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Ductile iron pipes, fittings, accessories and their joints compatible with plastic (PVC or PE) piping systems, for water applications and for plastic pipeline connections, repair and replacement

Tuyaux, raccords et accessoires en fonte ductile et leurs assemblages compatibles avec les canalisations plastiques (PVC ou PE) pour la distribution d'eau et pour les connexions, réparations et remplacements des canalisations en matières plastiques

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 5, *Ferrous metal pipes and metallic fittings*, Subcommittee SC 2, *Cast iron pipes, fittings and their joints*.

Ductile iron pipes, fittings, accessories and their joints compatible with plastic (PVC or PE) piping systems, for water applications and for plastic pipeline connections, repair and replacement

1 Scope

This International Standard specifies the requirements and test methods applicable to ductile iron pipes, fittings, accessories and their joints with dimensions compatible with plastic (PVC or PE) piping systems:

— to replace or repair existing plastic pipelines;

— to convey water (e.g. for human consumption, raw water, etc.);

— operated with or without pressure;

— installed below or above ground;

— defined according to their external diameter (DN/OD series);

— classified according to pressure (C class).

The pressure class specified in this International Standard is C25. This pressure resistance level will meet or exceed those of plastic pipes. These ductile iron pipes, fittings, accessories and joints can be used along with plastic pipelines, where they are needed (for example, with higher pressure rating sections, higher traffic load, etc.), for the construction of water pipelines.

The dimensions of the products according to this International Standard, in the size range DN/OD 50 to DN/OD 225, are compatible with those of plastic pipes (ISO 1452-2 for PVC and ISO 4427-2 for PE). The spigots of plastic pipes used for water applications can be inserted into sockets of pipes manufactured according to this International Standard. The spigots and sockets of products defined in this International Standard are not dimensionally compatible with the products defined in ISO 2531.

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

This International Standard covers 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/OD 50 to DN/OD 225 inclusive.

It is applicable to pipes, fittings and accessories which are

— manufactured with socketed or spigot ends for jointing by means of various types of gaskets (which are not within the scope of this International Standard), and

— compulsory delivered internally and externally coated.

This International Standard is also applicable to socketed fittings which include flanged connections.

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

1) 100 kPa = 1 bar.

2 Normative references

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

ISO 1167-1:2006, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 1: General method*

ISO 1452-2, *Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure — Unplasticized poly(vinyl chloride) (PVC-U) — Part 2: Pipes*

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

ISO 4016, *Hexagon head bolts — Product grade C*

ISO 4034, *Hexagon regular nuts (style 1) — Product grade C*

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

ISO 4427-2, *Plastics piping systems — Polyethylene (PE) pipes and fittings for water supply — Part 2: Pipes*

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*

ISO 6892-1, *Metallic materials —Tensile testing — Part 1: Method of test at room temperature*

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

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

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

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

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

ISO 10802, *Ductile iron pipelines — Hydrostatic testing after installation*

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

ISO 13846, *Plastics piping systems — End-load-bearing and non-end-load-bearing assemblies and joints for thermoplastics pressure piping — Test method for long-term leaktightness under internal water pressure*

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

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

3.2
pipe
casting of uniform bore, with straight axis, having either socket, spigot or flanged ends, except for flanged sockets, flanged spigots and collars which are classified as fittings

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

Note 1 to entry: In addition, flanged sockets, flanged spigots, flange adaptors and collars are also classified as fittings.

3.4
accessory
component other than a pipe or fitting, which is used in a pipeline, such as

— glands and bolts for *mechanical flexible joints* (3.14), and

— glands, bolts and locking rings or segments for *restrained joints* (3.15).

Note 1 to entry: Valves and hydrants of all types are not covered by the term accessory.

3.5
component
product defined in 3.2 to 3.4

3.6
flange
end of a pipe or fitting, extending perpendicular to its axis, with bolt holes equally spaced on a circle

Note 1 to entry: A flange may be fixed (e.g. integrally cast, threaded-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 pipe axis before jointing.

3.7
spigot
male end of a pipe or fitting

3.8
spigot end
maximum insertion depth of the spigot plus 50 mm

3.9
socket
female end of a pipe or fitting to make the connection with the spigot of the next component

3.10
gasket
sealing component of a joint

3.11
joint
connection between the ends of pipes and/or fittings in which a gasket is used to effect a seal

3.12
flexible joint
joint which provides significant angular deflection and movement parallel and/or perpendicular to the pipe axis

3.13
push-in flexible joint
flexible joint assembled by pushing the spigot through the gasket into the socket of the mating component

3.14
mechanical flexible joint
flexible joint in which sealing is obtained by applying pressure to the gasket by mechanical means, e.g. a gland

3.15
restrained joint
joint in which a means is provided to prevent separation of the assembled joint

3.16
flanged joint
joint between two flanged ends

3.17
nominal size
DN/OD
alphanumerical designation of size for components of a pipework system, which is used for reference purposes

Note 1 to entry: It comprises the letters DN/OD followed by a dimensionless whole number which is indirectly related to the physical size, in millimetres, of the outside diameter of the end connections.

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

Note 1 to entry: 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.

[SOURCE: ISO 6708:1995, 2.1, modified]

3.19
nominal pressure
PN
numerical designation expressed by a number which is used for reference purposes

Note 1 to entry: All components of the same nominal size DN/OD designated by the same PN number have compatible mating dimensions (see ISO 7268).

3.20
allowable operating pressure
PFA
maximum internal pressure, excluding surge, that a component can safely withstand in permanent service and designated, C

3.21
maximum allowable operating pressure
PMA
maximum internal pressure, including surge, that a component can safely withstand in service

3.22
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 1 to entry: This test pressure is different from the system test pressure which is related to the design pressure of the pipeline.

3.23
diametral stiffness of a pipe
characteristic of a pipe which allows it to resist diametral deflection under loading

3.24
longitudinal bending resistance
characteristic of a pipe which allows it to resist bending deformations under loading when installed

3.25
batch
quantity of castings from which a sample may be taken for testing purposes during manufacture

3.26
type test
proof-of-design test which is done once and is repeated only after change of design

3.27
laying length of a socket and spigot pipe
laying length L_e, equal to the overall length of pipe (L_{tot}) minus the maximum spigot insertion depth (L_i) as given by the manufacturer and as shown in Figure 4

3.28
standardized length
standardized length of socketed pipes and fittings (L_u or l_u for branches) is equal to the overall length L_{tot} minus the depth of socket (L_2) as indicated in the manufacturer's catalogues, as shown in Figure 5 for pipes and Figure 6 to 14 for fittings

3.29
spigot end
maximum insertion depth of the spigot plus 50 mm

3.30
deviation
amount by which the design length may differ from the standardized length of a pipe or a fitting

Note 1 to entry: Pipes and fittings are designed to a length selected in the range of standardized length plus or minus the deviation. They are manufactured to this length plus or minus the tolerance (see 8.1.4).

3.31
ovality
out of roundness of a pipe section, equal to:

$$100\,\frac{\left(A_1 - A_2\right)}{\left(A_1 + A_2\right)}$$

where

A_1 is the maximum axis of the pipe cross-section, in millimetres;

A_2 is the minimum axis of the pipe cross-section, in millimetres.

3.32
hoop stress
σ
stress in a pipe or fitting under pressure, acting tangentially to the perimeter of a transverse section

3.33
thickness
e_{nom}
nominal thickness of a pipe or a fitting

3.34
minimum thickness
nominal thickness of a pipe or a fitting minus the manufacturing tolerance

4 Technical requirements

4.1 General

General requirements, pressure classification and dimensional requirements, material characteristics, coatings and linings, marking and packaging and handling are specified in 4.2, 4.3, 4.4, 4.5, 4.6, 4.7 and 4.8, respectively.

When, by agreement between the manufacturer and the purchaser, pipes and fittings, with different pressure classes, lengths and/or coatings and other types of fittings are supplied with reference to this International Standard, they shall comply with all the other requirements of this International Standard.

4.2 General requirements

4.2.1 Pipes and fittings nominal sizes

The standardized nominal sizes DN/OD of pipes and fittings are as follows according to ISO 161-1:

— 50, 63, 75, 90, 110, 125, 140, 160, 180, 200 and 225.

4.2.2 Surface condition

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

Repairs which affect the wall thickness are not allowed. Pipe whose wall thickness is below the local minimum thickness required, after repair, shall be rejected.

4.2.3 Types of joints and interconnection

4.2.3.1 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 water applications. When materials other than rubber are necessary, they shall conform to the appropriate ISO standards.

4.2.3.2 Flexible joints

Pipes and fittings with flexible joints shall be in accordance with 4.3.2 for their spigot ends 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 leaktightness requirements of Clause 5.

4.2.3.3 Restrained joints

Restrained joints for ductile iron pipelines shall be designed in accordance with ISO 10804. Their spigot ends external diameters DE and their tolerances shall comply with 4.3.2.

4.2.3.4 Flanged joints

4.2.3.4.1 General

Flanged joints designed according to this International Standard meet the performance requirements of ISO 2531.

By agreement between the manufacturer and supplier, special socketed pipes for welding can be identified and delivered.

4.2.3.4.2 All flanged pipes and fittings

Flanged pipe and flanged fittings, in which all connections ends are flanges, are in conformity with ISO 2531. Flanges are in conformity with ISO 7005-2.

NOTE No other specification to all flanged components will be given in this International Standard; reference documents are ISO 2531 and ISO 7005-2.

4.2.3.4.3 Fittings with DN/OD dimensions including flanges

Fittings including flanges shall be classified by PN number.

Flange joints shall be designed such that they can be attached to flanges whose dimensions and tolerances comply with ISO 7005-2. This ensures interconnection between all flanged components (pipes, fittings, valves, etc.) of the same flange DN and PN and adequate joint performance.

Bolts and nuts shall comply as a minimum with the requirements of ISO 4016 and ISO 4034, grade 4.6, where washers are required that they shall comply with ISO 7091.

Although it does not affect interconnection, the manufacturer shall indicate in his catalogue whether the products are normally delivered with fixed flanges or loose (or rotatable) flanges.

4.2.4 Materials in contact with water intended for human consumption

When used under the conditions for which they are designed, in permanent or in temporary contact with water intended for human consumption, ductile iron pipes, fittings and their joints shall not have detrimental effects on the properties of that water for its intended use.

Ductile iron pipeline systems, including pipes, fittings and accessories, are comprised of various materials. When used for conveying water intended for human consumption, the materials in contact with water shall meet the relevant requirements of the national standards or regulations in the country of use with respect to effect on water quality.

The following are the materials in contact with water:

— internal linings of the pipes and the fittings;

— internal linings of the socket of the pipes and fittings;

— external coating of the spigot, including the spigot end;

— external coating of the chamfer;

— gasket material.

4.3 Pressure classification and dimensional requirements

4.3.1 Pressure classification

4.3.1.1 General

Components with flexible joints shall be classified by the allowable operating pressure in bar (PFA), prefixed by the letter C.

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

4.3.1.2 Pressure class

The pressure class of components with flexible joints is C25.

Allowable pipeline pressures shall be as follows:

— allowable operating pressure (PFA) = C = 25 bar;

— maximum allowable operating pressure (PMA) = 1,2 × PFA = 30 bar;

— allowable site test pressure (PEA) = PMA + 5 = 35 bar.

4.3.1.3 Allowable pressures of components with flanged joints

Allowable pressures of components are as given in Table 1.

Table 1 — Allowable pressures of components with flanged joints

Pressure class PN	Allowable operating pressure PFA bar	Maximum allowable operating pressure PMA bar	Allowable site test pressure PEA bar
10	10	12	17
16	16	20	25
25	25	30	35

Appropriate limitations shall be taken into account, which can prevent the full range of these pressures being used in an installed pipeline. For example, operation at the PFA values may be limited by the lower pressure capability of other pipeline components, e.g. flanged pipework, certain types of tees and specific designs of flexible joints. When other limitations exist due to the joint type or to any specific design arrangement, they shall be given in the manufacturer's handbook or catalogues.

4.3.2 Diameter

Table 10 specifies the values of the external diameter, DE, and positive and negative tolerances of the spigot end of pipes, when measured as specified in 6.1.1.

The external diameter of the pipe barrel shall be such as to allow the assembly of the joint over at least two thirds of the pipe length from the spigot end to allow the pipe to be cut on site.

Table 16 gives the values of the external diameter, DE, and positive and negative tolerances of the spigot end of flanged spigot fittings, when measured as specified in 6.1.1.

The values given in Table 16, for flanged spigot, allow inserting spigot end in PVC and PE pipes sockets in compliance with ISO 1452-2 and ISO 4427-2. Ductile iron pipe spigot end in accordance with this International Standard shall not be directly inserted in PVC and PE pipes sockets in compliance with ISO 1452-2 and ISO 4427-2 (refer to Annex F).

4.3.3 Wall thickness

The wall thickness of the pipes shall be in conformity with Table 11 and Table 14 for fittings, when measured in accordance with 6.1.2.

The manufacturing tolerance on nominal pipe wall thickness shall be less than 0,8 mm. The minimum thickness can only appear locally at a few distinct points, not along the length or the circumference of the pipe.

The manufacturing tolerance on nominal fitting wall thickness shall be less than 1,0 mm.

NOTE These thicknesses are defined in order

— to reach the characteristics of C25 components as specified in 4.3.1.2 and using the design procedure specified in ISO 10803, and

— to manufacture components using the state of the art of casting technologies (refer to Bibliography).

4.3.4 Length

4.3.4.1 Socket and spigot pipes

Pipes shall be supplied to the standardized lengths given in Table 12.

4.3.4.2 Fittings

Fittings shall be supplied to the lengths as given in Tables 15 to 22 except that alternatively, socket fittings may be supplied to the lengths of the national standard of the country of manufacture.

4.3.5 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 case of dispute, the deviation shall be measured in accordance with 6.2.

4.4 Material characteristics

4.4.1 Tensile properties

Pipes, fittings and accessories made of ductile iron shall have the tensile properties given in Table 2.

Table 2 — Tensile properties

Type of casting	**Minimum tensile strength**, *Rm* MPa	**Minimum elongation after fracture,** *A* %
Pipes centrifugally cast	420	10
Fittings	420	5

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

— 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 in accordance with 6.3, or

— a system of process control testing (e.g. non-destructive) where a positive correlation can be demonstrated with the tensile properties specified in Table 2. 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.

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 in accordance with 6.4.

The Brinell hardness shall not exceed 230 HBW for centrifugally cast pipes and 250 HBW for not 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 delivered externally coated and internally lined.

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 aggressiveness. Relevant factors are given in A.1.

In its basic version, the ductile iron pipes shall be delivered with an enhanced corrosion protection than the ones specified in ISO 8179-1 and ISO 8179-2, i.e. equivalent or superior than 200 g/m^2 of pure zinc (refer to A.2).

These external coatings shall comply with the corresponding existing International Standards or, where no International Standards exist, they shall comply with national standards or with an agreed technical specification.

The joint areas are generally coated as follows:

— external surface of spigot ends: same as external pipe coating;

— sockets (face and internal surface): synthetic resin paint, alone or as a supplement to a primer or zinc coating.

External coatings repairs shall be carried out in accordance with ISO 2531 and the manufacturer's instructions.

4.5.3 Internal linings

Ductile iron pipeline systems can be used to convey a wide range of raw waters and potable waters. These internal environments can be characterized according to their aggressiveness. Relevant factors to be considered for cement mortar linings are given in B.1.

If cement mortar lining is used to line the pipes, it shall be in accordance with ISO 4179.

Other internal linings can be specified in agreement with the purchaser provided that they ensure equal or better corrosion protection than cement mortar lining. These internal linings requirements shall comply with the corresponding existing International Standards or, where no International Standards exist, they shall comply with national standards or with an agreed technical specification.

Internal linings repairs shall be carried out in accordance with ISO 2531 and the manufacturer's instructions.

4.6 Coatings and linings for fittings and accessories

Fittings and accessories shall be delivered internally and externally coated.

These external coatings and internal linings shall comply with the corresponding existing International Standards (refer to Annexes A and B) or, where no International Standards exist, they shall comply with national standards or with an agreed technical specification.

Metallic parts of accessories made from metal other than ductile iron shall have a corrosion resistance at least equal to the coated ductile iron parts. The corrosion resistance may be attained from the material itself or a suitable coating protection system.

4.7 Marking

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

— the manufacturer's name or mark;

— the identification of the year of manufacture;

— the identification as ductile iron;

— DN/OD and DN for flanged components;

— the PN rating of flanges when applicable;

— the C pressure class of socket and spigot pipe;

— the longitudinal bending strength of the pipe only;

— the reference to this International Standard.

The first five markings above shall be cast-on or cold stamped. The last three indications can be applied by any method, e.g. painted on the castings.

"DN/OD" shall be marked near the numerical value of the DN/OD.

Proof of the durability of the marking shall be provided by the manufacturer.

4.8 Packaging and handling

Pipes shall be delivered in bundles. In the case of orders smaller than the content of a bundle, unbundled delivery is permitted. The manufacturer shall give information in its documentation on the bundle design for each DN/OD.

Fittings shall be transported in lattice box pallets. Order-picking onto disposable pallets for deliveries to installation sites is permissible. Separate parts or articles which will not fit into a lattice box pallet are to be order-picked onto pallets and transported on them. Any projection beyond the edges of pallets shall be avoided.

The stacking and arrangement shall ensure that pipes and fittings cannot damage one another during transportation, stocking and handling.

Pipes and fittings socket end and spigot end shall be closed off with the appropriate protective caps.

5 Leaktightness requirements

5.1 Pipes and fittings

Pipes and fittings shall be designed to be leaktight at their allowable site test pressure (PEA). They shall be tested in accordance with 6.5 and shall exhibit no visible leakage, sweating or any other sign of failure.

5.2 Flexible joints

5.2.1 General

The leaktightness of the flexible joint shall be proven in the two following configurations:

— ductile iron socket assembled with ductile iron spigot end (see 5.2.2);

— ductile iron socket assembled with plastic spigot end (see 5.2.3).

All flexible joints for ductile iron pipes and components shall be designed in compliance with the requirements of 5.2.2. 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 7.1.1 for internal pressure, in accordance with 7.1.2 for external pressure and in accordance with 7.1.3 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 castings tolerances and joint movements.

There shall be a type test for at least one DN/OD for each of the groupings given in Table 3. One DN/OD is representative of a grouping when the performances are based on the same design parameters throughout the size range.

Table 3 — DN/OD groupings for type tests

DN/OD groupings	50 to 125	140 to 225
Preferred DN/OD in each grouping	110	160

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

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

Gaskets designs may be different according to the material of the spigot end (ductile iron, PVC or PE).

5.2.2 Ductile iron socket assembled with ductile iron spigot end

5.2.2.1 General

The allowable angular deflection per joint declared by the manufacturer shall be not less than those given in Table 4.

Table 4 — Minimum allowable angular deflection

DN/OD range	Non-restrained joints	Restrained joints
DN/OD 50 - 225	4°	2°

All non-restrained joints shall be designed to provide axial movement; thereby, the allowable withdrawal shall be declared by the manufacturer.

NOTE This permits the installed pipeline to accommodate ground movements and/or thermal effects without incurring additional stresses.

5.2.2.2 Test parameters

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 plus 0 % minus 5 %. 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 type tested with a spigot having an average iron wall thickness (over a distance of 2 × DN/OD, in mm from the spigot end face) equal to the specified local minimum value for the pipe for which the joint is designed plus 10 %, minus 0 %. It is permissible to machine the spigot end of the pipe bore to achieve the required thickness.

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

5.2.2.3 Internal pressure

The leaktightness of joints to internal pressure shall be type tested in accordance with 7.1.1 at a test pressure which shall be not less than their allowable test pressure 1,5 × PFA + 5; the joints shall exhibit no visible leakage in the two following positions:

— joint aligned and subjected to shear: the shear force across the joint, expressed in N, shall be not less than 30 × DN/OD;

— joint deflected: the test angular deflection shall be the maximum allowable deflection indicated in the manufacturer's catalogue, but not less than 4° for DN/OD 50 to DN/OD 225.

5.2.2.4 External pressure

The leaktightness of joints to external pressure shall be type tested in accordance with 7.1.2; the joints shall exhibit no visible leakage when subjected to a shear load, expressed in newton, not less than 30 × DN/OD.

The test pressure shall be not less than 2 bar.

5.2.2.5 Negative internal pressure

The leaktightness of joints to negative internal pressure shall be type tested in accordance with 7.1.3 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 two following positions:

— joint aligned and subjected to shear: the shear force across the joint, expressed in N, shall not be less than 30 × DN/OD;

— joint deflected: the test angular deflection shall be the maximum allowable deflection indicated in the manufacturer's catalogue but not less than 4° for DN/OD 50 to DN/OD 225.

5.2.3 Ductile iron socket assembled with plastic spigot end

5.2.3.1 General

The allowable angular deflection per joint declared by the manufacturer shall be not less than those given in Table 5.

Table 5 — Minimum allowable angular deflection

DN/OD range	Push in joints and mechanical restrained joints	Mechanical non-restrained joints
DN/OD 50 - 225	1°30'	3°30'

All non-restrained joints shall be designed to provide axial movement; thereby, the allowable withdrawal shall be declared by the manufacturer.

NOTE This permits the installed pipeline to accommodate ground movements and/or thermal effects without incurring additional stresses.

The manufacturer shall declare the lowest and the highest pipe pressure class for which the fitting is intended to be used.

The leaktightness shall be tested at short term as specified in 5.2.3.2 and long term as specified in 5.2.3.3.

5.2.3.2 Short-term leaktightness

5.2.3.2.1 Test conditions

All joint designs shall be type tested with the lowest and the highest PVC and PE pipe pressure class as declared by the manufacturer. Where supporting sleeves (inserts) are required for joints for PE pipes, it shall be clearly stated and such supports shall be included in the test assembly. The tests results shall record the PE grade diameter and SDR rating. The following conditions of tolerance and joint movement are applicable:

a) joint of maximum annulus (see 5.2.3.2.2.1), aligned, withdrawn to the allowable value declared by the manufacturer, and subjected to shear (see 5.2.3.2.2.2);

b) joint of maximum annulus (see 5.2.3.2.2.1), deflected to the allowable value declared by the manufacturer (see 5.2.3.1).

The application of a shear load, as stated in 5.2.3.2.2.1, is only required for PVC pipes.

The joints shall exhibit no visible leakage when subjected to the following tests:

— test 1: positive internal hydrostatic pressure in accordance with 7.2.2; the test pressure shall be (1,5 p) bar, where p is the allowable operating pressure (PFA) of the joint declared by the manufacturer;

— test 2: negative internal pressure in accordance with 7.2.3 of 0,8 bar below atmospheric pressure (approximately 0,2 bar absolute pressure).

Table 6 summarizes the test requirements and the test conditions given in 5.2.3.2.

Table 6 — Summary of test conditions

Test	Test requirement	Test conditions[1] PVC pipes	Test conditions[1] PE pipes
Positive internal hydrostatic pressure	- Test pressure: 1,5 × PFA - Test duration: 2 h - no leakage	- joint of maximum annulus, aligned, withdrawn, and subjected to shear load	- joint of maximum annulus, aligned, withdrawn
		- joint of maximum annulus, deflected	- joint of maximum annulus, deflected
Negative internal pressure	- Test pressure: -0,8 bar - Test duration: 2 h - maximum pressure change : 0,08 bar	- joint of maximum annulus, aligned, withdrawn, and subjected to shear load	- joint of maximum annulus, aligned, withdrawn
		- joint of maximum annulus, deflected	- joint of maximum annulus, deflected

[1] Test temperature is comprised between 15 °C and 25 °C.

5.2.3.2.2 Test parameters

5.2.3.2.2.1 Annulus

All joints shall be type tested at the extremes of manufacturing tolerance such that the annular gap between the sealing surfaces of the socket and of the spigot is equal to the maximum design value plus 0 %, minus 5 %. It is permissible to machine socket internal surfaces to achieve the required annulus for the type test even though the resultant diameter can be slightly outside the normal manufacturing tolerance.

5.2.3.2.2.2 Shear

When applicable, joints shall be type tested with a resultant shear force across one joint of not less than 10 × DN/OD in newton, taking into account the weight of the pipe and of its contents and the geometry of the test assembly (see 7.2.2).

5.2.3.2.2.3 Restrained flexible joints

All restrained joint designs shall be type tested in accordance with 7.2.2 and 7.2.3 following the requirements of 5.2.3.2.1 and 5.2.3.2.2 except that

— the withdrawal condition shall not apply, and

— there shall be no external axial restraint in positive internal pressure tests so that the joint is subjected to the full end thrust.

During the positive internal pressure tests, the axial movement shall reach a stable value and cease.

When the restraining mechanism and the sealing component of the restrained joint are independent, such a joint need not be subjected to test 2 of 5.2.3.2.1 if the unrestrained version of the joint has passed this test.

5.2.3.3 Long-term hydrostatic strength test

5.2.3.3.1 PE pipes

5.2.3.3.1.1 Leaktightness

This test is applicable to restrained joints for PE pipe.

When tested by the method described in 7.2.4, the jointed assembly shall not leak nor shall the pipe fracture when subjected to the test pressures resulting from the stresses given in the following test options:

a) PE 100 pipes:

   1) temperature 80 °C with a circumferential stress of 5,3 N/mm^2 for 165 h;

   2) temperature 80 °C with a circumferential stress of 5,0 N/mm^2 for 1 000 h;

   3) temperature 60 °C with a circumferential stress of 6,8 N/mm^2 for 165 h;

   4) temperature 60 °C with a circumferential stress of 6,5 N/mm^2 for 1 000 h;

   5) temperature 50 °C with a circumferential stress of 7,8 N/mm^2 for 165 h;

   6) temperature 50 °C with a circumferential stress of 7,4 N/mm^2 for 1 000 h.

b) PE 80 pipes:

   1) temperature 80 °C with a circumferential stress of 4,3 N/mm^2 for 165 h;

2) temperature 80 °C with a circumferential stress of 4,1 N/mm^2 for 1 000 h;

3) temperature 60 °C with a circumferential stress of 5,5 N/mm^2 for 165 h;

4) temperature 60 °C with a circumferential stress of 5,2 N/mm^2 for 1 000 h;

5) temperature 50 °C with a circumferential stress of 6,3 N/mm^2 for 165 h;

6) temperature 50 °C with a circumferential stress of 6,0 N/mm^2 for 1 000 h.

The pressure to be applied for the options (1) to (6) shall be calculated using Formula (1):

$$P = (20\sigma) \times [e_{nom}/(DE - e_{nom})] \quad (1)$$

where

P is the test pressure, in bars;

σ is the circumferential stress to be induced by the test pressure (1) to (6), in megapascal.

If after the test period the sample has not failed, the test shall be discontinued and the sample subjected to the test as detailed in 5.2.3.3.1.2.

5.2.3.3.1.2 Pull out test at 25 °C

After having been subjected to the requirements of 5.2.3.3.1.1, the assembly shall be tested by the method described in 7.2.5.

The pipe shall not fracture within the jointed assembly. Whilst initial movement of the pipe within the joint is allowed, no further such movement is permitted after the test loads calculated from Formula (2) has been attained:

$$F = [1{,}2 \times p \times \pi \times (DE)^2] \times 10^{-4}/4 \quad (2)$$

where

F is the longitudinal test force to be applied, in kilonewtons;

1,2 is the safety factor;

p is the maximum working pressure (PFA) of the pipe, in bars;

DE is the external diameter, in millimetres.

5.2.3.3.2 PVC pipes

This test is applicable to both non-restrained and restrained joints for PVC pipe.

When tested by the method described in 7.2.6, the jointed assembly shall not leak at any point of the jointing areas during the test period when subjected to the test pressure from one of the following test options:

a) pipe with a design stress of 10 MPa:

1) temperature 20 °C for 1 000 h; test pressure = 1,7 p;

2) temperature 40 °C for 1 000 h; test pressure = 1,3 p;

b) pipe with a design stress of 12,5 MPa:

1) temperature 20 °C for 1 000 h; test pressure = 1,65 p;

2) temperature 40 °C for 1 000 h; test pressure = 1,3 p.

where

p is the nominal pressure rating of the pipe/fitting, in bar.

6 Test methods

6.1 Dimensions

6.1.1 External diameter

The external diameter of the pipe barrel shall be measured with a circumferential tape.

Pipes with sockets and spigot ends shall be measured at their spigot end 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 end for compliance with the ovality tolerance and, in case of doubt, checked by measurement of the maximum and minimum axes. This control may also be carried out by 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 and fittings thicknesses 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.

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

6.2 Straightness of pipes

The pipe shall be rolled on two supports or rotated along its axis on rollers, which in each case are separated by at least two thirds of the standardized 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 specified in 4.3.5.

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

6.3 Tensile test

6.3.1 Centrifugally cast pipes

A sample shall be cut from the pipe. This sample may be cut perpendicular to or parallel with the pipe axis.

6.3.2 Fittings and accessories

Samples shall be taken, at the manufacturer's option, 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.

6.3.3 Test bar

A test bar, in conformity with ISO 6892-1, shall be machined from each sample to be representative of the metal.

6.3.4 Equipment and test method

The tensile testing machine shall have suitable holders or grips to attach to the test bar ends so as to positively apply 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 MPa per second to 30 MPa 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.

6.3.5 Test results

Test results shall comply with Table 2.

6.3.6 Test frequency

The frequency of testing is related to the system of production and quality control used by the manufacturer. The maximum batch sizes shall be as given in Table 7.

Table 7 — Maximum batch size for tensile testing

Type of casting	DN/OD	Maximum batch size	
		Batch sampling system	Process control testing system
Centrifugally cast pipes	DN/OD 50 to 225	200 pipes	1 200 pipes
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, they shall be performed either on the casting in dispute or on a sample cut from the casting. The surface to be tested 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 1,0 mm or 2,5 mm or 5,0 mm diameter.

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

6.5 Works leaktightness test of pipes and fittings

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 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 Centrifugally cast pipes

The internal hydrostatic pressure shall be raised until it reaches the works hydrostatic test pressure given in Table 8. The total duration of the pressure cycle shall be not less than 15 s, including 10 s at the test pressure.

Table 8 — Works hydrostatic pressure test for pipes

Pressure class C	Works pressure test PFA bar
C25	35

6.5.3 Fittings

At the manufacturer's option, fittings shall be submitted to a hydrostatic pressure test or air test.

When the hydrostatic pressure test is carried out, it shall be undertaken in the same way as for centrifugally cast pipes, except for the test pressures, which shall be as given in Table 9.

Table 9 — Works hydrostatic pressure test for fittings and accessories

DN/OD	Fittings and accessories
DN/OD 50 to 225	25[a]
[a] 16 bar for pipes and fittings with PN 10 flanges.	

When the air test is carried out, it shall be with an internal pressure of at least 1 bar and a visual inspection time 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. All necessary safety precautions should be taken for the duration of the pressure test.

7 Type tests

7.1 Type tests on ductile iron spigot ends

7.1.1 Leaktightness of joints to internal pressure

This type test shall be carried out on an assembled joint comprising two pipe sections at least 1 m long each (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/OD in millimetre or 200 mm from the socket face (whichever is the largest); 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 5.2.3.2.2.2, taking into account the mass M of the pipe and its contents and the geometry of the test assembly:

$$W = \frac{F \times c - M\,(c - b)}{c - a} \tag{3}$$

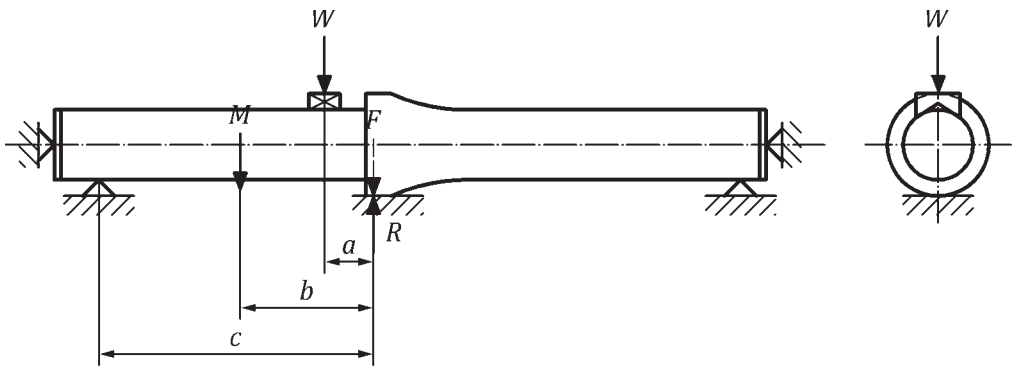
where

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 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 5.2.2; 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.

CAUTION — All necessary safety precautions should be taken for the duration of the pressure test.

7.1.2 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 to test one joint under internal pressure and one joint under external pressure (see Figure 2).

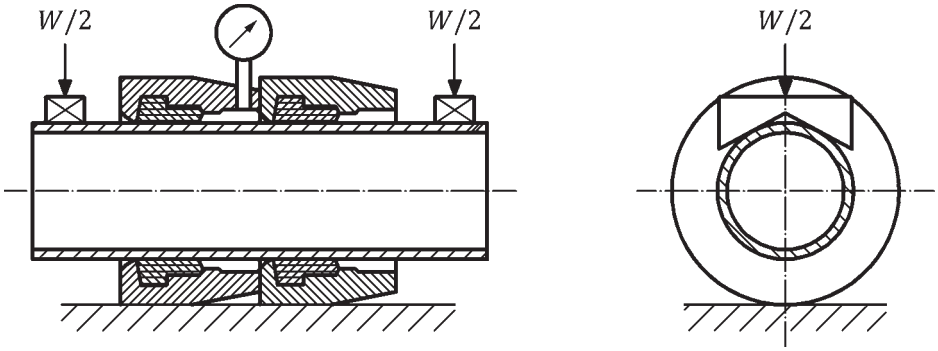


Figure 2 — Leaktightness of joints (external pressure)

The test assembly shall be subjected to the shear load defined in 5.2.2.4; 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/OD in millimetres or 200 mm from the end of sockets (whichever is the largest); the sockets shall bear on a flat support.

The test assembly shall then be filled with water and suitably vented of air. The pressure shall be steadily increased until it reaches the test pressure given in 5.2.2.4 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.

7.1.3 Leaktightness of joints to negative internal pressure

The test assembly and test apparatus shall be as given in 7.1.1 with the pipe sections axially restrained to prevent them from 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 5.2.2.5) 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.

7.2 Type tests on plastic spigot ends

7.2.1 General

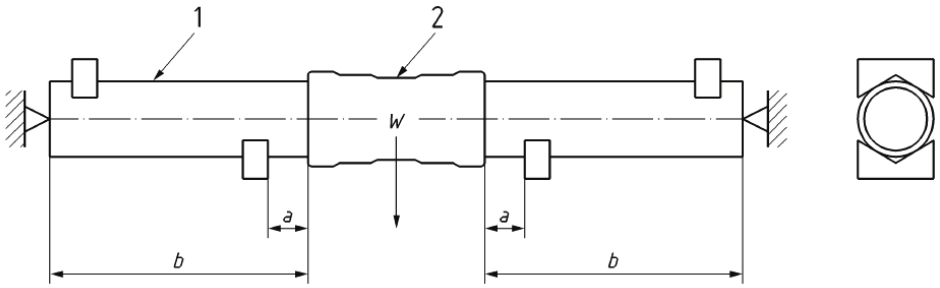
Tests on plastic pipes shall be realized according to ISO referenced standards.

7.2.2 Leaktightness of joints to internal hydrostatic pressure

7.2.2.1 Couplings and two sockets fittings

The test shall be carried out on an assembled joint comprising a fitting, including sockets, and two plastic pipes section (see Figure 3).

The test apparatus shall be capable of providing suitable end and lateral restraints whether the joint is in the aligned position, deflected or subjected to a shear load. It shall be equipped with a pressure gauge with accuracy in relation to the range of measured pressures of ≤3 %.



Key

1 plastic pipe section
2 ductile iron fitting
a distance between block support and socket face
b length of pipe section
W vertical force

Figure 3 — Internal hydrostatic testing for couplings and two sockets fittings

The testing equipment shall be as shown in Figure 2. The plastic pipes shall be supported by means of V-shaped blocks with an angle of (120 ± 10)°, located at a distance, *a*, of 0,2 DN/OD in mm from the socket face and up to a maximum of 50 mm. The length of each pipe section, *b*, shall be at least 2 DN/OD in mm and with a minimum of 1 m. The vertical force, *W*, shall be applied to the fitting. The vertical force, *W*, shall be such that the resultant shear force, *F*, across the joints is equal to the value specified in 5.2.3.2.2.2 taking into account the mass, *M*, of the fitting and its contents and the geometry of the test assembly, as given in Formula (4):

$$W = 2F - M \tag{4}$$

where

F is the resultant shear force;

W is the vertical force.

The test assembly shall be filled with water and suitably vented of air. The test shall not begin before the temperature of the test assembly has stabilized between 15 °C and 25 °C. The pressure shall be raised steadily until it reaches the test pressure given in 5.2.3.2; the rate of pressure increase shall not exceed 1 bar per s. The test pressure shall be kept constant within ±0,5 bar for at least 2 h.

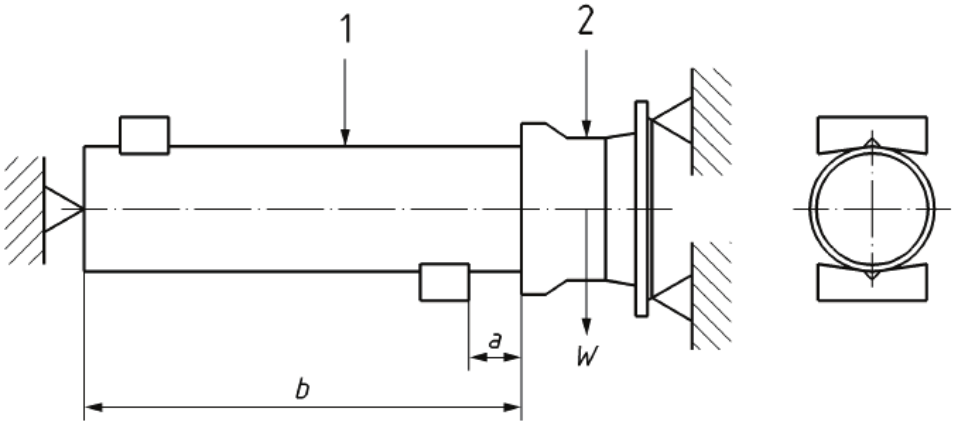
CAUTION — All necessary safety precautions should be taken for the duration of the pressure test.

For a restrained joint, the test assembly, the test apparatus and the test procedure are identical, except that there shall be no end restraint so that the axial thrust is taken by the restrained joint under test.

7.2.2.2 Flange adaptors and one socket fitting

For a flange adaptor and one socket fitting, half of the test apparatus shall be used (see Figure 4).

The test apparatus shall be capable of providing suitable end and lateral restraints whether the joint is in the aligned position, deflected or subjected to a shear load. It shall be equipped with a pressure gauge with accuracy in relation to the range of measured pressures of ≤3 %.



Key

1 plastic pipe section
2 flanged socket adaptor
a distance between block support and socket face
b length of pipe section
W vertical force

Figure 4 — Internal hydrostatic testing for flange adaptor and one socket fitting

The testing equipment shall be as shown in Figure 4. The plastic pipes shall be supported by means of V-shaped blocks with an angle of (120 ± 10)°, located at a distance, *a*, of 0,2 DN/OD in mm from the socket face and up to a maximum of 50 mm. The length of each pipe section, *b*, shall be at least 2 DN/OD in mm and with a minimum of 1 m. The vertical force, *W*, shall be applied to the fitting. The vertical force, *W*, shall be such that the resultant shear force *F*/2 across the joints is equal to the value specified in 5.2.3.2.2.2 taking into account the mass, *M*, of the fitting and its contents and the geometry of the test assembly, as given in Formula (5):

$$W = F - M \tag{5}$$

where

F is the resultant shear force;

W is the vertical force.

The test assembly shall be filled with water and suitably vented of air. The test shall not begin before the temperature of the test assembly has stabilized between 15 °C and 25 °C. The pressure shall be raised steadily until it reaches the test pressure given in 5.2.2; the rate of pressure increase shall not exceed 1 bar per s. The test pressure shall be kept constant within ±0,5 bar for at least 2 h.

CAUTION — All necessary safety precautions should be taken for the duration of the pressure test.

For a restrained joint, the test assembly, the test apparatus and the test procedure are identical, except that there shall be no end restraint so that the axial thrust is taken by the restrained joint under test.

7.2.3 Leaktightness of joints to negative internal pressure

The test assembly and test apparatus shall be as given in 7.2.2 with the pipe sections axially restrained to prevent them from moving towards each other.

The test assembly shall be empty of water and shall be evacuated to a negative internal pressure of 0,8 bar (see 5.2.3.2.1) and then isolated from the vacuum pump. The test assembly shall be left under

vacuum for 2 h during which the pressure shall not have changed by more than 0,08 bar. The test shall begin at a temperature between 15 °C and 25 °C, which is then kept constant at ±2 °C for the duration of the test.

For a restrained joint, the test assembly, the test apparatus and the test procedure are identical.

7.2.4 Long-term hydrostatic strength test for joints of fittings for PE pipes

7.2.4.1 Test piece

A test piece shall be assembled with PE 100 or PE 80 pipe in accordance with the manufacturer's instructions. Specimens shall be conditioned prior to test by being kept at (25 +0/−4) °C in air for not less than 24 h. For hydrostatic tests involving liquid immersion, the specimens shall be conditioned in the liquid at the test temperature for not less than 24 h.

The end caps used shall comply with ISO 1167-1:2006, type A. There shall be a free length of pipe, between the two fittings or a fitting and an end cap, of not less than three times the nominal size of the fitting for test pieces of nominal size up to and including 225 and a minimum of 1 m for sizes greater than nominal size 225.

7.2.4.2 Test procedure

The test shall be carried out in accordance with EN ISO 1167-1 and the assembly shall be subjected to the relevant pressure, temperature and time as detailed in 5.2.3.3.1.

Failure of the pipe within a distance of less than 0,1 L (where L is the free length between fitting and end cap) from the mouth of the fitting shall be disregarded and a new test piece evaluated. Any axial movement of the pipe within the joint at the end of the test shall be determined and recorded using suitable equipment having an error limit of ±0,5 mm.

7.2.5 Pull out test at 25 °C for restrained joints for PE pipes

7.2.5.1 Test piece

The test piece from the successful long-term hydrostatic strength test shall be used.

7.2.5.2 Apparatus

The apparatus shall be capable of applying a tensile load as required in 5.2.3.3.1.2, at a cross head speed of not more than 25 mm/min.

7.2.5.3 Test procedure

Plain metal plugs shall be inserted in the end of the PE pipe(s) to support the pipe(s) under the action of the loading grips of the testing equipment.

The test shall be carried out at a temperature of (25 +0/−4) °C. A tensile axial load shall be applied to the fitting under test at a cross-head speed of (25 ± 1) mm/min until the maximum load is reached.

The fitting passes the test provided the minimum load as calculated in 5.2.3.3.1.2 is attained without pull out occurring and no further axial movement once the test load has been attained. If fracture of the pipe occurs, the test shall be repeated on a completely new assembly. If the pipe yields at a distance greater than 0,1 L from the mouth of the socket or loading grip, the fitting shall be deemed to have satisfied the requirements of this test.

7.2.6 Long-term hydrostatic strength test for joints of fittings for PVC pipe

7.2.6.1 Test piece

A test piece shall be assembled with PVC pipe in accordance with the manufacturer's instructions.

Specimens shall be conditioned prior to test by being kept in the test room or conditioning chamber for at least 3 h for test temperatures more than 25 °C or for at least 20 min for test temperatures equal to or less than 25 °C. If the test temperature is specified as 'ambient temperature', carry out the conditioning at any temperature between 15 °C and 25 °C. During subsequent testing, maintain the test temperature constant to within ±2 °C and within the range of 15 °C to 25 °C.

There shall be a free length of pipe, between the two fittings or a fitting and an end cap, equal to DN/OD, but not less than 150 mm.

For non-restrained joints, tie rods or external frames shall be used as necessary to prevent any separation.

7.2.6.2 Test procedure

The test shall be carried out in accordance with ISO 13846 and the assembly shall be subjected to the relevant pressure, temperature and time as detailed in 5.2.3.3.1.2.

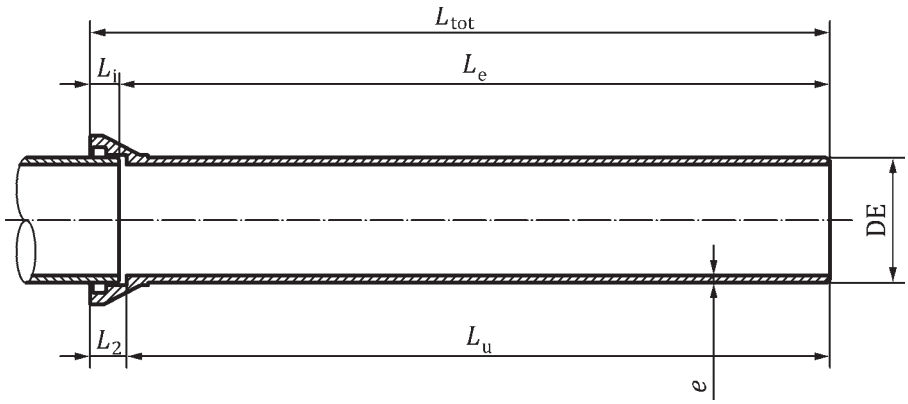
If rupture occurs in the pipe section between the joints under test or in an end closure not included as part of the test assembly, the test shall be disregarded and the failed component replaced by another. After replacement, the test procedure shall be continued. If the failure of the component causes damage to any of the joints or assemblies on test, these test pieces shall be rejected and the test procedure repeated.

8 Tables of dimensions

8.1 Pipes

8.1.1 General

The nomenclature for socket and spigot pipes is defined in Figure 5.



Key

DE nominal external diameter of spigot, in millimetres
e 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 — Pipe dimensions

8.1.2 External diameters

DN/OD series pipes shall be supplied to the external diameter given in Table 10.

Table 10 — DN/OD series external diameter DE of spigot of pipes

DN/OD	External diameter DE mm	
	Nominal	Maximum limit deviations
50	50	–1,8/+0,4
63	63	–1,8/+0,4
75	75	–1,8/+0,5
90	90	–2,8/+0,6
110	110	–2,8/+0,7
125	125	–2,8/+0,8
140	140	–2,8/+0,9
160	160	–2,8/+1,0
180	180	–2,8/+1,1
200	200	–2,8/+1,2
225	225	–2,8/+1,4

8.1.3 Wall thickness

The nominal wall thickness of pipes is in accordance with Table 11.

Table 11 — Pipes wall thickness

DN/OD	e_{nom} mm
50	3,0
63	3,0
75	3,0
90	3,0
110	3,0
125	3,0
140	3,1
160	3,2
180	3,3
200	3,4
225	3,5

8.1.4 Pipes length

Pipes shall be supplied to the lengths given in Table 12.

Table 12 — Standardized lengths of socket and spigot pipes

DN/OD	Standardized lengths, L_u m
DN/OD 50 to 225	3,0, 5,0, 5,5 or 6,0

The manufacturers' design lengths L_u shall be within a deviation of ±250 mm with respect to the lengths given in Table 12 and shall be given in their handbooks or catalogues. Of the total number of socket and spigot pipes to be supplied in each diameter, the percentage of shorter pipes shall not exceed 10 %.

8.1.5 Sockets for push-in flexible joints

Table 13 — Standardized lengths of socket and spigot pipes

DN/OD	Minimum socket inside diameter d_i mm	Minimum depth of engagement p mm
50	50,5	42
63	63,5	42
75	75,6	42
90	90,7	44
110	110,8	47
125	125,9	49
140	141,0	51
160	161,1	54
180	181,1	57
200	201,3	60
225	226,5	64

8.2 Fittings

8.2.1 General

In Tables 15 to 22, all the dimensions are nominal values and are given in millimetres. The values of L_u and l_u have been rounded up to the nearest multiple of five.

8.2.2 Wall thickness

The nominal wall thickness of fittings is in accordance with Table 14.

Table 14 — Fittings wall thickness

DN/OD	e_{nom} mm
50	5,0
63	5,0
75	5,0
90	5,0
110	5,0
125	5,0
140	5,0
160	5,0
180	5,0
200	5,0
225	6,0

8.2.3 Sockets for push-in socketed fittings

Specification given in Table 13 applies also for socketed fittings.

8.2.4 Flanged socket

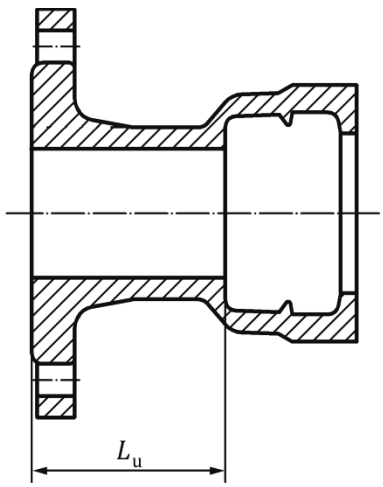


Figure 6 — Flanged socket

Table 15 — Flanged socket

DN/OD	Nominal diameter of the flange DN	Minimum standardized length, L_u mm
50	40	15
63	50, 60	15
75	60, 65	15
90	80	15
110	100	15
125	100, 125	20
140	125	20
160	150	35
180	150	35
200	200	40
225	200	40

8.2.5 Flanged spigot

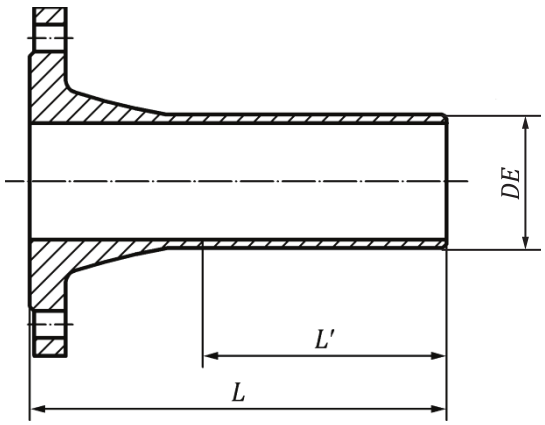


Figure 7 — Flanged spigot

Table 16 — Flanged spigot

DN/OD	Tolerance on DE[a] mm	Nominal diameter of the flange DN	Minimum overall length, L mm	Minimum standardized length, L' mm
50	0,2	40	140	89
63	0,3	50, 60	150	93
75	0,3	60, 65	155	98
90	0,3	80	160	102
110	0,4	100	170	110
125	0,4	100, 125	180	114
140	0,5	125	185	119
160	0,5	150	190	127

[a] The tolerance is expressed in the form (0, DN/OD + x) where "x" is the value of the tolerance.

Table 16 *(continued)*

DN/OD	Tolerance on DE[a] mm	Nominal diameter of the flange DN	Minimum overall length, *L* mm	Minimum standardized length, *L'* mm
180	0,6	150	200	133
200	0,6	200	210	139
225	0,7	200	220	147

[a] The tolerance is expressed in the form (0, DN/OD + x) where "x" is the value of the tolerance.

8.2.6 Collars

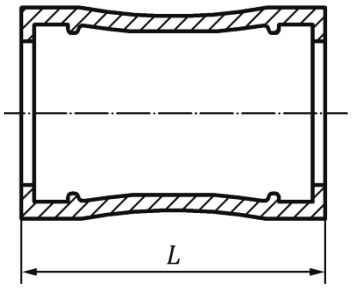


Figure 8 — Collar

Table 17 — Collar

DN/OD	Overall length, *L* mm
50	200
63	206
75	254
90	265
110	275
125	295
140	305
160	315
180	325
200	335
225	345

8.2.7 Double socket bend 90° (1/4)

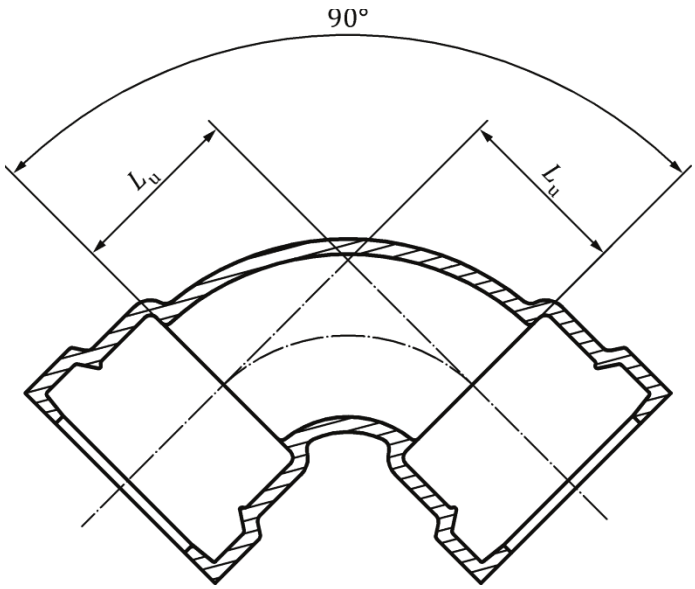


Figure 9 — Double socket bend 90° (1/4)

Table 18 — Double socket bend 90° (1/4)

DN/OD	Minimum standardized length, L_u mm
50	60
63	65
75	70
90	75
110	85
125	110
140	110
160	130
180	160
200	160
225	160

8.2.8 Double socket bend 45° (1/8)

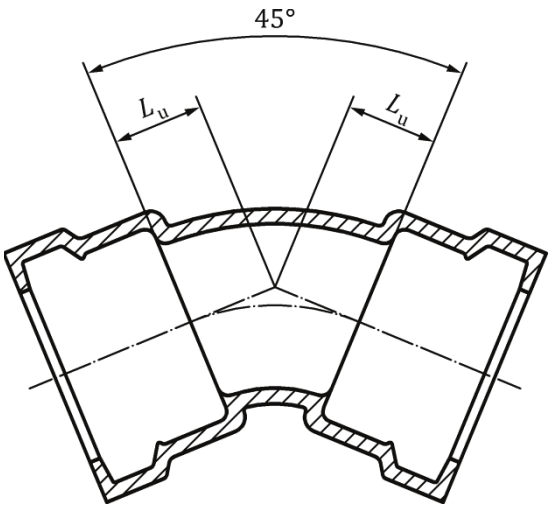


Figure 10 — Double socket bend 45° (1/8)

Table 19 — Double socket bend 45° (1/8)

DN/OD	Minimum standardized length, L_u mm
50	40
63	40
75	40
90	50
110	60
125	65
140	65
160	70
180	70
200	70
225	80

8.2.9 Double socket bend 22°30’ (1/16)

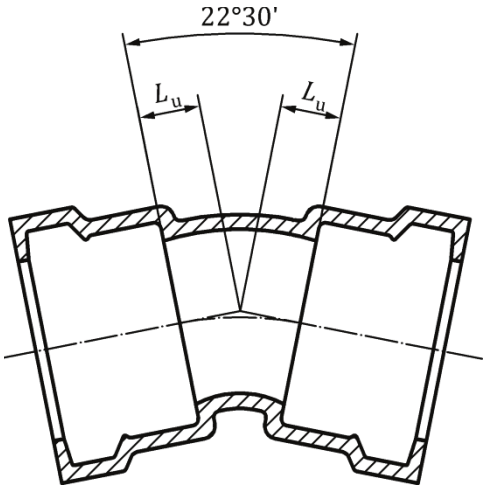


Figure 11 — Double socket bend 22°30’ (1/16)

Table 20 — Double socket bend 22°30’ (1/16)

DN/OD	Minimum standardized length, L_u mm
50	20
63	20
75	25
90	25
110	30
125	30
140	30
160	35
180	40
200	40
225	45

8.2.10 Double socket bend 11°15’ (1/32)

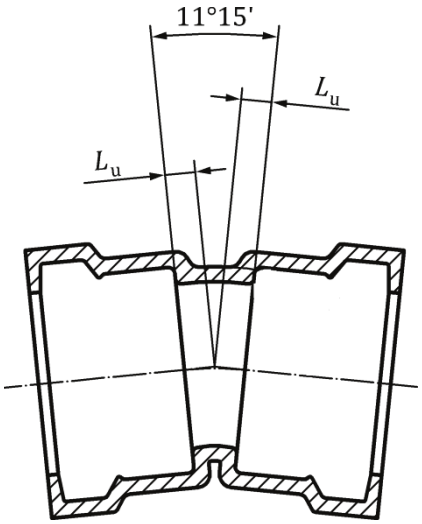


Figure 12 — Double socket bend 11°15’ (1/32)

Table 21 — Double socket bend 11°15’ (1/32)

DN/OD	Minimum standardized length, L_u mm
50	20
63	20
75	25
90	25
110	30
125	30
140	30
160	30
180	30
200	30
225	40

8.2.11 Double socket tee with flanged branch

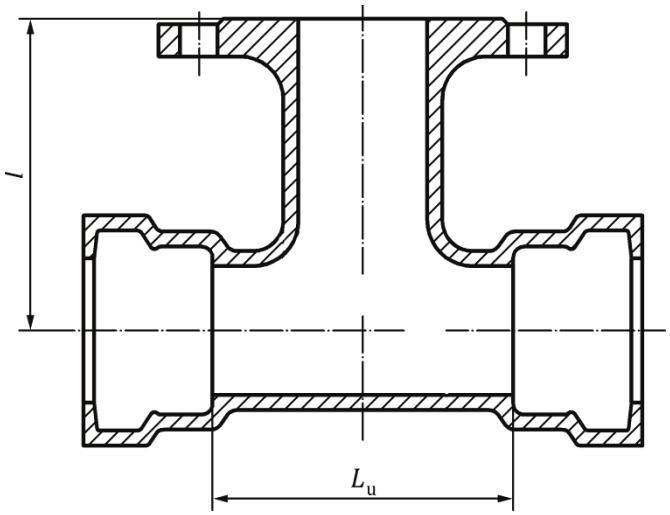


Figure 13 — Double socket tee with flanged branch

Table 22 — Double socket tee with flanged branch (check with ISO 7005)

DN/OD	Nominal diameter of the branch DN	Minimum standardized length L_u mm	Minimum height l mm
50	40	40	85
63	40	70	140
	50	70	140
	60, 65	70	140
75	40	70	130
	50	70	140
	60, 65	85	140
90	40	65	135
	50	75	145
	60, 65	90	155
	80	115	160
110	40	65	145
	50	75	145
	60, 65	90	165
	80	105	170
	100	125	170
125	40	65	160
	60, 65	90	160
	80	105	170
	100	125	180
	125	150	180

Table 22 *(continued)*

DN/OD	Nominal diameter of the branch DN	Minimum standardized length L_u mm	Minimum height l mm
140	40	65	160
	60, 65	90	180
	80	105	185
	100	125	195
	125	150	200
160	40	65	170
	50	75	170
	60, 65	90	190
	80	105	200
	D100	125	205
	125	150	210
	150	175	220
180	40	65	195
	50	75	195
	60,65	90	215
	80	105	225
	100	125	230
	125	150	240
	150	175	245
	200	220	250
200	40	100	195
	50	110	195
	60, 65	125	215
	80	140	225
	100	160	230
	125	185	240
	150	210	245
	200	260	250
225	40	100	195
	50	110	195
	60, 65	125	215
	80	140	225
	100	160	230
	125	185	240
	150	210	245
	200	260	260

8.2.12 All socket tee

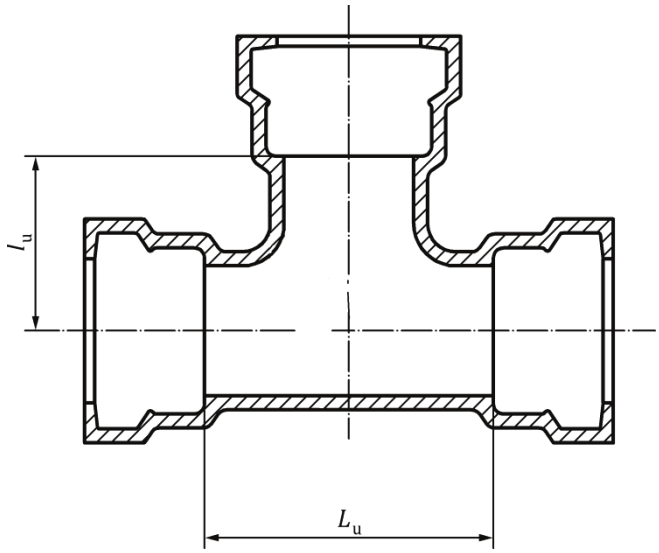


Figure 14 — All socket tee

Table 23 — All socket tee

DN/OD	Nominal diameter of the branch DN	Minimum standardized length L_u mm	Minimum height l_u mm
50	50	60	30
63	63	70	30
75	63	70	45
	75	85	45
90	63	75	50
	75	90	50
	90	105	50
110	63	75	60
	75	90	60
	90	105	60
	110	125	60
125	63	75	70
	75	90	70
	90	105	70
	110	125	70
	125	150	70

Table 23 *(continued)*

DN/OD	Nominal diameter of the branch DN	Minimum standardized length L_u mm	Minimum height l_u mm
140	63	75	75
	75	90	75
	90	105	75
	110	125	75
	125	150	75
	140	150	75
160	63	75	85
	75	90	85
	90	105	85
	110	125	85
	125	150	85
	140	150	85
	160	175	85
180	63	75	95
	75	80	95
	90	90	95
	110	125	95
	160	175	95
	180	190	95
200	63	110	105
	75	125	105
	90	140	105
	110	160	105
	125	160	105
	140	185	105
	160	210	105
	180	230	105
	200	240	105
225	63	110	120
	75	125	120
	90	140	120
	110	160	120
	160	210	120
	200	240	120
	225	260	120

8.2.13 Double socket taper

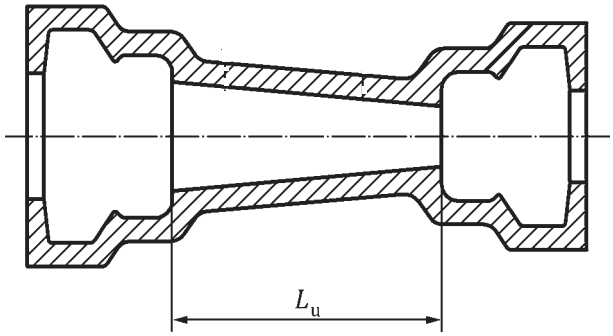


Figure 15 — Double socket taper

Table 24 — Double socket taper

Nominal outside diameter of the pipe		Minimum standardized length	
		Series A	Series B
dn1	dn2	Long	Short
		L_u	L_u
63	50	70	20
75	63	80	20
90	50	80	20
	63	80	25
	75	80	20
110	63	160	35
	75	120	35
	90	85	30
125	75	190	55
	90	135	35
	110	100	40
140	75	190	55
	90	135	45
	110	100	40
	125	100	40
160	90	190	55
	110	150	50
	125	100	40
	140	100	40

Table 24 *(continued)*

Nominal outside diameter of the pipe		Minimum standardized length	
		Series A	Series B
dn1	dn2	Long	Short
		L_u	L_u
180	90	250	90
	110	250	80
	125	200	70
	140	145	65
	160	145	60
200	90	250	95
	110	250	85
	125	250	75
	140	200	70
	160	145	70
	180	145	60
225	125	250	80
	140	200	75
	160	145	70
	180	145	65
	200	145	60

Annex A
(informative)

External coating

A.1 Factors characterizing aggressiveness 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

In the case of active protection, evidence of the long-term performance of enhanced coatings (e.g. tests and references) should be provided by the manufacturer. It is the responsibility of the manufacturer to prove the enhancement in comparison with ISO 8179-1 or ISO 8179-2 of the performances with the appropriate methods.

In the case of other protection, evidence of the long-term performance of enhanced protection (e.g. tests and references) should be provided by the manufacturer. It is the responsibility of the manufacturer to prove the enhancement in comparison with ISO 8180 of the performances with the appropriate methods.

For other types of pipe coatings including their repair method, refer to national standards or pipe manufacturers.

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

Only ISO standardized coatings are given here. Other coatings are permitted as follows:

— 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 fitting and accessory coatings, including their repair method, refer to national standards or pipe manufacturer’s specifications.

Annex B
(informative)

Internal lining

B.1 Factors characterizing aggressiveness of raw and potable waters

— pH;

— sulfates;

— magnesium;

— ammonium;

— aggressive CO_2.

B.2 Centrifugally cast pipe linings for protection against aggressive raw and potable waters

Only ISO standardized internal linings are given here. Other linings are permitted as follows:

— Portland cement mortar, in accordance with ISO 4179;

— blast furnace slag cement mortar, in accordance with ISO 4179;

— cement mortar with seal coat, in accordance with ISO 16132.

For other types of pipe linings, including their repair method, refer to national standards or the pipe manufacturer's specifications.

B.3 Fitting and accessory linings for protection against aggressive raw and potable waters

Only ISO standardized internal linings are given here. Other linings are permitted as follows:

— Portland cement mortar, in accordance with ISO 4179;

— blast furnace slag cement mortar, in accordance with ISO 4179;

— cement mortar with seal coat, in accordance with ISO 16132.

For other types of fitting and accessory linings, including their repair method, refer to national standards or the pipe manufacturer's specifications.

Annex C
(normative)

Stiffness determination

C.1 Diametral stiffness determination

The diametral stiffness S of a pipe is given by Formula (C.1):

$$S = 1\,000 \times E/12 \times (e_{stiff}/D)^2 \quad \text{(C.1)}$$

where

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

e_{stiff} is the pipe wall thickness for the calculation of the pipe diametral stiffness, in millimetres;

NOTE $e_{stiff} = e_{min} + 0,5\ (e_{nom} - e_{min})$.

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

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

DE is the nominal pipe external diameter, DN/OD, in millimetres;

E is the modulus of elasticity of the material, in megapascal (170 000 MPa).

For each DN/OD, the manufacturer shall provide to the purchaser the diametral stiffness value for the pipes.

C.2 Longitudinal bending moment determination

The longitudinal bending moments are calculated by Formula (C.2):

$$M = 0,25 \times \pi \times 10^{-6}\ R_f \times D^2 \times e_{min} \quad \text{(C.2)}$$

where

M is the bending moment, in kilonewton metres;

D is the mean pipe diameter ($DE - e$), in millimetres;

DE is the nominal pipe external diameter, DN/OD, in millimetres;

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

R_f is the allowable stress in the pipe wall, $R_f = 250$, in megapascals.

For each DN/OD, the manufacturer shall provide to the purchaser the longitunal bending value for the pipes.

Annex D
(normative)

Quality assurance

D.1 General

The manufacturer has the responsibility to demonstrate the conformity of his products with this International Standard by

— carrying out type tests (see D.2), and

— controlling the quality of the manufacturing process (see D.3).

D.2 Type tests

The type tests specified in Clause 5 of this International Standard shall be carried out either by the manufacturer or, at his request, by a competent testing institute in order to demonstrate compliance with the requirements of this International Standard. Full reports of these type tests are retained by the supplier of pipes, fittings and gaskets as evidence of compliance.

If fittings or gaskets are supplied separately from pipes, full reports of the type tests on these components and their compatibility with pipes shall be made available to the client by the fittings or gaskets suppliers.

D.3 Quality control

The manufacturer controls the quality of his products during their manufacture by a system of process control in order to comply with the technical requirements of this International Standard.

It is recommended that the manufacturer's quality system conforms to ISO 9001.

If third-party certification to ISO 9001 is involved, it is recommended that the certification body is accredited to a relevant International Standard as applicable.

Annex E
(informative)

Safety factors

The following safety factors are used in the design for minimum thicknesses for ductile iron pipes:

Table E.1 — Safety factors for ductile iron pipes

Design criteria	Safety factor	Mechanical property
PFA	3,0	Minimum ultimate tensile strength of 420 MPa
PMA	2,5	Minimum ultimate tensile strength of 420 MPa
External loads	1,5	Yield bending strength of 500 MPa

Annex F
(normative)

Water pipeline systems incorporating ductile iron and plastic components

F.1 Maximum allowable operating pressure

The maximum allowable operating pressure of the system shall take into account the rating of pipework or equipment that may be connected to these pipes:

— ductile iron components and their joints

  — the rating of pipes and fittings is 25 bar but attention shall be paid to the joints, non-restrained and restrained, performances;

— plastic components and their joints

  — many kind of pressure ratings exist for plastic pipes and fittings, such as 10 bar, 16 bar, 25 bar. If plastic pipes are connected to ductile iron pipes in conformity with this International Standard, the pipeline maximum allowable operating pressure shall not be higher than the plastic pipe pressure rating;

  — attention shall be paid to the leaktightness of the joints;

— other flanged components

  — attention shall be to the PN rating of flanged components, such as flanged fittings, flange adaptors, valves, hydrants.

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

F.2 Dimensional compatibility

Plastic pipe spigot end can be inserted in ductile iron sockets of pipes, or fittings, in conformity with this International Standard. Special gaskets or devices, designed for plastic pipes, shall be used if it is intended to self-restrain the pipeline.

Only spigot end of flanged-spigot fitting (see 8.2.5) can be inserted in plastic pipes sockets. The spigot end of flanged-spigot fitting has a narrow tolerance gap which allows this dimensional compatibility.

F.3 On-site pressure test

The on-site pressure test needs to be suitable for a DI-PVC or DI-PE combination.

In the absence of national standards, regulation or guideline, the on-site pressure test should be done according to ISO 10802.

Annex G
(informative)

Environmental aspects

G.1 Recycled material

Ductile iron pipes and fittings can be produced using two main sources of iron as follows:

— iron ores with blast furnaces;

— iron scraps (steel scraps, cast iron scraps, ductile iron scraps, etc.) with cupolas or electric furnaces.

The pipes and fittings made with these two sources of iron have identical mechanical performances.

G.2 Recyclability

Old cast iron pipe or old ductile iron pipes and fittings can be reused to produce new ductile iron pipes and fittings with performances and requirements in conformity with this International Standard.

It is recommended to remove from the ground old buried pipes and fittings and to recycle them as metal scraps.

G.3 Packaging materials

Packaging materials should be recyclable.

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

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This document has been used to define the leaktightness requirements and test methods on plastic pipes.

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