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SPECIFICATION FOR MECHANICAL FITTINGS AND JOINTS FOR POLYETHYLENE PIPES FOR NOMINAL SIZES 90 TO 1000

FOREWORD

This specification was prepared by WRc plc under the direction of the Water Services Association/Foundation for Water Research Sewers and Water Mains Committee in consultation with the Water Industry and Fittings Manufacturers. It has been updated to take account of the introduction of European Standards, changes in water quality requirements and to reflect current practice with regard to quality assurance. The properties required for mechanical fittings for use with polyethylene pipe conforming to WIS 4-32-03 and/or WIS 4-32-13, for the conveyance of cold potable water are defined. Such fittings may be made of metal, plastics or a combination of both.

These fittings are designed for jointing pipe to pipe and pipe to metal fittings such as valves, tees and bends as well as for effecting repairs.

NOTE: Where fittings are required for SDR17 pipe, it is advisable to check that the fittings supplied, particularly the inserts, are for SDR17 and not SDR17.6 pipe.

Three types of fittings are covered by this specification, classified according to their end-load performance, as follows:

Type 1 fittings: where the end-load resistance of the joint is greater than the longitudinal strength of the pipe;

Type 2 fittings: where the end-load resistance of the joint is greater than the maximum axial forces assumed to be acting on the joint (see IGN 4-01-02);

Type 3 fittings: where the end-load resistance of the joint is less than that required for Type 2 fittings.

Anchor blocks will normally be required with Type 3 fittings and the advice of the manufacturer should be sought.

The specification includes a fatigue test for sizes up to and including 315. It is assumed that the behaviour of fittings of sizes greater than 315 will be similar to that of fittings of the same design up to and including size 315.

Attention is drawn to the second edition of the Manual for polyethylene pipe systems for water supply applications which provides guidance on the practical design, installation and operation of PE water pipeline systems.

Attention is also drawn to the following Water Industry Specifications:

WIS 4-32-09
WIS 4-32-14
WIS 4-32-15

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

This 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 European Standard, British Standard, Water Industry Specification or any other specification applies equally to any equivalent specification.

This specification includes the use of procedures that may be injurious to health if adequate precautions are

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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 UK Water Industry Research Ltd, Water UK nor WRc plc can accept any responsibility for actions taken by others as a result.

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1. SCOPE

1.1 This specification specifies the materials and design details together with the testing requirements for mechanical fittings, including flanges, for use with polyethylene pipe complying with WIS 4-32-03 and/or WIS 4-32-13, in the size range 90 to 1000 inclusive.

The requirement for Type 1, 2 or 3 end-load resistance fittings for a particular application should be assessed by the water company.

1.2 Fittings shall be designated by the nominal size of the pipe which they are to be used and the material for which they are intended to connect, e.g. PE80 or PE100.

1.3 Three types of fittings are covered by this specification, classified according to their end-load performance, as follows:

Type 1 fittings: where the end-load resistance of the joint is greater than the longitudinal strength of the pipe;

Type 2 fittings: where the end-load resistance of the joint is greater than the maximum axial forces assumed to be acting on the joint (see IGN 4-01-02);

Type 3 fittings: where the end-load resistance of the joint is less than that required for Type 2 fittings.

NOTE The titles of the publications referred to in this document are listed under Clause 9 - REFERENCES.

2. MATERIALS

2.1 The body of the fitting shall be made either of metal, coated where applicable (see 3.3) or plastics which do not suffer from corrosion in potable water or low resistivity soils. These materials shall comply with the relevant parts of 4.2.

2.2 Fittings of copper and copper alloy shall comply with the requirements of BS EN 1254-3: 1998: 4.2 (Materials). In addition, when tested in accordance with BS EN ISO 6509, the materials shall be Grade A as specified in 4.5.2 of BS EN 1254-3: 1988.

2.3 Materials shall comply with the relevant British Standards, or equivalent, where available. Where such materials are likely to come into contact with potable water, they shall meet the relevant requirements of 4.2.

2.4 Elastomeric sealing rings shall conform to BS EN 681-1 and BS 7874.

NOTE BS 7874 details the test method to determine microbiological deterioration of elastomeric seals previously contained in Annex B of BS 2494:1990.

2.5 All materials shall be chosen so as not to introduce a risk of bimetallic corrosion into the assembled fitting.

3. GENERAL DESIGN REQUIREMENTS

3.1 Fittings to this specification shall be suitable for use with polyethylene pipe to WIS 4-32-03 and/or WIS 4-32-13 as applicable, at working pressures specified in these documents.

3.2 Fittings shall be capable of being assembled and meeting the requirements of clauses 4 and 5 under the extremes of pipe dimensional tolerances specified in WIS 4-32-03 and/or WIS 4-32-13, as applicable.

3.3 Metallic fittings shall be suitably protected against corrosion. Where applicable, hot dip galvanising shall be carried out to BS 729 and zinc plating to BS 3382: Part 2. Polymeric anti-corrosion coatings shall be in accordance with WIS 4-52-01.

3.4 Flanged joints

3.4.1 Flanged joints shall be constructed such that they may be attached to flanges designated PN 16 in BS EN 1092-2.

3.4.2 The faces of flanges to this specification shall be at right angles to, and concentric with, the longitudinal axis.

4. TYPE TEST REQUIREMENTS

4.1 General

4.1.1 The requirements in this section shall be met before compliance with this specification can be claimed. If there is a change in process techniques or a new or modified material is introduced, then it will be necessary to ensure that the conditions of this specification are still satisfied.

4.1.2 Unless otherwise specified, the test samples shall be taken from a production batch which has complied with all the other requirements of this specification.

Details and results for each type test relevant to each material composition and manufacturing process

shall be made available to the purchaser or his representative on request.

4.1.3 All sizes, types (shape and design) and pressure classes of fittings produced by the manufacturer shall conform to all the requirements of Clause 4.

Table 1 - Size ranges for test

Range No.	Nominal pipe size
1	90 - 315
2	355 - 500
3	560 - 1000

To ensure that a representative cross-section of the manufacturer's product range is evaluated, a minimum of the smallest fitting of the manufacturer's product range and the largest size manufactured within each size range given in Table 1, shall be evaluated.

4.2 Effect 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 system, 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 Committee on Chemicals and Materials of Construction for Use in Public Water Supply and Swimming Pools for consideration. Products shall also 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: The Committee, operated by the Drinking Water Inspectorate, undertakes toxicological assessments of products and may require leaching tests for substances of concern. A list of approved substances and products is published annually and is available from: The Drinking Water Inspectorate, Ashdown House, 123 Victoria Street, London, SW1E 6DE.

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' own premises. Approval under the Water Byelaws Scheme and listing in the Water Fittings and Materials Directory is desirable.

4.3 Long-term hydrostatic strength test at 20°C

When tested by the method described in Appendix A at a temperature of 20 (+2-1)°C, the jointed assembly shall withstand the appropriate pressures given in Table 2.

If after 1,000 or 10,000 hours, as appropriate, the sample has not failed, the test may be discontinued.

Table 2 - Requirements for long-term pressure tests at 20°C

Time to fail-ure	Minimum Pressure (bar)							
	PE80			PE100				
(h)	SDR 11	SDR 17	SDR 17.6	SDR 11	SDR 17	SDR 17.6	SDR 26	SDR 33
100 - 1000	22	13.8	13.3	24.8	15.4	14.9	9.9	7.8
5000 - 10000	20	12.9	12.5	23.0	14.4	13.9	9.2	7.2

4.4 Accelerated relaxation and end-load test

4.4.1 This test is applicable to Type 1 and Type 2 fittings only.

4.4.2 When tested by the method described in Appendix B, there shall be no detectable pull-out of the pipe from the fitting. Whilst initial movement of the pipe within the joint is permitted, no further such movement is allowed after the test load has been attained. The test load shall be maintained for not less than 500h.

NOTE: The test specified in sub-clause 4.4.2 is carried out at a temperature of 80°C. This test is therefore not suitable for fittings manufactured from thermoplastics with a lower softening point.

4.4.3 The assembly shall then be disconnected from the test rig and allowed to cool to ambient temperature. The following tests in accordance with Appendix A shall then be applied:

- (a) a test at an internal pressure of (25 ± 3) kN/m² (0.25 bar) below atmospheric pressure for 8 hours at a temperature of 20 (+2-1)°C (external pressure test);

- (b) a test at the maximum rated working pressure of the pipes for 8 hours at a temperature of 20 (+2 -1)°C.

The tests shall be carried out in accordance with the method described in Appendix A. During the tests, the assembly shall not leak or weep nor shall the pipe fracture.

The test described in 4.5 shall then be carried out.

4.5 Pull-out test at 23°C

This test is applicable to Type 1 and Type 2 fittings only.

After having been subjected to the requirements of 4.4, the assembly shall be tested by the method described in Appendix C. The pipe shall not pull out from the fitting nor shall it fracture within the jointed assembly. Whilst initial movement of the pipe within the joint is allowed, no further such movement is permitted after the test load has been attained.

4.6 Fatigue test

This test applies to fittings up to and including size 315.

When tested by the method described in Appendix D, the test assembly shall withstand 4×10^4 cycles.

Alternatively, the test specimens shall be conditioned and the test carried out at a temperature of 60 (+2 - 1)°C but otherwise in accordance with the method described in Appendix D. The test assembly shall withstand 25×10^4 cycles.

5. QUALITY CONTROL TEST REQUIREMENTS

5.1 Sampling frequency

Production quality control activities shall be carried out in accordance with an appropriate sampling plan drawn from BS 6001: Part 1. Guidance on the use of BS 6001 and sampling procedures for inspection by attributes is given in BS 6000.

The manufacturer shall not knowingly supply a defective unit in any batch.

5.2 External pressure test

When tested by the method described in Appendix A, the test assembly shall withstand a pressure of $25 \pm$

3kN/m² (0.25 bar) below atmospheric pressure for 8 hours at a temperature of 20 (+2 -1)°C.

5.3 1-hour pressure test at 20°C

When tested by the method described in Appendix A, the test assembly shall withstand a pressure of 1 bar for 1 hour followed by the relevant pressure from the table below:

SDR	11	17	17.6	26	33
PE80 (bar)	26.0	16.1	15.6	-	-
PE100 (bar)	30.0	18.7	18.1	12.0	9.4

5.4 Pull-out test at 23°C

This test is applicable to Type 1 and Type 2 fittings only.

When tested by the method described in Appendix C, the pipe shall not fracture within the jointed assembly. Whilst initial movement of the pipe within the joint is allowed, no further such movement is permitted after the test load has been attained.

5.5 Visual appearance

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

6. TEST CONDITIONS

During type testing or in any 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 over 12.7mm unless otherwise specified.

For hydrostatic tests involving liquid immersion, the specimens shall be conditioned in the liquid at the test temperature for not less than 24 hours.

7. MARKING

Fittings and liners (where required) shall be marked legibly in the colours given below:

SDR	11	17	17.6	26	33
Fittings for PE80 pipe	dark blue	*	red	-	-
Fittings for PE100 pipe	black	*	red	yellow	orange

* Check with supplier

The marking shall include:

- the manufacturer's identification;
- the number of this specification, i.e. WIS 4-24-01. (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);
- the nominal size of the fitting and its pressure rating;
- the word "WATER";
- the type of fitting, e.g. "Type 1", "Type 2" or "Type 3";
- material, i.e. PE80/PE100.

8. PROTECTION OF FITTINGS

8.1 Fittings shall be suitably protected, following manufacture, against damage during storage and handling.

NOTE Reference should be made to IGN 4-52-02 which covers the selection of appropriate coatings and the design, packaging and handling of coated products.

8.2 The faces of all flanges shall be protected against damage.

9. REFERENCES

This specification makes reference to the latest edition of the following publications (except otherwise stated) including all addenda and revisions, which should also be consulted.

British Standards

BS 729	Hot dip galvanised coatings on iron and steel articles.
BS 2494:1990	Specification for elastomeric joint rings for pipework and pipelines. (Superseded by BS EN 681-1 and BS 7874).
BS 6000	Guide for the selection of an acceptance sampling system, scheme or plan for inspection of discrete items in lots.
BS 6001	Sampling procedures for inspection by attributes Part 1 - Specification for sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection
BS 6920	Suitability of non-metallic products for use in contact with potable water intended for human consumption. Part 1 - Specification Part 2 - Methods of test.
BS 7874	Method of test for microbiological deterioration of elastomeric seals for joints in pipework and pipelines.
BS EN 681-1	Elastomeric seals - Materials requirements for pipe joint seals used in water and drainage applications. Part 1: Vulcanised rubber.
BS EN 921	Plastic piping systems - Thermoplastics pipes - Determination of resistance to internal pressure at constant temperature.
BS EN 1092-2	Flanges and their joints for pipes, valves fittings and accessories, PN designated. Part 2: Cast iron flanges.
BS EN 1254	Copper and copper alloys - Plumbing fittings - Part 3: Fittings with compression ends for use with use plastic pipes.
BS EN ISO 6509	Corrosion of metals and alloys - Determination of dezincification resistance of brass.

Water Industry Specifications

4-32-03	Specification for blue polyethylene
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(PE) pressure pipe for cold potable water (nominal size 90 to 1000) for underground or protected use.

4-32-09	Specification for black polyethylene pressure pipes for sewage and above ground potable water (nominal size 90 to 1000).
4-32-13	Specification for blue higher performance polyethylene, HPPE/PE 100, pressure pipes, nominal size 90 to 1000, for underground or protected use for the conveyance of water intended for human consumption.
4-32-14	Specification for PE80 and PE100 electrofusion fittings for nominal sizes up to and including 630.
4-32-15	Specification for PE80 and PE100 spigot fittings and drawn bends for nominal sizes up to and including 1000
4-52-01	Specification for polymeric anti-corrosion (barrier) coatings.

Information and Guidance Notes

4-01-02	The determination of end-loads for the performance testing of pipeline fittings.
4-52-02	The use of polymeric anti-corrosion (barrier) coatings.
	Manual for polyethylene pipe systems for water supply applications, 2nd edition, July 1994. Published by WRc plc.

APPENDIX A - HYDROSTATIC PRESSURE TEST

A.1 Test Piece

For the test specified in 4.3 and 5.2, more than one fitting may be tested at a time. A fitting shall be

assembled on polyethylene pipe conforming to WIS 4-32-03 or WIS 4-32-13, in accordance with the manufacturer's instructions and conditioned as specified in clause 6 of this specification.

The end caps used shall comply with sub-clause 4.1 of EN 921:1994. Type a) shall be used to test Type 1 fittings and Type b) shall be used to test Types 2 and 3 fittings. There shall be a free length of pipe, between any two fittings or a fitting and an end cap, of not less than three times the nominal size of the fitting for test pieces of nominal size up to and including 315 and a minimum of 1m for sizes greater than nominal size 315.

For type testing, three assemblies shall be evaluated at each test level.

A.2 Procedure

A.2.1 Internal pressure test

The test shall be performed in accordance with the method described in BS EN 921.

For each of the pressure ratings for which the fitting is designed, assemblies shall be tested both to the 100 - 1000 h. and the 5000 - 10000 h. test.

Failure of the pipe within a distance of less than $0.1L$ (where L is the free length of pipe between fittings or between fitting and end cap) from the mouth of the fitting shall be disregarded and a new test piece evaluated. Any axial movement of the pipe within the joint at the end of the test shall be determined and recorded.

The test pressures and times to failure shall be as specified in 4.3 and 5.2 of this specification.

A.2.2 External pressure test

The test equipment and procedure shall be that specified in BS EN 921 except that the pressurising unit is replaced by a vacuum pump. When the test pressure is attained, a suitable valve is closed to isolate the test piece from the pump.

The test shall be continued for 8 hours after which time the pressure shall not have changed from the initial value by more than 3kN/m^2 .

A.3 Test Report

The test report shall include at least the following particulars:

- (a) the type of test (internal or external pressure);
- (b) full identification of the test piece;
- (c) the type of end fitting used;
- (d) the test temperature;
- (e) the circumferential stress or pressure;
- (f) the test result and, in the case of premature failure, the time to rupture;
- (g) reference to this Specification.

APPENDIX B - ACCELERATED RELAXATION AND END-LOAD TEST

B.1 Test Piece

A fitting shall be assembled with polyethylene pipe conforming to WIS 4-32-03 and/or WIS 4-32-13, in accordance with the manufacturer's instructions.

There shall be a free length of pipe between any 2 fittings, or between a fitting and the end-loading grips of three times the nominal size (up to nominal size 315) and a minimum of 1m for sizes greater than nominal size 315.

B.2 Test Piece for Flange Assemblies

A typical test piece for the testing of flange assemblies is illustrated in Figure 1.

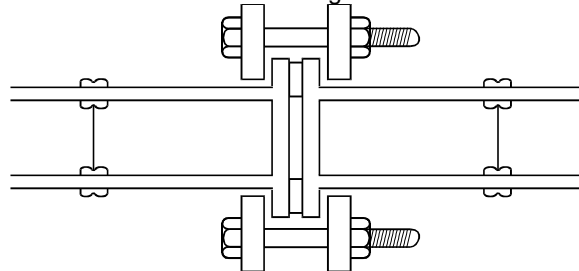


Figure 1 - Section through typical test piece for the testing of flange assemblies (for clarification only)

B.3 Procedure

B.3.1 The test piece shall be mounted in a jig capable of applying a constant tensile axial load to the pipe(s) and fitting. The fitting shall not be held in such a way that distortion or support of any of the fitting components can occur.

B.3.2 The test piece shall be suspended in a water bath at 80(+2 -1)°C for a minimum of 500 hours with an axial load in accordance with Table 3a or Table 3c for Type 1 fittings and Table 3.b or Table 3d for Type 2 fittings.

400	63	54	54	48	46
450	80	69	68	61	58
500	98	85	84	75	72
560	123	106	105	95	90
630	156	135	133	120	114
710	0	171	169	152	145
800	0	217	215	193	184
900	0	275	272	245	233
1000	0	339	335	302	288

Table 3c - Pull out test force at 80°C for Type 1 fittings for PE 100 pipe

Table 3a - Pull out test force at 80°C for Type 1 fittings for PE 80 pipe

Nom size	Test Force (kN) - minimum				
	SDR 11	SDR 17	SDR 17.6	SDR 26	SDR 33
90	7	5	5		
110	11	7	7		
125	14	9	9		
160	23	15	15	10	
180	29	19	19	13	
225	45	30	29	20	
250	56	38	36	25	
280	70	47	46	31	
315	89	60	58	40	
355	113	76	73	50	41
400	143	96	93	64	52
450	182	122	118	81	65
500	224	150	145	100	80
560	280	188	182	125	101
630	355	238	230	158	128
710	0	302	292	201	163
800	0	384	371	255	206
900	0	486	468	325	261
1000	0	600	579	400	322

Nom size	Test Force (kN) - minimum				
	SDR 11	SDR 17	SDR 17.6	SDR 26	SDR 33
90	9	6	6		
110	14	9	9		
125	18	12	11		
160	29	19	19	13	
180	37	25	24	16	
225	58	38	37	26	
250	71	48	46	32	
280	89	60	58	40	
315	112	75	73	50	
355	143	96	92	64	51
400	182	122	118	81	65
450	230	154	149	102	83
500	284	190	183	126	102
560	355	238	230	158	128
630	450	302	291	200	162
710	0	383	370	255	206
800	0	486	469	323	261
900	0	616	593	411	331
1000	0	760	733	507	407

Table 3b - Pull out test force at 80°C for Type 2 fittings for PE 80 pipe

Nom size	Test Force (kN) - minimum				
	SDR 11	SDR 17	SDR 17.6	SDR 26	SDR 33
90	3	3	3		
110	5	4	4		
125	6	5	5		
160	10	9	9	8	
180	13	11	11	10	
225	20	17	17	15	
250	25	21	21	19	
280	31	27	26	24	
315	39	34	33	30	
355	50	43	42	38	36

Table 3d - Pull out test force at 80°C for Type 2 fittings for PE 100 pipe

Nom size	Test Force (kN) - minimum				
	SDR 11	SDR 17	SDR 17.6	SDR 26	SDR 33
90	4	4	4		
110	6	5	5		
125	8	7	7		
160	13	11	11	10	
180	16	14	14	13	
225	25	22	22	20	
250	31	27	27	25	
280	39	34	34	32	
315	49	44	43	40	
355	62	55	55	51	49

400	79	70	70	64	62
450	100	89	88	82	79
500	123	110	109	101	97
560	155	138	137	126	122
630	196	175	173	160	154
710	0	222	220	203	196
800	0	282	279	258	249
900	0	356	353	327	315
1000	0	440	436	403	389

B.3.3 After 500 hours, the tests in accordance with clause 4.4.3 shall be carried out.

B.4 Report

The report shall include:

- (a) date of the test;
- (b) identification of the test piece;
- (c) type of fitting tested (Type 1 or Type 2);
- (d) evidence of leakage, weepage and fracture of the pipe during the 500 hour test;
- (e) compliance with the pressure tests in clause 4.4.3.

APPENDIX C - PULL OUT TEST AT 23°C

C.1 Test Piece

The test piece shall be a fitting jointed to polyethylene pipe, conforming with WIS 4-32-03 and/or WIS 4-32-13, in accordance with the manufacturer's instructions. The free length of pipe between the fitting under test and the end-loading grips shall be as specified in Clause B.1 of Appendix B.

C.2 Test Piece for Flange Assemblies

A typical test piece for testing flange assemblies is illustrated in Figure 1 of Appendix B.

C.3 Apparatus

The apparatus shall be capable of applying a tensile axial load, as given in Table 4(a) or 4(b), as appropriate, at a cross-head speed of not less than 25mm/min.

C.4 Test Procedure

C.4.1 Plain metal plugs shall be inserted in the end of the PE pipe(s) to support the pipe(s) under the action of the loading grips. Alternatively, mechanical fitting(s), not under test, shall be assembled on the end of the PE pipe(s). Loading grips shall not be applied to the fitting body under test.

C.4.2 The test shall be carried out at a temperature of $(23 \pm 2)^\circ\text{C}$. A tensile axial load shall be applied to the fitting under test at a cross-head speed of (25 ± 1) mm/min until the maximum load is clearly defined.

C.4.3 The fitting passes the test provided the minimum load in Table 4a or Table 4c for Type 1 fittings and Table 4b or Table 4d for Type 2 fittings is exceeded without pull-out occurring. If fracture of the pipe occurs, the test shall be repeated on a completely new assembly. If the pipe yields at a distance greater than 0.1L from the mouth of the socket or loading grip (A.2.1), the fitting shall be deemed to have satisfied the requirements of this test.

C.5 Report

The report shall include the following:

- (a) the date of test;
- (b) identification of the sample;
- (c) type of fitting tested (Type 1 or Type 2);
- (d) the maximum load at failure;
- (e) the type of failure (pull-out, necking of the pipe, fracture of the pipe).

Table 4a - Pull out test forces for Type 1 fittings for PE 80 pipe

Nom size	Test Force (kN) - minimum				
	SDR 11	SDR 17	SDR 17.6	SDR 26	SDR 33
90	32	21	20		
110	47	32	31		
125	61	41	39		
160	100	67	65	45	
180	126	85	82	56	
225	198	132	128	88	
250	243	163	158	109	
280	305	205	198	136	
315	386	259	251	173	
355	491	329	317	219	177
400	624	417	404	277	225
450	790	528	512	351	284
500	975	652	629	433	349
560	1219	818	789	543	440
630	1544	1035	1000	688	555
710		1315	1269	875	707
800		1670	1611	1109	895
900		2113	2037	1411	1135
1000		2609	2516	1740	1398

355	216	186	184	166	158
400	274	236	233	210	200
450	347	299	296	266	253
500	428	369	364	328	313
560	536	463	457	412	392
630	679	585	579	521	496
710		744	735	662	631
800		944	933	840	800
900		1195	1181	1065	1013
1000		1475	1458	1314	1251

Table 4c - Pull out test forces for Type 1 fittings for PE 100 pipe

Nom size	Test Force (kN) - minimum				
	SDR 11	SDR 17	SDR 17.6	SDR 26	SDR 33
90	40	27	26		
110	60	40	39		
125	77	52	50		
160	127	85	82	57	
180	160	107	103	71	
225	250	167	162	111	
250	308	207	200	138	
280	386	259	251	172	
315	489	328	317	219	
355	622	416	402	277	224
400	790	529	511	351	285
450	1001	669	649	444	359
500	1234	826	797	548	443
560	1544	1036	1000	688	557
630	1956	1312	1266	872	704
710		1666	1607	1109	896
800		2115	2041	1405	1134
900		2677	2580	1787	1437
1000		3305	3187	2204	1771

Table 4b - Pull out test forces for Type 2 fittings for PE 80 pipe

Nom size	Test Force (kN) - minimum				
	SDR 11	SDR 17	SDR 17.6	SDR 26	SDR 33
90	14	12	12		
110	21	18	18		
125	27	23	23		
160	44	38	37	34	
180	55	48	47	43	
225	87	75	74	66	
250	107	92	91	82	
280	134	116	114	103	
315	170	146	145	130	

Table 4d - Pull out test forces for Type 2 fittings for PE 100 pipe

Nom size	Test Force (kN) - minimum				
	SDR 11	SDR 17	SDR 17.6	SDR 26	SDR 33
90	17	15	15		
110	26	23	23		
125	34	30	30		
160	55	49	49	45	
180	70	62	61	57	
225	109	97	96	89	
250	134	120	119	110	
280	168	150	149	137	
315	213	190	188	174	
355	270	241	239	221	213

400	343	306	303	280	271
450	435	387	384	355	343
500	536	478	474	438	423
560	672	600	594	550	531
630	851	759	753	696	671
710		964	956	884	853
800		1224	1213	1122	1082
900		1549	1535	1421	1370
1000		1913	1896	1754	1691

APPENDIX D - FATIGUE TEST

The equipment shall consist of a thermostatically controlled water bath maintained at 80 (+2 -1)°C, together with equipment that permits the application of a fatigue load using pneumatics or other suitable means, to produce a trapezoidal pressure change profile (see Figure 2).

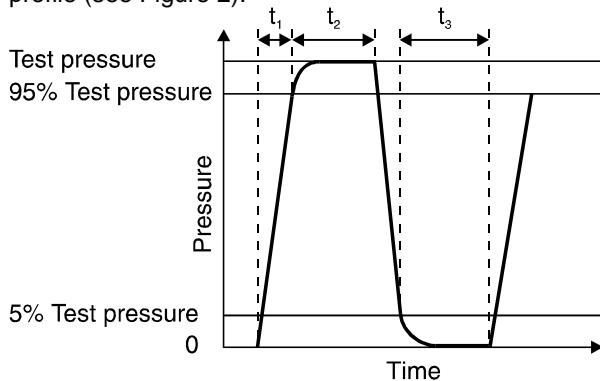


Figure 2 - Schematic representation of pressure loading profile

Typical equipment is illustrated in Figure 3 and consists principally of compressed air supplied from line A, filtered (B) and then regulated (C) to the desired pressure. The filtered and regulated compressed air is then passed through a 5 way solenoid valve (D) which is controlled by a dual timer (E). The valve D cycles the compressed air between two lines (F and G) which supply the two samples (SF and SG). By using a symmetrical loading profile, the greatest use is made of the one supply of compressed air (line A) with the two samples out of phase, as shown schematically in Figure 4. Between the 5-way valve (D) and the two samples (SF and SG) there are two 3-way solenoid valves (H and I) on the two lines (F and G) which are normally open. When one or both of the samples is detected as having failed, a current is supplied to either or both

solenoid valves (H and I) to isolate the sample(s) from the compressed air.

Equipment in which a pressure point is connected to a single sample is also permitted.

D.1 Test Pieces

For this test, 3 test pieces shall be evaluated.

NOTE: Testing may be carried out in pairs, in which case 4 test pieces rather than the usual 3 will be evaluated.

Test pieces shall consist of fittings into which pipes have been jointed together with suitable end caps. The free length (L) of pipe between fitting and end cap shall be calculated from:

L = 3 x outside diameter minimum for test pieces up to and including size 315.

The test pieces shall be filled with water and all air vented.

NOTE: Caution: testing with **compressed** air can be dangerous and the test specimen must be vented of all air.

D.2 Conditioning

The assembly shall be conditioned for not less than 2 hours at a temperature of 80 (+2 -1)°C, before testing shall commence.

D.3 Test Method

The sample shall be connected to the pressurising unit to produce the following pressure regime:

$$t_1 = 2 \pm 1.0 \text{ s}$$

$$t_2 = 5 \pm 0.5 \text{ s}$$

$$t_3 = 5 \pm 0.5 \text{ s}$$

where

t₁ = time to raise the pressure from 0 bar to 95% of the test pressure (e.g. 95% of 4.8 bar for a 6 bar fitting, 95% of 8 bar for a 10 bar fitting).

t₂ = time from when 95% of the test pressure has been reached to removal of the test pressure.

t_3 = time from when the pressure has decayed to 5% of the test pressure to the time when the pressure is raised.

NOTE 1: See Figure 2.

NOTE 2: The time from the end of cycle t_2 to the beginning of cycle t_1 is typically 6 - 8 seconds.

NOTE 3: The test pressure shall be reached and maintained during time t_2 at (4.8 ± 0.2) bar for a 6 bar fitting and (8 ± 0.2) bar for a 10 bar fitting.

NOTE 4: The test pressure shall reduce to 0 bar during time t_3 .

Failure of the pipe within a distance of less than 0.1L from the mouth of the fitting shall be considered to be a failure to meet the requirements of this test.

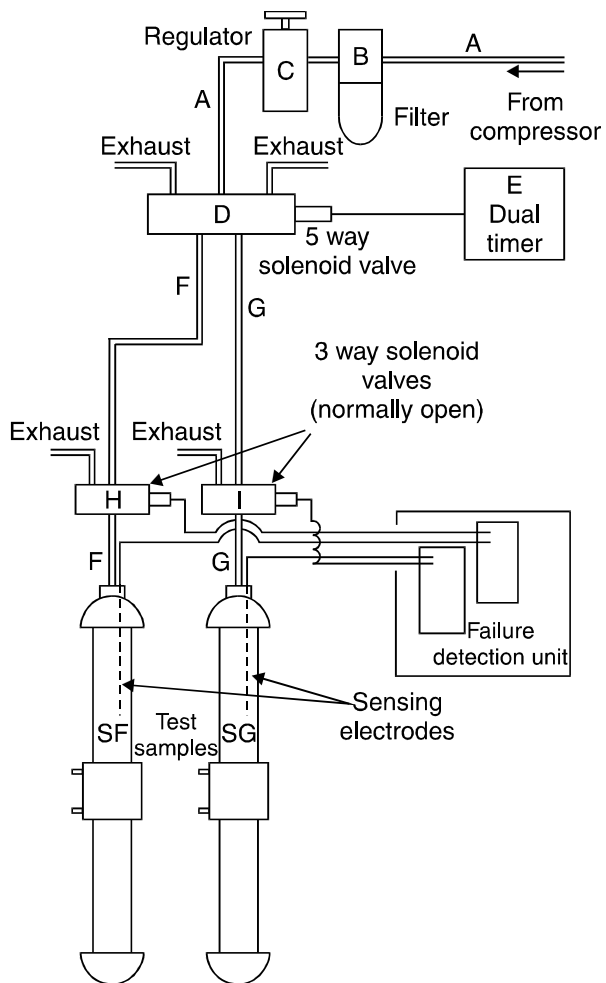


Figure 3 - Typical pneumatic equipment

D.4 Report

The report shall include:

- (a) date of the test;
- (b) identification of the sample;
- (c) type of fitting (Type 1 or Type 2);
- (d) test temperature;
- (e) maximum test pressure;
- (f) number of test cycles achieved.

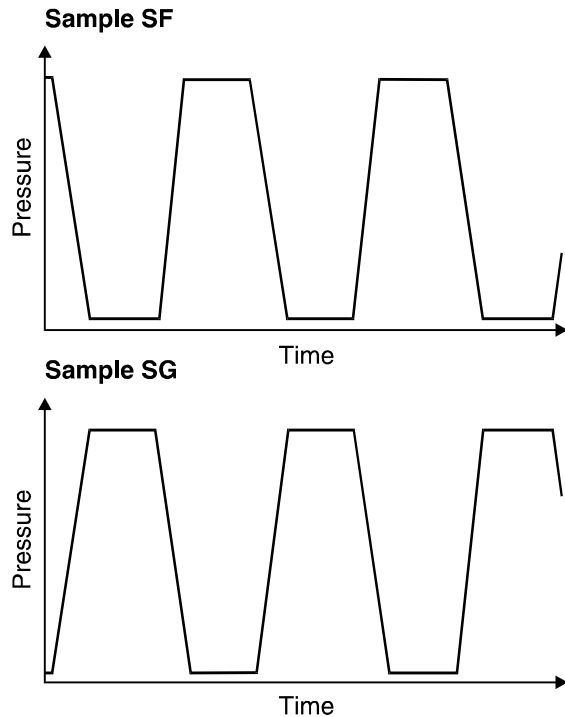


Figure 4 - Schematic presentation of internal pressure changes using one test point connected to two samples