (see Table) as a guide for application.

The area to be welded must be bright metal. Any fouling or zinc coating must be removed by filing or grinding.



When the clamping ring is removed, the cut edge of the spigot end should be matched to the form of an original spigot end and it and the area of the weld should be cleaned. Both these areas should finally be given an appropriate protective coating.

Disassembly

Push the pipe into the socket along its axis until it is in abutment and remove the locking segments through the opening in the socket end-face.

Special pipelines

Our Applications Engineering Division should be consulted if for example joints of this kind are to be used in casing tubes or pipes, on bridges, for the horizontal direction drilling technique or in culvert pipelines.

Pipelines on steep slopes should be installed from the top down, meaning that after each individual pipe has been extended the locking will be maintained by gravity. If this procedure cannot be followed, suitable steps must be taken to prevent the locking from being cancelled out by gravity.

Combining fittings belonging to other systems with BLS® joints

Our Applications Engineering Division should be consulted if pipe ends of the present type are to be combined with the sockets of fittings belonging to other systems.

Electrode consumption

DN nominal size	Electrodes per bead Ø 3.2 mm [unit]	Electrodes per bead Ø 4.0 mm [unit]	Time required per welded bead [min]
80	5	-	15
100	6		18
125	8		24
150	9		27
200	12		36
250	15		43
300	17		50
400	8	+	11
500	11	+	14
600	13	+	16
700	16	+	19
800	18	+	22
900	21	+	25
1000	23	+	27

The welded bead should normally be applied in two passes, the root pass normally being welded with a Ø 4.0 mm electrode on pipes of DN 400 size and above.

The electrode consumptions and times required given in the Table are only a guide.

7.3 Installation instructions for ductile iron pipes with a cement mortar coating (ZMU)

Applicability

These installation instructions apply to ductile iron pipes to EN 545 with a cement mortar coating (ZMU) to EN 15 542.

The installation instructions applicable to the given type of joint should be followed when assembling joints between pipes.

Recommendations for installation

Installation must be carried out in such a way that the cement mortar coating is not damaged. The following options are available for protecting the socket joints:

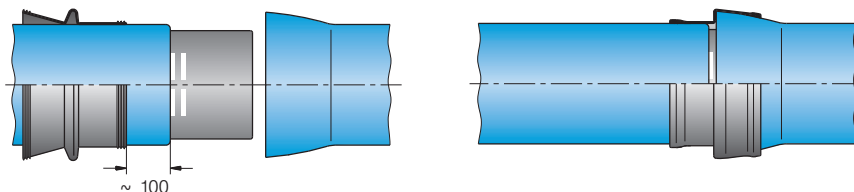
- Sleeves for protecting cement mortar
- Heat-shrink material or protective tapes (to DIN 30 672)
- Mortar bandages (e. g. made by the Ergelit company) for special applications.

Sleeves for protecting cement mortar

Sleeves for protecting cement mortar can be used for TYTON® and BRS® joints on pipes up to DN 700 in size and for BLS® push-in joints on pipes up to DN 600 in size.

Before the joint is assembled, turn the sleeve inside out and, with the larger diameter end leading, pull it onto the spigot end sufficiently far for the cement mortar coating to project from the sleeve by about 100 cm.

Fitting can be made easier by applying lubricant to the cement mortar coating.



Once the joint has been assembled and the seating of the gasket checked with the depth gauge, turn the sleeve back outside in, pull it along until it is resting against the end-face of the socket and hook it over the socket. It will then rest firmly and tightly against the pipes.

Shrink-on material and protective tapes

Shrink-on material and protective tapes can be used on all joints.

The shrink-on material must be suitable for the dimensions of the particular joint and for the intended use. Tape material should not be used for trenchless installation techniques.

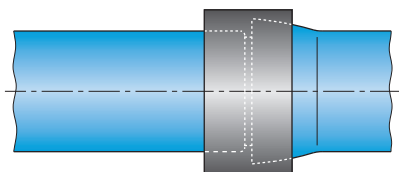
Fitting a shrink-on sleeve

Pull the shrink-on sleeve onto the socket end before the joint is assembled.

The surface to be covered should be prepared as detailed in Merkblatt GW 15, i. e. the area to which the sleeve is to be fitted should be freed of any rust, grease, dirt and loose particles.

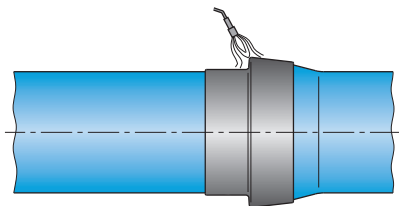
Preheat the surface to about 60 °C, and thus dry it, with a propane gas flame.

Then pull the shrink-on sleeve over the joint, leaving approximately half its length on the socket.



The protective lining present in the sleeve should not be removed until after the sleeve has been positioned on the socket and shortly before it is going to be heated.

With a propane gas flame set to a soft setting, heat the shrink-on sleeve evenly all round at the point where the end-face of the socket is situated until the sleeve begins to shrink and the outline of the socket appears within in. Then, while keeping the temperature even by fanning the burner up and down in the circumferential direction, shrink on first the part of the sleeve on the socket and then, starting from the end face of the socket, the part on the barrel of the pipe.



The process has been satisfactorily carried out when

- the whole of the sleeve has been shrunk onto the joint between the pipes
- it is resting smoothly against the surface with no cold spots or air bubbles and the sealing adhesive has been forced out at both ends
- the requisite overlap of 50 cm over the factory-applied coating has been achieved.

Covering a socket joint with a shrink-on sleeve of tape material

The shrink-on tape, which is coated with a special adhesive on the inside face, is supplied in 30 m rolls and should be cut to the appropriate length on site.

The surface to be covered should be prepared as detailed in Merkblatt GW 15, i. e. the area to which the tape is to be fitted should be freed of any rust, grease, dirt and loose particles. Preheat the surface to about 60 °C, and thus dry it, with a propane gas flame.

Detach the backing film from the tape for about 150 mm. Position the end of the tape centrally over the joint between the pipes, at right angles to the plane of the joint, and wrap the tape loosely round the joint, removing the rest of the backing film as you do so. The overlap between the ends of the tape should be at least 80 mm and should be situated at an easily accessible point in the top third of the pipes.

At low ambient temperatures, it is useful for the adhesive side of the point of overlap and of the sealing strip to be heated for a short period.

Important!

On the sealing strips, the lattice pattern of a fabric can be seen on the adhesive side.

Position the sealing strip centrally across the overlap and with a constantly moving soft yellow flame heat the strip evenly from the outside until the lattice pattern of the fabric becomes apparent. Then, wearing gloves, press the sealing strip hard against the tape. Moving the flame evenly in the circumferential direction of the pipes, shrink the tape first onto the socket, beginning on the side away from the sealing strip, and then, in the same way, onto the spigot end.

The process has been satisfactorily carried out when

- the whole of the tape has been shrunk onto the joint between the pipes
- it is resting smoothly against the surface with no cold spots or air bubbles and the sealing adhesive has been forced out at both ends
- the requisite overlap of 50 cm over the factory-applied coating has been achieved.

With the types of socket protection described above, the whole of the angular deflections specified in the installation instructions can still be used even after the protection has been applied.

Rather than the molecularly cross-linked Thermofit heat-shrinkable material, what may also be used are protective tapes of other kinds provided they meet the requirements of DIN 30 672 and carry a DIN/DVGW registered number.

Wrapping with protective tapes

Once the joint has been fully assembled, the protective tape is wrapped around the joint in several layers in such a way that it covers the cement mortar coating for ≥ 50 mm.

Wrapping with a mortar bandage (made by the Ergelit company)

Soak the mortar bandage in a bucket filled with water until no more air bubbles are released; maximum soak time should be two minutes.

Take the wet bandage out of the bucket and gently press the water out of it.

Wrap the bandage round the area to be covered (cover the cement mortar coating for ≥ 50 mm) and shape it to the contours of the joint.

For a layer 6 mm thick, wrap the bandage round twice or in other words make a 50 % overlap.

The protective bandage will be able to take mechanical loads after about 1 to 3 hours.

Filling of the pipeline trench

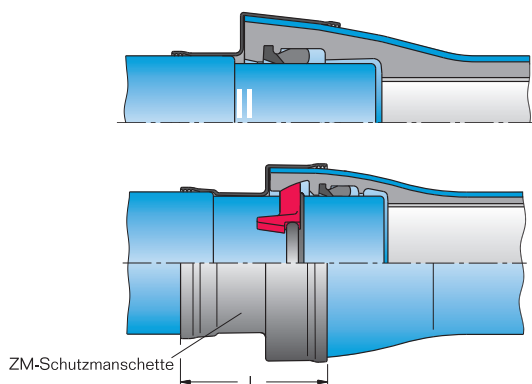
The bedding for the pipeline should be laid in accordance with EN 805 or DVGW Arbeitsblatt W 400-2.

Virtually any excavated material can be used as a filling material, even soil containing stones up to a maximum grain size of 100 mm (see DVGW Arbeitsblatt W 400-2). Only in special cases does the pipeline need to be surrounded with sand or with some other foreign material.

In the region of surfaces carrying traffic, the filling of pipeline trenches should follow the Merkblatt für das Verfüllen von Leitungsgräben (issued by the Forschungsgesellschaft für das Straßen- und Verkehrswesen of Cologne).

Push-in joints protected by sleeves for protecting cement mortar or by shrink-on material should be surrounded by fine-grained material or should be protected by pipe protection mats.

Rubber sleeves for protecting cement mortar, for pipes with a cement mortar coating (ZMU) and TYTON®, BRS® or BLS® push-in joints

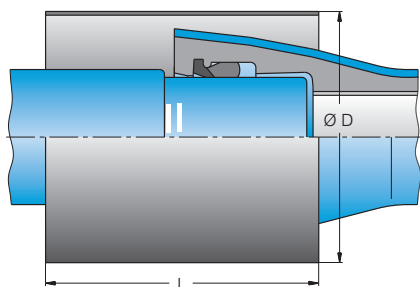


These are combination sleeves which will fit TYTON®, BRS® and BLS® push-in joints.

DN	Dimensions [mm] L
80	155
100	155
125	160
150	165
200	170
250	180
300	200
400	210
500	210
600	265
700	265
800	265
900	265
1000	265

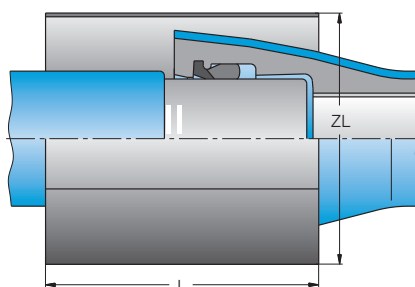
One-piece shrink-on sleeves for pipes with a cement mortar coating (ZMU) and TYTON®, BRS® or BLS® push-in joints

DN 80 to DN 500



Pre-cut shrink-on sleeves of tape material with a sealing strip for pipes with a cement mortar coating (ZMU)

DN 600 to DN 1000



DN	Product designation				Dimensions [mm]	
	Product	Loading class	Width L	Nominal size (DN)	L	ØD/Ød ¹⁾
80	MPSM	C30	300	DN XXX	300	200/80
100					300	235/100
125					300	280/135
150					300	280/135
200					300	340/205
250	PMO	C30	300	DN XXX	300	405/243
300					300	460/275
350					300	515/314
400					300	565/345
500					300	680/414

1) Ø D/Ø d = ~ in unshrunk state/smallest shrunken size; dimensions and degrees of shrinkage may vary slightly depending on the product; tape material should be used on joints of DN 600 size and above

Width L = 300 mm (12 inch) for TYTON®/BRS®; Width L = 450 mm (17 inch) for BLS®

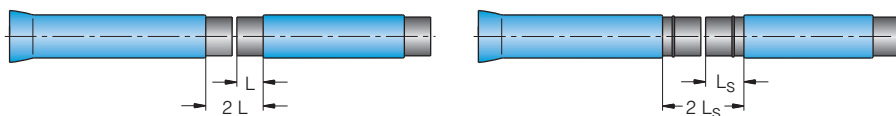
DN	Product designation				Dimensions [mm]
	Product	Loading class	Width L	Nominal size (DN)	ZL ¹⁾
600	MEPS	C30	300 or 450	DN XXX	2,500
700					2,950
800					3,260
900	WLOX	C30	300 or 450	DN XXX	3,600
1000					3,960

1) Sleeves are supplied already cut to the specified length and fitted with a sealing strip. Tape material in the form of 30 m rolls is available on enquiry for DN 250 to DN 1000 sizes

Cutting of pipes

Ensure that the pipes are suitable for cutting.

Before pipes are cut, the cement mortar coating must be removed for a length of $2L$ or $2L_S$, as the case may be, as shown in the Table below (for collars, allowance must also be made for the dimension for sliding on the collar).



DN	TYTON®/BRS® L (mm)	BLS® L _S (mm)
80	95	165
100	100	175
125	100	185
150	105	190
200	110	200
250	115	205
300	120	210
350	120	–
400	120	230
500	130	245
600	145	300
700	205	315
800	220	330
900	230	345
1000	245	360

The lengths of spigot ends free of cement mortar coating appropriate to TYTON® gaskets apply as follows to sockets to DIN 28 603

Form A up to DN 600
 Form B (long socket) DN 700 and above

Procedure for removing the cement mortar coating

- At the dimensions given in the above table, mark lines indicating the cuts to be made in the cement mortar coating
- Following the lines, make cuts into the cement mortar coating to about half the depth of the layer (to a depth of 2-3 mm). Important: Do not cut into the cast iron wall of the pipe! Protective workwear, especially safety goggles, must be used all the time.
 We recommend a special cutting disc.

- Make two or three longitudinal cuts (as described above) into the cement mortar coating, distributing the cuts around the circumference.
- In the case of pipes which have had a primer applied between the zinc coating and the cement mortar coating, the cement mortar coating should be heated to approx. 160-200 °C before it is detached. Such pipes are identified by a line below the marking for the coating standard, i. e. "DIN EN 15 542".
- Detach the cement mortar coating by gentle blows with a hammer – starting at the longitudinal cuts.
- Split all the cuts apart with a cold chisel.
- Remove the cement mortar coating and free the spigot end of any residual cement mortar with a scraper and wire brush.
- The pipe can now be cut and the spigot end bevelled.

It is essential for the new zinc-coated spigot ends which are produced to be repainted with a suitable finishing coating!

On-site repairs to the cement mortar coating (ZMU)

All repairs to any detached parts of the ZMU must only be carried out using the repair kit supplied by the pipe manufacturer.

Contents of the repair kit:

approx. 4 kg of sand/cement mixture
plus approx. 5 m of 200 mm wide gauze
1 litre of diluted additive.

These components are specially adjusted for use with Duktus pipes. They must not be replaced by any other material or used to produce classes of cement mortar different from those specified on the repair kit.

Repair instructions

A proper repair can only be made at temperatures of above 5°C. Apart from the repair kit, what you will also need are:

Rubber gloves
Dust-tight protective goggles
Wire brush
Spatula
Additional mixing vessel
Possibly water for mixing

If there is severe damage:

Hammer

Cold chisel

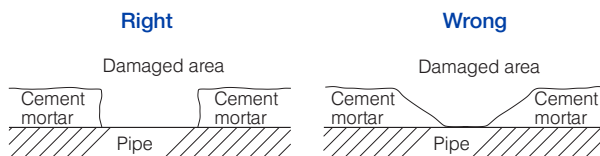
Preparing the damaged area

If there is only slight surface damage, simply remove any loose pieces of cement mortar and any pieces which are not firmly attached from the damaged area with the wire brush. Finally, moisten the damaged area.

If the damage is severe, it is advisable for the cement mortar to be completely removed (down to the bare metal) in the damaged area with a hammer and cold chisel.

The protective goggles must be worn when doing the above!

Remove the cement mortar in such a way that square edges are obtained:



Do not use excessive force when removing the cement mortar as this may cause the sound cement mortar to become detached in the region next to the damaged area.

Remove any loose material which is still present with the wire brush and moisten the damaged area.

Mixing

First of all stir the diluted additive well. Then mix the mortar, adding as little additive and water as possible, until a mixture which can be applied easily with the spatula is obtained – the amount of water contained in the additive is normally all that is needed. To begin with, use only the additive solution and add it in carefully. Then add extra water if necessary (e. g. at high temperatures in summer).

Application

Once the mortar is easily workable, fill the damaged area with it and level off the surface. Finally, smooth the repaired area, and especially the parts at the edges, with a moistened, wide paintbrush or a moistened dusting brush.

If the damage covers a large area, gauze is needed to provide support for the mortar in the damaged region. For this purpose the gauze should be positioned about 1-2 mm below the surface of the mortar. The gauze must not come into contact with the metal surface of the pipe because, if it does so, it will then act as a wick.

Having completed the repair, seal the repair kit again so that it is airtight.

Drying and entry into service

Repairs covering a particularly large area should be covered with plastic film to allow them to dry slowly, thus minimising the risks of cracks forming.

There should be a wait of at least twelve hours before repaired pipes are installed or the damaged area should be provided with adequate protection against mechanical loads.

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