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Water Industry Specification

SPECIFICATION FOR BUILDING AND CONSTRUCTION JOINT SEALANTS

FOREWORD

This specification has been prepared by WRc plc under the direction of the Sewers and Water Mains Committee in consultation with manufacturers, BRE, CIRIA and Water Industry.

The performance of sealants and changes after long term immersion in aqueous media have been investigated in detail to support the development of this specification (see refs. CIRIA/WRc reports). This foundation work was funded by the UK Water Industry, Department of the Environment and manufacturers. When sealants are exposed to aqueous media in the service environment a number of distinct phenomena may occur which can influence their performance, and may contribute to the failure of the sealant to perform the intended functions. The primary effects concerned are first, the absorption of water by the sealant, which may cause softening depending upon the chemical nature of the sealant, its cure mechanism and state of cure at the time it is first exposed to moisture. Secondly, the diffusion of liquid water to the sealant/primer/substrate interfaces may impair the adhesive bond of the sealant to the joint surfaces. The laboratory evaluation of these effects in this specification is based upon tensile testing in which the modulus and the extensibility of sealant test joints after varying durations of immersion in aqueous media are used as indices of performance. A system of performance evaluation based upon changes in these indices with immersion is defined. The requirements of this specification therefore address the need particularly for sealant materials to achieve their fully cured properties quickly and to maintain both their physical bulk and failure properties within specified limits after immersion.

This document specifies the primary performance and durability requirements for joint sealants for Water Industry use including tests for effect on water quality and the water resistance requirements for appropriate conditions of long term service. Appendix A defines the method of test for resistance to aqueous media and Appendix B defines a method for determining the acceptability of changes to sealants after this test providing a visual method of assessment. Appendix A is equally relevant to joint sealants used in concrete structures retaining water as well as other aqueous media. Application of the test method is also relevant to joint sealants used in less arduous conditions such as overflow structures and structures exposed to the weather with appropriate amendment to the duration and conditions of immersion. As a guide, a test period of 12 months is specified to assess long term resistance to aqueous media.

Attention is drawn to BS 3712: Part 4, and ISO 8339 from which the general method for tensile testing is derived.

The method of test for resistance to aqueous media included in this specification is relevant to sealants applied in a paste-like consistency to concrete surfaces using recommended primers. These sealants subsequently cure to generate elastomeric working properties under specified cure conditions.

This specification does not provide requirements to assess all aspects of use, i.e. during application or in service. Additional properties may need to be considered where appropriate, such as the resistance to high water flow rates, abrasion, aggressive chemicals encountered in service and movement accommodation. Agreed methods of test and limits of performance are not available for all these service requirements. However, guidance has been published, which is referenced in this document and preparation of a Water Industry guidance document is under development.

Compliance with this specification does not itself infer immunity from legal obligations. The specification does not purport to provide all the necessary provisions of a contract and users are responsible for its correct application. This specification may call for the use of substances and/or procedures that are 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.

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

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

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In this document reference to the use or adoption of a British Standard, Water Industry Specification or any other specification applies to any equivalent specification.

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

CONTENTS

1. SCOPE

This document identifies the performance, quality assurance and marking requirements for building and construction joint sealants for use in wet service conditions including tests for effect on water quality, where appropriate, and a method of test for resistance to aqueous test media (Appendix A). Requirements for test immersion regimes for different categories of use and acceptability of changes are indicated (Appendix B).

2. EFFECT OF MATERIALS ON WATER QUALITY

For use in public water supply in the UK 2.1 and 2.2 shall be complied with.

2.1 Basic requirements

When used under the conditions for which they are designated, non-metallic products in contact with or likely to come into contact with potable water shall comply with the requirements of BS 6920: Part 1: 1990.

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

2.2 DoE-CCM requirement

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

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

3. RESISTANCE TO AQUEOUS ENVIRONMENTS

3.1 The method of test and assessment of performance described in Appendix A and Appendix B shall apply. Sealants intended for a specific category of use and exposure to aqueous environments shall meet the test requirements of that category.

4. QUALITY ASSURANCE

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

5. MARKING

5.1 All tins or packs of sealant complying with the requirements of this specification, in addition to any other legitimate identification mark or instruction, shall be marked with the number of this specification i.e. WIS No. 4-60-01 and the category of use (see Appendix B). (The use of this mark is a claim by the manufacturer that the product has been manufactured in accordance with the requirements of this specification and the claim is his sole responsibility.)

6. IN-SERVICE CONSIDERATIONS

NOTE Guidance on selection of sealants for specific applications is available (see CIRIA/WRc Technical Note 128 and BS 6213).
Further guidance is under consideration for preparation as a Water Industry Information and Guidance Note (IGN).

7. REFERENCES

This specification makes reference to the latest edition of the following publications (except where otherwise indicated) including all addenda and revisions:

BS 1610. Materials testing machines and force verification equipment.
Part 1: Grading of the forces applied by materials testing machines.

BS 3712. Building and Construction Sealants.
Part 4 Methods of test for adhesion in peel, tensile extension and recovery and loss of mass after heat ageing.

BS 5750 Quality systems.
Part 2 Specification for production and installation.

BS 6213. Guide to the selection of constructional sealants.

BS 6920 Suitability of non-metallic products for use in contact with potable water intended for human consumption with regard to their effect on the quality of the water.
Part 1 Specification.

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

ISO 8339 Building Construction Jointing Products. Determination of tensile properties.

CIRIA/WRc Technical Note 128 1987. Civil Engineering sealants in wet conditions, review of performance and interim guidance on use.

CIRIA/WRc Project Report RP355 Phase 2 Stage 1, Development of a Water Resistance Test. CIRIA. 1989.

APPENDIX A

METHOD OF TEST FOR TENSILE EXTENSION PROPERTIES AFTER IMMERSION IN AQUEOUS TEST MEDIA

A1.1 SCOPE

Appendix A provides a method of test which can be used to assess the resistance to aqueous test media of joint sealants used under wet service conditions. It can be used for a range of sealants and as a means of predicting resistance to the effects of a range of aqueous service environments.

A1.2 DEFINITIONS

The definitions referred to within BS 3712: Part 4 apply.

A1.3 PRINCIPLE

Preparation of test specimen in which the sealant to be tested adheres to two parallel cement mortar test surfaces.

Pre-conditioning of the test specimens to provide "well cured" sealant.

Exposure of the test specimens to appropriate aqueous test media and subsequent extension to rupture whilst recording the tensile force/extension properties.

Examination of the results to determine:

(i) the properties of the sealant at different extensions and at break;

(ii) the change in properties after immersion in appropriate aqueous test media;

(iii) the type and change in the nature of failure after immersion in appropriate aqueous test media;

(iv) a prediction of longer term performance.

A1.4 APPARATUS AND ACCESSORY MATERIALS

A1.4.1 Calibrated extension machine, capable of operating at a rate of 5mm/minute to 6mm/minute, with provision for recording force/extension data meeting the requirements of Grade 1.0 of BS 1610: Part 1: 1985, and jaws able to hold the test assemblies.

A1.4.2 Spacer bars for assemblies with dimensions 12 × 19 × 50mm (see Figure 3, Type 3, BS 3712: Part 4: 1985).

A1.4.3 Power stirrer (maximum 150 rpm) or spatula for mixing multipart sealants.

A1.4.4 Container or system for immersing test specimens in water or specified aqueous test media with a minimum capacity of 0.5 litres for each immersed test assembly.

A1.4.5 Primer, sealant and release materials.

A1.4.6 Cement mortar test blocks prepared to Section 3.2 of BS 3712: Part 4: 1985 with dimensions 50 × 50 × 25mm.

A1.4.7 Polyethylene sheet.

A1.4.8 Ventilated chamber capable of maintaining 23 ± 2°C and 50 ± 5%rh.

A1.5 PREPARATION OF TEST ASSEMBLIES

Sufficient test assemblies shall be prepared to carry out the test programme required by this specification. For each test period, a minimum of 3 test assemblies shall be used for both immersion and dry control sets.

A1.5.1 Cleaning of test block surfaces. Remove loose dust by brushing, using a clean stiff bristle brush. If it is found after the preparation of the block that the surface has any cavity greater than 2mm diameter, reject the block.

A1.5.2 When appropriate, apply a primer to the inner substrate surfaces according to the instructions of the sealant manufacturer. Allow the primer to dry for the specified time prior to assembly of the test pieces.

A1.5.3 Condition an appropriate quantity of the sealant at 23 ± 2°C in a closed container or an unopened cartridge for a period of at least 16 hours. Then mix appropriate amounts of the conditioned components of multipart sealants, either by hand for 10 minutes using a spatula, or by using a power stirrer (A1.4.3) until uniform mixing is achieved, with the speed of rotation being such that the minimum amount of air is entrained in the mixed sealant.

A1.5.4 Assemble the appropriate test surfaces as shown in Appendix A type 3 of BS 3712: Part 4: 1985 (except that cement mortar test blocks as in A1.4.6 shall apply). Place the assembly on the polyethylene sheet (A1.4.7) and fill the void with sealant. Take care to avoid the formation of air bubbles and to bring the sealant firmly into contact with the inner substrate surfaces.

NOTE Alternative forms of test assembly with the same test bead size of 12mm × 12mm × 50mm are given in Appendix A of BS 3712: Part 4: 1985. These may be used to comply with international standards.

A1.6 PROCEDURE

A1.6.1 Cure the assemblies for 7n days at 23 ± 2°C and 50 ± 5%rh in a ventilated chamber (A1.4.8), where n is a whole number from 1 to 4.

A1.6.2 Remove spacer bars and immerse the test assemblies in water or specified aqueous test media (A1.4.4) for the duration of a specified immersion period, T, where T is in months with a value between 0.25 and 12. The aqueous test media shall be renewed every 28 days during longer term tests.

A dry control set of assemblies shall also be available for each specified immersion period (see Appendix B for guidance), stored at 23 ± 2°C and 50 ± 5%rh.

A1.6.3 Determination of tensile extension properties. At the completion of each specified immersion period up to T (months), remove a set of 3 (minimum number) assemblies from the specified aqueous environment together with a set of 3 (minimum number) dry control assemblies. Place, in turn, each individual assembly in the extension machine (A1.4.1) and extend it at a constant rate of between of 5mm/minute to 6mm/minute up to failure. Keep a continuous record of the force/extension diagram for each assembly tested. Maintain test temperature at 23 ± 2°C. Determine the force at 25% extension, the maximum force and the extension at maximum force for each individual assembly and the averages of those values for each test set (minimum of 3 assemblies). Determine the type of failure, whether cohesive in the sealant or adhesive at or near the test surface (see Appendix B).

Assemblies subjected to immersion in aqueous test media shall be removed individually and tested immediately where possible. Where this is not possible and with hazardous aqueous test media, wash and/or store the assemblies for up to 24 hours in distilled water after removal and prior to testing in a wet condition.

A1.6.4 Compare the performance of the wet test assemblies with the dry control test assemblies for each immersion period up to time T (months).

A1.7 TEST REPORT

The test report shall contain the following information:

(a) the number of this specification, 4-60-01;

(b) the name and type of sealant;

(c) the batch and expiry dates of sealant and primer from which the test assemblies were prepared;

(d) the duration of cure for n = 1, 2, 3 or 4;

(e) details of the wet test media;

(f) the immersion period, T (months), and immersion régime adopted;

(g) the number of test assemblies used for each specified immersion period;

(h) the measured force at 25% extension and the maximum force tabulated for each individual assembly and for the averages of the values of each test set;

(i) the measured extension at the maximum force tabulated for each individual assembly and for the average of each test set;

(j) observation of the type of failure (either cohesive in the sealant or adhesive at or near the test surface) for each test assembly and the change after immersion;

(k) for categories T_{12} and T_4 (see Appendix B) a graphical presentation of test data.

A1.8 ASSESSMENT OF TEST RESULTS

(a) An interpretation of acceptability of changes after immersion (see Appendix B).

(b) An interpretation of acceptability of changes in dry control properties between initial cure (selected value of n) and after period T (months) (see Appendix B).

APPENDIX B

TEST IMMERSION REQUIREMENTS AND ASSESSMENT OF ACCEPTABLE PERFORMANCE

B.1 INTRODUCTION

Sealants used in joints in Water Industry structures may be exposed to a wide range of service conditions in which water may have a significant effect upon performance. These range from joints in external walls, where exposure to water is usually intermittent and of short duration to fully immersed joints in water retaining structures, where the sealant must withstand prolonged exposure to aqueous media.

The absorption of water by porous materials such as concrete may present problems in securing adequate adhesion. At the time of application, the presence of water at the joint surface may also militate against securing an adequate bond. The correct use of appropriate primers is also an important factor controlling performance.

At least three phenomena may occur when sealant samples are immersed in water.

These will affect certain properties measured in the laboratory, referred to as "performance indices".

Firstly, an incompletely cured material may continue to change chemically (e.g. by cross-linking), which may be evident by an increase in the measured modulus or stiffness. For a meaningful assessment of properties it is therefore essential that sealants achieve their fully cured properties as quickly as possible. This also has practical implications on site (see B.4).

Secondly, the absorption of water by the sealant leads to softening and plasticisation, and is manifested by a reduction of the measured modulus.

Thirdly, the diffusion of water through the porous substrate, and through the sealant itself, to the sealant/primer/substrate interfaces is likely eventually to cause a degree of impairment of the sealant bond to the joint surface.

In practice, to measure sealant performance, a simple tensile test to destruction is used, after immersion of the test assemblies in the aqueous medium for a prescribed period related to the expected service conditions (see Table 1).

From such tests, using at least 3 replicate test assemblies, two performance indices may be readily derived:

- **Modulus (M):** this has been taken as the force to extend a standard test assembly by a given amount; 25% is used since this extension is not greatly in excess of the maximum strain values to which sealants are commonly subjected in correctly designed joints. A change in modulus (ΔM) is indicative of hardening or softening of the sealant.
- **Extensibility (E):** is measured as the percentage extension at which the maximum force is observed during the tensile test. A change in extensibility (ΔE) may be regarded as an index of bond integrity.

A further essential observation to be made in these tests is the nature of the failure, whether adhesive or cohesive in character, and whether there is any change in this when water-immersed specimens are compared with controls of the same age maintained in air at standard conditions (see Table 2).

Comparison of mean values for immersed and control specimens allows the calculation of the modulus difference (ΔM) and of the extensibility difference (ΔE), these being key performance factors for the sealant after exposure to aqueous media.

These considerations lead to a simple diagrammatic representation of the effects of aqueous media on sealant properties, which, if required, also allows the changes with increasing duration of immersion to be charted, and forms the basis of a simple rating system.

Figure 1 indicates the basis for the assessment and rating system in which data are plotted on $\Delta E/\Delta M$ coordinates.

The principles of the rating system based on Figure 1 may be expressed thus:

- bond integrity being regarded as a primary performance index, a significant increase in extensibility is given a positive rating;
- positive changes in the extensibility are then ranked and unacceptable (u) changes identified taking account of any softening of the sealant caused by water absorption.

B.2 TEST IMMERSION REQUIREMENTS

Table 1 - Immersion requirements for different sealant categories

Category	Months Immersion	Application
T_{12}	1, 4, 12	Increasing resistance to aqueous environments and more severe end-use requirements
T_4	0.25, 1, 4	
$T_{0.25}$	0.25	

Specified cure and immersion periods should relate to the service conditions, i.e. end-use application/environment envisaged for the sealant material. Since chemical characteristics of different aqueous environments vary, details of the particular test media are necessary for comparison with service requirements.

Sealants in Category T_{12} are intended for long term exposure to aqueous environments, e.g. water retaining structures, water excluding structures or sewage treatment works with joints subject to continuous water immersion.

Sealants in Category T_4 are intended for moderate exposure to aqueous environments, e.g. structures which are normally dry but subject to occasional immersion for periods of up to 1 month, such as overflow areas and poorly draining areas exposed to weather.

Sealants in Category $T_{0.25}$ are intended for brief exposure to water, e.g. free draining joints exposed to rain that dry out together with the adjoining substrate.

B.3 ASSESSMENT OF ACCEPTABLE PERFORMANCE

B3.1 Percentage change after immersion from dry controls at the same age

Possible bond impairment/bond improvement

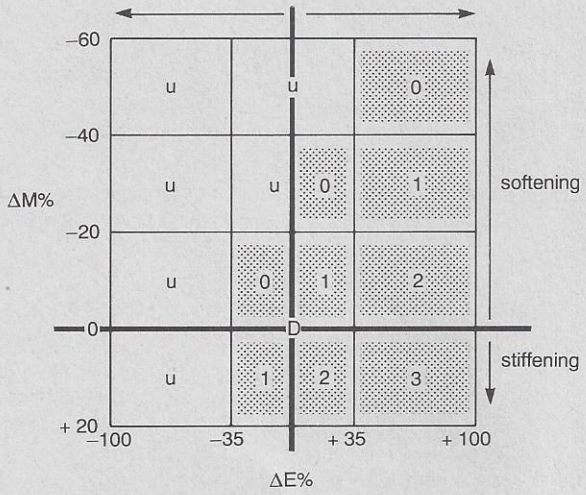

Figure 1 - Changes to modulus and extensibility after immersion

D = Datum point relating to dry controls of the same age;
ΔE = Percentage difference between extension at maximum force of immersed assemblies compared with dry controls at the same age;
ΔM = Percentage difference between force at 25% extension of immersed assemblies compared with dry controls at the same age;
–ΔM or –ΔE represent reductions in properties after immersion;

SHADED ZONES REPRESENT A **POTENTIALLY ACCEPTABLE** CHANGE, **UNSHADED ZONES UNACCEPTABLE** (u). LEVELS OF ACCEPTABILITY ARE INDICATED FROM +3 TO 0 AS SHOWN.

B3.2 Example of use to determine sealant category

Since zone 0 or any positive zone values are acceptable with order +3 +2 +1 and all other zones are unacceptable, the change in performance can be followed for different immersion periods:

For example:

Immersion period (months)	Example of possible zone rating achieved
0.25	+3
1	0
4	0
12	u

This may indicate the limit of suitability and the category of use (see B.2).

B3.3 Changes in mode of failure

Table 2 - Changes in mode of failure (CF/AF) after immersion

Before Immersion	After Immersion	Inference
CVF	CF	Increasing acceptability provided little or no change in extension to failure
AF	CF	
AF	AF	
CF	AF	
Note: CF = Cohesive failure in the sealant. AF = Adhesive failure at or near the test surface.		

B3.4 Graphical presentation and extrapolation

For Categories T_{12} and T_4 the modulus and extensibility properties shall be presented graphically to illustrate trends in performance with time, e.g. any tendency for immersion performance to stabilise with time, prediction of longer time performance, differences in performance in different aqueous media used.

B.4 SELECTION OF CURE TIME

The choice in selection of cure time is left to the manufacturer and shall be between n = 1 and n = 4.

NOTE In order to compare the true effects of immersion and to relate properties to end-use requirements, it is necessary to achieve a high level of initial cure prior to immersion. It is therefore recommended that the properties should be such that after the chosen initial cure time, they are at least 90% of the properties achieved after time period T, i.e. the material does not continue to cure in an indefinite manner.