BRITISH STANDARD

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545 : 1995

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

Requirements and test methods

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National foreword

This British Standard has been prepared under the direction of the Piping Systems Components Standards Policy Committee and is the English language version of EN 545 : 1994 *Ductile iron pipes, fittings, accessories and their joints for water pipelines — Requirements and test methods,* published by the European Committee for Standardization (CEN).

EN 545 was produced as a result of international discussion in which the UK took an active part.

This British Standard is one of the three new application standards for ductile iron pipelines which have been developed by CEN, the other standards being BS EN 598 (sewerage application) and BS EN 969 (gas supply). This standard replaces BS 4772 in respect of potable water applications and with the publication of all three application standards as British Standards, BS 4772 will be withdrawn.

National annex NB gives the constitution of the committee responsible for UK participation in the preparation of this standard.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

EUROPEAN STANDARD

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English version

Ductile iron pipes, fittings, accessories and their joints for water pipelines — Requirements and test methods

Tuyaux, raccords et accessoires en fonte ductile et leurs assemblages pour canalisations d'eau — Prescriptions et méthodes d'essai

Rohre, Formstücke, Zubehörteile aus duktilem Gußeisen und ihre Verbindungen für Wasserleitungen — Anforderungen und Prüfverfahren

This European Standard was approved by CEN on 1994-11-08. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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Foreword

This European Standard was prepared by AHG1, Water pipelines under pressure, of CEN TC 203, Iron pipes, fittings, accessories and their joints, the Secretariat of which is held by the French Standardization Association (AFNOR).

It is one of a series of standards for cast iron products for pipelines for various applications.

This European Standard deals with the subjects covered by the International Standards ISO 2531, ISO 4179 and ISO 8179. The major differences are the presentation in one single standard and the addition of product performance specifications.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 1995, and conflicting national standards shall be withdrawn at the latest by May 1995.

According to the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

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Introduction

This standard is in conformity with the general requirements already established by CEN TC 164 in the field of water supply.

The product which is in permanent or in temporary contact with water intended for human consumption, does not adversely affect the quality of the drinking water and does not contravene the EC Directives and EFTA regulations on the quality of drinking water.

1 Scope

This European Standard specifies the requirements and associated test methods applicable to ductile iron pipes, fittings, accessories and their joints for the construction of pipelines:

- to convey water (e.g. potable water);
- with or without pressure;
- to be installed below or above ground.

NOTE. In this standard, all pressures are relative pressures, expressed in bars (100 kPa = 1 bar).

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

This 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 a size range extending from DN 40 to DN 2 000, inclusive.

This standard applies to pipes, fittings and accessories which are:

- manufactured with socketed, flanged or spigot ends for jointing by means of various types of gaskets which are not within the scope of this standard;
- normally delivered externally and internally coated;
- suitable for fluid temperatures between 0 °C and 50 °C, excluding frost.

2 Normative references

This European Standard incorporates by dated reference provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. Subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision.

EN 196-1 : 1989	*Methods of testing cement - Determination of strength*
ENV 197-1 : 1992	*Cement-composition, specifications and conformity criteria Part 1: Common cements*
prEN 805 : 1992	*Water supply requirements for external systems and components*
prEN 1092-2 : 1993	*Flanges and their joints - Part 2 Cast iron flanges*
EN 10002-1 : 1990	*Metallic materials - Tensile testing - Part 1: Method of test at ambient temperature*
EN 29002 : 1987	*Quality systems - Model for quality assurance in production and installation*
EN 45012 : 1989	*General criteria for certification bodies operating quality system certification*
ISO 2531 : 1991	*Ductile iron pipes, fittings and accessories for pressure pipelines*
ISO 4633 : 1983	*Rubber seals - Joint rings for water supply, drainage and sewerage pipelines - Specification for materials*
ISO 6506 : 1981	*Metallic materials - Hardness tests - Brinnel test*
ISO 6708 : 1980	*Pipe components - Definition of nominal size*
ISO 7268 : 1983	*Pipe components - Definition of nominal pressure*
ISO 7268/A1 : 1984	*Pipe components - Definition of nominal pressure*
ISO 7483 : 1991	*Dimensions of gaskets for use with flanges to ISO 7005*

3 Definitions

For the purposes of this standard, the following definitions apply.

3.1 ductile iron

Cast iron used for pipes, fittings and accessories in which graphite is present substantially in spheroidal form.

3.2 pipe

Casting of uniform bore, straight in axis, having either socket, spigot or flanged ends, except for flanged-socket pieces, flanged-spigot pieces and collars which are classified as fittings.

3.3 fitting

Casting other than a pipe which allows pipeline deviation, change of direction or bore. In addition flanged-socket pieces, flanged-spigot pieces and collars are also classified as fittings.

3.4 accessory

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

- glands and bolts for mechanical flexible joints (see **3.13**);
- glands, bolts and locking rings for restrained flexible joints (see **3.14**);
- pipe saddles for service cocks connection;
- adjustable flanges and flanges to be welded or screwed-on.

NOTE. Valves of all types are not covered by the term accessory.

3.5 flange

Flat circular end of a pipe or fitting extending perpendicular to its axis, with bolt holes equally spaced on a circle.

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

3.6 collar; coupling

Connecting piece used to join together the spigots of mating pipes or fittings.

3.7 spigot

Male end of a pipe or fitting.

3.8 socket

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

3.9 gasket

Sealing component of a joint.

3.10 joint

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

3.11 flexible joint

Joint which permits significant angular deflection both during and after installation and which can accept a slight offset of the centreline.

3.12 push-in flexible joint

Flexible joint assembled by pushing the spigot through the gasket in the socket of the mating component.

3.13 mechanical flexible joint

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

3.14 restrained flexible joint

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

3.15 flanged joint

Joint between two flanged ends.

3.16 nominal size (DN)

Numerical designation of size which is common to all components in a piping system. It is a convenient round number for reference purposes and is only loosely related to manufacturing dimensions (see ISO 6708).

3.17 nominal pressure (PN)

Numerical designation expressed by a number which is used for reference purposes. All equipment of the same nominal size DN designated by the same PN number shall have compatible mating dimensions (see ISO 7268 and 7268/A1).

3.18 leaktightness test pressure

Pressure applied to a component during manufacture in order to ensure its leaktightness.

3.19 allowable operating pressure (PFA)

Internal pressure, exclusive of surge, that a component can safely withstand in permanent service (see prEN 805).

3.20 allowable maximum operating pressure (PMA)

Maximum internal pressure, including surge, that a component can safely withstand in service. (see prEN 805).

3.21 allowable 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. (see prEN 805).

NOTE. This test pressure is different from the system test pressure (STP), which is related to the design pressure of the pipeline and is intended to ensure its integrity and leaktightness; see also **A.1**.

3.22 diametral stiffness of a pipe

Characteristic of a pipe which allows it to resist ovalization under loading when installed.

3.23 batch

Quantity of castings from which a sample is taken for testing purposes during manufacture.

3.24 type test

Proof of design test which is done once and is repeated only after change of design.

3.25 length

Effective length of a pipe or fitting, as shown on the figures of clause **9**.

NOTE. For flanged pipes and fittings, the effective length L (l for branches) is equal to the overall length. For socketed pipes and fittings, the effective length L_u (l_u for branches), is equal to the overall length minus the spigot insertion depth as given in the manufacturer's catalogues.

3.26 deviation

Design length allowance with respect to the standardized length of a pipe or a fitting.

NOTE. Pipes and fittings are designed to a length taken in the range of standard length plus or minus the deviation (see table 5); they are manufactured to this length plus or minus the tolerance given in table 6.

3.27 ovality:

Out of roundness of a pipe section; it is equal to:

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

where:

A_1 is the maximum axis, in millimetres;

A_2 is the minimum axis, in millimetres.

4 Technical requirements

4.1 General

4.1.1 *Ductile iron pipes and fittings*

Nominal sizes, thickness classes, lengths and coatings are specified in **4.1.1, 4.2.1, 4.2.3, 4.4** and **4.5** respectively. When, by agreement between manufacturer and purchaser, pipes and fittings with different wall thickness classes, lengths and/or coatings and other types of fittings than those given in **9.3** and **9.4**, are supplied with reference to this standard, they shall comply with all the other requirements of this standard.

NOTE 1. Other types of fittings include angle branches, tees and tapers with other combinations DN × dn, draining tees, ...

The standardized nominal sizes DN of pipes and fittings are as follows: 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.

The functional properties of ductile iron pipes and fittings shall be as given in the annexes A to C dealing respectively with allowable pressures, longitudinal bending resistance and diametral stiffness.

NOTE 2. When installed and operated under the conditions for which they are designed (see annexes D to F), ductile iron pipes, fittings, accessories and their joints maintain all their functional characteristics over their operating life, due to the 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 lead to non-compliance with clauses **4** and **5**.

When necessary, pipes and fittings may be repaired, for example by welding, in order to remove surface imperfections and localized defects which do not affect the entire wall thickness, provided that:

- the repairs are carried out according to a written procedure included in the manufacturer's quality assurance system;
- 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 outside the scope of this standard.

Rubber gasket materials shall comply with the requirements of ISO 4633. When materials other than rubber are necessary (e.g. for flanged joints), they shall comply with the appropriate EN standard or, where no EN standard exists, the appropriate ISO standard.

4.1.3.2 *Flanged joints*

The dimensions and tolerances of the flanges of pipes and fittings shall comply with prEN 1092-2 and flange gaskets with ISO 7483. This ensures interconnection between all flanged components (pipes, fittings, valves, ...) of the same PN and DN and adequate joint performance.

Although it does not affect interconnection, the manufacturer shall state in his catalogues whether his products are normally delivered with fixed flanges or adjustable flanges.

4.1.3.3 *Flexible joints*

Pipes and fittings with flexible joints shall comply with **4.2.2.1** for their spigot external diameters DE and their tolerances. This offers the possibility of interconnection between components equipped with different types of flexible joints. In addition, each type of flexible joint shall be designed to fulfil the performance requirements of clause **5**.

NOTE 1. For interconnection with certain types of joints operating within a tighter tolerance range on *DE*, the manufacturer's guidance should be followed as to the means of ensuring adequate joint performance at high pressures (e.g. measurement and selection of external diameter).

NOTE 2. For interconnection with existing pipelines which may have external diameters not in compliance with **4.2.2.1**, the manufacturer's guidance should be followed as to the appropriate means of interconnection (e.g. adaptors).

4.1.4 *Materials in contact with potable water*

Ductile iron pipes, fittings and their joints include several materials given in this standard. 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 change the quality of that water to such an extent that it fails to comply with the requirements of EU and EFTA regulations at the end user.

For this purpose, reference shall be made to the relevant national standards, transposing EN standards when available, dealing with the influence of materials on water quality and to the requirements for external systems and components (see **4.1** in prEN 805 : 1992).

4.2 Dimensional requirements

4.2.1 *Wall thickness*

The nominal iron wall thickness of pipes and fittings shall be calculated as a function of the nominal size, DN, by the following formula, with a minimum of 6 mm for pipes and 7 mm for fittings:

$$e = K(0{,}5 + 0{,}001\ \mathrm{DN})$$

where:

e is the nominal wall thickness, in millimetres;

DN is the nominal size;

K is a coefficient used for determination of thickness class. It is selected from a series of whole numbers: ....8, 9, 10, 11, 12.....

The standardized thickness classes are given in the tables of clause **9**; other thicknesses are possible for pipes by agreement between manufacturer and purchaser.

For the fittings, the thickness e given in tables and on figures of 9.3 and 9.4 is the nominal thickness corresponding to the main part of the body. The actual thickness at any particular point requires to be increased to meet localized high stresses depending on the shape of the casting (e.g. at internal radius of bends, at the branch-body junction of tees, . . .).

The tolerances on nominal wall thickness of pipes and fittings shall be as given in table 1. The measurement of wall thickness shall be in accordance with **6.1.1.**

Table 1

Dimensions in millimetres

Type of casting	e	Tolerance[1]
Pipes centrifugally cast	6,0	−1,3
	>6,0	− (1,3 + 0,001 DN)
Pipes not centrifugally cast and fittings	7,0	− 2,3
	>7,0	− (2,3 + 0,001 DN)

[1] A negative tolerance only is given, so as to ensure sufficient resistance to internal pressure.

4.2.2 *Diameter*

4.2.2.1 *External diameter*

Subclause **9.1** specifies the values of the external diameter *DE* of the spigot ends of pipes and fittings and their maximum allowable tolerances, when measured using a circumferential tape in accordance with **6.1.2.** These tolerances apply to the spigot ends of all thickness classes of pipes and fittings.

NOTE 1. Certain types of flexible joints operate within a tighter range of tolerance (see **4.1.3.3**).

For DN ≤ 300, the external diameter of the pipe barrel measured with a circumferential tape shall be such as to allow the assembly of the joint over at least two thirds of the pipe length from the spigot end when the pipe needs to be cut on site. For DN > 300, the same applies to a percentage of the pipes, after agreement between manufacturer and purchaser.

In addition, the ovality (see **3.27**) of the spigot end of pipes and fittings shall:

- remain within the tolerance on DE (see table 14) for DN 40 to DN 200;
- not exceed 1 % for DN 250 to DN 600 or 2 % for DN > 600.

NOTE 2. The manufacturer's guidance should be followed as to the necessity and means of ovality correction; certain types of flexible joints can accept the maximum ovality without a 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 equal to the numbers indicating their nominal size, DN, and the tolerances shall be as given in table 2 which apply to lined pipes.

NOTE 1. These tolerances apply to pipe thickness classes up to K10 and to cement mortar lining thicknesses as given in table 8. Where thicker iron and/or cement mortar lining thicknesses are agreed between manufacturer and purchaser, these tolerances do not apply.

NOTE 2. Due to the manufacturing process of iron pipes and their internal linings; internal diameters with a maximum negative tolerance will only appear locally along the pipe length.

Compliance shall be demonstrated either by direct measurement according to **6.1.3** or by calculation from the measurements taken for pipe external diameter, iron wall thickness and lining thickness.

Table 2

DN	Tolerance[1] mm
40 to 1000	−10
1100 to 2000	−0,01 DN

[1] A negative tolerance only is given.

4.2.3 ***Length***

4.2.3.1 *Standarized lengths of socket and spigot pipes*

Pipes shall be supplied to the standardized lengths given in table 3.

Table 3

DIN	Standardized lengths, Lu[1] m
40 and 50	3
60 to 600	5 or 5,5 or 6
700 and 800	5,5 or 6 or 7
900 to 1400	6 or 7 or 8,15
1500 to 2000	8,15

[1] See **3.25**.

The permissible deviations on the standardized length L_u of pipes shall be as follows:

- for standardized length 8,15 m ± 150 mm;
- for all other standardized lengths: ± 100 mm.

The manufacturer shall show his design lengths (see **3.26**) in his catalogues.

The length shall be measured according to **6.1.4** and shall be within the tolerance given in table 6.

Of the total number of socket and spigot pipes to be supplied in each diameter, the percentage of shorter pipes shall not exceed 10 %, in which case the length reduction shall be:

- up to 0,15 m for the pipes in which samples have been cut for testing (see **4.3**);
- up to 2 m by increments of 0,5 m for DN < 700;
- up to 3 m by increments of 0,1 m for DN ≥ 700.

4.2.3.2 *Standardized lengths of flanged pipes*

Pipes shall be supplied to the standardized lengths given in table 4.

4.2.3.3 *Standardized lengths of fittings*

Fittings shall be supplied to the standardized lengths as given in **9.3** and **9.4.**

NOTE. Two series of dimensions are shown, the series A corresponding to ISO 2531 and the new series B, generally limited up to DN 450 at this stage.

The permissible deviations on the standardized length of series A fittings shall be as given in table 5.

Table 4

Type of pipe	DN	Standardized lengths L[1] m
With cast-on flanges	40 to 2000	0,5 or 1 or 2 or 3
With screwed-on or welded-on flanges	40 to 600 700 to 1000 1100 to 2000	2 or 3 or 4 or 5 2 or 3 or 4 or 5 or 6 4 or 5 or 6 or 7

[1] See **3.25**. Other lengths are available by agreement between manufacturer and purchaser.

Table 5

Type of fitting	DN	Deviation mm
Flanged sockets Flanged spigots Collars, tapers	40 to 1200 1400 to 2000	± 25 ± 35
Tees	40 to 1200 1400 to 2000	+50/- 25 +75/- 35
Bends 90° (1/4)	40 to 2000	± (15 + 0,03 DN)
Bends 45° (1/8)	40 to 2000	± (10 + 0,025 DN)
Bends 22° 30′ and 11° 15′ (1/16 and 1/32)	40 to 1200 1400 to 2000	± (10 + 0,02 DN) ± (10 + 0,025 DN)

4.2.3.4 *Tolerances on lengths*

The tolerances on lengths shall be as given in table 6.

Table 6

Type of casting	Tolerance mm
Socket and spigot pipes (full length or shortened)	± 30
Fittings for socketed joints	± 20
Pipes and fittings for flanged joints	± 10*)

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

4.2.4 ***Straightness of pipes***

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

The verification of this requirement is usually 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 of ductile iron shall have the tensile properties given in table 7.

During the manufacturing process the manufacturer shall carry out suitable tests in order to verify these tensile properties; these tests may be:

a) either a batch sampling system whereby samples are obtained from the pipe spigot or, for fittings, from samples cast separately or integrally with the castings concerned. Test bars shall be machined from these samples and tensile tested in accordance with **6.3**; or

b) a system of process control (e.g. by non-destructive testing) where a positive correlation can be demonstrated with the tensile properties specified in table 7. Testing verification procedures shall be based on the use of comparitor samples having known and verifiable properties. This system shall be supported by tensile testing in accordance with **6.3.**

4.3.2 ***Hardness***

The hardness of the various components shall be such that they can be cut, drilled, tapped and/or machined with normal tools. In case of dispute, the hardness shall be measured by the Brinell hardness test in accordance with **6.4.**

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

4.4 Coatings and linings for pipes

4.4.1 ***General***

Unless otherwise agreed between the manufacturer and the purchaser, all pipes shall be delivered with an external coating of zinc with finishing layer in accordance with **4.4.2** and an internal lining of cement mortar in accordance with **4.4.3.** The field of use of these pipes is given in annexes D and E.

NOTE. Pipes with cast-on flanges may be coated as fittings (see **4.5**).

Pipe ends are generally coated as follows:

- external surface of spigots: zinc coating with finishing layer;
- flanges and sockets (face and internal surface): bituminous paint or synthetic resin paint, alone or as a supplement to a primer or zinc coating.

Table 7

Type of casting	Minimum tensile strength, R_m MPa	Minimum elongation after fracture, A %	
	DN 40 to DN 2000	DN 40 to DN 1000	DN 1100 to DN 2000
Pipes centrifugally cast	420	10	7
Pipes not centrifugally cast, fittings and accessories	420	5	5

NOTE 1. By agreement between manufacturer and purchaser, the 0,2 % proof stress ($R_{p\,0,2}$) may be measured. It shall be not less than:
- 270 MPa when A ≥12 % for DN 40 to DN 1 000 or A ≥ 10 % for DN > 1000;
- 300 MPa in other cases.

NOTE 2. For centrifugally cast pipes of DN 40 to DN 1 000, the minimum elongation after fracture shall be 7 % for thickness classes over K12.

By agreement between manufacturer and purchaser, the following coatings may also be supplied, depending on the external and internal conditions of use, which may be different to those given in annexes D and E.

a) *External coatings*:

- zinc rich paint coating with finishing layer;
- thicker metallic zinc coating with finishing layer;
- polyethylene sleeving (as a supplement to the zinc coating with finishing layer);
- extruded polyethylene;
- extruded polypropylene;
- polyurethane;
- fibre cement mortar;
- adhesive tapes.

b) *Internal coatings (linings):*

- polyurethane;
- bituminous paint;
- thicker cement mortar lining;
- cement mortar lining with seal coat.

c) *End coating:*

- epoxy.

These external and internal coatings shall comply with the corresponding EN standards or, where no EN standard exists, they shall comply with ISO standards or with national standards, or with an agreed technical specification.

4.4.2 *External coating of zinc with finishing layer*

4.4.2.1 *General*

The external coating of centrifugally cast ductile iron pipes shall comprise a layer of metallic zinc, covered by a finishing layer of a bituminous product or synthetic resin compatible with zinc. Both layers shall be works-applied by spraying with suitable spray-guns, the design of which is outside the scope of this standard.

The zinc is normally applied on oxide-surfaced pipes after heat treatment; at the manufacturer's option, it may also be applied on blast-cleaned pipes. Prior to application of the zinc, the pipe surface shall be dry and free from rust or non-adhering particles or foreign matter such as oil or grease.

4.4.2.2 *Coating characteristics*

The metallic zinc coating shall cover the external suface of the pipe and provide a dense, continuous, uniform layer. It shall be free from such defects as bare patches or lack of adhesion.

The uniformity of the coating shall be checked by visual inspection.

When measured in accordance with **6.6**, the mean mass of zinc per unit area shall be not less than 130 g/m^2, with a local minimum of 110 g/m^2.

4.4.2.3 *Repairs*

Damage to coatings where the area of total removal of metallic zinc has a width exceeding 5 mm and areas left uncoated (e.g. under test token, see **6.6**) shall be repaired.

Repairs shall be carried out either by:

a) metallic zinc spray complying with **4.4.2**; or

b) application of zinc-rich paint containing at least 90 % zinc by mass of dry film; the mean mass of applied paint shall be not less than 150 g/m^2.

4.4.2.4 *Finishing layer*

It shall uniformly cover the whole surface of the metallic zinc layer and be free from such defects as bare patches or lack of adhesion.

The uniformity of the finishing layer shall be checked by visual inspection.

When measured in accordance with **6.7**, the mean thickness of the finishing layer shall be not less than 70 μm and the local minimum thickness not less than 50 μm.

4.4.3 *Internal lining of cement mortar*

4.4.3.1 *General*

The cement mortar lining of ductile iron pipes shall constitute a dense, homogeneous layer covering the total internal surface of the pipe barrel.

It shall be works-applied by a centrifugal spinning process or a centrifugal spray head or a combination of these methods. Smoothing with a trowel is permitted.

Prior to application of the lining, the metal surface shall be free from loose material and oil or grease.

The cement mortar mix shall comprise cement, sand and water; chloride-free admixtures may be used if necessary. The ratio by mass of sand to cement shall not exceed 3,5. At mixing stage, the ratio by mass of total water to cement depends on the manufacturing process and shall be determined such that the lining is in accordance with **4.4.3.2** and **4.4.3.3.**

The cement shall be one of those listed in ENV 197-1 or high alumina cement and it shall enable the cured lining to comply with **4.1.4**.

The sand shall have an appropriate grading and shall not contain organic impurities or fine clay particles which may affect the lining quality.

The water used in the mortar mix shall be potable water or water that has no harmful effect on the characteristics of the lining and of the conveyed water (see **4.1.4**).

After application of the fresh lining, controlled curing shall be carried out so as to provide sufficient hydration to the cement.

4.4.3.2 *Strength of the lining*

When measured in accordance with **6.8**, the compressive strength of the cement mortar after 28 days of curing shall be not less than 50 MPa.

NOTE. The compressive strength of the lining is directly related to other functional properties such as high density, good bond and low porosity.

4.4.3.3 *Thickness and surface condition*

The nominal thickness of the cement mortar lining and its tolerance shall be as given in table 8. When measured in accordance with **6.9**, the lining thickness shall be within the specified tolerance.

The surface of the cement mortar lining shall be uniform and smooth; trowel marks and protrusion of sand grains are acceptable, but there shall be no recesses or local defects which reduce the thickness to below the minimum value given in table 8.

If fine crazing and hairline cracks associated with cement rich surfaces appear in dry linings, there shall be no evidence of disbondment.

Table 8

Dimensions in millimetres

DN	Thickness		Maximum crack width and radial displacement
	Nominal value	Tolerance[1]	
40 to 300	3,5	− 1,5	0,8
350 to 600	5	− 2	1,0
700 to 1200	6	− 2,5	1,2
1400 to 2000	9	− 3	1,5

[1] A negative tolerance only is given.
NOTE. Pipe ends may have a chamfer of maximum length 50 mm.

When shrinkage cracks inherent to cement-bound materials have developed in the dry linings, the crack width and the corresponding radial displacement shall not exceed the values given in table 8.

NOTE. Storage of pipes and fittings in a hot, dry environment can cause metal expansion and mortar shrinkage which may result in the dry lining developing areas of disbondment and shrinkage cracks. When the lining is re-exposed to water, it will swell by absorption of moisture and the cracks will eventually heal by an autogenous process.

4.4.3.4 *Repairs*

Repairs to areas of damaged linings shall be effected by the use of either cement mortar (see **4.4.3.1**) or a compatible polymer mortar; application may be by hand.

Prior to the application of the repair mortar, the damaged area shall be cut back to the sound lining or to the metal surface and all loose material shall be removed. After completion of the repair, the lining shall be in accordance with **4.4.3.1**, **4.4.3.2** and **4.4.3.3**.

4.5 Coatings for fittings and accessories

4.5.1 ***General***

Unless otherwise agreed between the manufacturer and the purchaser, all fittings, accessories and pipes not centrifugally cast shall be delivered externally and internally coated by paint conforming with **4.5.2**; fittings may also receive an internal lining of cement mortar conforming with **4.4.3**, machine or hand applied, as a supplement to or as a replacement of the paint coating. Their field of use is given in annexes D and E.

By agreement between manufacturer and purchaser, the following coatings may also be supplied, depending on the external and internal conditions of use, which may be different to those given in annexes D and E.

a) *External coatings*:

- zinc coating with finishing layer;
- polyethylene sleeving (as a supplement to the bituminous paint or to the zinc coating with finishing layer);
- epoxy;
- adhesive tapes.

b) *Internal coatings (linings)*:

- polyurethane;
- epoxy;
- thicker cement mortar lining;
- cement mortar lining with seal coat.

These external and internal coatings shall comply with the corresponding EN standards or, where no EN standard exists, they shall comply with ISO standards or with national standards, or with an agreed technical specification.

4.5.2 ***Paint coatings***

4.5.2.1 *General*

The coating material shall be of a bitumen or synthetic resin base; appropriate additives (such as solvents, inorganic fillers, . . .) to allow easy application and drying are permitted.

Prior to application of the coating, the casting surface shall be dry, free from rust or non adhering particles or foreign matter such as oil or grease.

The coating shall be works-applied by dipping, by spraying or by brush.

4.5.2.2 *Coating characteristics*

The coating shall uniformly cover the whole surface of the casting and have a smooth regular appearance. Drying shall be sufficient to ensure that it will not stick to adjacent coated pieces.

When measured in accordance with **6.7**, the mean thickness of the coating shall be not less than 70 μm and the local minimum thickness shall be not less than 50 μm.

4.6 Marking of pipes and fittings

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

- the manufacturer's name or mark;
- the identification of the year of manufacture;
- the identification as ductile iron;
- the DN;
- the PN rating of flanges when applicable;
- the reference to this standard;
- the identification of third party certification when applicable;
- the class designation of centrifugally cast pipes when other than *K*9.

The first five markings given above shall be cast-on or cold stamped; the three other markings can be applied by any method, e.g. painting on the casting or attached to the packaging.

4.7 Leaktightness

4.7.1 *Pipes and fittings*

Pipes and fittings shall be designed to be watertight at their allowable test pressure (PEA).

They shall all be tested in accordance with **6.5** and shall exhibit no visible leakage, sweating or any other sign of failure.

4.7.2 *Joints*

Joints shall be designed to fulfil the following requirements:

a) to durably withstand without leakage the allowable maximum operating pressure (PMA) of corresponding pipes and fittings, or their own PMA as given in the manufacturer's catalogues, whichever is the lowest. This applies under all normal service conditions, including foreseeable surge pressures and joint movements (angular, radial and axial);

b) to be leaktight under negative internal pressure, which may occur under surge conditions;

c) to withstand without any ingress of water an external hydrostatic pressure of 2 bar, when they are intended for use deeper than 5 m below the water level (e.g. river, lake, aquifer).

In order to fulfil these requirements, the joints shall comply with the performance requirements of clause **5**.

5 Performance requirements for joints

5.1 General

In order to ensure their fitness for purpose in the field of water supply all the joints shall fulfil the performance requirements of clause **5**.

There shall be a type test (see **3.24**) for at least one DN for each of the groupings given in table 9. One DN is representative of a grouping when the performances are based on the same design parameters throughout the size range. If a grouping covers products of different designs and/or manufactured by different processes, the grouping shall be sub-divided.

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

5.2 Flexible joints

5.2.1 *General*

All joints shall be designed to be fully flexible; consequently, the allowable angular deflection declared by the manufacturer shall be not less than:

- 3° 30′ for DN 40 to DN 300;
- 2° 30′ for DN 350 to DN 600;
- 1° 30′ for DN 700 to DN 2000.

All joints shall be designed to provide sufficient axial movement; 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 *Test conditions*

All joint designs shall be type tested under the most unfavourable, applicable conditions of tolerance and joint movement as given below:

a) joint of maximum annulus (see **5.2.3.1**) aligned, withdrawn to the allowable value declared by the manufacturer, and subject to shear (see **5.2.3.3**);

b) joint of maximum annulus (see **5.2.3.1**), deflected to the allowable value declared by the manufacturer (see **5.2.1**).

Table 9

DN Groupings	40 to 250	300 to 600	700 to 1000	1100 to 2000
Preferred DN in each grouping	200	400	800	1600

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

- test 1: positive internal hydrostatic pressure in accordance with **7.1**; the test pressure shall be $1{,}5p + 5$ bar, where p is the allowable operating pressure of the joint declared by the manufacturer;
- test 2: negative internal pressure of 0,9 bar below atmospheric pressure (approximately 0,1 bar absolute pressure), in accordance with **7.2**;
- test 3 (optional; see **4.7.2**): positive external hydrostatic pressure of 2 bar, in accordance with **7.3** (under test condition a) only);
- test 4 (under test condition a) only): cyclic internal hydraulic pressure in accordance with **7.4**; the test shall comprise at least 24,000 pressure cycles between $0{,}5p$ and p.

NOTE. Test 4 is not necessary for joints which have already performed successfully for at least 10 years prior to the first publication of this standard.

5.2.3 *Test parameters*

5.2.3.1 *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 *Pipe thickness*

All joints shall be type tested with a spigot having an average iron wall thickness (over a distance of 2·DN in millimetres from the spigot end face) equal to the specified 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 test pipe in the bore to achieve the required thickness.

5.2.3.3 *Shear*

All joints shall be type tested with a resultant shear force across the joints of not less than 50 DN in newtons, taking into account the weight of the pipe and of its contents and the geometry of the test assembly (see **7.1**).

5.3 Restrained flexible joints

All restrained joints shall be designed to be at least semi-flexible; consequently, the allowable angular deflection declared by the manufacturer shall be not less than half of the value shown in **5.2.1.**

All restrained joint designs shall be type-tested in accordance with **7.1** to **7.4** following the requirements of **5.2.2** and **5.2.3**, except that:

- the withdrawal condition of **5.2.2a**) shall not apply;
- 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.

NOTE. When the restraining mechanism and the sealing component of a restrained joint are independent, such a joint does not need to be subjected to test 2 and test 3 of **5.2.2** if the unrestrained version of the joint has passed these tests.

5.4 Pipes with screwed-on or welded-on flanges

In order to demonstrate their strength and leaktightness in severe service conditions, pipes with screwed-on or welded-on flanges shall be subjected to a type test to prove the method of flange to pipe attachment. When tested in accordance with **7.5**; they shall show no visible leakage under the combined effects of a hydrostatic internal pressure equal (in bars) to 2·PN and of an external load sufficient to cause the bending moments given in table 10. The calculation of the external load to be applied shall take account of the bending moment due to the weight of the components and of the water in the test assembly.

NOTE 1. Flanged pipelines may be subjected in service to high bending moments caused by large unsupported spans and/or settlements of supports.

NOTE 2. The bending moments given in table 10 are equal to four times those resulting from the weight of the pipes and of the water over an unsupported length L between simple supports, with:

- $L = 8$ m for DN ≤ 250;
- $L = 12$ m for DN ≥ 300.

Table 10

DN	Bending moment kN.m	Minimum distance $X^{1)}$ mm	
		*K*9	*K*10
40	2,9	132	132
50	3,7	135	135
60	5,2	139	139
65	5,6	140	140
80	7,2	145	145
100	9,3	150	150
125	11,6	156	156
150	16,0	161	163
200	24,0	171	176
250	34,2	183	188
300	104	194	201
350	135	205	212
400	16	216	224
450	205	227	235
500	251	238	247
600	348	259	270
700	463	281	292
800	584	302	315
900	724	323	337
1000	886	343	359
1100	1060	364	381
1200	1250	385	403
1400	1690	427	447
1500	1900	447	469
1600	2190	468	491
1800	2500	509	535
2000	3080	551	579

1) See 7.5.

6 Test methods

6.1 Dimensions

6.1.1 *Wall thickness*

All centrifugally cast pipes shall be visually inspected for colour uniformity as they are extracted from the mould in order to detect iron wall thickness differences at an early stage.

The iron wall thickness shall be measured by suitable equipment, e.g. mechanical or ultrasonic, at regular intervals along the pipe barrel. The manufacturer's process control system shall specify the frequency of this test.

6.1.2 *External diameter*

Socket and spigot pipes shall be measured at their spigot end by means of a circumferential tape or controlled by pass-fail gauges. The manufacturer's process control system shall specify the frequency of this test.

In addition, they shall be visually inspected for compliance with the spigot allowable ovality and, in case of doubt, the maximum and minimum spigot axes shall be measured by suitable equipment or controlled by pass-fail gauges.

6.1.3 *Internal diameter*

The internal diameter of pipes shall be measured by means of suitable equipment. Two measurements shall be taken at right angles, at a cross section 200 mm or more from the end face. The mean value of these two measurements may then be calculated. The manufacturer's process control system shall specify the frequency of this test.

6.1.4 *Length*

The length of socket and spigot pipes shall be measured by suitable equipment:

- on the first pipe cast from a new mould, for as-cast pipes;
- on the first pipe, for pipes which are systematically cut to a pre-set length.

6.2 Straightness of pipes

The pipe shall be rolled on two gantries or rotated around its axis on rollers, which in each case are separated by not less than two-thirds of the standardized pipe length.

The point of maximum deviation from the straight axis shall be determined and the deviation measured at that point.

6.3 Tensile testing

6.3.1 *Samples*

The thickness of the sample and the diameter of the test bar shall be as given in table 11.

6.3.1.1 *Centrifugally cast pipes*

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

6.3.1.2 *Pipes not centrifugally cast, fittings and accessories*

At the manufacturer's option, samples shall be either cast integrally with the castings or cast separately. In the latter case they shall be cast from the same metal as that used for the castings. If the castings are subjected to heat treatment, the samples shall be subjected to the same heat treatment.

6.3.2 *Preparation of test bar*

A test bar shall be machined from each sample to be representative of the metal at the mid thickness of the sample, with a cylindrical part having the diameter given in the table 11.

The test bar shall have a gauge length equal to at least five times the nominal test bar diameter. The ends of the test bar shall be such that they will fit the testing machine.

The surface roughness profile of the cylindrical part of the test bar shall be such that $R_z \leq 6{,}3$.

Two methods of measuring the tensile strength of the test bar may be used at the manufacturer's option:

Method A:

Machine the test bar to its nominal diameter ± 10 %, measure the actual diameter before the test for ± 0,01 mm and use this measured diameter to calculate the cross-sectional area and the tensile strength; or

Method B:

Machine the test bar to its nominal area S_0 within a specified tolerance on diameter (see table 11) and use the nominal area to calculate the tensile strength.

6.3.3 *Apparatus and test method*

The testing machine shall have suitable holders or grips to suit the test bar ends so as to 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 accuracy class of the testing machine shall be in accordance with clause **9** of EN 10002-1 : 1990. The rate of stressing shall be as constant as possible within the limits of 6 N/mm^2 per second to 30 N/mm^2 per second.

Table 11

Type of Casting	Test bar method A	Test bar method B		
	Nominal diameter	Nominal area S_0	Nominal diameter	Tolerance on diameter
	mm	mm^2	mm	mm
Centrifugally cast pipes with wall thickness in millimetres:				
- less than 6	2,5	5,0	2,52	± 0,01
- 6 up to but not including 8	3,5	10,0	3,57	± 0,02
- 8 up to but not including 12	5,0	20,0	5,05	± 0,20
- 12 and over	6,0	30,0	6,18	± 0,03
Pipes not centrifugally cast, fittings and accessories:				
- integrally cast samples	5,0	20,0	5,05	± 0,02
- separately cast samples:				
- sample thickness 12,5 mm for casting thickness less than 12 mm	6,0	30,0	6,18	± 0,03
- sample thickness 25 mm for casting thickness 12mm and over	12,0 or 14,	—	—	—

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 extended gauge length shall be measured after piecing together the two parts of the test bar after fracture. The elongation shall be calculated using the ratio of the extended gauge length to the original gauge length. Alternatively, the elongation may be measured directly by means of an extensometer.

6.3.4 ***Test results***

Test results shall comply with table 7. If they do not comply, the manufacturer shall:

a) in the case where the metal does not achieve the required mechanical properties, investigate the reason and ensure that all castings in the batch are either re-heat treated or rejected. Castings which have been re-heat treated are then re-tested in accordance with **6.3**;

NOTE. The manufacturer may limit the amount of rejection by making tests until the rejected batch of castings is bracketed, in order of manufacture, by a successful test at each end of the interval in question.

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

6.3.5 ***Test frequency***

The frequency of testing is related to the system of production and quality control used by the manufacturer (see **4.3.1**). The maximum batch sizes shall be as given in table 12.

6.4 Brinell hardness

When Brinell hardness tests are carried out (see **4.3.2**), 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 using a steel ball of 2,5 mm or 5 mm or 10 mm diameter.

6.5 Works leaktightness test for 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 accuracy of ± 3 %.

6.5.2 ***Centrifugally cast pipes***

The internal hydrostatic pressure shall be raised steadily until it reaches the works hydrostatic test pressure given in table 13, which is maintained for a sufficient time to allow visual inspection of the pipe barrel. The total duration of the pressure cycle shall be not less than 15 s, including 10 s at test pressure.

6.5.3 ***Pipes not centrifugally cast and fittings***

At the manufacturer's option, they shall be submitted to a hydrostatic pressure test or to an air test, or to any other leaktightness test of equivalent performance.

When the hydrostatic pressure test is carried out it shall be in the same way as for centrifugally cast pipes (see **6.5.2**), except for the test pressures which shall be as given in table 13.

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 their external surface by a suitable foaming agent or submerged in water.

Table 12

Type of casting	DN	Maximum batch size	
		Batch sampling system	Process control system
Centrifugally cast pipes	40 to 300 350 to 600 700 to 1000 1100 to 2000	200 pipes 100 pipes 50 pipes 25 pipes	1 200 pipes 600 pipes 300 pipes 150 pipes
Pipes not centrifugally cast, fittings and accessories	40 to 2 000	4t[1)]	48t[1)]

[1)] Weight of crude castings, excluding the risers.

6.6 Zinc coating mass

A rectangular token of known weight per unit area shall be attached longitudinally along the axis of the pipe before passing it through the coating equipment. After coating and trimming, the size of the token shall be 500 mm × 50 mm. It shall be weighed on a scale having a precision of at least 0,01 g.

Table 13

DN	Minimum works test pressure bar		
	Pipes centrifugally cast		Pipes not centrifugally cast and fittings[1]
	$K < 9$	$K \geq 9$	All thickness classes
40 to 300	$0,5\,(K + 1)^2$	50	25[2]
350 to 600	$0,5\,K^2$	40	16
700 to 1000	$0,5\,(K - 1)^2$	32	10
1100 to 2000	$0,5\,(K - 2)^2$	25	10

[1] The works hydrostatic test pressure is less for fittings than for pipes because the shape of the fittings makes it difficult to provide sufficient restraint to high internal pressures during the test.

[2] 16 bar for pipes and fittings with PN 10 flanges.

The mean mass M of zinc per unit area shall be determined from the mass difference before and after zinc coating.

$$M = C\left(\frac{M_2 - M_1}{A}\right)$$

where:

M is the mean mass of zinc, in grammes per square metre;

M_1 and M_2 are the masses of the sample token, in grammes, before and after coating;

C is the predetermined correction factor, taking account of the nature of the token and of the difference in surface roughness between the token and the iron pipe;

A is the actual area of the trimmed token, in square metres.

NOTE 1. The value of C, generally lying between 1 and 1,2, is given in the manufacturer's quality assurance plan.

The uniformity of the coating shall be checked by the visual inspection of the token; in the event of a lack of uniformity, 50 mm × 50 mm pieces shall be cut from the token in the lighter mass zones and the local minimum mass of zinc determined on each piece by mass difference.

NOTE 2. Alternatively the mass of zinc per unit area can be measured directly on the coated pipe by any method having proven correlation with the reference method described above, e.g. X-ray fluorescence or chemical analysis.

6.7 Thickness of paint coatings

The dry film thickness of paint coatings shall be measured by either of the following methods:

a) directly on the casting by means of suitable gauges, e.g. magnetic, or by using a 'wet film' thickness gauge where a correlation between wet film thickness and dry film thickness can be demonstrated; or

b) indirectly on a token which is attached to the casting before coating and is used after coating to measure the dry film thickness by mechanical means, e.g. micrometer, or by a weight method similar to **6.6.**

For each casting to be controlled, at least three measurements shall be taken (either on the casting or on the token). The mean thickness is the average of all the measurements taken and the local minimum thickness is the lowest value of all the measurements taken.

6.8 Compressive strength of the cement mortar lining

The compressive strength shall be the arithmetic mean of six compressive strength tests performed on three prism samples after 28 days of curing.

The compressive strength shall be determined by a type-test in accordance with EN 196-1, except that:

- the sand, the cement and the water used for the prism samples are identical with those used for the mortar before application of the lining;
- the sand/cement ratio used for the prism samples is equal to that used for the mortar before application of the lining;
- the water/cement ratio used for the prism samples is equal to that of the lining immediately after application to the pipe wall.

NOTE. This takes into account the influence of the centrifugal spinning process which allows expelling the excess water.

6.9 Thickness of cement mortar lining

During manufacture, the thickness shall be measured on the freshly applied lining by a spear having a diameter of 1,5 mm or less and controlled on the finished hardened lining by means of a suitable gauge, e.g. magnetic.

The measurements shall be taken approximately 200 mm from the end face. The manufacturer's process control system shall specify the frequency of this test.

7 Type tests

7.1 Leaktightness of joints to positive internal pressure

The test shall be carried out on an assembled joint comprising two pipe sections, each at least 1 m long (see figure 1).

The test apparatus shall be capable of providing suitable end and lateral 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 with an accuracy of ± 3 %.

The vertical force W shall be applied to the spigot end by means of a V shaped block with an angle of 120°, located at approximately 0,5 DN in millimetres or 200 mm from the socket face whichever is the largest; the socket shall bear on a flat support. The vertical force W shall be such that the resultant shear force F across the joint is equal to the value specified in **5.2.3.3**, taking into account the mass M of the pipe and its contents and the geometry of the test assembly:

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

where

a, b and c are as shown in figure 1.

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 per 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. 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 shall be identical except that there shall be no end restraint, so that the axial thrust is taken by the restrained joint under test. In addition, possible axial movement of the spigot shall be measured every 15 min.

7.2 Leaktightness of joints to negative internal pressure

The test assembly and test apparatus shall be as given in **7.1**, with the pipe sections axially restrained to prevent them moving towards each other, or as given in **7.3**.

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**) and then isolated from the vacuum pump. The test assembly shall be left under vacuum for 2 h, at the end of which time the vacuum shall not have changed by more than 0,09 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.

7.3 Leaktightness of joints to positive external pressure

The test assembly shall comprise two joints made with two pipe sockets welded together and one double-spigot piece (see figure 2); it creates an annular chamber which allows to test one joint under internal pressure and one joint under external pressure.

The test assembly shall be subjected to a vertical force W equal to the shear force F defined in **5.2.3**; one half of this load shall be applied to the spigot end on each side of the test assembly, by means of a V shaped block with an angle of 120°, located at approximately 0,5 DN in millimetres or 200 mm from the ends of the sockets whichever is the largest; the sockets shall bear on a flat support.

The test assembly shall be filled with water and suitably vented of air. The pressure shall be steadily increased until it reaches the test pressure of 2 bar. The latter shall be 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.

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

7.4 Leaktightness of joints to dynamic internal pressure

The test assembly and test apparatus shall be as given in **7.1**. The test assembly shall be filled with water and suitably vented of air.

The pressure shall be steadily increased up to p, the allowable operating pressure of the joint, then automatically monitored according to the following pressure cycle:

a) steady pressure reduction to $0{,}5p$;

b) maintain $0{,}5p$ for at least 5 s;

c) steady pressure increase to p;

d) maintain p for at least 5 s.

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

The number of cycles shall be recorded and the test stopped automatically in the occurrence of a failure of the joint.

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.

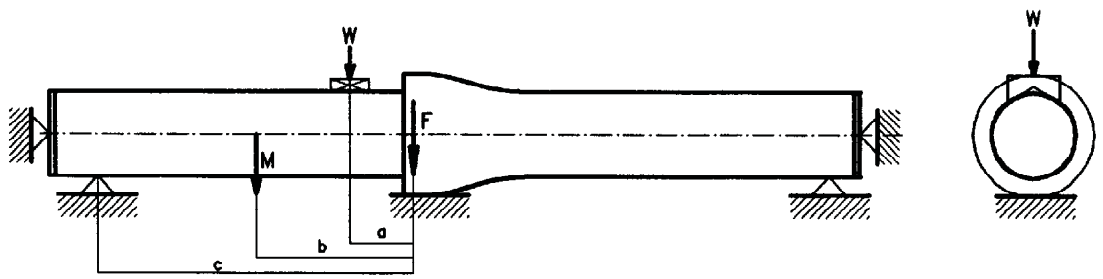

Figure 1

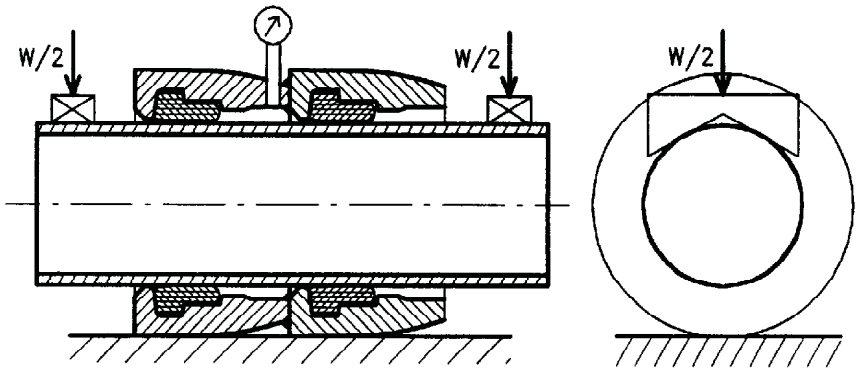

Figure 2

7.5 Leaktightness and mechanical resistance of screwed-on and welded-on flanges

The test assembly shall comprise two flanged pipes of approximately equal length, assembled together by means of a flanged joint; both ends of the test assembly shall be equipped with blank flanges.

The wall thickness of pipe used in the type test shall be the specified minimum thickness e_{min} (in millimetres) of its class plus 10 % minus 0 % over a distance X (in millimetres) from the jointing face of each flange at the joint to be tested:

$$X = 100 + 2{,}3\,(\mathrm{DN} \times e_{\min})^{0{,}5}$$

NOTE. See table 10 for values of X.

The test assembly shall be placed on two simple supports such that the assembled flanged joint is positioned at mid point. The minimum length of unsupported span shall be either 6·DN in millimetres or 4000 mm whichever is the smaller.

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 **5.4**. The external load shall be applied to the assembled flanged joint by means of a flat plate, in a direction perpendicular to the axis of the test assembly, so as to cause the bending moment given in table 10.

The internal pressure and the external load are kept constant for 15 min during which the flanged joint shall be thoroughly inspected.

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

NOTE. The elevated pressures and bending moments applied in the test, result in loading significantly greater than that acting normally in service. Consequently, the test may require the use of gaskets and bolts of higher performance than those normally supplied and the application of bolt torques in excess of those normally applied during site installation.

8 Quality assurance

8.1 General

The manufacturer shall demonstrate the conformity of his products with this standard by:

- carrying out performance type tests (see **8.2**); and
- controlling the manufacturing process (see **8.3**).

8.2 Type tests

The type tests specified in clauses **5** and **7** of this 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 standard. Full reports of these type tests shall be retained by the manufacturer as evidence of compliance.

8.3 Quality assurance system

The manufacturer shall control the quality of his products during their manufacture by a system of process control in order to comply with the technical requirements of this standard. Wherever possible, statistical sampling techniques should be used.

Consequently, the manufacturer's quality assurance system shall comply with the requirements of EN 29002.

The manufacturer's quality assurance system should be approved by a third party certification body who is accredited in accordance with EN 45012.

9 Tables of dimensions

9.1 Socket and spigot pipes

The dimensions of socket and spigot pipes shall be as given in table 14. The values of L_u are given in table 3. For external and internal coatings see **4.4**.

NOTE. The values of *DE* and their tolerances apply also to the spigot ends of fittings (see **4.2.2.1**).

Table 14

	External diameter DE mm		Iron thickness *e* mm		
DN	**Nominal**	**Tolerance**	***K*9**	***K*10**	**Tolerance**[1]
40	56	+1/−1,2	6,0	6,0	−1,3
50	66	+1/−1,2	6,0	6,0	−1,3
60	77	+1/−1,2	6,0	6,0	−1,3
65	82	+1/−1,2	6,0	6,0	−1,3
80	98	+1/−2,2	6,0	6,0	−1,3
100	118	+1/−2,8	6,0	6,0	−1,3
125	144	+1/−2,8	6,0	6,2	−1,4[2]
150	170	+1/−2,9	6,0	6,5	−1,5[2]
200	222	+1/−3,0	6,3	7,0	−1,5
250	274	+1/−3,1	6,8	7,5	−1,6
300	326	+1/−3,3	7,2	8,0	−1,6
350	378	+1/−3,4	7,7	8,5	−1,7
400	429	+1/−3,5	8,1	9,0	−1,7
450	480	+1/−3,6	8,6	9,5	−1,8
500	532	+1/−3,8	9,0	10,0	−1,8
600	635	+1/−4,0	9,9	11,0	−1,9
700	738	+1/−4,3	10,8	12.0	−2,0
800	842	+1/−4,5	11,7	13.0	−2,1
900	945	+1/−4,8	12,6	14.0	−2,2
1000	1048	+1/−5,0	13,5	15.0	−2,3
1100	1152	+1/−6,0	14,4	16.0	−2,4
1200	1255	+1/−5,8	15,3	17.0	−2,5
1400	1462	+1/−6,6	17,1	19.0	−2,7
1500	1565	+1/−7,0	18,0	20.0	−2,8
1600	1668	+1/−7,4	18,9	21.0	−2,9
1800	1875	+1/−8,2	20,7	23.0	−3,1
2000	2082	+1/−9,0	22,5	25.0	−3,3

[1] A negative tolerance only is given.
[2] −1,3 when the thickness is equal to 6,0 mm.

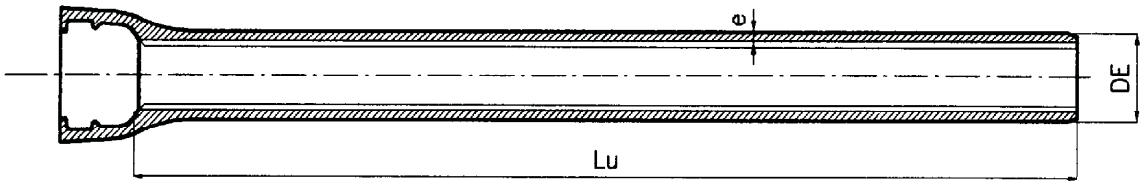

Figure 3

9.2 Flanged pipes

Standardized thickness classes, DNs and PNs of flanged pipes are specified in the following three subclauses. The values of L are given in table 4. For coatings and linings, see **4.4**.

NOTE. Flanged dimensions are in conformity with prEN 1092-2.

9.2.1 *Centrifugally cast pipes with welded-on flanges*

- DN 40 to DN 450: $K9$ for PN 10, PN 16, PN 25 and PN 40;
- DN 500 and DN 600: $K9$ for PN 10m PN 16 and PN 25; $K10$ for PN 40;
- DN 700 to DN 1600: $K9$ for PN 10, PN 16 and PN 25;
- DN 1800 and DN 2000: $K9$ for PN 10 and PN 16.

9.2.2 *Centrifugally cast pipes with screwed-on flanges*

- DN 40 to DN 450: $K9$ or $K10$ for PN 10, PN 16, PN 25 and PN 40;
- DN 500 and DN 600: $K9$ or $K10$ for PN 10, PN 16 and PN 25; $K10$ for PN 40;
- DN 700 to DN 1 200: $K10$ for PN 10, PN 16 and PN 25;
- DN 1400 to DN 2000: $K10$ for PN 10 and PN 16.

9.2.3 *Pipes with integrally cast flanges*

- DN 40 to DN 600: $K12$ for PN 10, PN 16, PN 25 and PN 40;
- DN 700 to DN 1600: $K12$ for PN 10, PN 16 and PN 25;
- DN 1800 and DN 2 000: $K12$ for PN 10 and PN 16.

9.3 Fittings for socketed joints

In the following tables, all the dimensions are nominal values and are given in millimetres. The values of L_u and l_u have been rounded off to the nearest multiple of five.

For coating and linings, see **4.5**.

9.3.1 *Flanged sockets*

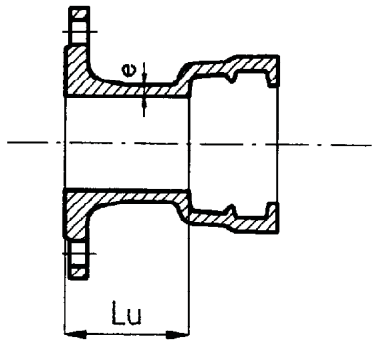

Figure 4a

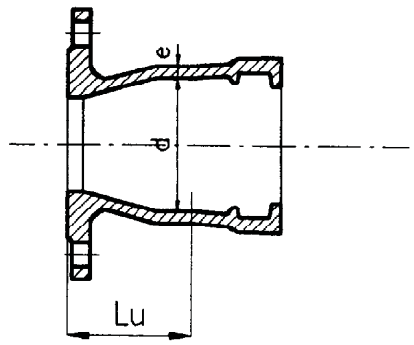

Figure 4b

Table 15

DN	e	L_u series A	L_u series B	d
40	7	125	75	67
50	7	125	85	78
60	7	125	100	88
65	7	125	105	93
80	7	130	105	109
100	7,2	130	110	130
125	7,5	135	115	156
150	7,8	135	120	183
200	8,4	140	120	235
250	9	145	125	288
300	9,6	150	130	340
350	10,2	155	135	393
400	10,8	160	140	445
450	11,4	165	145	498
500	12	170	-	550
600	13,2	180	-	655
700	14,4	190	-	760
800	15,6	200	-	865
900	16,8	210	-	970
1000	18	220	-	1075
1100	19,2	230	-	1080
1200	20,4	240	-	1285
1400	22,8	310	-	1477
1500	24	330	-	1580
1600	25,2	330	-	1683
1800	27,6	350	-	1889
2000	30	370	-	2095

9.3.2 ***Flanged spigots***

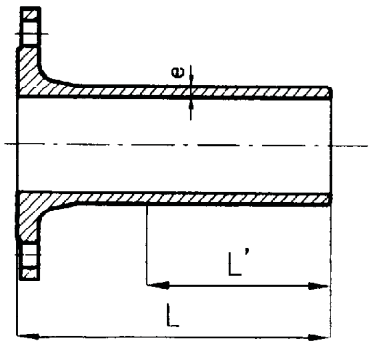

Figure 5

9.3.3 ***Collars***

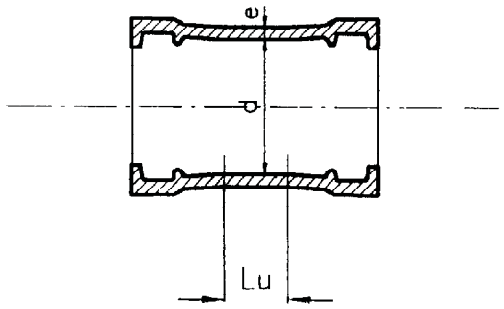

Figure 6

Table 16

DN	*e*	Flanged spigots			Collars		
		L series A	*L* series B	*L'*	L_u series A	L_u series B	*d*
40	7	335	335	200	155	155	67
40	7	340	340	200	155	155	78
60	7	345	340	200	155	155	88
65	7	345	345	200	155	155	93
80	7	350	350	215	160	160	109
100	7,2	360	360	215	160	160	130
125	7,5	370	370	220	165	165	156
150	7,8	380	380	225	165	165	183
200	8,4	400	400	230	170	170	235
250	9	420	420	240	175	175	288
300	9,6	440	440	250	180	180	340
350	10,2	460	460	260	185	185	393
400	10,8	480	480	270	190	190	445
450	11,4	500	500	280	195	195	498
500	12	520	–	290	200	–	550
600	13,2	560	–	310	210	–	655
700	14,4	600	–	330	220	–	760
800	15,6	600	–	330	230	–	865
900	16,8	600	–	330	240	–	970
1000	18	600	–	330	250	–	1075
1100	19,2	600	–	330	260	–	1180
1200	20,4	600	–	330	270	–	1285
1400	22,8	710	–	390	340	–	1477
1500	24	750	–	410	350	–	1580
1600	25,2	780	–	430	360	–	1683
1800	27,6	850		470	380	–	1889
2000	30	920		500	400	–	2095

NOTE. The length L' is the length to which the value of *DE* and its tolerance, as given in table 14, apply.

9.3.4 ***Double socket 90° (1/4) bends***

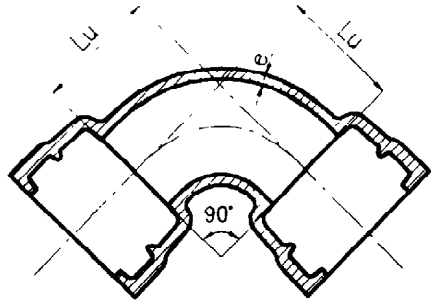

Figure 7

9.3.5 ***Double socket 45° (1/8) bends***

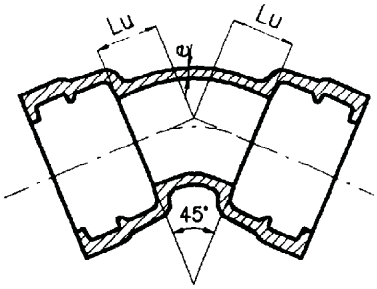

Figure 8

Table 17

DN	e	90° (1/4) bends		45° (1/8) bends	
		L_u series A	L_u series B	L_u series A	L_u series B
40	7	60	85	40	85
50	7	70	85	40	85
60	7	80	90	45	90
65	7	85	90	50	90
80	7	100	85	55	50
100	7,2	120	100	65	60
125	7,5	145	115	75	65
150	7,8	170	130	85	70
200	8,4	220	160	110	80
250	9	270	240	130	135
300	9,6	320	280	150	155
350	10,2	-	-	175	170
400	10,8	-	-	195	185
450	11,4	-	-	220	200
500	12	-	-	240	-
600	13,2	-	-	285	-
700	14,4	-	-	330	-
800	15,6	-	-	370	-
900	16,8	-	-	415	-
1000	18	-	-	460	-
1100	19,2	-	-	505	-
1200	20,4	-	-	550	-
1400	22,8	-	-	515	-
1500	24	-	-	540	-
1600	25,2	-	-	560	-
1800	27,6	-	-	610	-
2000	30	-	-	660	-

9.3.6 ***Double socket 22° 30' (1/16) bends***

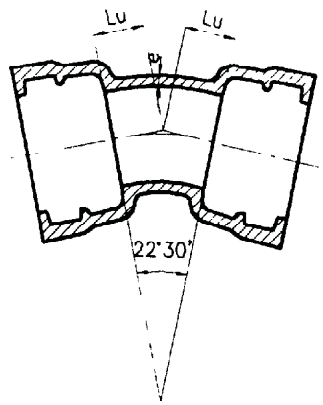

Figure 9

9.3.7 ***Double socket 11° 15' (1/32) bends***

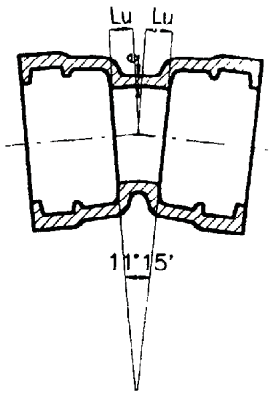

Figure 10

Table 18

DN	*e*	22° 30' (1/16) bends		11° 15' (1/32) bends	
		L_u series A	L_u series B	L_u series A	L_u series B
40	7	30	30	25	25
50	7	30	30	25	25
60	7	35	35	25	25
65	7	35	35	25	25
80	7	40	40	30	30
100	7,2	40	50	30	30
125	7,5	50	55	35	35
150	7,8	55	60	35	40
200	8,4	65	70	40	45
250	9	75	80	50	55
300	9,6	85	90	55	55
350	10,2	95	100	60	60
400	10,8	110	110	65	65
450	11,4	120	120	70	70
500	12	130	–	75	–
600	13,2	150	–	85	–
700	14,4	175	–	95	–
800	15,6	195	–	110	–
900	16,8	–	–	415	–
1000	18	–	–	460	–
1100	19,2	220	–	120	–
1200	20,4	240	–	130	–
1400	22,8	260	–	130	–
1500	24	270	–	140	–
1600	25,2	280	–	140	–
1800	27,6	305	–	155	–
2000	30	330	–	165	–

9.3.8 *All-socket tees*

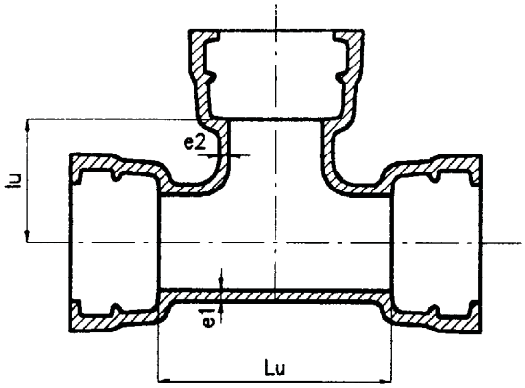

Figure 11

Table 19

DN × dn	Body			Branch		
	e_1	L_u series A	L_u series B	e_2	l_u series A	l_u series B
40 × 40	7	120	155	7	60	75
50 × 50	7	130	155	7	65	75
60 × 60	7	145	155	7	70	80
65 × 65	7	150	155	7	75	80
80 × 40	7	120	155	7	80	80
80 × 80	7	170	175	7	85	85
100 × 40	7,2	120	155	7	90	90
100 × 60	7,2	145	155	7	90	90
100 × 80	7,2	170	165	7	95	90
100 × 100	7,2	190	195	7,2	95	100
125 × 40	7,5	125	155	7	100	105
125 × 80	7,5	170	175	7	105	105
125 × 100	7,5	195	195	7,2	110	115
125 × 125	7,5	225	225	7,5	110	115
150 × 40	7,8	125	160	7	115	115
150 × 80	7,8	170	180	7	120	120
150 × 100	7,8	195	200	7,2	120	125
150 × 150	7,8	255	260	7,8	125	130
200 × 40	8,4	130	165	7	140	140
200 × 80	8,4	175	180	7	145	145
200 × 100	8,4	200	200	7,2	145	150
200 × 150	8,4	255	260	7,8	150	155
200 × 200	8,4	315	320	8,4	155	160
250 × 80	9	180	185	7	170	185
250 × 100	9	200	205	7,2	170	190
250 × 150	9	260	265	7,8	175	190
250 × 200	9	315	320	8,4	180	190
250 × 250	9	375	380	9	190	190
300 × 100	9,6	205	210	7,2	195	220
300 × 150	9,6	260	265	7,8	200	220
300 × 200	9,6	320	325	8,4	205	220
300 × 250	9,6	375	380	9	210	220
300 × 300	9,6	435	440	9,6	220	220

NOTE. The main nominal size is designated DN and the nominal size of the branch is designated dn.

9.3.9 *Double-socket tees with flanged branch, DN 40 to DN 250*

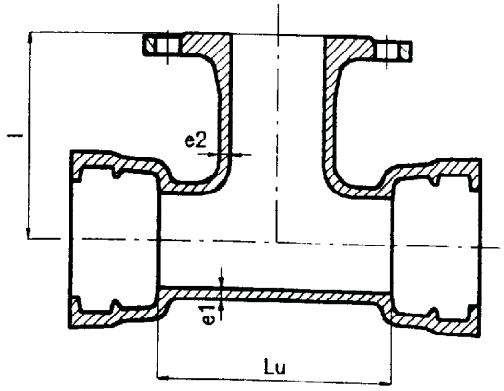

Figure 12

Table 20

DN × dn	Body			Branch		
	e_1	L_u series A	L_u series B	e_2	l series A	l series B
40 × 40	7	120	155	7	130	130
50 × 50	7	130	155	7	140	140
60 × 40	7	–	155	7	–	130
60 × 60	7	145	155	7	150	150
65 × 40	7	–	155	7	–	135
65 × 65	7	150	155	7	150	155
80 × 40	7	–	155	7	–	135
80 × 60	7	–	155	7	–	155
80 × 80	7	170	175	7	165	165
100 × 40	7	–	155	7	–	145
100 × 60	7	–	155	7	–	165
100 × 80	7	170	165	7	175	170
100 × 100	7,2	190	195	7,2	180	180
125 × 40	7,5	–	155	7	–	160
125 × 60	7,5	–	155	7	–	180
125 × 80	7,5	170	175	7	190	185
125 × 100	7,5	195	195	7,2	195	195
125 × 125	7,5	225	225	7,5	200	200
150 × 40	7,8	–	160	7	–	170
150 × 60	7,8	–	160	7	–	190
150 × 80	7,8	170	180	7	205	200
150 × 100	7,8	195	200	7,2	210	205
150 × 125	7,8	–	230	7,5	–	215
150 × 150	7,8	255	260	7,8	220	220

Table 20 *(concluded)*

DN × dn	Body			Branch		
	e_1	L_u series A	L_u series B	e_2	l series A	l series B
200 × 40	8,4	-	165	7	-	195
200 × 60	8,4	-	165	7	-	215
200 × 80	8,4	175	180	7	235	225
200 × 100	8,4	200	200	7,2	240	230
200 × 125	8,4	-	235	7,5	-	240
200 × 150	8,4	255	260	7,8	250	245
200 × 200	8,4	315	320	8,4	260	260
250 × 60	9	-	165	7	-	260
250 × 80	9	180	180	7	265	265
250 × 100	9	200	205	7,2	270	270
250 × 150	9	260	265	7,8	280	280
250 × 200	9	315	320	8,4	290	290
250 × 250	9	375	380	9	300	300

NOTE. The main nominal size is designated DN and the nominal size of the branch is designated dn.

9.3.10 *Double-socket tees with flanged branch, DN 300 to DN 700*

Table 21

DN × dn	Body			Branch		
	e_1	L_u series A	L_u series B	e_2	l series A	l series B
300 × 60	9,6	-	165	7	-	290
300 × 80	9,6	180	185	7	295	295
300 × 100	9,6	205	210	7,2	300	300
300 × 150	9,6	260	265	7,8	310	310
300 × 200	9,6	320	325	8,4	320	320
300 × 250	9,6	-	380	9	-	330
300 × 300	9,6	435	440	9,6	340	340
350 × 60	10,2	-	170	7	-	320
350 × 80	10,2	-	185	7	-	325
350 × 100	10,2	205	210	7,2	330	330
350 × 150	10,2	-	270	7,8	-	340
350 × 200	10,2	325	325	8,4	350	350
350 × 250	10,2	-	385	9	-	360
350 × 350	10,2	495	500	10,2	380	380
400 × 80	10,8	185	190	7	355	355
400 × 100	10,8	210	210	7,2	360	360
400 × 150	10,8	270	270	7,8	370	370
400 × 200	10,8	325	330	8,4	380	380
400 × 250	10,8	-	385	9	-	390
400 × 300	10,8	440	445	9,6	400	400
400 × 400	10,8	560	560	10,8	420	420
450 × 100	11,4	-	215	7,2	-	390
450 × 150	11,4	-	270	7,8	-	400
450 × 200	11,4	-	330	8,4	-	410
450 × 250	11,4	-	390	9	-	420
450 × 300	11,4	-	445	9,6	-	430
450 × 400	11,4	-	560	10,8	-	450
450 × 450	11,4	-	620	11,4	-	460
500 × 100	12	215	-	7,2	420	-
500 × 200	12	330	-	8,4	440	-
500 × 400	12	565	-	10,8	480	-
500 × 500	12	680	-	12	500	-
600 × 200	13,2	340	-	8,4	500	-
600 × 400	13,2	570	-	10,8	540	-
600 × 600	13,2	800	-	13,2	580	-
700 × 200	14,4	345	-	8,4	525	-
700 × 400	14,4	575	-	10,8	550	-
700 × 700	14,4	925	-	14,4	600	-

NOTE. The main nominal size is designated DN and the nominal size of the branch is designated DN.

9.3.11 *Double-socket tees with flanged branch, DN 800 to DN 2000*

Table 22

DN × dn	Body		Branch	
	e_1	L_u series A	e_2	l series A
800 × 200	15,6	350	8,4	585
800 × 400	15,6	580	10,8	615
800 × 600	15,6	1045	13,2	645
800 × 800	15,6	1045	15,6	675
900 × 200	16,8	355	8,4	656
900 × 400	16,8	590	10,8	675
900 × 600	16,8	1170	13,2	705
900 × 900	168	1170	16,8	750
1000 × 200	18	360	8,4	705
1000 × 400	18	595	10,8	735
1000 × 600	18	1290	13,2	765
1000 × 1000	18	1290	18	825
1100 × 400	19,2	600	10,8	795
1100 × 600	19,2	830	13,2	825
1200 × 600	20,4	840	13,2	885
1200 × 800	20,4	1070	15,6	915
1200 × 1000	20,4	1300	18	945
1400 × 600	22,8	1030	13,2	980
1400 × 800	22,8	1260	15,6	1010
1400 × 1000	22,8	1495	18	1040
1500 × 600	24	1035	13,2	1035
1500 × 1000	24	1500	18	1595
1600 × 600	25,2	1040	13,2	1090
1600 × 800	25,2	1275	15,6	1120
1600 × 1000	25,2	1505	18	1150
1600 × 1200	25,2	1740	20,4	1180
1800 × 600	27,6	1055	13,2	1200
1800 × 800	27,6	1285	15,6	1230
1800 × 1000	27,6	1520	18	1260
1800 × 1200	27,6	1750	20,4	1290
2000 × 600	30	1065	13,2	1310
2000 × 1000	30	1530	18	1370
2000 × 1400	30	1995	22,8	1430

NOTE. The main nominal size is designated DN and the nominal size of the branch is designated dn.

9.3.12 ***Double-socket tapers***

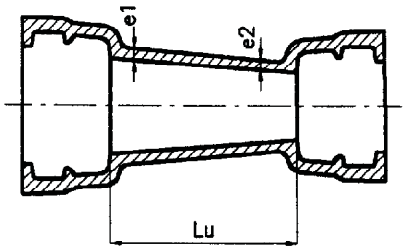

Figure 13

Table 23

DN × dn	e_1	e_2	L_u series A	L_u series B
50 × 40	7	7	70	75
60 × 50	7	7	70	75
65 × 50	7	7	80	75
80 × 40	7	7	-	80
80 × 60	7	7	90	80
80 × 65	7	7	80	80
100 × 60	7,2	7	-	120
100 × 80	7,2	7	90	85
125 × 60	7,5	7	-	190
125 × 80	7,5	7	140	135
125 × 100	7,5	7,2	100	120
150 × 80	7,8	7	190	190
150 × 100	7,8	7,2	150	150
150 × 125	7,8	7,5	100	115
200 × 100	8,4	7,2	250	250
200 × 125	8,4	7,5	200	230
200 × 150	8,4	7,8	150	145
250 × 125	9	7,5	300	335
250 × 150	9	7,8	250	250
250 × 200	9	8,4	150	150
300 × 150	9,6	7,8	350	370
300 × 200	9,6	8,4	250	250
300 × 250	9,6	9	150	150
350 × 200	10,2	8,4	360	370
350 × 250	10,2	9	260	260
350 × 300	10,2	9,6	160	160
400 × 250	10,8	9	360	380
400 × 300	10,8	9,6	260	260
400 × 350	10,8	10,2	160	155
450 × 350	11,4	10,2	260	270
450 × 400	11,4	10,8	160	160
500 × 350	12	10,2	360	-
500 × 400	12	10,8	260	-

Table 23 *(concluded)*

DN × dn	e_1	e_2	L_u series A	L_u series B
600 × 400	13,2	10,8	460	-
600 × 500	13,2	12	260	-
700 × 500	14,4	12	480	-
700 × 600	14,4	13,2	280	
800 × 600	15,6	13,2	480	-
800 × 700	15,6	14,4	280	-
900 × 700	16,8	14,4	480	-
900 × 800	16,8	15,6	280	-
1000 × 800	18	15,6	480	-
1000 × 900	18	16,8	280	-
1100 × 1000	19,2	18	280	-
1200 × 1000	20,4	18	480	-
1400 × 1200	22,8	20,4	360	-
1500 × 1400	24	22,8	260	-
1600 × 1400	25,2	22,8	360	-
1800 × 1600	27,6	25,2	360	-
2000 × 1800	30	27,6	360	-

NOTE. The larger end is designated DN and the smaller end is dn.

9.4 Fittings for flanged joints

In the following tables, all the dimensions are nominal values and are given in millimetres. For coatings and linings, see **4.5**.

9.4.1 ***Double-flanged 90° (1/4) bends***

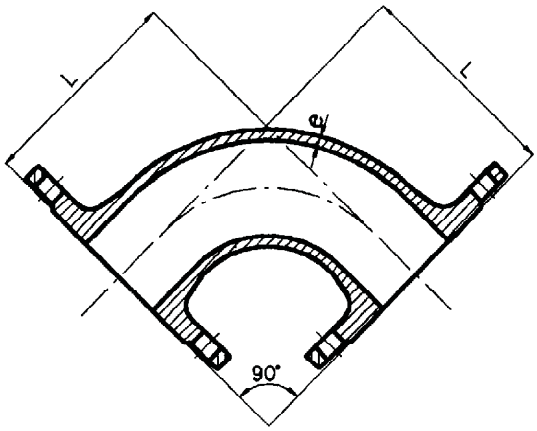

Figure 14

9.4.2 ***Double-flanged duckfoot 90° (1/4) bends***

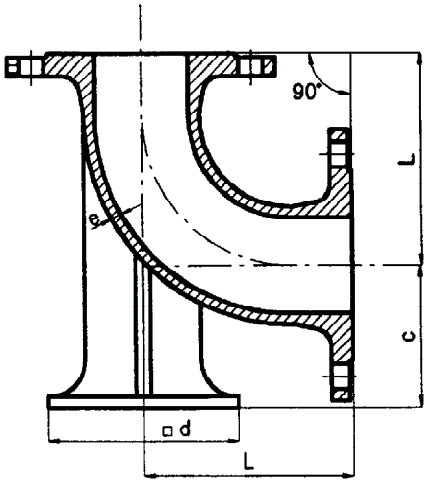

Figure 15

Table 24

DN	A and B series				
	e	**90° (1/4) bends**	90° (1/4) duckfoot bends		
		L	*L*	*c*	*d*
40	7	140	-	-	-
50	7	150	150	95	150
60	7	160	160	100	160
65	7	165	165	100	165
80	7	165	165	110	180
100	7,2	180	180	125	200
125	7,5	200	200	140	225
150	7,8	220	220	160	250
200	8,4	260	260	190	300
250	9	350	350	225	350
300	9,6	400	400	255	400
350	10,2	450	450	290	450
400	10,8	500	500	320	500
450	11,4	550	550	355	550
500	12	600	600	385	600
600	13,2	700	700	450	700
700	14,4	800	-	-	-
800	15,6	900	-	-	-
900	16,8	1000	-	-	-
1000	18	1100	-	-	-

9.4.3 *Double-flanged 45° (1/8) bends*

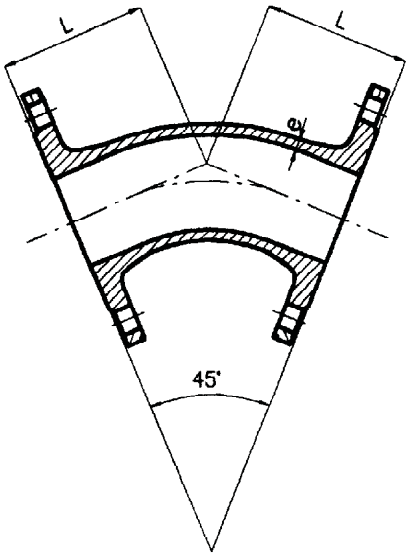

Figure 16

Table 25

DN	*e*	*L* series A	*L* series B
40	7	140	140
50	7	150	150
60	7	160	160
65	7	165	165
80	7	130	130
100	7,2	140	140
125	7,5	150	150
150	7,8	160	160
200	8,4	180	180
250	9	350	245
300	9,6	400	275
350	10,2	298	300
400	10,8	324	325
450	11,4	350	350
500	12	375	-
600	13,2	426	-

Table 25 *(concluded)*

DN	*e*	*L* series A	*L* series B
700	14,4	478	-
800	15,6	529	-
900	16,8	581	-
1000	18	632	-
1100	18,2	694	-
1200	20,4	750	-
1400	22,8	775	-
1500	24	810	-
1600	25,2	845	-
1800	27,6	910	-
2000	30	980	-

9.4.4 *All-flanged tees, DN 40 to DN 250*

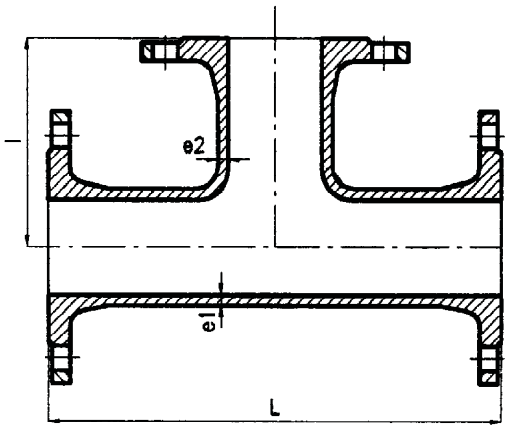

Figure 17

Table 26

DN × dn	Body			Branch		
	e_1	L series A	L series B	e_2	l series A	l series B
40 × 40	7	280	255	7	140	130
50 × 50	7	300	280	7	150	140
60 × 40	7	300	-	7	130	-
60 × 60	7	320	300	7	160	150
65 × 65	7	330	305	7	165	150
80 × 40	7	-	310	7	-	135
80 × 60	7	-	310	7	-	155
80 × 80	7	330	330	7	165	165
100 × 40	7,2	-	320	7		145
100 × 60	7,2	-	320	7		165
100 × 80	7,2	360	330	7	175	170
100 × 100	7,2	360	360	7,2	180	180
125 × 40	7,5	-	330	7	-	160
125 × 60	7,5	-	330	7	-	180
125 × 80	7,5	400	350	7	190	185
125 × 100	7,5	400	370	7,2	195	195
125 × 125	7,5	400	400	7,5	200	200
150 × 40	7,8	-	340	7	-	170
150 × 60	7,8	-	340	7	-	190
150 × 80	7,8	440	360	7	205	200
150 × 100	7,8	440	380	7,2	210	205
150 × 125	7,8	440	410	7,5	215	215
150 × 150	7,8	440	440	7,8	220	220
200 × 40	8,4	-	365	7	-	195
200 × 60	8,4	-	365	7	-	215
200 × 80	8,4	520	380	7	235	225
200 × 100	8,4	520	400	7,2	240	230
200 × 125	8,4	-	435	7,5	-	240
200 × 150	8,4	520	460	7,8	250	245
200 × 200	8,4	520	520	8,4	260	260

Table 26 *(concluded)*

DN × dn	Body			Branch		
	e_1	L series A	L series B	e_2	l series A	l series B
250 × 60	9	-	385	7	-	260
250 × 80	9	-	405	7	-	265
250 × 100	9	700	425	7,2	275	270
250 × 150	9	-	485	7,8	-	280
250 × 200	9	700	540	8,4	325	290
250 × 250	9	700	600	9	350	300

NOTE. The main nominal size is designated DN and the nominal size of the branch is designated dn.

9.4.5 *All-flanged tees, DN 300 to DN 700*

Table 27

DN × dn	Body				Branch	
	e_1	L series A	L series B	e_2	l series A	l series B
300 × 60	9,6	-	405	7	-	290
300 × 80	9,6	-	425	7	-	295
300 × 100	9,6	800	450	7,2	300	300
300 × 150	9,6	-	505	7,8	-	310
300 × 200	9,6	800	565	8,4	350	320
300 × 250	9,6	-	620	9	-	330
300 × 300	9,6	800	680	9,6	400	340
350 × 60	10,2	-	430	7	-	320
350 × 80	10,2	-	445	7	-	325
350 × 100	10,2	850	470	7,2	325	330
350 × 150	10,2	-	530	7,8	-	340
350 × 200	10,2	850	585	8,4	325	350
350 × 250	10,2	-	645	9	-	360
350 × 350	10,2	850	760	10,2	425	380
400 × 80	10,8	-	470	7	-	335
400 × 100	10,8	900	490	7,2	350	360
400 × 150	10,8	-	550	7,8	-	370
400 × 200	10,8	900	610	8,4	350	380
400 × 250	10,8	-	665	9	-	390
400 × 300	10,8	-	725	9,6	-	400
400 × 400	10,8	900	840	10,8	450	420
450 × 100	11,4	950	515	7,2	375	390
450 × 150	11,4	-	570	7,8	-	400
450 × 200	11,4	950	630	8,4	375	410
450 × 300	11,4	-	690	9	-	420
450 × 400	11,4	-	745	9,6	-	430
450 × 450	11,4	-	860	10,8	-	450
		950	920	11,4	475	460
500 × 100	12	1000	535	7,4	400	420
500 × 200	12	1000	650	8,4	400	440
500 × 400	12	1000	885	10,8	500	480
500 × 500	12	1000	1000	12	500	500
600 × 200	13,2	1100	700	8,4	450	500
600 × 400	13,2	1100	930	10,8	550	540
600 × 600	13,2	1100	1165	13,2	550	580
700 × 200	14,4	650	-	8,4	525	-
700 × 400	14,4	870	-	10,8	555	-
700 × 700	14,4	1200	-	14,4	600	-

NOTE. The main nominal size is designated DN and the nominal size of the branch is designated dn.

9.4.6 *All-flanged tees, DN 800 to DN 2000*

Table 28

DN × dn	Body		Branch	
	e_1	l series A	e_2	l series A
800 × 200	15,6	690	8,4	585
800 × 400	15,6	910	10,8	615
800 × 600	15,6	1350	13,2	645
800 × 800	15,6	1350	15,6	675
900 × 200	16,8	730	8,4	645
900 × 400	16,8	950	10,8	675
900 × 600	16,8	1500	13,2	705
900 × 900	16,8	1500	16,8	750
1000 × 200	18	770	8,4	705
1000 × 400	18	990	10,8	735
1000 × 600	18	1650	13,2	765
1000 × 1000	18	1650	18	825
1100 × 400	19,2	980	8,4	795
1100 × 600	19,2	1210	13,2	825
1200 × 600	20,4	1240	13,2	885
1200 × 800	20,4	1470	15,6	915
1200 × 1000	20,4	1700	18	945
1400 × 600	22,8	1550	13,2	980
1400 × 800	22,8	1760	15,6	1010
1400 × 1000	22,8	2015	18	1040
1500 × 600	24	1575	13,2	1035
1500 × 1000	24	2040	18	1095
1600 × 600	25,2	1600	13,2	1090
1600 × 800	25,2	1835	15,6	1120
1600 × 1000	25,2	2065	18	1150
1600 × 1200	25,2	2300	20,4	1180
1800 × 600	27,6	1655	13,2	1200
1800 × 800	27,6	1885	15,6	1230
1800 × 1000	27,6	2120	18	1260
1800 × 1200	27,6	2350	20,4	1290
2000 × 600	30	1705	13,2	1310
2000 × 1000	30	2170	18	1370
2000 × 1400	30	2635	22,8	1430

NOTE. The main nominal size is designated DN and the nominal size of the branch is designated dn.

9.4.7 *Double-flanged tapers*

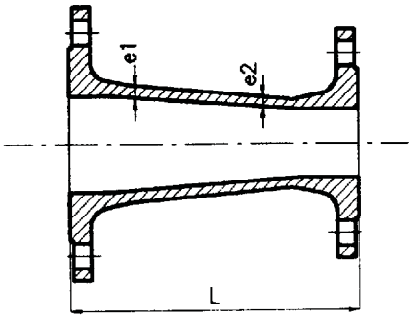

Figure 18

Table 29

DN × dn	e_1	e_2	L series A	L series B
50 × 40	7	7	150	165
60 × 50	7	7	160	160
60 × 50	7	7	200	190
80 × 60	7	7	200	185
80 × 65	7	7	200	190
100 × 80	7,2	7	200	195
125 × 100	7,5	7,2	200	185
150 × 125	7,8	7,5	200	190
200 × 150	8,4	7,8	300	235
250 × 200	9	8,4	300	250
300 × 250	9,6	9	300	265
350 × 300	10,2	9,6	300	290
400 × 350	10,8	10,2	300	305
450 × 400	11,4	10,8	300	320
500 × 400	12	10,8	600	-
600 × 500	13,2	12	600	-
700 × 600	14,4	13,2	600	-
800 × 700	15,6	14,4	600	-
900 × 800	16,8	15,6	600	-
1000 × 900	18	16,8	600	-
1100 × 1000	19,2	18	600	-
1200 × 1000	20,4	18	790	-
1400 × 1200	22,8	20,4	850	-
1500 × 1400	24	22,8	695	-
1600 × 1400	25,2	22,8	910	-
1800 × 1600	27,6	25,2	970	-
2000 × 1800	30	27,6	1030	-

NOTE. The larger nominal size is designated DN and the smaller nominal size is designated by dn.

9.4.8 ***Blank flanges PN 10***

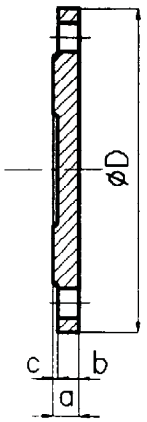

Figure 19

9.4.9 ***Blank flanges PN 16***

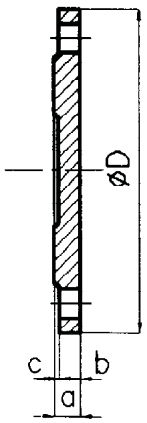

Figure 20

Table 30

DN	PN 10				PN 16			
	D	*a*	*b*	*c*	*D*	*a*	*b*	*c*
40	150	19	16	3	150	19	16	3
50	165	19	16	3	165	19	16	3
60	175	19	16	3	175	19	16	3
65	185	19	16	3	185	19	16	3
80	200	19	16	3	200	19	16	3
100	220	19	16	3	220	19	16	3
125	250	19	16	3	250	19	16	3
150	285	19	16	3	285	19	16	3
200	340	20	17	3	340	20	17	3
250	400	22	19	3	400	22	19	3
300	455	24,5	20,5	4	455	24,5	20,5	4
350	505	24,5	20,5	4	520	26,5	22,5	4
400	565	24,5	20,5	4	580	28	24	4
450	615	25,5	21,5	4	640	30	26	4
500	670	26,5	22,5	4	715	31,5	27,5	4
600	780	30	25	5	840	36	31	5
700	895	32,5	27,5	5	910	39,5	34,5	5
800	1015	35	30	5	1025	43	38	5
900	1115	37,5	32,5	5	1125	46,5	41,5	5
1000	1230	40	35	5	1255	50	45	5
1100	1340	42,5	37,5	5	1355	53,5	48,5	5
1200	1455	45	40	5	1485	57	52	5
1400	1675	46	41	5	1685	60	55	5
1500	1785	47,5	42,5	5	1820	62,5	57,5	5
1600	1915	49	44	5	1930	65	60	5
1800	2115	52	47	5	2130	70	65	5
2000	2325	55	50	5	2345	75	70	5

NOTE. For blank flanges of nominal diameter greater than or equal to DN 300, the centre of blank flanges may be dished.

9.4.10 ***Blank flanges PN 25***

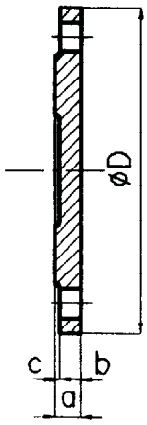

Figure 21

9.4.11 ***Blank flanges PN 40***

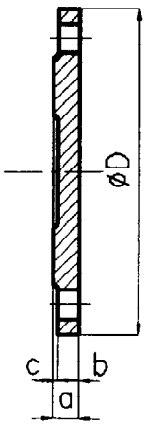

Figure 22

Table 31

DN	PN 25				PN 40			
	D	*a*	*b*	*c*	*D*	*a*	*b*	*c*
40	150	19	16	3	150	19	16	3
50	165	19	16	3	165	19	16	3
60	175	19	16	3	175	19	16	3
65	185	19	16	3	185	19	16	3
80	200	19	16	3	200	19	16	3
100	235	19	16	3	235	19	16	3
125	270	19	16	3	270	23,5	20,5	3
150	300	20	17	3	300	26	23	3
200	360	22	19	3	375	30	27	3
250	425	24,5	21,5	3	450	34,5	31,5	3
300	485	27,5	23,5	4	515	39,5	35,5	4
350	555	30	26	4	–	–	–	–
400	620	32	28	4	–	–	–	–
450	670	34,5	30,5	4	–	–	–	–
500	730	36,5	32,5	4	–	–	–	–
600	845	42	37	5	–	–	–	–

NOTE. For blank flanges of nominal diameter greater than or equal to DN 300, the centre of blank flanges may be dished.

9.4.12 *Reducing flanges PN 10*

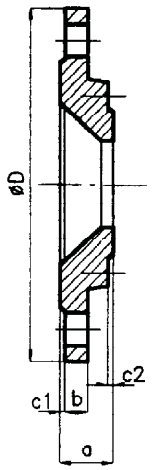

Figure 23

9.4.13 *Reducing flanges PN 16*

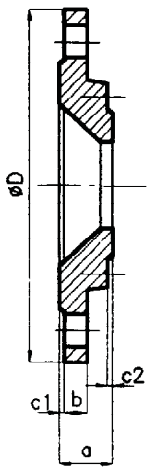

Figure 24

Table 32

DN × dn	PN 10					PN 16				
	D	*a*	*b*	c_1	c_2	*D*	*a*	*b*	c_1	c_2
200 × 80	340	40	17	3	3	340	40	17	3	3
200 × 100	340	40	17	3	3	340	40	17	3	3
200 × 125	340	40	17	3	3	340	40	17	3	3
350 × 250	505	48	20,5	4	3	520	54	22,5	4	3
400 × 250	565	48	20,5	4	3	580	54	24	4	3
400 × 300	565	49	20,5	4	4	580	55	24	4	4
700 × 500	895	56	27,5	5	4	900	67	34,5	5	4
900 × 700	1115	63	32,5	5	5	1125	73	41,5	5	5
1000 × 700	1230	63	35	5	5	1255	73	45	5	5
1000 × 800	1230	68	35	5	5	1255	73	45	5	5

NOTE. The larger nominal size is designated DN and the smaller nominal size is designated dn.

9.4.14 *Reducing flanges PN 25*

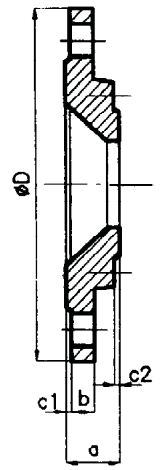

Figure 25

9.4.15 *Reducing flanges PN 40*

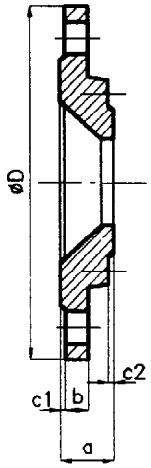

Figure 26

Table 33

DN × dn	PN 25					PN 40				
	D	*a*	*b*	c_1	c_2	*D*	*a*	*b*	c_1	c_2
200 × 80	360	40	19	3	3	375	40	27	3	3
200 × 100	360	47	19	3	3	375	47	27	3	3
200 × 125	360	53	19	3	3	375	53	27	3	3
350 × 250	555	60	26	4	3	-	-	-	-	-
400 × 250	620	60	28	4	3	-	-	-	-	-
400 × 300	620	61	28	4	4	-	-	-	-	-

NOTE. The main nominal size is designated DN and the nominal size of the branch is designated dn.

Annex A (normative)
Allowable pressures

A.1 General

The maximum values of PFA, PMA and PEA for pipes and fittings, as defined in **3.19, 3.20** and **3.21** respectively, shall be as given (in bars) in **A.2, A.3** and **A.4**.

Appropriate limitations shall be taken into account which may prevent the full range of these pressures being used in an installed pipeline, for example:

- operation at the PFA and PMA values given in **A.2** for socket and spigot pipes may be limited by the lower pressure capability of other pipeline components, e.g. flanged pipework (see **A.4**), certain types of tees (see **A.3**) and some designs of flexible joints (see **5.2.2**);
- site hydrostatic testing at the high PEA values given in **A.2** (especially for DN 40 to DN 150) may be limited by the type and design of the pipeline anchorage system and/or the design of flexible joints.

A.2 Socket and spigot pipes (see 9.1)

The maximum values of PFA, PMA and PEA as given in table A.1 are calculated as follows:

a) $\text{PFA} = \dfrac{20 \times e \times R_m}{D \times S_F}$

where:

e is the minimum pipe wall thickness, in millimetres;

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

DE is the nominal pipe external diameter (see table 14), in millimetres;

R_m is the minimum tensile strength of ductile iron, in megapascals

($R_m \times 420$ MPa; see **4.3.1**);

S_F is a safety factor of 3.

b) PMA: as PFA, but with $S_F = 2{,}5$; therefore PMA = 1,2 × PFA;

c) PEA = PMA + 5 bar in general;
PEA = 1,5 × PFA when PFA = 64 bar.

A.3 Fittings for socketed joints (see 9.3)

The maximum values of PFA, PMA and PEA are as follows:

- socketed fittings, except tees: their PFA, PMA and PEA are equal to those given in **A.2** for *K*9 pipes;
- socketed tees: their PFA, PMA and PEA may be less than those given in **A.2** for *K*9 pipes, they shall be given in the manufacturer's catalogues;
- fittings with one flange, such as double-socket tees with flanged branch, flanged spigots and flanged sockets: their PFA, PMA and PEA are limited by their flange; they are equal to those given in **A.4** for the corresponding PN and DN.

When other limitations exist due to the joint type or to any specific design arrangement, they shall be given in the manufacturer's catalogues.

A.4 Flanged pipes (see 9.2) and fittings for flanged joints (see 9.4)

The maximum values for PFA, PMA and PEA are given in table A.2.

Table A.1

DN		K9			K10	
	PFA	PMA	PEA	PFA	PMA	PEA
40	64	77	96	64	77	96
50	64	77	96	64	77	96
60	64	77	96	64	77	96
65	64	77	96	64	77	96
80	64	77	96	64	77	96
100	64	77	96	64	77	96
125	64	77	96	64	77	96
150	64	77	96	64	77	96
200	62	74	79	64	77	96
250	54	65	70	61	73	78
300	49	59	64	56	67	72
350	45	54	59	51	61	66
400	42	51	56	48	58	63
450	40	48	53	45	54	59
500	38	46	51	44	53	58
600	36	43	48	41	49	54
700	34	41	46	38	46	51
800	32	38	43	36	43	48
900	31	37	42	35	42	47
1000	30	36	41	34	41	46
1100	29	35	40	32	38	43
1200	28	34	39	32	38	43
1400	28	33	38	31	37	42
1500	27	32	37	30	36	41
1600	27	32	37	30	36	41
1800	26	31	36	30	36	41
2000	26	31	36	29	35	40

NOTE 1. See limitations given in **A.1**.
NOTE 2. For other wall thickness classes, the maximum values of PFA, PMA and PEA are calculated in the same way and in this case a PFA limitation different from 64 bar may be agreed between manufacturer and purchaser.

Table A.2

DN	PN 10			PN 16			PN 25			PN 40		
	PFA	PMA	PEA	PFA	PMA	PEA	PFA	PMA	PEA	PFA	PMA	PEA
40 to 50	see PN 40			see PN 40			see PN 40			40	48	53
60 to 80	see PN 16			16	20	25	see PN 40			40	48	53
100 to 150	see PN 16			16	20	25	25	30	35	40	48	53
200 to 600	10	12	17	16	20	25	25	30	35	40	48	53
700 to 1200	10	12	17	16	20	25	25	30	35	–	–	–
1400 to 2000	10	12	17	16	20	25	–	–	–	–	–	–

Annex B (normative)
Longitudinal bending resistance of pipes

Pipes with an aspect ratio (length/diameter) equal to or greater than 25 may be subjected to high stresses due to bending moments caused for example by ground subsidence or by differential settlement.

In order to provide a high degree of safety in such situations, ductile iron pipes shall withstand the bending moments given in table B.1, with no visible damage to the pipe wall and to the external and internal coatings. These bending moments have been calculated assuming a pipe of minimum wall thickness for its class and a bending stress in the metal equal to 250 MPa.

Table B.1

DN	Bending moments	
	kN·m *K9*	*K10*
40	2,4	2,4
50	3,4	3,4
60	4,8	4,8
65	5,5	5,5
80	8,0	8,0
100	11,8	11,8
125	17,9	18,2
150	25,2	26,7
200	44,4	50,6

NOTE 1. These bending moments, expressed in kilonewton metres, correspond to a load of the same value, expressed in kilonewton, applied at mid-point of a 4 m span.
NOTE 2. Bending moments that may cause failure of the pipes are at least 1,7 times higher than the given values.

Annex C (normative)
Diametral stiffness of pipes

Ductile iron pipes can undergo large ovalizations in operation while keeping all their functional characteristics. Allowable pipe ovalizations, when the pipeline is in service, shall be as given in table C.1.

NOTE. The ovalization is one hundred times the vertical pipe deflection in millimetres divided by the initial pipe external diameter in millimetres.

In order to withstand large heights of cover and/or heavy traffic loads in a wide range of installation conditions, ductile iron pipes shall have the minimum diametral stiffness values given in table C.1.

The diametral stiffness S of a pipe is given by the formula:

$$S = 1000 \frac{E \times 1}{D^3} = 1000 \frac{E}{12} \left(\frac{e}{D}\right)^3$$

where:

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

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

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

e is the wall thickness of the pipe, in millimetres;

D is the mean diameter of the pipe (D − e), in millimetres;

DE is the nominal pipe external diameter, in millimetres.

Table C.1

DN	Minimum diametral stiffness S kN/m²		Allowable pipe ovalization
	K9	K10	%
40	14000	14000	0,50
50	8000	8000	0,55
60	5000	5000	0,65
65	4000	4000	0,70
80	2400	2400	0,85
100	1350	1350	1,0
125	800	800	1,25
150	480	600	1,45
200	230	340	1,85
250	155	220	2,20
300	110	160	2,45
350	88	124	2,65
400	72	102	2,90
450	61	86	3,05
500	52	74	3,25
600	41	58	3,50
700	34	49	3,75
800	30	42	4
900	26	37	4
1000	24	34	4
1100	22	31	4
1200	20	29	4
1400	-	26	4
1500	17	24	4
1600	17	23	4
1800	16	22	4
2000	16	22	4

Note. The values of S have been calculated assuming a pipe wall thickness equal to the minimum thickness plus half of the tolerance, in order to take account that there are only a few points with a thickness equal or close to the minimum thickness.

Annex D (informative)

Field of use, characteristics of soils

Ductile iron pipelines supplied with external coatings complying with **4.4.2** and **4.5.2** may be buried in contact with the majority of soils, except those:

- with a low resistivity, less than 1500 Ω·cm above the water table or less than 2500 Ω·cm below the water table;
- with a low pH, below 6;
- with contamination by certain wastes or organic or industrial effluents.

In such soils, and also in the occurrence of stray currents or of corrosion cells due to external metallic structures, it is recommended that an additional protection is used (polyethylene sleeving) or other types of external coatings as appropriate (see **4.4.1** and **4.5.1**).

Annex E (informative)

Field of use, water characteristics

Ductile iron pipelines supplied with internal linings complying with **4.4.3** and **4.5.2** may be used to convey all types of potable water in conformity with the EEC Directive 80/778.

For other types of water, the limits of use are as given in table E.1, depending on the type of cement used for the lining.

Table E.1

Water Characteristics	Portland cement	Sulfate resisting cements (including blast-furnace slag cements)	High alumina cement
Minimum value of pH	6	5,5	4
Maximum content (mg/l) of:			
agressive CO_2	7	15	no limit
sulfates (SO_4^{-})	400	3000	no limit
magnesium (Mg^{++})	100	500	no limit
ammonium (NH_4^{+})	30	30	no limit

Annex F (informative)
Calculation method of buried pipelines, heights of cover

F.1 Calculation method

F.1.1 *Calculation formula*

The method is based on an ovalization calculation according to the formula below:

$$\Delta = \frac{100K\,(P_e + P_t)}{8S + (f \times E')}$$

where:

Δ is the pipe ovalization (%);

K is the bedding factor;

P_e is the pressure from earth loading, in kilonewtons per square metre;

P_t is the pressure from traffic loading, in kilonewtons per square metre;

S is the pipe diametral stiffness, in kilonewtons per square metre, see table C.1;

f is the factor of lateral pressure (f = 0,061);

E' is the modulus of soil reaction, in kilonewtons per square metre.

The ovalization calculated by means of this formula should not exceed the allowable ovalization shown in the table C.1. The allowable ovalization increases with DN while remaining well below the value that the internal cement mortar lining can withstand without damage; in addition, it provides a safety factor of 1,5 with respect to the elastic limit of ductile iron in bending (500 MPa minimum) by limiting the stress in the pipe wall at 330 MPa; finally, it is limited to 4 % for DN ≥ 800.

F.1.2 Pressure from earth loading

The pressure P_e, uniformly distributed at the top of the pipe over a distance equal to the external diameter, is calculated according to the earth prism method by the formula below:

$$P_e = \gamma H$$

where:

P_e is the pressure from earth loading, in kilonewtons per square metre;

γ is the unit weight of backfill, in kilonewtons per cubic metre;

H is the height of cover, in metres, that is the distance from the top of the pipe to the ground surface.

In the absence of other data, the unit weight of the soil is taken as being equal to 20 kN/m^3 in order to cover the vast majority of cases. If a preliminary geotechnical survey confirms that the actual unit weight of the backfill will be less than 20 kN/m^3, the actual value may be used for determining P_e. If, however, it appears that the actual value will be more than 20 kN/m^3, the actual value should be used.

F.1.3 Pressure from traffic loading

The pressure P_t, uniformly distributed at the top of the pipe over a distance equal to the external diameter, is calculated by means of the formula below:

$$P_t = 40\,\beta H\,(1 - 2 \times 10^{-4}\,\mathrm{DN})$$

where:

P_t is the pressure from traffic loading in kilonewtons per square metre;

β is the traffic load factor.

This formula is not valid for $H < 0{,}3$ m.

Three types of traffic loading are to be considered:

- traffic areas with main roads, β = 1,5 : this is the general case of all roads, except access roads;
- traffic areas with access roads, β = 0,75 : roads where lorry traffic is prohibited;
- rural areas, β = 0,5 : all other cases.

It should be noticed that all pipelines should be designed for at least β = 0,5 even where they are not expected to be exposed to traffic loading. In addition, pipelines laid in the verge and embankment of roads should be designed to withstand the full traffic loading expected on these roads. Finally, for pipelines which may be exposed to particularly high traffic loading, a factor β = 2 should be adopted.

F.1.4 *Bedding factor, K*

The bedding factor K, depends upon the soil pressure distribution at the top of the pipe (over a distance equal to the external diameter) and at the invert of the pipe (over a distance corresponding to the theoretical bedding angle 2α).

K normally varies from 0,11 for 2α = 20° to 0,09 for $2a$ = 120°. The value of 20° corresponds to a pipe which is simply laid on the flat trench bottom, with no compaction effort.

F.1.5 *Factor of lateral pressure, f*

The factor of lateral pressure f, is equal to 0,061; this corresponds to a parabolic distribution of the lateral soil pressure over an angle of 100°, according to the IOWA-Spangler model.

F.1.6 *Modulus of soil reaction, E'*

The modulus of soil reaction E', depends upon the nature of soil used in the pipe zone and upon the laying conditions.

In a given situation, the modulus of reaction which is required can be determined by means of the formula below:

$$E' = \frac{4000K}{\delta \times f}\left[\frac{\beta}{H}(1 - 2 \times 10^{-4}\,\mathrm{DN}) + 0{,}5\,H\right] - \frac{8\,S}{f}$$

where:

E' is the modulus of soil reaction, in kilonewtons per square metre;

δ is the allowable ovalization, in %.

In table F.1, values of E' equal to 1 000 kN/m^2, 2 000 kN/m^2 and 5 000 kN/m^2 are taken as guidelines; they correspond to a compaction level which is respectively nil, low and good. The value $E' = 0$ has also been shown as the limit case for unfavourable laying conditions in poor soils (no compaction, water table above the pipe, trench shoring removed after backfilling or embankment conditions).

If a preliminary geotechnical survey allows the determination of the value of the modulus of soil reaction, this value should be taken into account in the calculations.

F.2 Heights of cover

The table F.1 gives the most pessimistic range of values of the allowable heights of cover for each group of diameters. These values can be used without any additional calculation: they are given in metres, with E' in kilonewtons per square metre.

For heights of cover outside the ranges given in table F.1 and for better laying conditions, a verification can be made using the formulas given in F.1.

Table F.1

DIN		40 to 300	350 to 450	500 to 2000
K (2α)		0,110 (20°)	0,105 (45°)	0,103 (60°)
β = 0,75	E' = 0	0,3 to 10,5	0,3 to 7,5	0,5 to 2,0
	E' = 1 000	0,3 to 11,0	0,3 to 8,5	0,3 to 3,5
	E' = 2 000	0,3 to 12,0	0,3 to 9,0	0,3 to 4,5
	E' = 5 000	0,3 to 14,0	0,3 to 12,0	0,3 to 8,5
β = 1,50	E' = 0	0,3 to 10,5	0,4 to 7,0	*)
	E' = 1 000	0,3 to 11,0	0,4 to 8,0	0,6 to 3,0
	E' = 2 000	0,3 to 11,5	0,3 to 9,0	0,5 to 4,5
	E' = 5 000	0,3 to 14,0	0,3 to 12,0	0,3 to 8,0

*) Not recommended; only a specific calculation for each case can provide an adequate answer.
NOTE . The values given for the heights of cover have been established for the class $K9$; they are also valid for classes $K \geq 10$.

National annex NA (informative)

Additional information

NA.1 Introduction

This annex has been written to identify the most significant changes from BS 4772 (superseded) that have been adopted in BS EN 545; and it is not intended to contradict nor replace any of the clauses or provisions in BS EN 545.

NA.2 Materials in contact with potable water

Clause **4.1.4** of this standard requires that 'when used under the conditions for which they are designed, in permanent or in temporary contact with water intended for hyman consumption, ductile iron pipes, fittings and their joints shall not change the quality of that water to such an extent that it fails to comply with the requirements of EU and EFTA regulations at the end user'.

Pending the development of an agreed European mechanism for the acceptance of materials to be used in contact with potable water in public supply, and/or the publication of European Standards for assessing the suitability of materials for this purpose, all materials to be used in the UK public water supply system are currently covered by the requirements of Regulation 25 of the Water Supply (Water Quality) Regulations 1989 (as amended by the Water Supply (Water Quality) (Amendment) Regulations 1991), or of the Water Supply (Water Quality) (Scotland) Regulations 1990, as appropriate.

NA.3 Pipeline fittings and dimensions

This standard allows for two different series of ductile iron pipeline fittings for water supply applications, i.e:

- *Series A*: the dimensions and deviations (design tolerances) of these fittings correspond to those detailed in ISO 2531;
- *Series B*: the dimensions of these fittings are in accordance with a 'Unified Design' approach. The 'Unified Design' of fittings is an option by which standardization of laying lengths of fittings is achieved, this can have benefits to both the manufacturer and user. The series B fittings are gnerally limited to a maximum size of DN 450 at this stage.

It should be noted that the ranges of types and dimensions of both series A and series B fittings detailed in this standard do not in all cases coincide with those given previously in BS 4772 (superseded).

Consequently, when ordering fittings which are not detailed in the tables in this standard, the purchaser should consult the manufacturer' catalogues to:

- determine which of series A or series B fittings is being offered; and
- check the key dimensions of the products of interest, as these may differ significantly from one manufacturer to another.

For similar reasons, manufacturers' catalogues should be consulted when considering the replacement of existing ductile iron pipeline fittings, in order to ensure that any dimensional differences are identified and taken into account in the design of the replacement section.

NA.4 Surface imperfections

This standard requires that pipes, fittings and accessories shall be free from defects and surface imperfections which could result in non-compliance with the technical requirements and performance requirements given in clauses **4** and **5** respectively. No quantitative guidance is however given on the sizes or numbers of such surface imperfections. This is in contrast with BS 4772 (superseded), which defined the maximum permissible depths of surface imperfections on ductile iron pipes and fittings.

The only clearly unacceptable defect within the definitions of this standard is one which penetrates the full wall thickness of the pipe or fitting, repair of such defects is not permissible.

NA.5 Cement types

As written, this standard permits the use of any of the cements listed in ENV 197-1, or high alumina cement, provided that the cured lining meets the requirements of clause **4.1.4** in relation to the effect of materials in contact with potable water. (See also NA.2 above.)

However, it has been agreed between EUREAU (the Union of European Water Supply Association) and CEMBUREAU (the European Cement Association) that, for the time being, cements containing slags produced from the smelting of non-ferrous metals (which are allowed as a 0 % to 5 % minor additional constituent in EN 197-1) should not be permitted for applications involving either temporary or permanent contact with potable water in public supply. This agreement is to be incorporated in EN 197-1 as an amendment to table 1 of that standard.

In addition, it should be noted that ENV 197-1 has the effective status of a European Standard Draft for Development. As such, the CEN Internal Regulations permit the co-existence of national standards which conflict (i.e. cover the same ground as) with the ENV. Consequently, until ENV 197-1 is ratified as an agreed European Standard, UK purchasers who are subject to the requirements of the Public Procurement or Utilities Directive are recommended to continue to specify cements to those British Standards previously permitted in BS 4772 (superseded) in tender documents (subject to the normal qualification ' or equivalent'), i.e.:

- *Type A*: Portland pulverized-fuel ash cement (PFAC) in accordance with BS 6588 with a minimum pulverized fuel ash content of 25 %;
- *Type B*: Sulfate-resisting cement (SRC) in accordance with BS 4027;
- *Type C*: Ordinary Portland cement (OPC) in accordance with BS 12;
- *Type D*: Portland blast furnace cement (PBFC) in accordance with BS 146 : Part 2.

NOTE. Cement types A and B are suitable for the majority of pipeline installations which require the cement mortar lining to be sulfate resisting.

Where an installation requires a lining having a higher level of sulfate resistance than that provided by type A or type B cements, the purchaser should consult the manufacturer regarding the type of cement to be used.

Guidance on the selection of cements for use in situations, where the conveyed water contains high levels of sulfate is available in the Building Research Establishment (BRE) Digest 363 *Sulphate and acid resistance of concrete in the ground* (BRE, Watford, 1991).

NA.6 Cement mortar linings

The nominal cement mortar lining thicknesses and their tolerances are given in table 8.

For sizes DN80 to DN300, the combination of the lower nominal thicknesses together with their maximum permissible negative tolerances could result in lining thicknesses which are significantly less than the minimum required previously in BS 4772 (superseded).

Thicker linings are however permitted within the scope of this standard by agreement between the manufacturer and purchaser (see clause **4.4.1**b)).

For UK water supply applications, purchasers should exercise their perogative within BS EN 545 to specify thicker linings for ductile iron pipes and fittings in accordance with table A.1.

Table A.1 Cement mortar lining thicknesses for ductile iron pipes and fittings for UK water supply applications

DN	Thickness (mm)		
	Nominal	Minimum arithmetical mean value	Individual minimum
80	5	3,5	2,5
100 to 300	5	4,5	3,5
350 to 600	5	4,5	3,5
700 to 1200	5	5,5	4,5
1400 to 2000	5	8,0	7,0

In order to avoid excessive cement morter lining thicknesses when purchasing according to table A.1, users should additionally specify that the minimum clear bores in table A.2 should apply.

Table A.2 Minimum bore clearances of ductile iron pipe lined in accordance with table A.1

DN	Minimum bore of cement mortar lined pipe (mm)
80	67,0
100	87,0
150	137,0
200	187,0
250	237,0
300	287,0

This standard requires that the surface of cement mortar linings shall be uniform and smooth; trowel marks and protrusion of sand grains are acceptable, but there shall be no recesses or local defects which reduce the thickness below the minimum value given in table 8 (or the purchaser's specified minimum value, where this is different; see table A.1 above).

It should however be noted that:

a) there is no upper limit to the size of sand grains permitted by this standard in cement mortar linings; previously in BS 4772 (superseded), this had been set at a maximum of one-third of the minimum specified lining thickness; and,

b) previously, BS 4772 (superseded) had set a maximum value on the peak-to-trough height of trowel marks in cement mortar linings of ($0.008P + 0.3$ mm, where P (mm) is the pitch (spacing) between consecutive peaks in the pipe axial direction. The purpose of this limit was to ensure that the Hazen-Williams coefficient C for the lined pipe did not fall below the value of 143 for the relevant pipe sizes (i.e. DN 900 and greater).

NA.7 Seal coatings

The purchaser may order pipes with a cement mortar lining with seal coat. The purpose of the seal coat is to minimize lime leaching of the cement by soft waters which are prevalent in the UK. A draft British Standard is under preparation for 'bituminous seal coats for cement mortar lining'. This draft British Standard will cover the serviceability, testing and water quality requirements for the application of bituminous paint to cement mortar linings.

NA.8 Polyethylene sleeving

Where required, polyethylene (PE) sleeving for the external corrosion protection of buried ductile iron pipelines should be specified in accordance with BS 6067. This covers the specification of PE film for site application, and also factory-applied PE sleeving for pipes. Guidance on the handling and installation of site-applied and factory-applied PE sleeving is given in the UK Water Industry Information and Guidance Notes (IGNs) 4-50-01 and 4-50-02 respectively.

NA.9 Performance requirements and type tests

This standard includes the flange to pipe attachment type test given previously in BS 4772 (superseded) but goes further by including new requirements for leaktightness performance of flexible joints. Type tests are required for joints under positive internal pressure, negative internal pressure, positive external pressure and cyclic internal pressure with the joint subjected to shear loading in angular deflection (see clauses **5** and **7**).

These tests are a further addition to those previously given in BS 4772 (superseded). However the duration of these tests is relatively short when compared to the design service life of the pipeline products. This would not be expected to be an issue for those joint types produced by European manufacturers over the past 10 years which have performed successively in service.

This standard given requirements for allowable operating pressure (PFA) similar to those which existed in BS 4772 (superseded) but it also gives additional information concerning maximum internal pressure, including surge (PMA) and maximum site test pressure (PEA) (see annex A).

Further information not given in BS 4772 (superseded) concerns longitudinal bending resistance, and diametral stiffness of pipes (see annexes B and C respectively).

NA.10 Pipeline design — informative annex

The design calculation method given in annex F (informative) has been derived from existing methods as a simplified calculation procedure applicable to ductile iron pipeline installations.

Other calculation methods may also be used, at the responsibility of the pipeline designer, in order to provide a similar high degree of security for the pipeline during its operating life.

Work is currently being undertaken by CEN/TC 164/165/JWG 1 to evaluate the principle calculation methods currently being used in the various European Union Member States. Further design guidance will be given in the first edition of a European Standard currently being prepared by this JWG (Joint Working Group). The long term aim will be to provide harmonized calculation methods applicable to all of the major pipeline materials.

NA.11 Information to be supplied by purchaser

The following information should be supplied by the purchaser on his enquiry and order:

a) for socket and spigot pipes the quantity, size (DN), length (see table 3) series (see **4.2.3.3**) and type of joint;

b) for flanged pipes: the quantity, size (DN), flange rating (PN), length (see table 4);

c) for fittings: the quantity, size (DN), type of fitting and type of joint ends (including flange rating where necessary);

d) where required, the quantity of pipes > DN300 required to be suitable for cutting on site;

e) for pipes and fittings: identification of external and internal coatings which are required (see **4.4** and **4.5**);

f) for cement mortar linings, the type of cement required (see **4.4.3**), the lining thickness and minimum bore required (see tables A1 and A2);

g) whether a seal coat is required on cement mortar linings;

h) whether guidance is needed for jointing new products with existing pipelines or with other types of joints (see **4.1.3**).

NA.12 References

For further information and guidance reference can be made to the following.

a) UK Water Industry Information and Guidance Note IGN 4-21-01 *Ductile Iron Pipes and Fittings*, published by WRc plc, Frankland Road, Blagrove, Swindon, SN5 8YF. Tel 0793 511711. Fax 0793 511712.

b) Ductile Iron Pipe Committee, 8th Floor, Bridge House, Smallbrook, Queensway, Birmingham, B5 4JP. Tel 021 643 3377. Fax 021 643 5064.

National annex NB (informative)

Committees responsible

The United Kingdom participation in the preparation of this European Standard was entrusted by the Engineering Sector Board (E/-) to Technical Committee PSE/8, upon which the following bodies were represented:

Adhesive Tape Manufacturers' Association
British Foundry Association
Ductile Iron Pipe Committee
Institute of British Foundrymen
Institution of Mechanical Engineers
Institution of Water and Environmental Management
Pipeline Protection Association
Society of British Water Industries
Water Companies Association
Water Research Centre

National annex NC (informative)

Cross-references

Publication referred to	Corresponding British Standard
EN 10002-1 : 1990	BS EN 10002 *Tensile testing of metallic materials* Part 1 : 1990 *Method of test at ambient temperature*
EN 29002 : 1987[1)]	BS EN ISO 9002 : 1994 *Quality systems — Model for quality assurance in production, installation and servicing*
EN 45012 : 1989	BS 7512 : 1989 *General criteria for certification bodies operating quality system certification*

[1)] EN 29002 : 1987 has been superseded by BS EN ISO 9002 : 1994.

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