

Specification for

Polyethylene pipes for the supply of gaseous fuels

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- British Plastics Federation
- British Plumbing Fittings Manufacturers' Association
- British Valve and Actuator Manufacturers' Association
- Department of the Environment (Property Services Agency)
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- Royal Institute of Public Health and Hygiene
- Society of British Gas Industries
- Society of British Water Industries
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- Water Research Centre
- Water Services Association of England and Wales

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
- Standards Association of Australia

This British Standard, having been prepared under the direction of the Plastics Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on 31 July 1990

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Foreword

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

It introduces a specification for straight and coiled pipes made of polyethylene and intended for use in the conveyance and distribution of natural and manufactured gaseous fuels.

The nominal sizes of the pipes included in this standard range from 16 mm to 500 mm nominal outside diameter and are selected from BS 5556, i.e. metric series, with the addition of one intermediate size (55 mm) of widely established use.

The pressure ratings, which range from 1.5 bar to 8 bar, are based on use of four classes of materials with differing levels of long-term hydrostatic strength, and three different bases for design in respect of the design ratio of minimum outside diameter/minimum wall thickness [known as standard dimension ratios (SDR)] specifically SDR 11, SDR 17.6 and SDR 26. The resulting 12 combinations of material class and pipe SDR provide for nine different pressure ratings and reflect current operating practice, which is only aligned in part with the pressure ratings given in BS 5556.

This specification is based chiefly upon experience with use of such pipes to convey natural gas as available in the UK. Pipes complying with this specification are considered to be suitable also for the conveyance of landfill gas and liquefied petroleum gas provided that the gas composition and the operating conditions are such that the fuel remains at all times in the gaseous state. If other constituents are present and/or condensation of the fuel may affect the performance of the pipe, the maximum allowable working pressure should be carefully evaluated with reference to clause 4 and the note to that clause. Any additional potentially harmful effects to personnel if exposed to the pipeline contents, particularly in the case of landfill gases, should be taken into account.

The requirements of this British Standard for resistance to weathering of the pipe are intended to ensure that the pipe will be satisfactory after storage and handling in accordance with recommended practices prior to installation: it is assumed that in service the pipe will be buried or otherwise protected from direct weathering, for example by shielding.

Attention is drawn to CP 312-1 which gives general guidance on storage, handling and installation of plastics pipes and to CP 312-3 which includes such guidance specific to polyethylene pipes for pressure applications.

Attention is drawn also to booklets IGE/TD/3 and IGE/TD/4 published by the Institution of Gas Engineers¹⁾ which contain detailed guidance on the use of polyethylene pipe systems in the gas industry.

In the preparation of this British Standard, attention has been given to the work of Technical Committee 138 of the International Organization for Standardization (ISO), and in particular ISO 4437, but the requirements of that specification were not considered to be sufficiently stringent for UK application. Attention has also been given to the work aimed at international standardization of methods of extrapolation of data for assessing long-term performance: in the absence as yet of a public ISO document for cross-reference, those aspects of the method relevant to this standard have been summarized or reproduced in Appendix A.

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

¹⁾ Available from the Institution of Gas Engineers, 17 Grosvenor Crescent, London SW1X 2PS

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

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

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

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 30, an inside back cover and a back cover.

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

1 Scope

This British Standard specifies requirements for polyethylene (PE) pipes up to and including nominal outside diameter 500 mm for conveying the following natural and manufactured fuels when in the gaseous state:

- a) natural gas (see BS 1179);
- b) landfill gas (see 2.1);
- c) liquefied petroleum gas (LPG) (including butane and propane; see BS 1179).

Such pipes are intended for use at temperatures between $-20\text{ }^{\circ}\text{C}$ and $+40\text{ }^{\circ}\text{C}$ and at pressures up to and including 8 bar^2 , depending upon the material class, the pipe pressure classification and its particular application (see clause 4, including the note).

This standard is applicable to pipes normally handled and installed as straight lengths and to pipes suitable for storage as, and installation from, coils and intended for applications in which the pipe is buried or otherwise protected from weathering.

It gives requirements for materials, dimensions, physical properties, performance requirements, including resistance to hydrostatic pressure after jointing or squeeze-off and weathering, and marking.

Methods of test piece preparation and/or testing are given in Appendix A to Appendix K.

Information and guidance on quality control testing are given in Appendix L.

NOTE 1 Other gases may have a deleterious effect on the pipe and further testing and evaluation may be necessary.

NOTE 2 The titles of BSI and ISO publications referred to in this standard are listed on the inside back cover. References to publications (other than BSI and ISO publications) are identified in the text by numbers in square brackets and are listed in Appendix M.

2 Definitions

For the purposes of this British Standard, the definitions given in BS 1179 and BS 1755-1 apply, together with the following.

2.1

landfill gas

gas, consisting essentially of a mixture of methane and carbon dioxide, extracted during and following landfill operations

2.2

masterbatch

a well-dispersed mixture of a polymer and high percentages of one or more component(s) (colourants and/or other additives) in known proportions for use in blending in appropriate amounts with the basic polymer in the preparation of a compound

NOTE This definition is in accordance with ISO 472:1988.

2.3

standard dimension ratio (SDR)

for a pipe, the ratio of the specified minimum outside diameter to the specified minimum wall thickness

3 Materials

3.1 Basic materials

3.1.1 The base polymer shall be designated in accordance with BS 3412:1976 (as amended by Amendment Nos 1 and 2) as comprising a type A or type D polymer intended for pipe extrusion and having a conventional density of greater than 932 kg/m^3 at $23\text{ }^{\circ}\text{C}$ when determined in accordance with ISO 1872-1.

3.1.2 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 the acceptable variations in density, melt flow rate and colour variation and of the presence of impurities.

3.2 Additives

3.2.1 General. The base polymer shall include, or be blended with, only such additives (see 6.2.2 for pigment, 6.3 for antioxidants, 7.3 for ultraviolet stabilizers, 7.2.5 for weldability) as are necessary to produce a compound for the manufacture, storage and use of pipes in accordance with this standard.

3.2.2 Masterbatch. If the compound is produced from masterbatch and natural polymer, the masterbatch shall be based upon the natural polymer with which it is to be mixed.

3.2.3 Reworked material. If reworked 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. It shall be based upon the same resin as, and compatible with, any material to which it is added.

²⁾ $1\text{ bar} = 10^5\text{ N/m}^2 = 0.1\text{ MPa}$.

3.3 Compounded material

3.3.1 *Permeability.* When tested in accordance with BS 2782:Method 821A, using test specimens not less than 2 mm thick, the transmission rate per millimetre thickness for methane shall not exceed 75 cm³/m².24 h bar.

3.3.2 *Moisture content.* The compounded material shall be free from visible water.

3.3.3 *Long-term strength and material classification.* When compounded material in the form of pipe is tested in accordance with Appendix A, using reference conditions of 20 °C, 50 years and the 97.5 % lower confidence limit, the long-term hydrostatic strength, i.e σ [293 K, 5.65 (log hours), 0.975] (see A.2.6), shall be not less than 6.3 MPa. The material shall be classified in accordance with Table 1 depending upon the highest limit for the minimum required strength given therein which is exceeded by the measured long-term hydrostatic strength.

Table 1 — Classification of material

Material class	Minimum required strength
	MPa
A	6.3
B	8.0
C	10.0
D	11.2

4 Pressure classification

For the purposes of this standard, pipes are classified in four groups by maximum allowable working pressure, p_w , (see note), as a function of SDR (see 2.3), as shown in Table 2.

Table 2 — Pressure classification of pipes

Material class (see 3.3.3 and 7.2)	Pressure rating at 20 °C		
	Standard dimension ratio		
	SDR 11	SDR 17.6	SDR 26
	bar ^a	bar	bar
A	4	2.5	1.5
B	5.5	3	2
C	7	4	2.5
D	8	4.5	3

NOTE The pressure ratings given in Table 2 are the maximum allowable working pressures that may be sustained for not less than 50 years at a temperature of 20 °C, based on the following calculation.

$$p_w = 20 M/F_s (R - 1)$$

where

p_w is the maximum allowable working pressure (internal, gauge) (in bar);

M is the minimum required strength for the applicable material class in accordance with 3.3.3 and Table 1 (in MPa);

F_s is a design factor, for which a nominal value of 3 has been assumed;

R is the applicable standard dimension ratio (SDR).

The maximum allowable working pressure for a piping system depends on the design factor, which is also governed by many factors other than the material used for the pipe, such as jointing techniques, fitting system, risk of rapid crack propagating failure (see [1]), operating temperatures and the consequences of a failure. Hence a nominal design factor of 3 may not be suitable for all applications and the final design factor for a system should be determined by a designer taking into consideration all the relative factors. For such purposes, attention is drawn to the guidance given in IGE/TD/3 (see [2]) and IGE/TD/4 (see [3]).

5 Dimensions and tolerances

5.1 Nominal size

The nominal size of the pipe shall be the minimum mean outside diameter of the pipe in millimetres and shall be one of the nominal outside diameters (d_o) given in Table 3.

NOTE The “size” of a pipe, or an associated fitting, is a dimensionless number.

5.2 Outside diameter and wall thickness

When determined in accordance with Appendix B, the mean outside diameter and the wall thickness of the pipe shall comply with the limits specified in Table 3 for the relevant nominal outside diameter (size) and standard dimension ratio (SDR) of the pipe.

5.3 Ovality

When measured in accordance with Appendix B, the ovality shall not exceed the applicable limit given in Table 4. For tolerances on ovality after thermal treatment, see 6.4 c).

5.4 Length

Each end of the pipe shall be cleanly cut square with the axis to within the applicable tolerance given in Table 5. If the lengths of individual pipes are specified, such lengths shall be not less than that specified when determined at 23 ± 2 °C.

NOTE 1 The preferred lengths of straight pipe are 6 m or 12 m and of coils multiples of 50 m.

NOTE 2 These tolerances are applied primarily to the ends of lengths of straight pipe; coiled pipe is usually cut during installation to an out-of-square tolerance depending on the type of joint then to be used. Pipe in a nominal size less than 63 is not usually supplied in straight lengths but coiled, hence no tolerance has been established or specified in Table 5 for pipes of nominal size less than 63.

Table 3 — Outside diameter and wall thickness

Nominal outside diameter (d_e) (size)	Mean outside diameter		Wall thickness					
			SDR 11		SDR 17.6		SDR 26	
	min.	max.	min.	max.	min.	max.	min.	max.
mm	mm	mm	mm	mm	mm	mm	mm	mm
16 ^a	16	16.3	2.3	2.6	—	—	—	—
20 ^a	20	20.3	2.3	2.6	—	—	—	—
25	25	25.3	2.3	2.6	—	—	—	—
32	32	32.3	3.0	3.4	—	—	—	—
50	50	50.4	4.6	5.2	2.9	3.3	—	—
(55) ^b	55	55.4	5.1	5.7	—	—	—	—
63	63	63.4	5.8	6.5	3.6	4.1	—	—
75	75	75.5	6.9	7.8	4.3	4.9	—	—
90	90	90.6	8.2	9.2	5.1	5.8	—	—
125	125	125.6	11.4	12.7	7.1	8.0	—	—
140	140	141.0	12.8	14.2	8.0	8.9	—	—
180	180	181.2	16.4	18.2	10.2	11.4	—	—
200	200	201.2	18.2	20.2	11.4	12.7	7.7	8.6
250	250	251.5	22.8	25.2	14.2	15.8	9.7	10.8
280	280	281.6	25.5	28.2	15.9	17.6	10.8	12.0
315	315	316.8	28.7	31.7	17.9	19.8	12.2	13.6
355	355	357.1	32.3	35.7	20.1	22.3	13.7	15.2
400	400	402.3	36.4	40.2	22.7	25.1	15.4	17.1
500	500	502.9	45.5	49.7	28.3	31.3	19.3	21.4

^a The SDR ratings for pipe sizes 16 and 20 are smaller than the indicated nominal value (SDR 11) in order to maintain the minimum wall thickness values indicated in the table (i.e. pipe size 16 shall be marked as SDR 7 and pipe size 20 as SDR 9).

^b A non-preferred size, included because of established use but supplementary to the series given in BS 5556.

Table 4 — Maximum ovality

Form	Nominal outside diameter (d_e) (size)	Maximum ovality
Straight pipe	mm	mm
	≤ 75	$1 + 0.008 d_e^a$
	> 75 to ≤ 250	$0.02 d_e$
Coiled pipe	> 250	$0.035 d_e$
	≤ 180	$0.06 d_e$ for SDR 11
		$0.15 d_e$ for SDR 17.6

^a See Table 3.

Table 5 — Out-of-square tolerances for ends

Nominal outside diameter (d_e) (size)	Maximum out-of-square of each pipe end
mm	mm
63 to 90	2
> 90 to ≤ 140	3
> 140 to ≤ 200	4
> 200 to ≤ 315	5
> 315	7

5.5 Coiled pipe

Coiled pipe shall be acceptable provided that the dimensions of the coil are in accordance with the applicable limits given in Table 6 and that records are available (see Appendix L) to show that the maximum surface temperature of the pipe during coiling was in accordance with Table 6.

6 Physical properties

6.1 General

6.1.1 Conditioning. Coiled pipe shall be maintained in its coiled form for at least 7 days prior to sampling. Subsequently samples taken from coils shall be straightened. Samples taken from coils or straight lengths and test pieces of pipe material shall be conditioned or preconditioned in accordance with one of the procedures given in Appendix C. This shall be appropriate to both the purpose of the test and the references to that appendix in other clauses of this British Standard using minimum conditioning periods in air or liquid as a function of the pipe size and SDR as shown in Table 7.

NOTE The conditioning periods and conditions given in Appendix C are considered appropriate to the thermal conductivity and non-hygroscopic nature of the material and the need for some data for quality control purposes to be obtained with the minimum of delay.

Table 6 — Coil dimensions and winding temperatures

Nominal outside diameter (d_e) (size)	Minimum internal coil diameter	
	SDR 11	SDR 17.6
mm	m	m
16 ^a	0.6	—
20 ^a	0.6	—
25	0.6	—
32	0.7	—
50	1.0	—
(55)	1.3	—
63	1.3	1.9
75	1.5	2.2
90	1.8	2.5
125	2.5	2.5
180	3.0	3.0
	Maximum external coil diameter	
	m	m
All sizes	4.0	4.0
Maximum external surface temperature at time of coiling	35 °C	
^a The SDR ratings for pipe sizes 16 and 20 are smaller than the indicated nominal value (SDR 11) in order to maintain the minimum wall thickness values indicated in the table (i.e. pipe size 16 is marked as SDR 7 and pipe size 20 as SDR 9).		

6.2 Appearance

6.2.1 Surface appearance. When viewed without magnification, the internal and external surfaces of the pipe shall be smooth, clean and free from grooving and other features that would prevent the pipe from complying with this standard.

6.2.2 Pigmentation. The colour of the pipe shall be yellow within the range 10 E 50, 10 E 53, 10 E 55 and 08 E 53 of BS 5252. The appearance of the pipe shall be uniform in colour and opacity. When tested in accordance with BS 2782:Method 1106A using test pieces which represent all levels of the thickness of the pipe wall, the pigment dispersion shall be at least as uniform in appearance as that shown in photomicrograph 2 of Figure 1 of BS 2782:Method 1106A:1983, i.e. appearances similar to or less homogeneous than those shown in photomicrographs 3 to 6 of that figure are unacceptable.

6.3 Oxidation induction time

When tested in accordance with Appendix D, the oxidation induction time shall be not less than 20 min.

6.4 Circumferential reversion

When tested in accordance with Appendix E, the pipe shall satisfy the following requirement(s) as applicable:

- a) for all pipes, when measured at the marks at 1.0 to 1.1 diameters (d_e min.) from the end of the pipe, the average of the two results shall lie within the range given in Table 3 for the mean outside diameter for that size of pipe;
- b) for pipe sizes of greater than or equal to 50, the average of the two results for the mean outside diameters measured at the marks 0.1 diameters (d_e min.) from the pipe ends shall not differ from the average of the two results obtained at 1.0 to 1.1 diameters from the end of pipes by more than the tolerance range given in Table 3 for the mean outside diameter of that size of pipe;
- c) for coiled pipe, after testing in accordance with a) and, if applicable, b), the ovality when measured in accordance with Appendix B shall not exceed the applicable limit given in Table 4 for the corresponding size of straight pipe.

7 Performance requirements**7.1 Tensile properties**

7.1.1 Method 1. For pipes having a wall thickness not greater than 12.7 mm, no individual value for tensile stress at yield or elongation at break shall be less than the applicable limit given in Table 8 with reference to test method 1, for which the following conditions shall apply. The method of test shall be in accordance with BS 2782:Method 320A, using a rate of grip separation of 100 ± 10 mm/min and test specimens prepared in accordance with Appendix F of this standard.

7.1.2 Method 2. For pipes having a wall thickness greater than 12.7 mm, no individual value for tensile stress at yield or elongation at break shall be less than the applicable limit given in Table 8 with reference to test method 2, for which the following conditions shall apply. The method of test shall be in accordance with BS 2782:Method 320C, except for the use of test specimens having a shape and prepared in accordance with Appendix F of this standard and of a grip separation rate of $10 \text{ mm/min} \pm 10\%$ or $12.7 \text{ mm/min} \pm 10\%$.

Table 7 — Conditioning period

Minimum conditioning period		Nominal outside diameter (size)		
in air	in liquid	SDR 11	SDR 17.6	SDR 26
h	h	mm	mm	mm
12	1	≤ 125	≤ 200	≤ 250
24	2	> 125 and ≤ 250	> 200 and ≤ 400	> 250
36	3	> 250 and ≤ 355	> 400	—
48	4	> 355	—	—

7.2 Hydrostatic pressure resistance

7.2.1 Short-term hydrostatic pressure resistance at 20 °C. When tested in accordance with Appendix G, using a test temperature of 20 ± 1 °C after conditioning in accordance with Table 7, the pipe shall withstand the applicable minimum pressures given in Table 9, when the hydrostatic pressure in the test specimen is varied as follows. The pressure is raised steadily over a period of 30 s to 40 s to the applicable hold pressure, maintained at that pressure for 1 h, then raised over a period of not less than 15 s to the corresponding peak pressure and maintained at that peak pressure for 5 s minimum or until prior failure of the test piece.

7.2.2 Hydrostatic pressure resistance at 80 °C. The pipe shall comply with item a) and, as applicable, with item b) as follows.

a) *For unnotched pipe.* When tested in accordance with Appendix G, using a test temperature of 80 ± 1 °C and one unnotched test piece conditioned in accordance with 6.1.1 immediately prior to testing, the pipe shall withstand at least the minimum test pressure given in Table 10 for not less than the corresponding minimum test period given in Table 10.

b) *For notched pipe.* For pipe having a nominal outside diameter of 63 mm or greater, when tested in accordance with Appendix G using a test temperature of 80 ± 1 °C and one test piece notched in accordance with Appendix H to a depth of $20 \pm \frac{0}{1}$ % of the wall thickness in four locations at 90° intervals circumferentially and conditioned in accordance with 6.1.1 immediately prior to testing, the pipe shall withstand at least the minimum test pressure given in Table 10 for not less than the corresponding minimum test period given in Table 10.

Table 8 — Tensile properties

Density ^a of materials	Test method	Tensile stress at yield	Elongation at break
kg/m ³		MPa	%
> 947	1	19	350
	2	18	500
≤ 947	1	15	350
	2	14	500

^a Conventional density (see 3.1.1).

7.2.3 Long-term strength. When tested in accordance with Appendix G, no test piece shall fail in less time than the limits corresponding to the stresses consistent with the minimum regression line which links the applicable minimum required strength at 50 year point and the short-term failure points obtained between 50 h and 150 h.

7.2.4 Hydrostatic pressure resistance following squeeze-off. When tested using an unnotched test piece, in accordance with Appendix G or having a minimum length of 8 d_e (see G.3, whichever is the longer, which has been preconditioned and squeezed in accordance with Appendix I, the pipe shall comply with 7.2.2 a).

7.2.5 Hydrostatic pressure resistance of joints made by butt fusion. When tested using an unnotched test piece in accordance with Appendix G incorporating a butt fusion joint made in accordance with Appendix J, the pipe shall comply with 7.2.2 a).

7.3 Resistance to weathering

After exposure to sunlight in accordance with Appendix K, the pipe shall comply with 6.3 (oxidation induction time), 7.1 (tensile properties), 7.2.3 (long-term strength), 7.2.4 (hydrostatic pressure resistance following squeeze-off) and 7.2.5 (hydrostatic pressure resistance of joints made by butt fusion).

Table 9 — Minimum hydrostatic test pressure

Pipe SDR	Density ^a > 947 kg/m ³ Hold pressure (1 h)	Density ≤ 947 kg/m ³ Hold pressure (1 h)	Peak pressure
	bar ^b	bar	bar
7	49	40	53
9	38	31	41
11	30	24	32
17.6	18	14	19
26	12	9.6	13

^a Conventional density (see 3.1.1).
^b 1 bar = 10⁵ N/m² = 0.1 MPa.

8 Marking

8.1 All pipes shall be permanently and legibly marked along their length with a legend which shall be impressed to a depth of between 0.02 mm and 0.15 mm, using indelible coloured marking which shall be black or dark blue for ratios up to and including SDR 11, red for SDR 17.6 and green for SDR 26.

Pipe up to and including 32 mm nominal outside diameter shall be marked with a single strip and all other pipe sizes shall be marked along two strips on opposite sides of the pipe. The height of the characters shall be uniform and at least the following:

- a) 3 mm for pipe of less than or equal to 90 mm nominal outside diameter;
- b) 5 mm for pipe greater than 90 mm nominal outside diameter.

8.2 The legend shall be repeated at intervals of 1 m and shall consist of the word “GAS” repeated three times at regular intervals within the metre [but see j)], together with the following information once only per metre:

- a) the manufacturer’s identity and identification of the base polymer;
- b) the number and date of this British Standard, e.g. BS 7281:1990³⁾;
- c) the letters “PE”;
- d) the material classification in accordance with Table 1, e.g. class B;
- e) the nominal outside diameter of the pipe (in millimetres);
- f) the letters “MM”;
- g) the letters “SDR” followed by the standard dimension ratio of the pipe;

h) identification of the production line, batch of material and date of manufacture (this may be achieved by the use of a code).

For coiled pipe only, the legend shall include also the following:

- i) a sequential number, increasing at 1 m intervals along the pipe between 000 to 999.

For pipe intended for use conveying landfill gas the following shall apply:

- j) the words “LANDFILL GAS” shall be marked in place of “GAS”.

NOTE Such marking is considered essential because additional precautions against exposure to the pipework contents may be applicable during operation and maintenance of pipework systems for landfill gases, for example because of the possible presence of leachates.

³⁾ Marking BS 7281:1990 on or in relation to a product represents a manufacturer’s declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is therefore solely the responsibility of the person making the claim. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.