INTERNATIONAL STANDARD

ISO 7186

Third edition
2011-07-15

Ductile iron products for sewerage applications

Produits en fonte ductile pour l'assainissement

Reference number
ISO 7186:2011(E)

Contents

Page

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 7186 was prepared by Technical Committee ISO/TC 5, *Ferrous metal pipes and metallic fittings*, Subcommittee SC 2, *Cast iron pipes, fittings and their joints*.

This third edition cancels and replaces the second edition (ISO 7186:1996), which has been technically revised. A new classification system for pipes and fittings based on pressure is introduced with minimum wall thickness determined by allowable operating pressure.

Ductile iron products for sewerage applications

1 Scope

This International Standard specifies the requirements and test methods applicable to ductile iron pipes, fittings, accessories and their joints for the construction of drains and sewers outside buildings:

- to convey surface water (e.g. rainwater), domestic waste water and/or certain types of industrial effluents, either in separate systems or in combined systems;
- operating without pressure (gravity sewers) or with positive or negative pressure;
- for installation below or above ground.

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

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

This International Standard is applicable to pipes, fittings and accessories cast by any type of foundry process or manufactured by fabrication of cast components, as well as corresponding joints, in the size range DN 80 to DN 2600 inclusive.

It is applicable to pipes, fittings and accessories which are

- manufactured with socketed, flanged or spigot ends (joint design and gasket shape are outside the scope of this International Standard), and
- normally delivered internally and externally coated.

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 4016, *Hexagon head bolts — Product grade C*

ISO 4034, *Hexagon nuts — Product grade C*

ISO 4633, *Rubber seals — Joint rings for water supply, drainage and sewerage pipelines — Specification for materials*

ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

1) 100 kPa = 1 bar = 0,1 MPa; 1 MPa = 1 N/mm^2.

ISO 7005-2, *Metallic flanges — Part 2: Cast iron flanges*

ISO 7091, *Plain washers — Normal series — Product grade C*

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

EN 1092-2, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Part 2: Cast iron flanges*

3 Terms and definitions

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

3.1
ductile iron
type of cast iron used for pipes, fittings and accessories in which graphite is present primarily in spheroidal form

[ISO 2531:2009, definition 3.8]

3.2
pipe
casting of uniform bore, with straight axis, having either socket, spigot or flanged ends

NOTE This does not apply to flanged sockets, flanged spigots and collars, which are classified as fittings.

[ISO 2531:2009, definition 3.22]

3.3
fitting
casting other than a pipe, which allows pipeline deviation, change of direction or bore

NOTE Flanged sockets, flanged spigots and collars are also classified as fittings.

[ISO 2531:2009, definition 3.9]

3.4
accessory
any casting other than a pipe or fitting, which is used in a pipeline

EXAMPLE 1 Glands and bolts for mechanical flexible joints.

EXAMPLE 2 Glands, bolts and locking rings or segments for restrained joints.

[ISO 2531:2009, definition 3.1]

3.5
inspection chamber
component of a discharge system, of a drain or of a sewer providing access from the ground surface for inspection and maintenance equipment

3.6
manhole
component of a sewer of sufficient size to provide access from the ground surface for inspection and maintenance operations by personnel and equipment

3.7
flange
end of a pipe or fitting, extending perpendicular to its axis, with bolt holes equally spaced on a circle

NOTE A flange can be fixed (e.g. integrally cast, screwed-on or welded-on) or adjustable. An adjustable flange comprises a ring, in one or several parts bolted together, which bears on an end joint hub and can be freely rotated around the barrel axis before jointing.

[ISO 2531:2009, definition 3.10]

3.8
spigot
male end of a pipe or fitting

[ISO 2531:2009, definition 3.26]

3.9
spigot end
maximum insertion depth of the spigot, L_i, plus 50 mm

[ISO 2531:2009, definition 3.27]

See Figure 5.

3.10
socket
female end of a pipe or fitting to make the connection with the spigot of the next component

[ISO 2531:2009, definition 3.25]

3.11
gasket
sealing component of a joint

[ISO 2531:2009, definition 3.13]

3.12
joint
connection between the ends of pipes and/or fittings in which a gasket is used to effect a seal

[ISO 2531:2009, definition 3.15]

3.13
flexible joint
joint providing significant angular deflection and movement parallel and/or perpendicular to the pipe axis

[ISO 2531:2009, definition 3.12]

3.14
push-in flexible joint
flexible joint assembled by pushing the spigot through the gasket into the socket of the mating component

[ISO 2531:2009, definition 3.23]

3.15
mechanical flexible joint
flexible joint in which sealing is obtained by applying pressure to the gasket by mechanical means, e.g. a gland

[ISO 2531:2009, definition 3.18]

3.16
restrained joint
joint in which a means is provided to prevent separation of the assembled joint

[ISO 2531:2009, definition 3.24]

3.17
flanged joint
joint between two flanged ends

[ISO 2531:2009, definition 3.11]

3.18
nominal size
DN
alphanumeric designation of size for components of a pipework system, which is used for reference purposes

NOTE 1 It comprises the letters DN followed by a dimensionless whole number, which is indirectly related to the physical size, in millimetres, of the bore or outside diameter of the end connections.

NOTE 2 Adapted from ISO 6708:1995, definition 2.1.

3.19
nominal pressure
PN
numerical designation, which is a convenient rounded number, used for reference purposes

NOTE 1 All components of the same nominal size, DN, designated by the same PN number have compatible mating dimensions.

NOTE 2 Adapted from ISO 7268.

3.20
leaktightness test pressure
pressure applied to a component during manufacturing in order to ensure its leaktightness

3.21
allowable operating pressure
PFA
maximum internal pressure, excluding surge, that a component can safely withstand in permanent service

[ISO 2531:2009, definition 3.2]

3.22
allowable maximum operating pressure
PMA
maximum internal pressure, including surge, which a component can safely withstand in service

NOTE Adapted from ISO 2531:2009, definition 3.17.

3.23
allowable site test pressure
PEA
maximum hydrostatic pressure that a newly installed component can withstand for a relatively short duration, when either fixed above ground level or laid and backfilled underground, in order to measure the integrity and tightness of the pipeline

NOTE This test pressure is different from the system test pressure which is related to the design pressure of the pipeline.

[ISO 2531:2009, definition 3.3]

3.24
diametral stiffness of a pipe
characteristic of a pipe allowing it to resist diametral deflection under loading

[ISO 2531:2009, definition 3.7]

3.25
discharge system
system of pipes, fittings, accessories and joints used to collect and drain waste water and rainwater from a building

NOTE It comprises discharge pipes, stack ventilation pipes and rainwater downpipes, installed within the limits of a building or attached to the building.

3.26
drain
system of pipes, fittings, accessories and joints installed outside the limits of a building in order to connect the discharge system of the building to a sewer or a septic tank

3.27
sewer
pipeline designed to collect waste water and rainwater from buildings and surface water and to convey them to the point of disposal or treatment

3.28
gravity sewer
sewer operating normally under free flowing conditions

3.29
pumping sewer
pressure sewer
sewer (or section of a sewer) operating under positive pressure

3.30
vacuum sewer
sewer operating under negative pressure

3.31
combined sewer
sewer collecting together rainwater, surface water and waste water

3.32
separate sewer system
sewerage system which collects waste water separately from surface water

3.33
batch
quantity of castings from which a sample may be taken for testing purposes during manufacture

[ISO 2531:2009, definition 3.4]

3.34
type test
proof-of-design test, which is done once and is repeated only after change of design

[ISO 2531:2009, definition 3.29]

3.35
laying length
L_e
length by which a pipeline progresses when an additional pipe is installed

NOTE 1 For socket and spigot pipes, it is equal to the total length of the pipe, L_{tot}, minus the maximum spigot insertion depth, L_i, as given by the manufacturer and as shown in Figure 5. For flanged pipes, it is equal to the total length of the pipe.

NOTE 2 It is expressed in metres.

NOTE 3 Adapted from ISO 2531:2009, definition 3.16.

3.36
standardized length
length of pipe barrel and fitting body or branch

NOTE 1 For socket and spigot pipes, it is designated L_u (l_u for branches). For flanged pipes, and fittings, it is designated L (l for branches). See Figure 5 and ISO 2531.

NOTE 2 For flanged pipes and fittings, the standardized length L (l for branches) is equal to the total length. For socketed pipes and fittings, the standardized length L_u (l_u for branches) is equal to the total length minus the depth of socket, as indicated in the manufacturer's handbooks.

NOTE 3 Adapted from ISO 2531:2009, definition 3.28

3.37
ovality
out-of-roundness of a pipe section, equal to Equation (1):

$$100 \frac{(A_1 - A_2)}{(A_1 + A_2)} \quad (1)$$

where

A_1 is the maximum axis, in millimetres;

A_2 is the minimum axis, in millimetres.

[ISO 2531:2009, definition 3.21]

3.38
deviation
amount by which the design length may differ from the standardized length of a pipe or a fitting

NOTE 1 Pipes and fittings are designed to a length selected in the range of standard length plus or minus the deviation (see Table 3); they are manufactured to this length plus or minus the tolerance given in Table 4.

NOTE 2 Adapted from ISO 2531:2009, definition 3.6.

3.39
component
any product defined as an element of a pipeline, such as a pipe, fitting or accessory

[ISO 2531:2009, definition 3.5]

See 3.2, 3.3 and 3.4.

3.40
hoop stress
σ
stress in a pipe or fitting under pressure, acting tangentially to the perimeter of a transverse section

[ISO 2531:2009, definition 3.14]

4 Technical requirements

4.1 General

4.1.1 Pipes, fittings and accessories

Thicknesses, lengths and coatings are specified in 4.3.2, 4.3.3, and 4.5 and 4.6, respectively. Where, by agreement between the manufacturer and the purchaser, pipes and fittings with different lengths, thicknesses and/or coatings, and other types of fittings than those given in 8.2 and 8.3, are supplied in accordance with this International Standard, they shall comply with all the other requirements of this International Standard. This includes pipes and fittings manufactured to national standards and regulations.

The standard nominal sizes DN of pipes and fittings are the following:

80, 100, 125, 150, 200, 250, 300, 350, 400, 450, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1400, 1500, 1600, 1800, 2000, 2200, 2400, 2600.

The stiffness and allowable diametral deflection of ductile iron pipes are those given in Table 11.

The pressures PFA, PMA and PEA (see 3.21, 3.22 and 3.23) for pressure sewers are those indicated in Annex C.

NOTE Where designed, installed, operated and maintained with due regard to the factors described in Annexes A and B, ductile iron pipes, fittings, accessories and their joints maintain their functional characteristics over their service life, due to time-independent material properties and high factors of safety.

4.1.2 Surface condition and repairs

Pipes, fittings and accessories shall be free from defects and surface imperfections which can impair their compliance with the requirements of Clauses 4 and 5.

Where necessary, pipes and fittings may be repaired by the manufacturer, for example by welding, to remove surface imperfections and localized defects, which do not affect the entire wall thickness, provided the repaired pipes and fittings comply with all the requirements of Clauses 4 and 5.

4.1.3 Types of joints and interconnection

4.1.3.1 General

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

Rubber gasket materials shall conform to the requirements of ISO 4633 for sewerage applications. Where materials other than rubber are necessary (e.g. high-temperature flanged joints), they shall conform to the appropriate International Standards.

4.1.3.2 Flanged joints

Flanged joints shall be designed such that they can be attached to flanges whose dimensions and tolerances comply with ISO 7005-2 or EN 1092-2. This ensures interconnection between all flanged components (pipes, fittings, valves, etc.) of the same DN and PN and adequate joint performance. Bolts and nuts shall comply, as a minimum, with the requirements of ISO 4016 and ISO 4034, property class 4.6. Where washers are required they shall comply with ISO 7091.

In addition, each type of flanged joint shall be designed to meet the performance requirements as specified in ISO 2531.

Although it does not affect interconnection, the manufacturer's handbook shall indicate whether products contained therein are normally delivered with fixed or loose flanges.

4.1.3.3 Flexible joints

Pipes and fittings with flexible joints shall be in accordance with 4.3.1.1 for their spigot external diameters, DE, and their tolerances. This provides the possibility of interconnection between components equipped with different types of flexible joints. In addition, each type of flexible joint shall be designed to meet the performance requirements of 5.1.

For interconnection with certain types of joints operating within a tighter tolerance range on DE, the manufacturer's guidance should be followed as to the means of ensuring adequate joint performance up to the highest pressures (e.g. measurement and selection of external diameter).

For interconnection with existing pipelines, which can have external diameters not in accordance with 4.3.1.1, the manufacturer's guidance should be followed as to the appropriate means of interconnection (e.g. adaptors).

4.1.3.4 Restrained joints

Restrained joints for ductile iron pipelines shall be designed in accordance with ISO 10804. Their spigot external diameters, DE, and their tolerances shall comply with 4.3.1.1.

4.1.4 Colour identification

Pipes and fittings for sewers and drains shall be identified externally by a specific colour (see national standard). Identification is possible by various means, e.g. external paint, polyethylene sleeving or a warning tape.

NOTE This is to allow easy identification of installed sewers and drains and to avoid mistaking with pipelines for water and gas supply.

4.2 Pressure classification

4.2.1 General

Depending on the manner by which the surface water or sewerage is transported, the sewerage system can be classified as a pressure sewer or a gravity sewer and, accordingly, flexibly jointed pipeline systems can be classified as pressure pipes/fittings or gravity pipes/fittings.

The allowable pressures within a pipeline system shall be limited to the lowest pressure classification component within the system.

Components with flanged joints shall be classified by the PN number of the flange.

Pressure pipes can be used in gravity pipeline systems.

4.2.2 Gravity pipes

Gravity pipes are designed for gravity sewer applications. Their normal service, internal and external pressures are defined in Table 6.

4.2.3 Pressure pipes

Pressure pipes are designed for pressure sewer applications and are classified by the allowable operating pressure (PFA), prefixed by a letter C.

Allowable pipeline pressures relationships are as follows:

a) allowable operating pressure (PFA) = (C), in bar;

b) maximum allowable operating pressure (PMA) = 1,20 × (PFA), in bar;

c) allowable site test pressure (PEA) = (1,20 × PFA) + 5, in bar.

The pressure pipes shall be selected from the preferred pressure classes C25, C30 and C40 as defined in ISO 2531. Their normal service internal and external pressures are defined in Table 6.

Other pressure classes, specified in ISO 2531, may be used if applicable.

The allowable pressures within a pipeline system shall be limited to the lowest pressure classification component within the system.

4.3 Dimensional requirements

4.3.1 Diameter

4.3.1.1 External diameter

Table 12 gives the values of the external diameter DE of the spigot end of pipes and fittings, when measured circumferentially using a circumferential tape in accordance with 6.1.1. The positive tolerance is +1 mm and applies to all pressure classes of pipes and also to flanged spigot fittings.

The negative tolerance depends on the design of each type of joint and can be as specified in national standards, or, when not so specified, in the manufacturer's handbook, for the type of joint and the nominal size considered.

In addition, the ovality (see 3.37) of the spigot end of pipes and fittings shall

— remain within the tolerances on DE for DN 80 to DN 200, and

— not exceed 1 % of DE for DN 250 to DN 600 or 2 % for DN > 600.

The manufacturer's recommendations should be followed with respect to the necessity and means of ovality correction; certain types of flexible joints can accept the maximum ovality without the need for spigot re-rounding prior to jointing.

4.3.1.2 Internal diameter

The nominal values of the internal diameters of centrifugally cast pipes, expressed in millimetres, are approximately equal to the numbers indicating their nominal size, DN.

4.3.2 Wall thickness

4.3.2.1 Pipes with flexible joints

4.3.2.1.1 Gravity pipes

The minimum wall thickness for gravity pipes shall be as given in Table 12.

The minimum wall thickness, e_{min}, is equal to the nominal wall thickness, e_{nom}, minus 1 mm for DN 80 to DN 300 and minus 1,2 mm for DN 350.

4.3.2.1.2 Pressure pipes

The minimum wall thickness, e_{min}, and shall be not less than 3 mm and shall be determined using Equation (2):

$$e_{min} = \frac{\text{PFA} \times \text{SF} \times \text{DE}}{20 R_m + (\text{PFA} \times \text{SF})} \qquad (2)$$

where:

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

PFA is the allowable operating pressure, in bar;

SF is the safety factor for PFA (= 3);

DE is the nominal pipe external diameter (see Table 12), in millimetres;

R_m is the minimum tensile strength of ductile iron, in megapascals (R_m = 420 MPa; see Table 5).

NOTE Equation (2) is derived from Barlow's equation, i.e. hoop stress, σ = PD/2t (see 3.40).

For pressure pipes centrifugally cast, the minimum wall thickness, e_{min}, shall not be less than 3 mm. The nominal wall thickness, e_{nom}, is equal to the minimum wall thickness, e_{min}, plus (1,3 + 0,001 DN).

For pressure pipes not centrifugally cast, the minimum wall thickness, e_{min}, shall not be less than 4,7 mm. The nominal wall thickness, e_{nom}, is equal to the minimum wall thickness, e_{min}, plus (2,3 + 0,001 DN).

4.3.2.2 Flanged pipe

Flanged pipe shall be classified by PN number. The pressure class of the barrel of the flanged pipes shall be equal to or greater than a value, in bar, equal to the PN of the flanges. The pressure class of the flanged pipe barrel to be used for fabricated flanged pipe shall be as indicated in 8.2 for weld-on flanges, screwed-on flanges and integrally cast flanges.

NOTE Pipe threads are regarded as loss of wall thickness.

4.3.2.3 Fittings

4.3.2.3.1 Fittings for gravity applications

The iron wall thickness of fittings for gravity applications is defined by the manufacturer. The thickness shall be equal to or greater than those of pipes of the same DN.

4.3.2.3.2 Fittings for pressure applications

Fittings for pressure application shall be in accordance with 8.3.

4.3.3 Length

4.3.3.1 Socket and spigot pipes

The standardized lengths of socket and spigot pipes shall be as given in Table 1.

Table 1 — Standardized lengths of socket and spigot pipes

Dimensions in metres

DN	Standardized lengths, L_u[a]
80 to 600	4 or 5 or 5,5 or 6 or 9
700 and 800	4 or 5,5 or 6 or 7 or 9
900 to 2600	4 or 5 or 5,5 or 6 or 7 or 8,15 or 9
NOTE Not all the standardized lengths are available in all countries.	
[a] See 3.36.	

The manufacturer's design lengths, L_u (see 3.36), shall be within a deviation of ±250 mm of the lengths given in Table 1 and shall be given in their handbook. The actual length, L_u, shall be measured in accordance with 6.1.3 and shall not differ from the manufacturer's design length by more than the tolerance given in Table 4. Of the total number of socket and spigot pipes being supplied in each diameter, the percentage of shorter pipes shall not exceed 10 %.

NOTE 1 Pipes cut for test purposes can be excluded from the 10 % limitation and treated as full length pipes.

NOTE 2 When pipes are ordered on a meterage basis, the manufacturer can determine the required quantity of pipes to be supplied by the summation of the measured individual pipe laying lengths.

4.3.3.2 Flanged pipes

The lengths of flanged pipes shall be as given in Table 2. Other lengths are available by agreement between the manufacturer and the purchaser.

Table 2 — Standardized lengths of flanged pipes

Dimensions in metres

Type of pipe	DN	Standardized lengths, L[a]
With cast-on flanges	80 to 2600	0,5 or 1 or 2 or 3
With screwed-on or welded-on flanges	80 to 500	2 or 3 or 4 or 5
	600 to 1000	2 or 3 or 4 or 5 or 6
	1100 to 2600	4 or 5 or 6 or 7

[a] See 3.36.

4.3.3.3 Fittings

Fittings for gravity applications shall be in conformity with 8.2.

Fittings for pressure applications shall be supplied in conformity with ISO 2531.

Table 3 — Permissible deviations on lengths of fittings

Dimensions in metres

Type of fitting	DN	Deviation
Flanged sockets Flanged spigots Collars, tapers	80 to 1200	±25
	1400 to 2600	±35
Tees	80 to 1200	+50
		−25
	1400 to 2600	+75
		−35
Bends 90° (1/4)	80 to 2600	±(15 + 0,03 DN)
Bends 45° (1/8)	80 to 2600	±(10 + 0,025 DN)
Bends 22°30' (1/16) and 11°15' (1/32)	80 to 1200	±(10 + 0,02 DN)
	1400 to 2600	±(10 + 0,025 DN)
Fittings for gravity applications	80 to 2600	±(15 + 0,03 DN)

4.3.3.4 Tolerances on lengths

The tolerances on lengths shall be as given in Table 4.

Table 4 — Tolerances on lengths

Dimensions in metres

Type of casting	Tolerance
Socket and spigot pipes (full length or shortened)	−30 +70
Fittings for socketed joints	±20
Pipes and fittings for flanged joints	±10[a]

[a] By agreement between the manufacturer and the purchaser, smaller tolerances are possible, but not less than ±3 mm for DN ≤ 600 and ±4 mm for DN > 600.

4.3.4 Straightness of pipes

Pipes shall be straight, with a maximum deviation of 0,125 % of their length.

The verification of this requirement is normally carried out by visual inspection, but in case of doubt or in dispute, the deviation shall be measured in accordance with 6.2.

4.3.5 Inspection chambers

Inspection chambers shall be manufactured either as an integral item or by site assembly of a bottom part and a vertical part.

Normal access sizes shall be the following: 250, 300, 400, 600 mm.

The leaktightness of inspection chambers shall be in conformity with 4.8.

4.3.6 Manholes

Manholes are composed of a vertical part of DN ≥ 800, a bottom plate, a top plate capable of receiving a frame and a manhole cover, and 2 or more inlets/outlets fixed to the vertical part.

The number and location of the inlets/outlets shall preserve the hydraulic continuity inside the manhole.

The leaktightness of manholes shall be in conformity with 4.8.

4.4 Material characteristics

4.4.1 Tensile properties

Pipes, fittings and accessories made of ductile iron shall have the tensile properties shown in Table 5.

During the manufacturing process, the manufacturer shall carry out suitable tests to verify these tensile properties; such tests may be either

a) a batch sampling system whereby samples are obtained from the pipe spigot or, for fittings, from samples cast separately or integrally with the casting concerned (test bars shall be machined from these samples and tensile tested according to 6.3), or

b) a system of process control testing (e.g. non-destructive), by which a positive correlation can be demonstrated with the tensile properties specified in Table 5; testing verification procedures shall be based on the use of comparator samples having known and verifiable properties. This system of testing shall be supported by tensile testing in accordance with 6.3.

Table 5 — Tensile properties

Type of casting	Minimum tensile strength R_m MPa	Minimum percent elongation after fracture A %	
	DN 80 to DN 2600	DN 80 to DN 1000	DN 1100 to DN 2600
Pipes centrifugally cast	420	10	7
Pipes not centrifugally cast, fittings and accessories	420	5	5
By agreement between the manufacturer and the purchaser, the 0,2 % proof stress (R_{p02}) may be measured. It shall be not less than: 270 MPa when $A \geq 12$ % for DN 80 to DN 1000 or $A \geq 10$ % for DN > 1000; 300 MPa in other cases.			
For centrifugally cast pipes of DN 80 to DN 1000 and having a design minimum wall thickness of 10 mm or greater, the minimum elongation after fracture shall be 7 %.			

4.4.2 Brinell hardness

The hardness of the various components shall be such that they can be cut, tapped, drilled and/or machined with standard tools. In case of dispute, the hardness shall be measured according to 6.4.

The Brinell hardness shall not exceed 230 HBW for centrifugally cast pipes and 250 HBW for non-centrifugally cast pipes, fittings and accessories. For components manufactured by welding, a higher Brinell hardness is allowed in the heat-affected zone of the weld.

4.5 Coatings and linings for pipes

4.5.1 General

Pipes shall be normally delivered internally and externally coated.

4.5.2 External coatings

Ductile iron pipeline systems can be installed in a wide range of external operating environments. These environments can be characterized according to their aggressivity. For relevant factors, see A.1.

Coatings specified by relevant International Standards are available as specified in A.2. Other coatings are also available.

Except for the pipes intended only for the transportation of rainwater, domestic waste water in pressure applications, or non-septic domestic sewerage, the surfaces which can come into contact with the effluents (internal surface of the socket and external surface of the spigot end) shall be coated with a special coating, whose chemical resistance should be in conformity with 5.3.

4.5.3 Internal linings

Ductile iron pipeline systems can be used to convey surface water, domestic waste water and/or certain types of industrial effluents. These internal effluents can be characterized according to their aggressivity. Relevant factors to be considered are given in B.1.

Linings specified by relevant International Standards are available as specified in B.2. Other linings are also available.

Except for the pipes intended only for the transportation of rainwater, domestic waste water in pressure applications, or non-septic domestic sewerage, the chemical resistance should be in conformity with 5.3, and the abrasion resistance should be in conformity with 5.4.

4.6 Coatings for fittings and accessories

4.6.1 General

Fittings and accessories shall be normally delivered internally and externally coated.

4.6.2 External coatings

Ductile iron pipeline systems can be installed in a wide range of external operating environments. These environments can be characterized according to their aggressivity. For relevant factors, see A.1.

Coatings specified by relevant International Standards are available as specified in A.3. Other coatings are available.

Except for the fittings and accessories intended only for the transportation of rainwater, domestic waste water in pressure applications, or non-septic domestic sewerage, the surfaces which can come into contact with the effluents (internal surfaces of the socket and external surface of the spigot end) shall be coated with a special coating, whose chemical resistance should be in conformity with 5.3.

4.6.3 Internal linings

Ductile iron pipeline systems can be used to convey surface water, domestic waste water and/or certain types of industrial effluents. These internal effluents can be characterized according to their aggressivity. Relevant factors for consideration are given in B.1.

Linings specified by relevant International Standards are available as specified in B.4. Other linings are also available.

Except for the fittings and accessories intended only for the transportation of rainwater, domestic waste water in pressure applications, or non-septic domestic sewerage, the chemical resistance should be in conformity with 5.3, and the abrasion resistance should be in conformity with 5.4.

4.7 Systems design requirements

Installed sewer systems constructed with ductile iron components in conformity with this International Standard shall be leaktight to the pressures given in Table 6, depending on the way in which they are normally operated.

Table 6 — Operating pressure of sewer system

Type of operation	Internal pressure bar		External pressure bar
	Continuous	**Occasional**	**Continuous**
Gravity sewer	0 to 0,5	2	1
Pressure sewer	See PFA in Annex C	See PMA in Annex C	1
Vacuum sewer	−0,5	−0,8	1

This applies under all normal service conditions, including foreseeable external loads and joint movements (both angular and radial).

4.8 Leaktightness of pipeline components

Ductile iron pipes, fittings, inspection chambers and manholes shall be leaktight when used under the conditions for which they are designed (see 4.7).

When tested according to 6.5, pipes and fittings for positive pressure applications shall exhibit no visible leakage, sweating or any other sign of failure.

When tested according to 7.1, pipes and fittings for gravity applications shall exhibit no visible leakage, sweating or any other sign of failure.

When tested according to 6.6, pipes and fittings for vacuum applications shall exhibit no visible leakage, sweating or any other sign of failure.

4.9 Marking

All pipes and fittings shall be durably and legibly marked and shall bear at least the following indications:

a) a reference to this International Standard, i.e. ISO 7186;

b) the manufacturer's name or mark;

c) identification of the year of manufacture;

d) identification as ductile iron;

e) the DN;

f) the PN rating of flanges, if applicable;

g) identification of the application (gravity or pressure).

List items b) to f) shall be cast-on or cold stamped. List items a) and g) can be applied by any method, e.g. painted on the castings.

5 Performance requirements

5.1 Leaktightness of joints

5.1.1 General

All flexible joints for ductile iron pipes and components shall be designed in compliance with the requirements of 5.1. 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 as specified in 5.1.2 for internal pressure, as specified in 5.1.3 for external pressure and as specified in 5.1.4 for negative internal pressure is only required for significant changes in design, which could adversely affect the performance of the joint.

Joint designs shall be type tested to demonstrate leaktightness to both internal and external pressure under the most unfavourable conditions of casting tolerances and joint movements.

There shall be a type test for at least one DN for each of the groupings given in Table 7. One DN is representative of a grouping when the performances are based on the same design parameters throughout the size range.

Table 7 — DN groupings for type tests

DN groupings	**80 to 250**	**300 to 600**	**700 to 1000**	**1100 to 2000**	**2200 to 2600**
Preferred DN in each grouping	200	400	800	1600	2400

If a grouping covers products of different designs and/or manufactured by different processes, the grouping shall be subdivided.

If, for a manufacturer, a grouping contains only one DN, this DN may be considered as part of the adjacent grouping provided that it is of identical design and manufactured by the same process.

The type tests shall be carried out in the configuration of maximum design radial gap between the components to be jointed (smallest spigot together with largest socket).

In the type test, the maximum gap shall be equal to the maximum design radial gap with a tolerance of ${}_{-5}^{0}$ %. The internal socket diameter may be machined to achieve this, even if the resulting diameter is slightly outside the normal manufacturing tolerance.

All joints shall be performance tested with a spigot having an average iron wall thickness (over a distance of two times DN, in millimetres, from the spigot face) equal to the specified minimum value for the pipe for which the joint is designed, ${}_{0}^{+10}$ %. It is permissible to machine the spigot of the pipe bore to achieve the required thickness.

Restrained flexible joints shall be designed and tested in accordance with ISO 10804.

5.1.2 Positive internal pressure

The leaktightness of joints to positive internal pressure shall be tested as specified in 7.2; the joints shall exhibit no visible leakage during 2 h, in the two following positions:

a) joint aligned and subjected to a shear: the shear force across the joint, expressed in newtons, shall not be less than 30 times DN;

b) joint deflected: the test angular deflection shall be the maximum allowable deflection indicated in the manufacturer's handbook, but not less than 3°30' for DN 80 to DN 300, 2°30' for DN 350 to DN 600, 1°30' for DN 700 to DN 2600. These minimum deflections do not apply to restrained joints.

The test pressure shall not be less than their allowable test pressure PEA for the joints to be used on pressure pipelines and 2 bar for the joints to be used on gravity and vacuum pipelines.

5.1.3 External pressure

The leaktightness of joints to external pressure shall be tested as specified in 7.3; the joints shall exhibit no visible leakage when subjected to a shear load, expressed in newtons, not less than 30 times DN.

The test pressure shall not be less than 1 bar.

5.1.4 Negative internal pressure

The leaktightness of joints to negative internal pressure shall be type tested as specified in 7.4 at a test pressure of 0.9 bar below atmospheric pressure (approximately 0,1 bar absolute pressure). The maximum pressure change during the test period shall not be more than 0,09 bar after 2 h, when tested in the following two positions:

a) joint aligned and subjected to a shear: the shear force across the joint, expressed in newtons, shall not be less than 30 times DN;

b) joint deflected: the test angular deflection shall be the maximum allowable deflection indicated in the manufacturer's handbook, but not less than 3°30' for DN 80 to DN 300, 2°30' for DN 350 to DN 600, 1°30' for DN 700 to DN 2600. These minimum deflections do not apply to restrained joints.

5.2 Diametral stiffness

5.2.1 General

When tested according to 7.5, the pipes shall comply with the requirements of 5.2.2 and 5.2.3.

5.2.2 Integrity under service conditions

The diametral stiffness of the pipes shall not be less than the values specified in Table 11. When subjected to the loads specified in Table 11, the allowable ovalization specified in Table 11 shall not be exceeded. Ovalization shall be measured and recorded.

In addition, there shall be no damage to the internal and external coatings which could affect their performance. Local damage to the external coating at the bearing area is acceptable.

NOTE As ductile iron pipes are not subject to creep, the short-term and long-term values of the diametral stiffness are identical.

5.2.3 Resistance to ovalization

After the integrity test of 5.2.2, the pipes shall withstand twice the ovalization attained in the integrity under service conditions test (5.2.2) without failure of the iron wall.

5.3 Chemical resistance

Except for components intended only for the transportation of rain water, domestic waste water in pressure applications, or non-septic domestic sewerage, long-term performance of pipes, fittings and joints should be demonstrated by three-month exposure to an acid solution and to an alkaline solution according to 7.6.

After three months of exposure, the component shall comply with the following requirements:

- thickness of the cement mortar lining shall be within 0,2 mm of the original thickness;
- there shall be no visible cracking, blistering or disbonding of polymeric lining or coating (internal and external coating of pipes and fittings, which come into contact with effluent during service);
- there shall be no visible cracking on the rubber gasket; its hardness, tensile strength and elongation shall remain in conformity with the specified values.

However, if the lining has been tested and documented by the manufacturer to a national standard or to an agreed technical specification and successfully used for a minimum of five years, the performance of the type test in accordance with 7.6 is only required for significant changes in the coating material/type or formulation, which can adversely affect the performance of the lining.

5.4 Abrasion resistance

When tested in accordance with 7.7, the pipes shall not have an abrasion depth greater than 0,6 mm after 100 000 movements (50 000 cycles) for every type of cement lining, or 0,2 mm for polymeric linings.

In order to test the abrasion resistance of fittings, pipes may be lined as fittings, and tested according to 7.7.

However, if the lining has been tested and documented by the manufacturer to a national standard or to an agreed technical specification and successfully used for a minimum of five years, the performance of the type test in accordance with 7.7 is only required for significant changes in the coating material/type or formulation, which can adversely affect the performance of the lining.

6 Test methods and test frequencies

6.1 Dimensions

6.1.1 External diameter

Pipes with sockets and spigot ends shall be measured at their spigot by means of a circumferential tape for compliance with the outer diameter tolerance. They can also be verified by means of pass-fail gauges.

In addition, the pipes shall be visually inspected at their spigot for compliance with the ovality tolerance and, in case of doubt, checked by measuring the minimum and maximum axes. This control may also be carried out by means of pass-fail gauges.

The frequency of testing is related to the system of production and quality control used by the manufacturer.

6.1.2 Wall thickness

Pipe wall thickness compliance shall be demonstrated by the manufacturer; a combination of various means may be used, such as:

- pipe weight control;
- direct wall thickness measuring or gauging by suitable equipment, such as mechanical or ultrasonic equipment. The frequency of testing is related to the system of production and quality control used by the manufacturer.

6.1.3 Length

The length of centrifugally cast pipes with sockets and spigot ends shall be measured by means of suitable equipment:

— on the first pipe cast from a new mould, for full length pipes;

— on the first cut pipe, for pipes which are systematically cut to a predetermined length.

6.2 Straightness of pipes

The pipe shall be rolled on two supports or rotated around its axis on rollers, which in each case are separated by at least two thirds of the standard pipe length.

The point of maximum deviation from the true axis shall be determined and the deviation measured at that point shall not exceed the limit fixed in 4.3.4.

6.3 Tensile test

6.3.1 Sampling

6.3.1.1 General

The thickness of the sample and the diameter of the test bar shall be as indicated in Table 8.

6.3.1.2 Centrifugally cast pipes

A sample shall be cut from the spigot of the pipe. This sample may be cut perpendicular to or parallel with the pipe axis. But, in case of dispute, the sample cut parallel to the axis shall be used.

6.3.1.3 Pipes not centrifugally cast, fittings and accessories

Samples shall be taken, at the manufacturer's discretion, either from an integrally cast sample, from a sample attached to the casting, or from a sample cast separately. In the latter case, it shall be cast from the same metal as that used for the casting. If the casting is subjected to heat treatment, the sample shall be subjected to the same heat treatment.

6.3.2 Test bar

A test bar shall be machined from each sample to be representative of the metal at the mid-thickness of the sample, with a cylindrical part having the diameters given in Table 8. If the specified diameter of the test bar is greater than 60 % of the measured minimum thickness of the sample, a test bar with a smaller diameter may be machined, or another sample cut in a thicker part of the pipe. Other test bar shapes complying with International Standards or national standards are permitted.

The test bars shall have a gauge length at least five times the nominal test bar diameter. The ends of the test bars shall suit the testing machine.

The surface roughness of the machined gauge length of the test bar shall be such that $Rz \leq 6{,}3$ µm.

Two methods of measuring the tensile strength may be used at the manufacturer's discretion:

a) method A:

produce the test bar to a nominal diameter ±10 %, measure the actual diameter before the test with an accuracy of ±0,01 mm and use this measured diameter to calculate the cross-sectional area and the tensile strength, or

b) method B:

produce the test bar to a nominal area, S_o, within a specified tolerance on the diameter (see Table 8) and use the nominal area to calculate the tensile strength.

Table 8 — Dimensions of test bars

Type of casting	Test bar, method A	Test bar, method B		
	Nominal diameter mm	Nominal area S_o mm^2	Nominal diameter mm	Tolerance on diameter mm
Centrifugally cast pipes with wall thickness:				
— less than 6 mm	2,5	5	2,52	±0,01
— 6 mm, up to but not including 8 mm	3,5	10	3,57	±0,02
— 8 mm, up to but not including 12 mm	5	20	5,05	±0,02
— 12 mm and over	6	30	6,18	±0,03
Pipes not centrifugally cast, fittings and accessories:				
— integrally cast samples	5	20	5,05	±0,02
— separately cast samples:				
— thickness 12,5 mm for casting thickness less than 12 mm	6	30	6,18	±0,03
— thickness 25 mm for casting thickness12 mm and over	12 or 14	—	—	—

6.3.3 Equipment and test method

The tensile testing machine shall have holders or grips to attach to the test bar ends and positively transfer the test load axially. The testing machine shall have a force range suitable for testing the bars to failure whilst indicating the load applied.

The rate of stressing shall be as constant as possible within the limits of 6 N/mm^2 to 30 N/mm^2 per second.

The tensile strength shall be calculated by dividing the maximum force sustained by the test bar by the cross-sectional area of the test bar before testing. The elongation shall be measured by piecing together the broken parts of the test bar and taking the ratio of the extended gauge length to the original gauge length. Alternatively, the elongation may be measured directly by means of an extensometer.

6.3.4 Test results

Test results shall comply with Table 5. If they do not comply, the manufacturer shall:

a) in the case where the metal does not achieve the required mechanical properties, investigate the reason and ensure that all castings in the batch are either reheat treated or rejected; castings which have been reheat treated are then retested in accordance with 6.3;

b) the case of a defect in the test bar, carry out a further test. If it passes, the batch is accepted; if not, the manufacturer has the option to proceed in accordance with a) above.

NOTE The manufacturer can more accurately identify the number of pipes by making additional tests, in order of manufacture, until the rejected batch of castings is bracketed by a successful test at each end of the interval in question.

6.3.5 Test frequency

The frequency of testing is related to the system of production and quality control used by the manufacturer (see 4.4.1). The maximum batch sizes shall be as given in Table 9.

Table 9 — Maximum batch sizes for tensile testing

Type of casting	DN	Maximum batch size	
		Batch sampling system	Process control testing system
Centrifugally cast pipes	80 to 300	200 pipes	1 200 pipes
	350 to 600	100 pipes	600 pipes
	700 to 1000	50 pipes	300 pipes
	1100 to 2600	25 pipes	150 pipes
Pipes not centrifugally cast, fittings and accessories	All sizes	4 t[a]	48 t[a]

[a] Mass of crude castings, excluding risers.

6.4 Brinell hardness

When Brinell hardness tests are carried out (see 4.4.2), they shall be performed either on the casting in dispute or on a sample cut from the casting. The surface under test shall be suitably prepared by slight local grinding, and the test shall be carried out in accordance with ISO 6506-1 using a ball of 2,5 mm, 5 mm or 10 mm in diameter.

6.5 Works leaktightness test of pipes and fittings for pressure applications

6.5.1 General

Pipes and fittings shall be tested in accordance with 6.5.2 and 6.5.3, respectively. The test shall be carried out on all pipes and fittings before the application of their external and internal coatings, except for the metallic zinc coating of pipes which may be applied before the test.

The test apparatus shall be suitable for applying the specified hydrostatic test pressures to the pipes and/or fittings. It shall be equipped with an industrial pressure gauge with an error limit of ±3 %.

6.5.2 Pipes centrifugally cast

The internal hydrostatic pressure shall be raised until it reaches the works hydrostatic pressure equal to the pressure class and limited to the pressure of preferred classes. Higher pressures are permissible.

The total duration of the pressure cycle shall not be less than 15 s, including 10 s at test pressure. Visual inspection shall be made during or immediately after the pressure test.

6.5.3 Pipes not centrifugally cast and fittings

At the discretion of the manufacturer, these pipes and fittings shall be submitted to a hydrostatic pressure test, or to an air test.

When the hydrostatic pressure test is carried out, it shall be done in the same way as for centrifugally cast pipes (see 6.5.2), except for the test pressures which shall be as given in Table 10.

When the air test is carried out, it shall be with an internal pressure of at least 1 bar and a visual inspection time of not less than 10 s; for leak detection, the castings shall be either uniformly coated on the external surface by a suitable foaming agent or submerged in water.

Table 10 — Works test pressure for pipes not centrifugally cast and fittings

DN	Pipes not centrifugally cast, fittings and accessories bar[a]
80 to 300	25[b]
350 to 600	16
700 to 2600	10

[a] The works hydrostatic test pressure is less than for pipes because of the difficulty providing sufficient restraint to high internal pressure during test.

[b] For pipes and fittings with PN 10 flanges, 16 bar.

6.6 Works leaktightness test of pipes and fittings for vacuum applications

All the pipes and fittings shall be subjected to an air test with an internal pressure of at least 1 bar and an inspection time not less than 10 s for fittings and 1 min for pipes. For leak detection, pipes and fittings shall be submerged in water or uniformly coated on their external surface by a suitable foaming agent.

7 Type tests

7.1 Leaktightness of gravity pipeline components

Ductile iron pipes, fittings, inspection chambers and manholes, equipped with appropriate end restraints, shall be filled with water and suitably vented of air. The internal hydrostatic pressure shall then be raised to 2 bar and maintained constant for at least 2 h, during which a visual inspection for leak detection shall be carried out. The test shall be carried out at ambient temperature on coated products.

Where convenient, these type tests may be performed at the same time as those described in 7.2 for joints.

7.2 Leaktightness of joints to internal pressure

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

The test apparatus shall be capable of providing suitable end restraints whether the joint is in the aligned position or deflected, or subjected to a shear load. It shall be equipped with a pressure gauge having an accuracy of ±3 %.

The shear load, W, shall be applied to the spigot by means of a V-shaped block with an angle of 120°, located at approximately 0,5 × DN, in millimetres, or 200 mm from the socket face (whichever is the greater); the socket shall bear on a flat support. The load, W, shall be such that the resultant shear force, F, across the joint is equal to the value specified in 5.1.2, taking into account the mass, M, of the pipe and its contents and the geometry of the test assembly as given in Equation (3):

$$W = \frac{F \times c - M\left(c - b\right)}{c - a} \qquad (3)$$

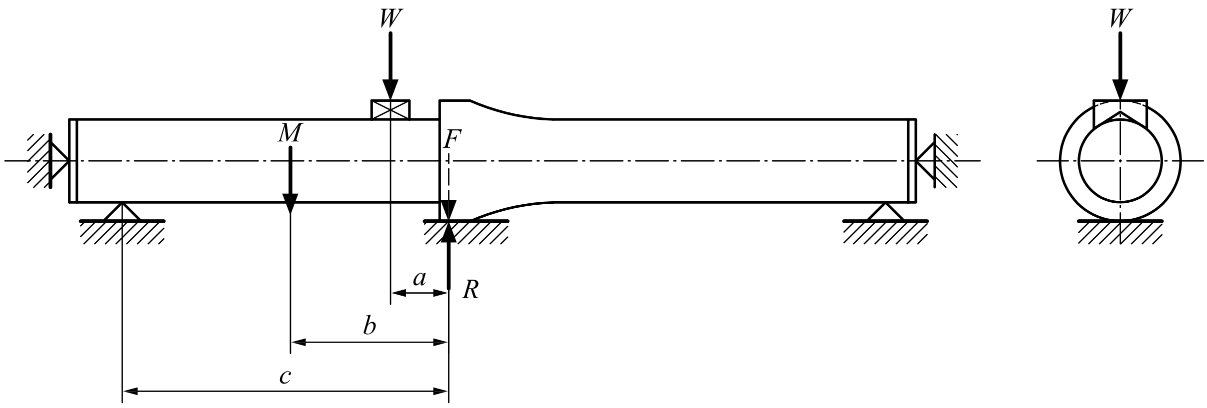
where

F is the resultant shear force across the joint, expressed in newtons;

M is the mass of the pipe and its contents, expressed in newtons;

W is the shear load, expressed in newtons;

a, b and c are given in Figure 1.



NOTE R is the reaction of the central support, expressed in newtons (R = F).

Figure 1 — Leaktightness of joints — Internal pressure

The test assembly shall be filled with water and suitably vented of air. The pressure shall be raised steadily until it reaches the test pressure given in 5.1.2; the rate of pressure increase shall not exceed 1 bar/s. The test pressure shall be kept constant within ±0,5 bar for at least 2 h during which the joint shall be thoroughly inspected every 15 min.

7.3 Leaktightness of joints to external pressure

This type test assembly, which applies only to push-in flexible joints, shall comprise two joints made with two pipe sockets connected together and one double-spigot piece so as to create an annular chamber allowing for the testing of one joint under internal pressure and one joint under external pressure (see Figure 2).

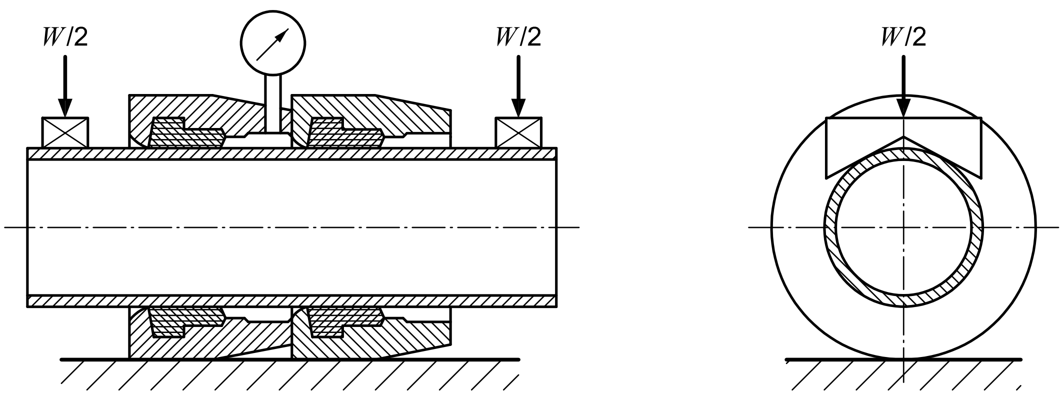


Figure 2 — Leaktightness of joints — External pressure

The test assembly shall be subjected to the shear load defined in 5.1.3; one half of this load shall be applied to the spigot on each side of the test assembly, by means of a V-shaped block with an angle of 120°, located at approximately 0,5 × DN, in millimetres, or 200 mm from the end of socket face (whichever is the greater); the sockets shall bear on a flat support.

The test assembly shall then be filled with water and suitably vented. The pressure shall be steadily increased until it reaches the test pressure in 5.1.3 and then kept constant within ±0,1 bar for at least 2 h, during which the internal side of the joint subjected to external pressure shall be thoroughly inspected every 15 min.

7.4 Leaktightness of joints to negative internal pressure

The test assembly and test apparatus shall be as given in 7.2 with the pipe sections axially restrained to prevent them moving towards each other.

The test assembly shall be empty of water and shall be evacuated to a negative internal pressure of 0,9 bar (see 5.1.4) and then isolated from the vacuum pump. The test assembly shall be left under vacuum for at least 2 h, during which the pressure shall not have changed by more than 0,09 bar. The test shall begin at a temperature between 5 °C and 40 °C. The temperature of the test assembly shall not vary by more than 10 °C for the duration of the test.

7.5 Diametral stiffness of pipes

The test shall be carried out on a pipe section (500 ± 20) mm long, cut from a finished pipe barrel. The pipe section shall be placed on a support approximately 200 mm wide and 600 mm long, having a V shape with an angle between 170° and 180° (see Figure 3). The load shall be applied at the pipe crown through a loading beam approximately 50 mm wide and 600 mm long. Both the V support and the loading beam shall be covered with a sheet of elastomer with a thickness of (10 ± 5) mm and a hardness greater than or equal to 50 IRHD. Before the test, the pipe section shall be immersed in water at ambient temperature for approximately 24 h.

The load shall be increased steadily until it reaches the test load corresponding to the minimum diametral stiffness given in Table 11 and kept constant for 1 min. The vertical deflection of the pipe section shall be measured and recorded and the calculated ovalization shall not exceed the allowable value given in Table 11. In addition, the pipe section shall be visually inspected in order to check that there is no damage to the external and internal coatings, which can affect their function.

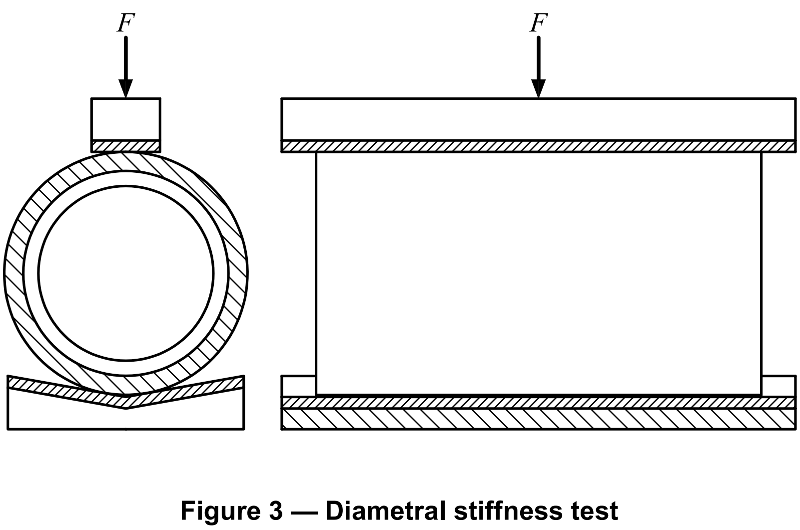


Figure 3 — Diametral stiffness test

The load shall then be increased until the vertical deflection reaches twice the value previously measured. The load shall be kept constant for 1 min.

Table 11 — Diametral stiffness test requirements

DN	Minimum diametral stiffness S kN/m²	Test load F kN/m	Allowable pipe ovalization %	e_{calc} mm
Gravity pipe				
80	400	30,9	1,5	2,9
100	227	25,3	1,8	2,9
125	123	21,4	2,3	2,9
150	74	17,9	2,7	2,9
200	32	10,5	2,8	2,9
250	32	13,4	2,9	3,6
300	32	16,5	3	4,3
350	32	19,8	3,1	4,9
Pressure pipe				
80	856	61,8	1,40	3,7
100	481	50,7	1,70	3,7
125	271	42,1	2,05	3,8
150	163	35,6	2,45	3,8
200	84	29,5	3,00	4,0
250	50	21,5	3,00	4,1
300	34	17,4	3,00	4,3
350	31	19,2	3,10	4,9
400	30	21,8	3,20	5,5
450	22	18,4	3,30	5,5
500	17	16,2	3,40	5,6
600	16	19,3	3,60	6,6
700	15	22,6	3,80	7,5
800	15	27,1	4,00	8,6
900	15	29,5	4,00	9,5
1000	14	31,9	4,00	10,5
1100	14	34,3	4,00	11,4
1200	14	36,7	4,00	12,4
1400	14	42,5	4,00	14,4
1500	14	44,9	4,00	15,3
1600	13	47,4	4,00	16,3
1800	13	52,2	4,00	18,2
2000	13	58,0	4,00	20,2
2200	13	62,9	4,00	22,1
2400	13	67,8	4,00	24,0
2600	13	73,5	4,00	26,0

NOTE 1 The ovalization is 100 times the measured vertical deflection, in millimetres (caused by the applied load) divided by the measured pipe external diameter in millimetres.

NOTE 2 The diametral stiffness, the vertical deflection and the applied load are given by Equation (4):

$$S = 0{,}019 \frac{F}{Y} \tag{4}$$

where

S is the diametral stiffness, in kilonewtons per square metre;

F is the applied load, in kilonewtons per metre length of pipe;

Y is the vertical deflection, in metres.

NOTE 3 The diametral stiffness, S, of a pipe is calculated using Equation (5):

$$S = 1\,000 \frac{E \times I}{D^3} = 1\,000 \times \frac{E}{12} \left(\frac{e_{\text{stiff}}}{D} \right)^3 \tag{5}$$

where

S is the diametral stiffness, in kilonewtons per square metre;

E is the modulus of elasticity of the material, in megapascals (170 000 MPa);

I is the second moment of area of the pipe wall per unit length, in millimetres, to the third power;

e_{stiff} is the pipe wall thickness equal to the average of the minimum pipe wall thickness and the nominal pipe wall thickness, in millimetres;

D is the mean diameter of the pipe (DE – e_{stiff}), in millimetres;

where

DE is the nominal pipe external diameter, in millimetres (see Table 12).

7.6 Chemical resistance to effluents

Two performance tests shall be carried out on test assemblies (see Figure 4) comprising

— a pipe section with cement mortar lining, including a socket with its internal coating,

— a spigot end of a fitting with its coating, and

— a rubber gasket.

The size of the pipe section and of the spigot end of the fitting shall be DN 200. The length of the pipe section shall be (0,5 ± 0,1) m, and the length of the spigot of the fitting shall be (0,4 ± 0,1) m. The surface of cement mortar lining shall be cleaned to remove any loose particles. Before testing, the pipe section shall be preconditioned by immersion in water at ambient temperature for approximately 24 h. After preconditioning, the initial thickness of the cement mortar lining shall be measured by an electromagnetic gauge with precision to 0,1 mm. The measurements shall be located at 15 regularly spaced points along each longitude line, respectively at 5 o'clock and 7 o'clock.

The two test assemblies shall be positioned horizontally:

— the first assembly shall be filled to mid-height with a solution of sulfuric acid at pH 3;

— the second assembly shall be filled to mid-height with a solution of sodium hydroxide at pH 13.

The assemblies shall be tested with a recirculating solution at an approximate flow rate of (1 ± 0,5) l/min. The test temperature shall be (18 ± 2) °C.

The pH value shall be regularly monitored and adjusted such that the change in pH is not more than ±0,3 from the initial value.

The Ca^{++} concentration shall be regularly monitored and adjusted by addition of soft water or deionized water such that the concentration does not exceed 200 mg/l.

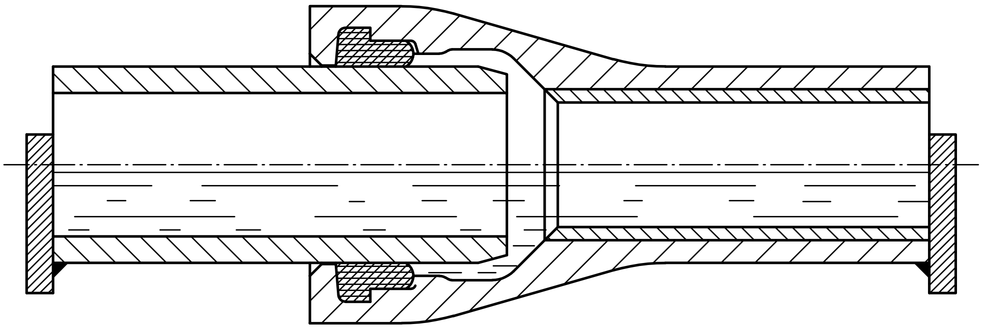


Figure 4 — Chemical resistance to effluents test

At the end of the three-month test period, the test assemblies shall be dismantled, rinsed and cleaned. At the location of lining thickness measured previously after preconditioning, the lining thickness shall be measured again. The thickness reduction shall be calculated and compared to the requirement listed in 5.4.

The necessary observations and measurements shall be carried out on the cement mortar lining, on the polymeric coatings and on the rubber gasket, to verify compliance with 5.4.

7.7 Abrasion resistance

7.7.1 Cement mortar lining

The test shall be carried out on a 1 m long DN 200 pipe sample, closed at both ends after enclosing the test material. The pipe section shall be internally brushed in order to remove the loose sand and loose mortar parts using a hard plastic brush and cleaned with compressed air.

Before testing, the cement mortar lined pipe section shall be immersed in water at ambient temperature for approximately 24 h.

The cement mortar lining thickness shall be measured along a longitudinal line located at 6 o'clock at 15 regularly spaced measurement points on each line excluding 150 mm at both ends. The location of the measurement points shall be identical before and after testing, preferably using a template. The thickness shall be measured using an electromagnetic measuring device.

The test material shall contain natural siliceous gravel to reach a level of (38 ± 2) mm above the invert with enough water to reach the same level. The gravel particle shall be of the rounded and not crushed type and shall have a size between 2 mm and 10 mm with an average of approximately 6 mm.

The pipe sample shall be fixed horizontally on a testing device capable of inclining the sample successively to an angle of +22,5° and −22,5° every 3 s to 5 s.

After 100 000 movements (or 50 000 cycles), the test assemblies shall be dismantled, rinsed and cleaned. On the pipe sample, the depth of abrasion of the cement lining shall be calculated as the difference between the average thickness on 15 points before and after testing.

7.7.2 Polymeric lining

The test shall be carried out on a 1 m long DN 200 pipe sample, closed at both ends after enclosing the test material.

The polymeric lining thickness shall be measured along a longitudinal line located at 6 o'clock at 15 regularly spaced measurement points on each line excluding 150 mm at both ends. The location of the measurement points shall be identical before and after testing, preferably using a template. The thickness shall be measured using an electromagnetic measuring device.

The test material shall contain natural siliceous gravel to reach a level of (38 ± 2) mm above the invert with enough water to reach the same level. The gravel particle shall be of the rounded and non-crushed type and shall have a size between 2 mm and 10 mm with an average of approximately 6 mm.

The pipe sample shall be fixed horizontally on a testing device capable of inclining the sample successively to an angle of +22,5° and –22,5° every 3 s to 5 s.

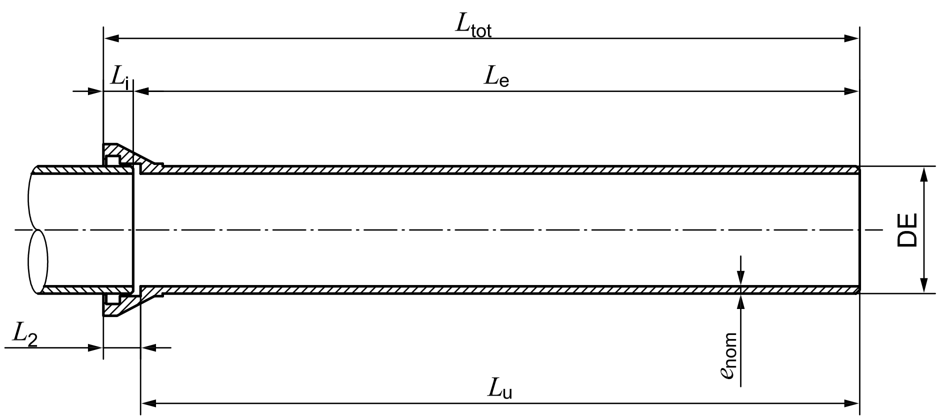
After 100 000 movements (or 50 000 cycles), the test assemblies shall be dismantled, rinsed and cleaned. On the pipe sample, the depth of abrasion of the polymeric lining shall be calculated as the difference between the average thickness on 15 points before and after testing.

8 Tables of dimensions

8.1 Socket and spigot pipes

The dimensions of the preferred pressure class and gravity socket and spigot pipes are as given in Figure 5. Wall thicknesses for pressure and gravity pipes are given in Table 12.

The values of L_u are given in Table 1.



Key

DE	nominal external diameter of spigot, in millimetres;
e_{nom}	nominal wall thickness, in millimetres;
L_2	depth of socket, in metres;
$L_e = L_{tot} - L_i$	laying length, in metres;
L_i	maximum insertion depth as given by the manufacturer, in metres;
L_{tot}	total length, in metres;
$L_u = L_{tot} - L_2$	standardized length, in metres.

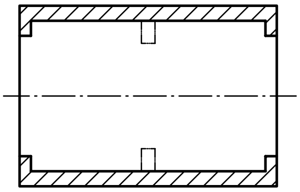
Figure 5 — Socket and spigot pipes

Table 12 — Socket and spigot pipe dimensions

DN	External diameter DE mm	Pressure sewer	Gravity sewer
80	98	4,4	3,4
100	118	4,4	3,4
125	144	4,5	3,4
150	170	4,5	3,4
200	222	4,7	3,4
250	274	4,9	4,1
300	326	5,1	4,8
350	378	5,7	5,5
400	429	6,3	
450	480	6,4	
500	532	6,5	
600	635	7,5	
700	738	8,5	
800	842	9,6	
900	945	10,6	
1000	1048	11,6	
1100	1152	12,6	
1200	1255	13,6	
1400	1462	15,7	
1500	1565	16,7	
1600	1668	17,7	
1800	1875	19,7	
2000	2082	21,8	
2200	2288	23,8	
2400	2495	25,8	
2600	2702	27,9	

8.2 Fittings for gravity applications

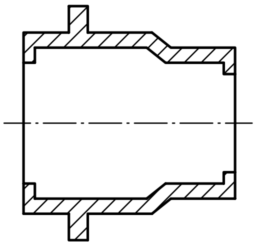
8.2.1 Collars



DN values are those from DN 80 to DN 2600.

Figure 6 — Collar

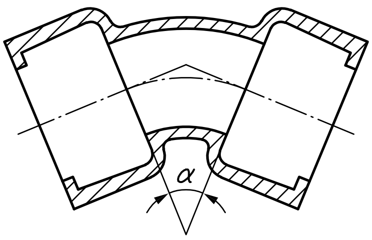
8.2.2 Manhole connectors



DN values are those from DN 150 to DN 2000.

Figure 7 — Manhole connector

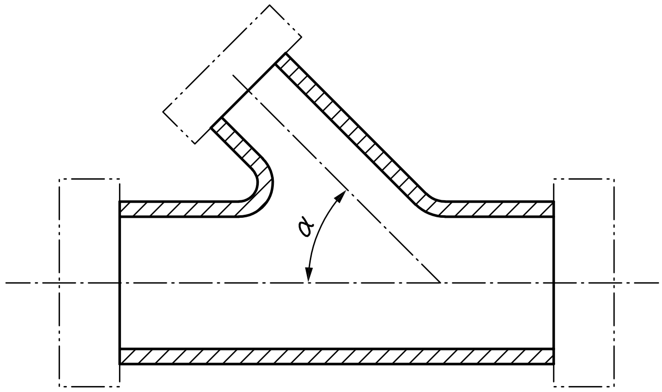
8.2.3 Double socket bends



DN values are those from DN 80 to DN 2600. The angles, α, of the bends shall be given in the manufacturer's handbook.

Figure 8 — Double socket bend

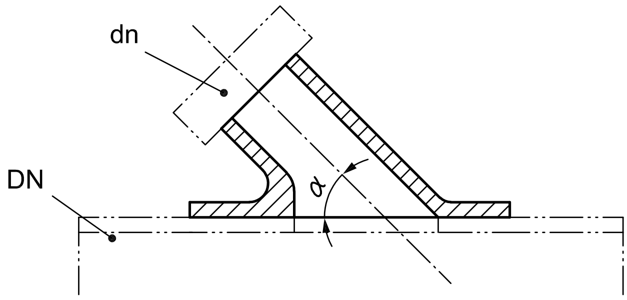
8.2.4 Angle branches



DN values are those from DN 100 to DN 500 for the body and from dn 80 to dn 250 for the branch. The various combinations DN × dn, the types of ends (socket or spigot) and the angle, α, of the branch shall be given in the manufacturer's handbook.

Figure 9 — Angle branch

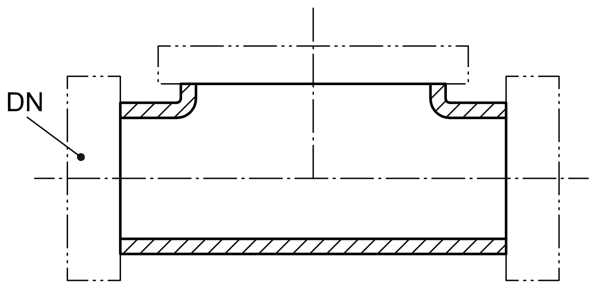
8.2.5 Connection branches



DN values are those from dn 100 to dn 250 for connection to pipes from DN 200 to DN 2600. The type of end (socket or spigot) for connection with different pipe materials shall be given in the manufacturer's handbooks, as well as the angle of the branch and the shape of the hole to be cut in the pipe (circular, square or rectangular).

Figure 10 — Connection branch

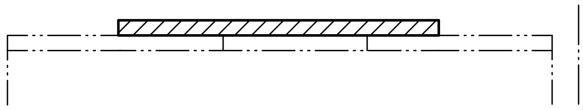
8.2.6 Inspection tees



DN values are those from DN 80 to DN 800. The type of ends (socket or spigot) shall be given in the manufacturer's handbooks as well as the shape and dimensions of the access branch.

Figure 11 — Inspection tee

8.2.7 Access traps



DN values are those from DN 150 to DN 1400. The shape and dimensions of the hole to be cut in the pipe shall be given in the manufacturer's handbooks, as well as the method of connection to the pipe.

Figure 12— Access trap

8.3 Fittings for pressure and vacuum applications

The types and dimensions of these fittings are defined in ISO 2531.

Annex A
(informative)

External protection

A.1 Factors characterizing aggressivity of external operating environments

— resistivity;

— pH;

— water table level;

— stray currents;

— corrosion cells;

— contamination.

A.2 Centrifugally cast pipe coatings for protection against aggressive external operating environments

— metallic zinc with finishing layer, in accordance with ISO 8179-1;

— zinc rich paint with finishing layer, in accordance with ISO 8179-2;

— polyethylene sleeving, in accordance with ISO 8180.

For other types of pipe coatings and their repair methods, see national standards or pipe manufacturers.

A.3 Fittings and accessory coatings for protection against aggressive external operating environments

— metallic zinc with finishing layer, in accordance with ISO 8179-1;

— zinc rich paint with finishing layer, in accordance with ISO 8179-2;

— polyethylene sleeving, in accordance with ISO 8180.

For other types of fittings and accessory coatings and their repair methods, see national standards or pipe manufacturers.

Annex B
(informative)

Internal protection

B.1 Factors characterizing aggressivity of effluent

— pH;

— temperature;

— hydrogen sulfide;

— sulfate SO_4^2;

— aggressive CO_2;

— chloride Cl^-;

— magnesium Mg^{2+};

— ammonium NH^{4+}.

B.2 Centrifugally cast pipe linings for protection against aggressive internal effluent

— cement lining, in accordance with ISO 4179.

For other types of lining and their repair methods, see national standards or pipe manufacturers.

B.3 Socket and spigot coating for protection against aggressive internal effluent

— metallic zinc with finishing layer, in accordance with ISO 8179-1;

— zinc rich paint with finishing layer, in accordance with ISO 8179-2.

For other types of coatings and their repair methods, see national standards or pipe manufacturers.

B.4 Fitting and accessory linings for protection against aggressive internal effluent

— cement lining, in accordance with ISO 4179.

For other types of lining and their repair methods, see national standards or pipe manufacturers.

Annex C
(normative)

Allowable pressure for pressure sewers

Allowable pipeline pressures relationships are specified in 4.2.3. The calculation of the minimum pipe wall thickness, as a function of allowable working pressure (PFA) and pipe external diameter (DE), is specified in 4.3.2.1.2. Table C.1 lists the relevant results.

Table C.1 — Allowable pressure for pressure sewers

DN	**Pressure class**	**Minimum thickness** mm	**DE** mm	**PFA** bar	**PMA** bar	**PEA** bar
80	C40	3	98	88	106	111
100	C40	3	118	73	88	93
125	C40	3	144	60	72	77
150	C40	3	170	50	60	65
200	C40	3,2	222	41	49	54
250	C30	3,3	274	34	41	46
300	C30	3,5	326	30	36	41
350	C30	4	378	30	36	41
400	C30	4,6	429	30	36	41
450	C25	4,6	480	27	32	37
500	C25	4,7	532	25	30	35
600	C25	5,6	635	25	30	35
700	C25	6,5	738	25	30	35
800	C25	7,5	842	25	30	35
900	C25	8,4	945	25	30	35
1000	C25	9,3	1048	25	30	35
1100	C25	10,2	1152	25	30	35
1200	C25	11,1	1255	25	30	35
1400	C25	13,0	1462	25	30	35
1500	C25	13,9	1565	25	30	35
1600	C25	14,8	1668	25	30	35
1800	C25	16,6	1875	25	30	35
2000	C25	18,5	2082	25	30	35
2200	C25	20,3	2288	25	30	35
2400	C25	22,1	2495	25	30	35
2600	C25	24,0	2702	25	30	35

Bibliography

[1] ISO 4179:2005, *Ductile iron pipes and fittings for pressure and non-pressure pipelines — Cement mortar lining*

[2] ISO 6708:1995, *Pipeworks components — Definition and selection of DN (nominal size)*

[3] ISO 7268, *Pipe components — Definition of nominal pressure*

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

[5] ISO 8179-2, *Ductile iron pipes — External zinc coating — Part 2: Zinc rich paint with finishing layer*

[6] ISO 8180, *Ductile iron pipelines — Polyethylene sleeving for site application*

[7] ISO 9001, *Quality management systems — Requirements*

[8] ISO 10803, *Design method for ductile iron pipes*

[9] ISO 16132, *Ductile iron pipes and fittings — Seal coats for cement mortar linings*

ICS 77.140.80; 93.030
Price based on 36 pages