

Concrete pipes and fittings, unreinforced, steel fibre and reinforced

ICS 23.040.50; 93.030

National foreword

This British Standard is the UK implementation of EN 1916:2002, incorporating corrigenda December 2003, December 2006 and April 2008. BS EN 1916:2002 supersedes DD 76-2:1983, which is withdrawn. BS EN 1916:2002 together with BS 5911-1:2002 supersedes BS 5911-100:1988 and BS 5911-120:1989, which are also withdrawn. Therefore, BS 5911-1:2002 is for use in conjunction with BS EN 1916:2002 and both came into effect simultaneously. In order not to create barriers to European trade, products under the scope of this British Standard should be specified as conforming to “BS EN 1916:2002 and BS 5911-1:2002 or equivalent”. The foreword of EN 1916:2002 explains why, and under what circumstances, complementary requirements and associated test methods outside the scope of that standard will be needed at national level.

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by CEN corrigendum December 2003 is indicated in the text by AC1 AC1.

EN 1916 is a “harmonized” European Standard and fully takes into account the requirements of the European Commission mandate M131, *Pipes, tanks and ancillaries not in contact with water intended for human consumption*, given under the EU Construction Products Directive (89/106/EEC), and is intended to lead to CE marking.

The UK participation in its preparation was entrusted to Technical Committee B/505, Wastewater engineering.

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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English version

Concrete pipes and fittings, unreinforced, steel fibre and reinforced

Tuyaux et pièces complémentaires en béton non armé,
béton fibré acier et béton armé

Rohre und Formstücke aus Beton, Stahlfaserbeton und
Stahlbeton

This European Standard was approved by CEN on 18 August 2002.

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 Management Centre or to any CEN member.

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

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



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Foreword

This document EN 1916:2002 has been prepared by Technical Committee CEN/TC 165 "Wastewater engineering", the secretariat of which is held by DIN.

It is a companion standard to EN 1917 "Concrete manholes and inspection chambers, unreinforced, steel fibre and reinforced".

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 April 2003, and conflicting national standards shall be withdrawn at the latest by October 2004.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative annex ZA, which is an integral part of this document.

This European Standard includes eleven normative annexes and one informative annex. Annexes A, B, C, D, E, F, G, H, I, J and K are normative, annex ZA is informative.

When the text of this European Standard was approved, complete agreement could not be achieved for all requirements in the existing national specifications of CEN members and so it includes only those requirements and associated test methods for which a consensus could be reached. Consensus was achieved on the requirements for quality control.

NOTE For the time being, for specification purposes, complementary (i.e. non-conflicting) requirements and associated test methods outside the scope of this European Standard (see Table 1) will be needed at national level. In order not to create any barrier to trade, any call for conformity to complementary requirements should always be qualified by incorporating the words 'or equivalent' after the reference to them.

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

1 Scope

This European Standard specifies performance requirements as defined in Table 1 and describes test methods for precast concrete pipes and fittings, unreinforced, steel fibre and reinforced, AC_2 for use in pipelines AC_2 with flexible joints (with seals either integrated in the units or supplied separately) and nominal sizes not exceeding DN 1 750 for units with a circular bore or WN/HN 1 200/1 800 for units with an egg-shaped bore, for which the main intended use is the conveyance of sewage, rainwater and surface water under gravity or occasionally at low head of pressure, in pipelines that are generally buried.

Provision is made for the evaluation of conformity of units to this European Standard.

Marking conditions are included.

Table 1 — Specified characteristics and exclusions

Characteristic	Exclusions
Materials	Specifications where relevant European Standards have not yet been published.
Concrete	Types and value(s) of minimum content of cement plus any pozzolanic or latent hydraulic addition, according to serviceability conditions.
Finish	Limitations on size of blemishes.
Geometrical characteristics	— nominal sizes; — internal dimensions with tolerances; — tolerances on the wall thickness; — tolerances on the internal barrel length; — deviation from straightness and from squareness of ends.
Joints and joint seals	— the choice of method from those listed in 4.3.4.2 for demonstrating the durability of joints; — provisions for interchangeability; — requirements for additional testing where watertightness of the joint assembly is dependent upon an internal pressure.
Crushing strength	Specific strength classes and corresponding minimum crushing loads.
Longitudinal bending moment resistance	None.
Watertightness	None.
Special requirements for steel fibre concrete pipes, reinforced concrete pipes, jacking pipes and pipes with inlet	— strength class exceeding class 165 for steel fibre and reinforced concrete units; — value(s) of minimum concrete cover for reinforced concrete units; — limitations on the spacing of reinforcement; — relationship between internal and external reinforcement cages; — requirements for weld testing of reinforcement cages; — tolerances on the external diameter of jacking pipes; — jacking pipe collars of materials other than weldable structural steel plate, stainless steel plate or reinforced plastics.
Marking	— symbols or letters for identifying the material of a unit; — symbols or letters for identifying serviceability conditions other than normal conditions as stated in 4.3.8.
NOTE Provisions for the following are also outside the scope of this European Standard: - units with nominal sizes greater than DN 1 750 or WN/HN 1 200/1 800; - units with a bore other than circular or egg-shaped; - lifting facilities; - resistance to high pressure jetting; - circumstances other than those stated; - any receiving inspection by, or on behalf of, the purchaser.	

2 Normative references

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

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

EN 10002-1, *Metallic materials - Tensile testing - Part 1: Method of test at ambient temperature*.

EN ISO 4287, *Geometrical product specification (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters (ISO 4287:1997)*.

EN ISO 4288, *Geometrical product specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture (ISO 4288:1996)*.

ISO 3384, *Rubber, vulcanized or thermoplastic - Determination of stress relaxation in compression at ambient and at elevated temperatures*.

ISO 4012, *Concrete - Determination of compressive strength of test specimens*.

ISO 10544, *Cold reduced steel wire for the reinforcement of concrete and the manufacture of welded fabric*.

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1

pipe

hollow precast concrete unit of uniform bore throughout its internal barrel length, except in the vicinity of the joint profile, manufactured with or without base. Joints of units are preformed as spigot and socket and incorporate one or more joint seals

3.1.2

unreinforced concrete pipe

pipe that does not contain structural steel reinforcement or steel fibre strengthening

3.1.3

steel fibre concrete pipe

pipe that is structurally strengthened by steel fibres

3.1.4

reinforced concrete pipe

pipe that is structurally reinforced with one or more steel cages, suitably positioned to resist tensile stresses in the pipe wall

3.1.5

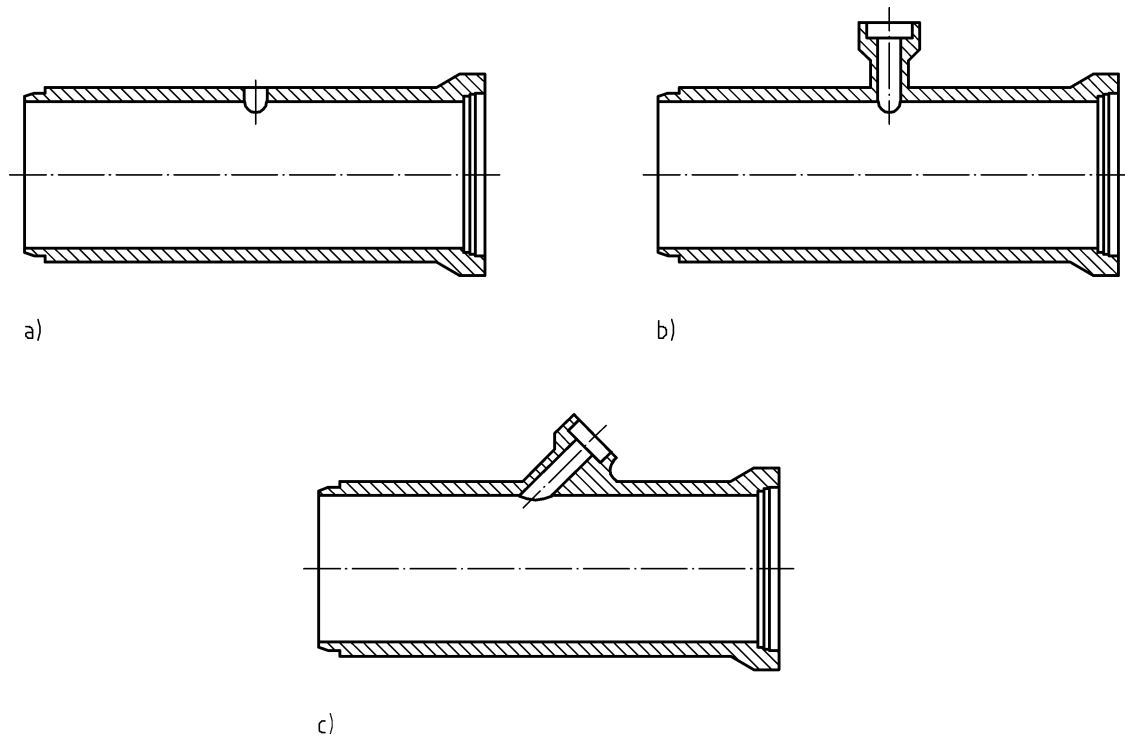
jacking pipe

unreinforced, steel fibre or reinforced concrete pipe, incorporating a flexible joint within the wall thickness, rebated or butt-ended with collar and which is intended for jacking

3.1.6

pipe with inlet

pipe as shown typically in Figure 1a, with one or more inlet-holes provided during or after manufacture



Key

- a) Typical pipe with inlet
- b) Typical junction with right-angled inlet
- c) Typical junction with angled inlet

NOTE Types of joint other than those shown are available.

Figure 1 — Junctions and pipes with inlet

3.1.7

circular pipe

pipe whose barrel cross-section in a plane perpendicular to its longitudinal axis is described by two concentric circles

3.1.8

fitting

adaptor, bend, connecting pipe, junction, $\boxed{AC_2}$ pipe with inlet $\boxed{AC_2}$ or taper (reducer)

3.1.9

adaptor

fitting that provides for connections to structures, to pipes of other materials, or to valves

3.1.10

bend

fitting that provides for a change of alignment within a pipeline

3.1.11

connecting pipe

short pipe with plain, spigot or socket ends

3.1.12

junction

unit as shown typically in Figures 1b and 1c

3.1.13

taper (reducer)

fitting whose bore is reduced along its internal barrel length

3.1.14

unit

pipe or fitting

3.1.15

type

units of the same manufacturing process, cross-section and material (unreinforced, steel fibre or reinforced concrete)

3.1.16

nominal size

numerical designation of the size of a unit, which is a convenient integer approximately equal to the manufacturing dimension(s) in millimetres; for a circular unit it is the internal diameter (DN), for a unit with an egg-shaped bore it is the internal width/height (WN/HN)

3.1.17

internal barrel length

length between the base of the socket and the end of the spigot of a unit as shown in Figure 2

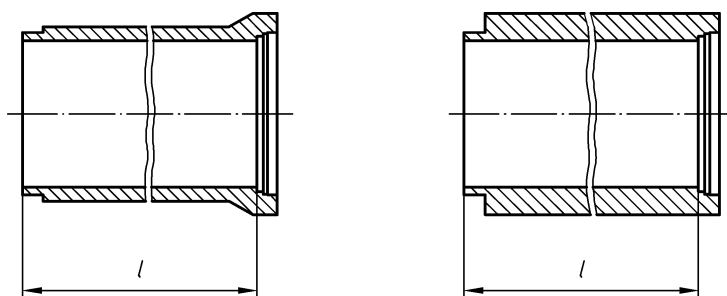


Figure 2 — Internal barrel length

3.1.18

integrated seal

seal incorporated into a unit during manufacture

3.1.19

strength class

minimum crushing load in kilonewtons per metre, divided by one thousandth of either a unit's nominal size (DN) or nominal width (WN)

3.1.20

minimum crushing load

load that a unit is required to withstand

3.1.21

ultimate (collapse) load

maximum load reached by the testing machine during a crushing test (i.e. when the load-recording facility does not show any further increase)

3.1.22

proof load

load that a steel fibre or reinforced concrete unit is required to withstand with a defined limit on cracking

3.1.23

concrete cover

actual thickness of concrete over any reinforcement

3.1.24

characteristic value

that value of a characteristic beyond which, with a 75 % confidence level, 5 % of the population of all possible measurements of the specified material may fall

NOTE A 75 % confidence level is recommended in ISO 12491.

3.1.25

inspection

process of measuring, examining, testing, gauging or otherwise comparing a unit with the applicable requirements

3.1.26

routine inspection

inspection by sampling at prescribed intervals in order to determine the acceptability of the items represented by the samples

3.1.27

continuous inspection

routine inspection according to a sampling plan which indicates the number of units from a specific process evaluated to have attained, and continue to be in, a state of control, and the associated acceptance criteria

3.1.28

sample

one or more units selected at random without regard to their quality

3.1.29

group

clearly identifiable collection of units, manufactured using the same process; units of different nominal sizes may be grouped together, provided that the ratio of largest to smallest nominal size is not greater than 2

3.1.30

specific process

manufacture of units of the same nominal size, strength class and type, essentially under the same conditions over any period of time

3.1.31

state of statistical control

state in which the variations among the observed sampling results can be attributed to a system of chance causes that does not appear to change with time

3.1.32

switching rules

rules that govern the decision to increase or decrease the severity of inspection

3.2 Symbols

Table 2 gives the meanings, units and references of symbols used in this European Standard.

Table 2 — Symbols

Symbol	Meaning	Unit	Reference
A_c	area of joint surface in compression	square metres	B.2, B.3.1, B.3.2, B.3.3, B.4.2
A_w	absorption of water by immersion	per cent	F.5
a_l	lever arm length	metres	D.3.2, D.4.1
a_s	distance between additional shear load and centre of joint seal	metres	E.5.3
b_t	effective tightened width	millimetres	4.3.4, A.1, A.2.5, A.2.6, A.2.7, A.3.2, A.3.3
C	constant equal to 0,013	kilonewtons per metre	4.3.6
d_e	external diameter of joint surface	metres	B.2, B.3.1, B.3.3, B.4.1, B.4.2
d'_e	diameter at front of rebated spigot	metres	B.3.1
d_i	internal diameter of joint surface	metres	B.2, B.3.1, B.3.3, B.4.1, B.4.2
d'_i	diameter of base of rebated spigot	metres	B.3.1
d_{so}	nominal internal diameter of socket	millimetres	4.3.4, A.1, A.2.5, A.2.7, A.3.2, A.3.3
d_{sos}	nominal internal diameter of socket at shear stop provision	millimetres	A.1, A.3.2, A.3.3
d_{sp}	nominal external diameter of spigot	millimetres	4.3.4, A.1, A.2.5, A.2.7, A.3.2, A.3.3
d_{sps}	nominal external diameter of spigot at shear stop provision	millimetres	A.1, A.3.2, A.3.3
E	modulus of elasticity	megapascals	A.1, A.3.2, A.3.3
e	load reduction (eccentricity) factor	-	B.2, B.3.3, B.4.2
F	measured tightening force	newtons	A.1, A.2.5, A.2.6, A.2.7
F'	jacking load applied on site	meganewtons	B.2, B.4.2
F_a	effective crushing test result	kilonewtons per metre	C.5, I.3.2, I.4.1
F_c	proof load	kilonewtons per metre	5.2.3, C.1, C.4.4, I.3.2, I.3.4, I.4.1
F_{cj}	maximum jacking load in closed joint situation	meganewtons	B.2, B.3.1, B.3.2, B.3.3, B.4.2
F_d	distributed unit force assumed to result from application of a specific shear load	newtons per millimetre	A.1, A.2.5, A.2.7
F_e	tightening force per unit length	newtons per millimetre	A.1, A.3.2, A.3.3
F_j	design jacking load	meganewtons	5.3.4, B.2, B.3.1, B.3.2, B.4.1, B.4.2
$F_{j\max}$	maximum theoretical design jacking load	meganewtons	B.2, B.3.1, B.3.2, B.4.1, B.4.2
F_{oj}	maximum jacking load in open joint situation	meganewtons	B.2, B.3.1, B.3.3, B.4.2

Table 2 (continued)

Symbol	Meaning	Unit	Reference
F_n	minimum crushing load	kilonewtons per metre	4.3.5, 5.1.2, 5.2.3, C.1, C.4.4, I.1.1, I.3.2, I.4.1, I.4.2, K
F_s	shear load	kilonewtons	4.3.4, A.1, A.2.5, A.2.7, E.5.3, E.5.4
F_u	ultimate (collapse) load	kilonewtons per metre	5.1.2, C.1, C.4, I.1.1, I.3.2, I.3.4, I.4.1, I.4.2, K
f	mean pressure on test piece	megapascals	4.3.4, A.1, A.2.6, A.2.7, A.3.2, A.3.3
f_{bt}	bending tensile stress in concrete	megapascals	K
f_{ch}	characteristic bending tensile stress in concrete	megapascals	K
f_{ck}	characteristic concrete compressive strength	megapascals	5.3.2, B.2, B.3.1, B.3.2, B.3.3, B.4.1, B.4.2
f_{des}	design bending tensile stress in concrete	megapascals	K
G	test per group	-	H
h_j	nominal height of joint seal	millimetres	4.3.4, A.1, A.2.5, A.2.7, A.3.3
h_m	height of applied joint seal	millimetres	A.1, A.2.5, A.2.7, A.3.2, A.3.3
J	test per 500 produced per group, with a minimum of one per month	-	H
K	composite tolerance factor	-	A.1, A.3.2, A.3.3
k	acceptability constant	-	I.4.1, I.4.2, K
k_b	conversion factor for crushing test	-	C.5
l	internal barrel length	metres	3.1, 4.3.6, C.4.1, C.5
l_b	distance between bottom bearing strip centres	metres	D.3.3, D.4.2
l_l	distance between centres of adjacent joint seals	metres	E.5.3
l_s	support span	metres	D.3.2, D.4.1
l_t	length of test piece	millimetres	A.1, A.2.6, A.2.7
l_1	length of joint seal before application	millimetres	A.1, A.2.5, A.2.7, A.3.3
l_2	length of joint seal after application	millimetres	A.1, A.2.5, A.2.7, A.3.3
M	moment (BMR value)	kilonewtons metre	4.3.6, D.4.1, D.4.2
m_1	constant mass of immersed sample	kilograms	F.4.1, F.5
m_2	constant mass of dry sample	kilograms	F.4.2, F.5
N	test per type and nominal size	-	H
n	number of consecutive samples	-	I.4.1, I.4.2, K

Table 2 (continued)

Symbol	Meaning	Unit	Reference
P	measured crushing load	kilonewtons	C.4.1, C.5
P^*	effective self-weight of load bearer	kilonewtons	C.5
P_b	total applied bending load	kilonewtons	D.3.2, D.3.3, D.4.1, D.4.2
Q	quality statistic	-	I.4.2, K
R	routine inspection test	-	6.1, C.1
R_a	arithmetical mean deviation of surface finish	micrometres	A.1, A.2.3
R_s	additional shear load	kilonewtons	E.5.3
r	radius of bend	metres	4.3.3
r_m	mean radius of pipe	millimetres	K
S	test per type, nominal size and strength class	-	H
s	estimated standard deviation	-	I.4.1, I.4.2, K
T	initial type test	-	6.1, C.1
t	design wall thickness	millimetres	H, I.3.2
t_{act}	mean measured wall thickness at crown of pipe	millimetres	K
t_{min}	minimum permissible wall thickness at crown of pipe	millimetres	K
W	test per type, nominal size and same wall thickness	-	H
W_w	weight of pipe filled with water	kilonewtons	E.5.3
x	measured value	-	I.4.2, K
$\bar{x}$	arithmetic sample mean	-	I.4.1, I.4.2, K
Y	test per type, nominal size and strength class produced, per 1 000, with a minimum of one per type and year	-	H
z	diametrical extent of compression in joint segment	metres	B.2, B.3.1, B.3.3, B.4.2
α	angle subtended by a bend	degrees	4.3.3
β	included testing angle	degrees	C.4.1
Δd_{so}	tolerance from internal socket diameter	millimetres	A.2.5, A.2.7, A.3.2, A.3.3
Δd_{sos}	tolerance from internal diameter of socket at shear stop provision	millimetres	A.3.2, A.3.3
Δd_{sp}	tolerance from external spigot diameter	millimetres	A.2.5, A.2.7, A.3.2, A.3.3
Δd_{sps}	tolerance from external diameter of spigot at shear stop provision	millimetres	A.3.2, A.3.3
Δh_j	tolerance from height of joint seal	millimetres	A.2.5, A.2.7, A.3.2, A.3.3
$\Delta \delta_{min}$	change from minimum deformation δ_1 as a result of shear load	per cent	A.1, A.2.5, A.2.7

Table 2 (continued)

Symbol	Meaning	Unit	Reference
$\Delta\delta_{\max}$	change from maximum deformation δ_2 as a result of shear load	per cent	A.1, A.2.5, A.2.7
δ_1	minimum deformation, ignoring shear load	per cent	4.3.4, A.1, A.2.5, A.2.7, A.3.2
δ_2	maximum deformation, ignoring shear load	per cent	4.3.4, A.1, A.2.5, A.2.6, A.2.7, A.3.2
$\delta_{\max}$	maximum deformation	per cent	4.3.4, A.1, A.2.5, A.2.6, A.3.2, A.3.3
$\delta_{\min}$	minimum deformation	per cent	A.1, A.2.5, A.2.6, A.2.7, A.3.2, A.3.3
ε	relative circumferential stretching of applied joint seal	-	A.1, A.2.5, A.2.7, A.3.3
σ	known standard deviation	-	I.4.1, I.4.2

4 General requirements

4.1 Materials

4.1.1 General

Materials under the scope of this European Standard shall be as listed in Table 3.

NOTE Where relevant European Standards have not yet been published, complementary requirements for the reference specifications of materials will be needed. These should take the form of national standards or, in the absence of these, regulations or provisions valid in the place of use of the units.

Table 3 — Materials under the scope of this European Standard

Material	Supplementary requirements to the reference specification
Cements	None.
Aggregates	Aggregates shall not contain harmful constituents in such quantities as may be detrimental to the setting, hardening, strength, watertightness or durability of the concrete, nor cause corrosion of any steel. It is permissible for the manufacturer to modify standard gradings to suit the manufacturing process.
Mixing water	Mixing water shall not contain harmful constituents in such quantities as may be detrimental to the setting, hardening, strength, watertightness or durability of the concrete, nor cause corrosion of any steel. ^a
Admixtures	Admixtures, when used, shall not impair the durability of the concrete, nor cause corrosion of any steel.
Additions	Additions, when used, shall not contain harmful constituents in such quantities as may be detrimental to the setting, hardening, strength, watertightness or durability of the concrete, nor cause corrosion of any steel.
Steel fibres	Steel fibres shall: - be manufactured from hard drawn steel wire and having a characteristic tensile strength of not less than 1 000 MPa (N/mm ²) when determined in accordance with EN 10002-1; - have a shape and/or surface texture that ensures their mechanical anchorage in the concrete.
Reinforcing steel	Reinforcing steel shall be weldable where welding is to be carried out. It is permissible for reinforcing steel to be plain, indented, profiled or ribbed. The same materials shall be used in the manufacture of any welded fabric. ISO 10544 shall be used in the absence of another reference specification for reinforcing steel.
Joint seals	See 4.1.2.
Jacking pipe collars (including welding, if ferrous)	See also 5.3.1.2.
^a Drinking water from public supply is generally suitable for the manufacture of concrete.	

4.1.2 Joint seals

Joint seals shall conform to EN 681-1 and to the durability requirements in 4.3.4. They shall be supplied by the pipe manufacturer either integrated in the unit or supplied separately.

4.2 Concrete

4.2.1 Concrete materials

Only materials as described in 4.1.1 shall be used.

4.2.2 Concrete quality

The concrete in any unit shall be dense, homogeneous and conform to the requirements of 4.2.3, 4.2.4 and 4.2.6.

4.2.3 Water content of concrete

4.2.3.1 General

Concrete shall have such a composition that the ratio of water to cement plus any pozzolanic or latent hydraulic addition in the fully compacted state is consistent with the serviceability conditions in 4.3.8.

4.2.3.2 Requirement for water/cement ratio

The ratio of water to cement plus any pozzolanic or latent hydraulic addition in the fully compacted state shall not be greater than 0,45.

4.2.4 Cement content of concrete

Concrete shall have such a composition that the minimum content of cement plus any pozzolanic or latent hydraulic addition in the fully compacted state is consistent with the serviceability conditions in 4.3.8.

4.2.5 Chloride content of concrete

4.2.5.1 General

The maximum amount of chloride ion in the concrete shall be evaluated by calculation.

4.2.5.2 Requirement for chloride content

The calculated chloride ion content of the concrete shall not exceed the relevant value given in Table 4.

Table 4 — Maximum chloride content of concrete

Type of concrete	Cl ⁻ by mass of cement
Unreinforced	1,0 %
Steel fibre	0,4 %
Reinforced	0,4 %

4.2.6 Water absorption of concrete

4.2.6.1 General

The water absorption of the concrete shall be tested in accordance with 6.7.

4.2.6.2 Absorption requirement

The water absorption of the concrete shall not exceed 6 % by mass.

4.3 Units

4.3.1 General

Units shall conform to the following requirements at the time of delivery.

4.3.2 Finish

Functional surfaces of joint profiles shall be free from irregularities that would preclude a durable watertight assembly.

Crazing within the cement-rich layer, shrinkage or temperature hairline cracks with a surface width not exceeding 0,15 mm and, for reinforced concrete pipes, residual cracks caused by testing and having the same limiting surface width, are permissible. At the manufacturer's discretion it is permissible to soak a unit for a maximum of 28 hours before measuring any crack widths.

Units with cracks other than those described above do not conform to this European Standard.

After any final treatment, a unit shall conform to all relevant requirements of this European Standard.

4.3.3 Geometrical characteristics

4.3.3.1 Internal barrel length

The internal barrel length of a pipe shall conform to that stated in the factory documents.

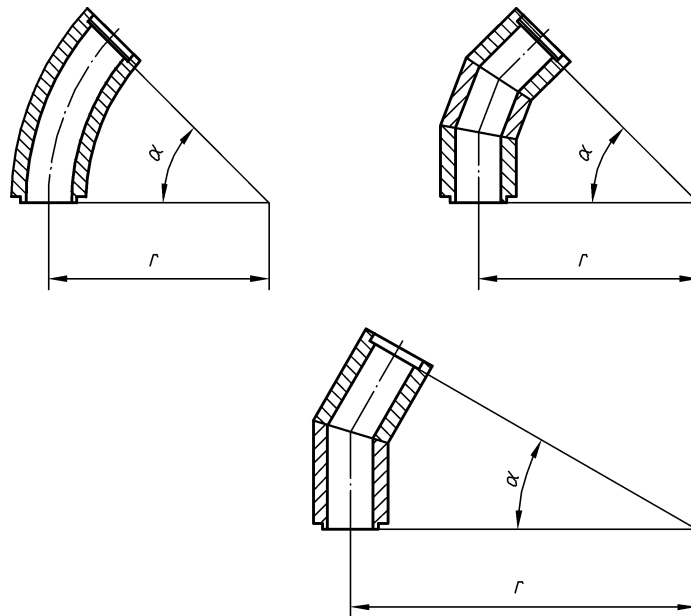
The internal barrel length of circular pipes up to and including DN 250 shall not exceed six times their external diameter, unless conforming to the requirements of 4.3.6.

4.3.3.2 Tolerances on joint assemblies

The profile of a joint shall conform to the corresponding design dimensions and tolerances stated in the factory documents. The tolerances stated for each joint profile and the maximum permissible tolerances on the seal(s) (which shall be not greater than that specified in EN 681-1) as stated in the factory documents shall be taken into account when calculating the relative deformation of the seal(s) in accordance with 4.3.4. The effect of any other dimensional tolerances that affect the functioning of the joint shall be taken into account, as appropriate.

4.3.3.3 Bends

Bends shall be manufactured as shown typically in Figure 3, either cast as one piece or fabricated from cut lengths of pipe conforming to this European Standard that have been bonded together with concrete or special mortar.



NOTE The illustrations show rebated joints. Spigot and socket joints are also available.

Figure 3 — Typical bends

4.3.4 Joints and joint seals

4.3.4.1 General

A joint shall comprise a spigot, socket (whether in-wall, as described in 5.3.1, or not) and joint seal(s) as described in the factory documents, be watertight according to 4.3.7 and shall be shown to conform to the following criteria, as appropriate, taking into account the most unfavourable combination of permitted tolerances.

A joint shall withstand the forces caused by the compression of the joint seal(s) when assembled and an internal hydrostatic pressure according to E.5.

Inlets or inlet-holes shall be provided with seals which satisfy the specification for the connecting component.

4.3.4.2 Durability of joints

4.3.4.2.1 General

A joint shall be shown to conform to the criteria in one of the following methods, taking into account the most unfavourable combination of permitted tolerances. Methods 1, 2 and 3 also take the shear load F_s into account, Method 4 does not.

NOTE 1 Methods 1, 2 and 3 are considered to be equivalent.

NOTE 2 Method 4 is only suitable where the ground and installation conditions are known to be such that the joint can safely be designed with no provision for shear load. In a European context, these conditions are likely to be rare.

Method 1

The minimum contact width b_t over which the seal is effective in an assembled joint, the mean pressure f across any zone of the seal involved in the sealing function and the maximum deformation $\delta_{\max}$ shall be evaluated in accordance with annex A. The zone of the seal involved in the sealing function shall be stated in the factory documents.

Method 2

- a) the maximum deformation $\delta_{\max}$ of the joint seal (whether integrated or not) in an assembled joint shall be evaluated in accordance with annex A. The zone of the seal involved in the sealing function shall be stated in the factory documents.
- b) the routine test for watertightness shall be as specified in E.5.4.

Method 3

In addition to the joint assembly test in E.5, a test in accordance with E.5.3 shall be carried out, immediately after which:

- the internal hydrostatic pressure shall be reduced to zero;
- at the manufacturer's discretion the infilling water shall be emptied;
- the shear load F_s shall continue to be applied for a further period of three calendar months, after first making any necessary adjustments to the loading arrangements in accordance with Figure E.1 as a result of emptying the infilling water;
- an internal hydrostatic pressure shall be re-applied in accordance with E.5.3 (after re-filling the unit if necessary and ensuring that the loading arrangements are in accordance with Figure E.1) and maintained for a period of 15 minutes, during which time the joint assembly shall be evaluated for conformity to 4.3.7, before reducing the internal pressure to zero;
- a record shall be made of whether the joint assembly conformed to the specified requirement.

Where pipes have different nominal sizes but identical joint profiles, an additional test as above relative to the largest size shall be accepted as representing all those sizes.

Method 4

The following shall be calculated in accordance with A.3 for an assembled joint:

- the minimum deformation δ_1 of the joint seal;
- the maximum deformation δ_2 of the joint seal;
- the minimum contact width b_1 over which the seal is effective.

4.3.4.2.2 Limiting criteria

Method 1

When a joint conforming to the surface finish requirements of 4.3.2 for joint profiles is assembled, the seal shall be effective over a width b_1 which is at least 50 % of the nominal radial annular space and the mean pressure f across any zone of the joint seal involved in the sealing function shall be not less than 0,15 Mpa (N/mm²). For integrated seals cast into the concrete the effective width and mean pressure shall be evaluated relative to the opposite face of the joint profile, but for all other seals both faces shall be considered. The relevant test method specified in A.2 shall apply.

NOTE 1 The "nominal radial annular space" is one half of the difference between the nominal internal diameter of the socket d_{so} and the nominal external diameter of the spigot d_{sp} .

NOTE 2 A joint assembly has to remain watertight throughout its working life and a significant factor in achieving this is that the physical characteristics of the installed seal are sustained at or above acceptable levels. In particular, stress relaxation of the rubber causes a decrease with time of the stress imposed on the seal by the constant strain, so initial values of limiting criteria have been set high enough to ensure continued performance throughout the joint's working life. In addition, the

deformation of joint seals is limited to 65 % of their initial height, whether or not they have mechanical means for limiting such deformation.

Where pipes have different nominal sizes but identical joint profiles and joint seals, a test in accordance with A.2 relative to the largest size shall be accepted as representing all of those sizes.

As an alternative to testing a section of joint seal, and at the pipe manufacturer's discretion, it is permissible to calculate the foregoing limiting criteria for a seal within an assembled joint in accordance with A.3, provided that all of the following conditions are met:

- the seal has a circular or other convex cross-section;
- the seal has no enclosed void (at least in the zone involved in the sealing function);
- the seal is used in a joint having mechanical means for limiting deformation of the seal to a maximum of 65 % of its initial height.

Method 2

When a joint conforming to the surface finish requirements of 4.3.2 for joint profiles is assembled, the maximum deformation $\delta_{\max}$ of the joint seal as evaluated according to annex A shall be limited to 65 % of its nominal height h_i .

Method 4

The seal shall have a circular or other convex cross-section and no enclosed void. When a joint conforming to the surface finish requirements of 4.3.2 for joint profiles is assembled, the following limiting criteria shall be met:

- the minimum deformation δ_1 shall be 25%;
- the maximum deformation δ_2 shall be 50%;
- the seal shall be effective over a width b_t of not less than 5 mm.

The foregoing criteria for a seal within an assembled joint shall be calculated in accordance with A.3.

4.3.5 Crushing strength

A pipe shall withstand the minimum crushing load F_n corresponding to its nominal size and strength class when tested in accordance with 6.4. For steel fibre and reinforced concrete pipes, see also 5.1.2 and 5.2.3 respectively.

4.3.6 Longitudinal bending moment resistance

4.3.6.1 General

The longitudinal bending moment resistance of a circular pipe up to and including DN 250 and having an internal barrel length greater than six times its external diameter shall be tested in accordance with 6.5.

4.3.6.2 Evaluation

The longitudinal bending moment resistance of a pipe shall be not less than that given by the following formula when tested as required by 4.3.6.1:

$$M = C \times DN \times l^2$$

where

M is the longitudinal bending moment resistance, in kilonewtons metre;

C is a constant equal to 0,013 kilonewtons per metre;

DN is the nominal size;

l is the internal barrel length, in metres.

NOTE Where the intended place of installation of a pipeline requires additional beam strength (e.g. a pipeline on piles), a specific structural design should be carried out.

4.3.7 Watertightness

When tested in accordance with 6.6 each unit or joint assembly shall not show any leakage or other visible defects during the test period; moisture adhering to the surface shall not constitute leakage. Units having a design wall thickness greater than 125 mm shall not be subjected to the hydrostatic test.

Where the same design of joint is used on pipes and fittings, at the manufacturer's discretion it is permissible to perform the tests for angular deflection and shear load (separately or combined) solely on pipes.

4.3.8 Serviceability

Units conforming to this European Standard are at least suitable for use in humid conditions and a slightly aggressive chemical environment (i.e. normal conditions for domestic sewage and treated industrial effluent, and for most soils and groundwaters). Special attention needs to be paid if more severe conditions are expected, primarily to the cement plus any pozzolanic or latent hydraulic addition in the concrete.

NOTE Definitions of "slightly aggressive" and more severe chemical environments can be found in national provisions for concrete.

4.3.9 Durability

The durability of installed units and their joints is specifically ensured by the following requirements:

- a maximum water/cement ratio of the concrete (see 4.2.3);
- a maximum chloride content of the concrete (see 4.2.5);
- a maximum water absorption of the concrete (see 4.2.6);
- conformity to the criteria in one of four methods for demonstrating the durability of joints (see 4.3.4.2);
- a minimum concrete cover in reinforced units (see 5.2.2);
- special requirements for jacking pipes (see 5.3.1.2 and 5.3.3).

5 Special requirements

Units shall conform to the following special requirements at the time of delivery.

5.1 Steel fibre concrete units

5.1.1 Steel fibre content

The amount of steel fibres introduced into the concrete shall be not less than that stated in the factory documents.

5.1.2 Crushing strength

A steel fibre concrete pipe shall conform to the following sequence of test requirements:

- it shall withstand a proof load of $0,67 F_n$ appropriate to its nominal size and strength class for one minute without showing any crack;
- the load shall be taken to ultimate (collapse) load F_u which shall be greater than F_n ;
- after the sustained load has fallen to 95 % or less of the ultimate (collapse) load it shall be released, then reapplied to $0,67 F_n$ and supported for one minute.

5.2 Reinforced concrete units

5.2.1 Reinforcement

The reinforcement shall conform to 4.1.1 and the factory documents.

The reinforcement of pipes shall relate to the appropriate minimum crushing strength according to their nominal size and strength class. The minimum percentage of reinforcement, relative to the longitudinal cross-sectional area of the barrel, shall be 0,4 % for plain steel and 0,25 % for indented, profiled or ribbed steel.

It is permissible for one or more cages of reinforcement to be used, either helically wound or as concentric hoops, or fabricated from steel fabric, securely connected.

Elliptical or other non-circular reinforcement cages are permissible. In this case a durable indication on the crown of the unit and incorporating means of locating the reinforcement shall be provided, at least inside the unit.

Circumferential and longitudinal (if any) steel bars shall be assembled by welding or splicing in order to control spacing and the shape of the reinforcement cage(s). The circumferential reinforcement shall be spaced at regular distances throughout the length of the unit. The reinforcement cage(s) shall be maintained in the designed shape.

5.2.2 Concrete cover

The minimum concrete cover shall be consistent with the serviceability conditions described in 4.3.8.

5.2.3 Crushing strength

In addition to the requirement in 4.3.5 a reinforced concrete pipe shall also withstand a proof (crack) load F_c of $0,67 F_n$ when tested in accordance with 6.4, with any stabilized surface crack in the tensile zones of the concrete being not greater than 0,3 mm over a continuous length of 300 mm or more.

5.2.4 Conformity of proof (crack) load tested pipes

Reinforced concrete pipes $\overline{AC_2}$ that have been $\overline{AC_2}$ tested only to proof (crack) load in accordance with 6.4 and meeting the requirements of 5.2.3 conform to this European Standard.

NOTE Taking the necessary installation conditions into consideration, the contractor could decide to use a reinforced concrete jacking pipe (see 5.3) subjected successfully to the proof (crack) load crushing test to complete a jacked pipeline.

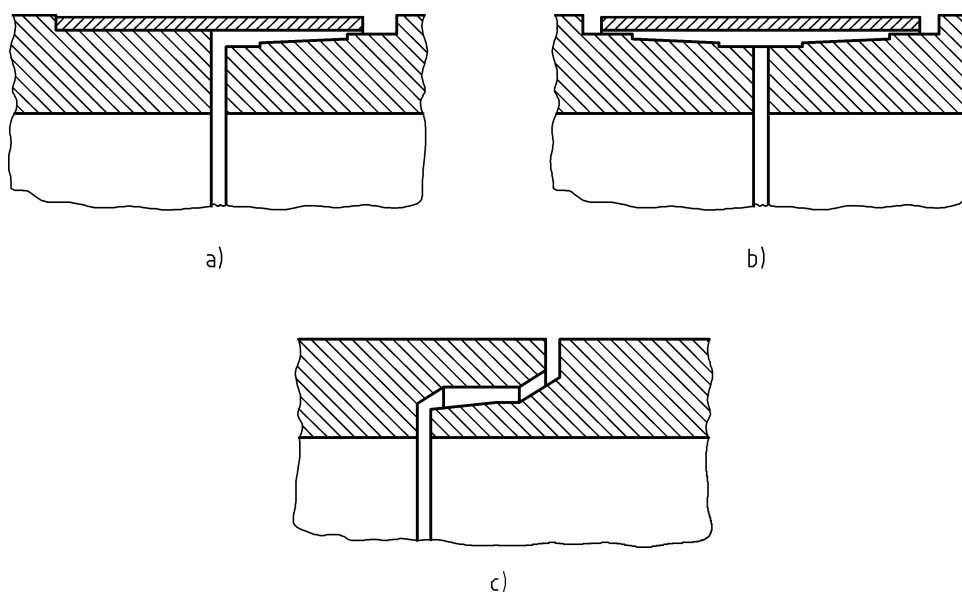
5.3 Jacking pipes

5.3.1 Joints

5.3.1.1 General

Joints of jacking pipes shall be in-wall flexible joints of either the collar or rebated type as shown typically in Figure 4. They shall be designed to include one or more joint seals. All joint surfaces which will transmit load during installation shall be plane and free from irregularities that could cause high local concentrations of stress.

NOTE The angle calculated from angular deflection (see E.5.2) is not necessarily that which can be accommodated during jacking operations. Consultation between contractor and manufacturer is recommended.



Key

- a) Fixed collar
- b) Loose collar
- c) Rebated

NOTE The joint seals have been omitted, for clarity.

Figure 4 — Typical in-wall joints

5.3.1.2 Collars

Collars shall be manufactured from weldable structural steel plate, stainless steel plate or reinforced plastics.

NOTE Weldable structural steel plate collars can be susceptible to corrosion from the ground, groundwater or the effluent carried. If corrosion is expected by the specifier, the design of a joint incorporating this type of collar should provide for a secondary sealing gasket to be applied on site by the contractor, for example by means of an appropriate sealant.

5.3.2 Concrete strength

5.3.2.1 General

The characteristic compressive strength of the concrete f_{ck} in jacking pipes shall be verified on the basis of testing in accordance with 6.8. The verified value of this strength shall be not less than the manufacturer's declared design characteristic strength as stated in the factory documents.

5.3.2.2 Strength requirement

The design characteristic strength declared by the manufacturer in the factory documents shall be not less than 40 MPa (N/mm²).

5.3.3 Concrete cover

For reinforced concrete jacking pipes the minimum concrete cover required by 5.2.2 shall be increased by 5 mm on external surfaces to be in permanent contact with the ground.

There shall be no steel within the concrete cover on joint surfaces which will transmit load during installation.

5.3.4 Jacking load

The manufacturer shall make available a statement of the jacking load for which each jacking pipe was designed (design jacking load F_j). This load shall be not greater than the maximum design load as determined by structural calculation in accordance with annex B.

The maximum stress resulting from the manufacturer's assumed installation parameters shall not exceed 60 % of his declared characteristic strength of the concrete (see annex B).

NOTE The design jacking load as declared by the manufacturer or calculated in accordance with annex B does not include any safety factor used by the contractor, having regard to the jacking method and subsequent deflection of the pipes, the nature of the ground and unforeseen conditions, or for the stress ratio across the jacking face (see Figure B.1).

5.4 Pipes with inlet

The design of the joint for a connection to a pipe with inlet shall ensure that conformity to 4.3.7 can be achieved. The bore of the inlet shall be free from burrs.

6 Test methods for finished products

6.1 General

6.2 to 6.8 inclusive shall apply to all units, unless stated otherwise in Table 5 for conformity evaluation.

Table 5 — Summary of test requirements

Clause	Requirement where specified	Pipes		Fittings				
		Pipe	Jacking pipe	Connecting pipe	Pipe with inlet	Junction	Taper (reducer), adaptor	Bend
4.2.6.1	Water absorption	T/R	T/R	T/R ^a	T/R ^a	T/R ^a	T/R ^a	T/R ^a
4.3.2	Visual inspection of finish	T/R	T/R	T/R	T/R	T/R	T/R	T/R
4.3.3	Geometrical characteristics: - units - joint profiles	T/R T/R	T/R T/R	T/R ^a T/R ^a	T/R ^a T/R ^a	T/R ^a T/R ^a	T/R ^a T/R ^a	T/R ^a T/R ^a
4.3.4	Joints and joint seals ^b	T	T	T ^c	T ^c	T ^c	T ^c	T ^c
4.3.5	Crushing strength	T/R	T/R	T/R ^a	T/R	-	-	-
4.3.6.1	Longitudinal BMR	T ^d	T ^d	-	T ^d	-	-	-
4.3.7	Watertightness: - hydrostatic - joint assembly	T/R ^e T/R	T/R ^e T/R	T/R ^e T/R ^g	T/R ^f T/R ^h	T/R ^f T/R ^h	T/R T/R ^h	T/R ^g T/R ^h
5.2.1, 5.2.2 and 5.3.3	Reinforcement and concrete cover	T/R	T/R	T/R ^a	T/R ^a	T/R ^a	T/R ^a	T/R ^a
5.3.2.1	Drilled core strength	-	T/R	-	-	-	-	-

T means initial type test;

R means routine inspection test;

^a means not applicable to fittings fabricated from pipes or parts of pipes that conform to this European Standard;

^b means that annex A is not applicable where Method 3 in 4.3.4.2 is adopted;

^c means not applicable to fittings having the same design of joint as pipes;

^d means not applicable to pipes > DN 250, nor to pipes ≤ DN 250 whose internal barrel length does not exceed six times their external diameter;

^e means not applicable to units with a design wall thickness > 125 mm;

^f means not applicable to units with main pipes > DN 800 or inlets > DN 300, for safety reasons;

^g means not applicable to bends > DN 300, for safety reasons;

^h means, at the manufacturer's discretion, not applicable to fittings having the same design of joint as pipes

6.2 Joint profiles

The critical dimensions of joint profiles and their respective tolerances shall be evaluated for conformity to the factory documents.

6.3 Reinforcement

A section shall be cut from an undamaged part of a reinforced concrete pipe that has been tested to collapse as required under a routine or initial type test, to enable both circumferential and any longitudinal reinforcement to be examined and the concrete cover evaluated for conformity to 5.2.1 and 5.2.2 or 5.3.3, as appropriate.

6.3.1 Placing and content of reinforcement

The spacing and content of circumferential bars shall be measured over a length of at least 1 metre and evaluated for conformity to the factory documents and 5.2.1. The distance of the circumferential reinforcement from the end of the spigot and of the socket shall also be evaluated for conformity to 5.2.1.

Longitudinal reinforcement (if any) shall be evaluated for conformity to the factory documents.

6.3.2 Concrete cover

The reinforcement shall be exposed, the concrete cover measured, and the minimum recorded to the nearest millimetre. The cover shall then be evaluated for conformity to 5.2.2 or 5.3.3, as appropriate.

6.4 Crushing strength(s)

Crushing strength(s) shall be determined in accordance with the relevant method(s) specified in annex C.

6.5 Longitudinal bending moment resistance

Longitudinal bending moment resistance shall be determined in accordance with one of the methods specified in annex D, the choice of method being at the manufacturer's discretion.

6.6 Watertightness

Watertightness of units, and of joint assemblies, shall be determined in accordance with the methods specified in annex E.

6.7 Water absorption

Water absorption shall be determined in accordance with the method specified in annex F.

6.8 Concrete strength in jacking pipes

Compressive strength of the concrete in jacking pipes shall be determined in accordance with ISO 4012 and the test carried out by drilling a sample at each third-point along the internal barrel length, then calculating the mean value of the two results.

The drilled cores shall have a height equal to their diameter ± 10 mm:

- when $100 \text{ mm} \pm 1 \text{ mm}$ diameter cores are used, the result shall be applied without any conversion factor;
- when $50 \text{ mm} \pm 1 \text{ mm}$ diameter cores are used, a conversion factor of $\sqrt[AC_2]{1,07 \sqrt[AC_2]{}}$ shall be applied to the results.

Linear interpolation for intermediate diameters of core is permissible.