



BS 5480 : Part 2 : 1982

UDC [628.143+628.24] : 621.643.2-036.5-037.52

Specification for

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

Part 2. Design and performance requirements

Spécification pour les canalisations et raccords en matière plastique renforcée de fibres de verre destinés à l'adduction d'eau ou à l'assainissement

Partie 2. Exigences de construction et fonctionnement

Spezifikation für glasfaserverstärkte Kunststoff-Rohre und -Armaturen für die Wasserversorgung oder Abwasser

Teil 2. Konstruktion und Leistungsforderungen

BS 5480 : Part 2 : 1982

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

Foreword

This British Standard has been prepared under the direction of the Plastics Standards Committee. Requirements are specified for glass fibre reinforced plastics pipes and fittings for use for water supply or sewerage and certain industrial applications.

This Part of BS 5480 specifies requirements for design limits, performance, workmanship, certification and inspection and describes methods of test.

Part 1 of BS 5480 specifies dimensions, materials and classification.

A British Standard for glass fibre reinforced plastics pipes and fittings for use in process plant systems is in course of preparation.

In the preparation of this standard account has been taken of the discussions on reinforced plastics pipes and fittings in progress within Technical Committee TC 138,

Plastics pipes, fittings and valves for the transport of fluids, of the International Organization for Standardization (ISO).

Water authorities state that materials used for the conveyance of potable water shall not impair the wholesome nature of the water. They require the manufacturer to give evidence that, within limits, the materials used shall not support microbial growth, or affect the taste, odour or turbidity of the water.

Attention is drawn to 7.4.1 of BS 5480 : Part 1 : 1977 where requirements for compatibility with potable water are specified. Work is currently being done by BSI committee EPC/44 on the effect on potable water of materials used in its distribution. A Draft for Development, DD 82, on this subject will be published shortly.

British Standard Specification for

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

Part 2. Design and performance requirements

Section one. General

1. Scope

This Part of this British Standard specifies the requirements for the design and testing of pipes and fittings made from glass fibre reinforced plastics (GRP) either with or without a thermoplastics liner for the construction of pressure and non-pressure pipelines intended for conveying above or below ground liquids including potable and non-potable water, foul sewage and storm water. The pipeline may also be used for those industrial wastes for which its suitability has been established by compliance with the requirements of clause 7.

For the purposes of this standard compliance with BS 5480 : Part 1, which specifies dimensions, materials and classification, is required.

NOTE. A guide to the clause references for the requirements and methods of test is given in appendix A.

2. References

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

3. Definitions

For the purposes of this Part of BS 5480 the following definitions apply.

3.1 ageing. The reduction of modulus of elasticity with time of a pipe or fitting subjected to an applied force.

3.2 aggressive industrial waste. A fluid that may have a detrimental effect on glass fibre reinforced plastics (GRP).

3.3 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.

3.4 inspection level. A characteristic of a sampling plan chosen in advance that determines the relationship between the lot size and the sample size.

3.5 lay-up. An assembly of resin impregnated material for processing.

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

3.7 semi-permanent set. The deformation remaining after loading and unloading the test piece that slowly reduces with time.

NOTE. In this standard the long-term effect is determined.

3.8 septic sewage. Sewage of an acidic nature, generally associated with the evolution of hydrogen sulphide,

giving conditions where sulphate-reducing bacteria proliferate.

4. Pipe design limits

4.1 General. The design limits given in 4.2 to 4.4 incorporate a factor M that relates to the method of manufacture and shall be as follows:

$M = 1$ for repeatable machine controlled production processes

$M = 2$ for all other manufacturing processes

NOTE 1. The design of pipes for water supply or sewerage is based on the long-term strength of the pipe (normally 50 years) which is determined by extrapolation. GRP pipes and fittings for process plants are designed on the basis of initial strength. A British Standard for GRP pipes and fittings for process plants is in course of preparation.

NOTE 2. Site considerations are not specified, but it should be noted that GRP pipes are flexible and buried pipelines rely on soil and bedding for their top load-bearing capacity. It is therefore essential that buried pipelines are surrounded with a suitable material that is adequately compacted and that the virgin soil has an adequate modulus of deformation.

NOTE 3. Particular attention is drawn to the need to confirm the regression curves for long-term properties for each resin and method of manufacture used.

4.2 All pipes. The recommended maximum permissible long-term ring deflection shall be declared by the manufacturer.

The composite factor of safety to failure shall at no time during the design service life of the pipeline fall below $1.3M$. The semi-permanent set (α) and the ageing factor (β), which tend to reduce the strength of the pipe with time, shall be determined in accordance with appendix B and used in the pipe design calculation details to ensure that the factor of safety is maintained during the design service life of the pipe.

The pipe design calculation details shall account for the classification and physical properties of the resin and glass used in the manufacture of the pipes and shall be supplied by the manufacturer if requested at the time of placement of order.

4.3 All pressure pipes

4.3.1 Pipes reinforced with continuous glass fibre reinforcement only shall be designed on the basis of hoop tensile glass strength.

The design hoop glass tensile stress (σ_{gd}) at the rated pressure shall not exceed the following:

$$\frac{\sigma_{gn}}{1.6M}$$

where

σ_{gn} is the long-term hoop glass tensile stress at a design service life of n years determined in accordance with appendix C.

4.3.2 Pipes reinforced with non-continuous glass fibre reinforcement only shall be designed on the basis of hoop wall tensile strength.

The design hoop wall tensile stress (σ_{wd}) at the rated pressure shall not exceed the following:

$$\frac{\sigma_{wn}}{1.6M}$$

where

σ_{wn} is the long-term hoop wall tensile stress at a design service life of n years determined in accordance with appendix C.

4.3.3 Pipes reinforced with both continuous and non-continuous glass fibre reinforcement shall be designed on the basis of both hoop tensile glass strength and hoop wall tensile strength.

The design tensile strength shall be calculated from σ_{gn} and σ_{wn} in the same proportion as the types of reinforcement.

4.3.4 Pipes designed to withstand end loads due to internal pressure (LS pipes) shall have a composite factor of safety against the long-term longitudinal strength of at least 1.6M.

The lower of the two values for tensile strength reported in C.7(f) shall be used in the formulae in 4.3.1 and 4.3.2.

4.4 Pipes carrying septic sewage or aggressive industrial waste. The total design circumferential strain, ϵ_d , at the manufacturer's maximum recommended ring deflection and at the working pressure of the pipeline shall not exceed the following:

$$\frac{\epsilon_n}{1.6M}$$

where

ϵ_n is the extrapolated circumferential failure strain at the design service life of n years determined in accordance with appendix D.

Section two. Type tests

5. General

Each type test shall be carried out on pipes or fittings representative of each classification. The tests shall be repeated when alteration of the design basis or laminate structures is made.

NOTE. If required, the density of laminate, resin content, glass distribution, and hardness can be determined as recommended in appendix R to check the construction of the pipe or fitting and the cure of the resin.

6. Impact resistance

When tested in accordance with appendix E, the pipe shall show no signs of weeping through the wall.

7. Long-term strain corrosion resistance

Pipes intended for use with septic sewage or aggressive industrial waste, when tested in accordance with appendix D, shall conform to the design requirements

that are related to the number of years of service (see 4.4).

In addition, the 95 % lower confidence limit of failure strain at 100 000 h shall not be less than 0.5 %.

8. Long-term hoop tensile strength

The long-term hoop tensile strength of reinforced plastics pipes under internal hydrostatic pressure shall be determined in accordance with appendix C.

NOTE 1. The initial hoop tensile strength is related to the long-term hoop tensile strength by the regression line determined by the method described in appendix C.

NOTE 2. The maximum working pressure of a pipeline is related to the long-term hoop tensile strength by the equation given in C.7.1.

9. Long-term semi-permanent set and ageing

The long-term semi-permanent set (α) and ageing (β) of reinforced plastics pipes by deflection shall be determined in accordance with appendix B.

10. Dimensions

10.1 General. The dimensions of GRP pipes and fittings shall be in accordance with BS 5480 : Part 1. Minimum wall thickness values shall be determined from the design calculations.

10.2 Measurement of diameters of pipes. The inside diameter of the pipe shall be measured in accordance with appendix F.

The values obtained shall fall within the manufacturing tolerances on the work size specified in 4.1.2 of BS 5480 : Part 1 : 1977.

10.3 Wall thickness. When measured by a method with an accuracy of measurement of 0.1 mm, the wall thickness at at least 3 points along the length of the pipe or around the circumference shall be not less than the figure declared and used by the manufacturer resultant from the calculations for the design of the pipe.

Section three. Quality assurance tests

11. Test frequency

Quality assurance tests shall be carried out to achieve an AQL of 10 % at an inspection level of S-3 as described in BS 6001 using the double sampling plan, except where 100 % testing is specified in this standard.

This inspection level covers production lots up to and including 150 units per size and classification and specifies sampling requirements and acceptance/rejection levels summarized in table 1.

NOTE. For information regarding the operation of the switching rules from normal to tightened inspection, normal to reduced inspection etc., see BS 6001.

12. Dimensions

12.1 Diameter. The inside diameter of the pipe shall be within the manufacturing tolerances on the work size specified in BS 5480 : Part 1.

The diameter shall be measured either as described in appendix F for the type test or by using a diameter tape that measures the outside diameter.

NOTE. If the outside diameter is measured, the inside diameter is obtained by subtracting twice the measured wall thickness at that location.

Table 1. Summary of sampling plans for inspection level S-3 and Ac/Re numbers

Lot size	Sample	Normal inspection				Tightened inspection				Reduced inspection			
		Sample size	Cumulative sample size	Ac	Re	Sample size	Cumulative sample size	Ac	Re	Sample size	Cumulative sample size	Ac	Re
1 to 150	First	3	3	0	2	5	5	0	2	2	2	0	3
	Second	3	6	1	2	5	10	1	2	2	4	0	4

NOTE. *Ac* is the acceptance number and *Re* is the rejection number.

12.2 Wall thickness. The wall thickness shall be in accordance with 10.3.

13. Leak tightness

13.1 Non-pressure pipes. Non-pressure pipes, i.e. those rated zero bar, shall be tested in accordance with appendix G to a pressure of 1.5 bar*.

No water shall pass through the pipe wall and appear on the outside surface.

NOTE. Pipes from a rejected lot may be accepted if they are individually tested.

13.2 Pressure pipes. Pressure pipes shall be tested in accordance with appendix G to a pressure of 1.6 times the rated pressure.

The test shall be carried out on all pressure pipes.

No water shall pass through the pipe wall and appear on the outside surface.

13.3 Fittings made from GRP. Fittings shall be tested at 100 mbar in accordance with appendix H to check that the fitting does not leak.

The test shall be carried out on all fittings.

There shall be no leakage of air evidenced by bubbling when the outer surface is painted with a 10 % solution of a wetting agent in water.

14. Initial specific stiffness and resistance to structural damage under ring deflection

The mean initial specific stiffness of the pipe shall be in accordance with 7.3 of BS 5480 : Part 1 : 1977 when tested in accordance with appendix J.

There shall be no evidence of structural damage of the test piece after the test.

15. Initial hoop tensile strength

The mean value of the initial hoop tensile strength of the pipe shall be in accordance with the value declared by the manufacturer in his literature and at the time of confirmation of the order when tested in accordance with one of the three methods described in appendix K, L or M and the method used shall be stated by the manufacturer at the time of confirmation of order. Pipes intended to withstand the end load resulting from internal pressure shall be tested in accordance with appendix K.

NOTE. The method given in appendix L using a split disc is not suitable for pipes where the hoop reinforcement is at an angle greater than 10° from the circumferential direction.

*1 bar = 10⁵ N/m² = 100 kPa.

16. Initial longitudinal tensile strength

The mean longitudinal tensile force per unit of circumference shall be in accordance with clause 8 of BS 5480 : Part 1 : 1977 or, in the case of pipe classified as LS, in accordance with the value declared by the manufacturer when tested in accordance with one of the methods described in appendix N, P or Q and the method used should be stated by the manufacturer at the time of confirmation of order. When tested in accordance with appendix Q, there shall be no rupture of the pipe, abrupt loss of load or increase in deflection.

NOTE. The method given in appendix Q using a beam test is only applicable to pipes up to 600 mm nominal diameter.

17. Strain corrosion resistance

Pipes intended for use with septic sewage or aggressive industrial wastes shall be tested in accordance with appendix D using one test piece for each strain level at the 10, 100 and 1000 h 95 % confidence limit determined from the type test (see clause 7).

No fluid shall pass through the pipe wall and there shall be no visible surface crack.

Section four. Fittings and joints

18. Fittings made from GRP

18.1 General. All fittings made from glass fibre reinforced plastics such as bends, tees, junctions and reducers shall be equal to or superior in performance to pipe of the same classification (see 5.1 of BS 5480 : Part 1 : 1977).

NOTE. It is usual to design fittings for buried applications as rigid structures to be surrounded in an in-situ concrete anchor block suitably designed to resist the resultant forces and the bending stresses on the fitting.

18.2 Fittings made from straight pipe. Fittings made from straight pipe shall conform to the declared design requirements and shall be suitably mitred. The mitre shall be overwrapped externally and if practicable, internally with woven roving and chopped strand mat to restore the longitudinal and hoop tensile performance to be at least equal to that of the pipe of the same classification.

18.3 Fittings made by moulding. Fittings made by moulding shall be made by hand lay-up, contact moulding, hot or cold press moulding or tape winding.

19. Joint performance

Joints may be rigid or flexible (mechanical) and shall be in accordance with clause 6 of BS 5480 : Part 1 : 1977.

In the case of flexible (mechanical) joints, the material of the sealing rings shall be in accordance with BS 2494.

Section five. Workmanship, inspection and certification

20. Workmanship

20.1 The manufacturer shall ensure consistency in both materials and fabrication, and shall provide adequate supervision at all stages of manufacture.

Manufacture shall be under environmental conditions compatible with producing satisfactory pipes and fittings, and raw materials shall be stored and used in compliance with the recommendations of their manufacturers.

20.2 Where pipes are being fabricated by repeatable machine-controlled processes, sufficient control shall be maintained of the mechanisms for metering and mixing resins, catalysts and accelerators, and emplacing the mixed resin together with reinforcement and fillers in the pipe wall, to ensure that the construction of the pipe complies with the quality assurance requirements specified in section three of this standard. In the event of malfunction, the suspect pipes or fittings shall be identified and set aside.

20.3 Where pipes are being fabricated by other methods, the requisite amounts of resin, catalyst or hardener and accelerator shall be measured out and thoroughly mixed in batches small enough to ensure utilization within the pot life at the workshop temperature. The number and types of reinforcement layers applied shall be recorded. The layers shall be consolidated with due care to avoid excessive pressure that could disturb the distribution of the layers and damage the reinforcement.

Adjacent pieces of reinforcement shall be overlapped by not less than 50 mm and their edges worked out to minimize the step. Such joints shall be staggered through the thickness of the wall. When directionally biased reinforcement is used, care shall be taken to ensure that the high strength direction is correctly aligned to give the designed balance of hoop and longitudinal strength.

20.4 The manufacturer shall ensure that good adhesion is obtained between successive layers of laminate either by correct time scheduling of the lay-up, or (particularly in the case of butt joints and fabrication of fittings from pipe sections) by removing the surface gloss of cured resin before further applications.

The internal surface of the pipe and fitting shall be smooth and both the internal and external surfaces shall be clean and free from defects such as protruding fibre, voids, bubbles, cracks, blisters or foreign matter that would impair their performance in service.

21. Inspection

In addition to the manufacturer's own inspection and supervision, the purchaser or his appointed inspecting authority shall have access at all reasonable times by arrangement with the manufacturer to those parts of the works engaged on the manufacture and testing of the pipes and fittings he has ordered and all the relevant test records.

22. Certification

The manufacturer shall, on request, furnish to the purchaser or purchaser's representative, duplicate copies of a signed certificate stating that the design, construction and testing of the pipes and fittings complies with the requirements specified in this standard. If required by the purchaser, the test results or a suitable summary shall be provided with the certificate.

In cases of joint responsibility for inspection and testing of pipes and fittings, signed documentary evidence of the results of all the completed inspections and tests shall be forwarded to the Inspecting Authority.

Appendix A

Guide to requirements and methods of test

Property	Requirement	Test method
Construction and cure	Clause 5 (optional)	Appendix R
Diameter of pipes	10.2, clause 12	Appendix F
Initial hoop tensile strength	Clause 15	Appendices K, L, M
Initial impact resistance	Clause 6	Appendix E
Initial longitudinal tensile strength	Clause 16	Appendices N, P, Q
Initial specific stiffness and resistance to structural damage	Clause 14	Appendix J
Joint performance	Clause 19	BS 2494
Leak tightness of fittings	13.3	Appendix H
Leak tightness of pipes	13.1, 13.2	Appendix G
Long-term hoop tensile strength	4.3, clause 8	Appendix C
Long-term strain corrosion resistance	4.4, clause 7	Appendix D
Semi-permanent set and ageing	4.2, clause 9	Appendix B
Short-term strain corrosion resistance	Clause 17	Appendix D
Wall thickness	10.3, 12.2	
Work size	10.2, 12.1	Appendix F

Appendix B

Method for the determination of the long-term semi-permanent set and ageing of reinforced plastics pipe

B.1 Principle. This method describes the test procedure to determine the long-term semi-permanent set and ageing of reinforced plastics pipes deflected as a ring in an aqueous environment. It is usual to carry out the test on pairs of test pieces.

The procedure consists of two test methods, one to determine ageing and semi-permanent set and one to determine ageing alone, semi-permanent set being obtained as shown in B.6.1.

B.2 Apparatus. The apparatus shall be as shown in figure 1 and shall be capable of maintaining the load at a constant value. The plates shall be 300 mm wide.

B.3 Test pieces. Test pieces shall be ring sections, 300 mm long, cut from a pipe. A minimum of four test pieces is required.

B.4 Test conditions. Conduct the test with the rings immersed in tap water at $15 \pm 10^\circ\text{C}$. For applications where the service temperature is higher than 30°C , conduct the test at the maximum service temperature.

B.5 Procedure

B.5.1 Determination of ageing plus semi-permanent set ($\alpha\beta$)

B.5.1.1 Assemble the rings without distortion between the plates and submerge the rings and plates in water controlled at the appropriate temperature.

B.5.1.2 Note the reading of the measuring devices and record the average as the datum reading.

B.5.1.3 Load the rings to give equal deflections at each measuring point until the total vertical pipe deflection from the datum condition is $5 \pm 0.5\%$ of the nominal diameter. 0.01 h after full load is applied, record the average deflection from the datum as d_1 .

B.5.1.4 Measure and record the average deflection from the datum as d_2 after the rings have been loaded for a total of 0.1, 1, 10, 100, 1000 and 10 000 h.

B.5.1.5 On log-log paper plot d_1/d_2 against time (graph 1). Determine the best regression line by the least squares method and extrapolate to 50 years.

Record the extrapolated value of d_1/d_2 at 50 years as $(\alpha\beta)_{50}$. An example is shown in figure 2.

B.5.2 Determination of ageing (β)

B.5.2.1 Assemble and load as described in B.5.1.1, B.5.1.2 and B.5.1.3, 0.01 h after full load is applied, record the average deflection from the datum as d_3 .

B.5.2.2 After the rings have been loaded for 1 h, record the average deflection from the datum as d_4 , remove the dead weights and 1 min after removing the weights record the average deflection as d_5 . Replace the dead weights and 1 min after replacing the weights record the average deflection as d_6 .

B.5.2.3 Repeat B.5.2.2 after the rings have been loaded for a total of 10, 100, 1000 and 10 000 h.

B.5.2.4 On log-log paper plot $2d_3/(d_4 + d_6 - 2d_5)$ against time (graph 2). Determine the best negative regression line by the least squares method and extrapolate to 50 years.

Record the extrapolated value of $2d_3/(d_4 + d_6 - 2d_5)$ at 50 years as β_{50} .

An example is shown in figure 2.

B.6 Calculation

B.6.1 The semi-permanent set factor, α_{50} , is obtained from the following equation:

$$\alpha_{50} = \frac{(\alpha\beta)_{50}}{\beta_{50}}$$

where

$(\alpha\beta)_{50}$ is obtained from graph 1;

β_{50} is obtained from graph 2.

B.6.2 The ageing factor, β_{50} is obtained from graph 2.