British Standard

BRITISH STANDARD

BS 5911-120: 1989

Incorporating Amendment No. 1

Precast concrete pipes, fittings and ancillary products —

Part 120: Specification for reinforced jacking pipes with flexible joints

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Cement, Gypsum, Aggregates and Quarry Products Standards Policy Committee (CAB/-) to Technical Committee CAB/12, upon which the following bodies were represented:

Association of Consulting Engineers
Association of Metropolitan Authorities
British Cement Association
British Precast Concrete Federation Ltd.
Concrete Pipe Association
Concrete Society
County Surveyor's Society
Department of the Environment (Property Services Agency)
Department of Transport
Federation of Civil Engineering Contractors
Institution of Civil Engineers
Institution of Highways and Transportation
Institution of Water and Environmental Management (IWEM)
Ministry of Agriculture, Fisheries and Food
Pipe Jacking Association
Sand and Gravel Association Ltd.
Water Authorities' Association

This British Standard, having been prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on
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The following BSI references relate to the work on this standard:
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Contents

Foreword

This Part of BS 5911 has been prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Policy Committee. Like the other Parts it is a specification incorporating tests on pipes in manufacturers' works or in testing stations.

The pipes covered by this Part of BS 5911 are intended for installation by jacking which is a technique of installing pipes by driving a line of them through the ground by means of hydraulic jacks from a jacking pit to a reception pit. After pushing a full pipe length into the ground, a new pipe is placed into the pit and the process repeated. The direction is controlled by a steerable shield at the front of the pipes. Spoil is excavated at the forward shield by machine or manually and is removed along the pipeline by means of skips, conveyors or conduit. Tests are included to assist pipe jacking contractors and specifying engineers in respect of the pipes' ability to be jacked and to carry sewage or surface water at atmospheric pressure without leaking or suffering structural damage, always provided that the pipes are jacked, jointed and laid in accordance with agreed codes of practice and design procedures, such as "Jacking Concrete Pipes[1)]" published jointly by the Pipe Jacking Association and the Concrete Pipe Association of Great Britain. This standard does not include the structural or hydraulic design of the pipeline, its durability under unusual environmental conditions or standards of workmanship and supervision during construction and operation.

For an enquiry or order to be fully understood it is essential that the manufacturer be given the information set out in Appendix A.

The joint face strength test (see **18.5**) is included in the absence of a suitable jacking strength test. Research is presently being undertaken in order to devise such a test and this may be incorporated in a future revision.

Since the publication of this Part of BS 5911 it has been found that the method described in Appendix C for assessing the out-of-squareness of pipe ends is mathematically incorrect. No problems have been reported with the existing method and as far as is known the discrepancy is largely academic. Nevertheless, the correction is published in recognition of BSI's duty of care.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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 to iv, pages 1 to 24, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

[1)] Obtainable from the Concrete Pipe Association of Great Britain, 60 Charles St., Leicester LE1 1FB or the Pipe Jacking Association, 56 Britton St., London EC1 5NA.

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Section 1. General

1 Scope

This Part of BS 5911 specifies requirements and describes methods of tests for precast concrete cylindrical pipes with flexible joints, reinforced with steel, intended to be installed by pipe jacking and to be used for the conveyance, under atmospheric pressure, of sewage or surface water, and for the construction of culverts. Requirements are given for materials, dimensions and inspection procedures.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 5911 the following definitions apply.

2.1
pipe

a hollow cylinder manufactured from concrete cast as one piece, reinforced with one or more prefabricated steel cages or hoops

NOTE When "pipe" is used alone in the text of this standard this indicates a jacking pipe, lead pipe or interjack pipe.

2.2
jacking pipe

a pipe of uniform cross section through-out its length, except at the joint, and which incorporates a flexible rebated joint or a butt-end joint with a fixed collar, in either case within the wall thickness

NOTE A jacking pipe is sometimes known as a line pipe.

2.3
lead pipe

a pipe designed for use behind a jacking shield

2.4
interjack pipe

a pipe designed for use at either end of an intermediate jacking station

2.5
nominal size (DN)

a numerical designation of the bore of a pipe, which is a convenient round number approximately equal to the internal diameter in millimetres

2.6
manufacturing diameter

a diameter of a pipe that a manufacturer seeks to achieve

2.7
actual diameter

a diameter found by measurement

2.8
effective length

the length of a pipe measured as shown in Figure 1

2.9
batch

the number of jacking pipes of a particular specification produced under uniform conditions during a given production period by one particular process

2.10
make-up pipe sections

pipe sections used to complete jacked pipe runs

2.11
reinforcement

steel, other than stainless steel, cast within a pipe so as to reinforce the concrete or to locate steel for that purpose

3 Marking

3.1 General

Each pipe shall be clearly marked with the following information:

a) the number of this British Standard, i.e. BS 5911-120[2)];

b) the letter "R", denoting the pipe is reinforced;

c) an indication of the crushing test load(s), which shall consist of either the letter "J" to denote "jacking" class pipes, or, where higher crushing test loads have been specified, the specified works proof and maximum crushing test loads in kilonewtons per metre of effective length (see **18.3.1**).

d) the letter "S", where sulphate-resisting Portland cement has been used;

e) the letter "B", where ground granulated blastfurnace slag (g.g.b.s.) has been used;

f) the letter "P", where pulverized-fuel ash (p.f.a.) has been used;

g) the letter "A", where an admixture has been used;

h) the day, month and year of manufacture;

i) the manufacturer's mark and works identification mark;

j) where tests, as specified in **18.1**, **18.2** or **18.3.2** have been successfully carried out on the pipe;

1) the words "Abs", "Hyd" "N/C" (i.e. "no crack"), as appropriate,

[2)] Marking BS 5911-120 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is therefore solely the responsibility of the person making the claim. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

2) the symbol "MU" indicating pipes suitable only for make-up duties (see **2.10** and **18.3.3**),

3) a reference symbol after the words in item 1) or 2) to identify the results of the tests in the manufacturer's quality control records.

NOTE Examples of marking

1. "C" "X"

BS 5911-120 "RJS"

2.5.89

"Hyd" "Z"

The above marking on a concrete jacking pipe would signify:

"Claimed by manufacturer "C" to have been made at his works "X" and to comply with BS 5911-120; to be reinforced, of class J and made with sulphate-resisting Portland cement; to have been made on 2 May 1989, and to have been successfully tested hydrostatically, as specified in **18.2** with results recorded in the manufacturer's quality control records "Z"."

2. "D" "Y"

BS 5911-120 "RA" 150

2.6.89

"N/C" "T"

The above marking on a concrete jacking pipe would signify:

"Claimed by manufacturer "D" to have been made at his works "Y" and to comply with BS 5911-120; to be reinforced; to contain an admixture and made to resist a maximum crushing test load of 150 kN per metre of effective length; to have been made on 2 June 1989, and to have been successfully subjected to the "no crack" load test, as specified in **18.3.2**, with results recorded in the manufacturer's quality control records "T".

3.2 Method of marking

Pipes shall be marked with either:

a) indelible paint, applied by stencil brush or spray as soon as possible after removal from the mould; or

b) impressed characters approximately 2 mm deep.

All marks shall be visible and legible and shall be on the internal surface of the pipe.

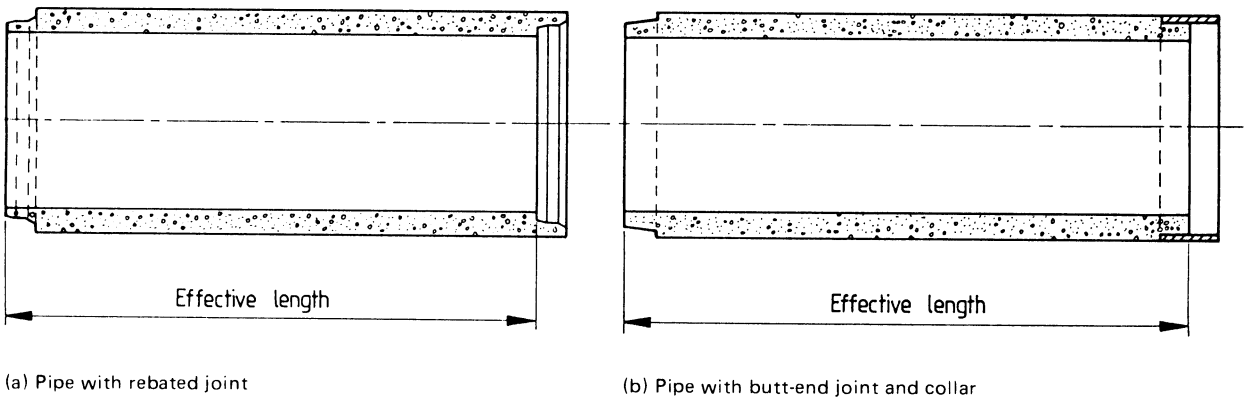


Figure 1 — Effective length of pipes

Section 2. Materials

4 Cement

The cement shall:

a) be factory-produced by the cement manufacturer and comply with one of the following standards as appropriate;

Type of cement	Standard to be complied with
ordinary and rapid-hardening Portland	BS 12
Portland-blastfurnace	BS 146-2
sulphate-resisting Portland	BS 4027
Portland p.f.a.	BS 6588

or

b) consist of a normal or special combination of cement complying with BS 12 and g.g.b.s. or p.f.a. in accordance with the following, to be included as part of the concrete mix by simultaneously combining them with the other concrete materials at the concrete mixer;

Cementitious component other than cement	Standard to be complied with	% by mass of total cementitious content	
		normal	special (additional resistance to sulphate, see note 1)
g.g.b.s.	BS 6699	0 % to 65 %	70 % to 90 %
p.f.a.	BS 3892-1	15 % to 35 %	25 % to 40 %

NOTE 1 The requirements specified in **7.1** for minimum cement content and maximum water/cement ratio will ensure that any of the permitted cements or normal combinations of BS 12 cement and g.g.b.s. or p.f.a. will provide resistance to sulphate attack equivalent to classes 1 and 2 of Table 6.1 of BS 8110-1:1985. Class 3 resistance will be provided by the use of a special combination of cement complying with BS 12 and g.g.b.s. or p.f.a. or by cement complying with BS 4027; the latter will also facilitate class 4 resistance if the minimum cement content is 370 kg/m^3. The advice of the pipe manufacturer should be sought where class 5 conditions exist.

NOTE 2 The purchaser should specify in the enquiry or order the classification of exposure conditions for sulphate attack if higher than class 2 (see Appendix A).

5 Aggregates

5.1 General

Aggregates shall consist of materials complying with BS 882:1983, except for the grading requirements of clause **5** of that standard.

NOTE The pipe manufacturer may modify the gradings to suit his manufacturing process. (See clause **0** of BS 882:1983.)

5.2 Mechanical properties

The limiting values on the mechanical properties of coarse aggregates shall be either a minimum 10 % fines value of 100 kN or a maximum aggregate impact value of 30 %. Flakiness index shall be not more than 35.

5.3 Nominal maximum size

The nominal maximum size of aggregate shall not exceed the least of the following:

a) 20 mm;

b) the concrete cover (see **8.2**);

c) one-quarter of the minimum thickness of the pipe;

6 Other concrete materials

6.1 Water

Water shall be clean and free from harmful matter in such quantities as would affect the properties of the concrete in the plastic or hardened state (see Appendix A of BS 3148:1980).

NOTE As a general rule, potable water, whether treated for distribution through the public supply or untreated, is suitable for making concrete.

6.2 Admixtures

Admixtures shall comply with BS 5075.

NOTE Admixtures, when used (see Appendix A), should not impair the durability of the concrete, nor combine with the ingredients to form harmful compounds nor increase the risk of corrosion of reinforcement.

The chloride ion content of admixtures shall not exceed 2 % by mass of the admixture or 0.03 % by mass of the cement.

The manufacturer shall make available details of:

a) the relevant production records;

b) the admixture(s) used;

c) the dosage rate of each admixture;

d) the effect of under-dosing and over-dosing.

7 Concrete mix, casting and finish

7.1 Cement content

The fully compacted concrete shall contain not less than 360 kg of cement (inclusive of any g.g.b.s. or p.f.a.) per cubic metre and shall have a water/cement ratio not greater than 0.45. Where a special combination of cement complying with BS 12 and g.g.b.s. or p.f.a. is used (see clause **4**), the minimum cementitious content shall be increased from 360 kg/m^3 to 380 kg/m^3.

7.2 Chloride content

The total chloride ion content of the concrete mixes shall be as given in Table 1.

7.3 Work in cold weather

Concrete, when placed, shall have a temperature of at least 5 °C, which shall be maintained until the concrete is hardened.

It is permissible to heat aggregates and water before mixing, to a temperature not exceeding 60 °C.

Other materials and moulds, if at a temperature below 0 °C, shall not be used.

Table 1 — Limits of chloride content of concrete

Type of concrete	Maximum total chloride content expressed as a percentage of chloride ion by mass of cement (inclusive of g.g.b.s. or p.f.a. when used)
	% *(m/m)*
Heat-cured concrete	0.1
Concrete made with cement complying with BS 4027	0.2
Concrete made with cement complying with BS 12, BS 146-2, or combinations of cement complying with BS 12 and g.g.b.s. or p.f.a.	0.4

7.4 Compaction

All pipes shall be compacted so that, when hardened they shall be free from honeycombing and from any individual large void (i.e. greater than 6 mm) as defined in **4.4.1** of BS 1881-120:1983. Blistering shall not be regarded as a void.

7.5 Surface finish

7.5.1 *Surface evenness.* When tested in accordance with **B.1**, the internal surface of a pipe shall not have irregularities that cause the central portion of the gauge to touch the pipe.

7.5.2 *Surface voids.* When tested in accordance with **B.2**, surfaces of pipes shall be free from voids that permit diametrically opposite points of the rim of the gauge to touch simultaneously the surface of the pipe.

Pipes exhibiting surface voids greater than 12 mm deep shall be deemed not to comply with this standard.

NOTE Voids up to and including 12 mm deep may be made good using material complying with **7.6.1**.

7.5.3 *Staining.* Pipes shall not exhibit rust marks that originate from steel within the pipe.

7.6 Making good

7.6.1 *Materials.* Materials for making good shall be one of the following.

a) Neat cement grout, with or without the addition of styrene-butadiene rubber (SBR), the type of cement being compatible with that in the pipe to be made good.

b) 1 : 3 cement/sand mortar proportioned by mass with or without the addition of SBR. The cement shall be compatible with that in the pipe to be made good and the sand shall comply with the requirements for fine aggregate in BS 882 but have a grading such that 100 % of the material passes a 5 mm sieve.

c) A sample of the concrete mix minus the aggregate retained on the 5 mm sieve, with or without the addition of SBR.

d) Epoxy or polyester resin, or polymer latex mortar.

NOTE For guidance on the use of epoxy and polyester resins, see CIRIA Report 69 "Effective use of epoxy and polyester resins in civil engineering structures", published by the Construction Industry Research and Information Association[3]. See also "The Repair of Concrete Structures' published by the Cement and Concrete Association[4], which also deals with polymer latex mortars, and **6.10.5** of BS 8110-1:1985.

7.6.2 *Blistering.* Any blistering shall be made good using material complying with **7.6.1** d).

NOTE Flaking of the surface of a pipe would not constitute blistering.

7.6.3 *Joint surfaces.* Before a pipe is tested for compliance it is permissible:

a) subject to **7.4**, to re-work a joint profile for compliance with clause **16** by the application of material complying with **7.6.1** b) or c) to a depth not exceeding 5 mm whilst the concrete is still green, or material complying with **7.6.1** d), or by grinding off;

b) subject to **7.4** and to items 1) and 2), to make good using material complying with **7.6.1** b) or c) any spalling of the arrises of spigots or sockets that has occurred during de-moulding or handling.

1) In any pipe the total exposed area of broken concrete shall not exceed $6 \times (DN)$ mm^2 with no individual area greater than $3 \times (DN)$ mm^2.

NOTE For example, the total area for a DN 900 pipe is 5 400 mm^2 with no individual area greater than 2 700 mm^2.

2) No exposed area of broken concrete shall be in contact with both the outer and inner surface of the spigot or socket of a pipe.

[3] Obtainable from CIRIA, 6 Storey's Gate, London SW1P 3AU.
[4] Obtainable from British Concrete Association, Wexham Springs, Slough, Bucks SL3 6PL.

If material complying with **7.6.1** d) is used, the permissible areas in b) 1) shall be doubled and item b) 2) shall not apply.

7.6.4 *Exposed steel.* Where, on de-moulding, bar steel not forming part of the reinforcement of a pipe is visible, or found to be within the concrete cover, it is permissible to remove a maximum of two such pieces each having a length not exceeding half the thickness of the pipe and to make good the void(s) with material complying with **7.6.1** d) before the pipe is assessed for compliance.

7.6.5 *Rubbing down.* After a pipe has been cured and prior to despatch, it is permissible to rub down where necessary to produce a surface finish complying with **7.5**.

7.7 Inserts for grouting

Any insert for grouting shall comply with **8.2** for concrete cover, shall be not less than 12 mm from the inner or outer face of the pipe and shall not be attached to reinforcement.

NOTE The purchaser should state on the enquiry or order if lifting holes, grout holes or inserts are required (see Appendix A).

8 Reinforcement

8.1 Materials and arrangement

Reinforcement shall comply with one of the following standards, as appropriate.

Type of reinforcement	Standard to be complied with
Carbon steel bars for the reinforcement of concrete	BS 4449
Cold reduced steel wire for the reinforcement of concrete	BS 4482
Steel fabric for the reinforcement of concrete	BS 4483

The main reinforcement shall be placed in a circular arrangement, in the form of concentric hoops, either hooked, butt welded or lap welded, or in the form of a continuous helix or fabric, suitably welded. Longitudinal bars or wires or any other effective method shall be used to control spacing and shape and to ensure safe handling.

The reinforcement shall continue from the barrel into the spigot and into the socket of rebated joints.

The clear space between circumferential bars shall be not less than the nominal maximum size of the coarse aggregate plus 5 mm.

8.2 Protection for reinforcement

The concrete cover over all reinforcement shall be such that, in any finished pipe, it is nowhere less than 12 mm.

An effective means shall be provided for maintaining the reinforcement in position and for ensuring correct cover during manufacture of the pipe. Spacers for this purpose shall be of grade 316S31 austenitic stainless steel complying with BS 970-1 or other rustproof material.

There shall be no steel, other than stainless steel, within the concrete cover, except when used for the anchorage of steel collars (see **16.2**).

Reinforcement shall be free from mud, oil, paint, retarders, loose rust, loose mill scale, snow, ice, grease or any other substance which can be shown to affect adversely the steel or concrete chemically, or to reduce the bond.

Section 3. Dimensions and tolerances

9 Nominal size and effective length

9.1 Nominal size (DN)

The nominal sizes (see **2.5**) of pipes shall be either:

a) those given in column 1 of Table 2, or

b) those halfway between the sizes in a), i.e. at intervals of DN 75.

If nominal sizes as specified in item b) are used, the tolerances on diameter and wall thickness shall be those relating to the next higher nominal size given in Table 2.

9.2 Effective length of pipes

The manufacturer shall make available information on the effective lengths of pipes that he is able to supply in a given nominal size named in an enquiry or order (see Appendix A).

10 Internal manufacturing diameter and actual diameter

The internal manufacturing diameter shall be the nominal size $^{+50}_{-20}$ mm.

The actual internal diameter (see **2.7**) shall not deviate from the manufacturing diameter by an amount greater than that given in column 2 of Table 2.

NOTE The manufacturer should make available, at the enquiry stage, information on the internal manufacturing diameters (see **2.6**) that he is able to supply (see Appendix A).

Table 2 — Nominal sizes and tolerances (see 9.1)

1	2	3	4
Nominal size (see **9.1**)	**Deviation of actual diameter from manufacturing diameter** (see clauses **10** and **11**)		**Variation of wall thickness** (see clause **12**)
	Internal	**External**	
DN	mm (±)	mm (±)	mm
900	6	3	6
1 050	6	3	6
1 200	10	3	10
1 350	10	4	10
1 500	10	4	10
1 650	10	4	10
1 800	10	5	10
1 950	16	5	16
2 100	16	5	16
2 250	16	6	16
2 400	16	6	16
2 550	16	6	16
2 700	16	6	16
2 850	16	6	16
3 000	16	6	16

11 External manufacturing diameter

The external manufacturing diameter (see **2.6**) of the barrel of a pipe shall be stated by the manufacturer.

The diameter as measured shall not deviate from the manufacturer's stated diameter by more than the amount stated in column 3 of Table 2.

12 Variation in the thickness of wall

The radial thickness of the wall of a pipe shall not vary by more than the amount stated in column 4 of Table 2 unless called for by the design of a recess in a lead pipe or interjack pipe.

13 Squareness of ends

When tested as described in Appendix C, the ends of each pipe shall be square with the outside of the barrel so that the variation across the external diameter shall not exceed the amount shown in Table 3 for the appropriate nominal size. Pipes designed to be jointed shall be capable of being jointed in any orientation with their axes coincident within the limits specified in **18.6.2**.

NOTE Squareness of ends of pipes is significant only as it relates to the jacking operation and to the performance of the joint assembly.

Table 3 — Maximum variation of squareness across an external diameter

Nominal size	Maximum variation of squareness across an external diameter
DN	mm
900 to 1 500	4
1 650 to 2 250	5.5
2 400 to 3 000	7

14 Deviation from straightness

When assessed as described in Appendix D, the pipe shall satisfy the criteria for straightness on both external and internal surfaces.

The test for deviation from straightness shall be applied to both the bore and the outside of the barrel.

15 Surface cracking

It is permissible for either of the following types of crack to be visible in the surface of a pipe:

a) structural cracks that have developed in the tensile zone of reinforced concrete, within the limits specified in **18.3.2** and **18.3.3**, as a result of testing in accordance with Appendix G;

b) crazing with any cement-rich surface layer.

Pipes exhibiting cracks other than those described in a) and b) shall be deemed not to comply with this Part of BS 5911, whether or not the cracks were caused by testing.

16 Joints

16.1 General

Joints of pipes shall, except at one end of lead or interjack pipes, be in-wall flexible joints of either the rebated or the fixed collar type. They shall be designed to incorporate an elastomeric ring complying with type D of BS 2494. Joint assemblies shall be tested as specified in **18.6** to the design dimensions recorded by the manufacturer. The profile of a joint shall comply with the design dimensions and tolerances for its size and class.

All joint surfaces which will transmit load during installation shall be plain, free from undulations and protuberances which could cause high local concentrations of stress and, subject to the requirements of clause **13**, shall be square to the pipe axis.

NOTE 1 For typical joints, see Figure 2.

NOTE 2 For guidance on jointing and installation, see "Jacking Concrete Pipes[5)]" published jointly by the Pipe Jacking Association and the Concrete Pipe Association of Great Britain.

16.2 Collars

16.2.1 Collars shall be fabricated from material complying with one of the following standards, as appropriate.

Collar material	Standard to be complied with
Weldable structural steel plate	BS 4360, grade 43A
Stainless steel plate	BS 1449-2, grade 316S31
Glass reinforced plastic (GRP)	BS 5480-1, for machine made collars
	BS 4994 for hand laid-up collars

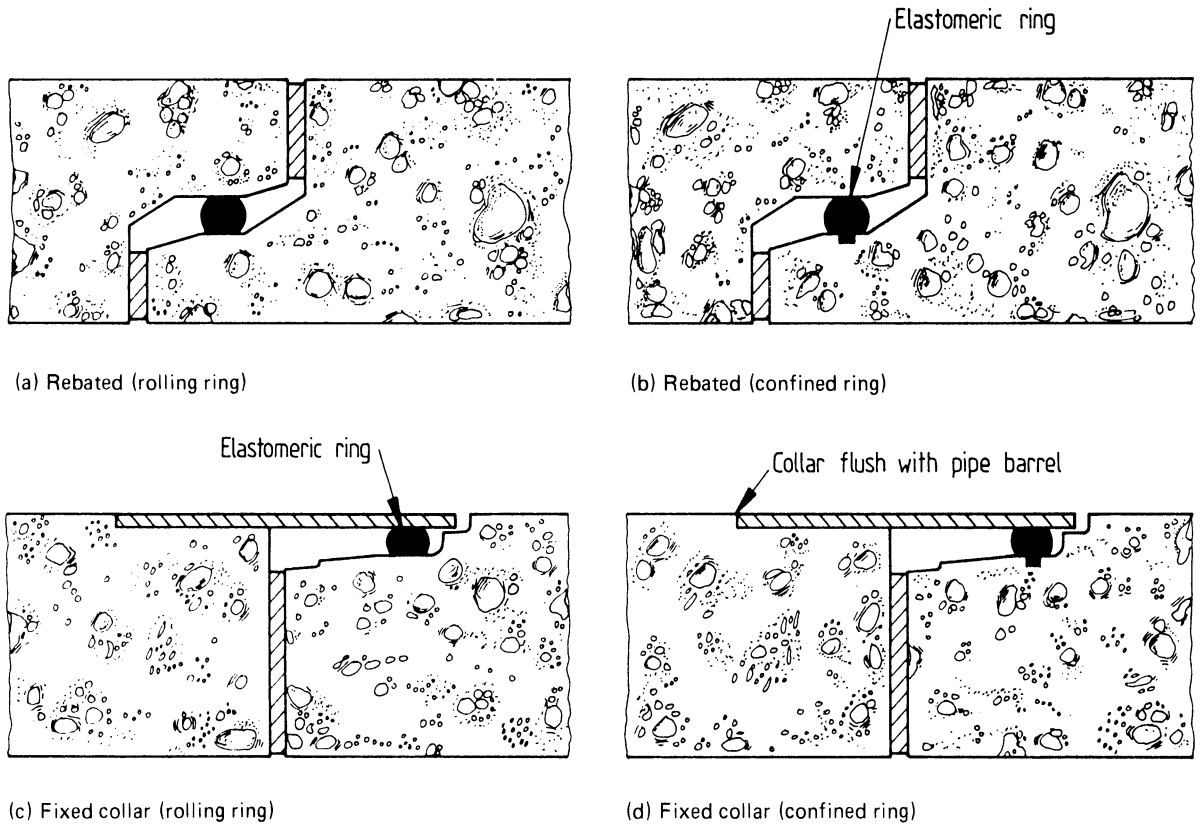
Collars shall not be attached to reinforcement.

NOTE Collars fabricated from weldable structural steel may be susceptible to corrosion from the ground, groundwater or the effluent carried. If corrosion can be expected, the design of joint incorporating this type of collar should provide for a secondary sealing gasket to be applied on site, for example by means of the cold-applied non-curing and heat-softened hand-applied types of sealant.

16.2.2 Welding on structural steel plate and stainless steel plate collars shall comply with BS 5135 and BS 3019-2 respectively.

Welds shall be inspected in accordance with clause **26** and Appendix H: quality category D of BS 5135:1984.

5) Obtainable from the Concrete Pipe Association of Great Britain, 60 Charles St., Leicester LE1 1FB or the Pipe Jacking Association, 56 Britton St., London EC1M SNA.



NOTE The figures are diagrammatic only and are not intended to fix design or to specify any joint packing material. Not all collars are cast integrally with the pipes. Some may be fixed after casting.

Figure 2 — Typical flexible joints

Section 4. Tests

17 General

17.1 Routine and type testing

17.1.1 Pipes shall comply with the appropriate routine and type test requirements given in this section and summarized in Table 4 and shall be inspected, using the procedures specified in section 5.

NOTE Inspection procedures are not given in this Part of BS 5911 for isolated batches of jacking pipes (see **20.1**).

17.1.2 For inspection purposes, the manufacturer shall be permitted to include flexibly jointed pipes complying with BS 5911-100 in the continuing series of batches produced at a particular works.

17.1.3 Type tests shall be carried out to prove the design of a component or assembly. They shall be undertaken wherever there is a change in design, type of material or method of manufacture. Where it is not practicable to carry out type tests on a lead or interjack pipe, it is permissible to manufacture only the relevant part of such a pipe and prove the design by testing it.

17.1.4 Records of all tests and inspection procedures shall be kept by the manufacturer.

17.2 Test equipment and facilities

The manufacturer shall either:

a) provide in his own works suitable equipment and facilities for sampling and testing the pipes before delivery; or

b) make arrangements for the provision of suitable equipment and facilities elsewhere for the same purpose.

The manufacturer shall provide certification to show that all test equipment is calibrated at least annually.

17.3 Acceptance of pipes

Pipes shall be considered ready for acceptance only after the design has been proven by type tests and the batch of which jacking pipes form part has been routinely tested and shown to comply with **18.2** and **18.3.2**.

All jacking pipes within any batch shall be cured and matured under similar conditions. Pipes shall not be despatched until they are at least 28 days old.

Pipes cored and treated as described in **18.1**, or jacking pipes that have the appropriate "no crack" load test shall be marked as specified in clause **3** and shall be taken to comply with this Part of BS 5911 in those respects.

18 Test requirements

18.1 Water absorption test

Pipes shall be sampled in accordance with **20.4** and prepared and tested in accordance with Appendix E.

The increase in the dry mass of a single test piece by absorption of water shall not exceed:

a) 3.6 % after 30 min;

b) 6.5 % after 24 h.

The hole in a pipe from which a core specimen has been taken shall be sealed with material complying with **7.6.1** d).

18.2 Hydrostatic test

Pipes of all nominal sizes shall be sampled and tested in accordance with Appendix F and shall withstand the internal hydrostatic pressure without cracking, sweating or showing other signs of distress such as leaking or dripping.

NOTE Sweating means the appearance of a damp patch on the outside of the pipe during the test, due to the internal hydrostatic pressure.

The permeability of concrete is such that, in service, the surface of a pipe may be expected to be cold and damp to the touch, but there should be no sign of water passing through the wall.

Prior to testing, a pipe shall not be treated with any coating or lining, but any lifting holes, grouting holes or inserts shall be temporarily sealed.

Table 4 — Summary of test requirements and inspection procedures

Test	Requirements given in clause	Test method given in	Required as type test (see **17.1.3**)	Required as routine test	Inspection procedures given in clause
Surface evenness	**7.5.1**	Appendix B	—	—	See note
Surface void	**7.5.2**	Appendix B	—	—	See note
Squareness	**13**	Appendix C	—	—	See note
Straightness	**14**	Appendix D	—	—	See note
Water absorption	**18.1**	Appendix E	√[a]	√[a]	**20.4**
Hydrostatic	**18.2**	Appendix F	√[a]	√[a]	**20.1**
"No crack" load	**18.3.2**	Appendix G	√[a]	√[a]	**20.1**
Maximum load	**18.3.3**	Appendix G	√[a]	√[a]	**20.2**
Cover to reinforcement	**8.2**	Appendix H	√	√	**20.2**
Joint face strength	**18.5**	Appendix J	√	√	**20.3**
Joint deflection	**18.6.2**	Appendix K	√	—	**20.5**
Joint, straight draw	**18.6.3**	Appendix K	√	—	**20.5**
Joint shear	**18.6.4**	Appendix K	√	—	**20.5**

NOTE These tests are to be carried out as and when required.

[a] This test is not required as a routine test for lead and interjack pipes (see also **17.1.3**).

18.3 Crushing tests

18.3.1 *General.* The maximum, works proof and "no-crack" crushing test loads for pipes shall be:

a) those shown in Table 5; or

b) interpolated between the values given in Table 5 for adjacent nominal sizes; or

c) where stronger pipes are designed and manufactured, appropriate higher loads.

The works proof load for all pipes in c) shall be 80 % of the declared maximum load. The "no-crack" load shall be the maximum load × R, where R is the ratio of the "no-crack" load to the maximum load, given in Table 5, for that nominal size of pipe.

18.3.2 *"No-crack" load test.* When tested in accordance with Appendix G, a pipe shall sustain for at least 1 min the appropriate "no-crack" load specified in Table 5 for its nominal size without developing any crack penetrable by a 0.03 mm feeler gauge as described in **G.4**.

NOTE The "no-crack" load test is used to facilitate routine testing without significant structural cracking of the pipes. It has no relevance to the design loads for pipes in the installed condition.

Table 5 — Crushing test loads

Nominal size	Test loads		
	"No-crack" load	Works proof load	Maximum load
	Kilonewtons per metre of effective length		
DN			
900	55	88	110
1 050	60	96	120
1 200	70	112	140
1 350	80	128	160
1 500	85	136	170
1 650	95	152	190
1 800	100	160	200
1 950	100	176	220
2 100	100	184	230
2 250	105	200	250
2 400	105	216	270
2 550	105	224	280
2 700	110	240	300
2 850	110	256	320
3 000	110	264	330

NOTE For information on the application of the above pipe crushing test loads to design of pipelines, reference should be made to 'Simplified tables of external loads on buried pipelines (HMSO 1986) and "A guide to design loadings for buried rigid pipes" (HMSO 1983).
In design the maximum load should be used and a minimum factor of safety of 1.25 adopted together with the relevant bedding factor.

18.3.3 *Maximum load test.* When tested in accordance with Appendix G, a pipe shall withstand for at least 1 min the appropriate works proof load specified in Table 5 for its nominal size without developing any cracks penetrable to a depth of 2 mm by a 0.25 mm feeler gauge on inspection at intervals of 20 mm to 50 mm over a length of 300 mm or more. In addition the pipe shall subsequently withstand, with no limit on crack width but without collapse, a load that is not less than the maximum test load specified in Table 5.

Any pipe that, under the maximum load, has exhibited cracks within these limits shall be acceptable only for use as a make-up section (see **2.10**).

NOTE Given the inspection procedures specified in this standard and the minimum cover specified in **8.2** for pipes not exposed to particularly aggressive environments, the permissible crack width of 0.25 mm is consistent with the crack control provisions given in BS 8110-1 and BS 8110-2.

18.4 Depth of cover to reinforcement

Pipes shall be sampled and tested in accordance with Appendix H.

Pipes that have been successfully tested shall be made good with material complying with **7.6.1** d) before despatch and shall be taken to comply with this Part of BS 5911 in that respect.

18.5 Joint face strength

When tested in accordance with Appendix J, the average ultimate strength of the concrete faces shall be not less than 100 N/mm^2 and no individual result shall fall below 70 N/mm^2.

NOTE 1 These strengths give an indication of the quality of the concrete in the joint faces but the permissible jacking load should on no account be taken to be that obtained by using them in conjunction with the areas of the jacking faces.

NOTE 2 The purchaser should specify in the enquiry or order whether he requires a statement of the jacking loads for which the pipes were designed (see Appendix A).

18.6 Tests for flexible joints

18.6.1 *General.* Type tests for flexible joints shall be carried out on pipes, or parts of pipes, that have been jointed and subjected to an internal hydrostatic pressure as described in Appendix K. Where more than one test is carried out simultaneously all the requirements of each test shall be met.

Joint packing material for use when jacking (see Figure 2) shall not be used whilst a test is being carried out.

NOTE The joint tests specified are quality assurance control type tests and the angles in Table 6 are not necessarily those that can be accommodated during the jacking operation.

18.6.2 *Deflection test.* When tested in accordance with **K.1** the pipes, or parts of pipes, that have been jointed shall, without loss of watertightness at the joint, provide angular deflection between the longitudinal axes of the two pipes, measured as shown in Figure 3 a), which is not less than that given in Table 6.

Table 6 — Minimum angular deflection and straight draw for joints (see note to **18.6.1)**

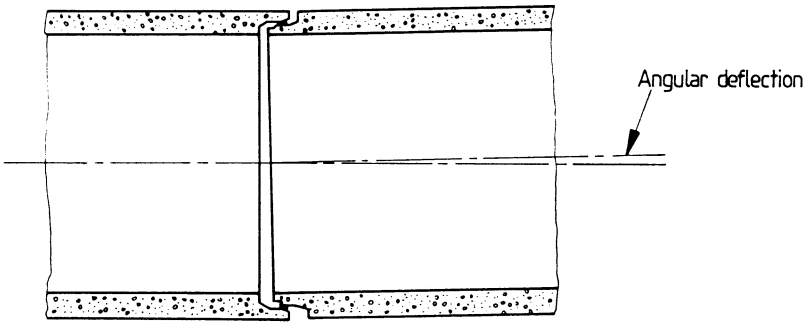
Nominal size	Minimum angular deflection	Minimum straight draw
DN	degree	mm
900 to 1 200	1	20
1 350 to 1 800	½	20
1 950 to 3 000	To be stated by the manufacturer	

18.6.3 *Straight draw test.* When tested in accordance with **K.2** the pipes, or parts of pipes, that have been jointed shall, without loss of watertightness at the joint, provide a straight draw, measured as shown in Figure 3 b), which is not less than that given in Table 6.

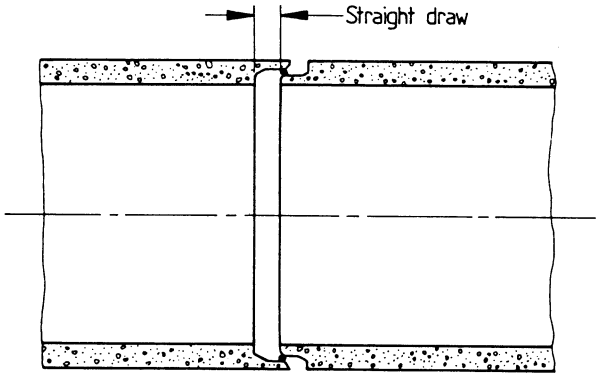
18.6.4 *Shear test.* When tested in accordance with **K.3** the pipes, or parts of pipes, that have been jointed shall, without loss of watertightness at the joint, withstand a test load which is not less than that given in Table 7.

Table 7 — Minimum shear test loads

Nominal size	Minimum load
DN	KN
900	22.5
1 050	26.25
1 200	30.0
1 350	33.75
1 500 to 3 000	37.5



(a) Angular deflection of joint



(b) Straight draw of joint

Figure 3 — Joint test measurements

Section 5. Inspection procedures

19 Type of inspection and batch size

19.1 Type of inspection

19.1.1 *Normal inspection.* Normal inspection shall be used when a process has been in operation long enough to be in a state of control.

19.1.2 *Tightened inspection.* Tightened inspection shall be used:

a) when inspecting a new product, a redesigned product or a new production line; or

b) when so directed by the switching rules in **19.2**.

19.1.3 *Reduced inspection.* Reduced inspection shall be substituted for normal inspection only when permitted by the switching rules given in **19.2.4**.

19.2 Switching rules

19.2.1 *General.* Changes from one inspection type to another shall be in accordance with the following switching rules. The rules given in **19.2.2**, **19.2.5** and **19.2.6** shall apply in all cases, whereas the rules given in **19.2.3** and **19.2.4** shall apply at the discretion of the manufacturer.

19.2.2 *Normal to tightened inspection.* When using normal inspection, switch to tightened inspection if two in five or less consecutive batches have been rejected.

19.2.3 *Tightened to normal inspection.* When using tightened inspection, switch to normal inspection only when five consecutive batches have been accepted.

19.2.4 *Normal to reduced inspection (hydrostatic and "no-crack" load crushing test).* When using normal inspection, switch to reduced inspection only if:

a) the last 10 batches (see Table 8) have been subject to normal inspection and have all been accepted; and

b) the total number of defectives in samples taken from the last 10 batches is less than or equal to the number given in Table 8. When double sampling is used, all samples inspected shall be included, i.e. not the first samples only.

Table 8 — Maximum number of individual defectives in last 10 batches permitted for switching to reduced inspection (hydrostatic and "no-crack" load crushing test)

Number of jacking pipes sampled from last 10 batches	Total number of defectives in last 10 batches on normal inspection
30 to 79	0
80 to 129	2
130 to 199	4
200 to 319	8
320 to 499	14
500 to 799	25
800 to 1 249	42

NOTE The values in this table are consistent with those in Table VIII of BS 6001:1972 for a target acceptable quality level (AQL) of 6.5 %.

19.2.5 *Reduced (hydrostatic and "no-crack" load crushing test) to normal inspection.* When using reduced inspection, switch to normal inspection if:

a) a batch is rejected; or

b) a batch is accepted where the acceptance number given in column 4 (single sampling) or 6 (double sampling) of Table 9 has been exceeded, but the rejection number in column 5 (single sampling) or 7 (double sampling) has not been reached; or

c) production becomes irregular or delayed.

19.2.6 *Tightened inspection to stopping production.* When using tightened inspection, stop production if it is not possible to switch to normal inspection (see **19.2.3**) after 10 consecutive batches. Investigate the cause of failure and take any necessary remedial action. Resume production using tightened inspection.

19.3 Size of batch

When inspecting jacking pipes, it is permissible to choose any size of batch, provided that:

a) it is in accordance with **17.3**; and

b) where a batch consists of more than 150 pipes, it is produced within a 24 h period.

20 Inspection procedures

20.1 Inspection procedure for the hydrostatic test or "no-crack" load crushing test

NOTE The sampling plan in this clause follows BS 6001-1:1972, which is intended primarily to be used for a continuing series of batches and warns that for isolated batches more stringent sampling plans will be required to give the desired protection (see also BS 6000). On that basis therefore, more stringent inspection criteria should be specified where batches are not to be produced as part of a regular pipe production process.

The inspection procedure given in items a) to f) shall be used whenever a regular process is in operation and jacking pipes are being produced on a continuing basis.

a) Determine the appropriate inspection type (see **19.1**).

b) Select the batch size (see **19.3**). For the hydrostatic test only, it is permissible to group together jacking pipes of different specifications, provided that all the following conditions are satisfied:

1) all pipes in such a batch are produced by the same manufacturing process;

2) the ratio of the largest to the smallest nominal size in the batch is not greater than 1.5;

3) the production period is not more than one week;

4) the size of the batch does not exceed 150 pipes;

5) any subsequent acceptance or rejection applies to all pipes in the batch.

c) Take a random sample of the size given in column 3 of Table 9 for the appropriate inspection type and size of batch.

d) Subject the sample to the hydrostatic test specified in **18.2** or the "no-crack" load test specified in **18.3.2**.

e) Assess the acceptability of the batch, as follows.

1) For batches of 25 or less (single sampling), if the number of defectives is nil (see "Accept" number in column 4 of Table 9), accept the batch. If the number of defectives is one or more (see "Reject" number in column 5 of Table 9), reject the batch.

2) For batches of 26 or more (double sampling), if the number of defectives is equal to or less than the "Accept" number in column 4 of Table 9, accept the batch, with the exception of any defectives. If the number of defectives is equal to or greater than the "Reject" number in column 5 of Table 9, reject the batch.

However, if the number of defectives is greater than the "Accept" number in column 4 but less than the "Reject" number in column 5, take a second random sample of the same size as the first one. Then if the cumulative number of defectives for both samples is less than the second "Reject" number (column 7), accept the batch, with the exception of any defectives [see also **19.2.5** b)]. If the cumulative number of defectives is equal to or greater than the "Reject" number in column 7, reject the batch.

f) Record the results.

Where a batch has been rejected during the inspection for the hydrostatic test, the manufacturer shall be permitted to test the remaining jacking pipes in that batch, and to claim compliance for those pipes that pass the tests.

20.2 Inspection procedure for the maximum load crushing test and test for depth of cover to reinforcement

When carrying out the maximum load crushing test and the test for depth of cover to reinforcement, the inspection procedure shall be as follows.

a) Select one jacking pipe at random from every 30 pipes of a given specification selected for the "no-crack" crushing test in accordance with **20.1**, provided that not more than one pipe is selected from consecutive batches comprising a total of 600 pipes or less of the given specification.

b) Subject the pipe to the maximum load crushing test specified in **18.3.3** and the depth of cover to reinforcement test specified in **18.4**.

c) If the pipe fails, record the result, discontinue the manufacturing process, investigate the cause of failure and take any necessary remedial action.

d) Restart the process and test the first three jacking pipes made thereafter.

e) If all three pipes pass the test, resume production and inspection, using the tightened rate of inspection for the "no-crack" crushing test (see **19.1.2**).

However, if any pipe fails, discontinue the manufacturing process and carry out further investigations and remedial action.

f) Repeat d) and e) until satisfactory results have been obtained.

Where a pipe fails the depth of cover to reinforcement test, the batch from which it was selected shall be rejected but it is permissible to subject the remaining pipes in the batch to the test. Only those that pass the test shall be accepted.

Where a pipe fails the maximum load crushing test, the batch from which it was selected shall be rejected.

A maximum load crushing test and test for depth of cover to reinforcement shall be carried out on each size manufactured at least once per year.

20.3 Inspection procedure for the joint face strength test

After carrying out a successful type test on each nominal size of pipe manufactured, a pipe shall be selected at random from a batch of one nominal size in each group of the production range and tested in accordance with procedure described in Appendix J. This test shall be repeated annually, selecting a different size of pipe within each group each year until the full range of production at a particular works is covered.

20.4 Inspection procedure for water absorption test

When carrying out the water absorption test, the following inspection procedure shall be used.

a) From each manufacturing process, select one in 500 or two pipes per week, whichever is the greater, and take specimens as described in Appendix E. Use the same type of specimen for all tests on a given product.

b) Subject the specimens to the water absorption test specified in **18.1**.

c) If the specimens pass the test, accept the pipes in the batch or batches from which they were taken. If any specimen fails, repeat a) and b) using a second sample.

d) If the specimens obtained from the second sample of pipes pass the test, accept the pipes in the batch or batches from which they were taken. However, if any of these specimens fail, proceed as follows.

1) Reject the batch or batches. However, it is permissible to take specimens from all the remaining pipes and subject them to the test. Only those pipes that pass the test shall be accepted.

2) Investigate the cause of failure and take any necessary remedial action.

3) Resume production and increase the rate of inspection to one in 250 or four pipes per week, whichever is the greater.

4) Resume the rate of inspection given in a) only after all samples taken during a production period of five consecutive weeks have passed the test.

It is permissible to group together pipes made to this Part of BS 5911 with those made to Part 100 of BS 5911 at the same works provided that:

i) the overall sampling rate complies with that specified above;

ii) all pipes are produced by the same manufacturing process;

iii) the ratio of the largest to the smallest nominal size is no greater than 1.5;

iv) the production period is not more than one week;

v) the size of the combined batch does not exceed 150 pipes;

vi) any subsequent acceptance or rejection applies to all pipes in the batch.

20.5 Inspection procedure for joints (angular deflection, straight draw and shear)

Pipes, or parts of pipes, of two nominal sizes from each of the first two groups given in Table 6, shall be so selected as to be representative of the range with regard to the rubber joint ring and that part of the joint profile that is effective when jointing. A joint assembly of each of these representative nominal sizes shall be submitted to the tests for deflection, straight draw and shear specified in **18.6**.

For nominal sizes greater than DN 1800, pipes, or parts of pipes, of one representative nominal size shall be selected.

If any of the specified size ranges includes more than one joint ring type or more than one joint profile, i.e. jointing surfaces of differing relative dimensions, separate type tests shall be carried out on representative samples of the differing profiles within that particular size range.

If any joint assembly is subsequently modified by changing any dimension affecting the joint, or if there is any modification of pipe joint ring specification that affects the joint performance, the type tests for the joint assembly shall be repeated.

Once a type test has been used to establish joint criteria, the manufacturer shall keep and make available a list of critical dimensions.

Table 9 — Inspection plans for hydrostatic and "no-crack" load crushing tests

1	2	3	4	5	6	7
Inspection type	**Batch size**	**Sample size** (see note 2)	**Accept**	**Reject**	**Accept**	**Reject**
			Numbers of defectives			
Normal	2 to 25	2 (single)	0	1		
	26 to 150	5 (double)	0	2	1	2
Tightened	2 to 25	3 (single)	0	1		
	26 to 150	8 (double)	0	2	1	2
Reduced	2 to 25	2 (single)	0	1		
	26 to 150	2 (double)	0	2	1	2

NOTE 1 This table follows tables in BS 6001-1:1972 and is consistent with a target acceptable quality level (AQL) of 6.5 % at General Inspection Level 1.
NOTE 2 Sample sizes given in this table are not suitable for assessing compliance with the standard on an isolated batch basis (see **20.1**).

Appendix A Information to be supplied in an enquiry and order

The following particulars cover essential details required by the manufacturer so that an enquiry or order may be fully understood.

a) Quantity and nominal size of pipe (see clause **9**).

b) Crushing test loads of pipes (see **18.3**). The maximum load if crushing test loads higher than those given in Table 5 are required.

c) The classification of exposure conditions for sulphate attack, if higher than class 2 (see clause **4**).

d) If samples of aggregates, and/or evidence of satisfactory performance of concrete made with such aggregates, are required (see Appendix L).

e) If any restriction on admixtures is required (see **6.2**).

f) If additional concrete cover is required because of unusual conditions of use (see foreword).

g) If details of internal diameter are required (see clause **10**).

h) If lifting holes, grout holes or inserts are required (see **7.7**).

i) The number and type of tests to be witnessed and if any additional tests are required (see Appendix L).

j) If the pipes are to be covered by a third party certification scheme (see Appendix L).

k) Sufficient details for the design of recesses in lead and interjack pipes.

l) If a statement of the jacking loads for which the pipes were designed is required.

m) The type of joint and material of any collar (see clause **16**).

n) If jacking pipes are not to be produced as part of a continuing series of batches, the specified inspection procedures (see **20.1**).

Appendix B Methods of assessing surface finish

B.1 Surface evenness

Place the gauge (see Figure 4) in the pipe so that its axis is in the same plane as the longitudinal axis of the pipe.

Roll the gauge around the inside of the pipe, taking care to ensure that its axis remains in the same plane as the pipe's longitudinal axis at all times.

Ascertain that the gauge rolls over any part of the internal surface without the central portion of the gauge contacting the pipe.

B.2 Surface voids

Apply the ball of the gauge (see Figure 5) to the void and observe whether or not diametrically opposite points in the rim touch the surface of the pipe.

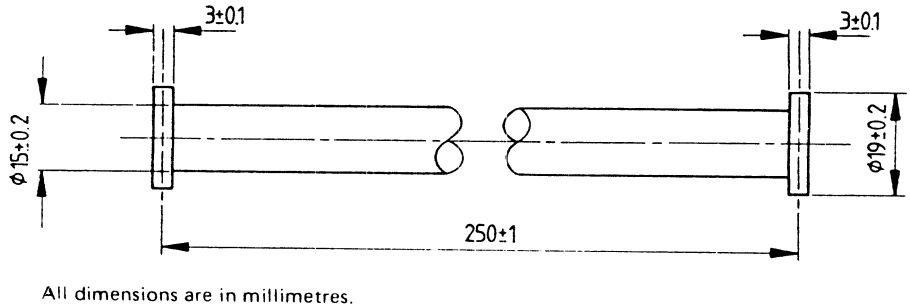
Appendix C Methods of test for squareness of ends

Lay end to end two pipes which are potentially capable of being jointed, obtaining best alignment as indicated by string lines or straight edges placed along the outside springings and crowns.

Mark one of the pipes as follows:

CROWN = A
SPRINGING(1) = B
INVERT = C
SPRINGING(2) = D

Measure and record the gaps between the jointing surfaces, both inside and outside, at the crowns, inverts and springings. Record these gaps as "A", "B", "C" or "D" and inside or outside as appropriate.



All dimensions are in millimetres.

Figure 4 — Gauge for assessing surface evenness

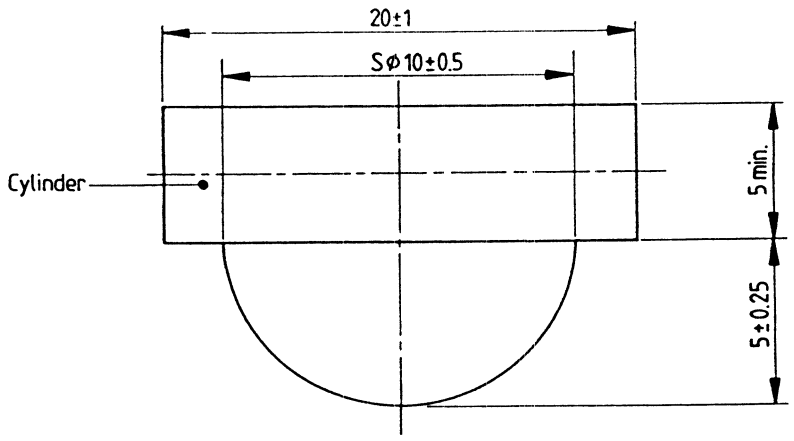


Figure 5 — Gauge for assessing surface voids

Rotate one of the pipes about the longitudinal axis through 180°. Realign the pipes. Make eight further gap measurements at crown, invert and springings, inside and out. Record these gaps as "A_R", "B_R", "C_R" or "D_R" and inside or outside as appropriate.

Calculate the out of squareness for each corresponding pair of measurements using the appropriate formula and compare this figure with the permitted tolerance in Table 3.

ROTATED PIPE:

Crown/Invert $= |((C - A) + (A_R - C_R))/2|$

Springing(1)/ Springing(2) $= |((D - B) + (B_R - D_R))/2|$

STATIONARY PIPE:

Crown/Invert $= |((C - A) - (A_R - C_R))/2|$

Springing(1)/ Springing(2) $= |((D - B) + (B_R - D_R))/2|$

For pipes with collars, measurement of external joint gap is not practicable and the above measurements and calculations shall be made using only the internal gap dimensions.

Appendix D Method of assessment of deviation from straightness

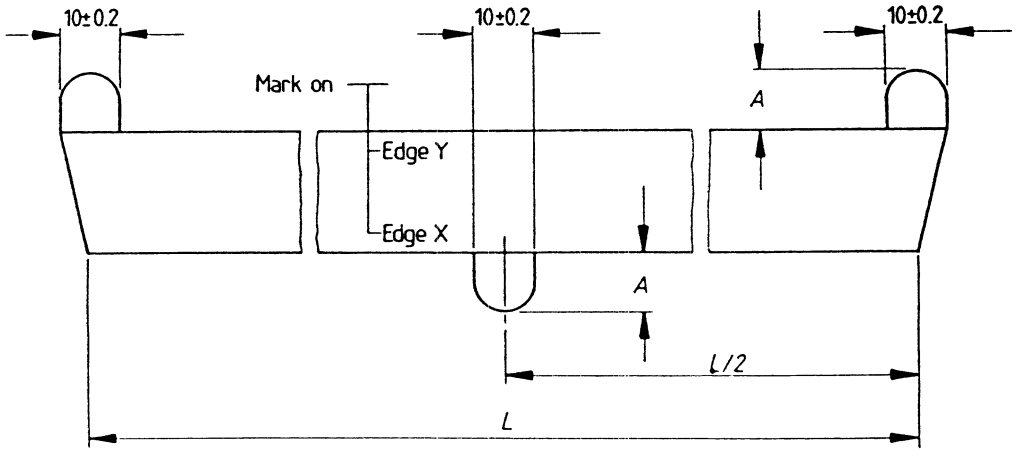
Assess the deviation from straightness of pipes using the following method.

Place a rigid straightedge, made into a gauge of the form and dimensions shown in Figure 6, in the bore of the pipe with edge X in contact with the pipe and on a line parallel to the pipe axis. Hold the plane of the gauge in a radial plane. If both ends of the gauge, wherever so placed, are in contact with the internal surface of the pipe, the deviation from straightness is excessive.

b) If both ends of the gauge, when used as described in a) above, are not in contact with the internal surface of the pipe at both ends, reverse the gauge so that edge Y, placed as in a) above, is adjacent to the internal surface of the pipe.

If the two studs in edge Y cannot be made to touch the surface of the pipe simultaneously, the deviation from straightness is excessive.

c) Repeat the procedure [in a) and b)] on the outside of the barrel.



A = [3.5 × effective length (in m)] mm ± 5 % for the inside of all pipes and for the outside of pipes above DN 1800.
A = [2.5 × effective length (in m)] mm ± 5 % for the outside of pipes up to and including DN 1800.
L = (effective length of the pipe – 10) mm (to the nearest mm).
NOTE The studs should be detachable from the basic straight edge to facilitate checking and replacement.

All dimensions are in millimetres.

Figure 6 — Gauge for measuring deviation from straightness

Appendix E Method of test for water absorption

From each pipe selected for test, take a specimen that is either approximately 100 mm square or a core approximately 75 mm in diameter and of the full thickness of the pipe.

Dry the specimen at a temperature of 100 ± 5 °C for not less than 72 h in a ventilated drying oven that complies with BS 2648. On removal from the oven, allow to cool to room temperature, weigh (M_1) and immediately submerge in potable water at a temperature of 20 ± 2 °C.

After 30 min, remove the specimen and immediately wipe with a dry towel for a total period of 30 s to remove surface water and reweigh (M_2).

After weighing, re-immerse the specimen in water for 23.5 h. Then remove, dry with a towel and weigh as before (M_3).

Calculate the 30 min and 24 h percentage absorptions of dry mass from the formula:

$$\frac{\text{wet mass } (M_2 \text{ or } M_3) - \text{dry mass } (M_1)}{\text{dry mass } (M_1)} \times 100$$

Appendix F Hydrostatic test method

Apply the hydrostatic pressure to the whole pipe, including the portion of the socket or rebated joint that is subjected to pressure in the "as laid" condition.

Take care to remove all air from the pipe before the pressure is applied.

Apply an internal hydrostatic pressure of 0.14 N/mm^2 to the pipe for 1 min. Ensure that the rate of application is such that 0.07 N/mm^2 is applied in not less than 5 s.

After 1 min, reduce the pressure to just above atmospheric pressure and inspect the pipe for signs of leakage.

Appendix G Crushing strength test methods

G.1 Testing machine

G.1.1 A testing machine having a device that will apply the load at a uniform rate of about 30 kN/m per minute, or in increments of not more than 1.5 kN/m at the same rate, shall be used for the test.

G.1.2 Ensure that the testing machine is substantial and rigid throughout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part and that, under the maximum load, the deflection of the pipe is uniform throughout its length. The bearings shall be as specified in **G.1.3** and be attached to the machine so as to receive and uniformly transmit the maximum loads required in the tests without lost motion, vibrations or sudden shock. The machine and bearings shall be designed to transmit the load in a vertical plane through the longitudinal centre lines of the bearings and pipe. Where the testing machine is so constructed that, instead of a single load, a number of equal individual loads, equally spaced, are applied along the bearer, ensure that the resultant of all such individual loads acts at the centre of the overall length of the pipe. The loaded length of the pipe used in this test may extend over the socket, at the discretion of the manufacturer.

G.1.3 The bearings shall consist of a lower member, being a rigid beam, on which two bearing strips are symmetrically disposed parallel to a vertical plane passing through the longitudinal axis of the pipe, and an upper member, also being a rigid beam, on which one bearing strip is centred and disposed so that it lies in the vertical plane passing through the longitudinal axis of the pipe.

It is permissible to interpose a timber packing strip between the beam and the rubber bearing strip as shown in Figure 7.

NOTE The machine may apply the test load either upwards or downwards on the pipe under test. For convenience, the description given here is for top loading.

G.2 Procedure

G.2.1 The pipe to be tested shall be supported in a horizontal position on two bearings parallel to its longitudinal axis. Apply the load to it along the length of the pipe through a third bearing on top of the pipe.

G.2.2 Use a low carbon steel plate to face the upper flange of the bottom beam. Ensure that the facing is straight and free of warping or twisting and is centrally and permanently located on the flange of the beam. The cross section of the facing shall be rectangular, 330 mm × 25 mm minimum, without a joint and with the addition of steel wedge strips attached to it as shown in Figure 7.

G.2.3 The bearing strips shall consist of rubber cut or formed from material having a hardness between 55 IRHD and 65 IRHD measured in accordance with BS 903-A26. The top bearing strip shall be of rectangular cross section having a width of 150 mm and a thickness of not less than 25 mm and not more than 40 mm. The two bottom bearing strips shall be of equal width and thickness: 150 mm wide and 25 mm thick.

Use the single top bearing strip with the 150 mm face in contact with the pipe.

NOTE 1 The strips may be positioned on the bearing by the use of wood or metal strips along its outside edges, provided the thickness of each positioning strip does not exceed one-half the thickness of the rubber bearing strip.

Lay the lower bearing strips on the 150 mm face.

NOTE 2 The strips may be positioned on the bearing with wood or metal strips between them and adjacent to their outside edges, provided the thickness of each positioning strip does not exceed one-half the thickness of the rubber bearing strips.

Ensure that the two strips are parallel and 25 mm apart for all nominal sizes of pipe.

NOTE 3 The rubber bearing strips may be attached to the facings or, in the case of the single upper strip, directly to the upper beam by adhesive provided such method of attachment results in the strip remaining firmly fixed in position when carrying the maximum load.

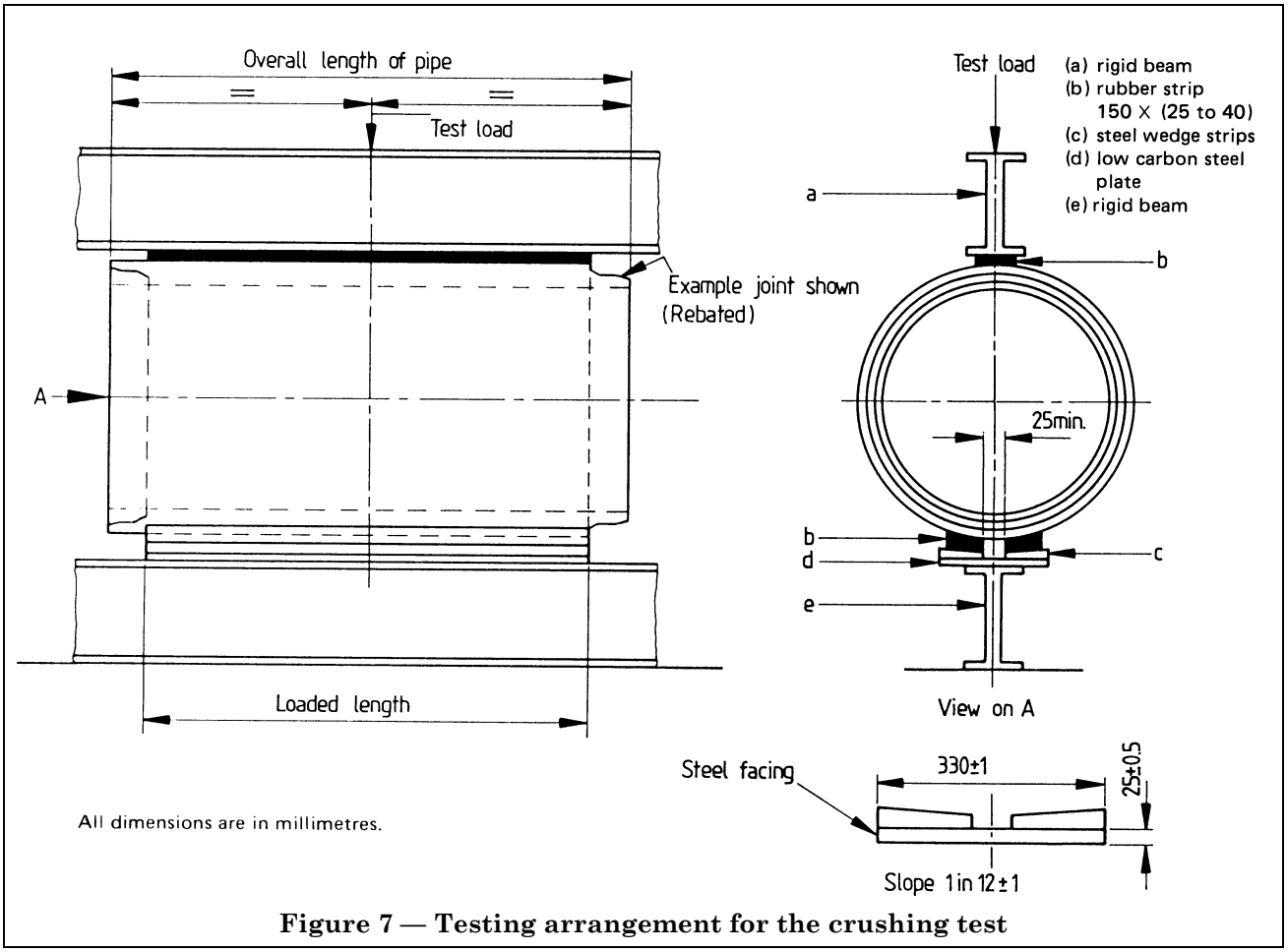
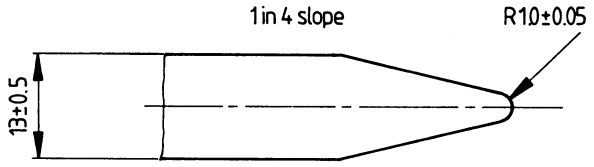


Figure 7 — Testing arrangement for the crushing test



NOTE Nominal thickness for "no-crack" load test is 0.03 mm. Nominal thickness for maximum load test is 0.25 mm.

All dimensions are in millimetres.

Figure 8 — Dimensions of feeler gauge for inspecting cracks

G.3 Loading

G.3.1 Apply the load to the top bearing at a point distant from the spigot end of the pipe equal to one-half of the overall length of the pipe including the socket, if any.

G.3.2 Apply the test load to the top bearing in such a way that the bearing is free to rotate in a vertical plane through the longitudinal centre lines of the top and bottom bearings.

G.3.3 Ensure that the loading of the pipe is a continuous operation and that the pipe is not under load longer than is required to apply the load.

G.3.4 Inspect the pipe and measure any cracks as described in **G.4**.

G.4 Inspection of crack

Inspect any crack by means of a feeler gauge complying with BS 957-2, with the dimensions as detailed in Figure 8.

Appendix H Methods of measuring depth of cover to reinforcement

Either make a channel at least 300 mm long and 25 mm wide to expose the reinforcement on all surfaces of the pipe and measure the depth of cover or determine the depth of cover by taking cores or cut sections.

NOTE For checking units not forming part of the sample it is permissible to use an electronic cover-measuring device in accordance with BS 4408-1 suitably calibrated for the size of reinforcement and curved surfaces where appropriate.

Appendix J Joint face strength test

The following test may be carried out with the pipes in any attitude.

Apply the load as indicated in Figure 9 and Figure 10 at a constant rate of 50 ± 10 kN/min until failure of the concrete occurs. Record the ultimate load.

Should the loading plate prove to have been located above longitudinal reinforcement, the test shall be repeated at a location free from such reinforcement.

For pipe sizes above DN 1200, make four tests on each joint face. For pipe sizes up to DN 1200, if there is a shortage of concrete due to spalling during tests, it is permissible to reduce the number of tests to three on any one surface, but the total tests shall not number less than fourteen.

Appendix K Methods of testing pipe joints for angular deflection, straight draw and shear

NOTE The reduction in internal hydrostatic pressure and the increase in time of application for joints over DN 1800 in these tests is for safety reasons and to avoid excessive end thrusts.

K.1 Angular deflection

K.1.1 The test apparatus shall accommodate two complete pipes, or parts of pipes, flexibly jointed so as to allow movement in relation to each other up to the limits required by the test. The two complete pipes, or parts of pipes, shall be jointed so that the angular deflection is not less than that stated in **18.6.2** throughout the test.

K.1.2 Fill with water, taking care to remove all air from the pipes before the full pressure is applied.

Apply an internal hydrostatic pressure to the jointed pipes of 0.07 N/mm^2 for pipes up to and including DN 1800, or 0.035 N/mm^2 for pipes larger than DN 1800. Ensure that the rate of application is such that the maximum pressure is applied in not less than 5 s.

After 5 min for pipes up to and including DN 1800, or 10 min for pipes greater than DN 1800, reduce the pressure to just above atmospheric pressure and inspect the joint for signs of leakage.

NOTE The use of a test pressure maintained for 5 min or 10 min is in order to provide an indication of the watertightness of the joint in service.

K.2 Straight draw

K.2.1 The test apparatus shall be as described in **K.1.1** and shall be adjusted to maintain the specified amount of straight draw specified in **18.6.3** throughout the test.

K.2.2 Measure the joint gap between the pipes as laid before the test.

The two complete pipes, or parts of pipes shall be axially aligned and jointed with a gap between the pipes equal to the joint gap plus the minimum straight draw specified in **18.6.3**.

Test the pipes or part pipes as described in **K.1.2**.

K.3 Shear

K.3.1 Two pipes, or parts of pipes, shall be axially jointed with a gap between the pipes equal to the joint gap between the pipes as laid before the test, plus a nominal 10 mm on the centre line (see Figure 11). Their ends shall be restrained to prevent further longitudinal movement during the test.

The pipe having the socket of the joint being tested shall be supported on blocks at each end of its barrel and be restrained from movement. The second pipe shall have a minimum effective length of 1 200 mm supported by a block at either its point of balance, or at least 600 mm from the joint being tested, whichever is the greater distance (see Figure 11). The length of the restraint or support, measured parallel to the pipe axis, shall be 150 mm or 1/10 of the nominal size of the pipe, whichever is the greater.

K.3.2 When the joint has been assembled, fill with water, taking care to remove all air from the pipes.

Keep the temperature of the water within 5 °C to 24 °C.

Apply hydrostatic test pressure, as described in **K.1.2** and the appropriate test load specified in **18.6.4** as shown in Figure 11.

NOTE The test load may be applied upward or downward.

Maintain the test conditions for not less than 5 min.

Reduce the pressure to just above atmospheric pressure and inspect the joint for signs of leakage.

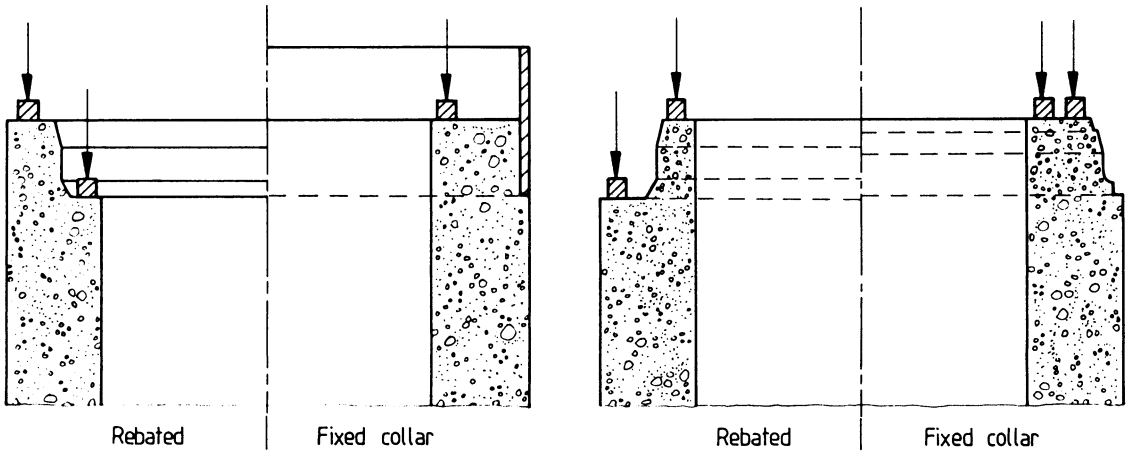


Figure 9 — Loading arrangements for joint face strength test

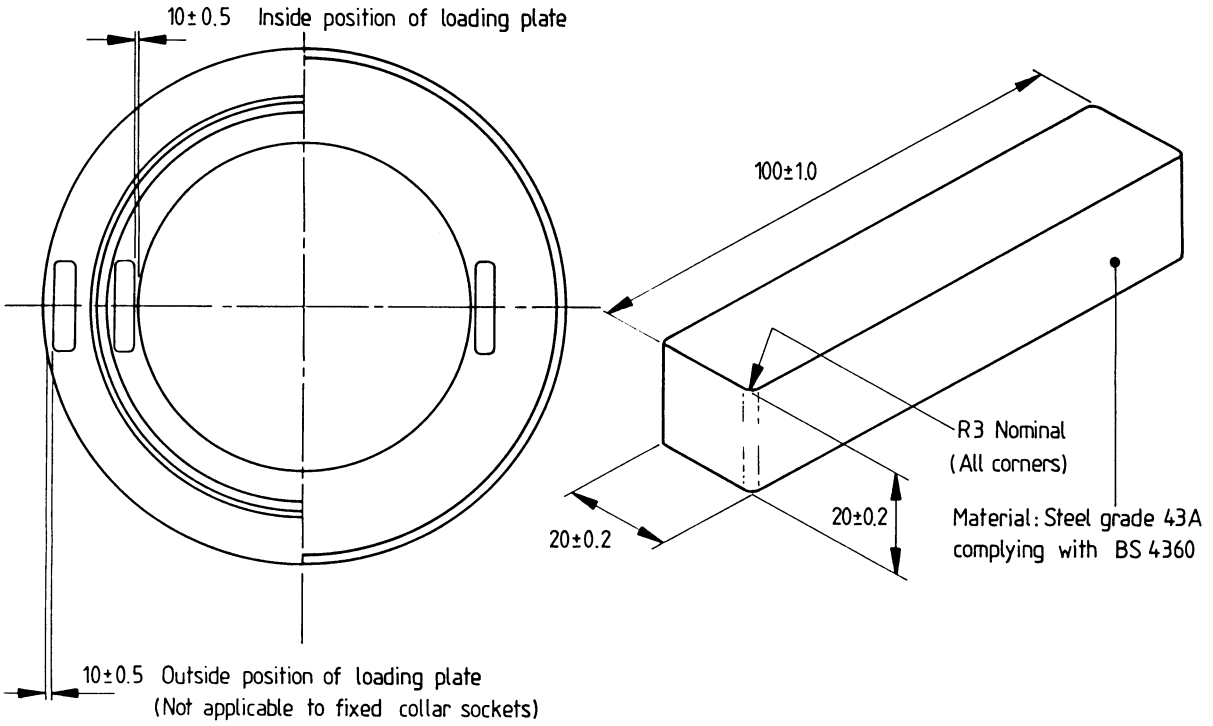


Figure 10 — Loading plate and location for joint face strength test

K.4 Combined tests

K.4.1 The test apparatus shall be as described in **K.1.1**, and shall be adjusted to maintain the specified amounts of angular deflection and/or straight draw.

Where the combined test includes a shear test the pipe support apparatus shall also be as described in **K.3.1**.

K.4.2 First, carry out the test procedure as described in **K.1.2**. After the successful completion of the procedure, carry out the procedure described in **K.3.2**.

Appendix L Facilities for purchasers

The purchaser or his representative, by arrangement with the manufacturer, should at all reasonable times have free access to the places where the pipes are manufactured and tested, for the purpose of examining quality control procedures and records and of witnessing the testing and marking of pipes.

Representative samples of the aggregates should be supplied to the purchaser on request.

When required by the purchaser, evidence of satisfactory performance of the concrete manufactured with such aggregates should be made available at the time of placing the order.

Where the manufacturer is not covered by a scheme of third party certification, the purchaser should be permitted to select samples for test, using the appropriate inspection criteria specified in this Part of BS 5911.

NOTE The allocation of the cost of carrying out any additional tests over and above the tests specified in this Part of BS 5911 is generally agreed between the manufacturer and the purchaser prior to testing.

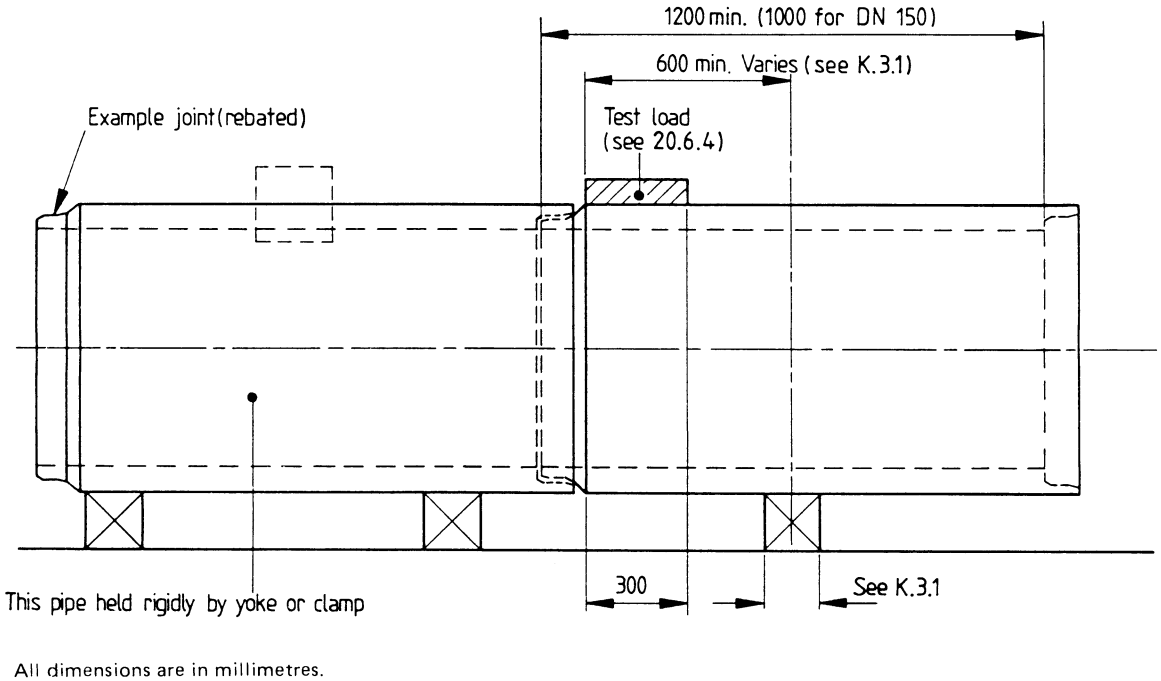


Figure 11 — Loading arrangement for shear test on joints

Publications referred to

BS 12, *Specification for ordinary and rapid-hardening Portland cement.*

BS 146, *Specification for Portland-blastfurnce cement.*

BS 146-2, *Metric units.*

BS 882, *Specification for aggregates from natural sources for concrete.*

BS 903, *Methods of testing vulcanized rubber.*

BS 903-A26, *Determination of hardness.*

BS 957, *Specification for feeler gauges.*

BS 957-2, *Metric units.*

BS 970, *Specification for wrought steels for mechanical and allied engineering purposes.*

BS 970-1, *General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels.*

BS 1449, *Steel plate, sheet and strip.*

BS 1449-2, *Specification for stainless and heat-resisting steel plate, sheet and strip.*

BS 1610, *Materials testing machines and force verification equipment.*

BS 1881, *Testing concrete.*

BS 1881-120, *Method for determination of the compressive strength of concrete cores.*

BS 2494, *Specification for elastomeric joint rings for pipework and pipelines.*

BS 2648, *Performance requirements for electrically heated laboratory drying ovens.*

BS 2971, *Specification for Class II arc welding of carbon steel pipework for carrying fluids.*

BS 3019, *TIG welding.*

BS 3019-2, *Austenitic stainless and heat-resisting steels.*

BS 3148, *Methods of test for water for making concrete (including notes on the suitability of the water).*

BS 3892, *Pulverized-fuel ash.*

BS 3892-1, *Specification for pulverized-fuel ash for use a cementitious component in structural concrete.*

BS 4027, *Specification for sulphate-resisting Portland cement.*

BS 4360, *Specification for weldable structural steels.*

BS 4408, *Recommendations for non-destructive methods of test for concrete.*

BS 4408-1, *Electromagnetic cover measuring devices.*

BS 4449, *Specification for carbon steel bars for the reinforcement of concrete.*

BS 4482, *Specification for cold reduced steel wire for the reinforcement of concrete.*

BS 4483, *Specification for steel fabric for the reinforcement of concrete.*

BS 4994, *Specification for design and construction of vessels and tanks in reinforced plastics.*

BS 5075, *Concrete admixtures.*

BS 5135, *Specification for the process of arc welding of carbon and carbon manganese steels.*

BS 5480, *Specification for glass fibre reinforced plastics (GRP) pipes and fittings for use for water supply or sewerage.*

BS 5480-1, *Dimensions, materials and classification.*

BS 5911, *Precast concrete pipes, fittings and ancillary products.*

BS 5911-100, *Specification for unreinforced and reinforced pipes and fittings with flexible joints.*

BS 6000, *Guide to the use of BS 6001, sampling procedures and tables for inspection by attributes.*

BS 6001, *Sampling procedures for inspection by attributes.*

BS 6001-1, *Specification for sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection.*

BS 6588, *Specification for Portland pulverized-fuel ash cement.*

BS 6699, *Specification for ground granulated blastfurnace slag for use with Portland cement.*

BS 8110, *Structural use of concrete.*

BS 8110-1, *Code of practice for design and construction.*

BS 8110-2, *Code of practice for special circumstances.*

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