

Guide to

Selection of constructional sealants

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Foreword

This British Standard Guide has been prepared under the direction of the Elements and Components (of Diverse Materials) for Buildings Standards Committee.

A number of British Standards and other documents exist that specify sealants according to their composition and in particular according to their chemical type. These generic types of specification are of principal value to the sealant manufacturer, enabling him to supply products that can be claimed to have met an acceptable level of quality during their manufacture. Generic specifications are not designed to be performance standards; their test methods do not simulate conditions of use nor do they accelerate service conditions to predict long term performance.

Performance standards require that sealants meet certain simulated or accelerated service conditions. The variety of conditions that can be encountered in terms of exposure and environment; frequency, rate and extent of movement; maintenance, etc. is enormous, even ignoring the vast variety of surfaces and surface treatments to which a sealant may be applied. The task of producing such standards is then hampered by the difficulties of adequately describing what performance is required of a sealant. Whilst attempts may be made to rationalize this state of affairs, a current solution is the publication of this guide, based on the empirical performance of some of the principal sealants currently available.

This guide is aimed at the specifier and user of sealants and is believed to be the first of its type in the United Kingdom. The guide includes much information that may be considered as background and thus secondary to the ultimate purpose of selecting a product by means of tabulated information. All the clauses are, however, considered important to a proper understanding of the selection of a sealant. Clause 3 contains information on categories of joints, joint movement and dimensions, and on the geometry, modulus, maintenance and causes of failure of sealants. Attention is particularly drawn to the concept of movement accommodation factor, and to the fact that not all manufacturers express movement in the same terms. All movement can be converted to the standard terminology used herein and it is stressed that users of this guide should satisfy themselves as to the validity of any data used.

In clause 4 it should be emphasized that exact guidance on use of primers for different substrates cannot be given in this guide, but where the use of a primer on a joint face is recommended by the sealant manufacturer to improve the bond, the primer has to be obtained only from the supplier of the sealant. Consideration of the information in clause 7 may lead to the conclusion that a specialist applicator will be required for all but the smallest of installations. An applicator may have views on the selection of sealants and may offer a guarantee covering the effectiveness of his workmanship when specifications for sealant application can be agreed.

As a complement to this guide on sealant selection, attention is drawn to BS 6093 and DD 121.

Attention is drawn to requirements under the Health and Safety at Work, etc. Act, 1974 concerning hazards regarding the handling of building sealants and any associated primers or solvents.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 30, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard gives guidance on types of constructional sealants and on their selection and correct application, so enabling the specifier to select properly, according to joint function and design.

The sealant types and selection tables given in clauses 4 and 5 cover the most commonly available cold-applied one- and two-component sealants; cold-applied, preformed strips; setting putty for glazing; and hot poured rubber/bitumen sealant. Whilst this standard gives guidance on the selection of sealants for slow moving vehicular and pedestrian areas, it does not cover the selection of sealants intended for areas of more onerous use, such as carriage-ways of roads, airport runways and similar areas.

A bibliography of publications relevant to the selection of sealants is given in Appendix A.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

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

2.1 Materials

2.1.1 sealant

a material that, when applied in a uniform state to a joint, seals it by adhering to appropriate surfaces within the joint

2.1.2 elastic sealant

a sealant that, after application, exhibits predominantly elastic behaviour, i.e. the stresses induced in the sealant as a result of joint movement are almost proportional to the strain

2.1.3 plastic sealant

a sealant that, after application, retains predominantly plastic properties, i.e. the stresses induced in the sealant as a result of the joint movement are rapidly relieved

2.1.4 elastoplastic sealant

a sealant that has predominantly elastic properties but exhibits some plastic properties when stressed for other than short periods

2.1.5 plastoelastic sealant

a sealant that has predominantly plastic properties with some elastic recovery when stressed for short periods

2.1.6 one-component sealant

a sealant ready for use

2.1.7 multi-component sealant

a sealant supplied in the form of two or more separate components to be mixed together before use in accordance with the manufacturer's instructions

2.1.8 gun-grade sealant

a sealant that permits application in a suitable joint of any aspect or inclination, without appreciable slumping at ambient temperature

NOTE This grade of sealant may also be applied by other means, e.g. trowel.

2.1.9 pouring-grade sealant

a sealant that will flow sufficiently to give a reasonably smooth level surface when applied in a horizontal upward-facing joint at ambient temperature

2.1.10 sealing strip

a preformed adhesive material that constitutes a seal when compressed between appropriate joint surfaces

2.1.11 primer

a surface coating applied to the faces of the joint before placing the sealant, in order to secure its adhesion

2.1.12 back-up material

material inserted in a joint that limits the depth of sealant applied and defines the back profile of the sealant

2.1.13 bond breaker

a film or thin strip material applied to the back of a joint to prevent sealant adhesion

NOTE A bond breaker is not required if a suitable back-up has been used.

2.1.14**elastomer**

macromolecular material that returns rapidly to approximately its initial dimensions and shape after substantial deformation by a weak stress and release of the stress

2.1.15**monomer**

a unit molecule from which a polymer is built up

2.1.16**polymer**

a substance, whose molecules consist of one or more structural units repeated any number of times. Vinyl resins are examples of true polymers. The name is also frequently applied to large molecules produced by any chemical process, e.g. condensation in which water or other products are produced. Alkyd resins are examples of these

2.1.17**copolymer**

a polymer whose molecule consists of more than one kind of structural unit derived from more than one monomer. Polyvinyl chloride-acetate, or polyvinyl acetate-acrylic copolymers are examples

2.2 Properties of a sealant**2.2.1****adhesion**

the property of a sealant to stick to a given substrate

2.2.2**ageing**

the deterioration of a sealant on exposure to a specified environment

2.2.3**application life**

the time after mixing a multi-component sealant (or after opening a sealed container of one-component sealant) within which the material may be successfully applied to a joint at a stated temperature

2.2.4**cohesion**

the property of a sealant subjected to tensile strain to hold together by intermolecular attraction

2.2.5**compatibility**

the property of a sealant to remain in contact with another material without unfavourable physical or chemical interactions

2.2.6**cure**

irreversible transformation of a sealant from a liquid or plastic-like state into a hardened or rubber-like solid state

2.2.7**service life**

the period of time during which sealant fulfils its function

2.2.8**elastic recovery**

the property of a sealant whereby the initial shape and dimensions of the material are wholly or partially restored on the removal of the forces causing deformation

2.2.9**extrudability**

the property required of a gun-grade sealant to be forced through a nozzle. It is tested under conditions of standard temperature, pressure and time

2.2.10**movement accommodation factor (MAF) of a sealant**

the maximum movement that a sealant is capable of tolerating throughout its working life, expressed as a percentage of the joint width

2.2.11**sealant tensile modulus**

the ratio between the tensile stress of a sealant at a particular relative elongation, and that relative elongation

2.2.12**slump resistance**

the ability of a sealant to remain within the confines of a joint

2.2.13**storage life**

the period following manufacture, during which a sealant stored under defined conditions may be used and will maintain its functional characteristics

NOTE The expiry date may be stated on the container and the product should not be used after this date.

3 Joint design considerations

3.1 Categories of joints. Joints may be considered in two broad groups as follows.

- a) Those that occur as a consequence of design discontinuity, the amount of movement being negligible. These joints vary widely in type and function. Examples are joints between window and door frames and the surrounding walls or construction joints in a concrete structure. Because negligible movement occurs in such joints, their position and size are usually determined by the requirements of component fit or the method of construction.
- b) Those that are designed to accommodate major movements. A further sub-division may be made as follows.
 - 1) Joints designed to accommodate expansion and contraction movements.
 - 2) Construction joints that are designed as planes of weakness in a structure and are usually subject to a once-only opening movement. Partial construction joints and dummy joints perform a similar function, but movement is much more restricted.

3.2 Joint movements. In considering joint movement, a summation of all the expected movements under the service conditions should be obtained in order to provide a total theoretical joint movement amplitude upon which the joint design will be based. The initial selection of suitable sealants is then made on the basis of their movement accommodation factors (MAFs).

However, it is important that the causes and nature of the expected movements are also considered, since these factors will influence the choice of sealants with a given MAF. For example, joints between thin metal or plastics components having little thermal inertia react rapidly to ambient temperature changes and to solar radiation. Movement joints between such components will move rapidly and therefore require an elastic sealant which is most able to accept such patterns of movement.

On the other hand, massive components having considerable thermal inertia will not respond appreciably to transient thermal effects, but rather to diurnal and seasonal cycles of change. The joints between these components therefore move slowly, so that sealants with a measure of stress relaxation are appropriate. Such sealants are described as elastoplastic and plastoelastic.

In joints in which movement is negligible, the sealant is usually acting only as a gap-filler and therefore the dynamic properties are not critical in the selection of the sealant. However, joints of this kind may be subject to small movements or to vibration deflections and in such cases an elastic or elastoplastic sealant is most appropriate.

3.3 Movement accommodation factor (MAF) and the calculation of the width of a butt joint

3.3.1 General. If a sealant is to perform its functions in the joint satisfactorily, it is essential that certain key factors are taken into account at the design stage. By adopting the procedure outlined here, the calculated value of the joint width will incorporate a factor of safety that takes account of the range of joint widths that will be achieved in practice and with which the sealant should perform adequately.

3.3.2 Inherent deviations. Inherent deviations arise from the properties of the materials from which the jointed components are formed. Dimensional changes in response to variations in temperature and moisture content are of primary importance.

The total movement (M) at each joint should be calculated from the available data regarding variations in climatic conditions and the properties of the components adjoining the joint.

NOTE Relevant information will be found in Building Research Establishment Digest Nos. 223, 227, 228 and 229.

The minimum width for the sealant (W_S), in mm, is given by:

$$W_S = \frac{M}{F} \times 100 \quad (1)$$

where

M is the total movement (in mm);

F is the movement accommodation factor.

3.3.3 Allowance for joint width at time of sealing. The designer often has to specify a joint width in the absence of any information about the climatic conditions at the time of sealing the joints. In the worst case, the sealant may have to be applied after the joints have closed to their minimum value in summer. To allow for this factor, the expression for the minimum joint width for the sealant given in equation 1 is modified as follows:

$$W_S = \frac{M \times 100}{F} + M \quad (2)$$

3.3.4 Induced deviations. The tolerances on component dimensions and inaccuracies that arise in placing components in position on the building are referred to as induced deviations. Taking account of these, the design width (W_D) for the joint becomes:

$$W_D = W_S + (d_1 + d_2) \tag{3}$$

where

d_1 and d_2 are the induced deviations ($\pm$) on the edge positions of the two jointed components (in mm).

In the convention adopted here a positive tolerance on either edge position reduces the joint width.

3.4 Working example of calculation of joint width. In the following example, it is assumed that the total movement at the butt joint is 4 mm and it is proposed to employ a sealant with a movement accommodation factor of 25 %. The tolerances on the edge positions of both the jointed components are 3 mm (see Figure 1).

$M = 4 \text{ mm}$
 $d_1 = d_2 = \pm 3 \text{ mm}$
 $F = 25 \%$

From equation (2)

$$W_S = \frac{4 \times 100}{25} + 4 = 20 \text{ mm}$$

From equation (3)

$$W_D = 20 + (3 + 3) = 26 \text{ mm}$$

The total joint width (W_{max}), in mm, is given by:

$$W_{\text{max}} = 26 + (3 + 3) = 32$$

Table 1 summarizes the range of achieved joint widths in the above example.

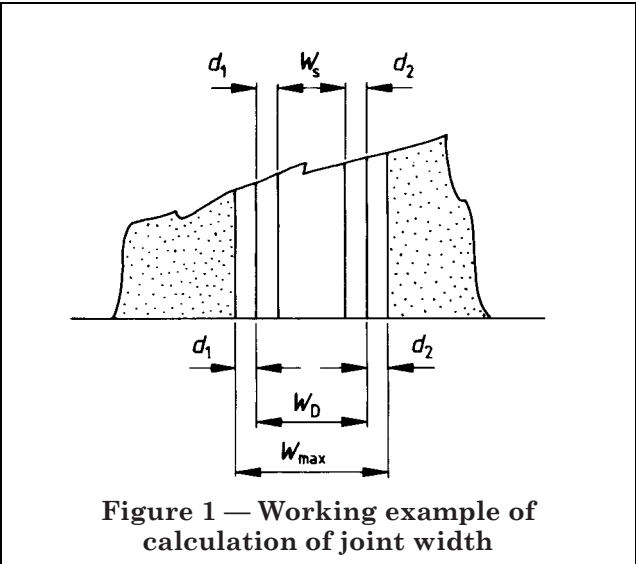


Table 1 — Range of achieved joint widths

Component edge positions	Joint closed	Joint open
	mm	mm
Maximum total joint width with positive induced deviations	20	24
Maximum total joint width with negative induced deviations	32	36

If the joint is sealed in summer when the narrowest joint width will be 20 mm, the total movement of 4 mm will be within the movement capacity of the sealant at that joint. If, however, the joints are sealed in winter, the maximum joint width will be 36 mm and it will be necessary to ensure that the sealant can be successfully applied to joints of up to this width without slumping.

3.5 Sealant geometry. Having considered the nature and causes of the movement at the joints, quantified the amount of the movement and selected a sealant with suitable dynamic properties and of adequate movement accommodation, it is necessary to consider the seal geometry required to achieve satisfactory performance of the sealed joint. The joint geometry, expressed as the ratio of width to depth of the sealant cross section, is related to the dynamic properties of the different types of sealant, with the object of minimizing the stresses induced in the sealant as a result of deformations caused by movement.

The preferred width to depth ratios for the different sealant types are:

Elastic sealants	2 : 1
Elastoplastic sealants	2 : 1 to 1 : 1
Plastoelastic sealants	1 : 1 to 1 : 2
Plastic sealants	1 : 1 to 1 : 3

Notwithstanding these ratios, care should be taken in narrow joints to ensure that the depth of the sealant is adequate, i.e. for porous substrates they should be a minimum of 10 mm, and for non-porous substrates they should be a minimum of 6 mm.

3.6 Sealant modulus. The modulus of a sealant at a stated degree of extension is a measure of the stiffness of the material and for many sealants this will tend to increase markedly at low temperatures. Sealants having high moduli may impose excessive stresses on the substrates to which they adhere and should therefore be avoided when specifying sealants for use with mortar and other materials likely to have weak surfaces. It should also be noted that for such sealants with high recovery properties (i.e. negligible stress relaxation), the persistence of high stresses at the sealant/substrate interface will increase the likelihood of this type of failure.

NOTE The modulus can only be assessed by laboratory evaluations, but changes in modulus may be indicated by changes in surface hardness measurements.

3.7 Maintenance. When specifying a sealant, the joint designer should give some thought to the need for maintenance and/or replacement of the sealant at some time during the expected lifetime of the building.

Lifetimes of the sealants themselves can only be estimated on the basis of current experience of their performance in service and on the assumption that the design of the joint, the erection of the jointed components and the application of the sealant have all been correctly performed (see Table 2).

The amount of exposure to weather, which is a function both of the locations of the building or structure and of the joint design, will also influence the effective life of the sealant in service.

In choosing between butt and lap joint designs, the designer should bear in mind that although the stresses imposed on the sealant will be lower for a lap joint to accommodate a given amount of movement, there may be more difficulty in applying the sealant and in removing and replacing it should this prove necessary, than for the equivalent butt joint solution.

Table 2 — Expected service life of sealant types

Types of sealant	Expected service life
Oleo-resinous Bitumen and rubber/bitumen Butyl	Up to 10 years
Acrylic (solvent) Acrylic (emulsion)	Up to 15 years
1-part polysulphide 1-part polyurethane Silicone 2-part polysulphide 2-part polyurethane	Up to 20 years
NOTE Under favourable conditions, the expected service life quoted above may be exceeded.	

Table 3 — Types of sealant failure and possible causes

Type of failure	Possible causes of failure						
	Incorrectly designed or formed joint or seal profile	Sealant unsuitable for joint type or service conditions	Excessive movement for width of joint or sealant type	Depth of seal	Inadequate surface preparation	Poor application technique	Incorrectly formulated sealant
Adhesion (including spalling)	X	X	X	X	X	X	X
Cohesive (splits, cracks)	X	X	X	X ^a X ^b		X	X
Excessive extrusion (during and after periods of joint closure)	X	X	X	X ^b		X	
Slumping (in vertical joints and horizontal joints in vertical plane)	X	X		X ^b		X	X
Folding and intrusion	X	X	X	X ^b			
Chemical attack (in specific environments, e.g. dairies and breweries)		X					
Displacement	X	X		X ^a	X	X	
^a Depth of seal too shallow.							
^b Depth of seal too deep.							

3.8 Performance in fire. The performance in fire of any structure or assembly of components containing a joint or joints sealed with a sealant may be assessed using the appropriate test procedures described in the various Parts of BS 476. The ratings so obtained will be applicable only to the particular combination of materials and components tested, so no specific fire ratings can therefore be attributed to a sealant alone.

3.9 Types and causes of failures

3.9.1 General. Common types of failure and their possible causes are given in the Table 3 and described in 3.9.2 to 3.9.10.

3.9.2 Adhesion failure. The most common type of failure is due to the failure of the bond between the sealant and the component material (see Figure 2).

3.9.3 Spalling. Although not a failure of the sealant itself, spalling has similar consequences to adhesion failure. It occurs when the cohesive strength of the sealant is greater than that of the surface layers of the material to which it is applied (see Figure 3).

3.9.4 Cohesion failure. Cohesion failure is a failure within the sealant material. The effect of movement is likely to make the failure progressive (see Figure 4).

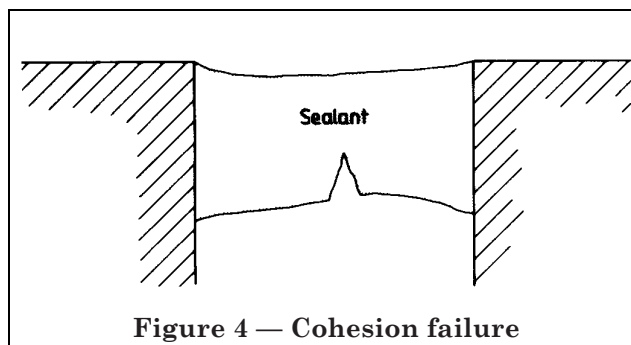


Figure 4 — Cohesion failure

3.9.5 Excessive extrusion. Excessive extrusion is ejection from the joint of part of the sealant, which becomes vulnerable to mechanical damage and impairs the future ability of the sealant remaining in the joint to perform its function.

3.9.6 Slumping. Slumping occurs when the sealant flows from its intended position owing to its own weight. This can commonly occur with joints that are excessively wide in relation to the rheological properties of the sealant. Excessive slumping constitutes a failure.

3.9.7 Folding. Folding occurs mainly with plastic and elastoplastic sealants under excessive movements, which result in permanent set. Subsequent movement leads to folding and to the progressive breakdown of the seal due to intrusion, removal of material, e.g. by traffic, or adhesion failure (see Figure 5).

3.9.8 Intrusion. Intrusion is common in horizontal joints in traffic areas and occurs when the sealant surface is penetrated by grit and debris. On subsequent closing, the grit is not ejected, causing abrasion and eventual failure of the sealant and in extreme cases impairing the functioning of the joint (see Figure 6).

3.9.9 Chemical attack. Chemical attack occurs mainly in specific aggressive environments, but it can also occur from the use of some cleaning materials and some decorative or other finishes.

3.9.10 Displacement. Displacement or removal of the sealant may occur by the scouring action of fast or turbulent water or by hydraulic pressure.

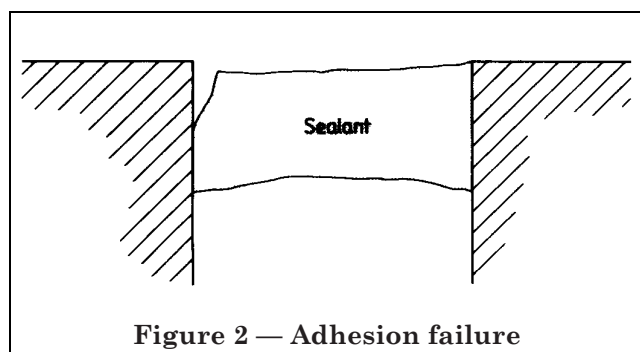


Figure 2 — Adhesion failure

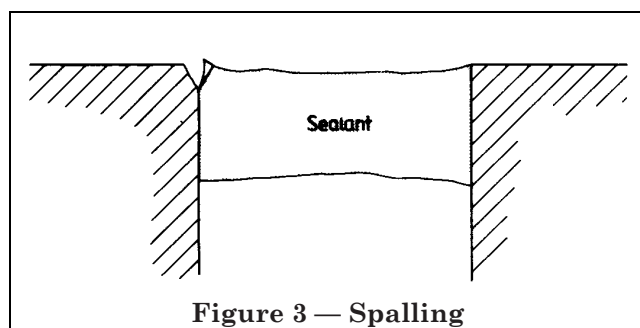


Figure 3 — Spalling