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

*Tuyaux, raccords et accessoires en fonte ductile et leurs assemblages
pour l'eau*

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Foreword

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

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

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

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

ISO 2531 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 sixth edition cancels and replaces the fifth edition (ISO 2531:1998), of which it constitutes a technical revision. A new classification system for pipes and fittings based on pressure is introduced with minimum wall thickness determined by allowable operating pressure.

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Ductile iron pipes, fittings, accessories and their joints for water 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 pipelines:

- to convey water (e.g. for human consumption and raw water),
- operated with or without pressure, and
- installed below or above ground.

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

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

This International Standard applies to pipes, fittings and accessories cast by any type of foundry process or manufactured by fabrication of cast components, as well as corresponding joints in the size range DN 40 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 shapes are outside the scope of this International Standard),
- normally delivered internally and externally coated.

Pipes and fittings are classified according to allowable operating pressure.

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 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*

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

1) 100 kPa = 1 bar

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

ISO 10803, *Design method for ductile iron pipes*

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

accessory

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

EXAMPLE 1 Glands and bolts for mechanical flexible joints (see 3.18).

EXAMPLE 2 Glands, bolts and locking rings or segments for restrained joints (see 3.24).

NOTE The term accessory is not relevant for valves or hydrants of any type.

3.2

allowable operating pressure

PFA

maximum internal pressure, excluding surge, which a component can safely withstand in permanent service

3.3

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.

3.4

batch

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

3.5

component

any product defined as an element of a pipe, fitting or accessory

See 3.1, 3.9 and 3.22.

3.6

deviation

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

NOTE Pipes and fittings are designed to a length selected in the range of standard length plus or minus the deviation (see Table 6); they are manufactured to this length plus or minus the tolerance given in Table 7.

3.7

diametral stiffness of a pipe

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

3.8**ductile iron**

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

3.9**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.

3.10**flange**

end of a pipe or fitting, extending perpendicular to its axis, with bolt holes equally spaced in 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 which can be freely rotated around the barrel axis before jointing.

3.11**flanged joint**

joint between two flanged ends

3.12**flexible joint**

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

3.13**gasket**

sealing component of a joint

3.14**hoop stress**

σ

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

3.15**joint**

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

3.16**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 4. For flanged pipes, it is equal to the total length of the pipe.

NOTE 2 It is expressed in metres.

3.17**maximum allowable operating pressure****PMA**

maximum internal pressure, including surge, which a component can safely withstand in service

3.18**mechanical flexible joint**

flexible joint in which sealing is obtained by applying pressure to the gasket by mechanical means

EXAMPLE A gland.

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
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.

3.21
ovality

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

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

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where

- A_1 is the maximum axis, in millimetres; [ISO 2531:2009](https://standards.iteh.ai/catalog/standards/sist/5e627a66-16c8-4bb0-b4f2-d3010f9d9650/iso-2531-2009)
- A_2 is the minimum axis, in millimetres. <https://standards.iteh.ai/catalog/standards/sist/5e627a66-16c8-4bb0-b4f2-d3010f9d9650/iso-2531-2009>

3.22
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.

3.23
push-in flexible joint

flexible joint assembled by pushing the spigot through the gasket into the socket of the mating component

3.24
restrained joint

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

3.25
socket

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

3.26
spigot

male end of a pipe or fitting

3.27**spigot end**

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

See L_i in Figure 4.

3.28**standardized length**

length of pipe barrel and fitting body or branch as defined in this International Standard

NOTE 1 For socket and spigot pipes, and fittings, it is designated L_U (l_U for branches). For flanged pipes, and fittings, it is designated L (l for branches). See Figures 4 to 27.

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 spigot insertion depth, as indicated in the manufacturer's catalogues.

3.29**type test**

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

4 Technical requirements**4.1 General**

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4.1.1 Pipes and fittings

Thicknesses, lengths and coatings are specified in this subclause, 4.2.3, 4.2.4 and 4.4 for pipes, and 4.5 for fittings. When, 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 8.3 and 8.4, are supplied in accordance with this International Standard, they shall comply with all the other requirements of this International Standard. This includes pipe and fittings manufactured to national standards and regulations.

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

40, 50, 60, 65, 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 and 2600.

The stiffness and allowable diametral deflection of ductile iron pipes are as given in Annex D.

NOTE When installed and operated under the conditions for which they are designed (see Annexes A and B), ductile iron pipes, fittings, accessories and their joints maintain all their functional characteristics over their operating life, due to constant material properties, to the stability of their cross-section and to their design with high safety factors.

4.1.2 Surface condition and repairs

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.

When necessary, pipes and fittings may be repaired, for example by welding, to remove surface imperfections and localized defects which do not affect the entire wall thickness, provided that 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 water applications. When 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 to facilitate attachment 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 flange joint shall be designed to meet the performance requirements of 5.3.

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

4.1.3.3 Flexible joints

Pipes and fittings with flexible joints shall be in accordance with 4.2.2.1 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 5.2.

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 4.2.2.1, 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 4.2.2.1.

4.1.4 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, accessories and joints, consist of various materials. When used for conveying water intended for human consumption, the materials in contact with the water shall meet the relevant requirements of the national standards or regulations in the country of use with respect to effect on water quality.

4.2 Pressure classification and dimensional requirements

4.2.1 Pressure classifications

4.2.1.1 General

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

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

Allowable component pressure relationships shall be the following:

- a) Allowable operating pressure (PFA) = C, in bar
- b) Allowable maximum operating pressure (PMA) = 1,20 × PFA, in bar
- c) Allowable site test pressure (PEA) = (1,20 × PFA) + 5, in bar

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

4.2.1.2 Preferred pressure classes

Preferred pressure classes of components with flexible joints are C25, C30, and C40. Other pressure classes are allowable, including C20, C50, C64 and C100.

Pressure classes for components with flanged joints are PN10, PN16, PN25 and PN40.

4.2.1.3 Allowable pressures

Allowable pressures of components are as given in Tables 1 and 2.

Table 1 — Allowable pressures of components with flexible joints for preferred classes

Pressure class	Allowable operating pressure	Maximum allowable operating pressure	Allowable site test pressure
C	PFA bar	PMA bar	PEA bar
25	25	30	35
30	30	36	41
40	40	48	53

Table 2 — Allowable pressures of components with flanged joints

Pressure class	Allowable operating pressure	Maximum allowable operating pressure	Allowable site test pressure
PN	PFA bar	PMA bar	PEA bar
10	10	12	17
16	16	20	25
25	25	30	35
40	40	48	53

The allowable pressure for fittings as specified in Tables 15 to 33 are as follows:

- socketed fittings, except tees, are given in Table 3;
- socketed tees may be less than those given in Table 3 and shall be given in the manufacturer's handbook;
- all flanged fittings and fittings with one flange, such as double-socketed tees with flanged branch, flanged spigots and flanged sockets, are limited by the flange PN and are given in Table 2.

Table 3 — Allowable pressures for socketed fittings

Nominal size DN	Allowable operating pressure PFA bar	Maximum allowable operating pressure PMA bar	Allowable site test pressure PEA bar
40 to 200	64	77	82
250 to 350	50	60	65
400 to 600	40	48	53
700 to 1400	30	36	41
1500 to 2600	25	30	35

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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 can 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.

4.2.2 Diameter

4.2.2.1 External diameter

Table 14 gives the values of the external diameter, DE, of the spigot end of pipes and fittings, when measured circumferentially using a circumferential tape as specified in 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 shall be as specified in national standards, or, when not so specified, in manufacturers' handbooks, for the type of joint and the nominal size considered.

In addition, the ovality (see 3.21) of the spigot end of pipes and fittings shall

- remain within the tolerances of DE for DN 40 to 200, and
- not exceed 1 % of DE for DN 250 to DN 600 or 2 % for DN > 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.

4.2.2.2 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 sizes, DN.

4.2.3 Wall thickness

4.2.3.1 Pipes with flexible joints

The minimum wall thickness for pipes, e_{\min} , shall be not less than 3,0 mm and shall be determined using Equation (2):

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

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 14), in millimetres;

R_m is the minimum tensile strength of ductile iron, in megapascals ($R_m = 420$ MPa; see Table 8).

NOTE Equation (2) is derived from Barlow's equation, i.e. hoop stress, $\sigma = PD/2t$ (see 3.14)

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

For 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).

For centrifugally cast pipes, nominal pipe wall thicknesses for preferred ductile iron pressure classes are given in Table 14. For other pressure classes, as given in Annex C, the user should confirm the availability with the manufacturer.

4.2.3.2 Flanged pipes

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 welded-on flanges, screwed-on flanges and integrally cast flanges.

NOTE Pipe threads are regarded as loss of wall thickness.

4.2.3.3 Fittings

Nominal wall thicknesses, e_{nom} , are given for fittings in Tables 15 to 29, with allowable pressures given in 4.2.1.3. The minimum wall thickness, e_{\min} , for fittings is: $e_{\min} = e_{\text{nom}} - (2,3 + 0,001 \text{ DN})$.

Fittings with other pressure classifications are allowed. The manufacturer shall be responsible for the design of the fittings including the determination of wall thickness. The minimum wall thickness, e_{\min} , shall be not less than 3,0 mm.

The design shall be carried out by a calculation method, e.g. finite element analysis, or an experimental method, e.g. hydrostatic testing, using a safety factor of 3 against failure with respect to PFA.

4.2.4 Length

4.2.4.1 Socket and spigot pipes

Pipes shall be supplied to the lengths given in Table 4.

Table 4 — Standardized lengths of socket and spigot pipe

Dimensions in metres

DN	Standardized lengths, L_u^a
40 and 50	3
60 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 3.28.	

The manufacturers' design lengths, L_u (see 3.28), shall be within a deviation (see 3.6) of ± 250 mm with respect to the lengths given in Table 4 and shall be given in their handbooks. The actual length, L_u , shall be measured according to 6.1.3 and shall not differ from the manufacturer's design length by more than the tolerance given in Table 7. Of the total number of socket and spigot pipes to be 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.

4.2.4.2 Flanged pipes

The lengths of flanged pipes shall be as given in Table 5. Other lengths are available by agreement between the manufacturer and the purchaser.

Table 5 — Standardized lengths of flanged pipe

Dimensions in metres

Type of pipe	DN	Standardized lengths, L^a
With cast-on flanges	40 to 2600	0,5 or 1 or 2 or 3 or 4
With screwed-on or welded-on flanges	40 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 3.28.		

4.2.4.3 Fittings

Fittings shall be supplied in the lengths given in 8.3 and 8.4 except that, alternatively, socket fittings may be supplied in the lengths of the national standard of the country of manufacture.

NOTE Two series of dimensions are shown, series A and series B, which is generally limited to DN 450 maximum.

The permissible deviations (see 3.6) on the lengths of series A fittings shall be as given in Table 6.

Table 6 — Permissible deviations on length of fittings

Dimensions in millimetres

Type of fitting	DN	Deviation
Flanged sockets Flanged spigots Collars, tapers	40 to 1200	± 25
	1400 to 2600	± 35
Tees	40 to 1200	+ 50 – 25
	1400 to 2600	+ 75 – 35
Bends 90° (1/4)	40 to 2600	$\pm (15 + 0,03) \text{ DN}$
Bends 45° (1/8)	40 to 2600	$\pm (10 + 0,025) \text{ DN}$
Bends 22° 30' (1/16) and 11° 15' (1/32)	40 to 1200	$\pm (10 + 0,02) \text{ DN}$
	1400 to 2600	$\pm (10 + 0,025) \text{ DN}$

4.2.4.4 Tolerances on lengths

The tolerances on lengths shall be as given in Table 7.

Table 7 — Tolerances on length

Dimensions in millimetres

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	$\pm 10^a$

^a By agreement between manufacturer and purchaser, smaller tolerances are possible, but not less than ± 3 mm for $\text{DN} \leq 600$ and ± 4 mm for $\text{DN} > 600$.

4.2.5 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 dispute, the deviation shall be measured in accordance with 6.2.

4.3 Material characteristics

4.3.1 Tensile properties

Pipes, fittings and accessories made of ductile iron shall have the tensile properties given in Table 8.