

Specification for

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

The European Standard EN 969:1995, with the incorporation of amendment A1:1998, has the status of a British Standard

ICS 23.040.10

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee PSE/10, Iron pipes and fittings, 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
- Water Services Association of England and Wales

This British Standard, having been prepared under the direction of the Engineering Sector Board, was published under the authority of the Standards Board and comes into effect on 15 January 1996

© BSI 09-2000

The following BSI references relate to the work on this standard:
Committee reference PSE/10
Draft for comment 92/86270 DC

ISBN 0 580 24999 9

Amendments issued since publication

Amd. No.	Date	Comments
10946	September 2000	Amendments to Clause 2 and 4.1.

Contents

	Page
Committees responsible	Inside front cover
National foreword	ii
Foreword	2
Text of EN 969	5
National annex NA (informative) Significant changes from BS 4772	40

National foreword

This British Standard has been prepared by Technical Committee PSE/10. It is the English language version of EN 969:1995 *Ductile iron pipes, fittings, accessories and their joints for gas pipelines — Requirements and test methods*, including amendment A1:1998, published by the European Committee for Standardization (CEN).

In conjunction with BS EN 545 and BS EN 598 it supersedes BS 4772, which is withdrawn.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index” or by using the “Find” facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 41 and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

ICS 23.040.10

Descriptors: Gas pipelines, pressure pipes, gas pipes, pipe fittings, cast iron products, spheroidal graphite cast iron, dimensions, dimensional tolerances, mechanical characteristics, coatings, joining, specifications, tests, quality assurance

English version

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

(includes amendment A1:1998)

Tuyaux, raccords et accessoires en fonte ductile et leurs assemblages pour canalisations de gaz —
Prescriptions et méthodes d'essai
(inclut l'amendement A1:1998)

Rohre, Formstücke, Zubehörteile aus duktilem Gußeisen und ihre Verbindungen für Gasleitungen —
Anforderungen und Prüfverfahren
(enthält Änderung A1:1998)

This European Standard was approved by CEN on 1995-07-13. Amendment A1 was approved by CEN on 1998-11-05. 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.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Foreword

This European Standard was prepared by Technical Committee CEN/TC 203, Cast iron pipes, fittings and their joints, the Secretariat of which is held by AFNOR.

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

It deals with the subjects covered by the International Standards ISO 2531 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 February 1996, and conflicting national standards shall be withdrawn at the latest by February 1996.

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, and the United Kingdom.

Foreword to amendment A1

This amendment EN 969:1995 A1:1998 to EN 969:1995 has been prepared by Technical Committee CEN/TC 203, Cast iron pipes, fittings and their joints, the Secretariat of which is held by AFNOR.

This amendment to the European Standard EN 969:1995 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 1999, and conflicting national standards shall be withdrawn at the latest by June 1999.

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

Contents

	Page
Foreword	2
Introduction	5
1 Scope	5
2 Normative references	5
3 Definitions	5
4 Technical requirements	7
4.1 General	7
4.1.1 Ductile iron pipes and fittings	7
4.1.2 Surface condition and repairs	7
4.1.3 Types of joints and interconnection	7
4.2 Dimensional requirements	8
4.2.1 Wall thickness	8
4.2.2 External diameter	8
4.2.3 Length	8
4.2.4 Straightness of pipes	9
4.3 Material characteristics	9
4.3.1 Tensile properties	9
4.3.2 Hardness	10
4.4 Coatings and linings for pipes	10
4.4.1 General	10
4.4.2 External coating of zinc with finishing layer	10
4.5 Coatings for fittings and accessories	11
4.5.1 General	11
4.5.2 Paint coatings	11
4.6 Marking of pipes and fittings	11
4.7 Leaktightness	11
4.7.1 Pipes and fittings	11
4.7.2 Joints	11
5 Performance requirements for joints	12
5.1 General	12
5.2 Flexible joints	12
5.2.1 General	12
5.2 Test conditions	12
5.2.3 Test parameters	12
5.3 Restrained flexible joints	12
5.4 Pipes with screwed-on or welded-on flanges	13
6 Test methods	13
6.1 Dimensions	13
6.1.1 Wall thickness	13
6.1.2 External diameter	13
6.1.3 Length	13
6.2 Straightness of pipes	13

	Page	Page
6.3 Tensile testing	13	Figure 9 23
6.3.1 Samples	13	Figure 10 23
6.3.2 Preparation of test bar	14	Figure 11 24
6.3.3 Apparatus and test method	14	Figure 12 25
6.3.4 Test results	14	Figure 13 28
6.3.5 Test frequencies	14	Figure 14 30
6.4 Brinell hardness	14	Figure 15 30
6.5 Works leaktightness test for pipes and fittings	14	Figure 16 30
6.5.1 General	14	Figure 17 31
6.5.2 Air testing	15	Figure 18 34
6.5.3 Hydrostatic testing	15	Figure 19 35
6.6 Zinc coating mass	16	Figure 20 35
6.7 Thickness of paint coatings	16	Figure 21 36
7 Type tests	16	Figure 22 36
7.1 Leaktightness of joints to internal pressure	16	Table 1 8
7.2 Leaktightness of joints to external water pressure	16	Table 2 9
7.3 Leaktightness and mechanical resistance of screwed-on and welded-on flanges	17	Table 3 9
8 Quality assurance	17	Table 4 9
8.1 General	17	Table 5 9
8.2 Type tests	17	Table 6 12
8.3 Quality assurance system	18	Table 7 13
9 Tables of dimensions	18	Table 8 15
9.1 Socket and spigot pipes	18	Table 9 15
9.2 Flanged pipes	20	Table 10 15
9.3 Fittings for socketed joints	20	Table 11 19
9.4 Fittings for flanged joints	30	Table 12 20
Annex A (normative) Longitudinal bending resistance of pipes	37	Table 13 21
Annex B (normative) Diametral stiffness of pipes	37	Table 14 22
Annex C (informative) Field of use, characteristics of soils	38	Table 15 23
Annex D (informative) Calculation method of buried pipelines, heights of cover	38	Table 16 24
Figure 1	17	Table 17 26
Figure 2	18	Table 18 27
Figure 3	18	Table 19 29
Figure 4	20	Table 20 30
Figure 5	20	Table 21 31
Figure 6	21	Table 22 32
Figure 7	22	Table 23 33
Figure 8	22	Table 24 34
		Table 25 35
		Table 26 36
		Table A.1 37
		Table B.1 37
		Table D.1 39

Introduction

In preparing this standard it was recognized that there may exist various national regulations in the individual member states of Europe which may influence some of the requirements. This standard makes allowance for this by referring to national regulations at relevant places.

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 air or combustible gases (e.g. natural gas or town gas) at pressures up to 16 bar;
- to be installed below or above ground.

NOTE 1 A combustible gas is a gas or any fuel that is in gaseous state at a temperature of 15 °C at a pressure of 1 bar.

NOTE 2 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 600 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 gas temperatures between – 15 °C and 50 °C.

2 Normative references

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

EN 545:1994, *Ductile iron pipes, fittings, accessories and their joints for water pipelines — Requirements and test methods*.

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*.

EN 1092-2:1997, *Flanges and their joints — Part 2: Cast iron flanges — PN designated*.

ISO 2531:1991, *Ductile iron pipes, fittings and accessories for pressure pipelines*.

ISO 6447:1983, *Rubber seals — Joint rings used for gas supply pipes and fittings — Specification for material*.

ISO 6506:1981, *Metallic materials — Hardness tests — Brinell 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, e.g.:

- 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 components of the same nominal size DN designated by the same PN number have compatible mating dimensions (see ISO 7268 and ISO 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)

maximum pressure that a component can withstand continuously in service

3.20 diametral stiffness of a pipe

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

3.21 batch

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

3.22 type test

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

3.23 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.

3.24 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 3); they are manufactured to this length plus or minus the tolerance given in Table 4.

3.25 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

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 coating of paint in accordance with 4.5.2, or, when pipes have to be capable of carrying either gas or water, an internal cement mortar lining in conformity with 4.4.3 of EN 545:1994. The field of use of these pipes is given in Annex C.

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 $\times$ dn, etc.

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.

The functional properties of ductile iron pipes and fittings shall be as given in Annex A and Annex B dealing respectively with longitudinal bending resistance and diametral stiffness.

NOTE 2 When installed and operated under the conditions for which they are designed (see Annex C and Annex D), 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 6447. 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 EN 1092-2 and flange gaskets with ISO 7483. This ensures interconnection between all flanged components (pipes, fittings, valves, etc) 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 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, the manufacturer's guidance should be followed as to the appropriate means of interconnection (e.g. adaptors).

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 DN)

where:

- e is the nominal wall thickness, in millimetres;
- DN is the nominal size;
- K is a coefficient used for thickness class designation. 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, etc).

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 ^a
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)

^a A negative tolerance only is given, so as to ensure sufficient resistance to internal pressure.

4.2.2 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. For DN > 300, the same applies to a percentage of the pipes, when they need to be cut on site, after agreement between manufacturer and purchaser.

In addition, the ovality (see 3.25) of the spigot and of pipes and fittings shall:

- remain within the tolerances on DE (see Table 11) for DN 40 to DN 200;
- not exceed 1 % for DN 250 to 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.

4.2.3 Length

4.2.3.1 Standardized lengths of socket and spigot pipes

Pipes shall be supplied in standardized lengths of 3 m, 5 m, 5,5 m and 6 m.

The permissible deviations on the standardized length L_u of pipes shall be ±100 mm:

The manufacturer shall show his design lengths (see 3.24) in his catalogues.

The length shall be measured according to 6.1.3 and shall be within the tolerance given in Table 4.

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.

4.2.3.2 Standardized lengths of flanged pipes

Pipes shall be supplied to the standardized lengths given in Table 2.

Table 2

Type of pipe	Standard lengths L^a m
With cast-on flanges	0,5 or 1 or 2 or 3
With screwed-on or welded-on flanges	2 or 3 or 4 or 5
^a See 3.23. Other lengths are available by agreement between manufacturer and purchaser.	

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 specified in Table 3.

Table 3

Type of fitting	Deviation mm
Flanged sockets Flanged spigots Collars, tapers	±25
Tees	+50/ – 25
Bends 90° (1/4)	±(15 + 0,03 DN)
Bends 45° (1/8)	±(10 + 0,025 DN)
Bends 22° 30' and 11° 15' (1/16 and 1/32)	±(10 + 0,02 DN)

4.2.3.4 Tolerances of lengths

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

Table 4

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 ^a
^a By agreement between manufacturer and purchaser, smaller tolerances are possible, but not less than ±3 mm.	

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 5.

Table 5

Type of casting	Minimum tensile strength R_m , MPa	Minimum elongation after fracture, A %
Pipes centrifugally cast	420	10
Pipes not centrifugally cast, fittings and accessories	420	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 $A \geq 12$ %; — 300 MPa in other cases.		
NOTE 2 For centrifugally cast pipes the minimum elongation after fracture shall be 7 % for thickness classes over K 12.		

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 5. Testing verification procedures shall be based on the use of comparator 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 coating of paint in conformity with 4.5.2. The field of use of these pipes is given in Annex C.

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.

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 Annex C.

- 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.

- 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 bituminous product of 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 surface 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/m², with a local minimum of 110 g/m².

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/m².

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.

4.5 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. Their field of use is given in Annex C

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 Annex C.

- 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.

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, etc.) 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 K9.

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 leaktight at their allowable operating pressure (PFA).

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 operating pressure (PFA) of corresponding pipes and fittings, or their own PFA as given in the manufacturer's catalogues, whichever is the lowest. This applies under all normal service conditions and joint movements (angular, radial and axial);
- b) 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 gas supply all the joints shall fulfil the performance requirements of clause 5.

There shall be a type test for at least one DN for each of the groupings given in Table 6. One DN is representative of a grouping when the performances are based on the same design parameters throughout the size range.

Table 6

DN Groupings	40 to 250	300 to 600
Preferred DN in each grouping	200	400

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.

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).

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

- test 1: internal pneumatic pressure in accordance with 7.1; the test pressure shall be $1,5 p + 5$ bar, where p is the allowable operating pressure of the joint declared by the manufacturer;

- test 2 (optional; see 4.7.2): external hydrostatic pressure of 2 bar, in accordance with 7.2 [under test condition a) only].

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 $2 \cdot DN$ in millimetres from the spigot end face) equal to the specified minimum value for the pipe for which the joint is designated 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 $50 \cdot DN$ 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 and 7.2 following the requirements of 5.2.2 and 5.2.3, except that:

- the withdrawal condition of 5.2.2 a) shall not apply;
- there shall be no external axial restraint in internal pressure tests so that the joint is subject to the full end thrust.

During the 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 of 5.2.2 if the unrestrained version of the joint has passed this test.

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 7.3, they shall show no visible leakage under the combined effects of a hydrostatic internal pressure equal (in bars) to $2 \cdot PN$ and of an external load sufficient to cause the bending moments given in Table 7. 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 7 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 $DN \leq 250$;
- $L = 12$ m for $DN \geq 300$.

Table 7

DN	Bending moment kN · m	Minimum distance X^a mm	
		K9	K10
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	168	216	224
450	205	227	235
500	251	238	247
600	348	259	270

^a See 7.3

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 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 8.

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 subject 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 Table 8.

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 with an accuracy of $\pm 0,01$ 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 8) 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 to 30 N/mm^2 per second.

The tensile strength shall be calculated by dividing the maximum force sustained by the test bar by the cross-sectional area of the test bar before testing. The 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 5. If they do not comply, the manufacturer shall:

- a) in the case where the metal does not achieve the required mechanical properties, investigate the reason and ensure that all casting 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 frequencies

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 9.

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 for leaktightness using air, water or other means, e.g. vacuum test. The type of test required shall be on the basis of this standard and take account of the relevant National Regulations which may exist in each country.

Pipes and fittings shall be tested before the application of their external and internal coatings, except for the metallic zinc coating of pipes which may be applied before the test.

Table 8

Type of casting	Test bar method A	Test bar method B		
	Nominal diameter mm	Nominal area S_0 mm ²	Nominal diameter mm	Tolerance on diameter 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	±0,02
— 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 12 mm and over	12,0 or 14,0	—	—	—

Table 9

Type of casting	DN	Maximum batch size	
		Batch sampling system	Process control system
Centrifugally cast pipes	40 to 300 350 to 600	200 pipes 100 pipes	1 200 pipes 600 pipes
Pipes not centrifugally cast, fittings and accessories	40 to 600	4t ^a	48t ^a

^a Weight of crude castings, excluding the risers.

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 Air testing

When the air test is carried out, it shall be with an internal pressure not less than 2 bar and an inspection time of not less than 30 s for pipes and 10 s for fittings.

For leak detection, the castings shall be either uniformly coated on their external surface by a suitable foaming agent or submerged in water.

NOTE National regulations may specify special safety requirements which must be observed during air testing.

6.5.3 Hydrostatic testing

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

Table 10

DN	Minimum works test pressure bar	
	Pipes centrifugally cast	Pipes not centrifugally cast and fittings ^a
40 to 300	50	25 ^b
350 to 600	40	16

^a At the manufacturer's option an air test (see 6.5.2) or any other leaktightness test of equivalent performance can be used in place of the hydraulic test.

^b 16 bar for pipes and fittings with PN 10 flanges.

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.

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 relevant document of the manufacturer's quality assurance system.

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 determined by either of the following methods:

- 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
- 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.

7 Type tests

7.1 Leaktightness of joints to 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 $0,5 \cdot DN$ 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:

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

where a , b and c are as shown in Figure 1.

The air pressure in the test assembly 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. The leak detection shall be carried out by spraying a suitable foaming agent or by submerging the test assembly in water. 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.

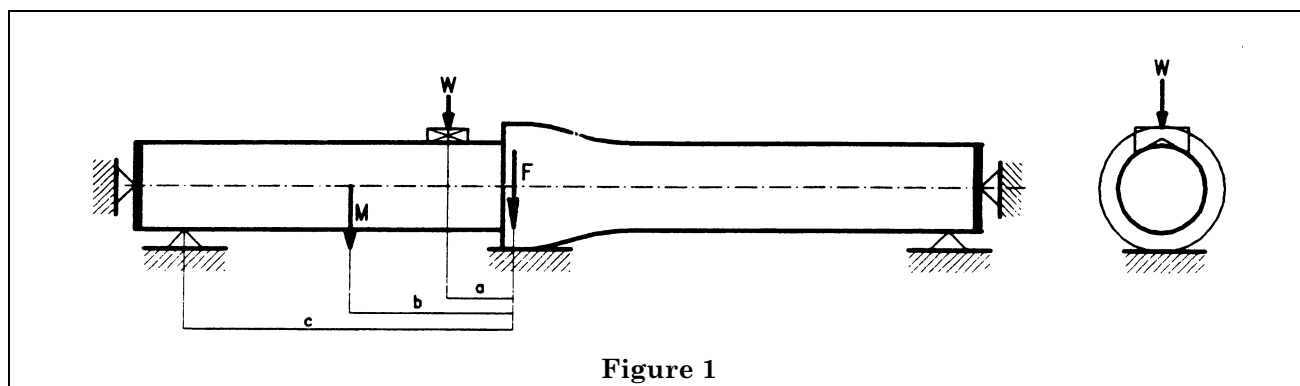


Figure 1

7.2 Leaktightness of joints to external water 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 5.2.3.3; 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 $0,5 \cdot DN$, 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 $\pm 0,1$ 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 shall be identical.

7.3 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:

$$X = 100 + 2,3 (DN \cdot e_{\min})^{0.5}$$

NOTE See Table 7 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 $6 \cdot DN$ in millimetres or 4 000 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 7.

The internal pressure and the external load shall be 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 loadings significantly greater than those 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 11. The values of L_u are given in 4.2.3.1. For external and internal coatings see 4.4.

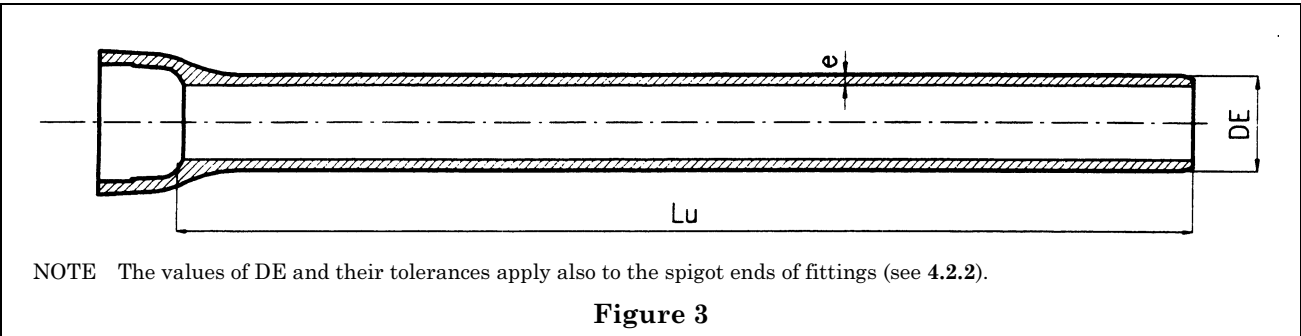
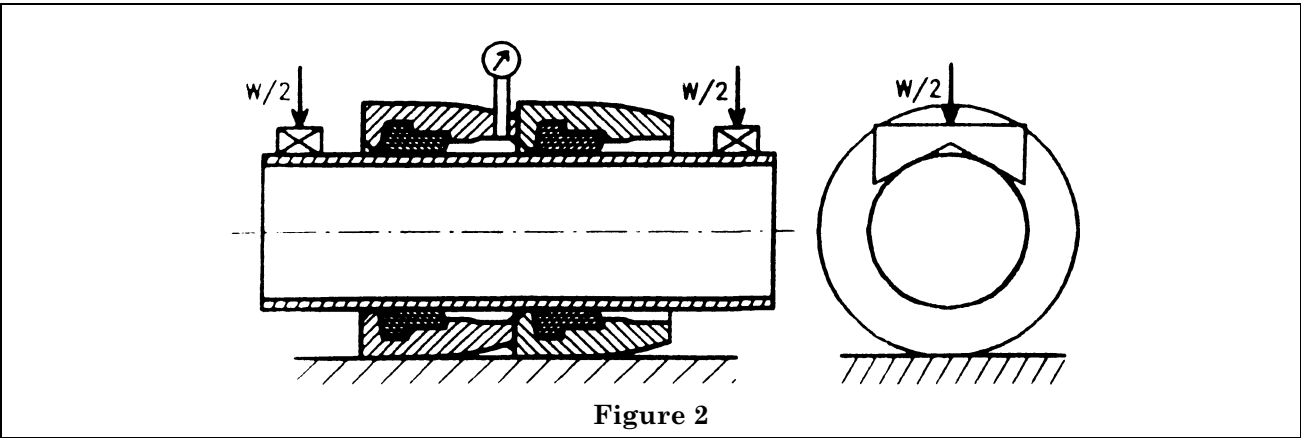


Table 11

DN	External diameter DE mm		Iron thickness <i>e</i> mm		
	Nominal	Tolerance	K 9	K10	Tolerance ^a
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 -2,7	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 ^b
150	170	+1 -2,9	6,0	6,5	-1,5 ^b
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

^a A negative tolerance only is given.
^b -1,3 when the thickness is equal to 6,0 mm.

9.2 Flanged pipes

Standardized thickness classes and PN of flanged pipes are specified in the following three subclauses. The values of L are given in Table 2. For coatings and linings, see 4.4.

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

9.2.1 Centrifugally cast pipes with welded-on flanges

Classes K9 and K10 for PN 10 and PN 16.

9.2.2 Centrifugally cast pipes with screwed-on flanges

Classes K9 and K10 for PN 10 and PN 16.

9.2.3 Pipes with integrally cast flanges

Class 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 coatings and linings, see 4.5.

9.3.1 Flanged sockets

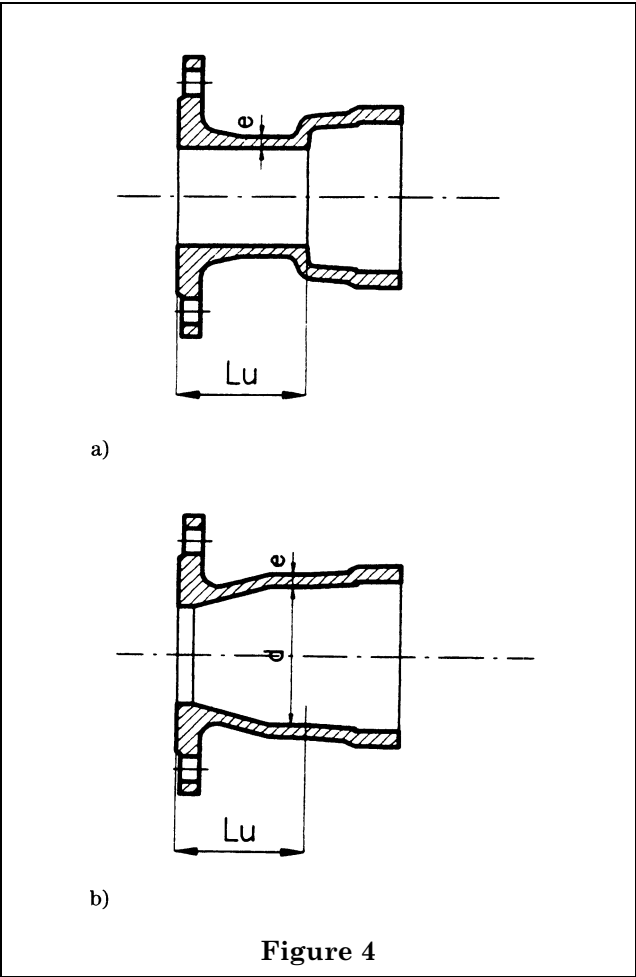
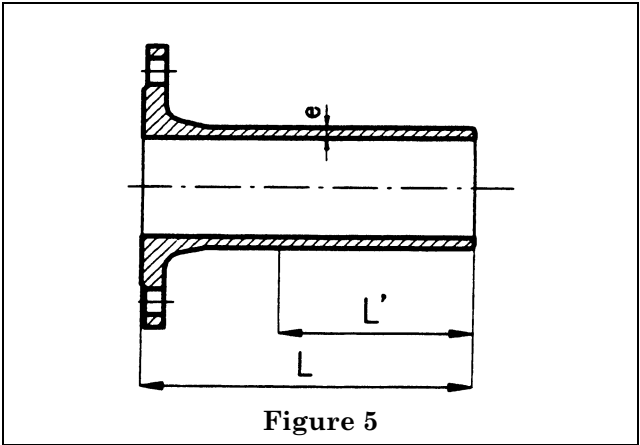


Table 12

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

9.3.2 Flanged spigots



9.3.3 Collars

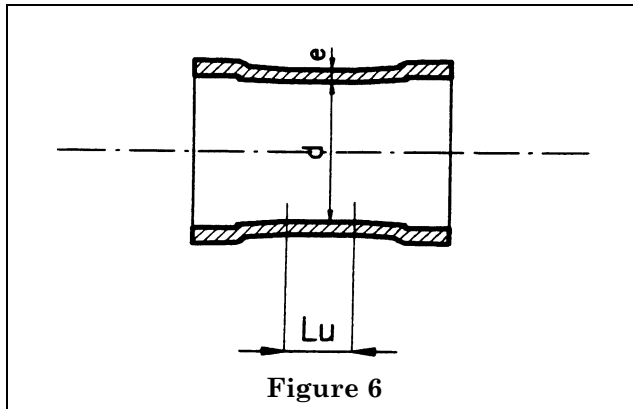


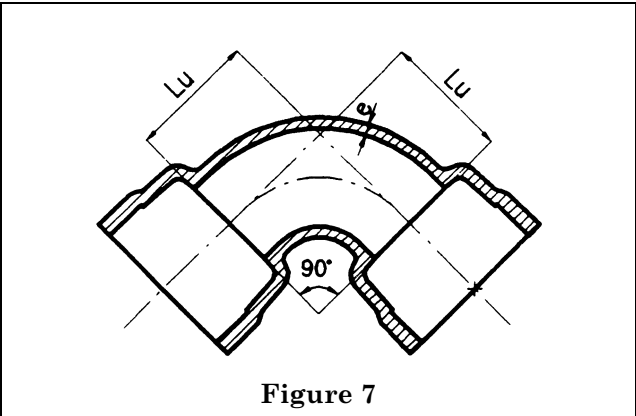
Figure 6

Table 13

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
50	7	340	340	200	155	155	78
60	7	345	345	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

NOTE The length L' is the length to which the value of DE and its tolerance, as given in Table 11, apply.

9.3.4 Double socket 90° (1/4) bends



9.3.5 Double socket 45° (1/8) bends

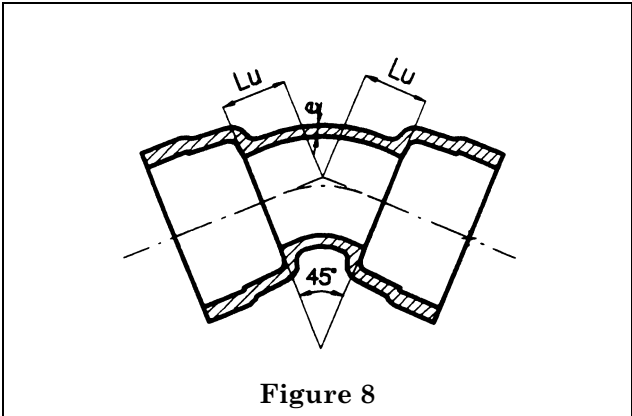
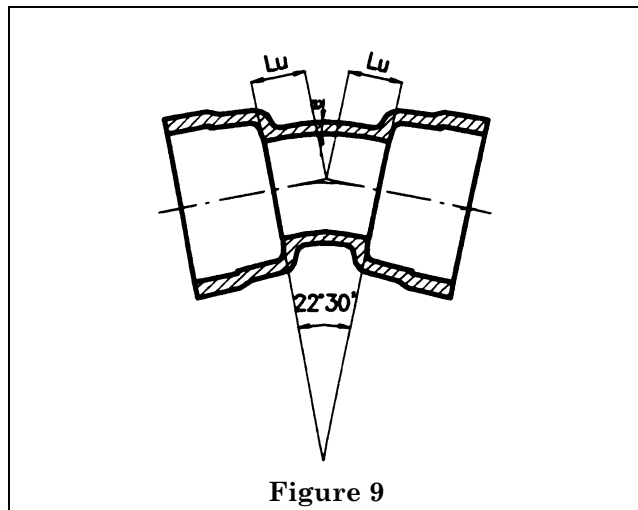


Table 14

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	—

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



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

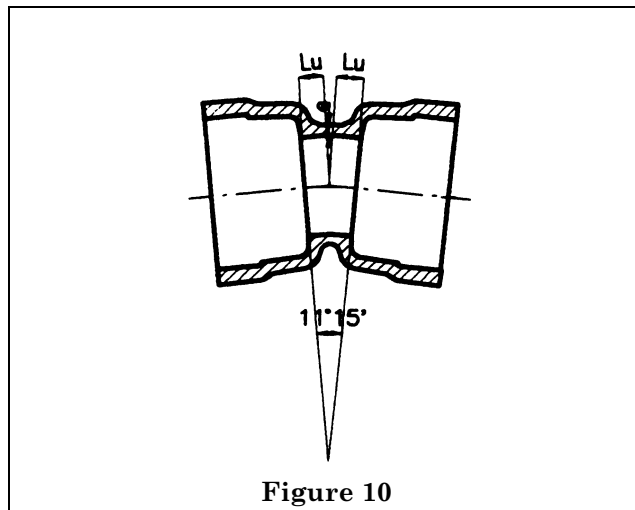


Table 15

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	—

9.3.8 All socket tees

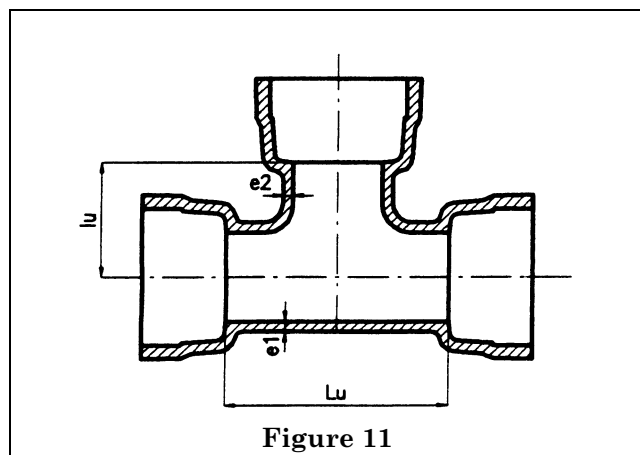


Figure 11

Table 16

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

Table 16

DN × dn	Body			Branch		
	e_1	L_u series A	L_u series B	e_2	l_u series A	l_u series B
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

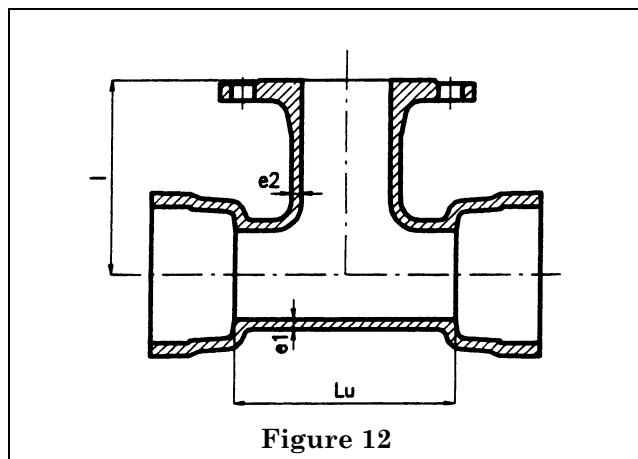


Figure 12

Table 17

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	—	130
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	7,2	—	155	7	—	145
100 × 60	7,2	—	155	7	—	165
100 × 80	7,2	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
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	185	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 600**

Table 18

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	—

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

9.3.11 Double socket tapers

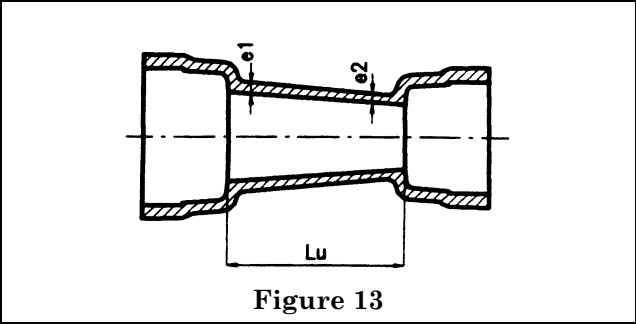


Table 19

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	—
600 × 400	13,2	10,8	460	—
600 × 500	13,2	12	260	—
NOTE The main nominal size is designated DN and the nominal size of the branch is designated 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

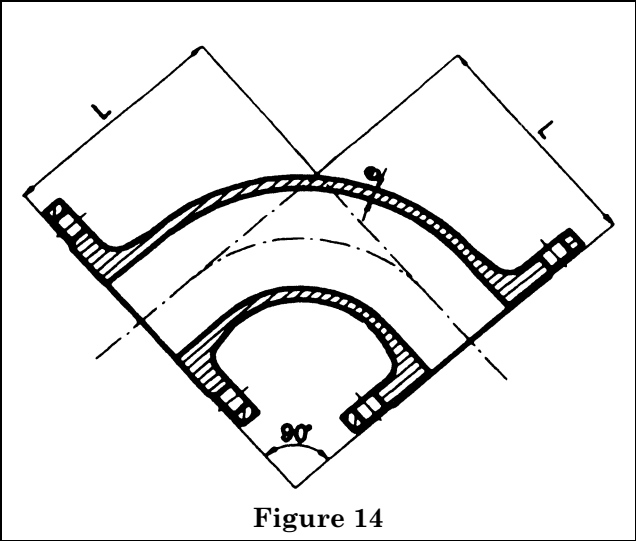


Figure 14

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

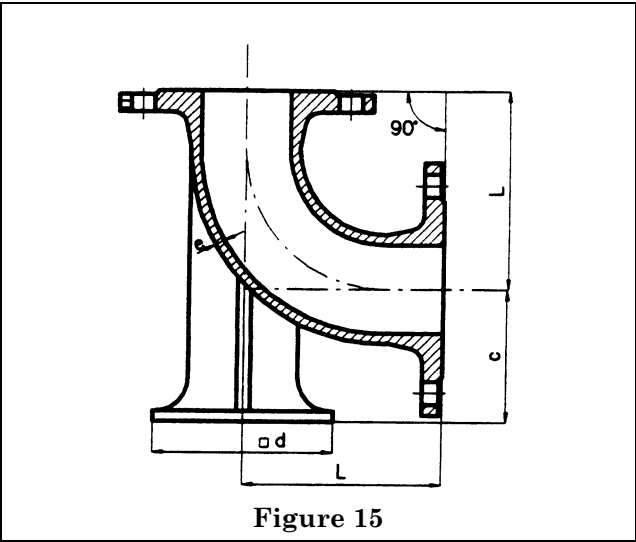


Figure 15

Table 20

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

9.4.3 Double-flanged 45° (1/8) bends

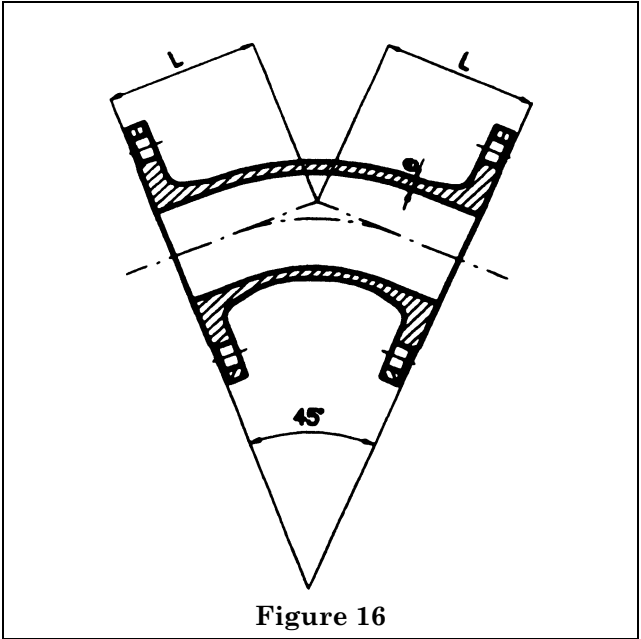


Figure 16

Table 21

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	—

9.4.4 All-flanged tees, DN 40 to DN 250

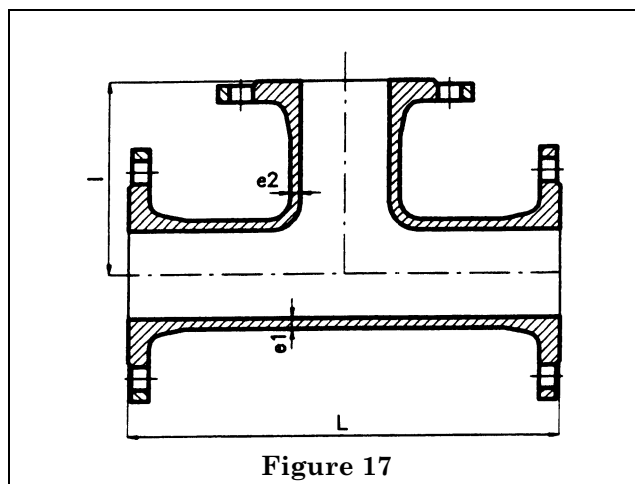


Table 22

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
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 600

Table 23

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	—	355
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	15	7,2	375	390
450 × 150	11,4	—	570	7,8	—	400
450 × 200	11,4	950	630	8,4	375	410
450 × 250	11,4	—	690	9	—	420
450 × 300	11,4	—	745	9,6	—	430
450 × 400	11,4	—	860	10,8	—	450
450 × 450	11,4	950	920	11,4	475	460
500 × 100	12	1 000	535	7,2	400	420
500 × 200	12	1 000	650	8,4	400	440
500 × 400	12	1 000	885	10,8	500	480
500 × 500	12	1 000	1 000	12	500	500
600 × 200	13,2	1 100	700	8,4	450	500
600 × 400	13,2	1 100	930	10,8	550	540
600 × 600	13,2	1 100	1 165	13,2	550	580
NOTE The main nominal size is designated DN and the nominal size of the branch is designated dn.						

9.4.6 Double-flanged tapers

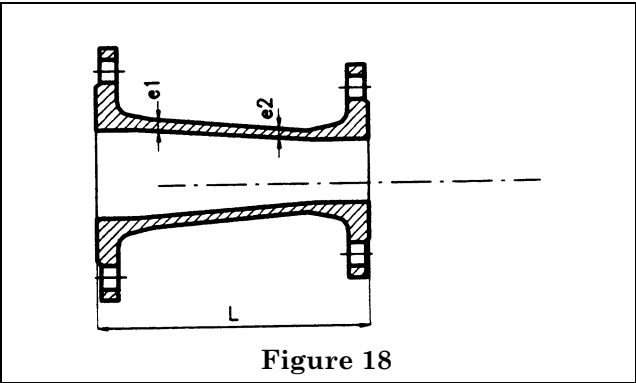
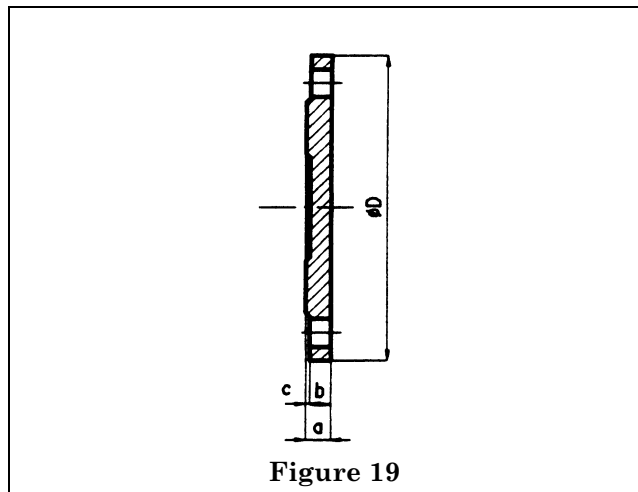


Figure 18

Table 24

DN × dn	<i>e</i> ₁	<i>e</i> ₂	<i>L</i> series A	<i>L</i> series B
50 × 40	7	7	150	165
60 × 50	7	7	160	160
65 × 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	—
NOTE The larger nominal size is designated DN and the smaller nominal size is designated dn.				

9.4.7 Blank flanges PN 10



9.4.8 Blank flanges PN 16

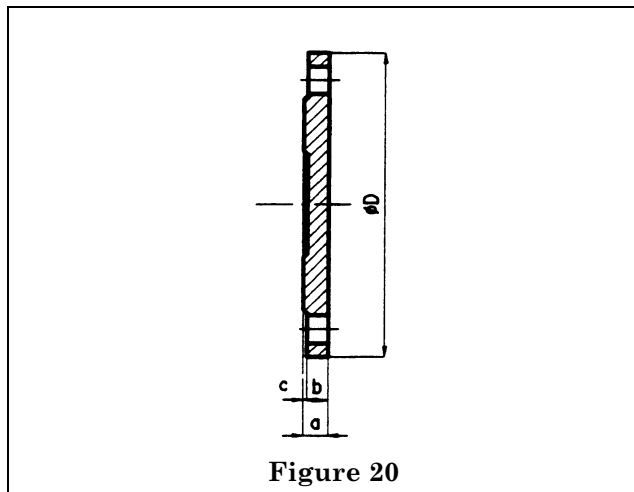
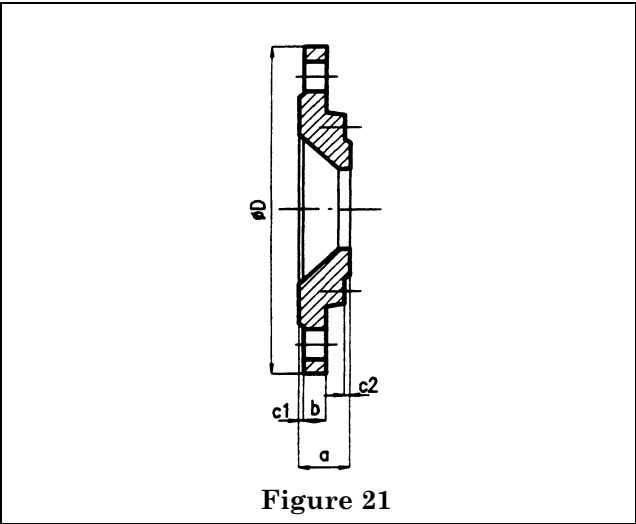


Table 25

DN	PN 10				PN 16			
	<i>D</i>	<i>a</i>	<i>b</i>	<i>c</i>	<i>D</i>	<i>a</i>	<i>b</i>	<i>c</i>
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	26,0	4
500	670	26,5	22,5	4	715	31,5	27,5	4
600	780	30	25	5	840	36	31	5

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

9.4.9 Reducing flanges PN 10



9.4.10 Reducing flanges PN 16

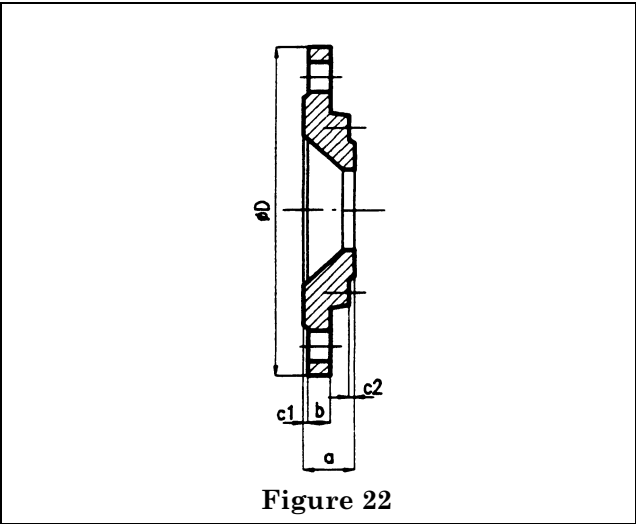


Table 26

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

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

Annex A (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 A.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 A.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 kilonewtons, 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 B (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 B.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 B.1.

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

$$S = 1\,000 \frac{E.I}{D^3} = 1\,000 \frac{E}{12} \left(\frac{e}{D} \right)^3$$

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 ($DE - e$), in millimetres;

DE is the nominal pipe external diameter, in millimetres.

Table B.1

DN	Minimum diametral stiffness S kN/m ²		Allowable pipe ovalization %
	K9	K 10	
40	14 000	14 000	0,50
50	8 000	8 000	0,55
60	5 000	5 000	0,65
65	4 000	4 000	0,70
80	2 400	2 400	0,85
100	1 350	1 350	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

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 C (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 1 500 Ωcm above the water table or less than 2 500 Ωcm 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 D (informative)

Calculation method of buried pipelines, heights of cover

D.1 Calculation method

D.1.1 Calculation formula

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

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

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 B.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 B.1. The allowable ovalization increases with DN; 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.

D.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:

$$P_e = \gamma \cdot H$$

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/m³ 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/m³, the actual value may be used for determining P_e . If, however, it appears that the actual value will be more than 20 kN/m³, the actual value should be used.

D.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:

$$P_t = 40 \frac{\beta}{H} (1 - 2 \cdot 10^{-4} DN)$$

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

It should be noticed that all pipelines should be designed for at least $\beta = 0,5$ 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 $\beta = 2$ should be adopted.

D.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 reaction angle 2α).

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

D.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.

D.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:

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

where:

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

δ is the allowable ovalization, in %.

In Table D.1 values of E' equal to 1 000 kN/m², 2 000 kN/m² and 5 000 kN/m² 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.

D.2 Heights of cover

Table D.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 D.1 and for better laying conditions, a verification can be made using the formulas given in D.1.

Table D.1

DN	40 to 300	350 to 450	500 and 600
$K (2\alpha)$	0,110 (20°)	0,105 (45°)	0,103 (60°)
$\beta = 0,75$ $E' = 0$	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
$\beta = 1,50$ $E' = 0$	0,3 to 10,5	0,4 to 7,0	^a
$E' = 1\ 000$	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
NOTE The values given for the heights of cover have been established for the class K9; they are also valid for classes $K \geq 10$.			
^a Not recommended; only a specific calculation for each case can provide an adequate answer.			

National annex NA (informative) Significant changes from BS 4772

NA.1 General

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 545 (water applications) and BS EN 598 (sewerage applications). This standard replaces BS 4772:1988 in respect of gas applications, and with the publication of all three application standards as British Standards, BS 4772 will be withdrawn.

This annex has been written to identify the most significant changes from BS 4772 that have been adopted in BS EN 969 and it is not intended to contradict nor replace any of the clauses or provisions in BS EN 969.

NA.2 Surface imperfections

This standard requires pipes, fitting and accessories to be free from defects and surface imperfections which could result in non-conformance to the technical requirements and performance requirements given in clauses 4 and 5 respectively. However, no quantitative guidance is given on the sizes or number of such surface imperfections. This is in contrast with BS 4772, which specified the maximum permissible depths of surface imperfections in ductile iron pipes and fittings.

The only defect surface, the repair of which is clearly unacceptable, is one which penetrates the full wall thickness of the pipe or fitting (see 4.1.2).

NA.3 Pipeline fittings and dimensions

This standard allows for two different series of ductile iron pipeline fittings for gas applications.

- a) series A: the dimensions and tolerances of these fittings correspond to those detailed in ISO 2531.
- b) 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. At present, the series B fittings are generally limited to a maximum size of DN 450.

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. When ordering fittings which are not detailed in the tables in this standard, the purchaser should consult the manufacturers’ catalogues to determine which of the series A or series B fittings are being offered and to 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 Polyethylene sleeving

Where polyethylene (PE) sleeving is required for the protection of buried ductile iron pipelines against external corrosion, it 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.

NA.5 Performance requirements and type tests

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

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

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

NA.6 Pipeline design

The design calculation method given in Annex D (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 discretion of the pipeline designer, in order to provide a similarly high degree of security for the pipeline during its operating life.

NA.7 Information to be supplied by the purchaser

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

- a) For socket and spigot pipes, the quantity, size (DN), length (see 4.2.3.1), and type of joint.
- b) For flanged pipes, the quantity, size (DN), flange rating (PN), length (see Table 2).
- 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 > DN 300 required to be suitable for cutting on site (see 4.2.2).

e) For pipes and fittings, identification of the external and internal coatings that are required (see 4.1.1, 4.4.1 and 4.5.1).

f) Whether guidance is needed for jointing new products with existing pipelines or with other types of joints (see 4.1.3.3).

NA.8 Further information

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

- a) Ductile Iron Pipe Committee, 8th Floor, Bridge House, Smallbrook, Queensway, Birmingham, B5 4JP. Tel. 0121 643 3377, Fax 0121 643 5064.
- b) The UK ductile iron pipe manufacturers.

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

Copyright subsists in all BSI publications. BSI also holds the copyright, in the UK, of the publications of the international standardization bodies. Except as permitted under the Copyright, Designs and Patents Act 1988 no extract may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, photocopying, recording or otherwise – without prior written permission from BSI.

This does not preclude the free use, in the course of implementing the standard, of necessary details such as symbols, and size, type or grade designations. If these details are to be used for any other purpose than implementation then the prior written permission of BSI must be obtained.

If permission is granted, the terms may include royalty payments or a licensing agreement. Details and advice can be obtained from the Copyright Manager. Tel: 020 8996 7070.