

Specification for

Glass reinforced plastics (GRP) pipes, joints and fittings for use for water supply or sewerage

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- British Plumbing Fittings Manufacturers' Association
- British Valve and Actuator Manufacturer's Association
- Department of the Environment (Building Research Establishment)
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- Department of the Environment (Property Services Agency)
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The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- Association of Consulting Engineers
- Federation of Civil Engineering Contractors
- Institution of Mechanical Engineers
- Pipeline Industries Guild

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Foreword

This British Standard has been prepared under the direction of the Plastics Standards Policy Committee.

It is a revision of BS 5480-1:1977 and BS 5480-2:1982 which are now withdrawn. BS 5480 specifies requirements for pipes, fittings and joints made of glass reinforced plastics (GRP) based on thermosetting resins in sizes corresponding to internal diameters ranging from 100 mm to 4 000 mm for use for water supply or sewerage, including some industrial drainage, under gravity flow or internal pressures up to 25 bar¹⁾. Requirements are specified for materials, design limits, dimensions, classification, physical properties, performance properties and marking. Where cross-references to other standards are not appropriate, associated methods of test are described in appendices. Guidance on sampling and quality control testing is provided as Appendix Q and a bibliography as Appendix R. For the construction of GRP piping systems for sewerage and/or drainage, attention is drawn to BS 8005 and BS 8301, and for the construction of pipelines using GRP pipework, attention is drawn to BS 8010 and in particular BS 8010-2.5.

For the design and performance of GRP pipes and fittings for process plants, attention is drawn to BS 6464; for the design and construction of GRP piping systems for individual plants or sites, attention is drawn to BS 7159.

In the preparation of this British Standard, account has been given to the work of Technical Committee 138 of the International Organization for Standardization (ISO), but this has not yet given rise to a corresponding specification. Nevertheless the opportunity has been taken to align this standard with the current ISO terminology and philosophy in respect of the determination of stiffness and in requirements for joints, with particular consideration being given to ISO/DIS 8639.

The major changes between this revision and the previous editions of BS 5480-1 and BS 5480-2 are as follows.

- a) The requirements and specific test methods have been consolidated into a single publication.
- b) The requirements are verifiable where appropriate, so that third party certification may be applicable. For guidance on installation, reference is made to applicable codes of practice. Information and guidance on sampling and quality control testing has been provided in an advisory appendix.
- c) The requirements for materials for use with potable water have been updated, to make reference to BS 6920-1.
- d) For the pipe design limits:
 - 1) the limit for long term circumferential strength is based on the lower 95 % confidence limit of the extrapolated mean value obtained by statistical linear functional relationship analysis, instead of the extrapolated mean value previously used;
 - 2) a factoring method is used to estimate the long term longitudinal strength from the short term longitudinal strength;
 - 3) the short term longitudinal strength requirement is based on a draft ISO document, but with a minimum value of 100 kN/m of circumference.
- e) Attention is drawn to the fact that special consideration is necessary for design limits for pipe intended to carry septic sewage or aggressive industrial waste if under pressure.
- f) The nominal size range has been changed from (25 to 4 000) to (100 to 4 000), to better reflect current practice.
- g) The deviation of the work size from the nominal size has been changed from $+1\%$ to $\pm 3.5\%$. (The manufacturing tolerances thereon are unchanged.)
-3.5

¹⁾ 1 bar = 10^5 N/m² = 10^5 Pa.

- h) The pressure class range has been changed from (0 bar to 65 bar) to (0 bar to 25 bar), for consistency with the purpose of the specified components.
- i) The stiffness class range has been changed from (250 N/m² to 8 000 N/m²) to (1 250 N/m² to 20 000 N/m²), for enhanced resistance to distortion.
- j) The significance of any visual discontinuities, such as voids or contamination, is related to the requirements of this specification, instead of intangible or insignificant “impairment of performance in service”.
- k) For the determination of longitudinal tensile strength, the applied load is a function of the size and pressure class of the pipe.
- l) The method for the determination of impact resistance allows the performance of the test piece to be assessed, and therefore any variations between samples can be assessed, instead of a simple pass/fail test. (For lack of suitable data, the basic requirement has not been made more stringent.)
- m) The test pressure for the leaktightness of pressure pipes has been changed to (1.5 × pressure rating).
- n) Requirements have been introduced for the leaktightness of prefabricated joints.
- o) A method is provided for the assessment of long term stiffness consistent with the methods for determining compliance with the requirements for initial stiffness, which now includes the corresponding ISO method of test. It replaces the tests for semi-permanent set and ageing.
- p) Requirements and associated methods of test (based on ISO/DIS 8639) are introduced for joints.
- q) Basic statistical equations are provided (as Appendix P) for analysis of long term data, together with a data set and worked example for validation of use of alternative statistical computing packages.
- r) Sampling and quality control procedures are provided in the form of revised guidance (as Appendix Q), as a basis for preparing quality plans and are designed to involve less destructive testing and to allow more comparison with the design performance of the pipe.

Product certification. Users of this British Standard are advised to consider the desirability of third party certification of product conformity with this British Standard based on testing and continuing surveillance, which may be coupled with assessment of a supplier’s quality systems against the appropriate Part of BS 5750.

Enquiries as to the availability of third party certification schemes will be forwarded by BSI to the Association of Certification Bodies. If a third party certification scheme does not already exist, users should consider approaching an appropriate body from the list of Association members.

Attention is drawn to the provisions of the Health and Safety at Work etc. Act 1974 and the need to ensure that appropriate precautions are taken to ensure the safety of personnel when carrying out methods of test required by this standard.

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 46, 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 Scope

This British Standard specifies requirements for materials, dimensions, classification, design, testing and marking for pressure and non-pressure pipes, fittings and joints made from glass reinforced thermosetting plastics (GRP) with or without an aggregate filler. It is applicable to pipes and associated fittings having nominal diameters from 100 to 4 000 for use at pressures up to 25 bar²⁾ and intended for the conveyance of potable and non-potable water, foul sewage and storm water. The pipework may also be used for conveying industrial wastes providing its suitability has been established.

Methods of test are given in Appendix A to Appendix N. Methods for statistical analysis of long term data from GRP pipes and fittings are given in Appendix P.

Guidance and information on quality control testing and associated sampling is given in Appendix Q. A bibliography is given in Appendix R.

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 British Standard, the definitions given in BS 1755-1 and BS 6464 apply, together with the following.

2.1

aggressive industrial waste

a fluid that may have a detrimental effect on glass reinforced plastics (GRP)

2.2

angular deflection

the angle of deflection of part of a joint related to the diametrical centreline of the fixed component of a joint

NOTE See Figure 7.

2.3

acceptable quality level (AQL)

the maximum percentage defective (or the maximum number of defectives per hundred units) that, for the purposes of sampling inspection, can be considered satisfactory as a process average

2.4

C glass

an alkali calcium glass with an enhanced boron trioxide content and intended for applications requiring enhanced chemical resistance accordingly

NOTE This definition is identical with 2.1 of BS 7158:1989. It is consistent with ISO 2078:1985 and equivalent to DIN 1259-1:1986.

2.5

draw

the maximum longitudinal movement of a joint

NOTE 1 See Figure 8.

NOTE 2 See also “total draw”.

2.6

effective length

for a straight pipe, the distance between two planes normal to the pipe axis and passing through the extreme end points of the pipe, excluding the maximum design depth of insertion of the spigot in the socket where applicable

2.7

flexible joint

a joint capable of allowing relative movement between the component parts

NOTE 1 Flexible joints may have resistance to axial loading built into their design.

NOTE 2 Examples of this type of joint are:

- a) a socket and spigot joint with an elastomeric sealing element (including double socket designs);
- b) a flexible locked socket and spigot joint with an elastomeric sealing element (including double socket designs);
- c) a clamped joint, for example a bolted coupling including joints made from materials other than GRP.

2.8

inspection level

a characteristic of a sampling plan chosen in advance that determines the relationship between the lot size and the sample size

2.9

lay-up

an assembly of resin impregnated material for processing

2.10

lot

a collection of units of a product for which a sample is representative and inspected to determine conformance with the acceptability criteria, and which may differ from a collection of units designated as a lot for other purposes, e.g. production, shipment

2.11

maximum service temperature

the maximum temperature that can occur during normal operation

²⁾ 1 bar = 10⁵ N/m² = 10⁵ Pa.

2.12**nominal size (DN)**

a numerical designation of size which is common to all components in a piping system other than components designated by outside diameters or by thread size. It is a convenient round number for reference purposes and is only loosely related to manufacturing dimensions

NOTE 1 It is designated by DN followed by a number.

NOTE 2 Not all piping components are designated by nominal size, for example steel tubes are designated and ordered by outside diameter and thickness.

NOTE 3 The nominal size DN cannot be subject to measurement and shall not be used for purposes of calculation.

NOTE 4 This definition and notes 1 to 3 are equivalent to the definition given in ISO 6708:1980. For the purposes of this standard, the following information is also relevant.

- a) For pipes complying with BS 5480, DN is closely but not exactly related to the work size (see 2.21) and hence the internal diameter of the pipe (see 5.2.2).
- b) Thermoplastics pipe sizes designated in accordance with ISO 161-1 are sized with reference to their outside diameters: their wall thickness will depend upon their intended application and corresponding product specification.

c) With reference to note 3, it is not appropriate to use values of DN as a basis for design, but they are considered suitable and convenient as a basis for establishing certain test conditions, such as the length of a pipe test piece. (See, for example, Appendix H.)

2.13**non-pressure pipes and fittings**

pipes and fittings subject to an internal pressure not greater than 0.5 bar measured at the top of the pipe cross section

2.14**out-of-squareness**

the maximum distance between an end plane normal to the axis of a pipe and passing through the extreme end point of the pipe and a parallel plane passing through the nearest full wall section of the pipe, excluding the design depth of the socket, where applicable

NOTE See Figure 1.

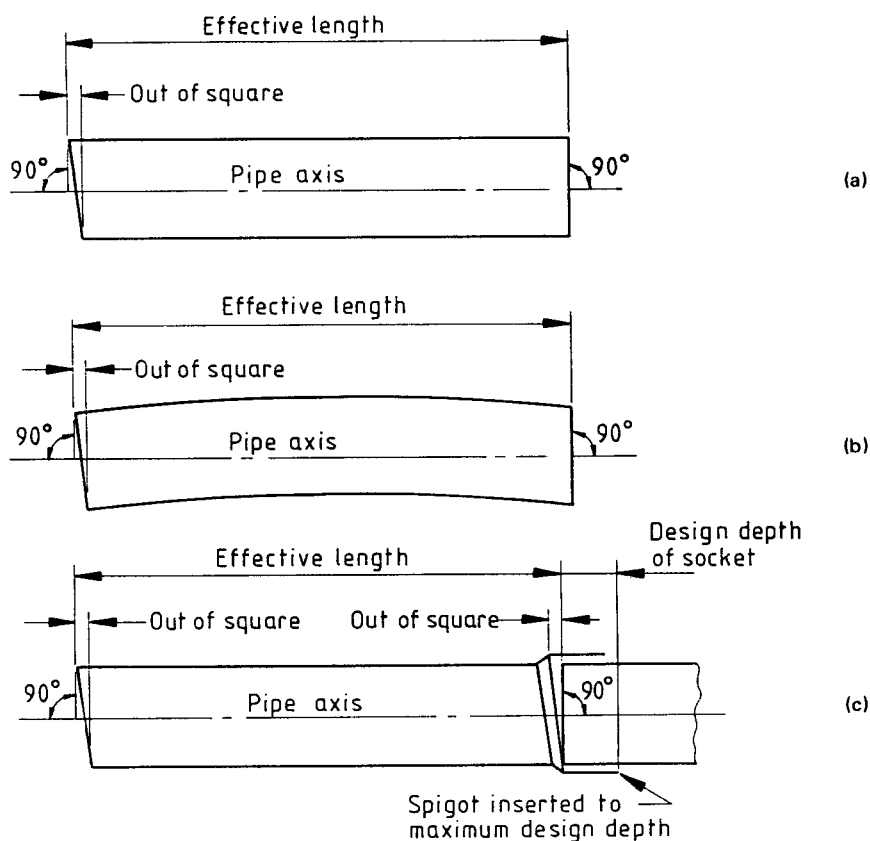


Figure 1 — Dimensional boundaries for effective length and out-of-squareness of nominally straight pipe

2.15**pressure pipes and fittings**

pipes and fittings to be used with internal pressures greater than 0.5 bar

2.16**pressure rating**

the maximum sustained working pressure for which the component is suitable for use for its intended purpose and design life

2.17**rigid joint**

a joint which does not allow angular deflection and has an incorporated resistance to axial loading

NOTE Examples of this type of joint are:

- a) a flanged joint, including integral and loose flanges;
- b) a butt joint;
- c) a rigid locked socket and spigot joint, with an elastomeric sealing element (including a double socket design);
- d) a cemented socket and spigot joint (including a double socket design);
- e) a threaded joint.

2.18**septic sewage**

sewage of an acidic nature, generally associated with the evolution of hydrogen sulphide

2.19**stiffness**

for a pipe, the resistance of a pipe to circumferential deflection in response to external loading applied along one diametric plane: the stiffness of the pipe, S (in N/m^2), is given by the relationship

$$S = E/lD_m^3 \quad (1)$$

where

E is the modulus of elasticity in flexure in the circumferential direction (in N/m^2);

l is the second moment of area of the pipe wall in the longitudinal direction, per unit length (in m^4/m);

D_m is the mean diameter of the pipe (in m),
e.g.

$$D_m = D_i + e$$

where

D_i is the internal diameter of the pipe;

e is the minimum wall thickness of the pipe.

2.20**total draw**

the sum of the draw and the longitudinal movement of joint components due to the presence of angular deflection

NOTE 1 See Figure 9.

NOTE 2 See also "draw".

2.21**work size (DW)**

a design internal diameter related to the nominal size of the pipe and relative to which manufacturing tolerances are applied

3 Materials**3.1 Resins**

The resin shall be a thermosetting resin such that when cured according to a schedule representative of that to be used for the finished pipework and then tested in accordance with BS 2782:Method 121A, the temperature of deflection of the resin shall be not less than 20 °C higher than the maximum service temperature at which the pipework component is to be used, if known, and otherwise not less than 50 °C.

If a polyester resin system is used, it shall comply with BS 3532.

NOTE Other thermosetting resin systems may be used providing that their temperature of deflection complies with 3.1 and that the finished pipe, fitting or joint complies with all the applicable requirements of this British Standard.

3.2 Fibrous reinforcement

Except for alternative surface tissues (see 3.3) all fibrous reinforcement shall be derived from continuously drawn filaments of E. glass³⁾ (see note) and shall be used in the following forms alone or in any combination subject to compatibility with the resin used:

- a) rovings complying with BS 3691;
- b) chopped strand mat complying with BS 3496;
- c) woven fabrics complying with BS 3396-1, BS 3396-2 or BS 3396-3 as applicable;
- d) woven fabric complying with BS 3749.

NOTE Such glass includes either alumino-borosilicate glass or alumino-calco-silicate glass, in either case optionally containing other oxides, mainly aluminium trioxide, incorporated for enhanced corrosion resistance and then sometimes described as E.CR glass.

³⁾ Defined by term 1146 in BS 3447:1962.

3.3 Surface tissues

If surface tissues are incorporated into the superficial layers of the internal and/or external surfaces of a GRP pipe or fitting, they shall be made from glass materials complying with 3.2 or of C glass (see 2.4) or from woven or non-woven textiles based on polyester or acrylic fibres.

3.4 Additional materials

3.4.1 Aggregates. Aggregates (inert granular material of a size range between 0.05 mm and 5 mm), such as graded silica sands, may be incorporated where they are a designed part of the composite structure.

3.4.2 Fillers. Inert fillers (fine material with a particle size below 0.05 mm), may be incorporated either on their own or with aggregate.

3.4.3 Additives. Additives may be incorporated for modifying the properties of the resin, e.g. for viscosity control of fire retardancy.

3.4.4 Colourants. The resin may incorporate pigments or dyes.

3.5 Effect of non-metallic products on water quality

When used under the conditions for which they are designated, non-metallic products in contact with or likely to come into contact with potable water shall comply with the requirements of BS 6920-1:1988. In the case of a GRP pipe, fitting or joint, such products shall be marked in accordance with 11.1 h) of this standard.

NOTE 1 Non-metallic products for installation and use in the United Kingdom which are verified and listed under the UK Water Fittings Byelaws Scheme are deemed to satisfy the requirements of this subclause. Details of the Scheme are obtainable from the Water Research Centre Byelaws Advisory Service, 660 Ajax Avenue, Slough SL1 4BG.

Non-metallic products approved by the Department of the Environment Committee on Chemicals and Materials of Construction for use in Public Water Supply and Swimming Pools are considered free from adverse health effects for the purpose of compliance with this subclause.

NOTE 2 A list of approved chemicals and materials and details of the approvals scheme is available from the Secretary of the Committee at the Department of the Environment, Water Division, Romney House, 43 Marsham Street, London SW1P 3PY.

4 Pipe design limits

4.1 Pipes carrying non-aggressive materials

The pipes shall be designed so that the design wall tensile stress or circumferential glass tensile stress, as applicable, at the rated pressure and throughout the design life of the pipe, does not exceed $0.625S_{\phi 95}$ or $0.625S_{\phi g 95}$, as applicable, where $S_{\phi 95}$ or $S_{\phi g 95}$ is the applicable 95 % lower confidence limit of the long term circumferential tensile strength, depending upon the form of the reinforcement glass.

Pipe designed to withstand end loads induced by internal pressure shall be designed so that the longitudinal tensile stress does not exceed $0.625S_{xL}$, where S_{xL} is the long term longitudinal tensile strength.

The long term longitudinal strength per unit of circumference, Q_{xL} (in N/mm) is obtained by factoring the initial longitudinal tensile strength, determined in accordance with Appendix A or Appendix B as applicable. The factor to be used is obtained by dividing the short term circumferential strength, determined in accordance with Appendix C or Appendix D, by the long term circumferential strength, determined in accordance with Appendix E. Thus

$$Q_{xL} = Q_{xi} \times \left\{ \left(\frac{S_{\phi L}}{S_{\phi i}} \right) \text{ or } \left(\frac{S_{\phi Lg}}{S_{\phi ig}} \right) \right\} \quad (2)$$

where

$S_{\phi i}$ or $S_{\phi ig}$ is the applicable initial circumferential tensile strength (in MPa) (see C.6.3 or D.6);

$S_{\phi L}$ or $S_{\phi Lg}$ is the applicable long term circumferential tensile strength (in MPa) (see E.6.3);

Q_{xi} is the initial longitudinal strength per unit of circumference (in N/mm) (see A.6 or B.5.2).

4.2 Pipes carrying septic sewage or aggressive industrial waste

For non-pressure pipes the total design circumferential strain, at the manufacturer's recommended maximum long term ring deflection, shall not exceed $0.625\epsilon_{95}$, where ϵ_{95} is the lower 95 % confidence limit of the extrapolated circumferential failure strain at the design service life when determined in accordance with Appendix F.

NOTE For pipe operating under internal pressure and hence under conditions of constant load in such environments, the method given in Appendix F is not suitable for determining the design strain. GRP pipes and fittings are often suitable for carrying septic sewage or industrial waste under pressure but in the absence of a suitable test method or criteria, no related requirements are included in this specification in respect of such applications. Constant load conditions are more arduous than those of constant deflection and if the nature of the sewage or waste is such that the corrosive effects are potentially severe the advice of the manufacturer should be obtained regarding the design of pressure pipe for such applications.

5 Dimensions

5.1 General

Dimensions shall comply with 5.2 to 5.4 inclusive. In case of dispute, compliance with dimensional limits specified in this standard shall be determined at 23 ± 2 °C, using any applicable method of sufficient accuracy to establish compliance.

NOTE Attention is drawn to BS 2782:Method 1101A.

5.2 Diameter of pipes

5.2.1 Nominal size. Pipes shall be designated by a nominal size (DN) selected from the values given in Table 1.

Table 1 — Nominal sizes of pipes

Nominal size (DN)	Increments
≥ 100 to 500	50
> 500 to 2 600	100
> 2 600 to 4 000	200

5.2.2 Work size. The work size (DW) shall be declared in millimetres by the manufacturer and shall not differ from the value of the nominal size of the pipe by more than ± 3.5 %.

5.2.3 Manufacturing tolerance. The manufacturing tolerance on the work size shall comply with one of the following sets of permissible deviations, as applicable:

- a) for pipes up to and including 150 nominal size: ± 1.5 mm;
- b) for pipes of nominal size over 150 and up to and including 600: ± 3.0 mm;
- c) for pipes over 600 nominal size: ± 0.5 %.

In case of dispute, when measured in accordance with Appendix G, all deviations from circularity, with the exception of pipe deformation due to its own mass, shall be contained within the limits given in a), b) or c) as applicable.

NOTE If the total deviations from circularity fall within the specified limits, it is not necessary to determine or compensate for the deflection of the pipe in response to its own mass.

5.3 Effective lengths of pipe

5.3.1 Effective length. The pipe shall comprise a straight length (see 5.5) for which an effective length (see 2.6 and Figure 1) of 3 m or 6 m in accordance with 5.3.2 shall be preferred, subject to the following conditions.

- a) Other effective lengths are permissible and may be supplied by agreement between the manufacturer and the purchaser.
- b) Apart from item c), of the total length supplied in any one nominal size and class on any one order, the manufacturer shall supply no more than 5 % in random lengths where the random length shall be not less than 1.5 m. The manufacturer shall supply additional pipes, and where appropriate, jointing components to make up any difference in the total length stated in the order.
- c) Where it is necessary to cut pipes for quality control purposes to an extent that would conflict with item b), the variation in effective lengths to be supplied shall be agreed between the manufacturer and the purchaser.

5.3.2 Tolerance on effective length. The permissible deviations on the effective length shall be ± 25 mm.

NOTE For some applications closer tolerances may be desired, in which case these should be agreed between the manufacturer and the purchaser.

5.4 Out-of-squareness of pipe

5.4.1 Unflanged pipe. The out-of-squareness of unflanged pipes shall not exceed (2 mm + 0.005 DW) or 10 mm, whichever is the smaller, where DW is the work size of the pipe in millimetres.

5.4.2 Flanged pipe. For pipes of up to and including nominal size 400, the flange face shall be perpendicular to the axis within 0.5° and shall be flat to ± 0.5 mm, and for pipes of larger nominal size it shall be perpendicular within 0.25° and flat to ± 0.5 mm.

5.5 Straightness

The deviation from straightness of the bore of the pipe shall not exceed 0.3 % of the effective length of the pipe or 15 mm, whichever is the smaller.

6 Classification

6.1 General

The classifications given in 6.2 and 6.3 relate to sustained service temperatures up to 30 °C.

NOTE GRP pipes are generally suitable for intermittent use up to 45 °C, but if it is intended to use the pipe persistently at temperatures above 30 °C the manufacturer should be consulted.

6.2 Pressure

Pipes shall be classified for use under gravity, indicated by G, or by a pressure rating selected from the range 1 to 25 inclusive in increments of 0.5, where classification G shall imply that the component is capable of withstanding internal hydrostatic pressures up to 0.5 bar. Otherwise the pressure rating selected shall be equal to or less than the maximum internal hydrostatic pressure, in bar, which the pipe is capable of withstanding for a design life of 50 years (see clause 4 concerning design limits).

NOTE 1 For the purposes of this standard, all references to pressure relate to gauge pressure unless otherwise stated.

NOTE 2 Unless specifically designed to the contrary, GRP pipes are not normally designed to withstand end loads developed by internal pressure, therefore external anchorages are necessary at changes in direction.

6.3 Stiffness

Pipes shall be classified according to their minimum initial specific stiffness when determined in accordance with Appendix H and with reference as applicable to the following preferred numbers (SN values) for nominal minimum initial stiffness in newtons per metre squared:

1 250; 2 500; 5 000; 10 000; 15 000; 20 000.

In case of dispute, compliance shall be determined using method A of Appendix H.

NOTE 1 The actual minimum stiffness established by design and measurement may comprise any value and may be supplied and declared as additional information (see 11.2).

NOTE 2 To eliminate ambiguity, for marking purposes, stiffness numbers are not subdivided into groups of 3 digits or less.

7 Physical properties

7.1 Appearance

When inspected with the unaided eye, the internal surface of the pipe or fitting shall be smooth and both the internal and external surfaces shall be clean and free from any imperfection that would impair its compliance with this standard.

7.2 Dimensions

7.2.1 Inside diameter. The inside diameter of the pipe shall comply with the manufacturing limits on the work size declared and derived in accordance with 5.2.2 and 5.2.3.

7.2.2 Wall thickness. When measured to an accuracy of 0.1 mm the wall thickness shall be not less than the figure declared and used by the manufacturer in the calculations for the design of the pipe.

7.3 Beam strength

NOTE 1 The ability of a pipe to support beam loads may be measured by its longitudinal strength. The following requirement is intended to ensure adequate strength for normal handling and laying purposes. It is not intended for use for design purposes.

Pipes of all classifications shall have an initial longitudinal tensile strength per unit of circumference of not less than the applicable value given in Table 2, when measured in accordance with either Appendix A or Appendix B. In case of dispute, Appendix A shall be used.

NOTE 2 Appendix B is not applicable to pipes of nominal size greater than 600.

NOTE 3 The limits given in Table 2 are applicable to the average value obtained in accordance with Appendix A.

7.4 Impact resistance

When tested in accordance with Appendix J, H50 shall be at least 0.3 m.

8 Performance properties of pipes

8.1 Leaktightness

8.1.1 Non-pressure pipes. When tested in accordance with Appendix K to a pressure of 1.5 bar, a non-pressure pipe, i.e. pressure rating G, shall not allow any water to pass through the pipe wall and appear on the outside surface.

8.1.2 Pressure pipes. When tested in accordance with Appendix K to a pressure of 1.5 times its pressure rating, a pressure pipe shall not allow any water to pass through the pipe wall and appear on the outside surface.

8.2 Strain corrosion resistance

When tested in accordance with Appendix F, the 95 % lower confidence limit on the mean of the line at 50 years shall not be less than 0.5 %.

8.3 Long term specific ring stiffness and creep factor

If such data is essential for design purposes it shall be obtained using Appendix H, Appendix L and Appendix P.

NOTE This standard does not include requirements for either long term specific ring stiffness or the creep factor [i.e. the ratio of the initial specific stiffness/long term specific stiffness (of the same test piece)], both the measurement of and requirements for which are currently under consideration by Technical Committee 138 of the International Organization for Standardization (ISO). Such data may however be of interest for design purposes, and therefore a method for obtaining such data consistent with the methods included in this standard for measurement of initial specific stiffness (Appendix H) and analysis of long term data (Appendix P) is provided, as Appendix L.

Table 2 — Minimum values for initial longitudinal tensile strength per unit of circumference

Nominal size (DN)	Pressure rating (in bar)					
	≤ 4	> 4 ≤ 6	> 6 ≤ 10	> 10 ≤ 12½	> 12½ ≤ 16	> 16 ≤ 25
	Minimum initial longitudinal tensile strength per unit of circumference					
	kN/m	kN/m	kN/m	kN/m	kN/m	kN/m
100	100	100	100	100	100	100
150	100	100	100	100	100	115
200	100	100	100	100	105	138
250	100	100	100	107	123	164
300	100	100	107	121	141	190
350	100	101	120	136	159	216
400	100	102	132	150	176	242
450	100	111	144	165	194	268
500	100	119	156	179	211	294
600	114	136	180	207	246	345
700	126	152	204	236	281	397
800	150	169	228	265	316	449
900	153	186	252	294	351	506
1 000	166	203	276	322	387	552
1 100	179	220	301	351	422	—
1 200	192	236	325	380	457	—
1 300	205	253	349	409	492	—
1 400	218	270	373	437	527	—
1 500	231	287	397	466	563	—
1 600	244	303	421	495	598	—
1 700	258	320	445	524	633	—
1 800	271	337	469	552	668	—
1 900	284	354	493	581	703	—
2 000	297	370	517	609	738	—
2 100	310	387	542	638	774	—
2 200	323	404	566	667	809	—
2 300	336	421	590	700	844	—
2 400	349	437	614	724	879	—
2 500	362	454	638	—	—	—
2 600	375	471	662	—	—	—
2 800	401	504	710	—	—	—
3 000	428	538	759	—	—	—
3 200	454	571	807	—	—	—
3 400	480	605	855	—	—	—
3 600	506	638	903	—	—	—
3 800	532	672	952	—	—	—
4 000	558	706	1 000	—	—	—

9 Fittings

9.1 Fittings made from GRP

NOTE GRP fittings are not subject to tests for strength and it is essential that external restraint be considered for installation.

9.1.1 General. All GRP fittings, such as bends, tees, junctions and reducers, shall be equal or superior in performance to pipe of the same classification and shall be smoothly finished internally.

9.1.2 Fittings made from straight pipe. The fitting shall be fabricated from complete pipes or portions of straight pipe complying with this standard as applicable for the pipe classification. The fitting shall comply with the declared design requirements and be suitably mitred. The mitre shall be overwrapped externally and, if practicable, internally with woven roving and/or chopped strand mat to ensure the longitudinal and circumferential tensile strength is at least equal by design to that of the pipe with which the fitting is to be used.

9.1.3 Fittings made by moulding. Moulded GRP fittings shall be made by hand lay-up, contact moulding, hot or cold press moulding or tape winding.

9.1.4 Tolerances for GRP fittings

9.1.4.1 Except for flanged pipework, which may require closer tolerances, the permissible deviations from the stated value of the angle of change of direction of a fitting such as a bend, tee or junction shall not exceed $\pm 1^\circ$.

9.1.4.2 Except for flanged pipework, which may require closer tolerances, the permissible deviations on the manufacturer's declared length of a fitting, exclusive of the socket where applicable, shall be ± 25 mm taken from the point of intersection to the end of the fitting.

10 Joints

10.1 General

Joints may be flexible (see 10.2) or rigid (see 10.3), and in either case may incorporate one or more joint rings (see 10.4) or other seals.

If they are intended for pipework for use in contact with potable water, any non-metallic joint components likely to come into contact with the water shall comply with 3.5.

10.2 Flexible joints

10.2.1 Design performance. Flexible joints such as rolling or restrained joint ring joints or clamped joints shall be by design equal or superior in performance to pipe of the classification of the main pipe barrel in the circumferential direction only, up to the limits of angular deflection and straight draw indicated by the manufacturer of the joint.

10.2.2 Leaktightness. When a joint, assembled in accordance with the manufacturer's instructions and subject as applicable to the conditions in items a) to d), is tested in accordance with Appendix M, including full sequential testing in accordance with **M.4.2** and/or **M.4.3**, as applicable, the joint shall comply with items e) and f).

- a) The maximum draw for which the manufacturer declares the joint to be suitable and which shall be not less than a draw, including Poisson contraction and temperature effects, of 0.3 % of the effective length of the longest pipe with which the joint is intended to be used.
- b) The maximum angular deflection for which the manufacturer declares the joint to be suitable and which shall be not less than the applicable value given in Table 3.
- c) A misalignment force, F_r , dependent upon the nominal size of the pipe as follows:
 - 1) for pipes up to and including DN 1800, a force of $(20 \times \text{DN})$ N;
 - 2) for pipes of DN greater than 1800, a force of 36 kN.
- d) The applicable test pressure(s) and pressure cycle(s) given in Table 8.
- e) The joint shall not leak when inspected visually or, for loss of vacuum, as indicated by a change of pressure greater than 0.08 bar (0.008 MPa).
- f) The joint shall not exhibit damage in the form of crushing, cracking or delamination of the joint components or dislocation of any intermediate seal component such as a joint ring when assessed for the following properties:
 - 1) initial leaktightness while subject to angular deflection and draw;
 - 2) leaktightness while subject to angular deflection and draw;
 - 3) leaktightness while subject to misalignment and draw;
 - 4) vacuum leaktightness while subject to misalignment and draw.

10.3 Rigid joints

10.3.1 Design performance. Rigid joints, such as flanged joints, butt and overwrap joints, socket and spigot joints with bonding compounds and screwed joints, shall be by design equal or superior in performance to pipe of the same classification in both the circumferential and longitudinal directions.

Table 3 — Angular deflection limits relative to the nominal size of the pipework

NOTE 1 The limits given in column 2 should be regarded as minimum values for the purpose of testing for joint design or performance and maximum recommended values for installation design.
NOTE 2 Attention is drawn to the warning given at the beginning of Appendix M.

Nominal size (DN)	Angular deflection
	degrees
< 500	3
≥ 500 to < 900	2
≥ 900 to < 1 800	1
≥ 1 800	0.5

10.3.2 Leaktightness. When a joint assembled in accordance with the manufacturer's instructions is tested in accordance with Appendix N, including sequential testing in accordance with **M.4.2** and/or **M.4.3** as applicable, and using the applicable test pressure(s) and pressure cycle(s) given in Table 8, the joint shall comply with the following.

- a) It shall not leak when inspected visually or, for loss of vacuum, as indicated by a change of pressure greater than 0.08 bar (0.008 MPa).
- b) It shall not exhibit damage in the form of crushing, cracking or delamination of the joint components or dislocation of any intermediate seal component such as a joint ring, when assessed for the following properties:
 - 1) initial leaktightness while subject to static pressure of 0.5 bar;
 - 2) leaktightness while subject to positive static pressure;
 - 3) vacuum leaktightness while subject to negative pressure.

10.4 Elastomeric joint rings

In the case of joints incorporating elastomeric joint rings, the joint rings shall comply with BS 2494 as appropriate for the application(s) for which the jointed pipework is designed.

11 Marking and information

- 11.1** All pipes and fittings supplied shall be indelibly marked with the following information.
- a) The number and date of this British Standard, e.g. BS 5480:1990⁴⁾.
 - b) The manufacturer's name, initials or identification mark.
 - c) The nominal size.

⁴⁾ Marking BS 5480:1990 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.

- d) The pressure rating. To avoid possible confusion, pipes rated at a non-integer value shall be marked with a fraction, e.g. 12½ bar and not 12.5 bar.
- e) The nominal minimum initial stiffness (in N/m²).
- f) The date of manufacture.
- g) The effective length, if other than 3 m or 6 m.
- h) The letter “P” set in a square, where the pipe or fitting is suitable for use with potable water, otherwise an empty square.
- i) The letters “LS” set in a square, where pipes and fittings are designed to withstand longitudinal end loads developed by internal pressure.
- j) The angle of bend (in degrees) of fittings.

This information shall be stated in the following order.

BS 5480:1990 – ABC – 300 – 16 – 5 000 –

Jan '90 – 900 – P – LS – 90°

11.2 The information given in **11.1** may be arranged in several lines provided that the sequence is preserved. Any additional marks required by the purchaser shall be the subject of agreement between the manufacturer and the purchaser. The manufacturer may add other marks provided that they do not conflict with those stated in **11.1**.

11.3 The following information shall be provided upon request, as applicable.

- a) For non-pressure pipes, the manufacturer's recommended maximum long term ring deflection (see **4.2**).
- b) For pipes, the work size (DW) (see **5.2.2**).
- c) For pipes, any variation in effective length agreed in accordance with **5.3.1 c**).
- d) For pipes or fittings ordered for use at temperatures above 30 °C, the applicable classification(s) (see clause **6**, including the note to **6.1**).
- e) For pipe, the design wall thickness (see **7.2.2**).
- f) For a flexible joint, the maximum draw and maximum angular deflection for which the joint is suitable [see **10.2.2 a**) and b)].

Appendix A Method for determination of initial longitudinal unit tensile strength by a tensile strip test

A.1 Principle

The initial longitudinal unit tensile strength is determined as the average of the maximum forces sustained per unit width by longitudinally aligned strips removed from the pipe wall when extended to breaking in tension in a restricted period of time.

A.2 Apparatus

A.2.1 A tensile testing machine capable of indicating the force applied to the test piece with an accuracy of within $\pm 1\%$ of the indicated value.

A.3 Test pieces

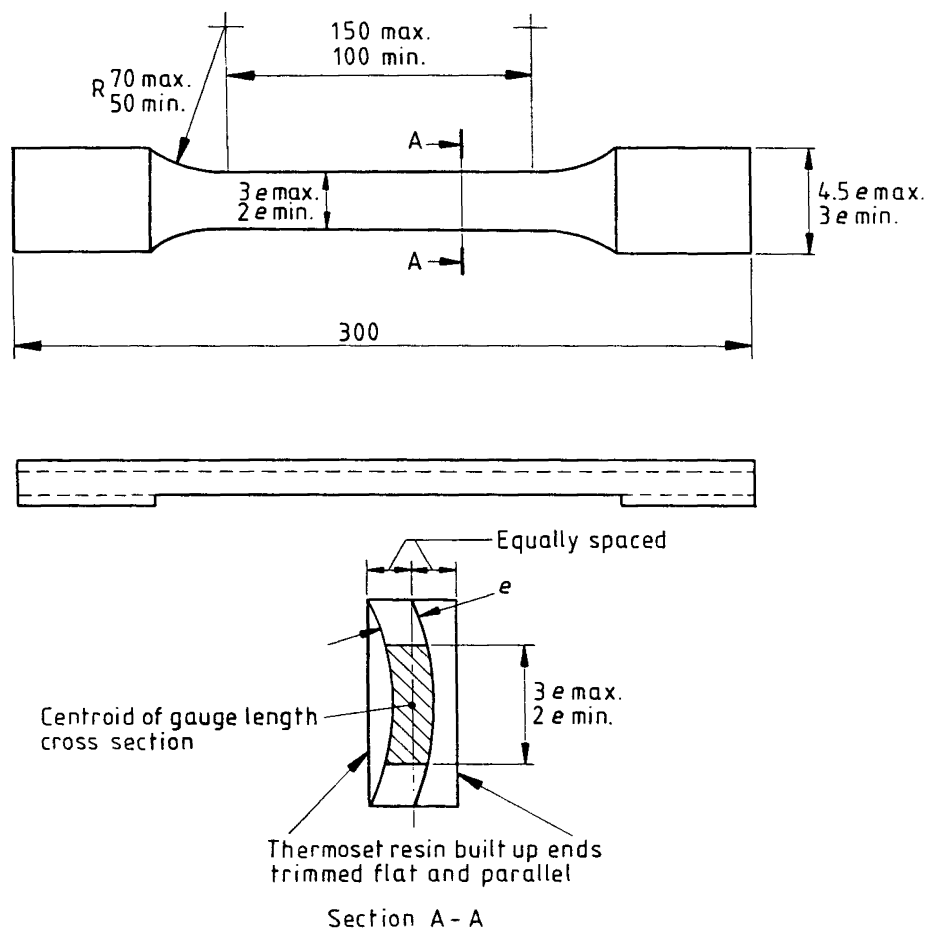
Each test piece shall comprise a strip cut from a pipe and profiled to the dimensions shown in Figure 2. A minimum of three test pieces is required (see A.5.5).

It is permissible to cut the test pieces from the ring used for the determination of initial specific stiffness in accordance with Appendix H.

If profile cutting is impractical, parallel-sided test pieces of width between $2e$ and $3e$ (see Figure 2) shall be used, where e is the thickness of the test piece.

A.4 Test conditions

Conduct the test at $15 \pm 10^\circ\text{C}$ except in cases of dispute, in which case conduct the test at $23 \pm 20^\circ\text{C}$.



All dimensions are in millimetres.

Figure 2 — Strip test piece for determination of initial longitudinal unit tensile strength

A.5 Procedure

A.5.1 Measure the width and thickness of the test piece at the centre of the gauge length and at points within 5 mm of each end of the gauge length. Record the average width as w , and the average thickness as e .

A.5.2 Either use curved jaws or build up the thickness of the test piece ends over the grip length with a compatible thermosetting resin. When cured, trim the built up ends flat and parallel and ensure that the centroid of area of the curved pipe wall section will lie on the loading centreline of the testing machine when gripped.

A.5.3 Grip the test piece in the testing machine with the test piece centreline positioned along the loading axis of the machine.

A.5.4 Extend the test piece by separating the grips at a rate selected to ensure that failure occurs between 1 min and 3 min. Record the maximum force as the failure force F .

A.5.5 Repeat **A.5.1** to **A.5.4** until three results have been obtained. Discard any test piece that breaks outside the gauge length and test additional test pieces until three results are obtained.

A.6 Calculation

For each test piece, calculate the initial longitudinal tensile strength of the pipe per unit of circumference, Q_{xi} (in N/mm), using the following equation:

$$Q_{xi} = \frac{F}{W} \quad (3)$$

where

F is the failure force (in N);

w is the average width of the gauge length portion of the test piece (in mm).

NOTE The difference between w and the arc length is considered to be negligible.

A.7 Test report

The test report shall include the following.

- The size and classification of the pipe and the manufacturer's code.
- A reference to this method of test, i.e. Appendix A of BS 5480:1990.
- The date of testing.
- The shape of the test piece used, i.e. profile or parallel sides.
- The width, w , and thickness, e , of the test piece.
- The failure force, F , for each test piece.
- The individual values and average value of the initial longitudinal unit tensile strength Q_{xi} (in N/mm).
- The test temperature.

Appendix B Method for assessing initial longitudinal unit tensile strength by a beam test

B.1 Principle

For pipe of not more than 600 mm nominal diameter, compliance with a minimum level of the initial longitudinal unit tensile strength is assessed by loading the pipe in 4 point bend to induce a proof stress to be supported without signs of failure for at least 10 min.

B.2 Apparatus

The apparatus shall be as shown in Figure 3.

B.3 Test pieces

The test piece shall be a pipe of sufficient length to provide a span of length, L , as given in Table 4, when supported as shown in Figure 3.

B.4 Test conditions

Conduct the test at 15 ± 10 °C except in cases of dispute, in which case conduct the test at 23 ± 20 °C.

B.5 Procedure