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(Page 1 of 22)
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WATER INDUSTRY SPECIFICATION

UK Water Industry
Engineering and Operations Committee

SPECIFICATION FOR PE80 AND PE100 ELECTROFUSION FITTINGS FOR NOMINAL SIZES UP TO AND INCLUDING 630

FOREWORD

This document is the specification for PE80 and PE100 electrofusion fittings in the nominal size range up to and including 630 for use with PE80 and PE100 pipe and fittings, with nominal pressure ratings up to and including 16 bar. It supersedes WIS 4-32-06.

This specification has been prepared by WRc plc under the direction of the Water Industry Engineering and Operations committee in consultation with the British Plastics Federation.

Where possible, this specification has been harmonised with the draft CEN standard for plastics piping systems for water supply - Polyethylene (PE) - Part 3:Fittings.

The dimensions and pressure ratings of the pipes with which fittings manufactured in accordance with this specification are to be used, are based on BS 5556 and are given in WIS 4-32-03, WIS 4-32-09, WIS 4-32-13, and WIS 4-32-15. WIS 4-32-08 covers site fusion jointing of PE80 and PE100.

The WSA/WRc manual for polyethylene pipe systems for water supply, offers guidance to the UK Water Industry on the practical design, installation and operation of PE water pipeline systems.

The specification does not purport to include all the necessary provisions of a contract. Users of this specification are responsible for its correct application. Reference to a British Standard, Water Industry Specification or any other specification applies equally to any equivalent specification.

Compliance with this specification does not of itself confer immunity from legal obligations.

This specification includes the use of substances and/or procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

It has been assumed in the drafting of this specification that the execution of its provisions is entrusted to appropriately qualified and experienced people.

Information contained in this specification is given in good faith. Neither the UK Water Industry Research Ltd, the Water Services Association nor WRc plc can accept any responsibility for actions taken by others as a result.

Enquiries regarding the availability of National Accreditation and Certification of Competence Board (NACCB) or equivalent accredited third party certification should be addressed to an appropriate third party certification body or to WRc.

This document has been prepared by the UK Water Industry Engineering and Operations Committee and published by WRc plc.
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CONTENTS

1. SCOPE

This specification defines the performance requirements for blue and/or black pigmented polyethylene electrofusion fittings for use with PE 80 and PE 100 pipe and spigot fittings at nominal pressure ratings of up to and including 16 bar for nominal sizes up to and including 630.

NOTE: Blue is the preferred colour for underground polyethylene fittings for potable water use. If such fittings are used above ground, protection from sunlight is required.

Site fusion jointing of electrofusion fittings shall be conducted in accordance with the requirements of WIS 4-32-08, and with reference to the manufacturer's jointing instructions.

2. DEFINITIONS

For the purpose of this specification, the following definitions apply:-

MRS - The minimum required strength value, based on the 50 year lower confidence limit of the failure stress at 20°C obtained by long term extrapolation in accordance with ISO TR 9080.

The MRS is divided by an overall service (design) coefficient (C) to obtain the Design Stress (σ_s) at 20°C (see Table 1).

Table 1 - Relationship between Minimum Required Strength and Design Stress

Material Class	MRS (MPa)	C	σ_s (MPa)
PE 80	8.0	1.25	6.4
PE 100	10.0	1.25	8.0

PE80 - Polyethylene with an MRS equal to or greater than 8.0MPa. This includes MDPE pipe conforming to WIS 4-32-03 or WIS 4-32-09.

ISSN 1353-2510

PE100 - Polyethylene with an MRS equal to or greater than 10.0MPa. This includes HPPE pipe conforming to WIS 4-32-13.

PN - The nominal operating pressure of a pipe or component which will give a minimum 50 yr design life.

NOTE: The titles of the publications referred to in this document are listed under Clause 12 - REFERENCES.

3. QUALITY ASSURANCE

Manufacturers shall operate a quality system relating to this specification in compliance with BS EN ISO 9002 (BS 5750: Part 2). This shall include a quality plan whereby details and results for each test relevant to each material composition and manufacturing process shall be made available to the purchaser or his representative on request.

NOTE: The use of a quality assurance product certification mark on this product is an indication that a certification body is satisfied that the product conforms to this specification and in addition it is produced under a quality system which complies with the requirements of BS EN ISO 9002 (BS 5750: Part 2).

4. MATERIAL REQUIREMENTS

4.1 Base polymer

The base polymer shall be a single grade of polymer, with a conventional density greater than 931kg/m^3 at 23°C, when determined in accordance with BS 3412. Copolymers of ethylene and higher olefins, in which the higher olefin constituent does not exceed 10% by mass are permitted.

The melt flow rate shall be determined in accordance with Clause 2.2.1.3 of BS 3412: 1992 and conform to the requirements of Table 5 of that standard.

4.2 Compound composition

The base polymer shall be compounded with additives (antioxidants, pigment, carbon black, UV stabilisers, etc.) that are necessary for the manufacture, storage and use of fittings to this specification.

The blue compound shall be Class C for PE 100, and class N for PE 80, and the black compound class W as defined in BS 3412: 1992.

Black compound shall conform to all relevant clauses of BS 3412 except where otherwise stated by this specification. The carbon black content shall be not less than 2% nor more than 2.5% by mass and the particle size shall be 0.01µm to 0.025µm.

Additives shall be evenly distributed throughout the fitting. Compliance with Clause 4.5 indicates adequate dispersion of additives.

4.3 Antioxidants

Only antioxidants listed in Table 7 of BS 3412: 1992 (excluding 6,6' ditertbutyl-4,4' thiodi-m-cresol) shall be used.

4.4 Rework material

Clean rework polyethylene material (e.g. sprues, runners or moulded preforms), generated from a manufacturer's own production of PE 80 or PE 100 fittings and/or pipe may be used. The manufacturer shall not incorporate any other reprocessable polyethylene material. Rework material shall be reground under the manufacturer's supervision. Fittings produced from this rework material and/or a virgin/rework blend shall meet the requirements of this specification.

Fittings manufactured totally or in part from PE rework material shall be identifiable as such through reference to the batch identification code in Clause 10 - Marking.

4.5 Colour

Fittings shall be blue and/or black. The colour of blue PE 100 shall lie within the range 20D44 to 20D45 or 20E53 to 20E56 of BS 4901. The colour of blue PE 80 fittings shall lie within the range 18E51 to 18E53 of BS 4901.

Blue materials shall, when tested in accordance with BS 2782: Method 1106A, have a pigment dispersion equivalent to or better than that shown in photomicrograph 1 or 2.

Black materials shall, when tested according to BS 2782: Method 823B, have a carbon black dispersion equivalent to or better than that shown in photomicrograph 4.

4.6 Metallic components

4.6.1 All exposed metallic components used in the fitting's electrical terminal connection shall be corrosion resistant or suitably protected against corrosion prior to jointing. Compliance with this requirement shall be demonstrated by immersing the component for seven days at (23±2)°C in an aqueous sodium chloride solution of (30±1)g/l, after which there shall be no visual evidence of rust spots or corrosion.

4.6.2 The internal cutting device of saddle fusion fittings shall be corrosion resistant under the conditions for which they are designed.

They shall be capable of cutting the main at air temperatures of -5°C.

Cutters shall retract clear of the bore of the connecting pipe. The coupon shall be retained by the cutting device.

The cutter shall be retained within the fitting when retracted after cutting a main which is held at its rated pressure and a temperature of 30°C during both cutting and retraction.

4.7 Classification and designation

When tested as extruded pipe, or injection moulded pipe if the material does not lend itself to extrusion, the MRS shall not be less than 10.0MPa for a PE 100 material, nor less than 8.0 MPa for a PE 80 material.

5. DESIGN REQUIREMENTS

5.1 Design requirements for fittings

5.1.1 The maximum PN of each fitting design, and if applicable the minimum PN, shall be determined by the manufacturer, taking account of the design stress of the material. The PN shall take account of any known stress concentrations.

Preferred PN ratings are shown in Table 2.

Table 2 - Preferred PN ratings for PE fittings

Fitting PN	For use with pipe	
16	SDR 11	PE 100
12.5/12[1]	SDR 11	PE 80
10	SDR 17[2]	PE 100
8	SDR 17[3]	PE 80
6	SDR 26	PE 100

Note 1: Includes 12 bar service pipe sizes
2: Does not include SDR 17.6
3: May include SDR 17.6

5.1.2 On request, the fittings manufacturer shall declare which pipe materials are compatible with his fittings.

Compatability shall be demonstrated by conformance to the performance requirement of Clause 8.4.

5.1.3 Fusion indicators may be incorporated on all fittings.

5.1.4 When pipe ends are cut cleanly and normal to the pipe axis and are inserted to the correct penetration depth, melt from the fusion operation shall not exude outside the confines of the fitting or into the pipe/fitting bore other than that at fusion indicators.

5.1.5 A means of restricting over-penetration of the pipe within the socket shall be provided.

5.1.6 The design of the fitting shall be such that after conditioning both pipe and fitting at any given temperature in the range -5°C to +23°C, joints shall be capable of being fused at that temperature to meet the relevant requirements of this specification.

5.1.7 The maximum jointing time (i.e. fusion plus cooling time) shall be declared by the manufacturer. The maximum cooling time for fittings up to and including nominal size 180 when determined by the method described in Appendix H of BS 7336 shall not exceed 20 mins.

5.2 Electrical characteristics

5.2.1 Preferred nominal voltages are (40±1)V rms and (80,+1-2)V rms.

5.2.2 The maximum power requirements shall be:

ISSN 1353-2510

(a) 2.5kW at up to and including 40V rms nominal;

(b) 4.8kW at greater than 80V rms nominal.

5.2.3 The preferred design for fitting terminals and shrouds are shown in Figure 1.

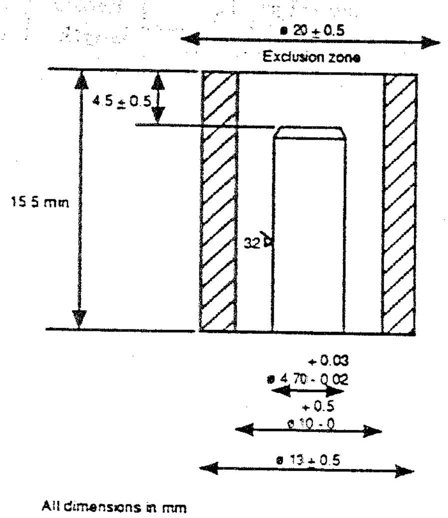


Figure 1(a) - Terminals and shrouds - preferred design for 40V systems

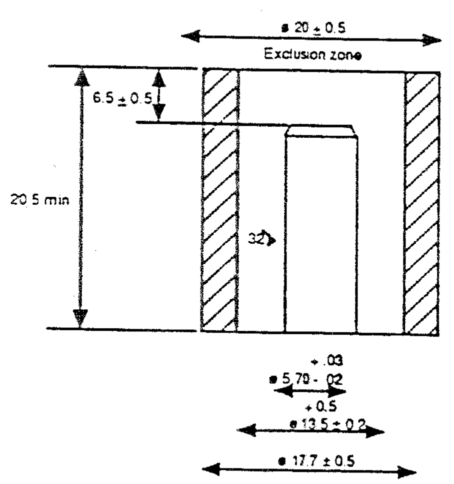


Figure 1(b) - Terminals and shrouds - preferred design for 80V systems

5.2.4 The heating elements shall be designed to prevent accidental short circuiting or local overheating/underheating during the fusion operation when a pipe end has been inserted to the correct penetration depth.

5.2.5 The heating element wire shall be embedded within the fitting to prevent dislodgement during field assembly of the fitting.

Where coated wires are used for heating elements in fittings, the coating material shall be attached to the fitting to prevent dislodgement during field assembly of the fitting.

5.2.6 All fittings up to and including nominal size 63 shall be fused in a single operation. Fittings up to and including nominal size 250 incorporating two electrofusion sockets shall have both sockets fused in a single operation.

5.2.7 In the case of fittings with the heating elements wound in parallel, if an element becomes open circuit during the fusion process, any fusion indicators (see 5.1.3) shall not operate.

6. DIMENSIONS AND TOLERANCES

6.1 General

6.1.1 When measured in accordance with BS 2782: Method 1101A the dimensions shall meet the requirements of 6.1.2. As dimensions may change after manufacture, procedures for measurement shall be generated accordingly. In case of dispute, fittings shall be measured a minimum of 14 days after manufacture and subsequent conditioning at (23±2)°C for a minimum of 5 hrs.

6.1.2 The minimum wall thickness of any part of a fitting exposed to the full hydrostatic pressure shall not be less than that of a pipe of the same material with the same nominal pressure rating.

6.1.3 The minimum bore diameter in any cross-section, (excluding pipe penetration stops) shall be not less than the maximum outside diameter of the pipe or fittings, for which the socket is intended.

6.1.4 The ovality within the bore of a socket shall be not greater than $0.015d_e$, where d_e is the minimum mean outside diameter of the pipe or fitting for which the fitting is intended.

6.1.5 A lead-in as shown in Figure 2, and with a minimum length of 2mm shall be provided in each socket to ease assembly.

6.1.6 For fittings with sockets or spigots of different sizes (e.g. unequal tees and reducers), each socket or spigot shall be allocated a nominal size.

6.1.7 Spigots shall conform to the applicable limits specified in Table 3. Over the minimum length, L_3, see Figure 3, the fitting shall conform to the dimensional requirements for the corresponding size of pipe in accordance with the relevant pipe and fittings standards.

Table 3 - Dimensions of spigot connections (mm)

Nominal Size	Mean Outside Diameter		Length L_3 Minimum
	Minimum d_e	Maximum	
20	20.0	20.3	37.0
25	25.0	25.3	40.0
32	32.0	32.3	44.0
50	50.0	50.4	55.0
63	63.0	63.4	63.0
75	75.0	75.5	70.0
90	90.0	90.6	79.0
110	110.0	110.6	82.0
125	125.0	125.6	87.0
160	160.0	161.0	98.0
180	180.0	181.2	105.0
225	225.0	226.4	120.0
250	250.0	251.5	130.0
280	280.0	281.6	139.0
315	315.0	316.8	150.0
355	355.0	357.1	165.0
400	400.0	402.3	180.0
450	450.0	452.6	195.0
500	500.0	502.9	215.0
560	560.0	563.4	232.0
630	630.0	633.8	255.0

6.2 Fittings up to and including size 180

6.2.1 The dimensions of sockets shall conform to the limits specified in Table 4 and as defined in Figure 2.

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

Table 4 - Dimensions of sockets (mm) up to size 180

Nominal fitting size	Measured over nominal fusion length, L_2				Nominal Fusion length, L_2	Overall length of coupler, L_c
	Limits for average internal diameter, d_s		Penetration depth of pipe or spigot end, L_1			
	min.	max.	min.	max.	min.	max.
20	20.3	20.6	20.0	37.0	12	82.0
25	25.3	25.6	25.0	40.0	14	82.0
32	32.3	32.9	30.0	44.0	17	82.0
50	50.4	51.1	35.0	55.0	20	110.0
63	63.5	64.1	43.0	63.0	21	126.0
75	75.9	76.4	45.0	71.0	25	142.0
90	91.1	91.5	47.0	79.0	28	158.0
110	111.1	111.6	53.0	82.0	32	168.0
125	126.2	126.7	57.0	87.0	35	174.0
160	161.4	162.1	67.0	98.0	42	196.0
180	181.5	182.1	69.0	105.0	46	210.0

6.3 Fittings greater than size 180

6.3.1 The maximum overall length, L_c, shall be $(0.66d_e+90)$mm.

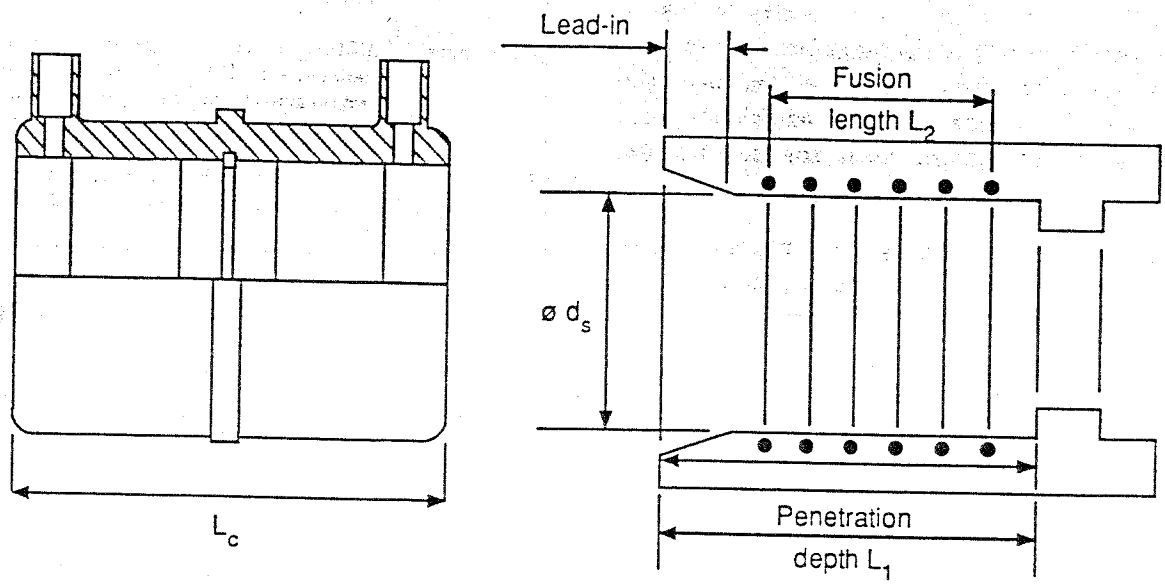
6.3.2 The minimum average internal diameter, d_s, shall be greater than the maximum mean outside diameter specified for the corresponding size of pipe or fitting.

6.3.3 For conventionally designed fittings and couplers, the fusion length, L2, should normally be greater than (0.2de+15)mm.

This may be relaxed where a fitting meets the type test performance requirements of this specification given in clause 7.

6.3.4 The length of each inner cold zone shall be not less than $0.1d_e$ mm.

ISSN 1353-2510



Where: d_s is the average internal diameter of the socket measured over the fusion length, L_2;
L_2 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 penetration" of the pipe or male end of a spigot fitting. In the case of a coupler, it shall not be greater than half the total length of the fitting;
L_c is the overall length of the coupler.

Figure 2 - Socket and coupler dimensions

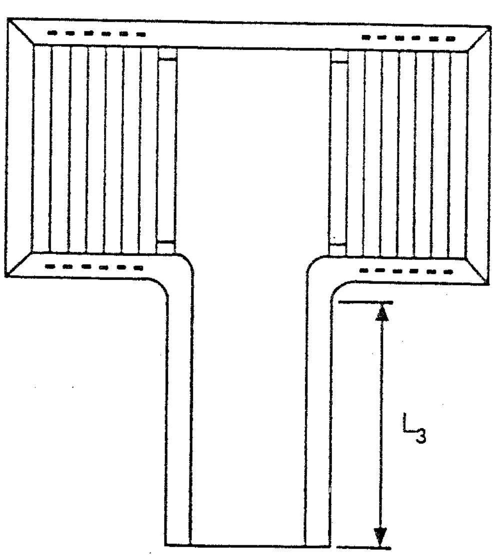


Figure 3 - Length of spigot, L_3

7. TYPE TESTS

7.1 General requirements

Type tests shall be performed on fittings which conform to the requirements of clauses 4, 5 and 6 of this specification. If there is a significant change in process or technique, or a new or modified material is introduced, then it will be necessary to ensure that the requirements of this specification are still satisfied. For third party certificated products, the significance of changes and any additional tests required shall be agreed with the certification body.

To ensure that, initially, a representative cross-section of the manufacturer's product range is evaluated, a minimum of the smallest and the largest fitting shall be evaluated from each size range (see Table 5(a)) for each class of fitting (see Table 5(b)) and shall conform to the requirements of 7.3 to 7.5 inclusive, and to clauses 7.6 to 7.9 as appropriate. Sampling to meet the requirements of 7.2 shall be in accordance with clause 2.1 of BS6920:1990.

Following satisfactory completion of initial type tests, for ongoing confirmation purposes, at least one test piece shall be tested on rotation from each of the size, class and pressure combinations within the manufacturer's product range, and shall conform to the requirements of 7.4 and 7.5, and where appropriate clauses 7.6 to 7.9. All size, class and pressure combinations shall meet the requirements of 7.4 in a 2 year period.

When a manufacturer extends his product range, the product with the largest new nominal size in the size range shall be tested and shall conform to the requirements of 7.3 to 7.5, and of 7.6 to 7.9 as appropriate.

Where a fitting includes sockets of different sizes (e.g. reducers, unequal tees) the fitting shall be considered as belonging to the size range of its largest part.

Table 5a - Size ranges for test

Range Number	Nominal Size
1	20 - 63
2	75 - 225
3	250 - 500
4	560 - 630

Table 5b - Identifying fittings classes for testing purposes

Class	Description
Bends	Fittings with up to two sockets not sharing a common axis, including elbows.
Branches	Any fitting with more than two sockets and/or spigots.
Connectors	A fitting with up to two sockets sharing a common axis. This includes couplers with two sockets the same size, reducers with one socket smaller than the other, and end caps.
Saddles	Saddle fittings which do not enclose the entire pipe circumference (including tapping tees).

7.2 Effects of materials on water quality

When used under the conditions for which they are designed, all materials in contact with, or likely to come into contact with, water for public supply shall be introduced in accordance with the requirements of Regulation 25 of the Water Supply (Water Quality) Regulations 1989. [Water Supply (Water Quality) (Scotland) Regulations 1990 in Scotland]

For products not approved under the former voluntary systems, and not eligible for use under Regulation 25(1)(b) or 25(1)(c), Secretary of State approval shall be obtained via submission of the product to the "Department of the Environment Committee on Chemicals and Materials of Construction for Use in Public Water Supply and Swimming Pools" for consideration. Products shall comply with the requirements of BS 6920: Part 1: 1990; evidence of compliance shall be submitted to the above committee by the manufacturer.

NOTE 1: A list of approved substances and products is published annually and is available from the Technical Secretary of the Committee at the Drinking Water Inspectorate, Room B153, 43 Marsham Street, London SW1 3PY.

NOTE 2: Regulation 25 applies only to products used by water companies in the treatment and distribution of public water supplies; it does not apply to use of fixtures and fittings on consumers' premises. All such fixtures and fittings should satisfy the requirements of BS 6920. Approval under the Water Byelaws Scheme and listing in the Water Fittings and Materials Directory is desirable.

ISSN 1353-2510

7.3 Long term hydrostatic strength at 20°C

Test pieces shall each consist of a single fitting connected to pipes with the same PN as the fitting. Subject to the conditions indicated below, they shall be tested in accordance with the requirements of Appendix G of BS7336.

Prior to jointing, the test samples shall be conditioned in accordance with case 2 of Table 9. The conditioned test pieces shall be jointed in accordance with the manufacturer's instructions and with reference to WIS 4-32-08. With the exception of the maximum OD, the dimensions of the completed assembly shall conform to the dimensional requirements of Appendix G of BS7336.

The failure times recorded shall not be less than 2500, 5000 or 10000 hrs at a test pressure not less than that which would, according to the regression curve used to determine the PE class of the pipe(s) connected to the fitting, cause failure at 2500, 5000 and 10000 hrs respectively.

A sample which survives the 2500 hr test may be left for an additional 2500 hrs at or above the appropriate 5000 hr test pressure as a 5000 hr sample, or for a further 7500 hrs at or above the appropriate 10000 hr test pressure as a 10000 hr sample. A sample which survives a 5000 hr test may be left on test for an additional 5000 hrs at or above the appropriate 10000 hr test pressure as a 10000 hr test sample.

The test pressure P_t (in bar) for each test time shall be determined from the stress as follows:

$$P_t = \frac{20\sigma_t}{(SDR - 1)}$$

Where σ_t is the stress in MPa corresponding to a failure time t, and SDR is the SDR of the pipe used.

In the event that P_t would be different for different pipe sections connected to the fitting then the highest calculated value of P_t shall be used.

Manufacturers may obtain provisional acceptance of this requirement providing:

(1) the 2,500 hr test has been satisfactorily completed;

(2) samples to comply with the 5,000 and 10,000 hr tests are in progress.

If testing is not completed within 21 months, provisional acceptance shall be automatically withdrawn.

7.4 1,000 hr hydrostatic strength at 80°C

When tested by the method described in Appendix L of BS7336 at a temperature of (80,+2,-1)°C, fittings shall withstand internal pressures as specified in Table 6 for a minimum of 1,000 hrs without leakage of the joint or rupturing of the fitting. The fitting/joint assembly shall be sectioned after testing. There shall be no visual evidence of stress cracking.

Table 6 - 1,000 hr hydrostatic pressure test at 80°C

PN	Test Pressure
16 bar	10.1 bar
12.5 bar	7.9 bar
10 bar	6.3 bar
8 bar	5.1 bar
6 bar	3.8 bar

7.5 Melt exudation test

Compliance with the requirements of Clause 5.1.4 shall be checked by sectioning assemblies of pipes and fittings and examining the inside surface of the joint. There shall be no signs of exudation into the bore of the fitting or into the pipe/fitting bore.

7.6 Impact resistance of tapping tees

After testing in accordance with Appendix A at a temperature of (23±2)°C, the impacted test piece shall remain leak tight when subjected to an internal hydrostatic pressure of 2PN or 20bar, whichever is lower, for 1hr.

7.7 Crush strength test

For fitting sizes up to and including 110 and all tapping tees and branch saddles, when tested by the method described in Appendix J of BS7336, no cracking shall occur at the fusion interface. End effects over the first two turns of wire shall be ignored.

7.8 Joint toughness test

For fitting sizes 125 and above, when tested in accordance with Appendix B, the test specimens shall show ductile failure over a minimum of 75% of the axial length of the heating elements and the fracture toughness value recorded at the onset of failure shall have a minimum value of $1.7 MNm^{-3/2}$. Figures 4 and 5 show the typical appearance of ductile and brittle failures.

7.9 Tolerance to contamination

When fittings size 110 and above are fused to pipe whose external surface has been contaminated with talc in accordance with Appendix C, the short term pressure resistance shall be 2.5 x PN or 20 bar whichever is the higher.

8. QUALITY CONTROL TESTS

8.1 General requirements

Test pressures are shown as a proportion of the PN of the fitting.

For quality control testing samples shall be conditioned for 1 hour at ambient temperature prior to assembly.

Saddle fusion fittings shall be tested as complete assemblies and the integral cutter shall cut through the pipe and be retracted before testing.

8.2 165 hr hydrostatic strength at 80°C

Fittings shall withstand the minimum pressures shown in Table 7(a) for 165 hrs at a temperature of (80+2-1)°C without leakage of the joint or rupturing of the fitting.

Table 7(a) - 165 hr hydrostatic strength at 80°C

PN	Test Pressure
16 bar	11.6 bar
12.5 bar	9.0 bar
10 bar	7.2 bar
8 bar	5.8 bar
6 bar	4.4 bar

A fracture in a brittle mode in less than 165 hours shall constitute failure. However, if a sample fractures in a ductile mode in less than 165 hours, a retest may be conducted at one of the stresses shown in Table 8(b). Fracture in any mode in less than the specified time shall constitute failure of the retest.

Table 7(b) - Hydrostatic strength at 80°C - retest requirements

PN	Test pressure in bar for minimum failure time of					
	165 hrs	233 hrs	332 hrs	476 hrs	688 hrs	1000 hrs
16 bar	11.6	11.2	11.1	10.8	10.6	10.1
12.5 bar	9.0	9.0	8.8	8.4	8.3	7.9
10 bar	7.2	7.0	6.9	6.7	6.6	6.3
8 bar	5.8	5.6	5.6	5.4	5.3	5.1
6 bar	4.4	4.2	4.2	4.1	4.0	3.8

8.3 100 hr hydrostatic strength at 20°C

Fittings shall withstand the minimum pressures shown in Table 8 for 100 hrs at a temperature of (20,+2-1)°C without leakage of the joint or rupturing of the fitting.

Table 8 - 100 hr hydrostatic strength at 20°C

PN	Test Pressure
16 bar	24.8 bar
12.5 bar	19.4 bar
10 bar	15.5 bar
8 bar	12.4 bar
6 bar	9.3 bar

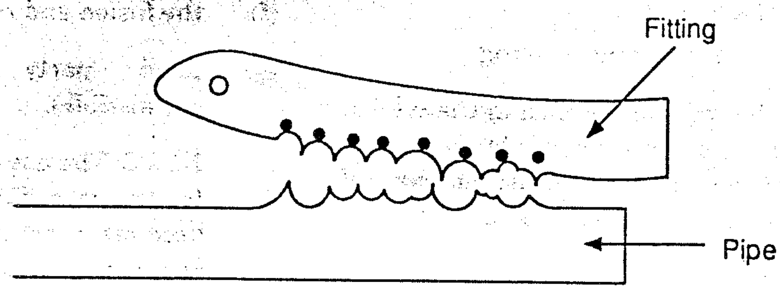
8.4 Joint adhesion test for electrofusion assemblies

When tested in accordance with Appendix K of BS7336, the tear along the fusion length shall be ductile over a minimum of 75% of the axial length of the heater elements.

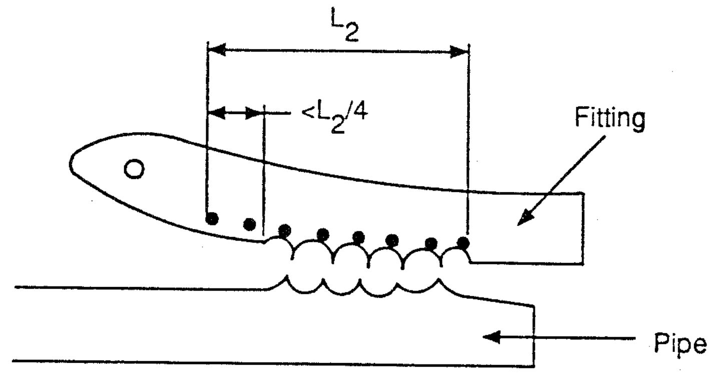
8.5 Oxidation induction time

When tested in accordance with Appendix D of BS7281, the material in fitting form shall have an oxidation induction time (OIT) of at least 20 mins.

ISSN 1353-2510



(a) Ductile failure



(a) Predominantly ductile failure

Figure 4 - Typical ductile fractures

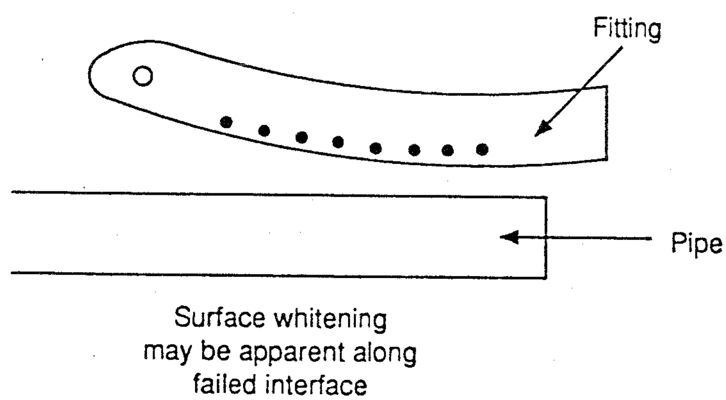


Figure 5 - Typical brittle fracture

8.6 Freedom from defects

The internal and external surfaces of the fitting shall be free from features such as cracks, holes, blisters, distortion, inclusions and dents which may impair the performance of the product in service.

8.7 Melt flow rate after processing

When tested by the method specified in Clause 4.1, the melt flow rate of specimens, obtained from fittings, shall not vary from the measured value of the compound by more than +10%, -25%.

8.8 Dimensions

The dimensions of fittings shall comply with the requirements of Clause 6.

CONTROL OF TEST CONDITIONS

9.1 Test conditions

Unless otherwise specified, test measurements shall be conducted at (23±2)°C.

9.2 Specimen conditioning

For type testing or in case of disagreement, specimens shall be conditioned prior to test by being kept at (23±2)°C in air for not less than 12 hours for fittings of wall thickness up to and including 12.7mm or not less than 24 hours for fittings of wall thickness greater than 12.7mm, unless otherwise stated.

For hydrostatic tests involving liquid immersion the specimens shall be conditioned in the liquid at the test temperature for at least one hour.

10. MARKING

Marking shall remain legible under normal handling, storage and installation procedures. No method of marking shall prejudice the performance of the fitting. The marking shall give the following information:

(a) the manufacturer's identification;

(b) the polymer type identification, i.e. PE 100 or PE 80;

(c) batch identification including date of manufacture code;

(d) the nominal size of the fitting and maximum nominal pressure rating in bar, at which the fitting is intended to be used;

(e) the number of this specification i.e. WIS 4-32-14 ;

(f) the fusion and cooling times;

(g) third party certification mark (if permissible).

NOTE: The use of this mark is a claim by the manufacturer that the product has been manufactured in accordance with the requirements of this specification and the claim is his sole responsibility.

NOTE TO (b), (c), (e) and (g) This information may be integral or printed on a label.

11. PROTECTION OF FITTINGS

The heating elements of tapping tees and branch saddles shall be protected by a shield which should remain in place during normal handling.

Electrical terminal shrouds shall be protected by a removable cap. This shall be designed to remain in place during normal handling until the time of use, and be capable of being replaced after fusion.

Fittings shall be individually packaged in transparent heat sealed bags to protect them from moisture and contamination during normal storage and site handling prior to use.

NOTE 1: Bags may be loose enough to permit the fitting to be picked up by grasping the bag without damage to either the fitting or the bag, or may incorporate a handle, strap or other carrying aid. These considerations need not apply to fittings with integral handles which can be used without damage to the packaging.

NOTE 2: 500 gauge polyethylene is the preferred material.

Good practices shall be employed while fittings are being sealed into the bags to prevent the entrapment of moisture and contamination.

12. REFERENCES

British Standards

BS 1610 Materials testing machines and force verification equipment. Part 1: Specification for the

ISSN 1353-2510

	grading of the forces applied by materials testing machines.
BS 2782	Methods of testing plastics. Part 0: Introduction. Method 720A: Determination of melt flow rate of thermoplastics. Method 823B: Methods for the assessment of carbon black dispersion in polyethylene using a microscope. Method 1101A: Measurements of dimensions of pipes. Method 1106A: Assessment of pigment dispersion in polyolefin pipes and fittings: microtome method.
BS 3412	Specification. Polyethylene materials for moulding and extrusion.
BS 4728	Methods for determination of the resistance to constant internal pressure of thermoplastics pipes.
BS 4901	Specification for plastics colours for building purposes.
BS 5214	Specification for testing machines for rubbers and plastics. Part 1: Constant rate of traverse machines.
BS 5556	Specification for general requirements for dimensions and pressure ratings for pipe of thermoplastics materials.
BS 5750	Quality systems. Part 2: Specification for production and installation.
BS 6572	Specification for blue polyethylene pipes up to nominal size 63 for above ground use for cold potable water.
BS 6730	Specification for black polyethylene pipes up to nominal size 63 for above ground use for cold potable water.
BS 6920	Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of water. Part 1: Specification. Part 2: Methods of test.
BS 7281	Polyethylene pipes for the supply of gaseous fuels.
BS 7336	Specification for polyethylene fusion fittings with integral heating element(s) for use with polyethylene pipes for the conveyance of gaseous fuels.
BS EN ISO 9002	Specification for production, installation and servicing (to be published to replace BS 5750: Part 2).

International Standards

ISO 4065	Thermoplastic pipe - Universal wall thickness table.
ISO TR 9080	Thermoplastics pipes - standard extrapolation method for the long term resistance to constant internal pressure.

Water Industry Specifications

4-32-03	Specification for blue polyethylene (PE) pressure pipe for cold potable water (nominal sizes 90 to 1000 for underground or protected use).
4-32-06	Specification for polyethylene electrofusion couplers and fittings for cold potable water

	supply for nominal sizes up to and including 180 (withdrawn).
4-32-08	Specification for site fusion jointing of PE 80 and PE 100 pipe and fittings.
4-32-09	Specification for black polyethylene pressure pipes for potable water above ground or sewerage (nominal sizes 90 to 1000).
4-32-13	Specification for blue higher performance polyethylene, HPPE/PE 100, pressure pipes, nominal sizes 90 to 1000, for underground or protected use for the conveyance of water intended for human consumption.
4-32-15	Specification for PE80 and PE100 spigot fittings and drawn bends for nominal sizes up to and including 1000.

Other References

WSA/WRc	Manual for polyethylene pipe systems for water supply.
HMSO	Water Supply (Water Quality) Regulations 1989.
HMSO	Water Supply (Water Quality) (Scotland) Regulations 1990.
British Gas	Technical Specification GBE/PL2: Pt 4 Fusion Fittings with Integral Heating Elements. November 1993.

APPENDIX A - METHOD OF TEST FOR IMPACT RESISTANCE OF TAPPING TEES

A.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.

A.2 APPARATUS

A2.1 Falling weight apparatus, consisting essentially of the following items (see Figure 6):

(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 2000mm relative to the point of impact on the test piece, such that the guide is rigid and vertical to within 1°;

(b) Striker of mass (5.0+0.2,-0)kg, which can fall freely subject to the guide. It shall be equipped with a hardened hemispherical striking surface 25mm 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;

(c) Means for supporting the test piece assembly, generally as shown in Figure 11 and including the following essential components:

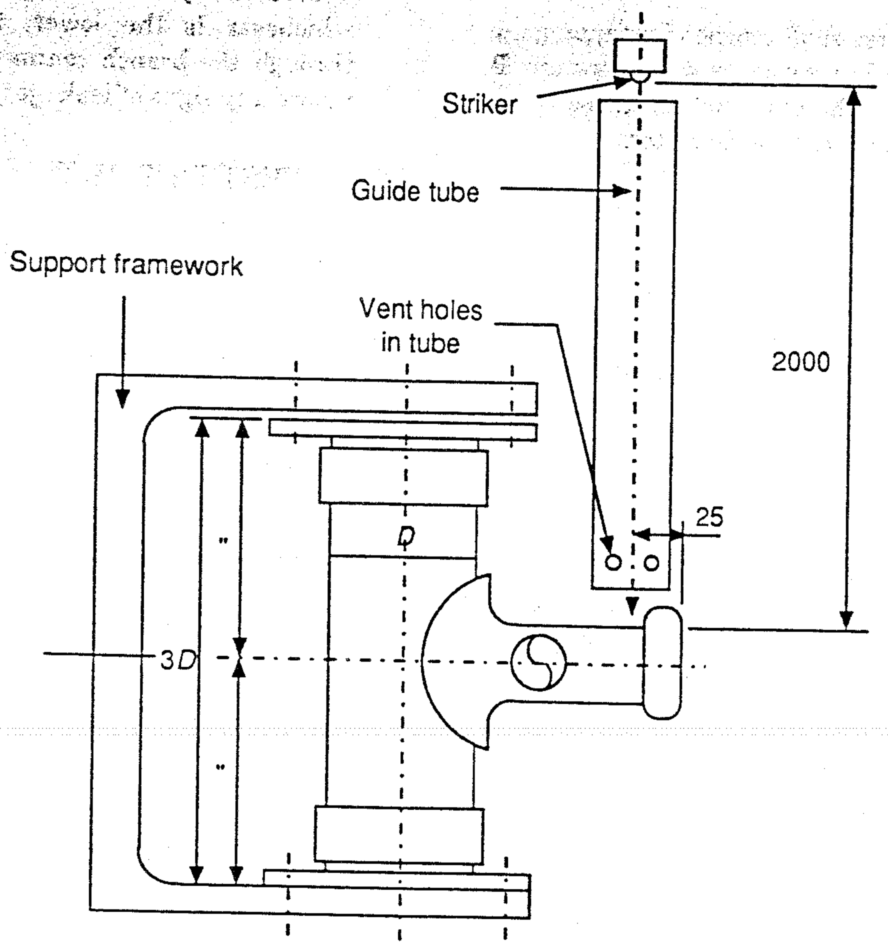
(i) end plug to fit into either end of the test piece assembly without providing support to the saddle under test;

(ii) 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 2000mm 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;

ISSN 1353-2510



All dimensions are in mm

Figure 6 - Typical impact test assembly

A2.2 Conditioning chamber, capable of conditioning one or more test piece assemblies at (-5±2)°C.

A2.3 Pressure testing equipment, comprising means for sealing the test piece assembly and applying a specified internal pneumatic pressure.

A.3 TEST PIECE ASSEMBLIES

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

A.4 PROCEDURE

4.1 The procedures described in A4.2 to A4.9 shall be carried out at least 24 hours after fusion jointing of the test piece assembly.

A4.2 Fit end plugs (A2.1(c)(i)) to each end of the main pipe of the test piece assembly.

A4.3 Condition the assembly at (-5±2)°C for at least 1 hour immediately prior to testing.

A4.4 Using an ambient test temperature of (23±2°)C, complete the procedures of A4.5 to A4.8 within 5 minutes of removing the assembly from the conditioning chamber (A2.2).

A4.5 Fix the test piece assembly to the rigid base plates and mount them in the rigid frame (A2.1(c)(ii)).

A4.6 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±1)mm from its free end (see Figure 6);

(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 Clause 7.6) above the point of impact.

A4.7 Release the striker and allow it to strike the tapping tee once.

A4.8 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 A4.7.

A4.9 Inspect the test piece assembly for fractures and record any present; otherwise apply hydrostatic pressure of 2xPN or 20 bar, whichever is the lower, to the assembly through the branch connection for 1hr, and record any signs of leakage.

A.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;

(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.

APPENDIX B - JOINT TOUGHNESS TEST

B.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.

B.2 APPARATUS

All tests shall be conducted on a tensile testing machine conforming to grade A of BS 5214: Part 1: 1975 or grade 1.0 of BS 1610: Part 1: 1985.

ISSN 1353-2510

The tensile testing machine shall incorporate a means of providing a permanent record of the force/displacement history during the test.

B.3 JOINTING CONDITIONS

B3.1 Joints shall be made in general conformance to WIS 4-32-08.

B3.2 For each test, 3 couplers from a single production run shall be evaluated. Each size range shall be evaluated from at least 5 different production runs.

B3.3 Joints shall be made using the manufacturer's recommended heating times and minimum power input to the coupler.

B3.4 Three joint assemblies shall be made using pipes and couplers preconditioned for at least 2 hours in accordance with the requirements of Table 9.

Table 9 - Conditioning temperatures before fusion jointing

Sample	Temperature Before Fusion (°C)		Applied Voltage
	Pipe	Fitting	
1	-5	-5	Minimum
2	-5	+23	Minimum
3	+23	+23	Maximum

B3.5 All joints shall be made using clamping systems recommended by the coupler manufacturer.

B3.6 The ends of the pipes to be jointed shall be prepared immediately prior to jointing using a pipe surface preparation tool which removes a layer of at least 0.2mm from the pipe outside surface. The complete surface area of the end of the pipe to be inserted into the coupler shall be so prepared.

B.4 PREPARATION OF SAMPLES

B4.1 Preparation of standard test pieces

B4.1.1 Following jointing and cooling to (23±2)°C, the coupler shall be cut into rectangular sections - see Figure 7.

B4.1.2 At least 6 samples shall be cut using a sharp bandsaw or equivalent from each end of the joint spaced at equidistant intervals around the joint circumference.

B4.1.3 To form a flat surface to act as a register for further machining, the sample shall be held flat on a linisher or skimmed with a saw/planer to remove the curved edges on the pipe surface - see Figure 8.

B4.1.4 A bandsaw or similar apparatus shall then be used to produce rectangular samples with flat parallel surfaces which are symmetrical about the axis formed by the weld interface.

B4.1.5 For couplers of nominal size up to and including 180, the sample width shall be 20mm.

For couplers of larger diameter, the width shall be increased to 30mm.

B4.1.6 One hole of at least 5mm diameter shall be drilled through the pipe and one hole of equal size through the fitting at the ends containing the 'cold zones' - see Figure 9.

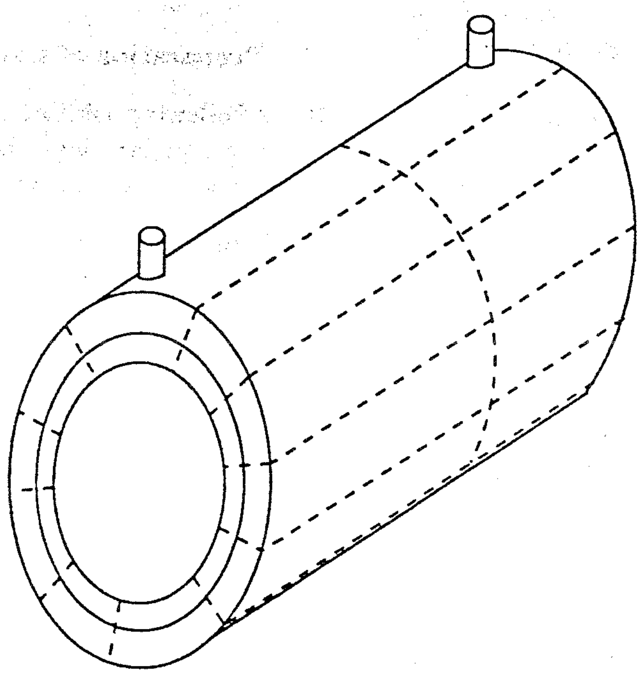


Figure 7 - Cutting samples from coupler/pipe joint

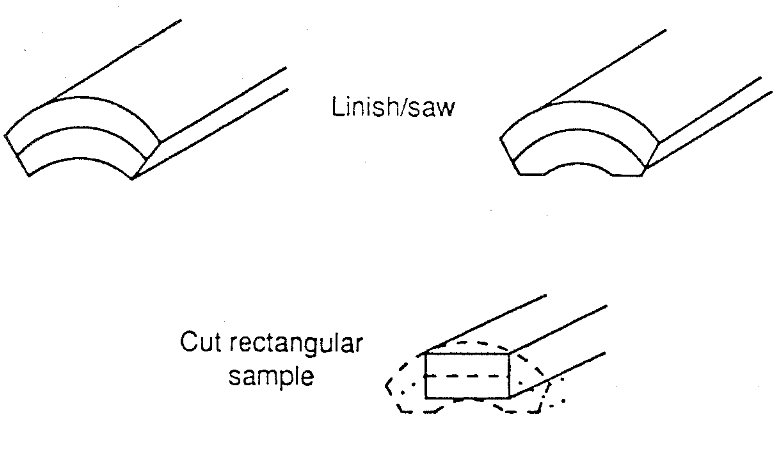


Figure 8 - Preparing samples

ISSN 1353-2510

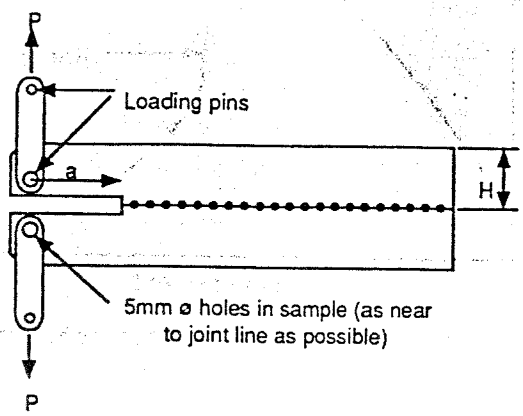


Figure 9 - Loading arrangements for joint adhesion samples

B4.1.7 The holes shall be aligned vertically plane and shall be located as close to the joint interface as possible.

NOTE: Standard dimensions are not specified as individual manufacturer's dimensions vary.

B4.2 SIDE GROOVING

B4.2.1 If the joint cannot be broken using a flat faced sample, a side groove shall be machined in the sample.

B4.2.2 Using a shaping machine (or similar apparatus), machine a 5mm wide groove along the joint line - see Figure 10.

Grooves shall be machined into both faces of the sample, penetrating to a quarter of the sample width.

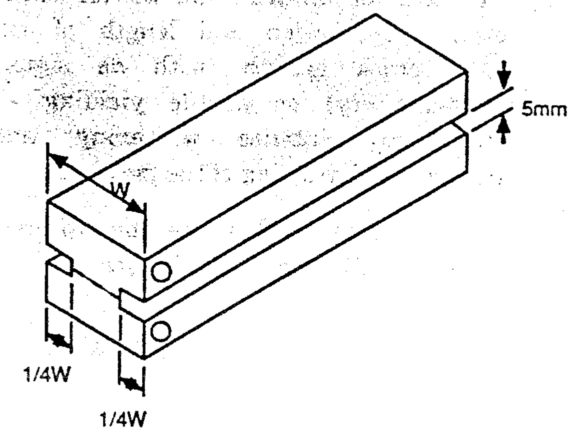


Figure 10 - Side grooving for tough joints or pipe/coupler where beam depth (H) is small

B4.2.3 The joint interface shall be along the centre of the groove.

B.5 TESTING OF JOINTS

B5.1 The test temperature shall be (23±2)°C.

B5.2 Push fit metal pins shall be placed in the holes drilled in the sample and drilled side plates attached which allow free movement during alignment - see Figure 9.

B5.3 The tensile force shall be applied using a cross-head separation rate of (25±2.5)mm/min.

B5.4 The test shall be continued until there is complete separation of the sample.

B5.5 A force/displacement trace shall be obtained for each test - see Figure 11.

B5.6 The peak force (P) obtained during the test shall be recorded.

B5.7 After failure has occurred, the size of the initial "crack" formed by the unfused section and cold zone shall be measured using a microscope and recorded.

B5.8 The initial "crack" size (a) shall be taken as the distance from the centre-line of the loading pin hole to the start of the joint. This is defined by the presence of first signs of stress whitening due either to the onset of slow crack growth or ductile yielding.

NOTE: Whatever the failure mode, a white zone can always be discerned at the origin of the initial "crack".

B5.9 The mode of failure shall be recorded by noting the location and length of either brittle crack growth (with no signs of macro-ductility) or ductile yielding - as defined by intense whitening and/or extensive cold drawing of the polymer.

Figures 5 and 6 illustrate the differences between ductile and brittle failure.

B.6 CALCULATION OF JOINT TOUGHNESS

For each joint tested, a value of the fracture toughness, K_c, shall be calculated using the equation:

$$K_c = \frac{Pa}{WH^{3/2}} \left(3.46 + 2.38\frac{H}{a}\right) MNm^{-3/2}$$

where P (in Newtons) is the force measured at onset of failure.

W, H and a are dimensions defined in Figures 9 and 10.

NOTE: When using side grooved samples, W is the width across the ligament between grooves.

B.7 TEST REPORT

The report shall include the following information:

(a) identification of the assembly (size, SDR and batch no.);

(b) details of the jointing conditions and equipment used;

(c) the peak force P and dimensions W, H and a;

(d) the calculated value if K_c;

(e) visual assessment of the failure mode (ductile or brittle);

(f) the date of the test.

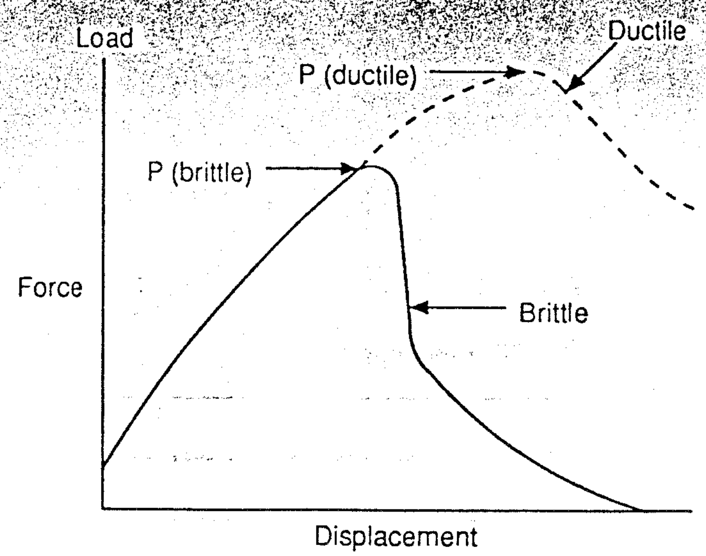


Figure 11 - Typical force/displacement traces from joint adhesion tests

APPENDIX C - TOLERANCE TO CONTAMINATION

C.1 PRINCIPLE

This test assesses the resistance of an assembled electrofusion coupler to contamination on the pipe surface.

A fitting is assembled and fused at minimum power onto two pipe lengths, at least one of which has previously been scraped, cleaned and then contaminated with a fine china talc.

The performance of the assembled joint is assessed by the application of internal pressure at a constant rate until burst.

C.2 APPARATUS

C.2.1 Temperature-controlled water bath or room capable of maintaining a temperature of (23 ± 1)°C.

C.2.2 Pressurisation equipment capable of applying and displaying pressure at a constant rate of 5 bar/min to a minimum 25% beyond the peak test pressure required.

C.2.3 End caps, to fit on each end of the test piece assembly, capable of maintaining a pressure of at least 25% greater than the peak test pressure required. The end caps shall be

ISSN 1353-2510

provided with connections for the entry of water and the release of air.

The test pressure shall be monitored using a gauge connected to the end closure of the sample using 3/8" nominal pressure hose (or metric equivalent).

C.2.4 A 31 g/m² textile mesh screen with 34μm thread and 53μm aperture at a tension of 140kN/m².

The screen shall include a stencil of length equal to the nominal circumference of the test pipe, and a width greater than the fusion zone of the coupler under test, surrounded by a border of minimum width 100mm.

C.2.5 Flexible squeegee set in a variable angle holder used to force the talc through the screen.

C.2.6 A flexible squeegee of Shaw hardness 70-75 set at an angle (75±1)° to the screen. The blade shall be changed when damage is visible without magnification or at least once a year if sooner.

C.2.7 A rig that allows the pipe to rotate and the screen to move over the pipe at a distance of (7±0.5)mm, and which allows the screen to move over the pipe at a contact load of (1000±100)N/m of squeegee length.

C.2.8 Fine china talc with a particle size of 0.63μm to 6.3μm.

C.3 TEST PIECE ASSEMBLIES

The test piece assembly shall comprise a coupler fused to prepared polyethylene pipe. The length of free pipe between the coupler and the end cap shall be less than the nominal diameter of the pipe.

NOTE: Limiting the free length of pipe to less than one diameter constrains the effect of hoop strain on the pipe, enabling the test pipe to withstand much higher pressures than would normally be expected of a polyethylene pipe.

C.4 PREPARATION OF THE CONTAMINATED SURFACE

After cleaning, six dummy pipe samples shall be prepared prior to applying contamination to the test piece. Dummy samples shall be prepared in accordance with Clauses C.4.1, and C.4.4 to C.4.8.

C.4.1 Ensure that the test pipes are free from burrs and that the pipe ends are perpendicular to the pipe axis.

C.4.2 Scrape the pipes, in accordance with the requirements of WIS 4-32-08, using a mechanical scraper and ensure that the scraped area is free from ridges.

C.4.3 Clean the scraped pipe surfaces with an alcohol impregnated wipe and allow to dry.

C.4.4 Place the screen and the test pipe onto the rig (C.2.6) and lock the pipe into position.

C.4.5 Deposit a ridge of talc along the border of the screen.

NOTE: The talc should be deposited on a masked area of the screen to prevent loss through the mesh.

C.4.6 Lower the flexible squeegee and lock into position adjacent to the ridge of talc on the side away from the stencil.

C.4.7 Holding the flexible squeegee in position, move the screen horizontally such that the talc is deposited evenly across the surface of the rotating pipe.

C.4.8 Remove the pipe from the rig. The prepared surface of the pipe shall not be handled or otherwise disturbed.

NOTE 1: Do not touch the screen with the pipe.

NOTE 2: The mesh should be cleaned after use with a vacuum cleaner and subsequently by wiping with ethanol on a lint-free cloth. The mesh should be visually inspected for signs of damage and replaced where necessary.

C.4.9 Place the contaminated pipe surface into the coupler immediately and fuse the coupler onto the pipe surface.

C.5 BURST PRESSURE TEST

C.5.1 Assemble the coupler on the test pipes and fuse at the minimum power.

C.5.2 Fit the end caps (C.2.3) to each end of the assembly.

C.5.3 Fill the assembly with water and remove all air.

C.5.4 Condition the assembly at (23 ± 2)°C in accordance with 9.2 and maintain the temperature throughout the test.

C.5.5 Pressurise the assembly at a constant rate of 5 bar/min to at least 2.5 x PN.

C.5.6 Record the failure pressure or maximum pressure reached. Record the type of failure.

C.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;

(c) the failure pressure or maximum pressure reached;

(d) the type of failure;

(e) the date of testing.