INTERNATIONAL STANDARD

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Trenchless applications of ductile iron pipes systems — Product design and installation

Application des systèmes de canalisations en fonte ductile en pose sans tranchée — Conception des produits et mise en oeuvre

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13470 was prepared by Technical Committee ISO/TC 5, *Ferrous metal pipes and metallic fittings*, Subcommittee SC 2, *Cast iron pipes, fittings and their joints*.

Trenchless applications of ductile iron pipes systems — Product design and installation

1 Scope

This International Standard specifies the requirements, test methods and installation technologies applicable to ductile iron pipes used in trenchless applications:

— to convey water or wastewater;

— operated with or without pressure.

NOTE In this International Standard, all pressures are relative pressures expressed in bar(s)[1].

This International Standard specifies materials, dimensions and tolerances, mechanical properties and standard coatings of pipes, fittings and accessories. It also gives performance requirements for all components including joints.

Joint design and gasket shapes are outside the scope of this International Standard.

This International Standard applies to pipes, fittings and accessories cast by any type of foundry process or manufactured by fabrication of cast components, as well as corresponding joints, of a size range DN 80 to DN 2 600 inclusive.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2531, *Ductile iron pipes, fittings, accessories and their joints for water applications*

ISO 7186, *Ductile iron products for sewerage applications*

ISO 8180, *Ductile iron pipes — Polyethylene sleeving for site application*

ISO 10804, *Restrained joint systems for ductile iron pipelines — Design rules and type testing*

EN 14628, *Ductile iron pipes, fittings and accessories — External polyethylene coating for pipes — Requirements and test methods*

EN 15189, *Ductile iron pipes, fittings and accessories — External polyurethane coating for pipes — Requirements and test methods*

EN 15542, *Ductile iron pipes, fittings and accessories — External cement mortar coating for pipes — Requirements and test methods*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

1) 100 kPa = 1 bar.

3.1
allowable angular deflection
angular deflection that a joint between two components can safely withstand in service under the allowable operating pressure (PFA)

3.2
allowable pulling force
maximum pulling force that can be applied on a string of pipes during laying by horizontal directional drilling, pipe bursting or casing technologies

3.3
allowable pushing force
maximum pushing force that can be applied on a string of pipes during laying by pipe jacking, pipe bursting or casing technologies

3.4
bentonite
clay mineral, primarily montmorilonite, with high swelling properties, which forms the primary component in drilling muds used in horizontal directional drilling technology

3.5
bore
cavity that is created to receive a pipe or conduit

3.6
casing
continuous structural shell that acts as an envelope and support for the service pipeline during construction and service

3.7
casing method
method in which a casing is put into place and then a pipe is inserted into the casing

3.8
drilling fluid
fluid created by mixing water and bentonite as well as other additives to facilitate drilling and transport of drill cuttings from the drill bit to the surface

3.9
horizontal directional drilling
steerable method for the underground installation of pipes using a surface launched drilling rig

3.10
pilot hole
initial bore drilled along the drill path

3.11
pipe bursting method
method for replacement of an existing pipe by longitudinal splitting

3.12
pipe jacking method
system of directly installing pipes behind a cutting head and/or shield, by hydraulic thrust

3.13
pulling head
reusable component mounted at the beginning of the pipe string, which transmits the pulling force from the drilling rod to the pipes

3.14
service pipeline
ductile iron pipeline intended to carry water or wastewater, operated with or without pressure

3.15
sheath
coating, sleeving or encasement of the pipe body, which makes the profile uniformly cylindrical

See Figure 6.

3.16
trenchless technology
any technology for constructing pipelines in the ground without opening trenches

4 Trenchless technologies

4.1 General

This International Standard deals with the following trenchless technologies:

— horizontal directional drilling (HDD);

— pipe bursting (PB);

— casing method (CM);

— pipe jacking (PJ).

See Table 1.

Table 1 — Corresponding DNs for trenchless technologies

	Pulling methods	Pushing methods
Horizontal directional drilling (HDD)	Yes DN 100 to DN 1 200	No
Pipe bursting (PB)	Yes DN 100 to DN 1 200	Yes DN 100 to DN 1 200
Casing method (CM)	Yes DN 80 to DN 2 600	Yes DN 80 to DN 2 600
Pipe jacking (PJ)	No	Yes DN 250 to DN 2 600

4.2 Horizontal directional drilling (HDD)

4.2.1 General

HDD is a steerable trenchless method of installing underground pipes along a prescribed bore path by using a surface launched drilling rig, with minimum impact on the environment (see Figure 1). Directional boring is used where trenching or excavating is not practicable. It is suitable for a variety of soil conditions and projects, including road and river crossings.

The sequence of operations is generally divided into three successive steps.

4.2.2 First step — Pilot bore

The pilot bore is the first step in producing a bore, running from the starting point to the arrival pit, and is driven under steered control by a drilling head at the tip of a drilling string.

An aqueous suspension of bentonite emerges at high pressure from the drilling head, which

— drives the head forward,

— helps to cut the soil,

— carries away the cut material, and

— supports the bore.

The pilot bore is steered by controlled rotation of the drilling head; it is detected above the path of the bore by radio signals, gyroscope or other means.

4.2.3 Second step — Upsize bore

During upsizing, an upsizing head is pulled through the bore, while rotating continuously; in this way, it enlarges the size of the pilot bore.

The soil that is cut away is carried out with the drilling mud, which also supports the bore.

The upsizing process is repeated with increasingly larger heads until the bore is of the desired diameter.

4.2.4 Third step — Pulling in

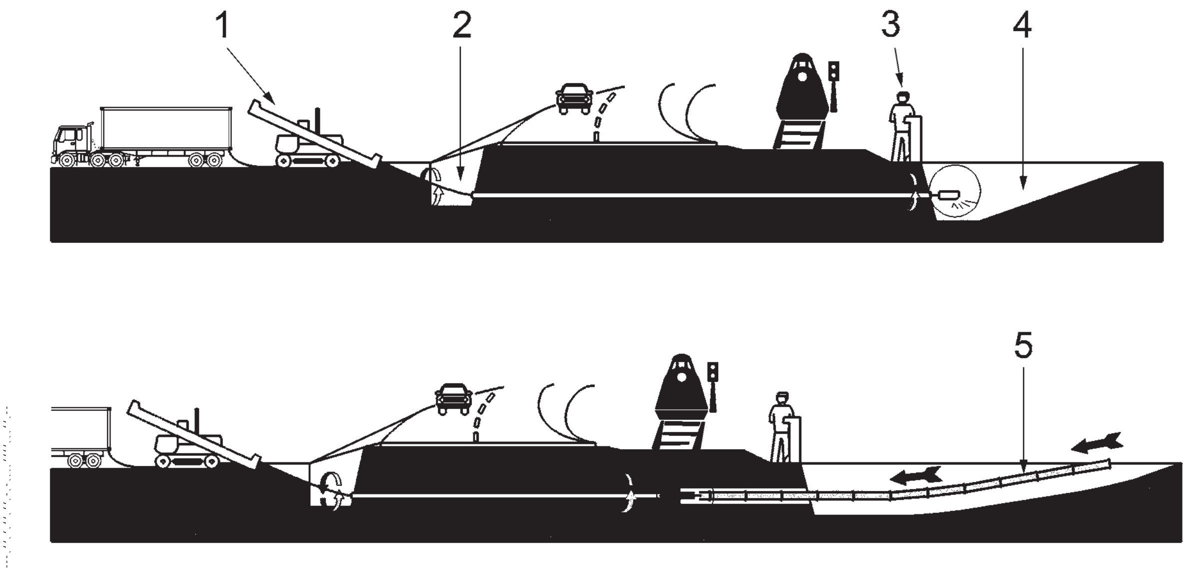
For this third step, prior to pulling the pipes, three devices are attached to the drilling rods:

— a reaming tool;

— a rotary joint (which stops the string of pipes from turning with the reaming tool);

— a pulling head (connected to the string of pipes by mechanical locking).

As the pulling in progresses, drilling mud is pumped through the drilling linkage. It emerges from the reaming tool, carrying away the soil and reducing the frictional forces.



Key

1 drilling unit

2 tunnel head earthworks

3 piloting the drill

4 tunnel exit earthworks

5 anchored joint ductile iron pipes

Figure 1 — Horizontal directional drilling method

4.3 Pipe bursting (PB)

4.3.1 General

The pipe bursting technique is used for the trenchless renovation of pipelines where the new pipeline is meant to follow the same path as the old (see Figure 2). For this purpose, the existing old pipeline is destroyed by a bursting head; at the same time, the fragments are pushed into the surrounding soil and the new run of pipe is pulled in.

Old pipes made of brittle as well as of ductile materials, such as steel or ductile iron pipes, may be renewed by this process, where suitable bursting or cutting heads are used. Before the pipe bursting operation, the existing profile of the piping shall be known. The trench shall be opened and the bends shall be removed. The valves and the concrete block shall be removed.

The new pipe which is pulled in may be of the same nominal size as the old pipe or, as dictated by the widening head which is used, of a larger size.

Because the soil conditions are generally unknown and, above all, because of the sharp-edged fragments, which most certainly occur with the burst lining technique, care should be taken to see that the pipeline material used is one which is not sensitive to factors of this kind.

With pipe bursting, a distinction is made between the dynamic and static variants.

4.3.2 Dynamic variant

Where using the dynamic variant, the force required for bursting is applied in the longitudinal direction of the pipe using a suitable pneumatic bursting tool. This is driven by a compressor, which is connected to it by a flexible hose. To guide the bursting head, it is pulled along by a winch from the arrival pit on a hook-equipped pulling rope, which is pulled through the old pipe.

The dynamic variant is particularly suitable for highly compacted and stony soils.

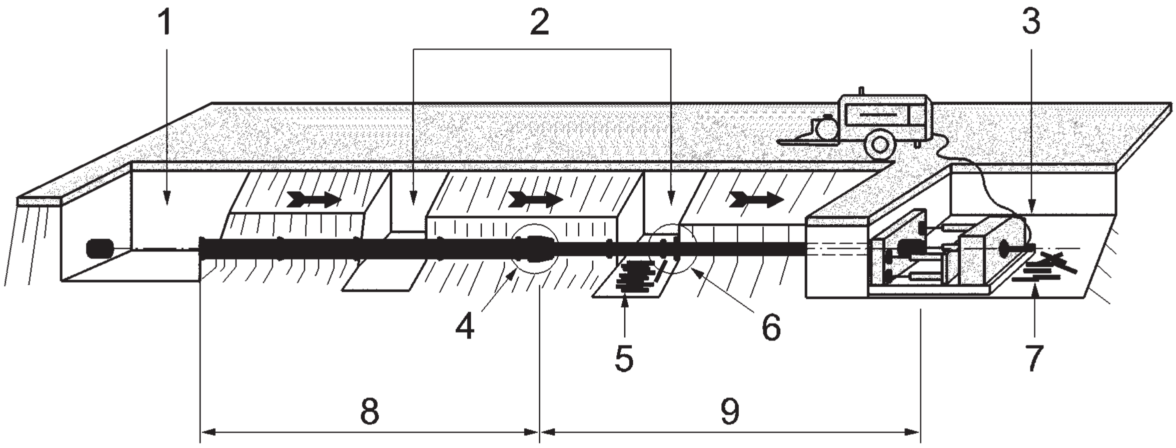
4.3.3 Static variant

In this case, a widening head (the first widened part of which may be fitted with breaker ribs) is pulled through the old pipeline from the pulling unit to the bursting head, which operates continuously and without any vibration, and in this way, the old pipeline is burst open.

The new pipes are coupled straight to the bursting/widening head and are pulled into the bore, which is widened to approximately a 10 % oversize.

The static variant is well suited to homogeneous soils, which can be easily displaced.

For ductile pipes (e.g. steel pipes and ductile iron pipes), a cutting head with roll knives cuts the pipe longitudinally, with subsequent widening of the cut pipe. The new pipes are pulled into this widened pipe.



Key

1 starting point of earthworks
2 intermediate point of earthworks
3 exit point of earthworks
4 expansion cone and drawing tool
5 waste
6 bursting cone
7 traction rod segment
8 new ductile iron pipe
9 old pipe

Figure 2 — Pipe bursting method

4.4 Casing method (CM)

4.4.1 General

In the casing method, a casing is first installed through the soil, between two pits on the pipeline alignment (see Figure 3). Ductile iron pipes are subsequently inserted through the casing, building the pipeline by adding and jointing one pipe at a time. The process continues until the service pipeline is completed, at which time it is connected and commissioned.

This method is also well established to renovate old pipelines for water or sewerage by pulling or pushing in new pipes, where the hydraulic design allows a diminution of the internal diameter.

4.4.2 Installing the casing

The casing normally comprises 6 m long steel cylindrical shells or sections with a D/t (mean diameter divided by the shell thickness) fraction/quotient of approximately 120 to 150. It is installed between a launching pit and receiving pit. A hydraulic jack, surveying lasers and excavating and soil removal equipment are installed in the launching pit.

Excavation can be carried out using various techniques depending on the size of the casing and the nature of the soil. These techniques typically include water jetting, auguring and full face cutter heads. Soil removal is carried out to match the excavation rate and includes such methods as slurry returns, augurs, conveyors and scrapers.

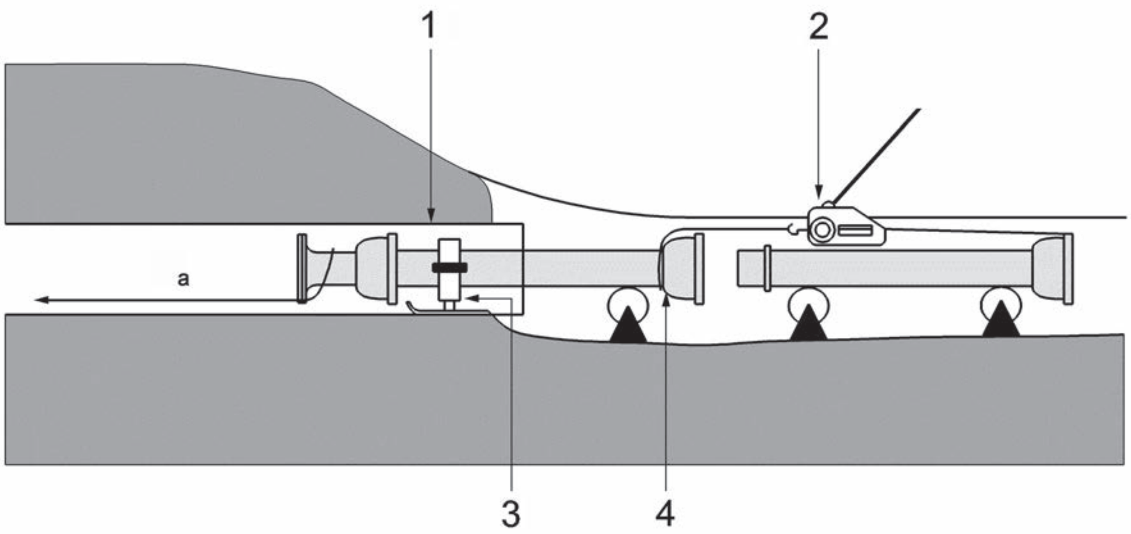
As the excavation progresses, the casing is jacked behind the excavation face and built up by welding on subsequent sections, one at a time, in the launching pit.

4.4.3 Installing the service pipeline

The service pipeline may be assembled by push or pull. Most applications take advantage of flexible pipeline joints and their ease of assembly. If the pull method is used, however, some means of anchoring the joints to prevent separation is required. If the push technique is used, care should be taken not to damage the cement mortar lining as the pipe spigot bears on the bottom of pipe socket.

The service pipeline is assembled very much like the casing, one pipe at a time, with the service pipeline being pulled or pushed through the casing. To assist in this operation, it is advisable to use skids which set at 120° around the pipe circumference and strapped to the ductile iron pipes at centres of 2 m. The typical frictional forces required to be overcome may be estimated using a coefficient of friction of μ = 0,2 – 0,3 (greased wood on steel).

Pipe pulling installation in the casing may be achieved, either by using a pulling head or a rope encircling the socket of the first pipe (see footnote a of Figure 3, which indicates the direction of pulling).



Key

1 casing

2 assembly tackle

3 guidance collar

4 restrained joint

[a] Direction of pulling by rope.

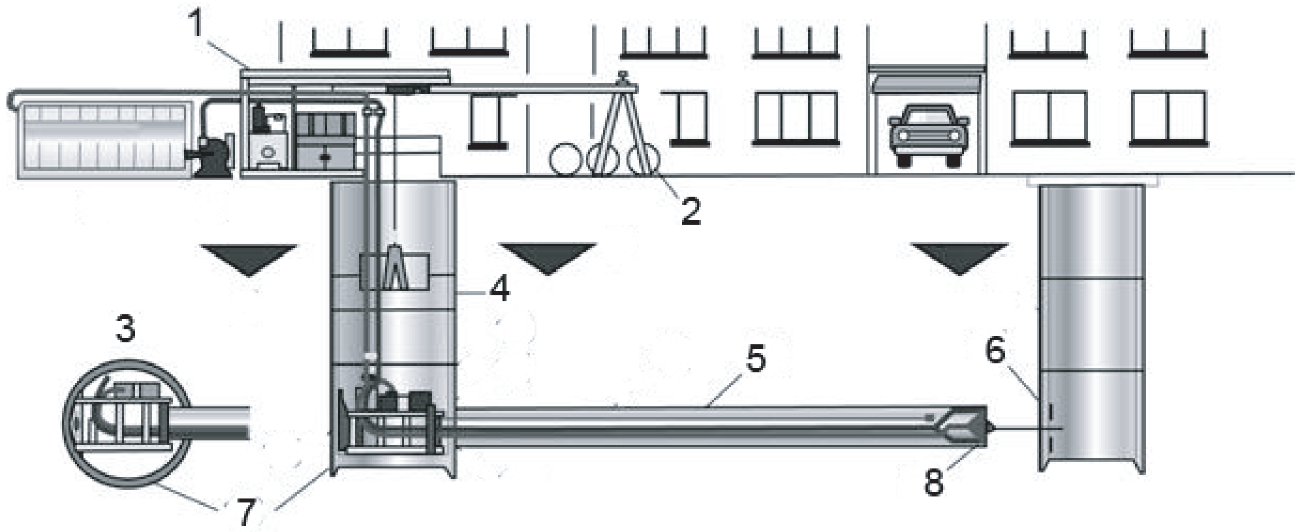
Figure 3 — Casing method

4.5 Pipe jacking (PJ)

Pipe jacking involves pushing pipes through the ground (see Figure 4) with thrust provided by powerful hydraulic jacks, while soil is excavated at the front of the pipe string.

A number of excavation methods are available for pipe jacking; the appropriate system should be used, taking into account the soil conditions, jacking distance and pipe size.

Thrust and reception pits are constructed while this method is being used.



Key

1 control container
2 jacking pipes
3 plan view on launch shaft
4 launch shaft
5 jacking pipes
6 reception seal
7 jacking frame
8 lead pipe

Figure 4 — Pipe jacking method

5 Technical requirements

5.1 General requirements

5.1.1 General

Pipes, fittings and gaskets used in trenchless applications shall comply with the relevant International Standard depending upon the final application, i.e.:

— ISO 2531 for water applications;

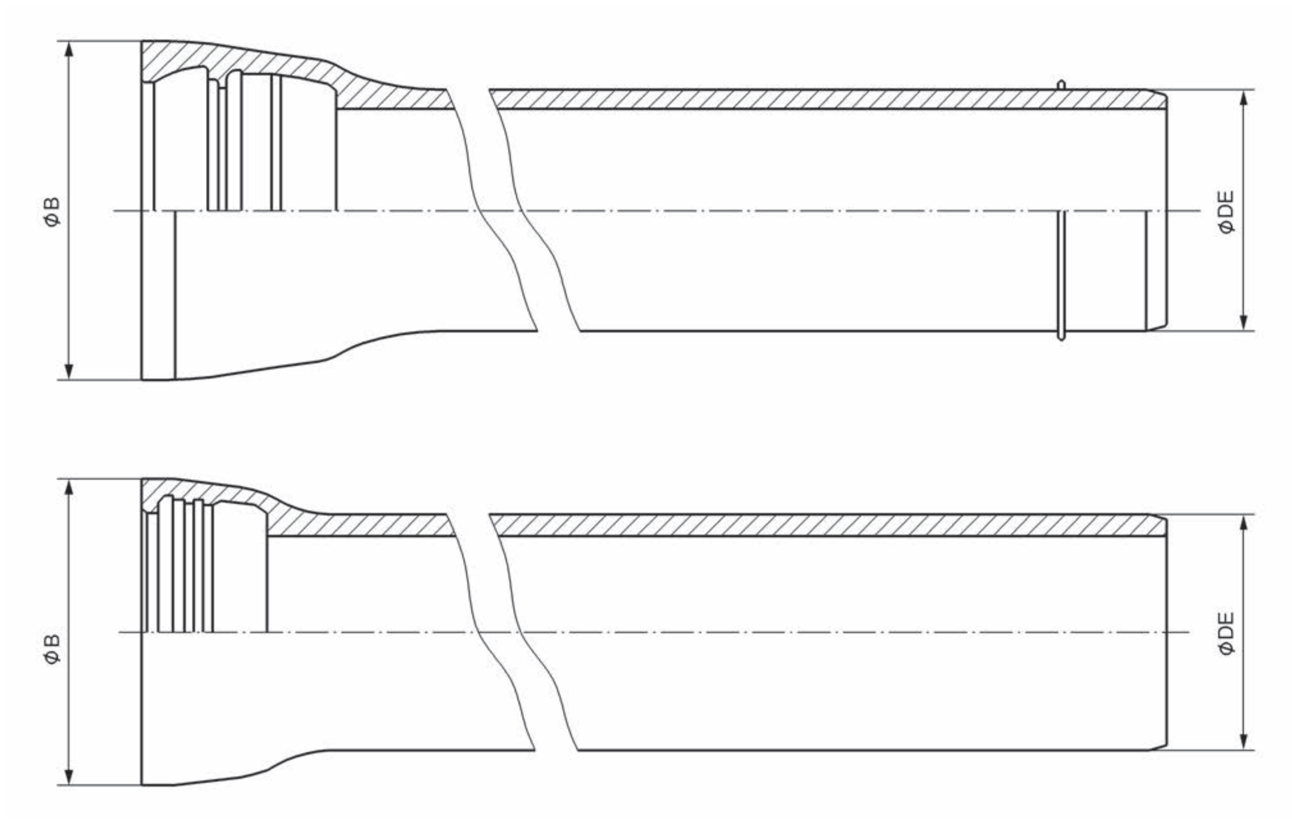
— ISO 7186 for sewerage applications.

5.1.2 Pipe profile

5.1.2.1 Pipe profile for pulling methods

The pulling force is transmitted from pipe to pipe using a restraint joint.

For pipes and pulling heads used in HDD, the maximum value of the external socket diameter shall be such that the fraction/quotient (ØB – 60 – ØDE)/ØDE shall be less than 0,1 (see Figure 5).



Key

B socket external diameter

DE pipe barrel external diameter

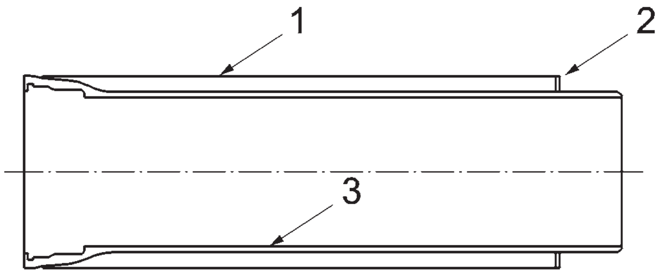
Figure 5 — Restrained or non-restrained HDD pipe profiles

5.1.2.2 Pipe profile for pushing methods

5.1.2.2.1 Pipe jacking method

The thrust force is transmitted to the other pipe by pushing the end face of socket on a flange located on the spigot (see Figure 6).

It is not recommended to jack the pipe by pushing the spigot in direct contact with the bottom of the socket. Such action can result in the damage of spigot or lining.



Key

1 sheath

2 flange

3 pipe

Figure 6 — Jacking pipe profile

5.1.2.2.2 Other methods

The thrust force is transmitted to the other pipe by pushing as described in 5.1.2.2.1 or by a weld bead on the spigot bearing on the socket mouth.

Care shall be taken that no damage occurs to the pipe or the lining. Manufacturer's recommendations shall be followed.

5.1.3 Pulling head

The pipe pulling head used in HDD and PB shall be made of ductile iron conforming to ISO 2531 or ISO 7186, or steel with equivalent mechanical properties. The pipe pulling head shall be designed and provided by the pipe manufacturer or an approved supplier. The pulling head joint shall have the same performance requirements (e.g. leaktightness and restraint) as the pipe to which it is being connected. To prevent damage of the pipes and joints, the pulling forces shall be measured directly and transmitted online to the operator. Pulling force transmission shall be stopped automatically once the admissible forces have been achieved.

The pulling head shall be designed to be leaktight at the allowable test pressure (PEA).

A special pipe breaking device should be used to burst the old pipe in pipe bursting.

5.1.4 Centring device

A pipe casing centring device should be used to ensure correct positioning of the pipeline.

5.2 Coatings and linings for pipes

5.2.1 External coatings

5.2.1.1 Pulling methods

External pipe coating shall be resistant to the forces generated by the trenchless laying technique.

The recommended external protection includes the following:

— thick polymeric external coating, such as PU (in accordance with EN 15189), HDPE (in accordance with EN 14628);

— thick cement mortar external coating reinforced by appropriate fibres (in accordance with EN 15542);

— PE sleeve in accordance with ISO 8180.

Where International Standards do not exist, coatings shall comply with national standards or with an agreed technical specification.

5.2.1.2 Pushing methods

5.2.1.2.1 Pipe jacking methods

The coating shall prevent contact between the soil and the ductile iron surface or zinc-metallic surface, where relevant, arising from the loads imparted by the trenchless laying technique. It is the responsibility of the pipe manufacturer to prove by appropriate means (calculations, laboratory tests, field trials, etc.) that the coating is suitable for the trenchless laying technique.

Ductile iron pipe used for pipe jacking shall be surrounded and protected by a sheath. The sheath shall be cylindrical, making the sheathed external diameter similar to the socket external diameter (see Figure 6). A certain level of step is permitted on the outer surface between the external sheath diameter and the external socket diameter, but this shall not hinder the smooth jacking of the pipe. The sheath may be produced with concrete or any other material shown to be suitable by the manufacturer to withstand the jacking forces.

The external diameter of the sheath shall be within the range of maximum diameter of the pipe ±15 mm for DN 250 to DN 600, and ±30 mm for DN 700 to DN 2 600. The length of the sheath shall be determined by considering the socket depth of the next pipe to be connected. The external diameter of pipes may be in compliance with national standards by agreement between the manufacturer and purchaser.

External coatings, which are not surrounded by a sheath, shall comply with ISO 2531 or ISO 7186.

Grout holes may be made in jacking pipe in order to inject lubricant or back-filling materials outside of the pipes.

5.2.1.2.2 Other methods

The coating shall prevent contact between the soil and the ductile iron surface or zinc-metallic surface, where relevant, after the loads imparted by the trenchless laying technique. It is the responsibility of the pipe manufacturer to prove by appropriate means (calculations, laboratory tests, field trials, etc.) that the coating is suitable for the trenchless laying technique.

5.2.2 Internal linings

Internal linings shall comply with the requirements of ISO 2531 or ISO 7186.

5.3 Joint protection

5.3.1 HDD, PB

Joints should be protected against soil and bentonite intrusion.

This protection may be provided by appropriate means, such as

— heat-shrink sleeve,

— elastomeric sleeve, or

— PE sleeving.

Mechanical protection of the physical protection may be provided by appropriate metallic means, such as a steel sheet shell.

5.3.2 Pipe jacking and casing methods

In pipe jacking (PJ) and casing (CM) methods, special joint protection is not necessary in most cases. Where, in the renovation process, new pipes are pulled or pushed into the old pipeline, conic metal sheet protection is recommended where the pipes are inserted without centring guidance collars and/or where, later on, the annulus space shall be grouted.

6 Performance requirements joints

6.1 General requirements

Joints shall comply with the requirements of ISO 2531 or ISO 7186.

The grouping of the performance tests by DN shall comply with ISO 2531 or ISO 7186.

6.2 Requirements for joints for pulling methods

6.2.1 Joints for HDD and PB

Joints used for directional drilling and pipe bursting shall be boltless, flexible and restrained.

Due to dynamic angular deflection occurring during the installation, joints shall be restrained using a mechanical support given by any of the following:

— metallic weld bead on the pipe barrel;

— metallic ring welded-on the pipe barrel;

— as cast bead.

The use of gaskets with metallic inserts is only permitted at straight pipeline routes because angular deflections under traction can lead to the dismantling of the joints.

Restrained joints for ductile iron pipelines shall be designed in accordance with ISO 10804.

6.2.2 Joints for CM

Restrained joints shall provide the resistance to withstand the pulling force.

6.2.3 Pulling force resistance

6.2.3.1 Pulling force resistance determination

The method for determination of pulling force resistance (PFR) shall be derived from the type test conducted on restraint joint to determine their pressure resistance, which is calculated as given by Formula (1):

$$\mathrm{PFR} = \frac{\mathrm{PFA} \times \pi \left(\text{ØDE}\right)^2}{4 \times 10^4} \qquad (1)$$

where

PFR is the pulling force resistance, in kilonewtons;

PFA is the allowable operating pressure of the restrained joint, in bar;

ØDE is the external diameter, as given in ISO 2531 or ISO 7186, in millimetres.

The safety factor for the PFA shall be at least 1,5 times PFA plus 5 bar.

6.2.4 Pulling force minimum values

The minimum value of the PFA of the restrained joint used in HDD or PB shall be 16 bar.

NOTE 1 Higher pulling forces can be available; the pipe manufacturer can be consulted for their recommended maximum allowable pulling forces.

NOTE 2 For a given restraint system, using a higher pressure class to increase the pipe thickness can be a method to increase the pulling force resistance. If using an increase in pipe wall thickness, it is expected that care be taken to ensure the mechanical compatibility of the socket.

NOTE 3 For long pulling lengths (e.g. 400 m), the allowable pulling force can be lower than the value calculated by Formula (1). In this case, it is intended that the manufacturer indicate this in the technical literature.

6.2.5 Allowable angular deflection minimum values

The minimum allowable deflection shall not be less than 3° for DN 80 to DN 300, 2° for DN 350 to DN 600 and 1° for DN 700 to DN 1 200.

6.3 Joints for pushing method

6.3.1 Joints for CM

Joints used for pipe jacking shall be flexible.

6.3.2 Pushing force resistance

6.3.2.1 Pushing force resistance for casing method

For laying lengths exceeding 60 m, the pushing force resistance shall be not less than the value given in Table 2:

Table 2 — Minimum pushing force resistance for casing method

DN	Minimum pushing force resistance kN
80	140
100	170
125	210
150	245
200	320
250	400
300	450
350	520
400	600
450	690
500	750
600	900
700	1 050
800	1 200
900	1 350
1 000	1 500
1 100	1 650
1 200	1 800
1 500	2 250

6.3.2.2 Pushing force resistance for pipe jacking method

Pipes for jacking shall be designed to be resistant against the pushing force. They shall be tested in accordance with 7.2 and shall exhibit no visible defect in ductile iron and transmission parts of the pushing force under the loading of the allowable pushing force. If the design has been tested and documented by the manufacturer and successfully used for a minimum of 10 years, the performance of a type test in accordance with 7.2 for pushing force resistance is only required for significant changes in design, which can adversely affect the performance of the joint.

The pushing force resistance shall be not less than the value given in Table 3.

Table 3 — Allowable pushing force resistance for pipe jacking

DN	Pushing force resistance kN			
	C20	C25	C30	C40
250	—	—	—	920[a]
300	—	—	720[b]	1 240[a]
350	—	700[b]	1 270[a]	1 740[b]
400	—	850[b]	1 350[a]	2 190[b]
450	—	1 110[b]	1 560[a]	2 760[b]
500	—	1 300[b]	1 910[a]	3 300[b]
600	—	1 910[b]	2 720[a]	3 730[b]
700	1 650[b]	2 720[a]	3 670[b]	6 350[b]
800	2 110[b]	3 300[a]	4 760[b]	6 570[b]
900	2 640[b]	4 140[a]	5 990[b]	6 570[b]
1 000	3 300[b]	5 080[a]	7 240[b]	9 020[b]
1 100	3 950[b]	6 110[a]	8 890[b]	9 020[b]
1 200	4 650[b]	7 240[a]	9 020[b]	9 020[b]
1 400	6 350[b]	9 020[a]	9 020[b]	—
1 500	7 240[b]	11 350[a]	12 360[b]	—
1 600	8 320[b]	12 360[a]	12 360[b]	—
1 800	10 390	12 360[a]	12 360[b]	—
2 000	12 860[b]	16 970[a]	16 970[b]	—
2 200	15 600[b]	16 970[a]	—	—
2 400	16 970[b]	16 970[a]	—	—
2 600	21 650[b]	23 340[a]	—	—

NOTE For higher pressure classes, see the manufacturer's handbook.

[a] Preferred classes of pipe.

[b] Other classes of pipe (background in grey shading).

7 Test methods

7.1 Pulling force resistance measurement

The allowable operating pressure (PFA) measurement method is specified in ISO 10804 as the test method for the positive internal pressure.

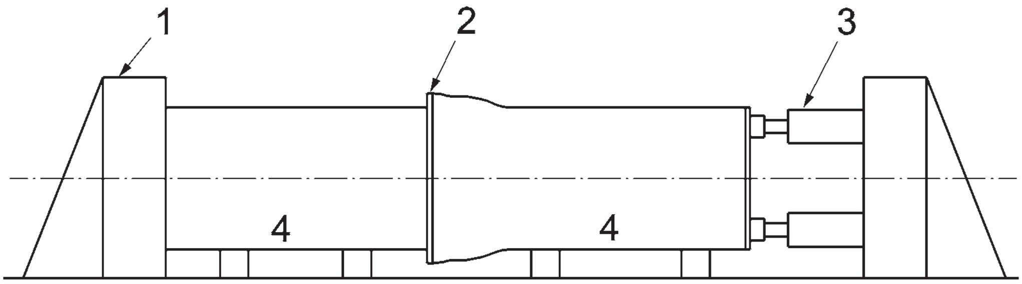
7.2 Pushing force resistance

Each pipe design for pushing methods in trenchless technologies shall be tested in order to demonstrate its pushing force resistance.

This type test shall be carried out on an assembled joint comprising two pipe sections each of at least 1 m in length (see Figure 7).

In the type test, the joint shall be assembled with no angular deflection and be tested to the allowable pushing force resistance.

Pipes for this type test may be used without a sheath.



Key

1 frame against hydraulic force

2 flange

3 hydraulic jack

4 pipe

Figure 7 — Pushing force resistance test

8 Laying procedure

8.1 General

Prior to beginning the work, the contractor shall submit to the engineer a work plan detailing the procedure and schedule to be used to execute the project. The work plan shall include a description of all equipment to be used, down-hole tools, a list of personnel and their qualifications and experience (including back-up personnel in the event that an individual is unavailable), a list of subcontractors, a schedule of work activity, a safety plan (including a material safety data sheet of any potentially hazardous substances in use), traffic control plan (if applicable), an environmental protection plan and contingency plans for possible problems. The work plan shall be comprehensive, realistic and based on actual working conditions for the particular project. The plan shall document the thoughtful planning required to successfully complete the project

Specifications on material to be used shall be submitted to the engineer and the material shall include the pipe, fittings, drilling mud, drilling additives and any other item, which is to be an installed component of the project or used during construction.

8.2 Pulling methods

8.2.1 Assembly method

8.2.1.1 Cartridge assembly method

The cartridge assembly option is defined as the assembling of individual sections of flexible restrained joint ductile iron pipe in a secured entry and assembly pit. The pipe sections are assembled individually and then progressively pulled into the bore path over a distance equivalent to a single pipe section. This assembly-pull process is repeated for each pipe length, until the entire line is pulled trough the bore path to the exit point.

8.2.1.2 Ramp assembly method

The ramp assembly method is defined by the pre-assembly of multiple lengths of flexible restrained joint ductile iron pipe, with subsequent pulling installation into the bore path as a long pipe string. With this option, the contractor shall provide an entry ramp to the entrance of the bore path. The ramp shall be of sufficient length and grade such that any one pipe joint does not exceed the allowable joint deflection at any point prior to the pipe string entering the bore path. The contractor shall be responsible for providing the necessary equipment or ground surface preparation to allow the pipe to be pulled back along the surface prior to the entry ramp and bore path without damaging the external coating/sleeving. The contractor shall repair any damage prior to the pipe section entering the bore path.

8.2.2 Drilling hole determination

The drilling hole diameter is technology and project specific. The following are some basic guidelines:

a) HDD:

   — for a straight project: the hole diameter less 1,25 times pipe socket external diameter;

   — for a curved project: the hole diameter less 1,5 times pipe socket external diameter;

b) PB: a pipe that is larger than the pipe to be replaced may be used. The difference in diameters depends on the pipe material and the ground characteristics;

c) CM: a minimum gap of 50 mm should be used;

8.2.3 Pulling force control

The maximum pulling force used during the laying of the pipe shall be not higher than the pulling force resistance given by the manufacturer.

There are several methods to moderate the pulling force level. These methods include:

— the mass of the pipeline;

— friction to the ground, using appropriate fluids (characteristics of bentonite lubricant, adjustment, etc.);

— ballasting (with water and thicker pipes);

— reduction of the angle of deflection.

The contractor shall control the value of the pulling force by appropriate means. The pulling force progression shall be recorded accurately. A report, including the pulling force diagram, shall be made available by the contractor.

8.3 Pushing methods

8.3.1 Surveying

The underground conditions, where the pipe is to be installed by pipe jacking, shall be surveyed in order to ensure a safe work environment.

Soil characteristics and groundwater levels shall be surveyed at appropriate intervals, along the full jacking length to ensure that they do not adversely affect the excavation method or pushing force. If necessary, ancillary methods, such as wellpoint systems and chemical grouting systems, may be applied, based on the results of the survey.

Underground facilities, such as water, sewerage and gas pipes, telecommunication and electricity cable and other objects, shall be surveyed with the relevant organizations, in order to avoid their interference with jacking. Ancillary methods, such as chemical grouting systems, may be applied if it is predicted that the underground facilities are at risk from the jacking procedure.

8.3.2 Drilling hole determination

The drilling hole diameter is technology and project specific. The following are some basic guidelines:

a) casing method: a minimum gap of 50 mm should be used;

b) pipe jacking method: special attention should be paid to the diameter of the tunnelling equipment; see the handbook of the tunnelling equipment manufacturer.

8.3.3 Pushing force control

The maximum pushing force used during the laying of the pipe shall be not higher than the pushing force resistance given by the manufacturer.

There are several methods to moderate the pushing force level. These methods include:

— mass of the pipeline;

— friction to the ground using appropriate lubricant fluids.

The contractor shall control the value of the pushing force by appropriate means. The pushing force progression shall be recorded accurately. A report, including the pushing force diagram, shall be made available by the contractor.

8.3.4 Employment of excavation method

A number of excavation methods are available for pipe jacking; the appropriate system should be used, taking into account the pipe size, jacking distance and results of the survey.

The lubricant injection method may be applied in order to decrease the jacking force. In this case, lubricant shall be spread evenly along the pipe string.

8.3.5 Angular deflection of joint during jacking

Pipes should be pushed in line. Any angular joint deflection during pushing can result in a reduction in the pushing load and/or component damage.

8.3.6 Jacking procedure

Thrust and reception pits are constructed with this method.

The thrust pit shall be constructed in order to accommodate the thrust wall, hydraulic jacks and guide rails to push the pipes. The thrust pit shall also be suitably designed to take into account the earth pressure, groundwater pressure and the reaction force caused by the pipe jacking. The pit should be of sufficient size to not only accommodate the necessary equipment, but also be long enough to accommodate the jacking pipe length and the excavation machine.

The reception pit shall be designed to take into account the earth and groundwater pressure, and shall also be long enough to remove the excavation machine.

The location of the lead pipe shall be checked continually during jacking in order to ensure accurate alignment.

The pushing force shall be checked and recorded continually during jacking, and the force shall be maintained within the allowable pushing force of the pipes.

If a void between the outside surface of pipes and the ground occurs during jacking, a back-fill material, such as a cement fluid, shall be injected to fill the void after jacking.

8.4 Site pressure test

Trenchless pipe installations should be tested separately from the rest of the pipeline. An additional pressure testing of the assembled pipe run prior to the pulling in may be recommended.

For the testing procedure, see the national requirements.

8.5 Safety procedures

Safety procedures should be in accordance with national regulations.

Bibliography

[1] ISO 4179, *Ductile iron pipes for pressure and non-pressure pipelines — Cement mortar lining*

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[5] ISO 8179-1, *Ductile iron pipes — External zinc-based coating — Part 1: Metallic zinc with finishing layer*

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