BS EN 1796:2013

BSI Standards Publication

Plastics piping systems for water supply with or without pressure — Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP)

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National foreword

This British Standard is the UK implementation of EN 1796:2013. It supersedes BS EN 1796:2006+A1:2008 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PRI/88/2, Plastics piping for pressure applications.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Plastics piping systems for water supply with or without pressure - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP)

Systèmes de canalisations en plastiques pour l'alimentation en eau avec ou sans pression - Plastiques thermodurcissables renforcés de verre (PRV) à base de résine polyester non saturé (UP)

Kunststoff-Rohrleitungssysteme für die Wasserversorgung mit oder ohne Druck - Glasfaserverstärkte duroplastische Kunststoffe (GFK) auf der Basis von ungesättigtem Polyesterharz (UP)

This European Standard was approved by CEN on 14 December 2012.

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 CEN-CENELEC Management Centre or to any CEN member.

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Foreword

This document (EN 1796:2013) has been prepared by Technical Committee CEN/TC 155 “Plastics piping systems and ducting systems”, the secretariat of which is held by NEN.

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of an identical text or by endorsement, at the latest by August 2013, and conflicting national standards shall be withdrawn at the latest by August 2013.

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

This document supersedes EN 1796:2006+A1:2008.

The following list is a list of significant technical changes that have been made since the previous edition:

- changes to many test method references to the more up to date ISO methods;
- extension of the diameter range to 4 000 mm;
- completion of the axial strength tables for all PN classes;
- restructure of the fittings section to be more practical;
- update of the joint testing criteria.

This European Standard is a system standard for plastics piping systems using glass-reinforced thermosetting plastics based on polyester resin (GRP-UP), for water supply with or without pressure.

System standards are based on the results of the work being undertaken in ISO/TC 138 "Plastics pipes, fittings and valves for the transport of fluids", which is a Technical Committee of the International Organization for Standardization (ISO). They are supported by separate standards on test methods, to which references are made throughout the system standard.

System standards are consistent with standards on general functional requirements.

According to the CEN/CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This system standard specifies the properties of a piping system and its components when made from glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) intended to be used for water supply with or without pressure.

The working group responsible for this European Standard is currently working on a test method and requirements for assessing resistance to impact damage. When this work is completed, it may result in additional requirements being incorporated into this European Standard.

This European Standard was prepared recognising the guidelines of EN 476 [1].

1 Scope

This European Standard specifies the required properties of the piping system and its components made from glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) intended to be used for water supply (drinking or raw) with or without pressure. In a pipework system, pipes and fittings of different nominal pressure and stiffness ratings may be used together.

It is the responsibility of the purchaser or specifier to make the appropriate selections taking into account their particular requirements and any relevant national regulations and installation practices or codes.

This European Standard is applicable to GRP-UP, with flexible or rigid joints (see 3.33 and 3.34), primarily intended for use in buried installations.

NOTE Piping systems conforming to this European Standard can also be used for non-buried applications provided that the influence of the environment, e.g. from UV-radiation, and the supports are considered in the design of the pipes, fittings and joints.

It is applicable to pipes, fittings and their joints of nominal sizes from DN 100 to DN 4000, which are intended to be used for the conveyance of water at temperatures up to 50 °C, with or without pressure.

This European Standard covers a range of nominal sizes, nominal stiffnesses and nominal pressures.

This European Standard is applicable to fittings made using any of the following techniques:

a) fabricated from straight pipe;

b) moulded by:

   1) filament winding;

   2) tape winding;

   3) contact moulding;

   4) hot or cold press moulding.

This European Standard is applicable to the joints to be used in GRP-UP piping systems to be used for the conveyance of water, both buried and non-buried. It is applicable to joints, which are or are not intended to be resistant to axial loading. It covers requirements to prove the design of the joint. It specifies type test performance requirements for the following joints as a function of the declared nominal pressure rating of the pipeline or system:

c) socket-and-spigot (either integral with pipe or sleeve coupling) or mechanical joint;

d) locked socket-and-spigot joint;

e) cemented or wrapped joint;

f) bolted flange joint.

Recommended practices for the installation of buried pipes made in accordance with this standard is addressed in CEN/TS 14578. Guidelines for the structural analysis of buried GRP-UP pipelines are addressed in CEN/TS 14807.

Guidance for the Assessment of Conformity of products made in accordance with this standard is addressed in CEN/TS 14632.

2 Normative references

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

EN 681-1, *Elastomeric seals — Materials requirements for pipe joint seals used in water and drainage applications — Part 1: Vulcanized rubber*

EN 1119, *Plastics piping systems — Joints for glass-reinforced thermosetting plastics (GRP) pipes and fittings — Test methods for leaktightness and resistance to damage of non-thrust resistant flexible joints with elastomeric sealing elements*

EN 1447, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of long-term resistance to internal pressure*

CEN/TS 14578, *Plastics piping systems for water supply or drainage and sewerage — Glass-reinforced thermosetting plastics (GPR) based on unsaturated polyester resin (UP) — Recommended practice for installation*

CEN/TS 14632, *Plastics piping systems for drainage, sewerage and water supply, pressure and non-pressure — Glass reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) — Guidance for the assessment of conformity*

CEN/TS 14807, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) — Guidance for the structural analysis of buried GRP-UP pipelines*

EN ISO 75-2:2004, *Plastics — Determination of temperature of deflection under load — Part 2: Plastics, ebonite and long-fibre-reinforced composites (ISO 75-2:2004)*

EN ISO 527-4, *Plastics — Determination of tensile properties — Part 4: Test conditions for isotropic and orthotopic fibre-reinforced plastic composites (ISO 527-4)*

EN ISO 527-5, *Plastics — Determination of tensile properties — Part 5: Test conditions for unidirectional fibre-reinforced plastic composites (ISO 527-5)*

EN ISO 1452-3, *Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure — Unplasticized poly(vinyl chloride) (PVC-U) — Part 3: Fittings (ISO 1452-3)*

EN ISO 3126, *Plastics piping systems — Plastics components — Determination of dimensions (ISO 3126)*

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

ISO 4200, *Plain end steel tubes, welded and seamless — General tables of dimensions and masses per unit length*

ISO 7432, *Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Test methods to prove the design of locked socket-and-spigot joints, including double-socket joints, with elastomeric seals*

ISO 7685, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of initial specific ring stiffness*

ISO 8483, *Plastics piping systems for pressure and non-pressure drainage and sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin — Test methods to prove the design of bolted flange joints*

ISO 8513, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of longitudinal tensile properties*

ISO 8521, *Plastic piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Test methods for the determination of the apparent initial circumferential tensile strength*

ISO 8533, *Plastics piping systems for pressure and non-pressure drainage and sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin — Test methods to prove the design of cemented or wrapped joints*

ISO/TR 10465-3, *Underground installation of flexible glass-reinforced pipes based on unsaturated polyester resin (GRP-UP) — Part 3: Installation parameters and application limits*

ISO 10466, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Test method to prove the resistance to initial ring deflection*

ISO 10468, *Glass-reinforced thermosetting plastics (GRP) pipes — Determination of the long-term specific ring creep stiffness under wet conditions and calculation of the wet creep factor*

ISO 10471, *Glass-reinforced thermosetting plastics (GRP) pipes — Determination of the long-term ultimate bending strain and long-term ultimate relative ring deflection under wet conditions*

ISO 10928, *Plastics piping systems — Glass reinforced thermosetting plastics (GRP) pipes and fittings — Methods for regression analysis and their use*

ISO 11922-1, *Thermoplastics pipes for the conveyance of fluids — Dimensions and tolerances — Part 1: Metric series*

3 Terms, definitions and symbols

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

3.1
nominal size
DN
alphanumerical designation of size of component, which is a convenient integer approximately equal to a manufacturing dimension in mm and which can apply to either the internal diameter (DN-ID) or the external diameter (DN-OD)

Note 1 to entry: The designation for reference or marking purposes consists of the letters DN-ID or DN-OD plus a number.

3.2
nominal stiffness
SN
alphanumerical designation for stiffness classification purposes, which has the same numerical value as the minimum initial specific ring stiffness value required, when expressed in Newtons per square metre (N/m^2)

Note 1 to entry: The designation for reference or marking purposes consists of the letters SN plus a number (see 4.1.4).

3.3
specific ring stiffness
S
physical characteristic of the pipe, expressed in Newtons per square metre (N/m^2) which is a measure of the resistance to ring deflection per metre length under external load and is defined by Formula (1):

$$S = \frac{E \times I}{d_{\mathrm{m}}^{3}} \quad (1)$$

where

E is the apparent modulus of elasticity, which can be derived from the result of the ring stiffness test, i.e. ISO 7685, expressed in Newtons per square metre (N/m^2);

d_m is the mean diameter of the pipe, in metres (m) (see 3.4);

I is the second moment of area in the longitudinal direction per metre length, in metres to the fourth power per metre, (m^4/m) (see Formula (2)):

$$I = \frac{e^3}{12} \quad (2)$$

where

e is the wall thickness, in metres (m)

3.4
mean diameter
d_m
diameter of the circle corresponding with the middle of the pipe wall cross section which is expressed in metres (m), by either Formula (3) or Formula (4):

$$d_m = d_i + e \quad (3)$$

$$d_m = d_e - e \quad (4)$$

where

d_i is the internal diameter, in metres (m);

d_e is the external diameter, in metres (m);

e is the wall thickness of the pipe, in metres (m)

3.5
initial specific ring stiffness
S_0
value of S obtained when tested in accordance with ISO 7685, in Newtons per square metre (N/m^2)

3.6
wet creep factor
$\alpha_{x,\text{creep,wet}}$
ratio of the long-term specific ring stiffness, $S_{x,\text{wet}}$ at x years determined under sustained loading in wet conditions when tested in accordance with ISO 10468, to the initial specific ring stiffness, S_0 is given by Formula (5):

$$\alpha_{x,\text{creep,wet}} = \frac{S_{x,\text{wet}}}{S_0} \quad (5)$$

3.7
calculated long-term specific ring stiffness
$S_{x,\text{wet}}$
calculated value of S at x years (see 4.6), obtained by Formula (6)

$$S_{x,\text{wet}} = S_0 \times \alpha_{x,\text{wet}} \quad (6)$$

where

x is the elapsed time in years specified in this European Standard;

$\alpha_{x,\text{wet}}$ is the wet creep factor (see 3.6);

S_0 is the initial specific ring stiffness, in Newtons per square metre (N/m^2)

Note 1 to entry: See 3.5 and 4.6.

3.8
rerating factor
R_{RF}
multiplication factor that quantifies the relation between a mechanical, physical or chemical property at the service condition compared to the respective value at 23 °C and 50 % relative humidity (R.H.)

3.9
nominal pressure
PN
alphanumeric designation for pressure classification purposes, which has a numerical value equal to the resistance of a component of a piping system to internal pressure, when expressed in bars[1)]

Note 1 to entry: The designation for reference or marking purposes consists of the letters PN plus a number.

3.10
type tests
tests carried out to prove that a material, component, joint or assembly is capable of conforming to the relevant requirement

3.11
quality control tests
tests carried out for the purpose of process control and/or release of product

3.12
nominal length
numerical designation of a pipe length which is equal to the pipe's laying length (see 3.14), expressed in metres (m), rounded to the nearest whole number

Note 1 to entry: See 3.14.

3.13
total length
distance between two planes normal to the pipe axis and passing through the extreme end points of the pipe including, where applicable, the affixed sockets; expressed in metres (m)

3.14
laying length
total length of a pipe minus, where applicable, the manufacturer's recommended insertion depth of the spigot(s) in the socket; expressed in metres (m)

3.15
normal service conditions
conveyance of surface water or sewage, in the temperature range 2 °C to 50 °C, with or without pressure, for 50 years

1) 1 bar = 10^5 N/m^2 = 0,1 MPa.

3.16
minimum initial design pressure
$P_{0,\mathrm{d}}$
least value for mean short term burst test failure pressure, which is evaluated in accordance with the procedures described in ISO 10928 and used to design the pipe, expressed in bars

3.17
minimum initial failure pressure
$P_{0,\mathrm{min}}$
least value for short term burst test failure pressure, which is evaluated in accordance with the procedures described in ISO 10928, expressed in bars

3.18
minimum long-term design pressure
$P_{x,\mathrm{d}}$
least value for mean long-term burst failure pressure, expressed in bars, which is evaluated in accordance with the procedures described in ISO 10928 and includes a design factor of safety, FS_{d}

Note 1 to entry: It is one of the parameters used to determine the minimum initial design pressure.

3.19
minimum long-term failure pressure
$P_{x,\mathrm{min}}$
least value for long-term burst failure pressure, expressed in bars, which is evaluated in accordance with the procedures described in ISO 10928 and includes a factor of safety, FS_{min}

Note 1 to entry: It is one of the parameters used to determine the minimum initial design pressure.

3.20
pressure regression ratio
R_{RP}
relationship between the extrapolated mean failure pressure at 50 years to the extrapolated mean failure pressure at 6 min derived using Formula (7) as follows:

$$R_{\mathrm{R,P}} = \frac{P_{x,\,\mathrm{mean}}}{P_{6\,\mathrm{min,\,mean}}} \quad (7)$$

where

$P_{x,\mathrm{mean}}$ is the extrapolated long-term (50 year) mean failure pressure;

$P_{6\,\mathrm{min,mean}}$ is the extrapolated short-term (6 min) mean failure pressure

3.21
break
condition where a test piece can no longer carry load

3.22
non-pressure pipe or fitting
pipe or fitting, subject at its top to an internal pressure not greater than 1 bar

3.23
pressure pipe or fitting
pipe or fitting having a nominal pressure classification which is greater than 1 bar and which is intended to be used with the internal pressure equal to or less than its nominal pressure when expressed in bars

3.24
buried pipeline
pipeline, which is subjected to the external pressure, transmitted from soil loading, including traffic and superimposed loads and, possibly, the pressure of a head of water

3.25
non-buried pipeline
pipeline subject only to forces resulting from its supports and environmental conditions, including, where applicable, internal negative and positive pressures, snow and wind

3.26
sub-aqueous pipeline
pipeline which is subjected to an external pressure arising from a head of water and may be subject to conditions such as drag and lift caused by current and wave action

3.27
design service temperature
maximum sustained temperature at which the system is expected to operate, expressed in degrees Celsius (°C)

3.28
relative ring deflection
y/d_m
ratio of the change in diameter of a pipe, y, in metres, to its mean diameter, d_m derived as a percentage (%) when using Formula (8):

$$\text{relative ring deflection} = \frac{y}{d_m} \times 100 \quad (8)$$

Note 1 to entry: See 3.4.

3.29
minimum initial relative specific ring deflection before bore cracking occurs
$(y_{2,\text{bore}}/d_m)_{\text{min}}$
initial relative specific ring deflection, expressed as a percentage (%), at 2 min, which a test piece is required to pass without bore cracking when tested in accordance with ISO 10466

3.30
minimum initial relative specific ring deflection before structural failure occurs
$(y_{2,\text{struct}}/d_m)_{\text{min}}$
initial relative specific ring deflection, expressed as a percentage (%), at 2 min, which a test piece is required to pass without structural failure when tested in accordance with ISO 10466

3.31
extrapolated long-term ultimate relative ring deflection
$y_{\text{u,wet,}x}/d_m$
value, expressed as a percentage (%), at x years, derived from the ultimate relative ring deflection regression line, obtained from long-term deflection tests performed under wet conditions in accordance with ISO 10471

Note 1 to entry: See 4.6.

3.32
minimum long-term ultimate relative ring deflection
$(y_{\text{u,wet,}x}/d_m)_{\text{min}}$
required minimum extrapolated value, expressed as a percentage (%), at x years (see 4.6), derived from the ultimate relative ring deflection regression line obtained from long-term ultimate ring deflection tests performed under wet conditions in accordance with ISO 10471

3.33
flexible joint
joint which allows relative movement between the pipes being joined

EXAMPLES

a) Socket-and-spigot joint with an elastomeric sealing element (including double socket designs);

b) locked socket-and-spigot joint with an elastomeric sealing element (including double socket designs);

c) mechanical clamped joint e.g. bolted coupling including joints made from materials other than GRP.

End-load-bearing flexible joints have resistance to axial loading.

3.34
rigid joint
joint which does not allow relative movement between the pipes being joined

EXAMPLES

a) Flanged joint, including integral and loose flanges;

b) wrapped or cemented joint.

Non-end-load-bearing rigid joints do not have resistance to axial loading.

3.35
angular deflection
δ
angle between the axes of two adjacent pipes, expressed in degrees (°)

Note 1 to entry: See Figure 1.

3.36
draw
D
longitudinal movement of a joint, is expressed in millimetres (mm)

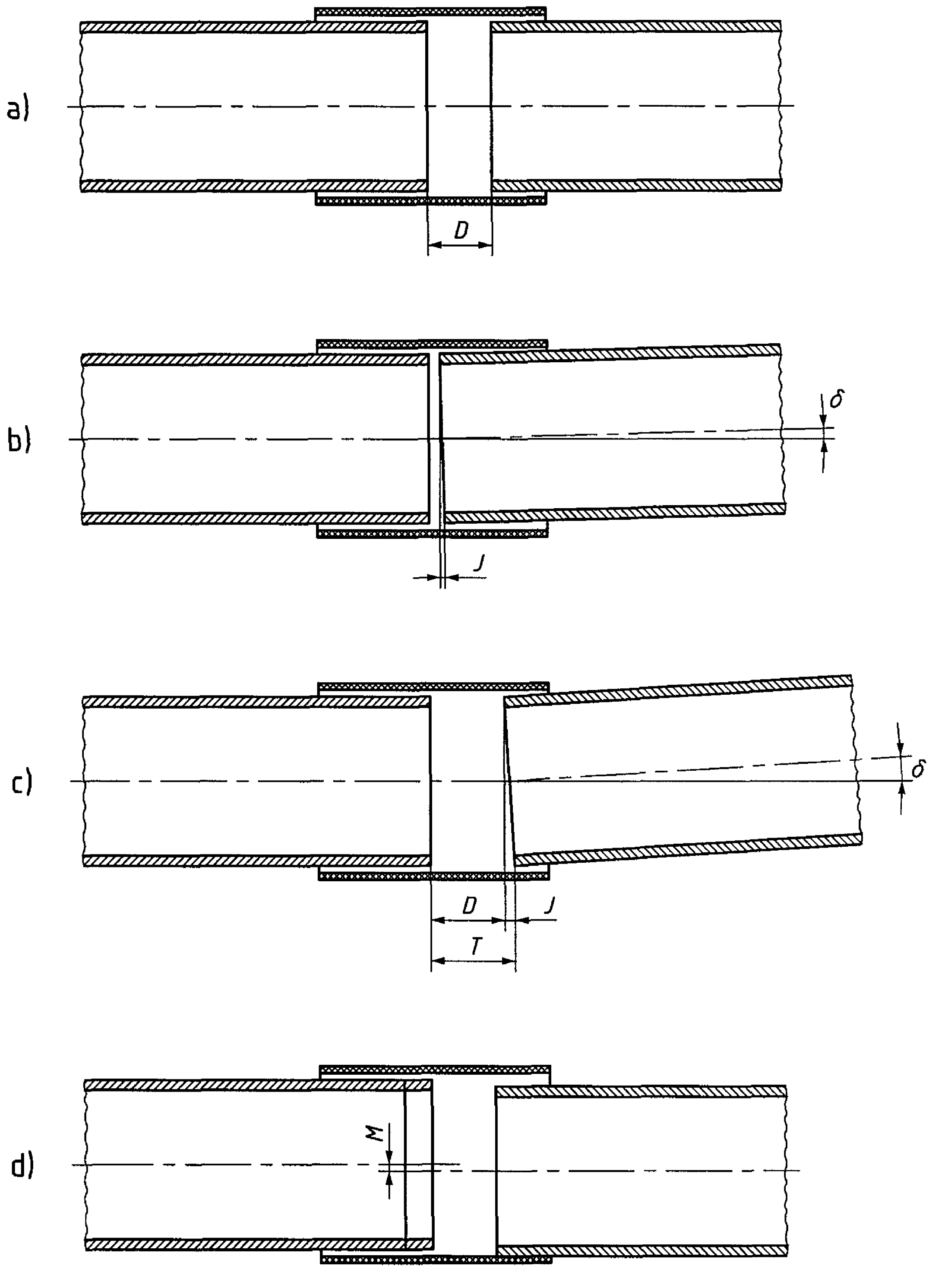
Note 1 to entry: See Figure 1.

3.37
total draw
T
sum of the draw, D, and the additional longitudinal movement, J, due to the presence of angular deflection, expressed in millimetres (mm)

Note 1 to entry: See Figure 1.

3.38
misalignment
M
amount by which the centrelines of adjacent pipes fail to coincide

Note 1 to entry: See Figure 1.



Key

D	is draw
J	is longitudinal movement arising from angular deflection of the joint
δ	is angular deflection of the joint
T	is total draw
M	is misalignment

Figure 1 — Joint movements

4 General requirements

4.1 Classification

4.1.1 General

Regarding the practices for the installation of buried pipes made in accordance with this standard, see CEN/TS 14578.

Guidelines for the structural analysis of buried GRP-UP pipelines are addressed in CEN/TS 14807.

Guidance for the Assessment of Conformity of products made in accordance with this standard is addressed in CEN/TS 14632.

4.1.2 Categories

Pipes and fittings shall be classified according to nominal size (DN) (see 3.1), nominal pressure (PN) (see 3.9) and joint type.

In addition, pipes shall include nominal stiffness (SN) (see 3.2) in their classification.

4.1.3 Nominal size

The nominal size (DN) of pipes and fittings shall conform to the appropriate Tables in Clause 5. If a thermoplastics liner is present, its internal diameter shall be declared by the manufacturer. The tolerance on the diameter shall be as specified in Clause 5.

4.1.4 Nominal stiffness

The nominal stiffness, SN, shall conform to one of those given in Table 1. These nominal stiffnesses correspond to the values specified in Clause 5 for the minimum initial specific ring stiffness, in Newtons per square metre (N/m^2).

Pipes of nominal stiffness less than SN 1250 are not intended for laying directly in the ground.

Where special applications require the use of pipes having a higher nominal stiffness than those given in Table 1 the pipe shall be marked SN *v*, where *v* is the number equal to the pipes nominal stiffness.

Table 1 — Nominal stiffnesses (SN)

Nominal stiffnesses (SN)
630
1 250
2 500
5 000
10 000

4.1.5 Nominal pressure

The nominal pressure (PN) shall conform to one of those given in Table 2.

Where pressure ratings other than the nominal values in Table 2 are to be supplied, by agreement between the manufacturer and the purchaser, the pressure marking PN on the component shall be replaced by PN *v* where *v* is the number equal to the components nominal pressure.

Table 2 — Nominal pressures (PN)

Nominal pressure (PN)	
1	12,5
2,5	16
4	20
6	25
10	32
NOTE Components marked PN1 are non-pressure (gravity) components.	

4.2 Materials

4.2.1 General

The pipe or fitting shall be constructed using chopped and/or continuous glass filaments, strands or rovings, mats or fabric, synthetic veils, and polyester resin with or without fillers and if applicable additives necessary to impart specific properties to the resin. The pipe or fitting may also incorporate aggregates, and if required, a thermoplastics liner.

4.2.2 Reinforcement

The glass used for the manufacture of the reinforcement shall be one of the following types:

a) a type 'E' glass, comprising primarily either oxides of Silicon, Aluminium and Calcium (alumino-calcosilicate glass) or Silicon, Aluminium and Boron (alumino-borosilicate glass);

b) a type 'C' glass, comprising primarily oxides of Silicon, Sodium, Potassium, Calcium and Boron (alkali-calcium glass with an enhanced boron trioxide content) which is intended for applications requiring enhanced chemical resistance;

c) a type ‘R’ glass, comprising primarily oxides of Silicon, Aluminium, Calcium and Magnesium without added Boron.

In either of these types of glass small amounts of oxides of other metals will be present.

NOTE These descriptions for 'C' glass and 'E' glass are consistent with, but more specific than those given in EN ISO 2078 [2].

The reinforcement shall be made from continuously drawn filaments of a glass conforming to type E, type C or type R, and shall have a surface treatment compatible with the resin to be used. It may be used in any form, e.g. as continuous or chopped filaments, strands or rovings, mat or fabric.

4.2.3 Resin

The resin used in the structural layer (see 4.3.2) shall have a temperature of deflection of at least 70 °C when the test specimen is tested in accordance with Method A of EN ISO 75-2:2004.

4.2.4 Aggregates and fillers

The size of particles in aggregates and fillers shall not exceed 1/5 of the total wall thickness of the pipe or fitting or 2,5 mm, whichever is the lesser.

4.2.5 Elastomers

Each elastomeric material(s) of the sealing component shall conform to the applicable requirements of EN 681-1.

NOTE Gaskets complying with EN 681-1 are deemed to satisfy the design life of the pipe systems made in accordance with this standard.

4.2.6 Metals

Where exposed metal components are used, there shall not be evidence of corrosion of the components after the fitting has been immersed in an aqueous sodium chloride solution, 30 g/l, for seven days at (23 ± 2) °C.

4.3 Wall construction

4.3.1 Inner layer

The inner layer shall comprise one of the following:

a) a thermosetting resin layer with or without aggregates or fillers and with or without reinforcement of glass or synthetic filaments;

b) a thermoplastics liner.

The thermoplastic liner may require a bonding material compatible with all other materials used in the pipe construction.

The resin used in this inner layer need not conform to the temperature of deflection requirements given in 4.2.3.

4.3.2 Structural layer

The structural layer shall consist of glass reinforcement and a thermosetting resin, with or without aggregates or fillers.

4.3.3 Outer layer

The design of the outer layer of the pipe shall take into account the environment in which the pipe is to be used. This layer shall be formed of a thermosetting resin with or without aggregates or fillers and with or without a reinforcement of glass or synthetic filaments.

The of use special constructions is permitted when the pipe is expected to be exposed to extreme climatic, environmental or ground conditions, for example provision for the inclusion of pigments or inhibitors for extreme climatic conditions or fire retardation.

The resin used in this outer layer need not conform to the temperature of deflection requirements in 4.2.3.

4.4 Appearance

Both internal and external surfaces shall be free from irregularities, which would impair the ability of the component to conform to the requirements of this European Standard.

4.5 Reference conditions for testing

4.5.1 Temperature

The mechanical, physical and chemical properties specified in all clauses of this European Standard shall, unless otherwise specified, be determined at (23 ± 5) °C. For service temperatures over 35 °C and up to and including 50 °C type tests shall, unless otherwise specified, be carried out at least at the design service temperature (see 3.27) $^{+5}_{0}$ °C, to establish re-rating factors for all long-term properties to be used in design.

4.5.2 Properties of water for testing

The water used for the tests referred to in this European Standard shall be tap water having a pH of (7 ± 2).

4.5.3 Loading conditions

Unless otherwise specified, the mechanical, physical and chemical properties specified in all clauses of this European Standard shall be determined using circumferential and/or longitudinal loading conditions, as applicable.

4.5.4 Preconditioning

Unless otherwise specified, in case of dispute store the test piece(s) in air at the test temperature specified in 4.5.1 for at least 24 h prior to testing.

4.5.5 Measurement of dimensions

Measurements shall be made in accordance with EN ISO 3126 or otherwise using any method of sufficient accuracy to determine conformity or otherwise to the applicable limits. Routine measurements shall be determined at the prevailing temperature or if the manufacturer prefers at the temperature specified in 4.5.1. In case of dispute, the dimensions of GRP-UP components shall be determined at the temperature specified in 4.5.1.

4.6 Elapsed time for determination of long-term properties, (x)

The subscript x, in for example $S_{x,\text{wet}}$ (see 3.7), denotes the elapsed time for which the long-term property is to be determined. Unless otherwise specified, the long-term properties shall be determined at 50 years (438 000 h).

4.7 Joints

4.7.1 General

If requested, the manufacturer shall declare the length and the maximum external diameter of the assembled joint.

4.7.2 Types of joint

A joint shall be classified as either flexible (see 3.33) or rigid (see 3.34) and in each case whether or not it is capable of resisting end-loads.

4.7.3 Flexibility of the jointing system

4.7.3.1 Allowable maximum angular deflection

The manufacturer shall declare the allowable maximum angular deflection for which each joint is designed.

Except for locked joints, flexible joints shall have an allowable maximum angular deflection that is not less than the following applicable value:

a) 3° for pipes and/or fittings with a nominal size equal to or less than DN 500;

b) 2° for pipes and/or fittings with a nominal size greater than DN 500 and equal to or less than DN 900;

c) 1° for pipes and/or fittings with a nominal size greater than DN 900 and equal to or less than DN 1800;

d) 0,5° for pipes and/or fittings with a nominal size greater than DN 1800.

The manufacturer of locked joints shall declare for each joint its allowable maximum angular deflection.

Flexible joints intended to be used at pressures greater than 16 bars may have lower allowable maximum angular deflections than those given in this clause, by declaration and agreement between the manufacturer and the purchaser.

4.7.3.2 Maximum draw

The manufacturer shall declare the maximum draw (see 3.36) for which each joint is designed.

For flexible joints, the maximum draw, which includes the Poisson contraction and temperature effects, shall not be less than 0,3 % of the laying length of the longest pipe with which it is intended to be used, for pressure pipes and 0,2 % for non-pressure pipes. For locked joints, the manufacturer shall declare the maximum draw.

4.7.4 Sealing ring

The sealing ring shall not have any detrimental effect on the properties of the components with which it is used and shall not cause the test assembly to fail the functional requirements of Clause 7.

4.7.5 Adhesives

Adhesives, if required, shall be specified by the manufacturer of the joint. The joint manufacturer shall ensure that the adhesives shall not have any detrimental effects on the components with which it is used and shall not cause the test assembly to fail the functional requirements of Clause 7.

5 Pipes

5.1 Geometrical characteristics

5.1.1 Diameter

5.1.1.1 Diameter series

GRP-UP pipes shall be designated by nominal size in accordance with one of the following two series:

a) **Series A** - which specifies the internal diameters in millimetres (mm);

b) **Series B** - which specifies external diameters in millimetres (mm).

NOTE In standardising the diameters of (GRP-UP) pipes, difficulties are encountered because of the varying methods of manufacture (e.g. filament winding, centrifugal casting or contact moulding). GRP-UP pipes are typically produced by controlling either the internal diameter, or the external diameter to a fixed value.

5.1.1.2 Nominal size

The nominal size, DN shall be chosen from those given in Table 3.

Table 3 — Nominal size DN

Nominal size DN			
100	600	1800	3100
110	700	(1900)	3200
125	(750)	2000	3300
150	800	(2100)	3400
200	900	2200	3500
(225)	1000	(2300)	3600
250	(1100)	2400	3700
300	1200	(2500)	3800
350	(1300)	2600	3900
(375)	1400	(2700)	4000
400	(1500)	2800	
450	1600	(2900)	
500	(1700)	3000	
NOTE Figures in parentheses are non-preferred nominal sizes.			

5.1.1.3 Specified diameters

5.1.1.3.1 General

Pipes shall be supplied conforming to either 5.1.1.3.2 (Series A) or 5.1.1.3.3 (Series B).

It is permitted to supply pipes having other diameters by agreement between the manufacturer and the purchaser.

5.1.1.3.2 Series A (Internal diameter specified)

The internal diameter, in millimetres, shall conform to the applicable values relative to the nominal size given in Table 4.

5.1.1.3.3 Series B (External diameter specified)

The external diameter, in millimetres, shall conform to the applicable value relative to the nominal size given in Table 5 or Table 6.

Pipes with nominal sizes between DN 300 and DN 4000, which are to be used with GRP-UP fittings conforming to Clause 6 shall conform to the dimensions of Series B1.

Pipes with nominal sizes between DN 100 and DN 600 which are to be used with either:

- GRP-UP fittings conforming to Clause 6 or
- ductile iron fittings conforming to ISO 2531

shall conform to the dimensions of series B2.

Pipes with nominal sizes between DN 100 and DN 600, to be used with either:

- GRP-UP fittings conforming to Clause 6, or
- PVC fittings conforming to EN ISO 1452-3 and to the tolerances to ISO 11922-1

shall conform to the dimensions of series B3.

Pipes with nominal sizes between DN 100 and DN 300 intended to be used with either:

- GRP-UP fittings conforming to Clause 6; or
- steel pipes conforming to ISO 4200

shall conform to the dimensions of Series B4.

When specifying fittings made to other specifications care should be taken to ensure their dimensional compatibility with the GRP-UP pipe.

Table 4 — Series A - Specified pipe internal diameters and tolerances

Dimensions in millimetres

Column 1	**Column 2**	**Column 3**	**Column 4**
Nominal size DN	**Range of declared pipe internal diameters**		**Permissible deviations from declared internal diameter**
	minimum	**maximum**	**± mm**
100	97	103	1,5
110	107	113	1,5
125	122	128	1,5
150	147	153	1,5
200	196	204	1,5
225	221	229	1,5
250	246	255	1,5
300	296	306	1,8
350	346	357	2,1
400	396	408	2,4
450	446	459	2,7
500	496	510	3,0
600	595	612	3,6
700	695	714	4,2
800	795	816	4,2
900	895	918	4,2
1000	995	1 020	5,0
1200	1 195	1 220	5,0
1400	1 395	1 420	5,0
1600	1 595	1 620	5,0
1800	1 795	1 820	5,0
2000	1 995	2 020	5,0
2200	2 195	2 220	5,0
2400	2 395	2 420	6,0
2600	2 595	2 620	6,0
2800	2 795	2 820	6,0
3000	2 995	3 020	6,0
3200	3 195	3 220	6,0
3400	3 395	3 420	6,0
3600	3 595	3 620	6,0
3800	3 795	3 820	7,0
4000	3 995	4 020	7,0

NOTE 1 When a non-preferred size is selected from Table 3, the range of diameters and the permissible deviations will be interpolated between the preferred size immediately above and below the non-preferred size.

NOTE 2 Where a manufacturer supplies pipes with a definable change in diameter from one end to the other then they can declare the diameters at each end and these declared values will be subject to the tolerances given in column 4.

5.1.1.4 Minimum internal diameters for pipes with a prefabricated thermoplastics liner

The internal diameter of the thermoplastics liner shall be not less than 96,5 % of the nominal size of the GRP-UP pipe.

5.1.1.5 Tolerances

5.1.1.5.1 General

Where interchangeability is required, see Clause 7 for further information.

5.1.1.5.2 Series A — Tolerances on internal diameter

The declared internal diameter of a pipe shall be between the minimum and maximum values given in columns 2 and 3 of Table 4. The average internal diameter at any point along its length shall not deviate from the declared internal diameter by more than the permissible deviations given in Column 4 of Table 4.

For GRP-UP pipes, which have a liner made from thermoplastics pipes, the tolerances on internal diameter shall be as specified in the relevant thermoplastics pipes standard. For GRP-UP pipes, which have a liner fabricated from thermoplastics sheet, the internal diameter and the tolerances on internal diameter shall conform to Table 4.

5.1.1.5.3 Series B1 — Tolerances on external diameter

The external diameter of a pipe at the spigot shall be as given in Table 5. The actual external diameter of a pipe at the spigot shall not deviate from the declared diameter by more than the permissible deviations given in Table 5.

Table 5 — Series B1 - Specified pipe external diameters and tolerances

Dimensions in millimetres

Nominal Size DN	External pipe diameter mm	Permissible deviations		Nominal size DN	External pipe diameter mm	Permissible Deviations	
		Upper Limit	Lower limit			Upper Limit	Lower Limit
300	310	+1,0	-1,0	**1800**	1 842	+2,0	-3,0
350	361		-1,2	**2000**	2 046		-3,0
400	412		-1,4	**2200**	2 250		-3,2
450	463		-1,6	**2400**	2 453		-3,4
500	514		-1,8	**2600**	2 658		-3,6
600	616		-2,0	**2800**	2 861		-3,8
700	718		-2,2	**3000**	3 066		-4,0
800	820		-2,4	**3200**	3 270		-4,2
900	924		-2,6	**3400**	3 474		-4,4
1000	1 026	+2,0	-2,6	**3600**	3 678		-4,6
1200	1 229		-2,6	**3800**	3 882		-4,8
1400	1 434		-2,8	**4000**	4 086		-5,0
1600	1 638		-2,8				
When a non-preferred size is selected from Table 3, the range of diameters and the permissible deviations shall be interpolated between the preferred size immediately above and below the non-preferred size.							

5.1.1.5.4 Series B2, B3 and B4 — Tolerances on external diameter

The tolerances on the external diameter, at the spigot, for series B2, B3 and B4 pipes shall be as given in Table 6.

Table 6 — Series B2, B3 and B4 — Specified pipe external diameters and tolerances

Dimensions in millimetres

Nominal size [a] DN-OD	Series B2			Series B3			Series B4		
	External diameter	Permissible deviation		External diameter	Permissible deviation		External diameter	Permissible deviation	
		Upper limit	Lower limit		Upper limit	Lower limit		Upper limit	Lower limit
100	115,0		+0,3	110	+0,4		114,3		
125	141,0		+0,2	125	+0,4		139,7		
150	167,0		+0,1	160	+0,5		168,3		
200	220,0		0,0	200	+0,6		219,1		
225	---		---	225	+0,7		---		
250	271,8	+1,0	-0,2	250	+0,8	0	273,0	+1,5	-0,2
300	323,8		-0,3	315	+1,0		323,9		
350	375,7		-0,3	355	+1,1		---		
400	426,6		-0,3	400	+1,3		---		
450	477,6		-0,4	450	+1,4		---		
500	529,5		-0,4	500	+1,5		---		
600	632,5		-0,5	630	+1,9		---		

[a] When a non-preferred size is selected from Table 3, the range of diameters and the permissible deviations shall be interpolated between the preferred size immediately above and below the non-preferred size.

5.1.2 Wall thickness

The minimum total wall thickness, including the liner, shall be declared by the manufacturer and shall not be less than 3 mm.

5.1.3 Length

5.1.3.1 Nominal length

The nominal length (see 3.12) shall be one of the following preferred values: 3, 5, 6, 10,12 or 18.

Other lengths may be supplied as agreed between the manufacturer and the purchaser.

5.1.3.2 Laying length

The pipe shall be supplied in laying lengths (see 3.14) in accordance with the requirements given in the following paragraph. The tolerance on laying length is ± 60 mm.

Of the total number of pipes supplied in each diameter, the manufacturer may supply up to 10 % in lengths shorter than the effective length unless a higher percentage of such pipes is to be supplied by agreement between the manufacturer and the customer. In all cases where the laying length of the pipe is not within 60 mm of the nominal length then the actual laying length of the pipe shall be marked on the pipe.

5.2 Mechanical characteristics

5.2.1 Initial specific ring stiffness

5.2.1.1 General

The initial specific ring stiffness, S_0 (see 3.5) shall be determined using either of the methods given in ISO 7685. The test pieces shall conform to 5.2.1.2 and 5.2.1.3. The test shall be conducted using a relative ring deflection (see 3.30) between 2,5 % and 3,5 %. When the nominal stiffness exceeds SN 10 000 the test shall be performed using a percentage relative ring deflection determined using Formula (9):

$$\frac{y}{d_{\mathrm{m}}} \times 100 = \frac{65}{\sqrt[3]{\mathrm{SN}}} \pm 0{,}5\ \% \qquad (9)$$

where

SN is the nominal stiffness;

$\frac{y}{d_{\mathrm{m}}} \times 100$ is the percentage relative ring deflection for the initial stiffness test, in percent (%).

The determined value of initial specific ring stiffness, S_0, shall not be less than the applicable value of $S_{0,\mathrm{min}}$ given in Table 7. For nominal stiffnesses greater than SN 10 000 the initial stiffness in N/m^2 shall be not less than the numerical value of the nominal stiffness.

5.2.1.2 Number of test pieces for type test purposes

Unless otherwise specified two test pieces, of the same size and classification and conforming to 5.2.1.4, shall be used.

5.2.1.3 Number of test pieces for quality control test purposes

Unless otherwise specified one test piece, of the same size and classification and conforming to 5.2.1.4, shall be used.

Table 7 — Minimum initial specific ring stiffness values

SN [a]	$S_{0,\mathrm{min}}$ [b] N/m^2
630	630
1 250	1 250
2 500	2 500
5 000	5 000
10 000	10 000

[a] See 4.1.4.

[b] For other stiffnesses the value of $S_{0,\mathrm{min}}$ shall be equal to SN v (see 4.1.4).

5.2.1.4 Length of test pieces

The length, $L_{p,}$ in metres of the test piece shall conform to Table 8 subject to permissible deviations of ± 5 % on the length.

Table 8 — Lengths of test pieces

Nominal size **DN**	**Length, L_p** m
All	0,3

5.2.2 Long-term specific ring stiffness under wet conditions

5.2.2.1 Temperature and pH of the water

The temperature and pH of the water shall be in accordance with 4.5.

5.2.2.2 Method of test to determine S_0

Before performing the tests detailed in 5.2.2.5 the initial specific ring stiffness, S_0, of the test pieces shall be determined in accordance with 5.2.1 using test pieces conforming to 5.2.2.7.

5.2.2.3 Time intervals for measurement

Commencing at 1 h after completion of loading and continuing for more than 10 000 h, measure to within 2 % of the initial value and record the deflection readings. The intervals between readings shall be such that ten readings are taken at approximately equally spaced intervals of log-time for each decade of log-time in hours.

5.2.2.4 Elapsed time at which the property is to be determined

The elapsed time at which this property is to be determined is 50 years.

Some design or analysis procedures may use a 2-year value for long-term stiffness. This value can be determined from the same test data.

5.2.2.5 Method of test

The long-term specific ring creep stiffness, $S_{x,\text{wet,creep}}$, and the creep factor, $\alpha_{x,\text{creep,wet}}$, shall be determined from data derived from the test performed in accordance with ISO 10468 using an initial strain between 0,13 % and 0,17 %.

5.2.2.6 Requirement

When tested in accordance with the method given in 5.2.2.5, using test pieces conforming to 5.2.2.7, determine the creep factor, $\alpha_{x,\text{creep,wet}}$,. The determined value of the factor shall be declared.

5.2.2.7 Number of test pieces for type test purposes

Unless otherwise specified, two test pieces of the same size and classification and conforming to 5.2.1.4 shall be used.

5.2.3 Initial resistance to failure in a deflected condition

5.2.3.1 General

The initial resistance to failure in a deflected condition shall be determined using the method given in ISO 10466. The test pieces shall conform to 5.2.1.4. The test shall be conducted using mean diametrical deflections appropriate to the nominal stiffness (SN) of the pipe as specified in 5.2.3.3.1 for item a) of 5.2.3.2 and as determined in accordance with 5.2.3.3.2 for item b) of 5.2.3.2.

5.2.3.2 Requirement

When tested in accordance with the method given in ISO 10466 each test piece shall conform to the following requirements:

a) when inspected without magnification, the test piece shall be free from bore cracks (see 5.2.3.3.1);

b) the test piece shall be without structural failure apparent in any of the following forms (see 5.2.3.3.2):

1) interlaminar separation;

2) tensile failure of the glass fibre reinforcement;

3) buckling of the pipe wall;

4) if applicable, separation of the thermoplastics liner from the structural wall.

5.2.3.3 Minimum initial ring deflection

5.2.3.3.1 For bore cracks

The minimum initial relative specific ring deflection without bore cracks (see 3.32) is given in Table 9 for the appropriate nominal stiffness of the test piece. For nominal stiffnesses greater than SN 10 000 the minimum initial relative specific ring deflection before bore cracking, $y_{2,\text{bore}}/d_\text{m}$ in percent, shall be calculated using Formula (10):

$$(y_{2,\text{bore}}/d_\text{m})_{\text{new,min}} \times 100 = \frac{194}{\sqrt[3]{\text{SN}}} \tag{10}$$

where

$(y_{2,\text{bore}}/d_\text{m})_{\text{new,min}} \times 100$ is the required minimum two minute initial relative specific ring deflection calculated for the nominal stiffness of the test piece, in percent (%);

SN is the nominal stiffness of the test piece.

For individual test pieces having a nominal stiffness greater than SN 10 000 the minimum initial relative specific ring deflection before bore cracking, $y_{2,\text{bore}}/d_\text{m}$ in percent, shall be calculated using Formula (10) except that the measured initial specific ring stiffness of the test piece shall be used instead of its nominal stiffness:

Table 9 — Minimum 2 minute initial relative specific ring deflection before bore cracking, $(y_{2,bore}/d_m)_{min} \times 100$

Nominal stiffness, SN	630	1 250	2 500	5 000	10 000
No sign of bore cracking at a % relative ring deflection of:	22,7	18	14,3	11,3	9

5.2.3.3.2 For structural failure

The minimum initial relative specific ring deflection without structural failure (see 3.30) is given in Table 10 for the appropriate nominal stiffness of the test piece. For nominal stiffnesses greater than SN 10 000 the minimum initial ring deflection before structural failure, $y_{2,struct}/d_m$, in percent, shall be calculated using Formula (11):

$$(y_{2,\,struct}/d_m)_{new,min} \times 100 = \frac{324}{\sqrt[3]{SN}} \qquad (11)$$

where

$(y_{2,struct} / d_m)_{new,min} \times 100$ is the required minimum 2 min initial relative specific ring deflection calculated for the nominal stiffness of the test piece, in percent (%);

SN is the nominal stiffness of the test piece.

For individual test pieces having a nominal stiffness greater than SN 10 000 the minimum initial relative specific ring deflection without structural failure, $y_{2,struct}/d_m$ in percent, shall be calculated using Formula (11) except that the measured initial specific ring stiffness of the test piece shall be used instead of its nominal stiffness:

Table 10 — Minimum initial percentage ring deflection before structural failure, $y_{2,struct}/d_m)_{min} \times 100$

Nominal stiffness, SN	630	1 250	2 500	5 000	10 000
No structural failure at a percentage relative ring deflection of:	37,8	30,0	23,9	18,9	15

5.2.3.4 Number of test pieces for type test purposes

Unless otherwise specified three test pieces shall be used for the tests detailed in 5.2.3. Each test piece shall be of the same size and classification, and of length, L_P, conforming to 5.2.1.4.

5.2.3.5 Number of test pieces for quality control test purposes

Unless otherwise specified one test piece of length, L_P, conforming to 5.2.1.4 shall be used.

The use of the same test piece(s) for the tests detailed in 5.2.1 and 5.2.3 is permitted.

5.2.4 Ultimate long-term resistance to failure in a deflected condition

5.2.4.1 General

The ultimate long-term resistance to failure in a deflected condition shall be determined using the method given in ISO 10471 on a strain basis using at least 18 test pieces conforming to 5.2.4.5.

5.2.4.2 Requirement

When tested in accordance with the method given in ISO 10471 on a strain basis and without preconditioning, using a minimum of 18 test pieces conforming to 5.2.4.5, the extrapolated x years value (see 4.6) of failure strain, calculated in accordance with ISO 10928 and converted into deflection for the applicable nominal stiffnesses, shall be not less than the applicable value given in Table 11.

The deflection values in Table 11 are based on the assumption that the maximum allowable long-term deflection when buried in the ground is 6 %. The manufacturer of the pipes is permitted to specify a long-term deflection different to the assumed value of 6 %. In such cases the requirements in Table 11 shall be adjusted proportionately e.g. if the manufacturers value is 3 % then the required values shall be 50 % of those in Table 11 while a manufacturer's deflection value of 8 % results in required values being 133 % of those in Table 11.

For nominal stiffnesses greater than SN10 000 the same procedure shall be followed except that the calculated maximum long-term deflection shall be used rather than 6 %. Formula (10) shall be used to calculate the long-term deflection. For nominal stiffnesses greater than SN 10 000 the maximum allowed long-term deflection when buried in the ground shall not exceed 67 % of the calculated minimum extrapolated long-term ring deflection.

NOTE The ultimate ring deflection values in Table 11 induce the same flexural strain for all the stiffness classes. Therefore the deflection determined for one stiffness class can be converted into strain and this in turn can be converted into a deflection for any other stiffness class.

Table 11 — Minimum extrapolated long-term relative ultimate ring deflection under wet conditions, $(y_{u,wet,x}/d_m)_{min}$

Nominal stiffness (SN)	**630**	**1 250**	**2 500**	**5 000**	**10 000** [b]
Minimum extrapolated % long-term ring deflection [a]	22,7	18	14,3	11,3	9

5.2.4.3 Criteria for failure

The criteria for failure shall be as given in ISO 10471.

5.2.4.4 Distribution of failure times

The times to failure, t_U, of the 18 or more test pieces shall be distributed between 0,1 h and over 10^4 h and the distribution of ten of these results shall conform to the limits given in Table 12.

Table 12 — Failure time distribution

Failure time - t_u h	Minimum number of failure values
$10 \leq t_u \leq 1\,000$	4
$1\,000 < t_u \leq 6\,000$	3
$6\,000 < t_u$	3 [a]
[a] At least one of these shall exceed 10 000 h.	

5.2.4.5 Test pieces for type test purposes

The test pieces required by the test detailed in 5.2.4 shall be cut from pipes having the same nominal size, nominal stiffness and nominal pressure classification and have a length, L_P, conforming to Table 8.

5.2.5 Initial specific longitudinal tensile strength

5.2.5.1 General

The initial specific longitudinal tensile strength shall be determined in accordance with Method A, Method B or Method C of ISO 8513 using test pieces conforming to 5.2.5.3.

When pipes having a nominal pressure or diameter other than those given in Table 13 are tested the required minimum initial specific longitudinal tensile strength shall be linearly interpolated or extrapolated from the values given for the relevant diameter.

Table 13 — Minimum initial specific longitudinal tensile strength

Nominal size DN [a]	Nominal pressure PN [a]							
	≤ 4	6	10	12.5	16	20	25	32
	Minimum initial specific longitudinal tensile strength, in N/mm of circumference							
100	70	75	80	85	90	100	110	125
125	75	80	90	95	100	110	120	135
150	80	85	100	105	110	120	130	145
200	85	95	110	115	120	135	150	155
250	90	105	125	130	135	155	170	190
300	95	110	140	145	155	175	200	220
400	105	130	165	175	190	215	250	285
500	115	145	190	205	225	255	300	345
600	130	160	220	235	255	295	350	415
700	140	175	250	265	290	335	400	475
800	155	190	280	300	325	380	450	545
900	165	205	310	330	360	420	505	620
1000	180	225	340	365	395	465	555	685
1200	205	255	380	415	465	540	645	790
1400	230	290	420	460	530	620	745	915
1600	255	320	460	520	600	700	845	1 040
1800	280	350	500	570	670	785	940	1 160
2000	305	385	540	625	740	865	1 040	1 285
2200	335	415	575	675	810	945	1 140	1 410
2400	360	450	620	730	880	1 025	1 240	1 530
2600	385	480	665	785	945	1 110	1 335	1 655
2800	410	515	710	840	1 015	1 190	1 435	1 780
3000	435	545	755	890	1 080	1 270	1 535	1 900
3200	460	575	805	950	1 150	1 350	1 630	2 025
3400	490	610	850	1 005	1 220	1 430	1 730	2 150
3600	520	645	895	1 060	1 290	1 515	1 830	2 250
3800	550	680	940	1 115	1 355	1 595	1 930	2 400
4000	580	715	985	1 170	1 425	1 675	2 025	2 520
	[a] When pipes having a nominal size or pressure than those given in this table are tested, the required minimum initial specific longitudinal tensile strength shall be linearly interpolated or extrapolated from the values given in this table.							

5.2.5.2 Requirement

5.2.5.2.1 For pipes not required to resist the longitudinal load produced by the internal pressure acting on the relevant end-load conditions, when tested in accordance with Method A, Method B or Method C of ISO 8513, using test pieces conforming to 5.2.5.3 for each test pipe, the average value for the initial specific longitudinal tensile strength σ_l^* of the test pieces taken in accordance with 5.2.5.3 shall be not less than the value given in Table 13, applicable to the nominal size, DN, of the pipe under test. For each pipe, the average value for elongation to break (see 3.21) of the test pieces taken in accordance with 5.2.5.3 shall be not less than 0,25 %. The average elongation at break and the average initial specific longitudinal tensile strength shall be declared.

5.2.5.2.2 For pipes required to resist the longitudinal load produced by the internal pressure acting on the relevant end conditions the minimum initial longitudinal specific tensile strength, σ_l^*, expressed in Newtons per millimetre circumference, shall be not less than the value determined from Formula (12):

$$\sigma_1^* = 25 \times P_{0,\mathrm{d}} \times d_\mathrm{m} \tag{12}$$

where

$P_{0,\mathrm{d}}$ is the initial design pressure, in bars, determined in accordance with 5.2.6.1;

d_m is the mean diameter of the pipe tested, expressed in metres (m).

5.2.5.3 Number of test pieces for type test purposes

For testing in accordance with Method A of ISO 8513, five test pieces shall be cut from each of three different pipes of the same nominal size, nominal stiffness and nominal pressure classification.

For testing in accordance with Method B of ISO 8513, one test piece shall be cut from each of three different pipes of the same nominal size, nominal stiffness and nominal pressure classification.

For testing in accordance with Method C of ISO 8513, five test pieces shall be cut from each of three different pipes of the same nominal size, nominal stiffness and nominal pressure classification.

5.2.5.4 Number of test pieces for quality control test purposes

For testing in accordance with Method A of ISO 8513, unless otherwise specified, five test pieces shall be cut from one pipe.

For testing in accordance with Method B of ISO 8513, unless otherwise specified, one test piece shall be used.

For testing in accordance with Method C of ISO 8513, unless otherwise specified, five test pieces shall be cut from one pipe.

5.2.6 Initial failure and design pressures for pressure pipes

5.2.6.1 General

For pressure pipes (see 3.23) the initial failure pressure shall be determined in accordance with one of the Methods A to F of ISO 8521 using test pieces conforming to 5.2.6.5. Method A is considered the reference method. However, all methods in ISO 8521 have equal validity and provided a correlation of any of the Methods B to F with Method A is established by a comparative test programme then that method shall be accepted as the reference method.

5.2.6.2 Requirement

5.2.6.2.1 When tested in accordance with ISO 8521 by one of the Methods A to F, using test pieces in accordance with 5.2.6.4, the value of the initial failure pressure calculated in accordance with 5.2.6.2.2 shall conform to the value derived using the procedure given in ISO 10928 for verification using destructive test data.

5.2.6.2.2 Using the pressure regression ratio, R_{RP} (see 3.20), obtained from long-term pressure testing conducted in accordance with EN 1447 and evaluated by the procedures detailed in ISO 10928 the minimum initial failure pressure, $P_{0,min}$ (see 3.17), and the minimum design pressure, $P_{0,d}$ (see 3.16), both expressed in bars, shall be determined.

All methods described in ISO 8521 result in a circumferential tensile wall strength. To compare these results with the requirements given in 5.2.6.2.1, the specific circumferential tensile wall strength shall be converted into pressure values by the appropriate one of the following formulas:

$$P_{0,\mathrm{A}} = 0{,}02 \times \sigma^{*}_{\mathrm{c,A}} / d_{\mathrm{i}};$$

$$P_{0,\mathrm{B}} = 0{,}02 \times \sigma^{*}_{\mathrm{c,B}} / d_{\mathrm{i}};$$

$$P_{0,\mathrm{C}} = 0{,}02 \times \sigma^{*}_{\mathrm{c,C}} / d_{\mathrm{i}};$$

$$P_{0,\mathrm{D}} = 0{,}02 \times \sigma^{*}_{\mathrm{c,D}} / d_{\mathrm{i}};$$

$$P_{0,\mathrm{E}} = 0{,}02 \times \sigma^{*}_{\mathrm{c,E}} / d_{\mathrm{i}};$$

$$P_{0,\mathrm{F}} = 0{,}02 \times \sigma^{*}_{\mathrm{c,F}} / d_{\mathrm{i}};$$

where

$\sigma^{*}_{\mathrm{c,A}}$ to $\sigma^{*}_{\mathrm{c,F}}$ are the average of the circumferential tensile wall strength values, determined in accordance with ISO 8521, expressed in Newtons per millimetre of length (N/mm);

d_{i} is the internal diameter of the pipe tested, expressed in metres (m);

$P_{0,\mathrm{A}}$ to $P_{0,\mathrm{F}}$ is the initial failure pressure, expressed in bars.

5.2.6.3 Number of test pieces for type test purposes

When testing in accordance with Method A of ISO 8521, test pieces from three pipes of the same nominal size, nominal stiffness and nominal pressure class shall be used.

When testing in accordance with one of the Methods B to F of ISO 8521 the appropriate number of test specimens shall be taken from each of three different samples of the same nominal size, nominal stiffness and nominal pressure class. From each sample, either one test piece per metre of circumference or five test specimens shall be used, whichever gives the greater number of test results. The average of the five results shall be taken as the result of the test.

5.2.6.4 Number of test pieces for quality control test purposes

For testing in accordance with Method A of ISO 8521, unless otherwise specified, one test piece shall be used.

Unless otherwise specified, for testing in accordance with one of the Methods B to F of ISO 8521 five test pieces shall be taken from the pipe. The average of the five results shall be taken as the result of the test.

5.2.6.5 Dimensions of test pieces

5.2.6.5.1 For Method A

The length of the test pieces between the end sealing devices shall be as given in Table 14.

Table 14 — Length of test pieces for Method A

Nominal size DN	Minimum length [a] mm
≤ 250	3 × [DN] + 250
> 250	[DN] + 1000

[a] It is permissible to use lengths less than those shown providing the end restraints do not have any effect on the result.

5.2.6.5.2 For Method B

The dimensions of the test piece shall conform to ISO 8521.

5.2.6.5.3 For Method C

The width of the test piece shall conform to ISO 8521.

5.2.6.5.4 For Method D

The width of the test piece shall conform to ISO 8521.

5.2.6.5.5 For Method E

The dimensions of the test piece shall conform to ISO 8521.

5.2.6.5.6 For Method F

The dimensions of the test piece shall conform to ISO 8521.

5.2.7 Long-term failure pressure

5.2.7.1 General

For pressure pipes (see 3.23) the long-term failure pressure shall be determined in accordance with EN 1447 using test pieces conforming to 5.2.7.4.

5.2.7.2 Requirement

Using the data obtained from the test performed in accordance with 5.2.7.1 and the extrapolation procedures detailed in ISO 10928 determine the regression ratio $R_{\mathrm{R,P}}$. Pipes shall be designed using the procedure in ISO 10928 and the factors of safety in Table 15 to ensure:

a) that the minimum long-term failure pressure $P_{x,\mathrm{min}}$ is at least FS_{min} times PN, expressed in bars, and

b) that the minimum long-term design pressure $P_{x,\mathrm{d}}$ is at least FS_{d} times PN, expressed in bars.

The factors of safety in Table 15 assume the pipe is buried and operating at a pressure equal to PN and take into account the combined effects of bending and pressure. The values for FS_d are derived using an assumed value for the coefficient of variation for the initial circumferential tensile strength of 9 % or less. FS_d is based on a constant factor of safety on combined loading (from pressure and bending) of 1,5. See ISO/TR 10465-3 for a fuller explanation.

NOTE The symbol $\eta_{t,PN,97,5LCL}$ in ISO/TR 10465-3 is FS_{min} in this document and similarly $\eta_{t,PN,mean}$ is FS_d.

Table 15 — Minimum long-term factors of safety FS_{min} and FS_d

Factor of safety [a]	PN32	PN25	PN20	PN16	PN12,5	PN10	PN6	PN4	PN2,5
FS_{min}	1,3	1,3	1,4	1,45	1,5	1,55	1,6	1,65	1,7
FS_d	1,6	1,6	1,7	1,8	1,85	1,9	2,0	2,05	2,1
	[a] If the coefficient of variation is greater than this assumed value of 9 % then the factors of safety shall be increased.								

When tested in accordance with EN 1447, using air as the external environment, the value for the extrapolated x year failure pressure, P_x, calculated in accordance with ISO 10928, shall not be less than the long-term design pressure, $P_{x,d}$.

5.2.7.3 Number of test pieces for type test purposes

A sufficient number of test pieces shall be taken so that at least 18 failure points are obtained to carry out the analysis in accordance with ISO 10928.

5.2.7.4 Length of the test pieces

The length of the test pieces between the end sealing devices shall conform to Table 14.

5.2.7.5 Distribution of failure times

The times to failure of the 18 or more test pieces shall be between 0,1 h and over 10^4 h and the distribution of 10 of these results shall conform to the limits given in Table 12.

5.3 Marking

5.3.1 Marking details shall be printed or formed directly on the pipe in such a way that the marking does not initiate cracks or other types of failure.

5.3.2 If printing is used, the colouring of the printed information shall differ from the basic colouring of the product and such that the markings shall be readable without magnification.

5.3.3 The following marking details shall be on the outside of each pipe, and in the case of pipes of DN 600 or greater shall be either on the inside or on the outside surface.

a) number of this European Standard, i.e. EN 1796;

b) nominal size DN and diameter series, i.e. A, B1, B2, etc.;

c) stiffness rating in accordance with Clause 4 of this European Standard;

d) pressure rating in accordance with Clause 4 of this European Standard;

e) manufacturer's name or identification;

f) date or code of manufacture;

g) if applicable, the letter "R" to indicate the pipe is suitable to be used with axial loading, or the letters “RA” to indicate the pipe is suitable to be used for axial loading and assessed in accordance with Annex A.

h) letter “H” to indicate suitability for use above ground, if applicable;

i) standard quality mark, if applicable.

6 Fittings

6.1 General

In addition to the particular requirements detailed for a certain type of fitting all fittings shall conform to the requirements specified in 6.1.1 to 6.1.8.

6.1.1 Diameter series.

The diameter series of the fitting shall be that of the straight length(s) of pipe to which it is to be joined in the piping system.

6.1.2 Nominal pressure (PN).

The nominal pressure rating (PN) of the fitting shall be selected from the values given in Clause 4 and shall be not less than that of the straight pipe(s) to which it is to be joined in the piping system.

6.1.3 Nominal stiffness (SN).

Nominal stiffness is not a defining characteristic for fittings. A fitting for which the wall thickness and construction is the same as a pipe of the same diameter will have a stiffness equal to or greater than that of the pipe. This is due to the fittings geometry. It is therefore not necessary to test fitting stiffness.

6.1.4 Joint type.

The type of joint shall be designated as flexible or rigid in accordance with 3.33 or 3.34 and whether or not end-load-bearing.

6.1.5 Pipe type.

The type of pipe or pipes i.e. whether or not suitable for resisting the longitudinal load produced by the internal pressure, with which the fitting is intended to be used shall be designated.

6.1.6 Mechanical characteristics of fittings.

Fittings shall be designed and manufactured in accordance with relevant design practices to have a mechanical performance equal to or greater than that of a straight GRP-UP pipe of the same pressure and stiffness rating when installed in a piping system, and, if appropriate, supported by anchor blocks or encasements.

The manufacturer of the fitting shall document as a part of his quality system the fitting design and manufacturing procedure.

6.1.7 Installed leak-tightness of fittings.

Where a specific site installation test is declared by the purchaser or is agreed between the manufacturer and the purchaser, the fitting and its joints shall be capable of withstanding that test without leakage.

6.1.8 Dimensions.

The broad design and process flexibility afforded by GRP-UP materials makes it difficult to totally standardise GRP-UP fitting dimensions. The dimensions and tolerances given as minimums in Clause 6 are to be taken as only indicative of common practice values and it is therefore permissible to use other dimensions. The use of other dimensions does not preclude the components from being covered by this European Standard.

6.2 Bends

6.2.1 Classification of bends

6.2.1.1 General

Bends shall be designated in respect of the following:

a) nominal size (DN);

b) diameter series i.e. A, B1, B2, etc.;

c) nominal pressure (PN);

d) joint type i.e. flexible or rigid and whether or not end-load-bearing;

e) fitting angle in degrees;

f) bend type i.e. moulded or fabricated;

g) pipe type, if applicable.

6.2.1.2 Nominal size (DN)

The nominal size (DN) of the fitting shall be that of the straight length of pipe to which it is to be joined in the piping system and shall be one of the nominal sizes given in Clause 5.

6.2.1.3 Bend type

The type of bend shall be designated as either moulded or fabricated, as shown by Figure 2 and Figure 3.

6.2.2 Dimensions and tolerances of bends

6.2.2.1 Tolerance on diameter

The tolerance on the diameter of the bend at the spigot positions shall conform to 5.1.1.5.

6.2.2.2 Fitting angle and angular tolerances

The fitting angle α, shall be the angular change in direction of the axis of the bend (see Figure 2 and Figure 3).

The deviation of the actual change in direction of a bend from the designated fitting angle shall not exceed either ($\alpha \pm 0,5$)° of the specified angle if the joint is flanged or ($\alpha \pm 1$)° of the specified angle for all other types of joint with which it is intended to be used.

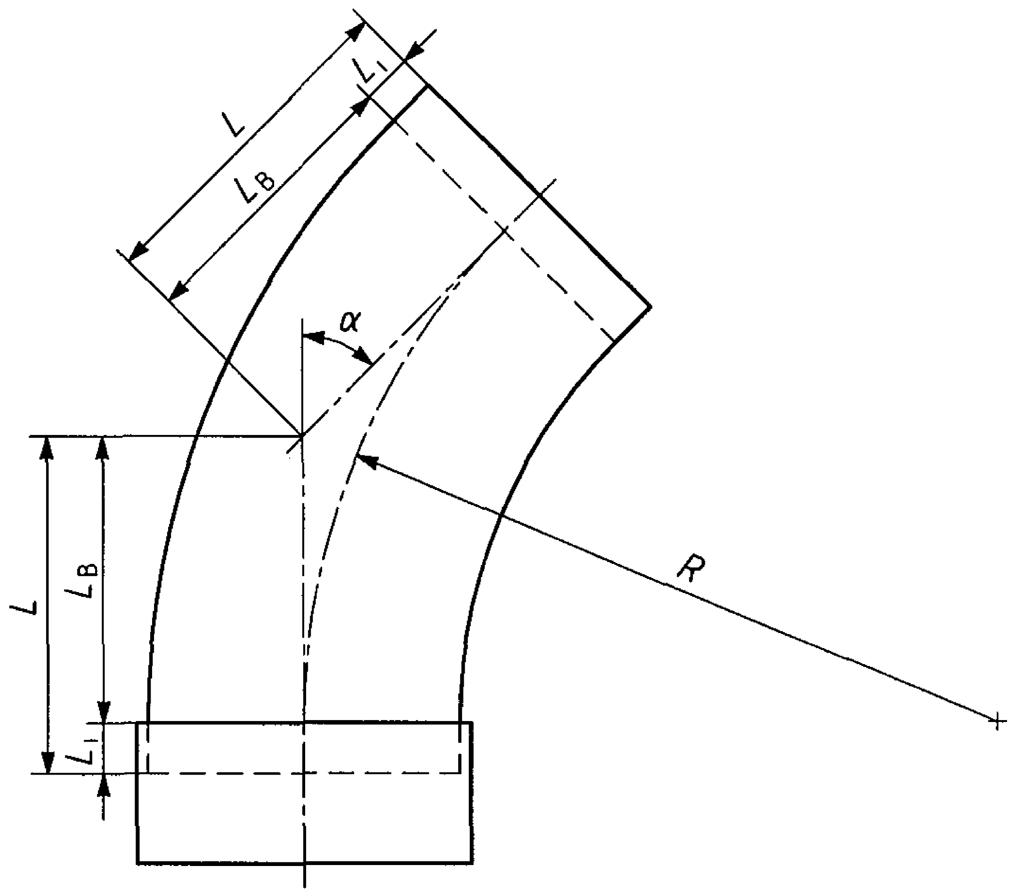
In the interests of rationalisation, the preferred values for the fitting angles for bends are 11,25°; 15°; 22,5°; 30°; 45°; 60° and 90°, but it is permissible for fittings angles other than these to be supplied by declaration and agreement between the purchaser and the manufacturer (see 6.1.8).

6.2.2.3 Radius of curvature (R)

6.2.2.3.1 Moulded bends

The radius of curvature of moulded bends (see Figure 2) shall be not less than the nominal size (DN) in millimetres of the pipe to which it is to be joined in the piping system.

The typical radius of curvature is $R = 1,5 \times$ [DN], expressed in millimetres. Where a radius of curvature different to this is required, this may be supplied by declaration and agreement between the purchaser and the manufacturer (see 6.1.8).



Key

L is the laying length

L_i is the spigot insertion depth

L_B is the body length

R is the radius of curvature

α is the fitting angle

Figure 2 — Typical moulded bend

6.2.2.3.2 Fabricated bends

Bends made by fabrication from straight pipe (see Figure 3) shall not provide more than 30° angular change for each segment of the bend. The base of each segment shall have sufficient length adjacent to each mitre joint to ensure that necessary wrapping (external or internal as required by the design) can be accommodated.

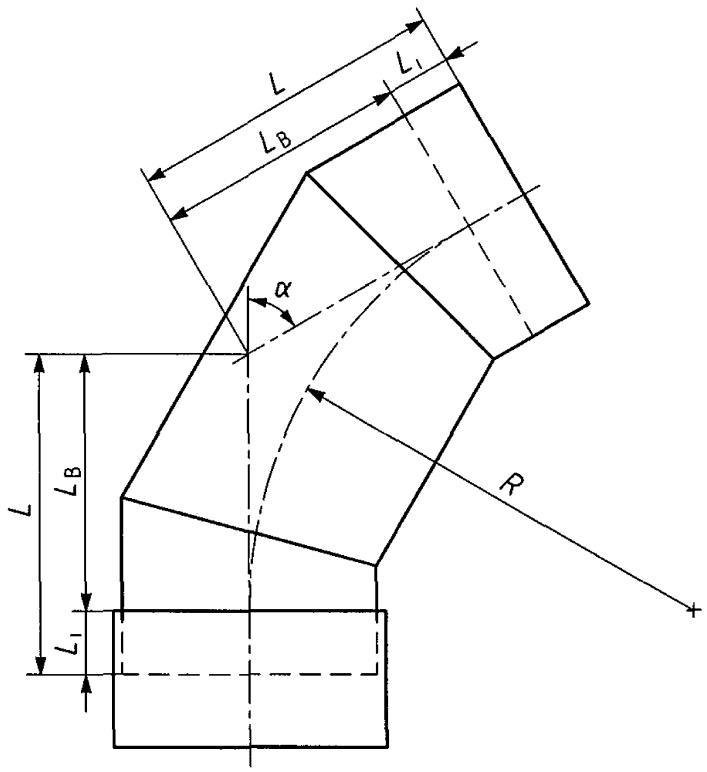
The radius of curvature, R, of fabricated bends (see Figure 3) shall be not less than the nominal size (DN) in millimetres of the pipe.

The typical radius of curvature is R = 1,5 × [DN] in millimetres. Where a radius of curvature different to this is required, this may be supplied by agreement between the purchaser and the manufacturer (see 6.1.8).

6.2.2.4 Length

6.2.2.4.1 General

Lengths of individual bends are dependent upon the designated fitting angle, the radius of curvature, and the length of any linear extensions provided for jointing or other purposes. The declared dimensions for laying length, L, (see 6.2.2.4.2) shall conform to the tolerances given in 6.2.2.5.



Key

L is the laying length
L_B is the body length
L_i is the spigot insertion depth
R is the radius of curvature
α is the fitting angle

Figure 3 — Typical fabricated bend

6.2.2.4.2 Laying length

The laying length, L, of the bend shall be the distance from one end of the bend, excluding the spigot insertion depth, L_i, of a socket end where applicable, projected along the axis of that end of the bend to the point of intersection with the axis of the other end of the bend.

For an end of a bend containing a spigot, the laying length, L, is the body length, L_B, plus the spigot insertion depth of the joint, L_i, (see Figure 3).

6.2.2.4.3 Body length

The body length of the bend, L_B, shall be the distance, from the point of intersection of the two axis of the bend to a point on either axis, equal to the laying length minus a spigot insertion depth, L_i.

6.2.2.5 Tolerances on lengths of bends

6.2.2.5.1 Bends for use with rigid joints

The permissible deviations on the manufacturers declared laying length, L, are given in Table 16.

6.2.2.5.2 Bends for use with flexible joints

For moulded bends, the permitted deviations on the laying length shall be (L ± 25) mm.

For fabricated bends, the permitted deviations on the laying length shall be (L ± 15 × n) mm where n is the number of mitres of the bend.

6.3 Branches

6.3.1 Classification of branches

6.3.1.1 General

Branches shall be designated in respect of the following:

a) nominal size (DN);

b) diameter series i.e. A, B1, B2, etc.;

c) nominal pressure (PN);

d) joint type i.e. flexible or rigid and whether or not end-load-bearing;

e) fitting angle in degrees;

f) branch type i.e. moulded or fabricated;

g) pipe type, if applicable.

6.3.1.2 Nominal size (DN)

The nominal size (DN) of the fitting shall be that of the straight length of pipe to which it is to be joined in the piping system and shall be one of the nominal sizes given in Clause 5.

6.3.1.3 Fitting angle

The fitting angle, α, shall be the angular change in direction of the axis of the branch (see Figure 4).

6.3.1.4 Branch type

The type of branch shall be designated as shown in Figure 4.

6.3.2 Dimensions and tolerances of branches

6.3.2.1 Tolerance on diameter

The tolerance on the diameter of the branch at the spigot positions shall conform to 5.1.1.5.

6.3.2.2 Angular tolerances

The deviation of the actual change in direction of a branch from the designated fitting angle, α, shall not exceed either $(\alpha \pm 0,5)°$ of the specified angle if the joint is flanged or $(\alpha \pm 1)°$ of the specified angle for all other types of joint with which it is intended to be used (see 6.1.8).

6.3.2.3 Length

6.3.2.3.1 General

Dimensions other than those specified can be used by declaration and agreement between the purchaser and the manufacturer (see 6.1.8).

6.3.2.3.2 Body length

The body length, L_B, (see Figure 4), of the fitting is equal to the laying length, L, of the main pipe minus two spigot insertion depths, L_i. The body length will be dependent on the fabrication process and the length as may be needed to provide for layups (either internal or external or both).

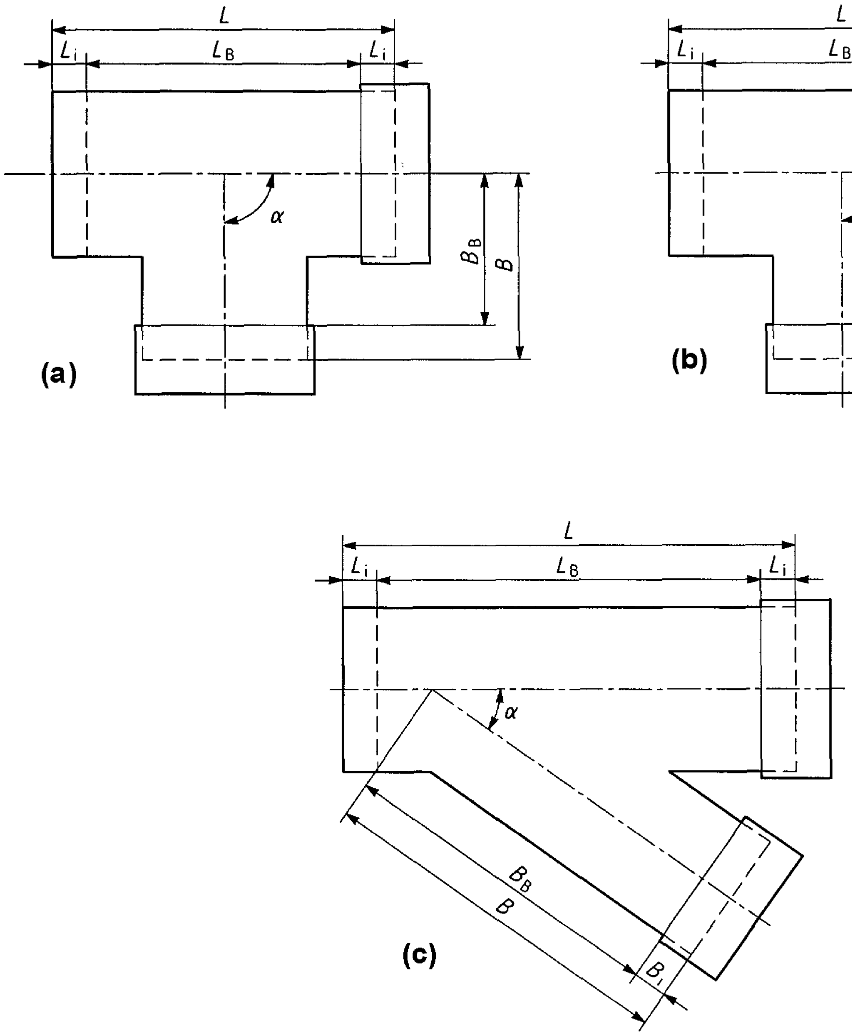
6.3.2.3.3 Offset length

The offset length, B_B, (see Figure 4) of the branch shall be the distance from the end of the branch pipe excluding, where applicable, the spigot insertion depth of a socket end, to the point of intersection of the straight through axis of the fitting with the extended axis of the branch pipe.

The offset length, B_B, of equal tee branches shall be 50 % of their body length, L_B.

6.3.2.3.4 Laying length

For a main pipe of a branch containing a spigot and a socket, the laying length, L, is the body length, L_B, plus the spigot insertion depth of the joint, L_i, at the spigot end (see Figure 4). For a main pipe of a branch containing two spigots, the laying length, L, is the body length, L_B, plus two spigot insertion depths, L_i (see Figure 4).



Key

(a) is an equal "tee" branch
(b) is an unequal "tee" branch
(c) is an unequal oblique branch
B is the laying length of the branch
B_B is the offset length of the branch
B_i is the spigot insertion depth of the branch
L is the laying length of the main pipe
L_B is the body length of the main pipe
L_i is the spigot insertion depth of the main pipe
α is the fitting angle

Figure 4 — Typical branches

6.3.2.3.5 Tolerances on laying length

6.3.2.3.5.1 Branches for use with rigid joints

The permissible tolerances on the manufacturer's declared laying lengths, L and B, of the branch are given in Table 16.

Table 16 — Tolerances on laying lengths for use with rigid joints

Nominal size DN-ID	Deviation limits on specified length mm
100 ≤ [DN] < 300	± 1,5
300 ≤ [DN] < 600	± 2,5
600 ≤ [DN] ≤ 1000	± 4,0

6.3.2.3.5.2 Branches for use with flexible joints

The permissible deviations on the manufacturer's declared laying lengths of the fitting are either:

(B ± 25) mm or (L ± 25) mm;

or

(B ± 1 %) or (L ± 1 %),

whichever is the larger.

6.4 Reducers

6.4.1 Classification of reducers

6.4.1.1 General

Reducers shall be designated in respect of the following:

a) nominal size (DN_1 and DN_2);

b) diameter series i.e. A, B1, B2, etc.;

c) nominal pressure (PN);

d) joint type i.e. flexible or rigid and whether or not end-load-bearing;

e) reducer type i.e. concentric or eccentric;

f) pipe type, if applicable.

6.4.1.2 Nominal size (DN)

The nominal sizes (DN_1 and DN_2) of the reducer shall be the same as those of the straight lengths of pipe to which it is to be joined in the piping system and shall conform to the nominal sizes given in Clause 5.

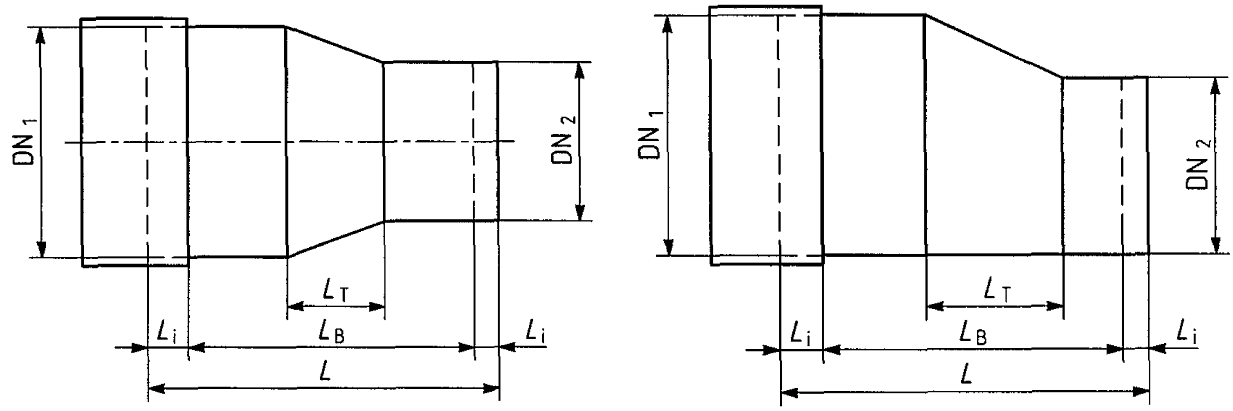
6.4.1.3 Reducer type

The type of reducer shall be designated as either concentric or eccentric (see Figure 5).

6.4.2 Dimensions and tolerances of reducers

6.4.2.1 Tolerance on diameter

The tolerance on the diameter of the reducer at the spigot positions shall conform to 5.1.1.5.



a) b)

Key

a) is a concentric reducer

b) is an eccentric reducer

DN_1 is the larger nominal size

DN_2 is the smaller nominal size

L is the laying length of the reducer

L_B is the body length of the reducer

L_i is the spigot insertion depth of the joint

L_T is the length of the tapered section

Figure 5 — Typical reducers

6.4.2.2 Wall thickness

6.4.2.2.1 The wall thickness of the tapered section of the reducer shall not be less than the wall thickness determined by Formula (13):

$$e_{T,min} = FS \times \frac{P}{2} \times \frac{d_i}{0,01 \times \sigma_T} \quad (13)$$

where

FS is the factor of safety = 6;

P is the internal pressure corresponding to the nominal pressure, expressed in bars;

d_i is the internal diameter of the straight piece labelled DN_1 in Figure 5, expressed in metres, (m);

$e_{T,min}$ is the minimum wall thickness of the tapered section of the reducer, expressed in millimetres;

σ_T is the short-term circumferential tensile strength of the tapered section laminate (see 6.4.3), expressed in Newtons per square millimetre (N/mm^2).

The above analysis is directed at the pressure capability of the reducer section. For lower pressure applications, consideration should also be given to possible vacuum conditions and the thickness of the reducer section may need to be adjusted.

6.4.2.3 Length

6.4.2.3.1 General

The lengths, L, L_B and L_T, of Figure 5 shall be declared by the manufacturer and be subject to the tolerances given in 6.4.2.3.5.

6.4.2.3.2 Laying length

The laying length L of the reducer shall be the total length, excluding the spigot insertion depth of a socket end where applicable.

6.4.2.3.3 Body length

The body length, L_B, (see Figure 5), of the fitting is equal to the laying length minus two spigot insertion depths, L_i.

6.4.2.3.4 Length of tapered section

The length L_T (see Figure 5), shall not be less than 1,5 × (DN_1 - DN_2) expressed in millimetres.

NOTE It is normal practice when designing a non-pressure eccentric reducer for L_T to be lower than that for an equivalent concentric reducer, for reasons of hydraulic capacity.

6.4.2.3.5 Tolerances on laying length

6.4.2.3.5.1 Reducers for use with rigid joints

The permissible deviation on the manufacturer's declared laying length, L, of the reducer is given in Table 16.

6.4.2.3.5.2 Reducers for use with flexible joints

The permissible deviations on the manufacturer's declared laying length, L, of the fitting shall be (L ± 50) mm or (L ± 1 %) whichever is the greater.

6.4.3 Mechanical characteristics of tapered section laminate

To verify the properties of the laminate used in the tapered sections panels shall be made using the same materials and lay-up as that used in the tapered part of the reducer.

Samples taken from the panel, and when tested in accordance with either EN ISO 527-4 or EN ISO 527-5, as applicable, shall have an initial circumferential tensile strength, σ_t, of at least 80 N/mm^2.

6.5 Non Pressure Saddles

6.5.1 Classification of saddles

6.5.1.1 General

Saddles shall be designated in respect of the following:

a) nominal size (DN);

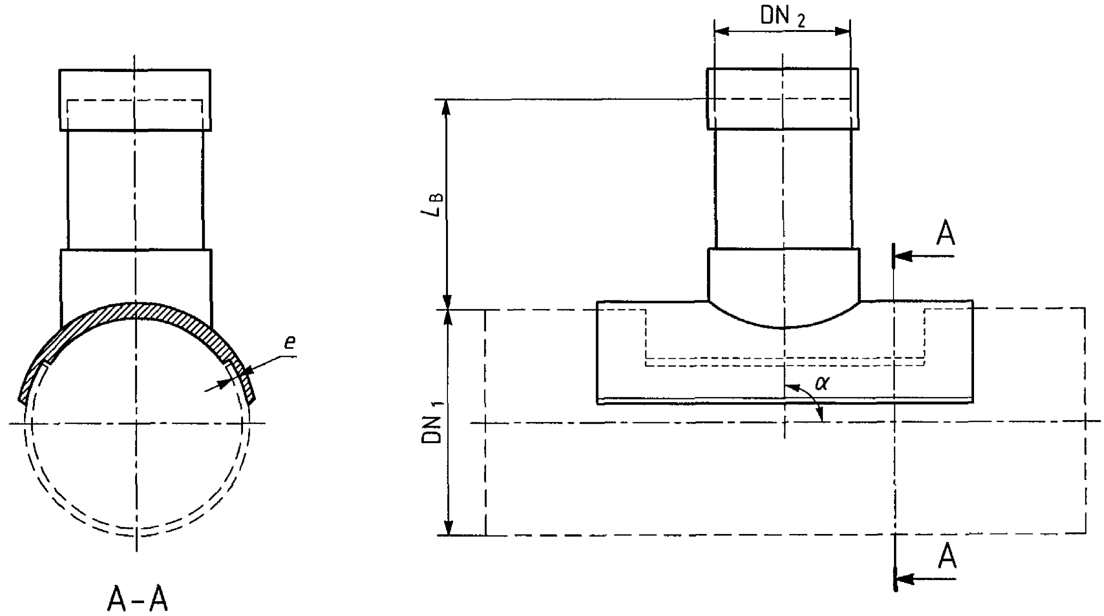
b) diameter series i.e. A, B1, B2, etc.;

c) wall thickness;

d) joint type i.e. flexible or rigid and whether or not end-load-bearing;

e) fitting angle (90°);

f) pipe type, if applicable.



Key

DN_1 is the nominal size of the branch pipe

DN_2 is the nominal size of the pipe to which the saddle is to be connected

L_B is the length of the branch pipe

e is the wall thickness of the pipe

α is the fitting angle

Figure 6 —Typical non-pressure saddle

6.5.1.2 Nominal size (DN)

The nominal size (DN) of the saddle shall be a combination of the nominal size of the straight pipe to which it is to be connected in the pipeline and the nominal size of the branch pipe to which it is to be joined. The nominal size of the straight pipe shall be one of the nominal sizes given in Clause 5. The nominal size of the branch pipe shall be one of those given in the applicable standard for the pipe to which it is to be joined.

NOTE The designation DN 600/150 is a saddle for connecting a DN 150 branch pipe to a DN 600 pipeline.

6.5.1.3 Wall thickness

The wall thickness, e, shall be at least equal to that of the pipe to which it is to be connected. The wall thickness of the branch pipe shall be at least equal to the pipe to which it is to be joined.

6.5.1.4 Fitting angle

The fitting angle, α, shall be the nominal angular change in direction of the axis of the saddle (see Figure 6).

6.5.2 Dimensions and tolerances of saddles

6.5.2.1 Tolerance on diameter

The tolerance on the diameter of the branch at the joint position shall conform to 5.1.1.5, if applicable.

6.5.2.2 Length

The length of the branch L_B, depends upon the fitting angle, α, and the length provided for jointing or other purposes. The length shall be not less than 300 mm.

Other dimensions may be used by declaration and agreement between the customer and the manufacturer (see 6.1.8).

6.6 Flanges

6.6.1 Classification of flanges

6.6.1.1 General

Flanges shall be designated in respect of the following:

a) nominal size (DN);

b) diameter series i.e. A, B1, B2, etc.;

c) nominal pressure (PN);

d) end-load bearing or non-end load bearing;

e) gasket sealing system i.e. flat face, raised face, O-ring in groove;

f) flange drilling specifications:

   1) reference standard, if applicable;

   2) bolt hole circle;

   3) number of bolt holes;

   4) bolt hole diameter;

   5) bolt size and specification;

   6) washer diameter;

g) flange type:

1) fabricated on pipe section;

2) loose steel ring flange;

3) bonded ring flange.

6.6.1.2 Nominal size (DN)

The nominal size (DN) of the flange shall be that of the straight length of pipe to which it is to be joined in the piping system (see Clause 5).

6.6.1.3 Flange designation

The mating dimensions of the flange shall conform to the purchasers requirements e.g. bolt circle, bolt hole diameter, flat or raised face, flange O.D, washer diameter etc.

NOTE Flanges are frequently specified by reference to a specification for bolting considerations and that includes a PN value. This PN is not necessarily the same as the PN for the flange.

The flange manufacturer shall supply full information on the flange, the gasket, the bolts, the allowable bolt torque, the degree and nature of the bolt lubrication, and the bolt tightening sequence.

6.6.2 Dimensions and tolerances for flanged adaptors

6.6.2.1 Diameter

For flanges supplied as adaptors i.e. flange on one end and spigot on the other (see Figure 7) the tolerance on the diameter of the adaptor at the spigot position shall conform to 5.1.1.5.

6.6.2.2 Length

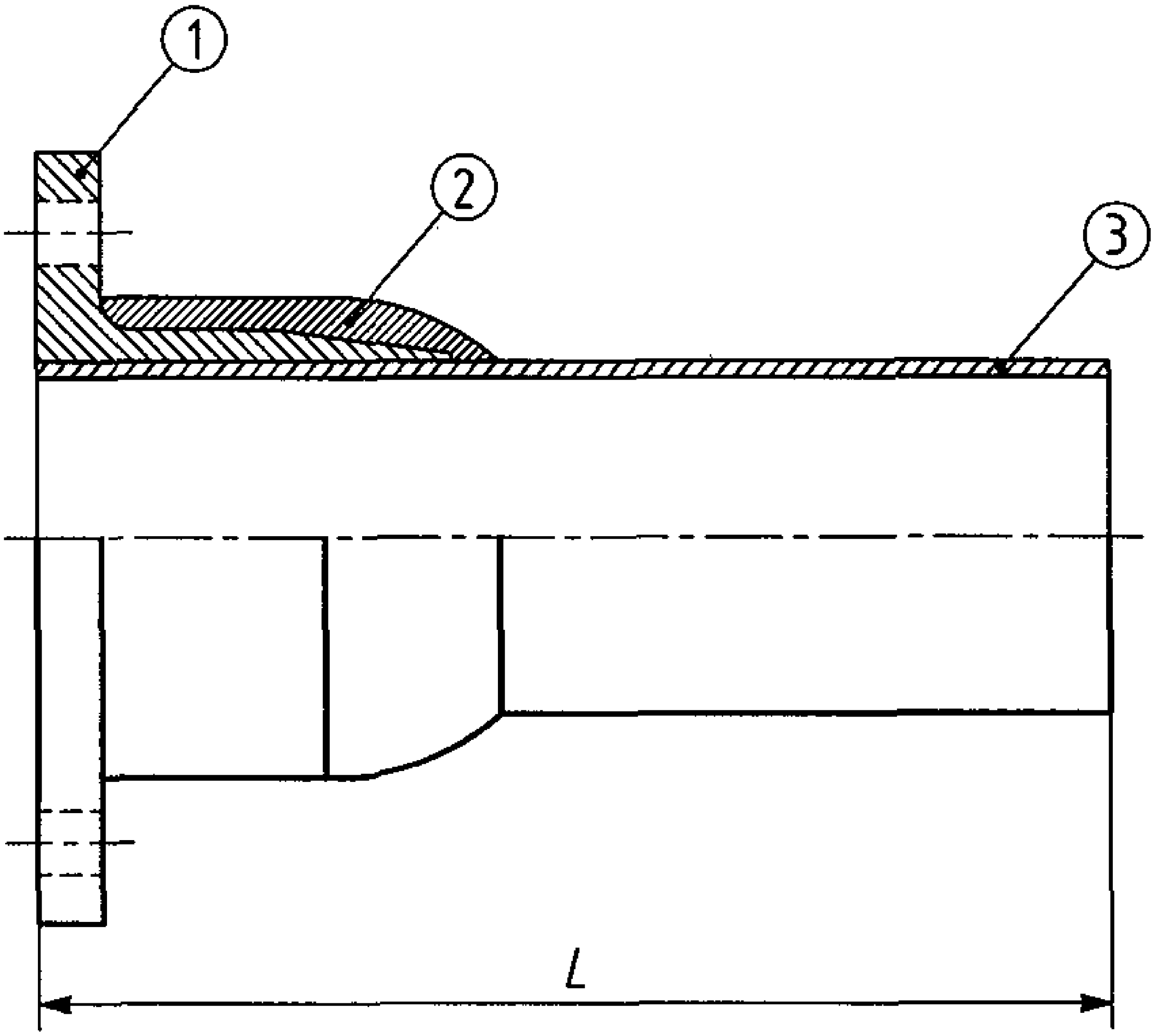
6.6.2.2.1 Tolerances on length

6.6.2.2.1.1 Flanged adaptors for use with end load bearing joints

The permissible deviations on the manufacturer's declared length of a flanged adaptor shall be as given in Table 17.

6.6.2.2.1.2 Flanged adaptors for use with non-end load bearing joints

The permitted deviation on the manufacturer's declared length of the fitting is ($L \pm 25$) mm.



Key

① is the flange
② is GRP over-wrapping if used
③ is the spigot joint
L is the length of the fitting

Figure 7 — Typical flanged adaptor

NOTE The length of flanged adaptors depends upon the diameter, loading requirements and method of manufacture.

Table 17 — Limits for deviations from length

Nominal size DN	Limits for deviations from the declared length mm
[DN] ≤ 400	± 2
400 < [DN] ≤ 600	± 5
600 < [DN]	± 10

6.7 Marking

Marking details shall be printed or formed directly on the fitting in such a way that the marking does not initiate cracks or other types of failure.

If printing is used, the colouring of the printed information shall differ from the basic colouring of the product and such that the markings shall be readable without magnification.

The following marking shall be on the outside of each fitting:

a) number of this European Standard, i.e. EN 1796;

b) nominal size DN and diameter series, e.g. A, B1, B2;

c) for bends, branches or saddles, the designated fitting angle;

d) for reducers nominal sizes DN_1 and DN_2;

e) stiffness rating in accordance with Clause 4;

f) pressure rating in accordance with Clause 4;

g) joint type in accordance with Clause 4 of this European Standard and whether or not end-load-bearing;

h) manufacturer's name or identification;

i) date or code of manufacture;

j) if applicable:

   1) letter "R" to indicate the fitting is suitable to be used with axial loading, or

   2) letters “RA” to indicate the fitting is suitable to be used with axial loading and assessed in accordance with Annex A;

k) letter “H” to indicate suitability for use above ground, if applicable;

l) standard quality mark, if applicable.

7 Joint performance

7.1 General

7.1.1 Interchangeability

Interchangeability between products from different suppliers can only be achieved with appropriate regard to the pipe and joint dimensions.

7.1.2 Test temperature

The joint tests described in Clause 7 shall be performed at a temperature of (23 ± 15) °C.

7.1.3 Non-pressure piping

For non-pressure piping (see 3.22) PN as used in Tables 18, 19, 20 and 21 is 1 bar.

7.2 Dimensions

All dimensions of the tested joints, which may influence the performance of the system, shall be recorded.

7.3 Non-end-load-bearing flexible joints with elastomeric sealing rings

7.3.1 General

Non-end-load-bearing flexible joints with elastomeric seals shall be tested using test pieces conforming to 7.3.4, for conformance to the test performance requirements under hydrostatic pressure detailed in 7.3.2.

7.3.2 Requirements

7.3.2.1 General

A joint made between pipes conforming to Clause 5 and/or fittings conforming to Clause 6 shall be designed so that its performance is equal to or better than the requirements of the piping system, but not necessarily of the components being joined.

For a particular design of joint, the manufacturer shall declare the draw and angular deflection.

7.3.2.2 Draw

Non-end-load-bearing flexible joints shall be capable of conforming to 7.3.2.5 to 7.3.2.8 when a maximum draw, D (see 3.36 and Figure 1), including Poisson contraction and temperature effects, of not less than 0,3 % of the laying length of the longest pipe with which the joint is intended to be used for pressure pipes and 0,2 % for non-pressure pipes, or the manufacturers declared maximum value whichever is the greater, is applied.

7.3.2.3 Angular deflection

Non-end-load-bearing flexible joints shall be capable of conforming to 7.3.2.8 when an angular deflection, δ (see 3.35 and Figure 1), appropriate to the nominal size of the piping system, of not less than the values given in 4.7.3.1 is applied.

7.3.2.4 Leak-tightness when subject to internal pressure following assembly

When assembled in accordance with the pipe manufacturer's recommendations, the joint shall withstand without leakage an internal pressure of 1,5 × PN for 15 min, and shall subsequently conform to 7.3.2.5, 7.3.2.6, 7.3.2.7 and 7.3.2.8.

Failure at the end closures shall not constitute failure of the test.

7.3.2.5 Leak-tightness test when subject to negative pressure

When the joint is subjected to the declared maximum draw, D, (see 3.36 and Clause 4) it shall not show any visible signs of damage to its components nor exhibit a change in pressure greater than 0,08 bar/h (0,008 MPa/h), when tested by the appropriate method given in EN 1119 at the pressure given in Table 18.

7.3.2.6 Leak-tightness test when simultaneously subject to misalignment and draw

When the joint is subjected to the declared maximum draw, D (see 7.3.2.2), and a total force F_1 of 20 N per millimetre of the nominal size DN, in millimetres, it shall not show any visible sign of damage to its components nor leak when tested by the appropriate method given in EN 1119 at the pressure given in Table 18.

7.3.2.7 Leak-tightness test when subject to positive cyclic pressure

When the joint is subjected to the declared maximum draw, D (see 7.3.2.2), and a total force F_1 of 20 N per millimetre of the nominal size DN, in millimetres, it shall not show any visible sign of damage to its components nor leak when tested by the appropriate method given in EN 1119 at the positive cyclic pressure given in Table 18.

7.3.2.8 Leak-tightness test when simultaneously subject to angular deflection and draw

When the joint is subject to an angular deflection in accordance with 7.3.2.3 and a total draw, T, equal to the manufacturers maximum draw (see 7.3.2.2) plus the longitudinal movement, J (see 3.37 and Figure 1), resulting from the applied angular deflection, it shall not show any visible signs of damage to its components nor leak when tested by the appropriate method given in EN 1119 at the pressure given in Table 18.

7.3.3 Number of test pieces for type test purposes

The number of joint assemblies to be tested for each test shall be one.

The use of the same test assembly for more than one of the tests detailed in Table 18 is permitted.

7.3.4 Test pieces

A test piece shall comprise a joint and two pieces of pipe such that the total laying length, L, is not less than either the values given in Table 14 or that is required to meet the requirements of the test method.

Table 18 — Summary of test requirements for non-end-load-bearing flexible joints

Property to be tested	Tests to be performed	Test pressure in bars	Duration
Initial leakage	Initial pressure	1,5 × PN	15 min
External pressure differential	Negative pressure [a]	–0,8 bar (–0,08 Mpa)	1 h
Misalignment and draw	Positive static pressure	2,0 × PN	24 h
	Positive cyclic pressure	Atmospheric to 1,5 × PN	10 cycles of 1,5 min to 3 min each
Angular deflection and draw	Initial pressure	1,5 × PN	15 min
	Positive static pressure	2,0 × PN	24 h
[a] Relative to atmospheric, i.e. approximately 0,2 bar (0,02 MPa) absolute.			

7.4 End-load-bearing flexible joints with elastomeric sealing rings

7.4.1 General

End-load-bearing flexible joints, including locked socket-and-spigot joints with elastomeric seals, shall be tested using test pieces conforming to 7.4.2.3, for conformance to the test performance requirements under hydrostatic pressure detailed in 7.4.2.1, with reference to methods of test given in ISO 7432.

NOTE ISO 7432 refers to locked-socket-and-spigot joints as rigid but in this European Standard they are classified as flexible.

7.4.2 Performance requirements for locked-socket-and-spigot joints with elastomeric sealing rings

7.4.2.1 Resistance to pressure including the end thrust

7.4.2.1.1 General

When tested by the appropriate method described in ISO 7432, and with reference to the nominal pressure of the piping system in which the joint is designed to be used, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

7.4.2.1.2 Initial leakage

When subjected to a static pressure test in accordance with ISO 7432 with a test pressure equal to 1,5 times PN expressed in bars, for a time period of 15 min, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

7.4.2.1.3 External pressure differential

When subjected to a negative pressure test in accordance with ISO 7432 of -0,8 bar (-0,08 MPa), i.e. approximately 0,2 bar (0,02 MPa) absolute for 1 h the test piece shall not show any visible signs of damage to its assembled components nor exhibit a change in pressure greater than 0,08 bar/h (0,008 MPa/h).

7.4.2.1.4 Misalignment with internal pressure

When subjected to a misalignment static pressure test in accordance with the appropriate method given in ISO 7432 including the manufacturers declared maximum draw, D, whilst subject to a total force, F, of 20 N per millimetre of the nominal size expressed in millimetres, using a test pressure equal to 2,0 times PN expressed in bars, for a time period of 24 h, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

When subjected to a misalignment with positive cyclic pressure test in accordance with appropriate method given in ISO 7432 including the manufacturers declared maximum draw, D, whilst subject to a total force, F, of 20 N per millimetre of the nominal size expressed in millimetres, of ten cycles, of 1,5 min to 3 min each, between atmospheric pressure and 1,5 times PN expressed in bars, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

7.4.2.1.5 Short duration resistance

When subjected to a static pressure test in accordance with method given in ISO 7432, with a test pressure equal to 3,0 times PN expressed in bars, for a time period of 6 min the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

7.4.2.1.6 Resistance of the joint to bending and pressure including, if applicable, end thrust

7.4.2.1.6.1 General

When the joints intended to be either used in buried applications, where the soils are known to have very poor properties, or where particular non-buried applications make their use appropriate, use the applicable method in either ISO 7432 or Annex A. The method used shall be agreed between the purchaser and manufacturer, taking into account the foreseen installation conditions.

7.4.2.1.6.2 Testing in accordance with ISO 7432

When subjected to an initial pressure in accordance with ISO 7432 at the pressure given in Table 19, for a time period of 15 min, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

When subjected to a static bending test in accordance with ISO 7432 using a test pressure equal to 2,0 times PN, expressed in bars, for a time period of 24 h, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

7.4.2.1.6.3 Testing in accordance with Annex A

When tested in accordance with Annex A, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

7.4.2.2 Number of test pieces for type test purposes

The number of joint assemblies to be tested for each test shall be one.

The use of the same test assembly for more than one of the tests detailed in Table 19 is permitted.

7.4.2.3 Test pieces

For the tests detailed in 7.4.2.1.1 to 7.4.2.1.6 a test piece shall comprise a joint and two pieces of pipe such that the total laying length, L, is not less than either the values given in Table 14 or that is required to meet the requirements of the test method.

Table 19 — Summary of tests required for flexible end-load-bearing joints

Property to be tested	Tests to be performed	Test pressure	Duration
Initial leakage	Initial pressure	1,5 × PN	15 min
External pressure differential	Negative pressure	–0,8 bar (–0,08 MPa)	1 h
Misalignment with internal pressure	Maintained pressure	2,0 × PN	24 h
	Positive cyclic pressure	Atmospheric to 1,5 × PN and back to atmospheric	10 cycles of 1,5 min to 3,0 min each
Short duration resistance	Maintained pressure	3,0 × PN	6 min
Resistance to bending	Preliminary hydrostatic pressure	1,5 PN	15 min
	Maintained hydrostatic pressure	2 PN	24 h

NOTE 1 Nominal pressure (PN) is an alphanumeric designation of pressure related to the resistance of a component of a piping system to internal pressure.

NOTE 2 For the bending test see Annex A as applicable.

7.5 Wrapped or cemented joints

7.5.1 General

Wrapped or cemented joints shall be tested for conformance to the test performance requirements under hydrostatic pressure detailed in 7.5.2.1 and Table 20, using test pieces conforming to 7.5.4. The methods of test are those given in ISO 8533, as appropriate.

7.5.2 Performance requirements

7.5.2.1 Resistance to pressure excluding the end thrust

When tested by the appropriate method in ISO 8533, and with reference to the nominal pressure of the piping system in which the joint is designed to be used, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

7.5.2.2 Resistance to pressure including the end thrust

For joints intended to resist end thrust when tested by the appropriate method in ISO 8533, and with reference to the nominal pressure of the piping system in which the joint is designed to be used, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

7.5.2.3 Resistance of the joint to bending and pressure including, if applicable, end thrust

7.5.2.3.1 General

When the joints intended to be either used in buried applications, where the soils are known to have very poor properties, or where particular non-buried applications make their use appropriate, use the applicable method in either ISO 8533 or Annex A. The method used shall be agreed between the purchaser and manufacturer, taking into account the foreseen installation conditions.

7.5.2.3.2 Testing in accordance with ISO 8533

When subjected to a static pressure test in accordance with ISO 8533 with a test pressure equal to 1,5 times PN expressed in bars, for a time period of 15 min, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

When subjected to a static bending test in accordance with ISO 8533 using a test pressure equal to 2,0 times PN expressed in bars for a time period of 24 h, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

7.5.2.3.3 Testing in accordance with Annex A

When tested in accordance with Annex A, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

7.5.3 Number of test pieces for type test purposes

The number of joint assemblies to be tested for each test is one.

The use of the same test assembly for more than one of the tests detailed in Table 20 is permitted.

7.5.4 Test pieces

A test piece shall comprise a joint and two pieces of pipe such that the total laying length, L, is not less than either the values given in Table 14 or that is required to meet the requirements of the test method.

Table 20 —Summary of pressure tests requirements for wrapped or cemented joints

Property to be tested	Tests to be performed	Test pressure	Duration
Initial leakage	Initial pressure	1,5 × PN	15 min
External pressure differential	Negative pressure	–0,8 bar (–0,08 MPa)	1 h
Resistance to bending and pressure [a]	Preliminary pressure	1,5 × PN	15 min
	Maintained pressure	2,0 × PN	24 h
Resistance to internal pressure	Preliminary pressure	1,5 × PN	15 min
	Maintained pressure	2,0 × PN	24 h
	Positive cyclic pressure	Atmospheric to 1,5 × PN and back to atmospheric	10 cycles of 1,5 min to 3,0 min each
Short duration resistance	Maintained pressure	3,0 × PN or 2,5x PN	6 min 100 h
[a] This test may alternatively be conducted in accordance with Annex A.			
NOTE 1 Nominal pressure (PN) is an alphanumeric designation of pressure related to the resistance of a component of a piping system to internal pressure. NOTE 2 For joints intended to resist end-thrust loads the above tests are performed with end-loads applied to the joint. For non-end-load-bearing joints the tests are performed without the end-loads and the thrust is transferred to other sections of the test rig.			

7.6 Bolted flange joints

7.6.1 General

Bolted flange joints shall be tested for conformance to the test performance requirements under hydrostatic pressure detailed in 7.6.2.1 or 7.6.2.2, as appropriate and Table 21, using test pieces conforming to 7.6.4. The methods of test are those given in ISO 8483, as appropriate.

7.6.2 Performance requirements

7.6.2.1 Resistance to pressure excluding the end thrust

When tested by the appropriate method in ISO 8483 and with reference to the nominal pressure of the piping system in which the joint is designed to be used, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

7.6.2.2 Resistance to pressure including the end thrust

Joints intended to resist end thrust when tested by the appropriate method in ISO 8483, and with reference to the nominal pressure of the piping system, in which the joint is designed to be used, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

7.6.2.3 Resistance of the joint to bending and pressure including, if applicable, end thrust

7.6.2.3.1 General

When the joints intended to be either used in buried applications, where the soils are known to have very poor properties, or where particular non-buried applications make their use appropriate, use the applicable method in either ISO 8483 or Annex A. The method used shall be agreed between the purchaser and manufacturer, taking into account the foreseen installation conditions.

7.6.2.3.2 Testing in accordance with ISO 8483

When subjected to a static pressure test in accordance with ISO 8483 with a test pressure equal to 1,5 times PN expressed in bars, for a time period of 15 min, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

When subjected to a static bending test in accordance with ISO 8483 using a test pressure equal to 2,0 times PN expressed in bars for a time period of 24 h, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

7.6.2.3.3 Testing in accordance with Annex A

When tested in accordance with Annex A, the joint shall remain leak-tight and there shall be no visible damage to the assembled joint components.

7.6.3 Number of test pieces for type test purposes

The number of joint assemblies to be tested for each test is one.

The use of the same test assembly for more than one of the tests detailed in Table 21 is permitted.

7.6.4 Test pieces

A test piece shall comprise a joint and two pieces of pipe such that the total laying length, L, is not less than either the values given in Table 14 or that is required to meet the requirements of the test method.

7.6.5 Joint assembly details

The joint manufacturer shall supply full information on the flange, the gasket, the bolt torque, the degree and nature of the bolt lubrication, and the bolt tightening sequence: these shall be fully complied with before commencing the tests detailed in ISO 8483.

7.6.6 Torque resistance

When tested by the appropriate method in ISO 8483 using a factor of 2 for the torque, and with reference to the nominal pressure of the piping system in which the joint is designed to be used, there shall be no visible damage to the assembled joint components.

Table 21 — Summary of tests required for bolted flange joints

Test	Tests	Test pressure	Duration
Initial leakage	Initial pressure	1,5 × PN	15 min
External pressure differential	Negative pressure	−0,8 bar (−0,08 MPa)	1 h
Resistance to bending and pressure [a]	Preliminary Pressure	1,5 × PN	15 min
	Maintained Pressure	2,0 × PN	24 h
Resistance to internal pressure	Maintained pressure	2,0 × PN	24 h
	Positive cyclic pressure	Atmospheric to 1,5 × PN and back to atmospheric	10 cycles of 1,5 min to 3,0 min each
Short duration resistance	Maintained pressure	3,0 × PN or 2,5 x PN	6 min 100 h

[a] This test may alternatively be conducted in accordance with Annex A.

NOTE 1 Nominal pressure (PN) is an alphanumeric designation of pressure related to the resistance of a component of a piping system to internal pressure.

NOTE 2 For joints intended to resist end-thrust loads the above tests are performed with end-loads applied to the joint. For non-end-load-bearing joints the tests are performed without the end-loads and the thrust is transferred to other sections of the test rig.

Annex A
(normative)

Test method for the resistance to bending and pressure of end-thrust loaded joints in pipe systems

A.1 Principle

The joint is subjected to a bending load of such a magnitude that the axial tensile stress in the pipe is equal to that developed from a pressure of 0,5 times PN [see Formula (A.1)].

$$\sigma_{\mathrm{b}} = 0{,}5\frac{0{,}1[\mathrm{PN}]\times(d_{\mathrm{i}}+e)}{4e} \qquad \text{(A.1)}$$

In addition, the joint is then pressure tested for 10 cycles from atmospheric to 1,5 times PN, which then results in a total axial stress (bending plus pressure), σ_{ax}, equivalent to 2 times PN, i.e.:

$$\sigma_{\mathrm{ax}} = \frac{0{,}1[\mathrm{PN}]\times d_{\mathrm{i}}}{2e} \qquad \text{(A.2)}$$

During the test the joint is inspected for any signs of leakage and at the end of the test the assembled joint is inspected for any visible damage.

A.2 Apparatus

A.2.1 End-sealing devices, of size and method appropriate to the pipe system under test and anchored to the test pipes according to the requirements of the test being carried out.

A.2.2 Straps or cradles, supporting the pipe barrel or outside diameter of the joint and fixed at appropriate positions to provide a bending load such that they do not restrain free movement of the ends.

The strap or cradle shall be attached to a suitable loading device. The reaction points shall have no detrimental effect on the test piece.

A.2.3 Means of applying and measuring the required bending load, to an accuracy within ± 5 %.

The required bending load to be applied through the strap or cradle is calculated in accordance with A.5.

A.2.4 Source of hydrostatic pressure, capable of applying the required pressure in the test piece.

A.2.5 Pressure measuring device, capable of measuring the positive pressures at the top of the pipe to an accuracy within ± 2 %.

A.3 Test pieces

The lengths of pipe between the end closure and the joint, which is positioned in the middle, shall be at least 3 times DN, with a minimum of 0,5 m.

The joint shall be assembled in accordance with the manufacturer's field installation instructions.

A.4 Test temperature

The test shall be conducted at a test temperature of (23 ± 15) °C.

A.5 Calculation of the bending load F

A.5.1 General

The selection of whether to test in horizontal or vertical orientation will depend on several factors including the diameter, magnitude of the bending load and end sealing devices and support. Both orientations are equally acceptable. Formulas (A.5) and (A.6) are the general expressions giving all possible loadings.

If tested in the horizontal plane, with the pipe fully supported, Formula (A.5) reduces to Formula (A.4).

If tested in the vertical plane, the own weight of the test piece including the joint, the end caps and the contained water, see Figure A.1 and Formula (A.6), are made use of, which can reduce the load F to be applied.

A.5.2 Calculation of F, if applied in the horizontal plane

Calculate the required bending moment, M_b, using Formula (A.3).

$$M_b = \sigma_b \times S = 0{,}5 \times \frac{(0{,}1 \times [\mathrm{PN}] \times (d_i + e)}{4e} \times \frac{\pi}{32} \times \frac{(d_i + 2e)^4 - d_i^4}{d_i + 2e} \qquad \text{(A.3)}$$

where

M_b is the bending moment, in Nmm;

σ_b is the bending stress, in N/mm^2;

S is the section modulus of the pipe cross section, in mm^4/mm;

[PN] is the value of the nominal pressure, PN, of the piping system for which the joint is designed, expressed in bars;

d_i is the internal diameter of the corresponding pipe, in millimetres;

e is the declared wall thickness of the pipe for a nominal pressure, PN, in millimetres.

Using the value obtained for the bending moment M_b, calculate the bending load, F, using the appropriate value for L and Formula (A.4):

$$F = \frac{4M_b}{L} \qquad \text{(A.4)}$$

A.5.3 Calculation of F, if applied in the vertical plane

Calculate the required bending moment, M_b, using Formula (A.3).

Using the value obtained for the bending moment, M_b, calculate the bending load, F, using the appropriate value of L and Formula (A.5), see Figure A.1:

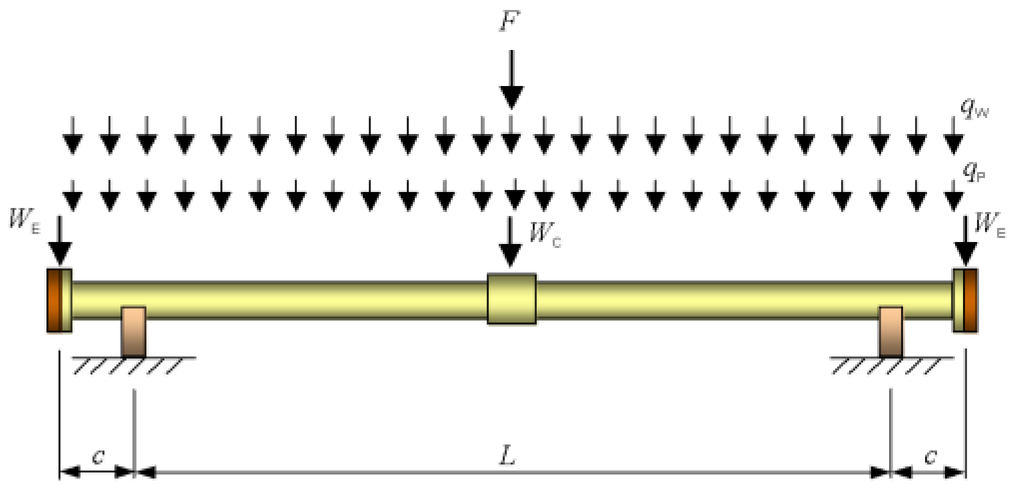


Figure A.1

$$F = \frac{4M_b}{L} - (q_w + q_p)\frac{(L^2 - 4c^2)}{2L} + \frac{4(W_E \times c)}{L} - W_C \qquad \text{(A.5)}$$

which is derived from the following Formula (A.6):

$$M_b = \frac{(q_w + q_p) \times L^2}{8} + \frac{(F + W_C) \times L}{4} - W_E \times c - \frac{(q_w + q_p) \times c^2}{2} \qquad \text{(A.6)}$$

where

q_w is the load induced by the water, in Newtons per millimetre;

q_p is the load induced by the weight of the pipes, in Newtons per millimetre;

F is the applied bending load, in Newtons;

W_C is the weight of the joint, in Newtons;

W_E is the weight of the end sealing device, in Newtons;

L is the distance between the centre of the supports, in millimetres;

c is the distance between the centre of the support and centre of the end sealing device, in millimetres.

A.6 Procedure

A.6.1 If the bending load is calculated in accordance with A.5.1, ensure that the test piece is supported the full length.

A.6.2 Fill the test piece with water and vent all entrapped air carefully.

A.6.3 Apply the bending load, F, determined in accordance with A.5.1 or A.5.2, as applicable.

A.6.4 Apply and maintain for 15 min a hydrostatic pressure of 1,5 times PN.

A.6.5 Reduce the pressure to atmospheric pressure.

A.6.6 Raise the internal pressure to 1,5 times PN and reduce again to atmospheric pressure; complete the cycle in 1,5 min to 3 min.

A.6.7 Repeat the cycle given in A.6.6 a further nine times.

A.6.8 During the test, inspect the joint and record any signs of leakage.

A.6.9 Depressurise, remove the bending load and inspect to the joint components and record any visible damage of the assembled joint.

A.7 Test report

The test report shall include the following information:

a) reference to this Annex;

b) full identification of the pipes and tested joints;

c) nominal pressure, PN, of the pipes and joint;

d) details of the jointing materials and procedures used;

e) temperature range during the tests;

f) description of the tests to which the joint was subjected;

g) pressures applied, in bars;

h) applied bending moment, M_b, in Newtons times millimetres;

i) any observations on the leaktightness of the joint during the tests;

j) any observations on the condition of the joint components at the end of the testing cycles;

k) details of interruptions, if any, to the test sequence;

l) any factors which may have affected the results, such as incidents or operating details not specified in this European Standard;

m) dates of the period of test.

Bibliography

[1] EN 476, *General requirements for components used in drains and sewers*

[2] EN ISO 2078, *Textile glass — Yarns — Designation (ISO 2078)*

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