

Australian Standard™

**Liquid membrane-forming curing
compounds for concrete**

This Australian Standard was prepared by Committee BD/33, Chemical Admixtures for Concrete. It was approved on behalf of the Council of Standards Australia on 4 September 1998 and published on 5 November 1998.

The following interests are represented on Committee BD/33:

Association of Consulting Engineers Australia
Australian Chamber of Commerce and Industry
Australian Concrete Repair Association
Australian Pre-mixed Concrete Association
AUSTROADS
Cement and Concrete Association of Australia
Concrete Institute of Australia
Department of Land and Water Conservation N.S.W.
Institution of Engineers Australia
University of New South Wales
University of Western Sydney

Review of Australian Standards. To keep abreast of progress in industry, Australian Standards are subject to periodic review and are kept up to date by the issue of amendments or new editions as necessary. It is important therefore that Standards users ensure that they are in possession of the latest edition, and any amendments thereto.

Full details of all Australian Standards and related publications will be found in the Standards Australia Catalogue of Publications; this information is supplemented each month by the magazine 'The Australian Standard', which subscribing members receive, and which gives details of new publications, new editions and amendments, and of withdrawn Standards.

Suggestions for improvements to Australian Standards, addressed to the head office of Standards Australia, are welcomed. Notification of any inaccuracy or ambiguity found in an Australian Standard should be made without delay in order that the matter may be investigated and appropriate action taken.

This Standard was issued in draft form for comment as DR 97547.

Australian Standard™

**Liquid membrane-forming curing
compounds for concrete**

Originated as AS 3799—1990.
Second edition 1998.

Published by Standards Australia
(Standards Association of Australia)
1 The Crescent, Homebush, NSW 2140

ISBN 0 7337 2224 5

PREFACE

This Standard was prepared by the Standards Australia Committee BD/33, Chemical Admixtures for Concrete, to supersede AS 3799—1990.

The objective of this Standard is to provide manufacturers and users of liquid membrane-forming curing compounds for concrete, with specification covering classification and performance of curing compounds. It addresses sampling procedures, methods of test for water retention efficiency and drying time and provides general information on and properties of curing compounds.

The original issue of the standard was found to be not acceptable as a Product Standard, because it included reference to a method of classification by composition which was not verifiable within the terms of the Standard. Accordingly, the Standard was deemed to be 'not a Product Standard' and the section describing the types of classification, e.g. Wax Emulsion, Chlorinated Rubber, and so on, was included in Informative Appendix D, and omitted from the main body of the standard.

The Committee have decided that the situation has changed from that which applied at the time the Standard was first issued, in that the classification by composition is now verifiable by means of the Material Safety Data Sheet (MSDS), which is a compulsory requirement for each product, and which must indicate the composition of the ingredients of the product. The MSDS is a legally verifiable document and fulfils the requirements of Standards Australia for this purpose. There is, therefore, no obstacle to AS 3799 being classed as a Product Standard.

As originally issued, the procedure in Appendix B, Water retention efficiency, allowed for the application rate of the compound to be varied from the standard value of 5 m²/L as 'specified by the manufacturer' (Clause B9.1.1). This provision was found to give unreliable comparison between different compounds and, consequently, this allowable variation has been removed, and any application rate other than the standard rate will now be regarded as non-standard.

Other minor changes to the text include modification to the mortar mixing procedure to make it more workable without changing the nature of the mortar, and expanding the Definitions section to make it more informative.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the Appendix to which they apply. A 'normative' Appendix is an integral part of a Standard, whereas an 'informative' Appendix is only for information and guidance.

© Copyright — STANDARDS AUSTRALIA

Users of Standards are reminded that copyright subsists in all Standards Australia publications and software. Except where the Copyright Act allows and except where provided for below no publications or software produced by Standards Australia may be reproduced, stored in a retrieval system in any form or transmitted by any means without prior permission in writing from Standards Australia. Permission may be conditional on an appropriate royalty payment. Requests for permission and information on commercial software royalties should be directed to the head office of Standards Australia.

Standards Australia will permit up to 10 percent of the technical content pages of a Standard to be copied for use exclusively in-house by purchasers of the Standard without payment of a royalty or advice to Standards Australia.

Standards Australia will also permit the inclusion of its copyright material in computer software programs for no royalty payment provided such programs are used exclusively in-house by the creators of the programs.

Care should be taken to ensure that material used is from the current edition of the Standard and that it is updated whenever the Standard is amended or revised. The number and date of the Standard should therefore be clearly identified.

The use of material in print form or in computer software programs to be used commercially, with or without payment, or in commercial contracts is subject to the payment of a royalty. This policy may be varied by Standards Australia at any time.

CONTENTS

	<i>Page</i>
SECTION 1 SCOPE AND GENERAL	
1.1 SCOPE	4
1.2 APPLICATION	4
1.3 REFERENCED DOCUMENTS	4
1.4 DEFINITIONS	5
1.5 CLASSIFICATION OF CURING COMPOUNDS	5
SECTION 2 CHARACTERISTICS	
2.1 GENERAL CHARACTERISTICS	7
2.2 SPECIFIC CHARACTERISTICS	7
SECTION 3 REQUIREMENTS	
3.1 ACCEPTANCE TESTING	8
3.2 UNIFORMITY TESTING	8
3.3 COMPLIANCE WITH STANDARD	9
APPENDICES	
A SAMPLING PROCEDURE	10
B WATER RETENTION EFFICIENCY OF LIQUID MEMBRANE-FORMING CURING COMPOUNDS FOR CONCRETE	12
C DRYING TIME	19
D GENERAL INFORMATION ON THE PROPERTIES OF LIQUID MEMBRANE-FORMING CURING COMPOUNDS	20

STANDARDS AUSTRALIA

Australian Standard

Liquid membrane-forming curing compounds for concrete

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE This Standard sets out requirements for liquid membrane-forming curing compounds for concrete (referred to as curing compounds). It specifically excludes compounds applied to concrete, which do not form a membrane as defined in Clause 1.4, Definitions, of this Standard.

Appendices set out sampling procedure, methods of test for water retention efficiency and drying time, and a final appendix discusses general information and properties of curing compounds.

1.2 APPLICATION This Standard is a means by which curing compounds can be classified and described, and their performance assessed. The Standard sets limits of performance in a number of properties, and curing compounds that comply with these limits shall be regarded as being in compliance with AS 3799 for those properties.

This Standard may also be used to test curing compounds to a method recommended by the manufacturer, which involves a modification to the application procedure in Appendix B, in that an application rate other than the standard 5 m²/L is used, or the compound is applied in multiple coats with a drying interval between. When the standard method is so modified, the result shall be reported as Non-standard and shall not be used for the determination of compliance with this Standard.

1.3 REFERENCED DOCUMENTS The documents below are referred to in this Standard:

AS

1160	Bitumen emulsions for construction and maintenance of pavements
1216	Class labels for dangerous goods
1580	Paints and related materials—Methods of test
1580.301.1	Non-volatile content by mass
2350	Methods of testing portland and blended cements
2350.12	Preparation of a standard mortar and moulding of specimens
2701	Methods of sampling and testing mortar for masonry constructions
2701.7	Method for determination of water retention
3972	Portland and blended cements

AS/NZS

1580	Paints and related materials—Methods of test
1580.202.1	Density
1580.202.2	Density of water—Dispersed paints subject to foaming
1580.211.1	Degree of settling
1580.214.5	Consistency—Rotational viscometer

ASTM	
C156	Test method for water retention by concrete curing materials
C778	Specification for standard sand
D1309	Test method for settling properties of traffic paints during accelerated storage
E1347	Standard test method for color and color-difference measurement by tristimulus (filter) colorimetry

1.4 DEFINITIONS For the purposes of this Standard, the definitions below apply.

1.4.1 Emulsion—a liquid mixture comprised of a continuous aqueous phase in which is dispersed, as discrete particles, a semi-solid or viscous liquid phase. The formation of a membrane after application is caused by coalescence of the dispersed particles which are brought together when the water of the aqueous phase evaporates, or is absorbed into the concrete. After coalescence, there may be further evaporation of volatile material from the membrane.

1.4.2 Flammable—capable of being ignited and of burning in air.

1.4.3 Latex emulsion—a stable dispersion of water immiscible natural or synthetic polymer, in water.

NOTE: When an emulsion film is painted onto a green concrete or mortar surface the water evaporates and the suspended polymer coalesces to form a continuous polymer film.

1.4.4 Lot—quantity of admixture produced under essentially uniform conditions, usually a unit shipment or a single production quantity.

1.4.5 Membrane—a continuous film, substantially impermeable to water vapour, designed to cover the surface of the concrete after the application of the curing compound.

NOTE: Those compounds which, when applied to concrete, do not form a continuous film, but modify the concrete by being absorbed into it, are not membrane-forming, and are not covered by this Standard, as they do not comply with Section 2. These products, such as sodium silicates, silicones and silanes, are normally designed to act as surface modifiers or water repellents, and are generally ineffective in preventing the escape of water vapour from the concrete surface.

1.4.6 Plasticizing material—non-volatile modifying agent added to prevent embrittlement of resin.

1.4.7 Resin—either natural or synthetic polymeric material containing (where appropriate) added plasticizer.

NOTE: For the purposes of this Standard the term is restricted to hydrocarbon resins i.e. Class B—Hydrocarbon resin-based compounds

1.4.8 Solution curing compound—a solution compound is a single phase consisting of a film-forming material, such as a hard resin, acrylic or other polymer, or chlorinated rubber, dissolved in an organic solvent.

1.4.9 Vehicle—the total sum of the constituents of the liquid phase(s) of the curing compound. In the case of latex emulsions, the vehicle includes the dispersed polymer.

1.5 CLASSIFICATION OF CURING COMPOUNDS

1.5.1 General Curing compounds are available as waterborne or solvent-borne compounds. Refer to MSDS for specific details.

1.5.2 Class Curing compounds are classified by the chemical nature of their membrane-forming ingredients. The classes are as follows:

- (a) *Class A* Wax-based compounds. Waxes may be natural paraffin or synthetic waxes.
- (b) *Class B* Hydrocarbon resin-based compounds. Resins may be natural or synthetic.
- (c) *Class C* Chlorinated rubber-based compounds. These compounds are based on the same types of chlorinated rubber polymers which have been used for many years as chemically resistant surface coatings.
- (d) *Class D* Synthetic polymer-based compounds. The polymers may be either made from a single monomer or a mixture of monomers (copolymers).
- (e) *Class Z* Other membrane-forming compounds. The effective constituent may be one which does not conform with any of Classes A to D, or may be a combination of classes.

The classification for Classes A, B, C and D is determined solely by the membrane-forming constituent of the vehicle. The composition of the non-volatile portion of the vehicle shall be entirely that indicated by the class, combined with whatever modifying agents that are necessary for effective membrane formation, which can include the following:

- (i) For *emulsions*—emulsifying, stabilising and coalescing agents.
- (ii) For *Classes B, C and D*—plasticizing agents if required to reduce brittleness.

A compound that includes, in the vehicle, a modifying ingredient, which is itself a membrane-forming material not of the same class as the main constituent, shall be classified as Class Z, as shall any compound that is a combination of any two or more classes.

NOTE: A more detailed description of these classes is provided in Appendix D.

1.5.3 Type Curing compounds are grouped into types by appearance, as follows:

- (a) *Type 1* Clear or translucent without dye.
- (b) *Type 1-D* Clear or translucent with fugitive dye.
- (c) *Type 2* White pigmented or containing aluminium reflective pigments.
- (d) *Type 3* Black or coloured, other than white.

SECTION 2 CHARACTERISTICS

2.1 GENERAL CHARACTERISTICS When stored and used in accordance with the manufacturer's recommendations, a curing compound shall have the following general characteristics:

- (a) It shall be of such consistency that it may be readily applied by spraying (or by brushing or rolling, where specified) to a uniform coating at temperatures above 4°C.

NOTE: For uniform application in the field, on vertical concrete surfaces, two coats, applied at an interval of approximately 1 h, may be necessary.

- (b) It shall adhere to—
- (i) freshly placed concrete that has stiffened or set sufficiently to resist marring during the application; and
 - (ii) damp, hardened concrete.
- (c) It shall form a continuous film when applied at the specified rate.
- (d) When dry, the covering shall be continuous, sufficiently flexible to withstand normal temperature variations without cracking, and without visible breaks or pinholes. It shall remain as an unbroken film for at least 7 days after application.
- (e) The compound shall not react deleteriously with the concrete in any way. In particular, emulsion compounds shall not 'break' on application, that is, they shall not agglomerate in such a way as to affect water retention performance.
- (f) 12 h after application, the compound shall not be tacky or track off concrete when walked upon.
- (g) It shall be possible to store the curing compound for at least 6 months without deterioration, except that compounds of the water-emulsion class will not be expected to resist freezing. Emulsions or pigmented compounds shall not settle out excessively or cake in the container, and shall be capable of being mixed to a uniform consistency by moderate stirring.
- (h) The volatile portion of the curing compound shall have a flashpoint higher than 23°C (low flammability).

NOTES:

- 1 Volatile ingredients should comply with air pollution requirements for maximum permissible emission of photochemically reactive solvents, as established.
- 2 The manufacturer should classify his product in accordance with AS 1216, and should identify any potential hazards in its transport, storage and use.

2.2 SPECIFIC CHARACTERISTICS Curing compounds shall have the following specific characteristics:

- (a) Types 1 and 1-D curing compounds shall be colourless or light in colour. If the curing compound contains a fugitive dye (Type 1-D), it shall be readily distinguishable upon the concrete surface for not less than 4 h after application, but shall become inconspicuous within 7 days after application, if exposed to direct sunlight.
- (b) Type 2 curing compounds shall consist of finely divided white or reflective pigment and vehicle, ready-mixed for immediate use without alteration. The compound shall present a uniform white or reflective appearance when applied evenly to a new concrete surface at the specified rate of application.
- (c) Type 3 curing compounds shall be black or coloured, with no other special characteristics.

SECTION 3 REQUIREMENTS

3.1 ACCEPTANCE TESTING

3.1.1 General The sample, which has been selected in accordance with Appendix A, shall be tested for compliance with Clause 3.1.2, and the tests in Clauses 3.1.8 and 3.1.9 shall also be performed, since their results are required for the Clause 3.1.2 test. Compliance with Clause 3.1.3 applies only to Type 2 (white pigmented) compounds, and shall be determined, unless the requirement is not included in the specification. The compliance tests of Clauses 3.1.4 and 3.1.5 shall be performed, as well as the compliance tests of Clauses 3.1.6 and 3.1.7 unless they are specifically excluded.

3.1.2 Water retention When the sample is tested in accordance with the method of Appendix B (i.e. standard application in one coat), the Efficiency Index shall be calculated after 72 h drying. The sample shall have an Efficiency Index of not less than 90%.

3.1.3 Reflectance When tested in accordance with ASTM E1347, Type 2 curing compound shall have a daylight reflectance of not less than 60% of that of magnesium oxide.

3.1.4 Drying time When tested in accordance with Appendix C, the curing compound shall have a drying time not exceeding 4 h.

3.1.5 Viscosity When tested in accordance with AS 1580.214.5, (at a speed of 60 r/min, using No. 1 spindle), the curing compound shall have a viscosity not less than 0.05 Pa.s for emulsions and not less than 0.02 Pa.s for solutions. If the reading is off the scale of the viscometer defined above, the next highest reading number spindle shall be used. The speed of the instrument shall not be varied.

NOTE: The Brookfield Model LV Viscometer has been found to be suitable.

3.1.6 Residue on 150 µm sieve When tested in accordance with AS 1160, the residue of material retained on 150 µm sieve shall not exceed 0.2% by mass.

3.1.7 Shelf life When tested for long-term settling, in accordance with AS/NZS 1580.211.1, the compound shall have a rating of not less than 4 at the end of 6 months. An accelerated test over two weeks, as described in ASTM D1309, can be used to provide interim results.

3.1.8 Non-volatile content The non-volatile content of the curing compound shall be tested in accordance with AS 1580.301.1.

3.1.9 Density The density of the curing compound shall be tested in accordance with AS/NZS 1580.202.1. Where the method is not appropriate because of a tendency of the compound to froth, AS/NZS 1580.202.2 may be used.

3.2 UNIFORMITY TESTING The manufacturer shall carry out tests to assess the uniformity of each lot of product. The manufacturer shall report the results of these tests. Uniformity tests shall include the following:

- (a) *Non-volatile content* The value of the non-volatile content shall be that established in Clause 3.1.8, +2%, -1%.
- (b) *Density* The value of the density shall be that established in Clause 3.1.9, ±0.01 kg/L.

NOTE: Additional tests for uniformity such as infrared spectroscopy may be carried out by agreement between the manufacturer and purchaser.

3.3 COMPLIANCE WITH STANDARD The manufacturer shall be satisfied, on the basis of his quality assurance scheme, that the curing compound, when it leaves his control, complies with this Standard. If requested, the manufacturer shall provide a test certificate, giving the current test results appropriate to the curing compound supplied.

APPENDIX A SAMPLING PROCEDURE

(Normative)

A1 SCOPE This Appendix sets out the procedure for sampling liquid membrane-forming curing compounds for the determination of properties in accordance with this Standard.

A2 SAMPLING AT THE POINT OF MANUFACTURE If taken at the point of manufacture of the compound, at least three grab samples of the curing compound shall be taken in one of the following ways:

- (a) Where the compound is stored in a bulk tank with agitating equipment, the compound shall be agitated thoroughly before taking samples.
- (b) Where the compound is stored in a bulk tank without agitating equipment, three grab samples shall be taken at approximately quarter, half and three-quarter points of depth below the liquid surface.

NOTE: The grab samples may be taken by means of drain cocks placed at the appropriate levels in the sides of the tank or by weighted sampling bottles fitted with stoppers which can be removed after the bottles have been lowered to the desired levels in the tank.

- (c) Where the compound is not stored in a bulk tank, the grab samples shall be taken at regularly spaced intervals during the discharge of the compound from the final mixing equipment.

A3 SAMPLING AT THE POINT OF DELIVERY If taken at the point of delivery to the user, at least three grab samples of the curing compound shall be taken in one of the following ways:

- (a) Where the compound is delivered in a bulk tanker, the grab samples shall be taken at approximately quarter, half and three-quarter points during the discharge of the compound from the tanker.
- (b) Where the compound is delivered in drums, the grab samples of between 0.5 L (for 20 L drums) and 1 L (for 200 L drums) shall be taken from at least four drums selected at random from the lot.

A4 PREPARATION OF TEST SAMPLES A composite sample, of about 2 L, shall be prepared by thoroughly mixing the grab samples.

NOTE: All filled containers represented should be sealed to prevent leakage, substitution or dilution. At the time of sampling, each container should be suitably marked for later identification and correlation.

A5 IDENTIFICATION, MARKING, STORAGE The test sample, of minimum volume 2 L, shall be identified, marked and stored until tested in an impermeable, clean, airtight container which is not attacked by the curing compound. Samples containing organic solvents shall be stored in metal containers. Samples shall be stored in accordance with the manufacturer's recommendations on temperature, and all such stipulations shall be marked on the sample label.

A6 REPORT The following information shall be reported for each sample selected for testing:

- (a) Manufacturer and distributor.
- (b) Class and type of curing compound.
- (c) Source and identification of the lot, including whether bulk or drums.
- (d) Name and location of testing authority.
- (e) Date and location of sampling.

APPENDIX B

WATER RETENTION EFFICIENCY OF LIQUID MEMBRANE-FORMING CURING COMPOUNDS FOR CONCRETE

(Normative)

B1 SCOPE This Appendix sets out the method for determining the water retention efficiency of liquid membrane-forming curing compounds for concrete as measured by their ability to prevent moisture loss during the early hardening period.

B2 PRINCIPLE The water retention test is intended to test the curing compound in a practical manner in the most severe conditions likely to be found in the field, i.e. at 38°C and 32% relative humidity.

The curing compound is applied in its normal manner (most commonly by spraying) to the surface of a mortar prepared by a standard reproducible method. Rate of application in litres per square metre can be at a standard rate of 0.2 L/m². The specimens (3 for each sample being tested) are placed into the test chamber for 72 h, and the weight of water lost during that period measured by weighing the specimens before and after the 72 h period. Simultaneously, uncoated mortar specimens are subjected to the same treatment, and the corresponding water loss also measured. Effectiveness of the compound in retaining moisture is assessed as the percentage of water retained in the test specimens relative to the uncoated control specimens. This percentage is described as the Efficiency Index, and a value of 90% is the minimum required for compliance with the Standard.

NOTE: While the principle behind the test method is straightforward enough, the techniques involved are of such sensitivity that unless the correct methods are followed exactly, the value of the results can almost be completely negated.

B3 MATERIALS The following are required:

- (a) Clean quartz sand of substantially rounded grains, with the grading requirements, specified in Table B1.

NOTE: This corresponds to Ottawa standard graded sand as in ASTM C778.

- (b) Type GP Portland cement complying with AS 3972.

TABLE B1
GRADING REQUIREMENTS

Aperture size	Passing percent
1.18 mm	100
600 µm	96 to 100
425 µm	65 to 75
300 µm	20 to 30
150 µm	0 to 4

B4 APPARATUS The following apparatus is required:

- (a) *Moulds* Watertight moulds made of metal, glass, or plastics. Moulds shall be rigidly constructed to prevent distortion, and shall be 300 mm × 150 mm at the top, 295 mm × 145 mm at the bottom. All measurements shall be within ±5 mm, provided that the top measurement exceeds the bottom measurement by 5 ±1 mm. The depth shall be 50 ±2 mm measured on the inside. The moulds shall have a flat outer rim at the top on all sides, of approximately 6 mm wide.

- (b) *Pans* Shallow pans for the determination of the loss of volatiles from the curing compound being tested shall be metal pans or plates with the edges raised approximately 3 mm. They shall have dimensions equal to the top of the specimen, i.e. 300 mm × 150 mm, both measurements to be within ±5 mm.
- (c) *Mortar mixer* A planetary-type mixer of suitable capacity.
NOTE: A mixer unit complying with the requirements of AS 2350.12 has been found to be satisfactory.
- (d) *Tamping rod* The tamping rod (for compacting mortar in the moulds), shall be made of a non-absorptive, non-abrasive, non-brittle material, such as a rubber compound having a Shore A durometer hardness of 80 ±10. Alternatively, it may be of seasoned hardwood, which has previously been rendered non-absorptive by immersion for 15 min in paraffin wax at approximately 200°C. The rod shall have a cross-section of approximately 25 mm × 13 mm, and be of a convenient length (125 mm to 150 mm). The tamping face shall be flat and at right angles to the length of the rod.
- (e) *Wood float* The wood float for striking off the specimens shall have face dimensions of approximately 280 mm × 75 mm and be approximately 20 mm thick.
NOTE: A commercial wood float equipped with a substantial handle can be readily reduced to these dimensions.
- (f) *Spray gun* Equipment capable of uniformly spraying the curing compound to the required coverage shall be used. The gun should be of such size, that when loaded with liquid, it shall have a mass of less than 1 kg.
- (g) *Brush* A soft bristle brush 25 mm in width.
- (h) *Balance* Weighing balance, having a capacity of 10 kg and capable of weighing to an accuracy of ±0.1 g.
- (i) *Drying cabinet* A cabinet or room with adequate circulation of air, for storing the specimens at a temperature of 38 ±2°C and a relative humidity of 32 ±2%, capable of maintaining these conditions for the duration of the water-retention efficiency test.
- (j) *Flow table* A flow table complying with AS 2701.7.

B5 PREPARATION OF TRIAL SPECIMEN The trial specimen (to determine the proportion of sand to Portland cement) shall be prepared as follows using the procedure in Paragraph B6:

- (a) Add sufficient dry sand to a cement paste having a water/cement ratio of 0.40 by mass to produce a flow of 35 ±5.
- (b) Determine the flow in accordance with AS 2701.7. The table is subjected to 10 drops in 6 s.

The trial specimen shall be discarded once the proportion of sand to Portland cement is determined, and shall not be used for making the test specimens.

B6 PREPARATION OF TEST SPECIMENS

B6.1 Number of specimens A set of three test specimens shall be prepared in order to constitute a test for a given curing compound, and for each test series, a set of three blank specimens and a set of three pans shall also be prepared.

B6.2 Mixing mortar Mortar shall be mixed as follows:

- (a) Set the room temperature to 23 ±2°C and a relative humidity of 50 ±10%.
- (b) Place the cement in the bowl of the mortar mixer, add the water and mix for 30 s (speed 1).

- (c) Mix for a further 30 s, adding the sand (as determined in Paragraph B5) during this period.
- (d) Mix for 30 s, stop mixer, and remove bowl.
- (e) Scrape bowl for 30 s, removing all mortar adhering to bowl.
- (f) Replace bowl, mix for 2 min.
- (g) Check that the temperature of the mortar (after mixing) is $23 \pm 2^\circ\text{C}$.

NOTE: Preconditioning of sand, cement and water may be required prior to mixing to achieve a mortar temperature of $23 \pm 2^\circ\text{C}$.

B6.3 Moulding specimens Specimens shall be moulded as follows:

- (a) Thoroughly clean the moulds and thinly coat with oil, grease, or mould release compound except for the top rim which should be free of contamination.

NOTE: The use of masking tape on the top rim during application of release compound has been found satisfactory.

- (b) Place a layer of mortar in the mould, to a depth of approximately 25 mm, and tamp 50 times.
- (c) Place a second layer of mortar, to slightly overfill the moulds, and tamp 50 times.
- (d) Fill the indentations made by the tamping and level the surface using a vigorous compactive effort with the palm of the gloved hand.
- (e) Using a sawing motion of the wood float and making no more than two passes in the direction of the long axis of the specimen, strike off the specimen level with the top of the mould. Ensure that the face of the float is firmly in contact with the mortar and the edges of the mould so that the float creates a uniformly dense test surface free of voids and cracks.

B7 STORAGE OF SPECIMENS Specimens shall be stored as follows:

- (a) Immediately after moulding, place the specimens in the drying cabinet. Ensure that the specimens are stored level and not subject to vibration.
- (b) Arrange specimens and pans in the cabinet so as to provide a clear space of from 50 mm to 175 mm between the individual specimens and between the specimens and the side walls of the cabinet. Ensure that the spacing is the same for all specimens in the cabinet, within these limits.
- (c) Use dummy specimens, such as empty moulds, to fill the shelves of the cabinet when they are not filled with other specimens.
- (d) Ensure that the movement of conditioned air within the cabinet is such that the volatiles from the curing compound will be readily evaporated. During the first day, admit sufficient fresh air into the cabinet to permit these volatiles to be quickly eliminated.
- (e) Store all specimens so that they are subjected to similar conditions of air circulation.

B8 PREPARATION FOR TESTING Before commencing testing, take note of the following preliminaries:

- (a) Nominal mass of curing compound to be applied should be calculated as follows:

$$m = \frac{A q}{r}$$

... 1

where

m = nominal mass of curing compound to be applied, in kilograms

A = area including the rim to which curing compound is to be applied, in square metres

q = density of curing compound, in kilograms per litre (Clause 3.1.9)

r = nominal application rate, in square metres per litre (standard $r = 5 \text{ m}^2/\text{L}$)

- (b) When curing compounds containing solvents other than water are to be applied by spraying, it may be necessary to make allowance for loss of solvent by evaporation during spraying. This may be done as follows:

(i) Spray the pan with the curing compound in the same described manner, but place the pan in an oven at 105°C instead of in the drying cabinet.

(ii) Reweigh the pan after conditioning at 105°C for 3 h, and calculate the non-volatile content (as sprayed) of the compound. The application rate is adjusted by multiplying with the following correction factor:

$$c = \frac{\text{Non-volatile content (see Clause 3.1.8)}}{\text{Non-volatile content (as sprayed)}} \quad \dots 2$$

- (c) The actual coverage rate should be determined from the following equation:

$$r' = \frac{Aqc}{m'} \quad \dots 3$$

where

r' = actual application rate, in square metres per litre

A = area to which curing compound is to be applied, in square metres

q = density of curing compound, in kilograms per litre (Clause 3.1.9)

c = correction factor (Step(b)(ii) above)

m' = mass of curing compound applied, in kilograms

Where no correction factor has been determined, then $c = 1$.

The application shall be considered as standard if the actual application rate is within $\pm 5\%$ of the nominal standard rate of $5 \text{ m}^2/\text{L}$.

B9 PROCEDURE

B9.1 General In this procedure, 'specimen' denotes either a test specimen or a blank specimen, as appropriate. All references to weighing of the specimen shall include the mould.

B9.2 Procedure The procedure is as follows:

- (a) Remove the specimen from the drying cabinet immediately upon the disappearance of surface water and lightly brush the surface with the paint brush, with sufficient force to remove laitance and glaze but not hard enough to scarify the mortar surface.
- (b) If surface water reappears upon brushing, return the specimen to the cabinet for 10 min and repeat Step (a).

NOTE: The proper surface condition will be attained when brushing does not bring free water to the surface or produce smearing. The final condition can be determined by pressing an area with the finger tip, to check for the appearance of moisture.

- (c) Form a V-shaped groove approximately 3 mm deep, and not more than 3 mm wide between the edges of the specimen and the mould.

- (d) Fill the groove with a suitable sealing compound that will not be affected by the curing material under test. Ensure that the sealing compound effectively seals against moisture loss between the boundary of the specimen and the mould and does not extend more than 6 mm from the mould onto the surface of the specimen.

NOTE: Modelling clay has been found satisfactory for sealing.

- (e) Weigh the specimen or pan, as appropriate, to the nearest 0.1 g; return specimen designated as a blank specimen to the cabinet.
- (f) Apply the curing compound to the test specimen immediately and simultaneously to a pan at the nominal rate of 5 m²/L (see Paragraph B8(a)).

Curing compound for spraying shall be applied to the surface, with the spray gun held normal to the specimen, at the height required to give uniform application and minimum overspray.

Curing compound for brush application shall be applied uniformly to the surface of the specimen.

- (g) Immediately after application, reweigh test specimen and pan.
- (h) Return the test specimen and pan to the cabinet.
- (i) After approximately 3 h, weigh the specimen to check if any unusual loss has been caused by a leaking mould or faulty seal. In such a case, discard the specimen and repeat the test with a fresh specimen. Otherwise, return the specimen to the cabinet.
- (j) After leaving each specimen and pan in the cabinet for 72 h from the time of application of curing compound, remove and determine the total mass loss.

B10 CALCULATIONS The following results should be calculated:

- (a) The mass of volatiles lost from curing compound during curing period, as follows:

$$m_v = m_1 - m_2 \quad \dots 4$$

where

m_v = mass of volatiles lost from curing compound during curing period, in kilograms

m_1 = mass of pan with curing compound, in kilograms

m_2 = mass of pan with curing compound at completion of curing period, in kilograms

- (b) Mass of water lost from mortar of test specimen, as follows:

$$m_{wt} = m_3 - [m_4 + m_v] \quad \dots 5$$

where

m_{wt} = mass of water lost from mortar of test specimen, in kilograms

m_3 = mass of test specimen and mould after edge sealing and application of curing compound, in kilograms

m_4 = mass of test specimen and mould at completion of curing period, in kilograms

m_v = mass of volatiles lost from curing compound during curing period, in kilograms

- (c) Mass of water lost from mortar of blank specimen, as follows:

$$m_{wb} = m_5 - m_6 \quad \dots 6$$

where

m_{wb} = mass of water lost from mortar of blank specimen, in kilograms

m_5 = mass of blank specimen and mould after edge sealing, in kilograms

m_6 = mass of blank specimen and mould at completion of curing period, in kilograms

- (d) Determine and record average moisture loss for three test specimens (\bar{m}_{wt}) and three blank specimens (\bar{m}_{wb}). If the difference in moisture loss between any of the test specimens and the average exceeds 20% of the average, the test shall be repeated.
- (e) Determine Efficiency Index as follows, and record:

$$e = \frac{\bar{m}_{wb} - \bar{m}_{wt}}{\bar{m}_{wb}} \times 100 \quad \dots 7$$

where

e = efficiency Index, in percent (to nearest whole number)

\bar{m}_{wb} = average mass of water lost from mortar of blank specimens, in kilograms

\bar{m}_{wt} = average mass of water lost from mortar of test specimen, in kilograms

B11 NON-STANDARD TESTING In the case of a product being tested by a method that deviates from the Standard in any way, all such deviations shall be reported and indicated on the report as 'non-standard'.

The results of non-standard tests, as calculated in Paragraph B10, shall not be used for the determination of compliance with this Standard.

B12 RECORDS The following information should be recorded:

- (a) Identification of the sample including—
- (i) manufacturer;
 - (ii) brand name;
 - (iii) source of sample;
 - (iv) class and type; and
 - (v) laboratory identification, as appropriate.
- (b) Date and time of test.
- (c) Records of temperatures and humidity in drying cabinet during test.
- (d) Brand and type of cement used.
- (e) Description of sand used.
- (f) Temperature and relative humidity of laboratory and temperature of mortar mix.
- (g) Details of sampling of curing compound.
- (h) Linear measurements of exposed surface of specimen and calculated area.
- (i) Method of application and actual application rate of curing compound.

- (j) Determined density of curing compound.
- (k) Mass of curing compound to be applied
- (l) Mass of specimens before and after application of curing compound.
- (m) For each specimen, time of mixing and time of application of curing compound or, in the case of blank specimens, time of placing in the cabinet after edge sealing.
- (n) Mass of blank specimens after edge sealing.
- (o) Check mass of blank specimens and test specimens approximately 3 h after application of curing compound.
- (p) Mass of blank specimens and test specimens 72 h after application of curing compound.
- (q) Mass of pan used for correction for evaporation of curing compound.
- (r) Mass of pan with curing compound immediately after application.
- (s) Mass of pan with curing compound 72 h after application.
- (t) Correction for loss in mass of curing compound during test.
- (u) Loss of mass of water from the specimens at 72 h after application of curing compound or, in the case of blank specimens, from the time of exposure.
- (v) Correction for loss of volatiles from curing compound during test.
- (w) Efficiency Index.
- (x) Deviations from Standard.
- (y) Such other results from tests, as listed in Clause 3.1, as may be requested.

B13 REPORT The report, if provided, shall include the following information:

- (a) Identification of the sample including—
 - (i) manufacturer and supplier;
 - (ii) brand name;
 - (iii) source of sample;
 - (iv) class and type; and
 - (v) laboratory identification, as appropriate.
- (b) Date of sampling.
- (c) Details of quantity represented by the sample (if appropriate).
- (d) Method of application and the rate of application.
- (e) Density of sample.
- (f) Non-volatile content of sample.
- (g) Efficiency Index of compound.
- (h) Deviations from Standard.
- (i) Such other results from tests, as listed in Clause 3.1, as may be requested.

APPENDIX C DRYING TIME

(Normative)

C1 SCOPE This Appendix sets out the method for determining drying time of liquid membrane-forming curing compounds for concrete.

C2 PRINCIPLE The curing compound is applied to an impervious test panel. The test panel is then exposed to an environment of controlled temperature, relative humidity, and air velocity, and the time taken for the film to dry is determined.

C3 PROCEDURE The procedure shall be as follows:

- (a) Apply the curing compound to the panel at the standard rate of 5 m²/L.
- (b) Expose the test panel to air at 23 ±2°C and 50 ±10% relative humidity and at a velocity of approximately 3 m/s horizontally across the surface of the test panel.
- (c) Test the formed film for dryness with a finger knuckle of a freshly washed and dried hand, using moderate pressure.

C4 INTERPRETATION OF RESULTS The film shall be considered to be dry when it is no longer soft and tacky and when the film feels firm. The time taken to reach this condition shall be recorded.

C5 RECORDS AND REPORT The following information concerning the test shall be recorded, and reported if required:

- (a) Identification of the sample, including—
 - (i) manufacturer;
 - (ii) brand name;
 - (iii) source of sample;
 - (iv) class and type; and
 - (v) laboratory identification, as appropriate;
- (b) Details of quantity represented by the sample, if appropriate.
- (c) Drying time.

APPENDIX D
GENERAL INFORMATION ON THE PROPERTIES OF LIQUID
MEMBRANE-FORMING CURING COMPOUNDS

(Informative)

D1 SCOPE This Appendix outlines existing knowledge concerning liquid membrane-forming curing compounds (referred to as curing compounds) for use on concrete.

D2 DESCRIPTION A membrane-forming curing compound is a liquid material applied to concrete to restrict the loss of water during the early hardening period. It consists of non-volatile solids mixed with either water or a solvent. The solvent, or blend of solvents, can be an aliphatic or aromatic hydrocarbon, or other type of organic solvent. After application the volatiles evaporate leaving the solid material deposited as a thin film over the concrete surface.

D3 USES Curing compounds are used on concrete surfaces to restrict the rate of moisture loss and, hence, to increase the degree of hydration of the cementitious materials in the concrete. They are used as curing media for fresh concrete or for further curing of concrete after removal of forms or after moist curing. With the inclusion of a reflective pigment they can also be used to reduce the temperature rise in concrete exposed to solar radiation. Effective curing helps concrete to attain its maximum strength potential and, for pavements, increases abrasion resistance and reduces dusting. Retention of water also reduces the tendency to plastic cracking in fresh concrete.

D4 CLASSIFICATION Curing compounds can be classified as follows:

- (a) *Class A* Wax-based compounds.
- (b) *Class B* Hydrocarbon resin-based compounds.
- (c) *Class C* Chlorinated rubber-based compounds.
- (d) *Class D* Synthetic polymer compounds.
- (e) *Class Z* Other membrane-forming compounds.

Each of the above classes could be used, at least in theory, in both solution and emulsion forms. The exact nature of these classes is covered in Paragraph D5.

D5 DESCRIPTION OF CLASSES

D5.1 General The classes of concrete curing compound quoted in Paragraph D4 cover all the types of compound in use in industry.

Additionally, curing compounds can be categorized as either 'Waterborne' or 'Solvent-borne' depending on their principal dispersing medium. The advantages or disadvantages of each category are as follows:

- (a) Waterborne compounds have the great advantage of being free of toxic or flammable solvents, which removes problems with safe storage and simplifies cleaning of equipment. A disadvantage in cold conditions is that the drying time of the compound may be excessive. The compound may also be liable to instability in freezing conditions.
- (b) Solvent-borne compounds, despite the obvious disadvantages, may be preferable in some circumstances, because their film-forming properties may be more rapid and more positive than those of waterborne compounds. When a solvent-borne compound is used, the appropriate regulations and safety precautions have to be applied, in relation to handling, application, storing and transporting.

D5.2 Class A—Wax-based compounds Wax-based compounds are based on natural paraffin or synthetic waxes.

When comparisons are made between the moisture retention properties of the different classes or curing compounds, wax-based compounds are generally considered to be among the most effective. Their performance is related to the wax content expressed as the solid content of the compound. A 40% solids compound is generally more effective than a 30% one. However, the solids content should not be too high, as storage, stability, and ease of spraying will be affected detrimentally. The melting point of the wax base is also important. Too low a value will cause melting under hot conditions with subsequent excessive penetration into the concrete surface, resulting in less effective moisture retention. Low melting point waxes soften in hot weather, and their use may result in a tacky surface. Premature exposure to pedestrian traffic over pigmented waxes can cause tracking problems onto adjacent surfaces.

The use of wax-based materials can cause slipperiness on trafficable surfaces.

Wax-based compounds are divided into the following two categories.

- (a) *Waxes emulsified with water* Wax-based curing compounds are usually wax-in-water emulsions. The small wax particles, 1 μm to 2 μm in size, are kept in suspension by the addition of a small amount of a surface-active agent which affects the wetting properties of the particle/liquid interfaces. After application, the water phase evaporates and the wax particles remain on the concrete surface and coalesce to form a continuous film.

As the particles are only in suspension they can float out if the emulsion stability is poor. Thus, unstable wax emulsions form a crust at the upper level in the container and have to be remixed before use, which is a disadvantage on sites with limited facilities for remixing.

NOTE: Waxes emulsified with water are the most commonly used.

- (b) *Waxes dissolved in solvents* The wax particles in this group of compounds are dissolved in a solvent, and are subsequently deposited on the concrete surface as the result of evaporation of the solvent.

The use of dissolved wax compounds has been largely displaced by the emulsified waxes, owing to their improved ease of use with no loss of performance.

D5.3 Class B—Resin-based compounds Resin-based compounds basically consist of a petroleum hydrocarbon resin dissolved in a low aromatic hydrocarbon solvent such as white spirits.

These curing compounds are formulated with a high solids content, usually in the range 35% or greater and, because of this, they have a tendency to be brittle and will often crack and eventually flake off the concrete surface after a period of weathering. Suitable plasticizers can be added to the formulae to avoid this feature.

In recent years, compounds have been developed in which resins have been dissolved in a solvent to form a viscous liquid which is then emulsified in water. These compounds can also have a high water retention efficiency, with a reduced solvent odour.

D5.4 Class C—Chlorinated rubber-based compounds Chlorinated rubber-based compounds consist of rubber polymers that have been treated with a chlorination process which gives a higher resistance to sunlight, and makes the compound more resistant to chemical attack and to embrittlement. The process also enables the rubber to be dissolved more readily in solvent and permits a more flexible and uniform film to be applied.

These compounds generally have moisture retention properties comparable with those of the waxes. It is also claimed that they increase the resistance of concrete to the attack of many oils and fats and some acids and alkalis. For these reasons, chlorinated rubber-based compounds are sometimes used as a finishing treatment to improve the durability of concrete surfaces as well as curing media.

The solvent used is commonly of the aromatic type, and because of flammability and toxicity, these compounds should not be used in confined spaces unless appropriate safety precautions are taken. Good ventilation is essential.

NOTE: Use of this type of compound may be subject to local or state regulations. Reference to Material Safety Data Sheets for precautions is recommended.

After exposure to sunlight and weather, chlorinated rubber-based compounds tend to become brittle and yellow. They should not be used for curing pigmented concrete or on exposed decorative concrete finishes, unless pilot trials indicate they do not have a detrimental effect on the appearance.

These curing compounds are being used less and less due to supply shortages of chlorinated rubber resin in the market place and high levels of aromatic hydrocarbon solvent used in these formulations.

D5.5 Class D—Synthetic polymer compounds

D5.5.1 General The term polymer refers to a wide range of chemical materials which have been formed by small molecules (monomers) joining together to form large molecules (polymers). Although there are some natural polymers, those used to form curing compounds are invariably synthetic.

Polymer compounds can be in either emulsion or solution form, and either form can be of varying efficiencies, depending on the nature of the membrane that is formed when the water or solvent evaporates. Significant factors are the rate at which the membrane is formed, and the permeability of the membrane to water vapour after it has been formed. The latter is affected by the degree of continuity of the membrane (obviously the presence of holes in the membrane will increase its permeability), and also by its chemical nature.

It would be anticipated that a solution compound of a polymer would be more effective in retaining moisture than the corresponding emulsion of a similar polymer, because of the much finer pore structure in the film.

The advantages and disadvantages of the emulsion and solution types of polymer compound, and a description of the various polymers used in each type, are discussed in Paragraph D5.5.2 and D5.5.3.

D5.5.2 Emulsion polymer compounds Emulsion polymer compounds are referred to as latex emulsions, and are prepared from a wide variety of chemical monomers, either from a single monomer (e.g. methyl methacrylate), or from a combination of monomers which interact to form a combined polymer, called a copolymer (e.g. styrene-butadiene). Their membrane-forming process is dependent on the evaporation of water which results in the polymer particles coming into contact with each other and coalescing. A typical latex emulsion has a particle size of 0.1 to 0.5 μm . The effectiveness of the coalescence and the rate at which it occurs have a considerable relation to the water retaining efficiency of the compound, particularly in respect to the size and number of pores in the deposited membrane. These pores are a characteristic feature of latex emulsion films, and impose a limiting factor on the efficiencies that can be attained. Regardless of this limitation, some emulsions, have achieved efficiencies of 90% or greater.

The other disadvantage of waterborne emulsion compounds is that in cold conditions, because of their reliance on water evaporation for membrane formation, drying may be retarded. For most uses however, this potential problem is outweighed by the considerable advantages; i.e. absence of irritant or toxic fumes, non-flammability, safety in storage and transport, and ease of clean-up.

NOTE: Polyvinyl Acetates (PVAs) fit into this category, but have so far been unacceptable in water retention, which has generally been found to be less than 30% efficient.

D5.5.3 Solution polymer compounds Most currently available solution compounds are based on acrylic polymers, but other polymers would also be adaptable to this form of compound.

Performances of solution compounds is variable, but some can exceed 90% efficiency. Acrylic solutions are available in pigmented form, and can also be used as architectural coatings.

D5.6 Class Z—Other membrane-forming compounds Class Z includes membrane-forming curing compounds that do not fall into any of the listed classes A to D. Examples of compounds that are included in Class Z are the following:

- (a) Bitumen based compounds, generally in emulsion form.
- (b) Epoxy-based compounds, or other two-pack compounds.
- (c) Compounds that are neither waterborne nor solvent-borne, e.g. solvent-free epoxies.

Class Z does not include compounds that do not form a membrane, but are designed as impregnants, such as silicates, silicones and silanes.

D6 IMPREGNANTS There are many products on the market, which are designed for use as surface treatments for concrete, and which do not fall into one of the above categories. These fall into the class of impregnants. Basically, they are silicon compounds, such as silicates, silicones and silanes, and are usually solutions in either water or organic solvent. Their purpose is to be absorbed into the concrete surface and to act as a barrier to the ingress of water or waterborne contaminants. This is a completely different mechanism from the action of curing compounds and, without exception, they are not able to function as a curing compound.

D7 CURING COMPOUND CHOICE No curing compound can provide a complete barrier to evaporation from freshly placed concrete; therefore, curing compounds are less effective in promoting strength development than traditional methods such as ponding with water, covering with damp sand or polyethylene sheets, when these methods are used to full effectiveness. However, a compound of proved efficiency would be only marginally inferior to ponding in effectiveness, and would be considerably better than any of the traditional methods used in a careless manner. For this reason, combined with convenience of use, a good quality curing compound, applied in the correct manner, is likely to be beneficial in promoting the strength and durability of concrete.

For very high strength concrete, the use of curing compounds may not always be advisable. When the water/cement ratio by mass of a mix is less than 0.45, sealing the concrete instead of moist curing can lead to a process of self-desiccation, which reduces the rate of strength gain and may have a detrimental influence on the rate of hydration. Water curing also keeps the temperature of the concrete surface considerably lower than would be the case under a membrane, whether clear or pigmented. In thin slab construction, membrane curing may be insufficient to prevent warping and cracking due to thermal stress.

The choice of a curing compound should not be based solely on cost per litre, but should be evaluated on a cost effective basis, as the cost reduction may have been achieved by reduction in solids level, or by substitution of inferior ingredients (see Paragraph D9.2).

D8 APPLICATION

D8.1 General Most curing compounds should be applied to the exposed surfaces of concrete after the sheen of moisture, brought to the surface by the final screeding and trowelling operations, has disappeared but while the concrete is still damp. At the same time, the concrete should have hardened sufficiently to ensure that the surface is not damaged during the application of the curing compound. Undue delay will reduce the effectiveness of the treatment. If the compound is applied to a dry surface, it may soak into the concrete and not form a continuous film. Because of delays in finishing slabs, the curing compound is sometimes not applied until the day following the placement of the concrete. By this time the top of the slab may have dried out or plastic cracking may have taken place. Application of curing compounds at this time could result in the hydration of the cement being affected

detrimentally; dustiness, cracking, and loss of strength and durability can result. (These problems can sometimes be overcome by thoroughly moistening the concrete before applying the curing compound.)

As part of an investigation into the influence of curing compounds on the strength development of concrete carried out by the National Building Technology Centre (Ref. 1), a chlorinated rubber-based compound that had given good results in other tests was applied 24 h after the placement of the concrete on a warm, summer day. The 7-day and 28-day compressive strengths of cores taken from the coated slab were little different from those of cores taken from an adjacent part of the slab that was not given any curing treatment, although the later strength gain was more favourable (see Figure D1).

Prompt commencement of curing is particularly important for the satisfactory development of compressive strength of concrete containing pozzulana.

When an unexpected delay in placement or finishing occurs, the surface of the concrete should be kept moist until the curing compound is applied. On the other hand, a premature application of the compound is also undesirable in that the film may not adhere to the concrete or may be broken, particularly if excessive bleeding of the concrete occurs. Water-based compounds are more susceptible to dilution by residual bleed water than compounds which are solvent-based (Ref. 2).

Because of surface irregularities, the actual surface area to be sealed can be of the order of 30% more than the theoretical plane area. This is often not allowed for in determinations of the quantities required for the appropriate coverage rate. Because of their relatively low viscosity, there is also a tendency for some curing compounds to run off peaks on a rough surface and form thicker layers in the hollows. For this reason, the use of wax emulsions should be discouraged on heavily textured surfaces (Ref. 3).

Concrete that has been stripped of formwork should be moistened by light spraying until the surface will not readily absorb more water prior to the application of the curing compound. Failure to pre-wet the concrete may not only have a detrimental influence on the effectiveness of the curing treatment but may also result in a patchy appearance of the concrete.

D8.2 Methods of application Curing compounds can be applied by roller, brush, or spray. Where large areas are to be covered, spraying is usually preferred. A uniform application can best be obtained by spraying half the recommended quantity back and forth in one direction and the remainder at right angles. Windy conditions at the time of spraying can make it difficult to obtain a uniform coverage at the specified rate and additional applications may become necessary. Some curing compounds contain a fugitive dye that has no curing properties but is useful in ensuring that a uniform application is achieved. The density of the pigmentation enables the operator to judge whether sufficient coverage has been achieved. As many curing compounds (with and without pigments) are suspensions of solids, they may have to be stirred frequently to overcome settlement and to avoid blockages of the spray nozzle.

The choice of a suitable consistency for spraying can be influenced by the ambient temperature. At very low temperatures, it may be necessary to store wax emulsions in insulated containers and to keep the containers covered during use to prevent application difficulties associated with excessive viscosity. On the other hand, at very high temperatures the viscosity of some compounds may be reduced sufficiently to create problems of running or sagging when they are sprayed on vertical surfaces. Wax emulsions can 'break' or separate at extremes of temperature; the wax component floats to the surface leaving a clear aqueous layer at the bottom of the container.

Care should be taken to prevent the formation of excessive pinholes in the membrane as appreciable evaporation can take place through them. A second application at right angles to the first will improve the likelihood of sealing all pinholes.

The need to check the effectiveness of curing compounds by means of laboratory tests has been recognized for a long time, but the use of a compound that complies with the

requirements of an Australian or ASTM specification does not necessarily ensure that the concrete will be cured effectively. Often, when the compound is applied by spraying, no attempt is made to check whether the rate of application complies with the job specification. Windy conditions, high temperatures associated with rapid evaporative losses, or lack of care on the part of the operator can result in large variations in the rate of application. It is not sufficient to measure the volume of material sprayed over a large area to determine the average coverage rate, because this will not indicate the uniformity of coverage nor the volume blown away by the wind. This uncertainty can be quantified by placing pre-weighed absorbent pads at different places on the area to be sprayed. After the applicator has covered the area concerned, the pads are immediately folded with their wet sides together, placed in plastic bags to prevent evaporative losses and weighed. Any significant difference in the masses of the wetted pads indicates lack of uniformity of coverage.

If brushing is used and concrete is still wet enough to be marked by the brush, it is too early to apply the curing compound because continued brushing will open the surface of the concrete, allowing excessive penetration of the curing compound and breaking the continuity of the film.

When dry, the coating should be continuous, flexible and without visible breaks or pinholes, and should remain as an unbroken film for at least 7 days after application. The compound should not react detrimentally with the concrete.

D9 MISCELLANEOUS ASPECTS

D9.1 Adhesion Wax-based compounds have a serious limitation in that they impair bond. (Waxes are used as debonding agents in concrete construction, this property being used to advantage in the practice of applying a coating of wax-based curing compound between concrete layers in road construction, thus preventing reflection cracking.) Where concrete toppings or cement-based render will be applied later, the use of wax-base compounds is not recommended. Complete removal of a wax film requires the use of mechanical scarification and sandblasting. The removal process is difficult and expensive and, hence, wax-based components are not usually specified where a surface finish or coating will be required.

For all other classes of curing compound, it should be remembered that most of them are not designed to provide a durable film and, therefore, the application of any subsequent material, such as paint, concrete topping or vinyl flooring, has to be undertaken with adequate precautions. It will be necessary in most cases to obtain verification that any applied coating or adhesive is compatible with the curing compound and, where there is doubt, to ensure that the curing membrane has been removed before another material is applied.

The film left by the compound, when exposed to the weather, becomes harder and eventually more brittle. Hydrocarbon resin films are usually brittle almost immediately, and tend to crack and flake off the surface fairly rapidly, while chlorinated rubber is initially more flexible and will remain on the surface for a longer time, as will most polymers. The process is considerably slower when the film is pigmented, or when the surface is partially protected from direct sunlight. Individual cases vary considerably, and the breakdown may take from a few weeks to many months.

D9.2 Top-coating over concrete curing compounds Top-coating is related to the nature and length of the exposure and the length of the interval between the curing compound application and subsequent surface treatment. Even under the most favourable weathering conditions it will be unwise to apply a surface treatment earlier than four weeks after the curing compound application, unless it is removed by mechanical means.

In general, the rate of degradation of a curing compound under sunlight will depend on its composition, the rate of coverage, and how dry the concrete surface is when the compound is applied. If the surface is too dry, the compound may penetrate and key into the concrete, and will break down slowly.

Top-coating with adhesives, paints, and the like, is a matter between the supplier of the curing compounds and the supplier of the adhesives and paints.

Under some circumstances, topcoats can also be used as curing membranes if they have a water retention efficiency of 90% or higher. These top coats will often be more expensive than a simple curing membrane, but their use eliminates the need to remove the curing membrane before having the top coat applied, which saves time and money.

Some waterborne and 100% solids epoxy resin systems satisfy these requirements as do some solvent and waterborne architectural coatings. Advice should be sought from the manufacturer, and a current test certificate, showing that the top coat has >90% water retention efficiency when tested to AS 3799, should be insisted on.

D9.3 Heat reflectance The addition of a reflective pigment such as white titanium dioxide or leafing aluminium to a curing compound can help to reduce solar heat gain during a period of high temperatures and, hence, lessen moisture losses and damaging thermal stresses in the concrete. The effects of reflectivity on surface temperatures are shown in Figure 2 where the surfaces of four 7-day-old concrete specimens were coated with aluminium, a white curing compound, a clear compound and a matt black finish. The four surfaces were then exposed to infra-red lamps and the surface temperatures measured (Ref. 4).

D9.4 Drying time The curing compound should dry quickly, but not so quickly that any subsequent movement of the setting concrete will damage the membrane. The drying time (see Appendix C) should not exceed the setting time of the concrete.

D9.5 Viscosity The viscosity should be such that the compound will not flow across the surface when applied, nor flow away from the high spots leaving them insufficiently covered. The compound should also not be so viscous that it cannot be applied readily, especially when applied by spray.

When the compound is applied to a vertical surface, it may be applied in layers so that no sagging is experienced, with successive coats being applied with minimum delay, as soon as the underneath coat has set up enough to take the next coat, until the nominal application rate has been achieved.

D9.6 Resilience The curing membrane should be sufficiently resilient to provide a coherent flaw-free film under most site conditions. Although this is a very important property, no suitable test has yet been devised to assess its effectiveness in curing compounds.

D9.7 Flammability Solvent-based compounds are flammable, but should the applied film catch fire, the solvent content is usually insufficient to cause the whole sheet to burn. The risk of flammability with solvent-based Class A materials is usually low because of the low solvent content. Also, the flashpoint of waxes is generally high enough not to create a hazard. Nevertheless, manufacturers are required, by statute, to provide data concerning possible safety hazards.

D9.8 Pollution Waste disposal is a major problem with both wax emulsions and solvent-based compounds as they may not be washed into the stormwater or drainage system because of the possibility of pollution or of a fire explosion hazard. Spills can be soaked up with an inert absorbent material and then shovelled into containers for later disposal in land fill by following the specified guidelines laid down by law.

D9.9 Storage Curing compounds do not have an unlimited storage life, but should be capable of being stored for at least 6 months without deterioration; however, Class A compounds will be affected detrimentally if they are allowed to freeze. Curing compounds should not be stored for long periods in the sun where they will be exposed to high temperatures. Wax emulsions can also be affected detrimentally by bacterial action, and it is necessary to keep the containers sealed during storage to prevent airborne contamination.

As certain curing compounds consist of a suspension of solids which have a tendency to settle and form a cake in the container, it will be necessary to stir them thoroughly before use to

obtain a uniform consistency. When stored in drums for a period of six months after manufacture, the compound should be capable of being mixed to a homogeneous condition by rotating the drum.

D9.10 Safety The application of curing compounds on concrete can create health hazards arising from the inhalation of fine particulates or solvent vapour. Solvent-based compounds (Classes B and C) generate fumes that can cause respiratory damage. The risk is increased when these curing compounds are sprayed in unventilated areas or confined spaces.

Excessive exposure to solvent-based materials can have a defatting effect on the skin and can cause dermatitis. Water-based compounds can be highly alkaline and contact with the skin should be avoided. Always refer to Material Safety Data Sheets before specifying, ordering or using the materials.

The use of appropriate masks and equipment are strongly recommended.

D10 TESTING

D10.1 Moisture retention This Standard, AS 3799, was developed as a replacement for ASTM C156, which had served as the only criterion of quality for many years. ASTM C156 involved measuring the water loss from a mortar prism ($300 \times 150 \times 50$ mm), coated on one face with the compound, and stored in a drying cabinet (38°C and 32% r.h.) for 72 h.

AS 3799 uses the same basic procedure, the essential difference being that whereas ASTM C156 reported the result as an absolute loss of water in g/cm^2 , a result that is sensitive to test conditions (e.g. air velocity), AS 3799 reports the result as a percentage of water retained relative to uncoated controls. The AS 3799 result is thus independent of unspecified conditions in the test chamber.

The test provides information about the moisture retention ability of the membrane in temperature and humidity conditions which could be classed as fairly severe in respect of drying of concrete. It cannot claim to represent all the possible field conditions which might affect performance of the compound in practical use; therefore, a successful test result is no guarantee of success in the field. It would be a reasonable presumption, however, that if the membrane was proved to be satisfactory in the laboratory, and the compound could be applied to form a continuous coherent coating in field conditions, then the performance in the field would also be satisfactory.

AS 3799 also attempts to provide specifications and tests for other properties which may be relevant to performance and stability, and to provide a basis for continuing Quality Assurance.

D10.2 Uniformity testing The user may require that the supplier provides information on the uniformity of his product to ensure that its properties are likely to be similar to those checked in the type tests. Accordingly, it is necessary to check the solids content and the density of the curing compound. Other uniformity tests such as infra-red spectroscopy or pH may be carried out if required.

D11 CONCLUSIONS AND RECOMMENDATIONS There are significant differences between the water retention effectiveness and other properties of different classes of curing compound. Some general conclusions can be made concerning the various classes of compound.

Wax emulsion (Class A), hydrocarbon resin (Class B) and chlorinated rubber solution (Class C) compounds have had consistently better water retention than other classes. Each of these classes, however, has disadvantages in some applications because of other properties. Waxes are liable to cause low friction and lack of recoatability, chlorinated rubber has problems with solvent odour and toxicity, while resin types have rapid embrittlement as well as solvent problems.

Latex emulsion polymers (Class D) do not suffer from the disadvantages mentioned above, but with some exceptions tend to have lower water retention efficiencies.

No PVA-based compounds have yet been found to be even moderately acceptable, and their use as curing compounds should be avoided.

In general, it is advisable to use only products that are backed by reputable companies. Preference should be given to those companies that provide full information on their products' constituents and performance, and are willing to produce test results to support the performance claims.

D12 REFERENCES

- 1 HEIMAN, J.L., KEYWOOD, P. and MORGAN J., *Curing Compounds and Bonding Agents for Concrete and their Effects on Strength Development and Adhesion*. TR 52/75/404. Sydney: Experimental Building Station, Feb. 1973.
- 2 CLARKE, S.R., *Test Method for Liquid Membrane-forming Curing Compounds*. CIA News (Concrete Institute of Australia) Vol 10 No 2 page 15, July 1984.
- 3 WOODSTROM, J.H., and NEAL, B.F., *Curing Compounds for Portland Cement Concrete*. CA-DOT-TL-5149-2-76-63. Sacramento, California: Transportation Laboratory, Dec 1976.
- 4 HUNT, J.G., *The Curing of Concrete Pavement Slabs in Hot Weather*. TRA 435. London: Cement and Concrete Association, Nov. 1969.

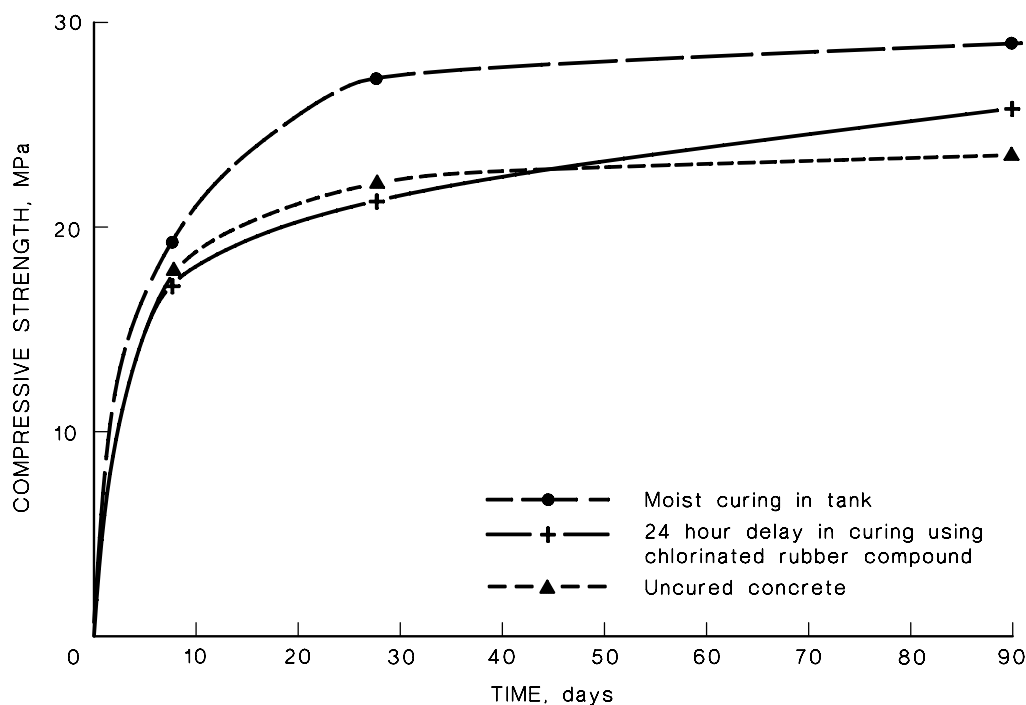


FIGURE D1 THE INFLUENCE OF DELAY IN CURING ON STRENGTH DEVELOPMENT

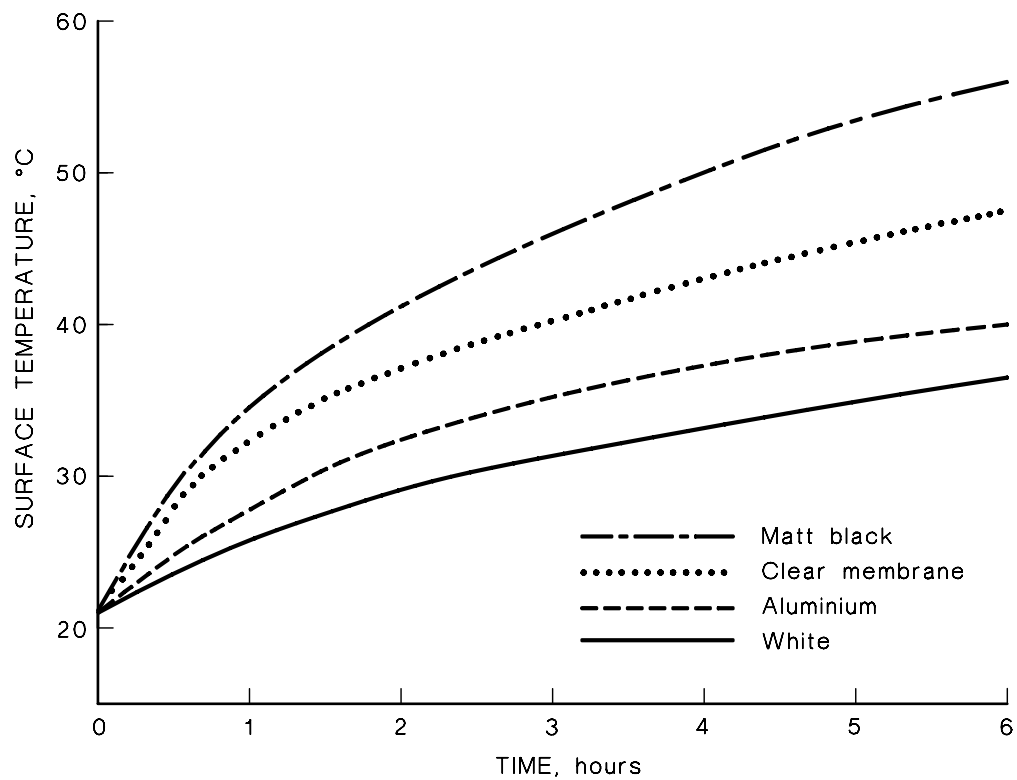


FIGURE D2 THE EFFECT OF FOUR SURFACE COATINGS ON THE REFLECTIVITY OF A CONCRETE SURFACE

This page has been left blank intentionally.