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British Standard Specification for

Black polyethylene pipes up to nominal size 63 for above ground use for cold potable water

Tubes en polyéthylène noir de diamètre nominal ⩽ 63 pour canalisations d'eau potable froide non-enterrées — Spécifications

Oberirdisch verlegte Kaltwasserleitungen bis DN 63 aus schwarzem Polyethylen

British Standards Institution

Foreword

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

It introduces a specification for black polyethylene pipes designated by their nominal metric size, up to and including nominal size (DN) 63, for carrying cold potable water. It includes requirements for the effects of materials on water quality, to enable pipes complying with this British Standard to be acceptable to water undertakings. Because of their optimum resistance to ultraviolet (UV) light, black pipes may, for above ground systems, be preferred to the corresponding pipes coloured blue to comply with colour coding for identification of buried thermoplastics utilities services for potable water agreed by the National Joint Utilities Group.

The minimum wall thicknesses in this standard have been calculated using a maximum working stress of 6.3 MPa at 20 °C for the material in pipe form. These thicknesses, which will sustain a working pressure of 12 bar* at 20 °C, are based on data obtained using higher stresses and temperatures and including extrapolation of failure times at 20 °C to a period of 50 years.

Polyethylenes are manufactured by different processes and contain a range and varying quantities of co-monomers, which can result in substantial differences in basic properties, such as melt flow rate, density and creep resistance. Different materials each known to be suitable for the manufacture of pipe in accordance with this standard may not be compatible for fusion jointing, and so the guidance of the manufacturer should be sought before fusion jointing dissimilar materials.

Attention is drawn to CP 312 : Parts 1 and 3, which have been prepared to assist users in assessing the suitability of plastics pipes for particular purposes and to give guidance on their proper application.

The scope of this standard covers part of that of BS 3284, which is obsolescent, and part of BS 1972, which has been amended to relate to above ground uses.

Attention is also drawn to BS 6572 for blue polyethylene pipes up to nominal size 63 for cold potable water for use in below ground systems or otherwise enclosed, to distinguish such pipes from other services and in particular from buried electric cables with black sheathing.

Complementary British Standards for polyethylene pipes for use in cold potable water services for sizes greater than nominal size 63 are in preparation.

A British Standard for fusion joints and fittings for use with pipes complying with this standard, BS 6730, and with the proposed standards for pipes of nominal sizes greater than 63 is in preparation.

A British Standard for copper based compression fittings which will enable pipes complying with this standard, BS 6730, or with BS 6572 to be joined by mechanical means is being prepared as BS 864 : Part 4.

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 the methods of test required by this standard.

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

Compliance with a British Standard does not of itself confer immunity from legal obligations. In particular, attention is drawn to water industry requirements for materials in contact with potable water.

* 1 bar = 10^5 N/m^2 = 0.1 MPa.

Contents

Specification

1 Scope

This British Standard specifies requirements for the composition, physical attributes, performance and identification of black pigmented polyethylene (PE) pipe for use in above ground cold potable water services at pressures up to 12 bar* at 20 °C.

The pipes are specified in nominal sizes 20 to 63 as straight or coiled pipe. Methods of test and information on quality control testing are given in appendices.

NOTE 1. For below ground systems, BS 6572 for equivalent PE pipes characterized by a blue colour is applicable.

NOTE 2. The information on quality control testing is included because of particular features associated with the method of manufacture of these products; adherence to the various clauses of appendix J will facilitate the production of pipes which comply with the requirements of this British Standard.

NOTE 3. The titles of publications referred to in this standard are listed on the inside back cover.

2 Definition

For the purposes of this British Standard, the following definition applies.

ovality. The difference between the measured maximum outside diameter ($d_{y,max}$) and the measured minimum outside diameter ($d_{y,min}$) in the same cross section of the pipe.

3 Dimensions and tolerances

3.1 Nominal size

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

Table 1. Pipe dimensions

Nominal size DN	Mean outside diameter		Wall thickness	
	min.	max.	min.	max.
	mm	mm	mm	mm
20	20.0	20.3	2.3	2.6
25	25.0	25.3	2.3	2.6
32	32.0	32.3	3.0	3.4
50	50.0	50.4	4.6	5.2
63	63.0	63.4	5.8	6.5

3.2 Outside diameter and wall thickness

The mean outside diameters of pipes shall comply with the limits specified in table 1, when determined in accordance with BS 2782 : Method 1101A at a point at least one diameter away from the pipe end.

The wall thickness of pipes shall comply with the limits specified in table 1, when determined in accordance with BS 2782 : Method 1101A at any point around the circumference.

3.3 Ovality

NOTE. The ovality of pipe in coils is assessed in accordance with **3.3.1** or **3.3.2**. The ovality of straight pipe is assessed in accordance with **3.3.2**.

3.3.1 *Pipe in coils as manufactured.* When determined in accordance with appendix A, the ovality, expressed in millimetres, of pipe from coils in the as-manufactured condition shall not exceed the value of 0.06 of the nominal size (DN) of the pipe.

3.3.2 *Pipe in coils after relaxation and straight pipe.* When determined in accordance with appendix A, the ovality, expressed in millimetres, both of pipe from coils subjected to relaxation and of straight pipe shall not exceed the value of 1 + [0.008 of the nominal size (DN) of the pipe].

3.4 Tolerance on length

Each end of the pipe shall be cleanly cut square with the axis to within the tolerances given in table 2. If the lengths of individual pipes or coils are specified, such lengths shall be not less than that specified when determined at 23 ± 2 °C.

NOTE. The preferred lengths of straight pipe are 6 m or 12 m and of coils 50 m, 100 m or 150 m.

Table 2. Out-of-square tolerances for ends

Nominal size DN	Maximum out-of-square of each pipe end
	mm
20 to 32	2
50 to 63	3

3.5 Coil diameters

Coiled pipes shall have a minimum internal coil diameter in accordance with table 3.

Table 3. Coil diameters

Nominal size of pipe DN	Minimum internal coil diameter
	m
20	0.6
25	0.6
32	0.7
50	1.0
63	1.3

* 1 bar = 10^5 N/m² = 0.1 MPa.

4 Compound composition

4.1 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 to 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.

4.2 Base polymer

4.2.1 The base polymer shall be polyethylene, or a copolymer of ethylene and higher olefins in which the higher olefin constituent does not exceed 10 % by mass, with a derived density, as defined in appendix B of BS 3412 : 1976, (as amended by Amendment Nos. 1 and 2) of between 930 kg/m^3 and 944 kg/m^3 inclusive at 23 °C, when determined in accordance with the same standard.

4.2.2 The base polymer shall be in accordance with clauses **4**, **5** and **9** of BS 3412 : 1976 (as amended by Amendment Nos. 1 and 2) in respect of density, melt flow rate, colour variation and impurities.

4.3 Additives

4.3.1 *General.* The base polymer shall include or be blended with such additives (see **4.3.2** for anti-oxidants, **4.4.2** for pigment, **6.3** for UV stabilizers, etc.) as are necessary to produce a compound for the manufacture, storage and use of pipes in accordance with this standard.

The compound shall be in accordance with class W and clauses **4**, **5** and **9** of BS 3412 : 1976 (as amended by Amendments Nos. 1 and 2) in respect of density, melt flow rate, colour variation and impurities.

4.3.2 *Antioxidants.* The compound shall be class W as defined in BS 3412 : 1976 (as amended by Amendment Nos. 1 and 2) and the antioxidants used shall comply with **8.1** and **8.2** of that standard. In addition, with the exception of 6,6′-di*tert*butyl-4,4′-thiodi-*m*-cresol, which shall not be used for the purposes of this British Standard, only antioxidants listed in table 2 of BS 3412 : 1976 (as amended by Amendment Nos. 1 and 2) shall be used.

4.3.3 *Carbon black.* When determined in accordance with the method given in column 3 of table 4, the carbon black shall be in accordance with column 2 of table 4 for the property concerned.

Table 4. Carbon black characteristics

Property	Requirement	Method
Toluene extract	0.10 % by mass max.	Appendix B
Extinction coefficient	0.1 max.	Appendix C
Volatile matter	2 % by mass max.	Appendix D
Particle size or iodine number	0.010 µm to 0.025 µm or ⩾ 110 mg of iodine per g of carbon black	**5.4** of BS 5293 : 1976

4.3.4 *Rework material.* If rework material is added or used, it shall be clean, derived from pipe produced in accordance with this standard and reground under the supervision of the same manufacturer, and it shall be compatible with any materials to which it is added.

4.4 Pipe material

4.4.1 *Conditioning.* Test pieces of pipe material, comprising or taken from samples of pipe, shall be conditioned or preconditioned in accordance with one of the procedures given in appendix E, as appropriate to both the purpose of the test and the references to that appendix in other clauses of this British Standard.

NOTE. The conditioning periods and conditions given in appendix E are considered appropriate to the non-hygroscopic nature of the material, the limited thickness of test pieces required by this British Standard and the need for some data for quality control purposes to be obtained with the minimum of delay.

4.4.2 *Pigment dispersion.* The colour of the pipe shall be black. When tested in accordance with BS 2782 : Method 823B, the numerical ratings for the dispersion for test pieces from carbon black pigmented pipes shall be 5 or less and the uniformity of appearance in respect of smears

and streaks shall be equal to or better than photomicrograph A of figure 1 of BS 2782 : Method 823B : 1978.

4.4.3 *Thermal stability*

4.4.3.1 *General.* The material of which the pipe is made shall meet the requirements of either **4.4.3.2** or **4.4.3.3.**

4.4.3.2 *Residual antioxidant.* The total residual antioxidant content of samples taken across the full wall section shall be not less than 0.02 % (*m/m*), when tested in accordance with BS 2782 : Methods 434B, 434C or 434D.

4.4.3.3 *Induction temperature.* The induction temperature of material in pipe form shall be at least 230 °C when tested in accordance with appendix F.

5 Physical properties

5.1 Appearance

The internal and external surfaces of the pipe shall be free from defects visible without magnification, and the internal surface shall appear to be clean when viewed without magnification.

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

5.2 Hydrostatic pressure resistance

5.2.1 *Hydrostatic pressure resistance at* 20 °C. The pipe shall withstand a pressure equivalent to a circumferential stress of 12.0 MPa for 1 h at 20 ± 1.0 °C, when tested in accordance with BS 4728, using the type of end cap shown in figure 1 of BS 4728 : 1971 and one test piece. The test piece shall comprise a pipe with a free length between end caps of 250 mm minimum and shall be conditioned in accordance with **E.2.**

5.2.2 *Hydrostatic pressure resistance at* 80 °C. The pipe shall withstand a pressure equivalent to a circumferential stress of 4.0 MPa for 170 h at 80 ± 1.0 °C, when tested in accordance with BS 4728, using the type of end cap shown in figure 1 of BS 4728 : 1971 and one test piece, which shall comprise a pipe with a free length between end caps of 250 mm minimum and shall be conditioned in accordance with **E.2.**

5.3 Elongation at break

The value of elongation at break shall be not less than 350 % from each of four test pieces of full wall thickness, taken from positions equally spaced around the circumference of the pipe, when tested in accordance with BS 2782 : Method 320A, using a rate of grip separation of 100 ± 10 mm/min and test pieces prepared in accordance with appendix G.

6 Type test requirements

6.1 General

The requirements given in **6.2** to **6.4** shall be met 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 preceding requirements of this standard.

6.2 Hydrostatic properties

6.2.1 *Long-term hydrostatic strength at* 20 °C. When samples from the smallest and from the largest nominal size of pipe in the manufacturer's range, in respect of this British Standard, are tested in accordance with BS 4728 and the results for each size analysed separately in accordance with appendix H, the following shall apply:

(a) the extrapolated failure time at a stress of 8.3 MPa shall be greater than 50 years;

(b) the 97.5 % lower confidence limit of the failure time at a stress of 8.0 MPa shall be greater than 100 000 h;

(c) no test piece shall fail in a brittle mode without visible yield deformation, as illustrated in figure 1(b), in less than 10 000 h.

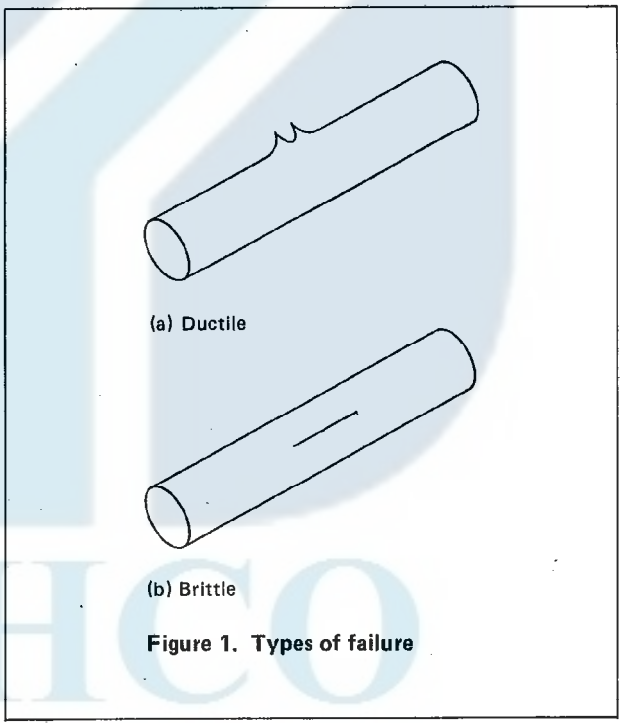

Figure 1. Types of failure

6.2.2 *Hydrostatic pressure resistance at* 80 °C. The requirements of **5.2.2** shall be satisfied by each of five test pieces from each of three pipe sizes, including the largest and smallest sizes from the manufacturer's range in respect of this British Standard.

6.3 Fusibility

The requirements of **5.2.2** shall be satisfied by test pieces of pipe fusion welded to sockets using the manufacturer's recommended technique.

6.4 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 **6.2** and **6.3**, or for a change in material formulation or in the 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 **6.2.1** shall be met.

(b) At failure times up to 2500 h, the requirements of **6.2.1**(a) and **6.2.1**(c) 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 **6.2.1**.

(d) The requirements of **6.2.1** shall be met subsequently by the test pieces under test in accordance with **6.4**(c).

7 Marking

7.1 All pipes shall be indelibly marked, by printing along the pipe in green 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 6730 : 1986*;

(c) the nominal size, as specified in table 1, followed by the letters 'PE' and the pressure rating of 12 bar;

(d) identification of the shift, production line and date of manufacture. Coding of this information is permitted provided that the meaning of the code is available on request.

In addition:

(e) the word 'WATER' shall be marked at regular intervals three times within each metre length.

7.2 The marking shall remain legible under handling, storage and installation procedures in accordance with CP 312 : Parts 1 and 3. Marking by indentation to a depth not greater than 0.15 mm shall be deemed to comply with this clause without infringing the wall thickness requirements of **3.2**.

7.3 The manufacturer shall ensure that all non-compliant pipe is either rejected or not marked with the number of this British Standard.

* Marking BS 6730 : 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.

Appendices

Appendix A. Method for the determination of ovality

A.1 Apparatus

A.1.1 *Measuring apparatus*, as described in BS 2782 : Method 1101A for the outside diameter at any point method.

A.1.2 *Water bath*, having a length, expressed in millimetres, of at least six times the nominal size (DN) of the pipe. (see **A.2.**)

A.1.3 *Heating device*, capable of maintaining the water in the water bath at 80 ± 1 °C. (See **A.2.**)

A.2 Preparation of test piece

If a test piece taken from a coil is to be tested after relaxation (see **3.3.2**), carry out the following relaxation procedure. Cut a test piece to a length, expressed in millimetres, corresponding to five times the nominal size (DN) of the pipe, immerse the test piece in water maintained at 80 ± 1 °C in the water bath (**A.1.2**) and leave for 30 min. Remove the test piece from the water bath and allow it to cool in air without restraint to 23 ± 2 °C.

A.3 Procedure

Use the procedure given in BS 2782 : Method 1101A for the measurement of outside diameter at any point to measure the maximum outside diameter ($d_{y,max}$) and the minimum outside diameter ($d_{y,min}$).

A.4 Calculation

Calculate the ovality, expressed in millimetres, from the following equation.

$$\text{Ovality} = d_{y,max} - d_{y,min}$$

A.5 Test report

The test report shall include the following:

(a) the identification of the test piece;

(b) the ovality (in mm);

(c) the date of the test.

Appendix B. Method for the determination of a toluene extract of carbon black

B.1 Reagent

B.1.1 *Toluene*, of a recognized analytical grade and sulphur free.

B.2 Apparatus

B.2.1 *Extraction thimble*, paper, double thickness, fat extracted.

B.2.2 *Soxhlet apparatus*, in accordance with BS 2071.

B.2.3 *Shallow weighing dish*, 50 mL capacity, of borosilicate glass.

B.2.4 *Desiccator.*

B.3 Procedure

Place 5 g to 8 g of the pelletized carbon black or 2 g to 5 g of the compressed fluffy black under test in a previously weighed extraction thimble (**B.2.1**) and weigh accurately. Record the mass (in g).

Insert the extraction thimble into the Soxhlet extractor and measure 50 mL to 60 mL of toluene (**B.1.1**) into the Soxhlet flask.

Assemble the Soxhlet apparatus (**B.2.2**) and extract for 22 h.

Evaporate successive small portions of the extract solution (filtered if necessary) nearly to dryness in the previously cleaned, dried and weighed 50 mL shallow glass weighing dish (**B.2.3**). Rinse the extraction flask with toluene and add the washings to the weighing dish.

Evaporate the combined extracts on a hot plate to a volume of approximately 5 mL to 10 mL and, finally, dry the dish and contents in an oven at 115 °C, until dry.

Cool in a desiccator to room temperature and weigh. Record the mass (in g).

B.4 Calculation

Calculate the toluene extract, as a percentage, from the following equation.

$$\text{Toluene extract} = \frac{\text{mass of extract}}{\text{mass of sample}} \times 100$$

B.5 Test report

The report shall include the following:

(a) the identification of the carbon black;

(b) the percentage of toluene extract;

(c) the date of the test.

Appendix C. Method for the measurement of the extinction coefficient of the cyclohexane extract of carbon black at λ=386 nm

C.1 Reagent

C.1.1 *Cyclohexane*, of a recognized analytical grade.

C.2 Apparatus

C.2.1 *UV spectrophotometer*, with a recorder.

C.2.2 *Cell*, of optical path length 5 cm.

C.2.3 *Calibrated round-bottomed flask*, 100 mL capacity.

C.2.4 *Measuring glasses.*

C.2.5 *Filters*, having a retentivity to particles in liquids, as defined in accordance with **2.22** of BS 6410 : 1984, of 2.5 μm.

NOTE. A suitable filter is a laboratory filter paper, (i.e. a type 1 filter paper in accordance with appendix A of BS 6410 : 1984) of the specified retentivity, which is ashless and which has a grammage of 85 g/m² to 87 g/m², for use in a supporting funnel. An example of such a filter paper is Whatman No. 42*.

C.3 Procedure

Accurately weigh 1.00 g of the carbon black under test into the calibrated 100 mL round-bottomed flask (**C.2.3**), put into suspension with about 30 mL of cyclohexane (**C.1.1**) and add cyclohexane up to the 100 mL mark. Stopper the flask with a ground glass stopper and leave in a dark room for 24 h at ambient temperature.

Filter part of the supernatant liquid through the filter (**C.2.5**) into the 5 cm path length cell (**C.2.2**), or, if the solution is perfectly clear, decant the solution into the cell. Take the UV spectrum of the clear solution relative to cyclohexane in the region $\lambda = 500$ nm to $\lambda = 250$ nm and, after correcting the base line if necessary, determine the extinction coefficient at $\lambda = 386$ nm.

C.4 Test report

The report shall include the following:

(a) the identification of the carbon black;

(b) the value of the extinction coefficient at $\lambda = 386$ nm;

(c) the date of the test.

Appendix D. Method for the determination of volatile matter from carbon black

D.1 Apparatus

D.1.1 *Oven*, capable of being controlled at 100 ± 2 °C.

D.1.2 *Platinum crucible.*

D.1.3 *Muffle furnace*, capable of being controlled at 950 ± 5 °C.

D.1.4 *Analytical balance*, with an accuracy of 0.1 mg.

D.1.5 *Desiccator.*

D.2 Procedure

Heat the platinum crucible (**D.1.2**) for 5 min at 950 ± 5 °C; cool in the desiccator (**D.1.5**) and weigh.

Place approximately 1 g of the carbon black to be tested in the platinum crucible and place in the oven (**D.1.1**) for 10 min at 110 ± 2 °C; cool in a desiccator and weigh. Reheat the platinum crucible and test sample for a further 5 min at 110 ± 2 °C; cool in a desiccator and reweigh.

Repeat this procedure until masses within 1 mg of each other are obtained consecutively. Record the smaller of these two masses as mass *A* (in g). Heat the crucible and test sample in a muffle furnace for 7 min at 950 ± 5 °C; cool in a desiccator and weigh. Record as mass *B* (in g).

D.3 Calculation

Calculate the amount of volatile matter, as a percentage, from the following equation.

$$\text{Volatile matter} = \frac{A - B}{A} \times 100$$

D.4 Test report

The report shall include the following:

(a) the identification of the carbon black;

(b) the percentage volatile matter;

(c) the date of the test.

Appendix E. Conditioning

E.1 General conditioning

Test pieces shall be conditioned in air at 23 ± 2 °C for not less than 12 h for:

(a) any type test requirement;

(b) any tests performed in case of dispute, to condition test pieces prior to testing at 23 ± 2 °C or to pre-condition test pieces prior to conditioning at other temperatures;

(c) testing by reference to methods which specify a longer period of conditioning at 23 ± 2 °C, with or without controlled humidity, in particular by reference to BS 2782 : Part 0.

E.2 Hydrostatic testing

Except in case of dispute, where test pieces shall first be preconditioned in accordance with **E.1**, test pieces for hydrostatic tests involving liquid immersion shall be conditioned for not less than 1 h in liquid maintained at the temperature required for testing.

E.3 Abbreviated conditioning

Except in case of dispute, where test pieces shall be conditioned in accordance with **E.1**, test pieces shall be conditioned in accordance with any defined procedure for which the effects of any deviation from conditioning in accordance with **E.1** or **E.2**, as appropriate, have been established for the property to be tested.

* This information is given for the convenience of the user and does not of itself constitute an endorsement of the product by the British Standards Institution.

Appendix F. Method for the determination of induction temperature

F.1 Apparatus

A differential scanning calorimeter (DSC) shall be used to determine the induction temperature of the pipe material, using indium as a temperature reference. Except when in conflict with this appendix, the operating instructions of the instrument manufacturer shall be followed.

F.2 Test pieces

Three test pieces of suitable size (depending on the apparatus used) shall be cut across the full wall section of a sample of the pipe.

F.3 Procedure

Place one test piece in one pan of the DSC and a reference sample of indium in a similar pan. Use a heating rate of 10 °C/min in static air to determine the induction temperature of the polyethylene, where the induction temperature is the temperature at which the base line, on a graph of temperature change or heat absorption rate against temperature, intersects a line tangential to the leading slope of the exothermic decomposition peak, as shown in figure 2.

Repeat the procedure for each test piece and record the individual results.

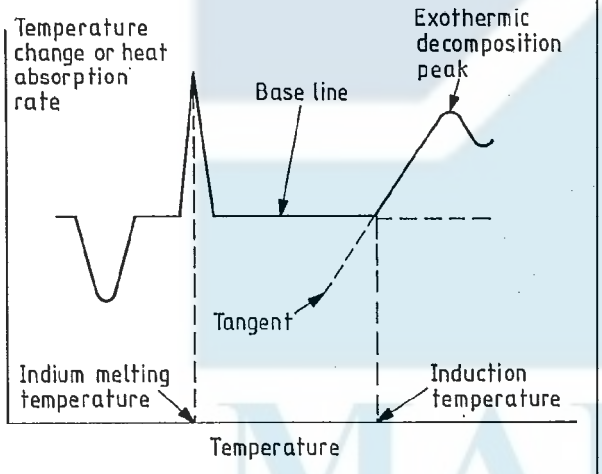

Figure 2. Example of DSC trace

F.4 Test report

The report shall include the following:

(a) the identification of the test pieces;

(b) the individual results, in °C;

(c) the date of the test.

Appendix G. Method for the preparation of test pieces for the determination of elongation at break

G.1 Principle

Dumb-bell test pieces are punched from strips cut from pipe, marked to define a gauge length portion on the waist of the test piece, and conditioned immediately prior to testing.

G.2 Apparatus

G.2.1 *Punches*, having cutting edges with the dimensions given in figure 3 and table 5. The cutting edges shall be sharp and free from notches.

G.2.2 *Marker**, comprising an ink transfer tool having two parallel knife edges 25 mm apart, ground smooth and true, 0.05 mm to 0.10 mm wide at the edge and bevelled at an angle of not more than 15°, together with a source of an ink having no deleterious effect on the material being tested and of a suitable contrasting colour.

G.3 Procedure

G.3.1 Without using heat as an aid to cutting and without permanently flattening the pipe or the test piece, cut four strips of equal width from the pipe, with the long axis of each strip parallel to the long axis of the pipe and offset by 90° circumferentially from any previously cut strip.

NOTE. A piece of pipe long enough to produce a test piece may be opened out sufficiently for the punching out of a test piece after being cut once longitudinally.

G.3.2 Punch test pieces from the centre of the strips, using a single stroke of the punch (**G.2.1**). The thickness of the narrow parallel portion of the test piece (see table 5) shall nowhere deviate by more than 2 % from the mean.

NOTE. The mean and extreme thicknesses of the narrow parallel portion of the test pieces may be determined in accordance with BS 2782 : Method 320A, using a wall thickness measuring apparatus which is in accordance with the requirements of BS 2782 : Method 1101A, so that the circumference of the fixed contact point is parallel to the longitudinal axis of the test piece.

* If pairs of clip-on extensometer markers or jaws which do not physically damage the test pieces are to be used when testing for compliance with **5.3**, then this method of marking is not appropriate.

G.3.3 Without scratching, impressing or otherwise physically damaging the test pieces, provide two reference lines on the narrow portion of the test piece as shown in figure 3, equidistant from its centre and at right angles to its longitudinal axis*.

G.3.4 Except in cases of dispute or for type testing, when **E.1** shall apply, condition the test pieces in accordance with procedure **E.3**.

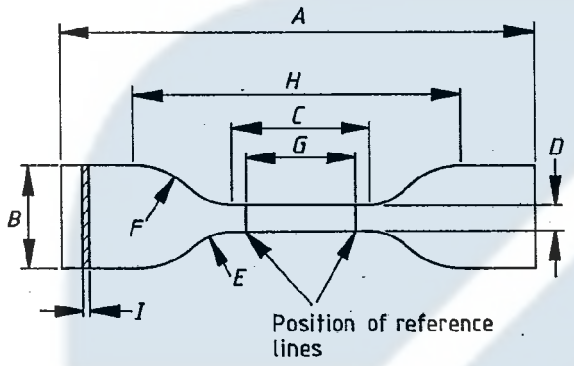

Figure 3. Punched test piece

Table 5. Dimensions of punched test piece

Designation on figure 3	Description	Full size dimensions
		mm
A	Overall length, min.	115
B	Width at ends	25 ± 1
C	Length of narrow parallel portion	33 ± 2
D	Width of narrow parallel portion	$6^{+0.4}_{-0}$
E	Small radius	14 ± 1
F	Large radius	25 ± 2
G	Distance between reference lines	25 ± 1
H	Initial distance between grips	80 ± 5
I	Thickness*	⩽ 12.5

*Although test pieces cut from any pipe covered by the scope of this British Standard will satisfy this requirement, this limitation upon the applicability of the test piece is included to complete the description of the test piece.

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

H.1 Procedure

Obtain at least 18 test results for the calculation of the log (time) versus log (stress) regression line with failure point distribution as given in table 6. Include as failures at the time of testing those test pieces that have not failed after being under test for more than 10 000 h, if they increase the value of the extrapolated time (see **H.2.4** and **H.2.5**).

Table 6. Failure point distribution

Failure time range	Minimum data point distribution	Recommended* data point distribution
h		
> 10 but < 50	2	⩾ 4
⩾ 50 but < 2500	3	⩾ 5
⩾ 2500 but < 6500	3	⩾ 4
⩾ 6500 but < 10 000	2	⩾ 4
⩾ 10 000	1	⩾ 1
Total	11 + 7 others	⩾ 18

*Whilst 18 data points, distributed as shown in column 2, is the minimum pattern required, it is recommended that sufficient data points be obtained so that 18 data points distributed as shown in column 3 are included.

H.2 Calculation of linear regression with one independent variable

H.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:

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

H.2.2 Calculate the following three quantities:

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

* If pairs of clip-on extensometer markers or jaws which do not physically damage the test pieces are to be used when testing for compliance with **5.3**, then this method of marking is not appropriate.

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

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

H.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, the results shall be rejected.

H.2.4 Calculate the mean failure time (in h) at a stress of 8.3 MPa from equation (3).

H.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 8.0 MPa 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_ν is Student's t for $\nu = n - 2$ degrees of freedom, as given in table 7 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 8.0).

H.3 Test report

The report shall include the following:

(a) the identification of the test pieces;

(b) the mean failure time (in h) at stress equal to 8.3 MPa;

(c) the lower 97.5 % confidence limit at stress equal to 8.0 MPa;

(d) the date of the test.

Table 7. Percentage points of Student's t distribution (upper 2½ % points)

ν	t_ν	ν	t_ν	ν	t_ν
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	2.0066	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	1000	1.9623
45	2.0141	90	1.9867	∞	1.9600

Appendix J. Quality control testing

J.1 General

To demonstrate continuing satisfactory quality in day to day production, sampling frequency patterns are recommended in this appendix for the control of start-up operations and of production operations for producing pipe complying with this British Standard.

In addition to 'normal' sampling frequencies specified for determining specific properties following process start-up (see **J.3**), more frequent (tightened) sampling is recommended in the event of material (production batch) or process changes or of unsatisfactory test results, and less frequent (reduced) sampling may be used subject to certain conditions after consistent production of satisfactory pipe has been established.

Alternative methods of measurement to those specified may be used, e.g. automatic equipment for measuring dimensions, provided that any such method is no less stringent than that specified for determining compliance of the pipe with this British Standard.

J.2 Sampling and frequency patterns

J.2.1 Tightened sampling should be applied at a minimum frequency of one sample every 6 h for the parameter(s) in question, when any three consecutive results have been unsatisfactory when obtained using normal sampling.

J.2.2 Normal sampling should be applied at a minimum frequency of one sample every 12 h, unless otherwise recommended by this appendix:

(a) after start-up as given in **J.3**; or

(b) after using tightened sampling, when satisfactory results have been obtained for at least 24 h of continuous production; or

(c) after using reduced sampling, if one or more unsatisfactory results have been obtained.

J.2.3 Reduced sampling frequencies may be applicable by a manufacturer operating a nationally accredited quality system complying with, for example, the requirements of BS 5750 : Part 2. In such circumstances, the reduced sampling frequency should be at a minimum of one sample every 24 h, and should be applicable only after using normal sampling, when satisfactory results have been obtained for at least 24 h of continuous production.

J.3 Start-up procedure

At the start of each production run for each nominal size, or at each change of material formulation, or for each interruption of production greater than 1 h, pipe from each manufacturing machine should be checked for compliance with the following:

(a) dimensions to **E.3** and **3.2** and **3.3**;

(b) appearance to **5.1**;

(c) marking to clause **7.**

When pipe complies with these requirements, samples should be taken and tested for compliance with the following:

(d) short-term hydrostatic pressure test at 20 °C to **E.2** and **5.2.1**;

(e) elongation at break to **E.3** and **5.3.**

When pipe also complies with these requirements, then production to this British Standard is considered to have commenced at the time when the pipe samples which complied with all these requirements were taken.

J.4 Process control tests

J.4.1 General

Following the commencement of pipe production as described in **J.3**, unless otherwise specified in **J.4.2** and **J.4.3**, samples should be taken from each machine in production at least at the normal sampling frequencies stated in **J.2.2.**

J.4.2 Material quality control

J.4.2.1 When material is already compounded and is provided by the material supplier as complying with **4.1** to **4.3**, **4.4.2** and **4.4.3**, then one sample of material in pipe form should be tested, at intervals not exceeding one month of production, for each of the following:

(a) pigment dispersion to **4.4.2**;

(b) thermal stability to either **4.4.3.2** or **4.4.3.3.**

J.4.2.2 When material is prepared by the pipe manufacturer by batch mixing, or by compounding, or where the material is already compounded and is not provided by the material supplier as complying with **4.1** to **4.3**, **4.4.2** and **4.4.3**, then one sample of material in pipe form should be tested at intervals not exceeding 12 h, when normal or tightened sampling is being used, and at intervals not exceeding 24 h when reduced sampling is being used, for each of the following:

(a) pigment dispersion to **4.4.2**;

(b) thermal stability to either **4.4.3.2** or **4.4.3.3.**

J.4.2.3 When material is processed by a continuous mixing method which is part of the extruder lines, then one sample of material in pipe form should be tested at intervals not exceeding 12 h when normal and tightened sampling is being used, and at intervals not exceeding 7 days when reduced sampling is being used, for each of the following:

(a) pigment dispersion to **4.4.2**;

(b) thermal stability to either **4.4.3.2** or **4.4.3.3.**

J.4.3 Product quality control

J.4.3.1 In the case of coils, a minimum of one check should be made on every coil or every 150 m, whichever is the less frequent, or in the case of straight lengths, a minimum of one check should be made at intervals not greater than 1 h for each of the following:

(a) dimensions to **E.3** and **3.2**;

(b) appearance to **5.1**;

(c) marking to clause **7.**

J.4.3.2 One test should be taken at random, at the applicable frequency specified in **J.2** for each of the following:

(a) short-term hydrostatic pressure test at 20 °C to **E.2** and **5.2.1**;

(b) elongation at break to **E.3** and **5.3**;

(c) dimensions to **E.3** and, for coiled pipe, to **3.3.1** only or, for straight pipe, to **3.3.2** and **3.4.**

J.4.3.3 A minimum of one sample from each size of pipe being produced on each extruder should be taken each week or part of a week for testing for each of the following:

(a) pigment dispersion to **4.4.2**;

(b) hydrostatic pressure resistance at 80 °C to **E.2** and **5.2.2.**

J.5 Limitations

In the event of a failure occurring, the production since the previous successful quality control inspection or test, as appropriate, should be checked for the parameter(s) in question and all failures rejected.

J.6 Records

Records of all inspection procedures and test results pertinent to the production of pipe in accordance with this British Standard should be kept by or on behalf of the relevant manufacturer for a minimum period of 10 years.

J.7 Test equipment and facilities

The manufacturers should ensure that equipment and facilities used for sampling and testing pipe or test pieces thereof for the purposes of this British Standard are certified or calibrated to a system satisfying the requirements of BS 5781.

Publications referred to

BS 864*†	Capillary and compression tube fittings of copper and copper alloy Part 4 Specification for compression fittings for polyethylene pipes with outside diameters to BS 5556
BS 1972*	Polythene pipe (type 32) for above ground use for cold water services
BS 2071	Soxhlet extractors
BS 2782	Methods of testing plastics Part 0 Introduction Methods 320A to 320F Tensile strength, elongation and elastic modulus Method 434B Determination of antioxidants in polyolefin compounds by ultra-violet absorption of the chloroform extract Method 434C Determination of antioxidants in polyolefin compounds by ultra-violet absorption of the toluene/ethanol extract in ethanol solution Method 434D Determination of antioxidants in polyolefin compounds by a spectrophotometric method Methods 823A and 832B Methods for the assessment of carbon black dispersion in polyethylene using a microscope Method 1101A Measurement of dimensions of pipes
BS 3284*	Polythene pipe (type 50) for cold water services (obsolescent)
BS 3412	Polyethylene materials for moulding and extrusion
BS 4728	Determination of the resistance to constant internal pressure of thermoplastics pipe
BS 5293	Sampling and testing carbon black for use in the rubber industry
BS 5750	Quality systems Part 2 Specification for manufacture and installation
BS 5781	Measurement and calibration systems
BS 6410	Methods of test for filter papers
BS 6572	Specification for blue polyethylene pipes up to nominal size 63 for below ground use for potable water
CP 312	Plastics pipework (thermoplastics materials) Part 1 General principles and choice of material Part 3 Polyethylene pipes for the conveyance of liquids under pressure

'Guidelines for drinking water quality' Vol. 1 'Recommendations', World Health Organization (WHO), Geneva‡

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 to 29)‡

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

* Referred to in the foreword only.

† In preparation.

‡ Available from HMSO.

§ Available from the Water Research Centre, Water Byelaws Advisory Service, 660 Ajax Avenue, Slough, Berkshire SL1 4BG.

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