BRITISH STANDARD

BS 3505:1986

Incorporating Amendment No. 1

Specification for

Unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water

UDC 621.643.29:678.743.22:696.11

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Plastics Standards Committee (PLM/-) to Technical Committee PLM/9, upon which the following bodies were represented:

British Gas Corporation
British Plastics Federation
British Valve Manufacturers' Association Ltd.
Copper Tube Fittings Manufacturers' Association
Department of the Environment (Housing and Construction Industries)
Department of the Environment (Property Services Agency)
Department of Transport (Highways)
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
Institution of Civil Engineers
Institution of Production Engineers
Institution of Public Health Engineers
Institution of Water Engineers and Scientists
National Association of Plumbing, Heating and Mechanical Services Contractors
Plastics and Rubber Institute
Plastics Land Drainage Manufacturers' Association
Royal Institute of Public Health and Hygiene
Water Authorities Association
Water Companies Association
Water Research Centre

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

Institute of Plumbing
Ministry of Agriculture, Fisheries and Food
National Brassfoundry Association
Standards Association of Australia

This British Standard, having been prepared under the direction of the Plastics Standards Committee, was published under the authority of the Board of BSI and comes into effect on 31 December 1986

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Second revision

The following BSI references relate to the work on this standard:
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Amendments issued since publication

Amd. No.	Date of issue	Comments
6130	November 1988	Indicated by a sideline in the margin

Contents

Foreword

This revision of BS 3505 has been prepared under the direction of the Plastics Standards Committee and supersedes the 1968 edition, which is withdrawn.

The main differences between this revision and the 1968 edition are as follows.

a) The size range has been rationalized with the removal of nominal sizes 2½, 7, 9 and 22. (Although the pipe dimensions are expressed in metric units, this standard continues to designate the nominal size of pipes in inch equivalent figures to avoid confusion with pipe sizes having dimensions in accordance with metric series values in ISO 161/1.) The class B classification has also been removed.

b) Requirements for the effects of materials on water quality have been modified.

c) The method for the determination of long-term hydrostatic strength has been modified, so that the maximum period over which test results are to be obtained at 20 °C has been extended from not more than 1 000 h to not less than 10 000 h.

d) A requirement for resistance to hydrostatic pressure at 60 °C has been added.

e) A requirement for fracture toughness has been added, together with an associated method of test (see appendices C and D).

f) The method for assessment of impact resistance has been modified to establish a maximum true impact rate (TIR) at a specified confidence level.

g) Some restrictions have been placed on the colour of pipes, depending upon their size and intended installation and taking the following into account.

The National Joint Utilities Group has agreed that all buried thermoplastics utilities services up to 75 mm in external diameter should be colour coded for identification purposes. Among the conclusions given in the Group's Publication No. 4 "The identification of small buried mains and services" is that the colour selected for potable water pipes be blue. For this purpose, it is desirable to avoid the shade allocated for use by compressed air lines in accordance with BS 1710. If grey, the colour should be dark enough to avoid those shades used for telecommunications ducting.

h) The requirements of this standard have been made verifiable, so that third party certification may be applied. Guidance provided on the periodic maintenance of equipment or on quality control testing is therefore given in the form of notes and in an advisory appendix (see appendix E).

The recommended maximum working stress of the material continues to be based on three values according to nominal size, as follows: a maximum stress of 9.8 MPa has been used for calculating the minimum wall thickness of pipes of nominal size up to ¾, one of 11.0 MPa for nominal sizes 1 to 6 inclusive and one of 12.3 MPa for pipes of nominal size 8 and above.

Attention is drawn to CP 312-2, which gives guidance on the use of pipes manufactured in accordance with this standard.

Attention is also drawn to BS 4346-2, which specifies joints and fittings for use with unplastized PVC pressure pipes.

It has been assumed in the preparation of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced personnel.

Purchasers ordering to this standard are advised to specify in their purchasing contract that the supplier operate a quality system in compliance with BS 5750-2 to assure themselves that products claimed to comply with BS 3505 consistently achieve the required level of quality.

Certification. Attention is drawn to the certification facilities described on the inside back cover.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 18, 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.

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1 Scope

This British Standard specifies requirements for unplasticized polyvinyl chloride (PVC-U) pipes up to and including nominal size 24, for conveying cold potable water at pressures up to and including 9, 12 or 15 bar[1)] at 20 °C, depending on the size.

Methods of test, associated guidance and information on quality control testing are given in appendices.

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

2 Material

2.1 Base material

The material from which the pipe is produced shall be polyvinyl chloride with additives as necessary for the manufacture of pipe in accordance with this standard and to satisfy colour requirements, if applicable (see foreword and **6.1.2**).

2.2 Reworked material

If reworked material is added or used, it shall be clean and in accordance with **2.1**; it shall be derived from pipe produced in accordance with this standard, reground under the supervision of the same manufacturer and used only in the production of pipe sizes up to and including nominal size 6.

3 Pressure classification of pipes

Pipes are classified by maximum sustained working pressure, as follows:

a) 9 bar (class C);

b) 12 bar (class D);

c) 15 bar (class E).

NOTE The working pressures given above are the calculated maximum sustained working pressures for the conveyance of cold water at a temperature of 20 °C. For use at higher temperatures or under conditions of pulsating pressures, reference should be made to CP 312-2.

4 Dimensions and tolerances

4.1 Nominal size

The nominal size of the pipe shall be one of the sizes given in Table 1.

4.2 Outside diameter

When determined in accordance with BS 2782: Method 1101A, the outside diameter of the pipe shall comply with the limits specified in Table 1 for the relevant nominal size of the pipe.

4.3 Wall thickness

When determined in accordance with BS 2782: Method 1101A, the wall thickness of the pipe shall comply with the limits specified in Table 1 appropriate to the nominal size and class of pipe. The average wall thickness of the pipe shall be determined by taking the arithmetic mean of at least the following number of measurements of wall thickness around the pipe, including both the minimum and maximum values:

a) up to and including 6 mm wall thickness: four measurements;

b) greater than 6 mm wall thickness: six measurements.

4.4 Tolerance on length

The ends of pipes shall be cut cleanly and squarely. If the length of a pipe is specified, the effective length shall be not less than that specified, when determined at 23 ± 2 °C.

NOTE The preferred effective lengths of pipe are 6 m or 9 m. For plain-ended pipes, the effective length corresponds to the overall length. For pipes with an integrally formed ring seal joint in accordance with BS 4346-2, the effective length does not include the length required for the joint.

5 Performance requirements

5.1 General

The requirements given in **5.2** and **5.3** shall be met, subject to **5.4**, which shall apply whenever a change in process technique or introduction of a new or modified compound has occurred.

The relevant tests shall be applied to pipe taken from a production run from which the product has complied with all the other requirements of this standard.

5.2 Hydrostatic properties

NOTE Attention is drawn to advice given in appendix E concerning samples of pipes of different design stress categories, formulations, pressure classifications and sizes.

5.2.1 *Long-term hydrostatic strength at 20 °C.* When test pieces in accordance with **5.2.2** are tested at 20 ± 1 °C in accordance with BS 4728, and the results are analysed in accordance with appendix A, the extrapolated values for circumferential wall stress for the periods of time given in Table 2 shall comply with the limits specified in Table 2 according to the applicable design stress category.

[1)] 1 bar = 10^5 N/m^2 = 0.1 MPa

Table 1 — Pipe dimensions for 9 bar (class C), 12 bar (class D) and 15 bar (class E) pipes

Nominal size	Mean outside diameter		Individual outside diameter		Wall thickness								
	min.	max.	min.	max.	9 bar (class C)			12 bar (class D)			15 bar (class E)		
					Average value[a]	Individual value		Average value[a]	Individual value		Average value[a]	Individual value	
					max.	min.	max.	max.	min.	max.	max.	min.	max.
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
3/8	17.0	17.3	17.0	17.3	—	—	—	—	—	—	1.9	1.5	1.9
1/2	21.2	21.5	21.2	21.5	—	—	—	—	—	—	2.1	1.7	2.1
3/4	26.6	26.9	26.6	26.9	—	—	—	—	—	—	2.5	1.9	2.5
1	33.4	33.7	33.3	33.8	—	—	—	—	—	—	2.7	2.2	2.7
1¼	42.1	42.4	42.0	42.5	—	—	—	2.7	2.2	2.7	3.2	2.7	3.2
1½	48.1	48.4	48.0	48.5	—	—	—	3.0	2.5	3.0	3.7	3.1	3.7
2	60.2	60.5	60.0	60.7	3.0	2.5	3.0	3.7	3.1	3.7	4.5	3.9	4.5
3	88.7	89.1	88.4	89.4	4.1	3.5	4.1	5.3	4.6	5.3	6.5	5.7	6.6
4	114.1	114.5	113.7	114.9	5.2	4.5	5.2	6.8	6.0	6.9	8.3	7.3	8.4
5	140.0	140.4	139.4	141.0	6.3	5.5	6.4	8.3	7.3	8.4	10.1	9.0	10.4
6	168.0	168.5	167.4	169.1	7.5	6.6	7.6	9.9	8.8	10.2	12.1	10.8	12.5
8	218.8	219.4	218.0	220.2	8.8	7.8	9.0	11.6	10.3	11.9	14.1	12.6	14.5
10	272.6	273.4	271.6	274.4	10.9	9.7	11.2	14.3	12.8	14.8	17.5	15.7	18.1
12	323.4	324.3	322.2	325.5	12.9	11.5	13.3	17.0	15.2	17.5	20.8	18.7	21.6
14	355.0	356.0	353.7	357.3	14.1	12.6	14.5	18.6	16.7	19.2	22.8	20.5	23.6
16	405.9	406.9	404.3	408.5	16.2	14.5	16.7	21.1	19.0	21.9	26.0	23.4	27.0
18	456.7	457.7	454.9	459.5	18.2	16.3	18.8	23.8	21.4	24.6	—	—	—
20	507.5	508.5	505.4	510.6	20.2	18.1	20.9	—	—	—	—	—	—
24	609.1	610.1	606.5	612.7	24.1	21.7	25.0	—	—	—	—	—	—

[a] See **4.3**.

5.2.2 *Test pieces.* Up to nominal size 12, the test piece shall be a pipe of minimum free length between end fittings in millimetres of [three times the nominal size] or 250 mm, whichever is the greater. For nominal sizes above 12, that minimum free length shall be 1 000 mm. The test piece shall be closed with pressure-tight caps or plugs in accordance with any of the types shown in figure 1, 2 and 3 of BS 4728:1971.

5.2.3 *Long-term hydrostatic pressure resistance at 60 °C.* When tested at a temperature of 60 ± 1.0 °C in accordance with BS 4728, samples of pipe shall withstand an internal pressure equivalent to a hoop stress of 10.0 MPa for 1 000 h without failure. The samples of pipe shall comprise test pieces in accordance with **5.2.2**.

Table 2 — Minimum circumferential wall stress values

Design stress category	Nominal size	Minimum circumferential wall stress	
		Lower 97.5 % confidence limit at 100 000 h	50 year stress
MPa		MPa	MPa
9.8	Up to ¾	18.0	20.6
11.0	1 to 6	20.0	23.0
12.3	8 to 24	23.0	26.0

5.3 Effect of materials on water quality

When used under the conditions for which they are designed, non-metallic materials in contact with or likely to come into contact with potable water shall not constitute a toxic hazard, shall not support microbial growth and shall not give rise to unpleasant taste or odour, cloudiness or discoloration of the water.

Concentrations of substances, chemicals and biological agents leached from materials in contact with potable water, and measurements of the relevant organoleptic/physical parameters shall not exceed the maximum values recommended by the World Health Organization in its publication "Guidelines for drinking water quality" Vol. 1 "Recommendations" (WHO, Geneva, 1984) or as required by the EEC Council Directive of 15 July 1980 relating to the quality of water intended for human consumption (Official Journal of the European Communities L229 pp 11–29), whichever in each case is the more stringent.

NOTE 1 Requirements for the testing of non-metallic materials in these respects are set out in the UK Water Fittings Byelaws Scheme Information and Guidance Note No. 5-01-02, ISSN 0267-0313 obtainable from the Water Research Centre, Water Byelaws Advisory Service, 660 Ajax Avenue, Slough, Berkshire SL1 4BG.

NOTE 2 Pending the determination of suitable means of characterizing the toxicity of leachates from materials in contact with potable water, materials 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 toxic hazard for the purposes of compliance with this subclause. A list of approved chemicals and materials is available from the Technical Secretary of that Committee at the Department of the Environment, Water Division, Romney House, 43 Marsham Street, London SW1P 3PY.

NOTE 3 Products manufactured for installation and use in the United Kingdom which are verified and listed under the UK Water Fittings Byelaws Scheme administered by the Water Research Centre (address as in note 1) are deemed to satisfy the requirements detailed in this subclause.

5.4 Extension to nominal size, formulation or process range

For the extension of a manufacturer's range of sizes beyond that already tested in accordance with **5.1** to **5.3** or for a change in either the material formulation or pipe manufacturing process, the manufacturer can claim compliance for the modified range, provided that the additional pipes in the range satisfy the following requirements.

a) All the requirements of this standard except **5.2.1** shall be met.

b) At failure times up to 2 500 h, the requirements of **5.2.1** in respect of the minimum circumferential wall stress for 50 years shall be met.

c) Sufficient test pieces shall be under test, at appropriate stress levels, to enable a full regression analysis to be carried out in accordance with **5.2.1**.

d) The requirements of **5.2.1** shall be met subsequently by the test pieces under test in accordance with (c).

6 Physical properties

6.1 Appearance

6.1.1 *Superficial appearance.* When viewed without magnification, the internal and external surfaces of the pipe shall be free from defects and the internal surface shall appear to be clean.

NOTE The ends of the pipes may be plugged or covered to maintain their condition and exclude contamination.

6.1.2 *Colour.* The following shall apply.

a) In the case of pipes of nominal size 2 or smaller intended for buried utilities for cold potable water, the colour of the pipe shall be blue within the range 18 E 51 and 18 E 53 of BS 4901.

b) In the case of pipes of nominal size 2 or smaller, if grey, the colour shall be darker than colour 00 A 09 of BS 4800.

6.1.3 *Opacity*. When tested in accordance with BS 2782: Method 1104A, the pipe shall not transmit more than 0.2 % of the luminous flux.

6.2 Longitudinal reversion

When tested in accordance with BS 2782: Method 1102A using a temperature of 150 °C and the appropriate immersion period specified in Table 3, at no position around the pipe shall the length change by more than 5.0 %.

Table 3 — Test piece immersion periods

Pipe wall thickness	Minimum immersion period
mm	min
≤ 8.6	15
> 8.6 but ≤ 14.1	30
> 14.1	60

6.3 Resistance to delamination

The test piece shall be tested in accordance with BS 2782: Method 1102A, except that reference marks need not be scribed on the test piece, by immersing the test piece in the bath at a test temperature of 150 °C for the applicable period of time specified in Table 3. Immediately after removal of the test piece from the bath, use a razor-sharp blade to make four cuts, each of minimum length 150 mm, along the length of the test piece and through the full wall thickness at positions equidistant around its circumference.

After testing, the test piece shall show no delamination, cracks, cavities, inclusions or blisters when examined visually without magnification.

6.4 Short-term hydrostatic pressure resistance at 20 °C

When tested at a temperature of 20 °C in accordance with BS 4728, the 1 h failure pressure shall be not less than the value given in Table 4, according to the class.

Table 4 — Minimum 1 h failure pressure

Class of pipe	Minimum 1 h failure pressure
	bar
9 bar (class C)	32.4
12 bar (class D)	43.2
15 bar (class E)	54.0

6.5 Impact resistance at 20 °C

When tested in accordance with appendix B, the pipe shall have a true impact rate (TIR) below 10 % at a confidence level of 90 %.

6.6 Fracture toughness

This requirement shall only apply to pipes of nominal size 3 or greater, which, when tested in accordance with appendix C, shall withstand for not less than 15 min without breaking or cracking at the notch the test force corresponding to a true fracture toughness, K_{IC} (see appendix D), of not less than 3.25 MN $m^{-3/2}$ for pipes of wall thickness e_n less than 6 mm or not less than 3.75 MN $m^{-3/2}$ for pipes of wall thickness e_n greater than or equal to 6 mm.

7 Marking

7.1 All pipes shall be indelibly marked in accordance with **7.2**, at intervals not exceeding 1 m with the following information:

a) the manufacturer's identification, as a clear text or logo;

b) the number and date of this British Standard i.e. BS 3505:1986[2)];

c) the letters "PVC-U";

d) the pressure classification, in bars, in accordance with clause **3**, e.g. 12 bar[3)];

e) the nominal size in accordance with Table 1;

f) a batch identification.

7.2 The marking shall be imprinted longitudinally in one of the following colours, as applicable:

a) for 9 bar (class C) pipe: black[4)] or dark blue;

b) for 12 bar (class D) pipe: green;

c) for 15 bar (class E) pipe: brown.

[2)] Marking BS 3505:1986 on or in relation to a product is a claim by the manufacturer that the product has been manufactured in accordance with the requirements of the standard. The accuracy of such a claim is therefore solely the manufacturer's responsibility. Enquiries as to the availability of third party certification should be addressed to the appropriate certification body.
[3)] Inclusion of e.g. "(class C)" in the marking is optional.
[4)] This option is at variance with BS 5556, but is included for clarity purposes, especially for use on pipes up to and including nominal size 2 in blue for buried installations (see foreword and **6.1.2**).

Appendix A Method for the analysis of results from the determination of the long-term hydrostatic strength of pipe at 20 °C

NOTE 1 References in this appendix to logarithms relate to base 10.

NOTE 2 Attention is drawn to advice given in appendix E concerning samples of pipes of different design stress categories, formulations, pressure classifications and sizes.

A.1 Procedure

Obtain at least 18 test results for the calculation of the log time versus log stress regression line such that the failure point distribution is in accordance with Table 5.

Table 5 — Failure point distribution

Failure time range	Minimum data point distribution	Recommended[a] data point distribution
h		
> 10 but < 50	2	4
≥ 50 but < 2 500	3	5
≥ 2 500 but < 6 500	3	4
≥ 6 500 but < 10 000	2	4
≥ 10 000	1	1
Total	11 + 7 others	18

[a] Whilst a distribution of 18 data points in accordance with column 2 is the minimum data pattern required, it is recommended that sufficient data points be obtained, so that 18 data points distributed as shown in column 3 are included.

Fit a straight line to the data using the method of least squares, regressing log time on log stress as the independent variable.

A.2 Calculation of linear regression with one independent variable

A.2.1 The following symbols are used.

n is the number of observations.

f_i is the log of stress (in MPa) of observation $i;i = 1, ..., n$.

h_i is the log of time (in h) of observation $i;i = 1, ..., n$.

$\bar{f}$ is the arithmetic mean of all f_i values $= \frac{1}{n}\sum_{i=1}^{n} f_i$ (1)

$\bar{h}$ is the arithmetic mean of all h_i values $= \frac{1}{n}\sum_{i=1}^{n} h_i$ (2)

The regression equation of log time (h) on log stress (f) is:

$$h = a + bf \quad (3)$$

A.2.2 Calculate the following three quantities.

$$S_{ff} = \sum_{i=1}^{n} f_i^2 - n(\bar{f})^2 \quad (4)$$

$$S_{hh} = \sum_{i=1}^{n} h_i^2 - n(\bar{h})^2 \quad (5)$$

$$S_{fh} = \sum_{i=1}^{n} f_i h_i - n\bar{f}\bar{h} \quad (6)$$

A.2.3 Calculate b and a from the following equations.

$$b = \frac{S_{fh}}{S_{ff}} \quad (7)$$

$$a = \bar{h} - b\bar{f} \quad (8)$$

If the slope of the regression line, b, is not negative, reject the results.

A.2.4 Using equation (3), calculate the mean stress for a time of 50 years for each design stress category (see Table 2).

A.2.5 Calculate the lower 97.5 % confidence limit as follows.

a) Determine the residual variance about the regression line, s_r^2, from the following equation.

$$s_r^2 = \frac{1}{n-2}\left[S_{hh} - \frac{S_{fh}^2}{S_{ff}}\right] \quad (9)$$

b) Calculate the lower 97.5 % confidence limit for one future observation at a given stress of:

1) 18.0 MPa for nominal sizes up to ¾,

2) 20.0 MPa for nominal sizes 1 to 6,

3) 23.0 MPa for nominal sizes 8 to 24

from the following equation

$$h_0 = a + bf_0 - t_\nu s_r \sqrt{\left[1 + \frac{1}{n} + \frac{(f_0 - \bar{f})^2}{S_{ff}}\right]} \quad (10)$$

where

t_υ is Student's t for $\upsilon = n - 2$ degrees of freedom, as given in Table 6, which gives the upper 2½ % points;

h_0 is the estimated log time before failure (in h);

f_0 is the log of the stress (in MPa) (in this case log 18.0, log 20.0 or log 23.0 according to the design stress category given in Table 2).

A.3 Test report

The report shall include the following:

a) the identification of the test pieces;

b) the type of end caps used in accordance with BS 4728;

c) the mean stress for a failure time of 50 years for the relevant design stress category;

d) the lower 97.5 % confidence limit at the stress for the relevant design stress category;

e) the dates between which the test was conducted.

Table 6 — Percentage points of Student's *t* distribution (upper 2½ % points)

v	t_v	*v*	t_v	*v*	t_v
1	12.7062	46	2.0129	91	1.9864
2	4.3027	47	2.0117	92	1.9861
3	3.1824	48	2.0106	93	1.9858
4	2.7764	49	2.0096	94	1.9855
5	2.5706	50	2.0086	95	1.9853
6	2.4469	51	2.0076	96	1.9850
7	2.3646	52	2.0068	97	1.9847
8	2.3060	53	2.0057	98	1.9845
9	2.2622	54	2.0049	99	1.9842
10	2.2281	55	2.0040	100	1.9840
11	2.2010	56	2.0032	102	1.9835
12	2.1788	57	2.0025	104	1.9830
13	2.1604	58	2.0017	106	1.9826
14	2.1448	59	2.0010	108	1.9822
15	2.1315	60	2.0003	110	1.9818
16	2.1199	61	1.9996	112	1.9814
17	2.1098	62	1.9990	114	1.9810
18	2.1009	63	1.9983	116	1.9806
19	2.0930	64	1.9977	118	1.9803
20	2.0860	65	1.9971	120	1.9799
21	2.0796	66	1.9966	122	1.9796
22	2.0739	67	1.9960	124	1.9793
23	2.0687	68	1.9955	126	1.9790
24	2.0639	69	1.9949	128	1.9787
25	2.0595	70	1.9944	130	1.9784
26	2.0555	71	1.9939	132	1.9781
27	2.0518	72	1.9935	134	1.9778
28	2.0484	73	1.9930	136	1.9776
29	2.0452	74	1.9925	138	1.9773
30	2.0423	75	1.9921	140	1.9771
31	2.0395	76	1.9917	142	1.9768
32	2.0369	77	1.9913	144	1.9766
33	2.0345	78	1.9908	146	1.9763
34	2.0322	79	1.9905	148	1.9761
35	2.0301	80	1.9901	150	1.9759
36	2.0281	81	1.9897	200	1.9719
37	2.0262	82	1.9893	300	1.9679
38	2.0244	83	1.9890	400	1.9659
39	2.0227	84	1.9886	500	1.9647
40	2.0211	85	1.9883	600	1.9639
41	2.0195	86	1.9879	700	1.9634
42	2.0181	87	1.9876	800	1.9629
43	2.0167	88	1.9873	900	1.9626
44	2.0154	89	1.9870	1 000	1.9623
45	2.0141	90	1.9867	∞	1.9600

Appendix B Method for the determination of impact resistance at 20 °C

B.1 Apparatus

B.1.1 *Falling weight apparatus*, which shall consist essentially of the following (see Figure 1).

a) *Main frame* rigidly fixed in a vertical position.

b) *Guide rails*, carried on the inside of the main frame and adjustable to keep them parallel and vertical.

c) *Striker*, which may be weighted and which can fall freely within the guide rails. It shall be equipped with a hardened hemispherical striking surface 25 mm in diameter, which shall be free from flats and other imperfections. The combined mass of striker and weight shall be not less than the nominal value given in Table 7, in accordance with the size of pipe to be tested, and shall not exceed that nominal mass by more than 10 % for nominal masses less than or equal to 1.75 kg or by more than 5 % for nominal masses greater than or equal to 2.25 kg.

Table 7 — Mass of striker

Nominal size of the test piece	Nominal mass of weighted striker
	kg
⅜	0.5
½	0.75
¾	1.0
1	1.25
1¼	1.375
1½	1.5
2	1.75
3	2.25
4	2.75
5	3.25
6	3.75
8	5.00
10	6.25
≥ 12	7.50

d) *Test piece support*, comprising a 120° vee-block, at least 230 mm in length, so positioned below the guide rails that the tip of the striker is not more than 2.5 mm from either axis of the vee-block.

e) *Release mechanism*, such that the striker can fall through the test height onto the top surface of the test piece.

f) *Means for maintaining a constant height of fall*, by vertical movement of either the vee-block, the release mechanism or the main frame, in order to accommodate different diameters of pipe.

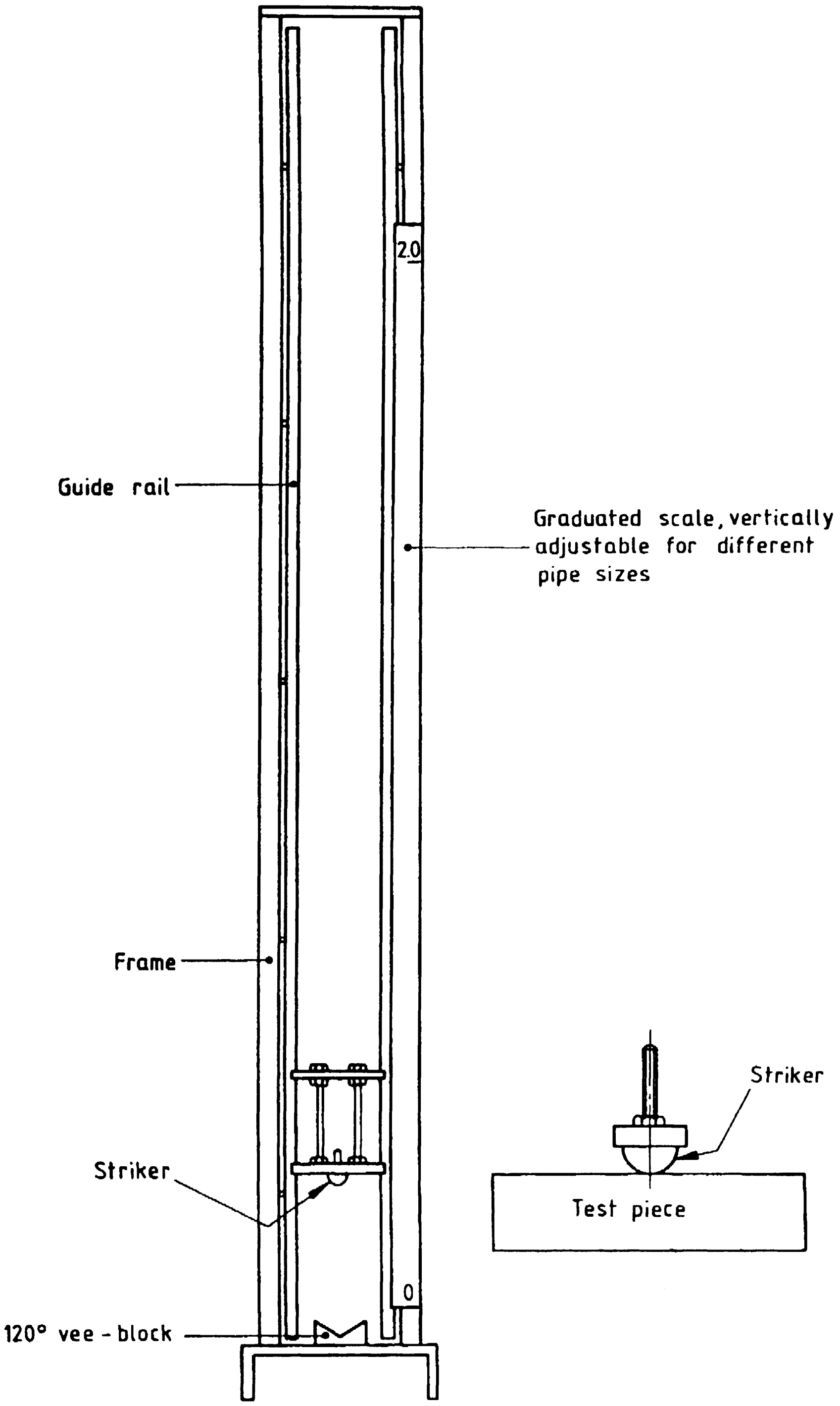


Figure 1 — Suitable type of impact testing apparatus

B.2 Test pieces

Each test piece shall be a length of pipe having undamaged ends cut square to the longitudinal axis. Each test piece shall be a complete section of pipe of a length in millimetres equal to 50 times the nominal size, or 150 mm, whichever is the greater, subject to a maximum length of 300 mm. For nominal size 2 and above, draw a straight line along the entire length of each test piece, randomly positioned on the pipe's circumference. Draw further lines parallel to the first line, equally spacing them around the circumference, to bring the total number to that given in Table 8.

Table 8 — Number of lines to be drawn along test specimens

Nominal size	Number of lines
< 2	0
2	3
3	4
4	6
5	8
6	8
8	12
10	16
12	16
14	16
≥16	24

B.3 Procedure

Condition the test pieces at 20 ± 1 °C for at least 30 min.

Set the falling weight apparatus (**B.1.1**) to give a height of fall of $2\,000^{+10}_{-0}$ mm, measured from the hemispherical striking surface of the appropriately weighted striker [**B.1** c)] to the top of the test piece. Determine the weight to be used according to the pipe diameter [see Table 7 and **B.1** c)].

Within 1 min of removing a test piece from the conditioning environment, place it on the test piece support [**B.1** d)] with one of the marked lines uppermost, where applicable, and allow the weighted striker to fall freely onto the test piece. If the test piece does not fail, as defined by cracking completely through its wall thickness, and subject to its not being out of the conditioning environment for more than 1 min, rotate it until the next line becomes uppermost and in this position strike it again. Repeat this process until each line has been struck once or the test piece has failed. Test further test pieces in the same manner. When any test piece fails, remove it from the machine, record the number of strikes up to the point of failure and recommence the test using a further test piece. Use as many test pieces and strikes as it takes to obtain a conclusion in accordance with **B.4**.

B.4 Determination and interpretation of results

Refer to Figure 2 to compare the number of strikes with the number of failed test pieces and interpret the result as follows.

a) If the true impact rate falls within region C (TIR above 10 %), report the result as a failure.

b) If the true impact rate falls within region A (TIR below 10 %), report the result as a pass.

c) If the result falls on or within the boundaries of region B, the result is indeterminate, in which case continue testing until a positive result is obtained (see note) or until it becomes clear that a result within region A is most unlikely, and in this case report the result as a failure.

NOTE This will usually require a sequence of not less than 10 further blows which produces either no failed test pieces or at least two failed test pieces.

Appendix C Method for the determination of fracture toughness

NOTE 1 References in this appendix to logarithms relate to base e, expressed as "In (value)".

NOTE 2 Guidance on calculation of fracture toughness is given in appendix D.

C.1 Principle

On the basis of the prior response of a test piece of pipe to immersion in dichloromethane, a selected portion of a ring section of a pipe test piece is notched on its internal face and subjected in the form of a "C" profile cantilever to a sustained flexural stress for a specified period. It is then examined for breakage or cracking at the notch.

C.2 Determination of the response to immersion in dichloromethane (previously known as methylene chloride)

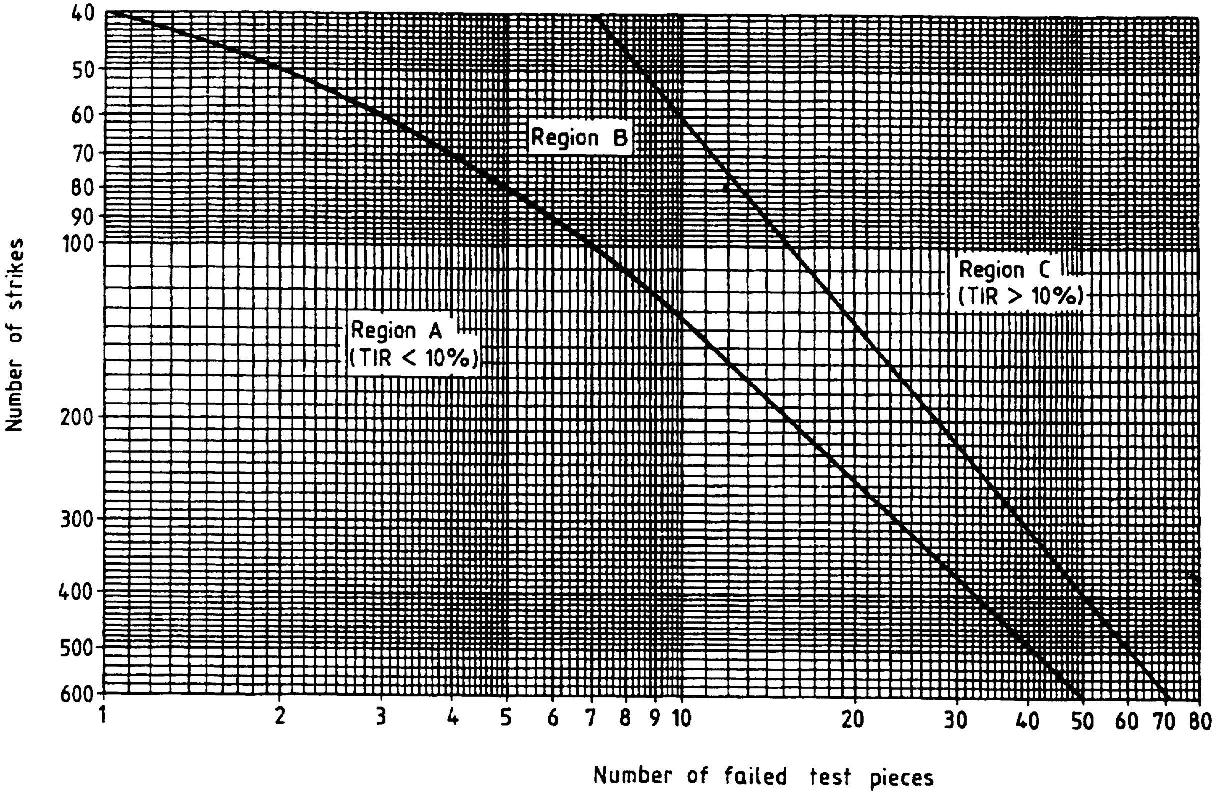
WARNING Dichloromethane liquid is harmful to the skin and eyes and the vapour should not be inhaled.

NOTE Dichloromethane is also known as "methylene dichloride" or "methylene chloride", but "dichloromethane" is the preferred term in accordance with BS 1994 and BS 2474. The latter standard does not include "methylene chloride" as an alternative.

C.2.1 Material

C.2.1.1 *Dichloromethane*, clean and complying with BS 1994. It shall be in use, for the purposes of this test, for not more than three months without complete replacement

NOTE To maintain the cleanliness of the dichloromethane during its 3 months' period of use, it is desirable to filter it at least once every 15 days. If, during that period, the dichloromethane becomes heavily contaminated, additional filtering may be required.



NOTE. *Example of use of graph*

If for 100 strikes there are 20 failed test pieces, the TIR lies within region C and the batch TIR is greater than 10 %, i.e. a failure is recorded.

If for 100 strikes there are 12 failed test pieces, the TIR lies within region B and no decision can be made about pass or failure until further strikes are made. In this case testing is continued until a definite conclusion can be reached.

If for 100 strikes there are 5 failed test pieces, the TIR lies within region A and the batch TIR is less than 10 %, i.e. a pass is recorded.

Figure 2 — Chart for number of strikes needed to obtain a true impact rate (TIR) of 10 % with a 90 % confidence limit

C.2.2 Apparatus

C.2.2.1 *Cutting equipment*, capable of cutting a test specimen of pipe at an angle relative to the pipe axis so as to prepare an external chamfer as required by **C.2.3.4**.

C.2.2.2 *Covered tank*, to contain the dichloromethane and capable of maintaining it at 20 ± 2 °C.

NOTE For construction of the tank, glass and stainless steel have been found to be suitable materials.

C.2.3 Test pieces

C.2.3.1 The initial test piece shall be a pipe at least 200 mm long:

C.2.3.2 Draw a reference line along the complete length of the test piece in such a manner that the pipe is not scored. The ends of the test piece shall be clearly identified.

C.2.3.3 Cut from the test piece a ring of length 30 ± 5 mm in such a manner that the cut surfaces are perpendicular to the longitudinal axis of the pipe. Retain this ring for testing for fracture toughness by the method described in **C.3**.

C.2.3.4 Cut a chamfer on the remaining ring, which is the test piece for the dichloromethane test, in such a manner that the chamfer has a minimum length of 10 mm and penetrates the wall thickness by not less than 90 %.

If the tank is not big enough to take a large diameter pipe, cut the initial test piece longitudinally into sections so marked that the resultant sections can be related to the reference line.

C.2.4 Procedure

C.2.4.1 Place the chamfered end(s) of the test piece in the covered tank (**C.2.2.2**) containing the dichloromethane (**C.2.1.1**), such that the chamfer is completely submerged. Maintain at 20 ± 2 °C for a minimum period of 15 min.

C.2.4.2 Remove the test piece to a well-ventilated area maintained at 20 ± 2 °C until the dichloromethane has evaporated from its surface.

C.2.4.3 Inspect the chamfered surface. In accordance with the following bleaching and whitening classifications, record its response in relation to the reference line.

a) type 1, where the surface exhibits no apparent bleaching or whitening;

b) type 2, where the surface exhibits uniform bleaching or whitening;

c) type 3, where the surface exhibits non-uniform bleaching or whitening, in which case identify the position where the effect of bleaching is greatest.

C.3 Method of test for fracture toughness

C.3.1 Apparatus

C.3.1.1 *Sharp cutting tool*, capable of cutting a notch of uniform depth, such that the tip of the notch has a radius not exceeding 0.05 mm.

NOTE A broach is a suitable tool, subject to regular sharpening at intervals of not more than 1 month during routine use.

C.3.1.2 *Deadweight loading equipment*, suitable for applying a sustained force to the test specimen to satisfy the requirements of **C.3.4**.

C.3.1.3 *Timing device*, accurate to ± 5 s over a period of 15 min.

C.3.1.4 *Measuring equipment*, complying with BS 2782: Method 1101A.

C.3.1.5 *Rigid clamps or rods* to support parts of a ring test piece section profile (see **C.3.2.6** and Figure 3 and Figure 4).

C.3.2 Test piece preparation

C.3.2.1 The test piece shall be derived from the 30 mm long pipe ring prepared as described in the dichloromethane test (see **C.2.3.1** to **C.2.3.3**) as follows.

C.3.2.2 Measure, in accordance with BS 2782: Method 1101A, the mean outside diameter, d_m, of the test specimen to the nearest 0.05 mm.

C.3.2.3 For a test ring from pipe which gave a type 1 or type 2 response in the dichloromethane test (see **C.2**), measure, at the reference line and in accordance with BS 2782: Method 1101A, the wall thickness, e_n, to the nearest 0.05 mm and the width of the test ring to the nearest 1 mm.

Alternatively, for a test ring from pipe which gave a type 3 response, measure, at the area corresponding to that of greatest change (identified using the reference line and pipe ends as data) and in accordance with BS 2782: Method 1101A, the wall thickness to the nearest 0.05 mm and the width of the test ring to the nearest 1 mm.

C.3.2.4 Cut the notch, in the bore of the test ring at the point at which the wall thickness was measured, such that the notch is cut across the complete width, B, of the test ring to a depth of [25 % of the wall thickness, e_n, at that point] ± 0.1 mm (see Figure 3).

C.3.2.5 Cut a segment out of the ring opposite the notch, such that the distance between the ends is 20 ± 2 mm (see Figure 3). The remaining segment shall be the test piece.

C.3.2.6 If clamps (**C.3.1.5**) are used (see the note), ensure that they are fixed within 10 ± 2 mm of the notch tip, as shown in Figure 4.

NOTE It is permissible for clamps to be used to ensure that a controlled bending moment is transmitted to the notched section, and this has been accounted for in the method of calculation given in **C.3.4.2**. It is necessary, however, where clamps are not used, to make an allowance for the bending moment applied to the notched section, in accordance with **C.3.4.3**.

C.3.3 Procedure

C.3.3.1 Condition the test piece, with clamps, if fitted, at 23 ± 2 °C for the applicable period specified in Table 3.

C.3.3.2 Calculate the required mass of the test weightpiece using the applicable method given in **C.3.4**.

C.3.3.3 Support the test piece on the cut-out section opposite the notch and apply a force to the test piece in the form of a hanging weightpiece, as shown in Figure 4. Maintain the force on the test piece in air at 23 ± 2 °C for 15 min or until the test piece fails at the notch by breaking or by developing cracks visible without magnification, whichever period is the shorter.

C.3.3.4 At the conclusion of the test remove the weight-piece from the test piece and record the duration of the test.

C.3.4 Calculation of the mass of the weightpiece

C.3.4.1 Calculate the mass required for the weightpiece in accordance with **C.3.4.2** or **C.3.4.3** as applicable.

C.3.4.2 For a test piece supported by clamps, calculate the mass of the weightpiece (m_w) from the following equation:

$$m_w = F_e \times F_r \qquad (1)$$

where

m_w is the mass (in kg) of the weightpiece, including the mass of the hanger;

F_e is the pipe wall thickness factor from Table 9 corresponding to the measured pipe wall thickness, e_n, in mm;

F_r is the ring geometry factor from Table 10 corresponding to the nominal size of pipe and ring width of the test piece.

If the test piece is mounted in the vertical plane, the mass of the weightpiece shall be reduced to take account of the effective moment of the lower support clamp.

C.3.4.3 For an unsupported test piece, calculate the mass (m_w) of the weightpiece from the following equation:

$$m_w = \frac{F_e B}{A} \qquad (2)$$

where

m_w is the mass (in kg) of the weightpiece, including the mass of the hanger;

F_e is the pipe wall thickness factor from Table 9 corresponding to the measured pipe wall thickness, e_n, in mm;

B is the width (in mm) of the test ring at the point where the notch was cut;

A is the moment arm (in mm) (see Figure 4).

NOTE For a notch cut in accordance with **C.3.2.4**.

$$A = d_m - 0.75e_n \qquad (3)$$

where

d_m is the measured mean outside diameter (in mm) of the test ring prior to the notch being cut;

e_n is the measured wall thickness (in mm) at the notch, including the depth of the notch.

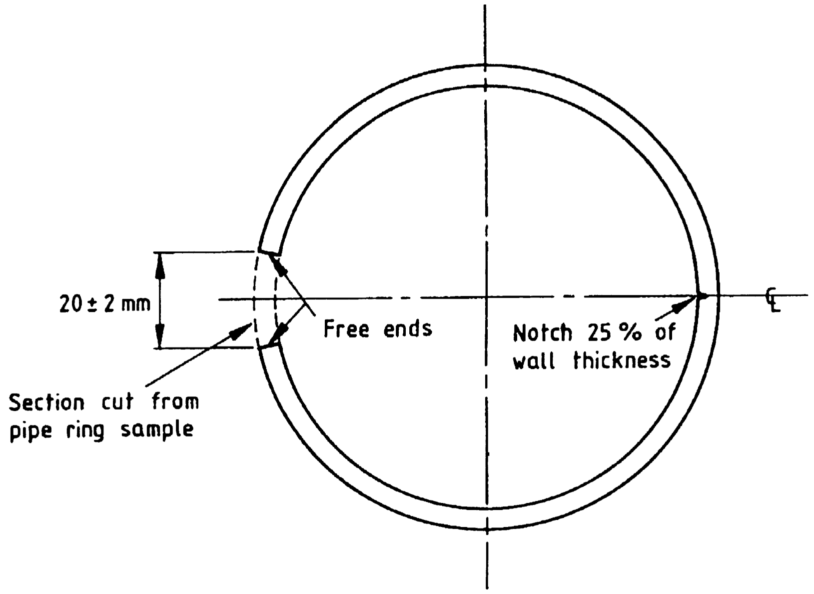


Figure 3 — Fracture toughness test piece

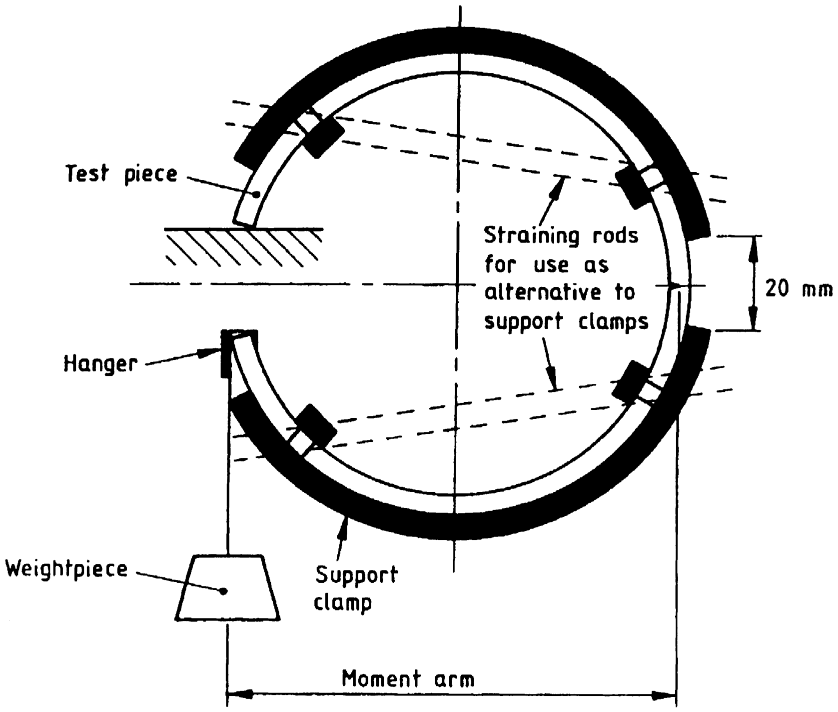


Figure 4 — Typical arrangement of the test piece and equipment for testing for fracture toughness

Table 9 — Pipe wall thickness factor, F_e[a]

Integer pipe wall thickness	Decimal pipe wall thickness (in mm)																			
	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
mm																				
3.00	7.17	7.38	7.60	7.82	8.04	8.26	8.48	8.71	8.98	9.16	9.39	9.63	9.86	10.1	10.3	10.5	10.8	11.0	11.3	11.5
4.00	11.8	12.0	12.3	12.5	12.8	13.1	13.3	13.6	13.9	14.1	14.4	14.7	14.9	15.2	15.5	15.8	16.0	16.3	16.6	16.9
5.00	17.2	17.5	17.8	18.1	18.3	18.6	18.9	19.2	19.5	19.8	20.1	20.4	20.7	21.1	21.4	21.7	22.0	22.3	22.6	22.9
6.00	25.7	26.0	26.4	26.8	27.1	27.5	27.9	28.3	28.6	29.0	29.4	29.7	30.1	30.5	30.9	31.3	31.6	32.0	32.4	32.8
7.00	33.2	33.6	34.0	34.4	34.8	35.2	35.6	36.0	36.4	36.8	37.2	37.6	38.1	38.5	38.9	39.3	39.7	40.1	40.6	41.0
8.00	41.4	41.8	42.3	42.7	43.1	43.5	44.0	44.4	44.8	45.3	45.7	46.2	46.6	47.0	47.5	47.9	48.4	48.8	49.3	49.7
9.00	50.2	50.6	51.1	51.5	52.0	52.5	52.9	53.4	53.8	54.3	54.8	55.2	55.7	56.2	56.6	57.1	57.6	58.1	58.5	59.0
10.00	59.5	60.0	60.4	60.9	61.4	61.9	62.4	62.9	63.4	63.9	64.4	64.9	65.4	65.9	66.4	66.9	67.4	67.9	68.4	68.9
11.00	69.4	69.9	70.4	70.9	71.4	71.9	72.4	72.9	73.4	74.0	74.5	75.0	75.5	76.0	76.6	77.1	77.6	78.1	78.7	79.2
12.00	79.7	80.2	80.8	81.2	81.8	82.3	82.9	83.4	84.0	84.5	85.1	85.6	86.1	86.7	87.2	87.8	88.3	88.9	89.4	90.0
13.00	90.5	91.1	91.6	92.2	92.7	93.3	93.9	94.4	95.0	95.5	96.1	96.7	97.2	97.8	98.4	98.9	99.5	100	101	101
14.00	102	102	103	104	104	105	105	106	106	107	108	108	109	109	110	111	111	112	112	113
15.00	114	114	115	115	116	117	117	118	118	119	120	120	121	121	122	123	123	124	124	125
16.00	126	126	127	128	128	129	129	130	131	131	132	133	133	134	134	135	136	136	137	138
17.00	138	139	139	140	141	141	142	143	143	144	145	145	146	146	147	148	148	149	150	150
18.00	151	152	152	153	153	154	155	156	156	157	158	158	159	160	160	161	162	162	163	164
19.00	164	165	165	166	167	167	168	169	170	170	171	172	173	173	174	175	175	176	177	177
20.00	178	179	179	180	181	181	182	183	184	184	185	186	186	187	188	188	189	190	191	191
21.00	192	193	193	194	195	196	196	197	198	199	199	200	201	201	202	203	204	204	205	206
22.00	206	207	208	209	209	210	211	212	212	213	214	215	215	216	217	218	218	219	220	220
23.00	221	222	223	223	224	225	226	226	227	228	229	229	230	231	232	233	233	234	235	235
24.00	236	237	238	238	239	240	241	242	242	243	244	245	245	246	247	247	248	249	250	251
25.00	252	252	253	254	255	256	256	257	258	259	259	260	261	262	263	263	264	265	266	266
26.00	267	268	269	270	271	271	272	273	274	275	275	276	277	278	279	279	280	281	282	283
27.00	283	284	285	286	287	287	288	289	290	291	292	292	293	294	295	296	296	297	298	299
28.00	300	301	301	302	303	304	305	305	306	307	308	309	310	310	311	312	313	314	315	316

[a] For example, the pipe wall thickness factor for a test piece 15.45 mm thick is determined from the intersection of the 15.00 row and the 0.45 column as 119.

Table 10 — Ring geometry factor, F_r

Nominal size of pipe	Measured width of ring (in mm)										
	25	26	27	28	29	30	31	32	33	34	35
3	0.29	0.30	0.33	0.33	0.34	0.35	0.36	0.38	0.39	0.40	0.41
4	0.23	0.24	0.26	0.26	0.26	0.27	0.28	0.29	0.30	0.31	0.32
5	0.19	0.19	0.21	0.21	0.22	0.22	0.23	0.24	0.25	0.25	0.26
6	0.15	0.16	0.17	0.17	0.18	0.19	0.19	0.20	0.20	0.21	0.22
8	0.12	0.12	0.13	0.13	0.14	0.14	0.15	0.15	0.16	0.16	0.17
10	0.095	0.10	0.10	0.11	0.11	0.11	0.12	0.12	0.13	0.13	0.13
12	0.080	0.083	0.087	0.090	0.093	0.10	0.10	0.10	0.10	0.11	0.11
14	0.073	0.076	0.079	0.081	0.084	0.087	0.090	0.093	0.096	0.099	0.10
16	0.064	0.066	0.069	0.071	0.074	0.076	0.079	0.081	0.084	0.086	0.089
18	0.056	0.058	0.061	0.063	0.065	0.067	0.070	0.072	0.074	0.077	0.079
20	0.050	0.052	0.054	0.056	0.058	0.060	0.062	0.064	0.067	0.069	0.071
24	0.042	0.044	0.045	0.047	0.049	0.050	0.052	0.054	0.055	0.057	0.059

C.4 Reproducibility

This method of test has been accepted by industry in conjunction with the preparation and use of the Water Authorities Association Sewers and Water Mains Committee Information and Guidance Note No. 4-31-04, ISSN 0267-0305. Data are still being gathered to quantify the reproducibility of this test method.

Appendix D Guidance on calculation of fracture toughness

For notch-sensitive materials, including unplasticized polyvinyl chloride, failure may be predicted in the presence of a sharp notch using the linear fracture mechanics model. Where the dimensions of the test piece are large by comparison with those of the notch, failure occurs at a fracture toughness given by the equation:

$$K_c = \frac{3YM}{Be_n^{3/2}} \times 10^{-6} \qquad (1)$$

where

K_c is the fracture toughness (in $MN \cdot m^{-3/2}$).

Y is the geometry correction factor.

NOTE $Y = 1.08 \sqrt{\pi}$ for (notch depth/e_n) = 0.25.

M is the bending moment applied to the test piece (in N·m).

B is the width (in m) of the test ring at the point where the notch was cut.

e_n is the wall thickness (in m) at the notch including the depth of the notch.

For product dimensions in accordance with this standard, a model which compensates for the dimensions of the test piece should be used in conjunction with equation (1) as follows:

$$K_{IC} = \left[-2x^2 \ln \left(\cos \frac{K_c}{x} \right) \right]^{1/2} \qquad (2)$$

where

K_{IC} is the true fracture toughness (in $MN \cdot m^{-3/2}$);

x is $32.56 \sqrt{e_n}$ for notch depth/e_n = 0.25, assuming an ultimate tensile strength of 50 MPa.

To enable tests for higher fracture toughness to be performed if required, the bending moment, M, (in N·m) to be applied for other values of K_{IC} may be calculated by rearranging equations (1) and (2) thus:

$$M = \frac{Be_n^{3/2} x}{3Y} \cos^{-1} \left[\exp \left(\frac{-K_{IC}^2}{2x^2} \right) \right] \times 10^6 \qquad (3)$$

In accordance with custom, for the purposes of equations (1), (2) and (3), values for lengths are based on units in metres. For convenience, a value of true fracture toughness of 3.25 $MN \cdot m^{-3/2}$ or of 3.75 $MN \cdot m^{-3/2}$ has been used as applicable (see **6.6**) to calculate the values given in Table 9 and Table 10, to be compatible with measurement of d_m, B and e_n in millimetres (in accordance with **C.3.2.2** and **C.3.2.3**) for calculating the weightpiece mass in kilograms in accordance with **C.3.4.2** or **C.3.4.3**. In equation (2) appendix C, ($d_m - 0.75\ e_n$), expressed in mm, corresponds to the moment arm illustrated in Figure 4.

Appendix E Quality control testing

The following guidance about the nature of the requirements and test methods specified in this British Standard is provided to assist in the preparation of quality plans for the manufacture of pipes in accordance with this standard.

Type tests are intended to prove the suitability and performance of a material composition, compounding or processing technique or design or size of pipe. Such tests should be performed when a change is made either in material composition or to the design or size or method of manufacture of pipe, but they may be performed more frequently by incorporation into a plan for monitoring the consistency of manufacture.

Quality control tests are carried out during manufacture to monitor the quality of product pipe. Certain test methods and associated requirements have been included because of the practicability and speed with which they may be performed in conjunction with a production process in comparison with some of the type tests.

The primary purposes of the requirements and test methods in this standard are indicated in Table 11. Some of the requirements are relevant to both type and quality control testing, e.g. those for dimensions. Attention is drawn to **4.14** of BS 5750-5:1981, which concerns the use of alternative property determination procedures and equipment for production quality control to the methods specified in this standard, e.g. for on-line monitoring of pipe dimensions.

Because hydrostatic pressure testing is prolonged, guidance is given in the notes to Table 11 on the level of testing agreeable to pipe manufacturers and the UK water industry in respect of type or approval testing or for monitoring satisfactory production.

Table 11 — Primary purposes of requirements and test methods

Property	Clause	Method	Test type	
			Type test	Quality control
Material	**2**		X	
Dimensions	**4**	BS 2782: Method 1101A[a]	X	X
Long-term hydrostatic strength at 20 °C	**5.2.1**	Appendix A	X[b]	X[c]
Long-term hydrostatic pressure resistance at 60 °C	**5.2.3**	BS 4728	X	X[d]
Effect on water quality	**5.3**		X	
Superficial appearance	**6.1.1**			X
Colour	**6.1.2**		X	X
Opacity	**6.1.3**	BS 2782: Method 1104A	X	
Longitudinal reversion	**6.2**	BS 2782: Method 1102A		X
Resistance to delamination	**6.3**	**6.3**		X
Short-term hydrostatic pressure resistance at 20 °C	**6.4**	BS 4728		X
Impact resistance at 20 °C	**6.5**	Appendix B	X	X
Fracture toughness	**6.6**	Appendix C	X	X
Marking	**7**			X

[a] For production quality control, it may be practicable and desirable to use other methods under prevailing conditions, e.g. for continuous on-line monitoring of dimensions. The specified procedures and requirements are applicable to static pipe under corresponding standard conditions to establish compliance with this specification.

[b] Each design stress category (see Table 2) and formulation combination should be subject to a full regression analysis based on a minimum of 18 results (see appendix A) from any pipe size and class combination included in the particular design stress category/formulation combination.

[c] Subject to a type test having been performed, thereafter continuous testing should be carried out for each design stress category/formulation combination, with a minimum of one sample per design stress category/formulation being stressed, based on the manufacturer's regression data to generate a failure after a period greater than or equal to 2 500 h.

[d] Samples should be taken such that each size/class combination manufactured is tested at least once every 24 months.

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Publications referred to

BS 1710, *Specification for identification of pipelines and services*[5].

BS 1994, *Dichloromethane (methylene chloride).*

BS 2474, *Recommendations for names for chemicals used in industry.*

BS 2782, *Methods of testing plastics.*

BS 2782:Method 1101A, *Measurement of dimensions of pipes.*

BS 2782:Method 1102A, *Longitudinal reversion of pipes: immersion bath method.*

BS 2782:Method 1104A, *Measurement of opacity of thermoplastics pipes and fittings.*

BS 4346, *Joints and fittings for use with unplasticized PVC pressure pipes.*

BS 4346-2, *Mechanical joints and fittings, principally of unplasticized PVC.*

BS 4728, *Determination of the resistance to constant internal pressure of thermoplastics pipe.*

BS 4800, *Paint colours for building purposes.*

BS 4901, *Plastics colours for building purposes.*

BS 5556, *General requirements for dimensions and pressure ratings for pipe of thermoplastics materials (metric series).*

BS 5750, *Quality systems.*

BS 5750-2, *Specification for manufacture and installation.*

BS 5750-5, *Guide to the use of BS 5750-2 Specification for manufacture and installation.*

CP 312, *Plastics pipework (thermoplastics materials).*

CP 312-2, *Unplasticized PVC pipework for conveyance of liquids under pressure.*

ISO 161/1, *Thermoplastics pipes for the transport of fluids — Nominal outside diameters and nominal pressures — Part 1: Metric series.*

National Joint Utilities Group Publication No. 4. "The identification of small buried mains and services"[5][6].

"Guidelines for drinking water quality" Vol. 1 "Recommendations" (WHO, Geneva, 1984)[7].

EEC Council Directive of 15 July relating to the quality of water for human consumption (Official Journal of the European Communities L229 pp 11–29)[7].

UK Water Fittings Byelaws Scheme Information and Guidance Note No. 5-01-02, ISSN 0267-0313[5][8].

Water Authorities Association Sewers and Water Mains Committee Information and Guidance Note No. 4-31-04, ISSN 0267-0305[9].

[5] Referred to in the foreword only.
[6] Available from The National Joint Utilities Group, 30 Millbank, London SW1P 4RD.
[7] Available from HMSO.
[8] Available from the Water Research Centre, Water Byelaws Advisory Service, 660 Ajax Avenue, Slough, Berkshire, SL1 4BG.
[9] Available from WRc Engineering, Frankland Road, Blagrove, PO Box 85, Swindon SN5 8YR.

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