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# WATER INDUSTRY SPECIFICATION

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**WIS 4-35-01**

July 2000: Issue 1

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ISSN 1353-2510

Reprinted June 2006  
for web publication

UK Water Industry

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## SPECIFICATION FOR THERMOPLASTICS STRUCTURED WALL PIPES, JOINTS AND COUPLERS WITH A SMOOTH BORE FOR GRAVITY SEWERS FOR THE SIZE RANGE 150-900 INCLUSIVE

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### FOREWORD

This specification has been prepared by the "Steering Group for Structured Wall Gravity Sewer and Drainage" under the direction of Water UK in consultation with the Water Industry, the British Plastics Federation Pipes Group and WRc plc.

It gives the material and testing requirements for structured wall pipes, couplers and joints made from thermoplastics materials suitable for the construction of gravity sewers. These are currently defined as Poly(Vinyl Chloride) (PVC-U), Polypropylene (PP), and Polyethylene (PE).

It specifies the minimum requirements for pipeline design but does not give detailed dimensions relating to individual products. Because of permitted variations in geometric details, conformity to this standard does not ensure interchangeability of pipes, and other components from different manufacturers and / or different designs.

For pipes greater than 500, lower long-term stiffness classes than quoted in 6.15 are permitted but structural soil calculations must be carried out for every installation and the installation technique modified to suit the results of that calculation.

General requirements and pipe diameters addressed in this standard have been based on the TC 165 document BS EN 476 "General requirements for components used in discharge pipes, drains and sewers for gravity systems".

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

Reference to a British Standard, Water Industry Specification or any other specification applies equally to any equivalent specification.

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

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

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

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

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This reprint has been prepared by the UK Water Industry and published by WRc plc.

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## 1. SCOPE

This Specification specifies the materials, performance and test requirements for thermoplastics structured wall pipe and joints having a smooth bore for gravity sewers in nominal sizes of 150 to 900.

It covers pipes jointed using separate moulded or formed couplers, formed integral sockets and factory-fitted moulded couplers forming sockets which are an integral part of the supplied pipe.

## 2. DEFINITIONS

For the purposes of this standard, the definitions given in BS ISO 472, BS EN 476, and BS 3502: Part 1: 1991 apply. In addition the following definitions apply.

### 2.1 Pipes

**2.1.1 Thermoplastics structured wall pipes:** products which have an optimised design with regard to material usage to achieve the relevant performance requirements.

### 2.2 Geometrical definitions

**2.2.1 Nominal size DN:** a numerical designation of size of a component, which is a convenient round number approximately equal to the manufacturing dimension in millimetres. This can apply to the internal diameter (DN/ID) or external diameter (DN/OD).

### 2.3 Material definitions

**2.3.1 Virgin material:** material in form such as granules or powder that has not been subjected to use or reprocessing other than that required for their manufacture and to which no reprocessable or recyclable materials have been added.

**2.3.2 Own rework material:** material from rejected unused pipes and fittings, including trimmings from the production of pipes and fittings, that will be reprocessed in the manufacturer's plant after having been previously processed by the same manufacturer by a process such as moulding or extrusion and for which the complete formulation is known.

**2.3.3 External rework material:** material comprising either one of the following:

a) material from rejected unused pipes or fittings, or trimmings therefrom that had been originally processed by another manufacturer;

b) material from the production of unused products other than pipes and fittings regardless of where they had been manufactured.

**2.3.4 Recyclable material:** material comprising either one of the following:

a) material from used pipes or fittings which has been cleaned and crushed or ground and possibly recompounded;

b) material from used products other than pipes or fittings which has been cleaned and crushed or ground and possibly recompounded.

## 2.4 Structural definitions

### 2.4.1 Intermediate layer

The layer sandwiched between solid skins produced by a multi-extrusion process.

## 3. MATERIALS

3.1 The material shall be one of the following, Poly(Vinyl Chloride) (PVC-U), Polypropylene (PP) or Polyethylene (PE) to which are added those additives that are needed to facilitate the manufacture of pipes and couplers conforming to this standard.

3.2 The material shall be virgin as defined in 2.3.1 or manufacturer's own clean rework material as defined in 2.3.2. Rework shall only be incorporated in products of the same base polymer.

3.3 It is permissible in multi-layer pipes for external rework material as defined in clause 2.3.3, recyclable material as defined in 2.3.4, and/or additional mineral fillers and/or foaming agents be used for the manufacture of the intermediate layer. Both the external and internal layers must only incorporate materials complying with 3.2 of this standard.

Any external rework material and recyclable material shall comply with the relevant requirements of prEN 13476-1.

3.4 Elastomeric sealing rings shall comply with the requirements of BS EN 681-1, type WC. The sealing ring shall have no detrimental effects on the properties of the pipe or of the other components that will cause the assembly to fail the performance requirements of this standard.

## 4. DIMENSIONS

### 4.1 Nominal sizes of pipes

The preferred nominal sizes of the pipes are given in Table 1. Other sizes agreed between manufacturers and users are permitted.

Products manufactured to specific sizes shall conform to the corresponding inside diameter limits and mean diameters.

**Table 1 - Preferred Nominal Pipe Sizes**

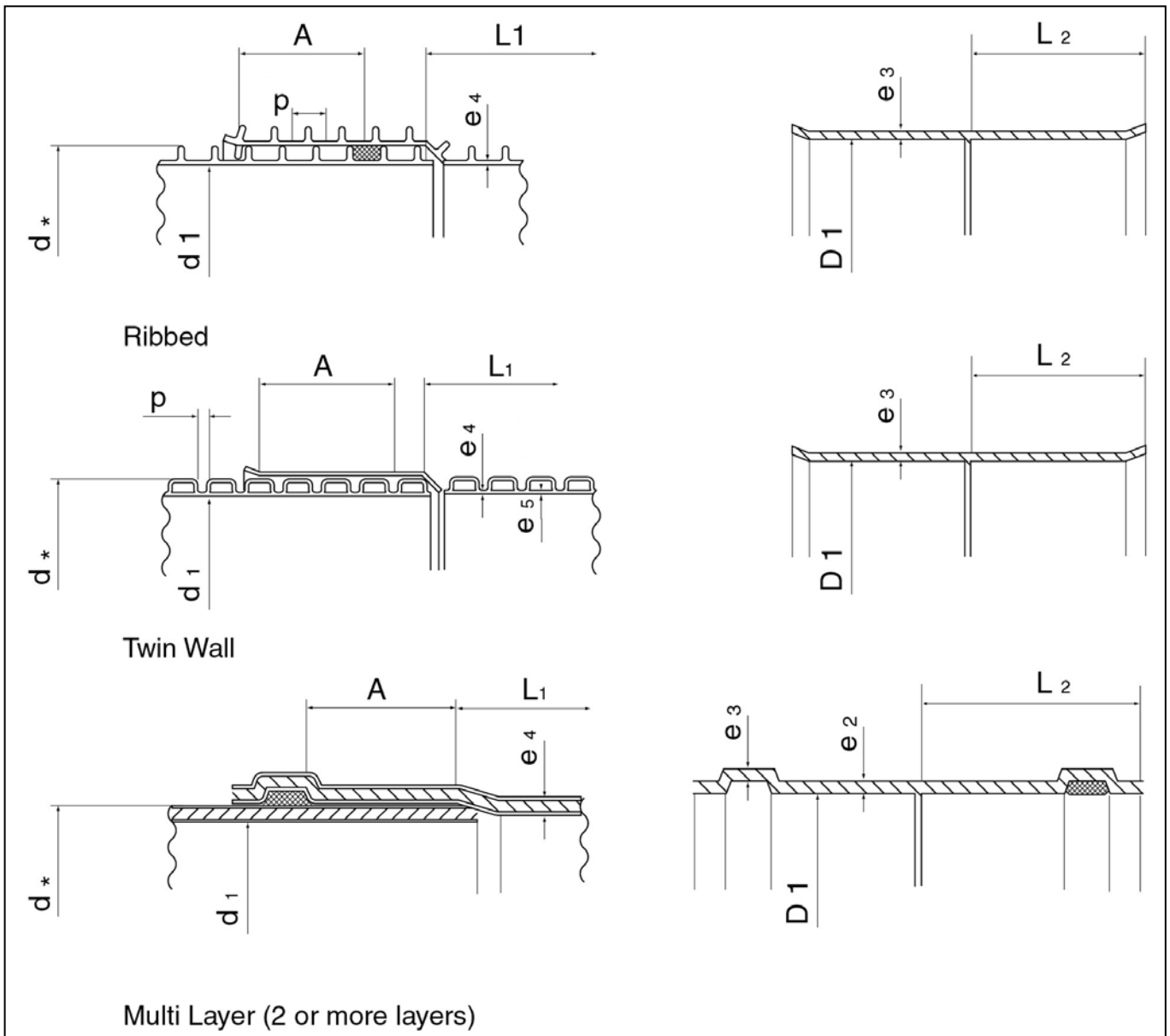
Nominal Size DN/ID	Minimum mean inside diameter $d_{i \min}$ (mm)	Maximum mean inside diameter $d_{i \max}$ (mm)	Minimum I.D. at any point (mm)	Maximum I.D. at any point (mm)
150	145	155	140	160
180	175	185	170	190
200	195	205	190	210
225	220	230	215	235
250	245	255	240	260
300	294	306	288	312
355	348	362	341	369
375	368	382	360	390
400	392	408	384	416
450	441	459	432	468
500	490	510	480	520
600	585	615	574	624
750	735	765	720	780
800	785	815	768	832
900	882	918	864	936

Note: The above table has been derived from EN 476.

### 4.2 Other dimensions

The manufacturer shall specify all the dimensions shown in the following Figures 1a, 1b and 1c as appropriate to the pipe profile.

<b>A</b>	length of engagement of the sealing point.
<b><math>d_i</math></b>	mean inside diameter
<b><math>D_{i, \min}</math></b>	minimum mean inside diameter
<b><math>e_4</math></b>	thickness of pipe wall
<b><math>L_{1 \min}</math></b>	effective length of pipe
<b><math>d_e</math></b>	mean outside diameter
<b><math>L_2</math></b>	overall socket depth of couplers
<b><math>e_5</math></b>	min thickness of internal wall of twin wall pipe
<b>p</b>	distance between ribs or corrugations
<b><math>e_2</math></b>	minimum thickness of socket wall
<b><math>e_3</math></b>	minimum wall thickness in ring seal housing



**Figure 1 - Typical examples of structured wall pipe and couplers**

#### 4.3 Effective length

The lengths of pipe shall be not less than that specified by the manufacturer when measured to the point shown in Figure 1. The preferred lengths are 3m and 6m.

#### 4.4 Ends of the pipes

The ends of the pipes shall be cut cleanly and square to the axis of the pipe or within the cut zone recommended by the manufacturer.

## 5. APPEARANCE

### 5.1 Surface

The internal surface of the pipe shall be clean and free from defects which might impair performance in service.

### 5.2 Colour

The colour of the outside of pipes and couplers shall be brown in the range 06D45 to 06D43 of BS4901:1976 or black darker than 10B29 of BS4901:1976.

## 6. PERFORMANCE TESTS

### 6.1 General Requirements

The requirements of this section shall be met before compliance with this specification can be claimed. If there is a change in design, in material and/or in the production method other than routine in-process adjustments and extensions to the product range it will be necessary to demonstrate that the requirements of this specification are still satisfied.

The type tests as listed in Table 2 shall be carried out on samples from each diameter in the manufacturer's product range unless specified otherwise in this specification. In addition, quality control tests (marked as 'Q') shall be carried out at a frequency defined in the manufacturer's quality plan.

**Table 2 - Test requirements applicable for different construction materials**

Test	Clause	Material of Construction		
		PVC-U	PP	PE
Ring flexibility	6.2	√	√	√
Leaktightness of seals - distortion	6.3	√	√	√
Leaktightness of seals - deflection	6.4	√	√	√
Long term strength and heat resistance (BLT)	6.5	√	√	√
Long term ring stiffness	6.6	√	√	√
Vicat softening temperature	6.7	√	-	-
Stress rupture	6.8	√	√	√
Internal puncture	6.9	√	√	√
Water jetting	6.10	√	√	√
Longitudinal bending	6.11	√	√	√
Heat test	6.12	Q	√	√
Stress relief of injection moulded couplers	6.13	Q	√	√
Impact	6.14	Q	Q	Q
Short term ring stiffness	6.15	Q	Q	Q

### 6.2 Ring Flexibility

When tested in accordance with BS EN 1446, the deflection shall be equal to 30% of the outside diameter ( $d_o$ ) or 90 mm which ever is the smaller.

Measurements shall be made at the following points:

- Position of the mould part lines at 12 and 6 o'clock under the loading plate.
- Position of the mould part lines at 3 and 9 o'clock (90°) under the loading plate.
- Position of the mould part lines at 1.30 and 7.30 o'clock (45°) under the loading plate.

*NOTE: For diameters  $\geq 300$  mm, the ribs or corrugation can be supported by a rubber pad shaped to the outside profile of the pipe. The rubber should extend no more than 6 mm above the maximum OD of the pipe.*

Where appropriate there shall be no signs of:

- decrease in the test load;
- cracking in any part of the wall structure;
- wall delamination except possible delamination between outside and inside wall of double wall pipes occurring in reduced welding zone in the ends of the test piece. For helically formed pipes, tears initiated at the cut end of a rib shall not be considered as a failure;
- other types of rupture in the test piece.
- permanent buckling of the inner wall in any direction.

(30 ± 3) minutes after removal of the load, the minimum inside radius of curvature of the pipe inner wall shall be at least 80 % of the original mean inside radius;

### 6.3 Leaktightness of elastomeric sealing ring joints under distortion

When tested in accordance with BS EN 1277 method 4, the following conditions shall be applied to the assembled joint.

- spigot deflection :  $\geq 10\%$
- socket deflection :  $\geq 5\%$
- with an overall difference :  $\geq 5\%$

The joint shall meet the following requirements without showing signs of leakage:

- an internal pressure of 0.05 bar for a minimum of 15 mins (for the lower pressure test);
- an internal pressure of 0.5 bar for a minimum of 15 mins (for the higher pressure test);

- 3) a negative pressure of 0.3 bar for a minimum of 15 mins and shall not have changed by more than 0.03 bar at the end of the test period.

#### 6.4 Leaktightness of elastomeric sealing ring joints under angular deflection

When tested in accordance with BS EN 1277 method 4, and using the angular deflections specified in 3.3.3 of that standard the joint shall meet the following requirements:

- 1) an internal pressure of 0.05 bar for a minimum of 15 mins (for the lower pressure test);
- 2) an internal pressure of 0.5 bar for a minimum of 15 mins (for the higher pressure test);
- 3) a negative internal pressure of 0.3 bar for a minimum of 15 mins and shall not have changed by more than 0.03 bar at the end of the test period.

#### 6.5 Resistance to combined temperature cycling and external load

The resistance of 150DN to 375DN pipe to combined temperature cycling and external loading shall be tested in accordance with the Box Loading Test (BLT) described in Appendix A.

*NOTE: Reference to this Appendix should be replaced by EN1437 when published.*

When testing pipes at least one socket or coupling shall be included.

The requirements are as follows:

- a) the maximum vertical deformation as measured with the load still applied shall not exceed 5% of the original diameter;
- b) the test assembly shall show no visible leakage either during the test or when subjected to a hydrostatic pressure of 0.5bar for 5mins after completion of the cycles and with the load still applied;
- c) there shall be no visible cracking;
- d) when tested for straightness in the axial direction the distance between the rule and the pipe wall shall not have increased by more than 3 mm;
- e) the radius at the bottom of the pipe shall be not less than 80% of the original radius if the failure mode is heart-shaped.

#### 6.6 Creep ratio

When tested in accordance with BS EN ISO 9967 the creep ratio shall be not more than that given in Table 3.

**Table 3 – Creep ratio**

Material	Creep Ratio
PVC-U	≤ 2.5
PE/PP	≤ 4

#### 6.7 Vicat Softening Temperature

When tested by the method described in BS EN 727, the Vicat softening temperature of test pieces taken from PVC-U pipes or couplers shall be not less than 79°C.

#### 6.8 Resistance to internal pressure

Note: This test is intended to assess the materials used in production of the pipe.

When tested in accordance with the method described in BS EN 921, the sample shall meet the requirements of Table 4. Using the lowest measured value of  $e_4$  determine the internal pressure using the formula :

$$P = \frac{20 \cdot \sigma \cdot e_4}{d_i + e_4}$$

Where :

- $\sigma$  = circumferential stress introduced (MPa)
- P = internal water pressure in the pipe (bar)
- $d_i$  = mean inside diameter of the pipe (m)
- $e_4$  = minimum wall thickness of the pipe (see Figure 1) (m)

*NOTE : This test may be carried out in the form of a conventional solid wall pipe made from the skin material.*

**Table 4 - Internal pressure test requirements**

Material	Circumferential Stress (MPa)	Minimum test time (h)	Test temperature (°C)
PVC-U	10.0	1000	60
PP	3.6	1000	80
PE	2.8	1000	80

## 6.9 Resistance to internal puncture

Note: This test is intended to assess the toughness/general robustness of the internal wall of the product.

The test shall be carried out on a 150 DN pipe (or the pipe within the product range with the minimum internal wall thickness).

When tested in accordance with Appendix B, the pipe shall be capable of withstanding without damage (as defined in Appendix B) a minimum impact energy equivalent to 250 g from a 1m drop height (2.45 Joules).

## 6.10 Resistance to water jetting (only required for diameters $\leq$ DN300)

When tested in accordance with Appendix C of this specification, the pipe shall withstand a jetting pressure of 180 bar without damage as defined below (Notes A).

Note A: Damage is defined as penetration through:

- the wall of the pipe for solid wall pipe and multi layer pipe where all the layers are of solid construction;
- the inside wall for twin wall pipe. Penetration through the first inside layer of multi layer pipe where the intermediate layer is of foam or hollow construction.

NOTE B: Small diameters are generally unblocked using high pressure/low volume jetting machines. These can lead to high forces on the pipe wall.

## 6.11 Longitudinal bending

When tested in accordance with Appendix D of this specification, the pipe shall not sag by more than 5% of the overall length of the pipe.

The pipe shall be deemed to have failed if :

- (a) The difference in dimensions when measured in the vertical axis is greater than 5% of the pipe length;
- (b) If during the test the pipe incurs local permanent deformation.

## 6.12 Heat Test

When tested in accordance with ISO 12091 or BS EN 742 as appropriate for 30 minutes, PVC-U pipes at  $(150 \pm 2)^\circ\text{C}$ , PP pipes at  $(120 \pm 2)^\circ\text{C}$  and PE pipes at  $(110 \pm 2)^\circ\text{C}$  using test pieces  $(300 \pm 10)$  mm long shall conform to the following:

- a) there shall be no cracking on the internal or external surfaces;
- b) when sectioned into quarters along the axis of the pipe there shall be no delamination.

When testing pipes made from more than one material the lowest test temperature appropriate to those materials shall be used.

## 6.13 Stress Relief of Injection Moulded Couplers

When tested in accordance with BS 2782: Method 1103A for 30 minutes PVCU couplers at  $(150 \pm 2)^\circ\text{C}$ , PP couplers at  $(120 \pm 2)^\circ\text{C}$  and PE couplers at  $(110 \pm 2)^\circ\text{C}$  shall satisfy the following requirements as applicable:

- a) moulded couplers shall show no weld line splitting (see note);
- b) for couplers with one or more injection points, the depth of crack penetration in the area of the injection point(s) shall be not greater than 50% of the wall thickness at the point of injection;
- c) for couplers with an interior ring gate, the depth of crack penetration in the area of the ring gate shall be no greater than 50% of the wall thickness at the point of measurement;
- d) for couplers with an end ring gate, the depth of crack penetration shall be not greater than 25% of the socket depth.

*NOTE: Weld lines may become more pronounced and exhibit localised sinking, but this does not constitute failure if it is not accompanied by splitting.*

## 6.14 Impact Resistance

The impact strength of pipe shall be determined in accordance with BS EN 1411 using the values given in Table 5. The test shall be started at a falling height of 1.0m.

The impact strength B50 shall not be less than 1m.

**Table 5 - Mass of the tup**

Nominal Size (DN/ID)	Mass of the tup (kg)
150	7.50
180	9.00
≥ 225	12.50

**6.15 Nominal Short Term Ring Stiffness**

When tested in accordance with BS EN ISO 9969 : 1995, the nominal short term ring stiffness shall not be less than :-

- a) the given nominal value in Table 6, or
- b) the creep as obtained in 6.6 of this standard multiplied by the appropriate 2 year stiffness in Table 6

whichever is the greater.

**Table 6 - Stiffness Classes**

Nominal short term stiffness (kN/m <sup>2</sup> )	2 year stiffness (kN/m <sup>2</sup> )
8	4
4	2

**7. TEST CONDITIONS**

**7.1 Test Conditions**

Unless otherwise specified the tests shall be conducted at a standard laboratory temperature of (23 ± 5)°C.

**7.2 Conditioning During Type Testing or in cases of disagreement**

In the case of tests in air, test pieces shall be conditioned prior to test by being kept at (23 ± 2)°C in air, for not less than 12 hours for pipes of wall thickness up to and including 12.7 mm, or not less than 24 hours for pipes of wall thickness greater than 12.7 mm, unless otherwise specified.

**8. MARKING**

**8.1 Pipes**

Each length of pipe shall be indelibly and legibly marked with the following:

- a) the manufacturer's name / identification;
- b) the number of this specification, i.e. WIS No. 4-35-01;
- c) the nominal size;
- d) short term nominal stiffness class (Table 6);
- e) material i.e. PVC-U, PE, PP;
- f) if the pipe is any colour other than brown, the word SEWER.
- g) identification of the shift, production line and date of manufacture; (Coding of this information is permitted provided that the meaning of the code is available to purchasers or their representatives on request);
- h) a third party certification scheme mark, where appropriate.

**8.2 Marking of Loose Couplers**

Each coupler shall be indelibly and legibly marked with the following:

- a) the manufacturer's name/identification;
- b) the number of this specification, i.e. WIS No. 4-35-01;
- c) the nominal size;
- d) material i.e. PVC-U, PE, PP;
- e) a third party certification scheme mark. Where appropriate.

**9. REFERENCES**

British Standards	
BS 812	Testing aggregates. Part 2: Physical properties
BS 882	Aggregates from natural sources for concrete.
BS 3502	Part 1: 1991: Schedule for symbols for plastics.
BS 2782	Methods for testing plastics
	Method 1103A & B: Stress relief test for injection moulded fittings: oven method. (Dual numbered BS EN 763).
BS 4901 : 1976	Plastics colours for building purposes
BS 4962	Plastics pipes and fittings for use as subsoil field drains.

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European Standards	
BS EN ISO 9969	Determination of ring stiffness
BS EN ISO 9967	Determination of the creep ratio.
BS EN 295-3	Vitrified clay pipes and fittings and pipe joints for drains and sewers. Part 3: Test Methods.
BS EN 476	General requirements for components used in discharge pipes, drains and sewers for gravity systems.
BS EN 681-1	Elastomeric seals - materials requirements for pipe joint seals used in water and drainage applications. Part 1: Vulcanized rubber.
BS EN 727	Determination of the Vicat softening temperature
BS EN 743	Plastics piping and ducting systems. Thermoplastics pipes. Determination of the longitudinal reversion.
BS EN 921	Plastic piping systems: Thermoplastics pipes: Determination of resistance to internal pressure at constant temperature.
BS EN 1277	Determination for leaktightness of elastomeric sealing ring type joints for buried thermoplastics non-pressure piping systems. (Dual numbered BS 2782: Part 11: Methods 1112L, M, N, & Q).
BS EN 1295	Structural design of buried pipelines under various conditions of loading. General requirements.

BS EN 1411	Determination of resistance to external blows by the staircase method
BS EN 1446	Determination of ring flexibility.
prEN 1437 (Method 1111B)	Test method for resistance to combined temperature cycling and external loading (BLT). As modified by the BBA / BPF agreed method.

prEN 13476-1	Thermoplastics piping systems for non-pressure underground drainage and sewerage. Structured-wall piping systems of uPVC, PP, PE. Part 1: Specification for pipes, fittings and systems.
<b>Other</b>	
BS ISO 472 :1988	Plastics Vocabulary.
ISO/TR. 10358:1983	Unplasticized poly(vinyl chloride ) pipes and fittings- Chemical resistance with respect to fluids.
ISO TR 7474	Polyethylene (PE) pipes and fittings – Chemical resistance with respect to fluids
ISO TR TR 7471	Polypropylene (PP) pipes and fittings - Chemical resistance with respect to fluids
ISO 12091	Structured wall thermoplastics pipes : Oven test.

## EXPLANATION OF CALCULATION FOR LIMIT OF NOMINAL SHORT TERM RING STIFFNESS

### Clause 6.15 of WIS 4-35-01 – Calculation of the stiffness class of a pipe

The stiffness class is calculated from the short-term stiffness of the pipe.

The short-term ring stiffness must > 2 year stiffness value from Table 6 x creep ratio.

Hence for a stiffness class 8 pipe made of PE:

The creep ratio must not exceed 4 (Table 3 of WIS 4-35-01)

The 2 year stiffness value is 4 (Table 6 of WIS 4-35-01)

Hence the actual measured short term ring stiffness must be  $> 4 \times 4 \text{ kN/m}^2 = 16 \text{ kN/m}^2$

If the creep ratio is less than the limit, say 3, the measured short term ring stiffness must be  $> 12 \text{ kN/m}^2$ .

## APPENDIX A – RESISTANCE TO COMBINED TEMPERATURE CYCLING AND EXTERNAL LOAD

### A.1 Apparatus

A.1.1 A steel box capable of accommodating a test assembly of pipe and coupler so that alternate discharges of hot and cold water can pass through the assembly whilst it is subjected to a constant force acting through the gravel.

The box shall have a width of 900 to 1000 mm and shall have smooth vertical sides, with a minimum length of at least 1.2 m and be at least 1m deep. It shall be so constructed that after loading the sides or base of the box shall at no time deflect by more than 1.5 mm after loading.

The pipe shall run into and out of the box through sealed apertures which should impose minimum restraint on the assembly.

A.1.2 Loading device capable of applying at least 50 kN and generating a test load within a period of 1 to 2 minutes and of maintaining the load to within  $\pm 1$  kN throughout the period of the test and subsequent measurements.

A.1.3 A  $(450 \pm 1)$  mm x  $(300 \pm 1)$  mm flat steel plate of minimum thickness 25 mm with the 450 mm dimension being parallel to the long side of the box.

A.1.4 Gravel having the following characteristics:

- a) 10 mm single sized aggregate to BS 882;
- b) the uncompacted bulk density shall not be less than 90% of the compacted bulk density when measured in accordance with BS 812 : Part 2 : 1975;
- c) the particles shall be at least 50% angular / irregular, and at least 25% rounded in accordance with Table 2 and Figure 2 of BS 812 : 1967. Their surface texture shall be glassy or smooth in accordance with Table 3 of BS 812 : 1967.

A.1.5 A thermocouple with an accuracy of  $\pm 1^\circ\text{C}$  capable of determining the external temperature of the crown of the pipe within the gravel.

A.1.6 A rubber faced tamping tool having a 300 mm square foot and a total weight of  $(10 \pm 0.5)$  kg. The rubber shall be at least 25 mm thick and nominally 60 IRHD.

A.1.7 A bore micrometer or equivalent capable of an accuracy of  $\pm 0.05$  mm.

A.1.8 A system capable of producing water at the volumes and temperatures as required by the procedures of this test.

A.1.9 A straight edge of length 1.5 x outside diameter ( $\pm 10$  mm).

A.1.10 A rigid steel cylinder of diameter 0.8 x the original inside pipe diameter to be used as a gauge.

### A.2 Test Specimen

An assembly of two pipes with a central coupler of sufficient length to pass through the box along its long axis so as to allow connections to be made externally to the box.

### A.3 Procedure

#### A.3.1 Preparation

Pipes and coupler shall be conditioned in accordance with clause 7.

For the 150 mm size only, the width of the box shall be reduced to  $(700 \pm 20)$  mm. This may be accomplished by lining the sides of the box with bricks and a plywood facing.

#### A.3.2 Installation

A bed of gravel shall be laid in the base of the box with a fall inlet to outlet between 1:100 and 1:75. It shall be between 90 mm and 110 mm deep measured below the centre line of the loading plate after compaction.

A compaction procedure, of 75 blows of the compaction tool evenly spaced on the surface of the gravel when dropped from a height of  $(450 \pm 50)$  mm, shall be used.

The test assembly shall be placed on the gravel with the pipe ends passing through the sealed apertures with any coupler directly under the loading plate. The assembly shall be at the same gradient from inlet to outlet as the gravel bed along its entire length and that there are no voids under the pipe or coupler.

The thermocouple shall be fixed to the crown of the pipe, inside the box adjacent to the water inlet (within 100 to 150 mm from the inner face of the box ). The thermocouple shall be attached using a heat sink transfer compound and shall be additionally taped to the specimen.

### A.3.3 Backfilling

The box shall be filled in the following stages:

- a) to 100 mm above the crown of the pipe, minimising voids below the pipe, ensuring it is fully supported and compact as described in A.3.2;
- b) thereafter in two approximately equal layers to achieve the required depth of gravel between 0.6 to 0.65 m cover over the crown of the assembly.

The gravel shall be compacted as described in A.3.2 at each stage above.

### A.3.4 Loading

The minimum vertical internal diameter,  $d_1$  of the assembly shall be located and measured.

The rigid plate shall be lowered onto the surface of the gravel and an initial vertical load of  $(5 \pm 0.5)$  kN applied. The face of the plate shall be level and the four corners shall be measured as datum points.

The full load of  $(50 \pm 1)$  kN shall be applied steadily within a period of 1 to 2 minutes. If the plate sinks more than 20 mm from any of the datum points, the load shall be removed and the test restarted. In cases of dispute, the box shall be emptied and refilled before repeating the test. If the plate sinks into the gravel by more than 50 mm during the test, then the test shall be aborted.

### A.3.5 Temperature cycling on 150 mm pipe

The test assembly shall be subjected to the following testing schedule during which time it shall be monitored for leaks:

- a)  $(35 \pm 3)$  litres of water shall be passed through the assembly over a period of 90 to 95 seconds. The water temperature shall be  $(85 \pm 2)$  °C measured at the point of inlet to the assembly.

*[Note: After 20 cycles, the crown of the pipe should achieve a minimum of 30°C during the hot cycle. If necessary the ventilation through the pipe can be controlled at any time throughout the test to ensure that this requirement is achieved and maintained.]*

- b) rest and drain for a period of 60 to 70 seconds;
- c) at least 30 litres of water not exceeding 22°C (supplemented if desired by an air blast at ambient temperature) for a period sufficient to reduce the crown temperature of the test specimen to below 30°C;

*[Note: The cooling discharge should be introduced through a pipe of suitably small diameter positioned in the bore within the specimen and having perforations along its upper part so that the water is directed onto the upper surface of the assembly.]*

- d) rest and drain the assembly for a period sufficient to allow the assembly to be emptied;
- e) the whole test procedure (A.3.5 a) - d)) shall be repeated 2500 times the temperature and load shall be continually monitored throughout the test. If during the test, the water temperature drops below 83°C or the load below the minimum for a number of cycles then an equal number of cycles shall be added to the test schedule. If during the test the water temperature increases above 87°C or the load exceeds the maximum the test may be discontinued at the discretion of the manufacturer.

### A.3.6 High temperature on 180 mm to 375 mm pipe

When loaded in accordance with A.3.4, the test assembly shall be subjected to a continuous discharge of hot water for a period of 192 hours. The water temperature shall be  $(50 \pm 2)$ °C measured at the outlet.

### A.3.7 Assessment of deflection

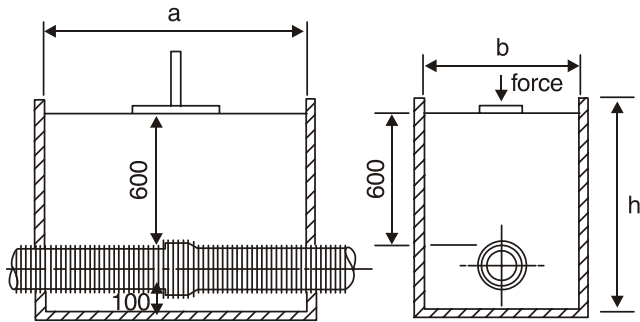
Upon completion of A.3.5 or A.3.6 above and prior to removing the force on the plate, the minimum vertical internal diameter of the assembly  $d_2$  shall be located and measured.

The ends of the test assembly shall be plugged and the test assembly filled with water, removing as much trapped air as possible. The water pressure shall be increased steadily to 0.5 bar over a period of not less than 1 minute and maintained for 5 minutes. During this time the pressure must not fall below 0.45 bar.

After removal from the gravel-filled box, the areas around the joint shall be examined for leakage.

Measure the straightness of the bottom of the test pieces on the outside by placing the straight edge across the outside of the pipe parallel to the longitudinal axis and determine the greatest deviation from straightness.

Compare local deformation of the radius on the bottom of the inside with the gauge. The gauge should only touch the pipe at one point.



**Figure A.1 - Box loading test (BLT) apparatus**

**A.3.8 Results**

The test assembly shall be dismantled and the components examined for any evidence of weld line cracking.

The percentage deformation of the internal diameter shall be calculated from the following equation:

$$\text{deformation} = \frac{(d_1 - d_2)}{d_1} \times 100$$

**A.4. Test Report**

The report shall include the following :

- a) identification of the components under test;
- b) aggregate type;
- c) load applied;
- d) water temperature range;
- e) any observation of signs of leakage at any of the joints;
- f) any observations of weld line cracking including depth;

- g) the percentage deformation of the vertical internal diameter of the test piece;
- h) deviation from straightness;
- i) radius deviation;
- j) the period of the test.

**APPENDIX B – RESISTANCE TO INTERNAL PUNCTURE**

**B.1 Principle**

A segment of pipe is subjected to impact on its internal surface whilst fully supported by its external surface.

**B.2 Apparatus**

**B.2.1** Standard drop weight pipe testing apparatus capable of dropping a tup from a height of 1 metre.

**B.2.2** A 250 g tup which can be varied by 25 g multiples with a striker consisting of a steel rod at least 25 mm in length, 5 mm in diameter and with a 2.5 mm radiused hemispherical end.

**B.2.3** A 250 mm x 250 mm box containing dry Leighton Buzzard sand (Garside quarry) such that there is at least 100 mm of sand beneath the test specimen when bedded down.

Typically:

Class	Lower Greensand
Specific Gravity	2.65 Mg/m <sup>3</sup>
Uncompacted bulk density	1560 kg/m <sup>3</sup>
Nominal size	1-2 mm
Coefficient of uniformity	<1.4

**B.2.4** A 5.5 kg hemispherical bar (max length 246 mm)

**B.2.5** Vibration apparatus upon which the box containing sand, specimen and 5.5 kg weight can be placed.

**B.3 Test pieces**

Twenty specimens shall be cut from a sample of structured wall pipe. The specimen shall be (243 ± 3) mm long with a chord length across the cut section of 140 mm min. and 246 mm max. It shall be cut at right angles to the longitudinal axis. Mark the intended point of impact on the inside of the pipe at the intersection of the centre lines.

Note: With profiled pipes the point of impact may have to be moved slightly from the intersection to ensure that it is mid way between the ribs or in the middle of a hollow corrugation.

## B.4 Procedure

**B.4.1** The test pieces shall be conditioned in air at a temperature of  $(23 \pm 5)^{\circ}\text{C}$  for a period of at least 30 minutes before the test.

**B.4.2** The test piece shall be bedded into the sand using the vibration apparatus with the inner surface of the test piece exposed and facing upwards.

**B.4.3** Place the 5.5 kg weight on top of the test piece.

**B.4.4** Vibrate the box until the sample is buried so that the inside wall of the pipe is level with the surface of the sand.

**B.4.5** Locate the box under the drop tube of the impact apparatus such that the marked point of impact is under the striker in line with the centre line of the tup.

**B.4.6** Drop the tup from a height of 1m onto the inner surface of the specimen.

**B.4.7** Examine the specimen for damage.

Note A: Damage is defined as a puncture or crack of the inside wall for twin wall pipe or multi-layer pipe where the intermediate layer is of foam or hollow construction. Ductile bending or "whitening" is not considered to be damage.

Note B: Damage is defined as a puncture or crack of the wall for solid wall pipe or multi-layer pipe where all the layers are of solid construction. Ductile bending or "whitening" is not considered to be damage.

**B.4.8** If the specimen exhibits a 'pass', the next test shall be tested using the next highest tup of 25 g greater weight. If the specimen fails reduce the tup weight by 25 g.

## B.5 Test report

The test report shall include:

- a) identification of the samples;
- b) test weight used for each sample;

- c) whether or not damage occurred for each sample;
- d) the average of the impact weights for all passes;
- e) if any individual failure below 250 g occurred.

## APPENDIX C – RESISTANCE TO WATER JETTING

### C.1 Apparatus

#### C.1.1 Pump Unit

The pump shall be a reciprocating piston pump capable of delivering at least 350 bar at 9 gallons per minute of water pressure e.g. Neolith Super Series 6. The hose length shall be approximately 90 m and of 15 mm (half inch) internal diameter. There shall be no sign of leakage from any part of hose or fittings.

#### C.1.2 Jetting nozzle

The jetting nozzle shall be manufactured from stainless steel. The orifice diameter shall be 1.5 mm. All dimensions and material shall be as stated in Figure C.1.

#### C.1.3 Pressure gauge

The pressure gauge shall be calibrated and capable of measuring to at least 350 bar to an accuracy of  $\pm 5$  bar. The gauge should be connected to the water supply immediately before the nozzle.

#### C.1.4 Test rig

The test rig shall be capable of withstanding pressures of at least 350 bar (5000 psi).

It shall also be capable of:

- clamping the nozzle at a constant vertical stand off distance of 5 mm ( $\pm 0.5$ ) mm from the inside surface of the pipe sample (Figure C.2)
- holding the nozzle at an angle of  $(30 \pm 1)^{\circ}$  to the inside surface of the pipe sample as shown in Figure C.2
- maintaining a fixed jet of water throughout the test period
- holding the test piece stationary throughout the test period

### **C.1.5 Measuring equipment**

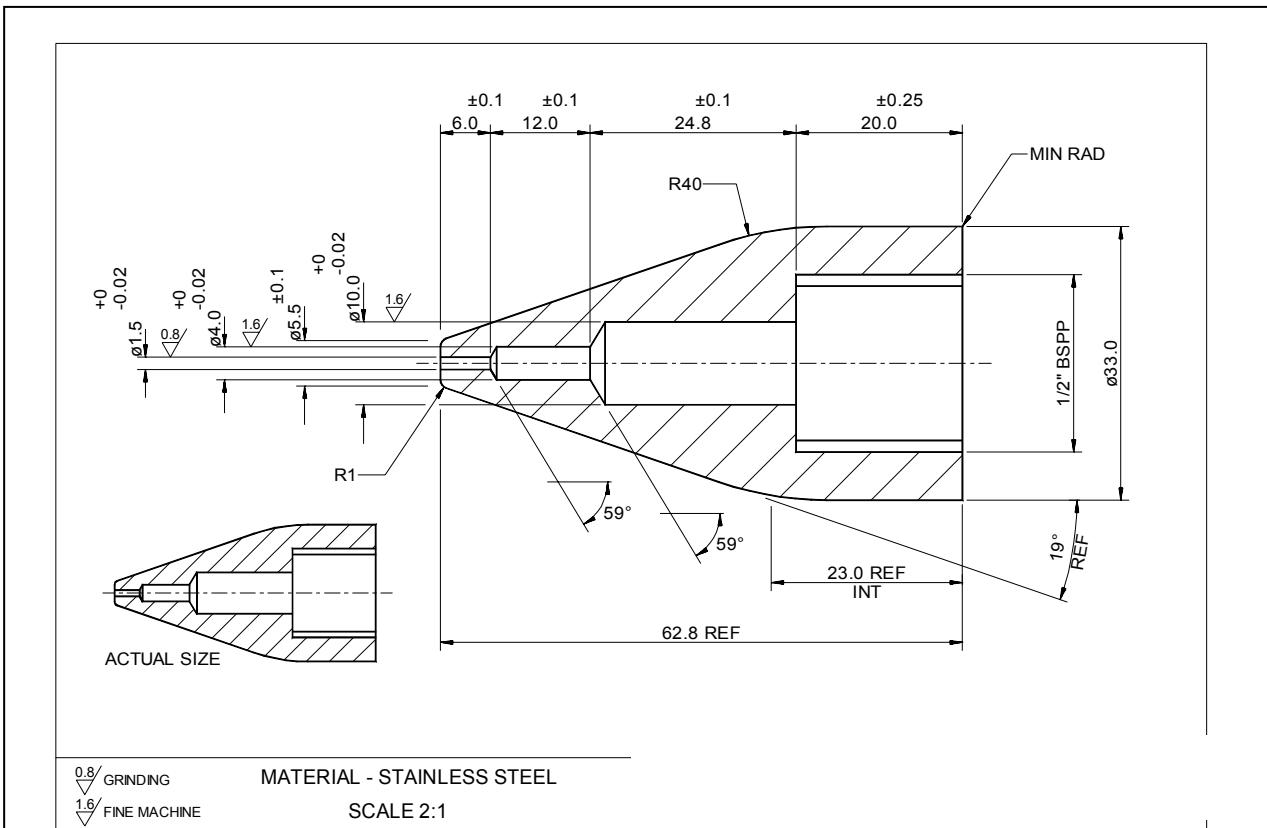
Suitable means of checking the vertical stand off distance between the internal pipe surface and the jet orifice (e.g. slips – with radiused bottom – Figure C.3)

Suitable means of measuring the orifice diameter in the jet nozzle to an accuracy of 0.002 mm.

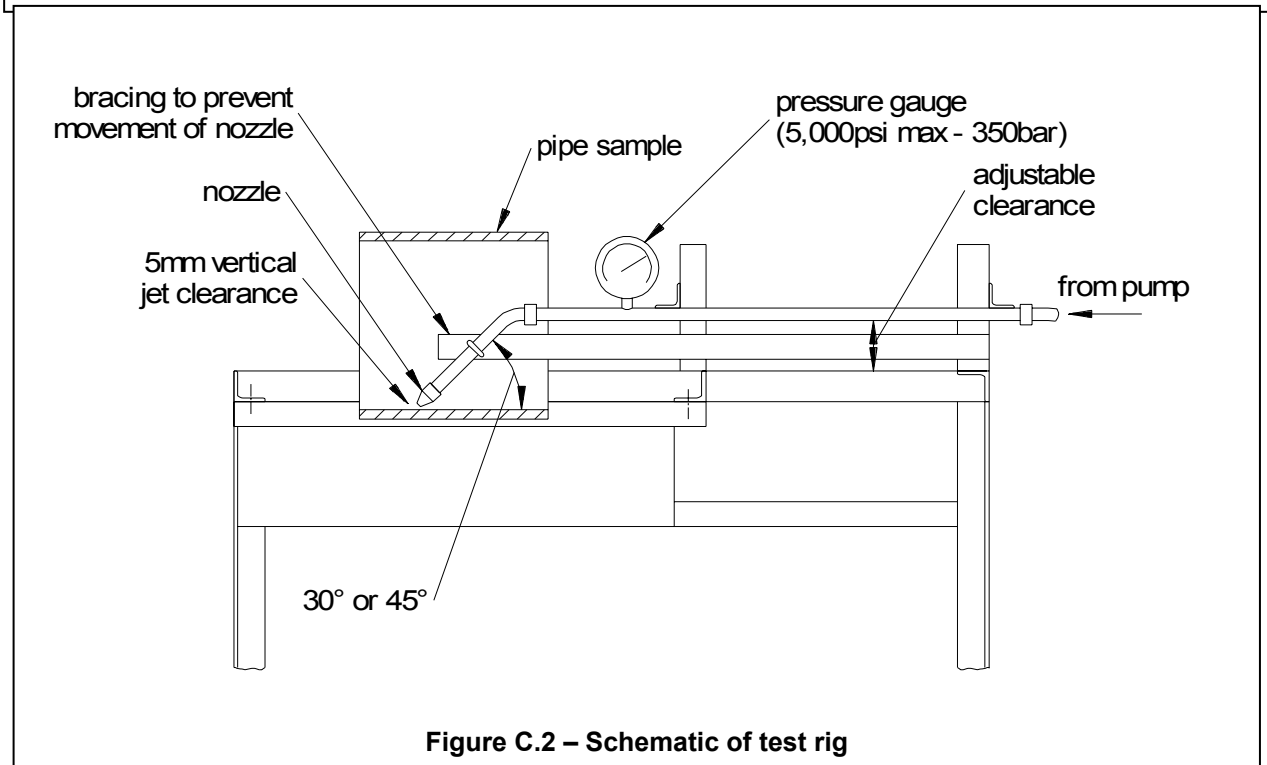
Suitable means of measuring the angle of the nozzle to the pipe wall to an accuracy of 0.1°.

### **C.2 Test piece**

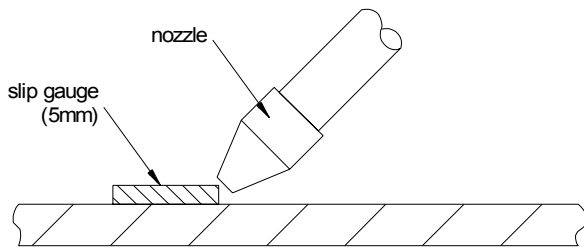
The test piece shall be a 300 mm long section of pipe of the pipe size to be tested. The test piece shall be marked off longitudinally along the pipe into 8 equidistant sections and numbered. The marking shall be waterproof.



**Figure C.1 – Nozzle for jetting rig**



**Figure C.2 – Schematic of test rig**



**Figure C.3 – Measurement of stand-off distance**

### C.3 Procedure to identify the pressure limit

**C.3.1** Run the pump for a period of approximately 5 minutes at full pressure or until all air has been purged from the supply and the pump is stabilised. The temperature of the water shall be  $(15 \pm 10)^\circ\text{C}$ .

**C.3.2** Stop the pump, place the test piece in the rig and secure so that the sample can not move when under test. Align the pipe with one of the marked sections in the jetting area. Record the segment number.

**C.3.3** Start the pump and increase the pressure to 180 bar uniformly over a time period of not less than 10 seconds and not more than 15 seconds.

**C.3.4** The test pressure shall be applied to the pipe surface for 120 seconds. Record the test pressure.

**C.3.5** After 120 seconds stop the water jet. Remove the test piece from the rig, inspect for signs of damage, and record pass or fail in accordance with Clause 6.10.

**C.3.6** The test shall be repeated 5 times at the test pressure. The pipe sample shall be turned to an untested segment for each test.

**C.3.7** If unacceptable damage is apparent in one or more of the five, a further 5 tests shall be carried out.

**C.3.8** If all five of these further tests show no unacceptable damage, the pressure limit is confirmed.

**C.3.9** If unacceptable damage is apparent in one or more of the five, the pipe is considered to have failed the test.

### C.4 Test Report

The test report shall include:

- identification of the sample;
- whether the requirements of Clause 6.10 are met.

## APPENDIX D – METHOD OF TEST FOR LONGITUDINAL BENDING

### D.1 Principle

The maximum length of pipe as sold by the manufacturer is placed on two end supports and the amount of sag measured.

The test is intended to eliminate very flexible pipe (e.g. coilable pipe) and pipe which is so weak that it might deform being handled on site.

### D.2 Apparatus

Two support blocks at least 250 mm wide and of sufficient height to allow the pipe to sag over its length without touching the ground. Typically this could consist of standard building blocks stood on their ends.

A means of measuring the vertical distance between the pipe at the centre of the span and a fixed point of reference (ground) to an accuracy of  $\pm 5$  mm.

### D.3 Test specimens

The length of pipe shall be conditioned for at least 1 hour in accordance with 7.1.

### D.4 Method

The supports are set at a distance apart equal to the length of pipe minus 500 mm.

Place the pipe symmetrically on the supports.

Measure the distance between the top of the supports and the ground or to any fixed reference point in the vertical axis through the centre line of the pipe.

After a period of two minutes measure the distance between the centre line of the pipe at mid span and the fixed reference point. Record the difference in readings as a percentage of pipe length.

## **APPENDIX E (Informative) – CHARACTERISTICS OF PLASTICS**

### **E.1 Chemical Resistance**

Plastic piping systems conforming to this standard are resistant to corrosion by water with a wide range of pH - values such as domestic waste water, rainwater, surface water and ground water.

If piping systems conforming to this standard are to be used for chemically contaminated waste waters, such as industrial discharges, chemical and temperature resistance have to be taken into account.

Piping systems conforming to this standard are highly resistant to hydrogen sulphide attack where it occurs. Further information about the chemical resistance of the materials is given in the following documents:

<b>ISO/TR. 10358:1983</b>	Unplasticized poly(vinyl chloride ) pipes and fittings- Chemical resistance with respect to fluids.
<b>ISO TR 7474</b>	Polyethylene (PE) pipes and fittings - Chemical resistance with respect to fluids
<b>ISO TR 7471</b>	Polypropylene (PP) pipes and fittings - Chemical resistance with respect to fluids.

### **E.2 Temperature behaviour**

Piping systems conforming to this standard are resistant to the temperature ranges specified in accordance with BS EN 476.

### **E.3 Abrasion resistance**

Piping systems conforming to this standard are resistant to the abrasive effects of hard particles in domestic waste and surface water.

Typical values for abrasion are between 0.06 and 0.20 mm per 50 years. For piping systems used in special circumstances the abrasion can be determined from the test method in EN 295-3.

### **E.4 Hydraulic roughness**

The internal surfaces of piping systems according to this standard are hydraulically smooth.