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Galvanske anode za katodno zaščito v slani vodi in slanih usedlinah (ISO/DIS 9351:2023)

Galvanic anodes for cathodic protection in seawater and saline sediments (ISO/DIS 9351:2023)

Galvanische Anoden für den kathodischen Schutz in Seewasser und salzhaltigen Sedimenten (ISO/DIS 9351:2023)

Anodes galvaniques pour la protection cathodique dans l'eau de mer et les boues salines (ISO/DIS 9351:2023)

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Contents

Page

Foreword

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This document was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 219, *Cathodic protection,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The anticipated performance of the cast galvanic anodes for use in sea water and saline mud or sediment is determined by their composition and the quality of their manufacture.

This document specifies galvanic anodes for use in seawater and sediment, their chemical compositions and physical characteristics together with inspection and test parameters, inspection procedures and their verification necessary to deliver the documented performance values.

Galvanic anodes for cathodic protection in seawater and saline sediments

1 Scope

This document specifies the minimum requirements and gives recommendations for the chemical composition, the electrochemical properties, the physical tolerances, and the test and inspection procedures for cast galvanic anodes of aluminium, magnesium and zinc-based alloys for cathodic protection in sea water, saline sediment and brackish water.

This document is applicable to the majority of galvanic anodes used for seawater sediment and brackish water applications, i.e. cast anodes of trapezoidal, or circular cross section and bracelet type anodes. The general requirements and recommendations of this document may also be applied to other anode shapes, e.g. half-spherical, button, etc., which are sometimes used for seawater applications.

NOTE Whilst other metals can be used as galvanic anode material to protect more noble metals than iron and steel e.g. soft iron, these are not covered in this standard.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 630, *Structural steels (all parts)*

ISO 12473, *General principles of cathodic protection in seawater*

ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods*

ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

EN 10025, *Hot rolled products of structural steels (all parts)*

ISO 10474:2013, *Steel and steel products — Inspection documents*

ISO 15607, *Specification and qualification of welding procedures for metallic materials — General rules*

ISO 15609-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 1: Arc welding*

EN 287-1, *Qualification test of welders — Fusion welding — Part 1: Steels*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org

3.1
acidity
presence of an excess of hydrogen ions over hydroxyl ions (pH <7)

3.2
alloy capacity
see “electrochemical capacity”

3.3
anode consumption rate
mass consumption rate
amount of anode material consumed for a current output of one ampere during one year

Note 1 to entry: The anode consumption rate is expressed in kilograms per amp year (kg/(A·y)).

3.4
batch
a group of anodes all produced from a single furnace cast

Note 1 to entry: Multiple batches of different anodes can be produced from a single cast.

3.5
bracelet anode
anode shaped as half-shells (annular castings) to be positioned on tubular items

Note 1 to entry: Two half-shell castings fit together to become a bracelet anode. Typically used for submarine pipelines; occasionally used for marine structure tubulars.

Note 2 to entry: Bracelet anodes may be fabricated as half or part shell castings with the structural core within the casting, or, as cast segments with only the supporting core within the casting and the structural steel elements external to the castings. Segmental bracelets comprise individual castings attached to external steel bands to fit around the pipeline or tubular structure.

3.6
calcareous deposit
layer consisting primarily of a mixture of calcium carbonate and magnesium hydroxides deposited on surfaces being cathodically protected in seawater due to the increased pH adjacent to the protected surface

3.7
cast
charge
heat
a single furnace load with a unique, analysed chemical composition from which anodes are produced

Note 1 to entry: If the casting sequence is interrupted, the anodes produced before, between and after the interruptions constitute "batches".

3.8
charge
see "cast"

3.9
closed circuit potential
closed circuit potential is the potential of an electrode measured with respect to a reference electrode or another electrode when a current is flowing in the circuit

3.10
cold shut
surface discontinuity in the cast anode alloy caused by solidification of a portion of a meniscus during the progressive filling of a mould, which is later covered with more solidifying metals as the molten metal level rises

Note 1 to entry: Cold shuts often occur remote from the point of pour.

3.11
core
see "insert"

3.12
crack
imperfection produced by a local rupture in the solid state, which may arise from the effect of cooling or stresses

3.13
driving voltage
voltage between the potential of a galvanic anode and the potential of the structure. For design purposes the driving voltage refers to the difference between the closed circuit potential of the anode and the design protective potential of the structure. This value is used to determine the maximum available anode current for a given circuit resistance

3.14
electrochemical capacity
total amount of electric charge that is produced when a fixed mass of anode alloy is consumed electrochemically.

Note 1 to entry: Electrochemical capacity is expressed in Ampere hours per kg (A·h/kg).

Note 2 to entry: This represents the practical amount of charge per unit mass available which is less than the theoretical, Faradaic value.

3.15
electrochemical efficiency
ratio of the practical electrochemical capacity to the theoretical Faradaic capacity and usually expressed numerically e.g. 0.90

3.16
electrochemical properties
properties of potential and electrochemical capacity that characterise a galvanic alloy and can be assessed by quantitative tests

3.17
flush mounted anode
anode fitted to a structure with one face in contact with or very close to the structure

3.18
free running test
electrochemical test where potential and current are not controlled

3.19
gas hole
blow hole, channel or porosity produced by gas evolution during solidification or entrapped air

Note 1 to entry: Gas holes can indicate

— contamination of the mould or core prior to casting or

— poor mould or insert design

— casting process permitting entrapped air during the pour

3.20
gross mass
mass (or weight) of a cast anode, including the mass of the steel core and any integral attachments on completion of casting

3.21
insert
structural item over which the anode is cast and which supports the alloy and can be used to connect the anode to the structure requiring protection

Note 1 to entry: The core is generally of steel. Its design is significant in determining the utilisation factor of the anodes.

3.22
ladle sample
specimen taken from a molten metal stream

3.23
net mass
mass (or weight) of cast anode, excluding the mass of the steel core and any integral attachments on completion of casting

Note 1 to entry: Net mass represents the weight of the galvanic alloy material and is used in cathodic protection design.

3.24
non-metallic inclusions
particles of oxides and other refractory materials entrapped in liquid metal during the melting or casting sequences

3.25
passive surface
condition of low surface activity or resistance to corrosion of a metal, as a result of protective film formation

3.26
pit
localised corrosion resulting in cavities extending from the surface into the metal

3.27
polarisation
change in the potential of an electrode as the result of current flow to or from that electrode

3.28
shrinkage depressions
natural concave surfaces which can be produced when liquid metal is allowed to solidify in a mould without the provision of extra liquid metal to compensate for the reduction in volume that occurs during the liquid and liquid–solid (solidification) contractions on cooling the liquid-solid transformation

Note 1 to entry: The term also applies to the concave surfaces produced when liquid metal is solidified in a closed mould in such a manner that the area is not “fed” by the liquid metal provided by the mould design.

3.29
stand-off anode
anode which is offset a certain distance from the object on which it is positioned

3.30
surface morphology
description of the features or structure of the anode surface
Topping up area surface of an open mould casting where the final solidification occurs and where, before final solidification, additional molten alloy can be added to top up any shrinkage to maintain final weight and dimension requirements

3.31
undercutting
the formation of subsurface cavities e.g. caused by pitting corrosion or inter-granular corrosion

3.32
utilisation factor
fraction of the galvanic alloy mass in an anode which can be used for cathodic protection current before the galvanic material is no longer supported by the core or the anode can no longer deliver the minimum required current

Note 1 to entry: Utilisation factor is generally expressed numerically e.g. 0.80 and is dependent on the detailed anode design and location of the insert. Utilisation factor is critical in the determination of anode mass requirements for a CP design.

3.33
void
a lack of bond between the steel core and the cast alloy of an anode that may be formed by movement of the anode core in the mould as the alloy solidifies

4 Symbols and abbreviations

4.1 Symbols

E	Anode consumption rate, kg/(A·y)
Q	Electrochemical capacity of the alloy, A·h/kg
CE	Carbon equivalent

4.2 Abbreviations

Al	Aluminium
CP	Cathodic protection
Eq. CO_2	Equivalent carbon dioxide content
EPD	Environmental product declaration
GACP	Galvanic anode cathodic protection
GWP	Global warming potential (Eq. CO_2)
ICCP	Impressed current cathodic protection
ISO	International standardization organization
ITP	Inspection and test plan
Mg	Magnesium
QC	Quality control
Zn	Zinc

5 Competence of personnel

It is the responsibility of personnel performing the design of the anode and the anode core to ensure that the anode, incorporating its core, is suitable to deliver the utilization factor, see clause 7. Those responsible for the core design shall have the appropriate level of competence for the tasks undertaken. Those responsible for all other aspects of the anode manufacture, inspection and testing shall also have the appropriate level of competence for the tasks undertaken; these should be the subject of the necessary training, assessment and documentation by the anode producer to ensure that the requirements of this document are met.

Competence of CP personnel to the appropriate level for tasks undertaken should be demonstrated by certification in accordance with ref. [12] or by another equivalent prequalification procedure.

6 Galvanic anode materials and their properties

6.1 General

In this standard, alloys used for galvanic anodes in seawater or saline sediment shall be based on aluminium (Al), magnesium (Mg) or zinc (Zn). The performance, and therefore the suitability of a particular alloy for a specific application, will depend on the composition and characteristics of both the alloy, the electrolyte, and operation conditions of the polarised anode.

The performance properties of an anode alloy may result from the performance data obtained in the given environmental conditions. The performance data shall include the electrochemical capacity in ampere-hours per kilogram (A·h /kg), and the closed-circuit anode to electrolyte potential of a working anode measured against a calibrated standard reference electrode (see 6.3 and Annex D).

Each anode shall be uniquely marked by hard stamping with the cast number during production. Other markings may be added by agreement between purchaser and manufacturer and may include for example, a manufacturer identification, an alloy designation, anode weight and a sequential production number within the cast. Marking should be by hard stamping on the anode surface located where it is visible when the anodes are stacked or palleted for storage or delivery.

6.2 Anode alloy composition

The performance of an alloy is dependent on the specific alloy composition. Variations in composition from established specifications can result in variations in activation, resistance to passivation, electrochemical capacity and corrosion surface morphology. In particular, some elements are known to have a detrimental effect on the anode performance and their content is normally subject to strict control.

The most common galvanic anode generic compositions for aluminium, magnesium and zinc based anode alloys are given in Annex C.

Strict control of the alloy chemical composition, both alloying elements and impurities, is essential and shall be carried out on each cast.

A minimum of two samples from each cast (ladle sample) shall be taken for chemical analysis. The samples shall be taken in the beginning and at the end of casting from the pouring stream. The sample shall be taken at the beginning of the first cast and at the end of the second cast, then in the beginning of the third cast and so on. The samples shall be analysed to verify the required chemical composition. All samples shall be identified with the cast number. All anodes from that particular cast shall be similarly identified with the cast number (see 6.1).

