Applied ductile iron pipe technologies for Horizontal Directional Drilling (HDD)

Mr. Steffen Ertelt – Head of Applications Engineering
Duktus (Wetzlar) GmbH & Co. KG, D – 35576 Wetzlar, Germany

The distribution networks are the backbone of every water supply system. In this context it becomes important to consider the total life cycle cost of different materials and installation techniques. The installation of ductile iron pipes using the trenchless installation method provides an outstanding possibility of securing and increasing the property value of existing network structures long term. The form-locking socket joint BLS®, in combination with an external cement mortar coating according to DIN EN 15542 [1], is ideally suited for the usage of trenchless technology to install ductile iron pipes. Those BLS® joints are made up of a pre-chamber cast onto the pipe joint for seating the locking elements, and a welding bead welded onto the insertion end of the pipe for load transmission to the next pipe. The use of TYTON® seals guarantees reliable sealing of the joint connection at all times in trenchless pipe installation.
This lecture presents the possibilities, advantages and requirements related to the material properties and the installation of ductile iron pipes on the basis of projects completed in the field by using HDD.

1. Economical Sustainability

1.1 Waterproofness by TYTON® gaskets

For hundreds of years now, cast iron pipes have been fitted together with push-in joints to form pipelines. Modern-day push-in joints are quick and easy to connect and also provide some major technical and economic advantages when being installed. The push-in joint most widely used in Germany is the TYTON® push-in joint system. Since it was launched on the German market in 1957, it has proved its worth a million times over in pipelines for drinking water, raw water, sewage, hydro power and many other applications. The sealing function in the TYTON® push-in joint (Figure 1) is performed by a profiled gasket which consists of a softer rubber mixture (the sealing part) and a harder rubber mixture (the retaining part).

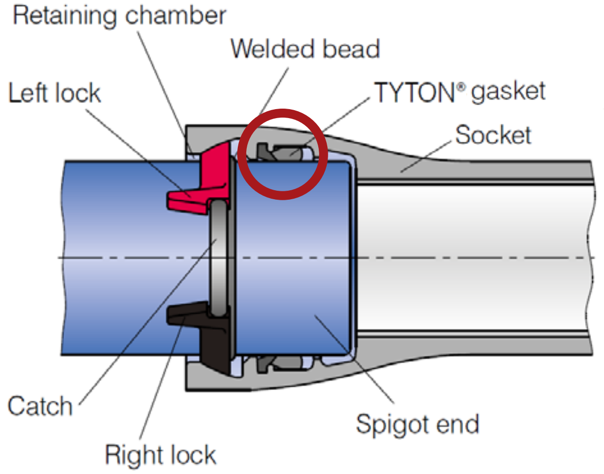

Fig. 1. Restrained socket joint BLS® with TYTON® gasket

1.2 Long-lasting durability by zinc with cement mortar coating (ZMU)

The external protection for pipes formed by a zinc coating (providing active protection) plus a cement mortar coating acc. to DIN EN 15542 [1] has proved highly satisfactory when there have been external mechanical loads of the kind which may occur in direct installation in coarse-grained native soils of grain sizes up to 100 mm. The fibres admixed in the cement mortar and the open-weave polyethylene bandage makes the cement mortar coating extremely resistant to mechanical stress. This is why pipes with this external protection are also being used for trenchless installation.
Blast furnace cement is used as the basic material for the pigmented cement mortar. The finished cement mortar is spread across the surface of the rotating zinc-coated pipes (Figure 2).

Fig. 2. Cement mortar application

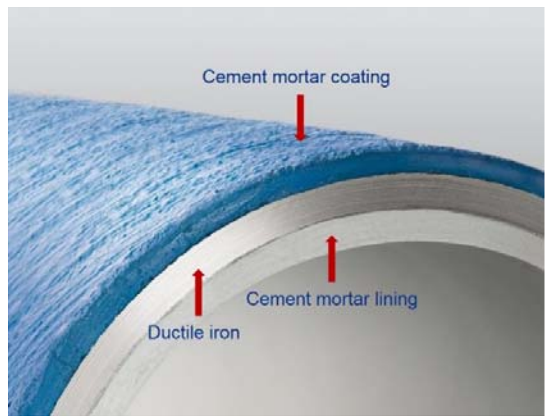

Fig. 3. Cement mortar coating acc. to EN 15542

This guarantees a coil-shaped spreading and an even thickness of the ensuing cement mortar coating. The cement mortar coating is then exposed to a secondary treatment carried out in a curing chamber allowing controlling the values for temperatures, air and humidity. This secondary treatment in combination with the added fibres and the bandaging results in the excellent resistance of cement mortar coating to impact and shock. The rated thickness of the cement mortar coating has been set to 5 mm for all rated pipe diameters in accordance with DIN EN 15542 [1]. The external cement mortar coating (Figure 3 and 4) has proved excellent for protecting ductile iron pipes against soils with all levels of corrosivity acc. to DIN EN 545, Annex D.2.3 [2] as well.

For cement mortar coated pipes a socket protection has to be used. There are shrink-on sleeves and rubber collars available. A sheet-metal cone (required for trenchless applications) will be applied as further protection from any possible mechanical damage of the socket protection during pipeline inserting into the gap (Figure 5).

Fig. 4. Pipes with cement mortar coating (ZMU)

Fig. 5. Socket protection with sheet-metal cone

The coating types formed by a zinc coating with a cement mortar coating are classified as active coatings. In the event of any unwanted damage to the external protection of pipes (in the course of transport and/or installation) they have a self-healing action produced by the zinc coating applied.

Ductile iron pipes are long-lived. Technical notice W401 [3] issued by the "Deutscher Verein des Gas- und Wasserfaches e.V." assesses their technical operating life for pipes with cement mortar coating at 100 to 140 years (Figure 6).

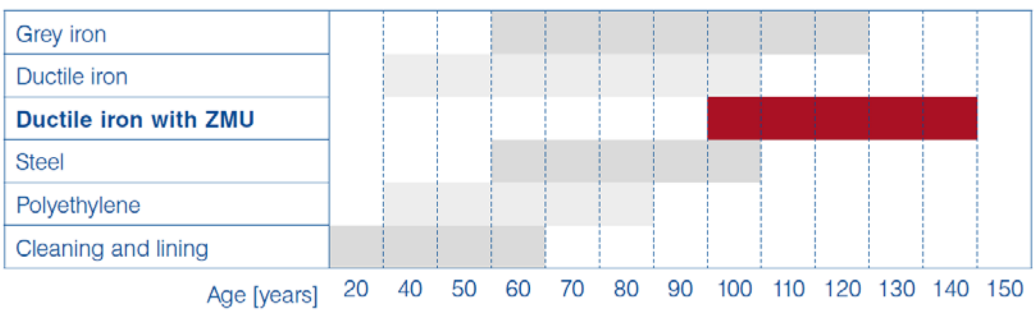

Fig. 6. Technical operating life by pipeline groups

1.3 Restrained socket joint BLS®

The BLS® joint (Figure 7 to 10) is a socket joint which operates on the basis of positive locking and which is restrained against longitudinal forces. Forces generated by internal pressure or external loads are absorbed by the pipeline and transferred to the surrounding soil by skin friction. Via a mechanical lock the welding bead transmits the forces, as a result of internal pressure or when pipes are used for trenchless installation, into the locking chamber to the next pipe. Extremely high forces can be transmitted in this way.

Fig. 7. BLS® socket joint DN 80 to DN 500

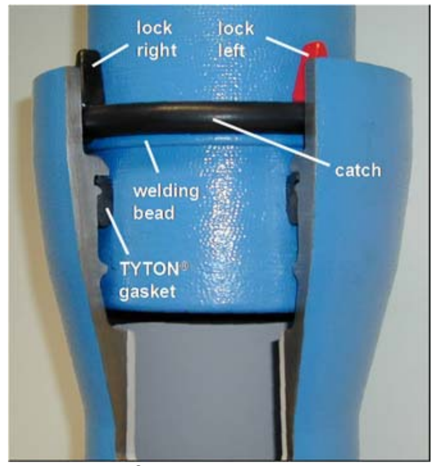

Fig. 8. BLS® DN 80 to DN 500

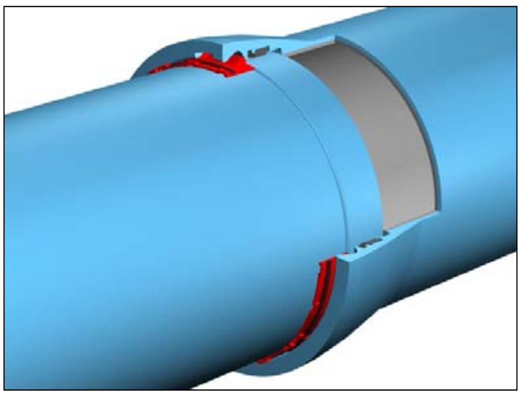

Fig. 9. BLS® socket joint DN 600 to DN 1000

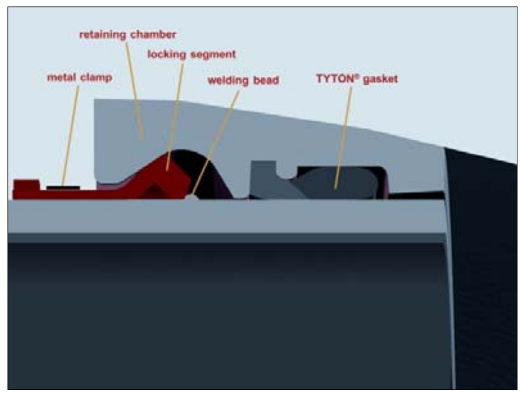

Fig. 10. BLS® DN 600 to DN 1000

At the beginning restrained joints have been used as replacement of concrete thrust blocks in conventional open trench laying. Over the last decades the application spectrum has been enlarged for several trenchless laying methods. Compared to traditional installation methods there are many benefits to trenchless technology like:

- Outstanding cost saving
- Less traffic interruption
- Improved safety aspects
- Shorter construction time
- Minimized risk of disturbing existing utilities
- Fewer inconveniences by noise and air pollution
- …

2. Trenchless laying techniques – Introduction

The steerable 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 worksheet GW 321 [4] gives rules relating to requirements, quality assurance and testing for it to ensure that quality is properly assured.

2.1 Permitted tractive forces for BLS®

In order to be able to determine the potential length of the pipeline, the tractive forces of the restrained socket joints must be known first. Information on this can be obtained from the DVGW (German Technical and Scientific Association for Gas and Water) worksheet GW 321 [4] and the Duktus Manual “Trenchless installation techniques using ductile iron pipes” [5] (Table 1). Many values of the permitted tractive forces for the BLS® socket joints exceed those stated in the DVGW worksheet due to results achieved in independently monitored internal pressure type tests.

Table 1. Permitted tractive forces BLS® [5]

DN	Allowable operating pressure PFA [bar] 1)	Allowable tractive force $F_{zul.}$ [kN] 2)		Max. angular deflect-ion at sockets3) [°]	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

2.2 Horizontal directional drilling (HDD) with ductile iron pipes

Pipes having the positive locking BLS® push-in joint combined with a cement mortar coating acc. to DIN EN 15542 [1], as an external protection able to withstand high mechanical loads, are available for trenchless installation of ductile iron pipes by horizontal directional drilling (HDD) technique.

2.2.1 Pulling in of pre-assembled pipelines

A point in favor of the pre-assembled pipeline is that pipelines can be pulled in one step. The tractive force of the pre-assembled pipeline can be reduced by reducing the friction factor (pipe surface against the ground). The friction can be reduced by pre-assembling onto sheets of metal greased with lubricant (Figure 11) or the trench can be water-filled (Figure 12) depending on the nominal diameter.

Fig. 11. Pre-assembling onto sheets of metal

Fig. 12. Pre-assembled with flooded pipe trench

Work on a project in Alzira, a small town near Valencia (Spain), has moved forward into a new dimension for trenchless installation of ductile iron pipes in 2007 [6]. For the first time in Europe, a ductile iron pipe with a nominal diameter of DN 900 has been laid by HDD. The parameters for the project are as follows: Pipeline length – 480 m, Drilling rig - 2500 kN, permitted tractive force DN 900 BLS® - 1845 kN, max. reached tractive force - 750 kN, widening bore hole - 3 times (Figure 13 and 14).

Fig. 13. Alzira – Widening borehole

Fig. 14. Alzira – Starting pulling process

2.2.2 Pulling in of single pipes

The pulling-in of single pipes is particular suitable for point sites without space for a pre-assembling of the complete pipeline. This means those installations will take places mostly within cities and towns. Compared to materials like steel or polyethylene for ductile iron pipes with BLS® socket joints is no time lost existing because of welding preparation and welding work. The pipe installation can be done inside the installation pit (length 7 m to 8 m) or via a ramp (Figure 15 and 16).

Fig. 15. Installation pit

Fig. 16. Installation via ramp

One project was carried out in Grobbendonk (Belgium) in diameter DN 900 in 2010 [7]. A 1000 kN drilling rig (Figure 17) was used for the drilling and the subsequent pulling-in of the ductile iron pipes. The pipes were connected one by one on a special connecting ramp. The first pipe was connected to the traction string and the barrel reamer by means of a BLS® traction head with built-in force-measuring equipment (Figure 18).

Fig. 17. Grobbendonk – Drilling rig 1000 kN

Fig. 18. Grobbendonk – Installation ramp

The parameters for the project are as follows: Pipeline length - 342 m, permitted tractive force DN 900 BLS® 1845 kN, max. reached tractive force - 500 kN, water ballasting of the pipeline.

3. Conclusion

Ductile iron pipes with TYTON® gasket and restrained BLS® push-in joints together with a cement mortar coating acc. to DIN EN 15542 [1] are very well suited for waterproof pipelines, trenchless installation and have already shown this to be the case on a large number of completed projects. The possibility of particularly high forces being transmitted from pipe to pipe allows economical and cost-saving installation and enables very long runs of pipe to be pulled in when using trenchless installation techniques.

4. References

[1] DIN EN 15542: 2008 – 06 „Ductile iron pipes, fittings and accessories – External cement mortar coating for pipes – Requirements and test methods”, German version EN 15542:2008 Beuth Verlag, D - 10772 Berlin (Germany)

[2] DIN EN 545: 2011 – 09 „Ductile iron pipes, fittings, accessories and their joints for water pipelines – Requirements and test methods”, German version EN 545:2010, Beuth Verlag, D - 10772 Berlin (Germany)

[3] DVGW technical note W 401 – September 1997 „Entscheidungshilfen für die Rehabilitation von Wasserrohrnetzen“ – ISSN 0176-3490 – Wirtschafts- und Verlagsgesellschaft Gas und Wasser mbH, D – 53123 Bonn (Germany)

[4] DVGW worksheet GW 321 – October 2003 „Steuerbare horizontale Spülbohrverfahren für Gas- und Wasserrohrleitungen - Anforderungen, Gütesicherung und Prüfung; mit Korrekturen vom Januar 2009“ – ISSN 0176-3512 – Wirtschafts – und Verlagsgesellschaft Gas und Wasser mbH, D – 53123 Bonn (Germany)

[5] Duktus manual – “Trenchless installation techniques using ductile iron pipes” – Duktus – 153 – 03/17 – Duktus (Wetzlar) GmbH & Co. KG, D – 35576 Wetzlar (Germany)

[6] 3R International Special-Edition 2/2007 – „Laying ductile cast iron pipes with horizontal directional drilling” - page 83 to 86 - Vulkan-Verlag GmbH, D – 45128 Essen (Germany)

[7] Fachgemeinschaft Guss-Rohrsysteme (FGR) e. V. European Association for Ductile Iron Pipe Systems EADIPS - The Annual Journal of the European Association for Ductile Iron Pipe Systems No.45 – “Horizontal directional drilling technique used for pipe-by-pipe pulling-in of DN 900 ductile iron pipes in Belgium” – page 46 to 49, Im Leuschnerpark 4, D – 64347 Griesheim (Germany)