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Second edition
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Plastics piping systems for pressure and non-pressure water supply — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin

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

Reference number
ISO 10639:2017(E)

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Foreword

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 6, *Reinforced plastics pipes and fittings for all applications*.

This second edition cancels and replaces the first edition (ISO 10639:2004), which has been technically revised. It also incorporates the Amendment ISO 10639:2004/Amd. 1:2011.

The main changes compared to the previous edition are as follows:

— inclusion of a guidance for the harmonization of design practices which are based on a partial safety factor concept and risk management engineering, as well as inclusion of the probability of failure and possible consequences of failures;

— addition of references to the general principle for the reliability of structures detailed in ISO 2394 and EN 1990;

— addition of a new safety factor concept for the hydrostatic pressure design;

— addition of a clear reference for assessment of conformity;

— changes in Clause 6, including pressure tests requirements for fittings;

— changes in Clause 7;

— changes in Annex A for the establishment of the design requirements.

Plastics piping systems for pressure and non-pressure water supply — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin

1 Scope

This document specifies the properties of piping system components made from glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP). It is suited for all types of water supply with or without pressure, including, but not limited to, raw water, irrigation, cooling water, potable water, salt water, sea water, penstocks in power plants, processing plants and other water-based applications. This document is applicable to GRP UP piping systems, with flexible or rigid joints with or without end thrust load-bearing capability, primarily intended for use in direct buried installations.

NOTE 1 For the purpose of this document, the term polyester resin (UP) also includes vinyl-ester resins (VE).

NOTE 2 Piping systems conforming to this document can also be used for non-buried applications, provided the influence of the environment and the supports are considered in the design of the pipes, fittings and joints.

NOTE 3 This document can also apply for other installations, such as slip-lining rehabilitation of existing pipes.

NOTE 4 This document is also referenced in ISO 25780, which specifies requirements for GRP-pipes used for jacking installation.

The requirements for the hydrostatic pressure design of pipes referring to this document meet the requirements of ISO/TS 20656-1 and the general principle for the reliability of structures detailed in ISO 2394 and in EN 1990. These International Standards provide procedures for the harmonization of design practices and address the probability of failure, as well as possible consequences of failures. The design practices are based on a partial safety factor concept, as well as on risk management engineering.

This document is applicable to pipes, fittings and their joints of nominal sizes from DN 50 to DN 4000 which are intended to be used for the conveyance of water at temperatures up to 50 °C, with or without pressure. In a pipework system, pipes and fittings of different nominal pressure and stiffness ratings may be used together. Clause 4 specifies the general aspects of GRP UP piping systems intended to be used in the field of water supply with or without pressure.

Clause 5 specifies the characteristics of pipes made from GRP UP with or without aggregates and/or fillers. The pipes may have a thermoplastics or thermosetting resin liner. Clause 5 also specifies the test parameters for the test methods referred to in this document.

Clause 6 specifies the characteristics of fittings made from GRP UP, with or without a thermoplastics or thermosetting resin liner, intended to be used for conveyance of water. Clause 6 specifies the dimensional and performance requirements for bends, branches, reducers, saddles and flanged adaptors. Clause 6 covers requirements to prove the structural design of fittings. It is applicable to fittings made using any of the following techniques:

— fabrication from straight pipes;

— moulding by

1) filament winding,

2) tape winding,

3) contact moulding, and

4) hot or cold compression moulding.

Clause 7 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 covers requirements to prove the design of the joint. Clause 7 specifies type test performance requirements for the following joints as a function of the declared nominal pressure rating of the pipeline or system:

a) socket-and-spigot (including double-socket) joints or mechanical joints;

b) locked socket-and-spigot joints;

c) cemented or wrapped joints;

d) bolted flange joints.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 75-2:2013, *Plastics — Determination of temperature of deflection under load — Part 2: Plastics and ebonite*

ISO 161-1, *Thermoplastics pipes for the conveyance of fluids — Nominal outside diameters and nominal pressures — Part 1: Metric series*

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

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

ISO 2394:2015, *General principles on the reliability for structures*

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

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

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

ISO 4633, *Rubber seals — Joint rings for water supply, drainage and sewerage pipelines — Specification for materials*

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 7509, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of time to failure under sustained internal pressure*

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

ISO 8483, *Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Test methods to prove the design of bolted flange joints*

ISO 8513:2016, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Test methods for the determination of the initial longitudinal tensile strength*

ISO 8521:2009, *Plastics 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 8639, *Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Test methods for leaktightness and proof of structural design of flexible joints*

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 the long-term ultimate relative ring deflection under wet conditions*

ISO 10928:2016, *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*

ISO 18851, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Test method to prove the structural design of fittings*

ISO/TS 20656-1, *Plastic piping systems — General rules for the structural design of glass-reinforced thermosetting (GRP) pipes — Part 1: Buried pipe*

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*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
break
condition where the test piece can no longer carry the load to which it is being subjected

3.2
coefficient of variation
V
ratio of the *standard deviation* (3.16) to the absolute value of the arithmetic mean, given by the following formula:

$$V = \text{standard deviation of the population} / \text{mean of the population}$$

Note 1 to entry: In this document, it is expressed as a percentage.

3.3 Diameter

3.3.1
declared diameter
diameter which a manufacturer states to be the internal or external diameter produced in respect of a particular *nominal size* (DN) (3.6)

3.3.2
mean diameter
d_m
diameter of the circle corresponding to the middle of the pipe wall cross-section and given, in metres (m), by either of the following formulae:

$$d_m = d_i + e$$

$$d_m = d_e - e$$

where

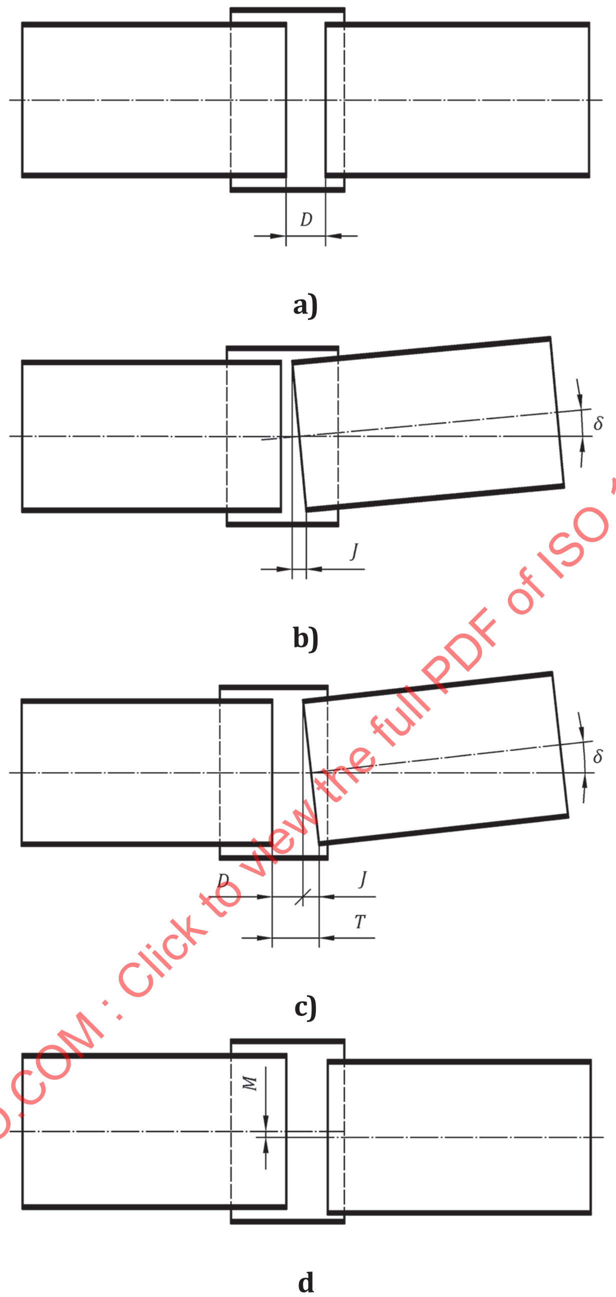
d_i is the internal diameter, in m;

d_e is the external diameter, in m;

e is the wall thickness of the pipe, in m.

3.4
laying length
total length (3.19) of a pipe minus, where applicable, the manufacturer's recommended insertion depth of the spigot(s) in the socket

3.5 Joint movement



Key

D draw

J longitudinal movement arising from angular deflection of the joint

δ angular deflection of the joint

T total draw

M deformation

Figure 1 — Joint movements

3.5.1
angular deflection
δ
angle between the axes of two consecutive pipes

Note 1 to entry: It is expressed in degrees (°).

Note 2 to entry: See Figure 1.

3.5.2
deformation
M
pipe deformation in the coupling as a result of a vertical force of 20 N/mm of the *nominal size* (3.6), in millimetres (mm) on the pipe and a supported coupling causing a step between the two pipe spigots at the loading position in millimetres (mm)

Note 1 to entry: See Figure 1.

3.5.3
draw
D
longitudinal movement of a joint

Note 1 to entry: It is expressed in millimetres (mm).

Note 2 to entry: See Figure 1.

3.5.4
flexible joint
joint which allows relative movement between the components being joined

Note 1 to entry: Flexible joints which have resistance to axial loading are classified as end-load-bearing. Examples of this type of joint are:

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

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

c) mechanically clamped joints, e.g. bolted couplings including components made of materials other than GRP.

3.5.5
rigid joint
joint which does not allow relative movement between the components being joined

Note 1 to entry: Rigid joints which do not have resistance to axial loading are classified as non-end-load-bearing. Examples of this type of joint are:

a) flanged joints including integral or loose flanges;

b) wrapped or cemented joints.

3.5.6
total draw
T
sum of the *draw*, *D* (3.5.3), and the additional longitudinal movement, *J*, of joint components due to the presence of *angular deflection* (3.5.1)

Note 1 to entry: It is expressed in millimetres (mm).

Note 2 to entry: See Figure 1.

3.6
nominal size
DN
alphanumerical designation of size, which is common to all components in a piping system, which is a convenient round number for reference purposes and is related to the internal diameter in millimetres (mm)

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

3.7
nominal length
numerical designation of pipe length which is equal to the *laying length* (3.4), in metres (m), rounded to the nearest whole number

3.8
nominal stiffness
SN
alphanumerical designation of stiffness classification purposes, which has the same numerical value as the minimum initial value required, when expressed in newtons per square metre (N/m^2)

Note 1 to entry: See 4.1.3.

Note 2 to entry: The designation for reference or marking purposes consists of the letters SN plus a number.

3.9
non-pressure pipe or fitting
pipe or fitting subjected to an internal pressure not greater than 1 bar

3.10
normal service conditions
conveyance of water or sewage in the temperature range 2 °C to 50 °C, with or without pressure, for 50 years

Note 1 to entry: At temperatures above 35 °C, it may be necessary to rerate the pipe.

3.11 Pipeline

3.11.1
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

3.11.2
non-buried pipeline
pipeline which is subjected to negative and positive pressure, forces resulting from its supports and environmental conditions

Note 1 to entry: Examples of environmental conditions are snow, wind and temperature.

3.11.3
sub-aqueous pipeline
pipeline which is subjected to an external pressure arising from a head of water and conditions such as drag and lift caused by current and wave action

3.12 Pressure

3.12.1
initial failure pressure
p_0
mean pressure at which failure occurs with specimens subjected to short-term tests performed in accordance with ISO 8521

3.12.2
nominal pressure
PN
alphanumeric designation for a nominal pressure class, which is the maximum sustained hydraulic internal pressure for which a pipe is designed in the absence of other loading conditions than internal pressure, this means that the nominal pressure shall be equal to or greater than the *working pressure* (3.12.11)

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

Note 2 to entry: The definition for the PN has been changed to the previous version of this document. The definition is more specific and related to internal pressure load exclusively.

3.12.3
minimum initial failure pressure
$p_{0,QC}$
initial failure pressure (3.12.1), determined in accordance with ISO 8521, which 95 % of products are required to exceed

3.12.4
mean design pressure
$p_{0,d}$
mean design initial failure pressure to ensure 95 % of products will exceed the *initial failure pressure*, $p_{0,QC}$ (3.12.1)

3.12.5
minimum safety factor for long-term pressure
FS_{min}
minimum safety factor for long-term pressure which is applied to the *nominal pressure* (PN) (3.12.2)

3.12.6
mean safety factor safety factor for long-term pressure
FS_{mean}
mean safety factor for long-term pressure which is applied to the *nominal pressure* (PN) (3.12.2)

3.12.7
minimum failure pressure at 50 years
$p_{50,min}$
95% lower confidence level (LCL) of the failure pressure after 50 years

3.12.8
pressure regression ratio
$R_{R,p}$
ratio of the *projected failure pressure at 50 years*, p_{50} (3.12.10), to the projected failure pressure at 6 min, p_6, obtained from long-term pressure tests performed in accordance with ISO 7509 and analysed in accordance with ISO 10928

3.12.9
pressure pipe or fitting
pipe or fitting having a nominal pressure classification, expressed in bar, greater than 1 bar and which is intended to be used at internal pressures up to its *nominal pressure* (PN) (3.12.2)

Note 1 to entry: It is expressed in bar.

3.12.10
projected failure pressure at 50 years
p_{50}
value at 50 years derived from the pressure regression line obtained from long-term pressure tests performed in accordance with ISO 7509 and analysed in accordance with ISO 10928

3.12.11
working pressure
p_W
maximum internal hydrostatic pressure, excluding surge, at which a system can be continuously operated

Note 1 to entry: It is expressed in bar.

Note 2 to entry: Working pressure is represented by the following fomula:

$$p_W \leq PN$$

where

p_W is the working pressure, in bar;

PN is the nominal pressure, in bar.

3.12.12
correction factor
C
ratio of the mean value of the tested initial failure pressure ($p_{0,mean}$) to the projected 6 min failure pressure (p_6) calculated from the regression line

3.13
rerating factor
R_{RF}
multiplication factor that quantifies the relationship of a product's mechanical, physical and chemical properties under service conditions above 35 °C [*service temperature* (3.18.1)] to those applicable at a standard test temperature of 23 °C

3.14 Ring deflection

3.14.1
extrapolated long-term relative ultimate ring deflection
$y_{u,wet,x}/d_m$
deflection value at x years derived from the ultimate deflection regression line obtained from long-term deflection tests performed under wet conditions in accordance with ISO 10471 and analysed in accordance with ISO 10928

Note 1 to entry: For x years, see 4.6.

Note 2 to entry: It is expressed as a percentage by multiplying by 100.

3.14.2
relative ring deflection
y/d_m
ratio of the change in diameter of a pipe, y, in metres (m), to its *mean diameter*, d_m (3.3.2)

Note 1 to entry: See 3.3.2.

Note 2 to entry: It is derived as a percentage from the formula:

$$\text{relative ring deflection} = \frac{y}{d_m} \times 100$$

3.14.3
minimum initial relative specific ring deflection before bore cracking occurs
$(y_{2,\text{bore}}/d_\text{m})_\text{min}$
initial relative deflection at 2 min which a test piece is required to pass without bore cracking when tested in accordance with ISO 10466

Note 1 to entry: It is expressed as a percentage by multiplying by 100.

3.14.4
minimum initial relative specific ring deflection before structural failure occurs
$(y_{2,\text{struct}}/d_\text{m})_\text{min}$
initial relative deflection at 2 min which a test piece is required to pass without structural failure when tested in accordance with ISO 10466

Note 1 to entry: It is expressed as a percentage by multiplying by 100.

3.14.5
minimum long-term relative ultimate ring deflection
$(y_{\text{u,wet,x}}/d_\text{m})_\text{min}$
required minimum extrapolated value at x years derived from the ultimate deflection regression line obtained from long-term deflection tests performed under wet conditions in accordance with ISO 10471

Note 1 to entry: It is expressed as a percentage by multiplying by 100.

Note 2 to entry: For x years, see 4.6.

3.15 Ring stiffness

3.15.1
initial specific ring stiffness
S_0
value of *S* obtained when determined in accordance with ISO 7685

Note 1 to entry: It is expressed in newtons per square metre (N/m^2).

3.15.2
long-term specific ring stiffness
$S_{\text{x,wet}}$
value of *specific ring stiffness* (3.15.3), *S*, at x years, determined in accordance with ISO 10468

Note 1 to entry: For x years, see 4.6.

3.15.3
specific ring stiffness
S
measure of the resistance, in newtons per square metre (N/m^2), of a pipe to ring deflection per metre (m) length under external load as defined by the formula:

$$S = \frac{E \times I}{d_\text{m}^3}$$

where

E is the apparent modulus of elasticity as determined in a ring stiffness test, in N/m^2;

I is the second moment of area in the longitudinal direction per metre length, in m^4/m, i.e.

$$I = \frac{e^3}{12}$$

where

e is the wall thickness, in m;

d_m is the mean diameter of the pipe, in m (see 3.3.2).

3.16
standard deviation
σ
positive square root of the *variance* (3.21)

3.17
surge
rapid change in internal pressure, either positive or negative, caused by a change in the flow velocity

Note 1 to entry: It is expressed in bar.

3.18 Temperature

3.18.1
service temperature
maximum sustained temperature at which a system is expected to operate

Note 1 to entry: It is expressed in degrees Celsius (°C).

Note 2 to entry: This temperature is used for the rerating of the product (see 3.13).

3.18.2
design temperature
maximum temperature at which a system can be exposed to occasionally

Note 1 to entry: It is expressed in degrees Celsius (°C).

3.19
total length
distance between two planes normal to the pipe axis and passing through the extreme end points of the pipe

Note 1 to entry: It is expressed in metres (m).

3.20
type test
test performed to prove that the material, product, joint, fittings or assembly is capable of conforming to the requirements given in this document

3.21
variance
measure of dispersion based on the mean square deviation from the arithmetic mean

3.22
wet creep factor
$\alpha_{x,wet,creep}$
ratio of the *long-term specific ring stiffness*, $S_{x,wet}$ (3.15.2), at x years, determined under sustained loading in wet conditions in accordance with ISO 10468, to the *initial specific ring stiffness*, S_0 (3.15.1), both measured at the same position referred to as reference position 1

Note 1 to entry: For x years, see 4.6.

Note 2 to entry: It is given by the formula:

$$\alpha_{x,wet,creep} = \frac{S_{x,wet}}{S_0}$$

4 General

4.1 Classification

4.1.1 Categories

Pipes and fittings shall be classified according to nominal size (DN) (see 3.6), nominal pressure (PN) (see 3.12.2) and joint type.

In addition, pipes shall include nominal stiffness (SN) (see 3.8) in their classification.

4.1.2 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.

4.1.3 Nominal stiffness

The nominal stiffness (SN) shall conform to one of those given in Table 1 (see Note to Table 1).

Table 1 — Nominal stiffness (SN)

Nominal stiffness
1 250
2 500
5 000
10 000
NOTE 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).

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 X, where X is the nominal stiffness of the pipe.

4.1.4 Nominal pressure

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

Where pressures other than the nominal values in Table 2 are to be supplied by agreement between the manufacturer and the purchaser the pressure marking shall be PN X, where X is the value.

Table 2 — Nominal pressure (PN)

Nominal pressure
1
(2,5)
(4)
6
(9)
10
(12,5)
(15)
16
(18)
(20)
25
32
NOTE 1 Values in parentheses are non-preferred nominal pressures.
NOTE 2 Pipes marked PN 1 are non-pressure (gravity) pipes.

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 and polyester resin with or without fillers and, if applicable, with those additives necessary to impart specific properties to the resin. The pipe or fitting may also incorporate aggregates and, if required, a thermoplastics or any other thermosetting liner.

NOTE For the purpose of this document, the term polyester resin includes both polyester and vinyl-ester resin.

4.2.2 Reinforcement

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

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) type "C" glass, comprising primarily oxides of silicon, sodium, potassium, calcium and boron (alkali metal calcium glass with an increased boron trioxide content) which is intended for applications requiring enhanced chemical resistance;

c) type "R" glass, comprising primarily oxides of silicon, aluminium, calcium and magnesium without added boron;

d) type "E-CR" glass, comprising boron-free modified E-glass compositions for improved resistance to corrosion by most acids.

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

NOTE These descriptions for type C glass and type E glass are consistent with, but more specific than, those given in ISO 2078.

The reinforcement shall be made from continuously drawn filaments of type E (E-CR), type C or type R glass, and shall have a surface finish 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. Surface mats or veils of synthetic (organic) fibres may be used on the surfaces of the components.

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 tested in accordance with ISO 75-2:2013, method A with the test specimen in the flatwise position.

4.2.4 Aggregates and fillers

The particle size of 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 smaller.

4.2.5 Thermoplastics liners

When using a thermoplastics liner that requires a bonding material, care shall be taken to ensure that the bonding material is compatible with all other materials used in the pipe construction.

4.2.6 Elastomers

The elastomeric material(s) of the seal shall conform to the applicable part of ISO 4633 or, if such material is not available, a similar standard that is acceptable to both the purchaser and supplier.

ISO 4633 is equal to EN 681-1 and gaskets complying with these standards are deemed to satisfy the 50 years design life of the pipe systems made in accordance with this document.

4.2.7 Metals

Metallic components may be used in the system.

4.3 Wall construction

4.3.1 Inner layer

The inner layer shall comprise one of the following:

a) any type of thermosetting resin layer with or without aggregates and fillers and with or without a reinforcement;

b) a thermoplastics liner.

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 construction 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 and fillers and with or without a reinforcement made of glass or synthetic filaments.

NOTE Special constructions may be necessary where the pipe is exposed to extreme climatic, environmental or ground conditions. For example, provision may be made for the inclusion of pigments or inhibitors for extreme climatic conditions or to give fire-retarding properties.

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

4.4 Appearance

Both the internal and the external surfaces shall be free from irregularities which could impair the ability of the component to conform to the requirements of this document.

4.5 Reference conditions for testing

4.5.1 Temperature

The mechanical, physical and chemical properties specified in this document shall, unless otherwise specified, be determined at (23 ± 5) °C. For service temperatures over 35 °C, type tests shall be carried out at least at the service temperature (see 3.18.1) to establish rerating factors for all long-term properties of relevance to the design of pipes and fittings.

Test conditions for fittings and joints are detailed in 6.1.6.3 and 7.1.3.

Testing stiffness and deflection to crack/damage on very large samples in controlled temperature conditions could be very difficult and costly and considering the sample size even dangerous. Therefore, it can be practical to carry out the test on the factory floor which is not necessarily temperature controlled. For routine batch release tests, it is allowed to perform the tests at prevailing ambient temperature, e.g. on the factory floor if the testing machine is located there.

4.5.2 Properties of water for testing

The water used for the tests referred to in this document 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 this document shall be determined using circumferential and/or longitudinal loading conditions, as applicable.

4.5.4 Conditioning

Unless otherwise specified, in cases 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

In cases of dispute, determine the dimensions of GRP components at the temperature specified in 4.5.1. Make all measurements in accordance with ISO 3126 or using any other method of sufficient accuracy to determine conformity or non-conformity with the applicable limits. Make all routine measurements at the prevailing temperature or, if the manufacturer prefers, at the temperature specified in 4.5.1.

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

The subscript x in, for example, $S_{x,wet}$ (see 3.15.2), denotes the time at 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).

NOTE The long-term testing procedures are conservative because the test pieces are subjected to higher strain levels than expected in service. For this reason, it can be assumed that the 50 years life time is a minimum in practice and experience suggests that longer lifetimes up to 100 years can be achieved.

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 3.5.4) or rigid (see 3.5.5), and in either case, the manufacturer shall declare whether or not it is capable of resisting end loads.

4.7.3 Flexibility of the joint

4.7.3.1 Allowable angular deflection

The manufacturer shall declare the allowable angular deflection (see 3.5.1) for which each joint is designed.

For locked joints, the manufacturer shall declare the maximum allowable angular deflection.

Other flexible joints which are not locked shall allow angular deflection that is not less than the applicable value given below:

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

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

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

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

By agreement between the manufacturer and the purchaser, flexible joints intended to be used at pressures greater than 16 bar may have lower allowable angular deflections than those given in this subclause.

4.7.3.2 Allowable draw

The manufacturer shall declare the maximum allowable draw (see 3.5.3) for which each joint is designed.

For flexible joints, the maximum allowable draw, which includes Poisson contraction and temperature effects, shall not be less than 0,3 % of the laying length of the longest pipe which it is intended for use in the case of pressure pipes and 0,2 % in the case of non-pressure pipes. For locked joints, the manufacturer shall declare the maximum allowable 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 performance requirements specified in Clause 7.

4.7.5 Adhesives

Adhesives, if required for jointing, shall be as specified by the manufacturer of the joint. The joint manufacturer shall ensure that the adhesives do not have any detrimental effects on the components with which they are used and shall not cause the test assembly to fail the performance requirements specified in Clause 7.

4.8 Effect on water quality

It shall be ensured that the piping system, intended to be used for the transport of water for human consumption, does not have any negative impact on the water quality.

4.9 Assessment of conformity

Assessment of conformity of products specified in this document shall be made according to CEN/TS 14632.

NOTE CEN/TS 14632 details procedures and tests for product assessments such as type tests (TT), audit tests (AT), batch release tests (BRT) and process verification tests (PVT), as well as tests to assess the effects of changes in the design, process and materials.

A testing laboratory for type tests (TT), audit tests (AT) and process verification tests (PVT) should meet the requirements of ISO/IEC 17025.

The scope of this document includes also large diameters. Thus type tests (TT), audit tests (TS) and process verification (PVT) may also include large sample sizes or difficult structures where special testing equipment is needed. In case the accredited testing laboratory is not equipped with these special testing facilities, the tests may be performed in the manufactures' laboratories under the supervision of the testing and certification institute.

5 Pipes

5.1 Type of pipes

The type of pipe or pipes shall be distinguished whether or not to be suitable for resisting the longitudinal load produced by the internal pressure.

5.2 Geometrical characteristics

5.2.1 Diameter

5.2.1.1 Diameter series

NOTE In standardizing the diameters of GRP pipes, difficulties are encountered because of the various methods used to manufacture them (e.g. filament winding, centrifugal casting or contact moulding). Typically, GRP pipes are produced by controlling either the internal diameter or the external diameter to a fixed value.

Unless otherwise agreed between the manufacturer and the purchaser, GRP pipes shall be designated by nominal size in accordance with one of the following two series:

— series A, which specifies the internal diameter in mm;

— series B, which specifies the external diameter in mm.

5.2.1.2 Nominal size

Unless otherwise agreed between the manufacturer and the purchaser, the nominal size (DN) shall be chosen from the values given in Table 3.

Table 3 — Nominal size (DN)

Nominal size			
50	600	(1 650)	(2 900)
75	700	(1 700)	3 000
100	(750)	1 800	(3 100)
125	800	(1 900)	3 200
150	900	2 000	(3 300)
200	1 000	(2 100)	3 400
250	(1 100)	2 200	(3 500)
300	1 200	(2 300)	3 600
350	(1 300)	2 400	(3 700)
(375)	(1 350)	(2 500)	3 800
400	1 400	2 600	(3 900)
450	(1 500)	(2 700)	4 000
500	1 600	2 800	
NOTE Values in parentheses are non-preferred values.			

5.2.1.3 Specified diameters

5.2.1.3.1 General

Pipes may be supplied conforming to 5.2.1.3.2 (series A), 5.2.1.3.3 (series B) or, by agreement between the manufacturer and the purchaser, another diameter series.

Pipes having other diameters may be supplied by agreement between the manufacturer and the purchaser.

5.2.1.3.2 Series A (internal diameter specified)

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

5.2.1.3.3 Series B (external diameter specified)

The external diameter, in mm, shall conform to the applicable value relative to the nominal size given in Tables 5, 6 or 7.

The dimensions of pipes with nominal sizes between DN 300 and DN 4 000 to be used with GRP fittings conforming to Clause 6 shall conform to those given for series B1.

The dimensions of pipes with nominal sizes between DN 100 and DN 600 to be used with either GRP fittings conforming to Clause 6 or with ductile-iron fittings conforming to ISO 2531 shall conform to those given for series B2.

When specifying the use of ductile-iron fittings with GRP pipes, care should be taken to ensure their dimensional compatibility with the GRP pipe.

The dimensions of pipes with nominal sizes between DN 100 and DN 600 to be used with either GRP fittings conforming to Clause 6 or with PVC fittings conforming to ISO 161-1 and the tolerances to ISO 11922-1 shall conform to those given for series B3.

The dimensions of pipes with nominal sizes between DN 100 and DN 300 to be used with either GRP fittings conforming to Clause 6 or steel pipes conforming to ISO 4200 shall conform to those given for series B4.

The dimensions of pipes with nominal sizes between DN 50 and DN 800 to be used with either GRP fittings conforming to Clause 6 or with metallic pipes conforming to standards not covered by series B2 or B4 shall conform to those given for series B5.

The dimensions of pipes with nominal sizes between DN 200 and DN 2 400 to be used with either GRP fittings conforming to Clause 6 or with GRP pipes conforming to Japanese standard JIS A 5350 shall conform to those given for series B6.

5.2.1.4 Tolerances

5.2.1.4.1 Series A — Tolerances on internal diameter

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

For GRP pipes which have a liner made from thermoplastics pipes, the tolerances on the internal diameter shall be as specified in the relevant thermoplastics pipe standard. The internal diameter of GRP pipes which have a liner fabricated from thermoplastics sheet shall conform to the applicable value in Table 4 and its tolerances.

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 ±mm
	minimum	maximum	
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
1 000	995	1 020	5,0
1 200	1 195	1 220	5,0
1 400	1 395	1 420	5,0
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.			
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.			

Table 4 *(continued)*

Column 1	Column 2	Column 3	Column 4
1 600	1 595	1 620	5,0
1 800	1 795	1 820	5,0
2 000	1 995	2 020	5,0
2 200	2 195	2 220	5,0
2 400	2 395	2 420	6,0
2 600	2 595	2 620	6,0
2 800	2 795	2 820	6,0
3 000	2 995	3 020	6,0
3 200	3 195	3 220	6,0
3 400	3 395	3 420	6,0
3 600	3 595	3 620	6,0
3 800	3 795	3 820	7,0
4 000	3 995	4 020	7,0
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. 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.			

5.2.1.4.2 Series B1 — Tolerances on external diameter

The external diameter of a pipe at the spigot shall be as given in Table 5. The manufacturer shall declare the actual maximum and minimum external diameters of the pipe at the spigot.

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

Dimensions in millimetres

Nominal size DN	External diameter of pipe	Permissible deviation	
		Upper limit	Lower limit
300	310	+1,0	−1,0
350	361		−1,2
400	412		−1,4
450	463		−1,6
500	514		−1,8
600	616		−2,0
700	718		−2,2
800	820		−2,4
900	924		−2,6
1 000	1 026	+2,0	−2,6
1 200	1 229		−2,6
1 400	1 434		−2,8
1 600	1 638		−2,8
1 800	1 842		−3,0
When a non-preferred size is selected from Table 3, the range of diameters and the permissible deviations shall be interpolated between the preferred sizes immediately above and below the non-preferred size.			

Table 5 *(continued)*

Nominal size DN	External diameter of pipe	Permissible deviation	
		Upper limit	Lower limit
2 000	2 046		−3,0
2 200	2 250		−3,2
2 400	2 453		−3,4
2 600	2 658		−3,6
2 800	2 861		−3,8
3 000	3 066	+2,0	−4,0
3 200	3 270		−4,2
3 400	3 474		−4,4
3 600	3 678		−4,6
3 800	3 882		−4,8
4 000	4 086		−5,0
When a non-preferred size is selected from Table 3, the range of diameters and the permissible deviations shall be interpolated between the preferred sizes immediately above and below the non-preferred size.			

5.2.1.4.3 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 DN	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	+1,5	−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	+1,2		—		
450	477,6		−0,4	450	+1,4		—		
500	529,5		−0,4	500	+1,5		—		
600	632,5		−0,5	630	+1,9		—		
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.									

5.2.1.4.4 Series B5 — Tolerances on external diameter

The declared external diameter for series B5 shall be between the values given in Table 7 for the applicable nominal size and be subject to the tolerances for the metallic pipes with which they are to be used.

The tolerances applicable to these dimensions depend on the joint. Upon request by the purchaser, the manufacturer shall provide detailed toleranced dimensions of the pipes used for particular joints.

Table 7 — Series B5 — Specified external diameters

Dimensions in millimetres

Column 1	Column 2	Column 3
Nominal size DN	Range of declared pipe external diameters	
	minimum	maximum
50	63	64
75	100	101
100	121	122
150	175	177
200	229	232
250	281	286
300	335	345
350	388	399
400	426	453
450	495	507
500	548	587
700	655	747
800	812	826

5.2.1.4.5 Series B6 — Tolerances on external diameter

The external diameter of a pipe at the spigot shall be as given in Table 8. The manufacturer shall declare the actual maximum and minimum external diameter of a pipe at the spigot.

Table 8 — Series B6 — Specified pipe external diameters and tolerances

Dimensions in millimetres

Nominal size DN	External pipe diameter	Permissible deviation	
		Upper limit	Lower limit
200	220	+1,5	−0,5
250	271		
300	322		
350	373		
400	424		
450	475		
500	526		

Table 8 *(continued)*

Nominal size DN	External pipe diameter	Permissible deviation	
		Upper limit	Lower limit
600	631	+2,0	−1,0
700	736		
800	840		
900	944		
1 000	1 050		
1 100	1 156		
1 200	1 262		
1 350	1 418		
1 500	1 574		
1 650	1 732	+2,5	−1,5
1 800	1 890		
2 000	2 098		
2 200	2 308		
2 400	2 518		

5.2.2 Wall thickness

If requested, the manufacturer shall declare the minimum total wall thickness, including the liner. It shall not be less than 3 mm.

5.2.3 Length

5.2.3.1 Nominal length

Unless otherwise agreed between the manufacturer and the purchaser, the nominal length (see 3.7) shall be one of the following values: 3, 4, 5, 6, 9, 10, 12 or 18.

5.2.3.2 Laying length

Pipes shall be supplied in laying lengths (see 3.4) in accordance with the requirements given in the following paragraph. The tolerance on the laying length shall be ±60 mm.

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

5.3 Mechanical characteristics

5.3.1 Initial specific ring stiffness

5.3.1.1 General

The initial specific ring stiffness, S_0 (see 3.15.1), shall be determined using either of the methods given in ISO 7685. The test pieces shall conform to 5.3.1.2, 5.3.1.3 and 5.3.1.4. Conduct the test using a relative ring deflection (see 3.14.2) between 2,5 % and 3,5 %. Where the nominal stiffness exceeds SN 10 000, perform the test using a relative deflection calculated using Formula (1):

$$\text{Reflective deflection } (\%) = \frac{65}{\sqrt[3]{\text{SN}}} \pm 0{,}5 \quad (1)$$

The value determined for the initial specific ring stiffness, S_0, shall not be less than the applicable value of $S_{0,\text{min}}$ given in Table 9. For nominal stiffnesses greater than SN 10 000, the initial stiffness, in N/m^2, shall not be less than the numerical value of the nominal stiffness.

Table 9 — Minimum initial specific ring stiffness values

Nominal stiffness (SN)[a]	$S_{0,\text{min}}$[b] N/m^2
1 250	1 250
2 500	2 500
5 000	5 000
10 000	10 000

a See Note to Table 1.

b For other stiffnesses, the value of $S_{0,\text{min}}$ shall be equal to SN X (see 4.1.3).

5.3.1.2 Number of test pieces for type testing

Two test pieces, of the same size and classification and conforming to 5.2.1.3, shall be used.

5.3.1.3 Number of test pieces for quality control test purposes

Unless otherwise specified, one test piece shall be used.

5.3.1.4 Length of test pieces

The length, L_p, of the test piece shall be 0,3 m ± 5 % for all nominal sizes.

5.3.2 Long-term specific ring stiffness under wet conditions

5.3.2.1 Temperature of the water

The temperature of the water shall be (23 ± 5) °C (see 4.5).

5.3.2.2 Method of test to determine S_0

Before performing the test detailed in 5.3.2.5, determine the initial specific ring stiffness, S_0, of the test pieces in accordance with 5.3.1 using test pieces conforming to 5.3.2.7.

5.3.2.3 Time intervals for measurement

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

5.3.2.4 Elapsed time at which the property is to be determined

The elapsed time at which this property is to be determined is 50 years in accordance with 4.6.

5.3.2.5 Method of test

The long-term specific ring creep stiffness, $S_{x,wet,creep}$, and the creep factor, $\alpha_{x,wet,creep}$, shall be determined from data derived from the test performed in accordance with ISO 10468 using an initial strain of between 0,13 % and 0,17 %. The wet creep factor shall be calculated in accordance with ISO 10928.

5.3.2.6 Requirement

When test pieces conforming to 5.3.2.7 are tested in accordance with the applicable method given in 5.3.2.5, the creep factor, $\alpha_{x,wet,creep}$, shall be as declared by the manufacturer.

5.3.2.7 Number of test pieces for type testing

Use two test pieces of the same size and classification and of length, L_p, conforming to 5.3.1.4.

5.3.2.8 Determination of minimum long-term specific ring stiffness

The manufacturer shall determine for the pipes he produces the minimum long-term specific creep stiffness, $S_{x,wet,creep,min}$, using Formula (2):

$$S_{x,wet,creep,min} = S_{0,min} \times \alpha_{x,wet,creep} \tag{2}$$

where

$S_{0,min}$ is the applicable minimum initial specific ring stiffness value given in Table 9.

The value(s) determined shall be as declared by the manufacturer.

5.3.3 Initial resistance to failure in a deflected condition

5.3.3.1 General

Determine the initial resistance to failure in a deflected condition using the method given in ISO 10466. The test pieces shall conform to 5.3.3.4 and 5.3.3.5. Conduct the test using mean diametrical deflections appropriate to the nominal stiffness (SN) of the pipe as specified in 5.3.3.3.1 for item a) of 5.3.3.2 and as determined in accordance with 5.3.3.3.2 for item b) of 5.3.3.2.

5.3.3.2 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 5.3.3.3.1);

b) the test piece shall not show structural failure in any of the following forms (see 5.3.3.3.2):

   1) interlaminar separation;

   2) tensile failure of the glass fibre reinforcement;

   3) buckling of the pipe wall;

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

5.3.3.3 Minimum initial relative specific ring deflection

5.3.3.3.1 For bore cracks

The minimum initial relative specific ring deflection before bore cracking occurs (see 3.14.3) is given in Table 10 for the appropriate nominal stiffness of the test piece. For nominal stiffnesses greater than SN 10 000, calculate the minimum initial relative specific ring deflection before bore cracking, $y_{2,\text{bore}}/d_\text{m}$, in %, using Formula (3):

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

where

$\left(y_{2,\text{bore}} / d_\text{m}\right)_{\text{new,min}}$	is the required minimum 2 min initial relative specific ring deflection before bore cracking calculated, in %, for the nominal stiffness of the test piece;
SN	is the nominal stiffness of the test piece.

For individual test pieces having a nominal stiffness greater than SN 10 000, calculate the minimum initial relative specific ring deflection before bore cracking, $y_{2,\text{bore}}/d_\text{m}$, in %, using Formula (3), but using the measured initial specific ring stiffness of the test piece instead of its nominal stiffness.

Table 10 — Minimum 2 min initial relative specific ring deflection before bore cracking, $(y_{2,\text{bore}}/d_\text{m})_\text{min}$

Nominal stiffness (SN)	1 250	2 500	5 000	10 000
No sign of bore cracking at a percentage relative to the specific ring deflection of the test piece	18	14,3	11,3	9

5.3.3.3.2 For structural failure

The minimum initial relative specific ring deflection before structural failure (see 3.14.4) is given in Table 11 for the appropriate nominal stiffness of the test piece. For nominal stiffnesses greater than SN 10 000, calculate the minimum initial ring deflection before structural failure, $y_{2,\text{struct}}/d_\text{m}$, in %, using Formula (4):

$$\left(y_{2,\text{struct}} / d_\text{m}\right)_{\text{new,min}} \times 100 = \frac{324}{\sqrt[3]{\text{SN}}} \tag{4}$$

where

$\left(y_{2,\text{struct}} / d_\text{m}\right)_{\text{new,min}} \times 100$	is the required minimum 2 min initial relative specific ring deflection before structural failure calculated, in %, for the nominal stiffness of the test piece;
SN	is the nominal stiffness of the test piece.

For individual test pieces having a nominal stiffness greater than SN 10 000, calculate the minimum initial relative specific ring deflection before structural failure, $y_{2,\text{struct}}/d_\text{m}$, in %, using Formula (4), but using the measured initial specific ring stiffness of the test piece instead of its nominal stiffness.

The deflection values in Table 11 are based on the assumption that the maximum allowable long-term deflection when buried in 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 requirement in Table 11 shall be adjusted proportionally, e.g. if the manufacturers value is 3 % then the required values shall be 50 %

of those in Table 11, while a manufacture's declaration values of 8 % results in required values being 133 % of those in Table 11.

NOTE The ultimate ring deflection values in Table 11 include the same failure strain for all 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 initial relative specific deflection before structural failure, $(y_{2,struct}/d_m)_{min}$

Nominal stiffness (SN)	1 250	2 500	5 000	10 000
No sign of structural failure at a percentage relative to the specific ring deflection of the test piece	30,0	23,9	18,9	15

5.3.3.4 Number of test pieces for type testing

Use three test pieces of the same size and classification and of length, L_p, conforming to 5.3.1.4.

5.3.3.5 Number of test pieces for quality control test purposes

Unless otherwise specified, one test piece of the same size and classification and length, L_p, conforming to 5.3.1.4 shall be used.

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

5.3.4.1 General

Determine the ultimate long-term resistance to failure in a deflected condition using the method given in ISO 10471, using at least 18 test pieces conforming to 5.3.4.5.

5.3.4.2 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 5.3.4.5, 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 stiffness, shall not be less than the applicable value given in Table 12.

The deflection values in Table 12 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 requirement in Table 12 shall be adjusted proportionally, e.g. if the manufacturers value is 3 % then the required values shall be 50 % of those in Table 12, while a manufacture's declaration values of 8 % results in required values being 133 % of those in Table 12.

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

NOTE The ultimate ring deflection values in Table 12 include the same failure strain for all 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 12 — Minimum extrapolated long-term relative ultimate ring deflection under wet conditions, $(y_{u,wet,x}/d_m)_{min}$

Nominal stiffness (SN)	1 250	2 500	5 000	10 000
Minimum extrapolated long-term relative ultimate ring deflection, %	18	14,3	11,3	9

5.3.4.3 Criteria for failure

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

5.3.4.4 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 10 of these results shall conform to the limits given in Table 13.

Table 13 — Failure time distribution

Failure time, t_u h	Minimum number of failure values
$10 < t_u \leq 1\,000$	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.

5.3.4.5 Test pieces for type testing

The test pieces required by the test detailed in 5.3.4 shall be cut from pipes having the same nominal size, nominal stiffness and nominal pressure class and shall have a length, L_p, conforming to 5.3.1.4.

5.3.5 Initial specific longitudinal tensile strength

5.3.5.1 General

Determine the initial specific longitudinal tensile strength in accordance with ISO 8513:2016, method A or method B using test pieces conforming to 5.3.5.2.

5.3.5.2 Requirement

Where pipes are not required to resist the longitudinal load produced by the internal pressure, the following applies:

a) the average value of the initial specific longitudinal tensile strength, σ_l^* of the test pieces shall not be less than the value, given in Table 14, applicable to the nominal size (DN) of the pipe under test;

b) the average value of the elongation to break of the test pieces shall not be less than 0,25 %.

For pipes required to resist the longitudinal load produced by the internal pressure acting under the relevant end-load conditions, the minimum initial longitudinal specific tensile strength, σ_l^*, in N/mm circumference, shall not be less than the value determined from Formula (5):

$$\sigma_l^* = 25 \times p_{0,i} \times d_m \qquad (5)$$

where

$p_{0,i}$ is the minimum design pressure (in bar) determined in accordance with 5.3.6.1 and Annex A;

d_m is the mean diameter of the pipe tested, in m.

Effects of additional loads, such as longitudinal bending or thermal expansion should also be taken into account.

5.3.5.3 Number of test pieces for type testing

When testing in accordance with ISO 8513:2016, method A, cut five test pieces from each of three different pipes of the same nominal size, nominal stiffness and nominal pressure class.

Table 14 — 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	120
125	75	80	80	95	100	110	120	135
150	80	85	90	105	110	120	130	145
200	85	95	100	115	120	135	150	170
250	90	105	110	130	135	155	175	200
300	95	110	125	145	155	175	200	230
400	105	130	145	175	190	215	250	290
500	115	145	170	205	225	255	300	350
600	130	160	195	235	255	295	350	420
700	140	175	215	265	290	335	400	475
800	155	190	240	295	325	380	450	545
900	165	205	260	320	360	420	505	610
1 000	180	225	290	350	395	465	555	675
1 200	205	255	340	405	465	540	645	790
1 400	230	290	380	455	530	620	745	915
1 600	255	320	430	515	600	700	845	1 040
1 800	280	350	480	570	670	785	940	1 160
2 000	305	385	520	625	740	865	1 040	1 285
2 200	335	415	570	675	810	945	1 140	1 410
2 400	360	450	620	730	880	1 025	1 240	1 530
2 600	385	480	665	785	945	1 110	1 335	1 655
2 800	410	515	710	840	1 015	1 190	1 435	1 780
3 000	435	545	755	890	1 080	1 270	1 535	1 900
3 200	460	575	805	950	1 150	1 350	1 630	2 025
3 400	490	610	850	1 005	1 220	1 430	1 730	2 150
3 600	520	645	895	1 060	1 290	1 515	1 830	2 265
3 800	550	680	940	1 115	1 355	1 595	1 930	2 400
4 000	580	715	985	1 170	1 425	1 675	2 025	2 520

[a] When pipes having a nominal size or pressure other 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.

When testing in accordance with ISO 8513:2016, method B, cut one test piece from each of three different pipes of the same nominal size, nominal stiffness and nominal pressure class.

When pipes having a nominal pressure or size different from those given in Table 14 are tested, obtain the required minimum initial specific longitudinal tensile strength by linear interpolation or extrapolation from the values given for the relevant nominal size.

5.3.5.4 Number of test pieces for quality control test purposes

When testing in accordance with ISO 8513:2016, method A, five test pieces of one pipe shall be used. When testing in accordance with ISO 8513:2016, method B, one test piece of one pipe shall be used.

5.3.6 Initial design and failure pressures for pressure pipes

5.3.6.1 General

For pressure pipes (see 3.12.1), the initial failure pressure shall be determined in accordance with ISO 8521:2009, methods A to F using test pieces conforming to 5.3.6.5. Method A is considered the reference method. However, all methods in ISO 8521 have equal validity when a correlation of any of the methods B to F with method A is established by a comparative test program.

NOTE Testing the initial failure pressure according to ISO 8521:2009, method A on very large samples could be very difficult and costly and, considering the sample size, even dangerous. Therefore, the correlation test program can be done on smaller diameters.

5.3.6.2 Requirement

When tested in accordance with ISO 8521 by one of the methods A to F, using test pieces in accordance with 5.3.6.3, the value of the initial failure pressure calculated in accordance with this clause shall be equal or greater than the value ($p_{0,QC}$) derived using the procedure given in A.6.

$$p_0 \geq p_{0,QC} \tag{6}$$

where

p_0 is the measured initial failure pressure, in bar;

$p_{0,QC}$ is the calculated minimum initial failure pressure, in bar (see A.6).

All the methods described in ISO 8521 result in circumferential tensile wall strength. To compare these results with the requirements given in 5.3.6.2, convert the specific circumferential tensile wall strength into a pressure value by any of the appropriate formulae [see Formulae (7) to (12)]:

$$p_{0,A} = 0{,}02 \times \sigma^{*}_{c,A} / d_m \tag{7}$$

$$p_{0,B} = 0{,}02 \times \sigma^{*}_{c,B} / d_m \tag{8}$$

$$p_{0,C} = 0{,}02 \times \sigma^{*}_{c,C} / d_m \tag{9}$$

$$p_{0,D} = 0{,}02 \times \sigma^{*}_{c,D} / d_m \tag{10}$$

$$p_{0,E} = 0{,}02 \times \sigma^{*}_{c,E} / d_m \tag{11}$$

$$p_{0,F} = 0{,}02 \times \sigma^{*}_{c,F} / d_m \qquad (12)$$

where

$\sigma^{*}_{c,A}$ to $\sigma^{*}_{c,F}$	are the average of the circumferential tensile wall strength values, determined in accordance with ISO 8521, in N/mm;
d_m	is the mean diameter of the pipe tested, in m;
$p_{0,A}$ to $p_{0,F}$	are the initial failure pressures, in bar.

5.3.6.3 Number of test pieces for type testing

When testing in accordance with ISO 8521:2009, method A, use test pieces from three pipes of the same nominal size, nominal stiffness and nominal pressure class.

When testing in accordance with one of ISO 8521:2009, methods B to F, take the appropriate number of test pieces from each of three different samples of the same nominal size, nominal stiffness and nominal pressure class. From each sample, use either one test piece per metre of circumference or five test specimens, whichever gives the greater number of test results.

5.3.6.4 Number of test pieces for quality control test purposes

For testing in accordance with ISO 8521:2009, method A, unless otherwise specified, one test piece shall be used.

Unless otherwise specified, for testing in accordance with one of the ISO 8521:2009, methods B to F, five test pieces shall be taken from the pipe. The average of the five results shall be taken as the result of the test.

5.3.6.5 Dimensions of test pieces

5.3.6.5.1 For method A

The length of the test pieces between the end-sealing devices shall be as given in Table 15.

Table 15 — Length of test pieces for method A

Nominal size **DN**	**Minimum length** mm
≤250	(3 × DN) + 250
>250	DN + 1 000
Lengths less than those shown may be used, provided the end restraints do not have any effect on the result.	

5.3.6.5.2 For method B

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

5.3.6.5.3 For method C

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

5.3.6.5.4 For method D

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

5.3.6.5.5 For method E

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

5.3.6.5.6 For method F

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

5.3.7 Long-term failure pressure

5.3.7.1 General

For pressure pipes (see 3.12.9), determine the long-term failure pressure in accordance with ISO 7509, using air as external environment and using test pieces conforming to 5.3.7.4.

5.3.7.2 Requirement

Using the data obtained from the test performed in accordance with ISO 7509 and the extrapolation procedures detailed in ISO 10928, determine the regression ratio, $R_{R,p}$, and the correction factor C. Pipes shall be designed using the procedure detailed in Annex A to ensure

a) that the minimum long-term failure pressure, $p_{x,min}$, is at least FS_{min} × PN, in bar, and

b) that the minimum long-term design pressure p_x is at least FS_{mean} × PN, in bar.

5.3.7.3 Number of test pieces for determination of the pressure regression ratio, $R_{R,p}$, and the correction factor for the initial failure pressure, C

Take a sufficient number of test pieces for at least 18 failure points to be obtained so that the analysis can be carried out in accordance with ISO 10928.

The correction factor, C, shall be based on a minimum of five test pieces.

5.3.7.4 Length of the test pieces

The length of the test pieces between the end-sealing devices shall conform to Table 15.

5.3.7.5 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 13.

5.4 Marking

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.

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

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

a) a reference to this document, i.e. ISO 10639;

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

c) the stiffness rating in accordance with Clause 4;

d) the pressure rating in accordance with Clause 4;

e) for pipes intended for the conveyance of drinking water, the code-letter "P";

f) the manufacturer's name or identification;

g) the date of manufacture, in plain text or code;

h) the code-letter "R" to indicate that the pipe is suitable for use with axial loading, if applicable.

6 Fittings

6.1 All types

6.1.1 General

In addition to the particular requirements detailed for each type of fitting, all fittings shall conform to the requirements specified in 6.1.2 to 6.1.8.

6.1.2 Diameter series

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

6.1.3 Nominal pressure (PN)

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

6.1.4 Nominal stiffness (SN)

The nominal stiffness rating (SN) of the fitting shall be selected from the values given in Clause 4.

NOTE For a given material, 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 geometry of the fitting. Hence, it is not necessary to test such fittings.

6.1.5 Fitting type

The type of fitting and its components shall be designated whether or not to be suitable for resisting the longitudinal load produced by the internal pressure.

6.1.6 Mechanical characteristics of fittings

6.1.6.1 General

Fittings shall be designed and manufactured in accordance with relevant design practices. Regardless of the design and installation conditions the fittings shall be designed to withstand hoop loads without additional support. Axial loads can be taken either by the fitting and its components or by an external thrust (e.g. anchor blocks or encasements).

Anchor blocks or encasements should be the same design as that was used for the qualification of the fitting. The manufacturer of the fitting shall document as a part of his quality system the fitting design and manufacturing procedures.

6.1.6.2 Test to prove structural design

Fittings of each particular configuration (branch, bend, taper, etc.) shall be tested for conformance to the requirements under hydrostatic pressure for fittings in accordance with ISO 18851.

6.1.6.3 Test temperature

Unless otherwise specified, the test can be performed at any temperature up to 35 °C. For service temperatures over 35 °C and up to including 50 °C type tests shall, unless otherwise specified, be carried out at least at the service temperature +5 °C and −0 °C to establish rerating factors.

6.1.6.4 Non-pressure fittings

For non-pressure fittings PN as used in ISO 18851 is 1 bar.

Pipes and laminates for fabricated non-pressure fittings or moulded non-pressure fittings shall meet the requirements for minimum longitudinal tensile strength of pipes PN ≤ 4 as specified in Table 14.

6.1.6.5 Test piece

A test piece shall comprise a fitting such that the total laying length, *L*, is not less than specified by the manufacturer and to meet the requirements of the test methods described in ISO 18851.

6.1.6.6 Number of test pieces for type testing

For testing in accordance with ISO 18851, unless otherwise specified, one test piece shall be used.

6.1.7 Installed leaktightness 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 standardize 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 document.

6.2 Bends

6.2.1 Classification of bends

6.2.1.1 General

Bends shall be designated in respect of the following:

a) the nominal size (DN);

b) the diameter series, e.g. A, B1, B2;

c) the nominal pressure (PN);

d) the nominal stiffness (SN);

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

f) the fitting angle, in degrees;

g) the bend type, i.e. moulded or fabricated;

h) the 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 Table 3.

6.2.1.3 Bend type

The type of bend shall be designated as either moulded or fabricated, as shown in Figures 2 and 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 5.2.1.4.

6.2.2.2 Fitting angle and angular tolerances

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

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

In the interests of rationalization, preferred values for the fitting angles of bends are 11,25°, 15°, 22,5°, 30°, 45°, 60° and 90°, but fitting angles other than these may be supplied by agreement between the purchaser and the manufacturer.

6.2.2.3 Radius of curvature, *R*

6.2.2.3.1 Moulded bends

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

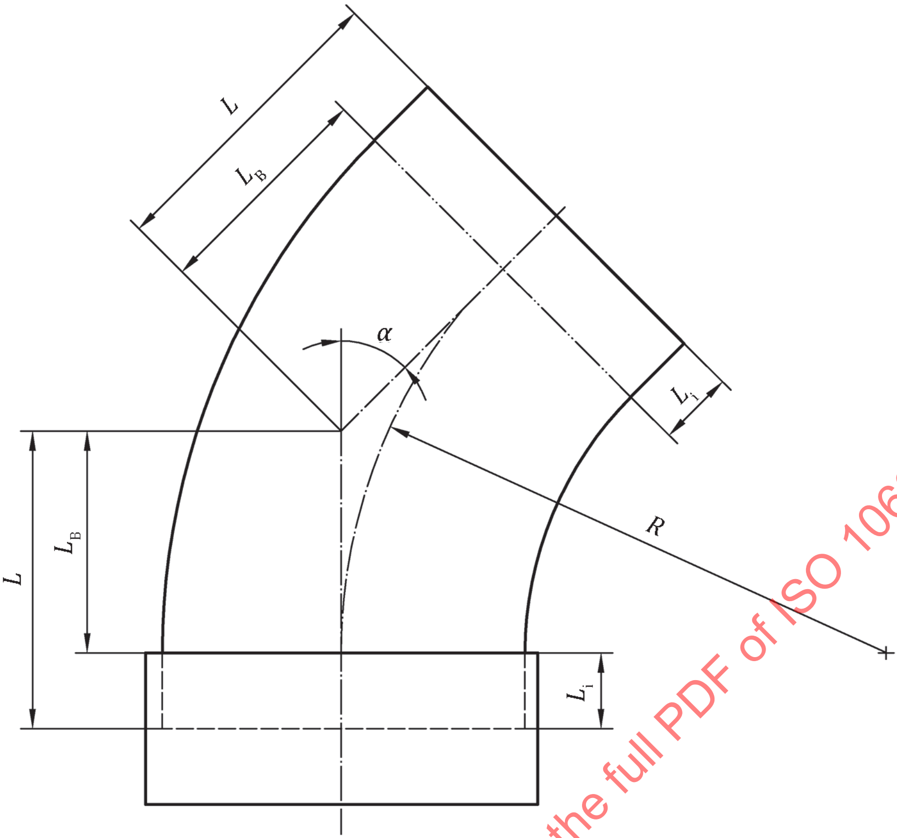
The typical radius of curvature is $R = 1{,}5 \times \text{DN}$, expressed in mm. Where a radius of curvature different to this is required, this may be supplied by declaration and agreement between the purchaser and the manufacturer (see 6.1.8).

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 joint to ensure that external wrapping can be accommodated.

The radius of curvature, *R*, of fabricated bends shall not be less than the nominal size (DN), in mm, of the pipe to which the bend is to be joined in the piping system.

The typical radius of curvature is $R = 1{,}5 \times \text{DN}$ in mm. 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).



Key

L_B body length

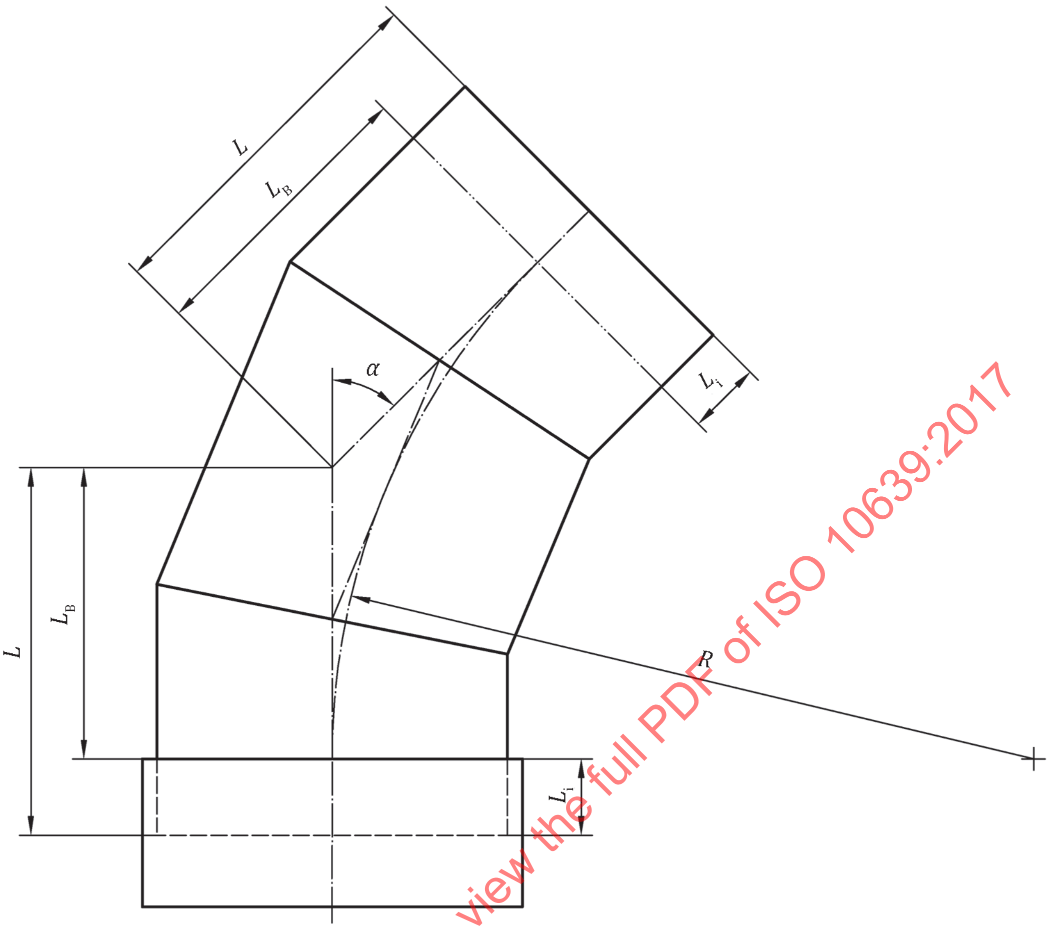
L laying length

L_i insertion depth

α fitting angle

R radius of curvature

Figure 2 — Typical moulded bend



Key

L_B body length

L laying length

L_i insertion depth

α fitting angle

R radius of curvature

Figure 3 — Typical fabricated bend

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 or specified laying length, L (see 6.2.2.4.2), shall conform to the tolerances given in 6.2.2.4.4.

6.2.2.4.2 Laying length

The laying length, L, of the bend shall be taken as the distance from one end of the bend, excluding the spigot insertion depth 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, shall be taken as the body length, L_B, plus the insertion depth, L_i (see Figure 3).

6.2.2.4.3 Body length

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

6.2.2.4.4 Tolerances on laying length

For moulded bends, the permitted deviation of the laying length from the declared value is (L ± 25) mm.

For fabricated bends, the permitted deviation of the laying length from the declared value is [L ± (15 × the number of mitres of the bend)], in mm.

6.3 Branches

6.3.1 Classification of branches

6.3.1.1 General

Branches shall be designated in respect of the following:

a) the nominal size (DN);

b) the diameter series, e.g. A, B1, B2;

c) the nominal pressure (PN);

d) the nominal stiffness (SN);

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

f) the fitting angle, in degrees;

g) the branch type, i.e. moulded or fabricated;

h) the 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 the fitting is to be joined in the piping system and shall be one of the nominal sizes given in Table 3.

6.3.1.3 Fitting angle

The fitting angle, α, which is 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.

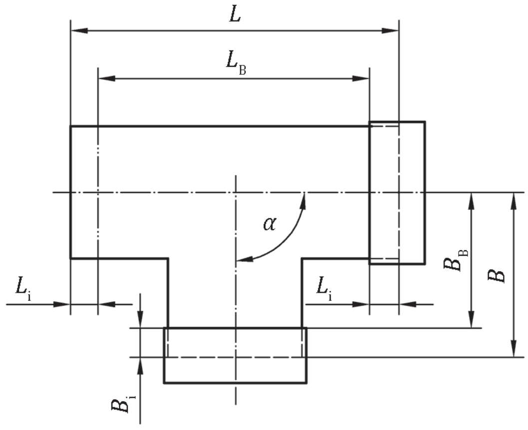
6.3.2 Dimensions and tolerances of branches

6.3.2.1 Tolerances on diameter

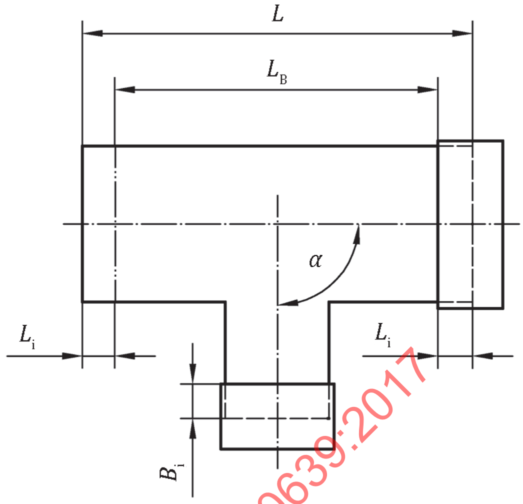
The tolerances on the diameter of the branch at the spigot positions shall conform to 5.2.1.4.

6.3.2.2 Angular tolerances

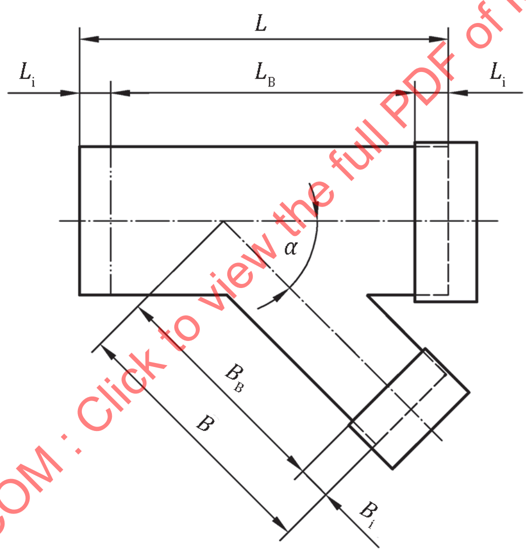
Any deviation from the declared change in direction of a branch shall not exceed either (α ± 0,5)° if the joint is flanged or (α ± 1)° for all other types of joint with which the branch is intended to be used.



a) Equal tee branch



b) Unequal tee branch



c) Unequal oblique branch

Key

α	fitting angle
B	laying length of branch pipe
B_B	offset length of branch pipe
B_i	spigot insertion depth of branch pipe
L	laying length of main pipe
L_B	body length of main pipe
L_i	spigot insertion depth of main pipe

Figure 4 — Typical branches

6.3.2.3 Length

6.3.2.3.1 General

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

The branch pipe shall be designed to resist longitudinal end-loading due to end thrust. The header pipe can be designed either to resist the longitudinal end-load thrust or not.

6.3.2.3.2 Body length

The body length, L_B, of the fitting (see Figure 4) shall be equal to the laying length of the main pipe minus two 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, of the branch pipe (see Figure 4) shall be taken as the distance from the end of the branch pipe, excluding, where applicable, the spigot insertion depth of a socked 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 the branch pipe of equal tee branches shall be 50 % of the body length, L_B.

6.3.2.3.4 Laying length

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

6.3.2.3.5 Tolerances on length

6.3.2.3.5.1 Branches for use with rigid joints

The permissible deviation from the manufacturer's declared offset length and body length of the branch is given in Table 16.

Table 16 — Deviation from declared length of branches for use with rigid joints

Nominal size DN	Limits of deviation from declared length mm
100 ≤ [DN] < 300	±1,5
300 ≤ [DN] < 600	±2,5
600 ≤ [DN] ≤ 1 000	±4,0

6.3.2.3.5.2 Branches for use with flexible joints

The permissible deviation from the manufacturer's declared offset length and body length of the branch is ±25 mm or ±1 % of the laying length, 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) the nominal sizes (DN_1 and DN_2);

b) the diameter series, e.g. A, B1, B2;

c) the nominal pressure (PN);

d) the nominal stiffness (SN);

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

f) the reducer type, i.e. concentric or eccentric;

g) the 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 Table 3.

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 5.2.1.4.

6.4.2.2 Length

6.4.2.2.1 General

The lengths L, L_B and L_T in Figure 5 shall be as declared by the manufacturer and be subject to the tolerances given in 6.3.2.3.5.

6.4.2.2.2 Laying length

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

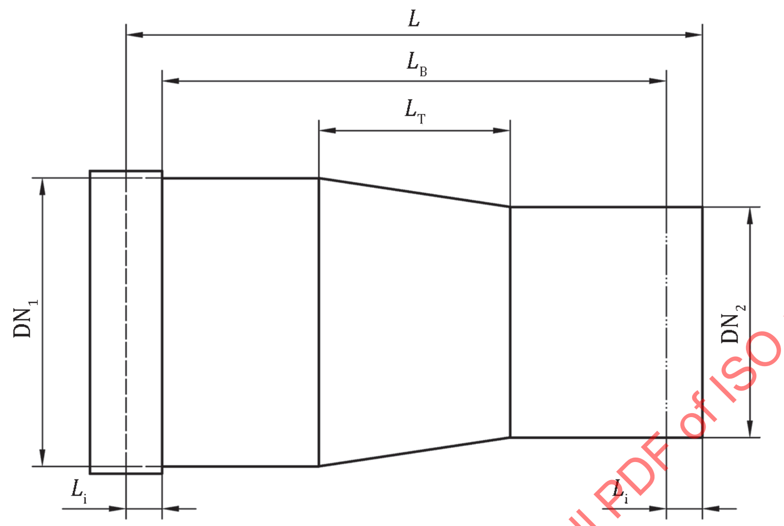
6.4.2.2.3 Body length

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

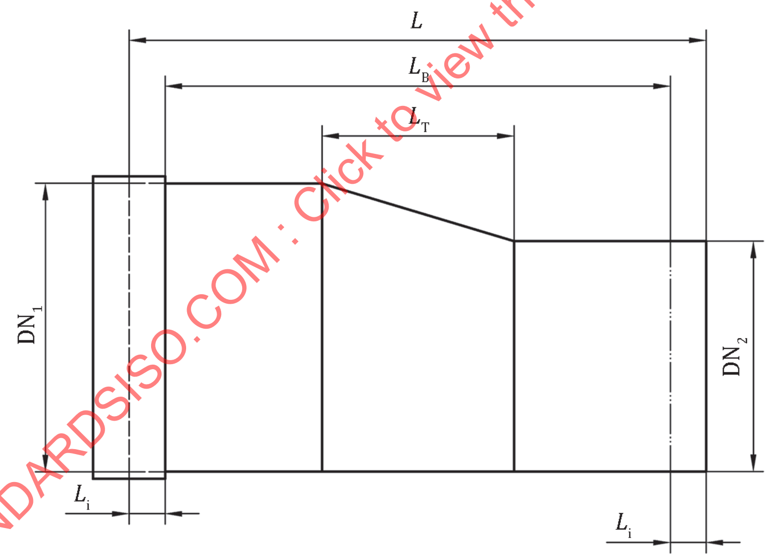
6.4.2.2.4 Length of tapered section

The length, L_T, of the tapered section (see Figure 5) shall not be less than 1,5 × (DN_1 – DN_2), expressed in mm.

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



a) Concentric reducer



b) Eccentric reducer

Key

L laying length
L_B body length
L_T length of tapered section
L_i spigot insertion depth
DN_1 larger nominal size
DN_2 smaller nominal size

Figure 5 — Concentric and eccentric reducers

6.4.2.2.5 Tolerances on laying lengths

6.4.2.2.5.1 Reducers for use with rigid joints

The permissible deviation from the manufacturer's declared laying length, *L*, of the reducer is as given in Table 16 for branches.

6.4.2.2.5.2 Reducers for use with flexible joints

The permissible deviation from the manufacturer's declared laying length, *L*, of the reducer is (L ± 50) mm or (L ± 1) %, whichever is the greater.

6.4.2.3 Mechanical characteristics of tapered-section laminate

To verify the properties of the laminate used in the tapered section, make panels using the same materials and lay-up as used for the tapered section of the reducer.

When tested in accordance with ISO 527-4 or ISO 527-5, as applicable, test pieces taken from the panel 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

The branch pipes can be made of other materials than glass reinforced thermosetting plastics, i.e. it is a common practice to provide saddles that are used for the connection to thermoplastic pipe systems. Saddles are intended for non-pressure applications only.

Saddles shall be designated in respect of the following:

a) the nominal size (DN);

b) the diameter series, e.g. A, B1, B2;

c) the nominal pressure (PN_1);

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

e) the fitting angle, α;

f) the pipe type, if applicable.

6.5.1.2 Nominal size (DN)

The nominal size (DN) of the saddle shall be a combination of the nominal size of the main pipe to which it is to be connected in the pipeline and the nominal size of the branch pipe. The nominal size of the main pipe shall be one of the nominal sizes given in Table 3. The nominal size of the branch pipe shall be one of those given in the appropriate standard for the pipe to which the branch pipe is to be joined.

NOTE The designation DN 600/150 indicates a saddle for connecting a DN 150 branch line to a DN 600 pipeline.

6.5.1.3 Fitting angle

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

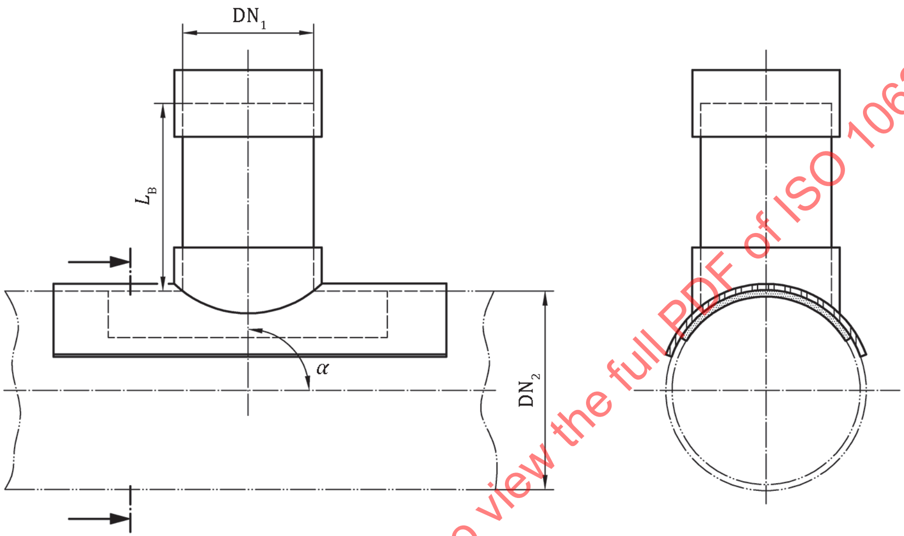
6.5.2 Dimensions of saddles and associated tolerances

6.5.2.1 Tolerance on diameter

The tolerance on the diameter of the branch pipe at the joint position shall conform to 5.2.1.4, 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 of the branch pipe shall not normally be less than 300 mm, although other lengths may be used by agreement between the purchaser and the manufacturer.



Key

DN1 nominal size of branch pipe

DN2 nominal size of main pipe

L_B length of branch pipe

α fitting angle

Figure 6 — Typical non-pressure saddle

6.6 Flanges

6.6.1 Classification of flanges

6.6.1.1 General

Flanged adaptors shall be designated in respect of the following:

a) the nominal size (DN);

b) the diameter series, e.g A, B1, B2;

c) the nominal pressure (PN);

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

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

f) the flange drilling:

   1) reference standard, if applicable;

   2) bolt hole circle;

   3) number of bolt holes;

   4) bolt hole diameter;

   5) bolt size 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 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 Table 3.

6.6.1.3 Flange designation

The mating characteristics of the flange shall conform to the purchaser's requirements, e.g. bolt circle, bolt hole diameter, flat or raised face, flange outer diameter and washer diameter.

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

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

6.6.2 Dimensions and tolerances for 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 5.2.1.4.