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Hot-applied joint sealant systems for concrete pavements —

Part 3: Methods of test

Committees responsible for this British Standard

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BAA plc
British Adhesives' and Sealants' Association
British Aggregate Construction Materials' Industries
British Cement Association
Concrete Society
County Surveyors' Society
Department of the Environment (Property Services Agency)
Department of Transport
Federation of Civil Engineering Contractors
Hot Extruded Sealant Association
Institution of Civil Engineers
Institution of Highways and Transportation
Coopted members

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Foreword

This Part of BS 2499 has been prepared under the direction of Technical Committee B/510, Road Materials. It supersedes the methods of test described in BS 2499:1973. Together with BS 2499-1:1993 and BS 2499-2:1992 it supersedes BS 2499:1973, which is withdrawn.

The specification for joint sealants is given in BS 2499-1:1993, and BS 2499-2:1992 is a code of practice for the application and use of joint sealants.

The tests are, as far as possible, related to practical conditions, and for this reason concrete test blocks, rather than mortar blocks, are specified for the extension test. Because of the many variables and the limited data available on the effects on adhesion of using different aggregates, a single coarse aggregate is specified for the blocks.

Exposure to excessive heat (e.g. jet blast) can have deleterious effects on all sealants but knowledge of this effect is very limited. Because of this the test method included in this standard is indicative of a minimum performance level only.

Requirements for cold-applied joint sealants are specified in BS 5212.

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

This British Standard 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.

Information on precision and traceability is given in Annex A.

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 and ii, pages 1 to 18, 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 Part of BS 2499 describes methods of test for hot-applied joint sealants for use in joints in roads, airfields and other concrete pavements.

2 References

2.1 Normative references

This Part of BS 2499 incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on the inside back cover. Subsequent amendments to, or revisions of, any of these publications apply to this Part of BS 2499 only when incorporated in it by updating or revision.

2.2 Informative references

This Part of BS 2499 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

For the purposes of this Part of BS 2499, the definitions given in BS 2499-1:1993 apply.

4 Preparation for testing

4.1 General

Precautions shall be taken during all the following operations to prevent local overheating of the sample and contamination by oil or other substances.

4.2 Apparatus

An oil bath employing a high flash point oil as the transfer medium shall be used for heating the joint sealant before pouring into test moulds. It shall have an inner container. The oil shall have a flash point of not less than 285 °C when measured in accordance with BS 6664-5:1990.

The inner container shall be made of metal, not thicker than approximately 1 mm and preferably formed by spinning or pressing. The joints, if any, shall be welded or brazed, and shall be leakproof. The container shall be approximately 100 mm in diameter and 150 mm deep. It may have a handle and shall be provided with a loose-fitting lid with facilities for allowing the admission of a stirrer and thermometer. A suitable design is shown in Figure 1a) and Figure 1b).

The oil bath, preferably constructed of sheet copper not thicker than 1.5 mm, shall have either a cylindrical recess into which the inner container fits loosely, or the inner container shall be suspended in the oil. The oil shall be free to circulate round the bottom and sides of the cylindrical recess, or the bottom and sides of the container, according to the design of apparatus adopted, to at least the same level as the level of the sealant.

If the inner container is suspended in the oil, no oil shall be allowed to come into contact with the sealant, when pouring the sealant.

Means for stirring continuously both the oil and the joint sealant being heated shall be provided. A suitable stirrer for stirring the sealant is shown in Figure 2.

4.3 Sample

For testing, obtain a sample of approximately 1 kg by taking, so far as is possible, equal and representative portions of each increment cut by means of a heated knife into about 50 pieces.

4.4 Procedure

Carry out the following procedure, except where stated otherwise in the individual tests.

a) Heat the oil bath, with the inner container fixed in position, until the oil is at a temperature approximately 30 °C above the manufacturer's minimum recommended pouring temperature for the sealant, or at the safe heating temperature for the sealant, whichever is the lower, and maintain it at this temperature until the requirements of d) below are met.

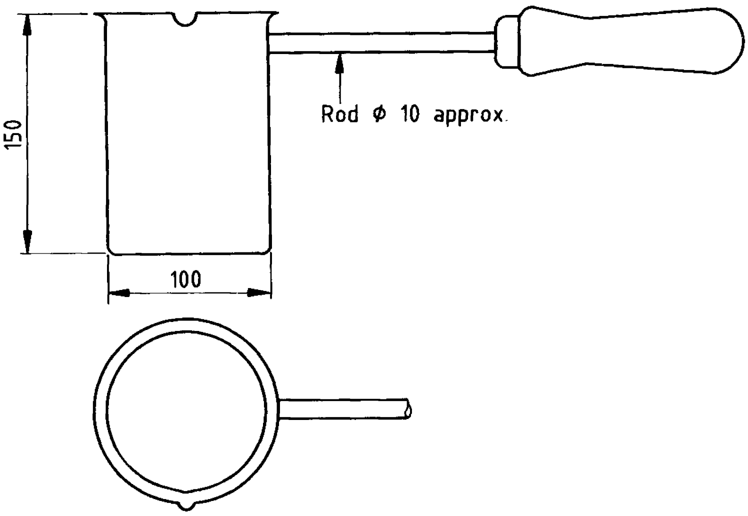
b) Place pieces of the sample in the inner container one at a time at approximately half-minute intervals starting when the temperature of the oil has reached at least the manufacturer's minimum recommended pouring temperature.

c) With the lid in position stir continuously both the oil and the material in the inner container.

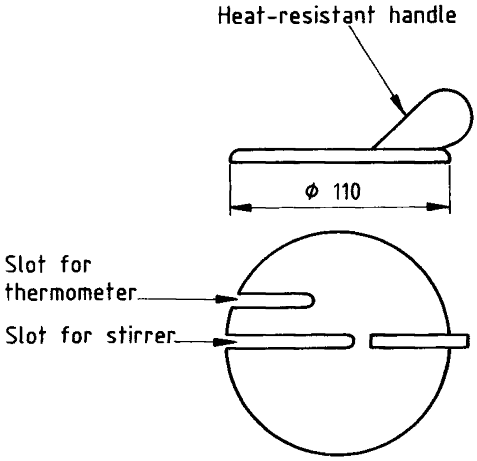
d) Heat the sample until it reaches 5 °C above the lower limit of the manufacturer's recommended pouring temperature. The time taken shall not exceed 1.5 h.

NOTE Time taken should normally be about 1 h.

e) Pour the test specimens into test moulds as soon as possible, in any case within 10 min of reaching the above temperature, taking care to avoid any contamination. Record the actual temperature at the end of pouring.



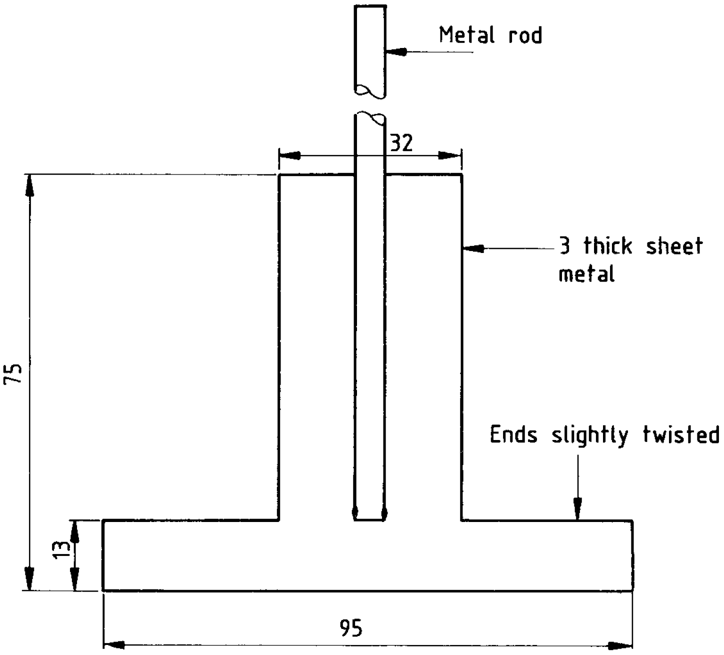
a) Inner container in which sample is heated for pouring of test specimens



All dimensions are in millimetres.

b) Lid for inner container

Figure 1 — Inner container



All dimensions are in millimetres.

Figure 2 — Suitable stirrer for stirring the sealant

5 Conditioning

Laboratory conditions, hereafter referred to as standard conditions, shall be at a temperature of (23 ± 2) °C, and (50 ± 10) % relative humidity.

6 Determination of flow resistance

6.1 Principle

The purpose of this test is to determine the resistance of joint sealants to flow in hot weather.

6.2 Apparatus

6.2.1 *Oven,* conforming to BS 2648:1955, capable of maintaining the specimen and apparatus at the test temperature of (60 ± 2.5) °C for N2 and F2 type sealants or (70 ± 2.5) °C for N1 and F1 type sealants.

6.2.2 *Metal frame,* with internal dimensions (40 ± 1) mm wide × (60 ± 1) mm long × (3 ± 0.1) mm deep.

6.2.3 *Aluminium plate,* not less than 60 mm wide × 80 mm long × 1.5 mm thick.

6.2.4 *Metal frame,* so designed to allow the aluminium plate containing the specimen to be mounted so that the longitudinal axis of the specimen is at an angle of (75 ± 2)° with horizontal and the transverse axis is horizontal.

6.2.5 *Stiff spatula.*

6.3 Preparation of sample

6.3.1 Prepare the sample of joint sealant as described in clause **4**.

6.3.2 Place the metal frame (**6.2.2**) on the aluminium plate (**6.2.3**) and fill the metal frame (**6.2.2**) with an excess of material.

6.3.3 After cooling for 1 h in air at standard laboratory conditions, trim the excess material in the frame (**6.2.2**) with a warmed spatula (**6.2.5**).

6.3.4 Remove the frame (**6.2.2**) and mark the existing profile of the sealant on the aluminium plate with an index line drawn parallel to and along the lower transverse edge of the test specimen.

6.4 Procedure

6.4.1 Place the other metal frame (**6.2.4**) in the oven (**6.2.1**) set at the required test temperature for 30 min before beginning the test.

6.4.2 Place the aluminium plate (**6.2.3**) containing the specimen on the metal frame (**6.2.4**), mounted so that the longitudinal axis of the specimen is at an angle of (75 ± 2)° with the horizontal and the transverse axis is horizontal. Maintain the temperature according to sealant type for 5 h ± 3 min.

6.4.3 After 5 h ± 3 min remove the assembly from the oven (**6.2.1**) and measure the movement of the lower transverse edge of the test specimen below the index line to the nearest 0.5 mm.

6.5 Expression of results

Express the results to the nearest 0.5 mm and report as the flow.

6.6 Test report

A test report, shall be completed in accordance with clause **18** of this standard.

7 Determination of flow resistance after heat degradation

7.1 Principle

The purpose of this test is to verify that the sealant still conforms to the requirements of this standard after extended heating.

7.2 Apparatus

The apparatus shall be as described in clause **6**.

7.3 Preparation of sample

7.3.1 Prepare a sample in accordance with clause **4** except that the heating period shall be extended to 6 h at the manufacturer's maximum recommended safe heating temperature.

7.3.2 Pour and condition and otherwise prepare the specimen in accordance with **6.3.2**, **6.3.3** and **6.3.4**.

7.4 Procedure

Test the specimen in accordance with **6.4** and **6.5** and report the results as the flow.

7.5 Test report

A test report shall be completed in accordance with clause **18** of this standard.

8 Determination of penetration

8.1 Principle

The test for penetration of the sealant is based upon BS 2000-50. The purpose of this test is to determine the penetration and recovery of hot-applied sealants.

8.2 Apparatus

8.2.1 *Metal container,* in which the specimen is tested, cylindrical in shape and having a flat bottom with a nominal capacity of 100 g. Its inside dimensions are nominally 56 mm in diameter and 35 mm in depth.

To facilitate pouring the right amount, a mark is made at a depth of 30 mm.

8.2.2 *Penetration cone,* constructed of stainless steel or brass and conforming to the dimensions shown in either Figure 3a or Figure 3b. Both types of cone have a smooth polished finish to the outside surface and the tip. The total moving mass of the cone and attachments is (150 ± 0.1) g.

8.2.3 *Water bath,* maintained at a temperature of (25 ± 0.1) °C, containing not less than 10 l of water and with a perforated shelf not less than 50 mm from the bottom of the bath. The specimen is immersed so that there is a depth of not less than 50 mm of water above it, when it is supported on the shelf.

8.2.4 *Penetration apparatus,* which will allow the cone to penetrate without appreciable friction, and which is accurately calibrated to measure the distance that the cone will penetrate vertically into the specimen of material at 25 °C in 5 s. The penetration is measured in millimetres.

NOTE A penetrometer conforming to BS 2000-50 has been found to be suitable.

8.2.5 *Transfer dish,* for the container, being a glass or metal cylinder with a flat bottom provided with means to ensure a firm bearing and prevent rocking of the container. The dish has a minimum inside diameter of 90 mm and a minimum depth above the bottom bearing of 56 mm.

8.2.6 *Two cleaning cloths.*

8.3 Preparation of sample

8.3.1 Prepare the sample in accordance with clause **4**.

8.3.2 Pour a subsample into the metal container (**8.2.1**) to a depth of at least 30 mm.

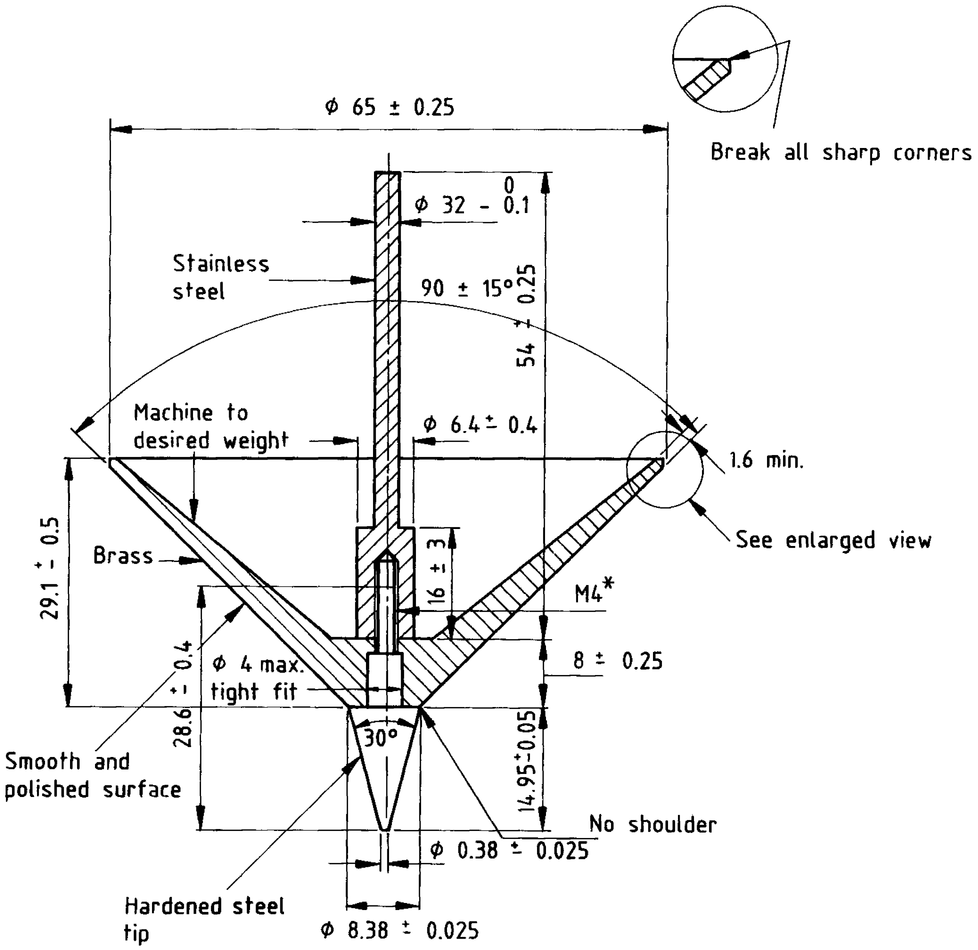
8.3.3 Loosely cover the container (**8.2.1**) and its contents as a protection against dust and allow to cool in air at a temperature of (23 ± 2) °C for (1.75 ± 0.25) h.

8.3.4 Place the container of subsample in the water bath (**8.2.3**) along with the transfer dish (**8.2.5**) and allow it to remain immersed for (1.75 ± .025) h.

8.4 Procedure

8.4.1 After the period of immersion in the water bath (**8.2.3**), place the specimen in the transfer dish (**8.2.5**) filled with water from the water bath (**8.2.3**) to sufficient depth to cover the metal container (**8.2.1**) completely.

8.4.2 Take the transfer dish (**8.2.5**) containing the specimen out of the water bath (**8.2.3**), place it on the stand of the penetration apparatus (**8.2.4**) and test within 1 min.

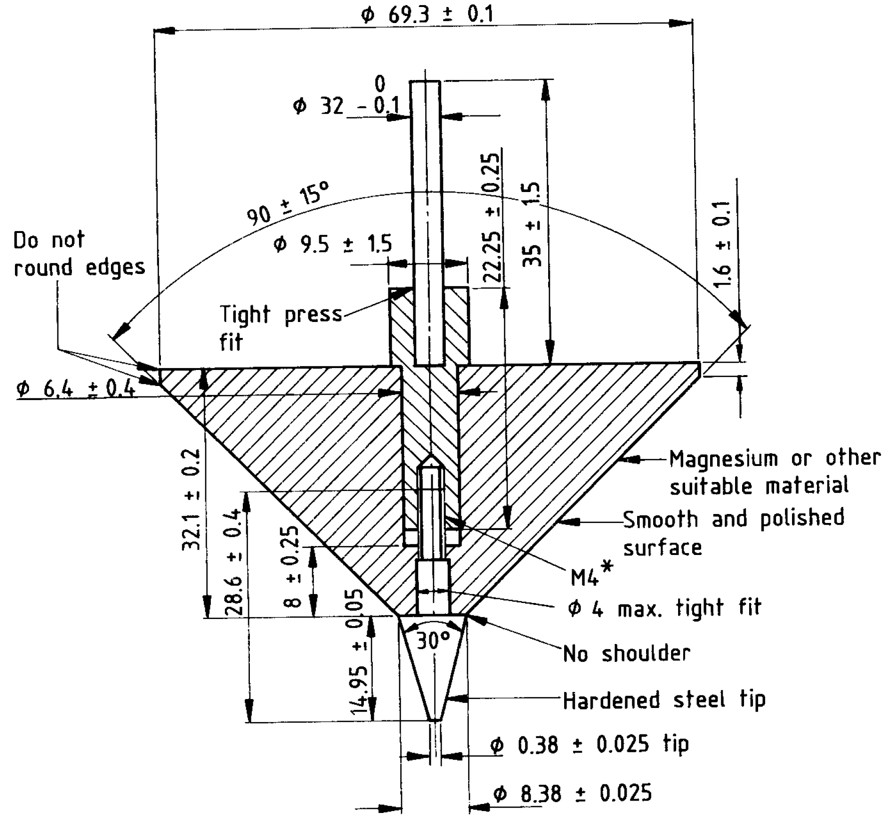


*In accordance with BS 3643 : Part 1 : 1981.

All dimensions are in millimetres.

a) Cone for penetration test

Figure 3 — Cones for penetration test



*In accordance with BS 3643 : Part 1 : 1981

b) Alternative cone for penetration test

Figure 3 — Cones for penetration test (*concluded*)

8.4.3 Adjust the penetration cone (**8.2.2**), which is also at a temperature of about 25 °C, so that the tip just makes contact with the surface of the specimen. Release the cone (**8.2.2**) for 5 s, secure it and measure the distance penetrated.

8.4.4 Make three determinations at points on the surface of the specimen not less than 16 mm from the side of the container (**8.2.1**) and from each other.

8.4.5 Between determinations, return the specimen and transfer dish (**8.2.5**) to the water bath (**8.2.3**) while carefully wiping the tip of the cone (**8.2.2**) clean with a clean cloth moistened with toluene, followed by a clean dry cloth (**8.2.6**).

8.4.6 If the result of any determination differs from the average of the three determinations by more than ± 0.5 mm, discard the results and repeat the test on a fresh subsample.

8.5 Expression of results

Report the penetration as the average, calculated to the nearest millimetre, of the three determinations.

8.6 Test report

A test report shall be completed in accordance with clause **18** of this standard.

9 Determination of penetration after heat degradation

9.1 Principle

The purpose of this test is to verify that the sealant still conforms to the requirements for penetration given in this standard after prolonged heating for the maximum period at the maximum temperature permitted in the manufacturer's instructions for use.

9.2 Apparatus

The apparatus shall be as described in clause **8**.

9.3 Preparation of sample

9.3.1 Prepare the sample in accordance with clause **4**, with the exceptions specified in **9.3.2** to **9.3.4**.

9.3.2 Heat the oil bath, with the lidded inner container fixed in position, until the oil is at a temperature of not more than 30 °C above the manufacturer's recommended safe heating temperature for the joint sealant. Maintain it as nearly as possible at this temperature until the sealant approaches the recommended safe heating temperature. Then adjust the temperature of the oil so that the sealant is maintained at the manufacturer's recommended safe heating temperature for the duration of the heating period.

9.3.3 Measure the heating period for the subsample from the moment when the sample reaches the lower limit of the manufacturer's recommended pouring temperature.

9.3.4 The duration of the heating period at the manufacturer's recommended maximum safe heating temperature shall be 6 h ± 15 min.

Immediately pour the specimens for the penetration tests and condition in accordance with **8.3.3** and **8.3.4**.

9.4 Procedure

Test the specimens in accordance with **8.2** to **8.5** of this standard.

9.5 Test report

A test report shall be completed in accordance with clause **18** of this standard.

10 Determination of penetration after fuel immersion

10.1 Principle

The purpose of this test is to verify that the properties of fuel-resistant type sealants do not deteriorate to an unacceptable degree as the result of contact with spilt fuel or oil.

NOTE The standard test fuel will give results which indicate the probable behaviour of a sealant coming into contact with the usual fuel and lubricating oils, but provision is made for the test to be carried out with a different fluid if the standard fuel is not representative of a particular type of spillage.

CAUTION. Attention is drawn to the Health and Safety at Work etc. Act 1974, and the need to ensure that this test is carried out under suitable environmental conditions to provide adequate protection to personnel against the risk of fire, inhalation of smoke and/or toxic products of combustion.

10.2 Apparatus

10.2.1 *Small container,* made of 1 mm metal sheet. Its nominal internal dimensions are 150 mm × 150 mm × 150 mm deep and it has a closely fitting lid which can be sealed with adhesive tape.

10.2.2 *Standard fuel,* being a mixture of 70 % iso-octane (V/V) having the properties shown in Table 1, with a 30 % (V/V) industrial grade toluene.

Table 1 — Properties of iso-octane[a]

Octane number	100 ± 0.1
Density at 20 °C, g/ml	0.691 93 ± 0.000 15
Refractive index, N_D	1.391 45 ± 0.000 15
Freezing point, °C	– 107.442 min.
Distillation: 50 % recovery, °C	99.238 ± 0.025
Increase from 20 % and 80 % recovery, °C	0.020 max.

NOTE Alternatively, if agreed between the purchaser and the supplier, a special fluid may be substituted, but the other conditions of the test shall not be varied.

[a] Technically identical with the ASTM knock test reference fuel.

10.2.3 *Adhesive tape.*

10.3 Preparation of sample

Prepare the sample in accordance with **6.3**.

10.4 Procedure

10.4.1 Place the test specimen, in its container, in the small container (**10.2.1**) and pour in standard fuel (**10.2.2**) to a depth of 100 mm. Seal the lid with adhesive tape (**10.2.3**).

10.4.2 Maintain the container (**10.2.1**) at a temperature of (23 ± 2) °C for a period of (24 ± 1) h. After removal from the fuel (**10.2.2**), dry the specimen in a stream of air having an average velocity of between 90 m/min and 150 m/min, as defined in BS 5060:1987, at standard conditions for 1 h.

10.4.3 Test the specimen in accordance with **6.4**.

10.5 Test report

A test report shall be completed in accordance with clause **18** of this standard.

11 Determination of resistance to fuel immersion (solubility)

11.1 Principle

The purpose of this test is to verify that the properties of fuel-resistant type sealants do not deteriorate to an unacceptable degree as the result of contact with spilt fuel or oil.

NOTE 1 This test applies to types F1 and F2 sealants.

NOTE 2 The standard test fuel will give results which indicate the probable behaviour of a material coming into contact with the usual petroleum fuel, but provision is made for the test to be carried out with a different fluid if the standard fuel is not representative of a particular type of spillage.

CAUTION. Attention is drawn to the Health and Safety at Work etc. Act 1974, and the need to ensure that this test is carried out under suitable environmental conditions to provide adequate protection to personnel against the risk of fire, inhalation of smoke and/or toxic products of combustion.

11.2 Apparatus

11.2.1 *Laboratory balance,* capable of weighing up to 400 g of sample to an accuracy of 0.01 g.

11.2.2 *Controlled environment,* capable of maintaining prepared specimens and fuel immersion containers at (23 ± 2) °C.

11.2.3 *Small containers,* made of 1 mm metal sheet of nominal internal dimensions 150 mm × 150 mm × 150 mm deep with a closely fitting lid which can be sealed with adhesive tape.

11.2.4 *Standard fuel* (see **10.2.2**).

11.2.5 *Water bath.*

11.2.6 *Fan,* 300 mm diameter, conforming to BS 5060-1987.

11.2.7 *Adhesive tape.*

11.3 Preparation of sample

Prepare one sample in accordance with **8.3**.

11.4 Procedure

11.4.1 Weigh the specimen to the nearest 0.01 g and note the initial weight (*IW*).

11.4.2 Place the specimen in the small container (**11.2.3**) and pour in standard test fuel (**11.2.4**) to a depth of 100 mm, sealing the lid with the adhesive tape (**11.2.7**).

11.4.3 Place the sealed container in a water bath (**11.2.5**) at a constant temperature of (50 ± 1) °C for F1 type sealants and (35 ± 1) °C for F2 type sealants, for a period of (24 ± 1) h.

11.4.4 After removing the specimens from the fuel (**11.2.4**), dry the specimen in a stream of air having an average velocity of (120 ± 30) m/min, as defined in BS 5060:1987 at standard conditions for 1 h.

11.4.5 Weigh the specimen after drying and record as the final weight (*FW*).

11.5 Calculation of results

Calculate the change in weight C (as %) from the equation:

$$C = \left(\frac{IW - FW}{IW}\right) 100$$

where

IW is the initial weight (in g);

FW is the final weight (in g);

11.6 Test report

A test report shall be completed in accordance with clause **18**.

12 Determination of resilience

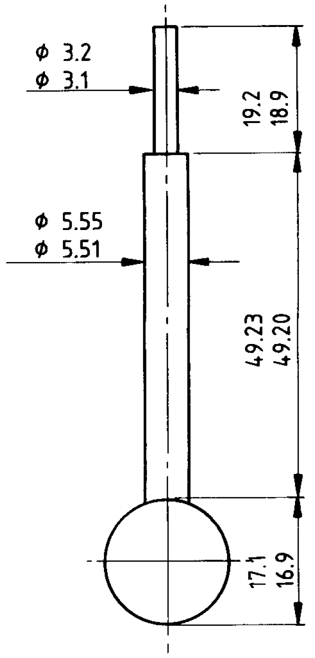
12.1 Principle

The purpose of this test is to determine the resilience of hot poured joint sealants using a standard penetrometer with a ball penetration tool.

12.2 Apparatus

12.2.1 *Penetrometer,* conforming to BS 2000-50:1985, in which the penetration cone has been replaced with a ball penetration tool (**12.2.2**).

12.2.2 *Ball penetration tool,* as shown in Figure 4, made of steel. The total mass of tool and standard penetrometer plunger is (75 ± 0.1) g.



All dimensions are in millimetres.

Figure 4 — Ball penetration tool

12.2.3 *Two metal containers,* having flat bottoms and measuring 70 mm in diameter × 45 mm in depth.

12.2.4 *Talcum powder.*

12.2.5 *Luminaire.*

12.3 Preparation of sample

12.3.1 Prepare the sample in accordance with clause **4**.

12.4 Procedure

12.4.1 Fill the two metal containers (**12.2.3**) with the specimen so that it is flush with the rim of the container.

12.4.2 Condition the specimens in accordance with **8.3.3** and **8.3.4**, except that the specimens be lidded prior to immersion in the water bath (**8.2.3**).

12.4.3 Remove the specimen from the water, remove the lid and perform the test immediately.

NOTE Do not test under water.

Lightly coat the surface of the specimen with talcum powder (**12.2.4**), any excess being removed by blowing.

12.4.4 Position a light (**12.2.5**) so that initial contact of the ball of the penetration tool (**12.2.2**) with the surface of the specimen can be observed readily.

12.4.5 Place the ball in contact with the surface of the specimen and set the indicating dial to zero.

12.4.6 Release the clutch for a period of (5 ± 0.1) s, thus allowing the ball to penetrate the specimen. Record the reading in millimetres to 0.1 mm as the initial ball penetration (*P*).

12.4.7 Without returning the dial pointer to zero, release the clutch and press the ball penetration tool (**12.2.2**) down an additional 10 mm (i.e. to a reading of $P + 10$ mm) at a uniform rate of 10 s.

12.4.8 Re-engage the clutch, thereby holding the ball in this position for a further 5 s and during this time push up the upper shaft of the penetrometer (**12.2.1**) until the dial reads zero.

12.4.9 Release the clutch and with the ball still supported by the specimen, allow the specimen to recover for 20 s and then re-engage the clutch.

12.4.10 Push down the upper shaft of the penetrometer (**12.2.1**) until it is in contact with the plunger and measure and record the final penetration (*F*) in millimetres to ± 0.1 mm.

12.4.11 Carry out the procedure at three points equally spaced and not less than 10 mm from each other and from the container rim.

12.5 Calculation and expression of results

Calculate the recovery *R* (as %) from the equation:

$$R = (P + 10 - F)\,\frac{100}{10}$$

where

P is the initial ball penetration (in mm);

F is the final penetration (in mm).

Record the recovery as the average of the three determinations and express it to the nearest 1 %.

Record the initial ball penetration, *P*, and the final penetration, *F*, to the nearest 0.1 mm.

12.6 Oven-aged specimen

Further condition the specimen in a forced draft oven conforming to BS 5060:1987, maintained at a temperature of (70 ± 1) °C for (24 ± 1) h. Cool the specimen in air at standard conditions followed by conditioning in a water bath maintained at (25 ± 1) °C for 1 h prior to testing.

Test the specimen in accordance with **12.4** and **12.5**.

12.7 Test report

A test report shall be completed in accordance with clause **18**.

13 Bond testing: Determination of adhesion and cohesion following extension and compression

13.1 Principle

The purpose of this test is to establish whether the sealant will remain cohesive and will continue to adhere to concrete (primed if the manufacturer of the sealant so recommends) when subjected to a comparatively rapid extension of 75 % followed by recompression and a second extension of the same amount at a temperature of – 20 °C in the case of types N1 and F1 and 0 °C in the cases of types N2 and F2 materials.

13.2 Preparation of concrete test blocks

13.2.1 ***Apparatus***

13.2.1.1 *Metal moulds,* preferably steel or cast iron, stout enough to resist distortion and of internal dimensions (50 ± 0.15) mm square and approximately 250 mm long, with holes for 10 mm bolts in the ends (see Figure 5).

13.2.1.2 *Two steel bolts* (per pair of test blocks), 10 mm size 76 mm to 80 mm in length, threaded one end and provided with two nuts per bolt, with shank split and splayed (in lieu of the normal bolt head) to form an anchorage in the concrete test block as shown in Figure 5.

13.2.1.3 *Sieves,* conforming to BS 410:1986.

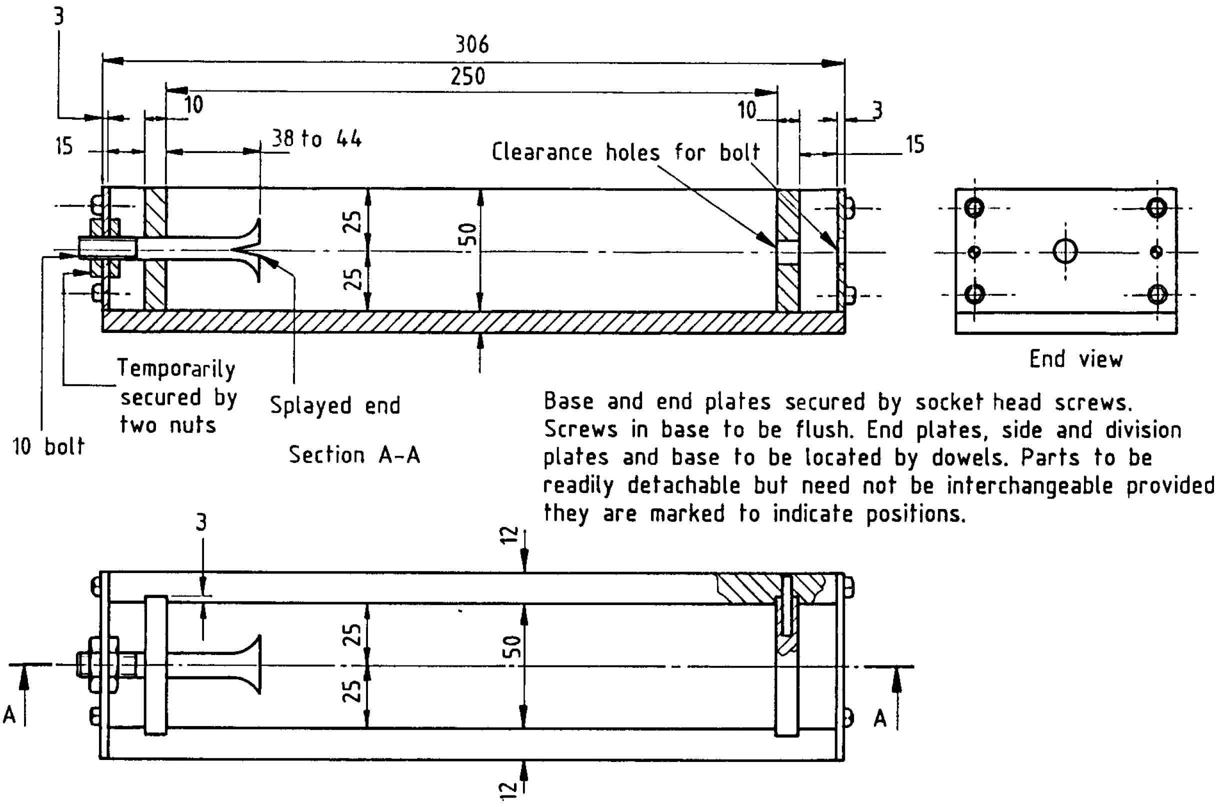
13.2.1.4 *Vibrating table.*

13.2.1.5 *Concrete saw.*

13.2.1.6 *Oven,* capable of maintaining a temperature of (105 ± 5) °C.

13.2.1.7 *Dessicator.*

13.2.1.8 *Cabinet,* capable of maintaining a temperature of 20 ± 2 °C and a relative humidity greater than 90 %.



Base and end plates secured by socket head screws. Screws in base to be flush. End plates, side and division plates and base to be located by dowels. Parts to be readily detachable but need not be interchangeable provided they are marked to indicate positions.

All dimensions are in millimetres.

Figure 5 — Typical mould for concrete test blocks

13.2.2 ***Materials for concrete***

13.2.2.1 *Coarse aggregate,* composed of crushed quartzite rock containing not more than 5 % of carbonate, conforming to BS 882:1992 and having a water absorption of less than 1.5 % when tested in accordance with BS 812-2:1975. Determine the carbonate content in accordance with the method described in BS 12:1991 for fine aggregate.

Use only coarse aggregate, all passing a 20 mm sieve (**13.2.1.3**) and being substantially retained on a 5 mm test sieve conforming to BS 410:1986. The amount passing a 75 μm test sieve determined by wet sieving in accordance with BS 812-103.1:1985 shall not exceed 0.5 % mass of total coarse aggregate.

13.2.2.2 *Fine aggregate,* composed of a natural siliceous sand, and conforming to the following requirements.

a) The carbonate content shall not exceed 5 %.

b) The particle size distribution shall conform to Table 4, (grading M) and **5.2** of BS 882:1992 except that the amount passing a 75 μm test sieve, determined by wet sieving in accordance with BS 812-103.1:1985, shall not exceed 2 % of the total fine aggregate.

c) The water absorption shall be not less than 1.5 % when tested in accordance with BS 812-2:1975.

13.2.2.3 *Portland cement,* conforming to BS 12:1991.

13.2.3 ***Drying***

Dry the aggregate in accordance with BS 812-2:1975. If not used immediately after it has cooled, store the aggregate in an airtight container.

13.2.4 ***Proportioning***

Use the following proportions (m/m) of cement, aggregate and water:

cement	1 part
aggregate	6 parts
water	0.6 part

Take sufficient fine aggregate so that it comprises between 35 % (m/m) and 45 % (m/m) of the total aggregate, the exact percentage being determined by an initial trial with a batch of sufficient size to obtain slump and workability as follows.

Adjust the grading and proportion of the coarse and fine aggregates by experiment until a true slump[1] of between 15 mm and 50 mm, determined in accordance with BS 1881-102:1983, is obtained with concrete which an experienced operator considers reasonably workable.

13.2.5 ***Mixing***

Mix the concrete either by machine, or, if not more than three specimens are required from the batch, by hand.

If mixed by machine, put the aggregate and cement in the mixer first, followed by the water, and mix the whole for 3 min.

If mixed by hand, first mix the cement and aggregate on a non-porous surface for 1 min or until the mixture is uniform; then add the water and mix the whole for 3 min with two trowels.

13.2.6 ***Casting***

Cast the blocks within 30 min of the mixing of the concrete. Transfer the concrete to the mould (**13.2.1.1**) in two approximately equal quantities placed in layers and compact each layer by vibration on a suitable vibrating table (**13.2.1.4**) in such a manner that full compaction is obtained without the occurrence of segregation or excessive laitance. Alternatively, compact layers by hand tamping. Smooth the top of the concrete with a trowel.

13.2.7 ***Storage***

Immediately after casting, put the blocks in their moulds in an atmosphere of at least 90 % r.h. at a temperature of (20 ± 2) °C. After 24 h remove the blocks from their moulds, grease the bolts (**13.2.1.2**) or, preferably, dip them in paraffin wax, and submerge the blocks in water at a temperature of (20 ± 2) °C for a total of at least 27 days. When required for use, remove them from the tank and wipe clean of mould oil using a cloth moistened with a small amount of trichloroethylene.

13.2.8 ***Cutting***

Cut the blocks at any time after 14 days in the water.

Cut the blocks into two parts, each approximately 125 mm in length, by means of an impregnated diamond concrete saw (**13.2.1.5**). Discard any block that becomes damaged by ravelling of the edge during sawing or saw again to a shorter length of not less than 110 mm. Then immediately resubmerge the blocks in water for the balance of the 27 days or longer, until required for testing. Before resubmerging, wash the concrete in trichloroethylene to remove oil and similar adherent matter taking care to avoid cleaning the grease or wax from the bolts or other means of fixing used.

13.2.9 ***Conditioning of test blocks***

Prepare the test blocks under accurately controlled conditions so that the residual moisture content of each block, expressed as a percentage by mass of the concrete when dried at a temperature of 105 °C for 48 h, is (5 ± 0.5) %. Achieve this as follows.

Take the sawn test blocks, at least 28 days old, from the water, and dry in an oven (**13.2.1.6**) at (105 ± 5) °C for 48 h. Then place in a desiccator (**13.2.1.7**) over anhydrous calcium chloride to cool for a minimum of 4 h and determine and record the mass. Then store in air in the laboratory at room temperature and humidity.

When required for use, submerge the test blocks in water maintained at (20 ± 2) °C for 24 h. Then remove from the water, and wipe the surfaces dry with clean absorbent cloth or filter paper. Allow the blocks to stand for (1 ± 0.25) h in the laboratory at normal room temperature and humidity. Weigh the blocks and calculate their moisture contents. Deduct the mass of the bolt or other means of fixing used (to the nearest gram) from both the dry mass and the mass, after conditioning in water for 24 h and standing in the laboratory for 1 h.

Reject any blocks which have moisture contents outside the limits of (5 ± 0.5) %.

13.3 Preparation of test specimens

13.3.1 ***Application of primer***

If a primer is used, apply it to the sawn test faces of the concrete blocks either in accordance with the manufacturer's instructions, or by using a clean stiff brush to brush the primer well on and then brush off the excess, so as to produce the thinnest possible film. Always use clean equipment, taking care to avoid contamination with surface active agents, grease etc. Ensure that the primer gives a continuous coating all over the face and extends 3 mm over all the edges.

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[1] A true slump is one in which the concrete remains substantially intact and retains a symmetrical shape.

13.3.2 *Drying*

Treat the primed blocks in accordance with the manufacturer's instructions or, in the absence of these, store in a dust-free atmosphere at room temperature until dry. In drying, do not place the primed blocks in an enclosed space which would hinder the drying of the primer. Use a short drying time (and, in any case, pour the compound within 16 h).

13.4 Test method

13.4.1 *Apparatus*

13.4.1.1 *Test jig,* constructed in mild steel, as illustrated in Figure 6.

13.4.1.2 *Extension apparatus,* able to accept and test within the working space at least three specimens at a time. It is essential that the performance of the test machine shall not be significantly affected by the number of specimens, differences in their lengths within the specified limits of 240 mm to 280 mm or by the premature failure of one or more specimens.

13.4.1.3 *Extension devices,* which shall be as follows:

a) motor driven through positive drives without slip or significant backlash, so that cycles of extension and compression are carried out steadily and automatically;

b) capable of moving blocks smoothly and linearly, so that their alignment is maintained at all times and the specimens are not subjected to torsion, bending, shocks or significant vibration;

c) capable of exerting on each specimen a tensile force and of extending each specimen uniformly under the specified conditions as described in **13.4.2.3**, **14.4** and **15.4.3** at a rate of (6 ± 0.25) mm/h;

d) capable of exerting a compressive force in order to compress each specimen uniformly under all specified conditions to its original length.

13.4.1.4 *Cooling chamber,* capable of reducing the temperature of a full complement of specimens to – 20 °C in not more than 4 h and then holding the specimens at (– 20 ± 1) °C for at least 36 h. In the working space the temperature variation, fluctuation and drift shall not exceed the limits given in BS 2648:1955.

Fit a maximum/minimum temperature indicator with its bulb or sensor as nearly as practicable at the point where the temperature fluctuation is known to be greatest or, failing such information, in the centre of the horizontal plane through the top of the highest specimen.

NOTE A suitable type of instrument is an alcohol-in-glass registering thermometer operating on the principle of a six's pattern thermometer but with the bulb extended through the wall of the cabinet and protected by means of a perforated tube of corrosion-resistant metal. The scale should be calibrated in divisions of 1 °C down to – 25 °C and should be correct to ± 0.5 °C under the conditions of use. Alternatively, an electronic device of equal sensitivity may be used.

13.4.1.5 *Force measuring device.* Fit a device outside the chamber capable of measuring with an accuracy of ± 1 N up to 100 N and with an accuracy of ± 1 % therafter the maximum tensile force applied to each specimen.

13.4.2 *Procedure*

13.4.2.1 *Placing blocks in jig*

Cover the inner faces of the test jig (**13.4.1.1**) with polytetrafluoroethylene (PTFE) about 0.025 mm thick, so as to prevent the poured sealant from adhering to them. Place the prepared concrete blocks in the jig (**13.4.1.1**), with sawn test face inwards, and firmly secure in position so that the two blocks are in line with each other and are (24 ± 0.5) mm apart.

13.4.2.2 *Pouring*

Allow the assembly to stand at (23 ± 2) °C for 15 min, after which pour the sealant melted in accordance with clause **4**, in one operation, into the space between the blocks in sufficient quantity to provide a small excess of material at the top of the test joint after cooling.

NOTE Some materials undergo a large shrinkage on cooling and it may be necessary to provide a rectangular shield of thin metal above the joint to enable sufficient material to be poured to allow for shrinkage.

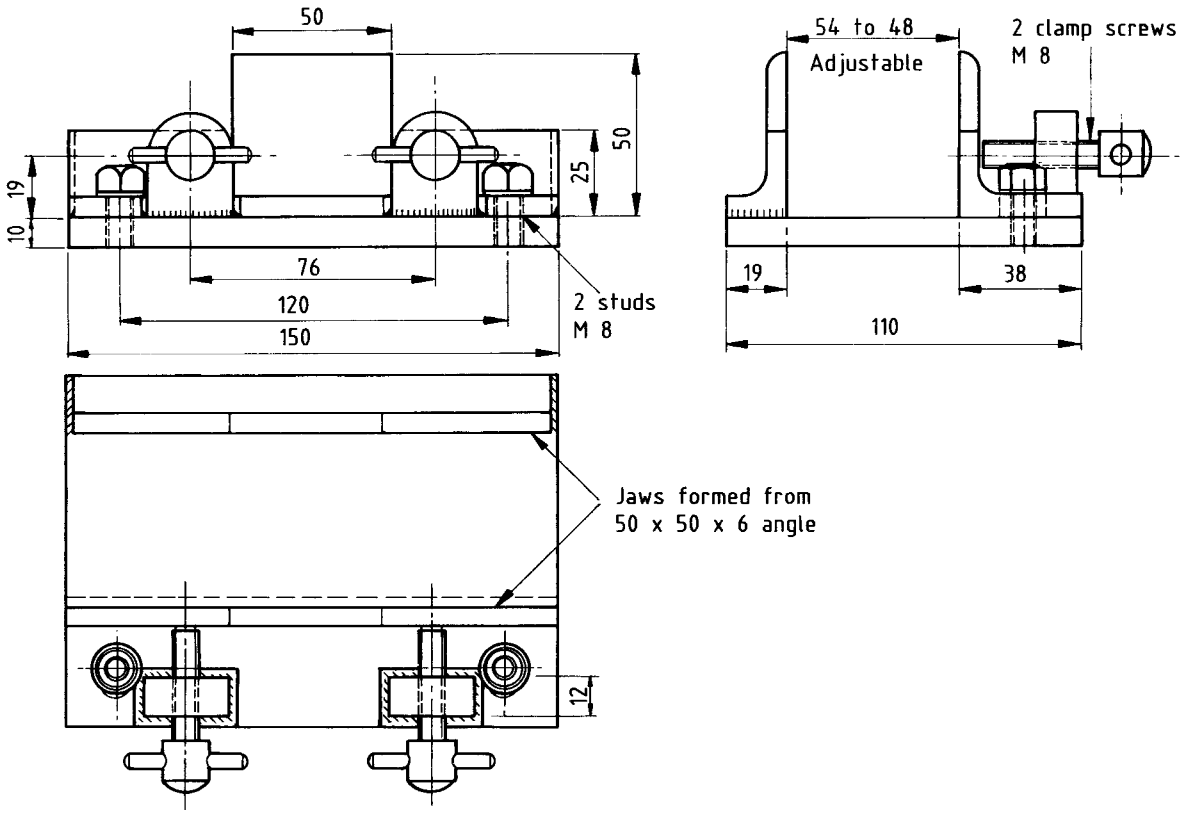
If the surface of the sealant shrinks below the top of the joint, discard the specimen.

Take care to prevent the temperature of the material falling below the specified pouring temperature during this operation.

13.4.2.3 *Extension*

Allow the specimen to cool for at least 2 h in still air at (23 ± 2) °C. Leave the concrete blocks together with test joint fixed in the jig (**13.4.1.1**) and firmly fix the whole assembly in the clamps of the extension apparatus (**13.4.1.2**). Slacken the clamps and remove the jig (**13.4.1.1**).

Arrange the apparatus so that the jigged specimens can be inserted into the clamps conveniently and without disturbing the specimens before, during or after the removal of the jig (**13.4.1.1**.)



All dimensions are in millimetres.

Figure 6 — Jig for pouring and handling of extension test specimen

Reduce the temperature of the atmosphere surrounding the test joint to (– 20 ± 1) °C for type N1 and type F1 and (0 °C ± 1) °C for type N2 and F2 compounds, and maintain at these temperatures respectively for at least 6 h and during the test.

NOTE Only the specimens and clamps should be subject to low temperature motors, and drivers should be situated outside the cold chamber.

If still adhering to the compound, remove the PTFE.

Extend the test joint 18 mm at a uniform rate of (6 ± 0.25) mm/h. After extending this distance, compress the specimen immediately at the same uniform rate and at the same temperature to its original dimensions without removal from the machine. Subject the specimen to a second and third extension carried out under the same conditions as those described above. Note the maximum force reached in each operation. Test three specimens. If any one fails, test a further three specimens all of which shall pass.

13.4.2.4 *Examination of specimens*

At the end of the third extension, immediately examine the specimen for failure in adhesion and cohesion. Typical failures are illustrated in Figure 7.

NOTE The specimen should not be examined during the test if the examination is likely to affect the result.

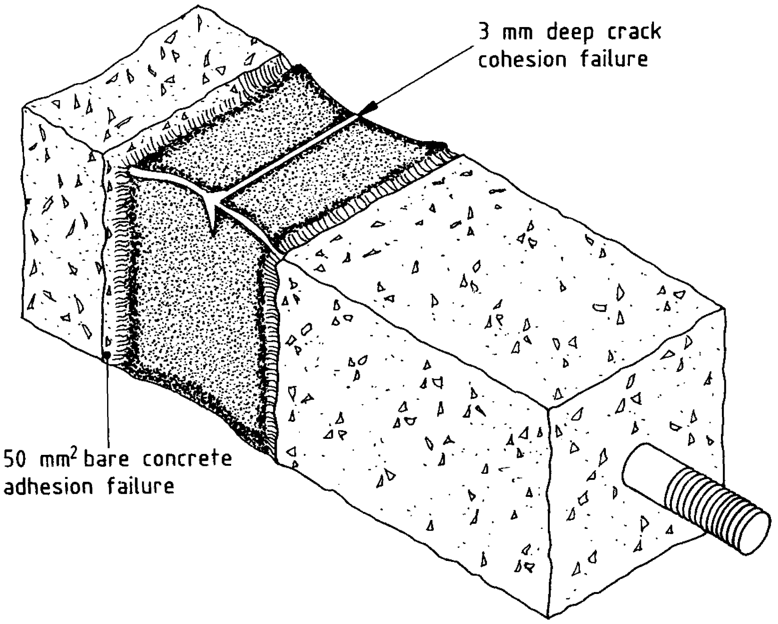


Figure 7 — Typical failures in extension test

13.4.3 ***Test report***

A test shall be completed in accordance with clause **18**. The test results shall be reported as follows:

a) the maximum tensile force to the nearest N;

b) adhesion, i.e. the sum of the areas on the faces of the concrete block from which the material has completely separated, to the nearest 20 mm^2;

c) cohesion; i.e. the sum of the superficial areas of any ruptures on the faces of the material to the nearest 5 mm^2. Report any cavity exceeding 3 mm in depth, measured normal to the face of the specimen.

14 Bond testing: Determination of adhesion and cohesion following extension and compression after heat degradation

14.1 Principle

The purpose of this test is to determine the adhesion and cohesion of hot-applied sealants when subjected to alternate cycles of tension and compression after heat degradation.

14.2 Apparatus

The apparatus shall be as described in clause **13**.

14.3 Preparation of sample

Prepare the sample in accordance with **9.3.1** and **9.3.2**.

14.4 Procedure

Condition and test the specimens in accordance with clause **13**.

14.5 Test report

A test report shall be completed in accordance with clause **18**.

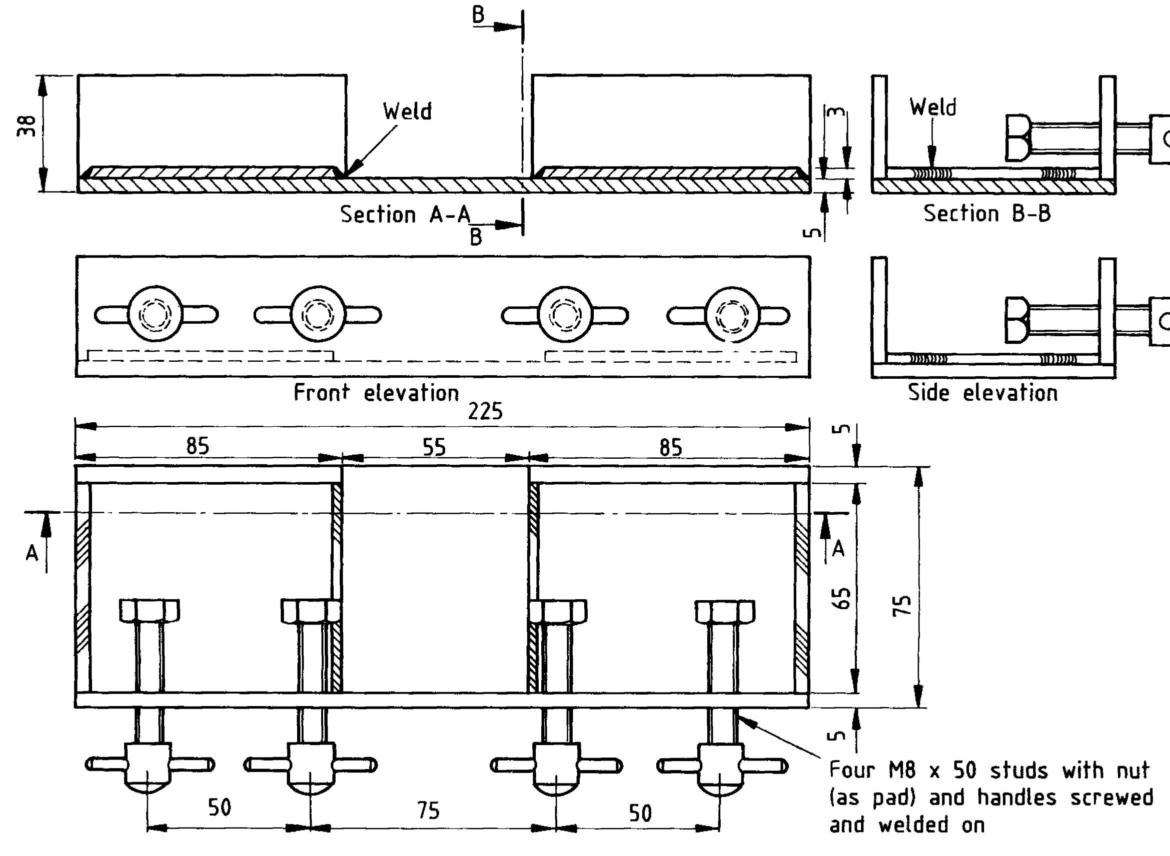
15 Bond testing: Determination of adhesion and cohesion following extension and compression after fuel immersion

15.1 Principle

The purpose of this test is to verify that the adhesive and cohesive properties of fuel-resistant type sealants do not deteriorate to an unacceptable degree as the result of contact with spilt fuel or oil.

NOTE The standard test fuel will give results which indicate the probable behaviour of a material coming into contact with the usual petroleum fuel and lubricating oils, but provision is made for the test to be carried out with a different fluid if the standard fuel is not representative of a particular type of spillage.

CAUTION. Attention is drawn to the Health and Safety at Work etc. Act 1974, and the need to ensure that this test is carried out under suitable environmental conditions to provide adequate protection to personnel against the risk of fire, inhalation of smoke and/or toxic products of combustion.



All dimensions are in millimetres.

Figure 8 — Transfer jig

15.2 Apparatus

15.2.1 *Large container,* made from 2 mm sheet metal, with nominal internal dimensions of 460 mm × 310 mm × 150 mm deep, with a closely fitting lid which can be sealed with adhesive tape.

15.2.2 *Small container,* made from 1 mm sheet metal, with nominal internal dimensions of 150 mm × 150 mm × 150 mm deep, with a closely fitting lid which can be sealed with adhesive tape.

15.2.3 *Transfer jig.* A suitable design is shown in Figure 8.

15.2.4 *Pouring jig,* as shown in Figure 6.

15.2.5 *Standard fuel* (see **10.2.2**).

15.2.6 *Adhesive tape.*

15.3 Preparation of test specimens

Prepare test specimens in accordance with clause **13**.

15.4 Procedure

15.4.1 Position, in a transfer jig (**15.2.3**), the specimen still held in the pouring jig (**15.2.4**) with the joint located over the cut-away section in the base of the transfer jig (**15.2.3**), and clamped securely. Remove the pouring jig (**15.2.4**), taking care to prevent the joint being subjected to any movement or stress during these operations. Remove the PTFE.

15.4.2 Check that the joint remains located over the cut-away section of the base of the transfer jig. Place the transfer jig (**15.2.3**) and specimen upside down in the large container (**15.2.1**) and pour the standard fuel (**15.2.5**) slowly and carefully without splashing until 13 mm of each specimen is immersed.

Place the specimen, in its container, in the small container (**15.2.2**) and pour in standard fuel (**15.2.5**) to a depth of 100 mm.

Place on the lids of both containers and seal them with adhesive tape (**15.2.6**).

Maintain both containers at (23 ± 2) °C for (24 ± 1) h.

15.4.3 Remove the specimens in the transfer jig (**15.2.3**) from the fuel (**15.2.5**) and place in an atmosphere at a temperature of (– 15 ± 1) °C for type F1 compounds and (0 °C ± 1) °C for type F2 compounds for a minimum period of 6 h, after which test the specimen as described in clause **13** except that the extension shall be 12 mm.

15.5 Test report

A test report shall be completed in accordance with clause **18**.

16 Determination of bitumen compatibility

16.1 Principle

The purpose of this test is to determine the bitumen compatibility of hot-applied joint sealants.

16.2 Apparatus

16.2.1 *Power-driven masonry saw.*

16.2.2 *Stiff-bristle brush.*

16.2.3 *Adhesive tape.*

16.2.4 *Forced draft oven,* capable of maintaining a temperature of (60 ± 3) °C for 72 h, conforming to BS 5060:1987.

16.3 Preparation of test specimens

16.3.1 Prepare duplicate test specimens in accordance with BS 598-107:1990 using 100 penetration grade bitumen conforming to BS 3690-1:1989.

16.3.2 Allow the test specimens to cool to room temperature, after which cut a groove 100 mm long by (13 ± 3.2) mm wide by (19 ± 3.2) mm deep in the top surface of each specimen by wet sawing with a power-driven masonry saw (**16.2.1**). Scrub the grooves thus formed with a stiff-bristle brush (**16.2.2**) while holding specimens under running water to remove all residue from sawing. Allow the specimens to dry and return to room temperature, after which securely wrap them with clothbacked adhesive tape, or otherwise reinforce to prevent slumping or collapse during the test period. Caulk the ends of the grooves to prevent leaking. Pour joint sealant prepared as described in clause **4** into the grooves, overfilling the grooves slightly. Allow no joint sealant to overflow onto the surface of the specimen adjacent to the grooves. After the sealing compound has cooled to room temperature, remove any overfill of sealing compound with a hot knife blade, so that the surface of the sealing compound is even with the surface of the specimen.

16.4 Procedure

Place the duplicate specimens in a forced draft oven (**16.2.4**) maintained at a temperature of (60 ± 3) °C for at least 72 h. Inspect the specimens at least once each day to prevent slumping or collapse during the test period.

16.5 Examination of specimens

Immediately after removing from the oven (**16.2.4**) and again after cooling to room temperature, examine the specimens for incompatibility of the joint sealant with the specimen.

16.6 Test report

A test report shall be completed in accordance with clause **18**.

17 Determination of bitumen compatibility after heat degradation

17.1 Principle

The purpose of this test is to determine the effect of prolonged heating on the bitumen compatibility of hot-applied joint sealants.

17.2 Apparatus

The apparatus shall be as described in clause **16**.

17.3 Preparation of sample

Prepare the sample of joint sealant in accordance with clause **3** except hold the temperature at the manufacturer's recommended pouring temperature instead of the safe heating temperature. Stir continuously for 6 h and then pour the sealant in accordance with **16.3.2**. Prepare duplicate test specimens in accordance with **16.3.1**.

17.4 Procedure

Test the sealant in accordance with **16.4**.

17.5 Test report

A test report shall be completed in accordance with clause **18**.

18 Test report

The test report shall affirm that the test was carried out in accordance with BS 2499-3:1993.

The test report shall include the following information:

a) name of sample and related primers if used;

b) source of sample and relevant primers;

c) batch number and date of manufacture where appropriate or expiry date of sample and related primers;

d) the particular clauses to which the material has been tested, i.e. the requirements specified in BS 2499-1:1993 and the methods of test described in BS 2499-3:1993;

e) the results of each test.

Annex A (informative)
Precision and traceability

A.1 Precision

Estimates of the repeatability and reproducibility of the test methods in this Part of BS 2499 and of the variability due to sampling are not yet available.

A.2 Traceability

The calibration of the test apparatus specified in this Part of BS 2499 to verify conformity to requirements should be traceable to the National Physical Laboratory either directly or indirectly through a hierarchical chain according to the accuracy demanded by the test. Systems used should conform to BS 5781.

List of references (see clause **2**)

Normative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 12:1991, *Specification for Portland cement.*

BS 410:1986, *Specification for test sieves.*

BS 598, *Sampling and examination of bituminous mixtures for roads and other paved areas.*

BS 598-107:1990, *Method of test for the determination of the composition of design wearing course rolled asphalt.*

BS 812, *Testing aggregates.*

BS 812-2:1975, *Methods for determination of physical properties.*

BS 812-103, *Methods for determination of particle size distribution.*

BS 812-103.1:1985, *Sieve tests.*

BS 882:1992, *Specification for aggregates from natural sources for concrete.*

BS 1881, *Testing concrete.*

BS 1881-102:1983, *Method for determination of slump.*

BS 2000, *Methods of test for petroleum and its products.*

BS 2000-50:1993, *Cone penetration of lubricating grease.*

BS 2499, *Hot-applied joint sealant systems for concrete pavements.*

BS 2499-1:1993, *Specification for joint sealants.*

BS 2648:1955, *Performance requirements for electrically heated laboratory drying ovens.*

BS 3643, *Specification for ISO metric screw threads.*

BS 3643-1:1981, *Principles and basic data.*

BS 3690, *Bitumens for building and civil engineering.*

BS 3690-1:1989, *Specification for bitumens for roads and other paved areas.*

BS 5060:1987, *Specification for performance and construction of electric circulating fans and regulators.*

BS 6664, *Flashpoint of petroleum and related products.*

BS 6664-5:1990, *Method for determination of flashpoint by Pensky-Martens closed tester.*

Informative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 2499, *Hot-applied joint sealant systems for concrete pavements.*

BS 2499-2:1992, *Code of practice for the application and use of joint sealants.*

BS 5212, *Cold applied joint sealant systems for concrete pavements*[2].

BS 5212-1:1990, *Specification for joint sealants.*

BS 5212-2:1990, *Code of practice for the application and use of joint sealants.*

BS 5212-3:1990, *Methods of test.*

BS 5781, *Quality assurance requirements for measuring equipment.*

BS 5781-1:1992, *Metrological confirmation system for measuring equipment.*

Other references

[1] GREAT BRITAIN. Health and Safety at Work etc. Act 1974. London: HMSO.

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[2] Referred to in the foreword only.

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