

## Information and Guidance Note

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# SPECIFICATION FOR PLASTICISED PVC WATERSTOPS FOR USE IN CONSTRUCTION, CONTRACTION AND EXPANSION JOINTS IN CONCRETE WATER RETAINING STRUCTURES.

## FOREWORD

This specification has been prepared by a Liaison Group under the direction of the Water Authorities Association Sewers and Water Mains Committee with membership drawn from both Water Industry and relevant UK manufacturers.

The properties of waterstop profiles must allow the product to be installed under practical site conditions as well as perform satisfactorily in service. Since PVC waterstops have typical thermoplastic properties, attention has been given to tests which reflect the required handling, storage, installation and service characteristics over an acceptable temperature range. This document is a significant development of currently adopted British and foreign specifications and manufacturers have agreed to a period of implementation during 1985.

No attempt has been made at defining waterstop profile shape or design to minimise restriction on development although a test has been included to assess the hydraulic sealing characteristics of the profile under simulated use conditions.

To complement this specification, a separate guidance note is being prepared, 4-31-03, which makes recommendations for use of PVC waterstop products. Additional guidance on design is contained within BS 5337 and a reference to the requirements for PVC waterstops is made in the Civil Engineering Specification for the Water Industry (CESWI).

It has been assumed in the drafting of this specification that the execution of its provisions is entrusted to appropriately qualified and experienced people, for whose guidance it has been prepared.

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

This specification does not claim to include all the necessary provisions of a contract.

Users of this specification are responsible for its correct application and it remains the manufacturers' responsibility to ensure that their products are suitable for use under specific service conditions.

Attention is drawn to the general Water Industry requirements for the effect on water quality of materials and products to be used in contact with potable water. Although no method of test is defined in this specification for assessment of biodeterioration resistance or resistance to particular chemicals to be encountered in service, the specifier is reminded of those potential performance requirements for aggressive water environments.

Attention is also drawn to the policy of the Water Industry to purchase products produced to an approved Quality Assurance and Third Party Certification Scheme.

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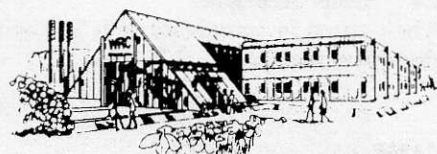
#### 7. REFERENCES

WATER RESEARCH



ENGINEERING

Frankland Road, Blagrove, P.O. Box 85, Swindon, Wiltshire SN5 8YR  
Tel: (0793) 488301 Telex: 449541



## 1. SCOPE

This document specifies the requirements for extruded PVC waterstop profiles used in the construction, contraction and expansion joints of concrete water retaining structures with a maximum water pressure head of 15m.

The requirements include materials, effect on the quality of water, chemical and physical testing, dimensional tolerances, appearances, product description, serviceability after storage and marking.

This specification does not define all the durability, chemical and microbiological deterioration resistance requirements relevant to specific applications.

## 2. REQUIREMENTS

### 2.1 Effect of non-metallic materials on water quality

When used under the conditions for which they are designed, materials in contact with or likely to come into contact with potable water shall not constitute a toxic hazard, shall not support microbial growth and shall not give rise to unpleasant taste or odour, cloudiness or discolouration of the water.

Concentrations of substances, chemicals and biological agents leached from materials in contact with potable water, and measurements of organoleptic/physical parameters shall not exceed the maximum values recommended by the World Health Organization in its publication 'Guidelines for drinking water quality' Vol 1 'Recommendations' (WHO, Geneva 1984) or as required by the EEC Council Directive of 15 July 1980 relating to the quality of water intended for human consumption (Official Journal to the European Communities L229 pp 11-29), whichever in each case is the more stringent.

NOTE 1. Requirements for the testing of materials in these respects are set out in the UK Water Fittings Byelaws Scheme Information and Guidance Note No. 5-01-02, ISSN 0267-0313 obtainable from the WRc Water Byelaws Advisory Service, 660 Ajax Avenue, Slough, Berks SL1 4BG.

NOTE 2. Pending the determination of suitable means of characterising the toxicity of leachates from materials in contact with potable water, materials approved by the Department of the Environment Committee on Chemicals and Materials of Construction for use in Public Water Supply and Swimming Pools are considered free from toxic hazard for the purposes of compliance with this clause. A list of approved chemicals and materials is available from the Technical Secretary of that Committee at the Department of the Environment, Water Division, Romney House, 43 Marsham Street, London, SW1P 3PY.

NOTE 3. Products manufactured for installation and use in the United Kingdom which are verified and listed under the UK Water Fittings Byelaws Scheme administered by the Water Research Centre (address as in Note 1) are deemed to satisfy the requirements detailed in this clause.

### 2.2 Biodeterioration and chemical resistance properties

Upon request, the manufacturer shall supply to the Specifier confirmation that the PVC waterstop product possesses suitable chemical and biodeterioration resistance to the specified environment.

### 2.3 PVC Compound

Products shall be extruded from PVC powder suitably dry blended with plasticisers, pigments, lubricant and stabilisers. No grind material shall be permitted.

### 2.4 Water absorption

When tested in accordance with 5.1 the maximum water absorption shall be 0.15% by mass.

### 2.5 Chemical resistance

When tested in accordance with 5.2 the maximum change in mass after the effect of alkali shall be between + 0.4% and - 0.3% by mass. The minimum tensile strength and elongation at break after the accelerated extraction test shall be 80% of the initial value.

### 2.6 Volatile loss

When tested in accordance with 5.3 the maximum loss in mass after heat ageing shall be 0.50% by mass.

### 2.7 Density

When tested in accordance with 5.4 the density of the finished product material shall be within  $\pm 20 \text{ kg/m}^3$  of the value specified by the manufacturer under 2.17.

### 2.8 Hardness

When tested in accordance with 5.5 the hardness over a temperature range of  $-20$  to  $+40 \pm 2^\circ\text{C}$  shall be within the range 65 to 95 IRHD.

### 2.9 Tensile strength and elongation at break

When tested in accordance with 5.6 the tensile strength and elongation at break of the extruded web section shall be greater than 10 MPa ( $\text{N/mm}^2$ ) and 225% respectively over the temperature range  $-20$  to  $+40 \pm 2^\circ\text{C}$ .

### 2.10 Profile stiffness in 3 point bend

When tested in accordance with 5.7 the force required to deflect a test sample by 25mm at  $-10 \pm 2^\circ\text{C}$  shall be less than 4 times the force to deflect a test sample profile by 25mm at  $23 \pm 2^\circ\text{C}$ .

### 2.11 Low temperature stiffness

When tested in accordance with 5.8 the product shall not fail in a brittle manner and shall show no surface cracking, crazing or stress whitening.

### 2.12 Hydraulic sealing

When tested in accordance with 5.9 during one test cycle the test joint assembly shall show no water leakage.

### 2.13 Marking

Products produced to this specification shall be marked according to clause 6.

### 2.14 Storage stability and ageing

Products shall meet the manufacturers claim for storage stability according to 2.17 and all the requirements of this specification over the claimed storage life period. The product shall also be capable of storage outside, exposed to weather and unprotected in the UK for the claimed storage life period.

### 2.15 Appearance

When laid on a flat surface for 1 hour at  $23 \pm 2^\circ\text{C}$  the manufactured waterstop shall be uniform in shape and free from deformity within the limits of the product description according to 2.17. The product shall be uniform in colour and free from visible extrusion defects.

### 2.16 Manufacturing tolerances

Manufactured tolerances on the dimensions specified under 2.17 for product laid on a flat surface for 1 hour at  $23 \pm 2^\circ\text{C}$  shall be 1.5% on overall width and 5% on thickness for the main web section.

### 2.17 Product description

To meet the requirements of 2.7, 2.14, 2.15 and 2.16, the manufacturer shall state the profile design and dimensions,

storage life and density for the product. The minimum thickness of the extruded web section excluding any designed profiles, ribs, or bulbs shall be 5mm.

### 2.18 Prefabricated systems

The minimum joint strength of prefabricated systems supplied by the manufacturer shall comply with the tensile strength requirements of 2.9 of this specification.

## 3. TYPE TEST REQUIREMENTS

All requirements under clause 2 shall apply for each product type, design and size and for any change in compound formulation or production process unless otherwise agreed in a Quality Assurance and Third Party Certification Scheme approved by the Water Research Centre.

### 3.1 Frequency of Type tests

Type Tests shall be repeated at an ongoing frequency to be agreed in a Quality Assurance and Third Party Certification Scheme approved by the Water Research Centre.

## 4. PROCESS CONTROL

The following requirements under clause 2 shall apply to confirm consistency of manufacture: 2.6, 2.8, 2.9, 2.10, 2.13, 2.15, 2.16 and 2.18 except that tests to be undertaken over a temperature range shall adopt the maximum and minimum test temperatures only.

### 4.1 Frequency of process control tests

The requirements of clause 4 shall apply for each single batch or production run or for each 4 hours of normal continuous production unless otherwise agreed in a Quality Assurance and Third Party Certification Scheme approved by the Water Research Centre.

### 4.2 Start up procedure

Normal production will be deemed to have commenced when the requirements of 2.13, 2.15 and 2.16 are met.

## 5. TYPE AND PROCESS CONTROL TESTS

### 5.1 Water Absorption

The test method shall be according to US Federal Specification 601 Method 6251, except that time of immersion shall be 24 hours.

### 5.2 Chemical resistance

Specimens shall be cut from the minimum web thickness of each profile design.

#### 5.2. Test for effect of alkali

A minimum of 3 specimens shall be cut from the extruded web section of the waterstop profile. The specimens shall have a maximum individual mass of  $150 \pm 10$ g. The mass of individual samples shall be determined and recorded to the nearest 0.001g.

The specimens shall be completely immersed in a freshly made solution containing  $0.5 \pm 0.01$ g each of chemically pure potassium hydroxide and sodium hydroxide in 1L of distilled water. Throughout the immersion period the solution temperature shall be maintained at  $23 \pm 2^\circ\text{C}$  and fresh solution shall be used every 7 days.

The specimens shall be immersed for a total period of 28 days, rinsed with distilled water, dried with a soft clean cloth followed by conditioning for 1 hour at  $23 \pm 2^\circ\text{C}$  in air and then individually weighed to the nearest 0.001g. The average percent change in mass for the sample set shall be determined and recorded.

### 5.2.2 Accelerated extraction test

10 tensile test specimens shall be cut from the web section of the waterstop profile according to the requirements of BS 2782: Method 320A. 5 of the specimens shall be tested for tensile strength and elongation at break to the above specification. The remaining 5 specimens shall be weighed to the nearest 0.001g, the mass recorded, and specimens placed in a 1L beaker with spout. The beaker shall be filled to within  $50 \pm 5$ mm of the top with a solution of  $5.0 \pm 0.01$ g each of chemically pure potassium hydroxide and sodium hydroxide in 1L of distilled water. The specimens shall be completely immersed and the top of the beaker covered with a watch glass. The beaker shall then be placed in a constant temperature bath which shall maintain the temperature of the solution at  $65 \pm 2^\circ\text{C}$ . A  $5 \pm 0.5$ mm diameter glass tube shall then be inserted into the spout of the beaker to within  $12 \pm 2$ mm of the bottom of the beaker. Air shall be gently bubbled through the solution at the rate of 3 to 5 bubbles per second. The solution shall be changed every 24 hours, the new solution being warmed to  $65 \pm 2^\circ\text{C}$  before replacing the old.

Once daily, each of the five test specimens shall be removed from the beaker (preferably at the time of renewing the solution) and shall be rinsed lightly with distilled water. Each specimen shall then be superficially dried with a soft clean cloth. After 10 minutes conditioning in air at  $23 \pm 2^\circ\text{C}$ , the specimens shall be collectively weighed to the nearest 0.001g. The sequence of testing shall continue until three consecutive weighings, calculated as a % change from the original mass, do not differ by more than 0.05%. Results shall be determined for a minimum period of 14 days or until the condition above applies whichever is the longer period. After the accelerated extraction period the specimens shall be rinsed in distilled water, dried with a soft clean cloth and tested for tensile strength and elongation at break in accordance with BS 2782: Method 320A using a grip separation rate of 100 mm/min. The average tensile strength and elongation at break after extraction shall be recorded and compared with the values obtained before extraction.

### 5.3 Volatile loss

Test material shall be cut from extruded waterstop profile or from compression moulded sheet using a documented procedure acceptable to WRC, and tested by the method described in BS 2782: Method 465A except that the sample thickness shall be  $2 \pm 0.2$ mm.

### 5.4 Density

Test material shall be cut from extruded waterstop profile and tested by the method described in BS 2782: Method 620A except that the test temperature may be relaxed from  $23 \pm 0.1^\circ\text{C}$  to  $23 \pm 2^\circ\text{C}$ .

### 5.5 Hardness

The hardness of a flat section of the extruded waterstop profile shall be measured at seven  $10 \pm 1^\circ\text{C}$  intervals in the range  $-20$  to  $+40 \pm 2^\circ\text{C}$  using an IRHD or Shore A hardness meter in accordance with BS 2782: Method 365B. Specimens for test shall be  $300 \pm 25$ mm cut lengths of waterbar profile and conditioned by suitable means for a minimum of 1 hour at each temperature prior to test.

The meter scale shall be read  $15 \pm 1$  seconds after indentation.

Five readings shall be taken at each temperature with indentations at least 6mm apart. Indentations shall be at least 12mm from any edge or change in section thickness.

The average of the five readings taken at each temperature shall be recorded.

### 5.6 Tensile strength and elongation at break

The tests shall be performed to BS 2782: Method 320A using a grip separation rate of 100 mm/min. Dumbell specimens shall be punched from the extruded waterstop profile from flat areas of the product with the gauge length in the extrusion direction. A 25mm gauge length shall be used.

NOTE: Care is required to prepare accurate test specimens.

Tests shall be undertaken at seven  $10 \pm 2^\circ\text{C}$  intervals over the range  $-20$  to  $+40 \pm 2^\circ\text{C}$ . Prepared test specimens shall be conditioned by suitable means at each test temperature for a minimum of 1 hour before test. Five specimens shall be tested at each test temperature. The average ultimate tensile strength, in MPa ( $\text{N}/\text{mm}^2$ ), and average % elongation at break shall be determined and recorded for the set of 5 test specimens at each temperature.

### 5.7 Profile stiffness in 3 point bend

The apparatus shall be of the form shown in BS 2782: Method 335A with a top loading nose radius of  $5 \pm 0.1\text{mm}$  and radius of side supports of  $4 \pm 0.1\text{mm}$ . The width of the loading nose and side supports shall be sufficient to support the full width of the waterbar under test. The span shall be  $100 \pm 1\text{mm}$ . Test specimens shall be cut lengths of extruded waterstop profile  $160 \pm 5\text{mm}$  in length. Three specimens shall be tested at each temperature. Test temperatures of  $23 \pm 2^\circ\text{C}$  and  $-10 \pm 2^\circ\text{C}$  shall be used. Test specimens shall be conditioned by suitable means for a minimum of 1 hour at each temperature before test. Each sample shall be supported in the test jig and loaded at a rate of 50 mm/min. The force required to deflect the specimens by 25mm shall be determined and the average for the test set recorded for both test temperatures. Products that are not symmetrical on both sides shall be placed in the test rig with the ribbed surface uppermost.

### 5.8 Mandrel test

A  $900 \pm 10\text{mm}$  length of waterstop profile shall be bent around the circumference of a  $300 \pm 10\text{mm}$  diameter mandrel at  $23 \pm 2^\circ\text{C}$ . The free ends shall be clamped together by suitable means and the test assembly left to condition under tension for 7 days at  $23 \pm 2^\circ\text{C}$ . The clamped test assembly shall then be conditioned in a low temperature cabinet set at  $-20 \pm 2^\circ\text{C}$  for a minimum of 4 hours. After low temperature conditioning the test assembly shall be removed from the cabinet, clamp removed and immediately opened over a period of  $5 \pm 1$  seconds so that when placed on a flat surface the free ends are  $180^\circ\text{C}$  apart. Record any failure of the specimen and any cracking, crazing or stress whitening visible through a  $10\times$  magnification lens.

Products that are not symmetrical on both sides shall be placed with the ribbed surface against the mandrel.

### 5.9 Hydraulic sealing test

The cut ends of a  $2000 \pm 20\text{mm}$  length of extruded waterstop profile shall be supplied by manufacturers suitably welded to form a ring approximately 600mm in diameter. For each test a  $1000 \pm 20\text{mm}$  diameter reinforced concrete cylinder shall be made in two  $300 \pm 10\text{mm}$  deep halves and incorporating the waterstop profile. The concrete for the second half shall be placed 7 days after the first and prevented from bonding to the lower concrete by a sheet of polyethylene. Both integral and surface type waterstop shall be embedded in the concrete (figure 1). Surface type waterstop shall be embedded in the concrete with the ribs innermost.

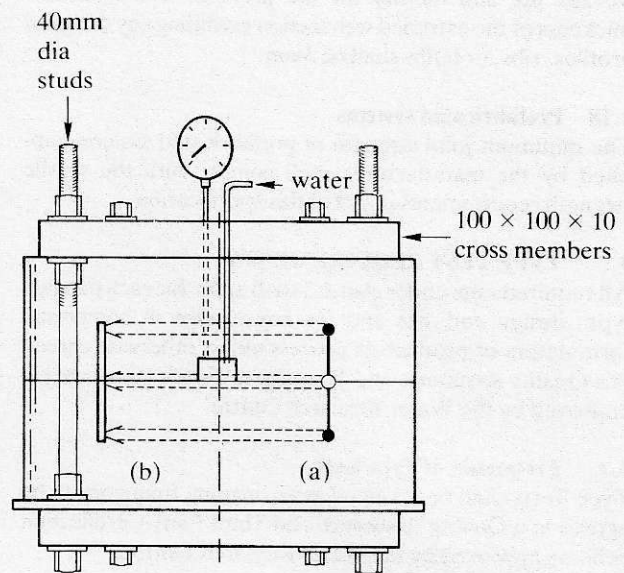


Figure 1: Elevation and section of test specimen incorporating either (a) integral or (b) surface type waterstop.

Hydraulic tubing shall be cast and sealed into the top half cylinder in order to introduce water to the centre of the test assembly and exert pressure on the waterstop. A suitable pressure gauge and means of providing the water under pressure shall be provided. Two pairs of steel cross members each  $100 \times 100 \times 10\text{mm}$  shall be secured by suitable means to the top and bottom cylinders and four 40mm diameter threaded studs located to control the gap between the two cylinders of concrete (see figure 1).

The concrete for the test shall be made from BS 4550: Part 4 aggregate, BS 4550: Part 5 sand and BS 12 ordinary Portland cement, with an aggregate/cement ratio of 5:1. A workable mix shall be used to facilitate compaction with between 50 and 75mm slump measured to BS 1881: Part 102. Each section of concrete shall be cured for 7 days and the completed assembly left for 28 days before testing.

Water pressure shall then be applied to the internal cavity of the test assembly and incremental movements of  $3 \pm 0.25\text{mm}$  applied to the waterstop via the threaded studs according to the test schedule shown in figure 2.

Any water leakage attributable to failure of the waterstop profile to seal the test joint shall be recorded. In the event of failure by leakage the test shall be repeated or alternatively two tests shall have been commenced simultaneously and the best result recorded.

## 6. MARKING

Products produced to this specification shall be clearly marked by suitable means. Marking shall be recognisable for a minimum period of the claimed storage life identified under 2.17. The markings shall include the following information repeated at a minimum frequency of every 15m length of production:

- Manufacturer
- Product type
- Product width (mm)
- Batch/Shift identification
- Date of manufacture
- The number 4-31-02

The number 4-31-02 shall only be marked on those products confirmed to have met the requirements of this specification by a Third Party Certification Scheme approved by the Water Research Centre.

## 7. REFERENCES

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

- BS 12 Specification for ordinary and rapid hardening Portland cement.
- BS 1881 Methods of testing concrete.  
Part 102 Method for determination of slump.
- BS 2782 Methods of testing plastics.  
Methods 320A to 320F Determination of tensile strength, elongation and elastic modulus.  
Method 335A Determination of flexural properties of rigid plastics.  
Method 365B Determination of indentation hardness by means of a durometer (Shore hardness).  
Method 465A & 465B Determination of loss of plasticisers (activated carbon method)  
Method 620A Determination of density of solid plastics excluding cellular plastics (immersion method).
- BS 4550 Methods of testing cements.  
Part 4 Standard coarse aggregate for concrete cubes  
Part 5 Standard sand for concrete cubes
- BS 5337\* Code of practice for the structural use of concrete for retaining aqueous liquids.

UK Water Fittings Byelaws Scheme Information and Guidance Note No 5-01-02 Requirements for the testing of non metallic materials for use in contact with potable water.

WAA Sewers and Water Mains Committee Information and Guidance Note No 4-31-03. (In course of preparation).

US Federal Specification 601 Method 6251. Change in weight, liquid immersion (also refers to methods 6001, 6111 & 6211)†.

'Guidelines for drinking water quality' Vol 1 'Recommendations'. World Health Organisation (WHO), Geneva 1984†.

EEC Council Directive of 15 July 1980 relating to the quality of water intended for human consumption (official Journal of the European Communities L229 pp 11-29)†.

WAA Civil Engineering Specification for the Water Industry.\*

\* Referred to in the foreword only.

† Available from HMSO.

† Available from American Information Retrieval Service, 12, Rickett Street, London SE6 1RU.

Figure 2. Test Schedule.  
Hydraulic Sealing Test

