British Standard

BRITISH STANDARD

BS 7336:1990

Specification for

Polyethylene fusion fittings with integral heating element(s) for use with polyethylene pipes for the conveyance of gaseous fuels

Committees responsible for this British Standard

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

British Board of Agrément
British Gas plc
British Plastics Federation
British Plumbing Fittings Manufacturers' Association
British Valve and Actuator Manufacturers' Association
Department of the Environment (Building Research Establishment)
Department of the Environment (Construction Industries Directorate)
Department of the Environment (Property Services Agency)
Department of Transport
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
Health and Safety Executive
Institute of Building Control
Institution of Civil Engineers
Institution of Gas Engineers
Institution of Production Engineers
Institution of Water and Environmental Management
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
Society of British Gas Industries
Society of British Water Industries
Water Companies Association
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

The following BSI references relate to the work on this standard:
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Contents

Foreword

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

It introduces a specification for fittings made substantially of polyethylene (PE) but incorporating integral heating element(s) to enable fusion jointing with pipes made with compatible grades of polyethylene and intended for use in the conveyance and distribution of natural and manufactured gaseous fuels.

The nominal sizes of the fittings covered by this British Standard are 16 mm to 500 mm where these sizes indicate compatibility of fit with PE pipes of the corresponding size (and nominal outside diameter) in accordance with BS 7281. The fittings are intended for use under the same range of operating conditions.

The requirements for the electrical components and systems are based upon the design philosophy that the fusion time shall be dependent upon the type and size of the fitting and independent of the grade of PE from which the pipe or fitting is made.

This specification is based chiefly upon experience with use of such fittings to convey natural gas as available in the UK. Fittings complying with this specification are considered to be suitable 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 fitting, 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 pipework contents, particularly in the case of landfill gases, should be taken into account.

The requirements of this British Standard for protection from weathering of the fitting are intended to ensure that the fitting will be satisfactory after storage and handling in accordance with recommended practices prior to installation; it is assumed that in service the fitting will be buried or otherwise protected from weathering.

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

Attention is also drawn to codes of practice IGE/TD/3 [1] and IGE/TD/4 [2], published by the Institution of Gas Engineers[1)], which contain detailed guidance on the use of polyethylene piping 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), but the requirements of the available draft standard 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 of BS 7281:1990.

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.

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.

[1)] Available from the Institution of Gas Engineers, 17 Grosvenor Crescent, London SW1X 7ES.

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 50, 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 fusion fittings made substantially of polyethylene (PE) and incorporating integral heating element(s), where the shape and composition of the fitting is suitable for jointing with PE pipe complying with BS 7281 up to and including nominal outside diameter 500 mm and for conveying the following natural and manufactured fuels in the gaseous state (see note 1):

a) natural gas (see BS 1179);

b) landfill gas (see **2.5**);

c) liquefied petroleum gas (LPG) (including butane and propane; see BS 1179).

Such fittings are intended for use at operating temperatures between 20 °C and + 40 °C and at pressures up to and including 8 bar[2)], depending upon the material class, the pipe pressure classification and the application (see clause **4** of this standard and clause **4** of BS 7281:1990, including the note).

This British Standard is applicable to fittings intended for applications in which the fitting is buried or otherwise protected from weathering.

It gives requirements for materials, design characteristics, dimensions, marking, assembly conditions, electrical connections, power requirements, fusion cycle controls, physical properties and hydraulic performance for individual or assembled fittings, as applicable.

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

Guidance on quality control testing and recommendations for sampling and testing are given in Appendix S and Appendix T respectively.

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

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

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
branch saddle

a lateral fitting which uses ancillary cutters for drilling the hole in the main

2.2
elbow

a curved cylinder enabling a change of direction with a maximum centreline radius of one times nominal bore

2.3
flange adaptor

a spigot fitting used with a seal/gasket and backing ring(s) for making a mechanical joint in a PE piping system

2.4
inner cold zone

for a socket, the distance between the inner end of the fusion coil and the pipe penetration stop of a socket fitting

2.5
landfill gas[3)]

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

2.6
masterbatch[3)]

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

2.7
spigot fitting

a fitting terminating with a cylindrical end stub, the dimensions of which comply with those of the corresponding pipe

2.8
standard dimension ratio (SDR)[4)]

for a pipe or equivalent hollow right cylinder of circular cross section, the ratio of the specified minimum outside diameter to the specified minimum wall thickness

2.9
tapping tee

a lateral fitting that contains an integral cutter which remains in the body of the fitting after installation

[2)] 1 bar = 10^5 N/m^2 = 0.1 MPa.
[3)] Definition consistent with BS 7281:1990.
[4)] Definition consistent with BS 5556:1978.

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 moulding. It shall be in accordance with clauses **4**, **5** and **9** of that standard in respect of the acceptable variation in density (see **3.1.2**), melt flow rate (MFR) (see **3.1.3**) and colour and of the presence of impurities.

3.1.2 When determined in accordance with ISO 1872-1:1986, the conventional density at 23 °C of the base polymer shall be greater than 930 kg/m^3 and not more than 960 kg/m^3 and shall be classified and coded in accordance with Table 2 of ISO 1872-1:1986, i.e. as having a code of 33, 40, 45, 50 or 57.

NOTE In accordance with ISO 1872-1:1986, the manufacturer states which cell will designate the material. If subsequent individual values lie on, or either side of, the cell limit because of manufacturing tolerances (see **3.1.1**), the designation is not affected. The code is applicable accordingly.

3.1.3 Subject to permissible deviations consistent with **4.3**, when determined in accordance with ISO 1872-1 the MFR of the base polymer shall correspond to a nominal value which shall be declared by the fitting manufacturer.

NOTE The effective permissible deviations for the MFR of the base polymer are partly dependent upon the effect on the MFR of the production process for the fitting and should be agreed between the fitting manufacturer and the material supplier.

3.2 Additives

3.2.1 *General.* The base polymer shall include, or be blended with, only such additives (see, for example, **4.1.3** concerning fusibility, **4.2.2** for pigment and **4.4** for anti-oxidants) as are necessary to produce a compound for the manufacture, storage and use of fittings in accordance with this standard.

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

3.3 Reworked material

If reworked PE material is used, it shall be clean, derived from fittings produced in accordance with this standard, which are free from any previously reworked PE material, and shall be reground under the supervision of the same manufacturer. Fittings comprising reworked PE material shall be identifiable as such through reference to the date of manufacture [see **8.1** f)].

3.4 Compounded material

The compounded material shall be free from visible water.

3.5 Heating elements

The following material properties of the integral heating elements shall be declared by the fitting manufacturer:

a) the permissible range of the temperature coefficient of resistance per Kelvin;

b) the permissible range of resistance per unit length (in Ω/m).

NOTE The composition or surface treatment of exposed electrical connections for heater elements is required to be corrosion-resistant (see **4.7**).

4 General requirements for fittings

4.1 Design

4.1.1 *Classification.* The fitting shall be classified with reference to the class of pipe in accordance with BS 7281:1990 as a function of the material type and SDR (see **2.8**) of the pipe with which it is to be used, as shown in Table 1.

Table 1 — Classification of fittings

Material class of pipe in accordance with BS 7281:1990	Pressure rating at 20 °C		
	Standard dimension ratio of the corresponding pipe		
	SDR 11	SDR 17.6	SDR 26
	bar	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 1 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.

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

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 of BS 7281:1990 (in MPa);

F_s is a design factor, for which a nominal value of 3 has been assumed for pipes in accordance with BS 7281;

R is the applicable SDR for the corresponding pipe in accordance with BS 7281.

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 or fitting, such as jointing techniques, fitting systems, risk of rapid crack propagation failure [3], 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 relevant factors. For such purposes, attention is drawn to the guidance given in IGE/TD/3 [1] and IGE/TD/4 [2].

4.1.2 *Nominal size and designation of fittings.* The nominal size of a fitting or of each individual connection thereon shall be designated by the nominal size of the pipe(s) with which it is to be used (see BS 7281). The method of designating the fitting shall be as follows, depending on the type of fitting.

a) *Straight fittings and bends.* For fittings having two unequal ends, the larger end is given first, e.g. 20 × 16.

b) *Tee fittings.* Tee fittings are designated first by the ends on the run, i.e. two ends in the same straight line with, if applicable, the larger of the two being specified first and then by the remaining end, as shown, for example, in Figure 1.

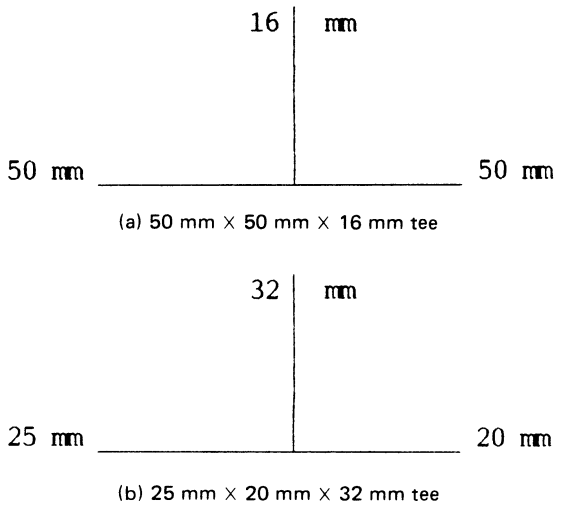


Figure 1 — Example designations for tee fittings

4.1.3 *Fusion jointing.* The fitting shall be capable of being jointed in accordance with the following conditions.

a) For each size and type of fitting produced by a manufacturer, the fusion time at a given voltage shall be selected (see **5.9** and associated tables, as applicable) and declared by the fitting manufacturer. It shall be the same for all pipes to be jointed to that fitting irrespective of the pipe SDR and material, where the pipes comply with BS 7281:1990.

NOTE The combination of the fitting design and the selection of the fusion time and voltage is also subject to constraints imposed in respect of other electrical considerations and of cooling times (see **5.9**).

b) A given type and size of fitting shall be capable of being jointed in accordance with Appendix A with any corresponding pipe in accordance with a), using the applicable fusion time and voltage at – 5 °C and + 23 °C to produce jointed assemblies that comply with clause **7**.

c) A permanent and obvious means of indicating that the joint has been subjected to the fusion cycle shall be provided on the external surface of the fitting, e.g. a fusion indicator.

d) With the exception of fusion indicators [see c)], melt from the fusion operation shall not exude outside the confines of the fitting or into the inner cold zone(s) of the fitting.

e) The fusion process shall not induce any of the following effects:

1) pipe collapse or internal creasing of the bore;

2) voids in the fusion interface that would prevent compliance of the joint with this standard.

f) When assembled subject to cooling and reheating in accordance with pattern 4 of Table A.2, a joint subjected to a single cooling and reheating cycle shall not deteriorate to an extent that would prevent compliance with the production tolerance on the nominal resistance of the heating element in accordance with **5.9.1**, the minimum long-term strength of the joint in accordance with **7.4** or the stress crack resistance of the joint in accordance with **7.5**.

4.1.4 *Means of handling.* For fittings of socket sizes of 250 mm or greater, means shall be provided to facilitate gripping of the fitting for handling purposes.

NOTE Examples of means of handling that have been found to be suitable include tough removable cardboard or film covers with associated straps or handles.

4.2 Appearance

4.2.1 *Surface appearance.* When viewed without magnification, the internal and external surfaces of the fitting shall be free from cracks, voids, blisters, distortion, dents, inclusions or any other such features to an extent that would prevent the fitting from complying with this standard.

4.2.2 *Pigmentation.* The colour of the fitting shall be yellow within the range 10 E 50, 10 E 53, 10 E 55 and 08 E 53 of BS 5252:1976. When tested in accordance with BS 2782:Method 1106A using test pieces which represent all levels of the thickness of the fitting 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 shall be unacceptable.

4.3 Melt flow rate (MFR)

When tested in accordance with ISO 1872-1, using test material representative of the full wall thickness of the thinnest parallel-faced wall section of the fitting, the MFR of material from the fitting shall meet the following conditions:

a) the MFR shall not differ by more than ± 30 % from the nominal value declared in accordance with **3.1.3**;

b) the MFR shall not differ by more than ± 20 % from the actual MFR of the base material used for the production of that fitting.

4.4 Oxidation induction time

When tested in accordance with Appendix D of BS 7281:1990, using test pieces representative of the inner surface, outer surface and mid-wall regions of the fitting, the oxidation induction time shall be not less than 20 min.

4.5 Conditioning and test conditions

Test pieces shall be conditioned in accordance with Appendix B, as appropriate to both the purpose of the test and the references to that appendix in other clauses of this British Standard. For type test purposes or in case of dispute, measurements of physical properties, including dimensions, and the preparation of jointed test piece assemblies shall not be undertaken within 14 days of the manufacture of the fitting or within 7 days of the manufacture of the pipe.

Unless otherwise specified in this standard, tests and measurements shall be conducted at a temperature of 23 °C ± 2 °C.

NOTE The conditioning periods and conditions given in Appendix B 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.

4.6 Dimensions

When determined in accordance with Appendix C the following conditions shall be met:

a) the minimum wall thickness between the mid-points of the fusion zones shall be not less than that appropriate to the internal diameter of the fitting cross section to give the equivalent SDR as that of the pipe in accordance with BS 7281 for which the fitting is intended;

b) the minimum bore diameter at any point between sockets in a fitting, excluding penetration stops, shall be $1.0075d_e$ (in mm) (see note);

c) the minimum bore diameter for any cross section including pipe penetration stops adjacent to a socket shall be not less than the maximum bore diameter of the pipe in accordance with BS 7281 for which the socket is intended.

NOTE Other dimensional requirements are given in respect of particular types of fittings or connections. Some dimensions are specified as a function of d_e, where d_e corresponds to the nominal size and hence the minimum mean outside diameter, in millimetres, of the pipe which the fitting or connection is intended to fit.

4.7 Exposed metal components

Where exposed metal components are used, there shall be no evidence of corrosion of the component(s) after the fitting has been immersed for 7 days at 23 °C ± 2 °C in an aqueous sodium chloride solution, 30 g/L, and then removed from the solution and examined for evidence of rust spots.

NOTE This clause is aligned with test conditions given in BS 4576-1:1989.

4.8 Elastomeric seals

If elastomeric rings are used in joints, they shall comply with the requirements of BS 2494 for joint rings for gas applications.

5 Individual types of fittings or connections

5.1 Sockets

NOTE See **4.5** and **4.6**.

5.1.1 The socket shall have a lead-in at least 5 mm long to ease assembly, as shown in Figure 2. The dimensions of socket fittings or connections shall comply with the limits given in Table 2 and indicated in Figure 2, where

d_s is the average internal diameter of the socket measured over the fusion length, L_f;

L_f is the nominal fusion length and comprises the length of the integral heating element from the first regular section of the element to the end of the regular section, on one side of the fitting, when measured from outside edge to outside edge of the wire;

L_1 is the depth of the penetration of the pipe or the male end of a spigot fitting.

5.1.2 When measured in accordance with Appendix C, the ovality within the bore of a socket shall be not greater than $0.015d_e$.

5.1.3 The minimum bore diameter at any point in a socket, excluding penetration stops, shall be $1.0075d_e$.

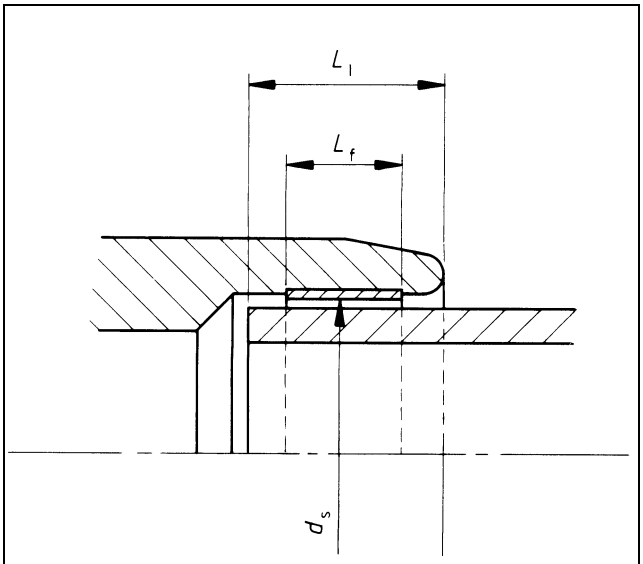


Figure 2 — Socket and coupler dimensions

5.2 Couplers

5.2.1 *General.* Straight couplers shall incorporate a means of preventing pipe penetration beyond the socket. The means shall not prevent use of couplers with longitudinally restrained pipes in a repair situation, i.e. it shall be possible to slide the coupler onto one pipe end far enough to allow the pipe ends to be aligned and the movement of the coupler reversed until it overlaps both pipe ends in position to be jointed.

NOTE See **4.5** and **4.6**.

Table 2 — Socket and coupler dimensions

Pipe size (d_e)	Measured over nominal fusion length, L_f				Nominal fusion length, L_f	Nominal overall length of couplers, L_c
	Limits for average internal diameter on each fitting, d_s		Depth of penetration of the pipe or spigot end, L_1			
	max.	min.	max.	min.	min.	max.
(mm)	mm	mm	mm	mm	mm	mm
16	16.6	16.4	41	27	15	82
20	20.6	20.4	41	28	16	82
25	25.6	25.4	41	30.5	18	82
32	32.9	32.5	41	31.5	18	82
40	41.0	40.6	49	32	18	98
50	51.1	50.7	50	35	20	100
55	56.1	55.7	59	36.5	21	118
63	64.1	63.7	59	39	23	118
75	76.3	75.9	62.5	42.5	25	125
90	91.5	91.1	77.5	47	28	155
110	111.6	111.1	82	53	32	164
125	126.7	126.2	85.5	57	35	171
140	141.7	141.2	92	57	38	184
160	162.1	161.4	98	67	42	196
180	182.1	181.5	105	69	46	210

5.2.2 ***Sizes up to and including 180 mm***

5.2.2.1 The maximum overall length, L_c, shall comply with the limit specified in Table 2.

5.2.2.2 The length of each inner cold zone shall be not less than $0.1d_e + 5$ mm for sizes up to and including 125 mm and $0.1d_e$ for larger sizes.

5.2.3 ***Sizes over 180 mm***

5.2.3.1 The maximum overall length, L_c, shall be $0.66d_e + 90$ mm (see Figure 2).

5.2.3.2 The minimum average internal diameter, d_s, shall be greater than the maximum mean outside diameter specified in BS 7281 for the corresponding size of pipe.

The maximum average internal diameter of the nominal fusion lengths of the coupler shall be such that when the coupler is assembled and tested in accordance with Appendix D, using pipes subject to a mutual axial angular deflection of not less than 1.5°, the following conditions are satisfied:

a) the maximum force required to position the coupler shall not exceed 500 N;

b) the heating element(s) shall not be dislodged;

c) the fused assembly shall comply with the peel test failure mode requirements of **7.2.2**.

The manufacturing tolerances on the mean internal diameter of the coupler shall be declared by the manufacturer.

5.2.3.3 Each nominal fusion length, L_f (see Figure 2), shall be greater than 50 mm.

5.2.3.4 The length of each inner cold zone shall be not less than $0.1d_e$ (in mm).

5.3 Reducers

5.3.1 ***General***

NOTE See **4.5** and **4.6**.

5.3.1.1 There shall be no sudden step changes of internal diameter.

5.3.1.2 Reducers shall incorporate a means of preventing pipe penetration beyond the smaller socket during installation.

5.3.2 ***Sizes with a major diameter up to and including 180 mm***

5.3.2.1 The minimum average internal diameter, d_s, and minimum nominal fusion length(s) shall comply with the limits specified in Table 2 and indicated in Figure 2 if applicable and otherwise the minimum average internal diameter at any point shall comply with **4.6**, where d_e is that of the smaller pipe with which the reducer is to be used.

5.3.2.2 The maximum overall length shall comply with the applicable limit specified in Table 3.

5.3.2.3 The length of the inner cold zone for each socket shall be not less than $0.1d_e + 5$ mm for sizes up to and including 125 mm and for larger sizes shall be not less than $0.1d_e$.

5.3.3 ***Sizes with major diameters over 180 mm***

5.3.3.1 The maximum overall length shall comply with the applicable limit specified in Table 3.

Table 3 — Overall length of reducers

Major diameter	Maximum length	Major diameter	Maximum length
mm	mm	mm	mm
32	105	200	245
50	105	225	260
55	120	250	280
63	120	280	300
75	140	315	320
90	180		
125	215		
140	215		
180	280		

5.3.3.2 The minimum average internal diameter, d_s, shall comply with the relevant limit specified in Table 2, if applicable, or shall be greater than the maximum outside diameter specified for the corresponding pipe in accordance with BS 7281.

The manufacturing tolerances on the average internal diameters of the reducer shall be declared by the manufacturer.

5.3.3.3 The nominal fusion lengths shall comply with the relevant limit(s) given in Table 2, if applicable, or shall be greater than 50 mm.

5.3.3.4 The length of the inner cold zone for each socket shall be not less than $0.1d_e$.

5.4 In-line electrofusion tees and associated spigots

NOTE See **4.5** and **4.6**.

5.4.1 The minimum average internal diameter, d_s, and the minimum nominal fusion lengths shall comply with the limits specified in Table 2 and indicated in Figure 2 if applicable and otherwise the minimum average internal diameter at any point shall comply with **4.5**, where d_e shall be the diameter of the smaller pipe.

5.4.2 The outlet spigot length shall comply with the applicable limit specified in Table 4. Over the minimum spigot length, the dimensions of the fitting shall comply with the requirements for the corresponding size of pipe in accordance with BS 7281.

5.4.3 The maximum overall length of the in-line electrofusion portion of the fitting shall be $2d_e + 90$ mm.

5.4.4 The length of the inner cold zones for each socket shall be 0.1 d_e + 5 mm for sizes up to and including 125 mm and for larger sizes shall be not less than 0.1d_e (in mm).

5.4.5 The fitting shall incorporate a permanent means of controlling pipe penetration within the socket, such as to prevent obstruction of the tee outlet, as shown in Figure 3.

5.4.6 The pressure loss across the fitting shall be less than 1.5 times the velocity head, when measured between the main pipe and the branch outlet with the main extension blanked off and determined in accordance with Appendix E using a nominal line pressure of 25 mbar at flow velocities of 1.5 m/s, 3 m/s, 5 m/s and 7.5 m/s.

5.4.7 The orientation of the terminal shrouds (see **5.9.3**) shall be as shown in Figure 4.

5.5 Elbows

NOTE See **4.5** and **4.6**.

5.5.1 The maximum overall length of the intersection of the fitting centre line to the mouth of the socket shall be d_e + 45 mm.

5.5.2 The length of the inner cold zone for each socket shall be 0.1d_e + 5 mm for sizes up to 125 mm and for larger sizes shall be not less than 0.1d_e (in mm).

Table 4 — Dimensions of spigot connections

Pipe/fitting size	Tubular length, L_2	Pipe/fitting size	Tubular length, L_2
	min.[a]		min.[a]
(mm)	mm	mm	mm
16	46	125	87
20	46	140	92
25	46	160	98
		180	105
32	46	200	112
50	49	250	130
55	55	280	140
63	63	315	150
75	70	355	165
90	79	400	180
110	82	500	212

[a] Actual spigot lengths should take account of couplers and use of installation tools, e.g. scrapers and pipe clamps.

5.5.3 The fitting shall incorporate a means of preventing pipe penetration beyond the socket, as indicated in Figure 3.

5.5.4 For fittings of sizes up to and including 180 mm, the pressure loss across the fitting, when determined in accordance with Appendix E using a nominal line pressure of 25 mbar at flow velocities of 1.5 m/s, 3 m/s, 5 m/s and 7.5 m/s, shall comply with the applicable limit as follows:

a) for 45° elbows, the pressure loss shall be less than 0.5 times the velocity head;

b) for 90° elbows, the pressure loss shall be less than 1.0 times the velocity head.

5.5.5 The orientation of the terminal shrouds (see **5.9.3**) shall be as shown in Figure 4.

5.6 Tapping tees

5.6.1 All fittings shall be capable of installation by using a force generated from above and on the centreline of the tapping tee stack, where the force applied to the fitting shall be in the range 1 000 N to 1 500 N.

5.6.2 Tapping tee outlets shall be spigot type. The outside diameter shall be either 32 mm $^{+0.3}_{-0}$ mm over a minimum spigot length of 46 mm or 63 mm $^{+0.4}_{-0}$ mm over a minimum spigot length of 70 mm. The spigot wall thickness shall comply with the limits given in Table 3 of BS 7281:1990 as applicable for the size and SDR of the corresponding outlet pipe.

5.6.3 The minimum wall thickness at any point of the fitting shall comply with the limit given in Table 3 of BS 7281:1990 as applicable for the size and SDR of the corresponding outlet pipe.

5.6.4 The tapping tee cap design shall incorporate means for the easy removal and replacement of the cap from an above-ground position. It shall be capable of passing all tests required of the fittings without additional fastenings or constraints when tightened with a torque of 4 N·m. It shall not fail by cracking when a torque of 15 N·m is applied.

5.6.5 If an "O" ring is used as a seal, it shall remain in position when the cap is removed and replaced.

5.6.6 Tapping tees shall provide a means of cutting through the pressurized main pipe and allowing gas to flow into the outlet pipe without allowing uncontrolled leakage of gas to atmosphere to occur.

The cutting device shall be capable of cutting the pressurized pipe over the range of temperatures – 5 °C to 23 °C without producing any swarf and so that the coupon is retained by the cutting device. For pipe sizes up to 180 mm, SDR 17.6, the operating torque applied at 5 turns/min shall not exceed 45 N·m. For larger pipe sizes, torque values shall be declared by the manufacturer.

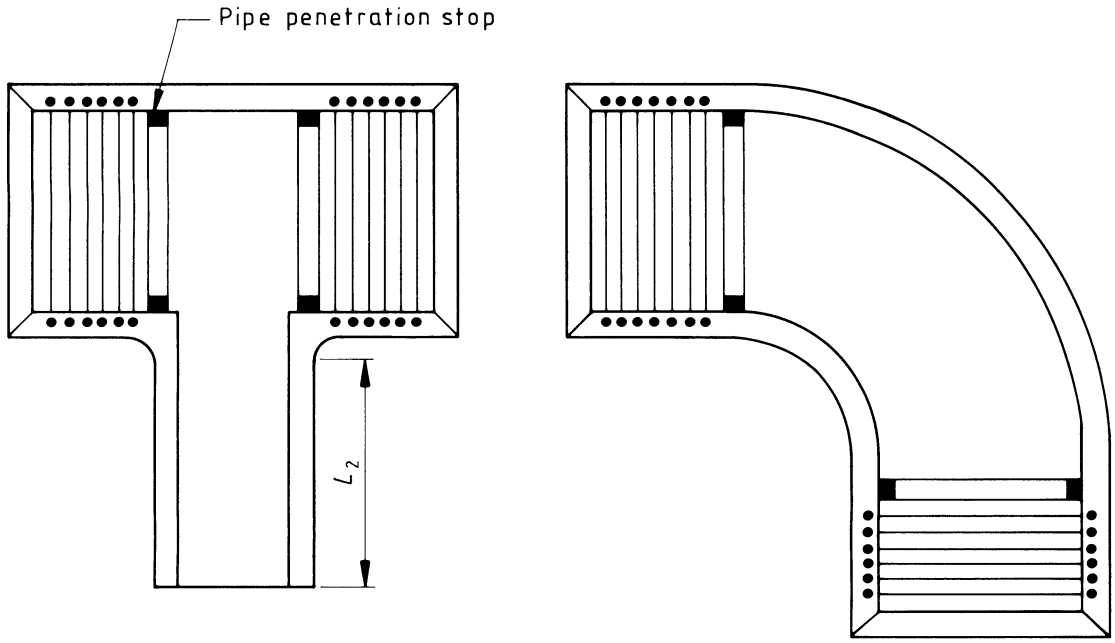


Figure 3 — Control of pipe penetration

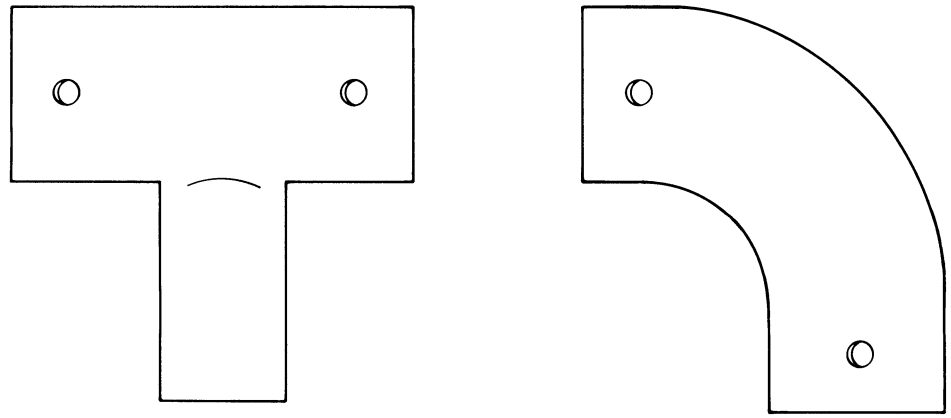


Figure 4 — Orientation of terminal shrouds

The integral cutter shall have a socket key recess of minimum depth 16 mm. The cutter shall be operated by a 12 mm hexagonal key having a cross section in accordance with BS 4168-9:1983 when s = 12. The key shall not include a thread follower.

NOTE 1 The length of the key is not restricted to the limits given in BS 4168-9.

NOTE 2 The key specified corresponds to a 12 mm AF key.

5.6.7 The fitting shall have the integral heating element clear of the path of the cutter. The fusion sealing width, i.e. the distance between the inner and outer turns, at any point of the fusion face shall be not less than 15 mm. The maximum saddle base dimension, along the main, for tapping tees of 32 mm outlet shall be 120 mm and for a 63 mm outlet shall be 200 mm.

5.6.8 The design of the tapping tee shall include provision for pressure testing of the connected service pipe and the fusion interface between the pipe and fitting without removal of the cutter prior to tapping the main.

5.6.9 When tested in accordance with Appendix F at a working pressure of 25 mbar ± 1 mbar with the applicable flow rate given in Table 5, the pressure drop for the appropriate gas shall not exceed the value given in Table 5.

Table 5 — Pressure drop through saddle connections

Fitting outlet size	Flow rate of methane[a]	Pressure drop across fitting[b] as service pipe velocity heads
mm	m^3/h	
32	4.3	4
63	18	4

[a] Corrected to standard temperature and pressure.
[b] Including electrofusion fitting fused to spigot outlet.

5.7 Branch saddles

5.7.1 For spigot outlet sizes up to and including 63 mm, the fitting shall be capable of installation by using a force generated from above and on the centreline of the branch saddle spigot, where the force applied to the fitting shall be in the range 1 000 N to 1 500 N. For outlet sizes greater than 63 mm, other methods of loading shall be permissible provided that the resultant joint complies with clause **7**.

5.7.2 For 90 mm nominal size and above, branch saddle outlets shall be either spigotted or flanged. Branch saddle outlets smaller than 90 mm shall be spigotted. A spigotted outlet shall have a minimum length, L_2, complying with the applicable limit given in Table 4. The length of a flanged outlet, when measured from the face of the stub flange to the crown of the main, shall comply with the applicable limit given in Table 6.

5.7.3 Any butt-fused assembly shall have both the internal and external beads removed.

5.7.4 The flanged portion on branch saddles shall comply with **7.6**.

Table 6 — Dimension from stub flange face to crown of the main

Flanged fitting	Shut-off method	Dimension	
		min.	max.
mm		mm	mm
90 off 125	Valve	230	254
90 off 125	Squeeze	1 255	1 275
125 off 180	Valve	204	228
125 off 180	Squeeze	1 255	1 275

5.8 In-line electrofusion flange adaptors

The electrofusion portion of the flange adaptor shall match the dimensional characteristics of a straight coupler of half length (see **5.2**). The flanged portion on branch saddles shall comply with **7.6**.

5.9 Electrical

5.9.1 For each size and type of fitting, the manufacturer shall declare the nominal resistance of the heating element and specify the production tolerance and limits for that resistance.

When joints are made using the two extremes respectively of the tolerance band for assembly and inspection in accordance with Appendix G, the following conditions shall be met:

a) the sectioned test assembly shall show no signs of collapse of the pipe or of creasing of the pipe bore;

b) sections from the joint shall comply with **7.2** as applicable.

5.9.2 The maximum power requirement for socket fittings up to and including 180 mm and for all saddles shall be 2 kW at 40 V r.m.s. and the fitting voltage supply shall be 39 V r.m.s. to 40 V r.m.s. Except in the case of socket fittings with a major diameter of up to 250 mm, which may be fused at 40 V r.m.s. provided that the power requirement does not exceed 2 kW, the maximum power requirement for socket fittings above 180 mm major diameter(s) shall be 4 kW at 80 V r.m.s. and the fitting voltage supply shall be 78 V r.m.s. to 80 V r.m.s.

The fitting fusion time shall be selected by the manufacturer from Table 7 or Table 8 as appropriate and declared [see **4.1.3** a)]. When selecting the fusion time, consideration of joint cooling time before handling is necessary such that the following conditions shall be met:

a) when determined in accordance with Appendix H, the maximum cooling time for fittings up to and including 180 mm size shall not exceed 20 min;

b) for sizes above 180 mm, the maximum jointing time (i.e. fusion plus cooling time) shall be declared by the manufacturer.

5.9.3 All fittings shall have mechanically shrouded male electrical terminals (see note 1). Fitting terminals and shrouds shall comply with the dimensions given in Figure 5(a) to Figure 5(c), where Figure 5(a) is applicable to connections unrelated to the fusion time to be used and Figure 5(b) and Figure 5(c) are applicable to connections in which the angular displacement of the inner key with respect to the outer slot is indicative of fusion times given in Table 7 or Table 8 as appropriate (see note 2).

The terminal pins shall have an upper limit for surface roughness of R_a 0.8 µm when determined in accordance with BS 1134-1. If hollow terminal pins are used, the hole at the top of the pin shall be less than 1 mm in diameter.

NOTE 1 Consideration should be given to the design of the shroud with respect to impact damage.
NOTE 2 The relative angular positions of the key and the slot are not restricted by this standard and should therefore be agreed between the purchaser and the supplier as necessary.

5.9.4 For fittings having two sockets of sizes up to and including 355 mm, the circuit connections shall be such that both sides of socket fittings shall be fused in one operation.

5.9.5 The heating elements shall be designed to prevent short circuiting or local overheating during the fusion operation. Any protective coatings applied to the heating element shall not prevent compliance of the joint with clause **7**.

5.9.6 The heating element wire shall not be disturbed during assembly in accordance with Appendix A.

5.9.7 The indicators [see **4.1.3** c)] shall not operate if any wire becomes open circuit during the first 50 % of the fusion cycle in accordance with Appendix A.

Table 7 — Fusion times for 40 V systems

Fusion time					
s	s	s	s	s	s
20	32	46	85	160	300
22	34	50	90	180	360
24	36	55	110	200	400
26	40	60	120	220	440
28	42	70	130	240	500
30	44	80	140	260	600

Table 8 — Fusion times for 80 V systems

Fusion time					
s	s	s	s	s	s
200	320	440	560	680	800
220	340	460	580	700	820
240	360	480	600	720	840
260	380	500	620	740	860
280	400	520	640	760	880
300	420	540	660	780	900

6 Long-term dimensional stability of individual fittings

6.1 Couplers and other forms of socket fittings

After storage for 12 months at 30 °C ± 20 °C, the fitting shall comply with either a) or b) as follows:

a) the fitting shall remain within all applicable dimensional limits of this standard (see note);

b) the fitting shall comply with the following conditions:

1) the average internal diameter shall comply with the applicable limit;

2) the fitting shall be capable of assembly by hand and jointing to pipe at 23 °C ± 2 °C in accordance with Appendix A;

3) fittings jointed in accordance with 2) shall comply with **7.5**.

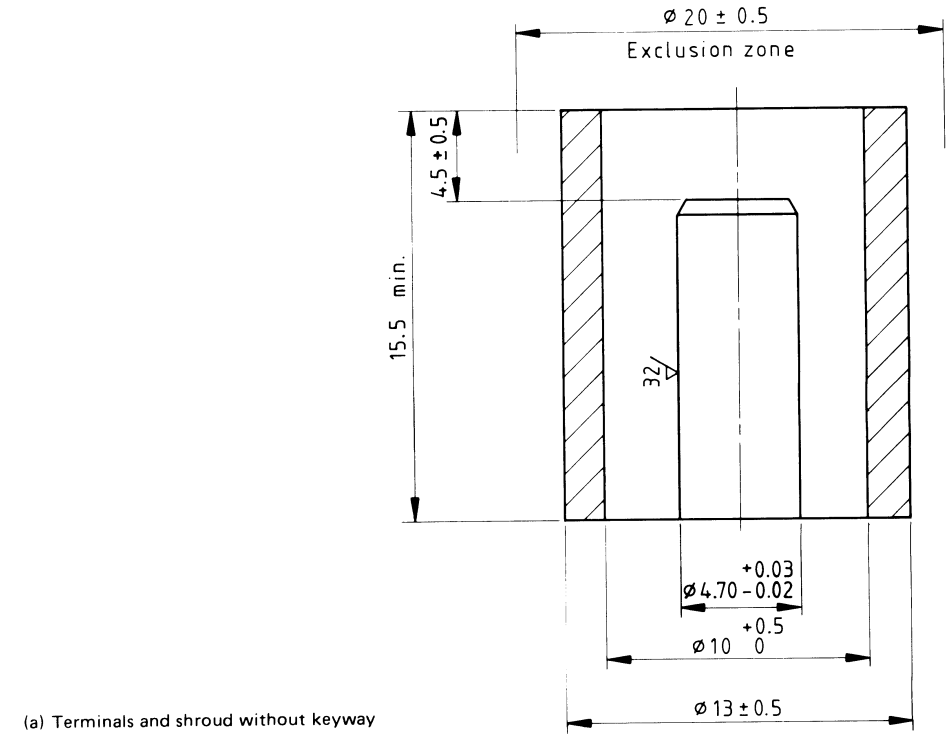
NOTE Specified or declared limits apply. See, for example, **5.2.2**.

6.2 Tapping tees and branch saddles

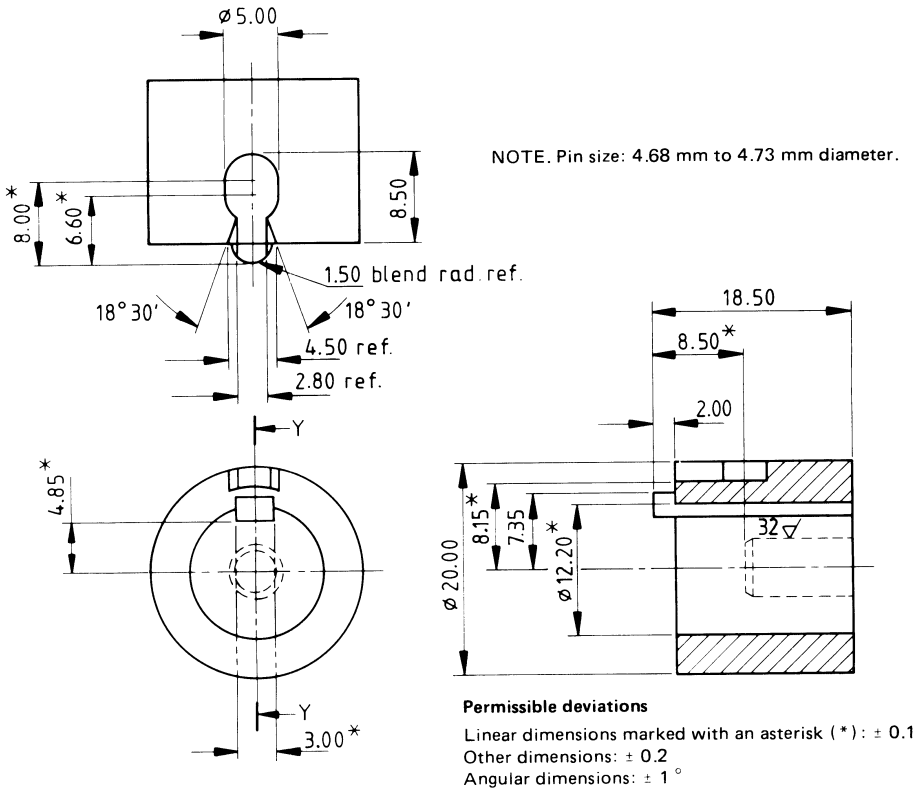
After storage for 12 months at 30 °C ± 2 °C, the fitting shall comply with either a) or b) as follows:

a) the fitting shall remain within all applicable dimensional limits of the standard;

b) the fitting shall be capable of assembly and jointing to pipe at 23 °C ± 2 °C and the resulting joint shall comply with **7.5**.



(a) Terminals and shroud without keyway



NOTE. Pin size: 4.68 mm to 4.73 mm diameter.

Permissible deviations

Linear dimensions marked with an asterisk (*): ± 0.1
Other dimensions: ± 0.2
Angular dimensions: ± 1°

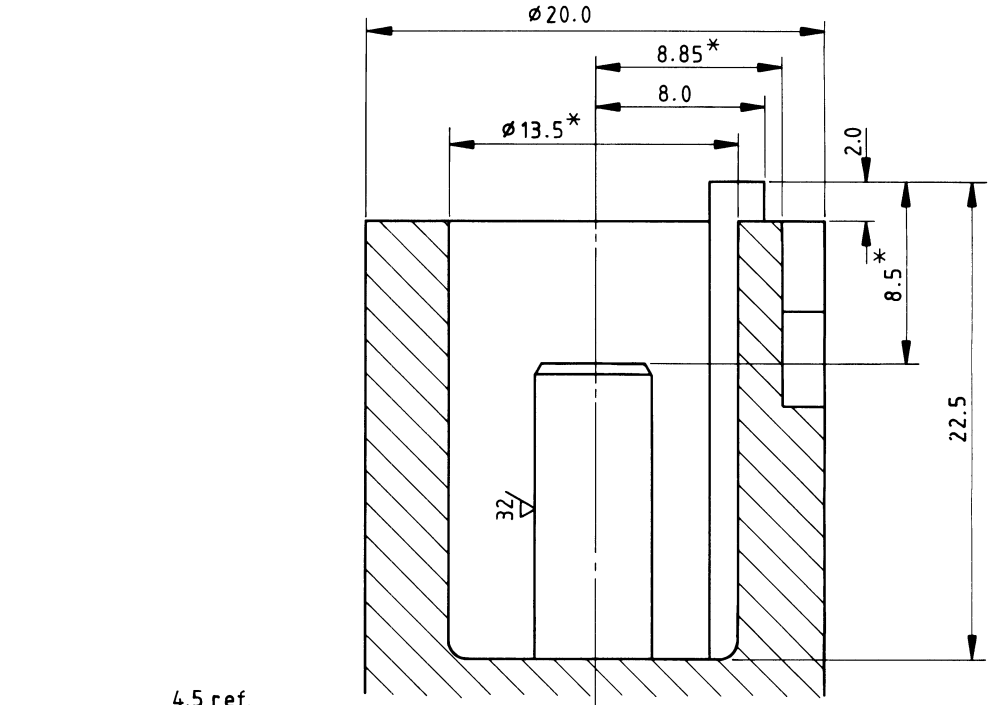
(b) Terminals and shroud with keyway for 40 V system

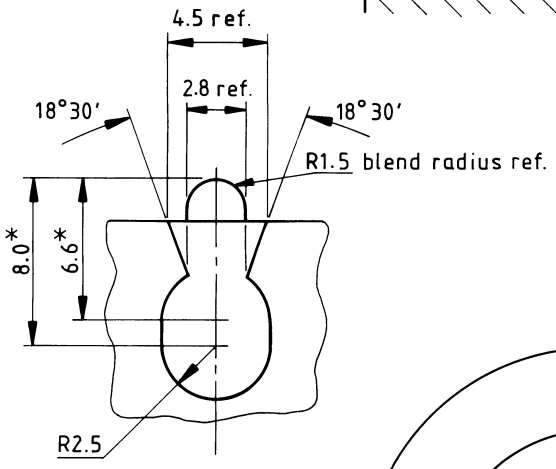
All linear dimensions are in millimetres.

Figure 5 — Terminals and shrouds

Permissible deviations

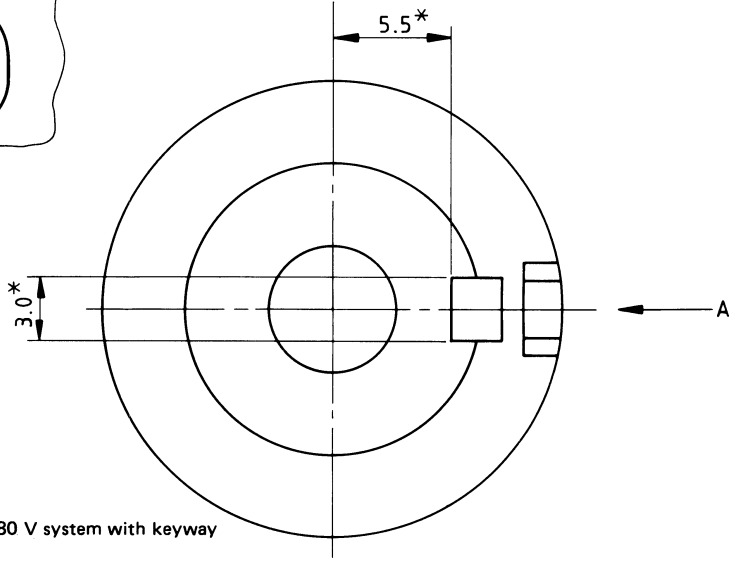
Linear dimensions marked with an asterisk (*): ± 0.1
Other linear dimensions: ± 0.2
Angular dimensions: ± 1 °





View A

NOTE. Terminal pin size 4: 5.69 mm to 5.74 mm diameter.



(c) Terminal arrangement for 80 V system with keyway

All linear dimensions are in millimetres.

Figure 5 — Terminals and shrouds *(concluded)*

7 Performance requirements for jointed pipe-to-fitting assemblies

7.1 General

Jointed pipe and fitting assemblies prepared in accordance with Appendix A shall comply with **7.2** to **7.9**.

7.2 Joint strength

7.2.1 *Socket fittings up to and including 75 mm and all tapping tees and branch saddles*. When each such connection of the fitting is tested for crush strength in accordance with Appendix J, no cracking shall occur at the fusion interface during a test period of 10 min unless the cracking is attributed to end effects over the first 25 % of the axial length of the heater coils, in which case the cracking shall be disregarded.

7.2.2 *Socket fittings of nominal size equal to or greater than 90 mm*. When each such connection of the fitting is tested for peel strength in accordance with Appendix K, the tear along the fusion length shall be ductile over a minimum length of 75 % of the axial length of the heater coils.

7.3 Short-term hydrostatic pressure resistance at 20 °C

When tested in accordance with Appendix L, using a test temperature of 20 °C ± 1 °C and test piece assemblies prepared in accordance with pattern 4 of Table A.2, the test piece assembly shall withstand the applicable minimum pressures given in Table 9, when the hydrostatic pressure in the test assembly 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 20 s ± 5 s to the corresponding peak pressure and maintained at that peak pressure for 5 s or until prior bursting of the test piece.

Table 9 — Minimum test pressures for short-term hydrostatic pressure resistance test

Pipe SDR	Density[a] ⩾ 948 kg/m^3 (i.e. density code 50 or 57) Hold pressure (1 h)	Density ⩽ 948 kg/m3 (i.e. density code 30, 40 or 45) 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 **3.1.2**).
[b] 1 bar = 10^5 N/m^2 = 0.1 MPa.

7.4 Long-term hydrostatic pressure resistance at 20 °C

When tested in accordance with Appendix L, using a test temperature of 20 °C ± 1 °C and test piece assemblies prepared in accordance with pattern 4 of Table A.2, the test piece assembly shall withstand the applicable internal pressure given in Table 10 for not less than 10 000 h without bursting.

There shall be no evidence of cracking when the joint is sectioned and then examined in accordance with **D.5.6**.

Table 10 — Minimum test pressures for long-term hydrostatic pressure resistance test

Pipe SDR	Test pressure			
	Pipe material in accordance with BS 7281			
	A	B	C	D
	bar	bar	bar	bar
7 and 9	18.8	23.7	29.8	33.3
11	15.0	19.0	23.8	26.6
17.6	9.0	11.4	14.3	16.0
26	6.0	7.6	9.5	10.6

7.5 Hydrostatic pressure resistance at 80 °C

When tested in accordance with Appendix L, using a test temperature of 80 °C ± 1 °C and test piece assemblies prepared in accordance with pattern 4 of Table A.2, the test piece assemblies shall withstand without bursting the applicable combinations of pressure and time given in Table 11.

There shall be no evidence of cracking when the joint is sectioned and then examined in accordance with **D.5.6**.

Table 11 — Test conditions for hydrostatic pressure resistance at 80 °C

Pipe SDR	Minimum hydrostatic test pressure for:	
	1 000 h	170 h
	bar	bar
7 and 9	10.4	12
11	8	9.2
17.6	4.8	5.52
26	3.2	3.68

7.6 Resistance to accelerated relaxation and end load (AREL test)

7.6.1 When tested in accordance with Appendix M, using an elevated temperature of 80 °C ± 2 °C for 500 h and at 23 °C ± 2 °C using an internal pneumatic pressure of 25 mbar minimum for 24 h followed by an internal pneumatic pressure of 6 bar minimum for 24 h, test assemblies in accordance with a) or b), as applicable, shall not leak.

a) For socket fittings, up to and including nominal size 75 mm sockets, the test piece shall be prepared in accordance with pattern 4 of Table A.2 and subjected during testing to an end load in accordance with Table 12.

b) For flanged fittings, the test piece assemblies shall be prepared in accordance with pattern 2 of Table A.2 and subjected during testing to an end load in accordance with Table 13.

Table 12 — End load conditions at 80 °C for jointed sockets or couplers

Pipe size (minor diameter, as applicable)	End load, subject to $^{+10}_{-0}$ %
mm	kN
16	0.35
20	0.45
25	0.57
32	0.96
50	2.3
55	2.8
63	3.65
75	5

Table 13 — End load conditions at 80 °C for flanged assemblies

Pipe size	End load subject to $^{+0.5}_{-0}$ kN	
	SDR 11	SDR 17.6
mm	kN	kN
90	7.5	5
125	14	9
140	18	11.5
180	29.5	19
250	57	37
315	90	58.5

7.6.2 When tested in accordance with Appendix N, using a test temperature of 23 °C ± 2 °C, a rate of extension of 25 mm/min ± 1 mm/min and test piece assemblies in accordance with **7.6.1**, the joint(s) shall not exhibit pull-out in response to a force which, when corrected as necessary to 23 °C (see **N.4.4**), is less than the applicable minimum force specified in Table 14.

7.7 Resistance to pull-off of branch saddle joints

When tested in accordance with Appendix P, using the conditions described in the next paragraph, the joint or fitting under test shall not pull off or otherwise crack, delaminate or neck in the joint fusion area, spigot outlet, pipe/fitting interface or saddle fitting body in response to a force which, when corrected as necessary to 23 °C (see **P.4.4**), is less than the applicable minimum force specified in Table 14.

The test shall be conducted using a test temperature of 23 °C ± 2 °C, a rate of extension of 25 mm/min ± 1 mm/min and test piece assemblies prepared in accordance with pattern 2 of Table A.2.

Table 14 — Minimum force for resistance to pull-out or pull-off

Pipe size (minor diameter)	Pipe SDR	Minimum force	Pipe SDR	Minimum force
mm		kN		kN
16	7	1.4	—	—
20	9	1.9	—	—
25	11	2.4	—	—
32	11	3.9	—	—
50	11	9.8	—	—
55	11	11.2	—	—
63	11	16.5	—	—
75	11	22	—	—
90	11	32	17.6	20
125	11	62	17.6	40
140	11	78	17.6	50
180	11	128	17.6	83
250	11	248	17.6	160
315	11	394	17.6	255

7.8 Impact resistance of tapping tees

When tested in accordance with Appendix Q, using a test temperature of 23 °C ± 2 °C a striker of mass 5.0 kg $^{+0.2}_{-0}$ kg falling through a height of not less than 2 000 mm to strike the tee stem 25 mm ± 1 mm from its free end and test piece assemblies prepared in accordance with pattern 2 of Table A.2, the impacted test piece assembly shall remain leak-tight when subjected to an internal pneumatic pressure of not less than 2 bar for not less than 1 h.

7.9 Circumferential reversion of spigot or pupped ends on fittings

When tested in accordance with Appendix E of BS 7281:1990, using test pieces having all spigot and/or pupped ends moulded or cut to comply with the out-of-square limits specified in Table 15, the dimensions of the spigot or pupped ends, when determined in accordance with Appendix C of this standard (BS 7336:1990), shall comply with **6.4** a) or **6.4** b) of BS 7281:1990, as applicable. The measurements shall be taken relative to the free end of the spigot or pupped end and the applicable limits shall be those for the corresponding dimensions of straight pipe in compliance with BS 7281.

Table 15 — Out-of-square limits for spigot or pupped fitting ends

Pipe size (d_e)	Maximum out-of-square of spigot or pupped ends
(mm)	mm
⩽ 63	1.5
75 and 90	2
125 and 140	3
180 and 200	4
250 to 315	5
355 to 500	7

8 Marking and information

8.1 All fittings shall be marked with the following information, using characters of minimum height 3 mm:

a) the manufacturer's identity and identification of the base polymer;

b) the number and date of this British Standard, e.g. BS 7336:1990[5)];

c) the letters "PE";

d) the class of pipe in accordance with BS 7281 for which the fitting is suitable, i.e. A, B, C or D (see **7.4**);

e) the size of the fitting (in millimetres);

f) the date of manufacture, in accordance with **8.3**;

g) the fusion time (in seconds);

h) the cooling time (in minutes).

For socket fittings or saddle fittings of nominal size greater than 125 mm the marking shall also include the SDR rating of the fitting.

8.2 All marking shall be embossed or heat indented into the fitting or otherwise as permanent and shall remain legible during handling, storage and installation in accordance with CP 312-1 or CP 312-3, as applicable.

8.3 The information shall enable identification of the individual day and/or shift applicable. It shall be permissible to use a code, provided that the meaning can readily be determined by reference to the manufacturer or, if applicable, the certification body.

[5)] Marking BS 7336:1990 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.

8.4 Information regarding the nominal MFR and the actual MFR of the base polymer (see **3.1.3** and **4.3**) shall be provided or shall be available by request to the fitting manufacturer or, if applicable, the certification body.

9 Packaging

9.1 Fittings shall be individually sealed in transparent bags of polyethylene film at least 75 μm thick, or an equivalent material for excluding contamination.

9.2 For saddle fittings, the interfacial surface heating elements shall be protected from contamination by a cardboard or similar shield designed to remain in place until immediately prior to use.

Appendix A Preparation of test piece assemblies

A.1 Equipment

A.1.1 *General.* The items detailed in this clause shall be capable of proper operation at ambient temperatures in the ranges – 5 °C ± 2 °C and 23 °C ± 2 °C, for the assembly of pipes and fittings at extremes of diameter and ovality tolerances in accordance with BS 7281 or this standard, as applicable.

A.1.2 *Pipe cutting or trimming tool*, capable of cutting a pipe or trimming a pipe end to produce a plane end, square to within 2° relative to the pipe axis.

A.1.3 *Pipe surface trimming tool or scraper*, capable of removing a minimum of 0.05 mm depth of material from the existing surface of the pipe, and of being set to remove not more than 0.1 mm depth from the surface of a pipe of nominal size less than 63 mm and/or not more than 0.2 mm depth from the surface of a pipe of nominal size greater than or equal to 63 mm.

The tool shall be capable of trimming the pipe surface such that no portion is left unprepared over a length that is not less than the minimum fusion length of the application fitting (see clause **5**), from a position starting within 0.1 times the nominal size of the pipe, in millimetres, from the end of the pipe.

A.1.4 *Restraining clamps*, capable of attachment to pipes on either side of a test piece fitting to restrict movement and aid alignment of adjoining pipe(s) during the jointing/cooling process without causing damage to the pipes or fitting(s).

Appropriate combinations of clamps shall be capable of jointing fittings to in-line pipes subject to an angular deflection of not less than 1.5°. Clamps shall be suitable for use with all fitting arrangements as shown schematically in Figure A.1 with associated dimensions.

Clamps shall cater for reductions in pipe size either side of the electrofusion socket fitting, e.g. when fusing a reducer.

A.1.5 *Saddle fusion tool*, capable of installing tapping tees and branch saddles connected at a specific interface to an adaptor located above the fitting, as shown in Figure A.2. One adaptor shall be capable of use with all fittings irrespective of mains or outlet size provided by a particular fittings manufacturer.

A method of indicating that the correct load is achieved shall be permanently provided on the machine. The application of the correct load shall be easily detected by the operator. When set at 1 400 N to 1 500 N, the indicator shall not drop below 1 200 N after a movement of 2 mm at the saddle interface. The indicator shall be capable of registering any overload.

Any screw action shall not apply a turning motion to the fitting.

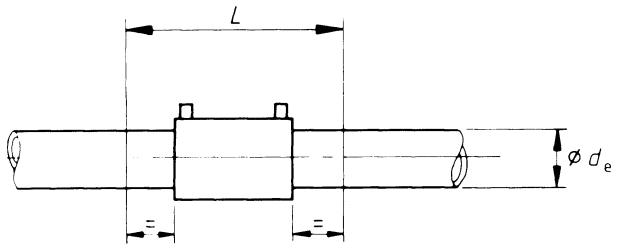
A.1.6 *Electrofusion energy control system*, complying with Appendix R and capable of operation in accordance with this appendix.

NOTE Attention is drawn to reference [4] which specifies equipment suitable for this purpose together with other features to facilitate assembly and/or appropriate to field installation.

A.1.7 *Environmental control equipment*, capable of conditioning pipe and fitting assemblies and accommodating electrofusion operations while maintaining the general ambient conditions within specified limits which shall include – 5 °C ± 2 °C and 23 °C ± 2 °C.

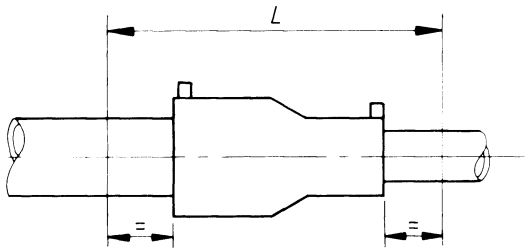
A.1.8 *End caps, plugs or flanges*, suitable for sealing test pieces or assemblies in a leak-tight manner while providing connections for the entry of water and release of air to enable hydrostatic pressure testing under conditions that impart the load to the component(s) under test.

Coupler

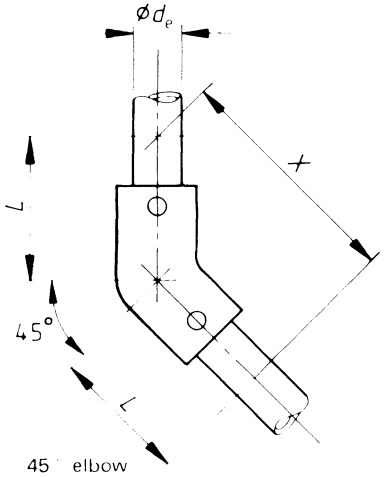


Clearance for connectors	
d_e	L
	min.
mm	mm
16 to 32	105
63 to 180	$1.5d_e + 90$

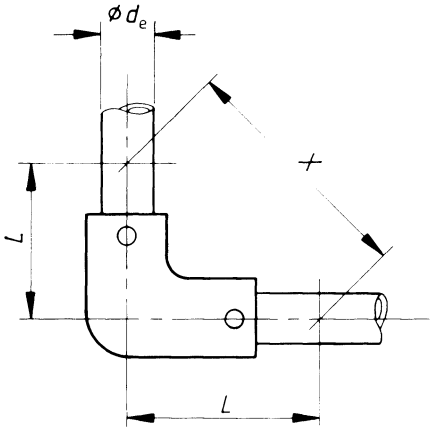
Reducer



(a) Connectors



45 ° elbow



90 ° elbow

(b) Elbows

45 ° elbow		
d_e	L	X
	min.	min.
mm	mm	mm
90	252	466
125	276	510
180	321	593

90 ° elbow		
d_e	L	X
	min.	min.
mm	mm	mm
20	125	177
25	135	190
32	140	198
63	230	325

Figure A.1 — Fitting arrangements

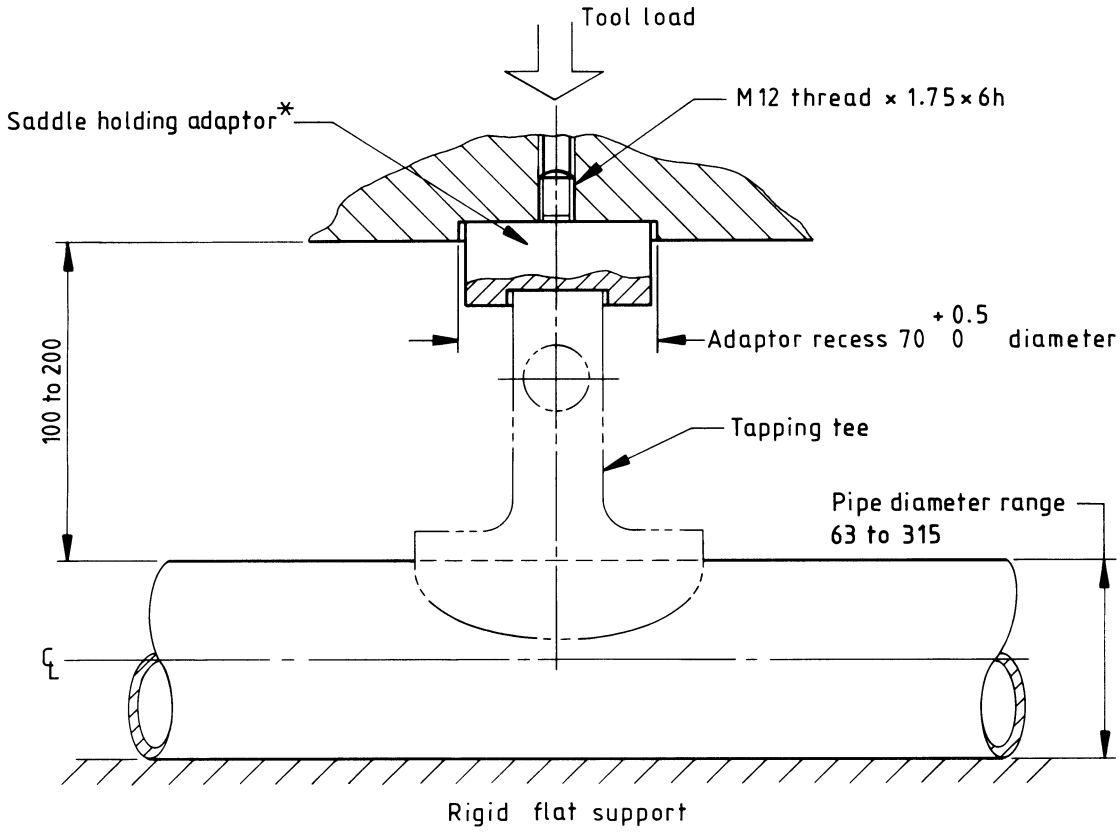


Figure A.2 — Interface for tapping tees and branch saddle tooling

A.2 Test pieces

A.2.1 Test pieces for assembly shall comprise one or more fittings having at least one electrofusion connection in accordance with this standard and a corresponding number of sections of pipe complying with BS 7281 and based on a polymer characterized by an MFR code (see note) of ⩽ D003 or D012, as applicable, in accordance with Table A.1 and Table A.2.

The pipe section shall be of sufficient length to ensure a free length between any fittings other than saddles connected thereby of not less than three times the pipe outside diameter for sizes below 250 and not less than twice the pipe outside diameter for sizes of 250 and greater. The minimum distance between saddles can be further reduced to one pipe diameter provided that alternate saddles are mounted on opposite sides of the pipe.

NOTE To enable evaluation of the fitting design and of the fusion conditions (fusion time and power input) nominated by the fitting manufacturer, some aspects of fusibility and of the consequent joint properties are assessed using joint assemblies in which some pipe components are made using a base polymer having an MFR of about 0.2 g/10 min and some are made using a base polymer having an MFR of about 1 g/10 min. Their respective use is indicated in this standard by the descriptions "MFR ⩽ D003" and "MFR D012"[6] (see, for example, Table A.2). The descriptions "PE-X" and "PE-A", which may be found to be used for this purpose in industrial literature, are not used for the purposes of this standard because of conflict with designations and symbols in accordance with ISO 1043-1.

A.2.2 Pipe sections for sizes up to and including 180 mm shall be taken from coils.

A.3 Conditioning

Prior to fusion, pipes and fittings shall be conditioned at the applicable temperature, subject to permissible deviations of ± 2 °C, for at least 8 h.

[6] Advice on descriptions and sources of typical polymers which are suitable are available from Enquiry Section, BSI, Linford Wood, Milton Keynes, MK14 6LE.

In the case of pipe samples taken from coils, the sample shall be taken from the coil immediately prior to conditioning.

A.4 Procedure

A.4.1 ***Assembly***

A.4.1.1 Determine the number of test piece fittings and the number of pipe sections required of the applicable MFR code(s) (see **A.2.1**), depending upon the purpose for which the test piece assemblies are required and the variety of fusion conditions to be used with reference to Table A.1 and Table A.2, as applicable.

A.4.1.2 Assemble the fitting(s) under test and associated pipes such that the free length of pipe between any fittings (under test or otherwise) is in accordance with **A.2.1**.

For a socket fitting, identify and measure the minimum socket inside diameter and the maximum outside diameter of the pipe or spigot end to be jointed to the socket. Assemble the joint so as to give the maximum radial clearance at one point and the minimum radial clearance at another, and to provide a gap of at least 0.05 times the pipe outside diameter between the pipe or spigot end and the pipe penetration stop(s).

For socket fittings of sizes greater than 180 mm, arrange clamps to produce and maintain 1.5° angular deflection between the axes of the socket and the pipe.

For a saddle fitting, adopt the appropriate alternative procedure under item a) and/or b) as follows.

a) Where saddle fittings are to be fused to coiled pipe, position fittings to be fused using a stack load of 1 000 N perpendicular to the minimum diameter of the pipe and otherwise, for fittings to be fused using a stack load of 1 500 N, position the fitting perpendicular to the maximum diameter of the pipe.

b) Where a saddle fitting has an integral cutter, cut the main pipe and retract the cutter into the body of the fitting before testing and otherwise, where the assembly contains a saddle fitting with a separate cutter, cut the main and remove the cutter before testing.

In the case of a tapping tee cap, tighten it to a maximum torque of 4 N m. During electrofusion, branch saddles and tapping tees shall be aligned and supported as shown in Figure A.2.

In the case of test pieces or assemblies for pressure testing, fit pressure-tight caps, plugs or flanges (see **A.1.8**), as appropriate.

NOTE Spigots may be closed without the use of electrofusion fittings.

A.4.2 ***Fusion***

Connect an electrofusion fitting to the energy control system (see **A.1.6**) and adjust the voltage from the control box to give the minimum power as determined in accordance with Appendix G.

For all pipe fitting assemblies where the pipe is conditioned at – 5 °C, conduct the fusion at that temperature (+ 2 °C). In such cases where the fitting has been conditioned at 23 °C, complete the assembly and commence fusion in the – 5 °C environment within 2 min of commencing the assembly.

Fuse each joint under test, for the appropriate declared time [see **4.1.3** a)] and then interrupt the power input and allow the assembly to cool.

Re-energize the fitting for a similar period, if applicable [see **4.1.3** f) and pattern 4 of Table A.2], inspect the resulting joint for evidence of compliance with **4.1.3** c), d) and e) and, if it complies, submit the assembly to further testing as appropriate.

A.5 Report

The report shall include the following information:

a) the identification of the fitting and pipe components of the test assemblies;

b) a reference to this assembly procedure, i.e. Appendix A of BS 7336:1990;

c) the fusion voltage and fusion time used;

d) the fusion environment temperature used;

e) a report of compliance or otherwise with **4.1.3** in respect of operation of the fusion indicator and/or other exudation and/or pipe collapse and/or interfacial voids;

f) the date of assembly.

Table A.1 — Test piece preparation and assembly conditions

Property	Requirement clause	Test method	Variety of test assemblies (for patterns see Table A.2)
AREL resistance of sockets up to nominal size 75 mm	**7.6**	Appendix M and Appendix N	4, as pattern 4
AREL resistance of flange adaptors	**7.6**	Appendix M and Appendix N	2, as pattern 1
Branch saddle fusion pull-off resistance	**7.7**	Appendix P	2, as pattern 2
Cooling time	**5.9.2**	Appendix H	1, as assembly 2 of pattern 2
Crush resistance	**7.2.1**	Appendix J	2, as pattern 1
Fitting resistance tolerance band	**5.9.1**	Appendix G	2, as pattern 2
Fusion indicator	**4.1.3** c)	—	2, as pattern 1
Long-term pressure resistance	**7.4**	Appendix L	4, as pattern 4
Peel strength	**7.2.2**	Appendix K	2, as pattern 1
Pressure drop	**5.6.9**	Appendix F	2, as pattern 1
Short-term pressure resistance	**7.3**	Appendix L	2, as pattern 1
Hydrostatic pressure resistance at 80 °C	**7.5**	Appendix L	4, as pattern 4
Tapping tee cutting torque	**5.6.6**	—	2, as assembly 1 or 2 for pattern 2. One assembly is cut with the pipe at 30 °C and the other is cut with the pipe at – 5 °C, in each case after the pipe has been conditioned at that temperature for 1 h.
Tapping tee impact resistance	**7.8**	Appendix Q	2, as pattern 2

Table A.2 — Test piece assembly and fusion condition patterns

Pattern 1

Assembly	Nominal temperature before fusion		Applied power in accordance with Appendix G	Pipe resin MFR code	Saddle fitting force
	Pipe	Fitting			
	°C	°C			N
1	– 5	– 5	Min.	⩽ D003	1 000
2	– 5	– 5	Min.	D012	1 000

Pattern 2

Assembly	Nominal temperature before fusion		Applied power in accordance with Appendix G	Pipe resin MFR code	Saddle fitting force	Pipe SDR[a]
	Pipe	Fitting				
	°C	°C			N	
1	– 5	– 5	Min.	⩽ D003	1 000	11
2	23	23	Max.	D012	1 500	17.6

Pattern 3

Assembly	Nominal temperature before fusion		Applied power in accordance with Appendix G	Pipe resin MFR code	Saddle fitting force
	Pipe	Fitting			
	°C	°C			N
1	– 5	– 5	Min.	⩽ D003	1 000
2	23	23	Max.	D012	1 500
3	– 5	23	Min.	⩽ D003 or D012	1 000

Pattern 4

Assembly	Nominal temperature before fusion		Applied power in accordance with Appendix G	Pipe resin MFR code	Saddle fitting force	Pipe SDR[a]
	Pipe	Fitting				
	°C	°C			N	
1	– 5	– 5	Min.	⩽ D003	1 000	11
2	– 5	23	Min.	⩽ D003	1 000	11
3	23	23	Max.	D012	1 500	17.6
4[b]	– 5	23	Max.	D012	1 500	11

[a] For 90 mm and 125 mm pipe only.
[b] This sample is fused at the stated condition, allowed to cool to ⩽ 23 °C and then re-energized for the manufacturer's stated fusion time.

Appendix B Conditioning

B.1 General conditioning

Condition test pieces in air at 23 °C ± 2 °C for not less than 12 h, depending on size (see Table B.1), for:

a) any type test requirement (see **4.5**);

b) any tests performed in case of dispute (see **4.5**), to condition test pieces prior to testing at 23 °C ± 2 °C or to precondition test pieces prior to conditioning at other temperatures;

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

B.2 Hydrostatic testing

Except in case of dispute (see **4.5**), where test pieces shall first be preconditioned in accordance with **B.1**, condition test pieces for hydrostatic tests involving liquid immersion, for not less than 1 h, depending on size (see Table B.1), in liquid maintained at the temperature required for testing.

B.3 Abbreviated conditioning

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

Appendix C Methods for determination of dimensions

C.1 General

All measurements shall be carried out in accordance with BS 2782:Method 1101A subject to the modifications described in **C.2** to **C.6** as applicable.

C.2 Determination of mean outside diameter

C.2.1 For diameters of 25 mm or less use measuring apparatus of the type having one fixed jaw and one moving jaw permitting a reading to the nearest 0.05 mm. Obtain four measurements of the outside diameter uniformly distributed around the circumference. For pipe, obtain the measurements at a distance of one diameter from the end of the pipe (see the note to **3.2** of BS 2782:Method 1101A:1981 and clause **4** of the same standard).

Express the mean outside diameter, d_m, as the arithmetic mean of the four readings rounded off to the nearest 0.05 mm.

C.2.2 For diameters greater than 25 mm determine the mean outside diameter by use of a circumference tape. For pipe, obtain the measurements at a position at least one diameter from the end of the pipe (see clause **3** of BS 2782:Method 1101A:1981).

Table B.1 — Conditioning period

Minimum conditioning period		Nominal size of fitting or pipe		
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 ⩽ 335	> 400	
48	4	> 355		

C.3 Determination of mean inside diameter

Determine the mean inside diameter, d_b, of the cross section in question by either of the following procedures, using apparatus capable of determining the measured value to an accuracy of within ± 0.5 %.

a) Determine the mean outside diameter, d_m, in accordance with **C.2** and the mean wall thickness, e_m, where e_m is the average value for the sum of six wall thicknesses obtained at regular increments (60°) around the same cross section.

Calculate d_b using the following equation:

$$d_b = d_m - 2e_m$$

b) Use internal calipers or equivalent to obtain readings for six individual internal diameters at regular angular increments (60°) around the cross section in question and calculate d_b as the average of those six readings.

C.4 Determination of maximum and minimum wall thicknesses

Using test pieces having ends free of cutting burrs, measure the wall thicknesses in accordance with clause **2** of BS 2782:Method 1101A:1981 to determine the maximum and minimum values of the wall thickness at any point around the circumference.

In the case of pipe, make the measurements at both ends not less than 10 mm from the cut ends.

NOTE The test piece may be rotated or the measuring instrument moved as convenient until maximum and minimum wall thickness values have been found.

C.5 Ovality

C.5.1 For pipes or spigots, determine the maximum outside diameter at any point, $d_{i,\,max.}$, and the minimum outside diameter at any point, $d_{i,\,min.}$, in the same cross section. Calculate the value of $d_{i,\,max.} - d_{i,\,min.}$ and express the result in millimetres, rounded off to the nearest 0.1 mm, as the ovality of the pipe or spigot.

C.5.2 For circular section passages, such as socket bores, determine the maximum and minimum internal diameters in the appropriate cross section and use these values in place of $d_{i,\,max.}$ and $d_{i,\,min.}$ respectively in accordance with **C.5.1** to calculate the ovality of the bore.

C.6 Length

The boundaries for the measurement of the length and out-of-square dimensions of the main pipe of a branch fitting, or an analogous spigot or pupped end, and of a socket shall be as shown in Figure C.1.

Appendix D Method of test for coupler assembly force and joint integrity subject to angular deflection

D.1 Principle

The coupler is slid onto one pipe and then partly onto an adjoining pipe subject to a mutual axial angular deflection until the coupler is centred across the joint while the maximum force necessary for moving the coupler is checked relative to a specified limit. Provided that the force limit is not exceeded and no apparent dislodgement of the heating element has occurred, the joint is fused under controlled conditions and the integrity of the resulting joint is assessed by subjection to a stress crack resistance test followed by a peel test for the weld failure mode.

D.2 Equipment

D.2.1 *Clamps*, capable of rigidly supporting two independent lengths of pipe at set distance apart with a set amount of axial deflection, typically 1.5°.

D.2.2 *Device for indicating a varying or limiting force involved in moving a coupler along a clamped pipe*, or the corresponding reaction in the pipe(s) [see **5.2.3.2** a)].

D.3 Test pieces

Test pieces shall comprise the following items.

a) Coupler.

b) Two lengths of pipe sized to suit the coupler. The opposing pipe ends shall be cut clean and square and a distance equal to one half of the overall length of the coupler shall be marked from the end of each of the pipe ends to be joined.

D.4 Conditioning and test temperature

The pipes and fitting shall be at 23 °C ± 2 °C.

D.5 Procedure

D.5.1 Clamp one pipe and slide the coupler, for its full length, onto the marked end [see **D.3** b)].

D.5.2 Position and clamp the second pipe so that relative to the pipe end bearing the coupler, the following conditions are satisfied.

a) the pipe axes intersect with the specified angular deflection (1.5°; see **5.2.3.2**);

b) the maximum pipe end-to-end clearance is 10 mm.

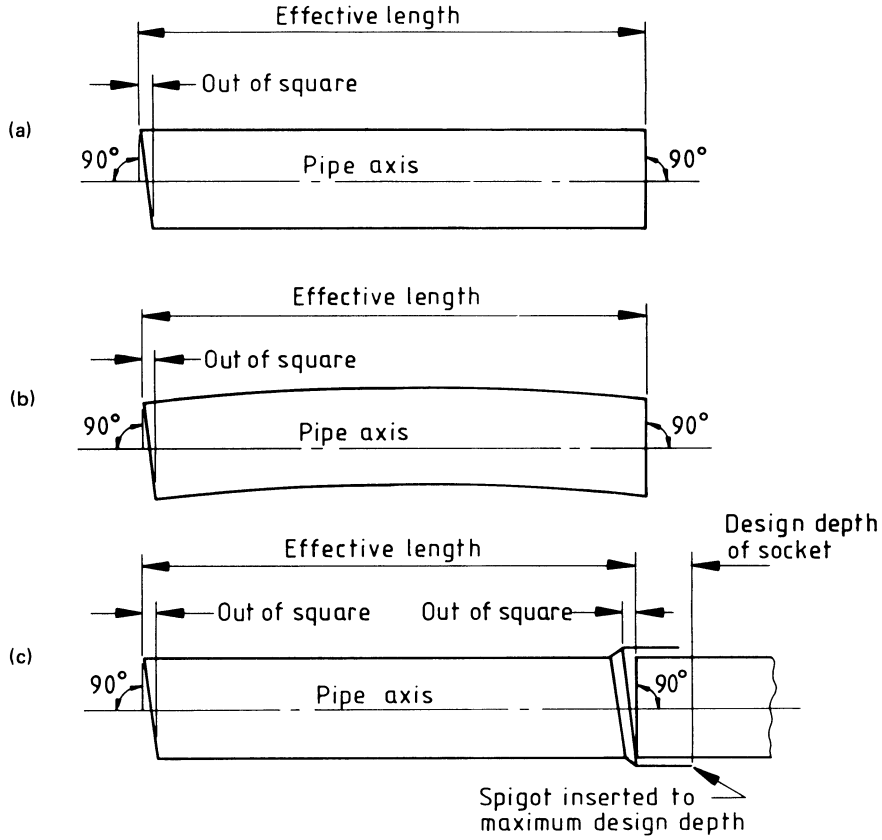


Figure C.1 — Out-of-square dimension boundaries

D.5.3 Reposition the coupler centrally between the marks on the opposing pipe ends while monitoring the force necessary relative to the specified limiting value [500 N; see **5.2.3.2** a)]. If the force was unacceptable record the failure, otherwise proceed in accordance with **D.5.4** to **D.5.7**.

D.5.4 While maintaining a general ambient temperature of 23 °C ± 2 °C, fuse the joint in accordance with Appendix A (using a minimum power input in accordance with Appendix F).

D.5.5 Cut the assembly to obtain test specimens for peel testing in accordance with Appendix K. Section the joint zones from the remainder of the assembly and inspect those sections with the aid of dye penetrants in accordance with **D.5.6** or equivalent methods for evidence of cracking. If any is found, record the failure, otherwise proceed in accordance with **D.5.7**.

D.5.6 Treat the cut surfaces of the joint section with a liquid dye penetrant and allow to dry. Finish the treated surface(s) sufficiently to remove superficial dye and inspect the finished surface by eye without magnification for evidence of penetration into cracks or voids.

D.5.7 Subject the residual test pieces obtained in accordance with **D.5.5** to a peel test in accordance with Appendix K. Record the mode of failure observed, i.e. ductile or brittle.

D.6 Test report

The test report shall include the following information:

a) the identification of the test piece(s);

b) a reference to this method of test, i.e. Appendix D of BS 7336:1990;

c) the maximum force (in newtons) necessary to position the fitting, if measured, and/or compliance or otherwise with the maximum specified force;

d) the fusion time, power and ambient temperature during joint fusion;

e) the observed failure mode induced by the peel test;

f) the dates of testing.

Appendix E Method of test for pressure loss for in-line tees and elbows

E.1 Principle

The velocity head loss along a fitting in series with pipe of the same size is measured at a specified system pressure at several flow rates and compared with the velocity head loss assigned to or measured for the pipe. The ratio of the velocity head losses for the fitting and the pipe respectively can then be compared with a specified design factor.

E.2 Apparatus

A typical layout of the test rig is shown in Figure E.1, with the approximate positions of the pressure tappings indicated in terms of the mean internal diameter of the pipe, e.g. d_b, and for which the essential components include the following.

a) A source of gas (e.g. air, nitrogen or methane) sufficient to sustain the specified test system pressures and flow rates.

b) A pressure regulator (A) capable of maintaining within ± 1 mbar the specified output pressure (25 mbar; see **5.4.6**).

c) A flowmeter (B) capable of measuring the flow rate of the relevant gas in the range 1 m/s to 10 m/s with an accuracy of ± 5 % of the measured value.

If the flowmeter is a diaphragm flowmeter, an associated reservoir (R) is mounted, downstream from the flowmeter, of sufficient capacity to smooth any consequent variations in the gas flow rate.

d) Supports for a length of pipe containing the fitting (F) under test, where the pipe size used is that of the size of the fitting under test.

e) Tapping points to measure the pressures upstream (P_1) and downstream (P_2) of the fitting under test, where the points are located in accordance with Figure E.1, flush with the pipe bore and free from burrs.

f) Differential manometer (D) or equivalent pressure measurement equipment capable of measuring the relevant pressure drop with an accuracy of ± 2 %.

NOTE Typically, a pressure drop of approximately 0.1 mbar may be expected through 6 m of 32 mm PE pipe at a velocity of 1.5 m/s.

g) A valve (E) located at the downstream end of the pipe (see Figure E.1) capable of controlling the flow rate.

E.3 Test piece

The fitting under test shall be assembled between two lengths of pipe of the same nominal size as the fitting and incorporated in the test rig layout as shown in Figure E.1.

E.4 Procedure

Conduct the following sequence of operations.

a) Set up the equipment and test piece as shown in Figure E.1.

b) Partially open the flow control valve (E) and open the inlet valve so that gas flows only from the flow control valve.

c) Using the pressure regulator (A), regulate the line pressure to 25 mbar and record the gas flow rate (B) and pressure loss.

d) Take readings of differential pressure for each of four increasing gas flow velocities (nominally 1.5 m/s, 3 m/s, 5 m/s and 7.5 m/s), obtained by opening the flow control valve (E) and readjusting the line pressure to maintain the specified pressure (25 mbar).

e) Calculate the head loss in the system for each velocity and determine an average value (see **E.5**). Obtain the velocity head loss attributed to the pipe K_p from Table E.1 and subtract it from the overall head loss. The tabulated value for each pipe size is conservative, and therefore if the result is a borderline failure, rerun the test with pipe only from the same batch as used in the fitting test and subtract this measured value from the head loss for the test on the pipe and fitting.

Table E.1 — Correction factors

Pipe size	Velocity head loss attributed to the pipe, K_p
mm	
20	0.73
25	0.66
32	0.61
63	0.51
90	0.47
125	0.43
180	0.4

NOTE The losses above are lower than would normally be found in practice.

E.5 Head loss calculations

Perform the following calculations to obtain the velocity head loss of the fitting, K_f.

$V_1 = Q/A_1$

$V_2 = Q/A_2$

$$C_d = \frac{V_1^2}{V_2^2} - 1$$

where

A_1 is the bore area of the approach pipe (in m^2);

A_2 is the bore area of the exit pipe (in m^2);

Q is the measured volume flow rate (in m^3/s);

V_1 is the velocity in the approach pipe, Q/A_1 (in m/s);

V_2 is the velocity in the exit pipe, Q/A_2 (in m/s);

C_d is the correction for change of diameter.

NOTE For most fittings $A_1 = A_2$, in which case $V_1 = V_2$ and $C_d = 0$.

Calculate the velocity head loss K_m specific to the system at each velocity using the following equation:

$$K_m = \frac{\Delta p\ 200}{\rho\ V_2^2} + C_d$$

where

Δp is the measured pressure drop at a velocity (in mbar);

ρ is the test fluid density (in kg/m^3).

Calculate the average velocity head loss K_f due to the fitting/assembly using the following equation:

$$K_f = \frac{\Sigma K_m}{n} - K_p$$

where

$\frac{\Sigma K_m}{n}$ is the average system velocity head loss, i.e. n is the number of different gas flow velocities at which data for K_m was obtained;

K_p is the correction for the pipe in the system, from Table E.1 or measurement [see **E.4** e)].

E.6 Test report

The test report shall include the following information:

a) the identification of the test piece(s);

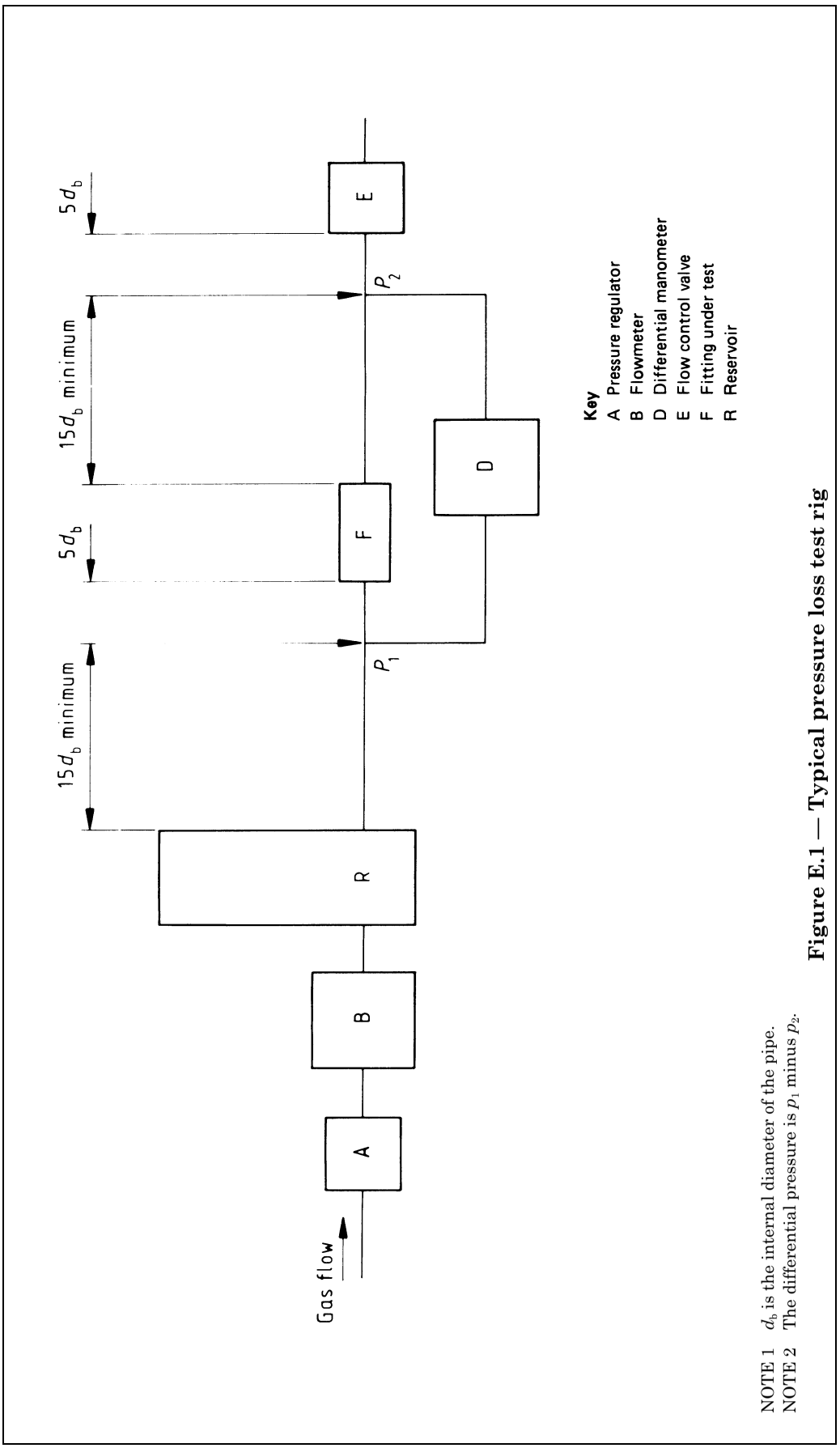
b) a reference to this method of test, i.e. Appendix E of BS 7336:1990;

c) the pressure at which flow measurements were obtained;

d) the gas flow velocities used and the pressure differential observed at each flow rate;

e) the average velocity head loss due to the fitting;

f) the date of test.



NOTE 1 d_b is the internal diameter of the pipe.
NOTE 2 The differential pressure is p_1 minus p_2.

Figure E.1 — Typical pressure loss test rig

Appendix F Method of test for pressure drop through a tapping tee

F.1 Apparatus

A typical arrangement of the test rig is shown in Figure F.1 to include the following items.

a) A source of gas (e.g. air, nitrogen or methane) sufficient to sustain the specified test system pressure and flow rates.

b) A pressure regulator, capable of maintaining within ± 1 mbar the specified output pressure (25 mbar; see **5.6.9**).

c) A volumetric flowmeter (B), accurate to ± 5 % and of the positive displacement or turbine meter type.

d) An inclined manometer (C), capable of measuring the operating pressure (25 mbar; see **5.6.9**).

e) A differential manometer (D) or equivalent pressure measurement equipment, for which the pressure tappings shall be set at least $2d_e$ (in mm) from any fitting or valve and, in the case of a tee, diametrically opposite it and upstream of it.

f) An outlet valve (E) located at the downstream end of the pipe (see Figure F.1) and capable of controlling the flow rate.

F.2 Test piece

The configuration of the test piece tee shall be as shown in Figure F.1.

F.3 Procedure

Conduct the following sequence of operations.

a) Connect the inclined manometer across the tee and partially open the outlet valve (E).

b) Open the inlet valve so that gas starts to flow and check that gas flows from the outlet valve only.

c) By means of pressure controller (A), regulate the mains pressure (C) to 25 mbar and measure and record the flow rate, Q, using the volumetric flowmeter (B), and the pressure drop ΔP, using the differential manometer (D).

d) Open the outlet valve (E) sufficiently to reduce the mains pressure (C) by approximately 5 mbar.

e) Increase the flow rate until the mains pressure (C) returns to 25 mbar and measure and record the flow rate (Q) and the pressure drop (ΔP).

f) Repeat the operations detailed in d) and e) until the outlet valve (E) is fully open.

F.4 Calculation

Calculate the factor B for each set of readings using the following equation:

$$B = \frac{\Delta P}{Q^2}$$

where

ΔP is the pressure drop (in mbar);

Q is the flow rate (in m^3/h).

From these results, determine the average value of B and use this average value to determine the pressure drop (ΔP) for a gas flow rate (Q) appropriate to the size of service fitting (see Table 5).

If air or nitrogen is used for this test, correct the flow rates using the following equation:

$$Q_{nat.} = Q_{med.}\sqrt{\left(\frac{\rho_{med.}}{\rho_{nat.}}\right)}$$

where

$Q_{nat.}$ is the flow rate using natural gas (in m^3/h);

$Q_{med.}$ is the flow rate using other gas (in m^3/h);

$\rho_{med.}$ is the density of other gas;

$\rho_{nat.}$ is the density of natural gas.

Calculate the number of velocity heads lost across the fitting K based on the velocity in the service pipe from the following equation:

$$K = \left(\frac{\Delta P}{\rho}\right)\left(\frac{200}{V_2^{\,2}}\right) + \left(\frac{V_1^{\,2}}{V_2^{\,2}} - 1\right)$$

where

ΔP is the measured pressure drop (in mbar);

ρ is the density of natural gas (0.71 kg/m^3);

V_1 is the velocity in main (in m/s), i.e. $Q_{nat.}/A_1$ where A_1 is the bore area of main;

V_2 is the velocity is service pipe (in m/s), i.e. $Q_{nat.}/A_2$ where A_2 is the bore area of service pipe under test.

NOTE The equation assumes the density effects due to velocity are negligible.

F.5 Test report

The test report shall include the following information:

a) the identification of the test pieces;

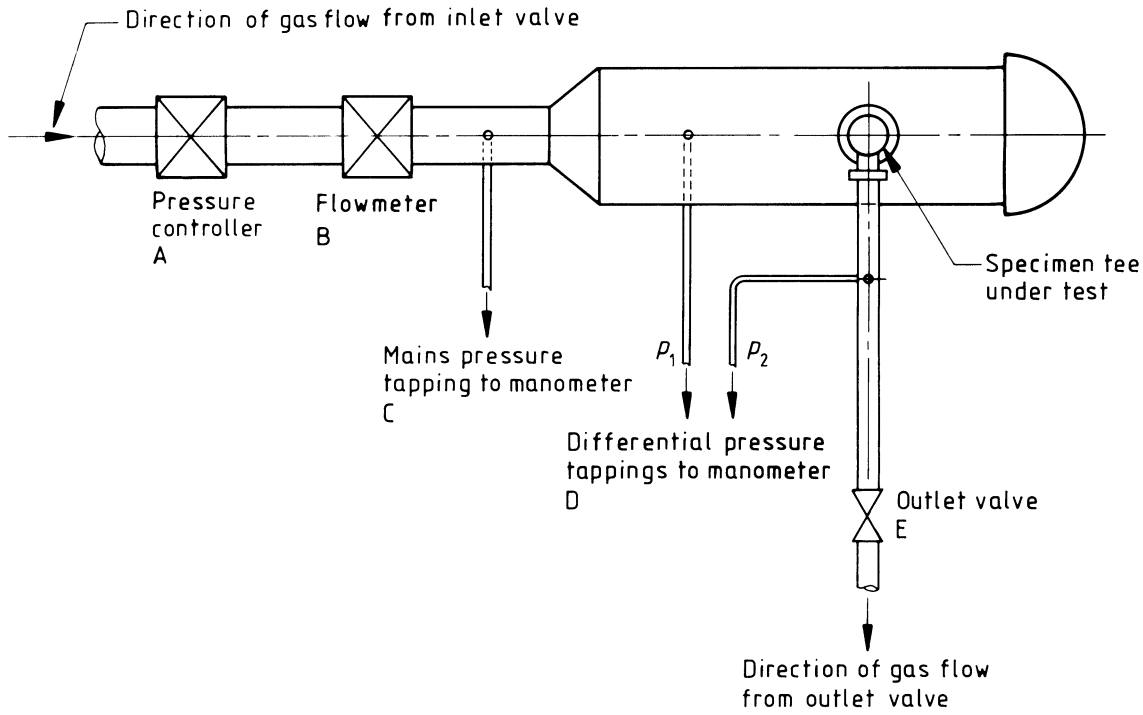
b) a reference to this method of test, i.e. Appendix F of BS 7336:1990;

c) the pressure at which the flow measurements were obtained;

d) the gas flow velocities used and the pressure differential observed at each flow rate;

e) the average velocity head loss due to the fitting;

f) the date of testing.



NOTE Tappings for the pressures p_1 and p_2 are at least $2d_e$ (in mm) from any fitting or valve and, in the case of the tee, diametrically opposite it and upstream of it.

Figure F.1 — Layout of test rig for tapping tee pressure drop test

Appendix G Assessment of fitting resistance tolerance band

G.1 Apparatus

G.1.1 *Four-wire resistance bridge*, with the characteristics given in Table G.1.

Table G.1 — Resistance bridge performance characteristics

Range	Resolution	Accuracy
Ω	mΩ	
0 to 1	0.1	± 0.25 % of reading
0 to 10	1	
0 to 100	10	

G.1.2 *True r.m.s. voltmeter*, accurate to within ± 0.1 % and providing a resolution of 10 mV in the range 0 V to 100 V.

G.1.3 *Temperature-controlled air space*, which can be maintained at – 5 °C ± 2 °C and 23 °C ± 2 °C.

G.1.4 *Adjustable output voltage control box*, in accordance with **A.1.6**.

G.2 Test pieces

For assessing the minimum (see **G.3.1**) and maximum (see **G.3.2**) limits of the tolerance respectively, the fitting shall be tested in conjunction with the appropriate number of portions of pipe where the base polymer used for the pipe has an MFR code of D012 or of less than or equal to D003 respectively (see **3.1.3** and associated note).

G.3 Procedure

G.3.1 *Minimum tolerance value*

G.3.1.1 Condition the fitting and the associated PE pipe(s) of MFR code D012 (see **G.2**) for the appropriate period at 23 °C ± 2 °C in accordance with Appendix B.

G.3.1.2 Measure the resistance of the fitting under test (R_{23}) at 23 °C ± 2 °C using the bridge (**G.1.1**).

G.3.1.3 Calculate the applied fitting voltage V_f (in V) using the following equation.

$$V_f = V\sqrt{\left(\frac{R_{23}}{R_{min.}}\right)}$$

where

V is 40 V or 80 V as applicable (see **5.9.2**);

$R_{min.}$ is the manufacturer's declared minimum fitting resistance (in Ω);

R_{23} is the measured resistance (in Ω) obtained at 23 °C in accordance with **G.3.1.2** for a fitting to be conditioned at 23 °C.

G.3.1.4 Using a resistive load on the output of the control box, set the control box output voltage to the voltage calculated in accordance with **G.3.1.3**.

G.3.1.5 Assemble and fuse the pipe(s) and fitting for the specified time (see **5.9.2**) and in accordance with Appendix A.

G.3.1.6 When the joint has cooled, section the sample and check it for signs of pipe collapse or of creasing of the pipe bore. Record any relevant observations and if the joint is still intact proceed to **G.3.1.7** and otherwise record the failure of the joint.

G.3.1.7 Test the sectioned samples in accordance with Appendix J if the size of the fitting is less than or equal to 75 mm and otherwise test the sectioned samples in accordance with Appendix K.

G.3.2 ***Maximum tolerance value***

G.3.2.1 Using the bridge (**G.1.1**), measure at 23 °C ± 2 °C the resistance (R_{-5}) of the fitting to be conditioned at – 5 °C.

G.3.2.2 Condition the fitting and the associated PE pipe(s) of MFR code D001 or D003 (see **G.2**) for the appropriate period at – 5 °C ± 2 °C in accordance with Appendix B.

G.3.2.3 Calculate the applied fitting voltage V_f (in V) using the following equation:

$$V_f = V\sqrt{\left(\frac{R_{-5}}{R_{max.}}\right)}$$

where

V is 39 V or 78 V as applicable (see **5.9.2**);

$R_{max.}$ is the manufacturer's declared maximum fitting resistance (in Ω);

R_{-5} is the measured resistance (in Ω); obtained at 23 °C in accordance with **G.3.2.1** of the fitting prior to conditioning at – 5 °C.

G.3.2.4 Using a resistive load on the output of the control box, set the control box output voltage to the voltage calculated in accordance with **G.3.2.3**.

G.3.2.5 Assemble and fuse the pipe(s) and fitting for the specified time (see **5.9.2**) and in accordance with Appendix A.

G.3.2.6 When the joint has cooled, section the sample and test it in accordance with Appendix J if the size of the fitting is less than or equal to 75 and otherwise test it in accordance with Appendix K.

G.4 Test report

The test report shall include the following information:

a) the identification of the test piece(s);

b) a reference to this method of assessment, i.e. Appendix G of BS 7336:1990;

c) the declared minimum fitting resistance and the measured values obtained (see **G.3.1.2** and **G.3.2.1**);

d) the applied voltage used;

e) any observations of signs of collapse or creasing of the pipe when tested following use of the minimum tolerance value and/or of the maximum tolerance value for joint assembly;

f) for fittings of nominal size up to and including 75 mm, any incidence of cracking when tested for crush strength;

g) for fittings of nominal size equal to or greater than 90 mm, the joint failure mode in response to a peel test;

h) the date of test.

Appendix H Determination of fitting cooling times

H.1 Apparatus

H.1.1 *Four-wire resistance bridge*, in accordance with **G.1.1**.

H.1.2 *True r.m.s. voltmeter*, in accordance with **G.1.2**.

H.1.3 *Thermocouples*, suitable for operation up to 400 °C connected to a temperature recording device.

H.1.4 *Adjustable output voltage control box*, in accordance with **A.1.6**.

H.2 Preparation of test pieces

H.2.1 Condition the fitting and associated pipe(s) at a temperature of 23 °C ± 2 °C for at least 8 h.

H.2.2 For socket fittings, position two thermocouples diametrically opposite each other with each thermocouple's tip on the outside surface of the pipe and so that the thermocouples will be positioned in the centre of the resulting fusion joint. One thermocouple shall be on the top of the pipe during the fusion operation.

H.2.3 For saddle fittings, position two thermocouples on the crown of the pipe, one either side of the outlet stack, at a position which will be in the centre of the resulting fusion joint.

H.3 Procedure

H.3.1 Using the bridge (**H.1.1**), measure the resistance of the fitting under test.

H.3.2 To simulate maximum power input into the fitting, adjust the control box to give an applied voltage V_f (in V) using the following equation.

$$V_f = V\sqrt{\left(\frac{R_{23}}{R_{min.}}\right)}$$

where

V is 40 V or 80 V as applicable (see **5.9.2**);

R_{23} is the measured resistance obtained in accordance with **H.3.1** (in Ω);

$R_{min.}$ is the manufacturer's declared minimum fitting resistance (in Ω).

H.3.3 Energize the fitting for the declared fusion time and record the temperatures attained.

H.3.4 On switching off the power, measure and record to the nearest minute the time for each thermocouple (**H.1.3**) to reach 110 °C.

H.3.5 Calculate and record the cooling time as the mean time for the thermocouples at one end to reach 110 °C. For reducing couplers, the higher of the two cooling times shall be taken as the fitting cooling time.

H.4 Test report

The test report shall include the following information:

a) the identification of the test piece(s);

b) a reference to this method of test, i.e. Appendix H of BS 7336:1990;

c) the declared minimum fitting resistance and the measured value obtained;

d) the applied voltage used;

e) the cooling time(s);

f) the date of test.

Appendix J Method of test for crush strength

J.1 Apparatus

J.1.1 *Vice or equivalent tool*, with flat-faced jaws of sufficient capacity and power to grip a portion of pipe adjacent to a joint as shown in Figure J.1 and flatten it in accordance with **J.3.3**.

J.2 Test piece assemblies

The jointed test piece assemblies shall be prepared in accordance with Appendix A, using the conditions applicable for pattern 1 in accordance with Table A.2.

J.3 Procedure

J.3.1 Cut the pipe and/or fitting in half along its length and transversely as necessary to leave approximately 150 mm of pipe protruding either side of the fitting.

J.3.2 Grip one half of the assembly in the vice with the jaws across the cut diameter as shown in Figure J.1.

J.3.3 Squeeze the pipe in the vice until the inner pipe surfaces meet. Maintain the assembly in this position for the specified period (10 min; see **7.2.1**) and then inspect the fusion interface. Note any delamination or cracking observed, including whether or not all of any cracking observed is attributable to end effects over the first two turns of wire.

J.4 Test report

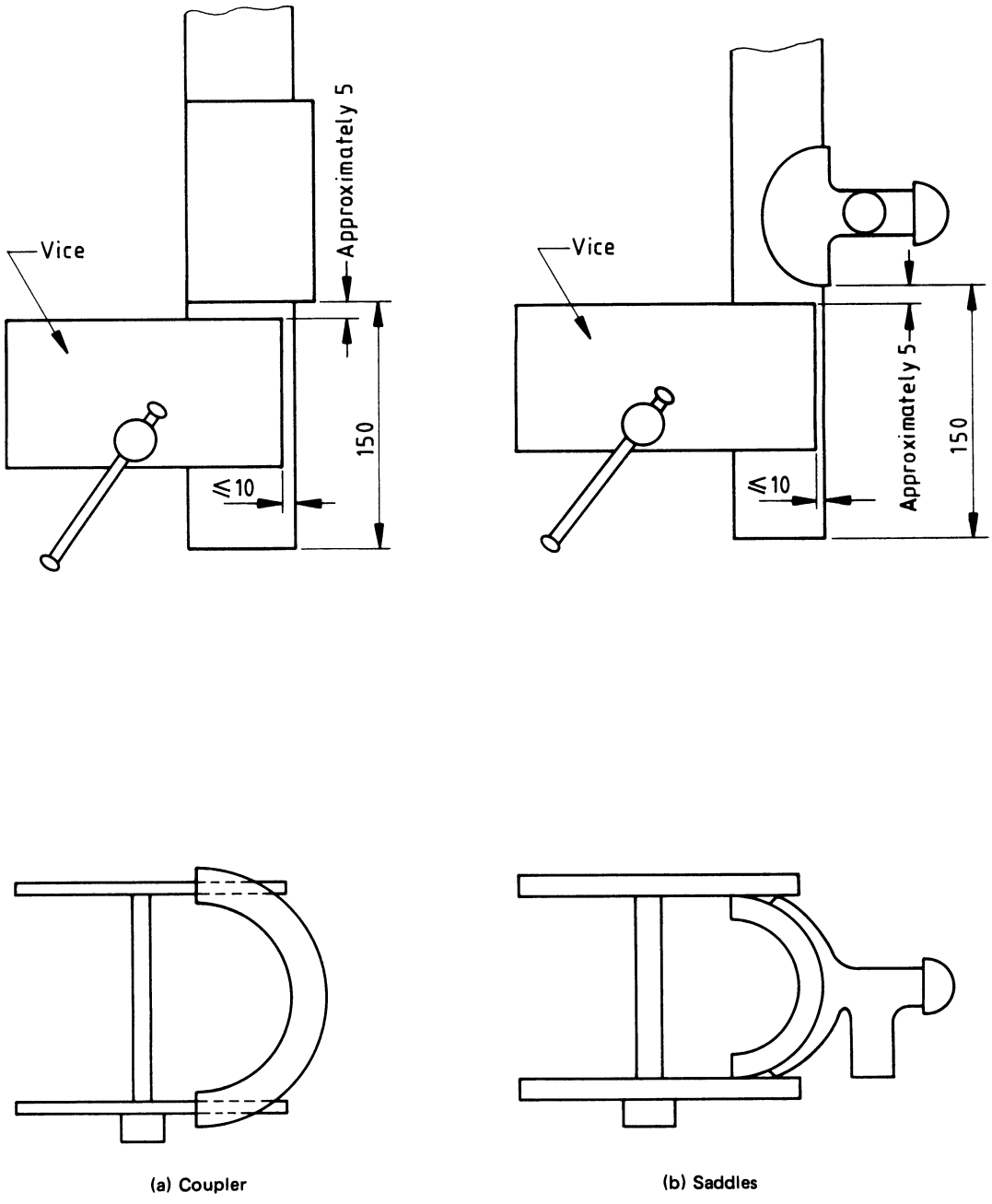
The test report shall include the following information:

a) the identification of the test piece(s);

b) a reference to this method of test, i.e. Appendix J of BS 7336:1990;

c) any observations of delamination or cracking of the joint and, if the latter, whether or not the cracking is solely attributable to heater end effects;

d) the date of testing.



All dimensions are in millimetres.

Figure J.1 — Crush test arrangements

Appendix K Peel test for fused socket joints

K.1 Principle

A fused socket joint is sectioned at four equidistant positions around the circumference of the fitting and subjected to a longitudinal peel test, such that the resultant peel should be along the length of the fusion interface. Separation of the joint components is taken to completion and the parted surfaces are inspected for evidence of ductile and/or brittle failure along the joint interface.

K.2 Apparatus

K.2.1 *Tensile testing machine*, or equivalent, capable of separating the two jaws at 25 mm/min ± 10 %. One jaw grips a segment of a pipe or fitting body at least 75 mm from the joint interface under test and the other jaw connects via a flexible link, such as a chain, or wire rope, at least 300 mm long, to a stirrup (**K.2.2**) pinned to a segment of a socket, in accordance with the general arrangement shown in Figure K.1.

K.2.2 *Stirrup*, having a general form and basic dimensions as shown in Figure K.2 and otherwise sufficiently robust to entrain and delaminate the socket segment under test.

K.2.3 *Drill*, sized to produce in the socket segment as shown in Figure K.3 a transverse hole of diameter 3 mm or 0.2*e*, whichever is the greater, where *e* is the thickness of the socket wall (in mm).

K.2.4 *Capping piece*, to fit the outer surface of the socket segment adjacent to the stirrup, as indicated in Figure K.1.

NOTE The need for the capping piece depends upon the relative strengths and dimensions of the socket and weld zone materials (see **K.3.5**).

K.3 Test piece preparation

K.3.1 Using sample fittings and one or more lengths (see **K.3.2**) of pipe as necessary for preparing jointed assemblies in accordance with pattern 1 of Table A.2, condition the pipes and fittings at – 5 °C for at least 8 h before fusion and then prepare the fused joints in accordance with Appendix A, using the minimum power input in accordance with Appendix G.

K.3.2 The pipe length(s) shall protrude at least 125 mm from their connection with the fitting.

K.3.3 Inspect the joint to identify the positions of the maximum and minimum visible gaps around the end(s) of the joint. Machine from four equidistant positions around the joint four longitudinal strips of width 15 mm $^{+3}_{-0}$ mm for sizes up to 90 mm or 25 mm $^{+5}_{-0}$ mm for larger sizes, such that the strips include the maximum and minimum observed gap zones previously identified.

In the case of couplings, the assemblies may be cut in half across the centre of the fitting, to produce eight test pieces from each coupling.

K.3.4 Drill a hole of diameter 3 mm or $0.2e_s$ (in mm), whichever is the greater, through the fitting as shown in Figure K.3, so that the axis of the hole is separated from the nominal fusion zone by a spacing, L_s, in accordance with Table K.1.

Table K.1 — Spacing of stirrup hole from the joint fusion zone

Size of socket	Spacing, L_s
mm	mm
⩾ 90 and ⩽ 180	5
> 180 and ⩽ 280	10
> 280	15

K.3.5 Brace the surface of the socket segment adjacent to the stirrup with the capping piece (**K.2.4**), as indicated in Figure K.1, if yielding of material adjacent to the drilled hole would otherwise occur before parting of the joint interface during testing in accordance with **K.4.2**.

K.4 Procedure

K.4.1 Using a test temperature of 23 °C ± 2 °C, fit the stirrup (**K.2.2**) to the test piece, mount the test piece assembly pipe stub in one jaw of the tensile testing machine (**K.2.1**) and connect the stirrup to the other axial jaw via a flexible link at least 300 mm long, as shown in Figure K.1.

K.4.2 Operate the testing machine to separate the axial jaws at 25 mm/min ± 10 % until complete separation of two parts of the test piece assembly occurs.

K.4.3 Inspect the fractured surfaces and classify the failure mode characteristic of the joint fusion interface zone as follows:

a) if pronounced deformation of surfaces, as illustrated in Figure K.4, occurred over at least 75 % of the nominal fusion length L_f, record the tear as ductile;

b) if a generally smooth separation, as illustrated in Figure K.5, occurred over more than 25 % of the nominal fusion length L_f, record the tear as brittle.

NOTE It is recommended that the resulting force/displacement relationship be recorded during testing in accordance with **K.4.2**, as the pattern of the resulting plot may also indicate the mode(s) of failure involved.

K.5 Test report

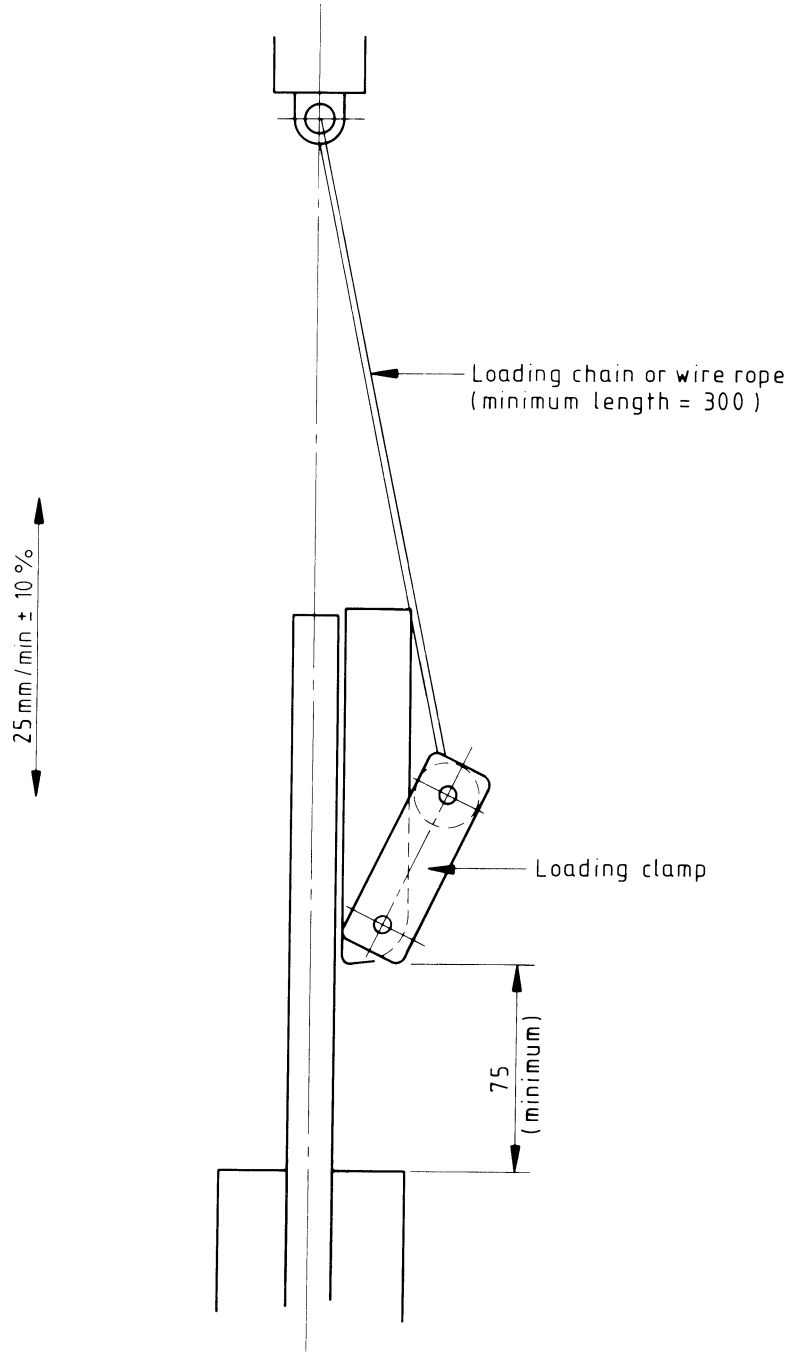
The test report shall include the following information:

a) the identification of the test piece(s);

b) a reference to this method of test, i.e. Appendix K of BS 7336:1990;

c) the nature of the failure mode(s) observed and the resulting classification, i.e. ductile or brittle;

d) the date of test.



All dimensions are in millimetres.

Figure K.1 — Peel test assembly

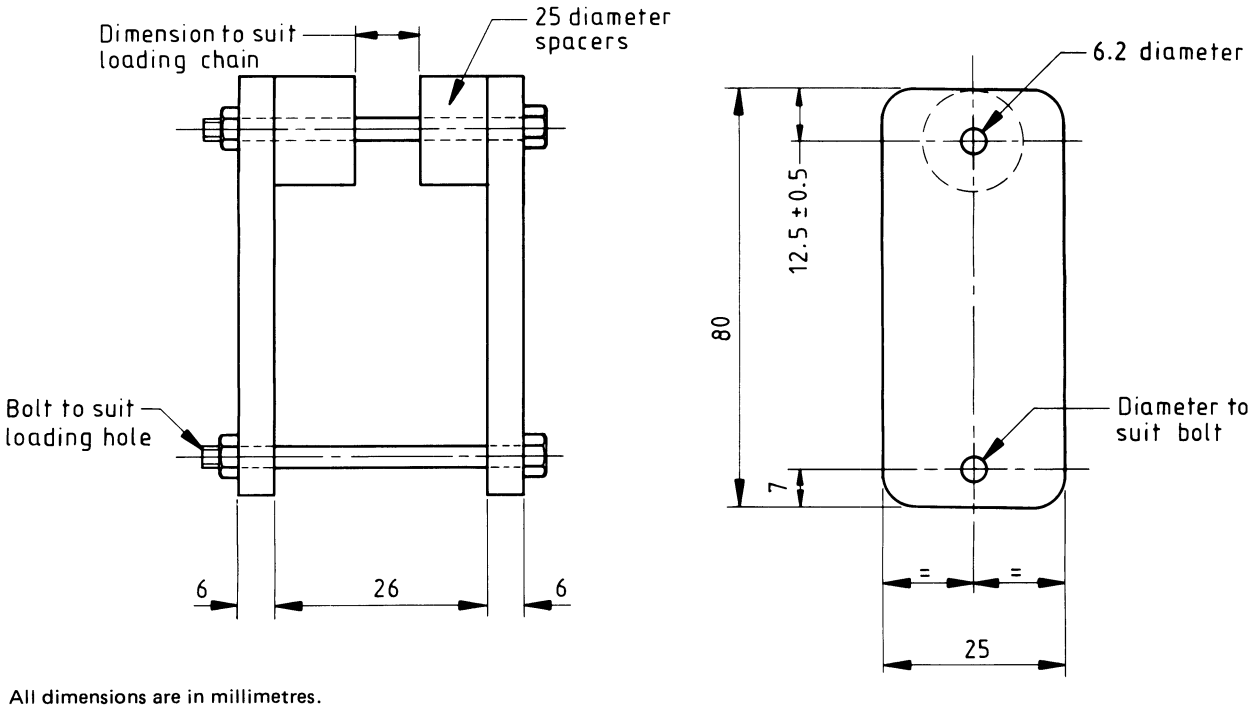


Figure K.2 — Loading stirrup

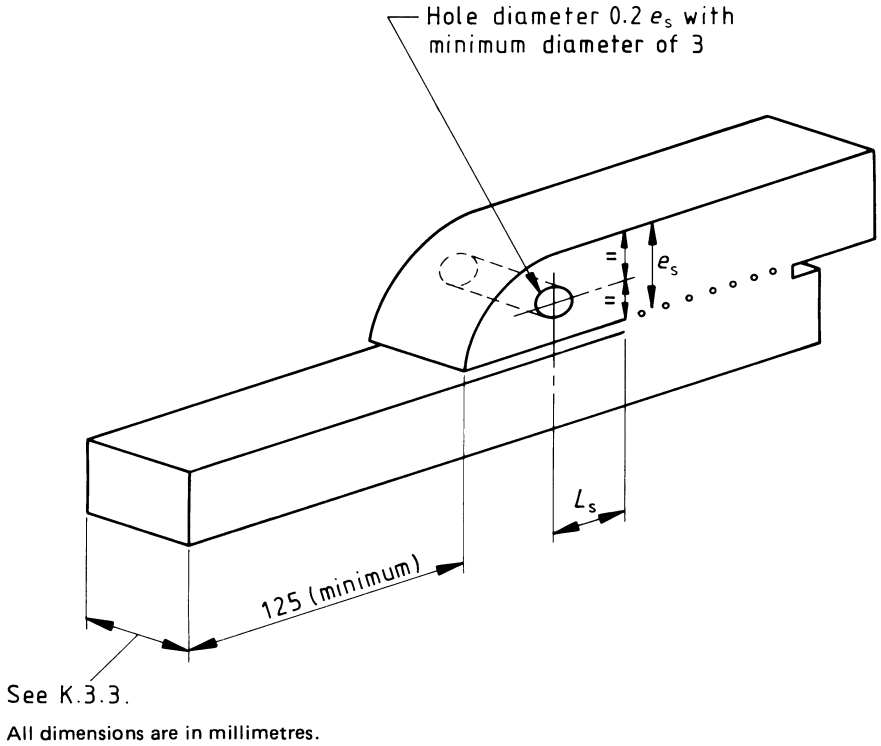
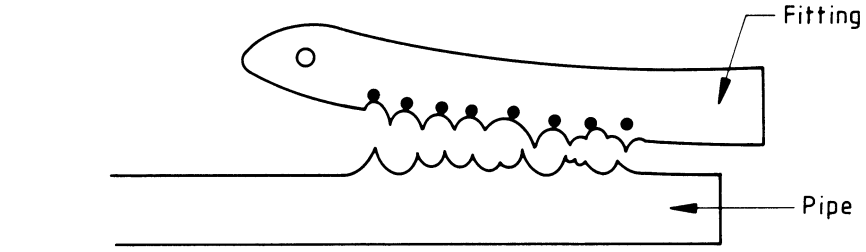
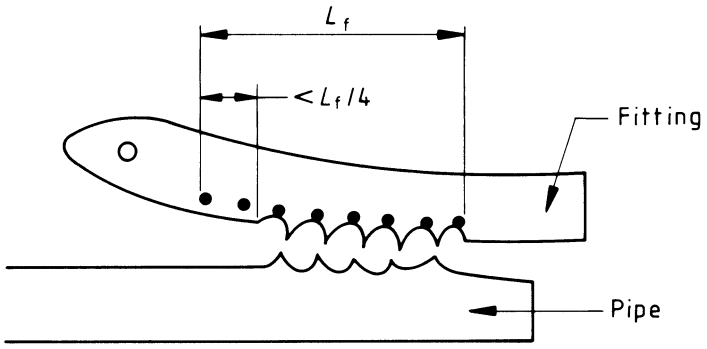


Figure K.3 — Test piece geometry



(a) Ductile failure



(b) Predominantly ductile failure

Figure K.4 — Typical ductile fractures

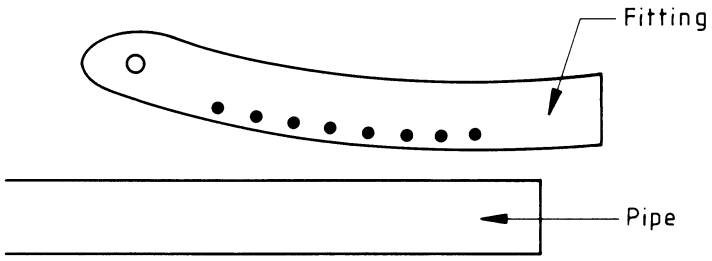


Figure K.5 — Typical brittle fracture

Appendix L Methods of test for resistance to hydrostatic pressure

L.1 General

Hydrostatic pressure testing shall be conducted in accordance with BS 4728 subject to compliance with the conditions of this appendix and specific requirements given elsewhere in this standard.

L.2 Apparatus

An air space maintained at the specified temperature may be used in place of a tank of water, i.e. the test may be conducted "with water in air" instead of "with water under water".

L.3 Test piece assemblies

Test piece assemblies shall be prepared in accordance with Appendix A.

NOTE The types of plugs and caps specified in Appendix A are those that will subject the fitting to the full hydrostatic end thrusts arising within the assembly.

L.4 Procedure

Condition the test piece assembly in accordance with Appendix B using the applicable test temperature (see **7.3** or **7.4**, as applicable), either after or immediately before incorporating the assembly in the hydrostatic pressure testing system as follows.

Support the test assembly, and/or adjacent piping, such that the test pieces are subjected to the hydrostatic end thrusts induced by the internal pressure.

Pressurize the assembly at a steady rate to attain the specified increase over a period of not less than 30 s and maintain the pressure for the applicable period.

Record any observations of bursting, loss of pressure or leakage.

L.5 Test report

The test report shall include the following information:

a) the identification of the test piece(s);

b) a reference to this method of test, i.e. Appendix L of BS 7336:1990;

c) the medium surrounding the test piece(s) when under test, i.e. air or water;

d) any observations of bursting, loss of pressure or leakage;

e) the date(s) on or between which the test piece assembly was under pressure.

Appendix M Method of test for resistance to accelerated relaxation and end load (AREL test)

WARNING. Attention is drawn to the need for adequate precautions when conducting tests involving pneumatic pressure.

M.1 Principle

A jointed assembly is subjected to an axial tensile load while maintained at an elevated temperature for a specified period and subsequently subjected to pneumatic leak testing after cooling.

M.2 Apparatus

M.2.1 *Means for gripping the pipe component(s) of the assembly*, to apply a constant axial tensile load to the pipe(s) and fitting such that no distortion or support of any of the fitting component(s) can occur.

M.2.2 *Means for sealing the test piece assembly*, and applying in turn at least two different controlled internal pneumatic pressures.

M.3 Test piece assemblies

Test piece assemblies shall be prepared in accordance with Appendix A, using lengths sufficient to enable subsequent testing in accordance with Appendix N.

M.4 Procedure

M.4.1 Mount the test piece assembly in the loading fixture (**M.2.1**) in such a way that no distortion or support of any of the fitting components can occur.

M.4.2 Bring the assembly to the specified temperature and apply the applicable axial load for the specified period (see **7.6.1**).

M.4.3 Unload the test assembly and allow it to cool to 23 °C ± 2 °C. Fit the seals (**M.2.2**) and apply a leak-tightness test using internal pneumatic pressure in two successive stages (see **7.6.1**). Inspect the test pieces and associated joints and record any signs of leakage. Report the observations and other information in accordance with **M.5** and, if the test piece assembly is still intact, test it in accordance with Appendix N.

M.5 Test report

The test report shall include the following information:

a) the identification of the test piece(s);

b) a reference to this method of test, i.e. Appendix M of BS 7336:1990;

c) the elevated temperature used;

d) the period under load at elevated temperature;

e) the combinations of pressure and time used for leak-tightness testing;

f) any incidence of separation or leakage of the test piece assembly;

g) the dates between which the test was conducted.

Appendix N Method of test for resistance to pull-out of jointed assemblies following accelerated relaxation

N.1 Principle

A jointed assembly is subjected to a specified rate of axial extension while measurement is made of the necessary force to determine whether this exceeds a specified value, dependent upon the nominal size and SDR of the relevant pipe, before the onset of pull-out, i.e. movement along the joint interface, or necking of the component pipe(s).

N.2 Apparatus

N.2.1 *Tensile testing machine*, capable of extending the test piece assembly (**N.3**) at the specified rate while measuring to an accuracy of within ± 2 % the resulting force at its maximum value or at the specified minimum value, whichever is the lesser.

N.2.2 *Means for securely gripping portions of axially aligned pipe sections of the test piece assembly* (see **N.3** and **N.4.2**).

NOTE This item of apparatus may consist of, for example, dilatant internal jaws or combinations of external jaws and close-fitting internal rigid plugs to support the pipe wall.

N.2.3 *Means for measuring the test temperature to the nearest degree Celsius.*

N.3 Test piece assemblies

Test piece assemblies shall be those prepared and tested satisfactorily in accordance with Appendix M.

N.4 Procedure

N.4.1 Condition the test piece assembly and any associated internal plugs (see **N.2.2**, including the note) in accordance with Appendix B.

N.4.2 Mount the test piece assembly in the tensile testing machine (**N.2.1**) so that the jaws grip portions of the associated PE pipes at positions at least three times the nominal pipe diameter away from the joint(s) or fitting under test.

NOTE Loading grips are not applied to the fitting under test.

N.4.3 Using the specified test temperature extend the test piece assembly axially at the specified rate until the maximum force is clearly established or until the applicable minimum force is exceeded, whichever is the lower. If the pipe necks at a force less than the specified minimum force, repeat the test (see **7.6.1** and **7.6.2**) on a completely new assembly.

N.4.4 Record the maximum force observed and to the nearest 1 °C the actual test temperature during the test. Correct the observed maximum force to the corresponding value at 23 °C using the applicable factor given in Table N.1.

Table N.1 — Maximum force correction factors

Test temperature	Correction factor
°C	
21	0.97
22	0.985
23	1
24	1.015
25	1.03

N.5 Test report

The test report shall include the following information:

a) the identification of the test piece(s);

b) a reference to this method of test, i.e. Appendix N of BS 7336:1990;

c) the actual test temperature used;

d) the maximum observed force;

e) a report of any incidence of pull-out and/or necking;

f) the date of testing.

Appendix P Method of test for resistance to pull-off of fused branch saddle joints

P.1 Principle

The outlet pipe of a branch saddle fitting is subjected to a specified rate of axial extension while measurement is made of the necessary force to determine whether this exceeds a specified minimum value, dependent upon the nominal size and SDR of the outlet pipe, before the following:

a) the onset of pull-off in the joint fusion area, spigot outlet and pipe/fitting interface or saddle body; or

b) the onset of necking in the outlet pipe.

P.2 Apparatus

P.2.1 *Tensile testing machine*, capable of entraining the extended outlet of the saddle fitting (see **P.3**) at the specified rate while measuring to an accuracy of ± 2 % the resulting force at its maximum value or at the specified minimum value, whichever is the lesser.

P.2.2 *Means for securely gripping a portion of the extension pipe on the spigot outlet of the saddle fitting* (see **P.3** and **P.4.3**).

NOTE This item of apparatus may consist of, for example, dilatant internal jaws or combinations of external jaws and a close-fitting internal rigid plug to support the pipe wall.

P.2.3 *Clamps*, for securing the mains pipe of the fitting or test assembly on either side of the saddle fitting, in accordance with **P.4.2**.

P.3 Test piece assemblies

Test piece assemblies shall consist of a branch saddle fitting fused in accordance with Appendix A to a length of PE pipe in accordance with **7.7**, and having a length of PE pipe complying with BS 7281 fused in accordance with Appendix A to the spigot outlet of the saddle fitting. The length of the pipe attached to the spigot outlet shall be four times the nominal size of the spigot outlet, in millimetres.

P.4 Procedure

P.4.1 Insert the rigid plug(s) (see **P.2.2**, including the note) as necessary to the ends of PE pipe(s) to support the pipe(s) under the action of the loading grips, and condition the test piece assembly and any associated internal clamps in accordance with Appendix B.

P.4.2 Clamp the mains pipe of the test specimen rigidly with the outlet pipe vertical so that the distance between the clamp inside faces is the saddle width + 30 mm.

P.4.3 Mount the test assembly and mains pipe clamps in the tensile testing machine (**P.2.1**) so that the spigot outlet extension pipe is gripped to accept a coaxial tensile force. Using the specified test temperature, entrain the extended spigot at the specified rate of extension until the maximum force is clearly established or until the applicable minimum force is exceeded, whichever is the lower.

P.4.4 Record the maximum load observed and to the nearest 1 °C the actual test temperature during the test. Correct the maximum observed force to the corresponding value at 23 °C using as necessary the appropriate factor given in Table N.1.

P.5 Test report

The test report shall include the following information:

a) the identification of the test piece(s);

b) a reference to this method of test, i.e. Appendix P of BS 7336:1990;

c) the actual test temperature used;

d) the maximum observed force;

e) a description of any observed cracking or rupture of the fusion joint area, spigot outlet and pipe/fitting interface or saddle fitting body and/or necking of the outlet pipe;

f) the date of testing.

Appendix Q Method of test for impact resistance of tapping tees

WARNING. Attention is drawn to the need for adequate precautions when conducting tests involving pneumatic pressure.

Q.1 Principle

The tapping tee assembly to be tested is held firmly against a rigid frame and so mounted that the stem of the tee is horizontal and will be struck normal to its surface near the free end by a falling striker of specified mass and drop height. The assembly is subsequently tested for leak-tightness.

Q.2 Apparatus

Q.2.1 *Falling weight apparatus*, consisting essentially of the following items (see Figure Q.1).

a) *Main frame*, rigidly fixed, supporting a guide, in the form of rails or a tube with perforated walls, sufficiently long for a striker [see b)] to fall freely through at least 2 000 mm relative to the point of impact on the test piece, such that the guide is rigid and vertical to within 1°.

b) *Striker*, which may be weighted and which can fall freely subject to the guide. It shall be equipped with a hardened hemispherical striking surface 25 mm in diameter which shall be free from flats or other imperfections. The combined mass of the striker and any associated weight(s) shall be not less than the nominal mass specified for the type and size of fitting to be tested.

c) *Means for supporting the test piece assembly* (see **Q.3**), generally as shown in Figure Q.1 and including the following essential components.

1) End plugs to fit into either end of the test piece assembly without providing support to the saddle under test.

2) A rigid frame to support the test piece assembly with the tee stem in a horizontal position and enable rotation of the assembly about the axis of the tee stem.

d) *Striker release mechanism*, such that the striker and any associated weight(s) can fall through a specified height of up to at least 2 000 mm onto the surface of the test piece.

e) *Means for adjusting and/or maintaining the height of fall by the striker*, e.g. by vertical movement of the test piece support [see c)], the striker release mechanism [see d)] and/or the frame supporting the guide [see a)], in order to accommodate different sizes of test piece assemblies.

Q.2.2 *Conditioning chamber*, capable of conditioning one or more test piece assemblies at – 5 °C ± 2 °C.

Q.2.3 *Pressure testing equipment*, comprising means for sealing the test piece assembly and applying a specified internal pneumatic pressure.

Q.3 Test piece assemblies

Test piece assemblies shall consist of a tapping tee fused in accordance with Appendix A centrally to a length of PE pipe in accordance with **7.8**, where the length of the pipe shall be three times the nominal main pipe outside diameter.

G.4 Procedure

Q.4.1 Ensure that the procedures described in **Q.4.2** to **Q.4.9** are carried out at least 24 h after fusion jointing of the test piece assembly.

Q.4.2 Fit end plugs [**Q.2.1** c) 1)] to each end of the main pipe of the test piece assembly.

Q.4.3 Condition the assembly at – 5 °C ± 2 °C for at least 1 h immediately prior to testing.

Q.4.4 Using an ambient test temperature of 23 °C ± 2 °C, complete the procedures of **Q.4.5** to **Q.4.8** within 5 min of removing the assembly from the conditioning chamber (**Q.2.2**).

Q.4.5 Fix the specimen to the rigid base plates and mount them in the rigid frame [**Q.2.1** c) 2)].

Q.4.6 Position the frame supporting the test piece assembly and/or the frame supporting the guide for the falling striker to meet the following conditions:

a) the tapping tee shall be impacted with the falling striker 25 mm ± 1 mm from its free end (see Figure Q.1);

b) the impact direction shall be parallel to the main pipe axis;

c) the falling striker shall strike the fitting normal to the surface under test;

d) the striker shall be released from the specified height (see **7.8**) above the point of impact.

Q.4.7 Release the striker and allow it to strike the tapping tee once.

Q.4.8 Turn the test piece assembly 180° about the axis of the tee stem. Reset the striker for the specified drop height and release it to impact the tapping tee on the opposite face from the position first struck in accordance with **Q.4.7**.

Q.4.9 Inspect the test piece assembly for fractures and record any such observations, otherwise subject the assembly to an internal pneumatic pressure of 2 bar for 1 h and inspect the assembly for, and record, any signs of leakage.

Q.5 Test report

The test report shall include the following information:

a) the identification of the test piece(s);

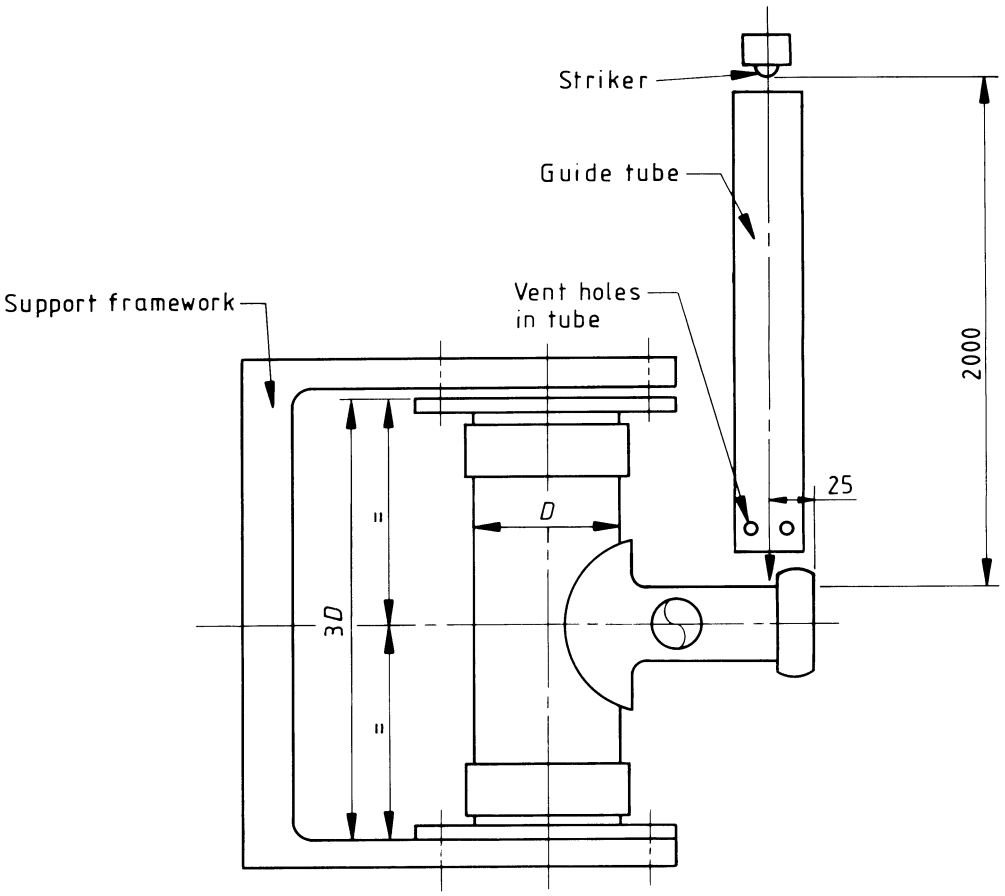
b) a reference to this method of test, i.e. Appendix Q of BS 7336:1990;

c) the striker mass and drop height used;

d) any observations of damage to the test piece assembly and/or signs of leakage when pressure tested;

e) the test pressure used;

f) the date of testing.



All dimensions are in millimetres.

Figure Q.1 — Typical impact test assembly

Appendix R Specification for electrofusion control equipment

NOTE The specification given in this appendix is based on PS/ECE 1 [4] as necessary to enable jointing with manual selection of fusion times, but requirements given in that document essentially to facilitate field installation jointing, e.g. within trenches and/or automatic selection or verification of fusion times, have been omitted. Such additional features are not precluded by this specification.

R.1 General

This appendix specifies the construction, operating requirements and performance criteria of electrofusion control boxes and associated cables suitable for the preparation of test assemblies in accordance with this British Standard (see **A.1.6**), based on manual setting of fusion times and operation at ambient temperatures in the ranges – 5 °C ± 2 °C and + 23 °C ± 2 °C.

This standard is applicable to control boxes utilizing power transformers and phase-angle firing techniques to achieve the required voltage and current outputs.

R.2 Control box

R.2.1 The control box shall comply with the requirements specified in **R.2.2** to **R.2.9**.

R.2.2 The output from the control box shall be stabilized to give 39 V to 40 V a.c. r.m.s. and/or 78 V to 80 V a.c. r.m.s. in either case when delivering a current in the range 1 A to 50 A. The stable voltage shall be achieved within 1 s from the start of applied voltage.

The control box circuitry shall use the voltage sensed at the fitting terminals to control the voltage to the electrofusion fitting (see Figure R.1).

R.2.3 The socket outlet shall be fixed to the control box panel. The socket outlet shall have a protective cap, and shall be suitable for use with a 5 pin connector (see **R.3.2.2** and Figure R.1) at 40 V or 80 V as applicable.

NOTE For additional information on suitable connections, see [4].

The case of the socket outlet shall be referenced to 0 V within the control box.

R.2.4 The control box shall include or utilize a timing device such that relevant fusion cycle times in the range 10 s to 999 s can be selected, and shall be controlled to an accuracy of ± 0.1 % for any setting over an ambient temperature range of 10 °C to + 25 °C. The timing system accuracy shall be maintained within these limits without adjustment for at least 12 months.

NOTE If a frequency-dependent timer is utilized, attention is drawn to effects that may arise because the frequency variation of a typical power supply generator may be between the limits of not less than 40 Hz to not greater than 70 Hz.

R.2.5 The control box shall check the integrity of the fusion coil and the continuity of the output circuit before the main power is allowed to be switched on to the fitting. The continuity circuit shall be powered by not more than 12 V. The control box shall not operate when attached to resistances above 200 Ω. The control box circuit shall measure continuity across power pins P_A and P_B on the output socket as indicated in Figure R.1. The continuity of this circuit shall be continuously monitored during the fusion cycle. Any break in the circuit shall switch the control box to "off" and indicate "FAULT".

R.2.6 Safety devices shall be fitted to the control box to prevent voltages greater than 42 V a.c. r.m.s. being present at the control box output. The safety device shall operate in less than 0.5 s.

R.2.7 The control box shall display the following information:

a) input voltage "on";

b) initial fusion cycle time, decrementing in seconds to zero;

c) fusion "complete";

d) "fault" (see **R.2.8**);

e) indication of number of operations completed.

Access to this display shall be from inside the control box.

R.2.8 Each of the following faults shall be uniquely identified when they occur.

a) Output voltage outside the tolerance band 39 V to 40 V and/or 78 V to 80 V. These trips shall be set at 39 V $^{+0}_{-0.1}$ V and 80 V $^{+0.1}_{-0}$ V respectively and shall operate in less than 6 s.

b) Break in circuit.

c) Fusion time not on preferred list of times.

d) Interrupted fusion cycle.

e) Input voltage in excess of 150 V.

The output circuit shall be switched off automatically if a fault occurs.

R.2.9 All displays shall be clearly visible both in bright sunlight and in subdued lighting conditions.

R.3 Cables

R.3.1 *Input cable*

The input cable shall be permanently attached to the control box and its nominal length shall be 10 m. The maximum voltage drop shall be 1.75 V (lead and return) when measured at the maximum input current, i.e. 24 A.

The input cable shall be flexible 3-core with overall screening. The earth conductor and screening shall be bonded to the transformer interwinding screen and any exposed metal parts. The input cable/insulation shall be of PVC complying with type TI1 of BS 6746:1984 with a PVC cable sheath complying with type TM1 of BS 6746:1984 and flexible conductors complying with BS 6360. The input cable shall terminate at a 3-pin, 110 V, 16 A[7)] plug complying with BS 4343 and protected in accordance with IP 44 of BS 5420:1977. The cable screen shall be made into a tail, sleeved, and connected along with the earth core of the cable into the earth pin of the plug.

If a residual current device (RCD) is to be fitted to the input service, it shall be protected from derating by any component or circuitry used in the control box.

NOTE Small d.c. currents may derate RCDs and thus give rise to a hazard.

R.3.2 *Output cable*

R.3.2.1 All materials used in the construction of output cable shall be suitable for use at temperatures in the range – 10 °C to + 25 °C. The output cable/insulation shall be of PVC complying with type TI1 of BS 6746:1984 with a PVC cable sheath complying with type TM1 of BS 6746:1984 and flexible conductors complying with BS 6360.

R.3.2.2 The nominal length of the cable shall be not more than 3 m. Terminations shall be fitted to the control box at one end and to the fitting at the other. The connection to the control box shall be a 5-pin plug for use at 40 V or 80 V, as applicable, for the purposes indicated in Figure R.1.

NOTE For additional information on suitable connectors, see [4].

R.3.2.3 The power cores shall have a maximum voltage drop of 1.6 V (lead and return) when measured at a maximum current of 50 A.

R.3.2.4 The cable supplied for use with manual selection snail be 4-cored and suitable for the following functions:

a) to supply electrical power to the fitting;

b) for sensing and feedback of output voltage at the fitting terminal power pin; the voltage sensing facility shall be isolated from item a).

R.3.2.5 The output cable and fitting connector shall withstand an axial pull of 100 N without failure or deterioration of the cable/connector joint.

R.4 Insulation resistance

When a nominal test voltage of 500 V d.c. is applied between supply poles and earth under the following conditions, the insulation resistance thus measured shall be not less than 1 MΩ.

The control box and input cable shall have the 110 V primary circuit connected as follows:

a) active control elements (e.g. thyristors or triacs) shall have all terminals shorted together;

b) where applicable, switches, circuit breakers and contactors shall be closed, and fuses shall be in;

c) both poles of the supply shall be connected together.

7) For non-continuous applications (i.e. electrofusion) high current levels can be tolerated by this plug design.

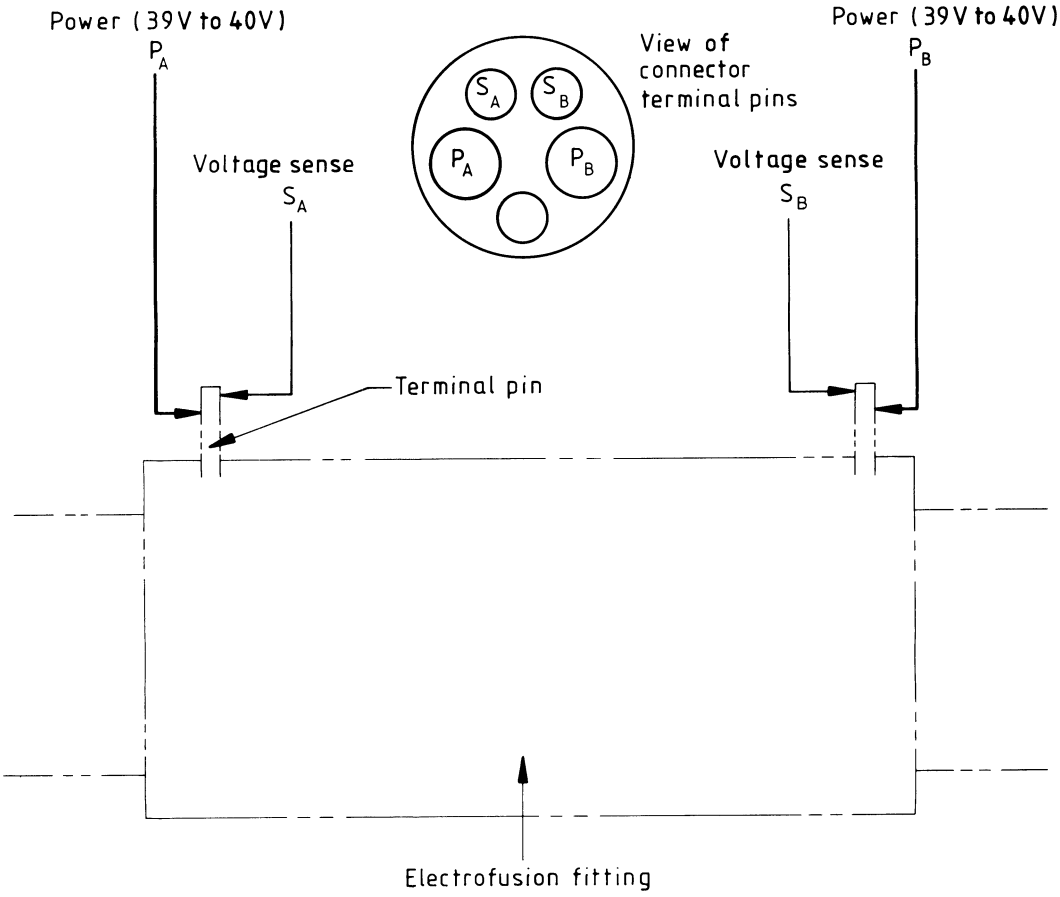


Figure R.1 — Schematic diagram of an output cable

Appendix S Guidance on quality control testing

S.1 General

The following guidance on 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 fittings to comply with this standard.

The applicability of specific requirements and associated methods of test to different types of fitting is summarized in Table T.1 and Table T.2, in which each requirement is classified as being considered particularly suitable for type test and/or inspection test purposes.

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

Inspection tests are carried out during and/or following manufacture to monitor the quality of a product item as applicable. Certain test methods and associated requirements have been included because of the practicality and speed with which they may be performed in conjunction with a production process in comparison with some of the type tests.

Some of the requirements in this standard are relevant to both type test and inspection purposes, e.g. those for dimensions. Attention is drawn to guidance given in **4.14** of BS 5750-5:1981 concerning possible use of alternative inspection procedures and equipment for quality control purposes under production conditions, e.g. on-line monitoring of dimensions, to the methods required by a British Standard for establishing the properties of the final product under laboratory conditions specified in the standard.

S.2 Example product approval and process control testing scheme

S.2.1 ***Manufacturer's testing protocol***

The following protocol is typical, for the topics covered, of a testing scheme which had been an agreed basis between a major user of such fittings and their suppliers for the conduct of approval testing (see **S.2.2**) and of process control (see **S.2.3**) with reference to the batch sampling and testing plans described in Appendix T.

When considering such schemes, it should be borne in mind that to comply with the specification, the product has to meet all the requirements of the specification regardless of the primary purpose for their inclusion.

S.2.2 ***Approval tests***

Satisfactory approval testing of each type and size of fitting may be necessary by agreement before a fitting is considered suitable for supply. For the purposes of this example, approval testing is undertaken in two parts, designated phase 1 and phase 2. For details see **T.3** and **T.4**.

The manufacturer may qualify his product by undertaking a series of preliminary approval tests (phase 1/2) followed by phase 1 and phase 2 approval tests. Submission for phase 1 approval should be made within 12 months or preliminary approval should be withdrawn. Details of such a test programme are set out in Appendix T.

Fittings awarded preliminary approval should be limited to operation at pressures not exceeding 2 bar.

Where the manufacturer does not have production fittings, phase 1 approval may be given on preproduction fittings. Thereafter, submission for phase 2 approval should be obtained on fittings representing at least 3 months' production and within 18 months of production following the receipt of phase 1 approval or phase 1 should be withdrawn.

In the event of a change in design, manufacturing technique, materials used or a long break in production, reappraisal of approval status should be required. The agreement of the purchaser should be obtained before the change or changes are made which may cause any or all of the approval tests to be repeated.

S.2.3 ***Process control tests***

Process control tests are necessary in order to demonstrate a continuing satisfactory level of product quality in day-to-day production.

Process control tests on fittings should be carried out using pipe approved for compliance with BS 7281 and jointed using tooling in accordance with this standard, i.e. BS 7336.

S.3 Quality systems

It is strongly recommended that the manufacturer set up and maintain such quality assurance and inspection systems as are necessary to ensure that the fittings supplied fully comply with this standard.

It should be noted that the purchaser may seek to assess such systems against the requirements of the applicable Parts of BS 5750 and to undertake such surveys as are necessary to ensure that the quality assurance and inspection systems are to the purchaser's satisfaction.

The purchaser may also seek the right to undertake inspection or testing of the fittings during any stage of manufacture at which the quality of the finished goods may be affected and to undertake inspection or testing of raw materials or purchased components.

S.4 Certification

Attention is drawn to the text in the foreword regarding certification. In the scheme upon which this example is based, the purchaser stipulated that certified records appertaining to the materials used, inspection and testing of all manufactured fittings be kept by the manufacturer and that such records be available for inspection by the purchaser at the manufacturer's or subcontractor's premises.

Appendix T Recommendations for sampling and testing PE electrofusion fittings and joints

T.1 General

All samples for testing, with the exception of those for oxidation induction time, MFR and temperature coefficient of resistance of the wire, should be fused, in accordance with Appendix A, before testing.

Tests should be carried out with pipes approved or certified as complying with BS 7281 and made from an appropriate base polymer.

T.2 Preliminary approval

Preliminary approval (phase 1/2) may be considered for each size and type of fitting which has been shown to meet the test schedule in Table T.1 and has also satisfied **T.5** and **T.6**.

T.3 Phase 1 approval

Phase 1 approval should be obtained within 12 months for fittings having preliminary approval or the preliminary approval should be withdrawn.

The schedule of tests listed in Table T.1 should be satisfactorily carried out on each size and type of fitting which has also satisfied **T.5** and **T.6**.

T.4 Phase 2 approval

Samples of each size and type of fitting should be selected and tested as detailed in **T.1**, from batches of fittings representative of at least 3 months' production.

T.5 Process control

Initially the checks specified in Table T.2 should be carried out at the stated frequency on production from each machine or manufacturing process. When the manufacturer has shown by consistently good results that it is not necessary to check at this frequency, authorization for reduced frequencies may be granted by the purchaser's Quality Assurance Department. The authorization should be in writing and should also thus be withdrawn at a later date if adverse change occurs in the relationship between recorded results and the requirements of this standard.

T.6 Batch acceptance

T.6.1 For moulded fittings, a batch should comprise the production of a machine, from the time it commences to produce fittings complying with this standard until the machine is closed down. A production batch should not exceed 170 h machine time or 10 000 components, whichever occurs first. Where any interruption occurs in production, steps should be included in quality control procedures to ensure that mouldings are not accepted until the agreed operating conditions have been re-established. Any break in production that exceeds 8 h should be deemed to comprise the termination of a batch.

For machined and/or fabricated fittings, the batch definition should be agreed.

T.6.2 Batch acceptance should be carried out by the manufacturer on fully normalized fittings subject to either of the following conditions:

a) until written authorization has been given by the purchaser to reduce or cease batch acceptance;

b) when required by the purchaser's Quality Assurance Department if process control by the manufacturer has been shown to be inadequate.

T.6.3 Batch acceptance may be carried out by the manufacturer under either of the following conditions:

a) at the manufacturer's subcontractor's works as part of the conduct of **S.2.3**, subject to a maximum frequency of one test per eight machine-weeks (see **T.6.1** for applicable batch limits);

b) at the manufacturer's works, in which case the batch for acceptance should be a manufactured batch.

T.6.4 When batch acceptance is carried out, the sampling plans given in Table T.3 and Table T.4 should be used. One sample should be taken from each batch preferably bearing different dates.

7.6.5 Rejected batches may be split into sub-batches based on the date of production. Each sub-batch should be tested for those aspects which were failed, to one of the sampling plans shown in Table T.5. All non-conforming items should be rejected.

Table T.1 — Recommended approval test scheme

Description of test/check	Total number of samples			Test method	Total time			Requirements clause
	Phase 1/2	Phase 1	Phase 2		Phase 1/2	Phase 1	Phase 2	
				4.7	h	h	h	
Corrosion resistance	1	—	—		168	N/A[a]	N/A	**4.7**
Fitting assembly force	1	—	—	Appendix D	N/A	N/A	N/A	**5.2.3.2**
Tapping tee cutting torque	2 See pattern 6[b]	—	—	—	N/A	N/A	N/A	**5.6.6**
Pressure drop	2 See pattern 5[b]	—	—	Appendix F	N/A	N/A	N/A	**5.6.9**
Assessment of fitting resistance tolerance band	2 See pattern 2[b]	2 See pattern 2[b]	—	Appendix G	N/A	N/A	N/A	**5.9.1**
Cooling time	1 See pattern 2, assembly 2[b]	—	—	Appendix H	N/A	N/A	N/A	**5.9.2**
Dimensional stability	—	2	—	—	N/A	5 000	9 000	**6**
Joint strength	2 See pattern 1[b]	2 See pattern 1[b]	Appendix J or Appendix K	N/A	N/A	N/A	N/A	**7.2**
Long-term hydrostatic pressure resistance at 20 °C	2 See pattern 2[b]	4 See pattern 4[b]	4 See pattern 4[b]	Appendix L	2 500	5 000	10 000	**7.4**
Hydrostatic pressure resistance at 80 °C	3 See pattern 3[b]	4 See pattern 4[b]	4 See pattern 4[b]	Appendix L	1 000	1 000	1 000	**7.4**
AREL test for sockets up to 75 mm	2 See pattern 2[b]	4 See pattern 4[b]	—	Appendix M and Appendix N	500	500	—	**7.6**
AREL test for flange adaptors	—	2 See pattern 1	—	Appendix M and Appendix N	—	500	—	**7.6**
Branch saddle fusion pull-off test	2 See pattern 2[b]	—	—	Appendix P	N/A	N/A	N/A	**7.7**
Tapping tee impact test	2 See pattern 2[b]	—	—	Appendix Q	N/A	N/A	N/A	**7.8**
Circumferential reversion of spigot outlets or pupped ends	1	1	1	Appendix E of BS 7281:1990	N/A	N/A	N/A	**7.9**

[a] N/A signifies "Not applicable".
[b] See Table A.2.

Table T.2 — Recommended process control schedule

Description of test/check	Initial frequency of test	Test method	Requirements clause
MFR	Daily	ISO 1872-1	**3.1.1** **3.1.3**
Operation of fusion indicator	Every 24 h rotating cavities as applicable (see note 1)	Visual examination to agreed limits	**4.1.3** c)
Oxidation induction time	Weekly	Appendix D of BS 7281:1990	**4.3**
Dimensions	Every 2 h or every 25th component, whichever is least frequent	See note 2	**5**
Heating element resistance check	Every fitting	—	**5.9.1**
Joint strength	Every 24 h rotating cavities as applicable	Appendix J Appendix K	**7.2.1** **7.2.2**
Short-term pressure test at 20 °C	Every 24 h rotating cavities as applicable (see note 1)	Appendix L	**7.3**
Short-term (170 h) pressure test at 80 °C	Every 24 h rotating cavities as applicable (see note 1)	Appendix L	**7.5**
Circumferential reversion test for outlets or pup ends	One per batch	Appendix E of BS 7281:1990	**7.9**

NOTE 1 Test piece assemblies should be made up to conform with either assembly 1 or assembly 2 in accordance with pattern 1 of Table A.2.
NOTE 2 Agreed dimensions of injection moulded fittings should be checked relative to each mould cavity on start up and thereafter only diameters of mouldings need be checked. The frequency and method of checking machined and/or fabricated fittings should be agreed with the purchaser.

Table T.3 — Sample size code letter

Batch size	Dimensional tests	Destructive tests			Other tests	
		Short-term pressure and operation of fusion indicators	Stress crack resistance and end reversion	Joint strength	Thermal stability	MFR
Less than 150	c	b	b	b	a	a
150 to 500	d	c	c	c	a	a
501 to 2 500	e	d	d	d	a	a
2 501 to 10 000	f	e	e	e	e	e

Table T.4 — Double sampling plans

Sample size code	Sample sizes			Action to be taken on number of rejects				
	1st	2nd	Total	1st sample			Total of both samples	
				Accept batch	Reject batch	Take 2nd sample	Accept batch	Reject batch
a	1	3	4	0	⩾ 2	1	1	⩾ 2
b	2	6	8	0	⩾ 2	1	1	⩾ 2
c	3	9	12	0	⩾ 2	1	1	⩾ 2
d	5	15	20	0	⩾ 2	1	1	⩾ 2
e	8	24	32	0	⩾ 2	1	1	⩾ 2
f	13	39	52	0	⩾ 2	1	1	⩾ 2

Table T.5 — Sub-batch sampling plans

Sub-batch size	Sample size	Action to be taken on number of rejects	
		Accept sub-batch	Reject sub-batch
Less than 500	5	0	1
500 and over	15	0	1

Appendix U References

The following is a list of publications (other than BSI and ISO publications) that are identified in the standard by the numbers in square brackets.

[1] *IGE/TD/3 Distribution mains*, 2nd ed. (1983). The Institution of Gas Engineers[8)].

[2] *IGE/TD/4 Gas Services,* 2nd ed. (1981). The Institution of Gas Engineers[8)].

[3] *Draft Technical Report — Rapid crack propagation in polyethylene gas pipes — Test methods* (Document ISO/TC138/SC4 N 500). International Organization for Standardization[9)].

[4] Draft British Gas Engineering Standard PS/ECE 1 Specification for Electrofusion Control Boxes; Stage 3, Issue 9, reference 87/277 (CMSC). March 1987[10)].

[8)] Available from the Institution of Gas Engineers, 17 Grosvenor Crescent, London SW1X 7ES.
[9)] Available from Enquiry Section, BSI, Linford Wood, Milton Keynes MK14 6LE.
[10)] Available from Production and Supply Division, British Gas plc, Rivermill House, 152 Grosvenor Road, London SW1V 3JL or from Enquiry Section, BSI, Linford Wood, Milton Keynes MK14 6LE.

Publications referred to

BS 1134, *Assessment of surface texture.*

BS 1134-1, *Methods and instrumentation.*

BS 1179, *Glossary of terms used in the gas industry.*

BS 1755, *Glossary of terms used in the plastics industry.*

BS 1755-1, *Polymer and plastics technology.*

BS 2494, *Specification for elastomeric joint rings for pipework and pipelines.*

BS 2782, *Methods of testing plastics.*

BS 2782-0, *Introduction.*

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

BS 2782:Method 1106A, *Assessment of pigment dispersion in polyolefin pipes and fittings: microtome method.*

BS 3412, *Polyethylene materials for moulding and extrusion.*

BS 4168, *Hexagon socket screws and wrench keys: metric series.*

BS 4168-9, *Specification for wrench keys.*

BS 4343, *Specification for industrial plugs, socket-outlets and couplers for a.c. and d.c. supplies.*

BS 4576, *Specification for unplasticized polyvinyl chloride (PVC-U) rainwater goods and accessories.*

BS 4576-1, *Half-round gutters and pipes of circular cross section.*

BS 4728, *Method for determination of the resistance to constant internal pressure of thermoplastics pipe.*

BS 5252, *Framework for colour co-ordination for building purposes.*

BS 5420, *Specification for degrees of protection of enclosures of switchgear and controlgear for voltages up to and including 1 000 V a.c. and 1 200 V a.c..*

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

BS 5750, *Quality systems.*

BS 5750-1, *Specification for design/development, production, installation and servicing.*

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

BS 5750-3, *Specification for final inspection and test.*

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

BS 6360, *Specification for conductors in insulated cables and cords.*

BS 6746, *Specification for PVC insulation and sheath of electric cables.*

BS 7281, *Specification for polyethylene pipes for the supply of gaseous fuels.*

BS 9522 N0001, *Detail specification for multi-contact circular electrical connectors for d.c. and low frequency applications. Bayonet coupling non-barrier sealed with rear release, with front release, rear removable crimp contacts and barrier sealed with non-removable solder contents. Full assessment level.*

CP 312, *Code of practice for plastics pipework (thermoplastics material).*

CP 312-1, *General principles and choice of material.*

CP 312-3, *Polyethylene pipes for the conveyance of liquids under pressure.*

ISO 1043, *Plastics — Symbols*[11)].

ISO 1043-1, *Basic polymers and their special characteristics.*

ISO 1872, *Plastics — Polyethylene (PE) and ethylene co-polymer thermoplastics.*

ISO 1872-1, *Designation.*

[11)] International Organization for Standardization.

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