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BSI Standards Publication

Specification for mechanical fittings for use in the repair, connection and renovation of pressurized water supply pipelines – Requirements and test methods

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Contents

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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 December 2013. It was prepared by Technical Committee B/504, *Water supply*. A list of organizations represented on this committee can be obtained on request to its secretary.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

In particular, attention is drawn to the following regulations. The commentary in this British Standard reflects the state of the regulations at the time of publication.

Water fittings

In this document, the following national regulations, which apply to requirements relating to plumbing systems in premises to which a supply of public mains water (municipal water supply) has been provided, are referred to as the "Water Fittings Regulations [1]":

- The Water Supply (Water Fittings) Regulations 1999, as amended, in England and Wales;
- Scottish Water Byelaws 2004, in Scotland; and
- The Water Regulations (Northern Ireland) 2006, in Northern Ireland.

Public water supplies

These regulations refer to the standards of wholesomeness for water quality parameters where the water is intended for public supply. In this standard, the following national regulations, which apply standards of wholesomeness to water provided from the public mains supply (municipal supply), are referred to as the "Water Quality Regulations [2]":

- The Water Supply (Water Quality) Regulations 2000 as amended, in England;
- The Water Supply (Water Quality) Regulations (Northern Ireland) 2007 as amended, in Northern Ireland;
- The Water Supply (Water Quality) (Scotland) Regulations 2001 as amended, in Scotland; and
- The Water Supply (Water Quality) (Wales) Regulations 2010, in Wales.

Private water supplies

These regulations refer to the standards of wholesomeness for water quality parameters in premises where the water for human consumption or food production has been sourced from a private supply. In this standard, the following national regulations, which apply standards of wholesomeness to water provided from private water sources (non-municipal supply), are referred to as the "Private Water Supplies Regulations [3]":

- The Private Water Supplies Regulations 2009 as amended, in England;
- The Private Water Supplies Regulations (Northern Ireland) 2009 as amended, in Northern Ireland;
- The Private Water Supplies (Scotland) Regulations 2006 as amended, in Scotland; and
- The Private Water Supplies (Wales) Regulations 2010 as amended, in Wales.

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1 Scope

This British Standard specifies the requirements and associated test methods applicable to fittings with flexible, flexible restrained and restrained joints intended for connection to existing water supply pipes for the purposes of localized repair, new branch connections or pipeline rehabilitation.

NOTE These fittings may additionally connect to new pipe materials to replace faulty sections of existing pipe.

It also specifies requirements for materials and dimensions and gives performance requirements for joints.

It applies to fittings in the diameter range of DN 50 to DN 1 800 made for use on the following pipe materials other than polyethylene (PE):

- grey iron;
- ductile iron;
- steel;
- polyvinyl chloride (PVC);
- fibre cement; and
- glass-reinforced polyester (GRP).

It applies to fittings in the diameter range of DN 63 to DN 1 000 made for use on the following PE pipe material:

- PE80 material (medium-density polyethylene – MDPE);
- PE100 material (high-density polyethylene – HDPE); and
- PE barrier pipe for contaminated land [4].

This specification applies to fittings including (but not necessarily limited to) pipe couplings, flange adaptors, under pressure tees (including any similar components permanently installed on mains as part of flow isolation techniques or to facilitate equipment access into mains), repair clamps, pipe saddles and joint encapsulation units for both potable and non-potable applications.

It applies to fittings which seal to both the existing water supply pipe, including corroded or physically degraded pipe surfaces, and any new pipe by mechanical compression of elastomeric seals, though pressure actuated sealing may additionally be incorporated.

It also gives performance requirements for fittings designed to provide axial restraint when installed on the existing pipe. Joint design and gasket shapes are not covered by this British Standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standards publications

BS 4190, *ISO metric black hexagon bolts, screws and nuts – Specification*

BS EN 545, *Ductile iron pipes, fittings, accessories and their joints for water pipelines – Requirements and test methods*

BS EN 681-1:1996, *Elastomeric seals – Material requirements for pipe joint seals used in water and drainage applications – Part 1: Vulcanized rubber*

BS EN 1092-1, *Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories, PN designated – Part 1: Steel flanges*

BS EN 1092-2, *Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories, PN designated – Part 2: Cast iron flanges*

BS EN 1563, *Founding – Spheroidal graphite cast irons*

BS EN 10025-2, *Hot rolled products of structural steels – Part 2: Technical delivery conditions for non-alloy structural steels*

BS EN 10088-2, *Stainless steels – Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes*

BS EN 12201-1:2011, *Plastics piping systems for water supply, and for drainage and sewerage under pressure – Polyethylene (PE) – Part 1: General*

BS EN 12201-2:2011, *Plastics piping systems for water supply, and for drainage and sewerage under pressure – Polyethylene (PE) – Part 2: Pipes*

BS EN 14901, *Ductile iron pipes, fittings and accessories – Epoxy coating (heavy duty) of ductile iron fittings and accessories – Requirements and test methods*

BS EN ISO 1167-1:2006, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids – Determination of the resistance to internal pressure – Part 1: General method*

BS EN ISO 3506-1, *Mechanical properties of corrosion-resistant stainless steel fasteners – Part 1: Bolts, screws and studs*

BS EN ISO 9445 (all parts), *Continuously cold-rolled stainless steel – Tolerances on dimensions and form*

BS ISO 3384, *Rubber, vulcanized or thermoplastic – Determination of stress relaxation in compression at ambient and at elevated temperatures*

Other publications

[N1] WIS 4-52-01/02*, Polymeric anti-corrosion (Barrier) coatings – The use of polymeric anti-corrosion (Barrier) coatings*. Water UK.

[N2] WIS 4-52-03*, Anti-corrosion coatings on threaded fasteners*. Water UK.

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1 allowable operating pressure (PFA)
maximum hydrostatic pressure that a component is capable of withstanding continuously in service

NOTE In BS EN 12201 (Parts 1 and 2), the term nominal pressure (PN) at 20 °C is used in place of PFA.

3.2 coupling
fitting providing connection between two spigot ends capable of absorbing a degree of ground/pipe movement and which provides a sufficient mechanical support to resist the self-weight of the pipe, the water contained therein, and the external imposed loadings (e.g. shear loadings from traffic/backfill/ground movement)

NOTE Couplings can be classified as Class A or Class B, see Table 1 for more details.

3.3 depth of engagement
when jointed, the distance between the end of the spigot and the face of the socket of the coupling or flange adaptor

NOTE This is also known as the "insertion depth".

3.4 flange adaptor
fitting providing connection between a spigot and a flange capable of absorbing a degree of ground/pipe movement and providing sufficient mechanical support to resist the self-weight of the pipe, the water contained therein and the external imposed loadings (e.g. shear loading from traffic/backfill/ground movement)

NOTE Flange adaptors can be classified as Class A or Class B, see Table 1 for more details.

3.5 flexible non-restrained joint
joint that permits significant angular deflection both during and after installation with no means provided to prevent separation of the assembled joint

3.6 flexible restrained joint
joint that permits significant angular deflection both during and after installation with a means provided to prevent separation of the assembled joint

NOTE 1 Flexible restrained joints can be classified as Type A or Type B, see Table 1 for more details.

NOTE 2 Some flexible restrained joints are intended for PE pipe in addition to other pipe materials and should be classified according to joints of fittings for polyethylene pipes for that application, see Table 1 for more details.

3.7 joint angular deflection
angle between the axis of the spigot and one end of the fitting that a single flexible joint can accommodate

3.8 joint encapsulation unit
fitting installed around a leaking pipe joint that seals to both sections of pipe barrel either side of the joint forming a pressure-tight container to contain the leakage

3.9 manufacturer's recommended bolt torque
bolt torque required for any specific installation condition, e.g. specific to pipe material

3.10 manufacturer's recommended maximum bolt torque
maximum value for any specific size of fitting

3.11 nominal pressure (PN)
alphanumerical designation related to a combination of mechanical and dimensional characteristics of a component of a pipework system, used for reference purposes, which comprises the letters PN followed by a dimensionless number

3.12 pipe nominal size (DN)
numerical designation of the size of pipe, which is a whole number approximately equal to the actual dimension in millimetres

NOTE For existing pipework in old imperial size pipe standards the nearest metric DN reference should be used.

3.13 pipe saddle
fitting attached and sealed to part of a pipe's surface to facilitate a connection to pipe with an outlet size greater than DN 50

NOTE 1 It is usually secured by clamp bands and seals only around the area that the connection is made. It may incorporate some form of valve to facilitate under pressure drilling and is usually used for smaller branch size threaded connections rather than for under pressure tees.

NOTE 2 Pipe saddles are not generally regarded as suitable for use on PE pipe material due to the visco-elastic properties of the pipe material affecting long-term sealing characteristics.

3.14 repair clamp
fitting installed around a leaking pipe barrel to effect a seal on both local and circumferential pipe defects

NOTE Repair clamps are not generally regarded as suitable for use on PE pipe material due to the visco-elastic properties of the pipe material affecting long-term sealing characteristics.

3.15 restrained joint
joint for PE pipe that permits no angular deflection both during and after installation with a means provided to prevent separation of the assembled joint

3.16 setting gap
when jointed, the distance between the ends of the spigots in a coupling or the end of the spigot and the flange face for a flange adaptor

3.17 under pressure tee (UPT)
fitting installed on/around a pipe to create a branch connection usually terminating in a flange outlet

NOTE 1 The fitting, along with other equipment and fittings, facilitates a live connection to the pipe without interruption to the supply flowing through it.

NOTE 2 Mechanical under pressure tees are not generally regarded as suitable for use on PE pipe material due to the visco-elastic properties of the pipe material affecting long-term sealing characteristics.

NOTE 3 Under pressure tees can be classified as Class A and Class B, see Table 1 for more details.

4 Classifications

Couplings, flange adaptors, under pressure tees, fittings for polyethylene pipes and flexible restrained joints shall be classified in accordance with Table 1.

*NOTE Fitting types are defined in Clause **3**.*

Table 1 **Classifications for fitting/joint types**

Classification	Fitting type	Differentiating performance characteristics
Coupling		
	Coupling class A	Minimum shear resistance in newtons (N) that is 50 times the largest pipe nominal diameter (DN) that the fitting is intended to accommodate.
	Coupling class B	Minimum shear resistance in newtons (N) that is 25 times the largest pipe nominal diameter (DN) that the fitting is intended to accommodate.
Flange adaptor		
	Class A	Minimum shear resistance in newtons (N) that is 25 times the largest pipe nominal diameter (DN) that the fitting is intended to accommodate.
	Class B	Minimum shear resistance in newtons (N) that is 12 times the largest pipe nominal diameter (DN) that the fitting is intended to accommodate.
Under pressure tee		
	Class A	Provides full pipe surface contact sealing against the risk of pipe failure.
	Class B	Provides localized pipe surface contact sealing around the outlet.
Joints of fittings for polyethylene pipes		
	Type 1	The end-load resistance of the joint is greater than the strength of the pipe.
	Type 2	The end-load resistance of the joint is greater than the maximum axial forces (see Table B.4) assumed to be acting on the joint.
Flexible restrained joints		
	Type A	The joint gripping mechanism is not energized by or manufactured from materials of time-dependant properties (e.g. plastics or elastomers).
	Type B	The joint gripping mechanism is energized by or manufactured from materials of time-dependant properties (e.g. plastics or elastomers).

*NOTE The manufacturer should be consulted as to the suitability of Type B flexible restraint joints (**3.6**) and restrained joints (**3.15**) as defined in this standard for above ground applications.*

5 Technical requirements

NOTE Fittings that already conform to BS EN standards for pipe couplings should take into account the additional requirements in this British Standard when used for the purposes of repair and connection to existing water supply pipes.

5.1 Fitting design life

Fittings shall be designed for a service life at PFA of at least 50 years.

5.2 Axial movement (withdrawal)

Each flexible non-restrained joint in a coupling or flange adaptor receiving a spigot shall be capable, when pressurized to the allowable operating pressure (PFA), of accommodating a minimum 5 mm of axial movement (withdrawal) without leakage for the service life of the fitting.

5.3 Joint angular deflection

The minimum angular deflection of a flexible joint under all assembly conditions shall be determined by the following ranges of pipe nominal diameters:

- up to and including (uti) DN 450 = 3.0°;
- > DN 450 to DN 600 = 2.5°;
- > DN 600 to DN 750 = 2.0°;
- > DN 750 to DN 1 200 = 1.5°; and
- > DN 1 200 to DN 1 800 = 1.0°.

NOTE This includes joint encapsulation units when installed on pipe joints where deflection has occurred.

The minimum joint angular deflection for repair clamps and class A under pressure tees shall be 0.25° uti pipe nominal diameter DN 200; above this diameter there is no requirement for pipe angular deflection.

5.4 End-load performance of joints of fittings intended for PE pipe materials

The following three types of fittings shall be classified according to their level of end-load performance (see Annex A):

- 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.

NOTE The requirement for Type 1 or Type 2 end-load resistance fittings for a particular application should be assessed by the end user.

5.5 Material characteristics

5.5.1 General

Where non-ferrous materials other than those covered by this British Standard are used in the construction of a fitting, they shall be of at least the same durability under service conditions and shall provide the required service life of the fitting.

All fittings for potable water applications shall ensure the constructional materials, coatings, seals or gaskets coming into contact with potable water present no risk to human health with regard to affecting the quality, appearance, smell or taste.

NOTE Attention is drawn to the following legislation for materials that are in contact with potable water; the Water Fittings Regulations [1], the Water Quality Regulations [2], and Private Water Supplies Regulations [3]. The specific legislation which applies in any circumstance will be dependent on where the fitting is to be used or the source(s) of the water supply. If in doubt contact the local water supplier or Local Authority's private water supply team (usually located within the Environmental Health teams) for advice.

5.5.2 Ductile iron

Ductile iron shall conform to BS EN 1563 or BS EN 545.

5.5.3 Sheet stainless steel

Sheet stainless steel shall conform to BS EN 10088-2 and BS EN ISO 9445.

5.5.4 Mild steel

Mild steel shall conform to BS EN 10025-2.

5.5.5 Fasteners

5.5.5.1 General

Fastener materials shall be either stainless steel or mild steel with corrosion protection.

5.5.5.2 Mild steel

Mild steel fasteners shall conform to BS 4190 (all tensile grades).

5.5.5.3 Stainless steel

Stainless steel fasteners conforming to BS EN ISO 3506-1 shall be protected against galling (seizure) by the selection of appropriate grades of material or applied lubricants.

5.5.6 Gaskets

Gaskets shall be manufactured from materials in accordance with BS EN 681-1:1996, type WA (cold potable water applications).

5.5.7 Coatings

All parts of ferrous components (excluding stainless steel) of fittings shall be protected from corrosion in accordance with BS EN 14901 or WIS 4-52-01/02 [N1] and/or WIS 4-52-03 [N2] as applicable.

NOTE BS EN 14901 might be applicable to components of fittings made from ferrous materials other than ductile iron.

5.5.8 Dimensional requirements for flanged joints

Flanged joints shall be designed such that they can be attached to flanges whose dimensions and tolerances are in accordance with BS EN 1092-2.

NOTE 1 This ensures interconnection between all flanged components (pipes, fittings, valves, etc.) of the same PN and DN, and adequate joint performance.

NOTE 2 Flanges may additionally accommodate connection to other, older flange standards, e.g. BS 10.

5.6 Product information

5.6.1 Marking requirements

All fittings shall be legibly and durably marked, and shall bear at least the following information:

a) manufacturer's name or mark;

b) the year of manufacture;

c) DN and PN rating of flanges where applicable;

d) identification of the minimum and maximum outside pipe diameters over which the product works;

e) reference to this British Standard [1)]; and

f) PFA of the fitting.

Where the fittings are cast, items a) to d) shall be cast on where practicable.

NOTE 1 Items e) and f) may be applied by any method, e.g. painting on the casting or attached to the packaging.

NOTE 2 A durable label fixed to the fitting may also be used where it is impracticable to cast on, or for non-cast products.

5.6.2 Additional information

The following information shall be supplied on or with each product:

- minimum depth of engagement and/or maximum setting gap;
- maximum allowable angular deflection;
- suitability of the coupling or flange adaptor for different pipe materials with either non-restrained or restrained joints;
- need for pipe supporting sleeves/inserts;
- manufacturer's recommended bolt torque; and
- where specified, manufacturers' recommended bolt torque and gasket types for flanged joints.

For fittings intended for use on PE, the following additional information shall be supplied on or with each product:

- joint end-load restraint performance, i.e. Type 1 or Type 2; and
- jointing instructions.

6 Performance requirements for fittings

*COMMENTARY ON CLAUSE **6***

GRP pipe might require special procedures or condition assessment so that fittings can make satisfactory connections to them. Advice on the suitability of fittings for these and any special installation requirements should be obtained from the fitting's manufacturer.

For work on fibre cement pipes, due care and attention should be taken with regards to health and safety. Special procedures or condition assessment might be required so that fittings can make satisfactory connections to them. Advice on the suitability of fittings for these and any special installation requirements should be obtained from the manufacturer.

The maximum and minimum pipe outside diameters and rated working pressure (PFA) for which fittings are designed to operate should be defined by the manufacturer and included in their literature.

Fittings intended for use on existing PE pipes should be designed to take into account the tendency of the pipe outside diameter (OD) to increase with time due to internal pressure.

[1)] Marking BS 8561 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

Performance and test requirements for PE pipe fittings are based upon PE100 pipe material (high-density polyethylene). Fittings meeting these requirements are also suitable for repair and for connection to PE80 pipe material (medium-density polyethylene).

If manufacturers wish to determine compliance with the Regulator's specification and the Water Fittings Regulations [1] relating to below ground fittings, the specification's set different test requirements for the following two tests.

- *Leak tightness under positive pressure (**6.5**), a test pressure of 2 × PFA is applicable.*
- *Leak tightness under negative internal pressure (**6.6**), a test pressure of 0.1 bar absolute is applicable.*

NOTE For further information, the Water Regulations Advisory Scheme (WRAS) should be contacted.

6.1 General

Performance tests shall be carried out in accordance with Table 2 to Table 5 for at least one size in each of the following groupings:

- Pipe materials other than PE:
  - DN 50 to DN 300;
  - > DN 300 to DN 700;
  - > DN 700 to DN 1 200; and
  - > DN 1 200 to DN 1 800.
- PE pipe materials:
  - DN 63 to DN 315;
  - DN 355 to DN 560; and
  - DN 630 to DN 1 000.

NOTE Where joint design is identical for couplings and flange adaptors, flange adaptors may be used as test specimens to determine joint performance in the relevant tests contained in Annex B.

6.2 Test conditions

6.2.1 General

All fittings shall be performance tested under the most unfavourable conditions of tolerance and joint movement in accordance with Table 2 to Table 5. With the exception of restrained joints for PE, the angular deflection shall be the maximum value declared by the manufacturer, but shall be not less than the values given in Table 2.

6.2.2 Annulus

6.2.2.1 General

Fittings where the main body of fitting does not adjust to the pipe diameter shall be performance tested as detailed in Table 2 to Table 5, at the extremes of their component's manufacturing tolerance, as declared by the manufacturer.

6.2.2.2 Maximum annulus

The annular gap between the sealing surface of the fitting and the spigot (including the grooved spigot) shall be equal to the maximum design gap within a tolerance of ±5%.

NOTE 1 This condition is also referred to as bottom tolerance (BT).

NOTE 2 The fitting internal surface and/or the external diameter of the spigot may be machined to achieve the required annulus for the performance test even though the resultant diameters can be outside the manufacturer's declared manufacturing tolerance.

NOTE 3 Any machining of the fitting components should not detrimentally affect the performance/integrity of the fitting when tested.

6.2.2.3 Minimum annulus

The annular gap between the sealing surface of the fitting and the spigot shall be equal to the minimum design gap within a tolerance as below:

a) sizes up to and including DN 600 tolerance of ±0.2 mm;

b) sizes greater than DN 600 tolerance of ±0.5 mm.

NOTE 1 This condition is also referred to as top tolerance (TT).

NOTE 2 The fitting internal surface and/or the external diameter of the spigot may be machined to achieve the required annulus for the performance test even though the resultant diameters can be outside the manufacturer's declared manufacturing tolerance.

NOTE 3 Any machining of the fitting components should not detrimentally affect the performance/integrity of the fitting when tested.

6.2.3 Pipe outside diameter

Fittings where the body of the fitting adjusts to the pipe diameter, e.g. repair clamps and flexible body coupling designs, shall be performance tested at the extremes of the pipe outside diameters for which they are declared by the manufacturer to accommodate.

For test purposes pipe outside diameters shall be manufactured to the declared maximum and minimum outside diameters with the following tolerances as measured using circumference tape:

a) minimum designed pipe diameter minus 0 mm plus 1 mm or minus 0% plus 0.1% whichever is the larger; and

b) maximum designed pipe diameter minus 1 mm plus 0 mm or minus 0.1% plus 0% whichever is the larger.

NOTE These conditions are referred to as TT (top tolerance) largest pipe diameter and BT (bottom tolerance) smallest pipe diameter.

6.2.4 Setting gap and depth of engagement

These parameters shall be determined by the manufacturer and used when tested in accordance with Annex B.

Table 2 **Performance testing of couplings and flange adaptors on pipe materials other than PE**

Performance requirements	Test conditions	Joint types	Test description	Test parameters	Test pipe material	Test pipe size/annulus	Test procedure	
							Coupling	Flange adaptor
Strength and resistance to distortion (**6.4**)	Single pipe/pipe(s) aligned	Flexible non-restrained joints and flexible restrained joints	Strength and distortion of fitting and fasteners	1.5 × manufacturer's recommended maximum bolt torque PFA for 2 h	Steel	Max Annulus (BT)	**B.1**	**B.1**
					Steel	Min Annulus (TT)	**B.1**	**B.1**
			Strength and distortion of connecting flange	1.5 × manufacturer's recommended maximum bolt torque PFA for 2 h	Steel	NA	NA	**B.1**
Initial leak tightness (**6.5**)	Pipe(s) aligned	Flexible non-restrained joints	Short-term hydrostatic test	(1.5 × PFA) + 5 bar for 2 h	Steel (see Note 2)	Max Annulus (BT)	**B.2.2**	**B.2.3**
					Steel (see Note 2)	Min Annulus (TT)	**B.2.2**	**B.2.3**
	Pipe(s) under shear (**6.3**) and withdrawal (**5.2**)	Flexible non-restrained joints	Short-term hydrostatic test	(1.5 × PFA) + 5 bar for 2 h	Steel (see Note 2)	Max Annulus (BT)	**B.2.2**	**B.2.3**
					Steel (see Note 2)	Min Annulus (TT)	**B.2.2**	**B.2.3**
	Pipe(s) under angular deflection (**5.3**)	Flexible non-restrained joints	Short-term hydrostatic test	(1.5 × PFA) + 5 bar for 2 h	Steel (see Note 2)	Max Annulus (BT)	**B.2.2**	**B.2.3**
					Steel (see Note 2)	Min Annulus (TT)	**B.2.2**	**B.2.3**
	Pipe(s) aligned and shear (**6.3**)	Flexible restrained joints (**6.9**)	Short-term hydrostatic test (see Note 1)	(1.5 × PFA) + 5 bar for 2 h	Steel (see Note 2)	Max Annulus (BT)	**B.2.2**	**B.2.3**
					Steel (see Note 2)	Min Annulus (TT)	**B.2.2**	**B.2.3**

Table 2 **Performance testing of couplings and flange adaptors on pipe materials other than PE**

Performance requirements	Test conditions	Joint types	Test description	Test parameters	Test pipe material	Test pipe size/annulus	Test procedure	
							Coupling	Flange adaptor
	Pipe(s) under angular deflection (**5.3**)	Flexible restrained joints (**6.9**)	Short-term hydrostatic test (see Note 1)	(1.5 × PFA) + 5 bar for 2 h	Steel (see Note 2)	Max Annulus (BT)	**B.2.2**	**B.2.3**
					Steel (see Note 2)	Min Annulus (TT)	**B.2.2**	**B.2.3**
					Other pipe materials	Max Annulus (BT) or specified pipe material OD	**B.2.2**	**B.2.3**
Leak tightness under negative internal pressure (**6.6**)	Pipe(s) aligned (no shear loading) with end restraints as required	Flexible non-restrained joints	Vacuum test	0.8 bar negative for 2 h	Steel (see Note 2)	As per pipe material	**B.3**	**B.3**
		Flexible restrained joints	Vacuum test	0.8 bar negative for 2 h	Steel (see Note 2)	As per pipe material	**B.3**	**B.3**
Long-term leak tightness (**6.7**)	Pipe(s) aligned	Flexible joints and flexible restrained joints	Option 1: Pressure/life test	Best fit curve extrapolated to 50 years > (1.2 × PFA)	Steel (see Note 2)	Max Annulus (BT) Min Annulus (TT)	**B.4.2**	**B.4.2**
			Option 2: Bolt-load relaxation	Predicted bolt-load after 50 years > (1.2 × bolt-load at which leakage occurs at PFA)	Steel (see Note 2)	Max Annulus (BT) Min Annulus (TT)	**B.4.3**	**B.4.3**

Table 2 **Performance testing of couplings and flange adaptors on pipe materials other than PE**

Performance requirements	Test conditions	Joint types	Test description	Test parameters	Test pipe material	Test pipe size/annulus	Test procedure	
							Coupling	Flange adaptor
End-load performance (**6.9**)	Pipe(s) aligned no shear loading	Flexible restrained joints Type B (**6.9.1**)	Joint end-load restraint test (see Note 1)	PFA at 60 °C for six months or PFA at 80^{+2}_{-1} °C for 500 h followed by 1.2 × PFA for 2 h	Steel (and other materials specified by the manufacturer (see Note 3)	Max Annulus (BT) or pipe OD for other materials (see Note 4)	**B.7**	**B.7**
		Flexible restrained joints Type A (**6.9.2**)	Joint end-load restraint test (see Note 1)	(1.5 x PFA) + 5 bar for 2 h at 20^{+2}_{-1} °C	Steel (and other materials specified by the manufacturer (see Note 3)	Max Annulus (BT) or pipe OD for other materials (see Note 4)	**B.6**	**B.6**

NOTE 1 No test end restraints.

NOTE 2 Ductile iron may be used where steel is specified at the manufacturer's discretion. For steel and ductile iron test pipes uti DN 600 test pipes should be grooved (see Figure 1).

NOTE 3 All such materials should be tested.

NOTE 4 The pipe OD (outside diameter) should be in accordance with the relevant specification for that pipe material.

Table 3 **Performance testing of repair clamps**

Performance requirements	**Test conditions**	**Test description**	**Test parameters**	**Test pipe material**	**Test pipe size** (**6.2.3**)	**Test procedure for repair clamp (clamps to repair all damage types)**
Strength and resistance to distortion (**6.4**)	Two pipes butted together/aligned	Strength and distortion of fitting and fasteners	1.5 × manufacturer's recommended maximum bolt torque PFA for 2 h	Steel (grooved) (see Note)	BT TT	**B.1**
Initial leak tightness (**6.5**)	Two pipes butted together/deflected (**5.3**)	Short-term hydrostatic test	(1.5 × PFA) + 5 bar for 2 h	Steel (grooved) (see Note)	BT TT	**B.2.2**
Leak tightness under negative internal pressure (**6.6**)	Two pipes butted together/deflected (**5.3**)	Vacuum test	0.8 bar negative for 2 h	Steel (grooved) (see Note)	BT TT	**B.3**
Long-term leak tightness (**6.7**)	Two pipes butted together/deflected (**5.3**)	Option 1) Pressure/life test	Best fit curve extrapolated to 50 years > (1.2 × PFA)	Steel (grooved) (see Note)	BT TT	**B.4.2**
	Two pipes butted together/deflected (**5.3**)	Option 2) Bolt-load relaxation	Predicted bolt-load after 50 years > (1.2 × bolt-load at which leakage occurs at PFA)	Steel (grooved) (see Note)	BT TT	**B.4.3**

NOTE Where steel is specified, ductile iron may be used at the manufacturer's discretion.

Table 4 **Performance testing of under pressure tees (UPT), pipe saddles and joint encapsulation units**

Performance requirements	**Test conditions**	**Test description**	**Test parameters**	**Test pipe material**	**Test pipe size** (see **6.2.2** and **6.2.3**)	**Test procedure**		
						Class A UPT	**Class B UPT and pipe saddles**	**Joint encapsulation unit**
Strength and resistance to distortion (**6.4**)	Two pipes butted together/ aligned	Strength and distortion of fitting and fasteners	1.5 × manufacturer's recommended maximum bolt torque PFA for 2 h	Steel (see Note 1)	BT TT	**B.1**	NA	**B.1**
		Strength and distortion of branch connecting flange	1.5 × manufacturer's recommended maximum bolt torque PFA for 2 h	Steel (see Note 1)	BT TT	**B.1**	NA	NA
	Drilled hole single pipe	Strength and distortion of fitting and fasteners	1.5 × manufacturer's recommended maximum bolt torque PFA for 2 h	Steel (see Note 1)	BT TT	NA	**B.1**	NA
		Strength and distortion of branch connecting flange	1.5 × manufacturer's recommended maximum bolt torque PFA for 2 h	Steel (see Note 1)	BT TT	NA	**B.1**	NA
Initial leak tightness (**6.5**)	Pipes butted together; for deflection details (**5.3** and **B.2.2.2.1**)	Short-term hydrostatic test	(1.5 × PFA) + 5 bar for 2 h	Steel (see Note 1)	BT TT	**B.2.2**	NA	**B.2.2** (no shear load)
	Drilled hole single pipe	Short-term hydrostatic test	(1.5 × PFA) + 5 bar for 2 h	Steel (see Note 1)	BT TT	NA	**B.2.2**	NA

Table 4 **Performance testing of under pressure tees (UPT), pipe saddles and joint encapsulation units**

Performance requirements	**Test conditions**	**Test description**	**Test parameters**	**Test pipe material**	**Test pipe size** (see **6.2.2** and **6.2.3**)	**Test procedure**		
						Class A UPT	**Class B UPT and pipe saddles**	**Joint encapsulation unit**
Leak tightness under negative internal pressure (**6.6**)	Two pipes butted together deflected (**5.3**)	Vacuum test	0.8 bar negative for 2 h	Steel (see Note 1)	BT TT	**B.3**	NA	NA
	Drilled hole single pipe	Vacuum test	0.8 bar negative for 2 h	Steel (see Note 1)	BT TT	NA	**B.3**	NA
	Two pipes butted together/ deflected (**5.3** and **B.2.2.2.1)**	Vacuum test	0.8 bar negative for 2 h	Steel (see Note 1)	BT TT	NA	NA	**B.3**
Long-term leak tightness (**6.7**)	Two pipes butted together deflected (**5.3**)	Option 1) Pressure/life test	Best fit curve extrapolated to 50 years > (1.2 × PFA)	Steel (see Note 1)	BT TT	**B.4.2**	NA	**B.4.2**
	Drilled hole single pipe	Option 1) Pressure/life test	Best fit curve extrapolated to 50 years > (1.2 × PFA)	Steel (see Note 1)	BT TT	NA	**B.4.2**	NA

Table 4 **Performance testing of under pressure tees (UPT), pipe saddles and joint encapsulation units**

Performance requirements	Test conditions	Test description	Test parameters	Test pipe material	Test pipe size (see **6.2.2** and **6.2.3**)	Test procedure		
						Class A UPT	Class B UPT and pipe saddles	Joint encapsulation unit
	Two pipes butted together deflected (**5.3**)	Option 2) Bolt-load relaxation test	Predicted bolt-load after 50 years > (1.2 × bolt-load at which leakage occurs at PFA)	Steel (see Note 1)	BT TT	**B.4.3**	NA	**B.4.3**
	Drilled hole single pipe	Option 2) Bolt-load relaxation test	Predicted bolt-load after 50 years > (1.2 × bolt-load at which leakage occurs at PFA)	Steel (see Note 1)	BT TT	–	**B.4.3**	NA

NOTE 1 Steel uti DN 600, use grooved.

NOTE 2 Where steel is specified, ductile iron may be used at the manufacturer's discretion.

NOTE 3 Where fittings have both fasteners and connecting flanges, the two tests may be run concurrently.

NOTE 4 Where a drilled pipe is specified as the part of the test assembly, the hole drilled should be a minimum diameter of 20 mm.

NOTE 5 References to BT and TT refer to the smallest and largest pipe diameter for which the fitting is intended.

Table 5 **Performance testing of couplings and flange adaptors on PE pipe materials [including barrier pipe]**

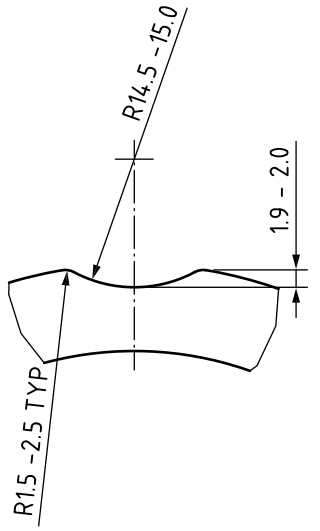
Performance requirements	Joint types/properties	Test description	Test parameters	Test pipe material in accordance with BS EN 12201 Parts 1 and 2	Coupling	Flange adaptor
					Test procedure	
Strength and resistance to distortion (**6.4**)	Restrained joints: structural strength (see Note 3)	Strength and distortion of fitting and fasteners	1.5 × manufacturer's recommended maximum bolt torque PFA for 2 h	PE100	**B.1**	**B.1**
		Strength and distortion of connecting flange	1.5 × manufacturer's recommended maximum bolt torque PFA for 2 h	PE100	NA	**B.1**
Leak tightness under negative internal pressure (**6.8.2**)	Restrained joints	Vacuum test	0.8 bar negative for 2 h	PE100	**B.5.2.4.3**	**B.5.2.4.3**
Short-term hydrostatic under positive internal pressure performance at 20 °C (**6.8.1**)	Restrained joints: short-term leak tightness (see Note 1)	Hydrostatic pressure test	20 °C 1.5 PFA + 5 bar (of pipe or fitting, whichever is lesser) for 2 h	PE100	**B.5.2.4.1**	**B.5.2.4.1**
Long-term relaxation and end-load performance (**5.3** and **6.8.4**)	Restrained joints: long-term leak tightness (see Note 1)	High temperature (80^{+2}_{-1} °C) tensile test followed by: a) hydrostatic / vacuum pressure test at 20 °C; b) pull-out test at 23 °C	Tensile load from Table B.1 or Table B.2 for 500 h at 80 °C	PE100	**B.5.3.3**	**B.5.3.3**
			0.25 bar below atmospheric for 8 h followed by PFA for 8 h at 20^{+2}_{-1} °C	PE100	**B.5.3.3.5**	**B.5.3.3.5**
			Tensile load from Table B.3 or Table B.4 at 23^{+2}_{-1} °C	PE100	**B.5.4**	**B.5.4**

NOTE 1 No test end restraints.

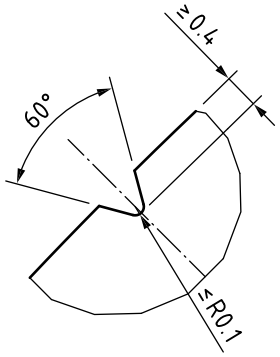
NOTE 2 There are different types of barrier pipe available and each type should be tested with the relevant fitting to determine their performance. See WIS 4-32-19 [4] for the performance of fittings and pipe relative to their resistance to the ingress of ground contaminants.

NOTE 3 Where the forces involved in this test might affect the structural integrity of the PE 100 pipe an alternative material may be used, machined to an equivalent pipe diameter in accordance with BS EN 12201 (Parts 1 and 2).

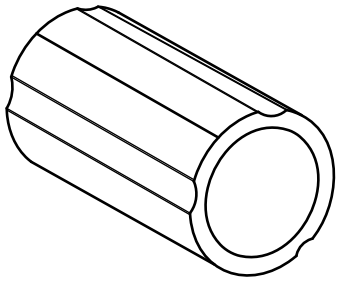
Figure 1 **External profile of grooved steel/ductile pipe: surface defects**



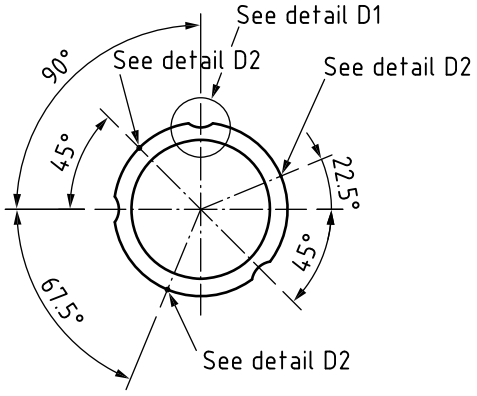
a) Detail D1



b) Detail D2



c) Isometric view of the grooved test pipe section



d) Sectional view showing positions of grooves on pipe surface

The length of the grooved area of the test pipe section shall be such that it extends beyond the fitting(s) it is intended for use with by a minimum of half the depth of engagement for each joint.

Where drilled pipe is required, it shall be a hollow test section with the external profile as per Figure 1; the drilled hole shall coincide with one of the grooves in a).

6.3 Shear strength

6.3.1 Class A flange adaptors/couplings

All Class A fittings shall be performance tested under the following conditions:

a) for flexible restrained joints, maximum setting gap/minimum depth of insertion; or for flexible non-restrained joints, withdrawn 5 mm (**5.2**) to the maximum setting gap/minimum depth insertion; and

b) then with a resultant shear force applied not less than 50 times the DN in newtons, taking into account the weight of the pipe, its contents and the geometry of the test assembly.

6.3.2 Class B flange adaptors/couplings

All Class B fittings shall be performance tested under the following conditions:

a) for flexible restrained joints, maximum setting gap/minimum depth of insertion; or for flexible non-restrained joints, withdrawn 5 mm (**5.2**) to the maximum setting gap/minimum depth insertion; and

b) then with a resultant shear force applied not less than 25 times the DN in newtons, taking into account the weight of the pipe, its contents and the geometry of the test assembly.

6.4 Strength and resistance to distortion

When tested in accordance with **B.1**, all fittings, their joints and fasteners shall withstand an over-tightening of 1.5 × the manufacturer's recommended maximum bolt torques and seal at PFA.

NOTE 1 For UPT/pipe saddle branches, the manufacturer should indicate the safe working loads able to be sustained by the fitting during installation and/or operation. If this information is unavailable then installers should take adequate measures to support equipment/pipes and fittings attached to the outlet.

For flanged joints where the manufacturer requires the use of specific gasket design/material types/grades and associated flange bolt torques, the recommended maximum bolt torques and gasket type shall be used for the strength and resistance to distortion test.

For fitting designs where no manufacturers' recommended bolt toque is stated, e.g. where bolts are tightened to physical stops, the running torque of the fasteners shall be measured at the point just preceding the stops contacting, and the value of 1.25 times that running torque shall be used for the purpose of this requirement and testing in accordance with **B.1**.

Where the manufacturer does not specify any requirements for these flange joints, the test shall be carried out using the bolt torque values in Table 6 and flange gaskets in accordance with **B.1.2.6**. These flanged connections shall withstand an over tightening of their fasteners by applying the torque values provided in Table 6 or 1.5 × the manufacturer's recommended bolts torques. There shall be no structural failure and/or deformation of any component or assembly that results in leakage at the PFA when tested in accordance with **B.1**.

NOTE 2 For flanges that are compatible with a range of flange specifications, e.g. BS EN 1092-1 and BS EN 1092-2, BS 4504 or BS 10, the size DN and rating PN nearest to the BS EN 1092-1 and BS EN 1092-2 flange should form the basis of any test torque values.

Table 6 **Flange bolt torques in Nm (1.5 × nominal torque to seal at the respective flange PN and DN)**

Flange nominal size (DN)	PN 10	PN 16	PN 25
80	105	105	130
100	115	120	190
150	175	180	280
200	195	175	270
250	180	250	375
300	195	270	355
350	190	265	495
400	255	330	655
450	250	325	615
500	255	405	730
600	340	550	1 050
700	345	700	1 195
800	450	945	1 725
900	450	970	1 780
1 000	585	1 255	2 430
1 100	595	1 275	2 485
1 200	745	1 710	2 910
1 400	885	1 950	3 595
1 600	1 150	2 535	4 120

NOTE If flanges are tested outside the diameter or pressure ranges given in this table, manufacturer's recommended values for the fitting application should be used.

6.5 Initial leak tightness test for joints of fittings for pipe materials other than PE under positive internal pressure

6.5.1 Couplings and flange adaptors

Under the test conditions in Table 2, the fitting shall remain leak tight under an internal pressure of (1.5 × PFA) + 5 bar when tested in accordance with **B.2**.

6.5.2 Repair clamps, UPTs, pipe saddles and joint encapsulation units

Under the test conditions in Table 3 and Table 4, the fitting shall remain leak tight under an internal pressure of (1.5 × PFA) + 5 bar when tested in accordance with **B.2**.

6.6 Leak tightness for joints of fittings under negative internal pressure

Under the test conditions in Table 2 to Table 5, the fitting shall remain leak tight under negative internal pressure conditions of 0.8 bar when tested in accordance with **B.3** for joints of fittings for all pipe materials and additionally in accordance with Table 5 and **B.5.2.4.3** for joints of fittings of PE.

6.7 Long-term leak tightness for joints of fittings for pipe materials other than PE

6.7.1 General

The long-term leak tightness test shall be carried out to simulate the service life at PFA of the fitting in accordance with the test methods in either **6.7.2** or **6.7.3**.

6.7.2 Pressure/life test

The predicted working pressure on an assembled joint after a 50-year life shall not be less than 1.2 × PFA of the fitting when tested in accordance with **B.4.2**.

6.7.3 Bolt-load relaxation

The predicted bolt-load on an assembled joint after a 50-year life shall be not less than 1.2 × the bolt-load at which leakage occurs when tested in accordance with **B.4.3**.

6.8 Leak tightness for joints of fittings for PE pipes

6.8.1 Short-term hydrostatic performance at 20 °C

Under the test conditions in Table 5, the fitting shall remain leak tight under positive internal pressure conditions of 1.5 PFA + 5 bar of the pipe or fitting, whichever is the least when tested in accordance with **B.5.2.4.1**.

6.8.2 Leak tightness of joints under negative internal pressure

Under the test conditions in Table 5, the fitting shall remain leak tight under negative internal pressure conditions of 0.8 bar when tested in accordance with **B.5.2.4.3**.

6.8.3 Long-term relaxation and end-load performance of joints of fittings for PE pipes

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

When tested in accordance with **B.5.3**, there shall be:

- no detectable pull-out of the pipe from the fitting. While initial movement of the pipe within the joint is permitted, no further movement shall be allowed after the test load has been reached. The test load shall be maintained for not less than 500 h at 80 °C, or 6 months at 60 °C;
- no leakage nor pipe fracture during:
  - internal pressure of 0.25 bar below atmospheric pressure for 8 h at a temperature of 20^{+2}_{-1} °C (negative internal pressure test); and
  - the test at the maximum rated working pressure of the pipes for 8 h at a temperature of 20^{+2}_{-1} °C.

6.8.4 Pull-out performance

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

After testing in accordance with **B.5.3**, the assembly shall be tested in accordance with **B.5.4**. The pipe shall not pull out from the fitting nor shall it fracture within the jointed assembly. While initial movement of the pipe within the joint is allowed, no further movement shall be allowed after the test load has been reached.

6.9 End-load performance for flexible restrained joints of fittings for pipe materials other than PE

6.9.1 When tested in accordance with **B.6** for Type A joints, at a pressure of 1.5 PFA + 5 bar in a test assembly without end restraints, there shall be no visible signs of leakage from the test assembly or withdrawal of the pipe from the joint during the duration of the test.

6.9.2 When tested in accordance with **B.7** for Type B joints, at a pressure of 1.2 PFA in a test assembly without end restraints, there shall be no visible signs of leakage from the test assembly or withdrawal of the pipe from the joint after pressurization.

NOTE 1 Type A and Type B joints are defined in Table 1.

NOTE 2 This requirement applies to joints made with each pipe material and minimum pipe wall thickness/pressure rating recommended by the manufacturer taking into account the minimum pipe wall thicknesses specified in the product standard. During the test there should be no significant structural deformation of the pipe wall.

Annex A (informative) Fittings for PE100 – Basis for determination of end-loads resistance requirements

A.1 General

Annex A indicates the basis for formulating test criteria to assess the resistance of mechanical fittings to end-loads for repair and connection to existing water supply pipe applications. It contains calculations to determine the end-loads imposed on fittings from those operating conditions that can be predicted. The calculations are for application for PE100 pipe materials of nominal size 90 mm to 1 000 mm.

Examples of the application of the theoretical calculations in **A.3** applied to PE100 pipe conforming to BS EN 12201-2 pipes and fittings have been included to demonstrate the use of the equations.

Annex B contains details of forces for pull-out tests on PE100 for use with the test methods.

A.2 Classifications

Mechanical fittings should be classified into three distinct end-load performance levels. For the purpose of this British Standard, the following definitions apply.

Type 1 fitting: The end-load resistance of the joint is greater than the longitudinal strength of the pipe.

NOTE 1 Type 1 fittings are applicable to polyethylene (PE) pipe only. Such fittings are used on PE pipelines, for example, in areas of mining subsidence and pull-through applications. Pipelines installed using this type of fitting do not normally require anchoring.

Type 2 fitting: The end-load resistance of the joint is greater than the maximum axial forces (see **A.3** to **A.6**) assumed to be acting on the joint.

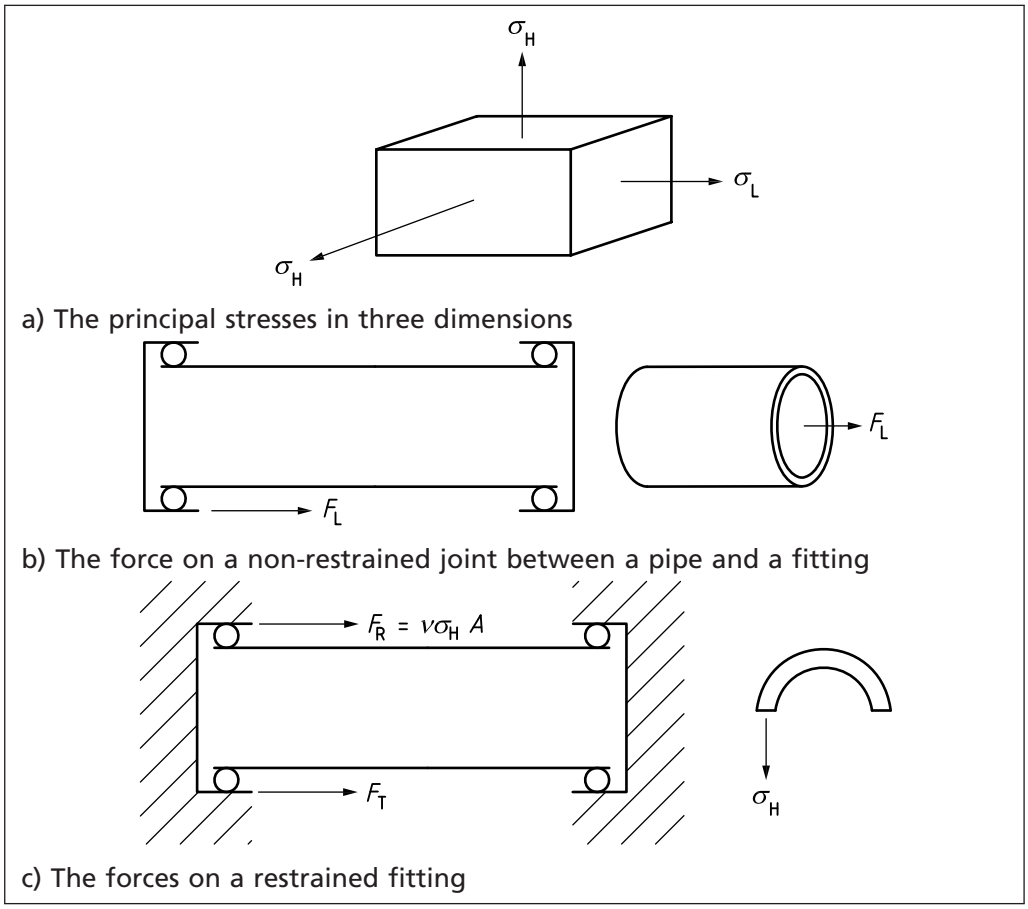
NOTE 2 Pipelines installed using Type 2 fittings do not normally require additional external anchorage.

A.3 Theoretical calculations (Type 2 fittings)

A.3.1 Principal stresses

When under pressure, three principal stresses might exist in the pipe wall: the longitudinal stress (σ_L), the circumferential (or hoop) stress (σ_H) and the radial stress (σ_R) (see Figure A.1).

Figure A.1 **The principal forces exerted on a joint due to positive internal pressure**



It has been assumed that the stresses exerted on the wall of a pressurized pipe can be best modelled by comparison with a thin-walled cylinder due to the hoop and longitudinal stresses being constant over the wall thickness, and the radial stress being small so it can be neglected. However, the use of the mean pipe diameter ($D–t$) in the calculations instead of the internal diameter (d) practically eliminates any error which might arise from this assumption.

Stresses from expansion or contraction of the pipe due to temperature change between installation and testing might be significant and have been included in the calculations.

Other stresses which can be induced in the pipeline in service, but which cannot readily be predicted, e.g. bending, external loading and shear, have not been included in these calculations.

The calculations in **A.3** to **A.6** involve the quantitative assessment of the forces which can separate the fitting from the pipe when a section of pipeline is pressurized.

It has also been assumed that fittings have a sealing element which forms a frictionless seal on the external surface of the pipe and which is fixed to the bore surface of the fitting in question.

NOTE For the sealing arrangements available, this gives a suitably conservative view of the forces that can cause separation of a fitting from the pipe.

A.3.2 Longitudinal forces at the joint due to pressure

A.3.2.1 Non-restrained joint

Where the joint between the fitting and the pipe is non-restrained and, using the assumptions in **A.3.1**, the force that can separate a fitting from a pipe when subjected to internal pressure (p) has a maximum value of F_L [see Figure A.1(b)]:

$$F_L = \frac{p\pi D^2}{4} \qquad (A.1)$$

where:

D is the external diameter of the pipe.

NOTE This might apply to above ground systems and to systems with a free end (e.g. end cap) undergoing a site pressure test.

Figures for end-load testing can be calculated from equation (A.1).

A.3.2.2 Restrained joint

When a section of pipe is pressurized, it can increase in diameter and reduce in length. The relationship between expansion in the hoop direction and contraction in the longitudinal direction is given by Poisson's ratio ν.
For example, an arrangement of a section of pipe between two fixed (encastré) fittings, the longitudinal force at each joint can achieve a maximum of F_R on pressurization due to Poisson's ratio effects.

Assuming that a pipe is represented by a thin-walled cylinder under pressure, the hoop stress acting on the longitudinal cross-section area of the pipe is:

$$\sigma_H = p(D - t)/2t \qquad (A.2)$$

As the pipe ends are restrained, the Poisson's ratio effect induces a longitudinal force at each joint that can separate the pipe from the fitting (F_R) [see Figure A.1(c)]:

$$F_R = \nu\sigma_H A = \nu p(D - t)\frac{A}{2t} \qquad (A.3)$$

where:

ν is Poisson's ratio;

A is annular cross-sectional area of pipe;

$D - t$ is the mean pipe diameter.

A.4 Longitudinal forces at the joint due to temperature effects

If the pipe ends are restrained, an additional force F_T might be induced due to temperature changes between installation and testing tending to separate the pipe from the fitting:

$$F_T = \sigma_T A = \Delta T \,.\, K \,.\, E \,.\, A \qquad (A.4)$$

where:

ΔT is the change in temperature (°C);

K is the coefficient of expansion ($°C^{-1}$);

E is Young's modulus (MPa).

A.5 Maximum longitudinal force on a joint

Based on **A.3.1**, **A.3.2** and **A.4**, the maximum longitudinal force F_{max} that a fitting can be required to withstand is given by:

Non-restrained end caps

$$F_{max} = \frac{p\pi D^2}{4} \qquad (A.5)$$

Restrained end caps

$$F_{max} = F_R + F_T = \nu p \frac{(D - t)A}{2t} + \Delta T \,.\, K \,.\, E \,.\, A \qquad (A.6)$$

For the purposes of type testing, the greatest value of F_{max} should be used to calculate the test forces.

A.6 Example uses of the equations for defining test forces for pipe/fitting assemblies

A.6.1 General

To determine of the end-load resistance of mechanical fittings, a pull-out test may be used. A test demonstrating the application of the theory in **A.3** to **A.6** is given in **B.6.4.3** to the calculation of pull-out forces for such performance tests.

NOTE The pull-out without pressure application represents the worst case. It is used because (a) end-load resistant fittings are expected to hold even when the system is depressurized and (b) dry test conditions are more practical.

A.6.2 PE 100 pipe/fitting assemblies

A.6.2.1 Assumptions

To calculate the maximum end-loads exerted on a fitting from the stresses in a pressurized SDR 11 125 mm PE100 pipe conforming to BS EN 12201 (Parts 1 and 2), the following assumptions should be made:

- maximum working pressure (P_w) = 16 bar;
- maximum site testing pressure (P_s) = 1.5 x P_w = 24 bar;
- maximum temperature variation (ΔT) = 40 °C;
- Poisson's ratio (ν) = 0.38;
- Young's modulus (E at 20 °C) = 712 MPa;
- coefficient of expansion (K) = 1.30 × 10^{-4} $°C^{-1}$;
- external diameter (D) = 125 mm;
- wall thickness (t) = 11.4 mm;
- internal diameter (d) = 102.2 mm.

Yield stress (σ_y) (measured at a strain rate of 125% min^{-1} and 23 °C) = 19 MPa (in accordance with BS EN 12201-1 and BS EN 12201-2).

The strength properties of polyethylene are strain-rate dependent. Where strain-rate dependent properties have been used in the calculations, the test forces should be applied at the equivalent strain rate.

NOTE 1 The maximum temperature variation has been estimated from the maximum recorded UK summer temperatures and the minimum recorded UK ground temperatures (at pipe cover depth).

*NOTE 2 The Young's modulus is defined as that appropriate to the mean of the temperatures used in the calculations in **A.6.2.3** (i.e. 20 °C).*

NOTE 3 Standard dimension ratio (SDR) defines the wall thickness as a proportion of the pipe diameter which determines the pressure rating of the pipe in conjunction with the PE material grade. For more information see BS EN 12201-1 and BS EN 12201-2.

A.6.2.2 Type 1 fittings

The applied pull-out force, F_y, should be equivalent to that which causes yield in a PE100 pipe to conform to the definition in **A.2**.

$$F_y = \sigma_y A \qquad (A.7)$$

where:

σ_y is the yield stress;

A is the pipe wall cross-sectional area.

The test forces for pipe sizes from 90 mm to 1 000 mm have been calculated using the appropriate PE100 dimensions and assuming a yield stress of 19 MPa (see **A.6.2.1** and Table B.3).

A.6.2.3 Type 2 fittings

Type 2 fittings should be capable of withstanding the maximum axial forces assumed to be acting on the joint under normal operating conditions to conform to the definition in **A.2**. To determine the end-load resistance, a Type 2 fitting should be assumed to be subjected to a force equivalent to that induced in a pipeline installed under conditions of maximum temperature change and operated at its site test pressure. Equations (A.8) to (A.12) should be used to determine the appropriate test forces.

From equation (A.1):

$$F_L = \frac{p\pi D^2}{4} \qquad (A.8)$$

$$= \frac{2.4 \times \pi \times 125^2}{4}$$

$$= 29.452\text{kN}$$

From equation (A.3):

$$F_R = \nu p(D - t)A/2t \qquad (A.9)$$

$$= 0.38 \times 2.4 \times \frac{(125 - 11.4) \times \pi}{8 \times 11.4} \times (125^2 - 102.2^2)$$

$$F_R = 18.487\text{kN}$$

$$F_T = \Delta T \,.\, K \,.\, E \,.\, A \qquad (A.10)$$

$$= 40 \times 1.3 \times 10^{-4} \times 712 \times \frac{(125^2 - 102.2^2) \times \pi}{4}$$

$$= 15.063\text{kN}$$

Non-restrained end caps

$$F_{max} = F_L = 29452\text{N} \quad (A.11)$$

Restrained end caps

$$F_{max} = F_R + F_T = 18487 + 15063$$

$$= 33550\text{N} \quad (A.12)$$

As $F_R + F_T > F_L$, F_{max} is assumed to be 33.6 kN.

F_{max} represents the maximum longitudinal force on a fitting joined to a predicted 16 bar rated, 125 mm PE100 pipe restrained at both ends and pressurized to a test pressure of 24 bar.

A Type 2 fitting should be used to maintain resistance to end-loads at least equivalent to F_{max}. For a pull-out test to determine the end-load resistance, the applied pull-out test force F should be that which can be induced by F_{max} plus a safety factor of 25%.

NOTE A margin of safety has been included in the calculations through the use of site test pressures and the maximum value of ⊿T. A small safety factor has been added to allow resistance to be maintained during integrity testing of the pipeline.

Using appropriate values of F_{max}, test forces (F) may be calculated for each remaining combination of pipe size and class. See Table B.4 for all test forces.

Annex B (normative) Test methods

B.1 Strength and resistance to distortion test

B.1.1 Principle

This test determines the structural integrity of the repair fittings and their ability to seal on leaking pipes with a margin of safety by the over tightening of fasteners.

B.1.2 Apparatus

B.1.2.1 *Test assembly*, in accordance with Figure B.1 or Figure B.2 and Table 2 to Table 5, as applicable. For flexible restrained joints, the test assembly, test apparatus and test procedure shall be identical, except that there shall be no end restraint, so that the axial thrust is taken by the restrained joint under the test.

B.1.2.2 *Pressurizing equipment*, in accordance with BS EN ISO 1167-1, capable of delivering the required test pressure.

B.1.2.3 *Pressure measuring device*, in accordance with BS EN ISO 1167-1, with a pressure gauge with an error limit of ±3%.

B.1.2.4 *Torque wrench*, capable of tightening to a value of 1.5 × the manufacturer's recommended maximum bolt torque value.

B.1.2.5 *Test assemblies consisting of sample fitting and steel or PE test pipes on maximum and minimum diameter.*

NOTE See Note 3, Table 5 for PE fittings test pipe(s).

B.1.2.6 *Flange gasket,* in accordance with BS EN 681-1 type WA and with hardness value in the range of 75 international rubber hardness degrees (IRHD) to 85 IRHD or in accordance with manufacturer's recommended material type/grade.

B.1.2.7 *Blank flange,* drilled in accordance with BS EN 1092-1 or BS EN 1092-2 depending on selected material (for use when testing flange adaptors or flange connections).

B.1.2.8 *Steel test pipes*, on maximum and minimum diameter or PE/steel test pipes with diameters in accordance with BS EN 12201 (see Table 5, Note 3).

NOTE A coupling may be tested with test pipes at TT/BT either end to minimize the number of tests required.

B.1.3 Procedure

B.1.3.1 Set up the test assembly.

B.1.3.2 Ensure that the fitting is jointed to the test pipe/flange in accordance with the manufacturer's installation instructions.

B.1.3.3 Tighten each fastener to 1.5 × the manufacturer's recommended maximum bolt torque values or 1.25 times the running torque. Use the appropriate bolt torque in accordance with **6.4**.

B.1.3.4 Apply the hydrostatic test pressure PFA and maintain within ±0.5 bar for at least 2 h.

B.1.3.5 Check for any leaks and/or structural failure of the fitting.

B.1.4 Expression of results

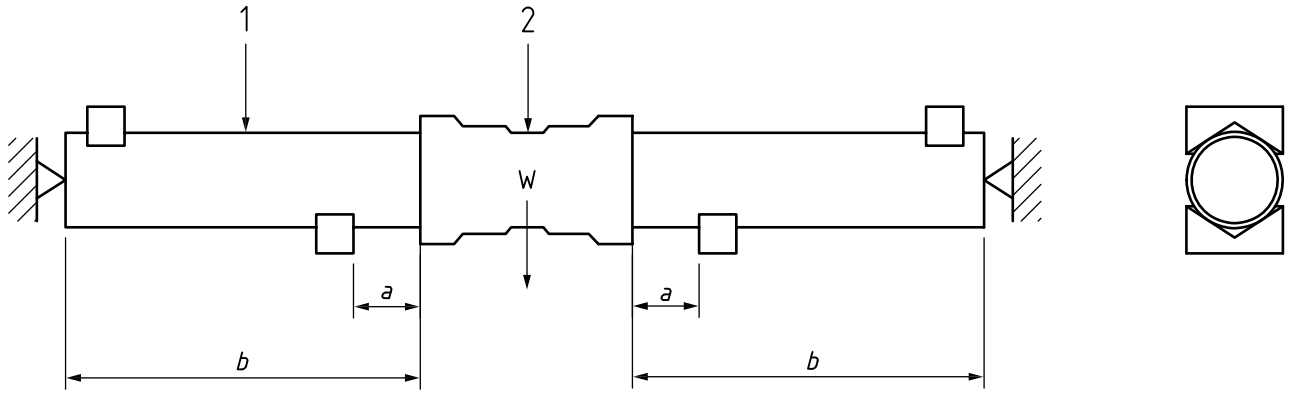
Record the following:

- value of the test pressure;
- torque level applied to the bolts;
- any leakage from the fitting; and
- any structural failure of the fitting.

B.1.5 Test report

The test report shall include the results of the test and any additional factors that might have affected the results of the test.

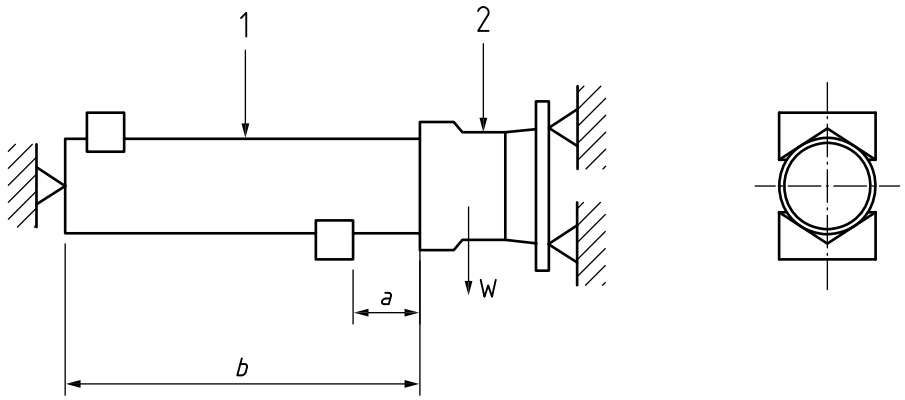
Figure B.1 **Test assembly for all fittings excluding flange adaptors**



Key

1	Pipe section	2	Fitting
a	Distance to support	*b*	Length of pipe section
W	Applied force		

Figure B.2 **Test assembly for flange adaptors**



Key

1 Pipe section
2 Flange adaptor
a Distance to support
b Length of pipe section
W Applied force

B.2 Initial leak tightness test for joints of fittings for pipe materials other than PE under positive internal pressure

B.2.1 Principle

These tests determine the leak tightness of joints to positive internal pressure for fittings excluding flange adaptors (**B.2.2**) and flange adaptors (**B.2.3**) intended for pipe materials other than PE.

B.2.2 Fittings excluding flange adaptors

B.2.2.1 Apparatus

B.2.2.1.1 *Test apparatus*, capable of providing suitable end and lateral restraints whether the joint is in the aligned position, angular deflected or subjected to a shear load. For flexible restrained joints, the test assembly, test apparatus and test procedure shall be identical, except that there shall be no end restraint, so that the axial thrust is taken by the restrained joint under the test.

B.2.2.1.2 *Pressurizing equipment*, in accordance with BS EN ISO 1167-1:2006, **5.4**, capable of delivering the required test pressure.

B.2.2.1.3 *Pressure measuring device*, in accordance with BS EN ISO 1167-1:2006, **5.5**, with a pressure gauge with an error limit of ±3%.

B.2.2.2 Assembly procedure

B.2.2.2.1 Test configurations

Carry out the following tests on assembled joints comprising a fitting and pipe section(s) (see Figure B.1 and Table 2 to Table 4).

Where restrained couplings are intended for use on pipe materials other than steel and ductile iron in the fully aligned condition, test with each additional pipe material and pressure rating for which they are designed.

Where testing the restrained couplings in a test assembly, they shall be without end restraints.

Joint encapsulation units shall be tested with pipe spigots deflected by the amount determined for the DN, see **5.3**.

Fittings shall be tested with pipe spigots deflected by the amount determined for the DN, see **5.3**.

Repair clamps and class A under pressure tees shall be tested with joint angular deflection of 0.25° where appropriate in accordance with **5.3**.

Under pressure tees and pipe saddles shall be tested with outlets suitably sealed.

B.2.2.2.2 Preparation

Support the pipes with V-shaped blocks at an angle of 120°, located at a distance, *a*, of 0.2 × OD in mm from the face of the fitting up to a maximum of 50 mm.

Fill the test assembly with water and suitably vent of air. Do not begin the test before the temperature of the test assembly has stabilized between 10 °C and 25 °C.

NOTE All necessary safety precautions should be taken for the duration of the pressure test.

B.2.2.3 Procedure

B.2.2.3.1 Where specified in Table 2, apply vertical force, *W*, to the fitting.

Apply vertical force, *W*, in accordance with Figure B.1, such that the resultant shear force, *F*, across each of the two joints is equal to the value in **6.3**, taking into account the weight, *M*, of the fitting and its contents:

$W = 2F - M$ where:

W is the vertical force (N);

F is the shear force (N);

M is the weight (N).

B.2.2.3.2 Carry out the tests specified in Table 2 to Table 4 using the same assembly in the appropriate conditions and sequence for the pipe material being tested. Raise the pressure steadily until it reaches the test pressure. Maintain the specified test pressure within ±0.5 bar for at least 2 h, inspecting the joint thoroughly every 15 min.

B.2.2.3.3 Where withdrawal condition is specified in Table 2 to Table 4, the test assembly is pressurized to (1.5 × PFA) + 5 bar and the support frame restraints relaxed to permit the pipe spigot(s) to withdraw from the fitting by 5 mm for each joint. To achieve this withdrawal condition each joint shall be initially assembled with the spigot inserted with an additional 5 mm depth of engagement or reduced setting gap to ensure that the withdrawn condition does not exceed the manufacturer's recommended depth of insertion/setting gap for the joint. At this point the restraint is fixed for the remainder of the test duration.

B.2.2.3.4 Where shear and withdrawal test conditions are specified in Table 2, the withdrawal condition is applied first and maintained, then the vertical force *W* is applied to the fitting.

B.2.3 Flange adaptor

B.2.3.1 Apparatus

B.2.3.1.1 *Test apparatus*, in accordance with Figure B.2.

B.2.3.1.2 *Pressurizing equipment,* in accordance with BS EN ISO 1167-1:2006, **5.4**.

B.2.3.1.3 *Pressure measuring device*, in accordance with BS EN ISO 1167-1:2006, **5.5**, with a pressure gauge with an error limit of ±3%.

B.2.3.2 Assembly procedure

B.2.3.2.1 Test configurations

Carry out the following tests on assembled joints comprising a flange adaptor and pipe section(s) (see Figure B.2 and Table 2 and Table 4).

When testing the restrained flange adaptors, they shall be tested in a test assembly without end restraints.

Where restrained flange adaptors are intended for use on pipe materials other than steel and ductile iron in the fully aligned condition, test with each additional pipe material and pressure rating for which they are designed.

Joints shall be tested with pipe spigots deflected by the amount determined for the DN, see **5.3**.

B.2.3.2.2 Preparation

Prepare the test assembly in accordance with **B.2.2.2.2**.

B.2.3.3 Procedure

B.2.3.3.1 Apply vertical force, *W*, to the flange adaptor such that the resultant shear force, *F*, across the joint is equal to the value specified in **6.3**, taking into account the weight, *M*, of the flange adaptor and of its contents. The test configuration may be altered from that shown in Figure B.2 to facilitate a different point of load application whilst maintaining the equivalent shear load and attitude of the joint.

NOTE For example, the flange of the flange adapter may be fixed, the pipe end may be supported and the shear force applied to the pipe adjacent the flange adapter.

$W = F - M$ where:

W is the vertical force (N);

F is the shear force (N);

M is the weight (N).

B.2.3.3.2 Carry out the tests specified in Table 2 in accordance with **B.2.2.3.2**, **B.2.2.3.3** and **B.2.2.3.4** using the same assembly in the appropriate conditions and sequence.

B.2.4 Test report

The test reports for fittings shall include the results of the test and any additional factors that might have affected the results of the test.

B.3 Leak tightness test for joints of fittings under negative internal pressure for joints of fittings for pipe materials other than PE

B.3.1 Principle

This test determines the leak tightness of joints to negative internal pressure.

B.3.2 Apparatus

B.3.2.1 *Test assembly* conforming to Figure B.1 or Figure B.2, as appropriate, with the pipe section(s) of steel/ductile axially restrained to prevent movement towards the fitting.

B.3.2.2 *Pressurizing equipment*, in accordance with BS EN ISO 1167-1:2006, **5.4**, but using a vacuum pump instead of a pressurizing unit.

B.3.2.3 *Pressure measuring devices*, in accordance with BS EN ISO 1167-1:2006, **5.5**.

B.3.3 Procedure

B.3.3.1 The test assembly shall be empty of water and shall be evacuated to a negative pressure of 0.8 bar (see Table 2) and then isolated from the vacuum pump. Leave the test assembly under vacuum for at least 2 h.

B.3.3.2 Carry out the test using test assemblies in accordance with **B.3.2.1** as appropriate.

B.3.3.3 Carry out the test at a temperature between 10 °C and 25 °C.

B.3.3.4 Do not vary the temperature of the test assembly by more than 10 °C for the duration of the test.

B.3.3.5 Measure and record the pressure within the fitting at the end of the test period with a maximum permitted pressure loss from the test assembly of 0.08 bar.

B.3.4 Test report

The test report shall include the results of the test and any additional factors that might have affected the results of the test.

B.4 Long-term leak tightness test for joints of fittings for pipe materials other than PE

B.4.1 Principle

The leak tightness test determines the useful working life of the fitting for pipe materials other than PE using the pressure/life test (**B.4.2**) or the bolt-load relaxation test (**B.4.3**).

B.4.2 Pressure/life test

B.4.2.1 Principle

This test determines the ability of the bolts to maintain sufficient clamping force, and therefore gasket sealing pressure, over a minimum working life of 50 years for the fitting operating at PFA. The pressure/life test is an alternative to the bolt-load relaxation test (see **B.4.3**) that indicates the useful working life of a fitting. Pressure capability (resistance to leakage at given pressures) is established against time with the target of sealing at 1.2 × PFA at 50 years. The factor of 1.2 is added to account for potential experimental inaccuracies. Tests are carried out at different pressures and for different durations to confirm conformity to pressure sealing capability. The tests measure the time taken for a sample of fittings to fail to seal (leak) at a range of pressures. All tests are undertaken at a temperature of (20 ±2)°.

B.4.2.2 Apparatus

B.4.2.2.1 *Pressurizing equipment*, capable of delivering and maintaining a pressure that exceeds the ultimate capability of the fitting in accordance with BS EN ISO 1167-1:2006, **5.4**.

B.4.2.2.2 *Pressure measuring devices*, in accordance with BS EN ISO 1167-1:2006, **5.5**.

B.4.2.2.3 *Test assemblies,* in accordance with Figure B.1 or Figure B.2, as appropriate, with end restraints.

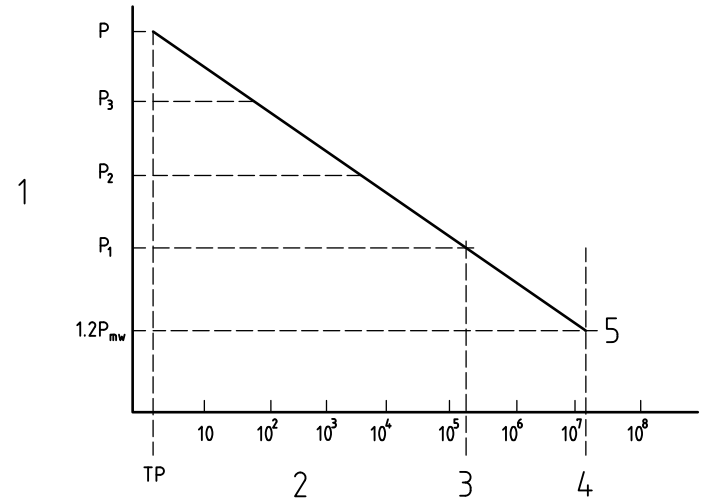
B.4.2.3 Procedure

B.4.2.3.1 Carry out the test on fittings assembled with minimum annulus and maximum annulus joints on aligned test pipes.

B.4.2.3.2 Using three test assemblies for each annulus condition for fittings uti DN 300 mm and two test assemblies for fittings > DN 300 mm, raise the pressure in each assembly at a max rate of 5 bar per min and record the lowest pressure (P) for each group of test assemblies at which leakage occurs.

B.4.2.3.3 Plot the result on a linear/log plot of pressure against time, in min (see Figure B.3). Use two separate graphs, one for each annulus condition.

Figure B.3 **Pressure/life testing graph**



Key

1	Pressure log scale	4	50 years
2	Time to failure (min) – log scale	5	1.2 × PFA
3	Six months		

B.4.2.3.4 Draw a straight regression line on each graph for each annulus result, joining the initial point Tp/P to the 50 year/1.2 × PFA point.

B.4.2.3.5 Determine pressure P1 from the intersection of the straight regression line at six months.

NOTE P1 is the pressure corresponding to six months on the time axis.

B.4.2.3.6 Determine pressures P2 and P3 to give points equidistant on a linear scale between P1 and P.

B.4.2.3.7 For fittings of uti DN 300 mm, if the variation in the pressures at which recorded leakage occurred in the tests according to **B.4.2.3.2** is within 10% (calculated as the overall difference divided by the average of the results), pressurize three test assemblies for each annulus and hold the first assembly at pressure P1, a second assembly at pressure P2 and a third assembly at pressure P3.

If the variation exceeds 10% then nine test assemblies for each annulus shall be pressurized with three at pressure P1, three at pressure P2 and three at pressure P3. Record the time to leakage for each test assembly.

For fittings > DN 300 mm, pressurize two test assemblies and determine the variation in results in accordance with the above.

If the variation in the pressures at which recorded leakage occurred in the tests according to **B.4.2.3.2** is within 10% (calculated as the overall difference divided by the average of the results), pressurize three test assemblies for each annulus and hold the first assembly at pressure P1, a second assembly at pressure P2 and a third assembly at pressure P3. If this variation exceeds 10% utilize a total of six test assemblies for each annulus conditions with two assemblies at pressure P1, two assemblies at pressure P2 and two assemblies at pressure P3.

NOTE The total number of fittings do not necessarily have to be under test simultaneously.

B.4.2.3.8 Plot the results obtained on each graph and, using the shortest failure time for each pressure P1, P2 and P3, determine the best fit curve and extrapolate to 50 years.

B.4.2.3.9 When the best fit curve is extrapolated to 50 years, establish the time at which the curve crosses 1.2 × PFA for both annulus results.

NOTE Where the line crosses 1.2 × PFA, the time should exceed 50 years.

B.4.2.4 Expression of results

Plot times at which leakage occurs at pressures P, P1, P2, P3, as shown in Figure B.3, and generate the best-fit curve to show extrapolation to 1.2 × PFA.

B.4.2.5 Test report

The test report shall include the results of the determination and any additional factors that might have affected the results of the test.

B.4.3 Bolt-load relaxation test

B.4.3.1 Principle

The bolt-load relaxation test carried out at 60 °C or 80 °C determines whether a fitting that relies upon compression of a gasket by tightening bolts to create a seal can achieve a minimum working life of 50 years.

The test procedure can be described in four distinct determinations, see **B.4.3.4** to **B.4.3.7**.

*NOTE The criteria for this test are based on the assumption that the bolt-load relaxation curve is modified using the 20 °C slope determined by **B.4.3.4**. However, if the bolt-load relaxation curve measured at 60 °C exceeds the requirement of **6.7.3** without modification by **B.4.3.4**, this modification may be omitted.*

B.4.3.2 Apparatus

B.4.3.2.1 *Test assembly*, in accordance with Figure B.1 or Figure B.2.

B.4.3.2.2 *Pressurizing equipment*, in accordance with BS EN ISO 1167-1:2006, **5.4**.

B.4.3.2.3 *Pressurizing measurement devices*, in accordance with BS EN ISO 1167-1:2006, **5.5**.

B.4.3.2.4 *Strain gauge*.

B.4.3.2.5 *Torque wrench*.

B.4.3.3 Conditioning

Condition the test assembly for type tests and test at 20 °C, unless otherwise specified. Control the temperature to $^{+2}_{-1}$ °C. Condition the test assembly in air or water for not less than 12 h for fittings of wall thickness up to and including 12.7 mm, or not less than 24 h for fittings of wall thickness over 12.7 mm. Control the test pressure to $^{+1}_{0}$ bar or +10% of the test pressure (whichever is the greater).

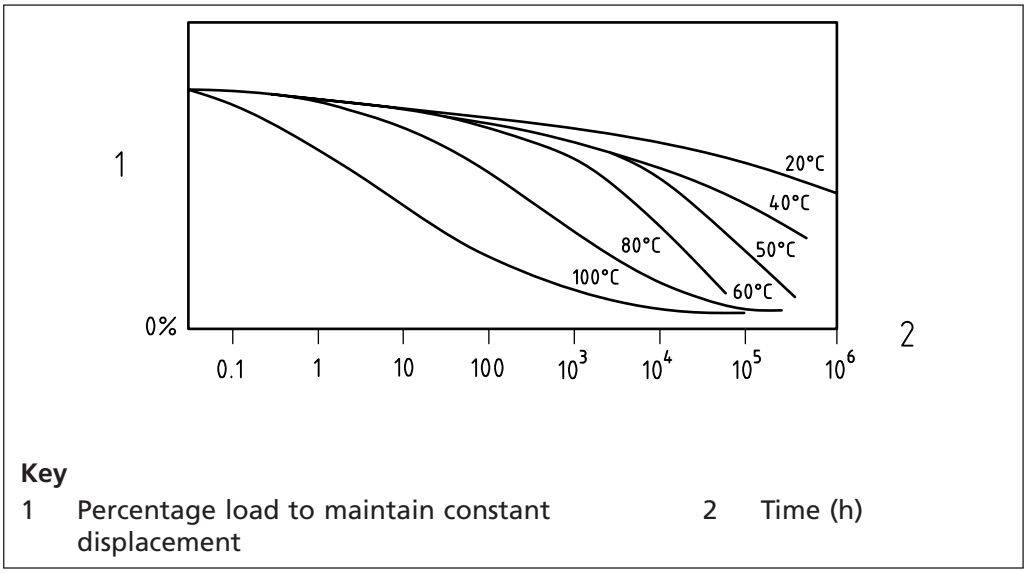
B.4.3.4 Determination of elastomeric stress relaxation behaviour

B.4.3.4.1 Procedure

B.4.3.4.1.1 Determine the experimental relationship between stress relaxation and time at 20 °C, 40 °C, 60 °C, 80 °C and 100 °C for the elastomeric seal material in accordance with BS ISO 3384.

B.4.3.4.1.2 For each temperature, plot the percentage load to maintain a constant displacement of elastomer (strain) against log time (see Figure B.4).

Figure B.4 **Stress relaxation curves at a range of temperatures**



Key

1 Percentage load to maintain constant displacement

2 Time (h)

B.4.3.4.1.3 For the value of the shift factor ("f"):

- determine the slope of the best straight line before the onset of chemical degradation (as indicated by a knee in the curve) for the 20 °C plot;
- draw a straight line tangential to the curve of the 20 °C plot after chemical degradation has begun;
- determine the log (time) at the intersection of the two straight lines and record the log (time) as "t20";
- repeat the above sequence for all other temperature plots and record the log times as "t40", etc.;
- plot the log times "t20", etc. against temperature; and
- draw the best straight line through the plots and determine the number of log decades of time between the intersection of the line and the temperatures 60 °C and 20 °C; and record the time value as "f".

NOTE 1 If the 20 °C plot does not exhibit a knee in the curve at the expiry of the test time, determine "f" by extrapolation of the higher temperature results or, if it results in a higher value of "f", by assuming that the "t20" is at the expiry of the test.

NOTE 2 If a knee is not established at any temperature (as can occur with peroxide-cured ethylene propylene diene monomer) assume that "f" = 0.

B.4.3.5 Determination of minimum bolt-load to seal

B.4.3.5.1 Preparation

Assemble the fitting on grooved steel/ductile pipe, in accordance with Figure B.1 and manufacturer's instructions. Hold at a constant temperature in accordance with **B.4.3.3**.

Where the fitting contains four or fewer bolts, fit each with a minimum of two strain gauges or load cells placed diametrically opposite on the bolt.

Where a fitting contains more than four bolts, fit the additional bolts, up to a total of eight, with a minimum of two strain gauges or load cells placed diametrically opposite on the bolt (or one strain gauge along the centre axis of the bolt) and uniformly spaced around the fitting.

B.4.3.5.2 Procedure

Determine the bolt-load (F1) at which leakage starts on a minimum of five samples as follows:

- tighten the bolts to the manufacturer's recommended maximum bolt torque and apply the test pressure of 1.2 × PFA; and
- progressively loosen the bolts by equal turns on each bolt until leakage occurs.

B.4.3.5.3 Expression of results

Record the average bolt-load as a percentage of the bolt-load at the manufacturer's recommended bolt torque.

NOTE F1 is the 95% Upper Confidence Limit (UCL) of the five average bolt-loads (expressed as a percentage) recorded at the point of leakage.

B.4.3.6 Determination of bolt-load relaxation curve

B.4.3.6.1 Preparation

Assemble the fitting on grooved steel/ductile pipe, in accordance with Figure B.1 or Figure B.2 and the manufacturer's instructions.

Where the fitting contains four or fewer bolts, fit each with a minimum of two strain gauges or load cells placed diametrically opposite on the bolt.

Where a fitting contains more than four bolts, fit the additional bolts, up to a total of eight, with a minimum of two strain gauges or load cells placed diametrically opposite on the bolt (or one strain gauge along the centre axis of the bolt) and uniformly spaced around the fitting.

B.4.3.6.2 Conditioning

Condition the assembly in air or water in accordance with **B.4.3.3** at a constant temperature of 60 °C.

B.4.3.6.3 Procedure

B.4.3.6.3.1 Tighten the bolts to the manufacturer's recommended bolt torque and apply a pressure of PFA.

B.4.3.6.3.2 Maintain a constant temperature of (60 ±2) °C throughout the test.

B.4.3.6.4 Expression of results

Record the bolt-loads (Fm) over a period of six months.

Record a minimum of two results per logarithmic decade of time.

B.4.3.7 Determination of initial slope

B.4.3.7.1 Preparation

Assemble the fitting on grooved steel/ductile pipe, in accordance with Figure B.1 and the manufacturer's instructions. Hold at a constant temperature of 20^{+2}_{-1} °C in accordance with **B.4.3.3**.

Strain gauge the fitting in accordance with **B.4.3.5.1**.

B.4.3.7.2 Procedure

Tighten the bolts to the manufacturer's recommended bolt torque and apply a pressure of PFA.

B.4.3.7.3 Expression of results

Record the bolt-loads over a period of up to six months as set out in **B.4.3.6.4**.

The following procedure for the analysis of the results is to predict the 50-year performance at 20 °C from the experimental curve. Plot the experimental values of Fm as a percentage of the originally applied bolt-load taken at time t = 0.1 h (for each gauged bolt) against $\log_{10}$ time. Plot a best fit curve from these results.

NOTE 1 While the analysis of the data and experimental curve fitting should be done mathematically, e.g. by fitting the data to a binomial or polynomial curve as appropriate. Fitting of the experimental curve to the data by eye is acceptable.

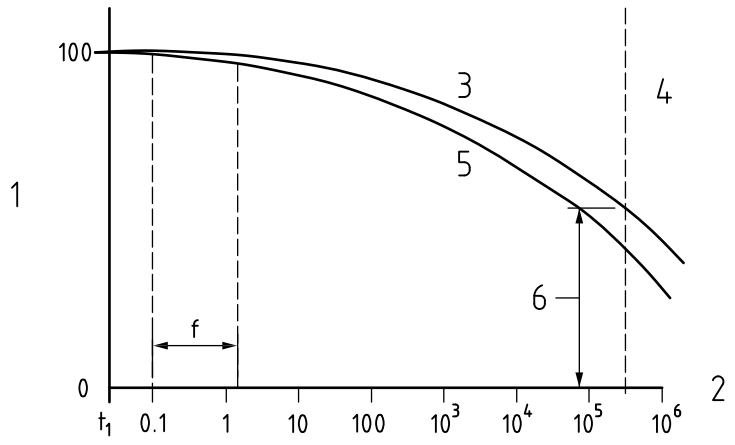
From the point t = 0.1 h, shift the curve horizontally by the shift factor "f". The resultant plot is the predicted 20 °C behaviour of the joint (see Figure B.5).

If the initial slope at 20 °C has been determined in accordance with **B.4.3.4.1.3**, the results of this determination can be superimposed on the above resultant plot to give the modified predicted 20 °C curve.

By extrapolation of the predicted 20 °C curve, the remaining bolt-load relaxation at 50 years can be read from the final graph.

NOTE 2 The value "1.2" is a factor of safety.

Figure B.5 **Predicted 20 °C bolt-load relaxation curve**



Key

1	Bolt-load relaxation (%)	4	50 years
2	Time (h)	5	Experimental 60 °C
3	Predicted 20 °C curve	6	≥ 1.2 × F1

Inspect the assembly for any signs of deterioration. Where a gasket shows evidence of cracking, splitting or shear failure, abandon the test, record the result and repeat the test.

B.4.3.7.4 Test report

The test report shall include:

- full identification of the specimens;
- description of pipe/fitting assembly;
- test conditions;

- observations and results of test;
- date of the test; and
- characteristics of the seal material conforming to BS EN 681-1.

B.5 Tests for leak tightness, long-term relaxation and end restraint for joints of fittings for PE pipes

B.5.1 Principle

These tests determine the leak tightness under positive and negative internal pressure and the resistance to end-load.

B.5.2 Hydrostatic pressure test

B.5.2.1 Apparatus

B.5.2.1.1 *Test apparatus*, in accordance with BS EN ISO 1167-1:2006, Clause **5**.

B.5.2.1.2 *Pipe sections*, in accordance with BS EN 12201-1 and BS EN 12201-2.

B.5.2.2 Preparation

NOTE For hydrostatic performance at 20 °C, more than one fitting may be tested at a time.

Assemble the fitting on polyethylene pipe conforming to BS EN 12201, in accordance with the manufacturer's instructions and conditioned in accordance with **B.5.2.3**.

Use Type A end caps to test Type 1 fittings.

Use Type B end caps to test Type 2 fittings.

Use a free length of pipe, between any two fittings or a fitting and an end cap, of not less than 3 × the nominal size of the fitting for test pieces of nominal size up to and including DN 315 and a minimum of 1 m for sizes greater than nominal size DN 315.

For type testing, evaluate three assemblies at each test level.

If the pipe fails within a distance of less than 0.1 *l* (where *l* is the free length of pipe between fittings or between fitting and end cap) from the mouth of the fitting, abandon the test, record the result and evaluate a new test piece.

B.5.2.3 Conditioning

Before the test, keep the fittings at 20^{+2}_{-1} °C in air for not less than 12 h for fittings of wall thickness up to and including 12.7 mm, or not less than 24 h for fittings of wall thickness over 12.7 mm unless otherwise specified.

For hydrostatic tests involving liquid immersion, keep the specimens in the liquid at the test temperature for not less than 24 h.

B.5.2.4 Procedure

B.5.2.4.1 Positive internal pressure test

B.5.2.4.1.1 Perform the test in accordance with BS EN ISO 1167-1.

B.5.2.4.1.2 For each of the pipe pressure ratings for which the fitting is designed, test the assemblies at 1.5 PFA + 5 bar (for the pipe pressure rating) for 2 h.

B.5.2.4.2 Expression of results

Determine and record any axial movement of the pipe within the joint at the end of the test. Record the test pressures and times to failure in accordance with **6.8.1**.

B.5.2.4.3 Negative internal pressure test

B.5.2.4.3.1 Perform the test in accordance with BS EN ISO 1167-1:2006, but use a vacuum pump instead of a pressurizing unit. When the test pressure is reached, an isolation valve closes to isolate the test piece from the pump.

B.5.2.4.3.2 Continue the test for 2 h. If the pressure has not changed from the initial value by more than 0.08 bar, the test is deemed successful. If it does change, abandon the test and record the result.

B.5.2.5 Expression of results

Record the test pressures and times to failure in accordance with **6.8.2**.

B.5.2.6 Test report

The test report shall include:

- type of test (internal or negative internal pressure);
- full identification of the test piece;
- type of end fitting used;
- test temperature;
- circumferential stress or pressure;
- test result and, in the case of premature failure, the time to rupture; and
- reference to this British Standard [2)].

B.5.3 Long-term relaxation and end-load test

B.5.3.1 Apparatus

B.5.3.1.1 *Test apparatus*, in accordance with BS EN ISO 1167-1:2006, Clause **5**.

B.5.3.2 Preparation

Assemble the fitting with PE pipe conforming to BS EN 12201 in accordance with the manufacturer's instructions.

Use a free length of pipe between any two fittings, or between a fitting and the end-loading grips, of 3 × the nominal size (up to nominal size DN 315) and a minimum of 1 m for sizes greater than nominal size DN 315.

B.5.3.3 Procedure

B.5.3.3.1 Mount the test assembly in a jig capable of applying a constant tensile axial load.

B.5.3.3.2 Hold the fitting in such a way that distortion or support of any of the fitting components does not occur.

B.5.3.3.3 Suspend the test piece in a water bath at 80^{+2}_{-1} °C for a minimum of 500 h or 60^{+2}_{-1} °C for a minimum of 6 months with an axial load in accordance with Table B.1 for Type 1 fittings and Table B.2 for Type 2 fittings.

[2)] Marking BS 8561 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

Table B.1 **Pull-out test force at 80/60 °C for Type 1 fittings for PE100 pipe**

Nominal size (DN)	Test force (kN)				
	SDR 11	SDR 17	SDR 17.6	SDR 26	SDR 33
90	9	6	6	N/A	N/A
110	14	9	9	N/A	N/A
125	18	12	11	N/A	N/A
160	29	19	19	13	N/A
180	37	25	24	16	N/A
225	58	38	37	26	N/A
250	71	48	46	32	N/A
280	89	60	58	40	N/A
315	112	75	73	50	N/A
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	572	383	370	255	206
800	726	486	469	323	261
900	919	616	593	411	331
1 000	1 135	760	733	507	407

Table B.2 **Pull-out test force at 80/60 °C for Type 2 fittings for PE100 pipe**

Nominal size (DN)	Test force (kN)				
	SDR 11	SDR 17	SDR 17.6	SDR 26	SDR 33
90	4	3	3	N/A	N/A
110	6	4	4	N/A	N/A
125	8	5	5	N/A	N/A
160	13	8	8	6	N/A
180	16	11	10	7	N/A
225	25	17	16	11	N/A
250	31	21	20	14	N/A
280	39	26	25	17	N/A
315	49	33	32	22	N/A
355	62	42	40	28	22
400	79	53	51	35	28
450	100	67	64	45	36
500	123	83	80	55	44
560	155	104	100	69	55
630	196	131	126	88	70
710	249	167	160	111	88
800	316	212	204	141	112
900	400	268	258	179	142
1 000	493	331	318	221	175

B.5.3.3.4 After 500 h or 6 months (according to temperature) disconnect the assembly from the test rig and allow to cool to ambient temperature.

B.5.3.3.5 Apply the following tests in accordance with **B.5.2**:

- test at an internal pressure of 0.25 bar below atmospheric pressure for 8 h at a temperature of 20^{+2}_{-1} °C (negative internal pressure test); and
- test at the maximum rated working pressure of the pipes for 8 h at a temperature of 20^{+2}_{-1} °C.

B.5.3.4 Test report

The test report shall include:

- date of the test;
- identification of the test piece;
- type of fitting tested (Type 1 or Type 2);
- evidence of leakage, weepage and fracture of the pipe during the 500 h test; and
- conformity with the pressure tests in **B.5.3.3.5**.

B.5.4 Pull-out test at 23 °C

B.5.4.1 Apparatus

B.5.4.1.1 *Test apparatus*, in accordance with BS EN ISO 1167-1:2006, Clause **5**. The apparatus shall be capable of applying a tensile axial load, as given in Table B.3 or Table B.4 as appropriate, at a cross head speed of not less than 25 mm/min.

B.5.4.2 Preparation

Using the test assembly that has been subjected to the tests in **B.5.3.3**, ensure a free length of pipe between the fitting under test and the end-loading grips as specified in **B.5.2.2**.

The fitting is deemed to pass if the minimum load in Table B.3 for Type 1 fittings and Table B.4 for Type 2 fittings is exceeded without pull-out. If fracture of the pipe occurs, abandon the test, record the result and repeat on a new assembly. If the pipe yields at a distance greater than 0.1 *l* from the mouth of the socket or loading grip (**B.5.2.2**), the fitting is deemed to have satisfied the requirements of this test.

B.5.4.3 Procedure

B.5.4.3.1 Insert plain metal plugs in the end of the PE pipe(s) to support the pipe(s) under the action of the loading grips.

B.5.4.3.2 Alternatively, assemble mechanical fitting(s), not under test, on the end of the PE pipe(s).

B.5.4.3.3 Do not apply loading grips to the fitting body under test.

B.5.4.3.4 Carry out the test at a temperature of (23 ±2) °C.

B.5.4.3.5 Apply a tensile axial load to the fitting under test at a cross head speed of (25 ±1) mm/min until the maximum load is clearly defined.

Table B.3 **Pull-out test force at 23 °C for Type 1 fittings for PE100 pipe**

Nominal size (DN)	Test force (kN)				
	SDR 11	SDR 17	SDR 17.6	SDR 26	SDR 33
90	40	27	26	N/A	N/A
110	60	40	39	N/A	N/A
125	77	52	50	N/A	N/A
160	127	85	82	57	N/A
180	160	107	103	71	N/A
225	250	167	162	111	N/A
250	308	207	200	138	N/A
280	386	259	251	172	N/A
315	489	328	317	219	N/A
355	622	416	402	277	224
400	790	529	511	351	285
450	1 001	669	649	444	359
500	1 234	826	797	548	443
560	1 544	1 036	1 000	688	557
630	1 956	1 312	1 266	872	704
710	2 487	1 666	1 607	1 109	896
800	3 157	2 115	2 041	1 405	1 134
900	3 995	2 677	2 580	1 787	1 437
1 000	4 933	3 305	3 187	2 204	1 771

Table B.4 **Pull-out test force at 23 °C for Type 2 fittings for PE100 pipe**

Nominal size (DN)	Test force (kN)				
	SDR 11	SDR 17	SDR 17.6	SDR 26	SDR 33
90	17	12	11	N/A	N/A
110	26	17	17	N/A	N/A
125	34	22	22	N/A	N/A
160	55	37	36	25	N/A
180	70	47	45	31	N/A
225	109	73	70	49	N/A
250	134	90	87	60	N/A
280	168	113	109	75	N/A
315	213	143	138	95	N/A
355	270	181	175	121	96
400	343	230	223	154	122
450	435	291	292	194	154
500	536	359	348	240	191
560	672	451	436	301	239
630	851	570	552	381	303
710	1 081	724	701	484	385
800	1 373	920	890	614	488
900	1 738	1 164	1 127	778	618
1 000	2 145	1 437	1 391	960	763

B.5.4.4 Test report

The test report shall include:

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

B.6 End-load performance test for Type A flexible restrained joints of fittings for pipe materials other than PE

B.6.1 Principal

This test determines the ability of the joints of Type A fittings to resist end-loads without the need to account for materials with time-dependant properties (**6.9.1**).

B.6.2 Apparatus

B.6.2.1 *Test apparatus*, in accordance with Figure B.1 for a fitting other than a flange adaptor.

B.6.2.2 *Test apparatus*, in accordance with Figure B.2 for a flange adaptor.

B.6.3 Procedure

B.6.3.1 Pressurize the test assembly to 1.5 × PFA + 5 bar.

B.6.3.2 Maintain the pressure for a minimum period of 2 h.

B.6.4 Expression of results

Record the following;

- condition time and temperature;
- test duration, pressures and temperature;
- any leakage; and
- any pull-out of the test pipe section(s) from any joint of the fitting.

B.6.5 Test report

The test report shall include the results of the test and any additional factors that might have affected the results of the test.

B.7 End-load performance test for Type B flexible restrained joints of fittings for pipe materials other than PE

B.7.1 Principal

This test determines the ability of the joints of the fitting to resist end-load for the design life where the gripping mechanism is energized by or manufactured from materials of time-dependant properties, see **6.9.2**.

B.7.2 Apparatus

B.7.2.1 *Test apparatus*, in accordance with Figure B.1 for a fitting other than a flange adaptor.

B.7.2.2 *Test apparatus*, in accordance with Figure B.2 for a flange adaptor.

B.7.3 Conditioning

Condition the assembly in accordance with **B.5.2.3** at a constant temperature of 60 °C.

B.7.4 Procedure

B.7.4.1 Assemble the fitting and tighten the bolts in accordance with the manufacturer's installation instructions, and apply and maintain a pressure of PFA.

B.7.4.2 At the manufacturer's discretion, maintain a constant temperature of 60^{+2}_{-1} °C throughout the test duration of six months or 80^{+2}_{-1} °C for the test duration of 500 h.

B.7.4.3 Upon completion of **B.7.4.2** increase the pressure to 1.2 × PFA for a period of 2 h.

B.7.5 Expression of results

Record the following:

- condition time and temperature;
- test duration, pressures and temperature;
- any leakage; and
- any pull-out of the test pipe section(s) from any joint of the fitting.

B.7.6 Test report

The test report shall include the results of the test and any additional factors that might have affected the results of the test.

Bibliography

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[4] WIS 4-32-19, *Polyethylene pressure pipe systems with an aluminium barrier layer for potable water supply in contaminated land – size 25 mm to 630 mm*. London: Water UK, 2007.

Further reading

BS 8558, *Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages – Complementary guidance to BS EN 806*

BS EN 805, *Water supply – Requirements for systems and components outside buildings*

BS EN 1333, *Flanges and their joints – Pipework components – Definition and selection of PN*

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