BS EN 295-3:2012

BSI Standards Publication

Vitrified clay pipe systems for drains and sewers

Part 3: Test methods

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 295-3:2012. It supersedes BS EN 295-3:1991, which is withdrawn.

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.

ISBN 978 0 580 70648 6

ICS 23.040.50; 91.140.80; 93.030

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 January 2012.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 295-3

January 2012

ICS 93.030

Supersedes EN 295-3:1991

English Version

Vitrified clay pipe systems for drains and sewers - Part 3: Test methods

Systèmes de tuyaux et accessoires en grès vitrifié pour les collecteurs et branchements - Partie 3: Méthodes d'essai

Steinzeugrohrsysteme für Abwasserleitungen und -kanäle - Teil 3: Prüfverfahren

This European Standard was approved by CEN on 19 November 2011.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 295-3:2012: E

Contents

Page

Foreword

This document (EN 295-3:2012) has been prepared by Technical Committee CEN/TC “Wastewater engineering”, the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by July 2012, and conflicting national standards shall be withdrawn at the latest by January 2013.

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

This document supersedes EN 295-3:1991.

The main changes with respect to the previous edition are listed below:

a) test method for resistance to high pressure water jetting added;

b) test method for water absorption added;

c) test methods from the previous parts 4, 5, 6 and 7 have been included in this European Standard;

d) editorially revised.

The standard series EN 295 "Vitrified clay pipe systems for drains and sewers" consists of the following parts:

— *Part 1: Requirements for pipes, fittings and joints;*

— *Part 2: Evaluation of conformity and sampling;*

— *Part 3: Test methods;*

— *Part 4: Requirements for adaptors, connectors and flexible couplings;*

— *Part 5: Requirements for perforated pipes and fittings;*

— *Part 6: Requirements for components of manholes and inspection chambers;*

— *Part 7: Requirements for pipes and joints for pipe jacking.*

This European Standard takes into account the requirements of EN 476.

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

1 Scope

This European Standard specifies requirements for testing of products manufactured from vitrified clay and other materials specified in the following standards:

— pipes, fittings and joints according to EN 295-1;

— adaptors, connectors and flexible couplings according to EN 295-4;

— perforated pipes and fittings according to EN 295-5;

— components of manholes and inspection chambers according to EN 295-6;

— pipes and joints for pipe jacking according to EN 295-7.

2 Normative references

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

EN 295-1:2012, *Vitrified clay pipe systems for drains and sewers — Part 1: Requirements for pipes, fittings and joints*

EN 295-4:2012, *Vitrified clay pipe systems for drains and sewers — Part 4: Requirements for adaptors, connectors and flexible couplings*

EN 295-5:2012, *Vitrified clay pipe systems for drains and sewers — Part 5: Requirements for perforated pipes and fittings*

EN 295-6:2012, *Vitrified clay pipe systems for drains and sewers — Part 6: Requirements for components of manholes and inspection chambers*

EN 295-7:2012, *Vitrified clay pipe systems for drains and sewers — Part 7: Requirements for pipes and joints for pipe jacking*

EN ISO 527-2:1996, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics (ISO 527-2:1993 including Corr 1:1994)*

EN ISO 868, *Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness) (ISO 868)*

EN ISO 1133:2005, *Plastics — Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics (ISO 1133:2005)*

CEN/TR 14920:2005, *Jetting resistance of drain and sewer pipes — Moving jet test method*

3 Terms and definitions

For the purposes of this European Standard, the relevant terms and definitions specified in EN 295-1:2012, EN 295-4:2012, EN 295-5:2012, EN 295-6:2012 and EN 295-7:2012 apply.

4 Symbols and abbreviations

Symbol	Description
A	Outside diameter of the spigot moulding
a_M	Measurement from inside of pipe barrel to mid point of inside of socket fairing, in millimetres (continuity of invert test).
a_p	Width of top bearer, in millimetres (crushing strength test and bending tensile strength test).
B	Nominal length of external barrel of pipe unobstructed by socket shape and/or jointing configuration, in millimetres (crushing strength test).
B_t	Distance from the outside surface of the spigot moulding to the internal surface of the pipe at one point at which the outside diameter of the spigot moulding (A) was measured, in millimetres (continuity of invert test).
b	Specimen width, in millimetres (fatigue strength test).
C_t	Distance from the outside surface of the spigot moulding to the internal surface of the pipe at the opposite end to B_t of the diameter measured as the outside diameter of the spigot (A), in millimetres (continuity of invert test).
c	Concentration of solution, in moles per litre (chemical resistance tests).
c_i	Factor for the upper (0,4) or lower (0,1) limit of the load (fatigue strength test).
D	Inside diameter of the socket moulding
DN	Nominal size - a numerical designation of size which is a convenient round number equal to or approximately equal to the internal diameter, in millimetres (bending moment resistance test).
D_S	Deviation from straightness
d_1	Barrel internal diameter, in millimetres (bending tensile strength test).
E_t	Distance from the internal surface of the socket moulding to the internal surface of the pipe at one point at which the inside diameter of the socket moulding (D) was measured, in millimetres (continuity of invert test).
F_i	Force for upper and lower limit, in kilonewtons (fatigue strength test).
F_N	Crushing strength, in kilonewtons per metre.
F_t	Distance from the internal surface of the socket moulding to the internal surface of the pipe at the opposite end to E_t, of the diameter measured as the inside of the socket moulding (D), in millimetres (continuity of invert test)
G_m	Mean annular gap, in millimetres (continuity of invert test).
IRHD	International Rubber Hardness Degrees of bearing strips/facings, in degrees IRHD (crushing strength test).
k_s	Hydraulic roughness in millimetres
l_4	Centre line distance between supports, in millimetres (fatigue strength test).
L_N	Nominal length of the pipe
L_T	Test length
M	Bending moment resistance, in kilonewton metres (bending moment resistance test).
M_b	Bending moment, in Newton millimetres (bending tensile strength test).
M_p	Mean particle size, in millimetres (abrasion resistance test).

M_1	Test piece mass before treatment, in grammes (chemical resistance test).
M_2	Test piece mass after treatment, in grammes (chemical resistance test).
S	Support span in metres
s_1	Specimen wall thickness, in millimetres (bending tensile test).
S_{min}, S_{max}	Extreme values of difference in invert, in millimetres (continuity of invert test).
S_t	Standard deviation, in millimetres (continuity of invert test).
s_f	Specimen wall thickness, in millimetres (fatigue strength test).
t	Time.
U	Degree of non-uniformity of particles (abrasion resistance test).
W_{15}	Water addition in 15 minutes, in litres per square metre (watertightness test).
β	Half the depth of a socket fairing, in millimetres (continuity of invert test).
Δa	Measurement of difference in invert levels, in millimetres (continuity of invert test).
Δs	Deviation from squareness in millimetres.
ε	Deformation of rigid fairing materials (creep resistance of rigid fairing materials test).
σ_i, σ_j	Restoring stress at $t = 10^i$ and $t = 10^j$, in N/mm^2 (polyurethane relaxation tests).
σ_{bz}	Bending tensile strength, in Newtons per square millimetre (bending tensile strength test).

5 Test for squareness of ends

5.1 Test of squareness of ends for pipes according to EN 295-1:2012

A whole pipe shall be placed horizontally on two supports which have a distance of 75 mm from each end of the barrel for up to and including DN 500 and 100 mm for pipes greater than DN 500.

The deviation from squareness shall be measured as the maximum difference, at either end, between distances from any point on the end of the barrel to a plane rectangular to the line joining the points of support. Any suitable apparatus may be used. An example is given in Figure 1.

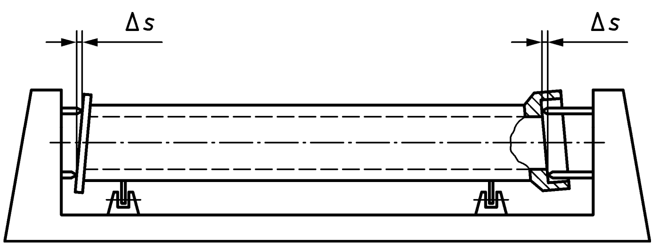
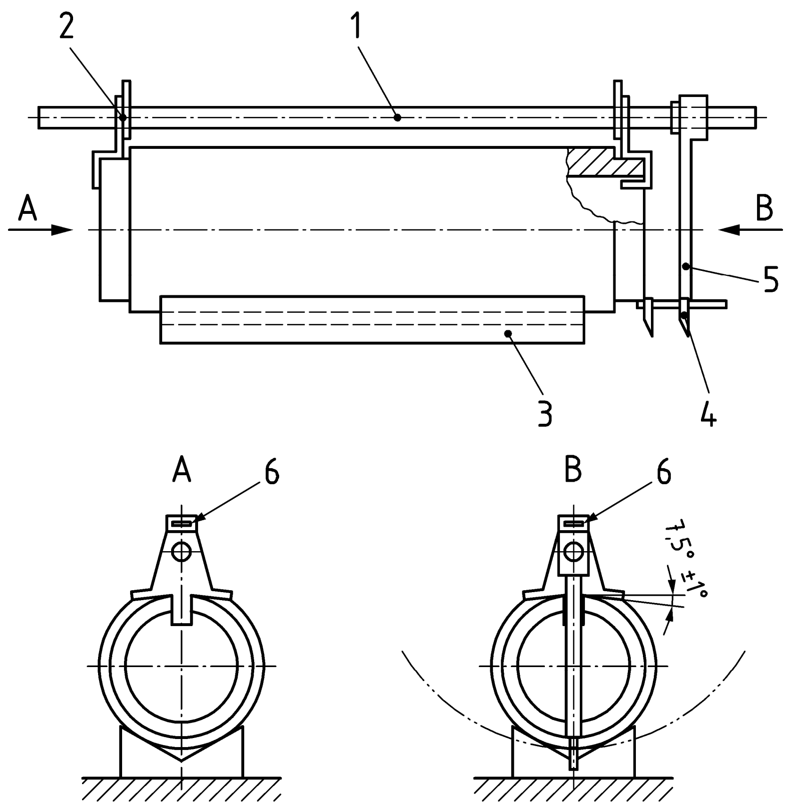


Figure 1 — Measurement of squareness of ends

5.2 Test of squareness of ends for pipes according to EN 295-7:2012

A whole pipe shall be placed on a horizontal support according to Figure 2. The gauge shall be clamped to the ground ends of the pipe. The pivot arm is located approximately 100 mm away from the cut end.

The distance between the pivot arm and the cut end is measured at 90° intervals. The deviation from squareness is the difference between the maximum and minimum measurements. This procedure shall be performed for both ends of the pipe. Any suitable apparatus may be used. An example is given in Figure 2.



Key

1 gauge
2 clamp
3 support
4 calliper gauge
5 pivot arm
6 spirit level

Figure 2 — Gauge for squareness of ends

6 Straightness test

The deviation from straightness of a pipe barrel is the maximum distance from the centre of a straight line equal to the test length spanning any concave curve on the outside of a pipe barrel to the pipe surface, D_s, as shown in Figure 3. It is permissible to test for straightness using any suitable apparatus.

The test length shall be 150 mm less than the nominal length of the pipe to allow for clearance at the shoulder of any socket and at any jointing material at the spigot end.

Key

L_N is the nominal length of the pipe

L_T is the test length

D_s is the deviation from straightness

$L_T = L_N$ – 150 mm at DN ≤ 500

$L_T = L_N$ – 200 mm at DN > 500

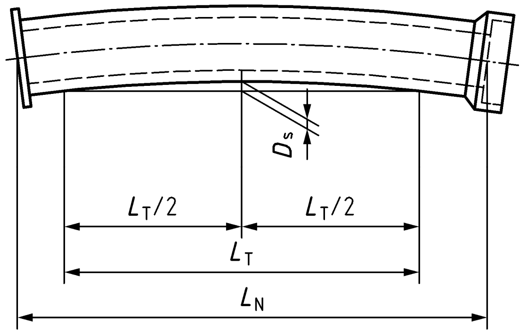


Figure 3 — Straightness test method

7 Crushing strength test

7.1 General

7.1.1 Preconditioning

Prior to crushing strength tests, sample pipes or pipe sections shall be preconditioned by either:

a) complete immersion in water at ambient temperature for the minimum times given in Table 1, where the wall thickness is the mean wall thickness of the batch,

Table 1 — Preconditioning time for strength tests

Wall thickness mm	**Minimum preconditioning time**	
	Unglazed, glazed only on interior or exterior surface, salt glazed h	Ceramic glazed h
up to 20	18	42
> 20 to ≤ 35	42	66
> 35	66	90

or

b) by complete immersion in a water pressure tank at ambient temperature for 24 h at a pressure of 250 kPa (2,5 bar).

An example of the pressure tank is given in Figure 4.

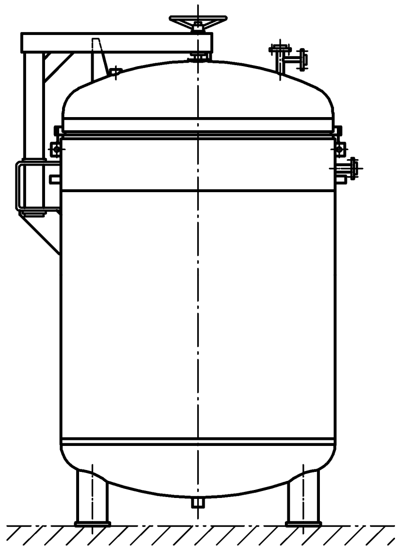


Figure 4 — Example of pressure tank for preconditioning

7.1.2 Testing machine

The testing machine for crushing shall be capable of applying compressive loads and shall be substantial and rigid throughout, so that the distribution of the load will not be affected by the deformation or yielding of any part. The machine and bearers shall be designed to transmit the load in a vertical plane through the longitudinal centre lines of the bearers and pipe.

The load shall be applied to the top bearer in such a way that the combination of support, bearers and bearing strips is free to rotate in a vertical plane through the longitudinal centre lines of the top and custom bearers.

The testing machine load shall be verified by calibration to an accuracy of 1 % by an approved agency at intervals of not more than 12 months.

7.1.3 Loading

The pipe or pipe section of no less than 300 mm long shall be placed between the bearer strips. When using the rigid system described in 7.3.3 the plane of any permitted longitudinal curvature shall be approximately horizontal.

The load shall be applied to the pipe or pipe section without vibration or sudden shock, at a uniform rate between 0,40 kN/m of pipe per second and 0,60 kN/m of pipe per second, or in increments of not more than 0,50 kN/m at the same rate, up to the point of failure or, in the case of acceptance (proof) testing, to the load corresponding to the required strength.

7.2 Bearers and bearing strips/facings

7.2.1 Bearers

The bearers shall consist of metal, teak or similar hard wood, be straight and free from knots, warping or twisting, and shall be centrally located on their supports.

The top and bottom bearers shall both have a minimum thickness of 25 mm. When bearing strips are used the widths of the bearers shall be not less than those of the corresponding bearer strips as shown in Figure 5 a). Bearers shall be located such that they are aligned both longitudinally and transversely.

When bearing facings are used, the widths shall be as necessary to support the pipe and the width of the top bearer shall not be less than the values given in Table 2, see Figure 5 b).

The cross-sectional shape of the bearers shall be in accordance with Figure 5. The slope of the V surface of the bottom bearer shall be between 0° and 5°.

Table 2 — Width a_p of the top bearer when bearing facings are used

DN	**100 to 200**	**225 and 250**	**300**	**350**	**400**	**450**	**500**	**600**	**700**	**800**	**900**	**1000**	**> 1000**
a_p	25	30	35	45	50	55	60	75	85	95	105	115	DN/9

7.2.2 Bearing strips/facings

Bearing strips shall consist of elastomeric material having a hardness of (55 ± 10) IRHD.

Strips shall be of rectangular cross section having a width of (50 ± 5) mm and a thickness of not less than 25 mm or more than 40 mm. The 50 mm dimension shall be in contact with the pipe.

The top bearing strip shall be concentric with the top bearer. The bottom bearing strips shall be symmetrically arranged on the bottom bearer, of equal thickness and parallel to one another at a distance apart of (25 ± 5) mm.

Facings shall be either

a) of elastomeric material of thickness not less than 15 mm nor more than 30 mm and of hardness (55 ± 10) IRHD, or

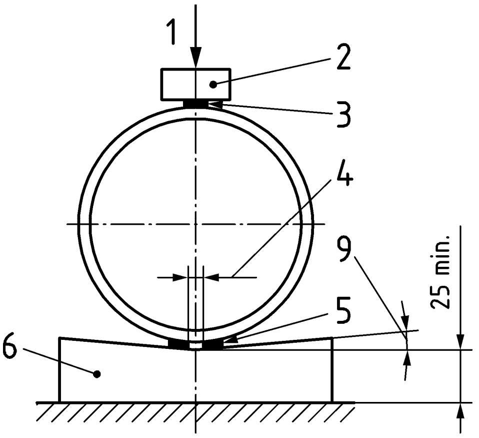
b) of felt of thickness (20 ± 2) mm and a density of (0,3 ± 0,025) g/cm^3.

7.3 Support system

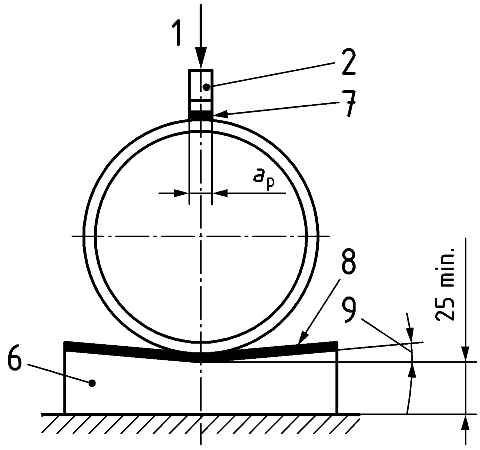
7.3.1 Flexible hose system (for use with any length of pipe, or pipe section not less than 300 mm in length)

The overall bearer length shall be (B - 50) mm for pipes up to and including 1 500 mm nominal length and (B - 100) mm for pipes greater than 1 500 mm nominal length, where B is the nominal length (in millimetres) of the external barrel unobstructed by socket shape and/or jointing configuration at either end (see Figure 6).

The top and bottom bearers shall be divided, along their length, into separate segments. These segments shall be supported by flexible high pressure hoses which are closed at each end. These hoses shall be filled with liquid and carried in U shaped channels below the bottom bearers and above the top bearers. Each segment shall be of the same length which shall not be greater than 300 mm except for individual shorter sections used to make up the overall bearer length. Alternatively, any excess of bearer length over the total length of segments may be distributed evenly as gaps between the segments. No gap shall be greater than one third of the length of a bearer segment. The length of each bearing strip or facing may be equal to the length of its appropriate segment.



a) — Bearer shape for bearing strips



b) — Bearer shape for bearing facings

Key

a_p width of the top bearer

1 load

2 top bearer

3 bearing strip

4 gap width (25 ± 5) mm

5 bearing strip

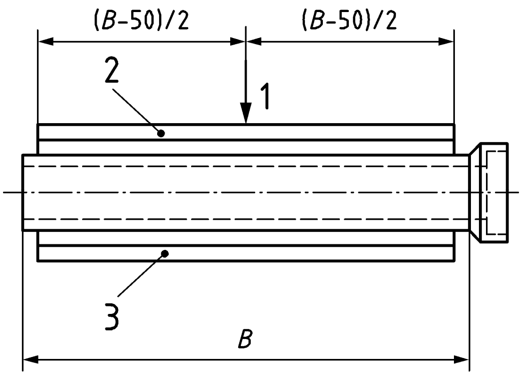
6 bottom bearer

7 facing

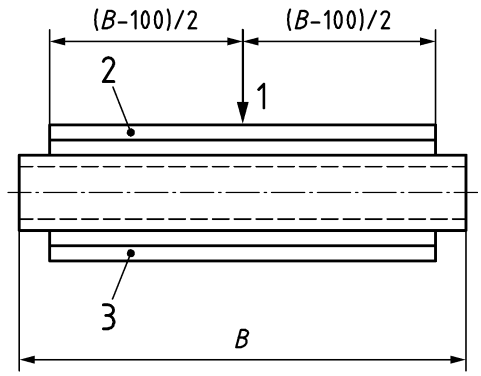
8 elastomeric or felt facing

9 slope of the V surface (0° to 5°)

Figure 5 — Bearer shape



a) — Example pipe length ≤ 1,5 m



b) — Example pipe length > 1,5 m

NOTE Segmented bearers can be used for all nominal pipe lengths. Rigid bearers can only be used for pipes of nominal length ≤ 1,1 m.

Key

1 load

2 top bearer

3 bottom bearer

B pipe nominal length

Figure 6 — Typical arrangement for crushing strength test

7.3.2 Common hydraulic manifold system (for use with any length of pipe, or pipe section not less than 300 mm in length)

The overall bearer length shall be (B - 50) mm for pipes up to and including 1 500 mm nominal length and (B - 100) mm for pipes greater than 1 500 mm nominal length, where B is the nominal length (in millimetres) of the external barrel unobstructed by socket shape and/or jointing configuration at either end of the pipe (see Figure 6).

The top and bottom bearers shall be divided along their length into separate segments. Each segment shall be supported by a common hydraulic system to provide uniform load along the length of the pipe barrel. The segments shall be of the same length which shall not be greater than 300 mm.

The length of each bearing strip or facing shall be equal to the length of each bearer segment.

The distance by which the overall bearer exceeds the total length of the bearer segment shall be distributed evenly as gaps between the segments. No gap shall be greater than one third of a bearer segment. No part of any bearer segment shall overhang either end of the pipe.

7.3.3 Rigid systems (restricted to use with pipes or pipe sections from 300 mm to 1 100 mm nominal length)

The overall length of each bearing strip/facing shall be (B - 50) mm, where B is the nominal length (in millimetres) of the external barrel unobstructed by socket shape and/or jointing configuration at either end (see Figure 6).

The overall bearer length shall not be less than the length of the bearer strip/facing. No part of any bearing strip or facing shall overhang either end of the pipe.

7.4 Test load application

7.4.1 Plain ended pipes

The test load shall be applied at the longitudinal centre of the overall bearer length for the systems described in 7.3.1 and 7.3.2, and at the longitudinal centre of the overall bearing strip/facing length for the system described in 7.3.3.

7.4.2 Socketted pipes

The test load of the systems described in 7.3.1 and 7.3.3 shall be applied at the positions given in 7.4.1. For the system described in 7.3.2 the position of the application of the test load should be adjusted to maintain horizontal stability.

7.4.3 Loading

The loading of the pipe shall be continuous operation. The pipe shall not be allowed to stand under load longer than is required to apply the load and to record the results when proof tests are being conducted.

7.5 Results and reporting

7.5.1 Acceptance (proof) tests

For tests on pipes sampled for testing by attributes the total test load to be applied in kN shall be calculated by multiplying the required crushing strength in kN/m by the nominal inside length of the barrel in m.

7.5.2 Ultimate tests

For tests on pipes sampled for testing by variables the crushing strength in kN/m is calculated by dividing the ultimate applied load at failure by the nominal inside length of the barrel in m.

If the bending tensile strength σ_{bz} is required, it can be calculated from the following equation using the symbols from 8.2

$$\sigma_{bz} = 0{,}3 \cdot F_N \frac{d_1 + s_1}{2} \cdot \frac{6}{s_1^2} \cdot \alpha_K \qquad (1)$$

7.5.3 Disputes

Where any dispute over the verification of crushing strength arises, the tests shall be carried out using the same method as the manufacturer.

7.5.4 Test records

As well as the test results and other relevant details, the records shall contain the following additional information:

a) method of preconditioning;

b) angle of slope of the lower support bearer;

c) whether bearing strips or facings were used, if so whether elastomeric material or felt;

d) type of support system, 7.3.1, 7.3.2 or 7.3.3, if 7.3.1 or 7.3.2, the nominal segment length.

8 Bending tensile test

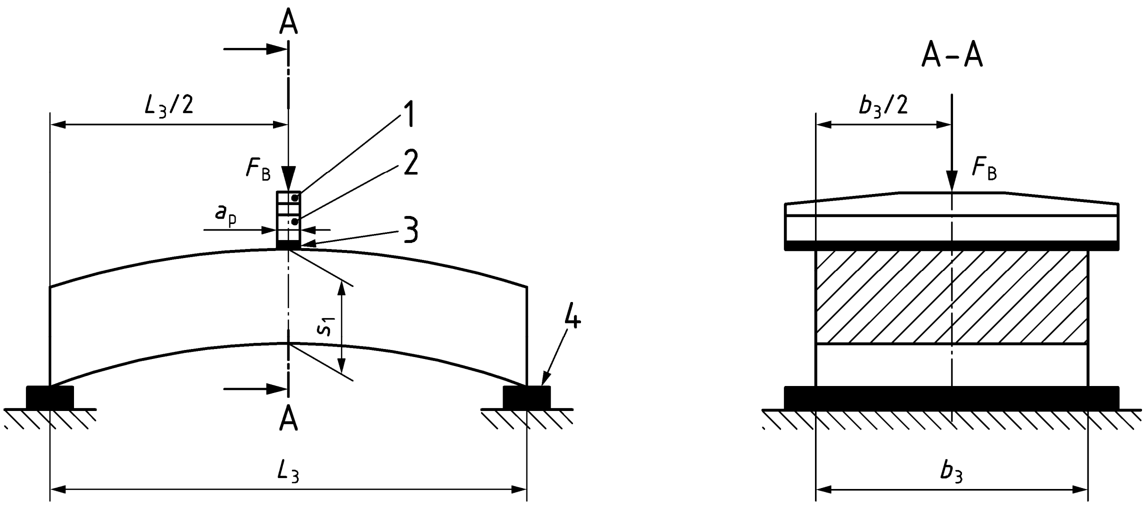
8.1 Preconditioning

Prior to bending tensile test, test pieces shall be preconditioned by complete immersion in water for the minimum times given in 7.1.1.

8.2 Test procedure

The bending tensile test shall be carried out on ten specimens having parallel surfaces, sawn from broken pieces distributed over the length and circumferences of a pipe. The dimensions shall be selected so that their length is approximately five times their wall thickness and their width approximately three times the wall thickness.

The long sides of the specimens shall be at right angles on the pipe axis. The specimens shall be supported so that free movement of one bearer is ensured. The force shall be applied centrally by means of a steel pressure beam with a rubber facing (Shore A hardness: (60 ± 5); thickness 3 mm). The width, a_p, of the pressure beam (top bearer) shall correspond to one tenth of the wall thickness of the specimen (see Figure 7) with a minimum of 2,5 mm.



a) Elevation **b) Cross-section A - A**

Key

1 pressure bar
2 pressure beam
3 rubber facing
4 rubber facing
a_p width of top bearer
F_B force at failure
L_3 centreline distance between supports
b_3 specimen width
s_1 specimen wall thickness

Figure 7 — Test arrangement for bending tensile strength

The test force shall be increased steadily and smoothly until the specimen fails. The bending tensile strength determined from the force at failure can be calculated from the following equation:

$$\sigma_{bz} = M_b \cdot \frac{\alpha_K}{W} = \frac{1000\ F_B \cdot L_3}{4b_3} \cdot \frac{6}{s_1^2} \cdot \alpha_K \qquad (2)$$

with

$$\alpha_K = \frac{3\ d_1 + 5\ s_1}{3\ d_1 + 3\ s_1} \qquad (3)$$

The corresponding crushing strength shall be calculated from the following equation:

$$F_N = \frac{1000}{0{,}3} \cdot \frac{2}{d_1 + s_1} \cdot \frac{F_B \cdot L_3}{4\ b_3} \qquad (4)$$

where

σ_{bz} is the bending tensile strength, in N/mm^2;

F_B is the force, at failure, in kN;

L_3 is the centre line distance between supports, in mm;

b_3 is the specimen width, in mm;

d_1 is the barrel internal diameter, in mm;

s_1 is the specimen wall thickness, in mm;

α_k is a correction factor;

F_N is the crushing strength, in kN/m;

M_b is the bending moment, in Nmm;

W is the section modulus, in mm^3.

The testing machine load shall be verified by calibration to an accuracy of 1 % by an approved agency at intervals of no more than 12 months.

9 Bending moment resistance (BMR) test

9.1 General

9.1.1 Preconditioning

Prior to BMR tests sample pipes or pipe sections shall be preconditioned by complete immersion in water for the minimum times given in 7.1.1.

9.1.2 Testing machine

The testing machine shall be substantial and rigid throughout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part. The method of support and loading for the pipe shall be as specified in either 9.2 or 9.3 and the load shall be applied to the pipe without vibration or sudden shock.

The testing machine load shall be verified by calibration to an accuracy of 1 % by an approved agency at intervals of no more than 12 months.

9.1.3 Loading

Apply the load at a uniform rate (in kN/s) of between 0,04 DN/50 and 0,06 DN/50 or in increments of not more than 0,05 DN/50 at the same rate, where DN is the nominal size of the pipe or pipe section in millimetres, up to the point of failure or to the load corresponding to the required BMR.

The loading of the pipe shall be a continuous operation. The pipe shall not be allowed to stand under load longer than is required to apply the load and to record the results when proof tests are being carried out.

9.1.4 Choice of test method

The test method specified in 9.3 is suitable where the mode of any failures produced in pipe samples is clearly one of beam fracture. If it is clear that such fractures are not being induced (e.g. if end-crushing is evident) then the test specified in 9.2 shall be used.

9.2 Four point loading test

9.2.1 Test procedure

A whole pipe or a shorter piece with or without a socket and with a nominal length not less than 1 100 mm shall be used in the test.

Support the pipe in a horizontal position on two slings. Each sling shall be perpendicular to the axis of the pipe and symmetrical about the centre of its length. The two supporting slings shall be separated by a minimum support span of 900 mm (see Figure 8). Apply the load to the pipe through two further slings with a distance between centres fixed at 300 mm.

Each sling shall be 150 mm wide and shall be designed so that there is a contact angle of at least 120° around the pipe circumference. At no time during the test shall the pipe make contact with anything other than the four slings.

9.2.2 Testing by attributes

For tests on pipes sampled for testing by attributes the total test load to be applied in kN is calculated by multiplying the required bending moment resistance in kNm by two and dividing by the lever arm in m.

$$P_{\mathrm{b}} = \frac{2}{a} \cdot M^{1} \qquad (5)$$

where

M^{1} is the required BMR in kNm;

P_{b} is the applied load in kN;

a is the lever arm length, which is ½ (S – 0,3) in m;

S is the support span in m.

9.2.3 Testing by variables

For tests on pipes sampled for testing by variables the bending moment resistance in kNm is calculated by multiplying the ultimate applied load at failure by the lever arm divided by two.

$$M = P_{\mathrm{b}} \cdot \frac{a}{2} \qquad (6)$$

where

M is the BMR in kNm;

P_{b} is the applied load in kN;

a is the lever arm length, which is ½ (S – 0,3) in m;

S is the support span in m.

9.3 Three point loading test

9.3.1 Test procedure

A whole pipe or shorter piece with or without a socket and with a nominal length not less than 1 100 mm shall be used in the test.

The pipe to be tested shall be supported on two bearing strips in a horizontal position so that the concave side of any permitted longitudinal curvature faces upwards. The distance between the centres of the bottom bearing strips shall be 150 mm less than the external length of the pipe barrel and they shall be placed symmetrically about the centre of its length. Apply the load vertically to the top centre of the pipe barrel through a similar bearing strip (see Figure 9).

Bearing strips shall each be at least 75 mm long, the pipe lying at right angles to the length and shall be made from elastomeric material having hardness of (55 ± 10) IRHD. They shall be of rectangular cross section having a thickness of (30^{+10}_{-5}) mm and a width of (50 ± 5) mm. The two lower bearing strips shall be of equal thickness.

Place the lower bearing strips on a firm unyielding horizontal support which may be a flat or angled shape and apply the load to the upper bearing strip through a rigid backing having an area at least as great as the bearing strip beneath it.

9.3.2 Testing by attributes

For tests on pipes sampled for testing by attributes, the total test load to be applied in kN is calculated by multiplying the required bending moment resistance in kNm by four and dividing by the distance between the centres of the bottom bearing strips in m.

$$P_{\mathrm{b}} = \frac{4}{d} \cdot M^{1} \tag{7}$$

where

M^{1} is the required BMR in kNm;

P_{b} is the applied load in kN;

d is the distance between the centres of the bottom bearing strips in m.

9.3.3 Testing by variables

For tests on pipes sampled for testing by variables the bending moment resistance in kNm is calculated by multiplying the ultimate applied load at failure by the distance between the centres of the bottom bearing strips in m and dividing by four.

$$M = P_{\mathrm{b}} \cdot \frac{d}{4} \tag{8}$$

where

M is the BMR in kNm;

P_{b} is the applied load in kN;

d is the distance between the centres of the bottom bearing strips in m.

Dimensions in millimetres

Key

1 supporting slings

2 loading slings

3 lever arm (*a*) 300 mm min

4 support span (*S*)

P_b applied load in kN

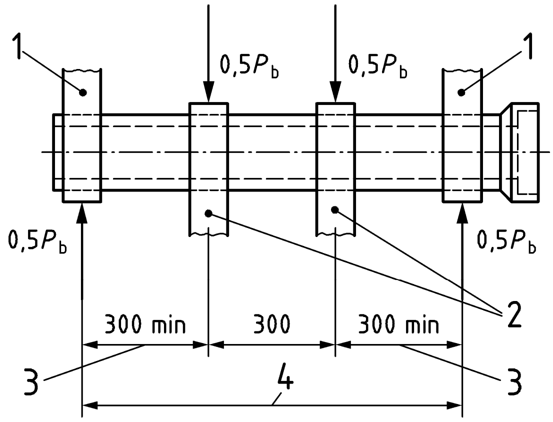


Figure 8 — Arrangement of the four point loading test method

Key

d distance between the centres of the bottom bearing strips in m

P_b applied load in kN

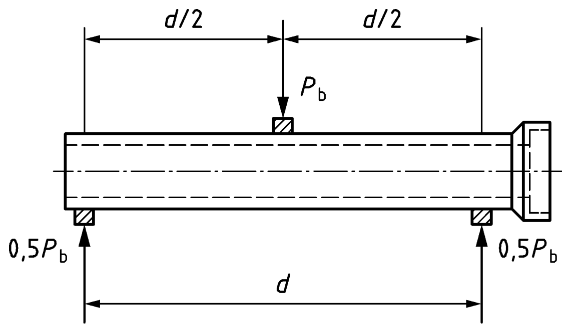


Figure 9 — Arrangement of the three point test method

10 Bond strength of adhesive

The test piece having a bonded face of at least 100 mm^2 shall be fabricated with the adhesive from two pieces of fired clay and allowed to cure under the same conditions as the fitting(s). The test piece shall then be subjected to a loading test in such a way that the maximum stress imposed at the adhesive joint shall increase at a rate not exceeding 50 N/mm^2/min.

11 Tests for fatigue strength

11.1 Preconditioning

Prior to fatigue strength tests, which may be carried out according to either 11.2 or 11.3, sample pipes, pipe sections or test pieces, shall be preconditioned by complete immersion in water for the minimum times given in 7.1.1.

11.2 Test using a pipe or pipe section

A pipe or pipe section shall be tested as in Clause 7 for crushing strength, but with the load cycling between 0,1 F_N and 0,4 F_N with a maximum frequency of 12 Hz for 2×10^6 cycles.

11.3 Test using sawn test specimens

The fatigue strength test shall be carried out on ten specimens having parallel surfaces, sawn from one pipe and distributed over the length and circumference of the pipe. The dimensions shall be selected so that their length is approximately five times their wall thickness and their width approximately three times the wall thickness.

For support the test pieces shall be ground at both ends so that the bearing strips with a width of about one third of the wall thickness form one single plane.

The long sides of the specimens shall be at right angles to the pipe axis. The specimen shall be supported so that free movement of both bearers is ensured. The force shall be applied by means of a steel pressure beam (see Figure 10).

The pulsating test force shall be increased and decreased steadily between minimum and maximum values with a maximum frequency of 12 Hz for 2×10^6 cycles.

The total loads shall be calculated as

$$F_i = \frac{2}{3} \cdot \frac{b \cdot s_f{}^2}{l_4 \cdot \alpha_{kf}} \cdot \sigma_{bz} \cdot c_i \quad (9)$$

where

σ_{bz} is the bending tensile strength, in N/mm², calculated from crushing strength, by

$$\sigma_{bz} = 0{,}3\ F_N \cdot \frac{d_1 + s_f}{2} \cdot \frac{6}{s_f^2} \cdot \alpha_k \quad (10)$$

d_1 is the barrel internal diameter in mm;

F_N is the crushing strength in kN/m;

F_i is the force (upper and lower limit), in kN;

l_4 is the centre line distance between supports, in mm;

b is the specimen width, in mm;

s_f is the specimen wall thickness, in mm;

α_k is a correction factor (see Clause 8);

c_i is the factor for the upper (0,4) or lower (0,1) limit of the load.

Dimensions in millimetres

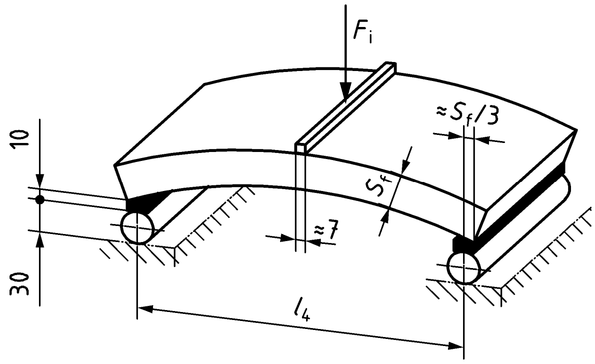


Figure 10 — Test arrangement for the fatigue strength test when carried out to 11.3

12 Test for watertightness

12.1 General

The watertightness test shall be carried out on individual pipes, bends, junctions or pipe sections at ambient temperatures.

The specimen(s) shall be clamped into a suitable apparatus to test the watertightness (of the specimens). They shall be filled slowly with water and completely vented.

12.2 Pipes and junctions

Pipes and junctions shall either be preconditioned in accordance with the test method in 7.1.1 (a) or (b), or pre-treated by maintaining the test pressure for one hour prior to the test period.

The test shall be carried out at a water pressure of 50 kPa (0,5 bar) for 15 min. During this time the water addition required to maintain the pressure head shall be measured and W_{15}, the volume added per square metre of wetted internal surface area, shall be calculated.

12.3 Fittings other than junctions and terminal fittings

The test shall be carried out at a water pressure of 50 kPa (0,5 bar) for 5 min without visual leakage.

13 Chemical resistance test for pipes and fittings

Test pieces shall be freshly broken pieces of pipe, each 5×10^4 mm^3 to 9×10^4 mm^3 in volume, free from cracks or shattered edges. Clean and dry them thoroughly at a temperature of no less than 150 °C until no further loss of mass is noted on successive weighing. Immerse one test piece in solution a) and one test piece in solution b) for 48 h in 500 ml of the test solutions at a temperature of (20 ± 5) °C.

The test solutions shall be:

a) Sulphuric acid solution, c (H_2SO_4) = 0,5 mol/l prepared by adding 28,5 ml of concentrated acid (1,84 g/ml) to 971,5 ml distilled water to produce 1 l of solution;

b) Sodium hydroxide solution, c (NaOH) = 1,0 mol/l taken as containing 40 g of sodium hydroxide per litre.

The weighing apparatus used shall be accurate to within 0,01 g when loaded with 200 g.

On removal from the solution, carefully and thoroughly wash each test piece with hot distilled water and then boil in 500 ml of distilled water for ½ h. Thereafter boil it in a further 500 ml of distilled water for another ½ h. Then dry the test piece at a temperature not lower than 150 °C until no further loss of mass can be noted on successive weightings. Calculate the loss of acid or alkali soluble matter in the test piece as a percentage of the dry mass as follows. If the mass of the test piece before treatment is M_1 in grams and the mass of the test piece after treatment is M_2 in grams, then:

$$\%\ \text{loss in dry mass} = \frac{(M_1 - M_2)\cdot 100}{M_1} \tag{11}$$

Typical values of mass loss with these solutions are from 0,1 % to 0,25 %.

14 Determination of hydraulic roughness

The wall roughness shall be determined hydraulically. For this purpose, determine the pressure losses occurring on a test pipe line between a point x and a point y for various flow rates Q, and calculate the resistance coefficient λ from these as

$$\lambda = \frac{g \cdot \pi^2 \cdot d_i^5}{8 \cdot Q^2} \cdot \frac{h_x - h_y}{L_H} \tag{12}$$

where

λ is the resistance coefficient;

g is the acceleration due to gravity, in m/s²;

d_i is the average internal diameter of the pipeline, in m;

Q is the flow rate, in m³/s;

h_x is the pressure head at point x, in m;

h_y is the pressure head at point y, in m;

L_H is the length between x and y, in m;

k_s is the hydraulic roughness, in mm.

The parameter d_i/k_s for which the calculated values fulfil the Prandtl-Colebrook equation for Reynolds number $Re > 10^5$ shall be established by representing the values calculated from the measurements as a function of the Reynold's number. The effect of losses in addition to that of the wall friction shall be eliminated beforehand. Determine the hydraulic roughness k_s, in mm, from the values d_i/k_s resulting.

15 Abrasion resistance test

Close off a semicircular channel pipe, (1 000 ± 10) mm long, by end plates, fill with a sand/gravel/water mixture (test material) and cover with a further plate. Tilt this channel pipe alternately in the longitudinal direction through ± 22,5° in order to procedure the abrasive action to be tested by the movement of the test material (see Figure 11). The test material used shall be natural, unbroken round-grained quartz gravel with the following characteristics:

M_p = d_{50} = 6 mm;

d_{80} = 8,4 mm;

d_{20} = 4,2 mm;

U = d_{80} / d_{20} = 2.

where

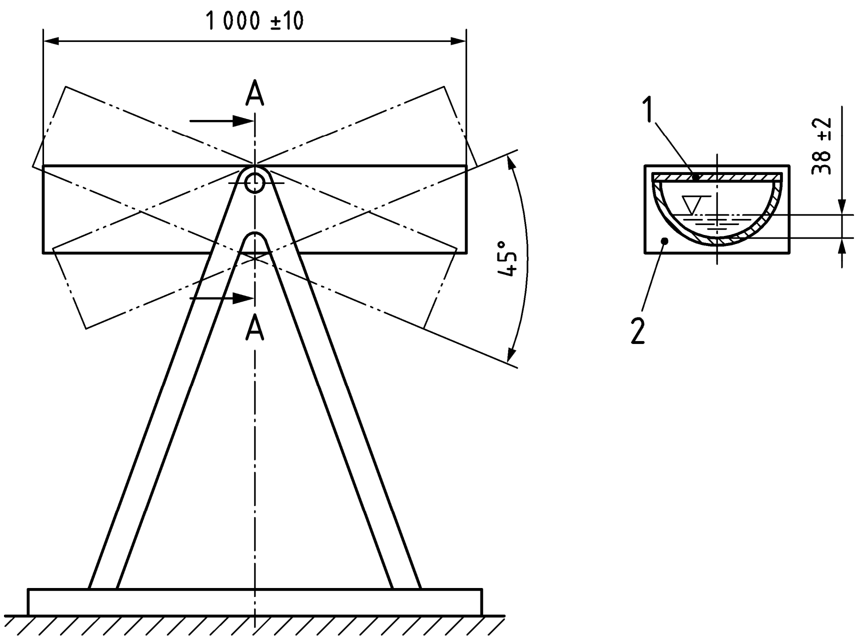
M_p is the mean particle size, in mm;

U is the degree of non-uniformity;

d_{50} / d_{80} / d_{20} are the particle size, in mm, not exceeded by 50 % or 80 % or 20 % by mass of the material.

Place the quantity of the test material specified in Table 3 in the channel pipe and fill up with water up to a level of (38 ± 2) mm.

Dimensions in millimetres



Key

1 cover plate

2 end plate

Figure 11 — Test apparatus for the abrasion test

Pipes or sizes listed in Table 3 from the same production batch shall be tested in the place of pipes with nominal sizes greater than 500.

The channel pipe shall be subjected to 100 000 load cycles (abrasion from sliding in the tilt process). The tilt process shall be sinusoidal at a frequency of about 20 cycles per minute.

One load cycle consists of two tilt processes. One tilt process consists of a movement from 0° to -22,5° to +22,5° and back to 0° resp. the movement from 0° to +22,5° to -22,5° and back to 0°.

The depth of abrasion along the invert shall be determined over a test length of 700 mm omitting 150 mm at each end of the channel. Measurements shall be taken at least every 10 mm and the mean depth of abrasion calculated. This value is the average abrasion.

Table 3 — Quantity of test material

DN	Quantity of test material kg
100	2,8
125	3,1
150	3,4
200	4,0
250	4,5
300	5,0
400	5,8
500	6,5

16 Airtightness test

Close the ends of the pipe, bend, junction or short length of pipe made for test purposes using the same material and firing process with airtight seals. Connect a suitable measuring apparatus, with an accuracy of 2 mm water gauge, to one of the airtight seals and a means of applying the air pressure to another airtight seal. Apply pressure to achieve a value of 10 % higher than the required initial pressure for the impermeability test and allow 5 min for stabilisation of the air temperature. Adjust air pressure to the required initial pressure at the commencement of the test. During stabilisation and testing the ambient temperature and atmospheric conditions of the test should, as far as possible, remain constant.

17 Tests for resistance to high pressure jetting

17.1 General

17.1.1 Water source

The water shall be in accordance with drinking water quality standards in respect of chemicals and particulates.

17.1.2 Pressure measurement

A pressure measurement device capable of pressure measurement with an accuracy of ± 1 % shall be connected to the water supply no more than 1 m from the nozzle. The pipe between the position where the pressure is measured and the nozzle shall have an unrestricted bore of diameter of no less than 15 mm.

17.1.3 Test temperature

The tests shall be carried out at an ambient air temperature of (15 ± 10) °C with water at a temperature of (15 ± 10) °C near the pump inlet.

17.2 Moving jet test

The moving jet test shall be carried out at a pressure of 12 MPa using the test method described in CEN/TR 14920:2005.

17.3 Stationary jet test

17.3.1 General

The stationary jet test shall be carried out at a pressure of 28 MPa.

NOTE This test is not representative for cleaning practices but relates to material properties.

17.3.2 Apparatus

17.3.2.1 Pump unit

The pump unit shall be capable of delivering water at a pressure of at least the test pressure and at a flow rate of at least 10 l/min. A means of controlling the pressure variation shall be provided to control the pressure to ± 1 %.

17.3.2.2 Guard plate

A removable metal guard plate having a similar curvature to the inside wall of the test pipe shall be used to protect the pipe material from the jet until the operating pressure and flow have been attained.

17.3.2.3 Nozzle

The nozzle shall have an orifice diameter of ($1{,}0^{+0{,}05}_{-0}$) mm and all dimensions according to Figure 12. The orifice diameter shall be measured to an accuracy of ± 0,01 mm.

Dimensions in millimetres

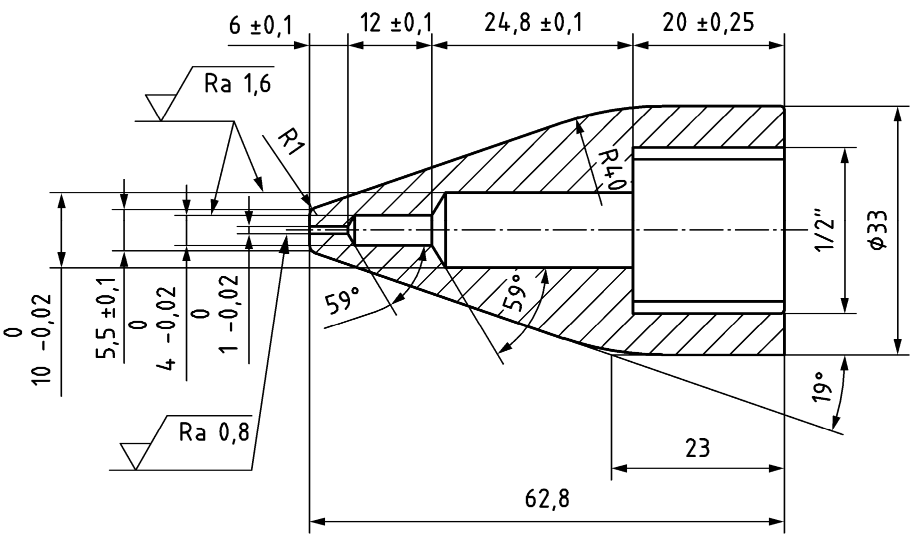


Figure 12 — Nozzle geometry

17.3.2.4 Flow rate accuracy

A means of measuring flow rate to an accuracy of ± 0,1 l/min shall be used.

17.3.2.5 Test rig

The test rig shall be capable of supporting the test piece and holding the nozzle at an angle of (30 ± 1)° to the test piece axis, at vertical distance of (5 ± 0,5) mm measured to the centre of the orifice, from the internal test piece surface. There shall be a means of moving the jet longitudinally through the test piece and a means of ensuring that this longitudinal traverse is parallel to the test piece axis.

17.3.3 Test pieces

The test pieces shall be at least 1 m in length and shall be marked on the outside surface to identify 10 equally spaced segments. The wall thickness shall be measured once in each segment. The interior surface of the test piece shall be inspected prior to testing and any imperfection shall be recorded.

17.3.4 Procedure

17.3.4.1 Pretest procedure

Start the pump unit with the flow running to dump, then divert the flow to the nozzle and adjust the test pressure at the transducer to 28 MPa. Confirm that the flow rate is between 6,15 l/min and 8,25 l/min. If the flow rate is not in this range, then check the nozzle orifice diameter/ conditions and all connections. Repeat the pretest procedure until the unit is running at a steady flow rate within the range.

Place the test piece in the rig with a segment marker at the pipe crown and adjust to level. The nozzle shall be fixed at an angle of (30 ± 1)° to the test piece in a position 250 mm along the test piece axis with the centre of the nozzle orifice at (5 ± 0,5) mm vertically above the test piece invert. Insert a metal guard plate between the test piece surface and the jet.

NOTE 1 MPa = 10 bar = 145 psi, 28 MPa is approximately 4 000 psi.

17.3.4.2 Test procedure

With the unit running at the test pressure, simultaneously remove the guard plate and start the stopwatch to measure the time. Continue the jetting for the full 3 minute test period and then divert the flow to dump.

Move the jet forward by 50 mm and rotate the test piece to the next marked segment. Insert the guard plate and repeat the jetting test sequence. Continue this until 10 tests have been carried out. After completion of the 10 tests, remove the test piece carefully from the test rig. Examine the test piece for damage to interior surface. Evaluate surface damage, if any.

17.3.4.3 Recording results

Any imperfection noticed before testing shall be recorded.

The following parameters shall be recorded:

— clear identification of test pieces;

— ambient temperature, water inlet temperature;

— test pressure;

— nozzle orifice diameter;

— flow rate;

— calculated C_d.

The coefficient of discharge of the nozzle (C_d) is calculated as follows:

— measure the diameter of the nozzle;

— collect and measure the volume of the jet outflow for a measured period of time at the test pressure measured at the transducer.

— Calculate C_d from the equation

$$C_d = 0{,}474 \frac{Q}{d^2 p^{1/2}} \quad (13)$$

The arithmetic mean of three determinations shall be taken as the value of C_d for the nozzle,

where

C_d is the coefficient of discharge of the nozzle;

Q flow rate in l/min;

d orifice diameter of the nozzle insert in mm;

p pressure measured not more than one metre upstream of the nozzle in MPa.

18 Hardness test for polyurethane

18.1 Test pieces

In order to exclude the influence of surface discontinuities as far as possible, the test pieces shall be cut from the inside of the sealing elements or from cast panels. The material shall be at least 7 days old. The test pieces may be obtained by grinding, cutting or slitting; it shall be ensured however that no change which might affect the measurement occurs in the surface structure.

18.2 Test method

The Shore A hardness shall be determined in accordance with EN ISO 868 on 4 test pieces of each type, where the test piece shall be a cylinder with a diameter of (13 ± 0,5) mm and a height of (6,3 ± 0,3) mm.

The Shore A hardness shall only be measured using vertically mounted machine and shall be read after 3 s. The measurement shall be taken at three points on the two flat surfaces of each test piece.

19 Tests for material requirements of polypropylene sleeve couplings

19.1 Melt flow index

The melt flow index of material taken from the coupling body shall be determined in accordance with EN ISO 1133:2005, Tables A.1 and A.2, Condition 12.

19.2 Tensile strength and elongation at break

Tests for tensile strength and elongation at break shall be conducted on samples (avoiding engraving, weld lines and split lines) prepared from coupling bodies. The shape of the test specimen shall be Type 5A according to EN ISO 527-2:1996. Where the presence of engraving and/or weld lines and/or split lines prevents this shape being taken a smaller shape shall be used in accordance with the sizes according to Table 4 (using nomenclature according to EN ISO 527-2:1996, Figure A.2):

Table 4 — Sizes of test sample

Symbol	Designation	Size mm
A_L	Overall length minimum	75
B_e	Width at ends	(12,5 ± 1)
C	Length of narrow parallel portion	(25 ± 1)
D_W	Width of narrow parallel portion	(4 ± 0,1)
E	Small radius	(8 ± 0,5)
F	Large radius	(12,5 ± 1)
G	Distance between reference lines	(20 ± 0,1)

The specimens shall be conditioned for at least 3 h at (23 ± 2) °C before testing.

The tests shall be conducted in accordance with the procedures given in EN ISO 527-2 with the rate of grip separation being 50 mm/min ± 10 %. The tensile strength at yield shall be expressed in MPa.

19.3 Elevated temperature test

The sampling coupling body shall be stored horizontally on a flat surface in an oven at (150 ± 3) °C for one hour. After this period it shall be removed from the oven and allowed to cool at room temperature.

The sample coupling body shall be checked for any blisters, cracks or delaminations. Any of these shall be considered as defects.

20 Performance test for polypropylene sleeve couplings

A line displacement test shall be conducted on a rig which has two mandrels each representing the spigot end of a pipe. The outside diameter of one mandrel shall be within the upper quartile of the dimensional range. The outside diameter of the other mandrel shall be within the lower quartile of the dimensional range detailed. After jointing the coupling onto the mandrel ends to form a joint assembly they shall be axially aligned and then a line displacement of not less than 6 mm shall be applied.

21 Mechanical test methods for joint assemblies

21.1 General

The apparatus shall accommodate two pipes, flexibly jointed and supported in such a way that they can move in relation to each other to the limits required by the tests.

With the pipes closed by watertight seals, fill the pipes with water at a temperature not exceeding 30 °C; expel all air and apply the test pressure for each appropriate test configuration.

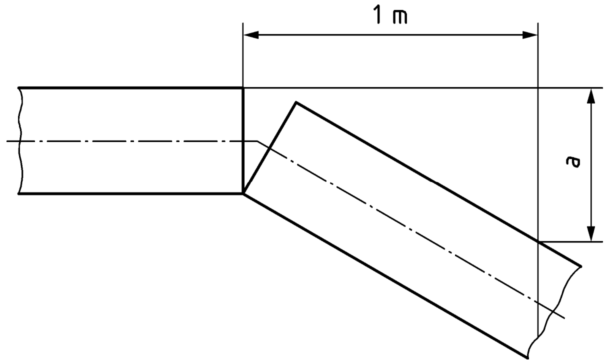
For initial type testing the clearance in the joint shall lie within the upper third of the range of possible values.

NOTE Owing to the requirements for the test rigs, these tests are only applicable to pipes over 800 mm in length.

If it is not practicable to apply precisely the deflection pressure, load or separation required, a joint assembly shall be deemed to satisfy the test requirements provided that the levels applied are greater than those specified.

21.2 Deflection test

Deflection is defined, in millimetres per metre, as the distance from the extended longitudinal axis of one pipe to the longitudinal axis of the other pipe at its free end, as shown in Figure 13.

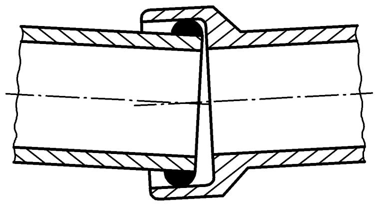


a deflection in mm/m

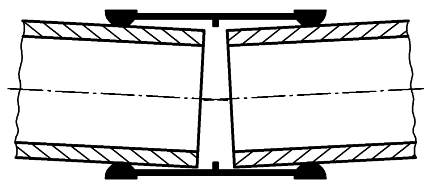
Figure 13 — Deflection of joint

Fully engage the pipes in the joint, axially align them and then separate them on the longitudinal axis with their ends restrained to prevent further longitudinal movement. The separation shall be 5 mm for pipes of less than 300 DN. For pipes of 300 DN and larger, the separation shall be the minimum to permit the deflection given in EN 295-1:2012, Table 12 to be applied.

Deflect to the test requirement one pipe angularly with respect to the other with the fulcrum on the longitudinal axes of the pipes and within the joint (see Figure 14).



a) Socket type joint



b) Sleeve type joint

NOTE The Figure is diagrammatic only and not meant to represent any particular joint designs

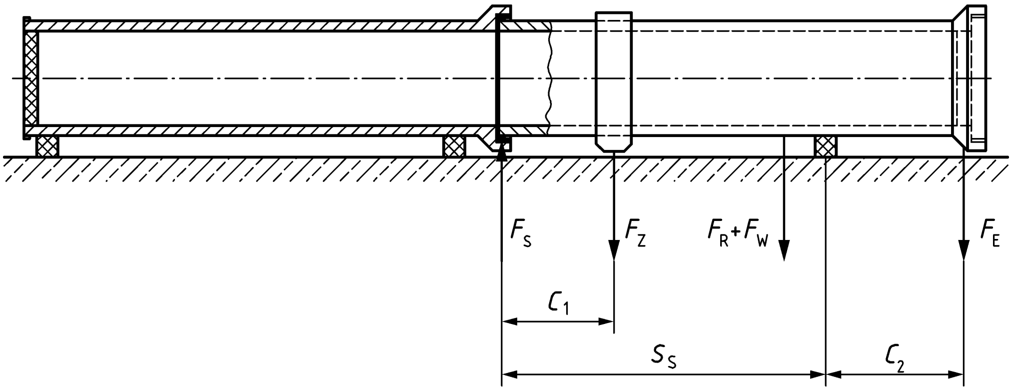
Figure 14 — Deflection test

21.3 Shear resistance test

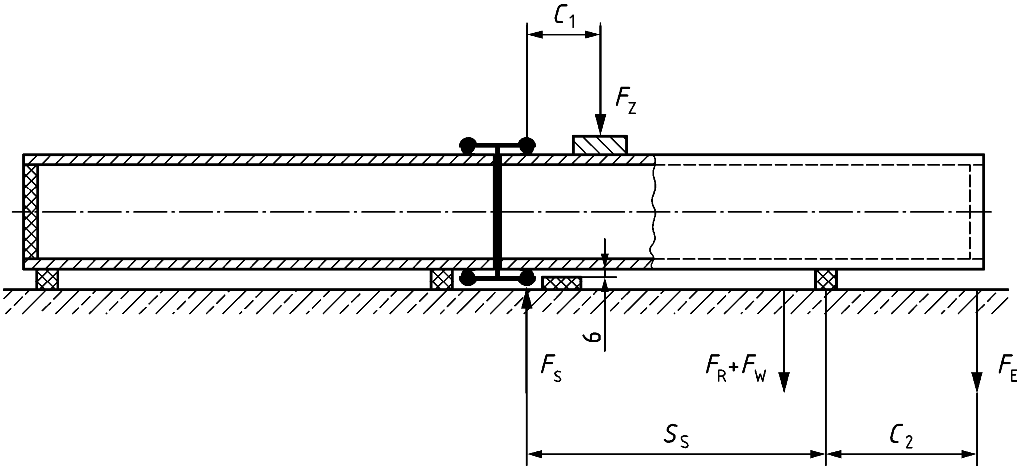
21.3.1 Loading arrangements for shear resistance

The pipes shall be fully engaged in the joint, axially aligned and then separated by 5 mm on the longitudinal axis with their ends restrained to prevent further longitudinal movement (see Figure 15).

Dimensions in millimetres



a) Shear resistance test for socketted pipes (the joint cannot move up to the full 6 mm vertical movement)



b) Shear resistance test for sleeve-jointed pipes (the joint can move up to the full 6 mm vertical movement)

Key See Equation (14).

Figure 15 — Shear resistance test

The socketted pipe having the socket of the joint assembly or one pipe in a sleeve joint assembly shall be firmly supported and restrained from movement. The second pipe shall be supported at a suitable distance S_S from the joint under tests. The vertical movement of the free pipe of the joint shall be restricted to a maximum of 6 mm by a stop of suitable dimensions to prevent damage to the pipe. The shear load on the joint seal is produced by the externally applied loading as well as by the self-weight of the inserted pipe and the associated water content. The external load to be applied, F_Z, is determined by the distance of the load application point from the pipe joint and by the length of the free, inserted pipe between pipe joint and support S_S, calculated using Equation (14):

$$F_Z = \frac{1}{S_S - C_1}\left[F_S \cdot S_S + F_E \cdot C_2 - \frac{F_R + F_W}{2}(S_S - C_2)\right] \quad (14)$$

where

F_E is the nominal self weight of stopper, in kN;

F_R is the nominal self-weight of pipe (which may be obtained by calculation - volume and density), in kN;

F_S is the shear load in kN;

F_W is the weight of water in pipe, in kN;

F_Z is the applied load, in kN;

S_S is the distance between seal and right hand support, in m;

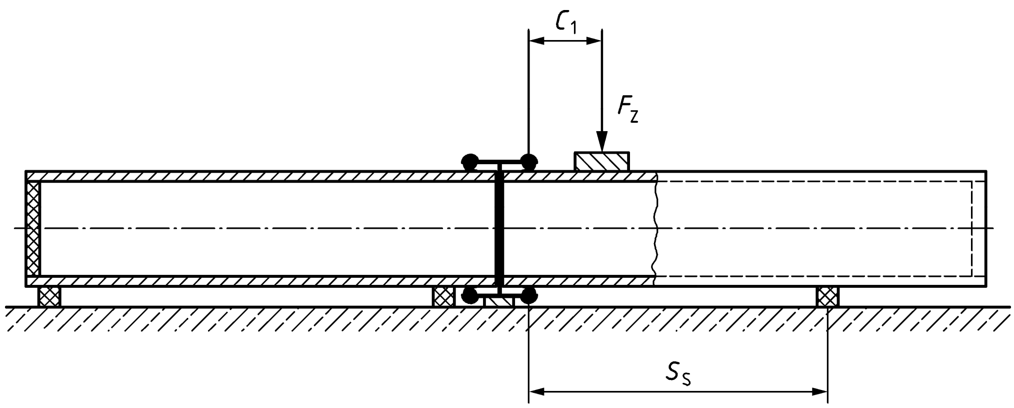
C_1 is the distance between seal and load application line for F_Z, in m;

C_2 is the distance between right hand support and load line for F_E, in m.

21.3.2 Short-term shear resistance test

Testing for shear resistance of joint assemblies shall be conducted in accordance with the procedures given in 21.3.1, with the load being applied for a period of 15 min.

For joint assemblies which undergo 6 mm vertical movement an additional test shall be carried out where the load shall be applied with the pipes set up as before but with the underside of the joint assembly supported on a firm flat surface and restrained from movement (see Figure 16).



Key See Equation (14).

Figure 16 — Arrangement with coupling laid on a support

21.3.3 Long-term shear resistance test

Testing for long-term shear resistance of joint assemblies shall be conducted in accordance with the procedures given in 21.3.1 with the load being applied for a period of 3 months. At the end of this period the pressure test shall be carried out for 15 min.

For joint assemblies which undergo 6 mm vertical movement an additional long-term test shall be carried out where the load shall be applied with the pipes set up as before but with the underside of the joint assembly supported on a firm flat surface and restrained from movement (see Figure 16).

22 Continuity of invert test

22.1 Test methods

For pipes and fittings which are marked to show the top of the pipe, the test method in accordance with 22.2 shall be used.

For randomly jointed socketted pipes and fittings and jacking pipes, the test method in accordance with 22.3 shall be used.

22.2 Pipes and fittings with top marking

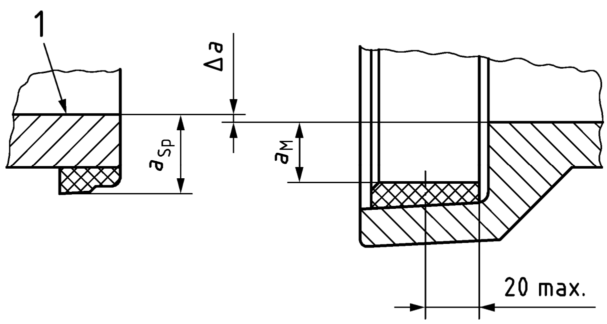
The difference in invert Δa for joint assemblies of socketted pipes shall be calculated in accordance with Equation (15) using dimensions a_{Sp} and a_M (see Figure 17).

$$\Delta a = a_{Sp} - a_M - 1 \quad (15)$$

The difference in invert Δa for joint assemblies of jacking pipes shall be calculated in accordance with Equation (16) using dimensions a_{J1} and a_{J2} (see Figure 18).

$$\Delta a = a_{J1} - a_{J2} \quad (16)$$

Dimensions in millimetres



Key

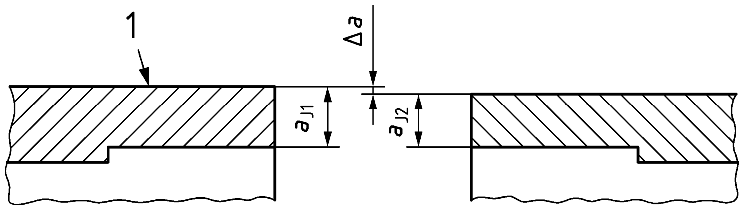
a_{Sp} Measurement from inside of pipe barrel to mid point of inside of socket fairing

a_M Measurement from inside of pipe barrel to outside of spigot moulding

Δa Measurement of difference in invert levels

Figure 17 — Invert (top marked pipes)

Dimensions in millimetres



Key

a_{J1} and a_{J2} Measurement from inside of pipe barrel to jointing surface of adjacent pipes

Δa Measurement of difference in invert levels

Figure 18 — Invert of jacking pipes (top marked pipes)

22.3 Pipes and fittings randomly jointed

22.3.1 Sampling and dimensions

Select 20 jointed pipes or fittings at random. For each sample measure the following at a random position (see Figure 19):

— the outside diameter (A) of the spigot moulding, and at the same position the distance from the outside diameter of the spigot moulding to the internal surface of the pipe on both sides (B_t and C_t).

— the internal diameter (D) of the socket moulding, and at the same position the distance from the internal diameter of the socket moulding to the internal surface of the pipe on both sides E_t and F_t .

22.3.2 Calculations

The mean annular gap G_m shall be calculated from the mean values of A and D (A_m and D_m respectively) in accordance with Equation (17).

$$G_m = 1/2(D_m - A_m) \qquad (17)$$

The combined mean value $(B_t + C_t)_m$ shall be calculated by adding the sum of B_t values and the sum of C_t values and dividing by 40. The corresponding mean $(E_t + F_t)_m$ shall be similarly calculated.

The mean difference in invert S_m shall be calculated using Equation (18).

$$S_m = (B_t + C_t)_m + G_m - (E_t + F_t)_m \qquad (18)$$

The combined standard deviation S_t of the values (B_t + C_t) and (E_t + F_t) shall be calculated using Equation (19).

$$S_t = \left[s^2_{(B_t + C_t)} + s^2_{(E_t + F_t)} \right]^{1/2} \qquad (19)$$

The extreme values (5 % and 95 % fractile) for the difference in invert shall be calculated using Equations (20) and (21)

$$S_{min} = S_m - 1{,}68 \cdot S_t \qquad (20)$$

$$S_{max} = S_m + 1{,}68 \cdot S_t \quad (21)$$

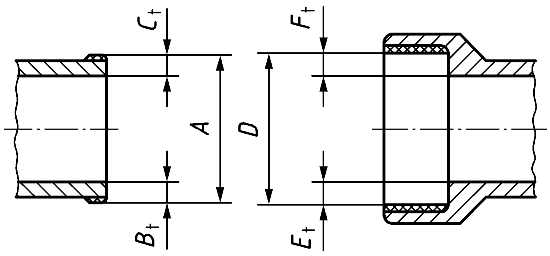


Figure 19 — Invert (randomly jointed pipes)

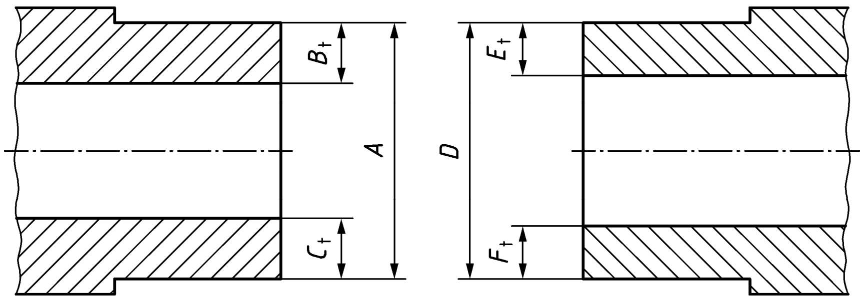


Figure 20 — Invert of jacking pipes (randomly jointed)

22.3.3 Evaluation

Neither of the calculated values (S_{min}, S_{max}) shall exceed the values given in EN 295-1:2012, 6.3 or EN 295-7:2012, 4.2.4 for the nominal diameter which is checked.

23 Chemical resistance test for joint assemblies

23.1 Test solutions

The test solutions shall be:

a) sulphuric acid solution c ($H_2 SO_4$) = 0,005 mol/l (pH = 2,0 approx);

b) nitric acid solution, c ($HN0_3$) = 0,01 mol/l (pH = 2,0 approx);

c) sodium hydroxide solution, c (NaOH) = 0,01 mol/l (pH = 12,0 approx);

d) sodium hypochlorite solution, c (NaOCl) = 0,01 mol/l stabilised with sodium hydroxide to pH = 12,0 approx.

23.2 Procedure

Flexibly join two sections of pipe, of length sufficient to enable an internal pressure test to be carried out on the joint when the immersion period is complete.

Immerse the assembly in the solution by standing it in a suitable vessel, such that the solution comes into contact with the joint from both inside and outside. Keep the solution at a temperature of (20 ± 5) °C for 168 h. At the end of this time remove the assembly and rinse it in water (see Figure 21.)

Then fill the assembly with water; expel all the air and apply the test pressure. A joint assembly tested with one of the solutions shall not be used for another chemical resistance test.

Key

1 reagent

2 joint

3 pipe

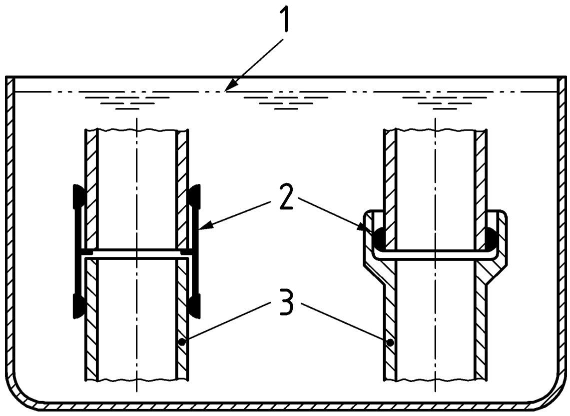


Figure 21 — Arrangement for tests for chemical resistance

24 Thermal stability

24.1 Thermal cycling stability

The complete joint assemblies shall be subjected to the following thermal cycle (in air):

— ambient temperature for 2h:

  — 4 times,

    — 8 h at (-10 ± 2) °C,

    — 16 h at (+ 70 ± 2) ° C,

    — 8 h at (-10 ± 2) °C,

— ambient temperature for 2 h.

Tightness tests (thermal cycling stability) as specified in EN 295-1:2012, 6.6 shall be carried out. The sealing and bonding faces shall be visually examined for defects.

The tests shall be carried out on DN 150 pipes as representative of the nominal size group DN 100 to DN 150 and on DN 225 or DN 250 pipes representing larger nominal sizes.

24.2 Long-term thermal stability

Join two full lengths or cut pipes. Seal the ends and fit them with an inlet and an outlet. Water shall be fed through the pipes to maintain a temperature of (45^{+5}_{0}) °C at the joint.

25 Creep resistance of rigid fairing materials

25.1 Deformation

25.1.1 Test samples

The test samples shall have the following dimensions in mm:

— cylinder (diameter × height), (13 ± 0,5) × (6,3 ± 0,3), or

— cuboid (11,5 ± 0,5) × (11,5 ± 0,5) × (6,3 ± 0,3).

The end faces of the cylinder shall be parallel.

25.1.2 Test apparatus

The test apparatus shall be capable of applying a load of 1,25 N/mm^2 onto the sample through a plate of 20 mm diameter. The sample height shall be measured to the nearest 0,01 mm.

25.1.3 Procedure

Put the sample on the test apparatus. Apply a constant load of 1,25 N/mm^2. Measure the height of the sample and calculate the deformation (ε) as percentage of the original height at the following times (t):

— t_0 = (1 ± 0,1) min,

— t_1 = (10 ± 1) min,

— t_2 = (100 ± 10) min,

— t_3 = (22 ± 2) h, and

— t_4 = (7 ± 0,7) days.

The measured values of time and deformation shall be plotted on a graph. The ordinates are plotted as log ε and the abscissa as log t. The best fit line shall then be plotted or calculated by regression to obtain the regression values for 10^0 min and 10^4 min.

The short-term deformation shall be calculated in accordance with Equation (22).

$$\Delta\varepsilon_{4;0} = \varepsilon_4 - \varepsilon_0 \qquad (22)$$

where

$\Delta \varepsilon_{4;0}$ is the short-term deformation expressed in %;

ε_4 is the regression value for the deformation after 10^4 min in %;

ε_0 is the regression value for the initial deformation after 10^0 min in %.

25.2 Indentation

25.2.1 Test samples

The test samples shall be cast a minimum of 48 h prior to testing and have the following dimensions in mm:

cuboid (50 ± 2) × (50 ± 2) × (10 ± 1)

25.2.2 Test apparatus

The test apparatus shall be capable of applying a load of 0,7 N/mm^2 to an indentation rod of 6 mm diameter. The indentation shall be measured to the nearest 0,01 mm. The sample shall be held at a temperature of (50 ± 5) °C throughout the test period.

25.2.3 Procedure

Place the sample centrally under the indentation rod and lower the rod onto the sample. Apply a force of 0,7 N/mm^2 to the indentation rod and measure the indentation after a period of ($24\,^{+0,5}_{0}$) h.

26 Water tightness test for assembled components of manholes and inspection chambers

A manhole or inspection chamber shall be assembled in accordance with the manufacturer's instructions. The pipeline connections shall be sealed.

The test assembly shall be filled with water and a test pressure shall be applied in order to achieve a pressure of (50 ± 2) kPa at the base of the test assembly. The pressure shall be maintained for 1 h, to within 100 Pa (± 10 mm water column).

After this time, the test shall be commenced by making measured additions of water as necessary to maintain the water level over the 15 min test period. After the specified time period, the manhole or inspection chamber shall be visually inspected externally for visible signs of water leakage.

27 Compressive strength of jacking pipes

27.1 Test methods

27.1.1 Testing machine

A compressive testing machine shall be used, equipped with a means of providing the rate of loading specified in 27.1.4 and with a pacing device. The capacity of the machine shall be such that the expected ultimate load on a specimen is greater than one-fifth of the machine scale range. The testing machine load shall be verified by calibration to an accuracy of 1 % by an approved agency at intervals of no more than 12 months.

The machine shall be equipped with two permanent steel bearing platens which shall be at least as large as any plywood packing or, where such packing is not being used, the bedding faces of the specimen being tested.

The upper machine platen shall be able to align freely with the specimens as contact is made but the platens shall be restrained by friction or other means from tilting with respect to each other during loading.

The lower compression platen shall be a plain, non tilting bearing block. The testing face of the platens shall be hardened and shall have a flatness tolerance of ± 0,05 mm.

The machine shall be substantial and rigid throughout, so that the distribution of the load will not be affected by the deformation or yielding of any part.

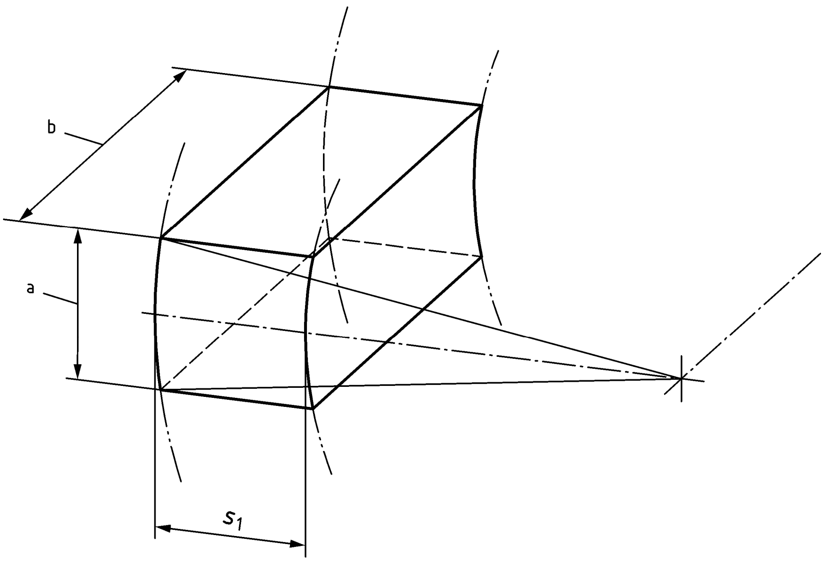
27.1.2 Selection and preparation of specimens

Specimens shall be selected to represent the whole pipe body (reasonably distributed over the ends and the central part of the pipe, over the circumference, and over the inner, outer and central part of the wall).

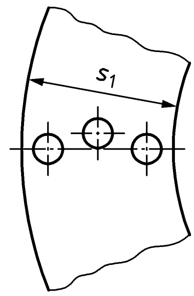
Specimens according to a) and b) below shall be selected

- for pipes < DN 400: over the whole pipe body,
- for pipes ≥ DN 400: in sets of 3 with for each set one specimen from the inner wall, one from the centre and one from the outer wall (see Figure 22).

Specimens according to c) below shall be selected from the whole pipe body.



a) cubes cut from the wall



b) cylinders cut parallel to the longitudinal axis of the pipe

Key
a height of specimen
b length of specimen
s_1 wall thickness of pipe

Figure 22 — Selection of specimen

Specimens shall be prepared according to one of the following procedures:

a) as cubes: cut from the pipe wall. They shall have a minimum length of side of 14 mm with the opposing faces which are to be in contact with the platens of the testing machine ground parallel and plane to a tolerance of ± 1 % of the largest side length;

b) as cylinders: cut parallel to the longitudinal axis of the pipe. They shall have a minimum diameter of 14 mm and their length shall be between 1 and 1,5 times of the diameter. They shall have flat top and bottom faces which are to be in contact with the platens of the testing machine, ground parallel and plane to a tolerance of ± 1 % of the diameter;

c) as sections of the pipe wall: cut parallel to the longitudinal axis of the pipe. The thickness shall be that of the pipe wall and the width measured around the outer circumference of the pipe shall be approximately the same as the wall thickness. The length shall be between 1 and 1,5 times the thickness. They shall have flat top and bottom faces which are to be in contact with the platens of the testing machine, ground parallel and plane to a tolerance of ± 0,50 mm.

Samples shall be pre-conditioned in water as described in 7.1.1. Samples from pipes which are already pre-conditioned, do not require further pre-conditioning. When samples are pre-conditioned according to 7.1.1, the pre-conditioning time is that for the wall thickness of the sample and for unglazed pipes. Pre-conditioning is not necessary for pipes which are produced more than 3 months before testing. Before testing, samples are to be dried.

The manufacturer shall decide on the shape of the sample either (a), (b) or (c) as given above.

27.1.3 Test procedure

Wipe clean the bearing surfaces of all the platens and remove any loose grit or other material from the surfaces of the specimen which are to be in contact with the platens.

To ensure a uniform bearing for the specimen, place it between plywood sheets to take up irregularities. The plywood shall be three-ply, nominally 4 mm thick, of European birch or softwood and free from knots. Ensure that the plywood exceeds the specimen size dimensions by 5 mm to 15 mm. Use a fresh pair of plywood sheets for each test.

Place the specimen centrally under the loading point of the upper platen in such a way that the applied load compresses it in a direction parallel to the longitudinal axis of the pipe.

27.1.4 Loading

Apply the load without shock and increase it at a rate of (200 ± 40) $N/mm^2/min$ and maintain this rate until failure. When the indicator needle falls back in spite of progressively adjusting the machine controls or the specimen undergoes explosive collapse.

Record the maximum load (in Newtons) carried by the specimen during the test.

From the maximum load carried by the test specimen and the area of the specimen in contact with the plywood facings, the compressive strength of the specimen is calculated in N/mm^2. The contact area is determined as the measured mean of the two opposing faces.

27.2 Calculation of compressive strength

The compressive strength of the clay body shall be calculated from the mean compressive strength of at least 12 specimens cut from the same pipe. The minimum compressive strength shall be calculated by subtracting twice the standard deviation of the sample from the mean value.

28 Water absorption

28.1 Test specimen

Test specimen shall be taken from the body of a pipe but not from within 150 mm of the end. The test specimen shall be of a thickness equal to the thickness of the pipe and the two unbroken surfaces shall each have an area of not less than $(1,25 \times 10^4)$ mm^2 and not more than (5×10^8) mm^2. The absorption test shall be carried out on similar pieces which have undergone similar firing conditions.

28.2 Water absorption test

Dry the test specimen at a temperature of not less than (115 ± 5) °C until no further loss of mass can be noted on successive weightings. Then immerse it in cold water and raise the temperature to boiling point. Maintain the water at that temperature for 1 h and, after it has been allowed to cool, remove the test piece, carefully wipe it with a dry cloth and then reweigh it. If the mass in grams of the test piece before treatment is M_1 and the mass in grams of the test piece after treatment is M_2, then:

Percentage water absorption over dry mass = $(M_2 - M_1) \times 100 / M_1$

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.

...making excellence a habit.™