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Water Industry Specification

SPECIFICATION FOR END LOAD RESISTANT MECHANICAL JOINTS AND COMPRESSION FITTINGS MADE PRINCIPALLY OF THERMOPLASTICS FOR USE WITH POLYETHYLENE PIPES OF NOMINAL SIZE ≤63 WITH OUTSIDE DIAMETERS TO BS 5556 (METRIC)

FOREWORD

This specification has been prepared by the Water Research Centre (WRc) under the direction of the Sewers and Water Mains Committee in consultation with the Water Industry and Manufacturing Associations to define the properties required of mechanical joints and compression fittings for use with polyethylene pipes in the size range 20 to 63 and manufactured to BS 6572*, BS 6730 and WIS No. 4-32-02*.

Throughout this specification, fittings are designated by a size related to the metric nominal outside diameters of the pipe with which the fitting is to be used. This follows the same practice as that used in WIS No. 4-22-01, the corresponding specification for compression fittings of copper and copper alloys for use with polyethylene pipes with outside diameters to BS 5556.

This specification includes a procedure for determining the rate of flow but does not specify limits which will be added at a later date.

Attention is drawn to the Manual for MDPE pipe systems for water supply which has been prepared to offer guidance to the UK Water Industry on the practical design, installation and operation of PE water pipeline systems, as well as to the following Water Industry Specifications:

WIS No 4-32-04
WIS No 4-32-06
WIS No 4-32-07
WIS No 4-32-08

Purchasers are reminded that this specification requires that the manufacturers shall operate a quality system relating to the manufacture of pipe and fittings to this specification in compliance with BS 5750: Part 2 (EN 29002) which ensures that products claimed to comply with this specification consistently meet the required level of quality. Enquiries regarding the availability of third party certification should be addressed to an appropriate NACCB or equivalent accredited third party certification body or to WRc.

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

This specification may call for the use of procedures that may be injurious to health and safety 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.

Compliance with this specification does not of itself confer immunity from legal obligations nor does the specification 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.

Information contained in this specification is given in good faith but neither the Water Services Association, Foundation for Water Research nor the Water Research Centre can accept any responsibility for actions taken as a result.

* BS 6572 is equivalent to WIS No. 4-32-02 and is now regarded as the lead specification.

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1. SCOPE

This specification stipulates the requirements for both blue and black pigmented mechanical joints and compression fittings, end-load resistant, and made principally of thermoplastics. They are for use in cold potable water services for sizes 20 to 63 for pressures up to 12 bar at 20°C.

These fittings are designed for use with pipe manufactured to BS 6572, BS 6730 and WIS No. 4-32-02.

NOTE 1 Blue is the preferred colour for thermoplastics fittings for use with blue MDPE pipe for underground potable water use.

NOTE 2 The titles of the publications referred to in this document are listed under clause 11 – REFERENCES.

2. QUALITY ASSURANCE

Manufacturers shall operate a quality system relating to this specification in compliance with BS 5750: Part 2 (EN 29002).

3. MATERIAL

The fitting shall be made principally from a thermoplastics material or materials which do not suffer from corrosion from potable water (pH range 6 – 8.5) or low resistivity soils (200 ohm.cm).

Any elastomeric sealing ring used in the construction of the fitting shall conform to Type W of BS 2494:1986.

4. DESIGN AND CONSTRUCTION

4.1

The wall thickness of compression fittings shall be such as to enable the fittings to meet all the requirements of this specification.

4.2

The fittings shall be free from internal flash or other irregularities which might restrict the free flow of fluid, and shall be so designed that the resistance to the flow of the fluid through the fittings is minimised.

4.3

Union nuts shall have suitable means for tightening.

4.4

Provision for gripping the body shall be made on all straight fittings with screwed ends.

4.5

Compression fittings shall be supplied with a means for ensuring the correct position of pipe within the fitting. This requirement does not apply to components designed as repair couplings.

4.6

The external and internal threads of the ends of transition fittings other than for compression ends, shall be screwed with one of the appropriate forms of threads in accordance with clause 4 of BS 864: Part 2: 1983. The use of tapered threads in accordance with clause 5.4 of BS 21: 1985 is also permitted.

NOTE Fittings with tapered threads should be provided with clear jointing instructions including the maximum permitted torque.

4.7 FLANGED JOINTS

Flanged joints shall be constructed such that they may be attached to flanges designated PN16 whose dimensions are shown in Table 9 of BS4504: Part 3: Section 3.3: 1989.

5. DESIGNATION OF SIZE OF FITTING

The size of fitting shall be designated by the nominal metric outside diameter of the pipe with which the fitting is to be used.

The method of specifying the nominal size of the ends of the fitting shall be in accordance with Appendix A of BS 864: Part 2: 1983.

6. EFFECT ON WATER QUALITY

6.1

When used under the conditions for which they are designated, non-metallic products in contact with or likely to come into contact with potable water shall comply with the requirements of BS 6920: Part 1: 1988.

NOTE 1 Non-metallic products for installation and use in the United Kingdom which are verified and listed under the UK Water Fittings Byelaws Scheme are deemed to satisfy the requirements of this clause. Details of the Scheme are obtainable from the Water Research Centre Byelaws Advisory Service, 660 Ajax Avenue, Slough SL1 4BG.

6.2

Non-metallic products approved by the Department of the Environment Committee on Chemicals and Materials of Construction for use in Public Water Supply and Swimming Pools are considered free from adverse health effects for the purposes of compliance with this clause.

NOTE 2 A list of approved chemicals and materials and details of the approvals scheme is available from the Secretary of the Committee at the Department of the Environment, Water Division, Romney House, 43 Marsham Street, London SW1P 3PY.

7. PERFORMANCE REQUIREMENTS

7.1 Sampling for performance testing

Three fittings of size 63, or the largest size of the manufacturer's range complying with this specification shall be tested to the requirements of 7.2.1.

Three fittings of all sizes of the manufacturer's range shall be tested to the requirements of 7.2.2 and 7.2.3 and one fitting for each size and type of the manufacturer's range complying with this specification shall be tested to the requirements of 7.3 to 7.9.

NOTE All performance tests shall be carried out initially and repeated annually or when any significant changes are made to the design, the manufacturing method or to the materials. However, when a manufacturer has a large product range, the third party certifying body may agree a test programme with the manufacturer which will ensure that all sizes and types of fittings covered by this specification are tested over at least a 3 year period.

7.2 Pressure tests at 20°C

7.2.1 *Pressure test at 5 000 to 10 000 hours*

The fittings assemblies shall be tested in accordance with the method described in Appendix A at the appropriate pressure stipulated in Table 1 to cause failure between 5 000 and 10 000 hours.

Table 1 – Test pressures for 5 000 to 10 000 hour test

Nominal size	Test pressure – minimum (bar)
20	26
25	20
32	20
50	20
63	20

If after 10 000 hours, the test assembly has not failed, the pressure shall be increased as described in Appendix A.

The pipe shall burst in a ductile manner (see Figure 1) prior to any leakage around the fitting seals or failure of the bond between pipe and fitting. Failure in a brittle manner (see Figure 1) or failure within a distance of less than 0.1L from the fitting (where L = free length of pipe between end caps and fitting) shall be disregarded.

7.2.2 *Pressure tests at 100 to 1 000 hours*

The fittings assemblies shall be tested in accordance with the method described in Appendix A at the appropriate pressure stipulated in Table 2 to cause failure between 100 and 1,000 hours.

Table 2 – Test pressure for 100 to 1 000 hour test

Nominal size	Test pressure – minimum (bar)
20	28.0
25	22.0
32	22.0
50	22.0
63	22.0

If after 1 000 hours, the test assembly has not failed the pressure shall be increased as described in Appendix A.

The pipe shall burst in a ductile manner (see Figure 1) prior to any leakage around the fitting seals or failure of the bond between pipe and fitting. Failure in a brittle manner (see Figure 1) or failure within a distance of less than 0.1L from the fitting (where L = free length of pipe between end caps and fitting) shall be disregarded.

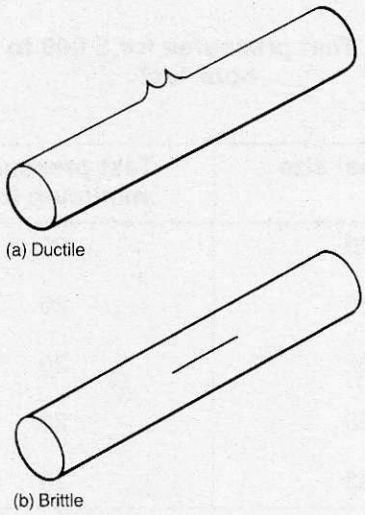


Figure 1. Types of failure

7.2.3 *Pressure tests at 1 to 10 hours*

The fittings assemblies shall be tested in accordance with the method described in Appendix A at the appropriate pressure stipulated in Table 3 to cause failure between 1 and 10 hours.

If after 10 hours, the test assembly has not failed, the pressure shall be increased as described in Appendix A.

The pipe shall burst in a ductile manner (see Figure 1) prior to any leakage around the fitting seals or failure of the bond between pipe and fitting. Failure in a brittle manner (see Figure 1) or failure within a distance of 0.1L from the fitting (where L = free length of pipe between end caps and fitting) shall be disregarded.

Table 3 – Test pressure for 1 to 10 hours test

Nominal size	Test pressure – minimum (bar)
20	32.0
25	25.0
32	25.0
50	25.0
63	25.0

7.3 Internal pressure resistance when subjected to bending stresses

Using an arrangement as shown in Appendix B with a maximum bend radius of 25 x nominal outside diameter, the test assembly shall then be subjected to a constant internal pressure in accordance with the procedure specified in Appendix A. The pressures to be applied are stipulated in Table 4.

Table 4 – Test pressure when subjected to bending stresses

Nominal size	Test pressure – minimum (bar)
20	32.0
25	25.0
32	25.0
50	25.0
63	25.0

If the test assembly has not failed after 1 hour, the pressure shall be increased as described in Appendix A.

The pipe shall burst in a ductile manner (see Figure 1) prior to any leakage around the fitting seals or failure of the bond between pipe and fitting.

Failure in a brittle manner (see Figure 1) or failure within a distance of less than 0.1L from the fitting (where L = free length of pipe between end caps and fitting) shall be disregarded.

7.4 External pressure resistance

When tested in accordance with the method given in Appendix C of BS 5114, a test assembly shall withstand an external pressure of 0.1 bar above atmospheric pressure for 1 hour followed by a pressure of 0.8 bar above atmospheric pressure for a further 1 hour without leakage at any time during the 2 hour test duration.

7.5 Resistance to pull-out of a test assembly at 20°C

Test assemblies shall be evaluated in accordance with and meet the requirements of Appendix C. In the case of dispute, the test method and requirements specified in Appendix C1 shall be used.

7.6 Resistance to freezing

Test assemblies as specified in A.2 of Appendix A shall be filled with water and left in a freezer at a temperature below −15°C for 24 hours. The test assemblies shall be removed from the freezer and conditioned for a period of not less than 24 hours at a temperature of 20 ±2°C.

One test assembly shall then be tested to the requirement of 7.2.3 and one to that of 7.5.

7.7 Impact resistance at 0°C

When tested by the method described in Appendix D, fittings shall neither crack nor break.

If the fitting does not crack or break, it shall then be conditioned for a period of not less than 24 hours at a temperature of 20 ±2°C.

One test assembly shall be tested to, and meet, the requirement of 7.2.3 and one to that of 7.5.

7.8 Resistance to external bending – male and female adaptors

When tested by the method described in Appendix E and applying the forces given in Table 5 for 1 hour, fittings shall neither crack nor break. For evidence of cracking, the test piece shall be viewed under an optical microscope at 40 x magnification.

7.9 Determination of head loss against size

The pressure differential (head loss) at a given flow rate shall be determined by the method described in Appendix F and shall be recorded.

Table 5 – Applied bending moment for external bending test

Nominal size	Applied bending moment – minimum (Nm)
20	80
25	110
32	150
50	250
63	300

8. QUALITY REQUIREMENTS

8.1 Voids and defects

None of the fitting samples evaluated shall show blisters, excessive delamination or cracking, or signs of weld line splitting.

For fittings moulded by conventional techniques, care shall be taken in examining the area around the point of injection, where no cracks or delamination shall penetrate to a depth greater than 20% of the wall thickness. For fittings moulded by end-gating techniques, e.g. ring or diaphragm methods, any cracks or delamination in the wall of the fitting adjacent to the injection area shall be parallel to the axis and shall not penetrate to a depth of more than 20% of the socket length.

The assessment of the depth of penetration of cracks or delamination shall be carried out by sectioning the specimen at the point of injection and measuring the depth to which these defects penetrate the wall thickness of the fitting.

NOTE: Non-destructive test methods may be used as an alternative if approved under a quality assurance scheme.

8.2 Pressure tests at 1 hour

Fittings shall be tested in accordance with the method described in Appendix A at the pressures specified in Table 3. If, after 6 hours the test assembly has not failed, the test may be discontinued.

Failure of the test assembly is defined as rupture of the fittings or leakage or weepage of the joint. Premature rupture of the pipe does not constitute failure but the test shall be repeated on an assembly made from the same batch of fittings.

8.3 Resistance to pull-out of a test assembly

Fittings shall be tested to, and meet, the requirements of 7.5.

8.4 Resistance to external bending – male and female adaptors

Fittings shall be tested to, and meet, the requirements of 7.8.

9. SPECIMEN CONDITIONING DURING TYPE TESTING OR IN ANY CASE OF DISAGREEMENT

Unless otherwise specified, fittings and test assemblies shall be conditioned for not less than 24 hours at 20 ±2°C.

10. MARKING

Fittings manufactured to this specification shall be clearly and legibly marked. No method of marking shall prejudice the performance of a fitting when

tested to the requirements of this specification.

The marking shall give the following information:

(a) Manufacturer's identification.
(b) Reference to this Water Industry Specification, i.e. WIS No. 4-32-11.
(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).
(c) Batch identification code.
(d) The letters PE.
(e) The nominal size and pressure rating in bar as given in 1 – Scope.
(f) A third party certification mark (if permissible).

Additional information shall be provided as specified in Appendix G.

11. REFERENCES

BS 21 Specification for pipe threads for tubes and fittings where pressure-tight joints are made on the threads (metric dimensions).

BS 864 Capillary and compression tube fittings of copper and copper alloy.
Part 2 Specification for capillary and compression fittings for copper tubes.

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

BS 4504 Circular flanges for pipes, valves and fittings. (PN designated).
Part 3 Steel, cast iron and copper alloy flanges.
Section 3.3 Copper alloy and composite flanges.

BS 4728 Determination of the resistance to constant internal pressure of thermoplastics pipe.

BS 5114 Performance requirements for joints and compression fittings for use with polyethylene pipes.

BS 5556 Specification for general requirements for dimensions and pressure rating for pipes of thermoplastics materials (metric series).

BS 5728 Measurement of flow of cold potable water in closed conduits.
Part 3: Methods of determining principal characteristics of single meters.

BS 5750 Quality Systems
Part 2 (EN 29002) Specification for production and installation.

BS 6572 Specification for blue polyethylene pipes up to nominal size 63 for below 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.

Water Industry Specifications:

No. 4-22-01 Specification for compression fittings of copper and copper alloy for polyethylene pipes with outside diameters to BS 5556 (metric).

No. 4-32-02 Specification for polyethylene pressure pipe for cold potable water (underground use).

No. 4-32-04 Specification for polyethylene socket and spigot fittings, saddles and drawn bends for fusion jointing for use with cold potable water PE pressure pipes.

No. 4-32-06 Specification for polyethylene electrofusion couplers and fittings for cold potable water supply for nominal sizes up to and including 180.

No. 4-32-07* Specification for electrofusion control boxes for use with fittings complying with IGN No. 4-32-06.

No. 4-32-08 Specification for site fusion jointing of MDPE pipes and fittings.

No. 5-01-02 Requirements for the testing of non-metallic materials for use in contact with potable water.

WRc/WAA Manual for MDPE pipe systems for water supply.

European Standard:

EN 29002 Quality Systems – Model for quality assurance in production and installation.

APPENDIX A – PRESSURE TESTS AT 20°C

A.1 Apparatus

The apparatus shall be that described in BS 4728.

A.2 Test assembly

The test assembly shall be a fitting with a minimum free length of pipe of 300mm fitted in each outlet. The type of end caps shown in Figure 1 of BS 4728 shall be used.

* In course of preparation

A.3 Procedure

The test assembly shall be tested in accordance with the procedure given in BS 4728 at a temperature of 20 ±2°C at the stipulated pressure and time. If the assembly has not failed after the stipulated time, the pressure shall then be increased at a steady rate so that failure occurs in a period of not less than 15 seconds.

A.4 Report

The report shall include the following:

(a) Identification of the test (e.g. delayed burst test, external pressure resistance test, etc.)
(b) Identification of the test assembly.
(c) Type of failure (e.g. ductile, brittle, etc.)
(d) Hold pressure and failure pressure.
(e) Test duration.
(f) Date of test.

APPENDIX B – APPARATUS FOR HYDROSTATIC PRESSURE TEST OF FITTINGS WHEN SUBJECTED TO BENDING STRESSES

APPENDIX C – RESISTANCE TO PULL-OUT OF A TEST ASSEMBLY AT 20°C

C1 TEST USING AN INCREASING TENSILE FORCE

C1.1 Test piece

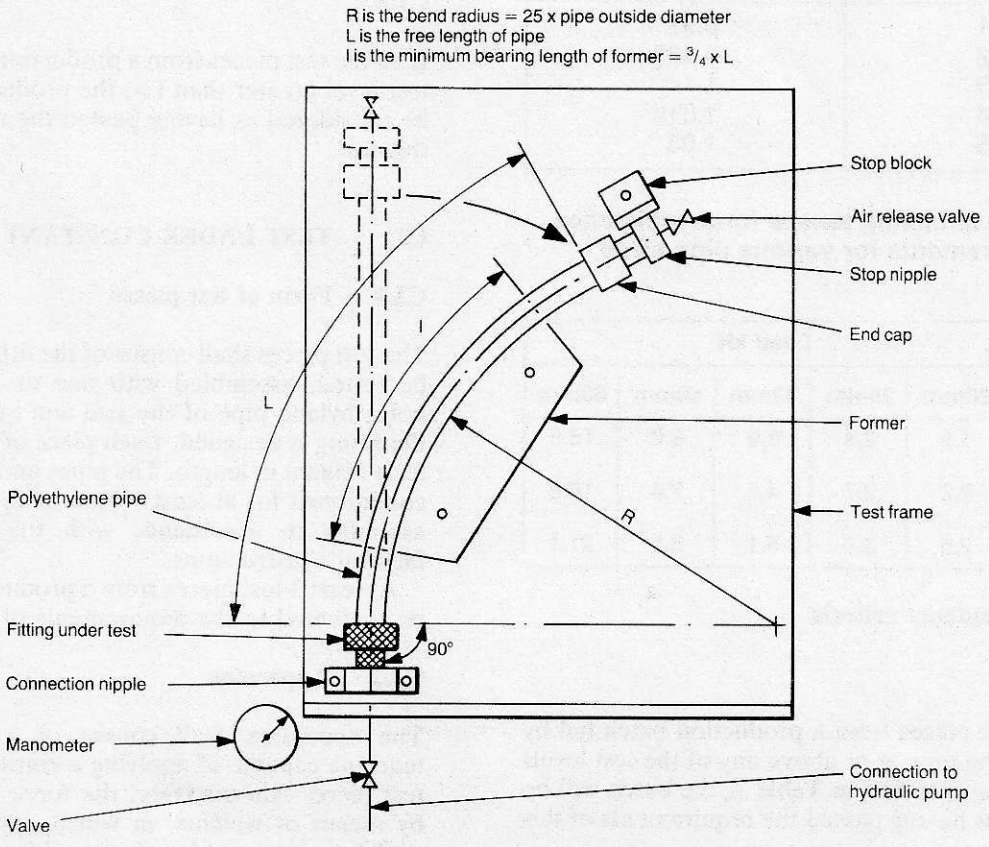
The specimen shall consist of the fitting joint under test, assembled with PE pipe in accordance with the manufacturer's instructions. Screwed outlets of transition fittings or service head adaptors shall be connected to suitable adaptors which shall be used to apply the tensile loads.

At least 3 test pieces from a production batch shall be evaluated to the requirements of this test.

C1.2 Procedure

C1.3

Loading grips shall not be applied to the fitting body under test. Plain metal plugs shall be inserted in the end of the PE pipe(s) to support the pipe 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). The mechanical fittings on the PE pipe shall be a distance of at least 4 x the nominal pipe diameter from the fitting under test.



† The end cap is only used for closing the test specimen and is not meant to be tested

Figure 2. Diagram of suitable apparatus for hydrostatic pressure test when subjected to bending stresses

C1.4

A tensile axial force shall be applied to the fitting under test at a cross-head speed of 25 ± 1mm/min, until either a distinct, localised reduction in the diameter of the PE pipe occurs (pipe yield) or a time period of 5 min has elapsed after maximum load has been reached.

C1.5

A record of the maximum tensile force shall be taken to an accuracy of ±2%. The test temperature within the limits 23 ± 2°C shall be recorded and the maximum force corrected to 23°C using the appropriate factor in Table 6.

C1.6

The acceptability of the fitting shall be judged against the requirements defined in clause C.1.8.

C1.7 Retests

In the event of the first test piece failing to comply, pipe pull out retests shall be carried out on two additional samples. If either sample fails the fitting shall be classified as a failure.

Table 6 – Force correction factors

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

Table 7 – Minimum tensile force resistance requirements for various pipe sizes

Specified test levels	Load kN				
	20mm	25mm	32mm	50mm	63mm
L_A	1.9	2.4	3.9	6.2	16.5
L_B	2.2	2.7	4.5	7.4	18.8
L_C	2.5	3.0	5.1	8.6	21.1

C1.8 Acceptance criteria

C1.8.1

If all the test pieces from a production batch fail by necking of the pipe at or above any of the test levels L_A, L_B or L_C specified in Table 7, the batch will be considered as having passed the requirements of this test.

C1.8.2

If any test piece from a production batch fails by pipe pull-out at test level L_A or less, the batch will be considered as having failed the requirements of this test.

C1.8.3

If any test piece from a production batch fails by pipe pull-out within the test levels L_A to L_B, further test pieces from the production batch may be taken and retested. If any test piece from the retest fails at a test level equal to or less than test level L_B, the batch will be considered as having failed the requirements of this test.

C1.8.4

If less than 34% of the test pieces fail by pipe pull-out within the test levels L_B to L_C, the batch will be considered as having passed the requirements of this test.

C1.8.5

If 34% or more of the test pieces fail by pipe pull-out within the test levels L_B to L_C, further test pieces from the production batch may be taken and retested. If any test piece from the retest fails at a test level equal to or less than test level L_C, the batch will be considered as having failed the requirements of this test.

C1.8.6

If all the test pieces from a production batch pass at a test level greater than L_C, the production batch will be considered as having passed the requirements of this test.

C2 TEST UNDER CONSTANT FORCE

C2.1 Form of test pieces

The test pieces shall consist of the fitting or fittings to be tested, assembled with one or more pieces of polyethylene pipe of the size and quality for which the fitting is designed. Each piece of pipe shall be at least 300mm in length. The pipes and fittings shall be conditioned for at least 1 hour at 23 ± 2°C prior to assembly in accordance with the fittings manufacturer's instructions.

At least 3 test pieces from a production batch shall be evaluated to the requirements of this test.

C2.2 Apparatus

The apparatus shall consist of a tensile testing machine capable of applying a constant force to the test piece. Alternatively, the force may be applied by means of weights, in which case the test piece shall be suspended in a frame with a suitable fixture

to hold the weights. A suitable apparatus of the latter type is shown in Figure 3.

C2.3 Procedure

Mount the test piece securely in the apparatus and apply the appropriate force given in Table 8 gradually over a period of 15 to 30s. Hold the test piece in constant tension for a period of 5 minutes (+30s – 0s) at a temperature of 23 ± 2°C. After removal examine the test piece for pull-out from the compression ring and/or fracture/tearing of the pipe. If appropriate, the cap nut shall be removed to permit examination.

C3 Report

The report shall include the following:

(a) The full identification of the specimens.

(b) Description of assembly instructions.

(c) The test carried out i.e. under tensile force or under constant force.

(d) The force applied.

(e) Comments on ring position on the pipe and pipe condition after test.

(f) The date of the test.

Table 8 – Test forces for test under constant load

Nominal pipe size	20	25	32	50	63
Test force (kN)	1.9	2.5	4.1	9.8	15.6

APPENDIX D – IMPACT RESISTANCE AT 0°C

For each test, 10 test specimens shall be evaluated. The test specimens shall be pre-conditioned at 0°C ±2°C for 3 hours prior to testing. The tests shall be conducted within 30 seconds of removal from the conditioning chamber/bath.

Each test specimen shall be dropped from a height of 2 ±0.05m in random positions, onto a flat concrete floor.

Visually examine the test specimens for breaks or cracks. Condition them for 24 hours at 20 ±2°C. One test specimen selected at random shall then be tested to the requirement of 7.2.3 and one to that of 7.4.

APPENDIX E – RESISTANCE TO EXTERNAL BENDING

Male and female adaptors shall be screwed into metal support plates, so arranged to allow the fitting to be loaded with a constant force.

The fittings shall be screwed hand tight into the supports and a bending moment applied to the fitting via a circular metal bar. The bar shall have a diameter equal to the nominal size of the fitting.

The test pressure for the appropriate size of fitting as given in Table 5 shall then be applied and the bending moment imposed for 1 hour. At the end of

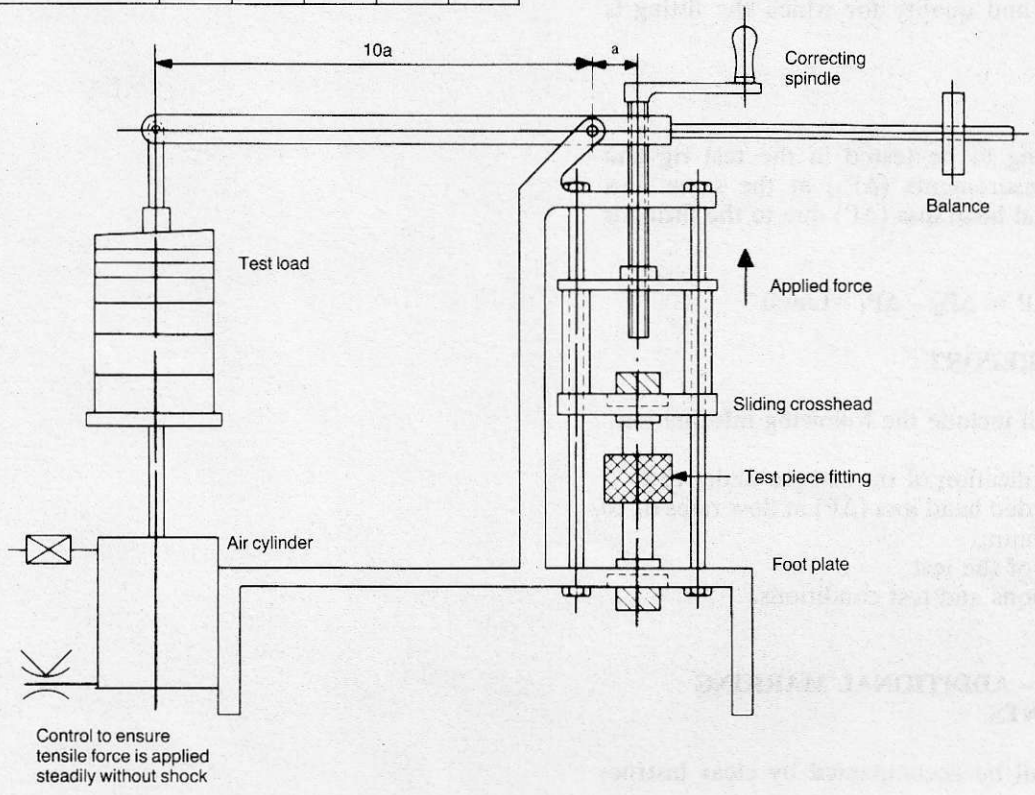


Figure 3. Diagram of suitable apparatus for test for resistance to pull-out of assembled joint

this period, the pressure is released and the fittings removed for inspection.

The fittings shall be examined under an optical microscope at 40 x magnification.

A typical assembly in illustrated in Figure 4.

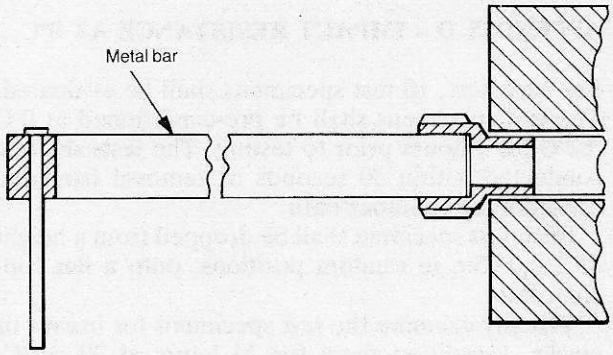


Figure 4. Typical apparatus for external bending

APPENDIX F – TEST METHOD FOR THE DETERMINATION OF HEAD LOSS AGAINST SIZE

F1 PROCEDURE

F1.1

The test shall be conducted in accordance with the procedure described in BS 5728: Part 3 using suitably accredited equipment.

F1.2

Measure the static differential pressure (ΔP_1) at flow rates of 10 and 25 L/min along a straight section of pipe of a size and quality for which the fitting is designed.

F1.3

Install the fitting to be tested in the test rig and repeat the measurements (ΔP_2) at the same flow rates. The actual head loss (ΔP) due to the fitting is given by:

$$\Delta P = \Delta P_2 - \Delta P_1 \quad \text{L/min}$$

F2 TEST REPORT

The report shall include the following information:

(a) Full identification of the sample under test;
(b) The recorded head loss (ΔP) at flow rates of 10 and 25 L/min;
(c) The date of the test;
(d) Observations and test conditions.

APPENDIX G – ADDITIONAL MARKING REQUIREMENTS

All fittings shall be accompanied by clear instructions giving:

1. Minimum pipe penetration depth needed to effect a seal to allow the fitting to meet the performance requirements.

2. If required, the chamfer angle necessary on the end of the MDPE pipe to allow the pipe to seal correctly in the fitting without disturbing any seal or clamping rings which might affect the performance of the joint.

3. Details of the type of insert, if any, needed to allow the fitting to meet the performance requirements.

4. The maximum out-of-square tolerance on the cut pipe end which can be tolerated.

5. Clear assembly instructions shall be provided. Where fittings rely on the tightening of an external nut to compress grip rings or seals, the degree to which the nut needs tightening to effect full performance shall be clearly indicated.