BS EN 14038-1:2016

BSI Standards Publication

Electrochemical realkalization and chloride extraction treatments for reinforced concrete

Part 1: Realkalization

bsi.

National foreword

This British Standard is the UK implementation of EN 14038-1:2016. It supersedes DD CEN/TS 14038-1:2004 which is withdrawn.

BSI, as a member of CEN, is obliged to publish EN 14038-1 as a British Standard. However, attention is drawn to the fact that during the development of this European Standard, the UK committee voted against its approval.

The UK committee is concerned that the standard is insufficiently rigorous in respect of the:

– requirements to uniformly deliver charge to all areas being treated;

– assessment of adequacy of charge delivered to all areas treated;

– control of process parameters during application of the technique;

– clarity with which the criteria of adequate treatment is detailed.

Further commentary from the UK committee on the application of EN 14038-1:2016 can be found in National Annex NA.

The UK participation in its preparation was entrusted to Technical Committee GEL/603, Cathodic protection.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Electrochemical realkalization and chloride extraction treatments for reinforced concrete - Part 1: Realkalization

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Contents

Page

European foreword

This document (EN 14038-1:2016) has been prepared by Technical Committee CEN/TC 219 “Cathodic protection”, the secretariat of which is held by BSI.

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of an identical text or by endorsement, at the latest by September 2016, and conflicting national standards shall be withdrawn at the latest by September 2016.

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This document supersedes CEN/TS 14038-1:2004.

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Introduction

The purpose of realkalization is to provide long-term corrosion protection of steel reinforcement in concrete, which has become carbonated.

There are other electrochemical procedures, which can be used to provide corrosion protection of steel in concrete structures. These include cathodic protection and chloride extraction. There are a European Standard for cathodic protection of steel in concrete (EN ISO 12696) and a Technical Specification for electrochemical chloride extraction (CEN/TS 14038-2).

The execution of the provisions of this standard should be carried out by appropriately qualified and competent people, for whose use it has been prepared.

1 Scope

This European Standard specifies a procedure for carrying out impressed current electrochemical realkalization (ER) of carbonated reinforced concrete in existing structures. It is applicable to atmospherically exposed parts of structures with ordinary reinforcement embedded in concrete.

This European Standard does not apply to concrete containing prestressing steel which can suffer hydrogen embrittlement during realkalization, or to concrete containing epoxy-coated or galvanized reinforcement, or if chloride contamination is contributing to reinforcement corrosion.

NOTE In case of post-tensioned prestressing concrete, the endangered tendon strands may be shielded by the tendon ducts from unwanted and/ or exceeded polarization into the cathodic range and respective water reduction.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1504-9, *Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 9: General principles for the use of products and systems*

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

EN 14630, *Products and systems for the protection and repair of concrete structures - Test methods - Determination of carbonation depth in hardened concrete by the phenolphthalein method*

CEN/TS 14038-2, *Electrochemical re-alkalization and chloride extraction treatments for rein-forced concrete - Part 2: Chloride extraction*

EN ISO 8044, *Corrosion of metals and alloys - Basic terms and definitions (ISO 8044)*

EN ISO 12696:2012, *Cathodic protection of steel in concrete (ISO 12696:2012)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 8044 and the following apply.

3.1
realkalization
electrochemical treatment for restoring alkalinity to concrete which surrounds reinforcing bars with a high pH pore solution corresponding to sound and non-carbonated concrete

4 General

4.1 Quality management systems

The design, the installation, the energising, the commissioning, the long-term operation of all elements of electrochemical realkalization systems for steel in concrete shall be fully documented.

NOTE EN ISO 9000 constitutes a suitable Quality Management Systems Standard which can be utilized.

Each element of the work shall be undertaken in accordance with a fully documented quality plan.

Each stage of the design shall be checked and the checking shall be documented.

Each stage of the installation, energising, commissioning and operation shall be the subject of appropriate visual, mechanical and/or electrical testing and all testing shall be documented.

All test instrumentation shall have valid calibration certificates traceable to national or European Standards of calibration.

The documentation shall constitute part of the permanent records for the works.

4.2 Personnel

Each aspect of the ER system design, installation, testing of the installation, energising, commissioning and long-term operational control shall be under the supervision of personnel with appropriate qualification, training, expertise and experience in the particular element of the work for which they are responsible.

NOTE ER of steel in concrete is a specialist multidiscipline activity. Expertise is required in the fields of electrochemistry, concrete technology, civil and/or structural engineering and cathodic protection engineering.

Personnel who undertake the design, supervision of installation, commissioning, supervision of operation, measurements, monitoring and supervision of maintenance of cathodic protection systems shall have the appropriate level of competence for the tasks undertaken. EN 15257 constitutes a suitable method of assessing Competence of Cathodic Protection Personnel which may be utilized for ER as well as cathodic protection.

Competence of Personnel to the appropriate level for tasks undertaken should be demonstrated by certification in accordance with EN 15257 and suitable experience with ER or by another equivalent prequalification procedure.

5 Principle

Realkalization of reinforced concrete is performed by applying an electric field for a limited period of time between the steel reinforcement embedded in the concrete and a temporary anode surrounded by an alkaline electrolyte solution containing carbonate or hydroxyl ions temporarily placed on the concrete surface.

NOTE 1 The carbonated area treated by realkalization lies beneath the anode and around the first layer of reinforcement.

NOTE 2 Details of the principle underlying this process are given in the European Federation of Corrosion report [1]and in LCP report [7].

Electrolyte solutions of sodium, potassium and lithium may be used.

6 Assessment and repair of the structure

6.1 General

Prior to undertaking realkalization, an assessment of the structure, including its physical condition, its structural integrity and the nature and extent of any repairs which might be needed shall be performed in accordance with EN 1504-9.

The investigations specified in 6.2 to 6.8 shall be carried out in order to:

a) determine the suitability of the structure for realkalization;

b) provide information for design.

6.2 Review of records

All available drawings, specifications, records and notes shall be reviewed for information on the location, quantity, nature (e.g. mild or high strength steel, smooth or deformed bar, galvanized, epoxy-coated) and continuity of the reinforcement, as well as the constituents and quality of the concrete.

The possible sensitivity to reduction of bond strength should be evaluated in the case of smooth reinforcement.

6.3 Inspection

An inspection shall be carried out to ascertain the type, causes and extent of defects and any features of the structure or of its surrounding environment, which could influence the application and effectiveness of realkalization. All areas of the structure, which require realkalization, shall be checked for delamination of the concrete cover. Defects such as delaminations, cracks, honeycombing or poor construction joints which could permit significant water penetration, or prevent current flow and thereby impair the effectiveness of the realkalization treatment, shall be recorded.

In areas, which have been previously repaired, the repair methods and materials used should be identified, as far as possible. If the concrete behind the repair is to be realkalized, the electrical resistivity and porosity of the repair media should be considered.

The cause of any deterioration, which is not attributable to corroding reinforcement, shall be determined.

If any signs of structural distress are evident, an assessment of both the load-bearing capacity of the structure and the need for temporary or permanent strengthening or support should be made.

6.4 Carbonation depth measurement

6.4.1 General

Carbonation depth shall be measured according to EN 14630 at several locations to ascertain its distribution.

NOTE In selecting locations for concrete sampling, the objective is to identify areas with various carbonation depths for comparison with post-treatment data.

6.4.2 Determination of chloride content

The chloride content of the concrete shall be determined according to EN 14629 as a proportion of the mass of cement or concrete.

Concrete samples shall be taken from areas expected to have the highest possible chloride content in order to ascertain whether chloride contamination is present.

If chloride contamination is found to be a cause of reinforcement corrosion, suitable treatment shall be determined in accordance with EN 1504-9, EN ISO 12696 or CEN/TS 14038-2.

6.5 Concrete cover thickness and reinforcement location measurements

Concrete cover thickness and reinforcement location measurements shall be carried out in order to enable a determination to be made of comparative current flow through areas of thick and thin cover, and to identify regions of varying reinforcement density. Any features that could impair the effectiveness of realkalization, such as shielding of the reinforcement, caused by embedded metal mesh, metal fibres, metal plates, plastic sheets or non-conductive repair materials shall be identified. Points at which short circuits between the reinforcing steel and the anodes could occur shall be noted.

6.6 Alkali aggregate reaction

If the concrete of the structure, which is to be realkalized, contains aggregates, which can be sensitive to alkali, the risk of provoking an alkali aggregate reaction (AAR) shall be considered prior to any treatment.

NOTE No case of induced AAR has been reported in connection with realkalization until the time of publication of this European Standard.

6.7 Reinforcement continuity and size

The reinforcement continuity shall be proven on site by measuring the electrical resistance between reinforcing bars in mutually remote locations across the structure and between all reinforcing bars exposed during concrete repairs (see 6.8.3) or other works following the method and acceptance criteria as specified in EN ISO 12696:2012, 7.1. These measurements shall include the following:

a) continuity between elements of the structure within each realkalization zone;

b) continuity of metallic items, other than reinforcement, with the reinforcement itself.

Reinforcement size shall be identified from drawings when available and shall be verified by direct measurements.

6.8 Repair

6.8.1 General

All operations comprising repair shall be performed in accordance with EN 1504-9, except where stated otherwise in 6.8.2 to 6.8.3 below.

6.8.2 Concrete removal

All delaminated and honeycombed concrete and repair materials with unacceptably high electrical resistivity (>200 % of parent concrete resistivity) and/or containing any other materials that may impair the effects of realkalization shall be broken out to achieve a clean, physically sound concrete surface. Any tying wire, nails or other metal at the concrete surface that are found in contact with the reinforcement shall be cut back or insulated.

6.8.3 Reinforcement preparation

Exposed reinforcement shall have any loose scale and oxide removed to ensure good contact between the steel and the repair material.

NOTE There is no need to clean reinforcement to bright metal.

Primers or coatings and insulating/resistive bonding agents shall not be applied to the steel.

Continuity assessment, bonding and installation of all connections to reinforcement should be performed only after reinforcement preparation.

7 Materials and apparatus

7.1 Calibration of instrumentation

All instrumentation used to carry out the measurements specified in Clauses 6, 8 and 9 shall have valid calibration certificates traceable to a national or European Standard of measurement.

7.2 Anode system

7.2.1 General

The anode system shall consist of an anode submerged in an alkaline electrolyte solution or wrapped by a suitable liquid retention material saturated in an alkaline electrolyte on the concrete surface.

7.2.2 Anode

The anode shall be capable of distributing and sustaining the current required for the realkalization treatment.

7.2.3 Anode zone

Each anode zone should be designed to provide uniform current density to the reinforcing steel. Typically one anode zone has a size not exceeding 50 m^2 of concrete surface or a current output not exceeding 2 A/m^2 of steel surface area.

NOTE 1 A typical anode zone does not exceed 50 m^2 of concrete surface or a current output of 100 A.

NOTE 2 This is also referred to in the text as a “realkalization zone”.

7.2.4 Alkaline electrolyte solution

The alkaline electrolyte solution shall be capable of:

a) conducting the current between the anode and steel reinforcement; and

b) providing alkalinity to the carbonated concrete.

NOTE Suitable electrolytes include 1 M solutions of sodium carbonate, potassium carbonate and lithium hydroxide.

According to Faraday's Law of Electrolysis the ER process will generate a maximum of 0,89 moles of acid (H^+) per amp.day (1 mole every 27 A.hours). The initial electrolyte concentration and further addition of alkali should be calculated using this relationship.

The pH of the electrolyte shall be tested with a portable pH-meter or other suitable test method.

Fixtures and fittings in the concrete around the treatment area may be subject to attack from alkaline or acidified electrolyte solutions and should be protected against leakage.

7.3 Electric cables

All cables shall be insulated.

All cables shall be uniquely identified by colour of insulation and by zone number. The following colour code shall be used:

a) cables to anodes (positive cables): red (at least at its connectors);

b) cables to reinforcement (negative cables): black (at least at its connectors).

Cables shall be dimensioned to:

1) carry the design current +25 % within a permissible temperature range allowed under national or European Standards;

2) be of adequate mechanical strength.

7.4 Power supply

The impressed current power supply shall be limited to 42 V DC with a ripple content not exceeding 100 mV rms with a minimum frequency of 100 Hz.or as required by the relevant national electrical codes for extra low voltages.

NOTE It has been found that operating ECE systems consistently below 30 V DC can lead to longer treatment times and less effective treatments.

The AC power supply and its cabling and the DC circuits shall conform to the requirements of applicable national or European electrical safety standards.

All fuses shall be labelled with circuit designation and fuse characteristics.

All output terminals shall be fully insulated from any metal within the box. The terminals shall be clearly marked "+ ANODE" and "– Reinforcement".

The DC power supply unit shall be rated for continuous short circuits, and be suitable for the environment in which it is to operate.

8 Installation procedures

8.1 Electrical continuity of reinforcement

The electrical continuity of reinforcement shall be tested in accordance with 6.7 before applying realkalization treatment.

Each zone to be realkalized shall be provided with multiple connection points to the reinforcement steel.

NOTE A frequency of 1 connection per 25m^2 of steel area or 50m^2 of concrete area is a practical limit for design purposes.

8.2 Performance monitoring

Each anode zone to be realkalized shall be provided with the means necessary to monitor the total charge in ampere-hour (A·h) and duration of the treatment.

8.3 Installation of anode system

Before installing the anode system, the concrete surfaces shall be free of electrically insulating contaminants.

Particular care shall be taken to avoid short circuits between the anodes and any metallic items at the surface of the concrete.

The anode in each zone to be realkalized shall be provided with multiple anode connections.

NOTE 5 connections per 25 m^2 Ti-MMO anode and max 5 A with a 2 mm^2 cable cross section has been found a practical design limit for zones.

8.4 Protection of electrolyte solution

The electrolyte solution shall be protected against climatic changes (e.g. sun, rain, wind, frost).

8.5 Electrical installation

Installation works shall be undertaken in accordance with applicable national or European electrical safety standards.

8.6 Preliminary testing and documentation

Prior to commissioning the installation preliminary testing shall be carried out and the results documented.

Polarity checks shall be carried out on all circuits.

Electrical continuity shall be checked by measuring resistances of all anode connections and all cathode connections within each treatment zone.

Insulation checks shall be carried out on all circuits to check the electrical insulation of the DC positive side from the DC negative side and from any metallic items on or adjacent to the concrete surface (e.g. scaffolding).

After applying the electrolyte solution, anode/cathode resistance and potential shall be measured for each realkalization zone to detect short circuits, which shall be corrected prior to energizing the system.

9 Commissioning, operation and termination of treatment

9.1 Visual inspection

Before the realkalization installation is energized, the installation and all its component parts shall be subjected to a complete visual inspection to check that all components and cables are properly installed, labelled and protected from environmental, human and animal damage.

9.2 Energizing and adjustment of current output

Energizing shall be undertaken only after completion of preliminary testing in accordance with 8.6 and visual inspection in accordance with 9.1.

The system shall initially be energised at a low level and all circuits and zones shall be checked for correct polarity, proper operation of power supplies and of monitoring systems.

The realkalization current density shall not exceed 2 A/m^2 of reinforcement surface.

The charge shall be delivered over a minimum period of 200 h.

9.3 Routine inspection and maintenance

Routine inspection shall be carried out at least once a day. The following checks shall be carried out and the data recorded:

a) confirmation that all realkalization zones are functioning;

b) confirmation that the current and time (A·h) monitoring system specified in 9.4 is correctly monitoring all realkalized zones;

c) measurement of output voltage to each realkalization zone;

d) visual checks of cable insulation and anode connections, to confirm their proper functions;

e) control of electrolyte solution and supply to ensure that the entire realkalization zones are fully encapsulated in electrolyte solution or by the electrolytic reservoir.

9.4 Realkalization process monitoring

In each zone of realkalization treatment the current and time of current discharge shall be measured and recorded at suitable intervals.

NOTE For automated systems a monitoring interval not exceeding 2 h or continuously using an A·h meter or suitable computer controlled recording devices is recommended.

9.5 Termination of treatment

Realkalization treatment can be terminated in most cases when a total charge of 200 A·h/m^2 has been delivered to the reinforcement surface. The effectiveness of the realkalization process shall be demonstrated by phenolphthalein pH testing in each anode zone.

NOTE For phenolphthalein pH testing, the extent of realkalization is indicated by pink colouration around the reinforcement to a minimum of 10 mm or the bar diameter whichever is smaller.

Phenolphthalein changes colour at pH 10. A pink colouration should be observed. Other indicators such as thymolphthalein which change colour at pH11 may be used but the colour change may be more difficult to observe on concrete.

EN 14630 shall be utilized for testing with phenolphthalein.

The steel reinforcement surface area, which shall receive the charge of 200 A·h/m^2, shall incorporate all of the reinforcement closest to surface being treated and due allowance shall be made for current discharged to other reinforcement.

If the extent of carbonation is beyond the reinforcement closest to the surface, all reinforcement within the areas of carbonation shall be incorporated into the calculation.

The allowance for current discharge to other reinforcement may be by calculation of all reinforcement surface area within a particular depth of concrete, typically 200 mm, which should all receive 200 A·h/m^2. Alternatively, the allowance may be of the reinforcement surface area of deeper layers and the assumption that second and subsequent reinforcement layers will receive a lower percentage of the current density received by the reinforcement layer above it. See [6] for information on distribution of current to lower layers of reinforcement.

In the case of pre-corroded reinforcement, much more charge may be required to generate a sustainable realkalization effect to the surrounding concrete. A larger quantity of impressed charge is then needed to penetrate or dissolve corrosion products, before oxygen reduction becomes the predominant cathodic reaction. Theoretically, more than 300 Ah/m^2 are required to reduce oxides on a corroded steel surface, when the concrete cover is undamaged. However, considerably less than 100 Ah/m^2 may be a sufficient charge on areas with uncorroded reinforcement.

10 Final report

Upon completion of realkalization a final report shall be issued. It shall include the following information:

a) a general description of the structure, its location and physical condition;

b) a concrete description (type of cement, type of aggregates, mix design if known, chloride profile content…);

c) details of the parties associated with the refurbishment works (e.g. client, design engineer, supervising engineer, contractor, subcontractors) and their respective responsibilities;

d) details of the design of the realkalization treatment including:

   1) the surface area calculation for the reinforcement, in order to demonstrate conformity with the requirements of 9.5;

   2) a copy of the specification for the works, including definition of acceptance criteria;

   3) materials used for the realkalization process (anode material, and electrolyte chemistry);

   4) drawings in accordance with which the system was installed and energized, indicating variations and key dates;

e) a description of the preparation prior to treatment, including surface preparation, repairs, reinforcing bar continuity tests and selected test locations for concrete sampling;

f) process monitoring data: A·h charge records for each zone and additional current and voltage values recorded during treatment as specified in 9.3 and 9.4;

g) analysis of the results, including a consideration of any local abnormalities or variations in results followed by a statement of treatment effectiveness;

h) other relevant documents.

11 Post-treatment coating and monitoring

Where required, aesthetic or protective coatings shall be applied to realkalized concrete.

Caution should be exercised in the selection and application of the coating as the treatment process may lead to a very wet, high pH surface depending on the anode system used.

Where required, devices shall be installed to enable post-treatment monitoring of the effectiveness of the treatment.

NOTE Several suitable devices exist. For example, embeddable probes for potential and corrosion rate measurements.

Bibliography

[1] MIETZ J., ed. *Electrochemical rehabilitation methods for reinforced concrete structures — A state of the art report. European Federation of Corrosion, Publication 24*. IOM Communications Ltd, London, 1998

[2] HONDEL A.W.M. van den and POLDER R. B., Laboratory investigation of electrochemical realkalisation of concrete. *Eurocorr '98*, Working Party 11, Reinforcement Corrosion, Utrecht, NL, 1998. European Federation of Corrosion

[3] POLIET V. *2000, COST 521 project reports B-2*. Office for Official Publications of the European Communities, 1999

[4] GRANTHAM M., ed. *Concrete Repair – A practical guide*. Taylor & Francis, 2011

[5] NACE SP 0107-2007 Electrochemical Realkalization and chloride extraction for Reinforced Concrete NACE International Houston TX, USA, 2007

[6] HASSANEIN, A. M.; GLASS, G. K., and BUENFELD, N.R. *Protection current distribution in reinforced concrete cathodic protection systems*. Cement & Concrete Composites 24. 2002; 159–167

[7] TONG Y., BOUTEILLER V., MARIE-VICTOIRE E., JOIRET S. *Traitement électrochimique de réalcalinisation pour la réparation du béton armé dégradé par carbonatation*, Series Editor: C. E. e. R. d. LPC Série Ouvrage d'Art N°66, 2010

[8] EN 15257, *Cathodic protection - Competence levels and certification of cathodic protection personnel*

National Annex NA
(informative)
Further commentary from UK Technical Committee GEL/603

NA.1 Introduction

EN 14038-1 sets a requirement that 'all reinforcement surface area, within a particular depth of concrete, typically 200 mm, shall receive a charge of 200 A.h/m^{2}' (see Clause 9.5).

This National Annex (NA) provides the reader with information on how to ensure this requirement is fulfilled when applying this technique.

NA.2 Requirements (see EN 14038-1, Clause 7)

The need for uniform current distribution throughout the anode zone is not quantified in clause 7.2.3. This means it is possible for some areas to receive less charge and thus be inadequately realkalized. Ensuring that the charge delivered within each anode zone and between individual zones is within +/-10% of the nominal can mitigate this risk. This may be achieved by adequate design of anode material and cable to anode connections, in particular respect of the volt drops within the anode and between the cable connections, and minimising these so that current is delivered uniformly within the +/-10% of the nominal value across the entire area of each anode zone.

NA.3 Control of Process Parameters (see EN 14038-1, Clauses 7 and 9)

In clause 7.2.4, although the importance of the electrolyte pH is detailed and its testing is required, the control of pH of the electrolyte during the process is not covered. In clause 9.3, although other parameters requiring routine inspection and testing during the process are detailed, the measuring of pH and maintaining its value, in accordance with clause 7.2.4. has not been listed. Thus the cover concrete in contact with the electrolyte may be acidified by the electrolyte, irrespective of the charge delivered and to the detriment of its performance in future.

The UK committee recommends that the pH of the solution should be maintained above pH 10 at all times throughout the treatment. This can be adjusted by further additions of alkali at sufficiently regular intervals; other measures can also be taken if these can be proven to ensure the pH of the solution remains above pH 10.

NA.4 Requirements (see EN 14038-1, Clause 9)

In clause 9.5, it states (contradictorily to the 200 A.hm/2 assumed minimum charge requirement) that realkalization shall be terminated 'in most cases when a total charge of 200 A·h/m^2 has been delivered to the reinforcement surface'.

The UK committee recommend that users ensure all areas treated receive the 200 A.h/m^2 charge or alternatively undertake pre-treatment testing to demonstrate that some lesser charge is adequate. With either strategy, users should then ensure that the phenolphthalein testing requirements in clause 9.5 paragraphs 1 and 2 are met, if necessary by continuing the treatment with incrementally higher charge values. This staged approach will meet the requirements in applications where corroded reinforcement is present in undamaged concrete cover, where a minimum charge of 300 A·h/m^2 may be required (9.5 paragraph 7). If the requirements of clause 9.5 paragraphs 1 and 2 are not met after the 200 A·h/m^2 charge, the UK committee recommend that additional charge is incrementally applied,

and repeat adequacy of realkalization testing is performed after each increment, until all testing meets the requirements of clause 9.5 paragraphs 1 and 2.

In clause 9.5 paragraph 6 it is stated that in some circumstances less than 100 A.h/m^2 may be a sufficient charge, on areas with uncorroded reinforcement, to achieve a sustainable realkalization affect. If this is suspected in a particular application and it is proposed to apply less than the minimum 200 A·h/m^2 charge, the UK committee recommends that a minimum charge of 100 A·h/m^2 is applied to all steel reinforcement within the carbonated areas (plus the allowances as in clause 9.5 paragraph 5) and the sufficiency of this charge be demonstrated by detailed testing as in clause 9.5 paragraphs 1 and 2. If insufficient realkalization is demonstrated by the testing, the minimum charge should be increased until the phenolphthalein testing requirements in clause 9.5 are met.

These recommendations are not new requirements beyond those defined in the Standard, but are considered necessary clarifications of the intent of the Standard due to contradictory wording.

NA.5 Assessment of adequacy (see EN 14038-1, Clause 9)

The UK committee recommend that the assessment of adequacy is, in accordance with clause 9.5 paragraphs 1 and 2, completed by phenolphthalein pH testing in each anode zone. The wording of these paragraphs and the Note to paragraph 1 could be open to wide interpretation. The UK committee recommend that these normative requirements are applied at more than one location in every anode zone and that it is made clear what action is taken if some areas tested do not meet the defined assessment criteria for termination of treatment.

It is recommended that samples are taken from representative anode zones at their edges, at points proximate to anode/cable connections and at points remote from anode/cable connections in order to demonstrate the uniformity of treatment as required in clause 7.2.3.

At all tested areas, the pH10 requirement shall be met for a minimum of 10mm around all bars (or the bar diameter around bars of less than 10mm diameter). If this requirement is not met it is recommended by the UK committee that further realkalization charge is applied in increments of not less than 50 A·h/m^2 until full compliance with the pH10 requirement is achieved.

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