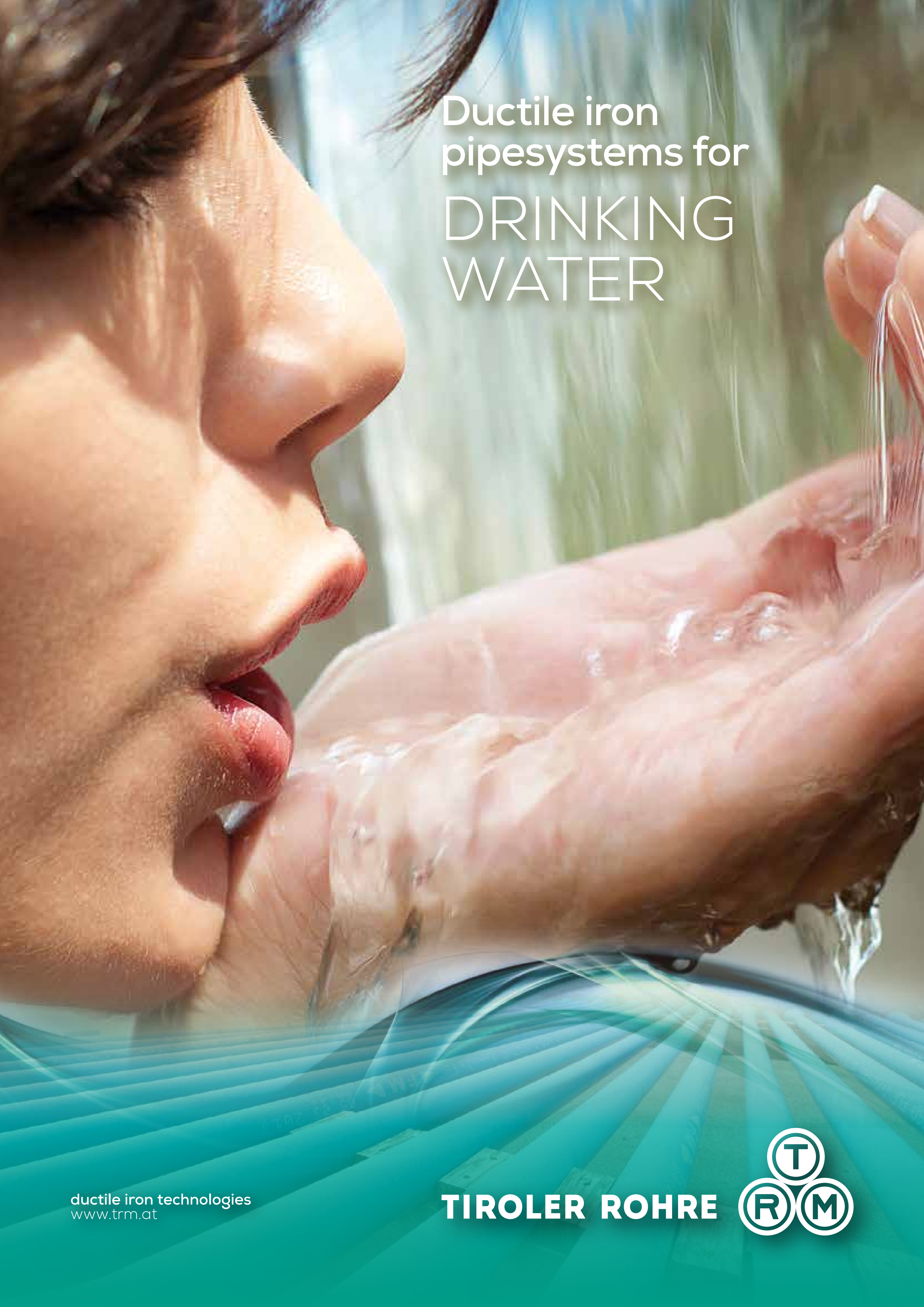

Ductile iron pipesystems for DRINKING WATER

ductile iron technologies
www.trm.at

TIROLER ROHRE

Our company

TRM develops, manufactures and markets high-quality systems for the transport of water and for deep foundation of structures – made of ductile cast iron.

We see ourselves as a Tyrolean manufacturer with a long-standing tradition specializing in pipe and pile systems made of ductile cast iron for the water industry and for deep foundation engineering.
We operate worldwide and have our core market in Europe. Since 1947, we have focused our activities on quality, safety, mutual trust and respect.
We see ourselves as a reliable and competent partner in a wide range of applications within our industry; a view that is shared by our partners.

Our products are high-performance, sustainable and robust. They stand out particularly due to their ecological and economical benefits. The features of ductile cast iron and our expertise in all fields of applications enable us to overcome even extreme challenges.

The sustainable properties of ductile cast iron combined with innovative technologies and professional expertise in all fields of application make us a leading partner in the water industry and deep foundation.

Due to our high competence, willingness and reliability, we are a powerful and long-term system partner.

TIROLER ROHRE GMBH

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Austria

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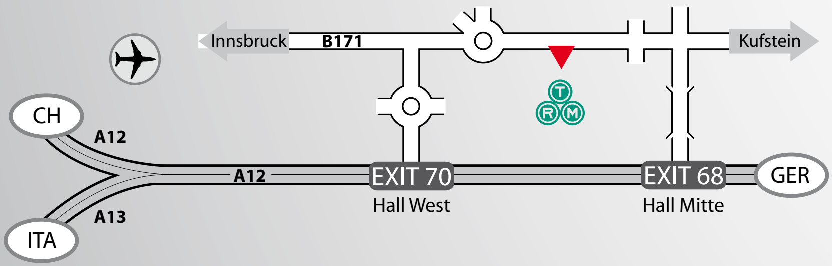
www.trm.at

Products:
Pipes according to EN 545 and EN 598 of nominal sizes from DN 80 to DN 1.000 and piles



General list of contents

1 - ADVANTAGES OF DUCTILE IRON PIPE SYSTEMS

The production process

Only materials of the very best quality are used as raw materials for our company's ductile cast iron pipes. What is used to obtain the pig iron is exclusively recycled material (iron and steel scrap). Not only the use of recycled material in production, but also their very long technical operating life of up to 140 years and the almost 100% recyclability which follows make ductile cast iron pipes particularly sustainable. From production and use right through to re-use at the end of their long life, ductile cast iron pipes are remarkably economical and environment-friendly.

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 regular intervals.

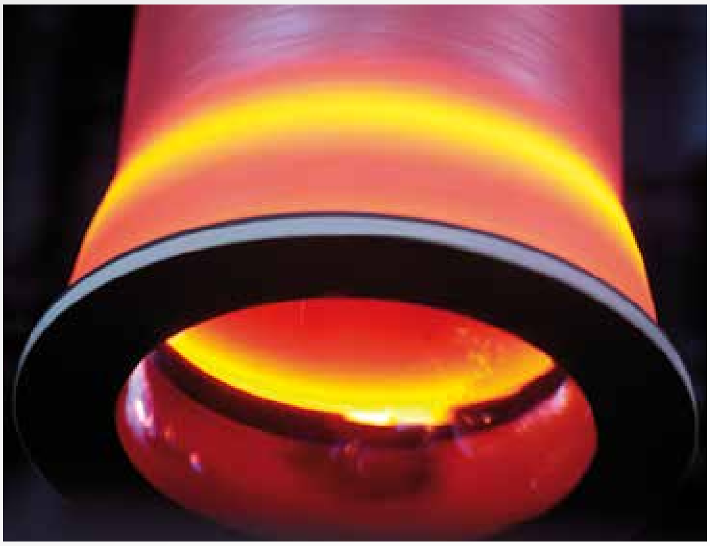
What is now, after the treatment with magnesium, ductile cast iron is distributed to the various centrifugal casting machines. In these, the "pipe blanks" are cast by the de Lavaud process. Sand cores whose external configurations differ to suit the type of joint are inserted in the centrifugal casting mould (permanent mould) to create the internal contours of the socket. This is followed by annealing at 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 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 VRS®-T joints before all the pipes are given a lining of cement mortar. This is done by method I under DIN 2880 and ÖNORM B2562.

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 polyurethane. However, what can be applied to the zinc-coated pipe as an alternative is epoxy finishing layer or a cement mortar coating. Pipes having a cement mortar coating, which is referred to in 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 using the trenchless method. What is more, the ZMU means that the expected technical operating life is lengthened to up to 140 years.

In the final part of the production process, the markings are applied, caps are fitted to drinking water pipes, the pipes are bundled, and a final quality control is carried out. This high quality in products and our services produces satisfaction for our customers. This is the supreme corporate aim of TRM Tiroler Rohre GmbH. We operate a quality management system which is certified under EN ISO 9001. At our production site in Hall, all our products and production processes are regularly monitored by by Municipal Department 39 (MA 39) – Research Centre, Laboratory and Certification Services – of the city of Vienna.



As well as this, TRM also operates an environmental management system which is certified under EN ISO 14 001 and an energy management system which is certified under EN ISO 16 001. The quality management system is a wide-ranging one and begins with a chemical analysis of the raw materials and additives. This is because, when the molten iron is being smelted and treated, there are stringent requirements which have to be met with regard to the purity and consistency of the raw materials, the monitoring of the smelting process, the maintaining of the chemical composition, and the injection technique.

In the actual production of the pipes, allowance has to be made for the particular way in which ductile cast iron behaves as it solidifies and shrinks. When the annealed pipes are being checked, the characteristics of the material, which are laid down in EN 545 (for drinking water pipes) and EN 598 (for sewerage pipes), have to be monitored. The sockets and spigot ends of all the pipes are checked with limit gauges and their wall thickness is measured. All the pipes undergo a thorough visual inspection for internal and external flaws. The internal pressure test is carried out with water and in it the pipes have to withstand the test pressures which are laid down for the given type of pipe.

The cement mortar lining

The cement mortar lining of the pipes is also subject to stringent quality controls – as well as the raw materials and the fresh mortar being checked, the layer thickness also has to be as prescribed for the given nominal size.

The external coating

The external coating has to pass an equally stringent check. As standard, TRM ductile cast iron pipes are given an external coating consisting of a zinc coating and a polyurethane finishing layer. Where pipes are to be used in highly corrosive or stony soils or for trenchless installation techniques, a high quality 5 mm thick coating of plastic-modified cement mortar is also available. This coating is very strong mechanically and highly resistant to chemicals. After marking, the pipes then undergo a final inspection. In the end-face of the socket there are parallel notch-like depressions some three millimetres deep which are an additional indication that the material is "ductile cast iron".

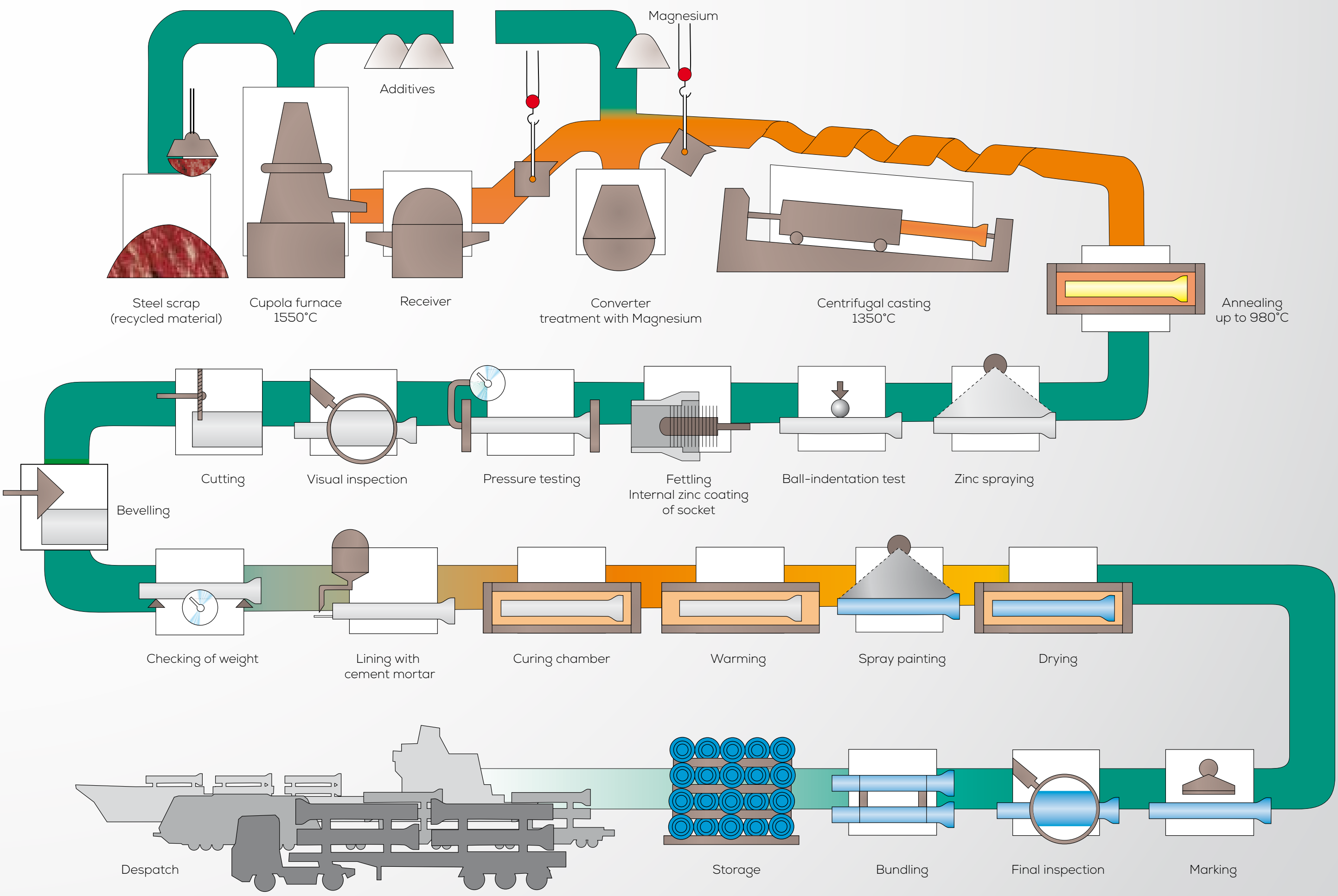
All products of TRM Tiroler Rohre GmbH for the supply of drinking water are of course certified by the DVGW (German Technical and Scientific Association for Gas and Water) and the ÖVGW (Austrian Association for Gas and Water). The basis for this certification is the DVGW's standards VP 545/ GW 337. All the materials used by us in manufacture which will subsequently come into contact with drinking water when pipes are in use, such as the lubricants, gaskets and cement mortar, have been tested to the appropriate DVGW standards. The possibility of the quality of drinking water being adversely affected by our products can therefore be ruled out.

All of our production and our in-house production controls and our products are subject to regular external monitoring.
In nominal sizes from DN 80 to DN 500, our ductile iron pipes with VRS®-T push-in joints also have FM approval. This allows them to be used for fire-fighting and fire extinguishing systems.

Our fittings are coated internally and externally with an epoxy finishing layer to EN 14 901. This coating also meets the stringent requirements laid down by the Gütegemeinschaft Schwerer Korrosionsschutz (GSK) (Quality Association for Heavy Duty Corrosion Protection). This means that our fittings to EN 545 can be installed in soils of any desired corrosiveness.

A selection of the most important certificates is available for downloading at **www.trm.at** or can be distributed by our sales team under **office@trm.at.**

Standard specifying texts for use in invitations to tender
English standard texts conforming to the current EN 545 for specifying our high quality pipes and fittings in invitations to tender are available at www.trm.at in a variety of formats (Word, pdf) or can be distributed by our sales team under **office@trm.at**



The material

What can be shown to be the first cast iron pipes were already being used in 1455 to supply water to the castle of Dillenburg and they remained in operation for more than 300 years. Over the following centuries the development of cast iron as a material continued in order to meet the increasing demands that were being made on it. Since the 1960's, pipes have no longer been composed of the grey cast iron that had been the usual material up until then but of ductile cast iron, normally referred to simply as ductile iron. The word "ductile" comes from the Latin verb ducere = to lead or reshape and means to be able to be stretched or shaped into a new form. This indicates one of the significant properties of ductile iron, its ability to deform under load and hence to withstand very high loads originating from traffic and internal pressure for example.

Ductile 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 iron principally in the shape of the graphite particles. 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. The so-called spheroids of graphite have only a minor effect on the properties of the microstructure of the metal. In the grey iron which was the standard material in the past, the graphite took the form of flakes or lamellae which had a notch effect and thus reduced the relatively high strength of the microstructure. 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. From the point of view of stress analysis, ductile iron pipes and fittings are considered to be flexible tubes.

Under EN 545, tensile strength and elongation after rupture can be tested on test bars.

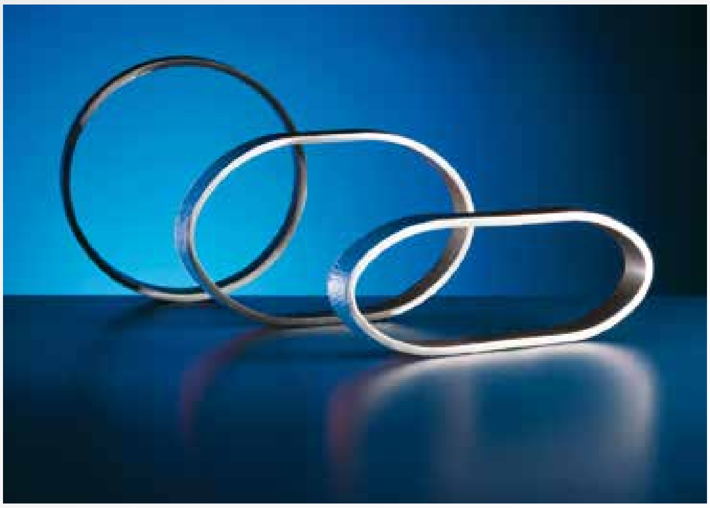
The table below provides an overview of the characteristics of ductile iron:

Characteristics	Units	Value
Tensile strength	N/mm²	420
0,2% proof of stress	N/mm²	300
Elongation after rupture	%	≥ 10
Compressive strength	N/mm²	900
E-Modulus	N/mm²	170.000
Bursting strength	N/mm²	300
Compressive strength at crown	N/mm²	550
Longitudinal bending stiffness	N/mm²	420
Oscillation banwidth	N/mm²	135
Mean coefficient of thermal expansion	m/mK	10 x 10-6
Thermal conductivity	W/cmK	0,42
Specific heat	J/gK	0,55

The mechanical properties of a metallic material like ductile iron remain the same throughout the whole of its operating life. That is why ductile iron pipes are still able to accept loads and are still safe even after decades.

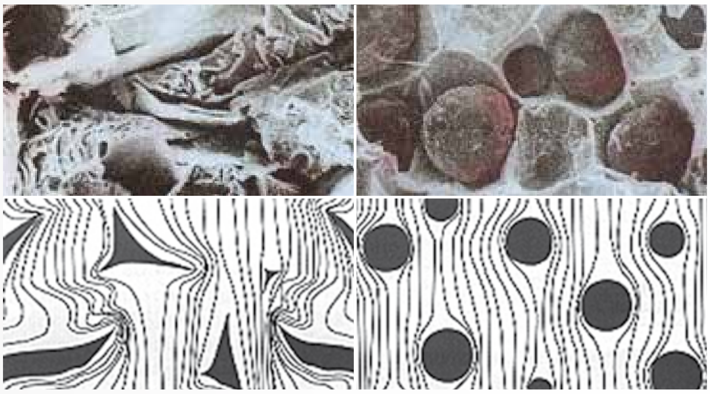
Made in Austria

Our ductile iron pipes are produced solely in Hall in Tirol. This ensures consistently high quality and short distances for deliveries. At the same time, it also safeguards jobs in Austria.



A tradition to live up to

Cast iron pipes have been produced since 1901. Initially the pipes were produced by the sand casting process but since 1925 this has been done by the de Lavaud centrifugal casting process. Over the years and decades, the production processes, the types of internal and external protection for the pipes, and the joint systems have been developed and refined to an ever higher standard. Today we can look back on our more than 100 years of experience and can invest the knowledge it has given us in the ongoing development of our products and can thus pass on its benefits to our customers.



The way of stress lines in cast iron with lamellar graphite (on the left) and spheriodal graphit (on the right).

Service

Our company has its primary sites in the heart of Europe and this not only enables us to keep the distances for transport short but also means that throughout the sales area our applications engineers and field sales staff can be at your service promptly to provide advice and assistance. We have an experienced team of technicians, engineers and salesmen ready to support you with help and advice.

Hygiene

One of the primary tasks of our civilisation is always to get water reliably to its destination. For generations now, our ductile iron pipes have set the standard for quality in water supply. Water is the most important nutrient on our planet and for this reason it has to be protected against contamination and the effects of chemicals while it is being transported through pipelines. Our ductile iron pipes are provided as standard with a cement mortar lining. Pipelines almost 100 years old which were lined with cement mortar have shown that

for long life and effectiveness cement mortar serving as a mineral lining is superior to all the other materials that have been used to date.
The cement mortar lining has both, an active and a passive protective action. Its active protective action is based on an electrochemical process. Water penetrates into the pores in the cement mortar, dissolves free lime, and rises to a pH of more than 12. At a pH of this level it is impossible for cast iron to corrode. The passive action results from the physical separation which exists between the pipe's cast iron wall and the water. The cement mortar lining consists of a mixture of sand, cement and water which is introduced into the pipe as the latter is rotating and which is then flung against the internal surface of the pipe by centrifugal force. The centrifuging process acts powerfully to drive out the water mechanically and compact the cement mortar tightly (water/cement ratio › 0.35:1). What this gives is firstly high strength for the cured cement and secondly extremely high resistance to any possible corrosive attack by water as a medium. For drinking water supply, the cement used is principally blast furnace cement or Portland cement.

Imperviousness to diffusion

Ductile iron drinking water pipes are sealed! And they are sealed in more than one way. Being an inorganic material, the cast iron of the pipe wall is sealed against (impervious to) diffusion. This means that nothing can penetrate through the pipe wall either from the inside outwards or vice versa. For drinking water, this means that no pollutants can find their way into the drinking water – an important matter especially when pipes are being laid in contaminated soils.

One pipe – many options

Our ductile iron pipes are versatile in the ways in which they can be used. There are two sophisticated and reliable restraint systems available in the form of our VRS®-T and BRS® push-in joint systems. Whereas pipes with BRS® joints are used mainly in urban water supply and serve as a replacement for concrete thrust blocks in this application due to the restrained nature of the joints, there are almost no limits to what can be done with the VRS®-T system.

Typical fields of application of the VRS®-T system are:

- replacement of concrete thrust blocks in conventional laying techniques
- bridge pipelines/above-ground pipelines
- temporary pipelines (for temporary water supplies)
- trenchless installation techniques (HDD, burst lining and press-pull techniques, pipe relining, floating-in, etc.)
- snow-making systems
- turbine pipelines
- laying on steep slopes
- fire-fighting and fire-extinguishing pipelines (FM Approval approval)
- use in regions at risk of earthquakes or settlement
- crossings below bodies of water/culvert pipelines
- building services
- urban water supply

A complete system

Also available to supplement our pipes is an extensive range of fittings for use both with TYTON®, BRS® and VRS®-T joints. Almost all the fittings available are listed in this Manual and others are available on enquiry. All our fittings are produced specifically for us by well-known German foundries.

Handling the ups and downs – pipeline stability

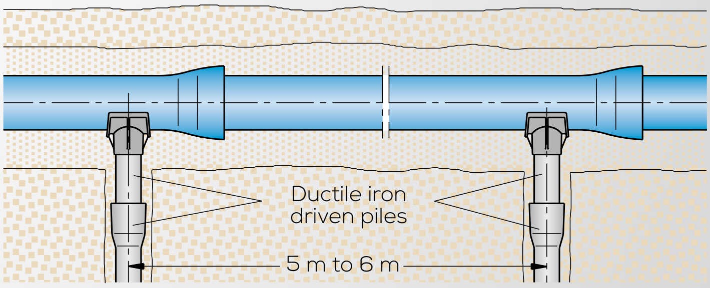
Because of their long laying length of 5 m to 6 m, ductile iron pipes are insensitive to changes in position caused by settlement or by inconsistencies in the supporting layer produced. Because of their high longitudinal bending stiffness, pipes are able to bridge faults in the supporting layer without being overloaded and suffering damage as a result.
What is more, depending on the nominal size and the type of joint, our push-in joints can be deflected angularly by up to a maximum of 5°. For a 6 m long pipe for example, this is equal to a deflection of about 50 cm from the axis of the socket of the pipe or fitting laid previously.
This means that even large areas of settlement cannot impair the leaktightness of the system and prevents unwanted restraints from being passed on from one pipe to the next.
In the event of settlement and hence changes in the length of the pipe string, the VRS®-T joint also safeguards pipes and fittings against longitudinal forces and stops them from being pulled apart.

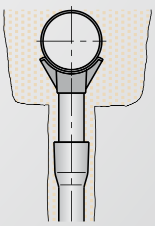
Not to be underestimated – structural safety/ laying on cradles carried on piles

Ductile iron pipes are equal to almost any load. For example, given the right nominal size, wall thickness and conditions of installation, our pipes can be laid with a height of cover of only 30 cm to withstand a traffic load conforming to the SLW 60 load model (heavy goods vehicle applying a total load of 600 kN).
This is achieved by means of the high diametral stiffness and longitudinal bending stiffness. Where elevated stress levels exist due to traffic, top cover, internal pressure, etc., it is possible for the wall thickness to be varied.

From the point of view of stress analysis, ductile iron pipes can be considered a system which is flexible in bending. Evidence of suitability for use can be obtained from the allowable deformation or stresses and from the checks made on fatigue strength. A service we offer for this purpose is the drawing up of checkable pipe stress analyses by our Applications Engineering Division.

Nor are there usually any stress-related problems with laying pipelines on cradles carried on piles. Because of the high load-bearing capacity of the pipes, only one cradle per pipe is needed in many cases.





Safety margins

When it is a question of supplying our most precious commodity, drinking water, safety should be a primary concern. Without exception, all pipes are therefore tested for leak tightness in the factory. Against internal pressure, ductile cast iron pipes have a safety factor of 3.

Coatings

Under EN 545, ductile iron pipes are provided with a metallic zinc or zinc-aluminium coating and a finishing layer. The mass of the zinc coating is 200 g/m² and that of the zinc-aluminium coating is 400 g/m². The finishing layer consists for example of blue paint of polyurethane, epoxy or of bitumen. The material used for the bedding may not exceed the following grain sizes:

- rounded material 0/32 mm
- fragmented material 0/16 mm

According to ÖNORM B2538 the designer has the possibility to increase the maximum grain size up to 100mm for ductile cast iron pipes coated with PUR (polyurethane finishing) or PUR-TOP (polyurethane finishing plus PE-tape). Essential condition therefore is no compression of the backfill area and settlements which maybe occur on top are acceptable (f.e. forest soils, agricultural areas,…).

Under DIN 30 675 Part 2, pipes with such a coating can be installed in soils of classes I (not aggressive to of low aggressiveness) and II (aggressive). If a pipe of this kind is bedded in an anode backfill, i.e. sand or gravel, it can even be laid in soils of class III (highly aggressive).

If the pipe is to be laid directly in highly aggressive or stony soils up to a maximum grain size of 100 mm, we recommend a zinc coating plus a cement mortar coating (ZMU) to EN 15 542. A ductile cast iron pipe with ZMU can be installed in almost any native soil without the soil having to be replaced.

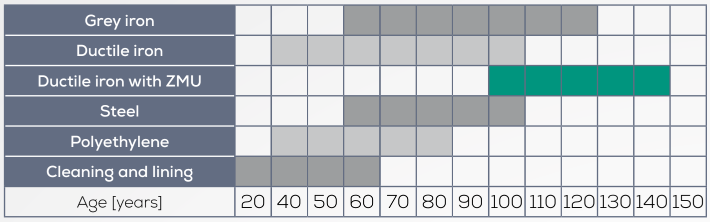
This means a considerable cost saving such as on dumping charges, purchase of replacement soil and transporting of bulk materials.
If the native soil can be re-used as backfill, there is the added benefit that this avoids the often undesirable draining effect that a pipe trench filled with gravel has.
Pipes with a ZMU can also be used for trenchless installation techniques such for example as the burst lining, horizontal directional drilling, push-pull and rocket plough techniques. Extra-careful attention has to be paid to the socket joint in this case. The VRS®-T joint is what we offer for this application.

Sustainability

Ductile cast iron pipes are long lived! Technical notice W401 issued by the Deutscher Verein des Gas- und Wasserfaches (German Technical and Scientific Association for Gas and Water) assesses their technical operating life at 100 to 140 years.

Cast iron pipes have been laid for more than 550 years for the purpose of transporting liquid media.
Even back in those early days the potential the material had was recogni- sed. It has been by the constant ongoing development of the production processes, the material itself and the joining techniques that such high standards of performance have been achieved.

Technical operating life by pipeline groups (from W 401)



This long life takes the strain off future rehabilitation budgets and the very low damage rates also help to make a saving on operating and maintenance costs. The very long technical operating life that cast iron pipe systems enjoy has been shown by the experience of the past six centuries. An impressive piece of proof this kind is provided by the drinking water pipeline of 1455 supplying the castle at Dillenburg.
This pipeline was in operation until it was destroyed in July 1760. These and innumerable other examples provide impressive confirmation of the legendary long life of cast iron pipes.

Economy

To assess the economy of pipeline systems, there is more than just the price of the pipe material that has to be taken into account. What also have to be considered are the cost of installation, the damage rate and the technical operating life.

Ductile iron pipes are well known for the quick and easy way in which they can be laid and for how forgiving they are of mistakes in the laying. Our TYTON®, BRS® and VRS®-T joint systems can be assembled in a very short time without the need for any special tools.

The damage statistics compiled by the DVGW (German Technical and Scientific Association for Gas and Water) show our ductile iron pipes to have one of the lowest damage rates (damaged points per km per year) of all materials. Coupled with a technical operating life of up to 140 years, this gives ductile iron pipe systems extremely good economic viability and thus lays the foundation for a sustainably economical drinking water supply system for future generations.

The following formula is one possible way of determining the approximate average annual cost of a pipeline in Euros per metre.

$$ØC = I \times (1/n + p/200)$$

ØC = average annual cost of the pipeline in Euros/m
I = capital investment cost (cost of production) in Euros/m
n = technical operating life in years
p = interest rate in %

From this formula it is very easy to see that the average annual cost of a pipeline depends principally on its technical operating life. Consequently, the high cost of production caused by the use of high grade materials for the pipeline works out to be perfectly economical over its lifetime. And this is true even without allowing for the advantages which ductile iron pipes have in terms of operating costs and costs arising from the frequency of damage.

Environmentally friendly

TRM ductile cast iron pipes are a model of friendliness to the environment. There are four factors which are the main reason for this:

1. We use only iron and steel scrap – i.e. recycled material – to obtain the molten pig iron. This not only saves valuable iron ore resources but also saves energy.

2. Because ductile iron pipes consist essentially of iron and cement mortar, they are almost 100% recyclable.

3. The main waste products generated in our production, such as slag and sand, are used in cement works and in road-building and hence are recovered for re-use.

4. Ductile iron pipe systems have an extremely long technical operating life of up to 140 years. Calculated over their life span, this reduces to a minimum the CO_2 and other emissions released in producing them.

Quality

Quality in the products it produces and satisfaction for its customers are the supreme corporate aims of TRM.
We operate a quality management system which is certified under EN ISO 9001 and an environmental management system which is certified under EN ISO 14 001. The products and production processes are regularly monitored by external materials testing institutions.

To ensure that we will continue to live up to our high aspirations in terms of quality in future, we produce our pipes only in our factory in Hall in Tirol in Austria. This ensures consistently high quality for our products and creates and safeguards jobs.

Advantages of ductile iron pipe systems

Ductile iron pipe systems are technically unbeatable

- Internal and external coatings make them resistant to corrosion
- Safe external protection for all soils and installation techniques
- Linings resistant to corrosive media
- High static load-bearing capacity
- Resistant to fracture
- High safety margins (to cater for fluctuations in pressure and static overloads and to counter the effects of external factors)
- Patented restrained joints
- Able to be deflected angularly up to a maximum of 5°
- Suitable for trenchless installation techniques
- Leaktight against high internal pressures, negative pressures and high water tables
- Pipe material is impervious to diffusion
- Resistant to the penetration of roots
- Properties of material remain constant (for long-term strength)

Ductile iron pipe systems are economically superior

- Quick and easy installation saves on costs
- Slim pipe walls mean narrow trenches
- Excavated material can generally be re-used
- No welding needed (very simple push-in joints)
- Laying is possible in all weathers
- Ideal for trenchless laying
- Material is not affected by ageing
- Long technical operating life
- Fittings and accessories give a complete system
- Efficient and inexpensive planning with the help of the TRM Applications Engineering Division
- Very low damage rate

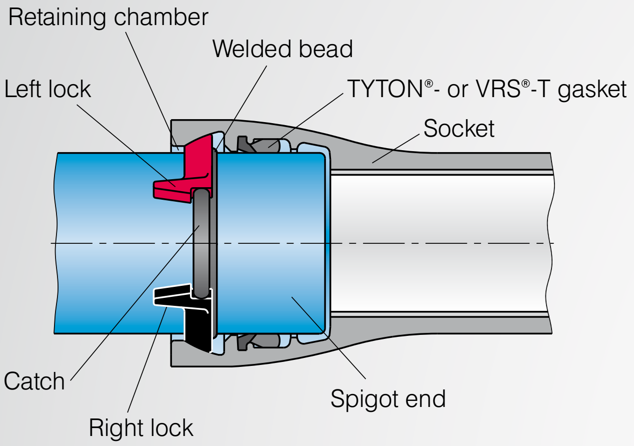
Ductile iron pipe systems – consciously kind to the environment

- Material is inorganic
- Produced from recycled iron which is itself fully recyclable
- Meets the most stringent requirements for hygiene
- The sand used for the cement mortar lining is free of binders and chemical additives
- Pipe wall is totally impervious to diffusion
- Life of up to 140 years

2 - THE POSITIVE LOCKING SYSTEM

Introduction

This chapter deals only with restrained push-in joints where the restraint is based on a positive locking interengagement. Positive locking push-in joints can always be recognised by a welded bead on the spigot end and a retaining chamber. The positive locking inter-engagement between the welded bead and the retaining chamber is obtained by inserting locking segments. This enables forces to be transmitted mechanically between the spigot end and the socket of the next pipe or fitting.



An example of a positive locking joint (VRS®-T joint)

Forces may be generated by internal pressure or external tractive forces. Allowable operating pressures (PFA) and allowable tractive forces are specified on the pages 71 ff as a function of nominal size. Higher pressures and tractive forces are possible; please check with our Applications Engineering Division.

TRM supplies the following positive locking push-in joints for pipes and fittings:

The VRS®-T joint (DN 80 to DN 500)

This joint has been a success for decades and can be assembled with a TYTON® or the VRS®-T gasket. Depending on the nominal size and the nature of the application, locking is from 2 to 4 locks. It is notable principally for its easy and quick assembly, the reliable high operating pressures and tractive forces and the versatility with which it can be used. A clamping ring can be used on cut pipes. This enables the on-site application of a welded bead to be dispensed with in most cases. Pipes with VRS®-T joints are available in laying lengths of 5 m and 6 m. You will find further information on the VRS®-T joint from p. 18 on.

The BLS® joint (DN 600 to DN 1000)

In this case a TYTON® gasket is used. The joint is locked by 9 to 14 locking segments which are inserted through openings in the socket and which are distributed round the circumference of the pipe. Pipes with BLS® joints are available in a laying length of 6 m. You will find further information on the BLS® joint from p. 19 on.

Fields of use/advantages

There are almost no limits to the versatility with which pipes and fittings with VRS®-T joints can be used. The quick and easy assembly and the very high allowable operating pressures and tractive forces for which they can be relied on make them suitable for virtually any conceivable application in the laying of pressure pipelines (for water or sewage).

- urban water supply
- replacement of concrete thrust blocks in conventional open trench laying
- bridge pipelines/above-ground pipelines
- temporary pipelines (for temporary water supplies)
- trenchless installation techniques (HDD, burst lining and press-pull techniques, pipe relining, floating-in, etc.)
- snow-making systems
- turbine pipelines
- laying on steep slopes
- fire-fighting and fire-extinguishing pipelines (FM Approval)
- crossings below bodies of water/culvert pipelines
- building services
- use in regions at risk of earthquakes or settlement

The very high angular deflectability of up to a maximum of 5° and the rotatability through 360° make these joints suitable even for the laying of complicated and demanding intersections.

PFA

Under EN 545, the allowable operating pressures (PFA) of the VRS®-T joints have to be stated in manufacturers' catalogues. See the following pages.

PMA = 1.2 x PFA (allowable maximum operating pressure for a short period, e.g. the period of a pressure surge).
PEA = 1.2 x PFA + 5 (allowable site test pressure).

The classification into C classes under EN 545 does not apply to positive locking joints. The minimum wall thicknesses therefore differ from those in Table 17 of EN 545 (which applies to non-restrained joints).

Compatibility

There is no compatibility with the positive locking systems used by other manufacturers. For possible solutions in this regard, please get in touch with our Applications Engineering Division.

E-mail address: anwendungstechnik@trm.at

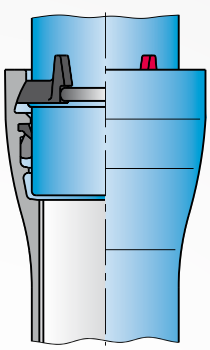
Clamping ring

The use of clamping rings is possible in the majority of cases on pipes of nominal sizes from DN 80 to DN 500. For details of the fields of use of the rings see p. 17 and for installation instructions see p. 72 on. By using clamping rings it is possible to dispense with the retrospec-tive application of welded beads to pipes which are cut on site.

2.1 Positive locking joints and pipes

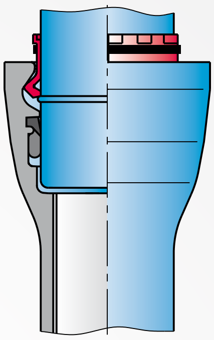
Overview

VRS®-T



DN 80 to DN 500

BLS®

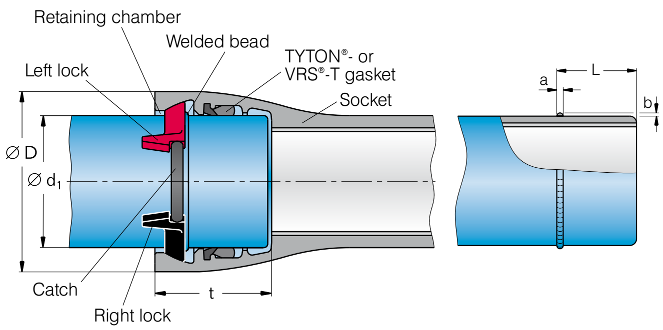


DN 600 to DN 1000

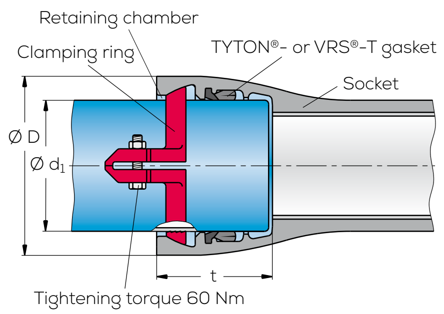
DN	PFA [1] [bar]	Allowable tractive force [3] [kN]	Max. angular deflection [°]
80 [2]	100	115	5
100 [2]	75	150	5
125 [2]	63	225	5
150 [2]	63	240	5
200	42	350	4
250	40	375	4
300	40	380	4
400	30	650	3
500	30	860	3
600	32	1,525	2
700	25	1,650	1.5
800	16/25 [2]	1,460	1.5
900	16/25 [2]	1,845	1.5
1,000	10/25 [2]	1,560	1.5

[1] PFA: allowable operating pressure – also applies to clamping rings; PMA = 1.2 x PFA; PEA = 1.2 x PFA + 5 – higher PFA's on enquiry. [2] Wall-thickness class K10 under EN 545:2006. [3] DN 80 to DN 250 with high-pressure lock – higher tractive forces on enquiry

VRS®-T joint
DN 80 to DN 500



VRS®-T joint with clamping ring
DN 80 to DN 500



Notes on the use of VRS®-T joints

- trenchless installation of DN 80 to DN 250 size pipes only with high-pressure lock
- for installation instructions see p. 71
- higher pressures are possible, e. g. for snow-making systems or turbine pipelines

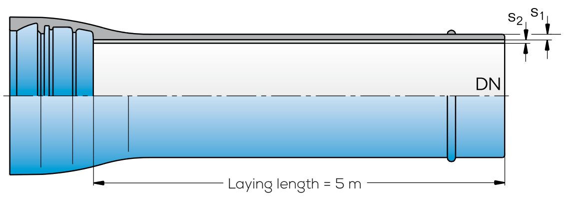
Notes on the use of clamping rings

- as a replacement for the welded bead, e.g. on pipes cut on site
- up to PFA of 16 bars in double socket bends, socket spigot-bends, 90° flange socket duckfoot bends and 90° duckfoot bends with side outlets; higher PFA's on enquiry
- not in above-ground pipelines or buried pipelines subject to pulsating pressures
- not in trenchless installation techniques
- tightening torque of bolts ≥ 60 Nm
- for installation instructions see p. 72

DN	Dimensions [1] [mm]						Weight [kg]				PFA [2] [bar]			Number of locks [3]	Allowable tractive force [4] [kN]	Max. angular deflection [°]	Min. radius [5] [m]
	d1	D	t	L	a	b	Set of locks	High pressure lock	Clamping ring	Gasket	Without high pressure lock	With high pressure lock	Clamping ring				
80	98 +1/-2.7	156	127	86	8	5	0.4	0.3	0.9	0.13	100	110	100	2	115	5	57/69
100	118 +1/-2.8	182	135	91	8	5	0.4	0.4	1.0	0.16	75	100	75	2	150	5	57/69
125	144 +1/-2.8	206	143	96	8	5	0.6	0.5	1.4	0.19	63	100	63	2	225	5	57/69
150	170 +1/-2.9	239	150	101	8	5	0.8	0.6	1.7	0.22	63	75	63	2	240	5	57/69
200	222 +1/-3	293	160	106	9	5.5	1.1	0.8	2.2	0.37	42	63	42	2	350	4	72/86
250	274 +1/-3.1	357	165	106	9	5.5	1.5	1.2	2.7	0.48	40	44	40	2	375	4	72/86
300	326 +1/-3.3	410	170	106	9	5.5	2.7	–	3.6	0.67	40	–	40	4	380	4	72/86
400	429 +1/-3.5	521	190	115	10	6	4.4	–	6.0	1.1	30	–	30	4	650	3	95/115
500	532 +1/-3.8	636	200	120	10	6	5.5	–	7.2	1.6	30	–	30	4	860	3	95/115

[1] Tolerances are possible, [2] PFA: allowable operating pressure; PMA = 1.2 x PFA; PEA = 1.2 x PFA + 5 – higher PFA's on enquiry, [3] Plus high-pressure lock if required with DN 80 to DN 250 sizes; [4] Higher tractive forces on enquiry, [5] Min. radius of curves (5 m pipe/6 m pipe), which results from the angular deflection possible at the sockets – applies to both open trench and trenchless laying, [6] Approx. assembly time of the joint not including any protection it may be given

VRS®-T pipe
DN 80 to DN 500

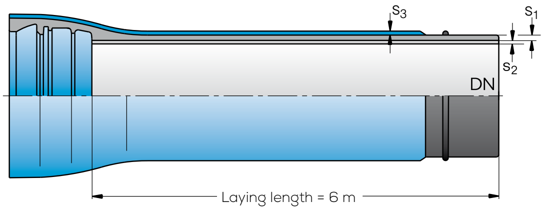


Laying length of 5 m.

External coatings
- Zinc coating with PUR-longlife polyurethane finishing layer
- Zinc coating with PUR-TOP Enhanced polyurethane finishing layer plus PE-tape
- WKG insulation
- Other coatings up on request

Internal coatings
- Portland cement
- High-alumina cement
- Other coatings up on request

For notes on the fields of use of coatings see chapter 5



Laying length of 6 m.

External coatings
- Cement mortar coating (ZMU)
- Zinc coating with finishing layer
- Zinc-aluminium coating with finishing layer (Zinc PLUS coating)
- WKG insulation
- ZMU PLUS cement mortar coating

Internal coatings
- Blast furnace cement
- High-alumina cement

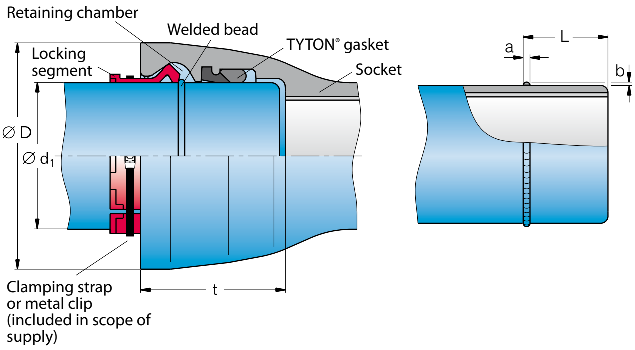
For notes on the fields of use of the coatings see chapter 5

DN	Dimensions [mm] [4]			Total weight [kg]		PFA [1] [bar]			Number of locks [5]	Allowable tractive force [6] [kN]	Max. angular deflection [°]	Min. radius [7] [m]
	s_1 Ductile iron	s_2 Cement mortar lining	s_3 Cement mortar coating	per m pipe [2]	per m pipe + cement mortar coating [3]	Without high-pressure lock	With high-pressure lock	Clamping ring [9]				
80	4.7	4	5	16.3	19.4	100	110	100	2	115	5	57/69
100	4.7	4	5	20.0	24.0	75	100	75	2	150	5	57/69
125	4.8	4	5	25.6	30.7	63	100	63	2	225	5	57/69
150	5.0	4	5	31.4	37.5	63	75	63	2	240	5	57/69
200	4.8	4	5	40.9	48.5	42	63	42	2	350	4	72/86
250	5.2	4	5	54.0	63.7	40	44	40	2	375	4	72/86
300	5.6	4	5	73.9	81.3	40	–	40	4	380	4	72/86
400	6.4	5	5	104.0	117.8	30	–	30	4	650	3	95/115
500	7.2	5	5	142.4	156.8	30	–	30	4	860	3	95/115

[1] PFA: allowable operating pressure; PMA = 1.2 x PFA; PEA = 1.2 x PFA + 5 – higher PFA's on enquiry, [2] Theoretical weight per m pipe inc. cement mortar lining, zinc (zinc-aluminium) and finishing layer, [3] Theoretical weight per m pipe inc. cement mortar coating & lining and zinc, [4] s1 = min. dimension, s2/s3 = nominal dimensions. Note that tolerances are possible

[5] Plus high-pressure lock if required with DN 80 to DN 250 sizes, [6] Higher tractive forces on enquiry, [7] Min. radius of curves (5 m pipe/6 m pipe), which results from the angular deflection possible at the sockets – applies to both open trench and trenchless laying, [8] Approx. assembly time of the joint, not including any protection it may be given, [9] See notes on the use of clamping rings, page 72

BLS® joint
DN 600 to DN 1000

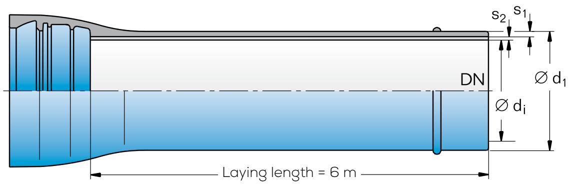


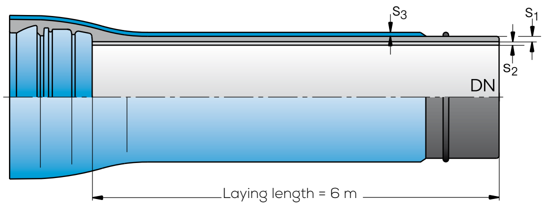
Notes on the use of BLS® joints
- trenchless installation only with metal clips
- for installation instructions see p. 74
- higher pressures are possible. e.g. for snow-making systems or turbine pipelines

DN	Dimensions [mm] [1]							Weight [kg]		Number of locks	PFA [2] [bar]	Allowable tractive force [3] [kN]	Max. angular deflection [°]	Min. radius [4] [m]
	d_1		D	t	L	a	b	Set of locks	Gasket					
600	635	+1 / -4	732	175	116	9	6	9	2.3	9	32	1,525	2.0	172
700	738	+1 / -4.3	849	197	134	9	6	11	4.3	10	25	1,650	1.5	230
800	842	+1 / -4.5	960	209	143	9	6	14	5.2	10	16/25 [6]	1,460	1.5	230
900	945	+1 / -4.8	1,073	221	149	9	6	13	6.3	13	16/25 [6]	1,845	1.5	230
1,000	1,048	+1 / -5	1,188	233	159	9	6	16	8.3	14	10/25 [6]	1,560	1.5	230

[1] Tolerances are possible. [2] PFA: allowable operating pressure; PMA = 1.2 x PFA; PEA = 1.2 x PFA + 5 – higher PFA's on enquiry. [3] Higher tractive forces on enquiry
[4] Min. radius of curves, which results from the angular deflection possible at the sockets – applies to both open trench and trenchless laying.
[5] Approx. assembly time of the joint. not including any protection it may be given, [6] Wall-thickness class K 10 under EN 545:2006

BLS®-pipe
DN 600 to DN 1000





Laying length of 6 m.

External coatings
- Cement mortar coating (TRM ZMU)
- Zinc coating with finishing layer
- Zinc-aluminium coating with finishing layer (Zinc PLUS)
- WKG insulation

Internal coatings
- Blast furnace cement
- High-alumina cement

For notes on the fields of use of the coatings see chapter 5

DN	Dimensions [mm] [4]			Weight [kg]		Number of locks	PFA [1] [bar]	Allowable tractive force [5] [kN]	Max. angular deflection [°]	Minimum radius [6] [m]
	s_1	Cement mortar lining s_2	Cement mortar coating s_3	per m pipe [2]	per m pipe + cement mortar coating [3]					
600	8.0	5	5	186.4	206.6	9	32	1,525	2.0	172
700	8.8	6	5	235.0	258.3	10	25	1,650	1.5	230
800	9.6	6	5	294.6	321.3	10	16/25 [8]	1,460	1.5	230
900	10.4	6	5	355.2	385.0	13	16/25 [8]	1,845	1.5	230
1,000	11.2	6	5	420.7	453.9	14	10/25 [8]	1,560	1.5	230

[1] PFA: allowable operating pressure; PMA = 1.2 x PFA; PEA = 1.2 x PFA + 5 – higher PFA's on enquiry, [2] Theoretical weight per m pipe inc. cement mortar lining, zinc (zinc-aluminium) and epoxy finishing layer, [3] Theoretical weight per m pipe inc. cement mortar lining & coating and zinc,
[4] s_1 = min. dimension, s_2/s_3 = nominal dimensions. Tolerances are possible
[5] Higher tractive forces on enquiry, [6] Min. radius of curves, which results from the angular deflection possible at the sockets – applies to both open trench and trenchless laying, [7] Approx. assembly time of the joint not including any protection it may be given,
[8] Wall-thickness class K 10 under EN 545:2006

2.2 Fittings with positive locking joints

Compatibility
There is no compatibility with positive locking systems used by other manufacturers. For possible solutions in this regard, please get in touch with our Applications Engineering Division.

E-mail address: office@trm.at

Laying lengths
Except where otherwise noted, the laying lengths Lu of fittings conform to the A series in EN 545.

Flanged fittings (see chapter 4)
When ordering flanged fittings, it is essential to give the PN pressure rating required. Accessories such as hex-head bolts, nuts, washers and gaskets must be obtained from specialist suppliers.

Coating
Except where otherwise specified, all the fittings shown below are provided internally and externally with an epoxy coating at least 250 µm thick. The coating complies with EN 14 901 and meets the requirements of the Quality Association for the Heavy Duty Corrosion Protection of Powder Coated Valves and Fittings (GSK).
All fittings to EN 545, Annex D.2.3., can thus be installed in soils of any desired corrosiveness.
For notes on the fields of use of the coating see chapter 5.

RAL GÜTEZEICHEN
SCHWERER KORROSIONSSCHUTZ
VON ARMATUREN UND FORMSTÜCKEN

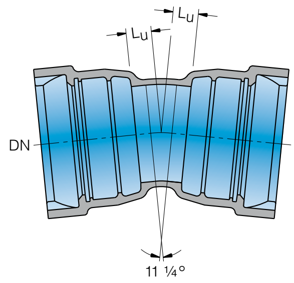
Allowable operating pressure (PFA)
(except where otherwise stated)

DN	PFA [bar]		
	VRS®-T	BLS®	Flanged
80–300	100	–	PFA = PN
400	30	–	
500	30	–	
600	–	40	
700	–	25	
800	–	25	
900	–	25	
1,000	–	25	

PFA: maximum allowable operating pressure in bars
- PMA = 1.2 x PFA (allowable maximum operating pressure for a short period, e.g. the period of a pressure surge)
- PEA = 1.2 X PFA + 5 (allowable site test pressure)

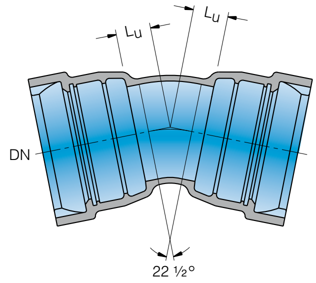
Scope of supply
The fittings supplied by TRM include all the gaskets, locks and other securing components required for all the sockets. For flanged joints, the gaskets, bolts, nuts and washers are not included in the scope of supply.

MMK 11 fittings
11¼° double socket bends
to EN 545



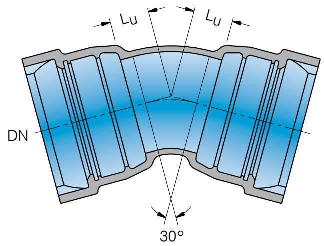
DN	Dimensions [mm] L_u	PFA [bar]	Weight [kg] ~
VRS®-T			
80	30		10.1
100	30		14.0
125	35		18.6
150	35	100	23.3
200	40		38.2
250	50		52.3
300	55		70.4
400	65	30	116.0
500	75		171.5
BLS®			
600	85	40	186.0
700	95		277.0
800	110	25	378.0
900	120		532.0
1,000	130		614.0

MMK 22 fittings
22½° double socket bends
to EN 545



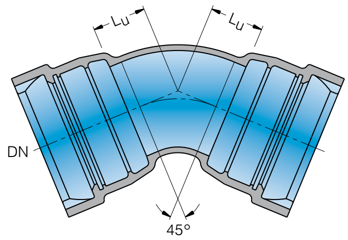
DN	Dimensions [mm] L_u	PFA [bar]	Weight [kg] ~
VRS®-T			
80	40		10.2
100	40		14.3
125	50		19.4
150	55	100	24.3
200	65		39.2
250	75		56.9
300	85		78.6
400	110	30	120.4
500	130		197.0
BLS®			
600	150	32	215.5
700	175		320.0
800	195	25	458.0
900	220		594.0
1,000	240		723.0

MMK 30 fittings
30° double socket bends
to DIN 28 650



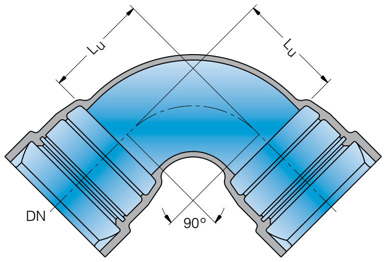
DN	Dimensions [mm] L_u	PFA [bar]	Weight [kg] ~
VRS®-T			
80	45		10.4
100	50		14.7
125	55		20.3
150	65	100	25.2
200	80		41.4
250	95		59.3
300	110		79.9
400	140	30	137.0
500	170		205.5
BLS®			
600	200	40	230.0
700	230		333.0
800	260	25	473.0
900	290		635.0
1,000	320		809.0

MMK 45 fittings
45° double socket bends
to EN 545



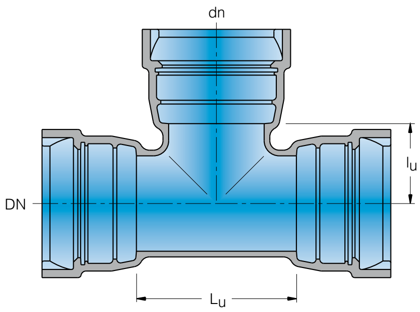
DN	Dimensions [mm] L_u	PFA [bar]	Weight [kg] ~
VRS®-T			
80	55		11.0
100	65		14.7
125	75		20.8
150	85	100	26.3
200	110		41.5
250	130		65.1
300	150		86.4
400	195	30	157.0
500	240		227.0
BLS®			
600	285	40	261.0
700	330		376.0
800	370	25	548.0
900	415		716.0
1,000	460		879.0

MMQ fittings
90° double socket bends
to EN 545



DN	Dimensions [mm] L_u	PFA [bar]	Weight [kg] ~
VRS®-T			
80	100	100	11.6
100	120		15.9
125	145		22.4
150	170		28.9
200	220		55.1
250	270		76.0
300	320		94.5
400	430	30	200.5

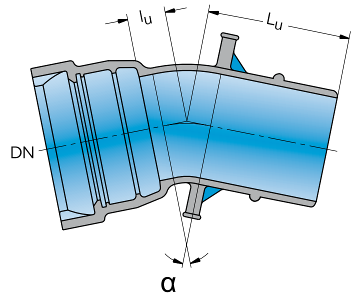
MMB fittings
All-socket tees with 90° branch
to EN 545



DN	dn	Dimensions [mm] L_u	Dimensions [mm] l_u	PFA [bar]	Weight [kg] ~
VRS®-T					
80	80	170	85	100	16.1
100	80	170	95		20.0
	100	190	95		22.4
125	80	170	105		25.1
	100	195	110		28.1
	125	225	110		31.0
150	80	170	120		33.6
	100	195	120		34.5
	125	255	125		39.0
	150	255	125		41.1
200	80	175	145		46.2
	100	200	145		47.3
	125	255	145		50.0
	150	255	150		54.3
	200	315	155		63.1
250	80	180	170		72.0
	100	200	170		63.9
	125	230	175		78.0
	150	260	175		70.6
	200	315	180		77.8
	250	375	190		89.1
300	80	180	195	100	93.0
	100	205	195		80.2
	150	260	200		88.6
	200	320	205		96.6
	250	375	210		109.0
	300	435	220		127.4
400*	400	560	280	30	236.0
500*	500	800	400		396.8

* To manufacturer's standard

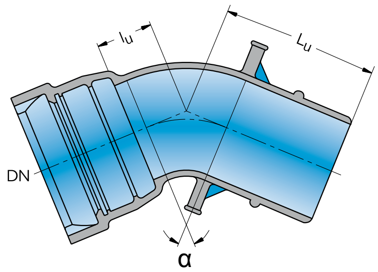
MK 11 and MK 22 fittings
11¼° and 22½° single socket bends
to manufacturer's standard



DN	Dimensions [mm] l_u	Dimensions [mm] L_u	PFA [bar]	Weight [kg] ~
VRS®-T; α = 11¼°				
80	30	175	100	8.4
100	30	185		11.1
125	35	200		15.1
150	35	210		20.1
200	40	230		32.7
250	50	250		51.0
300	55	270		71.0
400	65	375	63	125.0
500	75	405	50	220.0

DN	Dimensions [mm] l_u	Dimensions [mm] L_u	PFA [bar]	Weight [kg] ~
VRS®-T; α = 22½°				
80	40	185	100	8.7
100	40	195		11.6
125	50	215		15.9
150	55	230		21.5
200	65	255		35.3
250	75	275		53.0
300	85	300		73.0
400	110	420	63	138.8
500	130	460	50	220.0

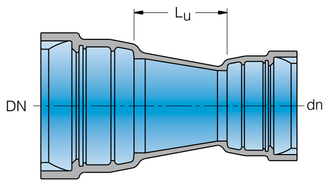
MK 30 and MK 45 fittings
30° and 45° single socket bends
to manufacturer's standard



DN	Dimensions [mm] l_u	Dimensions [mm] L_u	PFA [bar]	Weight [kg] ~
VRS®-T; α = 30°				
80	45	190	100	8.9
100	50	205		11.9
125	55	220		16.2
150	65	240		22.4
200	80	270		36.5
250	95	295		57.0
300	110	320		82.0
400	140	450	63	157.2
500	170	495	50	224.0

DN	Dimensions [mm] l_u	Dimensions [mm] L_u	PFA [bar]	Weight [kg] ~
VRS®-T; α = 45°				
80	55	200	100	9.1
100	65	220		12.3
125	75	240		17.0
150	85	260		24.2
200	110	300		39.7
250	130	335		60.5
300	150	365		87.3

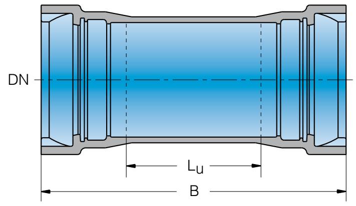
MMQ fittings
90° double socket bends
to EN 545



DN	dn	L_u [mm]	PFA [bar]	Weight [kg] ~
VRS®-T				
100	80	90	100	12.3
125	80	140		15.9
	100	100		16.7
150	80	190		19.9
	100	150		20.8
	125	100		21.0
200	100	250		29.6
	150	150		30.4
250	150	250		45.3
	200	150		46.7
300	150	350		57.0
	200	250		58.9
	250	150		62.8
400*	300	260	30	111.0
500*	400	260		148.0

* To manufacturer's standard

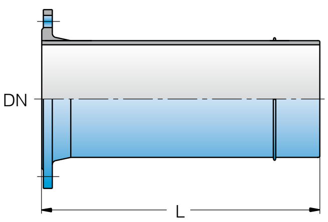
U fittings
Collars
to EN 545



DN	L_u [mm]	B [mm]	PFA [bar]	Weight [kg] ~
VRS®-T				
80	160	415	100	13.4
100	160	430		16.0
125	175	460		24.0
150	180	480		30.5
200	180	500		45.5
250	190	520		66.5
300	200	540		83.5
400	210	590	30	115.0
500	220	620		185.0

There are cases where collars with VRS®-T joints cannot be fully slid on.
They must be used only with TYTON® gaskets.

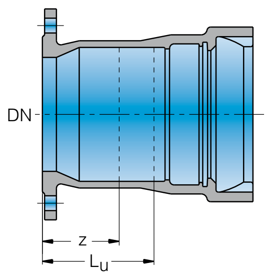
F fittings
Flanged spigots
to EN 545



DN	L [mm]	Weight [kg]					
		PN 10	PN 16	PN 25	PN 40	PN 63	PN 100
VRS®-T							
80	350	7.5				11.9	11.2
100	360	8.5		10.4		14.1	15.7
125	370	12.4		13.1	14.3	20.0	22.8
150	380	19.3		21.0	21.0	31.9	28.0
200	400	25.2	25.2	26.0	30.8	46.6	55.4
250	420	35.1	35.2	37.7	45.4	–	–
300	440	46.0	44.8	49.1	62.0	–	–
400	480	104.0	109.0	114.0	154.0*	–	–
500	500	146.0	156.0	161.0	–	–	–
BLS®							
600	560	134.3	160.3	174.3	235.3	–	–
700	600	180.6	195.6	229.6	–	–	–
800	600	228.0	247.0	296.0	–	–	–
900	600	348.0	359.0	–	–	–	–
1,000	600	503.0	538.0	–	–	–	–

* Take note of the PFA of the VRS®-T joint

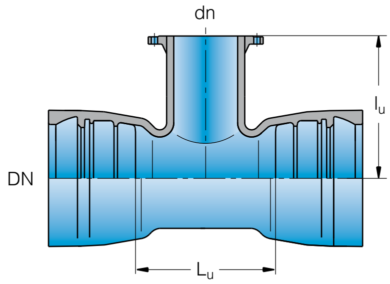
EU fittings
Flanged sockets
to EN 545



DN	L_u [mm]	z [mm]	Weight [kg]					
			PN 10	PN 16	PN 25	PN 40	PN 63	PN 100
VRS®-T								
80	130	90	10.2				12.3	–
100	130	90	12.2		12.7		16.3	20.7
125	135	95	15.5		17.0	17.0	26.8	–
150	135	95	19.9		22.1	22.1	31.5	33.4
200	140	100	28.7	28.9	29.6	34.6	49.0	56.4
250	145	105	40.6	39.7	44.3	51.9	67.5	86.4
300	150	110	52.3	52.1	56.1	69.9	84.9	120.0
400	160	120	85.5	89.0	102.0	127.5	–	–
500	170	130	125.0	140.5	151	162.0*	–	–
BLS®								
600	180	140	137.5	167.5	173.5	209.0*	–	–
700	190	150	202.0	248.0	278.0	–	–	–
800	200	160	269.5	270.0	316.0	–	–	–
900	210	170	347.0	370.0	427.0	–	–	–
1,000	220	180	439.0	464.0	549.0	–	–	–

L_u = laying length in the locked state
z = mean laying length (when used without a welded bead)
* Take note of the PFA of the VRS®-T joint

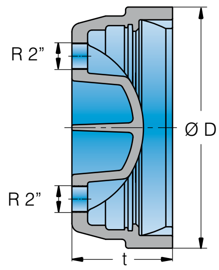
MMA fittings
Double socket tees with flanged branch
to EN 545



DN	dn	L_u [mm]	l_u [mm]	Weight [kg] PN 10	PN 16	PN 25	PN 40
VRS®-T							
80	80	170	165	15.8			
100	80	170	175	20.5			
	100	190	180	21.9		–	
125	80	170	190	24.8			
	100	195	195	27.6		–	
	125	255	200	–		–	–
150	80	170	205	30.6			
	100	195	210	33.0		–	
	150	225	220	39.0		–	–
200	80	175	235	45.4			
	100	200	240	46.8		–	
	150	250	250	51.6		–	–
	200	315	260	–	57.0	–	–
250	80	180	265	56.0			
	100	200	270	57.5		–	
	150	260	280	63.5		–	–
	200	315	290	–	71.5	–	–
	250	375	300	–	–	–	–
300	80	180	295	76.6			
	100	205	300	81.2		–	
	150	260	310	80.0		–	–
	200	320	320	–	–	–	–
	300	435	340	110.0	–	–	–
400	150	270	370	148.0		152.0	152.0
	200	440	380	170.0	171.0	173.0	–
	300	440	400	191.0	192.0	197.0	–
	400	560	420	200.0	205.0	217.0	–
500	200	450	440	192.5	192.5	194.5	–
	300	450	460	205.0	205.0	211.0	–
	400	565	480	297.0	303.0	315.0	–
	500	680	500	338.0	362.0	363.0	372*
600	150	570	490	237.0		238.0	–
	200		500	254.0	254.0	247.0	–
	300		520	266.0	266.0	272.0	–
	400		540	279.0	284.0	296.0	–
	600	800	580	376.5	401.0	415.0	–
800	150	1045	580	657.0		645.0	–
	200		585	667.0	667.0	655.0	–
	400		615	695.0	682.0	693.0	–
	600		645	745.0	770.0	784.0	–
	800		675	791.0	809.0	855.0	–
900	100	475	630	540.0	592.0	598.0	–
	125		635	541.0	593.0	594.0	–
	150		640	543.0	594.0	600.0	–
	200		645	546.0	596.0	603.0	–
	250		655	550.0	599.0	608.0	–
	300		660	555.0	603.0	613.0	–
1,000	100	480	690	672.0	738.0	745.0	–
	125		695	673.0	738.0	746.0	–
	150		700	675.0	739.0	747.0	–
	200		705	678.0	741.0	750.0	–
	250		715	682.0	741.0	750.0	–
	300		720	687.0	748.0	760.0	–

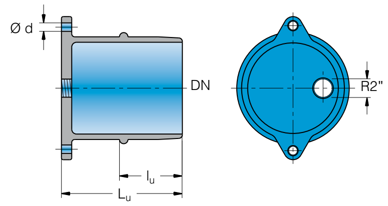
** Take note of the PFA of the VRS®-T joint*

O fittings
Spigot end caps
to manufacturer's standard



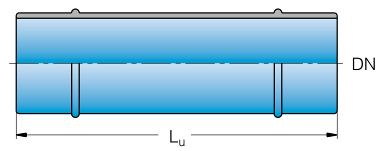
DN	t [mm]	D [mm]	PFA [bar]	Weight [kg]
VRS®-T O-Stücke				
400	225	540	30	117
500	240	650	30	170

P plugs
Socket plugs
to manufacturer's standard



DN	L_u [mm]	l_u [mm]	d [mm]	PFA [bar]	Masse [kg]
VRS®-T P-Stopfen					
80	170	86	M 12	100	4.1
100	175	91	M 12		4.4
125	195	96	M 16		6.7
150	200	101	M 16		9.2
200	210	106	M 16		14.5
250	250	106	M 20		27.2
300	300	106	M 20		49.4

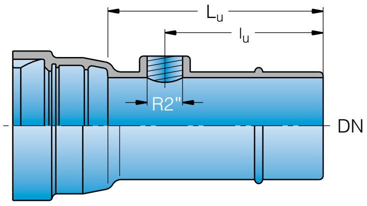
GL fittings (GDR fittings)
Plain ended pipe pieces
with two welded beads
to manufacturer's standard



DN	Weight [kg] PFA [bar] 10	16	25	30	40	63	100	Coating internal/ external
VRS®-T L_u = 400 mm oder 800 mm								
80	7.6 bzw. 15.4							Epoxy/ Epoxy
100	9.5 bzw. 18.8							
125	12.0 bzw. 25.0							
150	15.6 bzw. 31.0							
200	22.0 bzw. 44.0 [1)]							
VRS®-T L_u = 800 mm								
250	44.6					66.7		Epoxy/ Epoxy
300	55.8			56.8		98.0		
400	81.3				–			
500	104.0							
BLS® L_u = 800 mm								
600	127.6 [2)]				–	–	–	Cement mortar/ zinc + epoxy
700	164.1			–	–	–	–	
800	201.8		219.6	–	–	–	–	
900	240.4		263.2	–	–	–	–	
1,000	283.4	310.4		–	–	–	–	

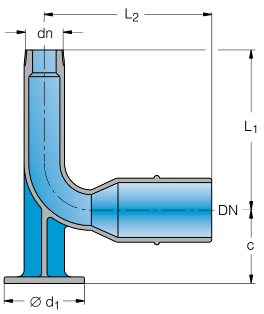
[1)] PFA of 100 with high-pressure lock [2)] Max. PFA of 32

HAS fittings (A fittings)
House service connection fittings with outlet with 2" female thread
to manufacturer's standard



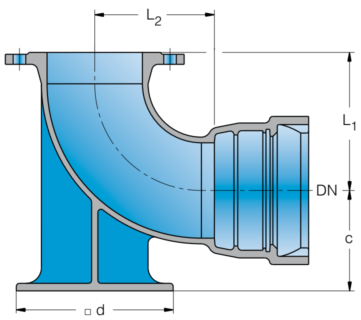
DN	L_u [mm]	l_u [mm]	PFA [bar]	Weight [kg]
VRS®-T HAS-fittings				
80	305	215	100	10.5
100	315	225		13.8
125	325	235		17.8
150	340	250		23.1
200	355	265		34.8
250	370	275		54.0
300	380	285		72.0

ENH fittings
90° duckfoot bends for hydrants with male threaded outlet
to manufacturer's standard



DN	dn ["]	L_1 [mm]	L_2 [mm]	c [mm]	d_1	PFA [bar]	Weight [kg]
VRS®-T ENH-fittings							
80	1.5	240	250	110	120	100	7.3
80	2.0	240	250	110	120	100	7.3

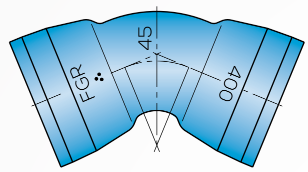
EN fittings
90° duckfoot bends
to manufacturer's standard

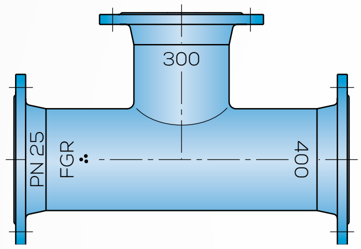


DN	Dimensions [mm]				Weight [kg]			
	L_1	L_2	c	d	PN 10	PN 16	PN 25	PN 40
VRS®-T EN-fittings								
80	165	145	110	180	16.4			
100	180	158	125	200	22.6		–	

Marking of fittings

All fittings produced by member companies of the "Fachgemeinschaft Gussrohrsysteme/European Association for Ductile Iron Pipe Systems (FGR/EADIPS)" carry the "FGR" mark indicating that all the guidelines required for the award of the "FGR Quality Mark" have been complied with.
As well as this, all fittings are marked with their nominal sizes and bends are marked with their respective angles.
Flanged fittings have the pressure ratings PN 16, 25 or 40 cast or stamped onto them. No pressure rating appears on flanged fittings for PN 10 or on any socket fittings.
To identify their material as "ductile cast iron", fittings are marked with three raised dots arranged in a triangle (∴) on their outer surface.
In special cases, there may be further markings which are specified as needing to be applied.





3 - THE NON-POSITIVE LOCKING SYSTEM

3.1 Overview

This Chapter deals only with non-positive locking push-in joints.

Dealt with below are the following non-restrained joints:

- **The TYTON joint (TYT) to DIN 28 603 – DN 80 to DN 1,000**
  The TYTON joint has been the leading joint for pipes and fittings on the international market since 1965. It can be deflected angularly to a maximum of 5°, is resistant to the penetration of roots and is leaktight at any desired internal water pressure.
- The bolted gland joint (STB) to DIN 28 602 – DN 400 to DN 1,000
  Available for certain fittings such as flanged sockets and collars
  Suitable above all for later connections into existing pipelines.

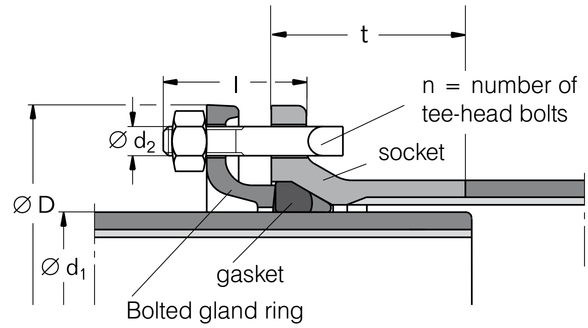
Pipes and fittings with non-positive locking joints are designed primarily for conventional open trench laying.

The sizing of thrust blocks and of the lengths of pipelines needing to be restrained is dealt with in outline in Chapter 8.

PFA – allowable operating pressure

Under EN 545:2010, ductile iron pipe with non-restrained push-in joints (e.g. TYTON® joints) are divided into pressure classes. These pressure classes are also known as C classes. The maximum PFA of a pipe corresponds to its pressure class (e.g. C 50 = PFA of 50 bars). **This applies only to non-restrained pipes.**

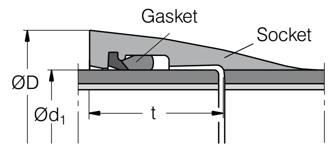
Bolted gland joint (STB)
to DIN 28 602



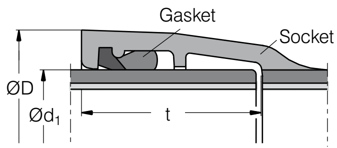
DN	Dimensions [mm]				n	Weight [kg] ~				Max. angular deflection	PFA
	Ø d_1	Ø D	Ø d_2	l		t	Bolted gland ring	Gasket	Tee-head bolt		
400	429	570	M 20	90	12	132	10.6	0.8	5.5	3°	25
500	532	680	M 20	100	16	138	15.0	1.1	7.7		25
600	635	790	M 20	100	16	143	20.9	1.5	7.7	2°	25
700	738	900	M 20	110	20	149	27.2	1.9	10.0		16
800	842	1,010	M 20	110	24	154	34.1	2.3	12.0	1.5°	16
900	945	1,125	M 20	120	24	160	44.0	2.9	12.5		16
1,000	1,048	1,250	M 24	120	24	165	56.9	3.5	18.5		16

PFA: allowable operating pressure in bars; may be lower depending on the pressure class
PMA = 1.2 x PFA; PEA = 1.2 x PFA + 5

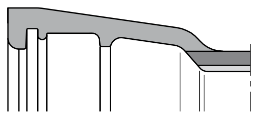
TYTON® push-in joint
to DIN 28 603



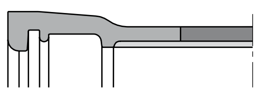
DN 80 to DN 600



DN 700 to DN 1000



Socket for fittings

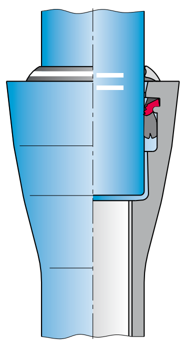


Socket for flanged sockets

DN	Dimensions [mm]			Weight [kg] ~				Max. angular deflection
					Socket			
	Ø d_1	Ø D[1)]	t	Pipe	Fitting	Flanged socket	Gasket	
80	98	142	84	3.4	2.8	2.4	0.13	5°
100	118	163	88	4.3	3.3	3.1	0.16	
125	144	190	91	5.7	4.5	4.0	0.19	
150	170	217	94	7.1	5.6	4.9	0.22	
200	222	278	100	10.3	8.0	7.1	0.37	
250	274	336	105	14.2	11.1	9.7	0.48	
300	326	385	110	18.6	14.3	12.5	0.67	
350	378	448	110	23.7	17.1	15.2	0.77	4°
400	429	500	110	29.3	20.8	18.6	1.1	
500	532	607	120	42.3	31.7	27.6	1.6	3°
600	653	732*	120	59.3	42.3	36.2	2.3	
700	738	849*	197	79.1	71.2	59.1	4.3	
800	842	960*	209	102.6	95.4	79.8	5.2	
900	945	1,073*	221	129.9	150.3	122.7	6.3	
1,000	1,048	1,188*	233	161.3	186.9	152.1	8.3	

*1) Richtwert; *kleinere D auf Anfrage*

BRS® joint

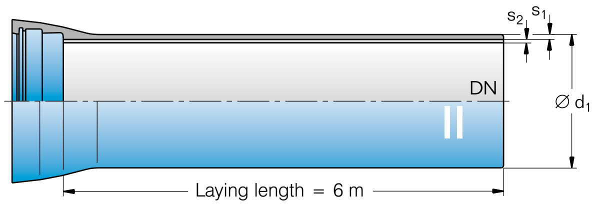


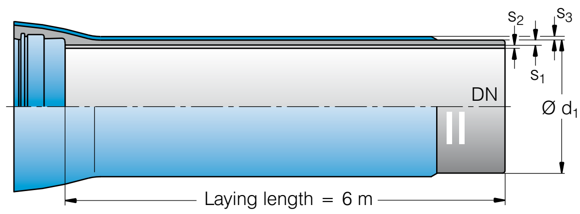
DN	PFA	Max. angular deflection	Weight [kg] ~ Gasket
80	32	3°	0.15
100	32	3°	0.17
125	25	3°	0.20
150	25	3°	0.24
200	25	3°	0.41
250	25	3°	0.56
300	25	3°	0.93
350	25	3°	1.15
400	16	2°	1.44
500	16	2°	2.20
600	10	2°	2.93

PFA: allowable operating pressure in bars; may be lower depending on the pressure class
PMA = 1.2 x PFA; PEA = 1.2 x PFA + 5

3.2 Tyton® pipes – 6 m laying length

TYTON® pipes – 6 m laying length
DN 80 to DN 1000
to EN 545:2010





External coatings
- cement mortar coating (TRM ZMU)
- zinc coating with finishing layer
- zinc-aluminium coating with finishing layer (TRM Zinc PLUS)
- WKG coating

Internal coatings
- blast furnace cement
- high-alumina cement

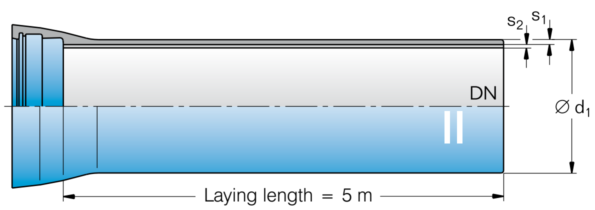
For notes on the fields of use of the coatings see Chapter 5

DN	d_1 [mm]	C 25		C 30		C 40			C 50			C 64			C 100			Weight ZMU [kg]	s_2	s_3
		s_1	Weight [kg]	s_1	Weight [kg]	s_1	Weight [kg]	PFA (BRS)	s_1	Weight [kg]	PFA (BRS)	s_1	Weight [kg]	PFA (BRS)	s_1	Weight [kg]	PFA (BRS)			
80	$98^{+1}_{-2.7}$								3.5	79.1	16				4.7 [3)]	94.0	32	19.5	4	
100	$118^{+1}_{-2.8}$								3.5	98.7	16				4.7 [3)]	118.4	32	24.0	4	
125	$144^{+1}_{-2.8}$								3.5	125.2	16	4.8 [3)]	150.4	25	5.0	155.5	25	28.0	4	
150	$170^{+1}_{-2.9}$								3.7 [1)]	154.3	16	4.7 [2)] 5.0 [3)]	175.4 183.8	25	5.9	205.8	25	33.0	4	
200	$222^{+1}_{-3.0}$								3.9	209.1	16	5.0 [2] 5.5 [3)]	245.4 259.2	25	7.7	323.1	25	43.0	4	
250	$274^{+1}_{-3.1}$					4.2 [1)]	272.9	16	5.2 [2)]	316.3	25	6.1	347.4	25	9.5	468.1	25	52.0	4	
300	$326^{+1}_{-3.3}$					4.6	351.8	16	5.7 [2)]	410.0	25	7.3	475.8	25				63.0	4	5
350	$378^{+1}_{-3.4}$			4.7	416.1	6.0 [2)]	496.0	25	6.6	524.8	25	8.5	615.6	25				72.0	5	
400	$429^{+1}_{-3.5}$			4.8	513.3	6.4 [2)]	601.3	16	7.5	661.5	16	9.6	775.4	16				82.0	5	
500	$532^{+1}_{-3.8}$			5.6	707.4	7.5	837.4	16	9.3	959.7	16							101.0	5	
600	$635^{+1}_{-4.0}$			6.7	982.1	8.9	1.162.0	10										121.0	5	
700	$738^{+1}_{-4.3}$	6.8	1,173.3	7.8	1,268.8	10.4	1.516.0	–										140.0	6	
800	$842^{+1}_{-4.5}$	7.5	1,479.1	8.9	1,631.8													160.0	6	
900	$945^{+1}_{-4.8}$	8.4	1,798.4	10.0	1,994.4													179.0	6	
1,000	$1{,}048^{+1}_{-5.0}$	9.3	2,151.3	11.1	2,395.9													199.0	6	

[1)] C40 under EN545:2006; [2)] K9 under EN 545:2006; [3)] K10 under EN 545:2006
s_1) Minimum wall thickness in mm; s_2) Nominal thickness of cement mortar lining in mm; s_3) Nominal thickness of ZMU in mm; Weight of the pipes = theoretical figures in kg inc. cement mortar lining, zinc-aluminium coating and epoxy finishing layer; Weight of ZMU = additional weight of ZMU in kg;
The maximum PFA of a pipe corresponds to its pressure class (e.g. C 50 = PFA of 50 bars); PFA (BRS) = allowable operating pressure in bars with BRS gasket;
PMA = 1.2 x PFA; PEA = 1.2 x PFA + 5;
Inside green frames: all coatings are possible; outside: only Zinc Plus

3.3 Tyton® pipes – 5 m laying length

TYTON® pipes – 5 m laying length
DN 80 to DN 500
to EN 545:2010



External coatings
- Zinc coating with PUR-longlife finishing layer
- Zinc coating with PUR-TOP finishing layer
- WKG coating
- Other coatings up on request

Internal coatings
- Portland cement
- High-alumina cement
- Other coatings up on request

For notes on the fields of use of the coatings see Chapter 5

DN	d_1 [mm]	C 30		C 40			C 50			C 64			C 100			s_2
		s_1	Weight [kg]	s_1	Weight [kg]	PFA (BRS)	s_1	Weight [kg]	PFA (BRS)	s_1	Weight [kg]	PFA (BRS)	s_1	Weight [kg]	PFA (BRS)	
80	$98^{+1}_{-2.7}$												4.7 [3)]	79.5	32	4
100	$118^{+1}_{-2.8}$												4.7 [3)]	97.3	32	4
125	$144^{+1}_{-2.8}$									4.8 [3)]	123.8	25	5.0	126.7	25	4
150	$170^{+1}_{-2.9}$									4.7 [2)]	146.3	25	5.9	167.1	25	4
200	$222^{+1}_{-3.0}$									5.0 [2)]	202.5	25	7.7	264.1	25	4
250	$274^{+1}_{-3.1}$			3.9	215.1		5.2 [2)]	260.1	25	6.1	285.9	25	9.5	382.0	25	4
300	$326^{+1}_{-3.3}$			4.6	293.5		5.7 [2)]	331.6	25	7.3	386.4	25				4
400	$429^{+1}_{-3.5}$	4.8	423.8	6.4 [2)]	497.2	16	7.5	547.3	16	9.6	642.3	16				5
500	$532^{+1}_{-3.8}$	5.6	585.3	7.5 [2)]	693.7	16	9.3	795.6	16							5

[1)] C40 under EN545:2006; [2)] K9 under EN 545:2006; [3)] K10 under EN 545:2006
s_1) Minimum wall thickness in mm; s_2) Nominal thickness of cement mortar lining in mm
Weight = theoretical figures in kg inc. cement mortar lining, zinc coating and polyurethane (PUR) finishing layer; The maximum PFA of a pipe corresponds to its pressure class (e.g. C 50 = PFA of 50 bars); PFA (BRS) = allowable operating pressure in bars with BRS gasket;
PMA = 1.2 x PFA; PEA = 1.2 x PFA + 5;

3.4 Fittings with non-positive locking joints

Compatibility

Except where otherwise noted, all fittings comply with DIN 28 603 (TYTON®). This means that TYTON®-SIT-PLUS® gaskets can also be inserted in their sockets, thus producing the friction locking BRS® push-in joint.

Laying lengths

Except where otherwise noted, the laying lengths Lu of fittings conform to the A series in EN 545.

Flanged fittings (see Chapter 4)

When ordering flanged fittings, it is essential to give the PN pressure rating required. Accessories such as hex-head bolts, nuts, washers and gaskets must be obtained from specialist suppliers.

Coating (see Chapter 5)

Except where otherwise specified, all the fittings shown below are provided internally and externally with an epoxy coating at least 250 µm thick.
The coating complies with EN 14 901 and meets the requirements of the Quality Association for the Heavy Duty Corrosion Protection of Powder Coated Valves and Fittings (GSK).

All fittings to EN 545, Annex D.2.3., can thus be installed in soils of any desired corrosiveness.

RAL GÜTEZEICHEN
SCHWERER KORROSIONSSCHUTZ
VON ARMATUREN UND FORMSTÜCKEN

Allowable operating pressure (PFA)

(except where otherwise specified)

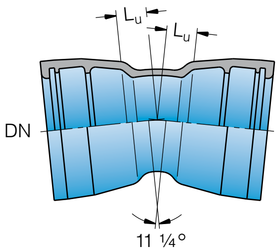
<table>
<tr><th rowspan="2">DN</th><th colspan="4">PFA [1] [bar]</th></tr>
<tr><th>TYTON®</th><th>BRS [2]</th><th>STB</th><th>Flange</th></tr>
<tr><td>80</td><td rowspan="2">100</td><td rowspan="2">32</td><td rowspan="8">–</td><td rowspan="15">PFA = PN</td></tr>
<tr><td>100</td></tr>
<tr><td>125</td><td rowspan="3">64</td><td rowspan="6">25</td></tr>
<tr><td>150</td></tr>
<tr><td>200</td></tr>
<tr><td>250</td><td rowspan="3">50</td></tr>
<tr><td>300</td></tr>
<tr><td>350</td></tr>
<tr><td>400</td><td rowspan="3">40</td><td rowspan="2">16</td><td rowspan="3">25</td></tr>
<tr><td>500</td></tr>
<tr><td>600</td><td>10</td></tr>
<tr><td>700</td><td rowspan="4">30</td><td rowspan="4"></td><td rowspan="4">16</td></tr>
<tr><td>800</td></tr>
<tr><td>900</td></tr>
<tr><td>1,000</td></tr>
</table>

1) PFA: allowable operating pressure in bars. PMA = 1.2 x PFA; PEA = 1.2 x PFA + 5
2) PFA depends on the C class of the pipe used, see p. 27

Scope of supply

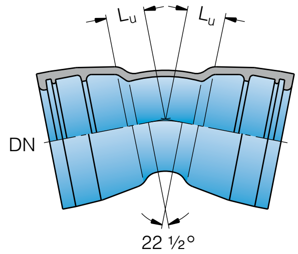
The socket fittings supplied include the gaskets required and with screwed socket joints and bolted gland joints they include the additional components required (slide rings, screw rings, bolted gland rings, tee-head bolts). For flanged joints, the gaskets, bolts, nuts and washers are not included in the scope of supply.

Socket fittings
MMK 11 fittings
11¼° double socket bends
to EN 545



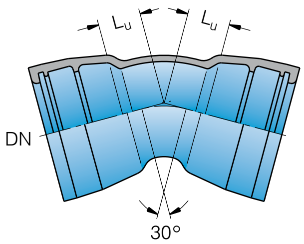
DN	Dimensions [mm]	PFA [bar]	Weight [kg] ~
	L_u		
80	30	100	7.5
100	30		8.5
125	35	64	12.8
150	35		16.5
200	40		24.9
250	50	50	34.2
300	55		43.0
350	60		60.5
400	65	40	70.9
500	75		100.0
600	85		140.0
700	95	30	190.7
800	110		271.2
900	120		393.5
1,000	130		495.7

MMK 22 fittings
22½° double socket bends
to EN 545



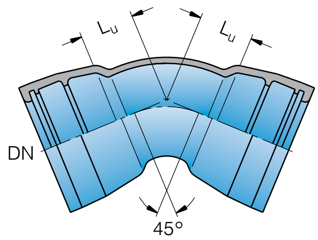
DN	Dimensions [mm]	PFA [bar]	Weight [kg] ~
	L_u		
80	40	100	7.7
100	40		9.4
125	50	64	13.3
150	55		17.5
200	65		21.0
250	75	50	30.7
300	85		40.4
350	95		64.6
400	110	40	80.2
500	130		100.4
600	150		140.5
700	175	30	185.7
800	195		315.8
900	220		456.0
1,000	240		575.9

MMK 30 fittings
30° double socket bends
to DIN 28 650



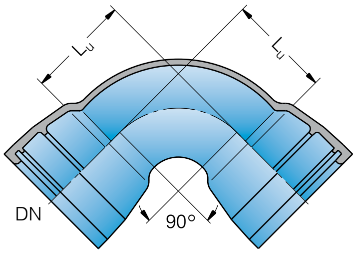
DN	Dimensions [mm]	PFA [bar]	Weight [kg] ~
	L_u		
80	45	100	7.7
100	50		9.7
125	55	64	14.0
150	65		18.0
200	80		22.0
250	95	50	32.0
300	110		43.2
350	125		71.5
400	140	40	85.3
500	180		109.2
600	200		155.9
700	230	30	275.3
800	260		345.9
900	290		496.3
1,000	320		630.3

MMK 45 fittings
45° double socket bends
to EN 545



DN	Dimensions [mm]	PFA [bar]	Weight [kg] ~
	L_u		
80	55	100	8.1
100	65		10.0
125	75	64	14.1
150	85		18.4
200	110		24.6
250	130	50	35.7
300	150		48.7
350	175		76.9
400	195	40	86.0
500	240		127.0
600	285		183.6
700	330	30	296.7
800	370		406.1
900	415		577.9
1,000	460		737.2

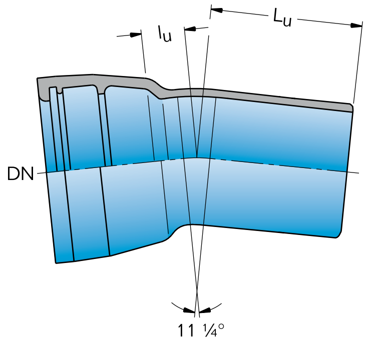
MMQ fittings
90° double socket bends
to EN 545



DN	Dimensions [mm] L_u	PFA [bar]	Weight [kg] ~
80	100	100	8.2
100	120		10.6
125	145	64	15.6
150	170		19.6
200	220		30.9
250	270	50	50.6
300	320		69.1
350 [1]	410		96.8
400 [1]	430	40	119.0
500 [1]	550		199.4
600 [1]	645		365.0
700 [1]	720	30	449.0
800 [1]	800		613.0

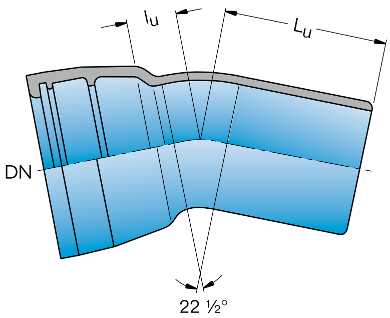
[1] *To manufacturer's standard*

MK 11 fittings
11¼° single socket bends
to manufacturer's standard



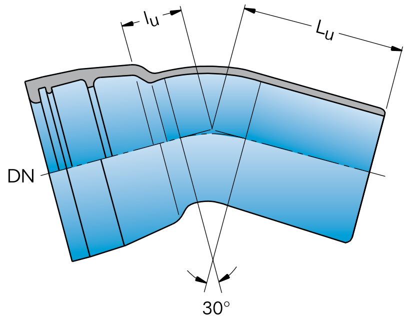
DN	Dimensions [mm] L_u	l_u	PFA [bar]	Weight [kg] ~
80	240	30	100	7.6
100	243	33		9.8
125	261	36	64	14.0
150	284	40		18.0
200	311	46		27.0
250	255	50	50	37.8
300	260	60		47.0
350	235	65		46.0
400	238	70	40	66.9
500	250	85		83.2
600	287	95		163.0
700	340	110	30	249.0
800	375	125		286.0

MK 22 fittings
22½° single socket bends
to manufacturer's standard



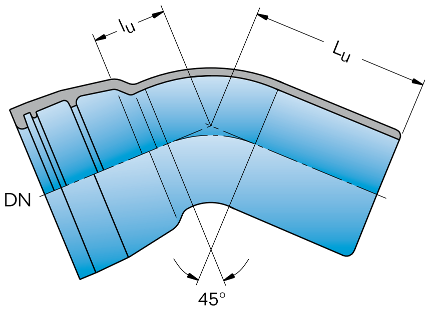
DN	Dimensions [mm] L_u	l_u	PFA [bar]	Weight [kg] ~
80	248	38	100	8.1
100	253	43		9.7
125	274	49	64	15.1
150	299	55		18.4
200	331	66		29.2
250	260	75	50	37.8
300	265	90		50.2
350	270	100		52.0
400	278	110	40	76.7
500	300	135		97.0
600	357	155		163.0
700	420	190	30	336.0
800	455	205		460.0

MK 30 fittings
30° single socket bends
to manufacturer's standard



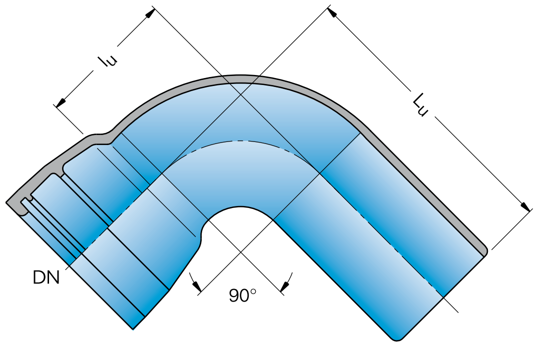
DN	Dimensions [mm] L_u	l_u	PFA [bar]	Weight [kg] ~
80	253	44	100	7.4
100	260	50		10.8
125	283	57	64	15.1
150	309	65		20.0
200	345	80		30.8
250	270	95	50	38.9
300	280	110		52.9
350	295	125		56.0
400	308	140	40	76.5
500	335	170		107.0
600	412	200		178.0
700	480	250	30	286.0
800	510	260		350.0

MK 45 fittings
45° single socket bends
to manufacturer's standard



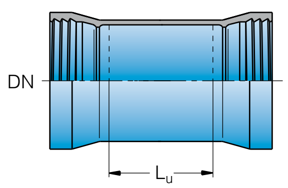
DN	Dimensions [mm]		PFA [bar]	Weight [kg] ~
	L_u	l_u		
80	265	55	100	8.4
100	274	65		10.8
125	301	76	64	16.2
150	331	87		20.5
200	374	109		33.5
250	300	130	50	44.3
300	315	155		59.4
350	345	175		68.0
400	368	200	40	91.0
500	405	240		187.0
600	529	285		250.5
700	610	380	30	441.0
800	625	370		–

MQ fittings
90° single socket bends
to manufacturer's standard



DN	Dimensions [mm]		PFA [bar]	Weight [kg] ~
	L_u	l_u		
80	312	102	100	9.0
100	333	123		11.2
125	374	49	64	18.4
150	419	174		25.4
200	491	226		43.8
250	583	280	50	76.1
300	660	330		83.2
350	580	410		139.0
400	625	430	40	186.3
500	715	550		235.4
600	805	645		314.0
700	900	720	30	473.0
800	1,080	800		644.5

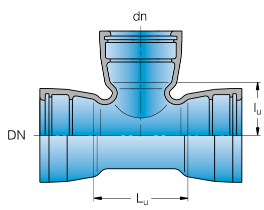
U fittings
Collars
to EN 545



DN	Joint	L_u [mm]	PFA [bar]	Weight [1] [kg]
500	Bolted gland	200	25	119.3
600		210		162.7
700		220	16	210.3
800		230		249.9
900		240		305.0
1,000		250		386.0

[1] Not including screw ring and bolted gland ring of the respective joints

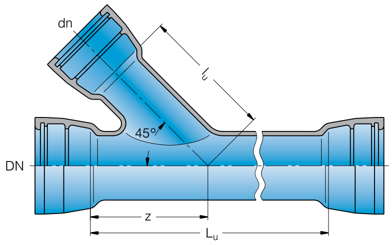
MMB fittings
All-socket tees with 90° branch
to EN 545



DN	dn	L_u [mm]	l_u [mm]	PFA [bar]	Weight [kg]
80	40 [1,2]	170	80	40	10.5
	80		85	64	13.7
100	40 [1,2]	190	90	40	13.6
	80		95	64	14.7
	100				16.6
125	40 [1,2]	170	100	40	15.1
	80		105	64	16.5
	100	195	110		17.8
	125	225	110		19.9
150	40 [1,2]	170	115	40	18.2
	80		120	62	19.9
	100	195			20.9
	150	255	125		25.5
200	40 [1,2]	200	140	40	29.5
	80 [1]		145	50	30.0
	100				31.0
	150	255	150		41.0
	200	315	155		44.6
250	80 [1]	200	170	43	44.4
	100		175		45.3
	125 [1]		175		45.5
	150	260	180		50.4
	200	315	185		54.4
	250	375	190		63.9
300	80 [1]	205	195	40	55.5
	100	205	200		57.0
	150 [1]	320	200		60.7
	200	320	205		64.4
	250 [1]	430	210		79.6
	300	430	215		89.4

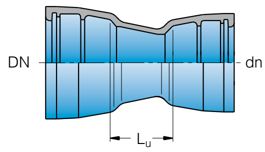
[1] To manufacturer's standard; [2] Screwed socket joint; weight not including screw ring

MMC fittings
All-socket tees with 45° branch
to manufacturer's standard



DN	dn	Dimensions [mm]			max. PFA [bar]	Weight [kg] ~
		L_u	l_u	z		
80	80	270	200	200	16	20.5
100	80	300	250	250	16	23.1
	100					27.9
125	100	350	250	250	16	37.5
	125					38.3
150	80	380	300	300	16	30.3
	100					33.1
	150					35.9
200	100	500	360	360	16	52.2
	150		380	380		57.5
	200					59.8
250	100	600	395	395	16	61.0
	150					64.2
	200		430	430		93.6
	250		460	460		111.9
300	100	700	430	430	16	81.0
	150					84.2
	200		500	500		85.2
	250					117.4
	300		525	525		131.2
350	150	700	470	470	16	143.5
	200		510	510		149.8
	250		530	530		160.5
	300		570	610		165.2
	350	880	690	760		183.0
400	100	440	480	440	16	119.0
	125		490	450		125.6
	150					127.8
	200	640	570	580		144.5
	300	850	650	700		165.6
	400			650		193.0
500	100	450	590	515	16	150.8
	150					160.0
	200	740	620	550		200.6
	250		640	620		209.3
	300		720	680		213.5
	400	850		750		241.0
	500	1,040	845	845		357.0
600	150	750	750	620	16	215.0
	200					218.5
	250		775	680		222.0
	300		800	740		229.5
	400	1,150		765		367.0
	500	1210	920	915		448.0
	600		985	975		471.0
700	200	575	825	675	16	272.0
	300	925	885	810		398.0
	400		940	890		408.5
	500	1,080	1,020	990		596.3
	600	1,380	1,070	1,055		653.0
	700		1,140	1,140		709.0
800	600	1,250	1,150	1,110	16	699.5
	800	1,550	1,275	1,275		964.0

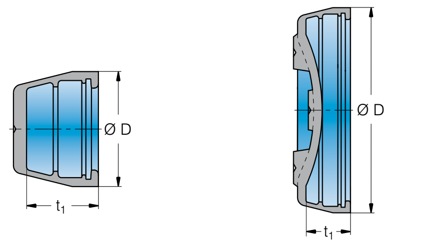
MMR fittings
Double socket tapers
to EN 545



DN	dn	L_u [mm]	max. PFA [bar]	Weight [kg] ~
100	80	90	100	9.0
125	80	140	64	9.9
	100	100		9.8
150	80	190		14.6
	100	150		15.3
	125	100		15.4
200	100	250		18.3
	125	200		18.7
	150	150		18.7
250	125	300	50	30.1
	150	250		33.6
	200	150		33.9
300	150	350		46.6
	200	250		41.9
	250	150		42.8
350	200	360		45.3
	250	260		44.8
	300	160		43.6
400	250	360	40	70.2
	300	260		65.5
	350	160		68.0
500	350	500		138.3
	400	500		146.7
600[1]	400	500		177.8
	500	500		181.8
700[1]	500	500	30	331.5
	600	500		346.2
800	600	480		276.3
	700	280		247.0
900	700	480		363.0
	800	280		340.0
1,000	800	480		453.0
	900	280		442.0

[1] *To manufacturer's standard*

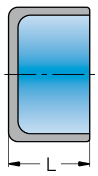
O fittings
Spigot end caps
to manufacturer's standard



DN 80 to DN 250 DN 300 to DN 600

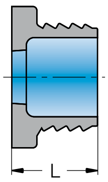
DN	Dimensions [mm]		max. PFA [bar]	Weight [kg] ~
	D	t1		
80	146	84	25	4.5
100	166	88	25	4.8
125	193	91	25	6.0
150	224	94	25	8.0
200	280	100	25	12.0
250	336	105	25	19.0
300	391	110	25	27.0
350	450	110	25	34.0
400	503	110	25	45.0
500	598	120	25	73.0
600	707	120	25	110.0

P fittings
P socket plugs for TYTON® joints and screwed sockets
to manufacturer's standard



DN	Joint	Dimensions [mm] L	max. PFA [bar]	Weight [kg] ~
40	TYT	82	16	1
80	TYT	90		3
100	TYT	98		4
125	TYT	99		6
150	TYT	103		7.5
200	TYT	108		12
250	TYT	120		18
300	TYT	125		25.5
350	TYT	125		37.5
400	TYT	125		46.5
500	TYT	173		80

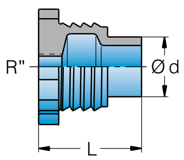
Screw rings for P socket plugs
to manufacturer's standard



DN	Joint	Dimensions [mm] L	Max. PFA [bar]	Weight [kg] ~
40	Screwed socket	65	16	1.6
50	Screwed socket	67		1.8
80	Screwed socket	72		2.9
100	Screwed socket	75		3.4
125	Screwed socket	78		4.4
150	Screwed socket	81		5.5
200	Screwed socket	86		9
250	Screwed socket	92		13
300	Screwed socket	94		17.5

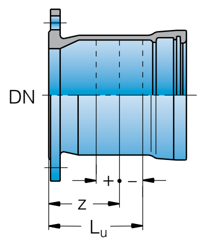
Screw rings for P socket plugs are used in conjunction with P socket plugs for closing off screwed socket joints.

PX fittings
Screw plugs for screwed socket joints
to manufacturer's standard



DN	Joint	Dimensions [mm] L	d	R	Max. PFA [bar]	Weight [kg] ~
40	Screwed socket	97	56	¾"–2"	16	2

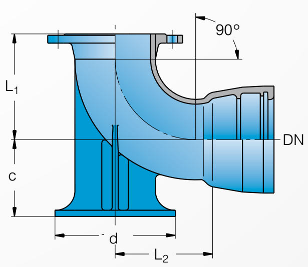
Flanged socket fittings
EU fittings
Flanged sockets
to EN 545



<table>
<tr><th rowspan="2">DN</th><th rowspan="2">Joint</th><th colspan="3">Dimensions [mm]</th><th colspan="4">Weight [kg] [2] ~</th></tr>
<tr><th>L_u</th><th>z[1]</th><th>+/-</th><th>PN10</th><th>PN16</th><th>PN25</th><th>PN40</th></tr>
<tr><td rowspan="2">80</td><td rowspan="2">TYT</td><td rowspan="2">130</td><td rowspan="2">86</td><td rowspan="2">40</td><td colspan="4">7.5</td></tr>
<tr><td colspan="2">7.8</td><td colspan="2">a.A.</td></tr>
<tr><td rowspan="2">100</td><td rowspan="2">TYT</td><td rowspan="2">130</td><td rowspan="2">87</td><td rowspan="2">40</td><td colspan="2">10.2</td><td colspan="2">10.7</td></tr>
<tr><td colspan="2">10.2</td><td colspan="2">a.A.</td></tr>
<tr><td rowspan="2">125</td><td rowspan="2">TYT</td><td rowspan="2">135</td><td rowspan="2">91</td><td rowspan="2">40</td><td colspan="2">11.4</td><td>12</td><td>13.2</td></tr>
<tr><td colspan="2">12.8</td><td colspan="2">a.A.</td></tr>
<tr><td rowspan="2">150</td><td rowspan="2">TYT</td><td rowspan="2">135</td><td rowspan="2">92</td><td rowspan="2">40</td><td colspan="2">15.5</td><td>18.5</td><td>19.5</td></tr>
<tr><td colspan="2">15.5</td><td colspan="2">a.A.</td></tr>
<tr><td rowspan="2">200</td><td rowspan="2">TYT</td><td rowspan="2">140</td><td rowspan="2">97</td><td rowspan="2">40</td><td>19.8</td><td>19.8</td><td>22</td><td>26.5</td></tr>
<tr><td>20.5</td><td>20.5</td><td colspan="2">a.A.</td></tr>
<tr><td>250</td><td>TYT</td><td>145</td><td>102</td><td>40</td><td>31.7</td><td>31.7</td><td>33.7</td><td>40.2</td></tr>
<tr><td>300</td><td>TYT</td><td>150</td><td>107</td><td>40</td><td>44</td><td>44</td><td>49.8</td><td>54</td></tr>
<tr><td>350</td><td>TYT</td><td>155</td><td>112</td><td>40</td><td>52</td><td>56</td><td>60</td><td>70.5</td></tr>
<tr><td rowspan="2">400</td><td>TYT</td><td rowspan="2">160</td><td rowspan="2">117</td><td rowspan="2">40</td><td>63.6</td><td>67.6</td><td>83.6</td><td>105.6</td></tr>
<tr><td>STB</td><td>68.1</td><td>71.6</td><td colspan="2">a.A.</td></tr>
<tr><td rowspan="2">500</td><td>TYT</td><td rowspan="2">170</td><td rowspan="2">127</td><td rowspan="2">40</td><td>92.3</td><td>105.8</td><td>115.8</td><td>126.8</td></tr>
<tr><td>STB</td><td>99.3</td><td>115.8</td><td colspan="2">a.A.</td></tr>
<tr><td rowspan="2">600</td><td>TYT</td><td rowspan="2">180</td><td rowspan="2">137</td><td rowspan="2">40</td><td>118.6</td><td>141.6</td><td>143.1</td><td>184.1</td></tr>
<tr><td>STB</td><td>138.1</td><td>159.6</td><td colspan="2">a.A.</td></tr>
<tr><td rowspan="2">700</td><td>TYT</td><td rowspan="2">190</td><td rowspan="2">147</td><td rowspan="2">40</td><td>171.8</td><td>185.2</td><td>195</td><td rowspan="2">–</td></tr>
<tr><td>STB</td><td>186</td><td>186</td><td>a.A.</td></tr>
<tr><td rowspan="2">800</td><td>TYT</td><td rowspan="2">200</td><td rowspan="2">157</td><td rowspan="2">40</td><td>236.2</td><td>256.2</td><td>276.2</td><td rowspan="2">–</td></tr>
<tr><td>STB</td><td>238.5</td><td>250</td><td>a.A.</td></tr>
<tr><td rowspan="2">900</td><td>TYT</td><td rowspan="2">210</td><td rowspan="2">167</td><td rowspan="2">40</td><td>274.2</td><td>271.2</td><td>345</td><td rowspan="2">–</td></tr>
<tr><td>STB</td><td>235.2</td><td>256.2</td><td>a.A.</td></tr>
<tr><td rowspan="2">1,000</td><td>TYT</td><td rowspan="2">220</td><td rowspan="2">177</td><td rowspan="2">40</td><td>332.1</td><td>347.1</td><td>442.1</td><td rowspan="2">–</td></tr>
<tr><td>STB</td><td>312.7</td><td>362.7</td><td>a.A.</td></tr>
</table>

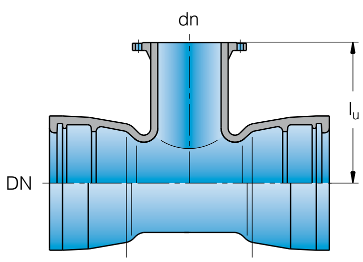
[1] Guideline dimension for installation, [2] Weight of screwed socket joint or bolted gland joint not including screw ring or bolted gland ring respectively

EN fittings
90° duckfoot bends
to DIN 28 650



<table>
<tr><th rowspan="2">DN</th><th colspan="4">Dimensions [mm]</th><th colspan="4">Weight [kg] ~</th></tr>
<tr><th>L_1</th><th>L_2</th><th>c</th><th>□ d</th><th>PN10</th><th>PN16</th><th>PN25</th><th>PN40</th></tr>
<tr><td>80</td><td>165</td><td>145</td><td>110</td><td>180</td><td colspan="4">15.3</td></tr>
<tr><td>100</td><td>180</td><td>158</td><td>125</td><td>200</td><td colspan="2">18.4</td><td colspan="2">18.4</td></tr>
</table>

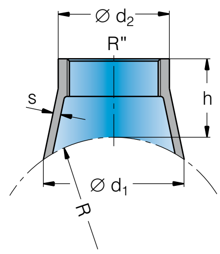
MMA fittings
Double socket tees with flanged branch
to EN 545



DN	dn	Dimensions [mm]		Weight [kg] ~			
		L_u	l_u	PN10	PN16	PN25	PN40
80	40[1)]	170	155	10.8			
	50[1)]		160	11.4			
	80		165	12.9			
100	40[1)]	170	170	12.6			
	50[1)]		170	13.2			
	80		175	14.5			
	100	190	180	15.8		16.3	
125	40[1)]	170	185	16			
	80		190	18			
	100	195	195	19.3		19.8	
	125	255	200	21.6		22.1	23.6
150	40[1)]	170	195	19.2			
	50[1)]		200	19.9			
	80		205	21.3			
	100	195	210	22.7		23.2	
	150	255	220	27.4		29.4	30.9
200	40[1)]	175	230	26.7			
	50[1)]		230	28			
	80		235	28.6			
	100	200	240	30.4		30.9	
	150	255	250	36.1		37.1	39.1
	200	315	260	42.2	41.7	43.7	49.2
250	80	180	265	37.9			
	100	200	270	39.7		40.2	
	150	260	280	46.3		47.3	49.3
	200	315	290	52.9	52.9	54.9	60.4
	250	375	300	61	60.5	64.5	74.5
300	80	180	295	47.2			
	100	205	300	50		50.5	
	150	260	310	57		58	60
	200	320	320	65	65	67	72.5
	300	435	340	83.6	83.1	88.6	104.6
350	100	205	330	59.3			59.8
	200	325	350	77.2	76.7	79.2	84.2
	350	495	380	106	109.6	117.6	138.6
400	80	185	355	67.8			
	100	210	360	71.4		71.9	
	150	270	370	81.4		82.4	
	200	325	380	91.1	90.6	92.6	98.1
	300	440	400	113.5	113.5	118.5	134.5
	400	560	420	135.6	140.6	152.6	185.6
500	80[1)]	215	415	103			
	100		420	104		104	
	150[1)]	330	430	126		128	
	200		440	127.9	127.9	129.9	134.9
	250[1)]	450	450	157	156	161	173
	300[1)]		460	156.7	155.7	161.7	176.7
	350[1)]	565	470	182	188	199	230
	400		480	182.5	188.5	199.5	233.5
	500	680	500	212.1	227.1	239.1	273.1
600	80[1)]	340	475	163			
	100[1)]		480	164		165	
	150[1)]		490	166		167	168
	200	340	500	168.5	168.5	170.5	175.5
	250[1)]	570	510	224	224	228	238
	300[1)]		520	230	230	235	251
	350[1)]		530	233	236	245	266
	400		540	233.3	239.3	250.3	284.3
	500[1)]	800	560	303	317	327	361
	600		580	308.7	335.7	349.7	401.7
700	80[1)]	345	505	250			-
	100		510	250		250	
	150[1)]		520	262		263	
	200		525	255.3	255.3	257.3	
	300[1)]	375	540	327	327	343	
	400		555	386.7	392.7	403.7	
	500[1)]	925	570	432	446	480	
	600[1)]	925	585	457	481	502	
	700	925	600	481	496	531	
800	100[1)]	350	570	325		326	-
	150[1)]	303	580	316		318	
	200	350	585	316.9	316.9	318.9	
	250[1)]	360		350	349	352	
	300[1)]	580	600	417	417	422	
	400		615	405.4	411.4	422.4	
	500[1)]	1,045	630	590	605	617	
	600		345	579	606	620	
	800		675	612	611	680	

[1)] *To manufacturer's standard*

Miscellaneous
Weld-on connections
for ductile iron pipes
Straight connections with female thread



Nominal size of connection	Radius	For pipes of nominal sizes	Dimensions [mm]				Weight
R"	R	DN	Ø d_1	Ø d_2	s	h	[kg] ~
2"	98	150-200	90	71	8	50	0.7

R has to be adapted for pipes of other nominal sizes (DN's)

Marking of fittings

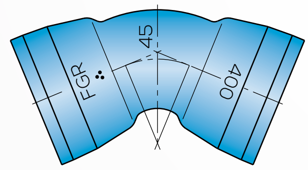
All fittings produced by member companies of the "Fachgemeinschaft Gussrohrsysteme/European Association for Ductile Iron Pipe Systems (FGR/EADIPS)" carry the "FGR" mark indicating that all the guidelines required for the award of the "FGR Quality Mark" have been complied with.

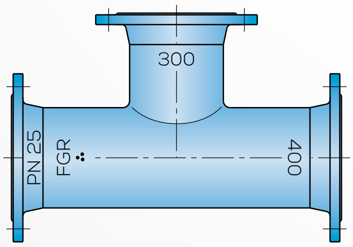
As well as this, all fittings are marked with their nominal sizes and bends are marked with their respective angles.

Flanged fittings have the pressure ratings PN 16, 25 or 40 cast or stamped onto them. No pressure rating appears on flanged fittings for PN 10 or on any socket fittings.

To identify their material as "ductile cast iron", fittings are marked with three raised dots arranged in a triangle (∴) on their outer surface.

In special cases, there may be further markings which are specified as needing to be applied.





4 - FLANGED JOINTS, PIPES AND FITTINGS

Introduction

The flanged joints described in this Chapter comply with EN 1092-2. The flanges may be integrally cast, bolted on or welded on.

Regardless of the material of which they are made, all flanges of the same DN and the same PN can be combined with one another. Shown on the following pages are flanged joints of the PN 10, PN 16, PN 25 and PN 40 pressure ratings.

PN 63 and PN 100 flanges are also possible. For further information on them see our leaflet entitled "Ductile iron pipe systems for Snow-making systems".

Fields of use/advantages

Flanged joints are restrained joints. Their primary field of use is above-ground pipeline laying, equipment in manholes, and building services. The standardised hole patterns also allow them to be used for transitions between different materials.

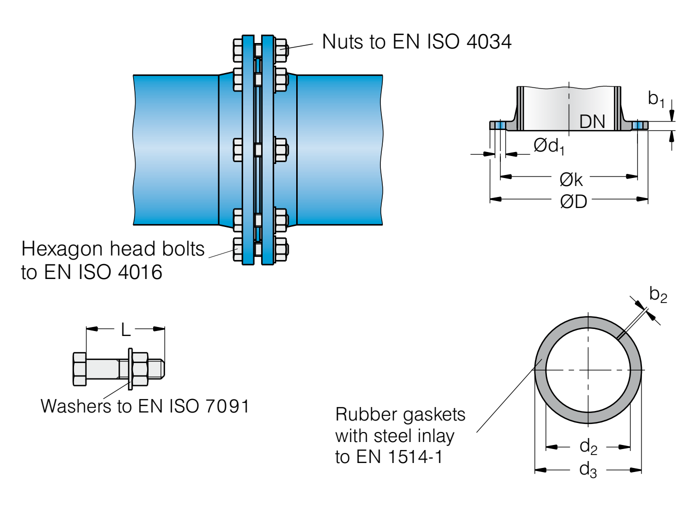
When buried pipelines are laid, flanges are used above all for the installation of shut-off devices.

PFA – allowable operating pressure

- the stated PN defines the allowable operating pressure (PFA)
- PMA = 1.2 x PFA (allowable maximum operating pressure for a short period, e.g. the period of a pressure surge)
- PEA = 1.2 X PFA + 5 (allowable site test pressure).

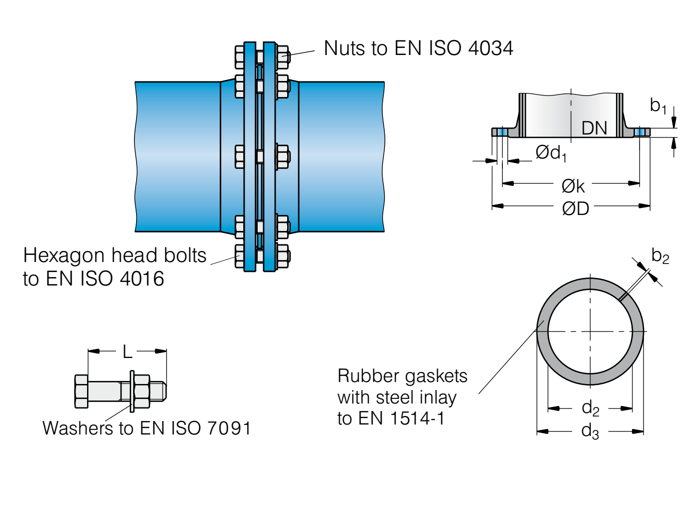
4.1 Flanged joints

PN 10 flanged joints
to EN 1092-2
Bolts, nuts, washers and gaskets should be obtained from other suppliers.



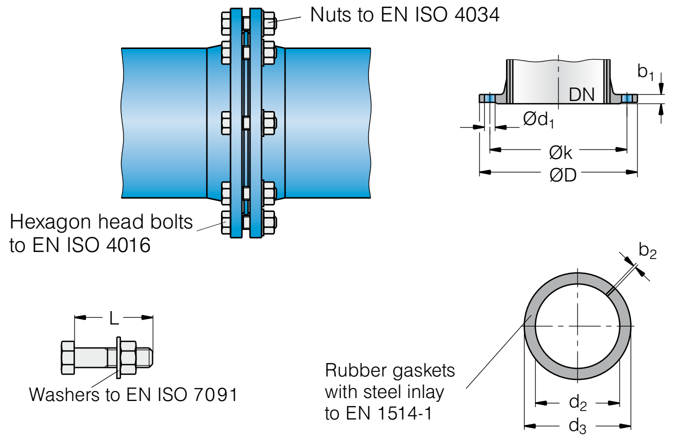
DN	Dimensions [mm]							Bolts		
	Flanges				Gasket					
	Ø D	b_1	Ø k	Ø d_1	d_2	d_3	b_2	Number	Thread	L
DN 40 to DN 150 are as for PN 16										
200	340	20	295	23	220	273	6	8	M 20	80
250	400	22	350	23	273	328	6	12	M 20	90
300	455	24.5	400	23	324	378	6	12	M 20	90
350	505	24.5	460	23	368	438	7	16	M 20	90
400	565	24.5	515	28	420	489	7	16	M 24	100
500	670	26.5	620	28	520	594	7	20	M 24	100
600	780	30	725	31	620	695	7	20	M 27	110
700	895	32.5	840	31	720	810	8	24	M 27	120
800	1,015	35	950	34	820	917	8	24	M 30	120
900	1,115	37.5	1,050	34	920	1,017	8	28	M 30	130
1,000	1,230	40	1,160	37	1,025	1,124	8	28	M 33	140

PN 16 flanged joints
to EN 1092-2
Bolts, nuts, washers and gaskets should be obtained from other suppliers.



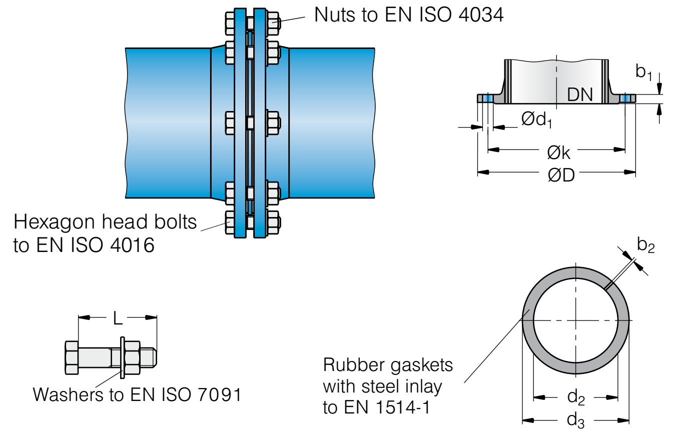
DN	Dimensions [mm]							Bolts		
	Flanges				Gasket					
	Ø D	b_1	Ø k	Ø d_1	d_2	d_3	b_2	Number	Thread	L
DN 40 to DN 80 are as for PN 25										
100	220	19	180	19	115	162	5	8	M 16	80
125	250	19	210	19	141	192	5	8	M 16	80
150	285	19	240	23	169	218	5	8	M 20	80
200	340	20	295	23	220	273	6	12	M 20	80
250	400	22	355	28	273	329	6	12	M 24	90
300	455	24.5	410	28	324	384	6	12	M 24	100
350	520	26.5	470	28	368	444	7	16	M 24	100
400	580	28	525	31	420	495	7	16	M 27	110
500	715	31.5	650	34	520	617	7	20	M 30	120
600	840	36	770	37	620	734	7	20	M 33	130
700	910	39.5	840	37	720	804	8	24	M 33	140
800	1,025	43	950	41	820	911	8	24	M 36	150
900	1,125	46.5	1,050	41	920	1,011	8	28	M 36	160
1,000	1,255	50	1,170	44	1,025	1,128	8	28	M 39	170

PN 25 flanged joints
to EN 1092-2
Bolts, nuts, washers and gaskets
should be obtained from other suppliers.



DN	Dimensions [mm]							Bolts		
	Flanges				Gasket					
	Ø D	b_1	Ø k	Ø d_1	d_2	d_3	b_2	Number	Thread	L
DN 40 to DN 100 are as for PN 40										
125	270	19	220	28	141	194	4.5	8	M 24	90
150	300	20	250	28	169	224	5	8	M 24	90
200	360	22	310	28	220	284	6	12	M 24	90
250	425	24.5	370	31	273	340	6	12	M 27	110
300	485	27.5	430	31	324	400	6	16	M 27	110
350	555	30	490	34	368	457	7	16	M 30	110
400	620	32	550	37	420	514	7	16	M 33	120
500	730	36.5	660	37	520	624	7	20	M 33	130
600	845	42	770	40	620	731	7	20	M 36	150
700	960	46.5	875	43	720	833	8	24	M 39	160
800	1,085	51	990	49	820	942	8	24	M 45	180
900	1,185	55.5	1,090	49	920	1,042	8	28	M 45	180
1,000	1,320	60	1,210	56	1,025	1,154	8	28	M 52	200

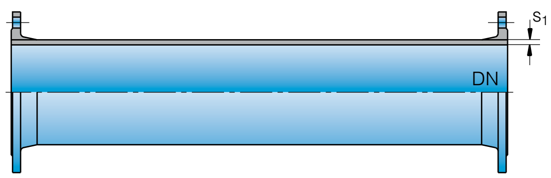
PN 40 flanged joints
to EN 1092-2
Bolts, nuts, washers and gaskets
should be obtained from other suppliers.



DN	Dimensions [mm]							Bolts		
	Flanges				Gasket					
	Ø D	b_1	Ø k	Ø d_1	d_2	d_3	b_2	Number	Thread	L
40	150	19	110	19	49	92	5.5	4	M 16	70
50	165	19	125	19	61	107	5.5	4	M 16	70
65	185	19	145	19	77	127	5.5	8	M 16	70
80	200	19	160	19	89	142	5.5	8	M 16	80
100	235	19	190	23	115	168	8	8	M 20	80
125	270	23.5	220	28	141	194	8	8	M 24	90
150	300	26	250	28	169	224	8	8	M 24	100
200	375	30	320	31	220	290	8	12	M 27	110
250	450	34.5	385	34	273	352	8	12	M 30	120
300	515	39.5	450	34	324	417	8	16	M 30	130
350	580	44	510	37	368	474	8	16	M 33	150
400	660	48	585	41	420	546	8	16	M 36	160
500	755	52	670	44	520	628	10	20	M 39	170
600	890	58	795	50	620	747	10	20	M 45	190

4.2 Ductile iron flanged pipes

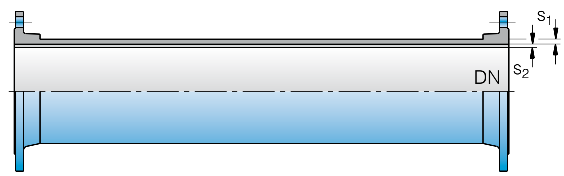
PN 10, PN 16 and PN 25 double-flanged pipes
PN 10, PN 16 u. PN 25
to EN 545
with integral flanges (type 21) to EN 1092-2



External protection: epoxy
Internal protection: epoxy

DN	Dimensions			Masse [kg] ~			
	[mm]		[m]	1 m of pipe without flange	One flange		
	d_1	s_1	Laying length		PN 10	PN 16	PN 25
80	98	7	0.1 - 2.0	16.1	2.8	2.8	2.8
100	118	7.2		20.4	3.3	3.3	3.8
125	144	7.5		26.4	4	4	4.7
150	170	7.8		32.4	5	5	6
200	222	8.4		46.1	6.9	6.7	8.7
250	274	9		61.3	9.8	9.4	13
300	326	9.6		78.1	13	12.6	17.7
350	378	10.2	0.2 - 2.0	96.5	14.7	17.5	25.4
400	429	10.8		116.2	17.2	22.1	33.2
500	532	12		160.6	23.2	37.4	47.2
600	635	13.2		211.3	32.8	57.6	68
700	738	14.4	0.3 - 2.0	268.5	44.3	57.4	–
800	842	15.6	0.4 - 2.0	332.1	58.5	76.8	–
900	945	16.8		401.7	69.6	91.4	–
1,000	1,048	18	0.4 - 3.0	477.7	87.6	127	–

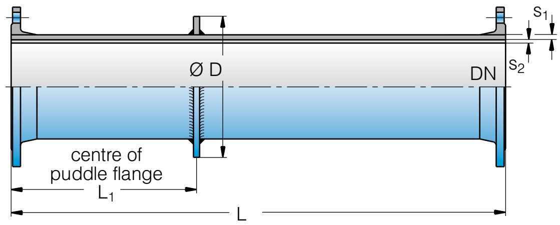
Ductile iron flanged pipes
PN 10, PN 16 and PN 25 double-flanged pipes
to EN 545
with screwed flanges (type 13) to EN 1092-2



External protection: zinc coating plus finishing layer
Internal protection: cement mortar lining (CML)

DN	Dimensions				Weight [kg] ~				
	[mm]			[m]	1 m of pipe without flange		One flange		
	d_1	s_1	s_2	Laying length	CML	Cast iron	PN 10	PN 16	PN 25
80	98	6	4	0.7 - 5.8	2	12.2	3.3	3.3	3.3
100	118	6			2.5	14.9	3.8	3.8	4.6
125	144	6.2			3.1	18.9	4.8	4.8	5.7
150	170	7.8			3.7	28	6	6	8.6
200	222	8.4			4.9	39.8	8.2	8	10.2
250	274	9			6.1	52.8	11.6	11.6	15.1
300	326	11.2			7.3	78.1	15.1	15.1	20.1
350	378	11.9	5	0.7 - 4.0	12.3	96.5	17.7	20.4	27.9
400	429	12.6			14	116.3	21	25.5	36.4
500	532	14			17.5	160.6	31	47	
600	635	15.4			20.9	211.3	42.7	66.2	

Ductile iron flanged pipes
PN 10, PN 16 and PN 25 double-flanged pipes
to EN 545
with puddle flange to manufacturer's standard

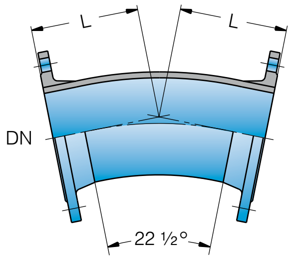


External protection:	zinc coating plus finishing layer, puddle flange bare metal
Internal protection:	cement mortar lining (CML)

DN	Dimensions [mm]			Weight [kg] ~		
	Ø D			One puddle flange		
	PN 10	PN 16	PN 25	PN 10	PN 16	PN 25
80	140			0.7		
100	160			0.8		
125	190			1		
150	230			1.5		
200	300			3		
250	320		370	1.7		5.7
300	380		430	2.3		8.2
350	440		500	3.1		13.1
400	500		530	4.9		10.4
500	620		650	8.8		
600	740		780	15.1		

Larger DN's and higher PN's available on enquiry; When ordering, please state: L, L1, whether to be in the form of a flanged spigot, Ø D if different from Table; puddle flanges can also be supplied in sections which can be welded-on on site. Minimum concrete class C20/25. Curing time of 3 days

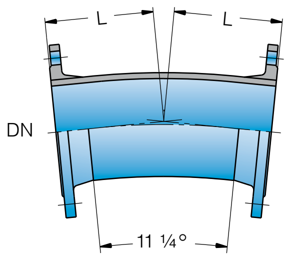
FFK 22 fittings
22½° double flanged bends
to EN 545



DN	Dimensions [mm]	Weight [kg] ~			
	L	PN10	PN16	PN25	PN40
80	130	9.5			
100	140	11.9		12.9	
125	150	15.3		17.8	20.5
150	160	19.7		21.5	25.5
200	180	29	27.5	32.5	42
250	210	41.5	41	48	65.5
300	255	60	59	69.5	96.5
350	140	58	64	81	128
400	153	67	75.5	98	156.5
500	185	99	127	148	232
600	254	182	227	248	350
700	284	313	339	334	–
800	314	428	646	445	

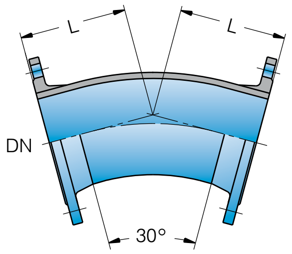
4.3 Flanged fittings

FFK 11 fittings
11¼° double flanged bends
to manufacturer's standard



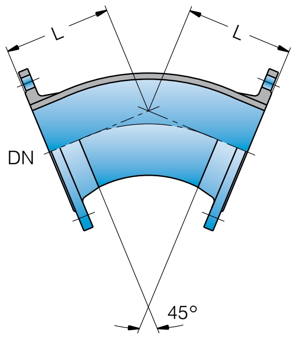
DN	Dimensions [mm]	Weight [kg] ~			
	L	PN10	PN16	PN25	PN40
80	130	9.5			
100	140	11.9		12.9	
125	150	15.3		17.3	20.5
150	160	19		21.5	25.5
200	180	26	25	29.5	39
250	210	41.5	41	48	65.5
300	255	60	59.5	69.5	96.5
350	105	56	61.5	77	135.9
400	113	58	67.5	90	165.3
500	135	85	113	134	232.8
600	174	157	202	223	253.2
700	194	243	269	299	–
800	213	330	366	333	

FFK 30 fittings
30° double flanged bends
to EN 545



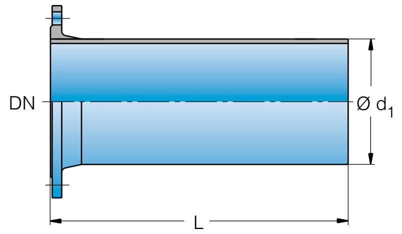
DN	Dimensions [mm]	Weight [kg] ~			
	L	PN10	PN16	PN25	PN40
80	130	9.5			
100	140	11.9		12.9	
125	150	15.3		17.8	20.5
150	160	19.5		19.5	25
200	180	29	27.5	32.5	42
250	210	41.5	40.5	48	65
300	255	59.5	59	69	96
350	165	65	71	88	138
400	183	73	82.5	106	163.5
500	220	109	137	158	256
600	309	212	257	278	284
700	346	360	386	430	–
800	383	493	529	674	

FFK 45 fittings
45° double flanged bends
to EN 545



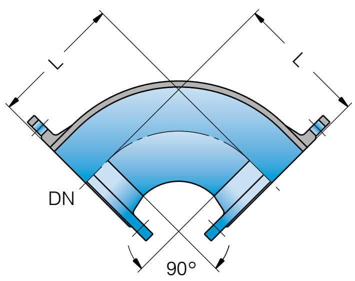
DN	Dimensions [mm]	Weight [kg] ~			
	L	PN10	PN16	PN25	PN40
80	130	9.4			
100	140/200*	11.3		12.3*	
125	150	14.5		15.7	18.3
150	160	18.4		20.5	24.5
200	180	27.5	27	31	41.5
250	350	54.5	54	61.5	82
300	400	77.2	76.2	87.7	118.2
350	298	75.5	82	99	141
400	324	94.4	106.4	128.4	196.4
500	375	143.5	173.5	196.5	264.5
600	426	210	263	292	397
700	478	292.5	322.5	392.5	
800	529	399.5	437.5	535.5	–
900	581	513	561	682	
1,000	632	661	744	899	

F fittings
Flanged spigots
nach EN 545



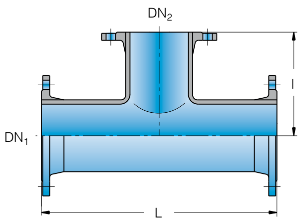
DN	Dimensions [mm]		Weight [kg] ~			
	L	d_1	PN10	PN16	PN25	PN40
80	350	98	7.5			
100	360	118	8.5		10.4	
125	370	144	12.4		13.1	14.3
150	380	170	15.6		16.6	17.5
200	400	222	24.6	24	24.5	29
250	420	274	32	31.5	36	45
300	440	326	43.2	42.7	47.7	63.2
350	460	378	52.3	55.3	64.3	85.3
400	480	429	64.3	70.3	81.3	115
500	520	532	93.9	109	121	154
600	560	635	133	159	173	226
700	600	738	179	194	228	–
800	600	842	226	245	294	–
900	600	945	272	295	356	–
1,000	600	1,048	328	369	447	–

Q fittings
90° double flanged bends
to EN 545



DN	Dimensions [mm]	Weight [kg] ~			
	L	PN10	PN16	PN25	PN40
80	165	9.7			
100	180	12.3		12.3	
125	200	18.0		21.1	22.3
150	220	19.8		21.8	26.3
200	260	31.2	30.2	34.7	45.2
250	350	50	49	57	77
300	400	69.9	68.9	80.4	110.9
350	450	93.1	102.2	146	190
400	500	133.2	146.2	205.5	272.5
500	600	179	209	233	300
600	700	269	322	350	455
700	800	381.5	411.5	481.5	
800	900	527	565.5	664.5	–
900	1,000	690	737	858	
1,000	1,100	896	979	1,135	

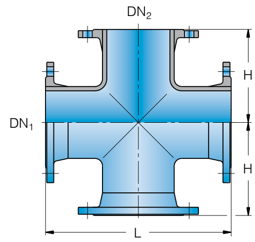
T fittings
All flanged tees
to EN 545



DN1	DN2	Dimensions [mm] L	Dimensions [mm] l	Weight [kg] ~ PN10	PN16	PN25	PN40
80	40[1]	330	155	14			
	50[1]		160	15			
	80		165	15.7			
100	40[1]	360	170	18		19	
	50[1]			17.1		18.1	
	80		175	18.4		19.6	
	100		180	19		20.5	
125	80	400	190	22.8		24.3	26.8
	100		195	23.8		25.8	28.3
	125		200	25.2		26.7	30.7
150	80	440	205	28.5		30.5	35
	100		210	29.4		31.9	35.9
	125		215	30.9		33.4	38.9
	150		220	32.2		35.3	41.9
200	80	520	235	42.2	41.7	45.7	56.7
	100		240	43.1	42.6	47.1	57.6
	125[1]		245	51	51	55	58
	150		250	46	45.5	50.5	63
	200		260	49.5	48.5	55	70.5
250	80[1]	700	265	72	71	79	99
	100		275	67.6	66.6	75.1	95.2
	125[1]			92	91	100	121
	150[1]		300	81	80	89	111
	200		325	75.2	74.2	84.2	109.7
	250		350	81	80	91.5	121.5
300	80[1]	800	290	98	97	108	142
	100		300	93.8	92.8	104.8	135.8
	150[1]		325	101	100	112	145
	200		350	102.4	101.4	114.4	151.4
	250[1]		400	113.9	112.9	128.9	175.9
	300[1]		375	117.4	113	128	168
350	100	850	325	115	121.5	138.5	181.5
	200			120.5	126.5	145.5	193.5
	350		425	138.8	147.8	172.8	236.8
400	80[1]	900	350	154.4	167.4	173	240
	100			158	173.2	174.4	241.4
	150[1]			144	156	179	249
	200			179.5	179.5	201.1	264.3
	300[1]		450	183	187.3	215	295
	400			182.5	209.5	238.5	340.5
500	80[1]	1,000	400	215.5	216	263	330
	100			218.5	247	287	331
	150[1]			225.5	255.5	270	344
	200			242.3	273.6	274	344
	300[1]			259	267	287	373
	400		500	266.9	327.4	337.1	427.7
	500			291.7	298.2	337.3	449.7
600	80[1]	1,100	450	335	366	351	445
	100[1]			350.7	385.5	352	446
	150[1]			363.6	365	357	453
	200			296.4	394.9	387	479
	300[1]		550	368	416.6	416	506
	400			355	409	482.1	569
	500[1]			370	435	468	598
	600			388	488	455	634
700	100[1]	650	525	310	336	458	–
	150[1]			310	336	458	
	200	870	555	339.3	377.1	470	
	300[1]			383	416	503	
	400			468.4	444.5	543.5	
	500[1]	1,200	600	539.8	532	644	
	600[1]			541.4	627.8	673	
	700			604	591	695	
800	80[1]	690	570	407.5	445.5	537.5	–
	100[1]			398.5	452	539	
	150[1]		580	438.2	409	543	
	200		585	448.7	455	550	
	300[1]	910	600	547.6	518	613	
	400		615	556.2	553	655	
	500[1]	1,350	645	697.6	698	801	
	600			654.4	729	832	
	700[1]		675	679	731	856	
	800			716	720	927	
900	100[1]	730	640	445	488	730	–
	200		645	432	480	603	
	300[1]	950	660	544	588	690	
	400		675	532.5	585.5	717.5	
	500[1]	1,500	690	784	842	960	
	600		705	771	846	981	
	900		750	818	890	1.071	
1,000	150[1]	770	705	561	640	790	–
	200			564	643	793	
	300[1]	990	735	645	724	879	
	400			657	738	899	
	500[1]	1,650	825	951	1,055	1,225	
	600[1]			966	1,082	1,243	
	700[1]			989	1,102	1,292	
	800[1]			1,016	1,123	1,339	
	900[1]			1,036	1,148	1,356	
	1,000			1,066	1,186	1,413	

[1] *To manufacturer's standard*

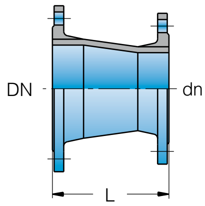
TT fittings
All flanged crosses
to manufacturer's standard



DN1	DN2	Dimensions [mm] L	Dimensions [mm] H	Weight [kg] ~ PN10	PN16
80	80	330	165	23.1	
100	80	360	175	23.8	
	100		180	27.1	
125	100	400	195	35	
	125		200	35.2	
150	80	440	205	38.5	
	100		210	41	
	125		215	43.4	
	150		220	46.6	
200	80	520	235	45.8	45.8
	100		240	51.6	51.6
	150		250	59.6	59.6
	200		260	68.7	68.7
250	80	700	270	99	99
	100		275	101	101
	125			103	103
	150		300	107	107
	200		325	114.8	114.8
	250		350	119.5	119.5
300	80	800	295	128	128
	100		300	141	141
	150		325	145	145
	200		350	167	167
	250		375	170	170
	300		400	196	196
350	100	850	325	126.5	132.5
	300		425	174	180
	350			193	199
400	80	900	345	148	158
	100		350	152	162
	150			157	167
	200			161.5	172
	250			176	181.5
	300		450	196	209
	350			218	231
	400			252	257
500	80	1,000	400	213	241
	150			336	364
	200			339	367
	250			343	371
	300		500	373	401
	400			378	411
	500			386	431
600	150	1,100	450	309	361
	200			314	364
	250			319	369
	300		550	372	422
	350			376	428
	400			381	444
	500			415	478
	600			530	547
700	400	870	555	446	482
	700	1,200	600	658	610

Crosses for higher pressures available on enquiry

FFR fittings
Double flanged tapers
to EN 545



<table>
<tr><th rowspan="2">DN[1]</th><th rowspan="2">dn</th><th>Dimensions [mm]</th><th colspan="4">Weight [kg] ~</th></tr>
<tr><th>L</th><th>PN10</th><th>PN16</th><th>PN25</th><th>PN40</th></tr>
<tr><td rowspan="3">80</td><td>40[1]</td><td rowspan="3">200</td><td colspan="4">7.8</td></tr>
<tr><td>50[1]</td><td colspan="4">7.9</td></tr>
<tr><td>65</td><td colspan="4">9.2</td></tr>
<tr><td rowspan="4">100</td><td>40[1]</td><td rowspan="4">200</td><td colspan="2">8.9</td><td colspan="2">9.7</td></tr>
<tr><td>50[1]</td><td colspan="2">9.4</td><td colspan="2">11</td></tr>
<tr><td>65[1]</td><td colspan="2">10.6</td><td colspan="2">12.6</td></tr>
<tr><td>80</td><td colspan="2">11.1</td><td colspan="2">13.1</td></tr>
<tr><td rowspan="5">125</td><td>40[1]</td><td rowspan="5">200</td><td colspan="2">12.5</td><td>13.5</td><td>13.5</td></tr>
<tr><td>50[1]</td><td colspan="2">12.6</td><td>14.5</td><td>14.5</td></tr>
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<tr><td>80[1]</td><td colspan="2">13</td><td>17.5</td><td>17.5</td></tr>
<tr><td>100</td><td colspan="2">13.1</td><td>18</td><td>18</td></tr>
<tr><td rowspan="6">150</td><td>40[1]</td><td rowspan="3">300</td><td colspan="2">14.4</td><td>15.4</td><td>17.4</td></tr>
<tr><td>50[1]</td><td colspan="2">17.4</td><td>18.4</td><td>20.4</td></tr>
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<tr><td>100[1]</td><td colspan="2">15.9</td><td>18.8</td><td>20.4</td></tr>
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<tr><td rowspan="5">200</td><td>50[1]</td><td rowspan="5">300</td><td>20.6</td><td>20.6</td><td>25.1</td><td>32.1</td></tr>
<tr><td>80[1]</td><td>22.9</td><td>22.9</td><td>28.1</td><td>34.1</td></tr>
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<tr><td>125[1]</td><td>25.5</td><td>25.5</td><td>30.9</td><td>38.5</td></tr>
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<tr><td>100[1]</td><td>29</td><td>32.5</td><td>33</td><td>44</td></tr>
<tr><td>125[1]</td><td>31.5</td><td>32.5</td><td>33</td><td>46.5</td></tr>
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<tr><td rowspan="4">300</td><td>100[1]</td><td rowspan="4">300</td><td>29</td><td>29</td><td>35</td><td>48</td></tr>
<tr><td>150[1]</td><td>33</td><td>32.5</td><td>38</td><td>55</td></tr>
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<tr><td>400</td><td>133.6</td><td>163.6</td><td>175.6</td><td>210.6</td></tr>
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<tr><td>500</td><td>185.5</td><td>226.5</td><td>257</td><td>343</td></tr>
<tr><td rowspan="3">700</td><td>400[1]</td><td rowspan="3">600</td><td>253.5</td><td>281.5</td><td>334.5</td><td rowspan="3">–</td></tr>
<tr><td>500[1]</td><td>258</td><td>273</td><td>337</td></tr>
<tr><td>600</td><td>301.4</td><td>332.4</td><td>285.4</td></tr>
<tr><td rowspan="3">800</td><td>500[1]</td><td rowspan="3">600</td><td>308.5</td><td>359.5</td><td>442.5</td><td rowspan="3">–</td></tr>
<tr><td>600[1]</td><td>363</td><td>375</td><td>459</td></tr>
<tr><td>700</td><td>397.3</td><td>431.3</td><td>484.3</td></tr>
<tr><td rowspan="3">900</td><td>600[1]</td><td rowspan="3">600</td><td>336</td><td>384</td><td>453</td><td rowspan="3">–</td></tr>
<tr><td>700[1]</td><td>456</td><td>497</td><td>481</td></tr>
<tr><td>800</td><td>374.2</td><td>414.2</td><td>518.2</td></tr>
<tr><td rowspan="2">1,000</td><td>800[1]</td><td rowspan="2">600</td><td>516</td><td>612</td><td>739</td><td rowspan="2">–</td></tr>
<tr><td>900</td><td>530.2</td><td>592.2</td><td>576.2</td></tr>
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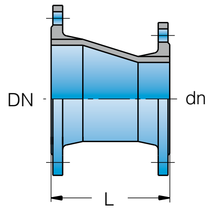
[1] To manufacturer's standard

FFRe fittings
Eccentric double flanged tapers
to manufacturer's standard



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<tr><td>65</td><td colspan="4">10.7</td></tr>
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<tr><td>50</td><td colspan="2">12.1</td><td colspan="2">12.1</td></tr>
<tr><td>65</td><td colspan="2">12.6</td><td colspan="2">12.6</td></tr>
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<tr><td>500</td><td>236</td><td>252</td><td>262</td><td>357</td></tr>
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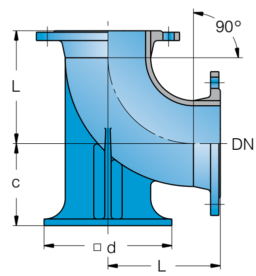
N fittings
Double flanged 90° duckfoot bends
to EN 545



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<tr><th rowspan="2">DN</th><th colspan="3">Dimensions [mm]</th><th colspan="4">Weight [kg] ~</th></tr>
<tr><th>L</th><th>c</th><th>d</th><th>PN 10</th><th>PN 16</th><th>PN 25</th><th>PN 40</th></tr>
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<tr><td>150</td><td>220</td><td>160</td><td>250</td><td colspan="2">28.8</td><td>30.8</td><td>35.8</td></tr>
<tr><td>200</td><td>260</td><td>190</td><td>300</td><td>46.2</td><td>45.2</td><td>49.7</td><td>60.2</td></tr>
<tr><td>250</td><td>350</td><td>225</td><td>350</td><td>73.5</td><td>72.5</td><td>80.5</td><td>101</td></tr>
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<tr><td>500</td><td>600</td><td>385</td><td>600</td><td>281</td><td>311</td><td>335</td><td>402</td></tr>
<tr><td>600</td><td>700</td><td>450</td><td>700</td><td>425</td><td>478</td><td>506</td><td>612</td></tr>
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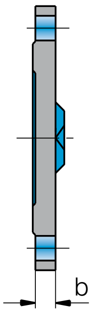
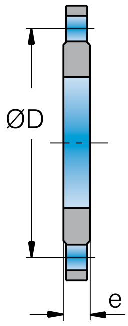
X fittings
Blank flanges
to EN 545



DN	b [mm]				Weight [kg] ~				Optional bored hole(s)
	PN 10	PN 16	PN 25	PN 40	PN 10	PN 16	PN 25	PN 40	["]
40	16				2.5				1 x ½" central
50	16				3				
65	16				4				
80	16				3.6				1 x 2" central
100	16				4.3		4.8		
125	16			20.5	5.6		6.2	7.9	
150	16		17	23	7.2		8.3	11.1	
200	17		19	27	11	10.8	13.3	20	
250	19		21.5	31	16.9	16.6	21	33.5	
300	20.5		23.5	35.5	26	25.5	32	51.5	2 x 2" eccentric
350	20.5	22.5	26	40[1)]	33	37	46	73.5	
400	20.5	24	28	44[1)]	41	49	62.5	106	
500	22.5	27.5	32.5	48[1)]	65	85.5	102	151	
600	25	31	37	53[1)]	99.5	136	159	230	
700	27.5	34.5	41.5[1)]	–	147	179	225	–	
800	30	38	46[1)]	–	207	252	325	–	
900	32.5	41.5	50.5[1)]	–	273	335	429	–	
1,000	35	45	55[1)]	–	360	453	578	–	

[1)] To manufacturer's standard, flange connection dimensions to EN 1092-2; flanges for higher pressures available on enquiry

DN 80 transition flanges
Flanges for PN 10 to PN 40 transitions
to manufacturer's standard



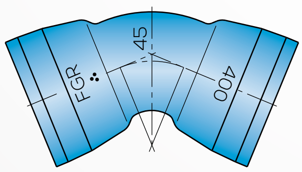
DN	Dimensions [mm]		PN [bar]	Weight [kg] ~
	D	e		
80	200	27	10/40	3.9

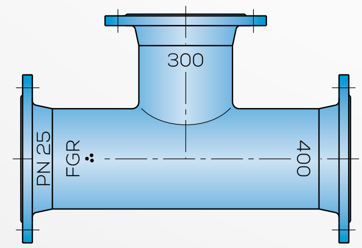
Marking of fittings

All fittings produced by member companies of the "Fachgemeinschaft Gussrohrsysteme/European Association for Ductile Iron Pipe Systems (FGR/EADIPS) carry the "FGR" mark indicating that all the guidelines required for the award of the "FGR Quality Mark" have been complied with.

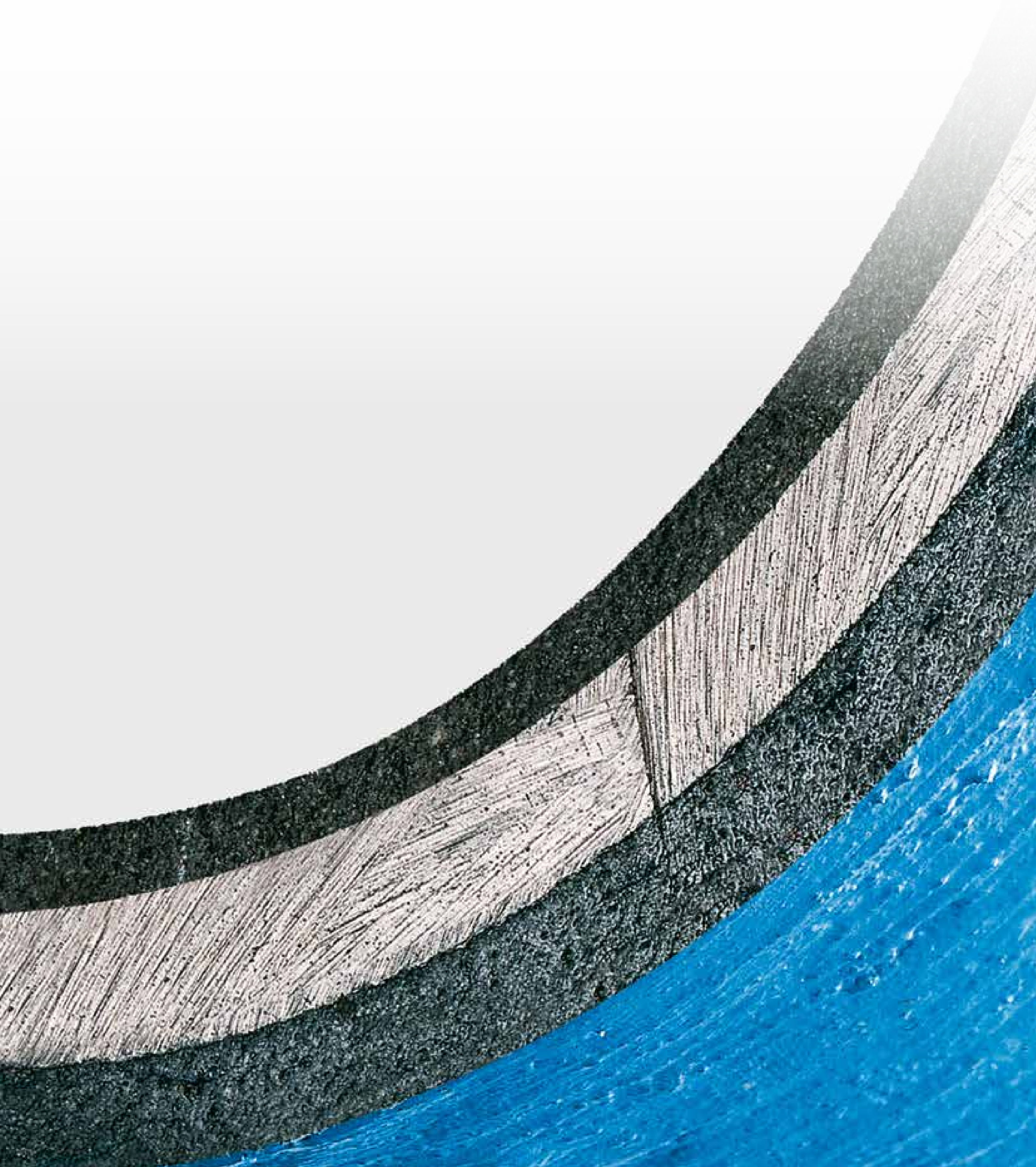
As well as this, all fittings are marked with their nominal sizes and bends are marked with their respective angles.
Flanged fittings have the nominal pressures PN 16, 25 or 40 cast or stamped onto them. No nominal pressure appears on flanged fittings for PN 10 or on any socket fittings.

To identify their material as "ductile cast iron", fittings are marked with three raised dots arranged in a triangle (∴) on their outer surface. In special cases, there may be further markings which are specified as needing to be applied.





5 - COATINGS



Preliminary remarks

In their as-supplied form, ductile iron pipes and fittings have factory-applied internal and external coatings. The various coatings available for pipes can be selected to suit a wide variety of factors and can be combined almost as desired.

Some of the crucial influencing factors are as follows:

- the medium to be carried
- the corrosiveness of the soil and groundwater
- the grain size of the bedding
- the temperature of the medium
- the ambient temperature
- the installation technique

The structure, operation and fields of use of the various internal and external coatings available for pipes are described in the following Chapter.

For fittings, what has shown itself to be the state of the art internal and external coating is the epoxy coating to EN 14 901. Fittings with this coating can be used both for the supply of drinking water and for the disposal of sewage and other wastewater. Other coatings such as a cement mortar lining, enamelling or bitumen are possible on enquiry.

5.1 External coatings
Zinc coating with polyurethane finishing layer (PUR Longlife coating)

Structure

A zinc coating with a polyurethane (PUR) finishing layer is available for 5 m laying length pipes of nominal sizes from DN 80 to DN 500 and for all push-in joints. The finishing layer consists of polyurethane.

It complies with Austrian Ö-NORM B 2560 and is available in the following colours:

- blue for drinking water
- black for snow-making systems and turbine pipelines

Other colours are available on enquiry.

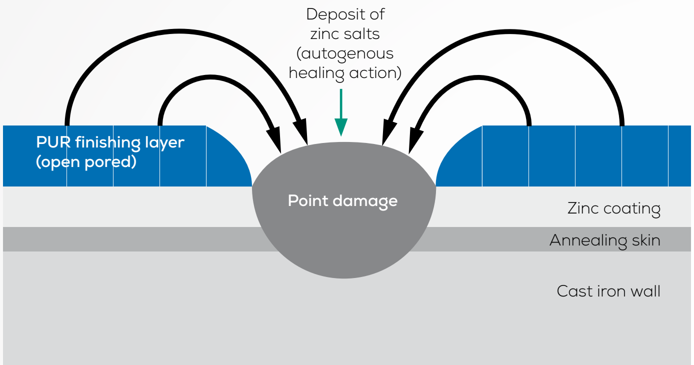
The mean thickness of the finishing layer is 120 µm. Below the finishing layer there is a zinc coating with a mass of at least 200 g/m².

Operation

There are three factors on which the protective action of the zinc coating with a finishing layer is based:

- the electrochemical action of the zinc
- a reduction in any subsequent diffusion of the attacking medium. caused by the products of reaction of the zinc which form and which are insoluble in water
- the anti-bacterial action of zinc salts

If there is damage to the corrosion protection which extends down to the surface of the cast iron, an electrochemical cell, a so-called macrocell, forms at the damaged point. When metals are arranged in the electrochemical series, zinc is a less noble metal than iron; it has a more negative electrode potential and if it is in conductive contact with iron and an electrolyte is present it goes into solution. In electrochemical terms, the exposed surface of the cast iron thus forms a cathode and the zinc-coated surface of the pipe an anode. Zinc ions migrate to the damaged point and form a layer of "scarring" which stops the corrosion.



Cathodic protective action of the zinc at injuries to the protective layer

When pipes are laid in the ground, over the course of time the layer of zinc changes into a dense, firmly adhering, impermeable and uniformly crystalline layer of insoluble compounds consisting of zinc oxides, hydrates and zinc salts of different compositions. Although the exchange processes between the zinc and the ground are hampered by the porous finishing layer, they are not completely suppressed and in a spatially confined region conditions are created for a slow conversion which encourages salts to crystallise out.
Even though the metallic zinc which was originally present has been converted, this layer of products of the corrosion of the zinc maintains the protective action.

In anaerobic soils in which bacterial corrosion by sulphate-reducing bacteria may occur, zinc provides additional protection as a result of its antibacterial action and its ability to increase the pH at the interface between the cast iron and the soil.

Fields of use

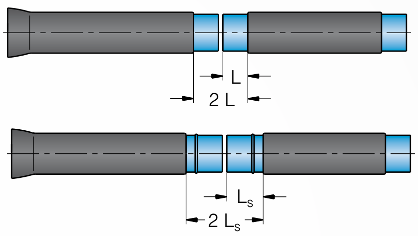
- Under Austrian ÖNORM B 2538, the allowable grain size of the pipe bedding material is limited to 100 mm
- With regard to the corrosiveness of the bedding material, the present external coating can be assumed to be comparable to the zinc coating and reinforced finishing layer under EN 545. Many soils are permitted as pipe bedding materials in this case but the following are exceptions
  - soils with a low resistivity of less than 1,000 ohms x cm when installation is above the water table or one of less than 1,500 ohms x cm when installation is below the water table
  - mixed soils, i.e. soils made up of two or more different types of soil
  - soils with a pH of less than 6 and a high base-neutralising capacity
  - soils which contain refuse, cinders or slag or which are polluted by wastes or industrial effluents.

Further information on the present subject can be found in Chapter 8.

5.2 The PUR-TOP special finishing layer

The PUR-TOP finishing layer is an enhanced version of the PUR Longlife finishing layer. The PUR finishing layer is increased to a thickness of 400 µm and it also has a polyethylene bandage for protection against impacts wound round it. The thickness of the impact protection bandage is ≥ 0.65 mm.
With regard to the corrosiveness of the bedding material, the PUR TOP coating constitutes a reinforced coating under EN 545. Soils of any desired corrosiveness are thus possible as bedding materials.

Installation instructions
The directions given in Chapter 8 relating to bedding materials and the cutting of pipes should be followed. Special requirement for PUR TOP coatings.
Before pipes with PUR TOP coatings are cut, the polyethylene bandage must be removed by pulling it off for a length of 2L or 2LS, 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®/ L (mm)	VRS®-T 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

Once the pipe joint has been assembled, the region in which the joint is situated should be covered with a shrink-on sleeve.

5.3 External coatings
Zinc coating with epoxy coating

Structure
A zinc coating with a finishing layer is available for 6 m laying length pipes of nominal sizes from DN 80 to DN 1000 and for all push-in joints. The finishing layer may consist of epoxy paint or bitumen.

It complies with EN 545 and is available in the following colours:
- blue for drinking water
- green for non-drinking water
- black (bitumen) for snow-making systems and turbine pipelines

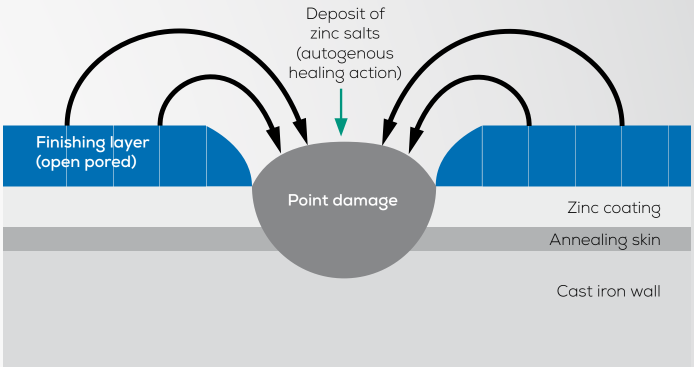
Other colours are available on enquiry.

The mean thickness of the finishing layer is 70 µm. Below the finishing layer there is a zinc coating with a mass of at least 200 g/m².

Operation
There are three factors on which the protective action of the zinc coating with a finishing layer is based:

- the electrochemical action of the zinc
- a reduction in any subsequent diffusion of the attacking medium, caused by the products of reaction of the zinc which form and which are insoluble in water
- the anti-bacterial action of zinc salts

If there is damage to the corrosion protection which extends down to the surface of the cast iron, an electrochemical cell, a so-called macrocell, forms at the damaged point. When metals are arranged in the electrochemical series, zinc is a less noble metal than iron; it has a more negative electrode potential and if it is in conductive contact with iron and an electrolyte is present it goes into solution. In electrochemical terms, the exposed surface of the cast iron thus forms a cathode and the zinc-coated surface of the pipe an anode. Zinc ions migrate to the damaged point and form a layer of "scarring" which stops the corrosion.



Cathodic protective action of the zinc at injuries to the protective layer

When pipes are laid in the ground, over the course of time the layer of zinc changes into a dense, firmly adhering, impermeable and uniformly crystalline layer of insoluble compounds consisting of zinc oxides, hydrates and zinc salts of different compositions. Although the exchange processes between the zinc and the ground are hampered by the porous finishing layer, they are not completely suppressed and in a spatially confined region conditions are created for a slow conversion which encourages salts to crystallise out.
Even though the metallic zinc which was originally present has been converted, this layer of products of the corrosion of the zinc maintains the protective action.

In anaerobic soils in which bacterial corrosion by sulphate-reducing bacteria may occur, zinc provides protection as a result of its antibacterial action and its ability to increase the pH at the interface between the cast iron and the soil.

Fields of use
Pipes with a zinc coating are used above all in applications where an exchange of soil is intended. There are two main factors which may dictate such an exchange:

- Under DVGW W 400-2, *Anhang G*, the allowable grain size of the pipe bedding material is limited to 0 to 32 mm (rounded grains) or 0 to 16 mm (fragmented grains)
- Many soils are permitted as pipe bedding materials under EN 545 but the following are exceptions
  - soils with a low resistivity of less than 1,500 ohms x cm when installation is above the water table or one of less than 2,500 ohms x cm when installation is below the water table

- mixed soils, i.e. soils made up of two or more different types of soil
- soils with a pH of less than 6 and a high base-neutralising capacity
- soils which contain refuse, cinders or slag or which are polluted by wastes or industrial effluents.

A thicker finishing layer with a local minimum thickness of 100 µm is able to widen the field of use to cover a soil resistivity of 1,000 ohms x cm when installation is above the water table and one of 1,500 ohms x cm when it is below the water table.
Further information on the present subject can be found in Chapter 8.

Installation instructions

The directions given in Chapter 8 relating to bedding materials and the cutting of pipes should be followed.

5.4 External coatings Zinc-aluminium coating with finishing layer (Zinc Plus)

Structure

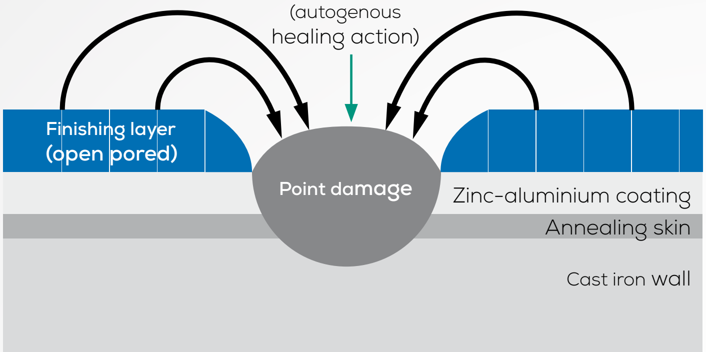
A zinc-aluminium coating with a finishing layer is available for 6 m laying length pipes of nominal sizes from DN 80 to DN 1,000 and for all push-in joints. The finishing layer consists of blue epoxy paint and complies with EN 545. Other colours are available on enquiry.
The mean thickness of the finishing layer is 70 µm. Below the finishing layer there is a zinc-aluminium coating (85% zinc and 15% aluminium) with a mass of at least 400 g/m².

Operation

There are three factors on which the protective action of the zinc-aluminium coating with a finishing layer is based:

- the electrochemical action of the zinc
- a reduction in any subsequent diffusion of the attacking medium. caused by the products of reaction of the zinc which form and which are insoluble in water
- the anti-bacterial action of zinc salts

If there is damage to the corrosion protection which extends down to the surface of the cast iron, an electrochemical cell, a so-called macrocell, forms at the damaged point. When metals are arranged in the electrochemical series, zinc is a less noble metal than iron; it has a more negative electrode potential and if it is in conductive contact with iron and an electrolyte is present it goes into solution. In electrochemical terms, the exposed surface of the cast iron thus forms a cathode and the zinc-coated surface of the pipe an anode. Zinc ions migrate to the damaged point and form a layer of "scarring" which stops the corrosion.



Cathodic protective action of the zinc at injuries to the protective layer

When pipes are laid in the ground, over the course of time the layer of zinc changes into a dense, firmly adhering, impermeable and uniformly crystalline layer of insoluble compounds consisting of zinc oxides, hydrates and zinc salts of different compositions. Although the exchange processes between the zinc and the ground are hampered by the porous finishing layer, they are not completely suppressed and in a spatially confined region conditions are created for a slow conversion which encourages salts to crystallise out.
Even though the metallic zinc which was originally present has been converted, the layer of products of the corrosion of the zinc maintains the protective action.

To delay the effect of this conversion for as long as possible, and thus to maintain the protective electrochemical action, the zinc has a 15% proportion of aluminium added to it. This and the increase in the total mass of zinc produces a further rise in the technical operating life which can be expected and an extension of the fields of use.
In anaerobic soils in which bacterial corrosion by sulphate-reducing bacteria may occur, zinc provides additional protection as a result of its antibacterial action and its ability to increase the pH at the interface between the cast iron and the soil.

Fields of use

Pipes with a zinc-aluminium coating (Zinc Plus) are used above all in applications where an exchange of soil is intended. Such an exchange is dictated mainly by the allowable grain sizes.

Under DVGW W 400-2, the allowable grain size of the pipe bedding material is limited to 0 to 32 mm (rounded grains) or 0 to 16 mm (fragmented grains).

Few limits are set in respect of the corrosiveness of the pipe bedding material and the only soils which are ruled out under EN 545 are the following:

- acidic peaty soils
- soils which contain refuse, cinders or slag or which are polluted by wastes or industrial effluents
- soils below sea level whose resistivity is less than 500 ohms x cm.

In soils of these kinds, and also where stray currents occur, it is advisable for pipes with a cement mortar coating to be used.

Further information on the present subject can be found in Chapter 8.

Installation instructions

The directions given in Chapter 8 relating to bedding materials and the cutting of pipes should be followed.

5.5 External coatings Cement mortar coating

Structure

The cement mortar coating (ZMU) is available for 6 m laying length pipes of nominal sizes from DN 80 to DN 1,000 and for all push-in joints. It complies with EN 15 542. The nominal layer thickness is therefore 5 mm. Below the ZMU there is always a zinc coating of a mass of at least 200 g/m^2.
An additional primer may be applied between the zinc and the ZMU but this can be dispensed with if the ZMU is of the polymer-modified type. The cement mortar is applied by an extrusion process (winding-on) or a spraying process. The sockets are protected by rubber protective sleeves or shrink-on material (see Chapter 6, p. 51).

For special conditions of use, such for example as for trenchless installation in non-cohesive soils, we can also supply our ZMU Plus coating. In this case the pipe is sheathed with cement mortar to a depth sufficient to give it an entirely cylindrical external outline.

Operation

The ZMU is highly effective in providing corrosion protection and protects against both chemical and mechanical attack.
The protective action against chemicals is based above all on the porosity and alkalinity of the mortar used, which is based on blast furnace cement. When the mortar is acted on by groundwater or the soil moisture, what is produced, in time, at the surface of the ductile iron pipe is a pH › 10, which is a reliable means of stopping corrosion from occurring.
In the unlikely event of the ZMU being damaged mechanically, the corrosion protection is maintained by the zinc coating situated below the ZMU.

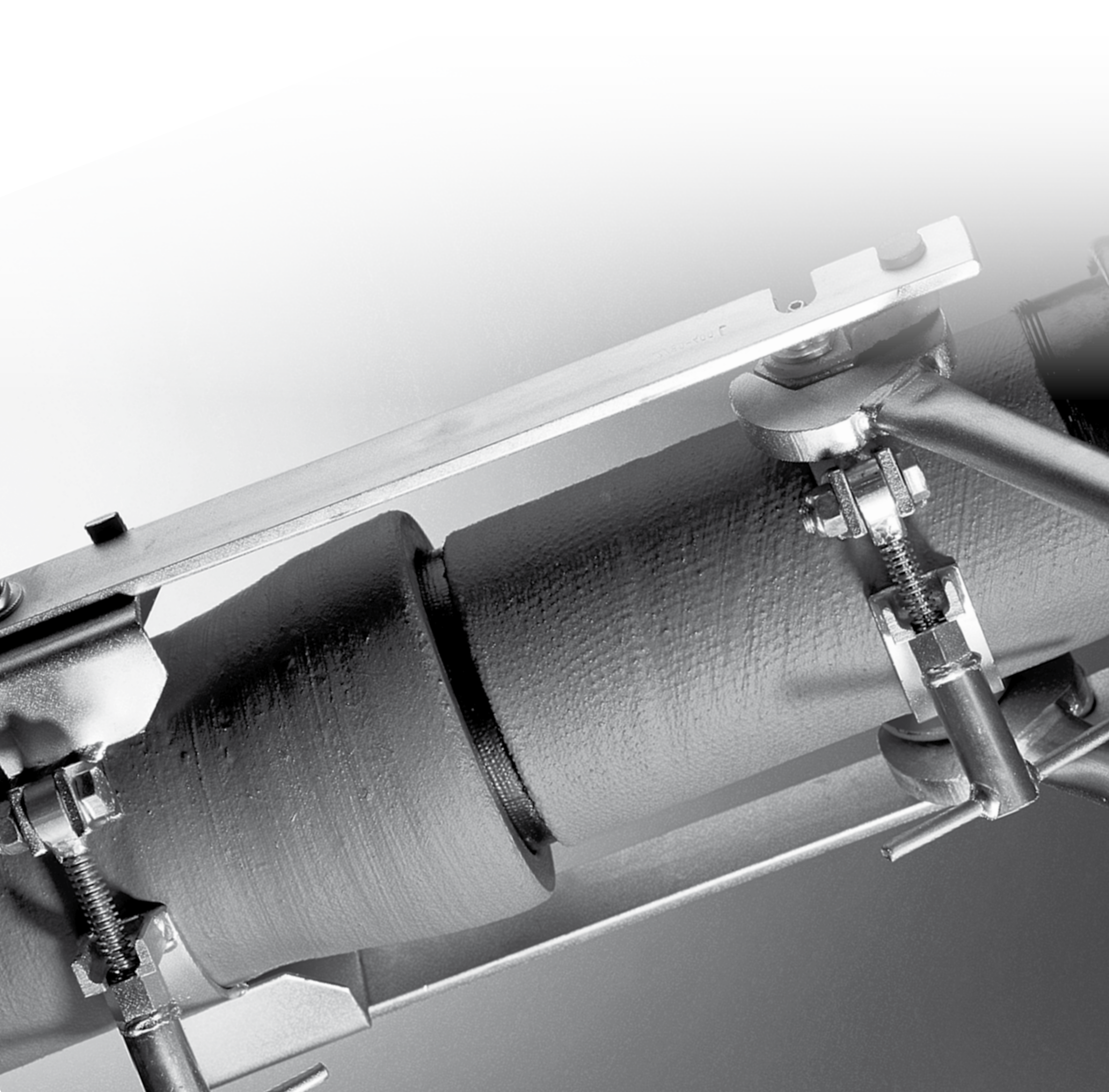
In addition to this, the allowable mechanical loads are laid down by stipulations relating to them in EN 15 542. Standardised figures are given for, amongst other things, strength of adhesion and impact resistance. The consequence is that the ZMU has an outstanding ability to carry mechanical loads.

Fields of use

Because of the excellent mechanical and chemical protective properties of the ZMU, pipes with an external coating of this kind can be used almost anywhere. Some of the significant fields of use are:

- corrosive/contaminated soils
  Under Annex D of EN 545, ductile iron pipes with a fibre-reinforced cement mortar coating to EN 15 542 can be installed in soils of any desired corrosiveness.
- coarse grained pipe bedding material
  DVGW Arbeitsblatt W 400-2 regulates the allowable grain sizes of the pipe bedding material. Under *Anhang G* to this *Arbeitsblatt*, a maximum grain size of 100 mm, where the grains are of a rounded or fragmented form, is allowable for pipes with a cement mortar coating.
- trenchless installation techniques
  The trenchless installation techniques for which ductile iron pipes are relevant are regulated in *DVGW Arbeitsblätter* GW 320-1 to GW 324. Under these documents, pipes with a cement mortar coating are approved for all such techniques.
- stray currents
  The latest investigations indicate that ductile iron pipes with a cement mortar coating should be used in areas subject to stray currents. In this way, by installing joints which are not electrically conductive, stray currents can be stopped from having an adverse effect on the pipeline.

6 - ACCESSORIES



Laying tools and other accessories for pipes and fittings with TYTON®, BRS® or VRS®-T push-in joints

The following laying tools and other accessories are needed for laying and assembling pipes and fittings:

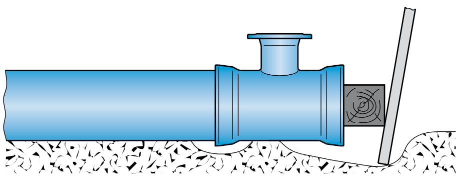
Note: a chain-hoist traction assembly must be used for assembling BRS® push-in joints of DN 350 size and above!

Laying tools

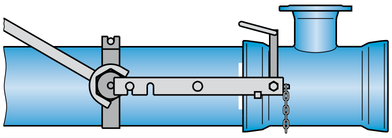
DN	Pipes	Fittings	
80		MMA. MMB.	Muffenbogen:
100	Lever	MMR und	Montagegerät
125		EU: Hebel	(z.B. Typ 1)
80	Laying tool		
100			
125	Type 1	As for pipes	
150			
200	Type 2	As for pipes. plus yoke and	
250		chain of Type 1 tool	
300			
350[1)]	Type 3	As for pipes	
400[1)]			
500			
600			
700	Chain-hoist traction	As for pipes	
800			
900			
1,000			

[1)] Use chain-hoist traction assemblies for BRS® push-in joints of DN 350 size and above.

Lever for sizes up to and including DN 125



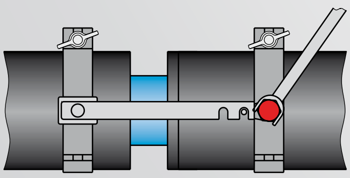
Laying tools for nominal sizes up to and including DN 400



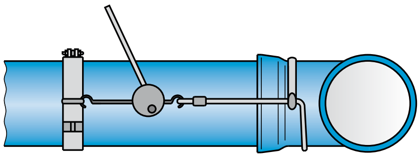
DN	Consisting of		Weight [kg] ~
	Type 1	Type 2	
80			13.8
100			14.0
125			15.0
150	1 mounting clamp		15.5
200	1 yoke	2 mounting clamps	17.1
250	2 levers	2 levers	18.1
300			20.5
350[1)]			23.5
400[1)]			25.0

[1)] Use chain-hoist traction assemblies for BRS® push-in joints of DN 350 size and above.

Laying tool type 1 for DN 80 to DN 400 size pipes and fittings with a zinc or zinc-aluminium coating and a finishing layer (silver identifying marking).
Laying tool type 2 for DN 80 to DN 400 size pipes with a cement mortar coating (blue identifying marking).
Laying tool type 3 for DN 80 to DN 400 size pipes and fittings with thermal insulation (WKG) (red identifying marking).



Chain-hoist traction assemblies for nominal sizes from DN 350 to DN 1000



DN	Consisting of	Weight [kg] ~
350[1)]	2 x 30 kN lever chain-hoists* 1 cable yoke 1 traction cable 1 mounting clamp	92
400[1)]		97
500		101
600		105
700		108
800		112
900	2 x 50 kN lever chain-hoists* 1 cable yoke 1 traction cable 1 mounting clamp	115
1,000		119

** Obtainable from specialist suppliers*
[1)] Use chain-hoist traction assemblies for BRS® push-in joints of DN 350 size and above.

Other accessories

Dusting brush, cotton waste, wire brush, spatula, scraper (e.g. bent screwdriver), paint brush, lubricant, depth gauge.

For cutting of pipes

Use a disc cutter or grinder fitted with a cutting disc for stone, e.g. the C24RT Spezial type. For bevelling the spigot end use a coarse-grain grinding disc.

Laying tools and other accessories for pipes and fittings with BLS®/VRS®-T push-in joints

As well as the usual laying tools and other accessories, the following may also be needed when pipes and fittings with VRS®-T push-in joints are being laid.

DN	Accessory	Used for
80 bis 500	Torque wrench able to apply a torque of at least 50 kN	Tightening the bolts of a clamping ring
80 bis 1000	Copper guide of the appropriate nominal size to guide the welded bead	Re-application of welded bead (e.g. to cut pipes)

Laying tools and other accessories for fittings with screwed socket and bolted gland joints

The following laying tools and other accessories are needed for assembling fittings with screwed socket and bolted gland joints.

Laying tools

DN	Screwed socket joints	Bolted gland joints
40	Hook spanner Wooden driver Yarning iron	
50		
65		
80		
100		
125		
150		
200		
250		
300		
350		
400		
500		Ring spanner Hardwood wedges
600		
700		
800		
900		
1,000		

Other accessories:

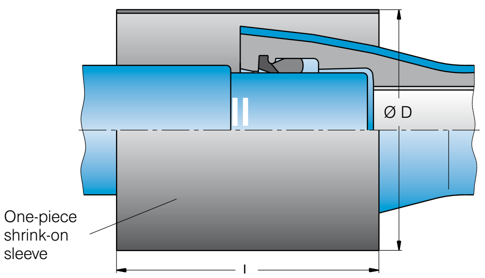
Dusting brush, wire brush, spatula, chalk, hammer, paint brush, lubricant.

Laying tools and other accessories for fittings with screwed socket joints

Hook spanner

DN	40	80	100	125	150
Weight [kg] ~	2.4	3.3	4	5.6	6
DN	200	250	300	350	400
Weight [kg] ~	7.7	10.5	10.7	16.2	18

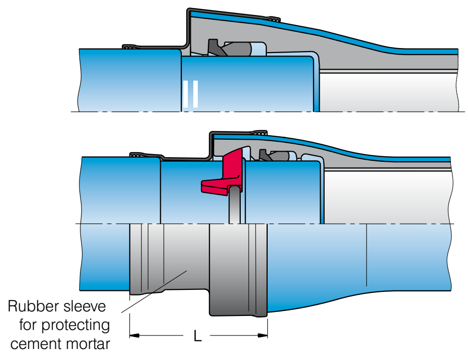
One-piece shrink-on sleeves for pipes with a cement mortar coating (ZMU) and TYTON®, BRS® or VRS®-T push-in joints DN 80 to DN 500



DN	Product designation: Product	Loading class	Width L	Nominal size (DN)	Dimensions [mm]: L	ØD/Ød[1]
80					300	200/80
100					300	235/100
125					300	280/135
150	**MPSM**	**C30**	**300**	**DN XXX**	300	280/135
200		or			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

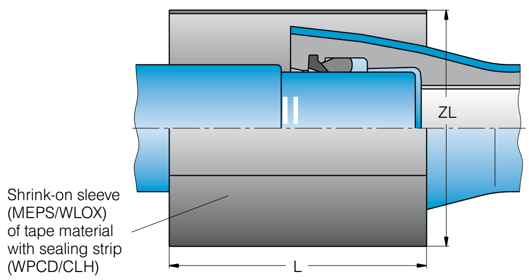
Rubber sleeves for protecting cement mortar, for pipes with a cement mortar coating (ZMU) and TYTON®, BRS® or VRS®-T push-in joints



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

DN	Dimensions [mm] L
80	155
100	155
125	160
150	165
200	170
250	180
300	200
350	135
400	210
500	210
600	265
700	265
800	265
900	265
1,000	265

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

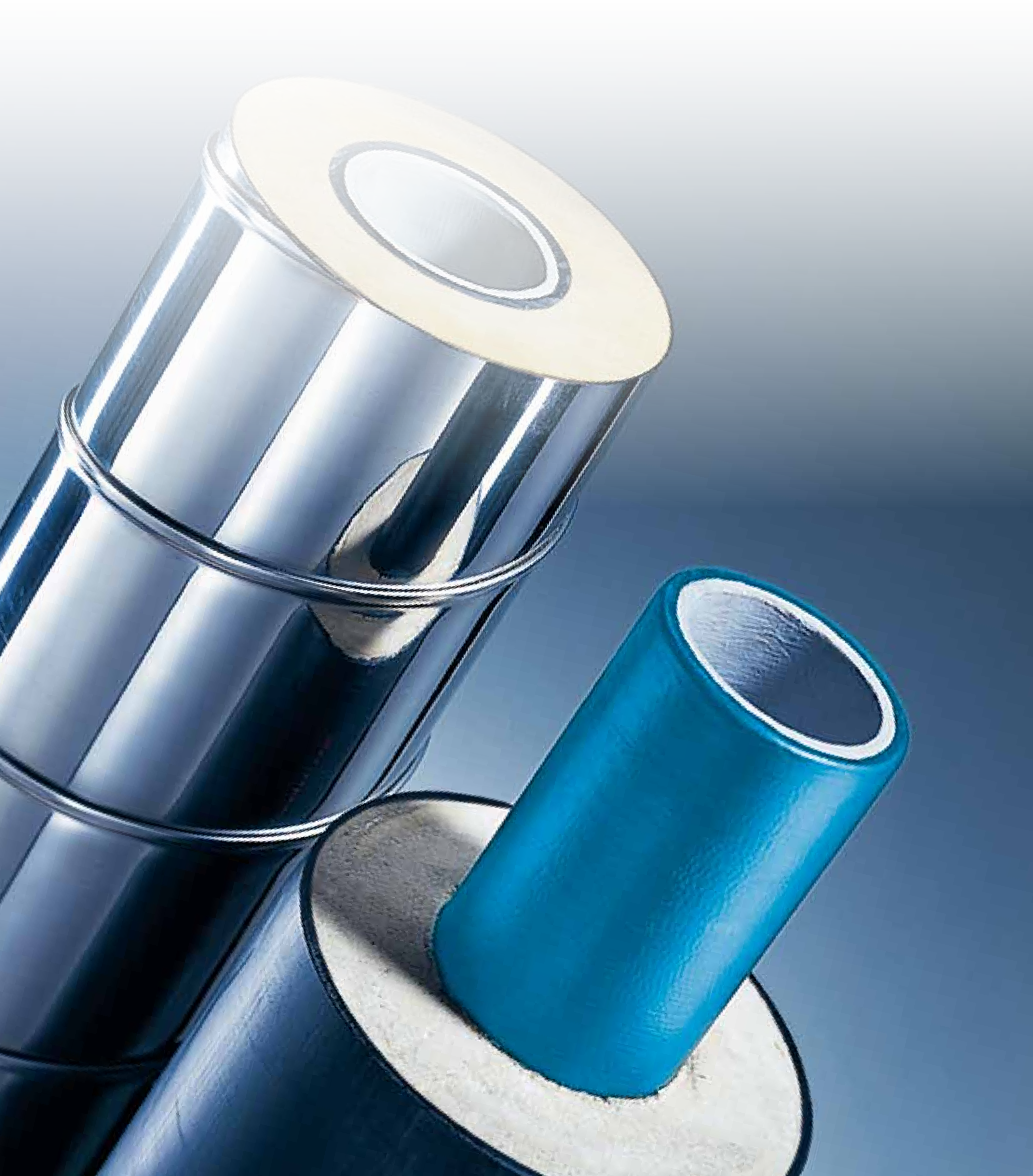


Width L = 300 mm (12 inch) for TYTON®/BRS®
Width L = 450 mm (17 inch) for BLS®

DN	Product designation: Product	Loading class	Width L	Nominal size	Dimensions [mm] ZL[1]
600	**MEPS**	**C30**	**300 or 450**	**DN XXX**	2.500
700	incl. WPCP IV 8x12 or 8x17				2.950
800		or			3.260
900	**WLOX**	**C30**	**300 or 450**	**DN XXX**	3.600
1,000	incl. CLH-150-300 or 450				3.960

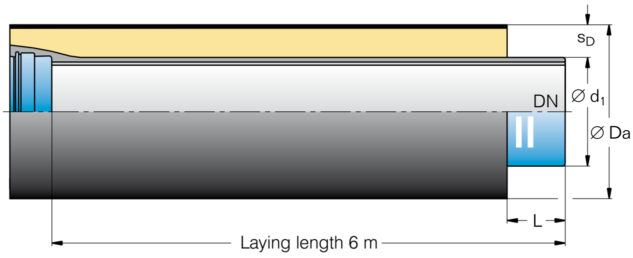
[1] Sleeves are supplied already cut to the specified length and fitted with a sealing strip. Tape material in the form of 30 m rolls is available on enquiry for DN 250 to DN 1000 sizes

7 - SPECIAL PRODUCTS



7.1 Product range

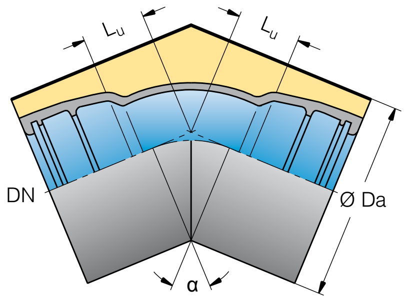
WKG pipes with TYTON® push-in joints
to DIN 28 603, or, up to DN 600, BRS® restrained push-in joints
Folded spiral-seam outer tubing (FL) HDPE outer sleeve (EL)



DN	Dimensions [mm]				Weight [kg] ~ 1)	
	Ø D_a	Ø d_1	L	s_D	FL-Rohr*	EL-Rohr
80	180	98	94	41.0	112	108
100	200	118	98	41.0	135	129
125	225	144	101	40.5	168	159
150	250	170	104	40.0	207	195
200	315	222	110	46.5	276	261
250	400	274	115	63.0	369	366
300	450	326	120	62.0	453	456
400	560	429	120	65.5	683	696
500	710	532	130	89.0	966	983
600	800	635	130	82.5	1,218	1,266
700	900	738	172	81.0	1,548	1,614
800	1,000	842	184	79.0	1,896	1,974

*1) Total weight; other nominal sizes, insulating layers of other thicknesses and trace heating are available on enquiry. * Where pipes are intended for use in above-ground pipelines it is essential to consult our Applications Engineering Division.*

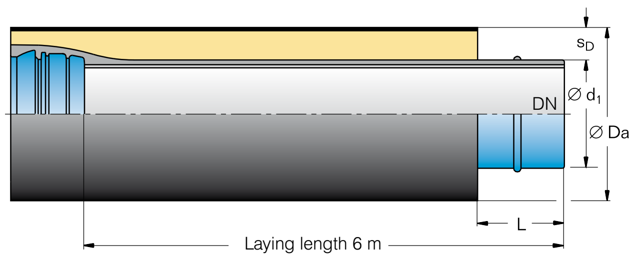
WKG socket bends (MMK) with TYTON® push-in joints or, up to DN 600, BRS® restrained push-in joints
Folded spiral-seam outer tubing (FL)/HDPE outer sleeve (EL)



DN	Ø Da	Dimensions L_u [mm]				
		MMK 11°	MMK 22°	MMK 30°	MMK 45°	MMQ (90°)
80	180	30	40	45	55	100
100	200	30	40	50	65	120
125	225	35	50	55	75	145
150	250	35	55	65	85	170
200	315	40	65	80	110	220
250	400	50	75	95	130	270
300	450	55	85	110	150	320
400	560	65	110	140	195	430
500	710	75	130	170	240	550
600	800	85	150	200	285	645

*Other nominal sizes, insulating layers of other thicknesses and trace heating are available on enquiry. Other types of fitting have to be insulated by the installer. * Where BRS® push-in joints are intended for use in above-ground pipelines it is essential to consult our Applications Engineering Division.*

WKG pipes with VRS®-T push-in joints
Folded spiral-seam outer tubing (FL)
HDPE outer sleeve (EL)

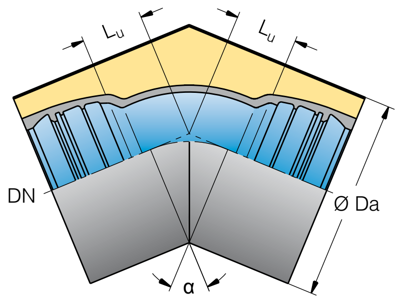


DN	Dimensions [mm]				Weight [kg] ~ 1)	
	Ø D_a	Ø d_1	L	s_D	FL-Rohr	EL-Rohr
80	180	98	207	41.0	121	110
100	225	118	215	53.5	149	140
125	250	144	223	53.0	180	171
150	280	170	230	55.0	212	204
200	355	222	240	66.5	300	288
250	400	274	265	63.0	383	378
300	450	326	270	62.0	476	471
400	560	429	290	65.5	705	715
500	710	532	300	89.0	986	1,003
600	800	635	280	82.5	1,266	1,314
700	900	738	302	81.0	1,632	1,698
800	1,000	842	314	79.0	2,004	2,082

1) Total weight; other nominal sizes, insulating layers of other thicknesses and trace heating are available on enquiry.

Dimension and weights of pipes of 5 m laying length are available on enquiry

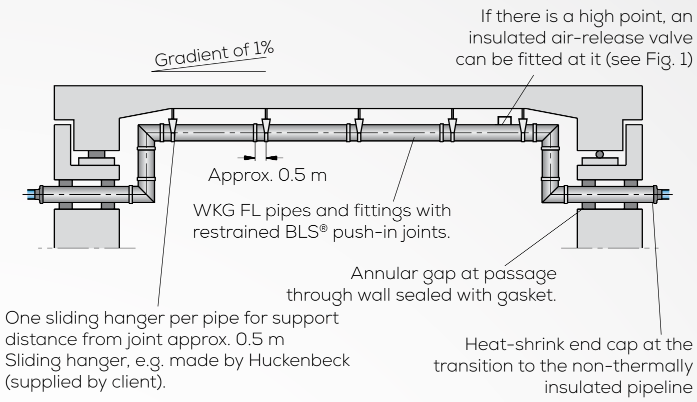
WKG socket bends (MMK) with VRS®-T push-in joints
Folded spiral-seam outer tubing (FL)/HDPE outer sleeve (EL)



DN	Ø Da	Dimensions L_u [mm]				
		MMK 11°	MMK 22°	MMK 30°	MMK 45°	MMQ (90°)
80	180	30	40	45	55	100
100	225	30	40	50	65	120
125	250	35	50	55	75	145
150	280	35	55	65	85	170
200	355	40	65	80	110	220
250	400	50	75	95	130	270
300	450	55	85	110	150	320
400	560	65	110	140	195	430
500	710	75	130	170	240	–
600	800	85	150	200	285	–

Other nominal sizes, insulating layers of other thicknesses and trace heating are available on enquiry. Other types of fitting have to be insulated by the installer.

Example: Installation of a bridge pipeline using WKG FL system and push-in joints



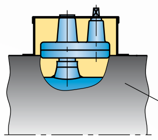
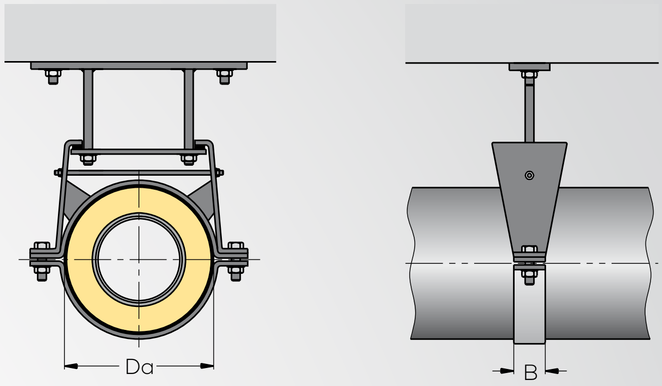


Fig. 1
Manual air-release valve
Hawlinger valve is used as standard

The change of length between the pipeline and the bridge can be compensated for by angular deflection at the bends.
If you have any questions, please consult our Applications Engineering Division.

Hangers for above-ground pipelines



Width B of clamp when hangers are spaced 6 m apart

DN	80-125	150-200	250-300	400-500	600-700	800
B	100	150	200	300	400	450

Sliding hangers with anti-lift-off guards. For fastening with anchor bolts or to brackets or bridges. Suitable for WKG pipes in line with structural requirements (e.g. made by Huckenbeck, supplied by the client)

Heat loss times for standing water in fully filled pipes (initial water temperature 8°C)

Above-ground pipelines (FL) with folded spiral-seam outer tubing and TYTON® push-in joints

DN of medium pipe	Thickness of insulation s_D [mm]	Temperature of ambient air -20°C		Temperature of ambient air -30°C	
		Cooling to 0°C [h]	Cooling to 25% ice [h]	Cooling to 0°C [h]	Cooling to 25% ice [h]
80	41.0	10	21	7	14
100	41.0	12	28	9	19
125	40.5	16	39	11	26
150	40.0	20	49	14	32
200	46.5	31	80	22	53
250	63.0	51	135	36	90
300	62.0	62	167	44	111
400	65.5	89	241	63	161
500	89.0	150	410	106	273
600	82.5	172	472	120	315
700	81.0	199	> 500	140	366
800	79.0	224		157	415

For other temperatures of ambient air, please consult our Applications Engineering Division.

Heat loss times for standing water in fully filled pipes (initial water temperature 8°C)

Buried pipelines (EL) with HDPE outer sleeves and TYTON® push-in joints

DN of medium pipe	Thickness of insulation s_D [mm]	Max. depth of frost penetration 1.4 m			
		Height of cover 0.3 m		Height of cover 0.5 m	
		Cooling to 0°C [h]	Cooling to 25% ice [h]	Cooling to 0°C [h]	Cooling to 25% ice [h]
80	41.0	24	68	32	102
100	41.0	31	94	41	142
125	40.5	40	130	53	196
150	40.0	49	169	64	254
200	46.5	76	292	100	440
250	63.0	125		164	
300	62.0	151		199	
400	65.5	214		282	
500	89.0	447	> 500		> 500
600	82.5			> 500	
700	81.0	> 500			
800	79.0				

For other depths of frost penetration and heights of cover, please consult our Applications Engineering Division.

7.2 Installation instructions for ductile iron pipes with WKG thermal insulation

Applicability

These installation instructions apply to thermally insulated (WKG) ductile iron pipes and fittings. For the assembly of the joints of pipes or fittings, see the particular installation instructions applicable to ductile iron pressure pipes with

- TYTON® push-in joints,
- restrained VRS®-T push-in joints,
- restrained BRS® push-in joints.

Special notes on transport and storage

When pipes are to be loaded or unloaded or moved about on site, and when they are being installed, slings should be used.
Pipes must only be placed down on at least 10 cm wide lengths of squared timber or other suitable materials spaced about 1.5 m away from the ends of the pipes.

They are not to be:

- put down with a jolt,
- thrown off the vehicle,
- dragged or rolled,
- stacked.

Laying tools and other accessories

- TYTON® assembly kit (bent screwdriver and depth gauge),
- V 303 laying tool for DN 80 to DN 400 pipes1),
- chain-hoist or cable-hoist laying tool for all other nominal sizes.

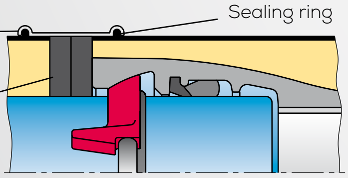
Plus. in the case of pipes with restrained VRS®-T push-in joints

- copper guide for welded bead
- clamping strap (DN 600 and above); see p. 18.

1) For BRS® push-in joints on pipes of DN 350 size and above, use a chain-hoist laying tool.

FL system for above-ground pipelines (folded spiral-seam outer tubing)

First the joint is assembled or assembled and locked, as the case may be, and then, depending on the type of joint (TYTON®, BRS® * or VRS®-T), one or more rings of soft polyethylene are inserted in the gap that is left between the spigot end and the end-face of the socket.
Finally, the joint is sealed off with a sheet-metal sleeve.



For this purpose, the installer inserts elastic sealing rings (supplied) in the beads formed on the sheet-metal sleeve and fixes the sleeve in position over the joint, in a centralised position, with self-tapping screws.

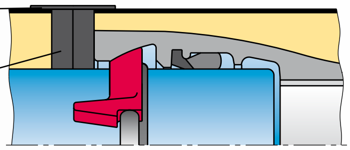
EL system for buried pipelines (outer sleeve of HDPE)

The gap is first insulated as in the case of the FL system.
The joint is then sealed off with heat-shrinkable material (a heat-shrinkable bandage).
One-piece sleeves have to be slid onto the barrels of the pipes before the joint is assembled.
Clean the surface area which is going to be covered of any grease. dirt and loose particles. Heat this area to about 60°C with a propane gas flame set to a soft setting. Peel the backing film protecting the adhesive away from the bandage for a distance
of about 150 mm.

* Our applications Engineering Division must be consulted when BRS® or TYTON® push-in joints are going to be used in above-ground pipelines.

Fix the free end of the bandage over the joint in a centralised position and at right angles to the plane of the joint and wrap the bandage loosely around the outer sleeve while at the same time peeling off the rest of the protective backing film. Overlap the bandage by at least 80 mm in an easily accessible area at the top of the pipeline.

At low ambient temperatures, it is advisable for the inner side of the overlapping part of the bandage and the inner side of the sealing strip to be heated briefly and pressed firmly against the pipes.



From the outside, heat the sealing strip evenly with a soft. constantly moving flame until the texture of the glass-fibre fabric can be seen. While wearing gloves, press the sealing strip firmly against the pipes by hand.
Shrink on the bandage in the circumferential direction using a soft, evenly moved, flame.

The shrinking-on has been properly carried out if

- the whole of the bandage has been shrunk on,
- it rests down flat, without any cold spots or air bubbles, and the sealing adhesive has been pressed out at both ends,
- the overlap on the outer tube is at least 50 mm.

The transition from a WKG thermally insulated pipe to ductile iron pipes with no thermal insulation is made by means of a heat-shrinkable end cap. With the appropriate changes, this is fitted in the same way as the shrink-on bandages.

Cutting of pipes

Ensure that the pipes are suitable for cutting (see p. 82).
Cuttable pipes are identified by a continuous longitudinal line (adhesive tape) on the outer tubing or outer sleeve and by the white stamped letters "SR" (*Schnittrohr* =
cuttable pipe) on the end-face of the socket.
Before the medium pipe is cut to the desired length, the outer tubing or outer sleeve and the polyurethane foam have to be removed in the region of the future spigot end.
The length required for the spigot end must be copied from the original pipe or taken from the Tables on p. 54.
When collars (EU and U fittings) having screwed socket joints or bolted gland joints are being used, allowance must be made at the

polyurethane foam and the outer tubing or outer sleeve for the larger amount of clear space required.
As dictated by the type of joint, the spigot ends should be finished as directed in the corresponding installation instructions.

Support for the FL system

Ensure that above-ground pipelines have supports, i.e. pipe hangers, of the minimum widths (see p. 55).

Underground installation of EL system

Bedding as per DVGW *Arbeitsblatt* W 400-2 or EN 805 should be provided for the pipes.
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*). When there are small heights of cover (< 0.5 m), load distributing slabs should be used above the pipeline zone.
Our Applications Engineering Division is at your service to answer any other questions you may have!

Trace heating

When WKG pipes with trace heating are being used, make sure that the heating cable is situated at the bottom of the pipes.

7.3 Coating of fittings (internal and external)

Structure

In a similar way to what is happening with valves, the powder coating of fittings with epoxy powder is becoming an increasingly important practice. Under EN 545, fittings coated in this way are suitable for use in soils of all classes of corrosiveness.
For this purpose, the fittings are first subjected to surface treatment by abrasive blasting (to give a standard of cleanliness of Sa 2.5). They are then heated to a temperature of approx. 200°C and are dipped into a fluidised bed of epoxy powder or are electrostatically coated by the use of a spray gun. Pore-free layers of a thickness of more than 250 µm are obtained when this is done. If the type of system being used is suitable, the coating process can be automated. When they have cooled, the fittings have their coatings made good at the points of suspension and are tested and packed.
The coating of our fittings meets the requirements of EN 14 910 and those of the GSK, the Quality Association for the Heavy Duty Corrosion Protection of Powder Coated Valves and Fittings.

RAL GÜTEZEICHEN
SCHWERER KORROSIONSSCHUTZ
VON ARMATUREN UND FORMSTÜCKEN

Operation

The action of the epoxy coating in protecting against corrosion is based on its absolutely pore-free nature, which keeps all corrosive factors away from the cast iron. Provided the coating is intact, there is a guarantee of protection. Any injuries to the coating should be avoided or should be repaired as quickly as possible.

Fields of use

Ductile iron fittings with an epoxy finishing layer to EN 14 901 can be used for transporting drinking water, non-drinking water, surface runoff, raw water, sewage and other wastewater.
Under EN 545 they can be used in soils of any desired corrosiveness. The grain size of the bedding material should not exceed 0 to 32 mm (rounded grains) of 0 to 16 mm (fragmented grains).

Installation instructions

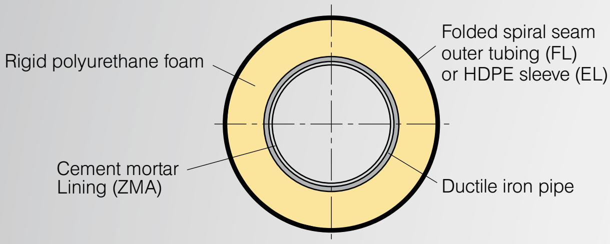
It is essential to avoid any damage to the internal and external coatings. Should any damage nevertheless occur, it must be repaired as quickly as possible. For this purpose, any loose parts of the coating must be removed and the damaged point repainted with a suitable epoxy paint. The point which has been repaired must be allowed to cure before the repaired fitting is re-installed.

7.4 External coatings Thermally insulated ductile iron pipes and fittings (WKG)

Structure of the WKG pipe system

The WKG pipe system consists of ductile iron pipes and socket bends (MMK, MMQ) to EN 545 (water) or EN 598 (sewerage) with TYTON® push-in joints to DIN 28 603 which may be restrained if desired.

The pipes are enclosed in thermal insulation formed by a CFC-free rigid polyurethane (PUR) foam with an average density of 80 kg/m^3. This rigid foam is protected from the effects of the weather in one of two ways: for above-ground pipelines (FL), by folded spiral-seam outer tubing of galvanized steel to EN 1506 or, as an option, of stainless steel, or for buried pipelines (EL) with a small height of cover which are thus at risk of freezing, by an outer sleeve of high-density polyethylene (HDPE) to EN 253.



The gap in the area of the push-in joint is filled with a ring of soft polyethylene and is covered with a sheet-metal sleeve (in the case of the FL system) or with a shrink-on polyethylene bandage (in the case of the EL system).

Operation

The insulation slows down the heat loss from the pipeline and hence from the drinking water it contains. In this way, even when the water stands still for quite long periods in the pipeline, it is possible for such periods to be waited out without the pipeline freezing. The exact periods depend on a variety of factors such as the ambient temperature, the temperature of the water, the thickness of the insulating layer and special local factors. The tables on p. 55 provide an overview of possible heat loss times.
If these times are not long enough, it is possible for a trace heating system to be incorporated. This system consists of a self-limiting heating cable which is bonded to the pipe carrying the medium and which is switched on at the desired temperature by means of a thermostat. The number and heating capacity of the cables have to be matched to the particular circumstances.

Fields of use

WKG pipes and fittings can be used anywhere where the pipeline can be expected to freeze. Some typical applications are the following:

- Bridge pipelines and pipelines laid above ground
  Positive locking joint systems (VRS®-T joints) should always be used in this case. The outer covering should be galvanized steel or stainless steel.

- Buried pipelines with small heights of cover
  A polyethylene outer sleeve should be used in this case. The grain size of the bedding material should not exceed 0 to 40 mm (rounded grains) or 0 to 11 mm (fragmented material). There is no limit to the corrosiveness of the bedding material. All the types of joint can be used, as dictated by the particular conditions.

8 - PLANNING, TRANSPORT AND INSTALLATION

8.1 Transport and storage

By carrying out comprehensive checks on all pipes and fittings during and after manufacture, including tests of their strength and leak tightness, we ensure that they are all in perfect condition when they leave us.

Provided our products are carefully handled during transport, storage and installation, the drinking water pipelines for which they are used will provide many years of trouble-free service. We therefore recommend that you only allow pipes and fittings to be unloaded and installed under the supervision of properly trained personnel.

Unloading and storage of pipes and pipe bundles

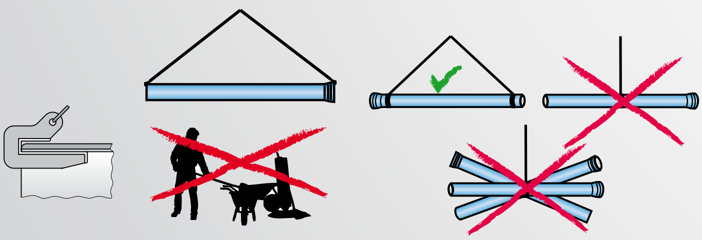
Pipes of up to DN 350 nominal size are supplied bundled. Above this size they are supplied as individual pipes. The exact number of pipes per bundle is shown in the table below. The weights of the pipes can, if required, be found from the pages dealing with the individual pipes.

	pipes per bundle							
DN	80	100	125	150	200	250	300	350
6 m-pipes	15	15	10	6	6	4	4	4
5 m-pipes	15	15	12	8	6	4	4	

When pipes or bundles of pipes are to be loaded or unloaded by crane, slings should be used. If individual pipes are unloaded with crane hooks, this must be done with wide, padded hooks fitted at the top of the ends of the pipe as otherwise there is a risk of the pipe and its coating or lining being damaged. Particularly with large pipes, an insert shoe matched to the shape of the pipe must be placed between the hook and the pipe.
As an alternative to loading and unloading by crane, suitable fork-lift trucks may also be used. In this case, particular attention must be paid to the following points:

- The pipes must not be able to tilt off the forks sideways (the forks should be at a width of at least 3 m).
- The pipes must not be able to roll off the forks.
- The forks must be adequately padded to prevent them from damaging the pipe.

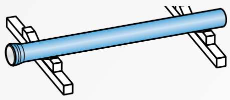
During the loading or unloading operation, no-one must stand below the pipe or pipe bundle or on it or in the danger area around the crane.
If pipes are to be moved around by hand, the caps fitted into the ends must first be removed temporarily.

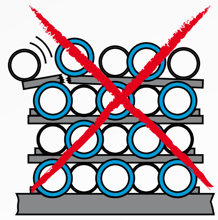


Pipes must only be placed down or stacked on lengths of squared timber or other suitable materials.

They are not to be:
- put down with a jolt,
- thrown off the vehicle,
- dragged, or to be rolled for any great distance.

They are to be
- secured against rolling and slipping,
- stored on level ground able to take their weight.



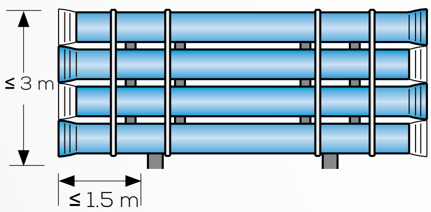


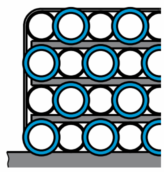
If ductile iron drinking water pipes are stored in stacks, they must rest on lengths of squared timber at least 10 cm wide. spaced approx. 1.5 m in from the ends of the pipes.

Maximum allowable heights of stack

DN	Layers
80–150	15
200–300	10
350–600	4
700–1,000	2

To prevent accidents, you should avoid building any stacks higher than 3 m. Thermally insulated ductile iron pipes (WKG pipes) must not be stacked!





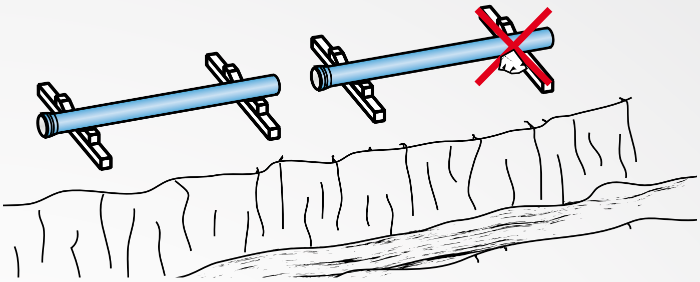
Unstrapping bundles of pipes

Steel or plastic straps are used to bundle our pipes. The straps should only be cut with suitable tools such as tin snips or side cutters. Using cold chisels, crowbars, pickaxes or the like may cause damage to the external coating of the pipes and also means a greater risk of accidents. Before the straps are cut, make sure that

- the bundle of pipes is standing on non-sloping ground which is as level as possible and which is able to carry the weight of the bundle,
- the pipes are secured against rolling and slipping,
- no-one is standing beside the bundle of pipes or on top of it.

Laying out the pipes on the installation site

If the pipes are laid out beside the pipe trench before they are installed, they should be stored on lengths of squared timber as described above and should be secured against slipping and rolling.
The caps fitted to seal off the ends of drinking water pipes should not be removed at this stage. They should only be removed just before the pipes are installed.



Storage of gaskets

To ensure that the pipeline will operate reliably, it is essential that the gaskets fitted are only ones which comply with the relevant quality specifications and are supplied with the pipes by the manufacturer. If other gaskets are used this may invalidate any claims under guarantee.

Gaskets should be stored in a cool, dry place without being in any way deformed. They should be protected from direct sunlight. Care must be taken to ensure that they are not damaged and do not get dirty.

At temperatures of below 0°C, the hardness of the gaskets increases to some degree. To make fitting easier, gaskets should therefore be stored at a temperature of more than 10°C when the outside temperature is below 0°C.
Gaskets should not be removed from the store until just before they are going to be fitted and should be checked for any fouling or damage at this time.

8.2 Pipeline trenches and bedding

Pipeline trenches should be set out and dug in accordance with current technical codes. Codes to be observed include:
EN 805, EN 1610, DIN 18 300, DIN 4124, DIN 50 929 Part 3, ONORM B 2538, DIN 30 375 Part 2, DVGW *Arbeitsblatt* W 400-2 or GW 9, ATV DVGW *Arbeitsblatt* A 139 and the *Merkblatt* on the filling of pipeline trenches.

Installation

Pipes and fittings should be installed in accordance with our installation instructions. The external coatings of pipes and the bedding material used for them should be selected in accordance with DIN 30 675 Part 2.

Pipe coating	Coating recommended for joints	Anode backfill	Fields of use in the form of soil classes
Zinc coating with finishing layer, to EN 545	None	No	I, II
		Yes	I, II, III [2]
Zinc-aluminium coating with finishing layer, to EN 545	None	No	I, II, III [2]
Cement mortar coating to EN 15 542	Rubber sleeves or heat-shrink material, or B-50M [1] or C-50M [1] coating to DIN 30 672 [1]	No	I, II, III

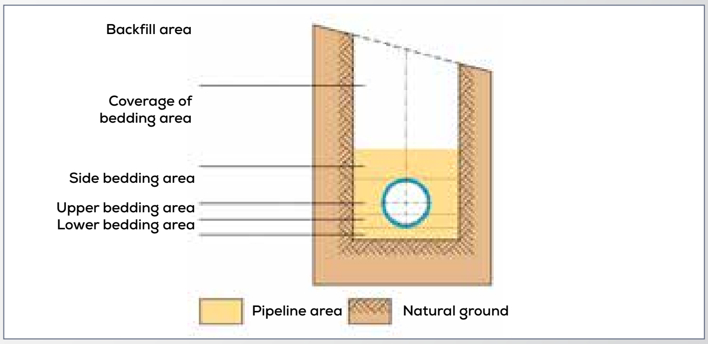
[1] *A B-50M or C-30M coating to DIN 30 672 may be used for joints at sustained operating temperatures of T 30°C.*
[2] *Not suitable when there is constant exposure to eluates of pH < 6 and in peaty, boggy, muddy and marshy soils. The directions given in section 4.1 of DIN 30 675 Part 2 must be followed.*

Classification of soils into main groups under DIN 50 929 Part 3		
Evaluation number	Soil class	Aggressiveness of soil
> 0	I a	Not aggressive
-1 bis -4	I b	Of low aggressiveness
-5 bis -10	II	Aggressive
< -10	III	Highly aggressive

Not only the aggressiveness of the soil but also its grain size has a part to play in the selection of the external coating for pipes. DVGW *Arbeitsblatt* W 400-2 provides an overview of the allowable grain sizes.

Pipe material	Coating	Grain size of rounded material	Grain size of fragmented material
Ductile iron pipes	Zinc/bitumen Zinc/epoxy Zinc-aluminium/epoxy Zinc/polyurethane	0-32 mm Individual grains up to a max. of 63 mm*	0-16 mm Individual grains up to a max. of 32 mm
Ductile iron pipes	Cement mortar	0-63 mm Individual grains up to a max. of 100 mm	0-63 mm Individual grains up to a max. of 100 mm

**According to ÖNORM B2538 the designer has the possibility to increase the maximum grain size up to 100mm for ductile cast iron pipes coated with PUR (polyurethane finishing) or PUR-TOP (polyurethane finishing plus PE-tape). Essential condition therefore is no compression of the backfill area and settlements which maybe occur on top are acceptable (f.e. forest soil, agricultural areas....).*



Pressure testing

The execution of pressure tests on pressure pipelines is governed by EN 805 or DVGW *Arbeitsblatt* W 400-2. During pressure testing, all work on the pipelines being tested must be stopped.
Particularly in the case of pressure pipelines, all personnel must remain at an adequate safe distance from the pipeline.

8.3 Calculating vertical offsets when using flanged fittings

Formulas

L_H = H/tan α

L_S = H/sin α

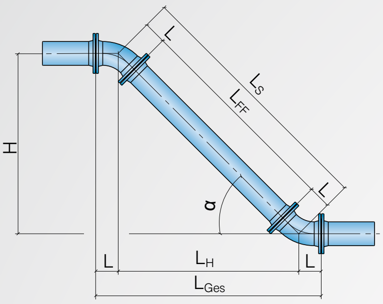
L_{FF} = L_S - 2 · L

L_{Ges} = L_H + 2 · L

H = Vertical offset from pipe axis to pipe axis

L = Centre-to-end length of the double flanged bend

α = Angle of the double flanged bend



How long does the double flanged pipe have to be when existing double flanged bends are being used and the vertical offset is known?

Worked example:

FFK 30°, DN 200, H = 70 cm

1. Find the value "L_S" from Table 2 for the known vertical offset and the angle **α** of the bend. — 140 cm
2. Find the centre-to-end length "L" of the bend from Table 1 or our Drinking Water Catalogue. — 18.0 cm
3. To find the length "L_{FF}" of the double flanged pipe, deduct twice "L" from "L_S". — L_{FF} = 140 cm - 2 • 18 cm = 104 cm

How large is the vertical offset "H" when an existing double flanged pipe and existing double flanged bends are being used?

Worked example:

FFK 30°, DN 200, L_{FF} = 104 cm

1. Measure the length "L_{FF}" of the double flanged pipe. — 104 cm
2. Find the centre-to-end length "L" of the bend from Table 1 or our Drinking Water Catalogue. — 18.0 cm
3. Calculate "L_S": L_S = L_{FF} + 2 • L. — L_S = 104 cm + 2 • 18 cm = 140 cm
4. Find the sin **α** of the bends which are being used from Table 2. — 0.5 cm
5. Calculate the vertical offset "H" given by the above as follows: H = L_S • sin **α**. — H = 140 cm • 0.5 = 70 cm

How long is the distance "L_{GES}" when the vertical offset "H" and the angle of the double flanged bends are known?

Worked example:

FFK 30°, DN 200, H = 70 cm

1. From the known vertical offset and the angle **α** of the double flanged bend. find the value "L_H" from Table 3. — 121.2 cm
2. Find the centre-to-end length "L" of the bend from Table 1 or our Drinking Water Catalogue. — 18.0 cm
3. Calculate "L_{GES}" as follows: L_{GES} = L_H + 2 • L. — LGES = 121.2 cm + 2 • 18 cm = 157.2 cm

Table 1: Centre-to-end lengths "L" of double flanged bends (FFK) as a function of the angle α and diameter DN

Angle α of FFK	Centre-to-end length L [cm] of double flanged bend								
	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250	DN 300	DN 350	DN 400
11°	13.0	14.0	15.0	16.0	18.0	21.0	25.0	10.5	11.3
22°	13.0	14.0	15.0	16.0	18.0	21.0	25.0	14.0	15.3
30°	13.0	14.0	15.0	16.0	18.0	21.0	25.0	16.5	18.3
45°	13.0	14.0	15.0	16.0	18.0	35.0	40.0	29.8	32.4
90°	16.5	18.0	20.0	22.0	26.0	35.0	40.0	45.0	50.0

Angle α of FFK	Centre-to-end length L [cm] of double flanged bend					
	DN 500	DN 600	DN 700	DN 800	DN 900	DN 1000
11°	13.5	17.4	19.4	21.3	–	–
22°	18.5	25.4	28.4	31.4	–	–
30°	22.0	30.9	34.6	38.3	–	–
45°	37.5	42.6	47.8	52.9	58.1	63.2
90°	60.0	70.0	80.0	90.0	100.0	110.0

Dimensions may differ from those shown. The centre-to-end lengths "L" can also be found in Chapter 4.

Table 2 for determining the length "L_s" as a function of the angle α and vertical offset "H"

Angle α of FFK	sin α	Length of the slope "L_S" [cm] – Vertical offset H [cm] (pipe axis to pipe axis)									
		5	10	15	20	25	30	35	40	45	50
11°	0.19081	26.2	52.4	78.6	104.8	131.0	157.2	183.4	209.6	235.8	262.0
22°	0.37461	13.3	26.7	40.0	53.4	66.7	80.1	93.4	106.8	120.1	133.5
30°	0.5	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0
45°	0.70711	7.1	14.1	21.2	28.3	35.4	42.4	49.5	56.6	63.6	70.7
90°	1	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0

Angle α of FFK	sin α	Length of the slope "L_S" [cm] – Vertical offset H [cm] (pipe axis to pipe axis)									
		55	60	65	70	75	80	85	90	95	100
11°	0.19081	288.2	314.4	340.7	366.9	393.1	419.3	445.5	471.7	497.9	524.1
22°	0.37461	146.8	160.2	173.5	186.9	200.2	213.6	226.9	240.2	253.6	266.9
30°	0.5	110.0	120.0	130.0	140.0	150.0	160.0	170.0	180.0	190.0	200.0
45°	0.70711	77.8	84.9	91.9	99.0	106.1	113.1	120.2	127.3	134.3	141.4
90°	1	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0	95.0	100.0

Table 3 for determining the length "L_H" as a function of the angle α and vertical offset "H"

Angle α of FFK	tan α	Horizontal length "L_H" [cm] of the offset. from centre to centre of bends – Vertical offset H [cm] (pipe axis to pipe axis)									
		5	10	15	20	25	30	35	40	45	50
11°	0.19438	25.7	51.4	77.2	102.9	128.6	154.3	180.1	205.8	231.5	257.2
22°	0.40403	12.4	24.8	37.1	49.5	61.9	74.3	86.6	99.0	111.4	123.8
30°	0.57735	8.7	17.3	26.0	34.6	43.3	52.0	60.6	69.3	77.9	86.6
45°	1	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0
90°	∞	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Angle α of FFK	tan α	Vertical offset H [cm] (pipe axis to pipe axis) – Vertical offset H [cm] (pipe axis to pipe axis)									
		55	60	65	70	75	80	85	90	95	100
11°	0.19438	283.0	308.7	334.4	360.1	385.8	411.6	437.3	463.0	488.7	514.5
22°	0.40403	136.1	148.5	160.9	173.3	185.6	198.0	210.4	222.8	235.1	247.5
30°	0.57735	95.3	103.9	112.6	121.2	129.9	138.6	147.2	155.9	164.5	173.2
45°	1	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0	95.0	100.0
90°	∞	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

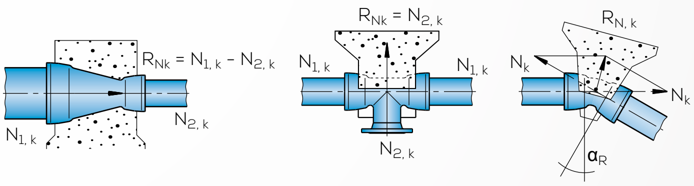
8.4 Dimensioning of concrete thrust blocks

This summary of the on-site procedure applies only to thrust blocks at dead ends, changes of direction and branches lying in a horizontal plane, under the following limiting conditions:

- nominal size ≤ DN 300
- concrete of strength class C30/37
- thrust block laid out symmetrically to the line along which the force to be absorbed (N, RN) acts
- load spread angle in the concrete: $2\alpha_K = 90°$
- outside temperatures of between +10°C and +30°C
- horizontal terrain
- concrete placed against undisturbed soil and vertical wall of trench
- depth of foundation h of the thrust block:
  1.0 m ≤ h ≤ 3.0 m
  $\frac{1}{4}h \leq h_G \leq \frac{2}{3}h$
- height h_G of thrust block against the trench wall:
  curing time until the pressure test: at least 3 days
- approximately square bearing area of thrust block against the trench wall: h_G x b_G
- water table lower than bottom face of thrust block

For practical reasons, no figures are given for the values (h_R and b_R) defining the area for transmitting force between the pipeline and the thrust block and it is recommended that the concrete covers the full width, to the sockets, of the pipeline component and that there is adequate concrete cover above the component.

For parameter values which differ from those given above, reference should be made to DVGW *Arbeitsblatt* GW 310, January 2008 version.



Taper Branch Bend

Characteristic longitudinal force:

$$N_K = p \cdot \frac{\pi \cdot d_a^2}{4} \quad [kN]$$

Characteristic resultant force:

$$R_{N,k} = 2N_k \cdot \sin\frac{\alpha_R}{2} \quad \rightarrow \quad R_{N,k} = N_k \cdot a \quad [kN] \quad \text{where} \quad a = 2 \cdot \sin\alpha_R \ / 2$$

(for a see table below)

d_a = outside diameter of pipe [m]
p = internal pressure (test pressure) [kN/m²] → 1 bar = 100 kN/m²

α	11°	22°	30°	45°	Dead ends and branches	90°
a	0.2	0.4	0.5	0.8	1.0	1.4

The following table shows the values of the resultant force RN,k calculated for the most widely used nominal sizes and bends, for a test pressure of 15 bars. With these figures, it is now possible to calculate the required bearing area of a thrust block against the soil.

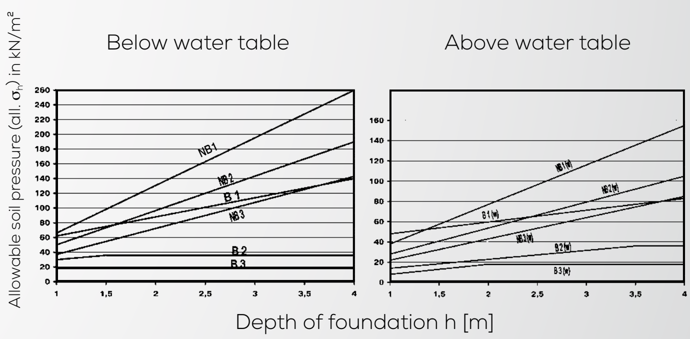
DN	N_k [kN] (15 bar)	$R_{N,k}$ [kN] for bends of angles 11¼°	22½°	30°	45°	90°
65	7.9	1.5	3.1	4.1	6.1	11.2
80	11.3	2.2	4.4	5.9	8.7	16.0
100	16.4	3.2	6.4	8.5	12.6	23.2
125	22.4	4.8	9.5	12.6	18.7	34.5
150	34.0	6.7	13.3	17.6	26.1	48.1
200	58.1	11.4	22.7	30.1	44.4	82.1
250	88.4	17.3	34.5	45.8	67.7	125.1
300	125.2	24.5	48.9	64.8	95.8	177.1
350	168.3	33.0	65.7	87.1	128.8	238.1
400	216.8	42.5	84.6	112.2	165.9	305.6
500	333.4	65.4	130.1	172.6	255.2	471.5
600	475.0	93.1	185.4	245.9	363.6	671.8
700	641.6	125.8	250.4	332.1	491.1	907.4
800	835.2	163.7	325.9	432.3	639.3	1,181.2
900	1,052.1	206.2	410.5	544.6	805.2	1,478.9
1,000	1,293.9	253.7	504.9	669.8	990.3	1,829.9

Required bearing area against the soil:

$$A_G = b_G \cdot h_G \quad [m^2] \qquad A_G = \frac{R_{N,k}}{\sigma_{h,w}} \quad [m^2]$$

Allowable $\sigma_{h,w}$ = allowable soil pressure [kN/m²]

Allowable soil pressure (allowable $\sigma_{h,w}$) as a function of soil group and depth of foundation h for thrust blocks with a square bearing area (h_G/b_G=1)



NB1: Sand, gravel or sharp-edged, natural broken stone, tightly compacted
NB2: Sand or sandy gravel, compacted to medium tightness
NB3: Sand or sandy gravel, loosely compacted
B1: Till, loam or clay, of at least semi-firm consistency (not kneadable)
B2: Loam, silt or clay, of at least soft consistency (difficult to knead)
B3: Loam, silt or clay, of at least soft consistency (easily kneadable)

For any desired test pressure p, the formula which applies to bearing area is:

$$A_G = \frac{R_{N,k}}{\text{Allowable } \sigma_{h,w}} \cdot \frac{p}{15} \quad [m^2]$$

Example:

Pipeline	DN 200
Test pressure	p = 30 bar
Soil pressure	Allowable $\sigma_{h,w}$ = 50 kN/m²
Angle of bend	α_k = 30°

Question: How large does the bearing area AG against the soil need to be?
R_N = 30.1 kN (see table below)

$$A_G = \frac{30{,}1}{50} \cdot \frac{30}{15} \quad [m^2]$$

$$A_G = \underline{1{,}204\,m^2}$$

For calculating concrete thrust blocks under DVGW *Merkblatt* 310, there is also a tool for calculation available at **www.eadips.org**
Table for the dimensioning of concrete thrust blocks at bends and branches. Figures were calculated for a test pressure of 15 bars and a soil pressure of 100 kN/m². Area = breadth B x height H.

DN	cm² cm x cm	α = 11°	α = 22°	α = 30°	α = 45°	α = 90°	Dead ends and branches [1]
80	F B x H	500 20 x 25	500 20 x 25	590 24 x 25	870 29 x 30	1.600 38 x 42	1.130 34 x 34
100	F B x H	500 20 x 25	640 25 x 26	850 29 x 30	1.260 35 x 36	2.320 48 x 49	1.640 40 x 41
125	F B x H	500 20 x 25	950 30 x 32	1.260 35 x 36	1.870 43 x 44	3.450 58 x 60	2.440 49 x 50
150	F B x H	670 20 x 25	1.330 36 x 37	1.760 42 x 42	2.610 50 x 52	4.810 69 x 70	3.400 58 x 59
200	F B x H	1.140 33 x 35	2.270 48 x 48	3.010 55 x 55	4.440 67 x 67	8.210 91 x 91	5.810 76 x 77
250	F B x H	1.730 42 x 42	3.450 59 x 59	4.580 68 x 68	6.770 82 x 83	12.510 112 x 112	8.840 94 x 94
300	F B x H	2.450 49 x 50	4.890 70 x 77	6.480 80 x 81	9.580 98 x 98	17.710 133 x 133	12.520 112 x 112
400	F B x H	4.250 65 x 66	8.460 92 x 92	11.220 106 x 106	16.590 129 x 129	30.560 175 x 175	21.680 147 x 148

[1] *These values apply only to dead ends and branches of the nominal sizes specified.*

8.5 Lengths of pipeline to be restrained

Forces are exerted at bends, branches, dead ends and tapers in pipelines and the size of these forces can be calculated on the basis of, for example, DVGW *Merkblatt* GW 310.

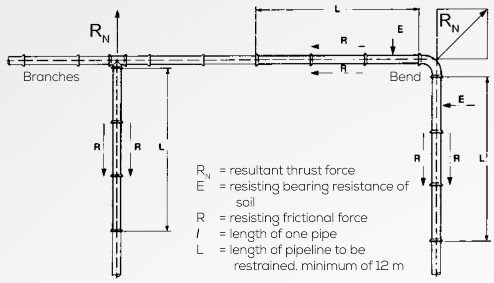
In pipelines which already have restrained joints, such as welded or flanged joints for example, these forces are transmitted by the pipe joints. In pipelines with non-restrained joints, e.g. push-in joints (TYTON® joints) or screwed socket joints, these forces have to be:

- absorbed by means of concrete thrust blocks (see GW 310), or
- transmitted longitudinally and transferred to the surrounding soil by providing restraint at a number of sockets (socket restraint).

The number of sockets which have to be restrained by the provision of longitudinal restraint depends on the test pressure, the nominal size of the pipes and the standard to which the pipeline trench has been backfilled (type of soil, degree of compaction).

The forces generated by the internal pressure are resisted by the following:

- at bends, branches, dead ends and tapers: the frictional forces between the pipe wall and the surrounding soil,
- at bends: additionally, the bearing resistance of the soil which acts on the adjoining pipes.



Coefficient of friction

The coefficient of friction μ for the friction between the soil and the pipe is between 0.1 and 0.6. Our recommended assumed figures are as follows:

μ = 0.5	for non-cohesive sands, gravels and tills (soil types NB1 to NB3 under GW 310)
μ = 0.25	for very loamy sand, sandy loam, marl, loess or loess loam and clay, of at least semi-firm consistency (soil type B1 under GW 310)
μ = 0.5	for pipes with a cement mortar coating
μ = 0	when a pipeline is laid below the water table and/or in cohesive soils of soft and stiff consistency which are difficult to compact (soil types B2 to B4 under GW 310) → In such cases we recommend restraining the entire pipeline.

Soil pressure

The soil pressure which is possible very much depends on the degree of compaction of the trench filling immediately surrounding the pipeline. This should be at least D_{pr} = 95% In this latter case, it can be expected that the values of allowable horizontal soil pressure (allowable $\sigma_{h,w}$) given in the graph from GW 310 (see page 63) will be reduced by 50%.

Notes

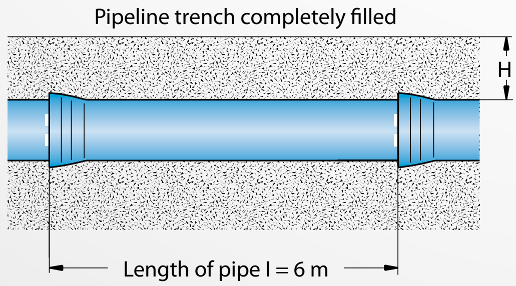
At least the following must always be restrained:

- in the case of bends: 2 sockets on each side,
- in the case of branches and dead ends: 2 sockets,
- in the case of tapers: 2 sockets on the side of the larger nominal size.

For a variety of parameters such as coefficient of friction, soil pressure, height of cover of pipes and system test pressure, the tables shown on the following pages give the lengths of pipeline to be restrained for ductile iron pipes. Where a bend at which the resultant force is directed towards the surface is to be restrained, the length of pipeline to be restrained is the same as for a branch or dead end (180°) There are other calculations which can be carried out by going to www.eadips.org

The tables on the following pages apply provided the following conditions are met:

- The pipeline trench is completely filled to the height H.
- The material used to fill the pipeline trench is carefully compacted (D_{pr} = 95%)
- There is no water in the pipeline trench.
- Ductile iron pipes with a wall thickness of class K9 are used



Length of pipeline to be restrained L [m] when the following parameters apply

Soil in the pipeline zone: Sand, gravel or broken stone, tightly compacted (NB1)
Coefficient of friction: μ = 0.50
Soil pressure: Allowable σh, w = 40 kN/m²
Height of cover of pipeline: H = 1.00 [m]
(pipeline trench completely filled)

Length of pipeline to be restrained L [m] at test pressure of 10 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	12	12	12	12	15	18	22	25	28	31	34
90°	12	12	12	12	12	12	12	12	15	18	21	24	27	30
45°	12	12	12	12	12	12	12	12	12	13	16	19	22	25
30°	12	12	12	12	12	12	12	12	12	12	12	15	18	21
22°	12	12	12	12	12	12	12	12	12	12	12	12	13	16
11°	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Length of pipeline to be restrained L [m] at test pressure of 15 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	12	13	16	19	24	30	34	39	44	48	52
90°	12	12	12	12	12	12	13	19	24	29	34	38	43	47
45°	12	12	12	12	12	12	12	13	19	24	29	33	38	42
30°	12	12	12	12	12	12	12	12	14	19	24	29	33	38
22°	12	12	12	12	12	12	12	12	12	14	19	24	28	33
11°	12	12	12	12	12	12	12	12	12	12	12	12	12	16

Length of pipeline to be restrained L [m] at test pressure of 21 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	14	19	23	27	34	41	48	55	61	67	73
90°	12	12	12	12	13	17	21	29	36	43	49	56	62	68
45°	12	12	12	12	12	12	15	23	30	37	44	51	57	63
30°	12	12	12	12	12	12	12	15	25	33	40	46	52	58
22°	12	12	12	12	12	12	12	12	20	27	34	41	48	54
11°	12	12	12	12	12	12	12	12	12	12	16	23	29	36

Length of pipeline to be restrained L [m] at test pressure of 30 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600
180°	12	15	18	21	27	32	38	49	59	69
90°	12	12	12	14	20	26	32	43	53	63
45°	12	12	12	12	15	24	29	38	48	58
30°	12	12	12	12	12	15	21	32	43	53
22°	12	12	12	12	12	12	16	27	38	48
11°	12	12	12	12	12	12	12	12	18	29

Length of pipeline to be restrained L [m] at test pressure of 45 bars

DN / Bogen	80	100	125	150	200	250	300
180°	18	22	26	31	40	49	57
90°	12	16	20	25	34	43	51
45°	12	12	14	19	28	37	45
30°	12	12	12	14	23	32	40
22°	12	12	12	12	17	26	35
11°	12	12	12	12	12	12	14

Soil in the pipeline zone: Very loamy sand, sandy loam, loam, clay, marl (B1)
Coefficient of friction: μ = 0.25
Soil pressure: Allowable $\sigma_{h,w}$ = 30 kN/m²
Height of cover of pipeline: H = 1.00 [m]
(pipeline trench completely filled)

Length of pipeline to be restrained L [m] at test pressure of 10 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	13	17	21	24	32	39	45	52	58	63	69
90°	12	12	12	12	12	15	18	26	33	40	46	53	58	64
45°	12	12	12	12	12	12	12	18	25	32	39	45	51	57
30°	12	12	12	12	12	12	12	12	17	25	31	38	44	50
22°	12	12	12	12	12	12	12	12	15	17	24	30	37	43
11°	12	12	12	12	12	12	12	12	12	12	12	12	12	16

Length of pipeline to be restrained L [m] at test pressure of 15 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	15	18	21	27	32	38	49	59	69	78	87	96	104
90°	12	12	12	13	19	25	31	42	52	62	71	81	89	97
45°	12	12	12	12	12	16	22	32	44	54	64	73	82	90
30°	12	12	12	12	12	12	14	26	37	47	57	66	75	84
22°	12	12	12	12	12	12	12	17	29	39	49	59	68	77
11°	12	12	12	12	12	12	12	12	12	12	22	31	41	50

Length of pipeline to be restrained L [m] at test pressure of 21 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	17	20	25	29	37	45	53	68	83	96	110	122	134	145
90°	12	13	17	21	30	38	46	61	76	90	103	115	127	139
45°	12	12	12	12	21	29	37	53	68	82	95	108	120	132
30°	12	12	12	12	13	21	29	45	60	74	88	101	113	125
22°	12	12	12	12	12	13	21	37	52	67	80	94	106	120
11°	12	12	12	12	12	12	12	18	22	38	52	66	79	92

Length of pipeline to be restrained L [m] at test pressure of 30 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600
180°	23	28	34	41	53	64	76	98	118	138
90°	17	22	28	34	47	58	70	92	113	132
45°	12	13	19	25	38	50	61	84	105	125
30°	12	12	12	17	30	42	53	76	97	118
22°	12	12	12	12	21	33	45	68	89	110
11°	12	12	12	12	12	12	14	37	59	81

Length of pipeline to be restrained L [m] at test pressure of 45 bars

DN / Bogen	80	100	125	150	200	250	300
180°	35	43	52	61	80	97	114
90°	29	36	46	55	73	91	108
45°	20	27	37	46	65	82	100
30°	12	19	29	38	57	74	92
22°	12	12	20	29	48	66	83
11°	12	12	12	12	16	34	52

Length of pipeline to be restrained L [m] when the following parameters apply

Soil in the pipeline zone: Very loamy sand, sandy loam, loam, clay, marl (B1)
Coefficient of friction: μ = 0.50
Soil pressure: Allowable $\sigma_{h,w}$ = 30 kN/m²
Height of cover of pipeline: H = 1.00 [m]
(pipeline trench completely filled)

Length of pipeline to be restrained L [m] at test pressure of 10 bars

DN Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	12	12	12	12	15	19	22	25	28	31	34
90°	12	12	12	12	12	12	12	12	16	19	23	26	29	32
45°	12	12	12	12	12	12	12	12	12	15	19	22	25	28
30°	12	12	12	12	12	12	12	12	12	12	15	18	22	25
22°	12	12	12	12	12	12	12	12	12	12	12	15	18	21
11°	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Length of pipeline to be restrained L [m] at test pressure of 15 bars

DN Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	12	12	15	18	24	29	34	39	43	47	52
90°	12	12	12	12	12	12	15	21	26	31	36	40	45	49
45°	12	12	12	12	12	12	12	16	22	27	32	37	41	45
30°	12	12	12	12	12	12	12	13	18	23	28	33	38	42
22°	12	12	12	12	12	12	12	12	14	19	25	29	34	39
11°	12	12	12	12	12	12	12	12	12	12	12	16	20	25

Length of pipeline to be restrained L [m] at test pressure of 21 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	13	18	22	26	33	41	48	54	61	67	73
90°	12	12	12	12	15	19	23	30	38	45	52	58	64	70
45°	12	12	12	12	12	14	19	26	34	41	48	54	60	66
30°	12	12	12	12	12	12	15	23	30	37	44	51	57	63
22°	12	12	12	12	12	12	12	18	26	33	40	47	53	60
11°	12	12	12	12	12	12	12	12	12	19	26	33	40	46

Length of pipeline to be restrained L [m] at test pressure of 30 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600
180°	12	13	16	20	26	32	37	48	59	69
90°	12	12	13	16	23	28	34	45	56	66
45°	12	12	12	12	18	24	30	41	52	62
30°	12	12	12	12	14	20	26	37	48	58
22°	12	12	12	12	12	16	22	33	44	54
11°	12	12	12	12	12	12	12	18	29	40

Length of pipeline to be restrained L [m] at test pressure of 45 bars

DN / Bogen	80	100	125	150	200	250	300
180°	17	21	25	30	39	48	57
90°	14	18	22	27	36	45	54
45°	12	13	18	23	32	41	49
30°	12	12	14	18	28	37	45
22°	12	12	12	14	23	32	41
11°	12	12	12	12	12	16	26

Soil in the pipeline zone: Sand, gravel or broken stone, tightly compacted (NB1)
Coefficient of friction: μ = 0.50
Soil pressure: Allowable $\sigma_{h,w}$ = 40 kN/m²
Height of cover of pipeline: H = 1.50 [m]
(pipeline trench completely filled)

Length of pipeline to be restrained L [m] at test pressure of 10 bars

DN / Bend	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	12	12	12	12	12	13	15	18	20	22	25
90°	12	12	12	12	12	12	12	12	12	13	15	18	20	22
45°	12	12	12	12	12	12	12	12	12	12	12	14	16	19
30°	12	12	12	12	12	12	12	12	12	12	12	12	13	15
22°	12	12	12	12	12	12	12	12	12	12	12	12	12	12
11°	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Length of pipeline to be restrained L [m] at test pressure of 15 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	12	12	12	12	16	20	24	27	31	34	37
90°	12	12	12	12	12	12	12	13	17	21	25	28	31	35
45°	12	12	12	12	12	12	12	12	13	17	21	24	28	31
30°	12	12	12	12	12	12	12	12	12	14	18	21	25	28
22°	12	12	12	12	12	12	12	12	12	12	14	18	21	25
11°	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Length of pipeline to be restrained L [m] at test pressure of 21 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	12	12	15	18	23	28	33	38	43	48	52
90°	12	12	12	12	12	12	15	20	26	31	36	41	45	50
45°	12	12	12	12	12	12	12	16	22	27	32	37	42	46
30°	12	12	12	12	12	12	12	12	18	24	29	34	38	43
22°	12	12	12	12	12	12	12	12	15	20	25	30	35	40
11°	12	12	12	12	12	12	12	12	12	12	12	17	22	27

Length of pipeline to be restrained L [m] at test pressure of 30 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600
180°	12	12	12	13	17	21	25	33	41	48
90°	12	12	12	12	15	19	23	31	38	45
45°	12	12	12	12	12	15	19	27	34	42
30°	12	12	12	12	12	12	15	23	31	38
22°	12	12	12	12	12	12	12	19	27	35
11°	12	12	12	12	12	12	12	12	13	21

Length of pipeline to be restrained L [m] at test pressure of 45 bars

DN / Bogen	80	100	125	150	200	250	300
180°	12	12	17	20	27	32	39
90°	12	12	14	17	24	30	36
45°	12	12	12	13	20	26	32
30°	12	12	12	12	16	22	29
22°	12	12	12	12	12	18	25
11°	12	12	12	12	12	12	12

Length of pipeline to be restrained L [m] when the following parameters apply

Soil in the pipeline zone: Very loamy sand, sandy loam, loam, clay, marl (B1)
Coefficient of friction: μ = 0.25
Soil pressure: Allowable $\sigma_{h.w}$ = 30 kN/m²
Height of cover of pipeline: H = 1.50 [m] (pipeline trench completely filled)

Length of pipeline to be restrained L [m] at test pressure of 10 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	12	12	14	17	22	27	32	37	41	46	50
90°	12	12	12	12	12	12	13	18	23	28	33	38	42	46
45°	12	12	12	12	12	12	12	13	18	23	28	32	37	41
30°	12	12	12	12	12	12	12	12	12	17	22	27	32	36
22°	12	12	12	12	12	12	12	12	12	12	17	22	26	31
11°	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Length of pipeline to be restrained L [m] at test pressure of 15 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	13	18	22	26	34	41	48	56	62	69	75
90°	12	12	12	12	13	18	22	30	37	45	52	59	65	72
45°	12	12	12	12	12	12	16	24	32	39	46	53	60	67
30°	12	12	12	12	12	12	12	18	26	34	41	48	55	62
22°	12	12	12	12	12	12	12	13	21	28	36	43	50	57
11°	12	12	12	12	12	12	12	12	12	12	19	23	30	37

Length of pipeline to be restrained L [m] at test pressure of 21 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	13	16	19	25	31	36	47	58	68	78	88	97	106
90°	12	12	13	15	21	27	32	43	54	64	74	84	93	102
45°	12	12	12	12	15	21	26	38	48	59	69	79	88	97
30°	12	12	12	12	12	15	21	32	43	54	64	74	83	92
22°	12	12	12	12	12	12	15	27	37	48	58	68	78	87
11°	12	12	12	12	12	12	12	12	17	37	38	48	58	68

Length of pipeline to be restrained L [m] at test pressure of 30 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600
180°	16	19	23	28	36	44	52	68	83	98
90°	12	15	19	23	32	40	48	64	79	94
45°	12	12	13	17	26	34	42	58	73	88
30°	12	12	12	12	20	29	37	53	68	83
22°	12	12	12	12	14	23	31	47	63	78
11°	12	12	12	12	12	12	12	26	42	57

Length of pipeline to be restrained L [m] at test pressure of 45 bars

DN / Bogen	80	100	125	150	200	250	300
180°	24	29	36	42	54	67	79
90°	20	25	31	38	50	63	75
45°	14	19	25	32	44	57	69
30°	12	13	20	26	39	51	64
22°	12	12	14	20	33	45	58
11°	12	12	12	12	12	24	36

Soil in the pipeline zone: Very loamy sand, sandy loam, loam, clay, marl (B1)
Coefficient of friction: μ = 0.50
Soil pressure: Allowable $\sigma_{h.w}$ = 30 kN/m²
Height of cover of pipeline: H = 1.50 [m] (pipeline trench completely filled)

Length of pipeline to be restrained L [m] at test pressure of 10 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	12	12	12	12	12	13	16	18	20	23	25
90°	12	12	12	12	12	12	12	12	12	14	16	18	21	23
45°	12	12	12	12	12	12	12	12	12	12	13	16	18	20
30°	12	12	12	12	12	12	12	12	12	12	12	13	16	18
22°	12	12	12	12	12	12	12	12	12	12	12	12	13	15
11°	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Length of pipeline to be restrained L [m] at test pressure of 15 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	12	12	12	13	16	20	24	28	31	34	38
90°	12	12	12	12	12	12	12	14	18	22	26	29	32	36
45°	12	12	12	12	12	12	12	12	15	19	23	26	30	33
30°	12	12	12	12	12	12	12	12	13	17	20	24	27	31
22°	12	12	12	12	12	12	12	12	12	14	18	21	25	28
11°	12	12	12	12	12	12	12	12	12	12	12	12	15	18

Length of pipeline to be restrained L [m] at test pressure of 21 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600	700	800	900	1000
180°	12	12	12	12	12	15	18	23	29	35	39	44	48	53
90°	12	12	12	12	12	13	16	21	27	32	37	42	46	51
45°	12	12	12	12	12	12	13	18	24	29	34	39	44	48
30°	12	12	12	12	12	12	12	16	21	26	32	36	41	46
22°	12	12	12	12	12	12	12	13	18	24	29	34	38	43
11°	12	12	12	12	12	12	12	12	12	13	19	24	29	34

Length of pipeline to be restrained L [m] at test pressure of 30 bars

DN / Bogen	80	100	125	150	200	250	300	400	500	600
180°	12	12	12	13	18	22	26	34	41	49
90°	12	12	12	12	16	20	24	32	39	47
45°	12	12	12	12	13	17	21	29	36	44
30°	12	12	12	12	12	14	18	26	34	41
22°	12	12	12	12	12	12	15	23	31	38
11°	12	12	12	12	12	12	12	13	21	28

Length of pipeline to be restrained L [m] at test pressure of 45 bars

DN / Bend	80	100	125	150	200	250	300
180°	12	14	17	21	27	33	39
90°	12	12	15	18	25	31	37
45°	12	12	12	15	22	28	34
30°	12	12	12	13	19	25	31
22°	12	12	12	12	16	22	29
11°	12	12	12	12	12	12	18

8.6 Installation instructions for pipes with a 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.

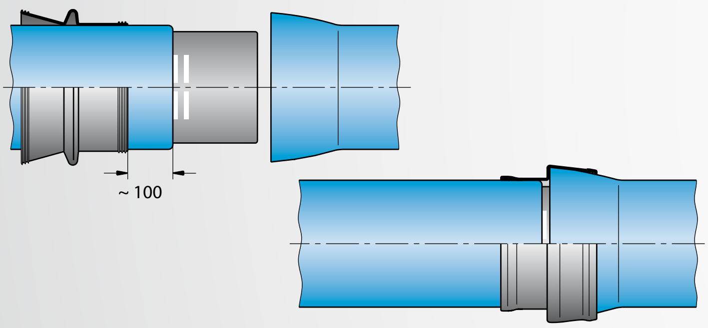
Recommendations for installation

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:

- rubber 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.

Rubber sleeves for protecting cement mortar

Rubber sleeves for protecting cement mortar can be used for TYTON®, BRS® and VRS®-T joints in pipes up to DN 800 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.

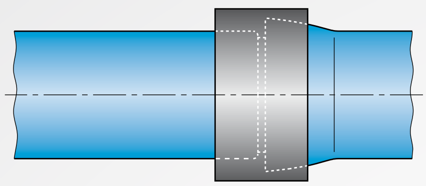
Shrink-on material and protective tapes

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; see Chapter 6. p. 51.

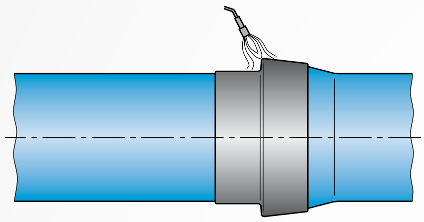
Fitting a shrink-on sleeve

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.

After the joint has been assembled, 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 it. 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 is available in pre-cut form with a sealing strip already incorporated or in 30 m rolls which include a sealing strip for each socket.
When in 30 m rolls, the shrink-on tape has to be cut to the appropriate length on site (see p. 51).
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 cm 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.

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, 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 50% of the bandage an overlap.
The protective bandage will be able to take mechanical loads after about 1 to 3 hours.

Filling of the pipeline trench

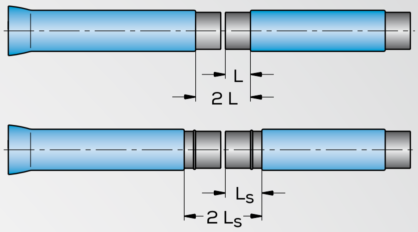
The bedding for the pipeline should be laid in accordance with EN 805 or DVGW *Arbeitsblatt* W 400-2.
Virtually any excavated material can be used as a filling material, even soil containing stones up to a maximum grain size of 100 mm (see DVGW *Arbeitsblatt* W 400-2). Only in special cases does the 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 F*orschungsgesellschaft für das Straßen- und Verkehrswesen* of Cologne).

Push-in joints protected by rubber 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.

Cutting of pipes

Ensure that the pipes are suitable for cutting (see p. 82).
Before pipes are cut, the cement mortar coating must be removed for a length of 2L or 2LS, 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®/ L (mm)	VRS®-T 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
1,000	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.
- 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. "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 as indicated in the section entitled "Cutting of pipes" (see p. 82).

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

Fitting pipe saddles

To make house connections to ductile iron pipes with a cement mortar coating, what should preferably be used are saddles with an internal sealing sleeve.

Within the hole in the pipeline, this type of pipe saddle seals directly against the surface of the ductile iron pipe in the drilled hole made in the pipe. Fittings of this kind are available from many manufacturers, e.g. Erhard, EWE and Hawle.

For further information see *DVGW-Merkblatt W 333*.

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

All repairs to any detached parts of the ZMU must 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 TRM 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:

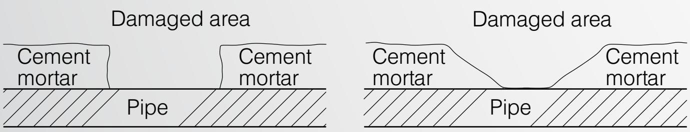
Hammer
Cold chisel

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 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:

Right | Wrong



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 meter 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, the gauze is needed to fix the mortar in place 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 12 hours before repaired pipes are installed or the damaged area should be provided with adequate protection against mechanical loads.

8.7 Installation instructions VRS®-T joints DN 80 to DN 500

Applicability

These installation instructions apply to ductile iron pipes and fittings of DN 80 to DN 500 nominal sizes with restrained VRS®-T push-in joints.

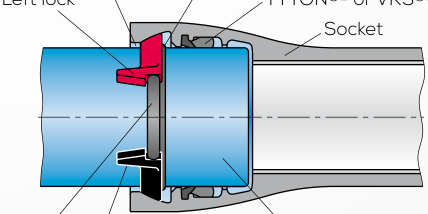
For recommendations for transport, storage and installation, see p. 60 ff. For laying tools and other accessories, see Chapter 6.
For very high internal pressures and trenchless installation techniques (e.g. the press-pull, rocket plough or HDD techniques), an additional high pressure lock should be used in pipes of DN 80 to DN 250 nominal sizes (see the section entitled "High pressure lock" on p. 17).
The number of joints to be restrained should be decided on in accordance with DVGW *Merkblatt* GW 368 (see p. 65 ff).

For allowable tractive forces for trenchless installation techniques, see table below or DVGW Arbeitsblätter GW 320-1, 321, 322-1, 322-2, 323 and 324.

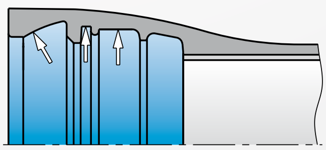
DN	PFA [bar][1]	Allowable tractive force $F_{all.}$ [kN] TRM	Max. angular deflection at sockets [3] [°]	Min. radius of curves [m]	Number of fitters	Assembly time without joint protection [min]	Assembly time when using a protective sleeve [min]	Assembly time when using a shrink-on sleeve [min]
80*	110	115	5	69	1	5	6	15
100*	100	150	5	69	1	5	6	15
125*	100	225	5	69	1	5	6	15
150*	75	240	5	69	1	5	6	15
200	63	350	4	86	1	6	7	17
250	44	375	4	86	1	7	8	19
300	40	380	4	86	2	8	9	21
400	30	650	3	115	2	10	12	25
500	30	860	3	115	2	12	14	28
600	32	1,525	2	172	2	15	18	30
700	25	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
1,000	10	1,560	1.5	230	2	20	–	35

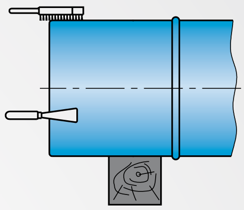
*[1] Basis for calculation was wall-thickness class K9. Higher pressures and tractive forces are possible in some cases and should be agreed with the pipe manufacturer. [2] When the route is straight (max. of 0.5° deflection per joint), the tractive forces can be raised by 50 kN. High-pressure lock is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

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 excess paint (paint humps, bubbles or pimples) from them. Use a scraper (e.g. a bent screwdriver) to clean the retaining groove.

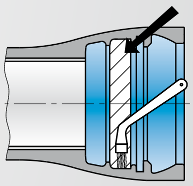
Clean the spigot end. Remove any fouling and any excess paint (paint humps, bubbles or pimples).

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

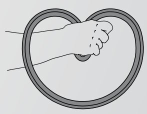
DN 80 to DN 250 DN 300 to DN 500

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. For WKG pipes with trace heating, care must be taken to see that the heating cable is positioned at the bottom of the pipe.

Inserting the gasket

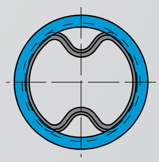


Lubricant should be used below TYTON® gaskets.
For this purpose. carefully wipe a thin film of the lubricant supplied with the pipes by the manufacturer over the sealing surface identified by the oblique lines.
Note: Do not put any lubricant in the retaining groove (the narrow groove)!
No lubricant is used with VRS®-T gaskets.



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

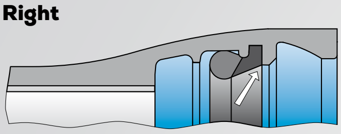
Fit the gasket into the socket so that the hard-rubber claw on the outside engages in the retaining groove in the socket.
Then press the loop flat.



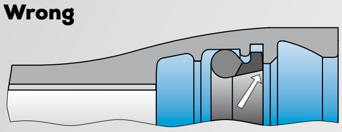
If you have any difficulty in pressing the loop flat, pull out a second loop on the opposite side. These two small loops can then be pressed flat without any difficulty.

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

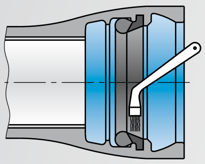
Right



Wrong

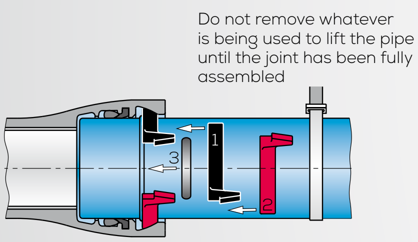


Apply a thin layer of lubricant to the gasket.



Spigot end with welded bead

Apply a thin layer of lubricant to the cleaned spigot end – and particularly to the bevel – and then pull or push the spigot end into the socket until it is in abutment with the end-wall of the socket. Pipes must not be in a deflected angular position when they are being pushed in or the locks are being inserted.



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

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

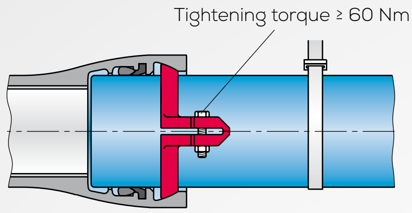
3) Press the catch into the opening in the socket.
On pipes of DN 300 size and above, steps 1 to 3 have to be carried out twice because 2x2 locks and 2 catches are used in this case.

Spigot end without a welded bead

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.

Apply lubricant to the cleaned spigot end – and particularly to the bevel – and then pull or push it in until it is fully home in the socket. 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.

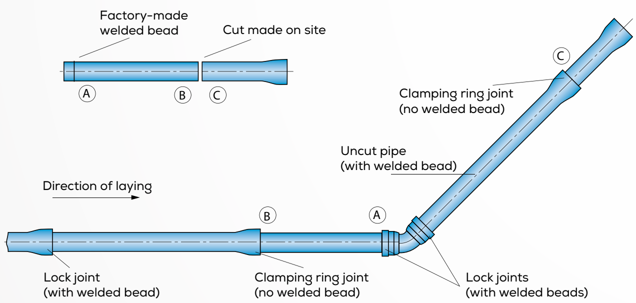
Pull the clamping ring towards the end-face of the socket as far as possible and then tighten the bolts ≥ 60 Nm.



Notes on clamping ring joints

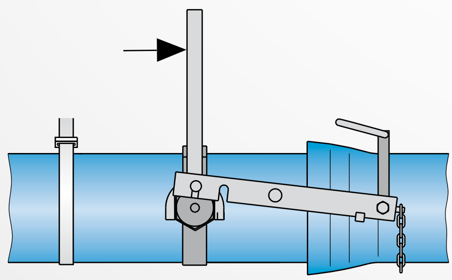
Care should be taken to see that clamping ring joints are not used in above-ground pipelines or pipelines subject to pulsations or for trenchless installation techniques. For single socket bends, double socket bends, 90° flange socket duckfoot bends and 90° duckfoot bends with side outlets, the PFA is a maximum of 16 bars. Please enquire for PFA's of more than 16 bars.
For connections at bends 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, socketed, piece of the cut pipe is installed, an uncut pipe is laid. The spigot end of the piece of cut pipe, which does not carry a welded bend, is then inserted in the socket of the uncut pipe.
Our Applications Engineering Division should be consulted before clamping rings are used in culvert or bridge pipelines and before joints using them are laid on steep slopes, in casing tubes or pipes, 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 adapter 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 firmly in abutment in the retaining chamber. The joint is now restrained.

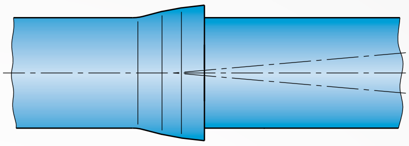


Angular deflection

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

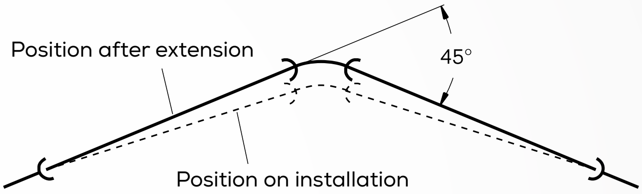
DN 80 to DN 150 – max. of 5°
DN200 to DN 300 – max. of 4°
DN400 and DN 500 – max. of 3°

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. With 5 m long pipes, 1° corresponds to approx. 9 cm.



Note on installation

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

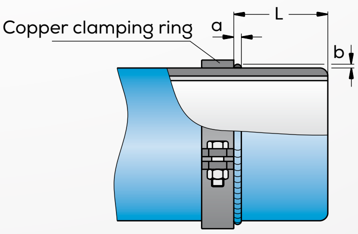


Cutting of pipes

Ensure that the pipes are suitable for cutting (see p. 82). If pipes have to be cut on site, the welded bead required for the VRS®-T 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 or the technical recommendations for welding given from p. 83 ff on.

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-EC, UTP FN 86, ESAB OK 92.58, Gricast 31 or 32.
The electrode diameter should be 3.2 mm below DN 400 and 4.0 mm at DN 400 and above.
For electrode consumption see p. 76

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 welding guide 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 welding guide is removed, the cut edge of the spigot end should be matched to the form of an original spigot end and the area of the welded bead should be cleaned. Finally, the appropriate protective coating should be applied to both these areas.

Disassembly

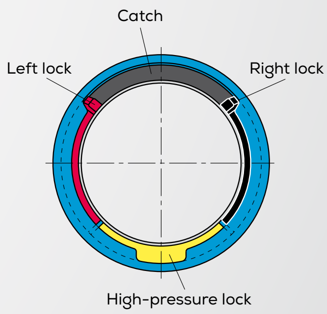
Push the pipe as far as possible into the socket along its axis. Remove the catch through the opening in the socket end-face. Slide the locks round and remove them through the opening. If a high-pressure lock is fitted, slide it round from the bottom of the pipe to the opening with a flat object (e.g. 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 whenever very high internal pressures are expected (e.g. in the case of turbine pipelines) and whenever 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 below shows a fully assembled VRS®-T socket with a high-pressure lock. The high-pressure lock can be used for pipes of nominal sizes from DN 80 to DN 250.

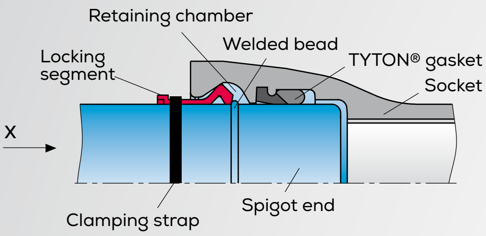


8.8 Installation instructions BLS® joints DN 600 – DN 1000

Applicability

These installation instructions apply to DN 600 – DN 1,000 ductile iron pipes and fittings with restrained BLS® push-in joints.
For recommendations for transport, storage and installation, see p. 60 ff. For laying tools and other accessories, see Chapter 6.

Construction of the joi

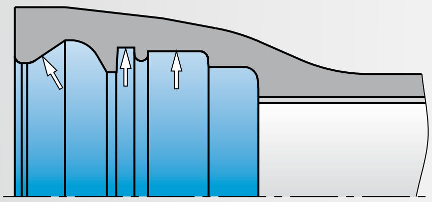


Number n of locking segments per joint

DN	600	700	800	900	1,000
n	9	10	10	13	14

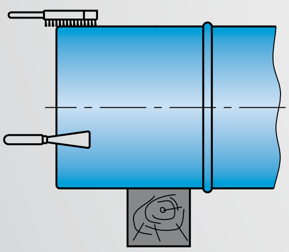
Cleaning

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 excess paint (paint humps, bubbles or pimples).



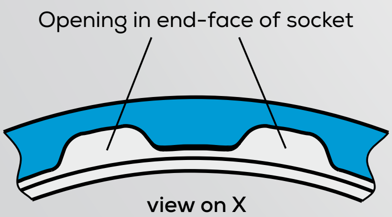
Use a scraper (e.g. a bent screwdriver) to clean the retaining groove.

Clean the spigot end. Remove any fouling and any excess paint (paint humps, bubbles or pimples).

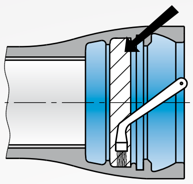


Positions of the openings in the socket end-face

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



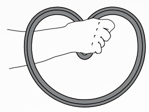
Inserting the gasket



Lubricant should be used below TYTON® gaskets.
For this purpose, carefully wipe a thin film of the lubricant supplied with the pipes by the manufacturer over the sealing surface identified by the oblique lines.

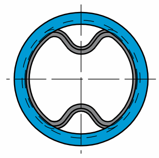
Note: Do not put any lubricant in the retaining groove (the narrow groove)!

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

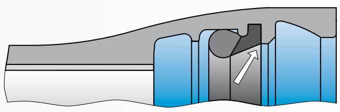


Fit the TYTON® gasket into the socket so that the hard-rubber claw on the outside engages in the retaining groove in the socket. Then press the loop flat.

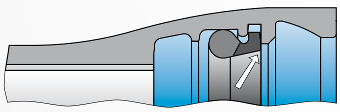
If you have any difficulty in pressing the loop flat, pull out a second loop on the opposite side. These two small loops can then be pressed flat without any difficulty.
The inner edge of the hard-rubber claw of the TYTON® gasket must not project below the locating collar.



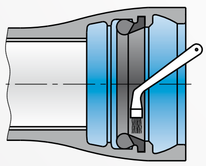
Right



Wrong

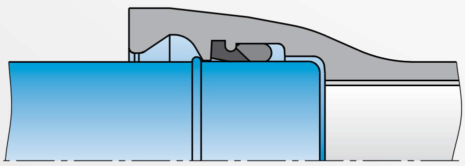


Apply a thin layer of lubricant to the TYTON® gasket.



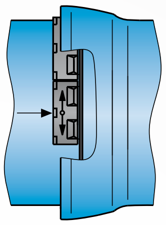
Assembling the joint

Apply a thin film of lubricant to the cleaned spigot end – and particularly to the bevel – and then pull or push it in until it is fully home in the socket. The pipes must not be at an angular deflection when being pulled in or when the lock segments are being fitted.



First insert the locking segments through the opening 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.

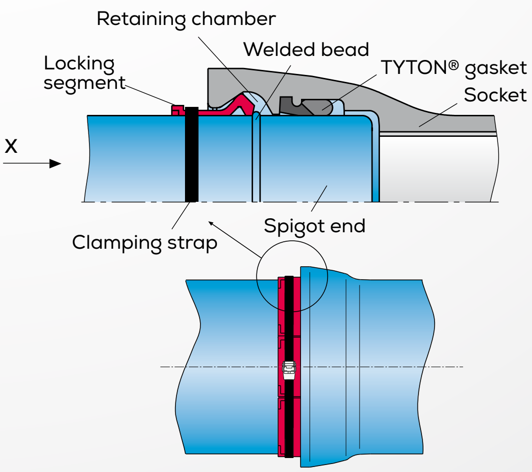


Do not under any circumstances hit the socket or the barrel of the pipe with the hammer!

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 enough 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: A metal clip rather than the clamping strap should be used in all trenchless techniques.

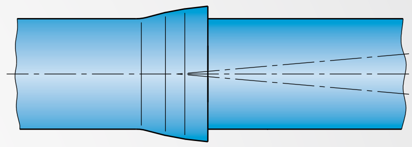


Angular deflection

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

DN 600 – max. of 2.0°
DN 700 – max. of 1.5°
DN 800 – max. of 1.5°
DN 900 – max. of 1.5°
DN1000 – max. of 1.5°

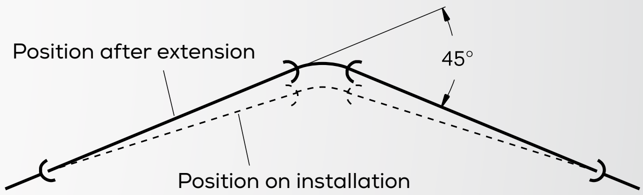
For a pipe length of 6 m, 1° of angular deflection causes the axis of the pipe to lie approx. 10 cm off the axis of the pipe installed previously, i.e. 3° = 30 cm.



Note on installation

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

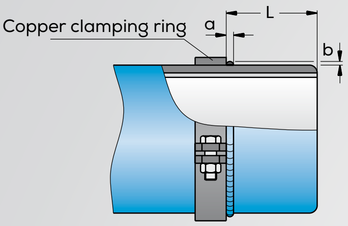
Ensure that the pipes are suitable for cutting (see p. 82).
If pipes have to be cut on site, the welded bead required for the BLS® push-in joint has to be applied using an electrode as specified by the pipe manufacturer. The welding work should be done in accordance with *Merkblatt* DVS 1502 or the technical recommendations for welding given from p. 83 ff on.

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-EC, UTP FN 86, ESAB OK 92.58, Gricast 31 or 32.

DN	600	700	800	900	1,000
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 welding guide 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 welding guide 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 welded bead should be cleaned. Finally, the appropriate protective coating should be applied to both these areas.

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 fitting sockets belonging to other systems.

Electrode consumption

DN nominal size	Electrode consumption per bead Ø 3.2 mm [unit]	Electrode consumption 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	57
500	11 +	14	75
600	13 +	16	87
700	16 +	19	105
800	18 +	22	120
900	21 +	25	138
1,000	23 +	27	150

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.

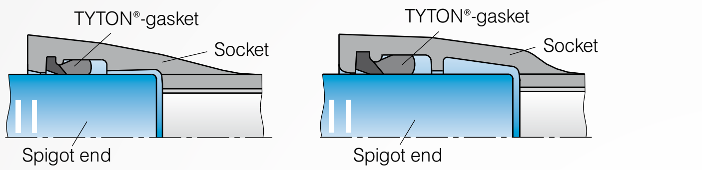
The electrode consumptions and times required given in the table are only a guide.

8.9 Installation instructions TYTON® push-in joints

Applicability

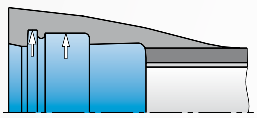
These installation instructions apply to ductile iron pipes and fittings to EN 545 and DIN 28 650 with TYTON® push-in joints to DIN 28 603. There are separate installation instructions for installation and assembly when using restrained joints (VRS®-T and BRS® joints) and/or for pipes with a cement mortar coating (ZMU).
For recommendations for transport, storage and installation, see p. 60 ff.
For laying tools and other accessories, see Chapter 6.

Construction of the joint

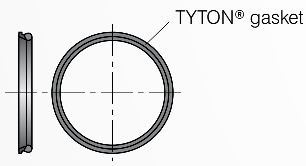


DN 80 to DN 600 DN 700 to DN 1000 (long socket

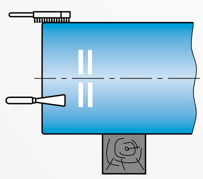
Cleaning



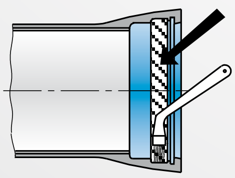
Clean the surfaces of the seating for the gasket and the retaining groove which are indicated by the arrows and remove any excess paint (paint humps, bubbles or pimples) from them. Use a scraper (e.g. a bent screwdriver) to clean the retaining groove.



Clean the spigot end back to the line marking. Remove any fouling and any excess paint (paint humps, bubbles or pimples)



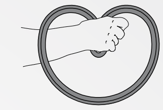
Carefully apply a thin coat of the lubricant supplied by the pipe manufacturer only to the sealing surface identified by the oblique lines.
Note: Do not apply any lubricant to the retaining groove (the narrow groove).



Assembling the joint

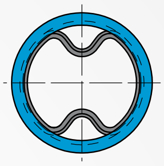
Inserting the TYTON® gasket.

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

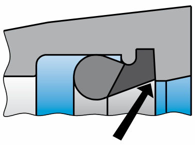


Fit the TYTON® gasket into the socket so that the hard-rubber claw on the outside engages in the retaining groove in the socket.

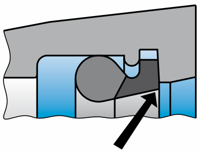
Then press the loop flat.
If you have any difficulty in pressing the loop flat. pull out a second loop on the opposite side. These two small loops can then be pressed flat without any difficulty.
The inner edge of the hard-rubber claw of the gasket must not project below the locating collar.



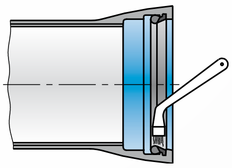
Right



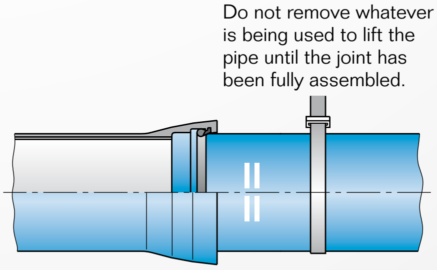
Wrong



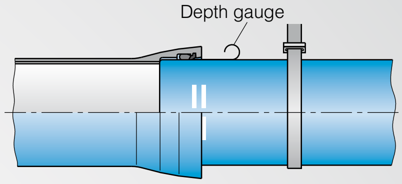
Apply a thin layer of lubricant to the gasket.



Apply a thin layer of lubricant to the spigot end – and particularly to the bevel – and then insert the spigot end into the socket until it is resting against the gasket in a centralised position. The axes of the pipe or fitting already installed and the fitting or pipe which is being connected to it should be in a straight line.



Push the spigot end into the socket until the first marking line can no longer be seen.



Once the joint has been assembled, check the seating of the gasket with the depth gauge around the entire circumference.

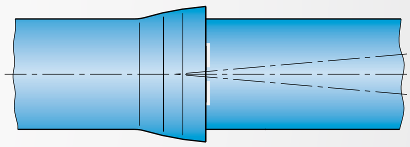
The gauge should penetrate into the gap between the spigot end and the socket to a uniform depth all round the circumference. If it is able to penetrate deeper at one or more points, it is possible that the gasket has been pushed out of the retaining groove at these points and hence that there will be leaks there.
If this is the case, the joint must be disassembled and the seating of the gasket checked.

Angular deflection

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

Up to	DN 300	–	max. of 5°
	DN 400	–	max. of 4°
	DN 1000	–	max. of 3°

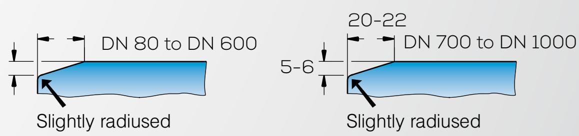
For a pipe length of 6 m, 1° of angular deflection causes the axis of the pipe to lie 10 cm off the axis of the pipe or fitting installed previously, i.e. 3° = 30 cm.
With 5 m long pipes, 1° corresponds to approx. 9 cm.



Cutting of pipes

Ensure that the pipes are suitable for cutting (see p. 82). Cut pipes must be bevelled at the cut end to match the original spigot end.

The bevel must be made as shown in the diagram.



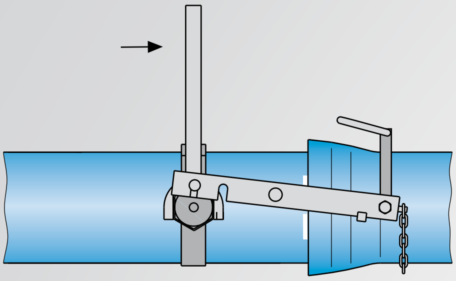
The cut surface must be re-painted (see p. 82).
Copy the line markings from the original spigot end to the new spigot end which has been cut.

Disassembly

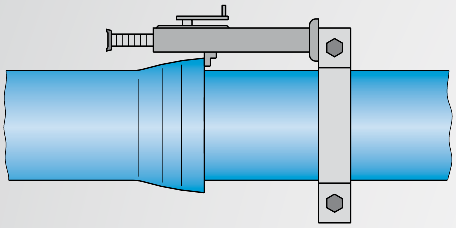
If newly installed pipes or fittings have to be disassembled, this can be done without any special tools. Either use the laying tool to do this or move the pipe or fitting gently to and fro while pulling on it.

Pipelines fitted with TYTON® push-in joints which have already been in place for quite some time can be disassembled as follows.

With a laying tool



With a clamp and a jack

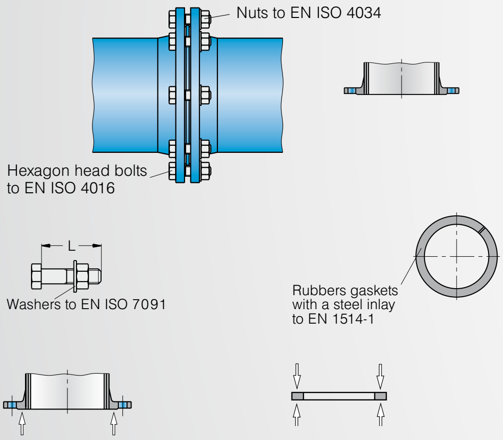


8.10 Installation instructions for flanged joints

Applicability

These installation instructions apply to ductile iron pipes and fittings to EN 545 with flanges to EN 1092-2.

Construction of the joint



Clean the bolt holes and the surfaces of the sealing ridge and the gasket which are indicated by the arrows and remove any excess paint (paint humps, bubbles or pimples) from them.

Assembling the joint

For recommendations for transport, storage and installation, see p. 60.

For better assembly and greater reliability in operation, only gaskets with a steel inlay should be fitted.

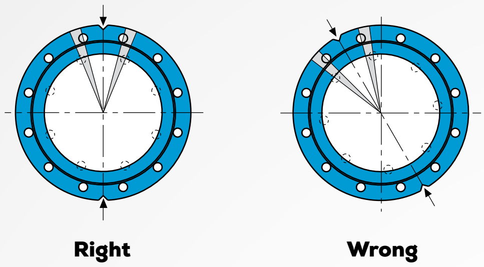
Flanged pipes and fittings must be carefully supported.
Rigid joints in pipes are unable to withstand differing loads and differing amounts of settlement. Under no circumstances must the pipes or fittings be supported on stones or other similar material.

Positioning the bolt holes

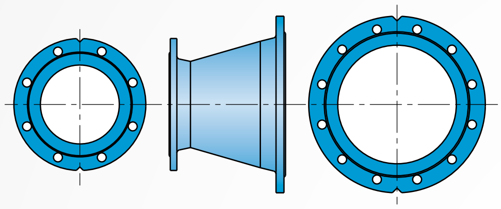
The rule for the positioning of bolt holes which applies to flanged pipes and flanged fittings is that no bolt holes must be situated on the vertical or horizontal centre-lines of the flanges.

Note in the installation of flanged fittings

To make it easier for flanged fittings to be installed properly, their flanges have two oppositely situated notches made in them. These notches must be in line with one another horizontally or vertically at the time of installation.



Installing double flanged tapers



The example shown is an FFR 300/200 PN 10 taper
Because of the differing numbers of bolt holes in the two flanges of double flanged tapers, the next valve or fitting will be skewed around its axis if the taper is not correctly installed. The amounts of skew may, depending on the nominal size, be up to 22.5°.

Important!

With large nominal sizes such skews are almost imperceptible.

Tightening torques

The tightening torque M_D depends on the gasket material, the nominal size DN and the pressure rating PN.

It can be calculated as follows:

$M_D PN10 = DN/3$ [Nm] $M_D PN16 = DN/1.5$ [Nm]
$M_D PN25 = DN/1$ [Nm] $M_D PN40 = DN/0.5$ [Nm]

8.11 Installation instructions BRS® push-in joints

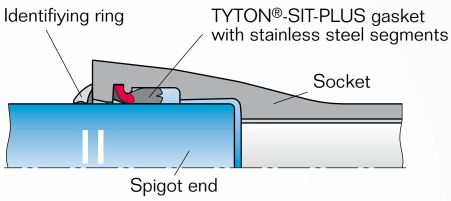
Applicability

These installation instructions apply to ductile iron pipes and fittings to EN 545 and DIN 28 650 with restrained BRS® 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).

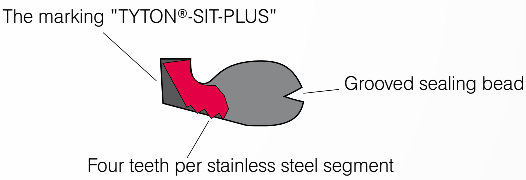
For recommendations for transport, storage and installation, see p. 60 ff. For laying tools and other accessories, see Chapter 6.
The number of joints which have to be restrained should be decided on in accordance with DVGW Arbeitsblatt GW 368 (see p. 65).

Our Applications Engineering Division should always be consulted before joints of the present type 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 unstable soil.

Construction of the joint

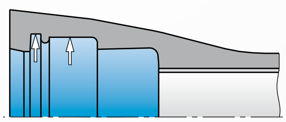


Important! There are three notable features by which the TYTON®-SIT-PLUS® gasket can be recognised:

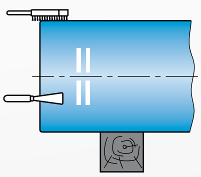


Cleaning

Clean the surfaces of the seating for the gasket and the retaining groove which are indicated by the arrows and remove any excess paint (paint humps, bubbles or pimples) from them.



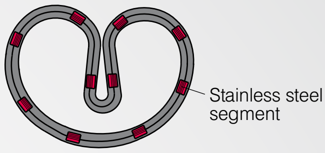
Use a scraper (e.g. a bent screwdriver) to clean the retaining groove.



Clean the spigot end back to the line marking. Remove any fouling and any excess paint (paint humps, bubbles or pimples).

Assembling the joint

Insert the TYTON®-SIT-PLUS® gasket as specified in the installation instructions for the TYTON® push-in joint (see p. 77).



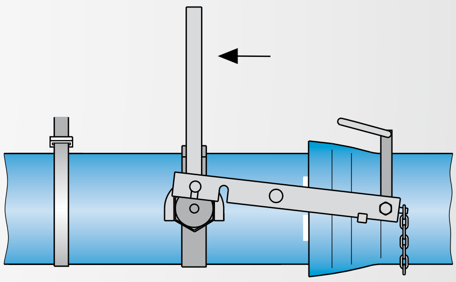
Clean the TYTON®-SIT-PLUS® gasket, make a loop in it so that it is heart-shaped, and fit it into the seating for the gasket.

Important! The point of the loop must always be between two segments.

Apply a thin layer of lubricant to the TYTON®-SIT-PLUS® gasket once it has been fitted into the seating.
Take the profiled identifying ring marked with a stripe of white paint and slide it onto the spigot end.

Apply a thin layer of lubricant to the spigot end – and particularly to the bevel – and then insert the spigot end into the socket until it is resting against the TYTON®-SIT-PLUS® gasket and is centralised.

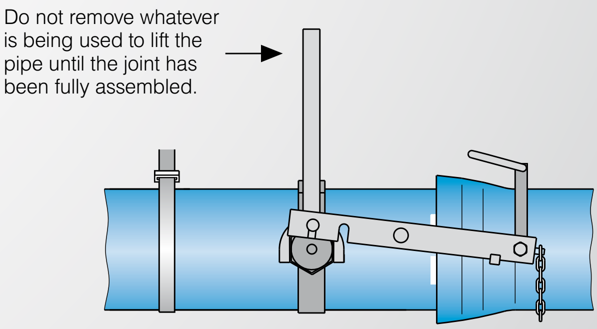
Fit the laying tool to the socket and the spigot end and use it to pull the spigot end of the pipe or fitting being inserted into the socket of the pipe already laid. Avoid any angular deflection when doing so.



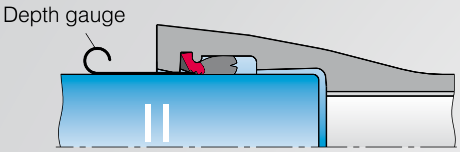
Push the spigot end into the socket until the first marking line can no longer be seen. It is now no longer permissible for either part of the joint to be turned.

Locking

Pull or press the pipe out of the socket, e.g. with a laying tool, until the stainless steel segments engage.



The joint is now restrained.



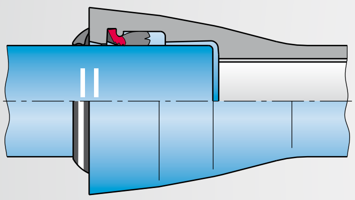
Once the joint has been assembled, check that the TYTON®-SIT-PLUS® gasket is correctly seated around the entire circumference with the depth gauge supplied. The gauge should penetrate into the gap between the spigot end and the socket to a uniform depth all round the circumference. The depth of penetration is usually greater in the region of the segments than in the rest of the gasket. If the depth of penetration is unduly large at one or more points, there may be a hump in the gasket and hence a possible leak at these points. If this is the case, the joint must be disassembled and the seating of the gasket checked.

Important:

Do not re-use TYTON®-SIT-PLUS® gaskets from joints which have been disassembled!

Identification of the joint

As a durable means of identifying the restrained push-in joint, we supply a profiled rubber ring carrying a stripe of white paint on its circumferential surface. The ring should be positioned as shown in the illustration before the joint is assembled.



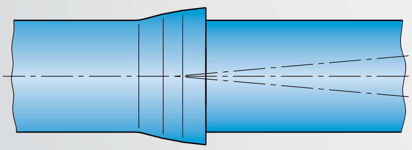
Angular deflection

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

DN 80 to DN 350 – max. of 3°

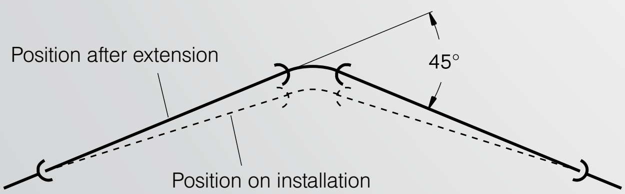
DN400 to DN 600 – max. of 2°

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. With 5 m long pipes, 1° corresponds to approx. 9 cm.



Note on installation

Make sure 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.

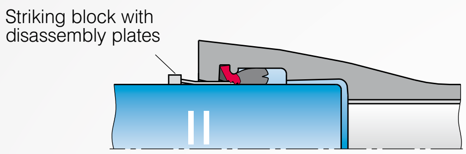


Cutting of pipes

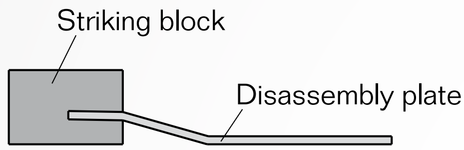
Ensure that the pipes are suitable for cutting (see p. 82).
Copy the line markings from the original spigot end to the new spigot end which has been cut.

Disassembly

Push the pipe into the socket until it is in abutment.
Apply lubricant to the disassembly plates and, using the striking block. drive them into the gap between the socket and the pipe all round. Then disassemble the joint with the laying tool or the dissembling clamp.



A dismantling tool consists of a striking block and the number of disassembly plates shown in the table below.



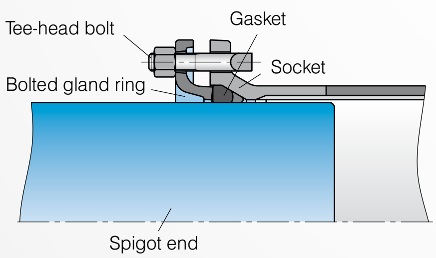
DN	80	100	125	150	200	250	300	350	400	500	600
Number of plates	4	4	5	6	8	10	12	14	16	19	23

8.12 Installation instructions Bolted gland joints

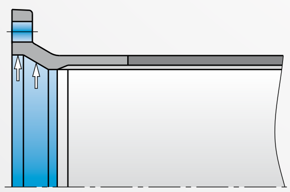
Applicability

These installation instructions apply to ductile iron fittings to EN 545 with bolted gland joints to DIN 28 602.
For recommendations for transport, storage and installation, see p. 60.
For laying tools and other accessories, see Chapter 6.

Construction of the joint

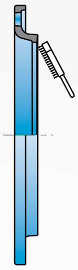


Cleaning

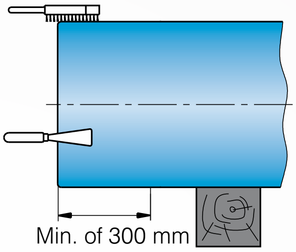


Clean the surfaces of the seating for the gasket which are indicated by the arrows and remove any excess paint (paint humps, bubbles or pimples) from them. Use a tool such as a wire brush to clean the seating for the gasket.

Clean the front pressure-applying face of the bolted gland ring thoroughly.

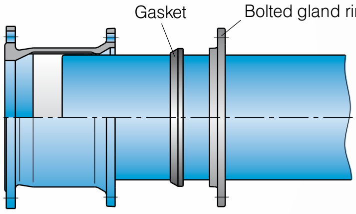


Clean the spigot end for a length of at least 300 mm. Remove any fouling and any excess paint (paint humps, bubbles or pimples).

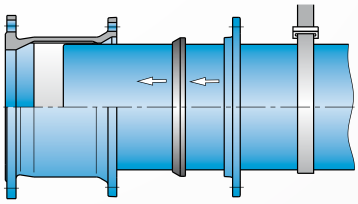


Assembling the joint

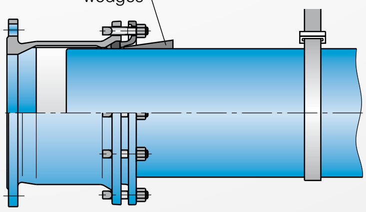
Slide the bolted gland ring and the gasket onto the spigot end.
Important! Do not use any lubricant!



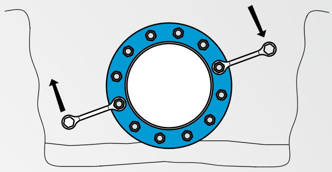
Using a piece of lifting equipment, insert the spigot end into the socket, centralise it and check the depth of insertion. Press the gasket into the sealing chamber to a uniform depth all round.



Slide the bolted gland ring in behind the gasket and centralise it with two hardwood wedges, which can easily be fitted in at the top between the bolted gland ring and the spigot end. When the bolted gland ring is accurately centralised, it is then easy for the tee-head bolts to be inserted.

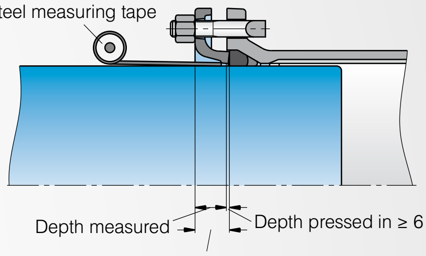


Insert the tee-head bolts through the flange and the bolted gland ring. Tighten the nuts as far as you can finger-tight, evenly all round. Then tighten the nuts in sequence with a ring spanner, always tightening two diametrically opposed nuts at a time by about half a turn to one full turn.



The gasket has been correctly compressed when the bolted gland ring has been pressed into the gasket to a depth of at least 6 mm.

How deep it has been pressed in can be found by measuring the overall depth of the bolted gland ring, and the depth from the outer face of the bolted gland ring to the gasket once the bolts have been tightened. The depth for which it is pressed in should be as even as possible all round for the given bolted gland joint.



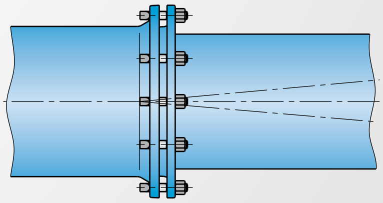
At least three measurements therefore have to be made at each joint. Check the correct depth of insertion again.
Re-paint the tee-head bolts and the nuts with a standard bitumen paint.

Angular deflection

Once the joint has been assembled with the pipe centralised, pipes and fittings can be deflected angularly by.

Up to	DN 500	–	max. of 3°
	DN 700	–	max. of 2°
	DN 1,000	–	max. of 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, e.g. 3° = 30 cm. With 5 m long pipes, 1° corresponds to approx. 9 cm.



Cutting of pipes

Ensure that the pipes are suitable for cutting (see p. 82).

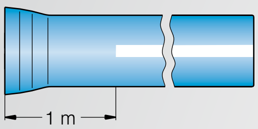
Disassembly

Unscrew the nuts and slide back the bolted gland ring. Pull the spigot end out of the socket.

8.13 Cutting of pipes

Suitability for cutting (6 m pipes)

Up to and including a nominal size of DN 300, the pipes supplied can be cut, in the region of the barrel, at points more than 1 m away from the socket, to enable a spigot end for a joint to be formed. Above a nominal size of DN 300 only pipes which carry a continuous longitudinal stripe can be cut. Pipes of this kind ("*Schnittrohre*" or cuttable pipes) have to be ordered separately. An additional identifier for a cuttable pipe is an "SR" marked on the end-face of the socket.



Suitability for cutting (5 m pipes)

Up to and including a nominal size of DN 300, the pipes supplied are within the permitted tolerance range, and can therefore be cut, in the region of the barrel, over 2/3 of their length measured from the spigot end.

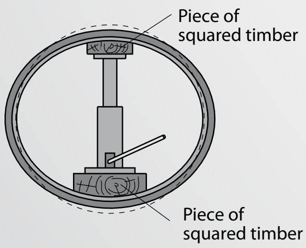
Above a nominal size of DN 300 the diameter of the pipes should be checked before they are cut (use a steel measuring tape to compare the circumference of the pipe at the spigot end and at the intended cutting point). Specially marked dimensionally accurate (cuttable) pipes of the kind available as standard up to and including DN 300 can also be ordered. The marking is a red longitudinal strip (approx. 0.5 m long) extending over the socket to the barrel.

Tools

The best way of cutting ductile iron pipes is with cutters using abrasive discs and powered in a variety of ways, e.g. by compressed air, electric motors or petrol engines.

The cutting disc we recommend is the C 24 RT Spezial type made of silicon carbide. These are cutting discs for stone but have proved successful in practice for cutting ductile iron pipes. Protective goggles and respiratory protection must be worn when cutting pipes with a cement mortar coating or lining. All swarf must be carefully removed from inside the pipe.

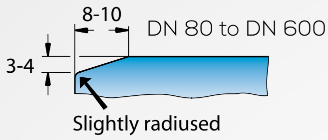
With pipes of fairly large nominal sizes it may happen that the new spigot ends produced are slightly oval after the pipes have been cut. If this happens, the spigot ends should be re-rounded with suitable devices applied to the inside or outside of the pipe, e.g. hydraulic jacks or re-rounding clamps.
The device should not be removed until after the joint has been fully assembled.

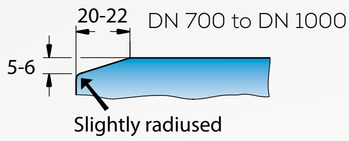


Grinding of cut ends

The cut ends of pipes shortened on site must be bevelled with a grinding disc to match the original spigot ends.

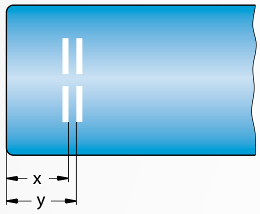
The bevelling should be done as shown in the diagrams.





Repaint the bare metal surface with a paint corresponding to the external protection which the pipe has. A quick drying finishing layer which complies with the requirements of the German Foodstuffs Law is suitable for this purpose.

To speed up the drying process, it is advisable to warm first the pipe ends, and then the paint when it has been applied, with a gas flame. Then copy the line markings on the original spigot end to the new spigot end which has been cut.



Dimensions for line markings

	DN	80	100	125	150	200	250	300	350
Form A Standard socket	X	69	73	76	79	85	90	95	95
	Y	82	86	89	92	98	103	108	108

	DN	400	500	600	700	800	900	1,000
Form A Standard socket	X	95	105	105	135	145	160	170
	Y	108	118	118	148	158	173	183
Form B Long socket	X	–	–	–	148	157	167	177
	Y	–	–	–	161	170	180	190

No line marking is used on pipes with VRS®-T joints. In place of it, a welded bead has to be applied to cut ends of pipes of this kind. On this point see the installation instructions for VRS®-T joints (see p. 71 ff) and the technical recommendations for welding on the next page .

For cutting pipes with a cement mortar coating, the directions given from p. 69 should also be followed.

8.14 Technical recommendations for manual metal arc welding

Applicability

Welding work can be done on ductile iron pipes to EN 545 in the following cases:

- on water pipelines having allowable operating pressures (PFA) of up to 16 bars
- for welding on DN 2" ductile iron or steel connections
- for welding on DN 80 to DN 300 ductile iron or steel outlets
- puddle flanges for building pipes into structures
- welded beads for restrained push-in joints

These recommendations do not apply to sand-cast fittings and pipes or to grey cast iron pipes.

Pipes with a minimum wall thickness of less than 4.5 mm must not be welded!

Process and electrodes

The process used should be manual metal arc welding using nickel-based stick electrodes, preferably ones complying with EN ISO 1071.
The recommended electrode types are for example:
Castolin 7330-EC, UTP FN 86, ESAB OK 92.58, Gricast 31 or 32.

Basically, the following standards of the German Welding Society (DVS) also apply:

DVS 1502, Parts 1 & 2
DVS 1148

The welders used should be qualified under DVS 1148.

1) Please consult our Applications Engineering Division before you carry out any welding work for the first time.

Preparing for welding work

When welding is being done, the temperature of the pipe wall must not be less than +20°C.
The workplace must be dry.

The area to be welded must be bright metal. Remove any fouling or zinc coatings by filing or grinding.

Pinholes should not be welded over. They must be ground out down to solid metal and filled with weld metal. Connectors should be matched to the outside diameter of the barrel of the pipe in such a way that, if at all possible, the gap does not exceed 0.5 mm.

Execution of welding work

Type of current

Either AC or DC can be used for welding work. Follow the guidelines for use issued by the electrode manufacturer.

Welding parameters

The current levels and rates of deposition specified by the electrode manufacturer should be taken as the guideline values.

Preheating

Preheating is generally an advantage. The area to be welded should be preheated as detailed in Table 1 before the tack welding and before the root pass is welded.

Table 1

Conditions for crack-free welds on ductile iron pipes.

Making of weld	In at least two passes (inc. for pipe to connection joints)		
Thickness of pipe wall (actual)	Not filled with water *)		Filled with flowing water
	Not cement-mortar lined	Cement-mortar lined	Cement-mortar lined
≥ 4.7 ... 6 mm	bei 20°C	At 20°C	Not allowed
6 ... 10 mm	bei 20°C	At 20°C	At 20°C
10 ... 12 mm	Preheat to 150°C	At 20°C	At 20°C
>12 mm	Preheat to 150°C	Preheat to 150°C	Preheat to 150°C

**) Also applies to partly filled pipelines when the areas for welding are above the water table*
***) Preheating is advisable when the pipe wall temperature is below 20°C*

Tack welding

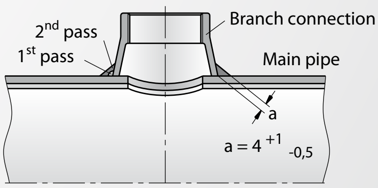
Fix the parts to be welded in place with suitable clamping devices. They must be tack welded at at least two points. The angles of the tack welds should be as shallow as possible so that they can be welded over; this can be achieved by grinding them if necessary. Check the tack welds to ensure they are free of cracks. Any cracks in tack welds must be ground out.

Welding

Any weld must be made as far as possible in a single operation. Interruptions in the welding work should be avoided. Make sure that the preheating temperature is maintained during the welding. If there are interruptions in the welding work, preheat again as in Table 1 before resuming welding.

Welding on of DN 2" ductile iron or steel branch connections

Branch connections are supplied in a ready-to-weld state and can be welded on with fillet welds once the zone for the welding has been prepared and the branch connection has been matched to the outside diameter of the main pipe. The weld should be made in two passes. The a dimension of the first pass (root pass) should be 3 mm. The second pass should be a weave pass between the main pipe and the branch connection over the top of the root pass.
The finished weld should be flat to slightly concave. The test of the weld for leaktightness should be carried out before the hole is drilled in the main pipe. On water pipelines it should be made at the system test pressure (STP), which is the nominal pressure + 5 bars.

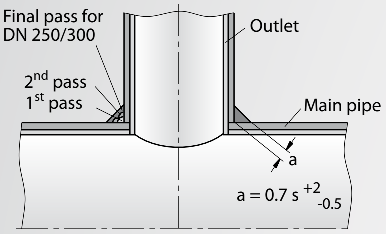


Welding on of DN 80 to DN 300 ductile iron or steel outlets

The nominal size of the outlets may not be more than half the nominal size of the main pipe.
Outlets are to be welded on with fillet welds. The welding should generally be done in two passes. The a dimension of the first pass (root pass) should be at least 3 mm. The second pass should be first a weave pass between the root pass and the main pipe and then a weave pass between the root pass and the outlet. The finished weld

should be flat to slightly concave and its a dimension should be $0.7s^{+2}_{-0.5}$ (s = thickness of the outlet). On outlets of DN 250 and DN 300 nominal size, a final pass may also be welded to give the a dimension.

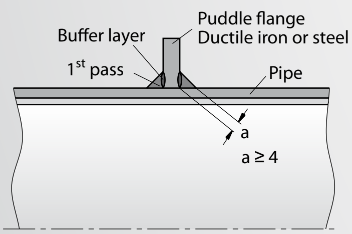
It may be an advantage for the welding-on of outlets of fairly large sizes to be done with a buffer layer. The test of the weld for leak-tightness should be carried out before the hole is drilled in the main pipe. On water pipelines it should be made at the system test pressure (STP), which is the nominal pressure + 5 bars.
When new pipelines are being laid it is advisable for outlets to be welded on out of the pipeline trench. In this case the hole in the main pipe can be drilled before the outlet is welded on. The internal pressure test on the outlet can then be carried out together with the pressure test on the pipeline.



Welding on of ductile iron or steel puddle flanges
Pipes with puddle flanges are used to allow pipes to be built into structures. By welding it is possible for puddle flanges to be fastened in place at any desired point along the barrel of a pipe.
Puddle flanges are supplied in annular sections and should be fitted tightly to the pipe.

Welding
Puddle flanges should be welded on with at least two-pass fillet welds and the a dimension of the welds should not be less than 4 mm. On pipes of fairly large sizes with corresponding wall thicknesses it is advisable for a buffer layer to be used.

The length of the weld should be decided on in line with the operating requirement (allowable thrust τ_{zul} = 130 N/mm²).
After being welded on, annular sections should be welded together.



Application of welded beads
When pipes with positive locking restrained push-in joints are cut on site, the welded beads have to be applied to the new spigot ends. The procedure, accessories and dimensions for this are given in the installation instructions under "Cutting of pipes".

Heat treatment after welding
No heat treatment of welded joints or welded parts is required after they have been welded.
The area of the weld should be cleaned once it has cooled and, after checking, should be carefully repainted with a protective paint such for example as a bitumen-based one.

Checking of welds
Welds should generally undergo a visual inspection and, where necessary, a non-destructive test for surface flaws and cracks. Welds which are not called upon to be leaktight, such as those fixing puddle flanges for example, should be randomly checked for surface flaws.

Flaws, such as surface pores or cracks in or next to the weld, which are found in the course of checking or testing should be fully ground out before they are repaired. Flaws may only be repaired once.

8.15 Pressure testing

Under EN 805, pipelines have to be subjected to an internal pressure test, For water pipelines, the codes governing the execution of this pressure test are EN 805 or DVGW *Arbeitsblatt* W 400-2.

Test sections
It may be necessary for pipelines of quite a considerable length to be divided into sections. The test sections should be decided on in such a way that

- the test pressure is reached at the lowest point of each test section.
- at least 1.1 times the system test pressure (MDP) is reached at the highest point of each test section.
- the amount of water required for the test can be supplied and drained away.
- the maximum length of a test section is not more than 2.5 – 3 km.

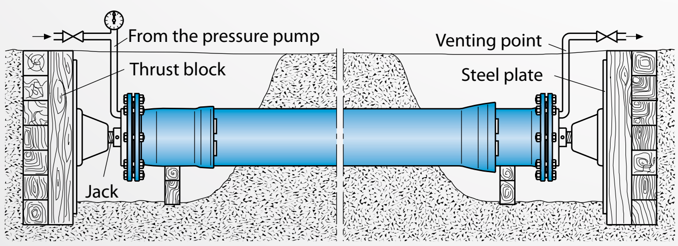
The pipeline should be vented as thoroughly as possible, using "pigs" if necessary, and should be filled with drinking water from the lowest point.

Backfilling and restraint
If necessary, pipelines must be covered with backfill material before the pressure test to avoid any changes in length. Backfilling around the joints is optional.

At their ends and at bends, branches and tapers, non-restrained pipelines must be anchored to resist the forces generated by the internal pressure. The thrust blocks required for this purpose should be dimensioned as directed in GW 310.

There is no need for thrust blocks to be installed for restrained systems provided that GW 368 has been observed in deciding on the lengths to be restrained.

There is no point in carrying out a pressure test against a closed shut-off valve. The temperature at the outer wall of the pipeline should be kept as constant as possible and must not exceed 20°C.



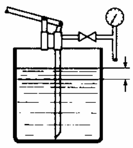
Filling the pipeline

It is useful for the pipeline to be filled from the lowest point so that the air contained in it is able to escape easily from venting points of adequate size provided at the highest points of the pipeline.

We recommend the following filling rates in l/s

DN	100	150	200	250	300	400	500	600	700	800	900	1,000
Filling rate	0.3	0.7	1.5	2	3	6	9	14	19	25	32	40

For drinking water pipelines, initial disinfection should be carried out in conjunction with the pressure test. This requires a concentration of at least 50 mg of chlorine per litre of water. Depending on how dirty the pipeline is, the level of chlorine may be increased to up to 150 mg per litre of water.
The relationship between the amount of water added and the increase in pressure obtained may serve as an indication of any leaks or of inadequate venting. As the pressure increases, the water consumption should therefore be noted bar by bar.



Water consumption for 1 bar

bar	mm	in litres
0-1		
1-2		
2-3		
3-4		
5-6		

Where a pipeline has been properly laid and is properly vented, the amount of water which needs to be pumped in per bar of increased pressure is approximately constant. Allowing for the compressibility of water and the elastic properties of the pipes, this amount is (theoretically) approximately 50 ml per cubic metre of space within the pipeline per bar. In practice, this figure is around 1.5 to 2 times higher because air trapped in the joints of pipes and fittings and in valves has to be compressed.
The Table shows the amounts of water required, in litres per bar of increased pressure, for pipeline lengths from 100 to 1,000 m, including a 100% allowance for trapped air.

DN	Amounts of water in litres per bar of increased pressure. for pipeline lengths [m] given in the column headings									
	100	200	300	400	500	600	700	800	900	1,000
80	0.05	0.09	0.14	0.19	0.24	0.28	0.33	0.38	0.42	0.47
100	0.07	0.13	0.20	0.26	0.33	0.39	0.45	0.52	0.59	0.65
125	0.12	0.24	0.36	0.48	0.60	0.72	0.84	0.96	1.05	1.20
150	0.18	0.35	0.53	0.70	0.87	1.05	1.22	1.40	1.54	1.75
200	0.32	0.64	0.97	1.28	1.60	1.93	2.25	2.55	2.90	3.20
250	0.52	1.04	1.57	2.10	2.60	3.15	3.65	4.20	4.70	5.20
300	0.78	1.56	2.35	3.15	3.90	4.67	5.45	6.25	7.05	7.80
350	1.06	2.12	3.20	4.25	5.30	6.38	7.43	8.50	9.55	10.60
400	1.44	2.90	4.30	5.80	7.20	8.65	10.10	11.55	13.00	14.40
500	2.35	4.70	7.05	9.40	11.80	13.10	16.20	18.80	21.10	23.50
600	3.45	7.00	10.50	14.00	17.15	21.00	24.50	28.00	31.50	35.00

Performing a pressure test

The following procedures for performing a pressure test on ductile iron pipes are described in DVGW *Arbeitsblatt* W 400-2:

- standard procedure (for pipes of all nominal sizes, with or without a cement mortar lining)
- shortened standard procedure (for pipes of nominal sizes up to DN 600 with a cement mortar lining)

We describe below the two procedures which are most frequently followed, the standard procedure and the shortened standard procedure.

In both these procedures the level of test pressure is as follows:

- for pipelines with an allowable operating pressure of up to 10 bars: 1.5 x nominal pressure
- for pipelines with an allowable operating pressure of above 10 bars: nominal pressure + 5 bars.

The standard procedure

The standard procedure is carried out in three phases:

- preliminary test
- pressure drop test
- main test

Preliminary test

The purpose of the preliminary test is to saturate the cement mortar lining and to extend the pipeline. To do this, the test pressure is kept constant for a period of 24 hours by pumping in more water as and when required. If any leaks are found or any changes in length exceeding the allowable limits occur, the pipeline must be de-pressurised and the reason found and remedied.

Pressure drop test

The purpose of the pressure drop test is to establish that the pipeline is free of air. Pockets of air in the pipeline may result in incorrect measurements and may mask small leaks.

A volume of water ΔV sufficient to cause a drop in pressure Δp of at least 0.5 bars is drawn off from the pipeline. The volume of water ΔV drawn off is measured. The pipeline must then be re-pressurised to the test pressure.

The pipeline is considered to have been adequately vented if ΔV is no greater than the allowable change in volume ΔV_{zul}. If it is greater, then the pipeline must be vented again.

ΔV_{zul} is calculated as follows:

$$\Delta V_{zul} = 1{,}5 \cdot a \cdot \Delta p \cdot L$$

ΔV_{zul} = allowable change in volume [cm³]
Δp = measured drop in pressure [bar]
L = length of the section tested [m]
a = pressure constant characteristic of the size of pipe [cm³/(bar x m)]
→ see Table below

DN	a	DN	a
80	0.314	400	9.632
100	0.492	500	15.614
125	0.792	600	23.178
150	1.163	700	32.340
200	2.147	800	43.243
250	3.482	900	55.679
300	5.172	1,000	69.749
350	7.147	1,200	103.280

Main test

Following the pressure drop test, the main test is then carried out.

The duration of the test is as follows:

Up to	DN 400	3 h
	DN 500 to DN 700	12 h
more than	DN 700	24 h

The test conditions are considered to have been met if the pressure loss at the end of the test is no higher than is specified below:

Nominal pressure	Test pressure	Max. pressure loss
10	15 bar	0.1 bar
16	21 bar	0.15 bar
more than 16	PN + 5 bar	0.2 bar

Test report

A test report should be produced. Templates for test reports are included in DVGW *Arbeitsblatt* W 400-2. The details required, such as the following, can be seen in these templates:

- description of the pipeline
- test parameters
- description of the performance of the test
- findings during the test
- note indicating report has been checked

The shortened standard procedure

The advantage of the shortened standard procedure is above all that it saves an enormous amount of time. The time required is only about 1.5 hours.

The shortened standard procedure is carried out in three phases:

- saturation phase
- pressure drop test
- leak test

Saturation phase

To achieve a high level of saturation, the test pressure is kept constant for half an hour by pumping in more water as and when required. The key factor in saturation is first and foremost the level of the test pressure. Unduly low pressure cannot be compensated for by increasing the length of the saturation phase.

Pressure drop test

The purpose of the pressure drop test is to establish that the pipeline is free of air. Pockets of air in the pipeline may result in incorrect measurements and may mask small leaks.

A volume of water ΔV_{zul} (see below) is drawn off from the pipeline at the test pressure. The resulting drop in pressure Δp is measured. This becomes the allowable drop in pressure Δp_{zul}, in the subsequent leak test. The pipeline must be re-pressurised to the test pressure after the pressure drop test.

ΔV_{zul} is calculated as follows:

$$\Delta V_{zul} = (DN \cdot L)/(100 \cdot k)$$

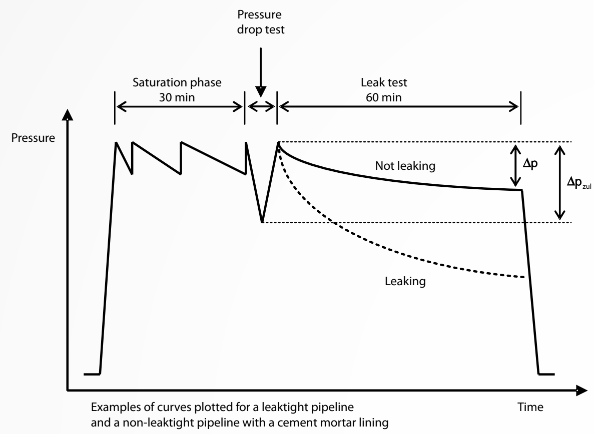
ΔV_{zul}	=	allowable change in volume [cm³]
L	=	length of the section tested [m]
100 x k	=	proportionality factor, k = 1 m/cm³

The pipeline is considered to have been adequately vented if, when the volume of water ΔV_{zul} is drawn off, the drop in pressure is equal to or greater than the minimum levels specified for Δp in the table below.

Nominal size DN	Minimum drop in pressure Δp [bar]
80	1.4
100	1.2
150	0.8
200	0.6
300	0.4
400	0.3
500	0.2
600	0.1

Leak test

The pipeline is considered not to leak if the loss of pressure Δp goes down at a constant rate over equal intervals of time and if, over the duration of the leak test, it does not exceed the level Δp_{zul} found in the pressure drop test. The duration of the test is one hour.



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- note indicating report has been checked

8.16 Disinfection of drinking water pipelines

Disinfection needs to be carried out both on the drinking water itself and on the infrastructure used to supply it. There are a variety of disinfectants and different methods of disinfection which can be used to produce the disinfectant effect. Only when satisfactory test results have been obtained is the disinfection of a pipeline considered to have been successfully completed.

General

Water supply companies have to provide drinking water which is in a satisfactory state hygienically. This requirement is laid down in the German Foodstuffs and Consumer Goods Law, the Federal Epidemic Control Law and the European Drinking Water Directive. Under these codes, drinking water must be of a nature such that its consumption does not harm public health. A prerequisite for this is that the drinking water pipelines are in a hygienically satisfactory condition.
This is achieved by disinfecting the pipelines.
Disinfection covers all the measures which reduce the number of bacteria in such a way that they do not adversely affect the quality of the water transported in the pipelines.
Such measures do relate to the drinking water but they also relate to the infrastructure used to supply it.
Under the Foodstuffs and Consumer Goods Law, pipelines are "requisites which are used in distributing drinking water and which thus come into contact with it".
Drinking water pipelines must be disinfected in accordance with DVGW *Arbeitsblatt* W 291. For ductile iron pipes with a cement mortar lining, it is useful for disinfection to be carried out at the same time as the pressure test.
When drinking water pipelines are being laid, the greatest possible care should be taken at the outset to stop pipes which will later be carrying water from getting dirty.
You should stop pipes from getting dirty as a result of actions by the personnel, as a result of items of equipment used (dirty rags used to wipe out sockets, etc.) or as a result of pollutants in the air (e.g. oily exhaust fumes from two-stroke pipe cutters). The ends of pipelines should be sealed off tightly in such a way that neither groundwater nor dirty water nor animal life can get in.

Disinfection is essential in the following cases:

- before drinking water pipelines are put into service
- after repairs and other work on the pipeline network
- if the drinking water becomes stagnant
- if drinking water pipelines become polluted with bacteria

Flushing out of drinking water pipelines

Under DVGW *Arbeitsblatt* W 291, flushing out with drinking water is the simplest means of reducing the concentration of bacteria and is normally all that is needed for pipelines of small nominal sizes up to DN 150. It is possible that this will make any additional disinfection unnecessary.

When flushing out takes place, ensure that the flow velocity is high enough (at least 1.5 m/s). The flushing action can be boosted by simultaneous pigging or by flushing out with a mixture of air and water.

The volume of water available to flush out the pipeline should be at least 3 to 5 times the capacity of the pipeline (for pipes of DN 150 size and below) or 2 to 3 times the capacity of the pipeline (for pipes of DN 200 size and above).

Attention should be paid to the following points when flushing out pipelines:

- You should only use items of equipment, such as hoses, which are suitable for drinking water and have been flushed out and, if at all possible, disinfected.
- Sloping pipelines should be flushed out from the top downwards.
- Any air which is injected should be free of oil and dust.
- Water from the section flushed out must not get into the supply network or to consumers.
- There must not be any non-allowable drop in pressure on the pipeline network.
- It must not be possible for dirty water to be sucked back into the pipeline when it is being drained.
- After flushing with a mixture of air and water, the pipeline must be fully vented.

Disinfectants

The choice of disinfectant should be made on the basis of the local conditions. These include for example whether the disinfectant can be properly handled and will be properly effective and whether it can be satisfactorily disposed of.
The following are the disinfectants most frequently used for disinfecting drinking water pipelines:

Sodium hypochlorite, potassium permanganate, hydrogen peroxide and chlorine dioxide.

Due to the checks required under the German Hazardous Materials Regulations, a critical view has to be taken of the use of disinfectants containing chlorine. If you cannot manage without a disinfectant, you should use mainly hydrogen peroxide or potassium permanganate. Both of these can be used as a working solution in a concentration which is below the threshold for hazardous materials (see Schlicht, issue 2/2003 of the magazine bbr).

Sodium hypochlorite (NaOCl)

Sodium hypochlorite is the most widely used disinfectant.
It is commercially available as a sodium hypochlorite solution (chlorine bleach solution).
The solution should contain at least 12% of free chlorine (150 to 160 g of chlorine per litre). Note that when the solution is stored there is a steady fall in the free chlorine
content. When solution has been in store for any great length of time, the chlorine content should therefore be checked.
A well-tried disinfectant solution for cast iron pipes with a cement mortar lining is for example a concentration of 50 mg of chlorine per litre of water.

For rechlorination, we recommend using a higher concentration (up to about 150 mg of chlorine per litre of water).
The pH of the sodium hypochlorite solution is between 11.5 and 12.5. When a pipeline is being disinfected, such a solution necessarily increases the pH of the water being treated.
We do not advise reducing the pH by mixing acids with the solution because this may cause chlorine gas to be released and may cause an accident. Mixing with very hard water may result in the precipitation of calcium carbonate.

Disinfectant solutions containing chlorine must always be treated to make them safe before they are allowed to make their way into the sewers or any waterways or bodies of water. This can be done by dilution or by chemical neutralisation with sodium thiosulphate.
Dechlorination is also possible by filtration through activated carbon filters.

Hydrogen peroxide (H_2O_2)

Hydrogen peroxide is a colourless liquid which mixes well with water. The commercially available solutions used have concentration of 35% and 50%.
Hydrogen peroxide gradually breaks down into water and oxygen and this process is speeded up by the effects of heat, light and dust and by heavy metal compounds and organic materials. The solution must therefore be stored where none of these things can affect it.
Disinfectants containing hydrogen peroxide solutions are commercially available under a variety of brand names. Commercially available hydrogen peroxide solutions are always diluted before being used for disinfection. They should not be used on site in a concentration of more than 5%. Concentrations of 150 mg per litre of water and standing times of 24 hours have proved suitable for newly laid pipelines. Unlike solutions containing chlorine, hydrogen peroxide can be drained into the sewers at these concentrations. There is normally no need for the solution to be treated before it is drained into the sewers.

Potassium permanganate ($KMnO_4$)

Potassium permanganate is available in the form of violet crystals and has a virtually unlimited shelf life in this form. Its solubility in water is very much dependent on temperature (28 g/litre of water at 0°c, 91 g/litre of water at 30°C).
Depending on its concentration, the solution is coloured as follows: deep violet for strong solutions, reddish violet for medium strength solutions and pink for weak solutions.

Being easy to work with and dispose of, potassium permanganate has been increasingly widely used for disinfection in recent years.
Disinfection with a potassium permanganate solution is carried in much the same way as with chlorine, except that 3 to 4% concentrations are used in this case.
The concentration used should be about 10 mg of potassium permanganate to 1 litre of water. Potassium permanganate solutions can be completely reduced by adding ascorbic acid (vitamin C). This can be recognised by a change in the colour of the solution from violet to colourless.

Chlorine dioxide (ClO_2)

Chlorine dioxide is a gas which is freely soluble in water and which is produced from two separate components, namely a sodium chlorite solution and sodium peroxide sulphate. Always follow the manufacturer's instructions when working with the ready-made solution. The container for the concentrated chloride dioxide stock solution (0.3 weight%) must be such that no chlorine dioxide gas is able to escape.

Chemical properties

In well sealed containers, the individual components for producing chlorine dioxide will remain stable and can be stored almost indefinitely. Chlorine dioxide itself is produced by mixing component 1 and component 2. Chlorine dioxide may break down into ionic end products when acted on by light and heat. The ready-mixed solution should therefore be stored in a cool, dark place. Under these conditions, a 0.3% aqueous solution of chlorine dioxide of neutral pH can be kept for around 40 days at 22°C.

Stock solution

An aqueous solution of 0.3% or 3 g/litre of ClO_2; this is added to the water to obtain the desired concentration of disinfectant.

Disposal

When water distribution systems are being disinfected, the excess chlorine dioxide and the chlorite, one of the by-products of its chemical reaction, must be de-activated (e.g. with calcium sulphite filters or activated carbon filters) before they are drained into the sewers or an open receiving water.

Disinfection procedures

Stand-in-place procedure

In this procedure disinfection is achieved by leaving the solution to stand in the pipeline for a fairly long period (not less than 12 hours). It is important in this procedure to ensure that the proportion in which the disinfectant solution is mixed with the water remains constant.
Infeed of the disinfectant solution must not be stopped until the entire pipeline is filled with it.
Of course, no disinfectant solution must be allowed to get into any part of the pipeline network which is in use!
While the solution is left to stand in the pipeline, you should also operate any gate valves or hydrants so that they too are disinfected.
If there are very stubborn bacterial deposits in the pipeline it will need to be disinfected more than once. The concentration of the disinfectant solution may be increased in this case.
It is also essential for the pipeline to be flushed out again with an adequate volume of water at a high flow velocity.
The disinfection process must be repeated until no microbiological contamination is found in the samples taken.
When sodium hypochlorite is used, there should still be evidence of chlorine in the water at the end of the stand-in-place period.

Flow procedure

With pipelines of large nominal sizes, it may be advantageous for the pipelines to be flushed out and disinfected at the same time over quite a long period of time.
If this is done, the concentration of the disinfectant in the water flowing out must be checked repeatedly in the course of the flushing-out process.
The total pipeline content should be replaced to 2 to 3 times.

Disinfection during the pressure test

The combining of the disinfection and pressure testing of a pipeline has proved to be a successful technique, the water which is used for the pressure testing being water which already has disinfectant admixed with it. The high pressure forces the disinfectant solution into the pores of the cement mortar lining. With this technique it is essential for the pipeline being disinfected to be isolated from all pipelines which are in service.

Disinfection measures when work is done on existing pipelines

When repairs are made or new pipes are connected in at a later date, there are often compelling reasons why a section of a network has to go back into service very quickly, meaning that disinfection cannot be carried out by the procedures described above.
Other measures then have to be taken to ensure that the drinking pipeline will be in a satisfactory state hygienically once the work has been completed.

For instance, the parts which are installed may already have been washed in clean water or disinfectant solution. Once the work is completed the pipeline should then be flushed out with water at a suitably high flow velocity.
Should any additional disinfection of the pipeline be necessary, care must be taken to see that no disinfectant solution gets into any of the adjoining parts of the system.
The pipeline may not be put back into operation until it has been thoroughly flushed out.

Disposal

Disinfectant solutions must be disposed of without any harm being done to the environment. Basically, all the relevant DIN standards and DVGW *Arbeitsblätter* must be observed. Particular note should be taken of DVGW *Arbeitsblatt* W 291 and the European Drinking Water Directive.
Close attention should also be paid to all product-specific information from disinfectant manufacturers, to the safety data sheets and to accident prevention regulations.

Microbiological checks and release for use

Once pipelines have been disinfected, i.e. once the flushing-out has been completed, water samples must be taken from them for microbiological examination. The samples should be taken from the ends of the pipelines and, where the pipelines are of any great length, from individual sections as well.
When taking samples, it is imperative that you take the steps specified in the standards document known as "German Standard Methods for the Examination of Water. Wastewater and Sludge" (DEV). These include the draining, cleaning and flame sterilisation of the valves used for sampling.
Under the existing directives and guidelines, disinfection can be regarded as successful if microbiological examination of the water shows that the colony count does not exceed the benchmark figure of 100 per ml of water. At the same time, the water must not contain any *Escherichia coli* (*E. coli*) or any coliform bacteria. If either of these requirements is not met, disinfection of the pipeline must be repeated.

Only when the results of the appropriate microbiological examinations show that everything is microbiologically safe can the drinking water pipeline be released for use. In all examinations, the guidelines laid down in the European Drinking Water Directive must be followed.

The disinfection process

To sum up, you must observe the following steps in your procedure when disinfecting drinking water pipelines (see also DVGW *Arbeitsblatt* W 291):

- Flush out the pipeline
- Disinfect the pipeline
- Drain off and if necessary neutralise the disinfectant solution after the appropriate stand-in-place time
- Flush out the pipeline
- Take samples and perform a microbiological examination

Only when the tests give satisfactory results can the pipeline which has been connected in be put into service.
In view of the important function performed by the disinfection of drinking water pipelines, it is essential for the process described above to be adhered to exactly.

8.17 Hydraulic calculation of drinking water pipelines

Calculations are needed to ensure that a pipeline will perform properly in hydraulic terms. High flow velocities result in considerable pressure losses. Particularly when pipelines are long, the flow velocity has a major impact on the economics of the supply system as a whole.
Low flow velocities result in the water standing still (stagnating) for long periods. This being the case, it has to be ensured that there is a sufficiently high exchange of water for hygienic reasons (to prevent turbidity and microbial contamination).

The texts governing the hydraulic dimensioning of water pipelines are DVGW *Arbeitsblatt* GW 303-1 and DVGW *Arbeitsblatt* GW 400-1.
The optimum flow velocities as a function of the type of pipeline (main pipeline, connecting pipeline, etc.) are specified in GW 400-1. These are mainly between 1.0 m/s and 2.0 m/s.
GW 303-1 has something to say about, amongst other things, the operating roughness (k2, which is referred to as ki – integral roughness – in it) of pipeline networks. What are subsumed under integral roughness are all the features of a pipeline or pipeline network which set up a resistance to flow, such as the roughness of the walls, socket transitions, deposits, and the effect of components inserted in pipelines (valves, bends, tapers, etc.). The following standard values have been laid down which apply equally to all pipeline materials:

ki = 0.1 mm for trunk mains and feeder mains which run for a considerable distance

ki = 0.4 mm for pipelines which run largely for a considerable distance

ki = 1.0 mm for new networks; this is an approximation which takes into account a high level of interconnection.

From the tables given below it is possible to make a rough estimate of the flow velocity (v) and the pressure losses (I). as a function of the DN, integral roughness (ki) and the volumetric flow rate (Q)

A calculation tool for the hydraulic calculation of ductile iron pipes is available for downloading free of charge at www.eadips.org

Pressure loss table for DN 80

Q [l/s]	DN 80			
	v [m/s]	k_i=0.1 J [m/km]	k_i=0.4 J [m/km]	k_i=1.0 J [m/km]
0.50	0.10	0.232	0.258	0.303
0.60	0.12	0.320	0.360	0.427
0.70	0.14	0.420	0.477	0.572
0.80	0.16	0.532	0.610	0.737
0.90	0.18	0.656	0.758	0.924
1.00	0.20	0.791	0.992	1.130
1.25	0.25	1.181	1.400	1.738
1.50	0.30	1.641	1.975	2.474
1.75	0.35	2.171	2.645	3.339
2.00	0.40	2.770	3.412	4.334
2.25	0.45	3.438	4.274	5.457
2.50	0.50	4.173	5.233	6.710
2.75	0.55	4.976	6.287	8.091
3.00	0.60	5.846	7.437	9.601
3.25	0.65	6.784	8.683	11.240
3.50	0.70	7.788	10.030	13.010
3.75	0.75	8.859	11.460	14.910
4.00	0.80	9.996	13.000	16.930
4.25	0.85	11.200	14.630	19.090
4.50	0.90	12.470	16.350	21.370
4.75	0.94	13.810	18.170	23.780
5.00	0.99	15.210	20.090	26.330
5.25	1.04	16.680	22.100	29.000
5.50	1.09	18.210	24.210	31.800
5.75	1.14	19.810	26.410	34.720
6.00	1.19	21.480	28.710	37.780
6.25	1.24	23.210	31.100	40.970
6.50	1.29	25.010	33.590	44.280
6.75	1.34	26.870	36.180	47.730
7.00	1.39	28.800	38.860	51.300
7.25	1.44	30.800	41.640	55.010
7.50	1.49	32.860	44.510	58.840
7.75	1.54	34.980	47.480	62.800
8.00	1.59	37.180	50.540	66.890
8.25	1.64	39.430	53.700	71.100
8.50	1.69	41.760	56.960	75.450
8.75	1.74	44.150	60.310	79.930
9.00	1.79	46.600	63.760	84.530
9.25	1.84	49.120	67.300	89.270
9.50	1.89	51.710	70.940	94.130
9.75	1.94	54.360	74.670	99.120
10.00	1.99	57.070	78.500	104.200
10.25	2.04	59.860	82.430	109.500
10.50	2.09	62.710	86.450	114.900
10.75	2.14	65.620	90.570	120.400
11.00	2.19	68.600	94.780	126.000
11.50	2.29	74.750	103.500	137.700
12.00	2.39	81.170	112.600	149.900
12.50	2.49	87.850	122.100	162.500
13.00	2.59	94.790	131.900	175.800
13.50	2.69	102.000	142.200	189.500
14.00	2.79	109.500	152.800	203.700
14.50	2.88	117.200	163.800	218.500
15.00	2.98	125.200	175.200	233.700
15.50	3.08	133.400	187.000	249.500
16.00	3.18	141.900	199.100	265.800
16.50	3.28	150.700	211.700	282.600
17.00	3.38	159.700	224.600	300.000
17.50	3.48	169.000	237.900	317.800
18.00	3.58	178.600	251.600	336.200
18.50	3.68	188.400	265.600	355.100
19.00	3.78	198.500	280.100	374.500
19.50	3.88	208.800	294.900	394.400
20.00	3.98	219.400	310.200	414.800
20.50	4.08	230.300	325.800	435.800
21.00	4.18	241.400	341.700	457.200
21.50	4.28	252.800	358.100	479.200
22.00	4.38	264.500	374.900	
22.50	4.48	276.400	392.000	
23.00	4.58	288.600	409.500	
23.50	4.68	301.000	427.400	
24.00	4.77	313.700	445.700	
24.50	4.87	326.600	464.300	
25.00	4.97	339.900	483.400	
25.50	5.07	353.300		
26.00	5.17	367.100		
26.50	5.27	381.100		

Pressure loss table for DN 100

Q [l/s]	DN 100			
	v [m/s]	k_i=0.1 J [m/km]	k_i=0.4 J [m/km]	k_i=1.0 J [m/km]
0.60	0.08	0.110	0.120	0.137
0.70	0.09	0.144	0.158	0.183
0.80	0.10	0.182	0.201	0.235
0.90	0.11	0.224	0.249	0.293
1.00	0.13	0.269	0.302	0.357
1.25	0.16	0.400	0.456	0.546
1.50	0.19	0.554	0.639	0.774
1.75	0.22	0.730	0.852	1.041
2.00	0.25	0.929	1.095	1.347
2.25	0.29	1.149	1.367	1.693
2.50	0.32	1.392	1.669	2.077
2.75	0.35	1.656	2.000	2.501
3.00	0.38	1.941	2.361	2.964
3.25	0.41	2.247	2.751	3.466
3.50	0.45	2.575	3.171	4.007
3.75	0.48	2.924	3.620	4.587
4.00	0.51	3.294	4.099	5.207
4.25	0.54	3.684	4.607	5.865
4.50	0.57	4.096	5.144	6.563
4.75	0.60	4.528	5.710	7.300
5.00	0.64	4.982	6.306	8.076
5.25	0.67	5.456	6.932	8.891
5.50	0.70	5.950	7.587	9.745
5.75	0.73	6.466	8.271	10.640
6.00	0.76	7.002	8.984	11.570
6.25	0.80	7.558	9.727	12.540
6.50	0.83	8.136	10.500	13.550
6.75	0.86	8.733	11.300	14.600
7.00	0.89	9.352	12.130	15.690
7.25	0.92	9.991	12.990	16.820
7.50	0.95	10.650	13.880	17.990
7.75	0.99	11.330	14.800	19.190
8.00	1.02	12.030	15.750	20.440
8.25	1.05	12.750	16.730	21.720
8.50	1.08	13.490	17.730	23.050
8.75	1.11	14.250	18.770	24.410
9.00	1.15	15.040	19.840	25.810
9.25	1.18	15.840	20.930	27.250
9.50	1.21	16.660	22.050	28.730
9.75	1.24	17.510	23.210	30.250
10.00	1.27	18.370	24.390	31.810
10.25	1.31	19.260	25.600	33.410
10.50	1.34	20.160	26.850	35.050
10.75	1.37	21.090	28.120	36.720
11.00	1.40	22.030	29.420	38.440
11.50	1.46	23.980	32.110	41.980
12.00	1.53	26.020	34.910	45.690
12.50	1.59	28.130	37.840	49.550
13.00	1.66	30.330	40.880	53.570
13.50	1.72	32.610	44.030	57.740
14.00	1.78	34.970	47.310	62.070
14.50	1.85	37.410	50.700	66.550
15.00	1.91	39.930	54.210	71.200
15.50	1.97	42.530	57.840	76.000
16.00	2.04	45.220	61.590	80.950
16.50	2.10	47.990	65.450	86.070
17.00	2.16	50.830	69.430	91.330
17.50	2.23	53.760	73.520	96.760
18.00	2.29	56.770	77.740	102.300
18.50	2.36	59.860	82.070	108.100
19.00	2.42	63.040	86.520	114.000
19.50	2.48	66.290	91.090	120.000
20.00	2.55	69.630	95.770	126.200
20.50	2.61	73.040	100.600	132.600
21.00	2.67	76.540	105.500	139.100
21.50	2.74	80.120	110.500	145.800
22.00	2.80	83.780	115.700	152.600
22.50	2.86	87.520	120.900	159.600
23.00	2.93	91.340	126.300	166.800
23.50	2.99	95.240	131.800	174.100
24.00	3.06	99.230	137.500	181.500
24.50	3.12	103.300	143.200	189.100
25.00	3.18	107.400	149.100	196.900
25.50	3.25	111.700	155.000	204.900
26.00	3.31	116.000	161.100	212.900
26.50	3.37	120.400	167.300	221.200
27.00	3.44	124.800	173.700	229.600

Pressure loss table for DN 125

Q [l/s]	DN 125			
	v [m/s]	ki=0.1 J [m/km]	ki=0.4 J [m/km]	ki=1.0 J [m/km]
1.00	0.08	0.090	0.098	0.112
1.25	0.10	0.134	0.147	0.170
1.50	0.12	0.184	0.205	0.240
1.75	0.14	0.242	0.272	0.321
2.00	0.16	0.307	0.348	0.414
2.25	0.18	0.379	0.433	0.518
2.50	0.20	0.458	0.527	0.635
2.75	0.22	0.544	0.630	0.762
3.00	0.24	0.636	0.742	0.902
3.25	0.26	0.736	0.862	1.053
3.50	0.28	0.841	0.992	1.216
3.75	0.30	0.954	1.130	1.390
4.00	0.32	1.073	1.277	1.576
4.25	0.34	1.198	1.433	1.773
4.50	0.36	1.330	1.598	1.983
4.75	0.38	1.468	1.772	2.203
5.00	0.40	1.613	1.954	2.436
5.25	0.42	1.765	2.146	2.680
5.50	0.44	1.922	2.346	2.935
5.75	0.46	2.086	2.555	3.203
6.00	0.48	2.257	2.772	3.481
6.25	0.50	2.434	2.999	3.772
6.50	0.52	2.617	3.234	4.074
6.75	0.54	2.806	3.479	4.387
7.00	0.56	3.002	3.732	4.713
7.25	0.59	3.204	3.993	5.049
7.50	0.61	3.413	4.264	5.398
7.75	0.63	3.628	4.543	5.758
8.00	0.65	3.849	4.831	6.130
8.25	0.67	4.076	5.128	6.513
8.50	0.69	4.310	5.434	6.908
8.75	0.71	4.550	5.749	7.314
9.00	0.73	4.796	6.072	7.732
9.25	0.75	5.048	6.404	8.162
9.50	0.77	5.307	6.745	8.603
9.75	0.79	5.572	7.095	9.056
10.00	0.81	5.843	7.454	9.521
10.50	0.85	6.404	8.197	10.480
11.00	0.89	6.990	8.976	11.490
11.50	0.93	7.601	9.790	12.550
12.00	0.97	8.237	10.640	13.650
12.50	1.01	8.897	11.520	14.800
13.00	1.05	9.583	12.440	16.000
13.50	1.09	10.290	13.400	17.240
14.00	1.13	11.030	14.390	18.530
14.50	1.17	11.790	15.410	19.870
15.00	1.21	12.570	16.470	21.250
15.50	1.25	13.380	17.570	22.680
16.00	1.29	14.220	18.700	24.150
16.50	1.33	15.070	19.860	25.670
17.00	1.37	15.960	21.060	27.240
17.50	1.41	16.870	22.300	28.850
18.00	1.45	17.800	23.570	30.510
18.50	1.49	18.760	24.880	32.220
19.00	1.53	19.740	26.220	33.970
19.50	1.57	20.750	27.590	35.770
20.00	1.61	21.780	29.010	37.620
20.50	1.65	22.830	30.450	39.510
21.00	1.69	23.910	31.930	41.450
21.50	1.74	25.020	33.450	43.440
22.00	1.78	26.150	35.000	45.470
22.50	1.82	27.310	36.590	47.540
23.00	1.86	28.490	38.210	49.670
23.50	1.90	29.690	39.870	51.840
24.00	1.94	30.920	41.560	54.060
24.50	1.98	32.170	43.290	56.320
25.00	2.02	33.450	45.060	58.630
25.50	2.06	34.750	46.850	60.990
26.00	2.10	36.080	48.690	63.390
26.50	2.14	37.430	50.560	65.840
27.00	2.18	38.810	52.460	68.340
27.50	2.22	40.210	54.400	70.880
28.00	2.26	41.640	56.370	73.470
28.50	2.30	43.090	58.380	76.100
29.00	2.34	44.560	60.430	78.780
29.50	2.38	46.060	62.510	81.510
30.00	2.42	47.590	64.620	84.290
30.50	2.46	49.130	66.770	87.110

Q [l/s]	DN 125			
	v [m/s]	k_i=0.1 J [m/km]	k_i=0.4 J [m/km]	k_i=1.0 J [m/km]
31.00	2.50	50.71	68.96	89.97
31.50	2.54	52.31	71.18	92.89
32.00	2.58	53.93	73.43	95.85
32.50	2.62	55.58	75.72	98.85
33.00	2.66	57.25	78.05	101.90
33.50	2.70	58.94	80.41	105.00
34.00	2.74	60.67	82.81	108.20
34.50	2.78	62.41	85.24	111.30
35.00	2.82	64.18	87.70	114.60
35.50	2.87	65.98	90.21	117.90
36.00	2.91	67.80	92.74	121.20
36.50	2.95	69.64	95.31	124.60
37.00	2.99	71.51	97.92	128.00
37.50	3.03	73.40	100.60	131.50
38.00	3.07	75.32	103.20	135.00
38.50	3.11	77.26	106.00	138.60
39.00	3.15	79.23	108.70	142.20
39.50	3.19	81.22	111.50	145.80
40.00	3.23	83.24	114.30	149.50
40.50	3.27	85.28	117.20	153.30
41.00	3.31	87.34	120.00	157.10
41.50	3.35	89.43	123.00	160.90
42.00	3.39	91.55	125.90	164.80
42.50	3.43	93.69	128.90	168.70
43.00	3.47	95.85	131.90	172.70
43.50	3.51	98.04	135.00	176.70
44.00	3.55	100.30	138.10	180.80
44.50	3.59	102.50	141.20	184.90
45.00	3.63	104.80	144.40	189.10
45.50	3.67	107.00	147.60	193.30
46.00	3.71	109.30	150.90	197.60
46.50	3.75	111.70	154.10	201.90
47.00	3.79	114.00	157.40	206.20
47.50	3.83	116.40	160.80	210.60
48.00	3.87	118.80	164.20	215.10
48.50	3.91	121.30	167.60	219.60
49.00	3.95	123.70	171.00	224.10
49.50	4.00	126.20	174.50	228.70

Pressure loss table for DN 150 cont.

Q [l/s]	DN 150			
	v [m/s]	k_i=0.1 J [m/km]	k_i=0.4 J [m/km]	k_i=1.0 J [m/km]
1.50	0.08	0.076	0.083	0.094
1.75	0.10	0.100	0.109	0.125
2.00	0.11	0.127	0.139	0.161
2.25	0.13	0.156	0.173	0.201
2.50	0.14	0.188	0.210	0.246
2.75	0.15	0.223	0.250	0.295
3.00	0.17	0.260	0.294	0.348
3.25	0.18	0.301	0.341	0.406
3.50	0.20	0.343	0.392	0.468
3.75	0.21	0.389	0.446	0.534
4.00	0.22	0.437	0.503	0.605
4.25	0.24	0.487	0.564	0.680
4.50	0.25	0.540	0.628	0.760
4.75	0.27	0.596	0.695	0.843
5.00	0.28	0.654	0.766	0.932
5.25	0.29	0.715	0.840	1.024
5.50	0.31	0.778	0.917	1.121
5.75	0.32	0.844	0.998	1.222
6.00	0.34	0.912	1.082	1.328
6.25	0.35	0.983	1.170	1.438
6.50	0.36	1.056	1.260	1.552
6.75	0.38	1.131	1.355	1.671
7.00	0.39	1.209	1.452	1.794
7.25	0.40	1.290	1.553	1.922
7.50	0.42	1.373	1.657	2.053
7.75	0.43	1.458	1.764	2.190
8.00	0.45	1.546	1.875	2.330
8.25	0.46	1.637	1.989	2.475
8.50	0.47	1.729	2.107	2.624
8.75	0.49	1.824	2.228	2.778
9.00	0.50	1.922	2.352	2.936
9.25	0.52	2.022	2.479	3.098
9.50	0.53	2.125	2.610	3.265
9.75	0.54	2.229	2.744	3.436
10.00	0.56	2.337	2.882	3.611
10.50	0.59	2.559	3.166	3.975
11.00	0.61	2.790	3.465	4.356
11.50	0.64	3.031	3.776	4.755
12.00	0.67	3.282	4.101	5.171

Q [l/s]	DN 150			
	v [m/s]	k_i=0.1 J [m/km]	k_i=0.4 J [m/km]	k_i=1.0 J [m/km]
12.50	0.70	3.542	4.439	5.604
13.00	0.73	3.812	4.791	6.055
13.50	0.75	4.091	5.155	6.523
14.00	0.78	4.380	5.533	7.009
14.50	0.81	4.678	5.925	7.512
15.00	0.84	4.986	6.329	8.033
15.50	0.87	5.303	6.747	8.571
16.00	0.89	5.630	7.179	9.126
16.50	0.92	5.967	7.623	9.699
17.00	0.95	6.313	8.081	10.290
17.50	0.98	6.668	8.552	10.900
18.00	1.01	7.033	9.037	11.520
18.50	1.03	7.407	9.535	12.170
19.00	1.06	7.791	10.050	12.830
19.50	1.09	8.184	10.570	13.500
20.00	1.12	8.587	11.110	14.200
20.50	1.14	8.999	11.660	14.910
21.00	1.17	9.421	12.220	15.640
21.50	1.20	9.852	12.800	16.390
22.00	1.23	10.290	13.390	17.150
22.50	1.26	10.740	14.000	17.930
23.00	1.28	11.200	14.610	18.730
23.50	1.31	11.670	15.240	19.550
24.00	1.34	12.150	15.890	20.380
24.50	1.37	12.640	16.550	21.240
25.00	1.40	13.130	17.220	22.100
25.50	1.42	13.640	17.900	22.990
26.00	1.45	14.160	18.600	23.890
26.50	1.48	14.680	19.310	24.820
27.00	1.51	15.220	20.030	25.750
27.50	1.54	15.760	20.770	26.710
28.00	1.56	16.310	21.520	27.680
28.50	1.59	16.880	22.280	28.680
29.00	1.62	17.450	23.060	29.680
29.50	1.65	18.030	23.850	30.710
30.00	1.68	18.620	24.650	31.750
30.50	1.70	19.220	25.470	32.810
31.00	1.73	19.830	26.300	33.890
31.50	1.76	20.450	27.140	34.990
32.00	1.79	21.080	28.000	36.100
32.50	1.81	21.720	28.870	37.230
33.00	1.84	22.370	29.750	38.380
33.50	1.87	23.020	30.650	39.540
34.00	1.90	23.690	31.560	40.730
34.50	1.93	24.370	32.490	41.930
35.00	1.95	25.050	33.420	43.150
35.50	1.98	25.750	34.370	44.380
36.00	2.01	26.450	35.330	45.630
36.50	2.04	27.160	36.310	46.900
37.00	2.07	27.890	37.300	48.190
37.50	2.09	28.620	38.300	49.490
38.00	2.12	29.360	39.320	50.820
38.50	2.15	30.110	40.350	52.160
39.00	2.18	30.870	41.390	53.510
39.50	2.21	31.640	42.450	54.890
40.00	2.23	32.420	43.520	56.280
40.50	2.26	33.210	44.600	57.690
41.00	2.29	34.010	45.700	59.120
41.50	2.32	34.820	46.810	60.560
42.00	2.35	35.630	47.930	62.020
42.50	2.37	36.460	49.070	63.500
43.00	2.40	37.290	50.220	65.000
43.50	2.43	38.140	51.380	66.510
44.00	2.46	38.990	52.550	68.040
44.50	2.48	39.860	53.740	69.590
45.00	2.51	40.730	54.950	71.160
45.50	2.54	41.610	56.160	72.740
46.00	2.57	42.500	57.390	74.340
46.50	2.60	43.400	58.630	75.960
47.00	2.62	44.310	59.890	77.590
47.50	2.65	45.230	61.160	79.250
48.00	2.68	46.160	62.440	80.920
48.50	2.71	47.100	63.740	82.610
49.00	2.74	48.050	65.040	84.310
49.50	2.76	49.010	66.370	86.030
50.00	2.79	49.980	67.700	87.780
51.00	2.85	51.940	70.410	91.310

Pressure loss table for DN 200

Q [l/s]	DN 200			
	v [m/s]	ki=0.1 J [m/km]	ki=0.4 J [m/km]	ki=1.0 J [m/km]
2.50	0.08	0.045	0.048	0.054
3.00	0.09	0.062	0.067	0.076
3.50	0.11	0.081	0.089	0.102
4.00	0.12	0.103	0.114	0.131
4.50	0.14	0.127	0.141	0.164
5.00	0.15	0.154	0.172	0.200
5.50	0.17	0.183	0.205	0.240
6.00	0.18	0.214	0.241	0.284
6.50	0.20	0.247	0.280	0.331
7.00	0.22	0.282	0.321	0.382
7.50	0.23	0.319	0.366	0.436
8.00	0.25	0.359	0.413	0.494
8.50	0.26	0.401	0.463	0.556
9.00	0.28	0.445	0.516	0.621
10.00	0.31	0.539	0.630	0.762
11.00	0.34	0.642	0.755	0.917
12.00	0.37	0.753	0.892	1.087
13.00	0.40	0.872	1.039	1.271
14.00	0.43	1.000	1.197	1.470
15.00	0.46	1.136	1.367	1.682
16.00	0.49	1.280	1.548	1.909
17.00	0.52	1.432	1.740	2.151
18.00	0.55	1.593	1.942	2.407
19.00	0.58	1.762	2.156	2.677
20.00	0.62	1.938	2.381	2.961
21.00	0.65	2.123	2.618	3.260
22.00	0.68	2.316	2.865	3.573
23.00	0.71	2.517	3.123	3.901
24.00	0.74	2.726	3.392	4.242
25.00	0.77	2.943	3.673	4.598
26.00	0.80	3.168	3.964	4.969
27.00	0.83	3.402	4.267	5.354
28.00	0.86	3.643	4.581	5.753
29.00	0.89	3.892	4.905	6.166
30.00	0.92	4.149	5.241	6.594
31.00	0.95	4.414	5.588	7.036
32.00	0.98	4.688	5.946	7.493
33.00	1.02	4.969	6.315	7.964
34.00	1.05	5.258	6.695	8.449
35.00	1.08	5.555	7.086	8.948
36.00	1.11	5.860	7.488	9.462
37.00	1.14	6.174	7.901	9.990
38.00	1.17	6.495	8.326	10.530
39.00	1.20	6.824	8.761	11.090
40.00	1.23	7.161	9.208	11.660
41.00	1.26	7.506	9.665	12.250
42.00	1.29	7.859	10.130	12.850
43.00	1.32	8.219	10.610	13.460
44.00	1.35	8.588	11.100	14.090
45.00	1.38	8.965	11.610	14.730
46.00	1.42	9.350	12.120	15.390
47.00	1.45	9.742	12.640	16.060
48.00	1.48	10.140	13.180	16.750
49.00	1.51	10.550	13.720	17.450
50.00	1.54	10.970	14.280	18.160
52.50	1.62	12.040	15.720	20.010
55.00	1.69	13.170	17.230	21.950
57.50	1.77	14.340	18.810	23.980
60.00	1.85	15.570	20.460	26.090
62.50	1.92	16.840	22.180	28.300
65.00	2.00	18.170	23.970	30.600
70.00	2.15	20.960	27.750	35.460
75.00	2.31	23.960	31.800	40.680
80.00	2.46	27.150	36.140	46.260
85.00	2.62	30.540	40.750	52.200
90.00	2.77	34.120	45.640	58.490
95.00	2.92	37.910	50.800	65.150
100.00	3.08	41.890	56.240	72.160
105.00	3.23	46.070	61.960	79.530
110.00	3.39	50.440	67.950	87.260
115.00	3.54	55.020	74.230	95.350
120.00	3.69	59.790	80.770	103.800
125.00	3.85	64.760	87.600	112.600
130.00	4.00	69.930	94.700	121.800
135.00	4.15	75.290	102.100	131.300
140.00	4.31	80.850	109.700	141.200
145.00	4.46	86.610	117.700	151.400

Pressure loss table for DN 250

Q [l/s]	DN 250			
	v [m/s]	k_i=0.1 J [m/km]	k_i=0.4 J [m/km]	k_i=1.0 J [m/km]
4.00	0.08	0.035	0.038	0.042
4.50	0.09	0.043	0.047	0.053
5.00	0.10	0.052	0.057	0.064
5.50	0.11	0.062	0.068	0.077
6.00	0.12	0.072	0.079	0.090
6.50	0.13	0.084	0.092	0.105
7.00	0.14	0.095	0.105	0.121
7.50	0.15	0.108	0.120	0.138
8.00	0.16	0.121	0.135	0.156
8.50	0.17	0.135	0.151	0.176
9.00	0.18	0.150	0.168	0.196
10.00	0.20	0.181	0.204	0.240
11.00	0.22	0.215	0.244	0.288
12.00	0.24	0.252	0.288	0.341
13.00	0.26	0.292	0.334	0.398
14.00	0.28	0.334	0.385	0.459
15.00	0.30	0.379	0.438	0.525
16.00	0.31	0.426	0.496	0.596
17.00	0.33	0.476	0.556	0.670
18.00	0.35	0.529	0.620	0.749
19.00	0.37	0.584	0.688	0.833
20.00	0.39	0.642	0.758	0.920
21.00	0.41	0.702	0.833	1.013
22.00	0.43	0.765	0.910	1.109
23.00	0.45	0.831	0.992	1.210
24.00	0.47	0.899	1.076	1.315
25.00	0.49	0.970	1.164	1.425
26.00	0.51	1.043	1.256	1.539
27.00	0.53	1.119	1.350	1.658
28.00	0.55	1.197	1.449	1.781
29.00	0.57	1.278	1.550	1.908
30.00	0.59	1.361	1.655	2.039
31.00	0.61	1.447	1.764	2.176
32.00	0.63	1.536	1.876	2.316
33.00	0.65	1.627	1.991	2.461
34.00	0.67	1.720	2.110	2.610
35.00	0.69	1.816	2.232	2.763
36.00	0.71	1.915	2.357	2.921
37.00	0.73	2.016	2.486	3.084
38.00	0.75	2.119	2.619	3.250
39.00	0.77	2.225	2.754	3.421
40.00	0.79	2.334	2.894	3.597
41.00	0.81	2.445	3.036	3.777
42.00	0.83	2.558	3.182	3.961
43.00	0.85	2.674	3.332	4.150
44.00	0.87	2.792	3.484	4.343
45.00	0.89	2.913	3.641	4.540
46.00	0.90	3.037	3.800	4.742
47.00	0.92	3.163	3.963	4.948
48.00	0.94	3.291	4.130	5.158
49.00	0.96	3.422	4.300	5.373
50.00	0.98	3.556	4.473	5.592
52.50	1.03	3.900	4.921	6.160
55.00	1.08	4.260	5.391	6.755
57.50	1.13	4.635	5.882	7.377
60.00	1.18	5.026	6.394	8.026
62.50	1.23	5.433	6.927	8.703
65.00	1.28	5.854	7.482	9.408
70.00	1.38	6.745	8.655	10.900
75.00	1.48	7.696	9.9140	12.500
80.00	1.57	8.710	11.260	14.210
85.00	1.67	9.785	12.690	16.030
90.00	1.77	10.920	14.200	17.960
95.00	1.87	12.120	15.800	20.000
100.00	1.97	13.380	17.490	22.140
105.00	2.07	14.700	19.260	24.400
110.00	2.16	16.090	21.110	26.770
115.00	2.26	17.530	23.050	29.250
120.00	2.36	19.040	25.080	31.830
125.00	2.46	20.600	27.190	34.530
130.00	2.56	22.230	29.390	37.330
135.00	2.66	23.920	31.670	40.250
140.00	2.75	25.680	34.030	43.270
145.00	2.85	27.490	36.490	46.410
150.00	2.95	29.360	39.020	49.650
155.00	3.05	31.300	41.650	53.010
160.00	3.15	33.300	44.350	56.470

Pressure loss table for DN 300

Q [l/s]	DN 300			
	v [m/s]	k_i=0.1 J [m/km]	k_i=0.4 J [m/km]	k_i=1.0 J [m/km]
6.00	0.08	0.030	0.032	0.036
7.00	0.10	0.039	0.043	0.048
8.00	0.11	0.050	0.054	0.061
9.00	0.12	0.062	0.067	0.077
10.00	0.14	0.075	0.082	0.094
11.00	0.15	0.089	0.098	0.113
12.00	0.16	0.104	0.115	0.133
13.00	0.18	0.120	0.133	0.155
14.00	0.19	0.137	0.153	0.179
15.00	0.20	0.155	0.174	0.204
16.00	0.22	0.174	0.197	0.231
17.00	0.23	0.194	0.220	0.260
18.00	0.25	0.216	0.246	0.290
19.00	0.26	0.238	0.272	0.322
20.00	0.27	0.261	0.300	0.356
22.00	0.30	0.311	0.359	0.428
24.00	0.33	0.365	0.424	0.507
26.00	0.35	0.423	0.493	0.593
28.00	0.38	0.485	0.568	0.685
30.00	0.41	0.551	0.649	0.784
32.00	0.44	0.620	0.734	0.889
34.00	0.46	0.694	0.825	1.002
36.00	0.49	0.772	0.921	1.121
38.00	0.52	0.853	1.022	1.246
40.00	0.55	0.939	1.128	1.378
42.00	0.57	1.028	1.240	1.517
44.00	0.60	1.121	1.357	1.663
46.00	0.63	1.218	1.479	1.815
48.00	0.65	1.319	1.606	1.974
50.00	0.68	1.424	1.738	2.139
52.50	0.72	1.561	1.911	2.355
55.00	0.75	1.703	2.092	2.582
57.50	0.78	1.852	2.281	2.819
60.00	0.82	2.006	2.479	3.066
62.50	0.85	2.167	2.684	3.324
65.00	0.89	2.333	2.898	3.592
70.00	0.95	2.684	3.349	4.159
75.00	1.02	3.059	3.833	4.768
80.00	1.09	3.458	4.350	5.418
85.00	1.16	3.880	4.899	6.110
90.00	1.23	4.327	5.481	6.844
95.00	1.30	4.797	6.095	7.619
100.00	1.36	5.291	6.741	8.435
105.00	1.43	5.808	7.421	9.294
110.00	1.50	6.350	8.132	10.190
115.00	1.57	6.915	8.877	11.130
120.00	1.64	7.504	9.654	12.120
125.00	1.70	8.116	10.460	13.140
130.00	1.77	8.752	11.300	14.210
135.00	1.84	9.412	12.180	15.310
140.00	1.91	10.100	13.090	16.460
145.00	1.98	10.800	14.030	17.650
150.00	2.05	11.530	15.000	18.890
155.00	2.11	12.290	16.000	20.160
160.00	2.18	13.070	17.040	21.480
165.00	2.25	13.870	18.110	22.830
170.00	2.32	14.690	19.210	24.230
175.00	2.39	15.540	20.340	25.670
180.00	2.45	16.410	21.510	27.150
185.00	2.52	17.310	22.710	28.670
190.00	2.59	18.230	23.940	30.240
195.00	2.66	19.170	25.210	31.840
200.00	2.73	20.140	26.510	33.490
205.00	2.79	21.130	27.840	35.180
210.00	2.86	22.150	29.200	36.910
215.00	2.93	23.180	30.590	38.680
220.00	3.00	24.250	32.020	40.500
225.00	3.07	25.330	33.480	42.350
230.00	3.14	26.440	34.970	44.250
235.00	3.20	27.570	36.500	46.190
240.00	3.27	28.730	38.050	48.170
245.00	3.34	29.910	39.640	50.190
250.00	3.41	31.110	41.270	52.250
255.00	3.48	32.340	42.920	54.360
260.00	3.54	33.590	44.610	56.500
265.00	3.61	34.860	46.330	58.690
270.00	3.68	36.160	48.080	60.920

Pressure loss table for DN 400

Q [l/s]	DN 400			
	v [m/s]	k_i=0.1 J [m/km]	k_i=0.4 J [m/km]	k_i=1.0 J [m/km]
9.00	0.07	0.016	0.017	0.019
10.00	0.08	0.020	0.021	0.023
12.50	0.10	0.029	0.032	0.035
15.00	0.12	0.041	0.044	0.050
17.50	0.14	0.054	0.059	0.067
20.00	0.16	0.068	0.075	0.086
25.00	0.20	0.102	0.114	0.132
30.00	0.24	0.142	0.161	0.188
35.00	0.27	0.189	0.215	0.253
40.00	0.31	0.241	0.277	0.328
45.00	0.35	0.300	0.347	0.413
50.00	0.39	0.364	0.424	0.508
55.00	0.43	0.434	0.509	0.612
60.00	0.47	0.510	0.602	0.726
65.00	0.51	0.592	0.703	0.849
70.00	0.55	0.679	0.811	0.982
75.00	0.59	0.773	0.926	1.125
80.00	0.63	0.872	1.050	1.277
85.00	0.67	0.977	1.181	1.440
90.00	0.71	1.088	1.319	1.611
95.00	0.75	1.204	1.466	1.793
100.00	0.78	1.326	1.620	1.984
105.00	0.82	1.454	1.781	2.185
110.00	0.86	1.587	1.950	2.395
115.00	0.90	1.726	2.127	2.615
120.00	0.94	1.871	2.312	2.845
125.00	0.98	2.022	2.504	3.085
130.00	1.02	2.178	2.704	3.334
135.00	1.06	2.339	2.911	3.593
140.00	1.10	2.507	3.126	3.861
145.00	1.14	2.680	3.349	4.140
150.00	1.18	2.859	3.579	4.427
155.00	1.22	3.043	3.817	4.725
160.00	1.26	3.233	4.063	5.032
165.00	1.29	3.429	4.316	5.349
170.00	1.33	3.630	4.577	5.675
175.00	1.37	3.837	4.846	6.012
180.00	1.41	4.050	5.122	6.358
185.00	1.45	4.268	5.406	6.713
190.00	1.49	4.492	5.697	7.078
195.00	1.53	4.721	5.996	7.453
200.00	1.57	4.956	6.303	7.838
205.00	1.61	5.197	6.617	8.232
210.00	1.65	5.443	6.939	8.636
215.00	1.69	5.695	7.269	9.049
220.00	1.73	5.953	7.606	9.473
225.00	1.77	6.216	7.951	9.905
230.00	1.80	6.484	8.303	10.350
235.00	1.84	6.759	8.664	10.800
240.00	1.88	7.039	9.031	11.260
245.00	1.92	7.324	9.407	11.730
250.00	1.96	7.616	9.790	12.210
260.00	2.04	8.215	10.580	13.210
270.00	2.12	8.837	11.400	14.240
280.00	2.20	9.481	12.250	15.310
290.00	2.28	10.150	13.130	16.410
300.00	2.35	10.840	14.040	17.560
310.00	2.43	11.550	14.980	18.740
320.00	2.51	12.280	15.950	19.970
330.00	2.59	13.040	16.960	21.230
340.00	2.67	13.820	17.990	22.530
350.00	2.75	14.620	19.050	23.870
360.00	2.83	15.440	20.150	25.250
370.00	2.90	16.290	21.270	26.670
380.00	2.98	17.150	22.430	28.120
390.00	3.06	18.050	23.620	29.620
400.00	3.14	18.960	24.830	31.150
410.00	3.22	19.890	26.080	32.720
420.00	3.30	20.850	27.360	34.330
430.00	3.37	21.830	28.670	35.980
440.00	3.45	22.830	30.000	37.670
450.00	3.53	23.860	31.370	39.390
460.00	3.61	24.910	32.770	41.160
470.00	3.69	25.980	34.200	42.960
480.00	3.77	27.070	35.670	44.800
490.00	3.85	28.180	37.160	46.690
500.00	3.92	29.320	38.680	48.610

Pressure loss table for DN 500

Q [l/s]	DN 500			
	v [m/s]	k_i=0.1 J [m/km]	k_i=0.4 J [m/km]	k_i=1.00 J [m/km]
15.00	0.008	0.0014	0.0015	0.0016
17.50	0.009	0.0018	0.0019	0.0022
20.00	0.100	0.0023	0.0025	0.0028
25.00	0.130	0.0035	0.0037	0.0042
30.00	0.150	0.0048	0.0052	0.0060
35.00	0.180	0.0063	0.0070	0.0080
40.00	0.200	0.0081	0.0090	0.1040
45.00	0.230	0.1000	0.1120	0.1300
50.00	0.250	0.1210	0.1370	0.1600
55.00	0.280	0.1450	0.1640	0.1920
60.00	0.300	0.1700	0.1930	0.2270
65.00	0.330	0.1970	0.2250	0.2660
70.00	0.350	0.2250	0.2590	0.3070
75.00	0.380	0.2560	0.2960	0.3510
80.00	0.400	0.2880	0.3350	0.3980
85.00	0.430	0.3230	0.3760	0.4490
90.00	0.450	0.3590	0.4200	0.5020
95.00	0.480	0.3970	0.4660	0.5580
100.00	0.500	0.4360	0.5140	0.6170
105.00	0.530	0.4780	0.5650	0.6790
110.00	0.550	0.5210	0.6180	0.7440
115.00	0.580	0.5660	0.6740	0.8120
120.00	0.600	0.6130	0.7320	0.8830
125.00	0.630	0.6620	0.7920	0.9570
130.00	0.650	0.7130	0.8540	1.0034
135.00	0.680	0.7650	0.9190	1.1140
140.00	0.700	0.8190	0.9870	1.1970
145.00	0.730	0.8750	1.0056	1.2830
150.00	0.750	0.9320	1.1280	1.3720
155.00	0.780	0.9920	1.2030	1.4630
160.00	0.800	1.0053	1.2800	1.5580
165.00	0.830	1.1160	1.3590	1.6560
170.00	0.850	1.1810	1.4400	1.7570
175.00	0.880	1.2470	1.5240	1.8600
180.00	0.900	1.3160	1.6100	1.9670
185.00	0.930	1.3860	1.6990	2.0076
190.00	0.950	1.4570	1.7900	2.1890
195.00	0.980	1.5310	1.8830	2.3040
200.00	1.000	1.6060	1.9790	2.4230
205.00	1.003	1.6830	2.0077	2.5440
210.00	1.005	1.7620	2.1770	2.6690
215.00	1.008	1.8430	2.2800	2.7960
220.00	1.100	1.9250	2.3850	2.9270
225.00	1.130	2.0009	2.4920	3.0060
230.00	1.150	2.0095	2.6020	3.1960
235.00	1.180	2.1830	2.7140	3.3350
240.00	1.200	2.2720	2.8290	3.4780
245.00	1.230	2.3640	2.9460	3.6230
250.00	1.250	2.4570	3.0065	3.7710
260.00	1.300	2.6480	3.3110	4.0076
270.00	1.350	2.8460	3.5660	4.3930
280.00	1.400	3.0051	3.8300	4.7220
290.00	1.450	3.2630	4.1040	5.0063
300.00	1.500	3.4820	4.3870	5.4160
310.00	1.550	3.7090	4.6800	5.7800
320.00	1.600	3.9420	4.9820	6.1570
330.00	1.650	4.1820	5.2940	6.5450
340.00	1.700	4.4290	5.6150	6.9450
350.00	1.750	4.6830	5.9450	7.3580
360.00	1.800	4.9450	6.2850	7.7820
370.00	1.850	5.2130	6.6350	8.2170
380.00	1.900	5.4880	6.9940	8.6650
390.00	1.950	5.7700	7.3620	9.1250
400.00	2.000	6.0059	7.7400	9.5960
410.00	2.006	6.3550	8.1270	10.0080
420.00	2.110	6.6590	8.5230	10.5700
430.00	2.160	6.9690	8.9290	11.0080
440.00	2.210	7.2860	9.3450	11.6000
450.00	2.260	7.6100	9.7700	12.1300
460.00	2.310	7.9410	10.2000	12.6700
470.00	2.360	8.2790	10.6500	13.2300
480.00	2.410	8.6240	11.1000	13.7900
490.00	2.460	8.9760	11.5600	14.3700
500.00	2.510	9.3350	12.0040	14.9600
525.00	2.630	10.2600	13.2600	16.4900
550.00	2.760	11.2300	14.5400	18.0090
575.00	2.880	12.2500	15.8800	19.7700

Pressure loss table for DN 600

Q [l/s]	DN 600			
	v [m/s]	ki=0.1 J [m/km]	ki=0.4 J [m/km]	ki=1.0 J [m/km]
25.00	0.09	0.014	0.015	0.017
30.00	0.10	0.020	0.021	0.024
35.00	0.12	0.026	0.028	0.032
40.00	0.14	0.033	0.036	0.041
45.00	0.16	0.041	0.045	0.051
50.00	0.17	0.050	0.055	0.063
55.00	0.19	0.059	0.066	0.075
60.00	0.21	0.069	0.077	0.089
65.00	0.23	0.080	0.090	0.104
70.00	0.24	0.092	0.103	0.120
75.00	0.26	0.104	0.118	0.137
80.00	0.28	0.118	0.133	0.155
85.00	0.30	0.131	0.149	0.174
90.00	0.31	0.146	0.166	0.195
95.00	0.33	0.161	0.184	0.216
100.00	0.35	0.177	0.203	0.239
110.00	0.38	0.212	0.244	0.288
120.00	0.42	0.249	0.288	0.342
130.00	0.45	0.288	0.336	0.400
140.00	0.49	0.331	0.388	0.462
150.00	0.52	0.376	0.443	0.529
160.00	0.56	0.425	0.501	0.601
170.00	0.59	0.476	0.564	0.677
180.00	0.63	0.529	0.630	0.758
190.00	0.66	0.586	0.700	0.843
200.00	0.70	0.645	0.773	0.933
210.00	0.73	0.707	0.850	1.027
220.00	0.76	0.772	0.930	1.126
230.00	0.80	0.840	1.015	1.229
240.00	0.83	0.910	1.102	1.337
250.00	0.87	0.983	1.194	1.450
260.00	0.90	1.059	1.289	1.567
270.00	0.94	1.137	1.388	1.688
280.00	0.97	1.218	1.490	1.814
290.00	1.01	1.302	1.596	1.945
300.00	1.04	1.389	1.705	2.080
310.00	1.08	1.478	1.819	2.219
320.00	1.11	1.570	1.935	2.363
330.00	1.15	1.665	2.056	2.512
340.00	1.18	1.763	2.180	2.665
350.00	1.22	1.863	2.308	2.823
360.00	1.25	1.966	2.439	2.985
370.00	1.29	2.071	2.574	3.152
380.00	1.32	2.180	2.712	3.324
390.00	1.36	2.291	2.854	3.499
400.00	1.39	2.405	3.000	3.680
410.00	1.43	2.521	3.150	3.865
420.00	1.46	2.640	3.303	4.054
430.00	1.49	2.762	3.459	4.248
440.00	1.53	2.887	3.620	4.447
450.00	1.56	3.014	3.783	4.650
460.00	1.60	3.144	3.951	4.857
470.00	1.63	3.277	4.122	5.070
480.00	1.67	3.412	4.297	5.286
490.00	1.70	3.550	4.475	5.507
500.00	1.74	3.691	4.657	5.733
520.00	1.81	3.981	5.032	6.198
540.00	1.88	4.282	5.422	6.681
560.00	1.95	4.593	5.825	7.183
580.00	2.02	4.915	6.244	7.702
600.00	2.09	5.248	6.676	8.240
625.00	2.17	5.679	7.238	8.937
650.00	2.26	6.127	7.822	9.663
675.00	2.35	6.592	8.429	10.420
700.00	2.43	7.074	9.058	11.200
725.00	2.52	7.573	9.710	12.010
750.00	2.61	8.089	10.380	12.850
775.00	2.69	8.621	11.080	13.720
800.00	2.78	9.170	11.800	14.610
825.00	2.87	9.736	12.540	15.540
850.00	2.95	10.320	13.310	16.490
875.00	3.04	10.920	14.100	17.470
900.00	3.13	11.540	14.910	18.480
925.00	3.22	12.170	15.740	19.520
950.00	3.30	12.820	16.600	20.580
975.00	3.39	13.490	17.470	21.680
1,000.00	3.48	14.170	18.370	22.800
1,050.00	3.65	15.590	20.240	25.130

Pressure loss table for DN 700

Q [l/s]	DN 700			
	v [m/s]	ki=0.1 J [m/km]	ki=0.4 J [m/km]	ki=1.0 J [m/km]
30.00	0.08	0.010	0.010	0.011
35.00	0.09	0.013	0.013	0.015
40.00	0.10	0.016	0.017	0.019
45.00	0.12	0.020	0.021	0.024
50.00	0.13	0.024	0.026	0.029
55.00	0.14	0.028	0.031	0.035
60.00	0.15	0.033	0.036	0.041
65.00	0.17	0.038	0.042	0.048
70.00	0.18	0.044	0.048	0.055
75.00	0.19	0.050	0.055	0.063
80.00	0.21	0.056	0.062	0.071
85.00	0.22	0.063	0.070	0.080
90.00	0.23	0.070	0.077	0.089
95.00	0.24	0.077	0.086	0.099
100.00	0.26	0.084	0.095	0.110
110.00	0.28	0.101	0.113	0.132
120.00	0.31	0.118	0.134	0.156
130.00	0.33	0.137	0.156	0.182
140.00	0.36	0.157	0.179	0.211
150.00	0.38	0.178	0.205	0.241
160.00	0.41	0.201	0.232	0.274
170.00	0.44	0.225	0.260	0.308
180.00	0.46	0.250	0.291	0.345
190.00	0.49	0.277	0.323	0.383
200.00	0.51	0.304	0.356	0.424
210.00	0.54	0.333	0.391	0.467
220.00	0.56	0.364	0.428	0.511
230.00	0.59	0.395	0.467	0.558
240.00	0.62	0.428	0.507	0.607
250.00	0.64	0.462	0.549	0.658
260.00	0.67	0.497	0.592	0.711
270.00	0.69	0.534	0.637	0.766
280.00	0.72	0.572	0.684	0.822
290.00	0.74	0.611	0.732	0.881
300.00	0.77	0.651	0.782	0.943
310.00	0.80	0.693	0.834	1.006
320.00	0.82	0.736	0.887	1.071
330.00	0.85	0.780	0.942	1.138
340.00	0.87	0.825	0.998	1.207
350.00	0.90	0.871	1.056	1.278
360.00	0.92	0.919	1.116	1.352
370.00	0.95	0.968	1.177	1.427
380.00	0.98	1.019	1.241	1.504
390.00	1.00	1.070	1.305	1.584
400.00	1.03	1.123	1.372	1.665
410.00	1.05	1.177	1.440	1.749
420.00	1.08	1.232	1.509	1.834
430.00	1.10	1.288	1.580	1.922
440.00	1.13	1.346	1.653	2.011
450.00	1.15	1.405	1.728	2.103
460.00	1.18	1.465	1.804	2.197
470.00	1.21	1.527	1.882	2.293
480.00	1.23	1.589	1.961	2.390
490.00	1.26	1.653	2.042	2.490
500.00	1.28	1.718	2.125	2.592
520.00	1.33	1.852	2.295	2.802
540.00	1.39	1.991	2.472	3.020
560.00	1.44	2.134	2.656	3.246
580.00	1.49	2.283	2.846	3.480
600.00	1.54	2.437	3.042	3.723
625.00	1.60	2.635	3.297	4.037
650.00	1.67	2.842	3.562	4.365
675.00	1.73	3.056	3.838	4.705
700.00	1.80	3.278	4.123	5.058
725.00	1.86	3.507	4.419	5.423
750.00	1.92	3.745	4.725	5.802
775.00	1.99	3.989	5.042	6.193
800.00	2.05	4.242	5.368	6.597
825.00	2.12	4.502	5.705	7.014
850.00	2.18	4.770	6.052	7.443
875.00	2.25	5.045	6.409	7.885
900.00	2.31	5.329	6.777	8.340
925.00	2.37	5.619	7.154	8.808
950.00	2.44	5.918	7.542	9.288
975.00	2.50	6.224	7.941	9.781
1,000.00	2.57	6.538	8.349	10.290
1,050.00	2.69	7.188	9.197	11.340
1,100.00	2.82	7.869	10.090	12.440

Pressure loss table for DN 800

Q [l/s]	DN 800			
	v [m/s]	k_i=0.1 J [m/km]	k_i=0.4 J [m/km]	k_i=1.0 J [m/km]
40.00	0.08	0.008	0.009	0.010
50.00	0.10	0.012	0.013	0.015
60.00	0.12	0.017	0.019	0.021
70.00	0.14	0.023	0.025	0.028
80.00	0.16	0.029	0.032	0.036
90.00	0.18	0.036	0.039	0.045
100.00	0.20	0.044	0.048	0.055
110.00	0.22	0.052	0.057	0.066
120.00	0.23	0.061	0.068	0.078
130.00	0.25	0.071	0.079	0.091
140.00	0.27	0.081	0.091	0.105
150.00	0.29	0.092	0.103	0.120
160.00	0.31	0.103	0.117	0.136
170.00	0.33	0.116	0.131	0.153
180.00	0.35	0.128	0.146	0.171
190.00	0.37	0.142	0.162	0.190
200.00	0.39	0.156	0.179	0.210
210.00	0.41	0.171	0.197	0.231
220.00	0.43	0.186	0.215	0.253
230.00	0.45	0.202	0.234	0.277
240.00	0.47	0.219	0.254	0.301
250.00	0.49	0.236	0.275	0.326
260.00	0.51	0.254	0.297	0.352
270.00	0.53	0.273	0.319	0.379
280.00	0.55	0.292	0.342	0.407
290.00	0.57	0.312	0.366	0.436
300.00	0.59	0.332	0.391	0.466
310.00	0.61	0.354	0.417	0.497
320.00	0.63	0.375	0.443	0.529
330.00	0.65	0.398	0.471	0.562
340.00	0.67	0.421	0.499	0.597
350.00	0.68	0.444	0.528	0.632
375.00	0.73	0.506	0.603	0.724
400.00	0.78	0.571	0.684	0.822
425.00	0.83	0.641	0.770	0.927
450.00	0.88	0.714	0.861	1.038
475.00	0.93	0.791	0.957	1.155
500.00	0.98	0.872	1.058	1.278
525.00	1.03	0.956	1.164	1.408
550.00	1.08	1.045	1.275	1.544
575.00	1.13	1.137	1.391	1.686
600.00	1.17	1.233	1.512	1.835
625.00	1.22	1.333	1.638	1.990
650.00	1.27	1.437	1.770	2.151
675.00	1.32	1.544	1.906	2.318
700.00	1.37	1.656	2.047	2.491
725.00	1.42	1.771	2.194	2.671
750.00	1.47	1.890	2.345	2.857
775.00	1.52	2.013	2.502	3.050
800.00	1.57	2.139	2.663	3.248
825.00	1.61	2.270	2.830	3.453
850.00	1.66	2.404	3.001	3.664
875.00	1.71	2.542	3.178	3.881
900.00	1.76	2.684	3.359	4.105
925.00	1.81	2.829	3.546	4.335
950.00	1.86	2.979	3.738	4.571
975.00	1.91	3.132	3.935	4.814
1,000.00	1.96	3.289	4.137	5.062
1,050.00	2.05	3.614	4.555	5.578
1,100.00	2.15	3.954	4.994	6.120
1,150.00	2.25	4.310	5.453	6.686
1,200.00	2.35	4.680	5.933	7.277
1,250.00	2.45	5.066	6.432	7.893
1,300.00	2.54	5.467	6.952	8.535
1,350.00	2.64	5.883	7.492	9.201
1,400.00	2.74	6.315	8.052	9.893
1,450.00	2.84	6.761	8.632	10.610
1,500.00	2.94	7.222	9.232	11.350
1,550.00	3.03	7.699	9.852	12.120
1,600.00	3.13	8.191	10.490	12.910
1,650.00	3.23	8.698	11.150	13.730
1,700.00	3.33	9.220	11.830	14.570
1,750.00	3.42	9.757	12.540	15.430
1,800.00	3.52	10.310	13.260	16.330
1,850.00	3.62	10.880	14.000	17.240
1,900.00	3.72	11.460	14.760	18.180
1,950.00	3.82	12.060	15.540	19.150
2,000.00	3.91	12.670	16.340	20.140

Pressure loss table for DN 900

Q [l/s]	DN 900			
	v [m/s]	ki=0.1 J [m/km]	ki=0.4 J [m/km]	ki=1.0 J [m/km]
50.00	0.08	0.007	0.007	0.008
60.00	0.09	0.010	0.010	0.011
70.00	0.11	0.013	0.014	0.015
80.00	0.12	0.016	0.018	0.020
90.00	0.14	0.020	0.022	0.025
100.00	0.15	0.025	0.027	0.030
110.00	0.17	0.029	0.032	0.036
120.00	0.19	0.034	0.038	0.043
130.00	0.20	0.040	0.044	0.050
140.00	0.22	0.045	0.050	0.057
150.00	0.23	0.052	0.057	0.065
160.00	0.25	0.058	0.065	0.074
170.00	0.26	0.065	0.072	0.083
180.00	0.28	0.072	0.081	0.093
190.00	0.29	0.080	0.089	0.104
200.00	0.31	0.087	0.099	0.114
210.00	0.32	0.096	0.108	0.126
220.00	0.34	0.104	0.118	0.138
230.00	0.36	0.113	0.129	0.150
240.00	0.37	0.123	0.140	0.163
250.00	0.39	0.132	0.151	0.177
260.00	0.40	0.142	0.163	0.191
270.00	0.42	0.152	0.175	0.206
280.00	0.43	0.163	0.188	0.221
290.00	0.45	0.174	0.201	0.236
300.00	0.46	0.185	0.214	0.253
310.00	0.48	0.197	0.228	0.270
320.00	0.49	0.209	0.243	0.287
330.00	0.51	0.222	0.258	0.305
340.00	0.53	0.234	0.273	0.323
350.00	0.54	0.247	0.289	0.342
375.00	0.58	0.281	0.330	0.392
400.00	0.62	0.318	0.374	0.445
425.00	0.66	0.356	0.421	0.501
450.00	0.70	0.396	0.470	0.561
475.00	0.73	0.439	0.522	0.624
500.00	0.77	0.484	0.577	0.691
525.00	0.81	0.530	0.634	0.761
550.00	0.85	0.579	0.695	0.834
575.00	0.89	0.630	0.758	0.911
600.00	0.93	0.683	0.824	0.991
625.00	0.97	0.738	0.892	1.074
650.00	1.00	0.795	0.963	1.161
675.00	1.04	0.854	1.037	1.251
700.00	1.08	0.915	1.114	1.345
725.00	1.12	0.979	1.193	1.442
750.00	1.16	1.044	1.275	1.542
775.00	1.20	1.111	1.360	1.646
800.00	1.24	1.181	1.447	1.753
825.00	1.27	1.252	1.538	1.863
850.00	1.31	1.326	1.630	1.977
875.00	1.35	1.402	1.726	2.094
900.00	1.39	1.479	1.825	2.214
925.00	1.43	1.559	1.926	2.338
950.00	1.47	1.641	2.029	2.465
975.00	1.51	1.725	2.136	2.596
1,000.00	1.55	1.811	2.245	2.730
1,050.00	1.62	1.989	2.472	3.008
1,100.00	1.70	2.175	2.709	3.299
1,150.00	1.78	2.370	2.958	3.604
1,200.00	1.85	2.572	3.217	3.922
1,250.00	1.93	2.783	3.487	4.254
1,300.00	2.01	3.003	3.768	4.600
1,350.00	2.09	3.230	4.060	4.958
1,400.00	2.16	3.466	4.363	5.331
1,450.00	2.24	3.709	4.677	5.716
1,500.00	2.32	3.961	5.001	6.115
1,550.00	2.39	4.221	5.337	6.528
1,600.00	2.47	4.490	5.683	6.954
1,650.00	2.55	4.766	6.040	7.394
1,700.00	2.63	5.051	6.409	7.847
1,750.00	2.70	5.344	6.787	8.313
1,800.00	2.78	5.645	7.177	8.793
1,850.00	2.86	5.954	7.578	9.287
1,900.00	2.94	6.272	7.990	9.794
1,950.00	3.01	6.598	8.412	10.310
2,000.00	3.09	6.931	8.845	10.850
2,050.00	3.17	7.274	9.290	11.400

Pressure loss table for DN 1000

Q [l/s]	DN 1000			
	v [m/s]	k_i=0.1 J [m/km]	k_i=0.4 J [m/km]	k_i=1.0 J [m/km]
60.00	0.08	0.006	0.006	0.007
70.00	0.09	0.008	0.008	0.009
80.00	0.10	0.010	0.010	0.012
90.00	0.11	0.012	0.013	0.014
100.00	0.13	0.015	0.016	0.018
110.00	0.14	0.018	0.019	0.021
120.00	0.15	0.021	0.022	0.025
130.00	0.16	0.024	0.026	0.029
140.00	0.18	0.027	0.030	0.033
150.00	0.19	0.031	0.034	0.038
160.00	0.20	0.035	0.038	0.043
170.00	0.21	0.039	0.043	0.049
180.00	0.23	0.043	0.047	0.054
190.00	0.24	0.047	0.053	0.060
200.00	0.25	0.052	0.058	0.067
210.00	0.26	0.057	0.064	0.073
220.00	0.28	0.062	0.069	0.080
230.00	0.29	0.067	0.076	0.087
240.00	0.30	0.073	0.082	0.095
250.00	0.31	0.079	0.089	0.103
260.00	0.33	0.085	0.095	0.111
270.00	0.34	0.091	0.103	0.119
280.00	0.35	0.097	0.110	0.128
290.00	0.36	0.104	0.118	0.137
300.00	0.38	0.110	0.126	0.146
325.00	0.41	0.128	0.146	0.171
350.00	0.44	0.147	0.169	0.198
375.00	0.47	0.167	0.193	0.227
400.00	0.50	0.188	0.218	0.257
425.00	0.53	0.211	0.245	0.290
450.00	0.56	0.235	0.274	0.324
475.00	0.59	0.260	0.304	0.361
500.00	0.63	0.286	0.336	0.399
525.00	0.66	0.314	0.370	0.440
550.00	0.69	0.342	0.405	0.482
575.00	0.72	0.372	0.441	0.526
600.00	0.75	0.403	0.479	0.572
625.00	0.78	0.436	0.519	0.620
650.00	0.81	0.469	0.560	0.670
675.00	0.84	0.504	0.603	0.722
700.00	0.88	0.540	0.647	0.776
725.00	0.91	0.577	0.693	0.832
750.00	0.94	0.615	0.741	0.889
775.00	0.97	0.655	0.790	0.949
800.00	1.00	0.696	0.840	1.011
825.00	1.03	0.738	0.893	1.074
850.00	1.06	0.781	0.946	1.140
875.00	1.09	0.825	1.002	1.207
900.00	1.13	0.870	1.059	1.276
925.00	1.16	0.917	1.117	1.348
950.00	1.19	0.965	1.177	1.421
1,000.00	1.25	1.064	1.302	1.573
1,050.00	1.31	1.169	1.433	1.733
1,100.00	1.38	1.278	1.570	1.901
1,150.00	1.44	1.391	1.714	2.076
1,200.00	1.50	1.510	1.864	2.259
1,250.00	1.56	1.633	2.020	2.450
1,300.00	1.63	1.761	2.182	2.649
1,350.00	1.69	1.893	2.351	2.855
1,400.00	1.75	2.031	2.526	3.069
1,450.00	1.81	2.173	2.707	3.291
1,500.00	1.88	2.320	2.894	3.520
1,550.00	1.94	2.472	3.088	3.758
1,600.00	2.00	2.628	3.288	4.003
1,650.00	2.06	2.789	3.494	4.255
1,700.00	2.13	2.955	3.707	4.516
1,750.00	2.19	3.126	3.926	4.784
1,800.00	2.25	3.301	4.151	5.060
1,850.00	2.31	3.481	4.382	5.344
1,900.00	2.38	3.666	4.619	5.635
1,950.00	2.44	3.855	4.863	5.935
2,000.00	2.50	4.050	5.113	6.242
2,050.00	2.56	4.249	5.370	6.556
2,100.00	2.63	4.453	5.632	6.879
2,150.00	2.69	4.661	5.901	7.209
2,200.00	2.75	4.874	6.176	7.547
2,250.00	2.81	5.092	6.458	7.892
2,300.00	2.88	5.315	6.745	8.246

Contact

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