BRITISH STANDARD

BS EN
588-1 : 1997

Fibre-cement pipes for sewers and drains

Part 1. Pipes, joints and fittings for gravity systems

The European Standard EN 588-1 : 1996 has the status of a British Standard

ICS 91.040.80

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee B/505, Waste water engineering, upon which the following bodies were represented:

Association of Consulting Engineers
British Plastics Federation
Chartered Institution of Water and Environmental Management
Clay Pipe Development Association Limited
Concrete Pipe Association
Department of the Environment
Department of the Environment (Property and Buildings Directorate)
Fibre Cement Manufacturers' Association Limited
Institute of British Foundrymen
Institution of Civil Engineers
London Technical Advisors' Group (Lotag)
METCOM
Water Services Association of England and Wales

The following body was also represented in the drafting of the standard, through subcommittees and panels:

Water Companies Association

This British Standard, having been prepared under the direction of the Sector Board for Building and Civil Engineering, was published under the authority of the Standards Board and comes into effect on 15 April 1997

Amendments issued since publication

Amd. No.	Date	Text affected

The following BSI references relate to the work on this standard:
Committee reference B/505
Draft for comment 91/18757 DC

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Contents

National foreword

This British Standard has been prepared by Technical Committee B/505 and is the English language version of EN 588-1 : 1996 *Fibre-cement pipes for sewers and drains — Part 1: Pipes, joints and fittings for gravity systems* published by the European Committee for Standardization (CEN).

EN 588-1 was published as a result of international discussion in which the UK took an active part.

This standard supersedes BS 3656 : 1990 which is withdrawn.

This standard together with a number of other ENs will form a comprehensive series of standards in the field of cement pressure pipes.

The manufacture of all asbestos products is covered by the requirements of The Control of Asbestos at Work Regulations 1987, introduced on 1 March 1988. These set out comprehensive provisions covering work activities involving exposure to asbestos. Advice on how to comply with these regulations can be obtained from the manufacturers of the material, from the Asbestos Information Centre Ltd., Derby Road, Cheshire WH8 9ND, from the local area office of the Health and Safety Executive or from the Environmental Health Department of the Local Authority.

WARNING. Breathing asbestos dust is dangerous to health and precautions have to be taken during the manufacture and use of these products.

Particular note has to be taken of the Asbestos Products (Safety) Regulations 1985, made under the Consumer Safety Act 1978, and of the Asbestos (Prohibitions) (Amendment) Regulations 1988, made under the Health and Safety at Work etc. Act 1974, which prohibit the supply of products containing amosite or crocidolite and set out requirements for the labelling of all products containing amosite or crocidolite and set out requirements for the labelling of all products containing asbestos.

All the above legislation implements EEC Directives.

Cross-references

Publication referred to	Corresponding British Standard
ENV 197-1 : 1992	DD ENV 197 *Cement. Composition, specifications and conformity criteria* Part 1 : 1995 *Common cements*
EN 512 : 1994	BS EN 512 : 1995 *Fibre-cement products. Pressure pipes and joints*
EN ISO 9001 : 1994	BS EN ISO 9001 : 1994 *Quality systems. Model for quality assurance in design, development, production, installation and servicing*
EN ISO 9002 : 1994	BS EN ISO 9002 : 1994 *Quality systems. Model for quality assurance in production, installation and servicing*
ISO 2859-1 : 1989	BS 6001 *Sampling procedures for inspection by attributes* Part 1 : 1991 *Specification for sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection*
ISO 3951 : 1989	BS 6002 *Sampling procedures for inspection by variables* Part 1 : 1993 *Specification for single sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection*

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 32, and inside back cover and a back cover.

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 588-1

August 1996

ICS 23.040.30; 23.040.50

Descriptors: Sanitation, sewage, gravity flow, piping tubes, pipe joints, accessories, asbestos cement products, designation, classifications, geometric characteristics, mechanical properties, physical properties, tests, corrosion resistance, acceptability, marking

English version

Fibre-cement pipes for sewers and drains — Part 1 : Pipes, joints and fittings for gravity systems

Tuyaux en fibres-ciment pour réseaux d'assainissement et branchements — Partie 1: Tuyaux, joints et accessoires à écoulement libre

Faserzementrohre für Abwasserleitungen und Abwasserkanäle — Teil 1: Rohre, Rohrverbindungen und Formstücke für Freispiegelleitungen

This European Standard was approved by CEN on 1996-06-17. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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

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CEN

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

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

Ref. No. EN 588-1 : 1996

Foreword

This has been prepared by Technical Committee CEN/TC 165, Waste water engineering, the Secretariat of which is held by DIN.

A distinction has been made between product appraisal (type tests) and routine quality control requirements (acceptance tests).

Attention is drawn to the need for observance of EU and/or EFTA Directives transposed into national legal requirements restricting the use of certain materials and to the related marking and labelling requirements.

The performance of a sewage network constructed with these products depends not only on the properties of the product as required by this standard but also on the design and construction of the network as a whole in relation to the environment and conditions of use.

This standard will be updated with the standard EN 476 *General requirements for components used in discharge pipes, drains and sewers for gravity systems* established by TC 165 WG 1 and the other functional standards as soon as these are available.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 1997, and conflicting national standards shall be withdrawn at the latest by February 1997.

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

Contents

1 Scope

This Part 1 of EN 588 specifies requirements for fibre-cement pipes, joints and fittings suitable for gravity systems at atmospheric pressure intended for sewerage and drainage applications. It is applicable only to the more commonly used fittings i.e. angled branches or tees and bends.

It defines general composition, classification, geometrical, mechanical and physical characteristics, acceptance tests, type tests and quality control.

For pressurized sewers, fibre-cement pipes and joints in accordance with EN 512 will be used with additional consideration relevant to sewerage transport.

NOTE 1. EN 588-2 specifies requirements for fibre-cement manholes and inspection chambers.

NOTE 2. Occasional momentary overpressures of no more than 100 kPa are acceptable.

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. Dated references, subsequent amendments to or revisions of any of these publications will 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.

ENV 197-1 : 1992	*Cement — Composition, specifications and conformity criteria — Part 1: Common cements*
EN 512	*Fibre-cement products — Pressure pipes and joints*
prEN 681-1	*Elastomeric seals — Materials requirements for pipe joint seals used in water and drainage applications — Part 1: Vulcanized rubber*
EN ISO 9001	*Quality systems – Model for quality assurance in design/development, production, installation and servicing* (ISO 9001 : 1994)
EN ISO 9002	*Quality systems — Model for quality assurance in production, installation and servicing* (ISO 9002 : 1994)
ISO 390 : 1993	*Products in fibre reinforced cement — Sampling and inspection*
ISO 2859-1 : 1989	*Sampling procedures for inspection by attributes — Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection*
ISO 3951	*Sampling procedures and charts for inspection by variables for percent nonconforming*

3 Definitions

For the purposes of this standard the following definitions apply.

3.1 nominal diameter (DN)

Numerical denomination of size of a component, which is a convenient round number approximately equal to the manufacturing dimension in millimetres of the internal diameter.

3.2 acceptance test

Test to establish whether a batch of products conforms to a specification of the standard. The tests are performed on samples drawn either from continuous production or from a consignment (ISO 390 : 1993).

NOTE. Tests methods, specifications and limit values are specified in this standard. Sampling levels and acceptance criteria are specified in ISO 390.

3.3 type test

Test for approval of a new product and/or a fundamental change in formulation or method of manufacture, or both. The test is performed on the as delivered product.

The type test is not to be taken as evidence of the conformity to specification of products subsequently produced in quantity (ISO 390 : 1993).

3.4 acceptable quality level (AQL)

When a continuous series of batches is considered, the quality level which for the purposes of sampling inspection is the limit of a satisfactory process average (ISO 2859-1 : 1989).

NOTE. A sampling scheme with an AQL of 4 % means that batches containing up to 4 % defective items have a high probability of acceptance.

3.5 pipe barrel

Cylindrical part of the pipe with a uniform cross-section excluding socket and spigot.

4 Pipes

4.1 General composition

Fibre-cement pipes shall consist essentially of cement or a calcium silicate formed by chemical reaction of a siliceous and a calcareous material, reinforced by fibres. The cement shall comply with relevant national standards of CEN members and/or ENV 197-1.

NOTE. Other components which are compatible with the composite and have no negative influence on the performance in use of the product, can be added.

Two types of fibre-reinforced cement products (pipes, joints and fittings) are included in this standard:

type AT (Asbestos Technology) for products the formulation of which contains chrysotile asbestos;

type NT (Non-asbestos Technology) for products the formulation of which does not contain asbestos.

For products of type AT and NT all the requirements of this standard shall be fulfilled.

4.2 Classification

The pipes shall be classified in accordance with their minimum crushing strength in three classes based on load per unit internal area: 60 kN/m^2, 90 kN/m^2, 120 kN/m^2. The load per unit area is the breaking load in kilonewtons per metre length of pipe divided by the nominal diameter of the pipe in metres (1/1000 of the nominal diameter values).

4.3 Pipe ends

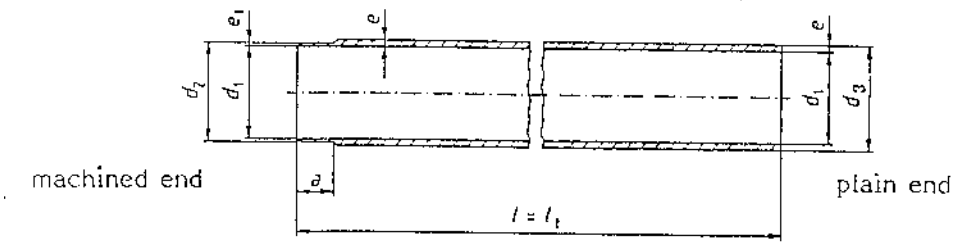
Pipes shall either have plain ends or with one end plain and the other end with a fixed socket. Plain ends may be machined or un-machined (see figure 1).

4.4 General appearance and finish

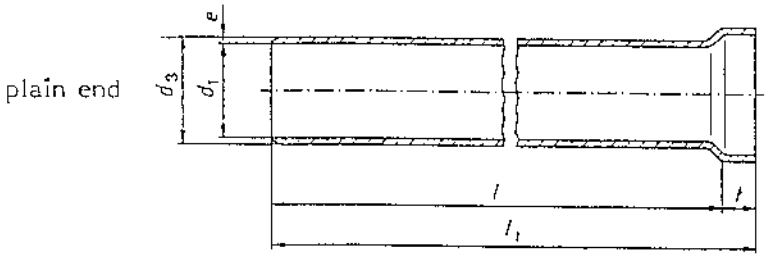
The pipes shall be straight, uniform and regular. The shape of the finished end shall be fixed by the manufacturer to suit the type of joint used.

The end faces shall be free from breakout and machining burrs. The parts of the pipe where the rubber jointing rings are located shall be free from irregularities which could affect the watertightness of the joint.

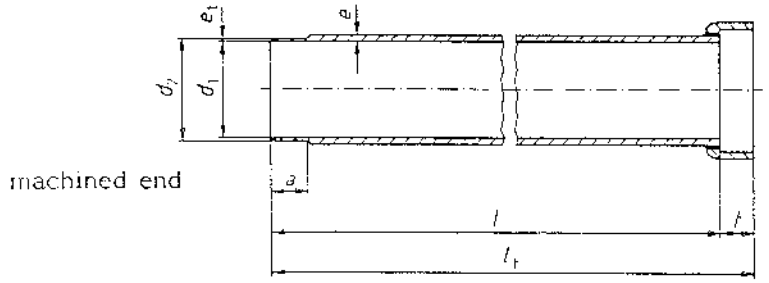
NOTE. If necessary, the pipes can be impregnated and/or coated internally and/or externally to meet special working conditions as agreed between manufacturer and customer. The coating and finish should comply with the relevant national standards (transposing the European Standard), if existing.



1a: Pipe with plain end



1b: Pipe with formed socket



1c: Pipe with adhesive jointed socket

a	length of machined end
d_1	internal diameter
d_2	external diameter of the machined end
d_3	external diameter of the barrel
e	thickness of the barrel
e_1	nominal thickness of the machined end

Figure 1. Pipe ends

4.5 Smoothness of bore

The internal surface of the pipe shall be regular and smooth. Slight scratches, indentations or small protrusions that do not affect the intended use or efficiency shall be acceptable.

4.6 Geometrical characteristics

4.6.1 *Nominal diameter (DN)*

Nominal diameters shall be as given in table 1. Nominal diameters without brackets are preferred.

Table 1. Nominal diameters (DN)

100	(1100)
125	1200
150	(1300)
200	1400
250	(1500)
300	1600
(350)	(1700)
400	1800
(450)	(1900)
500	2000
600	(2100)
(700)	2200
800	(2300)
(900)	(2400)
1000	2500

4.6.2 *Internal diameter*

When measured in accordance with **4.10.2.1** the internal diameter d_1(see figure 1), expressed in millimetres, of the pipe shall be equal to the nominal diameter, limit deviations excluded.

4.6.3 *Thickness of wall*

When measured in accordance with **4.10.2.3** the nominal thickness of the wall of the pipe shall be the thickness of the barrel e, expressed in millimetres, (see figure 1) of the pipe, excluding the machined end.

This nominal thickness shall be stated by the manufacturer in his literature.

If the extremity of the pipe is machined, the nominal thickness e_1 of the machined end shall be at least 3,3 % of the nominal diameter but not less than 6 mm.

4.6.4 *External diameter*

When measured in accordance with **4.10.2.2** the external diameter d_2 (see figure 1) of the pipe at the finished end where the rubber ring is located, expressed in millimetres, shall be stated by the manufacturer in his literature.

4.6.5 *Length of pipes*

When measured in accordance with **4.10.2.4** the nominal length l (see figure 1) of the pipe shall be the length measured between the extremities for pipes with plain ends and the total length l_t less the depth of the socket t for socketed pipes.

The nominal length shall be stated by the manufacturer in its literature in accordance with table 2.

Table 2. Nominal length of pipes

DN	**Nominal length** m
100	2,0
	2,5
to	3,0
	4,0
	5,0
2 500	6,0

Other pipe lengths than those stated in table 2 can be agreed on between purchaser and manufacturer by dividing the nominal length of table 2 by round numbers (1/2, 1/3, 1/4 length pipes).

In special cases, specified length can be agreed on between purchaser and manufacturer.

At least 90 % of the pipes supplied shall be of the nominal length agreed upon (subject to limit deviation given in **4.6.7.4**). The remainder can be shorter by no more than 1 m. However, the total length of the pipes supplied shall not be less than the length ordered.

4.6.6 *Length of machined end*

The length of the machined end a (see figure 1) shall not exceed the length of the coupling (or socket in case of socketed pipes) +10 mm.

NOTE. Longer machined end pipes can be supplied. In this case the manufacturer will indicate the minimum breaking load.

4.6.7 *Limit deviations*

4.6.7.1 *Internal diameter*

The limit deviation on the internal diameter shall be as given in table 3.

Table 3. Limit deviation on internal diameter

DN	**Limit deviation** mm
$\leq$ 1 200	$\pm$ (2,5 mm + 0,01d)
$>$ 1 200	$\pm$ 15 mm

NOTE. d being the nominal diameter, expressed in millimetres.

4.6.7.2 *Thickness*

The lower deviation on the thickness of the barrel and machined ends shall be as given in table 4.

Table 4. Lower deviation on barrel thickness

Thickness	Lower deviation
Up to 10 mm	−1,5 mm
Over 10 mm up to 20 mm	−2,0 mm
Over 20 mm up to 30 mm	−2,5 mm
Over 30 mm up to 60 mm	−3,0 mm
Over 60 mm up to 90 mm	−3,5 mm
Over 90 mm	−4,0 mm

The upper deviations on the pipe end thickness shall be such as the maximum thickness is as follows:

Table 5. Upper deviation on the pipe end thickness

DN	Upper deviation mm
≤ 300	$e_{max} = e_{min} + 6$
300 < DN ≤ 1000	$e_{max} = e_{min} + 0{,}02 \times DN$
> 1000	$e_{max} = e_{min} + 20$

where:

e_{max} is the maximum thickness at the end of the pipe (machined end or barrel) in millimetres;

e_{min} is the minimum thickness at the end of the pipe (machined end or barrel) equal to the nominal thickness stated by the manufacturer less the lower deviation of table 4, in millimetres.

4.6.7.3 *External diameter at finished end covered by the coupling*

The limit deviations on the external diameter d_2 of the pipe ends where jointing rings are located (plain ends), shall be established by the manufacturer in accordance with the type of joint used and taking into account the limit deviations acceptable in respect of the design of the joint and of the performance defined in **5.2** (see figure 1).

4.6.7.4 *Length l* (figure 1)

The limit deviation on the measurement shall be:

+ 5 mm;

−20 mm.

NOTE. Larger limit deviations can be agreed between customer and manufacturer.

4.6.7.5 *Straightness*

The maximum deviation *f* on straightness in accordance with the test method of **4.10.2.6** shall not exceed the following values given in table 6.

Table 6. Limit deviation on straightness

DN	Maximum deviation *f* mm
100 to 150	$3{,}0l_t$
200 to 1 000	$2{,}5l_t$
1 100 to 2 500	$1{,}5l_t$

NOTE. l_t is the length of the pipe in metres (see figure 1).

4.6.8 ***Interchangeability***

Interconnection between pipes of the same nominal diameter and class of different pipe end dimensions can be achieved by special couplings or special machining of the pipe ends.

4.7 Mechanical characteristics

4.7.1 ***Crushing strength***

When tested in accordance with **4.10.3.1** the minimum breaking loads for pipes of nominal diameter up to DN 1 000 shall be as given in table 7.

Table 7. Minimum breaking load in kilonewtons per metre
(kN/m)

DN	Class 60	Class 90	Class 120
100	–	–	20[1)]
125	–	–	21[1)]
150	–	–	22[1)]
200	15[1)]	18	24
250	15	22,5	30
300	18	27	36
350	21	31,5	42
400	24	36	48
450	27	40,5	54
500	30	45	60
600	36	54	72
700	42	63	84
800	48	72	96
900	54	81	108
1000	60	90	120

[1)] Minimum breaking loads exceed the calculated minimum requirement to satisfy other design criteria.

For DN > 1 000 the minimum breaking loads in kilonewtons per metre are given by multiplying the class in kilonewtons per square metre by 1/1000 the nominal diameter (diameter in metres).

e.g. when DN = 1 500 and pipe class is 90 kN/m^2 the minimum breaking load shall be:

90 kN/m^2 × 1,5 m = 135 kN/m

4.7.2 *Bending loads*

Breaking bending loads in accordance with **4.10.3.2** shall be as given in table 8.

Table 8. Minimum breaking bending loads

DN	Breaking bending load min. N
100	2 800
125	4 200
150	6 000
200	12 000

NOTE. When site circumstances require pipes to have higher bending strengths than those given, pipes of series *S* with a minimum breaking load 25 % higher than given in the table, or short length pipes can be specified.

4.8 Physical characteristics

4.8.1 *Long term vertical loading*

When tested in accordance with **4.10.4.1**, no test specimens shall fail (see annex C).

4.8.2 *Warm water test*

When tested in accordance with **4.10.4.2**, the lower confidence limit *L* calculated for the test specimens shall be not less than 0,75.

4.8.3 *Watertightness*

When tested in accordance with **4.10.4.3**, the pipe shall exhibit no fissure, leakage or sweating.

4.8.4 *Modulus of elasticity*

If necessary (e.g. for structural analysis), the modulus of elasticity shall be determined as a type test in accordance with the test method given in annex D.

4.9 Resistance to domestic sewage media

When tested in accordance with **4.10.5**, the lower confidence limit *L* calculated for the test specimens shall be not less than 0,75.

4.10 Test methods

4.10.1 *General*

4.10.1.1 *Acceptance tests*

Acceptance tests shall be carried out at the manufacturer's works on pipes as delivered whenever possible, or on test specimens cut from the pipes.

NOTE. The manufacturer can carry out the test as part of the routine quality control system at an earlier stage of maturity.

Acceptance tests consist of the following:

– visual inspection of appearance, finish and of marking;

– geometrical characteristics;

– crushing strength;

– bending loads.

4.10.1.2 *Type tests*

The following type tests shall be carried out on pipes as delivered:

– long term loading test;

– warm water test;

– watertightness test;

– resistance to domestic sewerage media.

When type tests are carried out the product shall also be subjected to the acceptance tests to ensure it complies with the requirements of this standard.

4.10.2 *Geometrical characteristics*

4.10.2.1 *Internal diameter*

The minimum and maximum internal diameter shall be measured at both ends of the element with an accuracy of 0,5 mm. The values obtained shall comply with the specifications of **4.6.2** and **4.6.7.1**.

4.10.2.2 *External diameter*

These measurements shall be carried out only at the plain or machined end of the pipe. The values obtained shall comply with the specifications of **4.6.4** and **4.6.7.3**.

For pipes of DN $\leq$ 400 two measurements of the external diameter shall be made and carried out at 90° to each other with an accuracy of 0,1 mm approximately where the rubber rings are located.

For pipes of DN > 1 500, determine the outer diameter by measuring the circumference with an accuracy of 0,5 mm taking into account the thickness of measuring tape.

For pipes of 400 < DN $\leq$ 1 500, one or the other of the above methods may be used; if the measurement of the circumference is carried out, the measurement of internal diameter (see **4.10.2.1**) shall be carried out on the same pipe.

4.10.2.3 *Thicknesses*

For pipes with plain or machined ends measure the thickness at each end and for socketed pipes measure the thickness at the plain end to an accuracy of 0,1 mm as follows:

– either at four points displaced at 90°;

– or the minimum and the maximum thickness.

These measurements shall be carried out:

a) on machined pipes:

– at 30 mm from the pipe end;

– at 30 mm beyond the machined part for the barrel;

b) on non-machined ends:

– at a distance of 30 mm approximately from the end.

These measurements shall comply with the specifications of **4.6.3** and **4.6.7.2**.

4.10.2.4 *Length of pipe*

Take the single values of two diametrically opposed measurements of the pipe length with an accuracy of 1 mm. The average shall comply with the specification of **4.6.5** and **4.6.7.4**.

4.10.2.5 *Length of machined ends*

Measure the length of the machined end a axially with an accuracy of 1 mm (see figures 1a and 1c). The values shall comply with the specification of **4.6.6**.

4.10.2.6 *Straightness*

4.10.2.6.1 *Test specimen*

The test specimen shall be a complete pipe.

4.10.2.6.2 *Apparatus*

The apparatus shall consist of:

4.10.2.6.2.1 *Two supports*, the distance between the centres of which is equal to 2/3 of the total length of the pipe to be checked.

Each support shall be equipped with a roller system which makes it possible to rotate the pipe around its axis without longitudinal or lateral movement.

4.10.2.6.2.2 *A dial gauge*, with semi-spherical shaped measuring faces or with rounded tips accurate to 0,1 mm and fixed on a stable base.

4.10.2.6.3 *Procedure*

Lay the pipe horizontally on the two supports. Place the dial gauge at an equal distance, from the supports, in such a way that the sliding spindle of the gauge is in radial contact with the pipe. Turn the pipe at least one complete rotation. Note the maximum deviation f obtained, rounded to the nearest millimetre (see figure 2).

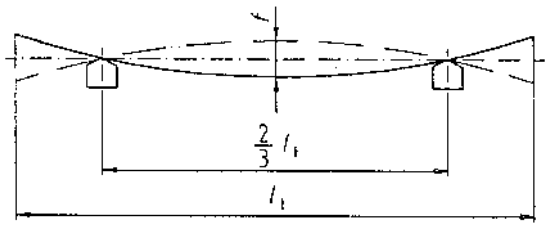


Figure 2. Arrangement for the straightness test

4.10.2.6.4 *Expression and interpretation of result*

Record the maximum deviation f. It shall comply with the specification of **4.6.7.5**.

4.10.3 ***Mechanical characteristics***

4.10.3.1 *Crushing test*

4.10.3.1.1 *Test specimen*

The test specimen shall be a piece of pipe cut from the barrel (excluding the machined end), length of which shall be:

– 200 mm for pipes ≤ DN 300;

– 300 mm for pipes > DN 300.

4.10.3.1.2 *Apparatus*

The apparatus shall consist of:

4.10.3.1.2.1 *A press*, with a loading error of ± 3 % maximum and a loading reproducibility error of ± 2 % maximum.

4.10.3.1.2.2 *A lower press block*,, formed by a V-shaped support having an included angle of 170° made of metal or hard wood, and a flat upper press block made of the same material. The length of these blocks shall be equal to the length of the test specimen (figure 3). The width of the upper press block shall not be more than the value given in table 9.

Table 9. Width of upper press blocks

DN	**Width** b mm
up to 450	50
500 to 600	60
700 to 800	85
900 to 1 000	105
1 100 to 1 200	130
1 300 to 1 400	150
1 500 to 1 600	175
1 700 to 1 800	195
1 900 to 2 000	220
2 100 to 2 200	240
2 300 to 2 400	265
2 500	290

Strips of rubber of suitable width and length shall be interposed between the press blocks and the test specimen[1)]. The rubber strips shall be 25 mm ± 5 mm thick and a shore hardness of 60 ± 5 IRHD.

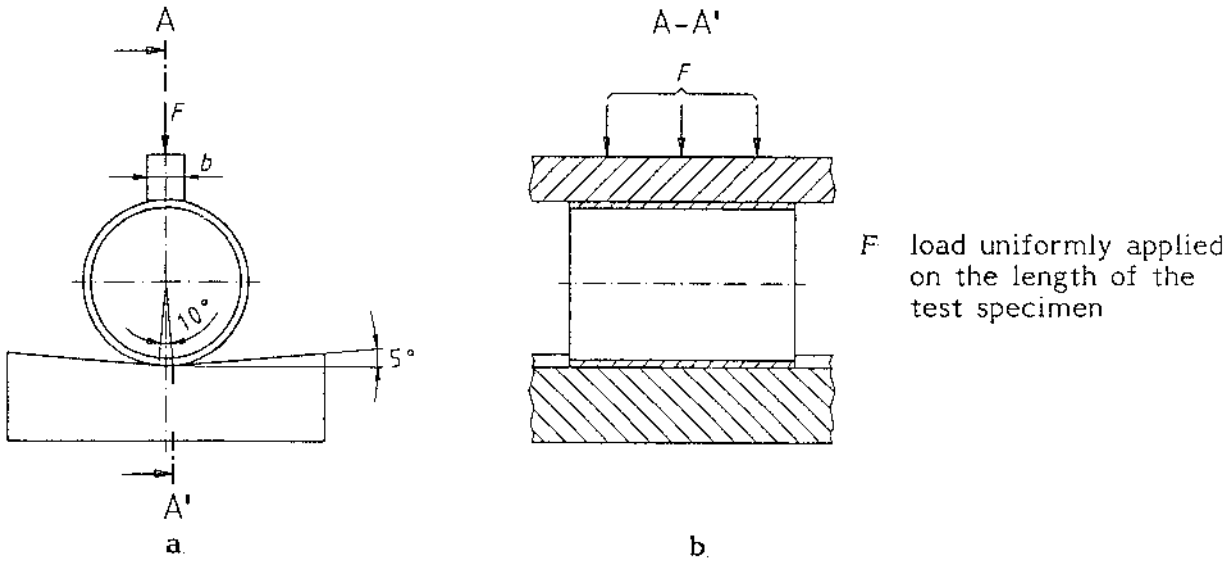


Figure 3. Arrangement for the crushing test

4.10.3.1.3 *Procedure*

Immerse the test specimen in water for 48 h. Measure the length of the test specimen with an accuracy of 1 mm along two diametrically opposed generating lines. Record the average of the two measurements.

Arrange the test specimen centred on the V-shaped support and put the upper press block in contact with it, apply the load uniformly so that the rupture occurs between 15 s and 30 s following application of the load (figure 3).

Record the value of the ultimate breaking load F and the length l of the test specimen.

4.10.3.1.4 *Expression and interpretation of results*

Calculate the quotient C_L, expressed in kilonewtons per metre:

$$C_L = \frac{F}{l}$$

where:

F is the ultimate crushing load, expressed in kilonewtons;

l is the effective length of the test specimen, expressed in metres.

This quotient shall comply with the specified value resulting from table 7 of **4.7.1**.

The unit stress may be calculated by the following formula:

$$R = n \frac{F(3d + 5e)}{Ie^2}$$

where:

R is the unit crushing strength in newtons per square millimetres or megapascals;

n is 0,26 for DN 100 and 0,3 for other diameters;

d is the actual internal diameter of the test specimen, in millimetres, taken as the average of two perpendicular measurements at 90°;

e is the actual thickness of the wall of the test specimen in the broken section, in millimetres, taken as the average of three measurements made along the line of fracture at the top of the ring.

4.10.3.2 *Bending strength test*

4.10.3.2.1 *Test specimen*

The test shall be carried out on a pipe or part of a pipe at least 2,1 m to 2,2 m long, which may be taken from the pipe having already provided the test specimens for the crushing test.

[1] For the purpose of internal quality control the rubber strips can be omitted when the test is also used to determine pipe ring deflection.

4.10.3.2.2 *Apparatus*

The apparatus shall consist of:

4.10.3.2.2.1 *A press*, with a loading error of ±3 % maximum, and a reproducibility error of ±2 % maximum.

4.10.3.2.2.2 *Two metal V-shaped supports*, having an included angle of 120° presenting a face 50 mm to 100 mm wide x to the pipe and free to move in the plane of bending on two horizontal axes 2 000 mm apart (figure 4).

The load shall be applied vertically at an equal distance from the supports in the plan passing through the axis of the test specimen. It is transmitted by a metal pad having the same shape as the supports, but with a width of 100 mm. Strips of rubber[2)] of 15 mm ±5 mm thick, and a hardness of (60 ± 5) IRHD shall be interposed between the supports and the test specimen, and between the pad and the test specimen.

4.10.3.2.3 *Procedure*

Immerse the test specimen in water for 48 h.

With the test specimen centred in the testing apparatus, the bending load shall be applied regularly so that the rupture occurs between 15 s and no more than 30 s following the commencement of the application of the load.

4.10.3.2.4 *Expression of results*

Record the value of the load at rupture, in newtons.

The result shall comply with the specification of **4.7.2**.

4.10.4 ***Physical characteristics***

4.10.4.1 *Long term vertical loading test*

4.10.4.1.1 *Test specimen*

The size of the test specimens chosen shall be a representative nominal diameter (DN) and class from the middle range of all diameters produced under the same conditions by the manufacturer.

The dimension of each test specimen shall be the same as given in **4.10.3.1.1**.

The number of test specimens shall be 10.

All test specimens shall be taken from different pipes.

4.10.4.1.2 *Apparatus*

Shall be the same as given in **4.10.3.1** and capable of sustaining a constant load on the test specimens for the duration of the test.

4.10.4.1.3 *Procedure*

Each specimen shall be stored in normal laboratory ambient conditions for one week before carrying out the following test:

– arrange each test specimen on the test machine as indicated in **4.10.3.1.2**;

– apply for 3 000 h a load equal to 50 % of the minimum breaking load specified for the class (see table 7).

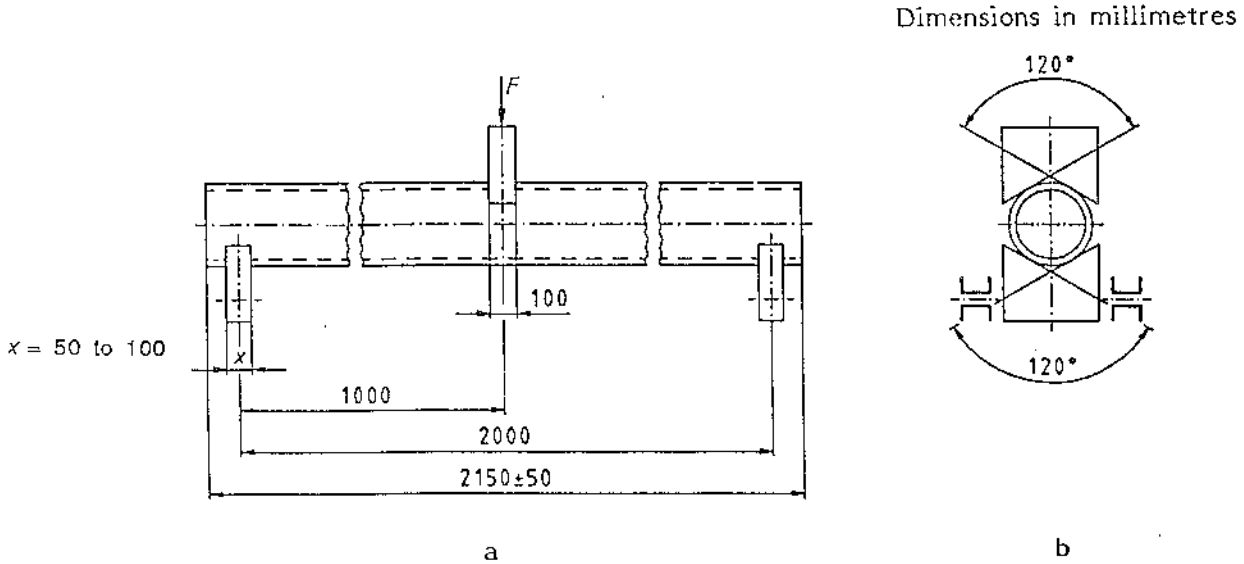


Figure 4. Arrangement for the bending strength test

[2)] For the purpose of internal quality control the rubber strips can be omitted when the test is also used to determine the pipe bending deflection.

4.10.4.1.4 *Expression of results*

Record if any test specimens fails during the test. The observation shall comply with the requirements of **4.8.1**.

4.10.4.2 *Warm water test*

4.10.4.2.1 *Test specimen*

The test shall be made on pipes between DN 100 to DN 300; the test specimens shall be as specified in the crushing test (see **4.10.3.1.1** and annex E).

From a single pipe 20 test specimens shall be cut and numbered as shown in figure 5. The test specimens with the same number shall be called paired test specimens.

4.10.4.2.2 *Apparatus*

4.10.4.2.2.1 *A water bath*, capable of temperature control at 60 °C ± 2 °C.

4.10.4.2.2.2 *A crushing test apparatus*, as described in **4.10.3.1**.

4.10.4.2.3 *Procedure*

Divide the paired test specimens to form two lots of 10 test specimens each. Lot one consisting of control test specimens 1 to 10 and lot two of specimens 1′ to 10′.

The first lot of 10 specimens shall be submitted to the crushing test in accordance with **4.10.3.1.3** and, at the same time, the 10 test specimens of the second lot shall be immersed in water saturated with the binder used for the test specimens, and the water temperature shall be maintained at 60 °C ± 2 °C for 56 days ± 2 days.

At the end of this period the test specimens shall be stored in normal laboratory ambient conditions for 7 days before carrying out the crushing test as specified in **4.10.3.1**, including preliminary conditioning as specified in **4.10.3.1.3**.

4.10.4.2.4 *Expression of results*

For each pair of test specimens (i = 1 to 10) calculate the individual ratio r_i:

$$r_i = \frac{t_i}{c_i}$$

where:

t_i is the crushing load in kilonewtons per metre after immersion;

c_i is the crushing load in kilonewtons per metre of the control test specimen.

Calculate the average r_m and standard deviation s of the individual ratios r_i. Calculate the 95 % lower confidence limit L of the average ratio r_m as follows:

$$L = r_m - 0{,}58 \times s$$

The result shall comply with the specification of **4.8.2**.

4.10.4.3 *Watertightness test*

4.10.4.3.1 *Test specimen*

This test shall be carried out on a pipe of at least 0,5 m length and of a nominal size and class representative of the middle range of all pipes produced under the same conditions.

4.10.4.3.2 *Apparatus*

The apparatus shall allow closure of the pipe ends by an appropriate device which avoids inducing significant longitudinal stresses into the pipe and capable of applying to the pipe the internal test pressure of 250 kPa (2,5 bars) and maintaining the pressure during a period of 24 h.

The hydraulic pressure shall be measured by a pressure gauge calibrated to give a reading accurate to within 10 kPa (0,1 bar).

4.10.4.3.3 *Procedure*

The test specimen shall be immersed in water at ambient temperature (5 °C) for 48 h before fitting into the pressure device.

The test shall be carried out in normal laboratory conditions.

Raise the hydraulic pressure gradually up to 250 kPa ± 10 kPa irrespective of the class of the pipe. Under this pressure the test specimen is then separated from the hydraulic pressure source and left for 24 h.

Inspect the test specimen visually and record any fissures, leakage or sweating.

If the internal pressure has dropped after the 24 h, it shall be restored to the initial value of 250 kPa ± 10 kPa by addition of water and the amount of water added shall be recorded.

4.10.4.3.4 *Expression and interpretation of results*

The result of the visual inspection shall comply with the specification of **4.8.3**.

The water absorption A can be calculated on the basis of the water restored:

$$A_{24} = \frac{W_{24}}{\pi \times d_{1m} \times l} \text{ in l/m}^2$$

where:

A_{24} is the amount of absorbed water in litres per square metre;

W_{24} is the amount of restored water after 24 h, in litres;

d_{1m} is the mean internal diameter in metres calculated from two measurements at 90 °C;

l is the length of the test specimen in metres.

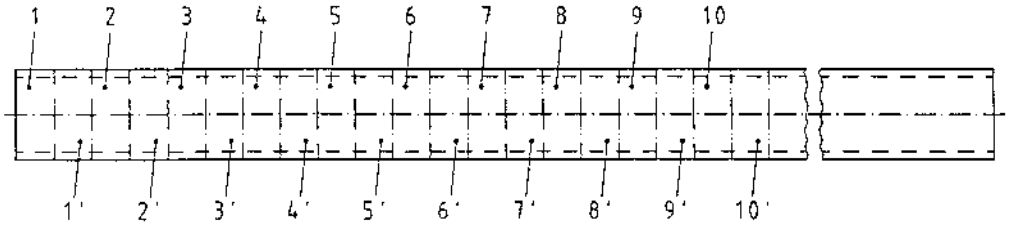


Figure 5. Cutting of paired test specimens

4.10.5 ***Resistance to domestic sewage media test***

4.10.5.1 *Test specimen*

The test shall be carried out on an uncoated pipe of DN 150 or the smallest DN produced under the same conditions in accordance with this standard.

The dimension of the test specimens shall be the same as in the crushing test (**4.10.3.1.1**).

Cut 20 test specimens from a single pipe and number them as in figure 5, the test specimens with the same number shall be called paired test specimens.

4.10.5.2 *Apparatus and reagent*

4.10.5.2.1 *A bath*, containing media as described in table 10, and maintained at a temperature between 18 °C and 28 °C.

Table 10. Test media

Component	**Concentration** mg/l
Polysaccharide (starch)	50
Sodium stearate	32
Sodium acetate	56
Glycerine triacetate	15
Urea	13
Ammonium sulfate	70
Protein (albumin)	90
NOTE. Industrial purity of components is required.	

4.10.5.2.2 The crushing test apparatus shall be as described in **4.10.3.1.2**.

4.10.5.3 *Procedure* (see also annex E)

Divide the paired test specimens to form two lots of 10 test specimens each. The first lot shall contain test specimens 1 to 10 and the second lot shall contain specimens 1' to 10'.

The first lot of 10 test specimens shall be submitted to the crushing test in accordance with **4.10.3.1.3** and, at the same time the 10 test specimens of the second lot shall be immersed in the media as described in table 10, for 28 days.

At the end of this period store the test specimens in a normal laboratory ambient atmosphere for 7 days.

Carry out the crushing test as specified in **4.10.3.1** including preliminary conditioning as specified in **4.10.3.1.3**.

4.10.5.4 *Expression of results*

For each pair of test specimens (i = 1 to 10) calculate the individual ratio r_i:

$$r_i = \frac{t_i}{c_i}$$

where:

t_i is the ultimate crushing load after immersion in the test media in kilonewtons per metre;

c_i is the ultimate crushing load of the control test specimen in kilonewtons per metre.

Calculate the average r_m and standard deviation s of the individual ratios r_i. Calculate the 95 % lower confidence limit L of the average ratio r_m as follows:

$$L = r_m - 0{,}58 \times s$$

The result shall comply with the specification of **4.9**.

NOTE. By agreement between the manufacturer and the certificate body an alternative mechanical test allowing the comparison of the ring bending strength before and after immersion in the test media can be used (e.g. bending strength test on ring segments).

4.11 Marking

The pipes shall be marked legibly and durably with at least the following information:

a) EN 588-1;

b) nominal diameter;

c) manufacturer's identification;

d) date of manufacture;

e) class;

f) series *S*, if relevant;

g) third party certification, where applicable;

h) (AT) for products of type AT,

(NT) for products of type NT.

NOTE. Attention is drawn to the EU and/or EFTA regulations on labelling (see foreword).

5 Joints

5.1 Requirements

5.1.1 *Types of joints*

The joints for fibre-cement pipes and fittings covered by this standard shall be sockets or sleeves (see annex F, figure F.1).

Sockets shall be formed in the same production process as the pipes (figure 1b) or may be jointed with adhesive material (figure 1c).

5.1.2 *Materials*

Sockets or sleeves made of fibre-cement shall be as given in **4.1**. Suitable materials other than fibre-cement may also be used for sleeves providing the material complies with the relevant national standards (transposing the European Standard), if existing. All materials are to be specified by the pipe manufacturer.

Sealing rings shall be of elastomeric material suitable for use with the liquid to be conveyed. The elastomeric material shall comply with prEN 681-1.

5.1.3 *General appearance and finish*

Sockets, sleeves and sealings rings shall be free of surface faults that could affect the ease of installation and the watertightness.

5.1.4 *Geometrical characteristics*

The dimensions and the shape of all parts of the sleeves, sockets and elastomeric rings shall be determined by the manufacturer of the pipes.

The limit deviation on all relevant dimensions of the sleeves and sockets shall be established by the manufacturer taking into account the limit deviations on the elastomeric rings and on the external diameters of pipe ends and fittings.

Dimensions and limit deviations shall allow assembly of the joint without damaging any component, or adversely affecting the efficiency of the joint even under the most unfavourable combination of limit deviations.

5.1.5 *Watertightness*

Joints shall be watertight against an internal or external infiltration hydrostatic pressure of 100 kPa $\pm$ 10 kPa (1,0 bar $\pm$ 0,1 bar).

When tested in accordance with **5.2.3**, the joints shall not exhibit fissures, leakages or sweating.

5.2 Tests

5.2.1 *General*

5.2.1.1 *Acceptance tests*

The acceptance tests shall be carried out at the manufacturers' works on joints as delivered.

NOTE. The manufacturer can carry out the test as part of the routine quality control system at an earlier stage of maturity.

These tests include the:

– visual inspection of appearance, finish and marking;

– geometrical characteristics.

5.2.1.2 *Type test*

The test shall be carried out joints as delivered. The type test concerns watertightness.

When type tests are carried out the products shall also be subjected to the acceptance tests to ensure it complies with the requirements of this standard.

5.2.2 *Geometrical characteristics*

The internal diameters of sleeves, sockets and grooves and the external diameter of sleeves and sockets shall be measured in accordance with **4.10.2**. Other dimensions of the cross-section of the jointing system that are relevant to jointing integrity and installation shall be measured using an adequate measuring device to an accuracy of 0,1 mm.

Sealing rings shall be measured in accordance with the relevant national standard transposing the European Standard, if existing.

5.2.3 *Watertightness*

This test certifies the watertightness of the jointing system when the most extreme combination of pipe, sleeve, socket and sealing ring manufacturing limit deviations and adverse site conditions result in the maximum decompression of the sealing rings.

All tests shall be carried out on one joint from each group of DN having the same transverse sealing cross-section and made of the same sealing material.

The tests shall be internal and external hydrostatic pressure tests. The hydrostatic test pressure is related to the crown of the pipe.

5.2.3.1 *Joint with pipes in straight alignment*

5.2.3.1.1 *Test specimen*

The test specimen is one joint assembled to pipe(s) or piece(s) of pipe(s). The dimensions of the pipe ends and the sleeve or socket respectively, shall give the minimum sealing ring compression allowed by the manufacturer.

Pipes and joints shall be of the same finish as delivered to the customer.

5.2.3.1.2 *Apparatus*

For internal pressure test:

5.2.3.1.2.1 *An installation*, capable of receiving the test specimen and withstanding the forces due to internal pressure.

5.2.3.1.2.2 *Sealing and closure devices*, for pipe ends.

5.2.3.1.2.3 *Devices*, for the evacuation of air and for filling the test specimen with water.

5.2.3.1.2.4 *A pressure gauge*, calibrated to give an accurate reading within 0,01 MPa (0,1 bar).

5.2.3.1.2.5 *A pump*, or similar device to raise the pressure.

5.2.3.1.2.6 *A chronometer*, for external pressure test (infiltration):

5.2.3.1.2.7 *A pressure tight box*, that allows the test specimen to be subjected to an external hydraulic pressure or any other device giving the same results, e.g. a joint with the sealing ring groove section especially machined facing in the opposite direction to a normal joint and with the sealing rings fitted in the reverse direction to normal allows the test specimen to be tested by the internal pressure test method.

5.2.3.1.3 *Procedure*

For internal pressure test.

Fill the test specimen with water and expel all air without producing internal overpressure. Apply the following water pressure in test sequences in accordance with table 11.

Table 11. Internal pressure test

Test pressure		**Period of time**
kPa	bar	min
0	0.0	5
20	0.2	10
100	1.0	30

The surface of the test specimen shall be inspected. Fissures, drops of water, water loss or traces of humidity shall be recorded.

For external pressure test.

Submit the joint to the same water pressure test sequence as for the internal pressure test.

The surface of the test specimen shall be inspected. Fissures, drops of water, water loss or traces of humidity shall be recorded.

5.2.3.1.4 *Expression and interpretation of results*

Observation during the test shall comply with the specification of **5.1.5**.

5.2.3.2 *Joint with deflected straight pipe*

5.2.3.2.1 *Test specimen*

In accordance with **5.2.3.1.1**.

5.2.3.2.2 *Apparatus*

In accordance with **5.2.3.1.2**.

5.2.3.2.3 *Procedure*

Deflect one pipe in the joint by turning its longitudinal axis in such a way as to obtain values y complying to table 12 and figure 6, or higher values in accordance with the maximum allowable deflection stated by the manufacturer.

Table 12. Minimum deflection of joints

DN	**Minimum deflection** y mm/m
<300	30
300 ≤ DN ≤ 600	20
600 < DN ≤ 1 000	10
<1 000	10 000/DN

Then carry out the internal and external pressure test in accordance with **5.2.3.1**.

5.2.3.2.4 *Expression and interpretation of results*

Observation during the test shall comply with the specification of **5.1.5**.

5.2.3.3 *Joint under shear load*

5.2.3.3.1 *Test specimen*

In accordance with **5.2.3.1.1** (see figures 7 and 8).

5.2.3.3.2 *Apparatus*

In accordance with **5.2.3.1.2** and in addition a device to apply the possible additional shear load (see figures 7 and 8).

5.2.3.3.3 *Procedure*

The shear load is given by the sum of any applied load, the weight of the pipe and the weight of the water contents and the weights of the apparatus depending on the test arrangement.

Fill the test specimen with water and expel all air without producing internal overpressure.

The additional load shall be applied in accordance with one or the other of the two following methods:

First method:

The additional load F_z shall be applied in accordance with figures 7 and 8.

$$F_z = \frac{1}{(l_c - c_1)} \times \left[F_s l_c + F_e c_2 - (F_r + F_w) \frac{(l_c - c_2)}{2} \right]$$

where:

l_c is the distance between joints and mid-support in metres (see figures 7 and 8);

c_1 is the distance between joints and axis of F_z in metres (see figures 7 and 8);

c_2 is the distance between support and axis of F_e;

F_e is the weight of the cap or plug in newtons;

F_r is the weight of the pipe in newtons;

F_s is the shear load (10 DN), expressed in newtons;

F_w is the weight of the water contents (pipe with shear load) in newtons;

F_z is the additional shear load in newtons.

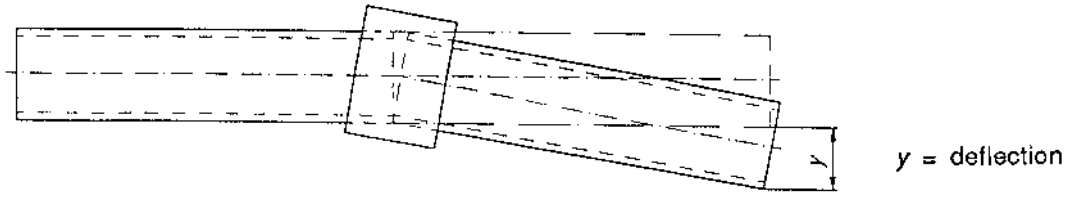


Figure 6. Joint with deflected straight pipe

Following application of the additional load the internal pressure shall be tested in accordance with **5.2.3.1.3**.

Second method (for non-socketed pipes):

Apply the additional load as indicated in figure 8 with F_s = Shear load = 20 DN expressed in newtons.

Following application of the additional load the internal pressure shall be tested in accordance with **5.2.3.1.3**.

In both methods inspect the surface of the test specimen.

5.2.3.3.4 Expression and interpretation of results

Observation during the test shall comply with **5.1.5**.

5.3 Marking

The joints shall be marked legibly and durably with at least the following information:

a) EN 588-1;

b) nominal diameter;

c) manufacturer's identification;

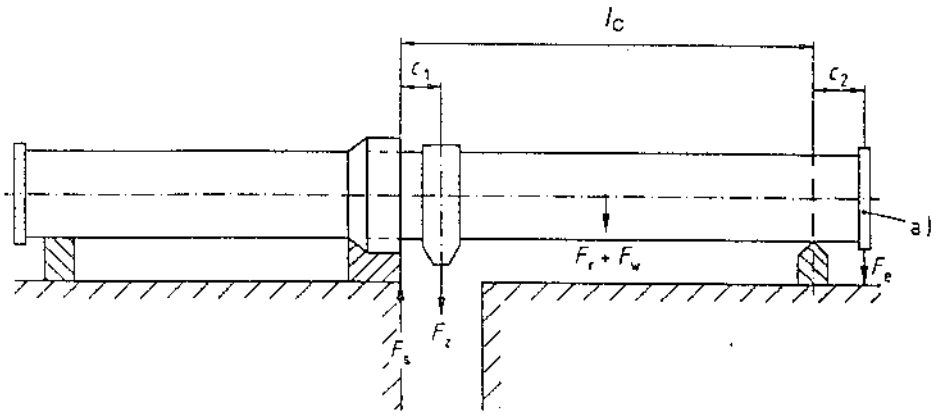
d) date of manufacture (at least the month and the year);

e) class, if relevant;

f) (AT) for products of type AT,

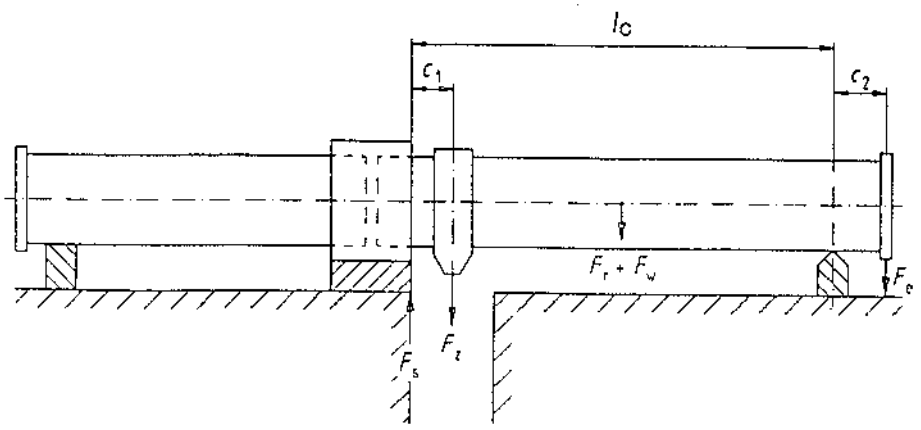
(NT) for products of type NT.

NOTE. Attention is drawn to the EU and/or EFTA regulations on labelling (see foreword).



a) Cap or plug equipped with devices for filling air evacuation, and protected against forces caused by the test pressure

Figure 7. Test arrangement for pipes with sockets



NOTE. For the definitions of the symbols in the figures see **5.2.3.3.3**.

Figure 8. Test arrangement for pipes with sleeves

6 Fittings

6.1 General

This standard is concerned only with the more commonly used fittings i.e.:

– angled branches or tees;

– bends.

NOTE 1. Typical types of fittings are given as examples in the informative annex F. Other fittings can be supplied provided they fulfil the requirements of this standard.

NOTE 2. The manufacturer can, when required, supply materials/fittings and advice for making connections in fibre-cement to established pipelines.

NOTE 3. Manholes and inspection chambers are not considered as fittings and are dealt with in Part 2 of this standard.

6.2 Composition

The composition of fittings shall comply with the requirements of **4.1**. When made by cutting and assembling pipe elements, epoxy based adhesive or other suitable bonding material shall be used for jointing the individual components.

The adhesive shall comply with **6.9**.

6.3 Ends of fittings

The ends of fittings shall comply with the requirements of **4.3**.

6.4 General appearance and finish

The fittings shall comply with the specification of **4.4**.

6.5 Smoothness of bore

The fittings shall comply with the specification of **4.5**.

6.6 Geometrical characteristics

The manufacturer's literature shall give the overall dimensions of fittings and other dimensions that are relevant to the design of the pipeline.

6.6.1 *Nominal diameter*

The nominal diameter shall comply with **4.6.1**.

6.6.2 *Thickness of wall*

The thickness of the barrel of the fitting shall be at least equal to that specified by the manufacturer for the corresponding class of pipe on which it may be assembled.

NOTE. Lesser thickness can be used, provided that the load bearing capacity is assured by other means (e.g. reinforcing the fitting on-site with concrete).

6.6.3 *External diameter*

The external diameter of the fitting ends shall comply with the external diameter d_2 for pipes of the corresponding class specified by the manufacturer.

6.6.4 *Length of machined ends*

The length of machined ends of fittings shall comply with the requirements of **4.6.6**.

6.6.5 *Angles for branches and bends*

The recommended values are given in table 13.

Table 13. Angles for bends and branches

For bends	For branches
15°	–
20° to 22° 30'	–
30°	–
45°	45°
60°	67° to 70°
90°	87 °to 90°

NOTE 1. For bends whenever possible 15° and 30° are recommended. For branches whenever possible 45° is recommended.

NOTE 2. Other angles can be supplied by agreement between manufacturer and customer.

6.6.6 *Radius of bends*

The recommended minimum centrelines radius of bends is $r = 0{,}5$ DN except for bends of DN > 200 and angles > 70° where the minimum radius is $r = 0{,}7$ DN.

6.6.7 *Limit deviations*

The limit deviations on internal diameter, external diameter, length of machined ends, nominal length and wall thickness shall be the same as specified in **4.6.7.1** and **4.6.7.2**.

6.7 Mechanical characteristics — crushing strength

Where the fittings are to be installed without additional reinforcement on site, the values of the breaking crushing strength per linear metre of fitting shall be equal to 90 % of that stated in table 7 of **4.7.1** in accordance with the nominal diameter and the class when tested as specified in **6.10.3**.

6.8 Physical characteristics — pressure

When tested as specified in **6.10.4**, the fitting shall exhibit no fissures, leakage or drops of water.

6.9 Bonding stability of adhesive

When tested as specified in **6.10.5**, the fitting shall exhibit no leakage or drops of water and the adhesive shall not exhibit changes which could affect its performance in use.

6.10 Test methods

6.10.1 *General*

6.10.1.1 *Acceptance tests*

The acceptance tests shall be carried out at the manufacturer's works on fittings as delivered.

NOTE. The manufacturer can carry out the test as part of the routine quality control system at an earlier stage of maturity.

These tests include the:

– visual inspection of general appearance and finish, and marking;

– geometrical characteristics as specified in **6.6**.

6.10.1.2 *Type tests*

These tests shall be carried out on fittings as delivered. When type tests are carried out the product shall also be subjected to the acceptance tests to ensure it complies with the requirements of this standard.

These tests include the:

– crushing test;

– pressure test;

– bonding stability of adhesive connections test.

6.10.2 ***Geometrical characteristics***

The methods of measurements are the same as in **4.10.2**.

6.10.3 ***Crushing test***

Fittings cut, machined, assembled and bonded from pipes, complying with this standard, shall not be tested.

In the other cases the test shall be conducted as in **4.10.3.1** with the following changes:

The test specimen shall be a complete fitting. The upper and lower press blocks shall be both flat. The part of the fitting submitted to crushing shall exclude the machined end or the socket, and the angled branch (in case of an angled branch, see figures 9 and 10). The press blocks shall be of such size as to be able to carry out the crushing test as described (see figures 9 and 10).

The length l of fitting to be taken into account is the effective length crushed between the press blocks.

The results are expressed in accordance with **4.10.3.1.4**, where l is the effective length crushed between the press blocks.

The result shall comply with **4.7.1**.

6.10.4 ***Pressure tightness test***

Carry out the test on a complete fitting connected to the source of pressure. The end forces due to the internal pressure shall be absorbed by suitable devices. The pressure shall be raised gradually to 100 kPa $\pm$ 10 kPa (1 bar $\pm$ 0,1 bar). This pressure shall be maintained for 30 min.

The result shall conform to the specification of **6.8**.

6.10.5 ***Bonding stability test***

Carry out the test on four fittings having adhesive connections.

Prior to testing store the fittings for 7 days in a controlled atmosphere with an air temperature of 20 °C $\pm$ 2 °C and a relative humidity of 65 $\pm$ 5 %, then check the pressure tightness in accordance with **6.10.4**.

They shall be submitted to 10 cycles as follows:

– 15 h storing at 85 % $\pm$ 5 % relative humidity and 70 °C $\pm$ 2 °C; and

– 9 h storing at 30 % $\pm$ 5 % relative humidity and 20 °C $\pm$ 2 °C.

Then subject them to 10 cycles as follows:

– 15 h storing at 20 °C $\pm$ 2 °C and 65 % $\pm$ 5 % relative atmospheric humidity;

– 9 h storing at −15 °C $\pm$ 2 °C.

Then subject the fittings to the tightness test in accordance with **6.10.4**.

The result shall comply with the specification of **6.9**.

6.11 Marking

The fittings shall be marked legibly and durably with at least the following information:

a) EN 588-1;

b) nominal diameter;

c) manufacturer's identification;

d) date of manufacture (at least the month and the year);

e) class, if relevant;

f) (AT) for products of type AT,

(NT) for products of type NT.

NOTE. Attention is drawn to the EU and/or EFTA regulations on labelling (see foreword).

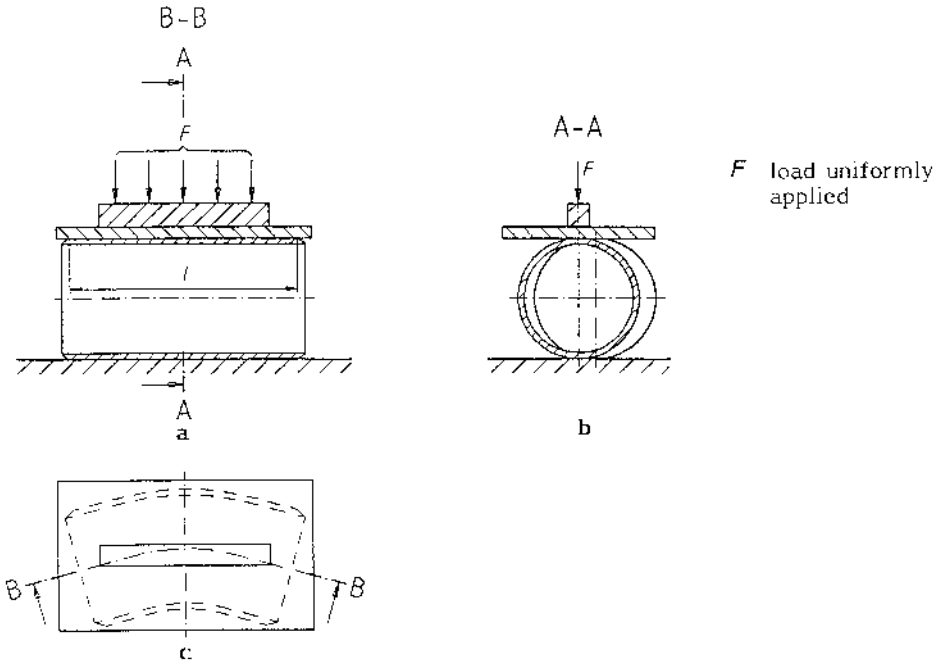


Figure 9. Bend — application of load

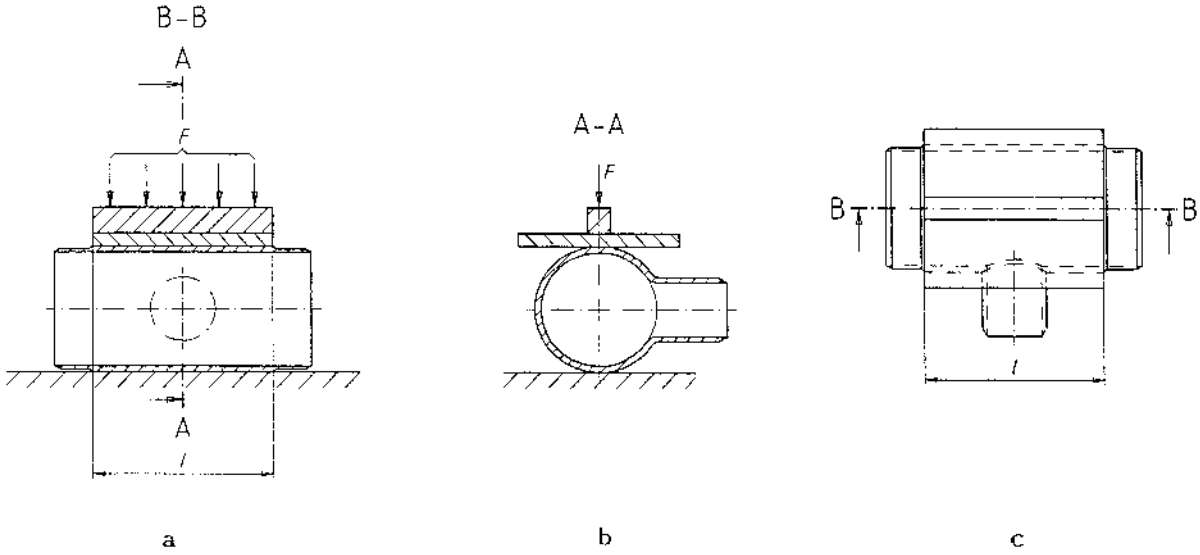


Figure 10. Branch — application of load

7 Quality control

7.1 General

Products manufactured and delivered in accordance with this standard shall be subjected to the following procedures for quality control:

a) the initial control of the products (type testing) (see **7.2**);

b) the internal quality control, to be carried out by the manufacturer (see **7.3**); and

c) the control carried out by an independent third party (third party inspection) (see **7.4**).

7.2 Initial control of the products (type testing)

The initial control in accordance with **4.10**, **5.2** and **6.10** of this standard shall be carried out at the manufacturer's laboratory or by another competent laboratory supervised by an independent testing institute recognized by EU or EFTA. Full reports of these tests shall be recorded and filed. They shall be made available to the third party for examination.

One single type test with positive results will be sufficient, provided no substantial change in the formulation and/or the manufacturing process, the effects of which cannot be predicted on the basis of previous experience, has been made. Otherwise the test shall be repeated.

7.3 Internal quality control carried out by the manufacturer

7.3.1 *Quality system*

The manufacturer shall establish and maintain an effective documented quality control system so as to achieve compliance with this standard.

The quality control system of the manufacturer shall comply with the transposed national standard for EN ISO 9001 or EN ISO 9002 within 6 years of the publication of this standard.

For factories not yet complying with EN ISO 9001 or EN ISO 9002 the quality organization shall conform at least to the requirements of annex A.

7.3.2 *Acceptance tests*

Each limit of specification will be subject to an AQL of 4 %. The sampling schemes provided in ISO 390, with an AQL of 4 % and an inspection level S_3, ensures that for large batches approximately 95 % of the items fulfil the requirements.

Once the type test on the joints has been fulfilled (**5.2.1.2**) conformity of the joint to this standard shall be verified by checking the relevant dimensions of the components of the joints and the conformity of the sealing rings with prEN 681-1.

7.3.3 *Inspection of a consignment of finished products*

Inspection of a consignment of finished products is not a requirement of this standard.

NOTE. If in special cases inspection is still required by the customer it can be carried out in accordance with annex B and ISO 390.

7.4 Third party inspection

7.4.1 *General*

For each production plant, the manufacturer shall establish and maintain a third party inspection, based on a contract between manufacturer and an inspection body.

The third party inspection shall be carried out by an official EU or EFTA recognized authority.

The purpose of the third party inspection is to carry out an independent quality control on products and to conform the ability of the manufacturer to produce products which continuously meet the requirements of this standard.

The third party certification in accordance with table 14 shall be established as soon as possible after publication of this standard but not later than within 2 years. For products not yet subjected to third party inspection acceptance test can be required in accordance with annex B. The product cannot be marked with the number of this standard until third party certification is established and maintained.

Table 14. Third party inspection of pipes, joints and fittings

Test specimen	Attribute	Requirement	Test method
Pipes	Appearance, finish	**4.4**	—
	Marking	**4.11**	—
	Dimensions	**4.6**	**4.10.2**
	Crushing strength	**4.7.1**	**4.10.3.1**
	Bending load	**4.7.2**	**4.10.3.2**
Fittings	Appearance, finish	**6.4**	—
	Marking	**6.11**	—
	Dimensions	**6.6**	**6.10.2**
Sleeves and sockets	Appearance, finish	**5.1.3**	—
	Marking	**5.3**	—
	Dimensions	**5.1.4**	**5.2.2**

7.4.2 Factories with certification and quality system in accordance with EN ISO 9001 or EN ISO 9002.

The inspection by the third party shall be made without previous announcements at least once a year at regular intervals.

The procedure for third party inspection shall consist of:

– controlling the validity of the certification of conformity granted to the manufacturer in accordance with EN ISO 9001 or EN ISO 9002 for his quality system;

– verifying that the results of the internal quality control are in accordance with the requirements of this standard;

– independent routine testing of finished products in accordance with table 14.

7.4.3 Factories without certification and quality system in accordance with EN ISO 9001 or EN ISO 9002.

The inspection by the third party shall be made without previous announcements at least four times a year at regular intervals.

The procedure of third party inspection shall consist of:

– assessing the adequacy of staff and equipment for continuous and orderly manufacture;

– verifying that the department responsible for internal quality control is independent of the production department;

– verifying that the type tests have been satisfactorily carried out in accordance with the requirements of this standard;

– verifying that the results of the internal quality control are in accordance with the requirements of this standard;

– independent routine testing of finished products in accordance with table 14.

The inspection by the third party may be reduced to two times a year provided that the third party is satisfied that:

– the manufacturer's internal quality control system is adequate;

– the inspections have been continuously carried out in a proper and effective way for 2 years; and

– the results are in accordance with the requirements of this standard.

This reduced frequency of inspection may remain valid for as long as no defective product is detected.

The third party shall ensure that the manufacturer's inspections and tests have been carried out in accordance with this standard, and that the results obtained meet the requirements.

7.4.4 ***Test report by the third party***

After completion of the inspection a test report shall be drawn up by the third party inspector.

The test report shall at least contain the following information:

– name and location of the third party body;

– name and/or identification of manufacturer;

– name and location of plant;

– number and title of this standard;

– description of products tested;

– test results and their evaluation;

– location and date of the test report;

– signature of third party inspector.

It shall further contain:

a) for manufacturers with certification in accordance with EN ISO 9001 or EN ISO 9002 statements regarding:

– the validity of the certificate covering the internal quality control system; and

– the conformity of the products;

b) for factories not yet complying with EN ISO 9001 or EN ISO 9002 statements regarding:

– whether the requirements of annex A are fulfilled; and

– the conformity of the products.

7.4.5 ***Re-testing***

If, during the third party inspection, a sample fails, a reinforced inspection in agreement with the third party shall be carried out on the characteristics which have failed; if this reinforced inspection fails, the production related to the failure(s) shall be excluded from shipment pending the outcome of further investigations.

The problem shall be identified and corrective actions shall be taken by the manufacturer in order to eliminate the nonconformity. On request the third party shall be informed of these measures.

8 Denomination of products covered by this standard

The denomination of pipes, branches and fittings shall include at least:

– reference to this standard;

– nominal diameter;

– length in metres;

– class;

– series *S*, if relevant;

– composition type: AT or NT.

Example: Pipe EN 588-1 - 600 - 5 - 60 - NT.

In addition any legal requirements restricting the use of certain materials shall be indicated (see foreword).

Annex A (normative)

Quality organization for factories not yet complying with EN ISO 9001 or EN ISO 9002

A.1 General requirements

A.1.1 *Personnel, resources and test equipment*

The responsibility, authority and the interrelation of all personnel engaged in the inspection and/or tests shall be defined by the manufacturer.

The manufacturer shall provide adequate resources and assign trained personnel for verification activities.

The manufacturer shall control, calibrate and maintain measuring and testing equipment.

A.1.2 *Quality records*

The manufacturer shall establish and maintain procedures for identification, collection, indexing, filling, storage, maintenance and disposition of quality records.

Quality records shall be maintained to demonstrate achievement of the required quality and the effective operation of the quality system. Relevant sub-contractor quality records shall be an element of this information.

Retention times of quality records shall be at least 5 years.

Quality records shall be presented to the third party inspection on demand.

A.1.3 *Statistical methods*

The manufacturer shall establish procedures for identifying adequate statistical methods required for verifying the results of the factory quality control.

A.2 Quality assurance

A.2.1 *General*

The manufacturer shall establish and maintain a documented quality system for each production plant as means of ensuring that products conform to requirements specified in this standard.

The quality system consists of an internal quality control and a third party certification.

A.2.2 *Internal quality control*

For each production plant, the manufacturer shall verify that pipes, joints and fittings conform to the specifications of this standard. The internal quality control includes the control of incoming raw materials, control of production process, control of product characteristics during production and final inspection and testing of finished products.

The requirements for internal quality control and corresponding test methods are given in the three following tables A.1, A.2 and A.3. The minimum sampling schemes shall be calculated in accordance with ISO 2859-1 for inspection by attribute (double sampling) with an AQL of 4 % and an inspection level S_1 or ISO 3951 for inspection by variable (method σ or s) with an AQL of 4 % and an inspection level S_3. These sampling schemes are given in table A.4.

Table A.1 Internal quality control for pipes – requirements and test methods

	Requirement	Test method
General appearance and finish	**4.4**	Visual inspection
Smoothness of bore	**4.5**	Visual inspection
Internal diameter	**4.6.2/4.6.7.1**	**4.10.2.1**
Thickness of wall	**4.6.3/4.6.7.2**	**4.10.2.3**
External diameter	**4.6.4/4.6.7.3**	**4.10.2.2**
Length of pipes	**4.6.5/4.6.7.4**	**4.10.2.4**
Length of machined ends	**4.6.6**	**4.10.2.5**
Crushing strength	**4.7.1**	**4.10.3.1**
Bending loads	**4.7.2**	**4.10.3.2**
Marking	**4.11**	Visual inspection

Table A.2 Internal quality control for fittings, requirements and test methods

	Requirement	Test method
General appearance and finish	**6.4**	Visual inspection
Smoothness of bore	**6.5**	Visual inspection
External diameter	**6.6.3**	**6.10.2**
Internal diameter[1)]	**4.6.2/4.6.7.1**	**6.10.2**
Thickness of wall	**6.6.2**	**6.10.2**
Crushing strength[1)]	**6.7**	**6.10.3**
Marking	**6.11**	visual inspection

[1)] Shall not be tested if made of pipes in accordance with this standard.

Table A.3 Internal quality control for joints, requirements and test methods

	Requirement	Test method
General appearance, finish of sockets sleeves sealing rings	**5.1.3** prEN 681-1	Visual inspection prEN 681-1
Shape and dimensions of sleeves or sockets	**5.1.4**	**5.2.2**
Shape and dimensions of sealing rings[1)]	prEN 681-1	prEN 681-1
Hardness of sealing rings[1)]	**5.1.2**	prEN 681-1
Marking of sleeves, sockets	**5.3**	—
Marking of sealing rings	prEN 681-1	prEN 681-1

[1)] Shall not be tested if the sealing rings were from a supplier certified by a third party recognized by the EU.

Table A.4 Internal quality control for pipes, joints and fittings – minimum sampling schemes

Size of batch	ISO 2859-1 Normal inspection Inspection by attribute (AQL 4 — level S_1)					ISO 3951 Normal inspection Inspection by variable method σ (AQL 4 — level S_3)	
	Sample size	Initial		Initial + second		Sample size	k
		Acn_1	Ren_1	Acn_2	Ren_2		
< 280	2	0	1	NA[1)]	NA	2	0,936
281/500	2	0	1	NA	NA	2	0,936
501/1 200	3	0	1	NA	NA	3	1,01
1 201/3200	3	0	1	NA	NA	4	1,11
3 201/10 000	3	0	1	NA	NA	5	1,20

[1)] NA = Not applicable.

NOTE. The size of a control batch will be chosen by the manufacturer up to a maximum of a production of one week.

A.3 Non-conforming products

All nonconforming products shall be segregated and excluded from dispatch, and instructions shall be given for further handling and administration (storage, marking).

If during internal quality control nonconforming products are detected the manufacturer's department for quality assurance shall remedy the failure(s).

Only after investigation, proper correction of the failure(s) and final inspection shall the quality control department of the manufacturer agree upon despatch of production.

Annex B (normative)

Acceptance test[3)] for products which are not subject to third party certification

B.1 When tenders and/or orders specify it, the acceptance test shall be carried out in lot(s) of the consignment in accordance with the test programme of this product standard, unless there is a special agreement. Therefore, the test programme necessarily covers the acceptance tests.

Details related to the application of the sampling clause shall be established in agreement between the manufacturer and the purchaser.

B.2 After agreement on the sampling procedure, sampling shall be carried out, in the presence of both parties, from lot(s) which are to be delivered to the purchaser. If the inspection lot(s) are not yet formed, the manufacturer should present to the purchaser the stock(s) from which the inspection lot(s) can be selected and marked. Unless otherwise agreed between the manufacturer and the purchaser, the maximum and minimum inspection lots shall be as follows:

– 400 and 100 pipes respectively for diameters up to DN 250 inclusive;

– 200 and 100 pipes respectively for diameters from DN 300 to DN 1 000 inclusive;

– 200 and 100 fittings or joints.

For pipes of DN > 1 000 an agreement between purchaser and manufacturer shall be made.

B.3 The tests shall be carried out by the laboratory of the manufacturer or by an independent laboratory selected by mutual agreement between the manufacturer and the purchaser. In cases of dispute, the tests shall be carried out in the presence of both parties.

B.4 When non-destructive tests are carried out and the results of the sampling inspection do not meet the acceptance tests requirements of the product standard, the tests shall be required on each item of the consignment. The units of the consignment which do not meet the requirements when tested one by one can be refused and disposed of, unless otherwise agreed between the manufacturer and purchaser.

Annex C informative)

Long term vertical loading test

The long term vertical loading test assesses the long term behaviour of a buried pipe under an external loading of 85 % of the pipe class for a minimum period of 50 years.

The method of test, the conditioning during testing and the loading specified induces more severe loading conditions to the test specimen than would occur after a long period to the pipe under normal buried pipe conditions.

[3)] See ISO 390.

Annex D (normative)

Test method to determine the modulus of elasticity

D.1 Test specimen

A short length pipe, having a length of 0,6 × DN, cut from the barrel. The nominal diameter of the test specimen shall be equal to the largest manufactured DN with a maximum of DN 1 000. The minimum number of test specimens shall be four, each cut from a different pipe of the same DN and class.

D.2 Apparatus

The test shall be carried out with a test arrangement in accordance with figure D.1, consisting of:

D.2.1 *A compression test machine*, in accordance with **4.10.3.1** of this standard.

D.2.2 *A lower and upper V-shaped press block*, made of knot-less hardwood, having an included angle of 170°.

For a uniform transmission of loading, the press blocks shall be supported on high pressure hoses between parallel flat surfaces of the test machine.

D.2.3 *A device*, set at both ends of the test specimen for measuring to an accuracy of 0,01 mm the vertical and horizontal deformation of the internal diameter under load.

D.2.4 *A measuring device*, for the length, internal diameter and wall thickness with an accuracy of 0,1 mm.

D.2.5 *A chronometer*.

D.3 Procedure

D.3.1 Before starting the test, the test specimens shall be stored in a normal laboratory atmosphere for 1 week.

D.3.2 Measure the internal diameter, the wall thickness and the length of all test specimens in accordance with **4.10.2** of this standard. Internal diameters, length of test specimens and wall thickness shall be determined to 0,1 mm, deformation of internal diameters shall be determined to 0,01 mm. The results shall be recorded.

D.3.3 Place a test specimen in the test apparatus, centrally trued to the axis of loading. Carry out a crushing test on one test specimen to determine the approximate ultimate load to be expected for all test specimens and record it.

D.3.4 Place a test specimen in the test apparatus, centrally trued to the axis of load and insert the measuring device for the pipe deformation in accordance with figure D.1.

D.3.5 Apply the lower test load F_{lo} = 300 N.

D.3.6 Increase the load up to the upper test load $F_{up} = 0.3\,F_{ultimate}$ and decrease the load down to F_{lo} without shock and with a constant speed of 500 N/s. Repeat this cycle two times.

D.3.7 After the three loading cycles and an interval of 30 s, carry out another loading between F_{lo} and F_{up}, measure and record both the vertical deformation Δd_v and the horizontal deformation Δd_h between these two loadings.

D.4 Expression and interpretation of test results

Calculate the modulus of elasticity using the following formula:

$$E = \frac{(F_{up} - F_{lo}) \times (d_1 + e)^3 \times 12}{16 \times l \times e^3} \times \times \left[\frac{0.1488}{\Delta d_v} + \frac{0.1366}{\Delta d_h}\right]$$

where:

E is the modulus of elasticity in newtons per square millimetres;

e is the mean value of the wall thickness of the test specimen taken out of four measurements on each end of the specimen, in millimetres;

F_{up} is the upper load in newtons;

F_{lo} is the lower load in newtons;

d_1 is the internal diameter, mean value out of four measurements taken at both ends of test specimen in millimetres;

l is the length of test specimen, mean value out of four measurements at the 90° crosspoints in millimetres;

Δd_h is the horizontal deformation, mean value out of measurements at both ends, measured between loads F_{lo} and F_{up} in millimetres;

Δd_v is the vertical deformation, mean value out of measurements at both ends, measured between loads F_{lo} and F_{up} in millimetres.

The test report shall at least include the following details:

– type of measuring devices used;
– class and dimensions of the test specimens;
– loads F_{lo} and F_{up};
– deformations Δd_v and Δd_h.

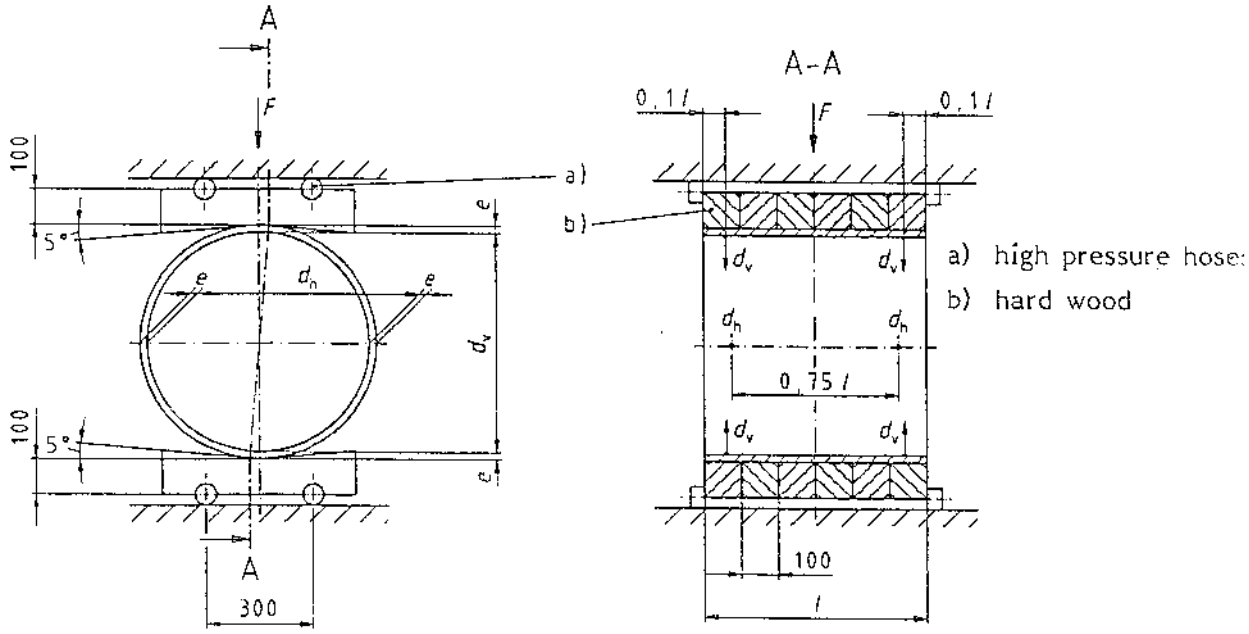


Figure D.1 Test arrangement for estimation of E-modulus

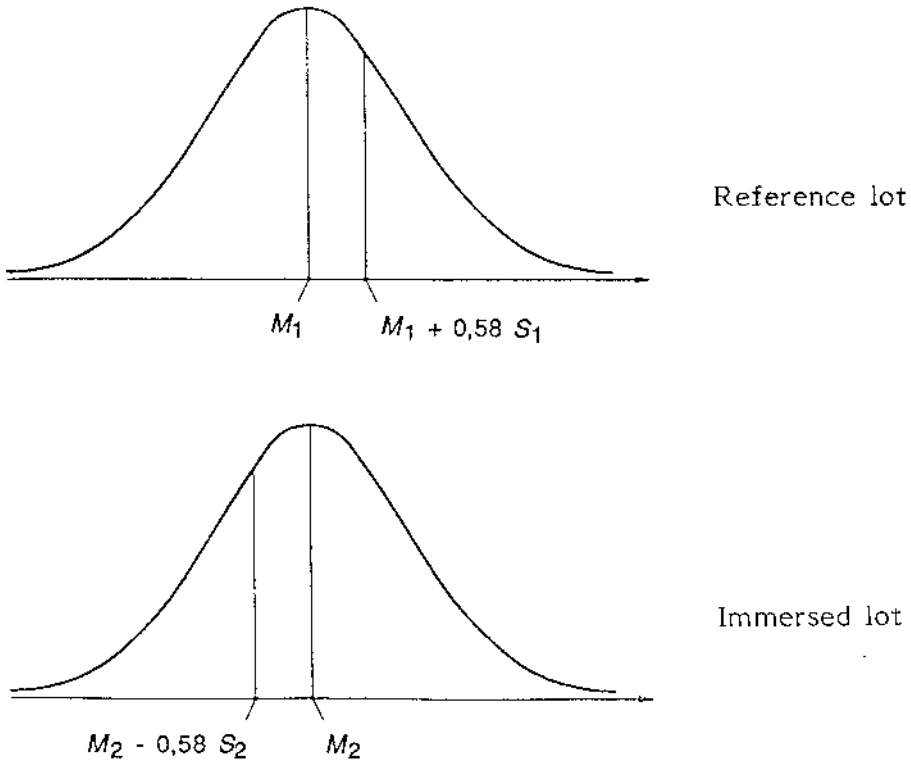
Annex E (informative)

Note on statistical comparison of paired test specimens

Warm water test (4.10.4.2) — Resistance to domestic sewage media test (4.10.5)

These tests are carried out on 10 paired test specimens. The main cause of difference between the two items of a same pair is the test itself (immersion in warm water, corrosion treatment).

The results of the crushing strength test on the two test specimens of the same pair are compared by their ratio (see figure E.1). The expression of L stated in the expression of results gives the lower value of the one-sided confidence interval of the mean of this ratio (see ISO 2602).



where:

M_1 is the mean crushing load of reference lot;

S_1 is the standard deviation of reference lot;

M_2 is the mean crushing load of immersed lot;

S_2 is the standard deviation of immersed lot.

Figure E.1 Theoretical distribution curve of the mean

Annex F (informative) Typical types of fittings

Joints

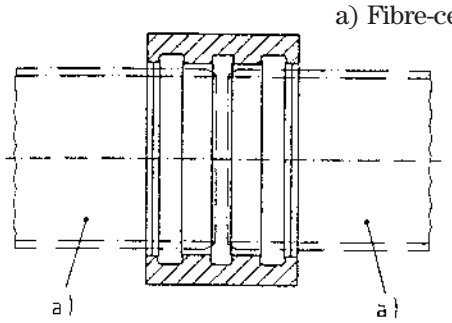


Figure F.1 Standard joint

a) Fibre-cement

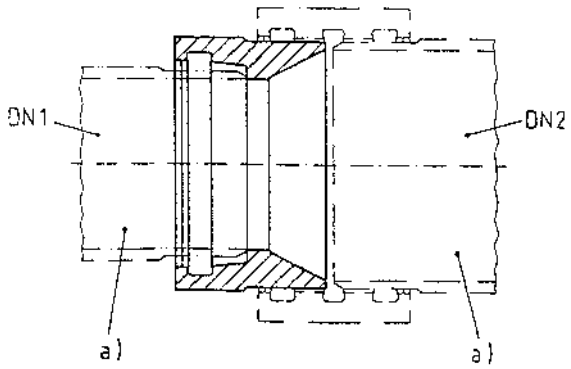


Figure F.2 Transition joint

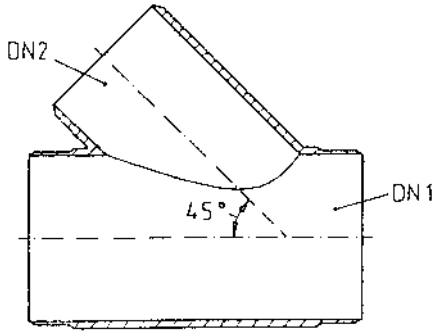


Figure F.3 Branch 45°

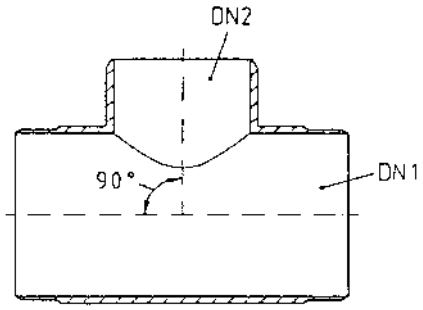


Figure F.4 Branch 90°

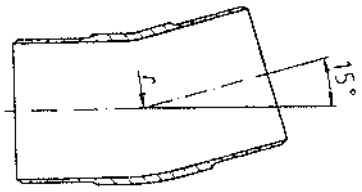


Figure F.5 Bend 15°

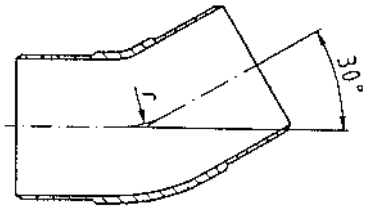


Figure F.6 Bend 30°

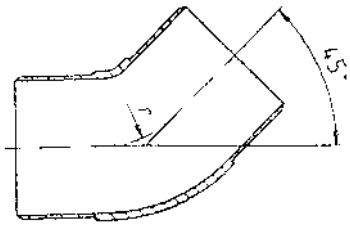


Figure F.7 Bend 45°

Connections to other pipe materials

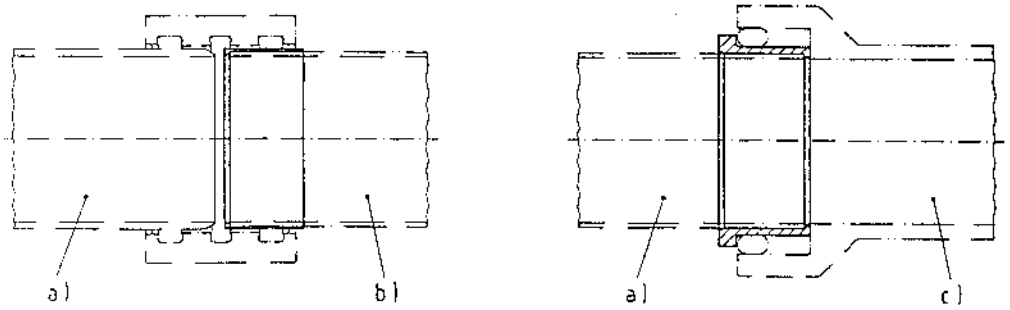
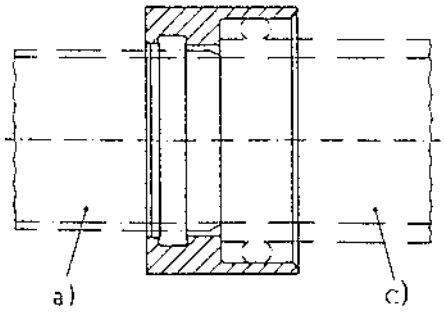


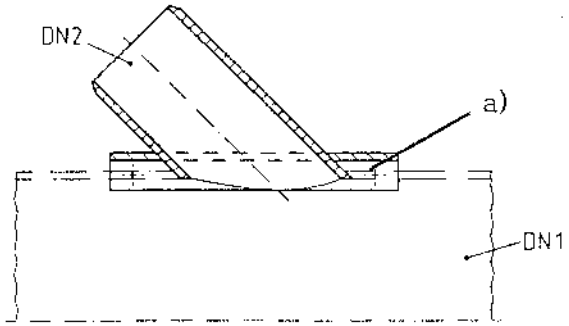
Figure F.8 Transition gasket



a) Fibre-cement
b) Cast iron/plastics
c) Clayware/concrete

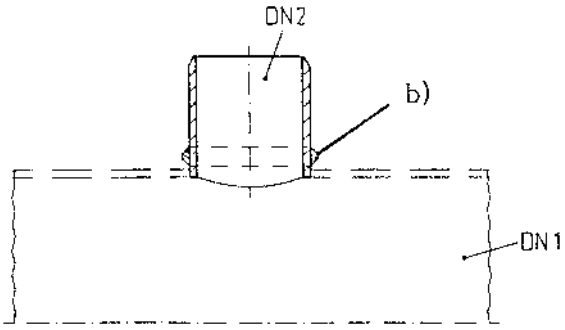
Figure F.9 Transition coupling

Connections to established fibre-cement pipelines



a) Elastomeric sealant, bolted

Figure F.10 Saddle piece 45°



b) Adhesive joint

Figure F.11 Connection stub

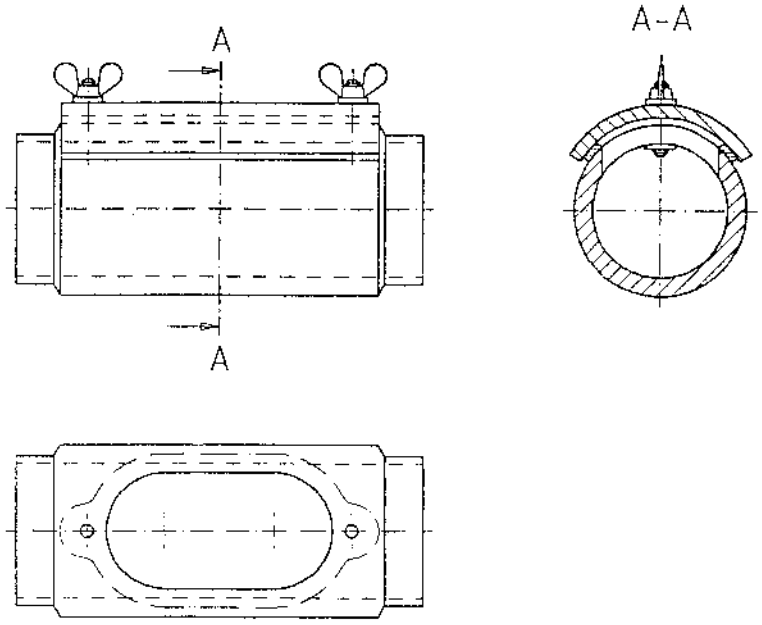


Figure F.12 Cleaning piece

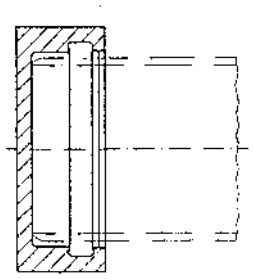


Figure F.13 Lock piece

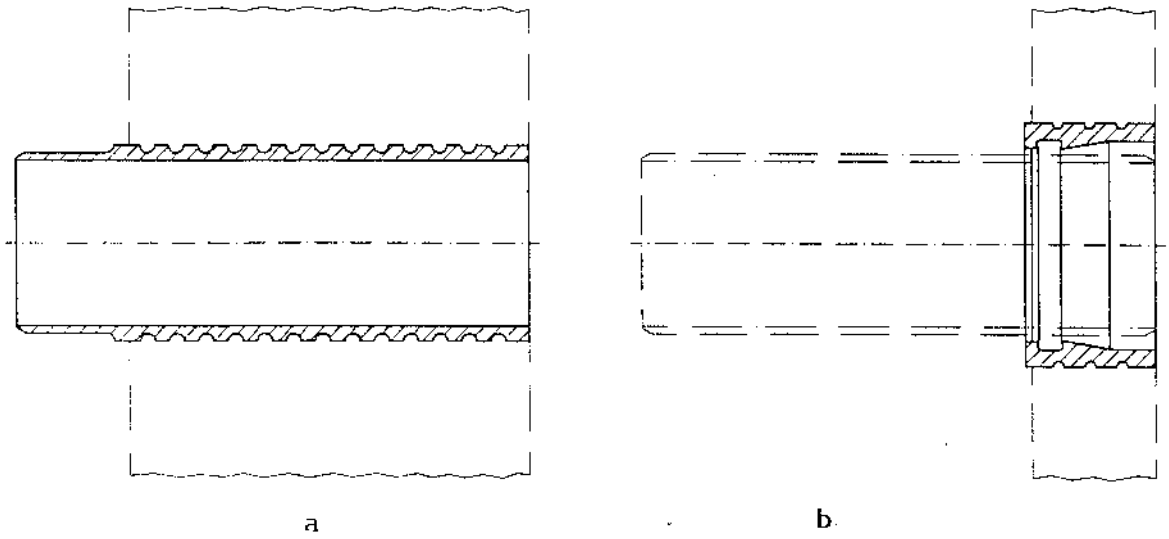


Figure F.14 Connection to concrete structures (female)

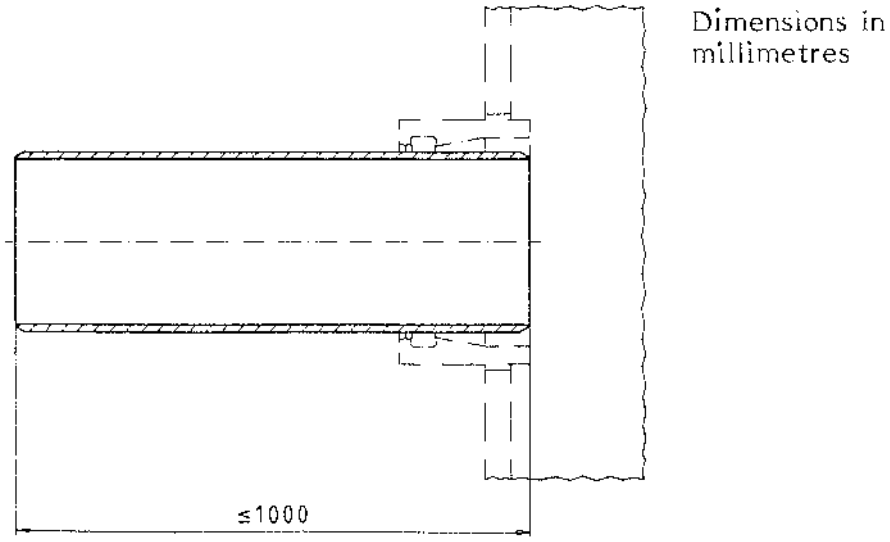


Figure F.15 Hinge or rocker pipe

Annex G (informative)

A-deviations

National deviations due to regulations, the alteration of which is for the time being outside the competence of the CEN member. In the relevant CEN countries these A-deviations are valid instead of the provisions of the European Standard until they have been removed.

National deviations type A, with regard to this European Standard, which falls under Directive 90/531/CEE, have been requested by Denmark, Germany, Norway and Sweden. The references of their national regulations are the following:

Clause	
4.1 General composition	**Denmark** Bekendtgørelse om asbest (Nr. 660 af 24. september 1986) Bekendtgørelser om aendring af bekendtgørelse om asbest (Nr. 139 af 23. marts 1987) (Nr. 984 af 11. december 1992)
	Germany Verordnung über Verbote und Beschränkungen des Inverkehrbringens gefährlicher Stoffe, Zubereitungen und Erzeugnisse nach dem Chemikaliengesetz (Chemikalien-Verbotsordnung) vom 14. Oktober 1993, BGBI. 1993 Teil 1, S. 1720 Verordnung zum Schutz vor gefährlichen Stoffen (Gefahrstoffverordnung) vom 26. Oktober 1993, BGBI. Teil 1, S. 1783
	Norway Forskrifter om asbest Fastsatt av Kommunaldepartementet 16. august 1991 med endringer fastsatt ved kgl. res. 30. juni 1995 med hjemmel i lov av 4. februar 1977 nr. 4 om arbeidervern og arbeidsmijø §§ 7 nr 2 og 3, 8 nr.4, 11 nr. 2, 3, 4 og 5, 12 nr. 5, 14 tredje ledd, 18 nr 3 og 22 og med hjemmel I lov av 11 juni 1976 nr. 79 om producktkontroll § 4.
	Sweden Arbetarskyddsstyrelsens kungörelse med föreskriffer om asbest, AFS 1992:2. Beslutad den 28 april 1992

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List of references

See national foreword.

BSI — British Standards Institution

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