

# Products and systems for the protection and repair of concrete structures — Test methods — Measurement of chloride ion ingress

The European Standard EN 13396:2004 has the status of a  
British Standard

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## National foreword

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English version

## Products and systems for the protection and repair of concrete structures - Test methods - Measurement of chloride ion ingress

Produits et systèmes de protection et de réparation des structures en béton - Méthodes d'essai - Mesurage de la pénétration d'ions chlorure

Produkte und Systeme für den Schutz und die Instandsetzung von Betontragwerken - Prüfverfahren - Messung des Eindringens von Chloridionen

This European Standard was approved by CEN on 24 March 2004.

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Management Centre: rue de Stassart, 36 B-1050 Brussels

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## Foreword

This document (EN 13396:2004) has been prepared by Technical Committee CEN/TC 104 "Concrete and related products", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2004, and conflicting national standards shall be withdrawn at the latest by December 2004.

Annex A is normative.

It has been prepared by sub-committee 8 "Products and systems for the protection and repair of concrete structures" (Secretariat AFNOR).

This European Standard is one of a series dealing with products and systems for the protection and repair of concrete structures. It contains a method for determining the resistance to chloride ion penetration of hardened CC or PCC repair products and systems.

This document includes a Bibliography.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

## 1 Scope

This European Standard specifies a method for determining the resistance to chloride ion penetration of hardened CC or PCC repair products and systems for the protection and repair of concrete, as defined in prEN 1504-3.

The provisions of the standard are applicable to cementitious grouts, mortars and concretes with a maximum aggregate size of 20 mm.

## 2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 196-1, *Methods of testing cement — Part 1: Determination of strength*.

EN 1504-1, *Products and systems for the protection and repair of concrete structures — Definitions, requirements, quality control and evaluation of conformity — Part 1: Definitions*.

EN 1015-2, *Methods of test for mortar for masonry — Part 2: Bulk sampling of mortars and preparation of test mortars*.

prEN 14629, *Products and systems for the protection and repair of concrete structures – Test methods – Determination of chloride content in hardened concrete*.

## 3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 1504-1 apply.

## 4 Principle

The test is carried out on cylindrical specimens with a diameter of at least 100 mm. The specimens may be cast or cut from a larger block of the repair product or system. The specimens are pre-conditioned by saturation under a vacuum to minimise chloride uptake by absorption. The test procedure is designed to promote the ingress of chloride ions into the trowelled face of the cylinder, accelerated by immersion in a 3 % chloride solution at a temperature of 21 °C.

After the test period, the chloride ion content in the repair product or system is determined at three depths from the exposed surface.

## 5 Equipment

**5.1 Cylindrical moulds** for producing specimens manufactured from non-absorbent rigid material, which is inert to cement paste or polymers, of at least 100 mm internal diameter and at least 100 mm depth.

**5.2 Formwork** for producing blocks of material from which a full set of test specimens can be obtained, produced from rigid non-absorbent material, not attacked by cement paste or polymers and at least 100 mm in depth.

**5.3 Diamond core drill and barrel** that enable the drilling of a  $(100 \pm 2)$  mm cylindrical specimen through the repair product and system if formwork according to is used.

**5.4 Demineralised water** conductivity approximately  $0,5 \mu\text{S}/\text{mm}$ .

**5.5 Electronic analytical balance** with a minimum accuracy of  $0,001 \text{ g}$ .

**5.6 Vibrating table.** Where required, to compact the concrete or mortar.

**5.7 Two water baths**

#### 5.7.1 General

Two water baths with tightly-fitting lids to reduce evaporation, into which the specimens are placed. The volume of each bath should be at least 1,5 times the volume of the specimens and allow free circulation of test solution around them, made of rigid non-corroding material.

**5.7.2** Bath 1 shall be filled with demineralised water maintained at  $(21 \pm 2) ^\circ\text{C}$ , connected to a water jet vacuum pump capable of achieving a vacuum of  $(2500 \pm 500) \text{ Pa}$  (for water saturation). For conditioning it shall be used at normal atmospheric pressure ( $100.000 \text{ Pa}$ ).

NOTE The bath should contain sufficient water above the specimens to allow for a drop in level due to absorption and possible loss under vacuum conditions.

**5.7.3** Bath 2 shall be filled with 3 % NaCl solution (by using 99,9 % pure NaCl and demineralised water) maintained at  $(21 \pm 2) ^\circ\text{C}$  (for the test specimens).

**5.8 Cutting equipment** capable of trimming or grinding-away the surface of the sample to an accuracy of  $(\pm 0,5 \text{ mm})$ .

NOTE Suitable equipment includes a milling machine and dust collection system, operating a horizontally mounted diamond edged grinding wheel, or a vertically mounted diamond coated milling tool.

**5.9 Grinding equipment** suitable for crushing slices of the sample into a fine powder, in accordance with prEN 14629.

**5.10 Potentiometric titration equipment** in accordance with prEN 14629.

**5.11 Hard bristled brushes** for wet scrubbing or cleaning dust from the specimens.

**5.12 Standard laboratory climate** in accordance with the requirements of annex A.

**5.13 Mortar mixer**, in accordance with EN 196-1, forced action pan mixer, or other mixer in accordance with the manufacturer's instructions.

**5.14 Compaction Tools and Equipment** for repair grouts, mortars and concretes according to EN 196-1 or EN 1015-2.

Compaction method shall be carried out in accordance with the manufacturer's instructions.

**5.15 Electronic balance** with a minimum accuracy of  $\pm 0,1 \text{ g}$ .

## 6 Test procedure

### 6.1 General

Seven specimens are required for determining the resistance to chloride ion penetration, as follows:

- 2 for testing at 28 days;
- 2 for testing at 3 months;
- 2 for testing at 6 months;
- 1 control specimen for testing at 28 days.

## 6.2 Preparation

All materials shall be conditioned in the standard laboratory climate of  $(21 \pm 2)$  °C and  $(60 \pm 10)$  % RH (5.12) for a period of not less than 24-h prior to mixing.

Unless otherwise instructed by the manufacturer, use the following mixing technique for preparing the specimens.

For PCC and CC, use the mortar mixer (5.13) set to a low speed, pouring the gauging liquid to the bowl and adding the dry ingredients, mixing for a total period of two minutes.

Where manufacturer's instructions preclude use of part bags of material, a forced action pan mixer (5.13) or other method recommended by the manufacturer shall be used.

NOTE It has been found that certain types of repair mortar can foam excessively under the action of the mortar mixer specified in EN 196-1. An alternative is to use a forced action pan mixer (5.13). The air content, strength and density of the mixes should normally be determined to characterise the mortar under test.

The mixed material shall be placed carefully into cylindrical moulds or formwork, tamping or vibrating (5.14) to achieve full compaction. The top surface shall be trowelled smooth and flat and protected from contamination. Release of the repair material may be helped by use of a light smearing of mould oil on the sides of the mould.

The specimens shall be demoulded 24 h after casting and then cured according to annex A to an age of 28 days. The specimens shall be clearly labelled with the mix number or reference and the specimen number.

After the 28 day curing period, the specimens shall be fully saturated by immersing them in a bath of demineralised water at  $(21 \pm 2)$  °C under vacuum (5.7.2) for 24 h and then weighed every 4 h intervals until the change in weight, after continued vacuum saturation, is less than 0,5 g per kg of specimen weight (5.15). If full saturation is not achieved after 72 h under vacuum, the specimens shall not be tested and a report prepared which gives the weight change.

## 6.3 Conditioning

### 6.3.1 General

After completion of the vacuum saturation period, the fully saturated specimens shall be blotted with a clean damp cloth, weighed with the balance (5.15) and then fully immersed in a bath containing the following solutions:

**6.3.2** Six specimens in a 3 % NaCl solution using demineralised water maintained at  $(21 \pm 2)$  °C (5.7.3).

**6.3.3** One control specimen in demineralised water maintained at  $(21 \pm 2)$  °C (5.7.2).

The specimens shall be laid on their sides with sufficient space between them so that the trowelled faces are freely exposed to water movement.



## 6.4 Sampling

After 28 days, 3-months and 6-months conditioning, two specimens shall be removed from the NaCl bath (5.7.3), blotted with a clean, damp cloth to remove surface water and weighed using the electronic balance (5.15). Each specimen shall be scrubbed lightly with the hard bristled brush and rinsed with demineralised water to remove saline solution from the surface.

The specimen shall be prepared immediately (i.e. sampling shall be completed within 15 min of removal from the NaCl bath).

Samples shall be collected from the specimen, at three depth increments from the trowelled face using cutting equipment (5.8):

- increment 1, between 0 mm and 2 mm depth;
- increment 2, between 4 mm and 6 mm depth;
- increment 3, between 8 mm and 10 mm depth.

To ensure material that could have been affected by multidirectional penetration is discarded, the sides of the specimen shall be trimmed away using suitable equipment to remove an outer 20 mm thick annulus of edge material. As an alternative, the trowelled face of the specimen may be ground by a milling machine in such a way as to exclude this annulus (e.g. as shown in Figure 1).

NOTE 1 Ignoring the outer 20 mm annulus shown in Figure 1 is usually sufficient to eliminate these effects for products and systems intended to be resistant to chloride ion penetration.

The samples from the three depth increments shall then be ground to a powder (5.9) in accordance with the requirements of prEN 14629.

NOTE 2 The sampling procedure should yield a sample mass of at least 10 g per depth increment.

The powder shall be dried in an oven at  $(105 \pm 5)$  °C to a constant weight, measured using the analytical balance (5.5) and then allowed to cool to room temperature in a desiccator. The samples may be stored in the desiccator until the chemical analysis is carried out. The chloride ion content of the powder shall then be determined according to prEN14629.

The results for the chloride ion content of the samples at the three depth increments shall be expressed as a percentage of the sample mass. The average result for each depth shall then be calculated to three decimal places for each of the three test durations defined in (6.1).

NOTE 3 The results for the three depth increments should show decreasing chloride ion contents for increments 1, 2 and 3, as shown in Figure 2. In some cases, the chloride ion content results for increment 3 may be zero for materials that have very high resistance to chloride ion penetration.

Where the results for a deeper increment (e.g. increment 2) is higher than for a shallower increment (e.g. increment 1), the result should be recorded as abnormal and the sample inspected for cracking, porosity or other defect.

## 6.5 Control specimen

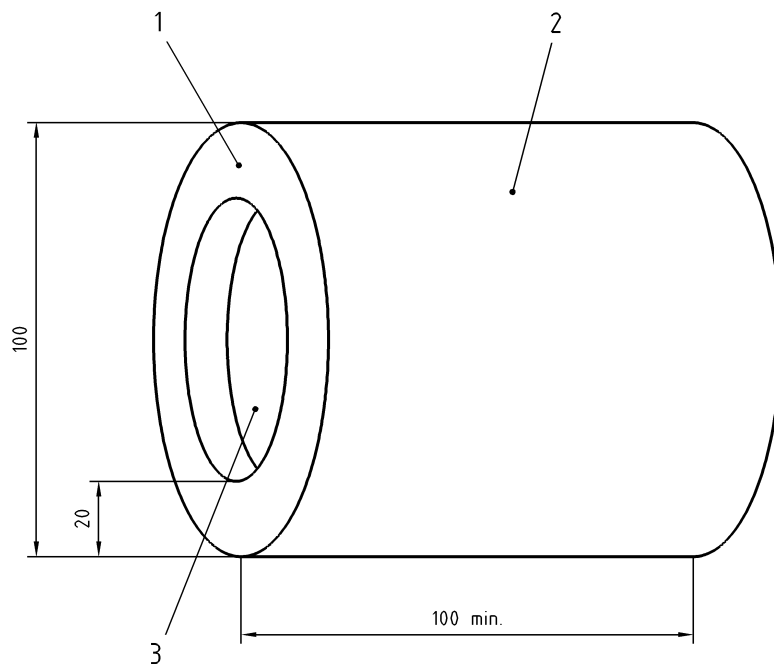
The control specimen shall be analysed following immersion for 28 days. The control specimen shall be broken in half, and a sample of at least 10 g taken from the centre of the specimen by cutting (5.8) or grinding (5.9). The sample shall then be prepared and analysed to establish the background chloride level by the method of prEN 14629. The result shall be reported as the chloride ion content of the samples expressed as a percentage of the sample mass to three decimal places.

## 7 Test report

The test report shall include the following:

- a) reference to the test method standard;
- b) name and address of the test laboratory;
- c) identification number and date of the test;
- d) name and address of the manufacturer or supplier of the product;
- e) name and identification marks or batch number of the product;
- f) date of supply of the product;
- g) date of preparation of the test specimens and any deviation from the prescribed method of preparation;
- h) conditions of storage of prepared specimens prior to test;
- i) date of test and details of the test equipment used, including the make, type and capacity and the calibration details or the identification number of the apparatus;
- j) test results, including the chloride ion content of the samples at each depth increment and at each age, including the individual results and the mean values and the background chloride ion content of the control specimen after 28 days immersion;
- k) precision data;
- l) date of test report and signature.

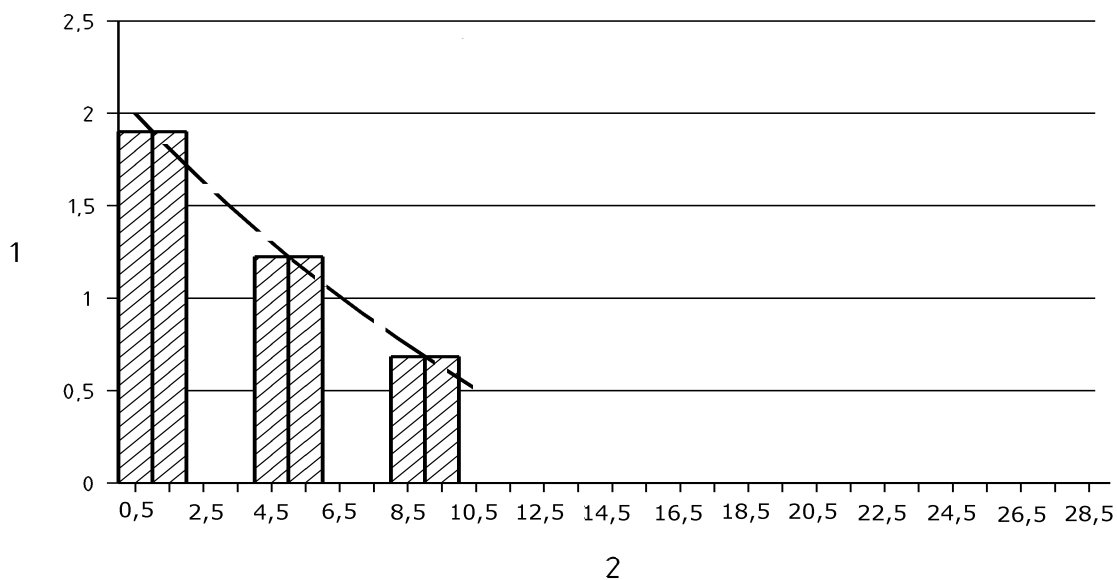
Dimensions in millimetres



**Key**

- 1 Trowelled face
- 2 Cylindrical specimen
- 3 Area of specimen ground for analysis

**Figure 1 — Specimen dimensions**



**Key**

- 1 Chloride ion content (%)
- 2 Depth increment (mm)

**Figure 2 — Typical results**

## Annex A (normative)

### Summary of temperatures and humidities for the curing, conditioning and testing of repair products and systems.

#### A.1 Curing

##### A.1.1 CC (grouts, mortars and concretes)

- Prepare as EN 196-1, cover in film for 24 h.
- Demould after 24 h.
- Cure under water at  $(21 \pm 2)$  °C for 27 days.

##### A.1.2 PCC (grouts, mortars and concretes)

- Prepare as EN 196-1, cover in film for 24 h.
- Demould after 24 h and wrap in film for 48 h.
- Unwrap and cure for 25 days in a standard laboratory climate of  $(21 \pm 2)$  °C and  $(60 \pm 10)$  % RH.

##### A.1.3 PC (grouts, mortars and concretes)

- Cure for 7 days at  $(21 \pm 2)$  °C and  $(60 \pm 10)$  % RH.

#### A.2 Conditioning and testing

##### A.2.1 For specific applications, the following definitions apply:

##### A.2.2 Standard laboratory climate (Dry conditioning):

- Take from the curing/storage environment and condition for 7 days in a standard laboratory climate of  $(21 \pm 2)$  °C and  $(60 \pm 10)$  % RH.

##### A.2.3 Wet Conditioning:

- Immerse for 7 days at  $(21 \pm 2)$  °C, or for CC take directly for test after at least 28 days of immersion;
- Remove all surface water by standing specimens upright for 30 min before using for tests.

## Bibliography

prEN 1504-3, *Products and systems for the protection and repair of concrete structures — Definitions, requirements, quality control and evaluation of conformity — Part 3: Structural and non-structural repair.*

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